RESEARCH PROPOSAL SUBMITTED TO
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OFFICE OF OCEANIC AND ATMOPSHERIC RESEARCH

TITLE:	Evaluating the Impact of Observations from NOAA SHOUT Field Program's Global Hawk UAS Remote Sensing Instruments on Tropical Cyclone Vortex-Scale Analyses and Forecasts
INSTITUTION:	University of Miami/RSMAS/CIMAS 4600 Rickenbacker Causeway Miami, FL 33149
CO-PRINCIPAL INVESTIGATORS:	Altug Aksoy and Jason P. Dunion
PERFORMANCE PERIOD:	January 1, 2018 - June 30, 2018
PROJECT COST:	$195,734
SUBMISSION DATE:	October 20, 2017

PERSONNEL:

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1. Summary

NOAA's Sensing Hazards with Operational Unmanned Technology (SHOUT) program ran field operations during the 2015 and 2016 hurricane seasons using the Global Hawk (GH) UAS. The data impact studies we conducted during this period mainly focused on the GH dropwindsonde (dropsonde) observations. The results of these studies indicated that GH dropsondes have the potential of improving tropical cyclone (TC) analyses and forecasts, especially in the absence of data from crewed reconnaissance aircraft (Christophersen et al. 2017a, b). The proposed work here is an extension of these dropsonde impact studies and proposes to use two remote sensing instruments that were flown on the GH and collected data during the SHOUT field campaigns: the High-Altitude Monolithic Microwave Integrated Circuit (MMIC) Sounding Radiometer (HAMSR; Brown et al. 2011) and the High-Altitude Imaging Wind and Rain Airborne Radar (HIWRAP; Heymsfield et al. 2013).

For HAMSR, our group has already started a preliminary investigation of data impact using retrieved thermodynamic profiles as observations. In the proposed study, we plan to continue our work with HAMSR retrievals. In addition, we will begin tests of assimilating HAMSR microwave radiance observations directly using the Canonical Correlation Analysis (CCA) technique as outlined in Haddad et al. (2015). We expect the parallel investigation of HAMSR retrieval and radiance assimilations to be complementary in nature to evaluating their relative strengths and weaknesses and to understand how best to utilize them jointly in data assimilation (DA) to maximize the impact of the HAMSR measurements on TC analyses and forecasts.

For HIWRAP, no work has yet been done during the SHOUT project to evaluate the impacts of the measurements from this instrument on TC analyses and forecasts. Our proposed work here will therefore primarily focus on establishing robust quality control and superobservation methods to process data from this instrument and prepare them for use in NOAA's operational and research DA systems. Co-I Jason Sippel has extensive experience in the processing and assimilation of HIWRAP data obtained from the earlier years of GH operations during NASA's Genesis and Rapid Intensification Processes (GRIP) experiment (Braun et al. 2013) as summarized in Sippel et al. (2014).

2. Statement of Work

Core science objectives will focus on the two remote sensing instruments that were operational on the GH during the 2015-2016 NOAA SHOUT field campaigns: HAMSR and HIWRAP. Impact of the data from these instruments will be specifically evaluated for vortex-scale data assimilation and forecasts. For this purpose, storm position, intensity, and structure will be compared in experiments that do and don't assimilate observations from HAMSR and/or HIWRAP to assess whether their assimilation leads to improvements in analyses and forecasts over not assimilating them.

2.1. Impact of HAMSR Observations

HAMSR, like other microwave radiometers, passively detects upwelling radiation emitted from the Earth's surface, as well as hydrometeors, especially rain. This radiation may be affected by attenuation – either scattering or extinction due to absorption – and represents an integrated quantity over the instrument's field of view. In the presence of hydrometeors, electromagnetic scattering of the signal becomes complex, uncertain, and wavelength dependent. The size, shape, and amount of all hydrometeors (liquid, solid, and melting) in the field of view contribute to the scattering properties. As the features necessary for scattering calculations are often unmodeled or under-modeled by the NWP model, additional assumptions not constrained by the model are often required. Unfortunately, these assumptions can have a very large impact on the computed HAMSR brightness temperatures. Using different, reasonable, published assumptions and/or radiative transfer models with the exact same atmospheric state can lead to differences of magnitudes which can drown out the desired signal. A single-shot forward radiative transfer calculation, therefore, is unlikely to accurately represent the observations to the accuracy required for data assimilation.

