NOAA Joint Hurricane Testbed (JHT)
Mid-Project Report, Year 2

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Project title: *Improvements in Statistical Tropical Cyclone Forecast Models*
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1. Long-Term Objectives and Specific Plans to Achieve Them

Although considerable effort is being made to improve dynamical tropical cyclone forecast models, statistical-dynamical models have generally provided the most accurate intensity predictions over the last few years. Four improvements to statistical-dynamical tropical cyclone forecast models were proposed in this project. These included: (1) Improving the method to estimate the intensity growth rate in LGEM so the forecasts can be extended to seven days; (2) Developing special versions of SHIPS and LGEM for the Gulf of Mexico region; (3) Improving the databases used to develop SHIPS and LGEM through use of the NCEP's new coupled reanalysis system; and (4) Developing an extended range climatology and persistence (CLIPER) model for track and intensity.

The timeline for Year 2 of this project is provided in the Appendix.

2. Accomplishments

The accomplishments on the four main project tasks are described below.

(1) A version of LGEM has been developed where all of the inputs that are only available at t=0 have been separated (persistence and GOES variables). This change reduces the number of coefficients that need to be calculated for estimating the model growth rate because most of the coefficients are no longer time-dependent, and allows the adjoint equation to be used to estimate the coefficients. This version can be run to any forecast time, in preparation for developing a 7 day version of LGEM. It was not possible to run the extended range version during the 2012 season because the 6 and 7 day NHC track forecasts were not accessible due to a security issue. Many of these were only available on hard-copy forecaster worksheets. To help create a database for post-season testing of the 7 day version of LGEM, we coordinated with James Franklin to get copies of the worksheets and digitized the 6 and 7 day positions and intensities. Code was also written to properly merge the new data with NHC's ATCF A-decks, some of which already contained 6 and 7 day forecasts. A complete set of all available 6 and 7 NHC forecasts from the 2012 season were provided to J. Franklin, and scripts have been written to re-run the 2012 season from these A-decks. The CIRA verification code was also re-written to accommodate forecasts beyond 5 days. Results from the 7-day runs will be presented at the Interdepartmental Hurricane Conference (IHC).

(2) Development has begun on specific versions of SHIPS and LGEM for the Gulf of Mexico. Results showed that the Gulf sample from 1982-2011 is too small to obtain stable coefficient for the SHIPS model beyond 48 h, but the version of LGEM with the t=0 variables separated has far fewer coefficients, and can be fitted to the small Gulf sample. Also, to help increase the Gulf sample size, Hurricane Frederic from 1979 was added to the SHIPS database. This required the use of the monthly Reynolds SST analysis instead of the weekly values because the Reynolds fields only go back to 1981. This Gulf version of the LGEM will be tested as part of the 7-day LGEM runs described above for the Gulf cases from the 2012 season. Preliminary results will be presented at the IHC.

(3) The new NCEP climate reanalysis fields from 1979 to 2009 were obtained from NOAA/ESRL. Versions of SHIPS and LGEM were developed from this data with an increased resolution (1 deg), but, unfortunately, not full resolution (0.5 deg) due to processing speed limitations. Even with this restriction, the fit of the observed intensity changes for the dependent sample showed a significant improvement compared with using the older 2.5 deg reanalysis fields in the SHIPS sample prior to 2000 and 2.0 deg resolution operational analysis for 2000 and later. Results also showed that the new reanalysis thermodynamic fields are much more consistent with current GFS operational analyses and eliminated the need to include a relative humidity bias correct in the developmental data for the old reanalysis cases. Despite these improvements with the dependent sample, tests on cases from 2007-2011 with operational input did not show this improvement, and, in fact, showed a small degradation. The problem appears to be related to the use of the lower resolution (2.0 deg) GFS forecast fields that are available from the SHIPS database for reruns. To allow for more consistent tests, the 1.0 deg GFS forecast files were collected during the 2012 season, so the model developed from 1.0 deg data can be tested with 1.0 deg forecast fields. Additional 1.0 deg GFS forecast fields from 2010 and 2011 are being obtained from the nomads system to increase the test sample size. This is a slow process since only a few days of forecasts can be ordered at time, but the plan is to have a large enough sample to adequately test the high resolution version of the models before the start of the 2013 season.

(4) The development of the new extended range baseline models is complete. The climatological track and intensity models use a trajectory approach (called T-CLIPER). The storm motion for the track forecast is determined from a time weighted average of the initial motion vector and a long term monthly climatology (1982-2011) of observed storm motion. The intensity forecast is from a version of LGEM with the MPI estimated from the climatological SST and the growth rate from a climatological value modified by persistence. To ensure T-CLIPER can run any time of year, the motion vector and growth rate climatology must be available over the entire Atlantic and east/central Pacific domains for each month of the year. For this purpose it was necessary to combine all cyclone cases from Jan-Apr, and to add the off season (Dec-May) Atlantic cases from 1946-1981.

