# Usage of Satellite Data in the HIRLAM New Snow Depth Analysis

*Alberto Cansado and Beatriz Navascués*
*Instituto Nacional de Meteorología (INM)*

***Abstract***

*A New Optimum Interpolation Snow Depth Analysis has been recently developed for HIRLAM. Now, SSMI derived NESDIS snow cover weekly product and MODIS TERRA daily 0.05º snow cover data have been tested as information supply for this analysis. Some conclusions are drawn from them. Additionally, we tested the differences found in the snow cover field depending on the spatial resolution of the experiments.*

## 1.- Introduction

Variability in snow cover causes dramatic changes in surface albedo and, as a consequence, in the land surface energy budget [Drusch et al, 2004]. So, a correct description of snow cover extent and snow water equivalent is important to produce accurate forecasts of screen level and surface variables

Recently, a New Optimum Interpolation Snow Depth Analysis has been developed based on the Canadian Global Snow Depth Analysis [Brasnett, 1999]. Major changes, including modifications on the background field and new autoregressive structure functions, and the results of some experiments have been described yet [Cansado et al, 2004]. Here, we are focusing on the usage of satellite data as a source of information to analyse snow depth.

Two different satellite derived snow cover information sources have been tested:

First of all, SSMI derived NESDIS snow cover product has been used besides conventional real-time data. This product is global, has a spatial resolution of 1/3 degree and is provided once a week.

Next thing we did is using MODIS TERRA global snow cover information. The spatial resolution in this case is 0.05 degrees, so much bigger than SSMI, and is produced daily. To build up the MODIS TERRA 0.05 degrees product, 500 m resolution MODIS data were used.

Both satellite products were not available in real time. Consequently, the purpose of our work is only to test if the assimilation of satellite derived snow cover information in HIRLAM is able to produce a more realistic snow cover analysis and to have a positive impact in analysed and forecasted surface of screen level variables such as 2 meters temperature and relative humidity or skin temperature.

Finally, a test compares qualitatively two different experiments in which the only difference was the spatial resolution. Both experiments included modified horizontal structure functions, new computation of the first guess and a bias correction scheme for mountain stations. The first one was run at 0.5 degrees resolution and the second one at 0.2 degrees.

## 2.- SSMI

SSMI derived NESDIS snow cover product has been used to try to improve the snow edge in our analysis. The product has a spatial resolution of 1/3 degree and a time resolution of 7 days. The information that supplies is the percentage of time during the week in which snow have been observed over a land pixel. We create 0 cm pseudoobservations that we included in our analysis. Wherever snow has been observed 0 per cent of time during a week, a 0 cm snow cover pseudobservation is introduced in the analysis every day of the considered week.

No other information was considered. We introduced SSMI satellite derived pseudobservations only at 6 UTC analysis where the amount of conventional data is big enough to ensure that a 0 cm pseudoobservation will not spread very much in the analysis, eliminating real snow from our background field.

An experiment (SND) was carried out to test how the usage of these satellite derived pseudobservations affects our analysis. The period considered was February 2003. The results were compared to SNA experiment (reference in this case) and SNC. SNA includes Optimum Interpolation Snow Depth Analysis, with changes in the first guess computation and a new autoregressive horizontal structure function. SNC includes a simple bias correction scheme and SND introduce SSMI derived pseudobservations. More information about SNA and SNC experiments in [Cansado et al, 2004].

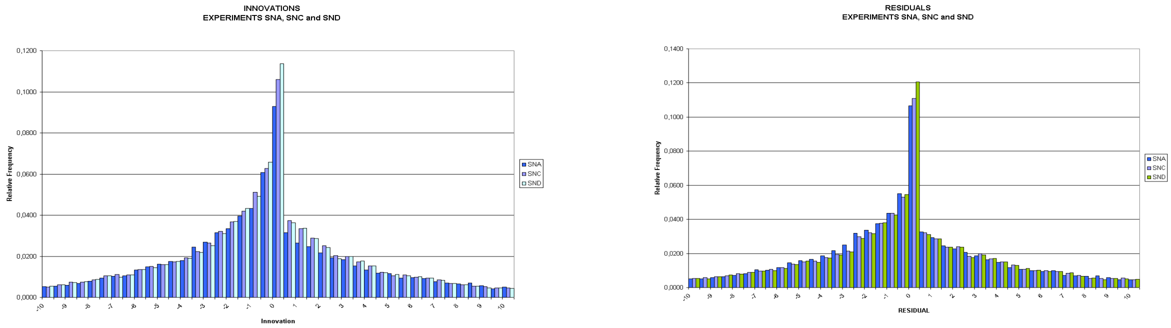


**Fig. 1. Innovation (left) and residual (right) histograms of experiments SNA, SNC and SND**

Histograms of innovations (left) shows how the usage of SSMI pseudobsevations makes the first guess to get closer to the observations. The same can be seen in the residuals histograms (right). The analysis get closer to the observations when SSMI pseudobservations are used.

## 3. MODIS

Up to now, we have not used daily data. MODIS (Moderate-Resolution Imaging Spectroradiometer) provides daily satellite snow cover data which can be ingested in HIRLAM in order to get a better snow depth analysis. MODIS data are available in different products at different spatial resolutions. We have chosen MODIS/TERRA MOD10C1 product. Its spatial resolution is 0.05 degrees and its coverage is global. To build up every single MOD10C1 pixel, 500 metres resolution MOD10A1 data are used.

HIRLAM resolution is much lower (0.5 degrees). Therefore, the amount of information coming from MODIS is huge. MOD10C1 MODIS product have 4 SDSs (Scientific Data Sets): snow cover percentage, confidence index, cloud obscured information and a spatial quality assessment [Riggs et al, 2003].

