WORLD CLIMATE RESEARCH PROGRAMME

42nd Session of the WCRP Joint Scientific Committee (JSC42)

ESMO – Earth System Modelling and Observations

Interim-co-chairs: Cath Senior and Susann Tegtmeier

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A new core project to bring together Models, data and Observations

Models, data and observations within the WCRP family

WMAC
WCRP Modelling Advisory Council

WGCM
Working Group on Coupled Modelling

WDAC
WCRP Data Advisory Council

WGNE
Working Group on Numerical Experimentation

ETCCDI
Expert Team on Climate Change Detection and Indices

Coordination?
Interactions?
Overlap?
Earth-System Approach?
New topics (AI)?

WGSIP
Working Group on Subseasonal to Interdecadal Prediction

Data and Modelling panels of the core projects, e.g., **OMDP** and **GSOP**

S2S
Subseasonal-to-Seasonal Prediction Project

And others …

The way forward

Decision at the last WCRP JSC meeting (41B) to start the establishment of the **ESMO core project in 2021**

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ESMO: Initial Structure

Project Office

ESMO core project

Secretariat support

Scientific Steering Group
Ex-officio from other homes, LHAs, and partners

WGNE

WGCM

CMIP

WGSIP

TIRA

S2S

Obs4MIPs

DAOS?

CORDEX?

Global Extremes?

New Topics? - Data Science, Obs Panel, ..

Broader stakeholders like UNFCCC, IPCC, GFCS (C3S), IOC-UNESCO, ISC, WMO, NMHSs, Regional Climate Centres, etc.

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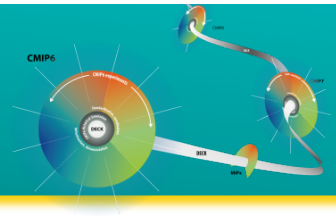
WGCM: Working Group on Coupled Modelling *(Greg Flato, Cath Senior)*
CMIP panel *(Jean-Francois Lamarque)*; **WIP** *(Matt Mizielinski, Paul Durack)*



Science Highlights

- CMIP6 MIPS contributed to AR6, Key papers, SPM figures etc
- CMIP International Office was awarded to ESA. Recruitment for Director is starting and hope support will be in place in Autumn 2021.
- The WIP are working to ensure continued support for new science as we move beyond CMIP6 and seamless access to 20PB data as the ESGF evolves.

Primary Science Issues next 3-5 years

- WGCM, CMIP Panel, and WIP are working on a substantive consultation involving the climate science community, modelling centres, data centres, and other stakeholders to develop plans for CMIP7.
- CMIP panel and WIP are planning some face-to-face meetings with Modelling groups and Stakeholders to follow-up survey results and ensure engagement in ways forward for CMIP7. These will be part of the 'Future of Climate Modelling' series of workshops held by ESMO

Issues and Challenges

- CMIP7 will not be like CMIP6; Modelling centre interest and capacity will be important as will supporting Science and stakeholder needs and Infrastructure (forcing, data, output archival, dissemination)
- Need to understand WGCM role in ESMO and interactions between ESMO-IPO and CMIP-IPO
- Need to build interactions with wider modelling priorities, e.g. LHA (Digital Earth), RIFS

WGSIP: Working Group on Seasonal to Interdecadal Prediction

(Bill Merryfield, June-Yi Lee)

Key Science Highlights

- Science projects addressing key prediction challenges (initialization shock/drift, monsoons, ocean prediction, extremes, information for decision making)
- Analyses of DCPP decadal prediction experiments
- WCRP Workshop on Extremes in Climate Prediction Ensembles hosted by APCC October 2021

Primary Science Issues next 3-5 years

- Improved Earth system state estimation (including biogeochemistry) for initialization & verification
- Developing seamless regional predictive information across time scales
- Application of ML as a climate prediction post-processing tool and for predictability understanding
- Prediction and attribution of near-term carbon cycle changes

Issues and Challenges

- Ex-Officio memberships (S2S, WMO IPET-OPSLS, TIRA…) needed to address WGSIP's expanding remit
- WGSIP/DCPP linkages with observation/data assimilation communities currently underdeveloped -> potential for strengthening through ESMO should be pursued
- Strengthened WGSIP/DCPP links to LHA 'Explaining and Predicting Earth System Change', 'My Climate Risk', 'Digital Earth', 'WCRP Academy' to address subseasonal to decadal predictive time scales
- Fragmentation of data standards and platforms across time scales, research vs operations -> huge benefit from convergence to CMIP/DCPP and/or C3S data standards, ESGF