In order to effectively assimilate HAMSR radiances in the presence of scattering hydrometeors, a statistical approach is necessary to constrain the uncertainty. We propose to use a previously successful approach based on canonical correlation analysis (CCA). This method involves creating a database of atmospheric profiles along forward radiative transfer calculations with multiple drop size distribution (DSD) parameters and scattering models. These parameters are chosen based on actual DSD and shape observations that give a representative, realistic spread in the forward calculations. This database leads to two corresponding sets of data: the model vertical profiles, and all channels of the brightness temperatures. The CCA technique seeks to identify relationships between the datasets that represent the maximally certain vectors, in decreasing order of R^2, known as Canonical Correlation Vectors (CCVs). These CCVs become the basis upon which observations are projected, giving a set of reduced order variables.

The proposed project will approach the assimilation of HAMSR observations from two perspectives:

a. Level-1 Radiance Data: This dataset comprises the raw microwave measurements from the HAMSR instrument. The level-1 data from the SHOUT project are processed and available online and will be used in the CCA technique as described above. As described in Haddad et al. (2015), the CCA technique involves an a priori training step to obtain CCV coefficients that are unique for the HAMSR microwave radiance measurements and the numerical model that is involved in DA. The raw data also need to be pre-processed to obtain corresponding CCVs that can then be assimilated using the calculated CCV coefficients.

b. Level-2 Retrieval Data: This dataset includes retrieved thermodynamic profiles in cloud-cleared regions. Our group has already started work to assimilate HAMSR level-2 retrievals as part of the SHOUT project, which has yielded techniques to quality-control and superob the dataset for vortex-scale assimilation. In the current project, we propose to continue our work with this dataset to improve these pre-processing techniques and carry out a detailed investigation of impacts from level-2 retrievals.

2.2. Processing of HIWRAP Measurements

During the SHOUT project, studies have yet to be conducted to assimilate HIWRAP Doppler radial wind observations into forecast models. To understand the potential impacts of HIWRAP data on vortex-scale analyses and forecasts, it is imperative to first develop robust routines to pre-process these data for quality control as well as superobbing. Similar robust procedures already exist for NOAA reconnaissance aircraft Tail Doppler Radar (TDR) Doppler wind observations (Lorsolo et al. 2013). Furthermore, Co-I Sippel has extensive experience with processing and assimilating HIWRAP wind observations from earlier NASA GRIP datasets (Sippel et al. 2014). These two strengths will be combined to develop routines to quality-control and superob HIWRAP Doppler radial wind observations. This will require adapting existing TDR superobbing routines to the downward conical scanning strategy of HIWRAP. There will also be a need to develop quality control techniques for HIWRAP's Ka- and Ku-band frequencies at 35 GHz and 14 GHz, respectively. One focus of this effort will be to develop such routines for later operational and research DA applications.

2.3. Using HIWRAP Data to Constrain Drop Size Distribution Parameters

We will also investigate the use of HIWRAP radar data to help constrain the DSD parameters needed for the calculation of HAMSR radiance CCVs. HIWRAP Doppler radar observations are sensitive to the same DSD that is viewed by the HAMSR radiometer, but due to the active ranging of the radar, additional information is available that can be used to retrieve the DSD parameters. Ideally, we will use HIWRAP to obtain collocated retrievals that would reduce the uncertainty in the DSD parameter space and potentially eliminate the need for offline assumptions in the radiative transfer models. This will be dependent upon the pre-processing (quality control, thinning/superobbing, etc.) of the HIWRAP and HAMSR datasets. Nevertheless, positive results offer the potential to improve CCV calculations because the uncertainty would be reduced and the correct CCV regime can be more easily classified and selected. For example, for a convective observation, one set of CCVs might be appropriate, while inside a stratiform region, another set of CCVs would be more applicable. Using independent coincident information from HIWRAP has the potential to provide more certainty in assigning CCVs to correct convective regimes in a TC.

