A Probabilistic TC Genesis Forecast Tool Utilizing an Ensemble of Global Models

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A Probabilistic TC Genesis Forecast Tool Utilizing an Ensemble of Global Models

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Abstract

Over the past decade numerical models have improved dramatically in their ability to initialize and forecast tropical cyclone (TC) genesis. This has followed an era in the 1980s to mid-1990s when global models were too coarse to address the complex physics involved. Subsequently, the mid 1990s to early 2000s global models had severe biases that either produced excessive genesis and intensification, or year-to-year changes in model configurations that rendered models unreliable. Since the early 2000s, models had stabilized, yet each model had unique biases that needed to be accounted for. Only recently has the historical record of model guidance become long enough to produce reliable statistics. Accordingly, the work proposed here builds on an established foundation to address these genesis forecast issues. Specifically, we propose to enhance, further test through validation and with success implement a previously developed and experimentally tested forecast tool that provides the probability of TC genesis based on forecasts from five global numerical models (CMC, ECMWF, GFS, NOGAPS, and UKMET). The tool will run in real-time as each model cycle arrives at NHC. It will objectively identify and give the normalized probabilities of genesis for all TCs that develop in the models out to 120 h and record values of relevant variables as defined by Halperin et al. (2012; hereafter H12) and Halperin et al. (2013; hereafter H13). Timely output will be available in both graphical and bulletin format so it can be used by forecasters to prepare products such as the GTWO.

The specific goals of the proposed forecast tool are to:

- Better utilize operational models to provide TC genesis forecasts.
- Give explicit probabilistic forecasts of TC genesis out to 120 h to serve as guidance for NHC's operational 48 h GTWO and NHC's experimental 120 h TC genesis forecasts, using:
    1) A previously published algorithm to objectively identify TCs in the model fields,
    2) An evaluation of model performance from prior seasons, and
    3) An evaluation of confidence based upon multiple model (dis)agreement of genesis.
- Conduct case studies of several recent TCs to identify any potential model biases.
- Refine the probabilities of genesis by developing multiple logistic regression equations for each model that include physically relevant predictors beyond those used in H13.
- Screen the predictors using forward selection.
- Verify TC genesis forecasts in real-time during the season so forecasters are aware of how the models are performing to date during a given season.
- Show the track and intensity of model TCs to aid pre-TC track and intensity forecasts.

This proposed research and deliverables address the following needs listed in the announcement of opportunity: NHC-3/JTWC-5, NHC-5/JTWC-17, NHC-8/JTWC-3, and EMC-2, and thus represents a broad and significant fraction of the operational needs specified in the JHT announcement. The established record of both PIs of operationally-related science, and its experimental testing, provides a strong foundation on which to ensure the proposed research will succeed in establishing a new frontier in tropical cyclone forecasting that addresses updated forecaster and societal needs.

STATEMENT OF WORK

1. Project Duration

We request two years of funding to enhance, evaluate, and propose implementation of an experimental guidance on guidance product that provide short-range (0-48 h) and medium-range (48-120 h) probabilities of tropical cyclone (TC) genesis based on global model forecast fields.

2. Project Description/Prior Results

a. Introduction to prior work

Forecasting TC genesis is a major challenge facing the operational centers because there is a general lack of calibrated guidance. Model forecast fields often exhibit structures resembling a TC during hurricane season, but determining if and when a TC will develop is difficult as models can often be under- or over-aggressive in development. Nevertheless, if an objective definition of a TC is developed for disturbances in model forecast fields, forecasters can obtain statistical guidance as to when TC genesis will occur. These model-indicated genesis forecasts can be verified against the Best-Track (BT; Jarvinen et al. 1984, McAdie et al. 2009) dataset.

While studies have investigated the skill of model-indicated TC track and intensity forecasts (e.g., Goerss 2000, Sampson et al. 2008), few have focused on model-indicated TC genesis forecasts (e.g., Cheung and Elsberry 2002). In preparation for this proposal, H12 and H13 created a set of calibrated objective criteria to define a TC in each of five global models (CMC, ECMWF, GFS, NOGAPS, and UKMET). This automated program identified the TC genesis events and verified them over the North Atlantic (NATL) basin during 2004-2011 (except 2007-2011 for the ECMWF). To our knowledge, H12 is the first to examine the performance of TC genesis forecasts from multiple models over a period of several years.

We designed the objective “TC Genesis Identification and Forecast Tool” (TCGIFT) with the needs of operational forecasters in mind and received feedback from NHC Senior Hurricane Specialist Dr. Richard Pasch during that development. The results yielded insight into how the models rank among each other and how the genesis performance of a given model varies by forecast hour (lead time), time of year, and location in the basin. Based on this information, we provided probabilistic forecasts of TC genesis for specific disturbances based on historical model performance. Although this climatology of TC genesis forecasts is a useful starting point and has been used experimentally by NHC during 2012, the addition of other model-derived predictors, a longer developmental dataset, and improved regression techniques certainly will lead to improved forecasts of genesis probability, as detailed next.

b. Defining a TC in the model forecast fields

Due to the number of physical processes that are parameterized in models as well as the limited number of in-situ observations that are assimilated into the models, it is unreasonable to expect that a model-indicated tropical depression (TD) will exhibit the same characteristics as a TD in reality (Walsh et al. 2007; Schenkel and Hart 2012). Therefore, an important component of H12 was to determine an objective definition of a TC in the model forecast fields. We conducted a series of statistical tests with different sets of criteria and determined their hit, miss, and false alarm (FA) rates during selected hurricane seasons. The criteria and their thresholds for each model (Table 1) that optimized the success rate, FA rate, and number of storms detected was used to define a TC specific to the model climatology. These criteria were:

1. A relative minimum in MSLP with at least one closed isobar at a 2 hPa interval,
2. A relative maximum in 850 hPa relative vorticity that exceeds a threshold value must be located within ± 2° latitude and longitude of the MSLP minimum.
3. A relative maximum in 250-850 hPa thickness that exceeds a threshold value must occur within ± 2° latitude and longitude of the MSLP minimum.
4. The wind speed at 925 hPa must exceed a threshold value.
5. Criteria 1-4 must be met for at least 24 h.

