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JSC-42
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Earth System Modelling and Observations (ESMO)

Core Project Report

42nd Session of the WCRP Joint Scientific Committee: 28 June – 2nd July 2021

1. Background

The Earth System Modelling and Observations core project was approved and initiated at JSC-41b (November 2020) to provide a coordination mechanism across all model, data and observations activities within the WCRP programme. This followed work by two Task Teams ("Modelling and Computing Infrastructure" and "Seamless Data and Data Management") to develop possible scenarios for the establishment of the new core project who then made recommendations to JSC41b, through two JSC members (M. Kimoto and M. Visbeck).
In February 2021, two new interim co-chairs (Susann Tegtmeier and Cath Senior) were appointed and asked to set-up an interim steering committee for ESMO to develop the governance, structure, strategic goals and partnerships. Brief details on progress are given below;

2. Scientific Steering Committee

An interim SSG has been appointed (members at Appendix 1) consisting of co-chairs of WGs that will now sit under ESMO, members of the WCRP Data and Modelling Advisory Councils (WDAC and WMAC) which are now subsumed into ESMO, representatives from other core projects, JSC liaison members and partners (e.g. key WMO, WWRP programmes). Diversity balance is currently difficult to achieve as the member groups must be represented by existing co-chairs, and work to improve this will be necessary as ESMO evolves and the interim SSG will be replaced by a new SSG. Deciding on the final membership of the SSG will need careful thought as the WGs will need to maintain direct engagement through their co-chairs, so appointment of both will need coordination.

3. Strategic Goals and Outcomes of the new Core Project

Based on the outcomes of the Task teams on Modelling and Computing Infrastructure and Seamless Data and Data Management, four overarching themes for EMSO were proposed around Research, Infrastructure, Access and Communication and Partnerships. Some key principles for these themes are;

a. **Research**
   - Seamless and value-chain model-data-observation approach across Earth system components, fundamental and applied disciplines, time and spatial scales, infrastructures
   - Optimise model development
   - Formulate observational requirements to monitor, understand and predict the climate system

b. **Infrastructure**
   - Integrated modelling and data infrastructures
   - Data policy, protocols and standards

c. **Access and communication**

- Share best practices, data, knowledge, opportunities
- Efficient communication across WCRP constituencies, communities, external partners and stakeholders
- Particular attention to engagement, equal access and inclusion of the 'global south'

d. **Partnerships and organisation**
- Identify stakeholders, scientific ambition and resourcing needs
- Develop a risk mapping and mitigation measures
- Remove fragmentation, duplications and suboptimal aspects in the programme

4. **Relationships**:

Key partners for ESMO will be GCOS, CEOS, CGMS, WWRP, GAW, GOOS, Future Earth, IPCC, UNFCCC, C3S, IOC, WMO and others. Many strategic links already exist based on the work of the former Advisory Councils and the Modelling WGs. While developing the structure and governance of ESMO over the next months, strengthening and re-establishing the links to the internal and external partners will be a special focus of the interim SSG.

5. **Structure**:

The new Core Project will need to combine various existing elements of the WCRP structure such as the Modelling WGs (WGCM, WGNE, WGSIP), the reanalysis group TIRA, Obs4MIPs, and S2S. Initial discussions have identified the need for the establishment of an Observation Panel to establish cross-WCRP observational requirements and interface with external groups. Potential new topics, such as ML/AI may also lead to further new groups being included. The interim SSG met for the first time in May this year to discuss the ESMO structure and strategic actions starting with input from the two Task Teams. A smaller group has subsequently met to discuss the evolving structure with first ideas emerging (slide will be presented at JSC-42). The intention is to highlight the links, connections and common themes between the various elements of ESMO and the links to internal and external partners.