WGNE: Working Group on Numerical Experimentation *(Nils Wedi, Carolyn Reynolds)*

Science Highlights

- MIPS (Aerosol, Gray Zone, Surface Flux, Model Uncertainty), often joint with other groups
- State of the Science documents (Blue Book, JWGFVR Process-based Diagnostics White paper)
- 6th WGNE Workshop on Systematic Errors to be held at ECMWF September 2022 *(https://events.ecmwf.int/event/241/)*

Primary Science Issues next 3-5 years

- Coupled modeling (systematic error reduction, DA, application-based complexity requirements)
- Technological issues (Exascale, IO & data handling, data governance, ML, diagnostic tools)

Issues and Challenges

- How does WGNE broaden remit without losing effectiveness? Ex-officio mechanism has worked well and could be enlarged.
- Through ESMO, WGNE will foster & improve knowledge transfer of modelling activities relevant to CLIVAR, GEWEX, SPARC, CliC & CORDEX
- WGNE projects well onto 'Digital Earth' lighthouse, but also links closely to 'Explaining and Predicting Earth System Change' and other lighthouses through a focus on model development and detailed process understanding.

Additional elements and new activities

- Data assimilation across space and time scales could bring ESMO elements (observations and modelling) close together

S2S: Sub-seasonal to Seasonal Prediction Project

(Andy Robertson, Frederic Vitart)

Science Highlights

- Launch of coordinated experiments with WGNE/GAW on interactive aerosols and stratosphere/troposphere interaction with SPARC/SNAP.
- 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, to run June-Oct, 2021.
- The 2-year S2S real-time pilot project (Nov 2019-Nov 2021) is planned to be extended until Nov 2022 because of COVID delays.
- S2S will end in Dec 2023; important for legacy will be operational implementation of routine S2S forecasts via a new WMO Lead Center; maintenance of the S2S database for research; and further promotion of seamless forecasting through WCRP & WWRP activities.

Primary Science Issues

- S2S Phase II science/modeling foci will continue on interactions between land-atmosphere, ocean-atmosphere, troposphere-stratosphere; ensemble generation; prognostic aerosols; MJO and teleconnections.

Issues and Challenges

- Three LHAs are relevant to S2S: Explaining and Predicting Earth System Change; My Climate Risk (may include regional climate services activities) and Digital Earths. How can WCRP facilitate the interaction?

Obs4MIPs: Observations for Model Intercomparison Projects *(Simon Pinnock and Peter Gleckler)*

- Initiated in 2010 to facilitate the use of obs in climate model evaluation/research, targeting the CMIP protocol
- 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

Current Status:

- Task team (TT) has become somewhat dormant in the last few years
- WCRP restructuring has contributed to a recent loss of direction
- Co-chairs attempting to reinvigorate activity by recruiting new TT members and encouraging new dataset submissions.

Current Priorities:

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

TIRA: Task Team for the Intercomparison of Re-Analysis

(Jan Keller with Mike Bosilovich and Masatomo Fujiwara)

- Initiated in 2017 to foster scientific exchange on reanalysis
- Aimed at establishing a permanent reanalysis-related project within WCRP

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)

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

Issues and Challenges

- Application-orientated approaches for reanalysis
- Ever growing data sets (e.g., increased resolution, ensembles) start to constrain / delay people's work **->** Optimized data utilization and dissemination efforts (e.g., cloud services)

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ESMO: Vision and Goals

Vision: Address overall coordination mechanism across all model, data and observations activities within the programme

1. **Research**
   - Seamless and value-chain model-data-observation approach
   - Across Earth system components, disciplines, time and spatial scales
   - Focus on coupled model systematic biases and development
   - Observational requirements to monitor, understand and predict the climate system

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

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

4. **Partnerships**
   - Identify stakeholders, scientific ambition and resourcing needs
   - Remove fragmentation, duplications and suboptimal aspects in the programme

ESMO: Timeline and roadmap

Apr 2021

Set up **Interim SSG**

- Co-chairs: C. Senior and S. Tegtmeier
- Representatives from working groups and partners

Jun 2021

Set the **governance and structure**

- Group discussing structure for ESMO (see next slide)
- Governance is a unique challenge to ensure representation of existing groups but also to entrain new thinking and engagement

International **Project Office**

- Prepare the solicitation of bids for IPO

Kick-off event and other workshops

- Organise a kick-off event in the second half of 2021?

