# Partners Project Title Page
# Proposal for a Partners Project

Title: **Evaluating the clarity and effectiveness of the National Hurricane Center's experimental probabilistic intensity forecast product**

Date: 28 April 2021

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SUMMARY OF BUDGET REQUEST:

COMET FUNDS: $14,924

NWS FUNDS: FY 1 $0 FY 2 $1,500

**Evaluating the clarity and effectiveness of the National Hurricane Center's experimental probabilistic intensity forecast product**

PIs: Robert Eicher[1] and Daniel Halperin[1]
Co-Is: Deanna Sellnow[2], Timothy Sellnow[2], and Derek Lane[3]
[1]Embry-Riddle Aeronautical University (ERAU), [2]University of Central Florida (UCF),
[3]University of Kentucky (UKY)

In partnership with the National Hurricane Center

## Summary

Accurately predicting tropical cyclone (TC) intensity remains a primary challenge in operational forecasting. Currently, the National Hurricane Center's (NHC) hurricane specialists can only *subjectively* convey uncertainty or confidence in an intensity forecast through products such as the forecast discussion and key messages. However, NHC is currently developing forecast graphics that will provide *objective* uncertainty information about TC intensity forecasts. The goal of this proposed study is to work with NHC to test the message clarity and effectiveness of these experimental graphics among disparate general publics (i.e., end-users). Results discovered from an analysis of survey responses will inform recommendations made to the NHC regarding which experimental forecast graphic(s) should be considered for operational implementation. Better communication of TC intensity forecast uncertainty has the potential to lead to more effective protective actions among general publics in preparation for a landfalling TC.

## 1. Background and Motivation

The National Hurricane Center's (NHC's) tropical cyclone forecast track graphic, commonly referred to as the cone of uncertainty, was introduced to the NHC website in 2002 (ERG 2019). Since then, it has become the most viewed graphic on the NHC website and is widely distributed through both legacy news media and social media (Millet et al., 2020). The cone represents the probable track of the center of a tropical cyclone (TC) and the size of the cone is related to the official forecast errors over the previous five years. Based on forecasts over the previous five years, the entire track of the tropical cyclone can be expected to remain within the cone roughly two-thirds of the time (https://www.nhc.noaa.gov/aboutcone.shtml). Put simply, the graphic is literally designed to express the uncertainty in the track forecast.

The NHC has made substantial improvements in TC track forecasting during the past half century (Cangialosi et al., 2020). Conversely, accurately predicting TC intensity has been a challenge in operational forecasting (Gall et al., 2013). The NHC's tropical cyclone intensity forecast errors were fairly consistent from the 1970s to the early 2000s and have only recently shown some improvement (Cangialosi et al., 2020). Despite the known uncertainty in intensity forecasts, there is currently no operational product that objectively communicates uncertainty in TC intensity forecasts (Bhatia & Nolan, 2015). The NHC's hurricane specialists can *subjectively* convey uncertainty or confidence in an intensity forecast through the publicly available forecast discussion and key messages. However, the forecast discussion is meteorological in nature and interpreting such information requires preexisting scientific knowledge that end-users may or may not possess

(Drake, 2012). Consequently, Drake (2012) found that users often misinterpret the TC intensity forecast as probable storm intensity at landfall, a forecast that technically does not yet exist.

Research reveals that conveying uncertainty information in weather forecasts can be beneficial. Joslyn and LeClerc (2012) discovered, for example, that "uncertainty information improved decision quality overall and increases trust in the forecast." That study focused specifically on road maintenance in icy conditions, but the authors believe it has implications on severe weather warnings and "other domains" (Joslyn & LeClerc, 2012). More specific to the current proposal, Bica et al. (2019) focused on the need to better communicate uncertainty regarding hurricanes. They discovered critical "opportunities for the innovation of new information products to support risk communication" and "risk representations should convey uncertainty as appropriate in understandable, meaningful ways so that people can make best use of the information in interpreting risk" (Bica et al., 2019). Although this study focused specifically on Twitter, it does point to the need for additional work in this area.

Research also confirms that when making decisions in uncertain situations, people tend to become "anchored" to a relevant value if available (Strack & Mussweiler, 1997; Tversky & Kahneman, 1974). The "anchoring effect" can be applied to weather forecasts. Drake (2012) found that users had "effectively frozen the hurricane in its current condition and adopted that description as their expectation for the future" and that "no sharp distinction was made between intensity in the present and in the future, with the hurricane's current description and its uncertain future all rolled up into one." Hurricane specialists at the NHC have also expressed concern that the general public becomes "anchored" to an initial hurricane forecast and therefore fails to fully recognize that the situation may have changed (Berg et al., 2019; Eosco & Sprague-Hilderbrand, 2020). This suggests that if the NHC offered a range of possible intensities rather than a single deterministic forecast, the public would be less likely to focus on that one number.

