FORECASTS OF BLOCKING AND CYCLONE DEVELOPMENTS OPERATIONAL RESULTS DURING WINTER 1986/87

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1. INTRODUCTION

The objective verification of numerical forecasts provides both the modellers and the users of the model output with feedback concerning the quality and the usefulness of the numerical guidance. Fig. 1 gives the evolution of the forecast skill for the ECMWF model for the years 1980 to 1987 as measured by the 1000 hPa height RMS height error over the Northern Hemisphere. Note that the graphs presented in Fig. 1 are 12-month moving averages. The curve therefore ends six months earlier than the last month used in the statistics.

The implementation of the high resolution model T106 in May 1985 (Jarraud et al., 1985) together with the modifications to the radiation scheme and to the physical parametrization implemented in late 1984/early 1985 led to a significant improvement in the predictive skill of the model, particularly in the medium-range of the forecast. Note that according to Fig. 1 the RMS height error for Day 7 has now reached the error level of a Day 5 forecast of the year 1980.

However, objective scores of model results averaged over large areas, such as the hemispheres, and over longer time periods only allow the evaluation of the long-term trend in the performance of the forecasting system. Operational forecasters need more detailed information on the predictive skill of the model in limited areas, under certain constraints of the large scale flow pattern and, if possible, also verification of weather elements rather than flow parameters.

In this paper an attempt is made to evaluate the model performance over Europe during winter 1986/87 when a block type flow dominated the circulation pattern and, when going by previous experience, the model is expected to perform well. Another important aspect of forecasting in mid-latitudes is the rapid development of deep cyclones, which will be briefly discussed in the second part of the paper.

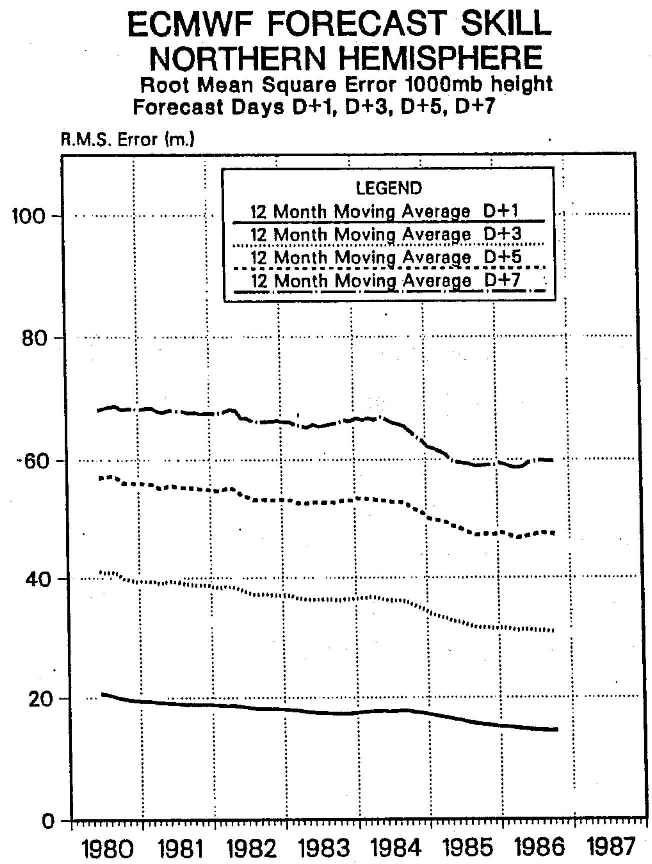

Fig. 1: The evolution of the RMS eror of 1000 hPa height between January 1980 and May 1987 for the Northern Hemisphere

2. MODEL PERFORMANCE DURING THE WINTER BLOCKING 1986/87

2.1 Objective scores

The magnitude of the RMS height error which was shown in Fig. 1 for the Northern Hemisphere depends to some extent on the observed variability in the atmosphere. The seasonal variability can be eliminated by long term averaging while the effect of the flow variance can be suppressed by normalizing the forecast error by the persistence error. The resulting skill score, with a positive orientation, is presented in Fig. 2 for the

European area. The overall trend in the model performance, which was described for the Northern Hemisphere results, is confirmed for the limited European area. The results exhibit more variability, which would be expected for a smaller region. They also indicate that in the forecast range of Day 5 to Day 7 a reduction in predictive skill was observed over the recent twelve months, while the model performance persistently shows the familiar upward trend in the early stages of the forecast.

