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IMPROVEMENTS IN TROPICAL CYCLONE TRACK AND INTENSITY FORECASTS USING A BOGUS VORTEX

Morris A. Bender, Rebecca J. Ross, Yoshio Kurihara and Robert E. Tuleya
Geophysical Fluid Dynamics Laboratory/NOAA
Princeton University, P.O. Box 308
Princeton, New Jersey, 08542

1. INTRODUCTION

The initialization technique proposed by Kurihara, et al. (1991) to specify the initial storm structure of tropical cyclones was tested with the GFDL high resolution movable nested grid hurricane model. The cases studied were Hurricane Gloria (1985) in the Atlantic basin and Hurricane Gilbert (1988) in the Gulf of Mexico. In order to determine the initial profile of the tangential wind, the scheme uses available observations of the storm intensity (maximum low level winds and minimum sea level pressure), as well as parameters related to storm size such as radius of maximum winds, radius of gale force winds, or other wind observations that are available. The scheme has enabled model integrations to begin with a much more realistic storm structure and a more accurate storm position and intensity.

The resulting track forecasts will be shown for several cases integrated with the bogus vortex as well as integrations run with the vortex which was originally resolved by the NMC global analysis. Comparisons will be made between the two sets of experiments. Finally a brief discussion will be made concerning the storm structure which evolved during one of the integrations starting from a specified bogus vortex.

2. DISCUSSION OF RESULTS

Results indicate that the proposed technique has dramatically improved the track forecasts, compared to integrations starting from global data sets in which the vortex structure was not well resolved or was much too weak and unrealistically large. The forecast errors are summarized in Table 1 for four sets of integrations of the nested grid model. Each set of experiments included both the integrations which started from an initial field which contained the original vortex resolved by the NMC global analysis and the new initial field with the specified vortex. Three sets of the integrations involved Hurricane Gloria, beginning at three different starting times (0000 UTC 25 Sept., 0000 UTC 24 Sept., 1200 UTC 22 Sept.) and Hurricane Gilbert beginning at 1200 UTC 14 Sept.. The average forecast error during the first 12 and 24 hours of model integration for the 4 caes with a bogus vortex was about one-third the forecast error of the integrations starting from the global analysis. In the first experiment, the forecast error remained below 70 km for the first 2 days of the forecast.

The storm tracks for two sets of integrations are shown in Fig. 1 (0000 UTC 25 Sept. starting time) and Fig. 2 (0000 UTC 24 Sept. starting time). Again we note the dramatic improvement in the forecast. Most of this improvement resulted from the elimination of the erratic storm motion which occurred during the first 48 hours of the integrations using the global analysis, during which time the large vortex underwent a "spin-up" process and adjusted to the much finer resolution of the limited area model. Because the bogus vortices were generated using

Table 1 Summary of the forecast error for each experiment.

TIME ——→	12	24	36	48	60	72h
			FORECAST ERROR IN KM:			
GLORIA (0000 UTC 25 SEPT., 1985):						
CLIPER	60	119	213	286	---	1023
NMC	111	155	6	81	103	280
BOGUS	14	19	39	68	167	380
GLORIA (0000 UTC 24 SEPT., 1985):						
NMC	150	124	147	198	239	200
BOGUS	54	90	128	98	61	39
GLORIA (1200 UTC 22 SEPT., 1985):						
CLIPER	123	259	349	402	---	620
NMC	183	317	445	513	492	395
BOGUS	77	93	171	275	290	249
GILBERT (1200 UTC 14 SEPT., 1988):						
NMC	80	118	140	62	76	114
BOGUS	18	43	78	142	277	264
AVERAGE:						
NMC	131	179	185	214	228	248
BOGUS	40	61	104	146	193	233

