Project name: Advancing the status of the AVHRR FCDR

Project (proposal) leader (name, affiliation, address):

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Team composition (participating organisations and eventually stakeholders):

- EUMETSAT Climate Monitoring SAF project (CM SAF) Involved scientists:

  Karl-Göran Karlsson, SMHI, Sweden (Key investigator)
  (Karl-Goran.Karlsson@smhi.se)

  Martin Stengel, DWD, Germany
  (Martin.Stengel@dwd.de)

  Jan Fokke Meirink, KNMI, The Netherlands
  (meirink@knmi.nl)

- NOAA/ NESDIS Center for Satellite Applications and Research, Involved scientists:

  Andrew Heidinger, USA (Key investigator)
  (Andrew.Heidinger@ssec.wisc.edu)

  Jon Mittaz, USA
  Jon.mittaz@noaa.gov

- ESA Climate Change Initiative project (ESA-CLOUD-CCI)
  Involved scientists:

  Caroline Poulsen, RAL, UK (Key investigator)
  (Caroline.Poulsen@stfc.ac.uk)

  Dave Smith, RAL, UK
  (Dave.Smith@stfc.ac.uk)

Identification of satellite CDR capability (geophysical parameters, satellite sensor record (inter)-calibration, processing chains, algorithms):

The AVHRR sensor was the first operational imaging instrument (launched 1978) with multispectral observation capability of clouds, aerosols and Earth surfaces. Numerous CDRs have been compiled based on AVHRR data through the years. Since the sensor still operates on current space platforms and since its spectral channels are inherited on many future sensors, the AVHRR dataset must be considered as one of the cornerstones of the satellite-based climate monitoring program.

Justification of the project including a very brief summary of the related work from the literature, and an assessment of the feasibility of the proposed activity:

Through the work of CEOS WGCV and GSICS there have been improvements in the methods to provide consistent radiometric calibration of optical sensors in recent years. The emphasis of this work has primarily focused on current operational missions to address the basic level-1 radiometry. Although this goes some way towards providing consistent datasets, this does not fully address the effects on long term FCDRs. Even for well calibrated sensors, differences in spectral response, view geometry and overpass times can introduce apparent biases that have major impacts on providing consistent FCDRs. It is therefore essential that these differences are well characterised and understood to account for these.

This project aims at securing a continuing improvement of the AVHRR fundamental climate data record (FCDR) comprising accurately calibrated and inter-calibrated radiances. Substantial progress has been achieved here in recent years (e.g., Heidinger et al., 2010) but additional efforts are needed for reaching optimal results (as pointed out by Molling et al., 2010). Uncertainties also remain regarding the calibration of the infrared channels (e.g. Mittaz & Harris 2011). Additionally, several other aspects than the pure calibration accuracy influence the ability to deduce trustworthy climate trends from AVHRR data.

Some of them are image navigation accuracies, temporal coverage and resolution (affecting observation homogeneity) and orbital drift. The intention is to also address some of these aspects in this activity.

The fact that the overall task is quite demanding and requiring coordination between several research groups motivates proposing this activity as a SCOPE-CM activity. Noteworthy is also that AVHRR calibration activities have been going on for a while also outside of the US (e.g. in the ESA-CLOUD-CCI project) which further emphasizes the need for an international coordination of the efforts.

References:

Heidinger, A.K., Straka, W.C., Molling, C.C., Sullivan, J.T. and Wu, X.Q.: Deriving an inter-sensor consistent calibration for the AVHRR solar reflectance data record. Int. J. Rem. Sens., 31(24), 6493-6517, 2010.

Mittaz, J.P.D. & A.R. Harris, "A Physical Method for the Calibration of the AVHRR/3 Thermal IR Channels. Part II: An In-Orbit Comparison of the AVHRR Longwave Thermal IR Channels on board MetOp-A with IASI", J. Atmos. Oceanic Technol., 28, 1072-1087, 2011

Molling, C., Heidinger, A., Straka, W. and Wu, X.: Calibrations for AVHRR channels 1 and 2: review and path towards consensus, Int. J. Rem. Sens., 31(24), 6519-6540, 2010.

Current and targeted Maturity Level (see Maturity Matrix Model):

Development has definitely passed the lowest maturity levels (1-2) but since full consensus about methodologies has still not been reached the current status is estimated to reside at level 3 for some time. A target could be to reach maturity level 4 within a five-year period.

