Letter of Intent for SCOPE-CM Phase 2

1. Project title

Atmospheric Motion Vectors (AMV) and Clear/All Sky Radiances (CSR/ASR) from historical meteorological satellites in geostationary and polar orbit

2. Main applicant:

Mr. Yoshihiko Tahara

Data Processing Department
Meteorological Satellite Center
Japan Meteorological Agency
3-235 Nakakiyoto, Kiyose-shi
Tokyo 204-0012, JAPAN
Japan

Telephone: +81-42-493-4970

Website: mscweb.kishou.go.jp

e-mail: y-tahara@met.kishou.go.jp

3. Composition of the project team for this project

JMA (Tokyo, Japan)	Yoshihiko Tahara, Toshiyuki Kurino Shinya Kobayashi
EUMETSAT (Darmstadt, Germany)	Jörg Schulz, Rob Roebeling
NOAA's NCDC (Asheville, NC, USA)	Ken Knapp, Jaime Danielson

4. Please identify the satellite Climate Data Records capabilities

a. Geophysical parameters

The major objective of this project is to provide Atmospheric Motion Vectors (AMV), Clear Sky Radiances (CSR) and All Sky Radiances (ASR) for the use in global and potentially regional Numerical Weather Prediction (NWP) model-based reanalysis. Furthermore, AMV data provided on regular grids may also be utilised in the analysis of dynamical systems in relation to water vapour transport or monsoon studies.

AMVs are derived by tracking clouds and water vapour features, computing the displacement vector and assigning a height to the resulting vector according to the temperature of the tracked element/structure. AMV height assignment is the major source of uncertainty in the AMV products[1]. Today's operational AMV products are not always equipped with a quantitative uncertainty estimate which is a major area for improvement.

The CSR/ASR products[2] provides radiances and brightness temperatures averaged over cloud-free/all pixels on a specific processing segment, e.g., 16 x 16 pixels. It is derived from images in all thermal (e.g. infrared and water-vapor) channels. In addition to clear sky radiances and brightness temperatures such products often contain cloud coverage information, statistical information, latitude/longitude of the clear pixels, satellite zenith and solar zenith angle of the clear pixels and land/sea flag.

[1] Velden, C.S., and K.M. Bedka, 2008: Identifying the Uncertainty in Determining Satellite-Derived Atmospheric Motion Vector Height Assignments. *J. Appl. Meteor.*, **48**, 450-463, DOI: 10.1175/2008JAMC1957.1.

[2]

b. Satellite sensor record

Table 1 shows the history of geostationary satellites, whose observed images were used for generation of AMV. Operations were started at four orbit positions around 1980, and full global coverage has been available since 1997 moving Meteosat-5over the Indian Ocean by EUMETSAT.

In addition to the geostationary imagers, AMVs can also be derived from instruments on board polar orbiting satellites providing measurements in infrared window and water vapour absorption channels. Instruments utilised by CIMSS and EUMETSAT are AVHHR (IR-window) [3] and MODIS (IR window and water vapour)[4]. AVHRR data coverage reaches back to 1979 and MODIS data coverage starts in 2000.

Table 1: Geostationary AMV data coverage.

Satellite System	Position Longitude	Period	Image rate for AMV derivation	Comments
GOES-E	75° W	1980 – today	Variable	
GOES-W	135° W	1980 – today	Variable	
Meteosat (2 - 10)	0°	1982 – 2004 2004 - today	30 min 15 min	
Meteosat (5 and 7)	63° E 57° E	1997 – 2005 2005 - today	30 min 30 min	Called Indian Ocean Data Coverage (IODC)
Meteosat 3	70° W 75° W	1991 – 1993 1993 – 1995	30 min 30 min	Called Atlantic Data Coverage (ADC) Called eXtended ADC (XADC)
GMS (GOES-9)	140° E 155° E	1978 – 2003 2003 – 2005	30 min 30 min	GOES-9 was put at the Western Pacific Region
MTSAT	140° E 145° E	2005 – 2010 2010 – today	15 min, 30 min, 60 min	

c. Algorithms and Processing chains

The overarching objective would be an AMV processing system that could be applicable to all historical geostationary satellites. The existing processing systems at EUMETSAT and JMA do not have this capability, but could be extended. The CIMSS AMV derivation algorithm is capable of reprocessing all historical MODIS, AVHRR, GOES, Meteosat and GMS/MTSAT images.