The T-CLIPER model was implemented on the NCEP IBM and was in run real time for most of the 2012 season out to 10 days. The missing cases from the early part of the

season were provided to J. Franklin for inclusion in the final version of the A-decks. As an initial test, the 2012 T-CLIPER runs were compared with the current operational baseline models SHIFOR and CLIPER out to 5 days. Figure 1 shows the percent difference of the T-CLIPER and SHIFOR intensity errors and T-CLIPER and CLIPER track errors for the 2012 Atlantic sample. This figure shows that the T-CLIPER track and intensity errors were up to 15% smaller than those from these baseline models in the short ranges but up to about 15% larger at the longer times. This variability was somewhat larger than was seen during the model development for a test sample that included five years. This comparison will be repeated when the final best tracks are completed, and for the east Pacific runs.

The SHIFOR model does not include inland decay. A version called decay-SHIFOR does include inland decay based on the CLIPER track. That version (called OCD5 when combined with the CLIPER track) is not run in real time, but is generated by J. Franklin as part of the final best track preparation for use as an intensity skill baseline. The T-CLIPER intensity errors will be compared to those from OCD5 when the OCD5 forecasts become available with the final A-Decks for the Atlantic and east Pacific.

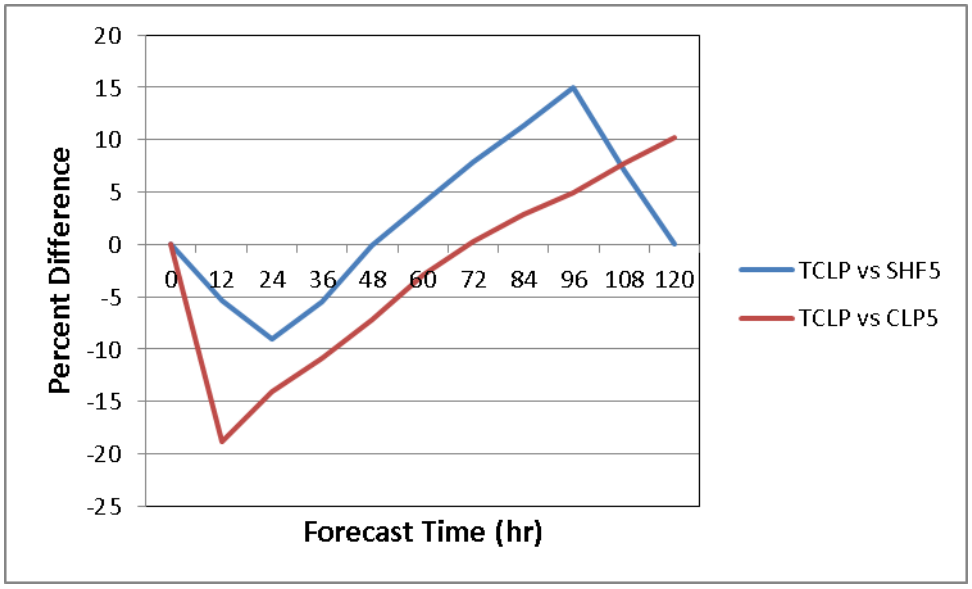

Figure 1. The percent difference between the average T-CLIPER track and intensity errors compared with those from SHIFOR and CLIPER, respectively. The percent difference is negative when the T-CLIPER errors were smaller.

3. Plans Second Half of Year 2

The testing and evaluation of the 7 day and Gulf versions of LGEM will be completed. The tests of the version of SHIPS and LGEM developed from the new reanalysis fields should also be completed. The new T-CLIPER baseline model will be compared with the OCD5 forecasts when those become available. Given the larger than expected errors of T-CLIPER compared with those from CLIPER and SHIFOR for 2012 at the longer

ranges, some additional years might be rerun to see if this is a just due to the use of a smaller sample than in previous tests (one year versus five years), or a consistent feature. If this a consistent feature, some reformulation of T-CLIPER might be needed.

Appendix
Year 2 Project Timeline

Aug 2012 – Implement Gulf-specific SHIPS/LGEM in parallel runs at CIRA
Sep 2012 – Begin development of LGEM/SHIPS with new high resolution database
Dec 2012 – Evaluate experimental models from 2012 season
Feb 2013 – Complete LGEM/SHIPS from new database and test on cases from 2011-2012 seasons
Mar 2013 – Present results at the IHC
May 2013 – Prepare all experimental statistical models for 2013 season (adjoint LGEM, Gulf-specific, extended baseline and SHIPS/LGEM from new database)
July 2013 – Evaluation of experimental models
July 2013 – Submit final report