Bias Correction of a Single-Forcing Dynamic Ensemble of Wave Climate Projections towards the End of the 21st Century

Gil Lemos
FCUL / Instituto Dom Luiz, Lisbon, Portugal

grlemos@fc.ul.pt
Earthsystems PhD program

6ªs JEH / 1ªs JLEH, November 4th, 2020

Álvaro Semedo (IHE Delft)
Mikhail Dobrynin (DWD Hamburg)
Melisa Menendez (IH Cantabria)
Pedro Miranda (Lisbon University)

➢ Wave climate projections: **why are they important?**

Wind waves: ocean surface gravity waves caused by the transfer of **momentum** from the **wind** to the **water**.

- **Most energetic ones**

(> 50% of the energy carried by all waves at the ocean surface)

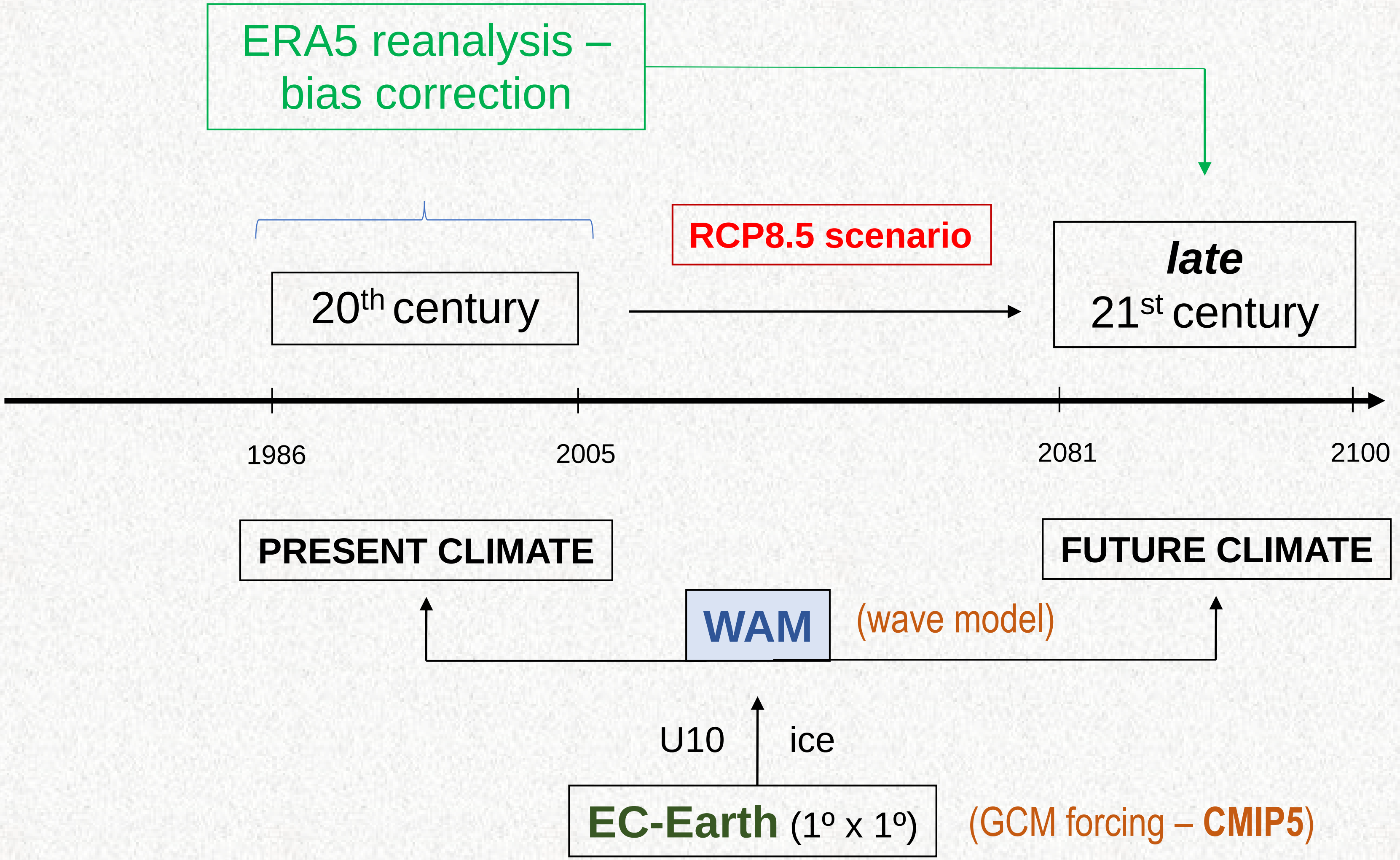
- **Why should we care about waves in the future?**

