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Geoscientific
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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 REVIEW 2 BY ANON

we would like to thank the reviewer for their constructive and useful comments. We have split reviewer comments (RC) where we have found this useful to do so. Authors comments are given by AC. Original, added or removed manuscript text is given by MT.

SPECIFIC COMMENTS:

RC1 The landsurface model GEOtop plays a major role in this publication and is not sufficiently described. A short paragraph describing the main characteristics should be

provided together with references that allow deeper insights.

AC1: Model description has been expanded and given its own subsection 4.2, which now reads as follows:

MT: 4.2 Land surface model We employ the open-source LSM GEOtop \citep{Endrizzi2010,Dall'Amico2011, rigon06} which is a physically based model that simulates the coupled energy and water balance with phase change in soil, a multi-layer physically-based snow-pack model and surface energy fluxes in 1D and distributed 2D modes. It has been designed specifically for application in mountain regions. The model domain consists of a soil column of user-specified depth (typically of a few meters) from the ground surface, which is, in turn, defined by a Digital Elevation Model (DEM). The heat and subsurface water flow equations are then solved with finite differences schemes.

The multi-layer snow pack scheme accommodates compaction as well as water percolation and refreezing. The influence of topography on micro-climatology is parameterized, allowing for the solution of the surface energy balance for differing topographic situations based on one driving climate time series (Endrizzi and Marsh, 2010, Liston and Elder, 2006). A vegetation canopy was not considered in these experiments. The soil is uniform over the entire simulation domain, parameterised using the Van-Genuchten model (1981), and has 5 layers and total depth of 3.1m. The model is run on an hourly timestep. We apply two years of spin up and then generate 1 year of data.

RC2: The distribution of meteorological input is not quite clear for both model setups (lumped vs distributed). Further information should be provided on these topics as the meteorological forcings strongly influence the LSM results.

AC2: Further details have been added to the new Section 4.2 (model description). This is as follows:

MT: The meteorological data, input as point time-series are spatially distributed by

GEOtop to each simulation point using principles of the Micromet model (Liston and Elder, 2006) . Specifically: (1) Air temperature follows a mean lapse rate (6.5°C/km). (2) Since relative humidity is a non-linear function of elevation, the dewpoint temperature is used for vertical extrapolation. (3) Model time step is used to calculate the solar radiation for that specific time. In addition, the influence of cloud cover, direct and diffuse solar radiation, and topographic slope and aspect on incoming solar radiation is accounted for. The distributed version has self and cast shadowing based on DEM, point has self and a uniform horizon elevation. (4) Precipitation is not adjusted.

RC3: (a) In section 3.1 the authors describe how the relationship between the TVs and the PREDs are determined using an informed sampling approach - further information on this method should be provided. (b) How is the temporal variability of the relation between e.g. solar radiation and slope/terrain azimuth is accounted for by TopoSUB if the preprocessor is only run once at the beginning of the simulations?

AC3(a): Informed sampling and its training routine is simply an initial simulation where all input predictors are scaled equally in the clustering algorithm, i.e. the assumption under equal scaling is that all predictors are of equal importance to the simulated target variable(s). This we call simple scaling (of predictors). In a second step, we perform a regression on each target variable of interest (single target variable is also possible). The resulting regression coefficients are then used to scale each predictor in an 'informed' fashion. This procedure is performed once and the scaling functions can then be used for all subsequent simulations, where predictors used and target variables required, are the same as the training simulation. We have added an equation describing simple scaling (Eq. 3) to accompany existing regression (now Eq. 4), informed scaling (now Eq. 5) and weighted scaling (now Eq. 6) formulae. We have also extended the text with an example to further explain the process:

MT: The resulting regression coefficients, beta_i provide an informed scaling of the PRED_i for the clustering algorithm by transforming them into equivalents of the TVn dimension and unit (Eq. 5). As an example, elevation (m), slope angle (°) would

be scaled into equivalents of [°C] if ground temperature was the target variable. We have also made the distinction between the K-means clustering algorithm and informed clustering clearer.

AC3(b): We think its important to clearly distinguish between (1) the physical attributes (e.g. topography, surface, subsurface) of the unit of computation, or sample as we call it in this study, and (2) the methods by which driving meteorology is extrapolated to a given point or virtual point at the earths surface where a numerical model may be simulated. This study focuses on (1) – that is, how do we make sure that physical attributes of samples best represent (or 'sample' in a true sense) our simulation domain, and therefore enable a result, approximating the quality of a distributed simulations, to be calculated. The job of the preprocessor then, is only to form samples based on input predictors and assign membership of pixels to samples.

