THE GREENLAND LEE-LOW AND A FORECAST ERROR OF THE 8 JANUARY 2005 DENMARK WINDSTORM

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Abstract: Forecasts of the 8 January Denmark Windstorm are compared. In a wrong forecast, the Greenland-lee low is far to shallow, there is less outflow of cold air from west of Greenland and consequently a poor development of the upper trough that fed the windstorm. The analysis of the forecasts and an ETKF analysis support that a correct analysis of the atmosphere in the region between Iceland and Greenland would have been of importance to get a correct forecast of the windstorm over Denmark 3 days later.

Keywords *– Greenland lee-low, Icelandic low, forecast error, THORPEX*

1. INTRODUCTION

On 8 January 2005 a violent windstorm hit Denmark and Southern Sweden. The windstorm was very well predicted by the 48 hr. deterministic forecast of the ECMWF, while the 72 hr. forecast of the same event was poor. Here, the forecasts are investigated and the error is traced back using quasi-geostrophic theory in a similar manner as in Einarsson et al., (2004). Areas of sensitivity to initial conditions are computed using the ETKF technique and the results are compared and discussed in connection with the Greenland lee-low.

2. THE WINDSTORM FORECASTS

Figure 1 shows the analyzed MSLP and temperature at 850 hPa. There is a deep low at the southwest coast of Norway and a very strong pressure gradient over the North Sea. The pressure gradient and the associated windstorm moved over Denmark and S-Sweden later the same day. Figure 2 shows a 48 hr. forecast valid at the same time as Fig. 1. This forecast is indeed successful in predicting the storm, the deep cyclone and the strong winds are present and located correctly. A 72 hr. forecast (initialized on 5 Jan at 12UTC) was on the other hand a failure: there was no windstorm present, but only a relatively uniform field of moderately strong southwesterly winds over Britain, the North-Sea and Denmark (not shown).

Comparing the 48 hr. and 72 hr. forecasts reveals a large difference in the upper tropospheric vorticity. The correct forecast has much more vorticity, and a deeper and sharper upper trough as it was located over the North-Atlantic, west of Britain a day before (on 7 January at 12 UTC). Comparing the low level flow in the wrong 72 hr. forecast with the correct 48 hr. forecast shows more cold air outflow from the area southwest and south of Greenland, leading to a sharper trough in the correct forecast. The difference between a successful forecast and a less successful forecast is best illustrated by looking at the analyzed MSLP on 7 January at 00 UTC (Fig. 3) and comparing it to a 48 hr. forecast initialized on 5 January 2005 at 00 UTC (Fig. 4). In the analysis in Fig. 3, there is a 963 hPa low east of S-Greenland, while in the 48 hr forecast valid at the same time, the mean sea level pressure is about 983 hPa or about 20 hPa too high.

3. THE ETKF METHOD

The ensemble transform Kalman filter (ETKF) is a technique for predicting in which areas the deployment of extra observations is expected to minimize the forecast error over a pre-defined verification region at a pre-defined future time (Bishop et al., 2001, Majumdar et al., 2002). The ETKF employs ensemble forecasts and attempts to predict the impact of extra observations on the spread of the ensemble and thus the forecast error variance. The method takes into account a pre-described observation network and observation errors as well as the ensemble forecasts. Here, 25 ensemble perturbations of wind and temperature at three vertical levels, 850, 500 and 200 hPa are applied and the reduction in the forecast error of total vertically integrated energy due to extra observations predicted (Fig. 5). The figure reveals a strong signal west of Iceland. Yet, the jet is located much further south.

