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# Temporal and spatial evaluation of surface albedo derived from geostationary satellite observations

In response to CGMS recommendation R33.07

This paper reports on the temporal and spatial evaluation of surface albedo derived from geostationary meteorological satellites. The temporal evaluation is performed for a Meteosat satellite at zero degree longitude, analysing times series of surface albedo over a limited number of targets. For the spatial evaluation, the broadband global surface albedo product derived from five geostationary spacecrafts has been compared with the MODIS product derived during the overlapping compositing period, *i.e.*, 1–10 May 2001.

It is recalled that the surface albedo retrieval algorithm could be made available to the CGMS members upon request for the processing of their own archived data (see CGMS Action 33.19).

# Temporal and spatial evaluation of surface albedo derived from geostationary satellite observations

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## 1 INTRODUCTION

An algorithm, referred to as the Geostationary Surface Albedo (GSA) has been developed to derive surface albedo from any meteorological geostationary observations in the VIS band. Products generated by this algorithm can be used for the generation of consistent time series of surface albedo. Two different evaluation activities are reported in this paper. The temporal consistency of surface albedo time series is evaluated for the zero degree mission covered by the Meteosat first generation spececrafts from 1983 up to now. The "global" coverage of this product is obtained by the combination of five different geostationary satellites. One global product has been generated for the 1-10 May 2001 period and has been compared with the albedo product derived from MODIS observations.

## 2 TEMPORAL EVALUATION

Meteosat VS archive has been sampled at regular interval with the GSA algorithm in order to evaluate the possibility to generate consistent time series of surface albedo from the zero degree mission. All VIS band data have been calibrated with the method proposed by Govaerts et al. (2004) and spectrally converted into the Meteosat-7 spectral response. Radiometrically stable targets selected over arid desert and vegetated areas have been selected for that purpose. On the average, four surface albedo products have been derived per year from 1983 up to now for that purpose. Results are shown on Figures 1 to 3.

Figure 1 represents time series of surface albedo derived over a semi-arid area located at the border between Namibia and South Africa. Estimated errors are much larger for surface albedo derived from Meteosat-2 data (6 bits) than for the ones derived from observation coded on 8 bits, which exhibits a fairly good temporal stability. Target shown in Figure 2 is located in the tropical part of Tanzania. In this case, there is almost no difference between products derived from 6 or 8 bit data. Finally, Figure 3 shows a time series extracted over a sand dune area located in Niger.

Despite this study shows only preliminary results, it demonstrates the possibility to derive consistent time series of surface albedos from the various Meteosat spacecrafts. Further investigations are still needed to reliably determine the accuracy and precision of these times series.

