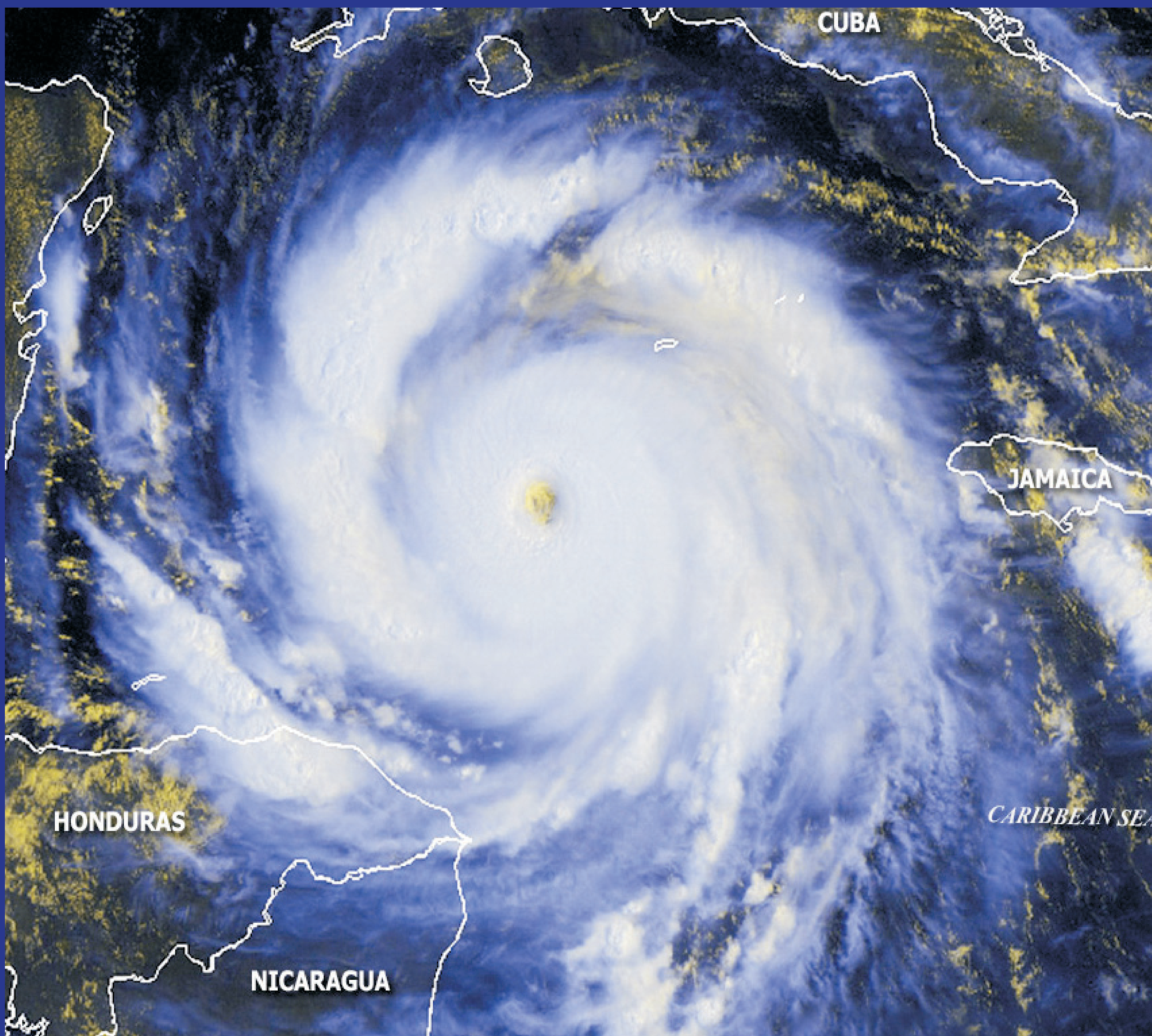
62nd Interdepartmental Hurricane Conference



Tropical Cyclone Operations and Research: Priorities for the Future

March 3-7, 2008
Charleston, S.C.

City of Charleston

Joseph P. Riley Jr.

Mayor

February 20, 2008

Dear Delegates:

I would like to welcome each of you attending the 62nd Interdepartmental Hurricane Conference annual event. We are pleased that you have chosen Charleston as the city to hold your special meeting.

While you are here, please take time to enjoy the exquisitely preserved architecture in this extraordinary setting with its Southern charm and grace, our genteel town is as much about its people as it is about history and the sights to see. Complete strangers will smile and say hello as you visit our sites, port, and exquisite restaurants. You will know you are in a unique place from the minute you arrive on "The Peninsula."

The citizens of Charleston recognize the important work that you do for our city and the country. Thank you for the unique contributions you make to our safety, security and preparedness.

Again, we are pleased to have all of you in Charleston and best wishes for a successful conference.

Most sincerely yours,

Joseph P. Riley, Jr.
Mayor, City of Charleston

JPR,jr./dm

P.O. Box 652, Charleston South Carolina, 29402

Telephone: 843-577-6970 Fax: 843-720-3827

UNITED STATES DEPARTMENT OF COMMERCE
The Under Secretary of Commerce
for Oceans and Atmosphere
Washington, D.C. 20230

March 3, 2008

Dear Colleagues:

Welcome to the 62nd Interdepartmental Hurricane Conference (IHC) and to the great city of Charleston, South Carolina! On behalf of all the interagency partners, including meteorology/oceanography operations and research and the emergency management community, I express my appreciation for your collective efforts to improve our Nation's hurricane forecast and warning program—the ultimate goal of the IHC.

Thank you for attending and actively participating. I wish you a highly productive and rewarding time together.

Sincerely,

Conrad C. Lautenbacher, Jr.
Vice Admiral, U.S. Navy (Ret.)
Under Secretary of Commerce for Oceans and Atmosphere
Chairman, Federal Committee for Meteorological
Services and Supporting Research

THE ADMINISTRATOR

OFCM

OFFICE OF THE FEDERAL COORDINATOR
FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

SUITE 1500, 8455 COLESVILLE ROAD
SILVER SPRING, MARYLAND 20910

March 3, 2008

Colleagues,

Welcome to the 62nd Interdepartmental Hurricane Conference! We are looking forward to a very informative and productive conference.

Last year's conference showcased the newly published, "Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead" and began addressing the recommendations. This year's conference focuses on one of the recommendations: to review Federal agency research and development activities and to develop an implementation strategy that addresses the research priorities summarized in the plan. The aim, as always, is to continue improving hurricane forecasts, warnings, and services.

In addition to the research priorities for tropical cyclones, other topics at this year's conference include:

- 2007 Tropical Cyclone Season in Review
- Observing the Tropical Cyclone and its Environment
- Tropical Cyclone Modeling and Prediction
- Field Experiments and Other Hurricane-Related Research/Projects
- Joint Hurricane Testbed: Project Updates and Plans for the Future
- Products and Services

Thank you again for attending the 62nd Interdepartmental Hurricane Conference. Enjoy the conference and also the great city of Charleston, South Carolina.

Sincere regards,

Samuel P. Williamson
Federal Coordinator for Meteorological Services and
Supporting Research

62nd Interdepartmental Hurricane Conference

Theme: Tropical Cyclone Operations and Research: Priorities for the Future

AGENDA

Monday, March 3, 2008

9:00 AM Early Registration *(9:00 AM-12:30 PM)*

Opening Session

12:30 PM	Conference Opening	Mr. Samuel P. Williamson Federal Coordinator for Meteorology
12:35 PM	Introduction of Mayor	Mr. Howard Chapman Executive Director, Charleston Area Regional Transportation Authority
12:40 PM	Welcome/Opening Remarks	The Honorable Joseph P. Riley, Jr. Mayor, Charleston, South Carolina
12:55 PM	Introductory Comments	Mr. Samuel P. Williamson Federal Coordinator for Meteorology
1:15 PM	Keynote Address	Ms. Mary M. Glackin Deputy Under Secretary for Oceans and Atmosphere (NOAA)
1:30 PM	Panel Introduction	Mr. Samuel P. Williamson Federal Coordinator for Meteorology
1:35 PM	**Panel:** *Priorities for Tropical Cyclone Research: A Senior Leader Perspective* **Moderator:** Dr. Elbert W. (Joe) Friday, Professor Emeritus, University of Oklahoma **Panelists:** **Dr. Alexander "Sandy" MacDonald,** Deputy Assistant Administrator for NOAA Research Laboratories and Cooperative Institutes **Mr. Robert Winokur,** Technical Director, Office of the Oceanographer and Navigator of the Navy **Dr. Jack Kaye,** Associate Director for Research, Earth Science Division, NASA **Dr. Fred Lewis,** Air Force Director of Weather **RDML (sel) David Titley,** Commander, Naval Meteorology and Oceanography Command **Dr. John "Jack" Hayes,** Assistant Administrator for Weather Services, NOAA	
3:00 PM	Introduction of Federal Agency Lead Representatives	Mr. Samuel P. Williamson Federal Coordinator for Meteorology

3:15 PM Afternoon Coffee/Soda Break *(3:15-3:45 PM)*

Session 1 Coordinator: Mr. Mark Welshinger (OFCM)

Session 1: The 2007 Tropical Cyclone Season in Review

Session Leaders Dr. Edward Rappaport (TPC/NHC) and CAPT John O'Hara (NMFC/JTWC		
3:45 PM	Overview of the 2007 Atlantic Hurricane Season	Richard D. Knabb (TPC/NHC); and M. Mainelli
4:00 PM	2007 Eastern North Pacific Hurricane Season Summary	Lixion A. Avila (TPC/NHC)
4:15 PM	2007 Atlantic and Eastern North Pacific Forecast Verification	James L. Franklin (TPC/NHC)
4:30 PM	Overview of the 2007 Central North Pacific Tropical Cyclone Season	James Weyman (CPHC)
4:45 PM	A Review of the Joint Typhoon Warning Center 2007 Tropical Cyclone Season	Lt Col Robert J. Falvey (JTWC)
5:00 PM	53 WRS 2007 Hurricane Season Reconnaissance Summary	Lt Col Rich Harter (53 WRS)
5:15 PM	NOAA Aircraft Operations Center (AOC) 2007 Season Summary and Future Plans	James D. McFadden (NOAA AOC); and J. Parrish

6:30 PM Reception/Icebreaker *(6:30-8:00 PM)*

<u>Tuesday, March 4, 2008</u>

7:00 AM Continental Breakfast

7:50 AM Opening/Administrative Remarks *Dr. Paul Try (OFCM/STC)*

8:00 AM Invited Presentation Mr. X. William (Bill) Proenza
Director, National Weather Service Southern Region

Sessions 2 and 3 Coordinator: Dr. Paul Try (OFCM/STC)

Session 2: Workshop: Interagency Priorities for Tropical Cyclone Research

8:15-10:15 AM	**Moderator:**	Dr. Robert Serafin, NCAR Director Emeritus
	Panelists:	Mr. Fred Toepfer, NOAA Dr. Scott Braun, NASA/GSFC Dr. Simon Chang, Naval Research Laboratory Ms. Pamela Stephens, NSF

10:15 AM Morning Coffee Break *(10:15-11:00 AM)*

Session 3: Observing the Tropical Cyclone and its Environment, Part 1

Session Leader Dr. Jim McFadden (NOAA/AOC) and Lt Col Jonathan Talbot (53rd WRS, AFRC)		
11:00 AM	Use of the Operational Air Force Reserve Stepped Frequency Microwave Radiometer during the 2007 Hurricane Season	Lt Col Jonathan Talbot (53d Weather Reconnaissance Squadron)
11:15 AM	The First Year of SFMR Surface Wind Observations from AFRC WC-130J Aircraft: Impact on Operational Hurricane Forecasts and Warnings, and Outlook for Use in WPAC TCS-08 Experiment	Peter G. Black (Naval Research Laboratory and SAIC, Inc.); and J. Talbot, I. Popstefanija, E. Uhlhorn and J. Franklin
11:30 AM	Evaluation of the 2007 Hurricane Season Deployment of Operational SFMR Instruments on the Hurricane Hunter Fleet	Ivan PopStefanija **(**ProSensing Inc.) and M. Goodberlet
11:45 AM	Radar Sea Level Pressure Remote Sensing for Improvements in Hurricane Predictions	Bing Lin (NASA Langley Research Center); and Q. Min, Y. Hu, S. Harrah, R.Lawrence, and D. Fralick
12:00 PM	Storm Surge Measurement with an Airborne Scanning Radar Altimeter	Edward. J. Walsh (NASA/Goddard Space Flight Center); and C. W. Wright, W. B. Krabill, W. A. Shaffer, S. R. Baig, M. Peng, L. J. Pietrafesa, A. W. Garcia, F. D. Marks, Jr., P. G. Black, J. Sonntag, and B. D. Beckley

12:15 PM Lunch (on your own) *(12:15-1:30 PM)*

Sessions 4 and 5 Coordinator: Mr. Mike Babcock (OFCM)

Session 4: Observing the Tropical Cyclone and its Environment, Part 2

Session Leaders Mr. Chris Velden (UW-CIMSS) and Dr. Paul Chang (NOAA/NESDIS)		
1:30 PM	The Hurricane and Severe Storm Sentinel (HS^3)	Scott Braun (NASA/GSFC); and M. Craig and P. Newman
1:45 PM	CIMSS Satellite Consensus (SATCON) Tropical Cyclone Intensity Estimation Algorithm	Derrick Herndon (Cooperative Institute for Meteorological Satellite Studies) and C. Velden
2:00 PM	Baseline Instruments for the GOES-R Series: Providing Major Improvements to Hurricane Observations	James J. Gurka (NOAA/NESDIS); and T. Schmit, T. Renkevens, M. DeMaria, and C. Velden

2:15 PM	Will we soon have a Geostationary Microwave Sounder, and what can we do with it?	Bjorn Lambrigtsen (Jet Propulsion Laboratory)
2:30 PM	Initial User Impact Studies of the Next Generation Ocean Surface Vector Wind Scatterometer Mission (XOVWM) in Operational Weather Forecasting and Warning at NOAA	Zorana Jelenak (Center for Satellite Applications and Research) and P. Chang

2:45 PM Afternoon Break *(2:45-3:30 PM)*

Session 5: Observing the Tropical Cyclone and its Environment, Part 3

Session Leaders Ms. Robbie Hood (NASA/MSFC) and Mr. Jeffrey Hawkins (NRL-Monterey)		
3:30 PM	Impact Assessment of Potential Hurricane Imaging Radiometer (HIRAD) Tropical Cyclone Observations from Aircraft and Satellite Platforms	Robbie Hood (NASA Marshall Space Center); and M.C. Bailey, P. Black, S. Chen, C. Hennon, M. James, J. Johnson, L. Jones, T. Miller, C. Ruf, K.Stephens, and E. Uhlhorn
3:45 PM	GPS-Based Tropical Storm Sensing Results for 2003-2007 Storm Seasons	Stephen J. Katzberg (NASA-Langley Research Center); and B. Lin
4:00 PM	Coastal Ocean Observing Systems: Oceanic Current and Wave Response to Hurricane Jeanne Detected by Wellen Radars	Lynn K. Shay (Rosenstiel School of Marine and Atmospheric Science); and J. Martinez-Pedraja, M. Powell, B. Haus, and Jodi Brewster
4:15 PM	Phased Array Radar: Applications to Landfalling Tropical Cyclones	Pam Heinselman (Cooperative Institute for Mesoscale Meteorological Studies); and D. Forsyth
4:30 PM	Hurricane Mesonet Initiative	Jay Titlow (WeatherFlow, Inc.); and B. Rule and K. Gurley

4:45 PM One-Minute Poster Previews
Coordinator: Lt Col Mark Fitzgerald (Air Force/OFCM)

5:10 PM **OFCM Staff Meeting** *(5:10-5:30 PM)*

5:30 PM Poster Session *(5:30-7:30 PM)* Plus Snacks and Cash Bar

P01	Comparison of Airborne SFMR, Dvorak Satellite and Best Track Maximum Surface Wind Estimates in Atlantic Tropical Cyclones: 1998-2006	Peter. G. Black (Naval Research Lab and SAIC, Inc.); and S. Mullins, C. S. Velden, M. D. Powell, E. W. Uhlhorn, T. L. Olander and A. Burton
P02	Pacific Islands Land-Ocean Typhoon Experiment (PILOT Experiment) and Typhoon Man-yi at Guam	C. E. Pollock (US Army Engineer R&D Center); and S. J. Boc, A. W. Garcia, J. P. Rhee, and M. A. Merrifield
P03	The Saharan Air Layer and Improved Understanding of Atlantic Hurricane Formation and Intensification: Hope or Hype?	Scott Braun (NASA/GSFC); and C. Shie
P04	Interactive Hurricane Surge Visualization for Charleston, South Carolina	Frank Alsheimer (National Weather Service); and R. Bright, B. Lindner, G. Miller, D. Timmons and J. Johnson
P05	Introducing the new CIMSS Tropical Cyclone Web Site	Christopher Velden (University of Wisconsin-CIMSS)
P06	Chesapeake Inundation Prediction System (CIPS)	Jay Titlow (WeatherFlow, Inc.) and Chesapeake Research Consortium
P07	Status of the NASA High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)	Gerald Heymsfield (NASA Goddard Space Flight Center); and L. Li, J. Carswell, D. Schaubert, J. Cretico, and M. Vega
P08	The Experimental Graphical Tropical Weather Outlook (GTWO): 2007 Results and Future Plans	Jamie R. Rhome (National Hurricane Center); and D. Brown, J. Franklin, C. Landsea, C. Lauer, and C. Juckins
P09	Monitoring Tropical Cyclone Impacts on Domestic Agriculture at the U.S. Department of Agriculture	Harlan Shannon (U.S. Department of Agriculture)
P10	Transportation Resources that May Be Used to Respond to Weather-Related Incidents	Kimberly C. Vásconez (Emergency Transportation Operations Team); and L. Radow

