Submitted to: OAR Office of Weather and Air Quality (OWAQ)

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

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

Reporting Period Start/End Date: 03/01/2016 - 08/31/2016

Report Term or Frequency: Quarterly

Reporting Timeline: Year-1 final report of a 2 year Project

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.   *Present year-1 results at the 70th Interdepartmental Hurricane Conference (March 2016)*
   - PI Dunion presented a project update at the IHC in Miami, FL 14-16 March 2016
   - Dunion, J.P., J. Kaplan, A. Schumacher, J. Cossuth, P.A. Leighton, and K. Musgrave, 2016: Improvement to the Tropical Cyclone Genesis Index (TCGI). Preprints, *70th Interdep. Hurr. Conf.,* Miami, FL. NOAA OFCM (Available online at http://www.ofcm.gov/homepage/text/spc_proj/ihc.html.]

ii. *Begin development of an ECMWF-based Atlantic TCGI using predictors and predictor weights that were developed for the GFS version of TCGI (April 2016)*

- ERA-Interim data has been collected and is currently being formatted for use in development of ECMWF-based Atlantic TCGI.
- This project deliverable is nearing completion and is anticipated to completed by December 2016 (~75% complete).

iii. *Develop and test graphical TCGI products with real-time cases (August-October 2016)*

- Based on feedback from the NOAA NHC points of contact on this project, development of a graphical version of TCGI has been eliminated as a funded deliverable for this current project.

iv. *Begin sensitivity testing for optimal combinations of Atlantic and Pacific TCGI predictors (GFS version);(June-November 2016)*

- New TCGI predictors have been added to the 2001-2014 Atlantic and East Pacific datasets. Predictors from these new datasets include WWLLN lightning and Tropical Overshooting Tops (only available in the Atlantic). New predictors calculated from the GFS analyses include (1) relative humidity calculated at 850-600 hPa and at 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 generated using the original TCGI 0-500 km radius search radius as well as a new 0-200 km search radius.
- All of the FORTRAN code that is used to process the developmental genesis datasets and subsequently derive the TCGI was modified to make it possible to assess the significance of the eight recently developed TCGI predictors as well as to evaluate the impact of varying the averaging radius of each of the GFS-based environmental variables from 200-500 km.
- Sensitivity tests were conducted to assess the significance of the eight newly developed TCGI predictors as well as to evaluate the impact of using the environmental variables that were averaged over the smaller 200 km versus the 500 km radius that is currently employed to evaluate the GFS environmental variables in the current real-time version of the TCGI for both the Atlantic and eastern and central Pacific basins. Fig. 1 shows the impact of averaging the GFS-based environmental variables that are employed in the current real-time version of the TCGI averaged over an annulus of 200-km versus 500-km radius for a homogeneous set of cases from the 2001-2014 developmental Atlantic and central/eastern Pacific basin samples. It can be seen that employing the variables that had been averaged over the smaller 200-km averaging radius results in a substantial increase in the Brier Skill Score in both basins for both the 0-48-h and 0-120-h versions of the TCGI particularly at the 0-48-h lead time.
- This project deliverable is nearing completion and is anticipated to completed by December 2016 (~80% complete).
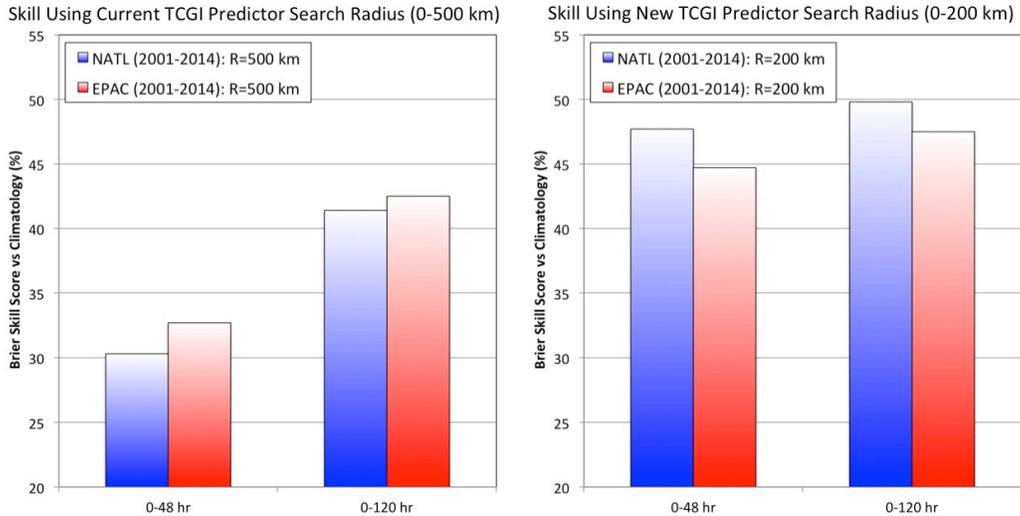
Fig. 1: Brier Skill Score (relatively to climatology) for the newly expanded 2001-2014 Atlantic (blue shading) and the newly developed 2001-2014 eastern/central Pacific (red shading) TCGI invest databases. The skill for 0-48 hr and 0-120 hr was determined using the six predictors that are currently used in the operational TCGI using the (left) current 0-500 km predictor search radii and (right) the newly developed/tested 0-200 km predictor search radius.

The proposed deliverables listed above (i-iv) are either completed or on track for completion according to the proposed timeline. This project is in the developmental year-1 phase and no training or professional development efforts apply to this reporting period. The code for producing the deliverable of this project (an upgraded TCGI for the North Atlantic and new version of TCGI for the eastern and central North Pacific) in on track tot be turned over to NOAA in August 2017 at which time it can disseminated to communities of interest. Current plans include completing deliverables ii and iv and beginning to work on the next set of deliverables:

March 2017	Present year-2 results at IHC
April 2017	Based on POC and IHC feedback, refine TCGI graphical products.
June-Aug 2017	Perform real-time tests of TCGI graphical products in-house at NHC or online at: http://rammb.cira.colostate.edu/realtime_data/nhc/tcgi/
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 TCGI for Atlantic
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, 2016: Improvements to the Tropical Cyclone Genesis Index (TCGI). *70th Interdepartmental Hurricane Conference - Tropical Cyclone Operations and Research Forum*, Miami, FL, Office of Fed. Coord. For Meteor. Services and Supporting Research, NOAA.
http://www.ofcm.gov/homepage/text/spc_proj/ihc.html
- 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):

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: PI Dunion
- Task ii: Co-PI Schumacher and Co-I Musgrave
- Task iv: Co-PI Schumacher, Co-I Musgrave, Co-PI Kaplan, Co-Leighton, and PI Dunion

4. IMPACT

This project is in the developmental year-1 phase the important NOAA-identified impacts for this reporting period do not apply. None of this project's funds have been budget has been spent in a foreign country.

5. CHANGES/PROBLEMS

Project deliverable iii (*Develop and test graphical TCGI products with real-time cases*) has been eliminated from the project deliverables at the request of NOAA NHC. No other changes other the methodology and approach for this project have been made for this reporting period. Project timelines, 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 a RL4 to RL5.

7. BUDGETARY INFORMATION

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

8. PROJECT OUTCOMES

The main deliverable 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. 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.