How much Numerical Products Affect Weather Forecasting

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ABSTRACT

The paper shows how much improvement can be achieved in weather forecasting by using NWP products. And for weather element forecasts, the types and number of NWP products highly impact on the quality of MOS forecasts and other utilities.

Numerical products have been extensively used in making weather forecasts issued to the public in China. NMC Beijing runs its own models to make NWP products. It also gets NWP products from other centers (e.g. ECMWF, US-NMC, and JMA). These products are daily transmitted to weather forecast offices across China. The products are used as the guidance to weather forecasters or for making MOS. Now NWP products have improved weather forecasting at many forecast offices,especially for day+2 to day+5 forecasts.

Now the question to be discussed here is that how much improvement is achieved by using numerical products.

Firstly, Fig.1 shows that the percentage of correct forecasts for heavy rain made by MOS techniques is 7 to 12%, higher than that by man-made ones. Note that these forecasts are for day +4 and for day +5. That indicates that for medium range, NWP-based forecasts outclass the man-made one.

$$\text{Percentage (\%) of correct forecasts} = (C / F) \times 100$$

where:

C is the total number of correct forecasts;

F is the total number of heavy rain forecasts for the area;

The threshold for the correct heavy rain forecasts is:

1) rainfall: at least one station receives 25 mm or more rainfall within 24 hours in the area; or two stations receive 10 mm or more.

2) valid time: it is allowed that heavy rain occurs one day earlier or later than valid time.

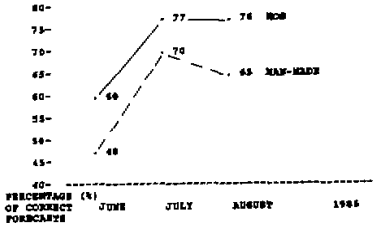

Fig. 1. Percentage of correct forecasts for heavy rain made in Xian city in West China. Solid line for MOS forecast is based on products from ECMWF, dash line for man-made one.

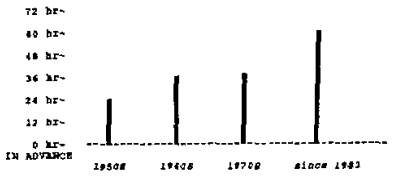

Fig. 2. Cold wave warnings with 80 % confidence of occurrence issued to the public 24 hours in advance in 1950s, 36 hours in advance in 1960s and 1970s, 60 hours in advance since 1983.

Secondly, Fig.2 shows that the cold wave warnings issued to the public have been 60 hours in advance since 1983. That is one day earlier than in 1970s. The major reason for the progress is that the numerical products come to forecast offices and forecasters have had the skill to use them.

For example, a cold wave hit most area of China in later November of 1987 and caused widespread high winds (50 to 70 km per hour) and sharp drop in temperature (10–20 degrees centigrade of dropping), as well as heavy snow and freezing rain. 60 hours in advance, NMC Beijing issued the cold wave warning to the public on radio and TV. Two and half days later the observations proved that the cold wave warning was successful. The major reason for the success is the weather forecasters employed the flow pattern forecasts both from ECMWF and our own models. For space saving, the pictures showing the cold wave are not given here.

Thirdly, a comparison has been made for the heavy rain forecasts by two different forecast offices. Fig.3 shows Threat Scores(TS) given to the forecast offices. The forecast office of Xi'an city was the winner of the better Threat Score (0.33), because the forecasters working there are skillful in using numerical products and taking guidance of MOS. The worse TS (0.13) came to the other forecast office whose forecasters made weather forecasts mainly by using traditional methods.

$$\text{Threat Score} = C / (F + O - C)$$

C: Number of correct heavy rain forecasts.

F: Total number of heavy rain forecasts.

O: Total number of observed heavy rain days.

The next topic to be discussed is whether or not the types and number of numerical products affect the quality of MOS forecasts. Fig.4. shows the comparison of the root mean square errors (RMSE) at 500-hPa height forecasts made by models of ECMWF and NMC Beijing. It was found that ECMWF model performed better than NMC Beijing model.

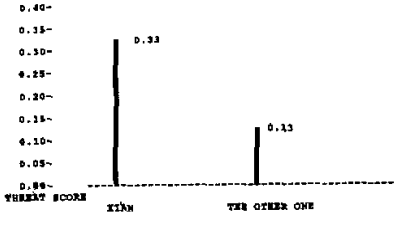

Fig. 3. Threat Scores for heavy rain forecasts made in Xi'an city and the other one in the summer of 1988.

