Surface Albedo CDR from Geostationary Satellites: Validation and further Prospects

Alessio Lattanzio, Jörg Schulz, Rob Roebeling

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Outline

- Introduction to Land Surface Albedo from GEO
- Validation within ALBEDOVAL
- Future contribution to the SCOPE-CM Initiative
- European QA4ECV Project

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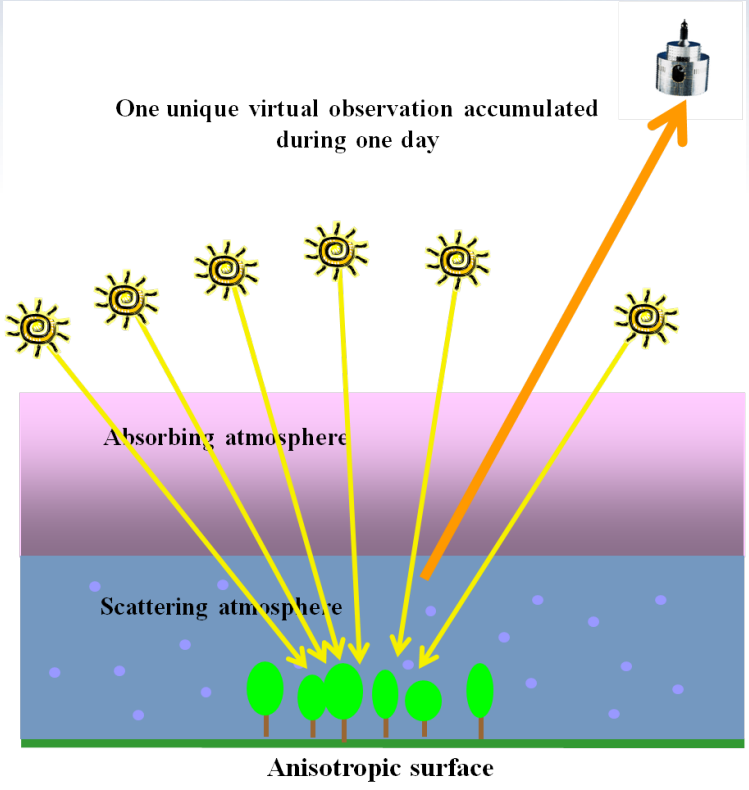
MSA: Retrieval strategy

- The Meteosat Surface Albedo (MSA) is based on a method proposed by Pinty et al. in 2000 which:

  - *relies on a daily sampling of clear sky radiances*
  - *assumes applicability of the reciprocity principle*
  - *performs the inversion with a fast RTM*
  - *ingests TCWV and TCO3 as input parameters*
  - *retrieves jointly spectral albedo and aerosol load*



- MSA processes single VIS band images
- Spatial resolution 2-3 km (instrument pixel size)
- Run time Assessment of measurement error
- Estimation of the retrieval uncertainty
- Final product: 10-days composite (minimizing the impact of cloud coverage)

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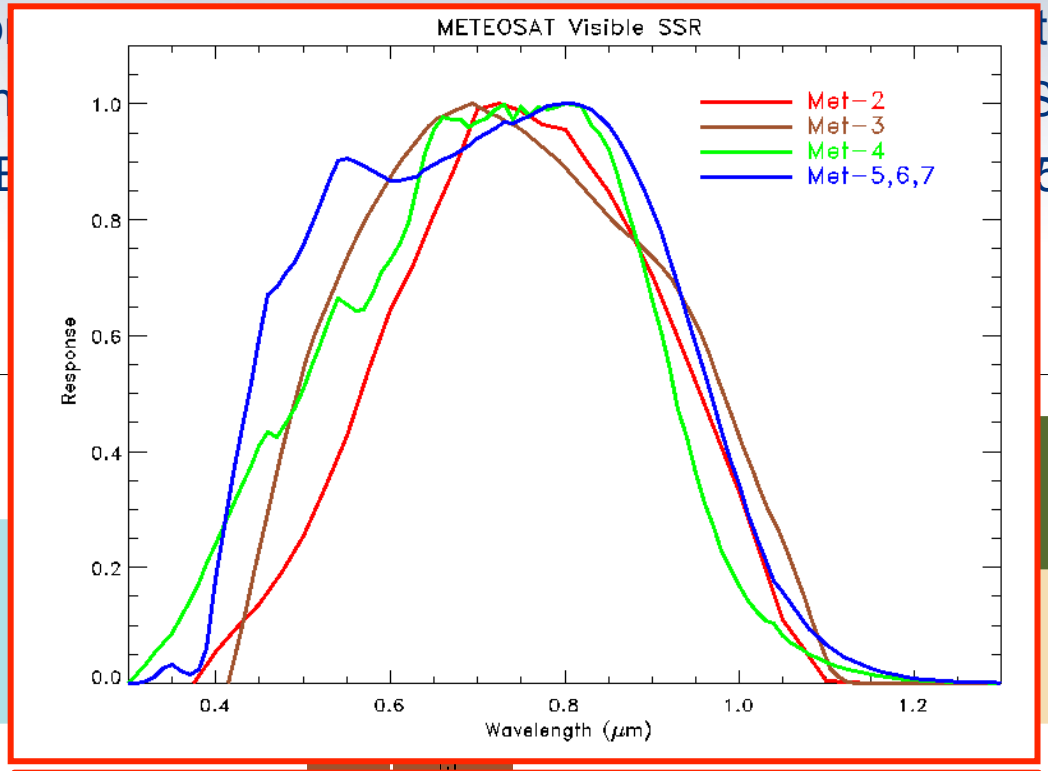
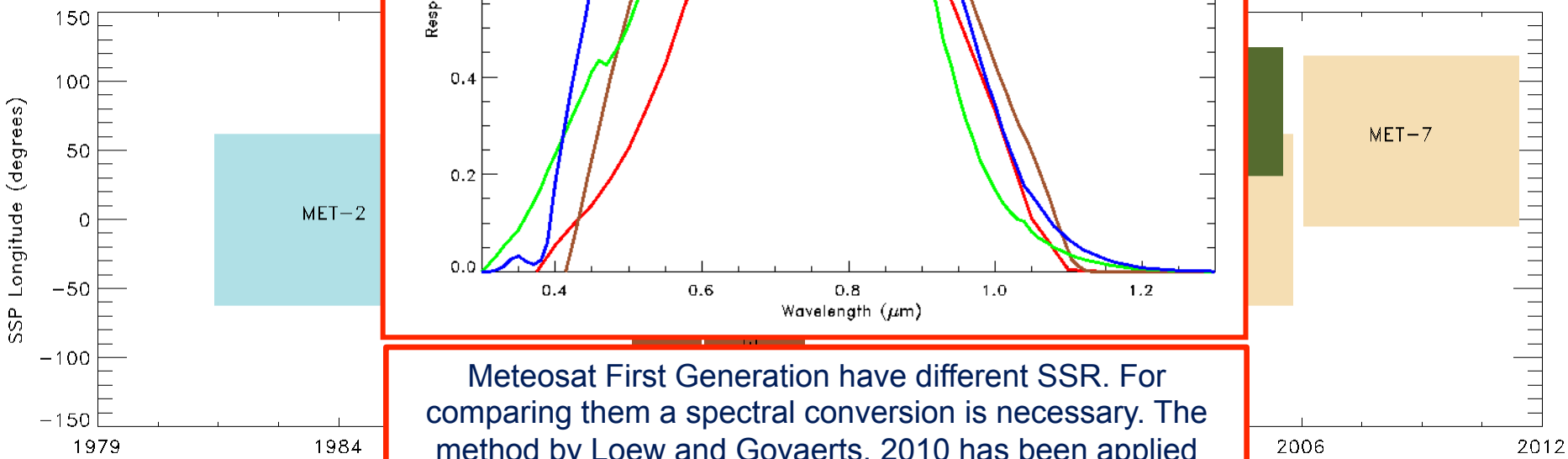
MSA: Dataset Coverage

