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ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

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Rosenstiel School of Marine and Atmospheric Science
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CIMAS
Cooperative Institute for Marine and Atmospheric Studies

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The attached proposal is being submitted to you for your consideration by a NOAA Cooperative Institute. Should you recommend funding for this proposal, we request that the funding be transferred through our current NOAA cooperative agreement # NA10OAR4320143. The NOAA contact (described below) for this cooperative agreement should be contacted immediately if this proposal is accepted for funding.

Title of Proposal: Evaluation and Improvement of HWRF Boundary Layer Parameterization Using Aircraft Observations

Principal Investigator(s): Jun Zhang and Xuejin Zhang

Proposal # R1300139

Period of Performance: 8/1/13-7/31/15

Funding (by year, if multi-year): $82,406 (yr. 1); $82,570 (yr. 2); $164,976 (total)

Task #: 3

Theme(s): (2) Tropical Weather

NOAA Goal: Weather Ready Nation

DUNS #: 152764007 EIN# 59-0624458 Congressional District: 18

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Please answer all questions

1. Is there a former DOC employee working for the CI host institution who represented or will represent the host institution before DOC or another Federal agency regarding this proposal? ☒Yes ☐No
2. Does this award include any sub award to a Minority Serving Institution? ☐Yes ☒No
3. Does the proposed award require any non-federal employees or sub awardees to have physical access to Federal premises for more than 180 days or to access a Federal information system ? ☐Yes ☒No
4. Is PROGRAM INCOME anticipated being earned during performance of this project? ☐Yes ☒No
5. Will a VIDEO be created for public viewing be part of this project? ☐Yes ☒No
6. Will DOC/NOAA owned equipment be provided to any investigator for use outside a Federal location for this project? ☐Yes ☒No
7. Are any permits required to conduct this project? ☐Yes ☒No
(If yes, please provide the name of the issuing agency and the permit number.)

RESEARCH PROPOSAL SUBMITTED
TO THE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION (NOAA)
Joint Hurricane Testbed (JHT) Program

TITLE: Evaluation and Improvement of HWRF Boundary Layer Parameterization using Aircraft Observations

PERFORMANCE PERIOD: August 1, 2013– July 31, 2015

AMOUNT REQUESTED:

Year 1: UM/CIMAS: $82,406, NOAA/AOML: $14,744, Total: $97,150
Year 2: UM/CIMAS: $82,570, NOAA/AOML: $15,540, Total: $98,110

SUBMITTING DATE: December 7, 2012

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New proposal to

National Oceanic & Atmospheric Administration (NOAA)
Joint Hurricane Testbed (JHT) Program

for

Evaluation and Improvement of HWRF Boundary Layer Parameterization Using Aircraft Observations

by

University of Miami
Rosenstiel School of Marine & Atmospheric Science
4600 Rickenbacker Causeway
Miami, FL 33149

PRINCIPAL INVESTIGATOR: Jun Zhang

PERIOD OF ACTIVITY: August 1, 2013 – July 31, 2015

AMOUNT REQUESTED:
Year 1: $ 82,406
Year 2: $ 82,570
Total: $164,976

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New proposal to

National Oceanic & Atmospheric Administration (NOAA)
Joint Hurricane Testbed (JHT) Program

for

Evaluation and Improvement of HWRF Boundary Layer Parameterization Using Aircraft Observations

by

University of Miami
Rosenstiel School of Marine & Atmospheric Science
4600 Rickenbacker Causeway
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PRINCIPAL INVESTIGATOR: Xuejin Zhang

PERIOD OF ACTIVITY: August 1, 2013 – July 31, 2015

AMOUNT REQUESTED:

Year 1: $ 82,406
Year 2: $ 82,570
Total: $164,976

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A RESEARCH PROPOSAL SUBMITTED
TO THE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION (NOAA)
Joint Hurricane Testbed (JHT) Program

For the
Atlantic Oceanographic and Meteorological Laboratory
4301 Rickenbacker Causeway
Miami, Florida33149

TITLE: Evaluation and Improvement of HWRF Boundary Layer Parameterization using Aircraft Observations

PRINCIPAL INVESTIGATOR: Sundararaman Gopalakrishnan NOAA/AOML

PERFORMANCE PERIOD: August 1, 2013 – July 31, 2015

AMOUNT REQUESTED: Year 1: $ 14,744
Year 2: $ 15,540

SUBMITTING DATE: December 7, 2012

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A RESEARCH PROPOSAL SUBMITTED
TO THE
NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION (NOAA)
Joint Hurricane Testbed (JHT) Program

For the
Atlantic Oceanographic and Meteorological Laboratory
4301 Rickenbacker Causeway
Miami, Florida33149

TITLE: Evaluation and Improvement of HWRF Boundary Layer Parameterization using Aircraft Observations

PRINCIPAL INVESTIGATOR: Robert Rogers NOAA/AOML

PERFORMANCE PERIOD: August 1, 2013 – July 31, 2015

AMOUNT REQUESTED: Year 1: $ 14,744
Year 2: $ 15,540

SUBMITTING DATE: December 7, 2012

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Evaluation and Improvement of HWRF Boundary Layer Parameterization using Aircraft Observations
(*In Response to NOAA-OAR-OWAQ-2013-2003469*)

Principal Investigator: Dr. Jun Zhang, University of Miami/CIMAS
Co-Principal Investigators: Dr. Sundararaman Gopalakrishnan, NOAA/AOML/HRD
Dr. Robert Rogers, NOAA/AOML/HRD
Dr. Xuejin Zhang, University of Miami/CIMAS
Collaborators: Dr. Young Kwon, NOAA/NCEP/EMC
Dr. Weiguo Wang, NOAA/NCEP/EMC

Proposed cost: **Year 1: $97,150, Year 2: $98,110**

Budget period: **August 1, 2013 - July 31, 2015**

ABSTRACT

The long term goal of this project is to improve physical parameterizations, based on the best available observations, in NOAA's operational Hurricane Weather Research and Forecast (HWRF) model, in order to improve the prediction of hurricane track, intensity and structure. This project targets the Joint Hurricane Testbed (JHT) programmatic priorities EMC-3 along with hurricane forecaster priorities NHC-1 and NHC-2 that focus on improving intensity forecasts. This project will be conducted under the auspices of the Cooperative Institute of Marine and Atmospheric studies (CIMAS) program at the University of Miami (UM).

As the horizontal resolution of the operational hurricane forecast models approaches 3 km (and eventually reaches 1 km), many of the physical parameterizations traditionally used with operational models may be inappropriate at these higher horizontal resolutions. Since the high-resolution model begins to resolve tropical cyclone (TC) structures with scales close to sub-grid turbulence, robust representation of boundary layer structure are therefore crucial to assess the realism of the high-resolution model. This proposal aims to evaluate and improve the planetary boundary layer (PBL) scheme in the operational version of the HWRF model beyond the current status through analyzing NOAA's aircraft observations. The observation-based PBL scheme will be evaluated using both idealized and retrospective real-case simulations. In addition to track and intensity error analysis, metrics for evaluating the multi-scale TC structure will be used for model diagnostics.

The specific objectives of this project are as follows:

1) To evaluate and improve the parameterization of boundary layer height in the PBL scheme in the operational version of the HWRF model;
2) To evaluate and improve the Prandtl number setup in the PBL scheme in the operational version of the HWRF model;
3) To evaluate and improve the parameterization of vertical diffusivities in both local and non-local PBL schemes in the HWRF model with emphasis on heat and moisture fluxes;
4) To evaluate and advance the observation-based PBL schemes for potential operational use with idealized and real-case HWRF simulations with emphasis on rapid-intensifying storms as well as weaker and sheared storms;
5) To select and implement the optimized PBL scheme based on aircraft observations in the operational HWRF model.

