# VALIDATION OF SURFACE AND NEAR SURFACE PARAMETERS AT ECMWF

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## 1. INTRODUCTION

As a part of its operational numerical weather prediction activity, ECMWF performs an extensive range of verifications of upper level and surface fields produced by the forecast model. In order to monitor the model performance near the surface, specific verifications are made for the main surface parameters for which observations are available in real time on the GTS, namely the 2m temperature, precipitation, cloud cover and 10m wind. This paper presents the information relevant to the validation of the land surface processes in the model which has been derived from these verifications.

## 2. THE OPERATIONAL ASSESSMENT OF THE SURFACE PARAMETERS

The parameters are verified against a fixed set of reliably reporting synoptic stations in Europe and North America; verification results are accumulated monthly for each station and are presented in charts or statistical summaries. At the moment, charts of monthly mean error and RMS error are produced every month for 2 meter temperature and total cloud cover at 60 and 72 hour range (corresponding to night-time and daytime over Europe) and for precipitation accumulated between 48 and 72 hours. When any feature requires further investigation, time series of daily forecasts against observed values are plotted for individual stations.

When considering the results, it is necessary to have in mind the effect of the horizontal grid interpolation and orography on the verification. All the direct model output of near-surface weather parameters is computed on the model grid used for the calculation of the physical processes, a gaussian grid of approximately 1.125 resolution in latitude and longitude. The model's land/sea mask is also defined on this grid (Fig 1). At the moment, the model values used for the verification are interpolated to the position of the stations; obviously this results in a loss of information, as the horizontal interpolations tend to smooth the fields. This effect is particularly important for the 2m temperature in the coastal areas, where quite large

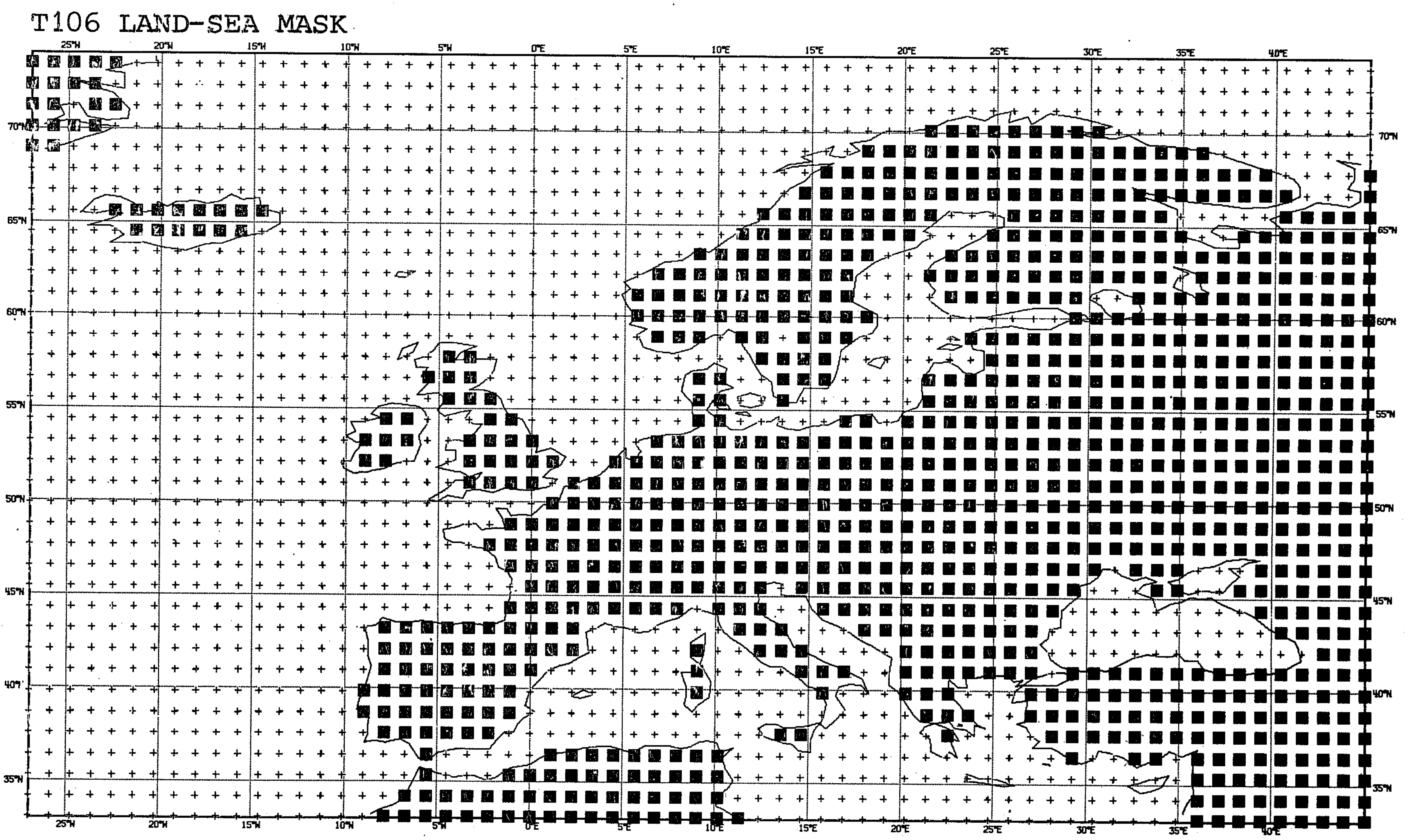

Fig 1 Model surface grid over Europe (full squares indicate land points).

