# ASSIMILATION OF WATER VAPOUR MOTION WINDS IN THE GLOBAL MODEL OF DWD

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ABSTRACT

The impact of satellite winds derived from the water vapour channel in the global model of Deutscher Wetterdienst (DWD) was investigated in different seasons for a total of more than 50 days. The enhanced coverage offered by the additional data improves considerably the forecast in the Southern Hemisphere whilst in the Northern Hemisphere the impact varies with time and regions, being often positive over North America but in some cases negative over Europe. Further experiments using the new high density GOES winds gave positive results everywhere. It was decided to start the operational use of the water vapour and high density winds in spring 1998. To test the new operational configuration a system observation experiment was run withholding all satellite winds from the assimilation system. The forecast of the experiment were on average worse than routine as expected. Over Europe the impact was neutral but some cases of better forecast without satellite winds occurred and had to be investigated in more details.

## 1 Introduction

The current numerical weather prediction system of Deutscher Wetterdienst (DWD) comprises a Global Model (GM) for large-scale predictions, whose output is used as boundary condition in the regional-scale model for Europe. The GM has a horizontal truncation of T106 and 19 vertical levels. The data assimilation of GM is based upon a 3D multivariate optimal interpolation (OI) for the analysis of mass and winds increments. Conventional observations, satellite soundings (SATEM) and satellite winds from geostationary satellites (SATOB) enter the analysis. The observation time window is 3 hours around the four synoptic hours. Until recently GM has been using only satellite winds derived from the infrared and visible channels. However the data coverage is enhanced when also Water Vapour Motion Winds (WVMW) (Laurent,1993; Velden et al, 1997) are considered in the assimilation process. The four geostationary satellites, GOES-8, GOES-9, METEOSAT and GMS extract and disseminate regularly this product. To evaluate the impact of WVMW in GM, assimilation experiments adding WVMW to the other observations ran in different seasons and their output was compared to that of the operational model. The experiment was repeated when the high density (HD) wind product from the US satellites GOES became available. Based on the results from these experiments it was decided to start to use the WVMW and HD in the operational model. The new operational configuration was finally tested with an experiment removing all satellite winds.

## 2 Assimilation experiment with WVMW

a) May 1997

A two week experiment using WVMW from all levels (above 700 hPa) and all satellites (GOES8, GOES9, METEOSAT and GMS) in May 1997 has shown a substantial positive impact in the medium-range forecast scores in the Southern Hemisphere, with almost 8 hour gain in predictability but gave no signal of improvement in the Northern Hemisphere and over

Europe (Fig.1). During the assimilation experiments statistics were computed comparing the satellite winds, both infrared and water vapour, to the short-range model forecast fields. The distribution of observation minus model winds, in particular the amount of large departures, varies considerably depending on the satellite system: GOES data present a smoother distribution than METEOSAT and GMS data. One explanation of this can be the different quality controls applied before the winds are disseminated to the users. It is interesting to mention that this difference was also found when comparing METEOSAT and GOES-8 observations derived for the same area and same level over the Atlantic. Such discrepancies can create some problems during the assimilation process.
The assimilation experiment was rerun with a revised quality control for all satellite winds. The rejections thresholds were tuned in order to reduce the inhomogeneities in the distribution of used winds from different satellites (Fig.2). The revised quality control rejected in percentage more outliers in the case of METEOSAT and GMS than in the case of GOES: for the formers the percentage of not active data is approximately 10% (for both infrared and water vapour channel), for the latter the same percentage is never above 6%. The highest percentage of rejections is found in the case of WVMW below 400 hPa. The forecast impact was slightly positive in the Northern Hemisphere and neutral in the Southern Hemisphere (Fig.1). This indicates that some winds rejected by the revised quality control were useful for the assimilation system in the Southern Hemisphere but detrimental in the Northern Hemisphere.