Model	**850 hPa relative vorticity (10^{-5} s^{-1})**	**250-850 hPa thickness (m)**	**925 hPa maximum wind speed (m s^{-1})**
CMC	15.3	9478.5	17.0
ECMWF	20.3	9473.0	15.4
GFS	13.9	9471.1	16.1
NOGAPS	7.9	9466.8	16.0
UKMET	14.4	9469.3	15.5

Table 1. Thresholds of parameters for each model based on historical TDs in model analysis fields. The thresholds are the 33rd percentile values. (Adapted from H13)

c. Classification of model-indicated TC genesis forecasts

Once TCGIFT identifies all model TCs based on the above criteria, it classifies each forecast according to the following definitions (note that early genesis and late genesis cases are collectively denoted as incorrect timing (IT) events):

<u>Hit</u>: A model-indicated TC exhibits genesis ± 24 h of the BT genesis time and is located ± 5° latitude and longitude of the BT genesis location.

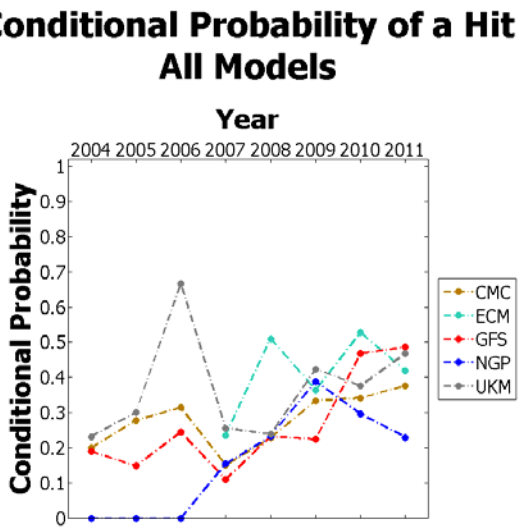
<u>Early Genesis (EG)</u>: TC genesis is forecast in the model, occurs at the same time as an existing NHC fix in the ATCF dataset (Sampson and Schrader 2000), and is ± 5° latitude/longitude of the fix. However, it is not the genesis position of a TC. These are cases when the model predicts genesis for a disturbance that ultimately becomes a BT TC, but the model predicts it too early.

<u>Late Genesis (LG)</u>: TC genesis is forecast in the model, it occurs at the same time as an existing BT position, and is ± 5° latitude and longitude of the BT location. However, it is not the genesis position of a TC. Instead, it is a BT position of a TC that already has formed. These are cases when the model predicts TC genesis too late.

<u>False Alarm (FA)</u>: TC genesis is forecast in the model, but does not occur ± 24 h of a BT time and is not located ± 5° latitude/longitude of any BT location. These are cases that cannot be classified as a hit, EG, or LG.

d. Results from the published analysis

The previously described and published analysis yielded results that provide guidance for operational forecasters. The models do have a capability to predict disturbance specific TC genesis events. Fig. 1 shows the probability of a hit (success) given model-indicated genesis for each model. For example, during 2011, there was a 49% chance that when the GFS predicted TC genesis using the above diagnosis, that forecast would verify as a hit. This is significant because it provides probabilistic guidance for a disturbance that may not yet exist in reality at initialization time. For example, forecasters would not have to wait until an African Easterly Wave (AEW) emerges from the coast to initiate a genesis forecast on it. Fig. 1 also reveals how the models rank among each other. The ECMWF and UKMET historically are top-performers, and the GFS has notably improved since 2010 thus rivaling the ECMWF and UKMET.



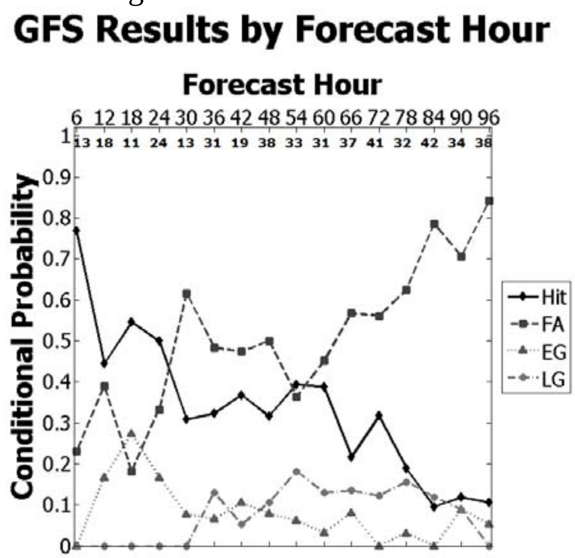


Figure 1 (left): The conditional probability of a hit for each model by season.
Figure 2 (right): Conditional probability of a hit (solid line), FA (dashed line), EG (dotted line), and LG (dot-dashed line) by forecast hour. Numbers below the forecast hours indicate total number of genesis events. Both adapted from H13.

These results can be interpreted in other ways for forecasting purposes. For example, looking at model performance by forecast hour (lead time) confirms that the models' capability to predict TC genesis expectedly decreases with increasing forecast hour. Fig. 2 illustrates this point with the GFS. Similar figures for the other models are available in H13.

One also can consider performance by geographic region. Fig. 3 shows locations of individual hit, FA, and IT events for the GFS. Splitting the NATL basin into six regions clearly indicates that the GFS performs better in some regions (e.g., main development region and Caribbean Sea) than others. The location of genesis may provide insight into the models' ability to forecast certain modes of TC genesis. For example, the GFS may better predict TC genesis from an AEW, but struggle with genesis from a disturbance having baroclinic origins (e.g., poleward of 20°N). Again, similar figures for the other models are available in H13. Prior studies have documented the diversity of NATL TC genesis (McTaggart-Cowan et al. 2008), and the geographic and temporal specificity of the genesis predictors in the proposed research (Section 3) will attempt to exploit that diversity.

We also examined the probability of genesis when more than one model predicted the same genesis event. While the probability of a hit did not necessarily increase substantially, the false alarm rate did decrease notably. This means that if multiple models predict the same genesis event, it is less likely to be a false alarm, but models may incorrectly predict the time of genesis. Table 2 provides statistics for selected model combinations.