Evaluation and Improvement of HWRF Boundary Layer Parameterization using Aircraft Observations

(*In Response to NOAA-OAR-OWAQ-2013-2003469*)

Principle Investigator: Dr. Jun Zhang, University of Miami/CIMAS

STATEMENT OF WORK

1. Project Duration 2 years: August 1, 2013 - July 31, 2015

2. Project description

2.1 Background

The Joint Hurricane Testbed (JHT) has provided a great opportunity for NOAA and other agencies to coordinate hurricane research needed to be directly transferred for operational use in order to significantly improve hurricane track and intensity forecasts. This proposal targets the Joint Hurricane Testbed (JHT) programmatic priorities EMC-3 along with hurricane forecaster priorities NHC-1 and NHC-2 that focus on improving intensity forecasts through evaluating and improving physics suitable for high resolution (~3 km or less) Hurricane Weather Research and Forecast (HWRF) model and developing advanced diagnostic tools to compare high resolution model output with observations. This project will be conducted under the auspices of the Cooperative Institute for Marine and Atmospheric Studies (CIMAS) program at the University of Miami (UM).

As the horizontal resolution of the operational hurricane forecast models approaches 3 km (and eventually reaches 1 km), many of the physical parameterizations traditionally used with operational models may be inappropriate at these higher horizontal resolutions. Since the high-resolution model begins to resolve tropical cyclone (TC) structures with scales close to that of sub-grid turbulence, robust evaluations of boundary layer structure are crucial to assess the realism of these models.

Turbulent transport of momentum, heat and moisture in the atmospheric boundary layer is known to play an essential role in the maintenance and intensification of tropical cyclones from previous theoretical studies (Rotunno and Emanuel 1987, Bryan and Rotunno 2009, Foster 2009; Smith and Montgomery 2010; Kepert 2012; Bryan 2012). Previous numerical studies demonstrated that simulated hurricane intensity and structure are affected by surface layer and planetary boundary layer (PBL) schemes that parameterize turbulent fluxes and vertical mixing in the boundary layer (e.g. Emanuel 1995; Braun and Tao 2000; Nolan et al. 2009).

Recently, Gopalakrishnan et al. (2012) demonstrated that the simulated storm intensity and structure are very sensitive to the parameterization of vertical diffusion in the planetary boundary layer (PBL) scheme using idealized HWRF simulations. They pointed out that both the intensity and size of the storm are sensitive to the choice of not only the magnitude of vertical eddy diffusivity (K_m) but also its distribution with altitude and radius. As an example, Fig. 1 shows the evaluation of the simulated intensity in terms of minimum sea level pressure, radius of maximum wind speed, and wind swaths with different values of K_m. This work also presented an example of how to use observational data to calibrate surface-layer and boundary-layer physics in the operational HWRF model.

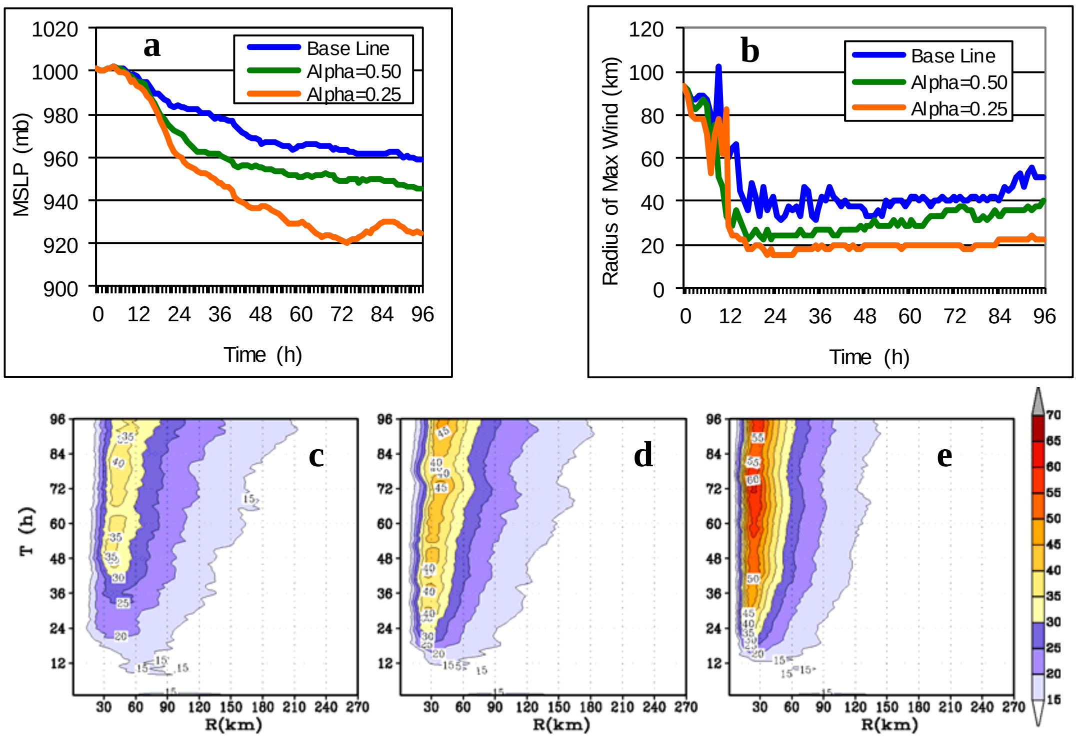

Figure 1: Time series of the intensification process in an idealized storm for the three simulations using HWRF: (a) minimum mean sea level pressure in hPa, (b) radius of maximum wind at the first model level; Hovemoller diagram of the axisymmetric mean wind at a height of 10 m for (c) baseline simulation (α=1), (d) K_m reduced to half (α=0.50), and (e) K_m reduced to a quarter (α=0.25). In these experiments, α is used to vary the vertical eddy diffusivity (K_m) as in Eq. 1.

In the current version of the operational HWRF model, the non-local PBL scheme (i.e., GFS scheme or MRF scheme) was used to parameterize the flux transport and subsequent vertical mixing in the atmosphere above the surface layer (Hong and Pan 1996). In this scheme, the vertical eddy diffusivity for momentum flux is formulated as:

$$K_m = k\,(u_*/\Phi_m)\,Z\,\alpha\,(1 - Z/h)^2, \qquad (1)$$

where k is the Von Kármán constant (k =0.4), u_* is the surface frictional velocity scale, Φ_m is the stability function evaluated at the top of the surface layer, Z is the height above the surface, and h is the PBL height. In neutral condition which is usually valid in the hurricane boundary layer, Φ_m = 1. Here, parameter α is used to tune K_m, and α =1 in pre-2012 version HWRF models and α =0.5 in the 2012 version HWRF. The PBL height (h) is determined using the critical Richardson number (Ri_{bcr}) as:

$$h = Ri_{bcr}\,\frac{\theta_{vs}(U_H - U_s)^2}{g(\theta_{vH} - \theta_{vs})}, \qquad (2)$$

where θ_v is virtual potential temperature, U is the wind speed, and subscripts s and H represent the surface and PBL top, respectively. It is assumed U_s = 0 in the current HWRF model, although this assumption requires thorough evaluation against observational data.

In a local PBL scheme such as the TKE-based MYJ scheme, the PBL height is also a key parameter that regulates the vertical distribution of turbulent kinetic energy (TKE) and turbulent fluxes, as well as K_m (Nolan et al. 2009). Furthermore, the PBL height is important because it is coupled with the maintenance of clouds and energy transport above the boundary layer (e.g., Louis 1979, Troeng and Mahrt 1986, Hong and Pan 1996, Noh et al. 2003).

In both local and non-local PBL schemes, heat and moisture fluxes are also parameterized through the eddy diffusivities (K_t and K_q). It is often assumed $K_t = K_q$, and K_t is proportional to K_m through the Prandtl number ($Pr = K_m / K_t$) (Hong and Pan 1996; Zhang and Drennan 2012). Although previous studies have improved the vertical mixing of momentum flux in the HWRF model based on observations (Gopalakrishnan et al. 2012), no work has been done to improve the vertical mixing of heat and moisture. Our recent model diagnostics (shown in next section) indicated that the representation of boundary layer thermodynamic structure as in the 2012-version operational HWRF model simulations still requires substantial improvement. Because the hurricane intensity is very sensitive to the moisture perturbation in the atmospheric boundary layer (M. Bender, personal communication 2012), it is crucial to improve the model physics that governs the boundary-layer thermodynamics.

