NOAA FY 15 Joint Hurricane Testbed (JHT) program

Project Title: Improvement and Implementation of the Probability-based Microwave Ring Rapid Intensification Index for NHC/JTWC Forecast Basins

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Recipient Organization: Florida International University,
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Project/Grant Period: 09/01/2015 – 08/31/2018 (on no-cost extension)

Reporting Period: 03/01/2018 - 08/31/2018

Report Term or Frequency: semi-annual

Final Annual Report? Yes

NOAA AWARD NUMBER: NA15OAR4590199

1. ACCOMPLISHMENTS

This project was under a one-year no-cost extension. The major proposed goal was to improve the probability-based tropical cyclone (TC) rapid intensification (RI) forecast method under our JHT FY-13 project by adding two additional 37 GHz predictors on top of the original the 37 GHz ring and three 85 GHz predictors. The final product is called the **probability-based microwave ring RI index (hereafter PMWRing RII).** It was proposed to implement the PMWRing RII in the NHC and JTWC forecast basins, including Atlantic (ATL), Eastern & Central North Pacific (EPA), North Western Pacific (NWP), North Indian Ocean (NIO), and Southern Hemisphere (SH) basins. Under this major goal, there were five tasks proposed, all of which have been completed. Please see the table below for the planned vs. actuals for these tasks.

Tasks	Planned	Actuals
Task 1	*Collecting historical microwave data from AMSR-E, SSM/I, and SSMIS and calibrating their T_B's to be compatible with TMI T_B's*	Completed, although we made some changes from the original plan. We chose to we choose to treat each sensor differently to avoid the sensor inter-calibration and different sensor resolution issue. The sample size is large enough for each sensor.
Task 2	*(CIRA) Generating the SHIPS RI developmental dataset for JHT basins*	Completed for North Hemisphere basins (ATL, EPA, NWP & NIO) and Southern Hemisphere(SH) basin
Task 3	*Development of the PMWRing RII for each basin*	Completed for North Hemisphere basins (ATL, EPA, NWP & NIO) and Southern Hemisphere(SH) basin
Task 4	*Real-time testing at NHC and JTWC*	Real-time testing has been completed for both 2016 and 2017 seasons for all basins including ATL, EPA+CP, NWP+NIO, and SH basins.
Task 5	*Evaluate the real-time testing results and refine the index based on lessons learned*	2016 season: We have finished the evaluation of 2016's real-time results. Problems were identified and the algorithm was refined based on the solution of the problems, as we presented at the 2017 IHC. 2017 season: we have finished the evaluation of 2017's real-time testing results for all NHC and JTWC basins. Results were presented at the 2018 IHC.

There were 6 milestones proposed for year-1 and 7 milestones for year-2. All of them have been completed as planned. Please see the table below.

Milestones for year-1	**Planned**	**Actuals**
Milestone 1 (Sep 2015)	FIU: Generate the developmental microwave data including TMI, AMSR-E, SSM/I, and SSMIS data for ATL, EPA, NWP and NIO basins; CIRA:	Completed as planned

	Generate the developmental SHIPS RII dataset for NWP and NIO basins	
Milestone 2 (Nov 2015)	FIU: develop RI thresholds for SHIPS RII and microwave predictors for ATL, EPA, NWP and NIO basins	Completed as planned
Milestone 3 (Jan 2016)	Begin development of the PMWRing RII for ATL, EPA, and NWP/NIO basins	Completed as planned
Milestone 4 (Mar 2016)	Present preliminary results at the IHC; Mid-year report	Completed as planned
Milestone 5 (May 2016)	Complete the algorithm development and implement the real-time testing code for 2016 Hurricane/Typhoon season in ATL, EPA, NWP, and NIO basins	Completed as planned
Milestone 6 (June 2016-Nov 2016)	Real-time testing in ATL, EPA, NWP, and NIO basins	Completed as planned
Milestones for year-2	**Planned**	**Actuals**
Milestone 1 (Sep 2016)	FIU: Generate the developmental microwave data including TMI, AMSR-E, SSM/I, and SSMIS data for SH; CIRA: Generate the developmental SHIPS RII dataset for SH	Completed as planned
Milestone 2 (Nov 2016)	FIU: develop RI thresholds for SHIPS RII and microwave predictors for SH	Completed as planned
Milestone 3 (Dec 2016)	Complete development of the PMWRing RII and implement the real-time testing code for 2017 TC season for SH;	Completed as planned
Milestone 4 (Jan 2017)	Evaluate the year-1 testing results for ATL, EPA, NWP, and NIO basins	Completed as planned
Milestone 5 (Mar 2017)	Adjust the index based on real-time testing results; Present preliminary results at the IHC	Completed as planned
Milestone 6 (Jun 2017)	Complete the algorithm refinement and implement the real-time testing code for 2017 Hurricane/Typhoon season in all northern hemisphere basins	Completed as planned
Milestone 7 (Jul-Aug 2017)	Year 2 final report	Completed as planned

