



41st Session of the
**World Climate
Research Programme
Joint Scientific Committee**

18–22 May 2020

Documents

Day 3 - Session 5

20 May 2020

World Climate Research Programme

JOINT SCIENTIFIC COMMITTEE (JSC)

41st online session

Grand Challenge on Carbon Feedbacks in the Climate System, Report (draft 1)

1. Highlights for JSC

- **Contribution to CMIP6**

GC-carbon strong contributor to C4MIP and ZECMIP, as well as to DCPD simulations including the carbon cycle: coordination, design, simulations, analysis and publications.

- **Contribution to GCP**

Strong interaction between GC-Carbon and Global Carbon Project. P. Friedlingstein leading the 2019 and 2020 Global Carbon Budgets.

- **Funding**

EU H2020 Project 4C (coordinator P. Friedlingstein, 2019-2023), focus on improving understanding of current carbon cycle, develop policy-relevant decadal predictions of carbon cycle and long-term projections of mitigation effort.

Project PalMod Phase II funded by the German Federal Ministry of Education and Research (BMBF, co-coordinator T. Ilyina, 2019-2022), focus on understanding slow feedbacks including the carbon-climate feedbacks in the Earth system during the last glacial cycle.

- **GC-Carbon meetings**

- Side meeting "carbon cycle predictability", Barcelona, March 2019
- Session on carbon cycle feedbacks at the AGU 2019
- Session at the Ocean Sciences Meeting and Town hall meeting on carbon cycle predictability, February 2020, San Diego

- **GC-Carbon related Publications**

- Arora et al., BGD, 2019, doi.org/10.5194/bg-2019-473
- Friedlingstein et al., ESSD, 2019, doi.org/10.5194/essd-11-1783-2019
- Jones et al., GMD, 2019, doi.org/10.5194/gmd-12-4375-2019
- MacDougall., et al., BG, 2020, doi.org/10.5194/bg-2019-492

2. Primary science issues (looking ahead, 3 to 5 years)

- Provision of a GC-Carbon Assessment on TCRE (following the format of the WCRP ECS assessment), led by Chris Jones (UK MetOffice), Tatiana Ilyina (MPI, Hamburg) and Pierre Friedlingstein (U. Exeter). Timeline: next 18-24 months
- Development of robust carbon annual to decadal prediction of the global carbon cycle to support the annual Global Carbon Budgets
- Encourage GC-Carbon focused analysis of carbon cycle and climate response in CMIP6 ESMs

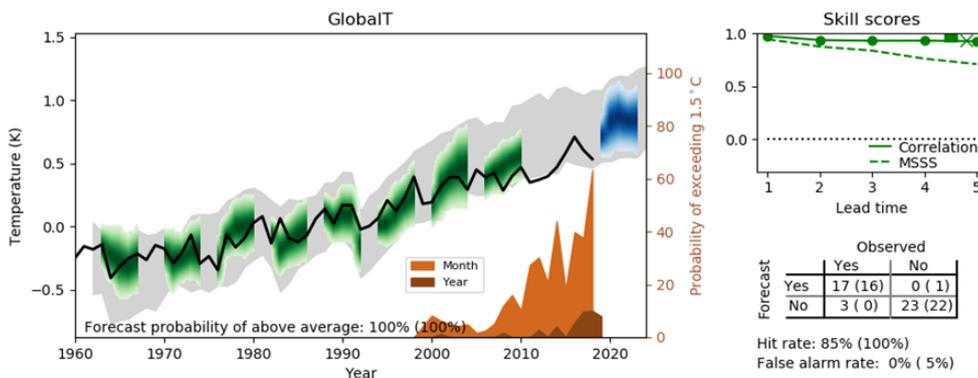
3. Issues and challenges, for example:

- Keeping the GC-Carbon momentum
- Lack of "long-term" (beyond current year) vision on WCRP funding and support
- Inadequacy of WCRP funding rules for supporting GC-activities

**Grand Challenge on Near Term Climate Prediction, Report
(draft 1)**

1. Highlights for JSC

- WMO operational decadal predictions have now completed a second year
- The WMO Lead Centre for Annual to Decadal Climate Prediction www site is improved and starting to providing data access to WMO members
- The Global Annual to Decadal Climate Update is being issued this month following 2 years of dry running. Example figure showing risk of 1.5 degree events:



- Comprehensive standards and verification methods are now prepared and are close to publication
- We are working closely across WCRP and WMO: with ET-OPSLs, CORA etc
- Almost delivered our initial outcomes: improved predictions, white paper, operational predictions, standards

2. Primary science issues (looking ahead, 3 to 5 years)

- Need to improve demonstrations of skill and utility of multiyear predictions
- Very large ensembles (100s) are needed to properly identify skill due to severe climate model signal to noise problems which may well apply to longer timescales

3. Issues and challenges, for example:

- Communication across WCRP and WMO is complex – CORA and WMO staff are helping
- Should we continue into decadal prediction climate services?
- If so, we need a new co-chair and membership refresh – plans in development
- Membership to include users from several sectors including finance, agriculture and energy
- How do we stitch together decadal with seasonal and long term projection information? Do we need to?
- We are not badly affected by funding or COVID as all work and meetings are done remotely

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WDAC Report (draft 1)

1. Highlights for JSC

- obs4MIPS documented and organized 100+ observational products according to CMIP output requirements with summary of achievements given in Duane et al., in revision
- Task Team for Intercomparison of Reanalyses (TIRA) proposed concept for a WCRP Earth System Reanalysis Intercomparison and Evaluation group
- Surface Flux Task Team White Paper
- WCRP/GCOS International Data Prize 2019 awarded to Dr Phu Nguyen (CHRS, University of California-Irvine, USA) and Dr Hamed Ashouri (Risk Management Solutions, CA, USA)
- Coordinated report from the 'WCRP Task Team on Seamless Data and Data Management' as input to the WCRP Implementation Plan

2. Primary science issues (looking ahead, 3 to 5 years)

- Observations for process understanding (including dedicated field experiments)
- Observational climate data records
- Reanalyses and data generated by climate models (need to define 'data' in general)
- Data assimilation
- Data availability, access and usability via open data infrastructures: definition of the role of operational infrastructures and gap analysis needed
- Strategy on capturing observational uncertainties/covariances
- Synthesis on data stability and quality control (need for guidelines within WCRP)
- Data science and data mining/machine learning (information and knowledge exchange)
- New sensors and data products (e.g., micro-satellites, IoTs, citizen science)
- Research-operations synergies (data management infrastructures, observational campaign vs operational networks, climate services)
- Training and education

3. Issues and challenges

There is a clear need to coordinate observations, reanalyses, data science and data management issues across the programme and across WMO (with WWRP and GAW in particular). The longer-term structure and mechanisms of the coordinating body overseeing seamless data and data management within WCRP should fit within the new science and implementation plan and can benefit from existing WDAC structures. To ensure current workflow, continuous memberships and coordination of current task teams and activities more information on the near-term future of WDAC would be beneficial.

