Probabilistic Prediction of Tropical Cyclone Rapid Intensification Using Satellite Passive Microwave Imagery

A Proposal to

The National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
NOAA-OAR-OWAQ-2015-2004200

For the Period
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Support Requested: $180,800
Year 1: $89,104 Year 2: $91,696

Submitted by the
University of Wisconsin-Madison

On behalf of
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Space Science and Engineering Center (SSEC)
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B. Abstract

Project Title: Probabilistic prediction of tropical cyclone rapid intensification using satellite passive microwave imagery

Personnel: ***Christopher Rozoff***, PI [Cooperative Institute for Meteorological Satellite Studies (CIMSS) / University of Wisconsin (UW)-Madison];
Christopher Velden, Co-PI (CIMSS/UW-Madison);
John Kaplan, Collaborator (Hurricane Research Division/National Oceanic and Atmospheric Administration)

This proposal describes a research-to-operations effort dedicated to improving the accuracy of probabilistic tropical cyclone (TC) rapid intensification (RI) forecasting. A suite of probabilistic RI models [including an updated version of the Statistical Hurricane Intensity Prediction System (SHIPS) Rapid Intensification Index (RII)] will be employed to examine potential environmental and storm structure predictors based on satellite passive microwave imagery (MI). This project builds on recently completed research funded through the JHT that demonstrates objectively determined MI predictors increase the skill of probabilistic RI prediction. Our proposed study will focus on testing these findings in an operational environment and innovating on RI models to better account for TC structure.

Specifically, a multi-model consensus of MI-based models will be used that includes logistic regression, Bayesian, and linear discriminant analysis-based (SHIPS-RII) probabilistic models for the Atlantic and Eastern Pacific Ocean basins. MI-based predictors accounting for the nature of TC organization, asymmetry, rainbands, and the proximity of latent heating with inertial stability will be objectively-determined, implemented into the models, and tested for impacts on RI forecasts. The model developmental datasets will include MI from all past and present microwave-based satellites. Finally, a significant portion of the proposed research will be dedicated to the testing of real-time versions of the MI-enhanced models during the 2016 and 2017 Atlantic and Eastern Pacific hurricane seasons.

This proposed project aims to provide a computationally efficient forecasting tool that improves upon current state-of-the-art probabilistic RI forecasting techniques originally developed for Atlantic and eastern Pacific TCs. Upon completion of the project, the highly portable code will be ready for operational implementation, fully supported by project personnel, and with complete technical documentation. The delivered modeling suite will be easily adaptable to other ocean basins, such as the Western North Pacific. Overall, the proposed work addresses a top priority of both the National Hurricane Center and Joint Typhoon Warning Center, which is improved intensity forecasting, particularly RI prediction.

C. Statement of Work

1. Project Duration: 2 years

2. Project Description

Tropical cyclone (TC) intensity prediction remains a challenging issue and a central priority in National Hurricane Center (NHC) operations. In light of this longstanding problem, recent innovations in operational numerical weather prediction (NWP) are encouraging (Tallapragada 2014; DeMaria et al. 2014). Even so, rapid intensification (RI) events (Kaplan et al. 2010; hereafter K10) remain a difficult forecast problem.

One contemporary avenue of research that has proven successful in providing skillful indications of RI has been in probabilistic prediction using statistically based models. The NHC currently uses a linear discriminant analysis (LDA)-based RI Index (RII) trained on Statistical Hurricane Intensity Prediction System (SHIPS) (K10). Given its promising skill, Rozoff and Kossin (2011; hereafter R11) developed additional probabilistic RI forecast aids, including logistic regression (LR) and Bayesian models of RI. A recently completed study supported by the JHT shows that a consensus of an experimental version of the NHC's SHIPS-RII and the LR and Bayesian models generally performs better than any individual model at all forecast lead times and regardless of the definition of RI (Kaplan et al. 2013; hereafter K13).

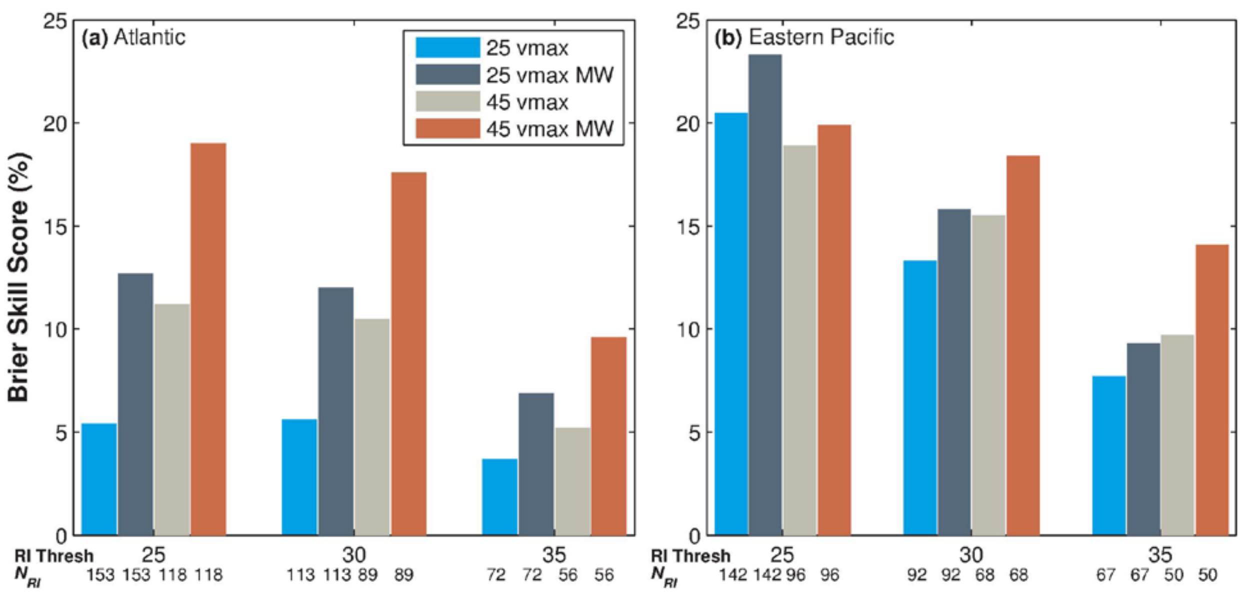

Fig. 1. Brier skill scores for the simulated real-time LR model at 25, 30, and 35 kt per 24-h RI thresholds without MI-based predictors (light blue and gray for TCs of at least 25 kt and 45 intensity, respectively) and with MI-based predictors (dark blue and red for TCs of at least 25 and 45 kt intensity) for (a) Atlantic and (b) Eastern Pacific TCs. In the Atlantic, the sample sizes for the 25- and 45-kt storm intensity thresholds are 1415 and 1021. In the Eastern Pacific, the sample sizes for the two intensity thresholds are 1312 and 880. The number of RI cases for each RI and intensity threshold is shown along the x-axis below each bar. Forecasts are compared for each model only when MI are available within 6 h of the initial forecast time (~50% of the time). Figure from R14.

Recently, Rozoff et al. (2014; hereafter R14) carried out an initial exploration of probabilistic RI prediction based on a new class of structural predictors. Noting the important roles of latent heating and its distribution in TC RI, a variety of simple passive MI-based predictors were incorporated into the LR model of R11. Compared with the baseline LR model of R11, independent testing confirmed the MI-enhanced model improved the forecast skill of RI prediction in the Atlantic and Eastern Pacific. A "proof-of-concept" experiment showed even greater relative skill improvements in a simulated real-time environment using archived real-time data from 2004-2013. This improvement occurs since, in the real-time setting, many non-MI-based predictors primarily rely on NWP-predicted values of environmental and storm-related parameters. Figure 1 shows the results from the simulated real-time environment. The relative improvements in the Atlantic are impressive, while the smaller improvements in the Eastern Pacific may indicate that the baseline model is closer to a predictability limit, at least for this particular model and the available data.