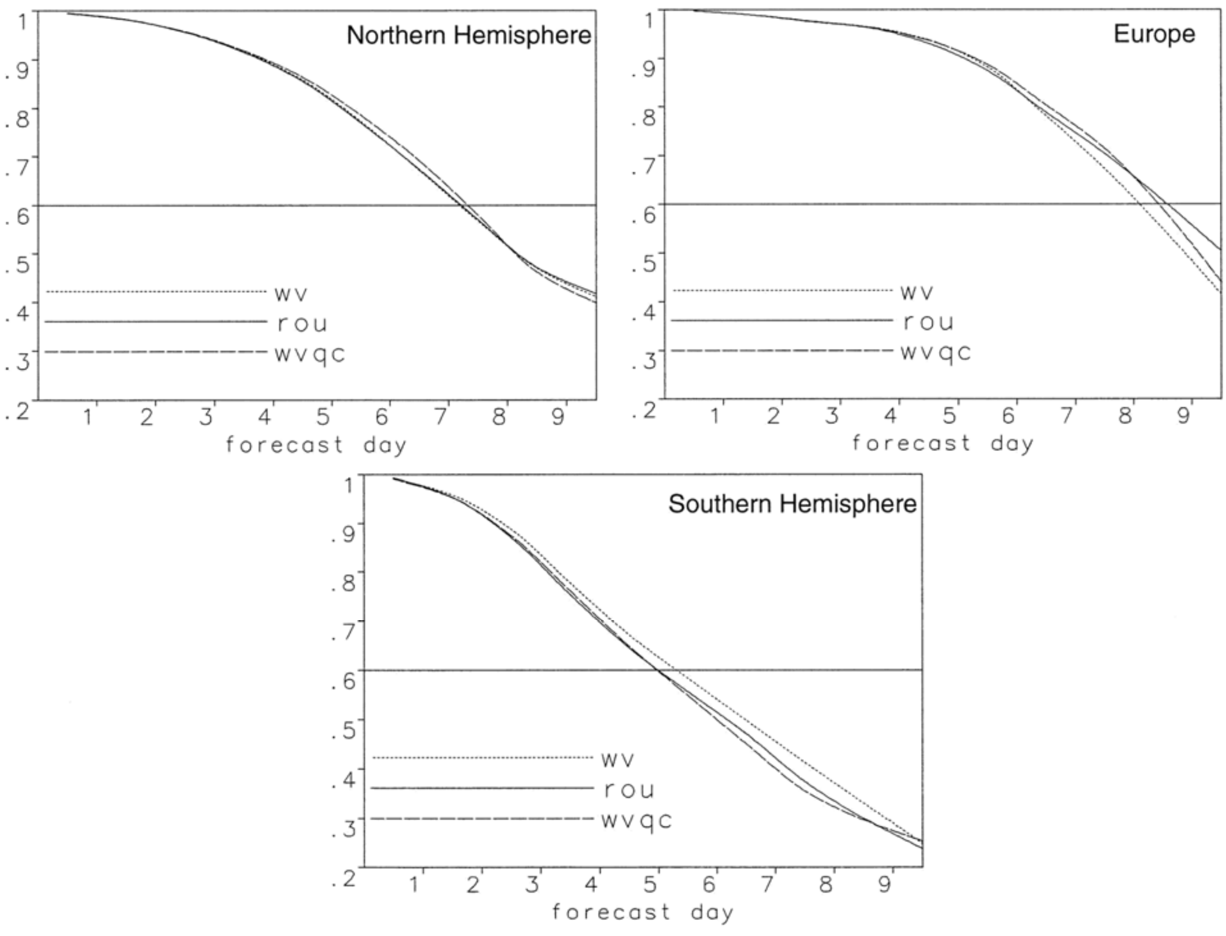
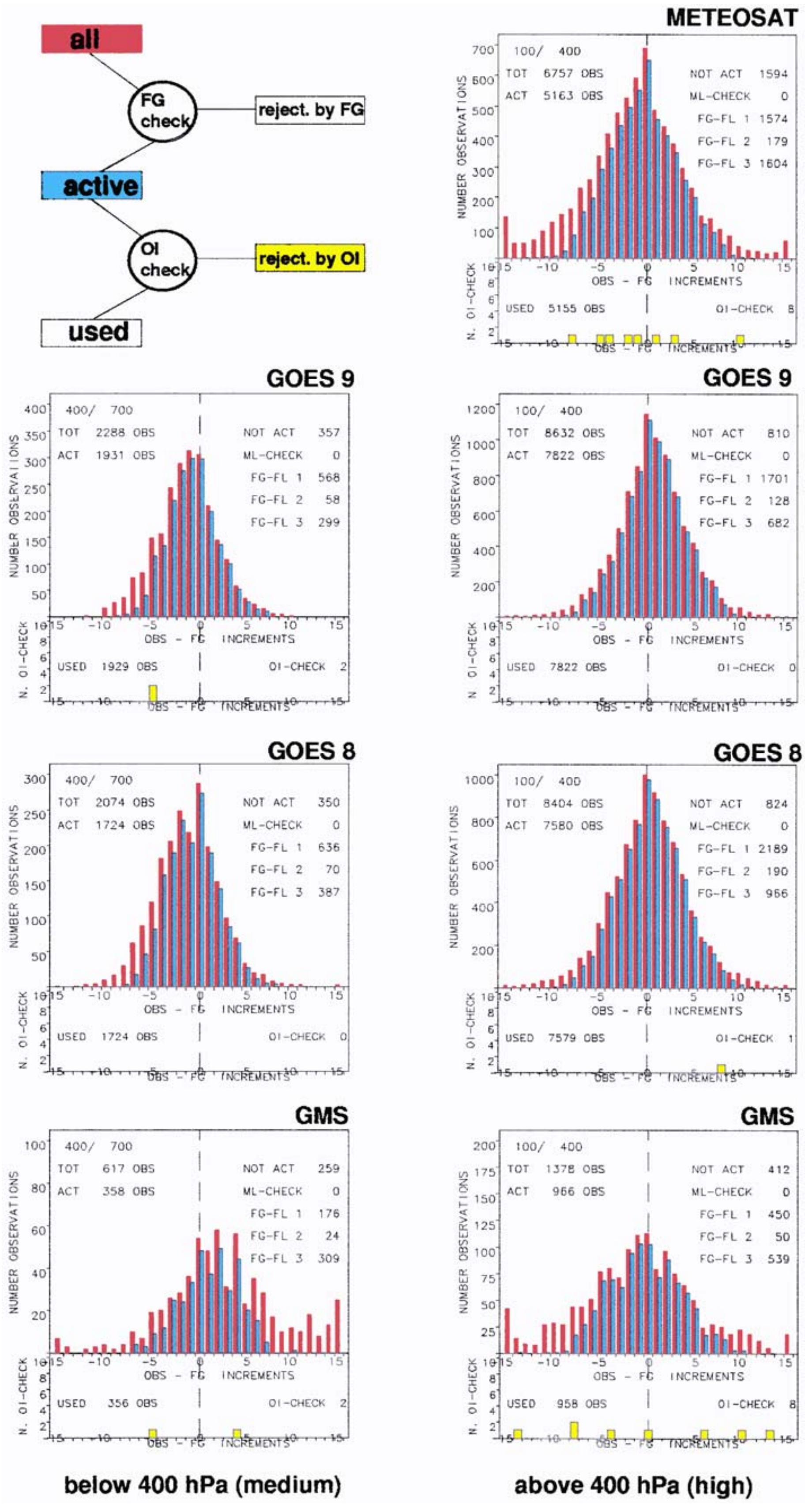



