Met Office
Hadley Centre

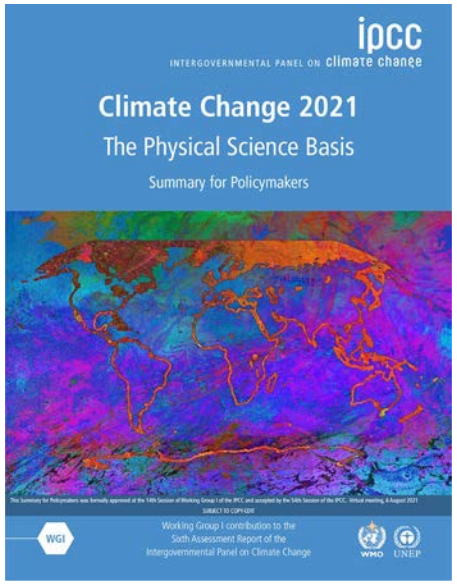
30 years
Leading climate science and services in our changing world

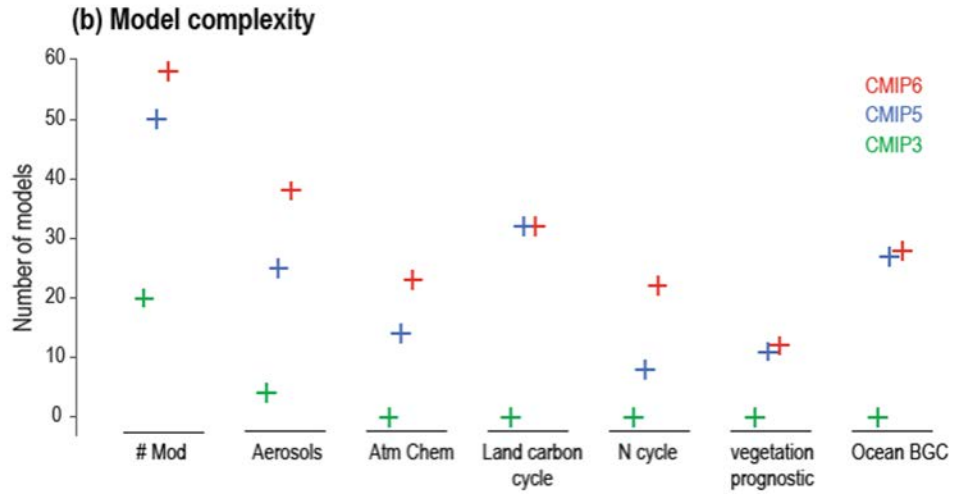
Overview of coupled modelling: CMIP and higher resolution models

