The new COWCLiP Phase-3 community ensemble for CMIP6 wave climate projections – future changes and uncertainties in wave extremes

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Contributing institutions: University of Melbourne, National Oceanography Centre, Instituto Dom Luiz,IHE-Delft, Environment and Climate Change Canada, IHCantabria, INCOIS, Mercator Ocean International, USGS/UC Santa Cruz.

Summary

- Context
- Data
- Methods
- Results
- Conclusions

Context

What is **COWCLiP**?

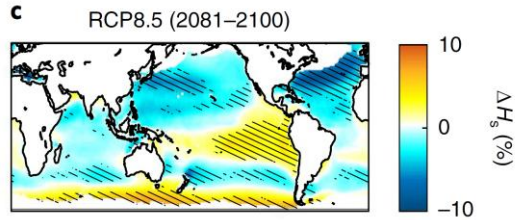
The Coordinated Ocean Wave Climate Project (**COWCLiP**) aims to aid comprehensive assessments of **climate driven changes** in wave characteristics (ultimately of global extent), both **historically** and in **projected** future scenarios , with understanding of associated **uncertainties**.

What have we done in COWCLiP so far in terms of **projected changes**?

Processing and sharing of big ensembles for the community

Two big global wave climate projection ensembles: CMIP3, CMIP5.

Development of associated scientific analysis



e.g., Morim et al., 2019

Where does **this work** fit within COWCLiP?

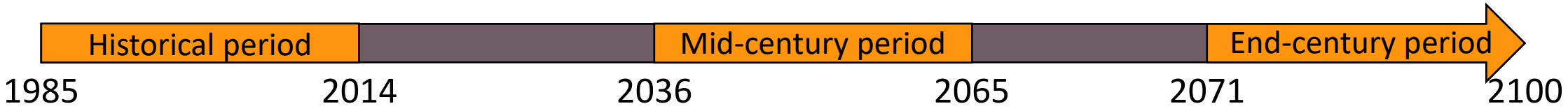
This study addresses the development and analysis of the new COWCLiP global wave climate projection ensemble, based on CMIP6 projections (**COWCLiP-3**).

It focuses on projected changes in **extremes**.

Data

Institutions	Models	Scenarios	Period	Variables	Statistics
University of Melbourne	EC-Earth3	SSP1-2.6	Mid-century	Hs	Total, monthly, seasonal, yearly means
NOC	ACCESS-CM2				
Instituto Dom Luiz	AWI-CM1-1-MR			Tm	Total, monthly, seasonal, yearly percentiles
Kyoto University	CMCC-CM2-SR5				
Environment and Climate Change Canada	IPSL-CM6A-LR	SSP2-4.5		Tp	Total, monthly, seasonal, yearly maximum values
IHCantabria	KIOST-ESM				
INCOIS	MRI-ESM2-0			Dirm	Total, monthly, seasonal, yearly standard deviations
Mercator Ocean International	MPI-ESM1-2-LR				
USGS / UC Santa Cruz	HadGEM3-GC31-MM	SSP3-7.0	End-century	CgE	
IHE-Delft	CanESM5				
	CNRM-CM6-1-HR				
	MPI-ESM1-2-HR				
	BCC-CSM2-MR				
	GFDL-CM4				
	MIROC6				
	EC-Earth3P-HR				
	HadGEM3-GC31-HH	SSP5-8.5			
	HadGEM3-GC31-HM				
	CMCC-CM2-VHR4				
	GFDL-CM4C192				
	MRI-AGCM				

Methods



Projected changes

Relative changes for each member: $\frac{X_{fut} - X_{hist}}{X_{hist}} x100$

Ensemble mean changes are calculated as the **weighted mean**, with all **members** assigned the **same weight**.

Extreme value analysis

Frequent extremes

- Threshold: P99 Hs in the historical period.
- Comparison frequency and magnitude of exceedances in the historical vs. future periods.