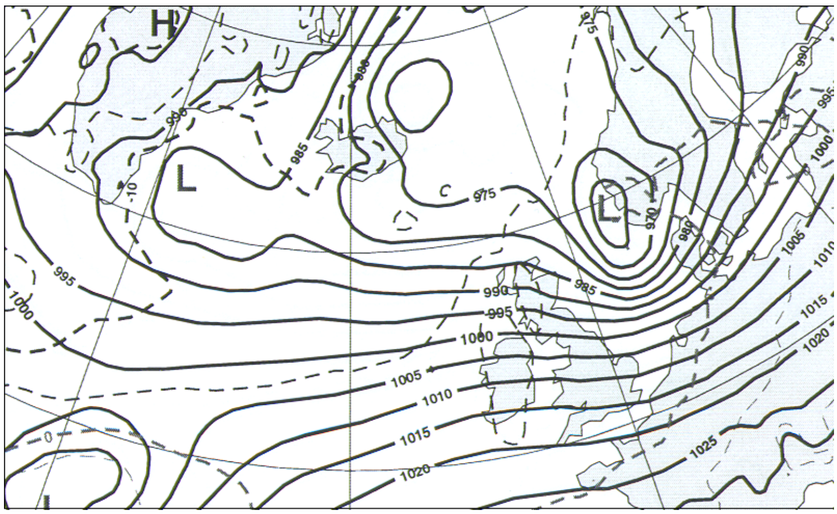

Figure 1. MSLP (hPa) and temperature at 850 hPa in an analysis valid on 8 January 2005 at 12 UTC

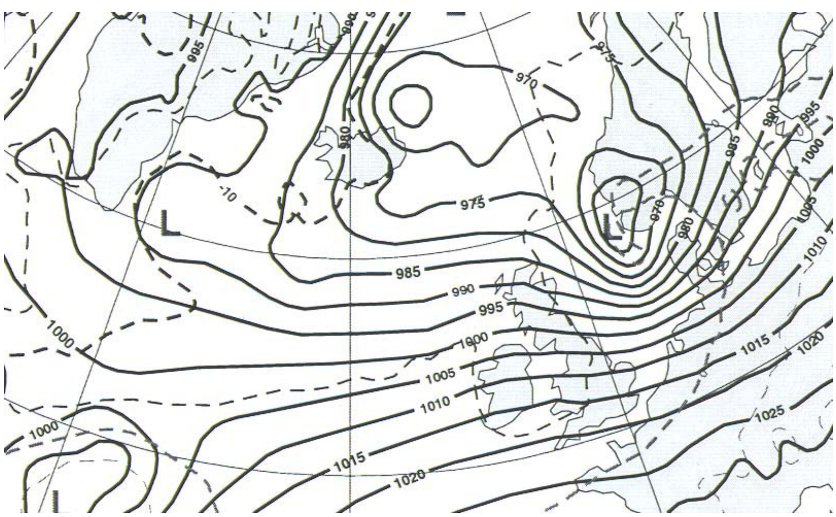

Figure 2. MSLP (hPa) and temperature at 850 hPa in a 48 hr. forecast valid on 8 January 2005 at 12 UTC

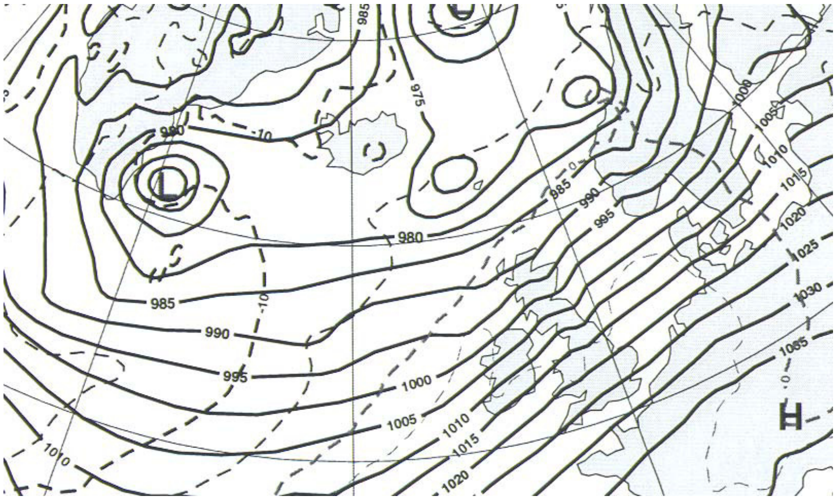

Figure 3. MSLP (hPa) and temperature at 850 hPa in an analysis valid on 7 January 2005 at 00 UTC

