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Discussions

Interactive comment on "A conceptual, distributed snow redistribution model" *by* S. Frey and H. Holzmann

Anonymous Referee #1

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Dear authors,

congratulations to Your manuscript! It represents an important contribution to current mountain hydrological modelling and science. However, three important aspects deserve additional attention and should be considerably improved. The modifications required represent a major revision. I hope You invest the effort and re-submit a second, extended version of the manuscript. The issue of the manuscript is in the scope of HESS.

General remarks

(i) The manuscript could be improved by clearly stating that a) lateral snow redistribution processes are either gravitationally or wind induced, b) these processes can either

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be modelled process-oriented or empirically, and c) You concentrate on wind-induced snow redistribution by means of an empirical approach. You should then extend Your literature and state-of-the-art review with relevant papers on exactly this (e.g., Helfricht et al. 2012, Dadic et al. 2010 etc. Base of all is Winstral and Marks (2002) and Winstral et al. (2002)).

(ii) Most common approaches to empirically parameterize wind-induced snow redistribution depending on topographical features use curvature, sky view factors, aspect, shelteredness/exposedness etc. Slope is a good indicator for the original transport route, but neither for the erosion nor the deposition areas. A detailed argumentation why You use slope, and why You use it in the way You do ("The model redistributes snow only to grid cells providing the steepest slope (acceptor cell) in the direct neighbourhood of the raster cell it searches from (donor cell).“), is missing in Your manuscript. If I understand correctly, then steep slopes are deposition areas in Your model. Observation suggests, however, that wind-blown snow is deposited where the wind speed drops, i.e. behind obstacles, and most snow is accumulated onto flat areas (best example: glacier accumulation areas, which are mostly flat! The glaciers in the Ötztal Alps are a very good example). Maybe You best begin with a visualization of the slope distribution with elevation for the basin.

(iii) Any topography-related parameterization is very much depending on the scale (i.e., size of the grid cells in a raster-based model). Since a 1 km resolution is very coarse for the high Alpine topography of the Ötztal Alps, You have to include a comprehensive discussion of the scale effect, including sensitivity analysis of Your approach to the resolution of the DEM used. Actually, You should prove that the parameterization You develop produces valid results for right reason. Can Your model transport snow uphill (wind-induced uplift is a common redistriubutin phenomenon)? If not: why, and how do You avoid this? If yes: following You model, snow can be eroded from the flat glacier accumulation areas and deposited on the steep mountain summit slopes around . . . ?

Remarks in detail

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- P610 L11-12: "... the standard model without using snow tansport“ should better be "the standard model without the parameterization for lateral snow redistribution“ - P611 L7: indicate here studies using conceptual approaches (e.g. degree-day) for snowmelt in which an attempt is made "to solve this problem“ - P611 L8: explain in this paragraph which approaches are conceptual (topography-dependent), and which are physically based (process representations); see general remark (i) above - P611 L12: replace "afflicted“ with "prone to“ - P611 L21-25: what about avalanches? In steep terrain their effect with respect to redistribution (and, e.g., glacier mass balance) is significant - P612 L1-3: Avoid the term "gymnosperms“: Spatial snow cover variability beneath canopies is mainly affected by different tree species (coniferous vs deciduous trees), LAI, canopy height and density, and gap sizes, all of them interfering with topographical features - P612 L4-12: newer literature is available (e.g., Strasser et al. 2008, Rutter et al. 2009, Warscher et al. 2013). It would be benefitial to distinguish between the wind-induced processes (i) preferential deposition of precipitation, (ii) redistribution by means of erosion/deposition, and (iii) sublimation from turbulent suspension - P612 L13-17: incorrect English, this paragraph must be improved. Also better write " ... snomelt rates from south-facing slopes ... " - P613 L9-10: Better "In the latter study, ...“ - P613 L19: Fig. 2 does only show one snow class?! In which properties do the five classes differ, in swe? What do they have in common, albedo? How are they initialized? Can a cell partly melt out? What about snow transport between the classes? How is snow distributed amongst them in the case of (i) precipitation, (ii) erosion and (iii) deposition? Please explain in more detail... - P613 L20: "fluid“ should better be "liquid“ - P613 Eq. (2): indicate the time step of the model. is Tair a mean daily temperature? - P614 L5ff: give units, and indicate if values are averages or instantaneous? - P615 L16: replace "then“ with "than“ - P616 L6-7: does that mean that snow is eroded from flat terrain and deposited in adjacent steep slopes? Observation suggests that snow is eroded from convex to concave terrain features?! Can it be that the reason to use this is an effect of Your resolution, i.e. Your highest pixels are flat, and such snow is removed downvalley? See general remark (iii) - P616 L12: "snow depth on the cell“

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is no good English, better "in“ or "of“ the cell - P616 L12: "lighter“: actually, no snow gets "lighter“; its a change in density only - P616 L15: use SI units (here kg m-3). "Acts“ is not an appropriate word: density doesn’t act. Maybe " . . .the value of 450 kg m-3 is used as threshold . . . “ - P616 L18: delete comma bevore "where“ - P617 L2: "snow depth on the cell“ is no good English, better "in“ or "of“ the cell - P617 L8: delete comma - P618 L4-5: "wind directory data“ should better be "wind direction“ - P618 L8, L10: "Target of“, "Validation period“: sentences should not begin with subjects without article, see also the caption of Fig. 8 ("Reason of“): better re-arrange or add article - P618 L15: "by Table 1“ should be "in Table 1“ - P619 L17-19: The sentence "Note that in Fig. 9 only model results from 2005 to 2010 are shown while the warm-up period is missing due to a better perceptibility. Therefore snow depth does not start at zero in the figure while it does at the beginning of the modelling“ should be moved into the figure caption. - P620 L13: better "in " the cell than "on“ the cell (same also in the caption of Fig. 8) - P620 L17: "pronounces“ should be "pronounced“ - P620 L19: "“ . . . that transports more snow on greater slopes . . . “: unclear. Do You mean: "that leads to deposition of more snow on steeper slopes“? - P620 L22-24: This sentence is no correct English - P621 L4: "on low elevations“ should be "in low elevations“ - P621 L3-8: entire paragraph is unclear and no correct English. Clarify whether processes in nature or their modelling are discussed, and which model is used, if the latter. The amount of snow remaining in the catchment is no good argument; and what is "This information“?

Fig. 2: "binded“ should be "bound“ Fig. 4: "an“ should be "a“ Fig. 8: please reconsider if this figure is meaningful. You indicate the reason why results are so similar . . . Fig. 9: "on elevation“ should be "in elevation“; I do see a clear positive trend also for Model A in the highes elevation zone. What about it? Fig. 10: "For visualisation the free available oe3d DEM (Rechenraum, 2014) was used“. This is not of interest here. The duration for which net deposition is accumulated is missing . . .

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