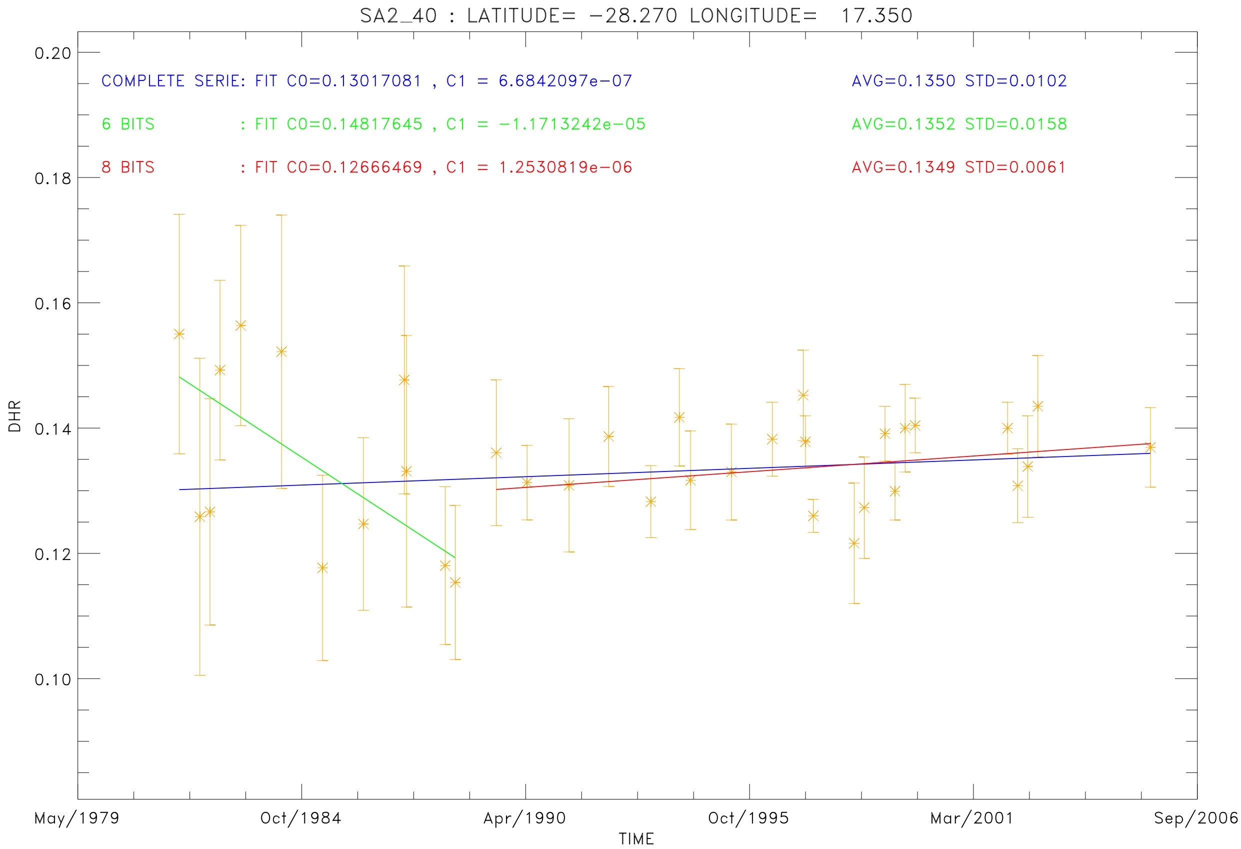


***Figure 1: Times series of surface albedo over a target located at 28.27°S and 17.35E. The star (orange) symbol corresponds to the 10-day best retrieval value and the vertical bar the estimated error. The solid lines correspond to the linear regression in green for VIS band data coded on 6 bits (Meteosat-2), in red for 8 bits data (Meteosat-4 to -7) and in blue for the entire period. Meteosat-3 data are not shown.***

