Reviewer 2

We thank reviewer 2 for their time and comments. We have revised the submission accordingly and added responses to each comment below.

This manuscript presents a nice contribution to the snowpack modeling community, through a robust assessment of the operational capability of the HRRR-forced iSnobal model to reproduce observed snow depths (point-based measurements from snow telemetry stations and lidar snow depth maps) and stream gauge discharge in the East River Watershed (Colorado). I am, however, left a bit disappointed by the lack of in-depth evaluation of the iSnobal model versus its current operational alternative, namely the temperature-based index model SNOW-17. In the introduction, the reasons for evaluating HRRR-iSnobal are very well presented, but I find that after reading the paper, the benefits of using HRRR-iSnobal over SNOW-17 are not made clear enough. I also do not understand why the authors use such a fine resolution (50 m) for the iSnobal model even though most of the relevant processes at these scales (such as interactions between snow, wind and vegetation) are not currently represented in the model. Justification for downscaling the model to such a fine scale is currently not clear to me. Apart from these two general comments, I have only minor comments, highlighted below. I therefore recommend publication of this manuscript once both my general comments and these minor comments have been addressed.

The advantages to use HRRR-iSnobal have been expanded in the discussion section 6.3. The section highlights the aspects on why we believe the introduction of HRRR-iSnobal will result in operational benefits for the CBRFC:

Accurately simulating the seasonal snow accumulation and depletion across multiple years and different topographic regions through a single model is still an unsolved challenge. However, physically-based models are better suited to fulfill this need when compared to temperature index-based models. Existing studies using long-term records of SNOTEL measurements have identified a need for physically based modeling approaches as they can better show the impacts on water supply from current and projected climatological changes (Harpold et al., 2012; Musselman et al., 2021; Trujillo and Molotch, 2014). Physically based models are capable of accounting for scenarios such as shifting snowmelt rates (Musselman et al., 2017), changes to the length of snow accumulation and melt season (Trujillo and Molotch, 2014), accelerated melt due to darker snow (Skiles et al., 2018), and rain on snow events (Marks et al., 1998).

The HRRR-iSnobal combination in this work closely simulated the snow depth observations from one region across different seasonal characteristics (average vs. non-average year) without a priori region-specific knowledge. All required forcing data per water year only used the HRRR forecasted observations of that year, replacing the sparse in-situ measurements that are interpolated and calibrated with historical data. The interpolation and calibration process is an essential step in the current Snow-17 workflow of the CBRFC and requires forecaster experience per region. Voiding this need gives a major operational advantage, simplifying model application and enhancing the ability to adapt to environmental changes across different regions and water years.

In addition to the streamlined forcing data preparation, the advantages during the water year simulation include the replacement of region-specific parameters required by index models, such as melt-factor in Snow-17, by the energy balance calculations in physical based models. The index model parameters depend again on forecaster experience and require forecaster changes in response to changing environmental conditions (average vs. non-average). In this work, there was no need to change the model configuration between the 2018 (average) and the 2019 (above-average) years in HRRR-iSnobal. The seasonal differences were accounted for explicitly as the snow energy balance calculation includes influences such as shortwave (Marks and Dozier, 1992), longwave radiation (Link and Marks, 1999), and turbulent fluxes from terrain-dependent wind speeds (Winstral and Marks, 2002).

Lastly, iSnobal is a spatially distributed model run with a user-defined pixel size (50 m in this study) and set up with site-specific elevation and vegetation data information from the model domain. This configuration negated the need to divide the model domain into uniform and simplified HRUs to simulate the topographic differences of the model domain accurately. In summary, physical based models remove the dependence on historical data, reduce the need for model application knowledge, and better account for physiographic factors, which result in improved scalability across different seasonal and terrain-dependent snowpack dynamics. Gradually adding these models into operational settings, with architectures presented in this work, can provide snowpack response information with current environmental perturbations. Their addition will enhance the quality and expand the ability to adapt to current and future water supply forecast needs.

We have also expanded the text on why we chose 50 m resolution. The addition includes added details to the model description in section 3.3, where the relevant processes in the model include longwave radiation and wind. Below is the expanded paragraph from the manuscript on the reasons for the 50 m resolution:

This spatial resolution was guided by the recommendations of Winstral et al. (2014), which found that iSnobal output resolutions of around 100 m kept the errors for SWE and SWI below +/-5% during melt season compared to coarser resolutions. We further selected the 50 m resolution to keep the resampling of the vegetation data from LANDFIRE minimal and removed the need to interpolate the spatial snow depth product used in validation (section 4 Model Comparison). This resolution additionally better represents the terrain complexity, relevant for radiation calculations and interpolation of the HRRR supplied within SMRF. Lastly, we also found that the 50 m resolution does not inhibit daily run times and scales for the operational requirements.

Inline Comments

To me, the use of the word "coupling" is incorrect, as in this work iSnobal is simply forced by HRRR data.

Changed the wording to HRRR-iSnobal combination throughout

l. 30: the full stop is missing at the end of the sentence.

Corrected

l. 42: "require" should be plural.

Corrected

l. 72: please consider revising the citation to: "in Havens et al. (2019)".

Corrected

l. 143: "and is available".

We revisited section 3 and adapted this suggestion

l. 196: the term "ASO" has not been defined yet.

We moved the definition to the first occurrence

l. 247: there is a word missing here: "and positive at Upper Taylor".

Updated

Figure 4: please consider enlarging the figure, as currently, the labels and text inside the figure are too small. For example, the two sub-figures could be placed on top of each other instead of side by side.

We increased the figure height to improve the readability and kept the width. Keeping the width enabled the side-by-side comparison for an 'above-average' (2019) vs. an 'average' (2018) snow depth year.

l. 293: there is a word missing: "across all sites in 2020".

Corrected