Coordinated Ocean Wave Climate Projections: COWCLIP

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and

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Other contributors:

Xiaolan Wang and Val Swail – Environment Canada

Ralf Weisse – Helmholtz-Zentrum Geesthacht, Germany

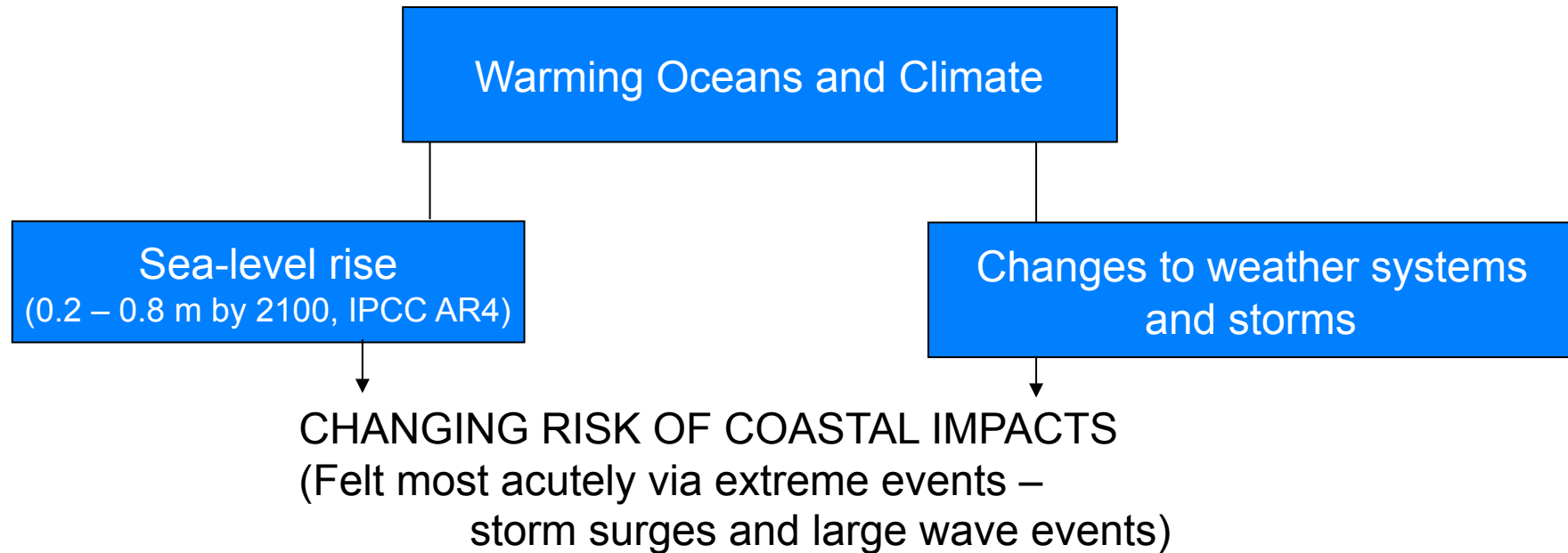Alvaro Semedo – Escola Naval-CINAV, Portugal and Uppsala University, Sweden

