Quality assessment and improvement of the EUMETSAT Meteosat Surface Albedo dataset

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A. Lattanzio[1], Frank Fell[2], Ralf Bennartz[3], Jan-Peter Muller[4], Isabel Trigo[5], A. Loew[6] and J. Schulz[1]

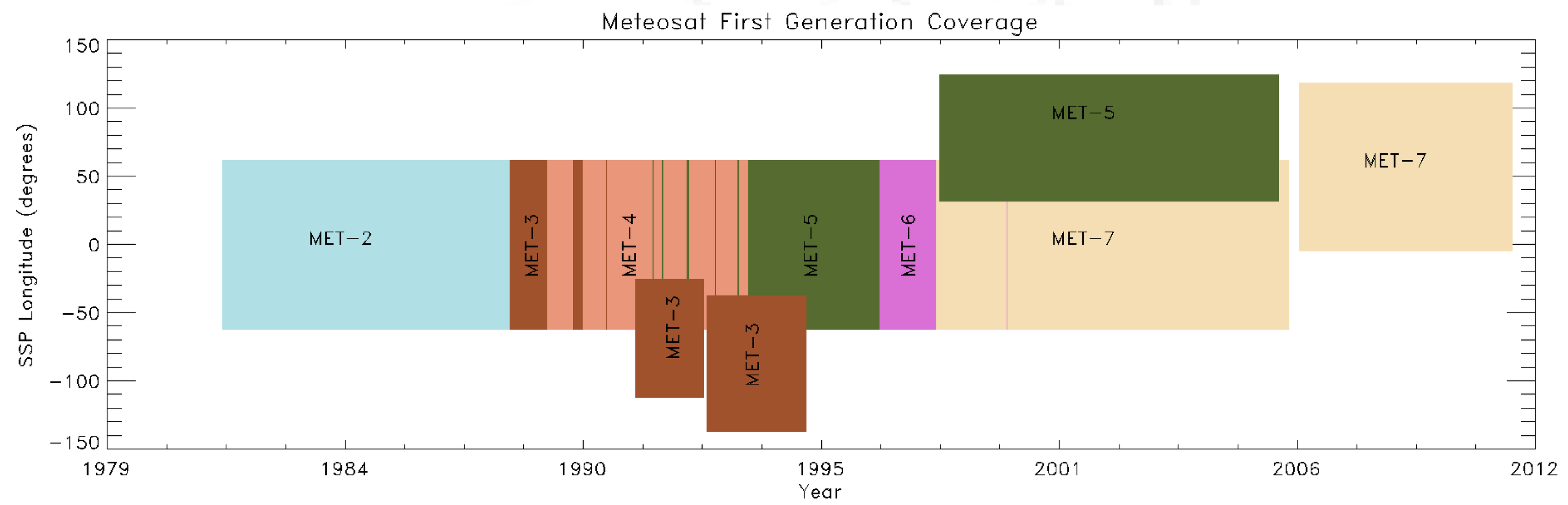
(1) EUMETSAT, (2) Informus GmbH Berlin, (3) University of Wisconsin-Madison, (4) University College London, (5) Instituto Portugues do Mar e da Atmosfera (IPMA) Lisbon, (6) LMU, Munich

Corresponding author address: Alessio Lattanzio, EUMETSAT, Eumetsat Allee 1 64295 Darmstadt, Germany. E-mail: alessio.lattanzio@eumetsat.int