These prior studies suggest that the public might be better served if the NHC were to communicate the uncertainty inherent in an intensity forecast in a manner similar to that of the track forecast. However, there is still a need for research focused on effectively communicating uncertainty in the TC forecast and warning system specifically (Gladwin et al., 2007; Morrow et al., 2015). This assertion is further validated by theories in the science of communication.

Chaos theory is well known for its applications in the atmospheric sciences (e.g., Lorenz, 1963). The same principles are used in the social sciences to explain that "precise, accurate, and unequivocal communication about the behavior of complex systems is inherently impossible" (Sellnow & Seeger, 2021). Thus, effective communication during times of uncertainty may include admitting both what is known and unknown (Sellnow & Sellnow, 2019). In essence, chaos theory in the context of communication emphasizes uncertainty and open-endedness and therefore "provides a particularly good model for crisis situations" (Murphy, 1996). Sellnow et al. (2002) found that "inappropriately unequivocal predictions" during the 1997 Red River Valley Flood in Minnesota "ultimately diminished the effectiveness of the region's crisis communication and planning" (Sellnow et al., 2002). Established doctrine suggests that prompt, complete and precise language bolsters an organization's reputation and integrity, but some scholars have begun arguing that precision is not always warranted or even ethical (Sellnow & Seeger, 2021). In other words, chaos theory informs the "bewildered sense of helplessness victims experience at the onset of an acute crisis and the urgent desire" to make sense of the situation (Sellnow et al., 2012).

Tropical cyclones are inherently complex, dynamic systems and chaos theory is already applied toward tropical cyclone predictions (e.g., ensemble forecasting). It therefore stands to reason that chaos theory should be applied to communicating tropical cyclone forecasts. With that, the following research question is posed:

*If the NHC were to objectively communicate uncertainty concerning tropical cyclone intensity in official forecast products, would that lead to more informed decisions regarding protective actions?*

The NHC is currently developing new forecast products to convey the uncertainty in TC intensity forecasts and prototype forecast graphics are expected to be available in 2021. The proposed study seeks to test these products for clarity and effectiveness via an online survey of general publics in TC prone areas of the U.S.

## 2. Project objective

The primary of objective of the proposed project in collaboration with NHC is to gather and analyze data regarding general publics' understanding of a new forecast intensity product from NHC and their planned protective actions that would result from this type of forecast information. The timing of this study would allow NHC to better understand public perception of their forecast product and potentially make refinements to the product before it becomes operational.

The following outcomes/deliverables are expected by the end of the project cycle:

- Recommendations to NHC regarding which of the prototype forecast intensity graphics is best understood by the general publics and would result in their taking actions to protect life and property. These recommendations can be considered by NHC as they finalize a new forecast intensity graphic for operational implementation.
- A peer-reviewed manuscript describing the methodology and results of the surveys conducted to assess the message clarity and effectiveness of NHC's prototype forecast intensity graphics.
- A presentation on the results of the study at the AMS Conference on Hurricanes and Tropical Meteorology.

## 3. Preliminary results from pilot study

A pilot study was conducted with undergraduate students at the University of Central Florida (n = 819, mean age = 20 years). Each student was asked to view a tropical cyclone forecast graphic typical of that currently seen in a television news broadcast with a single value for the forecast intensity at each interval (Figure 1, control). The same students then viewed the same graphic with a range of intensities at each interval instead of a single value (Figure 2, treatment). The range of intensities was generated based on the approximate average error for wind speed forecasts over the last five years. This is analogous to how the track forecast cone is currently generated.

After viewing each graphic, the students were asked to answer the same five questions related to their understanding of that graphic.

