WCRP REPORT
World Climate Research Programme

PROJECT REPORT

Report of the fifth session of the WCRP Data Advisory Council (WDAC)

The Collider, Asheville, USA
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Attendees of the WDAC5 session

PRESENT: Otis Brown (Co-Chair), Michael Bosilovich, Peter Gleckler, Kenneth Holmlund, Albert Klein-Tank, Pierre-Philippe Mathieu (remotely), Walt Meier, Joerg Schulz, Susann Tegtmeier, Jean-Noel Thépaut

INVITED EXPERTS: Jim Biard, Christina Lief, Glenn Rutledge, Mike Tanner, AOPC attendees (joint session)

EXCUSED: Toshio Koike (Co-Chair), Carol Ann Clayson, Pascal Lecomte, Konrad Steffen, Toshio Suga, Mark Bourassa, Brian Ward

WCRP JPS: Michel Rixen

WMO Secretariat: Carolin Richter, Caterina Tassone

1. Joint WDAC-AOPC session

a. Introduction

Otis Brown welcomed all WDAC and AOPC participants and thanked them for attending this important joint session. He recalled the role of WDAC to coordinate observations and data issues in the broadest sense and highlighted the opportunity to address matters of common interest to both WCRP and GCOS/AOPC. Essential Climate Variables (ECV) represents a key element of this process.

Kenneth Holmlund, on behalf of AOPC, noted the benefit of holding such joint sessions and the role of GCOS/WCRP panels as a mechanism to interface between both programmes. He invited all attendees to be forward looking and to identify requirements and success from a customer/end-user perspective.

b. Welcome address from NOAA / NCEI

Mike Tanner, Director of the NOAA Center for Weather and Climate of the National Centers for Environmental Information welcomed attendees and thanked everyone for travelling to Asheville. He briefed participants on the new NOAA structure, with the National Centers for Environmental Information (NCEI) being a merger of 4 NOAA data centers and headed by Thomas Karl until his recent retirement. He noted the opportunity of making close connections with the Copernicus Climate Change Services (C3S) and to build on lessons learned over the past 50 years at NOAA. He pointed to the importance of involving subject matter experts in tailoring end-user products.

c. WCRP update

Michel Rixen provided an update on WCRP matters. He recalled the mission of the Programme within global drivers such as the Paris Agreement, the Global Framework for Climate Services (GFCS), the Sendai Framework on

Disaster Risk Reduction, the expected new UN Urban Agenda and the plans for the IPCC 6th Assessment Report (AR6) and associated Special Reports.

He highlighted the WCRP Grand Challenges, including new ones on Carbon and Near-Term Climate Predictions to be discussed at the 37th session of the WCRP Joint Scientific Steering Committee. He recalled the WCRP vision for an integrated data infrastructure serving model simulations, observations and reanalysis data via the Earth System Grid Federation. He also drew attention to uncertainties associated with these products and the need to characterize and document them for robust decision-making. Some critical issues in climate observing systems were highlighted, such as the possible lack of limb sounder data in the near future. The WCRP-FPA2 Polar Challenge (http://www.wcrp-climate.org/polarchallenge) was presented as an innovative way to promote cost-effective, autonomous and scalable observing systems for the polar ocean.

d. GCOS update including Status Report and Implementation Plan

Carolin Richter provided an update on the GCOS Status Report and plans for the GCOS Implementation Plan to which the Satellite Supplement will be annexed and for which WCRP inputs are welcome. She recalled the recurrent FOA sponsorship issue regarding the Global Terrestrial Observing System. She presented the outcomes of the GCOS Conference held in Amsterdam in spring 2016.

e. GCOS panel reports

See item 1d.

f. Discussion

Kenneth Holmlund recommended strengthening reanalysis expertise on AOPC. He asked whether current ECVs are fit for purpose to address the water, energy and carbon cycles comprehensively and noted the importance of fluxes for these cycles, ECVs, Fundamental Climate Data Records (FCDRs) and Climate Data Records (CDRs) interdependencies and cross domain challenges. Requirements regarding IG3IS are being discussed in the context of the GCOS Implementation Plan legacy data sets, inconsistencies, cross-cutting issues, etc.).

Otis Brown suggested to have a more granular mapping of ECVs against these cycles and offered the WDAC Task Team on Fluxes and the WDAC TT on Reanalysis to look into this. He noted the Paris Global Stock Taking as an important element in the IG3IS context.

Joerg Schulz highlighted FIDUCEO as an effort to address uncertainties in metrological terms and the difficulty to propagate these along the value chain.

