Optimum Interpolation Analysis Method for Snow Depth

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1.- Introduction: Analysis Method

HIRLAM surface analysis has been modified to use the optimum interpolation method instead of the succesive corrections for the snow depth analysis. Preliminary runs have been carried out to check the impact of changes in the analized snow cover. Qualitative primary information have been learned from this.

The current surface analysis in HIRLAM makes use of the succesive correction (SC) method to analize snow depth. For a detailed description of the HIRLAM snow depth analysis see, for instance, [Rodriguez et al, 2003]. In order to improve the quality of the snow depth field, the optimum interpolation (OI) method have been essayed. This allows us to have an additional quality control of the observations.

The horizontal structure function has been modelled with a Gaussian function. The horizontal scale length L_H is 85 km, corresponding with an e-folding distance of approximately 120 km. The same e-folding value is also used by the snow depth global analysis at the Canadian Meteorological Centre, eventhough they use a second order autoregressive function to model the horizontal structure function [Brasnett, 1999]

The anisotropy induced by orography has been introduced in the O.I. structure function by means of a Gaussian function depending on the difference between model orography and observation height, Δz, with a vertical scale length L_V of 565 m, similarly to Canadian snow depth global analysis [Brasnett, 1999] and the HIRLAM 2-meter temperature and relative humidity analysis [Navascués, 1997]

So, the total structure function used in the optimum interpolation analysis is

$$\rho(r,\Delta z)=\exp\left\{-0.5\left(\frac{r^2}{L_H^2}+\frac{\Delta z^2}{L_V^2}\right)\right\}$$

2.- Preliminary tests

Preliminary parallel runs have been carried out for February 1996 to test the impact of the snow depth analysis method.

HIRLAM version 6.1.0 has been utilized, where surface temperature is relaxed to climatological values. The saturation water vapour pressure over ice for soil processes over snow covered fractions is not yet available in this release.

The results obtained by the objective verification against surface observations show very similar scores (not shown here) in most of the areas analized (all, ewglam, France, Scandinavia and Spain) for 2m temperature which is supposed to be the most sensitive variable to snow cover changes, but care must be taken when data are interpreted. The most important changes in snow cover are located over France and Italy where snow is more unusual. The pattern is very similar in Northern Europe in both experiments. So changes in the scores are expected to be greater for those areas (France), and in fact a slight improvement can be observed in France scores.

Moreover, differences in snow cover field can be observed between both analysis methods. The main divergences hold in the limit of snow cover, that is, over Southern Europe.

