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DOCUMENT

Eighth CCI Collocation Meeting Report

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1 SCOPE

This document summarises the outcomes of the eighth Collocation meeting of the ESA Climate Change Initiative, held at St. Hugh's College, Oxford, UK from 20-22 March 2018.

This was first Collocation meeting of the extended (CCI+) programme, which was approved by ESA member states at the Ministerial Council in December 2016, as an element of the European Earth Watch Programme. CCI+ capitalizes on the success of the CCI programme element, as well as previous investments in the space and ground segment by ESA, its Member States and its European partners, and their commitment to long term operational provision of global satellite observations, notably through the Copernicus Sentinel missions and the EUMETSAT meteorological missions.

The meeting brought together people from across the expanded CCI+ programme, including the nine new ECV project teams; the existing ECV project teams; representatives from cross-ECV activities including CMUG and the Sea Level Budget Closure project; and both current and new initiatives on Knowledge Exchange, including the Open Data Portal and CCI Toolbox.

The output of the Collocation meeting is recorded within this report as a collective assessment of the status of the CCI and a series of key actions, as formulated by the colocation participants, drawing upon the collective expertise of all CCI project teams.

2 INTRODUCTION

The original CCI programme objectives and scope are described in the document, "ESA Climate Change Initiative: Description [EOP-SEP/TN/0030-09/SP]". The CCI programme has evolved from this original description and is now split into four main themes:
CCI+ Extension, *i.e.* covering activities from 2017 up to the mid-term review scheduled in December 2020. The four themes are:

(i) Nine new ECVs
(ii) Additional R&D on 13 ECVs that were already included in CCI
(iii) Cross-ECV Projects
(iv) Knowledge Exchange

The work to be carried out on each ECV in projects that were part of the original CCI programme is described in the Statement of Work for the CCI, "ESA Climate Change Initiative Phase 2 Statement of Work" [CCI-PRGM-EOPS-SW-12-0012]. For the new ECV projects, formed as part of CCI+, the work to be carried out on each ECV in Theme (i) is specified the 'Climate Change Initiative Extension (CCI+) Phase 1 – New Essential Climate Variables – Statement of Work [ESA-CCI-PRGM-EOPS-SW-17-0032].

Key documents can be found on the CCI website: cci.esa.int

At the time of the 8th Colocation meeting the following original ECV projects were still in place:

CCI Project	Science Leader
Cloud_cci	Deutscher Wetterdienst (*R.Hollmann)*
Aerosol_cci	DLR / FMI (*T. Popp / G.De Leeuw*)
GHG_cci	U.Bremen IUP (*M. Buchwitz)*
Sea_Ice_cci	NERSC, *(S. Sandven)*
Sea_Level_cci	LEGOS-CNES (*A. Cazenave*)
SST_cci	U. Reading (*C. Merchant*)
Ocean_Colour_cci	Plymouth Marine Laboratory (*S. Sathyendranath)*
Glaciers_cci	U. Zurich (*F. Paul)*
Greenland_Ice_Sheet_cci	DTU Space *(R. Forsberg)*

Antarctic_Ice_Sheet_cci	U. Leeds *(A. Shepherd)*
Landcover_cci	Université Catholique de Louvain (*P. Defourny*)
Fire_cci	U. Alcala (*E. Chuvieco)*
Soil_Moisture_cci	TU Vienna *(W. Dorigo)*

The following projects were completed and did not attend the Collocation meeting:

Ozone_cci	BIRA-IASB (*M. Van Roozendael*)

The following projects from Theme (i) of CCI+ had contracts in place:

Water_Vapour_cci	U. Reading (*M. Hegglin)*
Salinity_cci	CNRS/LOCEAN/IFREMER (*J. Boutin/N. Reul*)
Sea_State_cci	CNRS/LOPS (*F. Ardhuin)*
Snow_cci	ENVEO, *(T. Nagler)*
Sea_Level_cci	LEGOS-CNES (*A. Cazenave*)
Permafrost_cci	B.GEOS (*A. Bartsch*)
Land_Surface_Temperature_cci	U. Leicester (*D. Ghent)*
Biomass_cci	U. Sheffield *(S. Quegan)*

The following projects from Theme (i) of CCI+ did not have contracts in place but were still able to attend the Collocation meeting:

High_Resolution_Land_Cover_cci	U. Trento *(L. Bruzzone)*
Lakes_cci	LEGOS/PML *(J. F. Crétaux/S. Simis)*

Through a separate ITT, the cross-cutting project, the 'Climate Modelling Users Group (CMUG)' was set up with the aim of ensuring integrated feedback between the ECV projects and the global climate modelling community. The CMUG provide a structured forum for guiding the ECV projects on the use of the data sets, discussing intercomparison methods, error characterisation, etc. and helping the projects to achieve the set performance targets for each ECV.

Each CCI project team typically includes experts from ten or more research organizations, including a Science Leader and a Project Manager, and contains three sub-groups. The sub-groups are organised into: specialist scientific expertise in EO; a Climate Research Group, including climate modellers; and system engineering experts.

Each science leader ensures the overall scientific integrity of the project throughout its lifetime. The science leader also ensures that each CCI project maintains effective working links to the appropriate international climate science programmes, initiatives and projects, and to other CCI project teams. Each science leader is directly supported by a project manager who ensures communication within the project team, maintenance of schedule, tracking of actions, deliverables and reporting to ESA.

Cross-project scientific activities also exist with the CCI, which demonstrate ECV exploitation and encourage the uptake of CCI ECVs by the user community. These currently include a project on the Sea Level Budget Closure, made up of participants from the following CCI projects: Sea Level, Glaciers, Greenland Ice Sheet, Antarctic Ice Sheet, Sea Surface Temperature and Sea Ice. Alongside this, the RECCAP (Regional Carbon Cycle Assessment and Processes) aims to generate and analyse regional carbon budgets. It uses CCI observations of the land surface and atmospheric composition to constrain and improve regional fluxes.

Sea_Level_Budget_Closure_cci	TU Dresden *(M. Horwath)*
RECCAP	LSCE *(P. Ciais)*

The Open Data Portal and Toolbox projects, together with the work on Visualisation are cross-project activities that help people use and understand the CCI data. The Open Data Portal project covers the development, implementation and operation of an online single point of access for the CCI ECV datasets, while the Toolbox will enable users of the data to more easily manipulate the CCI datasets and look at multiple ECVs together. The Visualisation activities include a Visualisation Tool for exhibitions and a Tablet App, Climate from Space, and the development of animations, which enable a less-expert audience to understand the work of the CCI programme and how satellites contribute to climate science.

There have been two cohorts of CCI Fellowships (2014 and 2015), these are post-doctoral positions aimed at engaging young scientists in ESA Member States pursuing a scientific career in Earth Observation, Earth System or Climate Science. The CCI Fellowships undertake cutting-edge research using the ECV products, maximising the scientific return of ESA EO missions and datasets through the development of novel methods, new products and fostering new scientific results.