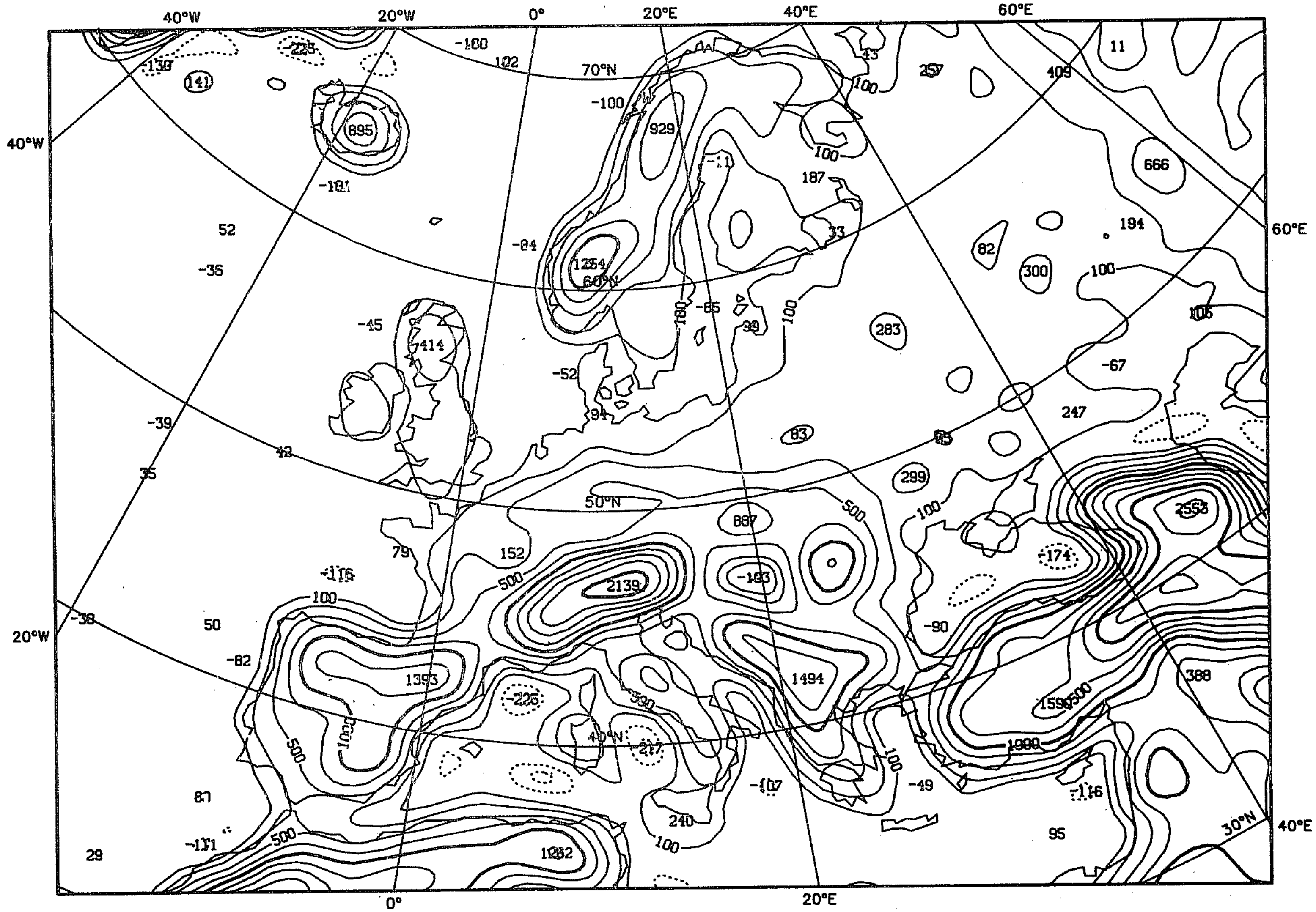

Fig 2 T106 orography, contour interval 250m, lowest contour line 100m.

differences between a land grid-point temperature and its nearby sea grid-points may occur (note that the interpolation will be replaced by the selection of the nearest land grid point in the near future).

Another factor which adversely affects the verification of local parameters derived directly from the model are the local discrepancies between the model orography and the real orography heights. No corrections are made for those discrepancies which are enhanced on average by the envelope representation of the orography. At the present T106 resolution of the ECMWF model, they are quite large for most stations in mountainous areas (Fig 2 for Europe, see for example Geneva: altitude 370 m, model grid 1560 m). This affects the temperature as well as precipitation and cloud cover.

## 3. TOTAL CLOUD AMOUNT

The verifications of model predicted cloud amount against synoptic surface observations are adversely affected by random sampling errors due to the way in which the synoptic observations are made. However, it is possible to draw some conclusions from the mean error characteristics. Figs 3 and 4 show the categorical distribution of the mean error over Europe since May 1987, at 60 and 72 hour time range. The stations are grouped into categories of correct, under and over-prediction; the bars indicates the percentage of stations in each category. The forecast for night-time (60 hours) is almost unbiased; during the day there is a systematic underestimation, which is somewhat more significant in the summer. It is probably caused by a poor representation of convective and low-level stratiform clouds in the model. The possibility of validating the cloud forecasts layer by layer is currently under investigation.

It should be noted that the parametrization change to the surface processes implemented in April 1987 had only slight impact on the cloud forecasts.