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)
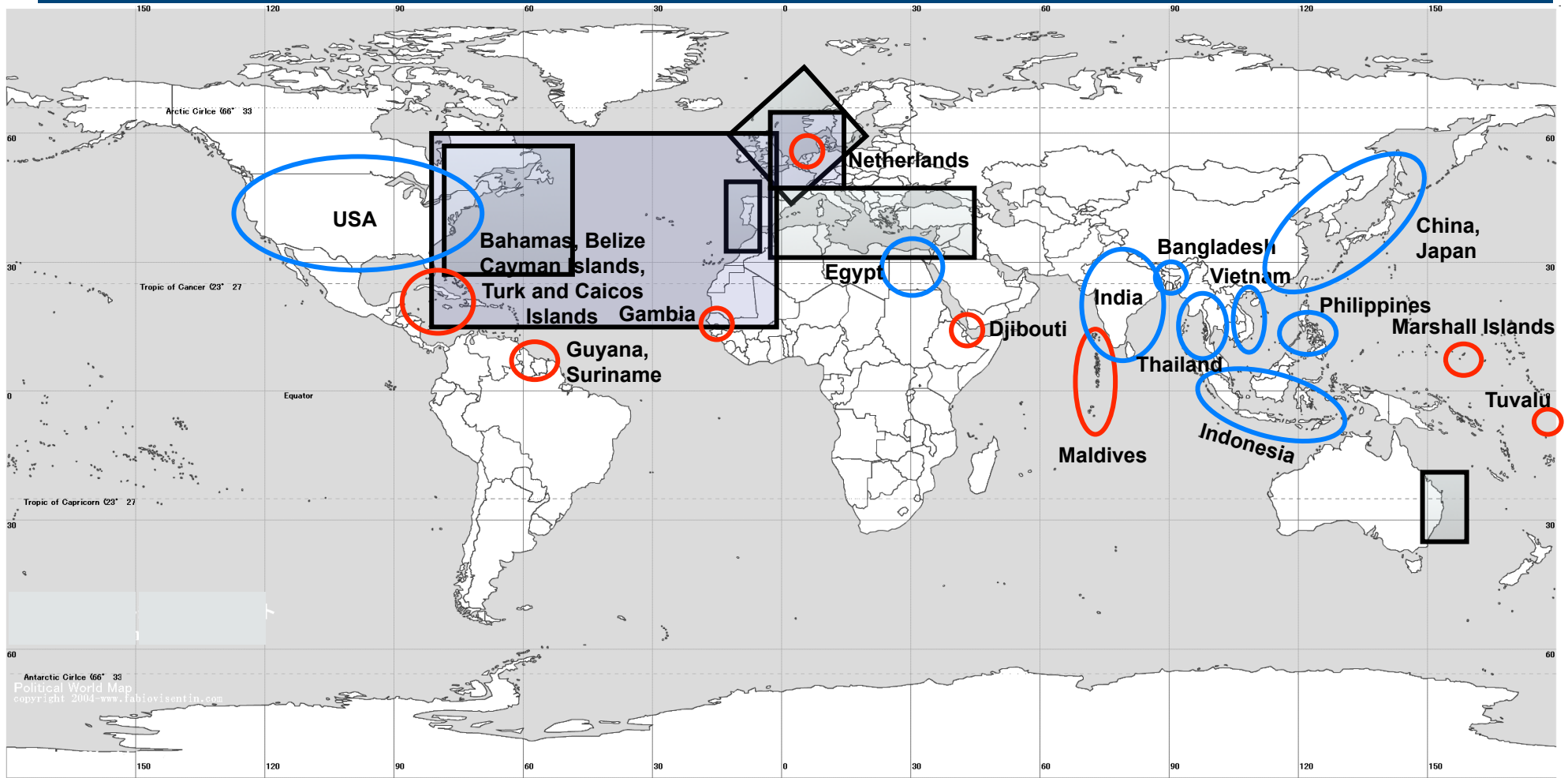
Map of current regional projections

