

**Land-atmosphere interactions in sub-polar and alpine climates in the CORDEX FPS  
LUCAS models: I. Evaluation of the snow-albedo effect**

**Reviewer #2:**

**General comments:**

In this paper snow albedo effect is studied in the Europe in winter and spring time. Simulations from Regional Climate Models are used to produce Snow Albedo Sensitivity Index (SASI) and these RCM based SASI values are compared to the SASI values derived from reanalysis and satellite observations. Conclusions are that accurate retrieval of SASI is more dependent of correct snow cover simulations than chosen atmospheric models. This leads to the observation that choosing correct Land Surface Model have an important role in simulating snow albedo effect. The subject itself is very interesting, and this study would be a good fit to The Cryosphere journal. However, I have some concerns.

Thank you very much for your interest in our work and your constructive comments. We believe that the modifications you suggested can be addressed. They will improve the quality of the article as some parts are unclear such as the derivation of SASI with satellite observations or the description of the LUCAS experiments. I will provide preliminary answers to the specific and minor comments below. A more detailed answer to your comments will be provided with the new version of the manuscript at a later stage.

**Specific comments:**

- I have some difficulties to understand how the satellite based SASI is formed. First, where the SW data is from? Secondly, if snow cover extent from MODIS is used, and that covers years 2003-2015, then I assume that satellite based SASI is covering years 2003-2015. Therefore, satellite based SASI cannot be used to verify/compare RCMs based SASI covering year 1986-2015. Due to the climate change, snow cover extent is vastly different in 2000s than in 1980s or 1990s (e.g. <https://www.ncdc.noaa.gov/snow-and-ice/extent/snow-cover/nhland/4>). I have doubts that weighting every grid point by the amount of MODIS data is enough to make satellite based SASI comparable to reanalysis and model based SASI.

Yes, we agree that the section describing the calculation of SASI based on satellite observations deserves more explanations as this is a complex calculation. This will be provided in the next version of the article. We will also further discuss the comparability of SASI based on satellite observations with SASI based on reanalysis and regional climate model outputs. We agree that this is also a point that deserves more explanations.

- The value 0.4 as the average albedo difference between a snow-covered and snow-free surfaces is problematic. First, chosen three areas have different vegetation. The Scandinavian area are mostly boreal forest (needleleaved evergreen forest) whereas the East Baltic and the East Europe have more deciduous trees. Throughout the year needleleaved evergreen trees have their “leaves” on, but deciduous trees don’t. So difference between snow-covered and snow-free surface albedo should be different in the Scandinavian area (high-latitudes) compared to the two other regions (midlatitudes). Also, the difference depends on whether snow is new or old. Old snow can

have impurities, which lowers albedo (Warren and Wiscombe, 1980)). And, in winter snow can sporadically accumulate on trees, which itself increases albedo. I suggest that authors modify  $\alpha$  corresponding better different scenarios.

Yes, we agree with the reviewer that the value of 0.4 as the average albedo difference between snow-covered and snow-free surfaces might not be ideal. The influence of the choice of this value can be tested and will be tested before we submit the manuscript again. Depending on the results we find we will keep or update this value and describe these sensitivity tests in the new version of the article.

### **Minor comments:**

The description of LUCAS experiments will need some clarifications and more details. It is of course allowed to specify manuscript to people with certain scientific knowledge, but as not every reader is familiar with climate models, it would be reader-friendly to provide more explanations. What is a rotated coordinate system, could that term be explained? What is the time resolution of the simulations? Hourly, daily, monthly? In line 121 is said that “outputs from ten ... RCM simulations”, are there more than

those chosen ten? If yes, why those specific ten simulations are chosen?

Table 1, could you open the used acronyms in Table 1 caption?

Are RCMs WRF 3.8.1 and WRF 3.8.1D the same? If not, what is the difference?

Thank you for these questions/comments, it was difficult to determine the level of information needed for the description of the LUCAS experiments. These points will be addressed, more information will be included in the next version of the article.

