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Project Title: Improvement to the Tropical Cyclone Genesis Index (TCGI)

Principal Investigator: Jason P. Dunion, Meteorologist; University of Miami/CIMAS – NOAA/HRD; jason.dunion@noaa.gov; (c) 305-720-3060

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Recipient Organization: University of Miami, 1320 S Dixie Hwy, Coral Gables, FL 33146

Project/Grant Period: 09/01/2015 - 08/31/2017

Reporting Period Start/End Date: 09/01/2016 - 02/28/2017

Report Term or Frequency: Quarterly

Reporting Timeline: Year-2 progress report

1. ACCOMPLISHMENTS

The main goal of this project is to implement improvements to the Tropical Cyclone (TC) Genesis Index (TCGI) that was transitioned to operations at the NOAA National Hurricane Center (NHC) in October 2014. TCGI is a disturbance-following scheme designed to provide forecasters with an objective tool for identifying the 0-48hr and 0-120hr probability of TC genesis in the North Atlantic basin. Progress made under this current funded project includes expanding the TCGI North Atlantic database to include the years 2001-2014, developing a new 2001-2014 Pacific (eastern north Pacific (EPAC) and central North Pacific (CPAC)) TCGI database, identifying new predictors to test in both the Atlantic and Pacific versions of TCGI, deriving an eastern/central Pacific basin TCGI utilizing predictors that were employed in the previously developed Atlantic basin version and developing an ECMWF-based Atlantic TCGI using predictors and predictor weights that were developed for the GFS version of TCGI. The following tasks were conducted and/or completed during this reporting period:

- i. Begin development of an ECMWF-based Atlantic TCGI using predictors and predictor weights that were developed for the GFS version of TCGI (April 2016)*
 - Code for testing the ECMWF-based Atlantic TCGI has been installed on the NOAA/NCEP Weather and Climate Operational Supercomputing System (WCOSS) and testing will begin in spring 2017.
- ii. Begin sensitivity testing for optimal combinations of Atlantic and Pacific TCGI predictors- GFS version (June-November 2016)*
 - New TCGI predictors using the 2001-2014 Atlantic and Pacific datasets were tested alongside ~60 other previously tested predictors. Sensitivity tests included WLLN lightning data, Tropical Overshooting Tops (only available in the

Atlantic), and several GFS-based predictors: (1) relative humidity (850-600 hPa and 1000-925 hPa), (2) moisture convergence at 850 hPa, (3) vertical wind shear magnitude and direction for the 850-500 hPa layer, (4) generalized vertical wind shear from 1000-100 hPa, and (5) vorticity x divergence at 850 hPa.

- All area-averaged predictors were calculated using the original TCGI 0-500 km search radius, as well as a smaller 0-200 km search radius. Although dependent dataset tests using the 0-200 km search radius produced superior statistics (relative to 0-500 km) for 0-48 hr TCGI forecasts, this dependent test benefitted “perfect prog forecasts” (i.e. tropical disturbance positions were known throughout the storm lifecycle), which is not representative of real-time operations. Simulated real-time testing for the years 2013-2015 indicated that TCGI had significantly less skill when the 0-200 km search radius was utilized and is likely related to track forecast uncertainty inherent in weak tropical disturbances. The skill of 0-48 hr TCGI forecasts that use both 0-300 km and 0-400 km predictor search radii will be examined in April and May 2017 to determine the optimal predictor search radius for 0-48 hr and 0-120 hr TCGI forecasts.
- Sensitivity tests were conducted to identify the optimal combination of predictors for the expanded version of the Atlantic TCGI and new Pacific TCGI. These 6 optimal predictors calculated using the 0-500 km search radius are highlighted in Fig. 1 and will be used for both the Atlantic and Pacific versions of TCGI. Figure 2 shows the Brier Skill Score for the current operational and new versions of the Atlantic and Pacific versions of TCGI.
- This project deliverable is nearing completion and is anticipated to be completed by May 2017 (~95% complete).

