TECHNICAL MEMORANDUM

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Point verification and simple statistical adaptation of ECMWF model forecasts of dewpoint(2M)

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1. Introduction

Meteorological Bulletin M3.4/1(3) contains the current ECMWF product catalogue. It includes, apart from "operational products", some "experimental products" such as total precipitation, wind at the 10m level, temperature at the 2m level (T at 2m) and model predicted cloud amount. The limitations of these model-dependent parameters, which are not model forecast variables but created in the post-processing, are well known and outlined in the Meteorological Bulletin. The values of wind, temperature and cloud, although suitable for use as possible predictors of near-surface weather parameters in a statistical forecasting scheme, cannot normally be used directly in local weather forecasting as they cannot be expected to be in agreement with observations. Orographic effects, local climatology and the model bias has to be taken into account in further interpretation of the direct model output.

In addition to the experimental products listed in the above mentioned product catalogue, the dewpoint at 2m above the model surface is available as a model output parameter and thus is a potential "experimental product". The dewpoint (TD at 2m) is calculated from surface values and those at the lowest sigma-level of the model. The interpolation is performed in a way analogous to the one described for the temperature at 2m in the Meteorological Bulletin M3.4/1(3). The purpose of this memorandum is to assess the quality of this product over land and over the ocean by comparing it to observations taken at OWS Lima in the North Atlantic and Hannover in northern Germany. An attempt is then made to give some guidance on the use of this product TD at 2m by demonstrating the application of simple statistical adaptation.

2. The data

For both locations, OWS Lima (57N,20W) and Hannover (52.5N,9.7E), the 24 hour forecast of TD at 2m and the observed dewpoint at 12z for each day is extracted from the European archive for the period November 1981 to May 1982. The grid interval in the European archive is 1.5 * 1.5 degrees latitude and longitude. It is created during the operational post-processing of ECMWF model output through linear interpolation from the original 1.875 degree model grid.

Ocean weather ships sometimes leave their positions for various reasons. In this study, ship Lima is allowed to deviate from its coordinates by two degrees in each direction; the observation is considered to be missing if the deviation exceeds this. Consequently, for verification of OWS Lima, the forecast of TD at 2m is averaged over the surrounding four gridpoints, giving a slightly smoother forecast while the observation is taken at one specific point within the area at the position of the ship. For Hannover, the forecast is interpolated linearly from the surrounding four gridpoints to the coordinates of the observing site.

As the dewpoint is very much a function of the temperature, a verification of absolute values of the dewpoint would obscure the model skill in predicting the humidity near the surface. Therefore, the dewpoint depression, which is the difference between temperature and dewpoint, is verified rather than the dewpoint itself.

3. Verification of dewpoint depression

In Fig. 1, OWS Lima, and in Fig. 2, Hannover, the observed dewpoint depression (T-TD) is plotted against the 24 hour prediction of this quantity obtained directly from the model and interpolated to the 2m level for the period 15 January to 25 May 1982. The x-axis is related to the time but the figure shows the of events available from this period and not the dates. Missing cases are eliminated. The strong bias in both forecasts in underpredicting the dewpoint depression is obvious, but there are differences between the two stations. No seasonal trend is observed over sea. The observed variability in the dewpoint depression is large over the whole period. Over land, the seasonal trend is quite pronounced in the observations as well as in the forecast. The variability increases from winter to spring and is much larger than over sea. In winter, the model predicted dewpoint depression is very low over land, much lower than over the ocean. It increases towards the end of the period.

Thus it appears that the direct model forecast of (T-TD) at 2m above the model surface cannot be regarded as a useful product for direct application.

4. Statistical adaptation

4.1 OWS Lima

The verification result at OWS Lima suggests that a simple statistical adaptation of the forecast aiming at the removal of the bias and at an increase in the dewpoint depression could result in the user being supplied with some useful information on the humidity near the surface.

