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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

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

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We would like to thank the reviewer for a very thorough evaluation of this manuscript. Replies to the comments raised are as follows:

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 CLARASAL. Perhaps a table with properties of the different datasets might be useful here.

OK, we will expand this section and include a comparative table of datasets.

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 deg) 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?

Possible temporal gaps in the satellite data are evident in the number of observations-datafield in every product file. Users may discard grid cells with too few observations at their pleasure. The choice of 0.25 degree regular grid was motivated by our experience that many users prefer products in the simple lat-lon projection, and that 0.25 degrees is an appropriate resolution for climate modeling users wishing to validate or compare their model data to ours. This projection also makes the dataset compatible to many other global meteorological datasets (that are frequently provided at 0.25 degree or 0.5 degree and many applications are therefore also implemented on such grids). Each GAC resolution pixel is first projected to a 0.05 degree lat-lon grid (or 5 km equal area grid for polar subsets). This resolution is close to the nominal GAC resolution (at nadir) and therefore the majority of the original observations are still represented in the reprojected grid. In this step, each observation is mapped to only one pixel (i.e. no averaging or interpolation is applied), so that the weighting of observations does not changed. Finally all these data are aggregated to the 0.25 degree (25 km) end product grids.

It is likely that some cloud-contamined scenes escape the cloud masking, but their proportion is small enough not to severely affect the temporal means. The pentad mean products are more vulnerable to cloud contamination effects, but our validation results show that such effects occur only rarely (for example Fig. 3, lower panel). Also, the reviewer may consider that the reflectance information in each 4.4 km (at nadir) GAC pixel is actually collected from a subset of LAC pixels within, therefore diminishing the cloud contamination probability. Aggregation in the regular grid is done by averaging those 0.05 degree products which fit within each 0.25 degree grid cell. We also wish to point out that the polar subsets of the timeseries are provided in an equal-area projection.

Theoretically, it could be possible to define the product in an equal area grid with a horizontal resolution as close as possible to the nominal nadir resolution of 4.4 km. However, this is only justified if the navigation accuracy is better than one GAC pixel. For the most recent series of NOAA/Metop satellites this is achievable but for the earlier satellites there are documented navigation errors that sometimes exceed 10 km. Until we have these navigation errors corrected (work is ongoing for this) it is better to compile results in a coarser resolution.

Landcover information is obtained with a nearest-neighbor retrieval from a 1-km USGS land cover dataset for each GAC overpass. While it is unavoidable that terrain heterogeneity will cause some errors in land cover assignment, their effect is not critical. Our BRDF correction model utilizes NDVI as its main parameter and does not typically introduce drastic corrections into the data. Also, the land cover information is aggregated into archetypal classes (forest, grassland, cropland, barren) prior to the correction, effectively ameliorating the problem. Our use of variogram estimators in the manuscript is intended to highlight the challenge of obtaining and validating a coarse resolution albedo dataset over heterogeneous terrain.

We will revise the manuscript to provide a more detailed treatment of these topics.

3. P25578, L25: Authors use constant values for O3 and AOD for the atmospheric

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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 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?

The reviewer has perhaps misunderstood the text. We do not claim that there is an upper limit of AOD effect on albedo at +-5%. That number is the **additional** retrieval error introduced by using an AOD of 0.1 (as the timeseries does) when the actual AOD of the atmosphere if 0.3 – given a typical grassland reflectance at AVHRR channels 1 2 and a typical illumination-viewing geometry. If the actual AOD is still higher than that or the viewing geometry is unfavorable, the additional error will increase – and the increase will actually be faster than linear. For regions such as Sahara where AOD$>$ 0.7 is not uncommon, the added error will be considerably larger than 5% (stated in manuscript, p. 10, lines 577-580). The use of a constant AOD was motivated by a) the fact that a universal and robust method of retrieving AOD simultaneously with albedo is not available for AVHRR, and b) our desire to avoid using climatological AOD values over a period of 28 years. The use of a single AOD value everywhere allows interested users to estimate the additional uncertainty/error if and when they have robust AOD data available, and also to perform a correction in CLARA-SAL before use.

For the reviewer's information, the analysis was done with the SAL algorithm using simulated data. Typical grassland values of channel 1 and 2 TOA reflectances, and illumination-viewing geometry were assigned while varying the AOD input of the SMAC atmospheric correction module. The sensitivity of the CLARA-SAL broadband albedo

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to AOD variations was then calculated from the difference of the altered AOD run against the standard run (with AOD of 0.1).