Expected results, challenges and potential contributions of the project

- Consensus about calibration of visible channels (either by choosing one single reference method or by merging results from different approaches)
- Using other calibration references (e.g., VIIRS, AATSR, MERIS) than the most recently used reference (MODIS)
- Reducing uncertainties in comparison with other sensors by modeling the impact of spectral variations for inter-comparison methods based on both selected surface sites and simultaneous nadir observations (SNOs)
- Finding appropriate correction schemes for infrared calibration or updated calibration coefficients/methods

- Revisiting AVHRR GAC navigation accuracy – complementing existing clock error corrections with image-based methods (pattern matching) for estimating effects of varying satellite attitude parameters
- Providing guidance for optimal homogenization of data (e.g., Level 2b vs Level 3, diurnal sampling, etc.)
- Testing approaches for orbital drift on all data levels (Level 1, Level 2, Level 3)

Expected project duration and tentative schedule

A long-term commitment (minimum 5 years) is foreseen. A more detailed schedule formulated around the previously mentioned tasks has to be defined but it is difficult to do this at present time (since pending the outcome of upcoming project proposals).

Funding situation (current grants, expected funding proposals)

Grants currently available (or foreseen) until 2016-2017 in CM SAF, NOAA and ESA-CLOUD-CCI.

CM SAF: ~ ½ scientist position

NOAA: : ~ ½ scientist position (Fy2013 only). No funding secured after this year.

ESA-CLOUD-CCI: ~ ½ scientist position

More resources are needed to guarantee sufficient progress. New proposals are being prepared or planned (e.g., proposals to national space agencies, proposals to ESA-CLOUD-CCI project Phase 2 or to NOAA CDR program).

Needed and available processing capacities:

Current processing facilities are probably sufficient. More important is to get scientists to work with these tasks.

Curriculum vitae of the key investigators and list of key partners (maximum 1 page for each investigator; these are not included in the 4-page limit of the letter of intent)

CVs for key investigators Karl-Göran Karlsson (CM SAF), Andrew Heidinger (NOAA) and Caroline Poulsen (RAL) are given in the following pages. Key partners are listed on previous pages 1-2.

Curriculum Vitae for Karl-Göran Karlsson

Name: Karl-Göran O. Karlsson

Date of birth: 29.04.1959
Place of birth: Falkenberg, Sweden

Professional status:
Since January 1990: Research Scientist, Meteorological Remote Sensing Section, Research and Development Department, SMHI. Status: permanent position, full time

Projects:
EUMETSAT Climate Monitoring Satellite Application Facility project (CM-SAF):
Project member representing SMHI since November 1998.
January 2004-February 2012: CM SAF Work Package manager for Cloud studies (full time). Responsible for activities in the CM SAF Clouds group consisting of about seven scientists at SMHI, DWD (Germany) and KNMI (the Netherlands).
March 2013 until present: Responsible for CM SAF Clouds, Albedo and Radiation dataset from AVHRR data (CLARA-A).

ESA-CLOUD-CCI project:
October 2010-present: Responsible for work packages related to AVHRR, MODIS, AATSR and MERIS calibration monitoring.

Publications (peer reviewed) related to recent projects:

Schulz, J. et al. (24 named authors), 2009: Operational climate monitoring from space:The EUMETSAT Satellite Application Facility on Climate Monitoring (CM-SAF), *Atmos. Chem. Phys.*, **9**, 1687-1709.

Kaspar, F., R. Hollmann, M. Lockhoff, K.-G. Karlsson, A. Dybbroe, P. Fuchs, N. Selbach, D. Stein and J. Schulz, 2009: Operational generation of AVHRR-based cloud products for Europe and the Arctic at EUMETSAT's Satellite Application Facility on Climate Monitoring (CM-SAF), *Adv. Sci. Res.*, **3**, 45-51.

Karlsson, K.-G., and A. Dybbroe, 2010: Evaluation of Arctic cloud products from the EUMETSAT Climate Monitoring Satellite Application Facility based on CALIPSO-CALIOP observations, *Atmos. Chem. Phys.*, **10**, 1789-1807.

Karlsson, K.-G., Riihelä, A., Müller, R., Meirink, J.F., Sedlar, J., Stengel, M., Lockhoff, M., Trentmann, J., Kaspar, F., Hollmann, R., and Wolters, E., 2013: CLARA-A1: The CM SAF cloud, albedo and radiation dataset from 28 yr of global AVHRR data. *Atmos. Chem. Phys. Disc*., **13**, 935-982, www.atmos-chem-phys-discuss.net/13/935/2013/ , doi:10.5194/acpd-13-935-2013.