Helene Hewitt
Met Office Hadley Centre
CMIP Panel Chair

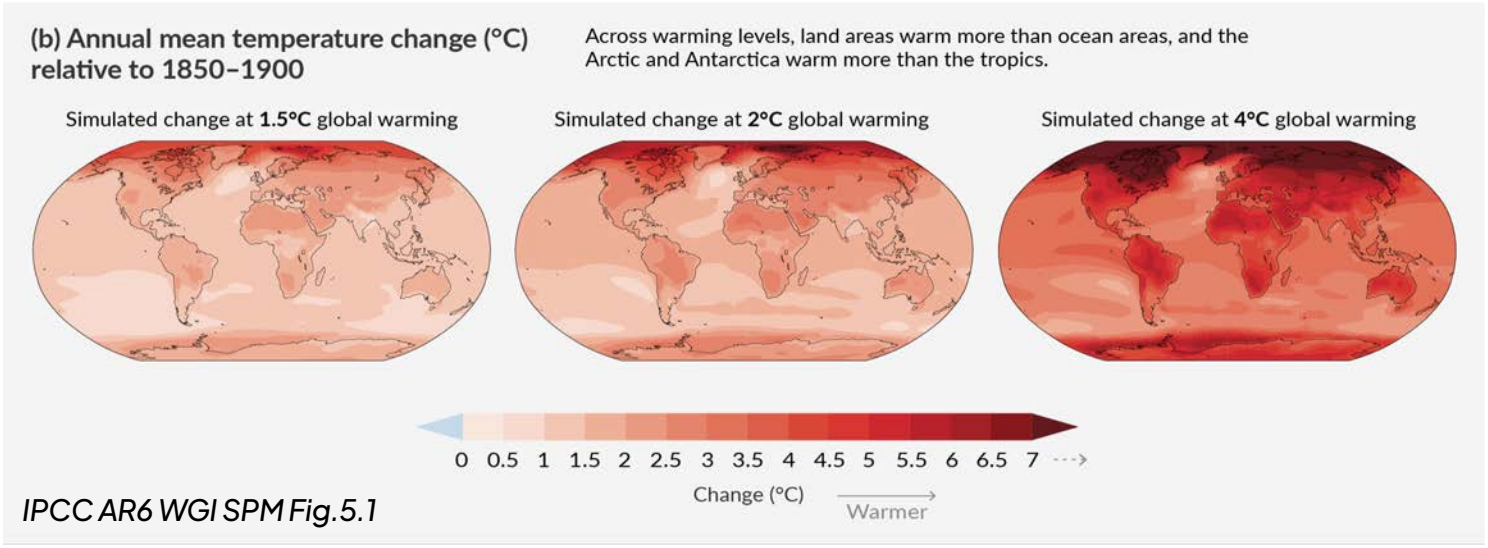
CMIP6 and plans for CMIP7

CMIP: driving science, informing policy





IPCC AR6 WGI TS Fig 2



IPCC AR6 WGI SPM Fig.5.1

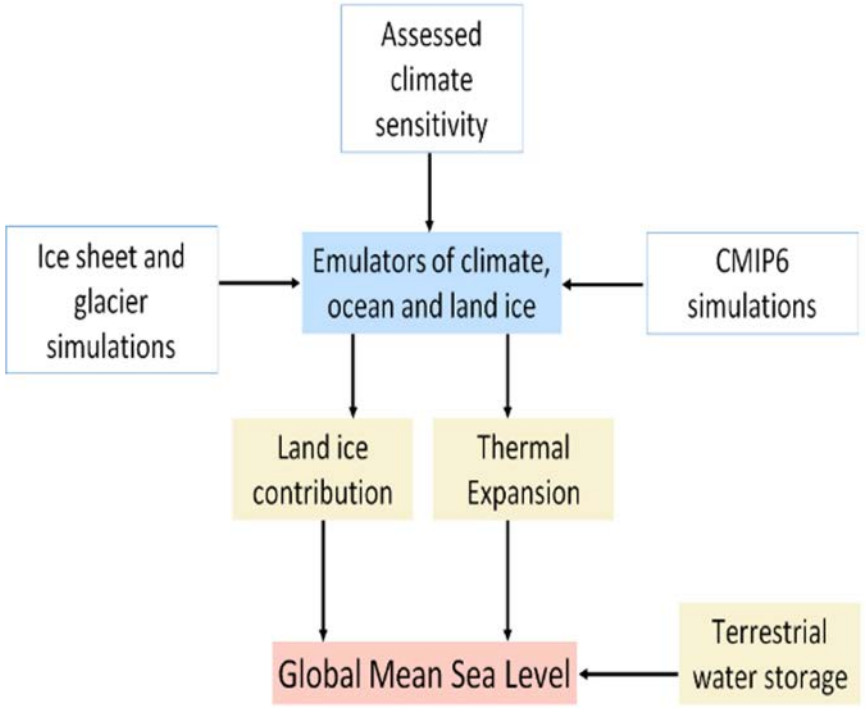
CMIP6: biggest yet!

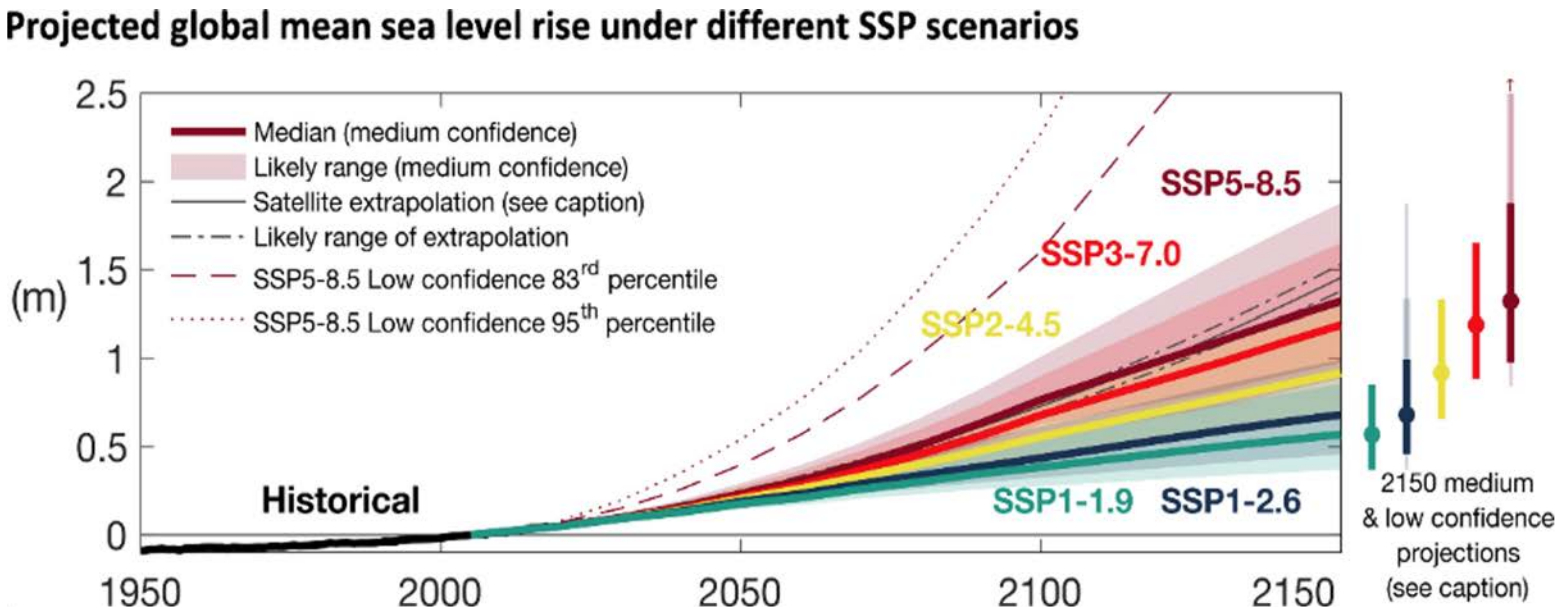
- 24 endorsed MIPs
- 26 countries
- 48 institutions
- 131 models
- 322 experiments
- Nearly 25 PB of CMIP6 data
- 30+ ESGF data nodes

CMIP

CMIP data in action

Combining different MIPs, producing ensemble projections





CMIP6 Community Survey: Priorities for CMIP7

- No big structural change from CMIP6 but evolution.
- Retain alignment to IPCC in some form – prioritisation of core MIPs/experiments.
- Reduce burden on modelling centres.
- Need for greater focus on climate impacts and adaptation relevant experiments (including updated scenarios).
- Need for critical elements to become operational (e.g., forcings).
- Less centralized coordination of specialist MIPs, potentially decoupled from IPCC timeline.
- Build on substantial CMIP6 data infrastructure progress to support improved, and more user friendly, data access.
- Continue and enhance active community input to the experimental design process.
- Nurture the future CMIP community and promote young and global South scientists.

