Report from working week on snow analysis in HARMONIE with CANARI at Météo-France, Toulouse, 19 – 23 October 2009

Participants
Lora Taseva, Lora.Taseva@meteo.bg
Françoise Taillefer, Francoise.Taillefer@meteo.fr
Mariken Homleid, mariken.homleid@met.no

Background

With view of snow in the Pyrenees the snow analysis in HARMONIE with CANARI where tested during one week in October 2009 at Météo-France. CANARI (Taillefer, 2002) is used for surface analysis in HARMONIE. Snow analysis was introduced in CANARI and tested in ALADIN and ARPEGE in 2000/2001 by Lora Taseva and Françoise Taillefer (Gaytandjieva, 2000/2001). met.no is running HIRLAM's snow analysis operationally. The current version was implemented by Cansado (2004) with references to Brasnett (1999).

The main features of the snow analysis as introduced in CANARI and HIRLAM are similar

- analysis method is Optimum Interpolation (OI)
- background error correlation includes a horizontal and a vertical term
- use only synoptic observations which are supposed to have uncorrelated error

The aim of the working week was to test the snow analysis with CANARI in HARMONIE, and also to perform further tests with CANARI in ALADIN. The ALADIN tests are documented in (Taseva, 2009). This report gives a summary of the first experiences with CANARI snow analysis in HARMONIE.

The stay at Météo-France also included participation in parts of a SURFEX training course and gave the possibility to consult SURFEX/surface specialists on topics related to the diagnosis and potential improvement of e.g. surface temperature forecasts from HARMONIE.

Preparations

To prepare for the testing of CANARI 's snow analysis, the performance of HIRLAM's snow analysis were examined during the spring and summer 2009. Diagnostics of HIRLAM's snow analysis in the operational Hirlam12, Hirlam8 and Hirlam4 for the winter 2008/2009 show that too much snow is accumulated during the winter and that the snow disappears too late in the spring. One of the consequences is that the forecasted 2m temperatures become too low. The problems related to too much snow in spring are more pronounced in HARMONIE and UM4 (Unified Model at 4 km resolution) which are run at met.no and get their initial fields from Hirlam8. Experiments to improve the performance of HIRLAM's snow analysis were performed with HIRLAM version 7.3beta1 on the Hirlam8 domain which covers Scandinavia and Svalbard. Minor changes of parameters related to quality control, influence radius and melting rate improved the performance considerably. Results from HIRLAM experiments are useful as a reference for the HARMONIE experiments.

Reading of snow observations from BUFR-files in the HARMONIE system were activated by Roger Randriamampianina, met.no.

Snow analysis experiments with CANARI in HARMONIE 1 to 8 March 2009

The experiments were performed with HARMONIE cycle 35h1.2, with hydrostatic dynamics, aladin physics, on a domain covering Scandinavia and Svalbard with 8 km resolution. Initial and boundary fields were from ECMWF. The experiments have been run without 3DVAR, implying that the upper air fields are cycled. The output from CANARI and mandalay were useful tools to diagnose the performance. In addition maps produced by the graphical tool diana and time series at synoptic stations have been produced and studied carefully.

Here follows a summary of the experimental setup based on our first experiences. Details are presented in Appendix 1.

- **No relaxation**.
- **The limit of the quality control** has been increased to include all available observations in the experiment. The default limit of the first guess quality control leads to rejection of most observations at locations with snow. There are several reasons for that:
  - The default limit is too narrow.
  - The initial snow field from ECMWF in March has too much snow in some areas.
- **The scales of the background error correlation** have been increased from 50 to **60 km** for the horizontal and from 0.05 to **0.06** for the vertical part, to be closer to experimental HIRLAM settings, see Fig. 1.
- The **standard deviations of observation and background errors** are by default **5 kg/ m^2**, and have not been changed.

- **Monthly mean values for snow density** have been introduced in the experiment and replace the value 100 kg/m^3 applied in the transformation from observed snow depth to snow water equivalent.

The first experiments with the above settings in CANARI were run from 1 to 8 March 2009. Fig. 2 shows the first guess field for the first analysis of the experiment performed 1 March 2009 06 UTC, and available observations. The initial snow field from ECMWF are relatively far from the observations, and the increments are substantial, see Fig. 2. Corresponding results for 4 March 06 UTC are presented in Fig. 3 and demonstrate that the snow analysis works as intended and give analysed fields in agreement with the observations, in areas with observations. One can notice that there are some areas which are not influences by any observations and where the snow field remains unchanged. Comparisons with HIRLAM experiments reveal that more observations are available in these experiments, see Fig.4 and 5. In operational HIRLAM runs at met.no even more observations are available. Before continuing the experiment the possibility for having more observations will be examined.

