Evaluation of CMIP6 global high-resolution wind forcing performance for regional wave climate modeling off the coast of South-East Australia

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UNIVERSITÀ DI TORINO

THE UNIVERSITY OF MELBOURNE

Summary

- An introduction to regional wave climate modeling
- Research methodology
- Wind forcing climatology comparison
- Regional wave climate modeling results: mean and extremes climatology

1. To provide a direct evaluation of the CMIP6 surface wind speed spatial resolution impact on regional wave climate modeling

2. To assess different strategies for regional wave climate modeling

Research goals

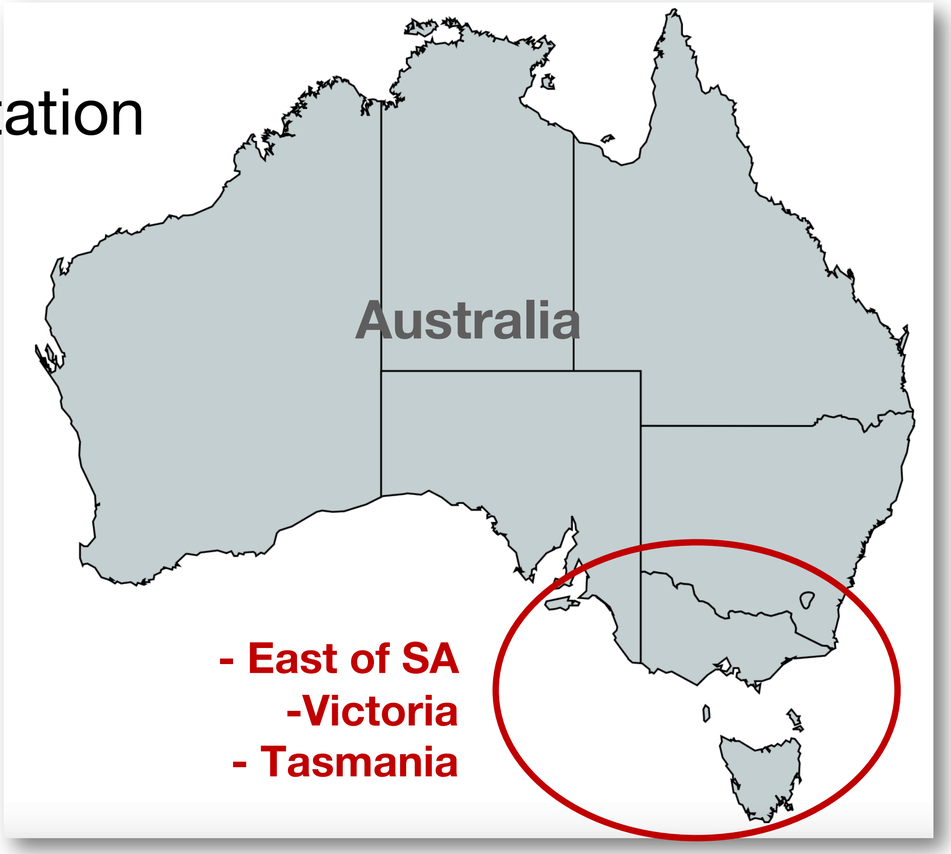
Understanding regional ocean wave climate

How wind waves extremes impact on South-East Australia wave climate

- Coastal safety
- Environmental impact
- Offshore operations
- Climate change adaptation

The Sunshine Coast shoreline (AU)