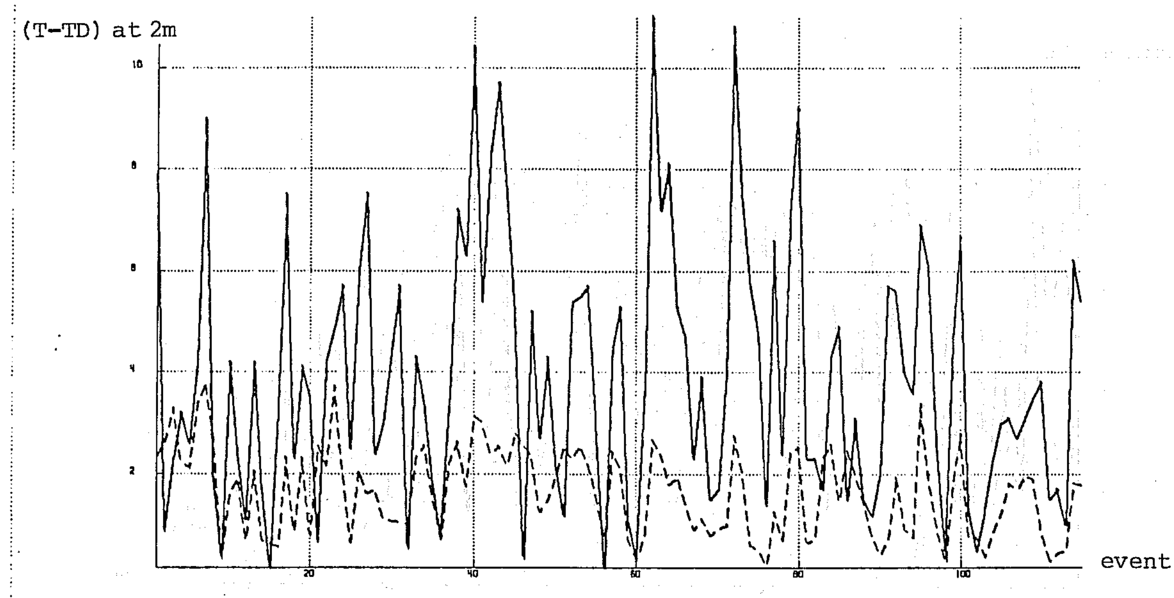

Fig. 1 24 hour forecast of dewpoint depression (T-TD) at 2m (broken line) and observed (full line) at OWS Lima, for each 12z observation (event) received between 15 January and 25 May 1982. Units are Kelvin.

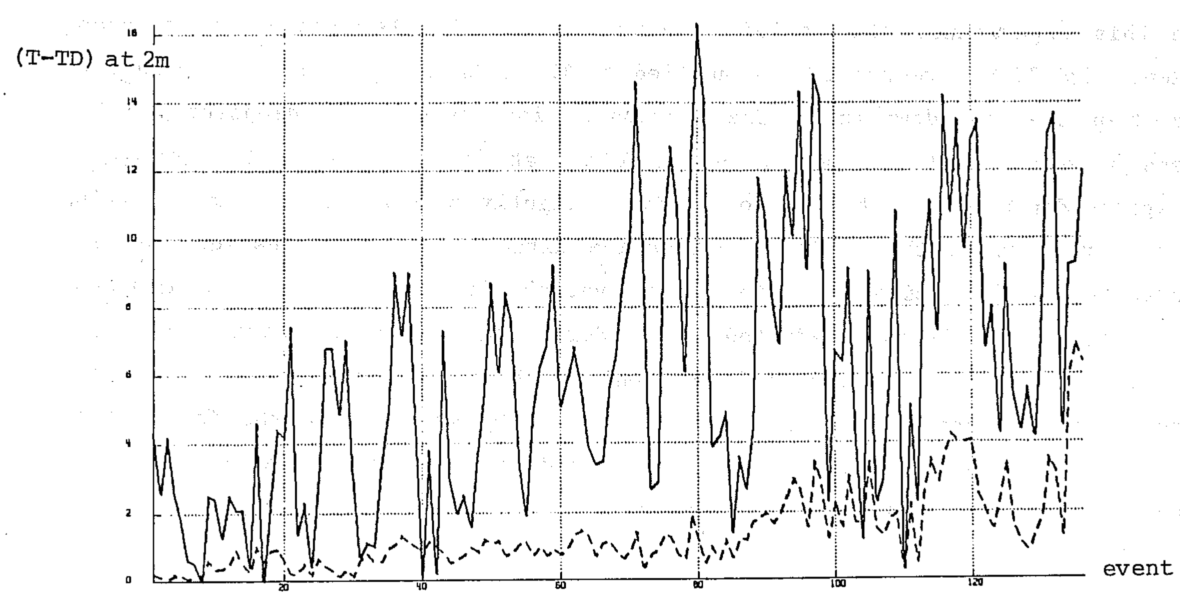

Fig. 1 24 hour forecast of dewpoint depression (T-TD) at 2m (broken line) and observed (full line) at Hannover, for each 12z observation (event) received between 15 January and 25 May 1982. Units are Kelvin.