## 4. PRECIPITATION

Fig 5 gives the categorical distribution of mean error of precipitation over Europe since January 1986. The main feature is the overestimation in winter and spring, followed by almost unbiased summer and autumn values. Fig 6 shows stations distributed into 5 categories, for summer and winter. It appears from daily monitoring that the over-forecasting during winter and spring

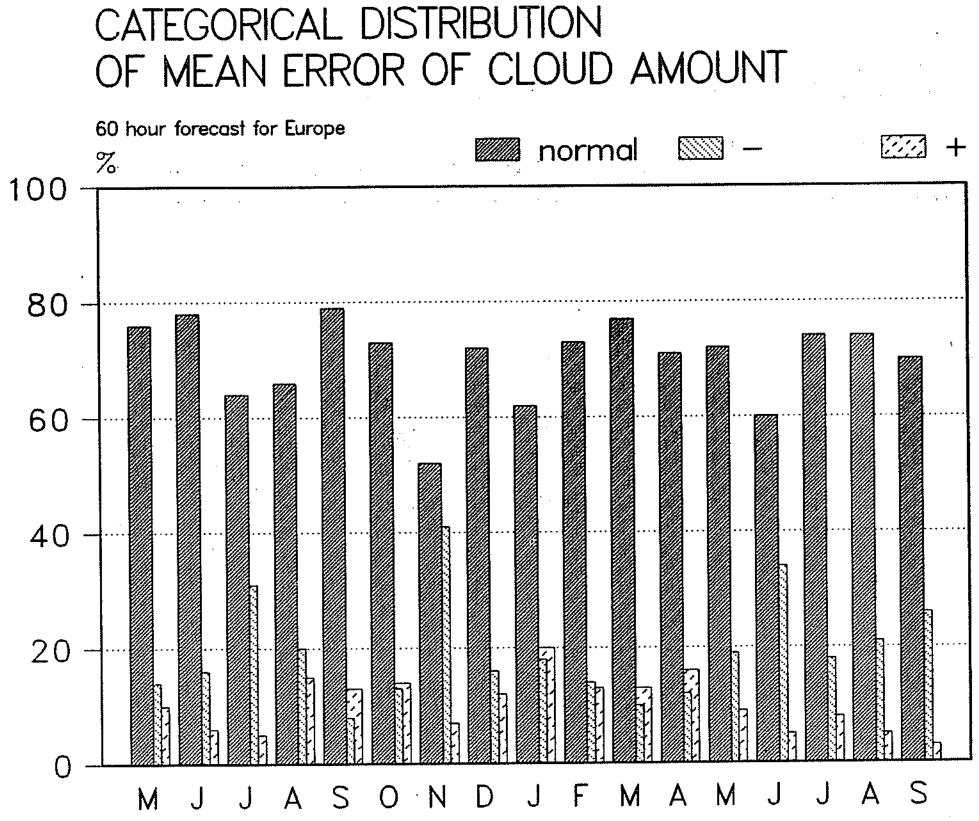

Fig 3 Categorical distribution of total cloud cover error for all available stations in Europe, 60 hour forecast. The bars indicate the number of stations (in percent) in each category, every month from May 1987 to September 1988.

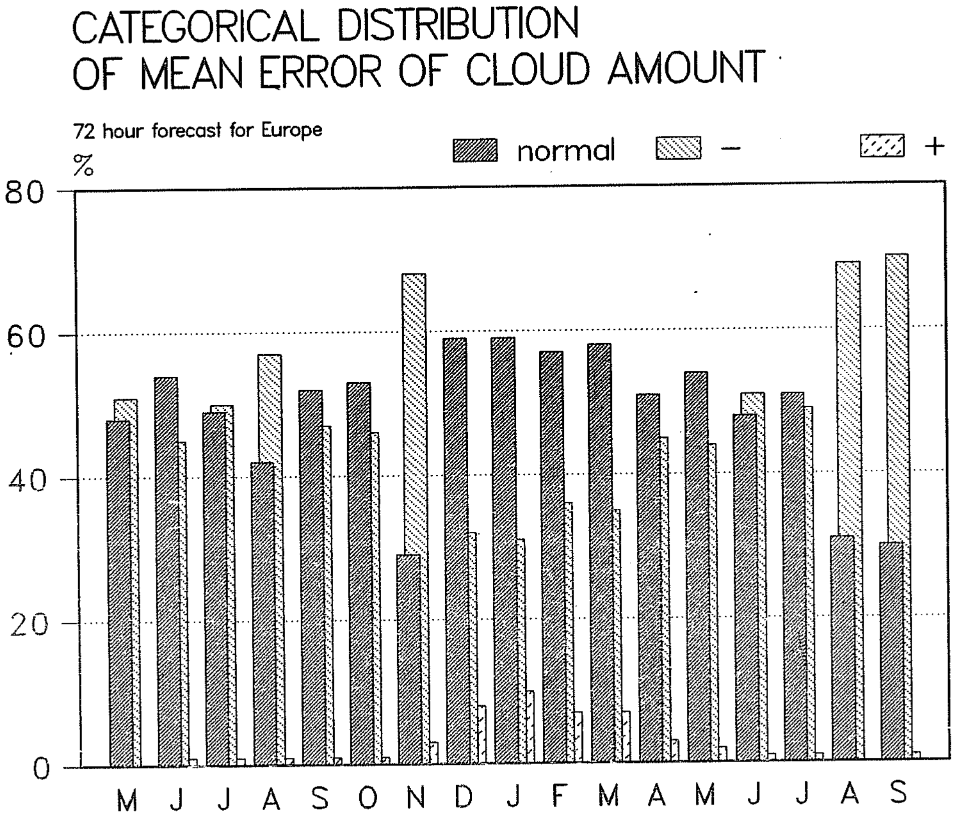

Fig 4 As Fig 3 for 72 hour forecast.

