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

Co-Principal Investigator: Andrea Schumacher, Research Associate III; Colorado State
University/CIRA; andrea.schumacher@colostate.edu; 970-491-8057

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)*
   - This deliverable was completed during the current reporting period and real-time code was implemented and tested on WCOSS in September 2017).

ii. *Begin sensitivity testing for optimal combinations of Atlantic and Pacific TCGI predictors- GFS version (June-November 2016)*
- This deliverable is complete and was reported on in our Year-2 final report.

iii. *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 (May-August 2017): http://rammb.cira.colostate.edu/realtime_data/nhc/tcgi/*
- This deliverable is complete and was reported on in our Year-2 final report.

iv. *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-August 2017)*
- During this reporting period, the proposal team worked with the Technology & Science Branch (TSB) at NHC to obtain real-time ECMWF tracks and forecast fields at CIRA so that parallel runs can be performed. The proposal team now has access to the ECMWF decks and pack files that are needed to run the ECMWF version of TCGI in real-time.
- Real-time tests of the ECMWF TCGI were conducted during Co-PI Schumacher's visit to NHC from 28 August – 1 September 2017. The ECMWF TCGI was set up to run immediately after the GFS version of TCGI runs.
- Subsequently, a small script error was found by Co-PI Schumacher that was preventing the ECMWF files from being created beginning on 1 September 2017. Co-PI Schumacher fixed this bug during a follow-up visit to NHC in November 2017.
- The proposal team anticipates conducting additional real-time tests of the ECMWF version of TCGI on WCOSS and in parallel at CIRA in the May-July 2018 timeframe when NHC begins producing real-time forecasts of invests in the North Atlantic and EPAC/CPAC basins.

v. *Finish development/evaluation of prototype ECMWF-based Atlantic TCGI (May-August 2017)*
- See item *iv* above.

vi. *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 (May-August 2017).*
- This deliverable is complete and was reported on in our Year-2 final report.

vii. *Final code for running both the Atlantic and Pacific versions of TCGI on operational NCEP computers will be provided to NHC/NCEP IT personnel if the project is accepted for operational transition (August 2017).*
- This deliverable was completed during the current reporting period.
- Atlantic and Pacific versions of the updated GFS-based TCGI and the new ECMWF-based TCGI are running in a quasi-production environment on WCOSS. A few minor bug fixes were implemented during Co-Pi Schumacher's visit to NHC in November 2017 based on product feedback gathered since the last updates made in September 2017.

viii.   *Final code for running both the Atlantic and Pacific versions of TCGI on operational NCEP computers will be provided to NHC/NCEP IT personnel if the project is accepted for operational transition (August 2017).*

