

Interactive comment on “High resolution modelling of snow transport in complex terrain using simulated wind fields” by M. Bernhardt et al.

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General Comments:

This work addresses the difficult but important issue of simulating the seasonal snow cover over complex, alpine terrain. Snow transport by wind is simulated using the SnowTran-3D model forced by interpolated and simulated, downscaled winds at a 30-m scale over the Berchtesgaden National Park of Germany. This area is characterized by steep topography, ranging from 603 m a.s.l. at the Königsee to 2713 m a.s.l. at Watzmann summit. Heavy snowfall and strong winds typify wintertime conditions, leading to a very deep and heterogeneous snowpack. The authors conclude that using the MM5 simulated, downscaled winds (rather than interpolated winds) to drive the SnowTran-3D model provides an improved representation of snowpack conditions in

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the region. Despite some innovative aspects, this work requires some substantial revisions prior to publication. Of greatest concern is the lack of information on how the numerical experiments were set up and how the snow depth model represents snowpack conditions throughout the entire winter season. The following provides a list of comments submitted to the authors for consideration in revising their manuscript.

Specific Comments:

Pages 513/514: Both the title and the abstract need to better reflect the area of study. Please add information to this effect in the title and abstract.

Page 517, Line 23: Equation 1 provides the evolution of snow depth over time. Among other parameters, the evolution of snow depth is a function of snow density; however it is not explained how snow density evolves over time (or is it kept constant?) and why blowing snow would have the same density as snowfall (P) at a given timestep. Further to this comment, how is rainfall (P) treated in this model? If the precipitation is liquid, does it actually increase snow depth, as suggested by this equation? Results presented later in the paper (Figures 11 and 12) clearly show the ablation of the snowpack; yet a snowmelt term is not included in Equation 1. Compaction and settling of the snowpack also affects snow depth; but these processes are not considered here. Thus it is unclear how SnowTran-3D simulates the evolution of snow depth throughout the entire winter season.

Page 518: Although the authors provide some details on the models, they fail to provide information on the experimental design and strategy. For instance, what is the model domain? What is the timestep used in the simulations? How are the model boundaries constrained? This applies both to the MM5 and SnowTran-3D simulations.

Page 524, Lines 15-23: Here the authors introduce a new vegetation type in their model that they qualify as 'sporadic trees'. However, no details on how this is achieved are given. What specific changes in their modelling framework accounts for sparsely distributed trees and how does it affect snow transport by wind?

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Page 524, Line 24: Why is section 8 entitled 'Results and discussion'; when there is another section (11) named 'Discussion'? Please combine all discussion items into one section (Section 11). Further to this, I recommend other changes to the structure of the paper. Section 9 could fall under a subheading of section 8 that provides the results. As well, details on the Landsat ETM+ data and their application to this study need to be provided in an earlier section rather than in section 10.

Pages 526-528: There appears to be some confusion as to the predicted model variable for snow here. The authors suddenly discuss simulations of snow water equivalent (SWE) rather than snow depth. The authors need to present a consistent set of results for either of these variables and use the appropriate terminology in the text. This applies to the results presented in Figure 18 as well.

Page 529, Lines 1-29: Some of the language in the discussion (Section 11) needs to be improved. Similar comments apply to the acknowledgements.

Pages 539-556: There is an inordinate amount of figures in this paper; perhaps some of these could be combined into multipanel ones instead, such as Figures 3 and 4, 9 and 10, 11 and 12?

Technical Comments:

Page 515, Line 5, Change 'Déry, 1999' to 'Déry and Yau, 1999'.

Page 517, Line 5: Was a field campaign also conducted during the winter of 2003/2004?

Page 518, Line 3: Does P include rainfall?

Page 518, Line 4: Is the prognostic variable in equation 1 for 'snow depth' or a 'change of snow depth'?

Page 518, Line 5: Is snow density treated as a constant in SnowTran-3D?

Page 518, Line 9: Note that it is: 'Liston and Elder, 2006'.

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Page 518, Line 10: Change 'Green' to 'Greene'.

Page 518, Line 15: Are values of the relative humidity with respect to water or ice? The latter should be used for computations of sublimation at subfreezing air temperatures.

Page 518, Lines 21-22: This sentence is incomplete. Please rephrase accordingly.

Page 520, Line 14: Change 'mountains' to 'mountain'.

Page 520, Lines 18-19: Can you provide values for the coefficients a1-a6 and b1-b6 in a table? What are Z and S?

Page 523, Line 21: Revise 'to low' to 'too low'.

Page 524, Line 12: Change 'SnowTran-3D/MM5 couple' to 'coupled SnowTran-3D/MM5'.

Page 524, Lines 22/23: A 'SnowModel' is referred to here but no details about it are given in the paper. A summary description of this snow model needs to be provided in Section 4 since it forms a vital part of the modelling framework and the results shown.

Page 524, Line 4: Given that the Bavarian Avalanche Service is active in the area, are avalanches affecting any of the sampling sites and/or results? Are avalanches considered within the modelling framework?

Page 525, Line 5: Delete 'a' in 'a over'.

Page 525, Line 24: Delete ')' in 'N)'. The same applies to line 1 on the following page.

Page 526, Line 18: Change 'progressed' with 'initiated'.

Page 527, Line 1: Change 'After than' to 'After that'.

Page 527, Line 17: Replace 'Mai' with 'May'.

Page 527, Lines 19-20: Why are 9 validation areas chosen for April and only 6 for May?

Page 532, Line 6: Why is it Liston and Elder, 2006a?

Page 533, Table 1: For consistency, change 'snow height' to 'snow depth'. What do the variables TS0 and RR represent in this table? There seems to be an error with the coordinates for Kührint. Also, please specify that longitudes are degrees east and latitudes are degrees north.

Page 534/5, Tables 2/3: Why not provide the mean and standard deviation for snow depth for each date on which measurements were taken?

Page 536, Table 4: Delete this table and just state the values within the text.

Page 537, Table 5: Add a space between 'MM5 wind'. The phrase 'The values belonging to the areas highlighted in Fig. 15' is incomplete.

Page 538, Table 6: Similar comments to those for Table 5. Why do the units change from 'mm' to 'SWE'?

Page 540, Fig. 2: Please add contours of elevation on this map. What does the boundary denote on this figure? Why not show all meteorological station locations rather than just those of Reiteralm 1, 2 and 3?

Page 542, Fig. 4: Why are none of the sample points within forested areas?

Page 545, Fig. 7: Apart from correlation analyses, were other errors (mean absolute errors, root mean square errors?) computed to assess the simulated wind fields?

Page 546, Fig. 8: The axis label should read 'model' and not 'modell'. Again, are there other errors that could substantiate the claims made in the paper?

Pages 547/548, Fig. 9/10: How do the measured and interpolated wind directions compare at Reiteralm 1?

Page 549, Fig. 11: Use the same vertical scale (0-5 m) for all 3 panels. Why are the horizontal lines at constant intervals solid in the final panel but dashed in the others?

Page 551, Fig. 13: Is the simulation domain restricted to the Berchtesgaden National

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Park? Why is there not a validation of wind direction as well here?

Page 552, Fig. 14: What does the colour scale represent on these plots? What is 'NDSI'? Change 'Mai' to 'May'.

Pages 553/554, Fig. 15/16: There are colours other than blue and red represented on these plots that need to be defined.

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