Abstract

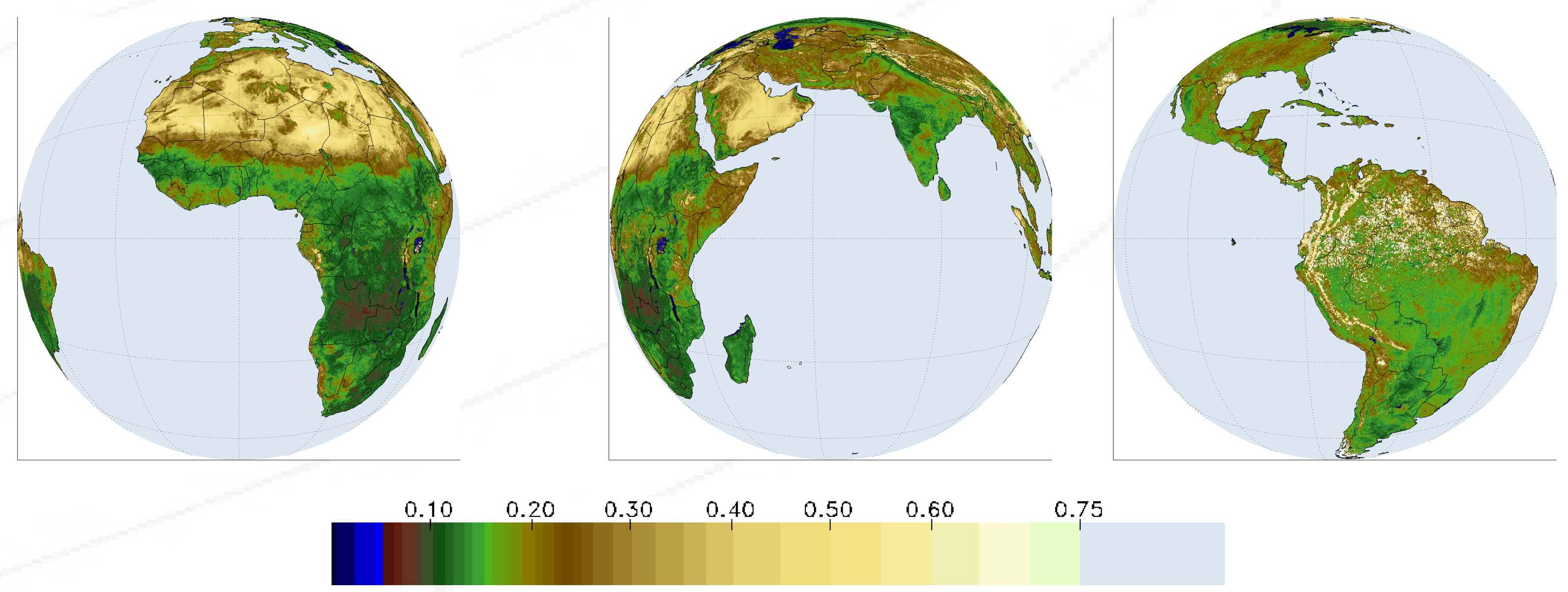
Surface albedo is an important parameter for quantifying and understanding the nature of the Earth's radiation budget. This study describes a comprehensive validation of the EUMETSAT Meteosat Surface Albedo (MSA) Climate Data Record (CDR) currently comprising up to 24 years (1982-2006) of continuous surface albedo coverage for large areas covering Africa, Europe and western parts of Asia. In addition it is discussing retrieval improvements as a consequence of the validation results. The MSA CDR has been generated within a project of the WMO entitled Sustained and Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) initiative (Lattanzio et al.2013). The MSA CDR went into a two step validation process. Firstly, the satellite product has been compared to available in situ and satellite data assessing systematic and random deviations among the products. This also included an assessment of the temporal stability over desert sites that are assumed to remain stable over time. Furthermore impact on product quality due to anisotropic effects or snow covered surfaces has been analysed. The evaluation has revealed a number of specific strengths and weaknesses. The long-term consistency is very high and meets the Global Climate Observing System (GCOS) stability requirements for desert reference sites (GCOS-154, 2011). The limitation in quality appears to be due primarily to clouds not removed by the embedded cloud screening procedure as the most significant weakness of the retrieval process. Two alternative strategies are followed to efficiently improve the cloud detection and removal. The first is based on the application of a robust and reliable cloud mask during the retrieval taking advantage of the information contained in the measurements of the infrared and visible bands. The second, in order to screen out outlier values, relies on a post processing analysis of the albedo seasonal variation together with the usage of a priori information contained in a background albedo map. The usage of a reliable cloud mask has a two-fold positive effect on product quality. It enhances the number of high quality retrievals over forest areas sensed under low view angles and removes unrealistic retrievals on similar surfaces sensed under high view angles. As expected it does not have any impact on desert areas. Future releases of the EUMETSAT MSA CDR will include the usage of a more reliable cloud mask.

Product Content and Coverage



- 1982-2006, prime 0° Sub Satellite Point (SSP) coverage (6 satellites);
- 1998-2010 Indian Ocean Data Coverage at 57°E and 63°E SSPs (2 satellites);
- 1991-1995, (Extended) Atlantic Data Coverage at 50°W and 75°W SSPs.