- Information on (and access to) datasets via inventory for all WCRP key research? Important step towards seamless approach. Can provide direct input for gap analyses. However, this would need to be adequately resourced in terms of staff time.

- Better transfer of knowledge/experiences of/in data management across WCRP entities
 - Establish a strong link to space agency bodies to exchange WCRP needs and space agency plans (involve GCOS and others to communicate requirements to space agencies)
 - Data management strategies should include observations, reanalyses and model simulations seamlessly (close collaboration with modelling group)
 - Strengthen coordination of reanalyses, in particular around Earth system reanalysis (TIRA white paper)
 - Promote a broader Earth System approach to observations with GCOS
 - Include data assimilation (OSEs/OSSEs in coordination with WWRP/DAOS/PDEF and WGNE)
 - Include data science and data mining as we face huge and steadily growing amount of data (connect with AI/IT communities more closely)
 - Interfacing/integrating (research) data infrastructure with their operational equivalent (WIS, C3S/CDS) is a necessary condition to the R-O goal
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WMAC Report (draft 1)

1. Highlights for JSC

- WMAC coordinated the award of the WCRP/WWRP International Prize for Model Development 2019 awarded jointly to Dr Clément Albergel from MétéoFrance and Dr Baoqiang Xiang from the Geophysical Fluid Dynamics Laboratory in the USA and delivered at the AGU 2019.
- WMAC has provided leadership and recommendations to the JSC as part of the task team on "Model Development and Computing Infrastructure".
- WMAC provided lead support to the CMIP6 Model Analysis Workshop in Barcelona in March 2019 <https://cmip6workshop19.sciencesconf.org>.
- WMAC has participated in the WCRP Flagship Workshop in Hamburg in February 2020 <https://www.wcrp-climate.org/wcrp-hamburg>.
- WMAC has been involved in the discussions about the operationalisation of some aspects of CMIP.
- WMAC provided comments on WMO Research Board draft concept notes and drew the JSC attention on the need to ensure that climate and Earth system modelling features prominently on the Board's priorities.

2. Primary science issues (looking ahead, 3 to 5 years)

- WMAC coordinates the organization of the 3rd WCRP Summer School on Climate Model Development at NCAR in 2021. It was originally planned for 2020, but the pandemic has led to some delays.
- The JSC chair has suggested the organisation of a modelling initiative to complement the development of the implementation plan. It was initially planned for autumn 2020. It is not clear if WMAC should be in charge of organising such an event, although WMAC has already proven its ability to bring together the modelling community in events like the first-ever Pan-WCRP Modelling Groups Meeting at the UK Met Office (Exeter, United Kingdom) on 9-13 October 2017. WMAC believes that such an event would be a unique occasion to bring closer together the modelling and data communities and identify common challenges and opportunities.
- A stronger integration with the data activities would be desirable.

3. Issues and challenges, for example:

- Coordination of modelling activities is more important than ever as we move into seamless, Earth system models, Research-Operations, modelling in different places at WMO. WMAC believes that this coordination role is needed with a staff person responsible assigned for the activities across all modelling in WCRP acting as the single point of contact for all matters relating to modelling in WCRP.

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CORDEX Report (draft 1)

1. Highlights for JSC

Many new simulations and in particular the CORDEX-CORE (Coordinated Output for Regional Evaluations) set of experiments were finalized by the larger contributors and are now available on ESGF <https://esgf-data.dkrz.de/search/cordex-dkrz/>, XXX-22 domains (for instance AFR-22, CAM-22).

The fourth Pan-CORDEX, ICRC-CORDEX 2019, conference was held in Beijing, 14-18 October 2019. At the event a number of workshops and side events were organized, for instance on Future Risk/Future Earth in cooperation with MAIRS-FE, a meeting followed by two workshops planned for 2020 if the current situation allows for it.

Two new Flagship Pilot Studies (FPSs) were endorsed at the ICRC-CORDEX 2019: 'Modelling the Southeast African regional Climate' and 'High resolution climate modeling with a focus on convection and associated precipitation over the Third Pole region' (the latter also proposed by Core Project Joint Initiative as a pilot FOCI project).

A number of other CORDEX-related events were organized, including:

- Euro-CORDEX General Assembly, Hamburg, Germany, 28-30 January 2019, see report here <https://www.euro-cordex.net/>
- Training Workshop of Access and Utilization of Regional Climate Downscaled Data of ESGF/ SARCCIS of CORDEX Southeast Asia, 22 January 2019, Bangkok, Thailand
- Session 31: Climate Change Scenarios in CORDEX Domains. Scenarios Forum 2019: Forum on Scenarios for Climate and Societal Futures. Denver, USA, 11-13 March 2019
- Sessions at EGU; Regional climate modelling, including CORDEX (CL5.01), CORDEX FPS Convection splinter meeting, Convection permitting modelling (CL5.04), Vienna, Austria, 7-12 April 2019
- Paper-writing Workshop on the Analysis of CORDEX-CORE Climate Projections, Trieste, Italy, 8-12 Apr 2019
- Conference sessions focused on regional climate modelling highlighting CORDEX at the Australian Meteorological and Oceanographic Society (AMOS) annual conference in Darwin Australia 11-14 June 2019; AOGS Singapore 28 Jul – 2 Aug 2019
- Third Workshop of the Second Phase of the Southeast Asia Regional Climate Downscaling (SEACLID)/CORDEX Southeast Asia Project, Manila, Philippines, 10–11 July 2019
- EMS2019, Climate modelling (UP3.5), Copenhagen, Denmark, 9-13 September 2019
- FPS –LUCAS annual meeting, Hamburg, Germany, 25-26 September 2019
- Workshop of Access and Utilization of Regional Climate Downscaled Data of ESGF/ SARCCIS of CORDEX Southeast Asia, Bangkok, Thailand, 3 October 2019
- Annual Joint Polar CORDEX meeting with focus on surface mass balance of Greenland and Antarctic ice sheets, model evaluation and coupled modelling/high-resolution challenges and benefits, Copenhagen, Denmark, 7-9 October 2019
- FPS –CPS annual meeting, hosted by Meteo-FR, Toulouse, France, 26-28 November 2019

