UNITED STATES OF AMERICA

ENVIRONMENTAL PROTECTION AGENCY

SEVENTH CONFERENCE ON AIR QUALITY MODELING

EPA Auditorium
401 M Street, S.W.

Washington, DC

June 28, 2000

VOLUME I

The above entitled meeting was called to order at 9:00 a.m. by Joseph A. Tikvart.

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SPEAKERS FROM AUDIENCE:

Mr. Sanjee (ph)

Mr. George Schewe
Environmental Quality Management, Cincinnati

Mr. Haines, Duke Power

Jules ..., Science Consultants, Toronto, Canada

Arnie Stracongas (ph), Utilized Radium (ph) (URS),
Austin, Texas

Mr. Biggs, Consulting meteorologist

Randy Stowe, Dow Chemical

Steve Lining (ph), Carolina Power and Light

Doug Blewitt, Air Quality Resource Management

Ron Peterson, CPP

Dick Schulze, Trinity Consultants

Pat Hanrahan, Oregon Department of Environmental Quality

Phyllis Diosi (ph), Malcolm Perny (ph)

Mark Garrison, ERM

Stanley Vasa, The Southern Company

Howard Feldman, API

Ralph Morrison, Environ

Larry Simmons, Energy and Environmental Management

Vinca Trom (ph), AERMIC committee

John Nolter (ph), National Park Service

Brian Harvey, T-3

George Haine (ph), Earth Tech

P R O C E E D I N G S

DR. TIKVART: Okay, let's go ahead. Good morning and thank you for all being here. I'm impressed by the size of the turnout here, it's probably a little bit more than we anticipated, but I think we will have ample room for everybody. I am Joe Tikvart, Group Leader for the Air Quality Modeling Group of the Office of Air Quality Planning and Standards in EPA. That office is located in Research Triangle Park, North Carolina, 27711. I will be the presiding officer for this, the seventh conference on air quality modeling. The dates and purpose of that conference were announced in the Federal Register on May 19, 2000. And by the way, if I move my glasses I seem to lose my place, it's because I'm trying to figure out which of three lenses to read the script from. I think there are a few others in the audience who might have a similar problem when they get up here. But -- I think I got it.

The purpose of this conference is to provide a forum for review of new modeling techniques that can be useful in regulatory applications. More specifically, the conference provides a focus for public review and comment on proposed revisions to the guidelines on air quality models. That guideline is published as Appendix W to 40 CFR Part 51. It is used by EPA, states and private industry in the review and preparation of new source permits and state implementation plans. It serves as a means by which consistency is maintained in air quality analysis. The proposed revisions are based on our review and analyses of comments received at the previous conference, that is the Sixth Conference on Air Quality Modeling that was held in August of 1995.

The modeling guideline was first incorporated in the Code of Federal Regulations in 1978 and was subsequently revised in 1986. In 1988 and 1993 new techniques were added as supplement A and supplement B. Supplement C extended refinements to the industrial source complex model and stability classification schemes. The guideline was republished in August of 1996 to adopt the CFR system for labeling paragraphs.

There are plenty of seats, you just have to find one. Come on down.

This conference also satisfied requirements of Section 320 of the Clean Air Act. A periodic conference on air quality modeling is required to help standardize and improve modeling practices within air pollution control programs such as PSD, our Prevention of Significant Deterioration. The first conference in 1977, the third in 1985, the fifth in 1991, and this the seventh conference addresses the modeling guideline and specific revisions and additions to that guideline. The second conference in 1981, the fourth in 1988, and the sixth in 1995 addressed new knowledge concerning modeling technology and the overall accuracy of air quality modeling systems.

The modeling conference will begin with presentations on new modeling systems for two key area: one is enhanced point source modeling, and the other is long range transport. The AERMOD system is focused on bringing boundary layer parameterizations into Gaussian dispersion models that are widely used for regulatory programs. AERMOD is a product of the AMS/EPA regulatory model improvement committee, or AERMIC, which is made up of representatives of the American Meteorological Society and EPA. A recommendation for EPA to adopt the CALPUFF system for long range transport is a product of the Interagency Work group on Air Quality Modeling, or IWAQM. This work group is made up of representatives of EPA, the National Park Service, the Forest Service, and the Fish and Wildlife Service, all of which are concerned with PSD impact on Class I areas.

Representatives of both AERMIC and IWAQM will have a major role in presenting their respective modeling systems to you this morning and this afternoon.

Today, we are also proposing revisions to existing modeling systems: ISC-PRIME, which is applicable to aerodynamic downwash was developed and tested by the Electric Power Research Institute. The Emissions and Dispersion Modeling System, EDMS, applicable to airport operations, was revised by the Federal Aviation Administration. There will also be presentations this afternoon on several models for consideration as alternative models, which would be listed in the compendium previously known as Appendix B to the modeling guideline.

More specifically, today we are proposing revisions to the modeling guideline that would do the following. First, replace ISC3 by AERMOD as a state-of-the-practice technique for many air quality impact assessments. Applications for which AERMOD is suited include assessment of plume impacts from traditional stationary sources in simple, intermediate, and complex terrain. Second, recommend the CALPUFF modeling system for refined use in modeling long-range transport and dispersion to characterize reasonably attributable impacts from one or a few sources for PSD Class I impacts. CALPUFF is also identified for use for all downwind distances for those applications involving complex wind regimes, with case by case justification. Third, ISC-PRIME is recommended for situations where aerodynamic downwash or dry deposition are of import beyond standard dispersion applications considered by AERMOD. Fourth, EDMS continues to be applicable where aircraft operations are important at airports or air bases. Additions and changes regarding these models are reflected in Appendix A to proposed revisions for the modeling guideline.

In addition to the revisions that I have just mentioned, other noteworthy changes that are proposed for Appendix W, but not discussed here in detail are the following:

Enhanced criteria for the use of alternative models,

Removal of some obsolete models,

Additional screening criteria for use of models on nitrogen dioxide issues,

Recognition of new National Ambient Air Quality Standards for ozone and particulate matter, along with identification of supporting regional scale modeling systems, such as Models-3 and REMSAD, and finally,

Various editorial changes to Appendix W in order to update and reorganize information.

Many of the documents that serve as background for today's presentations have been made available as electronic files on EPA's internet website at www.epa.gov/scram0001. Documentation of computer codes, test cases, user's guides, model evaluation, and peer review can be obtained by accessing this site. From past experience, we have the impression that most of you have found this to be an effective and timely way to get the information needed for a meaningful review of new modeling systems.

Tomorrow morning, there will be presentations from the American Meteorological Society and the Air and Waste Management Association. Jeff Weil and Bob Paine have coordinated their efforts of these respective groups, and will lead the critical review and discussion of the new modeling systems at this conference.

We also plan to feature a special panel presentation led by Richard Schulze on the next generation of air quality models that may be driven by output from four dimensional prognostic models. This will be followed by statements from representatives of state and local air pollution control agencies on proposed changes to the modeling guideline.

Beginning with tomorrow morning, invited statements will be provided by representatives of other governmental agencies. The conference will then be opened to statements and comments from the general public. Throughout this two day period we will try to provide time for questions and discussion.

We have specifically invited those governmental agencies identified in Section 320 of the Clean Air Act to participate in this conference. We have also tried to include any other agency that has an interest in air quality modeling. Peter Lunn, representing the Department of Energy, has requested time to speak for a government agency. There are no others speaking for government agencies at this time, with the exception of staff or ...

As I have already noted, that presentation by Peter will be tomorrow, probably late tomorrow morning.

Prior to today, we have received the following individual requests for the public to make oral presentations?

* Doug Blewitt, speaking for the Gas Research Institute
* Ken Steinberg, speaking for the American Petroleum Institute
* Andrea Field and Bob Paine, speaking for the Utility Air Regulatory Group, and
* Professor Shararan, making personal observations. I think I have not said that name correctly, and if he's in the audience and will correct me, I'd appreciate it.

These presentations will be tomorrow afternoon, right after lunch.

If there are any government representatives or members of the public who wish to make a presentation and I have not read your name, or you have not made arrangements this morning, please see Tom Coulter, who is just outside the door helping with entry to the building and registration -- see him at the registration desk in the back of the auditorium. I will announce an up-dated list of speakers tomorrow morning, or probably at close of today.

As required by the Clean Air Act, a verbatim transcript of these proceedings is being maintained. The recorder is Dave McCoy of Executive Court Reporters. Speakers are encouraged to provide extra copies of their presentation for the convenience of the recorder and the presiding officer. Dave is in the back of the auditorium and if you can get the extra copy to me or directly to him before you speak, that would be helpful. Interested persons will be permitted to enter into the record any written comments they do not present orally. The record will remain open for written statements and comment for 120 days following publication of the Federal Register notice on proposed changes to Appendix W, that is until August 21, 2000. This is an extension from the 90-day period originally announced with the Federal Register proposal of Appendix W. The transcript and all written statements will be maintained in Docket Number AQM-99-01 in the OAR Regulatory Docket, here at EPA, 401 M Street, S.W., Washington, D.C. 20460.

The comments and discussion during this conference will be informal and non-adjudicatory. While some longer presentations are scheduled for today and tomorrow morning, individual presentations tomorrow afternoon should generally be limited to 10 to 15 minutes, unless the speaker has earlier made arrangements with me to speak longer. When making a presentation, please give any written statements that you may have to the recorder and summarize your remarks, if they are lengthy. Come to the podium for your presentation. Projection equipment, including an overhead projector and computerized presentations are available. When making a statement, identify yourself, your organization, and your address, both verbally and on any written statement.

For the new models and modeling systems described at this conference, we ask that the following questions be addressed in your comments and discussion:

* Has the scientific merit of the models presented been established?
* Is model accuracy sufficiently documented?
* Are the proposed regulatory uses of individual models appropriate and reasonable for specific applications?
* Do significant implementation issues remain or is additional guidance needed?
* Are there serious resource constraints imposed by the modeling systems presented?
* And finally, what additional analyses or information is needed?

So that your comments can be as effective as possible, and to assist the agency in correctly interpreting your comments, make them as specific as you can relative to these questions. Commentors who are drawing conclusions from data or reports are requested to provide a copy of such data or reports if they are not available in the usual scientific journals.

If, at an appropriate time, you have a question or a brief observation, go to the nearest microphone, and there's two here on the floor, and after I recognize you, please clearly state your name and affiliation for the recorder before proceeding.

With those opening remarks, I would like to begin the technical presentations for today. Please note that we have a heavy schedule and that there will be no break this morning. We will go straight through till lunch at 12:00 noon. This session this afternoon, with a break, could easily go to five p.m. or later. There are still a few seats down here in front. There are some chairs there in back, so come and look for chairs. How are we doing as far as entrants? Has the line shortened or is it still pretty long? Okay, good.

Two other brief announcements. As you may note, with these lights on me as they will be on the other speakers, this presentation is being video taped -- it's being video taped by EPA's education and outreach group and by North Carolina State University for presentation in a telecast as you see here on the slide. The telecast is scheduled for August 1 and 2, later this year, from one to four p.m., and it will be for the presentations only made today. I do not believe there's any video taping tomorrow, so all the presentations made today will be in that telecast. I think that information is self-explanatory.

So I think I have made all the announcements I need to make. One other note. Between speakers, the recorders video taping this do have to change tapes, so there might be a short break between presentations.

So, with that, Jeff Weil of the University of Colorado, will you start by giving us an overview of the AERMOD system.

MR. WEIL: Thank you. As Joe said, my name is Jeff Weil, and it's a pleasure to be here this morning. The American Meteorological Society and EPA Regulatory Model Improvement Committee or AERMIC, is pleased to present AERMOD as a proposed replacement for the industrial source complex model at this conference. Our presentation will consist of a brief introduction by myself, an overview and evaluation of the model by Al Cimorelli, a comparison of AERMOD and ISC and other models by Warren Peters, and a discussion of AERMOD's regulatory implementation by Rob Wilson.

To give you some background on AERMIC, I'd first like to present some of the historic ... motivating the development of AERMOD. This history has its roots in the 1970's and 80's when significant advances were made in our understanding of turbulence and dispersion in the planetary boundary layer. As you know the PBL is that turbulent region of the atmosphere, extending upwards some one to two kilometers above the earth's surface during the day, and perhaps tens of meters to hundreds of meters at night. And it is in this layer, of course, that air pollutants are emitted, transported and dispersed.

During the 70's and 80's new insights, such as convective scaling of dispersion for the unstable or convective boundary layer emerged. Another new insight was the idea of the dividing streamline height for stably stratified flow above complex or elevated terrain. In the late 70's and 80's, this information began to be used by model developers to update and approve applied dispersion models.

In 1984, the AMS and EPA held the Clear Water workshop on updating applied diffusion models and reviewed the state of the science at that time and made some recommendations on improvements using this earlier information for developing new applied dispersion models.

In the 80's and early 90's, this was the period of key developments of new applied dispersion models for air pollution sources. We had such models as PPSP, OMO -- developed in Denmark in 1986, HPDM -- sponsored by ... put forth in 1989, CTDM-Plus, 80MS -- developed in the United Kingdom in 1992, and there were two others -- 2POS (ph) which was developed by EPA in 1986, and SCIPUFF which -- whose development started in the late 80's and has continued through the

90's.

Now with the exception of CTDM-Plus for tough backforces and complex terrain, there was no new regulatory model introduced into the EPA system for regulatory applications. This created a good deal of frustration on the part of people who were trying to use this new information in applied dispersion models.

So in 1991, the AMF, EPA's steering committee on air quality modeling, conducted a workshop for state and EPA meteorologists, with the idea of promoting the use of PBO primatization of winds and turbulence in the boundary layer -- a new concept, such as convective scaling, and utilizing this information in a regulatory type dispersion model. And the participants at that meeting heartily endorsed the idea and in July of '91, AERMIC was formed.

Now the members of AERMIC are on the AMS side, myself, Bob Paine, Vinca Trom (ph), and representing EPA, we have Al Cimorelli, Russ Lee, Steve Perry, Warren Peters and Rob Wilson. I'd also like to acknowledge here, Roger B... from PES, the organization that put the AERMOD code together.

Now, from the inception of AERMIC, our goal, our objective has been to introduce state of the art modeling concepts into an EPA air quality model for regulatory applications. And our focus has been a replacement for the ISC model. You say why? Number one, ISC is widely used in regulatory applications. It's considered the bread and butter model, and the workhorse of the EPA modeling systems. Secondly, we initially considered whether or not to focus on EMTR (ph) or CLUSTER, which were tall flat models, but since HPDM was being developed and actually -- was in the developing stage at that time, we decided not to have a duplication of effort and therefore wanted to stick with ISC for a wide variety of source types.

Another reason we focused on ISC is that it contains a number of outdated concepts and practices, such as dispersion based on PGT system, which is truly valid for surface sources only, but yet PGT is applied to surface, tough ... forces within the boundary layer, you know, several hundred meters high.

Another deficiency is that in treating plume penetration of elevated inversions, ISC assumes that this is an all or none process -- either the plume remains in the boundary layer completely, or it's completely above. Another ... is in dealing with complex terrain. There is no treatment for intermediate terrain sites.

I should mention one other reason that we decided to focus on ISC, and that was that the code had recently been put into a highly modular form, so it made the job of changing -- making changes in the code to accommodate new algorithms et cetera, much easier.

Now AERMOD has begun to overcome some of the deficiencies of the ISC model with dispersion -- number one, dispersion based on PBL, turbulence structure scalian concepts, i.e., forecasting dispersion from a minimum set of meteorological variables, micronet variables. We also had different treatments for surface and elevated sources, and ... relative to the stack height were included. These are just some of the improvements of AERMOD over ISC.

But at the outset, before we began the model formulation, we developed this set of design criteria for principles to guide us through the development process. And we believed then, as now, that the model should include state of the art science. Secondly, capture the essentially physics of the dispersion and transport process without undercomplication. Third, the model should provide robust concentration estimates over a wide range of meteorological conditions. And fourth, it should be easily implemented with simple inputs, and also be user-friendly. And finally, it should be a model that can evolve as our understanding of dispersion improves, and therefore it should be able to accommodate modifications with ease. So a highly modular code is certainly desirable.

Now, there were a number of key activities in the model development process. Of first importance was formulating the model. And here I would like to acknowledge the outstanding work of the 1980's such as primatization (ph) of the planetary boundary layer -- winds and turbulence profiles. Convective scaling. The use of the dividing streamline height, and others. We borrowed a number of these ideas and concepts from models that had been developed during the 80's.

Another key point is that the model had been extensively evaluated with ten data bases, which include surface sources such as prairie grass; tall stack releases in simple, flat, and complex terrain; and also a powerplant source in an urban environment in Indianapolis. And Al Cimorelli is going to summarize the model evaluation in just a minute or so.

We also had a number of model-to-model comparisons. AERMOD versus ISC, HPDM, CTDM-Plus, et cetera. And Ron Peters will talk about that, to give you some idea of how AERMOD predictions compare with the other models for simple cases -- for a number of cases.

Another very important and key part of this program is that the model has been reviewed and the public has been allowed to participate in the process. We considered the process open. There's been an internal peer review, with review from at least two EPA scientists formally reviewing the document. There's been an external peer review, a panel was issued the model formulation code and model results and examined that quite thoroughly and gave us a lot of comments. There's been beta testing at two stages, with about six beta testers in each group.

The model formulation has been made available to the public on the SCRAM -- EPA's bulletin board system, starting at least in 1996 and was updated in '98 and 2000. And the public has had a chance to look at it, download it, submit comments to us, and we've received a good number of comments from this.

Conference papers have been made, and as you can see here, in '92 and '96 and beyond, and also we presented the model at the Sixth Modeling Conference in 1995. So today we are here to present just a brief overview and some of the highlights of AERMOD for you. I would ask, if you want to find out details about the formulation, about how it compares with observations -- these ten data bases, the model-to-model comparisons, et cetera, go to the SCRAM site, EPA's bulletin board system and you can download all the information that you would like about AERMOD.

And now I'd like to introduce Al Cimorelli, who will give an overview and evaluation of the model.

MR. CIMORELLI: It will take me a minute to get the slides up here. As Jeff said, it's important that we keep changing glasses. Good morning. My name is Al Cimorelli. I am with EPA Region 3, and I've been with them for some 20 years or more.

What I'd like to do this morning is to give you an overview of the formulation of AERMOD and the evaluation. But rather than provide just a general overview of the model and its evaluation, what I thought would be most instructive is if we were to look at this formulation and evaluation in the present context of the proposed action. Because what we're truly after here is to look at the evidence that has been put together and try to answer a specific question, which I'll get to in a minute. Hopefully, by doing it in this fashion, I should be able to -- or hope to be able to provide the evidence that at least AERMOD believes supports the proposed action.

Okay, outline for the talk. First what I'd like to do is give you a simple statement of what that context is. Secondly, provide considerations for criteria that I believe should be used to judge any regulatory model that is being proposed for use. Thirdly, I'd like to discuss the approach that AERMOD has taken and then, finally, and most importantly, provide the evidence and the conclusions that we've reached.

Okay, to the context. The question before us, I think, is really quite simple. It's, should AERMOD be adopted as a replacement regulatory model for ISC? Now, another way of stating that would be, will AERMOD provide better concentration estimates for use in defining emission limits, because that is, in fact, what we are truly after.

Now, what considerations do we want to bring to bear on this? Well, judging the adequacy of any regulatory model, I believe there are -- the two most important criteria that need to be addressed are first, how well did the model estimate the concentration which is used to set that emission limit? We, in the trade, I suppose, call that the design value.

For most of the design values that we deal with, or that AERMOD is going to be dealing with, they represent the extreme values of the distribution of concentrations measured out there, typically the high/second high for SO2 and others. They've gone to a little more statistical nature for PM and others, but the bottom line is that we are looking at the extreme end of the concentration distribution to do that.

Secondly, and equally important, is the ability of the user community to use the model. A model is of no use to any of us in the regulatory community if it cannot be used by that community. And in order for that to happen, it's important that it be publicly available -- everybody can get a hold of it, use it and see what it's about, and that it has adequate documentation. And then finally, it needs to be easy to use and it has to have some reasonable inputs.

However, we all know that we can't possibly evaluate a model with enough data to cover all of the applications that a proposed, and then eventually approved, regulatory model will be used for. In essence, we need some evidence that this model is doing the job that we need and that it can be generalized to other applications. And the reason -- and I guess what we have to be certain of is that this model can be generalized to applications and be able to calculate or estimate in a reasonable sense, what that design value is.

The problem generally, is that we don't have enough data, generally, to look at all the possible applications. Certainly the design value itself, being an extreme value, is a rather -- is difficult from a statistical comparison. It's a fairly difficult statistic to deal with.

So what do we need to improve that confidence? First thing I think we need, clearly, is that the theoretical basis of that model needs to be firm. And we have, as Jeff has pointed out, had an extensive peer review. Any theoretical basis needs to deal with a peer review. Secondly, rather than just looking at the upper end of that distribution of concentration, we would gain more confidence if the model performs well across all the ranks in that distribution, from the highest to the lowest ranks. And finally, the amount and diversity of the observations that we use to actually make the comparisons should be large, or as large as possible.

If we do those things and we feel confident in those things, then that should improve our confidence that we can generalize this model to the applications that it was not tested for.

Next, now, on to the AERMIC approach. First and foremost, AERMIC's goal was to update the science in the model, as compared to ISC, and we wanted, of course, to do an extensive peer review and have done that, as Jeff has explained. Secondly, recognizing again that we are looking at a comparison, most importantly, against the design values, we have -- we have decided to use two, what I believe are, relatively important statistics. The first of which is the robust high concentration, which many of you know, many of you may not know. It is an estimate of that extreme value using the top 25 values or so of the distribution. So by using those top 25 values to estimate the high end, the high/second high or high, it gives you a more robust indicator or statistic of the design value. Secondly, the Quantile-Quantile plot, or what we call the Q-Q plot provides you a picture of the entire distribution, again, giving you the ability to look at the performance of the model across that entire distribution.

In terms of evaluation, as Jeff pointed out, the AERMOD model has been evaluated against ten data sets. That, in my opinion certainly, is a very extensive and diverse set of data. When you compare it to previous regulatory models at the stage of development that AERMOD is in, and that stage is the proposal stage, certainly after proposal, models that are presently in the guidelines have had a substantial amount of evaluation. But at the point of proposal, when the community has had to decide, the AERMOD clearly is providing, and will be providing us with the most extensive and diverse amount of data.

On to the evidence. First let me talk about the improved science that's in AERMOD, or just expound a little bit upon what Jeff has said. And I'm only going to talk about some of the major improvements that have gone on. First, in meteorology. Unlike ISC, where we use a single measurement height for the input parameters like wind and direction and so on, AERMOD utilizes the profiles of wind, temperature and turbulence in the atmosphere in a way that we are able to treat this vertical inhomogeneity. Now, I would direct you to the SCRAM bulletin board where the model formulation document exists, and you can see exactly how we've gone about doing that, and I would invite your comments to the record on that and others.

Next, another area, I think, that everyone would recognize as a major improvement. ISC, as you all know, parameterized turbulence using stability classes from which there was an inference on how the plume would spread over distance. AERMOD now uses actual turbulence, in fact, profiles of turbulence, to develop the statistics of plume spread.

Secondly, there is a recognition in AERMOD that there is a functional difference between the dispersion or physics that goes on in the lower portions of the atmosphere, near the surface, than when you get up into a more elevated release. AERMOD has that treatment, and as part of the criteria that we have set up in AERMOD, we have attempted to make as smooth a transition between different regimes as we can. One of our criteria has always been to avoid as many discontinuities as possible, and we have, I think, succeeded in reasonable measure in that regard.

And finally, in regards to dispersion in the stable boundary layer, AERMOD has a method of treating the lowest frequencies of the turbulence spectrum that do not disperse pollutants or diffuse pollutants, but actually translate or move the pollutants or move the plume back and forth. And that particular effect also contributes to the time average concentration, but differently from the way other models treat that, and that is treated in AERMOD.

Probably one of the more significant improvements, I think, from at least from an applications perspective, is the way AERMOD treats terrain. With the adoption of AERMOD, if it occurs, we will now have a continuous terrain model, meaning that there will be no reason to define the difference between simple, intermediate, and complex terrain. This is done in a fairly generic way. Unlike models like CTDM-Plus where you are actually modeling very specific dynamics and -- that's going on on a particular hill, AERMOD uses the concept of dividing streamline to define the general effect that the terrain will have about a receptor.

Convective boundary layer, another area of importance. For some time it's been known that the vertical concentration distribution of pollution in the convective boundary layer is not Gaussian. As you all know, ISC treats it as Gaussian. What AERMOD does is recognize that and we have in the model, a bi-Gaussian approximation to the probability density function that actually exists in the convective boundary layer. That's improvement one.

Improvement two is something that Jeff also alluded to, and that is the method by which ISC interacts with the boundary layer height, that is, if the plume rise is predicted to be above that height, you get no contribution to ground level concentrations. If it's predicted to be below, you get full contribution. AERMOD allows for partial penetration of the plume, depending on the amount of buoyancy and it also allows for a reentry of that plume. And finally, for that portion of the plume mass that has enough buoyancy to get up to the top of the boundary layer, but not enough to penetrate, it is allowed to -- it is actually delayed until it loses that buoyancy and then it is reflected back.

And finally, I would point out that in the urban boundary layer, AERMOD accounts for the effects of the urban boundary layer by enhancing the turbulence by urban-induced heat flux during night time conditions.

From an operational perspective, there is another nice feature that is presently in AERMOD, unlike ISC. In ISC you must identify all sources as being either urban or rural. In AERMOD, you will now have the option of picking individual sources as being urban, or rural, and running them in the same rough.

Okay, model evaluation. The concept in AERMOD was to evaluate the model in two phases, using the ten data bases that we have previously mentioned. The first phase, the developmental phase; the second, the performance phase.

In the developmental phase we had taken a number -- five of the data bases and said, we will -- as we build the model, we will test it against the real world and try to utilize that information to improve the formulation of the model. We then took five data bases and put them aside, and said we will not be touching those data bases, they need to be independent. Once we have the model formulated, we will then test its veracity against those data bases.

As Jeff mentioned, we had ten data bases, very extensive. They were both intensive and full year or long term, and for those of you who are familiar with these data bases, the intense data bases included prairie grass, Kincaid SS-6, Tracy in Indianapolis. For the long term data bases, the evaluation included Lovett, Clify Creek, Baldwin, Martins Creek, West Vaco, and Kincaid SO-2. Again, a very extensive and relatively diverse amount of data.

These data bases covered a wide range of conditions -- release heights that varied from near surface releases up to release heights of greater than 200 meters, downwind distances that went from 50 meters out to 50 kilometers, and it covered simple terrain, flat terrain, complex terrain, and the urban environment.

The statistics that were used, I had mentioned before, were the robust high concentration and the Q-Q plots. These were used primarily for the performance evaluation, and that one we are most interested in today. What is the evidence that this model is performing well? That, in my opinion, and I think in AERMIC's opinion, is the most important determinant of whether this model should be approved.

In this, we also want to look at the absolute comparison of AERMOD against observed data, since we are trying to decide what the best model that is available to us is -- is available to us for regulatory purposes. So we have also conducted a model-to-model comparison. Clearly what we want to look at is the existing regulatory models that AERMOD is going to be tested against, and that is primarily ISC, but since we are -- since this is a full terrain/complex terrain model as well, we are comparing against CTDM-Plus. We have also added, in a more limited way, HPDM -- I mean RTDM -- because it is presently in the guidelines as a screening model.

Additionally, we chose one other model to look at in a limited way, and that is HPDM. HPDM was submitted to the agency for consideration some time past, but has subsequently been withdrawn. But since it was submitted and approved for submission, we thought it was important for information, to at least do a limited evaluation of that -- or provide information for it.

Okay, on to the results. What you're looking at is a summary of the design comparisons for all of the simple terrain data sets for which we were able to calculate the observed design values. Now that translates into -- obviously, you can't use the intensive data bases because they're just one hour averages -- this translated into Kincaid S02, Clifty Creek and Baldwin. I will explain what this figure means and then I'll explain -- I'll point out some results.

First, let me point out here that on the vertical axis is the predicted robust high concentration -- again, the robust high concentration is sort of an estimate of the design value. It's a robust way of looking at the design value, and it's a ratio of the predicted robust high concentration to the observed robust high concentration. The value 1 represents perfect agreement with observations. You can notice this is a log scale -- that's rather important when you're viewing this. The dotted line down here represents a factor of two underestimation; this dotted line represents a factor of two overestimation. It's broken up into three groupings. This is the composite of the three hour average robust high concentrations over all of those three data bases. Likewise, the same for the 24 hour, and for the annual.

X is in the middle, that represents the geometric mean of the robust high concentrations of those three data bases. The bar represents the range of the high robust high concentration, and the low robust high concentration over those three data bases. What I would also point out in terms of interpretation of what that means -- you can think of is as how consistently a model performed over the variety of these three data sets.

Okay, one other thing I might point out so that I can maybe preempt a question later, is the annual -- you obviously can't get a robust high concentration from the annual because you only have one value, so think of this as just the highest annual found in the field.

Now, the point I'd like to make about this. First, it's I think fairly obvious when you look at this, for the 24 hour and for the annual, AERMOD is performing considerably better relative to the geometric mean over those data bases. For the three hour, you can see that both AERMOD and ISC are relatively unbiased. What I would also point out is that -- is that where AERMOD shows fairly consistent or actually quite good, consistent performance over the three data bases, ISC shows relatively inconsistent performance over those three data bases.

Additionally, I would add that across all averaging times, you would find that the consistency over the three data bases -- that AERMOD shows overiacy (ph) follows for all of those averaging times. The final point I would make here, is that for each of the averaging times across all of the data bases, AERMOD produced higher concentrations than ISC did. You'll see when one comes up here, that this is quite consistent with the model comparisons or the consequence analysis that he did.

Okay, on to complex terrain. Again, similar to the simple terrain, what this represents is a summary of all of the data bases that we had, all of the data bases that we had which would allow us to look at the observed design concentrations. What you see here is that AERMOD is relatively unbiased compared to the other models. The other significant -- the other models tend to very significantly overestimate compared to AERMOD or even not compared to AERMOD -- there's significant overestimations. AERMOD and CTDM-Plus, if you look at AERMOD relative to that, you can see that AERMOD is far more consistent than CTDM-plus is over those data bases, and I would point out here that the opposite has occurred in the complex terrain, namely, that for all the complex terrain data bases that we looked at, AERMOD produces lower concentrations, significantly lower concentrations than does the other two models.

Now, let me give you some examples of the Q-Q plots. The -- I could only choose a couple because of time, and so what I've chosen was a simple terrain, a complex terrain, and another one that I'll get to in a moment. The Clifty Creek three hour Q-Q plot is what I'm showing up here. The reason for choosing that, it was an independent data base. It was not used for development, and it had simple terrain in it, that is terrain that was moving, a rolling terrain that got up as high as half way up the stack height, which was -- the stack top which was greater than 200 meters, and the model was not developed in -- any of the ... data bases did not have that form.

Now, a Q-Q plot -- what is -- how do you read this? A Q-Q plot is a compared model to observed concentrations paired by rank. If I point over here to a -- if I look at this point right here which represents the top rank in a particular distribution, what it is, is it gives you -- compares the highest observed concentration anywhere in the network at any time, against the highest predicted anywhere at any time. Okay, on this line, if a point falls on that line it is perfect agreement by rank. This would be an overestimate of a factor of two, this would be an underestimate of a factor of two.

Now, if you look at the top end of this, what you find is that all three models are performing fairly close. As you move down the distribution, to lower and lower ranks, you can see that ISC and AERMOD are pretty much indistinguishable, but they separate, they diverge down here, where you see ISC dropping off more quickly than AERMOD. AERMOD maintains the distribution a little bit better. HPDM, on the other hand, is showing some overestimation, but well within a factor of two across the entire data base.