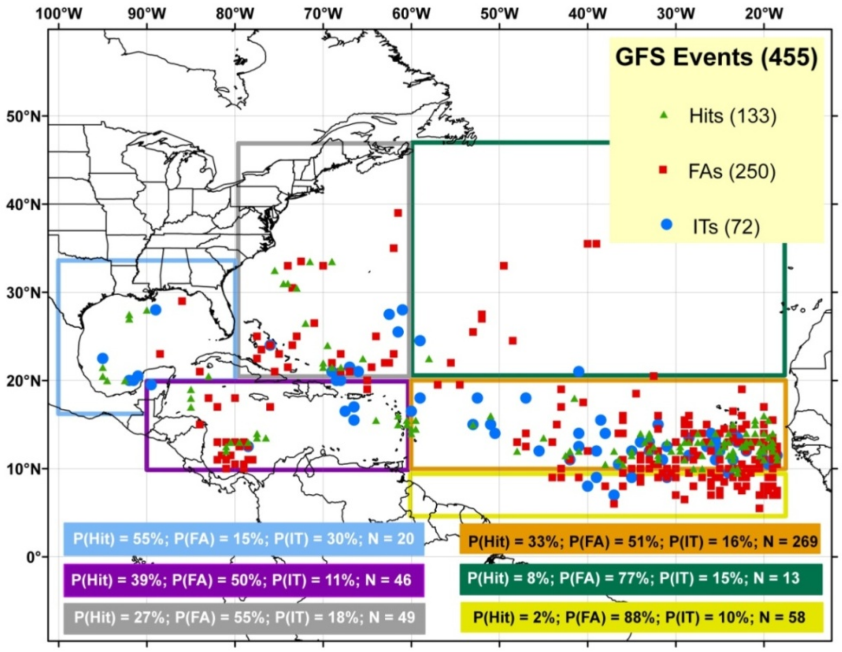


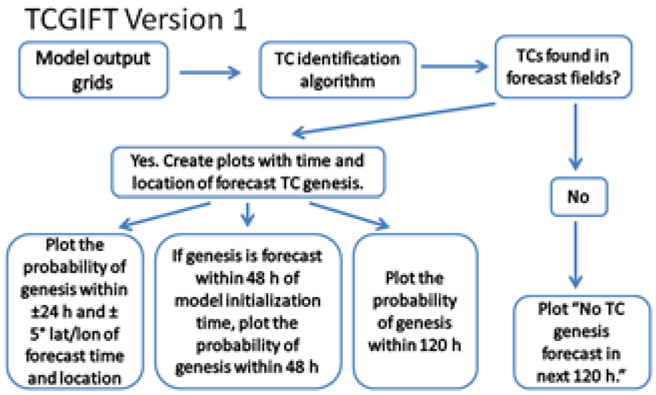
Figure 3. Event locations of GFS hit (green triangle), FA (red square), and IT (blue circle) during 2004-2011. Numbers in parentheses are the number of model-indicated events. Outlined polygons represent sub-regions where conditional probabilities were calculated. These conditional probabilities are given in the lower portion of the figure. (Adapted from H13)

Model Combination	**P(Hit)**	**P(FA)**	**Sample size**
2-model combinations			
ECM-NGP	0.22	0.06	36
ECM-CMC	0.35	0.07	112
GFS-UKM	0.47	0.13	103
ECM-GFS	0.34	0.14	90
CMC-GFS	0.39	0.15	117
3-model combinations			
GFS-NGP-UKM	0.48	0	23
CMC-GFS-UKM	0.37	0.04	54
ECM-GFS-UKM	0.32	0.07	44
ECM-GFS-NGP	0.25	0	20
4-model combinations			
CMC-ECM-GFS-UKM	0.26	0	27
CMC-GFS-NGP-UKM	0.33	0	18
All 5 models	0.20	0	10

Table 2. Multi-model consensus forecasts showing the probability of a hit for all models included (i.e., all models verify as a hit), and the probability of a FA for all models included (i.e., genesis does not occur). Probabilities are colorized from low success (orange) to moderate success (blue) to high success (green). (Adapted from H13)

e. Real-time TC genesis forecasts

Once the verification described above was completed, TCGIFT was converted to run in real-time during the 2012 season. Fig. 4 shows a conceptual flow chart detailing that version (denoted V1). Results were given in real-time at http://moe.met.fsu.edu/modelgen. For each model initialization cycle, the program checked for TC genesis events in the forecast fields. If an event was found, two different disturbance specific probabilities were displayed on the website, both based on the models' historical performance: (1) the probability of a hit, and (2) the probability of genesis at any time within 48 h. This product was meant to mirror NHC's operational GTWO in terms of layout although obviously the actual values arrived at were from



a different approach. We recently developed disturbance specific probabilities of genesis at any time within 120 h, similar to NHC's experimental 120 h TC genesis probabilities. However, this probability was not available during the 2012 hurricane season.

Figure 4 (left): Flowchart of V1 genesis probability calculation process, run experimentally but in real-time for 2012.

f. Learning from past and recent research in this area

Although we are not the only group seeking to improve TC genesis forecasts, we believe that our methodology is unique. Tim Marchok at NOAA/GFDL also has created real-time TC genesis probabilities from model output as part of NOAA's HFIP. But, there are significant and distinct differences between the products that lead to a useful diversity of genesis approaches:

- The Marchok group determines the probability of genesis based on the number of ensemble members, out of the total number, that predict genesis. For example, if 15 out of 20 ensemble members indicate genesis, their product issues a 75% probability of genesis. The probabilities for our product are based on models' recent performance verified against BT.
- Marchok's group's method uses absolute thresholds of detection rather than model-calibrated thresholds as done here.
- The approach here will calibrate for model spatial (basin geography) and temporal (time of year) biases for TC genesis.

In light of the significant differences noted above, it would considerably benefit forecasters to have an ensemble of genesis guidance as provided by the two approaches contrasted above. Using the previously described work as a foundation, we next describe the proposed work.

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3. Proposed Work Plan

a. Extension of TCGIFT to the eastern Pacific

We immediately will begin verifying TC genesis forecasts for the Eastern North Pacific (EPAC) basin, thereby covering NHC's entire area of responsibility. The thresholds noted for V1 in determining genesis for the NATL will not necessarily be the same for the EPAC, in particular given the sensitivity to disturbance type noted, and the fact that EPAC TCs are often smaller than their NATL counterparts. This basin-specific response was also noted well in genesis probabilities based on Dvorak estimates (Cossuth et al. 2012). We also will recalculate the genesis probabilities to include 2012's data. We expect to test and evaluate V1 locally in a quasi-operational environment during the 2013 hurricane season (with updated probabilities that include 2012's data). Code and technical documentation for V1 will be available to JHT staff.

b. Diagnosis of spatiotemporal model genesis biases

During year 1, we also plan to analyze several case studies to uncover any possible model biases. For example, the models may be more aggressive in developing TCs from AEWs compared to TCs from subtropical origins. Also, given the horizontal resolution of the models, it is likely that they are better able to predict TCs that develop from relatively large incipient disturbances; however, this has yet to be quantified. At IHC during Spring 2014, we will present results on the testing and evaluation of V1, show the updated probabilities that include the 2013's data, and report on the progress made in determining model biases.

c. Implementation of TCGIFT version 2 in real-time locally, including bulletins

During the 2014 hurricane season, we will locally test and evaluate TCGIFT version 2 (V2) in a quasi-operational environment. This will require a slight modification to the TC identification component. V1 only records information for forecast TCs. However, V2 will collect information for all disturbances (i.e., areas of low pressure) in the basin and output a text file with a table of relevant variables for each disturbance. From the list of disturbances, it will then identify the TCs (the definition of which remains unchanged), and a separate table will provide values of relevant variables for each TC (Fig. 5). This easy-to-use output file has been designed to emulate the clarity and organization of SHIPS-type output (DeMaria and Kaplan 1999), and allows the forecaster to quickly determine why a given disturbance did (blue values) or did not (red values) meet the criteria to be classified as a TC.

