Coordinated Ocean Wave Climate Projections: COWCLIP

Mark Hemer

CSIRO Wealth from Oceans Flagship

and

Centre for Australian Weather and Climate Research:

A partnership between CSIRO and the Bureau of Meteorology

Hobart, TAS, Australia

With input from:

Xiaolan Wang and Val Swail – Environment Canada

Ralf Weisse – Helmholtz-Zentrum Geesthacht, Germany

Alvaro Semedo – Escola Naval-CINAV, Portugal and Uppsala University, Sweden

Nobuhito Mori – Kyoto University, Japan

Yalin Fan – GFDL, USA

and other COWCLIP participants (see http://www.jcomm.info/COWCLIP)

Coastal Impacts of Climate Change

Warming Oceans and Climate

Sea-level rise
(0.2 – 0.8 m by 2100, IPCC AR4)

Changes to weather systems and storms

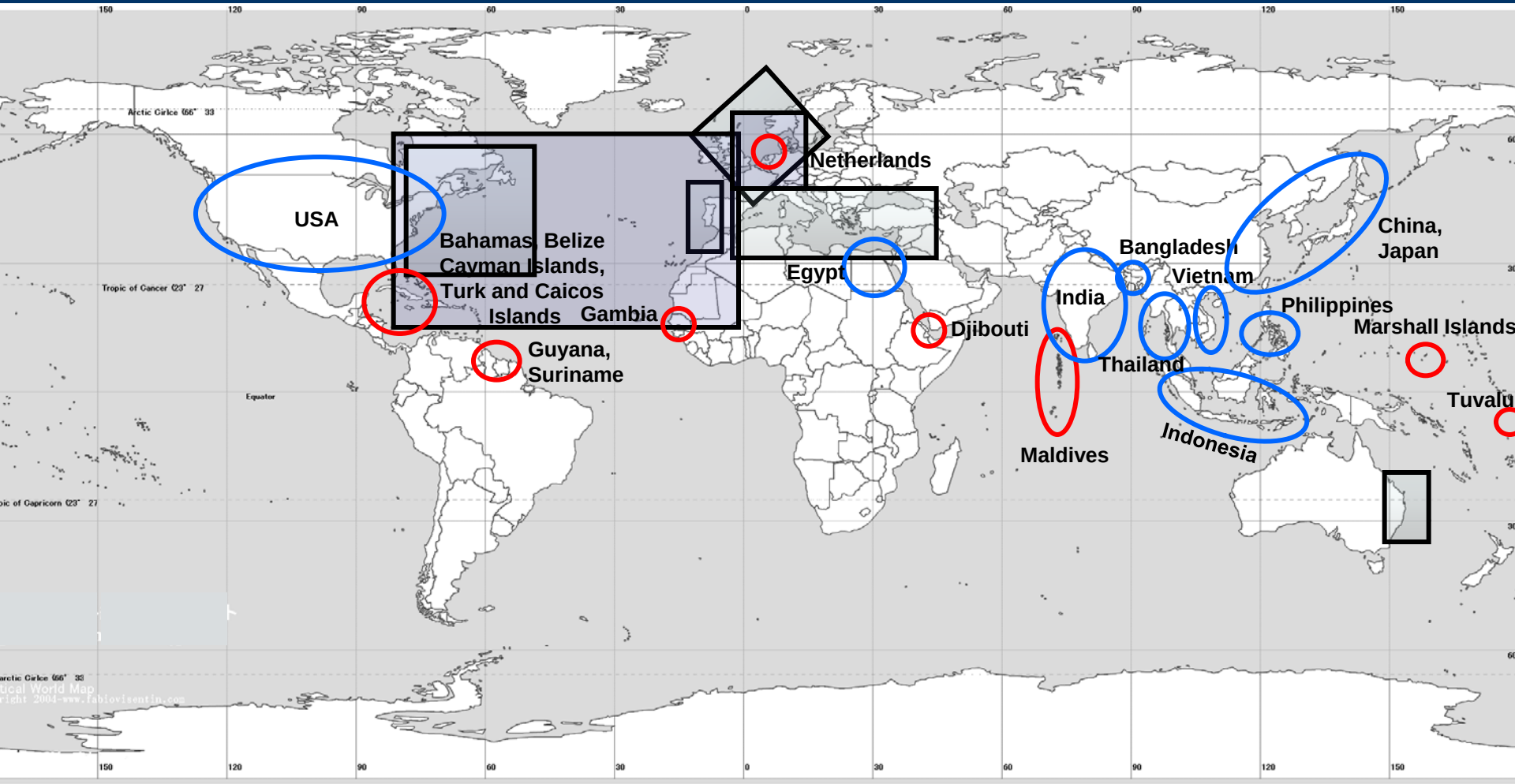
CHANGING RISK OF COASTAL IMPACTS
(Felt most acutely via extreme events –
storm surges and large wave events)

Disturbance (aquatic & terrestrial)

Inundation (SLR/Surge/Setup)

Erosion (SLR/runup/wave dir^{n} changes)

Map of current regional projections



Global projections: Wang & Swail, 2006
Mori et al., 2009

Countries with highest share of population within Low Elevation Coastal Zone (all countries)

Countries with most population within Low Elevation Coastal Zone, McGranahan et al. (2007)

Summarising current limitations of wave projections

- Lack of global coverage
  - Regions of higher risk (vulnerability or hazard) may be overlooked
- Poor sampling of uncertainty
  - Limited scenario, inter and intra model ensembles considered
- Inconsistencies in output parameters makes intercomparison difficult
  - No community standard for scenarios/projection periods/variables/

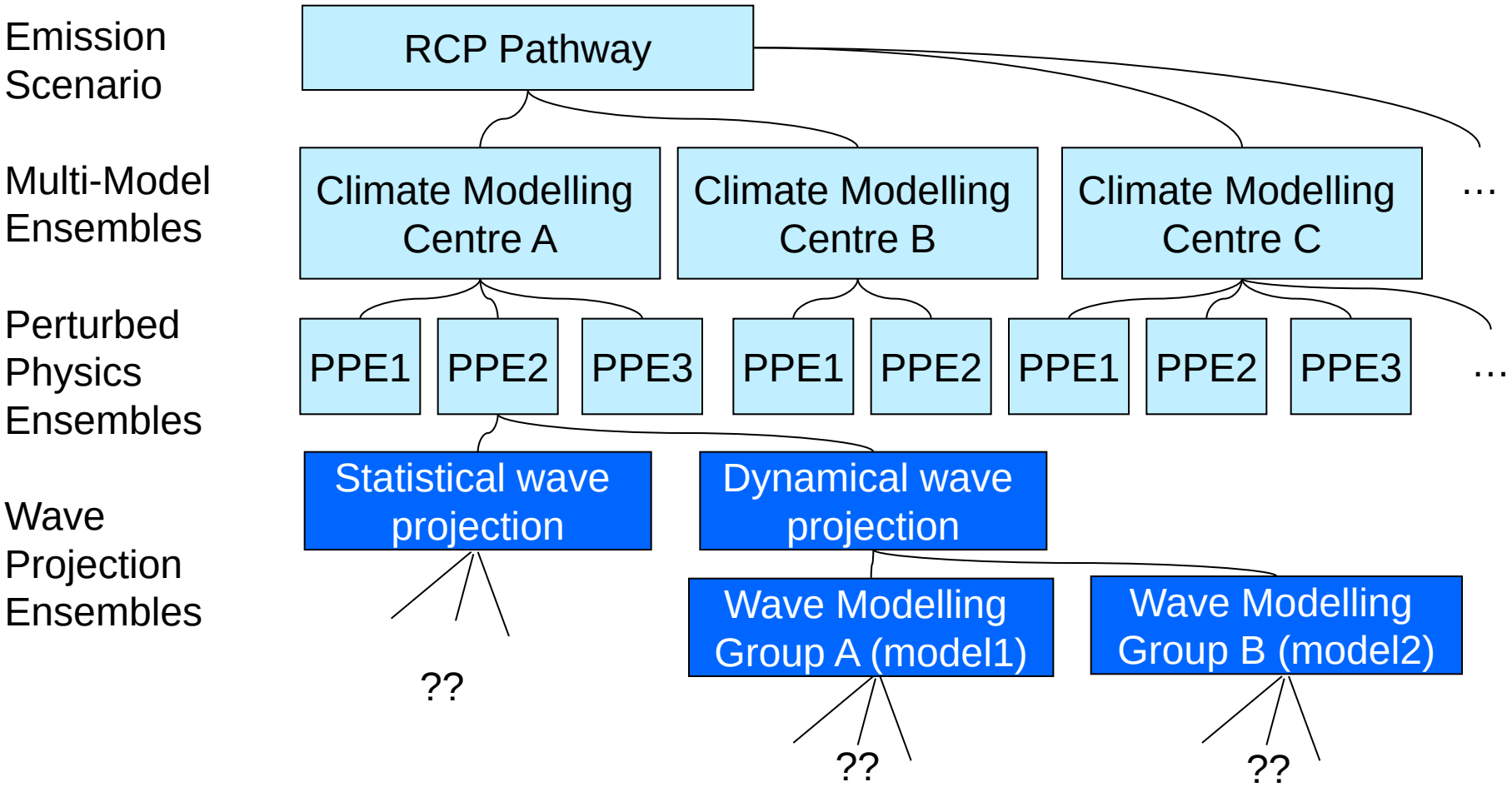
COWCLIP Aims:

To generate global wave climate projections and aid comprehensive assessments of their cascading uncertainty by:

- Providing a systematic, community-based framework and infrastructure to support validation, intercomparison, documentation and data access for wave climate projections forced from CMIP5 datasets,
- To describe best practice for regional wave projections
- Engaging interests of the wind-wave community into wider climate community and ultimately moving to coupled wind-wave AOGCM models, enabling quantitative estimates of wave-driven feedbacks in coupled climate system.