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

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

⭕ (blue) 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
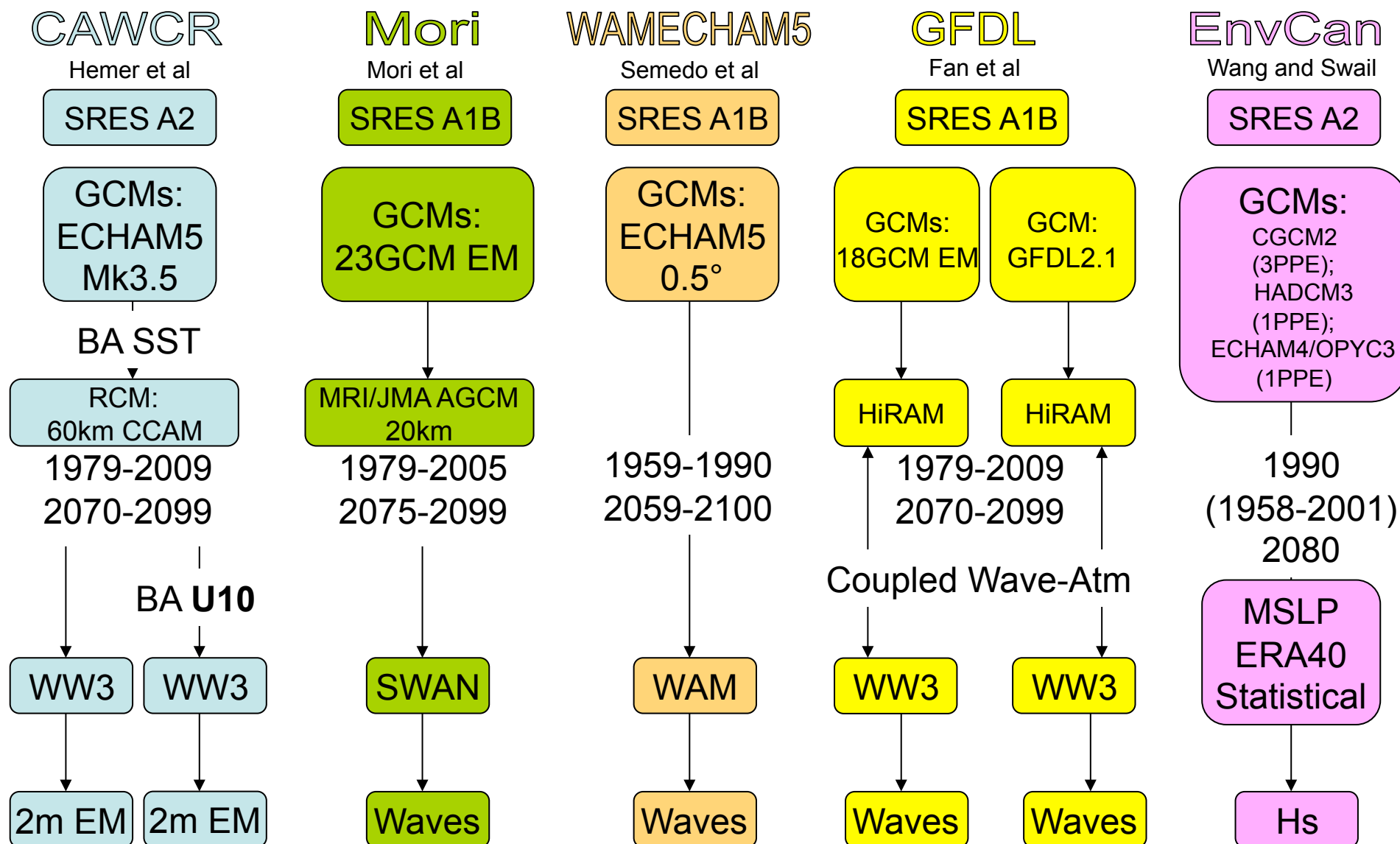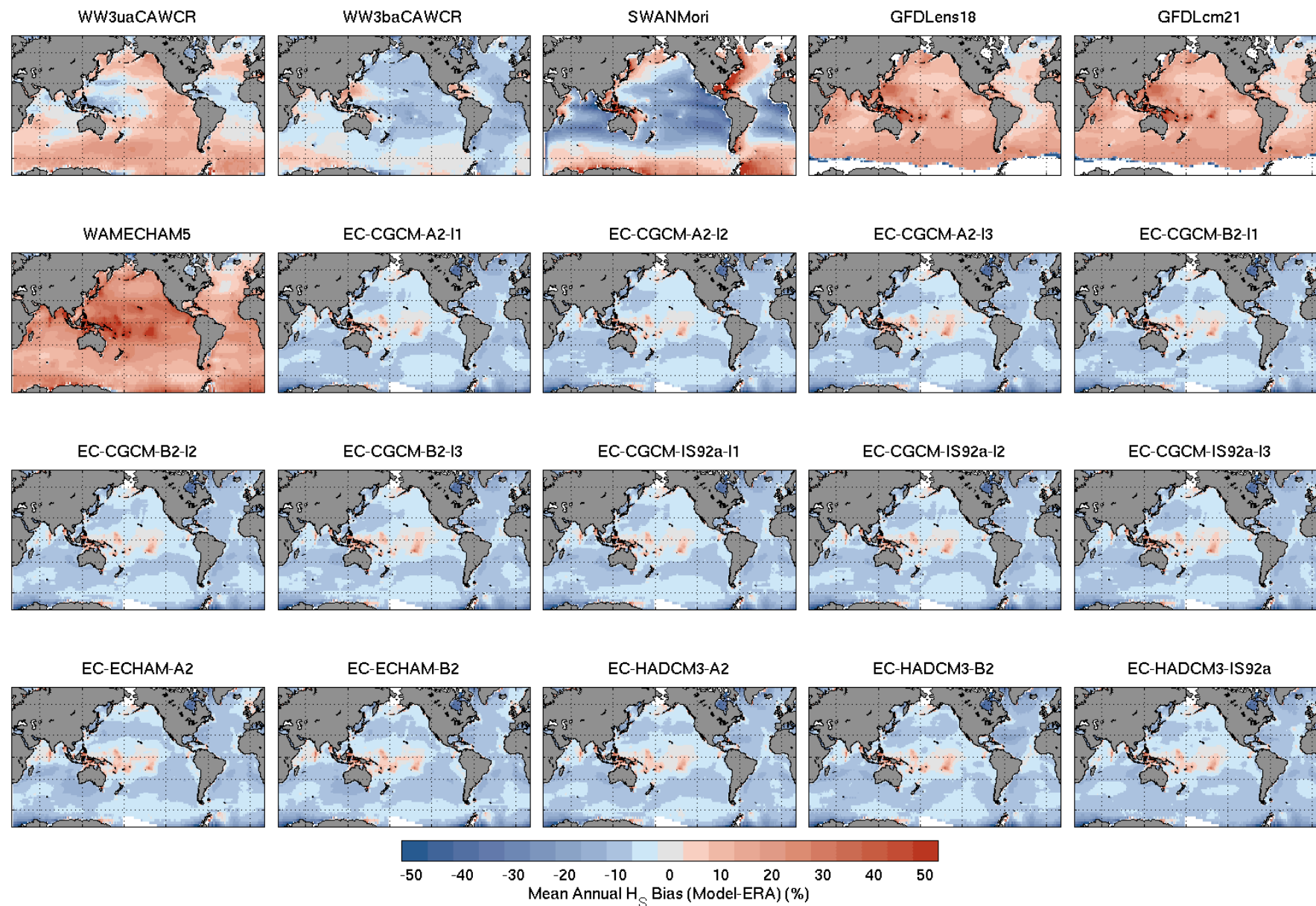
COWCLIP pilot phase (AR5 time-scale)