On to the next. Martin's Creek. Martin's Creek is an independent -- was another one of the independent complex terrain data bases. The reason I chose this is because it was the data base that has the best meteorological data set. It had SODAR data on-site and turbulence. The only thing different on this plot is that you now have CTDM-Plus and RTDM and HTDM doesn't appear because it's not a complex terrain model. The points I want -- on here are fairly obvious. All models except AERMOD are substantial over-estimators, well above a factor of two. AERMOD seems to reproduce the one-to-one line far better than any other model, and with the exception of these two top points at the bottom of the distribution, AERMOD again follows the shape, is moderately -- or I guess, is slightly overestimating, but again, well within a factor of two.

The final plot I want to show is Tracy. When we went out for peer review, we did not have this data set -- we did not use this data set. One of the comments that came back from the peer reviewers were you did not go out and get enough complex terrain data sets. You need to look across a greater depth of data. So in response to that, we picked up two data sets, one was AERMOD -- one was West Vaco, and the other was Tracy. Tracy here is a one hour, obviously, because it was a Tracer data set, so we're not really looking at design guidance.

The other point I want to make is that the Tracy data set was one of the developmental data sets for CTDM-Plus, and thus you can see the good agreement of CTDM-Plus. The first thing I would point out here is that ISC-3 is a clear overestimator across the entire part of -- this part of the distribution, and significantly greater than a factor of two in some parts. At the top end you can see that both models do fairly well, with CTDM-Plus being a slight overestimator, while

AERMOD appears to be completely unbiased across the entire distribution, as well as CTDM, from this point, is unbiased.

With that, let me get to the conclusions. First, and I think when I talk about these conclusions, think back about the criteria and the context. Do we want AERMOD to replace ISC?

First, AERMOD estimates design values better than ISC-3 and CTDM-Plus. I believe, AERMIC believes, that what I presented and what you will see in the full evaluation report, if you lock onto SCRAM, you will see the same pattern. It clearly estimates better design values.

Secondly, AERMOD contains more current science than does ISC. I think that's indisputable.

Next, AERMOD out-performs both ISC and CTDM-plus over a wider range of that distribution, helping to give us greater confidence that this model will perform well in areas that it hasn't been tested.

And finally, and most importantly, AERMOD's implementation burden is similar to ISC-3, so therefore the user community should not have as difficult a time as they might have using far more sophisticated -- I wouldn't say sophisticated -- more complicated models than AERMOD is. I think AERMOD is quite sophisticated in its use of the physics. It is easy to use and the data is readily available for using this.

So, and the final point that I will make is that it is AERMIC's position that, there is adequate evidence to support the proposed action of replacing both ISC-3 and CTDM-Plus with AERMOD for the applications described in the proposed action. And I'm not going to explain what that is. Rob Wilson will be, in the presentation after the next one, will describe what that means. And that concludes my presentation.

At this point, I'd like to introduced Warren Peters who will present the results of the consequence analysis that was performed.

MR. PETERS: We would like to present this morning, the highlights of the result of the consequence analysis and because there's about 100 pages within the consequence analysis, we only have time to present some of the basic information to give the audience a sense and appeal of answering this question about in proposing AERMOD what impact will it have on me? I've been using ISC for the last 20 years, now AERMOD is coming along, what will it mean to me? Will I have higher or lower concentrations for my particular source or source category?

And indeed that's the simple concept behind the consequence analysis -- it's a model-for-model comparison, no more and no less. We're going to be looking at regulatory design concentrations only, and of course, as we know, it's not a regulatory requirement, but obviously, this is a critical piece of information for you to decide what kind of an impact it will have on your programs, and whether this really is ready to go forth and be used.

This consequence analysis is similar to things we've done in the past, but we find that it's more complex, in the sense that we've looked at a large number of source combinations as this slide highlights to us. We have 76 combinations of source types -- and I say source types at final point area, and volume; stack heights raging from five to 200 meters; environments -- in this case we're looking at both urban and rural. We have two meteorological settings, one from the northeast, one from the southwest. And we have all kinds of terrain scenarios in here, both flat and simple and complex. And when I mention like simple terrain, I'm talking about terrain features that are below the top of the stack; complex terrain features being above the top of the stack.

We've also added some information about impact about how long it takes to run the model for typical sources, and of course, as we've been running all these sources through the model on our computers, we were gaining experience. Is this model easy to use? Does it take a lot longer to run the computer, setting up all the meteorological data bases? Is it stable over all different source scenarios? We're learning that as we go through this analysis.

And of course, as I mentioned, this is only the highlights. Please, if you have any interest in this information, go to the SCRAM site and download the report and look at some of the tables. We have numerous tables in there. Just look for the Seventh Modeling Conference in the AERMOD section.

Here's a summary table of some of the results, again, featuring the highlights of the analysis. In this case we're looking at simple terrain, which would include flat terrain -- most of these scenarios were for flat terrain here -- and we want to look at three different levels of information here. We'd like to look at the averages of all the ratios of the regulatory design concentrations for all the runs. We'd like to look at the highest ratios that we've seen when we compare AERMOD to ISC, and the lowest ratios that we've seen. And again, in this case, notice that we've had a total of 48 runs, so there's a considerable number of source scenarios that we've looked at here.

Now the most important feature people are going to be looking for are differences between the models, and if we look at the highest range of any one ratio that we've calculated for any one the 48 runs, we find that AERMOD, for the one hour, has as much as a factor of three higher estimate for the high/second high concentration -- on the one hour averaging time. And if we move over to the three hour averaging time, it was a little bit less than a factor of three; a little bit more than a factor of three for the 24 hour, and almost a -- close to a factor of four for the annual.

And these results ares something that we expected, at least this ratio of changes from small averaging time to long averaging time, when we go back to consider the model evaluation results. At the low end, we noticed that almost across the board it's fairly uniform, it's about a factor of four low at the extremes, as we compare the different model results.

On average, looking at the first row of data here, that the one hour over all 48 runs, basically showed similar results. We were high, we were low, and typically we had similar results as we combined all 48 cases together. And then, as we go across the three hour, 24 hour and annual, we find that that ratio increases slightly, as the averaging time increases. And again, we expect those results as a result of studying the model evaluation results.

Again, this table is in exactly the same format as what we had before, data is in the same presentation, except in this case now, we're looking at complex terrain, and we're comparing AERMOD to ISC-3, basically the complex-one module of ISC-3. Looking at the high ratio, in fact if we look across this table right here at the high ratio, no one case over all the 28 scenarios that we ran, no one case was -- where AERMOD produced higher concentrations than ISC in complex one. They ran approximately -- what -- three-quarters to about 0.3, when AERMOD was compared to the ISC ratios.

On the low end, the other extreme in here, we find that AERMOD produced regulatory design concentrations that were approximately a factor of ten lower, or perhaps even a little bit more than that. On average, we see that

AERMOD ran approximately a factor of three to a factor of four across the averaging times. And again, these results are pretty much expected.

In here, this complex terrain table is comparing AERMOD to CTDM-Plus, which is a refined regulatory model. And of course in this case, we would expect the models to have closer agreement, and as we look at the averaging times here over all 28 runs, you see that AERMOD runs approximately 75 percent of what we see for the highest regulatory design concentrations from CTDM-Plus, so these models look more closely alike.

On the high side, we find across the board here that AERMOD produces concentrations approximately twice as high, or perhaps a little bit lower, on the extreme high end. On the extreme low end, we find that AERMOD produces concentrations approximately about a factor of six or seven lower than CTDM-Plus, and again, it's over a series of 28 runs. These 28 runs, by the way, include some combination of distance from the hills to the source, the arrangement of the hill to the source itself that we were evaluating, and different stack heights.

Those are summary tables. Here are some examples of the individual results, grouped together in some combination that makes some sense. In this case, we're looking at the high/second high concentrations again, the regulatory design concentrations. We're looking at non-buoyant releases and flat terrain. And we see here we have three groups of stack heights. We have the five meter stack in these first two plots of data, ten meter stack, and the 20 meter stack. And we have two sets of met data -- the Oklahoma City met and the Pittsburgh met data lumped together here.

This track is very similar to what Al Cimorelli presented earlier in his presentation. It's a log scale. And notice in this case that the chart -- the bars in this case are arranged around the critical value of 1.0, which means -- or implies, rather -- that AERMOD and the ISC results are exactly the same. We're looking at -- for averaging times, here, this is the one hour, the three hour, the 24 hour, and the annual averaging time. So we have a block of four results for each model run.

We see here in this case, like in this first example here of the five meter stack for Oklahoma City met data, we have four results, for one hour, three hour, 24 hour and annual values that in this case, AERMOD was about a factor of two lower than the ISC for all concentrations and averaging times. And by the way, for your information, in this log scale, to help you read some of this data, these little dotted lines in here represent a factor of two difference in the model.

Now note in this case, as we go from the five to the ten meter stack, we have essentially the same result, they're ... at the same strength, they're all at the same end. There's not difference across the met data, but yet when we move up to the 20 meter stack, we find that the results do change considerably here. We find that AERMOD would produce concentrations lower than ISC-3, but it produces higher concentrations for the longer averaging times. There's almost -- this is a factor of two low, this is a factor of two high, approximately, in relation to each other. And again, the met data doesn't seem to have much of an impact right here. But we can see here that there is considerable difference as we change stack heights.

This next slide is in exactly the same format, the same data presentation, but in this case we're talking about taller stacks, and we have buoyant releases in this case, but we're still on flat terrain. This first set of -- these two first sets or two blocks of data are 45 meter stack, and then we go up to the 100 meters and then the 200 meters -- and if you notice, these results are kind of similar to what we saw on the previous slide with the 20 meter stacks -- we're seeing the same type of patterns. So now the stack heights don't seem to have as much of an impact on the relationships or the ratios between the two models.

Notice in this case that we see a lot of the models are -- AERMOD is producing concentrations up to a factor of two high across the board, especially true as we get to longer averaging times, and typically we see this kind of step function, where AERMOD produces higher and higher concentrations in relation to ISC as the averaging time increases. If you remember back to one of those first tables I presented, as we looked at the averages across all the source scenarios, we also saw the same pattern, so this is kind of a theme.

Now this slide is just a little bit of a different spin on the information we've looked at. Same -- similar format, but in this case now, for a complex terrain, we're comparing both ISC and CTDM-Plus to AERMOD. What we have over here in like this first example here, this first bar right here represents the AERMOD to ISC ratio as explained to you by colors -- the green represents AERMOD to ISC, the red color over here represents the relationship between AERMOD and CTDM-Plus, the more refined model.

We've expanded the log factor here because in this case here, as you notice, AERMOD produces concentrations lower than the two models in all cases across the board for our 28 source scenario in this case, and sometimes of course, they go below a factor of ten. But we do want to make note that in all cases we're below this value of one, so again, the downward direction of these charts show very dramatically that the AERMOD does produce concentrations lower.

So summing up here, general conclusions from some of this work. AERMOD does indeed provide different, sometimes significantly different results from some of the workhorse models and CTDM-Plus that we've seen in times past.

So, what that tell us is for that -- your scenario that you're concerned about, for your particular source that you're trying to model, is that your results may vary. If we sound like a weight reduction commercial on TV, your results may vary dramatically, so we have to be careful here in extending some of these results of the consequence analysis, but we can see that there's a warning light set up in here, the numbers are going to be different from the older models, and by nature of the new models, new capacities, we expect that.

Also, the second bullet down here, which is very important to us is that the results from the consequence analysis are generally consistent with the model evaluation results that Al Cimorelli highlighted this morning too, which is to us, very comforting.

We also found from the operation and running of many of these sources over and over again, that AERMOD was indeed very easily learned. The operating system, the control ... are very similar to ISC. We're up quickly, up and running, getting our analysis completed.

We had more difficulty, however, in preprocessing the mets -- the meteorological preprocessor, so I warn you that you want to spend more time and go through the training manuals and the users guide on the meteorological preprocessing.

There is an impact on the computer run times in here. For point of volume sources, the computer run times are five to six times slower than they are for ISC. But the good news is, of course, even when you're running -- it's like a typical point source, with AERMOD, you're still talking one to two minutes of time on a 200 megahertz computer, so the times are still reasonable, but they are slower.

Also, on the area source, which probably many of you are aware of, they take a lot of time -- computer time to run, AERMOD -- the timing results show that AERMOD runs two to three times slower for the area source.

Thank you very much. Now I'd like to present to you Rob Wilson from Region 10. He's going to be talking about the regulatory implementation.

MR. WILSON: I'm Rob Wilson with EPA Region 10, and I'm here to present the recommendations proposed in the revised guideline in air quality models for the regulatory application of the AERMOD modeling system. This is an outline of my presentation. I will describe the regulatory recommendations for the general application of AERMOD, screening for AERMOD, and how AERMOD fits in with the other recommended models. Then I'll give some recommendations related to each of the model codes that make up the AERMOD system.

As I describe the regulatory recommendations for the application of AERMOD, you will note there are some questions raised and some issues identified. EPA is inviting your comments on these issues.

AERMOD is intended to replace the Industrial Source Complex model as the state of the practice model for many air quality impact assessments. We're proposing a one-year transition period after the final revisions to the guideline are promulgated. During that transition period, either AERMOD or ISC-3 may be used as appropriate. After the transition period is completed, ISC-3 will no longer be recommended for use.

AERMOD is applicable to point, area and volume sources, and is applicable in both simple and complex terrain, and finally we have one model for all terrain. AERMOD is a steady state model, and EPA's policy has been and continues to be to apply such models where appropriate, up to distances of 50 kilometers. And finally, AERMOD does not currently contain algorithms to simulate deposition.

During its development work, the AERMIC committee took some initial steps in developing a screening version of AERMOD, however, due to funding limitations, that effort was not able to produce a final product. As a result, we are left with the currently available screening tools. As many of you are probably aware, the screen-3 model was developed as a screening method for the ISC-3 model. It can simulate point, area, volume, and flare source types in simple terrain, and screen-3 can make maximum concentration estimates for stable plume impact situations in complex terrain, using the simple algorithms of the valley model.

The CT-screen model is based on the CTDM-Plus model and is useful for estimating maximum impacts for point sources in terrain above the elevation of the top of the stack during stability conditions ranging from stable to unstable.

We recognize that these models, especially screen-3, may not be appropriate screening methods for use with AERMOD and we invite your comments on that issue.

In our proposed revisions to the guideline, AERMOD is the recommended model for a wide range of regulatory applications in all types of terrain. While AERMOD contains the building downwash algorithms that are in the current version of the ISC-3 model, it is the new ISC-PRIME model that's recommended in the guideline for modeling analyses in which building downwash or deposition is "important". You will hear more about the ISC-PRIME model in the next presentation.

Many regulatory applications must deal with the sources subject to aerodynamic downwash, so the proposed modeling guidance raises some important implementation issues. Some of the implementation issues are listed here:

What criteria should we use to determine whether or not downwash is "important"?

If downwash is determined to be important in our particular analysis, should we just use the ISC-PRIME model and forget about the AERMOD model, or should we somehow use both models for that application?

If we decide to use both models in an application, for what sources and receptors should we use each model? Should ISC-PRIME be applied only to sources subject to downwash that cause an important impact? And then apply AERMOD to all other sources? Or should ISC-PRIME be used to estimate concentrations at only certain receptors in the downwash area? And only during certain meteorological conditions that lead to the downwash conditions?

If such were the case -- being required to use two models -- a post processor of some sort would be a very useful tool in dealing with the concentration estimates from the two models.

As you can quickly discern, there are a number of questions that will have to be answered as we implement these two models for regulatory applications, and it is clear that the need to apply two models could probably be eliminated, if the PRIME downwash algorithms were installed in AERMOD.

Again, we invite your comments on these matters, on issues related to the application of two models, and on the need to develop a version of AERMOD with the PRIME and downwash algorithms.

In summary, our guidance is to in general apply AERMOD for traditional, stationary point sources. If downwash is important for a particular application, the ISC-PRIME model should be applied to the downwash sources. And if the ISC-PRIME -- and if deposition is important, an important part of your modeling analysis, such as for a risk assessment, then the ISC-PRIME model which retains the deposition and depletion algorithms in the current version of ISC-3 should be used.

The performance evaluations of AERMOD for complex terrain data bases, as you have seen, revealed that AERMOD in general was a better performer than CTDM-Plus. However, the CTDM-Plus model is being retained in our guidance as a refined model for complex terrain. In most regulatory complex terrain applications, AERMOD should be used. If the modeling analyses involves a well-defined hill or ridge and a detailed dispersion analysis of the spatial pattern of the plume impacts is of interest, and if adequate meteorological data are available, then the CTDM-Plus model can be used.

Now, I'm going to discuss some of the implementation issues associated with each of the three codes in the AERMOD system: AERMAP, AERMET, and AERMOD. First of all, with AERMAT, which is AERMOD's terrain pre-processor and receptor generator, terrain data will generally be required for all applications. AERMAP is designed to be used with the terrain data supplied by the U.S. Geological Survey. These data are developed using the USGS digital elevation or DEM models, and are available at the USGS website indicated on the screen here.

AERMAP can accept either the one degree data -- a 1:250,000 scale, or the seven and a half minute data -- 1:24,000 scale. Initial applications of AERMOD in complex terrain settings have indicated that the one degree data is sometimes unable to adequately characterize certain terrain features, especially when they occur near the source of concern. Therefore, we are recommending the use of seven and a half minute DEM data in most situations.

Guidance for refining receptor locations in AERMAP is essentially unchanged from past guidance about siting receptors for the ISC-3 model. Most applications will need to employ a combination of receptor -- regular receptor grids and discrete receptors to identify the maximum concentrations, especially in complex terrain. Multiple runs, working in from a course receptor spacing down to a fine receptor spacing may be necessary in some cases.

The user of AERMAP has the option to specify source elevations, or AERMAP can determine source elevations based on the input terrain data. When source receptor distances are small, users should take care in checking that the source elevations determined by AERMAP are correct.

The minimum meteorological data requirement -- whoops, sorry. Among other functions, AERMAP calculates a height scale for each receptor. Excuse me. Guidance for designing -- I'm sorry.

Among other functions, AERMAP calculates a height scale for each receptor location. The height scale is a function of the height difference between the highest and lowest terrain elevations within the user selected modeling domain. As a result, changing the extent of the modeling domain may change the height scale, and therefore the concentration estimates at a given receptor location within the domain. So users should be cautious in complex terrain settings, where, for example, a large isolated three dimensional terrain feature may exist. The disparity caused by one large feature may cause AERMAP to calculate unrealistic height scales for some receptors, and in such cases as these, the user may need to make multiple runs of AERMAP with different modeling domains.

The minimum meteorological data requirements for AERMAP -- the meteorological pre-processor for AERMOD, include the following:

* a valid windspeed measurement that is taken at a height above the ground between seven times the local surface roughness and 100 meters, typically that would be on a ten meter tower, for example;

* a wind direction measurement that adequately represents the plume transport direction;

* an ambient air temperature measurement that is taken at a height above ground between the local surface roughness and 100 meters;

* cloud cover data, which generally means the data from the nearest representative National Weather Service or FAA observing station will be required;

* the morning radial sun observation from the nearest representative National Weather Service upper air station;

* and the surface characteristics of surface roughness, bone (ph) ratio, and albedo, all of which are specified by the user.

Regulatory application of AERMOD requires careful consideration of the representativeness of the meteorological data to be employed in the analysis. To assist in judging whether or not the meteorological data is adequately represented for a particular application, our proposed guidance offers some principles to follow, rather than rigid criteria. I'll briefly mention some of these principles here.

First of all, the user needs to consider that the goal is to have AERMOD construct realistic and reasonably representative boundary layer profiles, which it does by scaling parameters developed from surface layer measurements. So it is important that these measurements are adequately representative of the surface layer which -- where the sources of concern are located. This is particularly true of the user-specified surface characteristics for which model results have an important sensitivity.

The area where the meteorological data are collected should have surface characteristics that are very similar to the surface characteristics in the vicinity of the sources of concern. It is best, especially in complex terrain situations, if measurements of wind and temperature are available up through the height of the plume above the ground. This reduces the uncertainty in determining plume rise and dilution, and the actual plume transport direction.

In considering how well the meteorological data represents the transport and dispersion for the source and the impact area, the user needs to think in terms of both its lateral and vertical representativeness. Another consideration for representativeness is that different criteria may apply to assess representativeness for different variables. For example, to adequately characterize plume transport, it may be critical to make wind direction measurements as near as possible to the stack and at the height of the plume. On the other hand, if it is a relatively hot exhaust, the ambient air temperature measurements at the nearby National Weather Service station may be adequately representative.

And finally, I'd like to point out that case by case subjective judgements will be required to determine whether or not the meteorological data available for a particular analysis are adequately representative, and evaluation by experienced meteorologists will be necessary.

You might be wondering whether or not AERMOD can be operated with the National Weather Service data alone, that is without the need to collect site-specific measurements. And the answer is yes, the model can be run with National Weather Service data alone as long as these data are adequately representative with a particular application.

Lastly, on representativeness, I point out that our meteorological monitoring guidance, which has been recently updated, has a very useful discussion of representativeness issues for a variety of meteorological measurements. The document referenced here is available for downloading from the SCRAM website.

One more point on AERMET, it is designed to handle missing data, if the missing values are filled with appropriate codes. If minimum data recovery requirements have been met by the measurement program, then the user of the data need not fill in the holes with fictitious meteorological values.

Concerning the AERMOD model, it is very similar to the ISC-3 as you've heard in its operation. It's a regulatory -- it has a regulatory default option to make sure the model is operating consistently with the regulatory recommendations. And as Al has explained, AERMOD does have an urban option but it operates a bit differently from the ISC-3 model. In a given run, each source is designated as being located in a rural or urban location, which allows you to have both rural and urban sources in a single run, and that differs from ISC in which rural/urban option is applied to all the sources in the run.

That concludes my presentation, and now AERMIC committee is available to take any questions for any of the previous speakers.

DR. TIKVART: Tom, since these are remote mikes and we're in here like sardines, rather than have people come in to the mikes, why don't we hand the mikes around to help those -- to facilitate any questions or comments. So Tom and I will pass the mikes around, and I'll remind you to provide your name and affiliation before you ask your question. So, make this gentleman here first, and Tom, if you will help.

MR. SANJEE: I'm Sanjee (ph) from ... Pick, and my question is have you compared with the model with any international models or have you just compared U.S. models?

MR. WILSON: We have compared it to the models that were described here. Did you have a specific model in mind?

MR. CIMORELLI: We haven't compared it with international models. Primarily we were looking in, especially the regulatory comparisons for models that were within the regulatory -- in the guidelines, or models that had been submitted up to this point. But no, we haven't been able to -- we have not done that.

MR. SCHEWE: My question is for Warren. Warren, did you look at individual point sources in the the consequence analysis, but not area and volume sources in the comparisons?

MR. PETERS: We did look at point sources, but we also looked at area and volume sources, and if you download that consequence analysis, you'll see there's a number of slides in there highlighting and showing those results.

PARTICIPANT: ... Canada. Right now we're talking about 50 kilometers distance. Don't you think this is a little bit big distance because you might have some wind shear effect on the plume itself, and it should be a little bit smaller, talking about 20 or 15 kilometers?

PARTICIPANT: I'm not sure why you would choose 15 to 20 versus 50 kilometers? 50 kilometers is a number that seems to be reasonable, and we do account for windshear. I mean if you're assuming or at least asking the question whether we should account for ... wind, is that your question? I mean I'm not sure what your question implies? Why should it be 20 kilometers rather than 50 kilometers?

PARTICIPANT: (Canada) Well, I think that when you have a longer distance, you would have a wind shear and you might after a while that you move -- doesn't it become less Gaussian? There is sufficient surface spread, so that's why I'm saying, I'm talking --

DR. TIKVART: Repeat your question.

PARTICIPANT: (Canada) -- (on mike) -- well, what I was asking about, the 50 kilometers, that is a long distance, so you might have the wind shear -- I mean, did you consider the vertical wind shear in that? Because if you don't consider the vertical wind shear, what would happen that your distribution doesn't distribution ... more a uniform distribution.

(Problems with maintaining mikes in "on" position.)

PARTICIPANT: I think there are a lot of a priori reasons for ... and that's what we have done. ... is operative. That's the final question we need to ask ourselves. And that's what we have done. We have taken the simplest possible approach. We have accounted for shear to some extent, and ... performance comparisons with observations. I can think of a thousand other reasons why ... work. Correct? But it ... data, that's the whole point.

PARTICIPANT: (Canada) ... the wind shear, yes?

PARTICIPANT: Yes, we took out ... wind shear.

DR. TIKVART: Thank you. Would you identify yourself?

PARTICIPANT: Oh, my name is (inaudible response)

PARTICIPANT: Jules ... from ... Consulting, Canada. I would like to comment -- you need some guidelines how to handle cloud cover from automatic serving systems and I think it's missing right now in AERMOD guideline document.

MR. WILSON: The AERMET pre-processor will take ASOS data -

- I guess you're talking about the limitations of the Automated Surface Observing Station data that the Weather Service is now collecting. They have a height limit of 12,000 feet, I guess, for cloud cover. So data -- clouds above that aren't recorded, and anyway -- those data -- the limitations of those data have been recognized and have been evaluated as in -- as they would affect concentration estimates in the ISC model, and I believe there's a report available -- I don't know if it's available on SCRAM or not -- that describes what the result of that evaluation was. But with respect to AERMET, it will take ASOS data. I mean it will use that information, it just lacks cloud information above 12,000 feet.

PARTICIPANT: (inaudible question.)

DR. TIKVART: Rob, would you repeat the question?

MR. WILSON: The question -- the point is that there's formatting issues with the National Climatic Data Center -- they've been changing formats and that is true, they are continuing to change. I understand there's a new -- yet another new format that's going to be available this year. That's being addressed by the Office of Air Quality Planning and Standards currently. There are some changes being made to the MPRM -- Meteorological Processor for Regulatory Models -- to allow for new formats and those, I assume, will eventually be also incorporated into AERMET.

MR. STRACONGAS: I'm Arnie Stracongas (ph) with Utilized Radium, Austin, Texas. I think my question is for Rob. It involves implementation. I think you were talking here about ... you mentioned already the issue about multiple models as being kind of thrown out there, and apart from the issues you mentioned, there's also another potential for multiple models being required because there's a mention that there's no ... processor with AERMOD as there is with ISC.

It appears that the AERMOD in terms of its one stream technology is about vintage 1995 ISC, I'm guessing. There's no formal capability for it to be in Fortran 90 as far as the model having the model having to be recompiled ... to increase receptor settings and things of that nature. Also, they still continue to release ISC 00101. I was just wondering if your design plan is to say we are going to fully implement what we have in terms of one stream technology with ISC's ability to do ... quickly, because it seems as though we've ... with this ability to do with speed analysis and do ... and things of that nature.

MR. WILSON: You're correct in your observations about the sort of the date of the AERMOD code. We started with an earlier version of ISC and some subsequent changes were made to that ISC code that have not been incorporated into AERMOD. We do have a plan in place to not only update the code for Fortran 90, as you characterized, but also to include the PRIME algorithm, that sort of thing. That plan has existed for some time. What we lack are the funds to implement the plan. And I guess we'll let OAQPS respond to it since that's the money -- whence the money comes from, but the money has not been available this year and there is some possibility that it may be next year, but we'll just have to wait and see.

MR. STRACONGAS: I guess the comment would be in terms of implementation, I see this graduation to AERMOD as amounting to significant issues to us in terms of cost to do the project -- that's just an immediate comment involved. And if we fully implement these things, obviously that becomes more of a -- in the current setting ISC is pretty much you go to ... for all these situations except in situations of complex terrain, and even in that, it's only a refined technique. So now we have a situation where we have multiple models proposed for various techniques. It would seem as though it's a serious implementation issue is what I tend to see. I don't know if any others here in the room agree with me.

MR. WILSON: I'm sure there are several who would agree with you on that, but we're inviting the comments, so, thanks.

MR. HAINES: Aldo... Haines, Duke Power. I was -- just from what I saw, first glance, it appeared that the -- in the performance evaluation, that AERMOD and CTDM-Plus were fairly close at the higher end, almost equal. Yet, in the consequence analysis, it appeared that AERMOD was about one and a half to two times higher than CTDM-Plus.

MR. CIMORELLI: Actually, if we could bring -- I don't know if we could bring that slide back -- there are two places, I guess, in the presentation. One would have been the summary of the three complex terrain data sets with the robust high concentration, the other one would have been the Martin's Creek slide to look at, and I think in both of those cases, quite the opposite is the case, that the CTDM-Plus predictions were considerably higher than AERMOD, and I think that was quite consistent with what we saw in the consequence analysis.

I think maybe you're referring to Tracy, where at the top end of the Tracy, which was one hour, which was the one hour Tracer study, that you saw fairly close comparisons between CTDM-Plus and ISC, and I would point out that in that case two things -- one, it was a one hour comparison, and two, it was a developmental data set that was used -- one of the developmental data sets that CTDM-Plus was built on. So I think the better comparison to look at and to look at in comparison with the consequence analysis would be the RHC plot -- summary plots for the three data bases and the Q-Q plot for Martin's Creek.

And I would invite you to go to the docket or to the SCRAM bulletin board yourself, and the evaluation report, and you'll find many more Q-Q plots for three, 24 hour averages, for West Vaco and for others, and you will see a very similar pattern.

MR. HAINES: You're saying then that -- that there's no inconsistency -- that in either case, when we're talking about performance evaluation or the consequence analysis, that AERMOD would be predicting higher concentrations?

MR. CIMORELLI: Lower. Lower concentrations.

MR. HAINES: Lower than CTDM-Plus?

MR. CIMORELLI: Lower than CTDM-Plus on average.

MR. HAINES: In general, on average?

MR. CIMORELLI: I think as Warren pointed out, one of the things that was very -- that we felt very good about -- I'm sorry, go ahead --

MR. HAINES; No, I was saying I'll have to recheck that, because what I wrote down it looked like AERMOD was higher than CTDM-Plus.

MR. WILSON: There was one data base, the Tracy data set where CTDM-Plus predicted slightly -- well, it underpredicted slightly, relative to AERMOD. AERMOD was about on the line. That was one of the slides that Al showed.

MR. CIMORELLI: Right, and on that slide in fact, I mean CTDM-Plus -- I mean they were so -- almost indistinguishable. I mean there was a slight underestimation by CTDM-Plus, and that wasn't model to model comparisons. That was again data and if you look back at that slide, AERMOD followed that 1:1 line almost perfectly, and it was only at the top end where CTDM-Plus is a slight underestimator.

MR. HAINES: The other question is was there any testing for -- in the consequence analysis -- was there testing including downwash?

MR. PETERS: No, we didn't include downwash in the analysis because AERMOD was not being proposed for downwash scenarios. So we eliminated it -- that scenario.

DR. TIKVART: Do I have time for one more? I have one back here before that.

MR. BIGGS: Hi, ... Biggs, consulting meteorologist. AERMOD at this point does not -- was verified not using downwash. If one runs the ISC model without downwash and then runs it identically again with downwash in it, the distant receptors are impacted as are those close in, and you get higher concentrations at a distance, outside of the downwash zone. Does this mean that if you were to put the PRIME downwash into AERMOD, I think you have to go back and do a total reassessment and reevaluation of the model, because now you're changing all of the numbers that you used in it to assess it with.

MR. CIMORELLI: Well, in reality, the data bases that we used to evaluate were not affected by downwash. So if you would have run ISC with PRIME in it, you should not get any different answer because there's really -- what's that?

MR. PETERS: For our data.

MR. CIMORELLI: For what we have shown -- I mean we weren't looking for downwash data sets because as Warren pointed out, that was not being proposed, so we did not utilize any data bases that were in any way affected by downwash.

MR. BIGGS: Very quickly, if you did incorporate the PRIME downwash into the model, then you have to restrict it to the downwash zone and then turn it loose when you go to the more distant receptors. ISC is not doing that at this point.