CMIP
Coupled Model Intercomparison Project

Questions for CMIP7

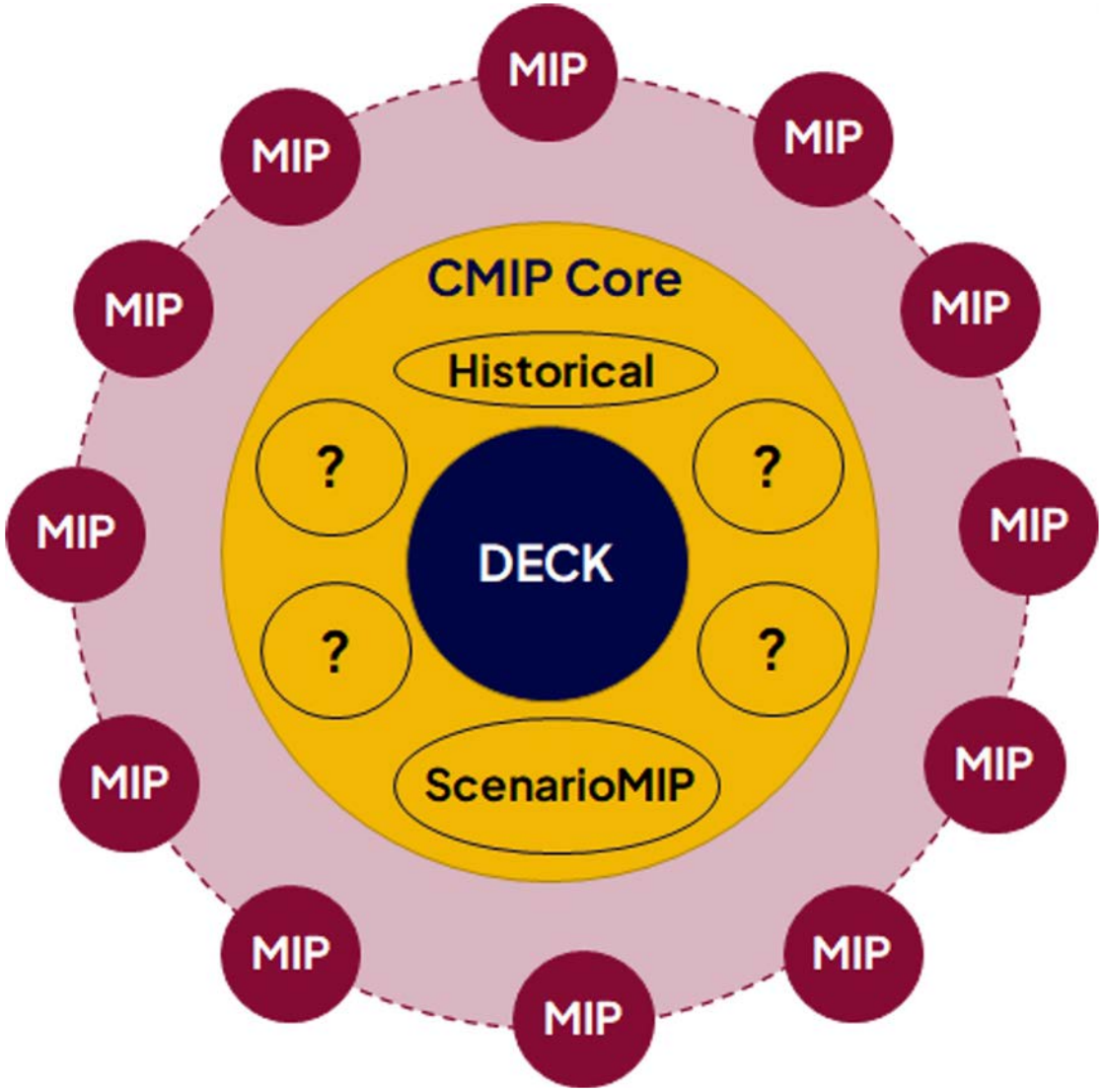
- How many of the CMIP6 simulations/models can we reuse?
- How many/which MIPs/scenarios do we really need?
- How many ensemble members do we need?
- How many high resolution simulations?
- Do we need all modelling groups to do everything with their State-of-the-Art model?
- How can we optimise data storage, analysis and access?
- Can we reduce CMIP7 CO_2 emissions by 50% relative to CMIP6?

The Task Teams

CMIP Task Teams have been established to drive forward definition of CMIP7 in an open and collaborative manner.

- Data access (*Robert Pincus and co-lead tbc*)
- Data citation (*Martina Stockhause and Sasha Ames*)
- Data Request (*Martin Juckes and Chloe Mackallah*)
- Forcings (*Paul Durack and Vaishali Naik*)
- Model benchmarking (*Birgit Hassler and Forrest Hoffman*)
- Model documentation (*David Hassell and Guillaume Levavasseur*)
- Strategic ensemble design (*Ben Sanderson and Isla Simpson*)

Potential CMIP7 structure



DRAFT

The DECK - remains as an entry card to CMIP supporting model characterisation

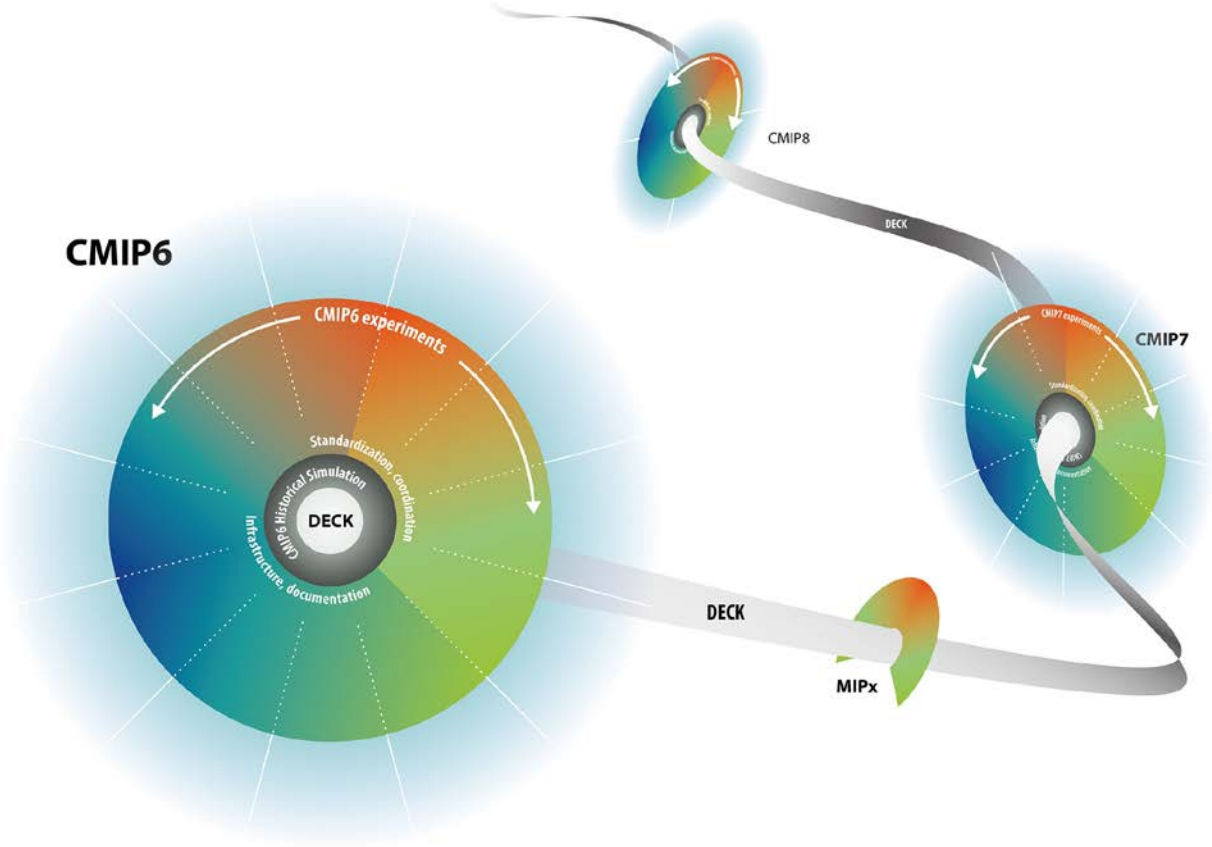
A Core set of streamlined policy focused MIPs/experiments aligned with key policy/decision making timelines (e.g., IPCC)

Community experiments/MIPs could operate on timeline driven by scientific and model development advances but can benefit from working with Core MIPs/experiments (aligning experiment design and data requirements, e.g. requesting variables from CMIP7 piControl and historical simulations).