TC Genesis Identification and Forecast Tool
GFS model initialized at 20120821 00 UTC

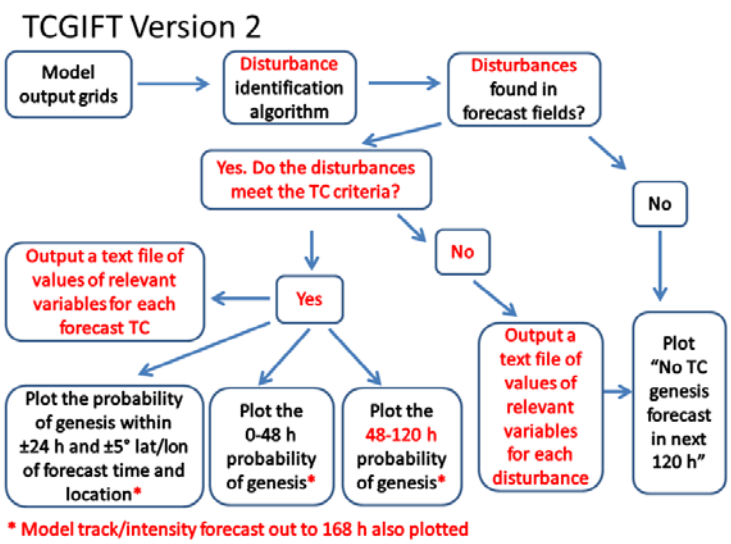
FORECAST TROPICAL DISTURBANCES:

				TC CRITERIA				**OTHER PREDICTORS**		
ID NUM	FCST HR	LAT (deg)	LON (deg)	MSLP (hPa)	850 VORT ($*10^{-5}$ s^{-1})	250-850 THICKNESS (m)	925 WIND (ms^{-1})	VORT ALIGN (deg)	RH ALIGN (deg)	VERT WIND SHEAR (ms^{-1})
1	12	18.5	-34.0	1008.7	12.4	9480.2	16.8	0.5	1.0	9.7
2	30	16.0	-57.5	1008.0	15.0	9485.6	19.9	0.0	0.5	6.2
3	54	11.5	-28.0	1009.6	11.3	9468.5	14.6	1.0	1.5	8.4
4	84	31.0	-60.0	1005.4	16.3	9421.7	17.5	1.0	1.0	11.6

FORECAST TROPICAL CYCLONES:

				TC CRITERIA				**OTHER PREDICTORS**			**PROBABILITIES**		
ID NUM	FCST HR	LAT (deg)	LON (deg)	MSLP (hPa)	850 VORT ($*10^{-5}$ s^{-1})	250-850 THICKNESS (m)	925 WIND (ms^{-1})	VORT ALIGN (deg)	RH ALIGN (deg)	VERT WIND SHEAR (ms^{-1})	PROB HIT	PROB GEN 0-48H	PROB GEN 48-120H
2	30	16.0	-57.5	1008.0	15.0	9485.6	19.9	0.0	0.5	6.2	33	43	51

Figure 5 (above): Hypothetical example of a text-based forecast output bulletin reporting the identification of genesis candidates from a GFS run from 2012.



The TC genesis probability plots in V2 will be the same as in V1, except they also will show the model-indicated track and intensity of the forecast TC out to forecast hour 168, thereby providing track and intensity guidance for TCs that have yet to develop, as shown in Fig. 6.

Figure 6 (left): Flowchart of genesis probability calculation process for proposed V2. Method enhancements and additions (compared to V1) are in red font.

d. Season-to-date updated performance statistics

During the 2014 hurricane season we also will test and evaluate a season-to-date verification that will provide the Hurricane Specialists Unit (HSU) with guidance on the performance of each model to date in that season. Since BT data will not be available, the season-to-date TC genesis forecasts will be verified against the time and location of the first NHC advisory of TC status declaration. The output from V2 and the results from the season-to-date verification will be made available to the HSU in real-time via ftp or a website. Code and technical documentation for V2 and the season-to-date verification will be available to JHT staff.

e. Extension and testing of new predictor pool

The current genesis probabilities based on forecast hour, time of year, and location in the basin will be useful to forecasters and serve as a good baseline. However, including additional predictors likely will provide more robust genesis probabilities. TCGIFT provides three probabilities of genesis for each TC identified in the model forecast fields (the probability of a "hit", the probability of genesis within 48 h, and the probability of genesis in 48 to 120 h). During year 2, we will refine each of these probabilities by calculating them using multiple logistic regression. We will calculate different regression equations for each model. The regression equations will be developed using 2004-2011 TC genesis forecasts as the "training set," and the equations will be tested using 2012-2013 TC genesis forecasts as the independent verification set. We will use the likelihood ratio test to determine the statistical significance of the regression equations. We will examine predictors that have been shown to have thermodynamic and/or dynamic relevance to TC genesis in the literature. Potential predictors that will be considered include but are not limited to the horizontal displacement distance between the relative vorticity maxima at 850 and 700 hPa (i.e., the vertical alignment of vorticity maxima), the vertical alignment of the relative humidity maxima, the magnitude of 200-850 hPa vertical wind shear, MJO phase, ENSO phase, and whether or not each of the other models also forecasts TC genesis within ± 5° latitude/longitude of the model for which the regression is being calculated. We will screen the predictors using the forward selection method. The problem of overspecification will be avoided during predictor selection by testing predictor covariance and requiring a threshold level of additional explained variance before inclusion.

Once the new regression equations have been developed, we will retroactively compare the calculated 0-48 h probability of genesis to NHC's GTWO 0-48 h probability of genesis during the 2012-2013 seasons. We will round the regression-based probabilities to the nearest 10% to allow a direct comparison to the GTWO probabilities. If the regression-based probabilities are comparable to, or outperform those generated on the GTWO, we will consider the new technique successful. At the conclusion of the 2014 season, we will recalculate the regression equations with the 2014 TC genesis forecasts included. We will present our results at IHC in Spring 2015. By June 2015, V2 will be locally tested and evaluated in real-time with the regression-based probabilities. Again, the results will be made available to NHC in real-time.

f. Summary

The *promising and relevant research* that led to the development of TCGIFT will help NHC realize its announced goal of improving 120 h TC genesis forecasts by providing guidance to the HSU for products such as their operational 48 h GTWO and the experimental 120 h TC genesis probabilities. Using data from a given model cycle (e.g., 12 UTC), TCGIFT will provide guidance in time for the forecaster to use it for the next GTWO (e.g., 18 UTC). The output will be structured in a *forecaster-friendly* format so that guidance may be interpreted efficiently.

