

RO-CLIM Project Plan and Progress Report

Note: Format, main outline is based on the Letter of Intent

1. Project title:

“Radio occultation based gridded climate data sets - RO-CLIM”

2. Main applicant¹:

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3. Project team:

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4. Purpose of the Document

This document collects the within the team agreed annual project plan steps and (once applicable), the progress reports of the RO-CLIM project. The overall aim of the 5 year RO-CLIM project is presented in the RO-CLIM Project Description [RO-CLIM PD]. Within this document the annual steps on the intended areas of activity for a particular year are summarized, and, after each year a short progress report is added. This progress report is then also used for reporting to the SCOPE-CM Executive Panel (SEP).

¹ The project lead of RO-CLIM was shifted from Axel von Engeln, EUMETSAT, to Hans Gleisner, EUMETSAT ROM SAF/DMI, on 24 March 2014.

5. Annual Project Plan

a. 2016

The RO-CLIM Project Description, originally submitted to SCOPE-CM, lists the expected results of the RO-CLIM project (summarized in Sections 5c and 7 in [RO-CLIM PD]). These are briefly: 1) to make the ROTrends CHAMP data set publically available, 2) to extend the CHAMP data time series by including more missions, 3) to provide a shorter-duration, higher-resolution post-CHAMP data set, 4) to generate a co-located reanalysis data set, and 5) an overall increased *maturity* of the data sets.

With this in mind, the following development steps are foreseen for the 3rd year. The lead institute, if any, is given in brackets:

- Work towards an extended RO-CLIM data set:
 - reprocess data from CHAMP, GRACE, COSMIC, Metop, and other available missions – if required, and pending resources (all centres);
 - collect observational profile data provided by each center, generate gridded monthly mean fields, and begin analysis according to plans (WEGC);
 - estimate uncertainties (due to measurement and residual sampling errors) following the methods devised by Scherllin-Pirscher et al. (WEGC);
 - use the RO-CLIM data set in a cal/val study, comparing RO, radiosonde, and ATMS/AMSU data. This activity depends on funding by NASA (UCAR, DMI);
 - initial maturity assessment of the extended data set according to the Maturity Matrix Model (DMI);
- Continue building capacity for climate-model usage of RO data:
 - work towards inclusion of RO data as a formal obs4MIPs data set, by submitting requests to the WCRP obs4MIPs task team (JPL, DMI);
 - seeking clarification of the possibility to provide bending angle and refractivity as a formal obs4MIPs data set for CMIP-6 (DMI);
 - promoting the use of COSP simulator/forward-modelling tools for RO data in climate-model runs (DMI);

6. Annual Progress Report

a. 2015

Administrative

The RO-CLIM project (SCM-08) is slowly progressing according to plan. During 2015, there were two telecon meetings held, in February and November, and the project status was reported at the SCOPE-CM Executive Panel meeting (SEP-10) in Geneva in March 2015. The project web page is now also accessible from the SCOPE-CM web site (<http://www.scope-cm.org/projects/scm-08>) with public access to RO-CLIM data sets and access to common project documents.

Project work

The RO-CLIM project largely builds upon the informal *ROtrends* collaboration between six RO processing centres, extended with expertise on RO technology, re-analysis, and climate modelling. The progress of the RO-CLIM project reflects this background.

1) Re-assessment of the currently implemented processing software, partly based on the outcome of *ROtrends*/RO-CLIM studies, has been done at several centres, e.g. the ROM SAF now use the BAROCLIM climatology as the default bending-angle *a priori* in the operational reprocessing system.

2) Several centers have generated, or are about to generate, new reprocessed data sets. These will be used in the extended, multi-mission data set to be analysed by WEGC (see point 4 below).

3) The CHAMP data set from the *ROtrends* project is now publically available at the RO-CLIM web page, together with a basic User Guide. The RO-CLIM climate data record (with version number 2, to conform with the *ROtrends* "rounds" numbering) thus consists of an *ensemble* of data sets from the participating centers. The data record has undergone a new maturity assessment.