- Quantitative intercomparison of **available** global wave climate projections.
- Contributors
  - CAWCR (Hemer)
  - Kyoto Univ (Mori)
  - Escola Naval-CINAV, Portugal, Uppsala Univ, HZG, MPI-M, U. Reading (Semedo)
  - GFDL (Fan)
  - Environment Canada (Wang)
- 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

CAWCR
Hemer et al
- SRES A2
- GCMs: ECHAM5 Mk3.5
- BA SST
- RCM: 60km CCAM
- 1979-2009 / 2070-2099
- BA **U10**
- WW3 → 2m EM
- WW3 → 2m EM

Mori
Mori et al
- SRES A1B
- GCMs: 23GCM EM
- MRI/JMA AGCM 20km
- 1979-2005 / 2075-2099
- SWAN → Waves

WAMECHAM5
Semedo et al
- SRES A1B
- GCMs: ECHAM5 0.5°
- 1959-1990 / 2059-2100
- WAM → Waves

GFDL
Fan et al
- SRES A1B
- GCMs: 18GCM EM
- GCM: GFDL2.1
- HiRAM / HiRAM
- 1979-2009 / 2070-2099
- Coupled Wave-Atm
- WW3 → Waves
- WW3 → Waves

EnvCan
Wang and Swail
- SRES A2
- GCMs: CGCM2 (3PPE); HADCM3 (1PPE); ECHAM4/OPYC3 (1PPE)
- 1990 (1958-2001) 2080
- MSLP ERA40 Statistical → Hs

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

Mean Annual H_S Bias (Model-ERA) (%)

Mean Annual HS Difference (Future-Present)

Mean Annual H$_S$ (Future-Present) (m)
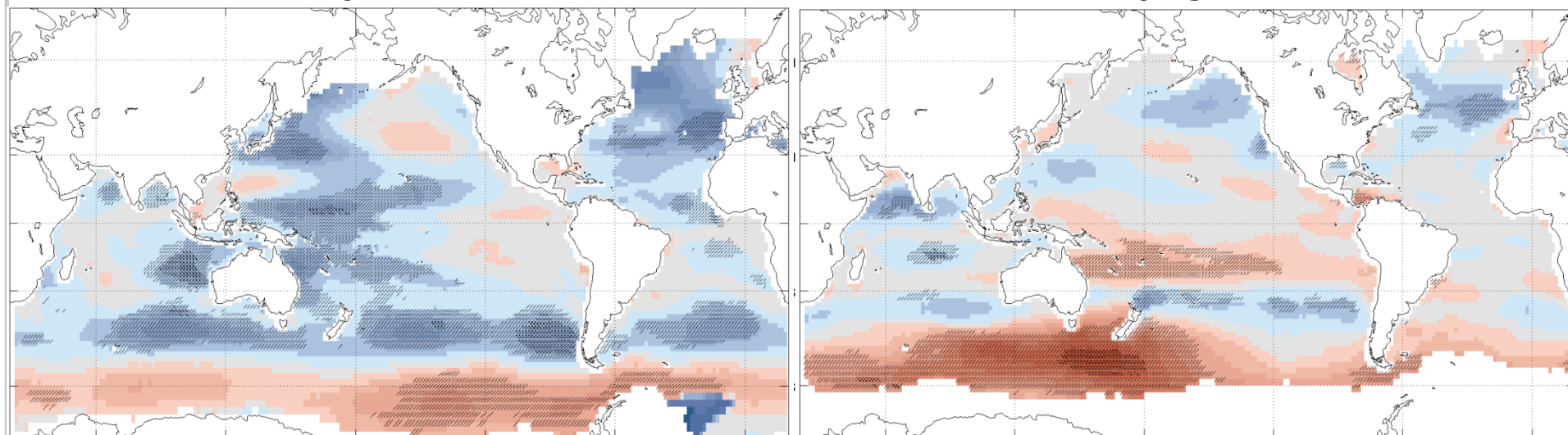
Annual