WCRP/JCOMM COWCLIP April 2011 Workshop Outcomes: http://www.jcomm.info/COWCLIP

The COWCLIP strawman

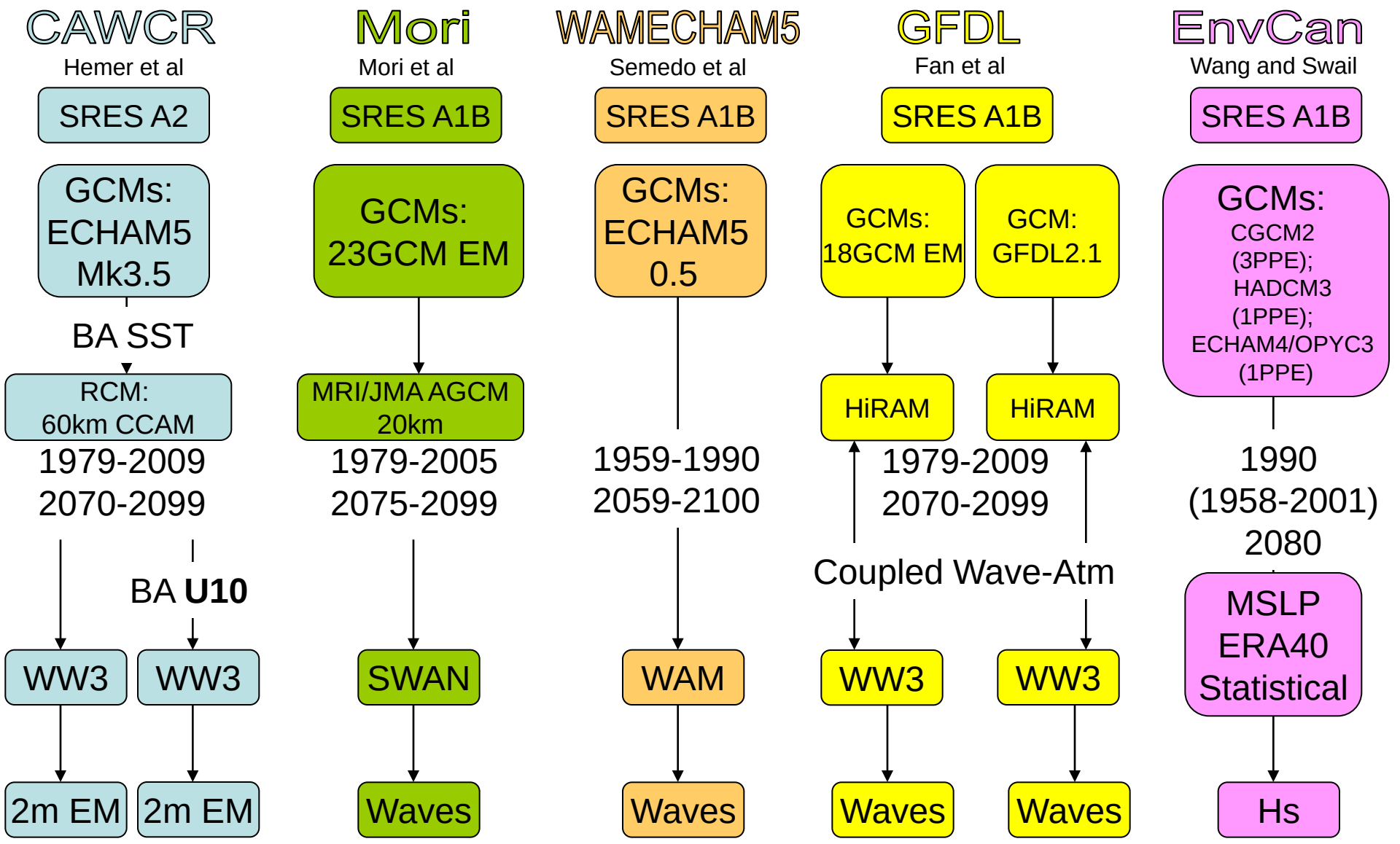


e.g., 1. Raw or corrected forcing/covariate,
2. Perturbed physics in dynamic wave model,
…

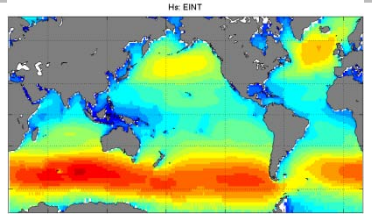
COWCLIP pilot phase (AR5 time-scale)

- Quantitative intercomparison of **available** global wave climate projections.
- Contributors
  - CAWCR (Hemer)
  - Environment Canada (Wang)
  - Escola Naval-CINAV, Portugal, Uppsala Univ, HZG, MPI-M, U. Reading (Semedo)
  - GFDL (Fan)
  - Kyoto Univ (Mori)
- Not a designed approach
  - Overlooks differences in experimental design (scenario, GCM, period, …)
- Aims
  - Assess robustness of available wave climate projections
  - Raise the profile of wave climate issues in the climate community
  - Develop a collaborative framework for COWCLIP production phase
  - Produce recommendations of how COWCLIP can be best supported, and contribute.
  - Compile details on CPU and disk space for processing and archive requirements
  - Encourage uptake of greater community involvement in ongoing COWCLIP activities