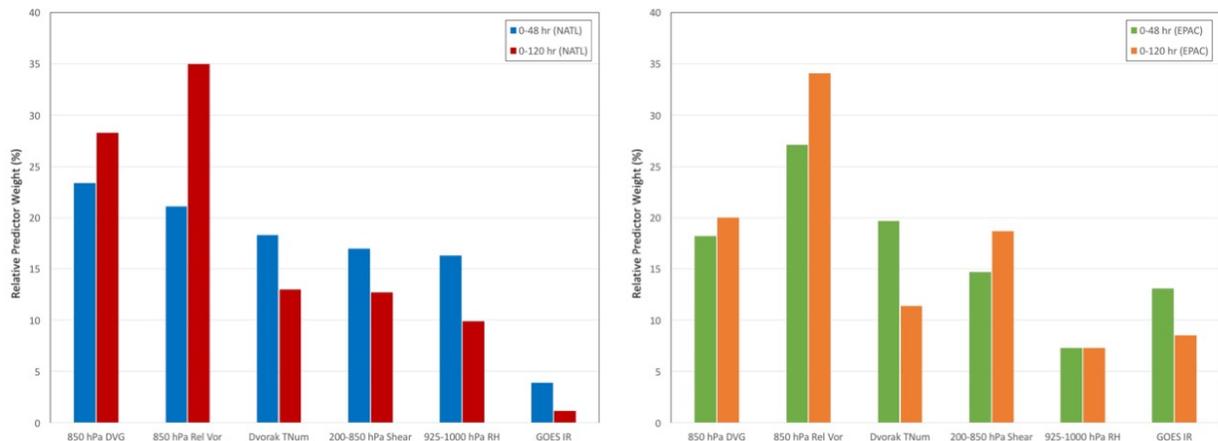


Fig. 1: Relative predictor weights for the expanded 2001-2014 Atlantic (left) and new Pacific (right) versions of TCGI. The 0-48 hr predictor weights are shown in blue (Atlantic TCGI) and green (Pacific TCGI) and the 0-120 hr predictor weights are shown in red (Atlantic TCGI) and orange (Pacific TCGI). Predictors include: 850 hPa divergence (DVG), 850 hPa relative vorticity (Rel Vor), Dvorak T-number (TNum), 200-850 hPa vertical wind shear (Shear), 925-1000 hPa relative humidity (RH), and GOES water vapor pixels <-40°C (GOES IR). Weights are based on the current 0-500 km predictor search radii that is used in the operational version of TCGI.

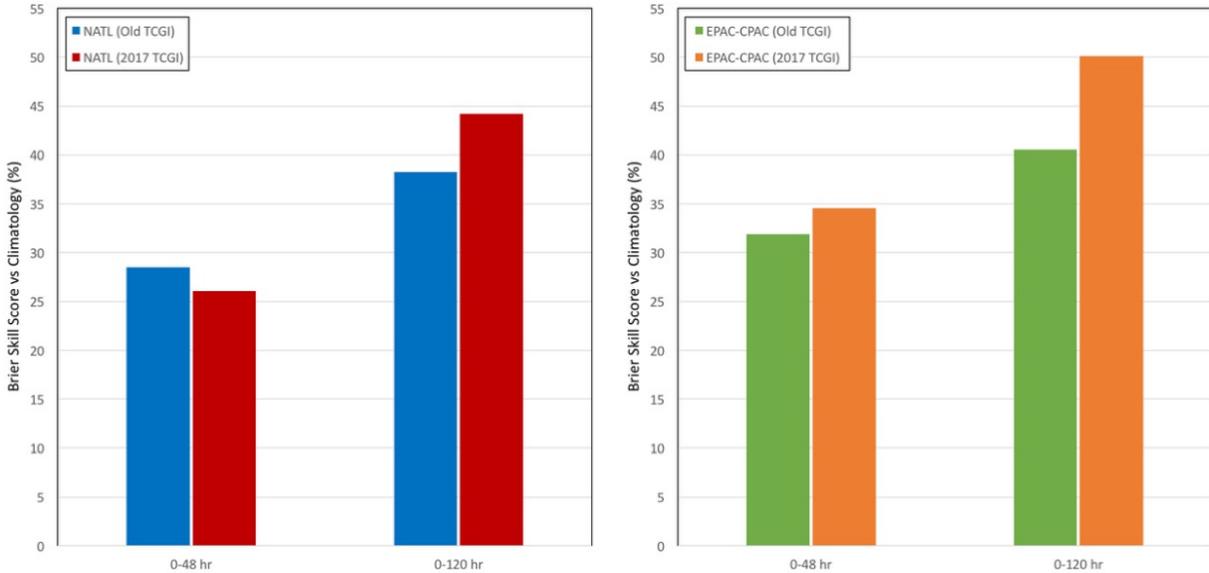


Fig. 2: Brier Skill Score (relatively to climatology) for the operational version of TCGI (Old TCGI) and the newly developed version of TCGI (2017 TCGI) for the Atlantic (left) and Pacific (right) for the 2001-2014 developmental samples.