- The 6th Med-CORDEX workshop Toulouse, France, November 2019 The three Med-CORDEX related FPSs (convection, air-sea and aerosol) annual meeting during the 6th Med-CORDEX workshop allowing some cross-FPS fertilization
- International Congress on Modelling and Simulation (MODSIM2019) Canberra Australia 1-6 December 2019

Other activities include:

- For the Arctic Ocean, a multi-model intercomparison with the ACSE2014 campaign data has been accomplished and Arctic and Antarctic sea-ice lead data sets have been compiled
- Many new scientific publications, for instance two by CORDEX Africa VIA scientists and two published and three under review on the European Convection and LUCAS FPSs
- Several contributions to the IPCC special reports and to the coming AR6
- Tutorial on how to download CORDEX Africa data
- 5x5 km downscaling by CORDEX SEA scientists for a number of SEA subdomains
- Contributions to Australian Climate Projection Strategy
- Contributions to the Hindu Kush Himalaya Assessment. Springer, Cham, 2019, pp. 57-97, doi: https://doi.org/10.1007/978-3-319-92288-1_3 and other assessment reports
- MED CORDEX simulations:
 - The description of the simulations including 5 modelling pillars can be found in Somot et al. 2018b and on medcordex.eu/simulations-phase2.php
 - Baseline runs: 11 modelling groups are participating with fully-coupled Regional Climate System Models (RCSM), 10 RCSM are ready to be used, 6 evaluation runs have been performed for this phase as well as 6 historical/scenario runs
 - FPS-convection: 11 evaluation runs are completed over the alpine domain as well as 6 historical/scenario pairs (end of the 21st century, RCP8.5, 10-year time slices)
 - FPS-aerosol: simulations have been performed for the 5 defined protocols, in particular 6 pairs of runs are available for protocol 1B (scenario with aerosol climatologies) and 8 runs for protocol 2A (case study with interaction aerosols)
 - FPS-air-sea: various baseline runs have been performed and sensitivity tests to the sea representation and air-sea coupling representation are in preparation
 - Concerning the Free Modelling Zone runs, 15 modelling actions are listed with model outputs available on request
- FPS: Convective Phenomena over Europe and the Mediterranean completed over 22 evaluation time slices and 12 scenario simulations and continued to analyze the output from their simulations and delivered new insights, for example, a strong shift towards higher convective precipitation intensities in the future
- FPS: Extreme events over South America includes a collaborative effort with modeling groups from Spain, Brazil and Argentina. 3 RCM simulations driven by reanalyses at convective permitting resolution over southeastern South America for a 6-month period were completed for evaluation.

2. Primary science issues (looking ahead, 3 to 5 years)

CORDEX White Paper developed by the SAT, to be circulated for comments in CORDEX community, highlights challenges and possibilities such as:

- Smaller domains with finer resolution; a common setup for convection permitting resolution domains will be proposed by the CORDEX-SAT, within the established CORDEX domains.

- Increasing complexity; as RCMs move towards Earth System Models (ESM) a compromise must be made between resolution and domain size.
- Increasing resolution; as GCMs/HighResMIP are moving towards RCM resolutions. In this context, CORDEX is focusing on specific regional/local climate change challenges and proposes to add value in providing a wider matrix for exploring uncertainty
- Exascale computing; RCMs have to be adapted to the new generation of high-performance computers.

3. Issues and challenges

- To increase the cooperation with other WCRP CORE Projects, HighResMIP and CORA is essential (with reference to for instance the challenge of smaller domains and higher resolution).
- The CORDEX community is continuously growing and the demand on CORDEX products/information is steadily increasing which is both encouraging and challenging as it puts pressure on performance/delivery.
- The CORDEX community are working with impact-, risk-, adaptation scientists as well as with decision makers and other users such as energy industry or agriculture, through projects, workshops, paper writing etc.
- The demand for interdisciplinary science and cooperation increases and CORDEX can help with the bridging between climate science and climate services through cooperation with groups such as Working Group on Information for Regions (WGIR), FOCI (see the first page, third paragraph), GFCS, Future Earth (MAIRS-FE), CORDEX workshops and African demonstrator.
- It is increasingly difficult and that is a big concern but none the less it is essential to attract both internal and external funding for fundamental science and the maintenance and growth of the data storage capacity (due to the increase of new simulations and higher resolutions). Thus the need for enhanced communication with funders and society increases with accelerating global focus on climate and climate change and with tougher competition for funding.

4. Early success and/or planned activities in 2020 if possible due to COVID-19 (this bullet point has been added but can be removed if not needed)

- Capacity building across regions through the following planned activities, whenever they are possible in the current context:
 - Regional training workshop, Kathmandu, Nepal, 29 June-3 July 2020.
 - 4th CORDEX Southeast Asia Workshop on Coordinated 5km Simulations, Quy Nhon, Vietnam, early October 2020
 - Final CORDEX Southeast Asia Workshop on Coordinated 5km Simulations, Bangkok, Thailand, end of 2020
 - Joint workshop for Southwestern African countries with focus on building the VIA community in the initiative as well as strengthen the already well developed climate science community and Regional workshop CORDEX southeast Africa FPS, Cape Town, South Africa, end of 2020
 - 2nd Regional training Workshop/CORDEX for the South/Central American domains, Sao Paulo, Brazil, fall 2020
 - Joint meeting CORDEX - MAIRS FE, Beijing, China
 - Conference on Regional Climate Modelling and Extreme Events over South America: Results from the CORDEX-Flagship Pilot Study / Lab training activity on how to use, interpret and compare the GCM/RCMs/ESD simulations, Buenos Aires, Argentina, 16 Nov 2020 - 20 Nov 2020
 - South East Asia; Coordinated Regional Climate Downscaling of 5 km x 5 km resolution by the five modelling groups continues
- Polar CORDEX workshop, Utrecht, Netherlands, 5-7 October 2020
- CORDEX-Australasia, conference session at AMOS, Fremantle, Australia, 10-14 February 2020