2.2 Previous work

Our previous work has addressed the important role of aircraft observations in hurricane model physics validation and improvement. We have developed a model developmental framework for improving the physical parameterizations using aircraft observations, with steps that include model diagnostics, physics development, physics implementation and further evaluation (Zhang et al. 2012).

We have developed an advanced observational dataset from three sources: Global Positioning System (GPS) dropsonde, Doppler radar and flight-level data. A total of 4000 dropsonde data from over 200 NOAA research and reconnaissance flights in 18 hurricanes have been post-processed and quality-controlled. These dropsonde data have been analyzed to study the axisymmetric boundary layer height scales (Zhang et al. 2011a) and surface inflow angle distributions (Zhang and Uhlhorn 2012). We have also analyzed tail Doppler radar data from NOAA WP-3D radial penetrations in multiple storms from the past twenty years. Composite analyses of the axisymmetric structures of the vortex-scale and convective-scale are documented by Rogers et al. (2012a). The Doppler radar data also provide information for the low-level kinematic structure such as radial inflow and outflow structure.

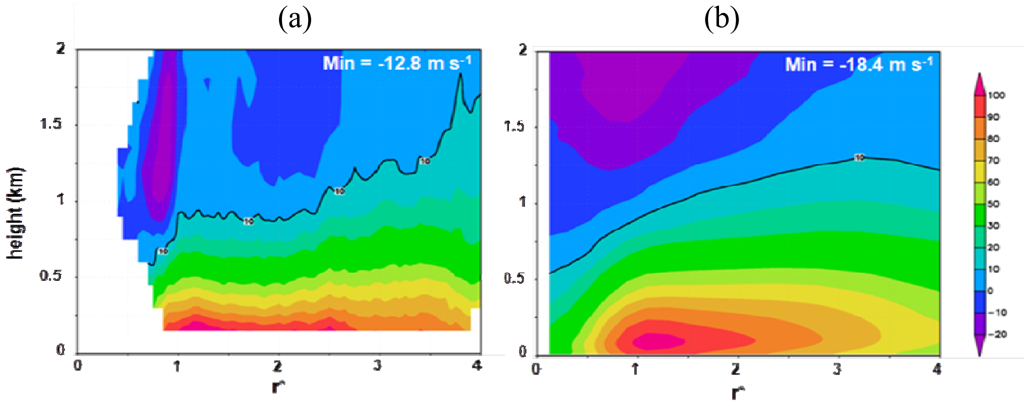

Figure 2: (a) Radius-height plot of axisymmetric radial flow from airborne Doppler composite dataset used in Rogers et al. (2012a). (b) as in (a), but for GPS dropsonde using composite dataset in Zhang et al. (2011a). Fields are plotted as percentages, scaled by radial flow at eyewall (r=1) and 150 m altitude (scaling value indicated). Positive (negative) values denote inflow (outflow). Dark line denotes contour representing 10% of scaling radial flow.*

Figure 2 shows composite boundary-layer radial flow calculated from both the Doppler radar and dropsonde datasets as a function of normalized radius and height. This comparison reveals many features in common, including inflow depth and its radial variation, radial location of peak inflow, and region of enhanced outflow above the inflow layer just inside the RMW. The fact that both composites, using completely independent data sources, calculation methods, and hurricanes, produce such similar features lends greater confidence that the boundary-layer radial flow structures described here are robust (Rogers et al. 2012b). These composite analysis results have been used in our previous work to evaluate the HWRF simulations (shown later).

The flight-level data analyzed in our previous work include fast-response (40 Hz) flight-level data collected by NOAA's WP-3D aircraft in the hurricane boundary layer (60-400 m above the sea surface) during the Coupled Boundary Layer Air-sea Transfer (CBLAST) experiment (Black et al. 2007; Zhang et al. 2008). We have developed a new parameterization of air-sea flux transfer for hurricane force wind regime that has been used in the operational HWRF model since 2010. We have also analyzed flight-level data (1 Hz) from the periods of eyewall penetrations in the intense Hurricanes Hugo (1989) and Allen (1980), and made the first estimate of vertical eddy diffusivity (Zhang et al. 2011b).

Our previous work on model diagnostics was based on HWRF simulations of 69 cases of 8 storms as part of the High-Resolution Hurricane (HRH) Test. These TCs were chosen by NHC forecasters and represent a variety of Atlantic basin tropical cyclones. To get meaningful diagnostic results, we composited model simulations in the same framework as in the dropsonde composite analysis. Figure 3 shows the composites of axisymmetric boundary layer inflow structure from the HRH simulations. Compared to our dropsonde composite (Fig. 2), the inflow field from the model composite shows peak inflow that is ~33% weaker than the observed in both the 27-9 km and 9-3 km resolution simulations. The outflow region seen in the observations is much weaker as well. Most significantly, the depth of the inflow is much larger than the observed (as in Fig. 2), reaching nearly 3 km altitude at r*=1 and extending off the figure by r*=3. This significant difference suggests a bias in the boundary layer parameterization scheme in pre-2012 version of the HWRF model.

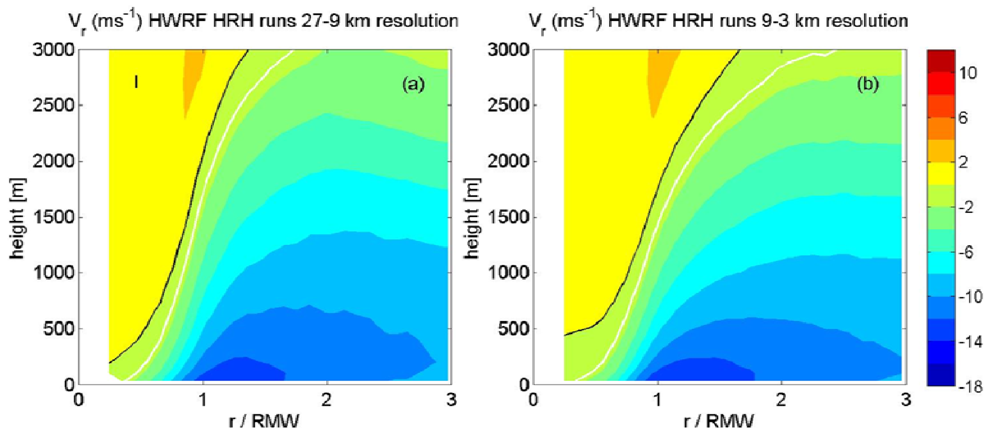

Figure 3: Composite normalized radius-height plot of axisymmetric radial wind from the HRH 69 runs for (a) 27-9 km resolution and (b) 9-3 km resolution (pre-2012 version) HWRF model, respectively. The black line represents the zero contours and the white line represents the inflow layer depth defined as the height for 10% of the peak inflow.

Our recent model diagnostics with the 2012-version HWRF model showed encouraging improvement in simulated boundary layer structure after PBL-physics upgrades as part of PIs' previous work. In particular, the simulated inflow layer depth has been substantially improved compared to that simulated using earlier versions of the HWRF model (Gopalakrishnan et al. 2012; Zhang et al. 2012). *However, there is still room for further improvement. In particular, the thermodynamic boundary layer height is still much higher than the observed one (Fig. 4).* The significant difference suggests a bias in the temperature and moisture distribution in the boundary layer, which is tied to parameterizations of heat and moisture fluxes.

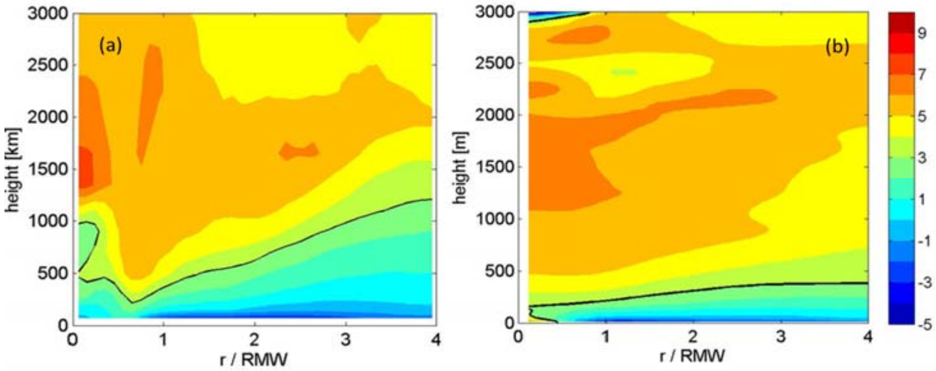

Figure 4: Comparisons of composite analysis results for (a) simulations of Hurricane Earl (2010) using the 2012 version HWRF model and (b) GPS dropsonde data. The shadings are the lapse rate of the virtual potential temperature ($d\theta_v/dz$). The black lines represent the thermodynamic boundary layer height defined as where $d\theta_v/dz$=3K/km following Zhang et al. (2011a).