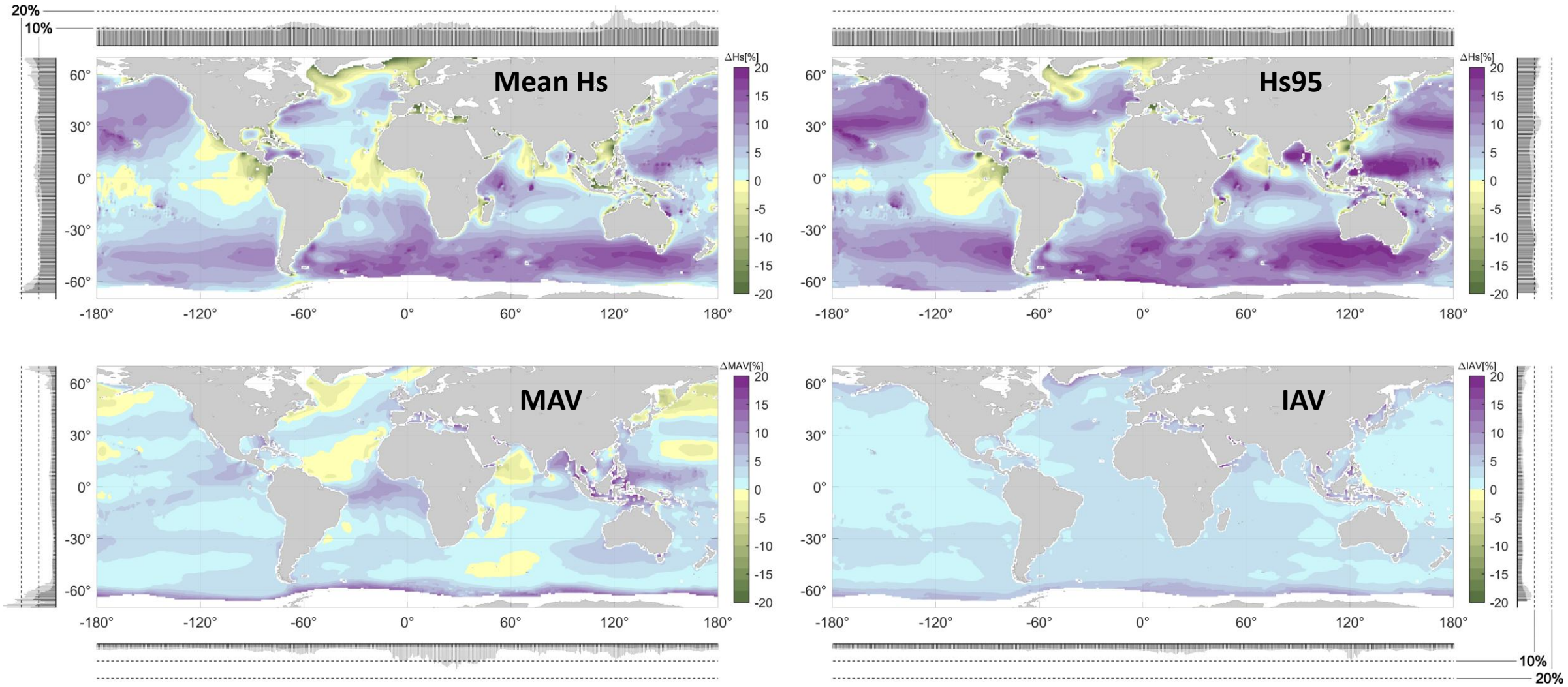
Rare extremes

- Non-stationary GEV (monthly maxima).
- Estimation of different Hs return levels (e.g. R10, R25).

Results

Ensemble evaluation: Biases

BIAS = GCM – ERA5 reanalysis



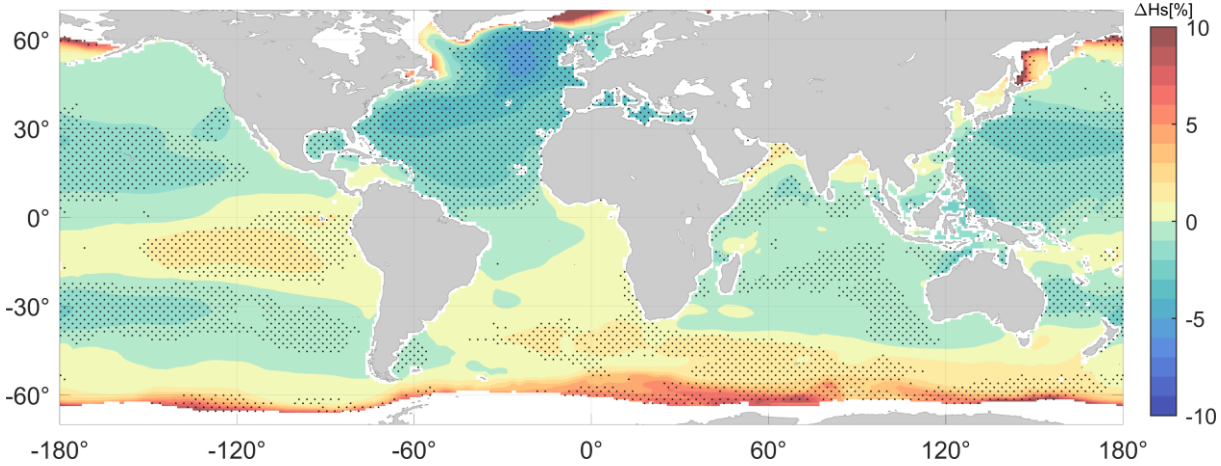
$$MAV = \frac{std(\bar{x}_m)}{mean(\bar{x}_m)}; \bar{x}_m: \text{monthly means}$$