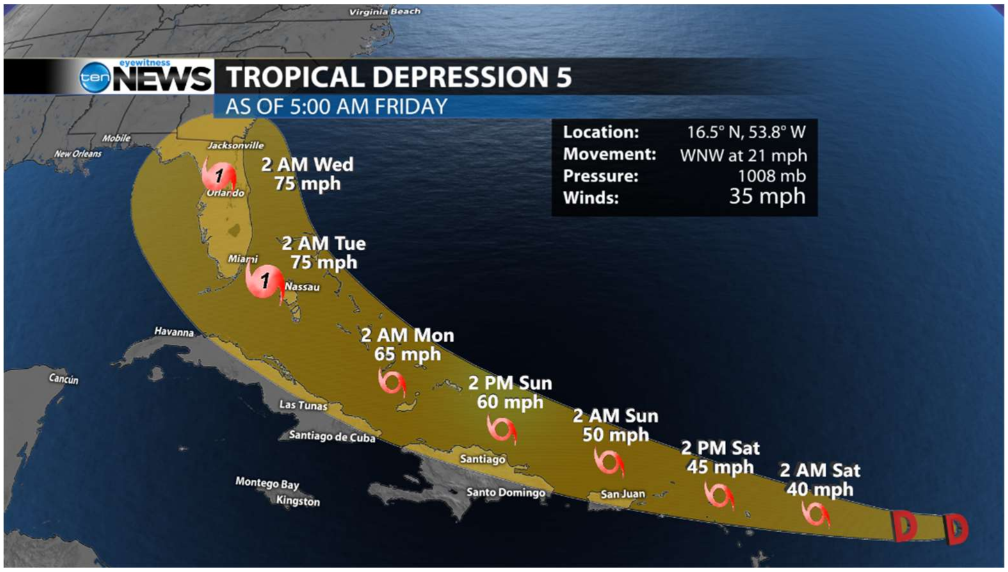


**Figure 1**. *Control graphic showing a single forecast intensity at each time period.*

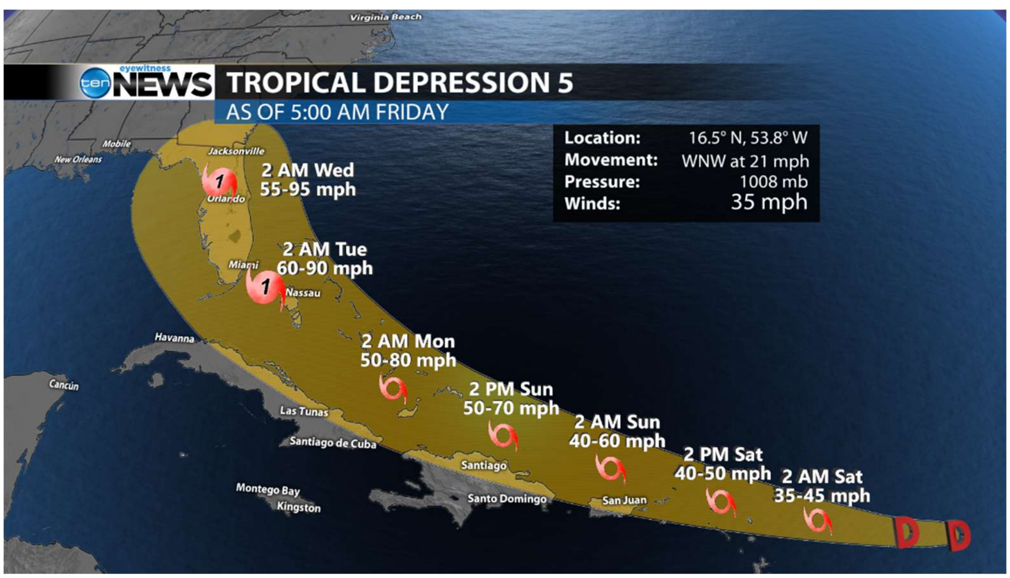


**Figure 2**. *Treatment graphic showing a forecast intensity range at each time period.*

The first question posed after each graphic was "what information in the above tropical cyclone forecast graphic do you believe to be LEAST reliable?" In both cases, control and treatment, 53% of the students answered, "The predicted location of the hurricane on Tue [day 4] and Wed [day 5]." Only 22.7% selected "The predicted wind speeds of the hurricane on Tue [day 4] and Wed [day 5]" after viewing the control graphic and only 24.5% made that selection after viewing the treatment graphic. This shows that, in either case, the students mistakenly believe that the track forecast is more challenging than the intensity forecast and therefore overvalue the accuracy of the intensity forecast.

The students were also asked to answer the question "As a Florida resident, what additional information, if any, would you most want after seeing the above forecast graphic?" Following the control graphic with a single value for intensity, 55.4% of the students selected "the highest possible sustained winds expected on Tue and Wed (i.e. - the worst-case scenario)." Following the treatment graphic with a range of intensities, that number dropped to 48.0%. That suggests that the students want information that is not currently provided – the highest possible sustained winds or worst-case scenario expected.

The students were also asked to rate their agreement with the statement "the above forecast graphic is easy to understand" using a five-point Likert scale. When the responses were reverse coded (5 = strongly agree, 1 = strongly disagree), the mean for the control graphic was 4.37 while the mean for the treatment graphic was 4.32. Even though the difference of the means amounts to only a few hundredths, it is statistically significant ($p = .016$). That implies that providing a range of forecast intensities did not make the graphic incomprehensible, but it did make the graphic slightly less understandable.

This pilot studies provides evidence that a range of intensities is desirable in tropical cyclone forecasts. However, careful messaging is required to avoid causing unwanted confusion. All of that suggests value in the proposed research.

## 4. Proposed research activities

### *a. Experimental design*

Huang et al. (2016) conducted a meta-analysis of 38 studies involving actual responses to hurricane warnings and 11 studies involving expected responses to hypothetical hurricane scenarios conducted since 1991. Their analysis found "the effect sizes from actual hurricane evacuation studies are similar to those from studies of hypothetical hurricane scenarios for 10 of 17 variables that were examined" (Huang et al., 2016). That suggests "laboratory and internet experiments could be used to examine people's cognitive processing of different types of hurricane warning messages" (Huang et al., 2016). Our study will do exactly that – test people's response to a hypothetical TC using an online survey as part of an experimental design.

