Year 2 Renewal Proposal

to

NOAA Joint Hurricane Testbed (JHT) Opportunities for Transfer of Research and Technology into Tropical Cyclone Analysis and Forecast Operations

for

**Continued Development of Tropical Cyclone Wind Probability Products**

Submitted by

Cooperative Institute for Research in the Atmosphere  
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Year 2: $ 22,650  
Total Amount Requested: $ 22,650

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Title: Continued Development of Tropical Cyclone Wind Probability Products

Principal Investigators: Mark DeMaria, NESDIS/ORA, Fort Collins, CO 80523
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Under previous JHT support a new, a Monte Carlo-based method for estimating the probability of 34, 50 and 64-knot winds from tropical cyclones for 0 through 120 hours (or MC) was developed. This method combines randomly sampled track and intensity error distributions from National Hurricane Center (NHC) official forecasts, and wind radii error distributions from a radii CLIPER model. This algorithm has been supplied to TPC, and is currently running every 6 hours for all tropical cyclone basins in the Northern Hemisphere.

Because this new and now operational product represents a significant change to the operational probability product produced by TPC for the last two decades, a tropical cyclone wind committee within the National Weather Service is providing oversight for the development of new operational products from the MC model output.

Because of the numerous changes the use of this model will bring to operations, the operational implementation of these products extends well beyond the time period and scope of the original JHT proposal and requires many additional tasks not anticipated in the previous JHT sponsored work. This proposal specifically seeks funding for these additional efforts by the developers, which will be required until and during the final implementation phase of all of the MC products. These efforts include, continued testing and modification of the existing methods, updating error distributions, coordination with TPC personnel related to operational transition, expertise provided for the development of probability training material and NWS products, and the development of a verification package for the tropical cyclone wind probabilities.
1. **Project Duration**
   This is a renewal of a previous proposal with a two-year duration.

2. **Project Description**
   Under previous JHT support a new method for estimating the probability of 34, 50 and 64 knot winds from tropical cyclones for 0 through 120 hours was developed (Gross et al 2004). This method uses a Monte Carlo (MC) technique that randomly samples from the track and intensity error distributions from National Hurricane Center (NHC) official forecasts, and wind radii error distributions from a radii CLIPER model. This algorithm has been supplied to TPC, and is currently running every 6 hours for all tropical cyclone basins in the northern hemisphere. Because this new probability program, now slated to be operational in 2006, represents a significant departure from the operational probability product produced by TPC for the last two decades, a tropical cyclone wind committee within the National Weather Service is providing oversight for the development of new operational products from the MC model output. The target date for new probability products and related education and training activities is the 2006 hurricane season. Potential wind probability products include the following:

   1. A new text-based product showing wind probabilities at a set of specified locations along the coast (this would replace the current probability text product).
   2. A graphical product for the TPC web site, similar to that currently generated at CIRA.
   3. Capabilities to display the MC output in the N-AWIPS system at TPC.
   4. Capabilities to display the MC output in AWIPS format at weather forecast offices.
   5. Capabilities to display the MC output in the ATCF to provide objective guidance for determining the breakpoints of watches and warnings.
   7. Training material for WFOs and emergency managers.

   Items 1, 2, 3, 4, 5 and 7 have either been accomplished or substantial progress has been made in the first year of funding.

   In addition to the products listed above, annual updating of the error distributions used to create the wind probabilities need to be updated. These distributions are compiled from the track and intensity errors for the last five years. So for the 2006 season the period will be 2001-2005. In this way, the probabilities become more skillful as the track and intensity forecast improve. These files will be updated once the final best track datasets have been compiled in the areas of responsibility. The transitioning of the duty of annually updating these distributions to TPC or JTWC personnel will be coordinated in the second year.

   A key aspect of this work that was not considered in the original proposal is the development of a verification package for the wind probabilities. A critical question is how skillful, biased, and/or reliable are the results of this methodology? Of specific interest to TPC is their relative skill at providing breakpoints for watches and warning. So, in addition to the items discussed above, a verification code will be created using standard techniques for evaluation of probabilistic forecasts, which will be run as part of the annual NHC track and intensity verification.

