The level of documentation required to substantiate an exceptional or natural event claim should be minimal if:

The Event is Mapped on the NOAA Fire Hazard Map

An event should be considered substantiated if:

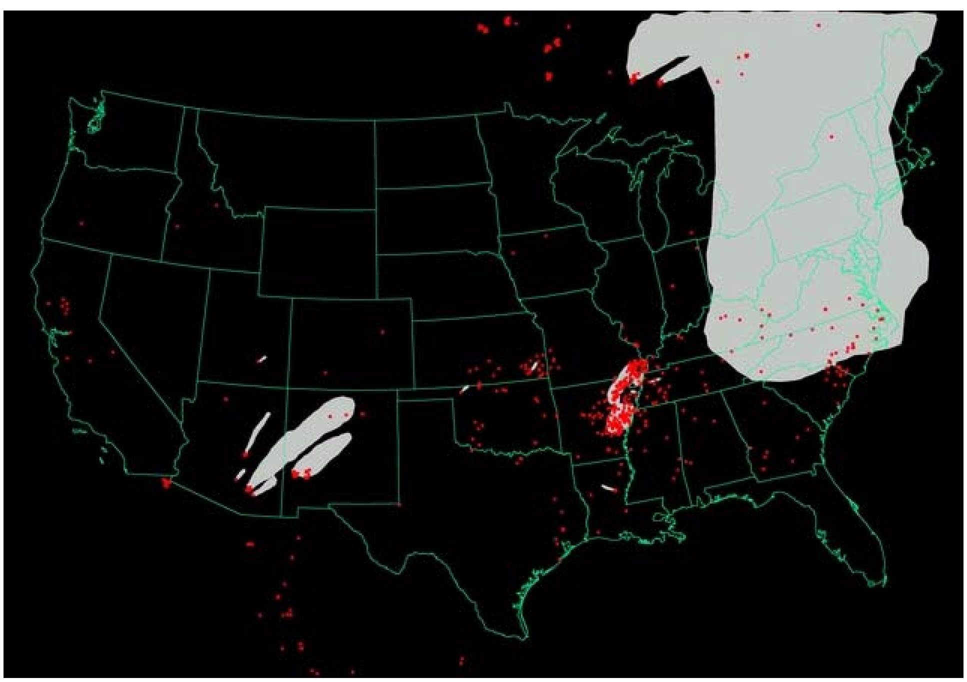
(1) the event is mapped on the Fire Hazard Map as having smoke over or adjacent to the location of concern the day before, the day of, or the day after

(2) the Fire Hazard Map indicates the probable source of the smoke.

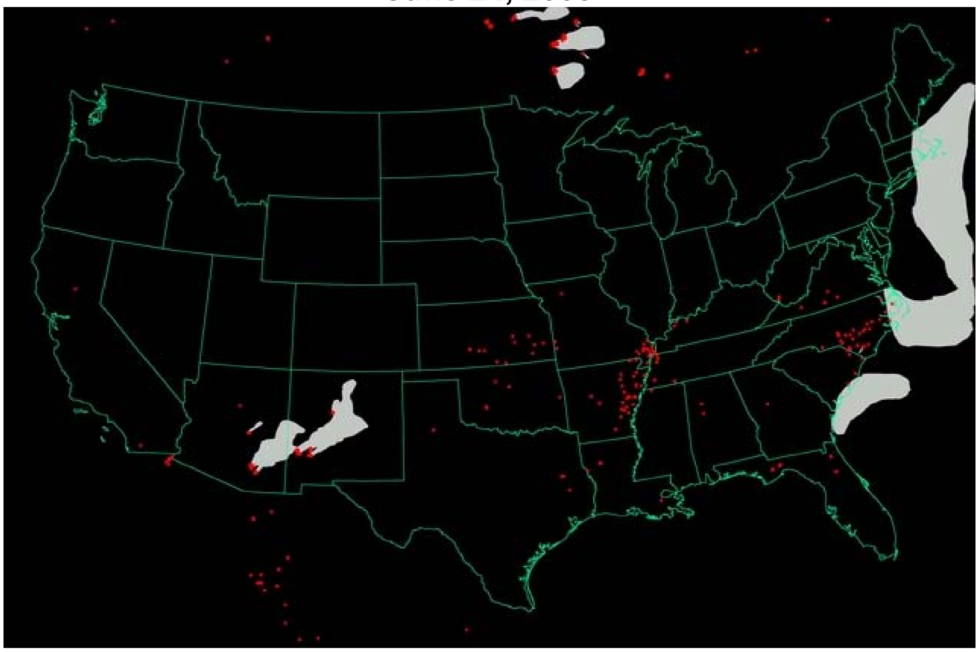
(3) the event can be documented by significantly elevated $PM_{2.5}$, total organic carbon, potassium, calcium, and/ or other fire markers for either the day before, the day of, or the day after by speciation monitoring at the location or at a nearby location that is regionally representative such as IMPROVE network monitors.

The fact that it is mapped on Fire Hazard means that it was recognized as smoke by NOAA scientists who plotted the smoke algorithms from actual satellite pictures, some of which may not be available to the public.

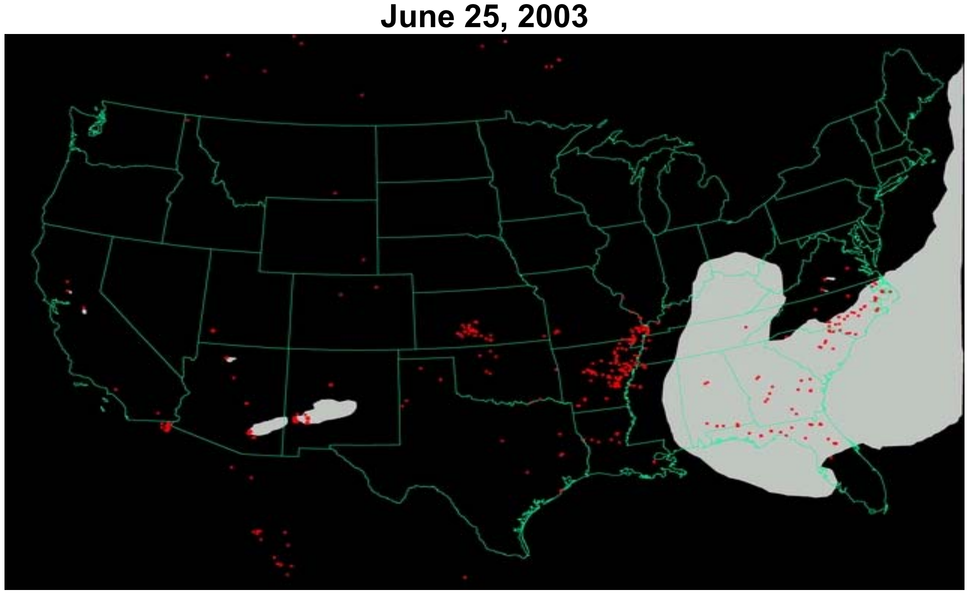
Example (1)
Canadian Fire Event June 23, 2003