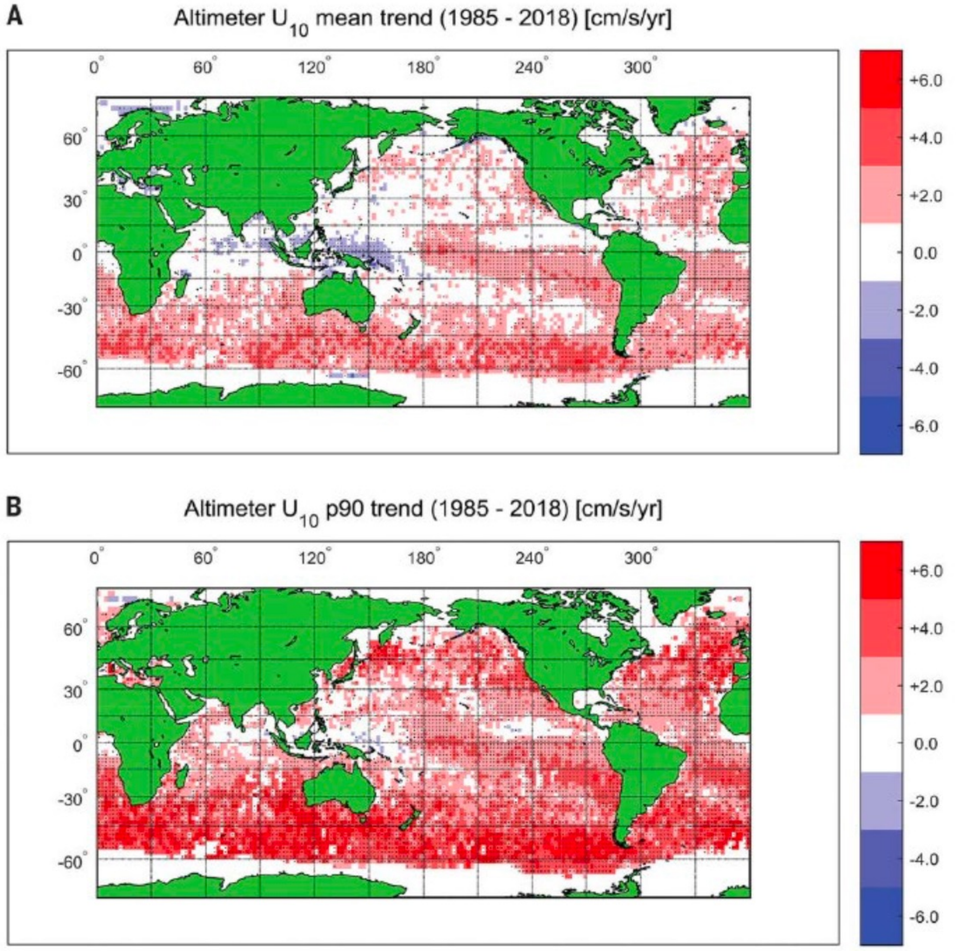
Offshore wind turbine

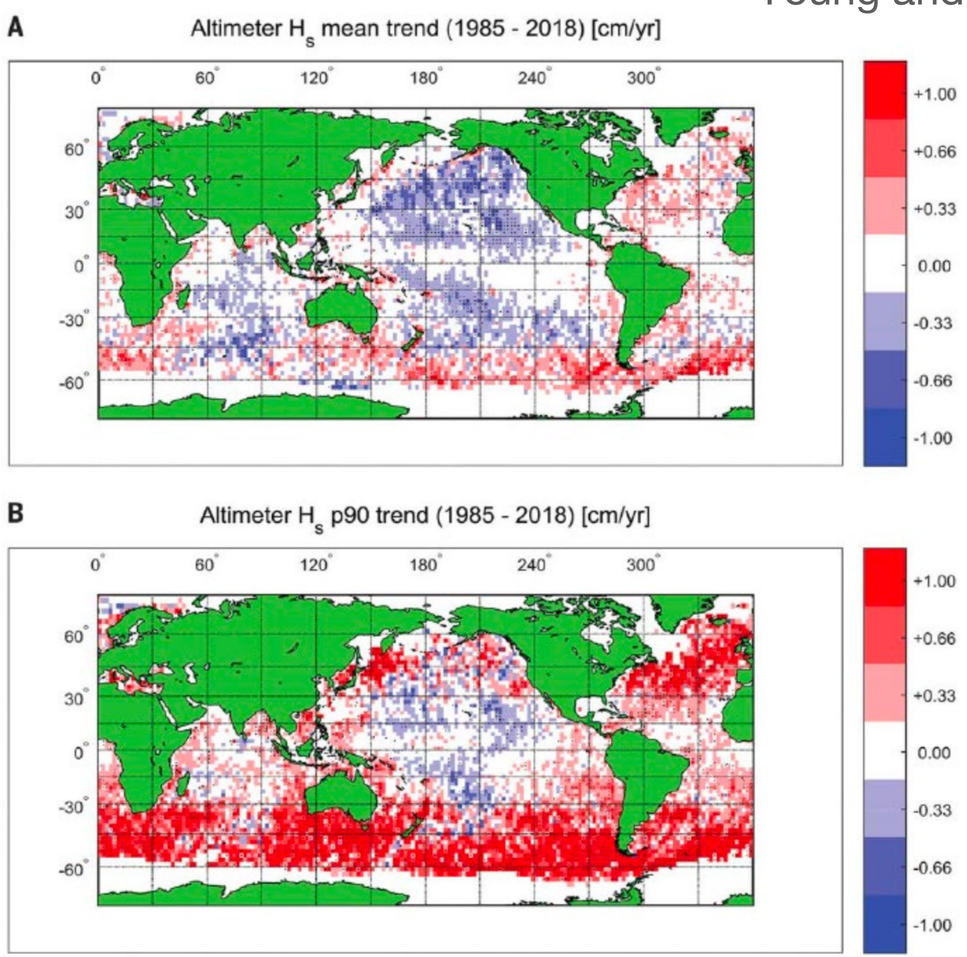


Evaluating global historical trends

Wind speed and significant wave height, 1985-2018*

*Young and Ribal 2019



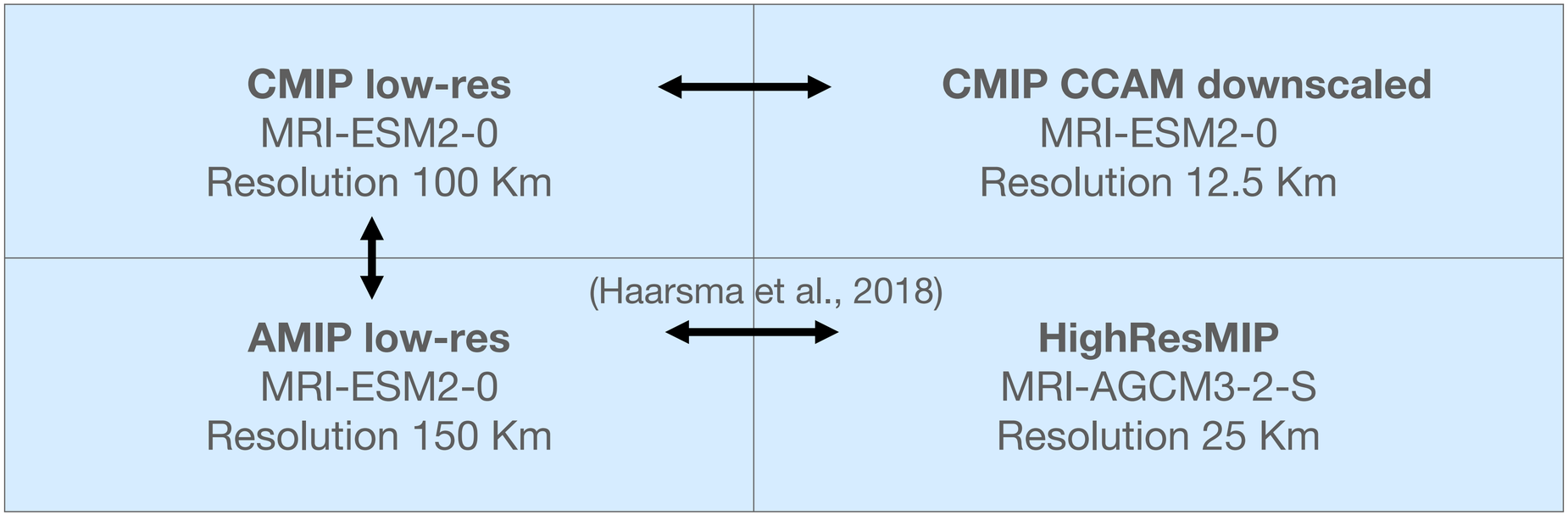


Experiments and datasets

Models with 3-hourly surface wind speed for the 30-years 1985-2014

from the **M**eteorological **R**esearch **I**nstitute (Japan)

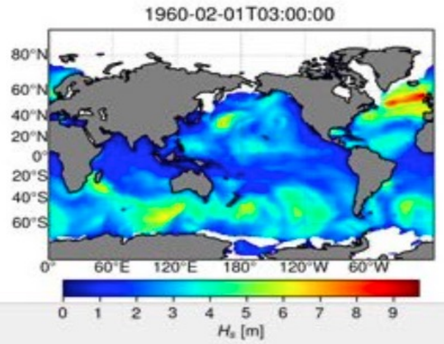
Experiments: **C**oupled (ocean-atmosphere) **M**odel **I**ntercomparison **P**roject, **A**tmospheric (only) **MIP** and HighRes**MIP**