WCRP World Climate Research Programme

CMIP

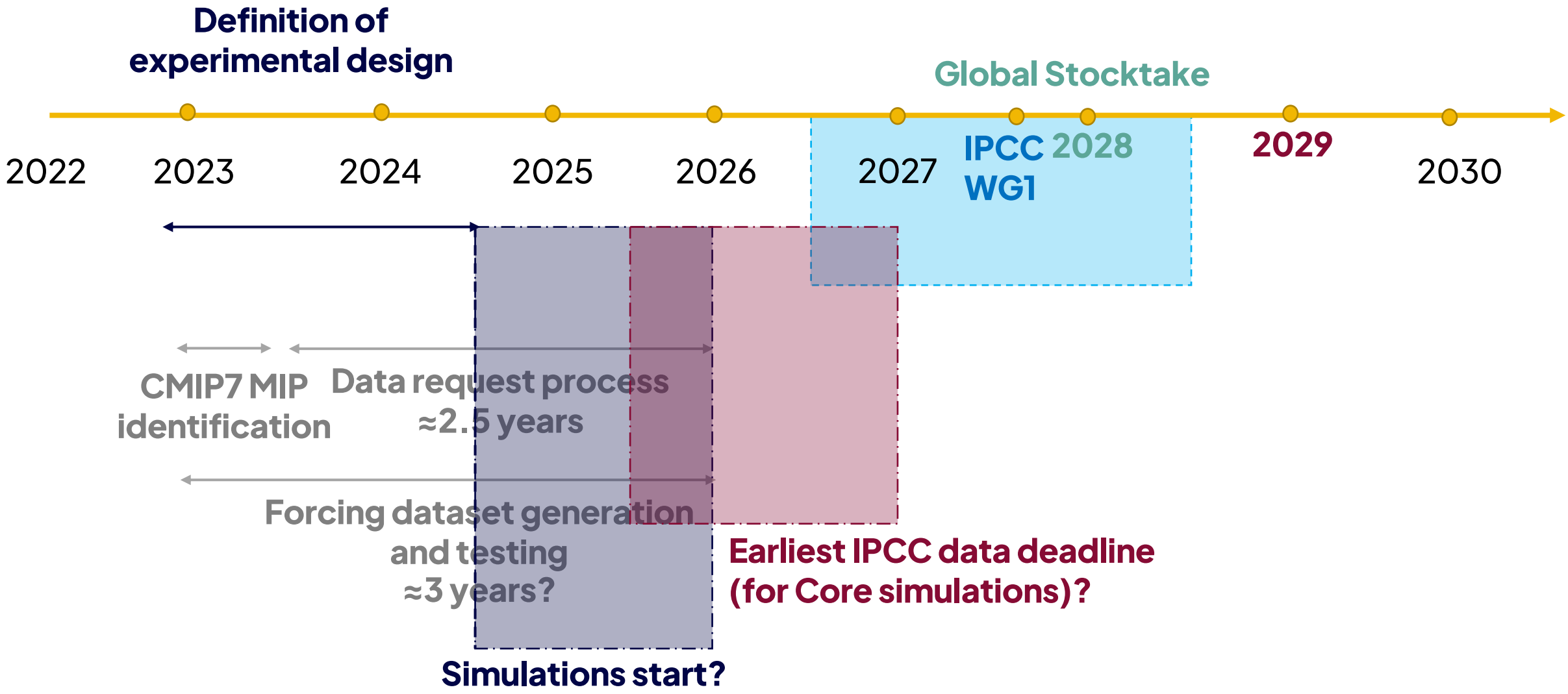
Supporting continuous activity (CMIP6+)

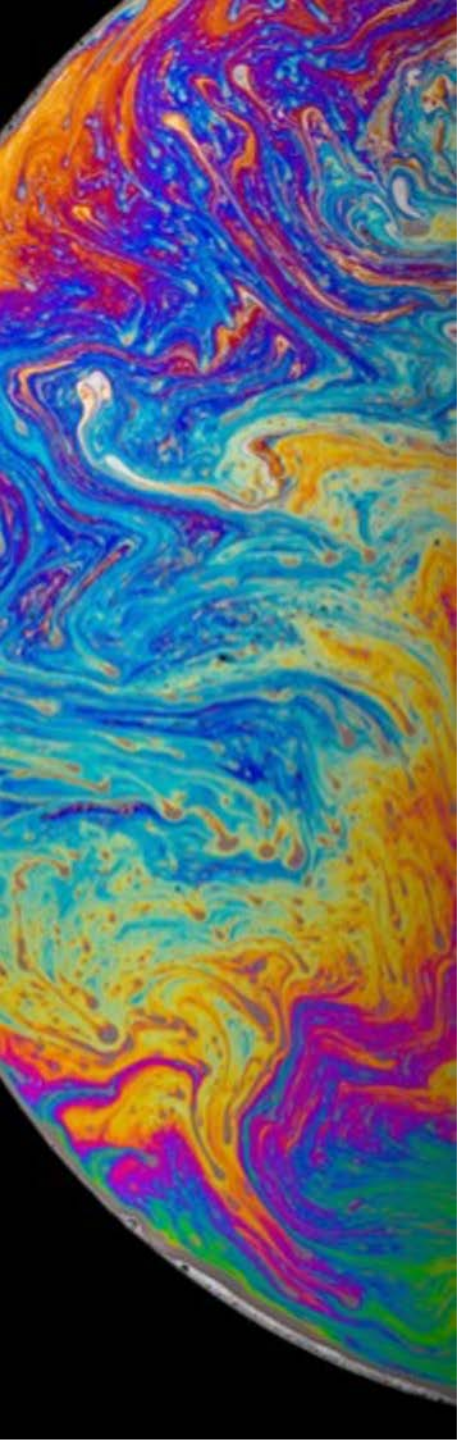


- Leveraging the CMIP6 infrastructure (CMIP6 compatible experiments).
- New and ongoing MIP activities can request guidance and limited support.
- Enable responsive activities (e.g., CovidMIP).
- Support CMIP evolution and potential operationalisation of components (e.g., testing next generation forcings).

