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Atmospheric Chemistry and Physics Discussions

Interactive comment on "CLARA-SAL: a global 28-yr timeseries of Earth's black-sky surface albedo" *by* A. Riihelä et al.

Anonymous Referee #2

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1 Introduction

The paper presents a novel 28-yr records of surface black-sky albedo. The novel dataset was generated in the scope of the EUMETSAT CM-SAF. The surface albedo dataset discussed is novel, as it is based on a new harmonized NOAA AVHRR GAC dataset and also includes topographic correction (geometric and radiometric) in its processing chain.

The purpose of the present paper is to introduce this dataset to the community and validate its accuracy. While the new data product seems to be a very interesting new ressource for land surface studies, the present paper unfortunately lacks a thorough analysis of the dataset and its accuracy. Many questions remain open and I will address several examples in my comments. A major concern that I have is, that this dataset is generated as part of the CM-SAF, which'S mission it is to provide best calibrated climate data records from satellite

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data. I **guess**, that it is planned to release the CLARA-SAL product as an official CM-SAF product and use the present paper as a reference paper. The present paper is however not suitable for that purpose, as it does not provide any insight into the longterm stability of the data record. I performed as a reviewer a small analysis of the dataset and will show that the dataset shows large inconsistencies in the timeseries, which are not mentioned or even discussed in the paper. The paper therefore needs major revisions and restructuring before it can be considered for publication in ACP.

2 Major comments

1. P25576, section 2.2 gives a rather brief overview of existing surface albedo products. The paragraph is rather short and does not provide any additional insight, how the authors see their own product in the spectrum of existing products. I was really missing a discussion on the pro and cons of the different products and the added value provided by CLARA-SAL. Perhaps a table with properties of the different datasets might be useful here.
2. P25577, section 3.1: The data processing is not really clear, even with the Annex provided by the authors. Authors use the GAC data which has a nominal resolution of 4.4 km on the ground. They say, that for each timestamp a GAC pixel is used and then aggregated to 25km (0.25°) resolution. The authors don't provide any kind of argument for that processing. I guess they have good reasons to do so, but the way the paper is written, this approach sounds arbitrary. Why is no product generated at 4km, or 10 km or 15 km ... ? I doubt that each 4.4 km pixel is always cloudfree at each timestamp. How are temporal gaps considered in the retrieval? How is the spatial aggregation performed, given the fact that the authors do not seem to use an equal area grid? Landcover information is crucial for the characterization of the BRDF. How is this practically done, given the fact that the land surface is neither homogenous at 4.4km nor at 25km scale?
3. P25578, L25: Authors use constant values for O3 and AOD for the atmospheric correction. They claim here that they will analyze the effect on the retrievals in section 7. In fact, section 7 is the discussion section. In this section, the authors mention that they performed a sensitivity study and that the effect of constant AOD/O3 on the albedo

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retrieval is marginal. In fact, I can not believe that, given the importance of AOD for the atmospheric RT. I would expect at least that authors provide the setup and results of their sensitivity analysis in the Annex. The effect of AOD should change during the season and also spatially. I simply can not believe, that the AOD changes only the albedo by 0.8 ... 5.2% (relative), like stated on P25590L16. How was this error calculated? How was the sensitivity analysis performed? What is the standard deviation and spatiotemporal pattern of this deviation?

4. P25579, section 4.1: The validation of the present dataset is limited. The authors provide actually a rather innovative approach for ground validation, taking into account also the spatial representativeness of the ground station. Their validation is however based on a very limited number of stations (11 stations) which were selected because of their longterm measurements (>10 yr). However, I don't understand this limitation to just a few BSRN stations. The authors would get a much more solid validation matchup database, if they would take all of the quality controlled BSRN stations. This would give a denser validation in more recent time, but nevertheless a much more robust statistic.

5. The authors provide validation results for the different stations in Table 2. Relative differences on a seasonal average range up to 46% (relative), which is huge!. It is not clear how much of this difference is attributed to bias and how much to random error. It is highly recommended to systematically separate random and systematic error components here.

6. One problem in validating satellite based coarse resolution surface albedo products is the discrepancy between in situ measurements and satellite grid scale. The authors therefore use a geostatistical approach to estimate the representativeness of the in situ observations. In section 4.5, the authors discuss very briefly the semivariogramm results and show that there is a relationship between the surface albedo RMSE and an error metric derived from the semivariogramm. However, the authors do not discuss the actual impliciations of these findings. How good is the CLARA-SAL data product really compared to the limited number of ground stations? What is the uncertainty on the error estimates?