Benchmark: ERA5

Methodology – Wave climate simulations

To evaluate the impact of high-resolution surface winds

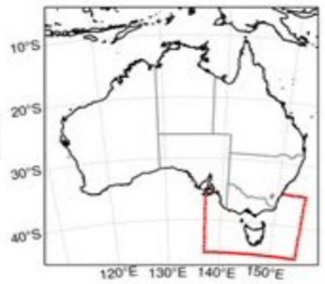


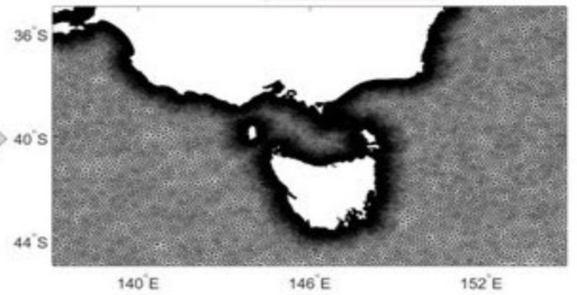
- **A1.** CMIP AMIP (>100km winds)
- **A2.** HighResMIP (25km winds)

A. ~55km **Global wave climate model**

B. 10km/500m **Regional wave climate model**

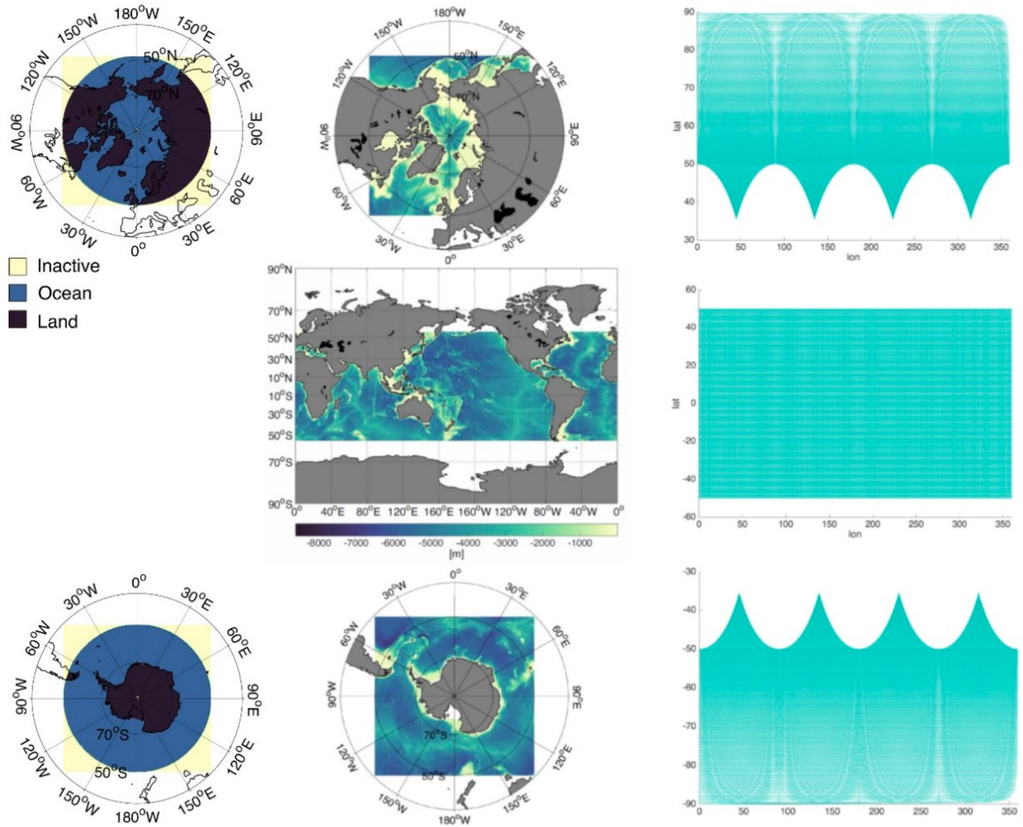
- **B1.** CMIP AMIP (>100km winds)
- **B2.** HighResMIP (25km winds)





Global Wave Model - setup

Implemented on WAVEWATCH III v6.07



- Curv. grid 34 Km res. @70°N
- Regular 0.5° rect. grid 55 Km res.
- Curv. Grid. 34 Km res. @70°S

Irregular **R**egular **I**rregular grid* *(Rogers et al., 2018)

Sea-ice

- <25% open ocean
- 25% < SI < 75% In deacy
- >75% land

Physics

- ST6 parametrization
- DIA scheme non-linear int.
- No currents

Outputs (Meucci et al., 2023)

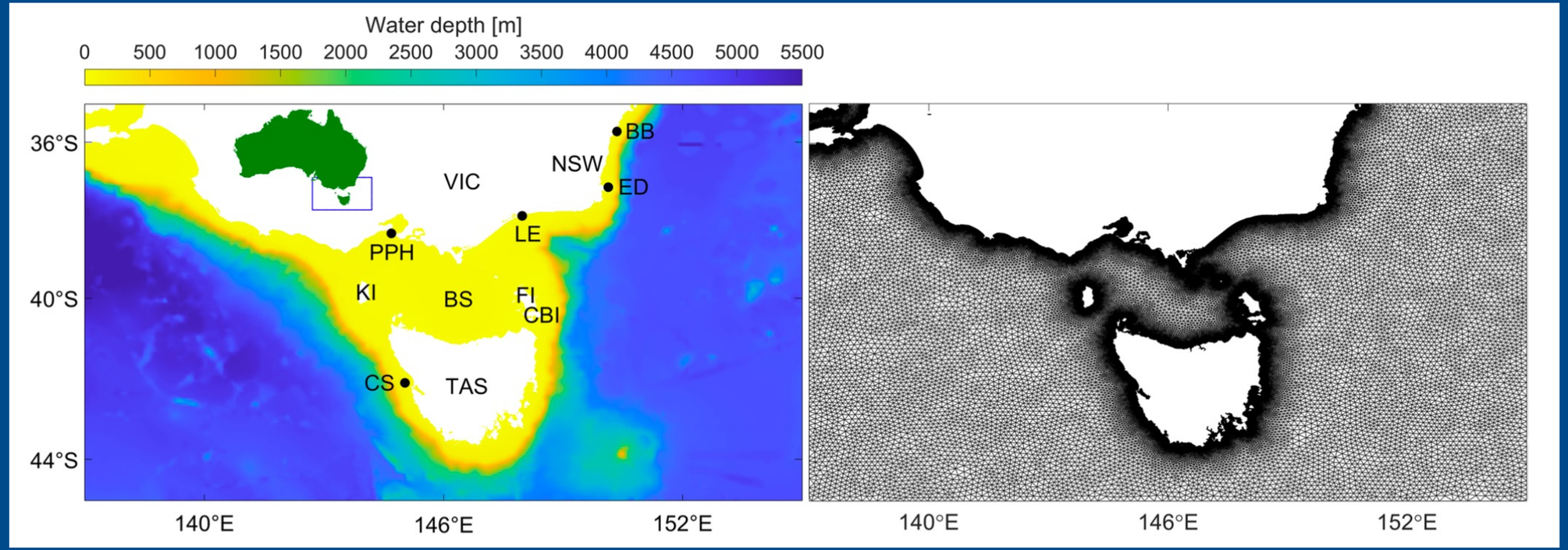
- 3-hourly re-gridded over a global 0.5° regular grid
- Spectral resolution: 50 freq. (0.35 – 0.96 Hz) and 36 dir. (delta = 10°)