Jan 2022

Next SSG will take over

- Update and revise governance
- Set specific research priorities with the project's constituencies
- Establish the external partnership arrangements

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ESMO: Evolving Structure

Cross-cutting Modelling Science

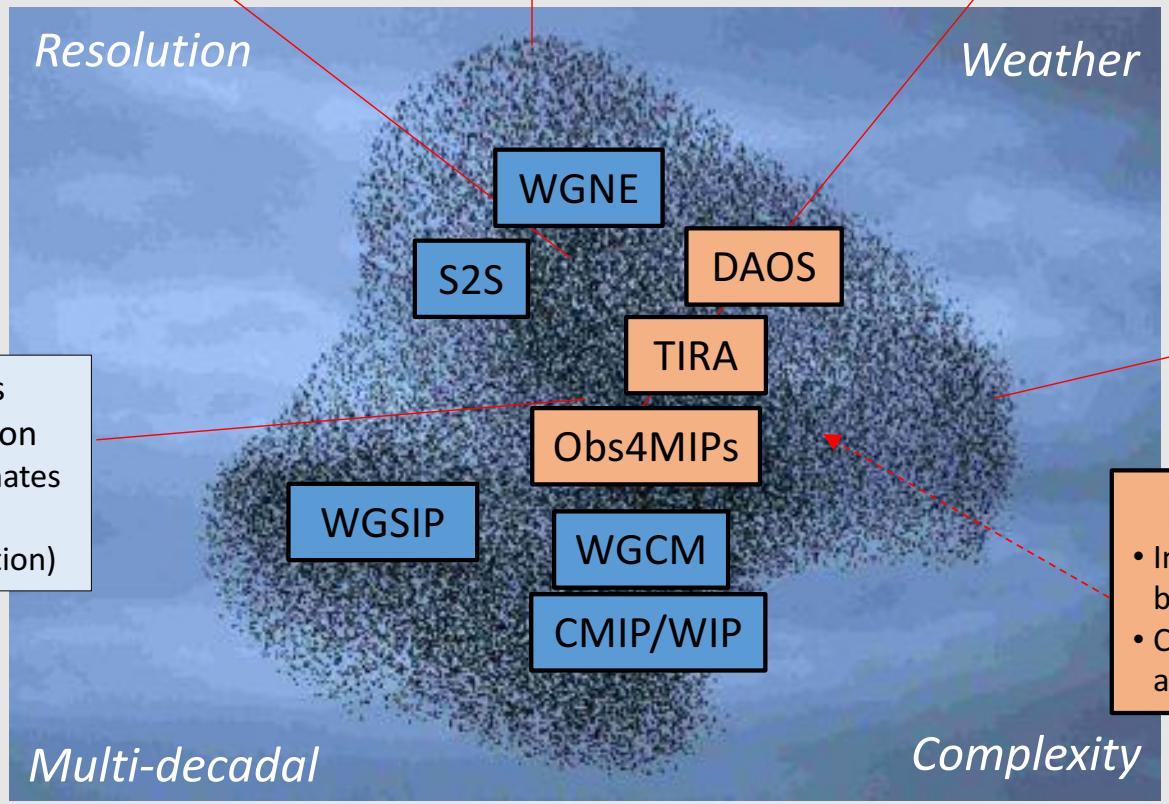
- Seamless ES modelling
- Multi-scale processes
- Process-based diagnostics
- Initialisation
- Global, regional and local climate change, extremes
- Km-scale modelling
- Urban environments

Earth System Modelling

Earth System Assimilation

Earth Observations

Coordination and knowledge transfer



- Climate feedbacks
- ES model evaluation
- Modelling past climates (for re-analysis & uncertainty estimation)

New Obs Panel?

- Interface with external bodies
- Coordinate requirement across all WCRP

Science on tools & methodologies: DA, ML,… ; Preparing for Exascale ; I/O & data handling; …
Infrastructure needs: Data governance ; diagnostic tools ; cloud – data access & distribution verification/validation/uncertainty quantification