$$IAV = \frac{std(\bar{x}_y)}{mean(\bar{x}_y)}; \bar{x}_y: \text{yearly means}$$

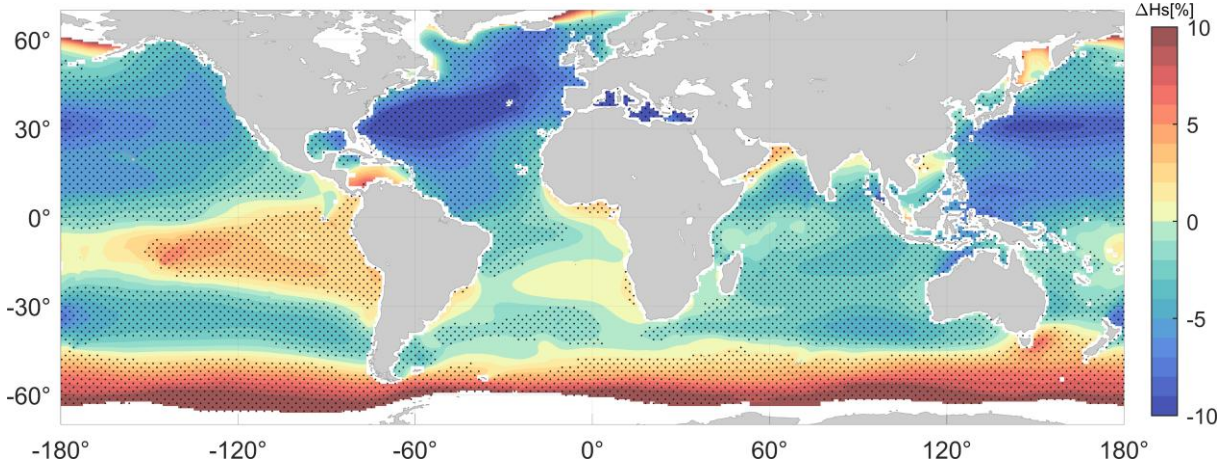
Results

Projected changes: Climatologies

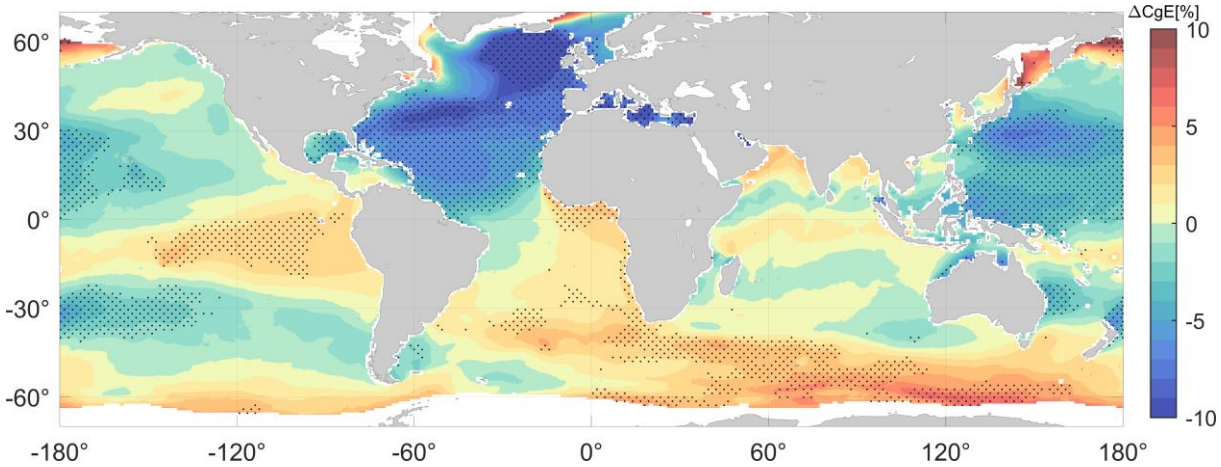
Mean Hs – end-century – SSP1-2.6 [20]



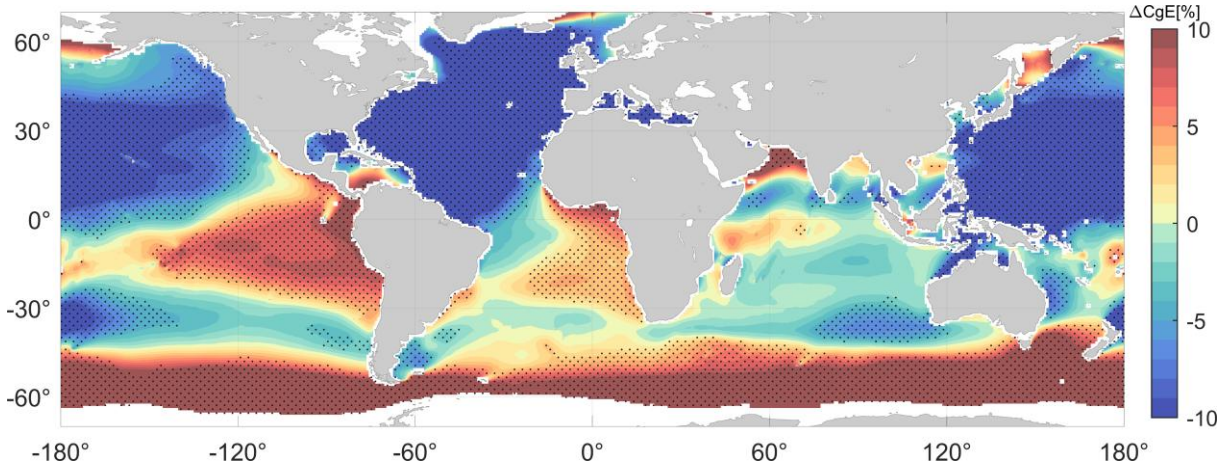
Mean Hs – end-century – SSP5-8.5 [28]