Wednesday, March 5, 2008

7:00 AM Continental Breakfast

7:50 AM Opening/Administrative Remarks *Lt Col Mark Fitzgerald (Air Force/OFCM)*

Sessions 6 and 7 Coordinator: Lt Col Mark Fitzgerald (Air Force/OFCM)

Session 6: Tropical Cyclone Modeling and Prediction, Part 1

Session Leaders Prof Russell Elsberry (NPS) and Dr. Mark DeMaria (NESDIS)		
8:00 AM	Advancement of the HWRF for Next Generation Hurricane Prediction at NCEP's Environmental Modeling Center	Naomi Surgi (NCEP/EMC); and R. Tuleya, Qingfu-Lui, V. Tallapragada, and Y. Kwon
8:15 AM	Improvements to GFDN Planned for Operational Implementation in 2008	Morris A. Bender (Geophysical Fluid Dynamics Laboratory); and I. Ginis, R. Yablonsky, and B. Thomas
8:30 AM	Hurricane Model Transitions to Operations at NCEP/EMC	Robert E. Tuleya (NCEP/EMC); and Y. Kwon, V. Tallapragada, and N. Surgi
8:45 AM	Modeling of Coupled Wind-Wave-Current Processes in Hurricanes	Isaac Ginis (Graduate School of Oceanography, University of Rhode Island); and Y. Fan, T. Hara and B. Thomas
9:00 AM	Evaluation and Improvement of Ocean Model Parameterizations for NCEP Operations	Lynn K. Shay (RSMAS); and G. Halliwell, J. Brewster, W. J. Teague
9:15 AM	Impact of Satellite Observations on Tropical Cyclone Track Forecasts	James S. Goerss (Naval Research Laboratory)

9:30 AM Morning Break (*9:30-10:15 AM)*

Session 7: Tropical Cyclone Modeling and Prediction, Part 2

Session Leaders Dr. Naomi Surgi (NCEP) and Dr. Nick Shay (RSMAS/UM)		
10:15 AM	The Impact of Horizontal Resolution on the Structure and Intensity of Hurricane Dennis in HWRF Simulations	Robert Rogers (NOAA/AOML Hurricane Research Division) and S. Gopalakrishnan
10:30 AM	Evaluation and Improvement of Spray-Modified Air-Sea Enthalpy and Momentum Flux Parameterizations for Operational Hurricane Prediction	Jian-Wen Bao (NOAA/Earth System Research Laboratory); and C. Fairall, S. Michelson, and L. Bianco
10:45 AM	Prediction of Consensus TC Track Forecast Error and Correctors to Improve Consensus TC Track Forecasts	James S. Goerss (Naval Research Laboratory)
11:00 AM	An Objective Tool for Identifying Hurricane Secondary Eyewall Formation	James Kossin (Cooperative Institute for Meteorological Satellite Studies) and M. Sitkowski
11:15 AM	The Quality of Pre-Advisory Model Guidance	Mike Fiorino (Techniques Development and Applications Unit, NHC)
11:30 AM	Tropical Cyclone Dressing: Next-Generation Goerss Predicted Consensus Error (GPCE)	Jim Hansen (Naval Research Laboratory)

11:45 AM Lunch (on your own) *(11:45 AM-1:00 PM)*

Sessions 8 and 9 Coordinator: Mr. Floyd Hauth (OFCM/STC)

Session 8: Field Experiments and Other Hurricane-related Research/Projects

Session Leaders Dr. Frank Marks (AOML/HRD) and Mr. Daniel Catlett (DHS/FEMA)		
1:00 PM	An Overview of the THORPEX-Pacific Asian Regional Campaign (T-PARC) during August-September 2008	Patrick Harr (Naval Postgraduate School); and R. Elsberry, D. Parsons and J. Moore
1:15 PM	Tropical Cyclone Structure (TCS08) Field Experiment in the Western North Pacific During 2008	Russell L. Elsberry (Naval Post-graduate School); and R. Ferek, S. Chang, D. Eleuterio, and P. Harr
1:30 PM	A review of the NOAA IFEX hurricane field experiments conducted in 2007	John Gamache (NOAA/AOML Hurricane Research Division)
1:45 PM	Research on Landfalling Hurricanes Utilizing Mobile Research Platforms	Kevin Knupp (University of Alabama in Huntsville); and D. Cecil, W. Petersen, and L. Carey
2:00 PM	A Roadmap for a Seamless Topobathy Surface	Lindy Dingerson (NOAA Coastal Services Center)
2:15 PM	Advanced Hydrologic Prediction Service (AHPS) Flood Inundation Maps	Douglas C. Marcy (NOAA Coastal Services Center); and G. Austin, T. Graziano, and V. Hom

2:30 PM Afternoon Break (2*:30-3:00 PM)*

Session 9: Joint Hurricane Testbed: Project Updates and Plans for the Future

Session Leaders Dr. Chris Landsea (TPC/NHC) and Ms. Shirley Murillo (HRD)		
3:00 PM	The Joint Hurricane Testbed (JHT): 2008 Update	Jiann-Gwo Jiing (Joint Hurricane Testbed); and C. Landsea and S. Murillo
3:15 PM	An Improved Wind Probability Program: A Joint Hurricane Testbed Project Update	Mark DeMaria (NOAA/NESDIS); and S. Kidder, P. Harr, J. Knaff, and C. Lauer
3:30 PM	Operational Use of Near-Real-Time Sea Surface Directional Wave Spectra Generated from NOAA Scanning Radar Altimeter Range Measurements	Edward J. Walsh (NASA/Goddard Space Flight Center)

3:45 PM	Validation and Processing Tools for the Air Force Reserve Command 53rd Weather Reconnaissance Squadron WC-130J Multi-Aircraft SFMR Systems	James Carswell (Remote Sensing Solutions); and P. Black, E. Uhlhorn, and P. Chang
4:00 PM	Web-ATCF, User Requirements, and Intensity Consensus	Charles R. Sampson (Naval Research Laboratory); and A. Schrader, C. Sisko, C. Lauer and A. Krautkramer
4:15 PM	High Wind Drag Coefficient and Sea Surface Roughness in Shallow Water	Mark D. Powell (NOAA/AOML Hurricane Research Division

5:15 PM **OFCM Staff Meeting** *(5:15-5:45 PM)*

7:00 PM **Conference Banquet** (Cash Bar at 6:30 PM)

Banquet Address (~7:45 PM): Dr. Steve Lyons, Tropical Weather Expert
The Weather Channel

Presentation of the Hagemeyer Award

Thursday, March 6, 2008

7:00 AM Continental Breakfast

7:50 AM Opening/Administrative Remarks *Mr. Floyd Hauth (OFCM/STC)*

Sessions 10 and 11 Coordinator: Mr. Floyd Hauth (OFCM/STC)

Session 10: Products and Services

Session Leaders Mr. Paul Trotter (NWS WFO New Orleans/Baton Rouge) and Mr. Scott Kiser (NOAA/NWS)		
8:00 AM	FEMA’s Utilization of Tropical Forecasts and Other Products	Michael Buckley (Mitigation Directorate, FEMA)
8:15 AM	A Preliminary Verification of the National Hurricane Center’s Tropical Cyclone Wind Speed Probability Forecast Product	Jaclyn A. Shafer (Florida Institute of Technology); and M. McAleenan, W. Roeder, K. Winters, S. Lazarus, and M. Splitt
8:30 AM	Verification of NHC Forecasts of Extratropical Transition	Jack Beven (National Hurricane Center)
8:45 AM	The NESDIS Tropical Cyclone Formation Probability Product: An Overview of Past Performance and Future Plans	Andrea B. Schumacher (CIRA); and M. DeMaria, J. Knaff, and D. Brown
9:00 AM	New and Updated Operational Tropical Cyclone Wind Products	John A. Knaff (NESDIS/StAR – RAMMB); and A. Krautkramer, M. DeMaria, and A. Schumacher

9:15 AM	The Future of NOAA's Seasonal Atlantic Hurricane Outlooks	Eric Blake (National Hurricane Center); and R. Pasch, C. Landsea, and G. Bell
9:30 AM	Federal Aviation Administration (FAA) Air Traffic Control System Command Center Hurricane Procedures	Danny Sims (FAA System Operations) and M. Brennan

9:45 AM Morning Coffee Break *(9:45-10:15 AM)*

Session 11: Workshop - Strong Local Partnerships: The Keys to Success

10:15 AM -12:15 PM	**Moderator:**	Dr. Denise Stephenson Hawk, NCAR Associate Director and Director of the SERE Laboratory
	Panelists:	Ms. Cathy Haynes, Director, Charleston County Emergency Preparedness Division Mr. Walt Dickerson, Director, Mobile County Emergency Management Agency Mr. Michael Emlaw, Meteorologist-in-Charge, NWS Weather Forecast Office, Charleston, SC Dr. Betty Hearn Morrow, Professor Emeritus Florida International University, Consulting Sociologist Ms. Naomi Moye, Hazards Communications Consultant Mr. Ronald Glaser, Sandia National Laboratories, Program Manager, Integrated Public Alert and Warning System

12:15 PM Lunch (on your own) *(12:15-1:30 PM)*

1:30 PM Working Group for Hurricane and Winter Storms Operations and Research Meeting
Dr. Edward Rappaport (TPC/NHC), Chairperson

4:00 PM **OFCM Staff Meeting** *(4:00-4:30 PM)*

Friday, March 7, 2008

7:30 AM Continental Breakfast

Final Plenary Session Coordinator: Mr. Mark Welshinger (OFCM)

Final Plenary Session

8:15 AM	Opening/Administrative Remarks	Mr. Mark Welshinger (OFCM)
8:20 AM	WG/HWSOR: Action Item Review	Dr. Edward Rappaport (TPC/NHC) Chairperson, WG/HWSOR
8:45 AM	Workshop Wrap-ups *Workshop: Interagency Priorities for Tropical Cyclone Research* *Workshop: Strong Local Partnerships: The Keys to Success*	 Dr. Paul D. Try (OFCM/STC) Dr. Denise Stephenson Hawk (NCAR Associate Director and Director of the SERE Laboratory)
9:15 AM	Final Wrap-up	Mr. Samuel P. Williamson Federal Coordinator
9:45 AM	Adjourn	

Session 1
The 2007 Tropical Cyclone Season in Review

SESSION 1

Overview of the 2007 Atlantic Hurricane Season

Richard D. Knabb and Michelle M. Mainelli
NOAA/NWS/NCEP/National Hurricane Center

The overall activity during the 2007 Atlantic hurricane season was near average. There were fifteen tropical and subtropical named storms, six of which became hurricanes, with two becoming major hurricanes (category three or greater on the Saffir-Simpson Hurricane Scale). For the 40-year period 1967-2006, the averages for named storms, hurricanes and major hurricanes are eleven, six, and two, respectively. Even though the number of named storms was above average, including a record-tying eight storms that formed in September, many of these storms were short-lived. In terms of the NOAA Accumulated Cyclone Energy (ACE) index, which measures the collective strength and duration of named storms and hurricanes, the season produced about 84% of the 1951-2000 median activity. This percentage is the lowest observed since 2002.

Despite the near-average overall activity, the impacts from Atlantic basin tropical cyclones were devastating outside of the United States. Two category five hurricanes made landfall in the basin during the season. Dean struck the Yucatan Peninsula of Mexico at category five strength in August, and soon thereafter came ashore in mainland Mexico as a category two hurricane. Felix then hit northeastern Nicaragua as a category five hurricane in early September. Hurricane Lorenzo later struck mainland Mexico in nearly the same location as Dean's final landfall. Late-season Noel and post-season Olga dumped heavy rains that caused flooding, mud slides, and large loss of life in the Caribbean. Overall, the combined international death toll from tropical cyclones during 2007 was about 380. One hurricane, one tropical storm, and three tropical depressions made landfall in the United States during 2007, causing a total of 10 fatalities and about $50 million in damages.

Highlights of the 2007 Eastern North Pacific Hurricane Season

Lixion A. Avila

NOAA/NWS/NCEP/National Hurricane Center

Highlights of the 2007 eastern North Pacific hurricane season will be reviewed. The eastern North Pacific produced fewer than average tropical storms and hurricanes. Henriette was the only hurricane of this basin that made landfall in Mexico this season producing nine deaths.

2007 Atlantic and Eastern North Pacific Forecast Verification

James L. Franklin

NOAA/NWS/National Hurricane Center

NHC official track forecasts in the Atlantic basin set records for accuracy from 36-92 h in 2007. On average, the official forecasts beat the consensus models at some time periods, but trailed the best of the dynamical models. Forecast errors continued their downward trends, although track forecast skill has been relatively flat over the past few seasons. Among the guidance models, the GFS and UKMET provided the best dynamical track guidance, while the GFDL and NOGAPS had relatively poor years. ECMWF performance in 2007 was mediocre. The HWRF, in its first year as an operational model, mostly outperformed the GFDL for track. It is important to note that the Atlantic forecast sample size in 2007 was quite small.

Atlantic official intensity errors in 2007 were up considerably over 2006. This can be explained in large part because of the inherent difficulty of the season's storms (at least as measured by Decay-SHIFOR), and in fact forecast skill was higher in 2007 than it was in 2006. The best intensity models in 2007 were the statistical models (which traditionally have been the best performers). The HWRF intensity guidance was not quite as good as the GFDL guidance. Post-season investigation suggests that a four-model intensity consensus (DSHP/LGEM/HWFI/GHMI) has promise.

For the eastern North Pacific, official track forecast errors set records at 12-36 h. The official forecast beat the dynamical models on average, but not the model consensus. As has been observed previously, there is a much larger difference between the consensus and its comprising models for this basin than for the Atlantic. In contrast to its performance for track in the Atlantic, the HWRF lagged the GFDL by a significant margin in the eastern Pacific.

Eastern North Pacific official intensity forecasts added considerable value over the objective guidance through 48 h, but lagged the guidance thereafter. The best intensity guidance was statistical, with the LGEM a relatively strong performer, although none of the objective guidance models was consistently skillful. The four-model intensity consensus, however, did show skill. The HWRF did not perform well, particularly at longer forecast periods.

Overview of the 2007 Central North Pacific Tropical Cyclone Season

James Weyman
(James.weyman@noaa.gov)

Central Pacific Hurricane Center/Weather Forecast Office Honolulu

In the central north Pacific, the 2007 tropical cyclone season activity was below normal with only two systems occurring within the area of responsibility of the Central Pacific Hurricane Center (CPHC) which extends from 140W longitude to 180 longitude. On average, between four and five tropical cyclones are observed yearly in the central Pacific. This has ranged from zero, most recently as 1979, to 11 in 1992 and 1994.

In 2007, no tropical cyclones formed in the central Pacific basin. Both tropical cyclones which did occur entered the central Pacific from the east. Tropical Depression Cosme weakened to a tropical depression just prior to crossing 140W on July 19, 2007 and moved almost directly westward before dissipating on July 22. Showers and thunderstorms north of Cosme reached the east and southeast slopes of the Big Island during the afternoon of 20 July, and persisted through the morning of 21 July. Highest rainfall totals were 4 to 7 inches.

Hurricane Flossie crossed longitude 140°W into the Central North Pacific during the morning of August 11, 2007. Flossie was a very impressive hurricane with a distinct eye embedded within a solid eye wall and a very impressive upper level outflow pattern. The hurricane maintained sustained wind speeds of 130 to 140 mph for the next two days. Hurricane Flossie was a relatively small system with winds speeds of 39 mph or higher extending out about 100 miles from the center. CPHC issued a hurricane watch for the Big Island of Hawaii early on the morning of August 13 due to the close proximity of the projected track as well as the intensity forecast which maintained Flossie as a strong hurricane at 36 hours. A tropical storm warning was hoisted for the Big Island later that same morning. Fortunately, due to the vertical wind shear took, Flossie weakened to a tropical storm on August 14. As it was passing south of the islands of Oahu and Kauai late on August15, Flossie weakened to a tropical depression due to increased vertical wind shear. CPHC issued its final advisory on August 16. Even though the center of Flossie passed about 100 miles due south of South Point on the Big Island of Hawaii, it generated very large waves along the southeast facing shoreline of that island. The height of the largest wave faces was estimated to be near 20 feet. Sustained winds of at least 39 mph were recorded on South Point as Flossie passed by, but no significant rainfall was reported.

A Review of the Joint Typhoon Warning Center
2007 Tropical Cyclone Season

Lt Col Robert J. Falvey
(robert.falvey@navy.mil)

Joint Typhoon Warning Center

A review of the overall tropical cyclone activity with discussion of significant events for the JTWC forecast area of responsibility, the Pacific and Indian Ocean, will be presented.

53d Weather Reconnaissance Squadron
2007 Hurricane Season Reconnaissance Summary

Lt Col Richard M. Harter, USAFR
(Richard.Harter@keesler.af.mil)

53d Weather Reconnaissance Squadron

The 2007 Hurricane season was much like 2006 in the sense that our total number of flying hours was similar. This season, the Hawaii deployment to fly Hurricane FLOSSIE increased our flying time in the Pacific. Flying hours in the Atlantic were dominated by two category 5 hurricanes—DEAN and FELIX, and a late season storm, Hurricane NOEL. During the 2007 hurricane season, five of the ten 53d Weather Reconnaissance Squadron's WC-130J aircraft were outfitted with the Stepped Frequency Microwave Radiometer. For the first time in our squadron's long history, surface wind speed and rainfall rate data were disseminated from the aircraft to the customer.