MR. STOWE: Randy Stowe from Dow Chemical. I just had a comment about the consequence analysis. I think that it's somewhat misleading when you run ISC without downwash and then compare your second highest concentration and you don't specify the locations that they're find. Your consequence analysis would be much better if you would also put the distance away from the source that these concentrations out there are found, instead of merging all this into one graph. I'm very concerned that AERMOD doesn't have a downwash algorithm.

MR. WILSON: It does have a downwash algorithm. The currently available -- the algorithms that are currently in ISC-3, that is the Huber-Schneider, Schulman-Skeery (ph) downwash algorithms are in the current version of AERMOD.

MR. STOWE: But there's no plans to ISC-PRIME, is that correct?

MR. WILSON: As I said, we have plans. We don't have funds.

MR. STOWE: Same thing.

MR. CIMORELLI: If I may make one more point about that, I need to reiterate all of the work done that you saw this morning and all of the work that was done for either the evaluation or for the consequence analyses, were not applications that had any downwash in them at all.

DR. TIKVART: Warren, I heard another question there, though, which was, can we indicate the distances at which the maximum concentrations without downwash occurred with ISC versus AERMOD. Can that be added to the information in the consequence analysis or is it already there?

MR. PETERS: The information is available somewhere in my computer, so we can add that to the tables.

DR. TIKVART: Can we add an addendum to the consequence analysis that provides that information?

MR. PETERS: I believe we can do that easily.

DR. TIKVART: Okay.

PARTICIPANT: What I was really getting at is running ISC with downwash and running AERMOD with a downwash algorithm also, if it's available in there and doing that analysis and showing the distances away from the sources at the same time.

MR. CIMORELLI: I think that would be a useful analysis if we were considering the AERMOD model with the present downwash algorithm. I think that's right.

PARTICIPANT: Well, it is rather, when we all have to run ISC with downwash, I've never run ISC without downwash in 20 years.

MR. COULTER: Show of hands, who needs downwash?

DR. TIKVART: That might be an introduction to our next speaker. We've got time for a couple more questions. Tom?

MR. COULTER: Show of hands?

MR. LINING: My name is Steve Lining (ph), with Carolina Power and Light. And my question is, as AERMOD is being proposed today, do we incorporate downwash parameters in your model when we would use it, or do we just go with AERMOD for complex terrain -- what would be the recommendation today?

MR. WILSON: I would be willing to give my opinion, not speaking for the agency, necessarily at this point. But yes, I would definitely run the model that way and -- that is, with downwash -- and try and identify situations where downwash is important. Now that isn't currently defined, what important is. That has to be figured out, but clearly, if you're seeing near standard violations or whatever, that's important, and you may want to then consider using the ISC-PRIME for those sorts of situations.

PARTICIPANT: It's basically the same status quo is what it sounds like. AERMOD is downline as it stands now with ISC, only ISC-PRIME, which they're going to talk about next, would be proposed for those special circumstances.

DR. TIKVART: Did the court reporter get that?

PARTICIPANT: I'm just providing anecdotal remarks anyway.

DR. TIKVART: For clarification, the proposal is for ISC-PRIME for downwash in deposition, and AERMOD for all other applications. That's the specific proposal. I should add that the proposal tends -- the intent of the proposal is to emphasize the sort of applications for which the various models apply. Yes, there are questions about the process and how you deal with each specific situation, and we found that we get over-prescriptive, that that would create as much confusion or more confusion than being under-prescriptive. So at this point we're only recommending which model for which application. If there are complications, we'll let that work out over time. I have another comment.

MR. BLEWITT: (Problems with mike) Doug Blewitt, Air Quality Resource Management. What kind of testing has been done looking at transition tools between rural and urban or urban and rural? I see this as a ... issue. It seems like ... chemical complexes, and it seems that there should be some significant testing with ... of the model.

MR. CIMORELLI: We would agree with you, but that testing has not been done.

MR. WILSON: I guess -- well, Warren did speak to the consequence analysis, we did -- we ran the model in both the urban and the rural modes in the consequence analysis, and those results are available in the report -- consequence analysis report. I guess my own general conclusion from what I saw in that was that the differences between urban and rural in AERMOD are not as great as the differences between urban and rural in ISC.

DR. TIKVART: Okay, Tom, this question and maybe one other one, and then we're going to have to transition to the next presentation.

MR. COULTER: I think this is a quick follow-up question on downwashing.

MR. LINING: It was basically a --

DR. TIKVART: Probably better give your name.

MR. LINING: Steve Lining (ph) again, from Carolina Power and Light. And it just basically has to do with the relationship between running PRIME -- running ISC-PRIME and then AERMOD, and it seems like going back where we were with terrain processing. We have to get this ... together. Is there any plan to provide that feature?

DR. TIKVART: The answer is only time will tell. We have to see how this proposal goes, and we'll deal with the issue of whether or not PRIME goes into AERMOD, which is a whole other question, after we take these public comments. I think, as somebody sort of tip-toed up to me if they knew, is once you put PRIME into AERMOD, you have to go through the whole evaluation process again. You can't just accept PRIME and AERMOD -- you can't take two independent systems, evaluate them and say they're both good and once you merge them, assume it's still good. So it's not a trivial undertaking to do that. So, we have to see how this public hearing process goes. I think we can take one more comment then we have to move on and Chuck, why don't you start moving towards the podium. I think Tom's got a -- if there are other questions, try and reach the speakers afterwards, or there'll be more time tomorrow afternoon.

MR. PETERS: Ron Peterson, CPP. I was just wondering on the surface characteristic inputs if there's guidance on how to calculate those, in particular the BY surface roughness?

MR. CIMORELLI: Bob, can you take it?

MR. PAINE: Bob Paine from ENSR. The AERMET users guide does have tables similar to that of CTDM-Plus -- look up tables. And you should also be aware that you can vary the roughness as a function of month of the year and by direction from the source. So if you're familiar with CTDM-Plus and its operation, it's very similar to AERMET.

DR. TIKVART: Okay, Jeff, I'd like to thank you and the other presenters on AERMOD. I think that was extremely informative and I think we had some good discussion. Other discussion or comments, I would advise the audience either to talk to these speakers afterwards, or if you want to save additional questions or comments for the more open process tomorrow afternoon, I would welcome that. Okay, we're going to change computers.

MR. HAKKARINEN: I do have my presentation on computer, so I won't have to use that.

DR. TIKVART: Okay, while you're doing that, the next presentation will be by Chuck Hakkarinen and his associates, concerning ISC-PRIME and its features, and as I mentioned earlier, the specific regulatory proposal is to use ISC-PRIME for downwash in deposition applications.

MR. HAKKARINEN: My name is Chuck Hakkarinen, and I work for the Electric Power Research Institute in Palo Alto, California, and I'm going to be the first of three speakers in a series to talk about ISC-PRIME. I'm going to give a little introduction and some of the motivation behind the development of this model.

PRIME is an acronym for Plume Rise Model Enhancements and it's an effort that began in 1993 in which were attempting to address what was then known as the existing limitations in modeling downwash in the regulatory models at that time. As was mentioned earlier, there are existing downwash algorithms in ISC, both Huber-Schneider and the Schulman-Skeery (ph) approaches, but there were limitations with them, and I've described some of those major limitations.

One they had limited comparisons, in those algorithms, with field data. They were based on wind tunnel observations, primarily, and rather a specific characterizations in those wind tunnel observations, notably that the winds were always assumed to be perpendicular to the face of the building as they were set up in the wind tunnel, and they were only done for neutral stability, with moderate to high wind speeds. Also, an important limitation was the location of the stack was not considered. It was always assumed the stack would be on the front or windward face of the building that was being simulated.

The next slide shows some of the additional limitations that were there. There was no consideration of plume buoyancy in calculating how the plume would interact with the wake that was generated by air flow over the building adjacent to the stack. There was no consideration of changes in wind speed with height to influence both plume rise as well as the behavior of the plume in interacting with the building wake. No consideration that streamline, as the air flows over the building can, in fact, descend in the lee side of the building. We have documented that in observations at field study sites and that was in fact incorporated into the algorithms. And finally, there could be major discontinuities in the model calculations between concentrations within the cavity immediately behind the building, and what would be observed further downstream.

So, with that, over the next several years from 1993 to about three years thereafter, we developed PRIME and the next speaker will give you more technical details on PRIME, but here's some of the key features in it. It is modular and in theory can be plugged into other air quality models, such as AERMOD. We applied it at the initial development stage to ISC-3.

It includes empirical -- a calculation of streamline (a typo) deflection, based primarily on EPA wind tunnel data. The dimensions of the wake are calculated by considering not only the direction of the wind and the stack, but also the orientation of the building or buildings themselves, so that you do not have to assume perpendicular flow over the buildings. It's based most of tunnel data and concepts from papers that are mentioned here.

The model includes a numerical plume rise algorithm that incorporates deflection of the streamlines, the vertical wind speed change with -- wind speed changes with vertical height, as well as the location of the stack. The stack can be displaced from the buildings, and also considers the wind speeds that are not perpendicular to the buildings.

The PRIME paradigm -- Rick Oser (ph) came up with that little term

-- is to show the basic components in the development process. The top part shows you that the there were four basic sets of information used to provide data for the development of the model. Not only did we collect and archive existing field measurement programs available from sites that might be influenced by downwash, but we undertook specific fluid modeling at two facilities to generate new data sets that could be used in both the development and the evaluation of the model.

We undertook a specific field program at a combustion turbine facility in New Jersey in which the stack height and building height were essentially the same, and that was conducted over a six week period to collect additional new information for testing and evaluation of the model.

And, as I mentioned, there was a specific numerical modeling component to look at plume rise issues.

All four of those data sources were used by Earth Tech to develop the model. We went through three rounds of beta testing with various representatives from the sponsoring community, to look particularly at how easy it was to use, find glitches in the model, formulation and implementation.

Once the beta testing was completed and the model developers were satisfied they had a code that was ready for testing, the model was frozen and then provided to the third speaker in this set of three, at ENSR, Bob Paine to do an independent model evaluation. Hands off, using data sets that had not been used in the development of the model.

Once the model evaluation was completed, and the evaluation was PRIME versus ISC, the sponsors agreed that the model was ready for submittal to EPA, and it was submitted to EPA in January of 1998 for consideration as a guideline model.

A couple more I'll mention here, that there were a lot of people involved in developing PRIME. The most important, certainly, the funds to do this development was provided by ten member companies of the Electric Power and Research Institute. There were in-kind contributions from the Electric Supply Association of Australia, provided use credits to use Monash University wind tunnel in Melbourne Australia.

The National Center for Atmospheric Research in Boulder provided use of their facility for measuring micro-meteorological parameters at field test site and archiving all the data at the field site. Jersey Central Power and Light provided access to and logistic support for the field measurements made at the combustion turbine facility in New Jersey. The project, as a whole, was managed by me at the EPRI.

There was a whole host of other players. These are the critical people who really do the work -- Earth Tech did the model development and evaluation. Joe Scire will speak immediately after me to that part. ENSR provided not only the effort to collect and archive data from the field and other's programs, but undertook the independent model evaluation.

Monash University and EPA provided in-kind support by doing direct wind tunnel simulations of -- not only for generic model configurations, but also for some specific field sites. The National Center for Atmospheric Research undertook a series of field data collections at the combustion turbine site. Washington State University did the numerical modeling as a sub-contract to Earth Tech, and Science and Technology Management, Inc. provided coordination among all the players, with the field efforts and managed the beta testing.

Finally, as I mentioned, we're having three presentations here on

PRIME. You've heard my introduction, and I'll be followed by Joe Scire, now of Earth Tech to describe the model. There are more details on the model in a 13-page paper published in the Journal of the Air and Waste Management Association in March. And following Joe, we'll have Bob Paine talk about the independent model evaluation. He may touch on the consequence analysis, at least -- well, in words if not in viewgraphs.

I brought with me, 50 copies which clearly are not enough for this audience, of my presentation, so if you didn't get what you wanted to out of mine, I have 50 copies here, hard copy, and I have 50 copies of Bob Paine's. If you don't get one of those, give me a business card and can e-mail them to you in California without any problem. So, with that, why don't I turn it over to Joe Scire.

DR. TIKVART: There'll have to be a delay while they --

MR. SCIRE: I'm going to be talking about the model development phase of the PRIME development. I'm sitting in today for Lloyd Schulman who is the manager of that project for Earth Tech. I was a participant and coauthor of the PRIME model, along with Dave Soroides (ph) and Lloyd Schulman.

As Chuck mentioned in his introduction, the downwash project involved a number of different phases. They were the field measurements and wind tunnel simulations that were used to provide data for the model development. In addition, there were numerical model experiments done with computational fluid dynamics model that aided in the design of the PRIME model development effort. And then a number of rounds of beta testing, and then formal evaluation, both developmental evaluation by Earth Tech, and then an independent evaluation by ENSR.

Just to give you a sense for what we're talking about when we speak of building downwash, the introduction of a building into a flow disturbs the flow. It results in a deflection of the streamlines, ascending streamlines in the front end of the building, and then descending streamlines in the back end. There are a couple terms -- the near wake, which is the recirculating cavity zone, and then the far wake, which is the zone beyond that.

The ISC model, for example, applies only in the far wake.

Shown in this schematic are two stacks, one on the building, which is the assumption that ISC makes, and then a stack displaced from the building -- and schematically, we're showing here that the influence of the stack position can have an influence on the extent to which the plumes are affected by the building induced turbulence.

Showing this in another way, in an elevation view, in a plan view, you can see the near wake -- the region -- this is the region where there's recirculation, that the flow near the ground is going counter to the gradient flow, and then the far wake which is an area of enhanced turbulence, and the turbulence induced by the building decreases as you move away from the building. And also on the plan view, you can see the width of the near wake and then the width of the far wake, which is -- both are a function of distance away from the building.

Chuck mentioned these considerations, but I'm going to go into a little bit more detail on each one of them. ISC has been a very useful tool, but there are a number of enhancements and limitations to the model which we've tried to address in the PRIME development.

One was the location of the stack. As I showed on the previous slide -- two slides ago -- the location of the stack is, in many cases, if it's displaced from the building, an important element, determining to what extent the building downwash affects the dispersion from that stack. In ISC, there is a calculation done to determine whether a stack is within the influence of the building at all. If it is, the building effectively is placed at the location of the stack, and then it receives the full enhancement of the building-induced turbulence.

Streamline deflection. In ISC, the streamlines are assumed to be unaffected by the presence of a building. So there is no streamline ascent or descent. If you have a buoyant or non-buoyant plume imbedded within this, you'll see, as we'll show later, that the trajectory of the plume will be affected streamline deflection.

A velocity deficit in the wake. When you introduce an obstacle into the flow, it creates a frictional drag on the flow and it will disturb or change the normal velocity profile -- the wind speed profile with height. And that velocity deficit has a couple of effects. One, is it will change the rate of plume rise because it's reducing the plume -- the velocity -- the wind speed at the top of the stack. And secondly, it will affect the amount of dilution that occurs when the stack emissions are injected into the atmosphere. So one tends to increase concentrations, and one tends to decrease concentrations. Which one dominates depends on the situation.

Wind direction effects. In the wind tunnel, it's quite clear that wind direction relative to the face of the building is an important parameter in determining the amount of downwash and how the plume interacts in the far wake region, and in the near wake as well. And that effect is considered in the PRIME development.

And finally, there was this issue of linkage and integrating a single model that would apply both in the near wake and in the far wake, for all stack heights, building height ratios. Currently, the Screen-3 model can be used to estimate concentrations in the near wake. ISC has two far wake models, but there is no attempt in the implementation of those models to match the concentrations at the interface between the two, resulting in several discontinuities within the ISC model.

Another issue that was noted early on and was addressed in PRIME is the general overprediction with the ISC algorithms during light wind speed, stable conditions. The reason for this overprediction is the fact that the stacks that are above 1.2 times the building height, there is enhancement of sigma Z in the ISC model, but there is no enhancement of sigma Y, resulting with that stability conditions of a situation where you may have a very narrow plume in the horizontal, but a very diluted plume or enhanced dispersion plume in the vertical. That issue has been addressed within PRIME.

The other element is that the ISC model itself can't be used in the cavity, you have to go to a different cavity model for that.

And then this third point has to do with the original development of the ISC dispersion coefficients. If you go back to that study -- Huber and Schneider study back in 1977 -- and analyze -- reanalyze the data, in order to match the ... of concentrations, given the fact that they didn't account for streamline descent and the effect of downwash on plume rise, it was a -- it had to be an underestimation of sigma Y and an overestimation of sigma Z in order to compensate for lack of a streamline deflection. And that actually is a factor that helps produce the overprediction that occurs in the stable conditions. That also has been addressed within PRIME.

There are a number of issues related to plume rise and the trajectory of the plume that are included within the PRIME downwash module, and I would really call it a module instead of a model because it's something that can conceivably be put into any other model. It's not necessarily a trivial task to do that, but it was designed to be modular in nature.

We use a numerical plume rise equation which calculates the effect of a lot of different parameters on a rate of rise, the presence of enhanced turbulence, the presence of a velocity deficit in the wake, and the presence of streamline deflection. Doing the calculations with the numerical model helps make that a bit easier, and there are a number of effects that can be included, all within the same framework.

There is the enhanced turbulence and dispersion in the wake region. What we're using is a calculation of turbulence intensity and a PDF model for the initial dispersion in the wake region. And beyond the region where the PDF applies, we have an eddy ... formulation, and eventually the turbulence in the wake decays to ambient turbulence. So the upwind turbulence will have an effect in the transition zone from the disturbed flow back to the ambient flow.

There was a fair amount of detail and effort spent in making the near and far wake interface and interaction as seamless as possible. The way the near wake, which is the cavity zone, works is if there is a fractional capture of the plume by the cavity, it's not all or nothing mixing as in Screen-3. It's -- we're using a simplification approximation -- uniform mixing within the cavity, and the cavity serves as the source to readmit pollutant that has been captured within the cavity region to the far wake, and that's treated within the model as a volume source. So at the interface between the near wake and the far wake, this continuous distribution -- or there are no discontinuities. There happens to be a sharp break at that point, but that's to be expected, but there's no discontinuity.

Regarding the plume rise module itself, it's a numerical solution to the mass/energy/momentum conservation equations. It does allow -- provide for increased plume growth due to building induced turbulence, so that the position of the stack relative to the building can and does influence the rate of rise of the plume. Plumes that are on the edge of the downwash region are affected less than plumes that are right on the building. And that goes for the treatment of enhanced turbulence as well as the treatment of plume rise.

And finally, it includes wind shear effects. ISC includes the rate of rise -- rate of increase of the wind speed up to the stack top, but above the stack top, the wind speed is assumed to be constant. For short, highly buoyant stacks, such as combustion turbulence, that's not necessarily a very good assumption. With the numerical plume rise equations in PRIME, we include the variation of wind speed with height, above the stack top as well as below the stack top.

Also the use of a numerical model allows you to input arbitrarily varying temperature in wind stratifications. There's no requirement that the wind speed vary according to a Palo Alto file or that the potential temperature gradient be constant. If you have a vertical profile of winds and temperatures, they can be used and the plume rise module will account for those effects.

Also, if there is initial plume size to the -- to the plume, that will be accounted for within the plume rise calculation as well. And if you happen to have a very hot plume for some reason, maybe a flare might be an example, there is a non-Boussinesq option within the plume rise model.

The wind speed profile is adjusted for the velocity wake deficit. What this means is that you would put a wind speed profile based on ambient measurements, and then that profile will be modified, based on the location of the stack relative to the building, to account for the fact that the structure itself introduces a drag on the flow and reduces the wind speed right in the vicinity of the building itself.

There's an empirical streamline ascent module which is added to the plume rise, so this ascent and descent depends on where you are relative to the building, and it's added in to the rising plume, so the two effects -- potentially, a plume rising due to buoyancy imbedded within a flow which is descending due to the descending streamlines.

If you have a situation where the -- the wind profile is constant, which is the assumption within the Briggs plume rise equation, the numerical model does approximate the Briggs solutions fairly well.

The weight dimensions -- I won't go through these equations, really, just to point out that there is empirical relationships in the model which determine a scale dimension. The vertical wake boundary is a function of that as well as downwind distance. The horizontal wake boundary is a function of that, and then the downwind cavity length. So all of these things have been predicted based on the building shape, the building width, height, length and the direction of the flow relative to that building.

There have been a number of data sets that were allocated to us as the model developers for use in the evaluation -- use in evaluating and developing the model. That included the EPA wind tunnel data set developed by Bill Snyder which included information for both combustion turbines and a steam boiler, as well as another EPA data set, Thompson's data set which included information in the vicinity of the building, the cavity region. Those particular sources were non-buoyant, no momentum releases.

The EPA wind tunnel data itself included about 300 concentration profiles for three different plant types and included variations of the stack height, the exhaust speed, the angle of the wind relative to the building, the Froude number, and then the stack location.

This is a streamline plot showing one of those cases. This is for the steam boiler and you can see the cavity zone, the near wake. You can also see the frontal cavity here. You can see that ascending streamlines and then the descending streamlines.

Here's another example on the bottom part of the frame is the wind tunnel data, and the top part of the frame is the model, the PRIME model predictions for that particular case. And you can see the length of the wake is generally fairly well predicted throughout all the different cases that we've looked at. We see descending streamlines in the front -- along the front edge of the building, and then the descending stream lines in the rear of the building here. And you can see the corresponding streamlines in the wind tunnel for that case.

There are many of these slides which have been included in the reports that have been produced, but this is just one example of the type of data.

The Thompson data set is shown here. In this -- this is saying that a particular building shape -- this is a cube -- when the stack is located two building heights downwind at a height equal to one times the building height, so this big red dot is the point of emissions. What's shown down below here is the concentration distribution as you move away from the stack. In this case what's -- the color and the size of the ball, both are proportional to the concentration, so it gets redder and bigger as the concentration goes up. And what you can see in fact, is the peak concentrations in the far wake for this type of building shape and source configuration. There's very little concentration captured within the cavity, even though the stack -- the point of release is at the same height as the building.

Another example -- this is a non-buoyant release, released at 25 percent above the top of the cube, and there is again, very little capture within the cavity -- some, but not too much. The peak concentrations are in the far wake.

So the location of the point of release is very important in determining whether there's capture in the wake and where the peak concentrations are being predicted.

Just showing another example. This was a second type of building, and here with the point of release at 1.5 times the structure height, you're seeing again, not too much capture within the cavity, but the peak concentrations are further downwind.

I mentioned the importance of the wind angle relative to the building in determining the concentrations. This is showing some results from the EPA wind tunnel test for the steam boiler case. Here the wind angle was varied from zero to 45 to 90 degrees, and then 135 and 180, so five different wind directions. ISC has no real variation with wind angle so its concentrations are essentially uniform and independent of that. The windtunnel results are shown is with the solid line which is showing at least a factor of three variability depending on the angle, and in the PRIME, the predictions are shown for these same cases. Generally the model did fairly well for that case.

This is the Thompson wind tunnel data set now. Here we're looking at a case where the source is located at the -- at half the height of the building and it's located right at the downwind edge of the building, and here there is capture within the wake, the near wake, and you can see the concentrations predicted and observed, especially in the far wake did very well. In the near wake, what's happening is PRIME uses a uniform mixing approximation and it gets an average concentration, which is similar to the observed. The ISC predictions are shown here and in this case, this is actually the Screen cavity prediction, so that the PRIME model did fairly well relative to the observations and did better than Screen in this case as well.

There are a couple data sets related to real observations. The wind tunnel is fine, but it's also nice to compare against observations, and there were a couple different data sets allocated to us as the model developers. In one case it was the Alaska North Slope Tracer study which involved the combustion turbine, the stack height was about 1.5 times the building height. There's 38 hours of data with fairly high winds, high wind cases.

The second observational data set was the Bowline Point study, and in this particular -- this particular data set was divided into two, half of it was given to us and half was given to Bob Paine who did the independent evaluation, so we were working with half the data set. That involves two 600 megawatt units with the stack:building height ratio of 1.33.

On the Alaska North Slope data, what we're looking at is the -- and this is the Quantile-Quantile plot -- this is similar to what Al Cimorelli explained -- same type of plot. The 1:1 line is shown here. ISC is shown with these open squares, and then the solid circles are the PRIME model. There is some overprediction, although the model did considerably better than the ISC model for his particular case.

The other case is the Bowline Point study. Here we looked at the top ten concentrations and what's shown -- the observations, the predictions with the PRIME model, the predictions with the ISC model and what is shown with the number next to the character -- the symbol -- is the stability class into which the high concentrations were predicted or observed.

And what you see is in the top ten, the observations are all stable -- I'm sorry, neutral conditions -- relatively high wind speed, neutral conditions, destability. ISC doesn't do too badly, really, with the slight overprediction, but within a factor of two of the observations, but it's predicting the concentrations -- approximately the correct concentrations, but for the wrong reasons in the sense that it's predicting the peaks under stable conditions -- most of the peaks -- well, the first four, and then here one with unstable astability.

PRIME does better in terms of the relationship to the concentrations, but also just as importantly, is that it predicts the right conditions under which the peaks are observed -- in other words, high wind speed neutral conditions. So we think we're getting the answers better, but also for the right reasons.

Okay, just to summarize. The model development of the PRIME model, the intent was to include new algorithms and better algorithms to enhance the treatment of the dispersion enhancement that occurs in the wake, both in the near wake and in the far wake, to include algorithms to treat the plume descent and ascent in the cavity zone and the building wake zone and the upwind zone of the building. A very important element was to include the location of the stack and the calculations so that the stack position relative to the building is something that's explicitly accounted for within the model.

Also, the issue was to eliminate the discontinuities associated with using different models and different modules that exist currently with the ISC and PRIME does that. It has a single algorithm for treating both near and far away -- all stack to building height ratios. It eliminates, as a result, the discontinuities that occur in ISC.

Now, I'll make one point about this. There is still a discontinuity in PRIME in the sense that at two and a half times the building height, you turn treatment of downwash off according to EPA guidance. PRIME actually can be applied and does in fact, predict, some small enhanced turbulence, even at two and a half times the building height, but the policy is at that point is to cut off the influence of building on the stack dispersion, so that's the way PRIME has been coded in the ISC-PRIME model.

In our data sets, and we'll hear more about this from Bob Paine, PRIME did as well or better in both the field study data sets and in the windtunnel data sets than ISC.

The next is Bob Paine, and as I mentioned, he did the independent evaluation work.

MR. PAINE: Okay, I have a primary responsibility to get you to lunch on time, so I'm going to go through this not too slowly. My name is Bob Paine, I'm going to talk about the evaluation of the Building Downwash Models, that is ISC-PRIME and ISCST3 with field and wind tunnel data. Go ahead, next slide.

I'm going to describe the evaluation of the data bases that we came up with and show the results of the evaluation and then provide a summary of the overall model performance and at the end I'm going to talk a little bit about a consequence analysis -- just a minute or two about that.

It's hard to find downwind data bases because people don't like to monitor close to their facilities. We did a very thorough search and came up with some Tracer experiments, three full-year monitoring networks, two of which were definitely not usable probably because of some sensitivity; and three wind tunnel studies.

Of all available data bases, we decided to divide them into developmental and independent data bases. There was only one of the full-year network that survived the cut and to give the model development people a fairer shake, we chopped up -- we had a very elegant algorithm to choose the Julian days to give to Joe Scire -- but we reserved the full run for the independent evaluation. There were four Tracer studies that were provided. There was also a field study during the winter of 1994 at a real facility, and there was, as Chuck mentioned, wind tunnel data provide from Bill Snyder and also from Monash University. Notice that in this mixed -- in the past there had been more wind tunnel studies and field data. In this case, we have more field data than wind tunnel studies for this application.

For the independent evaluation we set aside the one full year network, two of the Tracer data bases and the one wind tunnel study, a mixture of source types -- we'll get into in the next few slides.

Going through those now describing their features. The full year network involved two 600 megawatt units at an electric utility. The stacks were 87 meters high, and they involved typical buoyant releases from steam electric facility. There was a full year of data and the monitor distances were on the range of 250 to 850 meters. So if you multiply 87 by three, basically -- just beyond the cavity, up to just -- about ten stack heights, but since the building height was less than than, one of the monitors, some of the monitors were beyond ten building heights.

This shows the map of the network -- the stack being here. These two monitors ended up being downstream of northwest winds that were most heavily impacted. The numbers five and seven ended up not having a lot of data and were subsequently discarded from the analysis.

This just shows you the picture of the facility and showing basically two buildings and two stacks, and those were input to the enhanced BPIP algorithm that is used for ISC-PRIME.

One of the Tracer data bases, the outcome of an American Gas Association study in the early eighties, this was a gas compressor station type of source. There were actually two locations, Texas and Kansas. The stack height ranged from ten to 25 meters and they were buoyant releases. There were 63 tracer hours and this tracer sampling coverage was in the range of 50 to 200 meters.

The next slide shows a typical -- sort of a fuzzy slide and it shows with the stack being here, and the building here, and has various tracer samplers, so these would be -- these close in ones would be in the cavity region, and we have some within the wake region, up to ten building heights or so. Next slide.

There was another Tracer study with non-buoyant releases, a nuclear test reactor site, from the ground and rooftop, actually three different locations that were involving three different tracers, so that for one tracer alone, you could get three times the quantity of data than from a single tracer release gas. This was important because of the non-buoyant type of release and the fact that we actually had a ground level release, important for the RFP (ph) type of applications, you often have to consider, and the tracer sampler coverage involved seven receptor rings at a variety of distances, from 40 up to 1600 meters, and so some of these were in the cavity region, and some beyond.

Next slide shows a birdseye view of the facility, in the middle of the seven rings up to various distances, so all of these were candidate tracer sites for this data base.

Finally, a wind tunnel study was used to augment the data bases, involving Lee Power Plant and steam boiler stacks of about 65 meters high, buoyant releases, as was the Bowline Point. The total number of hours was over 1000 with various of combinations of units, loads, neutral and stable conditions and various wind directions, et cetera. The Monash University was able to construct their wind tunnel to accommodate stable impacts due to innovative techniques that they use there and the real-world effective distance coverage was 150 to 900 meters.

It's sort of hard to see this but that's how you can see the wind tunnel depiction of the various banks of stacks here and the building height here. Next slide.

What did we use for model evaluation procedures? Well, the primary statistic was that used in many studies, the fractional bias, which is a function of the average observation minus the average prediction divided by the sum of the two, multiplied by two. And what that does is it gives you a zero result for perfect model where the observations and predictions average out to be equal. And if -- they approach a plus or minus two for a model with no skill. In many cases we use the absolute value of this quantity in statistics reporting, and that's called the absolute fractional bias.

And then if we go off with more acronyms, the composite performance measure, CPM, in some cases was used as a weighted average of AFB or absolute fractional bias values over various regimes -- and regimes are selected as selected as predetermined stability and wind speed categories in this case, to determine how the model's doing for a variety of selections of those combinations that are of interest. And those were spelled out in the ... that was reviewed by EPA -- an EPA workgroup and approved.

Then when you have the composite performance measure for each model, you take the difference of those to determine whether the models are significantly different in performance and if you have 95 percent confidence interval of this model comparison measure that does not intersect zero, you have statistically determined that the model performance is significantly different.

For Bowline Point, since it was full year of data with the traditional application of the so-called Model Evaluation Methodology software developed by Earth Tech and provided by EPA, the two monitors that I showed you earlier were tested over a full year. For the American Gas Association and EOCR data bases, arc maxima were used because those were tracer data bases, and resampling techniques were used to determine 95 percent confidence intervals -- those were from Boot Software originated by Steve Heller (ph) and promoted by API.

The Lee Power Plant, similar -- we did have a centerline concentration with predictable wind directions and once we got the distance maxima, we used similar procedures for resampling and -- to get the 95 percent confidence interval for the differences of the fractional biases there too.

