THE NWP "BREAKTHROUGH" FOR CLIMATE ANALYSIS CENTER MONTHLY PREDICTIONS IN 1981

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1. INTRODUCTION

Progress in numerical weather prediction (NWP) is often described as "inch by inch", i.e. the immediate impacts of new physics, higher resolution, improved data assimilation, etc. are often not immediately obvious but show up over the course of a number of years. This is partly because improvements are subtle but also because natural day-to-day weather and year-to-year climate variability is considerable. It will be shown that in at least one instance for monthly forecasts an NWP innovation was made that led to an almost immediate quantum jump in official forecast skill. This increase in skill can be characterized without hyperbole as a "breakthrough" and was the result of the extension on March 18, 1981 at the former National Meteorological Center (NMC) of the global spectral model (Sela, 1980) from 48 to 144 hours at 00 GMT (Cooley, 1981).

The implementation was based on comparative tests between hemispheric and global versions of the model in which the latter clearly outperformed the former. Specifically forecasts of "useful" skill at day 5 occurred more often in the tests with the global version than with the operational hemispheric version. The result was anticipated by Somerville (1980), who convincingly showed adverse impacts on the predictability of ultra long waves in the time frame of 5 days from the use of a hemispheric instead of global model and further from the use of smooth boundary conditions near the equator (a practice employed by NMC for the 7LPE, Shuman and Hovermale, 1968). One of the cases Somerville examined is shown in Fig. 1, but the results were similar for all six cases he used.

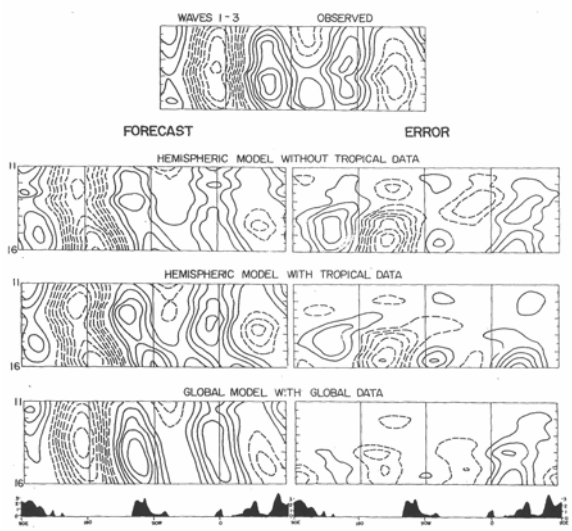

Fig. 1. Somerville (1980) case of 11 January 1973. Longitude-time plots of 500 hPa heights at 40N for zonal wave numbers 1-3 (30m contour interval, ridges solid lines, troughs dashed; date is ordinate, 90E to 90E is abscissa). Observed on top, three forecasts on left, errors on right. Clearly tropical data and using a global model improved the forecast.

2. VERIFICATION EVIDENCE

Unpublished verification studies for official monthly mean U. S. surface temperature forecasts made from 1973 through 1994 were conducted in the mid-1990s by the author. To eliminate regimal changes in predictability the differences in skill

(measured by a modified Heidke score used by the Climate Prediction Center, CPC) between the official forecasts and "operational persistence" were examined. Operational persistence is persistence of the observed monthly mean anomaly up to the date of release, usually 3 days before the end of the month. The 22-year skill difference series was smoothed with a 25-forecast running mean (one year's worth of twice-monthly forecasts) because the raw series was extremely noisy.

The resulting series has a large discontinuity in the skill timed closely to the implementation of the extension of the global runs to 6 days (Fig. 2); an increase in official forecast skill with respect to operational persistence coincides with the date of the global extension (March 18, 1981). The increase of 7 points in the

