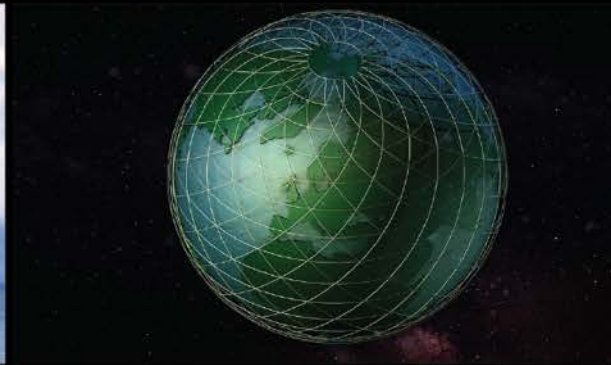


# WORLD CLIMATE RESEARCH PROGRAMME



## ESMO (Earth System Modelling and Observations) Strategic Plan

Interim-co-chairs: Cath Senior and Susann Tegtmeier

# ESMO: Vision and Goals

## Overall coordination mechanism across **all model, data and observations activities** within WCRP

### 1. Research

- Seamless and value-chain approach
- Across Earth system components, disciplines, time and spatial scales
- 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
- Engagement, equal access and inclusion of the 'global south'
- Communication across WCRP constituencies, communities, partners, stakeholders



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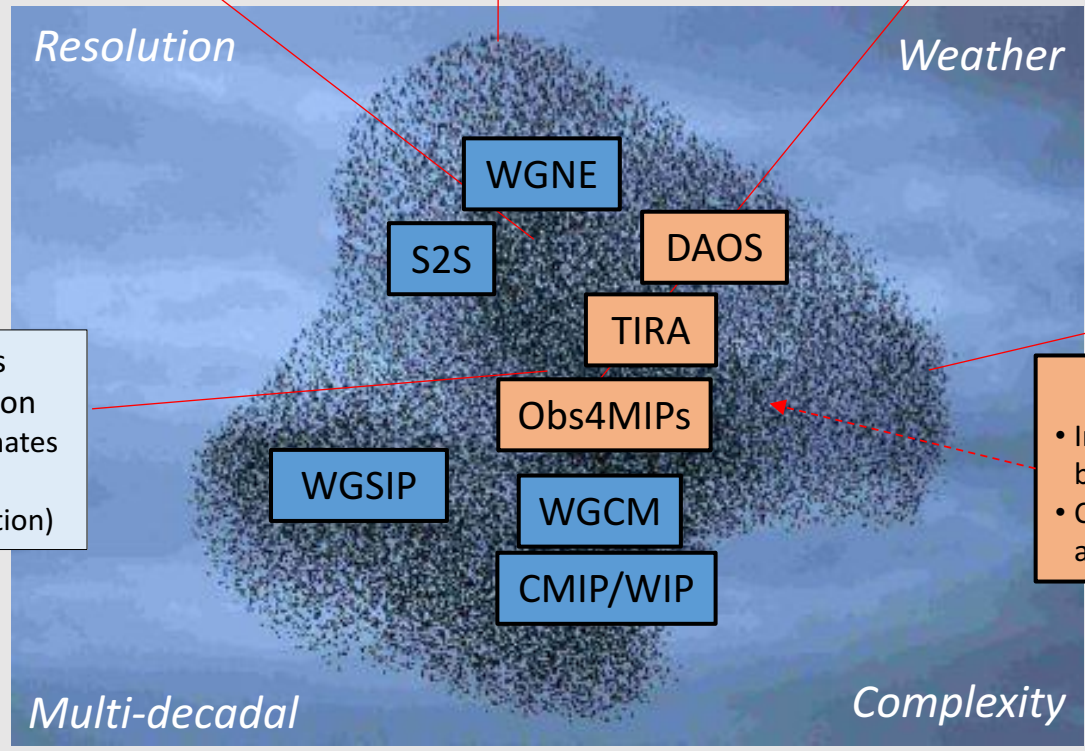
## Cross-cutting Modelling Science