The survey will be designed to accurately measure (1) the message clarity regarding the risk of TC wind impacts, including the forecast intensity uncertainty; and, (2) the message effectiveness based on responses regarding planned protective actions. These metrics will be tested using three different experimental forecast graphics (i.e., "treatments") with two different forecast intensity trends. Survey questions will be designed based on the approach developed by Noar et al. (2010) to measure perceived message effectiveness. Items may include "This forecast would catch my attention," "This forecast is effective," "This forecast would make me more likely to seek additional information," "Based on this forecast, how likely are you to take protective action?" or similar questions.

*b. Experimental testing*

Based on the above experimental design, the experimental test will contain three independent variables and two dependent variables.

*i. Independent variables*

There will be three forecast graphics tested. The "control" product is NHC's currently operational deterministic intensity forecast. The experimental graphics will include NHC's prototypes of the new TC intensity forecast graphics developed and provided by NHC.

We will test a hypothetical TC with two different forecast intensity trends. At the initial time, all respondents will answer questions regarding a TC that is forecast to make landfall in approximately five days with a given intensity forecast. Then, all respondents will be asked to imagine that two days have passed and the intensity forecast has changed. One subset of respondents will see an updated forecast with the TC forecast to be weaker at the time of landfall. The other subset of respondents will see an updated forecast with the TC forecast to be stronger at the time of landfall.

*ii. Dependent variables*

The first set of survey questions will measure the message clarity of the forecast regarding the risk of wind impacts from the TC, including whether respondents understand the uncertainty associated with the intensity forecast.

The second set of survey questions will measure the message effectiveness by asking respondents questions about the perceived risk from TC wind impacts to their life and property, and asking about what protective actions they plan to take in preparation for the landfalling TC.

The experimental phase of the project will include a 2 (intensity trend) X 3 (condition) mixed factorial design (see Table 1). An a priori power analysis using G*Power 3.1.9 with $\alpha = 0.05$ and power = 0.95 revealed that for a medium effect size, $f^2 = 0.25$, $F\,(5, 317) = 2.243$, Noncentrality parameter $\lambda = 20.19$, a minimum sample of 323 is required. Therefore, a sample of approximately 350 participants should be sufficient to minimize Type II error and to test the 2 X 3 factorial design. Participants will be recruited using a proprietary panel and data will be collected using an online Qualtrics survey. Participants will be randomly assigned to each of the six cells required to test the 2 X 3 factorial design.

Testing different treatments will provide insight regarding which format of the experimental graphics most clearly communicates the risk of TC wind impacts and the uncertainty associated with the intensity forecast. The different communication channels will reveal to what extent general public end-users can correctly interpret the intensity forecast and uncertainty based only on the static forecast graphic (e.g., from the NHC website and social media accounts). Asking the respondents to answer the same set of questions based on a forecast intensity that has changed over time will help determine if public end-users are "anchored" by the first forecast they receive or if they revise their planned protective actions based on the updated information.

A repeated measures analysis of variance (ANOVA) will be calculated to answer the following questions:

- Which experimental forecast graphic format/design most clearly conveys the risk of wind impacts posed by the TC?
- Are participants more or less likely to take extra protective actions after receiving information about the uncertainty associated with the forecast intensity of a TC?
- Are participants more likely to take extra protective actions after receiving new information that the forecast intensity of a TC has increased? Or, do they remain "anchored" by the information from the initial forecast?
- Are participants less likely to take extra protective actions after receiving new information that the forecast intensity of a TC has decreased? Or, do they remain "anchored" by the information from the initial forecast?

**Table 1.** *2 (Intensity Trend) X 3 (Condition) Factorial Design.*

| | | **Intensity** | |
|---|---|---|---|
| | | Initial forecast: ~5 days before landfall<br><br>Updated forecast: ~3 days before landfall, weaker cyclone | Initial forecast: ~5 days before landfall<br><br>Updated forecast: ~3 days before landfall, stronger cyclone |
| **Condition** | **Status Quo**<br>Current NHC forecast with track cone and categorical intensity | | |
| | **Treatment #1**<br>NHC prototype "A" intensity forecast | | |
| | **Treatment #2**<br>NHC prototype "B" intensity forecast | | |