P95 CgE – end-century – SSP1-2.6 [16]



P95 CgE – end-century – SSP5-8.5 [21]

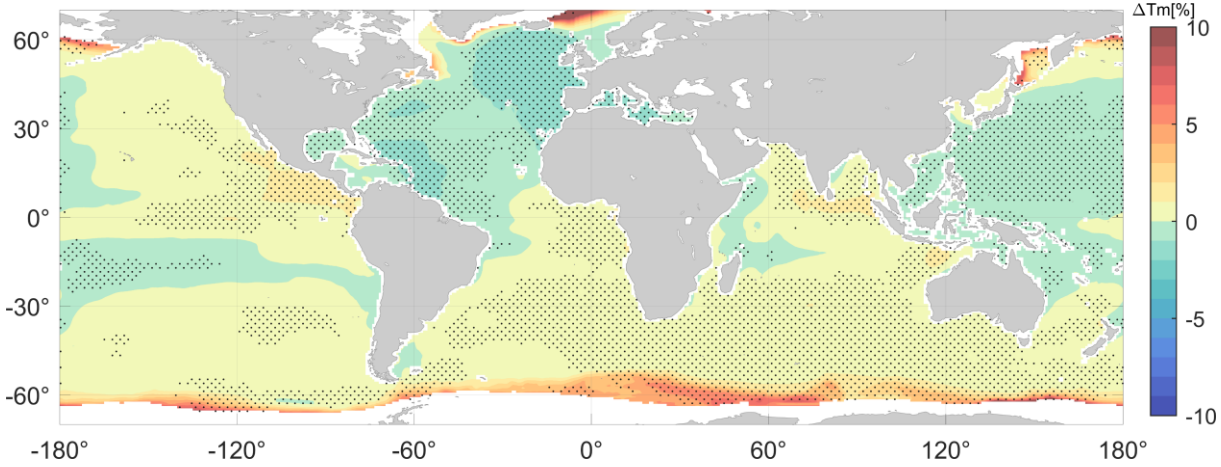


**Stippling indicates > 80% members agree on the sign of change*

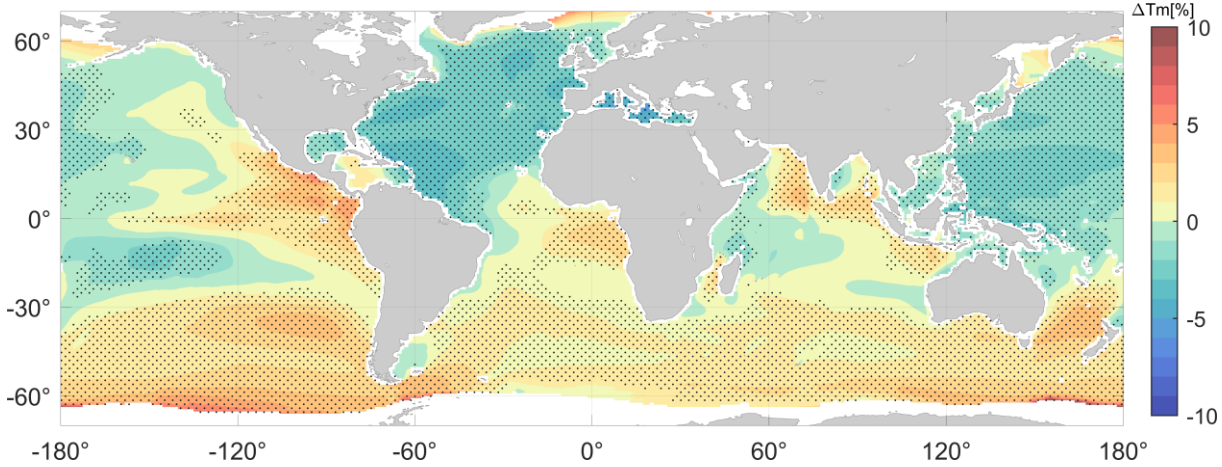
Results

Projected changes: Climatologies

