NOAA Joint Hurricane Testbed (JHT)
Final Report, Year 1

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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. Recent research has indicated that there is potential for further improvement of statistical-dynamical intensity forecasts. In this project, several improvements are proposed to the operational Statistical Hurricane Intensity Prediction Scheme (SHIPS) and the Logistic Growth Equation Model (LGEM). These improvements include the following: (1) Separating the persistence component of LGEM from the other inputs that are available throughout the forecast period, which allows the model to be run to any forecast length and the assimilation of the observed intensity up to the forecast time; (2) Developing versions of the SHIPS and LGEM models specifically for the Gulf of Mexico region; and (3) Improving the databases used to develop SHIPS and LGEM through use of the NCEP's new coupled reanalysis system. The project also includes a fourth task (4) to develop extended range versions of climatology and persistence models for track and intensity to be used as baselines for evaluation of other more general models beyond 5 days. A trajectory approach will be used for the new baseline models.

The timeline for Year 1 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. As part of this development, a method to further reduce the number of predictors is being tested. The predictors in LGEM are used to estimate the maximum potential intensity (MPI) and the growth rate. In the current operational version of LGEM, the MPI is estimated from the SST, and 18 other predictors are used to estimate the growth rate. In the new formulation, a more general MPI formula based on the theory of K. Emanuel is being tested. The new MPI is a function of CAPE modified by entrainment. The only free parameter is the

entrainment coefficient, which is parameterized in terms of shear. This formulation is more physically based, and much better represents the nonlinear interaction between shear and dry air. This version requires further modification of the adjoint, which has been derived and is in the process of being implemented. It is anticipated that this version of LGEM will be ready for preliminary real time tests by the 2nd half of the 2012 season. This version can also be run to 7 days.

(2) Development has begun on specific versions of SHIPS and LGEM for the Gulf of Mexico. Initial fits to the developmental data show that for the 1982-2011 sample, the number of cases that remained within the Gulf of Mexico for 24 h is 755, but decreases to just 48 by 96 hr. Thus, it will be necessary to restrict the range of the Gulf-specific SHIPS to about 48 hr. However, with the new formulation of LGEM described above, most of the coefficients are not time dependent, and are derived by fitting the full life cycle of each case. With this version of LGEM it will be possible to run the Gulf specific version to any forecast time. Development of the Gulf-specific models will continue in year 2 of the project.

(3) The new NCEP climate reanalysis fields back to 1979 were obtained from NOAA/ESRL. The grib files have been converted to the form used by the SHIPS and LGEM diagnostic code. Although the grib files include 0.5 deg lat/lon resolution, the storage and processing requirements at that resolution was not feasible for SHIPS and LGEM without a major reformulation of the code. Initial tests were performed 1 deg lat/lon resolution, which is still a considerable improvement over the current version, which was developed from a combination of 2.5 deg lat/lon resolution reanalysis fields (1982-1999) and 2 deg operational analyses (since 2000). The results of these tests showed that for the dependent data, the variance explained by fitting the model coefficients to the new reanalysis fields increased by a significant amount (up to several percent). Some of the problems with the old reanalysis fields were also resolved, including the systematic moisture bias. Encouraged by these results, all Atlantic cases from 2007-2011 were run using the SHIPS/LGEM models derived from the new reanalysis fields, but with operational input (forecast tracks instead of best tracks, GFS forecast fields instead of reanalysis fields). Unfortunately, the results with the new coefficients degraded the SHIPS and LGEM forecast by up to 10%. Further research will be performed in year 2 to better understand this result, and to determine if the encouraging results from the dependent sample can be realized with real time input. One hypothesis for the disappointing results is that for the tests with the real time input, the GFS forecast fields with 1 deg lat/lon resolution were not available in the SHIPS database, so the 2 deg resolution fields were used. It is possible that the incompatibility between the resolution of the developmental new reanalysis fields and the operational GFS fields is responsible for the reduction in skill of the forecasts developed from the new reanalysis fields, but run with the operational forecasts. Data collection of 1 deg operational GFS forecast fields began at the start of the 2012 season, which will be used to test the new models in a more consistent way in year 2 of the project.

(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 climatology (1982-2011) of observed storm motion. The intensity forecast is from a version of LGEM, where the MPI is estimated from the climatological SST and the growth rate is from a climatological value modified by persistence. A Barnes analysis with an e-folding radius of 1500 km was used to smooth the climatological motion vectors and growth rate fields. Separate analyses were performed for each month, which are time interpolated to the date of each forecast case in T-CLIPER. 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 1946-1980.

The T-CLIPER model was implemented on the NCEP IBM and is being run is real time for the 2012 season. A version was also provided to J. Franklin for additional testing. The real time version is being run out to 10 days for the initial evaluation.

3. Plans Year 2

The development of the adjoint version of LGEM that runs to 7 days will continue in preparation for real time tests during the latter part of the 2012 season. Work will also continue on the Gulf-specific versions of SHIPS and LGEM. Versions of SHIPS and LGEM with the new reanalysis fields will be compared to those with the old reanalysis input for 2012 cases using the 1 deg operational GFS fields that are now being collected. The new baseline model (T-CLIPER) will be evaluated at the end of the 2012 season and compared with the operational CLIPER and SHIFOR models out to 5 days.

Appendix
Year 1 Project Timeline

Sep 2011	Begin collection of new NCEP reanalysis fields
Nov 2011	Collection of 0.5 deg lat/lon operational files for selected cases to test impact of GFS resolution
Dec 2011	Complete the development of extended range baseline models
Jan 2012	Complete the development of the adjoint version of LGEM
Feb 2012	Perform tests of adjoint LGEM and baseline models on 2011 cases
Feb 1, 2012	Mid-year progress report due
Mar 2012	Report preliminary results at the IHC
Apr 3, 2012	Renewal proposal due
Apr 2012	Begin development of Gulf-specific models
Jun 2012	Implement adjoint LGEM and baseline models for real-time testing
Sep 3, 2012	Annual report due