In an operational-type setting, the MI-version of the model in R14 first ingests a variety of SHIPS-based predictors. Then, when MI is available (i.e., a satellite swath covers a sufficient amount of the inner-core of the TC within the last 6 h of the forecast time), a small set of predictors calculated from the MI is incorporated into the model. The model described in R14 uses very basic MI-based predictors, such as means and standard deviations of brightness temperatures (T_b) in selected storm-centric regions or in regions identified to represent a nascent or fully developed eye and eyewall.

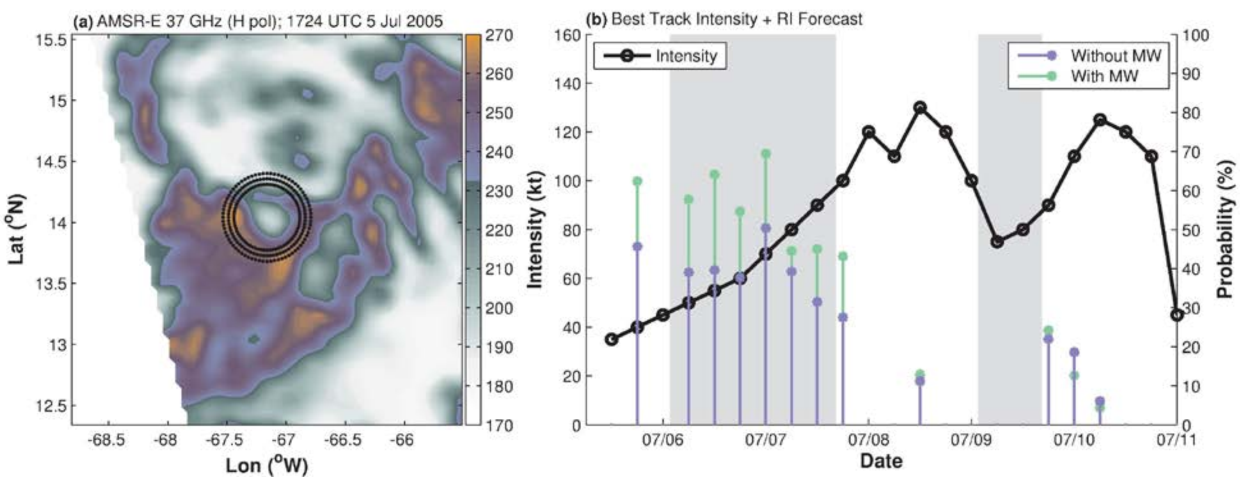

Fig. 2. (a) AMSR-E T_b (K) at 37 GHz (hor. pol.) of Atlantic Hurricane Dennis at 1724 UTC 5 July 2005, along with the objectively determined eyewall feature. (b) Dennis' observed intensity (solid line, kt) and the probability (%) of 25 kt (24 h)$^{-1}$ or greater intensification rates as predicted by the LR model without (purple) and with (green) MI-based predictors. Shaded regions indicate RI occurred in the next 24 h. Figure from R14.

One example of how MI can enhance the LR model probabilities of RI is provided in Fig. 2, which includes a MI snapshot of Atlantic Hurricane Dennis (2005), along with general intensity and LR model RI probabilities in time. Figure 2a shows 37-GHz (horizontal polarization) T_b from the Advanced Microwave Scanning Radiometer-EOS (AMSR-E). This image coincides near the beginning of the first RI period of Dennis, and the 37-GHz T_b pattern shows a circular precipitation structure organizing around the TC center, which is objectively identified as a forming eyewall-like feature by the automated detection algorithm described in R14. Since two of the LR model predictors are based on 37-GHz T_b in the eyewall region, this structure contributes to enhanced RI probabilities in the MI-based model. Overall, the MI-based version of the model successfully produces greater probabilities of RI than the non-MI baseline model during and prior to Dennis' first RI period. For the later RI period, there is an unfortunate lack of available MI passes. Otherwise, in later non-RI periods, both models produce similarly low probabilities of RI.

The other way in which MI can improve probabilistic models is shown in Fig. 3, a case study for Eastern Pacific Hurricane Raymond (2013). On 25 October, the baseline non-MI LR model produced notably high probabilities of RI since the environmental predictors in the LR model indicated conditions were favorable to RI (e.g., low vertical wind shear, a high potential intensity, and lower static stability) (Fig. 3b). However, the 85-GHz polarization-corrected temperatures (PCT) of the Special Sensor Microwave Imager/Sounder (SSMI/S) (Fig. 3a) showed a strongly asymmetric ice scattering signature offset from the TC center. This feature was picked up by a 85-GHz predictor used in the Eastern Pacific model, correctly reducing the model probabilities of RI on 25 Oct. (RI did not begin until 26 Oct.)

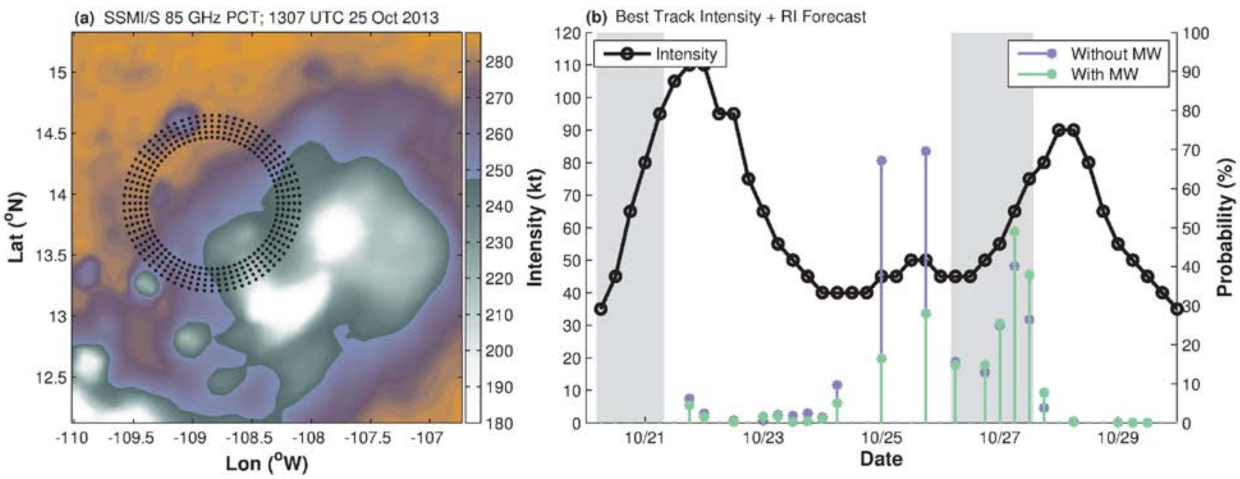

Fig. 3. Same as Fig. 2 except for (a) SSMI/S 85.5-GHz PCT (K) at 85.5 GHz of Eastern Pacific Hurricane Raymond at 1307 UTC 25 October 2013 and (b) best track data and forecast plotted in time for Raymond. Figure from R14.

The LR-based model framework developed above has potential to make a significant contribution to the operational forecasting of RI. While low-earth orbiting satellites do not always capture a TC scene in a timely manner, data less than 6-h old were roughly available half of the synoptic times analyzed in the study of R14. Of course, one challenge to contend with is the loss of AMSR-E in 2011 and the recent loss of Tropical Rainfall Measurement Mission Microwave Imager (TMI), along with the eventual losses of Special Sensor Microwave/Imager (SSM/I) and SSMI/S instruments. These losses are currently being mitigated by SSMI/S replacements (e.g., DMSP F19 and F20), along with recent new additions: the Advanced Microwave Scanning Radiometer 2 (AMSR2) and the Global Precipitation Measurement Microwave Imager (GMI). These data are being added to the LR model toolbox, and will be available for this study.

Overall, the MI-based LR model is ideal for operational adoption. Furthermore, the potential exists to innovate upon the above framework of R14 by adding MI to other available probabilistic models such as SHIPS-RII and the Bayesian model of R11. MI-based structure predictors will likely improve the skill of each model, and a follow-on consensus of these models can then readily be developed. K13 suggests the skill of the MI-based consensus should exceed that of any single MI-based model.