To double-check the results, for the revised manuscript we will also perform RTM simulations with a similar set-up and correct the numbers if required. We will also revise the text to avoid a misunderstanding such as this one.

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.

The number of stations was chosen for the longevity of the data record, as monitoring of year-to-year retrieval stability was considered important. However, to satisfy the reviewer, we are expanding the validation dataset now to include a further 10 BSRN sites in the results. To eliminate most of the cloudy skies samples from the new in situ data, we discard all samples where the standard deviation of irradiance is larger than 1% of the irradiance (as cloudy conditions cause a varying irradiance). This method is less accurate than for the original dataset, where timestamps of cloud-free AVHRR images at each site where recorded to match in situ data accordingly, but the difference between cloudy and cloud-free albedo is fortunately slight for vegetated surfaces.

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.

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The site with the highest differences (Payerne) suffers from a highly heterogeneous land cover at CLARA-SAL grid cell scale, including the presence of a large lake. As stated in section 4.3.2, analysis of of retrievals at GAC resolution over Payerne yields an RMSE error half as large as for the gridded product, indicating that spatial representativeness issues contribute very strongly to the observed error.

Splitting the observed difference into systematic and random errors is challenging. That is why we introduced the semivariogram estimator to provide the reader with more confidence that the sites showing largest errors are also the most heterogeneous in terms of land cover. Based on the variograms, we can estimate that systemic errors of the algorithm (excluding mismatched atmospheric correction effects) should be on the order of the difference observed at validation sites where variogram estimator is smallest, i.e. SGP and Sodankylä. This would lead us to consider the error level of 10-15% to be systematic, much as we have done in the conclusions. Mismatch in atmospheric conditions relative our applied baseline will contribute additional error; while this error can be considered a part of the bias, we have identified in the manuscript the regions most affected, where CLARA-A1-SAL should be used with great care, preferably calculating corrections prior to usage if accurate atmospheric constituent information is available to the user.

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?

Large semivariogram estimators are found at sites where in situ data representative-

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ness against coarse CLARA-SAL retrievals is poor. To better link this finding with the CLARA-SAL retrieval accuracy determination, we propose to include in the revised manuscript the following: a) We will calculate the mean retrieval accuracy as a weighted mean over all validation sites, using the variogram estimator integral (of the smallest common lag distance) as a basis for calculating the weights. This creates a mathematical link between the reliability of a site albedo to represent the larger area albedo, and the observed retrieval accuracy of CLARA-SAL. b) We further propose to present the mean retrieval accuracy metric separately for perennial snow cover sites using only the average monthly mean retrieval accuracy, as it is safe to assume that representativeness of in situ albedo measurements is always high.

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] 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.

Very well, we will expand this section, revise Figure 8 and also include more BSRN stations to the graph 8f (subject to Landsat image availability for appropriate period per site). As there is some variation in the variogram estimators resulting from the available Landsat images being from different seasons per site, we will further consider the selection criteria for Landsat imagery for this variogram calculation. A decrease in the variogram estimator at any given lag distance relative to preceding distances simply means that the mean reflectance of Landsat pixels at that particular distance interval is closer to the one observed at the validation site coordinates.

Additionally, after consideration of the reviewer comments we find that a normalized variogram estimator is the best metric for validation site representativeness analysis. We propose to normalize the variogram by maximum lag length to account for different physical dimensions of the CLARA-SAL 0.25 degree grid cell over different parts of the Earth. In the revised manuscript, we will also consider sources of uncertainty (and their strengths) for calculating the variograms.

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.

We will expand section 5 and provide a more detailed analysis on the differences between CLARA-SAL and MCD43C3. See also conclusions 3 comments below.

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

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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 abrupt 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 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.

It is impressive that the reviewer took the effort to obtain the dataset for personal study. Having repeated the same analysis, we wish to comment on the reviewer's findings: 1) To help the reader, we first note that the reviewer's Fig. 1 is shown so that 90 degrees North is at the bottom of the image(s). In the following, we use the more common convention of placing 90 N on the top left of the figures. 2) Our deseasonalized land surface albedo anomalies are quite close to the ones shown by the reviewer in his Fig.1 (see our Figure 1 below). Some difference results from the fact that the reviewer did not specify the reference period against which he calculated the anomalies. However, the main features are clearly similar, thus we may proceed with the discussion. 3) The reviewer refers to "considerable inconsistencies through time which are observable across large latitudinal bands". We assume that he refers to the anomalies observable mostly between -10 and 30 N occurring most strongly between late 1991 and late 1994. These anomalies, as well as the negative anomalies preceding that period, are related to variations in Saharan (primarily) and Southeast Asian (secondarily) aerosol loading of the atmosphere. A similar zonal AOD variation both in space and time has been observed using the Total Ozone Mapping Spectrometer (TOMS) [Torres et al., 2002]. The TOMS timeseries also exhibits rapid variations in AOD; similarly rapid variations in albedo retrieved with a static AOD assumption are to be expected. Strong anomalies closer to the poles are to be expected given the year-to-year variations in snow cover and its albedo. Figure 10 in the manuscript, and the associated text, was included to remind the reader that the region between -10 to 30 N has large aerosol variations and