- MED-CORDEX; Completion and publication of the planned simulations for the evaluation runs (Baseline runs, FPS) and availability of large ensemble of scenario simulations (Baseline runs, FPS)
 - EURO-CORDEX paper "Regional climate downscaling over Europe: perspectives from the EURO-CORDEX community" accepted for publication in Regional Environmental Change
 - The downscaling of CMIP6 will be initiated
 - Completion of CORDEX White Paper
 - Completion of IPOC Communication Plan
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S2S report (draft 1)

1. Highlights for JSC

- Real-time Pilot Initiative begun in Nov 2019 for two years, making the S2S forecasts available in real time to 16 climate-service demonstration projects, spanning developing and developed countries and a application sectors (Energy, agriculture, health, civil protection, humanitarian, water, forestry, fishing, media, etc).
- New S2S website created for Phase II of S2S (2019-2023), including collaboration wikis on new since sub-projects (Aerosols, Ensembles, Land, MJO/teleconnections, Ocean, Stratosphere), RTO, the Real-Time Pilot, as well as for the emerging area of machine learning (s2sprediction.net).
- Ocean/Sea-Ice fields are now being added to the S2S database, which is archived at ECMWF, CMA, as well as IRI Data Library which enables server-side computing and visualization.
- As of April 1, 2020, 130 articles have been published in the peer-reviewed literature using the S2S database, which now includes over 100TB of data.

2. Primary science issues (looking ahead, 3 to 5 years)

- MJO prediction and teleconnections in collaboration with the Working Group for Numerical Experimentation (WGNE) MJO Task Force with focus on MJO/high-impact weather relationships and tropical-extratropical interactions;
- Land initialization and configuration, to investigate the fidelity of model representations of land-atmosphere interactions, and how S2S forecasts may be improved by taking better advantage of the information contained in land surface states;
- Ocean and sea ice initialization and configuration to improve subseasonal predictions though improved initialization of the ocean-sea ice state and depiction of key ocean and sea ice processes that provide predictability at subseasonal time scales;
- The stratosphere, with focus on quantification and understanding of stratosphere/troposphere coupling, model biases, initial conditions and ensemble generation, and whole atmosphere diagnostics;
- Atmospheric composition, to assess the benefits of using prognostic aerosols rather than the climatology used in the current operational S2S models, identify the level of aerosol model complexity needed, and assess the predictability of aerosols (e.g. dust) at the S2S time scale and potential forecast value for applications;
- Ensemble generation, to determine (on the S2S scale) the optimal initial-perturbation strategies on S2S scale, sources of overconfident forecasts, importance of initial perturbations of the ocean, and stochastic parameterization schemes.
- Improving research-to-operations methodologies for calibration, multi-model combination, verification and generation of forecast products, especially for forecasts of precipitation and weather extremes over land.
- Connecting science to society through co-development of forecast-value demonstration projects involving climate scientists, forecasters and sectorial decision makers (Real Time Pilot Initiative)

3. **Issues and challenges**, for example:

- How do you work with other WCRP activities and partners outside of WCRP?
 - The stratosphere, in collaboration with the WCRP Stratosphere-troposphere Processes And their Role in Climate (SPARC) initiative on Stratospheric Network for the Assessment of Predictability (SNAP).
 - Atmospheric composition is in collaboration with WGNE and Global Atmospheric Watch (GAW).
 - Land initialization and configuration, in coordination with the Global Energy and Water Exchange/Global Land Atmosphere System Study (GEWEX/GLASS), Data Assimilation and Observing Systems (DAOS), Earth2Observe, and Working Group for Sub-Seasonal to Interdecadal Prediction (WGSIP) SNOWGLACE project.
 - Ocean and sea ice initialization and configuration is in coordination with WGSIP, DAOS, and PDEF (Predictability, Dynamics, Ensemble Forecasting) Working Groups.
 - Ensemble generation, is in collaboration with PDEF and WGNE.
 - Verification research activities of S2S forecasts is in collaboration with the Joint Working Group on Forecast Verification Research (JWGFVR).
 - Research to Operation activities of S2S forecasts is in collaboration with the WMO Inter-Programme Expert Team on Operational Predictions from Sub-seasonal to Longer-Time Scales (IPET-OPSLS).
 - We have begun discussion with CORA to integrate the S2S Real-Time Pilot initiative across WCRP time scales toward Objective 4: Connecting Climate Science with Society.
 - Discussions have been held with CORDEX, to develop a demonstration for the added value of dynamical downscaling of S2S forecasts over regions that combine good S2S skill at large scale, with complex small time & space scale climate dynamics, such as the maritime continent
 - Potential to link with WDAC on Data infrastructure: integration needed between S2S database, research S2S datasets (eg NCAR), and with CMIP data. There is already integration of S2S thru IRI Data Library to NMME, EU-C3S, SubX
- How you see your community evolving?
 - S2S is now in its second phase (2019–2023), by the end of which we envisage S2S forecasting - as part of climate services - being a routine component of operational forecasting carried out by global producing centers, with forecasts exchanged through WMO Lead Centers for multi-model sub-seasonal forecasts, and disseminated by national meteorological services (NMSs) throughout the world. This Research to Operations objective is well underway through the WMO's Expert Team (IPET-OPSLS).
 - By filling the gap between medium range weather forecasts and seasonal climate predictions, S2S provides a concrete example of one part of a broader evolution toward provision of seamless weather/climate information across scales from days to decades and local to global scale, with weather forecasting at one end and climate-change projections at the other.
 - S2S is focusing research on model and forecast improvement through the set of science sub-projects described above. But there will be no silver bullet and S2S predictability over land for precipitation and weather extremes is likely to remain low in general. We see further evolution toward identifying (in advance) windows of forecasts of opportunity when and where particular sources of predictability are strong, enabling useful probabilistic forecasts.

This demand requires climate science research (WCRP core projects) to improve climate services (as part of WCRP Objective 4), from days to decades.

