64TH INTERDEPARTMENTAL HURRICANE CONFERENCE SUMMARY REPORT

This document provides a summary of the 64th Interdepartmental Hurricane Conference (IHC), a conference that was sponsored and chaired by Mr. Samuel P. Williamson, Federal Coordinator for Meteorology, from March 1-4, 2010, in Savannah, Georgia. The summary report consists of Sections I-III as follows:

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I. OVERVIEW

Purpose and Theme:
The Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) annually hosts the IHC to educate attendees on the status and future plans of the Nation's hurricane forecasting and warning program. Additionally, the IHC provides a forum for the responsible Federal agencies, together with representatives of the user communities such as emergency management, to review the Nation's hurricane forecasting and warning program and to make recommendations on how to improve the program in the future.

During the IHC, the OFCM-sponsored Working Group for Hurricane and Winter Storms Operations and Research (WG/HWSOR) reviews submitted action items regarding the hurricane program, including recommended changes to the National Hurricane Operations Plan (NHOP). New approved procedures and agreements which are directly related to the provision of tropical cyclone (TC) forecasting and warning services are then documented for implementation in the NHOP, which is published annually prior to the upcoming hurricane season.

The theme of this year's conference was *Meeting Operational Needs through Comprehensive TC Research and Development*. With strong partnerships built over many years, the conference was attended by ~ 200 personnel for the 11th consecutive year, including representatives from eight federal agencies: DOC/NOAA, DOD (Navy, Air Force, Army COE), NASA, NSF, DHS (HQ

S&T, FEMA), DOT/FAA, DOI (USGS, MMS), and USDA. Attendees also included representatives from academia, industry, and the emergency management community. All of the presentations that were given at the 64th IHC can be found at: http://www.ofcm.gov/ihc10/linking_file_ihc10.htm.

Objectives: The Opening Session and 11 other sessions that were held during the conference (see Section II below) were structured to address the following conference objectives:

1. Review the Nation's TC forecasting and warning program
   - Address actions from previous IHC
   - Update the National Hurricane Operations Plan for 2010
2. Review an assessment of TC research and development activities and their contributions toward forecasting and warning center's operational priorities
3. Review Joint Hurricane Testbed (JHT) projects, and recognize candidates that may be successfully transitioned into operations
4. Examine aspects of the hurricane forecasting and warning process and ongoing social sciences-related research to aid in improved stakeholder / user response
5. Build upon TC partnerships, leveraging agency capabilities to meet the operational needs of the TC forecasting and warning centers

Key Takeaways:

The key takeaways from the 64th IHC are summarized below. Additional details for each of the subjects addressed can be found in section II of this report.

1. Regarding Objective #2, the OFCM-sponsored Working Group for TC Research (WG/TCR) summarized their work to date in the Session 2 panel, *Assessment of the TC R&D Activities in Contributing to the Operational Priorities of the TC Forecasting and Warning Centers*. Their work resulted in the first-ever, comprehensive interagency linkage of TC research to the TC forecast and warning center's operational priorities. The FY2008/09 snapshot analysis of all identified agency research efforts mapped against the TC research needs and also against the operational priorities was very revealing and an effort that needs to continue. The major points that came out of the workshop are summarized below:
   - The operational priorities of the TC forecasting and warning center's and the TC research needs are referred to as Tables 1 and 2, respectively, and can be found at: http://www.ofcm.gov/ihc10/Presentations/Session02/Table-1-and-Table-2.pdf.
   - Intensity change is the #1 operational priority and was identified jointly by NOAA's NHC/CPHC and DOD's JTWC. Fundamental research is still required in this area, as this is a very difficult and complex problem. This is a major emphasis in the Hurricane Forecast Improvement Project (HFIP), a NOAA-led initiative with many Federal and academia partners.
   - There are differences in operational priorities between JTWC and NHC/CPHC due to the customer base supported by each center.
   - From Attachment 3, which is the combined man-years mapped against detailed TC research categories, there is relatively low meteorological research investment (annotated with "circles" in the figure at Attachment 3) in the following 'Detailed Research Categories':

- Storm surge and wave response to tropical cyclones (A5a and A5b)
- Model development related to physical processes, especially areas B3c, B3d, B3e
- Model development related to studies to optimize model resolution and scale dependent parameterization.

In reference to the low research contributions in categories A2a-d, the Working Group noted that improvement in track forecasting is primarily accomplished through research investment in model development (B1-B3, B5-B7).

- From Attachment 4, which is the research needs mapped to JTWC and NHC/CPHC operational priorities, it was apparent that TC research is better aligned to JTWC operational priorities versus NHC/CPHC priorities.
- Communication of operational priorities to the research community is a good thing, and work should be done to strengthen the processes by which research investments are aligned to operational priorities.
- As shown in Attachment 4, there does not appear to be enough total investment to adequately address all operational priorities. Advanced development funding ("6.4" in DoD parlance) is inadequate to ensure that the discoveries of basic and applied research are efficiently transitioned to operations.
- The operational centers would like the research community to take more of an interest in improving the operational models (e.g., guidance on guidance, diagnostics, and model improvement).

2. Regarding Objective #4, a takeaway from the panel conducted during Session 3, *Understanding Hurricane Response for Improved Stakeholder/User Reaction*, is that the weather community needs to integrate the expertise of social scientists to improve information and services, reach out to diverse at-risk populations, communicate more clearly, improve societal response to save lives and to enhance critical partnerships with emergency managers, media, and the private sector.

   Other important points from the five presentations during Session 3 were:

   - Six important principles to consider for effective risk communication are complexity, diversity, redundancy, similarity, credibility, and specificity. Key changes in the warning process could include designing warning systems that reflect the complexity of people's lives, designing and testing warning messages with user audiences, showing people with disabilities navigating an unfamiliar shelter, tapping into social networks that people trust and believe, and using a process with redundant and diverse messaging for communicating risk.
   - Various studies are underway in NOAA and NCAR to examine and assess ways to integrate social science into the forecast and warning mission. This includes efforts associated with the Hurricane Forecast Improvement Project (HFIP), a ten-year program with multiple team research areas, one of which is social science. Communicating hurricane information is another of the research focus areas. This area includes message content, forecast/job mechanics (steps, actions, factors affecting mechanics of forecasters, emergency managers, and broadcasters), interactions (content and channels of information among partners, and provided to recipients), message development, interpretations (challenges of and factors influencing how to analyze and consider the data and/or message content), and uncertainty (messages that include or reference some ambiguity about the current state or future situation).