All of the software needed to run TCGIFT are freely available and can be run on a Linux platform. We will provide documentation and assistance so that JHT/NHC can run and test the software. All products that are tested in the JHT IT environment also will be run at FSU for redundancy/back-up purposes (excluding proprietary ECMWF products), with the output figures and statistics sent to NHC via ftp or made available via a website. FSU has a long history of providing reliable research-based guidance (e.g., http://moe.met.fsu.edu/cyclonephase, http://moe.met.fsu.edu/genesis, http://moe.met.fsu.edu/tcprob and http://fuelberg.met.fsu.edu), and this infrastructure will be exploited to ensure reliability.

Since the models are frequently upgraded, it is possible that the threshold values used to define a TC and the regression equations used to calculate the genesis probabilities will need to be reexamined in the future. If the proposed work is selected for implementation following the two-year award period, the PIs will, as time permits, revisit the definition criteria for model-indicated TCs and recalculate the regression equations as additional years of data become available. Also, if there are hardware or software conflicts between the local IT infrastructure at FSU and that at the JHT, the PIs will work with the JHT staff to achieve alternative solutions to ensure that TCGIFT is fully operational in the JHT/NHC IT infrastructure. Once established at NHC, we can develop regression equations for other basins and TCGIFT can be easily modified to run at other operational centers (CPHC, JTWC, etc.).

In conclusion, this proposed research and deliverables address the following needs listed in the announcement: NHC-3/JTWC-5, NHC-5/JTWC-17, NHC-8/JTWC-3, and EMC-2, and thus represents a broad and significant fraction of the JHT operational needs specified. The established record of both PIs of operationally-related science and its online dissemination provides a strong foundation on which to ensure the proposed research will address updated forecaster and societal needs.

4. Timeline

2013	
Aug	Determine EPAC-specific criteria thresholds for genesis and verify those forecasts.
Sep	Locally test and evaluate V1 during the remainder of the 2013 season. Provide code and technical documentation for V1 to JHT staff.
Nov	Begin conducting case studies of recent TCs to determine model biases.
2014	
Feb	Recalculate historical probabilities to include results from 2013.
Mar	Present mid-year 1 results at IHC.
Apr	Present mid-year 1 results at AMS Conf. on Hurricanes and Trop. Met.
Jun	Locally test and evaluate the season-to-date verification program.
Sep	Locally test and evaluate V2 for the remainder of the 2014 season. Provide code and documentation for V2 to JHT staff.
Jun-Nov	Develop multiple logistic regression equations to calculate probabilities of genesis using new predictors. Screen predictors using forward selection.
2015	
Jan	Test if probabilities based on regression perform better than those issued in GTWO.
Feb	Recalculate regression equations to include 2014 TC genesis forecasts.
Mar	Present mid-year 2 results at IHC.
Jun	Evaluate V2 with probabilities based on multiple logistic regression.
Jul	Complete final report.

5. Schedule and Needs for Expected Travel

September 2013: Halperin travels to NHC to demonstrate V1
Spring 2014: PIs travel to the Interdepartmental Hurricane Conference
Spring 2014: PIs travel to the AMS Conf. on Hurricanes and Tropical Meteorology
September 2014: Halperin travels to NHC to demonstrate V2
Spring 2015: PIs travel to the Interdepartmental Hurricane Conference

6. Estimates of JHT Staff Requirements

We expect that JHT staff will assist the PIs in implementing TCGIFT into NHC's IT environment. JHT staff also would be responsible for maintaining TCGIFT when the proposed project is complete, although the PIs would welcome continuing interaction.

Project Budget

	2013-2014	2014-2015	Total
DIRECT COSTS			
Salaries			
PI: R. Hart – 1 month (summer)	9,957	10,305	20,262
Co-PI: H. Fuelberg – 1 month (summer)	11,737	12,148	23,885
Co-I: Grad Asst. D. Halperin – 12 months	27,000	27,945	54,945
Total Salaries & Wages	**48,694**	**50,398**	**99,092**
Fringe benefits	3,506	3,629	7,135
Travel to IHC + NHC + AMS Tropical 2014	6,346	3,654	10,000
Graduate Student Tuition – 27 credits	12,529	14,409	26,938
JHT facility requirements, computing and communications funding, equipment funding	0	0	0
Total Direct Costs	**71,075**	**72,090**	**143,165**
INDIRECT COSTS (47% everything minus tuition)	**27,517**	**27,110**	**54,627**
TOTAL PROJECT COSTS	**98,592**	**99,200**	**197,792**

Budget Justification

Profs. Hart and Fuelberg each request 1 month of summer salary during year 1 and year 2.

The fringe rate for faculty is 15.29%. The fringe rate for the graduate student is 0.7%.

$700 per year has been added to the graduate student’s salary to support a health insurance subsidy as required by Florida State University.

We anticipate a 3.5% increase in salary for all associated personnel in year 2.

Tuition is assumed to increase 15% per year for each of the next two years. FSU policy requires that this increase be included in all proposals.

The indirect cost rate of 47% applies to all items except tuition.

Travel Detail

We expect to attend and present results each year at the Interdepartmental Hurricane Conference. Although the locations are not currently known, they typically occur on the East Coast, such as Charleston, SC.

We also expect to travel to the National Hurricane Center in Miami, FL to collaborate with the NHC specialists and JHT staff.

During year 1, we plan to attend the AMS Conference on Hurricanes and Tropical Meteorology. This conference will likely be in the western U.S. We will assume San Diego, CA.

Costs per trip are estimated below. To save costs, rooms will be shared (two persons per room).