Conclusions and short term plans

The main features of the snow analysis as introduced in CANARI and HIRLAM are similar. In the first tests of the snow analysis with CANARI in HARMONIE the parameters have been set in agreement with the HIRLAM specifications. Experiments with HARMONIE cycle 35h1.2 show that the snow analysis works as intended and give analysed snow fields in agreement with the observations, in areas with observations. There are however fewer observations available in the HARMONIE experiments than in HIRLAM experiments run at ECMWF, one will have to find out why?

A next step will be to run the experiment over a longer period to study the performance of the snow analysis and how it influences the surface temperature forecasts.

R E F E R E N C E S

Brasnett, B., 1999: A global analysis of snow depth for numerical weather prediction. Journal of Applied Meteorology. Vol. 38, pp 726-740.

Cancado, A., C. Martin, B. Navascués, 2004: Optimum interpolation New Snow Depth Analysis in HIRLAM. HIRLAM Newsletter No 45, pp 248-252.

Gaytandjieva, L., E.Gerard, F.Bouyssel, 2000a: Update and validation of snow analysis in CANARI/ALADIN. Final report of the work in MF (February - March 2000), available at http://www.cnrm.meteo.fr/aladin/

Gaytandjieva, L., E.Gerard, F.Bouyssel, 2000b: Validation of the snow analysis in CANARI/ ALADIN. Final report of the work in MF (September – November 2000), available at http://www.cnrm.meteo.fr/aladin/

Gaytandjieva, L., 2001: Snow analysis in ARPEGE/CANARI. Final report of the work in MF (June-July 2001), available at http://www.cnrm.meteo.fr/aladin/

Taillefer, F., 2002: CANARI - Technical Documentation -Based on ARPEGE cycle CY25T1 (AL25T1 for ALADIN), available at http://www.cnrm.meteo.fr/aladin/

Taseva, L., F. Taillefer, 2009: CANARI snow analysis scheme in ALADIN. Final report on the work done in Meteo-France in the period 11 – 24 October 2009, available at http://www.cnrm.meteo.fr/aladin/

FIGURES

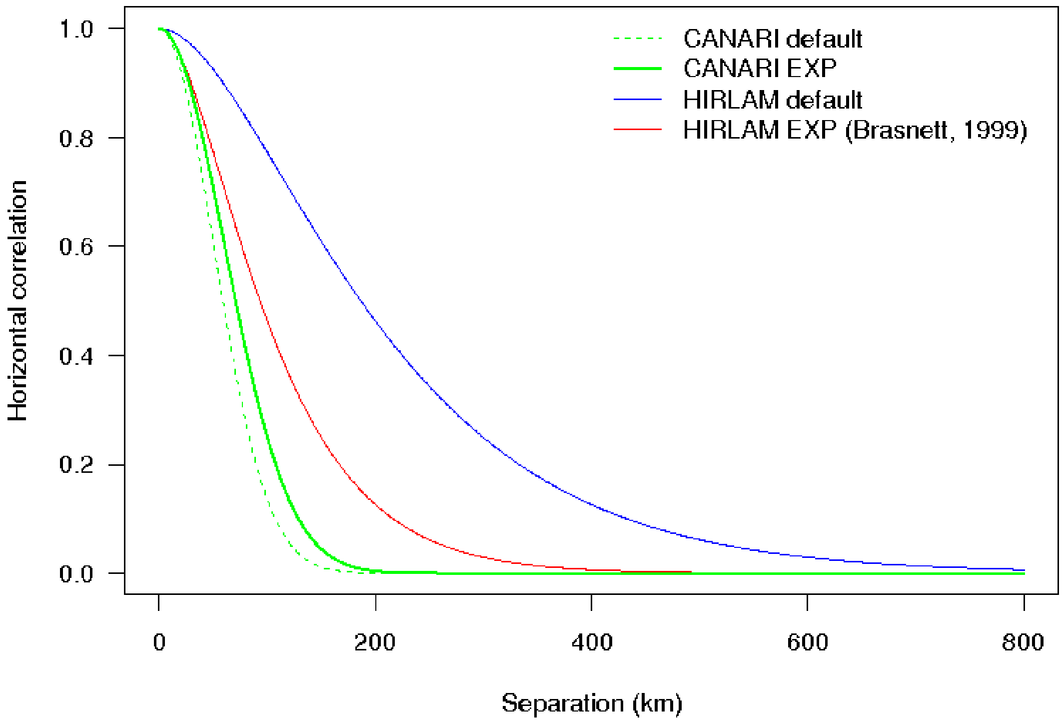


Figure 1a Horizontal correlation functions for snow depth analysis in CANARI and HIRLAM