NOAA Aircraft Operations Center (AOC)
2007 Seasonal Summary and Future Plans

Jim McFadden
Jim.d.mcfadden@noaa.gov

Jack Parrish,
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NOAA Aircraft Operations Center

After a relatively slow season in 2006 and with the seasonal forecast calling for above average storm activity in 2007, AOC was ready with its two WP-3Ds and G-IVSP aircraft to perform often and long during the summer months. In 2006, the NOAA aircraft flew a combined total of only 36 missions for 213.3 hours – one of the lowest totals in its history. Of this total, the G-IV flew only seven surveillance missions and nine research flights supporting the Saharan Air Layer (SALEX) experiment conducted by the Hurricane Research Division (HRD) of NOAA for a total of 113.3 hours. Fortunately, the season was light as AOC could only provide, because of maintenance and other programmatic activities, one P-3 to support the hurricane program. This lone aircraft flew a total of 20 flights totaling 100 hours supporting SALEX and Ocean Winds research along with operational tasking for Hurricane Awareness, ocean heat budget and Tropical Storm reconnaissance.

The 2007 season turned out to be a mixed bag with the total flight time again being quite low by 2005 standards. This was particularly for the G-IV, which flew only seven surveillance missions and two transit flights for a total of 64.8 hours. The seven surveillance missions were in support of operations for Hurricanes Dean and Noel and TD #10 and matched the number of such flights in 2006. There were, however, no research flights in 2007.

The P-3s had a little better time of it flying 37 missions for 207.9 hours in support of ocean winds research and the newly instituted 3-Dimensional Tail Doppler radar effort proposed jointly by HRD and NOAA's Environmental Modeling Center. These missions, designed to acquire data for assimilation into the HWRF model in an effort to improve intensity forecasts, were flown out of St. Croix and Barbados into Hurricane Felix and Tropical Storms Gabrielle and Ingrid. One additional flight was performed in support of the NASA/NOAA Aerosonde mission into Hurricane Noel.

Future plans for 2008 include the installation of the tail Doppler radar on the G-IV (on-going at the moment), completion of the depot level maintenance on N44RF, NOAA's third P-3, completion of the hi-speed SATCOM upgrades on the P-3s, completion of the development of a new generation dropsonde, continued work on the P-3 radar upgrades and development of the new aircraft data system. Navigation and avionics upgrades to both P-3s have been completed.

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Use of the Operational Air Force Reserve Stepped Frequency Microwave Radiometer during the 2007 Hurricane Season

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The Stepped Frequency Microwave Radiometer (SFMR) is currently being installed on Air Force Reserve Command WC-130J's. The first aircraft test flight using a Lockheed Martin designed pod and Pro Sensing SFMR radiometer was conducted in November 2006 from Lockheed Martin Marietta. The test was successful and showed that usable data can be obtained from 500ft above the ocean surface to nearly 30,000ft. The first operational aircraft was delivered in May of 2007. During the 2007 Hurricane Season, four aircraft were operational with the Pro Sensing SFMR. The equipment generally worked well although several software issues were noted. All 10 aircraft are expected to be complete by March of 2008.

The First Year of SFMR Surface Wind Observations from AFRC WC-130J Aircraft: Impact on Operational Hurricane Forecasts and Warnings, and Outlook for Use in WPAC TCS-08 Experiment

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For the first time since the development of the Stepped Frequency Microwave Radiometer began 25 years ago, implementation of the SFMR sensor on the WC-130J operational reconnaissance aircraft of the 53rd Weather Reconnaissance Squadron was realized during the 2007 hurricane season. Three of 10 aircraft were equipped with SFMR sensors at the beginning of the season, increasing to five near the end of the season. This development led to SFMR surface wind observations being sent to forecasters on almost 80% of operational reconnaissance flights during the 2007 season. Although a number of operational problems were encountered, nearly all were solved during the season leading to an unprecedented new data set of surface wind observations in tropical systems ranging from depressions to CAT 5 hurricanes. Key new observations are highlighted and a summary of impacts on 2007 operational forecasts is presented. Plans for use of the new operational SFMR technology from a WC-130J aircraft during an ONR-sponsored experiment next season in the Western Pacific, staging from Guam, (called TCS-08) will be outlined.

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Evaluation of the 2007 Hurricane Season Deployment of Operational SFMR Instruments on the Hurricane Hunter Fleet

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During the 2007 hurricane season, the Hurricane Hunter squadron of C-130J aircraft stationed at Keesler AFB, MS operated six Stepped Frequency Microwave Radiometers (SFMRs) installed on six different aircraft. At the same time NOAA/AOC in Tampa, FL operated two WP-3D Orion aircrafts each equipped with an operational SFMR. Installation of multiple SFMRs allowed for near-continuous coverage of ocean surface winds during the 2007 hurricane season. These instruments operated successfully throughout the season, providing ocean surface wind speed surveillance of all of the major 2007 hurricanes including Dean and Felix.

As an example, between August 16th and 21st Hurricane Hunter C-130J aircraft competed 6 missions through Hurricane Dean totaling 40 hours of surface wind measurements. SFMR data collected in Dean included 56 maximum wind speed measurements, corresponding to 56 eyewall penetrations by the reconnaissance aircraft. Data presented will include cases when SFMR-derived maximum winds exceeded wind speeds captured with dropsondes. The ability to continuously monitor surface levels winds, allowing precise determination of the location and amplitude of the wind speed maximum, is a significant benefit provided by SFMR.

After each reconnaissance flight, SFMR data was off-loaded and analyzed. This analysis indicated occasional problems with the convergence of the wind speed algorithm under high wind conditions, which required minor modifications to the SFMR processing code. An updated release of the real-time processing code was released and installed on all operational SFMR's prior to the end of the hurricane season.

In conclusion, we will report on the status of the task of equipping the entire C-130J Hurricane Hunter squadron with SFMRs for the 2008 hurricane season.

Radar Sea Level Pressure Remote Sensing for Improvements in Hurricane Predictions

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Weather forecast model assimilations demonstrate that sea level pressure measurements have great impact on hurricane predictions of intensity and track. However, the pressure measurements currently can only be obtained from in situ observations including buoy, ship and dropsonde measurements, which are sparse in spatial coverage and expensive to implement. There are no pressure remote sensing methods available even in experimental stages. This study considers use active microwave systems to obtain the differential O_2 absorption at 50-56 GHz bands to fill the observational gap. The numerical simulation results for homogeneous sea surface backgrounds show that the rms errors of the instantaneous surface pressure estimates can be as low as 4 mb. With multiple radar measurements the uncertainty in the sea surface pressure estimates would drop to about 1 mb which is similar to conventional in situ buoy measurements. This considered active system will have great potential for weather observations and other meteorological applications, especially for forecasts of hurricanes. Case studies show that with remotely sensed sea surface barometric pressure data, the errors of predicted hurricane center sea level pressures, the most important indicator of hurricane intensity, in weather prediction models would reduce to about 1/3 of the whole range of possible variations of hurricane center pressure. The uncertainties in predicted landfall positions or hurricane tracks would also shrink greatly from ~350 km to within 100 km. Based on our proposed concept, we have developed a prototype O_2-band radar system and integrated it into an aircraft for the test to prove the concept of the differential O_2 absorption for the pressure remote sensing measurements. Our first field campaign results of pressure measurements and the simulation of the pressure remote sensing for hurricane predictions will be presented.

Storm Surge Measurement with an Airborne Scanning Radar Altimeter

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Over the years, hurricane track and intensity forecasts and storm surge models and the digital terrain and bathymetry data they depend on have improved significantly. Strides have also been made in knowledge of the detailed variation of the surface wind field driving the surge. The area of least improvement has been in obtaining data on the details of the temporal/spatial variation of the storm surge dome of water as it evolves and inundates the land to evaluate the performance of the numerical models. Tide gages in the vicinity of the landfall are frequently destroyed by the surge. Survey crews dispatched after the event provide no temporal information and only indirect indications of the maximum surge envelope over land. The landfall of Hurricane Bonnie on 26 August 1998, with a surge less than 2 m, provided an excellent opportunity to demonstrate the potential benefits of direct airborne measurement of the temporal/spatial evolution of storm surge. Despite a 160 m variation in aircraft altitude, an 11.5 m variation in the elevation of the mean sea surface relative to the ellipsoid over the flight track, and the tidal variation over the 5 hour data acquisition interval, a survey-quality Global Positioning System (GPS) aircraft trajectory allowed the NASA Scanning Radar Altimeter (SRA) carried by a NOAA hurricane research aircraft to produce storm surge measurements that generally fell between the predictions of the NOAA SLOSH model and the North Carolina State University storm surge model. Most of the differences between observations and models are probably attributable to the tracks used. SLOSH used the NHC 6-hour interval Best Track while NCSU used the 2-hour interval eye locations issued in the NHC advisories during landfall, which diverted Bonnie 25 km west and advanced it 3 hours faster than the Best Track. Eye fixes by the SRA aircraft indicated a forward speed and track between the two NHC tracks. The NASA SRA has been decommissioned, but storm surge measurement is a potential capability of the new NOAA SRA which should be operational for the 2008 hurricane season.

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The Hurricane and Severe Storm Sentinel (HS^3)

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Hurricanes are the most destructive natural phenomena that confront the United States. The Hurricane and Severe Storm Sentinel (HS^3) is being developed to address the scientific goals of understanding hurricane genesis, intensification, and tracks, and potentially the implications of a warming climate on hurricanes. The project is designed for a 3 year duration and will use the NASA Global Hawk (GH). The GH is an autonomous unmanned aerial system (UAS) with a demonstrated high altitude (65,000 ft.), long duration surveillance (>30 hrs.), extreme range (18,000 km), and heavy payload (2000 lbs.) capability. The GH is based at NASA Dryden and should become science operational in March 2009 after a January 2009 series of test flights. We are proposing a three-phase project. The first phase of HS^3 would involve some simple flights from Dryden in the August-September 2009 period to sample both Atlantic and Eastern Pacific tropical cyclones with a basic payload that includes both imaging systems and dropsondes. This first phase is intended to test both the instrumentation and GH capabilities. The second phase of HS^3 would include a more complete payload that will be flown in August-September 2010 in conjunction with a planned NASA Weather Focus Area mission targeting hurricanes. This enhanced payload may include a cloud lidar, a Doppler radar, dropsondes, and multi-spectral imagers. The 3rd phase of HS^3 would be flown in August-September 2011. This 3rd phase would involve a remote deployment of the GH to the U. S. East Coast for closer proximity to Atlantic tropical cyclones. The payload for this 3rd phase might also include a wind lidar. By combining a wind lidar with a Doppler radar and dropsondes, this 3rd phase would provide high resolution (vertical and horizontal) wind profiles in both cloud systems and clear air.

CIMSS Satellite Consensus (SATCON) Tropical Cyclone Intensity Estimation Algorithm

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SATCON (SATellite CONsensus) is an algorithm that produces a weighted consensus of objective satellite-based estimates to determine Tropical Cyclone (TC) current intensity. The contemporary version of SATCON employs the CIMSS ADT (Advanced Dvorak Technique which uses geostationary IR imagery), the CIMSS AMSU (microwave sounder) method, and the CIRA AMSU method as consensus members. Each of the SATCON members have well-documented error characteristics which are situational dependant. For example the ADT skill is dependant on the IR scene type while the AMSU methods performance is primarily a function of instrument resolution. SATCON uses these error characteristics to assign weights to each member. The result is an estimate that is superior in skill to the individual members.

Initial work on this project involved evaluating a simple weighting scheme that produced a weighted consensus of the individual estimates based on each methods error characteristics. Results of this work suggested additional improvement could be gained using a cross-platform information sharing approach. Each algorithm contains parametric information that can be used by other members. Once corrected, the improved members can then be combined into a consensus estimate. For example both of the AMSU methods suffer from sub-sampling when the TC eye falls in between the AMSU scan positions which are spaced as much as 100 km apart. The CIMSS AMSU method uses information from the AMSU-B 89 Ghz channel to correct for this sub-sampling. A similar robust relationship exists between the CIRA AMSU error and the 89 Ghz signal thus the AMSU-B information can be used to correct the CIRA estimates of both MSLP and MSW. The ADT algorithm was developed using reconnaissance MSLP. Currently there is no correction made for TC's located in anomalous environmental pressure regions such as monsoon troughs or within the sub-tropical ridge. Therefore estimates of environmental pressure can be used to adjust the ADT estimates. The ADT produces estimates of eye size when there is a clear well-defined eye in the IR imagery. The AMSU methods can benefit from the ADT eye size estimates by using this parameter to correct for sub-sampling due to instrument resolution. Finally the ADT and CIRA AMSU methods were developed using MSW data that intrinsically includes storm motion. The average storm motion of a TC in the Atlantic is roughly 11 knots. Storm motions that significantly deviate from this value are added to the ADT and CIRA AMSU estimates in order to account for changes in MSW due to motion. Once all corrections are applied the SATCON weighted consensus is produced.

A development sample consisting of storms from 1999-2006 (N=258) coincident with reconnaissance was used to develop the member weights and assess SATCON skill. One requirement for skill is that SATCON must be superior to a simple average of the members. An independent evaluation was then conducted using 2007 storms in both the Atlantic and Eastern Pacific for cases when reconnaissance was available. Results indicate that SATCON estimates of both MSW and MSLP are superior to both the individual members and a simple average of the members for both the developmental and independent data sets.

SATCON web page: http://cimss.ssec.wisc.edu/tropic2/real-time/satcon/

Baseline Instruments for the GOES-R Series: Providing Major Improvements to Hurricane Observations

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In order to meet the requirements, documented by the Geostationary Operational Environmental Satellite (GOES) user communities, the instruments designated for the GOES-R series include an Advanced Baseline Imager (ABI), a Geostationary Lightning Mapper (GLM), space weather and solar instruments. This paper will focus on the instruments of primary interest to hurricane forecasters: the ABI and GLM.

The Advanced Baseline Imager (ABI) is a state of the art, 16-band imager covering 6 visible (VIS) to near-infrared (NIR) bands (0.47 um to 2.25 um), and 10 infrared (IR) bands (3.9 um to 13.3 um). Spatial resolutions are band dependent, 0.5 km at nadir for broadband VIS, 1.0 km for NIR and 2.0 km for IR. The ABI will be capable of scanning the Full Disk (FD) in approximately 5 minutes, although routine full disk scans every 15 minutes are likely. ABI will improve every product from the current GOES Imager and will introduce a host of new products.

The Geostationary Lightning Mapper (GLM) will complement today's operational ground based lightning detection systems, which only provide information on cloud to ground strikes over land, with information on total lightning flash rate (including both cloud to cloud and cloud to ground), over both land and adjacent oceans. The GLM will provide nearly continuous information on lightning flash rates, leading to improved: severe thunderstorm forecasts and warnings, aviation weather services, and lightning climatology.

The additional channels on ABI together with vastly improved radiometrics, spatial and temporal resolutions will provide significantly improved satellite derived winds in the storms environment and resultant improvements in model forecasts. It will also mean more frequent and accurate estimates of hurricane intensity based on pattern recognition, such as the Dvorak technique. The capability of observing the convective towers within the storm as often as every 30 seconds holds the potential for better understanding the mechanism for rapid intensification. The three water vapour channels, the 8.5 µm band, along with the restoration of the split window channel to better detect the Saharan dust layer, will promote a better understanding of the conditions leading to intensification or weakening. The new ozone channel (9.6 µm) will reveal information about troposphere/stratosphere exchanges, which may also be important for intensity changes. Likewise the capability to nearly continuously monitor the trends of total lightning flash rate will lead to a better understanding of the role of lightning in the hurricane life cycle.

Will we soon have a Geostationary Microwave Sounder, and what can we do with it?

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A year ago the National Research Council released its "decadal survey" of NASA and NOAA Earth space missions. Among the 15 missions recommended for NASA was one called the "Precipitation and All-weather Temperature and Humidity" mission (PATH). A "MW array spectrometer" was identified as the presumed instrument payload for PATH. Such an instrument, the Geostationary Synthetic Thinned Aperture Radiometer (GeoSTAR), has been developed at NASA's Jet Propulsion Laboratory, and it is likely that it will be implemented for a space mission in the near future. First conceived in 1998 for a NASA New Millennium Program mission and subsequently developed in 2003-2006 as a proof-of-concept prototype under the NASA Instrument Incubator Program, it will fill a serious gap in our Earth remote sensing capabilities – namely the lack of a microwave atmospheric sounder in geostationary orbit. GeoSTAR is a microwave sounder with the same capabilities as now available on low earth orbiting (LEO) satellites with the Advanced Microwave Sounding Unit (AMSU) system. Providing such a capability in geostationary orbit (GEO) has long been a goal for NOAA and NASA, since the GEO vantage point offers key advantages over LEO – such as a continuous and uninterrupted view of the entire life cycle of storms and hurricanes. Due to the very large antenna aperture needed for a GEO microwave sounder to provide the required spatial resolution, it has not been possible to develop such instruments until now. Only infrared sounders have been feasible, but they are severely hampered by clouds – which is not a problem for microwave sounders. GeoSTAR overcomes those difficulties by using a new approach to synthesize a large aperture, and the development of the GeoSTAR concept – and the proof provided by the prototype – therefore makes a GEO microwave sounder possible. NOAA has had a strong interest in GeoSTAR as a potential payload on a future series of geostationary weather satellites, and an intriguing possibility is to fly GeoSTAR as a Mission Of Opportunity on one of the first two satellites in the new GOES-R series, which will have unallocated payload space available due to the cancellation of the Hyperspectral Environmental Suite (HES). This space could be used for a GeoSTAR demonstration mission. One scenario would be for NASA to build the GeoSTAR instrument and NOAA to provide the platform and launch services. GeoSTAR will provide a number of measurements that are crucial for the monitoring and prediction of hurricanes and severe storms, including hemispheric 3-dimensional temperature, humidity and cloud liquid water fields, rain rates and rain totals, tropospheric wind vectors, sea surface temperature, and parameters associated with deep convection and atmospheric instability. Many of these are key to the detection of sudden intensification and weakening and can be used to improve the forecast models in this area. All are provided everywhere and all the time – every 15-20 minutes, even in the presence of clouds. With its ability to map out the three-dimensional atmospheric structure on a continual basis, GeoSTAR will significantly enhance our ability to observe hurricanes and other severe storms and would greatly improve the GOES-R capabilities in these areas. We discuss the GeoSTAR concept and basic design, the performance of the prototype, and the most important hurricane applications that will be possible with GeoSTAR.
The work reported on here was performed at the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration.