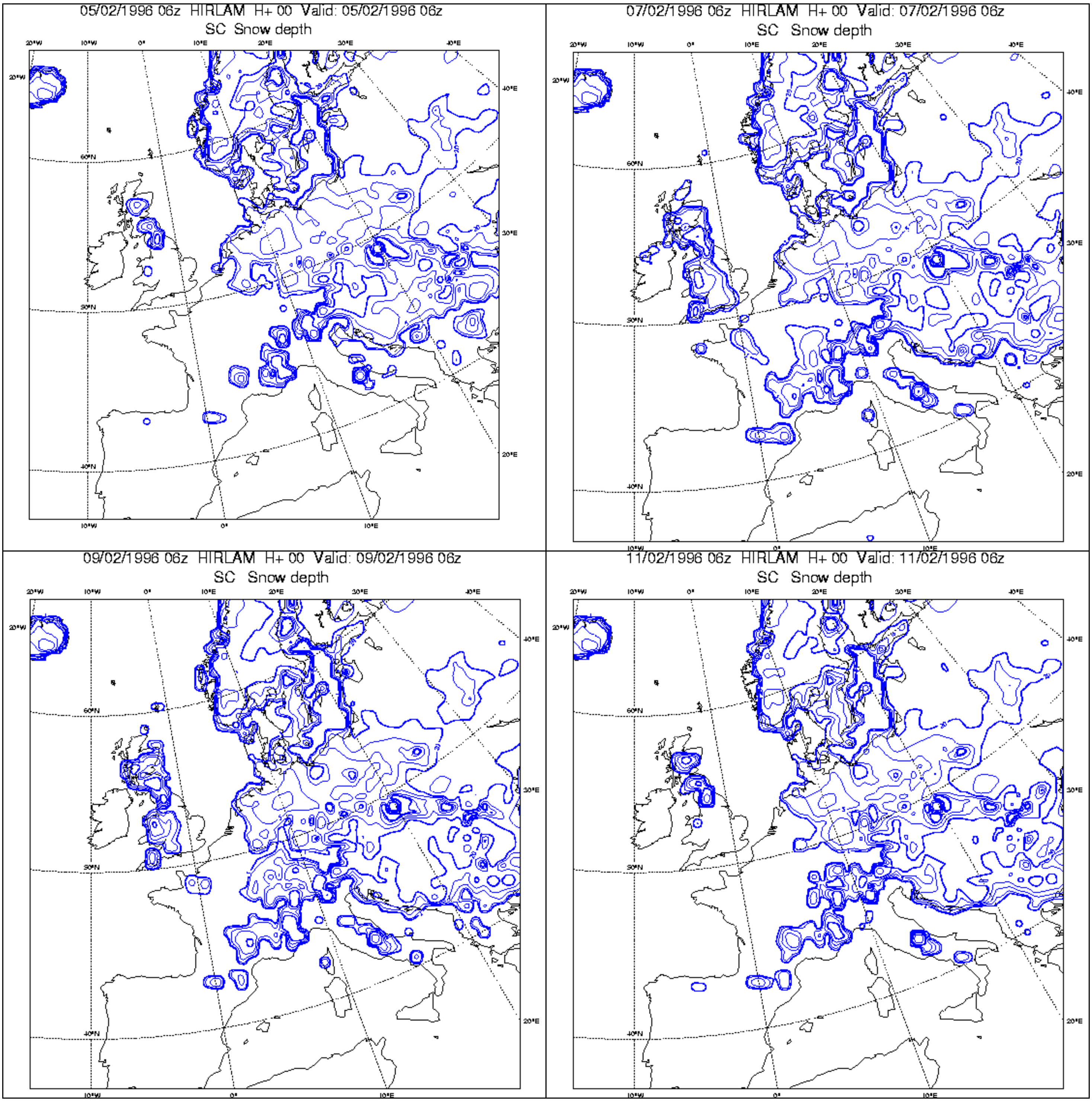

Figure 1. Analized snow cover field using succesive correction method on 1996 February 5th, 7th, 9th and 11th at 6 UTC. Contour intervals: 1 , 2 , 5 , 10 , 20 , 50 , 100 and 500 cm.

Optimum interpolation analysis seems to agree better to SSM/I derived snow cover produced routinely at the NOAA National Climatic Data Center. [http://lwf.ndcd.noaa.gov/servlets/SSMIBrowser].