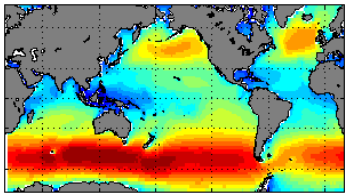
COWCLIP Contributions



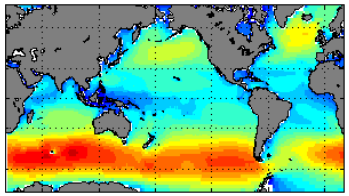
ERA-Interim



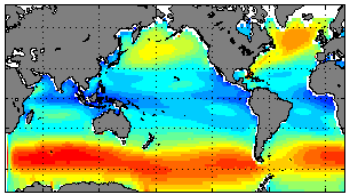
WW3uaCAWCR



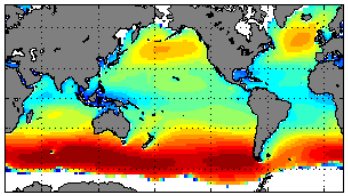
WW3baCAWCR



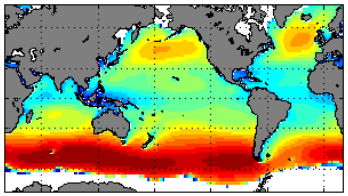
SWANMori



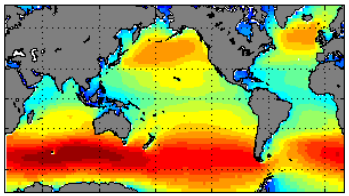
GFDLens18



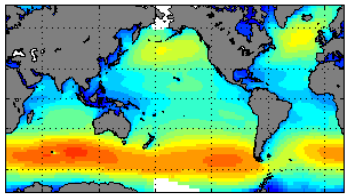
GFDLcm21



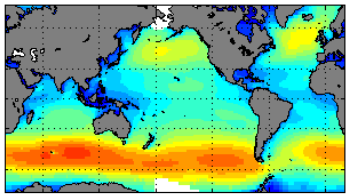
WAMECHAM5



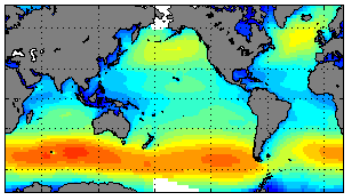
EC-CGCM-A2-I1



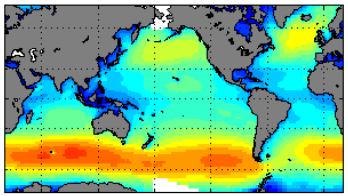
EC-CGCM-A2-I2



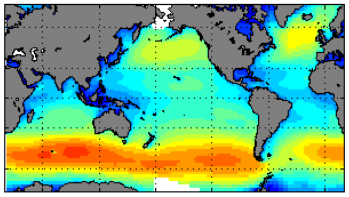
EC-CGCM-A2-I3



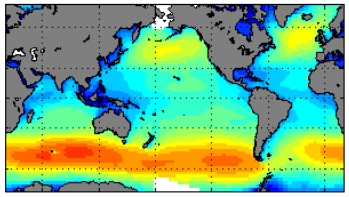
EC-CGCM-B2-I1



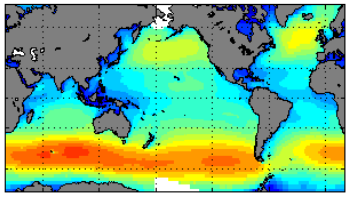
EC-CGCM-B2-I2



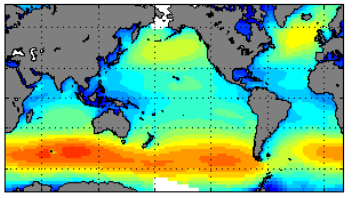
EC-CGCM-B2-I3



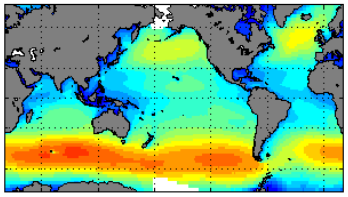
EC-CGCM-IS92a-I1



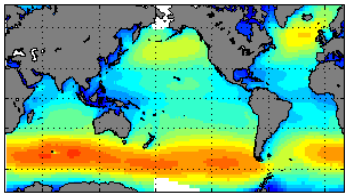
EC-CGCM-IS92a-I2



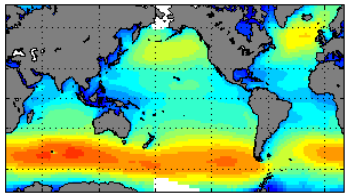
EC-CGCM-IS92a-I3



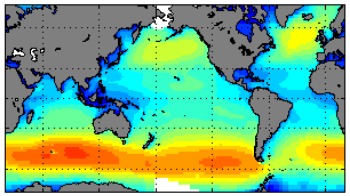
EC-ECHAM-A2



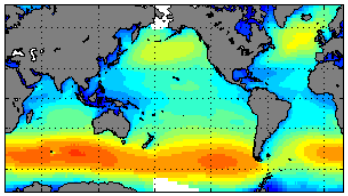
EC-ECHAM-B2



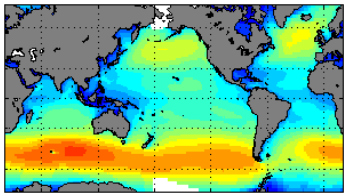
EC-HADCM3-A2



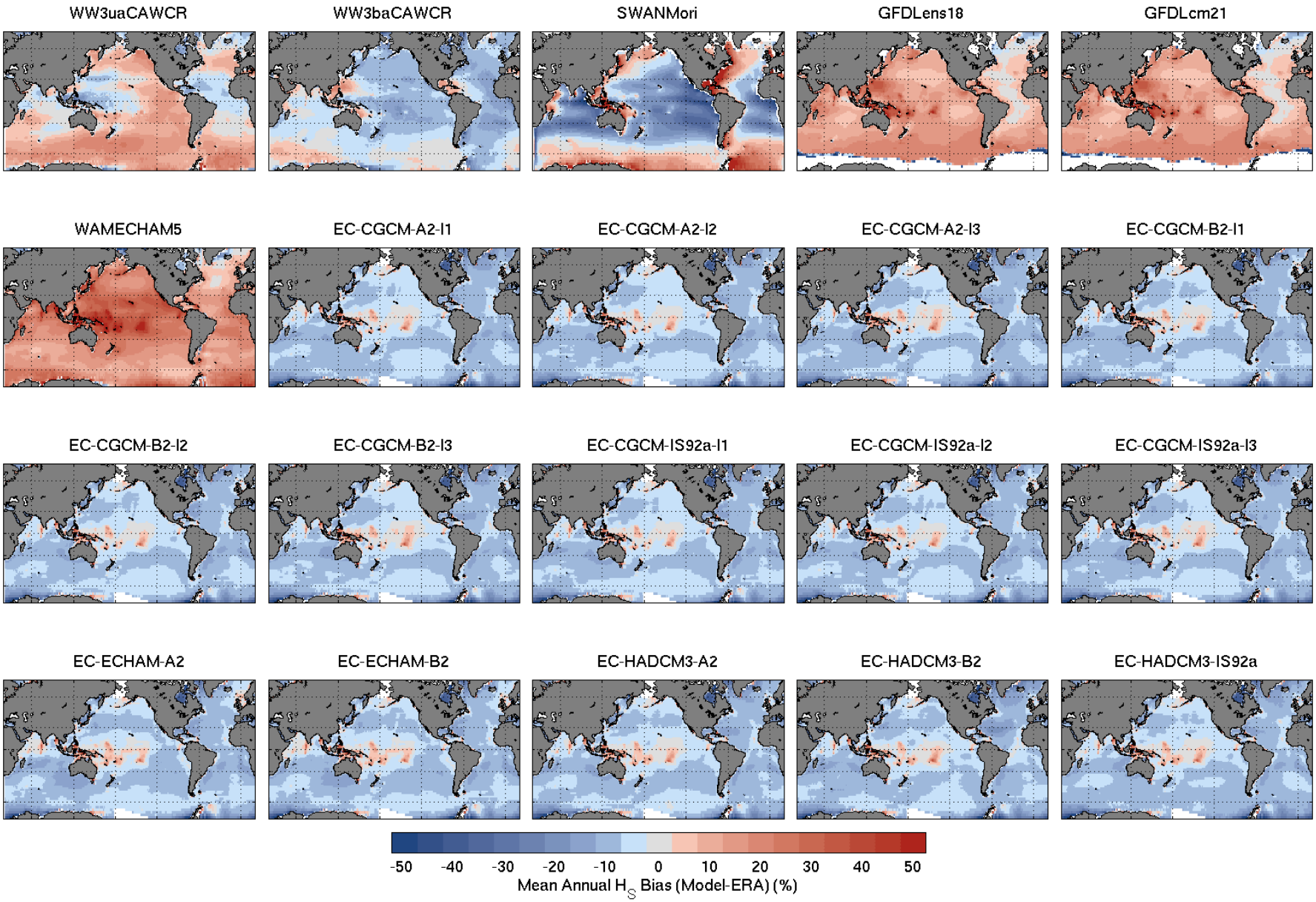
EC-HADCM3-B2



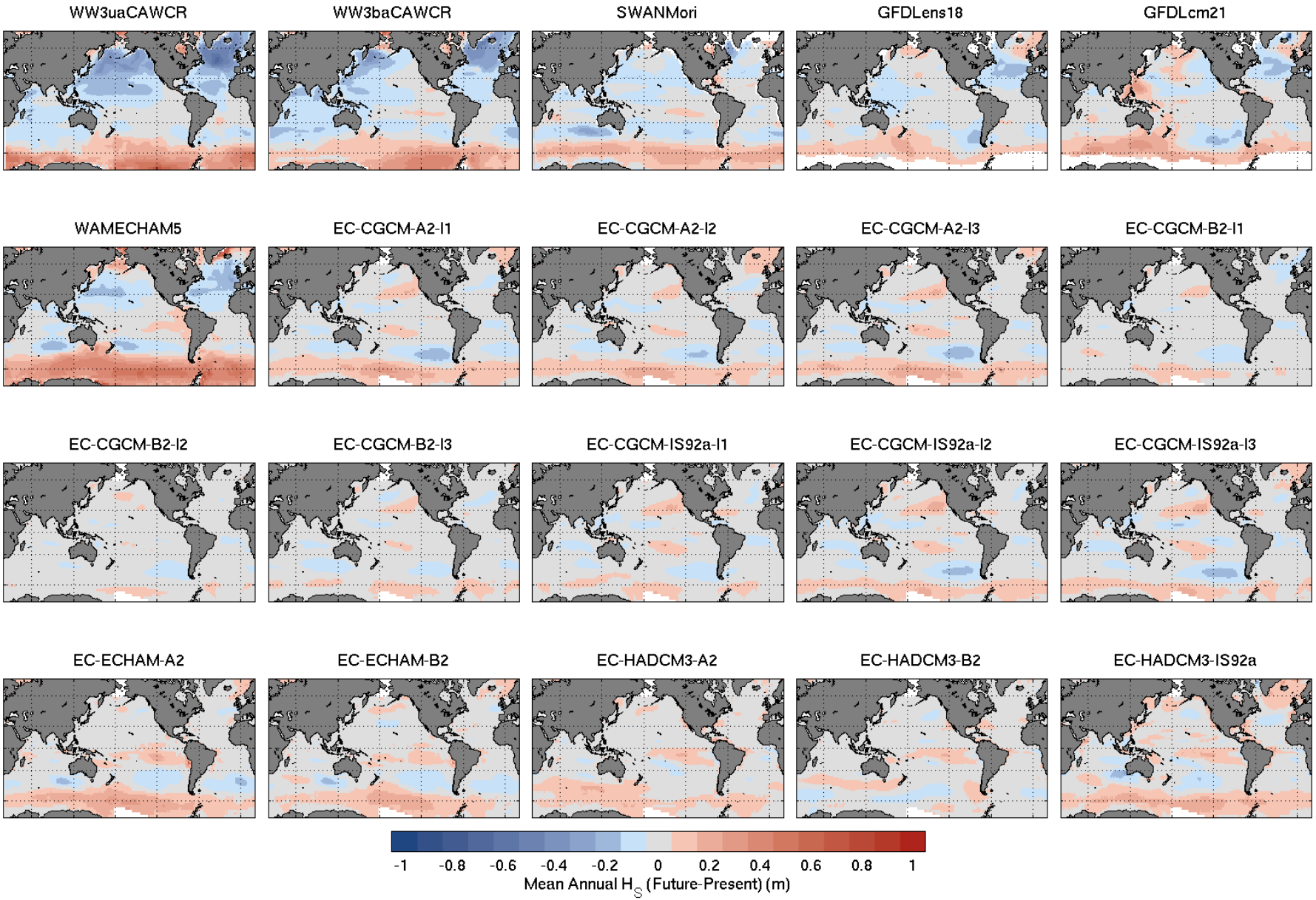
EC-HADCM3-IS92a



Mean Annual HS Bias (Model-ERA) (Percentage Error)



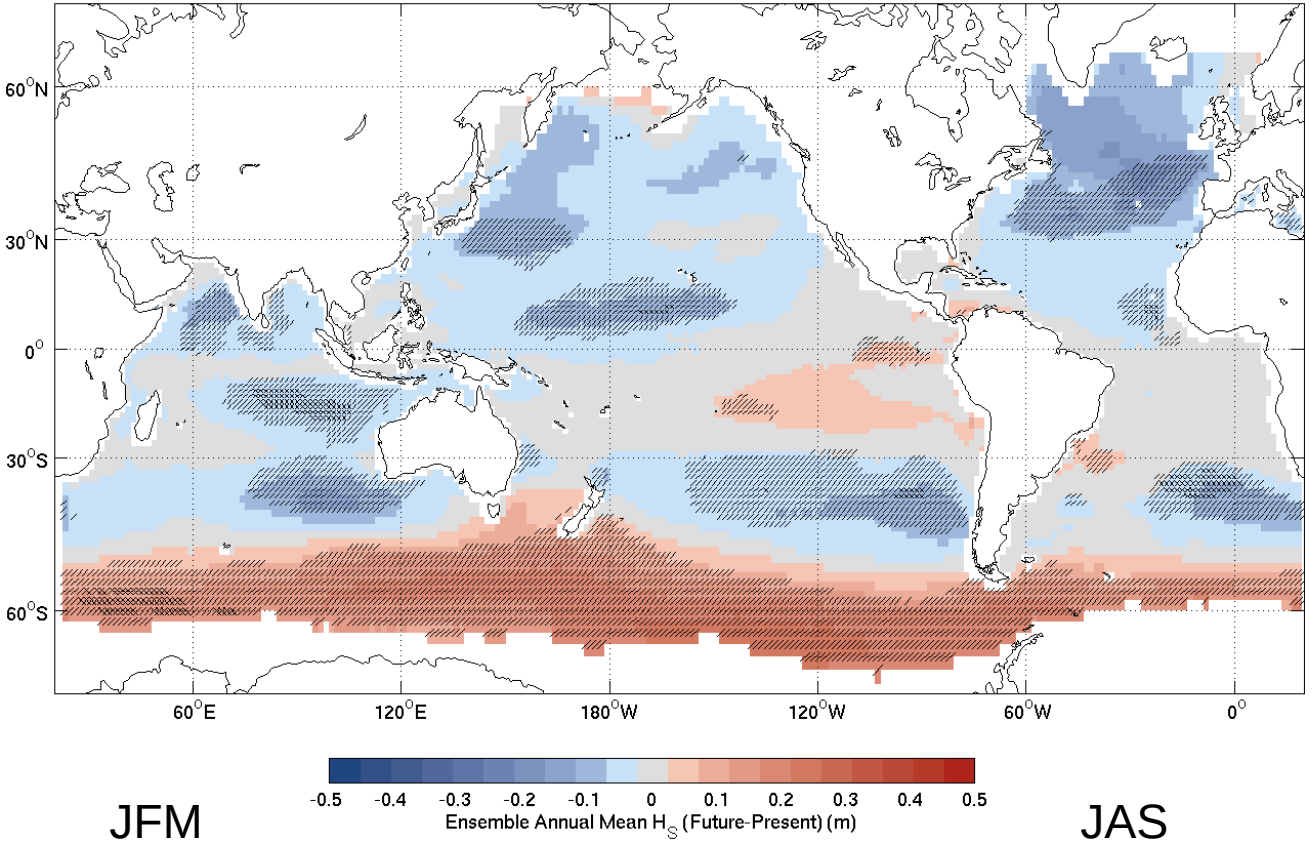
Mean Annual HS Difference (Future-Present)