- 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

Coordination and knowledge transfer



## Earth Observations

- 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

# Strategic Plan – Writing Teams

## Team 1 – Observations

Lead: J. Schulz

## Team 2 – Modelling

Lead: G. Flato

## Team 3 – Data Assimilation

Lead: J. Keller

## Team 4 – Carbon C

Lead: T. Ilyina

1. What are the WCRP observational requirements and best practices to derive these requirements?
2. What are the systematic errors in observation data and observation systems
3. What is the future of climate modelling?
4. What are the sources and magnitude of systematic errors across time and space scales in Earth System models?
5. How can we use variational methods, including data assimilation and sensitivity analysis, across timescales and in coupled systems?
6. What are the current and future changes in the Carbon Cycle?

**Four Writing Teams** addressed Q1&2; Q3&4, Q5, Q6 to develop

- a. Outcomes
- b. Activities
- c. Links with ESMO groups, WCRP LHA/core project, wider stakeholders
- d. Outreach/Capacity Building
- e. Maybe also Funding opportunities

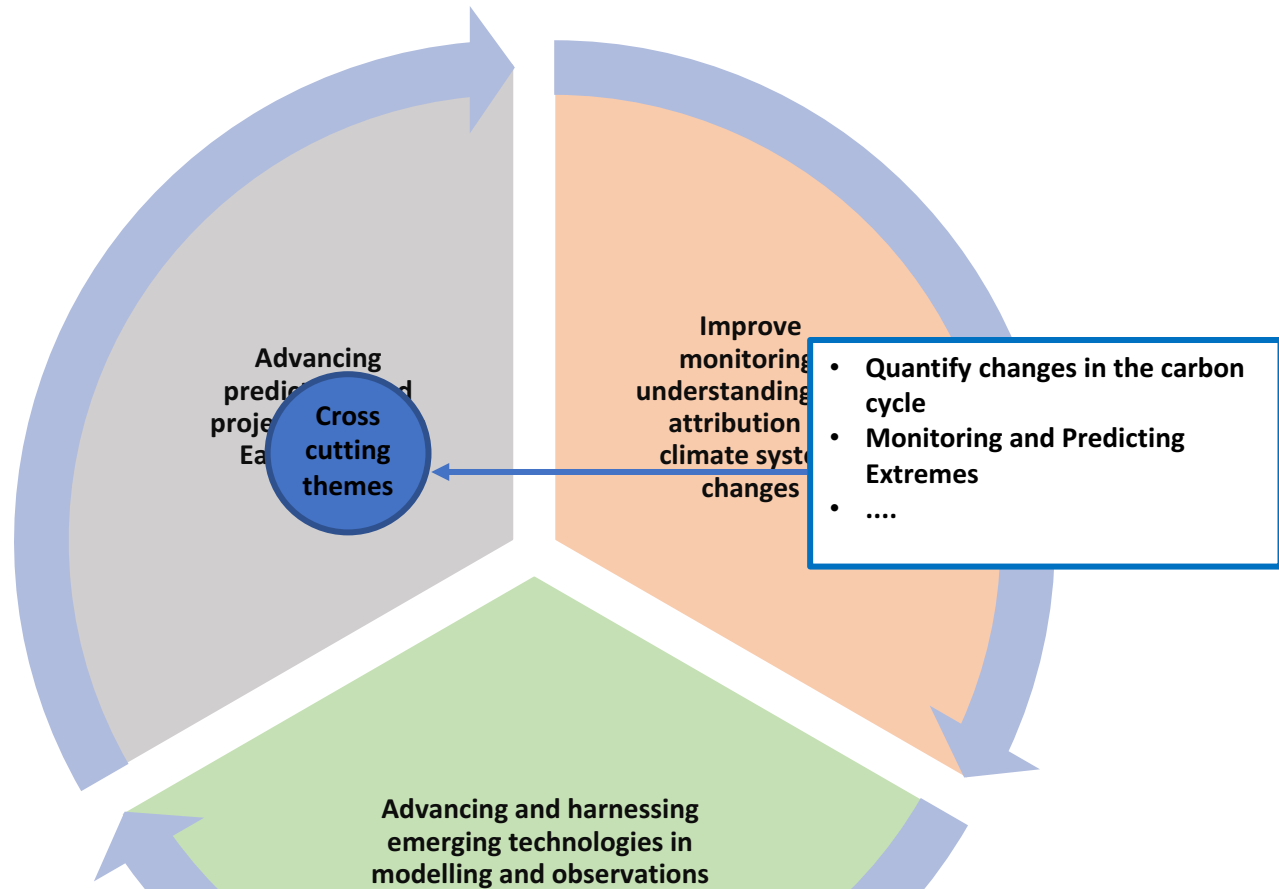


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# ESMO Objectives

- Three scientific objectives that will underpin and integrate the next decade of climate science modelling, data assimilation and observational activities
- Informed by the most pressing shortcomings in our ability of monitoring, predicting, and projecting the climate system from **days to centuries and from local to global spatial scales**
- Advance the core capabilities of the WCRP programme



- Quantify changes in the carbon cycle
- Monitoring and Predicting Extremes
- ....

- Recognise there is overlap with core projects, LHAs and work will continue where there is existing expertise
- ESMO focus on coordination of specific priority topics
- Themes where there is potential for strong collaboration across WCRP to obtain rapid results and benefits

# O1: Advancing predictions and projections of the Earth system

## Reducing systematic Errors

- Prioritisation of errors through ESMO continuation of WGNE surveys
- Use of tendency bias corrections from DA
- Well designed Model Intercomparison

## Evaluation and Initialisation

- ESMO survey of observational need
- Consistency and comprehensive coverage of observations across all ES components
- Quantified observational uncertainty and errors
- Use of multi-reanalyses
- Optimising spin-up approaches and use of Earth-system Data Assimilation

