Further Changes to the 1998 NCEP Operational MRF Analysis/Forecast System:

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***07 Oct 1998:*The changes described below were implemented on 5 Oct 1998 at 1200Z.**

Problems have arisen in the operational T170L42 MRF Analysis/Forecast System, which was implemented on 15 June 1998 and updated 21 July. The symptoms were a general decline in forecast quality as measured objectively by the standard statistics and noted subjectively by forecasters. It was also noticed that the analysis was not drawing well for the data. Since limited computer resources have precluded testing any improvements at full resolution, we have therefore prepared a reduced-resolution version of the system, tested it in parallel with the operational version and scheduled it for emergency implementation on 28 Sep.*(see above)

This new parallel version of the NCEP MRF has been running routinely since 00Z 1 September. It contains a reduction in resolution from T170/L42 to T126/L28 and additional iterations of the analysis to enable it to draw closer to observations. Although it is customary to allow much longer periods of pre-implementation testing of significant model changes, it was considered prudent to accelerate the implementation in this case due to the consistently superior performance of the parallel run and the increasingly obvious shortcomings of the T170.

Changes to be implemented

- Resolution reductions: Operational has T170L42 through 84 hours, then T126L28 through 168 hours; the new model will star at T126L28 through 168, then T62 to 384 hours as before.
- Iterations in analysis increased from 75 to 200 for better convergence.
- Physics kept the same as in the operational model (see TPB 449) except that an error in the ice albedo is corrected and the roughness lengths over land for heat and momentum are set equal.
- Observation error variances corrected to allow analysis to draw more closely to data

Comparison of new model with the operational

The improvements noted in the new model are associated mainly with better fits to the observed data. The following series of charts shows the geographical distribution of fits of the analysis, the six-hour guess and the 48-h forecast to rawinsonde observations ("OBS") for the operational ("FNL") and parallel ("PRY") systems, top and bottom respectively, averaged over nine days. This is done for the 850-mb temperature in Fig. 1a, Fig. 1b and Fig. 1c; the 250-mb windspeed in Fig. 2a, Fig. 2b and Fig. 2c; and the 500-mb height in Fig. 3a, Fig. 3b and Fig. 3c; Vertical profiles of fits to the data averaged over the globe for a 13-day period are shown for temperature in Fig. 1d and vector wind in Fig. 2d It is apparent both from the geographical plots and the profiles that the better fits to data in the guess and analysis are associated with better forecasts out to 48 hours.

The increase in the quality of the forecasts resulting from these improvements is quite prominent in verifications against analyses, such as in Fig. 4, a time series of 500-mb anomaly correlations for the operational (MRF), the parallel (Y) and the ECMWF five-day forecasts in the Northern and Southern Hemisphere extratropics, each verified against its own analyses. The MRF performed very poorly over the test period, while the Y was

consistently much closer to the ECMWF. Fig. 5a is a time series of 1-5 day Northern Hemisphere anomaly correlations for MRF (solid line) and PRY (dashed line) forecasts. The PRY is superior at all forecast lengths for virtually every case. Fig. 5b is an average of the cases presented in Fig. 5b further broken down into zonal wave number groups and with the results from the UKMO and FNOC models added (FNOC has a few cases missing). It can be seen that, although suffering some from lesser resolution, the PRY produces results comparable with the other models.

One of the best examples of the superior performance of the parallel T126 occurred in the forecasts originating 5 September. Shown here are the five-day forecasts valid 10 Sep from the MRF and the PRY and, as verification, the 12-hour MRF forecast valid at the same time. On the upper left in each figure are the 500-mb height and vorticity; on the upper right are the mean sea-level pressure, 24-hour precipitation, and isotherms of 12-hour maximum temperature. On the bottom are 850-mb streamlines and vorticity in the tropics. Several large differences between the 132-h forecasts are apparent at 500 mb, including the amplitude and location of the trough/ridge/trough system in the PRY over Western/Eastern Europe and the sharp ridge over Hudson's Bay. (The difference in anomaly correlation at day 5 was extreme in this case with a value of 0.41 for the operational and 0.72 for the Y). In the tropics, differences can be seen in the Gulf of Mexico and Baja California systems, especially at 850 mb.

A more complete picture of the behavior of the five-day forecasts of 500-mb height in middle latitudes can be seen in the time-longitude plots in Fig. 7. The diagrams show the height contours of 5-day forecasts averaged over the latitude band 40-50N in black, with the errors in color. A close look will show that while the forecasts are similar, the error level in the parallel system (lower half of plot) is consistently smaller.

One of the main reasons for this emergency implementation is the problems we have noticed in the behavior of tropical storms. A typical case is the series of forecasts for the Western Pacific from 00Z 11 Sep. The 72-h forecasts show the tendency of the T170 to produce more and deeper tropical systems. Successive updates of this forecast and show the T170 version weakening and the T126 strengthening. Although the models still don't agree on the verifying analysis, we have found in the limited number of cases available in this test period that while the T170 has continued mislocating tropical storms, over-intensifying them, and failing to give sufficient weight to synthetic data when available, the T126 draws better for the data and as far as intensity goes, probably errs on the conservative side.

In summary, our analysis indicates that the parallel run is behaving as anticipated and the operational run is producing unacceptable results. Hence, we are requesting this emergency implementatione to make the improved forecasts available to users as soon as possible.

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