CMUG Meeting Report

Name: Report on Third CCI Project Integration Meeting, 3-5 June 2013
Due date: 1 July 2013
Submission date: 18 September 2013
Version: 1.0

Climate Modelling User Group

Report on Third CCI Project Integration Meeting, 3-5 June 2013, MPI-M Hamburg

Centres providing input: MOHC, MPI-M, ECMWF, MétéoFrance

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0.1	17 July 2013	First draft for input by CMUG partners
0.2	6 August 2013	Including comments from CMUG
0.3	20 August 2013	ESA comments addressed
0.4	17 Sept. 2013	Updated with input from participants
1.0	18 Sept. 2013	Final submission to ESA

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MPI-M, Hamburg, Germany,

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This document summarises the scientific content of the meeting from presentations and discussions, and captures key points noted by delegates.

1. Overview

This meeting organised by the CMUG and hosted by MPI-M allowed CCI projects to show their results (preliminary, test or CRDP, as available), and brainstormed future CCI potential in the context of the science challenges that climate research faces. The meeting was also an opportunity for CMUG to present results from its work on precursor and CCI preliminary and final datasets. The aims for the meeting, prescribed in advance, were as follows:

1. *to review CCI progress and current status*
2. *to assess the tasks which remain for successful delivery of Phase 1*
3. *to scope ideas for Phase 2*
4. *to consolidate links to external agents*

The meeting started with three key note presentations from invited experts on the science challenges that climate research faces. The topics were on advanced dataset production, Earth System Model development, and understanding the climate through an Earth System component (soil moisture). After this high level view there were presentations and discussion on the CMUG research on datasets of: Ocean Colour, SST, SSH, Soil Moisture and Landcover (CCI preliminary datasets); Ozone (CRDP), Fire and Aerosols (precursor datasets). This was followed by a presentation on data visualisation.

The final activity of day 1 was a “scientific speed dating” session. The aim was to elicit rapid responses on topics of interest to the CCI through parallel brainstorming in small rotating groups. This activity was kept ‘light touch’ and ‘rapid’ to allow a broad set of responses without over analysis (see Section 7). This is the first time “scientific speed dating” was tried at an integration meeting, and it was unanimously agreed to have achieved its goals and be of benefit.

On Tuesday morning there were parallel sessions on the marine, atmosphere and land domains allowing the ECV teams to provide updates on how they are addressing research challenges. There followed two parallel brainstorming sessions comprising a substantive part of the meeting, one for science leads and the other for the Climate Research Groups. The free form discussion promoted in these groups allowed interesting ideas to be expressed on developing and delivering the remaining work, and how CCI Phase 2 could evolve. Summaries of these brainstorming groups were presented at a final plenary session on the final morning.

Lastly, on day three there were expert presentations on data metrics, Obs4MIPs, FP7 Core-Climax, and data visualisation. The final presentation was from the ESA heads of Climate and the CCI which gave their view of future CCI evolution, including Phase 2. The key points from the presentations and the outcomes from discussions are summarised in this report.

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All the presentations from the meeting are available on the CMUG web site at:
http://dialspace.dial.pipex.com/prod/dialspace/town/estate/gtp89/cmug/integration3.html

2. Summary of key note presentations

Key remarks from the key note presentations

1. Data handling and data mining techniques developed in other fields might be of use in climate research and processing climate data.
2. Knowledge of the process links between Earth domains, and their drivers, are key to developing and constraining climate models.
3. Climate models can be demonstrably shown to have improved over the last 10 years in their ability to model the climate for specific ECV variables, while there has been slow progress for other variables (e.g. precipitation)

The meeting was opened by Alex Loew **(MPI-M)** and Roger Saunders **(Met Office Hadley Centre)** describing the meeting aims and objectives. **Mark Doherty (ESA)** gave a short presentation of the programmatic context for the meeting and the opportunities it gave for advancing the CCI, including Phase 2.

David Lary (University of Texas) presented on Long Term Datasets: Uncertainty, cross-calibration, data fusion and machine learning. Using a different co-ordinate system based on PV-latitude for HCl measurements it was shown that PDFs of ozone observations were not coincident as would be expected. The separation of representative uncertainty from instrument uncertainty was demonstrated, and also the use of machine learning in the absence of adequate or complete theoretical models, through the use of regression and classification. Results of aerosol transport with these techniques was shown.

Colin Jones (SMHI) talked on Earth System Models and the role of observations. He described many of the linkages between Earth, ocean and atmosphere, including for example a higher chlorophyll concentration pulling CO_2 out of the atmosphere, and methane plumes released in the Arctic Ocean. Knowledge of these processes will help to constrain future climate change feedbacks. It was demonstrated that model simulations are improving in their ability to simulate climate through the advances in temperature and precipitation characterisation seen in CMIP2, CMIP3 and CMIP5 simulations. The biggest uncertainty in all this is the response of clouds in a changing climate. Compared EC-Earth and ERA-Interim data with Cloud CCI data, and found good agreement except over snow regions. Colin also tried using MODIS and CloudSAT datasets for a comparison with EC-Earth output from an ISCCP simulator, but the data sets were too different for this to work. Finally he showed that CO_2 uptake as a function of temperature can be used in present climate for future climate sensitivity.

Sonia Seneviratne (ETH) gave a presentation on soil moisture and why it is a key parameter in understanding the climate system, the water cycle and the carbon cycle. Soil moisture-temperature feedbacks were described, and it was also shown that precipitation is not the only factor which governs soil moisture but also evapotranspiration. The international soil moisture network is declining especially in Russia. Looking at the Soil Moisture CCI it was shown that some droughts are not captured probably because the data only looks at top thin layer of soil. A Taylor plot also showed that there is departure between observed soil moisture in the CCI and modelled values.

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3. Summary of CMUG dataset assessments

Key remarks
1. CMUG evaluations of preliminary CCI datasets have found areas to investigate for improvement.
2. CMUG results on all precursor datasets demonstrated a utility in their application to climate models.
3. It was stressed that not only the parameter but its associated uncertainty should be assessed.
4. CMUG assessments of precursor and preliminary datasets are available on the CMUG website.