## Energy-Water-Carbon Cycles

- Promotion of km-scale modelling for water cycle (MCS, tropical precipitation)
- Improved modelling of key processes of terrestrial and marine Carbon Cycle
- Monitoring and evaluation of Carbon Cycle

## Projections

- Interpretation and optimisation of Ensembles
- Adaptive scenarios



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# O2: Improve monitoring, understanding and attribution of climate system changes

## Design of Observational systems

- Intensified efforts on harmonizing observational reference data sets
- Methodologies for uncertainty quantification of observational data sets
- Co-ordination of community effort on OSEs and OSSEs for climate.
- Establish a strong interface to GCOS and the space agencies through the CEOS/CGMS Working Group on Climate to provide guidance on the needs of the WCRP research community for global climate observations

## Advanced Data Assimilation Methods for Climate

- Consistent representation of the different spatial and temporal scales that govern processes in the Earth system
- Promote the continuous curation of observation-space data sets of in-situ observations as input to data assimilation in reanalyses applications
- Framework for collaboration between reanalysis producers

## Energy-Water-Carbon Cycles

- Establish an active interface with GCOS on carbon observation requirements
- Promote the need for a coherent fully coupled land-ocean-atmosphere Carbon Cycle reanalysis of the recent past.



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# O3: Advancing and harnessing emerging technologies in modelling and observations

## Exploitation of Machine Learning

- Application of machine learning to develop physically constrained, scale-aware, stochastic parameterizations for subgrid-scale motions and fluxes informed by observational and modelling “big data”
- Application of machine learning for post-processing of initialized climate prediction for services and societal applications

## Exploitation of New Observing Platforms and capability

- Harnessing citizen Science contributions
- Coordination of unification of data types

## Technical Infrastructure Support and communication

- Share best practices and knowledge on data policy, protocols, and standards
- Provide a communication platform for tools for bringing models and observations together.
- Facilitate dialogue on application of exascale computing and data management. Between climate modellers, software engineers, and hardware designers to proactively enhance mutual understanding of the climate community’s evolving needs and the developing tools needed to realize them.



