NOAA AWARD NUMBER: NA13OAR4590191 (**FY 13 Joint Hurricane Testbed**)
Florida International University Project Number: 800002654

Annual Progress Report for Year-1 (Sep. 1, 2013 – Aug. 31, 2014)

Project Title: Improvement to the Satellite-based 37 GHz Ring Rapid Intensification Index

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1. Accomplishments during Year-1

1.1 Real-time testing during 2013 hurricane season and evaluations of 2013 real-time testing results

Both the real-time testing and evaluations of the real-time testing results for the 2013 hurricane season were accomplished during the first half year of year 1. Please refer to our year-1 mid-year progress report for a summary of these two accomplished items.

1.2 Real-time testing during 2014 hurricane season

Our 2014 hurricane season real-time testing started on May 15, 2014. We used the same output format as we did during 2012 & 2013 season. All the output and a readme file can be found online at an ftp site (http://tcpf.fiu.edu/JHT/). Whenever there is a positive RI forecast, an email will be sending to NHC points of contact for alert.

There are several planned tasks that were accomplished during year 1 to improve the 37 GHz ring RI index, as listed below:

1.2.1 Change the primary forecast frequency to 6-hourly (at each synoptic time)

Originally, our forecasts were made after each single microwave satellite overpass. This is a convenient choice for our researchers because the algorithm is based on each satellite input. However, as suggested by NHC folks, i.e., Dr. Mark DeMaria, NHC forecasters would rather to have this forecast at each synoptic time (every 6 hours). On 06/20/2014, we started to generate a new type of summary file to summarize all the satellite centric forecasts during the past 6 hours. For example, if all the satellite forecasts are no RI, then we give a "not RI" forecast for this synoptic time; if at least one satellite-based forecast is a "yes", then we give a RI forecast for the synoptic time. At the same time, instead of sending an email alert after *every single satellite overpass* if it gives a “yes” RI forecasts, we started to send an alert email to NHC points of contact *every 6 hours* when there is a “yes” RI forecast produced by the 37 GHz ring RI index. Instead of using the closest satellite overpass for each synoptic time, we choose to generate the 6-hourly forecast by summarizing the forecasts from all the microwave overpasses during the past 6 hours. This strategy is to avoid missing any ring feature which do not necessarily occurs closest in time with synoptic time due to satellite resolution, swath width, etc. issues.

1.2.2 Adapting the CIMSS ARCHER product for better TC center fixing

As found in 2012 real-testing, the center –fixing problem was a main factor for poor ring detections

during 2012 season, mainly for Atlantic storms. During the 2014 season, the CIMSS ARCHER product (PIs: Wimmers and Velden, JHT FY-13 project) became a real-time product. Therefore, another major improvement we made was to adapt the ARCHER storm center data. Since sometimes ARCHER produces no storm center output due to missing data or sensor problems, we still generate the linearly interpolated TC center from A-DECKS track and a re-centered lon/lat of the storm center using a simple recentering technique developed at FIU. When the ARCHER center is not available, the FIU center will be as the input of our RI algorithm. We also save all 3 center locations for each satellite overpass for after-season evaluation purpose.

1.2.3 Adding real-time AMSR2 data as an input

At the beginning of 2014 season, we were granted the access of the real-time AMSR2 data through NOAA NESDIS. So we were able to test the data format and add this sensor into our algorithm in June 2014. Now the input satellite data for the real-time 37 GHz RI index include the TMI data from NASA Goddard, and AMSR2, SSM/I, SSMIS, and WindSat data from NOAA NESDIS.

1.2.4 Implement and test the probability-based 37-GHz+85 GHz RI index

The current 37 GHz ring RI index is a "yes-and-no" type of forecast. A probability-based forecast is preferable to NHC. As proposed in our original FY-13 proposal, we will add three 85 GHz predictors in order to produce a probability-based RI index. These predictors include areas of 85 GHz polarization corrected brightness temperature (PCT) < 275 K, 250 K, and 225 K, respectively, within the inner core region. A combination of 37 GHz ring, SHIPS, and 85 GHz predictors will be used to generate the probability-based forecast. The probability-based RI index has been developed using a TMI-based database during 1998-2008 (see section 2c of the original proposal).

At the beginning of the 2014 season, we completed the implementation code and started to test the probability-based RI index in real-time, in a parallel mode with the real-time "yes-and-no" type of forecast by the 37 GHz ring only index. After a period of testing, at the time of this writing, we have added 85 GHz predictors on top of the real-time 37 GHz ring RI index. We have combined both the 37 GHz Ring Only "Yes" or "No" Forecast and the 37 GHz Ring + 85 GHz Probability-based Forecast output into one output file. Our final real-time output includes parallel forecasts from 1) 37 GHz only "yes" or "not" RI forecast for 30 kt RI threshold; 2) 37 GHz Ring + 85 GHz Probability-based forecast for 25, 30, 35 kt RI thresholds. As we have been doing, we'll send an email alert every 6-hour when there is a "yes" RI forecast by the 37 GHz only method. The readme file for the new output file format is here: http://tcpf.fiu.edu/JHT/FIU_37GHz_Ring+85Ghz_RII_README.txt.The 6-hourly forecast files can be found at: http://tcpf.fiu.edu/JHT/Summary/ (scroll down to the bottom of the page for the most recent forecast).