Initial User Impact Studies of the Next Generation Ocean Surface Vector Wind Scatterometer Mission (XOVWM) in Operational Weather Forecasting and Warning at NOAA

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Satellite ocean surface vector wind (OSVW) data from the NASA QuikSCAT research mission have become an extremely valuable tool in NOAA's operational marine and tropical cyclone weather forecasting and warning operations. The next challenge for global satellite OSVW measurements in the United States is to make the transition from a research capability to a sustained operational capability. NOAA is currently working with NASA's Jet Propulsion Laboratory (JPL) to study two OSVW mission options: (i) a QuikSCAT-equivalent capability and (ii) a more advanced satellite OSVW capability (XOVWM). The impacts that QuikSCAT wind measurements have had on NWS forecasts and warnings were reviewed at NOAA's Operational Ocean Surface Winds Workshop held in June 2006. What will be presented here are the results of a study to estimate the impact that OSVW measurements obtained from a next-generation scatterometer (XOVWM), rather than a QuikSCAT-equivalent scatterometer, could have on NOAA's operational weather forecasting and warnings. One focus of this study is on the anticipated performance, using simulated observations, of a next-generation scatterometer in hurricanes, where QuikSCAT has exhibited significant limitations.

To achieve the study goals we investigated the differences in performance between the two OSVW mission options in tropical cyclones, extratropical cyclones, and coastal wind jet events using simulated wind retrievals based on the design of both the QuikSCAT-equivalent instrument and XOVWM. The first set of studies as it applies to cyclones at sea assessed the extent that the increased resolution and decreased sensitivity to rain of with XOVWM, as compared to a QuikSCAT-equivalent capability, will result in:

- More reliable estimates of tropical cyclone intensity through all stages of development, from tropical depression to major hurricane
- Improved analysis of tropical cyclone wind field structure (34, 50, and 64 kt radii), which could contribute to more refined coastal watch/warning areas
- More accurate tracking of tropical cyclone centers and earlier identification of developing systems, contributing to more accurate initial motion estimates and numerical model initialization
- More accurate maximum wind estimates of extratropical cyclones and detection of all warning categories

A second set of studies addressed the extent to which one can achieve better definition of coastal wind features including orographically-induced or enhanced low-level jets with XOVWM. The results and implications of both studies will be presented and discussed.

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Impact Assessment of Potential Hurricane Imaging Radiometer (HIRAD) Tropical Cyclone Observations from Aircraft and Satellite Platforms

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The Hurricane Imaging Radiometer (HIRAD) is an innovative technology development, which offers new and unique remotely sensed satellite observations of both extreme oceanic wind events and strong precipitation. It is based on the airborne Stepped Frequency Microwave Radiometer (SFMR), which is a proven remote sensing technique for observing tropical cyclone ocean surface wind speeds and rain rates. The proposed HIRAD instrument advances beyond the current nadir viewing SFMR to an equivalent wide-swath SFMR imager using passive microwave synthetic thinned aperture radiometer technology. This sensor will operate over 4-7 GHz (C-band frequencies) where the required tropical cyclone remote sensing physics has been validated by both SFMR and WindSat radiometers. HIRAD incorporates a unique, technologically advanced array antenna and several other technologies successfully demonstrated by the NASA's Instrument Incubator Program. HIRAD will be a compact, lightweight, low-power instrument with no moving parts that will produce wide-swath imagery of ocean vector winds and rain during hurricane conditions when existing microwave sensors (radiometers or scatterometers) are hindered.

The technology investment in the HIRAD development, sponsored by the NASA Marshall Space Flight Center, has included funding for both hardware development and impact assessment of HIRAD observational capabilities evaluated with an Observing Systems Simulation Experiment (OSSE). The OSSE was designed to use a numerical forecast of Hurricane Frances as a nature run to simulate current observational assets such as QuikSCAT, dropsondes, SFMR, GOES cloud winds, etc. and future aircraft and satellite versions of HIRAD. The NOAA Hurricane Research Division H*Wind analysis system was used as the discriminating tool to evaluate the impact of HIRAD observations with the other assets. The OSSE results clearly demonstrate HIRAD could have a significant positive impact as either a new aircraft or satellite sensor. This presentation will address how the HIRAD development contributes to the "New observational technologies" priority and how the design template of the HIRAD OSSE contributes to the "Alternatives and tradeoffs for observing storms and their environment…" priority listed in **Table 5.1 - Research Priorities in Atmospheric and Oceanic Science** of the ***Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead***.

GPS-Based Tropical Storm Sensing Results for 2003-2007 Storm Seasons

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Since Year 2000, an instrument has been flying on the research P 3's at Aircraft Operation Center in MacDill AFB, Florida. This instrument represents the newest technique to become available to measure ocean surface winds remotely. At present there are only two other commonly used techniques to measure ocean surface winds, microwave radiometry and RADAR backscatter. The GPS technique uses a bistatic approach with the Global Positioning System satellites as illumination sources. Moreover the GPS hardware is represents miniscule cost with nearly zero platform impact. In operation wind speed is inferred by monitoring ocean surface roughness and its effect on the highly coherent GPS signal. A study published in 1999 demonstrated that ocean surface winds can be retrieved with this technique and subsequent experimental results have confirmed predictions. Recent calibration results have provided an empirical, nonlinear, function that can be used to extract ocean surface winds at tropical storm intensities. This paper will present a summary of results from hurricanes and tropical storms in 2003, 2005, and 2007 that show conclusively that the GPS reflection technique is capable of monitoring wind speeds in excess of 60 meter per second. Preliminary comparisons with SFMR, Flight Level Winds and Dropsondes will also be given. Anomalous behavior as will also be presented and some possibilities will be given as to their source.

Coastal Ocean Observing Systems: Oceanic Current and Wave Response to Hurricane Jeanne Detected by Wellen Radars

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A national plan is in the early stages to deploy high frequency (HF) radars along the coasts as part of NOAA's Integrated Ocean Observing System. These high frequency radars (i.e., phased array technologies) have the capability of not only measuring the surface currents, but the winds and waves in real time. In this framework, such measurements provide spatial variations of these fields over 100 km x 100 km footprints during the passage of tropical storms and hurricanes that affect the southeast and Gulf of Mexico states. In September 04, for example, hurricane Jeanne made landfall in South Florida as a category 2 storm. During this period, Hurricane Jeanne excited an energetic coastal current response as measured by a dual-station HF radar (Wellen Radar : WERA) deployed as part of the Office of Naval Research sponsored Southeast Atlantic Coastal Ocean Observing System.

A strong eastward current response of 1 m s^{-1} emanating from the Biscayne Bay was observed where offshore surface winds approached 25 m s^{-1} on the south side of the Jeanne. This surface current response forced an eastward bulge of ≈ 100 km^2 resulting in an offshore Florida Current meander. Given fetch-limited conditions of offshore winds, these data suggest that WERA can remain operational for winds up to 25 m s^{-1}, and perhaps even larger if radar sites can be hardened to withstand higher winds as part of the IOOS-sponsored network. Using the evolution of the forced surface currents and winds at Fowey Rocks, the surface drag coefficient is estimated from the forced shallow water equations under neutral conditions. Using adjusted surface winds from this Coastal Marine Automated Network (CMAN) station, the surface drag coefficient ranged between 1.5 to 2 x 10^{-3} during the period of strong forcing, consistent with previous studies. These high-resolution surface current measurements should be used to evaluate storm surge models given that the major component to the storm surge is due wind-driven currents. Thus, HF radar networks, measuring real-time winds, waves and currents, could provide forecasters high-resolution coastal ocean information during landfalling hurricanes similar to the WSR-88D atmospheric network.

Phased Array Radar: Applications to Landfalling Tropical Cyclones

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Electronically scanning phased array radar (PAR) offers great advantages over mechanically scanning radar in terms of higher update rate and agile beamforming. PAR's capability to scan particular volumes of the atmosphere intensively while maintaining full volume surveillance has great applications in a number of areas of meteorology, including landfalling tropical cyclones. The National Weather Radar Testbed in Norman, Oklahoma had a fortuitous opportunity in May 2007 to gather data from its Navy SPY-1 phased array radar on Tropical Storm Erin, which came ashore on the Gulf Coast of Texas, tracked north, and regained strength in central Oklahoma, well within range of the Testbed's PAR. Comparison of data from the SPY-1 and the collocated Norman WSR-88D reveals the power of PAR's rapid scanning in discerning features of interest in Erin's convective bands, in particular the rapid spin-off of tornadoes. Because the SPY-1 was able to revisit volumes of interest much more rapidly than was the WSR-88D, earlier detection of severe weather signatures was possible.

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In part of a growing, multi-partner, multi-stakeholder endeavor, WeatherFlow is designing, installing, and maintaining a hardened mesoscale observing network dedicated to collection and real-time transmission of high quality surface meteorological information during tropical storm and hurricanes.

WeatherFlow is supplying The National Hurricane Center and associated local NWS forecast offices with this valuable data resource. The construction of the network has been initiated in Florida, with 50 sites installed as of March 2008, and expansion underway for additional sites throughout the Gulf and Atlantic coasts, and Caribbean region. This public/private relationship is a prime example of fulfilling multiple needs through fiscal efficiency. As NOAA and the National Weather Service continue to try to fulfill its mission of "helping save lives" on limited budgets, this project provides a much needed augmentation to data collection efforts at no burden to the taxpayer.

This presentation will explain the project in more detail including strategies on siting, mounting structures, additional hardening techniques, parameters collected and associated sensors, sampling frequencies, while expanding on information related to project partner motivations and related important strategies such as data sharing agreements.

One of the most pivotal partnerships contributing to this program's success is that between Weatherflow and Florida Power and Light (FPL). The details of this partnership will be expanded on with several examples that accent each group's assets and contributions to the project, benefits to each partner, how the government benefits as a result, and how this relationship has been a catalyst for a continuously expanding group of stakeholders.

In addition to the unique collaboration between the private sector and the government, this project has strong ties to the academic sector. The University of Florida is playing an integral role as both user and provider. The UF wind research group, which focuses on residential construction vulnerability, will utilize the observing network for wind load characterization. Their experience with hurricane data collection and analysis together with WeatherFlow's expertise with operational coastal networks pools the necessary assets to bring this concept to reality.

This project is fulfilling the obvious benefits to government users via improved real-time situation awareness allowing for improved watch and warning capabilities; Contributing to hurricane research via post-event analysis, paving the way to increased understanding about storm structure; Providing valuable derived benefits on a multitude of economic and civic fronts, such as optimizing evacuation strategies, improving construction practices and establishing benchmarks for the insurance and re-insurance industries.

Poster Session

POSTER SESSION

Comparison of Airborne SFMR, Dvorak Satellite and Best Track Maximum Surface Wind Estimates in Atlantic Tropical Cyclones: 1998-2006

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The objective of this study is to compare GPS dropsonde-calibrated, remotely-sensed SFMR maximum surface wind against the objective, satellite-based Advanced Dvorak Technique (ADT) and forecaster-derived, consensus Best Track (BT) maximum surface wind (Vmax) estimates. The study is based on a 10-year data set from 1998 to 2006 that includes 178 radial flight legs from 53 separate flight patterns in 17 tropical cyclones using a consistently calibrated SFMR instrument combined with the most recent geophysical model function derived after the 2005 hurricane season.

Initial results show that mean of the Probability Density Function (PDF) for BT Vmax estimates from tropical storm to CAT4 hurricanes exceeds that from the SFMR Vmax distribution by 6 m/s, representing a 12-15%, or one storm category, overestimate. BT and SFMR Vmax estimates show close agreement for CAT5 storms. The issue of under sampling of SFMR Vmax due to flight tracks missing the true Vmax is addressed using two years of processed airborne Doppler radar data. Anew pressure-wind relationship derived using SFMR data shows a similar offset compared to BT pressure-wind relations used by forecasters.

Initial results show that the ADT derived Vmax tends to be an overestimate for weak CAT1 and CAT2 storms while underestimating CAT 4 storms. There is a bimodal distribution of ADT Vmax estimates with more CAT 1 and CAT 3/4 storms than indicated by SFMR Vmax and fewer ADT CAT2 storms than indicated by SFMR Vmax. This suggests that ADT may have trouble accurately identifying the eye feature as it is first appearing and transitioning storms from CAT 1 to CAT 3 intensity too quickly. Preliminary comparisons with conventional Dvorak technique Vmax estimates suggest that this effect is less pronounced. The present study suggests the possibility of reducing the uncertainty in tropical cyclone maximum surface wind estimates to the level of scatter in the SFMR vs GPS dropsonde comparisons by tuning future Best Track and satellite based ADT surface maximum wind estimates to those produced by SFMR surface wind measurements.

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Pacific Islands Land-Ocean Typhoon Experiment (PILOT Experiment) and Typhoon Man-yi at Guam

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Studies of methods to protect U.S. populations from the effects of land falling tropical cyclones have been confined primarily to the continental United States. These studies have emphasized evacuation of large populations from coastal areas as a primary mitigation measure against the effects of coastal storm surge and maximum cyclone winds. These methods may not be appropriate or effective in island environments. Cyclone effects that are of little or no concern to mainland residents may pose significant hazards in island environments. These effects can include terrain enhanced winds, elevated coastal water levels caused by wave-induced ponding on reefs, and mudslides caused by heavy rains. In contrast to mainland tropical cyclone hazard scenarios which have been extensively studied, island hazard scenarios have received little attention.

Adequate data exist to quantitatively depict some of the various geophysical processes during cyclone landfall in islands (e.g., coastal surge) such that competent models of these processes exist. However, data depicting other processes (e.g., wave transformation over reefs, wave induced ponding, wind-forced wave uprush) are inadequate or do not exist, consequently the physics of these processes are poorly understood, so adequate models are not available. Data of adequate quantity and quality depicting the physics of these processes are required to develop models which correctly simulate these effects.

The US Army Engineers established a field laboratory and observing system on the island of Guam to capture data at extreme wind speeds, wave heights, and coastal water levels. A near-shore directional wave buoy and a coastal water-level and meteorological station have been established, and shallow water wave gages and current meters have been deployed in a reef-rimmed lagoon.

In July 2007 super typhoon Man-yi made a point of closest approach to Guam of approximately 350km as a tropical storm. Maximum wind speeds recorded on Guam were approximately $20 ms^{-1}$ and the maximum significant wave height observed at Ipan Bay during Man-yi's passage was 7.11m with a maximum single wave height of 11.83m. Two cross-reef transects are instrumented with ten wave gauges and eight current recorders. The transect configuration captured information on wave dissipation and run-up as the storm waves traversed the reef. A water-level and meteorological station operated for the PILOT Experiment by the National Ocean Service recorded the storm surge and low-level winds at Pago Bay, about 10km north of the Ipan site. Data acquired during Man-yi's passage are presented along with estimates of the wave dissipation rates over the reef.

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The Saharan Air Layer and Improved Understanding of Atlantic Hurricane Formation and Intensification: Hope or Hype?

Scott Braun (NASA/GSFC) and Chung-Lin Shie (UMBC/GEST)

The existence of the Saharan air layer (SAL), a layer of warm, dry, dusty air frequently present over the tropical Atlantic Ocean, has long been appreciated. However, the impact of the SAL on tropical cyclones has only recently become an area of active research. The nature of this impact remains unclear, with some researchers arguing that the SAL amplifies cyclone development while others arguing that it inhibits it. In this study, we combine data for 2003-2006 from the TRMM multi-satellite precipitation analysis product, used to characterize the rainfall associated with storms that may evolve into tropical cyclones, with aerosol information from MODIS and thermodynamic data from AIRS on Aqua (temperature and humidity profiles) in order to characterize the dustiness and thermodynamic properties of the SAL. Data from NCEP global analyses are used to characterize the wind and other fields.