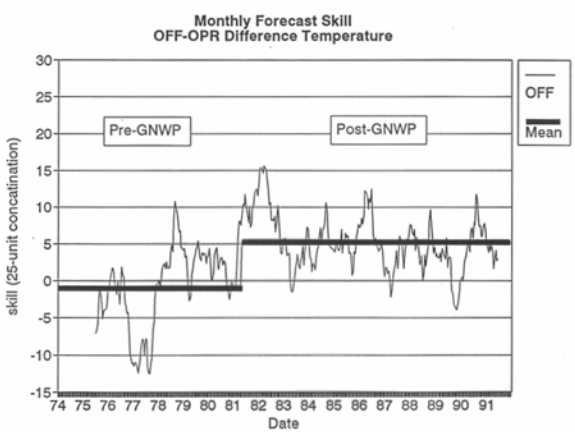

Fig. 2. Smoothed differences between modified Heidke scores for official monthly mean U.S. surface temperature forecasts (OFF) and operational persistence (OPR). The bold horizontal lines are the average differences for pre- and post-implementation of the extension of global NWP.

average skill difference is extremely large relative to the average skills themselves (prior to the global extension 10.3 and 12.1 for official forecasts and operational persistence respectively and after implementation 13.8 and 8.5). In a study by Livezey *et al.* (1995) the discontinuity is reflected less sharply (mainly because variations in predictability are unaccounted for) in the smoothed anomaly correlation score series for official Pacific-North America monthly mean 700 hPa extratropical height forecasts (Fig. 3). For a Northern Hemisphere domain the average anomaly correlation increased from 0.15 before the implementation of the extension of global NWP to 0.26 afterwards.

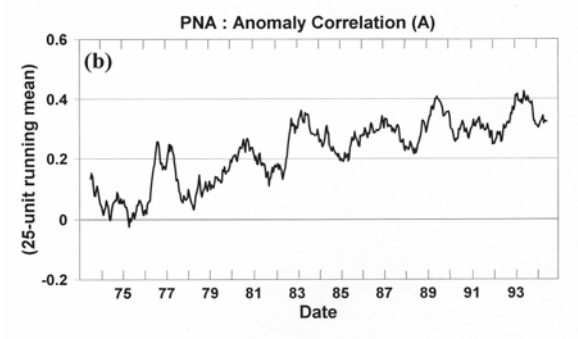

Fig. 3. Smoothed anomaly correlation scores for official Pacific-North America monthly-mean extratropical 700 hPa height forecasts (Livezey *et al.*, 1995).

3. DISCUSSION

The reason for the substantial and immediate positive impacts of extension of global NWP to 144 hours shown above is best understood in the context of forecast release days and the weight placed by monthly forecasters on the so-called "D+3" product. Recall from the previous section that monthly forecasts were finalized and released (from the 1970s through 1995) a few days (typically three) before the beginning of the verifying month. Because of the large noise to signal ratios for monthly means these forecasts were "front-loaded", i.e. heavily biased by the forecasters to what the short-range guidance was indicating out to day 5. This guidance

was encapsulated in the five-day average 700 hPa field from the latest model run, the D+3 guidance. In late March 1981 this guidance for the first time had credible direct relevance to the first few days of the following month, but more importantly provided a vastly improved estimate of the current state of the long waves (the principal basis for U. S. monthly mean temperature predictability) at the beginning of the month as a basis for persistence. It is quite likely a similar analysis of 6-10 day forecast scores will exhibit the same "breakthrough" in prediction capability. The analysis could take the form of a comparison of the difference between official scores and persistence of "D-3" temperatures before and after the March 18, 1981 implementation. The D-3 temperatures are those averaged over the five days preceding the release day of a 6-10 day forecast.

4. REFERENCES

Cooley, D. S., 1981: Extended range global guidance. NOAA memorandum dated February 23, 1981 to Recipients of Technical Procedures Bulletin Series.

Livezey, R. E., J. D. Hoopingarner, and J. Huang, 1995: Verification of official monthly mean 700-hPa height forecasts: An update. *Weather and Forecasting*, **10**, 512-527.

Sela, J. G., 1980: Spectral modeling at the National Meteorological Center. *Mon. Wea. Rev.*, **108**, 1279-1292.

Shuman, F. G., and J. B. Hovermale, 1968: An operational 6-layer primitive equation model. *J. Appl. Meteor.*, **7**, 525-547.

Somerville, R. C. J., 1980: Tropical influences on the predictability of ultralong waves. *J. Atmos. Sci.*, **37**, 1141-1156.