2.3 Objectives

The long term goal of this project is to improve physical parameterizations, based on the best available observations, in the operational Hurricane Weather Research and Forecast (HWRF) model, in order to improve the prediction of hurricane track, intensity and structure. The present proposal has five main objectives:

1) To evaluate and improve the parameterization of boundary layer height in the PBL scheme in the operational version of the HWRF model;
2) To evaluate and improve the Prandtl number setup in the PBL scheme in the operational version of the HWRF model;
3) To evaluate and improve the parameterization of vertical diffusivities in both local and non-local PBL schemes in the HWRF model with emphasis on heat and moisture fluxes;
4) To evaluate and advance the observation-based PBL schemes for potential operational use with idealized and real-case HWRF simulations with emphasis on rapid-intensifying storms as well as weaker and sheared storms;
5) To select and implement the optimized PBL scheme based on aircraft observations in the operational HWRF model.

2.4 Proposed methodology

The work proposed here consists of five main tasks: 1) Evaluation and improvement of the boundary-layer height parameterization in both non-local and local PBL schemes in the HWRF model using GPS dropsonde and Doppler radar data; 2) Evaluation and improvement of the Prandtl number setup and vertical eddy-diffusivity parameterization in the PBL schemes using flight-level data; 3) Evaluation and advancement of the PBL schemes using idealized simulations through comparisons with observations; 4) Further evaluation and advancement of the PBL schemes using retrospective simulations of multiple storms in the past 3 years in comparison with observation composites; 5) Selection and transition of the optimized PBL scheme to EMC to be used in the operational HWRF model for real-time forecast.

The first task will involve analyzing GPS dropsonde and Doppler radar data. For improving the boundary-layer height parameterization in the GFS scheme, we will use two new methods. The first method will use Eq. (2) as a baseline to formulate the PBL height and then determine the correct critical Richardson number that matches observations. The second method will modify Eq. (2) to take into account the effect of wind shear in the boundary layer. Currently, the Richardson number is computed assuming the surface wind is zero which may not be valid in hurricanes. In our method, 10-m wind speed will be used instead of zero wind. We will then use dropsonde data to optimize the critical Richardson number. For the TKE-based scheme, Doppler-radar measured TKE data (Rogers et al. 2012a) will be directly used to regulate the PBL height.

In the second task, we will first evaluate the Prandtl-number setup in the PBL schemes using PI's latest observational result (Zhang and Drennan 2012). Then we will evaluate vertical eddy diffusivities for momentum, heat and moisture fluxes using the flight-level data the PI documented recently (Zhang et al. 2009; Zhang et al. 2011b, Zhang and Drennan 2012). Next, we will use the in-situ data to calibrate and optimize both the magnitude and vertical distribution of the eddy diffusivities, notwithstanding the limitations of observations. Note that the vertical eddy diffusivity for momentum flux (K_m) has been improved in our previous work (Gopalakrishan et al. 2012). In this task, we will focus on improving the parameterization of vertical eddy diffusivities for heat and moisture fluxes (K_h and K_q).

The third task will evaluate the impact of the modified PBL schemes on storm intensity and structure using idealized HWRF simulations. Gopalakrishan et al. (2010) described details of the HWRF idealized hurricane modeling system. For our proposed work, we will utilize the existing capabilities of this system only modifying the physics options in terms of the critical Richardson number, PBL height, and Prandtl number. Sensitivity experiments will be conducted to advance the setup of the above mentioned parameters through comparisons with observational composites. In this task, we will focus on evaluating the boundary-layer structure metrics: the strength of the boundary-layer jet, the maximum inflow, the kinematic and thermodynamic boundary-layer heights and the inflow angle.

The fourth task will further evaluate the impact of the observation-based PBL schemes on storm track, intensity and structure using real-case simulations. We will conduct retrospective simulations for all the storms in the 2010-2012 seasons in the Atlantic basin. Statistical analyses on the track and intensity errors will be conducted against the National Hurricane Center's (NHC) best tracks. Beyond the track and intensity errors, we will also quantify errors in terms of structural metrics. In addition to metrics for evaluating the boundary-layer structure mentioned in Task 3, we will use metrics for evaluating vortex-scale and convective-scale structures, such as the slope of the eyewall, mean profiles and CFADs of vertical velocity, and mean profiles and CFADs of radar reflectivity. We will focus on diagnosing storms under rapid-intensifying (RI) as well as weaker and shear storms upon the JHT programmatic priorities. Through the above mentioned diagnostics, we will choose the optimal PBL scheme to be used in the operational HWRF model.

In task (5), we will first summarize our findings from tasks 1 to 4 and deliver the statistical analysis results for intensity, track and structure errors to EMC. We will also deliver the code containing the formulations for the modified PBL scheme with improved physics to EMC. This modified code will be developed through close interaction with our unfunded collaborators from EMC to ensure a smooth transition of the code to the operational HWRF model. After testing the consistency between the new scheme and the HWRF model, it will be used for operational forecast for the 2015 hurricane season.

3. Work plan

3.1 Testing and evaluation approach

Evaluation of the work progress will depend on analyzing observational datasets and running idealized and retrospective real-case HWRF simulations. The idealized version of the HWRF system will be obtained from EMC and HRD. We have composited the observational database for model evaluation purpose. Algorithms for model diagnostics of the boundary-layer structure have also been developed in our previous work. More analyses will be done once the idealized and retrospective simulations are conducted with the improved PBL scheme.

3.2 Metrics for success

Work from this proposal will be considered successful upon the acquisition and analysis of the observational data and model forecasts; the development and completion of the improved PBL physics; the complete diagnostics of the impact of the improved physics; and the transition of the improved PBL scheme to EMC for use in the operational HWRF model.

3.3 Project deliverables

1. An improved parameterization of the boundary-layer height will be developed using dropsonde and Doppler radar data for the PBL schemes in the HWRF model (year 1);
2. Parameterizations of Prandtl number and vertical diffusivities in the PBL schemes will be calibrated and improved using the flight-level data (year 1);
3. Observation-based PBL schemes will be tested and advanced using idealized HWRF simulations against observational composites (year 1);
4. The impact of the modified schemes will be quantified in terms of storm track and intensity errors for further improvement using retrospective HWRF simulations for all storms in the 2010-2012 seasons (year 1 and year 2);
5. Error analyses with metrics for evaluating vortex-scale, convective-scale and boundary-layer structures will be conducted using the retrospective runs with focus on rapid-intensifying storms as well as weaker and high-sheared systems (year 2);
6. The optimized PBL scheme will be selected and delivered to EMC, and will implemented in the operational HWRF model in close interaction with our unfunded EMC collaborators (year 2);
7. A written description of the improved PBL scheme and report on its impact in terms of error statistics will be provided to EMC (year 2).

3.4 Real-time operational data needed as input

The project will require access to operational HWRF forecast outputs for track and intensity error calculations as well as for evaluating the structural metrics.

3.5 Plan to port necessary codes to operational environment

The optimal PBL scheme with improved parameterization of boundary-layer height and vertical diffusivities will be reported to EMC upon completion of the project.

3.6 Time line for delivering scientific and technical documentation and training materials

A description of the code necessary for running the improved PBL scheme will be provided at the end of the second year.

3.7 Hardware and software needs

UM/CIMAS, HRD and EMC will use hardware and software already available. HRD requests $2,500 each year for software (e.g. Matlab) and hardware maintenance costs for observational data storage and running the HWRF simulations. UM/CIMAS requests $3,500 for the first year for computer hardware and software upgrades for processing and analyzing the observational data and HWRF model simulation outputs.