Validation is the other end of the chain and the GAIA-CLIM project aims to address individual measurement uncertainties (satellite pixel vs in-situ observation - e.g. GRUAN - collocation issue).

There are challenges associated with the characterization of uncertainties from the satellite retrieval process for a single ECV, henceforth further difficulties for fluxes because of covariances and this represents a long-term research endeavor.

It is important to follow fundamental principles from the start, as there are different opinions and approaches about homogenization, cross calibration, etc.

The FP7 project Climate Information Portal for Copernicus (CLIPC) is developing a pre-operational data service infrastructure for the Copernicus Climate Service.

Jim Butler noted that this requires a big learning curve and that metrology has done some good ground work on these issues. He further highlighted IG3IS' aim to provide sub-continental scale information on emissions, the focus being changed from control (COP15) to 'help to succeed' (COP21). This will require Observing Simulation System Experiments and a possible involvement of the World Weather Research Programme to investigate the impact of observations. Some relevant studies are conducted on urban areas in this context. The IG3IS Implementation Plan involves a team of 22 people.

g. Fluxes

This item was not discussed because of last-minute cancellation of the briefer.

h. Impact of observations

Jean-Noël Thépaut briefed participants on the latest research regarding impact of observations in NWP models. Observations being assimilated in NWP are increasing dramatically, representing big data in terms of volume (in space and time), velocity, and variety (parameters). Observation quality, usability, error characterization and tuning of the data assimilation system are all important. Significant remote benefits across variables can be achieved from 4DVar dynamical adjustments and Ensemble Data Assimilation (EDA) background error covariance specifications. Pros and cons of Observing System Experiments (OSE) and Adjoint Sensitivity Diagnostics (ASD) were discussed and several results presented.

The WMO 6th Workshop on the Impact of Various Observing Systems on NWP will be held in Shanghai, China, May 10-13 2016 and is being organized by the Inter Programme Expert Team on the Observing System Design and Evolution (IPET-OSDE).

Roger Saunders noted the decline in soundings (especially over islands) and possible impact on calibration of error covariances, which could be addressed at the Beijing meeting.

Michel Rixen noted that observations, operational reanalyses and data assimilation are also key in initializing climate prediction simulations.

The importance of SST and soil moisture for seasonal forecasts was emphasized. It was commented that assimilating aerosols was complex due to its dependence on so many parameters.

Kenneth Holmlund noted possible conflicting requirements between NWP and Climate Predictions.

Jean-Noël Thépaut commented on the opportunity to use reanalyses to address water, energy and carbon cycles syntheses.

i. Reanalyses

Michael Bosilovich noted that new reanalyses have become available in the last year. Specifically, MERRA-2, includes several changes directed at making a more consistent climate data set that incorporates satellite data assimilation. MERRA ceased production after 29FEB2016. ERA5 integration has begun. The ERA-20C surface pressure and wind only reanalysis is presently available, as well as the JRA-C, which uses only conventional (physical observations) data assimilation. NCEP's follow on reanalysis to replace NCEP-1 is presently underway. The CMA is also beginning an atmospheric reanalysis plan. Considering that all atmospheric reanalysis centers are implementing plans for "families of reanalyses", we can expect regular introduction of new reanalyses.

Over the last year, the white paper on the Task team for Intercomparison of Reanalyses (TIRA) has been circulated among the main WCRP panels. The white paper outlines the need for a task team on reanalyses and their intercomparison. The near term objective of the team is to define a reanalysis intercomparison project that will improve the communications among the developing centers as well as with the research community, and to foster the understanding of the strengths and weaknesses of reanalyses. The task team has members from the reanalysis development centers, and will be looking for representation from concerned WCRP panels.

Jean-Noël Thépaut recalled the end-user requests for hourly outputs in the context of ERA5.

Michel Rixen noted that the work of the Task Team can start, as its establishment was approved by the JSC.

Otis Brown clarified the distinction between CREATE-IP as a tool to support the general intercomparisons of reanalyses and the specific focus of ana4MIPs to support MIPs under CMIP6.

Michael Bosilovich noted that the precipitation observations used in MERRA are based on pentad GPCP data, but higher frequency inputs could also be used. He commented that observation-model misfits can be useful to detect issues at regional level, for example in Africa, South-east Asia and at high latitudes.

It was suggested to also involve reanalyses produced by CMA.

Roger Saunders mentioned that regional reanalyses are becoming a common product in several institutions.