4) An initial set of multi-mission data (including data from the CHAMP, GRACE, COSMIC, Metop, SAC-C, and TerraSAR-X missions) covering two months were previously collected and analysed by WEGC (Andrea Steiner). Collection of multi-mission data for the full time period Sep 2001 to Dec 2013 is ongoing, but will extend well into 2016. The data encompass a large fraction of currently available RO data, and will be analysed by WEGC according to current *ROtrends* plans. These data also form the basis for the extended RO-CLIM data set.

5) Bending angle profiles from the CHAMP mission for Dec 2006 and July 2008 were previously collected by JPL (Chi Ao). The impact of quality-control procedures on the data numbers and the causes of discrepancies between retrieved refractivity profiles were investigated. This has now been followed by studies and simulation experiments to understand the impact of vertical smoothing on L1 and L2 bending angle differences.

6) The JPL team has made substantial progress towards formally submitting an RO dataset for Obs4MIPs. The dataset is derived from the latest post-processed version of CHAMP and COSMIC profiles retrieved at JPL. It consists of monthly averages of temperature and geopotential height on a 5 degree x 5 degree latitude-longitude grid from 400 hPa to 10 hPa, obtained with a Bayesian mapping technique with spherical harmonics basis functions up to 18th degree.

7. Obsolete Annual Project Plans

a. 2014

The following development steps are foreseen for the 1st year, the lead institute/scientist is given in brackets:

- Increase maturity level of the *ROtrends* CHAMP data set by:
 - re-assess implemented processing software at center, in particular with respect to the initialization of bending angles at higher altitudes, re-process data set if required, investigate outlier statistics (all centres);
 - cross-check data set against radio occultation data from more recent missions that overlap with CHAMP, such as COSMIC, GRACE, GRAS (WEGC);
 - provide information on the structural uncertainty of the CHAMP data set in form of tables (Andrea Steiner);
 - generate an ensemble of products, i.e. RO data are provided by each centre, including uncertainty information (representative of each centre);
 - generate a re-analysis based data set that uses the same processing and gridding setup as the instrument one, using e.g. ERA-Interim data or ERA-CLIM if available (Sean Healy, Axel von Engel, Hans Gleisner);
 - improve documentation of data set (representative of each centre);
 - make information publicly available through <http://www.scope-cm.org>, pointing to a dedicated project page at <http://www.irowg.org> which includes links to the individual centres. The download data will be hosted at <http://www.romsaf.org>. (Andrea Steiner, Ben Ho, Hans Gleisner, Axel von Engel).
- Start the generation of the extended ROTrends data set that includes more recent missions and will be updated throughout the project:
 - develop a common Level 1A format that can be used across the different centers (Christian Marquardt, Doug Hunt, DMI, representative of each centre);
 - develop capability at the different centers to ingest this format into their processing (representative of each centre).

b. 2015

The following development steps are foreseen for the 2nd year. The lead institute and/or scientist is given in brackets:

- Increase maturity level of the *ROtrends* CHAMP data set by:
 - re-assessment of the high-altitude smoothing and initialization of bending angles that are currently used at the processing centres, and reprocess data set if required (JPL, all centres);
 - cross-check CHAMP data set against RO data from more recent missions that overlap with CHAMP, such as COSMIC, GRACE, Metop (WEGC, UCAR);
 - make the *ROtrends* CHAMP climate data ensemble, including uncertainty information and with a minimum amount of documentation, publically available on the RO-CLIM web page (DMI);
 - assessment of the CHAMP climate data set according to the Maturity Matrix Model (DMI);
 - generate a reanalysis data set that uses the same sampling and gridding setup as the instrument one, based on e.g. ERA-Interim (DMI, EUMETSAT);
- Initiate the development of higher-resolution RO climate data sets by:
 - identification of missions, time periods, resolutions, etc.
 - identification of gridding methods, handling of multi-mission data, etc.
- Build capacity for climate-model usage of RO data:
 - assessment of RO data as an obs4MIPs data set: potential of, e.g., dry temperature as a CMIP-5 observational data set, potential for an RO contribution to the CMIP-6/7 protocols, and clarification of the possibilities to provide several RO data sets or ensembles of data to obs4MIPs (JPL, DMI, UCAR);