3. Technical Project Plan

The proposed work will specifically focus on the impact of HAMSR and HIWRAP datasets for vortex-scale data assimilation. AOML/HRD has developed the Hurricane Ensemble Data Assimilation System (HEDAS; Aksoy et al. 2012, 2013) as a robust vortex-scale system designed for research applications. It is capable of assimilating all crewed aircraft and UAS observational datasets as well as satellite-derived atmospheric motion vectors (AMVs), thermodynamic retrievals from the NASA Atmospheric Infrared Sounder (AIRS) and GPS radio occultation (GPSRO) technique, rawindsonde profiles, Aircraft Communications Addressing and Reporting System (ACARS) measurements, and WSR-88D Doppler radar radial wind observations in a storm-relative framework (Aksoy 2013). It is also already equipped with CCV forward operators to assimilate CCV observations thanks to previous collaborative work with Co-I Jeff Steward. The numerical model will be the 2017 version of HWRF for DA cycling and deterministic forecasts. HEDAS and HWRF have been used successfully during the SHOUT project to demonstrate the potential positive value of GH dropsondes (Christophersen et al. 2017a, b).

For this proposal, we will specifically focus on the cases and data collected by the GH during the 2015-2016 SHOUT hurricane field campaigns. The datasets for both HAMSR and HIWRAP instruments are already processed by the respective science teams and available online at ftp://mwsci.jpl.nasa.gov/outgoing/epoch/ (for HAMSR) and https://har.gsfc.nasa.gov/index.php?section=62 (for HIWRAP).

The work plan is distributed into three 2-month increments for the 6-month period of the proposed project. Tasks will be carried out as follows:

<u>a. Months 1-2:</u>
1. Gather HAMSR level-1 radiance data for all available cases
2. Gather HAMSR level-2 retrieval data for all available cases
3. Gather HIWRAP level-1B data for all available cases
4. Test and optimize processing of HAMSR level-2 retrieval data
5. Begin calculation of CCVs for HAMSR level-1 radiances
6. Begin processing of HIWRAP level-1B data

<u>b. Months 3-4:</u>
1. Begin assimilation experiments for HAMSR level-2 retrieval data
2. Complete calculation of CCVs for HAMSR level-1 radiances
3. Begin assimilation experiments for HAMSR level-1 radiance CCVs
4. Continue processing of HIWRAP level-1B data

<u>c. Months 5-6:</u>
1. Complete assimilation experiments for HAMSR level-2 retrieval data
2. Complete assimilation experiments for HAMSR level-1 radiance CCVs
3. Complete processing of HIWRAP level-1B data
4. Time permitting, investigate use of HIWRAP data for DSD parameters
5. Time permitting, begin assimilation experiments for HIWRAP data

4. Deliverables

Five main deliverables are expected from the proposed project as follows:

1. HAMSR level-2 retrieval pre-processing routines: Routines to quality-control and superob HAMSR level-2 retrieval datasets will be developed and optimized for vortex-scale data assimilation.

2. HAMSR level-1 radiance CCV coefficient database: HAMSR level-1 radiance datasets will be used to calculate a CCV coefficient database for the HWRF model convective regimes. This database will be made available for HAMSR CCV assimilation in vortex-scale DA applications.

3. HIWRAP level-1B data pre-processing routines: Routines to quality-control and superob HIWRAP level-1B datasets will be developed and optimized for vortex-scale data assimilation.

4. Assessment of HAMSR level-2 retrieval data impact: A complete data impact study will be carried out for HAMSR level-2 retrieval datasets from all SHOUT 2015 and 2016 cases.

5. Assessment of HAMSR level-2 radiance CCV data impact: Case studies will be carried out to assess the impact of HAMSR level-1 radiance CCV datasets from select SHOUT 2015 and 2016 cases. Time permitting, we will attempt to extend this assessment to all cases of deliverable (4) to obtain complimentary results for direct assimilation of radiances versus indirect assimilation of retrievals for the HAMSR instrument.

5. Key Personnel

The project team has extensive experience in GH HAMSR and HIWRAP instruments as well as vortex-scale DA using aircraft observations, especially with the HEDAS and HWRF DA/modeling systems. The following individuals have been identified as key personnel to this proposal:

1. Altug Aksoy, Co-PI:	(2.5 person months for project duration.) Co-PI Aksoy (UMiami/CIMAS) will mainly be responsible for coordination and supervision of all activities related to the processing and assimilation of HAMSR and HIWRAP datasets.
2. Jason Dunion, Co-PI:	(1.0 person months for project duration.) Co-PI Dunion (UMiami/CIMAS) will be responsible to provide expertise on GH SHOUT field campaign cases and datasets as well as prepare project reports.