Annual

H_S

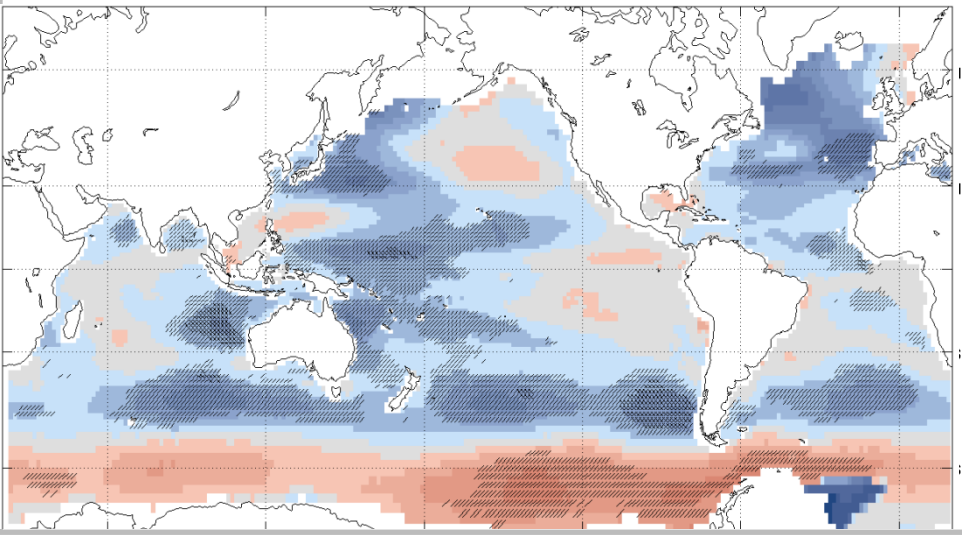
N=20



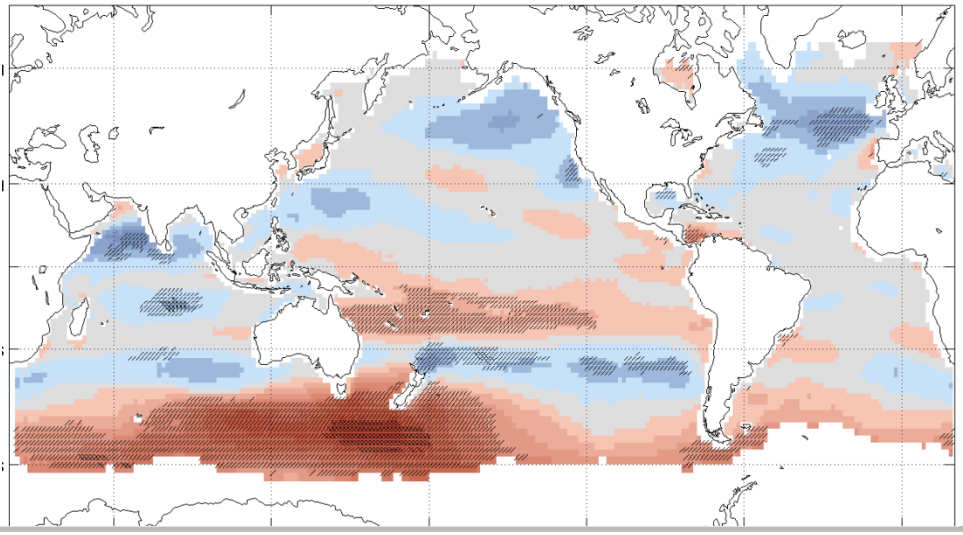
$\Delta_t > \sigma_e$

$\Delta_t > 2\sigma_e$

JFM



JAS

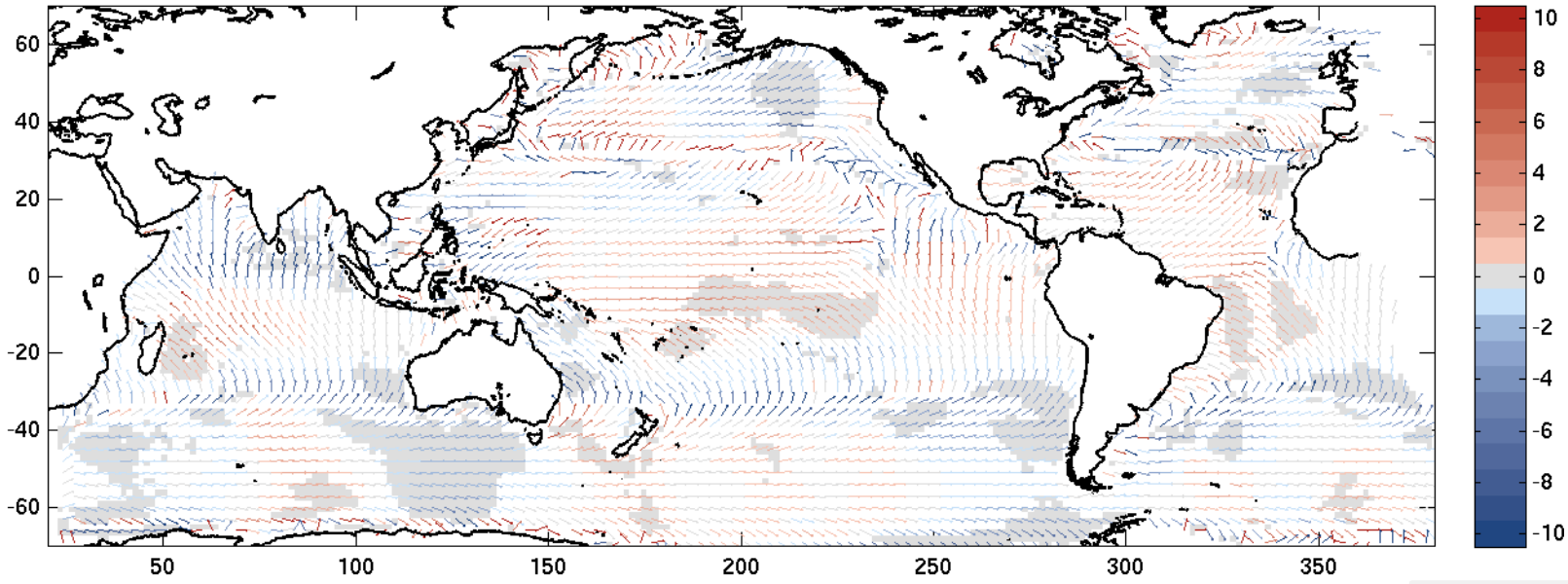


Annual

D_M

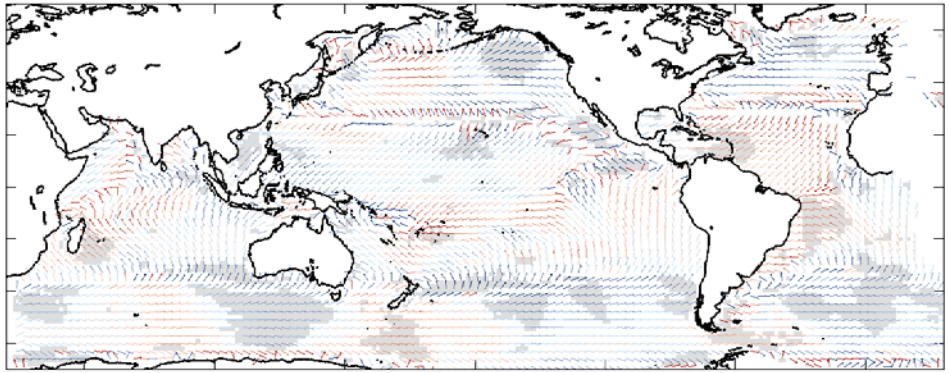
N=5

Ensemble Annual Mean D_M (Future-Present) ($^{\circ}$N)