When analysing the monthly verification statistics in more detail it becomes clear that in particular the model results of the winter months December 1986 to February 1987 contributed to the temporary reduction in the predictive skill.

Fig. 3 depicts the daily model performance for the European area during December 1986 to February 1987 as measured by the anomaly correlation of height at the 500 hPa level. For each model run the forecast range is shown at which the anomaly correlation coefficient drops to .6. Studies comparing this objective limit with subjective evaluations have indicated that .6 is generally the limit of a useful forecast. Fig. 3 highlights immediately the problem that every forecaster is faced with in the routine use of numerical guidance, which is the variability in the predictive skill of the model from one day to the next. However, it also points towards the fact that the model goes through periods of high and low predictive skill, especially during February 1987.

January 1987 is of particular interest as the model performance is rather consistent giving forecasts with an average usefulness of six days for most of the month, which is approximately 12 hours below the average skill experienced for winter months. Even more striking in this context is the fact that the circulation over the Atlantic and Europe during January 1987 was highly anonalous with a pronounced ridge at 500 hPa for the monthly mean flow indicating the occurrence of strong blocking activity (Fig. 4). When a block type flow persists over the Atlantic and Europe the model is expected to perform well.

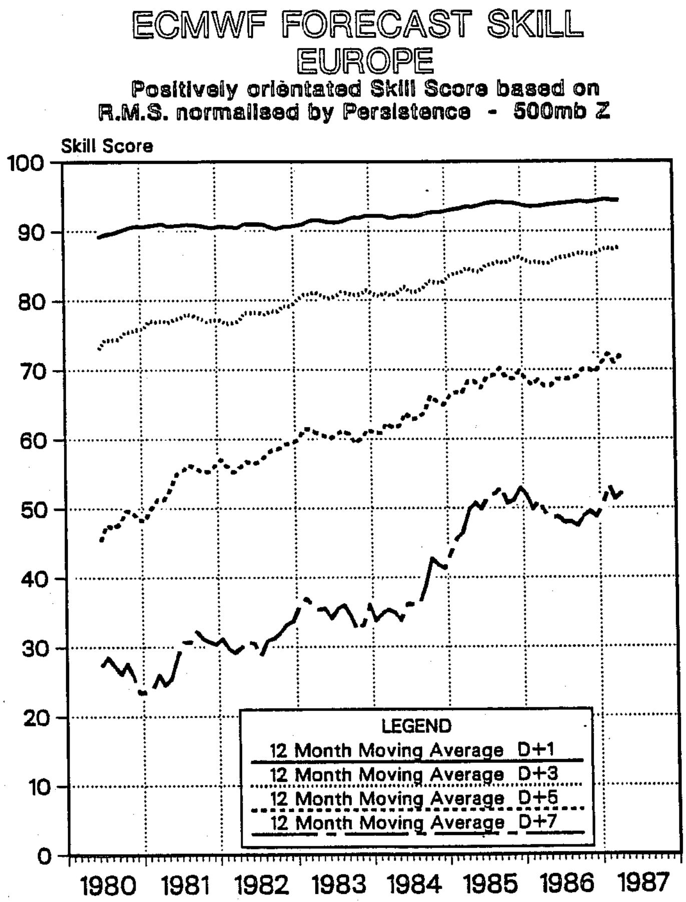

Fig. 2: Positively orientated skill score based on 500 hPa RMS height error normalised by persistence errors