This project has provided training and professional development opportunities for two post-doctoral research scientists (Jon Zawislak and Cheng Tao) and three graduate students (Yongxian Pei, Margie

Kieper, and Xinxi Wang). The results of the real-time RI index was disseminated to NHC & JTWC points of contact through emails and a website at http://tcpf.fiu.edu/JHT/ during 2016 & 2017 hurricane/Typhoon season. Publications and conference presentations have been made during the funded years (please see the following section).

2. PRODUCTS

There were two products/deliverables proposed. See the table below for the planned vs. actuals:

products/deliverables	Planned	Actuals
Product 1	Code (in IDL) that will produce the PMWRing RI index	completed
Product 2	A detailed document of the guidance for running the code, and predicting RI using the 37 GHz index with the SHIPS RI index	The document for predicting RI using the PMWRing RI index with the SHIPS RI index has been completed. The document of the guidance for running the code will be done if NHC/JTWC decides to implement this algorithm operationally.
Product 3	Not planned	1) A product of the FIU PMWRing RI Index 2) Publications (please see the list below)

Publications and presentations from this reporting period (wholly or partially supported by this grant):

Pei, Y. and **H. Jiang**, 2018: Quantification of Shear-relative Precipitation Asymmetries of Tropical Cyclones Using 16-yr TRMM Observations. *J. Geophys. Res.*, **123**, 8091–8114.

Jiang, H., J. P. Zagrodnik, C. Tao, and E. J. Zipser 2018: Classifying precipitation types in tropical cyclones using the NRL 37 GHz color product. *J. Geophys. Res.*, 123, 5509–5524. https://doi.org/10.1029/2018JD028324.

Cheung, K. Z. Yu, R. L. Elsberry, M. Bell, **H. Jiang**, T. C. Lee, K.-C. Lu, Y. Oikawa, L. Qi, R. F. Rogers, K. Tsuboki, 2018: Recent Advances in Research and Forecasting of Tropical Cyclone Rainfall. *Tropical Cyclone Research and Review*, **7(2),** 106-127.

Jiang, H. 2018: Tropical Cyclone Passive Microwave Intensity Estimation (PMW-IE) Model. *AMS 33rd Conference on Hurricanes and Tropical Meteorology Session 15C*, Ponte Vedra, FL, April 16-20, 2018.

Pei, Y. and **H. Jiang**, 2018: Quantification of Shear-relative Precipitation Asymmetries of Tropical Cyclones in Different Intensity Change Stages and during the Evolution of Rapid Intensification Using 16 years of TRMM Data. *AMS 33rd Conference on Hurricanes and Tropical Meteorology Session 14C*, Ponte Vedra, FL, April 16-20, 2018.

Tao, C. and **H. Jiang**, 2018: Climatology of Precipitation Types in Tropical Cyclones using Version 7 of the TRMM PR 2A23 Product. *AMS 33rd Conference on Hurricanes and Tropical Meteorology Session 11D.6A*, Ponte Vedra, FL, April 16-20, 2018.

Wang, X. and **H. Jiang**, 2018: Evolution of Environmental Characteristics in Rapidly Intensifying and Slowly Intensifying Tropical Cyclones in the North Atlantic and Eastern North Pacific. *AMS 33rd Conference on Hurricanes and Tropical Meteorology Session 9C*, Ponte Vedra, FL, April 16-20, 2018.

