Committee on Earth Observation Satellites

CGMS

WGClimate-22 & GHG-TT-4

Strengthening the climate modelling-observation interface

WGClimate
The Joint CEOS-CGMS Working Group on Climate

WGClimate-22 & GHG-TT-5

11 - 13 February, 2025
ESA ECSAT, Harwell, UK

Eleanor O'Rourke, WCRP
Agenda Item 1.7

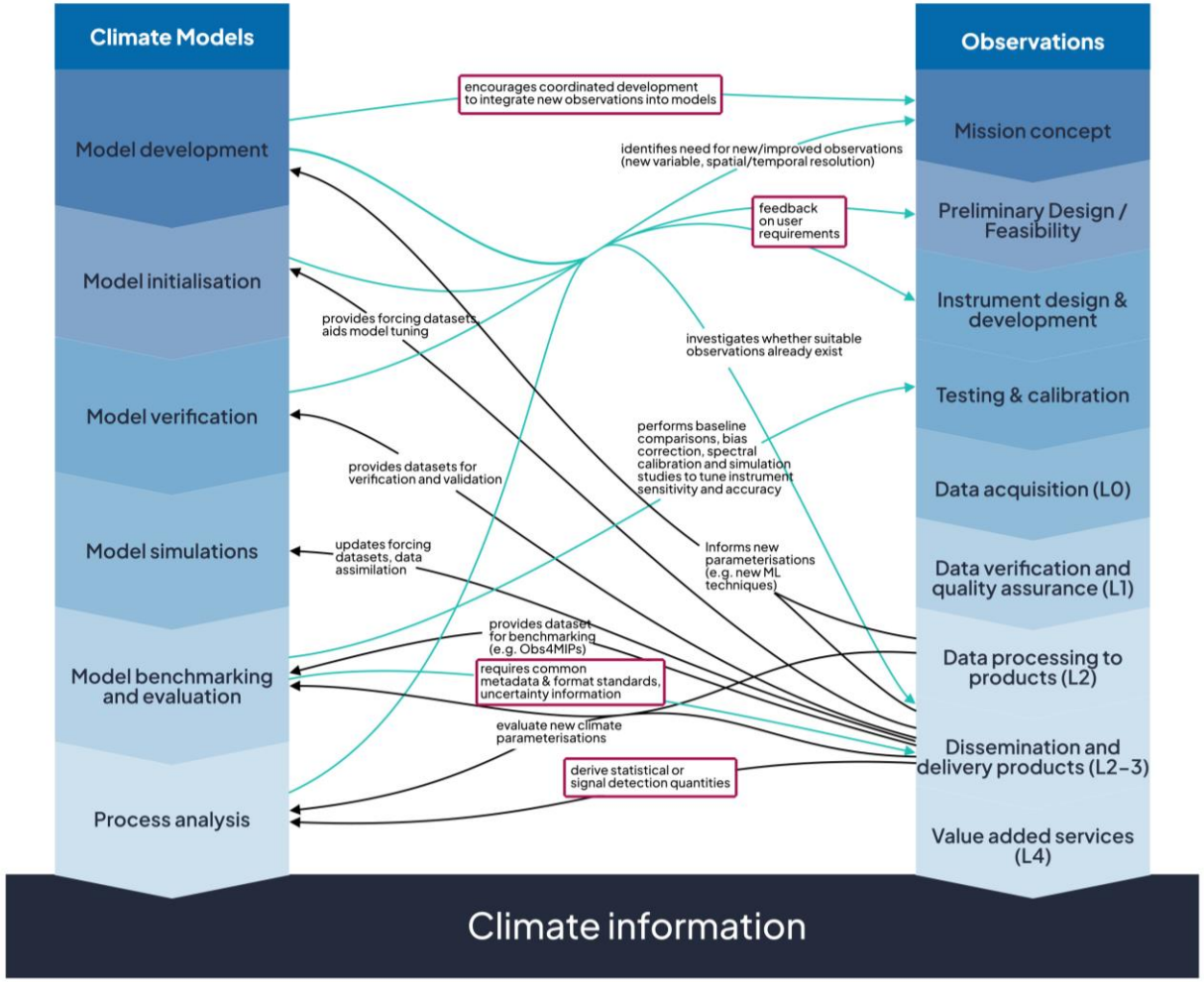
Session objectives

- **Provide an overview** of the World Climate Research Programme modelling community and their use of Earth observations
- **Highlight examples** of existing joint community action and opportunities to integrate into the EO data lifecycle, modeller's requirements
- **Identify and discuss opportunities** for CEOS WG Climate and ESMO WGORC to strengthen the climate Earth observation-modelling interface.

WCRP ESMO CMIP Coupled Model Intercomparison Project

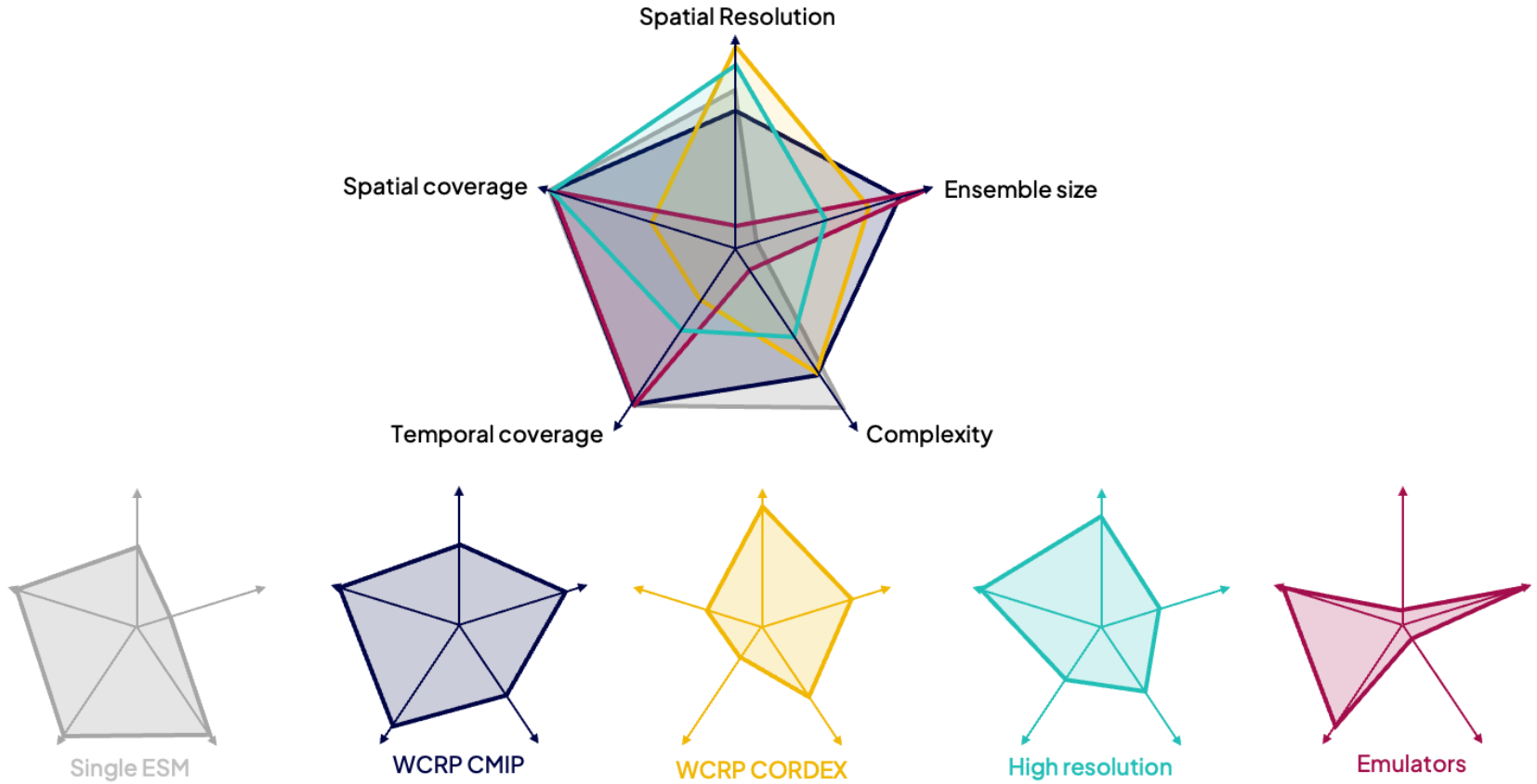
WGClimate
The Joint CEOS-CGMS Working Group on Climate