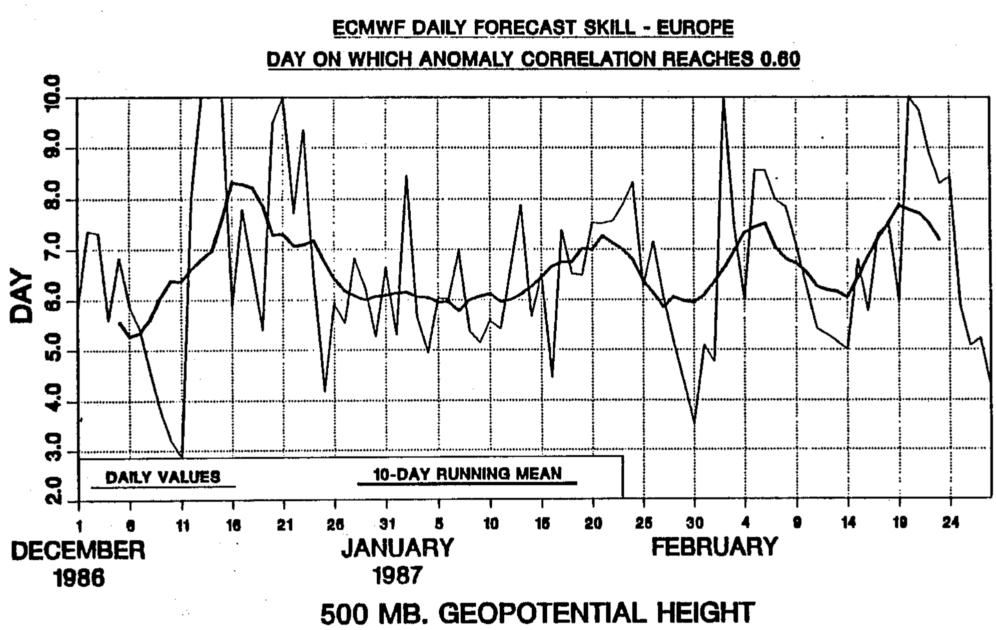

Fig. 3: ECMWF daily forecast skill - Europe.
Day on which anomaly correlation reaches 0.60.