Regional Wave Climate Model – setup

Unstructured grid for the South-East of Australia*

- Research domain: 137-155° E, and 35-45° S
- Grid resolution *from 10 Km to 500m*
- Same ST6 physics as the global model
- Complex bathymetry

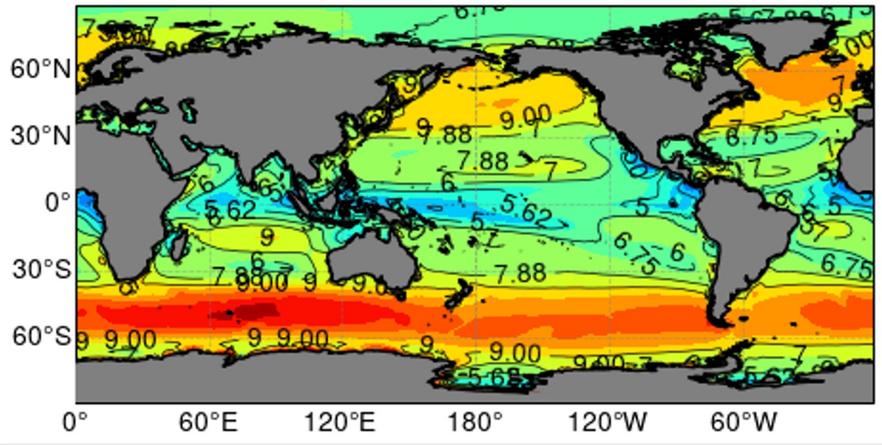
*Liu J. et al., 2022

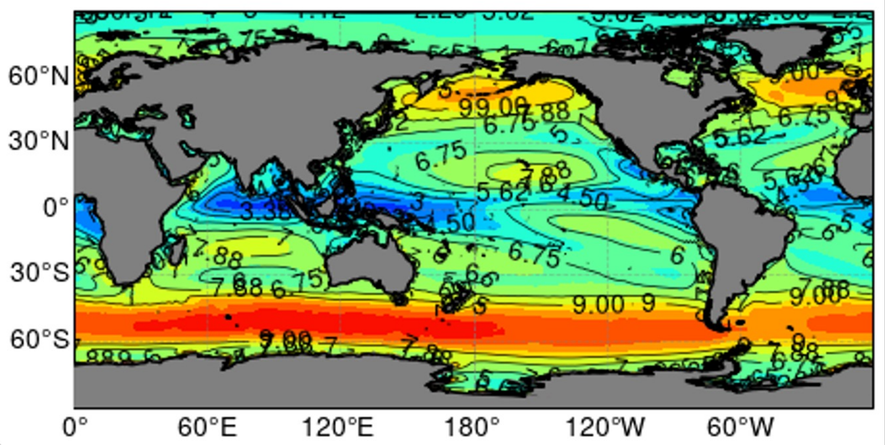


GCMs MIP experiments comparison

U10 mean 1985-2014 – global domain

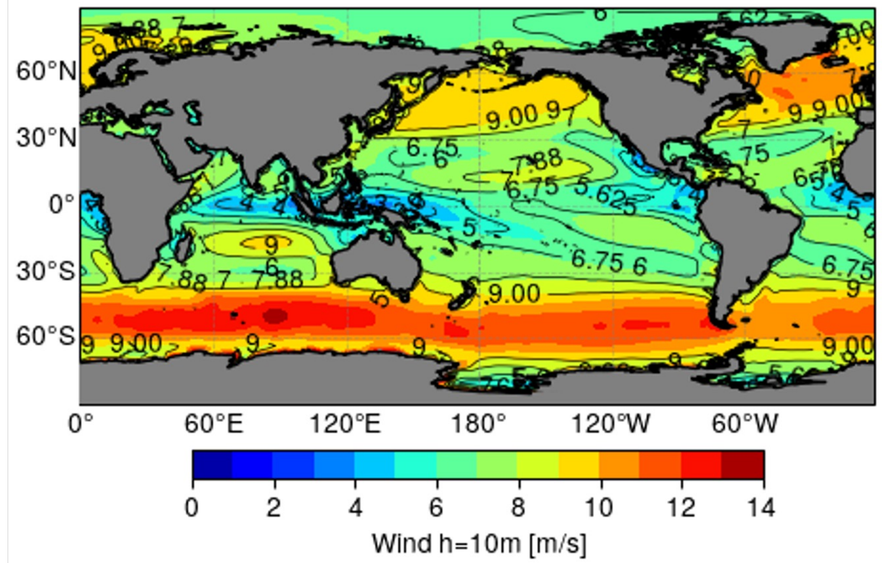
CMIP
MRI-ESM2-0
Res. 100 Km

