Geosci. Model Dev. Discuss., 5, C332–C336, 2012
www.geosci-model-dev-discuss.net/5/C332/2012/

Geoscientific
Model Development
Discussions

Interactive comment on "TopoSUB: a tool for efficient large area numerical modelling in complex topography at sub-grid scales" *by* J. Fiddes and S. Gruber

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Received and published: 29 June 2012

This comment was prepared with contributions from Y. Durand, E. Martin and E. Brun (Météo-France – CNRS, CNRM-GAME, Toulouse and Grenoble).

Fiddes and Gruber (2012) provide an interesting study relevant to semi-distributed simulations of the physical state of the Earth surface in mountainous areas. Indeed, alternatives to fully distributed simulations are often required to reach an appropriate compromise between the overall accuracy of the simulation, computing time, and relevance of the horizontal resolution of the simulation to the physical process(es) addressed in the land surface model.

This short comment provides context to a few studies, not referred to in Fiddes and Gruber (2012), and which are relevant to the current study. In the particular case of the physical properties of the snowpack, it is well known that the surface energy budget depends mostly on local slope and aspect, and that the meteorological conditions depend mostly on altitude within a given mountain range. These principles can be applied to perform numerical simulations of the physical properties of the snowpack that are relevant for operational avalanche hazard prediction without performing fully-distributed simulations. This is the root of the SAFRAN meteorological analysis tool, developed over 20 years ago and initially described by Durand et al. (1993). In practice, in each of the French mountain range (23 in the Alps, 23 in the Pyrenees and 2 in Corsica), the output from a mesoscale numerical weather prediction is analyzed homogeneously at the scale of mountain range with 300m high altitude bands (small deviations of the meteorological conditions as a function of slope aspect have been introduced to account for the asymmetry of the meterological conditions in a given mountain range against synpotic circulation). The energy and mass balance of the snowpack using the snowpack model Crocus (Brun et al., 1992 ; Vionnet et al., 2012) is then computed for each altitude band and for several slopes (0, 20, 40) and several aspects (operationnally : flat + N, E, SE, S, SW, W). Altogether, the system provides a wide overview of the simulated physical properties of the snowpack at the scale of the mountain range without resorting to a full distributed simulation - note that the latter would be impaired, anyway, by sub-grid processes such as wind-redistribution. Further details about this method are provided in Durand et al. (1999) and an example in the context of avalanche hazard studies is provided by Rousselot et al. (2010).

It appears that the method developed by Fiddes and Gruber (2012) draws from the same principles than the SAFRAN-Crocus model chain. The main two differences in the treatment of the topographical features of the simulation domain are that the classes used for mass and energy balance computations at the surface are not fixed a priori in contrast to the SAFRAN approach with a fixed, regular and arbitrary cluster distribution based on slope, aspect and altitude, and that the sky-view factor is additionnally taken into account in the TopoSUB approach.

For the upper Engadin region studied here, with an altitude range from 1556 to 4043 m, the SAFRAN-Crocus framework would perform surface computations on 9 elevation bands (1500 to 3900 m), and for each of them 1 simulation on flat terrain and 6 simulations for the various aspects of 20 and 40 degrees sloping surfaces, totalling 117 individual simulations. In this case, the optimum number of classes obtained by TopoSUB lies between 64 and 258. This indicates that the arbitrary classification scheme of SAFRAN-Crocus is very consistent with TopoSUB - note that the SAFRAN massifs have about the same size (40 x 40 km) than the tested area. However, the SAFRAN-Crocus approach may over- or underestimate some topographical features (higher than 40 degrees slope, significant shadowing, predominance of some slope aspects ...). It would be interesting if the authors could provide an assessment of the nature of the clusters resulting from the clustering algorithm, to see to what extent they differ from an arbitrary classification scheme such as SAFRAN-Crocus.

In terms of applications as a meteorological downscaling tool, it may worth recalling that SAFRAN has also been used to for a pionneering study on the impact of climate change on the French Alps snow cover (Martin et al., 1997). 20 years ago, computer ressources were even more critical than today and the use of SAFRAN to downscale GCM or reanalysis outputs proved a very efficent way to feed a snowpack model over a region with complex topography.

In the context of hydrological modeling, the arbitrary semi-distributed approach of SAFRAN-Crocus was successfully used for hydrological applications by Braun et al. (1994). A very similar classification scheme was used then (vertical classes of 200m instead of 300m were chosen) and provided very successful model runs on a 200 km^2 mountainous catchment. In this work, an original treatment of subgrid heterogeneity of snow conditions was developed in addition to the classification of meteorological conditions based on slope, aspect and altitude.

Last, the approach of Fiddes and Gruber (2012) could be compared to the AURELHY system that accounts for the topographic properties of the relief to mapping precipitation data (Benichou and Le Breton, 1987 ; Gyalistras, 2003).

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