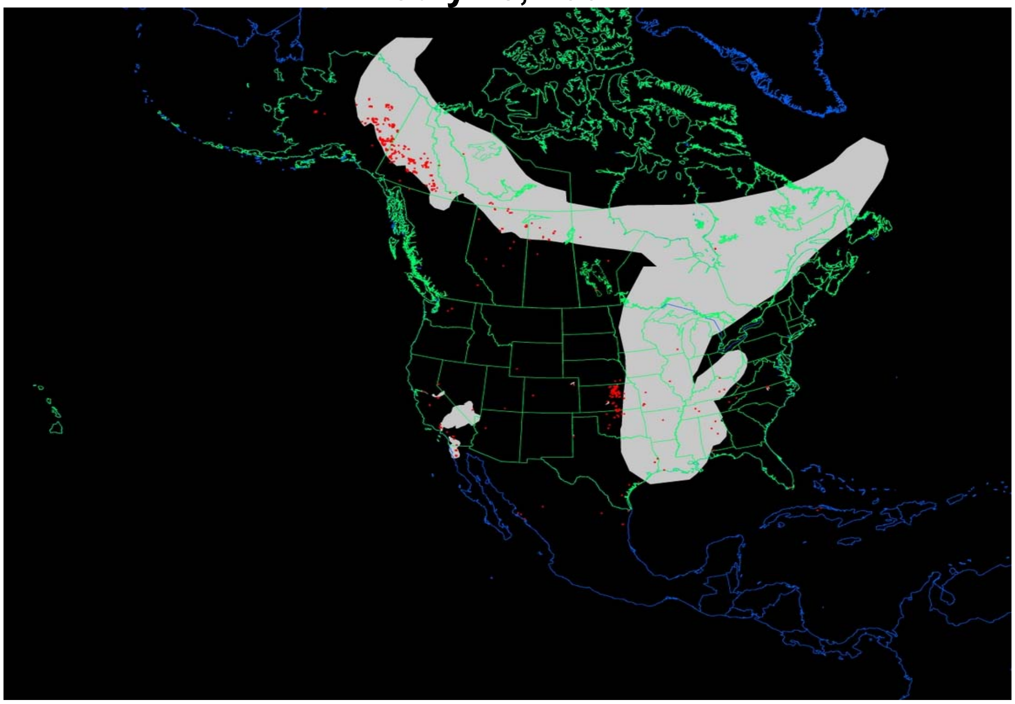
June 24, 2003



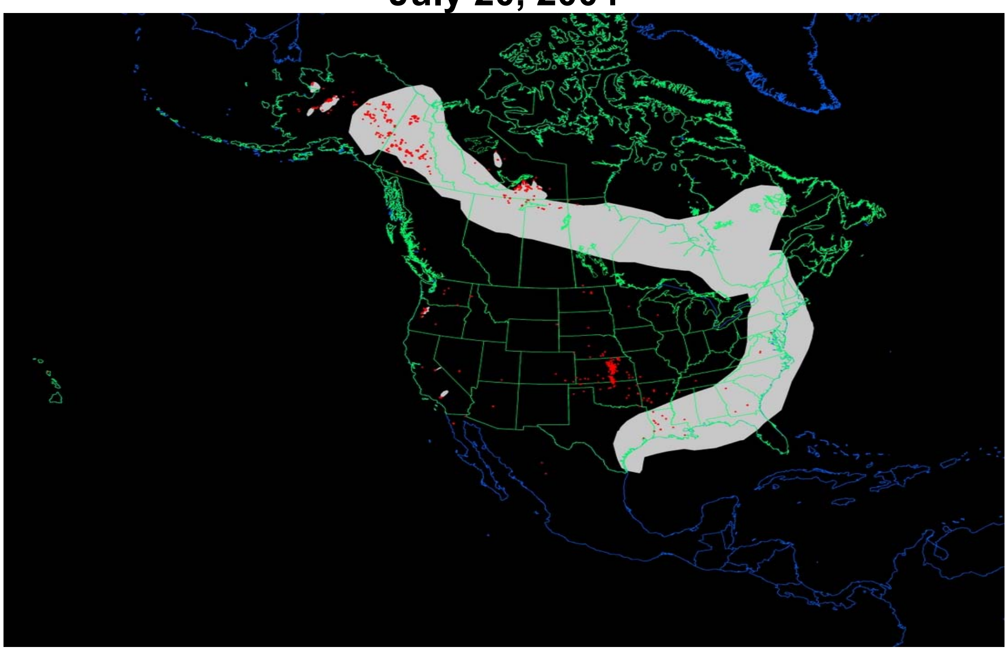
June 25, 2003



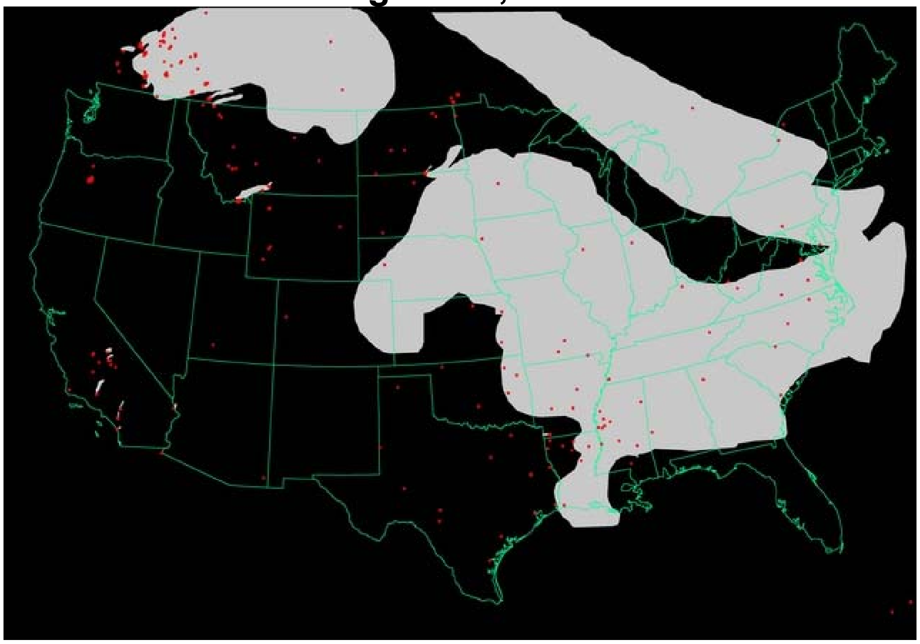
Example (2)
Alaskan/Canadian Fire Event
July 18, 2004



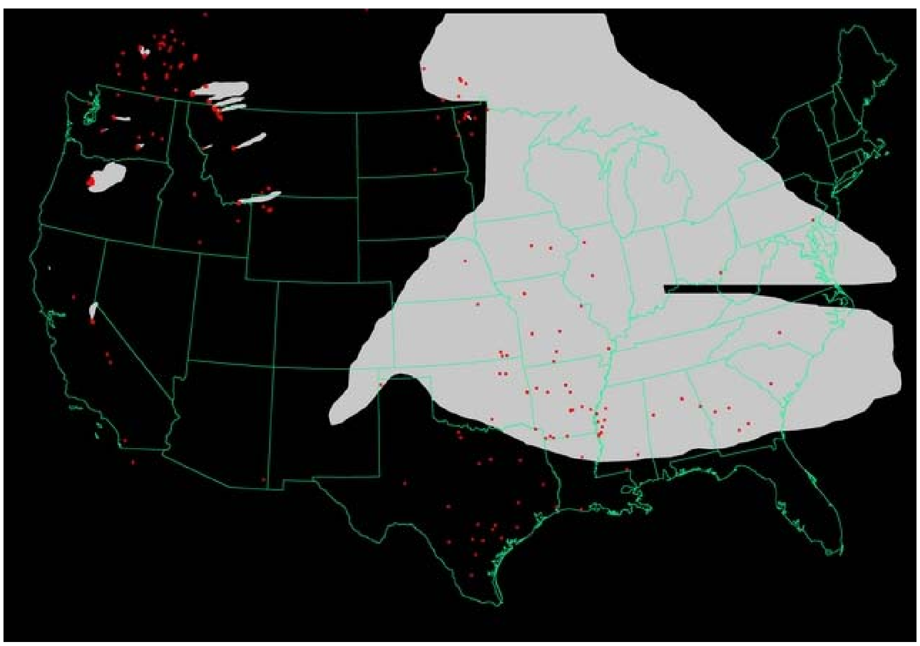
July 20, 2004



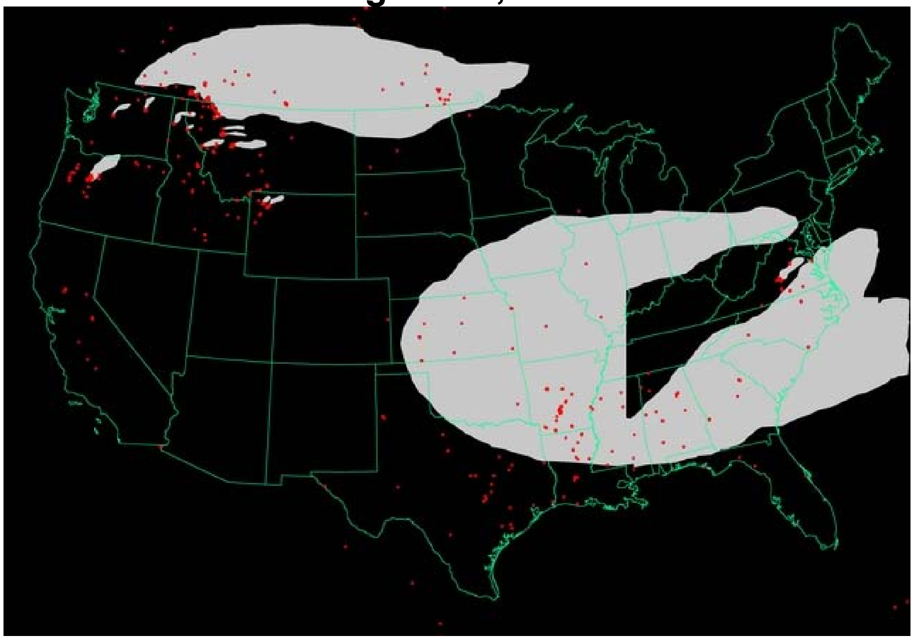
Example (3)
Canadian and Northwestern US Fire Event
August 23, 2003



