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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Reporting Period: 09/01/2016-02/28/2017

Report Term or Frequency: semi-annual

Final Annual Report? No

1. ACCOMPLISHMENTS

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. 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); need to complete the SH basin during year-2 as planned (please see section 6 for details).
Task 3	*Development of the PMWRing RII for each basin*	Completed for North Hemisphere basins (ATL, EPA, NWP & NIO); need to complete the SH basin during year-2 as planned (please see section 6 for details).
Task 4	*Real-time testing at NHC and JTWC*	Real-time testing ongoing for the 2016 season for ATL, EPA, NWP & NIO basins; need to complete the SH basin during year-2 as planned (please see section 6 for details).
Task 5	*Evaluate the real-time testing results and refine the index based on lessons learned*	We have finished 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 IHC.

There were 6 milestones proposed for year-1 and 7 milestones for year-2. All 6 milestones for year-1 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: Generate the developmental SHIPS RII dataset for NWP and NIO basins	Completed as planned
Milestone 2	FIU: develop RI thresholds for SHIPS	Completed as planned

(Nov 2015)	RII and microwave predictors for ATL, EPA, NWP and NIO basins	
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	FIU portion completed as planned; CIRA provided a preliminary SHIPS RII dataset on Feb. 2017, but the final version is on the way
Milestone 2 (Nov 2016)	FIU: develop RI thresholds for SHIPS RII and microwave predictors for SH	Preliminary work is done using CIRA's preliminary SHIPS RII dataset, but the results will need to be revised after getting the final version of SHIPS RII.
Milestone 3 (Dec 2016)	Complete development of the PMWRing RII and implement the real-time testing code for 2017 TC season for SH;	Preliminary real-time testing at SH has started, but the code will be revised after getting the final version of SHIPS RII.
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	Not started yet. Will do it as planned.
Milestone 7 (Jul-Aug 2017)	Year 2 final report	Not started yet. Will do it as planned.

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

Kieper). The results of the real-time RI index have been 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 also been made (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	Not completely finished yet
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 at the ending period of this project by closely collaborating with NHC/JTWC folks.
Product 3	Not planned	1)A product of the FIU PMWRing RI Index 2) A real-time RI forecast website: http://tcpf.fiu.edu/JHT/; 3) Publications (please see the list below)

Publications and presentations from this reporting period:

Jiang, H., J. P. Zagrodnik, C. Tao, and E. J. Zipser 2017: What type of precipitation is represented by different color regions in the NRL 37 GHz color tropical cyclone product? *J. Geophys. Res.*, under review.

Tao, C., H. Jiang, and J. Zawislak 2016: The Relative Importance of Stratiform and Convective Rainfall in Rapidly Intensifying Tropical Cyclones, *Mon. Wea. Rev*., **145**, 795-809.

Rogers, R. F., J. Zhang, Zawislak, J., H. Jiang, G. R. Alvey III, E. J. Zipser, and S. Stevenson, 2016: Observations of the structure and evolution of Hurricane Edouard (2014) during intensity change. Part II: Kinematic structure and the distribution of deep convection. *Mon. Wea. Rev*., **144**, 3355–3376.

Zawislak, J., H. Jiang, G. R. Alvey III, E. J. Zipser, R. F. Rogers, J. Zhang, and S. Stevenson, 2016: Observations of the structure and evolution of Hurricane Edouard (2014) during intensity change. Part I: Relationship between the thermodynamic structure and precipitation. *Mon. Wea. Rev*., **144**, 3333–3354.

Jiang, H., B. You, and C. Tao 2017: Estimation of Tropical Cyclone Intensity Using Satellite Passive Microwave Observations. 71st *Interdepartmental Hurricane Conference/2017 Tropical Cyclone Research Forum*, Mar 14-16, 2017.

Jiang, H., J. Zawislak, Y. Pei, C. Tao, K. Musgrave, and G. Chirokova 2017: JHT Project 3: "Improvement and Implementation of the Probability-based Microwave Ring Rapid Intensification Index for NHC/JTWC Forecast Basins" 71st *Interdepartmental Hurricane Conference/2017 Tropical Cyclone Research Forum*, Mar 14-16, 2017.

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), and Margie Kieper (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. The impact of this project on the prediction of rapid intensification in SH will be assessed later in year 2 as part of the evaluation of real-time testing results. 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 has started in June 2016 and is still ongoing. The real-time forecasts are 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 2017 Hurricane/Typhoon season:

   I.   What **concepts/techniques** will be tested? What is the scope of testing (what will be tested, what won't be tested)?

The PMWRing RII will be tested for RI forecasts in AL, EP/CP, WP/IO, & SH basins. We'll test the code for reading different microwave satellite data. We'll also test the strategy of using SHIPS RII as a criterion in generating our probability output.

II. **How** will they be tested? What **tasks** (processes and procedures) and activities will be performed, what preparatory work has to happen to make it ready for testing, and what will occur during the experimental testing?

We'll run the real-time code separately for each basin and each satellite sensor. All the preparatory work is complete except that "Preliminary real-time testing at SH has started, but the code will be revised after getting the final version of SHIPS RII", as mentioned in section 1 above. The real-time forecasts are 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/).

III. **When** will it be tested? What are **schedules and milestones** for all tasks described in section II that need to occur leading up to testing, during testing, and after testing?
For AL, EP/CP, and WP/IO basins, the 2017 testing will start on June 1, 2017. For the SH, the formal testing will be starting on Apr. 1, 2017. We plan to apply for a 1-yr no-cost extension of this funding. That way, we'll continue the real-time testing till the 2017 hurricane/Typhoon season ends at around Nov. 1, 2017. For the schedules/milestones, please see the table in section 1.

IV. **Where** will it be tested? Will it be done at the PI location or a NOAA location?

The testing code will run at FIU, the PI's location.

V. Who are the key **stakeholders** involved in testing (PIs, testbed support staff, testbed manager, forecasters, etc.)? Briefly what are their **roles and responsibilities**?

The PI and her research team will be responsible for maintaining the testing code & running; NHC Points of Contact Stacy Stewart, John Cangialosi, and Chris Landsea and JTWC Point of Contact Brian deCicco will help evaluate the real-time results.

VI. What **testing resources** will be needed from each participant (hardware, software, data flow, internet connectivity, office space, video teleconferencing, etc.), and who will provide them?

FIU will provide all the hardware & software for testing.

VII.   What are the **test goals, performance measures, and success criteria** that will need to be achieved at the end of testing to measure and demonstrate success and to advance Readiness Levels?

The **goal** is to test the code reliability and evaluate the performance of the algorithm. The **performance measures** are the Brier skill scores (BSSs), which should show the algorithm is at least skillful (better than climatology), and ideally better than the SHIPS RII. The **success criteria** are 1) the algorithm can run smoothly in an quasi-operational environment; 2) the performance measures are met.

VIII.   How will testing **results** be documented? Describe what information will be included in the **test results final report**.

The test results will be presented in IHC 2018. They will also be written in our final report, including the statistics of the algorithm performance for 2017 hurricane/typhoon season, i.e., POD, FAR, and BSS.

7. BUDGETARY INFORMATION

No significant changes to the budget have occurred for the FIU portion of this project.

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.