7. Figure 8: The variogramms need more careful discussion. First, the x-axis is not well defined. It ranges from 0 ... 600, but it is not clear if this corresponds to a distance in [m]

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or to an index that needs to be multiplied with the lag step (30m), which is what I guess. If the latter is the case, then the variogramms are showing lags for 0 ... 18km. It is not clear to me, how the authors think one could use the variogramms for further assessing the uncertainties in the CLARA-SAL data product. Thus, what are the uncertainties on the uncertainty estimates? I was also wondering, why a lot of the semivariogramms actually show a decrease of the semivariance with increasing lag distance. This needs a more thorough discussion in the paper.

8. Section 5 provides a short description on the differences between CLARA-SAL and MODIS (MCD43C3) products. CLARA-SAL is found to be 10-20% consistently higher than the MODIS surface albedo product. Potential reasons are **not** discussed by the authors. Which MODIS surface albedo is used: BSA, WSA? Why is CLARA-SAL higher? Is there some systematic dependency (e.g. AOD, landcover type, latitude ...) ? The reader should not be left with these questions. They are supposed to be addressed appropriately in the paper.

9. Section 6 investigates the product stability, which is a very important characteristic of a longterm satellite based climate data record. Validation of the longterm statbility is a challenging task. The authors investigate the longterm stability of their surface albedo data product by analyzing a timeseries from a single location over the greenland ice sheet. They show (P255589L8; Figure 10), that the surface albedo tends to be quite stable (deviation of 6.8%) throughout the time. They briefly relate these "uncertainties" to other uncertainties in the data product. Unfortunately, a proper discussion and a thorough analysis of the longterm stability of the surface albedo dataset is lacking. The reviewer therefore spent a few minutes to analyze the data in a very rough manner (Figure 1). The attached figure shows the zonal means of the surface albedo data product as well as the zonal means of the surface albeod anomalies, where the mean seasonality has been removed. Clear temporal inconsistencies in the dataset are detectable from this very simple quality control. The present dataset seems to have considerable inconsistencies through time which are observable across large latitudinal bands. The fact that these anomaly patterns occur fast and also across large regions is an indication that these anomalies are not caused by transitional changes of the land surface, but by abbrupt changes in the observations. Reasons could be a change of the satellite, calibration issues ... I did not perform any further detailed analysis, but the authors are expected to

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provide a much more critical anc complete assessment of the longterm stability of their dataset. In its present stage, I doubt that the dataset would be of easy use for climate research applications which I assume is one of the major purposes to generate this novel dataset.

10. I further wondered, why the authors are only using the Greenland ice sheet as a reference. There are numerous desert targets existing, where indpendent spectrometer measurements are available and also cross comparison against a matchup database from other sensors should be possible. As far as I know, CNES is maintaining such a database.

Given the critics above, I also consider the conclusions (section 8) of the paper to be poor.

- Conclusion 1: retrieval accuracy within 10-15% is not properly assessed in the paper I believe. Table2 shows relative differences from -46.7% to + 12.9%. How can authors conclude that the accuracy is (relative) wihtin 10-15% ??? The real accuracy of the data product remains unclear to a potential user after having read the paper
- Conclusion 2: The dataset is not longterm stable, like suggested by the authors. The reviewer has proven this with a very simple analysis. A much more thorough analysis and critical discussion of the longterm stability is needed
- Conclusion 3: Authors conclude similar patterns than MODIS, but a bias between the data products. The reader is left with the question, what causes this bias, if it is changing in space and time and which of the data products is supposed to have a better accuracy. Much more solid analysis is needed here!

3 Some general remarks on methodology and its presentation

- Black-sky albedo: why is the product focused on black-sky albedo only, while other products, like e.g. MODIS provide blac and white sky albedo. It is not mentioned at all in the manuscript *why* only BSA and not BSA + WSA is retrieved. What do authors consider

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as major advantages? From a user perspective, both, BSA and WSA are needed to be able to estimate the actual blue sky albedo.

- A unique feature of the novel dataset is, that it is performing geometric and radiometric terrain correction. According to the paper, the terrain correction is performed in "mountaineous" areas (P25574,L9), but it is not defined what mountaineous actually means, nor is the spatial scale well defined where the radiometric correction is applied (I guess it is 4km GAC resolution). If the radiometric correction is performed at 4km resolution, I wonder, if a radiometric correction using slopes from a rather smooth DEM really makes sense. I was missing any discussion on this or further references in the paper.
- The authors conclude that the dataset is comparable to previous longterm surface albedo datasets (P25574,L15). What is then the real added value of the new dataset?