August 24, 2003

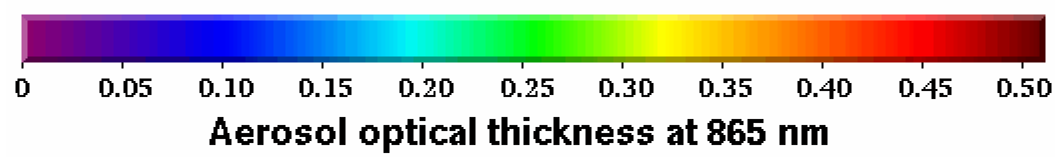


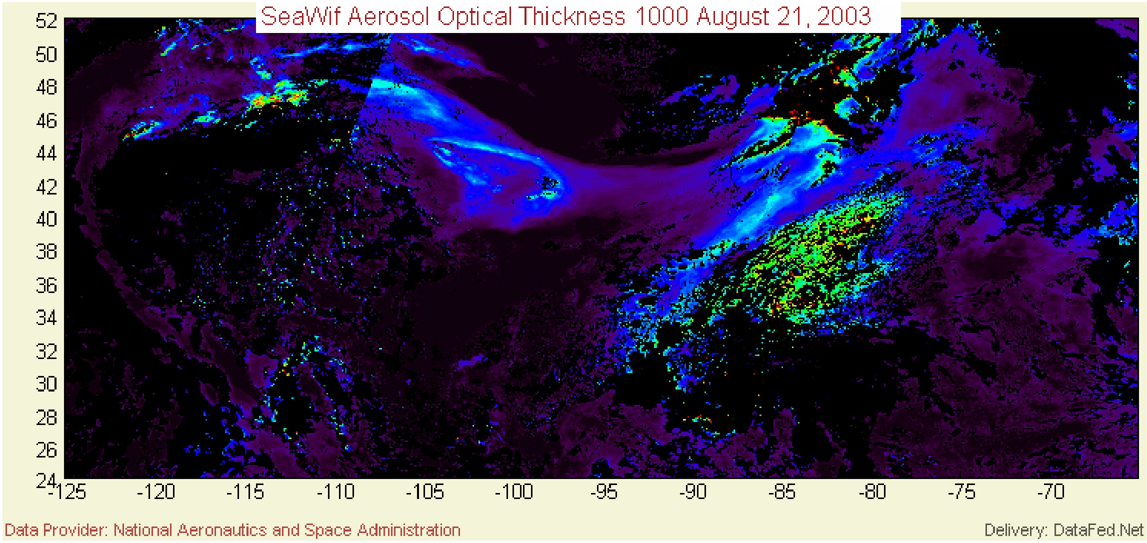
August 25, 2003



If EPA is uncomfortable with solely relying on the Fire Hazard Map, then additional satellite pictures can be required along with Fire Hazard. SeaWiFS or MODIS Mosaic (or thumbnail) can be specified as a required picture along with the Fire Hazard Map. Unfortunately, SeaWiFS are not available on the Datafed web site until the end of the calendar year for that year. MODIS thumbnails are available real-time and MODIS Mosaics are available a day or so later. Several requirement options should be in the guidance if additional satellite pictures are required by EPA.

For example, the SeaWif Enhanced to 1000 nm AOT pictures from the August event represented on Fire Hazard above:




SeaWif Aerosol Optical Thickness 1000 August 21, 2003
52
50
48
46
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42
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38
36
34
32
30
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26
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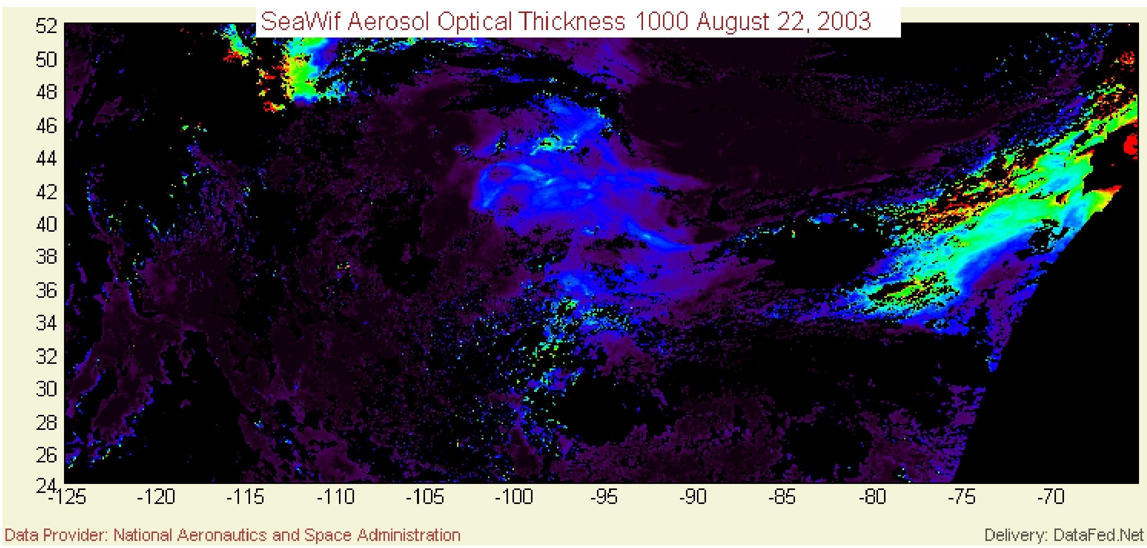
-125
-120
-115
-110
-105
-100
-95
-90
-85
-80
-75
-70
Data Provider: National Aeronautics and Space Administration
Delivery: DataFed.Net


SeaWif Aerosol Optical Thickness 1000 August 22, 2003
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
-125
-120
-115
-110
-105
-100
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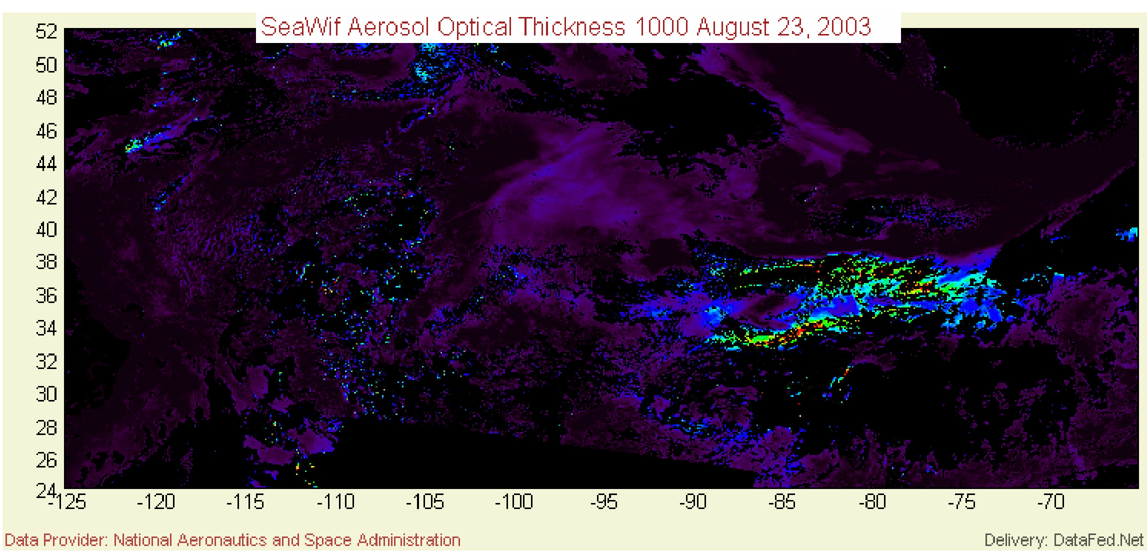
-90
-85
-80
-75
-70
Data Provider: National Aeronautics and Space Administration
Delivery: DataFed.Net