- Strong impact in coastal hazards (inundation, coastal erosion/deposition, etc.)
- Impact on coastal and offshore infrastructures
- Define ship and coastal/offshore structures design
- Impact operability, and safety factors (offshore platforms)

Historical & present wave climate
In-situ, altimetry, VOS, (…)

Future wave climate
Modellin[...]rts
GC[...]e models
BIASED

➢ **Methodolgy:** ensemble projections and bias correction



7-member ensemble
1º x 1º grid
6 hourly output

H_s, T_m, MWD, P_w

➢ **Results:** original and corrected biases during present climate (PC20)

- **EGQM**

$$X(q_i) = ECDF^{PC20^{-1}}(q_i) - ECDF^{ERA5^{-1}}(q_i), i = 1, \ldots, n_q$$

$$H_S{}^C(q_i) = H_S{}^{PC20}(q_i) + X(q_i), i = 1, \ldots, n_q$$

$$Bias = \frac{1}{N}\sum_{i=1}^{N} PC20_i - \frac{1}{N}\sum_{i=1}^{N} ERA5_i$$

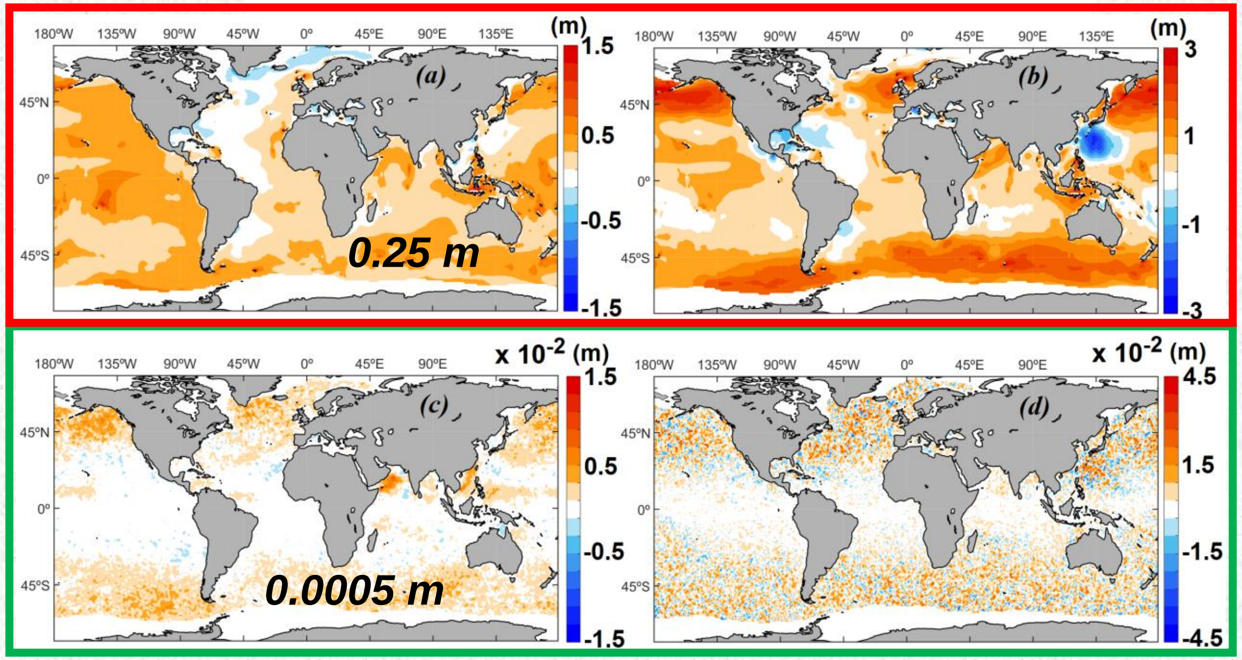
Quantiles chosen using a Gumbel distribution (focusing on extreme values)