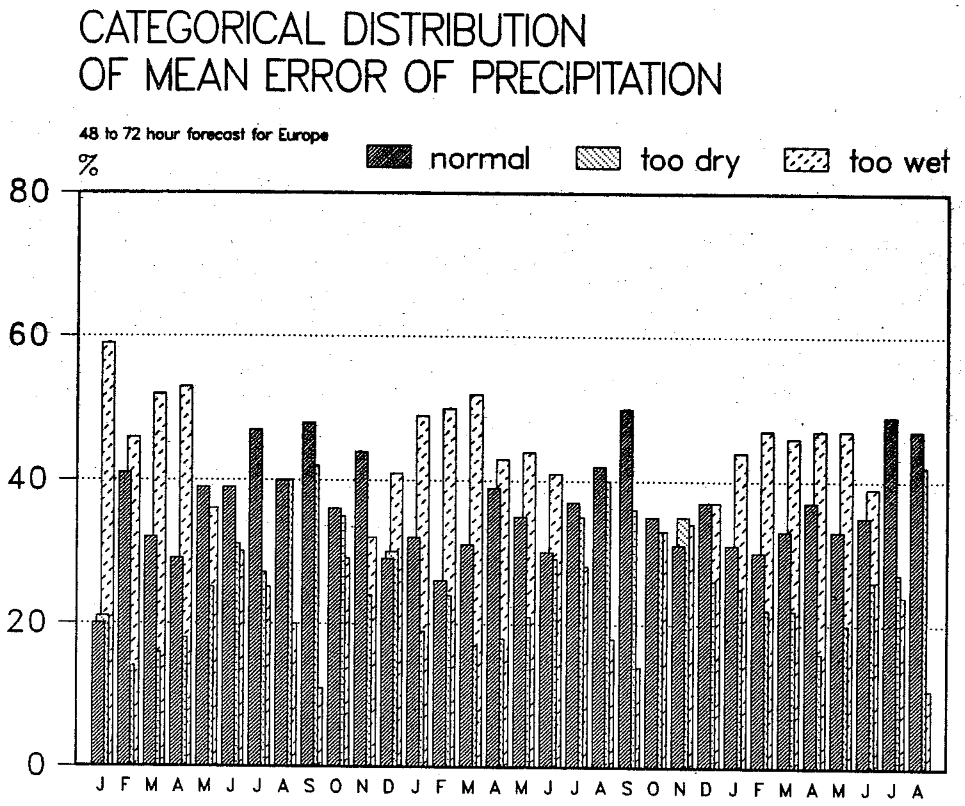

Fig 5 As Fig 3 for precipitations accumulated between 48 and 72 hour forecast, from January 1986 to August 1988.

occurs mainly in the range of active frontal zones embedded in strong westerly flows. Obviously the operational model cannot resolve any localised event (convective activity, or small scale orographic effects), which explains the spread of the distributions in Fig 6. The orography also leads to large biases.

## 5. 2 METRE TEMPERATURE

Figs 7 and 8 show the categorical distribution of the 60 and 72 hour forecast mean error over Europe since January 1986. There are distinct differences in the biases for the 00 and the 12 UTC forecast time. The most striking feature is the correction of the warm bias at 00 UTC following the introduction of the revised post-processing of the boundary layer parameters in April 1987 (C. Blondin, this volume). The strong overestimation of the 2 meter temperature under stable conditions was a deficiency of the post-processing in operation until 1987, often leading to errors greater than 5°C during clear nights when the radiation cooling is very effective (Blondin and Böttger 1987). This was due to the derivation of the parameters in the surface layer assuming a neutral profile in all cases; the revised method is based on the a priori specification of analytical profiles which are close to the theoretical profiles, the choice of analytical forms allowing exact vertical integration. Fig 9 illustrates the dramatic improvement achieved during the night in summer.

The distributions shown on Figs 7 and 8 might appear to show that the warm bias before April 1987 has been replaced by a cold bias of the same magnitude and stronger during the day. In fact, this is largely due to the smoothing of the fields in coastal areas, as described in para. 2, when the sea is colder than the land, and even more to the discrepancies between the real orography and the model orography in Alpine areas; a closer examination of the geographical distribution of the errors is necessary.

The first factor to point out is a warm bias over most of the continental part of Europe (Fig 10), of about 3° to 5°. This is related to the underestimation of the cloud cover in the daytime and is probably not due to the surface scheme itself.

