Annual Progress Report for Year-2 (Sep. 1, 2014 – Aug. 31, 2015)
& Work Plan for Year-3 (Sep. 1, 2015 –Aug. 31, 2016)

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

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1. Accomplishments during the first half year of Year-2 (09/01/2014-02/28/2015)

Accomplishments during the first half year of year-2 were summarized in our year-2 mid-year progress report in detail. Below is a simplified summary:

1)Tasks finished during the real-time testing of the rest of 2014 hurricane season
- *Modified the code to read the new format of the CIMSS ARCHER product*
- *Added real-time GMI data as an input*

2) Conducted Post-season Evaluations: results were presented on IHC 2015

2. Accomplishments during the second half year of Year-2 (03/01/2014-08/31/2015)

2.1. Re-structure the software code

In preparation for the real-time testing in 2015 Atlantic and East+Central Pacific Hurricane season, we have restructured the software code completely. Previously, the software ran in time order as each satellite overpass file comes in. This could cause problems of missing orbits when there are two or more orbits come at the same time range. The problem was not as severe when we have less microwave sensors. But now there are 7 microwave sensors (SSM/I, SSMIS F16, SSMIS F17, SSMIS F18, WindSat, GMI, AMSR2) available, and it's necessary to run each sensor separately to avoid data missing.

The new software is separated into 7 identical running codes, one for each sensor. These codes are running in parallel on our FIU server. Each microwave overpasses is processed at its available time. The threshold of the distance between swath center and the TC center is also increased so that an overpass will be processed as long as half of the TC inner-core is covered by the overpass.

During our meeting with NHC points of contact in March 4, 2015, it was noted that the operational SHIPS runs at 01-02 Z for 00Z forecast, and A-Deck 00Z forecasts is made at 03Z RII data. Therefore, it was suggested that we should run our 6-hourly summary forecast at current synoptic time +2 h. For example, if we are forecasting 00Z, the summary should be run at 02Z in order to use the most recent run of SHIPS RII for 00Z while still being in time for the 00Z A-Deck forecast. Our software was changed accordingly.

Two parallel forecasts are provided for North Atlantic and East & Central Pacific basins:
  1. 37 GHz Ring Only "Yes" or "No" Forecast

2. 37 GHz Ring + 85 GHz Probability-based Forecast

We have also made changes in our online output folders. The output folders include */Summary/*, */Txt/*, and */Figures/*:

1) The Txt folder: The real-time algorithm runs within ~30 minutes after each satellite overpass. The RI forecasts for each satellite overpass can be access at http://tcpf.fiu.edu/JHT/Txt/"basin"/"storm ID"/ (scroll down to the bottom of the page for the most recent forecast).

2) The Summary folder: We also provide RI forecasts at each synoptic time T (i.e., 00Z,06Z,12Z,and 18Z). Satellite overpasses within T-4h and T+2h (where T is a synoptic time) is used to make forecast for synoptic time T. Each 6-h summery file is generated at 2 hours after each synoptic time (T+2h) in order to use the most recent SHIPS RII output. The 6 hourly summary for each synoptic time T from all individual forecasts from all the available satellite overpasses between T-4h and T+2h can be access at http://tcpf.fiu.edu/JHT/Summary/"basin"/"storm ID"/.

3) The Figures folder: Figure files can be access at http://tcpf.fiu.edu/JHT/Figures/"basin"/"storm ID"/. There are 6 panels in each figure: 37 GHz color product, 37 GHz color ring detection analysis,37H, 37V, 37PCT, and 85 GHz PCT field with inner core radius shown as a black-lined cirlce.

