RESEARCH DEPARTMENT MEMORANDUM

To:	D, HR, HO, HMD, HMAS, HMOS, RD Division and Section Heads, DA section	
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From:	P. de Rosnay, G. Balsamo, L. Isaksen, J. Haseler	
Date:	30 March 2010	File: R48.3/PdR/1027
Subject:	**Snow fix in operations (36r1): Removal of snow excess over Denmark and south Sweden**	

1 Introduction

ECMWF has implemented on 25 March 2010 a correction that removed excessive snow cover from the operational analysis and forecast fields over Denmark and southern Sweden. The change was effective in the forecast from 12 UTC 25 March. The impact has been seen in 2 metre temperature fields over the affected areas. This report describes the snow issue over Denmark and Southern Sweden and explains the snow fix applied.

2 Excessive snow in Denmark and Southern Sweden in winter 2010

In recent months problems with the ECMWF snow analysis and forecast have resulted in accumulation of excessive snow amounts in some regions. In addition a geolocation issue has been found in the snow analysis concerning the use of the NOAA/NESDIS snow cover data [http://www.natice.noaa.gov/ims/, Drusch et al. (2004)]. These problems were respectively corrected in January (Balsamo and de Rosnay, 2010) and February (de Rosnay et al., 2010). However, the excessive snow has remained in some areas. In many places, observations (SYNOP reports and NESDIS satellite-based observations) have been effective in removing the snow in the past seven days. However in certain locations, especially island or coastal regions where NESDIS data cannot be used effectively, and where we do not have any complete SYNOP reports including snow depth, the excessive snow in the model can not melt as quickly as observed. This is the case in particular for parts of Denmark and southern Sweden that were in reality already snow-free on 24 March 2010 (see Figure1 for snow cover in Sweden and Denmark). In this area forecast snow fall in February was overestimated, giving more then 60cm of snow water equivalent (more than 100cm of snow depth) over Denmark (Jutland and Zealand) at the end of February 2010 (not shown). Figure 2 top and middle panels show snow water equivalent in cm on 17 March 2010 at 12 UTC and on 24 March at 18 UTC in the ECMWF operational analysis. It shows that snow water equivalent has been substantially reduced between 17 March and 24 March 2010 over Denmark/Jutland, due to snow melting and efficient use of "no-snow" NESDIS data in this area. However, snow water equivalent is still more than 30 cm (more than 100cm of snow depth) in most of the Danish Zealand Island. And it is more that 50 cm (125cm in snow depth) in southern Sweden. Even if "no-snow" observations were available in Sweden, this snow would not be removed because of the snow analysis Quality Control limit (50 cm departure active in snow depth the rejection criteria).