## 5. Timeline

| Time | Task | ERAU | NHC |
|---|---|---|---|
| Summer 2021 | NHC develops prototype graphics from a hypothetical advisory package for use in the survey of general publics. | | X |
| Summer-Fall 2021 | Survey questions designed to assess the clarity and effectiveness of the prototype graphics. | X | X |
| Fall 2021 | Obtain IRB approval for tests using human subjects. | X | |

| | | | |
|---|---|---|---|
| Fall 2021 | Conduct survey among the general publics. | X | |
| Winter 2022 | Analyze survey results. | X | |
| Winter 2022 | Make recommendations to NHC regarding forecast graphic design. | X | |
| Spring 2022 | Present project results at AMS Conference on Hurricanes and Tropical Meteorology. | X | |
| Summer 2022 | Forecast graphic testing and demonstration at NHC for potential implementation to operations. | | X |

## 6. Investigators

The project will be led by co-PIs Eicher and Halperin, Assistant Professors of Meteorology at ERAU. They will be assisted by co-Is D. and T. Sellnow, Professors of Strategic Communication at UCF, and D. Lane, Professor of Communication at UKY. The university investigators will collaborate with Brian Zachry, NHC Science and Operations Officer and Joint Hurricane Testbed Director.

Co-PI Eicher joined ERAU in 2018. He is an AMS Certified Consulting Meteorologist and has years of experience communicating tropical cyclone forecast information to the general public as an AMS Certified Broadcast Meteorologist working in the Central Florida television market.

Co-PI Halperin joined ERAU in 2017. He has published five peer-reviewed articles since 2017, three of which were related to tropical cyclone research. He has recently advised three undergraduate students on tropical cyclone related research. He also has experience in the research to operations process, including collaborations with the National Hurricane Center through Joint Hurricane Testbed projects.

Co-PI Zachry will coordinate the contributions from NHC, including the development of the prototype forecast intensity graphics to be used in the proposed study.

## 7. University and NWS/NHC contributions

ERAU will coordinate the design, management, and analysis of the survey of the general public that tests the clarity and effectiveness of NHC's prototype forecast intensity graphics. The co-PIs will co-supervise an undergraduate research assistant who will be assisting with the data processing and analysis. Co-Is at UCF and UKY will be consulted on the survey design and interpretation of the survey results.

NHC will provide the prototype forecast intensity graphics to be used in the survey. They will also be consulted on the survey design to ensure that the data gathered will be maximally useful for their decision regarding which prototype graphic is best suited for operational implementation.

All investigators and the undergraduate research assistant will participate in collaboration calls during the project cycle and will be co-authors on the peer-reviewed publication.

## 8. Budget justification

*a. University Personnel*

The University Personnel request is to support a part-time undergraduate research assistant. This student will have the opportunity to participate in all aspects of the study, but will primarily be responsible for analyzing the survey results. The student's participation will help them develop their computer programming skills and apply data analysis concepts learned in the classroom to a practical research question. It also provides the student invaluable experience conducting collaborative research that will make them competitive candidates for internships and/or graduate studies.

The co-PIs will donate their time to co-supervise the undergraduate research assistant and manage the project. The co-PIs hope that this study can be the start of additional collaborations with NHC regarding public perception of tropical cyclone forecast information.

*b. Travel*

Travel funding is requested to present the results of the study at the AMS Conference on Hurricanes and Tropical Meteorology in New Orleans, LA in May 2022. The request would support travel for the undergraduate research assistant and one co-PI. It will provide the undergraduate research assistant experience in communicating scientific results at a professional conference while also making the tropical cyclone community aware of the major findings of this collaborative study.

*c. Other data*

The "other data" funding request is to provide support for a third party (e.g., Qualtrics) to host and manage the survey of the general public. These companies typically charge per survey participant and a larger sample size will help ensure robust survey results.

*d. Publication costs (NWS/NHC)*

Funding is requested to pay for the publication page charges associated with one peer-reviewed manuscript describing the methodology and results of the surveys conducted to assess the message clarity and effectiveness of NHC's prototype forecast intensity graphics.

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| | COMET Funds | NWS Contributions |
|---|---|---|
| **University Senior Personnel** | | |
| 1. Robert Eicher | **0.00** | **NA** |
| 2. Daniel Halperin | **0.00** | **NA** |
| | | |
| **Other University Personnel** | | |
| 1. Undergraduate research assistant (hourly) | **2,000** | **NA** |
| 2. | | **NA** |
| | | |
| **Fringe Benefits on University Personnel** | | **NA** |
| 0.00% on student wages | **0.00** | |
| **Total Salaries + Fringe Benefits** | **2,000** | **NA** |
| | | |
| **NWS Personnel** | | |
| 1. Brian Zachry (NHC SOO and JHT Director) | **NA** | **Effort on this project compensated by normal federal duty hours** |
| 2. | **NA** | (# of hours) |
| | | |
| **Travel** | | |
| 1. Research Trips | **0.00** | |
| 2. Conference Trips | **2,000** | |
| 3. Other | | |
| **Total Travel** | **2,000** | |
| | | |
| **Other Direct Costs** | | |
| 1. Materials & Supplies | | **NA** |
| 2. Publication Costs (put in the NWS column if a co-author will be an NWS employee) | | **1,500** |
| 3. Other Data | **6,400** | |
| 4. NWS Computers & Related Hardware | **NA** | |
| 5. Other (specify) | | |
| **Total Other Direct Costs** | **6,400** | **1,500** |
| | | |
| **Indirect Costs** | | **NA** |
| 1. Indirect Cost Rate | **43.5%** | |
| 2. Applied to which items? All direct costs | **10,400** | |
| **Total Indirect Costs** | **4,524** | **NA** |
| | | |
| **Total Costs (Direct + Indirect)** | **14,924** | **1,500** |