Prime Mission centred over Africa — *Indian Ocean Data Coverage* — *Atlantic Data Coverage*



This dataset and user manual are available from the EUMETSAT Data Centre at: http://www.eumetsat.int/ -> Product Navigator

The products are provided in BUFR and HDF4 formats and comprise:

- The GSA product (BHR, DHR30, DHR30_10D_Error, Probability);
- The ancillary data containing in particular the retrieval uncertainty.

Note that in HDF4 the variables are provided in separate files while they are provided in a single file in BUFR.

References

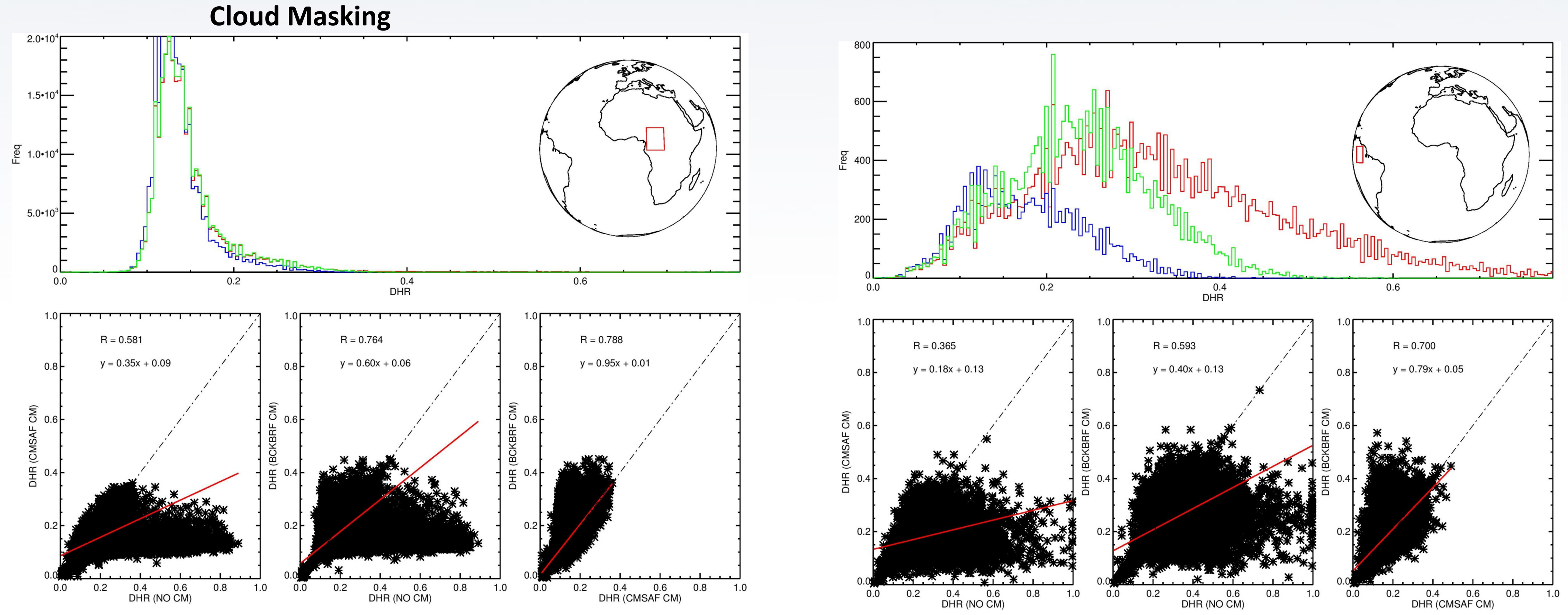
- GCOS-154 (2011). Systematic Observation Requirements for Satellite-based Products for Climate Supplemental details to the satellite-based component of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC - 2011 Update, WMO, Geneva, Switzerland.
- Fell et al., 2012 Evaluation of the Meteosat surface albedo climate data record (ALBEDOVAL): Final report, 119 pp. [available from alessio.lattanzio@eumetsat.int]
- Lattanzio, A. et al., 2013: Land Surface Albedo from Geostationary Satelites: A Multiagency Collaboration within SCOPE-CM. Bull. Amer. Meteor. Soc., 94, 205–214.
- Loew. A and Govaerts Y. Toward Multidecadal consistent Meteosat Surface Albedo Time Series. Remote Sensing, 2010, 2, 957-967.