The climate data record generated with this algorithm covers:

- 1982-2006, p tellites);
- 1998-today In SPs (2 satellites);
- 1991-1995, (E 5°W SSPs;





Meteosat First Generation have different SSR. For comparing them a spectral conversion is necessary. The method by Loew and Govaerts, 2010 has been applied

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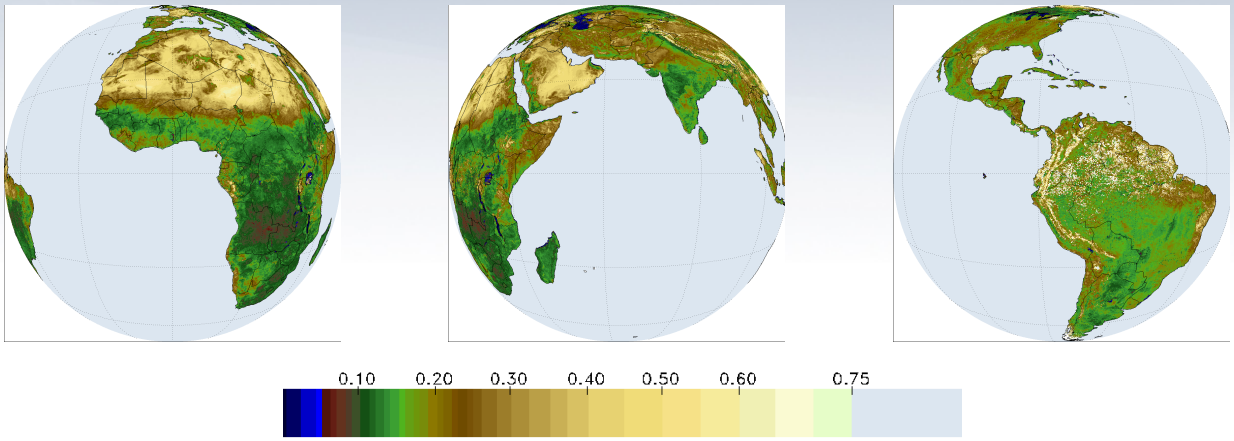
MSA: Dataset Coverage

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



This dataset and user manual are available free of charge 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, DRH30_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.

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Frank Fell[1], Ralf Bennartz[2], Bronwyn Cahill[1], Jan-Peter Muller[3], Neville Shane[3], Isabel Trigo[4], and Gill Watson[3]

[1]Informus GmbH, Berlin, Germany [2] University of Wisconsin, Madison, US
[3] University College London, UK [4] Instituto Portugues do Mar e da Atmosfera (IPMA), Lisboa, Portugal

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MSA Validation: ALBEDOVAL

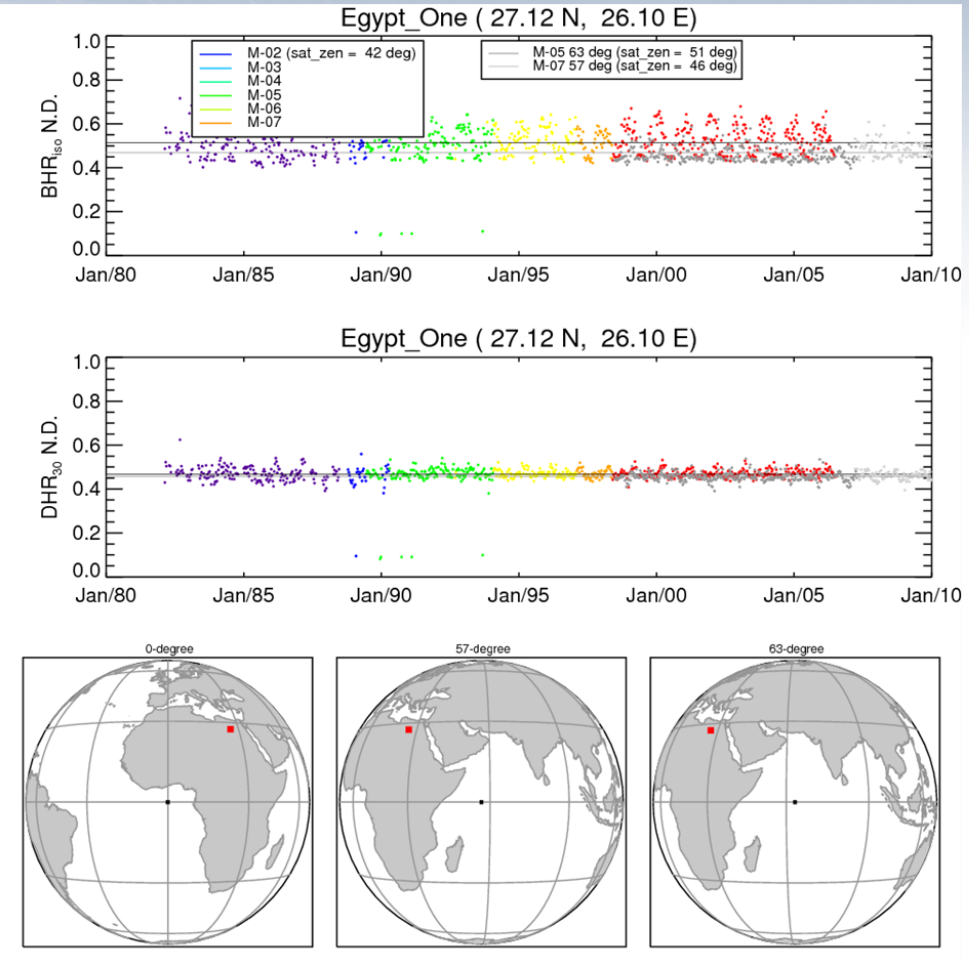
- Study for the MSA CDR performed by independent researchers in Europe and the US.

