Furhter tests with the ECOCLIMAP physiographic database in HIRLAM

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1 Introduction

This brief contribution presents further results on the ECOCLIMAP physiographic database (see Masson *et al.*, 2003) within the HIRLAM system. A description of the ECOCLIMAP database, its implementation in the HIRLAM system and some preliminary testing can be found in Fernandez and Rodriguez (2004) (hereafter referred as FR04). Many studies have demonstrated that both soil water content and vegetation parameters are critically conditioning the evolution of soil variables and the partition of heat fluxes. As many of the current soil moisture assimilation algorithms are based on the minimization of errors of forecasted 2-metre temperature and relative humidity, any other source of screen variable errors different from the correct soil moisture specification may lead to unrealistic adding/removing of soil water during the assimilation step. In particular, any inaccuracy of the physiographic description is frequently compensated by modifying soil water. Therefore, it is frequently difficult to separate the evaluation of soil water content and of vegetation parameters, except for a limited number of field experiments.

The question of how to assess a physiographic database was already addressed in FR04. If we restrict ourselves to the usage of a forecasting operational model and then we compare the forecasted relevant parameters against the corresponding observations using the standard scores, we should be very careful with the role played by soil moisture assimilation and by other compensatory mechanisms which can easily offset any incorrect assignation of vegetation and soil parameters. Parodi *et al.* (2004) used the average soil moisture increments over some extended assimilation period as a measurement of the quality of the soil moisture assimilation algorithm, when different assimilation methods were compared. The same approach can be applied here. Assuming that a negligible signal appears on the screen variables due to the compensatory effect of soil moisture increments, the size of soil moisture increments can be used in turn to estimate the quality of a physiographic database.

2 Experimentation with parallel runs

The same setup described in FR04 was used here to evaluate the ECOCLIMAP database against the reference physiography in the HIRLAM system. All experiments were conducted with version 6.2 of the HIRLAM model. Both 'reference' and 'modified' experiments have the common following features:

- Domain: Area corresponding to the INM operational suite with non-rotated grid (65.0N, 30.0E, 15.5N, 66.5E) and 0.5° horizontal resolution.
- 194 * 100 grid points; 31 levels in the vertical.
- Each suite with its own data assimilation (3DVAR, 6 h cycling).
- Lateral boundary conditions: ECMWF analyses.
- 48 h forecasts from all analyses (00, 06, 12 and 18 UTC).
- Period: 1-15 July 1995.

Several parallel experiments, differing only in the physiography used (either ECOCLIMAP or the reference one) and in switching on/off soil moisture assimilation were carried out:

- 620: Reference system (HIRLAM 6.2)
- 62A: The same as 620 but without soil moisture assimilation
- 62C: The same as 620 but assimilating soil moisture only over the low vegetation fraction
- ECO: The same as REF but veg, LAI, land fraction distribution, vegetation albedo, $R_{s_{min}}$ and root depth given by ECOCLIMAP

3 Impact of different physiography on screen variables and on soil moisture

Figure 1 shows the effective albedo, vegetation cover and leaf area index for 620 and ECO experiments. The effective value was computed weighting each surface parameter by the corresponding land fraction. Significant differences appear for the albedo over northern Africa, as it was already discussed in FR04. It is also noticeable that the ECOCLIMAP LAI is bigger than reference LAI over most of Europe. Regional differences also appear in some variables, *e.g.*, over Scandinavia the ECOCLIMAP albedo tends to be darker than the reference one, over southern Spain the ECOCLIMAP LAI is smaller than the reference one, etc.

It has already been shown (see FR04) that the impact of using either the reference or the ECOCLIMAP physiography was very small in terms of 2-metre temperature and relative humidity. Figure 2 shows 2-metre temperature H+48 bias averaged obtained with experiments 620 and ECO for the period 1-15 July 1995. All integrations start at 12 UTC. For most of the regions differences between both experiments are hardly appreciable. However, some clear differences appear over Scandinavia which could be explained by the different albedo. The ECOCLIMAP greenness (veg and LAI) seems to be bigger than the reference one and this effect would enhance evapotranspiration and consequently would produce colder temperatures with ECOCLIMAP. As the observed ECOCLIMAP temperatures are warmer than reference ones, it may as well happen that bigger veg and LAI would also produce bigger soil moisture corrections, as the coefficients appearing in the optimal interpolation algorithm are proportional to veg and LAI.