We use these data sets to generate daily-to-monthly climatologies of the SAL to characterize its properties and evolution. The purported negative impacts of the SAL are investigated, including: 1) low-level vertical wind shear associated with the African Easterly Jet (AEJ); 2) warm air, which increases thermodynamic stability; and 3) dry air, which produces cold downdrafts. Analysis of NCEP wind fields along with TRMM rainfall, AIRS thermodynamic data, and MODIS dust amount show that storms form on the southern, cyclonic vorticity rich side of the AEJ and do not cross the jet. In fact, the AEJ often helps to form the northern side of the storms, so AEJ-induced vertical wind shear does not appear to be a negative influence on developing storms. Failure of storms to intensify when surrounded by SAL air may not result from the SAL but from other coincidental factors (an example of Hurricane Erin in 2001 is given). In contrast, storms that intensify when surrounded by SAL air suggest that the SAL may have little impact on storm intensification. Examples of intensifying storms embedded within the SAL suggest that the warm air to the north of the AEJ has little impact on such storms. Dry air, while it may foster dry downdrafts, likely does not get near enough to the storm core to inhibit intensification.

Finally, monthly mean fields show three characteristic relative humidity zones in the Atlantic: the moist ITCZ region, very dry mid-latitude air (on the north side of the mean dust layer), and a transition region in the SAL with relative humidity decreasing northwards. The SAL air is typically much more humid than the midlatitude air, although still quite dry (RH~30-50%) relative to precipitating tropical regions. A global view of relative humidity shows moisture distributions in other ocean basins that are almost identical to the Atlantic. The dry zones correspond to regions of descending air on the eastern and equatorward sides of semi-permanent high pressure systems. Thus, the dry "SAL" air over the Atlantic appears to be more a product of the large-scale flow than anything uniquely related to the Sahara.

Interactive Hurricane Surge Visualization for Charleston, South Carolina

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Significant advances have been made in the accuracy of tropical cyclone surge forecasting. However, the warnings issued to the public in coastal cities have remained relatively unchanged, despite the fact that most people do not fully understand them. A survey of 202 Charleston area residents in 2001 found that 55% did not realize the main threat from a major hurricane in coastal areas was from storm surge, even though 93% had experienced hurricane effects sometime in their life. Attempting to make the risk of surge more understandable, an interactive website was developed which combines SLOSH estimated surge with elevation and tide data and then simulates the level of surge on photographs of nearly a thousand landmarks throughout the Charleston metropolitan area. Users then select a location on a GIS-based map, choose the strength of storm, and input either low or high tide. When completed, the web page will be highlighted at the top of the NWS Charleston, SC home page during the threat of a tropical cyclone affecting the Charleston area.

Initial results of the project will be presented in the poster session. Future work includes another survey of the public which will reveal the effectiveness of this approach. In addition, the results of the study will be used by the National Weather Service in Charleston to help convey the risks of storm surge in real-time landfalling tropical cyclone situations as well as with their hurricane outreach throughout the year.

Introducing the new CIMSS Tropical Cyclone Web Site

Christopher Velden, University of Wisconsin-CIMSS

It has been 13 years since CIMSS launched the first-of-its-kind web site on Tropical Cyclones (TCs). In all of that time, other than frequent updates and product additions, the site has not changed in any major way. The site rapidly gained popularity with both the TC community, and the general public. It is not unusual for satellite-derived products available for viewing on the site to get mentioned by the National Hurricane Center in public forecast discussions during important hurricane events. It is also common for the site to accrue daily "hits" in the millions during a major hurricane. In fact, on several occasions, web traffic from the public's site access has slowed down the entire UW network! Recent Net communications upgrades have alleviated this problem, but the site remains a very popular source for hurricane information, and as a portal for cutting edge CIMSS research on TCs.

For the past year or so, the CIMSS TC group has been working on a major site upgrade. Intended for a slightly more sophisticated user, the site includes a new layout and increased interactive capabilities. Interested analysts, researchers or just plain hurricane aficionados can find information on real time storms, regional analyses based on satellite-derived variables, special satellite imagery, and examples of the SSEC/CIMSS TC Group research projects. The new site can be found at: http://cimss.ssec.wisc.edu/tropic2. The existing TC web site will remain active for another year or so while the transition occurs to the new page, which is still a work in progress.

Featured on the new site is an interactive window for viewing and analyzing real time TCs we call "TCTrak". This analysis tool uses McIDAS utilities and allows multiple data and product overlays, animation manipulation, satellite-based TC estimates and diagnostics, and more. The intent is for a user to interrogate the meteorological conditions of a storm in real time. Included in the product suite available for viewing is multispectral imagery (IR and microwave) from virtually all operational (and some research) geo and polar orbiting satellites, SST analysis, satellite-derived products such as winds, shear, and intensity estimates, scatterometer winds, conventional observations, current TC track and forecast discussions, numerical model track forecasts, and more.

The new site was made available to the TC community in July of 2007, despite a few remaining glitches, in order to get feedback during the recent Atlantic TC season. The new site requires recent web browser versions to function properly. This kept a few users from being able to view the new site. Despite this, initial feedback as been overwhelmingly positive. Most users embrace the added functionalities and interactive access to the data/products. We will continue to add new features to the site, and are confident this will be a valuable TC web resource and outreach element to the community.

Chesapeake Inundation Prediction System (CIPS)

Jay Titlow (jtitlow@weatherflow.com, WeatherFlow, Inc.), Harry Wang, Jian Shen, Wenping Gong, Joe Cho, David Forrest, and Carl Friedrichs (Virginia Institute of Marine Science), Bill Boicourt, Ming Li, and Dennis King (University of Maryland Center for Environmental Science), Barry Stamey, Wade Smith, and David Garbin (Noblis, Inc.), Elizabeth Smith (Chesapeake Bay Observing System and Old Dominion University), Michael Koterba (U. S. Geological Survey), Tony Siebers and John Billet (NOAA National Weather Service Forecast Office Wakefield), Jim Lee and Chris Strong (NOAA National Weather Service Forecast Office Sterling), Gary Szatkowski (NOAA National Weather Service Forecast Office Mt Holly), Doug Wilson (NOAA Chesapeake Bay Office), Peter Ahnert and Joe Ostrowski (NOAA Middle Atlantic River Forecast Center), Mark Penn (City of Alexandria, VA), and Kevin Sellner (Chesapeake Research Consortium)

Recent Hurricanes Katrina and Isabel, among others, not only demonstrated their immense destructive power, but also revealed the obvious, crucial need for improved storm surge forecasting and information delivery to save lives and property in future storms. The Chesapeake Inundation Prediction System (CIPS) is being developed in collaboration with NOAA National Weather Service regional forecast offices to enhance current operational capabilities and improve the accuracy, reliability, and capability of flooding forecasts for tropical cyclones and non-tropical wind systems such as nor'easters by modeling and visualizing expected on-land storm-surge inundation along the Chesapeake Bay and its tributaries. An initial prototype has been developed by a team of government, academic and industry partners through the Chesapeake Bay Observing System (CBOS) of the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) within the Integrated Ocean Observing System (IOOS). For demonstration purposes, this initial prototype was developed for the tidal Potomac River in the Washington, DC metropolitan area.

The preliminary information from this prototype shows great potential as a mechanism by which NOAA National Weather Service (NWS) Forecast Offices (WFOs) can provide more specific and timely forecasts of likely inundation in individual localities from significant storm surge events. This prototype system has shown the potential to indicate flooding at the street level, at time intervals of an hour or less, and with vertical resolution of one foot or less. This information will significantly improve the ability of EMs and first responders to mitigate life and property loss and improve evacuation capabilities in individual communities.

This presentation will discuss current work in the CIPS end-to-end process including user engagement throughout the system development; observations and observing systems; numerical modeling (including boundary conditions and forcing fields); model-data comparisons and validation studies; data management, visualization, and methods of communicating forecasts and model uncertainty; and cost/benefit analysis and economic valuation for improved capabilities. We will also briefly discuss additional emerging applications that an end-to-end process like CIPS could support, such as the efficacy of storm inundation mitigation structures, predicting increased storm effects related to climate change and sea level rise, and other societal impacts including health and environmental quality, natural resources, commerce, and recreation.

Status of the NASA High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)

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Wind measurements are crucial for understanding and forecasting tropical storms since they are closely tied to the overall dynamics of the storm. The High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) is a dual-frequency (Ka- and Ku-band), dual-beam (30^0 and 40^0 incidence angle), conical scan, solid-state transmitter-based system, designed for operation on the high-altitude (20 km) Global Hawk UAV. With the inclusion of Ka-band, HIWRAP will be able to image the winds through volume backscattering from clouds and precipitation, enabling it to measure the tropospheric winds above heavy rain at high levels. It will also measure ocean surface winds through scatterometry, similar to QuikScat. These measurements from higher altitudes above storms, will be useful for providing higher spatial and temporal resolution than obtained by current satellites and lower-altitude instrumented aircraft.

HIWRAP is a progression of technology from the current fixed-beam NASA high-altitude Doppler weather radars using tube technology, and the lower altitude solid-state IWRAP system flown on the NOAA P3's. HIWRAP utilizes solid state transmitters along with novel pulse compression scheme that will result in a system that is considerably more compact in size, requires less power, and ultimately costs significantly less than typical radars currently in use for precipitation and Doppler wind measurements. HIWRAP is currently in the final year of development and first flights are planned later in 2008 on the NASA WB-57 manned aircraft (60-65kft ceiling). The presentation will discuss the measurements that can be provided by HIWRAP and their potential use in hurricanes, status of the instrument, and plans for test flights on the WB-57 and Global Hawk.

The Experimental Graphical Tropical Weather Outlook (GTWO): 2007 Results and Future Plans

Jamie R. Rhome*, Daniel Brown, James Franklin, Christopher Landsea, Chris Lauer, and Chris Juckins

NOAA/Tropical Prediction Center/National Hurricane Center

This paper describes a new experimental product, the graphical tropical weather outlook (GTWO), that the National Hurricane Center began issuing on an experimental basis during the 2007 hurricane season. The GTWO is a web-based graphic superimposed on the most recently available geostationary satellite mosaic of the GOES-East, GOES-West, and Meteosat 9 satellites. The graphic indicates the current locations of areas of disturbed weather discussed in the text Tropical Weather Outlook (TWO) by encircling them. Each encircled area is numbered, with textual descriptions of each numbered system given beneath the graphic. Active tropical cyclones are also shown on the GTWO in the form of a cyclone symbol (i.e. "L" for tropical depressions, a tropical storm symbol for cyclones of tropical storm strength, and a hurricane symbol for cyclone of hurricane strength). Text descriptions for the disturbances and active cyclones are also presented in the form of a pop up whenever a user moves the computer's mouse pointer over an encircled area or cyclone. The experimental GTWO was tested and evaluated during the 2007 hurricane season. This assessment included the routine issuance of an experimental version of the product, testing possible enhancements to the product, and gathering user input. Results from the 2007 experimental GTWO assessment are presented along with future plans for the product.

Monitoring Tropical Cyclone Impacts on Domestic Agriculture at the U.S. Department of Agriculture

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It is well documented that tropical cyclones and their remnants can have both negative and positive impacts on the U.S. agricultural sector. Landfalling hurricanes are arguably best known for their detrimental effects, such as causing flooding rains that have led to significant reductions in crop production, producing exceedingly high winds which have damaged the nation's forests and disrupted the movement of agricultural commodities, and generating storm surges that have devastated agricultural facilities located near coastlines. Tropical cyclones have also been very beneficial for domestic agriculture, however, providing timely moisture for crops in the moisture sensitive stages of development and bringing much-needed rainfall to drought-plagued pastures and rangelands.

Given the considerable impacts that tropical disturbances can have on domestic agriculture, meteorologists at the U.S. Department of Agriculture (USDA) closely monitor the movement and evolution of such systems to assess their potential and observed impacts. In recent years, USDA meteorologists have increasingly used geographic information systems (GIS) to overlay NOAA weather and USDA agricultural data to facilitate these assessments. Prior to a storm affecting the United States, these analyses are used to brief the Secretary of Agriculture and top staff on potential threats to U.S. agriculture. Following a storm, additional assessments are prepared to help senior management identify impacted agricultural areas, estimate crop and livestock losses, and develop Department assistance programs that provide emergency aid.

Assessments of tropical cyclone impacts on domestic agriculture have been well received by USDA decision makers. Much of the success of these assessments is attributed to the high quality data and analyses provided by the National Hurricane Center and National Weather Service. Many of the hurricane-related products are currently not provided in a GIS-compatible format, however, limiting the potential value of these products in the decision making process. USDA seeks to obtain operational hurricane-related products in a GIS-compatible format to improve Department assessments of tropical cyclone impacts on domestic agriculture.

Transportation Resources that May Be Used to Respond to Weather-Related Incidents

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Weather events--including hurricanes, tropical storms, tornadoes, inundating rains, winter weather—often lead to incident responses. These responses may be localized, regional or national in scope. Responders from a variety of disciplines—including transportation operations professionals, transit officials, emergency managers, law enforcement professionals, firefighters and other first responders—work together to save lives, reduce suffering and protect property. Clearly, law enforcement, firefighters, rescue professionals and emergency managers are directly involved in incident responses. However, the local, State and even Federal Departments of Transportation (DOTs) bring numerous resources to aid responses to weather-triggered incidents.

This poster session will expand upon the various tools, technical expertise and resources available through the DOTs that will aid in monitoring weather events, preparing responders for operations, and supporting response operations after an event impacts an area. The session will emphasize the need to include transportation operations professionals in planning for these types of events. FHWA will discuss the benefits of applying the following transportation operations capabilities to weather-related incident responses:

- Road Weather Management Maintenance Decision Support Systems
- Clarus
- Traffic Analysis & other Modeling Tools
- Full-Function Service or Courtesy Patrols
- Traffic Management Centers/Traffic Operations Centers
- Advanced Traveler Information, including 511, Reverse 911, NG-911 etc.
- Changeable/Dynamic/Variable Message Signage
- Evacuation Liaison Team
- Evacuation Decision Support Tools, such as the Emergency Transportation Information System (ETIS)
- Contraflow Operations
- Freight Operations & Technology
- HOT/HOV Management during Incidents
- Incident Management Operations, including Detection, Verification, Response & Clearance
- Traffic Control Devices
- Ramp Metering
- Real-Time System Management Information Program
- Towing & Recovery
- Traffic Control Flow Surveillance/Detectors
- Vehicle Infrastructure Integration (VII) Tools
- Work Zone Tools & Practice, and others

Session 6
Tropical Cyclone Modeling and Prediction
Part 1

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Advancement of the HWRF for Next Generation Hurricane Prediction at NCEP's Environmental Modeling Center

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Environmental Modeling Center/NCEP

The Hurricane Weather and Research Forecast system (HWRF) became operational at NCEP in 2007. Under development at EMC since 2002, the coupled HWRF system was uniquely designed to begin making significant advancements in improving operational forecast skill of intensity and structure forecasts in addition to advancing wave and storm surge forecasts to address the coastal inundation problem. Continued advancements in track prediction will remain an important focus of this prediction system. Further advancements will include coupling the HWRF to a land surface model for improved rainfall forecast for input to operational hydrology and inundation models to address the hurricane-related inland flooding problem.

The advanced design of the HWRF will be discussed in addition to the operational requirements for bringing a new hurricane model into operations for NHC. Future advancements of the HWRF at EMC will also be discussed in terms of increasing resolution, advancing data assimilation for both atmosphere and ocean, formulation of physics for advanced high resolution, coupled hurricane systems and developing hurricane ensembles to enhance NHC's hurricane intensity prediction capabilities.

Improvements to GFDN Planned for Operational Implementation in 2008

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In 1995 and 1996, major upgrades to the National Weather Service's (NWS) version of the GFDL Hurricane Prediction System were made in close collaboration with scientists at NCEP (National Centers for Environmental Prediction) and URI (University of Rhode Island). These upgrades included doubling of the finest resolution from 1/6 to 1/12 degree, upgrade of the moist physics with NCEP's Ferrier microphysics, and improved momentum flux parameterization. Tests results indicated that these upgrades significantly improved the reliability of both the model's track and intensity prediction. Indeed, in 2006 the GFDL model for the first time exhibited superior performance compared to the statistical models in most forecast time periods, beating even the official forecast in the Atlantic.

In 1996 a version of the GFDL model (called GFDN) was transferred to the United States Navy in order to provide forecast guidance in the western Pacific. Prior to 2003, it had been the practice to transfer the upgrades of the GFDL model to the Navy in time for operational implementation the following year. However, the major upgrades to the GFDL model that were made operational in 2005 and 2006 had still not been transferred to the Navy by 2007. In addition, the GFDN model remained uncoupled compared to the NWS version, which has been operationally coupled to a three-dimensional version of the Princeton Ocean Model (POM) in the Atlantic since 2001 and with a 1D version of POM in the eastern and central Pacific basin since in 2004.

It is believed that these factors have resulted in a steady decline in the reliability of the GFDN model, compared both to the global models and the version of the GFDL model run by the National Weather Service. To rectify these deficiencies, a major effort was undertaken at GFDL and URI in the summer of 2007, to transfer the 2005 and 2006 upgrades of the GFDL model to GFDN in time for the 2008 season. In addition, this new model will be coupled to a three-dimensional version of POM in the Atlantic with the 1D coupling extended beyond the eastern and central Pacific, to include all other basins including the western Pacific and ocean basins in the Southern Hemisphere.

The new upgraded GFDN model has been tested so far on 63 cases in the western Pacific from the previous 3 typhoon seasons, as well as a limited number of cases in the Atlantic, including Hurricanes Dean and Katrina. Preliminary results for both track and intensity prediction are quite encouraging. For example in the 3-5 day time period, the average track errors for the cases tested in the western Pacific were reduced about 13% compared to the current operational GFDN model. In addition, the average intensity error for the same cases was reduced about 12% at all time levels beyond 12h. Examples of the improved track and intensity prediction with the new GFDN model will be shown and the average improvement in skill will be summarized in detail.