Andreas Becker highlighted the challenge of reanalysis precipitation in monsoon regions and raised the issue of feedback to model development efforts. He also invited the Task Team to look into ensemble approaches and the spread from multiple reanalyses.

j. Development of a WCRP-GCOS Data Prize

Michel Rixen presented the main elements of a possible WCRP-GCOS International Data Prize. It was agreed to circulate the draft call for nominations to WDAC and GCOS for final approval.

k. WCRP-GCOS Data Policy

Michel Rixen presented the main elements of draft pan-WCRP Data Policy resulting from a compilation of various sources and inspired by WCRP's sponsors policies. It was agreed to circulate the draft document to WDAC and GCOS for final approval.

2. Data set products and requirements

Briefers were invited to focus their presentation specifically on climate data set requirements, assessments and dissemination, including fluxes, reanalyses and interfaces with other efforts such as obs4MIPs and ana4MIPs.

a. Review of WDAC4 actions

WDAC4 actions were reviewed and incorporated into the WDAC5 actions outlined in ANNEX A when appropriate.

The role of WCRP core projects representatives in ensuring a 2-way liaison with WDAC was re-emphasized.

b. CLIVAR – GSOP etc.

Pierre-Philippe Mathieu (remotely) provided an update on relevant CLIVAR activities. Climate is the result of energy transfer between the different components of the Earth's system. The Earth's Energy Imbalance (EEI) is the most fundamental measure of climate variability and the rate of global change (von Schuckmann et al., Nature Climate Change, 2016). Any climate forcing (of natural or anthropogenic origin) can perturb this energy balance and give rise to EEI. Quantifying EEI remains one of the key challenges faced by the climate research community. It can be done in 4 main and independent ways (e.g. satellite measurements at TOA, in-situ observations and reanalysis outputs for ocean heat content, mean energy flux measures of the Earth's surface budget, estimates of EEI from climate models) leading to different insights. Thus evaluating and reconciling the resulting budget imbalance has become a key emerging research topic in climate science, which has the potential to bring different communities together to achieve major advancements to reducing climate change uncertainties. Errors involved in deriving single components can lead to large imbalance differences in estimates of Earth's budgets and climate. Reconciling the different approaches however remains a challenge. In this context CLIVAR has started the 'Consistency between planetary energy balance and ocean heat storage' (CONCEPT-HEAT) research focus, bringing together different climate research communities all concerned with the energy flows in the Earth's System to advance the understanding of uncertainties through budget constraints: atmospheric radiation, air-sea-fluxes, ocean heat content, ocean reanalysis, atmospheric reanalyses, NWP, climate models and global sea level.

This CLIVAR research focus has the main objective to build up a multi-disciplinary community for climate research aiming to work on two different issues: (1) Quantify Earth's energy imbalance, the ocean heat budget, and atmosphere-ocean turbulent and radiative heat fluxes, their observational uncertainty, and their variability for a range of time and space scales using different observing strategies (e.g., in-situ ocean, satellite), reanalysis systems, and climate models and (2) Analyze the consistency between the satellite-based planetary heat balance and ocean heat storage estimates, using data sets and information products from global observing systems (remote sensing and in situ) and ocean reanalysis, and compare these results to outputs from climate models to obtain validation requirements (for model and observations).

The CONCEPT-HEAT ISSI working group has published a perspective paper in Nature Climate Change. The team also organized a workshop at the UK Met Office (Exeter, 30 Sep - 01 Oct 2015) to discuss the strengths and weaknesses of different measurement methods of EEI and how to reconcile them. The workshop brought together experts from ocean and atmospheric reanalysis, air-sea fluxes, ocean heat content (OHC), climate models, atmospheric radiation and sea level to better synthesize all the information available. The workshop made a synthesis of the key questions and challenges faced across communities.

http://www.clivar.org/events/workshop-energy-flow-through-climate-system

The team is also addressing the problem of inconsistency between planetary heat balance and ocean heat storage estimates, data sets and information products based on different parts of the global observing systems, including:

- Satellite with the ESA Ocean Heat Flux project developing a new climatology of turbulent heat fluxes based on an ensemble approach and validated through regional constraints from cages. See: http://www.oceanheatflux.org
- In situ observations of ocean heat content changes (GOOS and CLIVAR/GSOP)
- Ocean reanalysis for atmosphere-ocean heat exchange and ocean heat content estimate (CLIVAR/GSOP, SeaFlux)

Jean-Noël Thépaut remarked that coupled reanalysis could play an important role in this effort.

Pierre-Philippe emphasized the science issues related to fluxes and acknowledged the ECMWF efforts on coupled reanalysis. He further noted the need to develop DEEP ARGO to support CONCEPT-HEAT type of analysis in response to Peter Gleckler's comment on the contribution of the deep ocean in heat budgets, and supported the idea of WDAC putting a recommendation forward to that effect.