Figure 3 shows the corresponding mean and rms error soil water correction for the same period and also for both 620 and ECO experiments. In general, it can be said that the order of magnitude of the corrections is very comparable both in terms of bias and of rms error. There is however a tendency to show bigger corrections in the case of ECOCLIMAP, probably due to the above mentioned bigger greenness of ECOCLIMAP. As the soil moisture assimilation algorithm based on OI makes used of fixed coefficients which depend on vegetation parameters (veg, LAI, Rsmin, etc.), any modification of the physiography will alter in turn the vegetation parameters and consequently the size of soil moisture corrections during the assimilation step. Therefore any increase in the greenness will produce two effects: first, some enhancement of the evapotranspiration process and, second, bigger soil moisture corrections during the assimilation step.

4 Impact of soil moisture assimilation

Another experiment without soil moisture assimilation (experiment 62A) was conducted only for the reference physiography to check again the positive impact of soil moisture assimilation. An additional experiment was also done with soil moisture assimilation but only over the low vegetation tile (experiment 62C). The soil water over the forested tile was here left evolving without any assimilation correction. As most of the grid squares over Europe are partly covered with low vegetation and forest, we wanted to check if the assimilation algorithm acting only over the low vegetation tile was able to compensate the 2-metre temperature drift.

Figures 4 show the evolution of soil wetness index, 2-metre temperature and relative humidity increments and 6 h forecasted precipitation for the 620 reference experiment in some selected gridpoints. The evolution of soil wetness index is also shown for the experiment without soil moisture assimilation (62A) and with soil moisture assimilation only over the low vegetation tile (62C). The first noticeable feature is the big impact of soil moisture assimilation in terms of soil water evolution. The current assimilation algorithm tends to produce rather big increments which are dominating the soil moisture evolution. This negative characteristic is shared by many assimilation schemes as it was also discussed by Parodi *et al.* (2004). The reduction of the increments will be achieved by improving the surface model (better background field) and by using better assimilation methods with a diverse set of observations (screen variables, IR, MW) sampling the physical space in different directions.

One can also readily see that periods without precipitation tend to produce tile dispersion in terms of soil water within the same grid square. In this sense it would be reasonable to consider the possibility to impose some limit to the difference of soil moisture among tiles belonging to the same grid square.

Another feature of soil moisture evolution is its excessive jumpiness, noticing too much the passage of synoptic perturbations. This effect is particularly noticeable in cases with no precipitation contribution where one would expect some smooth decline of soil water due to evapotranspiration, which is absent in three of the selected points here shown. The overcorrection of the soil moisture assimilation optimum interpolation scheme was also detected in the ELDAS simulations (see Parodi *et al.* (2004) and suggests that some revision of the coefficients in the OI scheme is needed.

The experiment 62C clearly shows that the effect of compensation observed at the low vegetation tile during the soil moisture assimilation step when the forest tile was left to evolve freely. This effect is also noticeable in terms of 2-metre temperature scores. The bias and rms error of 2-metre temperature of experiments 620 and 62C hardly show any difference between forest and low vegetation tiles (see fig. 5).