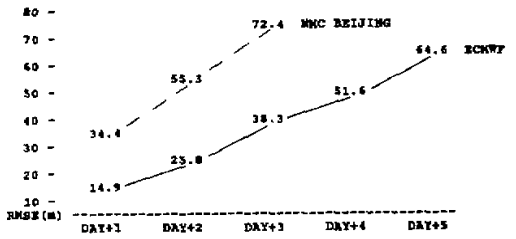

Fig. 4. Root mean square errors (RMSE, in m) at 500 hPa height forecasts covered the Northern Hemisphere averaged over 12 months of 1988, solid line for ECMWF model, dash line for NMC Beijing model.

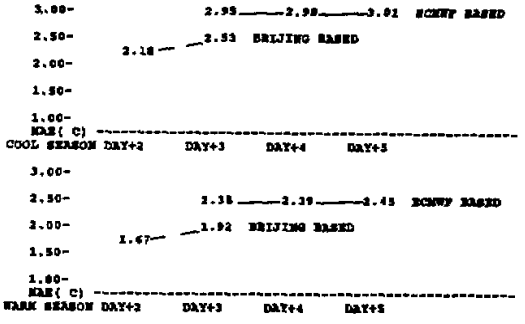

Fig. 5. Mean absolute errors of MOS minimum temperature forecasts for cool season (above, Oct. 1988—Mar. 1989). Warm season (below, Apr. 1988—Sep. 1988). For day+2 and day+3 based on NMC Beijing model products. For day+3 to day+5 based on ECMWF model products transmitted to Beijing. All are averaged over 260 cities across China.

NMC Beijing issues MOS temperature (max. and min.) forecastsfor day+1 to day+5 automatically once every day. The MOS forecastsfor day+1 to day+3 are based on our own model, for day+3 to day+5based on ECMWF model products we get from GTS (Global Transmission System).

Here are the verifications of MOS minimum temperature forecastsagainst observations (see Figs.5 and 6).

Note that the MOS minimum temperature forecasts for day+3 are based on both ECMWF and NMC Beijing models. It was found that the ECMWF–based has larger Mean Absolute Errors (2.95°C and 2.35°C) than the Beijing–based (2.53°C and 1.92°C).

Fig.6 shows the correlation coefficients between MOS forecasts and observations.

Now the question is that why ECMWF model performs better than NMC Beijing model while the ECMWF–MOS minimum temperature forecasts for day+3 are worse than the Beijing–MOS.

The answer to the question is that the model products available from ECMWF are much fewer than those from NMC Beijing. Table 1 shows the model products received from the two centers for mid– and high–latitudes.

Only three types of forecast fields for mid– and high–latitudes are available through international transmission line from ECMWF. For making MOS, many additional fields were

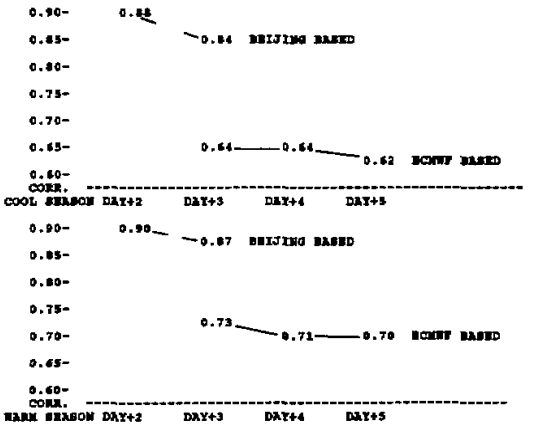

Fig. 6. Correlation coefficients between observations and MOS minimum temperature forecasts. The rest same as in Fig.5.

derived from the three, e.i. the 1000 / 500 thickness, the geostrophic vorticity, the U– and V–geostrophic wind components. But the ECMWF–based MOS forecasts are still less accurate than Beijing–based MOS. It indicates that the types and number of numerical products have a strong impact on the quality of MOS forecasts and other utilities.

Table 1. A List of Model Forecast Fields Available from Two Centers

ECMWF	Beijing	Beijing
H 500–hPa	H 500 hPa	Q 0.9 Sigma
P Sea Level	P Sea Level	U 500 hPa
T 850–hPa	T 0.9 Sigma	U 0.7 Sigma
	H 0.7 Sigma	U 0.9 sigma
	H 0.9 Sigma	V 500 hPa
	T 500 hPa	V 0.7 Sigma
	T 0.7 Sigma	V 0.9 sigma
	Q 500 hPa	P Ground
	Q 0.7 Sigma	T Sea Level

We can come to a conclusion from the fact stated above that to make good weather forecasts, meteorologists not only need advanced numerical models but also need adequate types of numerical products available. It is reasonable that NMC Beijing must develop its own medium–range NWP model, even though during the comingyears the model can not perform as well as those with higher resolution and perfect physics. But it can offer much more NWP products routinely than those transmitted from most of other countries and centers.

REFERENCE

ECMWF Annual Numerical Weather Prediction Progress Report, NWPP Report Series (1989), WMO, No.15, 41–61.