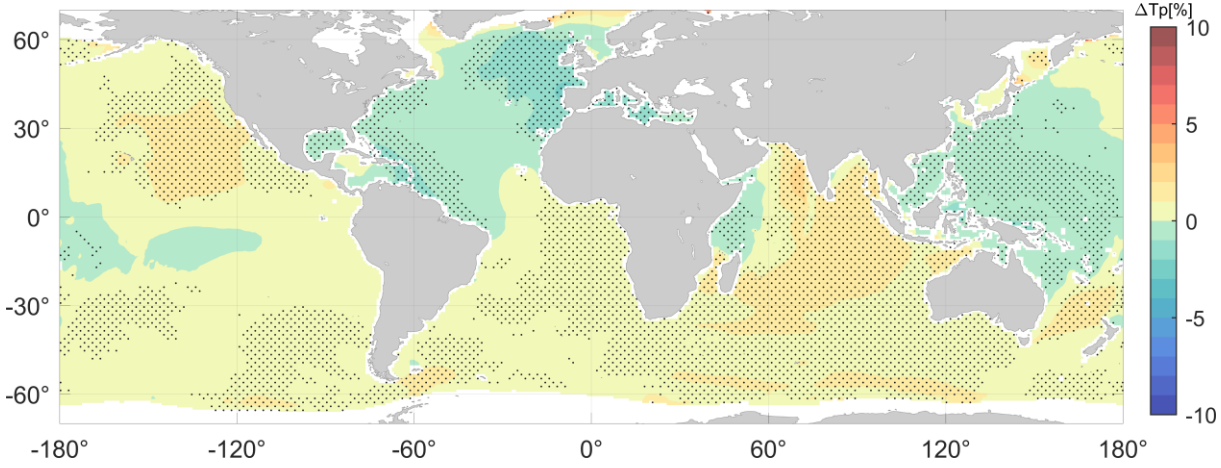
Mean Tm – end-century – SSP1-2.6 [20]



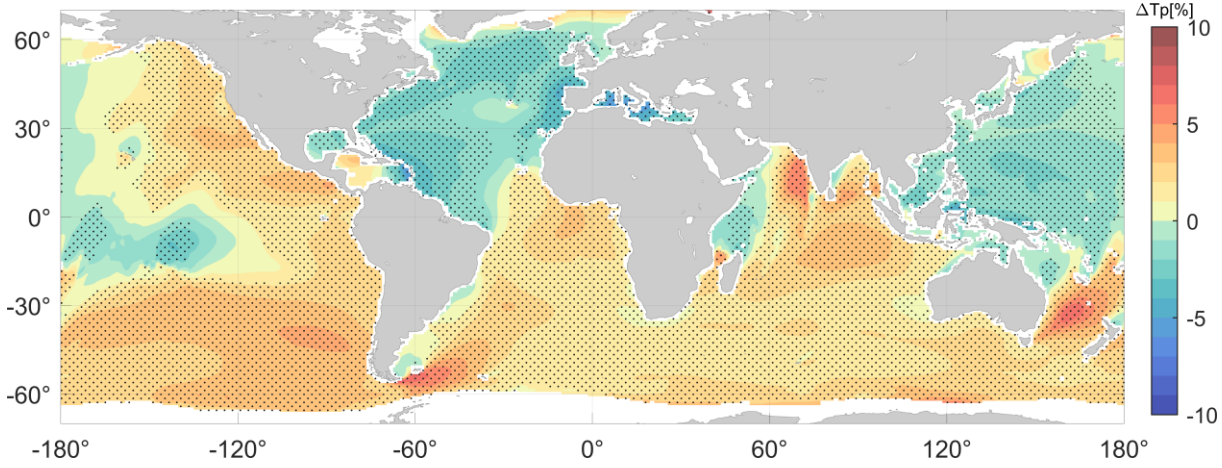
Mean Tm – end-century – SSP5-8.5 [28]



Mean Tp – end-century – SSP1-2.6 [20]



Mean Tp – end-century – SSP5-8.5 [28]