5 Conclusions

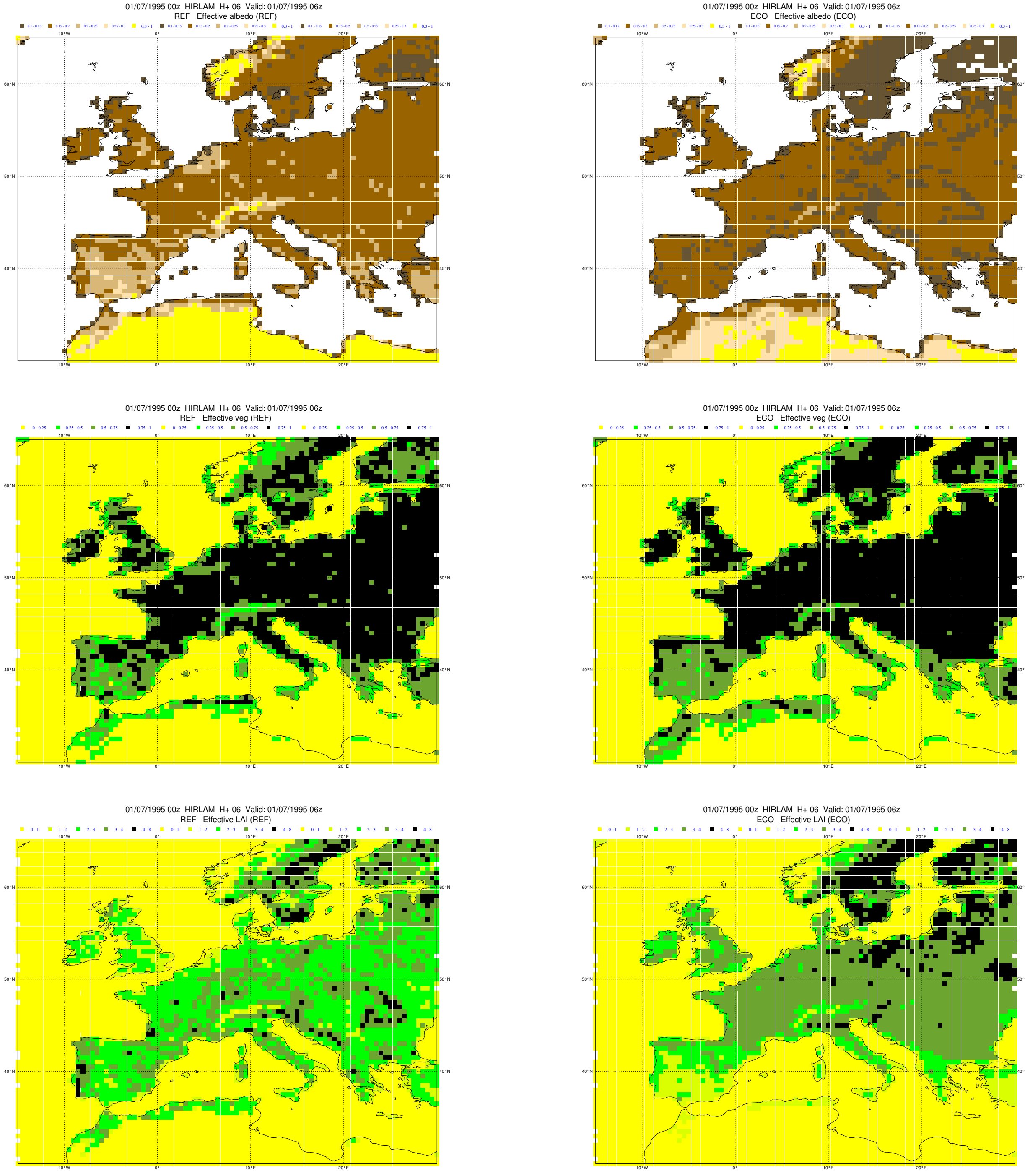
The vegetation parameters supplied by the ECOCLIMAP database have been added to the HIRLAM climatic files and used to substitute values assigned by the correspondance tables included in the HIRLAM surface code. So far, the following ECOCLIMAP fields have been explored: leaf area index, vegetation cover, land tile distribution, root depth, vegetation albedo and minimum stomatal resistance.

The effect of the vegetation parameters change has been offset by the soil moisture assimilation algorithm, which is able to compensate differences in vegetation parameters by changes in soil water content. Of course, if vegetation parameters are wrongly specified, it cannot be expected that soil moisture values are realistic. A complementary conclusion of this work is that the optimal interpolation method for soil moisture assimilation is a rather robust approach, which preserves surface heat fluxes rather well against changes in vegetation parameters by minimizing errors of forecasted 2-metre temperature and humidity. The possible errors or misspecification of vegetation parameters is therefore translated to the soil water content, which is an output not very much used of the weather prediction models.