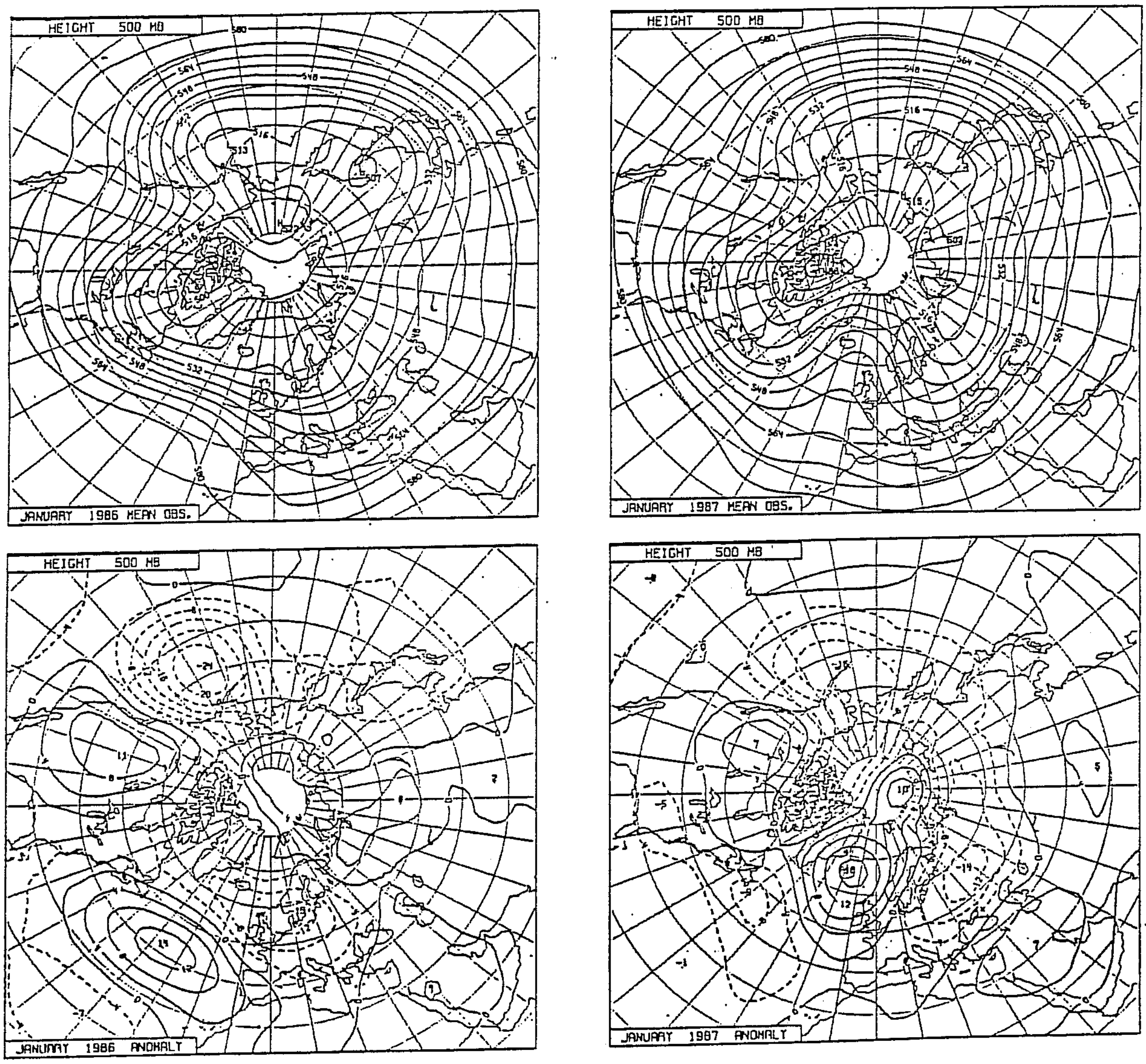

Fig. 4: Monthly mean height of 500 hPa level (top) and deviation from climate (anomaly, bottom), during January 1986 (left) and January 1987 (right)

However, a more detailed study of the flow during the winter 1986/87 (Klinker, personal communication) shows that the block in the mean flow pattern results from a strong transient blocking activity which is known to be difficult to predict by numerical models. Intercomparison of the performance of analysis and forecast systems from major global data processing centres confirms that similar forecast problems were experienced everywhere.

2.2 Predicting the large scale flow pattern

Previous investigations (Persson, 1984 a, 1984 b) indicate that at least during the winter season the large scale flow pattern which defines the dominating weather type is adequately described by forecast fields such as the 500 hPa height or the 850 hPa temperature when they are truncated at total wavenumber 10. It should be stressed in this context that it is in the presentation of the model result where this truncation is applied, while the analysis and forecasting system operates at full resolution. Such smoothing of the forecast guidance in the later stage of the forecast, i.e. after five days, takes away the details which are uncertain and often in error, leaving a much clearer picture of the large scale flow pattern. An example is shown in Fig. 5, where the retrogression of the blocking ridge over Europe was well captured in the forecast from 19 January 1987. The actual separation between the ridge and the downstream trough and the direction of the flow is clearly in error over Scandinavia and central Europe. However, in the time range of one week a forecaster will on the basis of these smoothed forecast fields have sufficient forecast guidance concerning the change in the configuration of the large scale flow. Further details will then need to be picked up at shorter forecast range.

The usefulness of the T10 forecast charts during winter 1986/87 was subjectively evaluated at ECMWF. There is evidence that such guidance contains much useful information for the medium-range (days 7 to 10) forecaster who has to rely on forecast material which, when used at full model resolution, is known to be below the limit of usefulness when the conventional objective verification procedures are applied.

2.3 Data problems during winter 1986/87

One of the key issues for successful medium-range weather forecasting is the availability of good quality global data sets. ECMWF undertakes routine monitoring of all the observational data which are received at the Centre and presented to the analysis. Data deficiencies have on various occasions been pointed out to the national weather services or the data producers as appropriate.

Serious data problems were encountered during the winter 1986/87 with the satellite sounding data. A summary of the events/problems with the satellite data is given in Table 1. Such data deficiencies are most likely to have had an impact on the performance of numerical forecasting systems at most of the major global data processing centres where use is made of the satellite sounding data.