Given the basic nature of the MI-based structural predictors used in R14, further improvements to the predictors themselves may also boost the performance of probabilistic models. The predictors in R14 were primarily based on TC-centric geometry and basic statistical properties of the T_b fields in azimuthally symmetric regions. More sophisticated predictors accounting for asymmetric precipitation patterns, including rainband activity, and also the relationship between precipitation and the wind structure could improve RI models. For example, predictors that can discern the amount of coupling of precipitation and higher inertial stability (Rogers et al. 2013) may indicate higher RI potential. Another potential innovation would be to better capture structure *changes*. For example, Zagrodnik and Jiang (2014) demonstrated that TCs just commencing RI produce less areal latent heating, while storms that have been undergoing RI for 12 h or more are more symmetric and have more widespread, intense latent heating. The temporal trends of precipitation structures relevant to RI in TCs are somewhat overlooked by the simple binary classifier approach taken by probabilistic RI models. Therefore, such models may wash out some of the temporal signals that could be beneficial to the prediction of RI. Identifying short-term (6-12 h) MI descriptor trends and employing them as predictors in the probabilistic RI models holds great promise for improving forecast skill. Some specific ideas on the ideas above are described below.

The primary goal of the proposed effort described here is to build upon the success of the MI-based LR model of R14 in a quasi-operational environment and extend that success to other statistically based RI models. A plan to innovate upon the work of R14 is outlined below.

Innovations in passive microwave-based predictors

A new family of MI-based structure predictors will be tested to focus on the following characteristics: precipitation asymmetries, the nature of rainband activity, and the juxtaposition of latent heating and inertial stability.

Asymmetric structure and rainband activity will be quantified in two ways. First, we will evaluate predictors that are the principle components of two-dimensional (2D) empirical orthogonal functions (EOFs) representing the MI developmental dataset. (To compute EOFs, each MI is rotated such that the storm motion vector points northward.) As seen in Fig. 4, wavenumber-1 asymmetries project on leading EOFs, while rainbands are captured in higher-order EOFs. A second set of predictors related to inner-core structure to be tested will be available from the Automated Rotational Center Hurricane Eye Retrieval (ARCHER) (Wimmers and Velden 2010), which is already used in determining the TC center for the MI in our developmental dataset and is being evaluated by NHC as a current Joint Hurricane Testbed study. ARCHER quantifies aspects of rainband organization in its spiral score. It also provides an estimate of inner-core symmetry and size from its ring score.

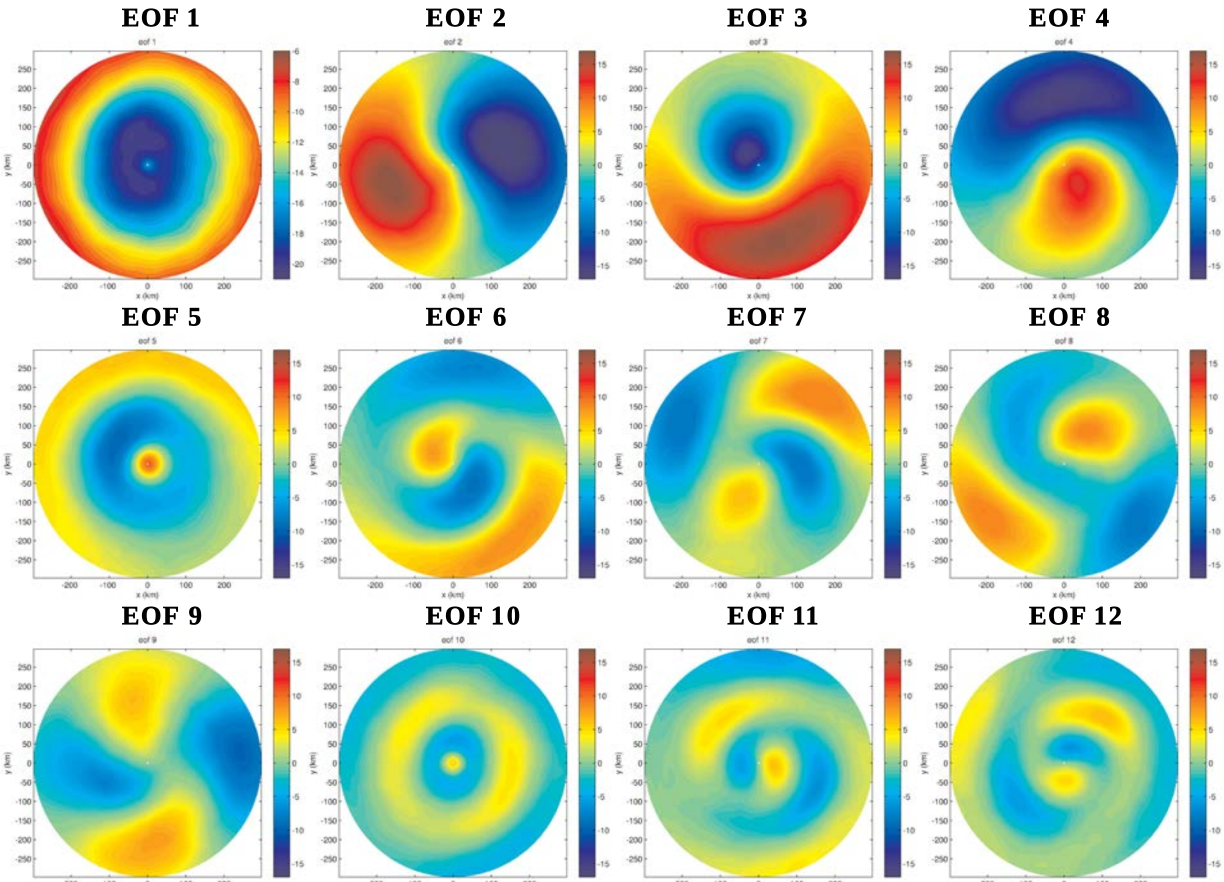

Fig. 4. The first 12 EOFs of the 37-GHz (hor. pol.) T_b for the developmental dataset used in R14. The first 12 EOFs describe almost all of the variance in the MI dataset. Data are plotted here from storm center to 300-km radius from center.

Inertial stability (and its spatial coupling to latent heating as indicated by MI) will be accounted for in another new class of predictors. Inertial stability-based predictors from two independent data sources will be tested. Only the superior data source will be chosen for the final version of the RI models. The first data source is the archived model output of the 2014 version of HWRF (which has reforecast data from 2008–2014). Initial analysis (T-0) inertial stability fields are currently being computed and collected by the PI and will be available at the start of this proposed project. Another approach to get a TC's inertial stability is described in Rozoff et al. (2015). Here, the azimuthal wavenumber 0-2 components of 2D aircraft reconnaissance wind field analysis dataset (Knaff et al. 2014) and data from the NHC's North Atlantic Hurricane Database (HURDAT) were related via multiple linear regression to the 2D EOFs of the MI in the developmental dataset. The resulting model thereby estimates the inner-core wind structure (thus, the inertial stability fields) from MI (e.g., Fig. 5).

Two simple approaches to account for temporal trends will be tested. First, predictors accounting for temporal trends in selected MI descriptors (i.e. changes in MI-based predictors in the previous 6-24 h) will be computed. Secondly, models accounting for the stage of RI (e.g., RI in its beginning stages verses RI long underway) will be tested. These proposed innovations are relatively easy to construct and test and, hence, are low risk experiments with potentially significant impacts.

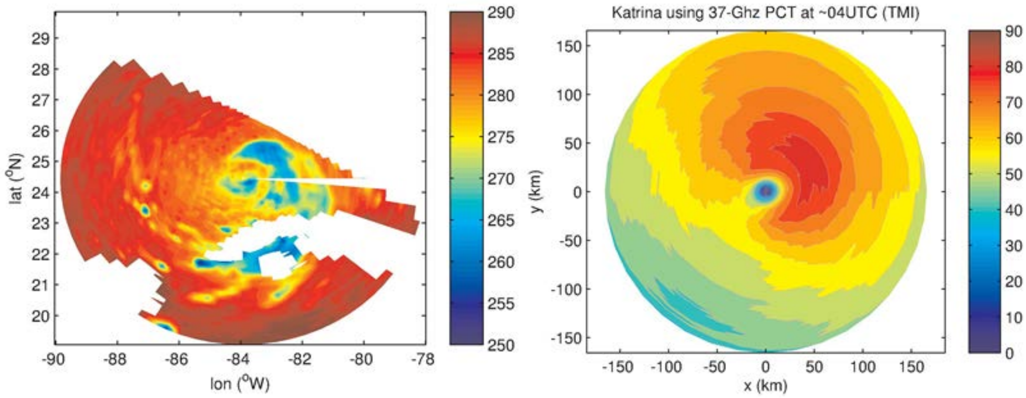

Fig. 5. (left) 37-GHz PCT (K) (TMI) of Hurricane Katrina (2005) at 0400 UTC 27 Aug. Missing data are seen in this image where there is land and in the northeast due to the region falling outside of the satellite swath. (right) Model diagnosed flight-level tangential winds (kt) associated with the 37-GHz MI at left. From Rozoff et al. (2015).