4. Time line

Year 1:

- Acquire and analyze dropsonde and Doppler radar data for improving the parameterization of the boundary-layer height in the PBL schemes (CIMAS and HRD)
- Evaluate and improve the setup of Prandtl number and vertical eddy diffusivities in the PBL schemes using in-situ flight-level data (CIMAS)
- Test and advance the observation-based PBL schemes using idealized HWRF simulations (CIMAS, HRD and EMC)
- Start running retrospective simulations of storms in the past 3 years using the HWRF model with the modified PBL schemes (CIMAS, HRD and EMC)

Year 2:

- Complete the retrospective HWRF simulations (CIMAS, HRD and EMC)
- Conduct statistical analysis on intensity and track errors using the retrospective runs and quantify the impact of the modified schemes (CIMAS, HRD and EMC)
- Evaluate the impact of the modified schemes on the overall simulated vortex-scale, convective-scale and boundary layer structure (CIMAS, HRD and EMC)
- Select the optimized scheme and implement it in the operational 2015 version HWRF for real-time forecast (CIMAS and EMC)

5. Travel schedule and needs

PIs from UM/CIMAS plan two trips each year, one to the IHC to present results, and one to EMC to consult with collaborators and JHT point of contact for progress report and code development.

6. JHT staff and computational requirements

We do not anticipate the need for any significant JHT staffing requirements, as HWRF simulations will be run on the necessary computing equipment from the home institutions. However, some assistance may be required to assure the HWRF model source code is accessible.

7. References (PIs' papers are highlighted in bold)

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Zhang, J. A., R. F. Rogers, D. S. Nolan, and F. D. Marks, 2011a: On the characteristic height scales of the hurricane boundary layer. *Mon. Wea. Rev.*, 139, 2523-2535.

Zhang, J. A., F. D. Marks, M. T. Montgomery, and S. Lorsolo, 2011b: Estimation of turbulence characteristics of the eyewall boundary layer of Hurricane Hugo (1989). *Mon. Wea. Rev.*, 139*,* 1447-1462.

Zhang, J. A., **S. G. Gopalakrishnan**, F. D. Marks, **R. F. Rogers**, and V. Tallapragada, 2012: A Developmental Framework for Improving Hurricane Model Physical Parameterizations Using Aircraft Observations. Invited submission to *Tropic. Cycl. Res. Rev.*

8. Budget and justification

This is a collaborative project between the UM/CIMAS, NOAA/AOML/HRD, and NOAA/NCEP/EMC. The total combined budget for request from all three agencies is $ 97,150 for year 1 and $98,110 in year 2. NOAA/NCEP/EMC will collaborate with us for help with running the retrospective HWRF simulations and implementing the improved PBL scheme in the operational HWRF with no cost from JHT. The break down for each of these agencies by year is provided below with the UM/CIMAS budget provided first, followed by NOAA AOML budgets.

8.1 UM/CIMAS budget

	YEAR 1			YEAR 2			
	months	%	AMOUNT	months	%	AMOUNT	TOTALS
Principal Investigator:							
1 Jun Zhang	4.0	33%	25,396	4.0	33%	26665	52,061
2 Xuejin Zhang	2.0	17%	13,276	2.0	17%	13940	27,216
TOTAL SALARIES			38,672			40,605	79,277
4. Fringe Benefits			13,690			14,374	28,064
TOTAL SALARIES & FRINGE BENEFITS			52,362			54,979	107,341
Travel Domestic			4,000			4,000	8,000
Modified Total Direct Costs:			56,362			58,979	115,341
I. Indirect Costs		40.0%	22,544			23,591	46,135
Capital Equipment-No Indirect			3,500				3,500
TOTAL PROJECT COSTS			82,406			82,570	164,976

8.2 UM/CIMAS budget justification

Dr. Jun Zhang needs 4 months of salary for each year to organize the dropsonde, Doppler radar and flight-level dataset, perform analysis of the observational data, running idealized simulations, perform model diagnostics, coordinate work of other project participants, and write JHT reports. Dr. Xuejin Zhang needs 2 months of salary for each year to help in setting up and running the idealized version of the HWRF model and running retrospective simulations. Dr. Jun Zhang will coordinate with Dr. Robert Rogers on acquiring radar composite and performing model diagnostics on the vortex-scale and convective-scale structures. Dr. Xuejin Zhang will work with HRD programmer Thiago Quirino and Dr. Sundararaman Gopalakrishnan on running the HWRF simulations. Drs. Jun Zhang and Xuejin Zhang will also work closely with our collaborators from EMC, Drs. Young Kwon and Weiguo Wang, to implement our observed-based and improved PBL scheme in the operational HWRF model.

Drs. Jun Zhang and Xuejin Zhang plan two trips each year, one to the IHC to present results, and one to EMC to consult with our collaborators and JHT point of contact for the progress report , model development and new scheme implementation. Estimated expenses for the each trip to IHC include $100 for abstract submission and registration fees, $400 for airfare,

$500 for lodging, $200 for per diem, and $100 for other possible expenses (such as taxi charges and baggage check, parking fees). Estimated expenses for each trip to EMC include $300 for airfare, $250 for lodging, and $150 for per diem.

While all of the numerical experiments described above will be carried out on NOAA's t-jet super computer and HRD's Ooyama cluster at no charge, extensive data analysis will also be needed as described which will be performed on PI's and co-PI's local computers. Miami requests $3,500 for computer hardware purchases, upgrades and software licenses (processor and storage) that are necessary to perform the tasks listed in the proposal, such as analyzing the observational data and conducting model diagnostics.

8.3 NOAA/AOML budget

			Budget Year 1				Budget Year 2			
			NOAA Requested		JHT Requested		NOAA Requested		JHT Requested	
			mm	Amount	mm	Amount	mm	Amount	mm	Amount
Personnel										
AOML	S. Gopalakrishnan	Co-PI	1.0	$ 9,288	0.0	$ -	1.0	$ 9,752	0.0	$ -
AOML	R. Rogers	Co-PI	1.0	$ 9,641	0.0	$ -	1.0	$ 10,123	0.0	$ -
AOML	T. Quirino	Programmer	0.0	$ -	1.0	$ 6,143	0.0	$ -	1.0	$ 6,450
Subtotal				$ 18,929		$ 6,143		$ 19,875		$ 6,450
Fringe Benefits		AOML		$ 2,972		$ 1,966		$ 3,218		$ 2,129
Total Salaries and Fringe Benefits				$ 21,901		$ 8,109		$ 23,094		$ 8,579
Indirect Costs		AOML		$ 6,253		$ 4,135		$ 6,745		$ 4,461
Total Labor Costs				$ 28,154		$ 12,244		$ 29,839		$ 13,040
Other (i.e. software/hardware maintenance costs etc...)						$ 2,500				$ 2,500
Total				**$ 28,154**		**$ 14,744**		**$ 29,839**		**$ 15,540**

8.4 NOAA/AOML budget justification

The budget includes a request for 1.0 months of computer programming support for T. Quirino. Financial support (1.0 month each) for Dr. Sundararaman Gopalakrishnan's assistance with running the idealized version of the HWRF system, and for Dr. Robert Rogers' assistant with accessing the Doppler radar data and composite analysis result is being provided by NOAA base funds. The software/hardware maintenance costs ($2,500 each year) are to cover the yearly licensing fees for the Matlab software and disk upgrades that is used for the observational and model data storage and analysis.

8.5 NOAA/NCEP contribution with no cost

Dr. Young Kwon and Weiguo Wang from NOAA/NCEP/EMC will collaborate with the PIs on performing our tasks that include running the retrospective HWRF simulations and implementing the modified PBL scheme in the operational HWRF with no cost from JHT. The proposed tasks request 2 months each year for their time.