The existing algorithms differ between AMV processing agencies, and a first step towards a more unified algorithm would be the analysis of the differences. The project would seek close inetraction with the CGMS International Winds Working Group (IWWG) to benefit from ongoing comparison activities that might need to be enhanced to cover the temporal dimension of the AMV long term records.

The reprocessing of AMV requires the background fields of NWP, which are crucial for its height assignment. The periods of the exsisting reanalyses fully cover the operation periods of historical meteorological satellites. Thus, the updated reanalysis fields are expected to be used in the AMV reprocess with the quality information of the reanalysis fields. The project would exchange information with reanalysis communities on their calculation plans and the quality.

[3] http://noaasis.noaa.gov/NOAASIS/ml/avhrr.html (NOAA/NESDIS)
http://www.eumetsat.int/Home/Main/Satellites/Metop/Instruments/SP_2010053153142514 (EUMETSAT)

[4] http://modis.gsfc.nasa.gov/ (NASA)

5. Justification of the proposed project

a. Historical overview of related activities

The first reanalysis was the 15-year ECMWF Reanalysis (ERA-15)[5]. ERA-15 collected and used historical AMV data generated operationally[6]. Such reanalysis activity was extended to other NWP centres such as NCEP/NWS/NOAA, JMA and NASA, and some of them performed reanalysis calculation repeatedly extending period and upgrading NWP and data assimilation system.

As the extension of reanalysis, accurate observation data were requested. To meet the requirement, EUMETSAT firstly reprocessed AMV for past Meteosat. It reprocessed Meteosat -2 - 7 AMV and provided to ECMWF for ERA-40[7]. The first reprocessing by JMA was performed to provide reprocessed GMS-3 to -5 AMV to the Japanese 25-year Reanalysis (JRA-25). EUMETSAT and JMA continued the reprocess of not only AMV but also CSR for their historical satellites under the framework of SCOPE-CM as phase 1 pilot project.

Currently, EUMETSAT is performing a reprocessing of AMVs, CSRs and ASRs for Meteosat-8 and 9 data within the ERA-CLIM project.

b. Summary of proposed project

The major points to work on to reach the goal of this project are:

- Analysis of the feasibility and usefulness of GOES based AMV products;
- Analysis of differences in AMV, CSR and ASR product definition, algorithms and processing chains for instruments in geostationary and polar orbit;
- Development of a plan for a more coherent product suite for all instruments;
- Enhancement of AMV algorithms with a quantitative uncertainty estimate;
- Establishment of a validation framework for AMVs by agreeing on a metric, certain quality analysed non satellite observations and by utilising means from reanalysis centres;
- Enhancement of the documentation towards a coherent description of the products

Close cooperation with the proposed inter-satellite calibration project for geostationary satellites is key to a successful processing of improved CSR and ASR products.

Cooperation with re-analysis projects is intended and needed; the project will encourage reanalysis centres to give feedback and support AMV, CSR and ASR validation exercises by involving observation feedback archives and associated tools as such developed at ECMWF. The best forum identified for discussion of data issues is the WCRP Data Advisory Council that has representation from reanalysis centres and CGMS that could represent the SCOPE-CM results. Furthermore in Japan a direct link to JMA reanalysis activities exist, and in Europe ECMWF and EUMESAT are collaborating in a European reanalysis project (ERA-CLIM).

c. Assessment of the feasibility of the proposed project

With the SCOPE-CM phase 1 pilot project JMA and EUMETSAT have demonstrated the feasibility of reprocessing of longer series from geosattionary data. CIMSS has demonstrated the potential for the reprocessing of data from polar orbit. The involved scientists have all

[5] GIBSON, J.K. ; KÅLLBERG, P. ; UPPALA, S. ; NOMURA, A.; HERNANDEZ, A. ; SERRANO, E.: ERA Description. In: ECMWF ERA-15 Project Report Series (1997), Nr. 1. – ECMWF

[6] ERA-15 Project Report Series No. 3 Uppala, S. Observing system performance in ERS September 1997

[7] Uppala, S. M. et al, 2005: The ERA-40 re-analysis, Q. J. of RMS, Vol. 131, Issue 612, pp 2961–3012.

necessary skills to perform the work including updates of the retrieval system, processing chains, etc.

The planned improvements to the retrieval scheme as well as product output need to be elaborated but the project length of 5 years allows a development even if the funding situation is not favourable at all times. The needed distributed processing infrastructure is mostly established with some upgrades foreseeable.