3. Jeff Steward, Co-I: (1.66 person months for project duration.) Co-I Steward (UCLA subcontract) will be the lead investigator for HAMSR radiance CCV calculations and their assimilation. He will also investigate the use of HIWRAP data in constraining the DSD parameters for CCV calculations and classifications.

4. Hui Christophersen, Co-I: (3.5 person months for project duration.) Co-I Christophersen will be responsible to process and assimilate both HAMSR level-1 and level-2 datasets and coordinate with Co-I Steward to carry out HAMSR radiance CCV calculations.

5. Jason Sippel, Co-I: (1.0 person months for project duration.) Co-I Sippel (AOML/HRD, in-kind contribution) will be the lead investigator for HIWRAP data pre-processing and development of quality control and superobbing routines.

6. Brittany Dahl, Co-I: (3.5 person months for project duration.) Co-I Dahl (UMiami/CIMAS) will be responsible to process HIWRAP data and develop quality control and superobbing routines.

7. Kathryn Sellwood, Co-I: (3.0 person months for project duration.) Co-I Sellwood (UMiami/CIMAS) will be responsible to process HIWRAP data and develop quality control and superobbing routines.

6. Budget Breakdown

We request a total dollar amount of $195,734 to fund the proposed research. A portion of these funds ($25,035) will be subcontracted to UCLA to cover project costs for Co-I Jeff Steward from that institution. The breakdown of the budget is as follows:

1. Personnel: The University of Miami (UM) personnel and their proposed effort and responsibilities are listed above in section (5). For the purposes of measuring % effort, we've used a base annual effort of 12 months. Total UM salary funding requested is $79,511.

2. Fringe Benefits: The UM FY18 fringe benefit rate was calculated at a 35.3% for a total of $28,471 requested.

3. Travel: The travel budget in the proposal is based on recent history regarding the amount of travel needed to conduct the research project, interact with collaborators, and present the results. UM reimburses actual travel costs for hotel and meal expenses up to a certain maximum rate. All travel must be approved by UM administration and the UM/CIMAS Director. Funding for one trip for each of the two Co-PIs and two Co-Is to present findings at an annual conference (5 days) is requested at a total estimated cost of ~$10,000 per year, with the following breakdown per trip per person (four trips total):

- Airfare: $500
- Hotel: $200 x 5 nights = $1,000
- Per Diem: $50 x 5 days = $250
- Car rental: $50 x 5 days = $250
- Conference registration: $500

→ Total: $2,500

4. Publication Costs: Funding is requested to publish two articles in peer-reviewed American Meteorological Society (AMS) journals to summarize findings from the proposed research. The AMS page charge per typeset page is $145. At 12 typset pages per article plus the Open Choice fee of $800, we estimate a cost of $2,540 per article, or a total cost of $5,080 for two publications.

5. UCLA Subcontract: The UCLA budget mainly reflects Co-I Jeff Steward's salary equivalent of 1.66-month effort ($15,272) plus 5.1% equivalent of fridge benefits ($779). Other Direct Costs include standard charges of Computer User's Fee ($33) and Technology Infrastructure Fee ($68). UCLA charges 55.0% for the indirect cost rate for $8,884. All items above add to a total UCLA subcontract budget of $25,035.

6. Indirect Costs: Currently at 26.0%, the UM indirect cost rate is directly negotiated with the U.S. government and is charged to all budget items related to UM effort ($31,996). The negotiated UM indirect cost rate for subcontracts is 40.5%, which is applied to the UCLA subcontract for subcontact indirect cost of $10,125.

7. CIMAS Admin Fee: For new proposals, NOAA requires that Cooperative Institutes and should ensure the CI includes the appropriate percentage of Task I (2.9%) in the proposal.

7. References

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Christophersen, H., A. Aksoy, J. Dunion, and K. J. Sellwood, 2017a: The Impact of NASA Global Hawk Unmanned Aircraft Dropwindsonde Observations on Tropical Cyclone Track, Intensity, and Structure: Case Studies. *Mon. Wea. Rev.*, **145**, 1817-1830.

Christophersen, H., A. Aksoy, J. Dunion, and S. Aberson, 2017b: Composite impact of Global Hawk unmanned aircraft dropwindsondes on tropical cyclone analyses and forecasts. Submitted to *Mon. Wea. Rev.* for publication.