| **Actions Before Proposal is Submitted to COMET** | **YES** | **NO** | **DATE** |
| --- | --- | --- | --- |
| 1. Did NWS office staff and university staff meet to discuss and form outline and scope of project? | X | | 3/29/21 |
| 2. Did NWS office consult Scientific Services Division (SSD) staff? | X | | 4/19/21 |
| 3. Was Statement of Work and budget formulated as a team effort between university and NWS staffs? | X | | 4/19/21 |
| 4. Was proposal submitted to SSD for review? | X | | 4/28/21 |
| 5. Did SSD forward copies of proposals dealing with WSR-88D<br>data to Radar Operations Center (ROC), Applications Branch Chief for review? | | | N/A |
| 6. Did SSD forward copies of proposals dealing with hydrometeorology to the Senior Scientist of National Water Center (under NWS Office of Water Prediction) for review? | | | N/A |
| 7. Did SSD review the data request for project to ensure its scope and criticality for proposal? | X | | 4/28/21 |
| 8. Is all data for the project being ordered by NWS offices through the National Center for Environmental Information (NCEI) (ncei.info@noaa.gov) free of charge? | | X | |
| 9. Does budget include publication charges and travel costs for NWS employees to present results at scientific conferences? | X (publication) | | 4/28/21 |
| 10.Does budget separate NWS costs into fiscal year costs and university costs into calendar year costs? | X | | 4/28/21 |
| 11.Does proposal include a separate justification for university hardware purchases which are usually not funded by the COMET Outreach Program? | | | N/A |
| 12. Have the following people signed off on the proposal cover sheet:<br>- MIC/HIC?<br>- SSD Chief?<br>- Regional Director? | X | | 6/2/21 |
| 13. Is a letter of endorsement signed by regional director attached? | X | | 6/3/21 |

| Actions after Endorsement by NWS | **YES** | **NO** | **DATE** |
| --- | --- | --- | --- |
| 1. University submits proposal to the COMET Program. | | | |
| 2. Proposal acknowledgment letter sent by the COMET Program to submitting university with copies to SSDs and NWS office. | | | |
| 3. COMET review of proposal (internal review for Partners Project proposals and formal review for Cooperative Project proposals). | | | |
| 4. The COMET Program sends acceptance, rejection, or modification letters to university with copies to SSD, NWS office, and NWS Office of Science and Technology Integration (OSTI). | | | |
| 5. The COMET Program allocates funds for university. | | | |
| 6. OSTI obligates funds for NWS offices. | | | |
| 7. SSD/NWS office orders data from NCEI. | | | |
| 8. NWS office or SSD calls OSTI for accounting code for expenses. | | | |
| 9. NWS office sends copies of all travel vouchers and expense records to OSTI. | | | |
| 10. NWS office or SSD sends copies of publication page charge forms to OSTI. | | | |
| 11. NWS office keeps SSD informed of progress on the project and any results or benefits derived from the project. | | | |

**ABBREVIATED CV for ROBERT EICHER**

Department of Applied Aviation Sciences
Embry-Riddle Aeronautical University
Daytona Beach, FL 32114

Phone: (386) 226-6856
E-mail: Robert.Eicher@erau.edu

**EDUCATION**

| | | |
|---|---|---|
| *2025* | Ph.D. in Strategic Communication | University of Central Florida *(expected)* |
| 2000 | M.S. in Meteorology | University of Maryland |
| 1998 | B.S. in Environmental & Earth Sciences | University of Maryland |

**PROFESSIONAL EXPERIENCE**

2018- Assistant Professor of Meteorology at Embry-Riddle Aeronautical University
1999- Broadcast Meteorologist at various local TV stations (currently News 13 Orlando)

**RELEVANT SERVICE**

2020 Coordinating Lead author of "Best Practices for Large Retail Outlets in Preparation for Severe Wind and Tornado Emergencies," a Best Practice Statement of the American Meteorological Society, adopted by the AMS Council September 2020
2019- Chair, AMS Board on Best Practices
2017 Coordinating Lead author of "Best Practices for Publicly Sharing Weather Information Via Social Media," a Best Practice Statement of the American Meteorological Society, adopted by the AMS Council January 2017
2015 Chair, AMS Board of Broadcast Meteorology
2015 Co-chair, AMS 43rd Conference on Broadcast Meteorology
2013 Co-chair, AMS 41st Conference on Broadcast Meteorology
2012 Co-chair, AMS 40th Conference on Broadcast Meteorology