- The analysis focussed on four aspects:
  - temporal consistency
  - Inter-comparison with other satellites
  - Validation against in-situ
  - uncertainty assessment

- ALBEDOVAL2 foreseen to be started in Q4 2013 to address some aspects not covered during the first study

Fell, F., Bennartz, R., Cahill, B., Lattanzio, A., Muller, J.-P., Schulz, J., Shane, N., Trigo, I. and Watson, G., 2012: Evaluation of the Meteosat Surface Albedo Climate Data Record (ALBEDOVAL), Final Report, 11p pp.
[Available from EUMETSAT, alessio.lattanzio@eumetsat.int].

ALBEDOVAL: 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 63° around the sub-satellite point to avoid potential effects caused by the different observation angles of IODC_63 and IODC_57. Regression slopes exceeding ±0.01/decade in bold

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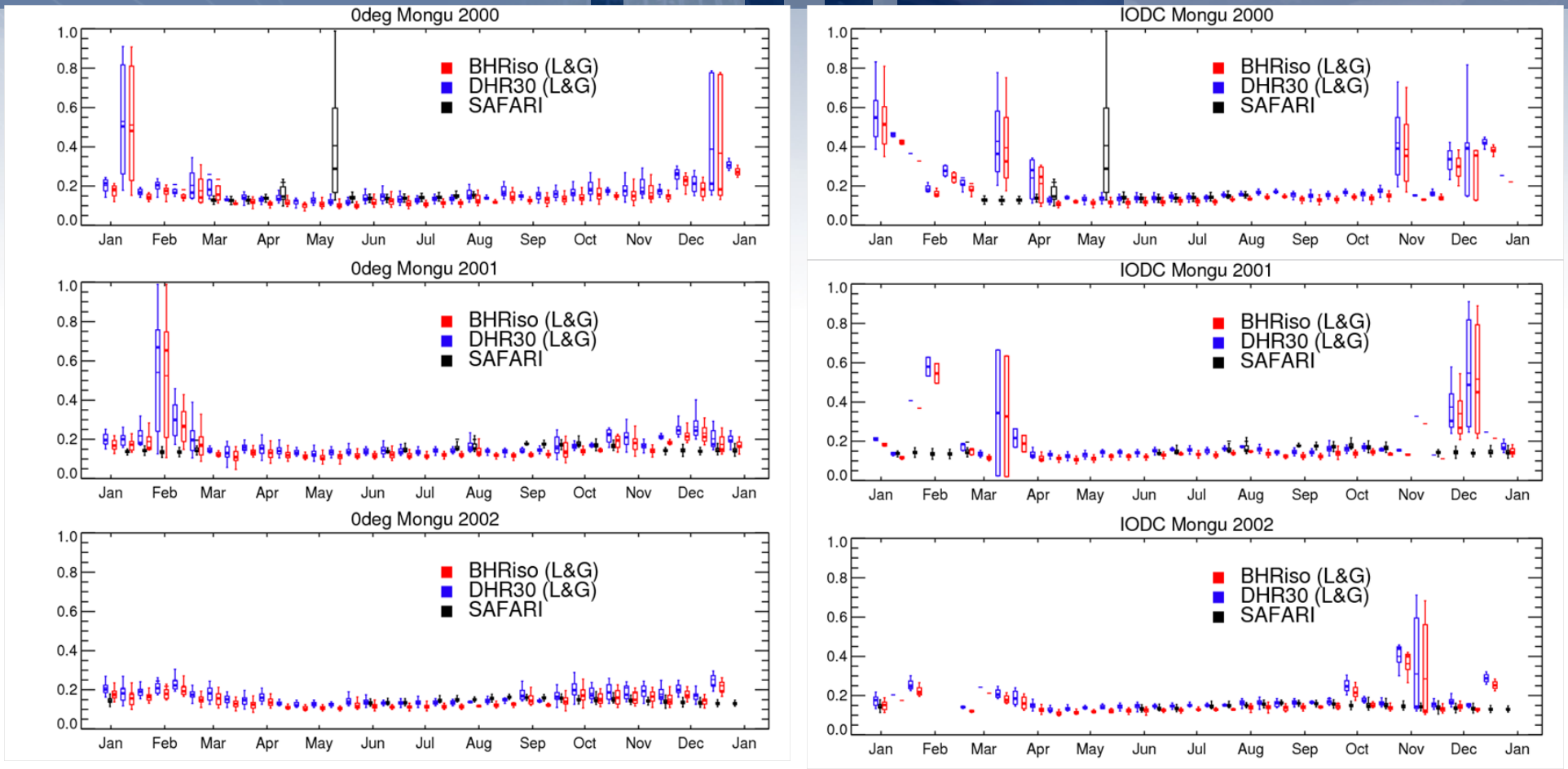