**Fig. 1** Forecast anomaly correlation of 500hPa geopotential averaged over 16 cases in May 1997 for: experiment WVMW (dotted line), routine (full line) and experiment with WVMW and revised quality control (dashed line).

**Fig. 2** Distributions of u-component of WVMW minus First Guess increments at high and medium level in the Southern Hemisphere for the two week experiment in May 1997 with revised quality control.



b) Winter 1997/1998

To better evaluate the impact of WVMW in the Northern Hemisphere and over Europe, a new assimilation experiment with WVMW was run during the winter season 1997/1998. Only WVMW above 400 hPa were used, with unmodified quality control of the SATOB data. The experiment ran in two different periods, (21-30 Nov. and 13 Dec.-11 Jan). The 10 day forecast scores averaged over 36 days (only forecasts from the third day of assimilation onwards are considered) show a small but clear positive impact of the data in the Northern Hemisphere (Fig.3). The average comes from very good forecasts in November, neutral to slightly negative cases during December and then again from some very good cases during January. Most of the improvement is a reduced forecast error over the North America, especially over the North-East Atlantic coastal regions, where the model performance was particularly poor. No SATOB data are used over land in the extratropics, so this signal is likely related to WVMW observations over the North Pacific. However the scores over Europe do not show any substantial improvements (figure not shown). This may be related to the inhomogeneity in the data over the North Atlantic, as mentioned above. In the Southern Hemisphere (Fig.3) the positive results of the May experiments were confirmed.

## 3 High density GOES winds

Further work was carried out to tune the operational usage of WVMW including the new high density wind product (HD) available from the GOES satellites. Because of the limited resolution of the GM (grid points at 125 km horizontal distance), a redundancy check was introduced to thin the number of SATOB. Only one observation is retained in a box which is slighter smaller than the grid box. Typically the result of this thinning is that only half of the HD GOES data enter the analysis cycle, whilst almost all METEOSAT and GMS data are retained. The reception of the HD wind product was initially irregular and an impact study could only be done for the period from 4 to 14 February 1998. The impact of the extra HD winds (infrared and water vapour) was clearly positive, with better medium-range forecast in the Northern Hemisphere than routine (using only infrared low density winds). Unfortunately further comparisons could not be performed because the dissemination of the low density wind product was terminated. The assimilation of high level WVMW and HD GOES, together with the introduction of redundancy check for SATOB data, started on March 1998.