Let's go through the evaluated data bases and show the results. I mention here for one of the monitors -- I'm going to show the other one on the next slide, excerpts of the top 50 concentrations and then ISC and ISC-PRIME predictions. Except for the one highest one, you'll note that the ISC-PRIME predictions are equal to or higher than the observed concentrations, where ISC tends to run a little bit higher, but by and large the ... are doing fairly well. But notice of those stable cases in the top 50, only four were observed, but ISCST3, as Joe Scire mentioned, went overboard on stable conditions as being a primary cause of downwash impact. So in overemphasizing that condition, and incorrectly so. ISC-PRIME doing very well in identifying five of the top 50 were due to stable conditions, compared to four observed.

For the other monitor, similar pattern. Again, ISC-PRIME generally higher than observed. ISCST3 higher than ISC-PRIME, again -- not too many stable cases out of the top 50 showing up in the observed. In this case ISCST3 didn't do too badly, ISC-PRIME emphasized no stable cases.

In terms of applying the whole model evaluation methodology, we found that the -- and remember the composite performance measure is a function of fractional bias, so the closer you are to zero, the better your model is. ISCST3 has a higher number than ISC-PRIME. When you took the difference of these and you took the 95 percent confidence interval, you notice that it barely will not intersect zero -- you noticed from the previous slide that the two models are not doing that much differently in terms of performance. ISC-PRIME is a little bit more towards being unbiased, and statistically -- it was statistically significantly better -- slightly -- on this data base.

In terms of the methodology for doing arc maxima, you would basically -- on these other two tracer data bases, you would look at each ring, find the highest observation and select that as being the representative number that you're going to do a prediction for and run that out. And sometimes, of course, they didn't line up perfectly, but this was used as the primary method.

So let's go to the AGA data base -- this is going to the result. The 95 percent confidence limits on the fractional bias can be translated to the prediction of the observed ratios and we find that for our ISCST3, the rate is about from two to three, whereas the ISC-PRIME rate is from nearly one to 1.6. So we're seeing ISC-PRIME is predicting less conservatively, and in fact, these ratios don't even overlap, so you can probably predict that the models are going to be significantly different in performance.

On the whole, the 95 percent confidence limits on the differences of the fractional biases have a range that does not intersect zero. The negative number means they're both overpredicting, that is to say ISC is overpredicting relative to ISC-PRIME, therefore the conclusion for this data base is that the difference is significantly different and ISC-PRIME is -- they're both overpredicting, but ISC-PRIME less so than ISCST3.

For EOCR we have a similar result qualitatively in that ISCST3 is showing overprediction tendencies ranging from 3.44 to seven. ISC-PRIME about one to 2.7, and again, these ranges did not intersect, so when we go through the entire procedure, 95 percent confidence limits on the differences of the fractional biases, again the range does not intersect zero, and the same story as for AGA, both models overpredict, the differences are statistically significant.

The Lee data base, we've looked at two types of data in terms of what I'm going to present, the high wind speed, neutral cases and the stable cases. In this case we have observations from a wind tunnel -- they were presumably representative of five different averages. We adjusted the averages to hourly by multiplying by a ... scaling factor of 0.61. Even though we did that, we found that these models apparently underpredicted, although ISC-PRIME underpredicted less. And since that result is inconsistent with the other data bases, it's just possible that we should have used even a higher -- a larger adjustment factor to go from the wind tunnel to the field studies.

But whatever you use for the adjustment for the observations, you can tell from the averages, you notice here that ISC-PRIME is predicting higher than ISCST3 in this one case. And in terms of the confidence limits on the differences in the fractional biases, we find that it does not intersect zero, so the two models have a significantly different performance and in this case, different than the other data bases, ISC-PRIME is actually more conservative than ISCST3 for the high wind, neutral cases.

Next slide. Clearly a different story for the stable cases. As has been reported by many investigators, ISCST3 is expected to overpredict substantially because of the combination of the conservative vertical potential temperature gradients and other factors that cause downwash to occur with the undiluted plumes and stable conditions, although you wouldn't expect it with light winds. We found that ISC was overpredicting by factors of 12 to 19 in general, where ISC-PRIME -- very close to being unbiased, but still on the high side.

And obviously, you'd expect that the confidence limits in the fractional biases do not intersect zero by any means, so here's a case where they're greatly different, and ISC-PRIME shows a much better result.

So the overall conclusions of -- ISC-PRIME is unbiased or nearly so, except for that one case in the Lee Power Plant wind tunnel and that's a function of how you go to one hour averages in a wind tunnel. But ISC-PRIME is essential unbiased, and overpredicts, generally, for each of the data bases, so its use if likely to be protective of air quality. ISCST3 is especially conservative for stable conditions, and in that case we saw that ISC-PRIME performs much better.

Under neutral conditions, the performance of the two models is more comparable. ISCST3 was developed with tunnel studies which are generally neutral conditions, but even there, in the cases we looked at, ISC-PRIME had a statistically better performance although less of a margin than in the stable conditions.

Next slide -- or is that the only -- okay, let me add a postscript here to mention that we did a consequence analysis similar to what Warren Peters presented for AERMOD. There was a 1998 AWMA paper that may be on the website, but it describes the result of the consequence analysis. I believe there are some documents on the website under the SCRAM001 that describe the consequence analysis results.

Just to summarize, we used two types of stacks, rural and urban conditions, squat, ... and super-squat buildings, and ... dispersion. The basic results were that the results are not inconsistent with what we have seen here in these real world evaluation results. And in general, ISC-PRIME predicted lower than ISCST3, but not always. ISC-PRIME in the cavity region predicted substantially less in many cases than Screen-3. But the ISC-PRIME results, we have found, are more sensitive than ISCST3 to the stack-building orientation and the stack to building distance. Of course ISCST3 doesn't know anything about the stack to building distance, so not a surprise there.

ISCST3 can sometimes be lower than ISC-PRIME for some wind angles and other stack to building orientations, so it's not always the case that it's a one-sided comparison. And that's basically a one to two minute recap of the consequence analysis. I think we have a few minutes for general questions.

DR. TIKVART: Any questions for Chuck or any of the speakers?

MR. PETERSON: Ron Peterson, CPP. I note that one of the improvements was the distance -- the stack from the building, and I didn't see any data sets testing how well the model did if the stack distance from the building varied. Has that been done, actually, to test that option in the model?

DR. TIKVART: I suspect that would be for Bob Paine.

MR. PAINE: Most of -- I think the data sets in the real world were the ones where the stack was on the building, but the consequence analysis did address a separation of the stack away from the building and we have descriptions of how that worked, and in that case, we generally found, as expected, and as you've seen in your equivalent building demonstrations, the farther away you put the stack from the building, the more likely you are to get a lower downwash effect. That's what the consequence analysis did. I don't think we have any real world data bases where we had the luxury of monitor concentrations, because those are very hard to find. Joe has a comment.

MR. SCIRE: I just had a couple words to add to that. I showed a couple slides today that did show some cases where the stack was displaced from the building -- that's the Thompson data set. There were no real world data sets that had that effect, but there were wind tunnel data sets that did include that effect.

DR. TIKVART: Dick, go ahead.

MR. SCHULZE: This is Dick Schulze for Trinity Consultants. Are you preserving the current features of ISC-3 in terms of invoking the downwash algorithm when the plume elevation is less than -- well -- GEP height? Where you take the sum of physical height plus momentum plume heights?

MR. SCIRE: The version that we have now uses the stack height as the cutoff, so that if the stack is less than two and a half times the building height for a squat building, PRIME is invoked. There's -- as I alluded to in my talk, there is some effect predicted by the PRIME model, even for plumes that are above two and a half times the building height. A stack that is less than two and a half times the building height, but rises to be greater than two and a half times the building height will still have some influence. Stacks that are above two and a half times will have no influence on the building.

MR. SCHULZE: And is it my recollection of Snyder's analysis or Snyder's document -- the fluid modeling guideline which was published I guess close to 20 years ago, said that when you did fluid modeling you would determine GEP height when the amplification of the building was 40 percent. And by taking the building in and out of a wind tunnel study -- in other words, your concentrations would be 1.0 without a building, if with a building it was 1.4, then that would determine GEP height. My recollection also that that was approximately equal to the formulaic GEP -- that is two and a half times the height of the building. So, I'm curious because I've always thought that the current downwash algorithm sort of underpredicts to a small extent, less than 40 percent, concentrations when the stack height is say, somewhere between two and a half and say four times the height of the building.

MR. SCIRE: I think that you are right about wind tunnel studies and the basis for the definition of what GEP is -- it's a significant increase in ground level concentrations and that was defined to be 40 percent. There are a couple issues, though. In the implementation, not in the formulation, of the PRIME model, we cut it off at the definition of GEP. So stacks above two and a half times the GEP height will have no influence by simply requiring that -- and that's really an EPA policy decision, not a model formulation decision.

The other point is whether stacks that are 2.5 times the building height will underpredict. You might think so, but there are a number of conservative elements within PRIME so that I think in practice, it won't. But in fact there could be expected to be some effect of the building, even at two and a half times the building height.

MR. HANRAHAN: Hi. I'm Pat Hanrahan with the state of Oregon.

I've got two questions. The first one is, where can we find documentation on the various empirical equations that are used in PRIME?

MR. SCIRE: Well, the PRIME document is the journal paper in the AWMA, and then secondly the PRIME code is available and it's all very explicit within the code as well.

MR. HANRAHAN: Okay, it's something I see important as far as understanding where these empirical equations are derived. The second question, probably more devious, and involved actually, AERMOD. You showed us for a number of cases that ISC-PRIME predicts less than ISC with the current Huber-Schneider and Schulman-Skeery (ph) algorithms. How easy would it be to identify those cases where the current downwash algorithms are conservative in the current ISC as compared to ISC-PRIME?

MR. SCIRE: I think the big split that we saw with what we did was the stable case -- for stable ISC was conservative over ISC-PRIME, for sure. I don't know if --

MR. PAINE: Yes, well the consequence analysis does show cases where one model would be higher than the other and although it's not guaranteed that AERMOD would exactly duplicate ISCST3 because it has different profiles of winds and so on, so it's a complex question that I don't think has been thoroughly researched. So I don't think we have a full answer to your question.

DR. TIKVART: Okay, we'll take two more questions, then that's going to be it, we're going to have to break. So, this gentleman here and the lady in back.

MR. IRESON: Rob Ireson, Consultant. This may be a question for AERMOD as well. Do you have any guidance on the minimum receptor distance that you feel is appropriate for ISC-PRIME? And is it a function of stack height?

MR. SCIRE: ISC-PRIME is designed to apply to receptors in the cavity, so you can have receptors that are close enough to the building to be within the cavity. The model is not designed to have receptors that are on the building face, so you wouldn't want to put receptors along the downward edge of the building or the top of the building, or the front edge of the building, but on the ground, the model does have the cavity algorithm.

MS. DIOSI: Phyllis Diosi (ph) with Malcolm Perny. Does ISC-PRIME consider other source types or is it only point sources?

MR. SCIRE: It's really point sources that it's designed for.

MS. DIOSI: Would you expect to see similar effects though, for wind deflection and other for area sources in the wake of a building? I've always -- I've always wondered what kind of effect you could expect and we don't seem to have a model to cover that.

MR. SCIRE: I think the phenomena occurs. Deflection is a physical thing that's happening to the flow, so it would apply. It would happen. It's not generally the case of most interest. Normally the issue is, you have a stack that's located near a building and that's what's of most concern. But the -- the deflection, the enhancement of turbulence within the wake, all those things do occur even for other types of sources. So that is true.

DR. TIKVART: Okay, I'd like to say thanks to Chuck Hakkarinen and the other speakers for the presentation on ISC-PRIME. As you go out the door, may I remind you that I will be starting again at 1:15 and if anybody plans to skip this afternoon, we start at 8:30 tomorrow morning. If you did not sign up on the signup sheet as you came in, there is a sheet back there to fill your name in if you would, and there are a few copies of the agenda back there, and Tom.

MR. COULTER: I've been asked to tell you that if you want to come back, please don't bring any food in here, water is fine but nothing else. That's the word.

DR. TIKVART: Okay.

PARTICIPANT: Do we have to sign in again?

DR. TIKVART: No.

(Whereupon, at 12:10 p.m., the hearing was recessed, to reconvene at 1:20 p.m., this same day, Wednesday, June 28, 2000.)

A F T E R N O O N   S E S S I O N

1:20 p.m.

DR. TIKVART: Okay, I want to thank you all for being prompt in coming back. We've got a full afternoon. We will take a break half way through, we won't make you bear through a three hour session without a break as we did this morning, so we will have a break midafternoon. We'll start with a presentation on CALPUFF, which is the other major, new model system that we're proposing to include as a regulatory application, and John Vimont from the National Park Service will lead that presentation based on recommendations from IWAQM. So, John, to you.

MR. VIMONT: I am going to be giving some introductory comments on the CALPUFF and the interagency workgroup on air quality modeling -- that was what IWAQM stands for. Joe Scire is going to be giving us some information on the updates that have been made to the CALPUFF modeling system, and John Irwin's going to talk about how this all fits into the regulatory framework. I'm going to try to keep my end of this short.

Some of this -- I guess we have a little bit of an advantage -- the CALPUFF, IWAQM procedures have been used for Class I analyses now for a number of years, and it's been done on an ad hoc basis and I think what we're going to be talking about today is bringing this forward into the mainstream of the regulatory process.

A little background. The -- we had some Class I areas, specifically Shenandoah National Park where we had a lot of source growth going on around it, and a lot of the source growth was beyond the 50 kilometer magic bright line. We in the Park Service became concerned about that, primarily because of impacts to the air quality related values at the Park, specifically deposition and visibility. There were really no good -- no long range transport models in the guidelines to be used for these analyses. The Forest Service, the Park Service, the EPA all have done some independent efforts in developing long-range transport models, and we all kind of got together and talked about it a little bit and decided to form the Interagency Workgroup on Air Quality Modeling to try to bring together a unified approach on how to do new source review and long range transport models.

We developed a -- what we called our Phase I recommendation, which we presented at the Sixth Modeling Conference and that included using ISC model as a screening technique and MESOPUFF-2 as a more refined technique -- not refined, I guess, in the sense of Appendix A, but it was in the Appendix B at that time and it was what was proposed for the long range transport part of it. At the Sixth conference we had a number of comments on the Phase I proposal, and we also discussed switching over to CALPUFF at that time and presented some information at the Sixth conference on CALPUFF.

From the conference, the comments that we got, we developed the Phase II recommendations. You can find those out on the EPA website and several other documents related to this whole process as well. The Phase II basically, we recommended that CALPUFF be used as the long range transport model of choice, and we defined a screening technique there and a -- suggestions on how you would use this in a refined analysis.

One of the things that came out of the Sixth Modeling Conference was the need for further evaluation of CALPUFF. As part of that, in response to that, and documented in the Phase II reports are several comparisons with Tracer data. Unfortunately there are not many data sets available, and they aren't necessarily the most ideal data sets for doing this, but this is all that's out there right now.

The various comparisons that were done were against Tracer data. There were also some trajectory comparisons done and then there were also some comparisons done with the ISC-3 model for looking at intermediate field situations.

Basic conclusions on the Tracer data were that the -- in most cases, the magnitude and spread of the impacts that were predicted by the CALPUFF system were basically okay. They matched up with the Tracer data pretty well. It was sensitive, however, to the wind directions. In some of the data sets you do not have -- you had nearby weather data that -- or meteorological data and that seemed to account for some of the differences in actually exactly where you hit in the arcs of receptors.

Most of the analyses were good within a factor of two. The -- there was one exception on a very nearby arc of Tracer samplers, that basically the vertical dispersion wasn't being captured properly by the model at that point but that was very near -- within a couple kilometers.

Another experiment was done with one of the data sets where they had a very rich meteorological data set so that you could specify the wind fields very well, which is unusual for most permitting kind of applications, and it come out very clearly that as you degraded the data there that the results also degraded -- the comparison with the Tracer.

Another experiment was done on Southwestern U.S., Project Mojavi where we -- it was again, not a very idealized data set. It was -- the Tracer data was put out there for other purposes and we tried to evaluate the model against it. We did not have arcs -- these were individual located receptors kind of randomly spaced in different areas. There we also had high density upper air profiler data which you would think would give you, in a diagnostic model such as CALMET, the opportunity for getting the wind fields done quite well.

As it turns out, you can do them quite well but you have to be very careful with it. The conclusion out of it, in complex terrain, as you're specifying data into the wind fields, we found that it was very critical exactly how you specified the range of influence of the various profiler data that we were putting in. The other thing that came out of that was -- this was in very complex terrain. The source release was 600 meters or so below the areas where most of the receptors and monitors were located, and you needed to have some terrain treatment in the model. You couldn't just go out on the fact that it was terrain following. It made quite a difference in concentration results.

This was discussed at the Sixth Modeling conference some, and was reaffirmed in the Phase II report, is that you can improve the trajectories that you're getting out of -- for long range transport with the CALMET-CALPUFF modeling system if you include four dimensional "data" simulation model results -- and I put "data" in quotes there because it's a model output and if you use that as part of your input strain to the CALMET processor, we found that you could increase the skill of the model quite a bit.

There were some comparisons done with ISC-3, and this is partly to account for the situation where you have a long range transport in combination with a near field situation, and you can't use this model for that same purpose. When you ran steady-state meteorology you can demonstrate the CALPUFF will pretty well reproduce the results of ISC-3. If you have varying meteorology, just straight observations, you have -- I put in quotes there -- "simple flows" -- something where you have kind of a random wind pattern, you tend to get similar results with CALPUFF. However, with the puff model, if you have something like stagnation or recirculation, it was found that you got much higher results frequently, and this just makes sense because this steady state model doesn't handle those situations. So those were the conclusions on the comparison with the steady state model.

We defined a screening technique in here and basically the normal way you would operate CALMET-CALPUFF is with CALMET and CALPUFF. You can't single station meteorology in an ISC kind of format. We recommend that if people use this screening technique, that it be done with five years of meteorological data, generally from National Weather Service data. The particular screening technique is only applicable to a single source or closely grouped sources.

The way it works as a screen is -- again, remember that most of our focus here originally, at least, was on Class I areas. So you put a receptor ring out at the distance from your source in your Class I area, and you use the highest concentration anywhere on that ring to do your assessments. It's strictly a screen. We don't have a lot of faith in the actual transport directions of a single source meteorology, particularly when you're going out 150 kilometers or something like that. So this was a way to get at a reasonable simulation that took into account the time dependence of the concentrations with chemistry and deposition as well as the causality effects that you get from having varying wind flows.

It was also found to be -- the screening technique is generally conservative, but not always. When these same rings were used for the same simulated sources with a complete wind field, the rings with the complete wind field would sometimes produce higher concentrations. Now when you're applying this to a Class I area you've got to remember the Class I area is usually going to be located somewhere in -- it is at a specific location, and we do a refined analysis, we look only at the area around the Class I area, whereas this was looking at the suite of things. The odds are you're probably still conservative when you're applying this for a Class I analysis.

The refined technique is basically using the same model, except now we're introducing the CALMET part of it -- time and space bearing wind field. We recommend that you use five years of Weather Service data or a minimum of one year of FDDA data. And I know in some of the reviews that were done of the system that are also listed out on the bulletin board, that was one of the concerns in there that one year may not be enough to capture -- because you do have inter-annual variability and that's very clear.

In this case, you would put receptors over the Class I area, dense enough to represent the concentrations very well. It's applicable for multi-source impacts. It's not fixed to a single source by any stretch, in fact we encourage a cumulative analysis to be done in the Phase II report -- that seems to be the way to do these kinds of things and have them done more centrally -- and that was also discussed at the Sixth conference. And use a combined -- use it for both long range transport and near field.

And basically, recommendation for the Class I areas at least, you can use the screened or the refined for source in question. You're using the chemical transformation removal. You can look at PSD increments and max. You can look at various AQRVs or the effects on AQRVs which will include visibility analyses and deposition of sulfur and nitrogen.

Maybe some of you are familiar with what we call FLAG. It was the -- I forget what the acronym was -- Federal Land manager Air working Group I think it was. The procedures we outlined in Phase II were somewhat of a placeholder because we -- a lot of AQRV analysis is the responsibility -- or specifying how it gets done and what parameters you look at is the responsibility of the Federal Land Manager. The intent in IWAQM was not to usurp that, but to provide some guidance at that time. So Phase II did outline procedures that were current at that time but they were changing and still are changing to some extent.

The FLAG report, which is out on the Park Service website -- you can get it that way -- is -- represents kind of the unified guidance between the various federal land managing agencies, because we did run into problems sometimes where say, the Forest Service and the Park Service had Class I areas that were side by side and we were giving different guidance, and we're trying to bring our guidance together.

Generally, the procedures in FLAG will supersede what is in the IWAQM Phase II report. For example, in the Phase II report is a table which describes how you calculate the nitrogen deposition. Well, missing in that is the components due to -- it's only oxidized nitrogen that we talk about there, not the total nitrogen which would include ammonia and other things.

So, anyway, that's kind of my introduction on this and how we got to where we're at. And Joe Scire is next going to discuss some of the enhancements that have been made to the modeling system and turn it over to Joe.

MR. SCIRE: Okay, I'm going to talk about the -- some of the capabilities of CALPUFF and focus on some of the new features that have been introduced over the last couple of years. By the way, there is a new version of the model that has been put on the website, so there is a version out there, as of last Friday, I believe, that has these capabilities.

The general idea behind CALPUFF was that it would be an integration of a number of different components -- meteorological components, the non-steady state puff model, as set of post-processors, to handle the processing of the results and formatting, and a regulatory type of analysis functions -- displaying of meteorological data. There's some user interfaces, graphical interfaces for Windows-based systems. And then there are a whole series of pre-processors that go with the system as well.

Basically all of the standard terrain, land use, meteorological products from the National Climatic data center can be put into the system. The design specifications originally for the development of CALPUFF -- this was actually started in 1987-1988 -- included the ability to treat near-field impacts from the fence line to long range transport of the order of several hundred kilometers away from a source, with averaging times anywhere from one hour to a full year. Including wet and dry deposition, removal due to precipitation as well as dry processes.

A simple chemistry -- originally the SO_x and NO_x were the pollutants of interest. Since then, secondary organic aerosols have been added. The formation of sulfate from SO_2 and nitrate from NO_x emissions is part of this.

The FLAG recommendation is the draft FLAG procedures have been implemented into the post-processor so that you can use the post-processor to calculate plume extinction and visibility effects. It's designed for complex terrains so that if you have hills, either resolved by the grid spacing or you can introduce subgrid scale hills into the model -- those effects will be accounted for. And because it has a three dimensional wind field, it does allow land characteristics to vary with space. It will account for land-water boundaries as well as urban-rural boundaries, as well as more subtle changes in land use character.

Specifically, there's a separate scale coastal module where you can get a very detailed separate scale representation of the coastline into the model and it does have an over-water b... module for transport dispersion over water surfaces.

The nature of the puff model is such that it can accommodate zero mean wind speed, calm conditions, as well as stagnation and recirculation, reverse in flows. It allows all the different source types that you probably ever encounter -- points, areas, lines and volumes. One unique thing about this is that it will account for buoyant sources, buoyant line, buoyant areas, buoyant volume sources as well as non-buoyant sources. And it's designed for cumulative impact assessments. We have many sources over your domain potentially being -- experiencing different flow conditions and dispersion conditions.

One question is why use a puff model? When would you want to use it? When would you want to consider its use? Well, it doesn't make the assumption of steady state conditions. It's a non-steady state model, so whenever you have complex flows where the steady state assumptions break down, it might be something you would want to consider.

It includes causality effects which means that when you release a pollutant it doesn't reach a receptor that's 50 kilometers away immediately. It takes some time to get there, and that transport time is accounted for in a non-steady state model, where in a steady state model it's assumed to reach all the receptors immediately.

If you have flows which are not straight line flows, they change in states, that's another consideration -- that might be due to train effects, it might be due to coastal effects or other reasons why the flow might vary in space. Any time you have a flow or turbulence condition that are not homogeneous, such as a coastal boundary, or maybe train induced flows -- those variabilities in the wind field is something that makes consideration of a puff model appropriate. Also more subtle changes, land use, surface characteristics, forested areas versus agricultural areas, urban areas versus rural areas -- those are things that can affect the turbulence and therefore may violate the assumption of steady state conditions.

If you have a cumulative impact assessment project that involves many different sources within a spatially varying field, that's a situation where you would want to consider it, and of course if you have calm wind or light wind conditions, you may have multiple hours of emissions contributing to the concentrations for a particular time, and that build-up of pollutants is something that can be quite important in many cases, especially in valleys where you have development of inversions and the build up of emissions over many hours, potentially.

Okay, now I want to shift out of this screen altogether -- okay -- this is an animation showing a steady state model ISC on the left, versus an unsteady state model. In this case, both models are being driven by the exact same meteorology -- single point meteorology so there is no spatial variability to the wind fields. It's just meant to show that causality effect, primarily, and also the potential for pollutant build up over multiple hours.

It's a 24 hour simulation. On the left is the steady state ISC model, on the right is CALPUFF. You can see the plumes responding to the flow. ISC -- every hour, all that is impacting the receptor are emissions for that one hour, whereas with CALPUFF you can see that it is responding to emissions from previous hours as well.

If you look at the 24-hour average pattern for the two models, on the left, the plume model is the sum of a number of different steady state plumes going off to infinity in each of the directions; whereas in the puff model, the flow is more complicated. There are cases where the material never reached these receptors in the puff model, but are predicted to reach the receptors with the plume approach. So it's a very powerful technique that allows you to account for the spatial variability but also the causality effects, and the multiple source build up -- multiple hour build up of plumes.

Oh, I guess we're going to shift to the slides now, actually. Some of my slides, the colors didn't quite work out so well. What this is showing is a wind field in a complex terrain area. This is actually the B... Teton area, wilderness area. The Teton National Park -- Grand Teton National Park is right here, and what is happening is the wind flow is showing a tremendous amount of variability -- southwest winds, southeast winds, northerly winds, southerly winds, downslope drainage flows off the high terrain. You can get almost every wind direction within this domain represented. You can see some flow channeling where the flows are coming together, converging within the valley and the valley is serving like a pipeline to bring pollutants up into the region and potentially up into the National Park.

You can also see that there's the deflection of flow away from the Class I area as well. So the sources here which have headed towards the Class I area get deflected by the downslope flows and the terrain effects of the high terrain. So it's a very complicated pattern, but it's one that's realistic in a complex terrain environment.

This shows a air field application in a valley in the Columbia River valley in Washington state where the terrain contours are shown in black, and the concentration contours are shown in blue, outlined in red. And you can see the plume which initially headed towards the terrain on the other side of the river, was channeled by the fairly steep terrain here and in fact followed the orientation of the river valley.

Now this is an important consideration for design concentrations because the previous modeling with a steady state model with the BLP model produced high -- very high predicted impacts here, which the evidence suggested that they didn't occur because they had vegetation sampling done at this particular facility. And so therefore, the curve trajectory is something that in complex terrain environments might very well be important for design concentrations.

Just to continue -- I'll go through the major features of the model fairly quickly. The source types -- various types of sources -- points, areas, volumes, lines -- as I mentioned, they can be buoyant or non-buoyant. Each one of these. In addition the emissions can vary cyclically, or they can be constant, or they can vary arbitrarily. So if you have hourly varying emissions from a volume source, you can account for that.

The turbulence parameterizations in the model -- there was a specific attempt to match ISC in steady state conditions in a particular mode. But the new developments in dispersion have also been introduced into CALPUFF as well, for example, the AERMOD type -- many of the AERMOD type enhancements.

For example, the PDF for convective conditions -- we have a PDF module based on AERMOD within CALPUFF. And the use of similarity theory and turbulence-based dispersion coefficients, convective scaling is in CALPUFF as well.

If you have direct turbulence measurements you can use those. So as the recommended approaches change in time from PG to more advanced techniques, the options are in CALPUFF to try to address those changes.

If you have dry deposition and wet deposition depleting the plume, if that's a significant factor, it can be accounted for in the model. That has two effects. One is it removes the primary pollutant from the atmosphere, so it's reducing concentrations. On the other hand, the deposition fluxes themselves are often one of the important predictions of the modeling technique for purposes of air quality-related values -- the nitrogen and sulfur deposition is an important parameter, and the model will provide estimates of those.

In the chemistry, there's SO_2, there's sulfate, NO_x to nitric acid and nitrate and SOA modules -- those are all in the version that was updated last week. Aqueous phase chemistry -- we were hoping that would be in, it's not quite in yet, but we're hoping to release that within a couple weeks, that we'll have the aqueous phase chemistry module.

Building downwash -- what's in CALPUFF is the ISC technique. We do have -- we do have intention, in fact, we have funding to put PRIME into CALPUFF and it will happen this summer, so we're very -- a version of CALPUFF with PRIME will be available by the fall and that will help address some of these issues related to downwash.

Subgrid-scale complex terrain -- there is a module where the skill of the hill is smaller than what can be resolved by the grid spacing, and you're allowed to put that kind of information into CALPUFF and it will treat the effects of the hill on the concentrations.

Overwater and coastal interaction effects I mentioned. CALMET has an overwater b... model in addition to an overland module, so it's using a different technique to calculate boundary parameters over water. Plume fumigation is something that results naturally from the formulation of the model, so you can get coastal fumigation effects, and also there's the ability to treat sub-grid coastal affects where the coastline is quite complex, you can specify the coastline boundaries with a separate subgrid scale, coastal boundary file.

Other features -- puff-splitting was introduced about a year or two ago in the vertical. The new version, we've introduced horizontal puff-splitting as well. One of the issues that has come up is what is the upper limit to the range or applicability of CALPUFF -- without horizontal puff splitting, the puffs would become quite large. With horizontal puff splitting, it has a larger range on the high end. It can be applied over longer distances than if you do not account for horizontal splitting.

And for plume rise, a number of things that we're talking about today -- this morning -- are in the CALPUFF model. Partial plume penetration to elevated inversions is very important. In addition we have effects -- local effects such as stack tip effects, building downwash effects on plume rise, and when PRIME is introduced, that technique will be in there as well.

In the vertical wind shear effects, it also issues if you have stacks that are not oriented in the vertical, maybe you're oriented horizontally or have rainhats. The disruption of the momentum out of the stack can be simulated by flipping a particular switch. That's a new feature as well.

Other things -- in terms of visibility calculations, you'll find in the new version of CALPOST, the post-processor, there are six visibility methods that have reflected changes over time. Method six is the current proposed FLAG methodology. It will produce percent change and extinction and decivues (ph) from a set of model sources, and is a full implementation of the FLAG methodology as proposed.

There are interfaces to other programs and other models, in particular, there's a processor now on the website that will allow you to take MMT data and convert that into a form that can be used by CALMET directly, and also there is a processor that will take the output of an emissions model developed by the Forest Service, EPM, emissions production model, which is a forest fire model and that can be used to generate CALPUFF compatible input emission files. And then there are also new versions of the ... interfaces which go with the new model.

The summary of recent developments -- the horizontal puff splitting is an important development. In practice, I'm not sure how much it's going to really affect design concentrations, but in theory it can have an effect in some conditions, so it is an option now.

Boundary condition module -- you will note that specified boundary conditions have inflow from the boundaries of the domain as well. Issues of tracking mass and fluxes across the domain -- you can put a line in the domain and it will calculate how much mass goes across that boundary.

The subgrid-scale coastal module is also a new module. Flight pole receptors -- you can have receptors above the top -- above the ground. The ring head option, the visibility option.

And then the chemistry -- secondary organic aerosol module is in the module that's been released. As I said, the aqueous phase chemistry -- we plan to have that -- it's not quite ready yet. The non-linear repartitioning of nitrate -- that is part of the new processor called post-util, which allows you to handle non-linear effects of ammonia limitations in the development of nitrate. The aqueous phase chemistry, as I said, I hope that will be within a couple weeks.

Other developments -- there's a whole set of new processors for appending files, for summing files from different source contributions, from different runs, for scaling files, for doing the repartitioning of nitrate, for doing the soils contribution analysis, for creating new species from the input species. For example, this program will read sulfate and nitrate and SO_2 and SO_4 and NO_x depositions, and create a total sulfur deposition, or a total nitrogen deposition. So it's a very, very powerful processor that gives you a tremendous amount of flexibility.