Haddad, Z. S., J. L. Steward, H.-C. Tseng, T. Vukicevic, S.-H. Chen, and S. Hristova-Veleva, 2015: A data assimilation technique to account for the nonlinear dependence of scattering microwave observations of precipitation. *J. Geophy. Res.: Atmospheres*, **120**, 2015JD023107.

Heymsfield, G. M., L. Tian, L. Li, M. Mclinden, and J. I. Cervantes, 2013: Airborne radar observations of severe hailstorms: Implications for future spaceborne radar. *J. Appl. Meteorol. Climatol.*, **52**, 1851–1867, doi:10.1175/JAMC-D-12-0144.1.

Lorsolo, S., J. Gamache, and A. Aksoy. 2013: Evaluation of the Hurricane Research Division Doppler radar analysis software using synthetic data. *J. Tech*., **30(6)**, 1055-1071, doi:10.1175/JTECH-D-12-00161.1 2013

Sippel, J. A., F. Zhang, Y. Weng, L. Tian, G. M. Heymsfield, and S. A. Braun, 2014: Ensemble Kalman filter assimilation of HIWRAP observations of Hurricane Karl (2010) from the unmanned Global Hawk aircraft. *Mon. Wea. Rev.*, **142**, 4559–4580.

UNIVERSITY OF MIAMI BUDGET

Project Date:	01/01/2018 - 06/30/2018
Project Title:	Evaluating the Impact of Observations from NOAA SHOUT Field Program's Global Hawk UAS Remote Sensing Instruments on Tropical Cyclone Vortex-Scale Analyses and Forecasts
Agency:	NOAA UAS Task II

		YEAR 1 months	%	AMOUNT	TOTALS	
Research Staff						
1	Dunion	1.0	8%	10,165	10,165	
2	Aksoy	2.5	21%	19,687	19,687	
3	Christophersen	3.5	29%	19,124	19,124	
4	Dahl	3.5	29%	13,894	13,894	
5	Sellwood	3.0	25%	16,641	16,641	
6	Sippel ($9580, NOAA in-kind)	1.0	8%	0	0	
Graduate Students						
1	Student support					
				79,511	**79,511**	79,511
Total Salaries						
	Faculty Fringe Benefits			0	0	28,471
	Staff Fringe Benefits			28,471	28,471	
Total Salaries and Fringe Benefits				**107,982**	**107,982**	107,982
	Travel Domestic			10,000	10,000	
	Travel Foreign				0	
Other Direct Costs						
	Consultant			0	0	
	Technical supplies			0	0	
	Expandable supplies			0	0	
	Drifters			0	0	
	Subcontract			0	0	
	Student Insurance			0	0	
	Publication Costs			5,080	5,080	
	Small boat rental charges			0	0	
	ASIST/SUSTAIN laboratory fees			0	0	
	Image Processing Fee			0	0	
	Outside Services			0	0	
Modified Total Direct Costs				123,062	123,062	
Facilities & Administrative Costs			26.0%	31,996	31,996	
Subcontract	Jeff Steward (UCLA)			25,035	25,035	
Subcontract Indirect (40.5%)				10,125	10,125	
Non - MDTC						
CIMAS Admin Fee (2.9%)				5,516	5,516	
Total Project Costs				**195,734**	**195,734**	
					195,734	

UCLA BUDGET
(SUBCONTRACT TO UNIVERSITY OF MIAMI)

	Base Salary & Fringe	Monthly Rate	01/01/18 - 06/30/18 Cal. Mos.	Cost	Total Cal. Mos.	Cost
A. Senior/Key Personnel						
PI: Jeffrey Steward	$110,400	$9,200	1.660	$15,272	1.66	$15,272
	5.1%			779		779
				$16,051		$16,051
Total Salaries				$15,272		$15,272
Fringe Benefits				$779		$779
Total Salaries & Fringe Benefits			1.66	**$16,051**	1.66	**$16,051**
Equipment				$0		$0
Travel						
Domestic:				$0		$0
Domestic:				$0		$0
International:				$0		$0
Total Travel				**$0**		**$0**
Participant Support				$0		$0
Other Direct Costs						
Materials and Supplies				$0		$0
Computer User's Fee				33		33
Publication Fee				0		0
Technology Infrastructure Fee				68		68
Total Other Direct Costs				**$101**		**$101**
Total Direct Costs				**$16,152**		**$16,152**
Modified Total Direct Costs				$16,152		$16,152
Indirect Costs			Year 1: MTDC Base			
Indirect Costs (F&A)	FY 17-18	55%	$16,151.87	$8,884		$8,884
Indirect Costs (F&A)	FY 18-21	56%	$0.00	$0		$0
Total Indirect Costs				**$8,884**		**$8,884**
Total Direct and Indirect Costs				**$25,035**		**$25,035**
Amount of This Request				**$25,035**		**$25,035**