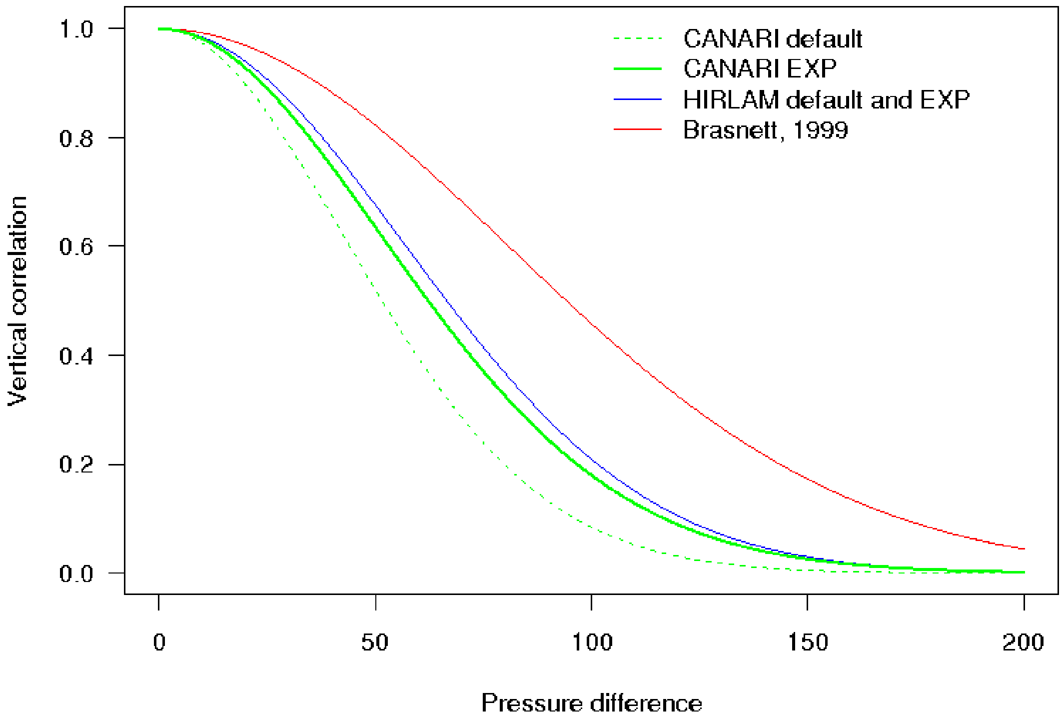


Figure 1b Vertical correlation functions for snow depth analysis in CANARI and HIRLAM