- NSF is also sponsoring social sciences-related research projects, including a 3 year project studying hurricane and flood warning decisions that addresses warning decisions in extreme weather events. Research will focus on how hurricane / flash flood warnings are communicated, obtained, interpreted, and used in decision making by participants in the warning process. Another NSF-sponsored project is being worked through the Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA). Through the use of field research, focus groups, in-depth interviews and surveys, the social scientists are examining how the end-user community—particularly emergency managers and the general public—access, interpret, utilize, and respond to weather forecasts.
- Effective relationships are key and are a direct result of developing partnerships in advance of disasters. The partnerships bring more knowledge and expertise to bear during the planning effort and lead to closer professional relationships among response and recovery organizations, translating into better coordination and teamwork during actual emergencies.

3. Regarding Objective #5, the panel discussion held during the Opening Session of the conference, *The Power of Partnerships to Meet Operational Needs*, made it very clear that partnerships and collaborations are strong and are extremely vital for improving TC forecasts and warnings. The senior leaders from NOAA, NASA, Navy, and Air Force acknowledged the importance of partnerships to tackle the complex research challenges associated with further improving TC forecasting and warning capabilities. The key Federal agency leaders who are involved in TC research and operations emphasized their commitment to collaboration and interagency cooperation.

II. CONFERENCE SYNOPSIS

Sessions Conducted:
In addition to the Opening Session on Monday afternoon, the Poster Session on Tuesday evening, and the Plenary Session on Thursday morning, there were 11 sessions conducted at the 64th IHC:

Session #	Title
1	The 2009 TC Season in Review
2	Workshop: *Assessment of the TC R&D Activities in Contributing to the Operational Priorities of the TC Forecasting and Warning Centers*
3	Workshop: *Understanding Hurricane Response for Improved Stakeholder/User Reaction*
4	Observations and Observing Strategies for TCs and their Environment, Part 1
5	Observations and Observing Strategies for TCs and their Environment, Part 2
6	Observations and Observing Strategies for TCs and their Environment, Part 3
7	TC Model Development and Technology Transfer, Part 1
8	TC Model Development and Technology Transfer, Part 2
9	Other Research to Improve the Prediction of TC Intensity and Structure, Track, Precipitation, Coastal and Inland Inundation, Part 1
10	Other Research to Improve the Prediction of TC Intensity and Structure, Track, Precipitation, Coastal and Inland Inundation, Part 2
11	Joint Hurricane Testbed Project Updates and Improved Products

Media Coverage:
The 64th IHC had coverage from the local NBC affiliate, WSAV Channel 3, including an interview with Bill Read, NHC Director. Portions of the interview and the opening session aired in the morning news on March 2. The NHC Director also took the opportunity to address local

media and public information officials at a separate meeting hosted by the Chatham County Emergency Management Agency, which generated coverage by the *Savannah Morning News* with a front page article on changes made at the hurricane center.

Key Events: Key events that took place during the 64th IHC were:

1. Working Group for Hurricane and Winter Storms Operations and Research (WG/HWSOR): The WG/HWSOR met on Monday morning, March 1, 2010, to address 23 action items submitted to the WG/HWSOR for discussion and deliberation. Of those, 11 will be closed through incorporation into the 2010 *National Hurricane Operations Plan*, six items were informational in nature, one item was not accepted, and one item—which was accepted by the WG/HWSOR—was not accepted by a subsequent meeting of the WMO RA-IV Hurricane Committee. The remaining four (plus four actions from previous IHCs) will be worked through follow-on actions by the group.
2. Conference Opening Remarks and Plenary Opening Remarks:

    - **The Honorable Edna Jackson:** During the opening session, the Mayor Pro Tem of Savannah, The Honorable Edna Jackson, welcomed the conference attendees to the city and thanked conference participants for their important work. She noted the importance of hurricane forecasts and warnings to city officials who help prepare their residents. She encouraged conference participants to explore the city and wished them a very successful meeting.

    - **Mr. William Craig Fugate:** Following the Mayor Pro Tem's remarks, Mr. W. Craig Fugate, Administrator of the Federal Emergency Management Agency, FEMA/DHS, provided plenary opening remarks. He appreciated the opportunity to help open up the conference and thanked the participants for the interagency efforts in improving the accuracy of hurricane forecasts, especially the 5-day track forecasts. He stressed that it's the public that ultimately uses the hurricane products and it's important to remember that no matter how good the forecasts are, we are not successful if people don't take the appropriate response actions. Mr. Fugate discussed the growing importance of social media (e.g., Facebook, Twitter) and the need to explore using these media to spread the message to aid response actions of the public.

    - **Ms. Monica Medina:** Following Mr. Fugate's remarks, Ms. Monica Medina, the Principal Deputy Under Secretary of Commerce for Oceans and Atmosphere, NOAA/DOC, also provided plenary opening remarks. She opened by noting that agencies working together is key to the success of responses to disasters such as the Chile earthquake response currently in progress. She commended OFCM for hosting this conference that brings together researchers, operational forecasting and warning experts, flight crews, emergency experts and senior leaders from various agencies to work together to plan and prepare for the upcoming hurricane season. The Obama Administration has given a clear message that effective incident management requires improved coordination and active listening to the concerns and priorities at all levels of government. This conference is a step in that important process. The interagency partnerships in hurricane observations, computer models, forecasts, planning and preparedness exercises, outreach and education allows the federal government to be effective in getting our citizens prepared for the next hurricane season.

      Ms. Medina highlighted the importance of contributions from sister bureaus within the DOC including Census, National Institute of Standards and Technology (NIST), and the National Telecommunications and Information Administration (NTIA). Accurate census

data will help inform the emergency management community about increases in population in coastal areas and also can be used to illustrate shifts in lower income population that would alter where resources may be needed. Census information helps determine how more than $400 billion dollars of federal funding each year is spent on infrastructure and services like hospitals, roads and emergency support, and NIST grants for construction projects that provide a major boost to scientific research enhancing innovation, public safety and environmental protection. One of the research facilities constructed will be used to better understand how structures withstand (or fail to withstand) wind, wave, and surge forces during a hurricane. Part of the facility will be used to study the physics and dynamics of hurricanes and associated impact of severe wind driven and wave-induced storm surges on coastal structures. NTIA is moving forward with implementation of the Broadband Technology Opportunities Program which is focusing on reducing the broadband gap in unserved or underserved areas of the United States. This will especially help communication capabilities needed by first responders.