SeaWif Aerosol Optical Thickness 1000 August 23, 2003
52
50
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-100
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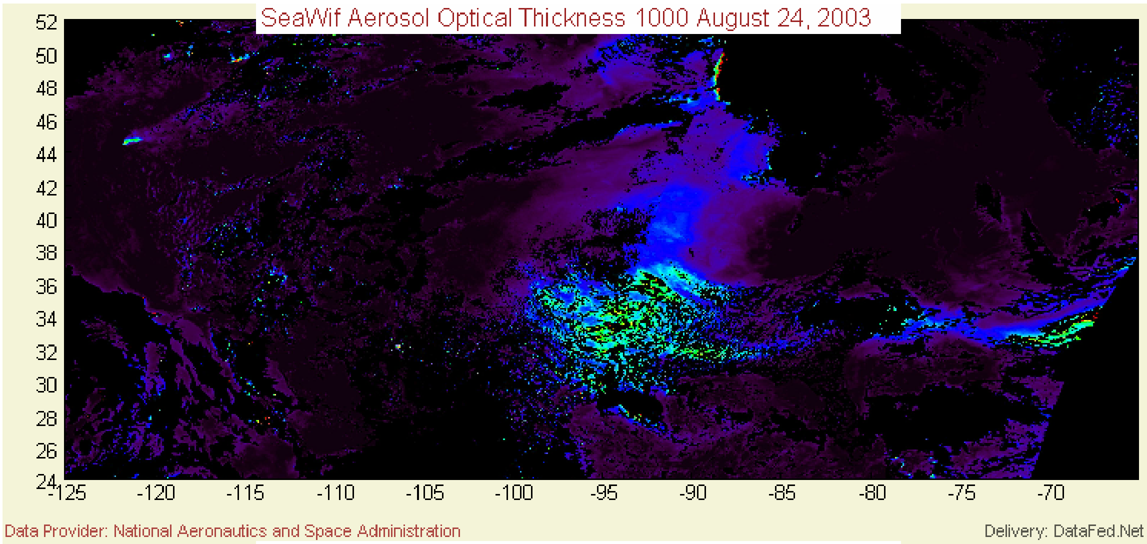
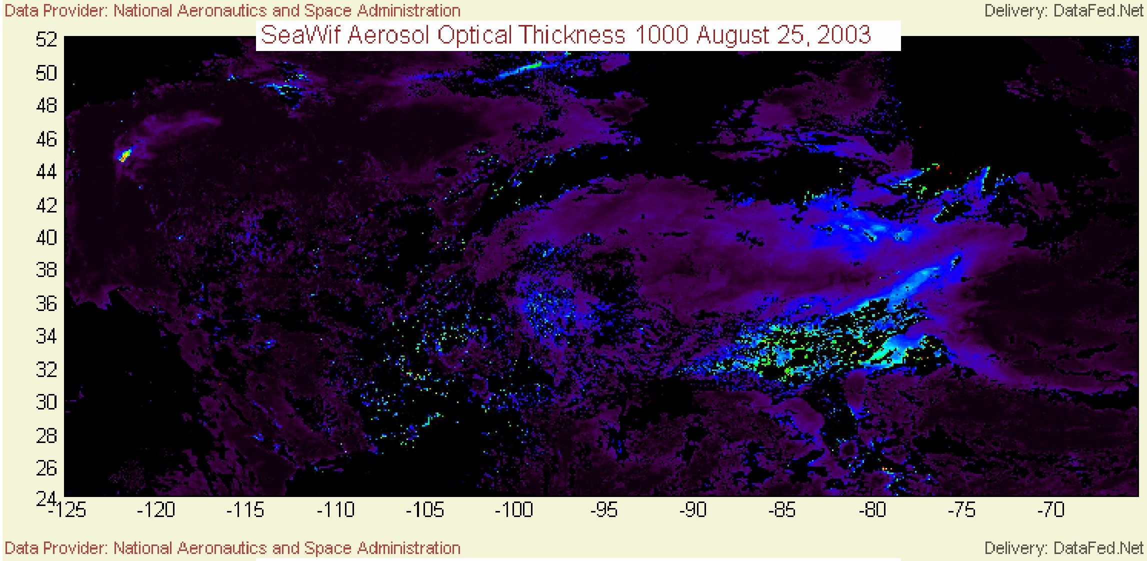
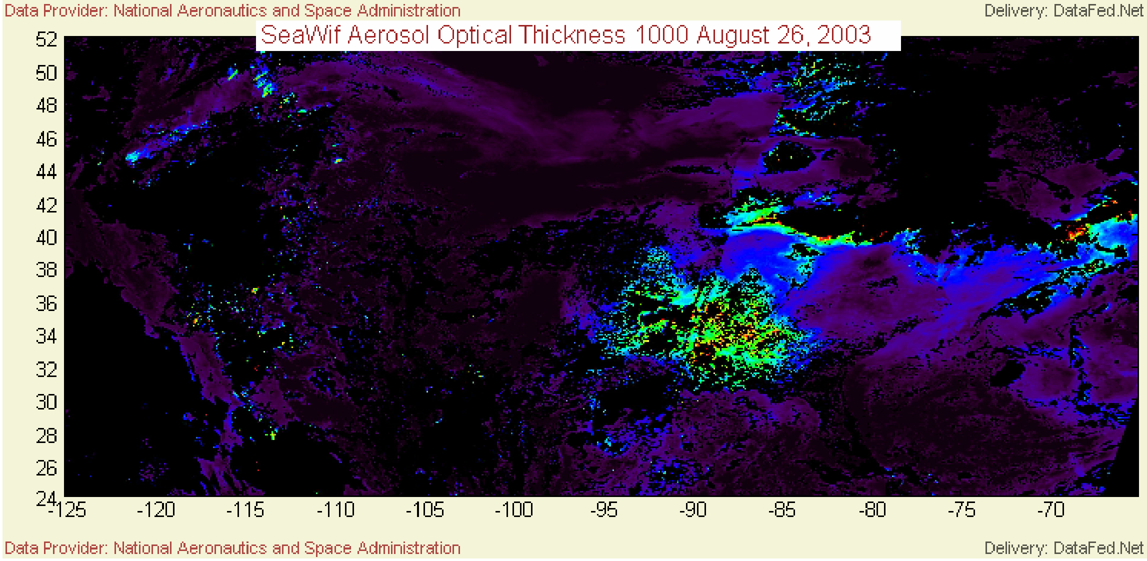
-90
-85
-80
-75
-70
Data Provider: National Aeronautics and Space Administration
Delivery: DataFed.Net


SeaWif Aerosol Optical Thickness 1000 August 24, 2003
52 50 48 46 44 42 40 38 36 34 32 30 28 26 24
-125 -120 -115 -110 -105 -100 -95 -90 -85 -80 -75 -70
Data Provider: National Aeronautics and Space Administration
Delivery: DataFed.Net


SeaWif Aerosol Optical Thickness 1000 August 25, 2003
52 50 48 46 44 42 40 38 36 34 32 30 28 26 24
-125 -120 -115 -110 -105 -100 -95 -90 -85 -80 -75 -70
Data Provider: National Aeronautics and Space Administration
Delivery: DataFed.Net

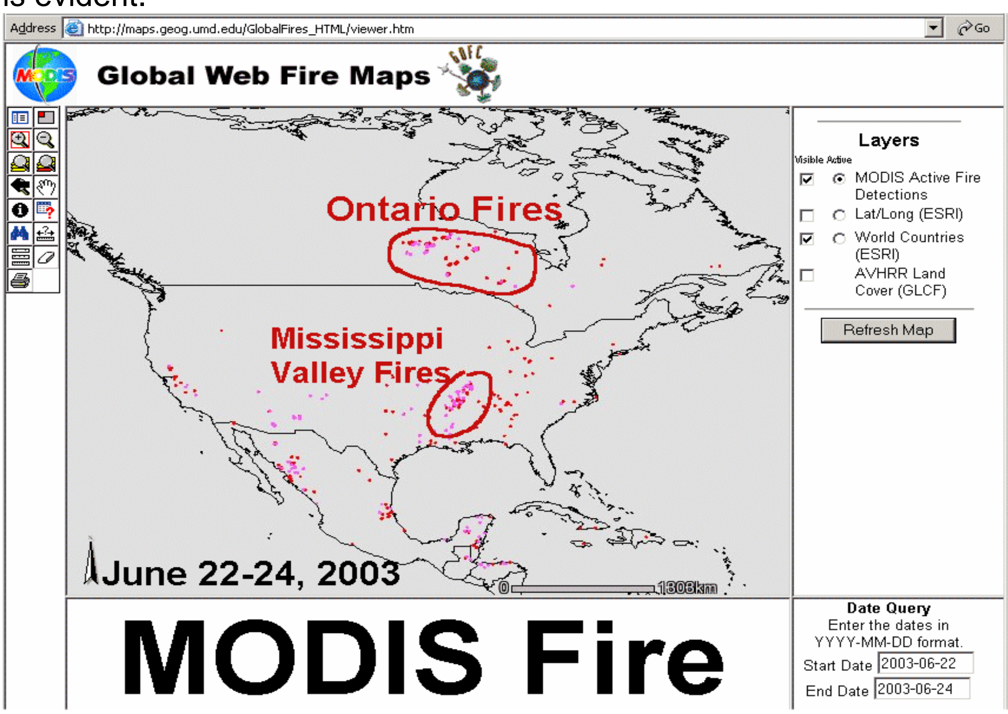

SeaWif Aerosol Optical Thickness 1000 August 26, 2003
52 50 48 46 44 42 40 38 36 34 32 30 28 26 24
-125 -120 -115 -110 -105 -100 -95 -90 -85 -80 -75 -70
Data Provider: National Aeronautics and Space Administration
Delivery: DataFed.Net

MODIS thumbnail- Actual Satellite Picture of Smoke from Northwest and Canada, August 22, 2003 Orientation: Great Lakes are in upper right of picture

If the Exact Source of the Smoke Incident Cannot be Identified

The smoke should be considered an exceptional event if it is mapped on Fire Hazard as a large event even if:

(1) the source of the smoke event is not able to be definitively located
(2) more than one fire emissions' source is possible (where emissions blend together from events on Fire Hazard). There is most certainly a contribution from agricultural burning during the June 23-26 Canadian Fire Event of 2003. Because the Mississippi Valley fires were most likely field burning to prepare for new crops, the emissions factors would be less than for Intermountain burning in Region 4 listed as 10 tons per acre on Table 13.1-1 of AP42. A reasonable emissions' number for wheat would be about 3-5 tons per acre. This is but a fraction of the emissions factors of boreal fires at 16 tons per acre, Table 13.1-1 in AP42, the minimum emission's factor for Alaska (Coastal Areas are listed as 60 tons per acre). On the same table, the factor given for the Pacific Northwest is 60 tons per acre. The Canadian fire emissions fall somewhere between 16 and 60. If the emissions factors are as high as 60 tons per acre as is attributed to the Northwest, there is no question as to where the origin of the bulk of the fire emissions was located. In the pictures of this event provided on pages 33, 34, and 35 the very large contribution from the Canadian Fires is evident.