Introduction
In this session CMUG researchers presented the results of their recent work on both precursor datasets and preliminary ECV datasets. Some of these results have been presented in the following CMUG deliverables published in the last twelve months which are available on the CMUG website.
D3.1_1A: Technical note on CMUG ECV Quality Assessment Report (v1.2)
D3.1_1B: Technical note on CMUG ECV Soil Moisture Assessment Report (v0.5)
D3.1_1C: Cross precursor assessment on Soil Moisture, Land Cover and Fire (v0.4)

SST
Roger Saunders summarised the Met Office assessment of a preliminary version of the SST CCI dataset, which was made through a comparison with the ARC SST dataset and in-situ observations. (The ARC SST dataset had also been evaluated by CMUG as a pre-cursor dataset.) The key results noted were the difference in coverage between ARC and CCI; a two channel bias in SST which was anomalously high for the short segment of data tested (6 months); and a three channel bias which is slightly higher than ARC. The SST team are looking into the differences and will issue a revised dataset. It was stated that the final analysis will cover the full time series of both (A)ATSR and (A)ATSR+AVHRR.

Ocean Colour
Also presented by Roger Saunders, for the Ocean Colour assessment a comparison was made between a preliminary version of the Ocean Colour CCI dataset and the GlobCOLOUR ocean colour pre-cursor dataset. It was seen that the two datasets are in general similar, but that OC CCI has greater geographical coverage, sometimes in key areas (Arabian sea during monsoon time). The CCI products have some high magnitude, noisy observations in the Southern Ocean, which is also seen at high latitudes in the winter hemisphere. Apart from at high latitudes, the CCI product is slightly smoother. The CCI dataset gives improved ocean reanalyses, above that seen with GlobColour, when assimilated into a climate model – which in turn has an effect on the carbon cycle in the model.

SSH
Serge Planton compared the AVISO SSH with the SSH CCI preliminary dataset and the RCSM4 coupled model reanalyses over the period 2993 to 2009. The results were that evaluation of coupled or uncoupled regional climate models with CCI SSH could demonstrate the added value of the new product (improved resolution, better accuracy, etc.). That evaluation over the Mediterranean area is a good opportunity due to MedCORDEX international modelling exercise and the HyMEX field experiment starting this year. Lastly that there is also the opportunity to evaluate consistency with other CCI products over the region (SST, aerosols, etc.) taking advantage of the development of regional climate system models.

Ozone
Rossana Dragani presented the results of her work on Ozone ECV dataset. The Ozone dataset comprised merged Level 3 data for nadir profile (2008) and total column (1996-2011) from ERA-interim and MACC. The results were, for merged Nadir Profiles that there was reasonable consistency in variability and absolute values; that the ozone mmr values seem to be underestimated at 10 hPa (ozone max) in the tropics, and globally below the maximum (30 hPa) compared with reanalyses; and that near the

tropopause, values are similar to ERA-Interim, but (~20%) lower than MACC. For merged total column ozone the results were that there was good annual variability, but not in phase with MACC; good homogeneity but some problems in spring 1997 perhaps caused by GOME anomalies and in mid-2002 that could be due to the introduction of SCIAMACHY. The ozone hole seems deeper than showed by reanalyses and standard deviations have a few unreasonably low values, lastly, quality flags may be useful also on L3.
Thierry Phulpin of CNES presented the results of his work on the Ozone CRDP which was done using the MOCAGE chemistry model with the ARPEGE climate model. Limb profile, total column and nadir profile were all examined for the year 2008. The results for limb profile was that good agreement between model outputs and CCI product was seen at certain conditions (levels, locations, time) but with some scattering. Large error estimates of CCI limb products below 100 hPa were seen. Better agreement with MOCAGE was seen when assimilated with IASI+ MLS. Artefacts are visible on the map of CCI products

Aerosol
Rossana Dragani presented the results of her work on the Aerosol ECV dataset. The aerosol dataset comprised the AOD from AATSR ADV, ORAC and SU, in the year of 2008. The results seen are that the three AATSR datasets are very close during winter months (Jan-Mar, and Oct-Dec), with the largest differences during Apr-Sept. The SU4.0 dataset seems to be the closest to the MACC reanalyses both in terms of global mean values and temporal evolution.

Fire, Land Cover and Soil Moisture
Silvia Kloster (MPI-M) presented results of the MPI-M work on the terrestrial ECVs which was done using the JSBACH model. Soil moisture is a prognostic variable, land cover is a boundary condition and burnt area is both. (Note: the soil moisture assessment has already been presented by CMUG in Report D3.1_v1b). For Fire CCI only data is for test sites at present but global data is being requested. GFED provides vegetation type and it is important that this should be included in the CCI burned area product also, as it is for better end users, especially modellers. The conclusions to date are as follows. For the Soil Moisture preliminary dataset there is reasonable agreement with the ERA‐interim and JSBACH modelled soil moisture, there are discontinuities in the time series, and a functional link exists between SM and Fire. For the Fire precursor dataset the conversion from burned area to fire carbon emissions needs the information of the vegetation type burned. For the Land Cover CCI preliminary dataset, comparison with GlobCover by use of both as boundary conditions in JSBACH gives very similar results.

4. Summary of Earth domain parallel groups

4.1 Introduction

Three parallel sessions were conducted, for the domains of Land, Ocean and Atmosphere. The science leads for the ECV projects in these domains presented their results from the last twelve months especially where preliminary or CRDP data has been produced.

4.2 Land

Key remarks
1. Data, where available, show clear improvements over existing products.
2. In depth descriptions of uncertainty for data products were not always given.

Land Cover
Reported that first prototype data has been produced. The contents for CRDP v1.0 were confirmed as: 7-d surface reflectance for MERIS FR and RR; Land cover states for 3 epochs; Land cover conditions for Snow, Burnt Areas, NDVI; Permanent Water bodies map; Aggregation tool (to convert LC map to gridded PFT).

Fire
The presentation went through the phenomena of fire, its causes, occurrence, key features and impacts. It also described future possible changes to trends of fire, and questioned the drivers of occurrence and magnitude which will affect these trends. It then went on to outline the objectives of the Fire CCI and the data products and production for Phase 1. The advantages for CCI Fire over current Fire datasets was given as: (i) improved pre-processing, (ii) extended time series, (iii) first global burned area product from MERIS, (iv) merged product from three ESA sensors (VGT-ATSR-MERIS), and (v) full validation and uncertainty characterization. Problems with discrimination in satellite data have been found, especially for seasonal changes.