$$x_{q_i} = q_{lo} + (i-1)\frac{q_{up} - q_{lo}}{n_q}, i = 1, \ldots, n_q$$

$$q_i = \exp\left[-\exp\left(-x_{q_i}\right)\right], i = 1, \ldots, n_q$$

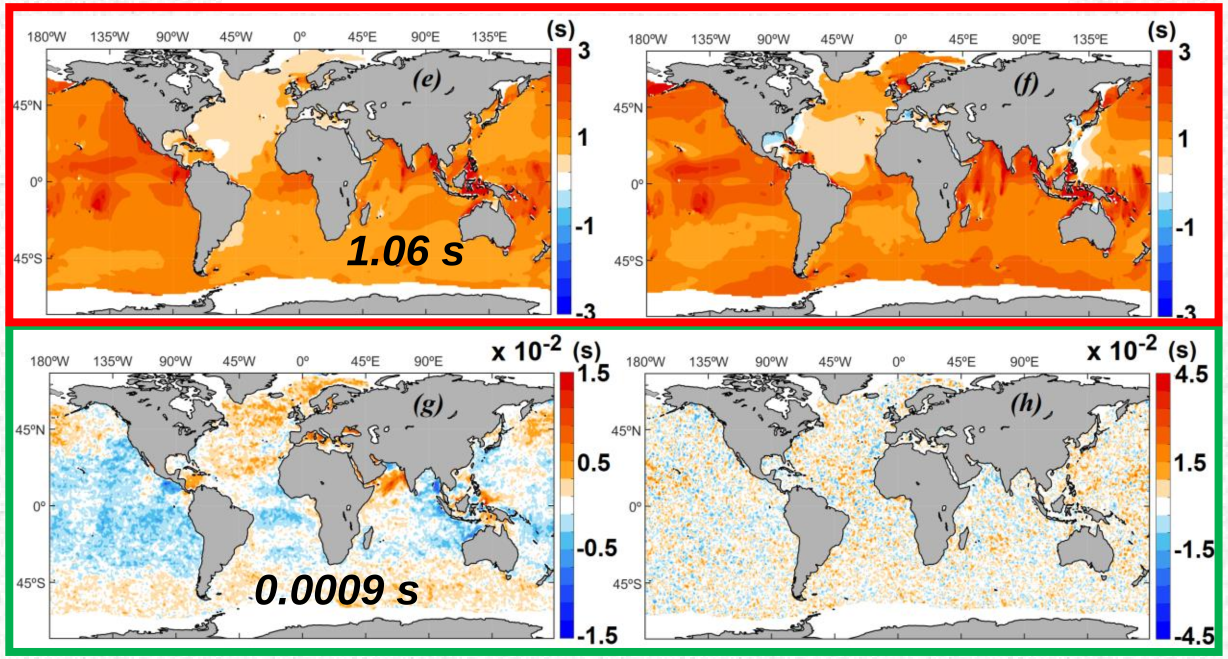
H_S

Mean | Extreme mean > p99



T_m

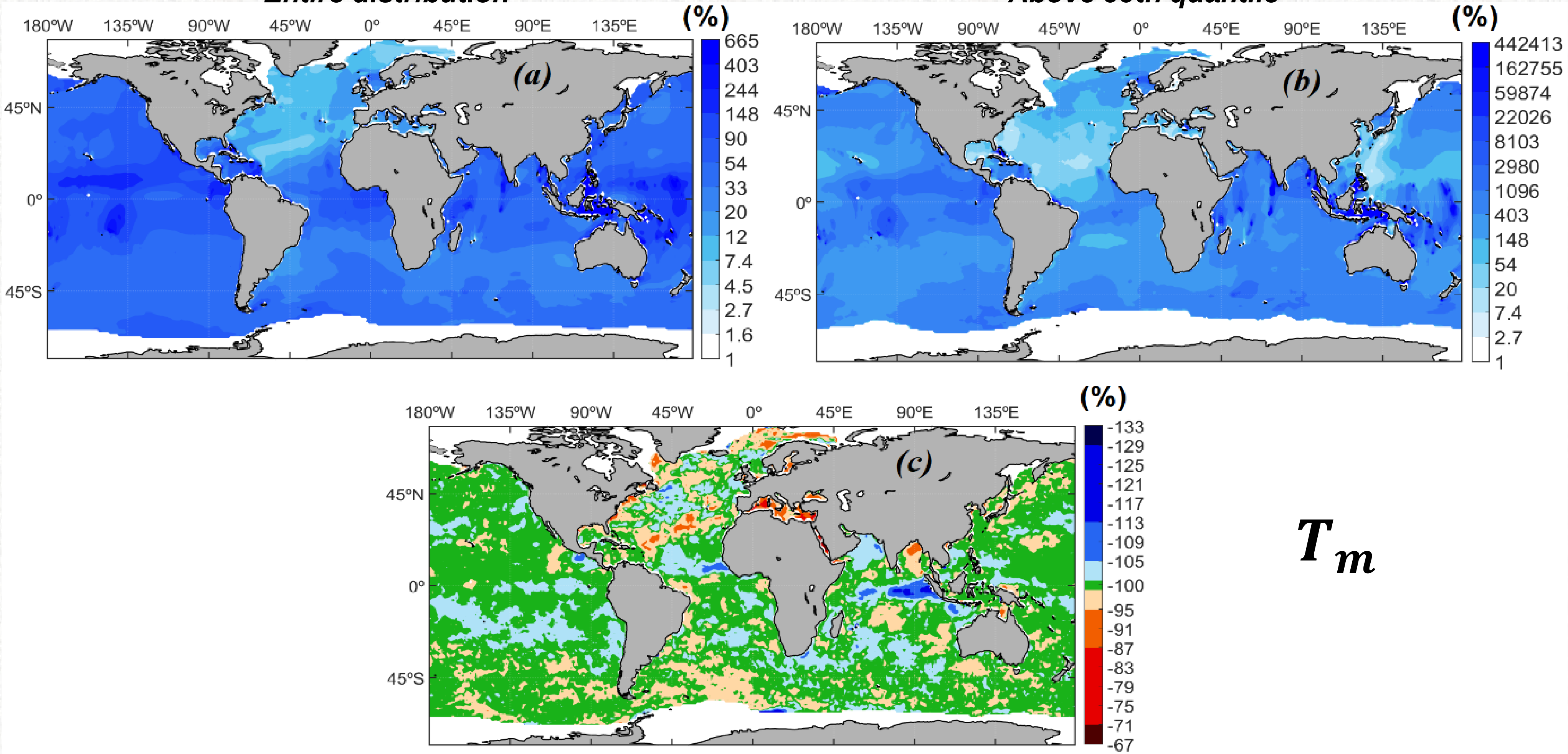
Mean | Extreme mean > p99



➢ **Results:** agreement between the H_s and T_m PDFs (PC20)

Increase in the PDF matching between ensemble and ERA-5 with bias correction (DAV; %)

Entire distribution ***Above 99th quantile***



Differences in the Yule Kendall Skewness Measure after bias correction (-100% = no skewness difference between ensemble and ERA-5)

Mean H_S

Where did the magnitudes of the projected changes increase with bias correction?

Subtropical North Atlantic **(1%)** / Pacific & around Indonesia **(~ 2%)**
SW Pacific & high latitudes of the Southern Ocean **(1%)**