This comment introduces an important issue: without expensive studies, source apportionment during multiple fire events cannot be determined except by estimating emissions using emissions factors and the size of the fire (which is basically the function of the Navy Aerosol Analysis and Prediction System- NAAPS- Smoke Surface Concentration Model). HYSPLIT models at different heights can go back to both fire areas at the same time on the same day. The farthest event will be modeled at the highest height, and the nearer event will model closer to or inside the boundary layer. Therefore, EPA must decide how EPA is going to evaluate an event that may involve more than one fire area and combined emissions from agricultural burning or prescribed burning and large wildfires.

Very large smoke areas plotted on Fire Hazard are usually emissions from very large fire areas. Normally NOAA also has extensive pictures available of the fire origin area itself. As has been previously stated Boreal Fires from Canada and Alaska produce 16 to 60 tons per acre of fuel where Kansas agricultural burning might produce 3 tons per acre. The Canadian Forest Service web site, http://fire.cfs.nrcan.gc.ca/facts_e.php says that boreal fires have high fuel consumption, high rates of fire spread, extremely high rates of sustained energy release, towering convection columns that can reach into the upper troposphere or stratosphere, and the fires can cause long range smoke transport.

Number of Days of the Event Should be Determined

In determining whether an event should be considered an exceptional event, the entire event should be studied, not just a single day out of the event. EPA will allow one day of an exceptional event sequence to be flagged with a status and not allow other days to be flagged in the same event. This happened with the Mexican Fires of 1998. Only days where satellite pictures indicated smoke over an area were allowed to be flagged, but days in between with compelling monitoring data were not. With 2.5, once an air mass has become homogenous, then the event can affect an area for days, especially since the settling time for 2.5 can be from 6 to 30 days.

A residence time graph Figure 2.1.2, page 2-3, (Hinds, 1982) published in EPA's ***Guidance for Network Design and Optimum Site Exposure for*** $\boldsymbol{PM_{2.5}}$ ***and*** $\boldsymbol{PM_{10}}$ indicates that $PM_{2.5}$ can remain in the air for a minimum of about 6 days and up to 30 days depending upon whether it is still or stirred.

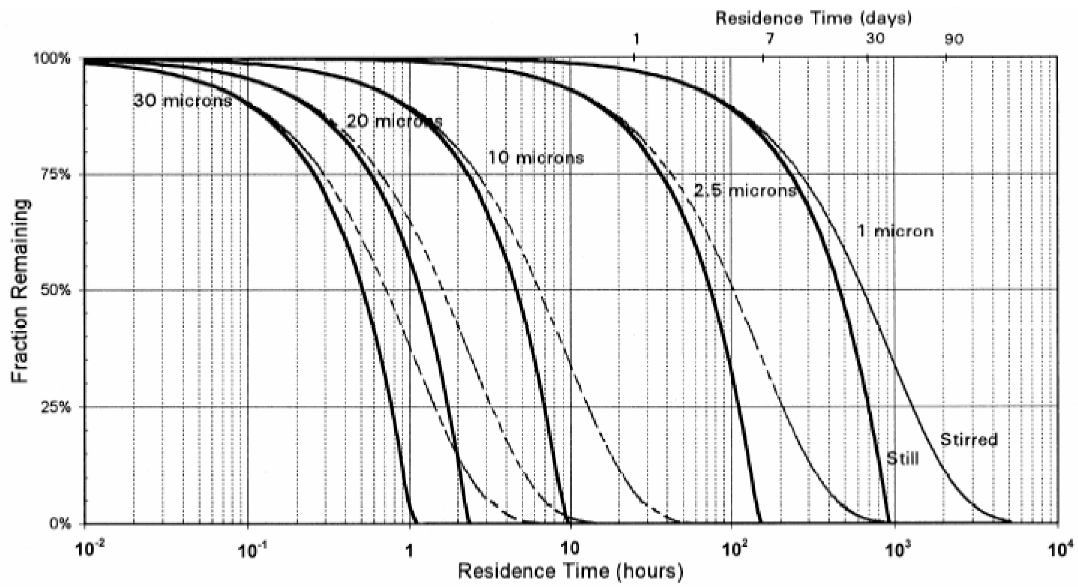


Figure 2.1.2. Residence times for homogeneously distributed particles of different aerodynamic diameters in a 100 m deep mixed layer. Gravitational settling is assumed for both still and stirred chamber models (Hinds, 1982).

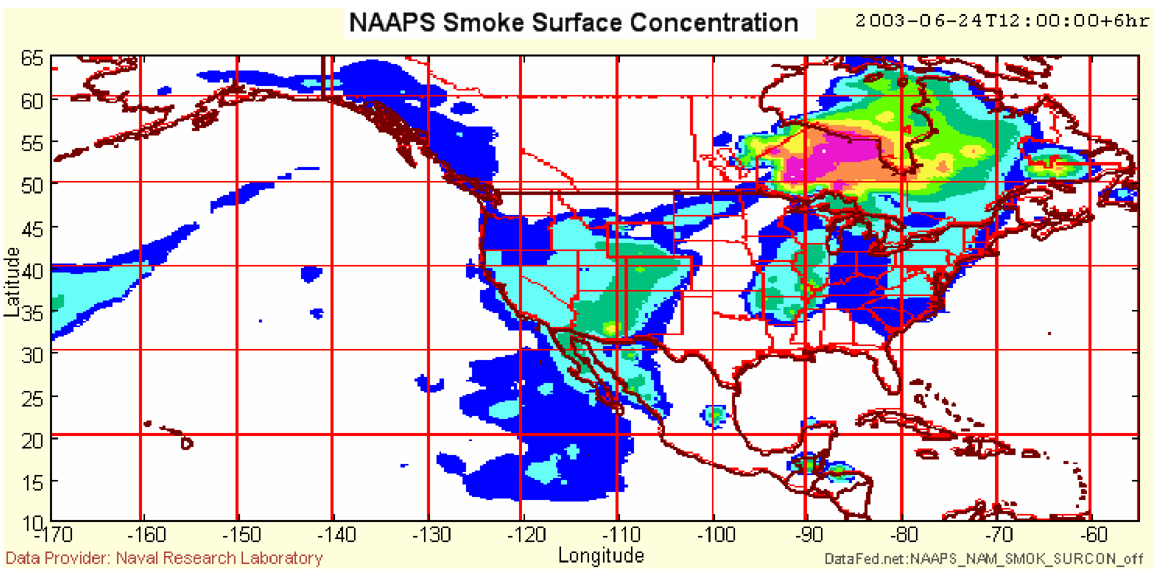
If Speciation Data Is Not Available

If speciation data is not available for the day before, the day of, or the day after an event at the location or a regionally comparable location, then as a substitute webcam pictures showing low visibility along with NAAPS smoke surface model pictures could be accepted. Or, some other specified picture and/or data should be determined acceptable. Regularly scheduled FRM monitoring data in conjunction with continuous data should also be acceptable if the data is shown to be elevated during an event for which there are satellite pictures.

NAAPS (the Navy Aerosol Analysis and Prediction System) Smoke Surface Model is a joint Navy, NASA, NOAA, and university project where the net emission for an individual fire is estimated by multiplying the total area burned, fuel mass available, average mass fraction of carbon in the fuel, the combustion factor, the average emission factor for particles, and the average time between burns. Chattanooga-Hamilton County has found fairly good correlation between actual satellite pictures and the model during most events. CHCAPCB has found that fire emissions usually spread beyond what NAAPS shows the fire emissions borders to be. The NAAPS models also illustrate on the June 24 and 25th pictures how difficult it is to separate emissions from Mississippi Valley agricultural fires and the Canadian Fire emissions.