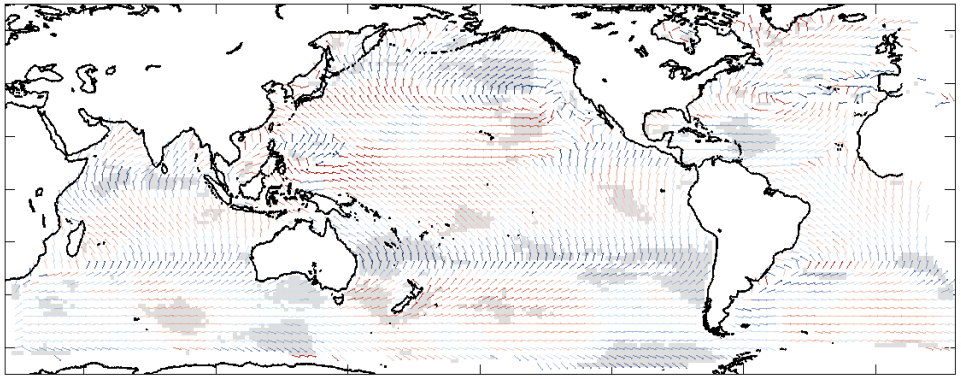


$\Delta_t > \sigma_e$

JFM

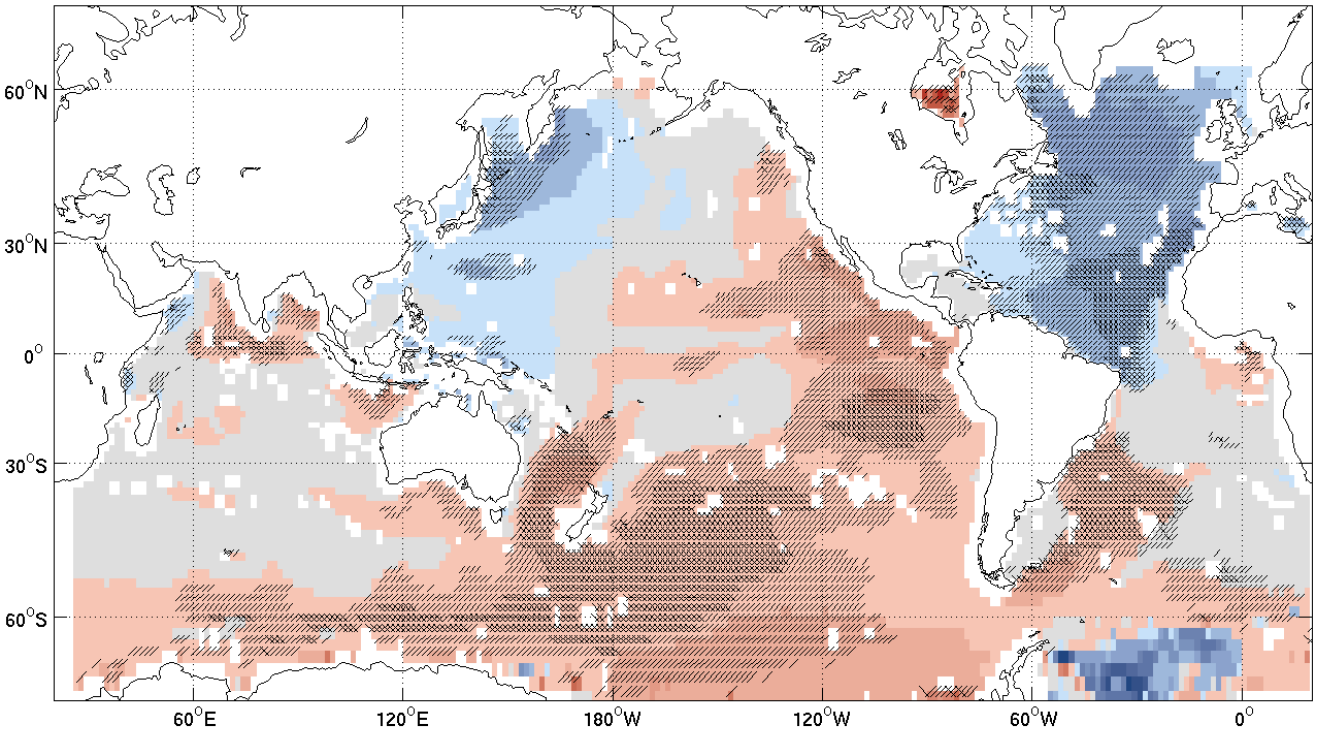


JAS



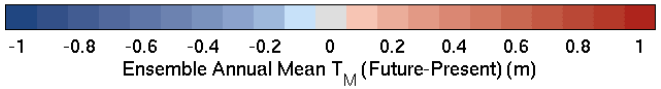
Annual

T_M
N=5

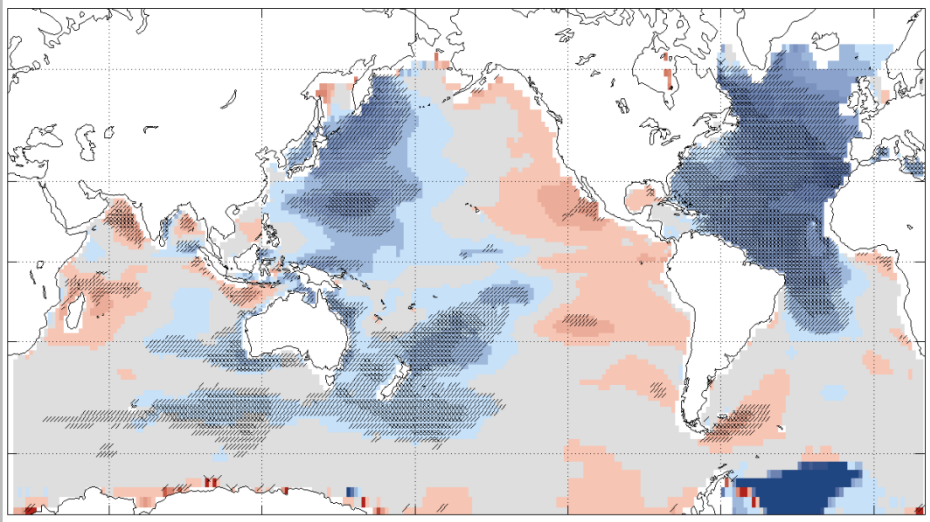


$\Delta_t > \sigma_e$

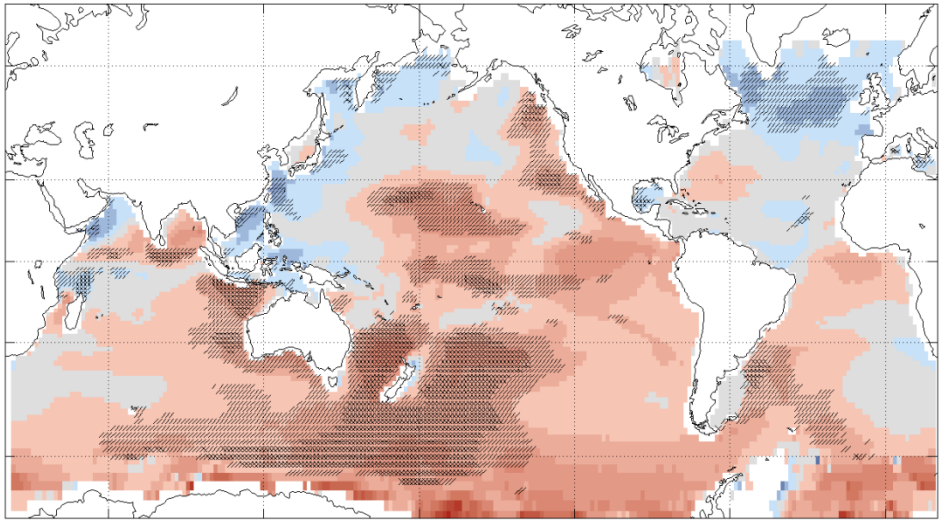
$\Delta_t > 2\sigma_e$



JFM

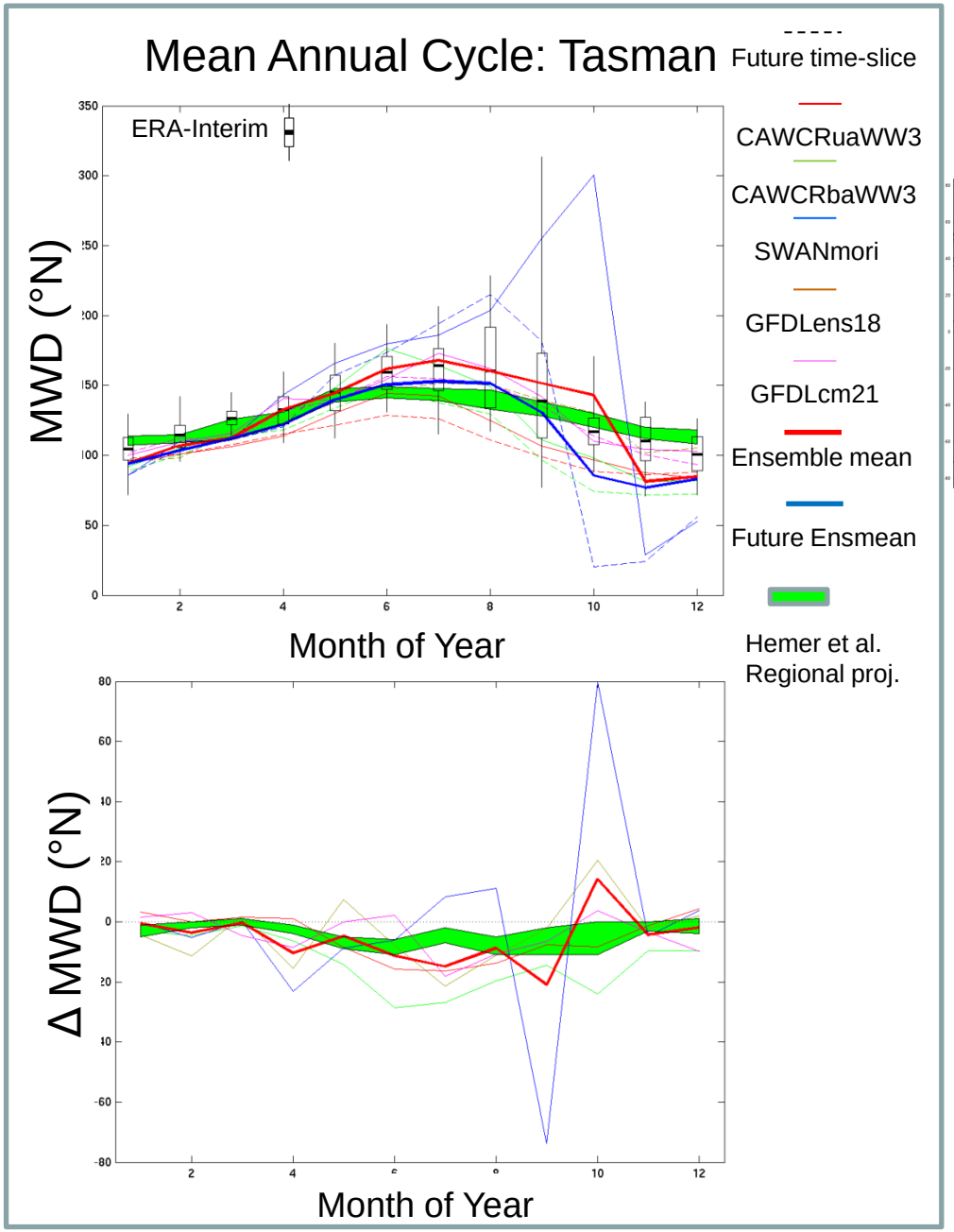


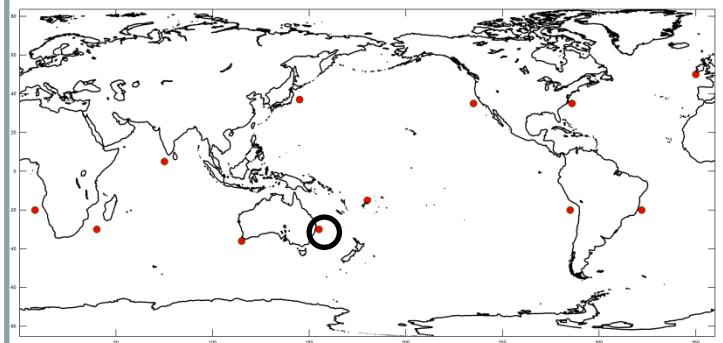
JAS



Including regional wave climate projection studies

D_M



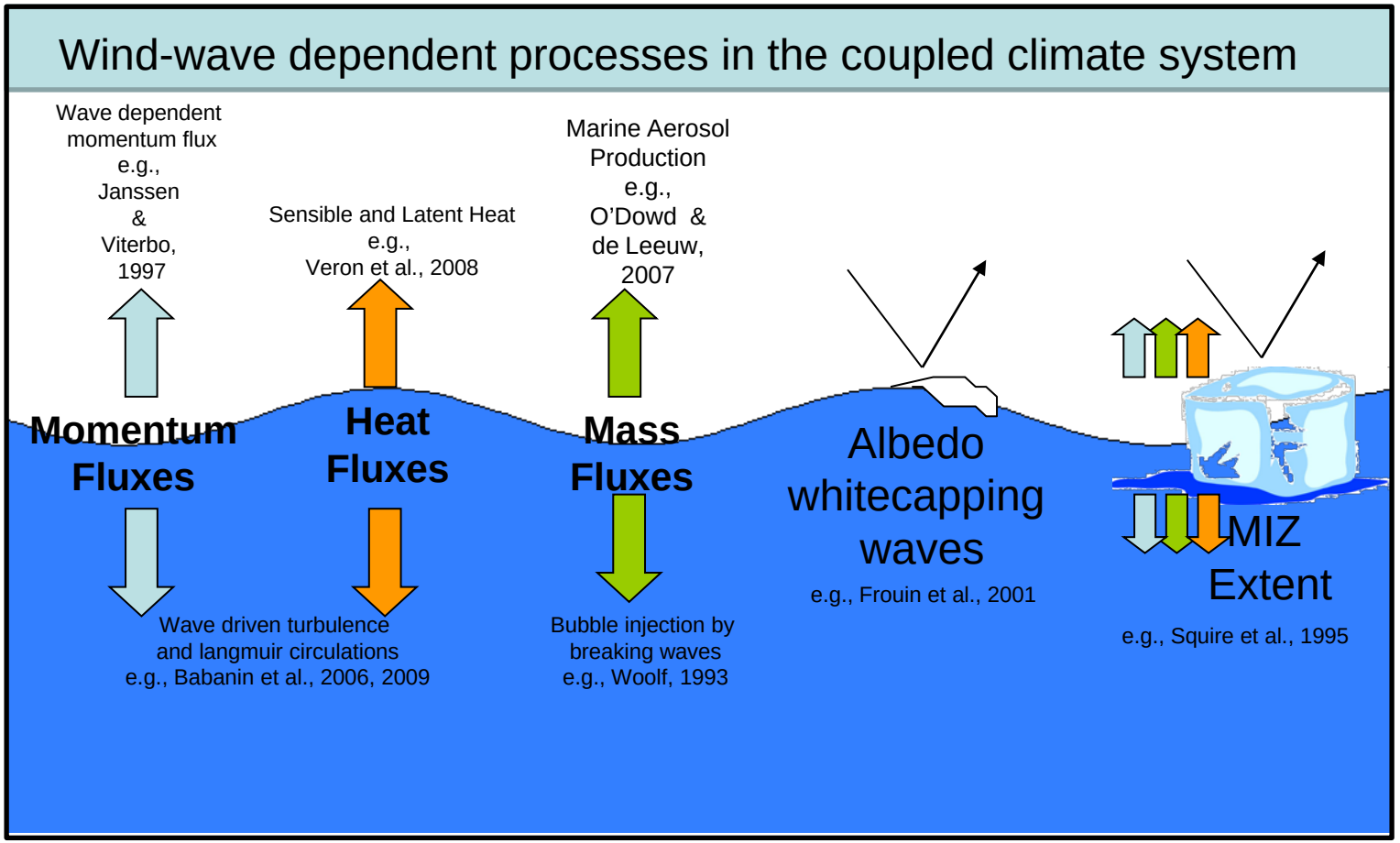


Ongoing COWCLIP activities (1)

- COWCLIP wave climate ensemble
  - Produce a community ensemble of wave climate projections to aid comprehensive assessment of uncertainty.
  - Designed approach – agreed RCP scenarios, time-slices defined by CMIP5 sub-daily surface winds archives (1979-2009, 2026-2045, 2080-2100).
  - What benefit can be extracted from the current generation of climate models for marine-meteorological applications?
  - How do different methods of deriving wave climate projections inter-compare?
  - What is the magnitude of uncertainty surrounding projected wave climate change? What sources dominate?