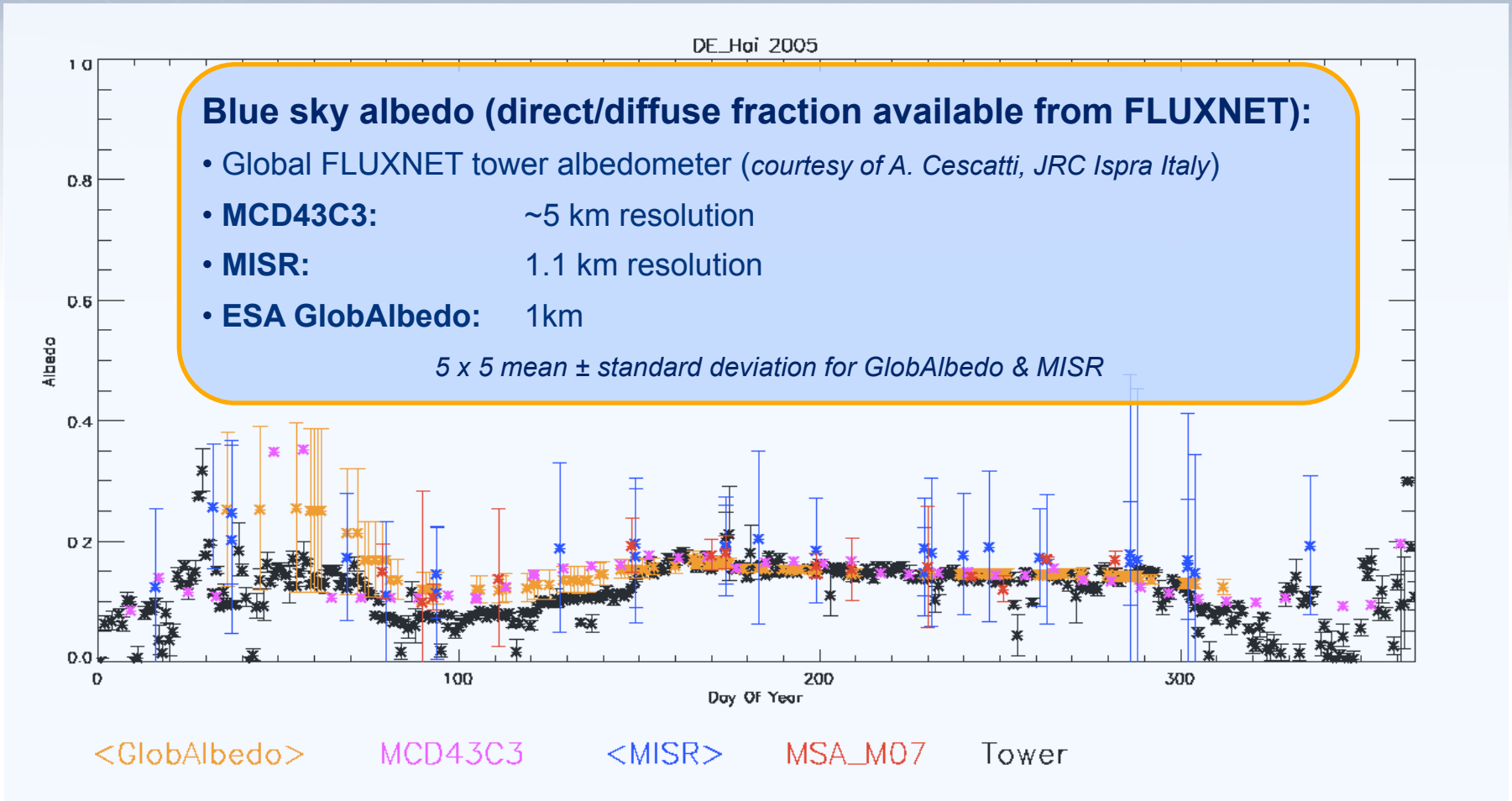
ALBEDOVAL : Validation against in-situ



Comparison of MSA vs. in situ albedo observations: The box-and-whisker diagrams represent the spatial variability (3x3) 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.

ALBEDOVAL : Comparison with FluxNet and several satellite data sets



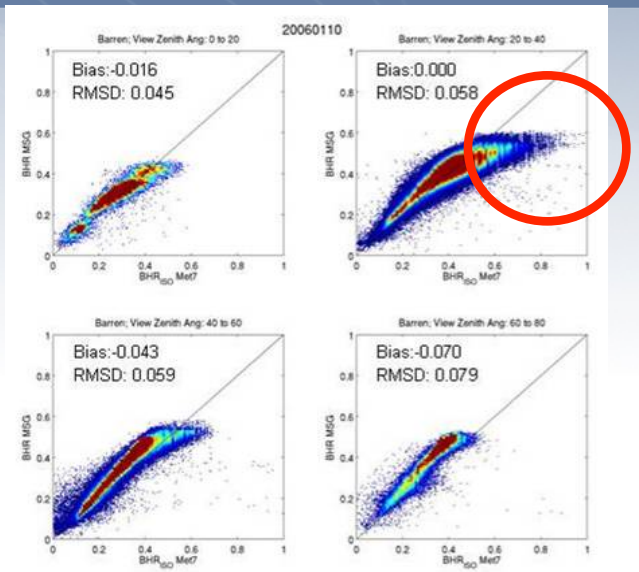
Blue sky albedo (direct/diffuse fraction available from FLUXNET):

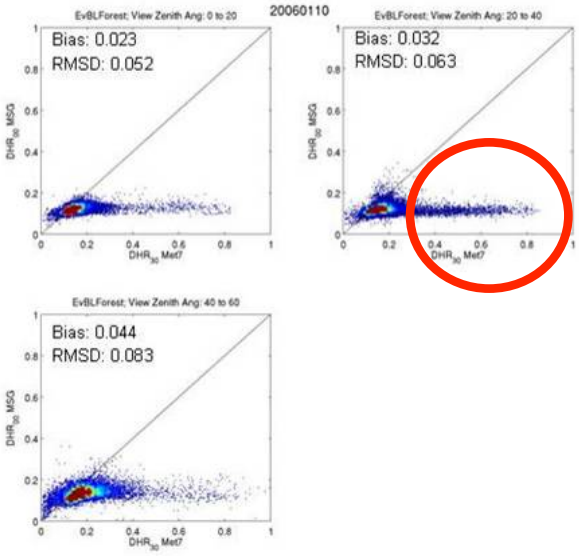
- Global FLUXNET tower albedometer (*courtesy of A. Cescatti, JRC Ispra Italy*)
- **MCD43C3:** ~5 km resolution
- **MISR:** 1.1 km resolution
- **ESA GlobAlbedo:** 1km

5 x 5 mean ± standard deviation for GlobAlbedo & MISR

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)

ALBEDOVAL: uncertainty assessment
Cloud Contamination





Upper 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.