- o Expanding data infrastructure, enabled through the TIGGE, S2S, SubX, NMME, EU-C3S, and CMIP databases has created a new opportunity for machine learning/artificial intelligence to improve forecasts and attribute extremes to weather/climate phenomena. Cloud computing is expected to play a key role in enabling these ML approaches as well as to allow researchers to connect these still-disparate databases together through rapidly-evolving python tools like Pangeo.
 - o Downscaling/regional modelling, and cloud-resolving modelling are future areas for S2S evolution (with the focus so far on "getting the synoptic scale right"), and naturally fit within the seamless forecasting concept.
 - How does current funding affect your community, your activities, your service?
 - o S2S is reliant on critical in-kind contributions such as ECMWF, CMA, the contributing forecast providers, as well as national/regional science funding agencies
 - o In the arena of big data, there are potential opportunities to engage big tech companies and their philanthropic wings. To date, support has mostly been restricted to cloud computing credits, rather than grant funding essential for salary supported.
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World Climate Research Programme JOINT SCIENTIFIC COMMITTEE (JSC) 41st online session

WGSIP/DCPP Report (draft 1)

1. Highlights for JSC

- A comprehensive synthesis of "[Current and emerging developments in subseasonal to decadal prediction](#)", informed by the recent International Conferences on Subseasonal to Decadal Prediction, was published in BAMS.
- **A new cycle of WGSIP projects** aligned with the WCRP's Strategic Plan was initiated at WGSIP's 21st session in Moscow in May 2019. These include:
 - Prediction capability**, which aims to fill knowledge gaps relating to key Earth system prediction capabilities, using existing hindcast datasets including WGSIP's Climate-system Historical Forecasting Project (CHFP). Three initial foci are [Monsoon prediction](#), seeking to better understand processes and mechanisms responsible for seasonal predictability of the Asian and global monsoons and to develop new diagnostics to describe monsoon forecast performance;
 - [Ocean prediction](#), assessing capabilities for predicting sea surface height (relevant to coastal flooding) and mixed-layer depth (relevant to ocean ecosystems);
 - [Temperature trends](#), assessing accuracy of temperature trends in climate forecasts and impacts of temperature trend errors on operational predictions.
 - Extremes**, which aims to assess the predictability of extreme events, and to better quantify the risks of extremes (including unprecedented events) in the current climate by using large ensembles of initialised climate model hindcasts. A WGSIP-organized [WCRP Workshop on Extremes in Climate Prediction Ensembles](#) scheduled to be held in Busan, South Korea in October 2020 will serve as a focal point for community research efforts in this area and involve scientists from developing Asian countries through pending support from the Asia-Pacific Network for Global Change Research.
 - Information for decision making (I4D)**, which is reviewing and intercomparing methods for calibration and combination of forecasts across time scales, and contributing capacity building and guidance to the operational community.
- **Ongoing WGSIP projects:** CHFP continues to add prediction systems to its hindcast database at CIMA in Argentina, and to inform WGSIP and community investigations, leading e.g. to papers on seasonal prediction of [tropical](#), [Indian Summer Monsoon](#) and [Central African](#) rainfall. In addition, projects examining [impacts of snow initialization](#) and [initial shock and drift](#) continue to be active.
- **DCPP CMIP6 simulations:** DCPP hindcasts and targeted predictability, mechanism and case study simulations have been completed by numerous modelling groups, and DCPP-led initial papers on [robust skill of decadal predictions](#) and [teleconnections from Atlantic multidecadal variability](#) published.
- **Capacity building:** WGSIP co-organized and gave lectures and lab sessions for the International Young Scientists School and Conference on Computational Information Technologies for Environmental Sciences ("CITES-2019", Moscow May-June 2019).

2. Primary science issues (looking ahead, 3 to 5 years)

- Atmospheric circulation has been viewed as a major source of irreducible uncertainty in climate predictions and projections. However, recent studies show that climate

models severely underestimate atmospheric circulation predictability, especially in the north Atlantic. On decadal timescales the predictable signal is ~10 times too small in models, requiring 100 times more ensemble members to extract it, and additional post processing to overcome underestimated teleconnections. There is evidence that multi-decadal responses to external drivers are also underestimated, in which case this issue affects understanding of past climate change as well as predictions and projections.

- Understanding the relative roles on internal variability and external forcing is crucial for attribution, prediction and projection. [Analysis of decadal predictions](#) suggests that external factors dominate and are able to produce decadal variability in addition to long-term trends. Hence an important issue is to better understand how the climate system responds to external forcing including solar, volcanoes, aerosols and ozone.
- Extending subseasonal to decadal prediction capabilities across Earth system components motivates understanding and quantifying their predictability, and requires novel approaches for initialization and verification of less well-observed variables.
- Development of regional and local forecast information, emphasizing probabilities of weather and climate extremes, that is seamless across time scales.

3. Issues and challenges

- Within WCRP, WGSIP/DCPP maintains cross-membership with GC-NTCP and S2S, and reviewed the GC's Annual-to-Decadal Climate Update while co-organizing its planned [2020 workshop](#) with S2S and GC-Extremes. WGSIP's Monsoon project is collaborating with the CLIVAR/GEWEX Monsoons Panel. WGSIP's Ocean Prediction project has discussed data standards and is exploring synergies with related S2S and C3S initiatives, and will do so with CLIVAR's Ocean Model Development and Global Synthesis and Observations Panels (OMDP and GSOP).
- An important WGSIP partner outside of WCRP is WMO's Expert Team on Operational Predictions from Sub-seasonal to Longer-time Scales (IPET-OPSLs). The WGSIP and ET co-chairs currently operate as an informal task team to address R2O and O2R issues, and have discussed formalizing this arrangement with JSC approval. An important step is agreement to create a data "pipeline" to incorporate hindcasts from past, present and future WMO Global Producing Centre seasonal forecasting systems in the CHFP archive. Besides enhancing CHFP-enabled research opportunities, this will enable tracking of changes in seasonal forecast system performance over time as requested to WGSIP by TPOS2020 and recommended in its [Second Report](#).
- The near future is likely to bring increasing emphasis on developing and improving seamless climate information for regions, as well as broadened Earth system prediction capabilities requiring increased communication and coordination with the observational, data assimilation and reanalysis communities. Application of machine learning to postprocessing of climate forecasts is likely to be a further growth area.
- WGSIP seeks for its membership to optimally represent regions, key operational and research centres, prediction time scales, and related groups and initiatives (through cross membership). This has become increasingly challenging as climate prediction activities worldwide have broadened and matured, and WGSIP would thus benefit from increasing its current membership of 13 (11 in 2020) by 1 or 2, and/or including ex-officio members representing related WCRP and WMO groups.
- Much could be achieved through a joint working meeting involving WGSIP, DCPP, GC-NCTP, S2S, IPET-OPSLs and core project representatives in 2021 or 2022. Objectives would include sharing approaches and results of interrelated research initiatives and formulating strategies for research and climate services development.
- Much potential added value of model outputs is being lost due to fragmentation of community research initiatives having differing experimental protocols and data standards. Going forward, this issue could be addressed by leveraging CMIP

protocols and ESGF data access for climate prediction experiments, using DCPP protocols as a starting point. Such a relatively small perturbation to CMIP/ESGF would yield great benefits for climate prediction research.