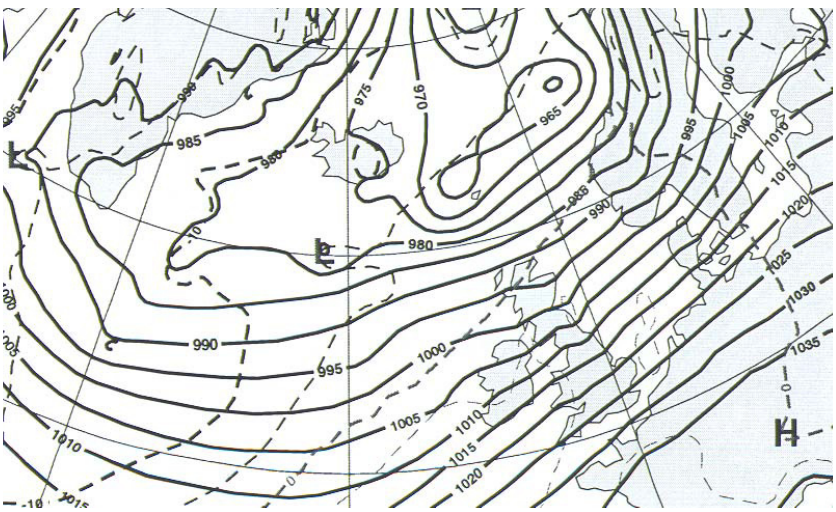

Figure 4. MSLP (hPa) and temperature at 850 hPa in a 48 hr. forecast valid on 7 January 2005 at 00 UTC

4. DISCUSSION

The above analysis indicates that the Greenland lee-low (or the Icelandic low) is important for the development of the Denmark windstorm. This impact is of a similar kind as shown in a study of a FASTEX cyclone by Petersen et al. (2003). The origin of the error in the prediction of the Greenland lee-low is not yet clear, but there are indications that it may be associated with the movement of airmasses along the east coast of Greenland and possibly down from Greenland. A lee-low, similar to this one was studied in Kristjánsson and McInnes (1999) and they showed that the low did indeed owe its existence to the blocking of cold air by Greenland.

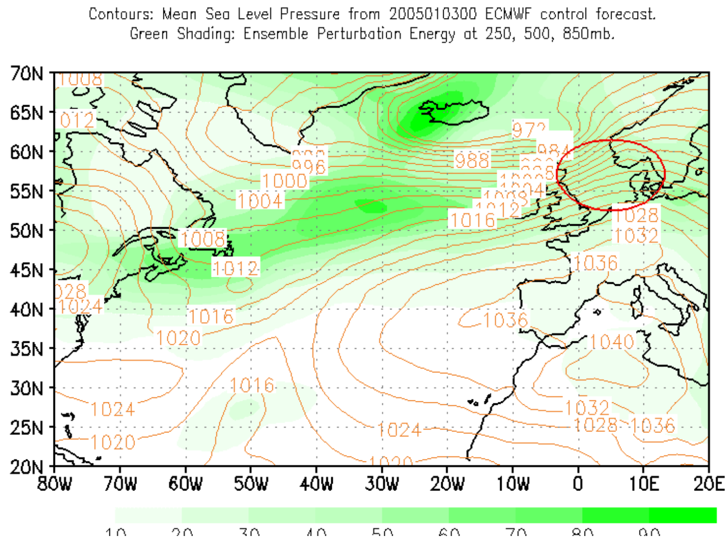

Figure 5. Ensamble perturbation energy (ETKF) for a 72 hr. forecast with verification time on 8 January 2005 at 12 UTC. Verification area is indicated with a red ellipse over the North-Sea.

5. CONCLUSIONS

The present case study indicates strongly that cyclone evolution near Greenland may be important for subsequent explosive cyclones over continental Europe and that the correct simulation of the Greenland-lee cyclone may depend upon accurate initialization in the Iceland-Greenland region, although the upper jet may be located further south. This case and other cases of orography-related forecast errors will be studied further within the framework of THORPEX.

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