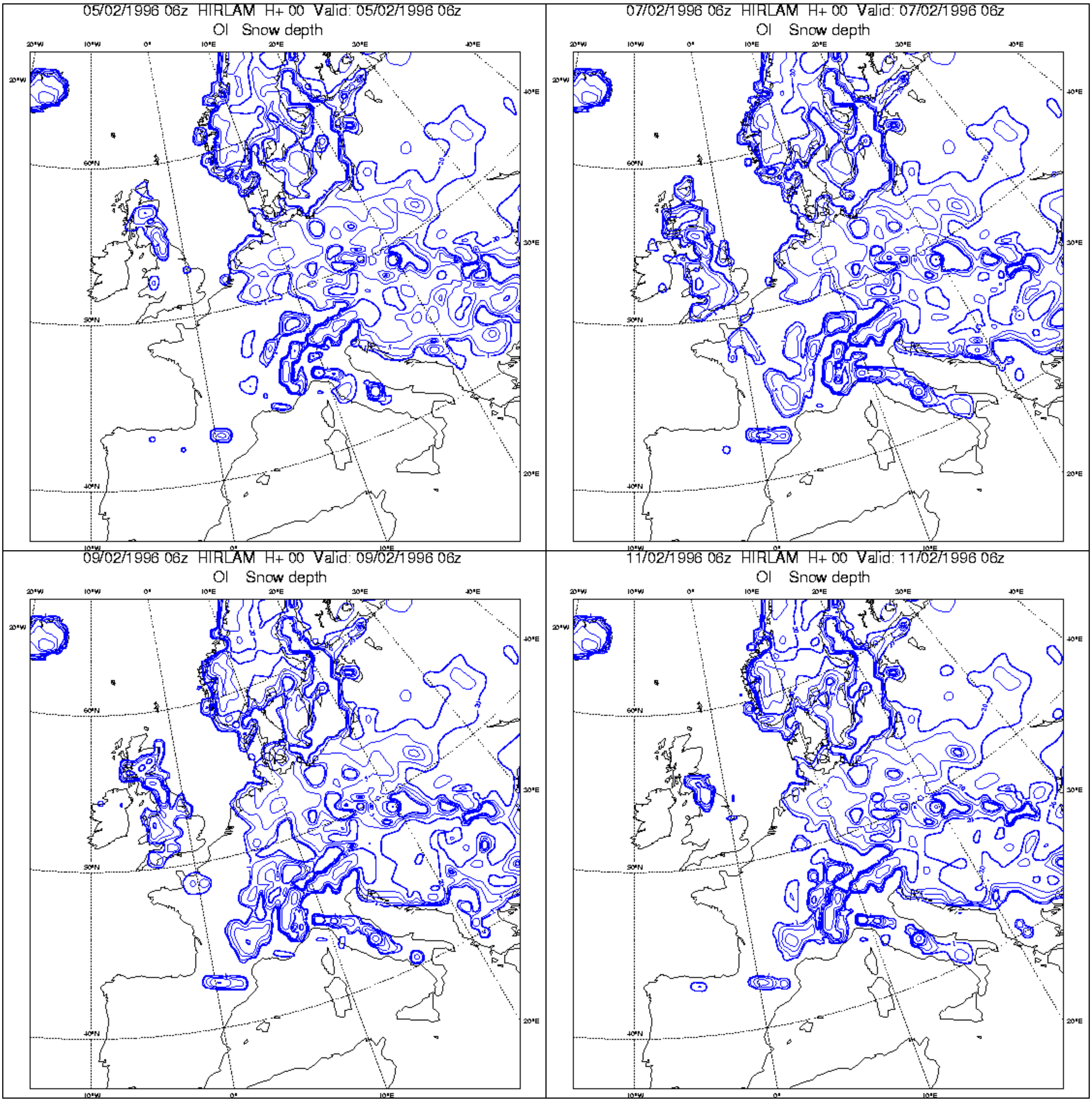

Figure 2. Analized snow cover field using optimum interpolation method on 1996 February 5th, 7th, 9th and 11th at 6 UTC. Contour intervals: 1 , 2 , 5 , 10 , 20 , 50 , 100 and 500 cm.

Figures 1 and 2 show the time evolution of analized snow depth field on February 1996 from 5th to 11th using succesive corrections (SC) and optimum interpolation (OI), respectively.

In Figure 3, SSM/I derived snow cover data are presented. Data are not directly comparable because SSM/I product shows percentage of time with snow cover observed during the week from 5th to 11th February 1996. However the SSM/I product tends to suggest a better fitting of the OI experiment, specially over Southern Europe, whereas in the rest of Europe differences remain quite small.

See, for instance, that O.I. is able to "see" the Rhône Valley free of snow in South Eastern France, how O.I. detects snow in North Western Italy (Piemonte, Emilia Romagna and Toscana areas) and that snow cover distribution in Greece and Albany is more accurate in O.I experiment according to SSM/I data.

In fact, it seems as if O.I. method seems to catch better the cases of transient snow, whereas differences are negligible over permanent covered areas.