CMIP

Proposed DECK and Core timeline (for discussion)



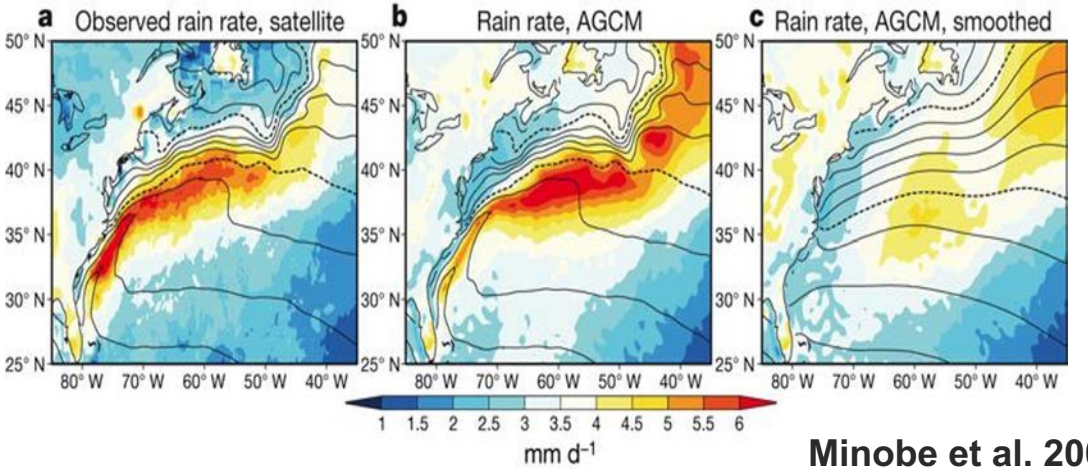


Community discussion and feedback opportunities

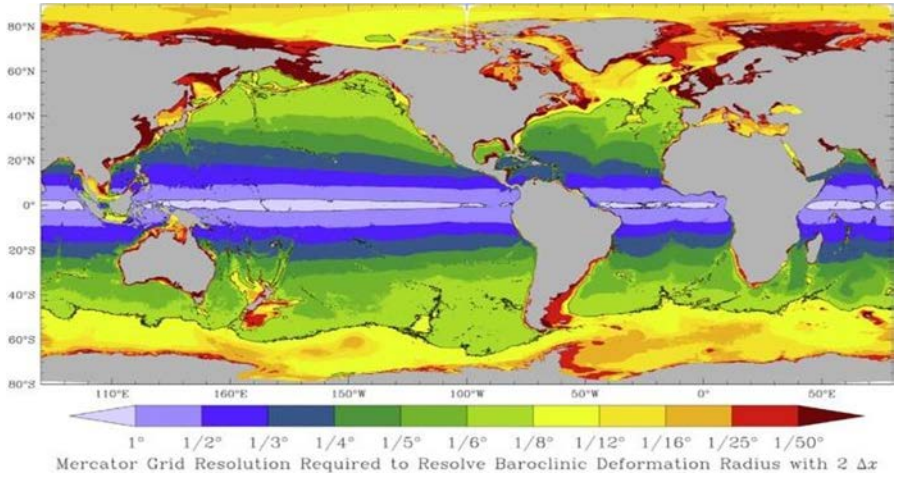
We are looking for wider engagement and feedback from the community like today, and with future:

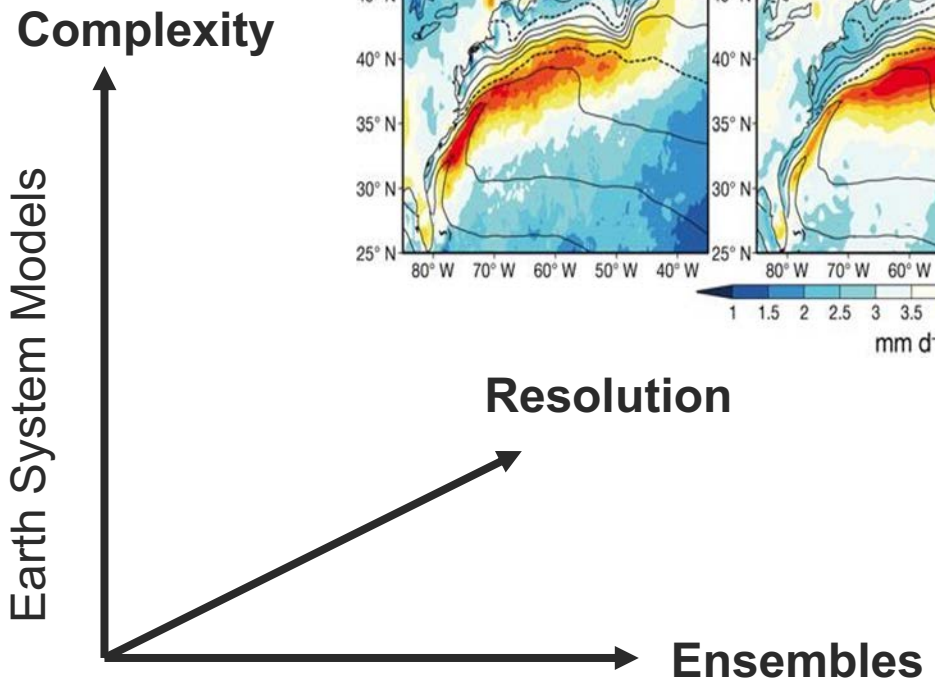
- Surveys and consultations.
- Workshops.
- Monthly drop in sessions.
- EGU23 Town Halls (Future CMIP and CMIP ECR views).
- Direct interaction with TT Co-leads, TT members and the IPO.

What about resolution?