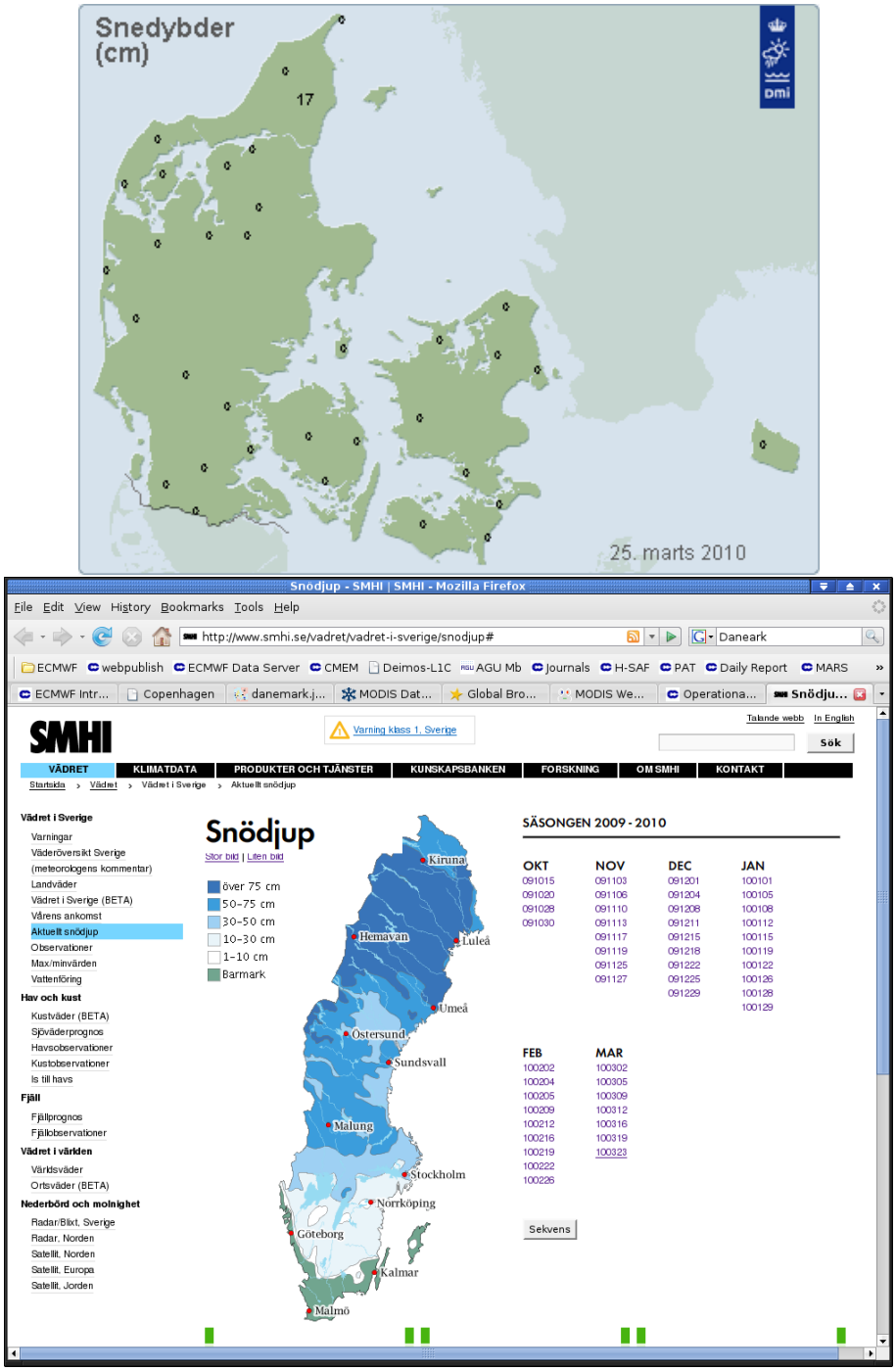

Figure 1: DMI snow depth data on 25 March 2010 (top) and SMHI data of snow depth on 23 March 2010 (bottom). South of Sweden is snow free on 23 March 2010.