Peter Gleckler encouraged the use of ESGF for publication of flux data, ocean reanalyses and CONCEPT-HEAT products. It was decided to consult with CLIVAR to that effect.

c. GEWEX – GDAP etc.

Joerg Schulz provided an update on the GEWEX Data and Assessment Panel and data products and assessment, including water vapor (GVAP), clouds, aerosols, surface radiation budgets, precipitation, sea and land fluxes, soil moisture, their interdependencies and integration. He highlighted the need for ground-based observations, in particular those provided by the BSRN (radiation), GPCC (precipitation) and ISMN (soil moisture) networks. New GDAP activities include surface radars for precipitation, upper tropospheric cloud and convection process evaluation (PROES) and uncertainty analysis for satellite data records (European projects such as FIDUCEO – focusing on systematic errors and GAIA-CLIM addressing metrological approaches to characterize ground-based reference and satellite data).

Otis Brown noted that all US radar data are publicly available from multiple cloud data providers at 1km every 5 minutes for 10 years. Associated products such as hail and wind shear will soon be available too.

Members recognized the need to advocate for critical observing systems, in particular radar data, BSRN and ISMN, some of them relying almost entirely on research funds.

d. SPARC – S-RIP etc.

Susann Tegtmeier updated WDAC on SPARC activities. SPARC has a well-established history of guiding the creation and analysis of long-term records of a range of essential climate variables including temperature, water vapour, ozone, and aerosols. In particular, merging of ground-based, balloon, aircraft, and space-based measurements by taking into account the sampling characteristics of each measurement type is promoted by several SPARC activities. The activity on 'Trends in the Vertical Distribution of Ozone' demonstrates the importance of high-quality ground-based instruments for the quantification of quality and stability of satellite measurements. Ozone CDRs are not only essential for assessing the effectiveness of the Montreal Protocol but also are needed for prescribing forcing in climate model simulations without stratospheric chemistry. The activity on Atmospheric Temperature Changes aims to include emerging novel observational records from GPS radio occultation, limb-viewing instruments and GRUAN radiosondes. The SPARC Reanalysis Intercomparison Project (SRIP) successfully established collaborative links between the reanalysis centres and the SPARC community and is evaluating the performance and quality of the currently available stratospheric reanalyses. The SRIP assessment will provide guidance on the appropriate use of reanalysis products.

Finally, SPARC summarized its data needs, which are the continued improvement of meteorological analyses and past records, as well as the continuation of existing core measurements. SPARC brought to the attention of WDAC that real funding pressure is threatening the closure of many ground-based observation sites and also led to a lack of planned limb satellite sounders. It has been noted that the latter in particular would make it difficult for SPARC to support WMO in observing the state of the ozone layer, a mandate given to WMO by the signatories of the Montreal Protocol.

Joerg Schulz recalled the role of the CGMS Radio Occultation Group and its relevance in addressing changes atmospheric temperature. He emphasized the need to advocate for continuous climate data records where the WG Climate can play an important role.

It was decided to raise the issue of decreasing ozone sondes and the risk posed to atmospheric composition limb sounder missions for broader sponsor discussion.

e. CliC

Walt Meier noted that the WCRP Climate and Cryosphere (CliC) group is focusing on model inter-comparison projects (MIPs) as a contribution to the

IPCC CMIP process. Three that are particularly active are: the Ice Sheet MIP (ISMIP), the Marine Ice Sheet-Ocean MIP (MISOMIP), and the Sea Ice MIP (SIMIP). ISMIP is an officially accepted CMIP6 project. The ultimate focus is to integrate dynamic ice sheet models into Earth System Models to have a fully-coupled ice sheet response to climate projections, particularly to properly understand the sea level rise contribution from ice sheets. In the shorter term, the focus is on bringing the ice sheet model community "in phase" with CMIP. In the past IPCC reports, the scenarios for ice sheet projections were not consistent with the CMIP emissions scenarios; the goal will be to use the CMIP6 emission scenarios (RCPs) for ice sheet model projections in IPCC AR6. MISOMIP is focused on better understanding ocean and ice sheet and ice shelf interaction and this is an area of emerging science; in particular, recent research has suggested that future ice sheet mass loss rates may be much faster than previously projected because of the interaction of warm ocean waters with the ice. SIMIP is a diagnostic MIP, meaning that there were be no specific model runs; the focus will be on preserving the most relevant sea ice variables from the CMIP runs to compare with observations and assess model performance.

Other sea ice activities include the enhancement of a system to record and archive systematic ship observations of ice conditions. The system has been developed, but needs a permanent archive. Also, wider use by operators in the Arctic is being sought. Seasonal sea ice prediction continues to be a focus and efforts are ongoing through the Sea Ice Prediction Network's annual Sea Ice Outlook.