H_S
N=20
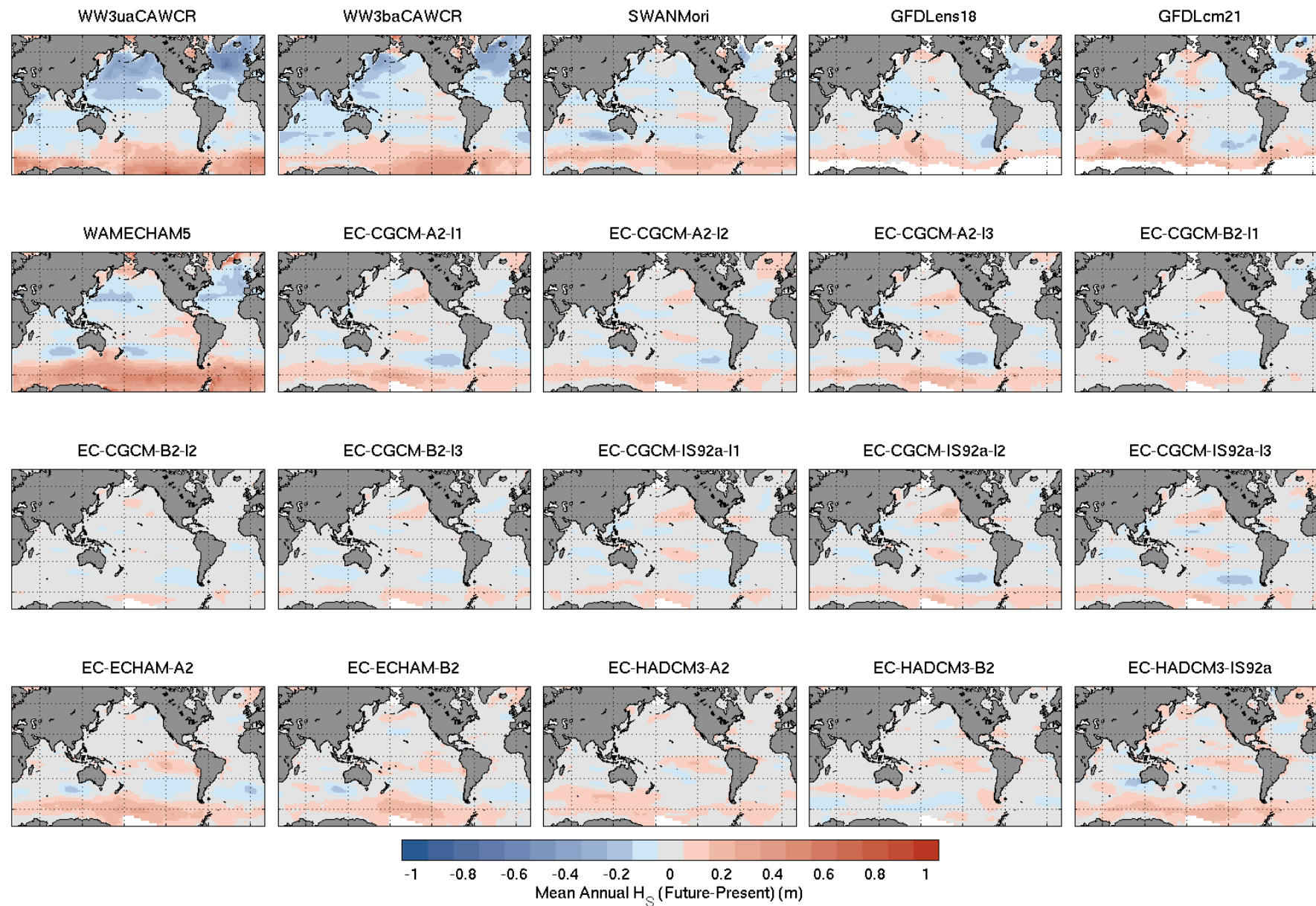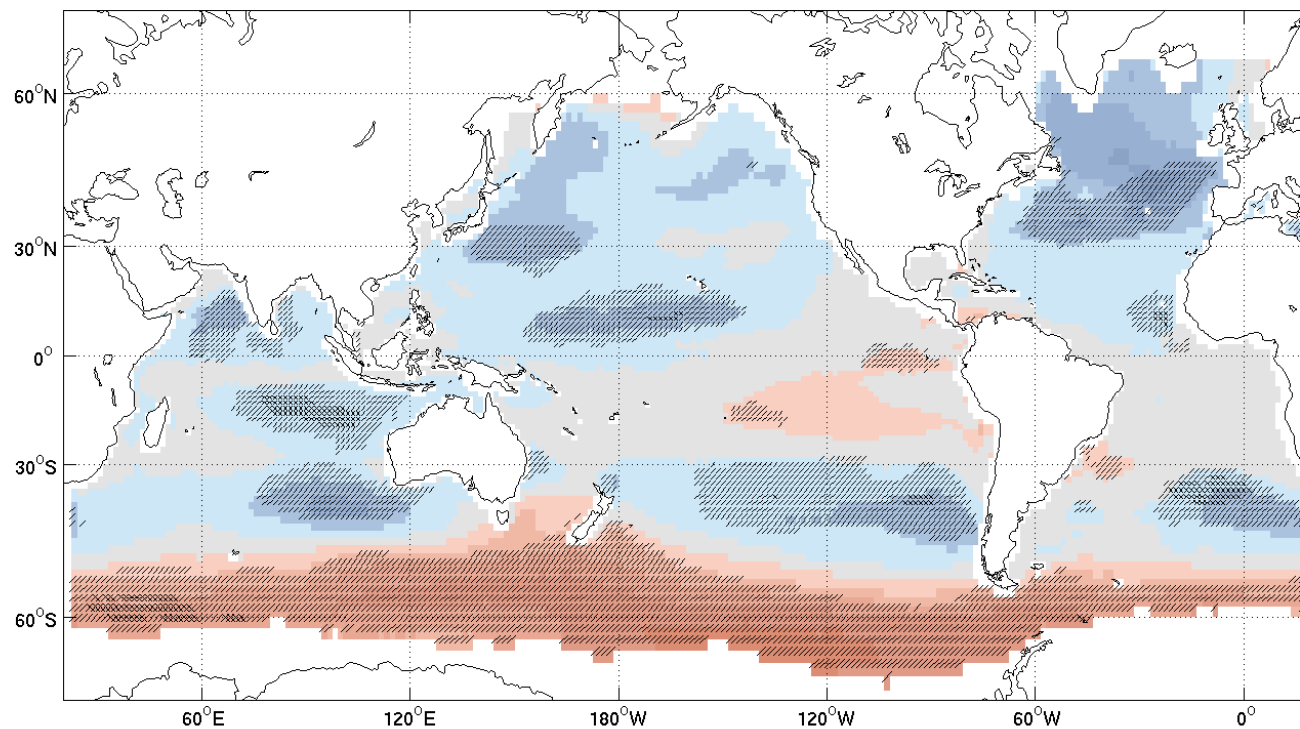
$/\!/ \quad \Delta_t > \sigma_e$