   In the first year of this proposal significant progress was made in the development of a verification package. The verification utilizes the probabilities (cumulative and incremental) for
all storms for a given time in GRIB format, the best track, the official forecast, and the wind radii
clipper model (providing wind radii forecasts beyond 72-h). In order to accomplish the
verification special data handling routines were written to handle the GRIB and ATCF datasets.
Subroutines to calculate Brier Scores (Brier 1950), Brier Skill Scores (BSS; Wilks, 2006),
Relative Operating Characteristics (ROC; Mason and Graham 1999) and the ROC Skill Score,
and Conditional Probabilities/Bernoulli probabilities (Wilks 2006) have also been developed.

These routines were developed and tested using the dataset of 5-day probabilities at the
watch warning break points for storms that hurricane warning were issued during 2004 and 2005.
Results, suggest that the probabilities are more skillful than the deterministic forecast (BSS
=28%, ROC SS=89%). The probabilities were shown to slightly under forecast the outcome, but
given the dataset, this is not necessarily a bad result. Also it was determined that many of the
warning could be dropped sooner using the probability forecasts as guidance – likely resulting
in less area warned. These results were presented at the 2006 IHC as well as the final report for
year 1 of this project.

The operational implementation of these products, now slated for the 2006 hurricane
season, still extends well beyond the time period of the original JHT proposal. To acquire and
refine the capabilities listed above will require considerable effort from developers of the
method, including additional software modification, coordination with JHT/TPC/NWS/NRL
personnel, and verification/testing. The developers’ expertise is required in the refinement and
display of proposed text and graphics products so that the most information without confusion
can be conveyed with the least effort from the user. In addition, the input of the developers will
be required for the creation of the training material as many questions concerning the
methodology will arise. All of these tasks need to be carried out for the successful
implementation of the MC products in the TPC’s and JTWC’s operational environment in 2006
and any needed revisions in 2007.

3. Work Plan

The verification code will be finalized early in the second year of this project. This code
will be tested on the 2004 and 2005 hurricane season probabilities to help with product
development and MC code evolution. The verification code will be delivered and training will be
provided to the TPC verification focal point (James Franklin) following the 2006 season and
modifications will be made as needed prior to the 2007 season. The computing requirements for
this part of the project are fairly minimal. It should be possible to run the verification code on a
standard UNIX or Linux platform.

The refinement of the training material for the Monte Carlo model will continue as
needed by TPC personnel. The continued refinement of this training will be a joint effort
between TPC and NESDIS/CIRA personnel, but the majority of the training will be delivered by
TPC. There continue to be no computer requirements for this part of the project.

We will provide the 5-year (2001-2005) track and intensity error distributions prior to the
2006 season. This portion of work is awaiting final best tracks. These distributions will replace
the previous 5-year error distributions on the IBM. No new computing capabilities will be
required for this part of the project since the model is already running on the NCEP IBM, and the
grib output files are already being generated in real time. Efforts to transition both the code and
the annual responsibility of updating these distributions to TPC and/or JTWC will also be
coordinated in the second year of funding.
The coordination with TPC on operational products that utilize the Monte Carlo model will depend somewhat on the pace of their development by TPC. Since the code is now slated to be operation in 2006, such coordination will likely been needed following the 2006 season. While some modifications to the code have been made following the results of the evaluation during the 2005 season, more are anticipated following the verification of the 2005, and 2006 seasons.

In an advisory role associated with this project, CIRA/NESDIS scientist will continue to be available during and following the 2006 and 2007 hurricane seasons. Expert advise will continue to support the development and revision of the operational products as well as any newly designed products.