When Dr. Jane Lubchenco became the NOAA Administrator she implemented a realignment of NOAA Headquarters leadership structure to move NOAA toward a more effective and responsive science-centered organization. She added an Assistant Secretary for Environmental Observation and Prediction, reinstituted the NOAA Chief Scientist position, and started the process of establishing the NOAA Climate Service. The Climate Service is expected to improve seasonal outlooks and predictions and improve understanding of climate change and its impact on hurricanes. NOAA is also putting more emphasis on social science. Much of the user community does not understand how to interpret and use weather forecasts and climate prediction that include explicit measures of risk and uncertainty. Social science can help NOAA and its partners communicate these risks more effectively—one of our most urgent needs.

Three major national reports were published calling for elements of a National Hurricane Research Initiative. As a result of these studies, NOAA launched the Hurricane Forecast Improvement Project (HFIP). This is part of a coordinated national effort to increase the overall preparedness of the Nation and reduce the impact of dangerous tropical storms on the people and economy of the U.S. The HFIP leverages research innovations to develop an advanced operational hurricane and coastal forecast system.

Over the past several years, NOAA has seen an increase in funding for modeling improvements, research, and operations. NOAA's overall investment in hurricane forecasting and research is over $300 million a year. This is dispersed through multiple NOAA offices including the NWS, NESDIS and the Office of Marine and Aviation Operations.

Ms. Medina closed by emphasizing that the hurricane program is a priority for NOAA. She expects NOAA to continue current partnerships as well as build new partnerships with everyone involved in the national effort to protect citizens and economy from hurricane disasters.

3. Senior Leader Panel – *The Power of Partnerships to Meet Operational Needs.* During the opening session on Monday afternoon, a panel of senior agency representatives provided senior leader perspectives on partnerships and their importance in meeting operational needs. The moderator and participants are indicated below.

Moderator: Dr. Elbert W. (Joe) Friday, Professor Emeritus of Meteorology, University of Oklahoma

Panelists:

Dr. Ramesh Kakar, NASA Weather Focus Area Lead and Program Manager for Atmospheric Dynamics
Dr. Fred Lewis, Air Force Director of Weather
RADM David Titley, Oceanographer and Navigator of the Navy
Dr. Jack Hayes, Director, National Weather Service, NOAA

- Dr. Ramesh Kakar discussed NASA's contribution to hurricane research. He detailed four focus areas that include satellite remote sensing, sensor development, field campaigns and numerical modeling. He showed contributions to hurricane research from eight satellite missions. Much can be learned from satellite data regarding storm rain structure, wind fields, oceanic heat content, hurricane positions and track forecasts. In addition, NASA's Columbia and Pleiades supercomputers support high resolution hurricane modeling.

  A TC data portal is being developed that will operate in real time and will put in the hands of the operational forecasters a wealth of satellite information and ensemble model runs, thus helping them in hurricane forecasting and warning services. NASA sponsored field campaigns have helped develop a better understanding of many hurricane properties including inner core dynamics, rapid intensification and genesis. Their next field campaign is scheduled for 2010 and will be a (Hurricane) Genesis and Rapid Intensification Processes Field Experiment (GRIP). This experiment is a collaboration of NASA, NOAA and NCAR and will deploy sensors and research teams for six to eight weeks in August/September 2010 timeframe in the western Caribbean.

  Dr. Kakar closed by stating that NASA satellite sensor data is being under utilized in hurricane research (assimilation of satellite data has a much greater potential impact on the track and intensity forecasts).

- Dr. Fred Lewis reported on the U.S. Air Force (USAF) TC support and operational priorities. He discussed critical partnerships and the importance of continued support from the collaborative research and operations communities.

  Dr. Lewis emphasized that the TC warning capability is critical to military missions in the Pacific and Indian Oceans. Improvements in forecast and warning accuracy over the past 30 years were based on joint research efforts and additional improvements will need the right mix of research and operational focus with technology as the enabler.

  Current Joint Typhoon Warning Center operational priorities requiring further research include rapid intensification, specification of cyclone structure (wind strength and distribution), genesis guidance, and satellite-based intensity/structure estimates – including microwave. Research community support is also needed to determine climate change influence on cyclone tracks/intensities on a global basis.

  The USAF's critical partnerships include Navy, NOAA (e.g., NHC, CPHC, NWS, NESDIS, OAR) and the RSMCs (Regional Specialized Met Centers). The USAF has supported these partners with reconnaissance and satellite data, application techniques, and by sharing expertise through conferences/meetings, educational forums, and the Joint Typhoon Warning Center operations.

Dr. Lewis closed by reiterating the need to significantly improve TC intensity forecasts by 2015 and that achieving this goal will require a team effort by all partners of the TC research and operational communities.

- Dr. Jack Hayes emphasized the promise of partnerships in improving NOAA's forecast services for TCs through improved hurricane forecast science and technology. He noted that science is a priority for President Obama as demonstrated by the increase in the NWS budget for hurricane prediction and other services. The Senate and House of Representatives each have bills under consideration that provide initiatives to address improvements in hurricane forecasting, mitigation of impacts on coastal infrastructures and communities, and provide training for the next generation of hurricane researchers and forecasters.

  Changes for the upcoming 2010 season include the National Hurricane Center and the Central Pacific Hurricane Center to provide greater lead time in watches and warnings. In addition, the Saffir-Simpson Hurricane Wind Scale will become operational. Earlier versions of this scale – known as the Saffir-Simpson Hurricane Scale – incorporated central pressure and storm surge as components of the categories. Central pressure and storm surge are not included in the new Saffir-Simpson Hurricane Wind Scale.

  The NWS has healthy partnerships with other agencies in many areas, including the National Unified Operational Prediction Capability (NUOPC)* (USAF, U.S. Navy, academia); high performance computing (DOE, NSF); and in TC research (NSF, Navy, NCAR, NASA, academia). In addition, the joint efforts in the Hurricane Forecast Improvement Project (HFIP) are expected to significantly improve guidance to NHC, CPHC, and JTWC for hurricane track and intensity forecasts. The HFIP goal is to reduce track and intensity errors by 50% so that the future 5 day forecast capability will match that of the current 2 day forecast capability.

  Dr. Hayes closed by announcing that the NWS draft strategic plan for 2035 is undergoing internal review. When it is issued in spring 2010 he asked federal partners attending the conference for their review and comments.