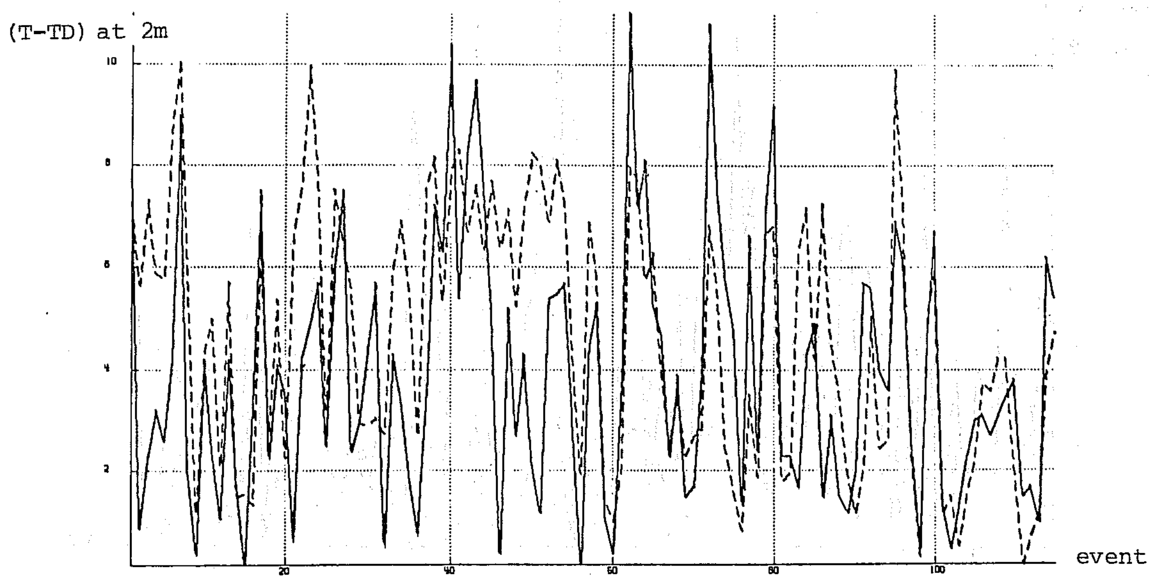

Fig. 3 24 hour forecast of dewpoint depression (T-TD) at 2m after statistical adaptation (broken line) and observed (full line) at OWS Lima 15 January to 25 May 1982, dependent sample.

In this experiment, the period January to May 1982 is used as a dependent sample and linear regression is applied to TD at 2m, giving a one predictor equation for the dewpoint. The regression forecast of the dewpoint is then used together with the model output of T at 2m to compute the predicted dewpoint depression. This approach gives slightly better results than applying the regression to the dewpoint depression directly. The regression forecast corrects for the bias, but the large variability in the observed dewpoint depression is still not predicted. This deficiency may be overcome by applying the inflation technique (Klein 1978), which will equate the variability of the regression forecast with that observed simply by multiplying the forecast by the ratio S_O/S_F, where S_O is the standard deviation observed and S_F that of the forecast. Before inflation, the parameters are expressed as departures from their mean value.

The 24 hour forecast of dewpoint depression after statistical adaptation including inflation is shown together with the observations in Fig. 3. Visual inspection alone indicates that compared to Fig. 1, the statistical adaptation helps to obtain a more realistic forecast. Though it is by no means ideal and some large errors remain, the usefulness of this product, which otherwise is very difficult to come by, is increased.

	Dependent Data		Independent Data	
	Direct Model Output	Statistical Adaptation	Direct Model Output	Statistical Adaptation
Number of events	115	115	63	63
Mean error	-2.3	.7	-2.8	.2
Stand. Dev. observed	2.5	2.5	3.0	3.0
Stand. Dev. predicted	.9	2.5	.8	2.6
RMS error	3.2	2.4	3.9	2.3
Correlation	.54	.59	.60	.67

Table 1: Verification of dewpoint depression (T-TD) at 2m at OWS Lima for direct model output and after statistical adaptation. Period for the dependent sample is 15 January to 25 May 1982 and for the independent sample 1 November 1981 to 15 January 1982. The units of mean error, standard deviation and RMS error are Kelvin.