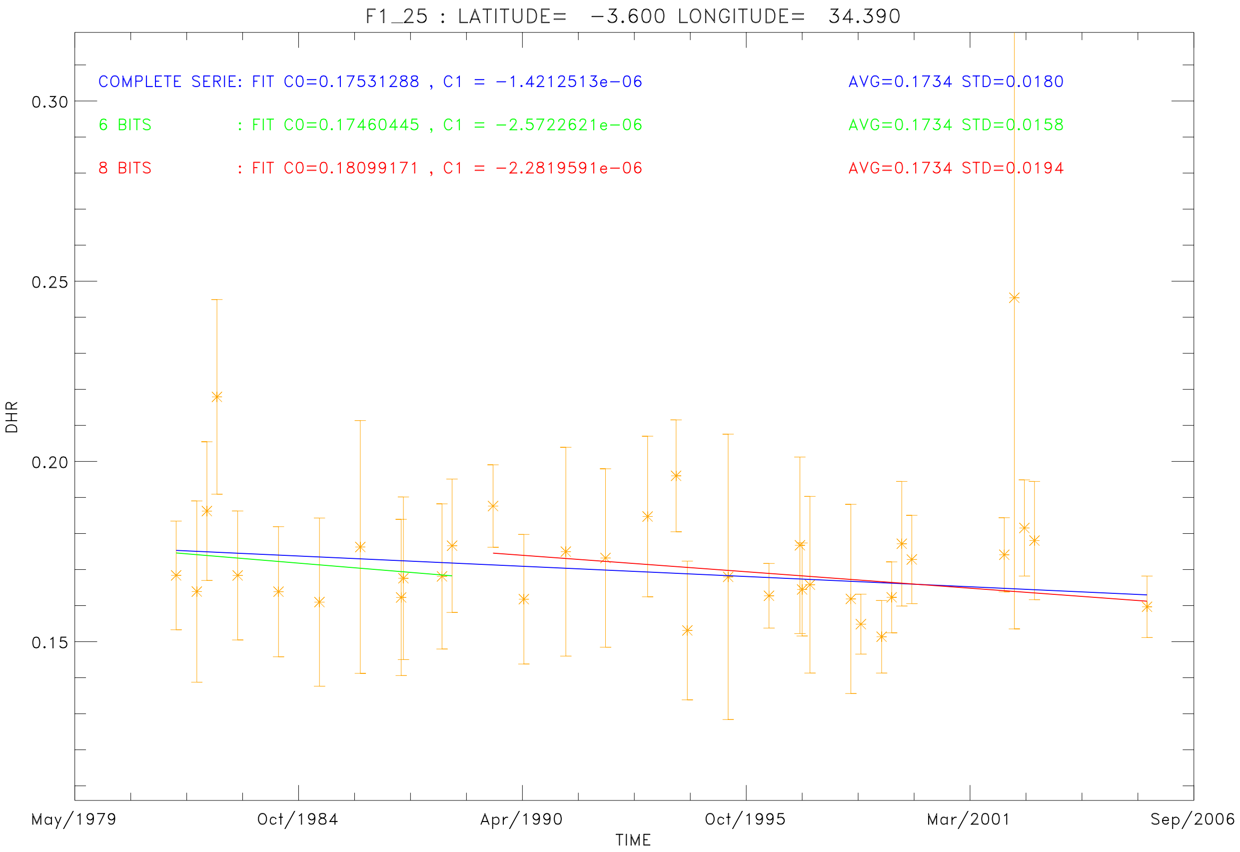


***Figure 2: Same as Figure 1 but for target located at 3.6°S and 34.39°E***

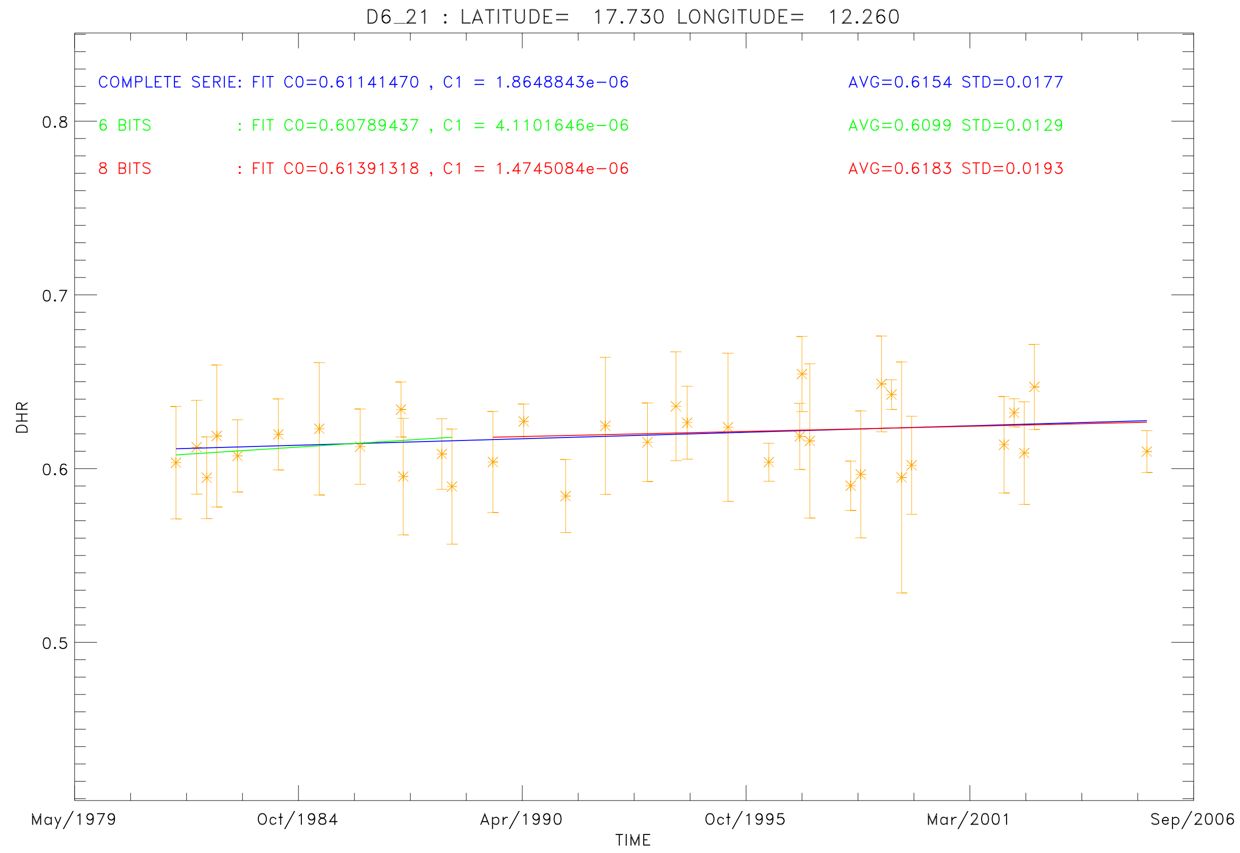


***Figure 3: Same as Figure 1 but for target located at 17.73°N and 12.26°E***

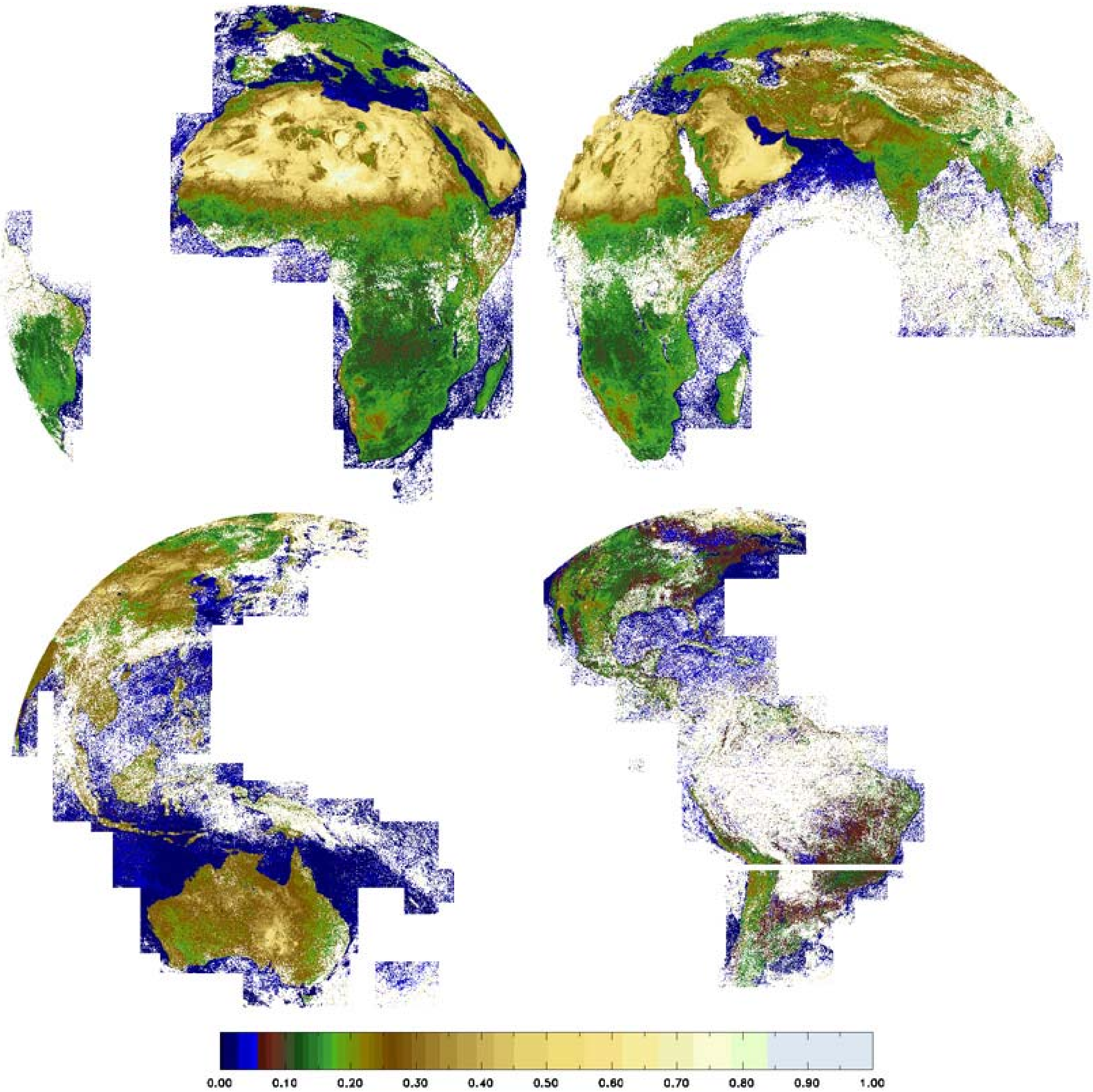


***Figure 4: Broadband bihemispherical surface albedo map derived at EUMETSAT with the GSA algorithm from Meteosat-7 (top left), Meteosat-5 (top right), GMS-5 (bottom left) and GOES-8 (bottom right) observations acquired on May, 1–10, 2001. GOES-10 retrieval is not shown.***

## 3 SPATIAL EVALUATION

A global map of broadband (BB) surface albedo has been derived between 60°N and 60°S from data acquired in 1–10 May 2001 from five different geostationary satellites (Figure 4). This demonstration product has been compared with a similar product derived from MODIS observations acquired during the corresponding compositing period (Schaaf et al., 2002). Surface albedos derived in the VIS band have been converted into BB surface albedo (Govaerts et al. 2006). Note that GOES-W data have not been included in this comparison due to the limited land surface area covered by this satellite. All the GSA products have been re-mapped in the MODIS product projection and the comparison performed on a pixel-per-pixel basis, keeping only reliable retrievals. Specifically, the isotropic bihemispherical reflectance, or white sky albedo, has been compared. An example of such comparison is shown on Figure (5). The following statistics have been