- This deliverable was completed during the current reporting period. All TCGI software has been installed and tested on the NCEP supercomputer (WCOSS) and will run in quasi-production for the 2018 season.
- Per a request from our NHC POCs, the proposal team conducted verification statistics for the new GFS version of TCGI for both the Atlantic and Pacific basins. This included performing retrospective re-runs of TCGI for the Atlantic (728 TCGI runs) and eastern/central North Pacific (882 TCGI runs) hurricane seasons for a five year period (2013-2017) and for 2017. Verification analyses include reliability diagrams and Brier Skill Scores [relative to climatology (derived from the 2001-2014 TCGI invest database)] for TCGI and NHC TWO 0-48 and 0-120-hr forecasts for 2013-2017 (Figs. 1 and 2) and 2017 (Figs. 3 and 4).
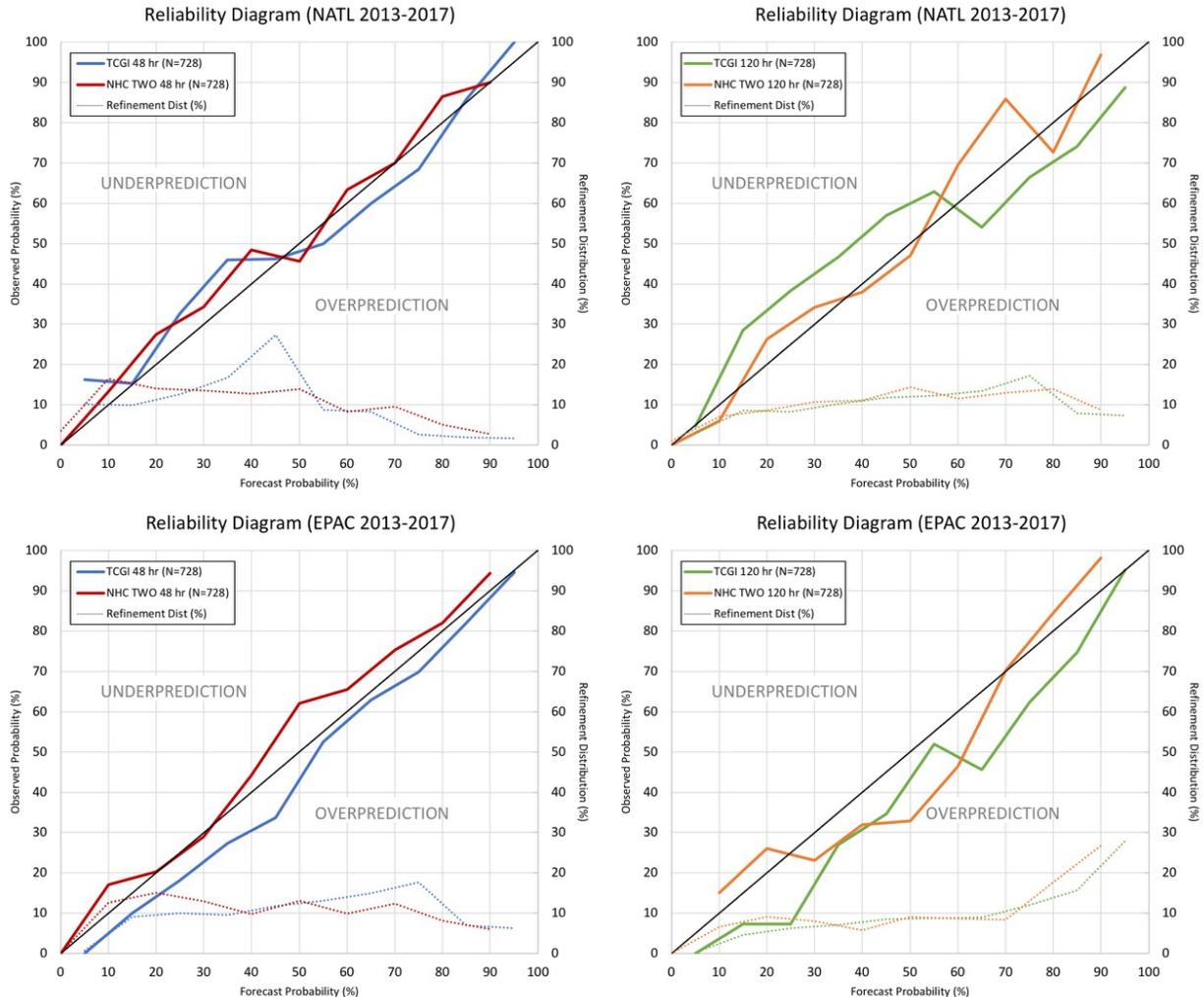

Fig. 1: Reliability diagrams for TCGI and a homogeneous sample of NHC TWO Atlantic probabilistic TC genesis forecasts for the 2013-2017 Atlantic and EPAC/CPAC hurricane seasons. The solid blue, red,