Finally, during 2008, an effort will be initiated to extend the one-dimensional ocean coupling in the western Pacific to a full three-dimensional coupling, using similar techniques as has been successfully employed in the GFDL model in the Atlantic. Details of this upgrade will be presented.

Hurricane Model Transitions to Operations at NCEP/EMC
A Joint Hurricane Testbed (JHT) Program

Robert E. Tuleya, Young Kwon, Vijay Tallapragada,
and Naomi Surgi (EMC/NCEP)

The 2005-2007 JHT project concentrated on HWRF development and its operational implementation. Before HWRF could be implemented, additional model output products had to be developed and tested. These products included wind and precipitation output files and graphics, as well as critical output text of hourly position and intensity. The swath graphics programs were based on GFDL products but considerable programming was necessary because of the HWRF grid configuration. This was successfully accomplished before the beginning of the 2007 hurricane season and ran well during the season. Examples will be shown.

This past season, the HWRF was accepted into operations after an extensive test period. This development was designed to take into account the strengths of the WRF software system, the use of the well tested NMM dynamic core, and the physics packages of the GFDL highly successful forecast system. The physics packages of the GFDL model were integrated into the software structure of the HWRF system. This past year the HWRF system ran successfully with few failures and in a timely manner. The HWRF system was competitive with the GFDL system showing improvements in track compared with the GFDL system in the Atlantic basin, especially beyond 2 days. At days four and five, HWRF was a respectable >40% better than CLIPER. On the other hand, it was not a very good year for intensity prediction for dynamic models including HWRF. HWRF was able to beat GFDL for the 1st 24 hours probably due to its more exact targeting of the initial wind field. Basin skill statistics will be shown as well as some individual storm cases where problems arose.

Once HWRF was made operational, the JHT 2007-2009 project has moved to solving production model problems and model improvement. Related to the poor model intensity performance was a diagnosed degradation of the pressure-wind relationship compared to the GFDL model. It has been discovered that despite similar physics, wind speeds in HWRF are smoothed out by the horizontal diffusion scheme. Both models use Smagorinky type diffusion. Sensitivity experiments indicate that a reduced value of diffusion leads to improvement in intensity prediction and the wind-pressure relationship. In addition other physics sensitivity experiments have been performed. Some computer bugs have also been fixed. In addition, a nagging noise problem in the mean sea level pressure has been diagnosed as a nest movement issue. This problem is being corrected. Results will be shown with corrections for the above-mentioned issues.

Modeling of Coupled Wind-Wave-Current Processes in Hurricanes

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We will discuss new strategies for modeling coupled wind-wave-current processes in hurricanes. They include the following components: 1) in the hurricane model, the parameterizations of the air-sea heat and momentum fluxes and the spray source functions explicitly include the sea-state dependence, ocean currents and sea surface temperature; 2) the wave model is forced by the sea-state dependent momentum flux and includes the ocean current effects; 3) the ocean model is forced by the sea-state dependent momentum flux that accounts for the air-sea flux budget. The key element of our coupled modeling approach is the air-sea interface model (ASIM) developed by our research group at URI that consists of the wave boundary layer model of Moon et al (2004a,b) and the air-sea energy and momentum flux budget model of Fan et al (2007a,b) and Fan et al. (2008). Several components of the ASIM model is presently being implemented into the HWRF coupled system.

We will show examples of idealized and real-case simulations. We have found that the hurricane-induced surface waves play an important role in reducing the momentum and turbulent kinetic energy fluxes into subsurface currents in the rear-right quadrant of the hurricane. In a Category 3 hurricane moving with a forward speed of 5 ms^{-1}, the variation of the surface gravity wave field (both in time and space) and wave-current interaction can reduce the momentum flux into the currents up to 10% relative to the flux from the wind. This reduction in the momentum flux into the ocean consequently reduces the magnitude of subsurface current and SST cooling to the right of the storm track and lessens mixed layer deepening in the wake of a hurricane. These results highlight the significance of the explicit air-sea flux budget calculations in coupled models. We have coupled the NCEP WAVEWATCH III wave model with the Princeton Ocean Model and demonstrated that the effect of wave-current interaction helps to improve the wave forecasts. The results of three case studies for Hurricane Ivan (2004) and comparisons with SRA wave measurements will be discussed.

Evaluation and Improvement of Ocean Model Parameterizations for NCEP Operations

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The ocean response to hurricane Ivan (Sept 2004) was simulated within the Gulf of Mexico using the Hybrid Coordinate Ocean Model (HYCOM), which has been selected by NOAA/NCEP as the ocean component of the coupled Hurricane Weather Research and Forecasting model. These simulations (1) demonstrate the importance of accurately initializing the ocean model; (2) reveal sensitivity of the current and temperature response to the vertical mixing parameterizations; and, (3) emphasize the critical importance of ocean observations for both initializing and evaluating the ocean model. Combined numerical-observational studies are critically important for evaluating and improving ocean model performance, particularly in regards to the magnitude and pattern of SST cooling driven by tropical cyclones. Improving ocean model performance in coupled hurricane forecast models thus has the potential to significantly improve intensity prediction. In this study, the ocean model response to hurricane Ivan is evaluated against satellite SST measurements and moored ocean current observations. Hurricane Ivan passed directly over 14 Acoustic Doppler Current Profiler (ADCP) moorings that were deployed as part of the Navy Research Laboratory *Slope to Shelf Energetics and Exchange Dynamics (SEED)* project from May through Nov 2004 (Teague et al., JPO, 2007). These observations enable the simulated ocean current response to a hurricane over a continental shelf/slope region to be evaluated with unprecedented detail.

The Ivan simulations were initialized by oceanic fields provided by the latest generation of the U. S. Navy ocean nowcast-forecast system being developed at the Naval Research Laboratory. This product provided a good initialization of the ocean heat content (OHC) distribution associated with the Loop Current, a recently-detached warm eddy, and two cold eddies adjacent to the warm eddy. This had a large impact on the simulated SST cooling pattern, with the largest cooling (> 5°C) occurring within the cold eddies presumably due to upwelling induced by the wind stress curl of colder water that was initially situated closer to the surface. The simulated cooling pattern was in reasonable agreement with microwave satellite measurements. The combination of ocean models and observations is important for providing accurate ocean model initializations. Upper ocean measurements prior to hurricanes must be acquired to insure the most accurate possible initial ocean fields. The simulated current response to Ivan in the *SEED* domain was dominated by vigorous near-inertial currents that contained both barotropic and baroclinic motions, in reasonable agreement with observations. Simulations performed using three mixing parameterizations reveal substantial differences in the vertical penetration of the currents, and also with respect to the temporal decay of the forced near-inertial oscillations. Detailed comparisons between simulations and observations are continuing to assess the veracity of the thermal and momentum balances aimed at improving ocean model performance in the HWRF prediction model.

Impact of Satellite Observations on Tropical Cyclone Track Forecasts

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The tropical cyclone (TC) track forecasts of the Navy Operational Global Atmo-spheric Prediction System (NOGAPS) were evaluated for a number of data assimilation experiments conducted using observations from two periods, one in 2005 and the other in 2006. The first period, July 4-October 31, 2005, was an extremely active one covering most of the record-breaking Atlantic season. For the Atlantic, there were 12 hurricanes (including Katrina, Rita, and Wilma) and 9 tropical storms. It was an active period for the North Pacific basins as well. The second period, August 1-September 30, 2006, was not nearly as active as the first. For the Atlantic, there were only 4 hurricanes and 3 tropical storms. The activity in the North Pacific basins was roughly half that for 2005 as well. The 2007 operational configuration of NOGAPS consisting of the NRL Atmospheric Variational Data Assimilation System with the assimilation of all available conventional and satellite observations and a T239L30 global spectral model was used as the control run. A number of data assimilation experiments were conducted designed to illustrate the impact on the NOGAPS TC track forecasts of the assimilation of different types of satellite observations. The satellite observations assimilated in these experiments consisted of feature-track winds from geostationary and polar-orbiting satellites, SSM/I total column precipitable water and wind speeds, AMSU-A radiances, and QuikSCAT and ERS-2 scatterometer winds.

When we looked at the combined results for the 2005-2006 test periods for the North Pacific and Atlantic basins, we found that the assimilation of the feature-track winds from the geostationary satellites had the most impact, ranging from 7 to 24 percent improvement in NOGAPS TC track forecasts, and that the impact was statistically significant at all forecast lengths. The impact of the assimilation of SSM/I precipitable water was consistently positive and statistically significant at all forecast lengths. The improvements due to the assimilation of AMSU-A radiances were also consistently positive and significant at most forecast lengths. There were no significant improve-ments/degradations due to the assimilation of the other satellite observation types (MODIS winds, SSM/I wind speeds, and scatterometer winds). The impact due to the assimilation of all satellite observations upon the NOGAPS TC track forecasts for the 2005-2006 test periods was similar for both the Atlantic basin alone and the combination of the Atlantic and North Pacific basins. The assimilation of all satellite observations resulted in a gain in skill of roughly 12h for the NOGAPS 48-h and 72-h TC track forecasts and a gain in skill of roughly 24h for the 96-h and 120-h forecasts. The improvement in the TC track forecasts ranged from almost 20% at 24h to over 40% at 120h. Furthermore, we found that although the assimilation of some of the satellite observation types did not result in statistically significant improvements, their assimilation contributed additively and even multiplicatively at some forecast lengths to reduction in NOGAPS TC track forecast error.

Session 7
Tropical Cyclone Modeling and Prediction
Part 2

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The Impact of Horizontal Resolution on the Structure and Intensity of Hurricane Dennis in HWRF Simulations

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One of the main challenges in tropical cyclone prediction is developing improved forecasts of the storm intensity. Numerical models such as the NOAA Hurricane Weather Research and Foreasting model (HWRF) are a key tool in producing these forecasts. Many elements of a numerical modeling system are important in tropical cyclone intensity forecasting: data assimilation and the specification of the initial vortex; model configuration, including horizontal and vertical resolution; and physical parameterizations. In this study attention is focused on the role of horizontal resolution on intensity forecasting by testing the impact of varying resolution on the ability of HWRF to produce the intensity evolution of Hurricane Dennis (2005). Simulations of Dennis are performed with HWRF at grid lengths of 27 and 9 km, the same grid length as that used with the operational HWRF, and additional runs are performed at 3 km grid length. The ability of the various simulations to reproduce the intensity evolution and the wind, mass, and precipitation structures of Dennis are compared.

Evaluation and Improvement of Spray-Modified Air-Sea Enthalpy and Momentum Flux Parameterizations for Operational Hurricane Prediction

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This presentation introduces the project sponsored by the Joint Hurricane Testbed in which a bulk parameterization scheme of sea-spray mediated air-sea heat and momentum fluxes developed at NOAA/ESRL is implemented and calibrated in the operational HWRF model. The scheme was developed as an extension of the TOGA-COARE bulk flux model (Fairall et al. 1994), and has been refined with observations from new field campaigns (such as the CBLAST experiment) and updated theoretical understanding. It was designed to address the lack of the treatment of sea spray in the traditional air-sea flux parameterizations under high wind conditions. Results from preliminary tests of the scheme with the current operational setup of the HWRF model indicate that the thermal flux component of the scheme may be used as a way to reduce the intensity bias since its impact on hurricane track prediction is small enough to be neglected. Our experiment with the HWRF model is also the first to investigate the sea-spray effect on the air-sea momentum flux in an operational model. Preliminary results suggest that because the very turbulence that transports momentum and heat across the air-sea interface is also responsible for the generation of sea spray, the resultant effect of sea spray on both the momentum and heat fluxes is complicated by the interaction between the sea spray, turbulence and mean flow.

Prediction of Consensus TC Track Forecast Error and Correctors to Improve Consensus TC Track Forecasts

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Funded by a previous JHT project, a graphical predicted consensus error product (GPCE) was developed and installed on the ATCF at both NHC and JTWC in 2004. Using GPCE's pool of predictors from the 2002-2006 seasons, revised regression models to be used for the 2007 season were derived and installed on the ATCF at both centers. These regression models are used to determine the radii of circular areas drawn around the consensus model forecast positions within which the verifying TC position is expected to be contained approximately 75% of the time. These circular areas are then graphically displayed on the ATCF for use by the forecasters at NHC and JTWC. For the 2007 Atlantic season, the circular areas displayed by GPCE drawn around the CONU forecast positions contained the verifying TC position 70%, 71%, 76%, 83%, and 83% of the time at 24h, 48h, 72h, 96h, and 120h, respectively. For the 2007 eastern North Pacific season, the GPCE circular areas contained the verifying TC position 83%, 84%, 92%, 89%, and 88% of the time at 24h, 48h, 72h, 96h, and 120h, respectively. For the Atlantic, the performance of GPCE was close to what was expected. For the eastern North Pacific, the circular areas displayed by GPCE contained the verifying TC position more often than expected. Because the GPCE areas contained the verifying TC position less often than expected for the eastern North Pacific in 2006, an adjustment was made to the radius calculations for 2007 increasing their size. That adjustment coupled with the exceptionally small CONU track forecast errors for 2007 (50 nm, 97 nm, 120 nm, 152 nm, and 180 nm at 24h, 48h, 72h, 96h, and 120h, respectively) produced the higher than expected GPCE verification percentages for the eastern North Pacific in 2007.

The techniques used to predict consensus error were then applied to predict the east-west and north-south forecast error of the consensus models. Regression models to predict CONU and GUNA east-west and north-south forecast error for all forecast lengths in the Atlantic and eastern North Pacific (CONU only) were derived using the pool of predictors for the 2001-2006 seasons. These predicted errors were used as correctors to be applied to the consensus models for the 2007 season. The means of the CONU and GUNA east-west and north-south forecast errors for all forecast lengths in the Atlantic and the eastern North Pacific (CONU only) were also found for the 2001-2006 seasons to be used as correctors for the consensus models for the 2007 season. The sample size for the eastern North Pacific for GUNA was not sufficient to produce reliable regression models. From previous work it was found that for both CONU and GUNA for the Atlantic, the bias correctors were more effective than the statistical correctors derived using the regression models for forecast lengths less than or equal to 72h. For CONU, the application of only the statistical corrector for the north-south error was most effective at 96h and 120h. For GUNA, the application of the statistical corrector for the north-south error and the bias corrector for the east-west error was most effective at 96h and 120h. Using these strategies, corrected consensus forecasts (CCON and CGUN) were produced for the 2007 Atlantic season. For the 2007 season, the CCON errors were 61 nm, 97 nm, 139 nm, 181 nm, and 262 nm at 24h, 48h, 72h, 96h, and 120h, respectively. The respective errors for CONU were 60 nm, 98 nm, 141 nm, 184 nm, and 262 nm. None of the CCON improvements were statistically significant. For the 2007 season, the CGUN errors were 53 nm, 97 nm, 134 nm, 160 nm, and 224 nm at 24h, 48h, 72h, 96h, and 120h, respectively. The respective errors for GUNA were 53 nm, 98 nm, 140 nm, 174 nm, and 252 nm. The CGUN improvements were significant at the 90%, 94%, and 85% levels at 72h, 96h, and 120h, respectively. From previous work it was found that for CONU for the eastern North Pacific, the statistical correctors derived using the regression models were most effective for all forecast lengths. Using this strategy, CCON forecasts were produced for the 2007 eastern North Pacific season. The CCON errors were 50 nm, 97 nm, 117 nm, 166 nm and 203 nm at 24h, 48h, 72h, 96h, and 120h, respectively. The respective errors for CONU were 49 nm, 94 nm, 116 nm, 152 nm, and 181 nm. The CGUN degradations at 96h and 120h were significant at the 89% and 83% levels, respectively.

An Objective Tool for Identifying Hurricane Secondary Eyewall Formation

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Hurricanes, and particularly major hurricanes, will often organize a secondary eyewall at some distance around the primary eyewall. These events are generally associated with marked changes in the intensity and structure of the inner core, such as large and rapid deviations of the maximum wind and significant broadening of the surface wind field. The latter has particularly dangerous consequences in terms of sea state, and storm surge and wind damage extent during landfall events. Despite the importance of secondary eyewall formation in hurricane forecasting, there is presently no objective guidance to diagnose or forecast these events. Here we introduce a new index that will provide forecasters with a probability of imminent secondary eyewall formation (SEF). The algorithm is based on environmental and geostationary satellite features from the SHIPS-model developmental dataset applied to a Bayesian classification scheme.

Table 1 shows the "confusion matrix" for the present forms of the algorithm applied to the North Atlantic. To create this, we reduced our continuous probability estimates to a simple binary classifier by using 50% as a threshold between predicting SEF and non-SEF. The effects that the environmental features and the GOES satellite-derived features have on the accuracy of the predictions can be seen by the changes in the elements of the matrix, and are further quantified in Table 2. Table 2 shows the Brier Skill Score, Probability of Detection (hits), False Positive Rate (false alarms), and False Negative Rate (misses) for climatology, and the algorithm with and without the inclusion of the satellite information. The algorithm performs skillfully and the satellite information measurably increases the skill. When the satellite information is included, the skill level is 30% above climatology. Cross-validation of the algorithm is in progress and we can expect some reduction of this skill in an operational setting. During our presentation, we'll introduce the details of our method and the results of the cross-validation.

Table 1: Confusion matrix resulting from North Atlantic climatology (top rows), and for the algorithm without the GOES features (middle rows) and with the GOES features (bottom rows). The two columns represent instances of the *predicted* class and the rows represent instances of the *observed* class. For the case of climatology, we would simply always predict no SEF (on average, we would be correct about 67% of the time and would miss all actual SEF). The improvements can be seen with the inclusion of the environmental features, and again with the further inclusion of the GOES information.

