Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-272-RC2, 2016

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Bridging glacier and river catchment scales: an efficient representation of glacier dynamics in a hydrological model" *by* Michel Wortmann et al.

Anonymous Referee #2

Received and published: 12 July 2016

General assessment

This manuscript introduces a distributed catchment model that incorporates a representation of glacier dynamics. The spatial representation within the model lies midway between semi-distributed models, which represent spatial variability using grouped response units (GRUs), and fully distributed models such as the grid-based DHSVM. The goal is to retain the physical realism attainable through the fully distributed approach while maintaining the computational efficiency of GRU-based models. If successful, such a model would be a valuable tool for making projections of future streamflow variability. Therefore, the topic of the manuscript is highly relevant to the readership of HESS. However, there are a number of points that require attention before

the manuscript could be accepted for publication. In particular, a number of the process representations appear ad-hoc, poorly constrained and/or physically unrealistic. A number of specific comments are provided below.

Specific comments

1. The authors model ice height, which requires an initial estimate of the elevation of the ice bed, which is made using the Glabtop2 approach. How sensitive are the modelled glacier dynamics to uncertainties in the initial elevation estimates?

2. Further to the preceding point, elevations of the glacier hydrotopes would vary through time as the glacier geometry evolves. Is this accounted for in the model – e.g., for air temperature calculation?

3. p. 2 line 34 to p. 3 line 2. Include example reference(s) for greater specificity on this point – perhaps Jost et al. (2012) HESS 16: 849-860.

4. Equation 3 seems ad hoc. Is there an empirical or theoretical basis for it? How sensitive is the model to this specific formulation?

5. Is there any way to validate the avalanche routine? How sensitive are model predictions to leaving it out?

6. Section 2.6. Is the melt factor for glacier ice enhanced relative to the melt factor for snow?

7. Section 2.6. Is the residence time constant? Many empirical and modelling studies have demonstrated a seasonal variation, especially in relation to the timing of snow disappearance.

8. Section 2.6. Glacier outflow is subject to infiltration into a soil layer and surface runoff when that layer saturates. This does not seem realistic. Much, if not most, glacier outflow occurs via subglacial channel networks that evolve through the melt season.

9. Section 2.6. Water is lost from glacier storage by evaporation at a rate determined by the Priestley-Taylor (P-T) equation (note spelling). However, the available energy term in standard applications of the P-T equation would not be appropriate for a glacier. Many express the available energy as Rn – G (Rn = net radiation, G = ground heat flux), which would be better expressed as Rn – M (M = energy consumption by melt) for a glacier. Some applications of the P-T equation leave out the ground heat flux (approximately justified for daily time steps on the basis that the net ground heat flux would be negligible). This approach would also not be appropriate for a glacier. How does the SWIM model represent the P-T equation?

10. Section 2.6. For calculating E using the P-T equation, is the air temperature adjusted to account for conditions within the glacier boundary layer? See papers by Ayala et al. (2015, JGR-Atmos. 3139-3157, DOI: 10.1002/2015JD023137) and references cited therein on the variations of temperature and humidity over a glacier relative to off-glacier measurements.

11. Equations 5 and 14. Are these derivatives or finite differences? If the former, use d_/d_ as the operator; if the latter, use upper-case delta for lack of ambiguity. What numerical scheme is used to solve the equations?

12. Equation 7. "E" has previously been used for evaporation. Use a different symbol.

13. Equation 7. Hydrologists and climatologists commonly use beta for the Bowen ratio. Consider using a different symbol to avoid confusion.

14. Equation 7. Is a temporally and spatially constant sublimation ratio physically realistic? Can the authors draw upon work on sublimation in the dry Andes, for example, to support their parameterization?

15. Equation 7. It seems redundant to compute both evaporation and sublimation at each time step. Evaporation would occur from a melting surface for which a water film covers ice or snow grains. Sublimation would occur from a non-melting surface lacking

a water film.

16. p. 8 line 1. Slope and aspect enhance insolation on equator-facing aspects, not just reduce it.

17. Equation 14. What are the units of C?

18. I have trouble understanding Equation 14. Shouldn't there be lateral flux terms (Q_i in Equation 2) to represent fluxes of sediment from the up-gradient unit and to the down-gradient unit?

19. I may have missed it, but I could not find which years were used for calibration and which for validation. For example, are the time series shown in Figure 4 for the calibration or validation period?

Editorial comments

1. Use the past tense when referring to previous studies.

2. There are a number of minor editorial corrections to be made. Some examples are provided below.

3. p. 7 line 28. Zhao et al. and Winkler et al. are not in the reference list.

4. p. 8 line 7. "sinus" should be "sine"

5. p. 8 line 13. "defuse" should be "diffuse"

6. p. 8 line 7. Use a colon rather than a semi-colon here.

7. p. 11 line 20. Nash-Sutcliffe misspelled

8. p. 11 line 27. . . . at least one objective . . . (?)

9. p. 12 line 28. "complimented" should be "complemented"

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-272, 2016.