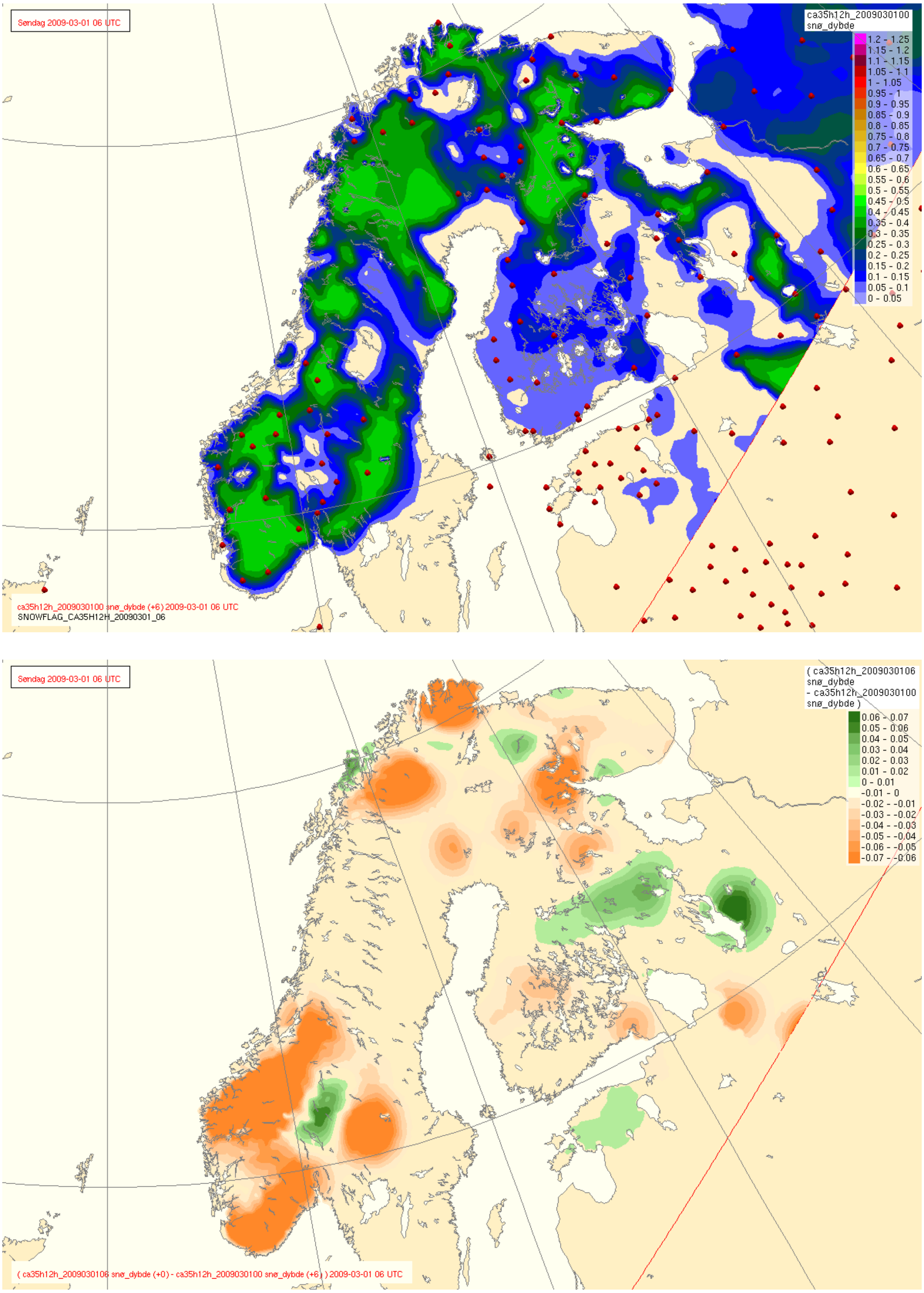
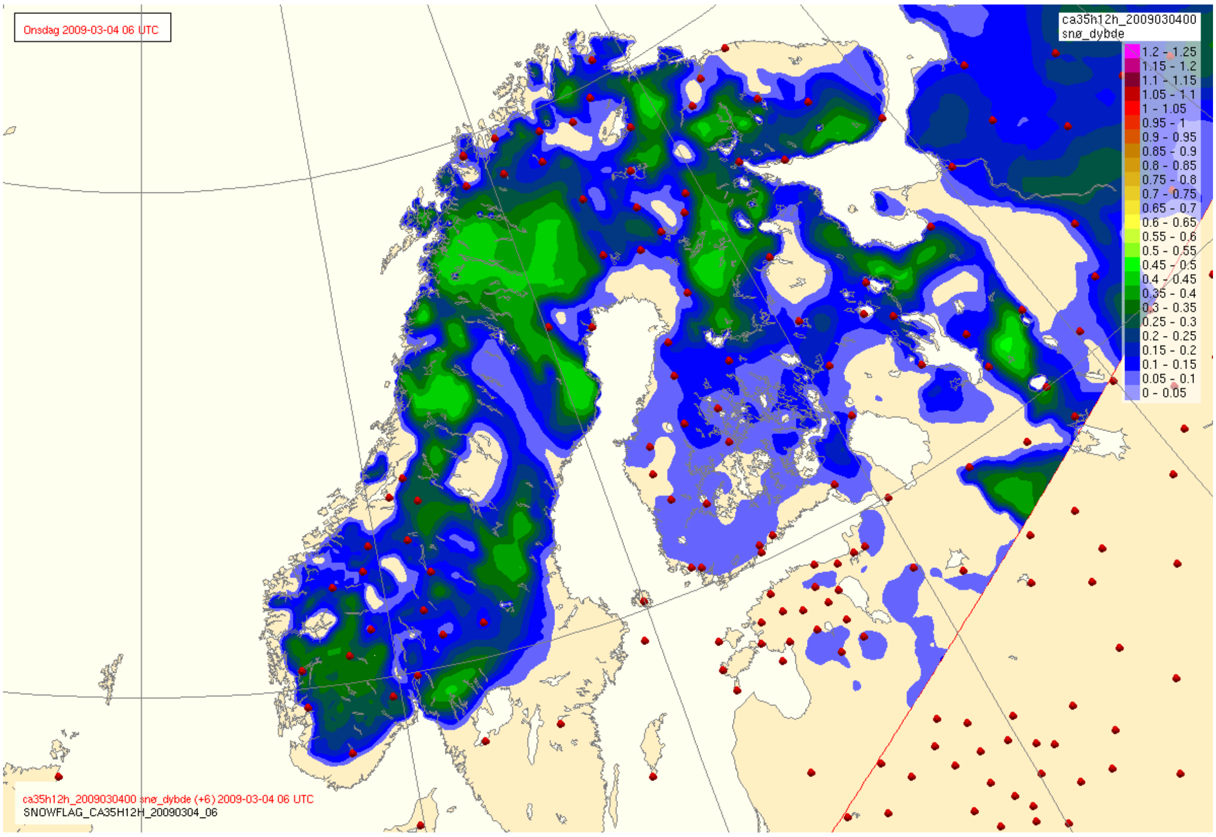


Figure 2 HARMONIE snow water equivalent (tonn/m2) 1. March 2009 06UTC first guess with observations used in the analysis (above) and analysis increments (below).