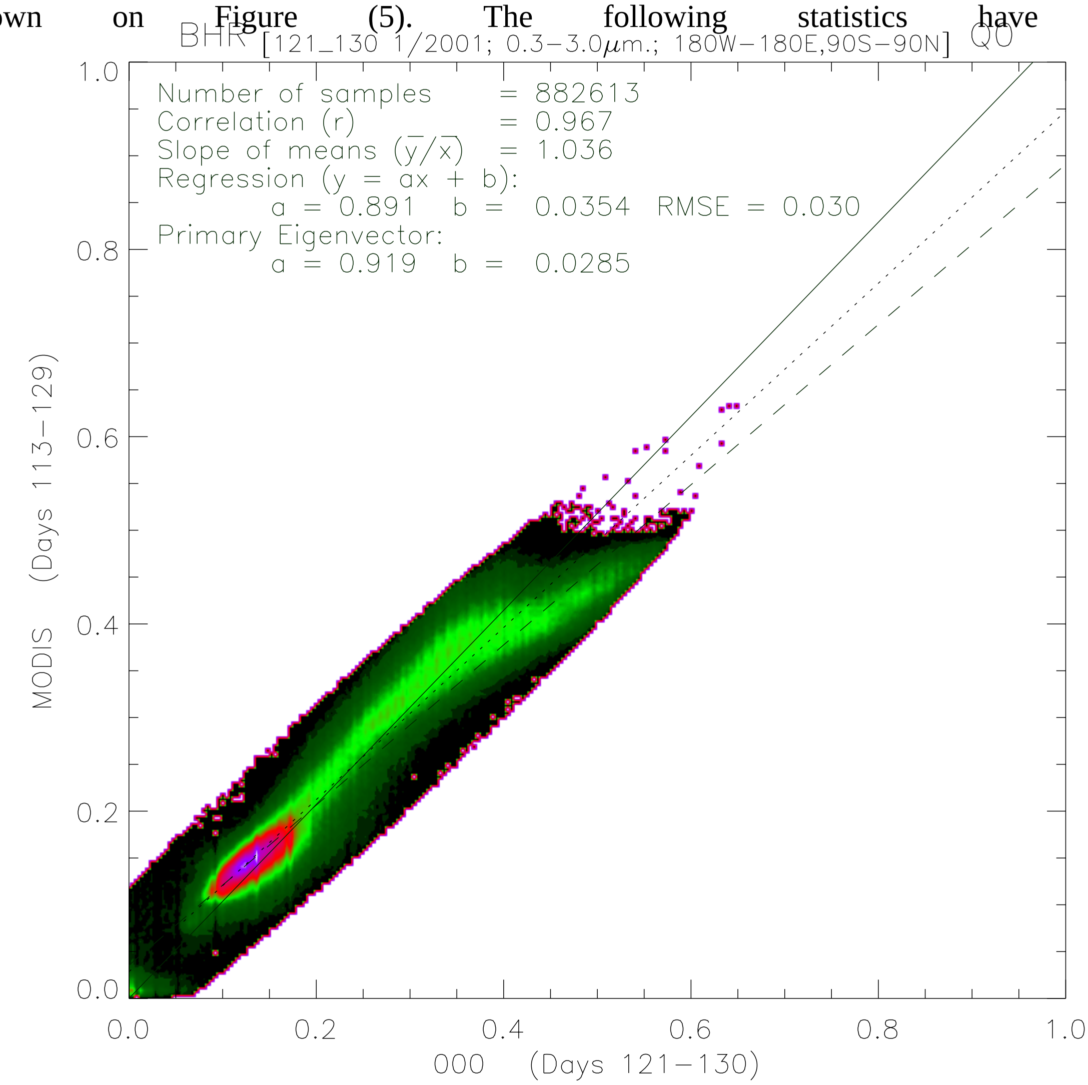


***Figure 5: Density plot between surface albedo derived from Meteosat-7 and MODIS.***

computed for each comparison: the correlation coefficient *r*, the slope of the means, *i.e.*, the ratio between the mean geostationary and MODIS values, the RMSE and finally the primary eigenvector *PE* (Pinty et al. 2004). Table (1) summarises the results of these comparisons.

| Sat | SSP | N. pixels | Correl. | Slope M. | RMSE |
|---|---|---|---|---|---|
| MET-7 | 0 | $0.883\ 10^6$ | 0.967 | 1.036 | 0.030 |
| MET-5 | 63 | $1.129\ 10^6$ | 0.970 | 1.045 | 0.024 |
| GMS-5 | 135 | $0.250\ 10^6$ | 0.904 | 0.906 | 0.024 |
| GOES-8 | 285 | $0.373\ 10^6$ | 0.786 | 1.019 | 0.023 |

Table 1: Overall results from the surface albedo comparison. See text for details.

The best correlation is obtained between the surface albedo derived from Meteosat satellites and MODIS, presumably due to the broader spectral response function. The VIS band spectral response function of the GOES instrument being narrower than the one onboard METEOSAT or GMS, the spectral conversion to broadband albedo is less accurate than for the other instruments. As concern the slope of the means, GMS-5 exhibits slightly higher difference than the other three satellites. None of these ratios exceed however 10%. On the average, BB surface albedo derived from GMS-5 overestimated by about 10% (relative difference) values derived from MODIS. For Meteosat, surface albedo underestimated the MODIS one by about 5%. The mean surface albedo are in a very good agreement for GOES-8 and MODIS. BB albedo derived from METEOSAT-7 shows the highest RMSE with respect to MODIS. As the area observed by this satellite encompasses the entire Sahara desert, many pixels have values exceeding 0.3, which explains the RMSE value slightly higher than for the other instruments.

## 4 CONCLUSIONS

The time series analysis of the Meteosat archive demonstrates the consistency of surface albedo derived from the operational period of the mission, *i.e.*, since Meteosat-4 up to Meteosat-7. There is a slight discrepancy between the products derived from Meteosat-2 (6 bits data) and the operational series where the VIS band data are coded on 8 bits. Many archived images prior to 1995 are still suffering from incorrectly or missing file header information. There is currently no practical committed plan to improve this situation. The current sampling activity allows however to identify images with a header which is not correctly populated.

As concerns the global product, the GSA product exhibits uniform comparisons with respect to MODIS, despite it is derived from different geostationary instruments. The RMSE between the two products is about 0.025. These results demonstrate the potential of combined geostationary satellite data to generate meaningful time series of essential climate variable such as surface albedo.

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