The method is now tested on independent data for the period 1 November 1981 to 15 January 1982. The direct model verification is given in Fig. 4. Again, the product does not seem to be of any practical use. However, the inflated regression forecast (Fig. 5) results in a substantial increase of skill in forecasting the observed variability between humid and dry days. This improvement of the direct model output is clear and obvious. The result is summarised in Table 1. Linear regression applied to the dewpoint serves only to reduce the bias and improve the correlation, both on dependent and independent data. Inflation, which of course does not affect the correlation, proves to be a successful tool to enhance the usefulness of the predicted dewpoint depression.

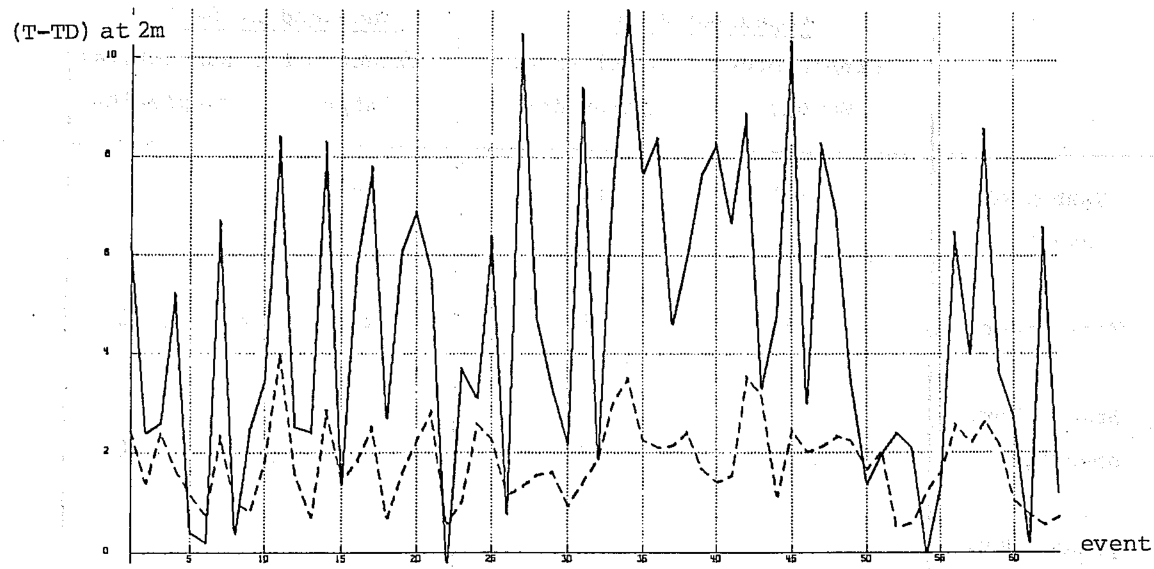

Fig. 4 Same as Fig. 1 for period 1 November 1981 to 15 January 1982, OWS Lima, direct model verification, independent sample.