Use of Earth observations



Hegedus, D., Turner, B., Ferdini, S., and Macintosh, C. (2025)
The climate modelling-observation interface

The climate modelling multiverse

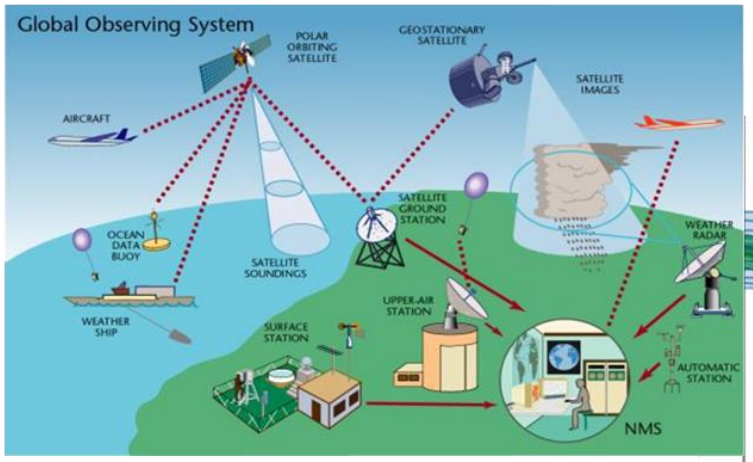


Dingley, B., O'Rourke, E., Hewitt, H., & Dunne, J. (2023). WCRP Modelling Multiverse. Zenodo. https://doi.org/10.5281/zenodo.8047805

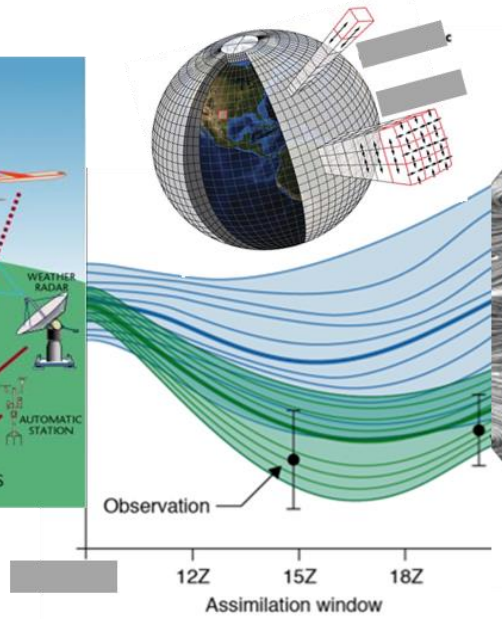
WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

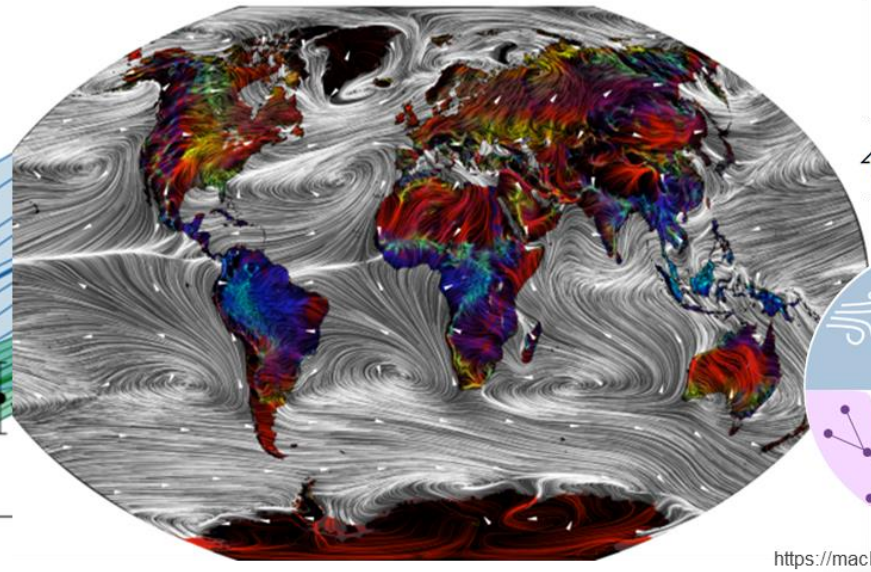
Earth System Modelling & Observations (ESMO)



WMO Global Observing system



Cambridge University Press Climate Model and ECMWF Data Assimilation schematic



Kling and Ackerly, 2020

https://machineclimate.de/

- **Advancing predictions and projections of the Earth system** on time scales from weeks to centuries and furthering model-observation integrated frameworks.
- **Improve monitoring, understanding, and attribution of Earth system changes and impacts** with robust uncertainty quantification through the synthetic use of models and observations.
- **Advancing and harnessing emerging technologies** in modelling and observations

WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

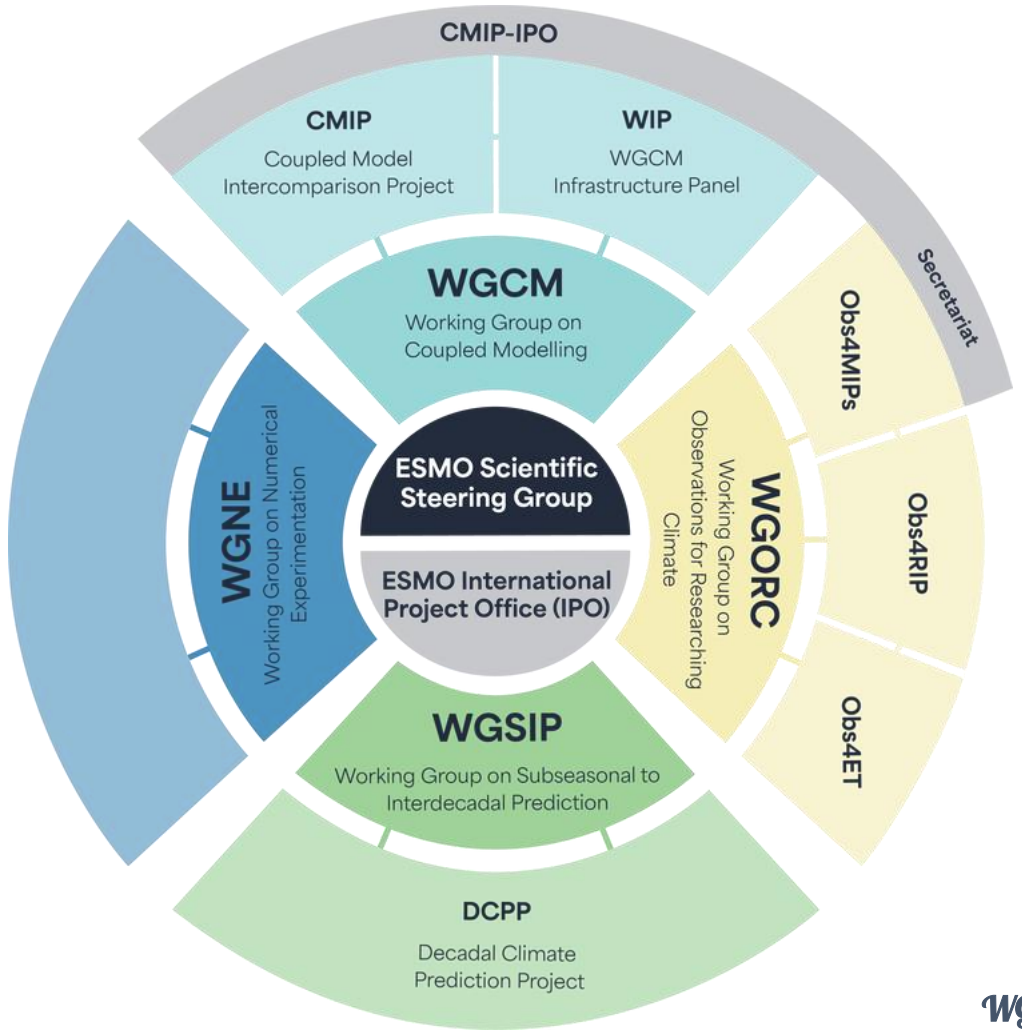
ESMO

❖ Scientific Steering Group Co-Chairs:

- Baylor Fox-Kemper (Brown University, USA)
- Susanne Tegtmeier (University of Saskatchewan, Canada).

❖ ESMO IPO:

- Based at the German Supercomputing Centre (DKRZ) in Hamburg



WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Working Group for Observations for Researching Climate (WGORC)

Mission:

This working group aims to identify and address research gaps in climate observation data and act as a facilitator for collaboration across diverse research and industry sectors.

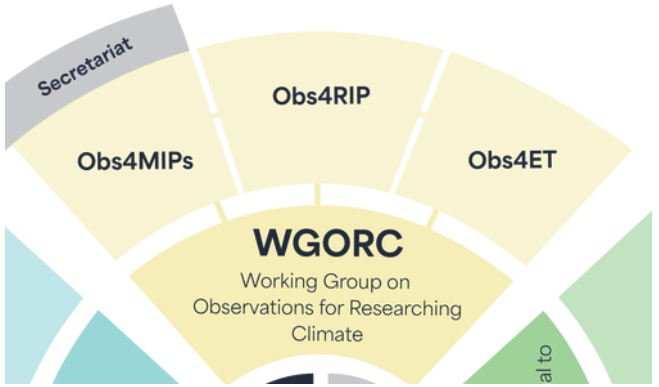
Co-chairs

Yuhan Douglas Rao,
North Carolina Institute for Climate Studies

Amy Doherty,
Met Office Hadley Centre

WGORC upcoming events:

- Call for members of the Working Group – Mar/Apr 25
- EGU General Assembly, Vienna - April 25
- ESA Living Planet Symposium, Vienna – June 25
- AMS Conference on Satellite Meteorology, Oceanography, and Climatology, San Diego – August 25



WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

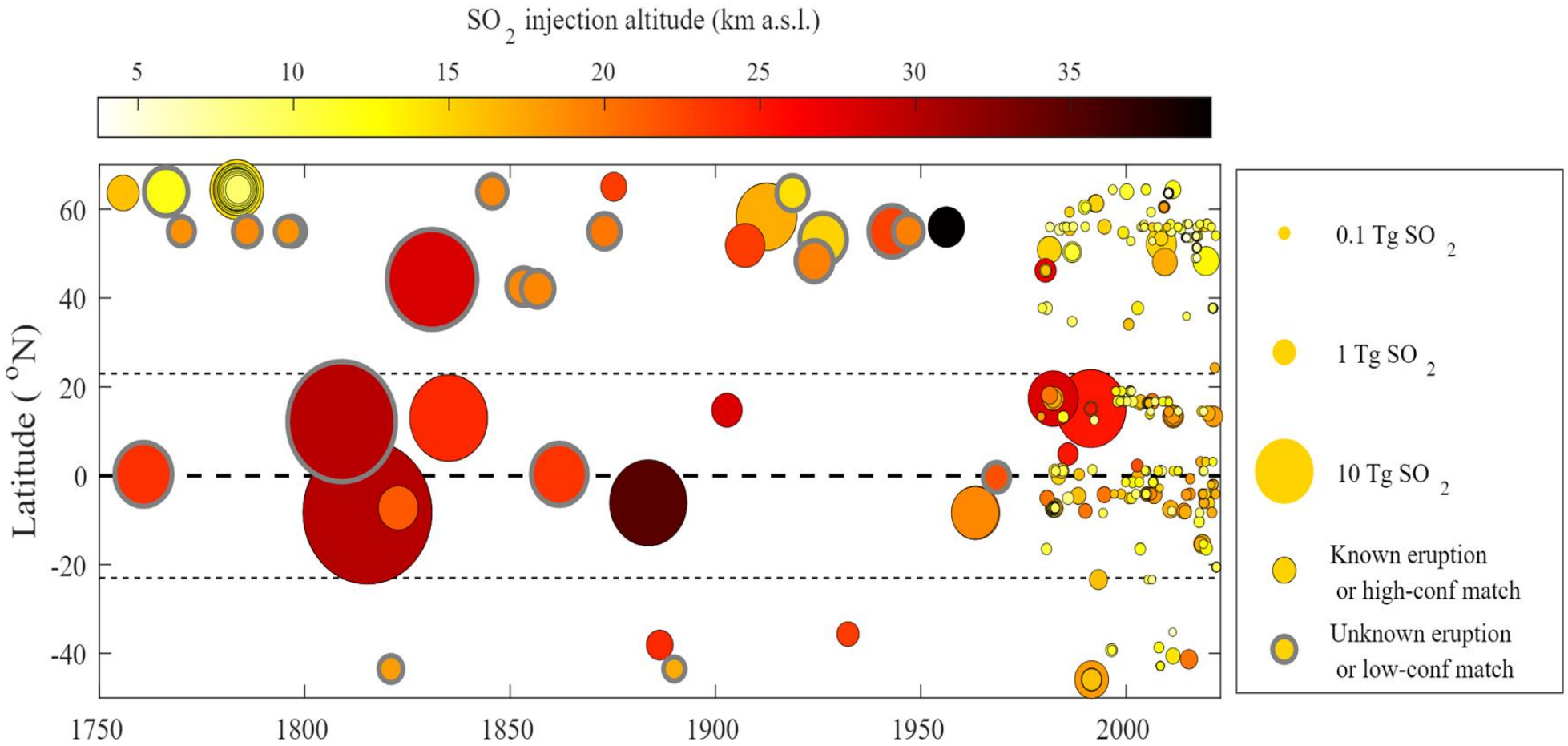
Interface highlight: Forcings

Baseline requirements

- Spatially complete
- ~1 degree, typically monthly
- Forcing, not assimilation, so uncertainties cannot be directly considered by the model.
- Stability…..1850-2023…..