A MI-based multi-model consensus

As demonstrated in K13, a multi-model consensus using non-MI based probabilistic RI models, including the SHIPS-RII, Bayesian, and LR models, provides higher skill than any individual model for all RI thresholds and lead times studied. Along with MI-based improvements to the LR model, our proposed effort will update the SHIPS-RII and Bayesian models with improved MI-based predictors to produce a multi-model consensus. The R14 model is based on a baseline LR model of R11 enhanced with statistically independent MI-based predictors that improve model skill. In the study proposed here, the objective feature selection method used in R11 and R14 will be used on all non-MI and MI-based predictors from the developmental dataset to objectively determine an optimal set of statistically independent predictors for each model. Letting the predictor search algorithm omit predictors that were chosen in the original non-MI baseline models of K10 and R11 will further optimize the reliability of each model.

Updated developmental datasets

The MI-based LR model of R14 is based on a TC dataset covering 1998-2013, and consists of all SSM/I, SSMI/S, TMI, and AMSR-E swaths that capture Atlantic and Eastern Pacific TCs. As a byproduct of our proposed study, this developmental dataset will be updated to include available 2014-2016 MI data (for sensors that still exist in this period). Also, newly available MI observations from SSMI/S on DMSP F19, AMSR2, and the GMI will be calibrated and added to the dataset. While CIMSS already has real-time feeds to most of these satellite datasets for simulated operational testing, any additional data streams will be added if necessary. Upon completion of the project, this updated developmental MI dataset will be made available to the research community.

Simulated operational testing

In addition to optimizing and testing the MI-enhanced model suite with our developmental data, real-time versions of the models will be tested during the Atlantic and Eastern Pacific hurricane seasons falling within the proposed project period. In addition, retrospective testing on the 2004-2014 TC seasons can also be conducted in simulated operational conditions since all needed real-time data from this period are archived at CIMSS. The models will be delivered in portable code designed to operate in a real-time environment within the chosen (by JHT) NCEP/NOAA infrastructure.

We note that the current suite of probabilistic RI models have only been developed for the Atlantic and Eastern Pacific and our study aims to further enhance the predictability of these models. However, this project should pave the way for expansion of the capabilities into other ocean basins, such as within the Joint Typhoon Warning Center areas of responsibility.

References

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3. Work Plan

In year 1, the primary focus is the natural next step of our previous JHT-supported effort. First, new TC structure predictors will be added to the updated MI-based developmental datasets. Then, the SHIPS-RII, LR, and Bayesian models will be re-derived in both the Atlantic and Eastern Pacific with the updated developmental datasets, which will contain new structure predictors, including MI-based predictors from old and new microwave sensors. The RI models will be derived for forecast lead times of 12, 24, 36, and 48 h. In each ocean basin, the three independent RI models will also be evaluated as a consensus product. The models will be tested at CIMSS on local computers where all model development infrastructure is already in place. All models will be evaluated via independent testing methods. Forecast skill and reliability will be compared against baseline, state-of-the-art tools such as the operational SHIPS-RII, and the models of K13 and R14. Later in the first year, automation and conversion of model codes compatible with the NCEP framework will begin. Real-time testing of the models in the TC season of 2016 will also commence. The real-time experiments will be run at CIMSS and results displayed to a website.

In year 2, conversion of model code for use on designated NCEP infrastructure will be completed. Further model evaluation will be carried out to determine any final model modifications and to test operability on the new infrastructure. Reforecasts will be carried out on storms from 2004–2016 to obtain a more robust operational performance and model skill assessment. If time/resources permit, another real-time trial will be conducted during the 2017 TC season. Finally, documentation for running and maintaining the model codes will be written and delivered to JHT.

Metrics for Success

- Updated probabilistic RI models should significantly exceed the skill and reliability of current operational or experimental RI models.
- As a natural byproduct of our proposed research effort, improved understanding of the RI problem should be achieved.
- Code and data streams should be readily portable to operational frameworks at the conclusion of the project.

Project Deliverables

- An updated MI-based SHIPS-RII, LR, and Bayesian probabilistic RI model suite for both the Atlantic and Eastern Pacific Ocean in NCEP-ready Fortran/C code;
- Semi-annual project progress reports;
- Training materials/user's guide for model operation and updates.

Timeline with Key Milestones

The project will take place over a two-year period. The tasks will be collaborative among the 3 investigators and will involve regular communication with JHT advisors to efficiently coordinate the completion of tasks. Our project timeline, which assumes a nominal starting month of Sep. 2015, is provided in the table below.

Task	Activity
1	Update developmental dataset to include MI of Atlantic and eastern Pacific TCs from all available sensors (1998-2016) [Sep. 2015–Jan. 2017].
2	Examine and test for significance of new MI-based predictors [Sep. 2015–Jan. 2016].
3	Update logistic regression model to incorporate improved MI predictors and

	evaluate on retrospective and real time cases [Jan.–Mar. 2016].
4	Enhance the Bayesian and LDA-based SHIPS-RII model with up-to-date MI dataset [Jan.–Mar. 2016].
5	Evaluation of updated SHIPS-RII and Bayesian models on retrospective dataset [Mar. –May 2016]
6	Convert code from Matlab (development framework) to Fortran and C so that code is portable to NCEP operations [Apr. 2016–Jan. 2017].
7	Real-time testing of models in the Atlantic and Eastern Pacific and continue reforecasts of previous seasons in simulated operational conditions with archived real-time data [May–Nov. 2016].
8	Evaluation of models and model updates, if necessary [Jan.–Jun. 2017].
9	Prepare final NCEP-ready code and documentation for running and maintaining models at conclusion of the project. [Feb.–Aug. 2017].
10	Optional 2nd real-time trial if requested by JHT and resources permit [Jun.–Aug. 2017].

It is also important to note that we will present results each year of the project at the annual Interdepartmental Hurricane Conference (IHC).

Plan to Port Codes to the Operational Environment

- All programs will be written and compiled in Fortran 90/C code.
- Existing data streams on NCEP servers will be tallied and any additional data streams needed for real-time use of models on NCEP servers will be added.

4. Timeline for Scientific and Technical Documentation and Training

Along with the progress reports provided throughout the course of the project, detailed technical documentation will be provided at the end of the project as well. Specifically, a scientific description of the project's models and their performance will be provided early in year 2. Also, technical and training documentation on how to operate and evaluate the models, along with instructions to update the models to future satellite sensors, will be provided by the end of year 2. Project PI advice (e.g., in updating to new satellite sensors) will be provided at no cost after the project concludes.

5. Schedule and Travel Needs

Spring 2015	PI travels to the Interdepartmental Hurricane Conference
Spring 2016	PI travels to the Interdepartmental Hurricane Conference

6. JHT Staff Requirements

The experimental models will be run on CIMSS servers with output displayed on a website. JHT staff may be requested to facilitate the migration of microwave data streams onto appropriate NCEP servers in year 2 for testing of operational conditions, especially if new data streams need to be added. The models will be written in a Fortran 90 framework, will work with the SHIPS predictors, and should therefore mesh well with NCEP infrastructure already used for the SHIPS and the SHIPS-RII. Coordination with JHT will be essential to facilitate seamless transitions to operations.

D. Budget Explanation

Part I: Budget Narrative

We request a total dollar amount of $180,800 to fund the research outlined in the project narrative. Explanations of the budget information are given directly below. The costs to conduct the activities described in this proposal are summarized in the budget pages provided. Cost estimates in these budget pages are based on historical events and experience.