Some of the pre-processors now allow the use of global terrain and land use data, as well as the -- certain types of Canadian terrain data as well. So new options on those. And then there's another option that allows for cooling tower type applications -- fogging and icing, visible plume lengths to be predicted as well.

The data requirements -- routinely available geophysical data required includes terrain and land use -- and as I mentioned, the standard U.S. geodata sets are -- can be entered into the processors, so you don't have to do code development for those. For meteorological data, the processors have been modified to handle the various formats. I understand there may be a new format which is kind of -- we're trying to stay ahead of the game here, but it's hard when they change. But CD144, SAMSON, HUSWO, as well as a general site specific format -- all of those are allowed in the processing options that are available in the current release. The upper air data is NCDC format. Precip data. Overwater buoy data is using the NOAA format, and then we have a processor to interface them all to MM5.

The data requirements, or other sources of data that can go into CALPUFF including ambient monitoring data. Ozone data is used as an input into the chemistry module and there are -- the source of those data, usually the AIRS data set or the CASTNET data set. Ambient ammonia is also something that can be derived from the CASTNET data sets and that's the source of the ammonia data, typically.

Background plume extinction values -- the FLAG report lists numbers for each Class I area in the country, and those are -- can be input into CALPOST for visibility analyses. And then of course, you need to specify the source information emissions data.

Computer needs -- well, it's a big -- it can be a big one. Anywhere from a few minutes for an ISC-mode type run, to a couple days, I think, for a typical big run for three-dimensional simulations. Disk requirements -- that's a big one too, especially for the meteorological fields -- anywhere from a few megabytes for a single station inputs to ten to 20 gigabytes for a very complicated flow over a large domain. But on the other side of that, it can be done with PCs. The current generation of PCs are perfectly adequate. There are one gigahertz PCs out that you can buy now for $35-3600, with the 40 gigs of disc space and plenty of ram. So when I say the requirements are one to two days for a large, full 3-D run, that's on a PC. You don't necessarily have to have a workstation.

I wanted to give some evaluation results from an important study in Wyoming. This was the southwest Wyoming study. It was presented at a public forum a couple months ago, involved using MM5 as the initial guest field for CALMET, using CALMET down to four kilometers resolution, and then using CALMET to predict visibility, deposition and ambient pollution concentrations.

And we used the improved SO_4 monitoring network at the Bridger (ph) Wilderness area, and this is a Quantile-Quantile plot showing the values -- 24 hour average values of sulfate, a secondary product of the modeling, versus observations. The perfect agreement line is shown here and the factor of two lines are shown here. The agreement is quite good, well within the factor of two and does well all the way down the distribution. A good amount of this is due to boundary conditions we found. In Wyoming the air is probably the cleanest air in the lower 48 states and inflow of material from outside the domain is quite important. But the model is picking it up and doing a good job representing the boundary conditions as well as the local sources. That's for sulfate.

The next one shows the nitrate, NO_3. This particular situation is very highly ammonia limited, so it was very important to have the ability to treat the repartitioning of ammonia and nitrate based on the availability of ammonia. Again, the results are quite encouraging, within a factor of two, and much better than that in a lot of cases.

There's a transmasometer (ph) at this site. This is showing the observed and predicted plume extension is one spike. The observed is the pink. There's one spike observed, but that may have been related to some kind of fogging event, I'm not quite sure. Usually those are filtered out. But excluding that, the seasonal pattern and the range of variability of the observations and the predictions are extremely good. The high, excluding this peak -- the high is about 42 observed -- 45 observed, and about 44-45 predicted. So it's quite good agreement. And the extinction includes the sum of sulfate plus nitrate plus other particulate matter, secondary organic aerosol, so it's a measure of how the model is doing on all secondary pollutants.

We also looked at the ability of the model to predict observations in terms of total sulfur deposition. This is at the NADP site in Pinedale, and these are weekly observations and weekly predictions, a Quantile-Quantile plot. The perfect agreement line, the factors of two. And the model seems to be doing reasonably well. Certainly it's not way out of line with the observations, normally it is within a factor of two.

Same plot for nitrogen deposition, again showing pretty good agreement within a factor of two for most of the distribution, and we felt that was a fairly good evaluation of the deposition.

There were two near field evaluations that were done, one was with the Kincaid SF_6 Tracer experiment that's been talked about a bit this morning, with the AERMOD, and also the Lovett power plant is a complex terrain application in the Hudson River valley and I want to show you a couple results from those -- from those two.

On this one, the same type of thing as we saw with the AERMOD presentations, the Quantile-Quantile plot, the factor of two underprediction, overprediction. In this application, ISC is underpredicting most of the distribution, including the high end. CALPUFF, without the PDF module, so using PG dispersion, does better for most of the distribution, but does tend to underpredict the peak values, but with the PDF module turned on, does better throughout the whole distribution, virtually. So, for tall stacks, certainly what was said this morning about the importance of the new science is true, at least that seems to be the case here.

For the Lovett evaluation, it's a power plant in a complex terrain. Here what's shown are the results from CTDM which we only have the top 25 values, so that's all that's plotted here. I'm sorry, this is RTDM -- with top 25 values. CTDM-Plus and CALPUFF -- and RTDM is roughly a factor of five overpredicting, CTDM-Plus is about a factor of two over, and CALPUFF is a little bit better, usually within a factor of two, maybe about 50 percent overpredicting. Slightly conservative, but still better than the other models.

That's a summary of the new features and where things stand with the evaluation work, some of which you probably haven't seen before and now I'll turn it over to John Irwin.

MR. IRWIN: Hello, my name is John Irwin. I'm a NOAA meteorologist on assignment to EPA for many years. In the next 20 minutes or so, I will be discussing CALPUFF's regulatory niche.

The discussion is divided into six sections. Where is CALPUFF discussed? What are the meteorological requirements? What is long range transport? What are complex winds? What are the case-by-case requirements? And what are some of the regulatory considerations?

I have found nine places in 40 CFR Part 51 that are directly relevant to CALPUFF. In the first, which is Section 3.2.2(e), this lists the conditions for the use of an alternative refined model which becomes important in understanding the recommendations for case-by-case use of CALPUFF for complex wind situations as discussed in 7.2.8 and for use of CALPUFF for assessment of reasonably attributable haze impairment as discussed in 6.2.1(e).

The second place is Section 6.2.1(e) offers use of CALPUFF on a case-by-case basis for assessment of reasonably attributable haze impairment due to one or a small group of sources.

The third place is Section 6.2.3 which recommends use of CALPUFF as a refined modeling technique for long range transport.

The fourth is Section 7.2.8 which suggests use of CALPUFF modeling system on a case-by-case basis for air quality estimates in complex, non-steady state meteorological conditions. And for those of you who are taking notes, there's a typo in page 21524 there's a reference to section 8.3.1.2(a) and that really should be 8.3.1.2(d).

The fifth place is Section 8.3.1.2(d) which encourages use of the output from prognostic mesoscale meteorological models for both long range transport and complex wind situations. It offers that diagnostic adjustments as performed by CALMET may be improved for local scale, complex wind domains though the use of strategically placed meteorological observations.

The sixth place is Section 8.3.1.2(d). It outlines the length of record of the meteorological data for long range transport modeling, and for modeling complex wind situations.

The seventh place is Section 8.3.3.2(h) which mentions that CALPUFF is capable of using direct turbulence measurements.

The eighth is Section 8.3.3.2(k) which recommends use of CALMET as the meteorological preprocessor for CALPUFF.

The ninth and last place that I could find was Appendix A.4 which provides the summary of the CALPUFF modeling system. I pay particular heed to Section A.4(a) which is outlining the recommendations for regulatory use of CALPUFF modeling system. And there's a typo in there where it refers to section A.4.a(3), that really, in that section it says go to Section 7.2.9(a) and there is no 7.2.9(a), it should have been 7.2.8.

Now, I've listed the nine places that I could find and I'd like to take a little time to discuss in more detail some of these. As we proceed through these topics, you will note that I've listed the relevant sections.

The first to be discussed are the meteorological processing requirements for CALPUFF. How long of a meteorological record is required?

If only National Weather Service data or standard comparable data are available or being used, five consecutive years of meteorological data, within or near the modeling domain, should be used. Less than five years of meteorological data may be used if mesoscale meteorological data are available as discussed in 8.3.2(d) and are used in conjunction with available National Weather Service or comparable standard meteorological observations, within and near the modeling domain.

The question often is asked if site-specific meteorological data required. The short answer is no. As discussed in 8.3(d), diagnostic meteorological processing, as with CALMET, may perform better if data is available from strategically placed site-specific meteorological observations.

Is CALMET the required meteorological process for CALPUFF? Short answer is yes.

Moving to long range transport. What is it? There's two parts to this answer. The first part is when modeling the pollutant impacts at receptors that are greater than 50 kilometers from sources being permitted. Historically, this has typically involved PSD analyses for Class I areas.

The second case, when modeling an application containing a mixture of both long range and short range source-receptor relationships in a large modeled domain, for example, several industrialized areas located along a river or a valley.

Is there a recommended screening approach? Short answer is perhaps. On a case-by-case basis, the screening approach outlined in the IWAQM Phase II report may be used. This has been tested for a situation involving one or more, several closely spaced sources, with impact on a specific location more than 50 kilometers away. No screening approach has been devised for the large modeling domain situation.

Is a protocol required for long range transport? The short answer is no, but if you read the guidance, it's strongly encouraged as a means for developing consensus in the methods and procedures to be followed between the applicant and the relevant reviewing authorities.

What is the role of the Federal Land Managers? The Federal Land Managers are to provide the procedures and the analysis techniques that will provide the information required in order for them to perform their review and approval of the permit. Basically, they define the processing steps that provide them the data they need and they define the decision criteria that they will use in making their determinations.

The next topic are complex winds. What are they? Well, the answer is, when it has been determined that a particular application involves stagnation or wind reversals, and/or time and space variations of meteorological effects on transport and dispersion such that -- and here's the key words -- the assumptions of steady-state straight-line transport are inappropriate.

Is there a recommended screening approach? No. The complex nature of the problem precludes the use of screening approaches.

Is a protocol required? Yes, absolutely. This is a case-by-case assessment, and it must meet the requirements listed in Section 3.2.2(e).

This brings us to case-by-case requirements. In order to perform a case-by-case assessment, you must meet the five requirements that are listed in Section 3.2.2(e). And note, this will require Regional Office approval.

The model has received a scientific peer review. This is a new requirement.

The model can be demonstrated to be applicable to the problem on a theoretical basis. This was there previous.

The necessary data bases are available and adequate. This was there previous.

Appropriate performance evaluation show the model is not biased toward underprediction. If you look closely, this is somewhat edited from the previous requirements.

And lastly, a protocol has been established. This is a new requirement.

Next to be discussed are regulatory considerations. EPA intends to continue the existing arrangement whereby EPA defines the version of the code as the accepted regulatory version and Earth Tech Incorporated's website will be the location for accessing the code and documentation for downloading.

Both CALMET and CALPUFF are written with all options available for the user to define.

Currently, the regulatory suggested model option settings are defined as the default settings. Just because a default is provided does not mean it is cast in concrete. Judgement is still required. For instance, the default settings is to turn off puff splitting. But as the transport distances increase, or as the flows become complicated with stagnation and flow reversals, puff splitting may become a viable option that you should consider.

You will find, more so with CALMET than with CALPUFF, that a few of the model switch settings have not been provided with any default settings.

This is meant to indicate that these settings will have to be tailored to the specific application. Past experience suggests that tailoring switch settings may involve developing side-analyses to provide the data to make an informed decision between different settings.

Currently, the default settings to select Pasquill-Gifford dispersion characterization. As AERMOD becomes acceptable, the use of similarity dispersion coupled with convective boundary-layer mixing to be more AERMOD-like seems reasonable. Likewise, when PRIME is installed into CALPUFF, it should be selected when appropriate and applicable.

In the preceding discussion I have tried to list all the sections where 40 CFR 51 are relevant to the regulatory use of CALPUFF. I've tried to define the meteorological requirements for the use of CALPUFF; and I've tried to outline the requirements for case-by-case. But finally, I think you all should realize that we aren't in an ISC land any more.

As you may have gathered from the discussion on regulatory considerations, we are not treating CALMET and CALPUFF as a modeling system that lends itself on a cookbook approach. It is recognized as being a more complex modeling system than ISC-3. In this regard, I would like to conclude with two quotes from the draft notice of proposed rulemaking.

In Section 1.d it says, "As modeling efforts become more complex, it is increasingly important that they be directed by highly competent individuals with a broad range of experience and knowledge in air quality meteorology. The judgement of experienced meteorologists and analysts is essential."

In Section A.4.a(3), it says, "Inevitably, some of the model control options will have to be set specific for the application using expert judgement and in consultation with the relevant reviewing authorities."

As I said before, we're not in ISC-land any more. This is a modeling system that demands experience and judgement. If all you know is ISC-3 and you think ISC is complex, you need not apply for the job.

I thank you for your attention. This concludes our prepared discussion outlining how CALPUFF came to be recommended, its technical capabilities and its regulatory niche. In the time remaining, we can field a few questions.

DR. TIKVART: Okay, thank you, John and John and Joe for a very excellent presentation, scientific presentation on a complex topic. So, questions for John Vimont and company? Tom you've got a customer.

MR. SANJEE: My question is more relating to the whole presentation of the day. You have all these models and I guess they were developed on Fortran, and as a user I sort of felt that if there were some easier software. Has that been considered?

MR. VIMONT: What do you mean by easier software?

MR. SANJEE: Basically to make it more user-friendly in terms of input.

MR. SCIRE: On the main -- the main programs in CALPUFF, there are graphical user interfaces that -- the traditional type of Windows-based interface -- that allows you to input the data. Not all of the elements of CALPUFF have those. Some of the older processors still you have to have an input file and enter the data. The three major components, CALMET, CALPUFF, and CALPOST do have a Windows-based user interface.

MR. BLEWITT: Joe, this is a question for you -- Doug Blewitt, Air

Quality Resource Management. Joe, back in the -- several years ago, EPA ran MM4 for a good portion of the United States on an 80 kilometer grid cell. Are you planning to do that with MM5 and make such data available to help simulation, sir?

DR. TIKVART: I'll answer part, and then I'll turn it over to -- John, you want to take this from the beginning? We have used MM5 to run a full year of data for 36 kilometer grids for our 1996, for the purposes of running numerical grid models. The extent to which this would be useful for CALPUFF, I'll defer to somebody else on it.

MR. VIMONT: Okay, the -- there is a 1992 MM5 data set done at 80 kilometers. It's not -- I have a copy of that data set and can make it available to people. It's in the same MM4 type format that was done before. The '96 data set should have been reformatted into a CAL-MM5 type format already except we ran into Shirley who is our contracting officer, so that should also be made available hopefully before the end of the summer.

DR. TIKVART: Okay, there were some other hands. I think Mark Garrison has the --

MR. GARRISON: I am Mark Garrison at the ERM. I have three, hopefully brief questions for Joe Scire. In your evaluation of CALPUFF at Lovett, could you tell us what complex terrain treatment options you used? That's the first question. Second question is did you generate a wind field with CALMET for that evaluation or did you just use the tower data? And the final question is are these evaluations available somewhere? They look very interesting and I just wondered if they're available somewhere.

MR. SCIRE: Okay, the first answer is that we used the default method that's in CALPUFF, which -- for the terrain treatment, which is the partial --

there is a partial height treatment, half height under neutral conditions, and 0.35 under stable. The question about what meteorological data set we used -- we did not do a full 3-D run in those cases. We used the tower data that were available. In that particular application, the terrain was just between two and three and a half kilometers away. And then the third question, related to the availability of a report, these is a full report -- that evaluation work was co-sponsored by the California Energy Commission and Jersey Central Power and Light. So there is a report. There is also an AWMA paper that's available that summarizes it. So there are two sources of information.

MR. GARRISON: Joe, just quickly -- the Wyoming evaluation, where you looked at deposition, evaluation and sulfate and so on -- is that also an evaluation that's available somewhere?

MR. SCIRE: That's going to be available very soon. The draft of that is due now, actually -- I won't say the real -- very shortly.

PARTICIPANT: ... Canada. I have two questions actually. The first one is for John Vimont. You mentioned that CALPUFF was used for a complex terrain in ISC-3 mode. It over predicted and it was significantly higher?

MR. VIMONT: I'm not sure that's what I said. The -- we did some tests with a full run, not an ISC-3 mode in complex terrain. And then -- I know what it is, the slide said complex flows -- that was in quotes. It was basically when you had situations of stagnation and recirculation, particularly near the source itself, you've got much higher concentrations out of the puff model than you did from the steady-state model, because when the steady-state model is going to ignore those situations or reset the values -- and doesn't have any recirculation, so it can't get back over on top of itself, so -- it's kind of two different things. It was a complex flow situation where it showed up -- the puff model gave higher concentrations.

PARTICIPANT: (Canada) Okay, the second one is about the Canadian grid data that is incorporated now in the model. Is it in the new version that is released yesterday or is it in the one that is going to be released in two weeks?

MR. SCIRE: The Canadian terrain data can be processed in the version that's currently out there. There's also the ability to process global data sets, so actually you can run it anywhere in the world, using the global data. It's not the best resolution on the global data, it's one kilometer resolution, but that capability does exist, and the Canadian format does exist as well.

MS. DIOSI: Phyllis Diosi from Malcolm-Perny (ph). I was interested in that fogging visibility module. Is that only for cooling towers and is it like a SAF-T type approach? Or can that be applied to other plumes as well?

MR. SCIRE: It doesn't mask balance for water vapor and liquid water, so it can be applied to other applications, primarily our experience has been in the plane of the cooling tower applications.

MR. STRACONGAS: Arnie Stracongas (ph), Utilized Radium (ph), Austin, Texas. I guess my question is for John and it involves implementation again. The -- it sounded as though the presentation you were making is about making CALPUFF the regulatory model for doing federal Class I analyses. You talked about all these other features that it has, and thinking about case-by-case. So what you're saying is that CALPUFF is the regulatory model of choice for the Class I analyses, but then in becomes an Appendix A or B or you can choose to use it if you wish to, but it's not a regulatory requirement for any other issues, other than Class I.

MR. IRWIN: I think you got there right at the end.

MR. STRACONGAS: Okay.

MR. IRWIN: It's not required for short-range, less than 50 kilometers, but it's your choice if you wish to use it, you may. And then if you go through the five steps that are required, the model has been peer reviewed, there are evaluations which may or may not be appropriate, but hopefully are appropriate for short range applications. So many of the steps, actually, have been completed for case-by-case analysis at short range. The one that hasn't been is you need regional office approval, and you will have to justify that it's necessary for this application, it's in the best interest of all parties that you use a CALPUFF model for this system. And if you do use it, it's implicit in that that you're going to run the full-scale, three-dimensional time-varying wind field. It isn't that you're going to take the CALPUFF model and run it with ISC meteorology.

MR. STRACONGAS: Oh, I guess --

MR. IRWIN: Did I answer your question?

MR. STRACONGAS: Possibly. Using your terminology -- (problems with mike) -- The -- what it relates is my earlier question -- you were talking about ISC-PRIME, AERMOD, ISC, now let's put CALPUFF in the mix -- so now as a result of what I'm hearing in our conferences here today is we're basically providing a lot of different alternatives, especially when the term case-by-case is put out there. So, from an implementation standpoint, and regulatory features it's like -- it's similar to Appendix B. These things are out there -- even Appendix B models have been used case-by-case in the current setting. So I don't know if you're introducing anything new here today or not, but I want to make sure from a regulatory standpoint, since that's what we're doing in this topic here, what we're telling is putting CALPUFF as a regulatory use and I think from what I hear is yes, for Class I it is there, but the other ones -- we're still talking about AERMOD and ISC-PRIME and CALPUFF is back there for these other situational meteorological conditions you may wish to turn to for stagnation, recirculation, et cetera?

MR. IRWIN: If you read between the lines and make a close word by word comparison with the case-by-case requirements of all -- with the case-by-case requirements of today that we're proposing, one of those was that you had to have, in order to do a case-by-case analysis, direct comparisons with modeling results on your site. That's no longer a requirement. The word is appropriate. If you can justify that you have the appropriate evaluations done to prove your case that this model is the one for your application, you can use it. There was a conscious decision in making that change in the case-by-case analysis, and that if you go back historically and look to see how many people have actually done a case-by-case analysis, I think you can count them on one hand, which is sort of ridiculous because there are good modeling techniques out there that will outperform steady state dispersion models, and it wasn't our intent to deny the people the right to use good modeling techniques when they were there and appropriate. So we're trying, making a good faith effort here, to promote the use of good modeling techniques, and in a way we're promoting or suggesting, consider CALPUFF for short range because there's a lot of work that's been done on CALPUFF in the short range.

PARTICIPANT: ... protocol.

MR. IRWIN: And there is a protocol required as well, so a lot of the openness that you might think you have, well once the protocol's written, things get tightened down again, but we are trying.

MR. VIMONT: Just one bit of clarification too. You mentioned Class I areas -- it's actually the niches for long range transport. It happens to be the Class I areas are what usually drive the long range transport or the need for long range transport analysis, so far at least. But it is generically for long range transport.

MR. IRWIN: Yes, the large domain application of many industrial areas along a particular river or valley -- there's nothing about that that's suggesting that it's a Class I situation.

PARTICIPANT: In the downloading of the files off the site. I tried to do that a couple of months ago that it refused to give me an access to some of them, and some of the modules were missing to make it all run. Has this been corrected yet?

MR. SCIRE: It's never been a problem. All the modules are there. Everything you need, and if you had problems downloading it, that's another issue. But the --

PARTICIPANT: Is MM5 available on that site?

MR. SCIRE: MM5 is an NCAR model. It's available from the NCAR site. It's not part of CALPUFF.

MR. VASA: This is Stanley Vasa from The Southern Company. My question relates to Joe's presentation. (mike problems) ... incorporating PRIME into CALPUFF. Is it going to be ... or is going to be ... going to be a change ... expressed this morning as part of the AERMOD-PRIME incorporation?

MR. SCIRE: The funding is in place, so it's a matter of doing the work. It will definitely happen, and we think the timeframe will be the summer for the implementation, and then the version of CALPUFF with PRIME will be released in the fall.

Regarding the second part of the question, I guess, I think it would simplify everybody's life a lot if PRIME were put into AERMOD, if that's what you're asking. I think that's quite obvious.

PARTICIPANT: Would you be ... when you have PRIME incorporated in the CALPUFF?

MR. SCIRE: We'll be --

PARTICIPANT: That's going to be a new model by itself.

MR. SCIRE: Well, we're not necessarily going to redo the evaluations that we've done in the past. Those evaluations didn't include downwash effects anyway, so they weren't really an issue. And the long range transport evaluations, I don't think downwash will be an issue either. But I think that part of what we have funding for does not include rerunning the PRIME evaluation case study data sets, if that's what you're asking.

MR. IRWIN: Your funding does not include that next step?

MR. SCIRE: No, there will be a version of the model that will be available. We or other people could do that if they wish to.

MR. COULTER: Got one more question in the back. This is Tom Coulter -- by the way, back to the question here, sir. Back to your question, I did mention in the proposal the website at NCAR where the MM5 system is available. Maybe you didn't see that, but it's in there, so --

PARTICIPANT: (inaudible)

MR. COULTER: Well, I just wanted to make the point that I did mention that, so Jeff, I wouldn't be looking for it on Earth Tech's site.

MR. FELDMAN: Howard Feldman with API. Joe, you mentioned a lot of very nice modules that are getting put in the model, and I think that's very commendable. I guess my question is are these being evaluated against data, for example, the SOA? Is there a data set that you're evaluating it against, or are there plans to do that?

MR. SCIRE: The SOA module in particular, there is an evaluation that was part of the swietap (ph) that Wyoming project where the predictions and observations were compared. So there was some evaluation done there. Not every new module has had evaluation with real data. Some of them have. The repartitioning features of the Post-Util program was part of the evaluation work that was shown with the sulfate and the nitrate, and then the plume extinction calculations. So a number of them have been evaluated, others are options within the model that will await future evaluation.

MR. MORRISON: Joe, I have a question. This is Ralph Morrison, Environ. A question on the chemistry. You've updated the SOA, but on the gas phase chemistry, I guess there's still just two options, the old 1982 Messelkoff (ph) algorithm for SO_2 to sulfate and NO_x to nitrate, and then there's the 1985 to 1988 ReVadarm-3 (ph). Are there any updates to that?

MR. SCIRE: The conversion routines have not been updated. Those are the two options for SO_x and NO_x. The only revision is this repartitioning of the nitrate, that's something that's new.

MR. MORRISON: And the second question, which is on the puff splitting. I guess the defaults are to have no puff splitting, and both you and John -- one of the Johns, maybe both -- mentioned that the -- with the puff splitting it probably has a longer transport validity. How long is CALPUFF valid now? How far down winds, say, without puff splitting and then with puff splitting?

MR. IRWIN: Well, I can tell you in writing the Phase II report, what we saw, and we haven't done all the possible evaluations that one could do for this, and there is one evaluation I discussed with Joe Scire about a week ago that both he and I agree would be a lovely test. In the first runs of CALPUFF, we had no puff splitting, and that was the work that was shown at the Sixth Modeling conference. And there we saw that the model overestimated the peak concentrations and underestimated the footprint of material on the ground. All of that was for 300 kilometers and beyond, and we attributed that to the fact that the model firstly could not split the puffs in the horizontal and take care of the strong wind shear which was a noted feature in many of the CAFTEXT (ph) experiments and the other was once the puffs got too big, they really needed to be subdivided so they could go in different directions. So we knew that it overestimated at 300 kilometers and beyond.

We have some evaluation work that goes out to around 95 to a little bit beyond 100 kilometers, and the model shows no bias. Sometimes a little over, sometimes a little under. So somewhere in the no man's land of about 200 kilometers to 300 kilometers is where puff splitting probably becomes very important. It doesn't mean you can't use the model beyond 200 kilometers. It just means that if you turn on no puff splitting, you're probably going to start to overestimate the impacts at the surface.

It would be at that point that I would say, let's -- if that's your range of application, and that's where your design concentrations are, I'd say it behooves you to turn on the puff splitting.

Now, the last thing is, have we evaluated it? On the CAFTEXT (ph) experiments that we did of old that went 300 kilometers and beyond, no, we haven't done that. We have the same problem as the AERMIC committee. We have absolutely no funds for the last four years.

MR. SCHEWE: (mike problems) George Schewe, Environmental Quality Management, Cincinnati. There are probably two or three groups in this room here. There's the folks who know what this is all about. Then there's the rest of us who are trying to keep up and trying to figure out how to proceed. And if you go back and look in your airplane, wherever you're going tonight, and try to figure out which one of these groups you're in, you'll say, yep, I can do that or nope, I'm still intimidated. I'm one of the guys that are a little bit intimidated by the cost of the computing capabilities to do this and what I'm going to have to figure out, if, based on what John just put on his last slide, I'm trying to figure out if I'm one of those qualified guys or not. I've been doing this for 25 years -- I think I am, but I don't know. So everybody is probably thinking that.

And I guess my question is to the whole group and to Joe, what's the agency going to do to help us out? We've got all our clients out there, sitting in a line and we're ... going to spend $50-100,000 running CALPUFF, and that's just to get started. And I've got to go tell my boss, uh, we need a workstation or whatever, to get this thing to run. What kind of resources are you all going to provide to us, if any, to help us figure out how to run this thing? Is there going to be any training available? I know that Joe, you guys have been ..., but I think the waiting list is pretty long. You're here, so you're not going to be able to train anybody today.

MR. SCIRE: Let me answer it as much as I can. Over the last four years, we've had 30 training courses and many of those have not been full. People are now trying to catch up and the last couple have been full. There is another one in September. We've made a special effort to provide training to the regulatory agencies, to consultants, to competitors, to Earth Tech. Everybody can attend these who want to attend them. Three days of intensive training. You will come out and you will be able to run the model and you will know all of the components of the model. That, we felt, was a responsibility, and that's the way we've tried to do it. It's not something new, it's been going on for four years.

Regarding the computer requirements and the cost. It doesn't cost $100,000 to do this. It might maybe the first time, but it's not a whole lot more than running -- running a complex application with ISC when you have a lot of experience to do it. And the cost of the computers -- what I tried to say in my presentation was you don't need a workstation. You need a PC, and if you have a current generation PC, the investment is less than $4000, you can run CALPUFF in a reasonable amount of time.

DR. TIKVART: There is one other aspect to that, and that is that one would guess that you get more concentration estimates using this more sophisticated technique, so there is a benefit, and using this might bear additional expense in terms of the sources seeking permits, so there is another aspect to this.

MR. SIMMONS: Larry Simmons with Energy and Environmental Management. I'd just like a show of hands of those people who have attended one of Joe's training classes. There's a lot of folks here that have run CALPUFF.

DR. TIKVART: Thank you for making that point. Let's see, there's a -- Vinca.

MR. TROM: Vinca Trom (ph) from the AERMIC committee. The nice thing about CALPUFF used to be its relative simplicity. Now you've got all these effects with puff splitting and all that sort of thing. At what point you make the transition to an open-grid model? Now you've got even secondary organic aerosols, you've got aerosol partitioning. Why not use a grid model with full chemistry?

MR. SCIRE: Well, at some point the grid model doesn't make sense and a lot of time a decision is based on the scale and the number of sources. To run CALPUFF for -- it's only for a few sources, does treat the near field effects better than any grid model, for sure. It's also more economical to run than a grid model for a long period of time, like a year's simulation. We've brought it up front to about 2000 sources for a full year. That was a fairly big application. But if you're running the eastern part of the U.S., you probably should be using a grid model.

MR. VIMONT: Well, I guess -- real quickly, too, in answer to that. The way this got started was back when IWAQM committee and what we are looking at now is really new source review kind of applications for PSD permits for locating near Class I areas. And most of the time you're looking at a small subset of the rural sources out there and for that application, I think it's appropriate. But again, I would certainly agree that when you get to the entire world, that grid model's the way to go.

MR. TROM: As soon as you get into modeling your chemistry, you have to account for all the other sources and especially if you're going to the secondary organic aerosols and nitrates and -- I mean the treatment you have right now is extremely simple. Try to make it slightly complex, and you'll have to account for all other sources.

MR. SCIRE: There is another feature, too, which as I mentioned, is this boundary condition feature. CALPUFF will interface very well with the Eulerian grid model, where you can use the Eulerian grid model to define the inflow conditions and on the boundary, and then use CALPUFF to define the local source contributions. And so it is possible to use a hybrid approach, where maybe sometimes that is the best approach. It really depends. I think it doesn't necessarily mean that CALPUFF should be used for every application, but certainly with non-linear chemistry, that's the strength of the Eulerian grid model.

DR. TIKVART: Okay, before we transition into EDMS team discussion, one more comment from Bob Paine and then we'll move on.

MR. PAINE: Bob Paine from ENSR. A question, probably for John Vimont. At the last modeling conference, there was this talk about initialization of data bases. Are the Federal Land Managers ready to hand out meteorological and emission data bases to applicants, and if not, who is going to have to undertake this burden?

MR. VIMONT: Answer A, no, we're not ready to hand them out. If you work away from a Class I, you don't have that problem.

PARTICIPANT: I'll do Ohio.

MR. VIMONT: And as it was, I think envisioned back in Phase I and it was repeated in Phase II, that it was seen as being a consortium of interested individuals that would undertake this, and obviously the sources that are located in an area would have an interest, the states, the Federal Land Managers. I think it's the appropriate way to go, but getting something off the ground is what's tough.

DR. TIKVART: Yes, I think that reemphasizes the point I made earlier, and that is, there is benefit to using the more sophisticated models to getting a more reasonable, lower concentration -- lower and more realistic concentration estimates, so I think there probably will end up being a consortium of interest among land management agencies, states, sources, et cetera. So I think that will help, and with time -- there's already some efforts that already have begun on that, so I think it will happen in the longer term. And we'll hear more about that from the Dick Schulze group tomorrow -- the seminar. So maybe that should be discussed. You guys put it together tonight, and maybe we can discuss that some more.