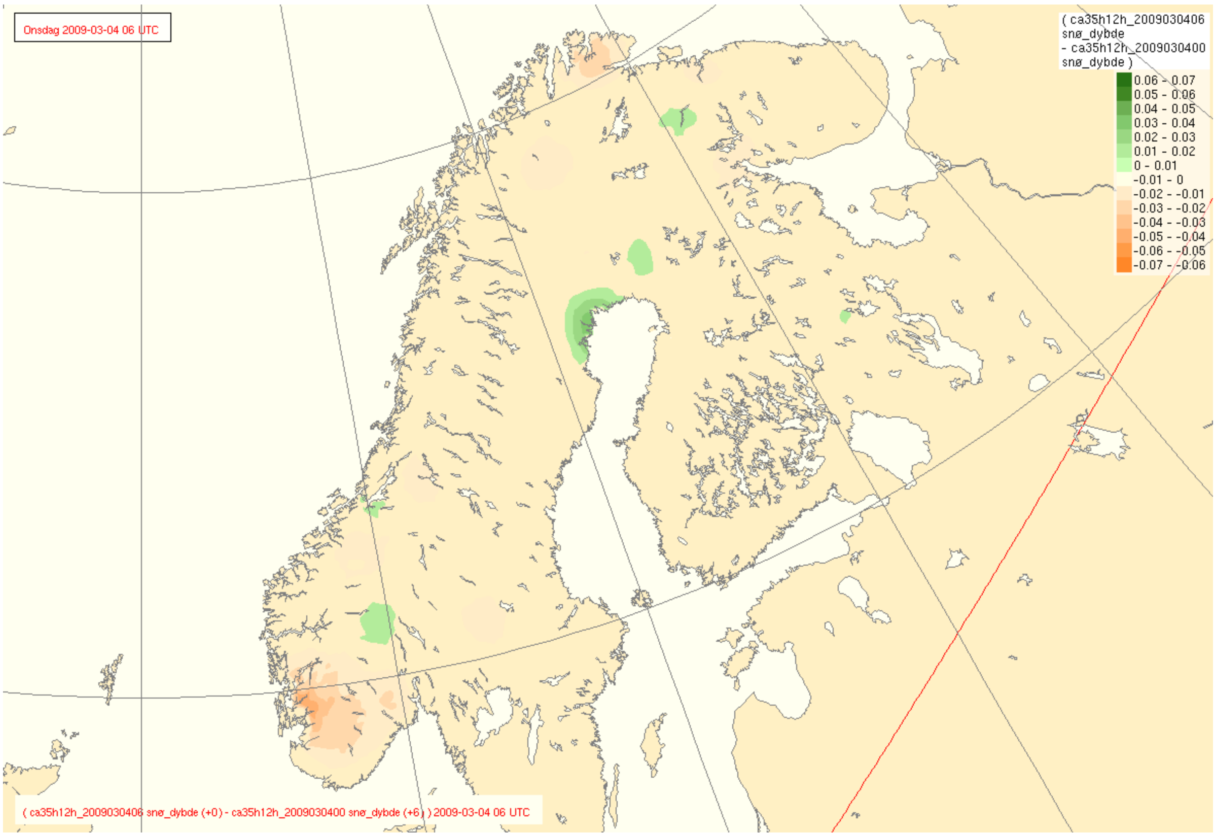
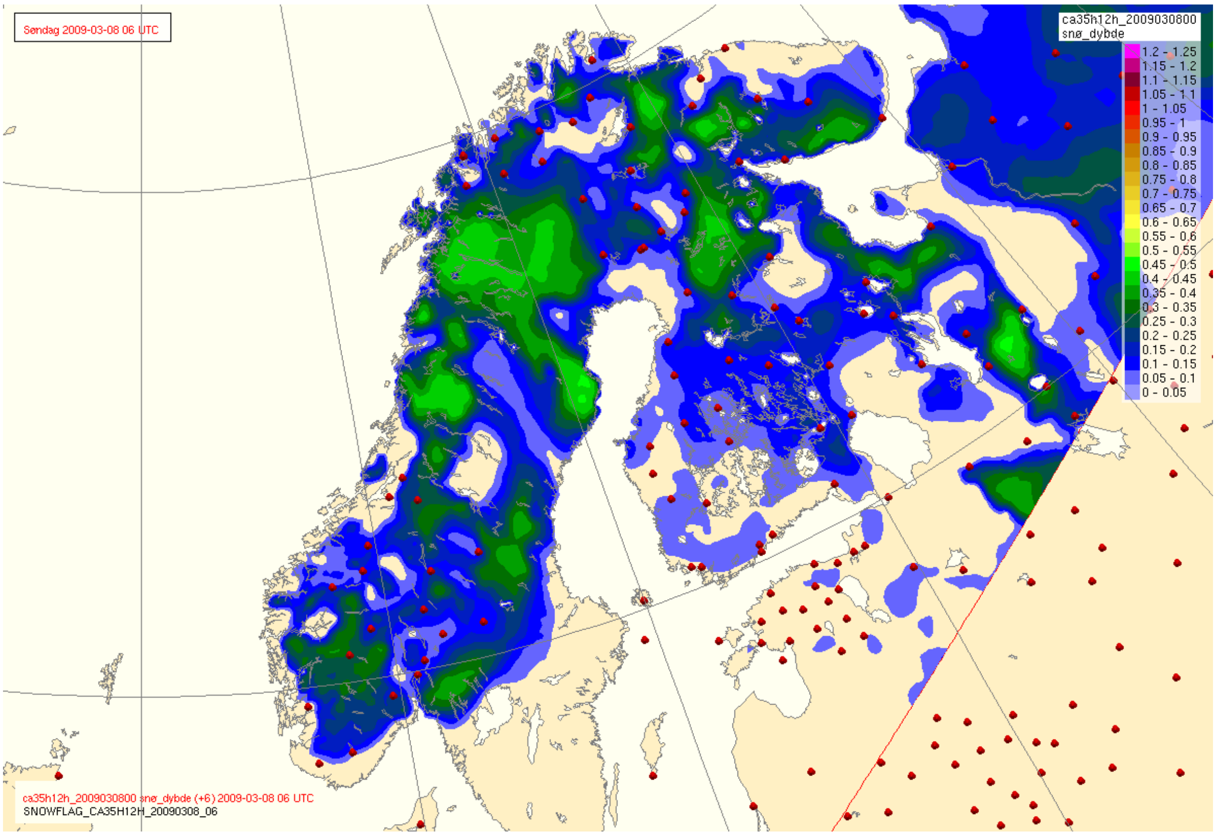