Quality Improvement

A clear outcome of the validation is that the most relevant issue impacting the quality of the MSA CDR is the partial failure in detecting clouds. A twofold strategy has been designed for tackling the problem;

- Cloud Masking: application of two different cloud masks. One based on the VIS channel only (BCK CM) and one on both the VIS and IR MVIRI bands (CMSAF CM). The impact on albedo retrieval is compared with the case of no cloud mask (NO CM);
- Cloud Removal: exploitation of the information in the time domain wrapped in the natural albedo seasonal variation in order to detect and remove outliers.

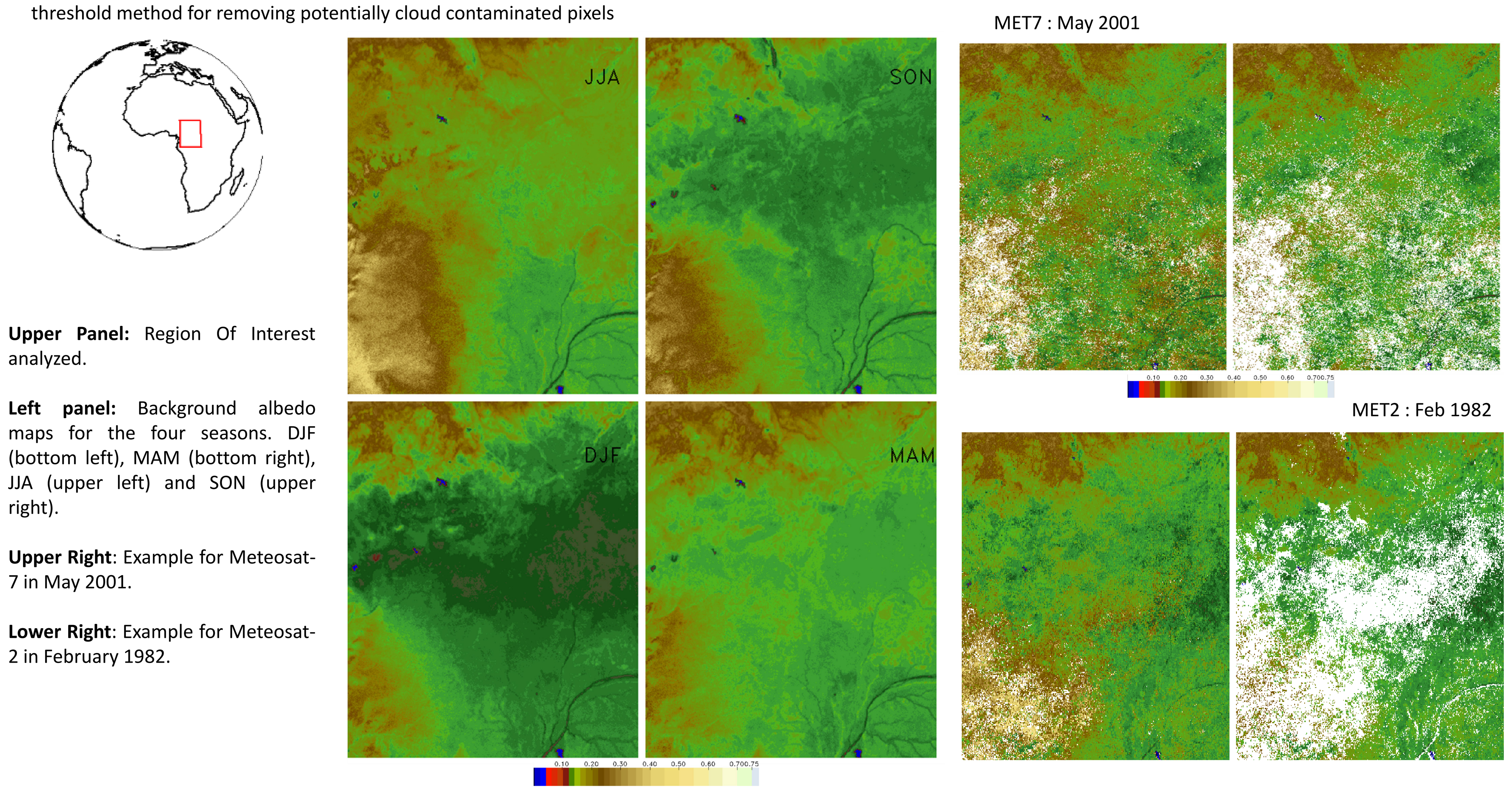
Cloud Masking



Tropical forest region viewed under a low view zenith angle (**left panel**). Comparison of surface albedo retrieval with no cloud mask (NO CM) in red, with a very simple one based on the VIS band only (BCK CM) in green and with a new cloud mask developed by CM SAF (CMSAF CM) in blue. Tropical forest area viewed under high view zenith angle (**right panel**)

Cloud Removal

Cloud Removal performed in three steps: (1) **Remove** all outliers from time series (1982-2002) using simple statistical approach, (2) **Generate** seasonal background maps (weighted average <- retrieval uncertainty) DJF (December, January, February), MAM (March, April, May), JJA (June, July, August) and SON (September, October, November), (3) **Apply** simple threshold method for removing potentially cloud contaminated pixels



Upper Panel: Region Of Interest analyzed.

Left panel: Background albedo maps for the four seasons. DJF (bottom left), MAM (bottom right), JJA (upper left) and SON (upper right).

Upper Right: Example for Meteosat-7 in May 2001.

Lower Right: Example for Meteosat-2 in February 1982.