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# Envisaged ESMO partnerships

<b>Objective</b>	<b>Main internal contributors</b>	<b>Main internal partners</b>	<b>Main external partners</b>
<b>Advancing predictions and projections of the Earth system</b>	<b>WGCM, CMIP, WGNE, WGSIP, S2S Obs4MIPs, WGOR</b>	<b>GSOP, OMDP, GLASS, GASS, CCMI, SNAP, EPESC, Digital Earths</b>	<b>WWRP, GCOS, GOOS, GAW, WG Climate, Future Earth</b>
<b>Improve monitoring, understanding and attribution of climate system changes</b>	<b>TIRA, WGSED, WGOR</b>	<b>S-RIP, TUNER, GDAP, EPESC, Digital Earth, Reanalyses.org</b>	<b>Global Carbon Project, WG Climate</b>
<b>Advancing and harnessing emerging technologies in climate science research</b>	<b>WGNE, WGCM, CMIP (WIP), WGSIP, TIRA, WGSED?</b>	<b>Digital Earth,</b>	<b>EU Destination Earth</b>

Recognising the broad and ubiquitous nature of modelling and observational activities within WCRP ESMO will;

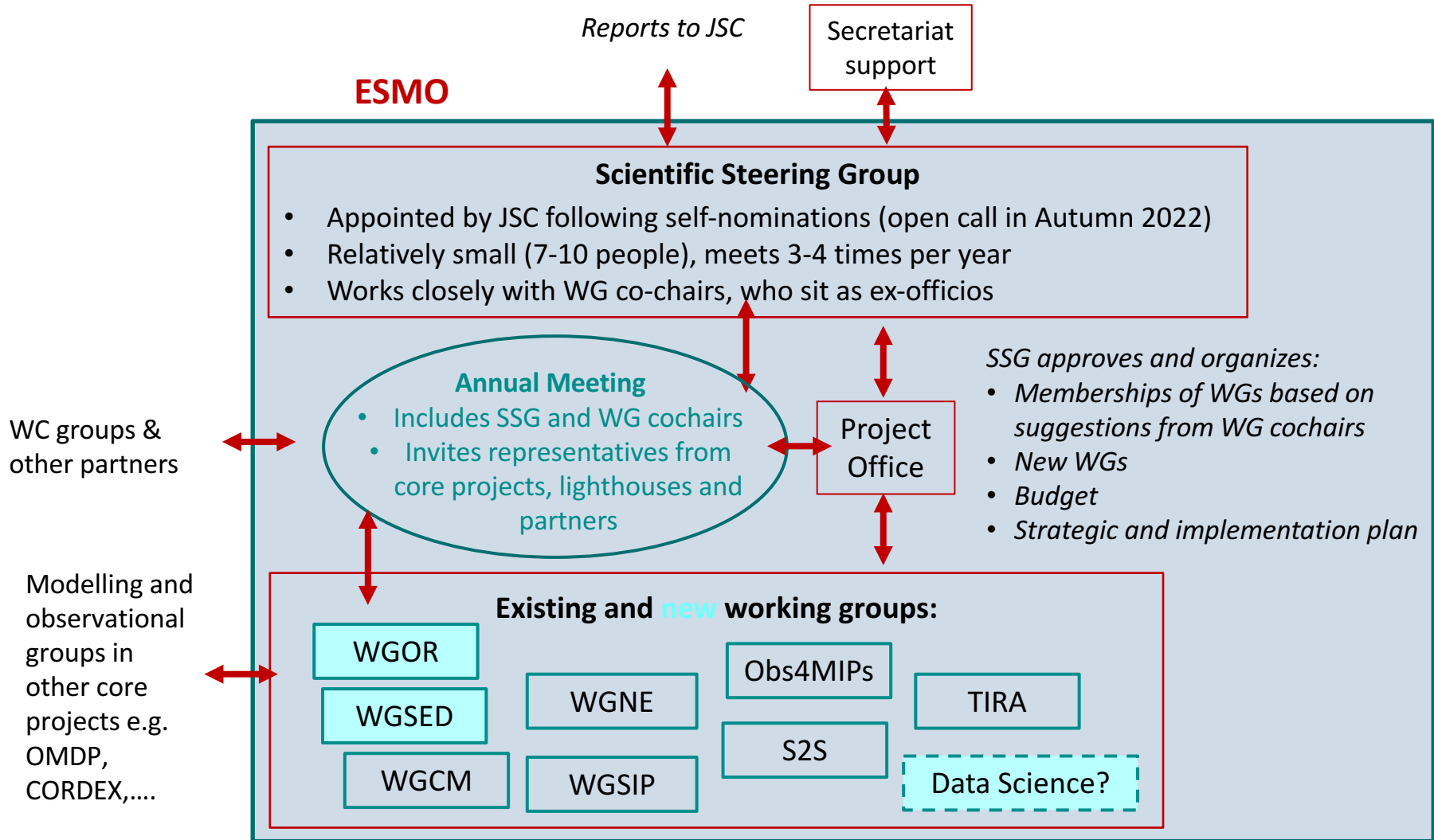
- Form connections and partnerships with all Core Projects and LHAs
- Act as a modelling and observations focal point for collaborations with external partners