For more information on CMIP historical forcing datasets see:
https://wcrp-cmip.org/cmip7-task-teams/forcings/

Interface highlight: Forcings



Changes to the observing system - volcanic forcing

Aubry et al., in prep

WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Interface highlight: Forcings

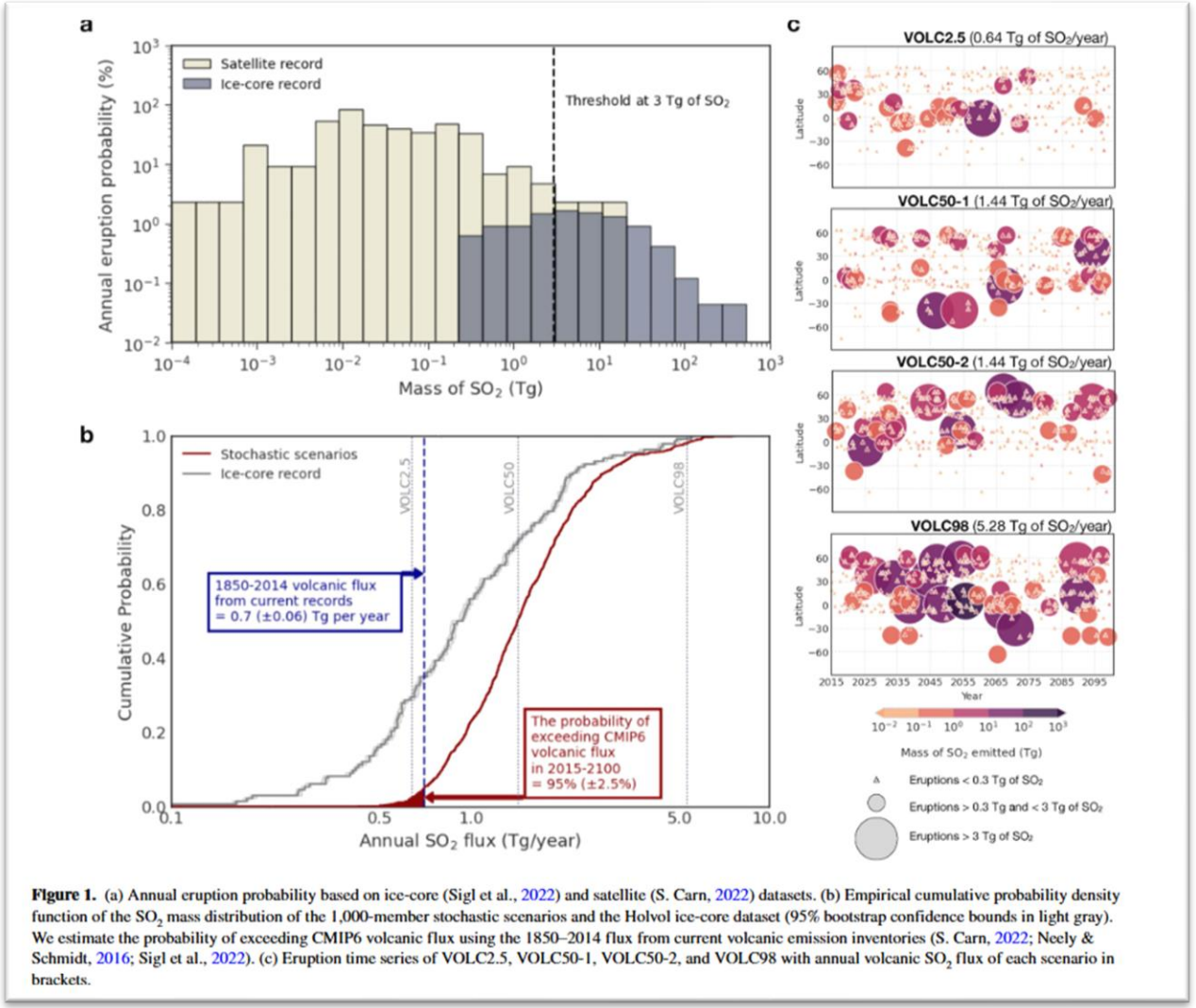


Figure 1. (a) Annual eruption probability based on ice-core (Sigl et al., 2022) and satellite (S. Carn, 2022) datasets. (b) Empirical cumulative probability density function of the SO_2 mass distribution of the 1,000-member stochastic scenarios and the Holvol ice-core dataset (95% bootstrap confidence bounds in light gray). We estimate the probability of exceeding CMIP6 volcanic flux using the 1850–2014 flux from current volcanic emission inventories (S. Carn, 2022; Neely & Schmidt, 2016; Sigl et al., 2022). (c) Eruption time series of VOLC2.5, VOLC50-1, VOLC50-2, and VOLC98 with annual volcanic SO_2 flux of each scenario in brackets.

Chim et al., GRL, 2023 https://doi.org/10.1029/2023GL103743

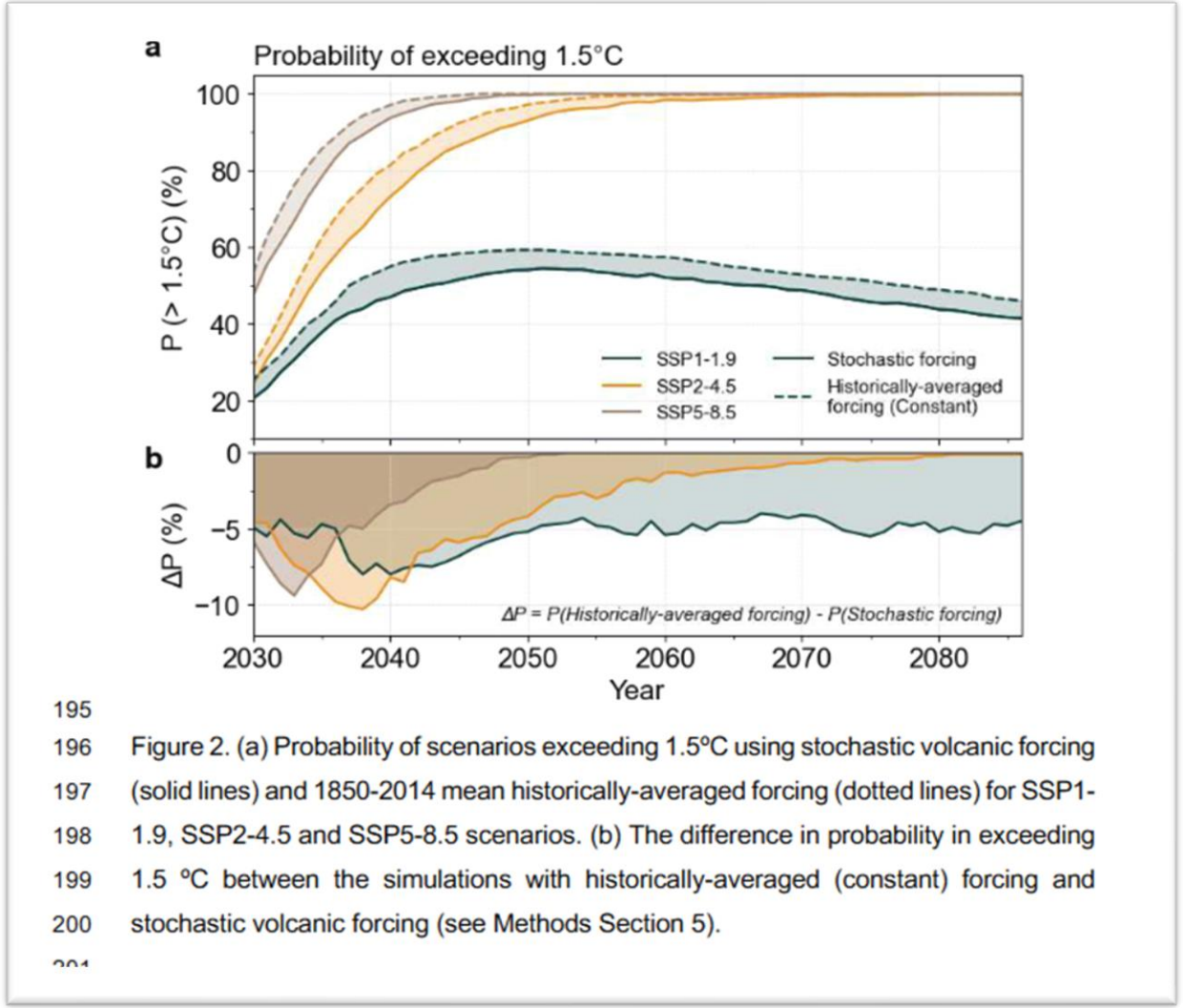
CMIP Coupled Model Intercomparison Project

ESMO

WCRP

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Interface highlight: Forcings



195
196 Figure 2. (a) Probability of scenarios exceeding 1.5ºC using stochastic volcanic forcing
197 (solid lines) and 1850-2014 mean historically-averaged forcing (dotted lines) for SSP1-
198 1.9, SSP2-4.5 and SSP5-8.5 scenarios. (b) The difference in probability in exceeding
199 1.5 ºC between the simulations with historically-averaged (constant) forcing and
200 stochastic volcanic forcing (see Methods Section 5).