Key Personnel

The following individual has been identified as key personnel to this proposal:

Christopher Rozoff, PI, 1,400 hours
Christopher Velden, Co-PI, 300 hours

Time quoted for key personnel is the total amount of anticipated effort required to complete the proposed effort over the life of the project, including during periods of no cost extension. All effort for key persons will be sponsor paid effort. Fulfillment of the effort commitment will be defined as a total for the entire project period. We cannot guarantee effort for key personnel commitments per budget period given the uncertain volatile nature of research and funding availability. Funding reductions will result in a scaled back effort; the project narrative, the budget, and key personnel obligations will all be reduced in the same manner (i.e. if the funding is cut 25%, we will cut 25% of the project narrative and 25% of the labor and cost involved) unless otherwise negotiated.

Personnel

This section identifies the staff required, their effort (hours needed), and salary information. To calculate hourly rates for salaried employee, the formula is Total Salary divided by billable hours. Hourly rates are calculated using a base of 1,350 hours per year for Faculty and 1,763 billable hours per year for Academic Staff. The base for a graduate student is 1,800 billable hours. Undergraduates are paid on an hourly basis, so no computation is required. Vacation, holiday and sick leave time is not charged directly to the projects. For budgets with duration greater than one year, we use a 3% inflation factor to labor rates to account for cost of living adjustment. We estimate an approximate total effort as follows:

			Year 1		Year 2	
Name	**Title**	**Classification**	**Hours**	**% Effort**	**Hours**	**% Effort**
Rozoff, Christopher	Principal Investigator	Academic Staff	700	39.7	700	39.7
Velden, Christopher	Co-Principal Investigator	Academic Staff	150	8.5	150	8.5

Fringe Benefits

Fringe rates are dependent on employee classification (which is listed under the Personnel section). Please see the below table for a detailed summary of how the fringe benefit rate is calculated at the University of Wisconsin-Madison:

Components of the 2014-2015 Fringe Benefit Rate

Benefit Category	Faculty & Academic Staff	Classified Staff	LTE	#1	#2	#3	#4	Student
Income Continuation	0.1	0.2						
Unemployment Comp.	0.1	0.1	2.2					
Worker's Comp.	0.1	0.1	0.1					
Social Security	5.5	5.8	6.1	5.3	0.1	6.1	0.4	2.6
Medicare	1.4	1.4	1.4	1.3	0.1	1.4	0.1	0.6
Health Insurance	15.8	28.1	2.7	16.7	24.3	0.3	14.7	0.1
Life Insurance	0.1	0.1						
Retirement	10.5	10.6	3.3					
Prior Year Adj.	0.1	0.1	0.1					0.7
Totals	**33.7%**	**46.5%**	**15.9%**	**23.3%**	**24.5%**	**7.8%**	**15.2%**	**4.0%**

#1 Research Associates and Research Interns
#2 Research Assistants, Project, and Teaching Assistants, Pre-Doc Fellows and/or Trainees
#3 Ad Hoc Program Specialists, Undergraduate Assistants and Undergraduate Interns
#4 Post-Doc Fellows and/or Trainees

Travel

Travel costs are for UW-Madison staff to attend meetings, workshops and professional conferences. The travel budgets in the proposal are based on recent history regarding the amount of travel needed to conduct the research project, interact with collaborators, and present the results. The SSEC travel office monitors current airfares, hotel costs, car rentals, taxi fares, etc and provides estimates for travel costs for frequent meeting sites. The UW-Madison, in accordance with state law, reimburses actual travel costs for hotel and meal expenses up to a certain maximum rate. All travel must be approved by the SSEC administration. Travel costs are reviewed by the SSEC travel office and one of the SSEC Executive Directors. One trip per year for 1 person for four days to attend a scientific conference at a cost of $1,800 per year has been budgeted. The costs are as itemized below.

1 Trip / 1 person / 4 days / IHC Conference				
	fares		subtotal	
Airfare	1	500	$500	
	# nights	cost / day		
Hotel	4	250	$1,000	
	# days			
Meals	4	50	$200	
Local Transportation-Madison	2	25	$50	
Local Transportation-IHC	2	25	$50	
				$1,800

Materials & Supplies

No materials and supplies are requested for this project.

Indirect Costs

Currently at 53%, the indirect cost rate is directly negotiated with the U.S. government and is charged to all budget items except capital equipment purchases over $5,000 and student tuition remission, which are free of overhead. A copy of the most recent rate agreement is attached to the end of the Budget Details section below.

Part II: Budget Details

		Hours	Rate	Salary	Fringe %	Fringe	Cost	Totals
Year 1								
1 Sept 2015 - 31 Aug 2016								
Labor and Fringe Benefits		Hours	Rate	Salary	Fringe %	Fringe	Cost	Totals
a)	PI - Chris Rozoff	700	43.38	30,366	33.7%	10,233	40,599	
b)	CoPI - Chris Velden	150	78.98	11,847	33.7%	3,992	15,839	
	Subtotal			42,213		14,225		$56,438
Travel								
a)	1 Trip / 1 person / 4 days / IHC Conference						1,800	
								1,800
Materials & Supplies								0
University Indirect Cost at 53%								30,866
	Year 1 Total							**$89,104**

Year 2 1 Sept 2016 - 31 Aug 2017								
Labor and Fringe Benefits		Hours	Rate	Salary	Fringe %	Fringe	Cost	Totals
a)	PI - Chris Rozoff	700	44.68	31,277	33.7%	10,540	41,817	
b)	CoPI - Chris Velden	150	81.35	12,203	33.7%	4,112	16,315	
	Subtotal			43,480		14,652		$58,132
Travel								
a)	1 Trip / 1 person / 4 days / IHC Conference						1,800	
								1,800
Materials & Supplies								0
University Indirect Cost at 53%								31,764
	Year 2 Total							**$91,696**

Summary 1 Sept 2015 - 31 Aug 2017							
Labor and Fringe Benefits		Hours	Salary	Fringe %	Fringe	Cost	Totals
a)	PI - Chris Rozoff	1,400	61,643	33.7%	20,773	82,416	
b)	CoPI - Chris Velden	300	24,050	33.7%	8,104	32,154	
	Subtotal		85,693		28,877		$114,570
Travel (see accompanying worksheet for detai							
	Year 1 travel					1,800	
	Year 2 travel					1,800	
	Travel Total						3,600
Materials & Supplies							0
University Indirect Cost at 53%							62,630
	Proposal Total						**$180,800**

F. Abbreviated Curriculum Vitae

Principle Investigator, Christopher Rozoff

CIMSS/UW-Madison | 1225 West Dayton Street, Madison, WI 53706
(608) 512-5099 | chris.rozoff@ssec.wisc.edu

Professional Preparation

Colorado State University	Atmospheric Science	Ph.D., 2007
Colorado State University	Atmospheric Science	M.S., 2002
University of Wisconsin-Milwaukee	Atmospheric Science, Math	B.S., 1999

Appointments

2014 – present	Researcher, CIMSS/UW-Madison
2011 – 2014	Associate Researcher, CIMSS/UW-Madison
2009 – 2011	Assistant Researcher, CIMSS/UW-Madison
2007 – 2009	Postdoctoral Fellow, CIMSS/UW-Madison
2000 – 2007	Graduate Research Asst., Colorado St. Univ.

Recent Publications

Rozoff, C. M., and W. D. Terwey, 2015: The dynamics of complexly sheared tropical cyclone convection and relationships with tropical cyclone evolution. *J. Atmos. Sci.*, to be submitted.

Rozoff, C. M., J. Knaff, and M. Amin, 2015: Estimating tropical cyclone wind structure from passive microwave imagery. *J. Appl. Meteor. Climate*, to be submitted.

Rozoff, C. M., C. S. Velden, J. Kaplan, J. P. Kossin, and A. J. Wimmers, 2014: Improvements in the probabilistic prediction of tropical cyclone rapid intensification with passive microwave observations. *Wea. Forecasting*, accepted with revisions.

Terwey, W. D., and C. M. Rozoff, 2014: Objective convective updraft identification and tracking. Part I: Structure and thermodynamics of convection in the rainband regions of two hurricane simulations. *J. Geophys. Res.*, **119**, doi:10.1002/2013JD020904.