4 Minor comments

- section 4: The whole of section 4 is hard to read, as authors somehow mix up methods and results. I would recommend a clearer structure here.
- The correlation between RMSE and area integral of the variogramm is **not** statistically significant (p<=0.05)! The p-value is 0.1. The significane problem should be at least mentioned in the manuscript.
- Figure 9: what is the upper plot showing exactly? Is it the *mean* relative difference? Authors use a timeperiod for the estimation, thus I assume it needs to be some averaged value. Why is Patagonia missing? What is the lower panel showing? Is it the global *mean* surface albedo? How large is then its variance? Are the differences between CLARA-SAL and MODIS statistically significant?
- Fig.3: how significant are the differences shown here? can you mark the differences which are statistically significant ?
- Table 1: I suggest to include a column specifying the landcover type of the station
- Fig1/Fig2: The colorbar needs improvement. A scaling from 0 ... 0.6 is suggested and a more intuitive colorbar is recommended (see e.g. doi:10.1016/j.rse.2008.01.012 Fig. 3)

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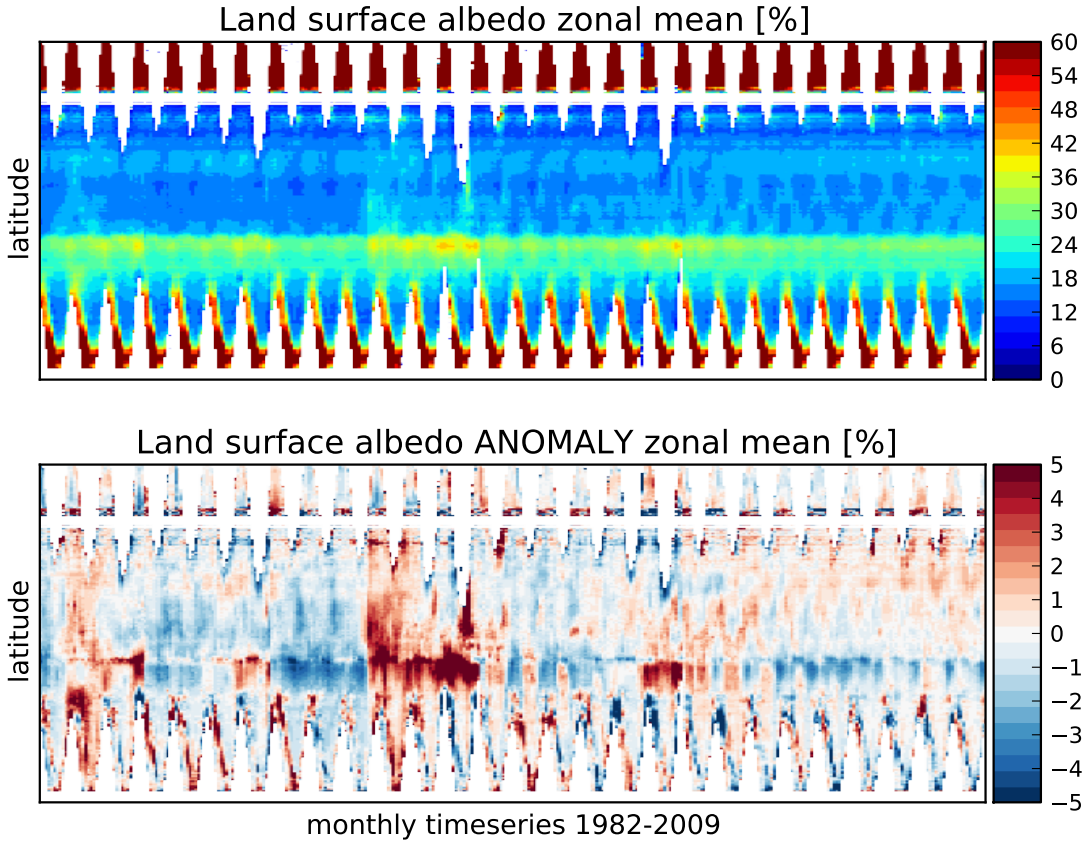

Fig. 1. Zonal means of surface albedo and deseasonalized surface albedo anomalies from CLARA-SAL

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