**AWARDS AND CERTIFICATIONS**

2021 AMS Certified Consulting Meteorologist
2020 Outstanding Faculty Performance Award, ERAU Dept. of Applied Aviation Sciences
2011 Seminole County FL Public Schools Outstanding Volunteer Speaker
2008 Florida Society of Professional Journalists Award for Excellence in Weather Reporting
2005 AMS Certified Broadcast Meteorologist
2002 National Weather Association (NWA) Television Seal of Approval

**PUBLICATIONS**

Halperin, D. J., **R. W. Eicher**, T. A. Guinn, J. R. Keebler, and K. O. Chambers, 2020: Implementing active learning techniques in an undergraduate aviation meteorology course. *J. Aviation/Aerospace Ed. & Research*, **29 (2)**, 149-171.

## ABBREVIATED CV for DANIEL HALPERIN

Department of Applied Aviation Sciences
Embry-Riddle Aeronautical University
Daytona Beach, FL 32114

Phone: (386) 226-7069
E-mail: Daniel.Halperin@erau.edu

### EDUCATION

2015 Ph.D. in Meteorology — Florida State University (FSU)
2012 M.S. in Meteorology — Florida State University
2009 B.S. in Applied Meteorology — Embry-Riddle Aeronautical University (ERAU)

### PROFESSIONAL EXPERIENCE

2017- Embry-Riddle Aeronautical University: Assistant Professor of Meteorology
2016-2017 I.M. Systems Group: Meteorologist Developer
2015-2016 University at Albany: Postdoctoral Research Associate

### RELEVANT SERVICE

2018 Topic Co-Chair, 9th WMO International Workshop on Tropical Cyclones
2016 Session Chair, 32nd AMS Conference on Hurricanes and Tropical Meteorology

### MANUSCRIPT REVIEWER

Monthly Weather Review, Quarterly Journal of the Royal Meteorological Society, Journal of Advances in Modeling Earth Systems, International Journal of Climatology, Atmosphere

### AWARDS

2019 Outstanding Faculty Performance Award, ERAU Dept. of Applied Aviation Sciences
2011 NASA Group Achievement Award (GRIP field experiment)

### PUBLICATIONS

Guinn, T. A., **D. J. Halperin**, and C. G. Herbster, 2020: Climatology of estimated altimeter error due to nonstandard temperatures. *J. Appl. Meteor. Climatol.*, **60 (3)**, 377-390.

**Halperin, D. J.**, A. B. Penny, and R. E. Hart, 2020: A comparison of tropical cyclone genesis verification from three Global Forecast System (GFS) operational configurations. *Wea. Forecasting*, **35 (5)**, 1801-1815.

**Halperin, D. J.**, R. W. Eicher, T. A. Guinn, J. R. Keebler, and K. O. Chambers, 2020: Implementing active learning techniques in an undergraduate aviation meteorology course. *J. Aviation/Aerospace Ed. & Research*, **29 (2)**, 149-171.

**Halperin, D. J.**, and R. D. Torn, 2018: Diagnosing atmospheric conditions associated with large short-term intensity forecast errors in the Hurricane Weather Research and Forecasting (HWRF) model. *Wea. Forecasting*, **33 (1)**, 239-266.

**Halperin, D. J.**, R. E. Hart, H. E. Fuelberg, and J. H. Cossuth, 2017: The development and evaluation of a statistical-dynamical tropical cyclone genesis guidance tool. *Wea. Forecasting*, **32 (1)**, 27-46.

**Halperin, D. J.**, H. E. Fuelberg, R. E. Hart, and J. H. Cossuth, 2016: Verification of tropical cyclone genesis forecasts from global numerical models: Comparisons between the North Atlantic and eastern North Pacific basins. *Wea. Forecasting*, **31 (3)**, 947-955.

**Halperin, D. J.**, H. E. Fuelberg, R. E. Hart, J. H. Cossuth, P. Sura, and R. J. Pasch, 2013: An evaluation of tropical cyclone genesis forecasts from global numerical models. *Wea. Forecasting*, **28 (6)**, 1423–1445.

Strazzo, S., J. B. Elsner, T. LaRow, **D. J. Halperin**, and M. Zhao, 2013: Observed versus GCM-generated local tropical cyclone frequency: Comparisons using a spatial lattice. *J. Climate*, **26 (21)**, 8257–8268.