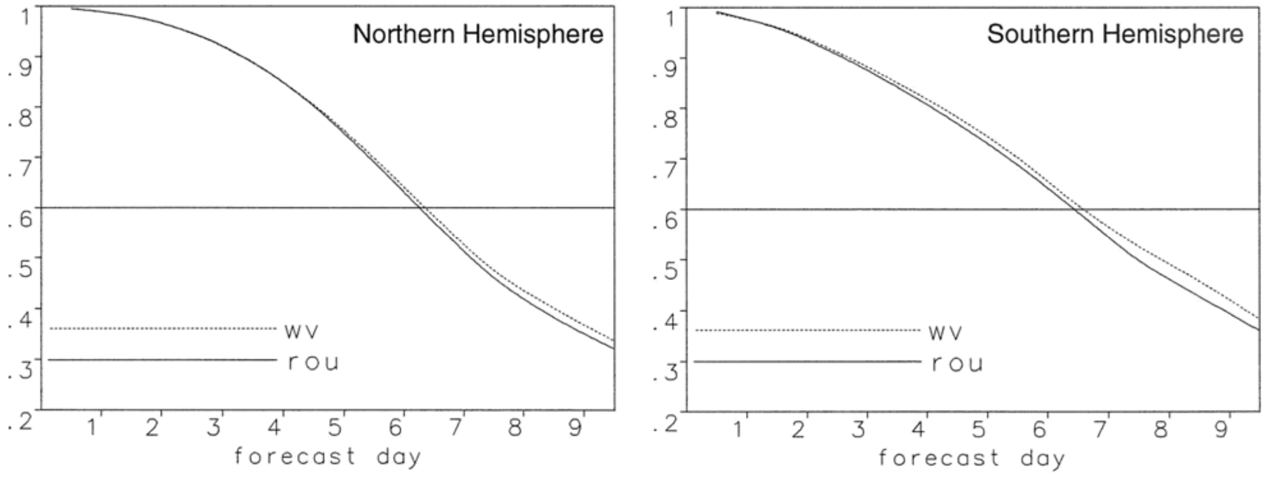



**Fig. 3** Forecast anomaly correlation of the 500 hPa geopotential averaged over 36 cases during the winter 97/98 .for: experiment WVMW (dotted line) and routine (full line).

## 5 Impact of satellite winds

An observation system experiment was performed in June 1998 to check the new operational configuration (i.e. use of WVMW and HD winds): all satellite winds were withheld from the assimilation system and the resulting analyses and forecasts compared with those of the routine assimilation (Fig. 4). The degradation of the experiment forecasts in the Southern Hemisphere confirms the key role played by satellite products in regions where conventional data are few (note that the initial gap between anomaly correlation curves is mostly due to the fact that the routine analysis is used as verifying one for both forecasts). The very similar scores of experiment and routine in the Northern Hemisphere indicate a neutral impact of satellite winds. Over Europe the slight impact of satellite winds is negative in the short-range and positive in the medium-range. The day by day comparison of routine and experiment shows that out of 19 forecasts the satellite winds are beneficial for the assimilation system in 7 cases, they are not in 7 and neutral in 5. One case of particular negative impact over Europe on the 16/06/1998 could be tracked back to a difference between the routine and experiment in the analysis of a low system over the Atlantic Ocean at around 50N-30W (Fig. 5). In the vicinity of the system several satellite observations above 400 hPa report a speed 3-4 $ms^{-1}$ slower than the background field. In the experiment (Fig.5a) not assimilating these wind vectors the trough is more pronounced and elongated to the south-west than in the routine (Fig. 5b). This corresponds to a difference in the analysis of the 500 hPa geopotential of about 20-40m (Fig.5c) which clearly propagates later in the forecast (Fig.5d-f). Especially over central and eastern Europe the 6 day forecast of the experiment is closer to the verifying analysis than routine (Fig. 6). The cases of positive impact were also investigated but they could not be easily tracked back to analysis differences due to the satellite winds.

