Applications in mountain areas

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1. Introduction

The issue of producing and validating ERA in mountain areas is not trivial. The atmospheric model orography is smoothed and can hardly be compared with the real one. In order to validate the surface variables and snow cover in the region of the French Alps, a set of observation from synoptic stations in the regions was used. This set was complemented by data from the analysis system SAFRAN (Système d'analyse fournissant des renseignements à la neige) and the snow model CROCUS. The analysis system SAFRAN used meteorological input data (from operational analysis) and a number of climatological and snow network stations to produce surface variable at different elevations. SAFRAN was able to account for the sharp horizontal gradients observed in the region, as it analysed the data using zones of approximately 1000 km^2.

2. Temperature

The ERA temperature was validated against an automatic weather station situated at 3000 m a.s.l. Usually, in mountain formed by isolated peaks, the 2m air temperature can be compared with a good accuracy to the free air temperature. That was the case for ERA15 and ERA40. The error was very small for both reanalyses, ERA40 and ERA15 being very close, and a little warmer than the operational analysis. A temperature inversion in winter was found in ERA15, which was too pronounced when compared to the temperature inversion observed in alpine valleys during winter. This effect was lower in ERA40.

3. Precipitation

Precipitations was validated using ten synoptic stations in and around the French Alps. ERA40 showed an improvement when compared to ERA15. The monthly variability of precipitation was quite well captured, although underestimated during the wettest months. ERA40 precipitation was better, but both re-analyses were unable to reproduce the fine scale patterns of precipitation in the region (precipitation triggered by orography in the first mountain barrier, shadowing effects in the central part of the French Alps). One concern was the underestimation of snowfall, when compared to analysed snowfall at the closest elevations available in the SAFRAN analysis database.

4. Snow cover

The snow cover simulated by ERA at a point representative of the northern Alps was compared to the SAFRAN/CROCUS analysis database at the same elevation. The ERA15 snow water equivalent was lower than the reference snow cover. This was linked to problems in the snow scheme and in the assimilation process. In ERA40, the results were improved and the major features of the interannual variability were captured. An attempt was made to extrapolate the data

At higher elevations, in order to evaluate the ability of ERA40 or GCM data to diagnose variables linked to glaciers, like the equilibrium line of glaciers. ERA40 captured reasonably the equilibrium line of the North of the Alps (3000 m a.s.l).

Although not a validation, it must be noted that the ERA data were used by the CNRM to extend its SAFRAN meteorological analysis database back to 1958. This offered the possibility to reanalyse some remarkable past avalanche periods during this period. The reference avalanche situation in France being the 1969/70 winter.

5. Conclusion

The ERA showed a significant improvement when compared to ERA15. It appeared that the temperature data were of sufficient quality for this study, except near the surface, were the winter temperature appeared too cold. This effect is more pronounced in ERA15.

For precipitation, ERA showed a good overall shape and a rather good monthly variability. The spatial pattern of precipitation were closely related to the model orography, precipitation being maximum at areas where the altitudinal gradients were maximum, and thus not match very well with the observed patterns.

Concerning snow cover, the validation was done using the SAFRAN/CROCUS analysed data. The simulation of snow cover was improved in ERA40, in relation with an improved snow scheme and an improved snow assimilation. ERA40 was able to capture a significant part of the interannual variability, while ERA15 not.

6. Implications for further steps

For temperature, the main point is how to simulate in a proper way the stable boundary layer in winter. This boundary layer is present in valleys and not in the slopes. The main question is how to represent this phenomenon in the model (which has no valleys) in a way that surface fluxes are realistic.

Sharp horizontal precipitation gradients are seen in mountain regions. By refining its grid, ERA will improve the mountain orography in some sense, but won’t be able to reproduce valleys. Improvements on this topic will probably be only seen with a very increase in the grid resolution. EURRA will be probably a good framework for that.

Snow cover is an important element of the climate system. For relatively small mountain areas, like the Alps, comparing simulated and observed (or analysed) snow cover is not simple. There are several options for the validation of the snow cover.

- The first one is to compare with local measurements or analysed data (the present study). One must aware of vertical interpolation problems in this case.
- Another option is to use it indirectly for hydrological validation at the basin scale. In this case, an averaged snow cover is validated. In this case, the issue is to have a correct distribution of elevation in the basin.
- One also can imagine to validate the snow cover in mountains using its impact on the atmosphere, using the surface fluxes and the impact on the local atmospheric circulation. In this case, the validation strategy is not obvious.

References

Martin, E.: Validation of Alpine snow in ERA-40, *ERA-40 Project Report Series* No. 14, February 2004

http://www.ecmwf.int/publications/library/ecpublications/_pdf/era40/ERA40_PRS14.pdf