For sea ice (and other cryospheric variables) a key observational need is grid cell level uncertainty estimates. Only in recent years, have such estimates become available. However, these uncertainties are empirically or theoretically derived and effectively are relative uncertainties. Further work is needed to calibrate and validate the uncertainties. Another emerging challenge is sustaining the long-term passive microwave radiometer record. Recently, two sensors failed and currently only one sensor (the JAXA Advanced Microwave Scanning Radiometer 2) is operating within its planned design lifetime. There are no planned launches in the immediate future and last year the U.S. cancelled the launch of an existing sensor platform due to budget concerns; other than that platform, the earliest launch of a passive microwave imager appears to be 2022 or later - far beyond the planned lifetimes of any current passive microwave sensor. Thus there is a high risk of a gap in coverage and it is hopeful that international agencies recognize this looming gap and work toward addressing it.

Members commented on the need to maintain a strong coordination with the WWRP Polar Prediction Project (PPP) and agreed there was a need to ensure continuous records through microwave imager/sounders for sea-ice products.

f. SOLAS

Brian Ward provided a short written update on SOLAS.

SOLAS and WCRP signed a MoU in January 2016 to develop activities of mutual interest focused on enhancement of research on ocean-atmosphere interactions.

The revised SOLAS science plan (for the period 2015-2025) was submitted to SCOR in March. This version of the plan took into account 8 reviews and was revised accordingly. SCOR needs to approve the science plan before committing continued funding for SOLAS.

The next stage is to work on the implementation plan, which will use the SOLAS annual national reports as a basis. The SOLAS Executive Committee will meet in June to finalize the implementation plan.

Two SOLAS workshops will take place in 2016:

- A SOLAS/ESA workshop led by Ilan Koren and Emmanuel Boss on `Concurrent Remote-Sensing Inversions of Ocean and Atmosphere`, Frascati, 13-16 June.

- `SOLAS and Society` will take place in Brussels, 26-27 October, and will be led by Christa Marandino and Erik van Doorn.

There were excess funds after the winding down of IGBP and the SOLAS IPO received some support for the salary of IPO personnel. Currently the two person IPO is secured until the end of 2016, but the IPO will have to reduce to one person unless further funding is secured. A proposal is currently pending with NASA and a second will soon be submitted to NSF.

There have been some recent efforts to improve estimates of air-sea fluxes in the Southern Ocean and a SOOS working group has been established - 'Enhancing Air-Sea Flux Observations in the Southern Ocean'. SOLAS will contribute to this effort through membership of the Steering Committee.

There are currently efforts to establish a Future Earth Knowledge-Action Network (KAN) to identify a set of the most societally pressing ocean issues and problems of relevance to society and target them with trans-disciplinary research towards developing solutions. SOLAS has responded to this initiative and will contribute towards the establishment of the next Ocean-KANs.

The next SOLAS Summer School is targeted for 2018, but details have yet to be defined.

The next SOLAS SSC meeting will be held in China, 24-26 October 2016, and be followed by a SOLAS China Symposium starting on the 27 October.

3. Data partnerships

a. ESA CCI and uncertainties

Pierre-Philippe Mathieu, on behalf of Pascal Lecomte, noted that the CCI Programme has delivered 13 ECV climate data sets and is continuously improving the algorithm. The Programme has involved more than 300 scientists, 100 research organizations and made a significant contribution to the IPCC AR5 (with 27 CCI scientists involved). The Programme has supported a series of cross-ECV & exploitation including the Climate Modeller User Group (CMUG), Research Fellowships, Ice Sheet Mass Balance Intercomparison Exercise (IMBIE) and several Cross-ECV work packages. The Programme is also starting new communication and user support activities including a CCI Visualisation Tool, CCI Open Data Portal and the CCI Toolbox and the ESMVal tool. The follow up called CCI+ will continue improving the quality of ECV products closer to meeting GCOS goals (e.g. accuracy, spatial resolution, long term stability), improve cross-ECV consistency, develop algorithms for "difficult" ECV variables required by GCOS (e.g. regional sea-level, coastal ocean color, aerosol absorption, sea-ice drift), extend ECV length by developing methods to bring older less well-calibrated satellite instruments into the time series (e.g. AVHRR), develop corrections for future instrument degradation, fully exploit the new capabilities of Sentinel and Earth Explorer instruments, develop climate-quality methods to join-up multi-mission time series, especially where there are gaps, e.g. Envisat to Sentinel-1/3, increase maturity of ECV product uncertainty estimates and perform algorithm round-robins to assess promising new ECV retrieval techniques. The CCI+ will also address new ECVs including ocean salinity, sea state (e.g. height/freq/dire waves), lakes (e.g. level, area, temp, phase), above ground biomass, snow cover (e.g. cover, SWE), long-lived greenhouse gases (e.g. CFC, SF6), precursors supporting the ozone and aerosol ECVs, high-resolution land cover, land surface temperature, and water vapour.