green, and orange lines indicate the relationship between the 48-hr (120-hr) forecast and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed lines indicate how the corresponding forecasts were distributed among the possible forecast values.
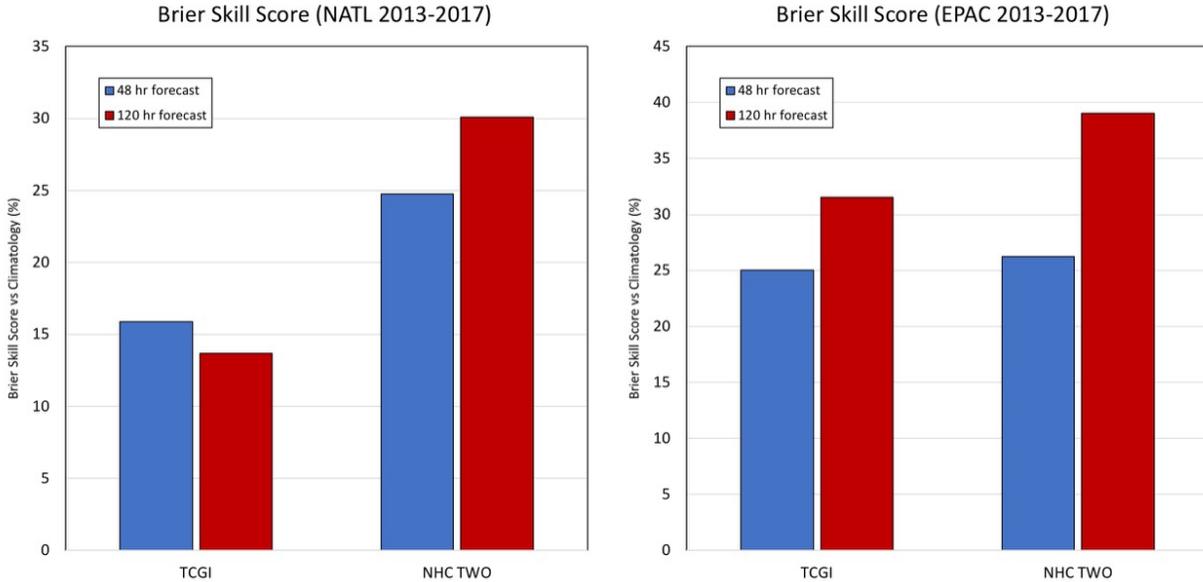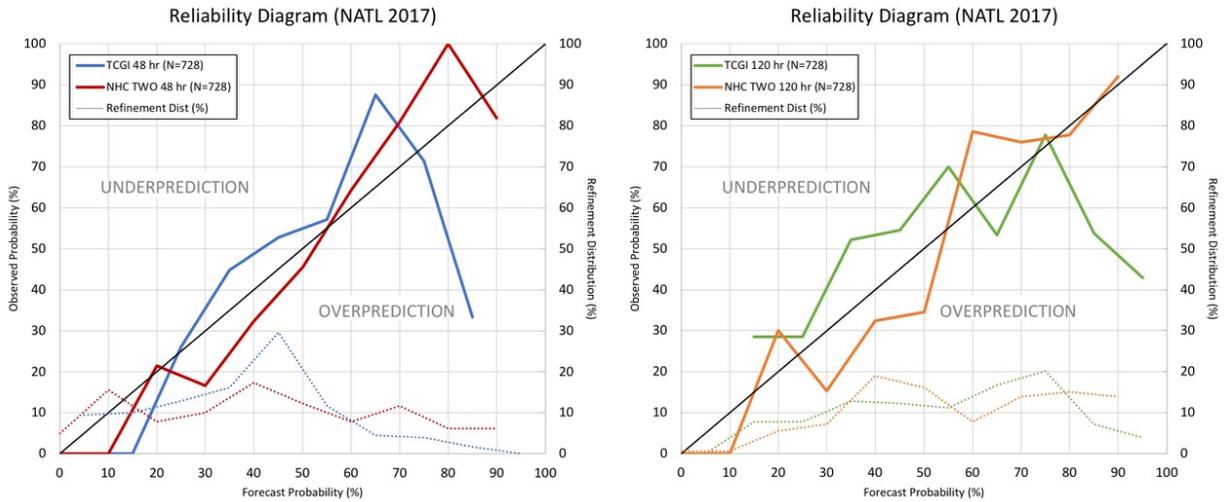