Bottom Panel: DHR_{30} / black-sky albedo for evergreen broadleaf forest.

- **Retrievals from Meteosat-7 are hampered by cloud contaminated observations.**
- **Residual cloud contamination is mainly a problem over dark vegetated areas. Effect due to higher cloud occurrence.**
- **The effect can be mitigated using the retrieval error to screen out "bad" retrievals**

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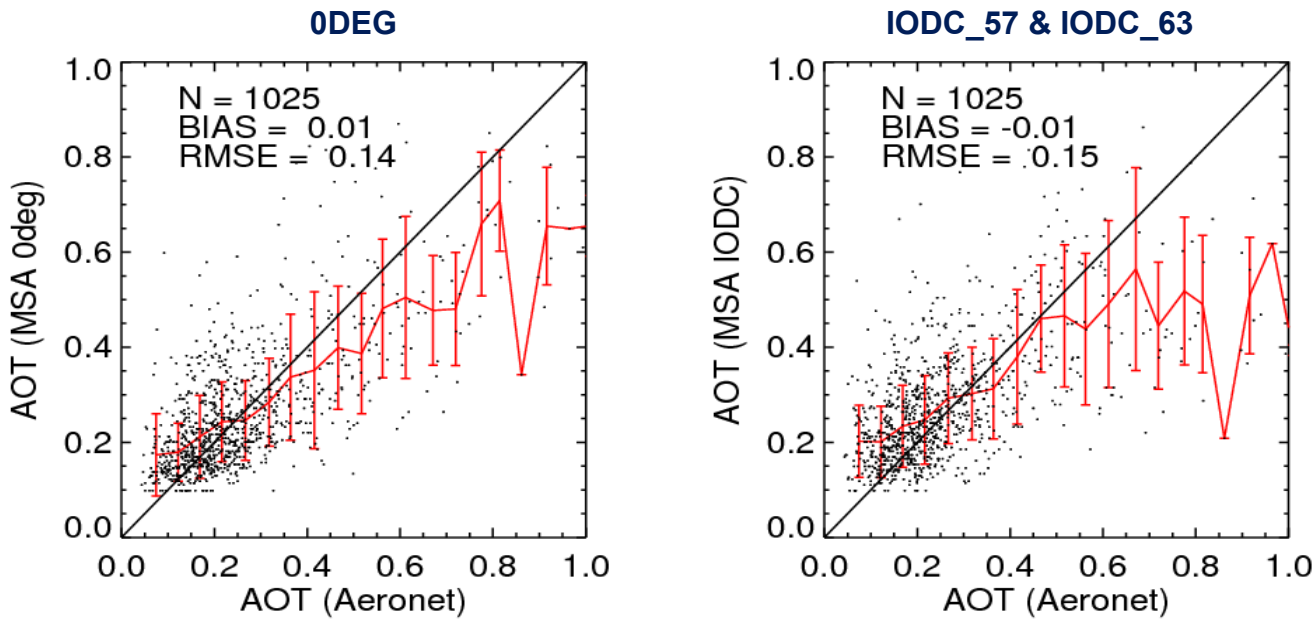
ALBEDOVAL: uncertainty assessment

Comparison of AERONET/MSA aerosol optical thickness (AOT).



- **MSA shows good agreement with AERONET AOD**
  MSA is based on a continental aerosol model only.
- **MSA will inevitably overestimate the AOD for values < 0.1.**
  This is due to the fact that the MSA retrieval is bound to discrete AOD values in the range between 0.1 and 1.0
- **MSA seems to slightly underestimate AOD for higher values**
  This statement is based on a limited number of observations as there exist only very few data points with AOD >0.5.

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ALBEDOVAL: Summary

- The evaluation of the MSA data record (ALBEDOVAL Final report, 2012) showed that the MSA data record agrees well with corresponding values from satellite-derived and ground-based observing systems under many observation conditions and that it has a high temporal stability.
- Some issues of the MSA CDR quality concerning cloud detection (much larger problem over vegetated areas due to higher cloud occurrence) and aerosol related effects (model using continental aerosol only and a limited set of pre-defined values) were also reported.
- 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.