World Climate Research Programme

JOINT SCIENTIFIC COMMITTEE (JSC)

41st online session

Working Group on Coupled Modelling (WGCM) Report (draft 1)

1. Highlights for JSC

- **Planning, coordination and delivery of CMIP6.** This has been executed by two sub-groups of WGCM: the CMIP panel and the WGCM Infrastructure Panel (WIP)
 - **CMIP6 planning** for a more continuous and distributed approach started in 2013. Engagement with modelling groups and the wider science community was at the heart of the design (including a WGCM-led paper on lessons learnt from CMIP5 (Stouffer et al), Survey of groups and users, face-to-face workshop). The design of a distributed approach and endorsed MIPS was agreed at the WGCM-18 meeting with modelling groups in 2014.
 - **CMIP coordination** has delivered 23 endorsed MIPS; forcing datasets for the required common experiments: DECK (AMIP, PI-Cntl, 1%, 4xCO₂, historical simulation, and ScenarioMIP future RCP scenarios; a data request to support diagnostics across all ~100 Tier-1 experiments in the DECK and MIPS, ESDOC documentation; co-ordination of data delivery to the ESGF. Documentation of the science and technical coordination is in the CMIP6 special issue on experimental design and infrastructure (https://www.geosci-model-dev.net/special_issue590.html).
 - **CMIP delivery** from more than 30 models so far (126 models registered) has been published on the ESGF (https://pcmdi.llnl.gov/CMIP6/ArchiveStatistics/esgf_data_holdings/) covering DECK and MIP experiments. Data from these models is being used directly in the IPCC 6th Assessment Report, used to drive regional model simulations under CORDEX and is being downloaded by climate science researchers across the globe with an expectation that 1000s of science papers will result.
- **Organisation and delivery of a series of CMIP analysis workshops** showcasing results from CMIP5 (Dubrovnik, 2015) and CMIP6 (Barcelona 2019). The First CMIP6 analysis workshop in Barcelona delivered first results and emergent properties of the CMIP6 multi-model ensemble. A WGCM-led paper (Meehl et al, 2020) that arose from discussions at the Barcelona workshop regarding the climate sensitivity of the CMIP6 ensemble has been accepted for publication in Science Advances.
- **Routine monitoring and evaluation of CMIP6 model data.** For CMIP6, routine evaluation tools have been applied to all model data uploaded to the ESGF. This has been designed to allow community evaluation tools (so far including ESMValTool, PMP and other packages) giving modelling groups early insight into model performance across a broad range of metrics and with reference to other CMIP6 models. See Eyring et al, 2016; <https://www.earth-syst-dynam.net/7/813/2016/esd-7-813-2016.pdf>. These tools are also being used extensively by authors of the IPCC 6th Assessment Report currently in preparation.

- **WCRP Grand challenges on Cloud, circulation and Climate Sensitivity and Carbon cycle feedbacks** were initiated in 2014 and 2016 and are led from WGCM. These grand challenges have brought together wide expertise on focussed themes under these topics and are delivering new understanding and strong vibrant research communities working on these key uncertainties. The GC on clouds, circulation and climate sensitivity has delivered 2 community assessment reports on climate sensitivity and aerosol forcing, synthesising multiple lines of evidence. These were submitted for publication in 2019 and are central to the IPCC AR6 WG1 science report.

2. **Primary science issues** (looking ahead, 3 to 5 years)

- **CMIP Future.** CMIP6 is an extremely ambitious undertaking that is already generating a lot of new scientific activity (e.g. understanding processes that influence climate sensitivity). However, the logistics on organizing and executing such a large, distributed but interwoven project is straining the capacity of the CMIP Panel, WIP and WGCM, challenging the feasibility of such a distributed organization, and pushing the limits of staff and computing resources at many climate modelling centres. In order for CMIP to continue delivering the large, coordinated, multi-model ensemble of historical simulations, process experiments, and future predictions and projections, a new approach may be required. WGCM will this year start the process of engagement with the International modelling community and the broad range of users of model output to try and build consensus on ways forward for CMIP
- **Extracting maximum value from the CMIP Multi-Model Ensemble (C-MME).** The C-MME arises from a heterogeneous mix of models, some of which share components, some of which are minor variants of others, all of which have errors or biases of some sort for different quantities or locations, have different sensitivity, different resolution, different levels of complexity in representing different physical or biogeochemical processes. An emerging topic that the WGCM would like to pursue more vigorously is improved methods for analysing this MME – questions of model weighting, model independence, the role of ensemble size, the benefits of MMEs vs LMEs (large individual model ensembles, etc. This will be essential to providing robust model information to support policy development and decision-making as well as providing science direction for the International modelling centres and the wider climate science community.

3. **Issues and challenges**, for example:

- WGCM activities are well integrated with research coordinated in other Core Projects. Many of the individual MIPs arose from, and are coordinated by, research teams that are primarily affiliated with a Core Project or Grand Challenge, and the analysis often relies on observational products that arise from other WCRP activities.
- The WGCM is the only body through which global Earth System Modelling Centres have an opportunity to plan joint activities, share experiences, and develop community perspectives or respond to questions/issues in a coordinated way. This has an influence on membership, in particular the issue that in order to be effective, a large portion of the WGCM membership must be from a modelling center and serve as a conduit to one or more centres.
- CMIP has been run as a volunteer effort since its inception. Many countries contribute extensively to the funded activities that underpin it – the development and execution of complex earth system models and the supercomputing facilities on which they run, the development, archival and dissemination of forcing and evaluation data, the archival and dissemination of CMIP model output, the development of evaluation tools, file and data standards, etc. At this point, without a project office to coordinate and advocate for these activities, CMIP is at risk. And the many entities that have come to rely on it (the IPCC, National climate

assessments, the climate science community in general) may not be well-served if we do not address this urgent need.