Soil Moisture
Version 0.1 data package was released in June 2012. The presentation described the satellite data sources, algorithm development and validation techniques. The data product is described in a BAMS publication. Other key points raised were: (i) validation based on in-situ data appears to be a delicate task, (ii) there is good correlation with in-situ data and reanalysis in areas with strong seasonal cycle (close to the Equator, Australia, central Asia); (iii) there is consistency over time with respect to ERA-Land, and (iv) SM seems to be useful for a better understanding of vegetation activity

Ice Sheets
An overview of user requirements and the product development and validation being conducted to meet them was given. The first prototype data will be released in September 2013.

Glaciers
The product development work and early velocity and elevation data products including Pamir test site were described (preliminary data available within the CCI for evaluation). Information about coupling glacier models with climate models was also given.

4.3 Ocean

Key remarks
1. A formal metric-based review of the CDRs should be considered.
2. In depth descriptions of uncertainty for data products were not always given.
3. No agreement in CCI has been reached on the use of the UncertML (Uncertainty Markup Language).

SST
The AVHRR SST work was described and also the problems encountered with the NOAA-12 satellite. There is a need to reprocess the Level 1 AVHRR data for SST, clouds and aerosol CDRs, but it is not clear whether NOAA will do this. It was proposed that a formal metric-based review of the CDRs should be considered to cover uncertainty and SI traceability. The *UncertML* could be used, but there is no agreement yet in the CCI on definition of variables. It took 6 weeks to get the ARC SST data into Obs4MIPs.

Sea-ice
The round-robin comparison results with 27 algorithms were presented. The OSI-SAF was the best and will be adopted for production. The new SMOS thin ice product is causing interest as this is not measured by Cryosat. Snow depth data is needed over ice.

Ocean Colour
The OC CCI project reported it is looking at a second round-robin comparison. They are also including a primary production dataset in their outputs. The problems of noise at high latitude in winter still need to be addressed.

Sea-Level
Clear improvements were shown in the CCI SL product over AVISO in the matching of Topex-Poseidon/Jason with ENVISAT. Although the ocean surface is now at a fairly constant temperature over the past 10 years the deep ocean is still warming at the same rate as earlier years. The project t is now demonstrating the requirement for a more stable radiometer to be flown for climate purposes. Detlef Stammer is looking at SL in ocean reanalyses and is using the O-B values as a measure of uncertainty. He uses GECCO to assimilate AVISO and CCI SL.

4.4 Atmosphere

Key remarks
1. GHG, Ozone and Aerosol CRDPs are available online and are being evaluated.
2. Data show clear improvement over existing products.
3. In depth descriptions of uncertainty for data products were not always given.

Aerosols
The Phase 1 CRDP data products currently available online were demonstrated. This included bias and uncertainty and comparisons with other available products. The comparison described the advantages of the CCI Aerosol over other products in accuracy, coverage and content. The justification for more than one AOD product was made.

Clouds
This overview presentation went through the objectives, results, validation and evaluation work conducted in the project to date. The product suite of COT, CTP, REF, CPH, CWP, and CMa was described, and example preliminary data products shown. Comparisons with EC-Earth model output were shown which highlighted deficiencies in the model output. Key achievements include: two datasets spanning 2007-2009 spanning different sensors; Improved homogeneity and stability of time series through Optimal Estimation technique; Data will be available later in 2013; Evaluation will be in GEWEX cloud assessment, and; Further comparisons with EC-Earth and ERA-Interim will be made.

Ozone
CRDP of L2, L3 and L4 products for Total Ozone, Limb Profile and Nadir Profile is available online. Users, including CRG, are evaluating the datasets. Showed bias description and analysis of consistency using bias tables. Showed monthly/latitude coverage for 2008 for 6 satellites. Showed merged products and a preliminary evaluation, and ground based validation.

Greenhouse Gases.
CRDP available online, including a L2 ensemble product, and project is at the validation and user assessment stage. Time series of data is longer and of better quality than existing satellite measurements for CO2. The EMMA algorithm for processing L2 CO2 was described. Model intercomparison plots (3 monthly average over 7 year period) were shown, assimilation of satellite products improves CO2 flux characterisation in models when compared with assimilation of flask measurements. Not many CRDP results for methane were shown.

5. Summary of expert presentations

Key remarks
1. The Ozone ECV should explore the advantages of engaging with CCMVAL.
2. CCI needs to remain informed about performance matrices being developed in Core-Climax.
3. Data record inventories is something the CCI datasets should consider using.
4. CMUG can offer precursor and CRDP datasets to Planetary Visions to demonstrate the improvement.

Introduction
Five experts who work in areas of relevance or the potential to support or enhance the CCI gave short presentations at the meeting. These were on topics such as the Obs4MIPs initiative at NASA-JPL, data visualisation, and an EC FP7 project which is one of the building blocks of Copernicus (formerly GMES) the nascent European Climate Service. Summaries of these presentations follows.

Michael Boettinger (DKRZ) gave some examples of movies to visualize climate model data. 100 PBytes storage system and 6PByte hard disks connected to supercomputer. There is a visualisation server for large datasets to save network bandwidth which uses AVIZO Green software for visualisation. He showed precipitation change at the end of this century relative to last century with bars showing total amount and colours of difference superimposed.

Veronika Eyring (DLR) stated that the climate community is becoming more aware that performance metrics are needed for their models. Models for carbon cycle metrics and an updated plot for CMIP5 were shown. Multi model in most cases out perform single models but not in all cases (e.g. 200hPa temperature). The Chemistry-Climate Model Initiative (CCMI) develops metrics and diagnostics for a process-oriented evaluation of ozone which is relevant to the Ozone CCI. Plot of improvement from CMIP3 to CMIP5 for Sfc T, OLR, Precip, SW cld-rad effects. The importance of CMUG to bridge the gap was emphasised. Metrics panel software on obs4MIPs. There is a need in the international climate modelling community for a joint Earth System Model evaluation tool.

Robert Ferraro (JPL) on obs4MIPS. Earth system grid federation (ESGF) now has 2PB of CMIP5 data. IPSL have contributed some of satellite simulator datasets for Calipso. There is a science WG for obs4MIPS. US, France, Germany, UK in that order have downloaded NASA datasets from the ESGF. Most users only download a few variables but a few get everything. All data are at 0.5 or 1 deg on standard grid, monthly means. Data providers must do averaging. For a few variables more than just monthly means are required (precip).