The CCI project deliverables for Phase 1 and Phase 2, and for the new ECVs have been specified in accordance with the "Guideline for the Generation of Satellite-based Datasets and Products meeting GCOS Requirements" (GCOS-129, March 2009). All completed documents and data products can be found on the project websites, accessible via the main CCI programme website.

3 UPDATE ON THE CCI PROGAMME

3.1 CCI Programme Overview

The eighth CCI Collocation meeting was opened by Pascal Lecomte who gave an update on the progress of the CCI programme and presented an overview of the extended CCI+ programme. At the ESA Ministerial at the end of 2016 the CCI+ programme was approved and funded for the next 7 years, up until 2024. This will be divided into two phases, similar to the original CCI programme.

The main objectives of the CCI programme are to: cover the research, development, qualification and delivery to users of pre-operational ECV products; to define, size and demonstrate ECV processing systems and also to transfer ECV production to operational entities outside ESA. The criteria for the ECVs are driven by climate user requirements defined by GCOS, under authoritative advice from CSAB, with strong coordination with the international Space Agencies response to GCOS via the Joint CEOS/CGMS Working Group on Climate (WGClimate).

The extended CCI programme has four themes:

1. Development of new ECVs (i.e. ECVs that were not started in CCI so far)
2. New R&D on ECVs that were started in CCI
3. Cross-ECV scientific exploitation
4. Outreach and Communication

Eleven new ECV activities were proposed for CCI+, among which the Climate Science Advisory Board recommended four as highest priority – Water Vapour, Sea Surface Salinity, Snow Cover and Permafrost – and five others, Land Surface Temperature, Above Ground Biomass, Lakes, Sea State, and High Resolution Land Cover, as important candidates for CCI+. Kick off of the new ECV projects are mainly scheduled for early April or May 2018, with some coming later in the autumn after further negotiation.

Concerning the new R&D on existing ECVs, ITT will be launched in April for proposals to be received before the summer break. It is hoped that these will be awarded to start in early 2019.

The cross-ECV proposal for CMUG is currently being evaluated, and should kick off in late spring or summer.

The Knowledge Exchange theme will continue the CCI activities on data access, use, and visualisation. This includes the Open Data Portal, in order to provide open, free, and easy access to the ECV datasets, the CCI

Toolbox to enable easier use of ECV data, visualisation of the data, an update to the CCI website, and use of CCI data in an educational context. The ITT will be launched in September for proposals received before the winter break.

3.2 CCI Cross-Project Working Groups

Working groups are intended to encourage and facilitate cross-project collaboration. The objectives are to develop best practice on common issues, to take advantage of common opportunities and avoid duplication of effort.

Every CCI project nominates a representative to take part in each of the 3 working groups, the Science Leaders, the Data Engineering Working Group (ex SEWG + DSWG) and the Climate Science Working Group.

Data Engineering Working Group (DEWG)
Led by Ed Pechorro (ESA Climate Office), this group of System Engineers will ensure the maximum usability of the datasets produced within CCI. Through common CCI data standards (ECV data product access, formats, processing best practice, chain architecture, etc.), the group will cultivate tools for the access, discovery and manipulation of CCI data. Several activities are included in this group, such as sharing experiences of "Big Data" processing, and community "Platforms", management of open source code repository, solving common EO data access issues, putting forward new technical evolution of ECV

Climate Science Working Group (CSWG)
Coordinated by CMUG (Climate Modelling User Group), the Climate Science Working Group includes the CRG members from each ECV. It is planned that CWSG will do an annual assessment of CCI progress towards input into the IPCC AR6 and Special Reports. Collaboration between ECV projects and CMUG on the exploitation of ECVs in climate science will be facilitated through meetings and discussions in this group. It is intended to share experiences of using ECV data in climate science research, understand and develop user requirements for cross-ECV consistency and specification of ECV uncertainties, coordinate outreach to the climate modelling and plan cooperation in international assessments (science papers, conferences).

Science Leaders meeting
A Science Leaders' meeting takes place as part of every Collocation meeting and permits exchanges and developments of cross-ECV project ideas, external opportunities and also coordinated feedback to ESA CCI management.

4 KEYNOTE: ECVS AND THE GLOBAL STOCKTAKE

Karsten Haustein from the University of Oxford's Environmental Change Institute, presented on, 'The metrics of progress towards a long-term temperature goal: ECVs and the global stock take'. As part of the contribution to the IPCC Special Report on 1.5 degrees, the team in Oxford looked at what constituted '1.5 degrees'. The 2015 Paris Agreement stated its aim of "*Holding the increase in the global average temperature to well below 2* °C *above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5* °C *above pre-industrial levels*". The phrase "global average temperature" could be given several reasonable interpretations, including annual observed GMST as determined by a single data series; annual observed GMST as determined by several data series; multi-year running means; or, assessments of the anthropogenic component of the observed warming.

Therefore, they have proposed a simple real-time index of global human-induced warming. The index minimizes sensitivity to natural fluctuations and is consistent with Structured Expert Dialogue that says we reached ~0.85°C of warming in 2010 and 1°C in 2017. However, the index is sensitive to the dataset used to define global average temperature.

This information is important for the global stock take because the current level and rate of human-induced warming determines future emission budgets under ambitious mitigation. However, as linked to the above discussion, how you define 'pre-industrial' and 'increase in global temperature' have big differences on mitigation requirements.

Looking at the threshold until we reach '1.5°C', the current warming has reached 1°C, and is rising at 0.2°C per decade. Human-induced warming accelerated over the past decade despite temporary slow-down in CO_2 emissions. The time to the threshold at current warming rates = the time to halve the warming rate to avoid crossing the threshold. Thus, the current rate of warming determines future warming under constant deceleration. At the current rate, it is estimated that temperatures would reach 1.5°C in 22 years. Relating rising temperatures to falling emissions is an essential component of the global stock-take – CO_2 emissions must fall at least as fast as the rate of human-induced warming. Hence we have at most 22 years' of current emissions to limit warming (as defined in AR5) to 1.5°C.

5 CURRENT ECVS AND TRANSITION TO C3S

5.1 Continuing cross-ECV work

Uncertainties in Climate Data Records

Uncertainty information in Climate Data Records (CDR) has become a CCI trademark and is gaining use and traction in user communities, which is why the accuracy of the data is fundamental. Cross-ECV work presents an importance interest for uncertainty in CDR estimations, fundamental to any measurement in science. In accordance with this issue, several requirements were established in CCI:

- CR-1: Characterize global satellite data products uncertainty
- R-12: Assess uncertainties in co-operation with CMUG
- Establishment of a global ECV Uncertainty Budget and Uncertainty Characterization Report

A number of uncertainty recommendations were developed within CCI for CDRs, the first being to provide uncertainty estimates, and that these should follow metrological conventions. Uncertainty information should be quantitative (standard uncertainty, standard fractional uncertainty, error covariance matrices, probability of mis-classification, variability across repeat evaluation), explain and put in the dataset, rather than expect users to hunt the literature for values. Uncertainties should be defined by tried-and-tested methodologies and use standard nomenclature. Uncertainty information should be given per datum if necessary.