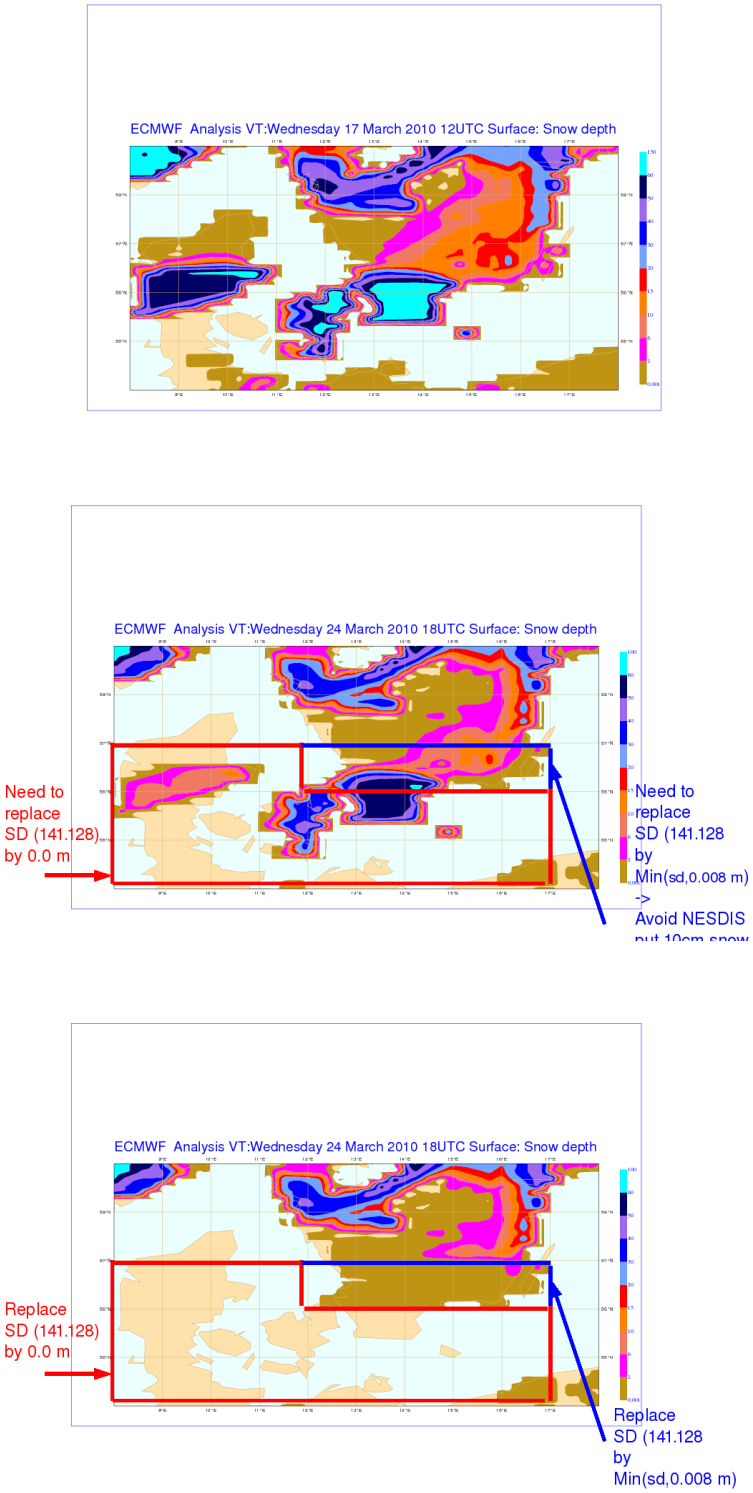

Figure 2: ECMWF Snow Depth fields (in cm water equivalent) on 17 March 2010 at 12UTC (top), and on 24 March 2010 at 18 UTC (middle and bottom). For 24 March 2010, the middle panel shows the original field while bottom panel shows the corrected field for which snow has been removed over Denmark and south of Sweden south of 56.1°N. A threshold of 0.8cm snow water equivalent has been left in south of Sweden between 56.1°N and 57°N to prevent NESDIS to add 10cm of snow depth.

3 Snow field patch and implementation

The ECMWF snow cover left for Denmark caused forecast problem for surface temperature over Denmark, with a cold bias of several degrees. The DMI (Danish Meteorological Institute) forecast department had to put some warning remarks about the temperature forecast to indicate temporal problems from ECMWF.
Therefore proposed to do an emergency fix by 'manually' removing the snow from the model fields for these specific areas. This was accepted by Head of Operation Department after discussions with Heads of Research Department model and data divisions.
Technically we introduced in the DCDA snow analysis field of 24 March 2010 at 18 UTC. We removed snow in Denmark and south of Sweden directly in a grib file. In order to prevent NESDIS data to propagate positive increments down to Denmark, we left a threshold 0.8 cm of snow water equivalent in south of Sweden where NESDIS indicated that there is still snow while SMHI (Swedish Meteorological and Hydrological Institute) indicates snow free areas. The patched DCDA snow field was then archived back using grib2fdb. This correction was first tested in the experiment fbtz. Then it was applied in the operational suite, as shown in Figure 2. The patched field was used for the 00 UTC 25 March DCDA (delayed-cutoff analysis) and for subsequent forecasts and assimilations. The correction has been effective from the 12 UTC on the 25^{th} March operational forecast.

4 Results

Figure 3 shows the operational DA snow water equivalent analysis on 25 and 26 March 2010. Figure 4 shows the Boundary condition analysis on 26 March 2010 at 18 UTC. The NESDIS analysis has added a small amount (0.01 m of snow water equivalent) of snow in South Sweden and east of Zealand on 25 March 2010. This is due to the fact that part of Sweden was snow free in the model while NESDIS data still indicated snow cover on 25 March 2010 in that area that has been used with a radius of influence of 250km. However this has been partly removed the next day on 26 March 2010 in the analysis since NESDIS data started to show snow free area in south of Sweden. As shown in Figure 5 the 2metre temperature cold bias over Denmark has been much reduced, by about 6K, from the first cycle of the snow fix.