We have considered February 2003 as a study period. With this MOD10C1 product, we build up superobservations by using all the satellite pixels within a *square* centered in the model gridpoint with a side equal to 0.5 degrees. So, we have a potential superobservation in every single gridpoint. From those potential superobservations we only use snow free land pixels with a confidence index equal to 100% and a quality assessment flag which indicates good quality of datum. The confidence index indicates how confident the algorithm is that the snow percentage in a cell is correct based on 500 m resolution data (snow, snow-free land, cloud, unknown) binned into the grid cell [Riggs et al, 2003]. What we found is that very few superobservations were created in high and mid latitudes (in some case, no superobservation were created above 32.6 N)

We think this could be probably due to the high difficulty of finding 0.05 degrees (~ 5 km) absolutely cloud free pixels in those areas in February.

The result is that the usage of MODIS 0 cm superobservations seems not to be satisfactory, at least using such a restrictive conditions, because very few superobservations are created and all of them are located at very low latitudes where they are not really useful.

A relaxation in the conditions imposed to allow superobservations to be built might be necessary. On the other side, it might be worth to test the impact in the analysis of introducing appropriate non-0 cm superobservations [Drusch et al, 2004], when no snow is present in the first guess while MODIS data see snow on the ground.

## 4. Impact of Spatial Resolution

Finally, a test was carried out comparing the snow cover fields produced by different experiments in which the only difference was the spatial resolution. The aim is to investigate if a better spatial resolution of the experiments can produce a better analysis of the field. We ran two experiments SNC and SHN. Both included the new autoregressive horizontal structure function, the new calculation of the snow depth first guess and the observation bias correction scheme to prevent mountain observations from being rejected in the quality control.

As we mentioned before, the only difference between both experiment was spatial resolution: SNC ran at 0.5 degrees and SHN ran at 0.2 degrees and both use HIRLAM 6.3.2 release.

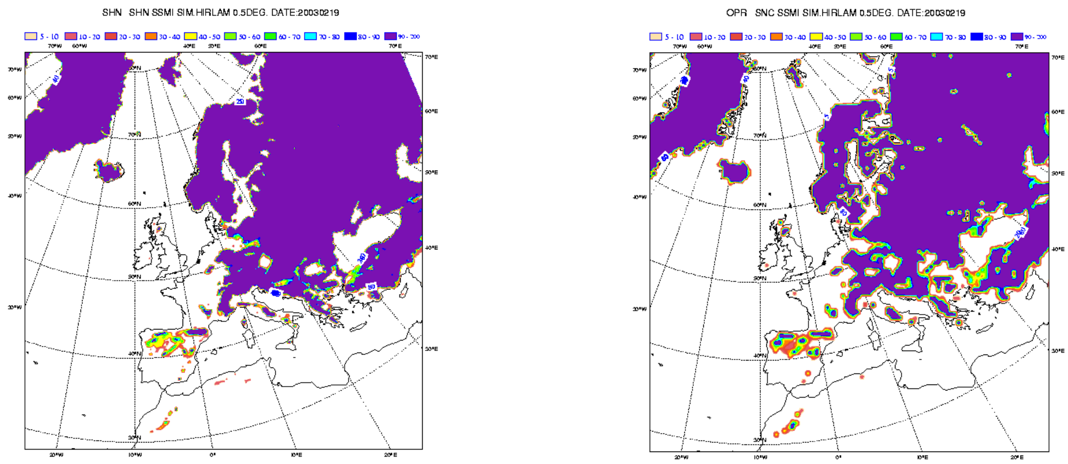


**Fig. 2. Percentage of time with snow on the ground during a week (19-25 Feb 2004) in SHN (left, 0.2 degrees resolution) and SNC (right, 0.5 degrees resolution)**

Figure 2 shows the differences between the snow cover field in SHN and SNC experiments. Qualitatively, we see that higher spatial resolutions help to produce, as one might expect, more realistic snow cover patterns in Southern Europe (Northwestern Iberia or Italy for instance) and North Africa (Atlas)

## 5. Conclusions

Two different satellite snow cover products have been tried to derive 0 cm snow depth observations.

The usage of satellite SSMI 0 cm pseudobservations is positive since, according to innovations and residuals histograms, this make the first guess and the analysis to get closer to observations.

The usage of daily MODIS 0 cm superobservations has not shown any impact because very few or none superobservation were created at high or mid latitudes due to the important restrictions we imposed to its creation. A relaxation in the conditions to build up superobservations might be necessary. However some care seems to be needed to ensure the quality of the derived snow depth observations.

Usage of appropriate non-0 cm superobservations [Drusch et al, 2004], wherever the first guess has no snow and MODIS satellite data see snow on the ground, should be essayed.

Other sources of information available in near real time (the daily NOAA/NESDIS Northern Hemisphere snow cover product or the LAND SAF snow cover product) will be tested in the future to try to improve the HIRLAM Snow Cover in an operational context.

Increasing the resolution helps to produce a more realistic analysed snow cover field.

## 6. Bibliography

Brasnett B. 1999. A Global Analysis of Snow Depth for Numerical Weather Prediction. Journal of Applied Meteorology. Vol. 38, No. 6, pp. 726-740.

Cansado A, Martín C and Navascués B. Optimum interpolation new snow depth analysis in HIRLAM. HIRLAM Newsletter 45, pp. 248-252

Drusch M, Vasiljevic D and Viterbo P. 2004. ECMWF's Global Snow Analysis: Assessment and Revision Based on Satellite Observations. Journal of Applied Meteorology. Vol. 43, No. 9, pp. 1282-1294.

Riggs G.A, Hall D.K, Salomonson V.V. 2003. MODIS Snow Products User Guide for Collection 4 Data Products. Revised January 2003. Available at http://modis-snow-ice.gsfc.nasa.gov/sug_main.html