Sitkowski, M., J. Kossin, C. M. Rozoff, and J. Knaff, 2012: Hurricane eyewall replacement cycles and the relict inner eyewall circulation. *Mon. Wea. Rev.*, **140**, 4035-4045.

Monette, S. A., C. S. Velden, K. S. Griffin, and C. M. Rozoff, 2012: Examining trends in satellite-detected overshooting tops as a potential predictor of tropical cyclone rapid intensification. *J. Appl. Meteor. Climate*, **51**, 1917-1930.

Rozoff, C. M., D. S. Nolan, J. P. Kossin, F. Zhang, and J. Fang, 2012: The roles of the expanding wind field and inertial stability in tropical cyclone secondary eyewall formation. *J. Atmos. Sci.*, **69**, 2621-2643.

Recent Community Service

Associate Editor of *Nature Scientific Reports* (2014 – current)
Associate Editor of *Mon. Wea. Rev.* (2012 – 2014)

Co-Principle Investigator, Christopher Velden

Current Position: University of Wisconsin – Space Science and Engineering Center Physical Sciences: Senior Scientist and Principal Investigator.

Chief Investigator for internationally-recognized UW-SSEC/CIMSS Tropical Cyclones Group and Satellite Winds Group

Address: Space Science and Engineering Center
University of Wisconsin-Madison
1225 West Dayton Street
Madison, Wisconsin 53706
Phone: (608) 262-9168
E-mail: chris.velden@ssec.wisc.edu

M.S. - Dept. of Meteorology, Univ. of Wisconsin-Madison.
Topic: Tropical Cyclone Warm Core Evolution: NOAA Satellite Microwave Views. June, 1982.

B.S. - Univ. of Wisconsin-Stevens Point. Majors: Natural Sci., Geography (minor - physics). June, 1979.

Awards: Amer. Meteor. Soc. Special Award, 2015
Amer. Meteor. Soc. STAC Committee Award, 2015
Univ. Wisc. Chancellor's Research Excellence Award, 2012
NOAA-CIMSS Science Collaboration Award, 2011
Elected Amer. Meteorological Society Fellow, 2008
Office of Federal Coord. for Meteorology Hagemeyer Award, 2003
Amer. Meteor. Soc. Banner Miller Award, 2001
Amer. Meteor. Soc. Special Award, 1998

Book Chapters:

C.S. Velden, J. Simpson, W. T. Liu, J. Hawkins, K. Brueske, and R. Anthes: *Chapter 11: The Burgeoning Role of Weather Satellites*, Hurricane! Coping with Disaster. American Geophysical Union Publication, Robert Simpson, Editor, 2003, 360 pp.

C.S. Velden: *Satellite Observations of Tropical Cyclones*, Global Perspectives on Tropical Cyclones: From Science to Mitigation, WMO New World Scientific Series on Earth System Science, C.P. Chang, Editor, 2010, 448 pp.

Major Refereed Publications (last 3 years)

Velden, C. S., and J. Sears, 2014: Computing Deep-Tropospheric Vertical Wind Shear Analyses for Tropical Cyclone Applications: Does the Methodology Matter? *Wea. Forecasting*, 29, 1169–1180.

Dunion, J., C. Thorncroft, and C. Velden, 2014: The Tropical Cyclone Diurnal Cycle of Mature Hurricanes. *Mon. Wea. Rev.*, 142, 3900–3919.

Wu, T., S. Majumdar, C. Velden, H. Liu and J. Anderson, 2014: Influence of Assimilating Satellite-Derived Atmospheric Motion Vector Observations on Numerical Analyses and Forecasts of Tropical Cyclone Track and Intensity. *Mon. Wea. Rev*. 142, 49-71.

Hoover, B., S. Majumdar and C. Velden, 2013: Physical Mechanisms Underlying Selected Adaptive Sampling Techniques for Tropical Cyclones. *Mon. Wea. Rev.*, 141, 4008-4027.

Reynolds, C., R. Langland, C. Velden, and P. Pauley, 2013: Tropical Cyclone Data Impact Studies: Influence of Model Bias and Synthetic Observations. *Mon. Wea. Rev.*, 141, 4373-4394.

Sears, J., and C. Velden, 2013: Investigating the Role of the Upper-Levels in Tropical Cyclogenesis. *Tropical Cyclone Research and Review*, 3 (2), 91-110.

Monette, S., C. Velden, and K. Griffen, 2012: Examining Trends in Satellite-Detected Overshooting Tops as a Potential Predictor of Tropical Cyclone Rapid Intensification. *J. Appl. Meteor. Clim*., 51, 1917-1930.

Sears, J., and C. Velden, 2012: Validation of Satellite-derived Atmospheric Motion Vectors around Tropical Disturbances. *J. Appl. Meteor. Clim*., 51, 1823-1834.

Berger, H., R. Langland, C. Velden and C. Reynolds, 2011: Impact of Enhanced Satellite-Derived Atmospheric Motion Vector Observations on Numerical Tropical Cyclone Track Forecasts in the Western North Pacific during TPARC/TCS-08. *J. Appl. Meteor. Clim*., Vol. 50, No. 11., 2309-2318.

Hawkins, J. and C. Velden, 2011: Supporting Meteorological Field Experiment Missions and Post-Mission Analysis with Satellite Digital Data and Products. *Bull. Amer. Meteor. Soc*., 92, 1009-1022.

Wimmers, A. and C. Velden, 2011: Seamless Advective Blending of Total Precipitable Water Retrievals from Polar Orbiting Satellites. *J. Appl. Meteor. Clim*., Vol. 50, 1024-1036.

Major Field and Professional Experience

Co-Chair, WMO Workshop on Tropical Cyclone Satellite Applications (2011)
Co-Chair, International Workshop on Tropical Cyclones (2010)
Co-Chair, AMS Annual Meeting (2008)
Chair, AMS Committee on Satellite Meteorology (2004-2007)
WMO/THORPEX International DAOS Science Team Working Group (2002-Present)
National Academy of Sciences NPOESS/GOES-R Study for NOAA/NASA (2007-2008)
National Academy of Sciences Decadal Study for NASA (2005-2007)
National Academy of Sciences TRMM/GPM Study for NASA/NOAA (2002-2004)
National Academy of Sciences CONNTRO Committee (2000-2003)
Bulletin of the AMS Journal Subject Editor (2002-2011)
Co-chair, WMO International Satellite Winds Working Group (1995-2008)
US Weather Research Project Science Steering Committee charter member (1996-1999)
Member AMS Committee on Satellite Meteorology (1997-2003)
Member AMS Committee on Tropical Meteorology and Cyclones (1990-1993; 2010-present)
Participant (PI or Co-I) in ~15 major atmospheric field programs since 1986
Visiting Scientist at the Australian Bureau of Meteorology (1987-1988)

G. Current And Pending Federal Support

Christopher M. Rozoff, PI

Current Support

Federal Award #	Agency	Project Title	Role	Project Start Date	Project End Date	Award Budget	Person Months Remaining
AGS1140234	NSF	Collaborative Research: The Relationships Between Sheared Convective Clouds and Tropical Cyclone Evolution	PI	1/1/2012	12/31/2014	$163,486	0.5
NA10NES4400013	NOAA	Improved Understanding and Diagnosis of Tropical Cyclone Structure and Structure Changes	Co-PI	5/1/2011	6/30/2015	$117,000	1.0
NA14NWS4680024	NOAA	Probabilistic Prediction of Hurricane Intensity with an Analog Ensemble	PI	8/1/2014	7/31/2016	$350,653	5.0

Pending Support

	Agency	Project Title	Role	Project Start Date	Project End Date	Proposed Budget	Person Months
	NCAR	Mexico MoMet: Infrastructure, Tools, and Training to Support the National Agency for Hurricanes and Severe Weather (ANHyTS)	Co-PI	5/1/2015	11/30/2018	$199,928	12.1