Fig. 2: Brier Skill Scores for TCGI and a homogenous sample of NHC TWO Atlantic probabilistic TC genesis forecasts for the 2013-2017 Atlantic and EPAC/CPAC hurricane seasons. Skill was measured against the climatological probability of tropical cyclogenesis determined from a 2001-2014 dataset of Atlantic and EPAC/CPAC invests.
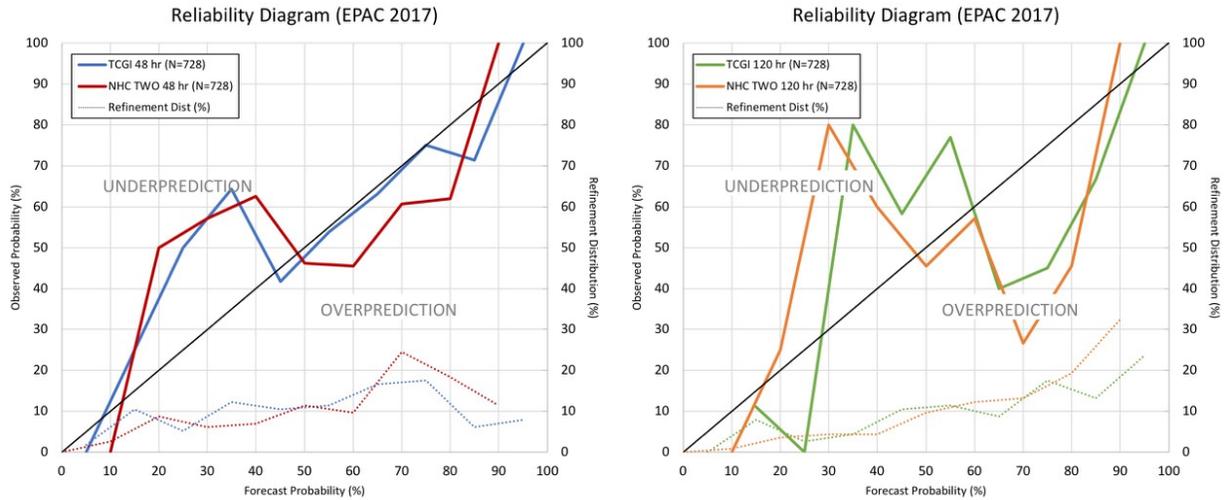
Fig. 3: Reliability diagrams for TCGI and a homogeneous sample of NHC TWO Atlantic probabilistic TC genesis forecasts for the 2017 Atlantic and EPAC/CPAC hurricane seasons. The solid blue, red, green, and orange lines indicate the relationship between the 48-hr (120-hr) forecast and verifying genesis percentages, with perfect reliability indicated by the thin diagonal black line. The dashed lines indicate how the corresponding forecasts were distributed among the possible forecast values.
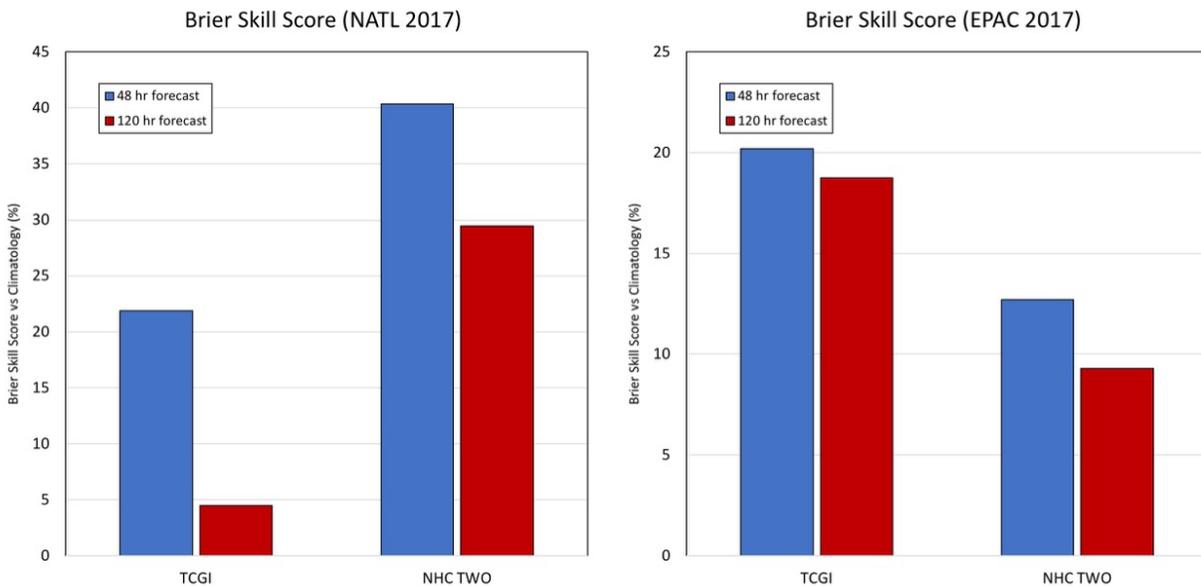