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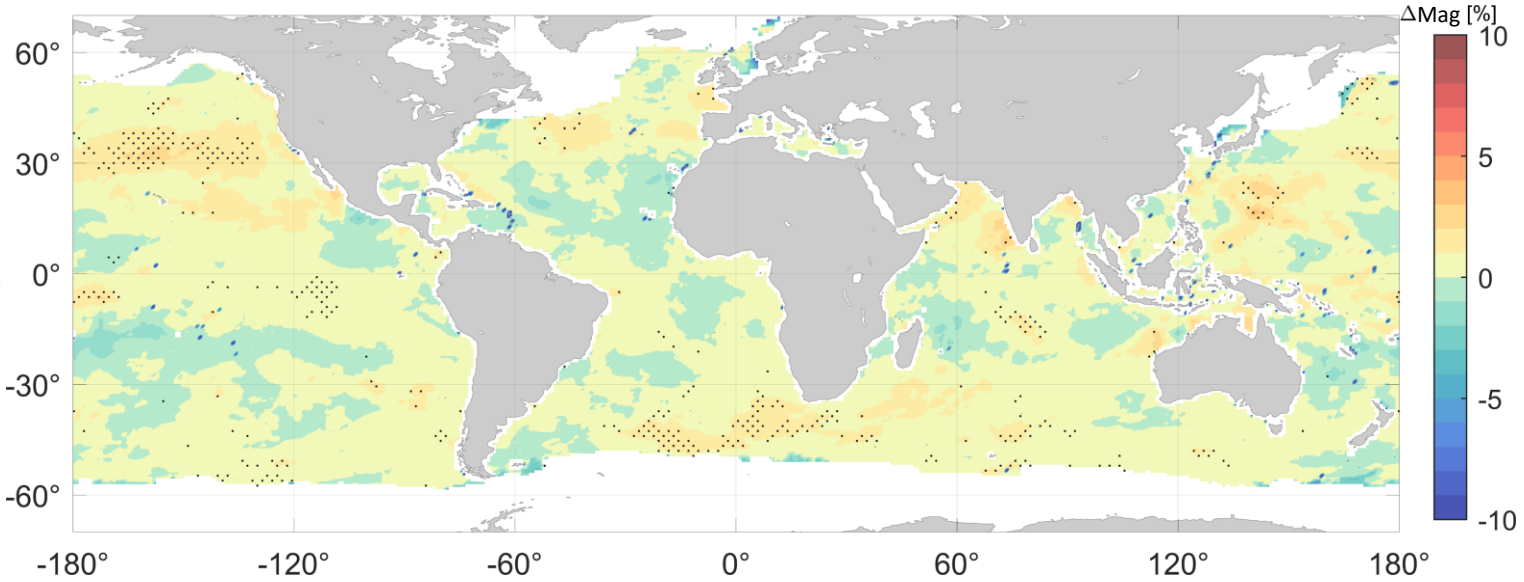
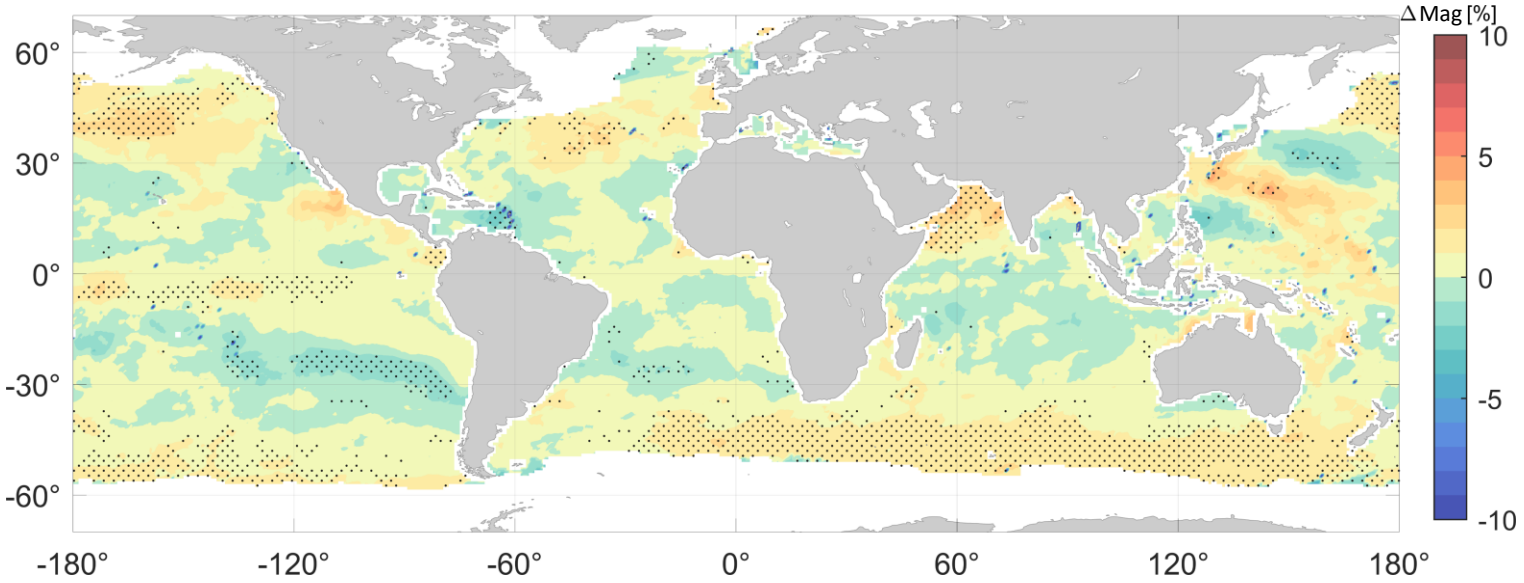
Results

Projected changes: Frequent extremes

Magnitude Hs storms end-century – SSP1-2.6 [20]



Magnitude Hs storms end-century – SSP5-8.5 [27]