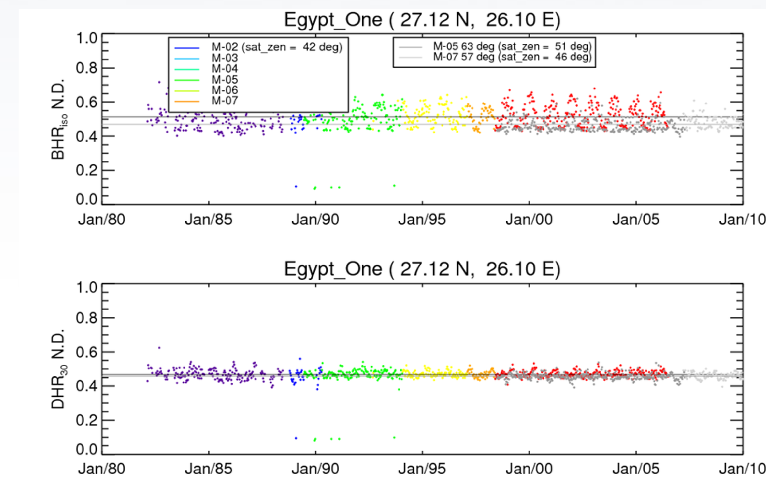
Summary

- The validation study ALBEDOVAL has clearly demonstrated that, even if generated exploiting old and not really adequate instruments such as MVIRI, the the MSA CDR shows a very good temporal stability. For most of the desert sites analyzed the stability satisfies the GCOS requirement;
- The positive impact of a new cloud mask applicable to all historic and current geostationary satellites on the quality of the retrieval has been shown;
- The impact of a cloud removal based on temporal and seasonal information wrapped in the dataset has been exploited. Such an approach should be carefully assessed because it might lead to remove good retrievals but will provide the users with a more robust and reliable Data Record.

Quality Assessment

- The evaluation of the MSA CDR (Fell et al., 2012) showed that the MSA CDR agrees well with corresponding values from other satellite-derived and ground-based observing systems under many observation conditions. In particular, the temporal stability of the CDR is fulfilling GCOS requirements;
- Some issues on the MSA CDR quality that were reported are caused by: less accurate cloud detection over vegetated areas due to high cloud occurrence, and aerosol related effects resulting from using a model with only continental aerosol and a limited set of pre-defined values.;
- The strengths underline the already high value of the MSA CDR for climate applications. The weaknesses need to be considered for specific applications and will be addressed in the context of a future re-processing within SCOPE-CM;
- The recommendations devised by the independent experts strongly support the improvement of the MSA CDR quality and its utility.