Ongoing COWCLIP activities (2)

- Support coupling waves into AOGCMs, with the aim to:
  - Quantify the magnitude of wind-wave driven feedbacks in the coupled climate system
  - Several groups working on different aspects of the system (UC-Boulder, FIO-China, GFDL, CAWCR, MPI-M, ….)



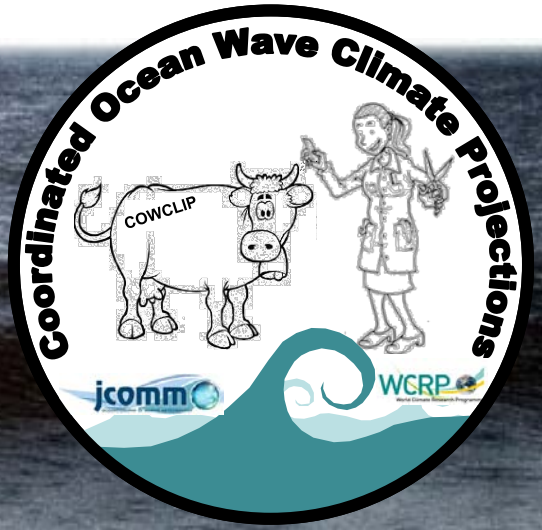
Concluding remarks

- COWCLIP is providing a framework for quantitative intercomparison of future wave climate projections, providing information on robustness within available ensemble
- COWCLIP is connecting the wind-wave and climate communities, to establish climate impacts on waves, and the impact of waves on climate.

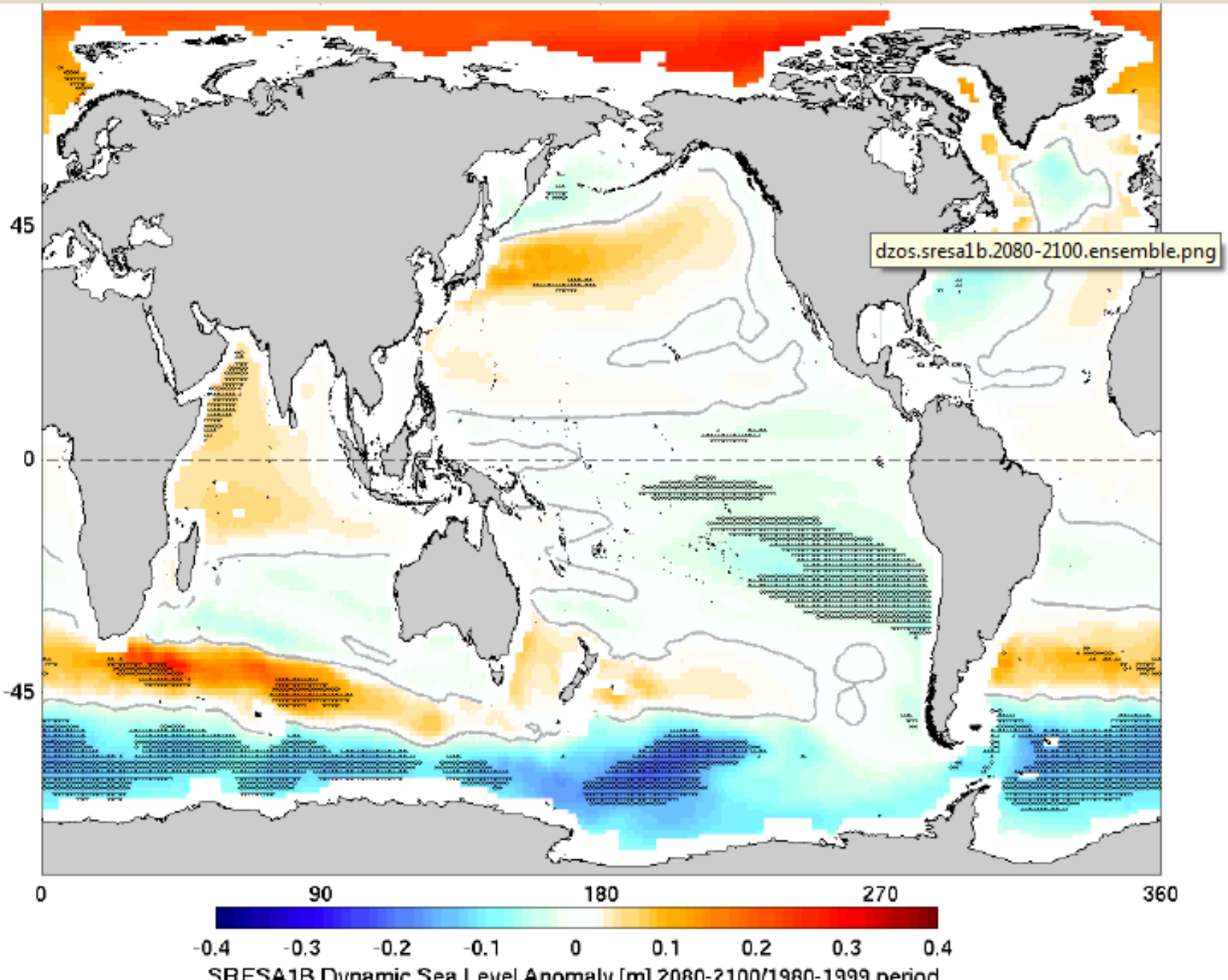
- COWCLIP Discussion, here after talks Tuesday. All welcome.

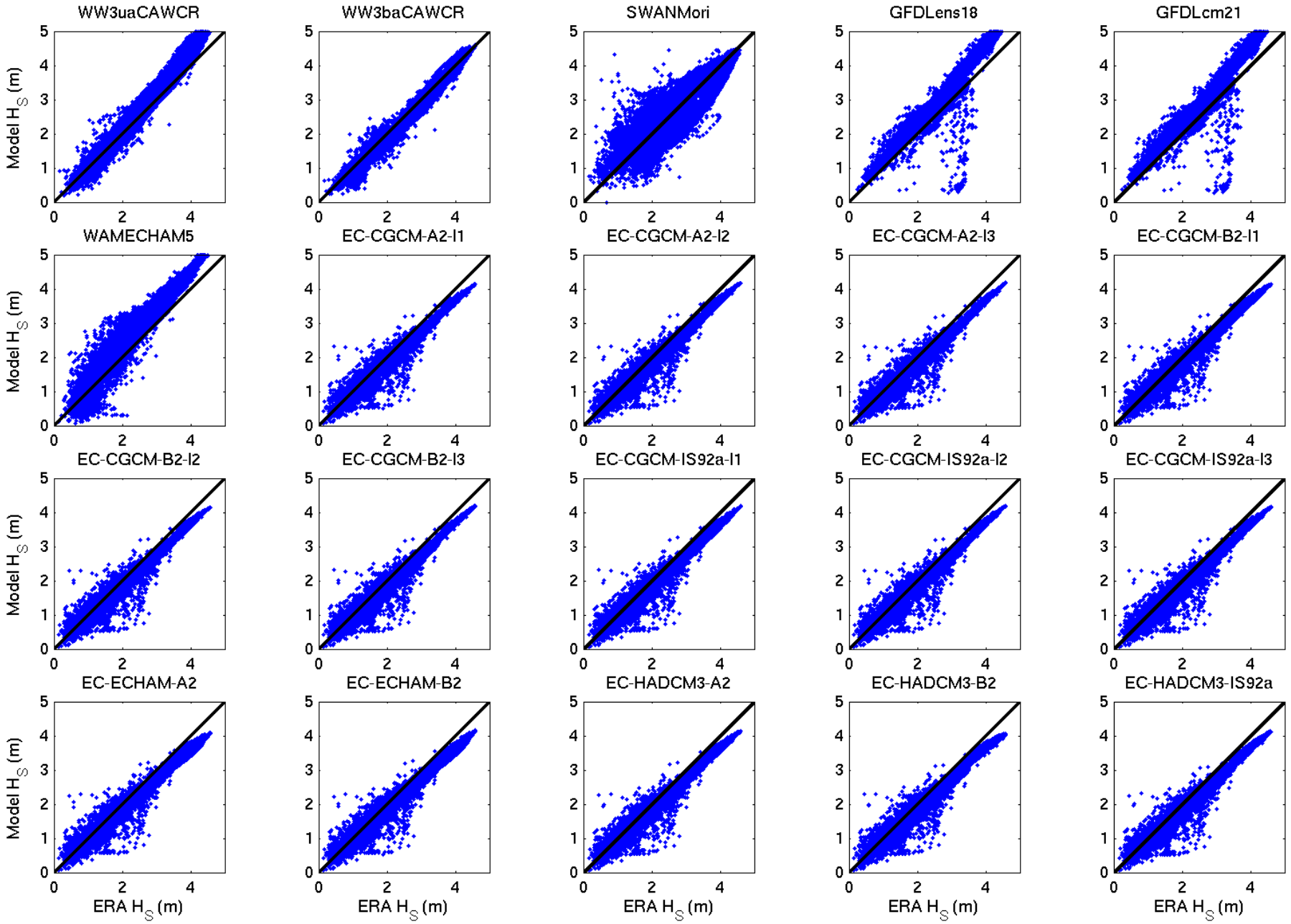
Thanks.

Contact: Mark.Hemer@csiro.au

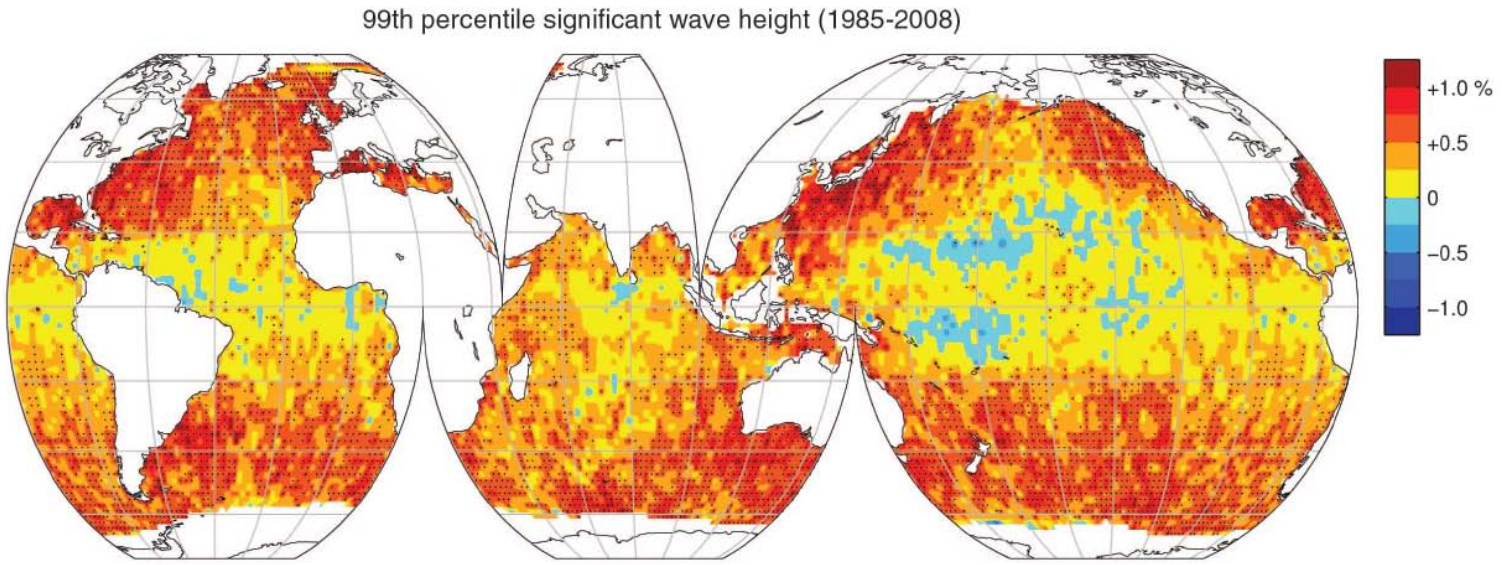


What is the regional distribution of sea level?