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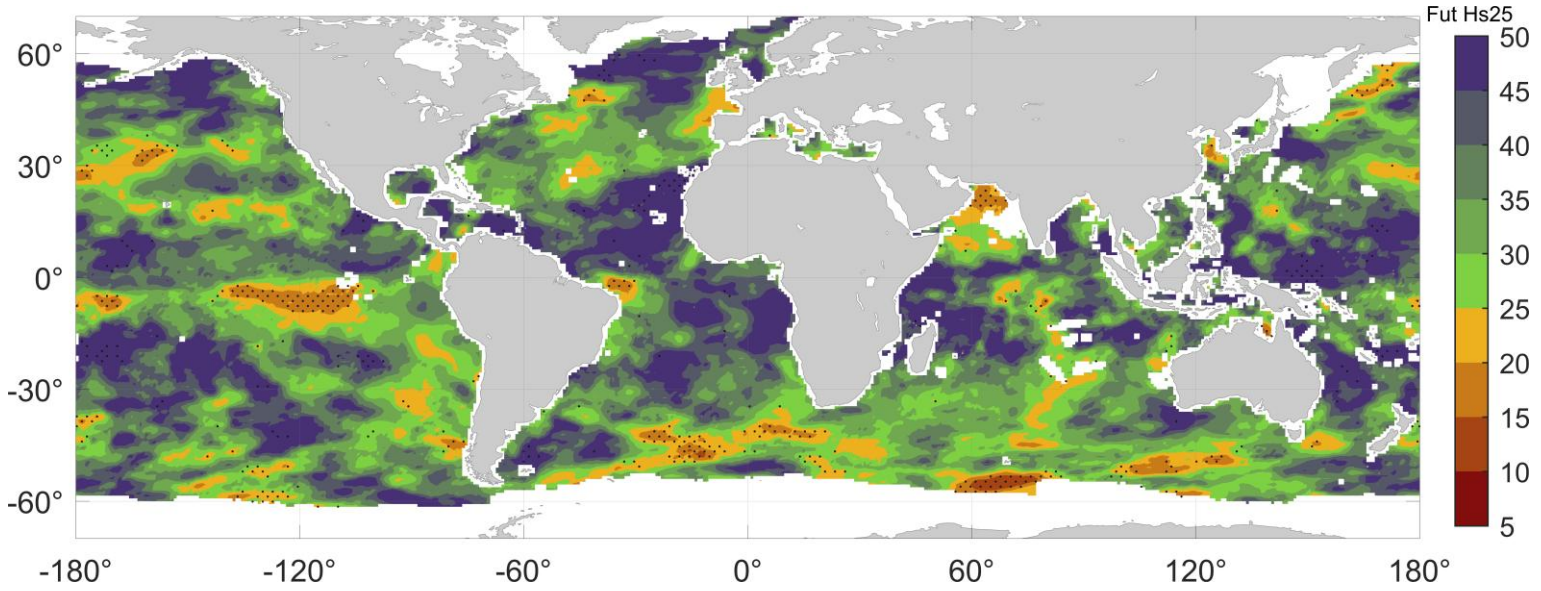
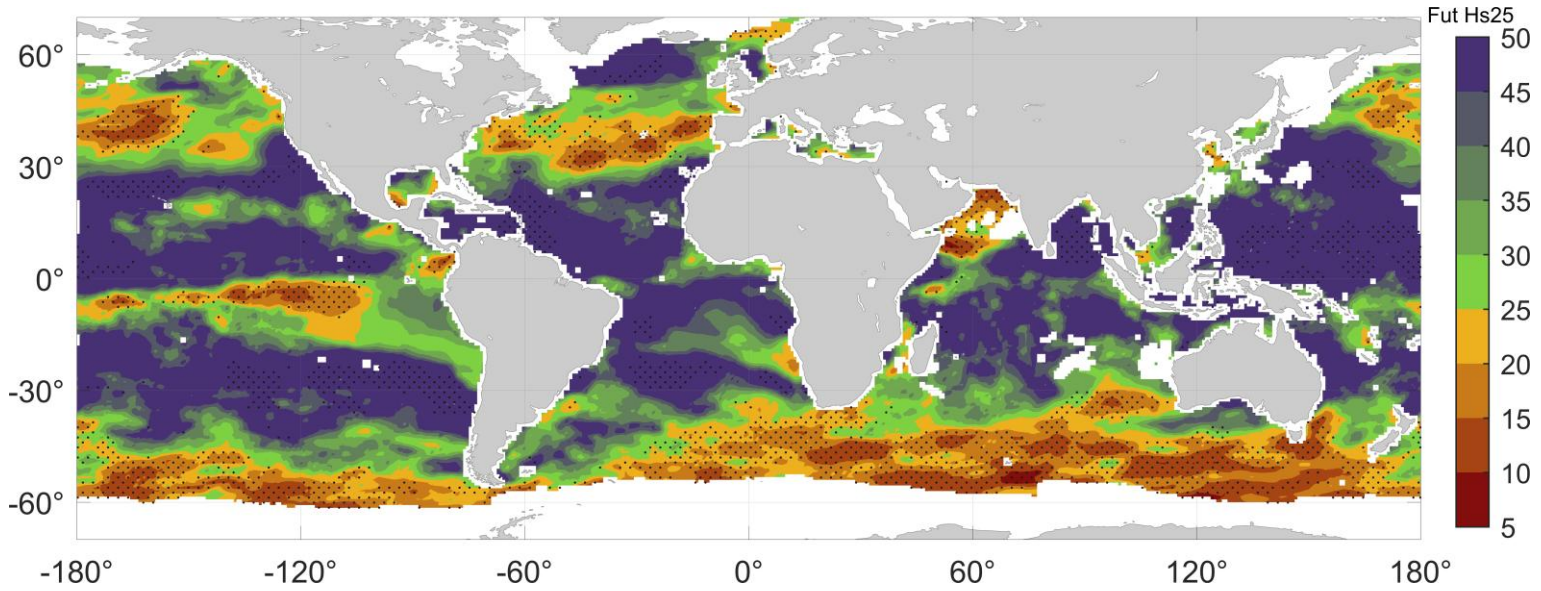
Results