World Climate Research Programme

JOINT SCIENTIFIC COMMITTEE (JSC)

41st online session

Working Group on Numerical Experimentation Report (draft 1)

1. Highlights for JSC

The WGNE systematic errors survey results (presented at JCS-40) indicated that all modelling groups (regardless of the time-scale they were developing their model for) highlighted convective precipitation, surface fluxes, surface temperatures (incl. diurnal cycle), cloud microphysics (incl. aerosol interaction) and representing model uncertainty as key issues to be addressed. WGNE have a number of projects now active in relation to these priorities:

- WGNE MJO task force - The research activity of the group is organized around four research themes: MJO simulations and mechanisms, MJO prediction, MJO and extratropics, and MJO-Maritime Continent (MC) interactions. The group has found a robust relationship of the mean state moisture pattern with MJO simulation fidelity in climate model simulations and with MJO prediction skill in hindcast datasets. MJO-TF is collaborating with PCMDI to implement several MJO metrics into PMP. MJO prediction skill in S2S and SubX models has been assessed. A standardized set of diagnostics and metrics to evaluate MJO teleconnections is being developed and applied to model simulations. Observations collected during YMC are being used to better understand the MJO-MC interaction. Climate model sensitivity simulations suggest that MC land masses affect the propagation of the MJO by altering the mean state moisture pattern.
- WGNE-GASS 'grey-zone' project - Many weather and regional climate models are, or will be, run at resolutions in the convective 'grey zone' where convection is partially resolved. The project's deep-convection component will leverage GATE phase III field campaign observations and the shallow-convection component is based around the recently completed EUREC4A field campaign, with the goal of informing the development of grey-zone convection schemes.
- WGNE Surface fluxes project - The protocol, was disseminated in February 2019. Ten centers have participated thus far, with about 1.5 Tb of data in total being archived at Météo France. Initial analysis has been carried out with more detailed analysis to follow. Further engagement may be needed to increase climate model participation.
- WGNE-GAW-S2S Aerosols project - The final version of the project protocol has now been released. The protocol has two components. The first is regional experiments focusing on short-range, high resolution, forecasts for South America and South Africa, Egypt and East Asia considering the years 2016-2018. The second is longer timescale global 32-day ensemble experiments for a 2003-2018 hindcast period. These will be used to explore the benefits of including a representation of aerosol impacts at different levels of complexity.
- WGNE-PDEF Model uncertainty project - A draft protocol has been written for a project to evaluate and inform the development of stochastic physics schemes. The project involves running km scale simulations, coarse graining them, applying to single column models and comparing their evolution (to be launched once the lead returns from maternity leave).

Other key activities of WGNE are:

- WGNE-GASS drag project – Previous analysis has shown that many CMIP models show biases consistent with too little overall surface drag. A previous WGNE project showed that drag partitioning between different schemes differs markedly amongst models. COORDE (CONstraining Orographic DRag Effects) is focussed on understanding impacts of differences in orographic drag parametrizations for modelled circulation and quantifying small-scale orographic drag with the use of high resolution simulations. The project is focussed on two regions: the Middle East and the Himalayas. Analysis of several submitted model simulations have now begun.
- Model verification and evaluation – WGNE continues to explore process-orientated evaluation methodologies. The JMA annual tropical cyclone (TC) verification is extremely valuable and has identified a clear reduction in TC track and intensity errors over the years. Traditionally, global models have underestimated TC intensities, however several NWP centres now produce TCs that are too intense (perhaps due to a lack of ocean coupling). The WGNE-WWRP JWGFVR have developed new forecast verification metrics using non-traditional observations. They continue to promote the exchange of surface temperature scores and precipitation verification, and have undertaken processes-orientated verification work on temperature errors. A WGNE-WGCM panel has been set up to focus on the evaluation of precipitation in climate models, with groundwork planned over the next year. Potential synergies and joint work between the JWGFVR and ESM precipitation benchmarking are being considered.

2. Primary science issues (looking ahead, 3 to 5 years)

- Earth System Modelling across timescales – WGNE has always taken a leading role developing models for use across weather and climate timescales. Traditionally this has been the atmosphere and land, but increasingly other Earth System model (ESM) components are being used across timescales and hence WGNE is evolving to gain expertise in these areas. Moving forward, WGNE will focus on reducing key systematic errors in ESMs. Many efforts will still be focused on the atmosphere and work will continue on the projects listed in the previous section, however key errors in other ESM components will need to be identified and investigated with the relevant communities.
- Exascale – WGNE has undertaken reviews of exascale developments in modelling centres. Some centres are progressing well in re-writing their code for exascale architectures while others, especially centres only involved with climate simulations, are yet to start. Thus far, WGNE has focussed on atmosphere and ocean codes, but other ESM components need to be considered in the future. WGNE plans to act as a focal point for sharing information amongst modelling centres on different approaches and is also exploring how reduced precision may be useful for accelerating codes.
- Machine Learning (ML) – WGNE will continue to share information around the use of ML for model development and evaluation. Most current applications aim to emulate existing parametrizations, replace parametrizations by emulating observations/high resolution models, or emulate full GCMs. A practical common difficulty is calling ML code (in e.g. Python) from model code (often Fortran). There has been significant and promising progress in this area, but key remaining concerns include going outside of training data (especially for climate change simulations) and model stability.

3. Issues and challenges, for example:

- The expertise of WGNE needs to be expanded to cover the full Earth System (atmosphere, land, ocean, cryosphere, chemistry, hydrology, etc.). However, a strength of WGNE is that it's an expert working group which undertakes coordinated studies and experiments. A large increase in the number of members or remit would be detrimental to this strength, hence we envisage building expertise through normal membership changes at the end of terms, with possibly a small number of additional members, and links to other groups. We see an essential continuing need for groups understanding key processes in model components such as GASS, GLASS, chemistry expertise within GAW, and a cross-timescale ocean group (OMDP?).

- As WGNE becomes the focal point for model development, WGNE members are being asked to sit on the panels/steering committees of an increasing number of other groups and/or representatives from many other groups are asking to attend the WGNE meetings with a danger of making them unproductively large. An efficient means of communication and reporting to working groups within WWRP, WCRP and GAW, together with the JSC, WWRP SSC and GAW SSC and Research Board which doesn't require attendance at a large number of meetings needs to be established.
 - There is a very strong argument for WGNE to act as a focal point for ESM across timescales. However, it is unclear if processes only relevant to long climate timescales (e.g. interactive ice sheets, long-timescale carbon-cycle processes) should be within the remit of WGNE or another group (e.g. WGCM where C4MIP resides).
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Coordination Office for WCRP Regional Activities (CORA) Report