Also, validation using match-ups can underpin uncertainty, for instance the OC-CCI product are sorted according to optical classes to establish uncertainties per optical class. This method generates accurate uncertainty characteristics per pixel. To make sure users are using properly the data, uncertainty information should be explained, with standard metrological vocabulary, advices and examples of how the user should exploit the information must be given. Uncertainty data has to be easy to associate with measured values.

There are trade-offs related to product size, complexity and research investment versus the degree to which uncertainty information is comprehensive. Thus, sufficient uncertainty information has to be provided to correct propagation of uncertainty to spatial and temporal averages of data. At the same time data volume must be minimized for users to download. This conflict can be solved by putting more complete uncertainty information separately to core data products or by providing two versions of data, one with summary and the other with comprehensive and guidance information, indicating the needs for different purposes. In addition, we require information about temporal stability of observations and evolution of trend uncertainty over time as temporal correlation of errors particularly arise from long-term systematic effects. In order to challenge this requirement, more general estimates of overall stability can be made.

Importance of consistency

CCI teams have produced over 110 new datasets, available through the Open Data Portal. For usability (data users, portal catalogue, software tools and data services), data files and their descriptions need to be consistent.

Hence, consistency requirements for formats (netCDF-4), metadata, filenaming conventions, vocabularies, directory structure are defined in the document "CCI Data Standards" updated in March 20108; the result of cooperation between the Data & Engineering Working Group and the CCI Open Data Portal team. Consistency is a key strength of the CCI programme – its analysis requires dedicated R&D efforts, builds on ECV high quality development, and should cover the full range of old and new ECVs.

5.2 Status of C3S and the Climate Data Store

The C3S (Copernicus Climate Change Service) supports European adaptation and mitigation policies by:

- Providing consistent and authoritative information about climate.
- Building on existing capabilities and infrastructures.
- Stimulating the market for climate services in Europe.

The C3S Climate Data Store (CDS) is a one-stop shop for information about the climate: past, present and future. It provides easy access to a wide range of climate datasets via a searchable catalogue. An online toolbox is available that allows users to build workflows and applications suited to their needs. Datasets for the CDS include observations, climate reanalysis data and model output.

Observations includes in situ and satellite observations, including products originally developed with the CCI. It provides users with timely, full and harmonized access to climate data from reference networks, global ECV products and archives. It also provides users with access to physically consistent estimates of multiple ECVs, by combining models with observations in the climate reanalysis data. The 1979 – present ERA5 datasets production will be completed in Q3 of 2018. There is also a regional reanalysis product for Europe and the Arctic at a higher resolution. Sectoral indicators and tools also exist to support adaptation.

The CDR itself has searching and browsing functions, discovery and retrieve functions, user requests and download functions. The Toolbox attached to the CDS provides an authoritative set of software that will allow users to develop applications to make use of the content. A Common Data Model has been built to provide a uniformed description (conventions, structures, formats etc.) of all data and products in the CDS, so that they can be combined and processed by the Toolbox in a consistent fashion. There is currently an on-premises private cloud with 32 computer servers. It reached operational stage early in 2018 and will continue to improve.

6 LESSONS LEARNED

6.1 CMUG Perspective

The CMUG (Climate Modelling User Group) was established by ESA to ensure a climate perspective at the centre of its CCI programme, and to provide a forum through which the Earth observation data community and climate modelling community can work closely together. The objectives of CMUG are to:

1. Assess the global satellite climate data records produced by CCI ECV projects.
2. Examine the consistency between ECVs, from a user perspective.
3. Refine the scientific requirements of the climate data based on the needs of GCOS, climate modellers and other users.
4. Provide technical feedback to the ECV projects.
5. Provide reanalysis data to the ECV projects.
6. Promote the use of ECV datasets to climate modellers and other users.
7. Coordinate the CSWG (Climate Science Working Group).

In CCI Phases 1 and 2 satellite records were assessed, verified, gridded, converted from L1 to climate variables and made accessible to the climate community by the ECV teams. This data has high temporal and spatial resolution and can be used for many purposes in climate models, including model validation, data assimilation, setting initial conditions in global models or analysis of climate processes.

In addition to the climate modelling studies and analysis tools, the CMUG work on cross-CCI projects. They are in charge of the uncertainty characterisation, the definition of the terminology between specialisms, the CSWG and DEWG coordination and of the organisation of the integration meetings.

The extended CCI presents multiple objectives for CMUG, including: **updating user requirements** for climate modelling applications and compare with CCI ECV specifications. The requirements gathering exercise is conducted across the climate modelling, climate research, and climate impacts and adaptation communities. It includes GCOS requirements, plus those of other international and regional organisations. To meet the evolving needs of the climate community, a "Foresight Report" is produced for use of EO data for climate applications (monitoring, model validation, reanalysis).

CMUG will also **assess the quality and consistency of CCI datasets** using climate models and provide feedback to the CCI teams. They produce a Technical Note on Product Assessment that provides feedback to ESA and the CCI teams on their plans for product assessments, this is communicated through the Climate Data Forum which is a one-stop shop for information on satellite climate datasets. In addition, the Scientific Impact Report documents the scientific impact of the CCI on the climate research community. Different experiments can be applied to achieve quality assessment as reanalysis, benchmarking, statistical and process analysis, hindcast or assimilation.

CMUG **exploit CCI products in MIP experiments** such as the evaluation of modelled system memory or model results considering internal variability or a combination of sources of uncertainties.

They are also in charge of **promoting CCI datasets** to the climate modelling and climate research communities through scientific engagement with programmes and initiatives (e.g. engaging with Horizon 2020 climate research projects, the CMUG data forum, websites, newsletters, posters, social media, etc). They also have the tasks of adapting climate **evaluation tools for CCI needs**, providing the CCI teams with an **integrated** perspective on research issues (uncertainty, data, obs4MIPs), **engaging at an international level** to ensure CCI datasets reach researchers around the world and c**oordinating climate research** activities through the CSWG (Climate Science Working Group).