BUDGET JUSTIFICATION

Project Period | January 1, 2018 – June 30, 2018
"Assimilation of Unmanned Aerial Vehicle High Altitude MMIC Sounding Radiometer (HAMSR) brightness temperatures in the Hurricane Ensemble Data Assimilation System"

Y1 | January 1, 2018 – June 30, 2018

A. Senior/Key Person **$15,272**

Position Title & Name	Annual Salary	Months	Total
PI: Jeffrey Steward	$110,400	1.66	$15,272

Dr. Jeffrey Steward, Associate Project Scientist at UCLA, will serve as the Principal Investigator (1.66 calendar months). He will be responsible for the proper use of all awarded funds, budget issues, and is the final authority for this task.

B. Fringe Benefits **$779**

Employment Type	Composite Benefit Rate	Total
Employees & Students with Limited Benefits	5.1%	$779

Fringe Benefits - UCLA employee benefits are charged as actual costs to contracts and grants and are calculated as a percent of salaries and wages. Fringe benefit rates are derived from payroll data. A copy of the Composite Benefit Rate Assessment can be found at https://www.finance.ucla.edu/composite-benefit-rate-assessment.

C. Other Direct Costs **$101**

- Computer User's Fee is required by the University department for the usage and maintenance costs on workstations, graphic systems, printers, tape drives, and other peripherals, which will be dedicated to this research effort. Cost is $20 per month x FTE. Total cost is $33.
- Technology Infrastructure Fee is a consistently-applied direct charge that is assessed to each and every campus activity unit, regardless of funding source, including units identified as individual grant and contract awards. TIF pays for campus communication services on the basis of a monthly accounting of actual usage data. These costs are charged as direct costs and are not recovered as indirect costs. For FY16/17 and all out years going forward, the charge is $41.22/FTE/month, pro-rated. Total cost is $68.

D. Total Direct Costs: $16,152

E. Indirect Costs: $8,884

The Indirect Cost rate pertaining to this budget is 55% of Modified Total Direct Costs for on-campus research. On May 3, 2017, the University of California and the United States Department of Health and Human Services (the responsible Federal audit agency) entered into new facilities and administrative (F&A) cost rate agreement for UCLA. These indirect cost rates are applied to a Modified Total Direct Cost (MTDC) base. MTDC consists of all salaries and wages, fringe benefits, materials and supplies, services, travel and the first $25,000 of each subaward (subgrant and subcontract) regardless of the period covered by the subgrant or subcontract. A copy of the rate agreement can be found at http://www.research.ucla.edu/ocga/Documents/F_A_Rate_Agreement_5-3-17.pdf.

F. Total Direct and Indirect Costs: $25,035

G. **Total *Amount Requested*: $25,035**

UNIVERSITY OF CALIFORNIA, LOS ANGELES **UCLA**

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October 19, 2017

Altug Aksoy
University of Miami

SUBJECT: New Proposal
Principal Investigator: Dr. Jeffrey Steward

Dear Dr. Aksoy:

On behalf of the Regents of the University of California, attached please find proposal on behalf of Dr. Jeffrey Steward titled, "Assimilation of Unmanned Aerial Vehicle High Altitude MMIC Sounding Radiometer (HAMSR) Brightness Temperatures in the Hurricane Ensemble Data Assimilation System". We are requesting funds in the amount of $25,035 for the period January 1, 2018 through June 30, 2018.

If you have any technical questions regarding this proposal, please contact Dr. Steward at (310) 794-9832, or via email at jsteward@jifresse.ucla.edu. Please contact me with any administrative questions at (310) 794-0259 or via email at mbailey@research.ucla.edu.

Regards,

Miesha K. Bailey
Contract and Grant Officer

cc: Dr. Jeffrey Steward
Ms. Nancy Hom

Internal Ref. #20181515