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# ESMO: Governance



# Meetings and Workshops (Sep 21- 22)

TIRA-DAOS joint symposium on DA and reanalysis	13-17	September	2021	Online
WCRP Workshop on Extremes in Climate Prediction Ensembles (ExCPEns)	25-28	October	2021	Online
WGNE-36	01-04	November	2021	Online
WGSIP-23	16-17	November	2021	Online
WGCM-24	07-09	December	2021	Online
The Future of Climate Modelling	21-24	March	2022	Online
Model Hierarchies Workshop	29 Aug – 01 Sep	August	2022	Stanford, CA, USA
Modelling the climate system at storm-resolving scales (Joint with Digital Earths)	03-07	October	2022	Boulder, USA or Exeter, UK (TBC)
6 <sup>th</sup> Workshop on Systematic Errors in Weather and Climate Models	31 Oct - 04 Nov	November	2022	Reading, UK
Joint WGCM-WGNE meeting	7-11	November	2022	Boulder, CO, USA
ESMO kick-off meeting		May?	2023	



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# ESMO: Timeline and roadmap

Jun  
2022

Approval for initial **Science Plan**

- Present to JSC-43
- Address feedback from JSC, wider WCRP community and partners

Jul  
2022

International **Project Office**

- Evaluate bids and appoint IPO

Sept  
2022

Open call for **ESMO SSG members**

Nov  
2022

- Ratification by JSC (November meeting)

Jan  
2023

**Next SSG** will take over

- Build on/implement governance
- Further define Strategic plan and cross-cutting themes
- Establish new groups and ways of cross-group working
- Establish the external partnership arrangements



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# ESMO members

Bill Merryfield	WGSIP co-chair,
June-Yi Lee	WGSIP, co-chair
Carolyn Reynolds	WGNE co-chair
Nils Wedi	WGNE co-chair
<b>Greg Flato</b>	WGCM co-chair
Cath Senior	WGCM co-chair,
Ben Galton-Fenzi	CLiC (and former WDAC)
Tingjun Zhang	CLiC and WDAC
Helene Seroussi	CLiC and WMAC
Gokhan Danabasoglu	CLIVAR, OMDP co-chair
Baylor Fox-Kemper	CLIVAR WMAC
Lijing Chen	CLIVAR WDAC
Michael Ek	GEWEX, WMAC
Remy Roca	GEWEX, WDAP chair, WDAC
Susann Tegtmeier	SPARC, WDAC co-chair
Andrew Robertson	S2S
Daniela Jacob	RfS
Martin Visbeck	JSC liaison
Piere Friedlingstein	JSC liaison
Krishnan Raghavan	JSC liaison
Huijun Wang	JSC liaison
Mark Dowell	former WDAC and CEOS/CGMS WG Climate chair
<b>Joerg Schulz</b>	WDAC co-chair, former CEOS/CGMS WG Climate chair
Simon Pinnock	WDAC, ESA Climate Office, Obs4MIPS
<b>Jan Keller</b>	WDAC, TIRA
Anna Rutgersson	WDAC, SOLAS
Magdalena Balmaseda	WDAC, Data Assimilation
<b>Tatiana Ilyina</b>	WMAC, AIMES
Sabrina Speich	GCOS, OOPC, Co-chair GOOS