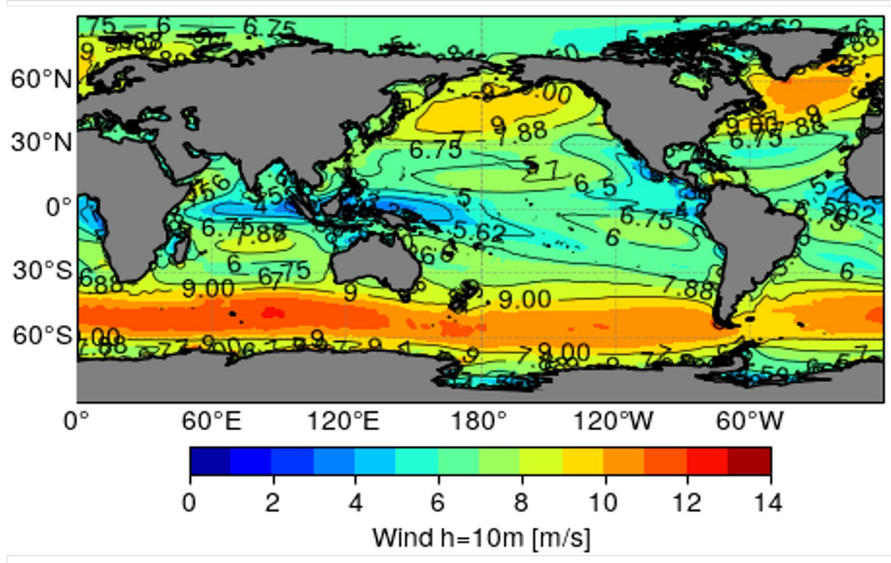




Downscaled CMIP CCAM
MRI-ESM2-0
Res. 12.5 Km

AMIP
MRI-ESM2-0
Res. 150 Km



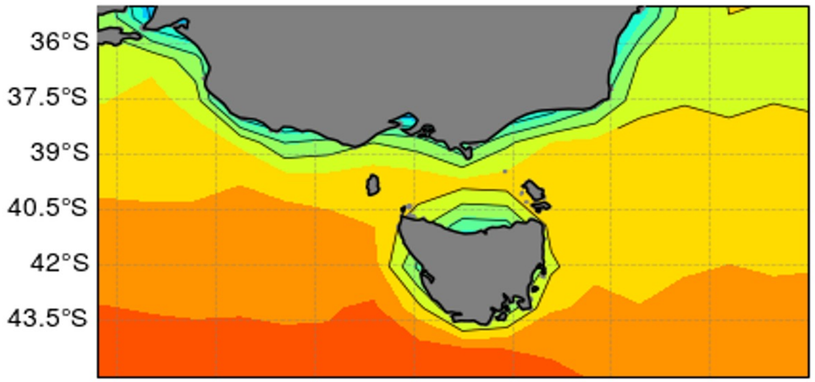


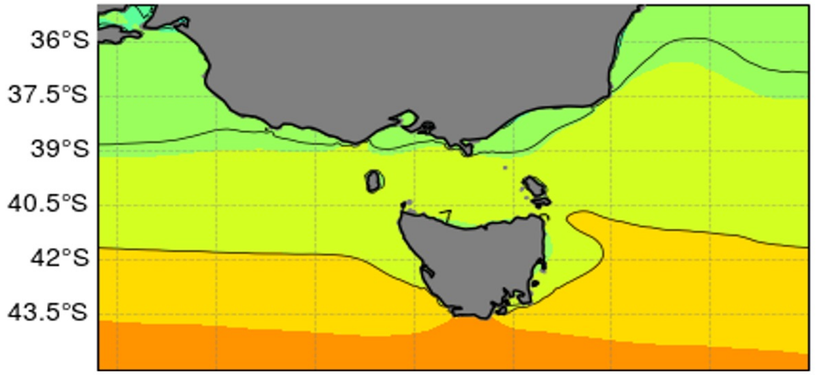
HighResMIP
MRI-AGCM3
Res. 25 Km

GCMs MIP experiments comparison

U10 mean 1985-2014 – regional domain

CMIP
MRI-ESM2-0
Res. 100 Km





Downscaled CMIP CCAM
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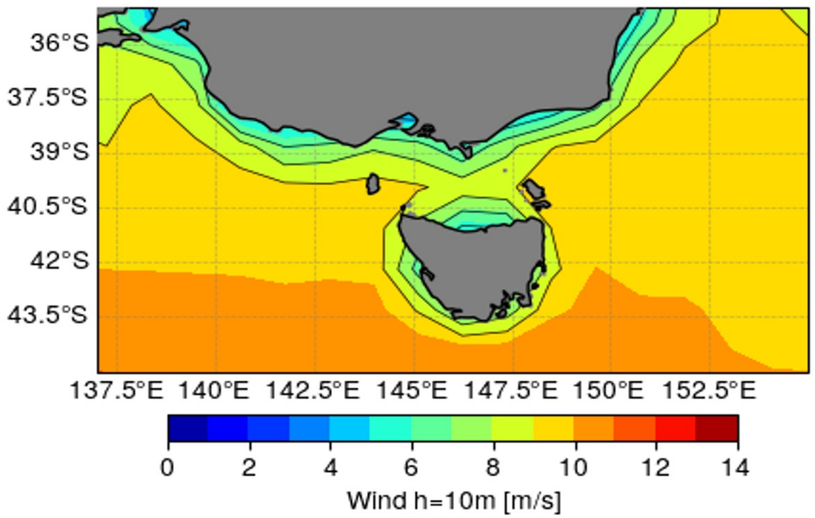
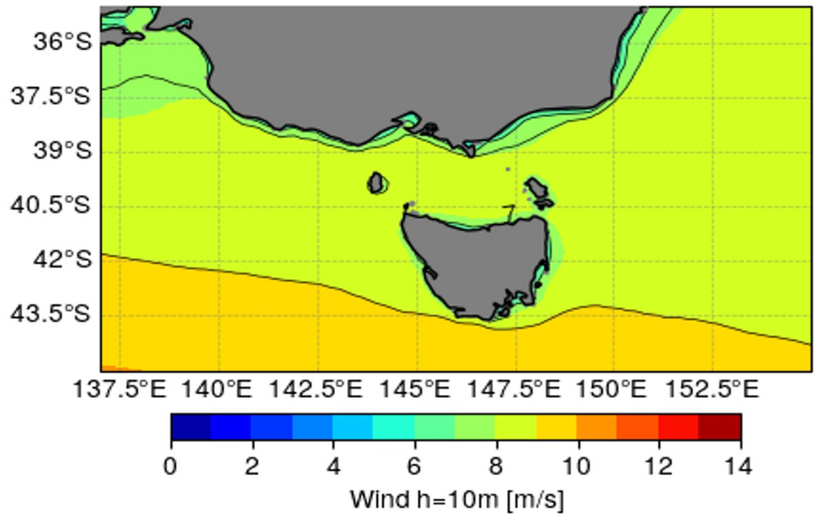