Jörg Schulz (EUMETSAT) outlined the FP7 Core-Climax project which is assessing the European capability for ECVs for climate reanalyses. One thing will be to access the ECMWF Ob-FG feedback files. A system maturity matrix and application performance matrix are being developed. There are several matrices proposed now and the CCI needs some clear recommendation on which to use. Data record inventories is something the CCI datasets should be using. CCI projects can perform a self assessment using the new capability assessment tools and GCOS guidelines.

Philip Eales (Planetary Vision) on the CCI visualisation corner. They have done a lot of globe graphics and immersive shows. An IPad app called solar system by Marcus Chown was shown and looked good. He showed good animations which showed GOCE and how it brought improvement. Their work will be presented at ESA Living Planet in Edinburgh in Sept. He is trying to get all the CCI datasets except IS/SI for September. CMUG also need to contribute datasets. Comparison of a pre-cursor with a CCI dataset is important to demonstrate the improvement.

6. Summary of breakout groups

6.1 Introduction

As with the previous two Integration Meetings a need was identified for the science leads and climate research groups of the ECV projects to have some time for dedicated brainstorming. This was requested to allow free form discussion to scope ideas for the future direction of the projects. It was also used to find solutions to issues within and between projects which if left unresolved may have constrained the CCI outputs. The Science Lead brainstorming group was led by Chris Merchant, and the CRG group by Colin Jones. Both leads reported back to plenary by presenting a summary of their groups discussions which are presented below.

6.2 Science Leads breakout group

Key remarks
1. Obs4MIPS now includes ARC SST, AVISO, and soil moisture, other ECVs to follow.
2. CCI friendly maturity index will be developed.
3. The RFQ timeline for CCI projects in Phase 2 is now clear.
4. Long term sustainability of CDRs means support from national institutes and/or international organisations, and integration in to climate services.

The science lead breakout group was led by Chris Merchant and was structured as: (i) review of progress since last integration meeting; (ii) Phase 2 challenges to be met; (iii) Post Phase 2 sustainability.

The first point from the review of progress was that Obs4MIPS now includes ARC SST, AVISO, and soil moisture. Other ECVs plan to put their data there when the CCI datasets have been properly tested. The discussion also covered the use of maturity indices and how they will help the CCI to meet GCOS requirements. Shortcomings in the Bates maturity index were noted and the CORE–Climax project is defining a more demanding index. A draft for a CCI-friendly system maturity index will be distributed at the Living Planet meeting for comment and to form basis of discussions. It was noted that “metrics of (system) maturity” and “measures of (data) quality” should be kept clearly separated. Work is ongoing to make a common land sea mask from the land cover CCI product is being investigated which could be a common mask for most CCI teams.

For the Phase 2 discussion the response to the CCI team RFQ is needed by 6 September. There was discussion about how the optional cross-ECV projects would be proposed. For Geo-return reasons the baseline proposals can remain the same as for phase 1 but not all countries can bid for the options. Collaboration in Phase 2 was seen as (a) sharing pre-processing costs; (b) sharing level 1b quality/consistency work; and (c) sharing instrument knowledge (e.g. ATSR reprocessing due in 2013). Other actions were raised on the future use of masks for Phase 2.

For the discussion on “beyond Phase 2” the evolving European climate services and its use, and funding, of long term CDRs was covered. Future Sentinel data and ESA’s support formed part of this discussion. CMUG was noted as having a lead role in promoting the use of CCI CDRs in the climate research community. Some ECVs will find a national home (e.g. UK CEMS, EUMETSAT SAF, DMI). Need to make the case for satellite CDRs in Climate Services.

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6.3 Climate Research breakout group

Key remarks
1. Better links between CMUG and CRG groups will improve climate research on CDRs
2. In-situ data for validation of ECVs is seen as important
3. Some end users feel that the uncertainty or error characterisation is not best suited to their needs.
4. Science Leads should announce to the CCI when the CRDP is available online.
5. PUG has a quick start guide and this should reside in the data directory.

The brainstorming session for the Climate Research Group was chaired by Colin Jones and attended by CRG representatives and other invited experts outside of the CCI. The discussion was structured around six topics and the results are summarised below:

Discussion of key climate science points from day 1 presentations and speed dating
It was agreed that the key note presentations were informative and relevant to the CRG, as too were the Science Lead presentations, although the real value comes in the Q&A after the presentations. The science speed dating was well received and welcomed as an alternative way for brainstorming ideas. Other points raised include:
- better interface of the CCI with datasets in other programmes, esp if other (non-CCI) data is used for validation etc.
- climate phenomena (e.g. El Nino) should be used for cross validation between applicable ECVs.
- other CDR datasets e.g. Obs4MIPS have consistency in uncertainty measurement.
- retrieval issues (e.g. over snow) may inform other ECVs.
- there are key regions and times of year when in-situ validation data is highly desired.
- would ESA pay for in-situ validation measurements.
- a common in-situ validation measurement across common ECVs might also bring benefits for consistency.
- ground based observers, satellite experts and modellers need to talk together on this
- EEA is coordinating ground based validation for GMES.
- suggest a co-authored paper across CRG in a special issue of an open access journal.
- lobby for limb O3 sensors on next satellite.

Data:
- how much data can be provided via an international data centre?
- versioning control is important.
- please make machine readable data and catalogues.

Uncertainty issues, how well does ECV data capture uncertainty? Best practice for uncertainty definition
Points raised included:
- what is the uncertainty in retrievals, can it be expressed per pixel, and in other ways (e.g. for a time series)?
- how do you assign uncertainty to merged products?
- how is the chain of uncertainty recorded through the Level processing chain?
- different methods for calculating uncertainty can appear confusing to users.
- can errors be assigned to regions or sub-regions?
- In SST four uncertainties are described, and there is a propagation tool for error characterisation.
- please provide error bars and uncertainty ranges for users, including a description of their sources.

Experiences with using preliminary ECV datasets
- non-overlapping errors found in aerosol data.
- can data providers give us anomalies as well?

ECV data coordination and delivery
- science Leads should announce to the CCI when the CRDP is available online.
- CRG email group would be useful (Note: this has now been set up).