Year 1

Collaboration at NHC in Miami, FL

Meals: $36.00/day * 4 days * 1 person = $144
Lodging: $100/night * 4 nights * 1 room = $400
Airfare: $400/person * 1 person = $400
Ground transportation: $100
Total: $1044

Interdepartmental Hurricane Conference, Charleston, SC

Meals: $36.00/day * 5 days * 2 people = $360
Lodging: $140.00/night * 5 nights * 1 room = $700
Airfare: $425/person * 2 people = $850
Conference registration: $350 * 1 faculty + $150 * 1 student = $500
Ground transportation: $100
Abstracts: $100
Total: $2610

AMS Conference on Hurricanes and Tropical Meteorology, San Diego, CA

Meals: $36.00/day * 5 days * 2 people = $360
Lodging: $140.00/night * 5 nights * 1 room = $700
Airfare: $491/person * 2 people = $982
Conference registration: $300 * 1 faculty + $150 * 1 student = $450
Ground transportation: $100
Abstracts: $100
Total: $2692

Year 1 Total: $6,346.00

Year 2

Collaboration at NHC in Miami, FL

Meals: $36.00/day * 4 days * 1 person = $144
Lodging: $100/night * 4 nights * 1 room = $400
Airfare: $400/person * 1 person = $400
Ground transportation: $100
Total: $1044

Interdepartmental Hurricane Conference, Charleston, SC

Meals: $36.00/day * 5 days * 2 people = $360
Lodging: $140.00/night * 5 nights * 1 room = $700
Airfare: $425/person * 2 people = $850
Conference registration: $350 * 1 faculty + $150 * 1 student = $500
Ground transportation: $100
Abstracts: $100
Total: $2610

Year 2 Total: $3,654.00

Project Total for Travel: $10,000.00

NOAA Grants and Cooperative Agreement Application Package

To be completed upon submission to grants.gov

Abbreviated Curriculum Vitae

Vita for ROBERT E. HART

Complete Vita available at http://moe.met.fsu.edu/~rhart/vita.pdf

OFFICE ADDRESS

Department of Earth, Ocean, and Atmos. Science	Phone: (850) 645-1552
The Florida State University	E-mail: rhart@fsu.edu
Tallahassee, FL 32306-4520	Web: http://moe.met.fsu.edu

EDUCATION

B.S. (Honors), M.S., Ph.D. in Meteorology	Pennsylvania State University	1995,97,2001

ACADEMIC PROFESSIONAL EXPERIENCE

Florida State University: Associate Professor in Meteorology	2009-
Florida State University: Assistant Professor in Meteorology	2003-
UCAR Visiting Scientist	2002-3

HONORS AND AWARDS:

Transformation through Teaching Award (FSU)		2011
Werner A. and Shirley B. Baum Endowed Professorship (FSU)		2010-2012
BAMS Editor's Paper of Note	American Meteorological Society	2008
Banner I. Miller Award	American Meteorological Society	2006

CHAIRS AND COMMITTEES:

Member, HFIP SRC Committee	2012-
Program Chair, 30th AMS Hurricanes and Tropical Meteorology Conference	2011-
Member, NASA Hurricane Science Team for GRIP Field Project	2010-
Chair, UCAR URC/PACUR NSF Proposal Review Subcommittee	2010-
Member, UCAR URC/PACUR NSF Proposal Review Subcommittee	2009-
Session Chair, AMS Hurricanes and Tropical Meteorology Conference	2008
Member of UCAR URC/PACUR Committee	2007-
Chair, FSU Tropical Meteorology Faculty Search Committee	2007-8
Associate Editor, Monthly Weather Review	2006-9
2007 AMS Hurricanes and Tropical Meteorology Symposium, Chair	2007
AMS Hurricanes and Tropical Meteorology Steering Committee, Member	2006-8
Max Eaton Committee: AMS Hurricanes and Trop. Meteorology Conference, Chair	2006
Undergraduate AMS Travel Committee, Florida State University	2005
Max Eaton Committee: AMS Hurricanes and Trop. Meteorology Conference, Member	2004

JOURNAL AND PROPOSAL REVIEWER:

Journal of Atmospheric Science	Journal of Atmospheric and Oceanic Technology
Nature Geoscience	NOAA Proposals
Quarterly Journal Royal Met. Society	Meteorology and Atmospheric Physics
Journal of Geophysical Research	Geophysical Research Letters
Bull. American Meteor. Society	National Science Foundation

Monthly Weather Review	Journal of Applied Meteorology
Journal of Climate	Weather and Forecasting

PUBLICATIONS WITHIN THE PAST THREE YEARS

In revision, review or preparation:

Hazelton, A. and **R. Hart**, **2013**: The relationship between eyewall tilt and intensity and intensity change as represented by GRIP and PREDICT radar imagery. *Wea. and Forec.*, conditionally accepted.

Helms, C. and **R. Hart, 2013**: Pre-genesis and genesis vorticity and thermodynamic budgets derived from GRIP, PREDICT, and CAMEX irregular spaced dropsondes. *Mon. Wea. Rev.*, conditionally accepted.

Creighton, C. G., **R. Hart**, P. Cunningham, **2013**: A spatial filter approach to evaluating the role of convection on the evolution of a mesoscale vortex. *J. Atmos. Sci.*, in revision.

Halperin, D., H. Fuelberg, **R. Hart**, R. Pasch, J. Cossuth, and P. Sura, **2013**: An evaluation of TC genesis forecast from global numerical models. Submitted to Wea. Forecasting

In Press or Published:

Cossuth, J., R. Knabb, D. Brown, and **R. E. Hart, 2012**: Tropical cyclone genesis guidance using pre-development Dvorak climatology. *Wea. and Forec*., in press

Schenkel, B. and **R. Hart**, **2012**: An Examination of TC Position and Intensity Differences within Atmos. Reanalysis Datasets. *J. Climate*. MERRA Special Collection. doi: 10.1175/2011JCLI4208.1

Schenkel, B. and **R. Hart, 2011**: Conference Notebook: Potential Precursors to Tropical Cyclone Passage. *Bull. Amer. Meteor. Soc.,* October 2011, 1282-1283.

Truchelut, R.E. and **R.E. Hart**, **2011**: Quantifying the possible existence of undocumented Atlantic warm-core cyclones in NOAA/CIRES 20th Century Reanalysis Data. *Geo. Res. Let.*, 38, L08811, doi:10.1029/2011GL046756.

Hart, R.E., **2010**: An inverse relationship between aggregate tropical cyclone activity and subsequent winter climate. Geo. Res. Lett., doi:10.1029/2010GL045612.

Guishard, M.P., J. E. Evans, **R. E. Hart, 2009**: Atlantic Subtropical Storms. Part II: Climatology. J. Climate, 22, 3574-3594.

OTHER RELEVANT PUBLICATIONS:

Evans, C. and **R.E. Hart, 2008**: Analysis of the wind field evolution associated with the extratropical transition of Bonnie (1998).Mon. Wea. Rev., 136, 2047-2065.

Manning, D. and **R. E. Hart, 2007**: Evolution of North Atlantic ERA40 Tropical Cyclone Representation. Geo. Res. Let., 34, L05705, doi:10.1029/2006GL028266.