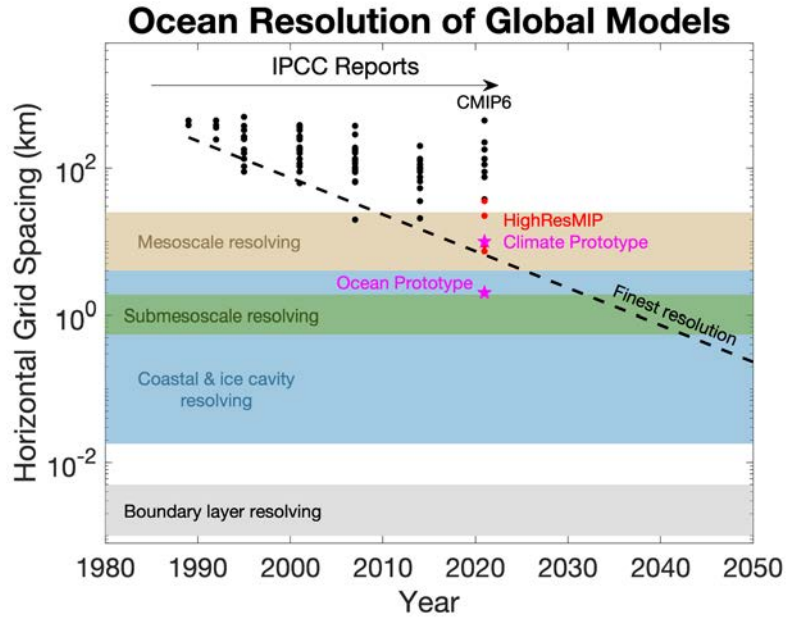


Minobe et al. 2008





Multi-model
Perturbed parameter
Initial condition



Hewitt et al, 2022

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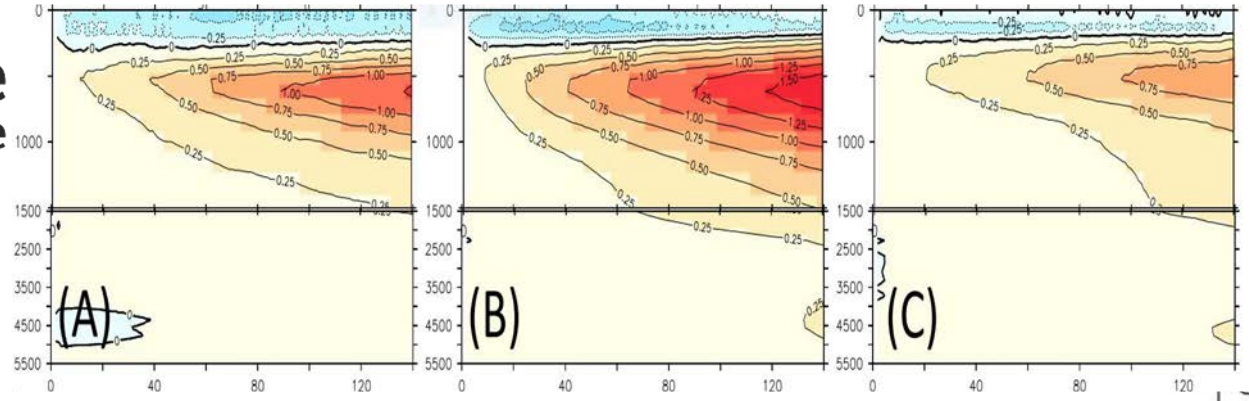
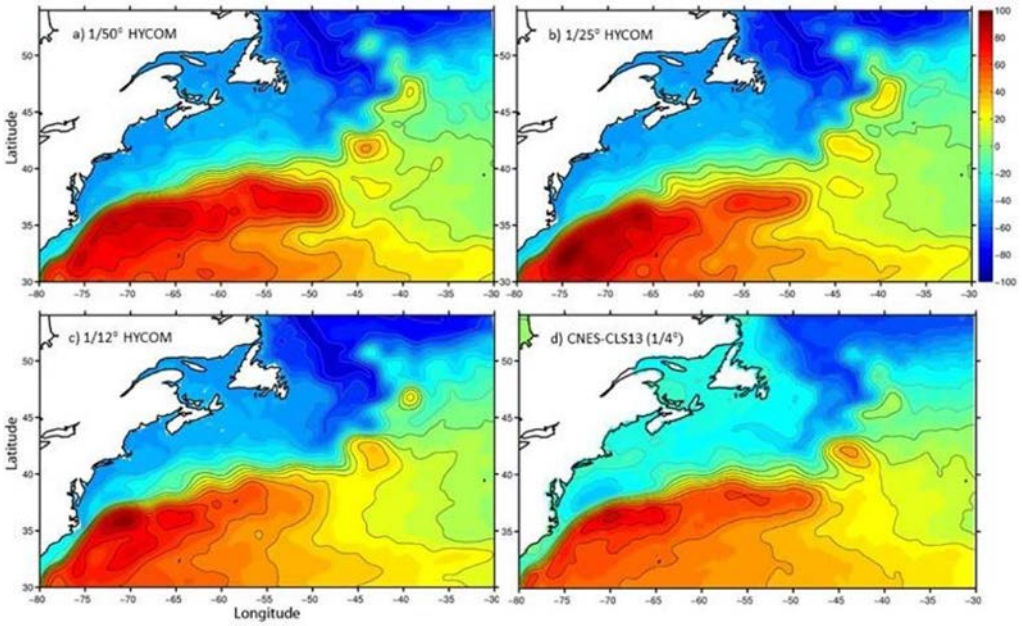
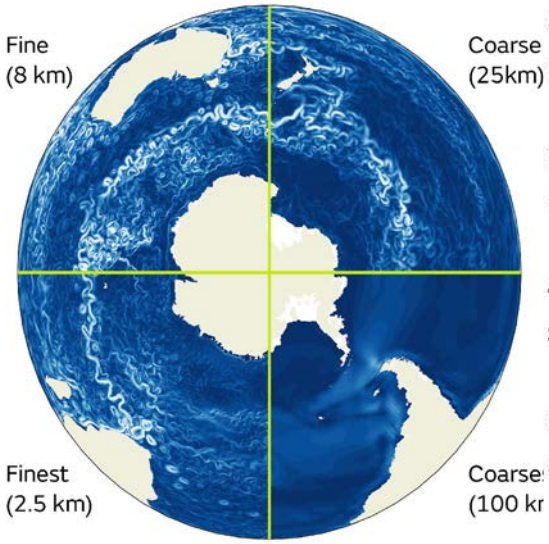
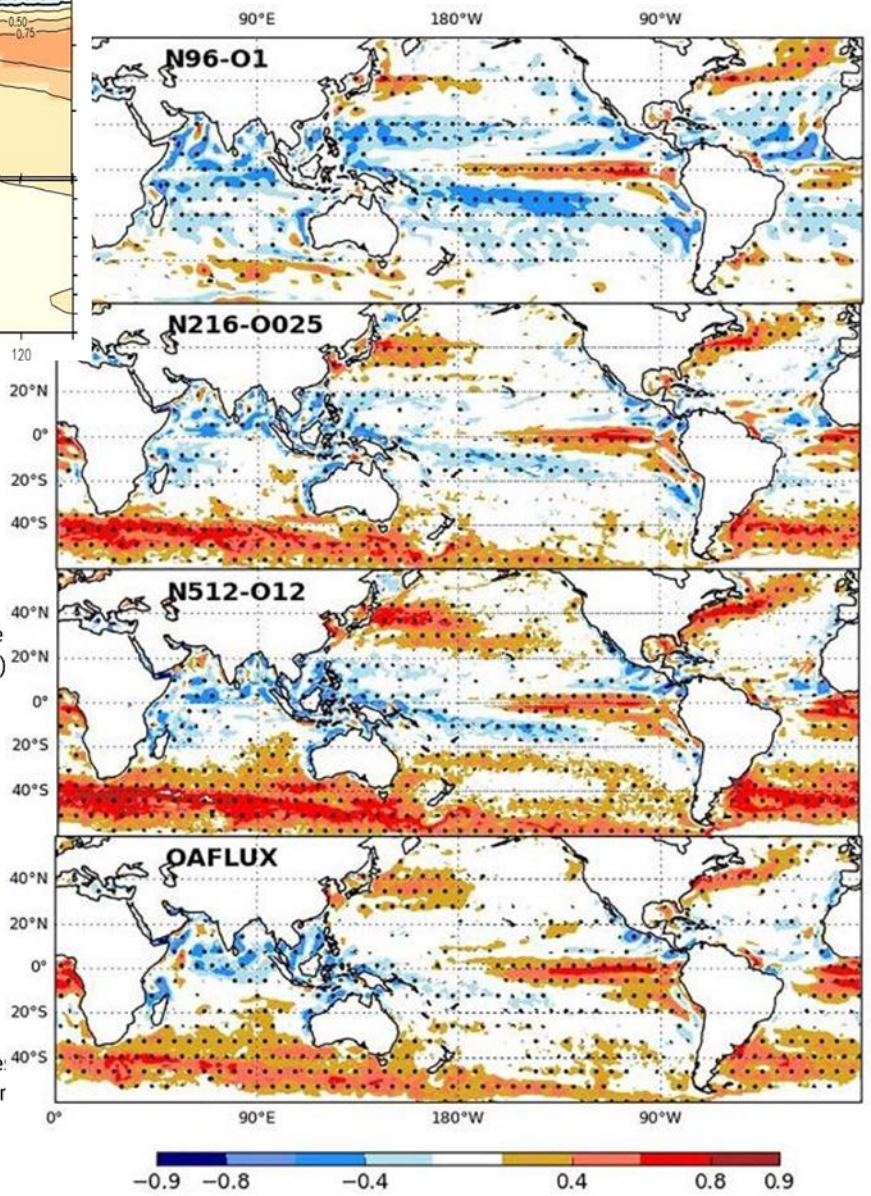