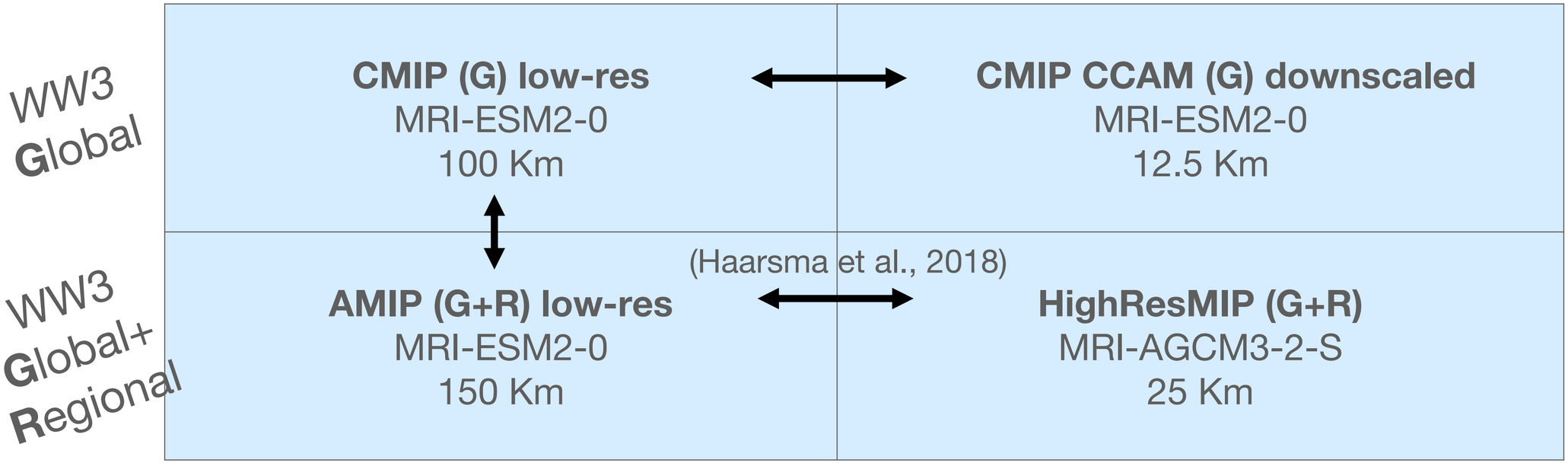
HighResMIP
MRI-AGCM3
Res. 25 Km

Climate simulations availability

WW3 with 3-hourly surface wind speed for the 30-years 1985-2014

from the **M**eteorological **R**esearch **I**nstitute (Japan)

Experiments: **C**oupled (ocean-atmosphere) **M**odel **I**ntercomparison **P**roject, **A**tmospheric (only) **MIP** and HighRes**MIP**

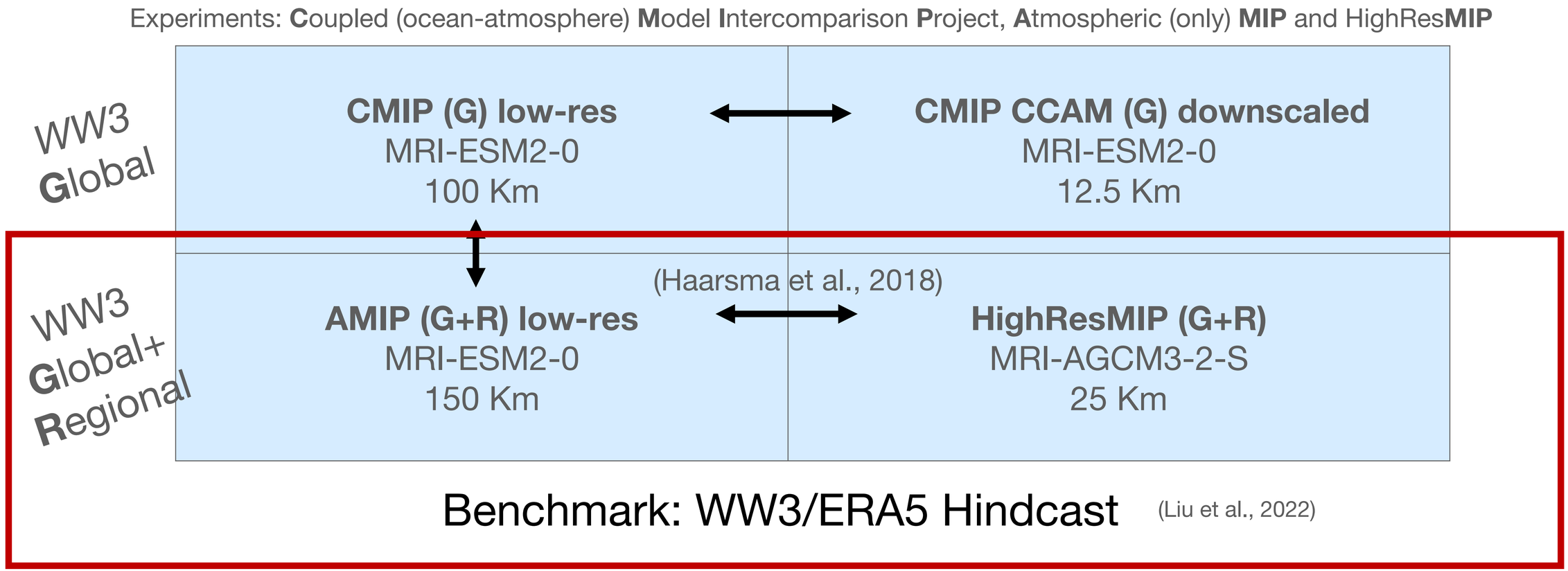


Benchmark: WW3/ERA5 Hindcast (Liu et al., 2022)