Guishard, M.P., E. A. Nelson, J. L. Evans, **R. E. Hart**, and D. G. O'Connell, **2007**: Bermuda subtropical storms. Meteor. And Atmos. Phys., doi: 10.1007/s00703-006-0255-y.

Hart, R., J. L. Evans, and C. Evans, **2006**: Synoptic Composites of the Extratropical Transition Lifecycle of North Atlantic Tropical Cyclones: Factors Determining Post-Transition Evolution. *Mon. Wea. Rev.*, **134**, 553-578.

Hart, R.,**2003**: A cyclone phase space derived from thermal wind and thermal asymmetry. *Mon. Wea. Rev.*, **131**, 585-616.

Vita for HENRY E. FUELBERG

Complete Vita available at http://fuelberg.met.fsu.edu/fuelberg/

Office:

Department of Meteorology
Florida State University
Tallahassee, FL 32306
Ph: (850) 644-6466
FAX: (850) 644-9642

Home:

2536 Noble Court
Tallahassee, FL 32308

Email: hfuelberg@fsu.edu
Web Site: http://fuelberg.met.fsu.edu

Education:

B.S. 1970	Texas A&M University	Meteorology
M.S. 1971	Texas A&M University	Meteorology
Ph.D.1976	Texas A&M University	Meteorology

Selected Experience:

Fall 2013	Meteorologist for NASA's SEAC^{4}RS Field Project
Summer 2010	Participant in NASA's GRIP Field Project
Spring 2008	Mission Meteorologist for NASA's ARCTAS Field Project in the Arctic
Fall 2005-Pres	David W. Stuart Professor of Meteorology, Florida State University
Spring 1996	Co-Lead Instructor for the UCAR/COMET Mesoscale Analysis and Prediction (COMAP) Course, Boulder, CO
1994-2005	Professor of Meteorology, Florida State University
1985-1994	Associate Professor of Meteorology, Florida State University
1980-1985	Associate Professor of Meteorology, Saint Louis University
1977-1980	Assistant Professor of Meteorology, Saint Louis University

Selected Service Activities:

Program Committee, 1985 Severe Local Storms Conference 1985
Program Chairman, 1988 Severe Local Storms Conference 1986-1988
AMS Committee on Severe Local Storms 1987-1990
Pathfinder GOES Science Working Group 1991-1993
AMS Committee on Severe Local Storms 1998-2000
Chairman, AMS Committee on Severe Local Storms 1999-2000
Program Committee, AMS 20th Conf. Severe Local Storms 1999-2000
Science Area Committee on Promotion and Tenure 2008
National Academy of Sciences Panel on the Significance
of International Transport of Air Pollutants (ITAP) 2008-2009

Selected Relevant Recent Publications:
Complete Publication List available at http://fuelberg.met.fsu.edu/fuelberg/publist.pdf

Reinhart, B., **H. Fuelberg**, R. Blakeslee, D. Mach, A. Heymsfield, A. Bansemer, S.L. Durden, S. Tanelli, G. Heymsfield, and B. Lambrigtsen, 2012: Understanding the Relationships between Lightning, Cloud Microphysics, and Airborne Radar-Derived Storm Structure during Hurricane Karl (2010). Submitted to Mon.Wea. Rev.

Halperin, D.J., **H.E. Fuelberg**, R.E. Hart, R.J. Pasch, J.C. Cossuth, and P. Sura, 2012: An evaluation of tropical cyclone genesis forecasts from global numerical models. Submitted to Wea. Forecasting.

Onderlinde, M.J., H.E. Fuelberg, S.J. Weiss, and A.I. Watson, 2012: A parameter for forecasting tornadoes associated with landfalling tropical cyclones. Wea. Forecasting, ready to submit.

Reinhart, B.J., **H. E. Fuelberg,** A. J. Heymsfield, R. J. Blakeslee, and S. L. Durden Understanding the Relationships Between Lightning, Cloud Microphysics, and Airborne Radar-Derived Storm Structure during Hurricane Karl (2010), 2012: 30th Conf. Hurricanes and Tropical Met., Amer. Meteor. Soc., Ponte Vedra Beach, FL, April 2012.

Halperin, D.J., **H.E. Fuelberg**, R.E. Hart, J. Cossuth, and R. Truchelut, 2012: Evaluating tropical cyclogenesis forecasts in four global models. 21st Conf. Probability and Statistics. Amer. Meteor. Soc., New Orleans, January 2012.

Halperin, D.J., **H. E. Fuelberg**, R. E. Hart, P. Sura, J. Cossuth, R. Truchelut, and R. J. Pasch, 2012: evaluating Tropical Cyclogenesis Forecasts from Four Global Numerical Models. 30th Conf. Hurricanes and Tropical Met., Amer. Meteor. Soc., Ponte Vedra Beach, FL, April 2012.

Austin, M.D., and **H.E. Fuelberg**, 2011: Linking lightning to tropical cyclone intensity change: A composite study of frequency and distribution. Paper 3.2, 5th Conf. Meteor. Application of Lightning Data, Seattle, Amer. Meteor. Soc., January 2011.

Saunders, P., **H. Fuelberg**, S. Hodanish, J. Mittelstadt, A. Watson, and S. Zubrick, 2011: Mesoscale lightning threat guidance for operational use at NWS offices. Poster 680, 5th Conf. Meteor. Application of Lightning Data, Seattle, Amer. Meteor. Soc., January 2011.

Onderlinde, M., **H.E. Fuelberg**, S.J. Weiss, and A.I. Watson, 2010: A new parameter for forecasting tornadoes in landfalling tropical cyclones. Paper 4B.2, 25th Conf. Severe Local Storms, Denver, Amer. Meteor. Soc., October 2010.

Austin, M.D., and **H.E. Fuelberg**, 2010: Assessment of synoptic and microphysical parameters related to lightning in tropical cyclone and storm intensification. Paper 16D.4, 29th Conf. Hurricanes and Tropical Met., Amer. Meteor. Soc., Tucson, May 2010.

Halperin, D.J., and **H.E. Fuelberg**, 2010: The sensitivity of TC intensity and structure to grid spacing in the Advanced Hurricane WRF. Paper 12D.4, 29th Conf. Hurricanes and Tropical Met., Amer. Meteor. Soc., Tucson, May 2010.

Austin, M.D., and **H. E. Fuelberg**, 2010: Assessing tropical cyclone lightning patterns and intensity changes using GIS-based methods. Vaisala 2010 ILDC/ILMC Lightning Conference, Orlando, April 2010.