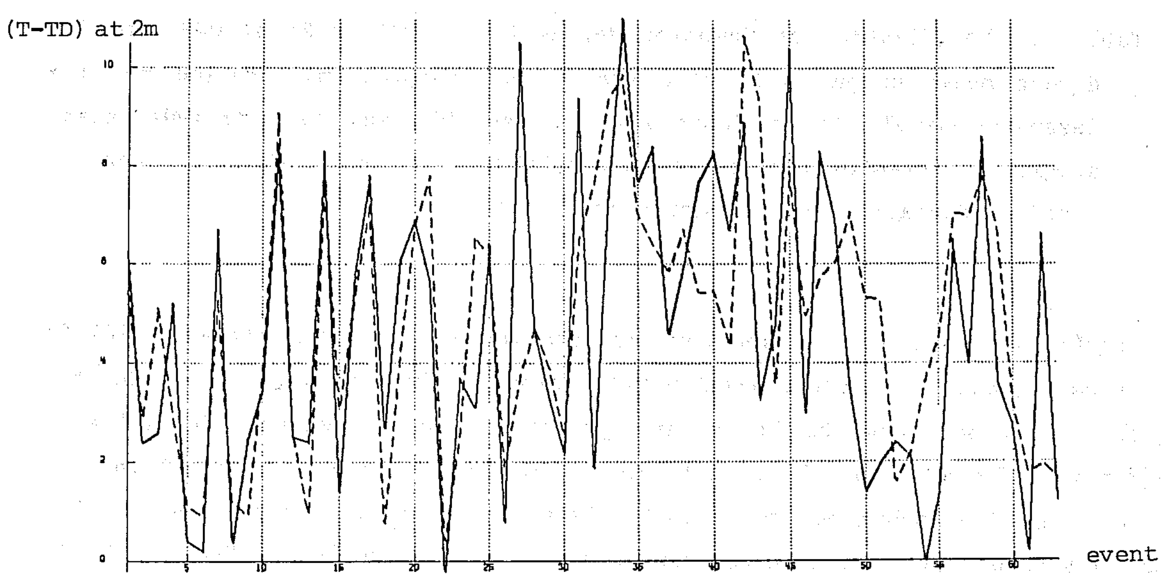

Fig. 5 Same as Fig. 3 for period 1 November 1981 to 15 January 1982, OWS Lima, statistical adaptation tested on independent sample.

4.2 Hannover

The seasonal trend observed in the dewpoint depression between winter and spring (Fig. 2) is partly introduced by the lack of the diurnal variation in the model. The data set has therefore to be stratified differently for Hannover. In this experiment, the winter season is split into a learning sample covering the period 1 November 1981 to 15 January 1982 and a test sample, 16 January until the end of February 1982. The same method of statistical adaptation as for the Lima data is applied to the Hannover forecast. In this case, the regression forecast applied directly to (T-TD) at 2m gives better results. Figures 6 and 8 show the direct model verification and Figures 7 and 9 show the regression forecast after inflation for both the dependent and independent samples. Note that inflation can give a negative value of the dewpoint depression, which in practical applications would be set to zero. Over land, the statistical methods cannot improve significantly on the forecast of humidity near the surface. The correlation remains at a level far below .5 where any results might be regarded as random.

5. Summary and conclusion

The dewpoint depression (T-TD) at 2m as a measure of humidity near the model surface is available as a direct model output parameter. The 24 hour forecast of (T-TD) at 2m has been verified at two locations, one over the Atlantic and the other over land, against observations for a transition period from winter to spring 1982. In general, the model is highly biased and gives values in the dewpoint depression which are too small. Further, it does not predict the large variability in the dewpoint depression. The verification gives hardly any correlation between forecast and observation over land while there is a better agreement over the ocean. Statistical adaptation using linear regression applied to the dewpoint as a single predictor and inflation applied to the dewpoint depression obtain from the regression forecast proves to be a useful method to adapt the forecast for further application.

Over the ocean the resulting forecasts of dewpoint depression are significantly improved both for the dependent and the independent sample. Over land the poor performance of the direct model output cannot be overcome. More sophisticated methods need to be tested.