6.2 Lessons Learned

The CCI Science Leaders of the original ECV projects collected their lessons learned from their experiences of being in the CCI and producing ECV datasets and gave the following advice:
Glaciers suggested to keep the document deliverables short, collaborate with peers and inform them of their results by keeping the web page up-to-date and informative or do algorithm with community and publish results. They encourage researchers to publish papers, which will last and give them credits. They should be adaptive to new data and get results out; stick to established community standards and follow what goes on for the other ECVs.
Aerosol stress that innovation is through collaboration, especially via cross-ECV and international collaboration. Indeed, cooperation, challenge or friendly competition by other communities drives improvement and critical feedback on uncertainties helps refine our concepts.
Ocean Colour define Research and Development as an integral part of the way forward, if the products are to remain up-to-date and meet user requirements. Furthermore, they mention the importance of exploiting Sentinel capabilities to the full, going forward and to create a system that is dynamic, adaptive, agile and responsive to new developments.
Fire have found the science leader meetings valuable for cross-EV interaction and the development of Special Issues. Close interaction with climate users is important; the generation of reference information has been a big part of the Fire work (global validation datasets were not available); better efficiency would be provided though the consistency of data formats, methods and input-output of the datasets. Some suggestions for CCI going forward: retrieve BA form S-3 sensors and move beyond binary BA to combustion completeness.
For Land Cover data, consistency of the data across years (as needed by modellers) and across ECVs sharing land-water masks, is key. Uncertainty impact analysis highlighted the critical importance of annual land cover for climate modelling and the limitation of models using prescribed vegetation. It was noticed that the significant uptake by the climate community (CMIP6) led to a nice success of the 1st LC CCI Users Workshop.

Some forthcoming challenges for the CCI include support for the R&D to transition LC time series to Sentinel-3; the uncertainty impact analysis, allowing the focus of research on priority issues (PFT Cross-Walking table, bare soil fraction quantification) for time series reprocessing; and the validation of annual land cover change, which still needs to be done.
GHG said a mix of cooperation and competition is key for continuous product improvement and resulting publications. Cooperation with the European user community via CCI was also very important (feedback, improvement, publications), GHG-CCI data products are now generated operationally in the framework of the Copernicus Climate Change Service (C3S) but, C3S does not fund R&D and important sensors had not been included in GHG-CCI (OCO-2, S-5P…).
The SST CCI dataset is the only project internationally that supplies an independent check on the *in situ* CDR, is fully physics based (radiative transfer and ocean modelling), supported coherent R&D across all levels of processing, integrated climate assessment activities directly (strong benefit) and systematically models satellite SST uncertainties on all levels. No other project internationally will support improvement of satellite SSTs through the 1980s. C3S support the operation, maintenance & evolution of current techniques to bring in new satellite missions, but no R&D to maintain the state-of-the-art science or applications. Strong benefits of SST being involved in CCI include: embedded working with CRG & CMUG, cross-ECV interactions including Sea Level Budget Closure, CDR uncertainties and greater international profile.
Sea Level found that international collaboration was strengthened through the CCI. The team have developed cross ECVs activities (Sea Level Budget Closure), as well as a global gridded sea level time series since 1993 and a new focus on coastal sea level (bridging phase). They notably improved the sea level product accuracy, in particular at climatic scales, bringing the data closer to GCOS requirements (better characterization of errors, improved links between successive altimetry missions and dedicated geophysical corrections).
The Greenland Ice Sheet developed the first 20-year elevation change series from European missions and a mapping of Greenland ice sheet velocity spanning 4 complete years. Although there are several competing products (NASA), the Greenland CCI products are uniformed, respect standard formats, are easy to use and are frequent released, giving users timely access to data.
The Antarctic Ice Sheet team focused on project impact (data users, outputs and publications) which has led to 200 outputs (papers, news items, presentation, etc.) and 10,000 users in 2018.

In conclusion, the lessons learnt and advices for the next period of the ECVs team are: collaborate (with the users, science leaders, ECV projects), do science, write papers and get them published and follow the standards established by the community. The forthcoming challenges for CCI+ and C3S are to continue to achieve the consistency and characterise the uncertainties for the datasets recently created and continue the R&D in CCI+ (also on existing ECVs), for this, new & up-coming sensors provide exciting new opportunities.

7 PRESENTATION OF NEW ECVS

Water Vapor
Michaela I. Hegglin (*University of Reading, UK*)
H_2O is a key component in Earth's hydrological cycle and a key mediator of Earth's energy cycle as it is the most important natural greenhouse gas. The three GCOS products for water vapour are: total column water vapour, tropospheric profiles and stratospheric profiles. The tropospheric profile product is important because 95% of H_2O resides between the surface and 5km, and will allow us to study the influences of Earth's radiative balance directly and indirectly, as well as the impacts of surface fluxes and soil moisture. The stratospheric H_2O profile, measured daily, is critical in determining stratospheric ozone levels as H_2O leads to ozone destruction via the HO catalytic radical cycle. Those two first products will be merged in ECV-4 which requires particular innovation since methods to do this are currently non-existent (stratospheric and tropospheric observations have historically been treated separately). The Total Column Water Vapour (TCWV), measured with a frequency of 4h and an uncertainty of 2% is delivered in the ECV-1 and ECV-2 products. Methods and techniques for obtaining water vapour data from satellites vary from microwave sounders, imagers, TIR or NIR imaging spectrometers or UV spectrometers. The technical challenges are to obtain values in NIR and

microwave, to merge measurements over land and ocean and to differ vertical resolution to get information content with the strongly limited spatial and temporal resolution of limb sounders.

The main goals in this new ECV are to analyse the variability and trends of water vapour on different spatial and temporal scales, including consistency between observations and theoretical expectations (or models). Also to quantify uncertainties and to connect to end users through early involvement (Definition of user requirements, of case studies that answer outstanding research questions), and to deliver high quality ECV products.

Salinity
J. Boutin (*LOCEAN*), N. Reul (*IFREMER*)
Sea Surface Salinity (SSS) information provides strong insights into global freshwater fluxes (precipitation, evaporation, runoff, freezing and melting of ice) and sea water density, which in turn governs ocean circulation & air-sea exchanges. For instance, in the tropics a 1 pss (practical salinity scale) surface salinity increase creates the same density change as 5 degrees warming temperature which is favourable to hurricane development**.** The CCI Salinity Project will provide a global scale, integrated homogenised multi-mission time series of SSS data, together with uncertainties, optimised for the climate science community. In order to achieve this, dedicated studies investigate specific processes controlling SSS, the oceanographic content of satellite SSS data with respect to historical record and SSS retrieval approaches.

This new ECV dataset will include a long-term multi-mission salinity Climate Data Record based on a combination of SMOS (2010-) with Aquarius (2011-2015) and SMAP (2015-) L-band radiometers. Additionally, C/X-band radiometers will be used to extend the time series back to 2002 in tropical river regions and Radio Frequency Interferences in highly contaminated zones (e.g. Asia). The user requirements consist of spatial and temporal error-correlation characteristics, expression of uncertainties, large scale bias correction and relevant spatial/temporal scales. Climate users will be engaged to feed in requirements and will run some experiments assessing new datasets (e.g. new prototypes) from an assimilation point of view. The length and number of those experiments would depend on funding available (and availability of new observations).