An email alert will be sent to NHC points of contact at 2 hours after each synoptic time if there is a "YES" RI forecasts by the 37 GHz ring-only RI index. For more details about the real-time testing algorithm and output, please see the updated readme file at: http://tcpf.fiu.edu/JHT/FIU_37GHz_Ring+85Ghz_RII_README.txt

2.2. Adopting ARCHER-2 code (in progress)

We have been using the CIMSS ARCHER TC center output as an important input of our algorithm. However, sometimes ARCHER real-time running could be delayed. In this kind of situation, we will not be able to get ARCHER data in time. The ultimate solution is to run ARCHER software locally at FIU. We have obtained the ARCHER version 2 Matlab code from CIMSS. We are currently working on connecting it with our IDL code.

3. Work plan for the rest of year 1 and year-2

There are four tasks to be completed for this project:

Task 1: More testing and refinement is needed to change the yes & no type of forecast to a probability-based RI Index. Both 37 & 85 GHz properties will be used & two more 37 GHz predictors will be added (not shown here, but in our FY-15 proposal).

Task 2: Continue to work on the ARCHER version 2 code.

Task 3: Modify the existing IDL code to make it compatible with NHC environment.

Task 4: Finalize the following manuscript:
Jiang, H., Y. Pei, T. Yuan, E. Zipser, and J. Kaplan, 2012: An objective rapid intensification index derived from the 37 GHz microwave ring pattern around the tropical cyclone center. *J. Geophys. Res.*, to be submitted.

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

Tao, C., and H. Jiang, 2015: Distributions of shallow to very deep convection in rapidly intensifying tropical cyclones. *J. Climate*, in press. doi: http://dx.doi.org/10.1175/JCLI-D-14-00448.1

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 very 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, 2012: Global distribution of hot towers in tropical cyclones based on 11-year TRMM data. *J. Climate*, **26**, 1371–1386.

Jiang, H., E. M. Ramirez, and D. J. Cecil, 2012: Convective and rainfall properties of tropical cyclone inner cores and rainbands from 11 years of TRMM data. *Mon. Wea. Rew.*, **141**, 431-450.

Kieper, M., and H. Jiang, 2012: Predicting tropical cyclone rapid intensification using the 37 GHz ring pattern identified from passive microwave measurements. *Geophys. Res. Lett.*, **39,** L13804, doi:10.1029/2012GL052115.

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

Jiang, H., Y. Pei, C. Tao, M. Kieper, and, J. Zagrodnik 2015: Improvement to the Satellite-based 37 GHz Ring Rapid Intensification Index—A Year-2 Update. 69th *Interdepartmental Hurricane Conference/Tropical Cyclone Research Forum*, Mar 2-5, 2015.

Jiang, H., M. Kieper, and Y. Pei, 2014: Improvement to the Satellite-based 37 GHz Ring Rapid Intensification Index. 68th *Interdepartmental Hurricane Conference/Tropical Cyclone Research Forum*, Mar 4-7, 2014.

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.

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.

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.

Jiang, H., M. Kieper, T. Yuan, E. Zipser, and J. Kaplan, 2013: Enhancement of SHIPS RI Index Using Satellite 37 GHz Microwave Ring Pattern: A Year-2 Update. 67th *Interdepartmental Hurricane Conference/Tropical Cyclone Research Forum*, Mar 5-7, 2013.

Jiang, H. and E. M. Ramirez 2012, Necessary Conditions for Tropical Cyclone Rapid Intensification as Derived from 11 Years of TRMM Data. *AGU Fall Meeting Session A23K (oral),* San Francisco, CA, December 3-7.

Kieper, M. and H. Jiang, 2012: Quantifying Intensity Forecasts for Rapid Intensification of Tropical Cyclones. *AGU Fall Meeting Session A13L (poster),* San Francisco, CA, December 3-7, 2012.

Tao, C. and H. Jiang, 2012: Contribution of tropical cyclones to global deep convection with overshooting tops. *AGU Fall Meeting Session A13L (poster),* San Francisco, CA, December 3-7, 2012.

