The Cryosphere Discuss., 6, C1176–C1181, 2012
www.the-cryosphere-discuss.net/6/C1176/2012/

The Cryosphere Discussions

Interactive comment on "Investigating the dynamics of bulk snow density in dry and moist conditions using a one-dimensional model" *by* C. De Michele et al.

Anonymous Referee #2

Received and published: 14 August 2012

Summary: This paper examines the bulk density of snow using a simple model consisting of three differential equations to simulate snowpack conditions. The prognostic variables in the model are snow height, water height, and dry snow density. The model is applied to two SNOTEL sites in the western United States forced by hourly meteorological data and is shown to provide accurate results with Nash-Sutcliffe coefficients in the range of 0.90-0.92 for the validation years.

I recommend the authors address the following comments prior to publication in The Cryosphere:

General Comments:

1) The title needs to be modified to read “dry and wet conditions” as it better reflects actual snowpack conditions. This terminology should also be used throughout the manuscript.

2) Some of the language used in the paper needs to be improved. Specific suggestions are listed below. Of note, please avoid the use of “In the next”, which does not add anything to the text.

3) The paper would benefit from some restructuring. Section 3 from page 2314, line 16 to page 2316, line 27 should form a section entitled “Data and model calibration”. The remainder of section 3 should then form a new section entitled “Results and discussion”.

4) In Section 2.2, the authors explain how the temperature of the snowpack is simulated, following an approach developed by Kondo and Yamazaki (1990). This approach assumes a bilinear behavior of the snow temperature with height above ground, with a dependence on air temperature. This neglects ground surface-snow heat transfers that are especially important early in the accumulation season and that may explain model deficiencies for snow depth and water equivalent during the validation period at S1 (see Figure 2). In addition, this ignores the “cold content” of the snowpack and will lead to melt as soon as air temperatures reach 0°C. This may explain why the simulated snow depth and water equivalent are always lower than observed. Have the authors considered incorporating some mechanism to track the “cold content” of the snowpack to consider its impact on snowpack evolution (see DeWalle and Rango 2008, for instance)?

5) Model validation of its evolution of liquid water content in a snowpack needs to be established. There are data from the NASA Cold Land Processes Field Experiment (CLPX-2002) that are suitable to perform this validation (Cline et al. 2003). Otherwise it is unknown how well the model simulates this component of the snowpack and how reliable the results are.

TCD
6, C1176–C1181, 2012

6) How does the model treat rain-on-snow events that can flush significant amounts of snow in a short period of time? This is also important for the energy balance of the snowpack, particularly in a maritime environment such as Thunder Basin, Washington.

Specific Comments:

1) P. 2306, line 6: Insert “the” before “literature”.

2) P. 2306, line 19: Insert “the” before “Western”.

3) P. 2307, line 13: Delete the comma after “problem”.

4) P. 2307, line 15: Replace “occurs” with “is employed”. In addition, replace “side” with “hand” and note the spelling mistake in “within”.

5) P. 2308, lines 1-5: This is a very long sentence, please consider breaking up in two.

6) P. 2308, line 6: Define “SNOTEL” here and insert “the” before “Western”.

7) P. 2308, line 14: It should read “phase dynamics”.

8) P. 2308, line 22: Rephrase this sentence to: “The model requires air temperature and precipitation as input”.

9) P. 2309, lines 3-8: What happens when the air temperature is 0°C?

10) P. 2309, line 6: Replace “smaller” with “less than”.

11) P. 2309, line 8: Replace “moist” with “wet”.

12) P. 2309, line 9: Insert “us” before “consider”.

13) P. 2309, line 20: Insert “us” before “indicate”.

14) P. 2310, line 2: Rephrase to “are described”.

15) P. 2310, line 5: Insert “to use” before “only one”.

16) P. 2310, lines 8-10: Many values here are missing units, e.g. “TA < 0”. Please add

TCD

6, C1176–C1181, 2012

the appropriate units for each. Also use superscripts for units when possible.