## 6 Conclusions

The assimilation experiments with WVMW have shown that these data have a positive impact in both hemispheres. Thanks to these results this product has became an operational product at DWD. However some single cases of negative impact of satellite winds (both infrared and water vapour) over Europe is still a worrying finding. Improvements are expected by recent developments in the satellite wind products. For example Eumetsat has started to disseminate all wind vectors with attached quality information derived during the product extraction (Holmlund, 1998) in BUFR format. The results is an increase in the yields of winds. The final decision whether or not to assimilate the wind observation is left to the users. Further work is required to tune the quality threshold most appropriate for the global model of DWD, especially when the new model version GME at higher resolution will be operational (planned autumn 1999).

REFERENCES

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Laurent, H. 1993: wind extraction from Meteosat water vapour channel image data, *J Apll. Meteor.*, Vol. 32, 1124-1133

Velden, C., C. Hayden, S. Nieman, P. Menzel and S. Wanzog, 1997: Upper-tropospheric winds derived from geostationary satellite water vapor observations, *Bull. Amer. Meteor. Soc.*, Vol. 78, 173-196.

**Fig. 4** Forecast anomaly correlation of the 500 hPa geopotential for the period from 8 to 26 June 1998 for the experiment without satellite winds (dashed line) and routine (full line).

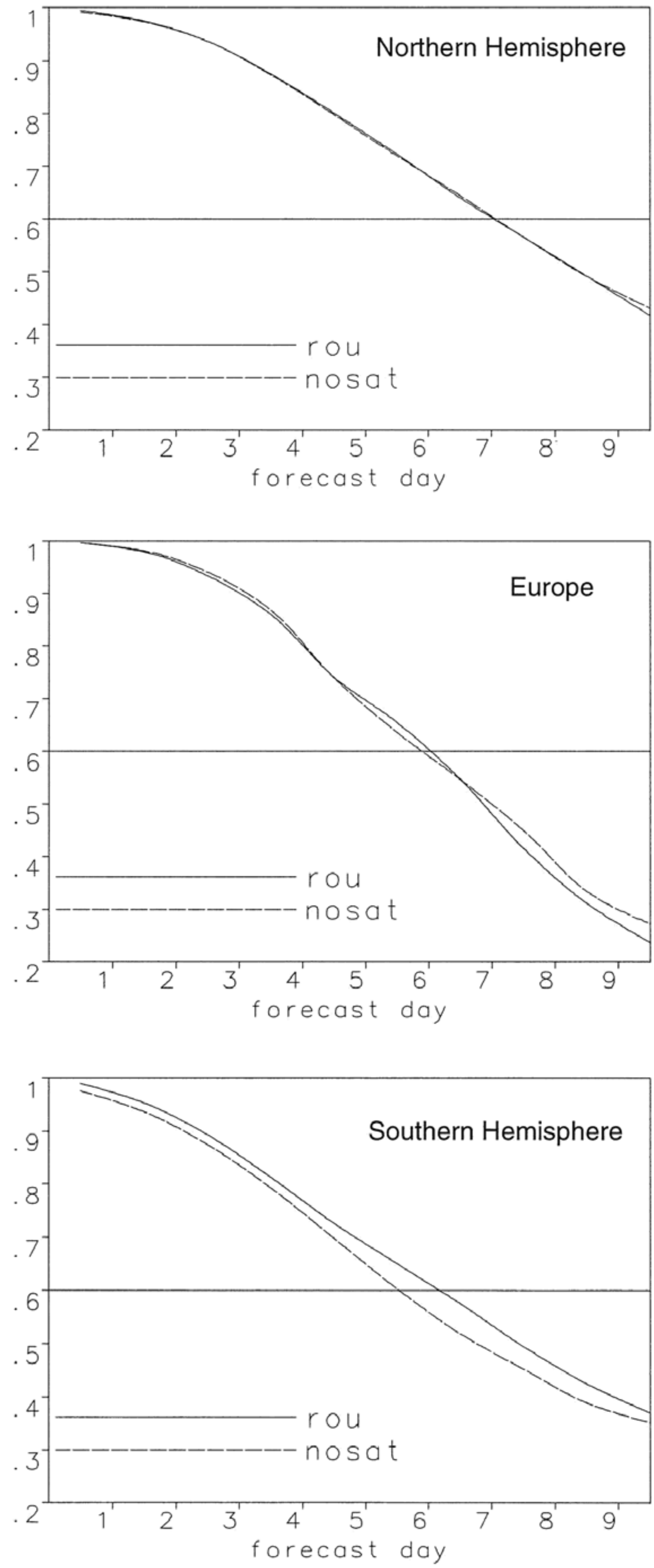

**Fig. 5** 500 hPa geopotential fields starting from 12 GMT 16/06/98. Analysis for **a)** experiment without satellite winds, **b)** routine and **c).** analysis difference experiment minus routine. Difference experiment minus routine at **d)** 1 **e)** 4 and **f)** 6 day forecast. Negative differences are dashed and contour interval is 20m for c), d), e) and 40m for f).