User experiences and feedback
- need to document user experiences for future reference.
- a product description file with the data would be useful
- PUG has a quick start guide and this should reside in the data directory
- need more info about things like, e.g. for aerosol – glint and absorption

High level strategy in Phase 2
- P1 = development, P2 = large data sets, semi-operational and large scale use
- what about further algorithm development?
- across ECV work should be encouraged.

7. Summary of science speed dating session

Key remarks
1. The science speed dating was seen as a useful tool to brainstorm new ideas for the CCI.

The science speed dating was well received and welcomed as an alternative way for brainstorming ideas. Holding it on the first day after the key note talks meant that delegates came at the questions informed, and with a fresh approach. Due to time constraints it was not possible to present the results of the science speed dating in plenary session at the meeting. However, they are presented in this report, in summary in this section, and in full in **Annex C**).

The fifty delegates were divided in advance of the session in to six groups, with each group balanced for composition by experts, science leads, CRG, CMUG, etc. Within each group half the members were pre-nominated to be 'travellers' – the members that moved around six times to ensure the group membership was continually re-arranged to 'refresh' the discussions. The six groups discussed each question in parallel, and the six questions were allocated five minutes discussion time each, running consecutively. The six questions and summary of the answers from all groups follow:

How to guarantee consistency between ECVs?
- Use the same L1 data, auxiliary data, grids, masks, etc.
- Consistency of masks at multiple resolutions
- Common auxiliary data
- Common standard for metadata and product evaluation
- Consistency must not hide uncertainty
- Use reanalysis as a tool to potentially identify inconsistencies

Should there be ground based data sets to validate ECVs?
- Yes, it already is used!

- Issues of scale of measurements and accuracy
- How to get this data / who will fund its collection and archiving?
- Different in situ data for different ECVs
- Time series of in situ data should match that of satellite data
- Colocation of in situ observing sites for similar ECVs (e.g. fire, LC, aerosol, SM) is scientifically of great interest/value

What should happen after Phase 2?

- Updating, reprocessing and re-evaluation
- Continue ECV production (extend time series)
- New missions should be added
- New ECVs ?
- Operational / automated systems
- All of the above for better climate research

What should CMUG do with ECV data?

- Global (integrated) assessment of CCI Products
- Demonstrate value of CCI programme to broader community (along with CRG)
- Use CCI products to challenge models to perform better
- Reinforce complementarity between CMUG and CRG
- Contribute to Climate Assessment and Environmental Assessment
- Encourage CCI teams to provide data in most accessible form

How to fill satellite gaps, e.g. ENVISAT?

- Communicate importance of mission continuity (inter-agency collaboration, coordination)
- Use other missions (esp if there is overlap)
- Explore use of in situ data or models, if appropriate, to fill gaps (a poor solution)
- No true solution to missing data: problem worse for longer gaps
- Overlap between missions crucial.

What is the best data access for all users?

- Existing online access points, but also other portals
- Tools to serve multiple data users
- Common interface(s)
- The cloud
- Online processing tools (CCI User Tool box, visualisation)
- Online support (help, catalogues, commentary)

8. Summary of ESA presentation on Phase 2

General conclusions of the meeting

1. Phase 1 CCI data is now available, and is being applied to research by CMUG and CRGs, with the benefits above existing state of the art data clearly emerging.
2. CCI teams who have yet to deliver their Phase 1 data now have clear examples from the ECVs who have delivered data on what constitutes good practice and quality data.
3. CMUG deliverables, and CMUG precursor and prototype data assessments provide clear feedback to the ECV teams on data quality and usability to the climate modelling / reanalyses community.
4. ESA has clearly described the roadmap for finalising Phase 1 and aims for Phase 2 of the CCI to the ECV projects and CMUG.

Mark Doherty and Pascal Lecomte summarised the status of preparations for Phase 2 of the CCI. Climate assessments of ECV data are still an integral part of each CCI proposal. ESA have strict criteria for Phase 2:

- Background to the work
- Understanding requirements
- Quality of work
- Adequacy of management (keep science leader and project manager separate)
- Compliance with tendering conditions
- Compliance matrix

There are several key meetings for the CCI in the run up to Phase 2, which include:
- Living Planet Symposium in Edinburgh Sep 9-14th 2013
- WCRP Cordex meeting in Brussels Nov 4-8th 2013
- CCI collocation meeting in Frascati Feb 4-6th 2014

The Climate Research Groups should now become more visible within the climate research community as Phase 1 data is now available. The CRGs will need to conduct more research in Phase 2 and will need to interact more with CMUG. Updates to CCI datasets should be at most on yearly upgrades. Publications need to include DOI of CCI datasets, like the SAF network is already working on. There will be an opportunity for post-docs funded by ESA to work on CCI datasets in Phase 2.

The climate change service of the EU emphasised they want to see all the current activities continued in addition to their contribution. There is a willingness in the EU member states to continue funding the CCI activity beyond Phase 2, maybe with new ECVs.

CMUG integration meetings will be held in the May/June timeframe in phase 2. For next year CMUG proposes to have more of a users symposium for climate modellers to demonstrate the utility of Phase 1 data. CMUG will be focussing on supporting the climate service community in Phase 2, especially in Europe. CMUG is the bridge between climate services and the CCI.

CMUG Meeting Report

Name:	Report on Third CCI Project Integration Meeting, 3-5 June 2013
Due date:	1 July 2013
Submission date:	18 September 2013
Version:	1.0

Annex A List of Participants

1. CMUG

Roger Saunders, Met Office
Paul van der Linden, Met Office
Alex Loew, MPI-M
Iryna Khlystova, MPI-M
Silvia Kloster, MPI-M
Serge Planton, MétéoFrance / CNRM
Thierry Phulpin, CNES
Rossana Dragani, ECMWF

2. ESA

Mark Doherty
Pierre-Philippe Mathieu
Pascal Lecomte
Victoria Bennett
Cat Downey
Stephen Plummer
Simon Pinnock
Craig Donlon