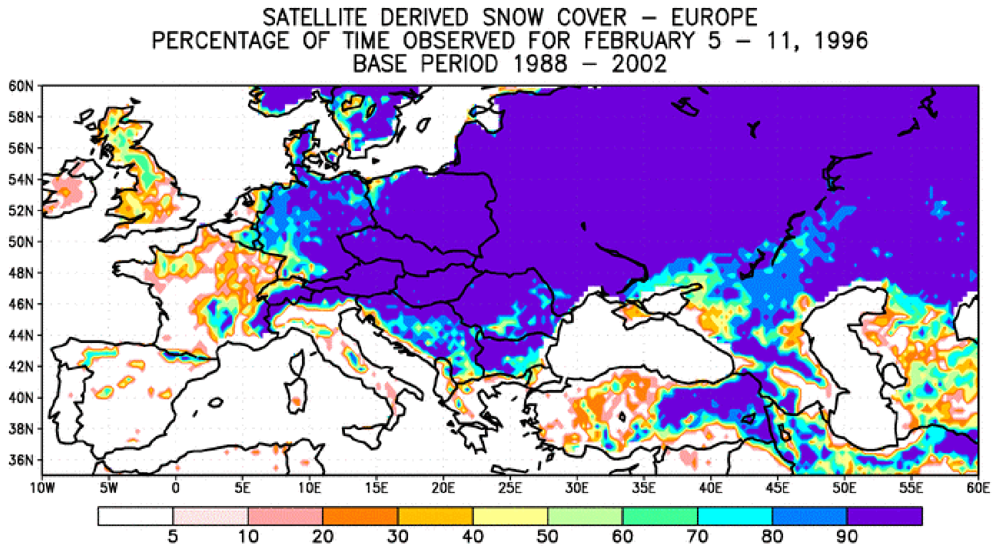

Figure 3. Snow Cover data from SSM/I. Percentage of time with observed snow cover in Europe region.

Other analysis diagnostic tools support O.I. against S.C. Figures 4 and 5 show innovations (observation minus first-guess) and residuals (analysis minus first-guess) histograms for the month of February 1996.

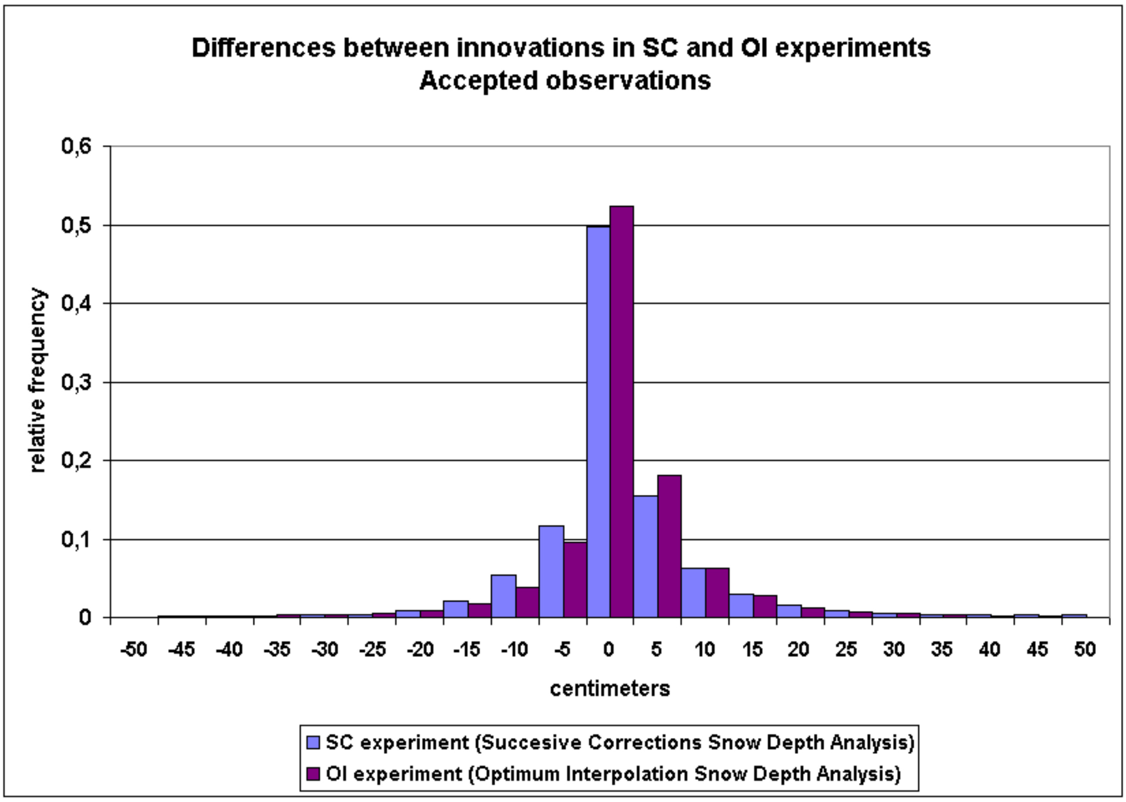

Figure 4. Innovations histogram for both experiments: SC and OI.