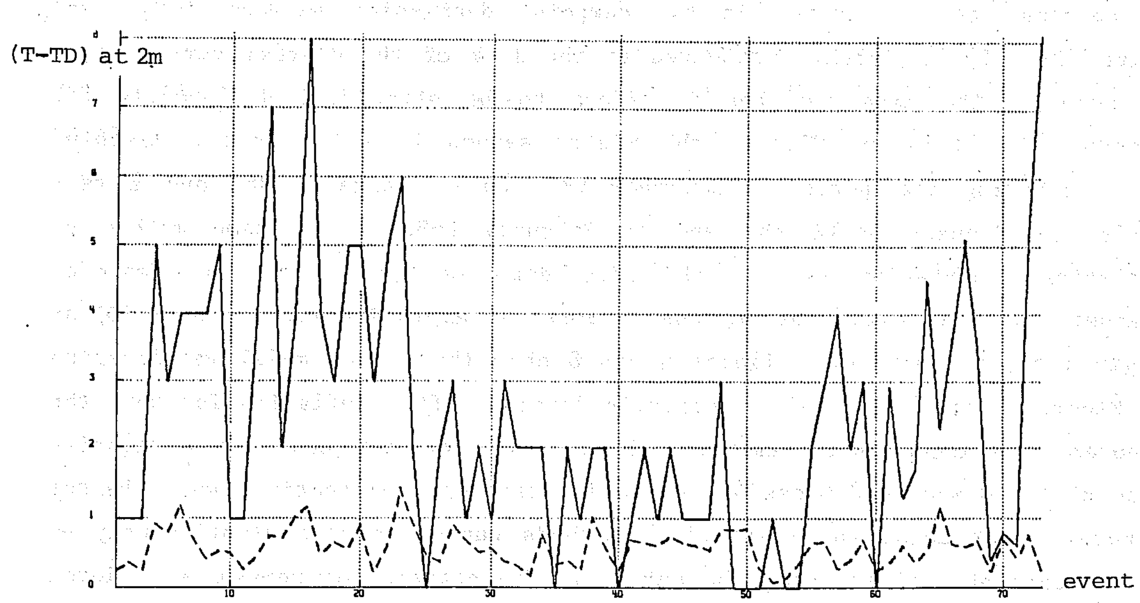

Fig. 6 24 hour forecast of dewpoint depression (T-TD) at 2m (broken line) and observed (full line) at Hannover, 1 November 1981 to 15 January 1982.

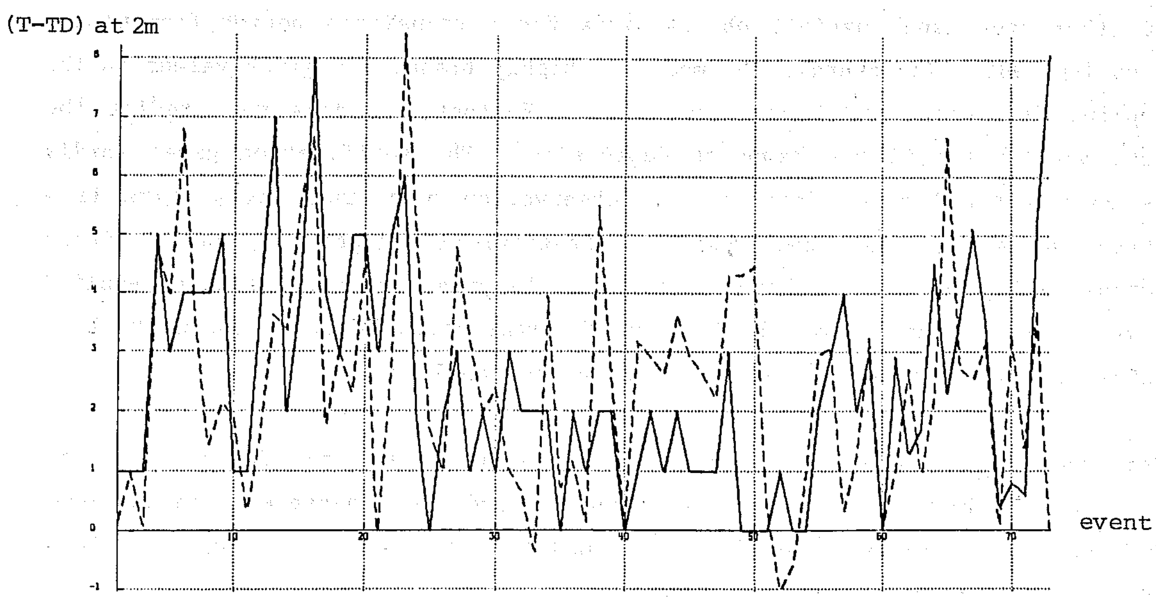

Fig. 7 24 hour forecast of dewpoint depression (T-TD) at 2m after statistical adaptation (broken line) and observed (full line) at Hannover, 1 November 1981 to 15 January 1982, dependent sample.