Projected changes: Rare extremes

Hs RP25 end-century – SSP1-2.6 [20]



Hs RP25 end-century – SSP5-8.5 [27]



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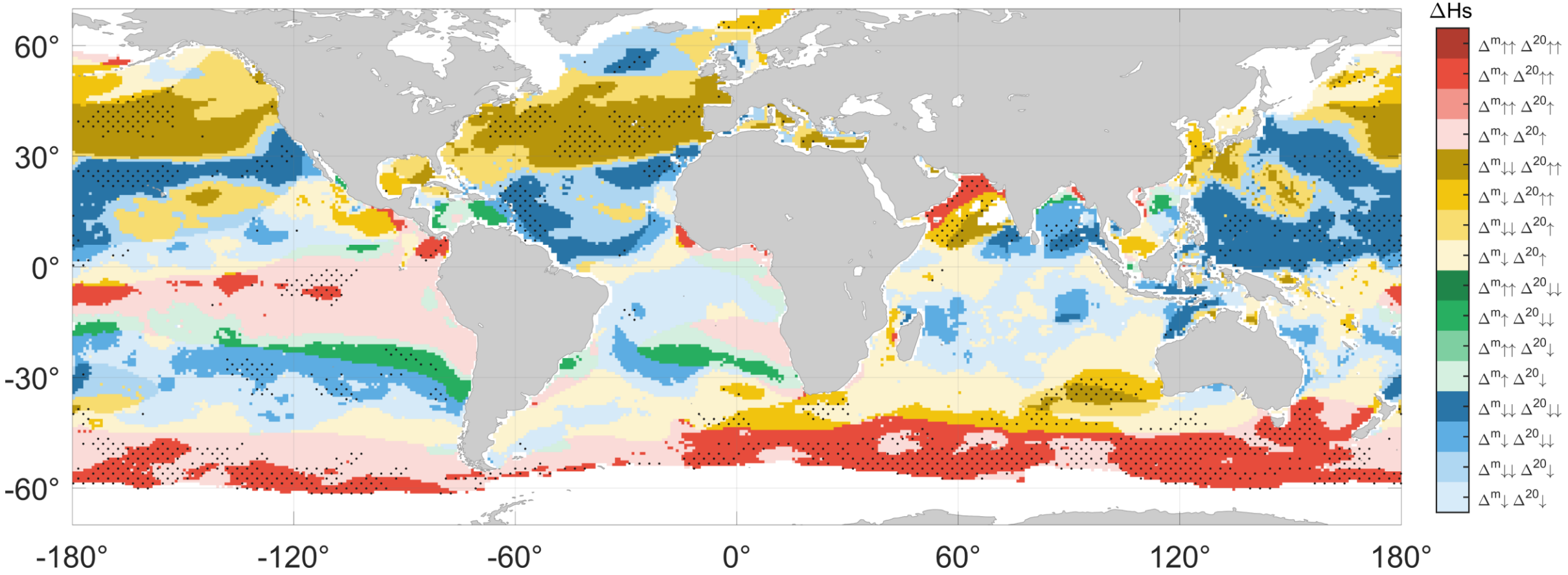
Results

Projected changes: Mean vs. Extreme conditions

Hs RP25 vs. mean Hs – end-century – SSP5-8.5



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Conclusions

- **New ensemble** based on **CMIP6** simulations covering **4 scenarios** and **2 horizon periods** with multiple members, focused on the assessment of changes in **extremes.**
- New variables included, such as **peak period** and **wave energy flux**.
- **Consistency between** projected changes in mean **climatologies** for **CMIP6-based** and **CMIP5-based** projections.
- **Robust increases** in **extreme** wave **height** events identified in the **North Pacific** and **North Atlantic**, consistent across the two approaches applied.
- Results highlight the **need for dedicated** studies to account for the **divergence** between **mean** and **extreme** conditions

Thank you! Questions?