Project Description for SCOPE-CM Phase-2

1. Project title

Land surface albedo from geostationary satellites (LAGS)

2. Main applicant

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3. Composition of the project team

EUMETSAT (Darmstadt, Germany)	Alessio Lattanzio, Rob Roebeling
NOAA's NCDC (Asheville, NC, US)	Jessica Matthews, Ken Knapp, William Hankins
JMA (Tokyo, Japan)	Masaya Takahashi

4. Satellite Climate Data Records Capabilities

a. Geophysical parameters

Land surface albedo is a key forcing parameter for the climate system controlling the radiative energy budget. It is the Global Climate Observing System (GCOS) terrestrial Essential Climate Variable (ECV) product T.5 that is described including product requirements in GCOS-154, thus, its monitoring is of primary importance for an understanding of the climate system. Its value changes in space and time, depending on both natural processes (vegetation growth, rain and snowfall and snow melting, wildfires, etc.) and human activities (forestation and deforestation, harvesting crops, anthropogenic fires, etc.). Ground-based measurements are of great importance for the assessment and evaluation of local and regional variability and change, while satellite remote sensing offers a unique opportunity for documenting and monitoring the spatial surface albedo distribution, its variability and change at continental scales. Observations acquired by geostationary satellites have the advantages of offering both a long-term dataset and an angular sampling of the surface as well as providing diurnal sampling of key parameters influencing the retrieval such as cloud cover and aerosol load. The project objective is the generation of a land surface albedo Climate Data Record (CDR) covering the Earth surface seen by geostationary satellites (Polar Regions are not included) for a time window of approximately 30 years. The project aims at a product that includes L2 and L3 surface albedo data records to be utilised in climate science and climate services.

b. GCOS requirements

GCOS defined target requirements for the albedo ECV product for horizontal resolution, temporal resolution, accuracy (uncertainty) and stability are given in GCOS 154. A recent evaluation of the albedo data record, derived from Meteosat First Generation (MFG) data (Fell et al., 2012), has compared product specifications and validation results to the GCOS requirements. In addition the study also assessed if the CDR is compliant with the GCOS Climate Monitoring Principles (GCMP). **Table 1** shows how the Meteosat surface albedo CDR currently stands in the context of GCOS requirements and GCMPs.

ID	Requirement	Source	Fulfilled
GCMP-SAT_01	Consistent sampling within diurnal cycle	GCOS-154	Y
GCMP-SAT_02	Overlap period for old and new satellite systems	GCOS-154	Y
GCMP-SAT_03	Continuity of satellite measurements	GCOS-154	Y
GCMP-SAT_04	Rigorous pre-launch instrument calibration and characterization	GCOS-154	Depending on satellite
GCMP-SAT_05	On-board calibration adequate for climate system observations	GCOS-154	N, vicarious calibr.
GCMP-SAT_06	Sustained operational production of priority climate products	GCOS-154	Does not apply
GCMP-SAT_07	Data systems to facilitate user access	GCOS-154	Y
GCMP-SAT_08	Use of functioning baseline instrument meeting calibration and stability requirements	GCOS-154	Does not apply
GCMP-SAT_09	Complementary in situ baseline observations	GCOS-154	Do not exist
GCMP-SAT_10	Identification of random errors and time dependent biases	GCOS-154	Y, e.g. in ALBEDOVAL
GCOS-HRES	Horizontal resolution (1 km)	GCOS-154	N
GCOS-TRES	Temporal resolution (1-7 days)	GCOS-154	N, but can be achieved
GCOS-ACCU	Accuracy (MAX (5%, 0.0025))	GCOS-154	N (plausible consideration)
GCOS-STAB	Stability (MAX (1%, 0.0001))	GCOS-154	Y (for bright surfaces)

Table 1: *GCOS (GCOS 154, 2011) target requirements and GCMPs for surface albedo along with the assessment for the Meteosat surface albedo data record.*

Table 1 clearly indicates that the target requirements are only partially fulfilled and this SCOPE-CM project is planning improvements to the product that will lead to a better fulfilment of these requirements. In particular, the temporal resolution can be improved because the geostationary sensor sampling is sufficient. However, the albedo study also revealed that the GCOS stability requirement appears to be inconsistent: The (relative) 1% criterion gives higher values than the (absolute) 0.0001 criterion for surfaces with albedo values >0.01 (1% of 0.01 equals to 0.0001). Even the darkest surfaces on Earth are characterised by albedo values >0.01 which implies that the 0.0001 stability criterion in practice never applies. To make it equivalent to the accuracy requirement, the GCOS stability requirement should read “MAX (1%, 0.0005)”. This will be communicated to GCOS and used in the SCOPE-CM project.