Reporting period: June 2019-April 2020

1. Highlights for JSC

- Staffing of CORA: Coordinator Wiebke Schubotz started on June 15th at GERICS. Thus, CORA only became operational since July 2019. CORA's terms of reference are available here <https://www.wcrp-climate.org/cora-tor>
- WCRP Survey: the coordinators performed a survey among the WCRP community in order to make them aware of the existence of CORA and to collect knowledge about on-going or planned regional activities. The survey was conducted between August and October 2019, consisted of a questionnaire targeted to the co-chairs and leaders of all WCRP bodies (Core Projects, Working Groups and Grand Challenges). We received input from half of the WCRP bodies inquired, notably from all the working groups and two grand challenges. The responses received are encouraging as it shows a clear need for support body within WCRP. Moreover, the kinds of activities they indicated support with align very well with the existing its terms of reference. The full survey with transcripts of the respondents is available upon request.
- Task Team on Regional Activities (TTRA): CORA was appointed member of the TTRA in order to advise the JSC on the implementation of structures and elements for activities on *climate knowledge and information for regions* and to develop a concrete work plan for the next two years on how they will intersect with each other and with WCRP core activities while each pursuing its unique role. The emphasis is on realising Objective 4 "Bridging Science with Society". CORA assisted the TTRA by organising 5 telecons between September 2019-February 2020 and contributed to the TTRA report for the WCRP science week at AGU. It also conducted a consultation with service partners and a WCRP stakeholder's stocktake. It is now contributing to the discussions regarding the establishment a new Working Group on Information for Regions and Society (WGIRS), drafting the terms of reference, membership and a concept document on *Framework of Climate Information (FoCI)* projects. The future work of the TTRA is pending the revision of the report of the WCRP workshop on scientific questions held in Hamburg in February. The TTRA will deliver its recommendations to the JSC at the 41st meeting in May
- WCRP activities database
CORA is presently building an on-line, map-based and searchable database (DB) of past and on-going WCRP activities. The database will be searchable by region/continent, science activity and topics, and by partner organisations. The DB has been programmed and is hosted by the Helmholtz-Zentrum Geesthacht (HZG) which provides services to GERICS own database tool. This is thus, an in-kind contribution from GERICS to WCRP. When full populated, the DB will contain about 200 records of information about WCRP global and regional activities. CORA and the JPS will thoroughly test the DB previous to its launch in mid-May. The DB link from the WCRP webpage and will be accessible to everybody.

2. Issues and challenges

- Working with other WCRP activities: CORA has established connections to the co-chairs of the Core Projects and personnel of their IPOs, the leader of most of the Grand Challenges and all the Working Groups. The office maintains regular telecon participation with some projects and it is invited to the Core Project annual meetings of the Scientific Steering Groups. CORA has also a fluid communication with the Joint Planning Staff (notably with Boram Lee, CORAs primary JPS contact until January 2020, when Narelle van der Wal took over).

CORA took the initiative to revamp the regular communication between the JPS and the Core Project's IPOs after a hiatus the last couple of years, and so telecons are now scheduled throughout 2020. Regarding CORDEX, CORA has also established regular telecons with the IPO in Sweden, and new activities are under planning.

Examples of interactions so far:

- CORA prepared a grant proposal for a workshop to consolidate the launching of a new GEWEX Regional Hydrology Project in East Asia.
 - CORA volunteered to coordinate the "Joint Core Project Initiative" proposed by the co-chairs of the CPs and CORDEX at the JSC-40. Thanks to this, the CP initiative will serve as pilots of the Framework of Climate Information (FoCI) projects proposed by the TTRA and subject to approval by the JSC.
 - CORA is assisting the Grand Challenge *Near Time Climate Prediction* and the S2S community in the distribution and collation of information, e.g. "WMO Annual to Decadal Climate Update" and the "WCRP/WWRP S2S phase II: real-time pilot projects initiative" respectively
- CORA connections with partners outside of WCRP:
CORA made a connection to Future Earth *Knowledge Action Network on Emergent Risks and Extreme Events (Risk-KAN)*. Scientists from the Grand Challenge Weather and Climate Extremes participate in this KAN and in this regard, CORA prepared a ppt about the GC for Sonia Seneviratne to present at the Risk KAN session organised at AGU 2019. CORA also connected to *Future Earth Coasts* hub regarding the organisation of a workshop in Australia on risk assessment of coastal impacts of sea level changes (cancelled due to the Coronavirus).

CORA was invited to participate in a number of events in 2020: (i) to the 6th International Conference of Climate Services, Pune, February, to hold a WCRP session together with Krishnan Raghavan, (ii) to a round table discussion at Climate Festival organised by *ClimatEurope*, Riga, May, (iii) to an EGU session organised by the Risk KAN to explore venues of cooperation regarding WCRP objective 4: "Bridging Science with Society". However, CORA failed to attend the Pune meeting due to the imminent coronavirus situation while the Riga and EGU were cancelled. Only the Risk KAN meeting will be held remotely and CORA will participate.

In the future, and in connection to the work of the TTRA, CORA will assist in the establishment of working and sustainable partnerships with a number of boundary organisations and partners, such key bodies of WMO (e.g. Global Framework for Climate Services and Commission for Climate Information, Regional Associations, etc), Future Earth, Climate Services Partnerships, the International Conference on Climate Services, Disaster Risk Reduction Communities, etc.

- Funding: The hosts of the CORA, Bjerknes Centre and GERICS have initially committed funds until 31st of December 2021. CORA is a pilot project and continued funding from the hosts will depend on the office being able to prove that its activities provide added value to the WCRP. An unexpected development was the resignation, early this year, of Wiekbe Schubotz the coordinator at GERICS which means that CORA has been operating at half machine since March.

Although CORA has had an active year, which includes reaching out to the entire WCRP family with a survey, we still have a way to go before everyone in the WCRP organization is familiar to CORA and the service it provides. Clear messages from the leadership would help to sort out any confusions that still exists.

CORA reports directly to the JSC. It is a challenge to secure good information flow on a more daily basis, and CORA would like to establish an informal reference group consisting of, for instance, key personnel from the TTRA. In this way we are confident that CORA will come closer to fulfilling its intended functions as communicator, facilitator and integrator.

Finally, we recognize that the year of 2019 has been particularly hectic for many WCRP scientists, in connection to the IPCC, the WCRP Implementation Plan and the WCRP Science Week. Because of all these, it has been difficult for CORA to try to coordinate and create synergies in a "moving landscape" as WCRP heads towards a new structure. With the ongoing covid-19 situation it seems that 2020 will also be an exceptional year, but at some time things will "fall into place" so WCRP can get the most out of CORA and the resources put into it by GERIC and Bjerknes Centre.