## COLLEGES AND UNIVERSITIES RATE AGREEMENT

EIN: 1590936101A1

ORGANIZATION:
Embry-Riddle Aeronautical University
1 Aerospace Boulevard
Daytona Beach, FL 32114-3900

DATE:09/18/2020

FILING REF.: The preceding agreement was dated 01/13/2020

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. | 07/01/2016 | 06/30/2022 | 43.50 | On-Campus | All Programs |
| PRED. | 07/01/2016 | 06/30/2022 | 23.00 | Off-Campus | All Programs |
| PRED. | 07/01/2016 | 06/30/2022 | 6.00 | Off-Campus | (A) |
| PROV. | 07/01/2022 | Until Amended | | | Use same rates and conditions as those cited for fiscal year ending June 30, 2022. |

*BASE

Modified total direct costs, consisting of all salaries and wages, fringe benefits, materials, supplies, services, travel and subgrants and subcontracts up to the first $25,000 of 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, student tuition remission, rental costs of off-site facilities, scholarships, and fellowships as well as the portion of each subgrant and subcontract in excess of $25,000.
(A) Intergovernmental Personnel Act Agreements. All ERAU campuses.

ORGANIZATION: Embry-Riddle Aeronautical University
AGREEMENT DATE: 9/18/2020

**SECTION I: FRINGE BENEFIT RATES****

| TYPE | FROM | TO | RATE(%) | LOCATION | APPLICABLE TO |
|---|---|---|---|---|---|
| FIXED | 7/1/2020 | 6/30/2021 | 29.10 | All | Full-Time Employees |
| FIXED | 7/1/2020 | 6/30/2021 | 8.00 | All | Part-Time Employees |
| PROV. | 7/1/2021 | Until amended | | | Use same rates and conditions as those cited for fiscal year ending June 30, 2021. |

** DESCRIPTION OF FRINGE BENEFITS RATE BASE:

Salaries and wages.

**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.

Full-Time Employees fringe benefits rate includes Group Health Insurance, Retirement, Tuition Waiver Employee, Personal Leave Paid at Termination, Unemployment, Workers' Compensation, and FICA Taxes.

Part-Time Employees fringe benefits rate include Unemployment, Workers' Compensation, and FICA Taxes.

DEFINITION OF EQUIPMENT
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.

*The one year rate extension of the indirect cost rate was granted in accordance with the OMB Memorandum M-20-17.*

Next F&A rates proposal based on actual costs for fiscal year ending 06/30/2021 will be due no later than 12/31/2021. Next Fringe Benefits rates proposal for fiscal year ending 06/30/2020 is due in our office by 12/31/2020.

ORGANIZATION: Embry-Riddle Aeronautical University

AGREEMENT DATE: 9/18/2020

## 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 Title 2 of the Code of Federal Regulations, Part 200 (2 CFR 200), and should be applied to grants, contracts and other agreements covered by 2 CFR 200, 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:

Embry-Riddle Aeronautical University

(INSTITUTION)

(SIGNATURE)

Randall B. Howard, PhD.

(NAME)

Senior Vice President and CFO

(TITLE)

10/06/2020

(DATE)

ON BEHALF OF THE FEDERAL GOVERNMENT:

DEPARTMENT OF HEALTH AND HUMAN SERVICES

(AGENCY)

Darryl W. Mayes -S

Digitally signed by Darryl W. Mayes -S
DN: c=US, o=U.S. Government, ou=HHS, ou=PSC, ou=People, 0.9.2342.19200300.100.1.1=2000131669, cn=Darryl W. Mayes -S
Date: 2020.10.05 10:02:25 -04'00'

(SIGNATURE)

Darryl W. Mayes

(NAME)

Deputy Director, Cost Allocation Services

(TITLE)

9/18/2020

(DATE) 2879

HHS REPRESENTATIVE: Lucy Siow

Telephone: (301) 492-4855

**UNITED STATES DEPARTMENT OF COMMERCE**
National Oceanic and Atmospheric Administration
National Hurricane Center
11691 Southwest 17th Street
Miami, Florida 33165

June 3, 2021

Brian C. Zachry, Ph.D.
Branch Chief, Technology & Science Branch
NOAA/NWS/NCEP/National Hurricane Center
11691 SW 17th St.
Miami, FL 33165

Dear Brian:

This letter confirms the National Centers for Environmental Prediction's (NCEP's) support of the UCAR/COMET NWS Partners Project proposal titled: **"Evaluating the clarity and effectiveness of the National Hurricane Center's experimental probabilistic intensity forecast product"**.

The mission of NCEP is to "Deliver national and global weather, water, climate and space weather guidance, forecasts, warnings and analyses to its Partners and External User Communities. These products and services are based on a service-science legacy and respond to user needs to protect life and property, enhance the nation's economy and support the nation's growing need for environmental information". Your proposal is in support of this mission with the intent to obtain social science input regarding a new forecasting intensity distribution graphic being developed at the National Hurricane Center (NHC).

Sincerely,

Michael Farrar

Dr. Mike Farrar
Director, National Centers for Environmental Prediction
NOAA/National Weather Service (NWS)
5830 University Research Ct, Suite 4600
College Park, MD 20740