Okay, let's move on to the EDMS team and that presentation, and I'd like to introduce I guess, Julie Draper from the FAA.

MS. DRAPER: I think we can get started, we're close to having it going. As Joe said, I'm Julie Draper. I'm with the FAA. I work in the FAA's Environmental Policy Office. It's a Headquarters office that provides environmental support for the entire FAA agency. Within our office we do various environmental impact areas, including local air quality, and within our local air quality program we do have several components, including model development, research, analysis, policy development, et cetera.

Our presentation today is going to focus on our model which is called the Emissions and Dispersion Modeling System, and it's a tool that we use for assessing air quality at airports so that we can comply with air quality requirements, the Clean Air Act, general conforming, et cetera.

EDMS has been an EPA preferred guideline model since 1993, and what our presentation will cover today is our proposed model development in the context of EPA's Appendix W and their guidelines. What we are proposing today is that we have reviewed EPA's proposed Appendix W and specifically, of course, how it describes EDMS and its dispersion algorithms. And based on our review, what we are proposing is that the description within the Appendix W be revised further to include AERMOD dispersion algorithms for EDMS.

Since many of you, I don't think, are familiar with EDMS, it is a very specific application. What I'd like to do is start out by giving you some introduction to it. What we'll do today is -- I will go ahead and give you some background information on EDMS so you'll know what we're talking about, and I'll give you a little bit more information on what our proposal is, on how we would propose including AERMOD dispersion algorithms into EDMS.

I will then turn it over to Ted Thrasher of CSSI, Incorporated, and he will describe to you how we propose changing EDMS to include AERMOD dispersion algorithms. Third, Roger Wayson will discuss our evaluation plan for using AERMOD, and finally, I'll provide a couple of concluding remarks. And just as our presentation has various people here presenting it to you -- this is just a couple members of our team -- we have a fairly large team of experts that represent atmospheric modeling, aircraft operational modeling, transportation air quality, even aircraft noise modeling, trying to get the various perspectives and make this a real team effort with all the various perspectives. And they've all contributed to this presentation and will contribute to further model research and development.

So with that, let me give you a little bit of history about EDMS. FAA developed it in cooperation with the U.S. Air Force, and they jointly came together -- brought together unique models in 1985. They then renamed it EDMS which is its current name. In 1993, as I mentioned, it became an EPA preferred guideline model. An important milestone was in '97 when it was re-engineered and brought into the Windows age and we incorporated PAL2 and CALINE dispersion algorithms, so there were both technical and user-friendly enhancements. We followed that up in 1998 with an FAA policy decision that EDMS would be our required tool for performing air quality analyses whenever we proposed to do an action at an airport. We need that, obviously, just like EPA does, for consistency of analyses, so we can make consistent decisions about our actions.

The current version is EDMS 3.2. Just as in the past there have been milestones and we have continued to perform research and model development. We are continuing to do that in the future, and have quite extensive plans for doing so, and we plan to release a new version, 4.0, in the near future.

EDMS has two distinct but related modules, and that is an emission inventory module, and a dispersion modeling module, and they're both very important for the different requirements that we have to comply with.

It does cover all airport sources, but understandably focuses on aviation sources. As you can imagine, an airport has lots of different sources, from stationary to aircraft. Because of our unique sources of aircraft auxiliary power units, and GSE -- ground transport equipment -- we do have the model focus on those sources, since there are other capabilities out there for the other sources.

And what we've done is we have compiled EPA methodologies and publicly available data. We've automated it, provided it a good user interface, and provided guidance on how it should be used. And we are in somewhat of a unique situation as to why we need EDMS, and that, of course, like you all, we need to comply with the air quality requirements that are out there. But EPA does not have specific methodologies set forth for aircraft dispersion, for example. So it's particularly important for us to have a model that takes the methodologies that are approved and established by EPA, and find an acceptable, good, and consistent method for applying those methodologies and the data to our sources so that we can provide quality, consistent analyses. And that's why EDMS is such an important tool to us, and how we are coordinating with EPA in proposing to keep up with their dispersion algorithms.

I'll do one more slide on EDMS, just to give you an idea -- a high level map of the steps to either an emissions inventory or a dispersion model. Obviously you start at the top center and you create the study that you're looking at for whatever airport. You identify your sources and the activity. And if that's basically all you're doing, you come down to the left and run an emissions inventory.

As I'm sure most of you know, to do a dispersion analysis, it's much more complex, where you're identifying where and when your sources occur; you place your receptors; you take into account weather data, et cetera. So this is the basic data flow within EDMS. I hope that's enough background information on EDMS because we really want to focus on what our proposal is and get into the details.

So I'd like to talk a few minutes on our next slide, which is the proposed enhancement to EPA's proposed Appendix W. And that is -- their current Appendix W, the 1999 version, identifies GIMM dispersion algorithms for EDMS. And in their proposed appendix which we're discussing today, they have identified PAL2 and CALINE dispersion algorithms for EDMS. In fact, we've had the PAL2 and CALINE dispersion algorithms in EDMS since 1997 as I mentioned in an earlier slide. And just as EPA is moving forward, so are we.

We are looking forward to AERMOD ourselves, and want to improve the dispersion modeling capability within EDMS. So what we are proposing today is that the EDMS description within the Appendix W be revised, enhanced, improved to include AERMOD dispersion algorithms. We want to move forward as EPA is moving forward.

The EPA has already talked at length this morning regarding the performance of AERMOD, and we feel that it's clearly a more accurate set of algorithms than PAL2 and CALINE, which are currently in EDMS. And what we are doing by proposing AERMOD be incorporated into EDMS and into the description in Appendix W is following EPA's proposal that AERMOD be our core dispersion algorithms.

Since EPA has already answered why AERMOD? What we want to try and answer in the rest of our presentation is how we propose incorporating AERMOD into our model for our unique sources, which are aircraft, for example. And so with that, what I'm going to do is turn it over to Ted Thrasher with CSSI and he is responsible for actually incorporating AERMOD into EDMS and he will describe for you how we propose doing that.

MR. THRASHER: Okay, like Julie said, my name's Ted Thrasher and what I'm going to talk about are the changes that are going to be required to EDMS to allow us to incorporate AERMOD for dispersion.

What I'm going to show you first is how EDMS currently handles dispersion, and what you can see -- it's just basically a flow diagram, showing you the different sources that are modeled within EDMS, the runways, the gates which include the ground support equipment, the stationary sources -- parking lots and training fires, and all those are currently modeled using PAL2 algorithms.

But for the roadways, the aircraft waiting for takeoff and then the aircraft taxiways, they use CALINE3. And one important thing to note here is that we have actually included the source code for PAL2 and CALINE within EDMS. They're not being run as separate applications, and since we are using two different dispersion models to handle the dispersion with EDMS, EDMS has its own report object which will combine the results from those modules to give you tabulated results at the end.

And if we go to the next slide, we'll see how this is going to change. You can see just from looking at this diagram that things do get a lot simpler after including AERMOD. Since AERMOD runs from an input file, what we will do now is take all of our source data and then generate an input file to AERMOD and then AERMOD -- I put in a dotted box on this slide, to show that that's going to be run as a completely independent application. We're not going to deal with bringing the AERMOD source code or maintaining the AERMOD source code ourselves, instead, we're just going to run AERMOD as a separate application that has been -- that has the input file that has been generated within the EDMS. AERMOD also has a very rich reporting capability that we're going to take advantage of.

So, get into some of the details. The first thing is that we need to create an input file object within EDMS. Right now the dispersion calculations handled by PAL2 and CALINE3, and we interface with those programs directly. AERMOD uses an input file, and so we will create our own software that will generate that input file. Then at the same time, users can edit this input file themselves if they want to make specific modifications which the user interface would not allow them to do.

Now, let's talk about runways in particular. And AERMOD does not have an accelerated line source in it like PAL2 does, and so what that means is that we're going to have to use some of the guidance from the AERMOD user manual and break up volume sources into multiple segments to model this instead. And there's a diagram at the bottom of the slide that will demonstrate this.

And what we're currently doing is using the CAL2 slant line to accelerate aircraft along the amount of runway that's used. Under AERMOD we would use multiple volume sources and to take advantage of the acceleration we have a couple of different options. What I'm showing you there is that as the aircraft accelerates, the same amount of pollutant is spread out over a larger area as the aircraft continues to accelerate.

For taxiways, again there is no line source available within AERMOD, and so we're going to use volume sources again for modeling aircraft moving along the taxiways. In this case we don't have to worry about the acceleration factor, this is just going to strictly be using line sources and going by the guidance in the AERMOD user manual, and that is to set sigma-Y as the length over 2.15 for estimating line source dispersion.

Okay, we go to the next slide. For gates -- and what that's really meaning is the ground support equipment, the baggage tugs, the fuel trucks and that kind of thing servicing the aircraft, and we're currently using the point source module of PAL2 for this, and there's a point source module in AERMOD, so this is going to be just a direct translation.

For parking lots -- in PAL2 we are currently using the area source module, and there is an area source module in AERMOD, but it has a lot more features than what PAL2 offered. For example, we can make, using AERMOD, polygon shaped parking lots, not just rectangles. They can be any number of sided polygons. And also you can rotate these parking lots around to any different direction, as opposed to having them be oriented with the cardinal axes. So this is going to add a lot of flexibility for users modeling parking lot dispersion.

Okay, as I mentioned before, currently in EDMS we offer our own averaging of results for the concentrations, and we've just concentrated on averaging to comply with the NAAQS. But a lot of states have their own requirements for different averaging periods that are called for -- that aren't called for in the NAAQS. One advantage to going to AERMOD will mean that since AERMOD has such a rich reporting capability, the user can specify their own averaging times as opposed to being constrained to what is currently in the EDMS interface.

Obviously we're going to have to make some user interface changes to EDMS to accommodate bringing in AERMOD, and the first thing that we're going to have to change is building an interface to AERMET, the preprocessor for the weather data coming into AERMOD, so we will develop an interface for that.

Next, since the parking lots now are not going to be oriented with the cardinal axes, and they can be polygons of different shapes, we're going to add some way for the user to provide that information to AERMOD.

And then, also AERMOD has a lot more flexibility in its receptor placement. Right now, in EDMS, you can set a cartesian grid of receptors, or you can place receptors individually. And that's it. And in AERMOD, you're able to use polar coordinates and set up networks of receptors as well as individual receptors and so that's going to be a big improvement, but we're going to have to build an interface to allow the user to take advantage of that.

On the next slide, continuing with some of the interface changes. Since we are replacing our reporting capability with the capability that is in AERMOD, we're going to have to develop some method to bring those results on to the screen, and so that will be an interface change to EDMS. And that's pretty much it for our changes to EDMS to bring in AERMOD.

Now, I'm going to turn it over to Roger, who's going to talk about his evaluation plan.

DR. WAYSON: Good afternoon. I'm Roger Wayson from the

University of Central Florida. I'll be taking my sabbatical to work on this project because I think it's going to be a very interesting project, and I'll be at the Volpe National Labs when I do that.

You may have noticed that we're going to be using AERMOD in a way that really -- a lot of different ways, things that are going to take some looking at to make sure that we've incorporated it right and that the answers that we're getting are right. If you think about it, we're dealing with a lot of ground level sources, for example, even the automobiles with the extra mechanical turbulence -- these things are going to have to be considered and jet aircraft. You can think of them sort of as a flare turned on its side, and we're going to try to be modeling that, so we're really using it in a different way.

To do that, we're going to have to have a complete evaluation process. We're going to do it in a stepped phase. We'll do sensitivity testing -- and I'll be talking about each of these in a second -- and then comparisons between the old model and the new model, which would be -- I call EDMS with PAL2 in it, versus EDMS with AERMOD in it. And then we'll compare it with other models as well, such as ADMS because ADMS of course is being used at airports in Europe very successfully, so we'll like to see how well that's working.

And then we'll actually do a true validation where we go out to take measurements at airports and then come back to compare that to our results. And then all these things will lead to improvements, and we'll be improving it along the way in the step process, and then at the end we'll continue to adapt the interface as needed to make it user friendly.

The sensitivity testing will be essentially to make sure that we have incorporated everything into EDMS in a proper fashion. To do that, we're going to have to look for discontinuities and problems with the implementation. And, as you know, when you work with models, one of the best things to do is do sensitivity analysis by holding all the variables constant except for one, and then exercising that one variable over an extended range that you might see to look for strange things that could happen in your model. And so we plan on doing that as a first step.

By doing this and then plotting and tabulating the results, we'll be able to find out if we have a continuous model -- if we have continuity, and if we have incorporated the things into the model so that they are at least working properly. This won't tell us anything about accuracy at this point, of course, but it will tell us if we've got things into the model correctly.

And the second step, then, will be to compare models. All of you know how expensive it is to actually do a true validation and take the monitoring data, so we want to try to be ahead of the game before we start spending all that money on monitoring, and we want to make sure that we're positioned that we feel that the model is predicting somewhat in the ballpark and giving us reasonable results.

So to do that, the first thing we'll do is we'll compare the EDMS as it currently exists to the new EDMS with the AERMOD incorporated in it. One of the things about the existing model is there has been some studies done, and there has been data taken at the same time -- measurement data -- so we do know that the model as it exists now is performing adequately. So we'd like to see how big a change we're going to get when we got to AERMOD. Are we going to get orders of magnitude changes? Are things going on here? We'd like to know that just as a first step.

Then we'd like to compare to ADMS and some of the results have been done at airports using that model. We're fortunate there in that we've been able to talk with the people in Europe and so we'll actually have somewhat of a joint effort going on here, They have a lot of data at some of their airports and then we'll also have some U.S. airports. We'll be able to compare ADMS performing quite well there, to our version of EDMS now using AERMOD, and to see if we're getting similar results. We should be getting close results, and that will give us more faith in the model and allow us then to run the similar cases, compare those cases, have faith in the model, before we go to the next step, which is going to be very expensive.

Of course, to compare those models we will do statistical testing, a lot of the statistics that you've heard about today of course will be done and we will look at those in great detail. And then of course our end result that we hope, is that we see an agreement between these models, and gives us confidence in the models.

Then we come to the true test of accuracy, how does it compare to results that you measure? And to do that, we're really going to do it in two different ways. We're going to do measurements of the sources themselves, very close field measurements, because there's a lot of questions about aircraft that we need to answer. And also we want to be along the sides of roadways and so on, we want to make sure it's performing right for the different types of sources that we're trying to model using AERMOD.

After doing that and being somewhat confident with all the sources individually, then we will do large measurement schemes where we will locate sensitive receptors at an airport and circle the airport with measurements, which will include, of course, all the other sources in the area, so background and other considerations will come into play there, and we'll try to see then if we're getting answers that the final user will really need. Of course the final user will need need to compare to the national air quality standards and what he wants to know is am I violating at the terminal or at Joe Smith's house or near the end of the runway -- and so those are the kinds of things that we will want to look at and the measurements we'll want to make.

Then by running the model and comparing to those particular places, we'll be able to tabulate those results, do comparison statistics, then to see the accuracy of how it's working and what's going on with the model. Expected results of this final phase of the overall analysis will then to get a sense for the accuracy of EDMS and what we've really gotten.

As I pointed out in the first slide, this will not be just changes made all at once, but we will be making continual changes along the entire way. So this will be an interactive process. Each of these tests, starting with sensitivity, going to comparison, to models, then to validation, will give us feedback on the model and changes will be made along the way.

This will result in aircraft-specific implementation of the algorithms for example, because we will be dealing with sources that are a little different than the common -- or the more common sources that you might run into. It will also give us a sense on how we want to process these particular algorithms -- other things, for example, how these cells along the runways that we're define, these zones of influence, how long should those be? What should we be using there? What is the dispersion going to be like coming off -- immediately off the runway? All those things will come out of our testing and allow us to adapt it as we go.

And then finally, after we're happy with the research version of the model, then we'll look at the user interface very hard and try to make it as user friendly as possible. One of the things that we deal with at airports, of course, is that a lot of the users have to comply with the standards and they may not be as great modelers as I see out here in this audience, and so we have to make sure of two things, that it's easy to use and also that the abuse is not there. You know, all of us know that there are ways to make models do different things. We want to make sure that the answers coming out are accurate, so that we can get a good analysis of the airport.

And at that point, I'd like to let Julie tell you about our final team effort, and we'll take questions.

MS. DRAPER: I just want to make a couple concluding remarks, and that is in general the FAA wants to say that we support EPA's efforts to standardize air quality modeling procedures for regulatory purposes, and we also strongly support the development and use of new and more accurate dispersion algorithms.

As far as today, we specifically support EPA's AERMOD proposal and we believe that it will be a strong improvement to have AERMOD within EDMS to make it a more accurate, defensible model.

As we stressed earlier, and have stressed throughout this presentation, EDMS research and development is a team effort. The end product of whatever we do and propose today will be a team effort, and not only, I think, within our ranks but also outside of the FAA and our contractors, we want to stress that we are coordinating with EPA, we're coordinating within FAA -- there's various offices and regions and airports that we are coordinating with. We're coordinating with users. We have review groups that we invited in to get individualized feedback so that we can take that into consideration because as we've mentioned, and EPA's mentioned it, that if the user can't use it and use it well and understand how it should be used, it's not of great use to us.

In addition, we're not only coordinating within the United States. Aviation, obviously, is an international business and we regularly coordinate internationally, and we are coordinating with our European counterparts on various research items, including this EDMS development item as Roger Wayson mentioned, we are coordinating with them on comparing one of their models ADMS, to our model.

So I believe we have a very good, strong, approach in all of our research and development items, as well as the one that we're proposing today. And I guess finally, before we take any questions, I just want to thank every one here today for listening to our proposal, and for EPA for inviting us to describe our proposal to you.

DR. TIKVART: Thank you, Julie. I think I'll ask the first question. What is the time frame in which you expect to complete the model development and the validation work?

MS. DRAPER: That's a very good question. I can answer some of it and then I'll let Roger and Ted chime in as well. We are on a fairly fast track, I believe. As most of you -- or as EPA has mentioned in the past, we haven't always had sufficient funding. We have sufficient funding all of a sudden, so we're rushing to use it very quickly --

DR. TIKVART: Before somebody takes it away, right?

MS. DRAPER: That's exactly it. And so we are rushing forward very quickly out of the blue to get this in and get it in quickly. But, obviously, we're doing as slowly as necessary to make it accurate and to do the proper coordination, US-internationally. We're looking at getting the dispersion algorithms into EDMS for internal testing by the end of this fiscal year. Shortly after that, what we will be doing is shine beta versions with individuals to get other perspectives on how well it's performing. After that we hope to incorporate any comments, make any necessary revisions and provide a release. That's on the initial model development.

We are also working on the validation effort. There are various components to that as Roger mentioned. The ones that we're looking at, how EDMS-PAL2-CALINE performs that EDMS-AERMOD we performed this fiscal year as well. The other thing we'll be doing near term is comparing how EDMS performs to EDMS and other established models, and that will also take place in the near term. As you can tell, these guys are going to be very busy in the near term.

We are also looking longer term at, as Roger mentioned, we are gathering existing monitoring data so that we can take data that's already out there and see how EDMS is performing. As we go along and look at how all that is going along, we're also developing a validation program where we actually go out there and take measurements ourselves. And so all of this will be happening, I guess, over the next six months to a year. But we also want to emphasize that this -- we believe that EDMS development and validation is an ongoing process, so we will be continuing to perform model validation efforts or components in future years, rather than just this year.

And just because I'm afraid I might have gotten something wrong, let me see if -- Roger, do you have anything to add to that?

DR. WAYSON: No, I think you summed it up pretty well, except the measurements themselves are about a year project, just in themselves, so you have to add about a year on for the measurement part of that.

DR. TIKVART: Okay, thanks. Questions for Julie and team?

MR. NOLTER: John Nolter (ph), National Park Service. I'm probably one of the few people in here that has actually reviewed an application of EDMS down in Homestead. I was wondering, is this model going to be publicly available? Right now, it's the only model that I know of that's not publicly available. Are you going to make it available on either the FAA website or the EPA website?

MS. DRAPER: That's a very good question. I guess it's available, it's just that there is a cost to it, just like with the other FAA models and Federal Highways models, for example. The reason is because it is such a unique application, a small community, we find there's a lot of tech support that's needed, so there is a -- we have contracted, as in other models, with private firms that distribute it and provide tech support. And what happens is the cost of the model is -- pays for that free tech support which people do use in order to do the accurate analyses that they need to do.

We are looking to the future, and working with EPA, and we work with multiple offices in EPA -- there's EPA Research Triangle Park dispersion algorithms. There's another office in Research Triangle Park for general conformity, and very importantly, there's an office -- the old office of Mobile Sources, which is now Transportation Air Quality, something like that, in Ann Arbor -- OTAQ, thank you -- and they are the ones that have the regulatory authority over us for how we do our emissions calculations and the data we use. So we are coordinated in multiple fronts in the EPA.

When we talked to the EPA in Ann Arbor, we've agreed that we need to have one model that they are referring SIP developers for, and that FAA is referring our modelers to, and in doing so -- I'm sorry to get there the long way -- in doing so, EPA requested that we look at finding a way of making it more affordable to people. So what we are in the process of agreeing -- finding agreement on is that we will make it available with two different charges -- one being just distribution costs, to get the manual out, to get the software out, et cetera. And to keep -- we do keep a user data base because we do communicate with our users. And that will be the first small cost which EPA Ann Arbor has agreed to a cost, say, of less than $50. That is a reasonable cost for someone to incur. The rest of -- another option will then be for the person to pay an additional cost for tech support because we do find that there is tech support need there.

MR. NOLTER: And how much will that be?

MS. DRAPER: We haven't finalized that yet. Right now it's a total cost of $200 and we haven't -- come to a complete agreement yet as to whether or not there will be a total cost for a blanket tech support, or whether you'll be paying on a per call basis, and we just haven't gotten there yet, to be honest.

MR. NOLTER: On the evaluation, are you going to be comparing the present version 3.2 against the monitor data and 4.0 against monitor data?

DR. WAYSON: Yes, because we want to know where we came from and where we're going, so we will be exercising both.

PARTICIPANT: We do a lot of airport air quality analyses, and mostly -- actually this is associated with the parking garage expansion, so I hope FAA is not proposing to do away with the CAL...CQ, CALINE3 option just to analyze the area impact from the parking garage or parking, or the traffic lane expansion project.

MS. DRAPER: I guess there's a couple parts to that answer, and that is we are going to be doing all our dispersion algorithms with AERMOD. But it's very important before you shake your head at me, it's very important to realize what our -- if you are familiar with doing airport analyses, hopefully you're familiar with our policy, and that is very specific, and our policy, which I didn't go into detail at first, is that we require EDMS be used for aviation sources, which are aircraft, APUs and GSEs. We do not require it be used for parking garages, roadways, et cetera, because we acknowledge that those are not aviation-specific sources, and to be honest, we have enough to handle. Just doing aircraft, APUs and GSE is a big effort. And we have two sets of users -- you, who want to use various models, the ideal model for this source, the ideal model for this source and bring them all together at the end. We also have users who want one stop shopping. So what we do is try and allow them the capability within EDMS to do anything they would want, within certain bounds, because we only have so much time and money to work on things, and then allow people in our policy to use an alternative model.

So, if you would like to use CALINE or anything else, you're free to use that.

MR. CARRUTHERS: David Carruthers from Cambridge in the UK. Somewhat related question and another question. I wonder what confidence you have that AERMOD will actually improve the predictions for this particular modeling application, given that most of these sources are ground level sources? And secondly, I may have missed it, but I wasn't quite sure which pollutants are being modeled and -- certainly in Europe we're worried about nitrous oxide, ozone, and particulates and their chemistry, and dealing with chemical reactions is very important.

MS. DRAPER: Thanks for that question, David. I am going to be a smart person and hand it over to Roger Wayson to handle.

DR. WAYSON: Well, David, we're optimistic. We're hoping for the best. But to be honest, this is kind of a new area for AERMOD and the question was asked earlier this morning, has it been validated for volume sources and the answer was yes, we do have data. But the thing is we're going to be using it in a different way. This morning you may have notice too, that one of the caveats was a 50 meter distance and so on. We're going to be closer than that. We're going to be using it for things like roadways with their own mechanical turbulence regime. So we're going to have a -- we're going to go in it with a very open mind, and that's why we're going to have that feedback loop to look at each source as we're going along the way. And at this point we can't say that it's -- you know, exactly what's going to happen, but we're hoping for the best.

MS. DRAPER: Roger, you had described for me that David's model, ADMS, is similar and has been compared to AERMOD and that is performing well. Would you address -- I mean, to some degree I wonder if, David, that answers your own question.

DR. WAYSON: Yes, I think -- of course, David's very aware that ADMS is used at the airports in UK, and then also across the channel at a couple of airports, and they -- in Europe, they have a tendency to take much more monitoring data at airports than we do in the states, and so they've been able to look at several airports -- Manchester, two of the airports in London, Birmingham, Shu... so they have data to back up that the results are working well with ADMS.

So one of the things we've been doing is looking at the reports comparing ADMS and AERMOD, and we've been very pleased to see the similar results and the good agreement that those models have had. So we're hoping the same thing comes out of AERMOD.

MS. DRAPER: So I guess -- are you confident that ADMS is working well, David?

MR. CARRUTHERS: That's a very complex question. And there are all sorts of -- despite a straight comparison between the specific features of AERMOD and ADMS, and I can talk a bit about that in my own presentation.

MS. DRAPER: Okay.

MR. CARRUTHERS: There are some other things I just mentioned, for instance, chemistry, which makes the whole thing -- it makes it very difficult to make a simple answer, an easy answer to that.

DR. WAYSON: There are two other things going on with -- you also mentioned particulates in chemistry, for particulates you have to have good emission data to start with, and so that's another thrust that we're not talking about today that will get done to get good emission data for aircraft, and that will in itself, be a huge improvement. And then the chemistry is very strange, because if we don't have the monitoring data for the chemical components at an airport and the mix that's going on, you know it yourself, we're making guesses on the chemistry in the mix and so putting huge amounts of faith in that, I think, can lead you down the wrong path. Zurich Airport, I think, put it in perspective when they said, well, yes, we run the chemistry modules but what we do is we take our monitoring data then to calibrate those results. So I think, you know, you have to be careful about that, because I think we have a long way to go in chemistry.

MS. DRAPER: We do have a long way to go and I want to mention something I forgot to mention -- on the bottom of the slide is our internet site and actually I'm going to revise that because I didn't see that this morning. Just go to www.aee.faa.gov -- forget the rest of it. There there's going to be an EDMS click button, and on there will be not only our presentation but it will also include a plan that we have for this year for our research and development. The FAA has a lot going on and we're trying to be very communicative with our community, and so various things that Roger's talking about, as well as a lot of others, are on that list of things that we are doing to try to improve what we know about aviation air quality.

MR. TROM: Vinca Trom from AERMIC. We are very happy that you are working with AERMOD. I think you might want to consider working with the AERMIC committee in making future plans.

DR. TIKVART: Okay, one more question and then we'll take a break.

MR. STRACONGAS: Arnie Stracongas (ph) with URS. I think this follows up on what the lady back here a couple rows back just mentioned. You talked about opting out of CALINE3 because you didn't see the thing needed for parking garages. Actually, a queuing theory and other things in the aircraft, the CALINE and the queuing theory is very important, but it's something the AERMOD does not have, and I was wondering if you guys are going to drop the queuing theory or similarly, keep it when the dispersion changes and that's the plan? And also, I guess a general remark as far as mobile sources go, there are other mobile source models out there that we haven't talked about, and obviously what we're talking about in the meeting today, we've talked about things related to stationary sources and how to better model those, and I think the committee has yet to provide any substantive changes to mobile sources, which is what you guys are, I guess, pursuing. Although we certainly recognize that if we had more data sets we'd do a better job of dispersion. So I guess my original comment was about CALINE, the queuing theory and roadway emissions and roadway dispersion.

DR. WAYSON: Actually, we had a big discussion about that -- actually in the beginning, I was leaning towards puff models, but I was convinced AERMOD was the way to go. And one of the things that was decided is that we want to go to a single model, but we will take the queuing theory out of those mobile source models and install them into EDMS, and so the emission densities will be determined using those same queuing theory.

DR. TIKVART: Okay, I don't see any other hands, we have a -- just quickly.

MR. SCHEWE: George Schewe with Cincinnati State Technical College. First of all I had a thought -- she's got some money, and you guys have got to fix AERMOD -- you need to get together. The second part, Roger ... EDMS just a couple of times and I know the pick list of aircraft engines is very, very, very long and your run times can get very, very, very long. If I had 60 or 70 taxiways and runways and parking lots, et cetera, the ... is just phenomenal. So I'm going to now take those line segments and chop those into 30 or 40 volume sources to represent each line segment -- those run times are just going to be incredible, and I don't know if you had addressed that or not.

DR. WAYSON: No, I think I have the same answer as the gentleman earlier. You get a one gigahertz PC -- and so those will be five times faster that what they've been running on, so if it takes five times longer, it'll take about the same time.

MS. DRAPER: By the way, I don't have any money any more. We gave it back.

DR. TIKVART: Okay, thank you very much, Julie and team. We have a break scheduled. Although I realize it might take you 15 minutes to get out of here and then you have to be back. Some of you may want to take a stretch break, so 15 minutes, come back please.

(Whereupon, a 15 minute recess off the record was taken.)

DR. TIKVART: Okay, I'm sure there are people outside, but they're just going to have to struggle in, come in when they can. We're going to proceed then with the last phase of today, where we're going to have presentations on five models which are considered to be alternative models for use on a case-by-case basis. Historically, these models would have been placed in Appendix B of the modeling guideline, but currently we're proposing to remove Appendix B from the guideline and make it simply available on the SCRAM internet website so that models can be added and subtracted at will and we don't have to go through a formal regulatory process to add those models. That's part of the proposal for Appendix W.

But five models have been brought to our attention and we're going to have a brief presentation on each one of those this afternoon. Talking to the presenters, it's going to be roughly 20 minutes each, that will include time for questions. So if you take five times 20, that's 120 minutes, which means it will probably be close to 5:30 as the agenda suggested, before we get out of here. I would also ask that each of the presenters give me and the Court Reporter a hard copy of their presentation if at all possible.

The five models are ADMS, CAMx, SCIPUFF, HYROAD and UAM-V. So first we'll go with ADMS and David Carruthers. David, if you would start off with your name and affiliation.

MR. CARRUTHERS: Thank you very much. I'm David Carruthers from Cambridge Environmental Research in South Hampton, that's CRC from

Cambridge in the UK. I'm very pleased to have the opportunity to present ADMS, or the Atmospheric Dispersion Modeling System here today. I certainly hope that I can add a little bit to the debate. I've got very limited time, so it'll be a rather lightning visit to ADMS. And if I go too fast through some bits, there are some copies of my presentation at the front. But if I find I'm running out of time, I may just skip to what I consider to be the most important points.

I'm going to start with some background, very briefly describe the main features, talk a little bit about flat terrain result validation, something about building and complex terrain modules, and then really a summary at the end.

So the -- really that slide says as much as I want to here. Development was started and commissioned in 1988 and it followed a report that we presented to the various regulatory authorities in the UK, and we've had much of this from Jeff Weil this morning -- the report highlighted advantages of the generally of the new way of doing meteorology, and the recommendations were consistent with the AMS/EPA meeting in Florida in 1984 -- and I should say that meeting was not just by Americans but by a number of Europeans as well, so it was an international meeting.

And sponsors you can see here, a number of major sponsors in the UK -- I don't think I need to go through those. Development by ourselves and the University of Surrey -- Professor Robbins was at the central electricity generating board when we started, UK Mets Office. Two of the names you will see there are Julian Hunt and Rex Britter, who were both at the AMS meeting and have been quite regular visitors in the past to the USCPA.

