Geoscientific Model Development Discussions

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Review Comment on gmd-2021-55

Anonymous Referee #2

Referee comment on "A parameterization of sub-grid topographical effects on solar radiation in the E3SM Land Model (version 1.0): implementation and evaluation over the Tibetan Plateau" by Dalei Hao et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-55-RC2, 2021

The authors incorporated a sub-grid topographic parameterization in the E3SM Land Model (ELM) to quantify the effects of sub-grid topography on solar radiation flux, which includes the shadow effects and multi-scattering between adjacent terrain. They found that incorporating the sub-grid topographic effects generally reduces the biases of ELM in simulating surface energy balance, snow cover and surface temperature particularly in the high-elevation and snow-cover regions over the TP. Overall, this manuscript is well organized and written. However, there are still a few places that require further clarifications and discussions. Please see my specific comments below.

Specific comments:

1. I suggest being more specific and accurate about “sub-grid topographic parameterizations”. This study actually focused on the subgrid terrain-radiation interactions instead of other subgrid topographic effects.

2. The authors mentioned that ELM uses a novel topography-based sub-grid spatial structure. How does this new sub-grid spatial structure interact with the implemented subgrid radiation parameterization? Are they coupled?

3. I suggest providing a schematic figure showing different flux components (Section 2.2) for the parameterization.

4. Section 2.2: the original parameterization includes a coupled flux term, which however was not included in the implementation (e.g., Eqs 10-11). Any specific reasons? How much impact would this missing of the coupled term have on simulation results?

5. The implementation adjusts albedo to account for the subgrid radiation effect. What is the rationale and justification to make this assumption? In theory, the surface albedo is a land surface intrinsic property, and by accounting for the additional subgrid terrain-radiation fluxes (e.g., reflected from neighboring terrain), the change should be in the incoming solar radiation instead of surface albedo.

6. Do the fitting parameters (A) in the subgrid radiation parameterizations vary across different scales? What are the values for the fitting parameters? A table listing these values would be good. What is the applicable range of spatial scales for the subgrid parameterization?

7. Some clarifications and descriptions are needed in Section 2.3. (1) What satellite data is used for LAI? (2) What are the native spatial and temporal resolutions of GSWP3v1 data and how did the authors interpolate the data to different simulation resolutions? (3) Since the authors focused on the analysis on snow and related surface quantities, a description of how ELM handles key snow processes and properties needs to be included.

8. The authors used a random forest model to quantify the sensitivity of topographic factors. Why not directly use the physics-based ELM model and vary those topographic factors to do the sensitivity tests? To me, the random forest model itself introduces additional uncertainties in the analysis.

9. I am a little concerned about the evaluation of surface albedo using MODIS albedo data. (1) Note that MODIS data is retrieved through algorithms that only assume plane-parallel radiative transfer. So it may not be reasonable to use MODIS albedo as a justification for the subgrid terrain-radiation improvement. (2) Also, it is not clear how much improvement in surface albedo comes from the direct treatment of subgrid radiation and how much comes from the snow cover improvement.