RC4(a): In general, it should be more clearly distinguished between the provision of meteorological input (by TopoSUB or alternatively by the meteorological preprocessor in GEOtop) and the actual process descriptions at the landsurface in the LSMs that are carried out by the same process descriptions.

AC4(a): Correct, meteorology is extrapolated by GEOtop from the driving station. This has now been addressed in response to comment 2.

RC4(b): Maybe a figure illustrating the model chains used in the paper would be helpful (TopoSUB–>GEOtop, meteorological pre- processor GEOtop–>GEOtop). AC4(b): As stated above (AC2), additional text has been added to make this more clear and Figure 3 should hopefully now be sufficient to explain the modelling flow.

RC5: In section 4.2 the authors describe the testing strategy. It should be made more clear that i) meteorological results from TopoSUB are compared to the results of the meteorological preprocessor in GEOtop and ii) the results of GEOtop using both sources of meteorological input are compared.

AC5: (i) Driving meteorology is not compared, it is extrapolated by the same methods (implemented in GEOtop) as described in AC2. (ii) The results simulated in TopoSUB (GEOtop 1D) are compared to results simulated by BASE (GEOtop 2D). The methods by which the driving meteorology is extrapolated to each sample or grid element is exactly the same in TopoSUB and the BASE simulation and is not the focus of this study, as well established methods exist (Liston and Elder, 2006). The difference is that the simulation units are samples resulting from clustering of predictors in TopoSUB and pixels at DEM resolution in BASE. We have added the following sentences to section 4.2 (now 4.3) to make this clearer:

MT: Both runs use the same LSM, GEOtop and same meteorology distribution scheme described in section 4.2. The difference is that the simulation units are (a) samples resulting from clustering of predictors in TopoSUB and, (b) pixels at DEM resolution in BASE runs.

RC6: Abbreviations for the lumped model and the distributed model should be defined that are consequently used in the paper. Sometimes different abbreviations are used for the same setup (BASE <–> DIST or LUMP <–> TopoSUB).

AC6: We have changed the naming convention to BASE and TopoSUB throughout the paper. BASE being the baseline distributed 25m simulation and TopoSUB being the lumped model developed and tested in this paper.

TECHNICAL CORRECTIONS

RC1: p. 1042, l.9: (LSM) should be corrected to (LSMs) as the authors are talking about landsurface models in plural (this applies to various abbreviations in the text (e.g. RCMs, GCMs), please check)

AC1: Done

RC2: p. 1042, l.13: ". . .provides a description . . . as well as assessing. . ." please correct to: ". ..provides a description . . . and assesses. . ." or ". . .provides a

description . . . as well as an assessment"

AC2: Done.

RC3: p. 1042, l.19: "freeing resources for treatment of uncertainties": uncertainties are an important issue and are often insufficiently analyzed, but is this really due to a lack of computational resources?

AC3: Essentially, TopoSUB makes it more efficient/possible to run multiple simulations – which is useful for exploring/ analysing uncertainties, e.g. run simulations under various parameter sets or scenarios of future climate conditions. We would argue that less resource-hungry methods certainly help with such tasks. We have generalised this statement as:

MT: and 4) freeing of resources for computationally intensive tasks e.g. treatment of uncertainty in the modelling process.

RC4: p. 1043, l.8: "both now and under a future climate" may need rephrasing to "under current and future climate conditions"

AC4: Done.

RC5: p. 1043, l.21: "precludes the application of distributed models over large areas": this only applies for coarse grid resolutions, not categorically for distributed models.

AC5: Do you mean: “this only applies for fine grid resolutions, not categorically for distributed models“? We have changed the sentence to:

MT: ...precludes the application of fine-scale distributed models over large areas.

RC6: p. 1046, l.4: "wich is a suitable" please replace with "which is suitable"

AC6: Done

RC7: p. 1046, l.10-16: an illustration of the described procedure would help the reader to follow.

AC7: We hope the text is sufficient as Kmeans is quite a well documented technique in the literature.

RC8: p. 1047, l.12: replace "valued" with "values"

AC8: Sentence changed to:

MT: A membership function is given with a value in the interval 0 – 1.

RC9: p. 1070, figure caption "x scale" should rather be "x-scale"

AC9: Done.

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