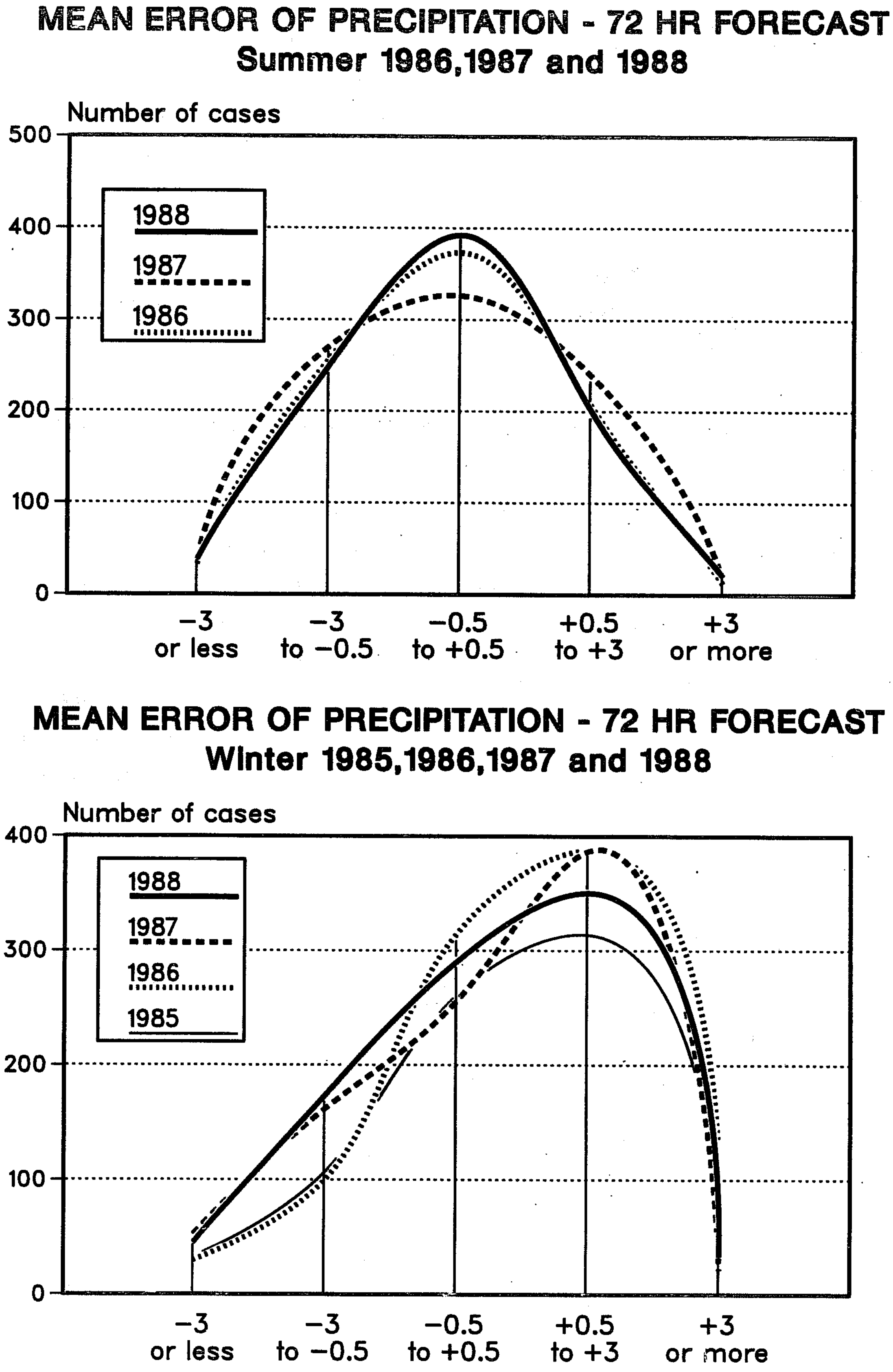

Fig 6 Mean error of 24 hour accumulated precipitation forecasts valid after 72 hours into the forecast for June to August of 1986, 1987 and 1988, and for December to February of the winters since 1984/85.