Pierre-Philippe noted that CCI will end in 2017 and will be hopefully followed by a new CCI+ initiative currently under consideration. ESA has efforts underway to integrate uncertainties as part of product developments. The aim is to develop the best possible climate data based not only on ESA missions.

Jean-Noël Thépaut highlighted the need for research and development for the existing ECVs within CCI+ because C3S is not focused on research.

b. WG Climate and uncertainties

Joerg Schulz, on behalf of Pascal Lecomte, highlighted the relevant outcome of COP-21 on “strengthening scientific knowledge on climate, including research, *systematic observation of the climate system* and early warning systems, in a manner that informs climate services and supports decision-making” in the framework of GFCS. He also mentioned the Climate Symposium 2014 outcome on “the need for an integrated observational

approach - one that is strategically designed to be cost effective and sustained over decades, yet remains targeted on key challenges and promotes the fusion of theory, models and observations." He further stressed the flow of requirements to products and the role of users and GCOS and reporting to CEOS, CGMS and SBSTA in this context. WG Climate has the lead on coordinating the implementation of the architecture for climate monitoring from space around the ECV inventory. He reviewed lessons learnt from Cycle #1 and proposed approach for Cycle #2 (collection and new and updated information from data providers, data incorporation and quality control, gap analysis and action plan).

Discussions noted the developments on the maturity concept, from the NOAA initial work to CORE-CLIMAX and GAIA-CLIM contributions. It was suggested to invite WDAC and obs4MIPs to review the beta ECV inventory.

c. obs4MIPs and ana4MIPs

Peter Gleckler provided an update on obs4MIPs and ana4MIPs in the context of supporting CMIP. He recalled the main features of this effort: CMIP5/6 standard output as a guideline for selecting observations, CMIP's application of the NetCDF CF convention, hosting on the Earth System Grid Federation, and requirements for technical notes. Data access and project connectedness is achieved via the CoG tools. Obs4MIPs data sets are growing steadily following a call issued earlier in 2016. Regular teleconferences are organized to advance the publication of data sets. Several topics were addressed, such as cataloguing, DOI's, maturity, CoG, expansion to new types of data (e.g. high frequency, non-gridded and in-situ). The Climate Model Output Rewriter (CMOR) being developed and improved at PCMDI is used by modeling groups to ensure their data is CF compliant and adheres to CMIP conventions. Importantly, the new version (CMOR3) can now be used to prepare gridded observational data sets for obs4MIPs. CMOR3 is available for modeling groups to begin testing, examples for how it can be used for obs4MIPs will be made available once the CMIP6 data standards (and consequently the obs4MIPs data standards) have been finalized. There remains a balancing act for the task team to both enable data providers to make their products accessible for climate research and to make judgments on whether a data set is suitable for evaluating climate models. An update on CREATE-IP and its link to ana4MIPs were highlighted in closing.

It was suggested to add a CREATE-IP link on the WDAC page. Joerg Schulz commented that ancillary data will most likely have DOI's in the future and search results could return such links.

Peter Gleckler mentioned that CMOR has been supported in a research capacity so far to support CMIP. It is open source, has been extended for seasonal to decadal prediction. There is a dedicated scientist at PCMDI currently working on these developments. Jean-Noël Thépaut offered a possible contribution to these developments but pointed to a possible

governance issue. Some coordination between C3S and PCMDI would be required to that effect.

Peter Gleckler commented that CMOR3, as it will be applied to obs4MIPs, can also be expected to facilitate the publication of flux gridded products on ESGF.

d. Planning for in-situ data in obs4MIPs

Jim Biard remarked that if the obs4MIPs program is going to expand to include a wider variety of observational data sets, it faces a few challenges. These challenges fall into three broad categories:

- Data sets that contain measurements not found in the CMIP5/6 list of requested variables.
- Data sets that don't fit into the standard model grid format.
- Improving the ability to make comparisons between model outputs and these more diverse observations.