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SCOPE-CM Initiative

Sustained Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring

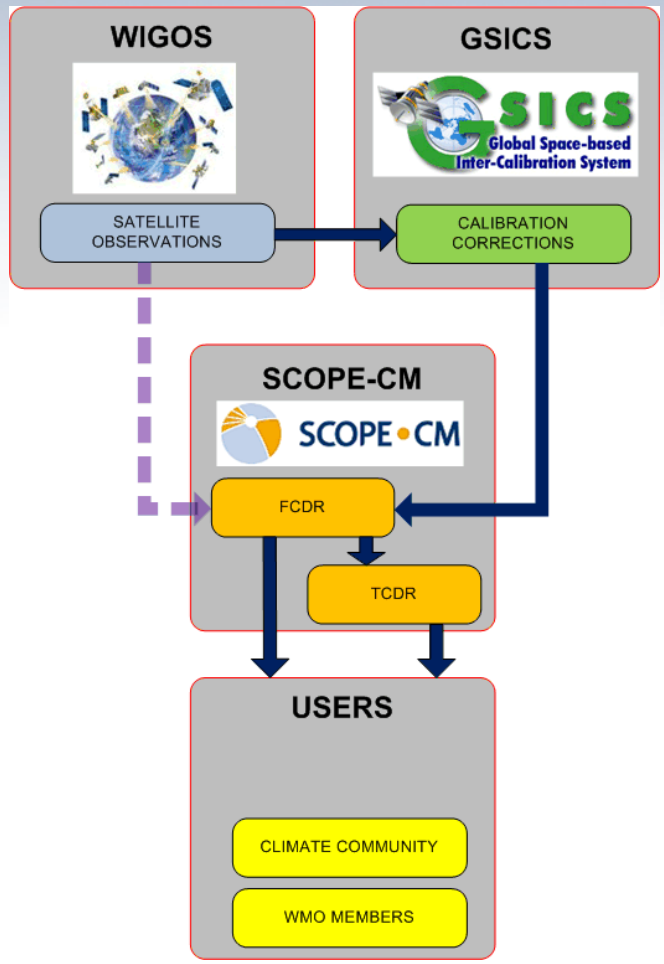
- **What:** Coordinated international network
- **Why:** produce CDRs from multi-agency mission data in operational environment addressing GCOS requirements
- **Who:**

  Operational Satellite operators:

  - NOAA, JMA, CMA, EUMETSAT

  Stakeholder:

  - WMO Space Programme, GCOS, CEOS, CGMS/GSICS, WCRP/GEWEX, ESA (observer)
- SCOPE-CM is "customer" of GSICS



✓ **Phase 1:** Establish the Network through 5 Pilot Projects one was the Land Surface Albedo retrieval from GEO satellites (EUM, NOAA, JMA). Cooperation efforts summarised in a paper appeared on BAMS February 2013.

❖ **Phase 2:** CDR Generation, more ECVs processed, partnership extended (new Implementation plan: Call for projects to be started in 2014)

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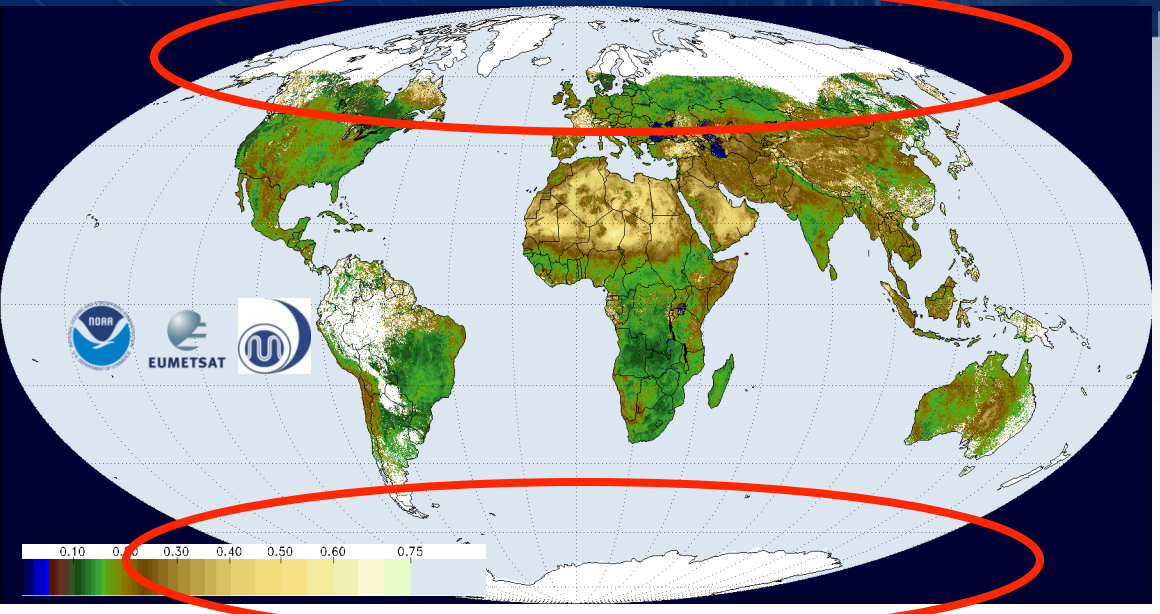
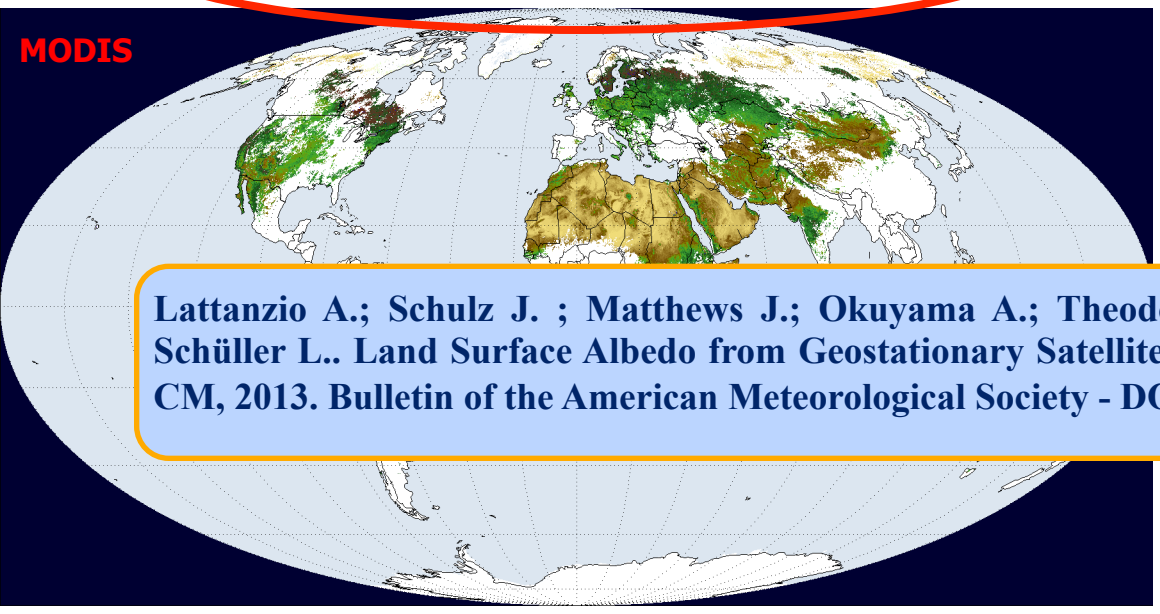
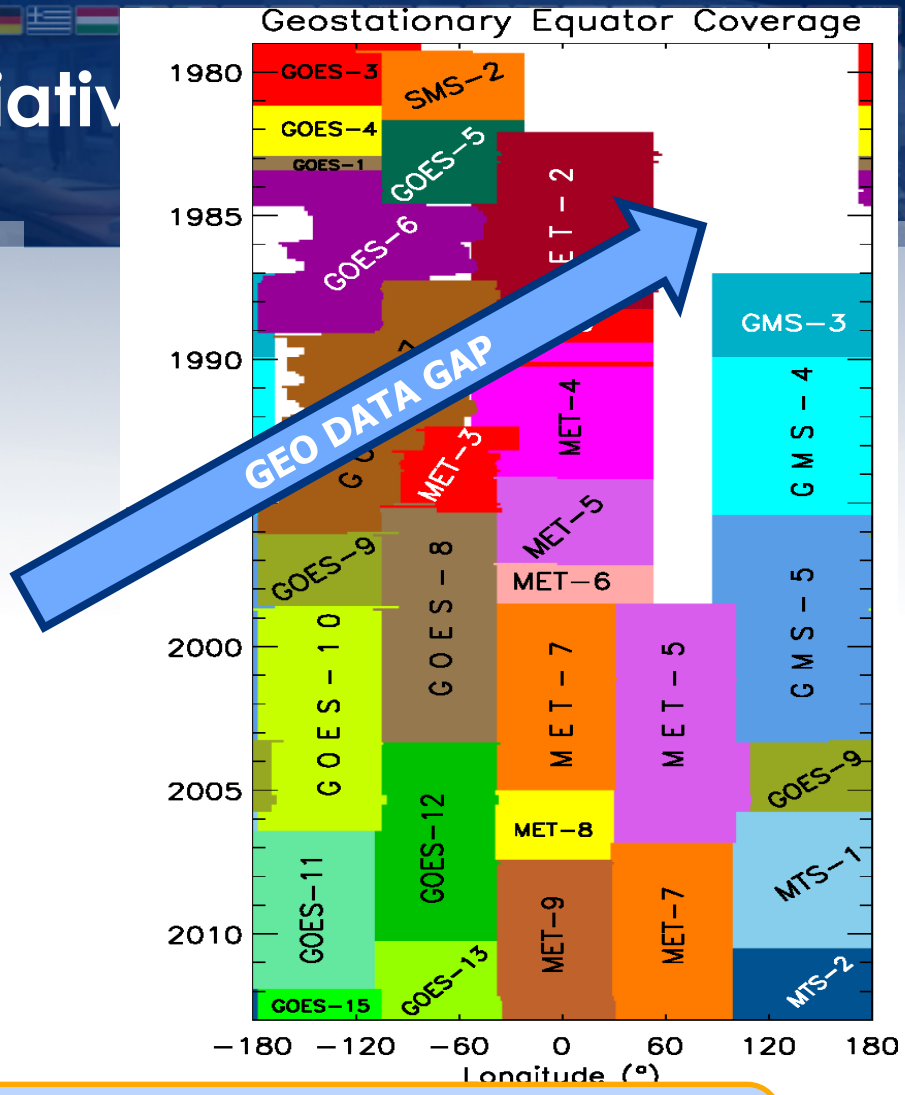
GSA within the SCOPE-CM initiativ