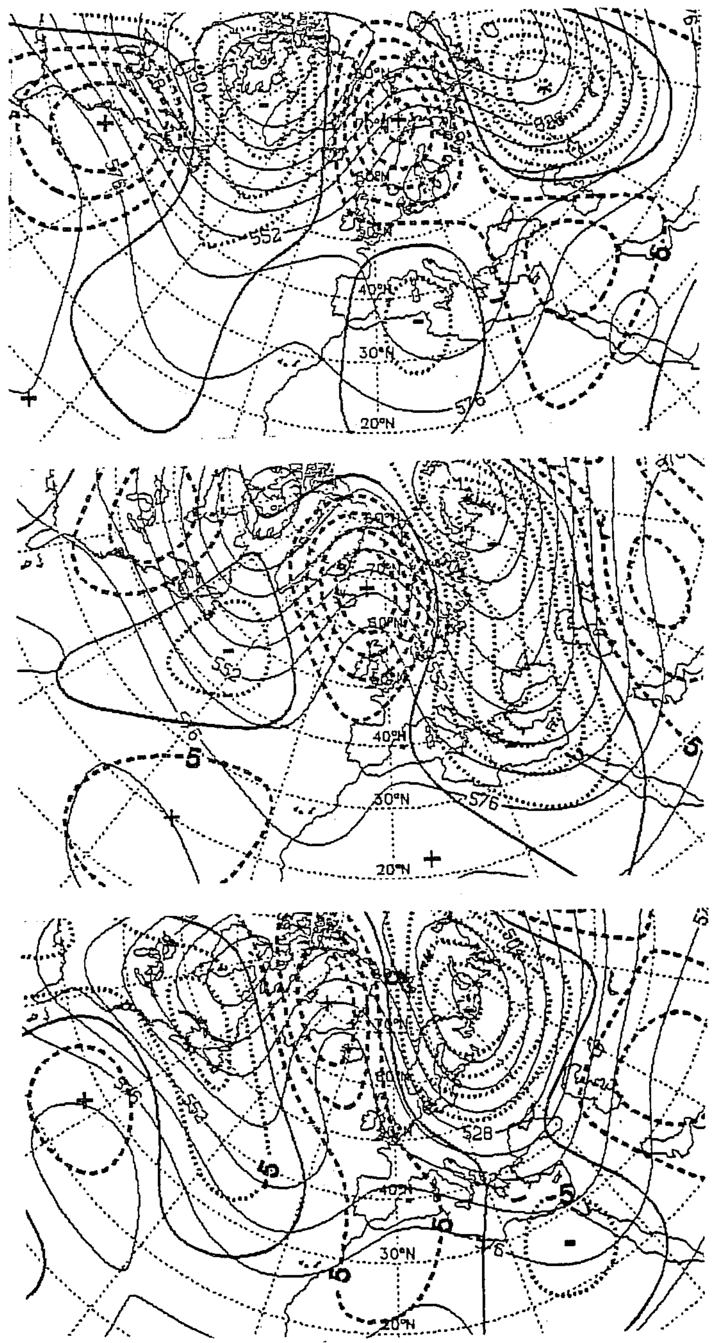

Fig. 5: Filtered (truncated at T10) 500 hPa height and height anomaly fields (deviation from monthly climate) for analysis on 19 January 1987 (top), D+7 forecast valid on 26 January 1987 (centre) and verifying analysis on 26 January 1987 (bottom); all fields valid at 12 UTC.

November 1986	Cosmic storm affected NOAA-9 instruments; NOAA-6 shut down
December 1986	Shift in instrument response on MSU 3 of NOAA-9; bias around 250 hPa; soundings erratic at times
December 1986	NOAA-10 activation delayed
1-2 January 1987	Earth location error
7 January 1987	NOAA-10 received for first time
14 January 1987	NOAA-10 used in analysis
January 1987	NOAA-9 and NOAA-10 soundings incompatible; retrieval problems over Asia and Europe
Jan-Feb 1987	NOAA-9 MSU channel 3 erratic (recurring problem)
Jan-Feb 1987	NOAA-9 HIRS instrument increasingly noisy resulting in reduced retrieval accuracy
9 March 1987	NOAA-9 MSU channel 2 instrument calibration lost; soundings production halted

Table 1: Satellite sounding data events/problems
November 1986 - March 1987

3. FORECASTS OF RAPID CYCLOGENESIS

The appearance on visible satellite imagery of rapid cyclogenesis over the eastern North Atlantic was first described by Böttger et al. (1975). A comprehensive study of the "bomb" in the Pacific and the western North Atlantic was given by Sanders and Gyakum (1980). Recently Reed and Albright (1986) have documented a case study of such cyclogenesis over the North Pacific (see also Reed's contribution in these Proceedings).

The forecast of rapid cyclogenesis is of crucial and life-saving importance and a great challenge for numerical weather forecasting, not only in the short-range but also in the medium-range. Consider for instance the application of medium-range forecasting for ship routing across the Atlantic and the Pacific, where preventive action needs to be taken on the time scale of days rather than hours.

Although it is desirable to study the model performance in forecasting the rapid and deep cyclogenesis in detail, it is often not possible to collect during one season a sample which is large enough to be representative.