6. Current and targeted Maturity Level

The software used to create AMV, CSR and ASR products is in operational use and can be considered mature. However, as one objective of this project is to present the products in a more coherent way by potentially using a common software some development can be envisaged. GOES data records have never been reprocessed, thus, some of the current maturity estimates here are based on the experience gained in the SCOPE-CM phase 1 pilot project performed by JMA and EUMETSAT.

	Software Readiness	**Meta Data**	**Documentation**	**Validation**	**Public Access**	**Utility**
Current Maturity level	3	3	3	2	4	5
Targeted Maturity level	5	5	5	5	5	6

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

As indicated above the major use of the products is within NWP-based reanalysis where AMVs are an important component. The projects strives for a delivery of coherent AMV, CSR and ASR products from the fleet of geostationary satellites and a few instruments in polar orbit.

Specific issues for this project are:

- GMS-1 to 5, GOES-9 (West Pacific) and MTSAT AMVs have been reprocessed by using the current operational processing algorithm to provide the JMA reanalysis project and now in the framework of the SCOPE-CM phase 1 pilot project. GMS-5, GOES-9 (West Pacific) and MTSAT CSRs have also been reprocessed. JMA plans to develop AMV and CSR algorithms for Himawari-8/9, and reprocess using the algorithms taking into account of adjustment for more coherent products and the selection of reanalysis fields.
- Meteosat First Generation AMVs, CSR and ASR products have been reprocessed in the framework of the SCOPE-CM phase 1 pilot project up to 2001. Meteosat Second Generation products from 2004 onwards will be reprocessed during 2013. In particular the CSR and ASR products show significant biases between the two satellite generations which need to be mitigated by proper recalibration (see letter of intent on Inter-calibration of geosataionary observations). Also the definition of the AMV product and the employed retrieval schemes are different and need to be adjusted to produce a more coherent product.
- Meteosat First Generation Data also suffer from changes in the navigation algorithm over time and image anomalies originating from eclipse times that are not treated in the best way one could. Also individual instrument issues such as the loose lense problem on Meteosat-5 need another analysis. EUMETSAT is currently preparing for an image reprocessing for the first generation data to improve this but it is a complex activity and it cannot be guaranteed that improved images will be used in this project.
- Analysis of actual image coverage for GOES satellites due to scheduling of image taking according to satellite locations and configurations (1 vs. 2 satellites on station), and weather events (i.e. rapid scan operations). This analysis needs to be performed

prior to any other activity to demonstrate the expected temporal and spatial coverage of the AMV reprocessing. The result shall also be run through a feedbackloop with major reanalysis centres.

- Calibration and navigation for GOES prior to 1995 is an issue and would need to be improved prior to any AMV reprocessing. This will include objective procedures to renavigate the images using landmarks and co-register them for AMV tracking, and conduct intercalibration with other satellites (e.g., AVHRR) to improve the radiometric information. Both of these are essential for accurate AMV determination. In addition, these improvements to the GOES data record will be useful for other climate applications (cloud analysis, etc.). The recalibration activities shall be performed in the geostationary satellites inter-calibration project.
- A complete AVHRR archive from 1982 to present of the operational satellites is available at CIMSS whch was also copied to ECMWF computers where it is accessible to EUMETSAT. CIMSS recently completed a reprocessing of AVHRR polar AMVs from 1982-2009 and EUMETSAT is processing Metop-A AVHRR data employing the full spatial resolution of AVHRR using the oeprational EUMETSAT algorithm and the CIMSS algorithm. After the analysis of results the project can aim at a second reprocessing of the AVHRR series employing an improved algorithm with an uncertainty estimate.
- MODIS data could be employed for a reprocessing of MODIS winds after adaptation of the existing processing chain used for AVHRR.
- Further challenges can be the use of a novel leo/geo concept for AMV processing (Hoover et al. 2012)[8] to fill in the gaps between geostationary and polar coverage: 60 – 70° N/S. Also new research activities to track features from satellite sounder humidity retrievals from AIRS (Santek et al. 2012)[9], CriS and IASI with the adavantage of providing more vertical levels at the expense of spatial resolutions can be computed in clear sky areas.
- To enhance the exchange of information on the activities of AMV and CSR/ASR reprocess by providers and reanalysis by users, a portal site of this project will be opened.