Some further experiments without soil moisture assimilation and with soil moisture assimilation but only over the low vegetation tile were also conducted to confirm the compensatory role of the soil moisture assimilation algorithm against changes in vegetation parameters.

References

1. Fernández, T. and Rodríguez, E. 2004. Tests with the ECOCLIMAP physiographic database in HIRLAM. HIRLAM Newsletter No. 45, 151-167.
2. Masson, V., Champeaux, J.L., Chauvin, F., Meriguet, C. and Lacaze, R. 2003. A Global Database of Land Surface Parameters at 1-km Resolution in Meteorological and Climate Models. *J. Climate*, **16**, 1261-1282.
3. Parodi, J.A., Navascues, B. and Rodriguez, E. 2004. Significance of ELDAS products for NWP. Proceedings of ECMWF /ELDAS Workshop on Land Surface Assimilation. Reading, U.K, 8-11 November 2004.



01/07/1995 00z HIRLAM H+ 06 Valid: 01/07/1995 06z
REF Effective albedo (REF)

01/07/1995 00z HIRLAM H+ 06 Valid: 01/07/1995 06z
ECO Effective albedo (ECO)

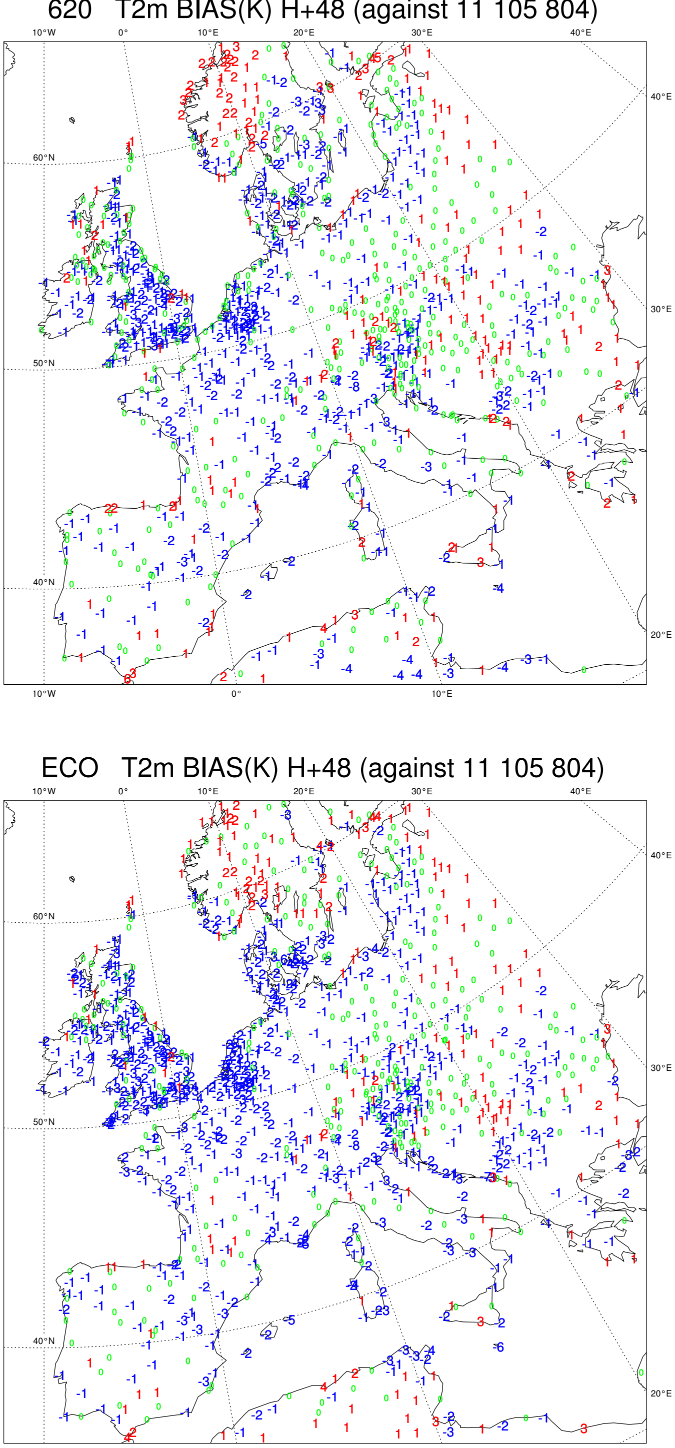
01/07/1995 00z HIRLAM H+ 06 Valid: 01/07/1995 06z
REF Effective veg (REF)