17) P. 2310, line 11: In establishing the overall snowpack temperature, at what height resolution (dz) is the integral computed?

18) P. 2310, line 12: What about energy exchanges with the ground, are these ignored?

19) P. 2310, lines 16-21: Please define t in the equations and provide units for each variable.

20) P. 2310, line 25: Insert “is” before “because”.

21) P. 2311, line 2: Insert “the” before “horizontal”.

22) P. 2311, line 6: Insert “a” before “first”.

23) P. 2311, line 11: Replace “snowy” with “snow”. In addition, insert °C after “-15”. The upper range of air temperatures should be 0°C given the threshold air temperature used to discriminate rainfall from snowfall is the freezing/melting point.

24) P. 2311, line 18: Delete “literature”.

25) P. 2311, line 21: Insert “a” before “degree-day”.

26) P. 2311, line 22: Insert “the” before “snowpack”.

27) P. 2312, line 8:Rephrase to read “on factors”.

28) P. 2312, line 21: Rephrase to read: “Considering Maxwell’s law as the . . .”

29) P. 2313, line 3: Insert “a” before “dry”.

30) P. 2313, line 13: Delete “the” before compaction. Is wind hardening of the snowpack considered by the model?

31) P. 2314, line 16: Insert “a” before “case”.

32) P. 2314, lines 16-21: A summary of climatic conditions at the two SNOTEL sites

TCD
6, C1176–C1181, 2012

should be provided, e.g. mean annual air temperature, precipitation, maximum SWE, snow cover duration, etc.

33) P. 2314, line 19: Insert “the” before “precipitation”.

34) P. 2314, line 24: Rephrase to read “We have selected data covering the period. . .”

35) P. 2315, lines 1-2: Rephrase to read “We have selected these periods of observation”.

36) P. 2315, line 3: Replace “where data” with “when data”.

37) P. 2315, line 5: What is the accuracy and possible errors with the SNOTEL snow depth and water equivalent data?

38) P. 2315, lines 8-9: I do not understand the use of a temperature filter to remove spurious snow depth data. Please replace “flutter” with “spurious”. Snow depth sensors are known to often provide spiky data even in winter, so it is unclear how these issues were dealt with in this study.

39) P. 2315, line 12: Change to “in the model runs”.

40) P. 2316, line 28: Rewrite as “relative to”.

41) P. 2317, lines 1-10: In the validation of the model simulations, are the Nash-Sutcliffe coefficients established over the entire water year? Does this imply that zero values appear in the time series that may artificially improve the simulations results?

42) P. 2317, line 8: Rewrite as “parameter values”.

43) P. 2317, line 17: Insert “with” before “respect”.

44) P. 2317, line 27: This is a very long paragraph and I suggest a break here with the sentence beginning with “Lastly”.

45) P. 2318, lines 1-17: It is unclear why this comparison with Techel and Pielmeier (2011) is introduced here. Alpine snowpacks may experience very different environ-

TCD
6, C1176–C1181, 2012

mental conditions including snow water contents than those in the Western United States.

46) P. 2319, line 8: Replace “capacity” with “ability”.

47) P. 2323, Figure 1: Delete the words “panel” in the caption.

48) PP. 2324/2325, Figures 2/3: Are these hourly or daily measurements and simulation results? Is the computation of the Nash-Sutcliffe coefficients based on hourly or daily simulation results?

49) P. 2325, Figure 3: May the large precipitation events in 2011 be erroneous?

References:

Cline, D., and Coauthors, 2003: Overview of the NASA cold land processes ïňĄeld experiment (CLPX-2002). Microwave Remote Sensing of the Atmosphere and Environment III, C. D. Kummerow, J. Jiang, and S. Uratuka, Eds., International Society for Optical Engineering (SPIE Proceedings, Vol. 4894), 361–372.

DeWalle, D. R. and Rango, A., 2008: Principles of snow hydrology, Cambridge University Press, New York.

Interactive comment on The Cryosphere Discuss., 6, 2305, 2012.