  *NUOPC is a national initiative led by NOAA, USAF and the U.S. Navy to design and implement the next generation national prediction capability.

- Due to a short-notice commitment, RADM David Titley was unable to attend the conference. Mr. William "Kim" Curry, Deputy Technical Director, represented RADM Titley. Mr. Curry described the process used by the Navy to minimize the impact of TCs on naval operations. This is a four tier process that has at its foundation the environment tier (remote sensing and in situ observations). The other three tiers include numerical modeling, performance (e.g., TC warnings and wave probabilities), and the decision layer tier (e.g., strike probabilities, conditions of readiness and sortie options).

  The Navy is heavily dependent upon partnerships for satellite based observational data. Their programmed investments are targeted at oceanographic applications. Mr. Curry also noted that their key capability gaps are ocean surface vector winds and soundings.

  Accurate track forecasts are key to enabling naval operations. The Navy views improvements to global modeling capability as the best means to improve track forecasts and the Navy/NOAA/USAF partnership is the key enabler for this effort. Improvements in structure and intensity forecasts are dependent on first improving track forecasts. Basic

research on intensity and structure is needed which will lead to further improvements to storm-scale modeling.

The Performance and Decision tiers link forecasts to decisions. A series of improvements in TC warnings (including wave heights, surge and inundation) over the past ten years have been incorporated into probability-based decision tools that describe and reduce uncertainty in naval operational decisions. Strong partnerships in all these activities have led to the success of TC warning applications used in Navy missions.

4. Invited Presentation, **Mr. X. William (Bill) Proenza**, Director, National Weather Service (NWS) Southern Region. Mr. Proenza's presentation focused on NWS's decision-support strategic initiative, which envisions delivering expanding local/state hurricane decision-support for a more resilient homeland. With 122 NWS Weather Forecast Offices (WFOs), emergency managers (EMs) and local/state governments are best served by their nearby WFO for local impact decision-making. The NWS's closest mission partners, the local/state EM community, are increasingly asking NWS for decision support. Mr. Proenza stated that the nation's resiliency is dependent on vital weather information to mitigate natural and technological hazards. In fact, local/state/federal EMs and other government officials indicate they need decision-assisting *focused/on-site* weather information, which is critical to effective protection of life. Mr. Proenza emphasized that the NWS's National Hurricane Center and Central Pacific Hurricane Center, along with the WFOs, seamlessly meet the EM needs.

5. Workshop - *Assessment of the TC R&D Activities in Contributing to the Operational Priorities of the TC Forecasting and Warning Centers*. A workshop panel consisting of members of the OFCM-sponsored WG/TCR provided a summary of the efforts of the group to date. The moderator and participants are indicated below.

Moderator: Dr. Elizabeth Ritchie, Associate Professor, Department of Atmospheric Sciences, University of Arizona

Panelists:
Dr. Frank Marks, Co-Chair, Working Group for TC Research and Director, Hurricane Research Division, NOAA AOML/HRD
Mr. James Franklin, Branch Chief, Hurricane Specialists Unit NOAA/NWS/NHC
Mr. Robert J. Falvey, Director, Joint Typhoon Warning Center
Dr. Ronald Ferek, Co-Chair, Working Group for TC Research and Navy/ONR

- Dr. Marks reviewed the membership and tasks of the OFCM-sponsored WG/TCR. He then highlighted the operational priorities of the TC forecasting and warning centers (i.e., NHC, CPHC, and JTWC) and the research needs to support further advancements in meeting the operational priorities. The operational priorities and the research needs are referred to as Tables 1 and 2, respectively, and can be found at: http://www.ofcm.gov/ihc10/Presentations/Session02/Table-1-and-Table-2.pdf. He noted that the research needs were categorized in three primary topic areas: General Research (Category A), Model Development (Category B), and Observations and Observing Strategies (Category C). Dr. Marks concluded by reviewing the processes used by members of the WG/TCR to gather all identified R&D projects for FY2008/09 and how the R&D efforts were mapped against the research needs (Table 2) and operational priorities of the TC forecasting and warning centers (Table 1).

- Mr. James Franklin and Mr. Robert Falvey followed Dr. Marks and reviewed the evolution of the operational priorities at their respective centers (see Attachments 1 and 2). Interesting to note, for NHC, intensity change—especially rapid intensity change—has been the #1 operational priority since the priorities were first published in 2001 as part of the JHT Announcement of Federal Funding Opportunity (AFFO). When JTWC began to coordinate and provide their operational priorities as part of the AFFO, their #1 priority was and continues to also be intensity change. Mr. Franklin and Mr. Falvey noted that there are differences in the operational priorities of their respective centers due to their customer base, and this will be discussed later in this section.

- Dr. Ron Ferek reviewed the analysis that was accomplished by the WG/TCR members from the perspective of the identified R&D activities mapped against the research needs. He indicated that for this FY2008/09 snapshot, there were a total of 228 man-years dedicated to all identified tropical cyclone R&D activities, with the following man-year breakout of the three main categories described previously: General Research – 112; Model Development Topics – 70; Observations and Observing Strategies – 47. As discussed by Mr. Franklin and Mr. Falvey, Dr. Ferek reiterated that intensity change is the #1 operational priority and was identified jointly by NOAA's NHC/CPHC and DOD's JTWC. He emphasized that fundamental research is still required in this area, as this is a very difficult and complex problem. He also stated that this was a major emphasis in the Hurricane Forecast Improvement Project (HFIP), a NOAA-led initiative with many Federal and academia partners involved. Using a figure similar to that at Attachment 3, which is the combined man-years mapped against detailed research categories, it was noted that there was investment from multiple agencies for most research areas. He indicated that the members of the Working Group did not attempt to evaluate whether there was sufficient research being conducted in each of the detailed research categories. However, the Working Group could make some general observations regarding the amount of research being conducted for some research needs compared to others. In reference to the low research contributions in categories A2a-d, the Working Group noted that improvement in track forecasting is primarily accomplished through research investment in model development (B1-B3, B5-B7). Also, there is relatively low meteorological research investment, annotated with circles in the figure at Attachment 3, in the following 'Detailed Research Categories': storm surge and waves response to tropical cyclones (A5a and A5b); model development related to physical processes, especially areas B3c, B3d, B3e; and model development related to studies to optimize model resolution and scale dependent parameterization.