Sea State
Fabrice Ardhuin (*LOPS, Brest, France)*
The Sea State is the statistics of wind-generated ocean waves, it is usually defined by the elevation spectrum and whitecap properties. The potential users of the ECV are coastal defences, marine energy field (profitability of investments depend on wind & wave climate), designers of ships or ocean platforms etc. There is presently no coordinated sustained effort to deliver global, high-quality sea-state information observations for climate which encouraged GCOS 154 to define Sea State as a new Essential Climatic Variable.

ESA and CNES funded GlobWave, which can be seen as a precursor project to CCI Sea State as it helped to reduce inconsistencies in sea state data already. The COWCLIP project also looked at trends in extreme wave events and their impact, e.g. erosion in the Arctic from increasing significant wave height. One of the priorities of the team is to provide high quality data by using new instruments, new algorithms and find applications in new areas. To do this, more work has to be done on other variables relevant to sea state (i.e. wind speed, currents, wave periods from altimeters and SAR) and extremes (tropical storms). Data quality issued will be tackled, potentially with new instruments using a different technique (unfocused SAR), addressing biased SAR wave spectra with new algorithms. The requirements are for a resolution of 25km, with an uncertainty of 10cm and a frequency of 3 hours, which at the moment is not possible with satellite data alone. Gridded daily maps aren't useful and can be mislead so products will combine model and observation data. There is 25 years worth of data from altimetry, 35 years for some buoys, so links with ship observations and microseisms will be made. Sea State will be closely connected to others ECVs like Sea Ice, Sea Level or SST and engage with the growing wave climate community.

Snow
Thomas Nagler *(ENVEO)*

The overarching goal of Snow CCI is the generation of homogeneous, well calibrated and long-term time series of key snow cover parameters (snow area extent and snow mass) from multi-sensor satellite data for climate applications. There are currently significant discrepancies in anomalies and trends from global snow cover time series from different products, detected in the ESA Snow Product Intercomparison project (SnowPEx) that CCI will try to address. The starting point for a consistent mulit-sensor snow extent time series is a baseline algorithm adapted to spectral bands of the various sensors. The development cycle of algorithm update – building a time series, intercomparison – feedback, will be performed several times to optimise the agreement between the different sensors, while minimising errors compared to the snow reference data.

The GlobSnow Snow Water Equivalent (SWE) version 2 product serves as a basis for the development of the CCI Snow SWE. This ESA CCI product combines microwave satellite data and in situ measurements from 1979 until 2015, with a 25km spatial resolution. It will focus on dynamic snow density development using an advanced snow emission model, improving treatment of lake ice and forest vegetation from snow depth and snow grain size estimation. It will use a baseline of SMMR, SSM/I and SSMIS data, combined with an assessment of AMSR-E & AMSR2 data as input data. Mountain areas will be filled using other datasets. To enhance the quality of the data, the brightness temperature resolution will increase from 25 km to 12.5km spatial resolution. The team will also have a combined product of snow extent with the SWE.

In order to ensure the suitability of the snow products, representatives of the climate research community are directly involved in Snow CCI, advising on product requirements, contributing to product evaluation, and utilizing the data for specific research tasks. Key science questions to answer include: how is the snow-albedo feedback changing? How much water is stored as seasonal snow and where has it changed?

Permafrost
Annett Bartsch, (*b.geos)* and Tazio Strozzi, (*Gamma Remote Sensing*)
CCI Permafrost will, for the first time, provide a huge quantity of information for different spanning years and meet the requirements for the production of a climate data record (CDR) on permafrost temperature and active layer thickness. The project is a follow-up to the GlobPermafrost Data User Element (DUE) initiative of ESA, who established an equilibrium model using MODIS LST and GlobSnow SWE as well as a landcover prototype from 2000 to 2015. In addition, the GlobPermafrost project provided regional scale trend analyses, local scale lowland permafrost (subsidence, ground- fast ice, mass movements) and mountain Permafrost (rock glaciers) data.

Permafrost use cases include the initialisation, evaluation and assessment of Team Climate Models. Evaluation and validation of MAGT in the CCI Permafrost Extent product and in simulations from climate models adapting GTN-P ground data. The mountain permafrost data will be validated with in-situ observations of ground temperatures, changes in subsurface ice, unfrozen water content and velocities of permafrost creep from PERMOS and satellite derived rock glaciers inventory. In the context of the horizon 2020 program, the Arctic climate change in coastal permafrost regions will be evaluated. Using GlobPermafrost products initially, CCI Permafrost will assess the links between carbon pools, land surface changes, and permafrost. The team will build on the GlobPermafrost product to undertake transient modelling to produce time slices, for this they need long-term records of LST and SWE, suitable for soil parameterization.

This new ECV has strong links with CCI LST and Snow for the formulation of user requirements, plus Landcover and HR Landcover post processing for permafrost modelling and consideration of consistency with Lakes results for application of CDR.

High Resolution Land Cover
Lorenzo Bruzzone, *(University of Trento, Italy)*
Land cover has a key role on surface energy, water carbon fluxes and variables. A large amount of work was done in the CCI Medium Resolution Land Cover (MRLC) project with products at 300m resolution. CCI HRLC aims at improving the understanding of the interaction between climate and land cover by increasing the spatial resolution of 1 order of magnitude (from 300m to 10-30m).

The primary objectives are to examine the role of the spatial resolution to support climate research, to study LCC in key regions exposed to extreme climate conditions and to understand the classification variability across spatio-temporal scales.

CCI+ HRLC will leverage the work of CCI MRLC for keeping spatio-temporal consistency. However, many new challenges should be addressed that concern EO science, validation, engineering and climate modelling. HRLC aim to fill the gaps in temporal data availability and to address cloud cover issues by using a systematic use of multisensory data. A new processing chain will be designed and implemented characterized by a large flexibility to handle data from multiple sensors, the capability to deal with large HR data volumes with promising methodologies and the computation of the uncertainty information within all the processing steps.

As a result, several EO products will be generated:
- A static HRLC at subcontinental scale at 10 m as reference static input to the climate models.
- A long-term record of regional HRLC maps at 30m in the regions identified, every 5 years.
- An update of HRLC map with a change information at 30 m and yearly scale
- The rescaled maps at intermediate multiple spatial resolutions.

The HRLC products can be used in climate modelling for various challenging tasks as improving land cover description as well as the representation of energy, water, carbon (CO_2, CH_4) and the understanding of surface-atmosphere interactions and climate change impacts on vegetation. They will support better evaluation of LCC impacts on climate, thereby supporting climate mitigation/adaptation strategies and policies at regional-local levels. This ECV is closely linked with Lakes, Permafrost, Biomass, and Land Surface Temperature.