The current obs4MIPs data format specification requires each obs4MIPs data set to correspond to (or be derivable from) an entry in the CMIP5 standard output tables. The table entry specifies (among other things) the kind of measurement, the units, and the name of the variable in the NetCDF files to be produced. The specification allows only the per-cell number of observations, standard deviation, and standard error to be included with the gridded measurements in the data set. There are many observational data sets that don't have entries in the tables at this time, and many which have tightly coupled auxiliary information (such as masks, quality flags, or other metadata) that need to be included for proper interpretation of the observations.

The current constraints will require the obs4MIPs team to make case-by-case decisions about new obs4MIPs submissions, generating new variable names for observations and auxiliary information as required. If inclusion of a wider range of observation types is desired and if it is not practical to have the obs4MIPs team perform this duty, some combination of obs4MIPs specification changes and relaxed governance will be required.

Not all observational data sets fit well into a regular grid. In particular, much in-situ data is composed of observations from loose networks of stations or from moving platforms. The current obs4MIPs specification has no way to accommodate these data sets, nor can it well accommodate lower-level satellite swath data sets. The lower-level satellite data sets often have quite high resolution in time and space, which can pose serious storage volume challenges. The obs4MIPs program will need to specify forms for these alternate organizations in order to support them.

The Climate & Forecast (CF) metadata conventions (which the obs4MIPs specifications are based on) currently specify forms for station and moving

platform measurements, but there is not good support for the auxiliary data that is often required. The conventions on forms for satellite swath data are still developing, as are conventions on forms for complex in-situ auxiliary information, and we can contribute to these efforts.

The obs4MIPs program can take a relatively hands-off approach to ensuring that a more diverse set of data forms and kinds can be compared, or it can work towards providing various transform modules to bridge these gaps. Standard modules could be developed that would interpolate between different grid resolutions; interpolate from swaths, stations, or moving platforms to grids; produce measurement estimates at station or moving platform locations from grids; and produce estimates of fundamental satellite measurements (such as TOA radiances) from climate model outputs. This represents an ambitious, longer-term goal, but it could foster increased interactions between the observational and modeling communities.

Joerg Schulz noted that the COSP simulator imposes more outputs to models, which could maybe wait until CMIP7. FCDR are useful for NWP and data assimilation too, and could be published on ESGF, but not necessarily on obs4MIPs.

Otis Brown commented that the publication of in-situ and other non-standard data will require a community based approach and cross-cultural collaboration. Regarding technical notes, it must be possible to parse the metadata.

Jean-Noël Thépaut advised to assess needs from CMIP and MIPS for in-situ, non-gridded and regional data sets. Michel Rixen commented that this depends on how one defines MIPs, as they are not limited to CMIP6.

It was decided to develop a path for the evolution of obs4MIPs to hold a wider variety of data sets beyond those currently in the process.

e. Discussion: uncertainties nomenclature and standards

The need for a framework to deal with uncertainties across WCRP was emphasized. This could build on several existing frameworks, e.g. from FIDUCEO, GAIA-CLIM, CLIPC.

An upcoming WDAC session could have a specific focus on uncertainty quantification.

ESA CCI has some dedicated efforts on this issue. A dedicated workshop on sea-ice uncertainties was held a couple of years ago.

EUMETSAT is planning a workshop in 2017 to quantify uncertainties in remote sensing data and will keep WDAC informed.

f. NOMADS, GEO and ESGF

Glenn Rutledge (NOAA/NCEI) presented short overviews of 3 programs: 1) the NOAA Operational Model Archive and Distribution System (NOMADS), 2) the Climate Data Access Task in the Group on Earth Observations (GEO), and 3) the Earth System Grid Federation (ESGF).

NOMADS continues to be a highly accessed model data archive service that provides over 250 million individual downloads per year providing over 1.4PB of data to researchers, the private sector and the operational forecasting community. NCEI and the NOMADS team are currently implementing the most recent version of the ESGF software suite that has undergone extensive security review led by NASA with participation across the international federation. Additionally, WCRP and the new GEO Climate Data Access Task (CA-03) are jointly advancing improved model data access within GEO to provide increased and easier access to advanced climate and weather models to and through the GEO community.

g. ECV inventory

Christina Lief noted that the Global Observing Systems Information Center (GOSIC) provides a clearinghouse that facilitates the discovery of and access to authoritative data, products, metadata and information for the Global Climate Observing System (GCOS), including a utility to access Essential Climate Variable (ECV) data. The ECV Data Access Matrix provides access to authoritative ECV space-based and in-situ data sets and information. These authoritative data sets have been submitted to critical appraisal and curated for quality and are properly documented with metadata. This matrix is in development and needs to be populated with additional data sets for each of the 50 ECVs. While there is an effort underway to query World Data Centers for space-based data, there is an equal need to query the World Data Centers for in-situ data sets. The space-based questionnaire has been adapted for in-situ data and is ready to be sent out to the World Data Centers but this effort needs buy-in and stewardship from the World Data Centers and the International community.