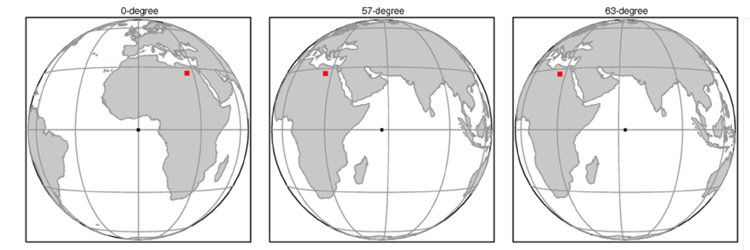
Temporal consistency

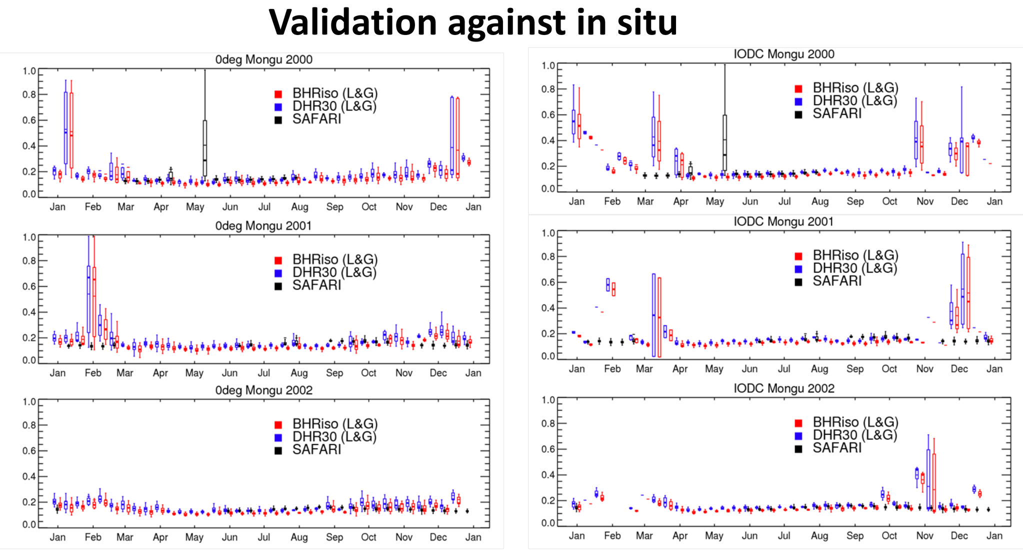


Name	0DEG		IODC	
	BHR [1/decade]	DHR [1/decade]	BHR [1/decade]	DHR [1/decade]
Murzuq desert	-0.0084	**-0.0325**	0.0102	0.0099
desert	0.0037	-0.0085	-0.0011	-0.0011
Egypt One	0.0083	0.0071	-0.0006	-0.0006
Omani desert	**0.0170**	**0.0133**	**0.0437**	**0.0421**

Regression slopes: IODC data are restricted to the 63° coverage to avoid potential effects caused by the different observation angles of IODC_63 and IODC_57. Regression slopes exceeding ±0.01/decade are shown in bold.