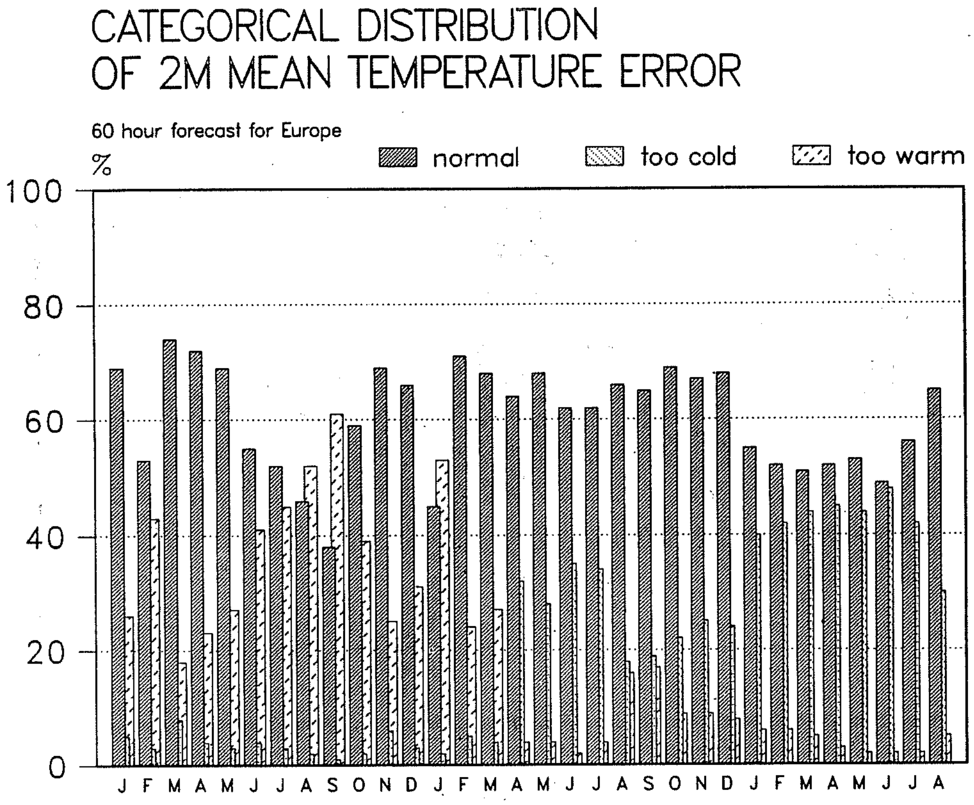

Fig 7 As Fig 3 for 60 hour forecast of 2 m temperature

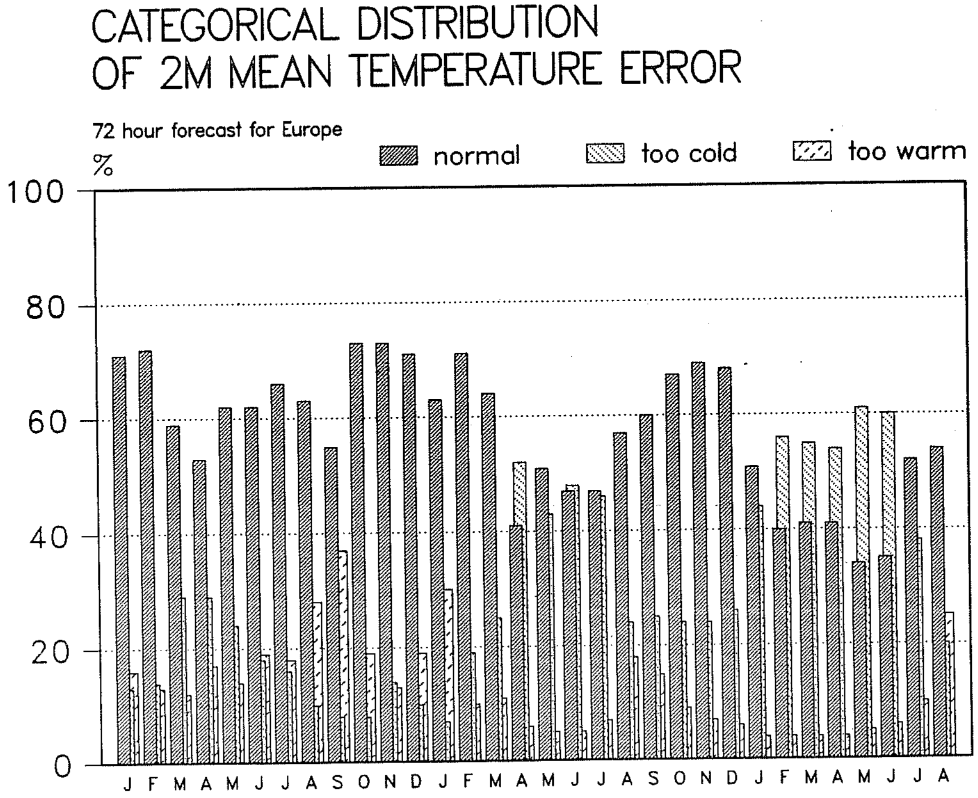

Fig 8 As Fig 3 for 72 hour forecast of 2 m temperature

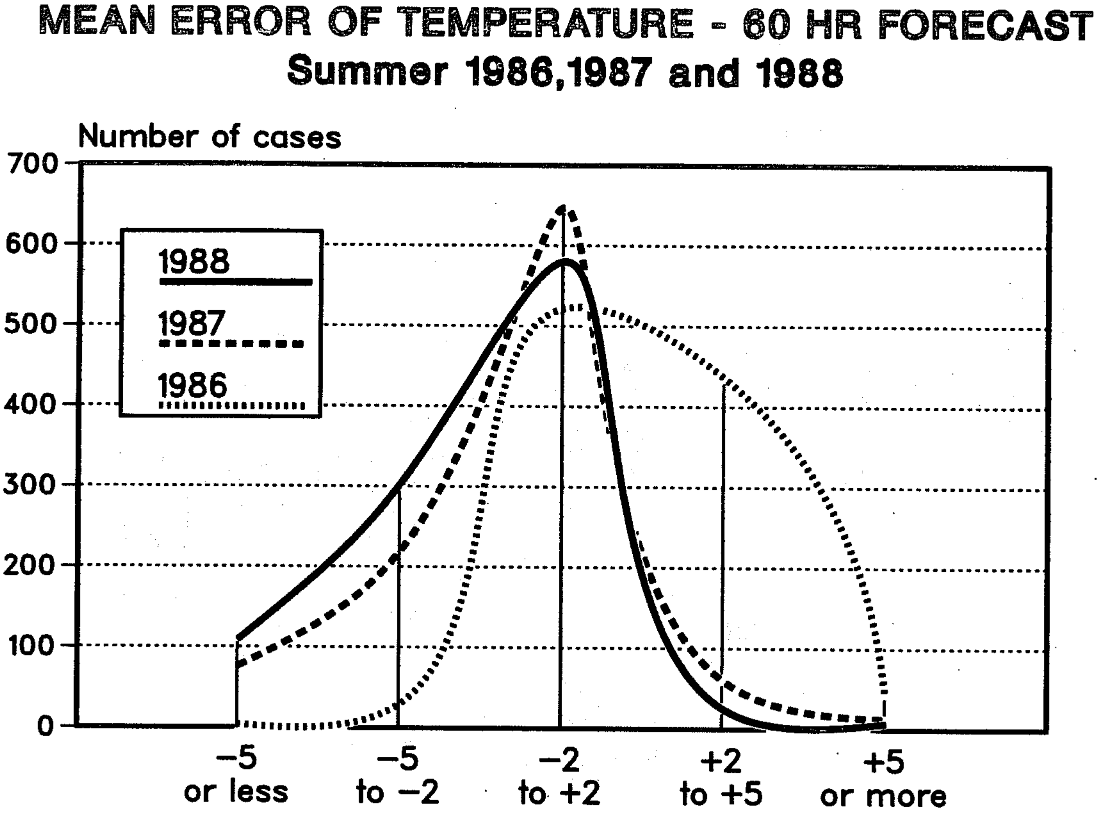

Fig 9 As Fig 6 for 2 m temperature, 60 hour forecast, for June to August 1986, 1987 and 1988.