Lattanzio A.; Schulz J. ; Matthews J.; Okuyama A.; Theodore B.; Bates J.J. ; Knapp K.R. ; Kosaka Y.; Schüller L.. Land Surface Albedo from Geostationary Satellites: a multi-agency collaboration within SCOPE-CM, 2013. Bulletin of the American Meteorological Society - DOI:10.1175/BAMS-D-11-00230.1.

%)
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% full
inversion retrieval)

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Project management: Phase 2 Schedule

Task	Year	Actors
– Updates to retrieval scheme including inclusion of common cloud mask approach, utilization of common method of inter-calibration, e.g., DCC method, implementation of common NWP data, implementation of other product output changes such as temporal resolution and format; – Adaptation of retrieval scheme to the SEVIRI and other instruments; – Set up of validation procedures for Level-2 product.	2014	EUM EUM EUM, JMA, NOAA
– Technical assessment of the improved retrieval scheme; – Implementation of updated retrieval scheme at all three agencies; – Processing of data with existing validation counterpart; – Validation of test products.	2015	EUM EUM, JMA, NOAA EUM, JMA, NOAA EUM, JMA, NOAA
– Adaptation and re-implementation of algorithm following validation exercise; – Processing of Level-2 data product for GEO tapestry; – Establish user documentation and prepare for public distribution; – Development of Level-3 product inclusive of user consultation.	2016	EUM EUM, JMA, NOAA EUM, JMA, NOAA EUM, NOAA
– Produce and validate Level-3 product and redistribute to partners; – Perform user driven studies on usage of the product to increase utilization; – Arrange distribution of L2 and L3 products from European, Japanese and US sites.	2017	EUM EUM , JMA, NOAA EUM, JMA, NOAA
– Update common calibration with results from SCOPE-CM inter-calibration project and rerun full data record; – Study product improvements with respect to utilization aspects.	2018	EUM, JMA, NOAA EUM, JMA, NOAA

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Copernicus FP7 Space projects (Call 6) under negotiation

European Commission

- SPA.2013.1.1-01: Global 20th century re-analysis and future coupling methods
- SPA.2013.1.1-02: Ensemble system of regional re-analyses
- SPA.2013.1.1-03: Traceable quality assurance system for multi-decadal ECVs

- SPA.2013.1.1-04: Provision of access to simulated and observed climate datasets and climate indicator toolbox
- SPA.2013.1.1-05: Attribution products

