

Geosci. Model Dev. Discuss., referee comment RC1
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Review of gmd-2021-231

Anonymous Referee #1

Referee comment on "Introducing CRYOWRF v1.0: multiscale atmospheric flow simulations with advanced snow cover modelling" by Varun Sharma et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-231-RC1>, 2021

Sharma and colleagues present a novel coupled modelling system called CRYOWRF that consists of three components: the atmospheric model WRF, the snow model SNOWPACK, and a new parameterization for snow drift. Only a handful of previous studies have attempted to improve the representation of cryospheric processes in WRF by integrating new modelling components, and there has been no publicly available implementation of blowing snow to date. The authors present three case study simulations across a wide range of horizontal grid spacings, with the associated namelists and scripts provided as templates to facilitate usage of the model by the scientific community. As such, the manuscript fits the scope of Geoscientific Model Development well, and provides a significant advancement in the field of coupled atmosphere-cryosphere modelling. Overall, the paper is very well written and organized. The methods are generally well explained, although I have highlighted a few aspects that would benefit from additional clarification in the minor comments. The main weakness of the paper is the dearth of model evaluation. There is also an issue in relying on asynchronous coupling (i.e., not calling SNOWPACK every WRF timestep) for computational efficiency if one is interested in investigating feedbacks, as mentioned in the major comments below.

Major comments

- The introduction does not mention previous efforts to improve the representation of cryospheric processes in WRF through integration of new modelling components, including Collier et al. (2013; <https://doi.org/10.5194/tc-7-779-2013>) and Eidhammer et al. 2021 (<https://doi.org/10.5194/hess-25-4275-2021>).
- In order to reduce the computational overhead of integrating SNOWPACK, the authors suggest to use, and present case studies that employ, asynchronous coupling between WRF and SNOWPACK through the namelist parameter `snpack_dt`. From the cryospheric perspective, there is no clearly no need to call the snow model every timestep (i.e., every 5 s in a 1-km grid spacing domain). However, from the atmospheric perspective,

the difference in the update frequency of turbulent heat fluxes and surface conditions will introduce numerical artefacts that are unrelated to the improved representation of cryospheric processes. The reliance on asynchronous coupling therefore limits the utility of CRYOWRF as a tool to investigate feedbacks, in particular between “offline” simulations with other LSMs and “online” simulations with SNOWPACK. This limitation should be clarified in the manuscript.

- With the exception of Figures 5 & 6, there is no model evaluation presented, and this task is repeatedly designated as future work. Figures 5 & 6 compare simulated near-surface meteorological variables with station data for the first case study (an analysis that is later stated as “establishing the accuracy of the model” at line 709), however there is no evaluation of surface mass balance, or more importantly, snow drift as simulated by the new parameterization. The manuscript would be strengthened by additional evaluation, even if suitable data are only available on a point scale (e.g., for blowing snow).
- In several places in the manuscript, the authors credit CRYOWRF with capabilities that are actually provided by WRF regardless of LSM choice (e.g., lines 411–412; line 552; lines 713-714; WRF is acknowledged at line 587). Therefore, the manuscript would benefit from more careful language around the value added by CRYOWRF.
- It would be helpful to clarify already in the methods section that SNOWPACK can function as a standalone LSM, and therefore also updates surface conditions and fluxes over non-glacierized grid cells. For readers unfamiliar with SNOWPACK, this capability is unclear until lines 623-626.

Minor comments

- Please provide references for the statements at lines 16-17 & lines 592-593.
- Lines 316-317: Please provide more information about how the stability correction is handled to avoid runaway cooling in the interactive implementation.
- Line 385: Is it correct that only those three variables – latent & sensible heat fluxes and surface albedo – are updated in WRF? If so, why aren’t other surface boundary conditions updated, like surface temperature and roughness?
- Section 4.1.1: Why was this simulation period selected?
- Section 4.1.4: Could the authors discuss why SNOWPACK improves on the warm bias simulated by the Noah-MP LSM?
- Line 529: Could the authors provide a justification for only calling SNOWPACK every 15 minutes? From the cryospheric perspective, this timestep is nearly 10x larger than a characteristic timescale for heat diffusion assuming a top layer height of 1 cm. From the atmospheric perspective, this is a 180x decrease in the frequency of updating surface fluxes and conditions in the 1-km domain ($dt=5s$).
- Line 687: Another important caveat would be that there has been no evaluation of the results.

Technical comments

- Line 46: Please rephrase “not to speak about”
- Line 129: “OpenMP”

- Line 351: OOP has not been defined
- Line 391: Please rephrase "performed using Noah-MP along with CRYOWRF" to clarify that separate simulations were performed and compared.
- Line 479: "Sublimation"
- Line 490: "period is between"
- Line 495: DDU has not been defined in the text
- Line 500: "topographic"