3. ECV projects

ECV	Science Lead	CRG Representative
Fire	Emilio Chuvieco	Angelika Heil
Glaciers	Frank Paul	M. Zemp + L. Andreassen
Landcover	Pierre Defourny	Stefan Hagemann
Aerosol	T. Holzer-Popp + G. de Leeuw	Stefan Kinne
Ozone	Michel van Roozendael	Martin Dameris
Clouds	Rainer Hollmann	Ulrika Willen
GHG	Michael Buchwitz	Thomas Kaminski
SL	Benoit Meyssignac	Gilles Larnicol + Detlef Stammer
SST	Chris Merchant	Nick Rayner
OC	Shuba Sathyendranath	Stephane Saux Picart
IS	René Forsburg	Jon Ove Hagen
SI	Stein Sandven	Stefan Kern + Dirk Notz
SM	Wouter Dorigo	Sonia Seneviratne

Experts

Michael Boettinger	DKRZ
Philip Eales	Planetary Visions
Veronika Eyring	DLR
Robert Ferraro	NASA-JPL
Colin Jones	SMHI
David Lary	University of Texas, Dallas
Joerg Schulz	EUMETSAT
Martin Schultz	University of Hamburg
Martin Scharffenberg	ZMAW

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Annex B Programme

version 13 - Final 23 May 2013 venue: MPI-M, Hamburg, Germany

Aim of the meeting: To review CCI progress and current status, and to assess the tasks which remain for successful delivery of Phase 1. Scope ideas for Phase 2.
Outcome: A brief report with agreed actions. Better links with external agents. Ideas developed for Phase 2.

Day One - Monday 3 June 13:00-19:30 Location: DKRZ

12:00 – 13:00 Registration
13:00 – 17:30 Plenary session
13:00 – 13:05 CMUG and MPI-M welcome and logistics, Roger Saunders, Alex Loew
13:05 – 14:35 Keynote climate science presentations describing key challenges in climate research
- Keynote 1: *Long Term Data Sets: Uncertainty, Cross-Calibration, Data Fusion & Machine Learning*. David Lary, Uni. of Texas, Dallas
- Keynote 2: *The next generation of Earth System Models – where do observations fit in?* Colin Jones, SMHI
- Keynote 3: *Soil moisture - component of the climate system, model variable or observation dataset?* Sonia Seneviratne, ETHZ

14:35 – 15:00 Coffee break
15:00 – 16:10 CMUG feedback on precursor datasets and CCI data (where available)
Marine: Met Office / MétéoFrance
Atmosphere: MétéoFrance / ECMWF
Terrestrial: MPI-M
16:10 – 16:30 *2D and 3D visualization of climate data,* Michael Boettinger, DKRZ
16:30 – 17:30 "Scientific Speed Dating" - Interactive discussion with small rotating groups to scope the objectives for the Day Two Break Out Groups, identifying the issues, and challenges to address to deliver the ECVs. Results feedback in to BOGs on day 2.
17:30 – 19:30 Icebreaker reception

Day Two - Tuesday 4 June 08:30-17:30, Location: DKRZ & ZMAW & Geomatikum

08:30 – 10:00 Parallel sessions
08:30 – 10:00 Three parallel sessions by domain, with presentation of latest results and data
- Terrestrial: LC, Fire, SM, Glaciers, Ice sheets — Geomatikum room 1729 (17th floor)
- Marine: OC, SSH, SST, SI — DKRZ seminar room
- Atmosphere: Clouds, Aerosol, Ozone, GHG — ZMAW room 101

10:00 – 10:30 Coffee break (ZMAW 1st floor)
10:30 – 15:30 Break Out Groups "BOGs"
11:00 – 12:00 BOG1 = ECV Science Leads (DKRZ room) BOG2 = ECV Climate Research Group (ZMAW room 101)
- led by Chris Merchant - led by Colin Jones

12:00 – 13:00 Lunch
13:00 – 15:30 BOGs continue
15:30 – 16:30 Coffee Break with poster session - one poster per ECV (ZMAW 1st floor)
16:30 – 17:30 Introduction and guided tour of DKRZ, German Climate Computing Centre ZMAW room
19:00 – 21:00 Self-funded Dinner.

Day Three - Wednesday 5 June 08:30-12:00 Location: DKRZ

08:30 – 12:00 Plenary session
08:30 – 09:30 Presentations by invited experts of direct relevance to the CCI
- *Metrics and data in global model evaluations.* Veronika Eyring. DLR
- *Update on Obs4MIPs.* Robert Ferraro, NASA-JPL
- *The FP7 CORE-CLIMAX project: Towards an assessment of the European ECV CDR capability.* Joerg Schulz, EUMETSAT
- *The CCI Visualisation Corner.* Philip Eales, Planetary Visions

09:30 – 10:30 Report back on BOGs, with discussion
10:30 – 11:00 Coffee Break
11:00 – 11:50 Phase 2 discussion, Mark Doherty, ESA
11:50 – 12:00 Summary and conclusions, Pascal Lecomte, ESA

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Annex C Full output from science speed dating session

Thanks to rapporteurs: Roger Saunders, Pascal Lecomte, Victoria Bennett, Cat Downy, Pierre-Philippe Mathieu, Paul van der Linden

1. How to guarantee consistency between ECVs?

- Large scale: assimilate multiple ECVs into an ESM and see whether the model is capable of matching ECVs within the uncertainties.

- Need consistency between certain variables within important cycles, e.g. carbon cycle, water cycle.
- Small scale: consistency across the ECVs for cloud and sea land masks. The work done jointly by aerosol and cloud projects will produce recommendations for the rest of CCI.
- Could aim to be consistent for the lowest scale grid at least.

Balance between being consistent and being independent.

- One option is to integrate some consistency measures into the production chain - e.g. one group does the cloud mask or aerosol corrections for everyone. But this then introduces error to all of them.
- Don't want to be consistent with something that is wrong! Don't want to 'pollute' the other ECVs.
- Don't want to end up using one ECV output as input into other ECVs – want to compare two outputs.
- Also need to allow for inclusion of the uncertainty in the products.
- Don't want consistency in ECVs if it masks uncertainties. But if it improves the uncertainties then welcome.

Consistency improvements
Look at the correlation between anomalies across ECVs? E.g. volcanic eruptions.

- Agreed this is a good idea but it will need climatologies. What is long enough? 10+ years for baseline comparison data. Preferably 30 years?

Consistency between specific ECVs.
How much are the ECVs related? E.g. Could Soil Moisture data help the cloud ECV?
It would be good to know or to document somewhere which ECVs are related in which way, and if there are interdependencies. Then could work out where they should be consistent. In Phase 1 it was shown that no single ECV was separate from all the others but all overlap with at least one other ECV.