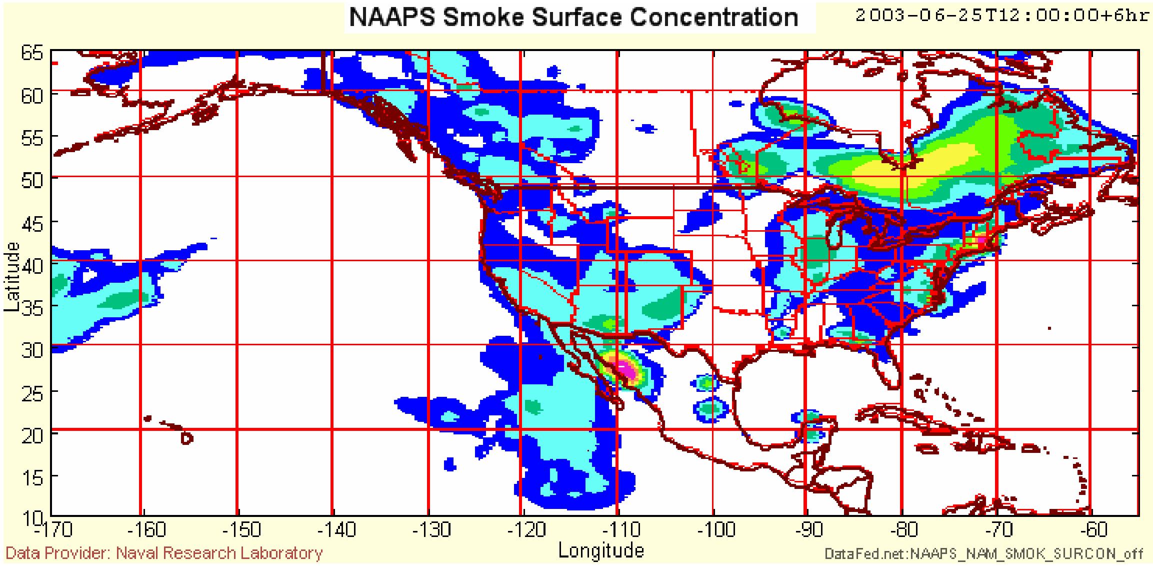
Example: June 2003 Canadian Fire Event

Great Smoky Mountains National Park
June 24, 2003
Visual range less than 30 miles



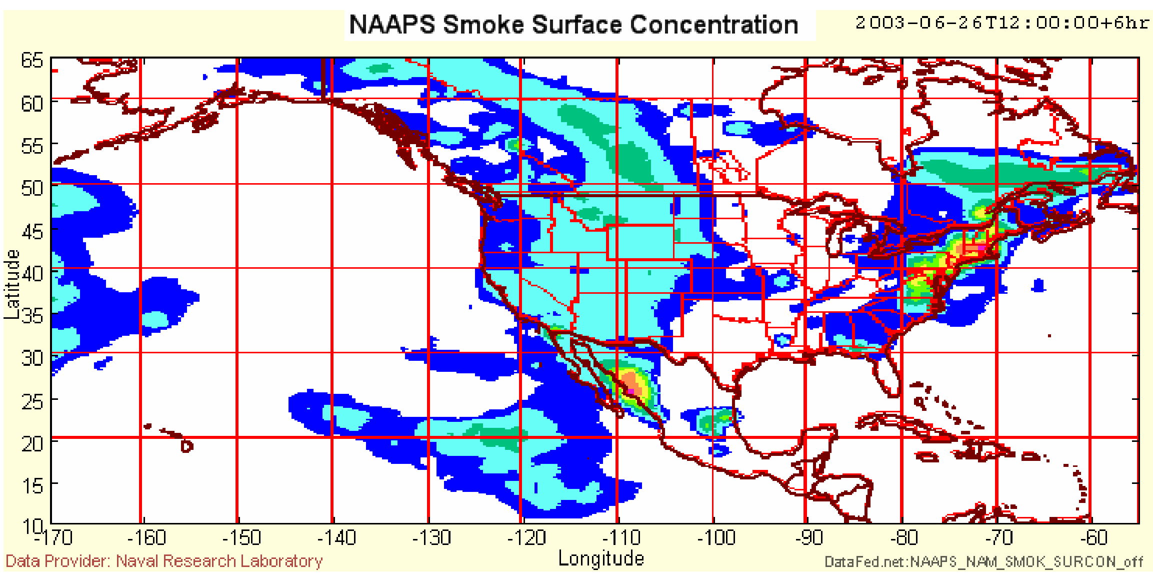
June 25, 2003

Visual range less than 15 miles

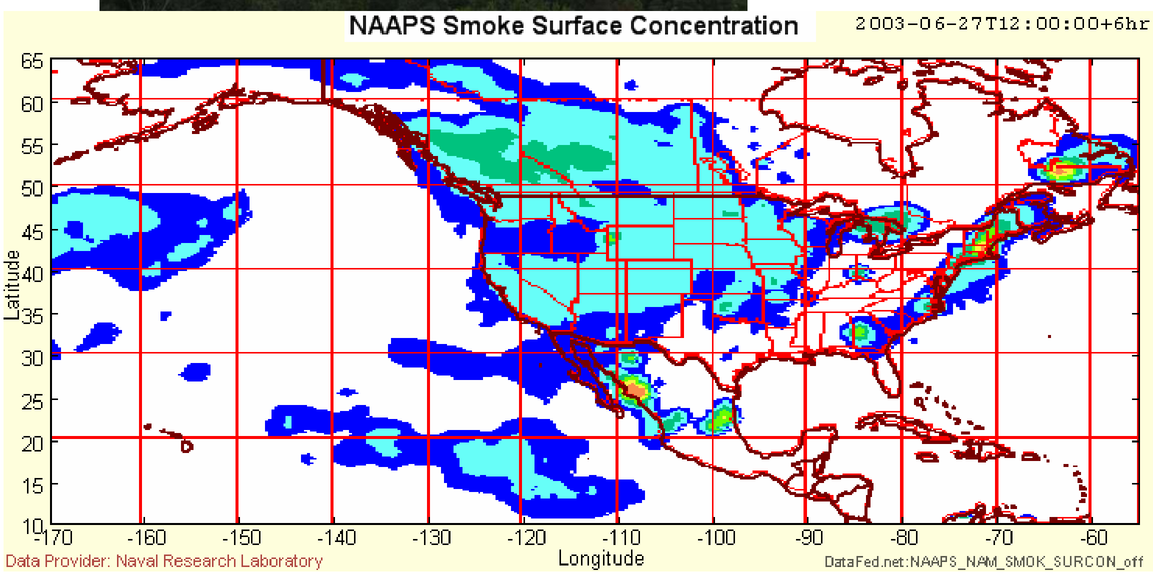


June 26, 2003

Visual range less than 13 miles



June 27, 2003
Visual Range less than 8 miles



Omission of Trajectory and Meteorological Data Requirement

For all of these circumstances, the omission of a requirement of trajectory models and meteorological data is deliberate. If the smoke or aerosol optical densities or thickness- depending on the product, is visible on the satellite pictures and the source is known and mapped on the Fire Hazard Map or there is event recognition on NASA's Earth Observatory or the CAPITA website, then the additional trajectory models and meteorological information are superfluous. Meteorologists do not readily recognize a satellite picture representation if the picture is in contrast with what the meteorological data seem to indicate. **But, an actual satellite picture is the reality.**

Burden of Proof

Even when events are widely recognized by NOAA, NASA, NRL, or university researchers, EPA is lagging behind on granting their recognition of the event itself. The entire burden of proof should not be on the state and local agencies who have severely limited resources. It is impossible to study the events properly and submit them in a timely manner. EPA personnel should be following the events as they happen and trying to determine the extent of the effect of the event while it is happening. Chattanooga-Hamilton County has alerted EPA employees at Region 4 and OAQPS on several occasions to events while they were occurring or just after they occurred.

EPA should be more familiar with the satellite products that are available. EPA has available free on the internet satellite data that is needed to make determinations- money does not need to be appropriated to purchase pictures (unless perhaps EPA wants SeaWiFS faster) and plan studies- but, there should be money appropriated for personnel. EPA should have satellite experts on staff to work in conjunction with their meteorologists because the determinations cannot be made solely through the meteorology. A purely meteorological review makes the review one-dimensional and can cause errors in the assessment. Satellite experts are needed on EPA's staff because NOAA is hesitant to interpret satellite pictures where the results may clash with national EPA policies.

For example, a meteorologist will argue that the June 2003 Canadian Fire incident could not have happened from a meteorological point of view. A past discussion with meteorologists is partially why that event is provided so many times in this document as an example of an event: SeaWiFS wide angle satellite pictures clearly indicate a Canadian fire event and CAPITA has collected a number of satellite pictures, animations, and modeling information about the event on their web site. **Therefore, the issue is not whether there was a Canadian Fire event that affected parts of the Eastern US, but whether the area in question was affected by the event.** The whole picture is not always evident until several satellite pictures are compared along with a study of the meteorology.