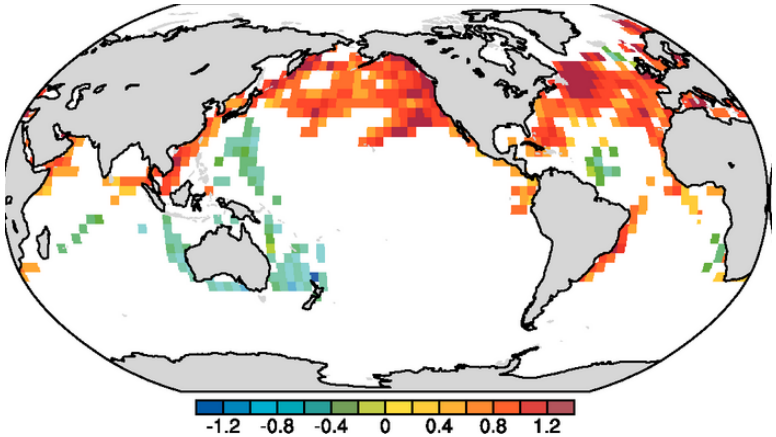



WW3uaCAWCR
WW3baCAWCR
SWANMori
GFDLens18
GFDLcm21
WAMECHAM5
EC-CGCM-A2-I1
EC-CGCM-A2-I2
EC-CGCM-A2-I3
EC-CGCM-B2-I1
EC-CGCM-B2-I2
EC-CGCM-B2-I3
EC-CGCM-IS92a-I1
EC-CGCM-IS92a-I2
EC-CGCM-IS92a-I3
EC-ECHAM-A2
EC-ECHAM-B2
EC-HADCM3-A2
EC-HADCM3-B2
EC-HADCM3-IS92a
Model H_S (m)
ERA H_S (m)

A changing wave climate



Linear trends in Hs from VOS data (1950-2002)



Source: IPCC AR4 (Trenberth et al., 2007)

IPCC AR4 (WG-I)

Box 11.5: Coastal Zone Climate Change

Introduction

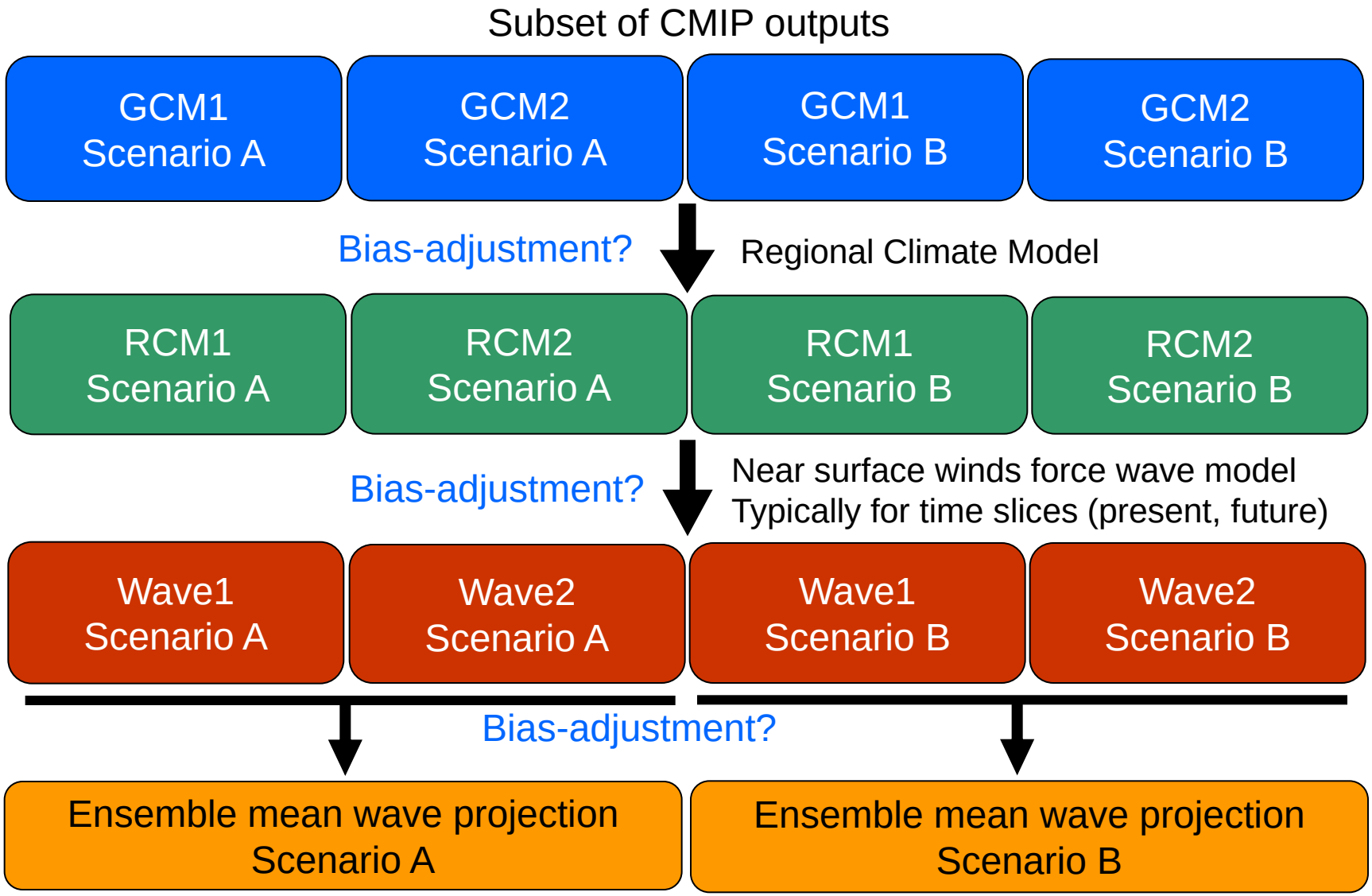
Climate change has the potential to interact with the coastal zone in a number of ways including inundation, erosion and salt-water intrusion into the water table..... **There is insufficient information on changes in waves or near-coastal currents to provide an assessment of the effects of climate change on erosion.**

…

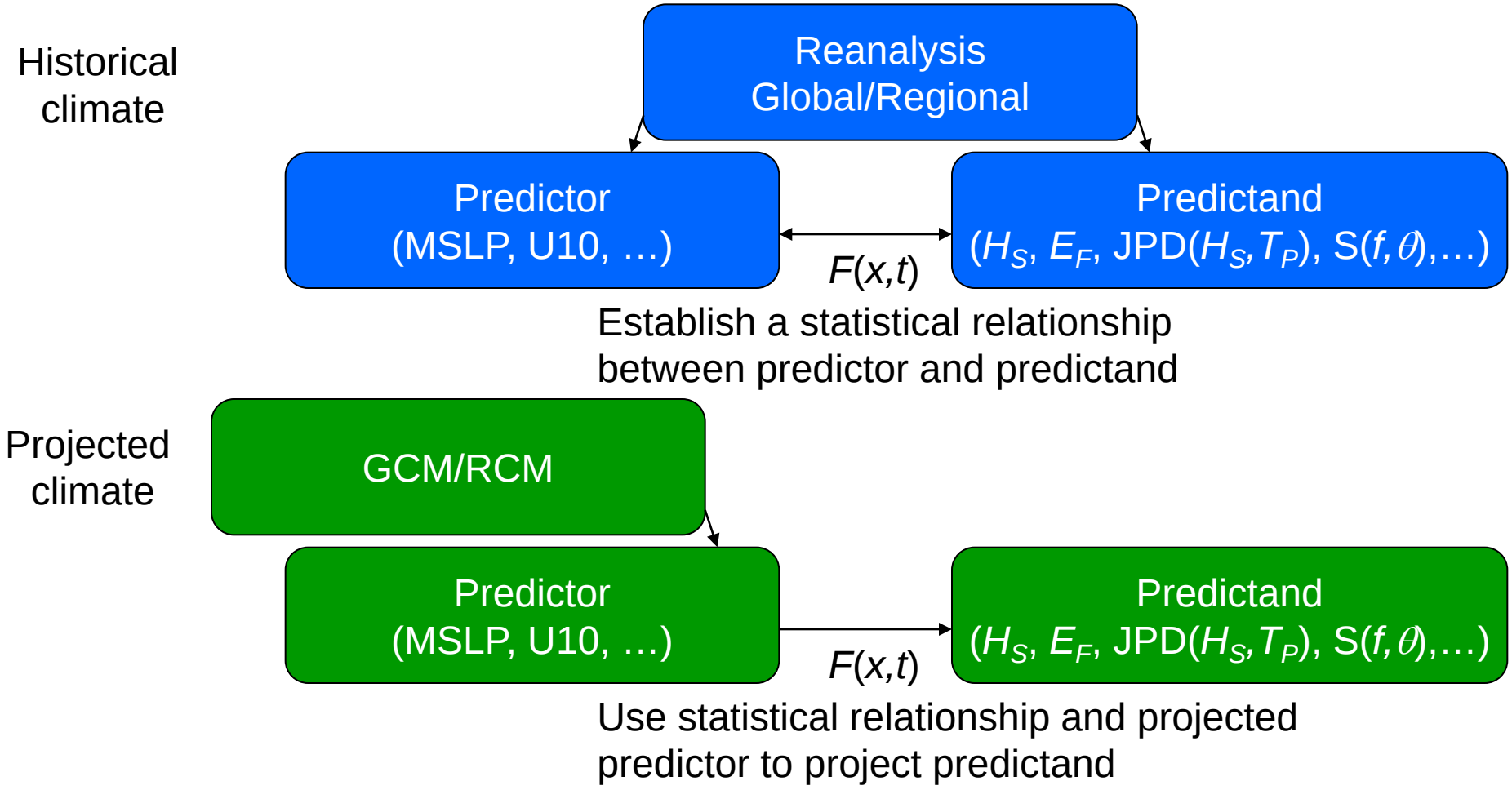
Changes in storm surges and wave heights have been addressed for only a limited set of models. Thus, we cannot reliably quantify the range of uncertainty in estimates of future coastal flooding and can only make crude estimates of the minimum values (Lowe and Gregory, 2005).