		SEF-YES (predicted)	SEF-NO (predicted)
Climatology	SEF-YES (observed)	0 (hits)	108 (misses)
	SEF-NO (observed)	0 (false alarms)	251 (correct negatives)
Environmental	SEF-YES (observed)	17 (hits)	91 (misses)
	SEF-NO (observed)	3 (false alarms)	248 (correct negatives)
Env. plus GOES	SEF-YES (observed)	36 (hits)	72 (misses)
	SEF-NO (observed)	5 (false alarms)	246 (correct negatives)

Table 2: Performance metrics of the algorithm.

	Brier Skill Score	Probability of Detection	False Alarm Rate	Miss Rate
Climatology	0%	0%	0%	100%
Environmental	20%	16%	1%	84%
Env. plus GOES	30%	33%	2%	67%

The Quality of Pre-Advisory Model Guidance

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With the current observing platforms now available, it is very rare for a tropical cyclone (TC) to go undetected prior to the issuance of the first official NHC advisory or JTWC warning. It is now common to monitor a pre-TC disturbance for several days before TC formation. These pre-TC "invests" are maintained as a working "best track" and used to run the guidance suite. For numerical models, this means running a tracking program on the model fields that locates a TC-like circulation near the INVEST initially and during the forecast. This early guidance is important to setting the forecast scenario for the critical first advisory – critical in how the first forecast constrains subsequent official forecasts.

In this paper, the quality of the early guidance from the primary models used in consensus is evaluated and model skill before and after the first advisory/warning for 2007 in all northern Hemisphere basins is analyzed. The general expectation is that early model guidance will be of low quality and that skill will improve as the TC develops. One reason for this expectation is that many models use the NHC/JTWC TC information (e.g., position, intensity, motion and wind radii) in their vortex initialization. Although it might be assumed that skill improves with a better initialization, the early guidance is found to have higher skill than might be expected and that better initial conditions after the first advisory/warning do not provide consistent improvement to the forecasts.

Tropical Cyclone Dressing: Next-Generation Goerss Predicted Consensus Error (GPCE)

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The aim of this work is to produce improved objective uncertainty guidance for Tropical Cyclone (TC) track forecasts. The goal is to produce sharp (different from climatology), reliable (e.g. forecast 30% events happen 30% of the time) probabilistic forecasts of tropical cyclone position. The proposed approach is fundamentally probabilistic, but uses the traditional approach of adding uncertainty information to a deterministic forecast as a null hypothesis (e.g. climatology, GPCE). Kernel density ideas are employed to explicitly treat forecast as arbitrary probability distribution functions (PDFs) of possible TC locations. Such PDFs could be used as guidance products by official forecasters to help improve TC forecasts and as input into other probabilistic forecast products, such as the spatial distribution of possible damaging winds.

A hierarchy of baseline uncertainty products have been developed, including isotropic climatological errors, climatological errors in latitudinal and longitudinal directions (including bias correction), climatological errors in across-track and along-track direction (including bias correction), and GPCE. Various configurations of TC Dressing algorithms are compared against these baselines.

Interactions with TC forecasters have elucidated an interest in a product that communicates the probability of where verification is likely to fall with respect to the consensus (e.g. left, right, forward, behind). Exploratory development is being undertaken.

Session 8
Field Experiments and Other Hurricane-related Research/Projects

S E S S I O N 8

An Overview of the THORPEX-Pacific Asian Regional Campaign (T-PARC) during August-September 2008

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During August-September 2008, a major field program titled THe Observing systems Research and Predictability Experiment (THORPEX) Pacific Asian Regional Campaign (T-PARC) will be conducted. As a multi-national field campaign, T-PARC addresses the shorter-range dynamics and forecast skill related to tropical cyclones of one region (Eastern Asian and the western North Pacific) and their downstream impact on the medium-range dynamics and forecast skill of another region (in particular, the eastern North Pacific and North America). While T-PARC encompasses varying time and space scales, the primary objectives of each region are the same: To increase understanding of the mechanisms that will lead to improved predictive skill of high impact weather events. This multi-scale approach of T-PARC is desirable as high impact weather events over these two regions have strong dynamical links. For example, high-impact weather events over the western North Pacific and East Asia, such as persistent deep tropical convection and tropical cyclones, can trigger downstream responses over the eastern North Pacific and North America via upper-tropospheric wave packets on the primary Asian wave guides. These wave packets can, in turn, be invigorated by subsequent cyclogenesis events, which make the impacts farther downstream fast-spreading, far-reaching, and associated with reduced predictability.

A combination of observational platforms that includes multiple aircraft and collaborative experiments will be utilized to observe the structure and evolution of the primary Asian/North Pacific wave guides high impact events (heavy rainfall, tropical cyclones and extratropical cyclogenesis) that take place over the western North Pacific and East Asian region that interact with these wave guides. Such an ambitious measurement strategy can only be reasonably accomplished with the level of international collaboration envisioned in 2008. A tropical measurement strategy is designed to examine the large-scale variability in the circulation of the tropical western North Pacific as it relates to enhanced and reduced periods of wide-spread deep convection, tropical cyclone formation and the variations in intensity and track as the systems move to the northwest.

These observations will be used in concert with an unprecedented variety of numerical models, which includes research modeling and assimilation systems together with access to the members of the ensemble forecasts of all the major operational centers through the THORPEX Interactive Global Grand Ensemble (TIGGE). T-PARC will be able to readily include the deterministic and probabilistic nature of the forecast problem associated with tropical cyclone formation, intensification, structure change, extratropical transition, and downstream impacts. Observations and results gathered during this program expect to be applicable to all ocean basins that contain tropical cyclones, which is a reason for such wide-spread international participation in T-PARC.

Tropical Cyclone Structure (TCS08) Field Experiment in the Western North Pacific During 2008

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The Office of Naval Research in conjunction with the Naval Research Laboratory and the U. S. Air Force is sponsoring a major field experiment called Tropical Cyclone Structure (TCS08) during August and September 2008. The three scientific foci of the field experiment are tropical cyclone formation, structure change including intensity changes, and the processes leading to recurvature. This TCS08 will then blend into the THORPEX-Pacific Asian Campaign (T-PARC) that focuses on the extratropical transition and downstream impacts, although the Asian countries also have common interests with TCS08.

A specific focus in the formation component is the relative roles of mesoscale processes in determining the location, timing and rate of tropical cyclone formation in the monsoon trough environment of the tropical western North Pacific. The concept of operations includes localization of potential formation areas based on global models and the use of the mesoscale model for planning detailed flight patterns, perhaps also with an adjoint targeting technique. While the Air Force Reserve WC-130 is providing observations of the environment, the Naval Research Laboratory (NRL) P-3 with the ELDORA and a wind lidar will be observing the mesoscale structure. During the structure change phase, the WC-130 with the Stepped Frequency Microwave Radiometer will be monitoring the internal structure while the NRL P-3 is exploring the near- and outer-core processes hypothesized to lead to structure change. A key role of the WC-130 is to obtain large numbers of intensity measurements necessary to evaluate satellite-based techniques that are essentially unvalidated in the western North Pacific since the discontinuation of aircraft reconnaissance in 1987. The WC-130 may also have a role in making targeted observations for situations leading to recurvature-type tracks.

This presentation is intended to provide an overview of the TCS08. Some of the satellite, model and targeting products that have been created to support the TCS operations will be described.

A Review of the NOAA IFEX Hurricane Field Experiments Conducted in 2007

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Since 2005, NOAA's hurricane field program has been part of an overall NOAA program known as IFEX (Intensity Forecasting Experiment). IFEX has three main goals:

1) Collect observations that span the TC lifecycle in a variety of environments;
2) Develop and refine measurement technologies that provide improved real-time monitoring of TC intensity, structure, and environment;
3) Improve our understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle.

The experiments in the 2007 field program were focused on these goals. The special emphasis was on collecting airborne Doppler and SFMR (Stepped Frequency Microwave Radiometer) observations that could be assimilated into the HWRF (Hurricane Weather Research and Forecasting) model. The goal of the collection of measurements is to document the core of a storm from the time it is depression until it is a major hurricane and then through dissipation or landfall. Observations were collected at all stages of development; however, we were not able to capture one storm from tropical depression to mature hurricane. As part of its operational reconnaissance requirements, NOAA probed TS Erin. Next, two NOAA WP-3D aircraft were deployed to St. Croix where, they probed Hurricane Felix, from approximately the time it was becoming a hurricane through its category 5 status. This intensification happened very rapidly, and the two NOAA WP-3D aircraft probed it, one at a time, every 12 hours. It was one of the most rapid intensifications to category 5 status from tropical depression, and a good portion of this intensification was captured. Both NOAA aircraft also deployed on two other occasions to Barbados, where they observed TS Ingrid and Hurricane Karen. Both Ingrid and Karen were weakened by high vertical shear of the environmental wind. Thus, a good deal of observations were collected in "stressed" systems, and this will help us learn to quality control observations in these systems with sparse precipitation. It also provides observations that will challenge HWRF to work with sparse, asymmetrically distributed, observations.

Another new measurement device deployed for the second time in an Atlantic tropical cyclone was the Unmanned Aerial Surveillance aircraft Aerosonde, which flew from Wallops Island into Noel. Observations in the first few hundred meters from the sea surface were collected in coordination with observations (including airborne Doppler) from a NOAA WP-3D aircraft.

The goal of IFEX in the 2008 hurricane season will be to continue to collect observations, in particular airborne Doppler and SFMR observations, throughout the life cycle of tropical cyclones. Again the major emphasis will be on collecting these observations in support of development of the HWRF model. We will provide example analyses from 2007, assess the 2007 season, and then update our goals for the 2008 hurricane season at the conference.

Research on Landfalling Hurricanes Utilizing Mobile Research Platforms

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Several research activities on various characteristics of landfalling tropical cyclones are underway at UAH. These research areas can be classified into the following closely-related categories, with a brief description of research activities listed under each topic:

a) Mesoscale aspects of the boundary layer transition of landfalling TC's. This research is concerned with characteristics of the boundary layer (depth, mean wind profiles, thermodynamics) around the landfalling TC.

b) Investigations of the kinematic and microphysical properties of rainbands and stratiform precipitation. This activity is currently focusing on mesoscale vertical motion and microphysical processes within both stratiform and convective rainbands. One goal is to better understand the production of cool air within mesoscale downdrafts, and the impact of this cool air on TC intensity change around the time of landfall.

c) Characteristics of hurricane spawned tornadoes and the characteristics of their parent rainband. We are particularly interested in tornadoes and mini supercell storms that occur or form near the coastal region, and how their formation is related to the boundary layer and mesoscale properties of the parent rainband.

d) Quantitative precipitation estimation of TC rainfall. With close connections to item (b), the goals of this research are to better understand the precipitation process within landfalling TC's. Part of this effort will utilize disdrometers and dual-polarization radar to examine Z-R relationships and their variability with the TC.

These research activities will utilize the UAH Mobile Integrated Profiling System (MIPS), the Mobile Alabama X-band (MAX) dual polarization radar, disdrometers, surface data from special towers, and WSR-88D radars. The intent is to collaborate closely with other university groups, the NOAA Hurricane Research Division, and NWS offices close to the deployment locations.

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A Roadmap for a Seamless Topobathy Surface

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A topobathy digital elevation model (DEM) is a single surface combining the land elevation with the seafloor surface—and which can be used to examine processes that occur across the coastal and nearshore areas. *A Roadmap to a Seamless Topobathy Surface* (*Roadmap*) is a series of documents and maps that seek to improve and streamline the process of creating a topobathy DEM. The series aims to make topographic and bathymetric data and reference information accessible and make connections between data set quality and DEM application (such as coastal inundation modeling). Understanding the links between input data quality and application can help users create a DEM surface designed for a particular purpose, can help data collectors provide data sets that meet needs, and can assist technical users in defining their data requirements more explicitly.

The *Roadmap* examines resources and processes associated with DEM creation, including the following: (1) available data resources, (2) processes to generate high-resolution DEMs that minimize error, and (3) examples of topobathy applications. The *Roadmap* may also be useful to managers who are involved in activities such as planning a data collection. This series of products will help detail the steps required to create seamless coastal maps—a task that has been highlighted as an important national need by the National Research Council.

The first part of the *Roadmap* series—this set of maps and information—is an inventory of available topographic and bathymetric data resources for the Gulf of Mexico: *Topographic and Bathymetric Data Inventory: Gulf of Mexico (Gulf Inventory)*. The Gulf of Mexico coastal area was chosen for this project to assist data coordination efforts and to enhance geospatial capacity across the Gulf states. The *Gulf Inventory* is meant to increase awareness and use of existing topographic and bathymetric data sets, decrease duplication of effort, and strategically target data collections to fill gaps. It is a "snapshot" of data availability as of November 15, 2007, and it identifies location, collection date, and sources of available data sets. This resource is currently available on the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center's website (*www.csc.noaa.gov/topobathy/*).

Topographic and Bathymetric Data Considerations: Datums, Datum Conversion Techniques, and Data Integration (Data Considerations) is the second part of the *Roadmap*. It is important for a surface to have data inputs that are positioned in reference to the same metric if it is to be used to accurately portray the nearshore and coastal areas. This document strives to improve and streamline the process of creating DEMs by providing a review of available datum conversion and integration techniques. It describes the importance of establishing a uniform reference for multiple data sets and techniques for manipulating and joining data sets.

The third part of the *Roadmap* will highlight some common coastal applications that can benefit from a highly accurate, high-resolution DEM. This reference, which is not yet completed, will describe applications of topographic, bathymetric, and topobathy DEMs and address standards for input data and the resulting DEM for an application.

Advanced Hydrologic Prediction Service (AHPS) Flood Inundation Maps

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National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) and National Ocean Services (NOS) are leading efforts to collaborate with the Federal Emergency Management Agency (FEMA), United States Geological Survey (USGS), Corps of Engineers (USACE), state, and regional authorities to communicate the risks of flooding through the use of inundation mapping. These flood inundation maps provide information on the spatial extent and depth of flood waters in the vicinity of NWS river forecast locations. Combined with river observations and NWS river forecasts, inundation maps enhance the communication of flood risk and provide decision-makers additional information needed to better mitigate the impacts of flooding and build more resilient communities.

Following the devastating floods caused by Hurricane Floyd (1999), the State of North Carolina worked with FEMA and assumed responsibility for the National Flood Insurance Program (NFIP) maps for all North Carolina communities. The North Carolina Floodplain Mapping Program (NCFMP) coordinates statewide flood hazard studies and creates "seamless" statewide Digital Flood Insurance Rate Maps (DFIRMS) using updated flood hazard data, new topographic data, and aerial imagery. This resource was invaluable to the inaugural creation of flood inundation map libraries established for more than a dozen North Carolina communities implemented in 2007.

Users are now able to display flood inundation maps for forecast river levels ranging from minor flooding through the largest observed flood on record. The flood inundation maps and associated geospatial data (e.g., shapefiles) are accessible via the AHPS webpage (http://www.weather.gov/ahps/). A list of current map library locations is available on the web at (http://www.weather.gov/ahps/inundation.php).

Hurricanes Katrina and Rita (2005) exposed the vulnerability of other coastal states, besides North Carolina, to hurricanes and flooding. The NWS is in the process of creating additional flood inundation map libraries at 35 locations in 4 Gulf States (TX, LA, MS, AL) to ensure that communities and property owners have accurate, up-to-date information about the flood risk. The majority of these new map libraries will be available before the mid-point of the 2008 hurricane season.

For the purposes of reducing loss of life and property, NOAA is vigorously building coalitions with additional emergency and floodplain managers to implement this new, cost-effective hazard visualization and communication technique for other vulnerable flood-prone areas. Emergency planners, managers, and administrators interested in the creation of inundation libraries for their communities are encouraged to coordinate with NOAA via the feedback page accessible through AHPS (http://www.weather.gov/ahps/) or, by contacting their local NWS office.

Session 9
Joint Hurricane Testbed: Project Updates and Plans for the Future

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The Joint Hurricane Testbed (JHT): 2008 Update

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New analysis and forecasting tools and techniques, developed by the research community, were tested and evaluated during 2007 at the Tropical Prediction Center/National Hurricane Center (TPC/NHC), in real time for the seventh consecutive hurricane season, as facilitated by the Joint Hurricane Testbed (JHT). Fifteen third round (FY05-06) JHT projects completed during the spring and summer of 2007. Ten fourth round (FY07-08) projects started during the 2007 hurricane season, following a proposal review and any necessary technique modifications or other preparations. These projects include upgrades to dynamical models and model components, enhancements to observed data and assimilation techniques, track forecasting algorithms, intensity estimation and forecasting algorithms, and tropical cyclone structure and wind and wave distribution.

An Improved Wind Probability Program: A Joint Hurricane Testbed Project Update

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Under Previous JHT support a new program for estimating the probability of occurrence of 34, 50 and 64 kt winds was developed by NESDIS and CIRA. A Monte Carlo (MC) method was utilized to combine the uncertainty in the track, intensity and wind structure forecasts. The MC probability program was transitioned to NHC operations for the 2006 hurricane season. A verification program was also developed and provided to NHC. Verification results showed that the probabilities were skillful using standard metrics for probabilistic forecasts, and were relatively unbiased.