Christopher Velden, Co-PI

Current Support

Federal Award #	Agency	Project Title	Role	Project Start Date	Project End Date	Award Budget	Person Months Remaining
NA10NES4400013	NOAA	CIMSS Participation in the GOES-R Development of AMVS	CoI	5/1/2014	6/30/2016	$100,000	1.2
S13-0010	NASA	Utilizing NASA Reconnaissance Assets to Investigate Hurricane Upper-level Warm Core Evolution, Inner Core Pulsing, and Near-Environment Moisture Interactions	CoI	7/1/2012	6/30/2015	$170,489	1.2
NA10NES4400013	NOAA	NOAA Hurricane Forecast Improvement Program: Assimilation of High-Resolution GOES AMVs in HWRF	PI	7/1/2014	6/30/2015	$130,007	1.1
NA13OAR4590189	NOAA	Integration of an Objective, Automated TC Center-fixing Algorithm Based on Multispectral Satellite Imagery into NHC/TAFB Operations	CoPI	9/1/2013	8/31/2015	$221,300	2.3
N00173-13-1-G004	DOD	Satellite-Based Applications to Benefit Navy Tropical Cyclone Analysis and Numerical Model Forecasts	PI	6/7/2013	6/6/2016	$749,619	2.9
N00014-14-1-0116	DOD	Importance of the Coupling of Tropical Cyclone Outflow Vents with the Environment: Observational and Model Sensitivity Studies	PI	1/1/2014	9/30/2016	$1,100,000	9.1

Pending Support

	Agency	Project Title	Role	Project Start Date	Project End Date	Proposed Budget	Person Months
	NASA	Observance of Upper-Level Typhoon Flow Lifecycle Over the West Pacific aka OUTFLOW Pacific	PI	1/1/2015	12/31/2019	$781,078	11.6

All projects are located at UW Madison unless otherwise noted

Proposal Budget Summary: NOAA/JHT Grant

Summary
1 Sept 2015 - 31 Aug 2017

		Hours	Salary	Fringe %	Fringe	Cost	Totals
I.	Labor and Fringe Benefits						
	a) PI - Chris Rozoff	1,400	61,643	33.7%	20,773	82,416	
	b) CoPI - Chris Velden	300	24,050	33.7%	8,104	32,154	
	Subtotal		85,693		28,877		$114,570
II.	Travel (see accompanying workshee						
	Year 1 travel					1,800	
	Year 2 travel					1,800	
	Travel Total						3,600
III.	Materials & Supplies						0
IV.	University Indirect Cost at 53%						62,630
	Proposal Total						**$180,800**

Proposal Budget Summary: NOAA/JHT Grant

Year 1
1 Sept 2015 - 31 Aug 2016

		Hours	Rate	Salary	Fringe %	Fringe	Cost	Totals
I.	Labor and Fringe Benefits							
	a) PI - Chris Rozoff	700	43.38	30,366	33.7%	10,233	40,599	
	b) CoPI - Chris Velden	150	78.98	11,847	33.7%	3,992	15,839	
	Subtotal			42,213		14,225		$56,438
II.	Travel							
	a) 1 Trip / 1 person / 4 days / IHC Conference						1,800	
								1,800
III.	Materials & Supplies							0
IV.	University Indirect Cost at 53%							30,866
	Year 1 Total							**$89,104**

Proposal Budget Summary: NOAA/JHT Grant

Year 2
1 Sept 2016 - 31 Aug 2017

		Hours	Rate	Salary	Fringe %	Fringe	Cost	Totals
I.	Labor and Fringe Benefits							
	a) PI - Chris Rozoff	700	44.68	31,277	33.7%	10,540	41,817	
	b) CoPI - Chris Velden	150	81.35	12,203	33.7%	4,112	16,315	
	Subtotal			43,480		14,652		$58,132
II.	Travel							
	a) 1 Trip / 1 person / 4 days / IHC Conference						1,800	
								1,800
III.	Materials & Supplies							0
IV.	University Indirect Cost at 53%							31,764
	Year 2 Total							**$91,696**

Proposal Budget Summary: NOAA/JHT Grant

Travel Detail

1 Sept 2015 - 31 Aug 2017

a) 1 Trip / 1 person / 4 days / IHC Conference

	fares		subtotal	
Airfare	1	500	$500	
	# nights	cost / day		
Hotel	4	250	$1,000	
	# days			
Meals	4	50	$200	
Local Transportation-Madison	2	25	$50	
Local Transportation-IHC	2	25	$50	
				$1,800

COLLEGES AND UNIVERSITIES RATE AGREEMENT

EIN: 1396006492A1

ORGANIZATION:

University of Wisconsin - Madison and Extension

21 North Park Street
Suite 6401
Madison, WI 53715

DATE: 06/18/2014

FILING REF.: The preceding agreement was dated 03/28/2014

The rates approved in this agreement are for use on grants, contracts and other agreements with the Federal Government, subject to the conditions in Section III.

SECTION I: INDIRECT COST RATES

RATE TYPES: FIXED FINAL PROV. (PROVISIONAL) PRED. (PREDETERMINED)

EFFECTIVE PERIOD

TYPE	FROM	TO	RATE(%)	LOCATION	APPLICABLE TO
PRED.	07/01/2013	06/30/2017	53.00	On Campus	Organized Research
PRED.	07/01/2013	06/30/2017	50.00	On Campus	Instruction
PRED.	07/01/2013	06/30/2017	36.00	On Campus	Public Service
PRED.	07/01/2013	06/30/2017	29.50	On Campus	Ext. Public Service
PRED.	07/01/2013	06/30/2017	37.00	On Campus	Primate Ctr Rate (A)
PRED.	07/01/2013	06/30/2017	16.00	On Campus	Primate Ctr Rate (B)
PRED.	07/01/2013	06/30/2017	26.00	Off Campus	All Programs
PROV.	07/01/2017	06/30/2019			Use same rates and conditions as those cited for fiscal year ending June 30, 2017.

*BASE

Modified total direct costs, consissting of all salaries and wages, fringe benefits, materials, supplies, services, travel and subgrants and subcontracts up to the first $25,000 or each subgrant or subcontract(regardless of the period covered by the subgrant or subcontract). Modified total direct costs shall exclude equipment, capital expenditures, charges for patient care, tuition remission, rental costs of off-site facilites, scholarships, and fellowships as well as the portion of each subgrant and subcontract in excess of $25,000.

(A) All Primate Center.

(B) Non P.51 Core grants only.

ORGANIZATION: University of Wisconsin - Madison and Extension
AGREEMENT DATE: 6/18/2014

SECTION I: FRINGE BENEFIT RATES**

TYPE	FROM	TO	RATE(%)	LOCATION	APPLICABLE TO
FIXED	7/1/2013	6/30/2014	34.50	All	(1)
FIXED	7/1/2013	6/30/2014	47.40	All	(2)
FIXED	7/1/2013	6/30/2014	24.20	All	(3)
FIXED	7/1/2013	6/30/2014	23.80	All	(4)
FIXED	7/1/2013	6/30/2014	14.50	All	(5)
FIXED	7/1/2013	6/30/2014	14.20	All	(6)
FIXED	7/1/2013	6/30/2014	6.00	All	(7)
FIXED	7/1/2013	6/30/2014	4.10	All	(8)
FIXED	7/1/2014	6/30/2015	33.70	All	(1)
FIXED	7/1/2014	6/30/2015	46.50	All	(2)
FIXED	7/1/2014	6/30/2015	24.50	All	(3)
FIXED	7/1/2014	6/30/2015	23.30	All	(4)
FIXED	7/1/2014	6/30/2015	15.20	All	(5)
FIXED	7/1/2014	6/30/2015	15.90	All	(6)
FIXED	7/1/2014	6/30/2015	7.80	All	(7)
FIXED	7/1/2014	6/30/2015	4.00	All	(8)

PROV.	7/1/2015	Until amended	Use same rates and conditions as those cited for fiscal year ending June 30, 2015.

** DESCRIPTION OF FRINGE BENEFITS RATE BASE:

Salaries and wages of faculty and staff including vacation, hoiday abd sick leave pay and other paid absences of only the faculty and staff. Rate does not apply to student employees, research or teaching assistants.