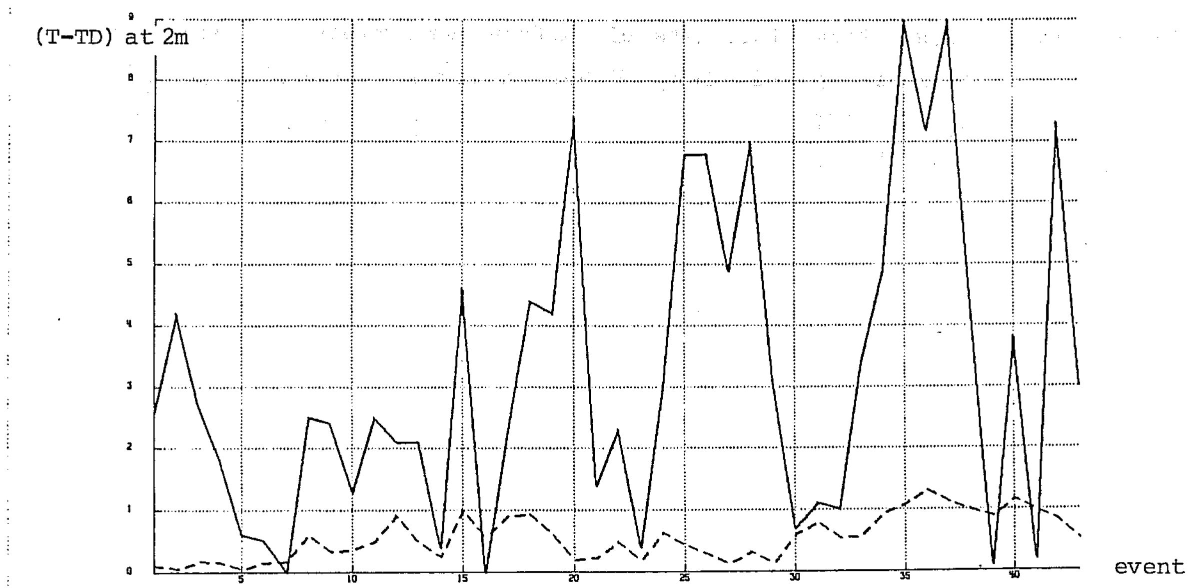

Fig. 8 Same as Fig. 6, but for period 16 January to 28 February 1982, Hannover, direct model verification.

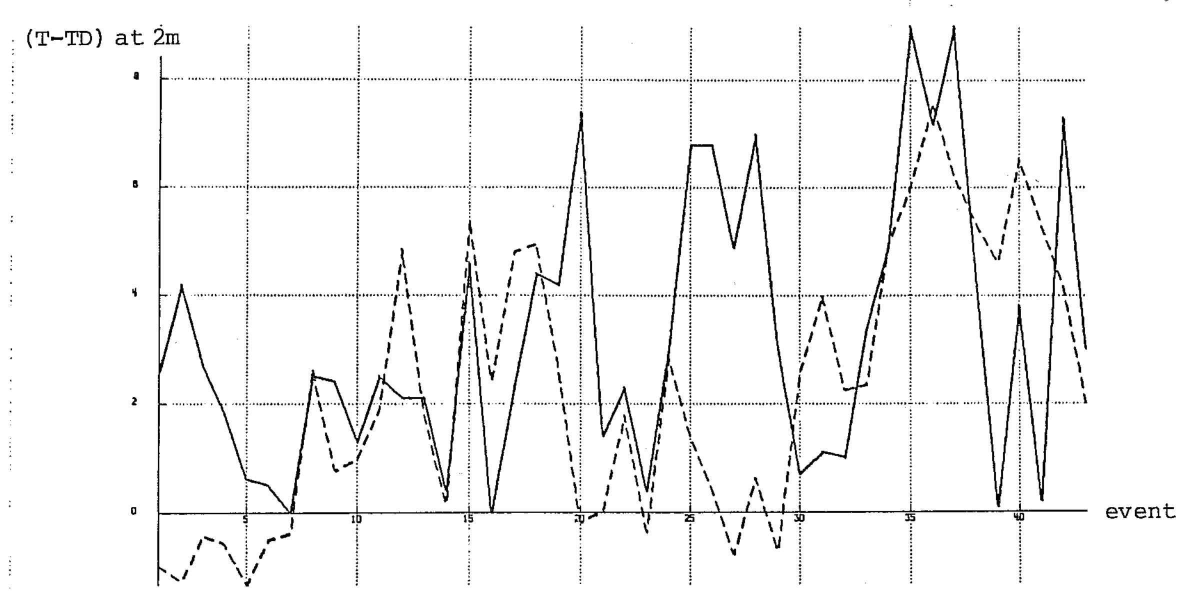

Fig. 9 Same as Fig. 7, but for period 16 January to 28 February 1982, Hannover, statistical adaptation tested on independent data.

Reference

Klein, W., 1978: Statistical forecasts of surface temperature from numerical weather prediction, ECMWF Seminar Proceedings 1978, pp. 221-272.