Christensen, J.H. et al. (2007) Regional Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S. et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Regional projections (dynamical method)

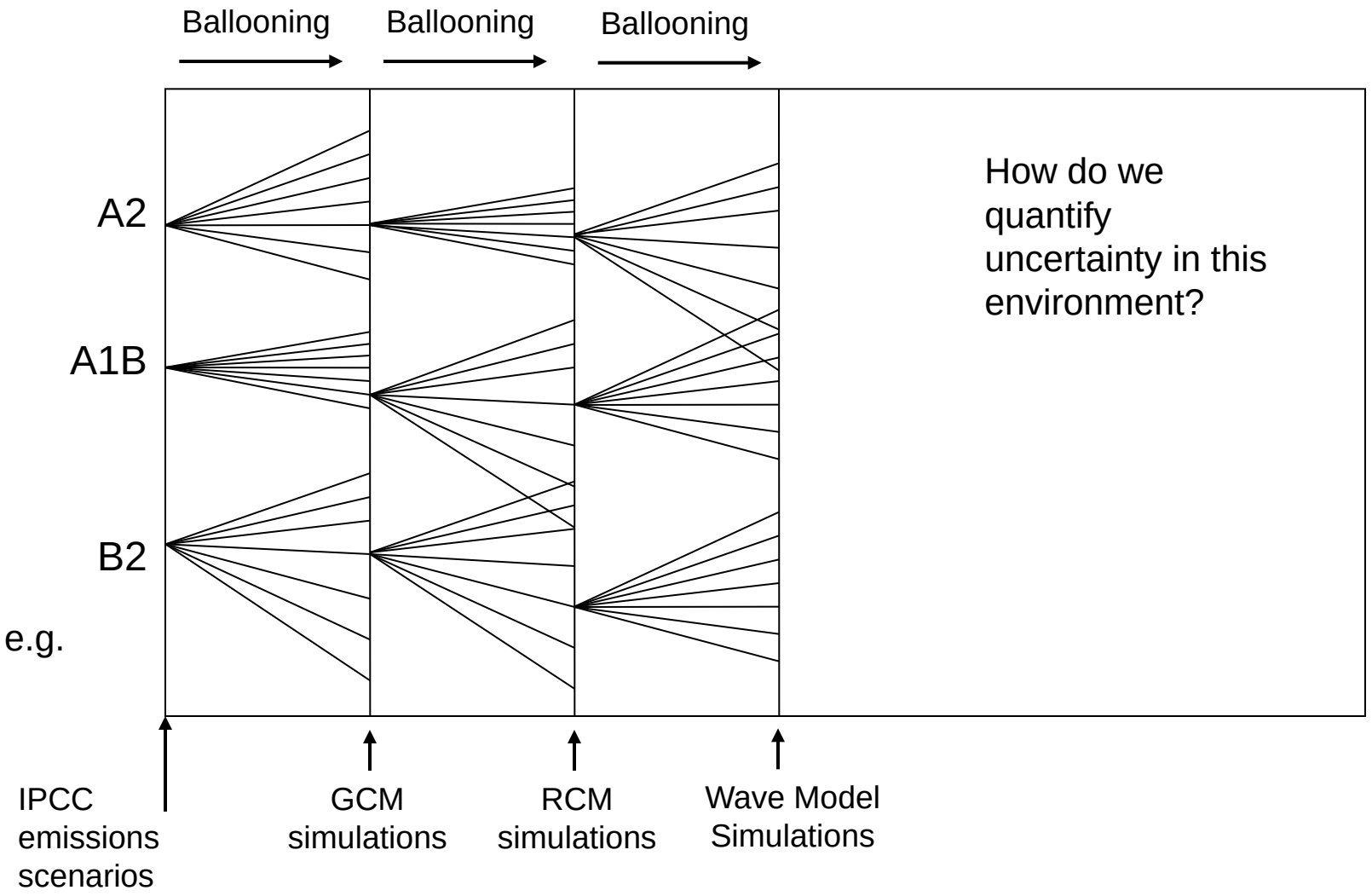


Regional projections (statistical method)



Also projections being carried out based on projected diagnostics (e.g., teleconnection indices, etc)

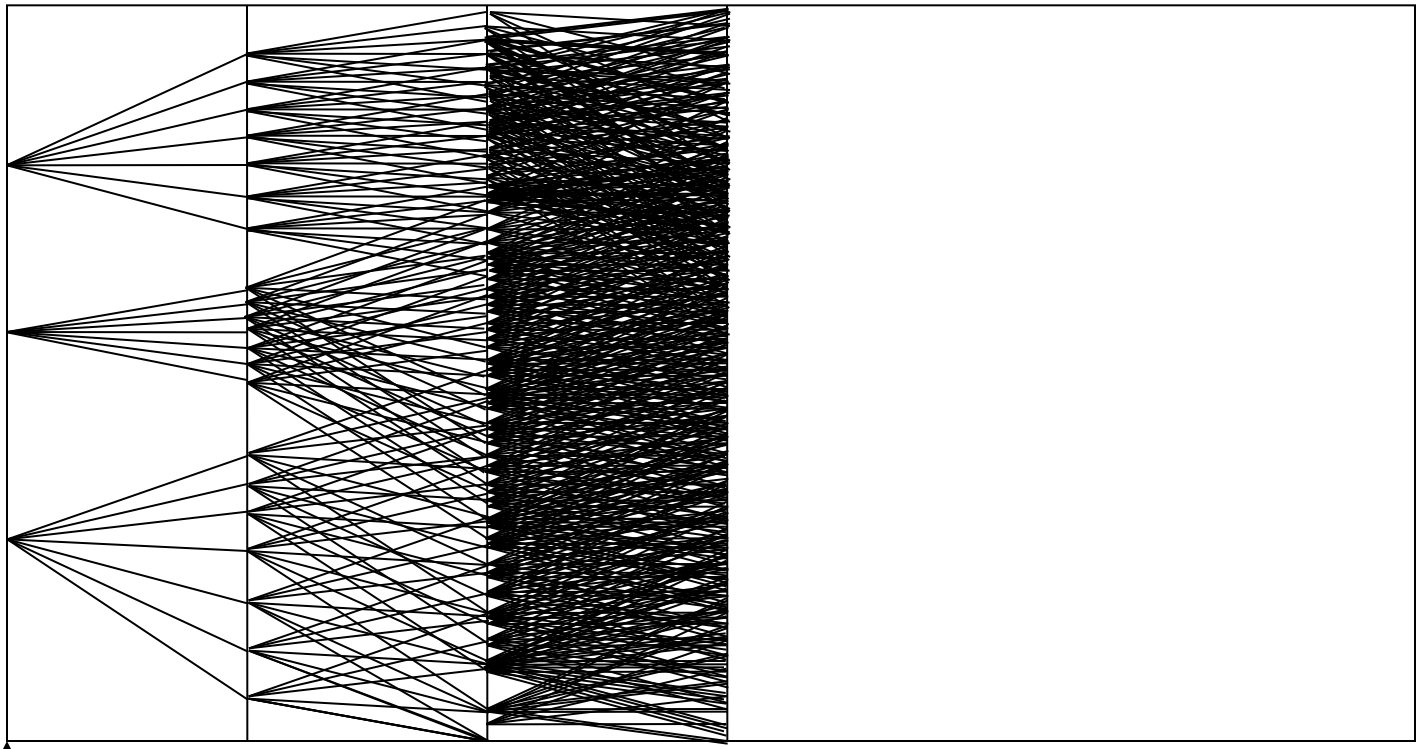
Cascading uncertainty in prediction problems



Cascading uncertainty in prediction problems

- To fully quantify variance of complete sample space is potentially very computationally expensive.

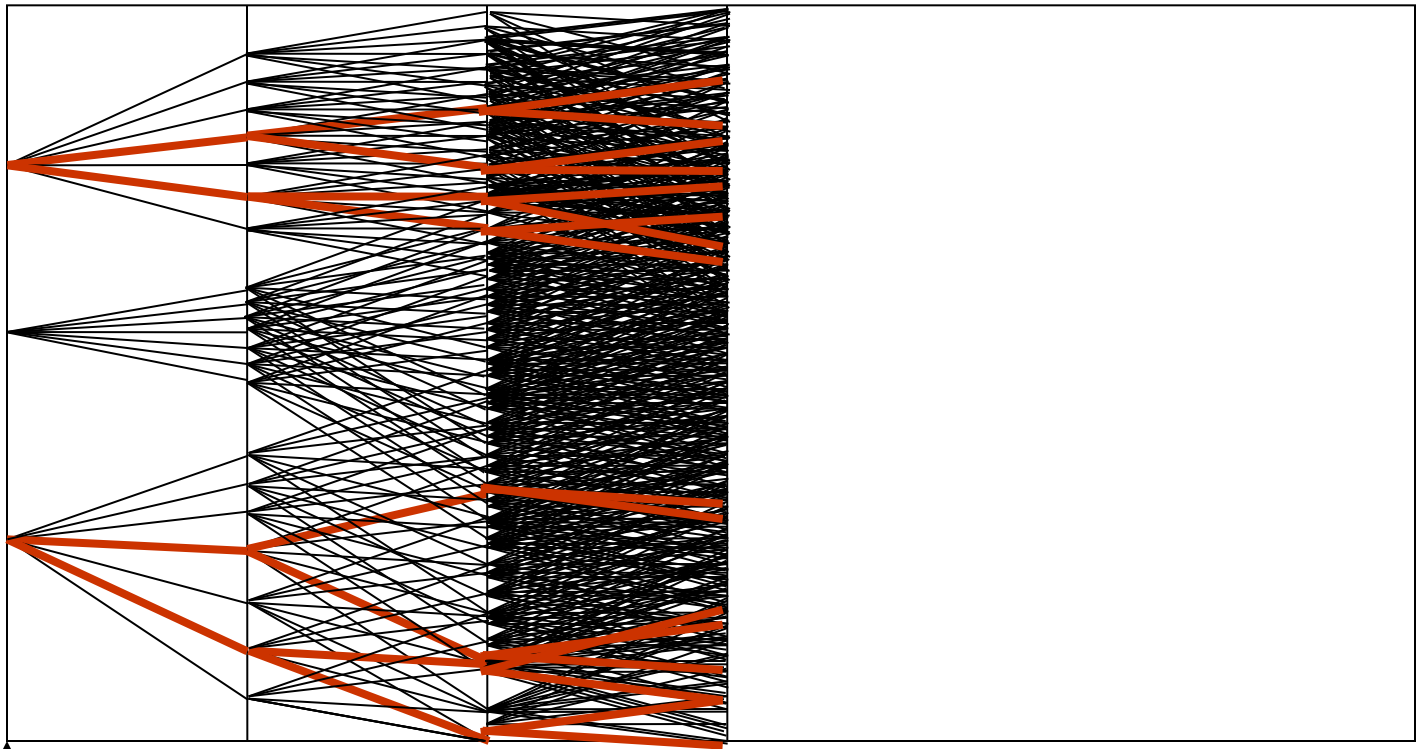
e.g.



Cascading uncertainty in prediction problems

- To fully quantify variance of complete sample space is potentially very computationally expensive.

e.g.



A need for designed approach to sample variance

Wang & Swail, 2006	Mori et al., 2009
2080-1990 diff. Statistical Hs projection Ensemble mean: CGCM2 (3PPE); HADCM3 (1PPE); ECHAM4/OPYC3 (1PPE) SRES A2 scenario	2075-2099 mean – 1979-2003 mean diff Dynamical (SWAN) Hs projection 20km MRI/JMA AGCM CMIP3 ensemble mean SST as BB forcing SRES A1B scenario