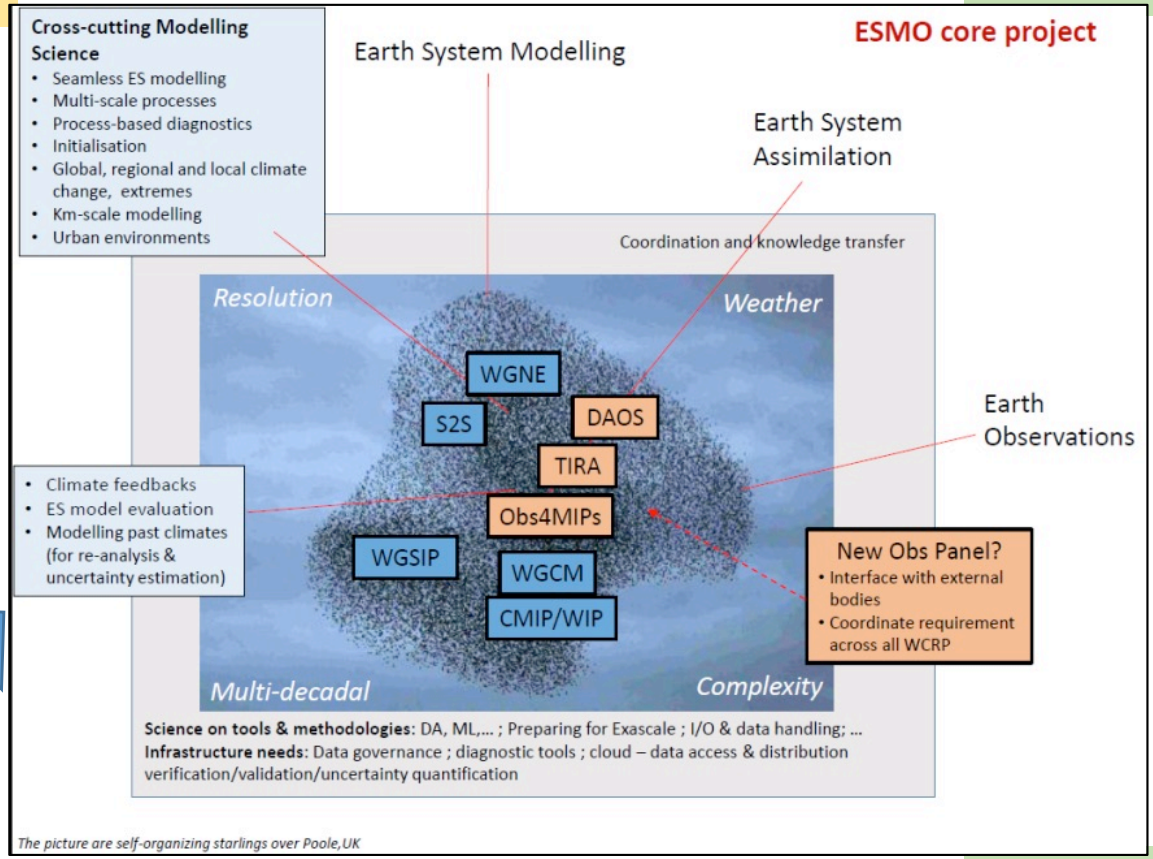
The picture are self-organizing starlings over Poole,UK

ESMO: Evolving Structure

Other CORE projects:
- GEWEX (Stewardship of observations)
- CLIVAR
- SPARC
- CLiC
- RIFS/CORDEX

External partners
- WWRP, GAW
- GCOS, GOOS
- Space agencies (via CEOS/CGMS WG Climate)
- Future Earth Projects (e.g. AIMES, SOLAS)

Outside groups: deep dive into topical questions, formulating modelling and observational needs, benefiting
from infrastructure & tools developments
as well as common investments



LHA
- Explaining and predicting CC
- My Climate Risk
- Safe Landings Climate
- Digital Earth

Stakeholders
- Climate Services: GFCS, C3S
- Policy makers: IPCC, UNFCC
- WMO operational entities: GDPFS, NMHSs, RCCs
- User groups of services

ESMO: Challenges

Scientific communities

- Adopt a common ground, ensure buy-in and merge communities
- Find routes to manage cross-cutting issues e.g. communities of practice, workshops, joint annual meetings,….

Existing groups and activities

- Keep current successful activities with their own priorities and momentum intact
- Adopt an evolutionary approach to structure identifying new groups

Define high-level **contributions and research priorities**

- E.g., understanding and reduction of systematic errors in Earth system models
- Future role of data science and machine learning
- Will be defined by working groups and partners
- Take into account value-chain and seamless approach

And more …

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ESMO: Work in progress

First detailed discussions on:

- Strategic actions on how to establish dialogues between groups
- Role of data assimilation as a way to link many of the subgroups
- Role of observations for WCRP and links to GCOS
- Data sharing
- How to connect to users and stakeholders

First steps:

Based on work in progress of a smaller group of volunteers

- Definition of high-level research topics, e.g.,
  - Observational requirements and best practices to derive these requirements
  - Understanding and reducing systematic errors in ESMs
- Definition of communities of practice for each topic (e.g., workshops)
- Linking different working groups and communities