2. Work plan for year-2

There are four tasks to be completed for this project:

Task 1: Modify the code to read the new format of the CIMSS ARCHER product

Recently, the CIMSS ARCHER product has updated its output format. During year 2, we will modify our code to read the new ARCHER output in order to continue to use the ARCHER product.

Task 2: Adding real-time GMI data as an input

The Global Precipitation Mission (GPM) satellite Microwave Imager (GMI) data has been available to us since July 2014. During year 2, our second task will be read the GMI data and add this sensor into our algorithm.

Task 3: Refine the probability-based 37-GHz+85 GHz RI index (post-season analysis)

After the real-time testing during 2014 season, we will identify successful and failed cases. Based on lessons learned, we'll be able to refine our index to make it better functional. Also during non-hurricane seasons when real-time testing won't take place, we will add microwave data from sensors other than TMI. Our probability-based RI index could be refined based on a larger database. The current plan is to obtain AMSR-E (from http://sharaku.eorc.jaxa.jp/TYP_DB/index_e.shtml) data back to 2002 and SSM/I and SSMIS data back to 1996 (available from Remote Sensing Systems). Real-time testing will also be done during 2015 season. After the real-time testing and algorithm refinement, we plan to implement the final probability-based 37 GHz ring RI index for AL and EA basins. The final RI index will be produced and made available to NHC for operational use.

Task 4: Modifying existing IDL code to make it compatible with NHC environment

All the existing code was written in IDL. IDL is excellent for satellite data processing. But according to NHC TSB branch chief Dr. Mark DeMaria, IDL is not a good language for operational use. We plan to gradually modify our IDL code to make it more compatible with either C or Fortran. The first step as suggested by Dr. DeMaria is to make sure the data input is a separate module, so it can easily be swapped out later for data that comes from an operational data stream. The second step will be to divide the code into several modules based on functions, and try to make the major IDL module executable under Fortran or C.

<u>Project deliverables and timeline</u> based on tasks listed above:

Year 2 (September 2014- August 2015): During year 2, we will complete the four tasks one by one. All of these tasks will be done by the PI, graduate students Yongxian Pei and Margie Kieper, and post-doc researcher Jon Zawislak (to be hired on oct. 15, 2014), in collaboration with forecasters at NHC.

Upon completion of this project, the following deliverables will be provided:

- Code (in IDL) that will produce the "yes and no" type of 37 GHz ring+SHIPS RI index
- Code (in IDL) that will produce the probability-based microwave (37GHz + 85 GHz) RI index
- A detailed document of the guidance for running the code, and predicting RI using the RI index

3. Journal Papers (wholly or partially supported by this grant)

Tao, C. and H. Jiang, 2014: Distributions of shallow to very deep convection in rapidly intensifying tropical cyclones. *J. Climate*, in revision.

Zagrodnik, J., and H. Jiang, 2014: Rainfall, Convection, and Latent Heating Distributions in Rapidly Intensifying Tropical Cyclones. *J. Atmos. Sci.*, **71**, 2789-2809.

Jiang, H. and C. Tao, 2014: Contribution of tropical cyclones to global deep convection. *J. Climate*, **27**, 4313-4336.

Jiang, H., and E. M. Ramirez, 2013: Necessary conditions for tropical cyclone rapid intensification as derived from 11 years of TRMM data. *J. Climate*., **26**, 6459-6470.

Tao, C., and H. Jiang, 2013: Global distribution of hot towers in tropical cyclones based on 11-year TRMM data. *J. Climate*, **26**, 1371–1386.

4. Conference Presentations (wholly or partially supported by this grant)

Jiang, H., Y. Pei and J. Zagrodnik, 2014: Rainfall and Convection Asymmetries of Tropical Cyclones from TRMM Precipitation Radar Observations. *AMS 31st Conference on Hurricanes and Tropical Meteorology*, San Diego, California, March 30- April 4, 2014.

Kieper, M., C. Landsea, and H. Jiang, 2014: The Internal Structure of 1969 Hurricane Camille for the Atlantic Hurricane Database Reanalysis Project. *AMS 31st Conference on Hurricanes and Tropical Meteorology Session 5C.7*, San Diego, California, March 30- April 4, 2014.

Tao, C. and H. Jiang, 2014: Distributions of convection in rapidly intensifying tropical cyclones. *AMS 31st Conference on Hurricanes and Tropical Meteorology Session 6D.1*, San Diego, California, March 30- April 4, 2014.

Pei, Y. and H. Jiang, 2014: Asymmetries of Tropical Cyclone Convection in Different Intensity Change Stages as Derived from Satellite 85 and 37 GHz observations. *AMS 31st Conference on Hurricanes and Tropical Meteorology Session 9C.6*, San Diego, California, March 30- April 4, 2014.

Fischer, M., J. Zagrodnik, H. Jiang, and M. E. Kieper, 2014: An Analysis of Rapidly Intensifying Tropical Cyclones Derived from 13 Years of TRMM Data. *AMS 31st Conference on Hurricanes and Tropical Meteorology*, San Diego, California, March 30- April 4, 2014.

Jiang, H., M. Kieper, and Y. Pei, 2014: Improvement to the Satellite-based 37 GHz Ring Rapid Intensification Index. 67th *Interdepartmental Hurricane Conference/Tropical Cyclone Research Forum*, Mar 4-7, 2014.