(1) Regular Faculty and Academic Staff
(2) Classified and UWEXT Permanent Staff
(3) Research Assistants, Project Assistants, Teaching Assistants, Pre-Doc Fellows and/or Trainees
(4) Research Associates and Grad Interns
(5) Post-Doc Fellows and/or Trainees
(6) Limited Term Employees (LTE's)
(7) Ad Hoc Program Specialists, Undergraduate Assistants and Undergraduate Interns
(8) Student Hourly Employees

Fringe Benefit rates are combined rates for Madison and Milwaukee Campuses and are applied to both the campuses. These Fringe Benefit rates are also included on the University of Wisconsin, Milwaukee rate agreement.

SECTION II: SPECIAL REMARKS

TREATMENT OF FRINGE BENEFITS:

The fringe benefits are charged using the rate(s) listed in the Fringe Benefits Section of this Agreement. The fringe benefits included in the rate(s) are listed below.

TREATMENT OF PAID ABSENCES

Vacation, holiday, sick leave pay and other paid absences are included in salaries and wages and are claimed on grants, contracts and other agreements as part of the normal cost for salaries and wages. Separate claims are not made for the cost of these paid absences.

OFF-CAMPUS DEFINITION: For all activities performed in facilities not owned by the institution and to which rent is directly allocated to the project(s) the off-campus rate will apply. Grants or contracts will not be subject to more than one F&A cost rate. If more than 50% of a project is performed off-campus, the off-campus rate will apply to the entire project.

Equipment Definition -
Equipment means an article of nonexpendable, tangible personal property having a useful life of more than one year and an acquisition cost of $5,000 or more per unit.

FRINGE BENEFITS:

FICA
Retirement
Disability Insurance
Worker's Compensation
Life Insurance
Unemployment Insurance
Health Insurance
Severance Allowance
ERA Administration
Income Continuation Insurance

Your next fringe benefit proposal based on actual costs for the fiscal year ending 06/30/14 is due in our office by 12/31/14. Your next F&A proposal based on actual costs for the fiscal year ending 06/30/16 is due in our office by 12/31/16.

SECTION III: GENERAL

A. LIMITATIONS:

The rates in this Agreement are subject to any statutory or administrative limitations and apply to a given grant, contract or other agreement only to the extent that funds are available. Acceptance of the rates is subject to the following conditions: (1) Only costs incurred by the organization were included in its facilities and administrative cost pools as finally accepted: such costs are legal obligations of the organization and are allowable under the governing cost principles; (2) The same costs that have been treated as facilities and administrative costs are not claimed as direct costs; (3) Similar types of costs have been accorded consistent accounting treatment; and (4) The information provided by the organization which was used to establish the rates is not later found to be materially incomplete or inaccurate by the Federal Government. In such situations the rate(s) would be subject to renegotiation at the discretion of the Federal Government.

B. ACCOUNTING CHANGES:

This Agreement is based on the accounting system purported by the organization to be in effect during the Agreement period. Changes to the method of accounting for costs which affect the amount of reimbursement resulting from the use of this Agreement require prior approval of the authorized representative of the cognizant agency. Such changes include, but are not limited to, changes in the charging of a particular type of cost from facilities and administrative to direct. Failure to obtain approval may result in cost disallowances.

C. FIXED RATES:

If a fixed rate is in this Agreement, it is based on an estimate of the costs for the period covered by the rate. When the actual costs for this period are determined, an adjustment will be made to a rate of a future year(s) to compensate for the difference between the costs used to establish the fixed rate and actual costs.

D. USE BY OTHER FEDERAL AGENCIES:

The rates in this Agreement were approved in accordance with the authority in Office of Management and Budget Circular A-21, and should be applied to grants, contracts and other agreements covered by this Circular, subject to any limitations in A above. The organization may provide copies of the Agreement to other Federal Agencies to give them early notification of the Agreement.

E. OTHER:

If any Federal contract, grant or other agreement is reimbursing facilities and administrative costs by a means other than the approved rate(s) in this Agreement, the organization should (1) credit such costs to the affected programs, and (2) apply the approved rate(s) to the appropriate base to identify the proper amount of facilities and administrative costs allocable to these programs.

BY THE INSTITUTION:

University of Wisconsin - Madison and Extension

(INSTITUTION)

Kim Moreland

(SIGNATURE)

KIM MORELAND

(NAME)

ASSOC. VICE CHANCELLOR

(TITLE)

6-30-14

(DATE)

ON BEHALF OF THE FEDERAL GOVERNMENT:

DEPARTMENT OF HEALTH AND HUMAN SERVICES

(AGENCY)

(SIGNATURE)

Arif Karim

(NAME)

Director, Cost Allocation Services

(TITLE)

6/18/2014

(DATE) 5121

HHS REPRESENTATIVE: Shon Turner

Telephone: (214) 767-3261

Application for Federal Assistance SF-424

* 1. Type of Submission:	* 2. Type of Application:	* If Revision, select appropriate letter(s):
☐ Preapplication	☒ New	
☒ Application	☐ Continuation	* Other (Specify):
☐ Changed/Corrected Application	☐ Revision	

* 3. Date Received:	4. Applicant Identifier:
12/03/2014	

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: The Board of Regents of the University of Wisconsin System

* b. Employer/Taxpayer Identification Number (EIN/TIN):	* c. Organizational DUNS:
396006492	1612021220000

d. Address:

* Street1:	21 N Park St Ste 6401
Street2:	
* City:	Madison
County/Parish:	
* State:	WI: Wisconsin
Province:	
* Country:	USA: UNITED STATES
* Zip / Postal Code:	53715-1218

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:	Christopher
Middle Name:			
* Last Name:	Rozoff		
Suffix:			

Title:

Organizational Affiliation:

* Telephone Number:	608-263-6733	Fax Number:	

* Email: chrisr@ssec.wisc.edu

Application for Federal Assistance SF-424

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

H: Public/State Controlled 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-2015-2004200

* Title:

FY 2015 Joint Hurricane Testbed

13. Competition Identification Number:

2498035

Title:

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

Add Attachment | Delete Attachment | View Attachment

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

Probabilistic prediction of tropical cyclone rapid intensification using satellite passive microwave imagery

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: WI-002

* b. Program/Project: WI-002

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

[ ] Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 09/01/2015

* b. End Date: 08/31/2017

18. Estimated Funding ($):

* a. Federal	180,800.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	180,800.00

*** 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: Brenda

Middle Name: [ ]

* Last Name: Egan

Suffix: [ ]

* Title: Managing Officer

* Telephone Number: 608-262-3822

Fax Number: 608-262-5111

* Email: preaward@rsp.wisc.edu

* Signature of Authorized Representative: Allison Lynch

* Date Signed: 12/03/2014

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. DOC/NOAA/OAR	11.459	$	$	$ 89,014.00	$	$ 89,014.00
2. DOC/NOAA/OAR	11.459			91,696.00		91,696.00
3.						
4.						
5. Totals		$	$	$ 180,710.00	$	$ 180,710.00

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SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total
	(1) DOC/NOAA/OAR	(2) DOC/NOAA/OAR	(3)	(4)	(5)
a. Personnel	$ 42,213.00	$ 43,480.00	$	$	$ 85,693.00
b. Fringe Benefits	14,225.00	14,652.00			28,877.00
c. Travel	1,800.00	1,800.00			3,600.00
d. Equipment	0.00	0.00			
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)	58,238.00	59,932.00			$ 118,170.00
j. Indirect Charges	30,866.00	31,764.00			$ 62,630.00
k. TOTALS (sum of 6i and 6j)	$ 89,104.00	$ 91,696.00	$	$	$ 180,800.00
7. Program Income	$	$	$	$	$

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SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8. DOC/NOAA/OAR	$	$	$	$
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	$ 180,800.00	$ 45,200.00	$ 45,200.00	$ 45,200.00	$ 45,200.00
14. Non-Federal	$				
15. TOTAL (sum of lines 13 and 14)	$ 180,800.00	$ 45,200.00	$ 45,200.00	$ 45,200.00	$ 45,200.00

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. DOC/NOAA/OAR	$	$	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$	$	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges: 118,170.00

22. Indirect Charges: 62,630

23. Remarks:

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OMB Number: 4040-0007
Expiration Date: 06/30/2014

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.

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
Allison Lynch	Managing Officer
APPLICANT ORGANIZATION	DATE SUBMITTED
The Board of Regents of the University of Wisconsin System	12/03/2014

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