8. Obsolete Annual Progress Reports

a. 2014

Administrative

The RO-CLIM project (SCM-08) is slowly progressing according to plan, although a few changes of the plan have been made during the period. The project lead was shifted from Axel von Engel (EUMETSAT) to Hans Gleisner (ROM SAF/DMI) on March 24, 2014. During 2014, there were two telecon meetings held, in March and September, as well as a splinter meeting at the COSMIC Data User Workshop in Boulder in October 2014. A project web page is now in place, with common access to documents (<http://irowg.org/projects/ro-clim-under-scope-cm>). RO-CLIM progress was reported by Hans Gleisner at the SCOPE-CM telecon on November 10, 2014.

Project work

The RO-CLIM project largely builds upon the informal *ROtrends* collaboration between six RO processing centres, extended with expertise on RO technology, re-analysis, and climate modelling. Over the last few years, the *ROtrends* collaboration resulted in three published journal articles on the quantification of uncertainties of RO data. The progress of the RO-CLIM project during the first year reflects this background.

1) Re-assessment of the currently implemented processing software, partly based on the outcome of *ROtrends*/RO-CLIM studies, has been ongoing at several centres, e.g. DMI has implemented the use of the BAROCLIM climatology as *a priori* in the statistical optimization of bending angles.

2) Bending angle profiles from the CHAMP mission for Dec 2006 and July 2008 were collected by JPL (Chi Ao). The impact of quality-control procedures on the data numbers and the causes of discrepancies between retrieved refractivity profiles were investigated. Earlier results on the importance of QC procedures were confirmed, and two causes of differences amongst centres were identified: vertical smoothing and high-altitude initialization of bending angles. These issues will be further addressed in the RO-CLIM project work.

3) An initial set of multi-mission data (including data from the CHAMP, GRACE, COSMIC, Metop, SAC-C, and TerraSAR-X missions) for July 2008 and Jan 2011 were collected by WEGC (Andrea Steiner). Statistics for each centre, as well as difference statistics for a subset of centres, were computed and presented at a RO-CLIM telecon. The results form the basis for a larger study on multi-mission data, encompassing a large fraction of the currently available RO data.

4) A common RO climate data set, consisting of a six-member ensemble based on data from the CHAMP mission, has been collected, and the associated structural uncertainties has been quantified and documented. A publically available access point for the RO climate data has been allocated at the RO-CLIM web page. The documentation is currently in the form of published journal articles, but will be extended with a brief note on usage and data format. The data set will be made publically available during 2015 – see Section 5b (annual project plans).

5) The JPL team has made substantial progress towards formally submitting an RO dataset for Obs4MIPs. The dataset is derived from the latest post-processed version of CHAMP and COSMIC profiles retrieved at JPL. It consists of monthly averages of temperature and geopotential height on a 5 degree x 5 degree latitude-longitude grid from 400 hPa to 10 hPa, obtained with a Bayesian mapping technique with spherical harmonics basis functions up to 18th degree.

6) The project plan for 2014 also covered the development of a common Level 1A file format (i.e., excess phase, amplitude, and satellite orbit data) to be used across the different centres and missions. However, it was concluded that the work required, and the complexities involved, in developing a generic Level 1A file format may be substantial, and most likely not worth the effort. Hence, it was agreed not to further pursue this task.

Presentations, international activities, etc.

A brief summary of the RO-CLIM project was contributed to a CEOS/CGMS WGClimate report to SBSTA-21 (solicited by John Bates, WGClimate Chair). SBSTA is a permanent subsidiary body of the UNFCCC and reports at the COP meetings.

9. References:

[RO-CLIM PD] SCOPE-CM RO-CLIM Project Description, EUM/RSP/DOC/13/701839, available at <http://www.scope-cm.org>.