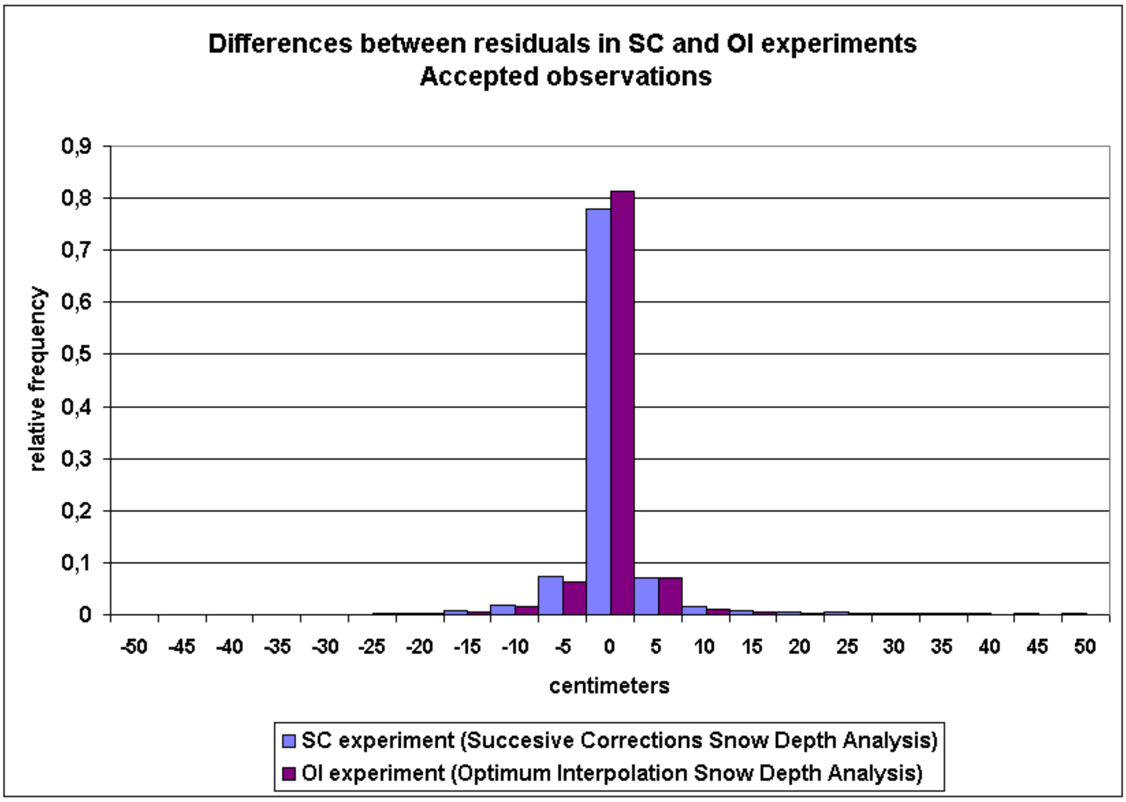

Figure 5. Residuals histogram for both experiments: SC and OI.

From Figure 4, it can be observed that the first guess is biased. Observed snow depth departure from first guess is mostly positive. However, Figure 5 shows that the analysis process is able to correct the first guess and to remove almost all the bias. So, it seems that the model physics might be the responsible for the degradation of snow depth field in the forecast.

It should be taken into account that the new tables of saturation water vapour pressure over ice were not used at any of the experiments here presented. The usage of the new tables reduces substantially the latent heat flux over snow covered surfaces and possibly may reduce the observed bias.

Both analysis and first guess distance to observations appears to be slightly smaller in OI than in SC experiment.

Histograms of rejected observations are very different for both experiments. Optimum interpolation has a different Quality Control System for the observations. Figure 6 shows innovations and residuals for the rejected observations in SC an OI experiments, respectively.