Figure 3 HARMONIE snow water equivalent (tonn/m2) 4. March 2009 06UTC first guess with observations used in the analysis (above) and analysis increments (below).



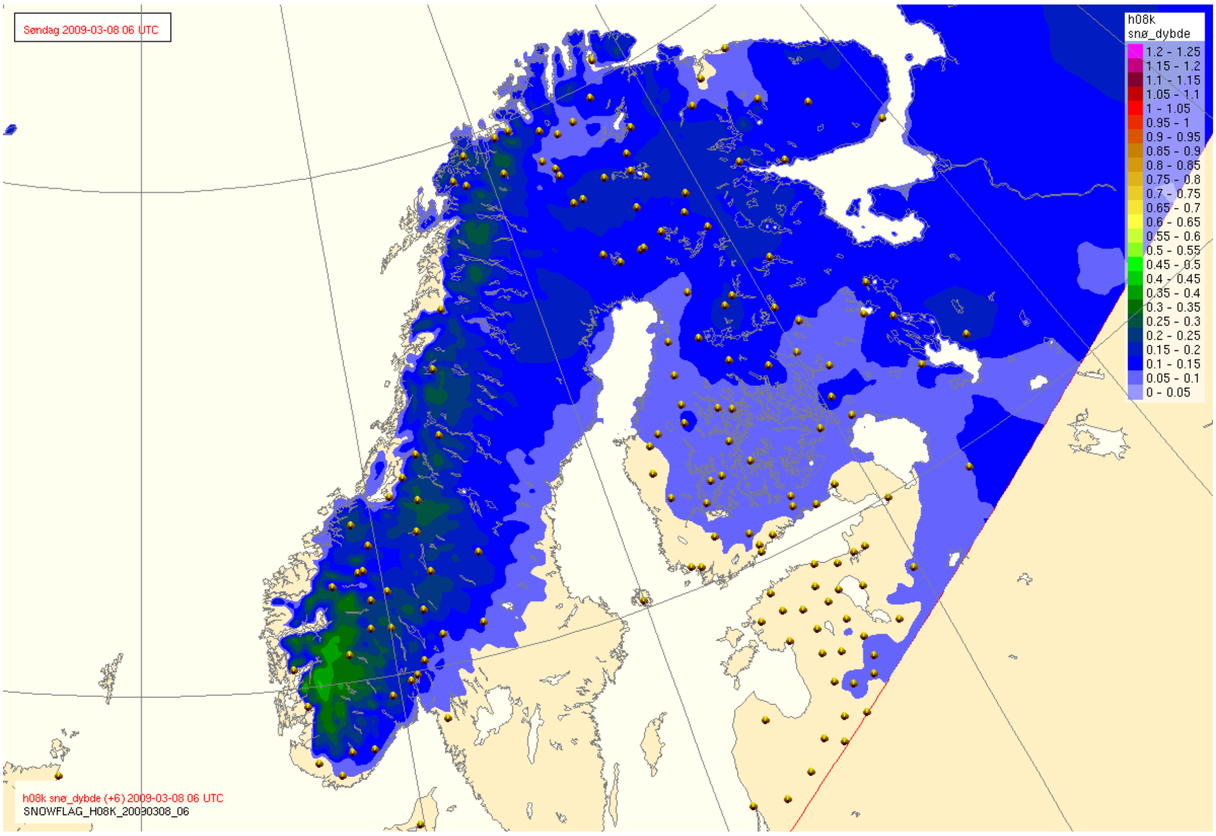


Figure 4 HARMONIE (above) and HIRLAM (below) snow water equivalent (tonn/m2)