Flagging Data Below the Standard

Data below the daily $PM_{2.5}$ standard of 65 micrograms per cubic meter that are obviously affected by the event should be flagged and excluded from a nonattainment determination. This is essential because elevated data can greatly skew the yearly average, especially if there is minimal data recovery in a quarter. EPA's NAAQS are aimed at reducing local and regional pollution by targeting coal- fired power plants, industry, and motor vehicle emissions. The real amount of contribution to local and regional pollution from power plants, industry, and motor vehicles cannot be determined if exceptional events are factored in to the comparison against the NAAQS. As was previously stated, most areas are not attempting to flag known events.

EPA is requiring a determination of what portion of the measured air quality level is attributable to the event in question (Step 2 in Section 4.1). This is impossible to determine without a major study. It is difficult to determine the exact contribution of, for example, a large wildfire event if the smoke emissions occur in conjunction with regional pollution plumes. In the TRACE-P study it was found that mixed industrial pollution/biomass burning plumes had higher 2.5 than a pure biomass plume. Researchers in that study established the chemical difference between a mixed pollution plume and a pure biomass plume. The NAAPS daily models during smoke events usually indicate high sulfates on the sulfate model and high smoke on the smoke surface concentration model in the same areas which would seem to indicate a mixed plume (if one attributes sulfates to industrial pollution and total organic carbon and potassium to biomass burning). Thus, it does appear from studying NAAPS that a mixed plume occurs most often during smoke events, and the mixed plume is the most devastating to $PM_{2.5}$ mass. Although there are technical papers that indicate that sulfates increase with biomass burning, the majority seem to associate high sulfates with industrial pollution plumes (see attached technical review). But, determining how much is attributable to each in a mixed plume is too difficult to prove without a major study.

This introduces another important issue: If EPA persists in requiring a demonstration of what portion is attributable to the event, then EPA will have to provide a mechanism for that determination in a mixed plume-either by a model or a formula. Or, EPA could recognize the NAAPS Smoke Surface Concentration Model.

Alaskan and Canadian Fires do not have a limited impact as one can determine from the July 2002 and June 2003 pictures provided (response to Step 3 in Section 4.1). Mexican Fires can have extensive impact as the TOMS picture from 1998 illustrates. Northwestern US fires also are particularly invasive, due to the high fuel loading per acre and because the emissions travel easily on the Jet Stream to the southeast. The impact of all of these fires cover many states-sometimes nearly the entire US according to NAAPS. Is the reporting agency to be responsible for identifying the entire impact of the event or just identifying that it affected an area in question? On page 37 of this document are aerosol optical pictures of the April 2003 Kansas/Oklahoma agricultural burning that indicate that approximately 10 states had elevated AOT from the event in the three days that are represented.

If the Event Is Not Recognized by Scientists and Good Satellite Pictures Do Not Exist

An event should be considered substantiated if an event is not generally recognized by NOAA, NASA, NRL, or a respected university research group and good satellite pictures do not exist if:

(1) Extensive Meteorological Data is submitted confirming the possibility of an event

(2) HYSPLIT back trajectories are provided that show a trajectory to a large fire area or an area where the smoke has accumulated from a large fire area

(3) The event can be documented by significantly elevated $PM_{2.5}$, total organic carbon, potassium, calcium, and/ or other fire markers for either the day before, the day of, or the day after by speciation monitoring at the location or at a nearby location that is regionally representative such as IMPROVE network monitors

(4) If speciation data is not available: the event can be documented by a special study or regularly scheduled monitoring data that includes continuous 2.5 data

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Stagnation May Be Caused by Smoke Exceptional Events

Cloud Suppression Caused by Smoke

Hansen (NASA) et al [1997] described how dark colored particles like soot absorb incoming sunlight and warm the atmosphere relative to the surface. The authors' theory was that the warming effect reduced upward movement of moisture and reduced cloud formation. *Ackerman (NASA) et al* [2000] used a computer model to demonstrate the same phenomenon over the ocean. These researchers said that the heating at the top of the boundary layer burns away clouds by accelerating the process of evaporation of existing clouds and by suppressing the upward flow of moisture from the surface that is needed to form new clouds. A third researcher, *Koren (NASA) et al* [2004] discovered that cumulous cloud cover went from 40% to 0 in the presence of smoke. Koren and his associates drew the same conclusions as the earlier researchers-that smoke suppressed the formation of cumulous clouds at the surface. Because the air above the surface is warmed while the surface air is cooled, convection is limited.

(credit for this discussion is to NASA's Earth Observatory website *Clouds are Cooler than Smoke* by David Herring).

If these researchers are correct, the implications for pollution effects are clear. If smoke can cause the dissipation of cumulous clouds, then smoke can cause a contribution to elevated pollution levels that has not previously been considered by air pollution experts. Certainly aerosol transport is recognized. But, the effect of cloud reduction due to smoke infiltration as being a factor in elevated $PM_{2.5}$ is not widely recognized. If convection is limited, as these authors suggest, due to the temperature differential between the atmosphere and surface air, then smoke can contribute to stagnant weather conditions that would elevate fine particulate. This is the opposite of the generally accepted theory that stagnant weather causes the high particulate events.

Chattanooga-Hamilton County contacted Dr. Ilan Koren, one of the researchers of this topic referenced above, at NASA and asked if it is possible that a smoke event actually can cause stagnant conditions. He answered this by e-mail: *I think that you are right in assuming the possibility of smoke affecting the local dynamics. Actually, we are in the process of studying such effects over China, in places where the smoke is very thick and absorbing. The smoke can do a few things that will tend to stabilize the local atmospheric conditions:*

1) warming the aerosol layer – reducing the RH, drying the layer

2) cooling the surface

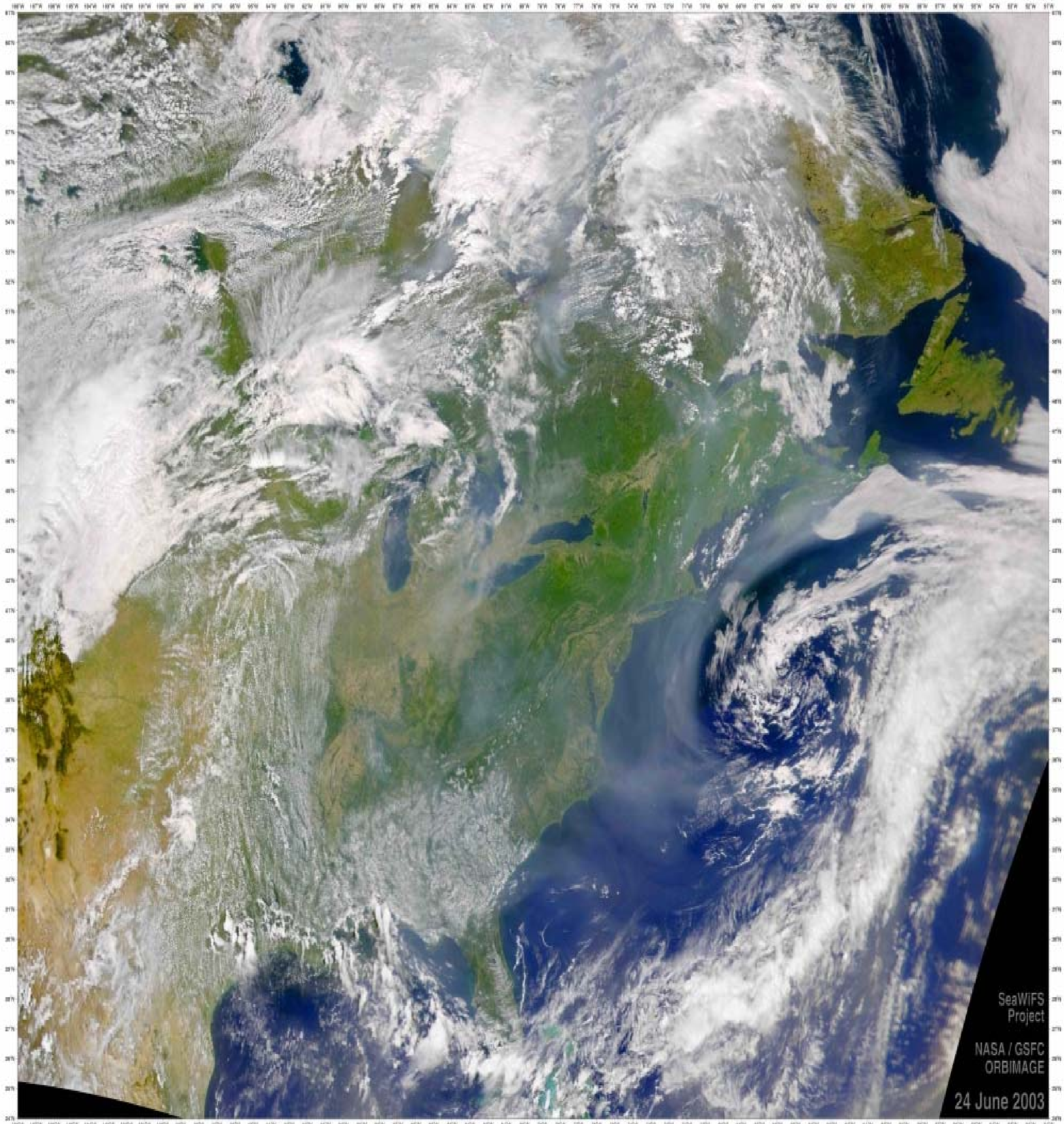
3) stabilizing the layer between the surface and the smoke and therefore suppressing upward fluxes (of humidity)