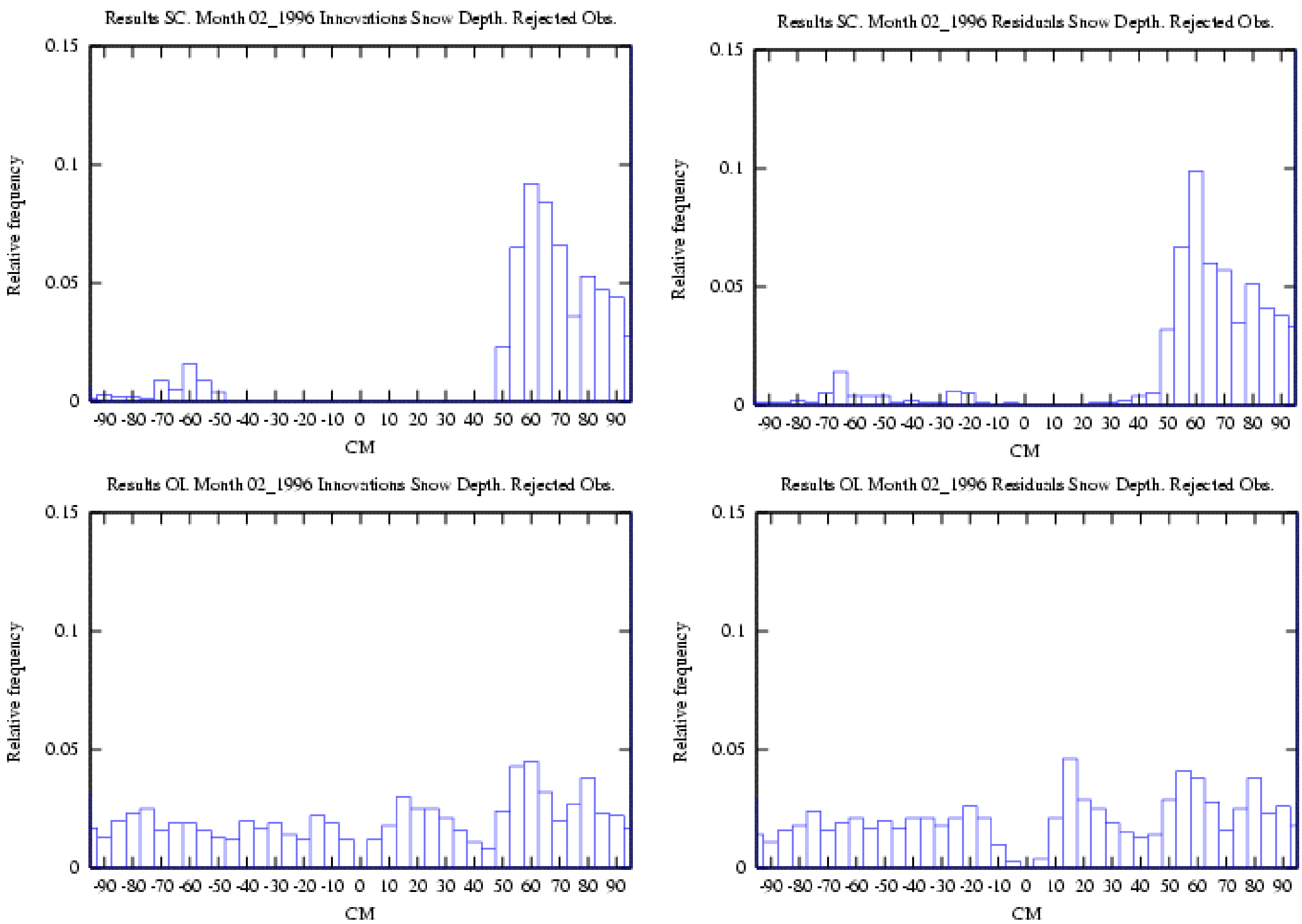

Figure 6. Histograms of innovations (left) and residuals (right) of rejected observations distribution in Succesive Corrections (top) and Optimum Interpolation (bottom) experiments.

We can see that observations near the first guess are always accepted in the SC analysis. OI analysis has an additional quality control of which observations are checked against neighbouring observations. This way, OI analysis is able to reject observations which are very different from others situated in the vicinity, not allowing the analysis to use observations which probably are incorrect.

3.- Conclusions and future directions

Up to now, we have seen that -even if verification scores are not very different for SC and OI experiments-, it seems that OI gives a better description of the snow cover field, especially over Southern Europe.

This effect appears to be linked with the zone where snow cover is not permanent during the period considered. So, it is possible that this effect will shift northwards as snow starts to thaw in Spring.

The work will go on, trying to build a snow depth first guess instead of using monthly constant homogeneous snow density [Brasnett, 1999] and tuning the structure functions parameters for snow cover in the same way as it has been done for 2-meter temperature and relative humidity.

4.- Acknowledgements

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