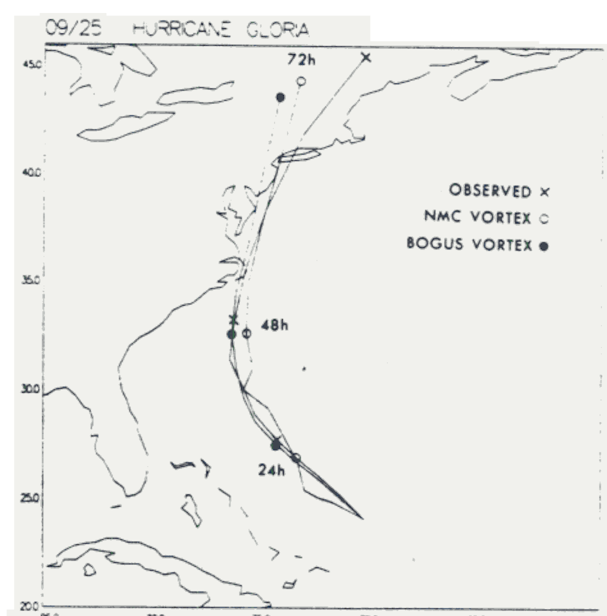

Fig. 1 The 72h storm track for the experiments starting on 0000 UTC 25 Sept.,1985 with the specified vortex and with the vortex resolved by the NMC global analysis. The best track of the National Hurricane Center is also plotted for comparison.

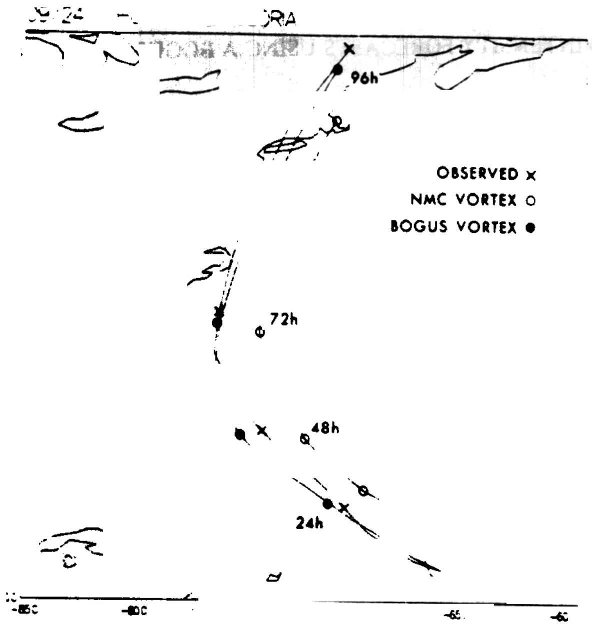

Fig.2 The 96h storm track for the experiments starting on 0000 UTC 24 Sept., 1985 with the specified vortex and with the vortex resolved by the NMC global analysis.

our prediction model and thus were well adapted to the model resolution and physics, no spin-up occurred.

In the second experiment (Fig. 2) which had a 96h forecast error of 125 km, we were also able to correctly predict changes in the storm intensity to a first degree. For example, during the last two days of this forecast, the model storm underwent gradual weakening from a minimum central pressure of 924 mb to a minimum central pressure of 975 mb by the end of the experiment . In contrast the deepest minimum central pressure (919mb) for Hurricane Gloria was observed about one day earlier, at about 0000 UTC 25 Sept., with a central pressure of 986 mb on 0000 UTC 28 Sept. Since the storm intensity is quite sensitive to the initial moisture field, any improvements in intensity prediction were certainly in part due to the more realistic moisture field of the bogus vortex generated by our scheme.