$\times\!\!\times \quad \Delta_t > 2\sigma_e$

-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
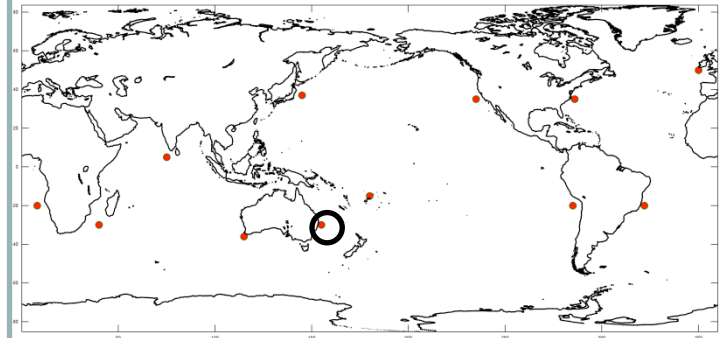Ensemble Annual Mean H_S (Future-Present) (m)

JFM

JAS

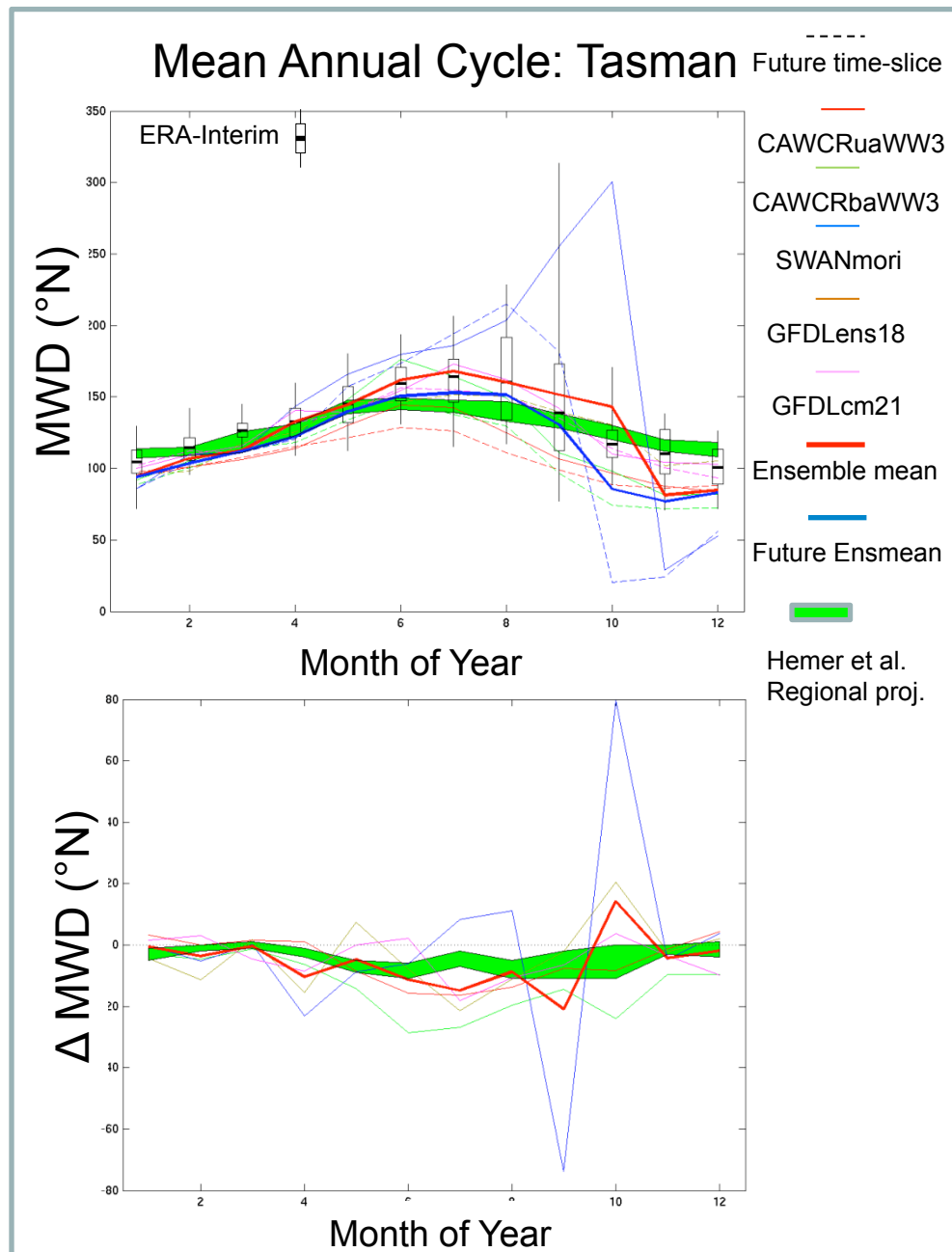# Including regional wave climate projection studies