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that the user should consider applying a post-processing correction to the product prior to use over these regions. We will revise the discussion section to make this clearer. 4) To further assess if the reviewer's suspicions about the stability of the timeseries, we have also calculated the mean albedo at the Dome-C site across the timeseries (see our Figure 2 below). The site is widely used for calibration and validation of optical polar imager data. The product does not show abrupt level shifts as would be the case if the radiance timeseries were inhomogeneous, similarly to what was shown in the manuscript. In case the reviewer objects generally to our use of snow/ice targets for stability analysis, we have also calculated the mean retrievable land surface albedo from the timeseries, excluding Greenland and Antarctica to remove their effect. The result is shown below in Figure 3. Again, there are no significant level shifts or abrupt changes visible in the dataset.

REFERENCE: Torres, O., P. K. Bhartia, J. R. Herman, A. Sinyuk, Paul Ginoux, Brent Holben, 2002: A Long-Term Record of Aerosol Optical Depth from TOMS Observations and Comparison to AERONET Measurements. J. Atmos. Sci., 59, 398–413. doi: http://dx.doi.org/10.1175/1520-0469(2002)059<0398:ALTROA>2.0.CO;2

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.

See results above from the widely used stability site of Dome-C in Antarctica as a second reference, plus mean retrievable land surface albedo with the ice sheets excluded. The fact that we are using a constant AOD signifies that stability considerations over desert sites are strongly influenced by mismatches between real and our assigned atmosphere. We will revise the discussion section to note that it is advisable to perform a post-processing correction to CLARA-A1-SAL over desert areas to account for AOD variation effects. In future releases of CLARA-SAL, where a dynamic atmospheric

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correction is planned, direct stability evaluation and use over desert sites will be appropriate.

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.

Accepting the observed in situ – satellite albedo difference directly as one's retrieval accuracy is not appropriate, because the in situ measurement does not capture the large-scale albedo variation in a satellite grid cell. Our use of semivariogram estimators was intended to show that much more emphasis should be placed on validation sites where semivariogram integrals are small,i.e. the point-like in situ measurement can represent the albedo of the site's surrounding area. As stated in point 6 above, we will provide separate mean retrieval accuracy estimates for perennial snow/ice and land/seasonal snow sites, weighing the land validation site accuracies by the normalized variogram integral to account for land cover heterogeneity effects in the overall "mean" retrieval accuracy. We will also reword the conclusions so that the reader better understands the strengths and weaknesses of the dataset.

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.

We disagree on this conclusion. The anomalies in the dataset are mainly related to AOD effects on the product, which the user may correct for if he/she has AOD datasets available over the region(s) of interest. Anomalies over the polar and sub-polar regions are a result of year-to-year variations in snow cover and sea ice and their albedo. Our use of the term 'stable' meant that there are no albedo jumps related to satellite changes, and that for most areas of the Earth, the AOD effects are not so large to threaten product usefulness. We will revise the text to make this definition clearer.

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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!

Evaluation of which dataset is most appropriate is entirely application-specific. While we will attempt to identify the most likely causes of the bias, we cannot answer with a simple yes or no whether or not this dataset is supposed to be better than MODIS. The MODIS instrument has a superior resolution and calibration, its value is undisputed in many land monitoring applications. Our dataset is intended to be a long-term, climate-model resolution dataset, whose main strengths have been found to lie in cryospheric applications. In addition, some components of the algorithms are present in only one or the other of the datasets, such as the topography correction in CLARA-A1-SAL. We will provide more analysis, but the reviewer seems to be asking here for too much simplification.

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

In terms of optical satellite remote sensing, WSA is mainly a mathematical quantity which needs to always be somehow derived from available clear-sky albedo retrievals. The users may therefore apply their favoured method to this dataset and the cloudiness products in the CLARA-A1 family to derive a WSA if required by their application. If user interest is expressed, we can expand the future CLARA-SAL releases to also include a WSA estimate. As the CLARA-SAL is designed to aid climate modeler work, focusing on BSA is logical, as BSA provides the information on the inherent albedo of terrain without atmospheric effects.