Chim et al, 2024, Nat Cli Change (submitted)
https://doi.org/10.21203/rs.3.rs-4938494/v1

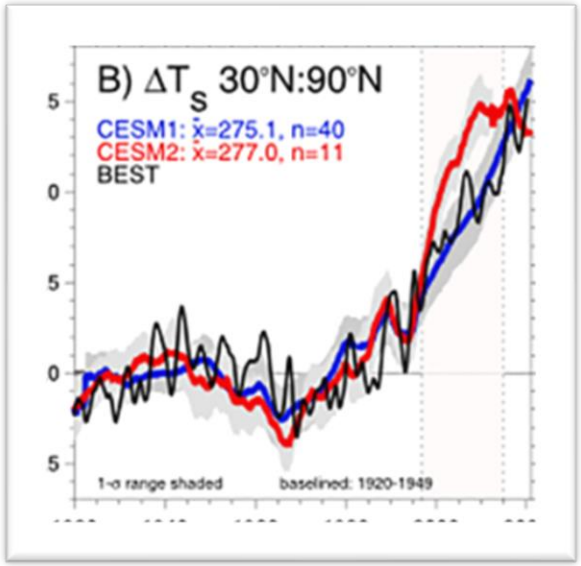
CMIP Coupled Model Intercomparison Project

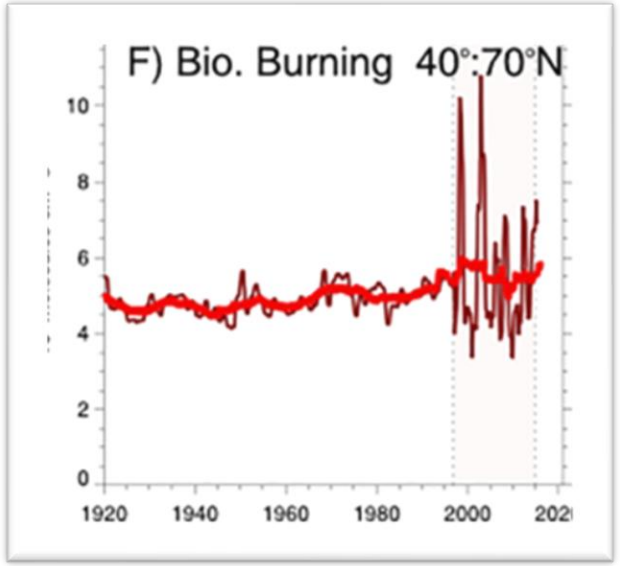
ESMO

WCRP

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Interface highlight: Forcings





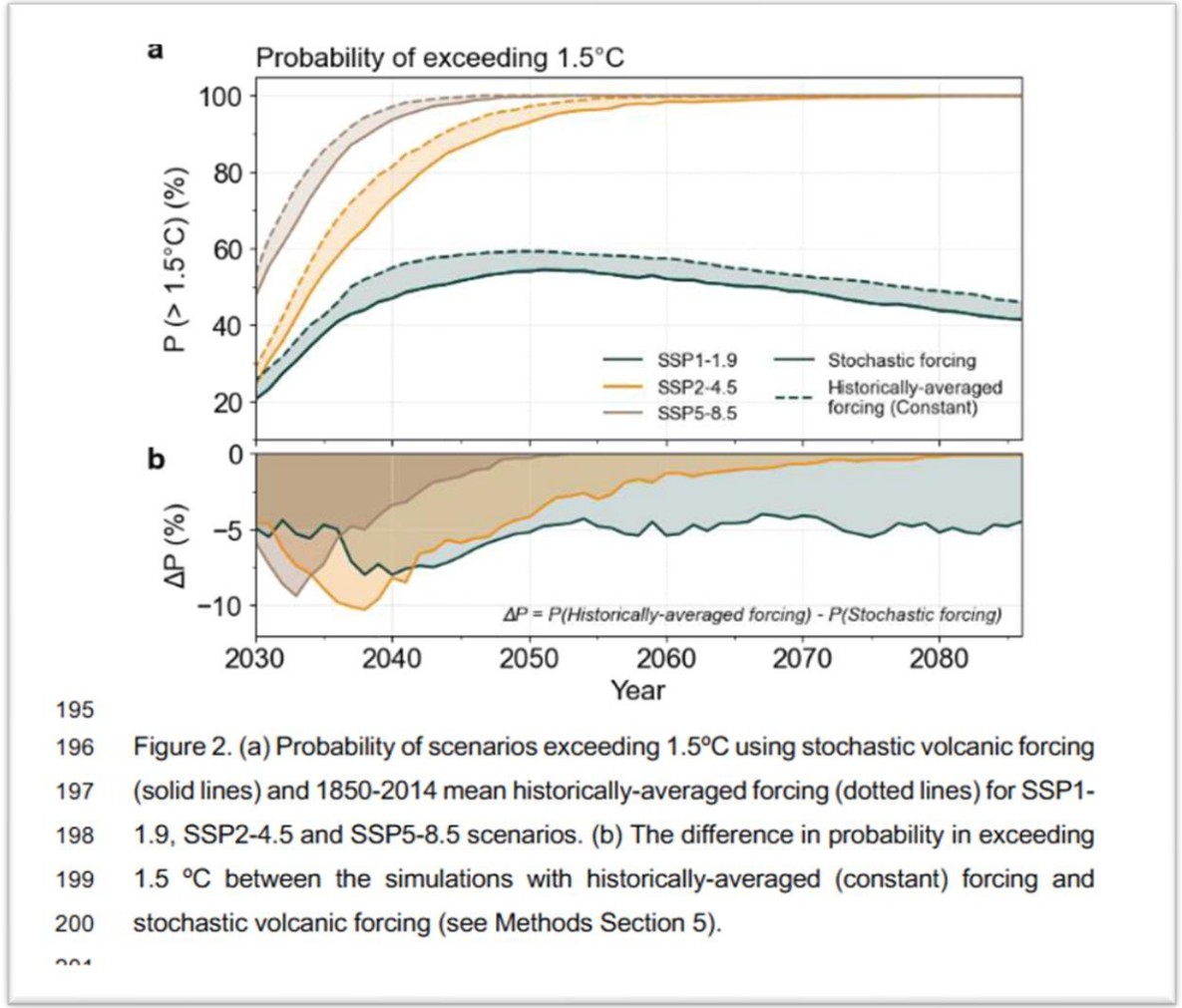


Figure 2. (a) Probability of scenarios exceeding 1.5°C using stochastic volcanic forcing (solid lines) and 1850-2014 mean historically-averaged forcing (dotted lines) for SSP1-1.9, SSP2-4.5 and SSP5-8.5 scenarios. (b) The difference in probability in exceeding 1.5 °C between the simulations with historically-averaged (constant) forcing and stochastic volcanic forcing (see Methods Section 5).

Chim et al, 2024, Nat Cli Change (submitted)
https://doi.org/10.21203/rs.3.rs-4938494/v1

Interface highlight: Forcings

1. How can we maximise use of information from the EO record?
2. How do we handle the impact of the changing observing system?
3. And, which aspects are important, where?
4. Links to fundamental data providers, and advocacy.