8. Duration of the project and tentative schedule

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

Task	Year	Actors
− Review on the use of AMV and CSR in past reanalysis; − Analyze requirement for future reanalysis; − Analyze the differences in AMV product definition, algorithms and processing chains and develop a plan for a globally coherent product; − Perform feasibility analysis of GOES AMV processing with respect to satellite observation schedule and forward analysis result to reanalysis centres; − Encourage other space agencies operating geostationary instruments to join the project; − Open a project portal site	2014	All All JMA, EUM, NOAA, NOAA JMA, EUM JMA
− Build common validation framework following agreed metric involving radiosonde observations and tools provided by	2015	EUM, JMA, NOAA

[8] Hoover, B., D. Santek, M. Lazzara, R. Dworak, J. Key, C. Velden, N. Bearson, 2012. High Latitude Satellite-Derived Winds From Combined Geostationary and Polar Orbiting Satellite Data. Proc. of the Eleventh International Winds Workshop, Auckland, NZ, 20-24 February 2012. http://cimss.ssec.wisc.edu/iwwg/iww11/talks/Session3_Hoover.pdf

[9] Santek D., S. Nebuda, C. Velden, J. Key, 2012. Deriving Atmospheric Motion Vectors From AIRS Moisture Retrieval Data. Proc. of the Eleventh International Winds Workshop, Auckland, NZ, 20-24 February 2012. http://cimss.ssec.wisc.edu/iwwg/iww11/talks/Session2_Santek.pdf

Task	Year	Actors
reanalysis centres; – Perform processing of geostationary products;		EUM, JMA, NOAA
– Perform processing of polar orbit data; – Perform processing of geostationary products (continue); – Validate products from geostationary satellites; – Analyze feedback on early phase products from reanalysis centers	2016	EUM EUM, JMA, NOAA All
– Update the documentation of all products in coherent style; – Validate products from polar orbiting satellites;	2017	EUM , JMA, NOAA
– Analyze feedback on products from reanalysis centres and other applications and develop a plan for SCOPE-CM phase 3	2018	All

9. Indicate the funding situation

Funding for this project is only provided by the participating institutions from their basic funding. This funding may not cover all activities proposed in this LoI as the needed fundig can be estimated to be about 5-6 FTEs for 5 years distributed over the partners. Currently, in Europe additional funding is being sought from competitive schemes for the years 2014-2016. The content of the proposal was discussed with NOAA but the current US funding situation remains difficult and a firm committment at the time of writing was not possible. However, the contribution of NOAA to the project is maintained.

10. Required and available processing capacities;

Currently available and planned processing environments are/will be capable of fulfilling all processing needs. For instance the current AVHRR AMV processing system on a Linux cluster at CIMSS can reprocess AMVs from two NOAA polar satellites over the entire archive in less than one week. Full reprocessing of geosationary needs more resources but technically it is certainly feasible.

11. Curriculum vitae of the key investigators

JMA:

Mr Toshiyuki Kurino: is the director of the Data Processing Department at MSC/JMA. After graduating from the Meteorological Collage, he joined MSC engaging mostly in development of GMS products. He also has seven years experiment to develop land surface analysis for climate forecast introducing microwave imagers.

Mr Yoshihiko Tahara: is the head of the System Engineering Division at MSC/JMA. He is now in charge of the operation of MTSAT and data process on the ground. He has nine years experience to develop data assimilation techniques of AMV, scatterometer and brightness temperature as well as to develop a fast radiative transfer model. Then, he has five years experience in validation for MTSAT calibration involved in GSICS.

Mr Shinya Kobayashi: has been a member of the Japanese Reanalysis (JRA) group of the Climate Prediction Division (CPD) at JMA since 2003. He has worked on the JRA-25 project and is presently working on the JRA-55 project. From April 2006 to March 2008, he also worked on the ERA-Interim project at ECMWF. He has 10 years experience in satellite data assimilation for reanalyses as well as in validation of the reprocessed AMVs and CSRs from GMS/MTSAT.

EUMETSAT:

Dr. Jörg Schulz: is the head of the Climate Section at EUMETSAT. He is leading EUMETSAT activities within the European Re-Analysis of Global Climate Observation project funded by the European Union that is concerned with the generation of CDRs for global model-based reanalysis containing Atmospheric Motion Vectors and radiance products. He has more than 25 years experience in retrieval of various atmospheric and oceanic parameters using observations in the visible, infrared and microwave spectral range, radiative transfer, satellite instrument inter-calibration and system engineering.

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 was leading a research group on cloud physics and head of the three Observations Sections within the Weather Research Division. In 2011, he started 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 is co-chair of the Cloud Retrieval Evaluation Working Group (CRE-WG). He publishes actively, and serves as editor for Meteorology and Atmospheric Physics and as reviewer for several journals.

NOAA:

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.