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.

Mountaineous in this dataset is defined by having a mean slope $>$ 5 degrees, based on GTOPO30 data. The topography correction is calculated in two parts. First, the apparent location of a pixel is computed and pixels are moved to their actual locations on a flat plane (within 1 pixel accuracy) using GTOPO30 slopes. Then, a high-resolution DEM from SRTM is fitted into the satellite data and viewing/illumination geometry data is applied to compute the number of SRTM slopes within the (GAC-resolution) satellite pixel that are illuminated, in shadow or illuminated/viewable but not within the BRDF model validity range. The unseen/shadowed slopes are assumed to have the same physical albedo as the observed slopes. The observed reflectance is corrected for assuming that the slopes that could not contribute to the observed reflectance would contribute to the albedo of the area equally much as the slopes that were visible in the observed satellite image. We will revise the annex to provide more details on the correction. For a more detailed discussion, the reviewer (and readers) are welcome to peruse the CLARA-A1-SAL Algorithm Theoretical Basis Document (ATBD), available from the product website (http://dx.doi.org/10.5676/EUM_SAF_CM/CLARA_AVHRR/V001), and also Manninen et al. (2011).

T. Manninen, K. Andersson, and A. Riihelä: Topography correction of the CM-SAF surface albedo product SAL. 2011 EUMETSAT Meteorological Satellite Conference, proceedings. http://www.eumetsat.int/Home/Main/AboutEUMETSAT/

Publications/ConferenceandWorkshopProceedings/2011/SP_2011114105950658

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?

To be precise, we have stated that the retrieval accuracy is comparable to previous longterm datasets. Beyond that, this dataset is currently the longest based on AVHRR data (28 years), it does not suffer from large satellite-to-satellite calibration difference effects, and its accuracy is found especially good for cryospheric and sea ice albedo applications, which we consider its best application area. Considering these points, we find that the dataset does have added value. We fully acknowledge that the dataset is not perfect and that we will continue to work on remedying its limitations in the future releases. However, we find that these imperfections are not so large as to invalidate its release, and neither did a full internal EUMETSAT review – which this dataset has already passed.

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

We will revise section 4 as recommended.

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.

There are uncertainties in the variogram estimation, which we will analyze further in the revised manuscript. Our preliminary analysis of an expanded Landsat variogram estimator dataset indicates that the relationship is statistically significant

*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*

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*global *mean* surface albedo? How large is then its variance? Are the differences between CLARA-SAL and MODIS statistically significant?*

The difference shown is the relative difference (CLARASAL – MODIS)/MODIS of the time period listed. The CLARA-SAL 16-day mean is constructed as a mean of the pentad CLARA-SAL products fitting into that 16-day mean +/- one day. The MODIS should also represent the mean albedo per grid cell for this 16-day time period. Patagonia is missing because of the SZA cutoff limit in CLARA-SAL. The lower panel is indeed the global (defined as the commonly retrievable area) mean surface albedo. Thank you for the suggestion to include variance and statistical significance information, we will revise the manuscript to include them.

Fig.3: how significant are the differences shown here? can you mark the differences which are statistically significant ?

We will, if visually possible, include statistical significance information in Fig 3., and expand on this point in the text of the revised manuscript.

Table 1: I suggest to include a column specifying the landcover type of the station

Revising as suggested.

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)

We will consider revising the color scheme in the colorbar, but we do not feel that such a large contraction of scaling is advisable. It is important that the reader can observe e.g. the decrease in albedo around the edges of the Greenland Ice Sheet in Fig.1, which will be lost if the colorbar is rescaled as suggested.