Fig. 4: Brier Skill Scores for TCGI and a homogenous sample of NHC TWO Atlantic probabilistic TC genesis forecasts for the 2017 Atlantic and EPAC/CPAC hurricane seasons. Skill was measured against the climatological probability of tropical cyclogenesis determined from a 2001-2014 dataset of Atlantic and EPAC/CPAC invests.

Deliverables *i*, *ii*, *iii*, *vi*, *vii,* and *viii* have been completed. Deliverables *iv* and *v* are nearing completion and will be carried out during the approved upcoming no-cost extension period of this project. We anticipate that all deliverables will be completed by August 2018.

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

a. Updated Real-Time TCGI Website (hosted by the Colorado State University-CIRA):
   - http://rammb.cira.colostate.edu/projects/tc_genesis/

b. TCGI Computer Code
   - Atlantic and Pacific versions of TCGI (GFS and ECMWF model versions) have been installed on WCOSS.

c. TCGI Verification Statistics
   - Verification statistics (reliability diagrams and Brier Skill Scores) for the GFS Atlantic and Pacific versions of TCGI and homogeneous sample of NHC Tropical TWO forecasts have been generated.

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: Co-PI Schumacher and Co-I Musgrave
- Task iv: Co-PI Schumacher
- Task vi: Co-PI Schumacher and Co-I Musgrave
- Task vii: Co-PI Schumacher
- Task viii: Co-PI Schumacher, PI Dunion, and Co-PI Schumacher

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. The project budget is on track and future changes are not anticipated. A few of the project timelines require assistance from TSB IT personnel at NHC and were delayed and NHC POCs also requested that the proposal team provide verification statistics for TCGI. A no-cost extension was requested and approved to allow extra time for these final deliverables to be completed.

6. SPECIAL REPORTING REQUIREMENTS

The readiness level for this reporting period is estimated to be RL5 to RL6. Upcoming efforts in fall 2017 will elevate the project to RL7 to RL8. 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 Atlantic and Pacific versions of TCGI are being tested in real-time on the NOAA/NCEP WCOSS computer.
- TC genesis forecasts from the new 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 are being run in a parallel real-time mode to the current operational version of TCGI. The computer code for the new TCGI has also been installed on WCOSS and is running in real-time.

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 (GFS) has been conducted since the beginning of the 2017 Atlantic hurricane season.

IV. *Where will it be tested? Will it be done at the PI location or a NOAA location?*
- The new TCGI is being run in parallel on both the NOAA/NCEP WCOSS computer and on servers at the Cooperative Institute for Research in the Atmosphere. Project personnel are testing and evaluating 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 is involved in testing and evaluating the new TCGI. Feedback from this project's NHC points of contact have also been vital and they have been included during the ongoing testing and evaluation process. Some

support/input from IT personnel at NOAA NHC has been 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 teleconferencing, 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 2013-2017 Atlantic and EPAC/CPAC hurricane seasons was 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 2013-2017 and 2017 Atlantic and EPAC/CPAC hurricane seasons have been made and include reliability diagrams and Brier Skill Scores. These results are included in this 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 by the end of the 2017 calendar year. Performance measures that are defined in this project are being achieved and although a few of the deliverables have been delayed, an approved no-cost extension has helped ensure that these deliverables will be completed.