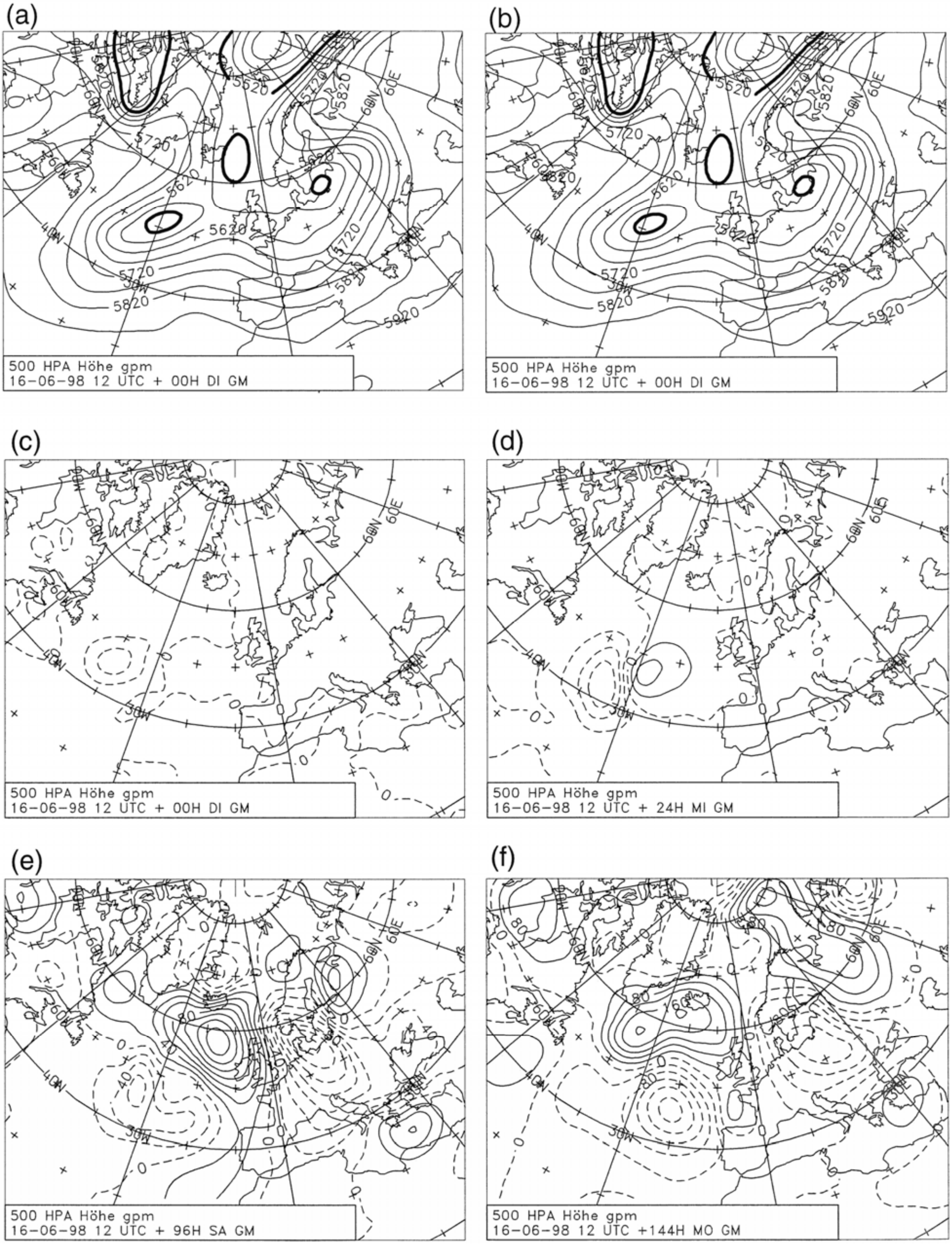

**Fig. 6** 500 hPa geopotential fields valid at 12 UTC 22/06/98 a) routine analysis, b) 6 day forecast for experiment and c) for routine.