Climate simulations availability

WW3 with 3-hourly surface wind speed for the 30-years 1985-2014

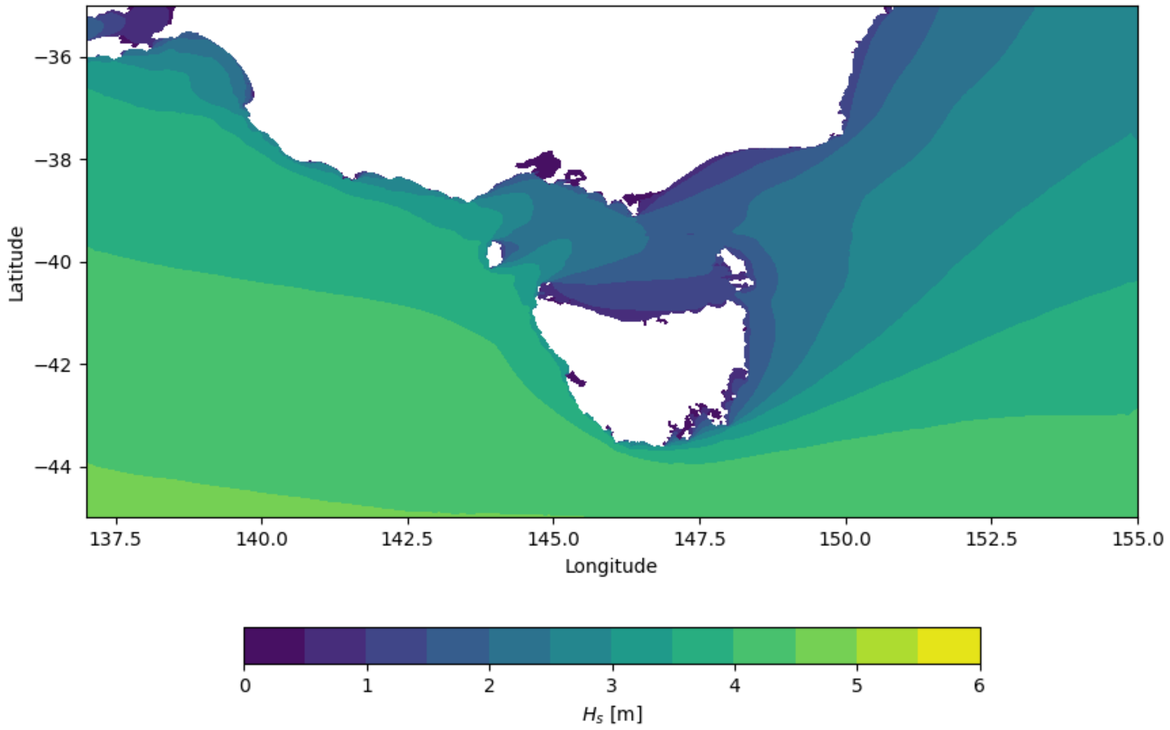
from the **M**eteorological **R**esearch **I**nstitute (Japan)



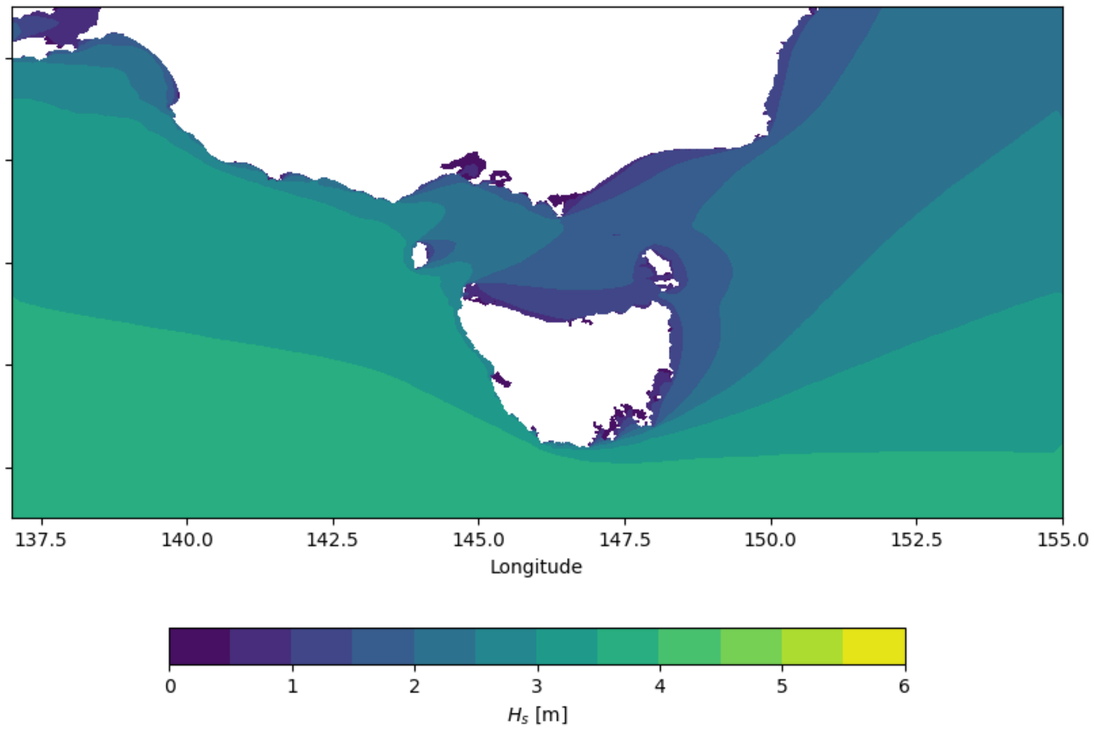
Regional wave climate modeling

Mean significant wave height, 1985 – 2014

Forced with u10 from
MRI-ESM2-0 - AMIP 150 Km



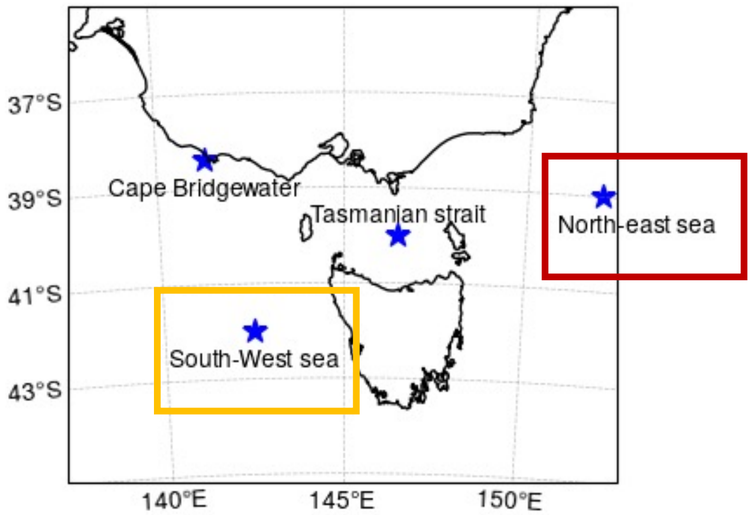
Forced with u10 from
MRI-AGCM3-2-S - HighResMIP 25 Km