9. CURRICULUM VITA

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Education:

2007 *Ph.D.*, Applied Marine Physics, *Univ. of Miami*, Miami, FL
2005 *M.S.*, Applied Marine Physics, *Univ. of Miami*, Miami, FL
2000 *B.S.*, Naval Architecture, *Dalian Univ. of Technology*, China

Experience:

- 2010-present: Asst. Scientist, Coop. Inst. for Marine & Atmospheric Studies, University of Miami, Miami, FL
- 2008-2010: National Research Council Postdoctoral Res. Assoc., Hurricane Research Division, Miami, FL

Selected Peer-Reviewed Publications:

Zhang, J. A., and W. M. Drennan, 2012: An observational study of vertical eddy diffusivity in the hurricane boundary layer. *J. Atmos. Sci.*, **69**, 3223 - 3236.

Zhang, J. A., and E. W. Uhlhorn, 2012: Hurricane sea-surface inflow angle and an observation-based parametric model. *Mon. Wea. Rev.*, **140**, 3587 - 3605.

Zhang, J. A., and M. T. Montgomery, 2012: Observational estimates of the horizontal eddy diffusivity and mixing length in the low-level region of intense hurricanes. *J. Atmos. Sci.*, **69**, 1306-1316.

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Education

B.S. Climatology, Nanjing Institute of Meteorology, July 1991
M.S. Synoptic Dynamics, Chinese Academy of Meteorological Sciences and Nanjing Institute of Meteorology, September 1996
Ph.D. Atmospheric Science, North Carolina State University, May 2007

Professional Experience

1991-1995 Assistant Engineer, Climate Analysis and Diagnosis, Climate Center of Liaoning Province, Liaoning, China
1996-2001 Engineer, Climate and Weather Analysis and Prediction, Weather Center of Liaoning Province, Liaoning, China
1996-1999 Visiting Scholar, Meteorological Field Experiment and Data Quality Control Chinese Academy of Meteorological Sciences, Beijing, China
2000-2001 Visiting Scholar, Regional Climate Model Development, North Carolina State University, Raleigh, NC
02/2007-02/2008 Post Doctoral Research Associate, Mesoscale Model Development, North Carolina State University, Raleigh, NC
03/2008-05/2012 Assistant Scientist, RSMAS/CIMAS, University of Miami, Miami, FL
06/2012-present Associate Scientist, RSMAS/CIMAS, University of Miami, Miami, FL

Publications

Refereed Journals in past three years

1. Rogers, R., Sim Aberson, Altug Aksoy, Bachir Annane, Michael Black, Joseph Cione, Neal Dorst, Jason Dunion, John Gamache, Stan Goldenberg, Sundararaman Gopalakrishnan, John Kaplan, Bradley Klotz, Sylvie Lorsolo, Frank Marks, Shirley Murillo, Mark Powell, Paul Reasor, Kathryn Sellwood, Eric Uhlhorn, Tomislava Vukicevic, Kevin Yeh, Jun Zhang, and **Xuejin Zhang**, 2012: NOAA's Hurricane Intensity Forecasting Experiment (IFEX): A Progress Report. *Bull. Amer. Meteor. Soc*., (In press).
2. Aksoy, A., S. D. Aberson, T. Vukicevic, K. J. Sellwood, S. Lorsolo, **Xuejin Zhang**, 2012: Towards improving high-resolution numerical hurricane forecasting: Influence of model horizontal grid resolution, initialization, and physics. *Mon. Wea. Rev.,* (Accepted).
3. Gopalakrishnan, S. G., Frank Marks, Jr., J A. Zhang, **Xuejin Zhang**, J.-W. Bao, and V. Tallapragada**. 2012:** A Study of the Impacts of Vertical Diffusion on the Structure and Intensity of the Tropical Cyclones Using the High Resolution HWRF system*. J. Atmos. Sci.*, doi: http://dx.doi.org/10.1175/JAS-D-11-0340.1. (in press).
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5. Laureano-Bozeman, M., D. Niyogi, S. Gopalakrishnan, F.D. Marks, **Xuejin Zhang**, and V. Tallapragada. 2012: An HWRF-based ensemble assessment of the land surface feedback on the post-landfall intensification of Tropical Storm Fay (2008). *Natural Hazards*, **63**,1543- 1571.
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7. **Zhang, Xuejin**, T. S. Quirino, K.-S. Yeh, S. G. Gopalakrishnan, F. D. Marks, Jr., S. B. Goldenberg, and S. Aberson, 2011: HWRFx: Improving Hurricane Forecast with High- Resolution Modeling. *Computing in Science and Engineering,* **13**, 13-21.
8. Gopalakrishnan, S. G., F. D. Marks, **Xuejin Zhang**, J.-W. Bao, K.-S. Yeh, and R. Atlas, 2011: The Experimental HWRF System: A Study on the Influence of Horizontal Resolution on the Structure and Intensity Changes in Tropical Cyclones using an Idealized Framework. *Mon. Wea. Rev*., **139**, 1762-1784.

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EDUCATION

Ph.D., Atmospheric Science, Indian Institute of Technology, New Delhi, India, 1991-96;
Master in Technology, Atmospheric Physics, Poona University, Poona, India, 1990.
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EMPLOYMENT

2007-current - Meteorologist & Modeling Team Leader, HRD/AOML/NOAA
2001-2007 - Research Meteorologist, EMC/NOAA/NCEP/SAIC
1998-2001- Research Scientist, Center for Atmospheric Physics, SAIC
1996-1998- Post-Doctoral Associate, Rutgers University, NJ

PUBLICATIONS in 2011-2012

(1) Bozeman L.M., D. Niyogi, S. Gopalakrishnan, F. D. Marks Jr., X. Zhang, and V. Tallapragada, 2012: An HWRF-based Ensemble Assessment of the Land Surface Feedback on the Post–Landfall Intensification of Tropical Storm Fay (2008), Natural Hazards – Special Issue on Tropical Cyclones, in press, vol 63, 1543-1571 (http://www.landsurface.org/publications/J116.pdf)
(2) Bao, J.-W., S.G.Gopalakrishnan, S.A.Michelson, F.D.Marks and M.T.Montgomery, 2012: Impact of Physics Representations in the HWRFX 2 Model on Simulated Hurricane Structure and Wind-Pressure Relationships, Mon. Wea. Rev. 3278–3299 (http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-11-00332.1)
(3) Gopalakrishnan, S. G., Q. Liu, T. Marchok, D. Sheinin, N. Surgi, M. Tong, V. Tallapragada, R. Tuleya, R. Yablonsky, and X. Zhang, 2011: Hurricane Weather and Research and Forecasting (HWRF) model: scientific documentation. NOAA/Development Tech Center, 81 pp. [Available online at http://www.dtcenter.org/HurrWRF/users/docs/scientific_documents/HWRFScientificDocumentation_August2011.pdf]
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(7) Pattanayak, S., U. C. Mohanty and S. G. Gopalakrishnan, 2012: Simulation of very severe cyclone Mala over Bay of Bengal with HWRF modeling system. Nat. Hazards, vol 63, 1413-1437 http://rd.springer.com/article/10.1007/s11069-011-9863-z
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PROFESSIONAL PREPARATION:

The Pennsylvania State University	Meteorology	Ph.D.,	1998	M.S., 1995
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APPOINTMENTS:

- 2003-current: Meteorologist, NOAA/AOML Hurricane Research Division, Miami, FL
- 2000-2003: Asst. Scientist, Coop. Inst. for Marine & Atmospheric Studies, University of Miami, Miami, FL
- 1998-2000: National Research Council Postdoctoral Res. Assoc., Hurricane Research Division, Miami, FL

SELECT RECENT PUBLICATIONS:

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SYNERGISTIC ACTIVITIES:

- Chair, Expert Team on Landfall Processes, Tropical Meteorology Research Program, World Weather Research Programme, World Meteorological Organization, 2011
- Topic Chair for Structure and Intensity Change session, Seventh International Workshop on Tropical Cyclones, 2010
- Field Program Director for the Hurricane Research Division Hurricane Field Program, July 1-November 30, 2010 and 2005
- Adjunct Faculty member, Department of Meteorology and Physical Oceanography, University of Miami/RSMAS
- Associate Editor, *Monthly Weather Review*, 2008-2012
- Associate Editor, *Weather and Forecasting,* 2003-present
- Member, Interdepartmental Working Group for Tropical Cyclone Research, 2008-present
- Member, NASA GRIP, HSRP, TCSP, and CAMEX-4 Science Teams 2001-present
- Member, NSF PREDICT, RAINEX Science Teams 2005-Present