I think it's fair to say that ADMS is the leading European short range air dispersion model in Europe, anyway, and just a bit of sort of adding to its credibility, the model's been featured in a number of European workshops and these were -- which have taken place over the last ten years or so, and these were held to discuss the protocols for short range dispersion modeling. So the idea wasn't to be prescriptive about models, but to decide on various scientific approaches, which is a little bit unlike the situation here.

So the key components of the model: PC-based with user friendly -- usual sort of thing; continuous or discrete releases; a whole range of different sources; skewed-Gaussian; meteorological preprocessor; integral plume rise model, rather like the model that was described for ISC-PRIME this morning, same sort of basis. Very important building effects; complex terrain -- and there, they can be used in combination, so the complex terrain air flow field can feed through to air flow effects; wet and dry depositions; simple chemical transformation -- and the list goes on -- radioactive decay; jets; fluctuation module, which enables you to calculate probabilities if certain concentration peaks are exceeded; a simple coastline b... model; and finally, a condensed plume visibility module.

Okay, on the regulatory applications, which really have been used for the UK and across parts of Europe. Multiple buoyant or passive industrial emissions; surface, near surface or elevated releases -- really all these sorts of things -- urban or rural areas; and very short periods to long term averaging times. I should say that we quite frequently have to deal with ten minute and 15 minute air quality standards.

Now, this transparency here -- it's merely to say a little bit about flat terrain validation. I will cover this very rapidly. We've done a great deal of validation with the data which is available, some of it ran through these European workshops, and I think it's fair to say that the general conclusion is that the model significantly outperforms ISC -- I meant that's generally accepted.

More recently we've done a lot of comparisons with AERMOD. This is not work that we did, but it's work done by Hanna et al for the American Petroleum Industry. I think it may be mentioned later, and really should be looking at the second table as the most up to date table, and that basically shows that -- and I think this will all come across later -- that the ADMS and AERMOD, both over flat terrain give similar sorts of statistical performance, and generally much better than ISC. That's -- I could say much, much more about this, but I haven't got time here today.

But I just wanted to show you this slide as well because although they are, I say fairly ... in terms of their statistics, that doesn't of course, preclude the fact that in different circumstances they can give very different predictions of concentrations. This is purely an example of a power station. There's no validation here. I'm not saying which model is better. But they are -- just wanted to make the point -- even though statistically they may be rather similar on flat terrain, they can give very different predictions.

Okay, so I wanted to talk about buildings and really my job has been done this morning because the ISC-PRIME which was presented, has many similar features to ADMS, and I think we feel quite flattered, really, that really all the features of ADMS, bar few, have been adopted in the ISC-PRIME model. So I really need to say very little more about this slide, which you can't actually read all that well anyway.

But there's one major difference with ISC-PRIME and that is that the use in the main wake -- it's in this region here, downstream of the cavity region -- the flow field is calculated by a wake model rather than from data -- from wind tunnel data. There's quite a big difference there. Again a great deal -- well, validation's more limited for buildings because there's much less data available, but we've done quite a lot of comparisons with both wind tunnel and field data, and quite interestingly, we've come across quite a little different data from that's which being used by ISC-PRIME.

This is just an example from a warehouse fire -- various different highlights in the roof were used as sources. The number varied, and we used different -- I'm sorry, data was collected from a wind tunnel, and some comparisons were done. The blue points represent very buoyant plumes which hit the top of the wind tunnel, so apart from that, the comparisons, in this case, sort of generally were within a factor of two-ish.

Okay, now, what I really wanted to talk about was a bit about the complex terrain, which is where I think we do have something to say. The ADMS has a quite sophisticated complex terrain model which is both on a calculated flow field, which I can't describe in detail here, but that model's been quite well validated against wind field data, and the flow field itself feeds into the model, and then the dispersion of the plume is calculated. And this -- this just illustrates the points here.

Now, rather than do validation because it's a limited amount of data available for complex terrain, we ... interested to look at these sort of physics of ADMS and AERMOD, and it's really quite interesting from our point of view, anyway.

If you first of all look at terrain amplification factors for 50 meter stack, no plume rise over an idealized hill, and the top part of the graph is concentrations, the bottom part, distance to the maximum concentration. Now, very quickly, if you've got a plume hitting a hill -- or air hitting the hill, you get streamlike convergence tends to increase the concentration where you think it would. Over the hill, you'd expect the plume to be -- go away from the hill, so you'd expect it to decrease in concentration. In the wake, just because of the turbulence and the streamline coming down, you'd expect an increase in concentration.

And that's exactly what ADMS shows, but AERMOD gives a very, very different pattern which is difficult to explain from a physical perspective.

And you can do the same thing looking at vertical crossections. The first set is from Lawson, Snyder and Thompson, US/UK windtunnel data, and that shows these elevated factors above, in front, and behind the hill, and ADMS gives the same sort of pattern, tends to somewhat underestimate it certainly, but the pattern is similar. It's doing the right sort of things.

And I don't think you can say the same about the next slide, which is quite peculiar. It really is, from my perspective, quite unphysical. And again -- sorry, I should have said, the last slide was for neutral flow. For a very stable flow you might get plume impaction for upstream sources, so you might expect the greatest amplification for upstream sources, which is what ADMS gives, but the other pattern is again, a little obscure.

But let's show a real case, and this is from an example from northwest England. It's a cement works, stacks are 100 meters high, buoyant plumes, and the hills that are about 300 meters above the base of the stacks, and now. We go to maximum concentration -- long term averages, and what ADMS is showing is that the maximum color quite close to the stack in convective conditions, and a long term average shows some channeling of the wind down the valley. AERMOD again shows a very different picture, but what it does imply is that plume impaction is a dominant mechanism for getting high -- sorry -- this is the main big tail here, so impaction here -- these are the high numbers -- and this over here, that is again plume impaction -- implying that that's what's causing the highest concentrations.

If you should go through a case-by-case, hour by hour of the meteorology, you find the current ... impaction is really very, very small, which in that case makes it very difficult to understand why you get this sort of pattern for the long term average.

Okay, next slide, coming to the end. This is just really some come backs to airports and sort of different sort of use of the model. We have within -- we have a different version of the model which is really used for urban quality, and that has mobile sources in it and street canyons and the more sophisticated chemistry model, and that's being used in a number of cities in Europe and across the world. But that's an example of an output actually -- annual mean NO_2 concentrations from London, so it's quite a lot of detail. Well, that was just to tell you that we do do other things with the model.

Now, in summary, I think what I say here is correct. ADMS includes in one model all the features of AERMOD, except you can't put observed boundary layer profiles in easily, ISC-PRIME, CTDM-Plus, and it obviously avoids potential difficulties of all of these -- same as though you've got complex terrain buildings, what do you do? And it's got other features -- concentration fluctuations, plume chemistry and condensed plume visibility.

And I just mentioned URBAN which as a lot of feature of CALINE, EDMS and other features. As far as costs are concerned, for ADMS, the industrial version, similar to commercially available versions of AERMOD and ISC. It's not free. ADMS was first released in 1993 and has been used in many critical applications since. And that's my name and my website. So I do hope that that will certainly mean ADMS features at least to some extent, in the date about what happens. Thank you very much.

DR. TIKVART: David, thank you for being so precise and concise. Questions for David? John.

MR. IRWIN: It's John Irwin, EPA. An obvious question for the USA community is can you explain to them how easy or hard it is for them to use the USA meteorology data they have in their model for application in the United States?

MR. CARRUTHERS: I think the answer is it's very straight forward. In fact, we do have a version which will work with typical U.S. meteorology. Certainly it's straight forward.

DR. TIKVART: Other questions?

PARTICIPANT: I was interested in your output requirements, take for instance PM-10. In this country we calculate somewhere between the fourth or seventh high, based on a standard of a 150 micrograms per cubic meter. My understanding of the UE standard is based on a 50 microgram per cubic meter standard, 24 hour basis, but you look at the 36th high. How does you model handle that? Is it just like ours or --

MR. CARRUTHERS: I think we do it -- I think there's no difference. You calculate the concentration hour by hour, or three hour by three hour and calculate the statistics, and certainly some of the UK standards as opposed to the UE standards have been for much higher percentiles, indeed the maximum has been used -- the maximum hourly average I should say.

PARTICIPANT: My understanding is that the UK now has to meet the UE standards which are in many cases, more lax.

MR. CARRUTHERS: Yes, but it also has its own standards which demand these other sorts of percentiles.

MR. TROM: Vinca Trom from AERMIC. You use words like peculiar, strange, inexplicable describing AERMOD's performance. There's a very easy way of finding out whether ADMS compares. You compare it with observations. Have you done that?

MR. CARRUTHERS: Sorry?

MR. TROM: Have you compared ADMS' performance against observations of concentrations in complex terrain?

MR. CARRUTHERS: Yes, we have done some, but --

MR. TROM: And how did the -- why didn't you show that?

MR. CARRUTHERS: Because I haven't done it myself and there's very limited data. But I understand the premise of your question. I think looking at the physics of the models is very important, how they respond to different situations. And that wind tunnel data, you know, it's data that cannot be ignored, for instance.

MR. TROM: You mean to say that reality does not follow physics?

MR. CARRUTHERS: Well I -- I beg your pardon?

MR. TROM: I mean are you implying that reality observations don't follow physical processes?

MR. CARRUTHERS: No, no. There are certain patterns of behavior, which I was trying to explain, and which you'd expect the model to conform to in terms of, for instance, as you move the stack over a hill in different conditions. You would expect to see the maximum concentration change in a certain way, and the wind tunnel shows it changing in a certain way. The results are not too precise, but what I'm trying -- I was looking at -- this is the background. I mean I can say more. The reason that AERMOD gives a rather, I would say, peculiar sensitivity in these situations is that -- is that you're combining concentrations for a plume going around the hill, with a plume going over the hill. So you're combining concentrations. Whereas in fact, it's much better to be more fundamental and calculate the flow field, and then calculate the concentrations from that flow field. And I thin you always have a problem if you try mix/match concentrations. I mean we tried to do the same ourselves. It's very difficult.

DR. TIKVART: Okay, we have one more question in back -- okay, two questions, and then we'll wind up and move on.

MR. HARVEY: Brian Harvey from T-3. It seems to me that one of the big differences between AERMOD and ISC and ADMS is that the AERMOD and ISC are kept from being black boxes by allowing people access to the source code. Do you have plans to put your source code into the public domain so that it --

MR. CARRUTHERS: I think the answer is we don't at the moment -- we don't plan to put it in the public domain, but we would put it in a position where it could be examined, certainly.

DR. TIKVART: Okay, one more.

PARTICIPANT: I just was interested in the cavity picture that you had -- you said that your -- the ADMS model used a numerical model. Do you have uniform flow in the cavity? Or are you able to --

MR. CARRUTHERS: Some --

PARTICIPANT: -- to discriminate? You said that it was a very different cavity area.

MR. CARRUTHERS: It was the main wake which is different, so the region downstream of the cavity -- ADMS uses a wake model, whereas ISC-PRIME calculates the displacement of the streamlines based on wind tunnel data. So there's a difference there.

PARTICIPANT: But what about in the cavity?

MR. CARRUTHERS: In the cavity it's very similar.

PARTICIPANT: You're assuming uniform concentrations within the cavity?

MR. CARRUTHERS: Yes.

DR. TIKVART: Okay, David, thank you very much for the nice presentation. Let's go with Ralph Morris and CAMx.

MR. MORRIS: We are staggering presentations here so that we don't have two computers going twice in a row. I'm going to talk about the CAMx model, which is a little different beast than what we've been talking about plume models and ozone and PM model. My name is Ralph Morris. I do want to acknowledge the other authors of CAMx, and we all work at Environ, a ... Corporation. That's Greg Yarwood, Chris Emory, and Jerry Wilson.

Before I start, I'll give you a little history of how CAMx came about, and for mine, I've been in model development for about 20 years, starting with developing models like reactive plume model and regional transport model in the early 80's. I was involved in the ...4 model and the UM-2 in the late 80's and then ...UM-4, and then also in the late 80's, early 90's we added nested grids to the regional transport model, and formed UMB.

In 1994 I joined Environ and there we had a chance to develop a grid model from scratch, and that -- it was nice in that we didn't derive from these legacy codes, but we had to code all new codes, and in fact, one of my programmers sat me down and said, you're not going to code any of this. There's been advances in computers in the last 20 years and we want no computer to go two loops, none of this stuff in the code. You give us the specs and design this model and we hired a contract programmer to actually do the programming. So that's sort of the history of where we started developing CAMx -- all new codes since 1994.

It's a little different model. It's 3-D Eulerian or grid model, and it treats the emission chemistry, dispersion, aerosols, and it's applicable to ranges of less than one kilometer, if you make the grid small enough, and you use the sub-grid scale ... grid, up to greater than 1000 kilometers. We use sort of the state of the science algorithms. As I said, it's all new coding. It's a modular framework.

I guess two weeks ago, some of us were at the Models-3 workshop and this modularity and community modeling system concept is kind of taking off. We did make it publicly available around 1996, and the website's down the bottom -- www.camx.com -- it's free, you just download it and use it.

I'm going to go over the technical features of the short version, which is version 2.0. Actually we have a version 2.03 is up on the website. The technical features are that we do have a two-way grid nesting -- that's horizontal and vertical. Right now we don't recommend using the vertical grid nesting for reasons I'll go into a little bit later, although it's available. It supports multiple levels of nesting -- 36, 12, 4, 2, 1 -- as many you want, multiple grids within each grid. We have subscale pluming grid module, and we also have a couple chemistry solvers in there, including a fast solver (ph) and also a more ... solver.

This is an example of a grid nesting for a domain that has a -- shows how to use the boundary buffer cells to support the two-way grid nesting. And unlike one-way nesting, when stuff goes around, you have stuff go out of the fine grid and circle around and say it -- the high pressure and come back into the fine grid. So one way nesting, once this stuff leaves the fine grid, it can no longer come back into the course grid.

CAMx currently supports several map projections -- latitude/longitude like you use in OTAG. There's UTM; there's the Lambert conformal (ph), which is used by MM5; and there's a rotated pol... air graphic that is used by RAMS MET model. We have an ozone source apportionment technology, which I'll talk about a little bit later, in which you can track the sources of ozone and allocate it at the receptor.

We also -- when we started developing CAMx, OTAG was the game in town, so we made it compatible with the OTAG data bases, now it's CAMx are in 1.0. In doing that we had to be consistent with the OTAG modeling approach. In CAMx 2.0 we kind of deviated from that, not so much the inputs but in some of the algorithms.

These are probably more detail than I need to get into here, but we do solve the continuity equations using time splitting. The Europeans tend to not like time splitting as much and have technical arguments that are valid, but we find that in order to get a computationally efficient model, it makes sense. And also it allows us to time step allocations -- taking a maximum time step possible within each one of our nested grids or, in the case of the chemistry, it'll cut the time step down to make sure you have your convergence. So you may go in there with a ten minute time step, when you go to your fine grid, you may be taking two minute time steps, but you know when you go into chemistry, you'll have to take a ten second time step in order to satisfy your convergence criteria.

The model as developed is designed to run on the same grid that you run the MET model, so if you run M5 on a Lambert conformal projection, it's -- ideally you should run CAMx on that same grid, although you can interpolate the data and run it on a say, a lot-long (ph) grid. You do introduce some mass inconsistencies in the wind field when you do that.

Our transport -- the invection solvers (ph) are -- we incorporate three of them to mass conservative. We link horizontal and vertical invection in a mass consistent fashion, and solve those together or sequentially. We have three -- three different horizontal invection solvers at this time -- this ... which was used in historical urban ... model in UMD. We have a BOS (ph) scheme which is used in a -- I believe the MaxSIP and I think it's also in Models-3 at this time, and then there's the piece-west-... method which is in Model-3 and which is actually my favorite. It has accuracy and is quite computation efficient.

This Burgal's (ph) ... scheme so that allows you to step through the time -- all one time and dry deposition is solved in the vertical transport.

For dry deposition we use the Wesely approach which is also used in Models-3 as well as UMB and some of the other models. It depends on the seasonal dependence and for aerosols we have an aerol ... spectrum approach.

Wet scavenging we just took it simple, we stole a simple scavenging coefficient approach from CALPUFF -- thanks Joe -- and it's a pretty simple scheme. We are currently implementing aqueous phase chemistry module that will have a more detailed scheme I'll talk about at the end.

Okay, and the photochemistry, we currently support two chemical mechanisms and two chemistry solvers, although you can't run both chemical mechanisms with both chemistry solvers. We have the -- we have the -- well, the

...4 mechanism in three different modes, one of them being the OTAG isoprene update mode, which is probably the most common. And then we've also put in the SAPRC97 mechanism which is more chemically up to date, has more species, takes about three times longer to run -- or two and a half to three times -- but it has a lot more species, a lot more detail and running aerosols, for example, it has some information that you need for aerosol modeling that's not in CD4.

And we have nitrogen concentration, and then we have, for the ...olysis rates, where we use NCAR's TUV preprocessors developed by Sachem Madronovich (ph), and he always keeps it updated with the latest spectral data and stuff, so that's publicly available at the NCAR website.

And then the cloud effects, there's the UMV approach, which has a single opaque cloud cover, and then there's a gravity approach where you integrate the effects of ...lysis rates through the clouds.

I'll talk a little bit about chemistry solvers. It's the most expensive component of photochemical modeling, takes the most time, and we developed a fast solver, which we call the chemical and mechanism compiler -- CAMx fast solver, which is an adaptive ... approach where radicals are solved in a steady state and then fast state species like ozone, L2 and NO are solved using a ... and then state species are solved by slower -- I mean a very computation efficient explicit -- so this is sort of an adaptive hybrid approach. It's a pretty efficient -- we've tested it over a wide range of conditions.

Also, I didn't mention that we have implemented the model which is on this slide, is a implicit/explicit hybrid approach which is a - matches the sort of the gold standard of the ... gear gold standard quite well.

For plume and grid model, we use plume and grid for near source, plume dynamics and plume chemistries. It's not designed to carry it out far downwind. The plume resolves the near source inorganic chemistry and then when the plume gets the size of the grid square, it releases that NO_x -- usually it's NO_x emissions -- into the grid. So you can't look at a plume model as a plume model, but it's a near-source plume dynamic and chemistry processor model.

In this schematic here -- figure how this works -- you can see that as the plume expands, I guess to the certain size of the grid square, and then the next expansion, which is kind of the translucent portion, is released to the grid model. So the plume never gets large enough so that it's expanding too many layers, and we're solving the near source plume chemistry and plume dynamics, and taking into account mainly the conversion of NO to NO_2 and then to more p...ly inert compounds like nitric acid, N_2O_5. So that's not a far downwind plume model, it's a near source plume model.

The ozone source apportionment is a technique inside the model that tracks precursors in parallel to the model, and then when ozone's formed, allocates that ozone to these precursor tracers so we know where the ... and NO_x came from that came from that ozone. It's really a big bookkeeping -- a bookkeeping approach for where did the precursors come that got formed from the ozone, and where that ozone that's formed goes downwind.

I have a couple of examples here. I do have a caveat on the bottom, which is you cannot quantify ozone except in response to NO_x or if you've got seed (ph) controls. For this given simulation, we can get an estimate of where the sources VOC and NO_x just came that contribute that ozone, but you can't say that if I do these controls that's going to reduce this ozone. Because as soon as you do the controls, you change the chemistry in the model and you change the source apportionment. So it's more of a -- kind of gives you a roadmap on which sources that it controls to give you the biggest ozone reduction. You can't say that if I control this NO_x ten percent, I'm going to see a ten percent reduction in its contribution to the ozone, because it's a non-linear response when you change the chemistry.

I have a couple examples here. This is an ozone source ... Lake Michigan area for one hour ozone exceedences and it breaks down contributions by different source types, or on the bottom, it's biogenics in the purple points is yellow, blue is motor vehicles, red is area. And the two bars side by side, for each one of the source regions, on the far left you have Lake Michigan's impacts on itself in terms of one hour ozone, and then the two bars together, one is a 2007 base case, the other is a 2007 sipcall (ph) strategy, which I guess we can talk about again.

You see that when you do the sipcall you see the bar -- the color bar as it goes down is the point sources because that's what the point sources targets, but one of the things you notice here is the contributions of Lake Michigan area on itself is around 70 parts per billion, while the next most important state or area is downstate Illinois which is around 20.

And you look at the next slide which is eight hour ozone, you see a contribution of Lake Michigan area on itself is around 40 -- this is now for eight hour ozone exceedences, so now you've gone from 70 to 40 for local contributions on a cell. And then on downstate Illinois, it's still around 20 parts per billion. So in other words, what we're seeing is that one hour ozone strategy in which you focus on local sources may not help you on an eight hour ozone, which is more regional in character.

This is just one of the uses of the source apportionment which --

there are many other uses which we've done, and we've used another ... called technoanalysis.

This one gets more complicated, which is a -- this is looking at the contributions to one hour ozone exceedences across a bunch of different source areas by source category, going from -- the blue is industrial, yellow is point, red is mobile, the gray is area, and then you've got the ... green the forest, an initial boundary ...

But you can see how different areas have different contributions, different source types. On the far left, you have the land where it's mainly -- there's some point, but there's a lot more mobile and area. You can go to some of the other areas, like say Cincinnati, there's a much bigger point source contribution. So this kind of helps you figure out which source categories in your area contribute the most. These are just a couple of examples of how it can be used for ozone planning.

Moving on -- the current version of CAMx now that's up on the website, treatment of particulate matter is we treat primary PM, and we have secondary organic aerosols where we use the aerosol yield approach, the OH attacks, the toluene then gives you a certain aerosol yield based on Seinfeld's yields. And then there's a sulfate-nitrogen-ammonium equilibrium empirical module in there that we -- that's taken from the UMLC approach, and then we also have an empirical aqueous sulfate chemistry.

And now the blockbuster coming this summer -- not from Disney, but from Environ -- is a CAMx version 3.0 and in this version we're updating several things, including this flexi-nesting which you can pop nests in and out -- and this is very useful because we've been running these high resolution four conical (ph) grids for a week, when we're only interested in the first four days initialization. Well now, you can just run that with the first grid and then pop in the fine grid, or if you have an area where you have exceedences in some areas, like in Texas, we have exceedences in Dallas and some days in Houston, running for two weeks, we can pop the grids in and out for when we need the fine grids. And so you can either provide the inputs or the model will interpolate in real time so you don't have to prepare as many inputs.

We also have a joint study with General Motors, with Alan Dunker where we are putting in a decoupled direct method, which is sort of like a ... support -- it gives you more information about your model simulation. In this case it does it through sensitivity coefficients that are run through the model and puts the relationship of CAMx estimated ozone, or in this case, any other species of the source apportionments going into ozone -- so it could be nitric acid or some other species. Do the sources and precursors, and that's -- right now we're implemented ... emissions ... initial conditions. And this is very useful for control strategy development, model performance evaluation and diagnostic analysis.

Also right now we are -- we have funding put in the -- that's a key word I notice today -- we have funding, so it's not that we have plans, we have funding and we are doing -- to put in an advanced particulate matter treatment, and this is a study that we're doing with Carnegie-Mellon University -- Spiros Pandas (ph) there as well as Fred Lehrman at Sn... Technology -- and we're putting in sort of the state of science aerosol modules into CAMx, although it's going slower than I thought because academic universities tend to move at different time scales, and there's vacations, and summers and grad students turn over.

We are -- going into each one of these components here -- we're trying to have the most state of science modules as well as intermediate good -- the best science modules that actually run in our lifetimes, and then we have tried to put in empirical modules in there too, all in the same modeling framework. And I'll go into each one of these components.

DR. TIKVART: You've got about three minutes.

MR. MORRIS: Okay. Gas phase chemistry, I talked about that, SAPRC and CARMA4 (ph) -- we'll use the sectional approach -- Model3 is the model approach, ... both ways. In the mass transfer we have an equilibrium approach which is cost effective, a hybrid approach, and then a dynamic approach.

The aerosol thermodynamics, the LCR approach is prioritized -- it's currently in the model, and then we're adding SCAPE2, which is a full science, and then ISORRPIA which is much faster than SCAPE2 and agrees 98 percent of the time with SCAPE2. The other two percent of the time, though, we're trying to figure out when we need to put in SCAPE2.

For aqueous phase chemistry, we have a bulk module and size resolved, different size section give -- chemistry goes at different speeds because of buffering. And on secondary organic aerosols, we have the aerosol ... approach in it as well as this more advanced one coming out of CMU. And there's coagulation, nucleation, dry deposition, wet deposition -- running out of time.

I want to talk about postprocessing tools for a second because that's the ultimate user. One is a tool we make available from CAMx direct that extracts grids -- a Fortran code. We use a code called SURFER, which is a PC-based. There's MAPS, which is the old ... alpine geophysics that does evaluation software. This PAVE by MCSC -- those in the old ... wars know this very well, it's a UNIX-based. VIS5D which works on various platforms.

There's a new software that we are ... for called CAMxDesk put out by Environmental Modeling out of Chile -- we received the prototype and the nice thing about this is that it's PC-based where you just point at the CAMx in file and it reads all the inputs and outputs without you having to tell it where to look, and it's on a PC, then you can cut and paste these figures from your PC into your picture, so it can be in Word or WordPerfect, or whatever.

I have two examples of that to close this up, which don't come out very well here. This is a wind field superimposed concentrations. It looks much better on the screen, but it's one -- you can plot the wind vectors and the concentrations, and this looks nice. The second one is a temperature -- surface temperatures and land use for the -- here we plotted the urban land use and we see all the major urban areas popping out, plus we're ... over Ohio and Pennsylvania.

The CAMx -- in our write-up that we have on the EPA website, we talk about the evaluations -- there's OTAG, L-MOS, Nostram, Arthees (ph) -- Dallas, Fort Worth, the Houston-Galveston, the Gulf Coast -- it also appears users atop there -- and the users are too numerous to talk about, but like the Texas folks use it for the SIP modeling -- both the Dallas-Fort Worth and Houston SIPs. We have downloads from Italy, Spain, France, UK, Korea, Japan -- it's everywhere.

Final note on computing requirements. Although we run on SGI Sun and Deck Alpha workstations, for testing we also run on PC -- Linux (ph) PCs and are actually running this 3-D ... grid model -- and it runs fastest on a Linux (ph) than on any of our UNIX workstations, so it's gotten to the point where you don't need to spend your $30,000 -- it runs faster on a $3000 Linux (ph) PCs. That's all I have.

DR. TIKVART: Okay, we had a similar result with other numerical grid models, so that's interesting. Unless somebody has a burning question that they simply can't contain for Ralph, I'd like to move on with Ian and talk about -- is it ski-puff (ph) or psi-puff (ph). Ski-puff (ph) okay. (SCIPUFF)

MR. SYKES: My name is Ian Sykes. I'm from the ARAP Group, Titan Corporation, located in Princeton, New Jersey. I'm kind of introducing our puff model, SCIPUFF, -- stands for Second order Closure Integrated puff -- that describes the kind of turbulence dispersion modeling basis of this model.

We really started development back in the middle eighties, funded by EPRI, but since the late eighties we've been mostly found working for the Department of Defense, so we're kind of introducing it back into the air quality arena.

Just a brief overview. I'm going to talk a little bit about the modeling approach, just mention the kind of interface and the IO requirements, and then briefly mention some of the model evaluation studies that have been done with the model.

I think probably most of you understand this, so I'll skip through it quickly. It is a Lagrangian puff model. It's based on a collection of Gaussian shared puffs. We solve the equations for the puff moments. Next one, please.

And the advantage of these models is that you can cover an arbitrary range of scales without any numerical diffusion, which you get usually with a grid model. And you get the generality of time-dependent spatially homogeneous conditions and arbitrary kind of source geometries and time dependence too.

Just to show up a few equations. The only thing I'd really like to point out here is when we sum up these concentrations for each Gaussian, we do use a general -- the only thing is we use a generalized, moment intensive, so this special sigmas -- we don't just work with sigma-x, sigma-y, sigma-z -- the generalized tensor (ph) -- we carry equations for these moments.

The next one will just show you generally the equations, pretty simplified here, but the mass is conserved; the centroid of the puff moves with the mean velocity of the centroid, so this is just a trajectory. But the kind of interesting equation is for this spread of the puff which involves this turbulence correlation. This is what you call a turbulent diffusion, and it also involves the velocity gradient, the shear effects, which distort the sigmas.

And second order closure is what we use to provide an equation for this turbulence moment -- these angle brackets, just the integral over an individual puff. Basically, it's driven by a turbulent velocity fluctuation correlation and there's a length scale in here. So this gives us kind of a generalized framework.

Which gives a direct relationship between turbulence and the velocity fluctuations, which is what's driving the dispersion in the atmosphere, and the diffusion rates. And it also provides this single diffusion framework. We don't have to use different models in different regimes if we can specify the velocity fluctuation spectra, we can essentially account for all the REG (ph) and atmospheric scales.

We have some aspects -- numerical aspects to the model. We do allow puffs to split, although that treatment of the wind shear allows you to distort a puff and account for wind shear, it really only models a linear variation of velocity. To account for more general homogeneity, you need to split the puffs, allow them to move separately and diffuse in different parts of the flow. If you really do allow split in the flow, you have to implement some kind of merging because puffs will continue to grow after you split them and split again and again, so we have an efficient merging algorithm to maintain a manageable number of puffs. We take adaptive time steps and we implement some techniques for doing the initial dispersion as a static plume section, essentially, for efficiency.

Other aspect of the model -- from a kind of benefit of using the second order closure model is that we can provide a model for the fluctuation variance which is always present in a turbulent dispersion scenario, since turbulence is random. And from that prediction of both the mean and the variance we estimate a probability distribution. This is empirical distribution.

I would say one of the main applications of this is for shorter time averages where the fluctuations are very important, and you can get significant differences in short duration concentrations from one hour or three hour type averages, so this allows you to estimate those things.

Also, the use of the explicitly spectrum of velocity fluctuations allows us to estimate the effects of time averaging on the dispersion in a rational way too, and that's kind of built into the model. Next one.

This is just kind of showing what the basis of our fluctuation is. This is a kind of seminal laboratory experiment from a wind tunnel, and this is the key plot here which shows the down wind evolution of the fluctuation intensity. This is the maximum amount MS fluctuation, over the maximum concentration. I'm sure you can't really see the lines here, but what Fractal and Robbins (ph) showed was that there is a strong dependence on source size in this downwind evolution. This is down to ten boundary layer heights from an elevated source. I forget what the source sizes are, but this very small source shows a very high fluctuation intensity and this is fairly close to the source. This is -- fluctuation is four times the mean. It's an intermittent plume and the model is basically designed to fit this data.

We've also got some plume rise. We associate dynamic equations. We don't really have a kind of a Briggs formula. We carry evolution equations for the puff moments of momentum and temperature, buoyancy effect, and so --

This is just a quick one which shows the momentum rise compared with -- this is actually just a laboratory jet data for a ridge of exhaust velocities. This is the ratio of exhaust velocity to wind speed, the stack height going from 15 to two, so the model fits that kind of data.

And the next one -- and this is just kind of a gee whiz plot to show that in general, you can deal with these kind of shear profiles -- there was a classic picture on the front of one of the AMS annual meetings showing two plumes going in opposite directions and this kind of wind shear, so -- This is a vertical section from the model with a low sack and a buoyant plume going this way, and a higher one going that way.

This was really a demonstration that using these full Gaussian tenses for the sigmas, and you could track the shear distortions very accurately. This is from a published paper in JAM. It's a numerical advection (ph) test where you wrap around a concentration distribution without diffusion, so it's just distorted and this is the puff model description, showing that we can split puffs and shear them and produce this kind of a spiral. It's not practical for atmospheric applications, but it does show that you can solve the metrics accurately.

To move on to the model inputs, we kind of do various release types -- continuous, instantaneous, of finite duration, moving sources, and we require some -- can do particles or gases. There's limited chemical properties in the version that we're putting out in the public domain at the moment, there's just linear decay. We are working on a full chemistry, full non-linear chemistry version for EPRI at the moment, and are hopeful that they will make that available in the future, so this current version doesn't do full modeling in chemistry.