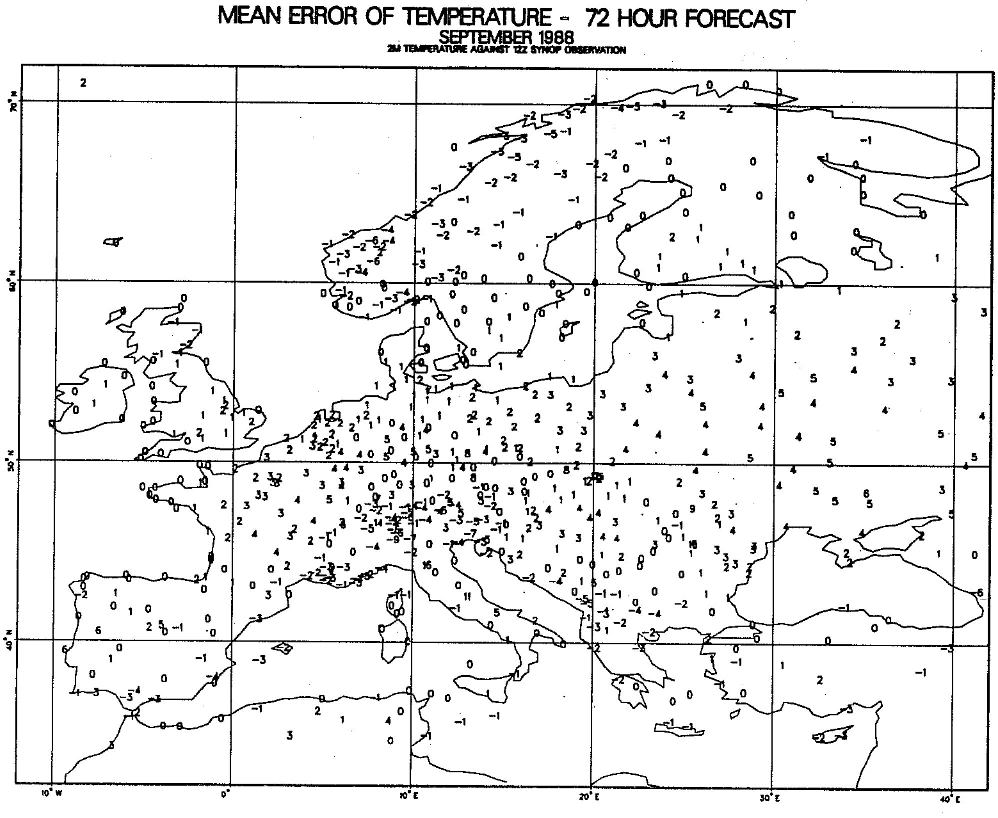

Fig 10 Mean error of 72 hour forecast of 2 m temperature at all available synoptic stations in Europe, September 1988.

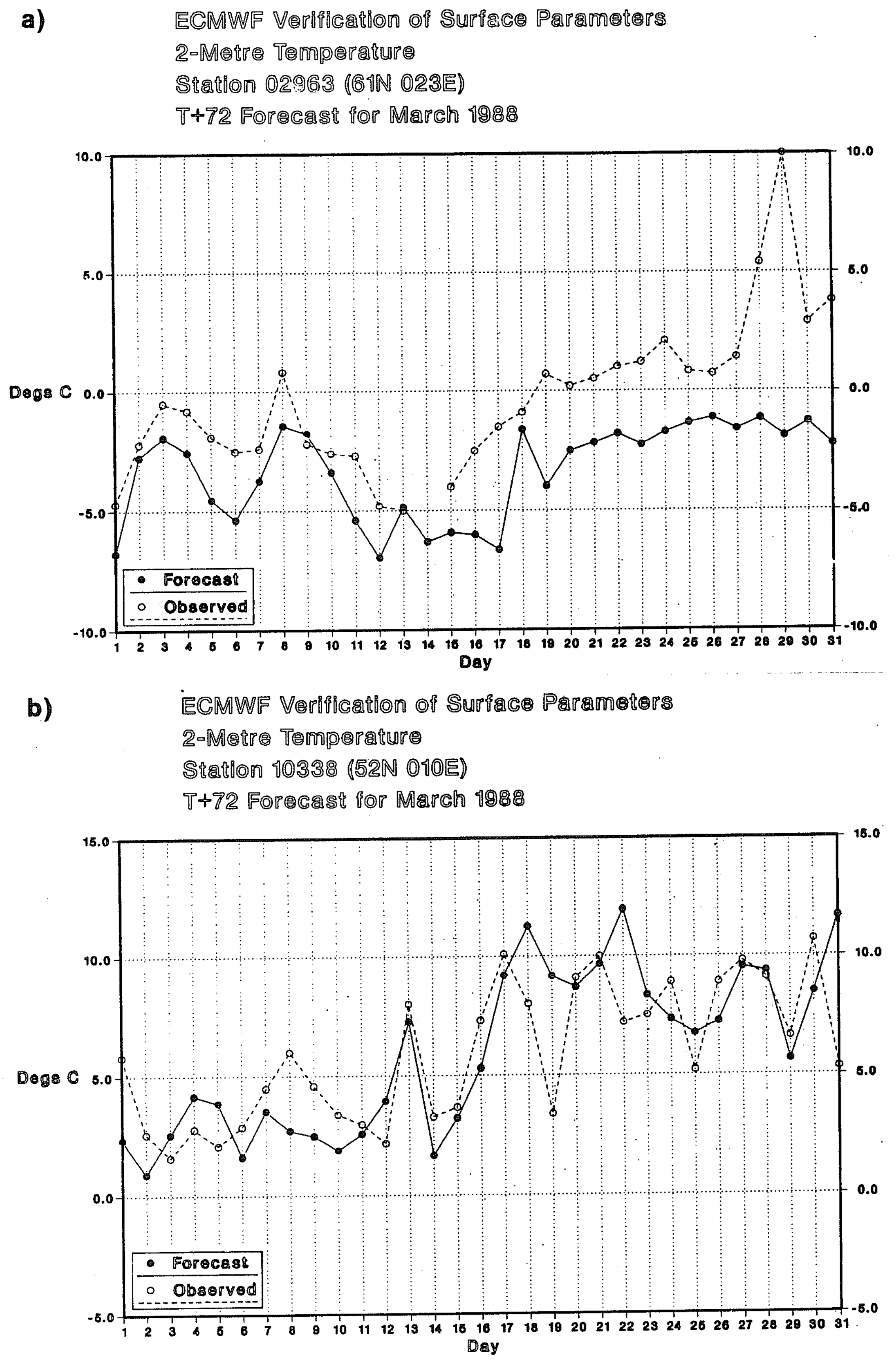

Fig 11 72 hour 2 m temperature forecast against observations for Jokioinen (a) and Hannover (b), in March 1988.