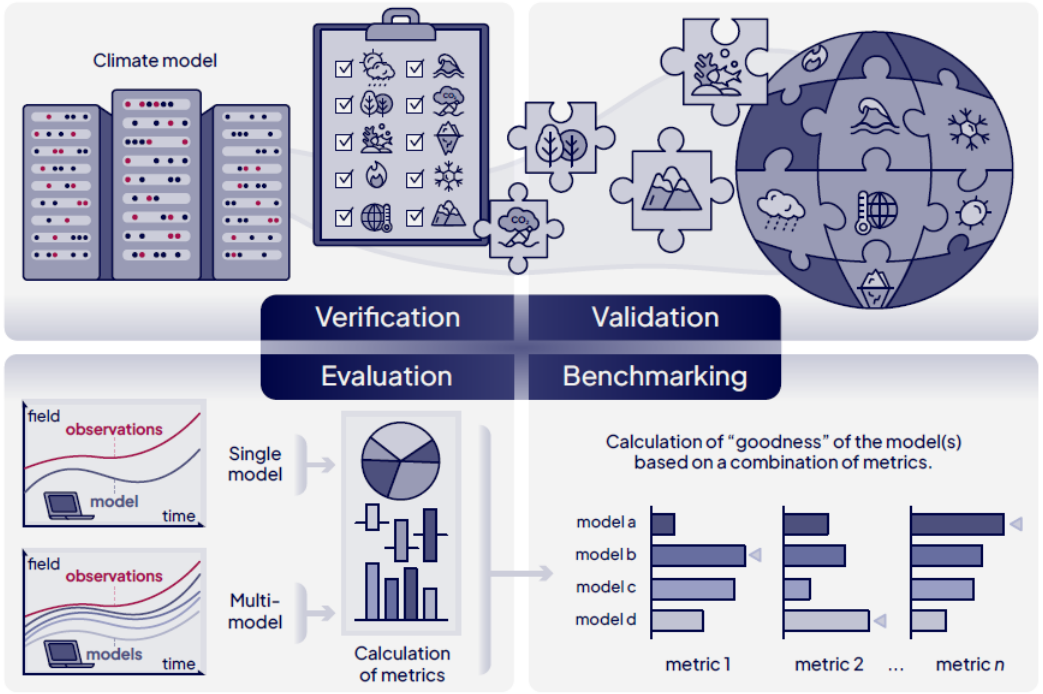
Upcoming events

- ESA Living Planet Symposium Agora, 23-27 June 2025, Vienna
- EGU and AGU sessions

CMIP Forcings workshop, November 2024, ECMWF, Reading, UK
https://wcrp-cmip.org/event/forcings-workshop/

Interface highlight: Rapid Evaluation Framework

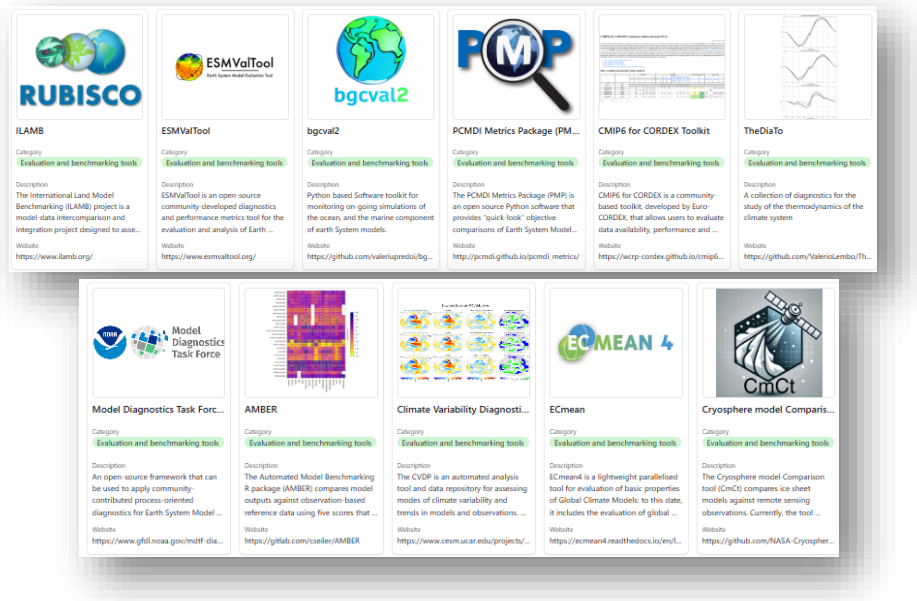
Use of observations in model evaluation



Hassler, B., Dingley, B., & Model Benchmarking Task Team. (2024). Definition of the terms verification, validation, evaluation and benchmarking for use in the climate model context. Zenodo. https://doi.org/10.5281/zenodo.13985652

Tools database

CMIP International Project Office hosts a database of open-source model benchmarking and evaluation tools

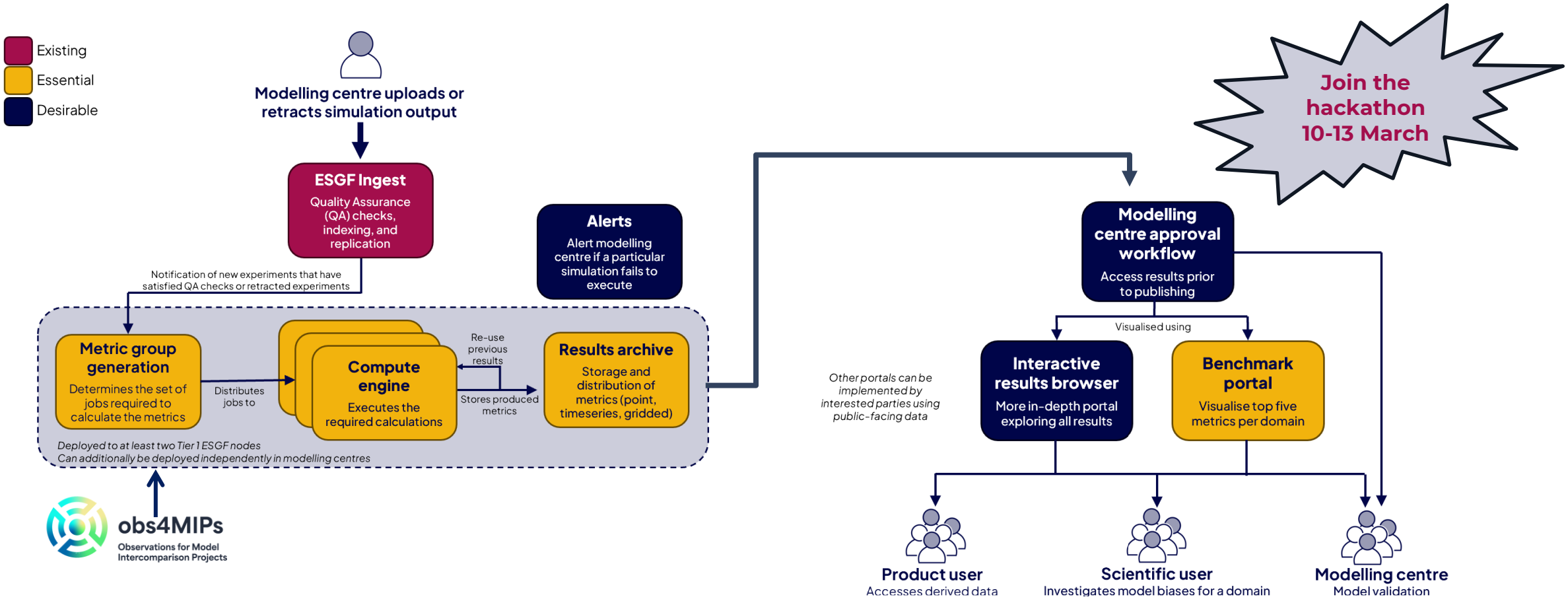


https://bit.ly/model-benchmarking-and-evaluation-tools

WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Interface highlight: Rapid Evaluation Framework