Lakes
Jean-François Crétaux, Stefan Simis
Lakes are a fundamental component of the continental surface when investigating the climate change. Indeed, they play a role of proxy, sentinels, regulators, integrator of climate change and are an essential contributor to regional water cycle. Lakes are of great interest in the disciplines of climatology, hydrology, limnology, biogeochemistry, physics and geodesy. Often, these user communities operate independently, missing the potential benefits of cross-disciplinary collaboration. Thus, Lakes ECV represents a first unique framework to provide a single consistent resource to these diverse communities: it is major challenge to align techniques and products.

We defined 5 new & complementary Lakes ECV products:
1. Lake Water Level (LWL): This daily dataset will be generated using satellite radar altimeters as well as the heritage of Hydroweb project which already produces LWL for 160 lakes. Time series of past missions (ERS-2) will be updating using current missions as Sentinel 3a and 3b in SAR mode. The overarching goal is to give the users a full reprocessing of radar altimetry measurements from 1992 (T/P) until present-day.
2. Lake Water Extent (LWE) will be generated using a combination of satellite imagery and altimetry
3. Lake Surface Water Temperature: Lake temperature is one of the most fundamental characteristics of a lake, it varies with depth and in time from daily to millennial time scales.
4. Lake Ice Cover: LIC combine dates of freeze-up and break-up of lake ice as well as monthly ice thickness. The data will be validated using in situ data and visual interpretation on selected lakes.
5. Lake Colour (reflectance): Colour varies with dissolved (organic) and particulate matter (phytoplankton, minerals, detritus). Seasonality and short-lived events easily obscure long-term trends, therefore, long time-series without gaps are needed. MODIS, VIIRS, SeaWifs have a limited scope, explored only for large or clear waterbodies, as a consequence, the continuity between MERIS and OLCI is a priority for the ECV.

A dialogue is established with users and interaction with climate model users (such as the CMUG) for both collecting and reviewing user needs for ECV products. The CRG will then assess and exploit the products, and look to see if lake data can improve the modelling of regional climate change. Four case studies will analyse the link between different variables based on simulation versus ECVs observations and help assessment of future impacts from climate change scenarios on the lake.

Biomass
Prof. Richard Lucas *(Aberystwyth University)*

Biomass is a key indicator for climate and an essential variable in the Earth System. It is highly sensitive to land use and management, partly controls fire emissions, is a storage reservoir of carbon and influences the climate by controlling biophysical climate effects. Biomass data can allow process-oriented evaluations of ESMs; facilitate model initiation and validation to consider dynamics and disturbance, and can constrain carbon budgets. This last point is valuable in a policy context, given the Paris Agreement and the 5-year global stock take cycle, which characterises biomass changes over time.

CCI Biomass focuses on the above ground biomass of woody vegetation, using combinations of radar, optical and LIDAR data for retrievals independent and consistent. The team will consider the influences and links with other environmental variables on EO data (e.g., soil moisture, water inundation) and others ECVs (e.g., Fire, GHG, Land Cover). It builds on the heritage of GlobBiomass, which produced a global 25m resolution map of above ground biomasss for 2010. In situ data support will come from forest inventories and airborne data. It is planned that CCI Biomass will help improve access to, and standardise the in situ datasets, whilst expanding the existing datasets and establishing a global plant biomass facility. This is necessary as the uncertainty assessment will require in situ data of high quality, representing a wide range of environments.

The Biomass team will use the data to benchmark land-surface models, understand carbon processes (e.g. allocation), constrain regional carbon budgets, and quantify emissions and sinks associated with the land use change and forestry sectors.

Land Surface Temperature
Darren Ghent *(University of Leicester)*
LST is an essential parameter for diagnosing Earth System behaviour and evaluating Earth System Models. Indeed, it provides a globally consistent record from satellites of clear-sky, radiative temperatures of the Earth's surface. It provides a crucial constraint on surface energy budgets, water stress and availability. It also provides metric of surface state when combined with vegetation parameters and soil moisture. A long, stable record of LST is particularly useful for model evaluation in regions where few in situ measurements of surface air temperature exist and for attribution of observed changes in such regions to their possible causes. This independent temperature data set helps quantify climate change complementary to the near-surface air temperature ECV based on in situ measurements and reanalysis.

The requirements and expectations for the LST ECV products are:
- To produce a seamless end-to-end LST ECV for complete multi-mission archives in a pre-operational context with an accuracy and precision less than 1 K
- A first assessment of the stability < 0.3 K per decade.
- A first global LST CDR with record length over 25 years and passive microwave time series over 20 years.
- Significantly increase maturity levels to at least level 4

The algorithm development will include retrieval algorithm consistency across LST ECV products and CDRs for bridging and filling the Envisat/Sentinel-3 gap with better time difference correction, and bias and time difference corrections of Level 1 data for CDRs. There will be a consistent approach to uncertainty (following FIDUCEO protocols) where components are separated according to their differing correlation properties and validation of uncertainties. Optimisation of cloud clearing detection across new sensors will take place for the long-term CDR and merged CDR.

Independent and rigorous product validation and intercomparisons will be extended to new sites and external datasets from the GlobTemperature dataset. The team aim for demonstration of climate applications resulting in at least four journal papers led by users. A close interaction with other ECV is essential, especially Permafrost, Snow, Land Cover, Lakes and Water Vapour.

8 KNOWLEDGE EXCHANGE

8.1 Communication, Visualization and Education

Paul Fisher, *ESA*

The overall objective for Knowledge Exchange activities in the CCI is to maximise awareness, access, use & understanding of the satellite data for climate observations, climate research & results. Within the new phase of the CCI programme, the plan is to expand audiences from purely science to cover a wider range of people, including policy makers (ESA delegates), CCI scientists, climate research and Earth system science community, general public, primary up to tertiary sector educators.

Knowledge exchange activities to date include the successful CCI Visualisation Tool and Climate from Space Tablet App. A MOOC on Climate from Space has also been developed, plus there is the CCI website and Twitter feed where information on the CCI can be found. A new ITT for Knowledge Exchange activities will be released at the end of 2018 that tries to harmonise some of this work and to develop it in a less ad-hoc way. It will include 5 elements:

- Website
- Visualisation
- Education
- Open Data Portal
- Toolbox

The website will be updated to be more responsive, user friendly, have better visual impact, be easy to digest for first time users and showcase CCI science. Visualisations will be available via a web browser version (no need to download) in order to maximise access to them, plus additional animated videos of ECV interactions will be developed. One of the objectives is to increase young people's awareness of ESA EO by utilising ECV data in school and university curricular and producing CCI toolkit. All the ECVs team can support the outreach of CCI communication by supporting CCI media request, keeping their project site updated, contribute to the production of fact sheets or videos and especially keep the communication team inform of upcoming papers, outputs, events and data releases.