- Mr. Franklin and Mr. Falvey followed Dr. Ferek's presentation and reviewed the analysis that was accomplished by the WG/TCR members from the perspective of the identified R&D activities mapped against the operational priorities. Using a figure similar to that at Attachment 4, it was apparent that TC research is better aligned to JTWC operational priorities versus NHC/CPHC priorities. In reviewing the top 10 priorities, there are apparent mismatches to JTWC and NHC/CPHC operational priorities (i.e., the circled operational priorities in Attachment 4 seem to have apparent mismatches with low research investments). Mr. Franklin and Mr. Falvey discussed these apparent mismatches one-by-one, with the highlights below:

  – **Statistically-Based Real-time Guidance on Guidance:** From Attachment 4 (and Table 1), an operational priority with an apparent mismatch with low meteorological TC research investment is 'statistically-based real-time guidance on guidance for track, intensity and precipitation (e.g., multi-model consensus approaches), provided

to forecasters in probabilistic and other formats' (JTWC 5 and NHC/CPHC 3). The crux of this priority is how best to use or blend disparate model tracks/intensities to arrive at a deterministic official forecast. Previous work has not been consistently successful (Systematic Approach, FSSE, Goerss corrected consensus); it's tough to beat a simple arithmetic average consensus. The presenters stressed that this remains one of the forecaster's biggest challenges.

- **Enhancement to Operational Environment:** From Attachment 4 (and Table 1), another operational priority with an apparent mismatch with low meteorological TC research investment is 'enhancements to the operational environment to increase forecaster efficiency, by expediting analysis, forecast, coordination, and/or communication activities' (JTWC 6 and NHC/CPHC 4). Improvements to the systems/environment allow forecasters more time to diagnose the meteorology. This would include items such as improvements to ATCF, N-AWIPS and development of new platforms. However, the presenters conceded that there are limited opportunities for the research community to assist with the operational platforms and it's not surprising that this activity is underrepresented (i.e., not a basic or applied research problem).

- **Additional Operational Guidance on Coastal Inundation:** From Attachment 4 (and Table 1), another operational priority with an apparent mismatch with low meteorological TC research investment is 'additional operational guidance on coastal inundation (e.g., storm surge and waves)' (JTWC 7 and NHC/CPHC 5). The presenters noted that coastal inundation is an interdisciplinary problem, and some work in non-meteorological disciplines may not have been fully captured (e.g., coastal geosciences, civil/coastal engineering). The NOAA Storm Surge Roadmap group is attempting to make these efforts more productive and operationally directed. While coastal inundation work is primarily focused on the U.S., the work is definitely applicable to DoD in the JTWC area of responsibility.

- **Improved and Extended Track Guidance; Reduction of Outliers:** From Attachment 4 (and Table 1), another operational priority with an apparent mismatch with low meteorological TC research investment is 'improved and extended track guidance; identification, and then reduction of, the occurrence of guidance and official track outliers, focusing on both large speed errors (e.g., accelerating recurvers and stalling storms) and large direction errors (e.g., loops), and on specific forecast problems, including interactions between upper-level troughs and tropical cyclones, track forecasts near mountainous areas, and extratropical transition' (JTWC 8 and NHC/CPHC 6). Operational staff has traditionally been unavailable to conduct case studies to diagnose model forecast failures. The research community by and large has not been effectively engaged with improving operational models, and/or had difficulty gaining access to operational models. The reduction of outliers is most important to improved model consensus and operational forecasts. There is some increased focus in this area, as HFIP is directing some funds to the Diagnostic Team to support this activity.

- **High Resolution Model Output vs. Lower Resolution Ensemble Model Output:** From Attachment 4 (and Table 1), another operational priority with an apparent mismatch with low meteorological TC research investment is 'guidance on the operational utility and relative merits of high resolution model output compared to

lower resolution ensemble model output' (JTWC 10 and NHC/CPHC 10). This is a high HFIP focus area, with research community involvement. High resolution models are still in "research" status and probably not ready for operations. Many components still need further development (e.g. air-sea coupling, convective fluxes, parameterizations).

Following a review of the operational priorities with apparent mismatches, Mr. Franklin and Mr. Falvey highlighted two operational priorities that had significant ranking differences between JTWC and NHC/CPHC, and these are discussed below:

- **JTWC 3 and NHC/CPHC 7 - Guidance for tropical cyclone genesis that exhibits a high probability of detection and a low false alarm rate, and/or provides probability of genesis:** From the NHC/CPHC perspective, Mr. Franklin stated that this priority seems to be over emphasized (see Attachment 4) given the NHC/CPHC priority. The result of genesis is virtually always a tropical depression or weak tropical storm. Mr. Franklin indicated that genesis is important, but operational genesis forecasts are of less significance or utility for NHC/CPHC users compared to track or intensity forecasts. From the JTWC perspective, Mr. Falvey stated the investment (see Attachment 4) is aligned with JTWC priority. Mr. Falvey emphasized that genesis is critical to DoD as genesis regions are close to major DoD installations. Also, having improved genesis guidance for forecasts is important to JTWC as there isn't any aircraft reconnaissance in the JTWC area of responsibility.

- **JTWC 4 and NHC/CPHC 9 - Guidance for changes in tropical cyclone size/wind structure and related parameters, including combined sea heights:** From the NHC/CPHC perspective, Mr. Franklin stated that this priority seems to be over emphasized (see Attachment 4) given the NHC/CPHC priority. Mr. Franklin indicated that there are insufficient observations available to define the current wind field (improved observations are NHC/CPHC priority #2). He stated that track and intensity errors overwhelm uncertainty in structure. From the JTWC perspective, Mr. Falvey stated the investment (see Attachment 4) is aligned with JTWC priority. The wind distribution is a key factor that drives [U.S. Naval] ship movements (along with seas). Tropical cyclone size/wind structure forecasts at 48-72 hours are critical to safety. Also, having improved tropical cyclone size/wind structure guidance is important to JTWC as there isn't any aircraft reconnaissance in the JTWC area of responsibility.