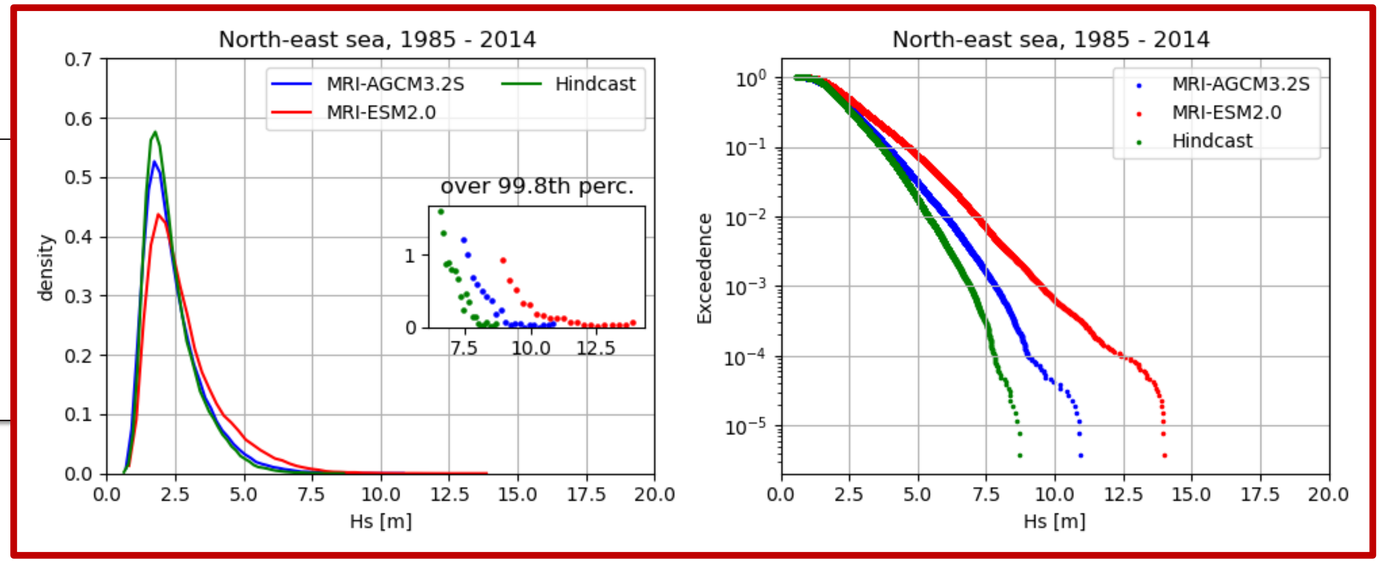


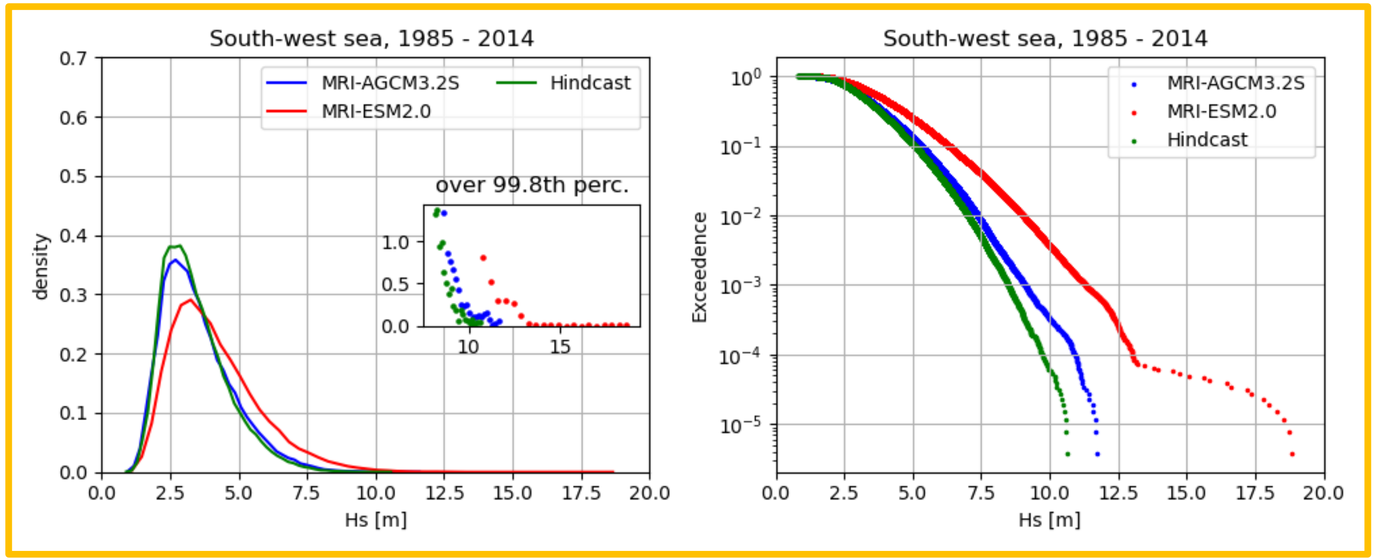
Regional wave climate modeling

Extremes analysis

- ERA5
- AMIP std res.
- HighresMIP







Conclusions

- The assessment of the AMIP and HighResMIP-forced RWCM **results showed that higher wind speed forcing res. does not imply larger extremes** in the region of SE Australia
- **HighresMIP has a better climatology** than the AMIP std res. product
- **The CMIP and AMIP models are biased high** in the Southern Hemisphere, particularly over the Southern Ocean

Future steps

- To extend our analysis to Tm02, CgE, wave direction
- CMIP CCAM downscaling* evaluation

CMIP (G+R) low-res MRI-ESM2-0 100 Km	**CMIP CCAM (G+R) downscaled** MRI-ESM2-0 12.5 Km
AMIP (G+R) low-res MRI-ESM2-0 150 Km	**HighResMIP (G+R)** MRI-AGCM3-2-S 25 Km

*Skytus. et al., 2023

Thanks for the attention

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Regional wave climate modeling

Extremes analysis

- ERA5
- AMIP std res.
- HighresMIP