Now we can accept meteorological data in various simple formats --

we can deal with just fixed winds for simple studies, which is not really very relevant for a puff model, but it enables testing. We can use observational surface, multiple surface stations and multiple profiles that we will interpolate with or without terrain, and we can accept a three dimensional grid format. So these are generally being driven by DOD inputs up until now.

We can accept terrain description, and we have an internal mass consistent wind fr...l model so that we will adjust observations to produce mass consistent flow.

On turbulence data, we really derive a planetary boundary layer -- description -- from simplified inputs. We don't expect, although we can accept vertical profile with full turbulence, but we don't expect that in general. So -- we also have a model for the mesoscale turbulence, based on Frank Gifford's concepts.

The boundary layer turbulence that we generate is really based on wind speed and roughness and a surface influx calculation, which requires the user to input surface albedo and cloud cover and bowen (ph) ratio, ... the standard. These things are really derived from METPRO which was another EPRI product of the eighties, and this will then calculate the diurnal variation of the boundary layer.

A couple of pictures of -- there's a graphical user interface that just allows you to specify things, like this is the release eddy that you can specify, a stack source location, give the duration rate, exit velocity, temperature -- you do all this. I should have said, this is PC-based interface.

And we can output time history -- that arbitrary number -- well, don't say arbitrary -- large, but finite, receptor locations -- these are 3-D locations, and the user interface allows you to plot slices of concentration at whatever times you've saved -- horizontal/vertical slices, and we can save integrated surface deposition of material from the deposition models, and this can be integrated with dosage.

Just a couple of plots -- this is probably the ETEX plot of integrated dosage on a lat/long, so this domain covers most of Europe. You just get a color plot. You can skip the next one -- you can also plot probabilities, but you don't need to see it, it looks just the same.

The model has been evaluated. Most of it, I would say, has been published. We have compared with PGT curves and instantaneous dispersion data, the ..., the lab dispersion -- this is kind of early development of the work. We've compared with ANATEX, which is the entire eastern half of North America -- that's published. The original work was done on the EPRI-PMV and we're re-looking at that.

Conflux is a DOD experiment. It has been published, the comparison hasn't although I'll show you a couple of pictures. And there's recent field test on instantaneous releases. This is Steve Hanna's model data archive which is principally prairie grass, at least for the passive cases, and there's an ETEX experiment. I'll show a couple of these.

This is the comparison of maximum concentrations at various arcs from Steve Hanna's compilation of prairie grass in Hamford (ph). Passive data shows that almost all of the data is predicted within a factor of two for this range, although this is good MET data, which is important. Next.

This was the conflux experiment, which is a short range experiment. As you can see the height of the plume here is only ten meters. It's a very small, near surface release. These are just four vertical sections at different distances downstream. The distances are only tens of meters. This is mean concentration, and what I really want to show is the next one which shows the concentration fluctuation intensity for those four, and the vertical distribution of it. So this is real field data done with very fast response instruments so that they can measure the concentration fluctuations, and as you see, the model is doing a pretty good job on all of these.

This was a quick plot of ETEX. If you don't know anything about it, this was a fairly short duration release in northwest France over here, and they tracked it with samplers, recording, I think, through three hour averages, all the way across Europe for 72 hours. So these are the observations of the cloud after 24, 48, and 72 hours. And these are the predictions. Same contour levels, not perfect by any means, but I think, a reasonably good prediction. So this is long range in contrast to the ten meters, this is 1000 kilometers.

And so that's really all I wanted to cover. We're kind of making the model available. It's kind of downloadable from our website here -- Titan's website. There's a technical document which describes the mathematical and numerical basis of it and covers some of the validation, and there's an on-line help which I hope is helpful as a user guide. That's it. Well, I can say we don't use the help, fortunately, we don't need it.

DR. TIKVART: Okay, thank you, Ian. Got time for maybe two questions. Anybody?

MR. COULTER: I have one question. As John Irwin asked earlier about the EDMS model, could you speak to the compatibility of commonly available NWS data to give the input module for SCIPUFF?

MR. SYKES: Yes, we really have our own formats for input, for use in the DOD arena. We have built a converter, which I think is on the website which will convert the NCDC -- oh -- the ISC input files -- will convert into our MET file format so that it can be run. Certainly, in the longer term we would like to accommodate whatever the commonly used inputs are, but we're kind of newcomers to this world.

DR. TIKVART: Bob Paine.

MR. PAINE: Bob Paine, ENSR. What would be the regulatory niche for this model? Does it, for example, -- the comfort downwash? Does it run for a full year with a lot of sources? Where would we want to use this model?

MR. SYKES: Well, I think it's kind of -- it's sense is very similar to CALPUFF in terms of its capabilities, so I think it's most useful in complex scenarios, whether they be longer range, where you have to account for time and space variations of the wind field, or shorter range where you know there are complexities introduced by terrain or other features. It's not got a downwash algorithm in it, although we're currently working with the British to include building effects, but I've no idea whether that -- again, that's the administrative fence there, so I can't really say whether that would be made available.

MR. HAINE: This is George Haine (ph) from Earth Tech. Ian, I don't know whether this is the right forum to ask this question, but the SCIPUFF model has been applied extensively in the DOD arena, and I've seen many people use the SCIPUFF to simulate high altitude explosions.

MR. SYKES: Yes.

MR. HAINE: Do we have a lot of data to support, to validate that kind of application?

MR. SYKES: High altitude?

MR. HAINE: Yes.

MR. SYKES: I think there is a lot of data from high altitude.

There's one or two experiments. We've had a small effort to model stratospheric aircraft plumes with plume chemistry, and we've had a little data from some transatlantic cross sections, where people have gone through plumes for up to an hour or two, I think, after emission. So we've compared with those, but it's very limited data. But it's hard to tell. Some of them you get data on, some of them you miss by factors of three -- I'm talking about the plume widths, so I think that's the problem with turbulence, basically outside the boundary layer. We understand neutral, shear driven turbulence and buoyancy driven turbulence well, but outside the boundary layer in kind of stable regimes, I don't think we understand how to model the intermittent state reliably.

So we really are, as I say, only using Frank Gifford's kind of spectrum, which is based on essentially a climatological spectrum and to apply that to individual cases, there's a fair amount of uncertainty.

DR. TIKVART: Okay, a last quick question from John Vimont then we need to move on.

MR. VIMONT: What kind of chemistry do you have in it? Or do you have chemistry in it?

MR. SYKES: In this version that's in the public domain, we only have a fixed linear decay rate -- well, I say fixed, it can be diurnally varying to simulate the effect of sunlight. For EPRI, currently, we're developing a full non-linear chemistry model for use as plume in grid and -- well, it's being developed in a flexible way. They're running it with CDM-4, but it's -- the chemistry is written in an import file. You can put anything you want in. And they're also hoping to use that as a stand alone model, and I'm hoping that they will put that in the public domain too. It's still really under development.

DR. TIKVART: Okay, Ian, thank you very much. Next we have a joint presentation by Ed Carr and Rob Ireson. First on HYROAD and then on UAM-V. I understand that HYROAD will be a little longer and UAM-V will be a little shorter.

MR. CARR: I'm Ed Carr. I'm ICF Consulting, and I'll be talking initially about the HYROAD model that we've been working on developing and Rob Ireson will give the technical overview of the model and I'll offer some concluding remarks.

First I'd like to acknowledge that the major sponsor of this work was NCHRP, National Cooperative Highway Research Program, with assistance from the Federal Highway Administration, and these are three -- I'm the project manager, and Rob's principal investigator, and ... Jinks is the program officer for NCHRP.

Today I want to go over the kind of background of the HYROAD model and focus mainly on the scientific basis and model formulation. This -- we're at a point in this project where we're someplace beyond where AERMOD was at the last modeling conference, but we're not quite as far along as AERMOD. This is sort of -- this presentation is meant to be a perspective on -- a status report of where we are with the model development, and we're getting close but we're not quite there. We haven't totally performance evaluation completed and the necessary steps, but we're close.

But to continue on, we'll go over the model application and resource need briefly, discuss the sensitivity tests, performance evaluation that has been done and where we're going, and also the next steps in the project and a time line of when we plan to complete these next steps.

I want to give a quick background on what the project is all about.

It's looking at developing an improved roadway intersection model for carbon monoxide, principally, and this is driven, to a large extent, by SIP requirements as well as conformity and environmental impact statements, where you need to look at potential impacts from congested intersections, and looking at ambient CO -- or CO concentrations.

In this study which began back in '93, with work with funding from the NCHRP, and it is a four-phase project where we've developed a site monitoring plan to study first of all what -- how we should conduct field programs to collect data to make this analysis. Most of the studies that had been done in this area had been done in the late, late 70's, earlier 80's -- GM-sulfate experiments, probably the most well known. So they were quite dated and a lot of things have changed in engine technology and so there was a strong desire to have a field program, and that's what was designed in the monitoring plan. We conducted our monitoring plan over two winters, starting in '94 and then continuing into the winter of '95-'96.

And then there was a data analysis phase lasting about a year, looking at all the data that was collected, and doing an assessment on it. And then finally, we've been most recently looking at model development, and just evaluating and testing the model. And we're just getting to the point where we're finishing the testing and we'll be going over the results of some of that today.

The final steps will be developing a graphical user interface and updating and revising the draft users guide that we've developed.

So, as a final thing I wanted to say was the -- overall we wanted to assemble a -- the major objective of the whole project that we were doing for NCHRP was to assemble this comprehensive national data base of a number of intersections scattered across the country, detailed information about traffic, emissions and dispersions in and around the roadway. And so we -- and then using that information, develop an improved, integrative roadway intersection model.

The -- we wanted to do -- the approach, the philosophy behind how we were going to do the model development was to do -- to first design this field program to collect all this data so that we could clearly understand what processes were important and which ones we could ignore, which ones, for example, could we ignore the effects of the heat from the exhaust from motor vehicles? Was that something that was such that it was not important relative to, say, the turbulence wake effects from the vehicles as they moved through the intersection.

So we designed our experiments and data collections to answer those questions. And then we developed the model based on the understanding of the key processes, and that's where we spent the year's time doing data analysis and looking at the data from the data collection efforts.

And with that, I'll let Rob describe more.

MR. IRESON: Thanks Ed. I apologize for talking quickly but I don't have time to apologize. As Ed said, there are a couple things I want to cover here, primarily the scientific basis of some of the resource needs for model application and sensitivity and performance testing that has happened so far and is ongoing.

Under the scientific basis for the model, I'll be talking about both the components of the model, the limitations of existing models, why we were doing what we were doing, the actual design and findings from the field program, and the formulation of HYROAD.

What problems do we face in intersection modeling? We've broken them into two general categories, the things that go on with traffic around intersections, queuing, acceleration and deceleration right at the intersection as well as cruise movements through the intersection. It's clearly a non steady-state kind of situation for emissions and for the things that traffic does to turbulence and dispersion.

On the emissions and dispersions side, for those of you who have been following emission factor model development, motor emission models are -- continue to be a research effort at this point. There's a lot of concern about power enrichment, the effect of low fuel - air ratios -- I'm sorry, high fuel - air ratios under heavy accelerations; concern about buoyancy and vehicle wake turbulence and also the short transport distances that are involved in intersections.

The guidance says look at maximum concentrations three meters off the traveled way. None of the models we've talked about so far today have talked anything about receptors three meters from the source.

Components of intersection models. Basically we've broken it into three -- a traffic module that's driven off of roadway and traffic inputs; an emission module, which primarily has used emission factors only in the past -- we'll talk about later introducing some meteorological inputs into it as well as the traffic flows themselves; and then the dispersion module.

Existing models -- CAL3QHC is the current EPA guideline model. It has two emission states that it treats in the vehicle dynamics, basically a through cruise movement at the average speed or the free flow speed for the lane, and idle emissions. Those are the only two operating activity modes. It's a steady-state Gaussian meteorological field that's used, and the queuing inputs, the way it treats and the delay of vehicles at the intersection is based on the quality of progression that's user specified. It's not a dynamic model along those things.

CALM4, which is used in California, tries to go a little bit beyond that through treating, empirically, acceleration effects on emission rates, as well as turbulence and buoyancy over the roadway. It also uses sigma theta for lateral dispersion, as opposed to sigma Y as a user specified input.

The field study was designed to provide inputs that would help resolve some of these questions. We had a number of elements that were collected at 15 minute averages over about an eight to 12 week period, depending on which of the three intersections we're talking about. Traffic volume, some detailed meteorological measurements, as well as carbon monoxide and carbon dioxide up to 24 receptor locations in some of these intersections. The CO_2 is there so we can look explicitly at the gram per gallon emission rates -- and I won't go into details on that at this point.

This is a map of the Denver intersection and just quickly, typically, wind flows were from the southeast, and so we had a large receptor array in this quadrant of the intersection, both at ground level at the edges of the roadway, as well as elevated sampling points, MET tower in the middle of the field, sonacanemometers at a number of locations through the area. We also had some short term elements to the study, including a tracer release during a couple periods of very light winds along here, and sulfur ...ide measurements at locations throughout the intersection.

We had separate sampling locations in all four quadrants, so no matter which direction the wind was blowing, we had good background concentrations for CO and for CO_2.

The short term studies, as I mentioned, included the tracer experiment, as well as surveys of drivers going through the intersection for ... and ...

car runs to get speed and acceleration distributions, basically time-distance plots for vehicle movements through the intersection.

The data base, I should point out, that we put together in this study -- we spent about four times as much on collecting the data as we spent on data analysis and model development. It's quite a nice data base. It is now available, and I think it will help a lot of people in both model development and some basic research activities.

The principal findings from the field program on model formulation -- will cover a couple of different areas. Frozen turbulence -- the induced flows that we saw were typically under high traffic conditions, greater than three meters per second at roadside, and since most of the high concentration events that show up in modeling have wind speeds of about one meter per second, this is clearly important. Not only that, with sonacanemometers, we were able to see the effect of these induced flows at distances more than 25 meters from the roadside. If you take the steady-state Gaussian formulation, you're clearly going to lose that.

The vertical dispersion rates that we saw from roadside and farther away from the intersection, under selected meteorological conditions, exceeded both those of the Pasquill-Gifford turner (ph) parameters, as well as those that are built into CALINE3 or CAL3QHC.

And then the other kicker was during tracer experiments, we were finding tracer concentrations as much as 100 meters upwind of where the tracer was being released, strictly as a result of induced flows down the roadway.

For traffic and emissions, the enrichment issues in motor emissions were really the keys for us. What we found was that first, from the floating car (ph) studies, the speed and acceleration distributions of vehicle traffic in the intersections didn't look anything like the driving cycles that are used for the development of mobile emission factors. We'll get to that a little bit more later.

Power enrichment events was observed to occur in the acceleration zone of the intersection, which didn't surprise us. What did surprise us is that we were really seeing constant gram per gallon emission rates on all legs, even though under some circumstances we're seeing enrichment, we did not see any appreciable contribution from enrichment during high concentration periods.

I'm going to go through this quickly, feel free to talk to me afterwards -- I also should say I -- if any of you want to get copies of this presentation, let me know, and I will be happy to e-mail it to you.

This is gram per gallon emission rates on the green phase of a depart leg from the intersection, 15 minute averages. Scatter plot is against the corresponding 15 minute period on the approach leg during red, and what this is basically saying is that we're seeing emission rates of up to 3,000 grams per gallon in the acceleration zone, even though we don't see anything like that in the idle queue or the approach to it.

But if you look at the corresponding carbon monoxide versus CO_2 or CO_2 plus CO concentration, what we see is again, 15 minute averages, CO versus CO_2. The points along this line are 15 minute periods which have an average emission rate of about 300 grams per gallon for carbon monoxide. The enrichment events are the ones that are to the left of this red line, that if you look at all the concentrations above six parts per million, the bulk of them are falling on this line over here. It's not being driven by the emission -- the enrichment events. Not something we expected to see. We believe it's because the first vehicle in a line of traffic is probably the only one that has an option of accelerating hard enough to go into enrichment.

So, quickly, back to the model formulation. We're using a microsimulation approach for the traffic module. We're developing, or we have developed, a speed distribution-based emission module that uses mobile 5 emission rates, but uses the speed distributions coming from the microsimulation model to actually get a better handle on the total emissions. And also, we're using the fuel consumption calculated from speed and acceleration in the traffic area to spatially and temporally allocate. The dispersion module is a hybrid which we'll talk about more as well in a second.

As I said, the traffic module is based on TRAF NETSIM, it's a microsimulation module that treats vehicle movements second by second through the course of the simulation and what we've done is set it up to get speed and acceleration distributions by ten meter roadway segments. So we have, for each, in this case, 15 minute time period, for each signal phase, the number of vehicle seconds that cars spend at each speed in acceleration within ten meter sections of roadway. It's about a 20 megabyte file, I guess, by the time we get through with it.

This is the actual, empirical speed and acceleration profile that we observed in Denver. The axis over here is acceleration, so zero acceleration in the middle, deceleration to the left, and speeds from zero to 60 feet per second. What we're seeing is a lot of speeds, cruise movements up here in the -- I guess it's the 40 mile per hour area, and about 38 percent idle time. Some hard accelerations that are beyond those that are actually treated in the mobile emission factor modeling.

This is the corresponding -- roughly corresponding NETSIMS simulation for a level surface C intersection. Again, we're seeing some high accelerations in this area that do reflect reality, and reasonable representation of the amount of idle time that's spent.

The emission model -- we set up to work off of the idle emission rate and the emission rate for six different speed distributions from mobile, and without going into details, using a multivariant regression approach to assign weights to each of the different speeds from mobile in order to best represent the speed distribution that comes out of NETSIM.

The total emissions are calculated and allocated spatially and temporally, based on fuel consumption that is calculated from speed and acceleration. This bar graph shows -- in the blue lines, the speed distribution that's coming out of NETSIM, that we're trying to reproduce. And here the red lines show the calculated speed distributions from the regression approach. What we do is also add in excess idle time for any amount of idle that is not explained by the speed distributions that underlie the mobile emission rates.

In contrast, CAL3QHC, as I said, uses two modes -- basically a cruise mode and enough idle to account for whatever queuing it believes is happening from the quality of progression, the traffic volumes. Typically, very, very high compared to what's actually observed.

For turbulence and flow -- what we've done is taking the traffic volumes from NETSIMS, basically the volume and speed by ten meter roadway segment and starting from the algorithm developed by Eskridge for roadway, have calculated two dimensional wind and turbulence fields for each of the signal phases, green east bound - west bound, green north bound - south bound, turn, left turns and so on. And the output is a grid of ten meter cells, two and a half kilometers square.

This is a little bit harder to see. I've overlaid a set of wind vectors on the intersection for the Tucson test case, and what we're seeing here is the effect of south bound flow on Albernon Way here, causing the wind vectors to carry the pollutants to the south before it goes straight west, both there and here, as well as some north bound influence. The east bound flow tends to counter the domain mean wind coming from the east, and so on.

Anyway, there's one of these fields generated for each signal phase for each of the simulation periods.

The dispersion module has actually two different modes. We had some concerns about the computer time that a detailed characterization might take, and we also felt that it probably was not necessary to get into the detailed flow fields for high wind situations. So we set up one module based on CALINE4 dispersion model, and then a puff model -- I'd like to thank Joe Scire for explaining why you need puff models for non steady-state conditions, because that's clearly what we have here.

What we're doing is again doing microsimulation across -- on a one second time scale, there's one puff coming up from each chimney or roadway segment for the course of the time period, 15 minutes, overlaying the wind and turbulence fields for each of the signal phases in progression, until we get through the time period.

Conclusions regarding formulation. What we've done, we believe, is integrated accepted modeling approaches in a way that actually treats the dynamics that had not been well handled in intersection models up to this point, in particular the induced flows and turbulence and the spatial and temporal allocation of the emissions. That may well be the single, most important change in the modeling approach from those that have been followed in the past.

Second topic is resource needs, and very briefly -- we're using standard inputs. The data that are required in terms of intersection geometry, traffic volume, speeds, meteorology and so on are those that you would have to have for any intersection model. There is some amount of time spent in preparing the inputs in the right form. At the present point we have not got a graphical user interface. That is planned. But since it's basically manual, and since there is a certain amount of redundancy right now in the inputs that are required, setting up an intersection for the NETSIM simulation takes about eight hours from start to finish. The emissions and set up for the dispersion module is about 12 hours. And the run times are, for NETSIMS, 30 seconds per simulation hour. For the dispersion module, particularly the puff, it's about four minutes per simulation hour. There are ways of speeding that up. So, although I wouldn't want to try to run a full year at this point, it wouldn't be all that painful to run a month -- we've been running close to that for some of the performance evaluations.

Final topic for me, the sensitivity and performance evaluation. We've done a set of sensitivity runs for a normal intersection and are looking at the results separately for the Gaussian and the puff model. We've got results for wind speed, wind direction, and stability sensitivity. I won't go into those here. Basically they're showing pretty much what we're expecting.

What I do want to show you is those comparisons between what happens with the puff model and what happens in the CALINE module. These are concentration fields, scale is over on the right. The differences between the CALINE, which is the steady-state meteorology and the puff modules are the location of the max, here in the southwest quadrant, shifts downward by -- each one of these grid cells is about 25 meters, so we're moving the peak about 50 meters further south on the leg and a little bit in, and we're dropping the magnitude by about 40 percent or so. But concentrations actually out on the corners, are a little bit higher in the puff module than for CALINE, primarily a result of reduced flows and the fact that we're treating the over roadway turbulence for the puffs as they're advectored through the system.

The data sets that we're using -- we have three different intersections that were monitored intensively. We'll be doing a total 528 hours from those three data sets. There are actually 6000 hours worth of data available. We've picked those periods that have complete data and interesting meteorology.

We also have eight SLAMS/NAMS sites for which we have assembled data sets. There's some uncertainty about the background concentrations that we should use for those in performance evaluation, since there's not typically a neighborhood scale station upwind during high concentration periods for these. But we will be going through that exercise as well.

The approach that we're taking is to look at concurrent puff model and CALINE4 module as well as CAL3QHC. We're doing scatter plots and the standard statistics, correlation coefficients, robust fast concentrations, and so on.

I realize most of the graphs that you've seen so far today have been the Quantile-Quantile plots. I'm going to take a risk here and show you the actual scatter plots with two minute averages, with some trepidation, but I'm not going to leave that one up very long, I'm going to go ahead to the Quantile-Quantile plot. The yellow is the CAL3QHC, the pink or the red is the CALINE4 module, and the blue diamonds are the puff model.

When you go to Quantile-Quantile you actually see pretty good agreement on here. This is typical of what's been seen in the past with CAL3QHC, tends to underpredict with real meteorology. One of the motivations underlying our study was the fact that when you run CAL3QHC in screening mode it has a tendency to overpredict -- come up with concentrations that are typically not seen in reality.

Preliminary performance results. And these are preliminary. We are still underway. We've completed the runs for Tucson, but we're still looking at different stratifications of the scatter plots to understand what's going on. The robust heights concentrations are clearly better with both puff model and CALINE4 module than we see with CAL3QHC. We do see some differences in performance at different receptors -- the corner versus other locations and we want to understand that better. It does appear to handle worst case situations better than others -- better than CAL3QHC in particular.

We're underway with the performance evaluation for the other intersections and we'll also be developing a screen methodology for use with HYROAD. And I'll turn it over at that point to Ed for wrapup.

DR. TIKVART: About ten minutes? You have ten minutes left. Can you hold it to about ten minutes?

MR. CARR: Oh, it'll be less than that.

DR. TIKVART: Okay, good.

MR. CARR: I just wanted to go over the planned applications of the model and where we see it being used.

DR. TIKVART: I'm sorry. Ten minutes including UAM-V.

MR. CARR: Oh, including UAM-V. Okay, then I'll make it quick. The refined applications would be looking at using it for SIPs and conforming analysis, and also we've seen some already used for some hot spot analysis, both for particulate matter and for some aerotoxic risk assessments, when we've been looking at benzene and other toxics.

The current project status is that we -- we need to make a decision on whether we want to use the puff and a line segment algorithm, or whether we want to stick with puff in the dispersion component of the model, and then we also want to complete the model for components evaluation. As Rob mentioned, we finished Tucson, and then we're going on to do the other two intensive intersections -- Virginia and Denver, and then with the eight SLAM sites as independent tests. And then we'll present those results to the committee -- the NCHRP panel.

Finally, the next steps will -- of course, I mentioned, we'll build a graphic user interface, update the draft users guide and our planned schedule for this is to complete the evaluation study by the end of August and develop the GUI and release a version of the model for beta testers to use in late this fall, and then update the user's guide once we have those elements completed. I think that's it.

I'll move on to the UAM-V presentation. We don't have time for questions. Let's take a few minutes to talk about both UAM-V and UAM-VPM -- these are the -- UAM-V is a variable grid model for modeling primarily ozone, and we've recently got to the point where we think we're ready to nearly release the UAM-VPM version of the variable grid model.

A lot of the similarities between this and CAMx, as Ralph mentioned, it's a three dimensional Eulerian grid model as far as the meteorological missions, land use information, and it produces hourly ozone concentrations, similar to UAM and other models, so that's pretty typical.

The core model that is available and supporting software, users models and example modeling data base is -- they're all available on our website at no charge -- and there's the website address. The only requirement is that you need to be registered and we are simplifying it so that in the future you'll be able to download it without -- just doing an online registration.

Two versions of the model -- there's an OTEC version available with the updated isoprene chemistry, and then the latest version on there is the toxic chemistry, which is a treatment for S-aldehyde. It has the secondary formaldehyde and ...aldehydes, some improvements were seen in incorporating those mechanisms. And then also it includes process analysis, which I will talk about a little later.

The other features of the modeling system -- it has the nested grid capabilities. It has a plume and grid treatment similar to CAMx. It accepts outputs from a variety of models and it most typically has been running with MM5 these days, and it also contains process analysis capabilities, which are primarily being able to look at processes that are important in figuring out how the ozone got to be where it was, looking at invection, deposition chemistry and those processes that lead to ozone formation.

Schemes that are included in the model -- the Smolarkiewyz scheme for invection, including transport. We have K theory for the turbulent infusion. Surface removal process, the same as in CAMx -- 1989 -- and chemistry is the carbon bond 4 with, I mentioned, with the updated isoprene and toxics chemistry.

As part of the modeling system is available is the EPS 2.5 version, emission processing system, and there's also the EPS postprocessing as well as the process analysis code that's included in there in the model. Also, looking at animations that are available, movie simulations for looking at how the ozone varies over time.

I won't go over the standard meteorological inputs that are needed in the model, fairly comprehensive. I mentioned the rainfall rate you can get independently from outside the MM5 model from observations.

The emissions input, it needs these listed here as well as -- but these need to be speciated and temporally allocated. Many of you are familiar with that.

The UAM-V input file requirements -- similar to the other photochemical grid models, requires that initial conditions be specified, that you have chemistry inputs, including the photolysis and chemical reaction rates, and also information on land use and albedo and ozone pollen.

The process analysis software is incorporated into the model in the latest version, that, like I said, is available. It allows you to differentiate what's source, where the ozone is being generated from for a particular grid cell or for a cluster of grid cells, depending on how you want to define it.

The next slide, I think, illustrates that. This is for the Gulf Coast. We're looking at a particular area where we're concerned about this hump -- this down in the bottom is the ozone curve, these are the observations. And this is simulated, a second hump late in the day, about eight p.m. in the evening, we were seeing this rise here. We ran process analysis looking at the different components. We looked up here and you can see there's a blue segment here indicating that horizontal invection was leading to this rise and increase in the ozone concentration.

So in looking at the bar field we were able -- that definitely concluded then that it was definitely a recirculation problem that was leading towards that increased ozone. So the process analysis gives you information about how you're getting to changes in the ozone at that location, so it gives you more information about how that works.

Just quickly, well, we have over 60 registered users, using the model now, including many in the U.S. and outside the U.S. A number of research as well as regulatory agencies in Europe and a number of private industrial clients. It also is beginning to be used in quite a number of developing countries, outside the U.S., especially ones that have ongoing ozone problems.

Application of the model -- it's included quite extensively in OTAG, as well as in Atlanta and the comparison with UM4 and has been used in a number of cities -- Houston, Chicago just to mention a couple, but also and more recently in Athens as well as in Paris in doing some simulations.

The next slide just shows the locations of where UAM-V has been -- either researchers are using it and the number of regulatory agencies and/or private companies that are using the model, either by state or in the country. So it's getting fairly wide global use.

The current applications of the model that we're principally involved with -- Gulf Coast ozone study, as well as the ATMOS study in the south, and we're also looking at using it in the model for demonstration purposes in Mexico City.

The multiple nested grid capabilities, just showing you an example of how it's being used in the Gulf Coast. Here's where we're focused on three areas, in Birmingham, having a nested grid of four kilometers as well as in Atlanta, and then down in Baton Rouge, having even higher two kilometer grids because of many point sources in that region. So this is kind of nesting, and it's typically employed in the model that can be used.

I'd like to take a few minutes to talk about UAM-VPM. One thing that's being updated is that it's being worked on as a CB2000 chemistry, and what this principally is is just a review and an update of the rate constants and p...lysis rates of the latest smog chamber studies. So that's being incorporated into the model -- into the gas phase portion of the model.

The important thing we're developing the particulate matter part of this is it's going to be a stand alone box, and we've done a lot of testing on that at this point, but it employs a method we call hybrid mobile sectional, and that's where we're taking the distribution and breaking them up into sections -- and that's all user defined as to how many modes you have and how many sections you break them up to, which relates back to how long, of course, how long it takes to run, to a large extent, depending on how fine a resolution you need in those different modes.

And what this allows you to do is allows you to use the best of many of the processes that are important, different processes may have -- modal selection may be more important than sectional cutting out of the different nucleation processor, coagulation may have differences, and what's important in the formation of the particulates. So -- I'll talk a little bit more about that in a second. But then the gas phase chemistry is just the same as UAM-4.

The features are -- and the idea is that the features are well known or have been hard coated into the model, such as nucleation or coagulation, and it's features that aren't well known, for example the distribution -- maybe the log normal distribution combinations that are used -- those are defined as dynamic user inputs.

So this variable hybrid approach allows us to use the best research grade algorithms to be used in a regulatory and planning platform, and also to grow as computational requirements -- as improvements in speed and technology improve.

Just quickly, the processes that are included in the UAM-V are all the important ones in performing particulates, but I just wanted to bring you -- most of our methods are from Jacobson -- it's used in the Gator (ph) research code that we've been working cooperatively with him on a lot of this UAM-VPM work, and essentially just wanted to highlight that that was the approaches that are being used in the model.

This is just to illustrate that the gas phase portion of the model is taking place in this part of the flow chart, and this is where all the gas to particle transformations -- so that all loops back up and the new emissions are injected in, so that it's a stand alone box, and so many of these modules can be pulled out and put in separately as improved understanding comes along in different portions of PM formation process.

I'll skip that and just go to the last slide, and that is where we're at. We've done the rigorous testing of the box model, that's been completed, and we're in to the testing of the full modeling system, and that's very near completion, that is, once -- we've integrated it into the box model and now we're testing it in Vancouver, which is for this ten day episode from 1993. Then we plan to very soon initiate application to Alberta, Canada and the schedule is that we anticipate, then, in the next three to six months that we'll have a code available for use to others. And with that I think I ran out of time.

DR. TIKVART: Okay, thank you very much to Ed and Rob. I would encourage anybody that has questions about any of our speakers this afternoon to catch them afterwards, and I'd like to thank all of them for their efforts, and I'd like to thank the audience for being here and sticking with us to this late time.

So, we'll adjourn for now and we'll start at 8:30 tomorrow morning. Thanks.

(Whereupon, at 5:40 p.m., the hearing in the above captioned matter was adjourned, to be reconvened tomorrow morning, Thursday, June 29, 2000, at 8:30 a.m.)