Validation against in situ

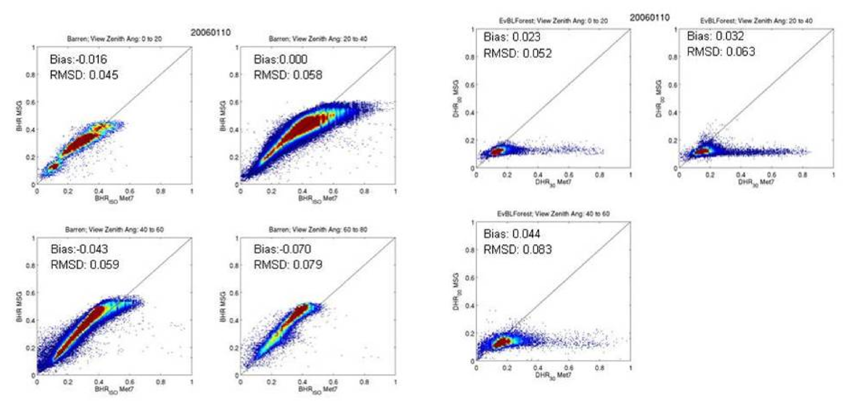




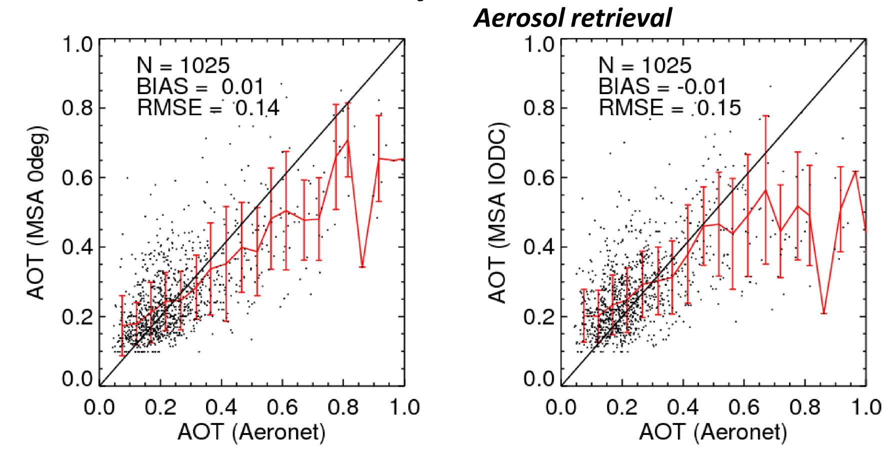
Comparison of MSA vs. in situ albedo observations: The box-and-whisker diagrams represent the spatial variability of the MSA observations (Loew and Govaerts, 2010 spectral conversion coefficients applied) within a 3x3 window centred at Mongu (Zambia). For the in situ observations (black), the diagrams represent the temporal variability within a ten-day observation period.

Uncertainty assessment

Cloud contamination



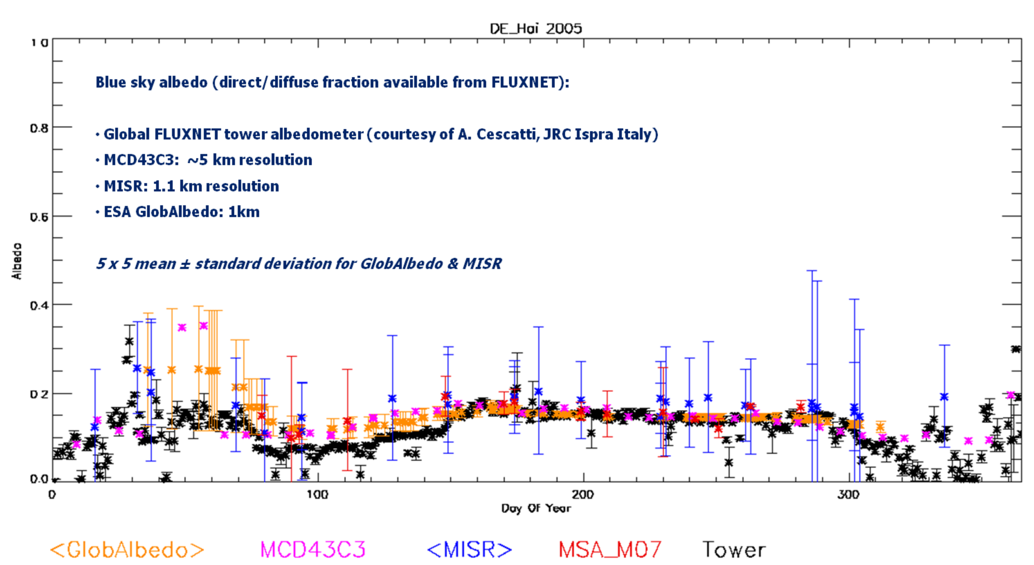
Aerosol retrieval



Left Panel: BHR_{ISO} / white-sky albedo (MSA x-axis, SEVIRI y-axis) for pixels classified as "Barren" Pixels are grouped according to MSA viewing angle ranges indicated in the top of each panel.
Right Panel: DHR_{30} / black-sky albedo for evergreen broadleaf forest.

Comparison of AERONET and MSA aerosol optical depth (AOD). Left: 0DEG coverage, right: IODC_57 and IODC_63.

Inter-comparison



Comparison with FLUXNET ground truth data ("Tower"): surface albedo products from GlobAlbedo, MODIS ("MCD43C3"), MISR, MSA on MVIRI_5 (IODC) and MVIRI_7 (0DEG) for one site in Germany (DE_HAI, IGBP: deciduous broadleaf forest).