Lines 158-168: snow schemes of CLM versions, Noah-MP and RCA4 system are described, but what about iMOVE, VEG3D and TERRA-ML?

More information will be provided in the next version of the article.

Lines 180-181: the two thresholds for cloud cover are used. 50% of cloud cover is quite a lot of clouds in one cell, why this threshold was chosen? How were these thresholds used?

We have tested several thresholds and will provide more information on this point in the next version of the article.

Line 182: why also “good” and “ok” flagged data was used?

Yes, this point deserves more explanation and will be clarified in the next version of the article.

Line 209: mention that the Scandinavian region have mostly needleleaved evergreen forest, whereas other two regions have more deciduous trees.

Yes, thank you, this point will be included in the next version of the article.

line 277: The peaks are quite pronounced in the East Europe and the East Baltic regions, but I think they are less pronounced in the Scandinavian region. Could it be due to the illumination conditions?

The illumination might be part of the explanation yes, we will comment this point in the next version of the article.

line 312: based on Figure 5, the snow cover for MODIS is from MODIS-TERRA, is that correct? Why MODIS-TERRA, if you also have MODIS-AQUA data?

Yes, this needs to be clarified in the next version of the article.

line 314: what are those limitations and biases that are referenced to in this sentence?

The reasoning behind this sentence will be expanded in the next version of the article.

line 328: also WRFb-CLM4.0 have high values during the ablation period. Should that model also be added?

Yes, this point should be mentioned in the article. Thank you.

lines 322-334: would it be more informative to add different markers whether models are over or under the range of reference datasets? For example, black dots when over and red?) x when under?

Thank you for the suggestion, we can test it and see if this option is more informative or if it becomes too messy.

line 346- 349: I would argue that REMO-iMOVE and WRFa-NoahMP have very different results, not REMO-iMOVE and CCLM-VEG3D, if these results are based on Figure 5. But also, based on Figure 3, CCLM-VEG3D do not reproduce SASI well at all.

We will come back to this part of the text and provide clarifications.

Figure2: colorbar ticks and color limits do not match, could it be modified?

Yes, this will be modified in the next version of the article.

Figure 3 and 4: can horizontal lines be added? It would make reading of the figures much easier. Also, it would be more informative to draw ERA5 and SATELLITE lines last so they would be top of everything.

Thank you, this is a good point, we will work on these modifications.

Figure 5: black color of MODIS-TERRA, especially black median line in the very dark grey bar is difficult to see. Can bar be made more lighter grey?

Yes, this can be modified in the next version of the article.

Table 1: Can table rows be listed based on RCM (as in Figure 2), not institute? It would be easier to read.

Yes, this can be addressed in the next version of the article.

#### **Technical corrections:**

lines 46-47: word “it” is ambiguous, could this sentence be modified to be easier to read?

Yes, this sentence will be modified.

line 80: open the “RCMs” acronym

Thank you, this will be corrected in the new version of the article.

line 107: “Section4 the last sections” -> remove “the last section”

Thank you, this will be corrected in the new version of the article.

line 175: add MODIS product names (for TERRA: MOD10C1 and for AQUA: MYD10C1)

Thank you, they will be included in the new version of the article.

line 176: reference to the same section 2.2 is not necessary, remove it or change it

This reference will be removed.

line 225: “The model data..” -> change it to “Most of the model data ...”

This sentence will be modified.

line 319: “.. snow cover varies between...” -> “..snow cover mean varies between...”

This sentence will be corrected.

#### **References:**

Warren, S. G., & Wiscombe, W. J. (1980). A Model for the Spectral Albedo of Snow. II: Snow Containing Atmospheric Aerosols, *Journal of Atmospheric Sciences*, 37(12), 2734-2745. Retrieved Nov 15, 2021, from [https://journals.ametsoc.org/view/journals/atsc/37/12/1520-0469\\_1980\\_037\\_2734\\_amftsa\\_2\\_0\\_co\\_2.xml](https://journals.ametsoc.org/view/journals/atsc/37/12/1520-0469_1980_037_2734_amftsa_2_0_co_2.xml)