- Huge thanks to the interim-SSG for all their work in developing the plan
- Cath will step down as ESMO co-chair (and WGCM co-chair after 7 years), but hopes to stay on in new ESMO SSG (and CMIP panel)



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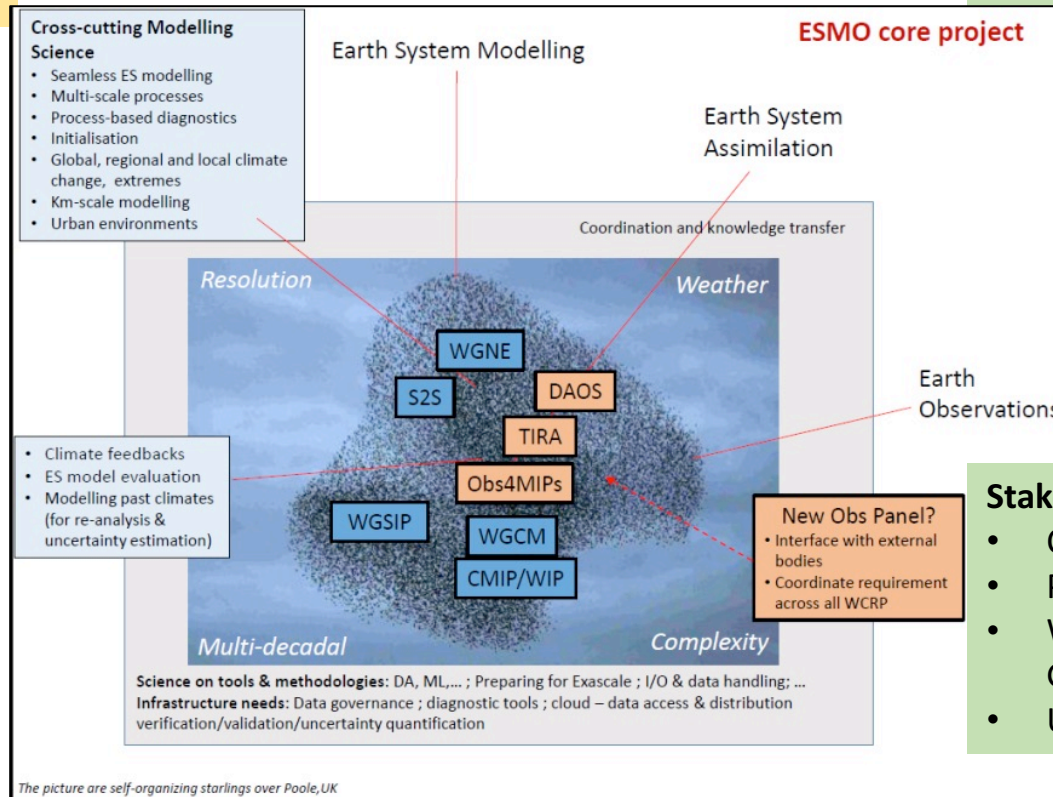
## Other CORE projects:

- GEWEX (Stewardship of observations)
- CLIVAR
- SPARC
- CLiC
- RIFS/CORDEX

# ESMO: Evolving Structure

## External partners

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



## Stakeholders

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

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