Young C. Kwon (EMC/NOAA, IMSG)

- **Professional Employment**
- **Feb 2011 -** Task Leader of the Hurricane Modeling Task at IMSG
- **July 2010 -** Support Scientist III
- I. M. System Group
- **2009 -** Team leader of the Non-hydrostatic Mesoscale Model
- Physics Team of the NOAA's hurricane Forecast Improvement Project
- **July 2006 – July 2010** Research Scientist
- NCEP/NOAA SAIC (Science Application International Corp.)
- Developing Hurricane WRF (HWRF)
- **Jan 2006 – June 2006** Postdoctoral Researcher
- Department of Meteorology
- The Pennsylvania State University
- **Oct 1994 – Aug 2000** Researcher
- Division of Numerical Weather Prediction
- Korea Meteorological Administration (KMA)
- **Aug 1991 – Jul 1994** Meteorological Officer (First Lieutenant)
- Division of Numerical Weather predication
- The 73rd Weather Group, Korean Air Force
- **Jan 1988 – Jan 1989** System Programmer
- System Engineering Research Institute (SERI)
- Korea Advanced Institute for Science and Technology
- **Education**
- **Dec 2005** Ph.D., Department of Meteorology,
- The Pennsylvania State University
- **Thesis Advisor: Dr. William M. Frank**
- Department of Meteorology, The Pennsylvania State University
- **Aug 1991** M.S., Department of Meteorology, Seoul National University
- **Thesis Advisor: Dr. Dong-Kyu Lee**
- **Publications**
- Kwon, Y. C. and W. M. Frank, 2005: Dynamic instabilities of simulated hurricane-like vortices and their impacts on the core structure of hurricanes. Part I: Dry Experiments. *J. Atmos. Sci.*, **62**, 3955-3973.
- Kwon, Y. C. and W. M. Frank, 2008: Dynamic instabilities of simulated hurricane-like vortices and their impacts on the core structure of hurricanes. Part II: Moist Experiments. *J. Atmos. Sci.*, **65**, 106-122.
- Gall, J. S., W. M. Frank, Y. C. Kwon, 2008: The effects of sea spray using an idealized model. *Mon Wea Rev.*, **136**, 1686–1705.
- **Membership of professional Organizations**
- **2000 – Current** American Meteorological Society
- **1997 – Current** Korean Atmospheric Scientist in America
- **1989 – 2000** Korean Meteorological Society

Weiguo Wang

Contact information

5830 University Research Ct. 2025
College Park, MD 20740
Phone: 301-683-3688
Email: weiguo.wang@noaa.gov

Education

- Pennsylvania State University, Department of Meteorology, Ph. D.
- Nanjing University, Department of Atmospheric Sciences, MS/BS

Experience

Scientist	IMSG/EMC/NCEP/NOAA	2008-
Post-doctoral RA	Pacific Northwest National Laboratory	2005- 2008
Research assistant	The Pennsylvania State University	2000-2005
Research assistant	University of Minnesota	1999-2000
Visiting researcher	The University of Hongkong	1997-1998

<u>Research interests</u>

- Atmospheric boundary layer dynamics and land-surface parameterization
- High resolution simulations (LES) of boundary layer turbulence and clouds
- GCM convection and microphysics parameterizations

Selected Publications

[1] Davies L, C. Jakob, R.J. Keane, M. A. Whitall, R.S. Plant, Y. Lin, **W.Wang**, A. Wolf, A. Del Genio, V. E. Larson, B. J. Nielsen, X. Liu, X. Shi, X. Song, G. Zhang, T. Komori, A. Hill, J. Petch, T. Hume, M. Singh, and K. Cheung, 2012, A Single Column Model Ensemble approach applied to the TWP-ICE experiment, submitted to **J. Geophy. Res.**

[2] **Wang, W.** 2009, The Influence of Thermally-Induced Mesoscale Circulations on Turbulence Statistics Over an Idealized Urban Area Under a Zero Background Wind, **Boundary Layer Meteorology**, vol.131(3), 403-423.

[3] **Wang, W**. 2009, The influence of topography on single-tower-based carbon flux measurements under unstable conditions: a modeling perspective, **Theoretical and Applied Climatology.** DOI 10.1007/s00704-009-0130-0

[4] **Wang, W**. and Liu X., 2009, An evaluation of updraft formulation in NCAR-CAM3 with high-resolution WRF simulations during TWP-ICE, **Geophysical Research Letters**, Vol 36. L04701, Doi: 10.1029/2008GL036692.

[5] **Wang, W**., X. Liu, S. Xie, J. Boyle, and S. A. McFarlane, 2009, Testing ice microphysics parameterizations in the NCAR Community Atmospheric Model Version 3 using Tropical Warm Pool–International Cloud Experiment data, **J. Geophys. Res.,** 114, D14107, doi:10.1029/2008JD011220.

10. Current and pending federal support:

10.1 PI name: Jun Zhang

Current:

1. Title: Advanced model diagnostics of tropical cyclone inner-core structure using aircraft observations

Agency: NOAA

Award Period Covered: 01/01/2012 – 12/31/2012

Amount Funded: $98,979

Person Months: 6.0

2. Title: Investigation of HWRF Model Error Associated With Surface-Layer and Boundary-Layer Parameterizations to Improve Vortex-Scale, Ensemble-Based Data Assimilation Using HEDAS (Co-PI)

Agency: NOAA

Award Period Covered: 01/01/2012 – 12/31/2012

Amount Funded: $107,043

Person Months: 3.0

Pending:

1. Title: Advanced model diagnostics of tropical cyclone inner-core structure using aircraft observations

Agency: NOAA

Award Period Covered: 01/01/2013 – 12/31/2013

Amount Budgeted: $103,613

Person Months: 4.0

2. Title: Investigation of HWRF Model Error Associated With Surface-Layer and Boundary-Layer Parameterizations to Improve Vortex-Scale, Ensemble-Based Data Assimilation Using HEDAS (Co-PI)

Agency: NOAA

Award Period Covered: 01/01/2013 – 12/31/2013

Amount Budgeted: $106,393

Person Months: 2.0

3. Title: Inclusion of Turbulent Effects Quantified by *in-situ* Observation for Horizontal Diffusion Parameterization in HWRF System

Agency: NOAA

Award Period Covered: 08/01/2013-07/31/2015

Amount Budgeted: Year 1: $112,865, Year 2: $115,790

Person Months: 2.0

10.2 PI name: Xuejin Zhang

Current and Pending Support:

PI	Co-PI Co-I	Supporting Agency	Project Title	Total Award	Period Covered	Salary Month
Xuejin Zhang	Da-lin Zhang	NOAA	Development of Multiple Moving Nests within a Basin-wide HWRF Modeling System	$150K	8/1/2011-7/31/2013	3.5
Xuejin Zhang	S.G. Gopalakrishnan Jian-Wen Bao Jun Zhang	NOAA	Inclusion of Turbulent Effects Quantified by *in-situ* Observation for Horizontal Diffusion Parameterization in HWRF System (NOAA-OAR-OWAQ-2013-2003469)	$228K	08/01/2013-7/31/2015*	2.0
Xuejin Zhang	John Michalakes	DTC	Development of Concurrent Integration of Multiple Nests Within HWRF Modeling System (DTC Visitor Program)	~$19.8K[#]	01/01/2013-12/31/20113*	1.0

* The award is still pending. The period covered will be adjusted accordingly

\# The requested amount is $11.8K for salary and about 8k for four trips

10.3 PI name: Sundararaman Gopalakrishnan

Current:

None

Pending:

None

10.4 PI name: Robert Rogers

Current:

1. Title: Hurricane Severe Storm Sentinel (HS3) (co-PI)

Agency: NASA

Award Period Covered: December 2010 – September 2015.