01/07/1995 00z HIRLAM H+ 06 Valid: 01/07/1995 06z
ECO Effective veg (ECO)

01/07/1995 00z HIRLAM H+ 06 Valid: 01/07/1995 06z
REF Effective LAI (REF)

01/07/1995 00z HIRLAM H+ 06 Valid: 01/07/1995 06z
ECO Effective LAI (ECO)

Figure 1: Effective albedo (top), vegetation cover (middle), LAI (bottom) for REF (left) and ECO (right) experiments


620 T2m BIAS(K) H+48 (against 11 105 804)

ECO T2m BIAS(K) H+48 (against 11 105 804)

Figure 2: 2-metre temperature H+48 bias for experiments 620 (upper) and ECO (lower) averaged for the period 1-15 July 1995. All integrations start at 12 UTC.

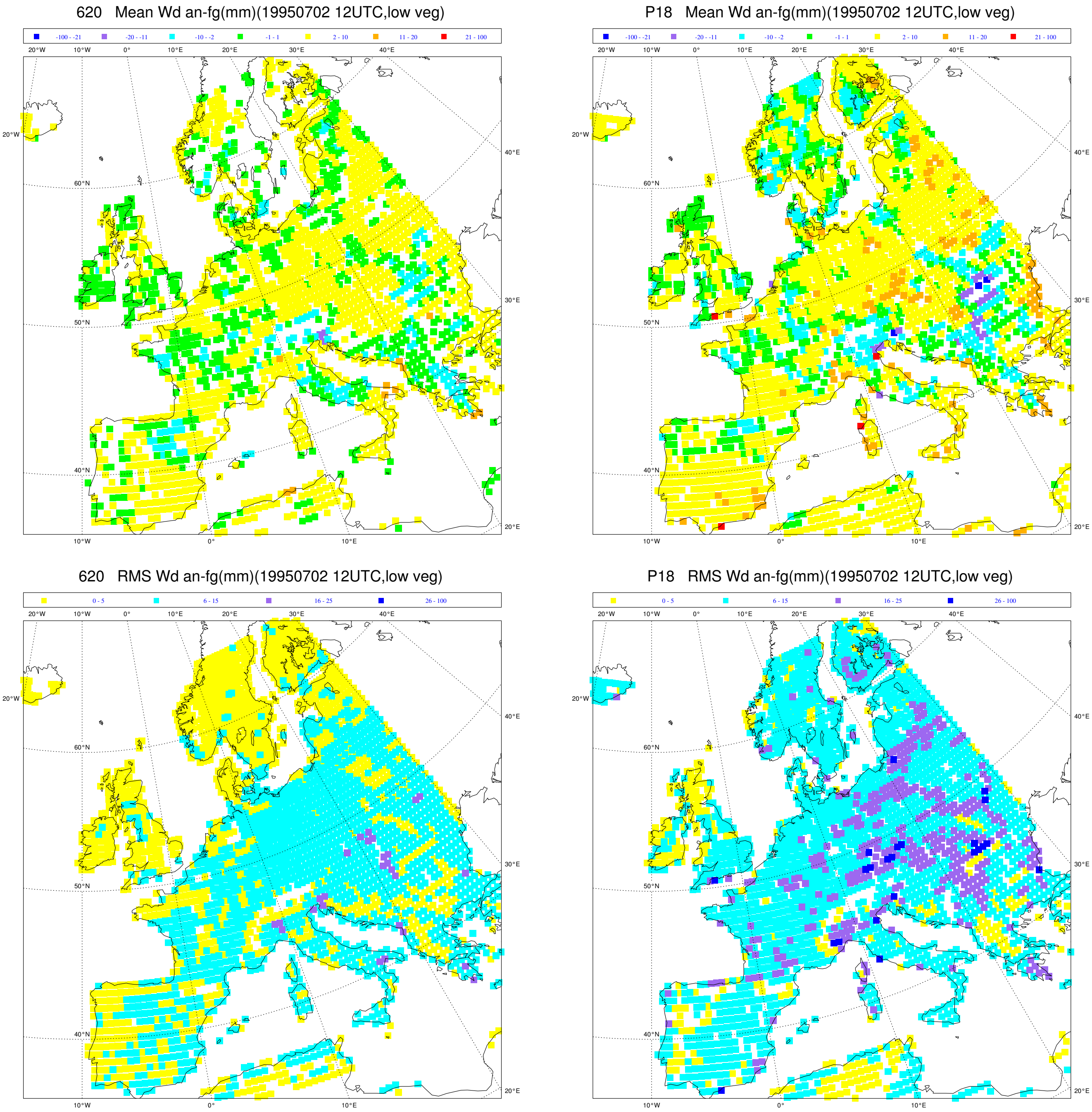


Figure 3: Mean (top) and rms error (bottom) of soil water increments at the 12 UTC assimilation step for experiments 620 (left) and (ECO) averaged for the period 1-15 July 1995. The increments here shown were computed only for the low vegetation tiles