iii. *Present year-2 results at the 71st Tropical Cyclone Operations and Research Forum (March 2017)*

- PI Dunion presented a project update at the TCORF in Miami, FL 14-16 March 2017
- Dunion, J.P., J. Kaplan, A. Schumacher, J. Cossuth, P.A. Leighton, and K. Musgrave, 2017: Improvement to the Tropical Cyclone Genesis Index (TCGI). Preprints, *71st TCORF Conf.*, Miami, FL. NOAA OFCM (Available online at <http://www.ofcm.gov/meetings/TCORF/ihc17/2017presentations.htm>]

The proposed deliverables listed above (i-iii) are either completed or on track for completion in the next 1-2 months. This project is in the developmental year-2 phase and no training or professional development efforts apply to this reporting period. The code for producing the deliverable of this project (an upgraded GFS-based TCGI for the North Atlantic, a new GFS-based TCGI for the Pacific, and a new ECMWF-based based TCGI for the North Atlantic) in on track to be turned over to NOAA in August 2017 at which time it can disseminated to NOAA NHC. Current plans include completing deliverable ii and beginning to work on the remaining set of project deliverables:

- May-Aug 2017 Perform real-time tests of 0-48 and 0-120 h Atlantic and Pacific TCGI (GFS version) on NESDIS computers at CIRA with output being made available online at: http://rammb.cira.colostate.edu/realtime_data/nhc/tcgi/
 Perform real-time tests of 0-48 and 0-120 h Atlantic and Pacific TCGI (ECMWF version) at NHC (requires computing and IT support from NHC)
- May-Aug 2017 Finish development/evaluation of prototype ECMWF-based Atlantic TCGI

- May-Aug 2017 Work with IT personnel at NOAA NHC to establish a means to more efficiently access real-time NOAA TAFB Dvorak fix information. This will help ensure increased reliability of real-time TCGI forecasts for use by NHC forecasters.
- Aug 2017 Final code for running both the Atlantic and Pacific TCGI on operational NCEP computers will be provided to NHC/NCEP IT personnel if the project is accepted for operational transition.

2. PRODUCTS

Efforts related to this project's current reporting period have produced the following:

- a. Conference Papers & Presentations
 - Dunion, J.P., J. Kaplan, A.B. Schumacher, J. Cossuth, K.D. Musgrave, and P. Leighton, 2017: Improvements to the Tropical Cyclone Genesis Index (TCGI). *71st Tropical Cyclone Operations and Research Forum*, Miami, FL, Office of Fed. Coord. For Meteor. Services and Supporting Research, NOAA.
<http://www.ofcm.gov/meetings/TCORF/tcorf.htm>
 - Dunion, J.P., J. Kaplan, A. B. Schumacher, J. Cossuth, K.D. Musgrave, and P. Leighton, 2016: The Tropical Cyclone Genesis Index (TCGI), *32nd Amer. Meteor. Soc. Conf. on Hurricanes and Tropical Meteor.*, San Juan, Puerto Rico.
<https://ams.confex.com/ams/32Hurr/webprogram/start.html>
- b. Real-Time TCGI Website (hosted by the Colorado State University-CIRA):
 - http://rammb.cira.colostate.edu/projects/tc_genesis/
- c. 2001-2014 Tropical Disturbance Database for the Atlantic and Pacific
 - An updated tropical disturbance database for the North Atlantic spanning the years 2001-2014 has been developed under this project.
 - A new tropical disturbance database for the central and eastern North Pacific spanning the years 2001-2014 has been developed under this project.
- d. Software for Analyzing Tropical Cyclone Genesis in Atlantic and Pacific
 - New software has been developed to analyze important tropical cyclone inner core and environmental predictors for forecasting tropical cyclone genesis.
 - Algorithms have been developed to analyze the 2001-2014 Atlantic and Pacific databases and will be incorporated into the upgraded (new) TCGI for the Atlantic (Pacific).

3. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

The following team members have contributed to this project (no changes to senior/key project personnel has occurred since the last reporting period and only the personnel and institutions listed below have been involved in the project during this reporting period):

PI:

Jason Dunion, University of Miami/CIMAS – NOAA/AOML/HRD, jason.dunion@noaa.gov

Co-PIs:

John Kaplan, NOAA/AOML/Hurricane Research Division, john.kaplan@noaa.gov

Andrea Schumacher, Colorado State University/CIRA, schumacher@cira.colostate.edu
Joshua Cossuth, Naval Research Laboratory-Monterey, Joshua.Cossuth.ctr@nrlmry.navy.mil

Co-Is:

Paul Leighton, NOAA/AOML/Hurricane Research Division, paul.leighton@noaa.gov
Kate Musgrave, Colorado State University/CIRA, Kate.Musgrave@colostate.edu

The following lists the tasks outlined in Sec. 1 and the project team members who contributed to those efforts:

- Task i: Co-PI Schumacher and Co-I Musgrave
- Task ii: PI Dunion and Co-PI Kaplan
- Task iii: PI Dunion

4. IMPACT

This project is in the developmental year-2 phase the important NOAA-identified impacts for this reporting period do not apply. None of this project’s awarded budget has been spent in a foreign country.

5. CHANGES/PROBLEMS

No changes to the methodology and approach for this project have been made for this reporting period. Project timelines and budget are on track and future changes are not anticipated.

6. SPECIAL REPORTING REQUIREMENTS

The readiness level for this reporting period is estimated to be RL4 to RL5. Upcoming efforts in spring 2017 will elevate the project to RL6 to RL7. The following outlines test plans for this USWRP-supported testbed project:

- I. *What concepts/techniques will be tested? What is the scope of testing (what will be tested, what won't be tested)?*
 - TC genesis forecasts from the new GFS model-based (and ECMWF model-based) Atlantic and Pacific versions of TCGI will be tested in real-time on the NOAA/NCEP WCOSS computer.

- 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?*
 - The new Atlantic and Pacific versions of TCGI will be run in a parallel real-time mode to the current operational version of TCGI. The computer code for the new TCGI has been installed on WCOSS. Project personnel will visit NOAA NHC in the late spring to test and implement the new code, at which time it will be ready for real-time testing.

- 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?*
- Testing and evaluation of the new TCGI code will be conducted in the May-August 2017 timeframe. We anticipate that real-time runs of the new TCGI will first be available in the late June to early July 2017 timeframe, at which time evaluation of the new TCGI real-time runs will begin.
- IV. *Where will it be tested? Will it be done at the PI location or a NOAA location?*
- The new TCGI will be run in parallel on both the NOAA/NCEP WCOSS computer and on servers at the Cooperative Institute for Research in the Atmosphere. Project personnel will test and evaluate TCGI on both computing systems.
- 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 entire project team will be involved in testing and evaluating the new TCGI. Feedback from this project's NHC points of contact are also vital and they will be included in the testing and evaluation process. Some support/input from IT personnel at NOAA NHC may also be required to ensure that the ECMWF model data is available in real-time for use in the ECMWF-based Atlantic TCGI.
- VI. *What testing resources will be needed from each participant (hardware, software, data flow, internet connectivity, office space, video conferencing, etc.), and who will provide them?*
- Continued access to the NOAA/NCEP WCOSS system will be required.
- 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?*
- Real-time availability of TCGI, as well as statistical assessments of TCGI's performance during the 2017 Atlantic and eastern/central North Pacific hurricane seasons will be assessed to demonstrate success and advance the readiness levels.
- VIII. *How will testing results be documented? Describe what information will be included in the test results final report.*
- Statistics of TCGI's performance during the 2017 Atlantic and eastern/central North Pacific hurricane seasons will be made and will include reliability diagrams and Brier Skill Scores. These results will be included in a final JHT report to NOAA.

7. BUDGETARY INFORMATION

This project's budget is on track and no budget changes are anticipated.

8. PROJECT OUTCOMES

The main deliverable of this project is to implement improvements to the Tropical Cyclone Genesis Index (TCGI) that was transitioned to operations at NOAA NHC in October 2014. The outcome of this effort will be to turn over the operational code for running the upgraded TCGI to NOAA in August 2017. Performance measures that are defined in this project are being achieved and are on track.