Resolution hierarchies







Roberts et al, 2016; Chassignet and Xu, 2017; Hewitt et al., 2017, 2022

Finer atmosphere resolution

Finer ocean resolution

a. HH

b. MH

c. HM

d. MM

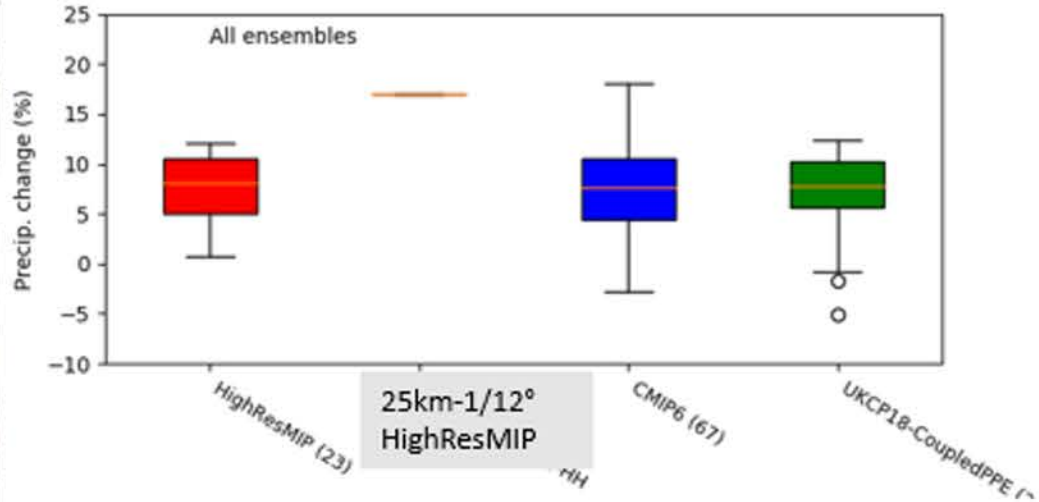
e. LL

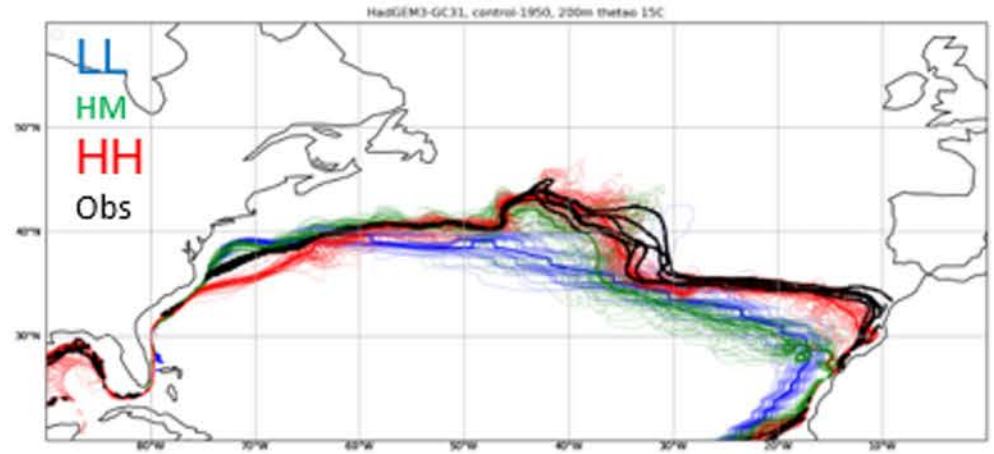
-7 -3 -0.8 -0.2 0.2 0.8 3 7

Anomalies in winter precipitation between 2030–2050 and 1960–1980
Stippling in (a) indicates anomalies in HH falling outside a distribution including anomalies from all the other resolutions

Result needs **both** atmosphere and ocean resolution

Rainfall %age change, DJF, 2030-50 - 1960-80 over Europe 20W-30E, 40-65N from different multi-model ensembles





Moreno-Chamarro et al., ERL, accepted;
Grist et al., GRL, 2021.