Halperin, D.J., and **H.E. Fuelberg**, 2010: Initialization techniques for tropical cyclones using the Advanced Hurricane WRF. UCAR 50th Anniversary Special Symposium, Amer. Meteor. Soc., Atlanta, Paper 2.3, January 2010.

Current and Pending Federal Support

CURRENT AND PENDING FEDERAL SUPPORT FOR ROBERT E. HART

Source of Support	Project Title	Period Covered	Award Amt.	Support (months/yr)
PENDING SUPPORT:				
NOAA	A Probabilistic TC Genesis Forecast Tool Utilizing an Ensemble of Global Models (this proposal). Grant # N/A.	08/01/13-07/31/15	$197,792	1
NOAA	Improved Forecasting of Extreme Rainfall Events Associated with Tropical Cyclones. Grant # N/A.	05/01/13-04/30/16	$301,749	1
NSF	The Application of 19-20th Century Reanalyses to the Diagnosis and Understanding of Historic TCs: Direct and indirect signatures and Numerical Modeling (in preparation). Grant # N/A.	01/15/13-01/14/15	$449,950	2
CURRENT SUPPORT:				
NASA	Breaking through the barrier of short-term hurricane intensity forecasting by interrogating remotely-sensed and reconnaissance datasets to predict core evolution. Grant #NNX09AC43G.	11/21/08-12/15/13	$599,950	1.5
NSF	The Climate Memory Of Tropical Cyclones: Dimensions, Magnitude, Mechanisms For Its Generation And Removal, And Implications. Grant #0842618.	01/31/09-01/31/13	$430,221	1.5

CURRENT AND PENDING FEDERAL SUPPORT FOR HENRY FUELBERG

Source of Support	Project Title	Period Covered	Award Amt.	Support (months/yr)
PENDING SUPPORT:				
NOAA	A Probabilistic TC Genesis Forecast Tool Utilizing an Ensemble of Global Models (this proposal)	08/01/13-07/31/15	$197,792	1
NOAA	Improved Forecasting of Extreme Rainfall Events Associated with Tropical Cyclones	05/01/13-04/30/16	$301,749	1
CURRENT SUPPORT:				
NOAA	Data Assimilation of Lightning in WRF 4-D VAR Using Observation Operators, Grant NA10NES4400008	06/01/10-05/31/13	$475,925	0.5
NASA	Diagnostic Studies and Numerical Simulations of Chemical Transport to the Upper Troposphere/Lower Stratosphere in the South Asian Monsoon during SEAC4RS Grant NNX 12AC07G	12/01/11-12/01/14	$404,972	1.5
USAF	Meteorological Modeling and Tracer Capabilities Study. Contract FA7022-11-R-0011	12/01/11-12/01/13	$123,353	0.5
NASA	Breaking through the barrier of short-term hurricane intensity forecasting by interrogating remotely-sensed and reconnaissance datasets to predict core evolution Grant NNX09AC43G	11/21/08-12/15/13	$599,950	1
NASA	Research on Arctic Transport Using a Synthesis of Satellite Data, In Situ Data, and Numerical Model Grant NNX08AH72G	01/01/08-12/31/12	$490,619	0.5
USAF	Lightning Cessation with Dual Polarization Radar Contract FA2521-11-P-0091	09/13/11-09/12/13	$104,633	0.2

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: 12/06/2012
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: Florida State University

* b. Employer/Taxpayer Identification Number (EIN/TIN): 59-1961248
* c. Organizational DUNS: 7908774190000

d. Address:

* Street1: Sponsored Research Services
Street2: 874 Traditions way, Third Floor
* City: Tallahassee
County/Parish: Leon
* State: FL: Florida
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 32306-4166

e. Organizational Unit:

Department Name:
Division Name:

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

Prefix: Mr.
* First Name: Greg
Middle Name: W.
* Last Name: Thompson
Suffix:

Title: Director

Organizational Affiliation:
Sponsored Research Services

* Telephone Number: 850-644-5260
Fax Number: 850-644-1464

* Email: noaaaward@mailer.fsu.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-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:**

A Probablistic TC Genesis Forecast Tool Utilizing an Ensemble of Global Models

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-002

b. Program/Project: FL-002

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	197,792.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	197,792.00

*** 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.

[X] 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 [X] 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)**

[X] ** 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: Dr.

* First Name: Gary

Middle Name: K.

* Last Name: Ostrander

Suffix:

* Title: Vice President for Research

* Telephone Number: 850-644-5260

Fax Number: 850-644-1464

* Email: noaaaward@mailer.fsu.edu

* Signature of Authorized Representative: Gary Ostrander

* Date Signed: 12/06/2012

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. FY 13-14	11.459	$	$	$ 98,592.00	$	$ 98,592.00
2. FY 14-15	11.459			99,200.00		99,200.00
3.						
4.						
5. Totals		$	$	$ 197,792.00	$	$ 197,792.00

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Prescribed by OMB (Circular A -102) Page 1

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total
	(1)	(2)	(3)	(4)	(5)
	FY 13-14	FY 14-15			
a. Personnel	$ 48,694.00	$ 50,398.00	$	$	$ 99,092.00
b. Fringe Benefits	3,506.00	3,629.00			7,135.00
c. Travel	6,346.00	3,654.00			10,000.00
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	12,529.00	14,409.00			26,938.00
i. Total Direct Charges (sum of 6a-6h)	71,075.00	72,090.00			$ 143,165.00
j. Indirect Charges	27,517.00	27,110.00			$ 54,627.00
k. TOTALS (sum of 6i and 6j)	$ 98,592.00	$ 99,200.00	$	$	$ 197,792.00
7. Program Income	$ 0.00	$ 0.00	$	$	$

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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	$ 98,592.00	$ 24,648.00	$ 24,648.00	$ 24,648.00	$ 24,648.00
14. Non-Federal	$				
15. TOTAL (sum of lines 13 and 14)	$ 98,592.00	$ 24,648.00	$ 24,648.00	$ 24,648.00	$ 24,648.00

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. N/A	$ 99,200.00	$	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$ 99,200.00	$	$	$

SECTION F - OTHER BUDGET INFORMATION	
21. Direct Charges: $143,165.00	22. Indirect Charges: $54,627.00
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
Gary Ostrander	Vice President for Research
*** APPLICANT ORGANIZATION**	*** DATE SUBMITTED**
Florida State University	12/06/2012

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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
Florida State University

* AWARD NUMBER
N/A

* PROJECT NAME
N/A

Prefix: Dr.
* First Name: Gary
Middle Name: K.
* Last Name: Ostrander
Suffix:
* Title: Vice President for Research

* SIGNATURE: Gary Ostrander
* DATE: 12/06/2012