- Dr. Ferek concluded the session with closing comments. As discussed above, there are differences in operational priorities between JTWC and NHC/CPHC due to the customer base supported by each center. Dr. Ferek pointed out that the prioritized operational needs (Table 1) were not readily available and widely known when previous agency investment decisions were made, so some of the apparent "mismatch" is understandable. As HFIP rolls out, much of this will be addressed. He emphasized that communication of operational priorities to the research community is a good thing, and work should be done to strengthen the processes by which research investments are aligned to operational priorities. As shown in Attachments 3 and 4, there does not appear to be enough total investment to adequately address all research needs and operational priorities. Dr. Ferek stated that advanced development funding ("6.4" in DoD parlance) is inadequate to ensure that the discoveries of basic and applied research are efficiently transitioned to operations. *An important outcome from this session is the operational centers would like the research community to take more of an interest in improving the operational models*

(e.g., guidance on guidance, diagnostics, and model improvement). Finally, Dr. Ferek concluded the closing comments by outlining the way ahead for the WG/TCR:

- Keep Tables 1 and 2 updated
- Biennially map agency research efforts against TC research needs and operational priorities; will do FY10 next
- WG/TCR meets as required to analyze, assess, and help inform agency research investments
- Brief OFCM-sponsored ICMSSR and FCMSSR, as required
- Update information at IHC
- Publish results and analysis of agency research

A short question and discussion period followed the formal presentations. One item that was highlighted during the discussion was that the WG/TCR should strive to make this work more widely known throughout the TC community, especially the TC researchers.

6. Workshop - *Understanding Hurricane Response for Improved Stakeholder/User Reaction*. The moderator and participants of the workshop panel are indicated below.

Moderator: Mr. Max Mayfield, Senior Executive Vice President of Governmental Relations, America's Emergency Network, and WPLG-TV Hurricane Specialist

Panelists:
Mr. David Caldwell, Director, Office of Climate, Water and Weather Services, NOAA/NWS
Dr. Brenda Phillips, Senior Researcher, Center for the Study of Disasters and Extreme Events, Oklahoma State University
Dr. Jeffrey Lazo, Director, Societal Impacts Program, NCAR
Ms. Jenniffer Santos-Hernandez, Graduate Research Assistant, Dept. of Sociology and Criminal Justice, University of Delaware
Mr. Walter S. Dickerson, President, Diversified Emergency Management Associates, LLC

- Mr. David Caldwell's presentation focused on understanding hurricane response for improved stakeholder/user reaction. Integrating the expertise of social scientists is needed to improve information and services, reach out to diverse at-risk populations, communicate more clearly, improve societal response to save lives and to enhance critical partnerships with emergency managers, media, and the private sector.

  Even though accurate hurricane warnings have been provided, deaths and damage have been high because warnings have not been understood or heeded. There is currently little empirical information available on watch/warning use in evacuation decision making, economic value of current forecasts, and how the public and partners receive and act upon NWS information.

  Various studies are underway in NOAA and NCAR to examine and assess ways to integrate social science into the forecast and warning mission so NWS can improve call-to-action statements to achieve intended response , improve expression of uncertainty in forecast and warning information, better understand the economic value/estimation of forecast improvements, better communicate risk, better understand how social networks effectuate response (race/ethnicity, culture, socioeconomic status), improve web design that enables us to more effectively convey the message, and effectively use social media.

- Dr. Brenda Phillips presented the principles for effective risk communication. These six principles are complexity, diversity, redundancy, similarity, credibility, and specificity. After explaining the factors that impact various age, ethnic and socioeconomic groups she related their social vulnerabilities to the way these groups respond or don't respond to disaster warnings.

  She suggested that key changes in the warning process would transform vulnerability into capacity. These changes would include designing warning systems that reflect the complexity of people's lives, designing and testing warning messages with user audiences, showing people with disabilities navigating an unfamiliar shelter, tapping into social networks that people trust and believe (points of intervention in local neighborhoods), and using a process with redundant, diverse messaging for communicating risk.

- Dr. Jeffrey Lazo discussed socio-economic research on hurricane forecasts and warnings. A working group was formed in 2003 to recommend research initiatives and projects that can be supported through interagency cooperation, funding for public and private sector academic and commercial research enterprises, and partnerships with private sector information consumers. Their focus is on the warning process, decision making, evacuation response behavior, and societal impacts and valuation. Their plan is to develop an applied research agenda to generate short-term immediate benefits, a basic research agenda addressing fundamental theoretical and exploratory research designed to generate long-term improvements, methods to enable the social science research community to gather and further develop research priorities and future agendas, and a concept for a long-term, multidisciplinary, institutional approach to undertaking identified research priorities.

  He presented the benefits of improved hurricane forecasting and highlighted current research at NCAR on societal impacts. The major effort now is the Hurricane Forecast Improvement Project (HFIP), a ten-year program with multiple team research areas, one of which is social science. The socio-economic impacts assessment is being coordinated by Betty Morrow and the household valuation by Jeff Lazo.

  Communicating hurricane information is another of the research focus areas. This area includes message content, forecast/job mechanics (steps, actions, factors affecting mechanics of forecasters, emergency managers, and broadcasters), interactions (content and channels of information among partners, and provided to recipients), message development, interpretations (challenges of and factors influencing how to analyze and consider the data and/or message content), and uncertainty (messages that include or reference some ambiguity about the current state or future situation).

  NSF is funding a 3-year project studying hurricane and flood warning decisions. This is an integrated multi-method approach to address warning decisions in extreme weather events. Research will focus on how hurricane / flash flood warnings are communicated, obtained, interpreted, and used in decision making by participants in the warning process. It will address challenges for decision making in the face of risk and uncertainty.

  Dr Lazo closed by providing a list of principal researchers, their areas of emphasis and a list of advisors assisting in the various projects/research.

- Ms. Jenniffer Santos-Hernandez discussed the social dimensions of risk communications. She reported on research conducted for NSF by the Engineering Research Center for

Collaborative Adaptive Sensing of the Atmosphere (CASA).Their project is an inter-disciplinary, multi-institutional research effort. Through the use of field research, focus groups, in-depth interviews, and surveys, their social scientists are examining how the end-user community—particularly emergency managers and the general public—access, interpret, utilize, and respond to weather forecasts.

Questionnaires, interviews and other sampling systems were used to determine demographic characteristics, awareness of severe weather, how and when warnings were received, action taken, and other factors related to warning response, perceived accuracy, and communication channels availability and effectiveness.

Regarding tornado watches, warnings and false alarms, respondents appear to have difficulty in understanding the differences between watches and warnings and the meaning of a false alarm. Participants seem to understand that watches and warnings represent some type of danger, but they are unable to clearly differentiate between these two concepts.

The research project will continue the survey but expand sample size and geographic areas and use the results to develop predictive models on protective action. Ms. Santos-Hernandez closed with a statement from Canon (1994) who asserted that technology is not socially neutral and that we must have an understanding of the context in which it is implemented. Technology matters, but what really matters is the application of the substantive knowledge that we generate regarding how individuals respond (or not) to severe weather events and how we can improve their response in order to minimize the devastating impacts associated with these events.