6. **Support from WCRP***:*

We understand that the JSC have already approved plans for an International Project Office to support ESMO and this is certainly the level of support the interim SSG suggests is necessary. We anticipate action to write a call for proposals will be taken forward by the JPS once the scientific and organisational requirements and Terms of Reference are established. The newly established CMIP-IPO will be governed within ESMO through WGCM (led by its CMIP-Panel and WIP). The governance, ToR and scientific requirements for the CMIP-IPO are clear and the interaction between the CMIP-IPO and ESMO-IPO will be pro-actively managed and we do not anticipate conflict.

7. **Resources***:*

Resources will be needed (money, JPS effort) to support existing WG annual meetings and workshops already developed, although many may remain online only in 2021. These include;

- WGSIP session and extremes workshop at APCC in Korea, 25-29 Oct
- WGNE session at NCAR, USA, week 1-5 Nov
- WGCM session at NCAR, USA, week 1-5 Nov
- TIRA-DAOS joint symposium on data assimilation and reanalysis, Bonn, 13-17 Sep
- Workshop on 'The future of climate modelling', online event, October 2021
- Kick-off event for the ESMOC CP towards the end of the year

We anticipate an increased need to meet in person during 2022 due to both the lack of face-to-face meetings of the existing communities for 2 years and also the development of new partnerships and cross-ESMO activities. Is it possible to move any residual funding from 2021 forward to facilitate this?

8. **Communities***:*
Connections to users and stakeholders exist to some level based on current WGs and activities (e.g., links to prediction operations and service via WGNE and WGSIP, links to reanalysis producing centers via TIRA). For the future, a systematic assessment of the different value chains (from a point of view of information and the stakeholders) at all steps was suggested by the interim SSG to identify gaps and missing stakeholders.

9. ***Other Issues***

Short reports from all the WGs and panels subsumed under ESMO are included at Appendix 2.

Appendix 1 : Members of Interim SSG

Bill Merryfield	WGSIP co-chair,	CAN
Carolyn Reynolds	WGNE co-chair	US
Nils Wedi	WGNE co-chair	UK
Greg Flato	WGCM co-chair	CAN
Cath Senior	**WGCM co-chair, ESMOC co-chair**	**UK**
Ben Galton-Fenzi	CliC (and former WDAC)	AU
Tingjun Zhang	CliC and WDAC	US
Helene Seroussi	CliC and WMAC	US
Gokhan Danabasoglu	CLIVAR, OMDP co-chair	US
Baylor Fox-Kemper	CLIVAR WMAC	US
Lijing Chen	CLIVAR WDAC	CHN
Michael Ek	GEWEX, WMAC	US
Remy Roca	GEWEX, WDAP chair, WDAC	FRA
Susann Tegtmeier	**SPARC, WDAC co-chair, ESMOC co-chair**	CAN
Martin Visbeck	JSC liaison	GER
Piere Friedlingstein	JSC liaison	UK
Krishnan Raghavan	JSC liaison	IND
Huijun Wang	JSC liaison	CHN
Mark Dowell	former WDAC, former CEOS/CGMS WG Climate chair	
Joerg Schulz	WDAC co-chair, former CEOS-CGMS WG Climate chair	GER
Simon Pinnock	WDAC, ESA Climate Office, Obs4MIPS	UK
Jan Keller	WDAC, TIRA	GER
Dorothee Bakker	WDAC, biogeochemistry	UK
Anna Rutgersson	WDAC, SOLAS	SWE
Magdalena Balmaseda	WDAC, Data Assimilation	UK
Tatiana Ilyina	WMAC, AIMES	GER
Sabrina Speich	GCOS, OOPC, Co-chair GOOS	FRA
Andrew Robertson	S2S	US

Appendix 2: Group Reports

WGCM report (Cath Senior, Greg Flato)