c. Satellite sensor record

The set of available geostationary satellites for the generation of a land surface climate data record (CDR) shown in **Figure 1** includes only satellites from Japan (Geostationary Meteorological Satellite (GMS) and Multi-Functional Transport Satellite (MTS)), Europe (Meteosat, (MET)) and United States (Geostationary Orbiting Environmental Satellites, (GOES)). The first result describing the generation of such a dataset can be found in Govaerts et al, 2008.Each sensor is currently calibrated separately employing each agency’s individual operational algorithms. The project targets a more homogeneous approach to calibrate the sensors, e.g., employing the Deep Convective Cloud approach as developed in the Global Space-based Inter-calibration System (GSICS). Additionally, the surface albedo is estimated in the instrument spectral band. For combining and comparing different instruments a spectral conversion needed to be applied, e.g., Loew and Govaerts (2010).

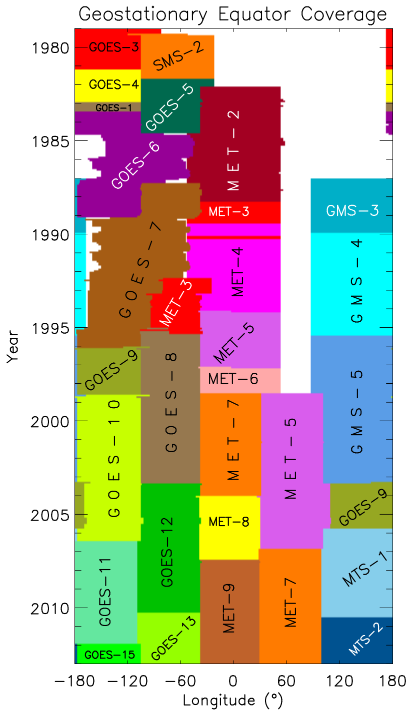

Figure 1: *Temporal and longitudinal coverage of the geostationary platforms planned to be used for generating a land surface albedo product within the SCOPE-CM.*

d. Processing chains

The basic processing chain has been developed by EUMETSAT and was adapted to each involved sensor in collaboration with the partner agencies in the phase 1 SCOPE-CM pilot project. The processing chain including all algorithms is implemented at each participating space agency to generate Level-2 products. A Level-3 product will be produced centrally at EUMETSAT and redistributed to each agency for further distribution to users.

e. Algorithms

Current Level 2 products are generated using one unique algorithm called Geostationary Surface Albedo (GSA). The details of the algorithm are documented in Lattanzio et al., 2012. Information about the retrieval strategy proposed by the Institute for Environment and Sustainability of European Joint Research Centre (IES-JRC) and scientific background can be found in the peer-reviewed literature (Pinty et al., 2000a and 200b). Details on the retrieval error estimation can be found in Govaerts and Lattanzio, 2007.

A recent validation study (Fell et al., 2012) for the MFG record suggested several improvements to the algorithm and to the product definition. Among them are the use of explicit cloud information, direct provision of broadband albedo, daily temporal resolution and NetCDF as output format. This project will incorporate these suggestions into an updated algorithm package.

f. Ancillary Data

The following ancillary data are currently used in the GSA for the generation of the surface albedo:

Data	Format	Description	Resolution	Class
Latitude	Binary	Geo-location of each pixel in the instrument field of view	Pixel resolution	Mandatory
Longitude	Binary	Geo-location of each pixel in the instrument field of view	Pixel resolution	Mandatory
Cloud Mask	Binary	Cloudy: 1 Cloud free: 0	Pixel resolution	Optional
NWP Data	Binary	Total Column Water Vapour (TCWV) and Total Column Ozone (TCO3)	1 degree	Optional (but highly recommended)

Table 2: *List of the GSA ancillary data*

The Latitude and Longitude file are static files generated only once for each processed satellites. The Cloud Mask and the NWP data are dynamic files. The GSA algorithm currently adopts in the first retrieval step a cloud screening module (Pinty et al, 2000b). The usage of a reliable cloud mask can increase the identification of stationary clouds resulting in higher retrieval quality by excluding cloudy pixels. The algorithm can be used with default values for the TCWV and TCO3, but the impact on the quality of the retrieval can be high (Pinty et al., 2000b). One of task planned for year 2014 is the identification of one unique suitable NWP dataset, agreed by all agencies. All the details concerning the GSA algorithm and ancillary data can be found in the software document (Lattanzio, 2010).