During winter 1986/87 five storm events were identified in the North Atlantic which fulfilled our criterion of a 25 hPa pressure fall within 24 hours in the centre of the developing disturbance. While the ECMWF model successfully simulated the storm development in four cases in the short-range and, to some extent, also in the medium-range out to five days, one case had to be discarded from the summary statistics as the model failed to develop the low beyond one or two days into the forecast.

Fig. 6 summarizes the model performance during the deepening phase and the early filling stage. Position errors of the centres of the lows have not been taken into account in this summary. Obviously the positions of the lows tend to exhibit a larger variability towards the medium-range. It was, however, always possible in these four cases to identify the lows within approximately 1000 km of their verifying positions.

Fig. 6 shows the model's capability to predict rapid and intense cyclogenesis during the first three days of the forecast, albeit that the observed intensity is slightly underestimated. This error becomes more prominent towards the medium-range of the forecast when a further deepening of the cyclones after the observed peak indicates a significant phase error in the development, thus missing to some extent the speed and the intensity of the phenomenon.

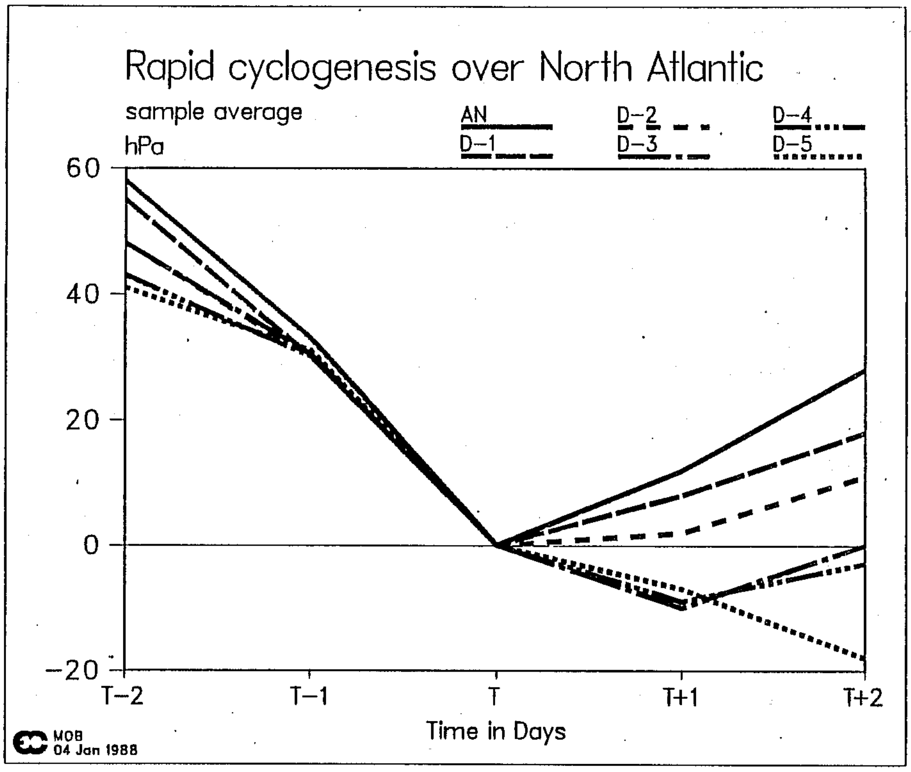

Fig. 6: Verification of centre pressure forecasts in rapidly deepening cyclone

4. CONCLUDING REMARKS

While objective verification procedures are an important and essential instrument to monitor the overall performance of numerical analysis and forecasting systems it is also essential to study synoptic aspects of the forecasts in view of particular forecast applications.

There is evidence that the ECMWF forecasting system provided useful guidance for the prediction of the persistence and the changes in the large scale flow pattern out to seven days ahead during winter 1986/87 which was characterized by a high non-persistent blocking activity over Europe.

Filtered forecast fields were found to be useful for identifying the large scale flow pattern in the later stage of the forecast.

At the other end of the time scale the model appears to handle quite successfully the development of rapid and intense cyclogenesis in the short range, while the forecast deficiencies become quite apparent after day 3. A more comprehensive study of the model performance in handling this phenomenon appears to be desirable.

5. ACKNOWLEDGEMENT

T. Tuna's contribution studying the rapid cyclogenesis in the forecast and L. Campbell's help in producing the filtered forecast fields was much appreciated.

6. REFERENCES

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