WGCM has continued to focus on coordination and delivery of CMIP6 and engagement and planning for requirements for future CMIPs. A WGCM-led paper on the climate sensitivity of the CMIP6 model ensemble was published in 2020 (Meehl et al; https://advances.sciencemag.org/content/6/26/eaba1981.abstract), as was a paper documenting progress across CMIP phases using routine evaluation tools, as pioneered under WGCM (Boch et al., 2020;https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2019JD032321). The CMIP6 data has delivered many hundreds of papers in the International Academic community which have contributed substantially to the IPCC 6th Assessment report. Going forward, the CMIP panel under WGCM is leading a substantial survey of modelling groups, Scientists and stakeholders of CMIP to determine science and user requirements of future phases.
Organisationally, the work to deliver CMIP will be considerably helped by the recent establishment of the CMIP International Project Office (CMIP-IPO) at ESA in the U.K. This team will support coordination, communication and outreach of all CMIP activities under the governance of the CMIP panel and the WIP (WGCM Infrastructure Panel). WGCM will sit under the newly formed WCRP Core Project on Earth System Modelling and Observations (ESMO) and the WGCM co-chairs are closely engaged in development of themes for the core project and in developing a structure for the existing groups, recognising gaps and opportunities for improved collaboration and common science goals.

WGSIP report (June-Yi Lee, Bill Merryfield)

WGSIP is addressing key climate prediction science questions by assessing capabilities for impactful Earth system predictions (monsoons, oceans, extremes) and improving predictive information for decision making, whereas the DCPP Panel is coordinating extensive analyses of CMIP6 decadal prediction experiments while shaping decadal experiments for CMIP7. WGSIP's commitment to capacity building continues through ECS training in conjunction with the Extremes in Climate Prediction Ensembles workshop in October 2021. Primary near-term science issues include improved Earth system state estimation incorporating biogeochemistry, developing regional predictive information that is seamless across time scales, machine learning application to large volumes of model output to improve predictions and the understanding of predictability, and predicting and attributing near-term carbon cycle changes caused by natural variability on top of anthropogenic trends. Ex-officio memberships and strengthened links with observation and data assimilation groups would greatly assist WGSIP's efforts to advance climate prediction science and services within ESMO, while opportunities exist to further address subseasonal to decadal predictive time scales within LHA. Finally, advancing climate prediction science and services will be greatly aided by integrating data standards and platforms across time scales and research/operations, which WGSIP continues to advocate and work towards**.**

WGNE report (Nils Wedi, Carolyn Renyolds)

Collaboration and information exchange with other WMO focus groups and representations from worldwide weather & climate model development centres with close connections to the provision of associated services and the arising needs from initialized and time-critical simulations are essential to WGNE's ability to foster model development across timescales. Expanding this network of expertise with a focus on the wider Earth System model components and with increased collaboration and communication enabled through the new ESMO home will help WGNE to enhance its effectiveness to the benefit of the wider community. Recent WGNE key science highlights include continued progress on several model intercomparison studies, most of which are joint with other working groups or efforts (e.g., GAW-S2S-WGNE Aerosol project; GASS-WGNE Gray Zone II, WGNE-PDEF Model Uncertainty project, WGNE surface flux intercomparison, and ocean initialisation). Regular updates on these activities are published at http://wgne.meteoinfo.ru/ and summarized in the meeting presentations available there. WGNE has expanded its "Blue Book" yearly updates on research activities to Earth system modeling, (current deadline for 2021 for contributions is 31 May). WGNE is also planning its 6th Workshop on Systematic Errors in Weather and Climate Models, to be held at ECMWF in September 2022 (https://events.ecmwf.int/event/241). The Science Steering Committee for this workshop will include representatives from the ESMO modeling groups, including WGCM, GLASS, GASS, and OMDP. Among the most challenging science issues facing the weather and climate modeling communities and related observing communities over the next 3-5 years concern aspects of coupled modeling at the interfaces of land-atmosphere and air-sea/ice exchanges. Priorities should include making better use of observations across these interfaces (e.g. including hydrological observations) with a focus on model systematic error reduction, data assimilation, and research into the required complexity within

lighthouse activities, for applications and users. Resolving the shared technical issues (e.g., exascale computing, IO and data handling, data governance, and machine learning) will be key enablers for both the modeling and observing community. An integrating activity for the participating groups in ESMO will be Data Assimilation across timescales and in coupled systems. Participation in ESMO will enable WGNE to foster and improve knowledge transfer of modeling activities relevant to CLIVAR, GEWEX, SPARC, CLiC, WGCM, and CORDEX. WGNE's focus on strengthening coupled modeling process studies strongly projects onto the Digital Earth lighthouse activity, but also has natural links to the modeling components, or modeling-enabled components, of all the other lighthouse activities. WGNE has found the ex-officio mechanism an effective way to foster collaboration between groups and recommends broadening and strengthening this mechanism among the different groups in ESMO as appropriate.