4. Time Line
May/June 2006 – update the five-year error distributions (awaiting best tracks)
November 2006 - Deliver verification code to TPC and provide training
March 2007 - Present verification results at TPC
April 2007 - Modify probability verification code as necessary
March 2007 – Presentation of project summary at the IHC
May 2007 – Coordination with TPC regarding the MC probability products
Nov 2007 - Make any final modifications to MC code for product implementation

5. Expected Travel
Dec 2006 – NHC
March 2007 – IHC

6. JHT/NHC Staff Requirements
NHC staff members M. Fiorino, C. Landsea, R. Knabb, C. Sisko, and M. Manelli will be involved in the implementation of the MC probability products. M. Fiorino/C. Sisko will update MC code on the IBM and develop a new text product, R. Knabb will help develop related training material, M. Manelli will be involved with N-AWIPS graphics development, C. Sisko and B. Sampson (NRL) will be involved in ATCF related work. J. Franklin will coordinate the transfer of the probability verification code. Of these personnel, C. Landsea and R. Knabb, will spend significant time on the development of the MC products and training, respectively. The time requirements on the other JHT/TPC personnel should be minimal.

References
EDUCATION
Ph.D. Colorado State University, Atmospheric Science, Summer 1997
MS Colorado State University, Atmospheric Science, Summer 1992
BS Texas A&M University, Meteorology, Spring 1989

EMPLOYMENT
Research Scientist II, CIRA, Colorado State University, May 1999 – Present
Post Doctoral Fellow, CIRA, Colorado State University, July 1997 - April 1999
Post Doctoral Research Associate, Colorado State University, April 1997 - July 1997.
Graduate Research Assistant, Colorado State University, July 1989- April 1997

AWARDS

SELECT PUBLICATIONS (LAST THREE YEARS)


Curriculum Vitae for Mark DeMaria

**Education**

Ph.D., Atmospheric Science, Colorado State University, 1983
M.S., Atmospheric Science, Colorado State University, 1979
B.S., Meteorology, Florida State University, 1977

**Experience**

1998-Present Leader, RAMM Team, NESDIS/ORA
1995-1998 Chief, Technical Support Branch, TPC/NHC
1987-1995 Research Meteorologist, NOAA/AOML/HRD
1985-1987 Assistant Professor, Dept. of Atmospheric Science, NCSU
1984-1985 NCAR Doctoral Fellow, Advanced Study Program

**Honors and Awards**

2002: NOAA Bronze Medal for the Hurricane Mitch Reconstruction Project
2002: AMS Banner I. Miller Award
1997: NOAA Bronze Medal for Hurricane Inland Wind Model
1992: DOC Gold Medal (Group Award) for performance during Hurricane Andrew
1989: AMS Banner I. Miller Award
1987: AMS Banner I. Miller Award
1981: AMS Max A. Eaton Prize
1977: Elected to Phi Beta Kappa (National Honor Society)

**Selected Publications (Last Three Years)**


**G. CURRENT AND PENDING FEDERAL SUPPORT**

*Current and Pending Federal Support (John Knaff)*

Project Title: NPOESS Applications to Tropical Cyclone Analysis and Forecasting  
Supporting Agency: NOAA/NESDIS  
Award Amount: 45 K  
Investigator Months: 0  
Duration: 1 year (January 2006- December 2006)

Project Title: Development and Evaluation of GOES and POES Products for Tropical Cyclone and Precipitation Analysis: Western Pacific Tropical Cyclone Formation Probabilities  
Supporting Agency: NOAA/NESDIS  
Award Amount: 50 K  
Investigator Months: 0  
Duration: 1 year (January 2006- December 2006)

Project Title: Development of an Annular Hurricane Eyewall Index for Tropical Cyclone Intensity Forecasting  
Supporting Agency: NOAA/NESDIS  
Award Amount: 45 K  
Investigator Months: 2 in 2006  
Duration: 1 year (January 2006- December 2006)

Project Title: Improved Statistical Intensity Forecast Models  
Supporting Agency: USWRP (Joint Hurricane Testbed)  
Award Amount: 47K in 2006/7  
Investigator Months: 4 in 2007  
Duration: 2 years (September 2005- August 2007), has to be renewed in 2006-7.

Project Title: Applications of Satellite Altimetry Data to Statistical and Simplified Dynamical Tropical Cyclone Intensity Forecast Models  
Supporting Agency: NOAA/NESDIS  
Award Amount: $126K in 2006  
Investigator Months: 4 in 2006  
Duration: 1 year (July 2005 – June 2006)
Current and Pending Federal Support  (Mark DeMaria)

Support for Mark DeMaria comes from NESDIS Base funds.