In the current project, three improvements to the MC program are under development. First, the timeliness of the MC model is being improved by optimizing and modifying the code. Second, the MC code is being modified to produce the output for the NHC "wind speed probability table" product. This product was developed separately from the MC model, but contains information based on out of date error distributions and only extends to 72 hr. If the table can be produced directly from the MC model, it will automatically be updated as part of the yearly MC model updates and will extend to 5 days. Third, the probability estimates are being refined by making the underlying track error distributions a function of the forecast uncertainty. The current MC model uses basin-wide error statistics but recent research has shown that the spread of track forecasts from various models can provide information about the expected track error. J. Goerss from NRL developed a real-time tool to quantitatively estimate the track forecast uncertainty (the Goerss Predicted Consensus Error, GPCE).GPCE input is being incorporated into the MC model to provide additional information about the concurrent track error distributions.

Progress on each of the above three tasks will be presented. Speeding up the most time consuming portion of the operational product on the large latitude-longitude grid by a factor of six has been accomplished by reformulating the probability algorithm in two dimensions. In addition, experiments were performed which showed that all of the input for the wind speed probability table product can be generated directly from the realizations of the MC model. Thus, a separate program will not be needed for that product. Preliminary results to determine the utility of the GPCE product to refine the MC probability estimates will also be presented.

DISCLAIMER: The views, opinions, and findings in this report are those of the authors and should not be construed as an official NOAA and/or U.S. Government position, policy, or decision.

Operational Use of Near-Real-Time Sea Surface Directional Wave Spectra Generated from NOAA Scanning Radar Altimeter Range Measurements

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ProSensing shipped the new NOAA Scanning Radar Altimeter (SRA) to the NOAA Aircraft Operations Center (AOC) in mid-October 2007. Unfortunately, due to other commitments, AOC has not been able to install it on N43RF. Although a detailed end-to-end simulation has been developed to test the SRA directional wave spectrum analysis software, a test flight to verify system performance will not be possible until May 2008 at the earliest. Programs to display the SRA output data have been developed and tested on a Joint Hurricane Testbed server by Jose Salazar (NHC) using dummy files generated from data acquired on an earlier hurricane flight with the NASA SRA. Providing SRA output files which mimic Jason satellite altimeter data has allowed Chris Lauer (NHC) to input SRA data into the N-AWIPS system so forecasters could use it interactively and view the SRA output with any other data sets they wish to overlay. There is a significant difference between a satellite altimeter and the SRA that needs to be considered in the N-AWIPS system. A satellite passes over the hurricane in about a minute, essentially providing an instantaneous snapshot of the wave heights along its track. The downside of a satellite altimeter is that an encounter with a hurricane is relatively rare and even when it does, its very narrow swath will generally not pass directly over the eye. In contrast, the SRA provides excellent azimuthal coverage within about 200 km of the eye and includes several eye penetrations, but the storm generally moves significantly during the typical 5 hour period it takes to acquire the data. Providing two SRA output files for N-AWIPS could optimize the SRA benefit. The most useful data for a hurricane in open water would be to assign the latitude and longitude values not to the observation positions, but to storm-relative positions corresponding to the eye location at the time of the last observation. Since the wave field moves with the storm, this would present the most consistent and realistic picture. A second file with latitude and longitude corresponding to the observation locations would allow users to see the wave information as collected, superimposed on shorelines where shallow bathymetry and land sheltering significantly modify the open water wave field variation.

Validation and Processing Tools for the Air Force Reserve Command 53rd Weather Reconnaissance Squadron WC-130J Multi-Aircraft SFMR Systems

James Carswell, Remote Sensing Solutions
Peter Black, Naval Research Lab and SAIC, Inc. (formerly NOAA AOML/HRD)
Eric Uhlhorn, NOAA AOML/HRD
Paul Chang, NOAA NESDIS

This JHT project seeks to improve the operational utilization of ocean surface wind and rain products derived from the Stepped Frequency Microwave Radiometer (SFMR) flown aboard the Air Force Reserve Command 53rd Weather Reconnaissance Squadron WC-130J aircraft and the NOAA WP-3D aircraft. Starting in 2007, both the Air Force and NOAA began flying multiple SFMR systems. Infrastructure, tools and a knowledge base for the NOAA SFMR has been established; however little to none exist currently for the Air Force SFMR systems. Remote Sensing Solutions (RSS) and NOAA Hurricane Research Division (HRD) have teamed to develop and deploy the tools and training that is necessary to validate and fully utilize the observations from the Air Force SFMR systems and to improve the overall performance and operational utilization of the SFMR wind and rain products from the Air Force and NOAA. This team is focused on four key areas:

1) **Calibration and Validation –** The retrieval products from the Air Force SFMR systems must be verified and monitored to ensure their quality. A solution that fits within operational constraints and is automated is required.
2) **Storm Relative SFMR-NAWIPS Processing and Post Processing Tool –** SFMR observations are being collected from multiple Air Force and NOAA aircraft. These observations span both time and space. An operational, real-time processing tool is required to map these observations to a storm relative coordinate system and produce N-AWIPS compatible files at specified center fix times so the SFMR observations may be displayed with NMAP.
3) **Improved SFMR Retrieval Algorithm Performance –** The current SFMR operational retrieval process produces higher variance wind and rain estimates under low to storm force winds. Its performance is also degraded during low altitude (e.g. 1500 feet) missions. Biases have been shown in shallow waters and some dependence on storm relative azimuth has been documented. These problems / issues must be addressed and corrections implemented to improve the quality and confidence in the operational SFMR retrieval products.
4) **Technical Expertise and Guidance –** The proposed team will provide guidance to NHC forecasters as they develop experience with the SFMR products from the Air Force. This team will also provide thorough and timely response to all questions posed by NHC and other users of the SFMR wind products throughout and following each hurricane season.

This presentation will discuss the progress and accomplishments from the first year of this effort and the tools and capabilities that will be available for test and evaluation during the 2008 hurricane season.

Web-ATCF, User Requirements, and Intensity Consensus

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The Automated Tropical Cyclone Forecasting System (ATCF) was developed by NRL and has been in use at the Joint Typhoon Center since 1987 and at NHC since 1990. Since this time, a concerted effort has been made to develop common data formats and functionality so that tropical cyclone information can be easily shared among the operational forecast centers in real-time. As a result, the ATCF has become a target platform for many NHC and JHT products. Moreover, all development is coordinated between the tropical cyclone forecast agencies and developers at NRL and NHC. Progress for the JHT project and other items of interest to various governmental agencies will be presented, including:

- Web-ATCF: The web-ATCF prototype adds powerful capability as a thin client software bundle that allows a variety of web proxy, web server and ATCF server configurations for use in demanding, secure IT environments. This prototype initiative and other web-enabling modifications will provide new cost effective capabilities that will promote hardware and software independence for demanding operational usage.
- User Requirements: At least 30 new user requirements will be addressed in upcoming ATCF 4.4 and 4.5 software version releases. These requirements include new forecast dialogs and changes to existing dialogs that simplify the forecast process and ease forecaster workload.
- Intensity Consensus: Intensity consensus aids were derived for a period covering 2003-2006. In this large sample, the data suggests that a two-model consensus (DSHP and GFDL) and a three-model consensus (DSHP, GFDL and GFDN) provide a reasonable skill baseline for evaluation of other more complex consensus methods. These results will be updated using 2006 and 2007 data.
- Products and Services: Current efforts are underway by NHC to produce tropical cyclone analysis and forecast products using GIS format specification (shape files). These GIS datasets, intended for use by the emergency management and scientific community, will be prototyped for evaluation in 2008. Parallel efforts are underway to produce a similar product suite for Google Earth and Google Maps. These supplemental products are being prototyped for possible near real-time dissemination; a requirement requested by external users.

High Wind Drag Coefficient and Sea Surface Roughness in Shallow Water

Dr. Mark D. Powell

NOAA Hurricane Research Division - AOML

This project examines how the aerodynamic roughness of the sea surface varies between shallow and deep water. All tropical cyclone GPS sonde data collected and post processed since 1997 were placed in a modern relational database, organized by water depth, and analyzed to provide values of surface stress, roughness, and drag coefficient Cd as a function of wind speed and water depth. This effort is applied towards numerical weather prediction priorities and is also related to hurricane forecast improvement needs. Preliminary analysis was conducted for sondes with mean boundary layer (MBL) winds of 30-39 m/s. For offshore flow 10 sonde profiles were available. A log Z vs wind speed plot indicates that for several sondes, the lower 50 m of the wind profile shows near constant wind speed profiles with height characteristic of internal boundary layer development. This behavior suggests non stationary conditions associated with the lower levels of the offshore flow accelerating due to a new (sea) underlying surface, whereas the upper levels of the boundary layer are characterized by higher shear associated with flow over land. For shallow water onshore flow 42 sonde profiles are available (Fig 4a) and a mean profile fit suggests a roughness length of about 0.7 mm. A mean profile constructed from all 294 sondes in the 30-39 MBL group suggests a smaller roughness length of about 0.3 mm, but these include the shallow water profiles. Preliminary indications suggest that the shallow water wind profiles are associated with higher roughness than the deep water profiles. Additional analysis to be presented includes limited numbers of shallow water wind profiles for the 20-29 m/s and 40-49 m/s MBL wind groups.

Session 10
Products and Services

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FEMA's Utilization of Tropical Forecasts and Other Products

Michael Buckley
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FEMA uses tropical forecasts and other products in a variety of ways to support its mission of leading and supporting the National Emergency Management System of Mitigation, Preparedness, Response and Recovery. The presentation will focus in particular on the relationship between these products and FEMA's support for hurricane emergency management decisions through the National Hurricane Program.

A Preliminary Verification of the National Hurricane Center's Tropical Cyclone Wind Speed Probability Forecast Product

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The 45th Weather Squadron (45 WS) provides comprehensive weather services to America's space program at Cape Canaveral Air Force Station (CCAFS), Patrick Air Force Base and NASA's Kennedy Space Center (KSC). Given the location of these facilities, on the central east coast of Florida, tropical cyclones (TC) pose a significant threat to these agencies. When a TC threatens the area, the 45 WS provides detailed information to launch agencies concerning the storm threat including track, timing, intensity and size. One of the support tools used by the 45 WS is the Tropical Cyclone Wind Speed Probability Forecast Product issued by the National Hurricane Center (NHC). The 45 WS relay this and other information to senior managers who then decide if and when to begin actions necessary to protect resources.

In 2004, Colorado State University created a TC probability forecast product which was adopted as an experimental product by the NHC in 2005 and was transitioned to operations in 2006. As a relatively recent product, the TC wind speed probability forecasts have yet to be fully evaluated. Some verification of the cumulative probability products has been conducted recently across the Atlantic basin. However, little verification has been performed for the interval probabilities – especially for land threatening or land falling events. This work presents a verification of the interval probability forecasts for Florida's east coast between Jacksonville and Miami. This study emphasizes an objective evaluation of the product's performance and interpretation of the product for operational applications, e.g. which forecast probabilities represent low/moderate/high risk for the various wind speed and forecast interval categories. This project focuses on four hurricane seasons from 2004 – 2007 and includes all storms approaching the east coast of central Florida. Verification statistics were computed for each of the 21 forecast categories of the NHC probability product; three wind speed criteria (≥ 34 Kt, ≥50 Kt, and ≥64 Kt) and seven forecast time intervals (12, 24, 36, 48, 72, 96, and 120 hours). Verifications included use of reliability diagrams, sharpness diagrams, and additional statistics to quantitatively measure the product's performance. In order to assess regional variability, the project will be expanded to include additional areas of interest centered on Charleston, SC, New Orleans, LA, and Corpus Christi, TX.

Verification of NHC Forecasts of Extratropical Transition

Jack Beven

National Hurricane Center

This talk will present the verification of National Hurricane Center forecasts of the extratropical transition of tropical cyclones from 1996-2007. It examines skill metrics of the forecasts as well as the associated timing errors.

The NESDIS Tropical Cyclone Formation Probability Product: An Overview of Past Performance and Future Plans

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The NESDIS Tropical Cyclone Formation Probability (TCFP) product was developed in response to the need for objective, real-time guidance to aid in the prediction of tropical cyclone (TC) formation. The TCFP product uses values from the GFS analysis fields, such as the vertical shear of the wind and vertical instability, in combination with water vapor brightness temperatures from the NOAA GOES-East and GOES-West and the JMA MTSAT-1R satellites to determine the probability that a tropical cyclone will form within the next 24 hours. The current TCFP product has been operational since 2005, and provides guidance for the N. Atlantic and eastern N. Pacific basins. In late 2006, the TCFP was updated by extending the domain to include the central and western N. Pacific basins, using a longer developmental dataset, and making minor improvements to the product algorithm. This updated product has been running experimentally at the Cooperative Institute for Research in the Atmosphere since spring of 2007.

Both the operational and experimental TCFP products have been evaluated using metrics such as the Brier skill score and relative operating characteristic (ROC), and have demonstrated forecast skill. In addition, the experimental product underwent formal evaluation by the Joint Typhoon Warning Center during the 2007 typhoon season. Once evaluations are complete for the 2007 season, this new extended product will replace the current version as the operational TCFP product. This transition will take place in collaboration with the NESDIS Office of Satellite Data Processing and Distribution.

Objective TC formation guidance is still needed in the Southern Hemisphere and Indian Ocean tropical basins. Given the demonstrated forecast skill of the TCFP product, there are plans to extend product coverage to these regions and hence provide global TC formation probability guidance. Other plans for the product include extending the TC formation probabilities from 24 hours to 48 hours and beyond and, in conjunction with the NOAA/NWS Tropical Prediction Center Tropical Analysis Forecast Branch (TAFB), including TAFB invest locations and intensity estimates as new predictors in the product algorithm.

New and Updated Operational Tropical Cyclone Wind Products

John A. Knaff – NESDIS/StAR - RAMMB, Fort Collins, CO
Alison Krautkramer – NCEP/TPC - NHC, Miami, FL
Mark DeMaria – NESDIS/StAR - RAMMB, Fort Collins, CO
Andrea Schumacher – CIRA/CSU, Fort Collins, CO

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This presentation will discuss two tropical cyclone wind products that are operational or are being transitioned to operations. These include the operational NCEP/TPC AMSU tropical cyclone intensity and wind structure algorithm and a new Multiplatform Tropical Cyclone Surface Wind Analysis (MTC-SWA) that is being transitioned to NESDIS operations. The AMSU algorithm was originally developed for the Atlantic and east Pacific as a JHT project and was later generalized to include global tropical cyclones under NESDIS support. The AMSU algorithm currently uses input from all available NOAA polar orbiting satellites, but is being improved by adding input from the AMSU from both the NASA AQUA and European Met-Op satellites. This addition will improve the time resolution of the AMSU intensity and wind structure estimates. Possible new uses of the AMSU retrievals will also be discussed. The MTC-SWA combines wind information from GOES, AMSU, passive microwave and scatterometers to provide a two-dimensional surface wind analysis. The MTC-SWA has been run experimentally at CIRA and is being transitioned to NESDIS operations The tropical cyclone fix (wind radii, RMW, intensity and MSLP) information from both products is available in the Automated Tropical Cyclone Forecast system at JTWC and NHC. Additional real-time output from these products is provided and past events are archived on the RAMMB TC web page (http://rammb.cira.colostate.edu/products/tc_realtime/). Examples of these products and comparisons of MTC-SWA based wind fields and wind radii estimates with other concurrent and independent analyses will be discussed.

The Future of NOAA's Seasonal Atlantic Hurricane Outlooks

Eric Blake [NHC – presenter], Richard Pasch [NHC], Christopher Landsea [NHC] and Gerry Bell [CPC]

Atlantic seasonal hurricane outlooks have been officially issued by NOAA since 1998. These outlooks are a collaborative effort between the Climate Prediction Center, National Hurricane Center, and Hurricane Research Division. The outlooks are issued in late May and early August, and are based mainly on predictions of the larger-scale climate factors (El Nino/Southern Oscillation, the tropical multi-decadal signal, and Atlantic sea-surface temperatures) that control much of the seasonal Atlantic hurricane activity.

Over the last 10 years, these outlooks have generally been more skillful than climatology or persistence. However, in both 2006 and 2007, NOAA significantly over-predicted the seasonal activity as measured by the ACE index, even though some individual forecast parameters did verify. Techniques to improve the seasonal forecasts will be presented, including methods that refine the actual forecast methodology. In addition different ways to reframe and communicate the forecast, including more explicit discussions about the limitations and uncertainties of the forecast, will be discussed. A brief look at conditions that might affect the 2008 Atlantic hurricane season will also be presented.

Federal Aviation Administration (FAA) Air Traffic Control System Command Center Hurricane Procedures

Danny Sims and Michael Brennan, FAA System Operations, Herndon VA

The FAA is responsible for the safe and efficient use of the National Airspace System. Specifically, the FAA's Air Traffic Control System Command Center is responsible for balancing air traffic demand with system capacity to ensure the maximum utilization of the airspace. Even on a fair weather day, this can be challenging due to the amount of airspace volume, airport runway closures, and other impacts. When significant weather is forecasted, this adds to the complexity. Hurricanes, due to their accompanying convective weather and strong winds, are one of the most significant weather events that the FAA must address. As a result, special procedures have been developed and adopted to help mitigate the effects of hurricanes. This presentation will provide an overview of the FAA's current procedures, along with the hurricane forecast products used, for addressing the impact of hurricanes that threaten the United States' airspace along with airspace in the Caribbean and Central America. The coordination that occurs between Aviation Navigation Service Providers and their customers will be presented. In addition, the FAA becomes involved with coordinating hurricane reconnaissance flights to ensure that priority is given to these flights. Finally, when a hurricane makes landfall in the United States, the procedures will be presented that the FAA makes to mitigate the impact and to resume aviation operations as quickly as possible.