8. March 2009 06UTC first guess with observations used in the analysis.

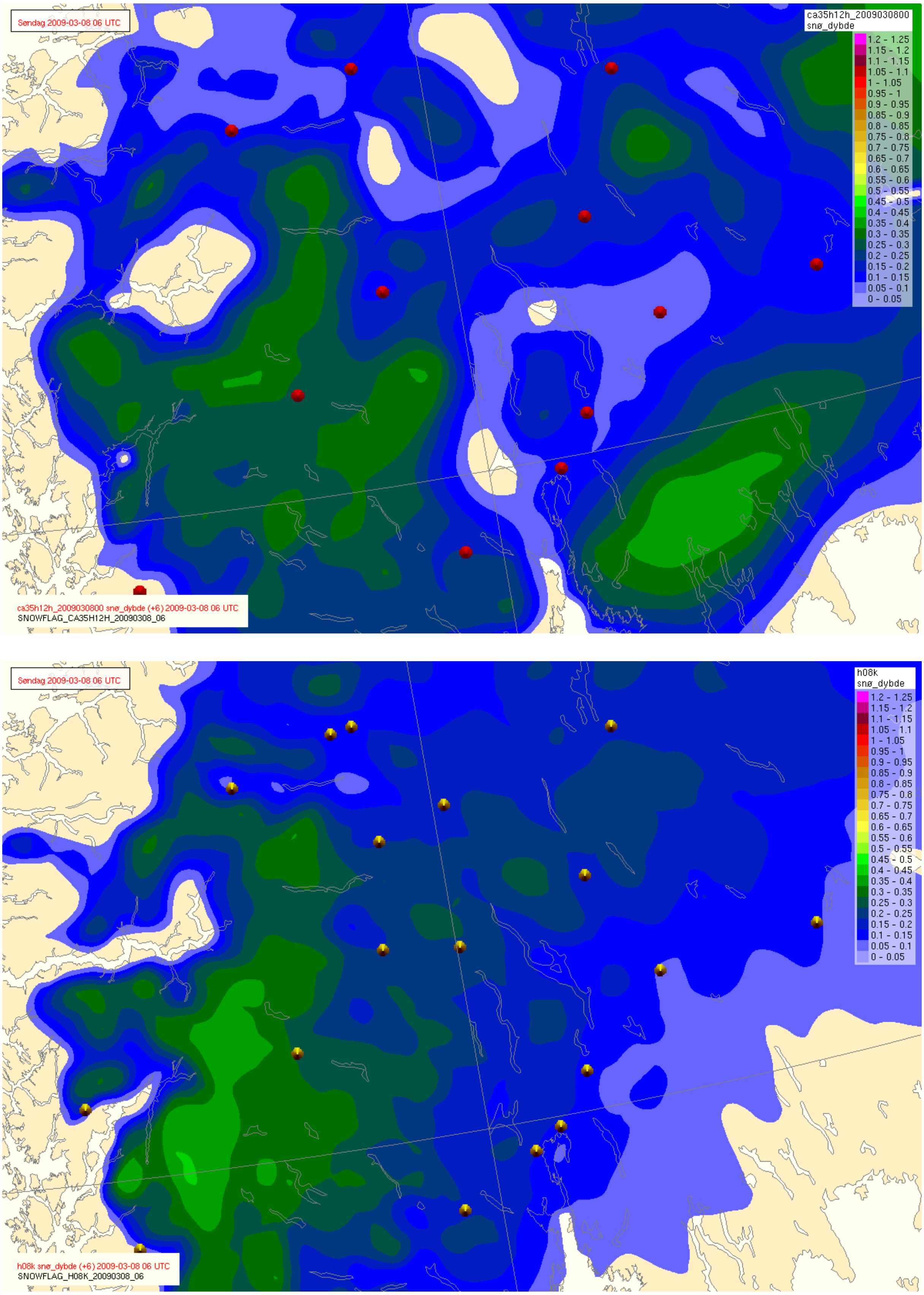


Figure 5 HARMONIE (above) and HIRLAM (below) snow water equivalent (tonn/m2) 8. March 2009 06UTC first guess with observations used in the analysis. South Norway.

