

***Interactive comment on "A parameterization of sub-grid topographical effects of radiation in the E3SM land model (version 1.0): implementation and evaluation over the Tibetan Plateau" by Dalei Hao et al.***

**General comments**

This manuscript uses an existing parameterization for sub-grid topographical effects on solar surface irradiance to show how accounting for sub-grid topography, instead of assuming a flat surface, affects the albedo, energy balance and temperature of the surface. The authors find that accounting for sub-grid topography can have large effects on the land surface model, depending on season, elevation and grid resolution. Furthermore, the authors use MODIS data to evaluate this newly implemented parameterization and find that accounting for sub-grid scale topography generally improves the representation of the surface.

The paper is interesting within the scope of the journal. However, I think the presentation of the manuscript can be improved. First of all, I would suggest to switch the order of sections 3.1 and 3.2, e.g. start with the effects of sub-grid topography on the land surface and then show to what extent this improves the results with respect to MODIS. Furthermore, I suggest to strongly reduce the number of figures in the manuscript. Figures 2-7 and 9-14 fill up a lot of space and are a bit repetitive. It certainly helps the reader to keep a few maps, but I would suggest to use a more concise visualization (e.g. such as in Figure 8) of the data.

I recommended major revisions based on the main comments above and the specific comments and technical corrections listed below.

**Specific comments**

1. p. 2, ln 66-68: Mention clearly where your evaluation and analysis of the sub-grid scale topography effects differs from Lee et al. (2019), besides the use of a different land surface model.
2. p. 3, ln 85-87: State more clearly that you use this parametrization to investigate for different seasons how the large the effects of using a sub-grid scale topography parametrization on solar irradiance are. And that both the simulation with and without this parametrization are compared to MODIS to investigate to what extent using this parametrization improves the land surface.
3. p. 4, ln. 99. "multi-scattered radiation": what is this term exactly, isn't it also part of the diffuse irradiance?
4. p. 5, ln. 151: "TP, known as the Third Pole" may suggest TP is the abbreviation of Third Pole, which is confusing. Suggestion: "The Tibetan Plateau (TP), also known as the Third Pole,"
5. p. 5, ln 161: I suppose that with "offline" you mean that ELM is not coupled to the atmospheric/oceanic model? If so, how do you derive the radiative fluxes at the top of the canopy, i.e. what is the atmospheric input for these RT calculations and are these similar for TOP and PP?
6. p. 6, ln. 188: What is the reason for these two times (10:30, 22:30)?
7. p. 6, ln. 181: "Relative difference" suggests something like  $(TOP-MODIS)/MODIS$  and  $(PP-MODIS)/MODIS$ , whereas the computed quantity seems to be the change in the bias with respect to MODIS between TOP and PP.
8. p. 6, ln. 193-195: How is the evolution of the snow cover determined in ELM? Besides snow cover, wouldn't snow depth be interesting as well?
9. p. 6, ln. 196: How valid is that assumption, given that you have seasonal changes in vegetation and snow cover as well as snow cover differences between the simulation.?
10. p. 7, ln 205: Is all data used to construct the random forests?
11. p. 7, ln 220-221: Can you explain why diffuse albedo is worse with sub-grid topographic effects?
12. p. 7, ln. 227 & ln 232 (and a few other locations in the manuscript): What does significant mean here?
13. p. 7, ln. 231: Looking at figure 6, the difference between TOP and PP in some regions actually does not seem to be very small in winter and spring.

14. p. 8, In 242: Does significant mean statistically significant or that the bias difference is small compared to the mean surface temperature? Also, the fact that the nighttime surface temperature in the upper two elevation bands performs worse with TOP for most of the region is interesting and worth mentioning. Do you have an explanation why it may be worse?
15. p. 10, In. 272-273: ", while the" You compare a difference in W/m<sup>2</sup> to a relative difference (%), which can be confusing.
16. p. 10, In. 279-280: Can you elaborate on this? Does it mean that the standard deviation of elevation can explain most of the sub-grid scale topography effects on the albedo?
17. p. 10, In. 282-283: "the absolute .. and -20%" The units and signs are a bit confusing here. First of all, I suggest to express snow cover fraction as a number between 0 and 1 instead of a percentage, to make the distinction between absolute and relative difference more clear. Also, "larger than" can be confusing because the difference is negative. You could rephrase as "the decrease in .... can be larger than ..."
18. p. 11, In. 296: "in winter", how are the elevation-dependent patterns in the other seasons compared to the winter?
19. p. 11, In. 304: Shouldn't "relative differences" be "absolute differences", given the  $\pm 0.1$ ? Also, it is not really clear to me what the exception ("except") described in this part of the sentences exactly is.
20. p. 11, In. 308: "sensitivity analysis" can you elaborate on this (e.g what kind of analysis)?
21. p. 16, In. 365: since the relative difference in snow cover fraction is negative (-20%), "maximum value" can be somewhat confusing for this quantity.
22. P. 16, Figure 17 (and Figures S2-S6): the location of the red line (r0125) is important because it serves as the 'reference', but the line is sometimes hard to see.
23. p. 17, In.398-408 & sections 2.4/2.5: Are you able to compare typical errors estimates of MODIS with the differences between TOP and PP?

### Technical corrections

24. p. 7, In 205: calculations -> calculation
25. p. 7, In 221; p. 10, In 284; p. 10, In 285 and more: "difference(s) of" -> "difference(s) in"
26. p. 7, In 222: : "regions"->"region", or perhaps: "the whole rectangular regions" -> "the whole domain"
27. p. 10, In. 277 & In. 289: "different seasons" -> "all seasons"?
28. p. 10, In.291: this 20% has already been mentioned in line 289.
29. p. 11, In. 297: "but" -> "therefore"?
30. p. 11, In. 300: "With the increase of elevation bands" -> "At higher elevations"
31. p. 11, In. 301: "to larger" -> "to a larger"
32. p. 16, In. 357: Figure S7 is referenced before figures S2-S6.
33. p. 17, In. 379 & In. 383: Why are "larger" and "and thinner atmosphere" in bold?
34. p. 18, In 427: "the study" -> "this study"
35. p. 18, In 432: "on solar radiation" -> "for solar radiation"