PRIMAVERA

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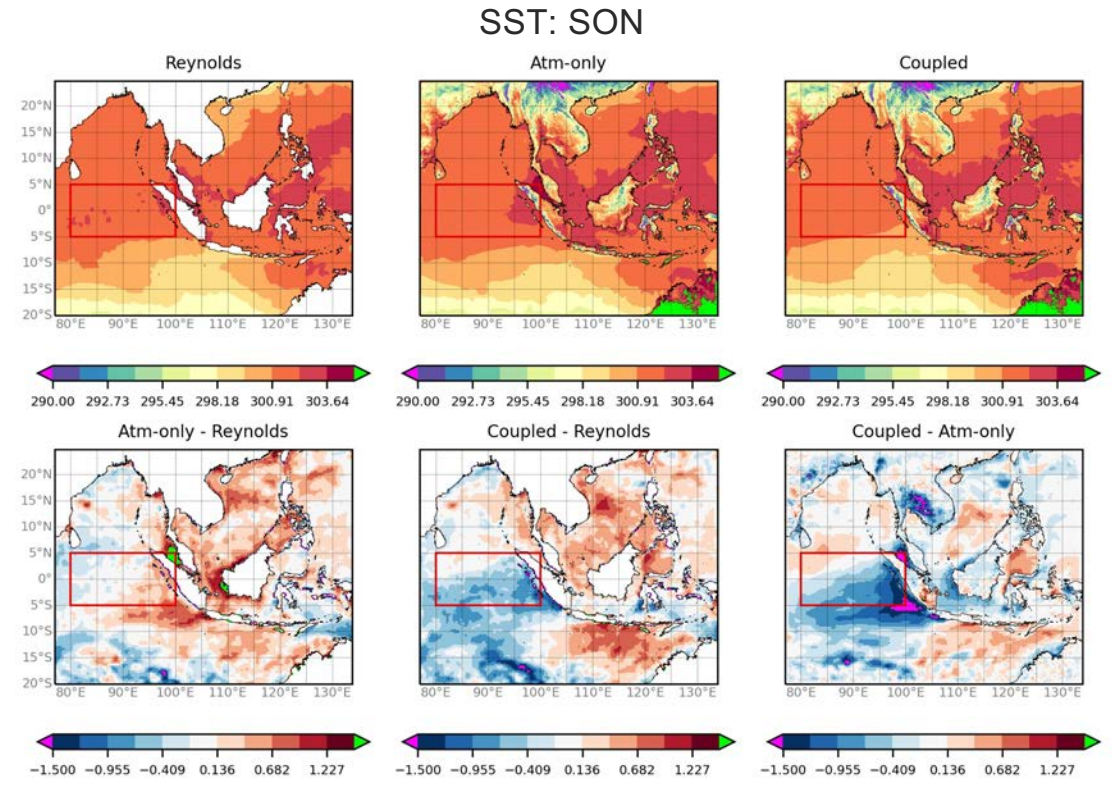
Pushing the frontiers to the kilometric scale

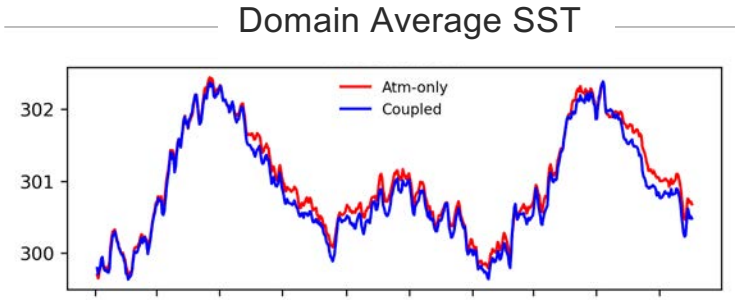
- Building on regional modelling, k-scale is being developed for global atmosphere models – many challenges both modelling and data storage/exploration
- More challenges for ocean, sea ice and coupling
- Met Office science theme on Pathway to High Resolution (Lead: Cath Senior)
- WCRP and other international efforts to move to k-scale

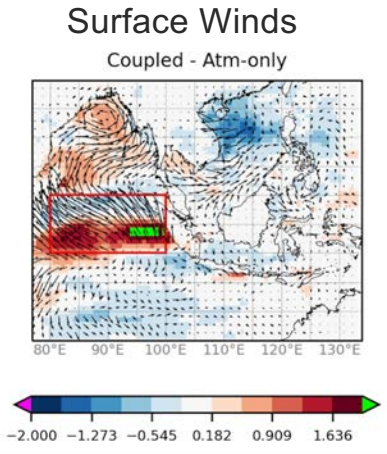
‘Weather for Climate’: K-scale coupled modelling

K-Scale climate development:

- **New** 10-year (2-years so far) RAL3 Maritime Continent coupled to NOC regional ocean model
- Comparison with Atmosphere only show:
  - No drift
  - Cold bias off SW coast of Sumatra that develops during JJA reaching peak magnitude in SON.
  - Stronger surface winds in corresponding to cooler SSTs in coupled model - more upwelling?
- Planned: Developing coupled LAM and CTC capability based on ORCA12
- Planned 4.4km CTC 10-year simulations (Atmos only+4k, coupled)







Chris Short, Alex Arnold

Met Office Hadley Centre

Summary

- CMIP has rapidly expanded in terms of number of models and the complexity of models
- Increases in resolution haven't progressed as fast as we might have expected 20 years ago
- Resolution is needed in both ocean and atmosphere to capture mesoscale air-sea interactions
- Computing costs/capability for higher resolution has limited our ability to assess how important resolution is for both the mean and the changing climate
- Should CMIP7 support more higher resolution models? What are the implications for the DECK? Should it interface to higher resolution efforts?