5. Justification of the proposed project

a. Historical overview of related activities

Within a pilot project during phase 1 of SCOPE-CM the algorithm and processing chain was extended for processing of other geostationary satellite in 2008. The algorithm and processing chain was successfully implemented at JMA and NOAA-NCDC. JMA processed GMS-5 data for the period 1998-2003 with some gaps due to input data missing. EUMETSAT processed the whole MFG record from 1982 – 2010 over the 0° and Indian Ocean Coverage. NOAA-NCDC processed GOES-W and GOES-E for the time period 2000-2003. By this it was demonstrated that the three partners are capable of implementing the system into their environment and to produce scientifically valid results. Although EUMETSAT undertook a validation study involving independent experts (Fell et al., 2012), the validation of the output of these processing activities is still ongoing and cannot be considered as having high maturity.

The geostationary surface albedo is complementary to its counterparts derived from polar orbiting satellites such as MODIS, MISR, VGT, MERIS and AVHRR. There are several activities in the US and Europe currently delivering surface albedo products in operational manner but not necessarily fulfilling climate requirements. In addition several research projects are targeting combinations of these sensors for a better spatiotemporal coverage, e.g., ESA GlobAlbedo. Within the EUMETSAT Satellite Application Facility network the Land Surface Application SAF has developed a surface albedo algorithm for SEVIRI which is operationally applied and the Climate Monitoring SAF has developed AVHRR surface albedo climatology.

All existing activities will be closely monitored and included in discussions when useful. In particular we plan to collaborate with another proposed SCOPE-CM project on a surface albedo CDR from a combination of MODIS and AVHRR data.

b. Assessment of the feasibility of the proposed project

With the SCOPE-CM phase 1 pilot project the involved agencies have demonstrated that the current approach is feasible. The involved scientists have all the necessary skills to continue the work including updates to the retrieval system. The team spirit during the unfunded activities of phase 1 was demonstrated by a joint publication in the Bulletin of the American Meteorological Society (BAMS) (Lattanzio et al., 2013).

The planned improvements to the calibration approach and the retrieval scheme as well as product output are straightforward and can be included into the currently working processing scheme and for this reason major issues with a first realisation of a longer record are not expected. The needed distributed processing infrastructure is mostly established with some upgrades foreseeable. The project length of 5 years allows for development even if the funding situation is not favourable.

6. Current and targeted Maturity Level

	Software Readiness	Meta Data	Documentation	Validation[1]	Public Access[2]	Utility
Current Maturity level	3	3	3	2	3	3
Targeted Maturity level	5	5	5	5	5	5

[1]The validation activities are currently more mature for Meteosat compared to GOES and GMS satellites. The overall value of 2 is the average of (MET: 3, GOES: 1 and GMS: 1).

[2]As for the validation category the public access is currently only realized for Meteosat but not for GOES and GMS data. The overall maturity of 3 is the average of (MET: 4, GOES: 2 and GMS: 2).

7. Expected results, challenges and potential contributions of the project

We are confident that the resulting CDR will contribute to climate studies answering questions such as on monsoon decadal scale variability. It will further contribute to the evaluation of quality of climate model simulations by entering the Obs4MIPs initiative and to direct estimates of global surface energy budget.

Scientific challenges are the utilization of results from GSICS and the SCOPE-CM project on inter-calibrated radiances including the validation of inter-satellite calibrated VIS channel data in overlapping geographical regions, the utilization of the SEVIRI and other instruments through improvement of the retrieval scheme, an extended validation of the quasi global surface albedo product employing other satellite and ground-based observations and the preparation of potential coupling with surface albedo data records estimated from satellites in polar orbit.

Technical challenges are the sharing and implementation of software in three different computational environments as well as the processing, archiving, exchange and public distribution of products.

8. Duration of the project and tentative schedule

Planned length of project: 5 years; proposed starting date: 1 Jan 2014

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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9. Funding situation

Funding for this project is provided by the participating institutions from their basic funding. This funding may not cover all activities proposed in the Letter of Interest. Currently, only in Europe additional funding is being sought from competitive schemes for the years 2014-2016.

10. Required and available processing capacities

Required is a distributed processing system capable of producing Level 2 output data with a rate of approximately 1 year of data per week limiting the processing time for the 5 geostationary 30 year record to approximately 30 weeks. The computational cost for producing Level 3 data is marginal compared to Level 2. In addition means for exchanging Level 2 and Level 3 data need to be established.

Currently available and planned processing environments are/will be capable of fulfilling these needs.

11. References

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12. Curriculum vitae of the key investigators

EUMETSAT:

Mr Alessio Lattanzio: has a master degree in Physics and has worked in the field of remote sensing since 1998. He has been involved in albedo retrieval development using geostationary satellite since 2002. He is author and co-author of many papers concerning development and validation of albedo and aerosol retrieval algorithms. Mr Lattanzio is working for SCYSIS, Germany and is currently delegated to EUMETSAT where he is involved in different projects concerning the generation of Climate Data Records (CDRs).