S2S Report (Andy Robertson, Frederic Vitart)

Phase II of S2S (2019-2023) science/modeling foci are continuing on interactions between land-atmosphere, ocean-atmosphere, troposphere-stratosphere; ensemble generation; prognostic aerosols; MJO and teleconnections, together with a major emphasis on research-to-operations (forecast calibration, multimodal ensembling, user-oriented forecast products, verification), and societal applications development. An important legacy of the project (after S2S ends in 2023) will be operational implementation of routine S2S forecasts via a new WMO Lead Center, with the need to maintain the S2S database for the research community, and further promote seamless forecast development (across timescales and from science to use) through WCRP & WWRP activities. S2S has launched coordinated experiments with WGNE/GAW on interactive aerosols and stratosphere/troposphere interaction with SPARC/SNAP, as well as coordinated OSE experiments to assess the impact of the current ocean observing system of S2S forecasts. S2S/WMO is organizing a prize challenge to use machine learning to improve S2S forecasts, June-Oct, 2021. The 2-year S2S real-time pilot project for forecast applications development (Nov 2019-Nov 2021) is planned to be extended until Nov 2022 because of COVID delays. S2S is highly relevant to several of the new WCRP LHAs Explaining and Predicting Earth System Change; My Climate Risk (may include regional climate services activities) and Digital Earths (including co-operability of databases and data-science frameworks). Strong S2S linkages with WMO operational services are an asset. An urgent task for the WCRP JSC is to facilitate these interactions, including with WGSIP.

TIRA Report (Jan Keller, Masatomo Fujiwara)

Key Science Highlights:

- Collaboration with WWRP-DAOS group, strong connection to SPARC project S-RIP
- Organization of the first Joint WCRP-WWRP conference on DA and reanalysis (this fall)
- Initiatives on reanalysis comparison (water and energy budgets, representation of climate)
- Promote data dissemination efforts for earth system data, e.g., WRIT, CREATE-IP (ana4MIPs)

1. Primary Science Issues next 3-5 years
   - More complex Earth system reanalysis efforts (strongly coupled to ocean / land / sub-surface) – will these efforts provide time series that better represent real world climate trends?
   - Integration of reanalyses as a pillar of a broader climate monitoring strategy; Reanalysis is a synthesis of models and observations through data assimilation for climate applications – this makes reanalysis a potential major hub for simulating and understanding the Earth system
2. Issues and Challenges
   - Application-orientated approaches for reanalysis
   - Ever growing data sets (e.g., increased resolution, ensembles) start to constrain / delay people's work à Optimized data utilization and dissemination efforts (e.g., cloud services)

Obs4MIPs Report (Simon Pinnock, Peter Gleckler)

Obs4MIPS was Initiated in 2010 to facilitate the use of obs in climate model evaluation/research, targeting the CMIP protocol. It provides gridded products technically aligned with CMIP, together with concise and accessible technical documentation.Substantial infrastructure connected to CMIP has been developed by a Task Team previously coordinated via the WDAC. The Task team (TT) has become somewhat dormant in the last few years and WCRP restructuring has contributed to a recent loss of direction. The co-chairs are attempting to reinvigorate activity by recruiting new TT members and encouraging new dataset submissions.

Current Priorities include:

- Update the database with new data submissions
- Analysing lessons learned from CMIP6 and understand new requirements for obs4MIPs in CMIP7
- Building links with the new WCRP Lighthouse Activities
- Liaising with the new CMIP-IPO