- Mr. Walter S. Dickerson described effective disaster relationships that result from developing partnerships in advance of disasters. The partnerships bring more knowledge and expertise to bear during the planning effort and lead to closer professional relationships among response and recovery organizations, translating into better coordination and teamwork during actual emergencies. He used the Mobile County Emergency Management Agency as an example of how developing collaborative partnerships at all levels of local community, region, state and federal support activities helped them deal successfully with hurricane disasters.

  Mr. Dickerson discussed the National Incident Management System (NIMS), its key principles and new and ongoing requirements. He also described the attributes, capabilities and benefits of an effective emergency operations center.

  Mr. Dickerson emphasized eight steps to develop relationships: strategically partner with all emergency stakeholders; think regionally, act locally; federal, state, local, NGO inclusiveness; engaged partnership philosophy; collaboration is the key; build a ‘culture of preparedness’; strengthen all relationships/partnerships; and use memorandums of understanding. He also noted the benefits of the team approach.

7. 64th IHC Banquet and Richard H. Hagemeyer Award. The significant events that occurred during the banquet are described below:

   - Banquet Address by Dr. Timothy Killeen, NSF Assistant Director for Geosciences: Due to a short-notice family emergency, Dr. Killeen was unfortunately unable to attend the banquet.

   - The 2010 recipient of the Richard H. Hagemeyer Award, which is presented annually in

honor of the longtime Director of the NWS Pacific Region and supporter of the IHC, was Dr. James Goerss. Mr. Williamson honored Dr. Goerss as being a recognized leader among his peers in the Nation's tropical cyclone forecasting and warning program; for his longstanding, outstanding contributions to improving TC forecasting capabilities; and for being a dedicated professional who has greatly contributed to and supported the IHC.

III. OUTCOMES

Conference Action Items:
The conference action items are listed below.

- Update the *National Hurricane Operations Plan*, reflecting changes accepted by the Working Group for Hurricane and Winter Storms Operations and Research, by May 1, 2010.
- Act on TC R&D issues (from Session 2)
  - Convene the OFCM-sponsored Working Group for Tropical Cyclone Research and work with agencies to gather and analyze the FY2010 data
  - Brief the Interdepartmental Committee, then Federal Committee for Meteorological Services and Supporting Research (ICMSSR, FCMSSR)
  - As required, provide updates to the Office of Science and Technology Policy
  - Publish in Bulletin of the AMS or other similar publications
  - Report update at 2011 IHC (65th IHC)
- Act on *Understanding Hurricane Response* (from Session 3)
  - Briefed ICMSSR meeting on August 6, 2009
  - Highlighted broader scope and need to expand social science effort to other natural hazards
  - Organize two mini-workshops to develop an initial set of priorities
  - Present results of the mini-workshops to the ICMSSR and FCMSSR
  - Establish a working group, likely under the Committee for Environmental Services, Operations, and Research Needs (CESORN)
  - Use working group to execute agreed-upon priorities

Tentative Location for Next Year:
The tentative location for the 2011 IHC (65th IHC) is the greater Miami, Florida, area.

Samuel P. Williamson/OFCM/March 23, 2010/301-427-2002/Samuel.Williamson@noaa.gov

ATTACHMENT 1: NHC / CPHC OPERATIONAL PRIORITIES EVOLUTION

NHC / CPHC

Operational Priorities Evolution

Topic	2001 IHC (informal)	FY-03 AO	FY-05 AO	FY-07 AO	FY-09 AO
Intensity change, especially RI	1	1	1	1	1
Enhanced TC observations	5	5	2	2	2
Guidance on guidance	2	2	3	3	3
Operational environment enhancements			4	4	4
Coastal inundation (storm surge)		13	5	5	5
Improve/extended track guidance	4	4	12	12	6
Genesis guidance		9	11	11	7
Analysis of surface wind field		7	6	6	8
TC size/structure forecasting	6	6	7	7	9
Hi-res deterministic vs low-res ensembles					10
TC precipitation	3	3	8	8	11
Utility of microwave/radar data		14	9	9	12
Intensity estimation over cold water		11	13	13	13
Seasonal forecasting			14	14	14
Probabilistic guidance on surface wind forecasts		8	10	10	✔
Specific track issues (e.g., upper troughs)		10			
Generalized strike probability program		12			