8.2 Raising Awareness of Data Protection

Ed Pechorro, *ESA*

The EU General Data Protection Regulation comes in to force on the 25th May 2018 and protects the privacy and data for all individuals within the European Union. It provides a right to access and a right to erasure. CCI teams must make sure they are compliant with GDPR if they have newsletters, mailing lists, etc.

8.3 CCI Open Data Portal

Victoria Bennet, *CEDA*

The CCI Open Data Portal is a single point of access to CCI Data. The user can search in the central Data Archive to get information on or download ECV datasets. There are different ways of accessing the data; there is a dashboard that is accessed from the CCI main website. A faceted search uses drop-down lists of search terms relevant to the ECV, e.g. processing level, institute, sensor. The Portal team indexes your data by pulling these terms from filenames and metadata – this relies on using **CCI vocabularies,** so data standards are important. Download is via Anonymous ftp, HTTP, OPeNDAP (netCDF, CCI standards compliant), WMS, WCS (suitable gridded L3 data).

The Archive includes 14 ECVs, over 100 datasets, 2.6 million files for a total of 122 Terabytes. The Catalogue provides "hand written" content for each dataset, pulled from the ECV teams' documents and information provided by each team. This includes: links to external documentation, papers, websites, authors or spatial/temporal coverage. ECV teams can help the Open Data Portal team provide good access to your data by: Telling the ODP about upcoming data, follow the CCI Data Standards, send some sample files early, ask for help with formats/metadata, use the portal and send feedback.

The Open Data Portal Team also supports CCI to prepare and submit data to OBS4MIPs: Observations for Climate Model Intercomparisons.

8.4 CCI Toolbox

Carsten Brockmann, *Brockmann Consults*
CATE is the ESA Climate Data Analysis and Tooling Environment, supporting multi-ECV analysis; it uses Open Source software that is easily extendable. Access to the datasets is provided through the Open Data Portal to scientists and climate users. With 3 different user interfaces (GUI, command line interface CLI, programming interface API) users can manage data, integrate it into their own python code and perform operations (backend) or get interactive analyses and visualisation (frontend) of the data. The frontend and backend communicate via http protocol (CATE is cloud-ready).

The Toolbox is still developing to support more ECVs (already in progress) like Glaciers, Land Cover, Greenhouse Gases, which have been validated with use cases. Other developments include API code examples and how to integrate Cate in users' programmes. Also, in progress are User Interfaces that will support outreach, communication, online videos (how to's) and training activities (robustness, easy work with arrays and 3D resources). The interface will explain to the user how to extend Cate by their plugin and how GUI is extended as well as providing CLI scripts and saved GUI workspaces complete use case.

9 CROSS ECV ACTIVITIES

9.1 Sea Level Budget Closure

The Sea Level Budget Closure project is a cross-ECV scientific exploitation project that is using CCI data to help answer one of the 'Grand Challenges' of the WCRP: how well do we *know* and *understand* sea level change and its causes? It involves Sea Level, Sea Surface Temperature, Greenland Ice Sheet, Antarctic Ice Sheet and Glaciers and looks at the quality, consistency and uncertainty characterisation of the datasets in order to answer the question. The objectives of the project are to: investigate in a coherent way the closure of the sea level budget and thereby assess the quality of CCI products; to study and to analyse the regional variability of sea level and its steric and mass components (the Arctic Ocean is chosen as study region); and to prepare the way for more comprehensive and operational sea level budget assessments.

The team have reviewed the datasets of the individual budget components and their uncertainties to create a first budget closure covering 1993-2015 (altimetry period) and 2003-2015 (ARGO and GRACE period). The v0 budget closure for the global mean sea level trend (2003-2015) was found to be within uncertainties *(for some choices of GRACE Ocean mass change)*. Work continues on the project to improve the datasets of the budget components and their uncertainty information and their consistency (e.g. use glacier model output as input to hydrological model). The methodology of budget closure assessment can be improved from consistent treatment of trends, inter-annual and seasonal components, and by including error correlations. There is a lot of benefit in having the authors of the data products involved in the consortium.

The future perspectives, beyond current project, are:
- The inclusion of new ECVs (snow, water vapour, potentially others).
- Extend regional assessments.
- More comprehensive and operational assessments.

9.2 ERA-5 and the use of ERA data

Hans Hersbach, *ECMWF*
Reanalysis offers a detailed overview of the past atmosphere by combining vast amounts of the best-available observations into global fields. It is consistent as it uses the same physical model and DA system

throughout and it also allows for a close monitoring of the Earth's climate system where direct observations are sparse. The ERA-Interim dataset is now 10 years old and will be replaced by ERA5. ERA5 includes many updates, such as newly reprocessed and new datasets (e.g. ERS ½ soil moisture and IASI, ASCAT, ATMS). Hourly data will be provided throughout, with better uncertainty estimates, with data from 1950. The spatial resolution will increase from 75 km to 31 km. For now, it is available from 2008 – 2017 with monthly updates 2-3 months behind real time. The release of other periods will be done in stages with data access via the **Climate Data Store** soon. By the end of 2018 the 1979 – 2009 release will take place and continue the ERA5 timely updates. ERA-Interim will continue for another 6 months after this release. uncertainty estimate. C3S User service Desk, Knowledge Base, FAQ's all exist as user support options. The performance of ERA5 is very promising in the troposphere, for winds and ocean waves, there is improved global hydrological and mass balance, reduced biases in precipitation, and refinement of the variability and trends of surface air temperature.

9.3 CCI Living Planet Fellowships

The Living Planet Fellowship in CCI was launched in 2014 in response to requests for opportunities to exploit the CCI data within the CCI Community. The overarching goal is to engage young scientists, at postdoctoral level, in ESA Member States to undertake leading-edge research on climate science maximizing the scientific return of ESA EO missions and datasets through the development of novel methods, new products and fostering new scientific results.

In total 13 projects have been funded through two calls for fellowship proposals in 2014 and 2015, and 36 scientific papers have been published as a result by 2017. The objective for CCI+ is to fund up to 15 research fellowships focusing on exploitation of CCI products and/or examination of consistency/joint use of ECV products and to make the Fellowships more attractive to all CCI countries. There will be three calls for CCI Research Fellowships, to be made at approximately 2-year intervals during CCI+, nominally in 2018, 2020, and 2022.

9.4 RECCAP-2

RECCAP-2, the second Regional Carbon Cycle Assessment and Processes, aims to establish the mean carbon balance of large regions of the globe at the scale of continents and large ocean basins, including their component fluxes. The method consists of comparing and reconciling multiple bottom-up estimates with the results of regional top-down atmospheric inversions, with attribution to main flux components. Then, the aim is to evaluate the regional 'hot-spots' of inter-annual variability and possibly the trends and underlying processes over the past two (or more) decades by combining available long-term observations and modelling. An original RECCAP project was successfully run in 2011, and given the improved data that we have now, an update is due. The Global Carbon Budget shows that, over time, carbon sinks have continued to grow with increasing emissions, but climate change will affect carbon cycle processes in a way that will exacerbate the increase of CO_2 in the atmosphere. There is still an imbalance in the budget, which reflects the limits of our understanding of the carbon cycle. Although the top-down and bottom-up estimates of surface CO_2 fluxes agree quite well at the global scale, there are large inconsistencies in regional budgets and their inter-annual variability.