The AR7 Fast Track diagnostics for the REF are available at: https://zenodo.org/records/14284375

For more information about obs4MIPs see: https://www.wcrp-esmo.org/projects-and-panels/obs4mips

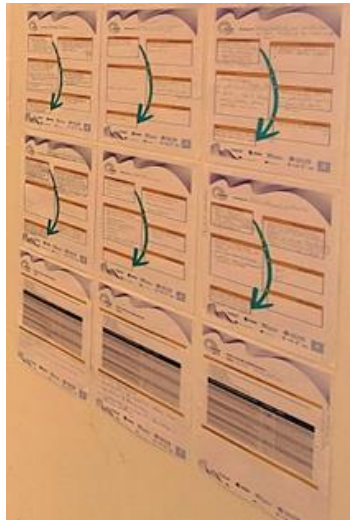
For further information about the REF see: https://wcrp-cmip.org/cmip7/rapid-evaluation-framework/

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Observation-modelling interface

GCOS World Café October 2022

Open Science Conference, October 2023



What are the game-changers?

- API metadata repository
- Common funding policy for in-situ data infrastructures
- Common Analysis Ready Data sharing platform & policy
- Harmonize in-situ data across the world with Reanalysis data globally
- Develop a set of definitions for what uncertainty is for relevant fields. i.e.. correlation length scales, component propagation at different temporal & spatial scales.

Now | 1-3 years | 4-9 years | 10+ years

Cross-cutting actions

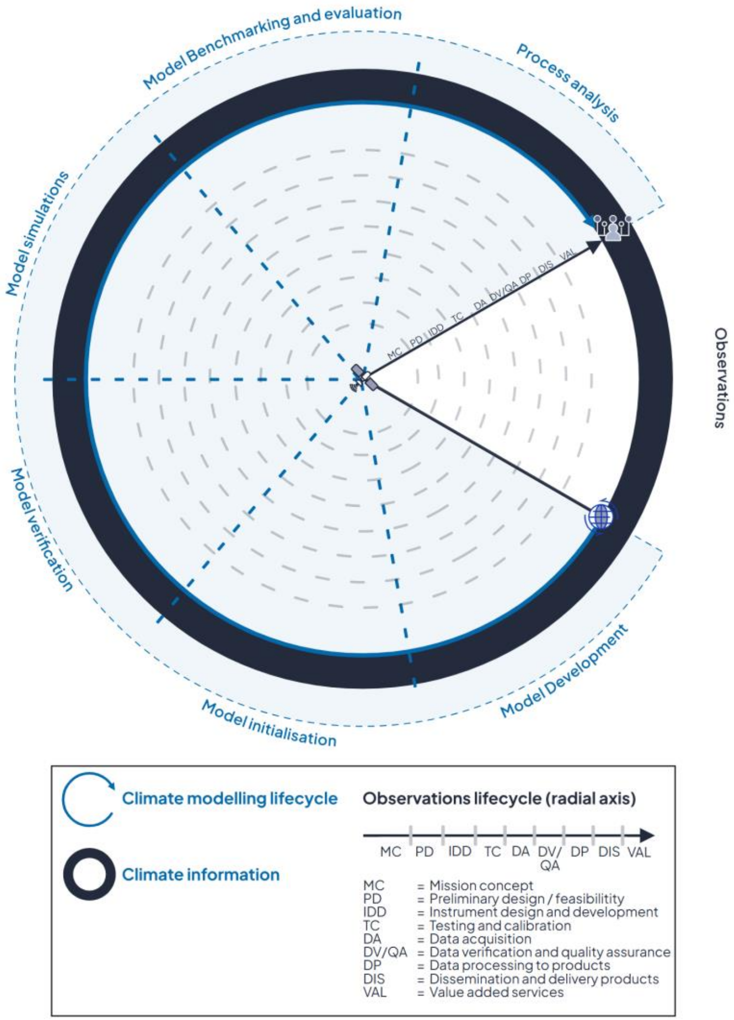
- **Building and sustaining** observation datasets
- Developing a **common language/approach**
- **Developing and sustaining** climate observation networks
- **Enabling robust use and transformation** of data throughout the climate data supply chain
- **Ensuring equitable access** to climate data
- **Identifying and addressing requirements** for global, regional and higher resolution modelling