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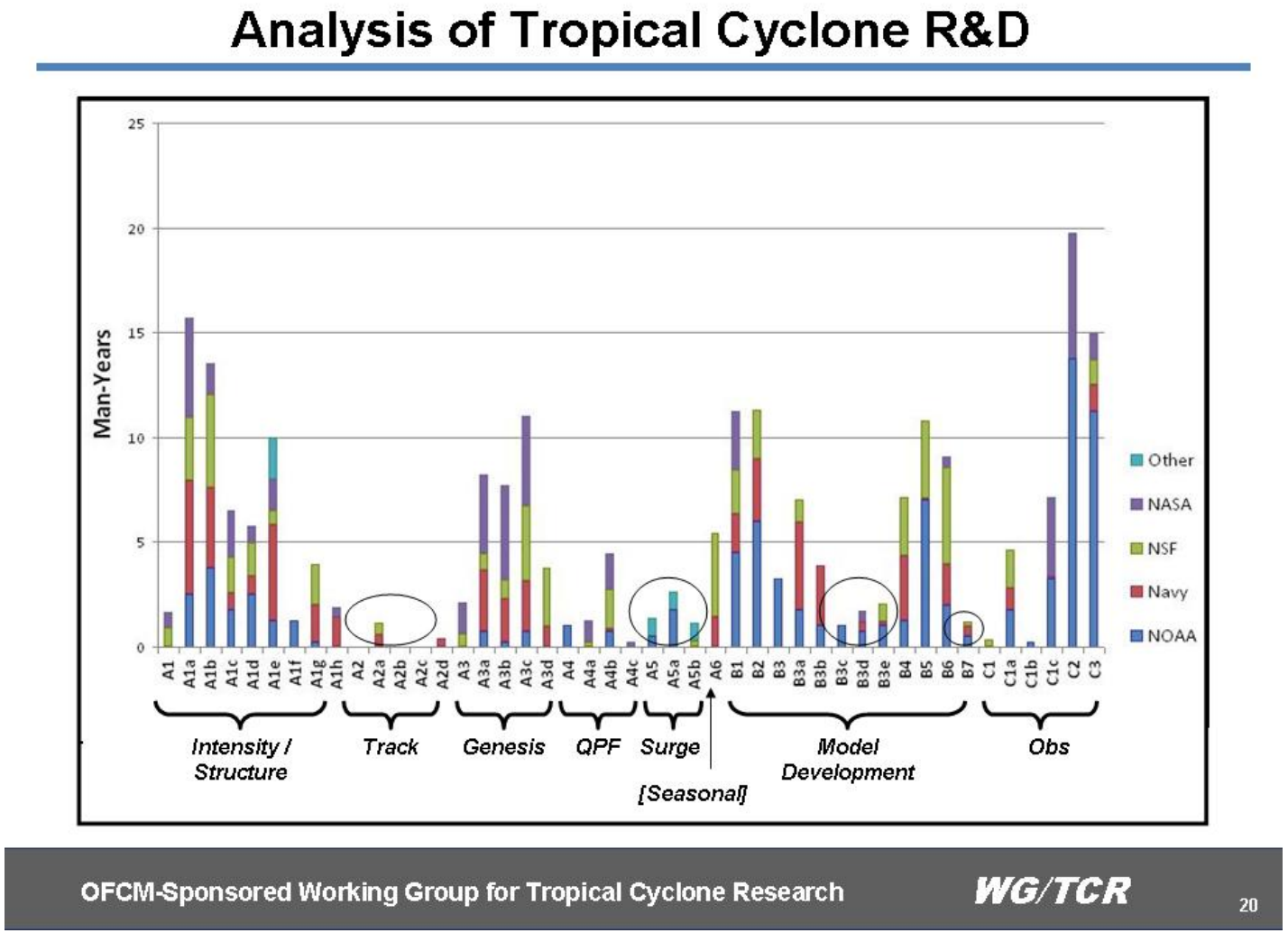
ATTACHMENT 2: JTWC OPERATIONAL PRIORITIES EVOLUTION

JTWC

Operational Priorities Evolution

Topic	FY-07 AO	FY-09 AO	Delta JTWC-NHC	Prelim Update
Intensity change, especially RI	1	1	0	1
Enhanced TC observations	2	2	0	2
Guidance on guidance	5	5	+2	5
Operational environment enhancements	6	6	+2	4
Coastal inundation (storm surge)	7	7	+2	10
Improve/extended track guidance	8	8	+2	6
Genesis guidance	3	3	-4	3
Analysis of surface wind field	9	9	+1	9
TC size/structure forecasting	4	4	-5	8
Hi-res deterministic vs low-res ensembles	10	10	0	11
TC precipitation	11	11	0	12
Utility of microwave/radar data	12	12	0	10
Intensity estimation over SST gradients	13	13	0	13
Seasonal forecasting	14	14	0	14
Probabilistic guidance on surface wind forecasts				
Specific track issues (e.g., upper troughs)				
Generalized strike probability program				

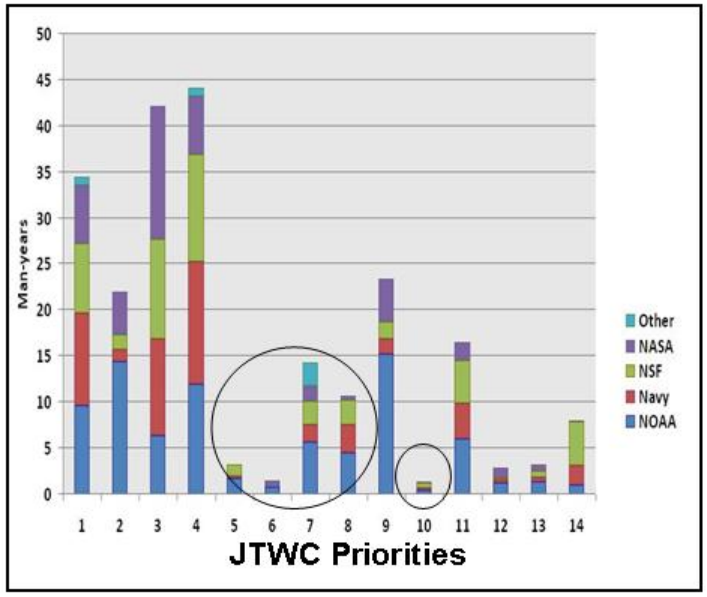
ATTACHMENT 3: COMBINED MAN-YEARS MAPPED AGAINST DETAILED RESEARCH CATEGORIES

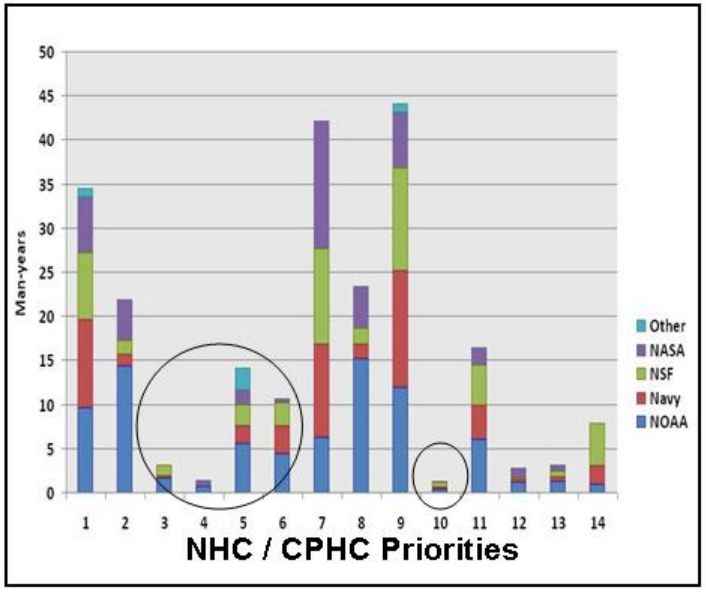


ATTACHMENT 4: RESEARCH NEEDS MAPPED TO JTWC OPERATIONAL PRIORITIES (LEFT FIGURE) AND NHC/CPHC OPERATIONAL PRIORITIES (RIGHT FIGURE). CIRCLES INDICATE APPARENT MISMATCHES WITH LOW RESEARCH INVESTMENTS

Analysis of Tropical Cyclone R&D

Research Needs Mapped to Operational Priorities





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