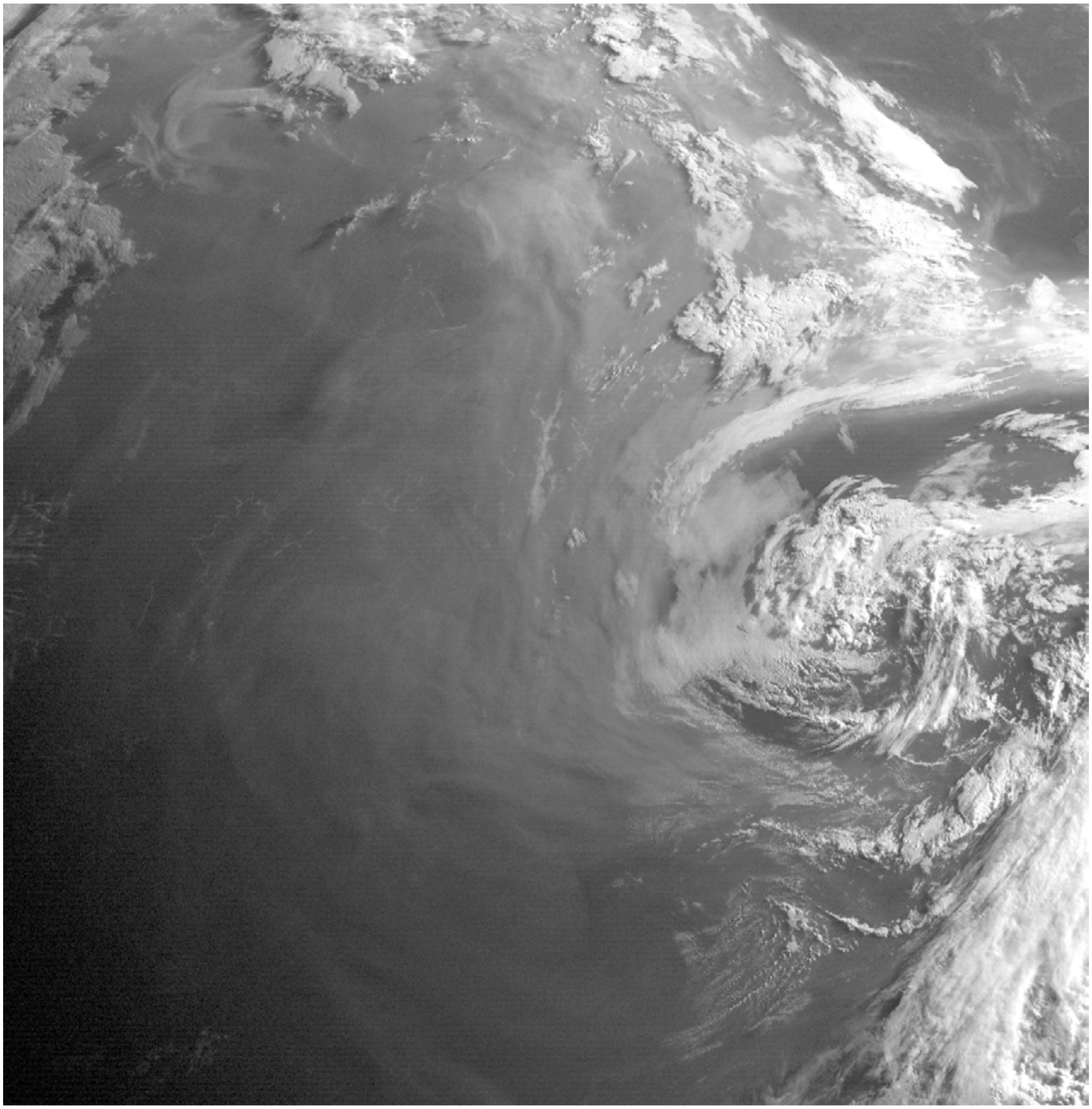
Scientists are now referring to this phenomenon as the indirect-radiative effect and it has become a recent topic addressed in the INTEX-NA 2004 study.

Since a smoke exceptional event can possibly be a causative factor in stagnant weather conditions, the fact that stagnant weather conditions exist during the event should not result in an event being disregarded.

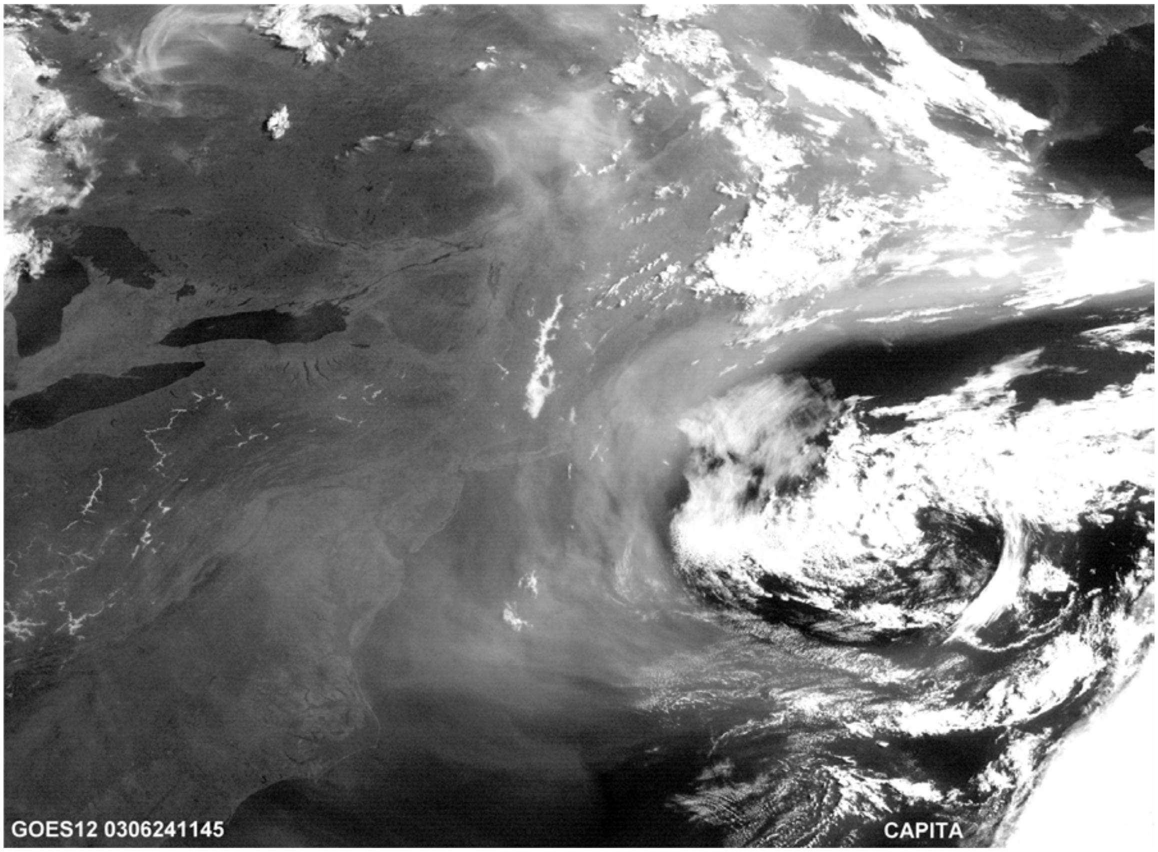
A SeaWif satellite picture of the June 24, 2003, Canadian fire event indicates this change in radiative effect might have happened during this event. There is an obvious large-scale hole in the clouds where the smoke was present. Pictures of the July 2002 event seem to indicate the same phenomenon.

SeaWif Land Reflectance for June 24, 2003





The orientation of this picture is a little different from the previous two. Use the Great Lakes and the North Carolina Coast for orientation.



Ozone Map for 8-hour averages from Airnow