Pei, Y., **H. Jiang**, K. Musgrave, J. Zawislak, and G. Chirokova, 2018: Improvement and Implementation of the Probability-based Microwave Ring Rapid Intensification Index (PMWRing RII) for NHC/JTWC Forecast – Year 3 Update, *72nd Interdepartmental Hurricane Conference/Tropical Cyclone Research Forum*, Miami, Florida, Mar 13-15, 2018.

Jiang, H., Y. Pei, and C. Tao*, 2018: Estimation of Tropical Cyclone Intensity Using Satellite Passive

Microwave Observations, *72nd Interdepartmental Hurricane Conference/Tropical Cyclone Research Forum*, Miami, Florida, Mar 13-15, 2018.

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Individuals have worked on this project include Haiyan Jiang (PI), Jon Zawislak (research scientist), Cheng Tao (Postdoc Research Associate), Yongxian Pei (PhD student, then postdoc researcher), Margie Kieper (PhD student), and Xinxi Wang (PhD student). There have been no changes in the PI and senior/key personnel since the last reporting period. FIU is partnering with CSU CIRA on this project. NHC points of contact (Chris Landsea, John Cangialosi, and Stacy Stewart) and JTWC point of contact (Brian DeCicco) have been involved.

4. IMPACT

According to the evaluation results of 2016 real-time testing & post-season re-run, our algorithm was able to provide a higher probability of detection (POD) in AL, EP, and WP basins and a lower false alarm ratio (FAR) in the WP basin than the SHIPS RII. According to the evaluation results of 2017 real-time testing & post-season re-run, both of our 37 GHz ring only RI Index and the PMW-Ring RI Index perform better than the SHIPS RI Index for the SH basin. The education and professional training impact is addressed in Section 1. None of the FIU portion of the budget has been spent in foreign countries.

5. CHANGES/PROBLEMS

No significant changes have occurred in the planned/completed work of the project.

6. SPECIAL REPORTING REQUIREMENTS

a. The project's Readiness Level:

Current: RL 6-7; At the start of project: RL 3

b. Transition to operations activities and summary of testbed-related collaborations, activities, and outcomes:

The quasi-real-time testing of the PMWRing RI index (RII) for ATL and EPA basins for NHC and NWP & NIO basins for JTWC was conducted during 2016 & 2017 seasons. The real-time forecasts were provided to NHC/JTWC points of contact through emails (only when a positive RI forecast is made) and our JHT project webpage (http://tcpf.fiu.edu/JHT/).

c. Has the project been approved for testbed testing yet? What was transitioned to NOAA?

Yes, the project has been approved for testbed testing. But it wasn't transitioned to NOAA because NHC and/or JTWC haven't decided to either transition it or not. The final decision will be made after this project is completed.

d. Test plans for the 2018 Hurricane/Typhoon season:

The project ends on 08/31/2018. There is no test plan for the 2018 season.

7. BUDGETARY INFORMATION

There are some changes in the original budget for the FIU portion of this project. We originally planned for 1.5 months of summer salary for the PI Jiang and 6 months of salary for the research scientist Dr. Zawislak. However, during year-1, only one month of salary for Dr. Zawislak was charged to the project. During year-2, the project paid 3 months of summer salary ($64515.13) for the PI Jiang during May 19, 2017-August 20, 2017. During fall 2017 and Spring 2018 semesters, the project paid 0.6 FTE of the graduate student salary for Xinxi Wang. The grant also covered 3 months of 2018 summer salary (about $65,512.41) for the PI Jiang and about $1.2K of travel expenses to the AMS Hurricane conference in April 2018.

8. PROJECT OUTCOMES

The milestones of this project and the progress towards them are discussed in Section 1, with the deliverables discussed in Section 2. The outcome of this award will be the implementation of the PMWRing RII if NHC and/or JTWC decide to transition the product, which will be decided after the project is completed (as discussed in Section 6). An additional outcome of this project is the list of products contained in Section 2.