More realistic structural changes in the specified vortex occurred as the model storm accelerated to the north, as opposed to the experimnet run from the global analysis. For example, throughout this period the wind field of the model storm gradually broadened. The radius of maximum wind measured at model level 14 (σ = .856) increased from about 60 km on the 25 Sept. to about 90 km about 48h later (Fig. 3). By the time of landfall over Long Island, the radius of maximum wind had increased to over 150 km. From Fig. 3 we can also observe that as the model storm began to approach the east coast of North Carolina, the strongest winds occurred on the east side of the storm, over the ocean. As the model storm continued to move north and the center eventually moved over central Massachusetts, sustained low level winds of over 35 m s^{-1} occurred along the Massachusetts coast well east of the storm center. Strong winds indeed occurred in this region as Hurricane Gloria moved over Massachusetts, with one value of 36 m s^{-1} observed.

Finally, it is interesting to note that in all the 6 forecasts of Hurricane Gloria, both with and without a specified vortex, the southern eye wall of the model storm began to weaken as the model storm moved up the coast, with no significant precipitation eventually occurring south of the storm . It appears that this structure change was due primarily to the influence of the large scale flow on the vortex.

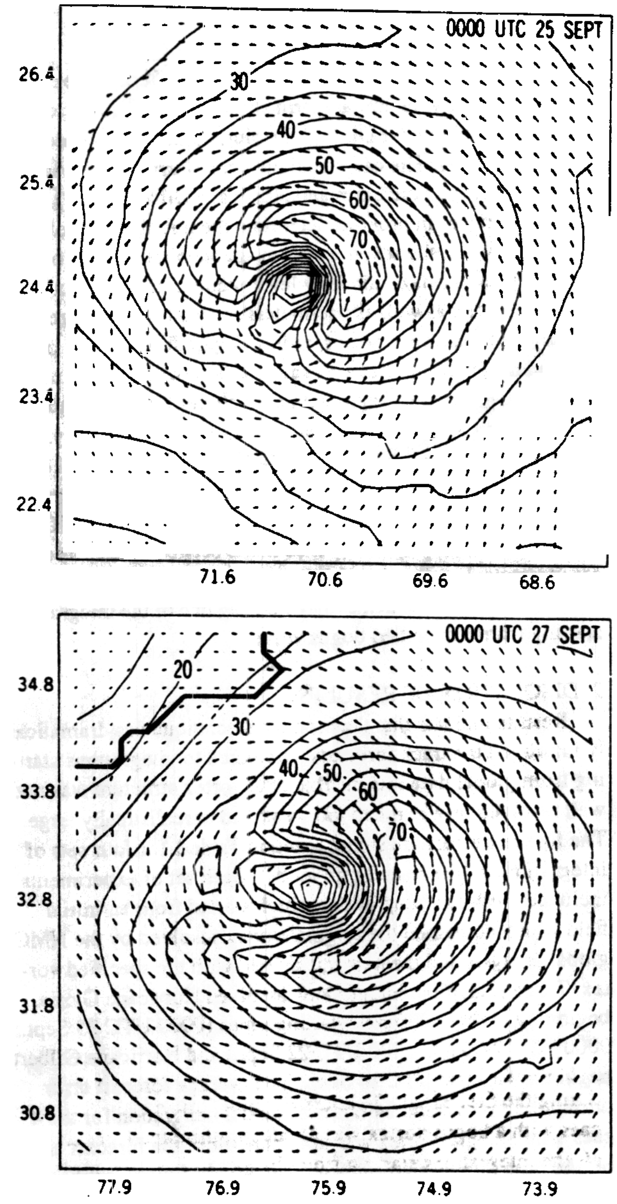

Fig. 3. Distribution of horizontal wind vectors and wind speed (m s^{-1}) at model level 14 (σ=.856) at 24 h (0000 UTC Sept. 25) and 72h (0000 UTC Sept. 27) of the forecast, for the experiment starting on 0000 UTC 24 Sept. with a bogus vortex.

3. REFERENCES.

Kurihara, Y., R.E. Ross and M.A. Bender, 1991: Toward improvement of the dynamical prediction of tropical cyclones: A hurricane model initialization scheme. To be presented in the *19th Conference on hurricanes and tropical meteorology.*