The ECV inventory is now hosted within the NCEI web site. Some members suggested a disclaimer regarding quality of the products. Joerg Schulz suggested product maturity as an alternative/complement to this issue. Jean-Noël Thépaut commented that this also applies to reanalyses.

There is a need for WG Climate and GOSIC to coordinate the development of satellite and in-situ ECV inventories.

h. Copernicus Climate Change Services

Jean-Noël Thépaut reported on the Copernicus Climate Change Services, vision, status of implementation of its four elements (Climate Data Store, Sectoral Information System, Evaluation and Quality Control, Outreach and Dissemination). The global reanalysis ERA5 is now in production.

The Climate Data Store will hold observations, ECVs, reanalyses, seasonal forecasts, climate projections and additional datasets (from other services, socio-economic data, etc.). It will make indirect use of other satellite data (land service, emergency service, marine service). Opportunities exist to coordinate with WCRP on win-win developments.

i. International Conference on Reanalyses

Jean-Noël Thépaut reported on the plans regarding the 5th WCRP International Reanalysis Conference, which will be organized by C3S in fall 2017. Several venues are currently being considered: UK, Spain, France. WDAC endorsed the idea and encouraged the JPS to mobilize resources for this event and Jean-Noël and Mike to develop all necessary practical aspects (science committee, call for abstracts, etc.).

4. WDAC Business

a. Inputs to WCRP Strategic Plan

The previous WCRP Strategy Plan 2005-2015 has come to an end and a new plan is under development, currently known as the 'WCRP Ahead' document. The outline is currently under review by the JSC. It will include some big picture/driver elements (Paris Agreement, IPCC AR6, etc.), a brief description of the WCRP mission and objectives, CMIP, core projects, grand challenges, advisory and working groups, partnerships, etc.

There is currently a placeholder for data matters entitled "Climate Data Sets and Analyses (open access, progress in model outputs and in situ datasets)"

A meeting will also be held 23-24 June 2017 at ICSU, Paris, with selected experts to identify key priorities/themes for the Programme as part of this process.

WDAC Members are invited to contribute actively to this document when the draft will be circulated.

b. Memberships

It was suggested to explore some representation of Asia on the Surface Flux Task Team. WDAC membership matters were discussed off-line.

c. Next WDAC Meeting – Date/Venue

Two offers to host the 6th session of WDAC were received and considered, ESRIN/ESA in Frascati, Italy and the Joint Research Center (JRC) in Ispra, Italy. It was decided to explore the first option and to hold the session in spring before the 38th session of the WCRP JSC if possible.

d. AOB

N/A

e. Review of Draft actions list

Draft actions were reviewed and are outlined in ANNEX A.

ANNEX A - WDAC5 Draft Action List

Development of a WCRP-GCOS Data Prize

1. Circulate draft call for nomination to WDAC and GCOS Chairs and finalize (Michel)

WCRP-GCOS Data Best Practices Policy

2. Circulate draft policy to WDAC and GCOS Chairs and finalize (Michel)

ESGF, obs4MIPs

3. CLIVAR to explore use of ESGF for ocean reanalysis (Pierre-Philippe)

4. C3S and PCMDI to liaise on CMOR developments as necessary (Jean-Noel and Peter)

5. Develop a path for evolution of obs4MIPs (or separate ESGF component) to accommodate support for non-global, in-situ and non-gridded data sets and associated uncertainties (Peter, Jean-Noel and Joerg)

Reanalysis conference

6. Mobilize funds from agencies and other sponsors (Michel)

7. Develop Science (Organizing) Committee and forward plan (Jean-Noel and Mike)

ECV Inventory

8. Invite WDAC and obs4MIPs to provide early feedback on the ECV inventory (Joerg, Pascal)

9. Inform the development of inventories (including on in-situ ECV) (Joerg with GOSIC)

Observation gaps

10. In-situ observing networks at risk: WDAC to prepare letter for JSC to WMO to support/promote (Michel) (+few sentences for every observing network)
    - BSRN
    - ARGO
    - ISMN (soil moisture)
    - Ozonesondes (GAW more generally)
    - Radar data to be archived
    - Microwave imager/sounder for polar applications

11. Satellite mission gaps: send letter to WG CLIM to advocate for (Michel)
    - Atmospheric composition: limb sounders
    - Sea-ice/precipitation: micro-wave imagers

Uncertainties

12. Keep WDAC informed about EO uncertainty workshop in 2017 and involve experts as necessary (Joerg, Otis).

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