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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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AUTHORS RESPONSE TO SHORT COMMENT BY S. MORIN

We would like to thank S. Morin for his extremely useful and constructive short comment. We have benefited from the open discussion and improved several aspects of our argumentation in this way. In this response we present two key points: (1) a descriptive comparison of TopoSUB and SAFRAN, and (2) results of an experiment comparing an arbitrary classification scheme similar to that used in SAFRAN and a clustering classification scheme that is used by TopoSUB. Finally, we briefly outline, how this will be reflected in the revised manuscript.

(1) DESCRIPTIVE COMPARISON

Both systems are based on the key principle that physical processes in mountain regions are likely to be similar within a reasonably homogeneous climate zone if key topographical factors, such as elevation, aspect and slope, are similar. The main differences between the two approaches, that we believe to be important, are given in the text below, together with a summary table (Table 1). This is a basis for the reader to better comprehend the respective focal areas and the expected performance differences between the two approaches.

(a) SAFRAN

The primary function of SAFRAN (Durand et al. 1993) is to provide the required meteorological inputs for the snow model CROCUS. It achieves this by performing a spatialisation of observed weather data available over the considered elevations, aspect and slopes of the different French massifs in question (Durand et al. 1999). This is achieved by classification of the domain along fixed class boundaries (elevation: 300m intervals, aspect: 6 directions [N,S,E,W,SW,SE] and slope: flat, 20, 40 degrees). SAFRAN then includes methods of assimilation and spatialisation of meteorological parameters to these predefined classes. In addition, SAFRAN is designed as a tool to provide inputs to the model CROCUS. It appears that the focus of the SAFRAN method is on the mechanisms of meteorological data assimilation and spatialisation to predefined topographical classes, while the arbitrary classification of topography is reasonably simple.

(b) TopoSUB

We consider TopoSUB to be conceptually distinct from SAFRAN in that it is first and foremost an efficient and flexible landscape segmentation tool. The focus is here put on how to classify topography, however, the approach is expected to generalise well to other applications. In this respect it is able to segment a given landscape along dimensions of variability, which are not fixed. While in Fiddes and Gruber (2012) we present results based on 4 key topographical attributes (ele, asp, slp. svf), TopoSUB is readily extended to accommodate additional dimensions, such as vegetation. The focus within TopoSUB is therefore not the method of spatialisation of meteorology (which currently follows standard methods, e.g. Liston and Elder 2006), but rather the definition of topographical samples to which meteorological parameters are spatialised and then a 1D land surface model may be applied. In addition, it is worth highlighting that the clustering algorithm is by definition self optimising (in terms of representing distribution of cluster members, or pixels, in attribute space) but also has a training routine which allows tuning of clustering to specific target variables by scaling of the input topographic predictors. TopoSUB is also efficient in that it can drop samples that represent relatively few members and reassign those pixels to nearest neighbour samples. In the current work we have additionally presented a measure of quality of the TopoSUB method by comparing to results obtained from distributed model simulations.

As illustrated in Figure 3 of the manuscript, TopoSUB has three main post-processor modules (a) AGGREGATE: produces summary statistics with respect to the coarse grid describing its sub-grid variability by a CDF or derived quantities; or (b) SPATIALISE: data spatialised to the original fine grid; or (c) VALIDATE: data estimated for a list of discrete points to support validation studies using ground truth data without the need for prior full spatialisation. The coarse-grid summary statistics are computed according to the aggregated membership functions of individual pixels to each sample. TVs are spatialised to fine grid resolution according to the membership functions (crisp or fuzzy) of each pixel to each significant cluster. This accounts for the sub-grid heterogeneity that exists between cluster centroids.

In summary, we suggest that the two key differences between the methods are (1) TopoSUB attempts to form optimal samples based on observed dimensions of variability together with relevance of those dimensions to the target variable(s) in question, while SAFRAN implements fixed arbitrary classes, and (2) TopoSUB provides a means to spatialise or aggregate numerical simulation output efficiently and accurately, while the focus of SAFRAN is on the spatialisation of assimilated driving meteorology. In

addition, we test the performance of our method against a distributed reference.

(2) EXPERIMENTAL COMPARISON

As it is difficult to make an accurate comparison between SAFRAN and TopoSUB due to the multitude of factors (such as distribution methods used etc), we have chosen to investigate to what extent the clustering algorithm used in TopoSUB produces different results to an arbitrary classification system, such as SAFRAN (we hope we address the authors key point here). Therefore our 'SAFRAN' setup has 9 elevation classes of 300m intervals (1500-4200m), 6 aspects (0, 90, 135,180, 225, 270) and 3 slope angles (flat, 20, 40 degrees). This gives a total of 117 samples of computation. We then compared this to a TopoSUB run of also 117 samples which are formed based on variables elevation, aspect and slope to allow for fair comparison. Results are presented from both crisp and fuzzy spatialisation modes. The simulation parameters in both cases are identical to those used in the manuscript.

RESULTS

Figure 1 illustrates the distribution of samples with respect to elevation, aspect and slope. Table 2 gives the results of the TopoSUB and SAFRAN-like simulation as compared to the distributed BASE simulation described in Fiddes and Gruber (2012). Correlation coefficient and RMSE statistics are given and show that the TopoSUB method performs better than the arbitrary classification method in all cases, except Tair (when crisply spatialised). The reduced Tair performance is likely caused by fewer elevation classes described by TopoSUB to accommodate higher resolution in the other dimensions of importance. Recalling that the training routine optimises the clustering according to all target variables of interest, and therefore that in this case the clustering represents a compromise in the resolution of dimensions of importance between all four target variables tested.

If we then include the fuzzy membership spatialisation routine of TopoSUB, we see improved performance in all target variables. In some ways this is unfair as we do not consider a more sophisticated method of spatialisation of the SAFRAN method. In this regard we prefer to present the results of the crisp simulation as the most transparent comparison of the two classification methods.

SUMMARY

We have described, what we consider to be important differences between the SAFRAN and TopoSUB approaches and argue that while both utilize a common concept of lumping of topographical attributes, there are quite fundamental differences in design and application. Furthermore, we have compared the mechanisms of topography classification, and have demonstrated that the clustering algorithm implemented within TopoSUB produces a generally superior result than an arbitrary classification system, such as implemented in SAFRAN. Furthermore, more variables (such as sky view factor and horizons which are currently part of the TopoSUB method) likely lead to a stronger advantage of the new approach than tabulated here. These results are given with the caveat that the experimental setup is solely focused on the classification mechanism and therefore does not claim to be a direct comparison between TopoSUB and SAFRAN.

We have now included references to the SAFRAN project in the introduction of our manuscript and further explained how and why we build on fixed, arbitrary classification methods. Additionally we have re-included a section on how we exclude insignificant clusters, as we find this useful in explaining how the method extends on a fixed classification system. We hope this contribution serves to further explain how the TopoSUB model setup may compliment existing topographical classification systems.

FIGURES AND TABLES (SEE SUPPLEMENT)

Table 1: Summary of key differences between SAFRAN and TopoSUB.

Table 2: TopoSUB and 'SAFRAN' statistics (R and RMSE) compared to distributed model simulation BASE.

Figure 1: Sample distribution in attribute space as generated by TopoSUB and an arbitrary classification system such as SAFRAN.

Please also note the supplement to this comment:
http://www.geosci-model-dev-discuss.net/5/C585/2012/gmdd-5-C585-2012-supplement.pdf

Interactive comment on Geosci. Model Dev. Discuss., 5, 1041, 2012.