Karlsson, K.-G., and Johansson, E., 2013: On the optimal method for evaluating cloud products from passive satellite imagery using CALIPSO-CALIOP data: Example investigating the CM SAF CLARA-A1 dataset, Accepted (January 2013) in *Atmos. Meas. Tech.*

Curriculum Vitae for Andrew Heidinger

Name: Andrew K. Heidinger

Date of birth: 28.04.1969
Place of birth: Cleveland, USA

Professional status:
Since January 1998: Physical Scientist, Center for Satellite Applications and Research, NOAA/NESDIS

Projects:

- Recalibration of AVHRR Solar Reflectance Channels
- Delivery and Maintenance of NOAA AVHRR Pathfinder Atmospheres Extended Data
- Lead of GOES-R AWG Cloud Team
- Lead of JPSS Cloud Team
- Responsible for current NOAA Operational Cloud Products from AVHRR and GOES

Recent Relevant Publications

Heidinger, Andrew K.; Evan, Amato T.; Foster, Michael J. and Walther, Andi. A naive Bayesian cloud-detection scheme derived from CALIPSO and applied within PATMOS-x. Journal of Applied Meteorology and Climatology, Volume 51, Issue 6, 2012, 1129–1144.

Walther, Andi and Heidinger, Andrew K. Implementation of the Daytime Cloud Optical and Microphysical Properties algorithm (DCOMP) in PATMOS-x. Journal of Applied Meteorology and Climatology, Volume 51, Issue 7, 2012, 1371–1390.

Foster, Michael J.; Bennartz, Ralf and Heidinger, Andrew. Estimation of liquid cloud properties that conserve total-scene reflectance using satellite measurements. Journal of Applied Meteorology and Climatology, Volume 50, Issue 1, 2011, pp.96-109.

Nielsen, J. K.; Foster, M. and Heidinger, A. Tropical stratospheric cloud climatology from the PATMOS-x dataset: An assessment of convective contributions to stratospheric water. Geophysical Research Letters, Volume 38, 2011, doi:10.1029/2011GL049329.

Zhao, X.-P. Tom; Heidinger, Andrew K. and Knapp, Kenneth R. Long-term trends of zonally averaged aerosol optical thickness observed from operational satellite AVHRR instrument. Meteorological Applications, Volume 18, Issue 4, 2011, pp.440-445.

Heidinger, Andrew K.; Straka, William C. III; Molling, Christine C.; Sullivan, Jerry T. and Wu, Xiangqian. Deriving an inter-sensor consistent calibration for the AVHRR solar reflectance data record. International Journal of Remote Sensing, Volume 31, Issue 24, 2010, pp.6493-6517.

Curriculum Vitae for Caroline Poulsen

Name: Caroline Poulsen

Date of birth: 13.07.1970

Place of birth: Melbourne, Australia

Professional status:

Since August 2002: Research Scientist, Rutherford Appleton Laboratory, RAL Space, Remote Sensing group. Status: permanent position, full time

Projects:

Caroline is involved in a diverse range of projects that are predominantly related to retrieving aerosol and cloud from visible-infrared passive remote sensing satellites. Since 2009 she has been a member of the ESA Cloud CCI Consortium and ESA Aerosol CCI consortium responsible for developing retrieval code for aerosol and cloud parameters. She has a particular interest in the AATSR instrument, is a member of the AATSR Science Advisory group and has participated in calibration projects for AATSR.

Publications (peer reviewed) related to recent projects:

Poulsen, C. A., Watts, P. D., Thomas, G. E., Sayer, A. M., Siddans, R., Grainger, R. G., Lawrence, B. N., Campmany, E., Dean, S. M., and Arnold, C.: Cloud retrievals from satellite data using optimal estimation: evaluation and application to ATSR, Atmos. Meas. Tech. Discuss., 4, 2389-2431, doi:10.5194/amtd-4-2389-2011 (Accepted June 2012)

Sayer, A. M., Poulsen, C. A., Arnold, C., Campmany, E., Dean, S., Ewen, G. B. L., Grainger, R.G., Lawrence, B. N., Siddans, R., Thomas, G. E., and Watts, P. D.: Global retrieval of ATSR cloud parameters and evaluation (GRAPE): dataset assessment, Atmos. Chem. Phys., 11, 3913-3936,doi:10.5194/acp-11-3913-2011, 2011

E. Carboni, G.E. Thomas, A.M. Sayer, R. Siddans, C.A. Poulsen et al Intercomparison of desert dust optical depth from satellite measurements, Atmos. Meas. Tech., 4, 1567–1580, 2011, www.atmos-meas-tech.net/4/1567/2011/doi:10.5194/amt-4-1567-2011

D.L. Smith, C. Poulsen, B. Latter, Multi Mission Cal-Val Report version 1.1 ESA technical report, Doc No: PO-RP-RAL-AT-0599 , 2009(S)