Figure 4: Evolution of (i) SWI of low vegetation and forest tiles for the experiments 620, 62C, 62A (see the text for further details); (ii) low vegetation and forest T2m increments (exp. 620); (iii) low vegetation and forest RH2m increments (exp. 620) and (iv) precipitation (exp. 620). Coordinates of the selected points are: (45N,23E; top left), (46.5N,26E; top right), (48N, 12.5E; bottom left) and (48N, 20.5; bottom right)

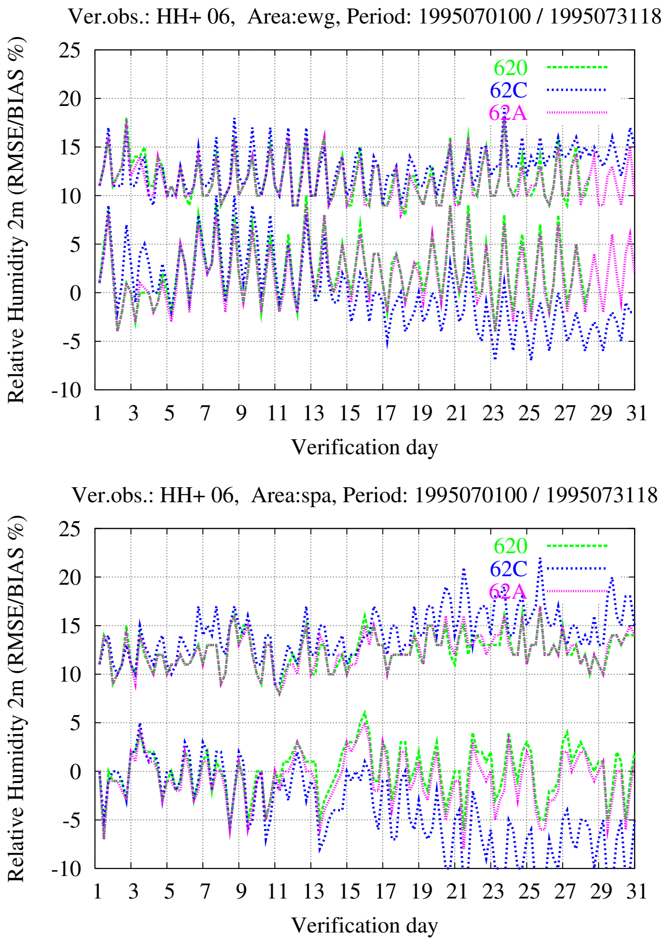


Figure 5: H+6 verification against observations of 2-metre relative humidity for the EWGLAM (top) and the Iberian peninsula (bottom) stations for the experiments 620, 62C, 62A (see the text for further details). Period: 1-15 July 1995