5 Conclusion

Cold winter conditions with large amount of snow over Europe has allowed to identify several conceptual issues in the Cressman snow analysis system as well as in the use of satellite data in the analysis. This memorandum reports the third snow fix conducted since January 2010. It resolved a significant 2 metre temperature bias problem due to excessive snow cover over Denmark and Sweden.
All these snow fixes have all very efficiently solved the snow issues. We will continue to monitor the model snow cover during spring snow melting conditions. Further improvements are on going to be submitted to IFS cycle 36r4 to replace the Cressman analysis by an Optimum Interpolation system similar to the method applied by HIRLAM and Environment Canada.

Acknowledgment

We thank Xiaohua Yang, from the Danish Meteorological Institute, and Tim Hewson for reporting the Denmark snow issue. Thanks to John Hodkinson and Alfred Hofstadler for the quick implementation in the osuite.

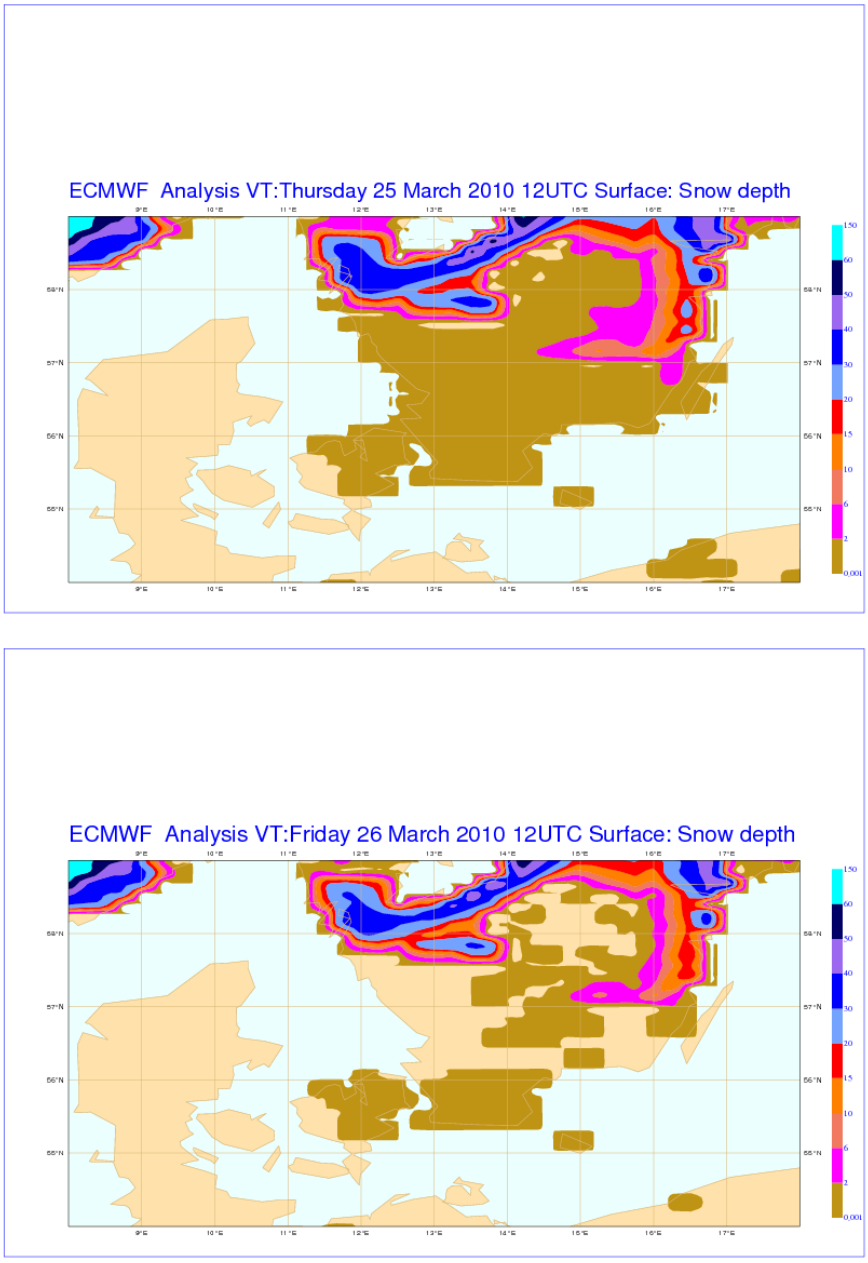

Figure 3: Operational DA analysis at 12UTC on 25 (top) and 26 (bottom) March 2010 respectively.