Dr. Ir. R.A. (Rob) Roebeling: holds a PhD in Environmental Sciences (2008) from Wageningen University, on Cloud Properties Retrievals from Satellite Observations. He has more than 20 years experience in the field of boundary layer meteorology, crop growth modelling, radiative transfer of the cloud atmosphere and multi-sensor remote sensing. From 2000 till 2011 Dr. Roebeling was employed at KNMI as Senior Scientist, where he acted as project manager, principal investigator and co-investigator of many research projects. In addition, he was leading a research group and head of the Observations Cluster within the Weather Research department of KNMI. Since 2011, he is working for EUMETSAT as Climate Product Expert, where he leads projects related to the generation of climate data records, and coordinates international efforts to better serve the climate research community with these records. He publishes actively, and serves as editor for Meteorology and Atmospheric Physics and as reviewer for several journals.

NOAA:

Dr. Jessica Matthews: holds a PhD in Applied Mathematics (2010) from North Carolina State University. She has more than 10 years experience producing mathematical models and implementing computer programs for physical and biological applications. Her research specialties include nonlinear parameter optimization, sensitivity analysis, and uncertainty quantification techniques. Dr. Matthews has been the point of contact for this project at NCDC since 2010.

William Hankins is a Scientific Programmer IV at Earth Resources Technology (ERT, Inc.) He has more than 25 years experience working on computer science projects. Since 2008 Mr. Hankins has supported Climate Data Record (CDR) generation for NOAA's National Climatic Data Center in Asheville, NC, USA.

Dr. Ken Knapp: holds a PhD from Colorado State University (2000) in Atmospheric Science. He has published numerous papers on scientific applications of geostationary data and is presently chief of the Products Branch in the Remote Sensing and Applications Division of NOAA's National Climatic Data Center.

JMA:

Mr. Masaya Takahashi: holds a Master of Science (2005) from Kyushu University in geophysics. He is currently the technical officer of System Engineering Division of the Meteorological Satellite Center, the Japan Meteorological Agency. He is GPRC (GSICS Processing and Research Centre) points of contacts for operational matters, and a member of the GSICS Research Working Group.

ANNEX A. Work plan for Year 2014

The work plan presented here contains a list of the tasks the team intends to perform and an indication of the schedule. The schedule is divided in quarters of year (Q1, Q2, Q3, and Q4). Some tasks starting in 2014 might need to be continued in 2015.

Regarding the availability of resources in EUM, JMA and NCDC this work plan is subject to change. Since the submission of the Letter of Interest to the SCOPE-CM secretariat, EUMETSAT has received a positive evaluation of a proposal to the European Commission that will likely enable EUMETSAT to perform the work as proposed here.

Task	Sub-Tasks	Period	Actors
Change of Level 2 product specifications	• Generation of a daily product instead of a 10 days composite • NetCDF4 format, Climate Forecast standard compliant: full definition and implementation of data and metadata	Q1	EUM
Residual Cloud Removal	• Investigate different approaches for cloud detection and removal (usage of the IR channel, seasonal variation, surface type, etc.) that could be included in the GSA retrieval scheme. • Investigate available cloud mask products at the proper spatial and temporal resolution for all GEO platforms involved.	Q1-Q3	EUM, JMA, NOAA
Inter-calibration	• Apply common methods for inter-calibration of the VIS channel. Existing GSICS methodology such as Deep Convective Clouds will be examined to allow progress with the production of an albedo time series. At a later stage, results from the SCOPE-CM project on inter-satellite calibration will be used for further improvements.	Q1-Q3	EUM, JMA, NOAA
NWP Data	• Establish a common set of NWP data (see Table 2)	Q2	EUM, JMA, NOAA
Inclusion of other GEO instruments	• Investigate available options for best usage of the SEVIRI instrument in the current retrieval scheme • Investigate potential inclusion of further instruments.	Q3-Q4	EUM EUM, JMA, NOAA
Implementation of changes to the GSA software	• Implement potential changes to the input image data ingestion due to new methods for residual cloud removal, inter-calibration and new instruments. • Develop software changes as needed.	Q4	EUM EUM, JMA, NOAA
Validation	• Start development of a common protocol for evaluation of the resulting time series (see for instance Fell et al., 2012), encompassing: methods, validation datasets, software.	Q4	EUM, JMA, NOAA
Reporting and Planning	• Report to SEP, establish web content and create work plan for 2015.	Q1,Q3 and Q4	EUM, JMA, NOAA