Take advantage of the fact that ECV products all come with error bars.

- In data production
  - Same cloud mask
  - Same coast mask
  - Same type of uncertainty information

- Same a priori info (era interim)
- Same calibration if same sensors
- Same atmospheric correction
- Same data formats

- Data harmonisation
  - Sensor/diurnal effects
  - Use model/assimilation/satellite simulators
- How check consistency?
  - Use trends and signals
    - E.g. el Nino see it in different ECVs
    - Detection and attribution/ human activity
    - Track specific events across ECVs
  - Put multiple related ECVs into a model (CRGs)

- **Use of the same L1 data**
- **Use of same auxiliary data**
- **Common grids (same format)**
- **Common masks**
- **Common tools, for example for resampling**
- **Make binned data available, Possibility to re-bin as needed**
- **Use re-analysis as a tool to potentially identify inconsistencies**
- **Consistency of masks at multiple resolution**
- **Common repository for auxiliary data**
- **Common standard for metadata**
- **Consistency in what is used as reference for product evaluation**
- **Consistency in time domain of products (useful for e.g. for bias correction)**

Ensure data formats, naming conventions, uncertainty all common
Documentation guidelines on how to process –common format
Use same ancillary data (land sea mask, ERA-Interim fields)
Common geographical projection
Ensure use same reference point in grid box
Common metadata
Cross-cutting activity needed to demonstrate consistency
DSWG to report issues and then allow teams to modify processing
Central repository to download ancillary data

2. Should there be ground based data sets to validate ECVs?

YES! (Where possible – not so easy for e.g. land cover)

How to fund ground based data collection?
This is a problem for GMES – networks are mainly funded regionally.
Is also a scaling issue – point based measurements only work within a certain scale as you don't want to scale up too far. There are issues of representation for e.g. soil moisture.

What does ground based cover?
Helicopter/plane scale? E.g. this scale of measurements is very valuable for Sea Ice data, and similarly for aerosol campaign data.
Different for each variable – and important areas for each ECV cover different geographical regions – sea ice and clouds are opposite!

Improving ground based data

- Document gaps in ground data, highlight key regions and times of year that are vital for each variable.
- There will be areas of added value – can evaluate in situ data with respect to the individual variable its intended for but then also with other variables, e.g. Clouds and aerosols.
- Improve areas where it's difficult to make a link between ground based and satellite data, e.g. this came up at a recent fire meeting. Develop methods of ground based data collection that would be more useful to validating satellite data.

Some ECVs are hard to validate with ground data, e.g. land cover – have to invite an expert network for each region, who then manually label all points they can on land cover maps. Then assess accuracy of this method – found to be 80%.

Role of IGBP/WCRP or GOCS in this – for coordination?

- Yes, critical, e.g. Aeronet for aerosol, airborne
- How to do it? Need committed people, agencies
- Standardisation and protocols, CEOS, GCOS
- Should it be held in a database and linked to?
- Issues of ownership, attribution and QC
- Reference sites, ensure consistency across ECVs?
    - But site/location plays important role and ECV dependent
    - There are instrumented sites which should be used but may not be relevant for all ECVs

- **But issues of what is "truth"**
- **Issues of scale of measurements**
- **Issues of representativeness (gap in data)**
- **Issues related to error budget of in-situ observations**
- **Time series of in situ data should match that of satellite data**

BSRN, Aeronet, glacier obs, sea-ice obs all examples of existing networks.
Currently funded from mission program budgets but only for commissioning
Feedback concerns from CCI to GCOS
Look to GMES for funds in the Climate Services
Calibration intercomparisons and ref to SI important
Need a global view, overcome national data release restrictions

3. What should happen after phase 2?

Phase 3! Need to persuade national delegates to carry on funding CCI!

Use answers from Q's 1 and 2: improve consistency of ECVs and improve validation techniques.

Should we improve what we have or include more ECVs?
Depends on what the delegates want funded. Can view it like NASA TOMS mission – which is now on version 17 or so, where data is continually reprocessed, and kept up to date – that's the method CCI should plan to follow.

Boundary between science and operational/service products
Should CCI merge with GMES? Both geared up to do the same thing but large differences in how they operate and in how efficiently they operate for scientists.
CCI community should link with CEOS better – when new satellites are planned can they include funding for this kind of ECV development? But GCOS, CEOS have no money – with ESA, NASA, funding agencies. CEOS can give guidance though.

ESA only funds science projects to demonstrate the value of ESA data. Operational data – more like weather data – should be a continuous effort but the current CCI remit has been agreed by member states and can't be expanded.

CCI and EUMETSAT link. Eumetsat is also developing ECVs separately – there's an overlap but ESA in discussion to avoid duplication of effort. Data users not keen on EUMETSAT charging for data.

- Phase 3! CCI-2
- Might think "operational" but this is ambition, need the science input.. think of phase 3 and phase 4
- Some ECVs could be taken on by operational centres
- Dependency on CMIP – ECVs will be used in CMIP6, so if there are future CMIPs …
- Higher level/downstream products. Climate services. Impact indicators, etc
- Non CCI ECVs e.g. radiation, albedo, FaPAR, precipitation, wind, biomass
- Don't want to lose all the investment to date, so we need to keep it going
- GMES climate services.. but perhaps not mature enough

- **A Phase 3**
- **Needed for:**
  - Iterative plans for updating, reprocessing and re-evaluation
  - Continue ECV production (Extend time series)
  - Extend Applications (Science)
  - New missions
  - Long-term stewardship (Working Groups)
  - New ECVs ?
  - Sentinel Phase
  - Explore multi ECV problems in context of Climate Change

Datasets continued to extend time series and further reprocessing of historical data
Short delay applications will become reliant on CCI
New sensors to improve accuracies, new round robins needed in Sentinel era
Prevent reinventing the wheel maintain knowledge, open access tools freely available datasets/open source tools
Widen international collaboration (CEOS, CGMS)

4. What should CMUG do with ECV data?

Comments
From presentations of CMUG work so far – want to see more regionalisation, not so much on global averages.
Danger of validating CCI data sets with model data – want comparison, not validation!
Get products in to a common reanalysis? Not sure enough people in CMUG to do this!
Strategy document of what could be done with the products on a large scale – what is the potential for developing the products and moving forward with the data. For key scientific questions in the climate community, CMUG could identify a list of variables that are needed from ECVs.