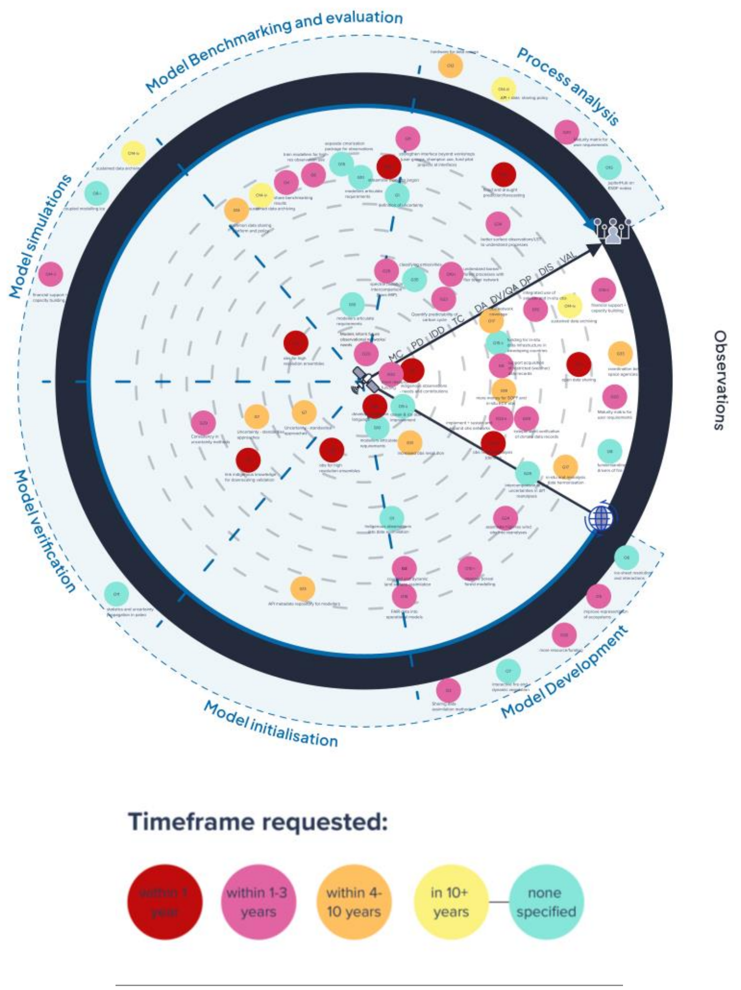
https://wcrp-cmip.org/om-roadmap/

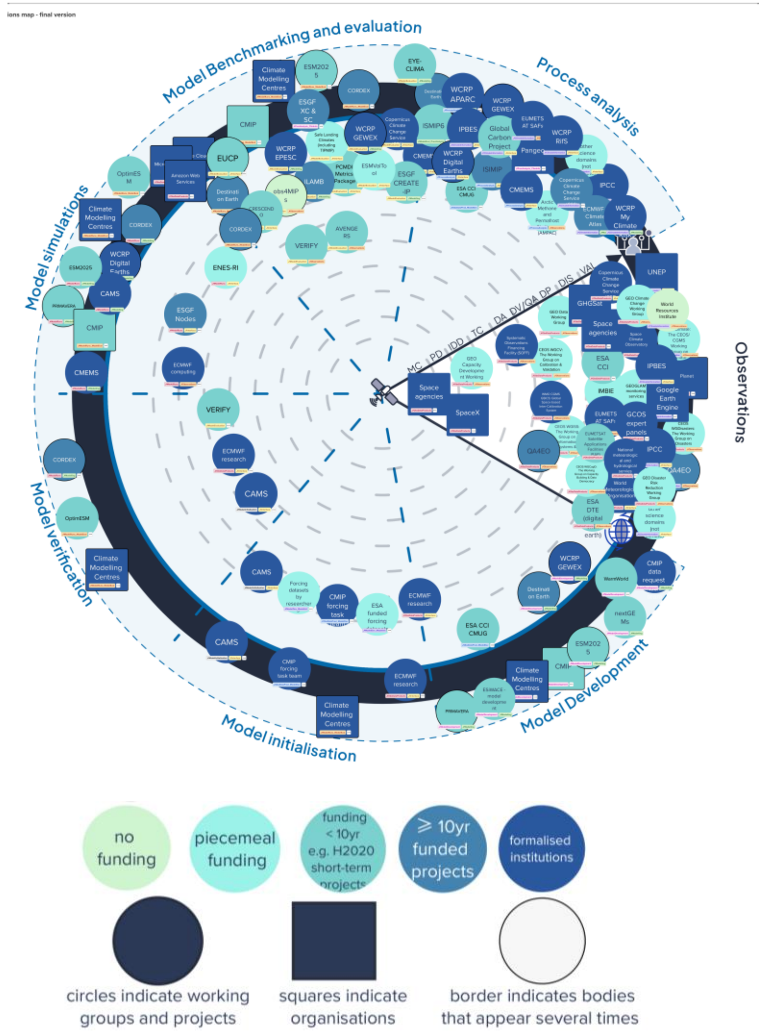
WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Mapping the interface







Hegedus, D., Turner, B., Ferdini, S., and Macintosh, C. (2025) Conceptual Framework: The climate modelling-observation interface.

Acknowledgements: Review and feedback provided by members of the Model Benchmarking Task Team, CMIP Panel, CMUG and participants at ESA Co-location 2024

WGClimate
The Joint CEOS-CGMS Working Group on Climate

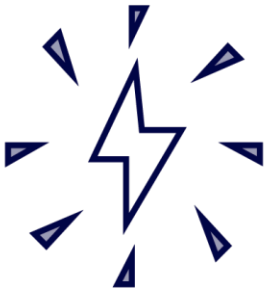
Interface champions

Strengthening the interface requires champions as well as institutions across all career stages. Together we could also build a change-maker network.

Establish a directory

Establish quarterly WGORC-WG Climate meetings and a proposal submission and resource award mechanism.

Host, maintain and publish shared databases and files.



Ongoing support for network coordination.

WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Observation-modelling interface

Recommendations:

❖ Requirements

- Improve ability of observations for physical process understanding – including opportunities for modelling community requirements input at mission concept and design stage
- Improve requirements articulation and gathering from modellers for a more efficient workflow for adaptation of observational datasets

❖ Data

- Improve observing networks in terms of data access, data sharing and global efforts to address observation network gaps
- Establish a forum for modelling community to identify key observation gaps in an agile fashion, including requirements for niche areas of science

❖ Coordination

- Improve data sharing, archiving between the two communities
- Develop a shared understanding of consistency and uncertainty - methods and language

Could we agree today that….

CEOS WG Climate and WGORC commit to a joint meeting twice a year to review the state of the community interface

WGORC works with CEOS WG Climate to develop an accessible database to improve requirements communication at the interface composed of:

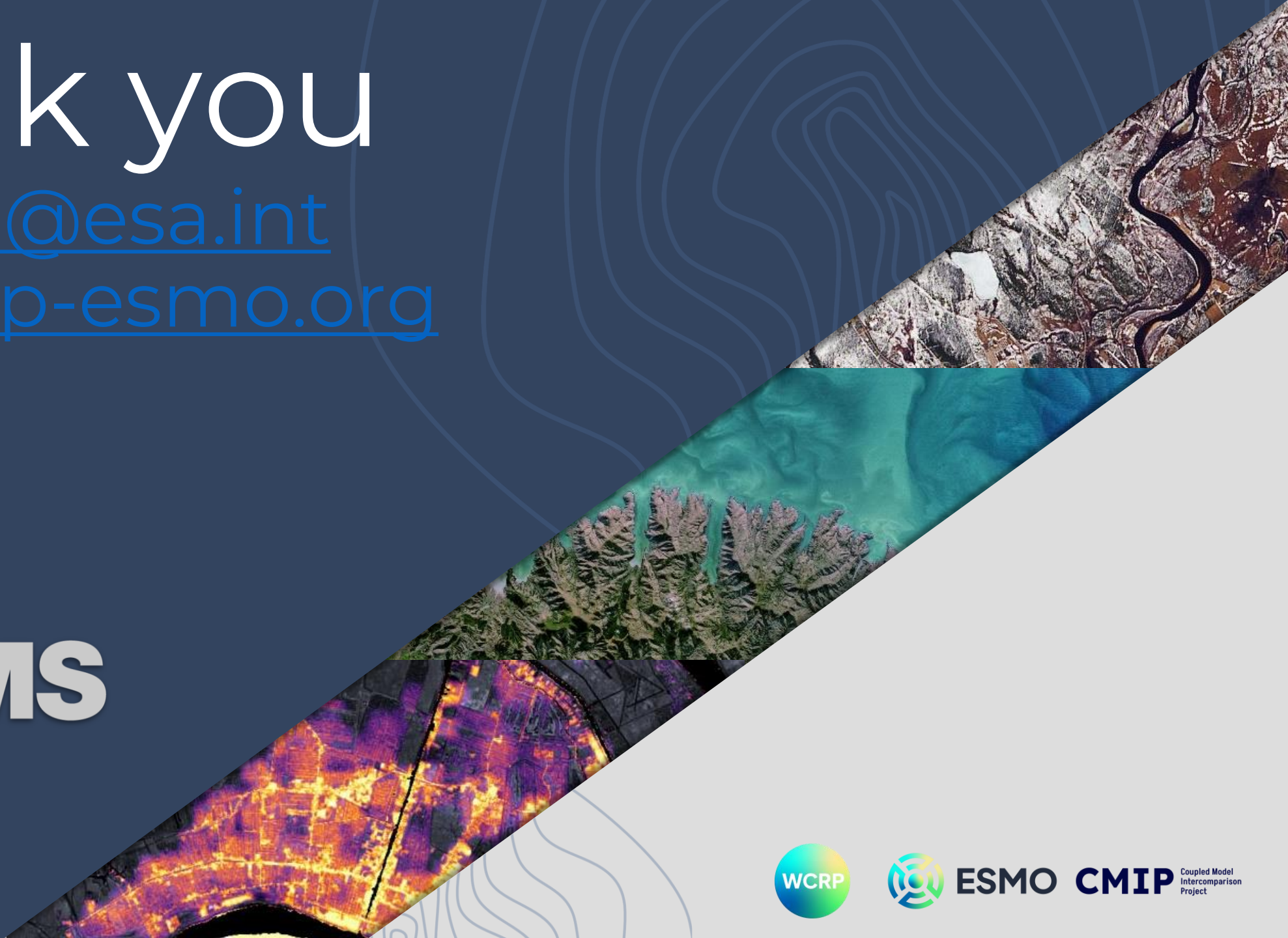
- ❖ [observation community] mission concepts and data products
- ❖ [modelling community] key observation gaps/ data needs

WCRP ESMO CMIP Coupled Model Intercomparison Project

WGClimate
The Joint CEOS-CGMS Working Group on Climate

Thank you

cmip-ipo@esa.int
ipo@wcrp-esmo.org



CGMS

CEOS
Committee on
Earth Observation Satellites

WCRP ESMO CMIP Coupled Model Intercomparison Project