Amount funded: $347,700

Person months: 1. 0

2. Title: Supplemental Education Awards, "Undergraduate Summer Education and Research program in Hurricane Monitoring and Forecasting Using Remote Sensing observations" (co-PI)

Agency: NASA

Award Period Covered: September 2011 – August 2013

Amount funded: $13,114

Person Months: 0.2 month/year

Pending:

1. Title: Precipitation Measurement Mission (PMM). "Using TRMM Measurements in a dynamically Constrained Framework to Better Understand Tropical Cyclone Intensification

Agency: NASA

Award periods: December 2012 – December 2015

Amount budget: $150,234,

Person Months: 2.0

10.5 Collaborator name: Young Kwon

Current: None

Pending: None

10.6 Collaborator name: Weiguo Wang

Current: None

Pending: None

OMB Number: 4040-0004
Expiration Date: 03/31/2012

Application for Federal Assistance SF-424

* 1. Type of Submission:	☐ Preapplication ☒ Application ☐ Changed/Corrected Application
* 2. Type of Application:	☒ New ☐ Continuation ☐ Revision
* If Revision, select appropriate letter(s):	
* Other (Specify):	
* 3. Date Received:	12/07/2012
4. Applicant Identifier:	
5a. Federal Entity Identifier:	
5b. Federal Award Identifier:	

State Use Only:

6. Date Received by State:	
7. State Application Identifier:	

8. APPLICANT INFORMATION:

* a. Legal Name:	University of Miami, RSMAS
* b. Employer/Taxpayer Identification Number (EIN/TIN):	590624458
* c. Organizational DUNS:	1527640070000

d. Address:

* Street1:	4600 Rickenbacker Causeway
Street2:	
* City:	Miami
County/Parish:	
* State:	FL: Florida
Province:	
* Country:	USA: UNITED STATES
* Zip / Postal Code:	331491031

e. Organizational Unit:

Department Name:	
Division Name:	

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:	
* First Name:	Bonnie
Middle Name:	
* Last Name:	Townsend
Suffix:	
Title:	Team Manager
Organizational Affiliation:	
* Telephone Number:	3054214084
Fax Number:	3054214876
* Email:	btownsend@rsmas.miami.edu

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

O: Private Institution of Higher Education

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Department of Commerce

11. Catalog of Federal Domestic Assistance Number:

11.459

CFDA Title:

Weather and Air Quality Research

*** 12. Funding Opportunity Number:**

NOAA-OAR-OWAQ-2013-2003469

* Title:

FY 2013 Joint Hurricane Testbed

13. Competition Identification Number:

2297052

Title:

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Evaluation and Improvement of HWRF Boundary Layer Parameterization Using Aircraft Observations

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: FL-018

b. Program/Project: FL-018

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 08/01/2013

* b. End Date: 07/31/2015

18. Estimated Funding ($):

* a. Federal	164,976.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	164,976.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☐ a. This application was made available to the State under the Executive Order 12372 Process for review on ______.

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☒ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

Prefix:

* First Name: Bonnie

Middle Name:

* Last Name: Townsend

Suffix:

* Title: Team Manager, Research Administration

* Telephone Number: 3054214084

Fax Number: 3054214876

* Email: btownsend@rsmas.miami.edu

* Signature of Authorized Representative: Bonnie Townsend

* Date Signed: 12/07/2012

BUDGET INFORMATION - Non-Construction Programs

OMB Number: 4040-0006
Expiration Date: 06/30/2014

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds: Federal (c)	Estimated Unobligated Funds: Non-Federal (d)	New or Revised Budget: Federal (e)	New or Revised Budget: Non-Federal (f)	New or Revised Budget: Total (g)
1. NOAA-OAR-OWAQ-2013-2003469	11.459	$	$	$ 164,976.00	$	$ 164,976.00
2.						
3.						
4.						
5. Totals		$	$	$ 164,976.00	$	$ 164,976.00

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SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total
	(1) NOAA-OAR-OWAQ-2013-2003469	(2) N/A	(3)	(4)	(5)
a. Personnel	$ 38,672.00	$ 40,605.00	$	$	$ 79,277.00
b. Fringe Benefits	13,690.00	14,374.00			28,064.00
c. Travel	4,000.00	4,000.00			8,000.00
d. Equipment	3,500.00	0.00			3,500.00
e. Supplies	0.00	0.00			
f. Contractual	0.00	0.00			
g. Construction	0.00	0.00			
h. Other	0.00	0.00			
i. Total Direct Charges (sum of 6a-6h)	59,862.00	58,979.00			$ 118,841.00
j. Indirect Charges	22,544.00	23,591.00			$ 46,135.00
k. TOTALS (sum of 6i and 6j)	$ 82,406.00	$ 82,570.00	$	$	$ 164,976.00
7. Program Income	$	$	$	$	$

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Prescribed by OMB (Circular A -102) Page 1A

SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8.	$	$	$	$
9.				
10.				
11.				
12. TOTAL (sum of lines 8-11)	$	$	$	$

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$ 82,406.00	$ 20,602.00	$ 20,602.00	$ 20,601.00	$ 20,601.00
14. Non-Federal	$				
15. TOTAL (sum of lines 13 and 14)	$ 82,406.00	$ 20,602.00	$ 20,602.00	$ 20,601.00	$ 20,601.00

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (YEARS)			
	(b)First	(c) Second	(d) Third	(e) Fourth
16. Year two	$ 82,570.00	$	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$ 82,570.00	$	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges: $118,841

22. Indirect Charges: $46,135

23. Remarks: The Joint Institute Cooperative Agreement Facilities and Administrative Rate is 40% MTDC

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ASSURANCES - NON-CONSTRUCTION PROGRAMS

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0040), Washington, DC 20503.

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C.§§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee- 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.

7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

Tracking Number:GRANT11285843 Funding Opportunity Number:NOAA-OAR-OWAQ-2013-2003469 Received Date:2012-12-07T14:35:10-04:00

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.

10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more.

11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).

12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).

14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.

15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.

16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.

17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

19. Will comply with the requirements of Section 106(g) of the Trafficking Victims Protection Act (TVPA) of 2000, as amended (22 U.S.C. 7104) which prohibits grant award recipients or a sub-recipient from (1) Engaging in severe forms of trafficking in persons during the period of time that the award is in effect (2) Procuring a commercial sex act during the period of time that the award is in effect or (3) Using forced labor in the performance of the award or subawards under the award.

* SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL	* TITLE
Bonnie Townsend	Team Manager, Research Administration
* APPLICANT ORGANIZATION	* DATE SUBMITTED
University of Miami, RSMAS	12/07/2012

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FORM **CD-511**
(REV 1-05)

U.S. DEPARTMENT OF COMMERCE

CERTIFICATION REGARDING LOBBYING

Applicants should also review the instructions for certification included in the regulations before completing this form. Signature on this form provides for compliance with certification requirements under 15 CFR Part 28, 'New Restrictions on Lobbying.' The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of Commerce determines to award the covered transaction, grant, or cooperative agreement.

LOBBYING

As required by Section 1352, Title 31 of the U.S. Code, and implemented at 15 CFR Part 28, for persons entering into a grant, cooperative agreement or contract over $100,000 or a loan or loan guarantee over $150,000 as defined at 15 CFR Part 28, Sections 28.105 and 28.110, the applicant certifies that to the best of his or her knowledge and belief, that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying.' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

Statement for Loan Guarantees and Loan Insurance

The undersigned states, to the best of his or her knowledge and belief, that:

In any funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this commitment providing for the United States to insure or guarantee a loan, the undersigned shall complete and submit Standard Form-LLL, 'Disclosure Form to Report Lobbying,' in accordance with its instructions.

Submission of this statement is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required statement shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure occurring on or before October 23, 1996, and of not less than $11,000 and not more than $110,000 for each such failure occurring after October 23, 1996.

As the duly authorized representative of the applicant, I hereby certify that the applicant will comply with the above applicable certification.

* NAME OF APPLICANT: University of Miami, RSMAS

* AWARD NUMBER: NA

* PROJECT NAME:

Prefix:

* First Name: Bonnie

Middle Name:

* Last Name: Townsend

Suffix:

* Title: Team Manager, Research Administration

* SIGNATURE: Bonnie Townsend

* DATE: 12/07/2012