Promote the datasets to the modelling community

- They should be bringing the data into the climate modelling community, rather the more hands off comparisons they've done so far.
- Climate modellers felt strongly about making data easy to use and easy to access. Modellers don't use that much satellite data in model validation and then when they do its NASA because it's easy to get.

Write papers

- CMUG should write a few high level papers, or perhaps a special issue, to promote and highlight CCI data sets. More visibility with a special issue. Some papers could look at consistency across the data sets.
- Make sure to involve the people producing the data – really develop these links. Should be in every contract to work with CMUG and for CMUG to bug projects to get their data in the most useful format so it is used!
- **Encourage CCI teams to get data in most accessible form.**
- Standard evaluation across the different data sets – guidelines for evaluation? So special issue can include certain tests applied to all ECVs. This has partially already been done; some documents are already on CMUG website – at the moment the methods are quite different but can follow up on the uncertainties, the wording is quite different at the moment.

Data access

- Help in the documentation of data explanations and the common website portal. Should make sure projects make the most of CMUG.

- Review the datasets, to become an ECV

- Coordinate with other organisations also producing ECVs (Japan, US)
- Science
- Check consistency, make sure the ECV products work together
- Scientific priority definition in ECV production
- Continue useful Phase 1 work
- Agree consistent ancillary data
- Promote CCI datasets
- Use CCI datasets
- Go to science meetings and get community feedback

- **Global (integrated) assessment of CCI Products**
- **Demonstrate value of CCI programme to broader community (along with CRG)**
- **Use CCI products to challenge models to perform better**
- **Reinforce complementarity between CMUG and CRG**
- **Contribute to Climate Assessment and Environmental Assessment**

Critical feedback (summarise strengths/weaknesses) + uncertainty
Provoke reprocessing if required
Promote data to modelling community through demos
Use data in CMIP-6
Ensure consistency between ECVs within uncertainty
Support development of simulators
Provide integrated view
Interface with climate services on datasets
Update requirements with GCOS this will be a 2-way process
More representation from users in phase 2 workshop
Look at including new science products

5. How to fill satellite gaps, e.g. ENVISAT?

Use 3rd party missions! Make sure that the sentinels get up and last!

European vs US data
For some ECVs there are 3rd party missions available to fill the gaps, and even some European. For ice sheets there's an Italian SAR mission that can be used. For ATSR and MERIS – no 3rd party mission except MODIS. There is MetOp which fills some gaps.

Should the ECVs be kept as independent European ECVs with no TPMs? Is it better to have a gap as a European ECV or fill gap with US data?
Or should we be filling the gaps now because down the line it'll be harder to do and there's real value in doing it now.

Using models or in situ?
Can manage with gaps if can combine ECVs with other data sets.
Model and reanalysis – can go back and leave out ENVISAT data

Produce time series without gaps but the other problem is linking over these haps – need to use models, in situ and US satellites so that gap ends can be linked.
For monitoring, clim services – can use model.
From science point of view – value is in getting a 'clean product'. Clim services – need continuous product. From modelling – better to have merged product with as many sensors as possible. But modellers also want 2-3 independent time series.

- Need to think of operational satellite programmes, e.g. Sentinels, not as explorers (new not continuity)
- Prioritise – need the right missions for priority ECVs
- MODIS & hoping it doesn't fail
- Icebridge (airborne altimetry until Icesat)
- Landsat continuity mission
- Ground based?
- Calibration across sensors important pre and post gap
- Reanalysis e.g. if using ground based
- Some ECVs not a problem if there is a 2 year gap (e.g. glaciers)

- **Communicate importance of mission continuity (inter-agency collaboration, coordination)**
- **Reinforce concept of reference missions**
- **Explore use of models, if appropriate, to fill gaps (a poor solution)**
- **Explore use of in situ data, if appropriate, to fill gaps (a poor solution)**
- **No true solution to missing data: p[problem worse for longer gaps,**
- **Overlap between missions crucial.**

Define transfer satellites for each ECV, MODIS, Proba-V, METOP, Geo?
Make agencies aware of impending gaps in future
Identify backups if there are any
What are implications of each loss of satellite/sensor?

6. What is the best access for all users?

Use well established databases and portals that the community already uses, e.g. Obs4MIPS, GLIMS. Make sure you cater for the different user groups – they all use different portals (main users – modellers, monitoring services).

Want multiple options for access – standard web portal, also ftp site, and mechanism for physical disk transport. Which users want depends on the data volume they want – web service that you can send queries to but if you want whole data set then access methods are always slow.

Want options for just accessing one variable for users, e.g. climate modellers, who don't want to sort through all the data.

Long term data preservation

Problem of when a project ends – maintenance of database access. There are existing data centres, often nationally funded, that are mandated to keep data – need to work closely with them.
Long term data preservation – hard to fund. National funding is key. Needs to be better coordinated but not easy to do.

Have all meta data as an option to download with the data – have option for 'clean fields only' or all auxiliary information. And after the project ends, don't lose the context and the meta data – cloud masks, quality flags, this needs to stay with the data.

Open access! Just compare US and ESA.

- Single catalogue
- Easy to access
- Free of charge
- Visualisations/vis tools
- As ESGF, replicated and federated archives
- Online access
- Summary available and size information before downloading big dataset
- If data large: pre-processing / analysis capability
- Can download full dataset if needed
- NetCDF format
- But others on demand, e.g. geotiff, hdf
- Help pages, guiding, search tool, helps users find what they need
- E.g. MyOcean, CMIP
- Opt in for versions changes alerts
- Simple registration

- **Single access point (a central portal with links to archives)**
- **Tailor tools to serve multiple data users**
- **Online processing tools (CCI User Tool box)**
- **Common interface(s)**
- **Easy to use**
- **Integration with Users (CCI wide User Workshop)**
- **Online help (as part of the portal, tool box)**

Free to all users
Easy/fast registration
Web based download
Common data aggregation
Metadata browser to see what is available quickly
Good documentation (e.g. like obs4MIPS)
D.O.I. needed
Appetiser to attract users (e.g. animation), example of data use, publications used data.