RECCAP-2 within the CCI programme will atmospheric inversions at regional resolutions to provide consistency with the approach used in the global carbon budget update, outputs from process-based terrestrial ecosystem models used in the TRENDY model intercomparison, outputs from data-driven models used in the FLUXCOM project and then synthesis and analysis of the results from the three approaches to examine changes as a function of key potential drivers in collaboration with the wider climate modelling community.

10 FEEDBACK AND WRAP UP

10.1 Global Climate Observing System (GCOS) Update

The Global Climate Observing System (GCOS) is a United Nations-ratified programme which regularly assesses the status of global climate observations and produces guidance for its improvement. Improved observations have significant benefits that start from developing ECV requirements, adequacy reports and plans. Then observations, and data products can be made open access. These are used to inform science, assessments and policy, from which climate services, risk assessments, early warning & disaster risk reduction policies can be developed. This allows successful adaptation and mitigation, reduced climate risks, enhanced livelihoods and food/water security.

At COP22 in 2016 the GCOS Implementation Plan was released at the SBSTA Conclusions. This includes actions on:

- Improving monitoring of Global Climate Cycles (Water, Energy and Carbon cycles)
- Additional Essential Climate Variables
- Adaptation and Mitigation
- Emphasis on more help for networks in developing countries
- Development of indicators of climate change

Relevant to the CCI, the GCOS Plan includes Action G3 on: Development of indicators of climate change, which will devise a list of climate indicators that describe the ongoing impacts of climate change in a holistic way. It will consider the work of the WMO, IPCC and others. There are also plans for indicators for adaptation and risk too.

In its review of the GCOS Plan, the UNFCCC's SBSTA noted the efforts undertaken by GCOS and the wider science community on the development of climate indicators, including global surface temperature, global atmospheric carbon dioxide and glacier change, and by WMO on the categorization of extreme events. They also noted the importance of ocean-related climate indicators, including ocean heat content, ocean acidification, sea level rise, and Arctic and Antarctic sea ice extent, for informing on the state of the global climate.

The GCOS Plan responds to Paris Agreement. Article 7 (7c) on 'strengthening scientific knowledge on climate, including research, systemic observation of the climate system and early warning systems.' It is reviewing how to best respond to parts of the Paris Agreement that are under development, such as the Global Stocktake. New areas identified for consideration that support the Paris Agreement include:

- Monitoring of urban areas – this is where people are and impacts felt
- Monitoring the impacts of adaptation
    - Adaptation in the built environment (changing patterns of urbanisation)
    - Track the land footprint of renewables
    - Near ground level wind speed (e.g. for wind power)
    - Track changes in heat loss from groups of buildings
- Track encroachment of buildings/agriculture into forests
- Track adaptation in forest management
- Design other urban based adaptation observations
- Consider improvements to pre-1880 temperature records

GCOS advocate for free and open products as that allows high-quality observations of many ECVs, long term accuracy, transparency, stability and comparability of observation. The provided data are traceable to an internationally accepted standard and has a comprehensive uncertainty analysis. GCOS ensure an understanding of the needs of its users and supports, though climate observations, main of the Sustainable Development Goals of UN.

The new GCOS Strategy encapsulates:

- Vision – "A world where users have access to the climate information they require"
- Aim – "Ensure the availability and quality of climate observations necessary to monitor, understand, predict and protect the global climate system and to assist communities and nations to live successfully with climate variability and change"
- Principles (e.g. free and open data)
- Strategic Goals and Actions

10.2 Science Leaders Meeting

The Science Leaders discussed how to maintain the CCI community and keep the added value we get from meeting twice a year, given that the current ECV teams are finishing soon (or have finished). The message to ESA was to adjust the number of meetings, or deliverables to be able to keep enough people.

Looking at how the CCI programme might evolve: we have progressed from developing single ECVs, for single sensors, for single years. Now we're developing single ECVs with multiple sensors and multiple years. In the future it's likely we'll see *joint* ECVs with multiple sensors, over multiple years.

The group reiterated that C3S will not do research, even though it is an essential part of the ECV work, so urges CCI to continue.

A CCI conference was proposed, to promote the programme internationally, and to set up and extend the community. A suggested date was the beginning of 2020 - after LPS and with time for the new projects to have developed products. The aim is to really push the multi ECV view and interaction, and to bring in the climate modelling and adaptation community.

The IPCC AR6 report was discussed too; the table of contents is different from the previous framing so there is an action on CMUG to review where CCI can fit.

There have been a number of successful joint papers, looking at a joined up approach to the Earth system and on ECV uncertainties. With new ECVs these ideas can be developed further.

CMUG meeting ideas were proposed: a special session with a focus on cross-ECV fellowships. Speed dating to develop cross ECV ideas.

Finally, the new chair of the Science Leaders group will be Darren Ghent.

10.3 Climate Science Working Group Feedback

The CSWG is a forum to examine the climate quality (e.g. the uncertainty characterisation) and consistency between CCI ECVs, and consider the scientific requirements of the climate data. Potential topics for discussion are: the use of reanalysis data; feedback on common issues between ECV projects and looking for synergies and efficiencies; coordination of outreach plans between climate modelling and user communities. They will aim to meeting the evolving needs of the climate community.

10.4 Data Engineering Working Group Feedback

The Data Engineering Working Group (DEWG) include one representative from each CCI project, who work together to cultivate common CCI benefits, opportunities and infra downstream. Their objective is

to supports the teams and ensure maximum usability of the datasets produced within CCI, and cultivate tools for their access, discovery and manipulation through common CCI data standards. The aims are:

- To provide a forum to manage data standards across CCI projects.
- To agree on common format and metadata requirements though CCI projects feedback and proposals.
- To share expertise, to enhance coordination and communication and thus avoid duplication of data engineering effort.
- To ensure that suitable existing standards are adhered to within CCI data products.
- To provide ESA with insight into the data engineering needs and challenges being experienced by CCI projects.

In accordance with the DEWG decisions, data should be produced in netCDF-4, conform with the CF (Climate and Forecasting) convention, as well as the variables names should respect CF standard. In case users require other formats then the standards should apply as far as possible but standardised netCDF products should also be produced.

10.5 Wrap Up and Discussion

Pascal Lecomte concluded the meeting by proposing the next Collocation meeting should be held again in Oxford, for similar dates in 2019.