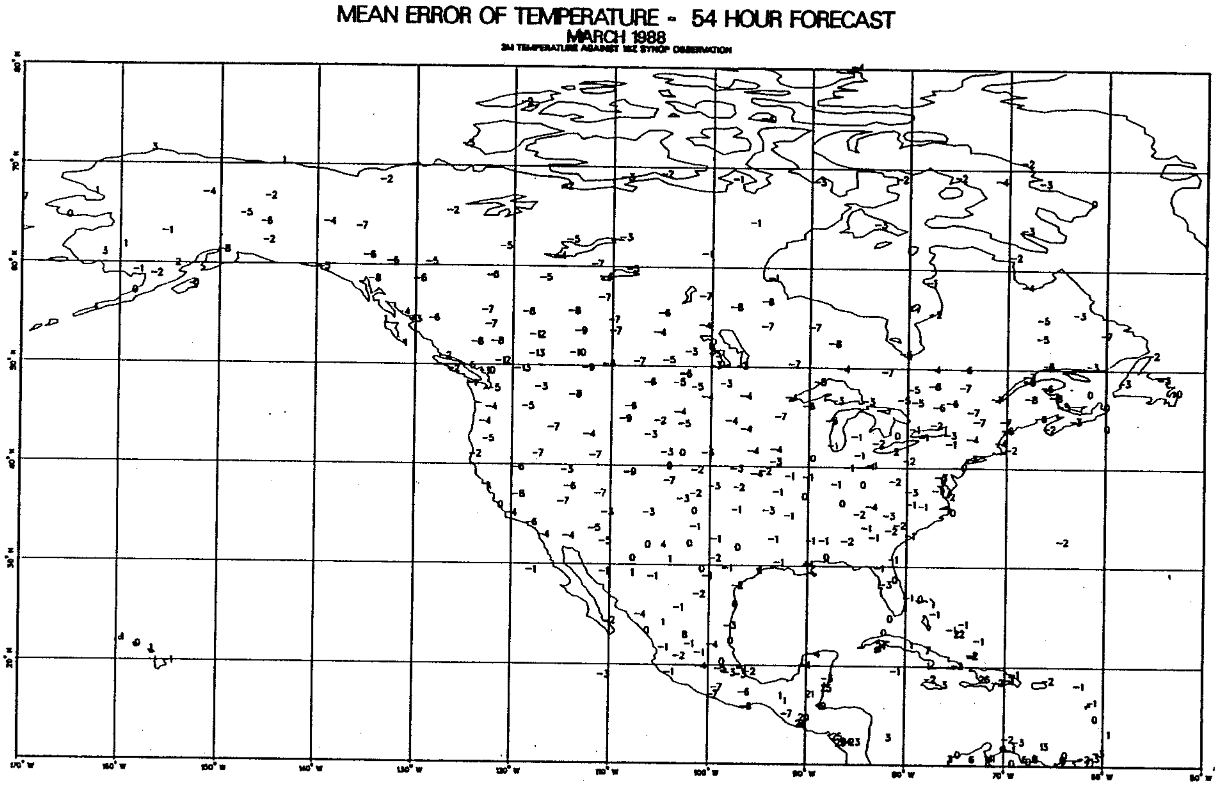

Fig 12 As Fig 10 for 54 hour forecast over North America.

The second is a cold bias over Scandinavia during spring. This occurs over melting snow areas or over areas partially covered with snow; it is probably the main problem left in the representation of surface processes in the ECMWF model (C. Blondin, this volume). Fig 11 shows daily time series of forecast versus observed 2 m temperature for 12 UTC during March 1988, at Jokioinen (latitude 61°N, id 02963) and Hannover (52°N, id 10338). Towards the end of the month, when the characteristics of the actual snow cover change significantly, the cold bias in Jokioinen increases, whereas the forecast for Hannover, south of the snow limit at this time, is almost unbiased.

The same problem occurs over North America: in Fig 12, showing the 54 hour forecast, daytime over the eastern regions, the continent can be roughly divided into 4 regions. To the west, a negative bias is due to the orography; in the east, south-east and mid-west the forecast is almost unbiased; around 50°N, a bias of 5° to 7° is related to the snow coverage; and further north, where the snow properties should be very close to those assumed by the parametrization scheme, the biases return to much smaller values.

## 6. CONCLUSION

The main results of operational verification of surface parameters at ECMWF have been presented. The level of performance achieved has been highlighted, as well as the main problems currently encountered. As far as verification itself is concerned, it is planned to improve and develop the existing facilities, for example the verification of forecast against analysis when the surface analysis is thought to contain reliable and independent information, and the verification of other parameters related to humidity. The implementation of the new Reports Data Base in BUFR in 1989 will provide much flexibility for the development of new verifications against observations.

## References

Blondin, C., 1988: this volume

Blondin, C., and H. Böttger, 1987: The surface and sub-surface parametrisation scheme in the ECMWF forecasting system: revision and operational assessment of weather elements. ECMWF Technical Memorandum No. 135.