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A SUMMARY OF HOW THE CURRENT 30-DAY OUTLOOK IS PRODUCED

[Editor's Note: This Technical Attachment is an extension and update of a paper entitled "Medium- and Long-Range Forecasting" by A. James Wagner which appeared in Weather and Forecasting, 1989.]

Introduction

Since the early 1940's, extended temperature and precipitation outlooks ranging from 5 to 30 days have been issued. The outlooks in their early stages, which were produced long before the development of numerical weather prediction (NWP) models, were based upon applications developed by the work of Rossby (1939), Namias and Clapp (1944), and various others. At that time, subjective interpretation and analysis of observed circulation patterns and the extrapolation thereof, were the dominant tools used to produce the forecasts. On the longer time scales, 30-day forecasts were weighted heavily by large-scale features which were then combined with statistical relationships relating mean 700 mb circulation anomalies to observed surface temperatures and precipitation amounts. These statistical relationships were also the principal tools used to produce the 90-day outlooks which began in the summer of 1974. With the aid of NWP models and their improving skill, the man-machine mix was introduced whereby the various outlooks (5-10, 30-, 90-day) consisted of a blend of model output and the forecaster's subjective modifications.

This paper reviews the most recent techniques used to create long-range temperature and precipitation outlooks, namely the 30-day outlooks. For clarity, the medium-range will be defined as the 5 to 14 day forecast period, whereas the long-range consists of forecasts beyond 14 days. Therefore, this paper will explore and summarize the scientific methods used to produce the 30-day temperature and precipitation forecasts.

The current method used to produce the monthly outlook is comprised of a well-balanced mix of the man-machine environment. The skeletal structure of the forecast methodology consists of dynamic model input, statistical guidance acquired from research, and the subjective viewpoint of the preparer. The forecaster first develops a mean height pattern for the upcoming 30-day period followed by the extraction of both the surface temperature and precipitation prog.

The Mean Circulation Pattern

The 500 mb mean height outlook for the upcoming month is the first product developed. As a first guess field, the dynamic model output from both the Medium-Range Forecast (MRF) model and the European Center for Medium-Range Weather Forecasts (ECMWF) model are used. The models provide guidance on the 1-10 day forecast period and are compared for accuracy against each other. The monthly outlook is produced over a 2-day period, thus the forecaster is able to judge the performance of the models and their run-to-run consistency to determine the amount of weight each should hold.

The relevance of the first ten days of the outlook on the monthly mean was investigated by Harnack et al. (1986). It was found that in the summer and winter seasons, the best correlation occurred between the upcoming monthly circulation pattern and the mean circulation over the previous 10 to 28 days. However, during spring and fall, the interval was much less, on the order of a few days, reflecting a more unstable mode. Therefore, the dynamic model output up to 10 days tends to reflect the monthly mean better (and should be weighed more heavily by the forecaster) during the summer and winter seasons. In other words, the dynamic model output through 10 days provides a better first guess of the upcoming mean monthly circulation pattern in summer/winter than spring/fall.

Also available to the forecaster is a linear regression forecast of mean 700 mb height anomalies for the upcoming month, which is based on the local month-to-month autocorrelation (or correlation in time) of the mean 700 mb height over the Northern Hemisphere. The amount of influence this product has on the forecast is determined by the consistency and strength of the correlations with the model output (MRF/ECMWF) previously described. One study by Barnston and Livezey (1987), which aides in the preparation of the forecast, showed that certain low-frequency, large-scale atmospheric circulations tend to persist during particular seasons.

Over recent years, tropical research has increased and with this, so has the importance of teleconnections on the large-scale global circulation patterns. Larger scale tropical forcing, such as El Nino/Southern Oscillation (ENSO), has been found to cause certain characteristic circulation regimes. For instance, during the warm, wet phase of ENSO, the persistence and predictability of surface temperatures and mean mid-tropospheric height patterns increase, as does the skill of the dynamic models when these initial conditions occur. A study by O'Lenic and Livezey (1989) showed that consistent error patterns in the MRF were related to principal modes of the initial circulation regimes. Also, certain circulation modes were found to be forced by anomalous tropical convection, especially in the cold season.

The forecaster then uses teleconnection patterns to check the various anomaly patterns and their consistency with the dynamic model output, tropical forcing anomalies, and persistence. The teleconnection patterns used were developed by Namias (1981) and Wagner and Maisel (1988) and are based on monthly and half-monthly means. Both studies generated similar anomaly charts for the Northern Hemisphere; however, the techniques used by each did differ slightly. These charts replaced the teleconnection work of O'Connor (1969), which was based on 5-day means, as it was found that the length of the averaging sample (5 days versus 30 days) was important to the resultant anomaly patterns.