D_M

Mean Annual Cycle: Tasman

Future time-slice

CAWCRuaWW3

CAWCRbaWW3

SWANmori

GFDLens18

GFDLcm21

Ensemble mean

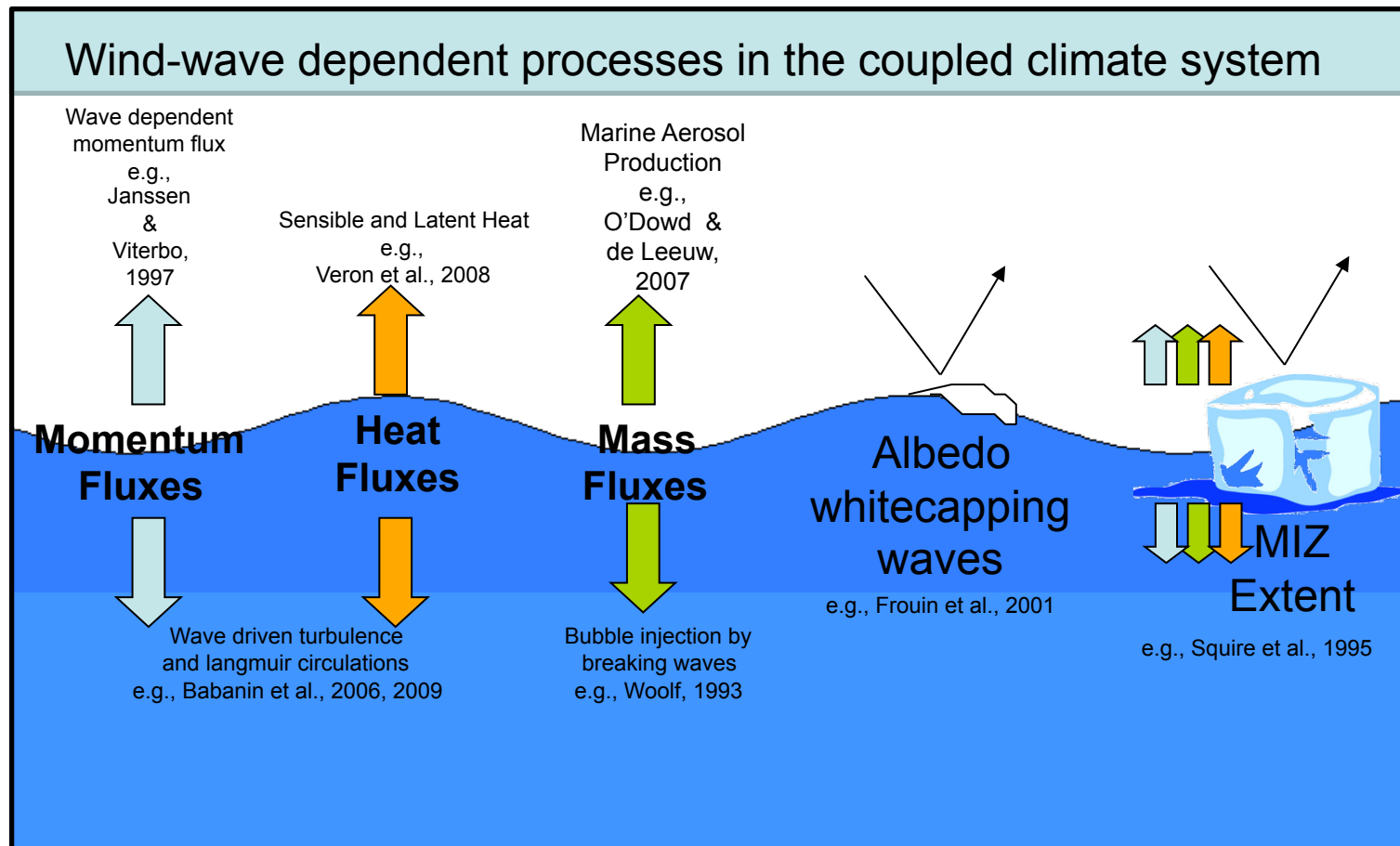Future Ensmean

Hemer et al. Regional proj.

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 (CAWCR, UC-Boulder, MPI-M, GFDL, ….)

Wind-wave dependent processes in the coupled climate system

Wave dependent momentum flux e.g., Janssen & Viterbo, 1997

Momentum Fluxes

Wave driven turbulence and langmuir circulations e.g., Babanin et al., 2006, 2009

Sensible and Latent Heat e.g., Veron et al., 2008

Heat Fluxes

Marine Aerosol Production e.g., O'Dowd & de Leeuw, 2007

Mass Fluxes

Bubble injection by breaking waves e.g., Woolf, 1993

Albedo whitecapping waves

e.g., Frouin et al., 2001

MIZ Extent

e.g., Squire et al., 1995

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.

Thanks.

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