A P P E N D I X 1

1. Snow analysis in CANARI

Snow analysis in CANARI was introduced and tested by Lora Taseva and Françoise Taillefer (Gaytandjieva, 2000/2001). Here follows a short summary of the algorithm.

- Snow depth in water equivalent (kg/ m^2) is analysed by OI
- In subroutine PPOBSN a model equivalent of the snow observation is calculated, taking into account the differences between model and real orography
- Observations (in m from BUFR-files) are transformed to snow water equivalent by assuming a snow density corresponding to new snow; 100 kg/ m^3.
- Horizontal correlation of background errors modelled by Gaussian structure functions
- Vertical correlation of background errors modelled by Gaussian structure functions as a function of pressure differences
- Standard deviation of observation errors and first guess error supposed to be equal, 5kg/ m^2
- Relaxation to climatology by RCLIMA set in namelist

2. Experiments with snow analysis performed by CANARI in the HARMONIE system

Only minor changes have been introduced in the first experiments, most of them in the namelists and some in the code. Here follows an overview of the most important parameter settings, with some comments related to the choices and settings.

2.1 Relaxation to climatology

RCLIMA set in namelist NACTEX defines relaxation to climatology for snow and also temperature and humidity. Default value is 0.045.
RCLIMA is set to 0 in the experiments. Default relaxation in the current setup of HARMONIE implies that the snow disappears very fast. An explanation for that is that the unit of snow water equivalent in the climatological snow fields is tonn/m^2.

2.2 Quality control

RCSNSY in namelist NAMCOK defines the limits for rejection of snow observations when compared to the first guess. Default value is 2.5 which correspond to 12.5 kg/m^2 or 12.5 cm new snow. RCSNSY is set to 1200 (!) in the experiments which correspond to 6000 kg/m^2. The default value implies that most of the observations are rejected because they are too far from the first guess. With RCSNSY=1200 all available observations pass the quality control, also the ones at Svalbard where the ECMWF snow cover is 10000 kg/ m^2!
For operational purposes a reasonable value could be e.g. RCSNSY=8 corresponding to 40 kg/m^2.

2.3 Statistical models for background and observation errors

The correlation of the background errors is defined by:

$cor(R, P_i,P_j) = cor_H(R) * cor_V(P_i,P_j)$, where

the horizontal part is a function of the distance between the points, R:

$cor_H(R) = exp(-0.5*(R/REF\_A\_SN)^2)$, R is distance in m.

The vertical part, included to take the orography into account, is expressed as a function of the pressure at the points:

$cor_V(P_i,P_j) = exp(-0.5*(log(P_i/P_j)/REF\_AP\_SN)^2)$

The length scales and the model standard deviation are set in namelist NAM_CANAPE:
REF_A_SN : reference horizontal length scale (default value 50000 m)
REF_AP_SN : reference vertical length scale(default value 0.05)
REF_S_SN : model error standard deviation (default value 5 kg/m^2)

The standard deviation of the observation error is initialized in the subroutine cabiyo.F90:
ECTERO(<synop>,1,<snow>,1) = 5 kg/m^2

In the experiments minor modifications of the parameters defining the length scales have been introduced to be closer to the settings in the HIRLAM experiments.
REF_A_SN = 60000 m
REF_AP_SN = 0.05

Figure 1 shows horizontal (a) and vertical (b) correlation functions with default and experimental CANARI and HIRLAM options.

Default values of the standard deviations were used in the experiments.

2.4 Introduction of monthly mean values for snow density

A transformation from observed snow depth to snow water equivalent has been introduced in subroutine calico F90. Monthly mean values of snow density have been taken from HIRLAM:

! Monthly climatological values to transform snow in cm to kg/m3
DATA ZSNDENS /2.22, 2.33, 2.40, 2.78, 3.12, 3.12, 3.12, 1.43, 1.43, 1.61, 1.82, 2.13/

2.5 Preprocessing of first guess

As a first step the first guess in observation points is obtained by horizontal interpolation. The preprocessing performed in PPOBSN taking real and model orography into account has not been tested.