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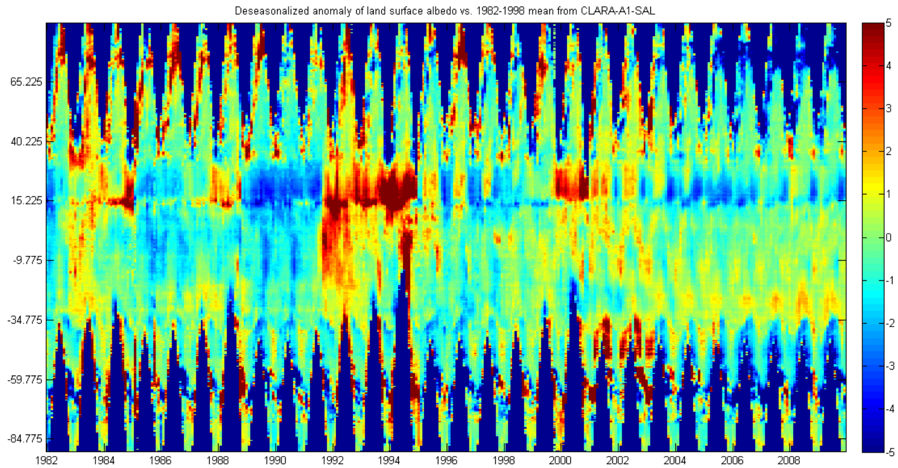

Fig. 1. CLARA-A1-SAL deseasonalized land surface albedo anomalies vs. 1982-1998 mean. Y-axis:latitude, X-axis: Date

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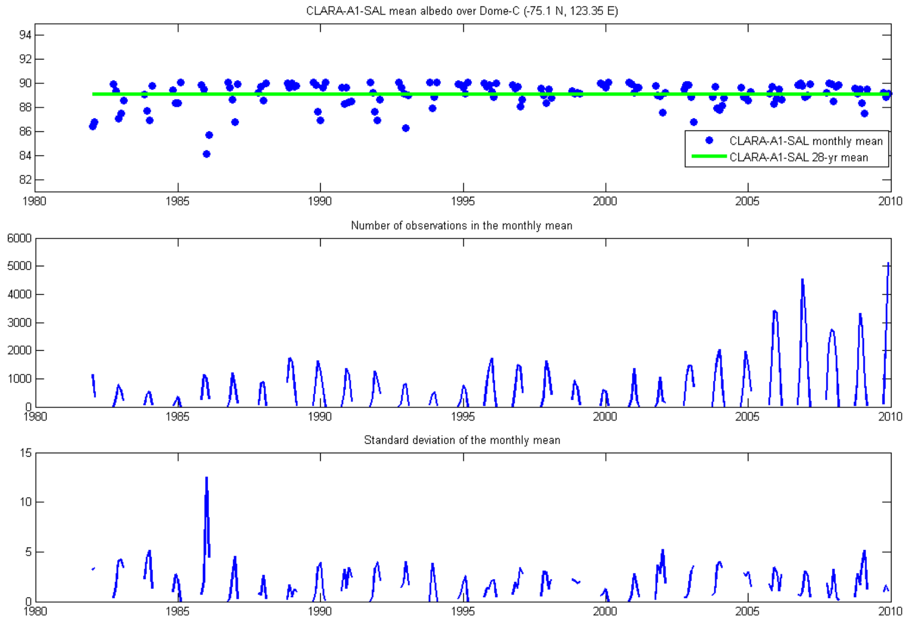

Fig. 2. CLARA-A1-SAL stability over Dome-C, Antarctica (upper panel: mean albedo [%], middle panel: observations per month, lower panel: standard deviation of monthly mean [%])

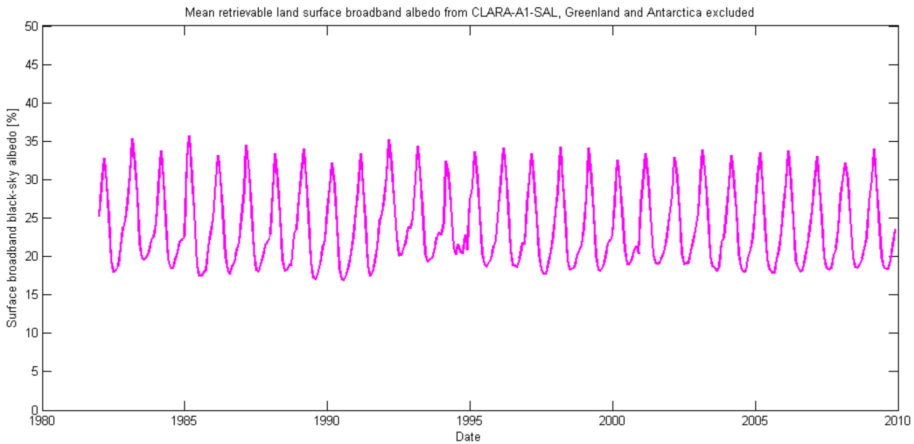

Fig. 3. Mean retrievable land surface albedo from CLARA-A1-SAL. Greenland and Antarctica have been excluded from the analysis.

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