Proposals retained for funding and currently under negotiation

Project Acronym	Title	Coordinator
ERA-CLIM2	European Reanalysis of the Global Climate System	ECMWF
UERRA	Uncertainties in Ensembles of Regional Re-Analyses	SMHI
QA4ECV	Quality Assurance for Essential Climate Variables	KNMI
CLIPC	Copernicus Climate Information Platform (CLIPC)	STFC
EUCLEIA	EUropean CLimate and weather Events: Interpretation and Attribution	UKMO

No Grant Agreements signed yet

Research Executive Agency

QA4ECV

Quality Assurance for Essential Climate Variables

Participant no.	Participant organisation name	Beneficiary short name	Country
1 (Coordinator)	Royal Netherlands Meteorological Institute	KNMI	The Netherlands
2	Belgian Institute for Space Aeronomy	BIRA	Belgium
3	University of Bremen	IUP-UB	Germany
4	Max Planck Institute*	MPI-C	Germany
5	Free University of Brussels	ULB	Belgium
6	CSIC Toledo	CSIC	Spain
7	University of Thessaloniki	AUTH	Greece
8	Eindhoven University of Technology	TUE	The Netherlands
9	Science & Technology	S&T	The Netherlands
10	University College London	UCL	United Kingdom
11	European Joint Research Centre	JRC	International
12	The European Organisation for the Exploitation of Meteorological Satellites	EUM	International
13	Brockmann Consult	BC	Germany
14	FastOpt	FO	Germany
15	Govaerts Consulting	YG	Belgium
16	National Physical Laboratory	NPL	United Kingdom
17	Logica Ltd	LOG	United Kingdom

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QA4ECV

Quality Assurance for Essential Climate Variables

Objectives:

1. Rigorous QA methodologies for satellite ECV products
   - QA framework applicable to many ECVs
   - SW tools for 'do-it-yourself' QA
   - SI standards as in QA4EO (through NPL)
2. Multi-decadal satellite-derived global ECV records
   - 3 Terrestrial and 3 Atmospheric ECVs w/ global coverage
   - Not yet covered by ESA or EUMETSAT activities; 20-30 yr
3. Traceable QA applied to ECV retrievals and products
   - QA4ECV approach applied to independent reference data, ECV retrievals, and final products
4. Information on quality and fit-for-purpose nature of datasets
   - QA Office to audit ECV records against GCOS, WMO crit.
   - Assess impact of ECV records for applications

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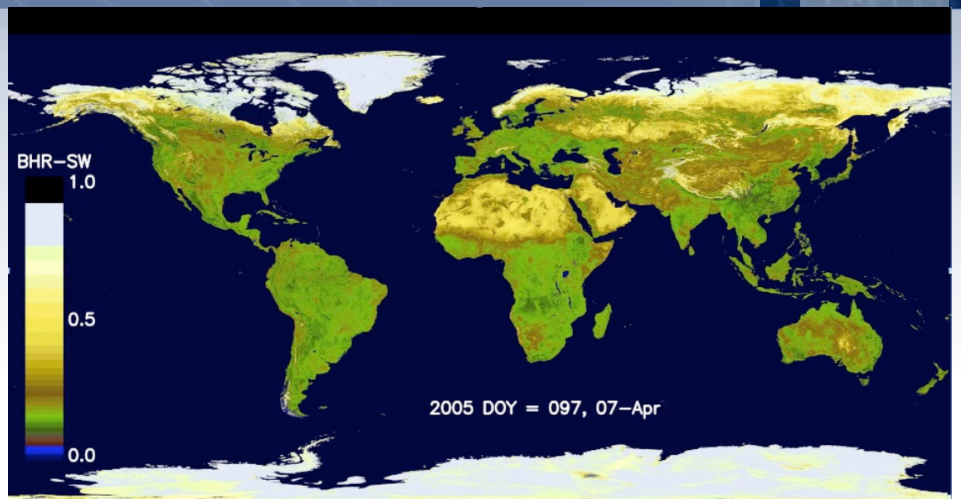
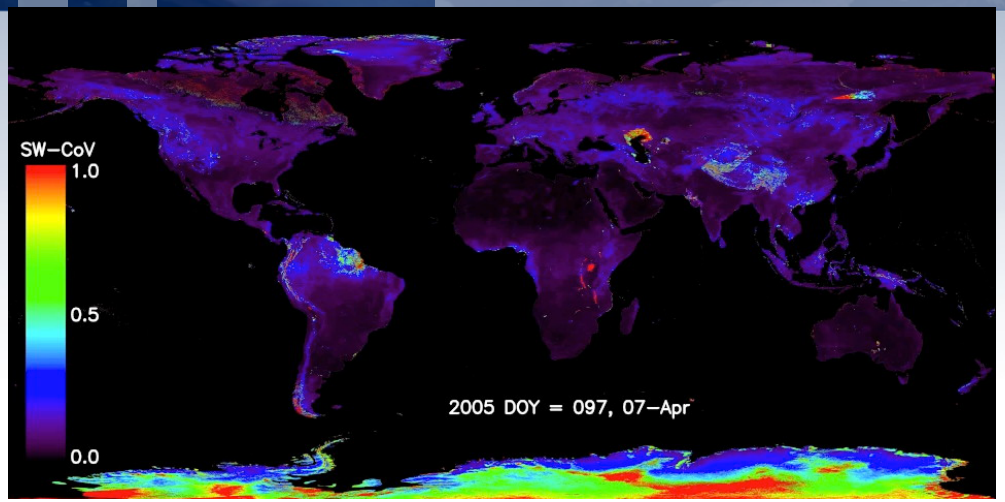
QA4ECV Terrestrial Data Records





Example of GlobAlbedo Shortwave BHR for DoY 97, 7 April 2005 with the corresponding coefficient of variation (i.e. uncertainty/mean) showing the impact of the onset of austral summer.

QA4ECV will make an attempt to produce a multi-decadal multi-instrument surface albedo, LAI, FAPAR data record using:

- Reflectance estimates for MERIS, VEGETATION, MISR and all available geostationary data as input to the GlobAlbedo OE merger;
- Using the surface albedo as input into the JRC Two Stream Package (Pinty et al. (2007)) to derive LAI and FAPAR.

The SCOPE-CM geo albedo project has a key function by providing the geo estimates.

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