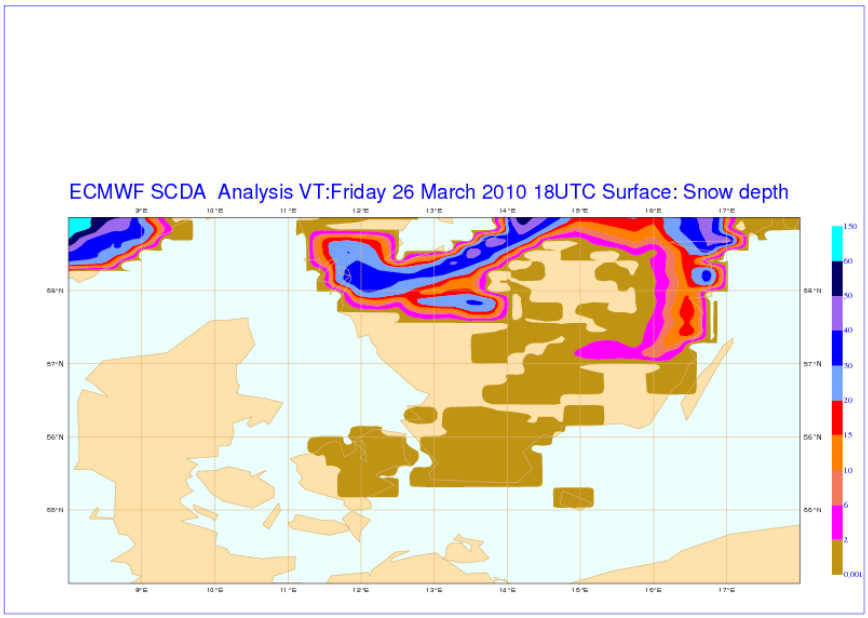

Figure 4: Operational BC analysis at 18UTC on 25 March 2010.

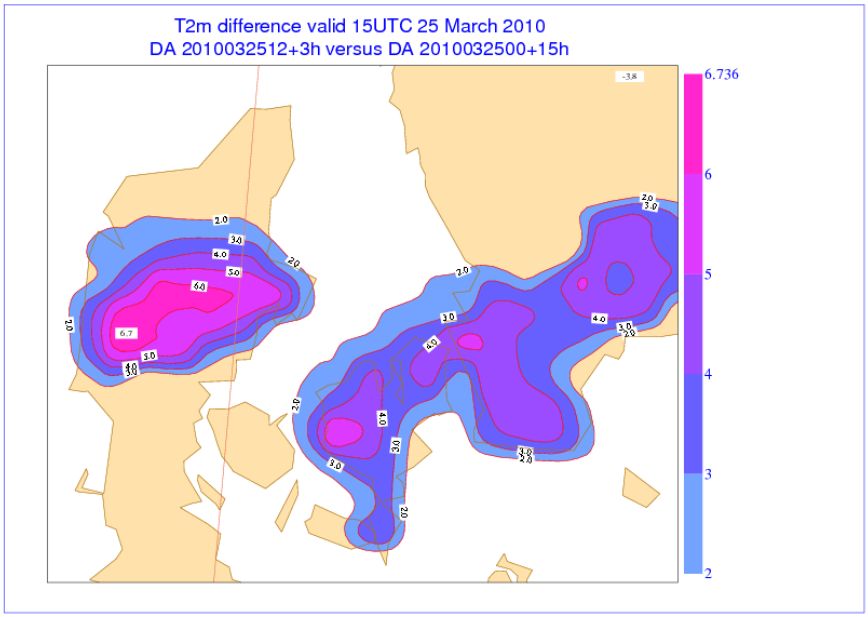

Figure 5: Difference in 2 metre Temperature (K) operational forecast for 25 March 2010 at 15 UTC between 25 March 2010 at 00 UTC step 15 and 25 March 2010 at 12 UTC step 3.

References

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