Surface Temperature and Precipitation

At this point, the 30-day circulation prog has been developed by the forecaster after considering all the information previously discussed. The next step is making the 30-day surface temperature and precipitation outlook, which has been made much easier and less subjective, through the use of objective schemes. The surface temperature forecast is extracted from the monthly mean 700 mb height analysis. The objective methods incorporate persistence of surface temperature which implicitly includes sea surface temperature anomalies, soil moisture, or anomalous snow cover.

The precipitation forecasts also use an objective scheme with the 700 mb mean height circulation as the input. As would be expected, the explained variance in the precipitation amounts related to the 700 mb height field is much less than for the surface temperature overall. However, in some areas such as the West, the precipitation is very well correlated to the height field, especially in the cold season. As of the later part of 1989, the United States was the only country to develop objective precipitation forecasts from monthly mean height patterns.

Another forecasting tool is the auto- and cross correlation studies of monthly mean surface temperature and precipitation, both simultaneously and at a lag of one month. Some studies have shown strong negative correlations between temperature and precipitation in monthly and seasonal means in certain locations, especially the Great Plains. Since 1989, the use of mixed analog-persistence temperature forecasts have been combined objectively and the assets of each extracted (Livezey, et al. 1989). Simply, the analog technique is based on the inference that a given (usually current) large-scale synoptic pattern will act or develop similar to a past situation if the essential characteristics are the same. This empirical tool is available to the forecaster and usually produces better guidance than standard persistence.

Yet another empirical tool (recently developed by Barnston, 1992) is the use of canonical correlation analysis (CCA). Although the statistical techniques of this method are beyond the scope of this Technical Attachment, the CCA captures the large-scale, low frequency portions of the predictability well and gives an added advantage over persistence forecasts. The CCA is ideal in capturing ENSO events and their teleconnection to extratropical height, temperature, and precipitation anomalies.

Although the 30-day outlook is made by one forecaster, the Climate Analysis Center (CAC) typically holds an open "group-think" where the mean 30-day circulation forecast is discussed and critiqued. Usually, any interested CAC personnel take part and offer insight on the surface temperature and precipitation forecasts as well. Therefore, the 30-day outlook is composed of a good man-machine mix, and the skill involved is not limited to the dynamic models (Fig. 1 provides a summary of the current forecast methodology used to create the 30-day outlook). This mix is not only important on the longer time scales, but is important to forecasting on all temporal scales to insure quality forecasts with the most confidence scientific limits allow.

Currently, a discussion of the 30-day outlook (*cccPMD30D*) accompanies the surface temperature and precipitation forecast graphics (*9ME, 9MT*) and provides insight into the amount of weight the various input parameters carry. It gives a good summary of the confidence level in the dynamic model output as well as any changes made to surface temperature and precipitation output obtained via objective analysis schemes.

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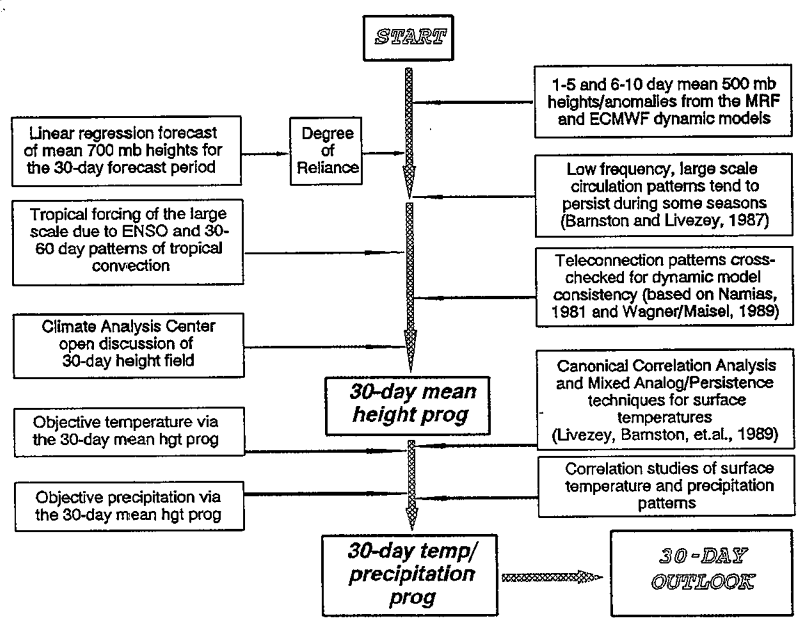

Fig. 1. Summary of the forecast methodology used to prepare the 30-day circulation, surface temperature, and precipitation outlook at the Climate Analysis Center.