Zagrodnik, J. P., and H Jiang, 2012: Comparison of TRMM PR and TMI Version 6 and Version 7 rainfall algorithms in Tropical Cyclones relative to the NEXRAD Stage-IV Multi-sensor Precipitation Estimate dataset. *AGU Fall Meeting Session H33C (poster),* San Francisco, CA, December 3-7, 2012.

Jiang, H., M. Kieper, and E. Zipser, 2012: The "Warm Rain" Ring Pattern and Tropical Cyclone Rapid Intensification. *NASA GRIP Science Team Meeting,* Wallops Flight Facility, VA, May 9-10, 2012, 2012.

Jiang, H., and E. M. Ramirez, 2012: Necessary Conditions for Rapid Intensification as Derived from 11 Years of TRMM Tropical Cyclone Precipitation Feature Database (TCPF). *NASA GRIP Science Team Meeting,* Wallops Flight Facility, VA, May 9-10, 2012.

Jiang, H., E. M. Ramirez, and D. J. Cecil, 2012: Convective and Rainfall Properties in the Inner Core and Tropical Cyclone Intensity Change Using 11-yr TRMM Data. AMS 30th *Conference on Hurricane and Tropical Meteorology*, Ponte Vedra Beach, FL, April 15-20, 2012.

Kieper, M., and H. Jiang, 2012: The 37 GHz Cyan Ring and Tropical Cyclone Rapid Intensification: What Does the Cyan Color Truly Represent? AMS 30th *Conference on Hurricane and Tropical Meteorology*, Ponte Vedra Beach, FL, April 15-20, 2012.

Tao, C., and H. Jiang, 2012: Climatology of Hot Towers in Tropical Cyclones Based on 12-year TRMM Data. AMS 30th *Conference on Hurricane and Tropical Meteorology*, Ponte Vedra Beach, FL, April 15-20, 2012.

Yuan, T., and H. Jiang, 2012: Evaluation of 37 GHz Microwave Ring Pattern for Forecasting Rapid Intensification of Tropical Cyclones from SSM/I, SSMI/S and AMSR-E data. AMS 30th *Conference on Hurricane and Tropical Meteorology*, Ponte Vedra Beach, FL, April 15-20, 2012.

Zagrodnik, J. P., and H. Jiang, 2012: Quantitative Comparison of TRMM Precipitation Algorithms in Tropical Cyclones. AMS 30th *Conference on Hurricane and Tropical Meteorology*, Ponte Vedra Beach, FL, April 15-20, 2012.

Jiang, H., M. Kieper, T. Yuan, E. Zipser, and J. Kaplan, 2012: Enhancement of SHIPS Rapid Intensification Index Using The 37-GHz Ring Pattern. 66th *Interdepartmental Hurricane Conference*, Charleston, SC, Mar 5-8, 2012.

Jiang, H., M. Kieper, T. Yuan, E. Zipser, and J. Kaplan, 2011: The 37-GHz Ring Pattern as An Early Indicator of Tropical Cyclone Rapid Intensification. *NASA GRIP Science Team Meeting,* Los Angeles, CA, Jun 6-9.

Jiang, H., C. Liu, and E. J. Zipser, 2011: The 13-yr TRMM-based Tropical Cyclone Cloud and Precipitation Feature (TCPF) Database. *NASA GRIP Science Team Meeting,* Los Angeles, CA, Jun 6-9.

Jiang, H., M. Kieper, T. Yuan, E. Zipser, and J. Kaplan, 2011: Improving SHIPS rapid intensification

(RI) index using 37 GHz microwave ring pattern around the center of tropical cyclones. *65th Interdepartmental Hurricane Conference*, Miami, FL, Feb. 28-Mar. 3.

Yuan, T., Jiang, H., and M. Kieper, 2011: Forecasting rapid intensification of tropical cylones in the Western North Pacific using TRMM/TMI 37 GHz microwave signal. *65th Interdepartmental Hurricane Conference*, Miami, FL, Feb. 28-Mar. 3.