SW Pacific, Indonesia **(~ 5%)**
High latitudes of the Southern Ocean **(2%)**

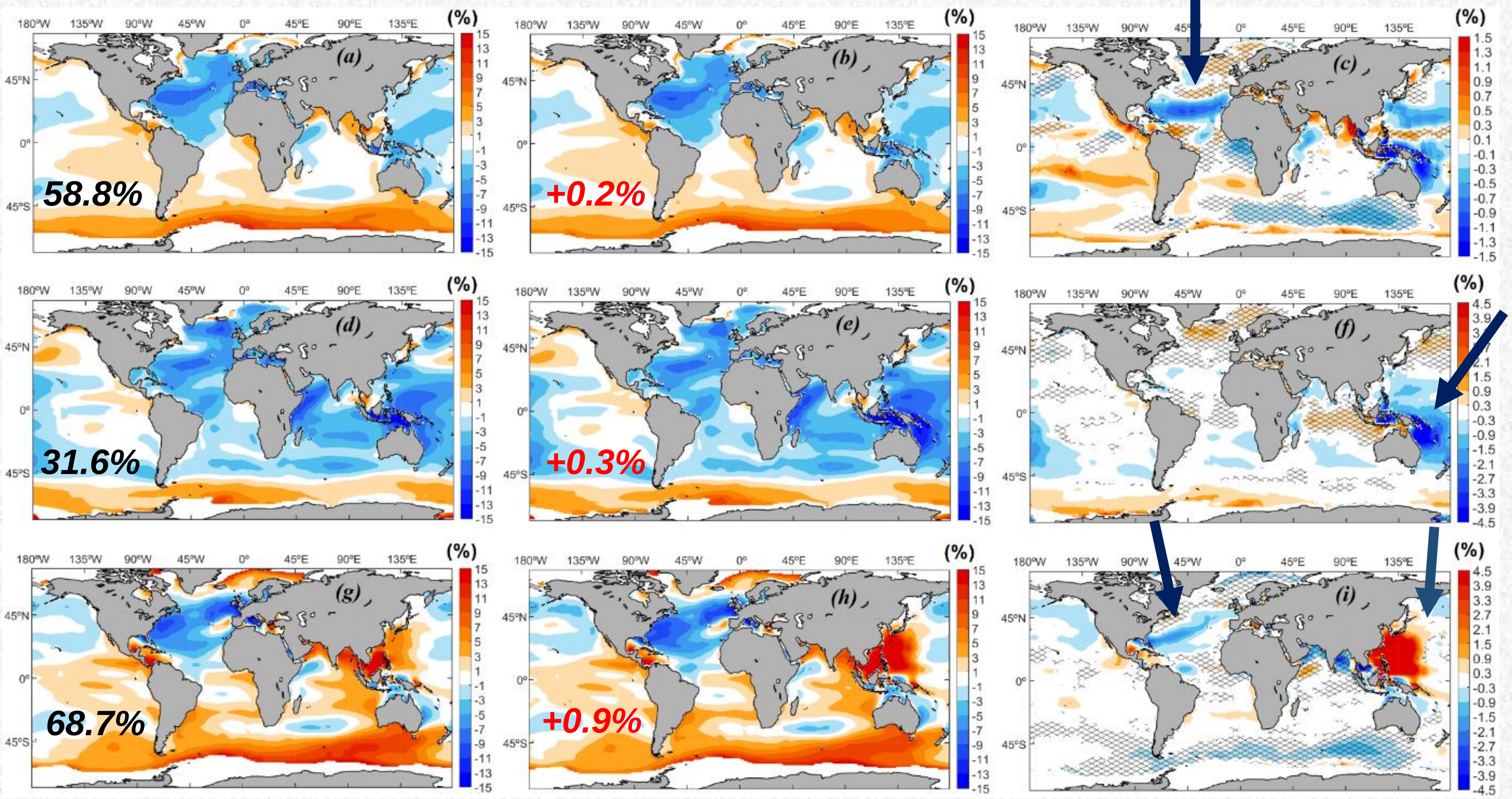
Midlatitudes of the North Atlantic **(2%)**
Philippines Sea **(~ 10%)**

Original Projections | **Corrected Projections** | **Differences**

A

DJF

JJA



Extreme mean H_S (> p99)

Where did the magnitudes of the projected changes increase with bias correction?

SW North Atlantic **(2%)** & South Philippines Sea **(~ 5%)**

Small areas along the three main basins' South halves **(1%-4%)**

South Philippines Sea, Coral Sea & tropical Indian Ocean **(3%-9%)**

Western North Atlantic **(6%-9%)**

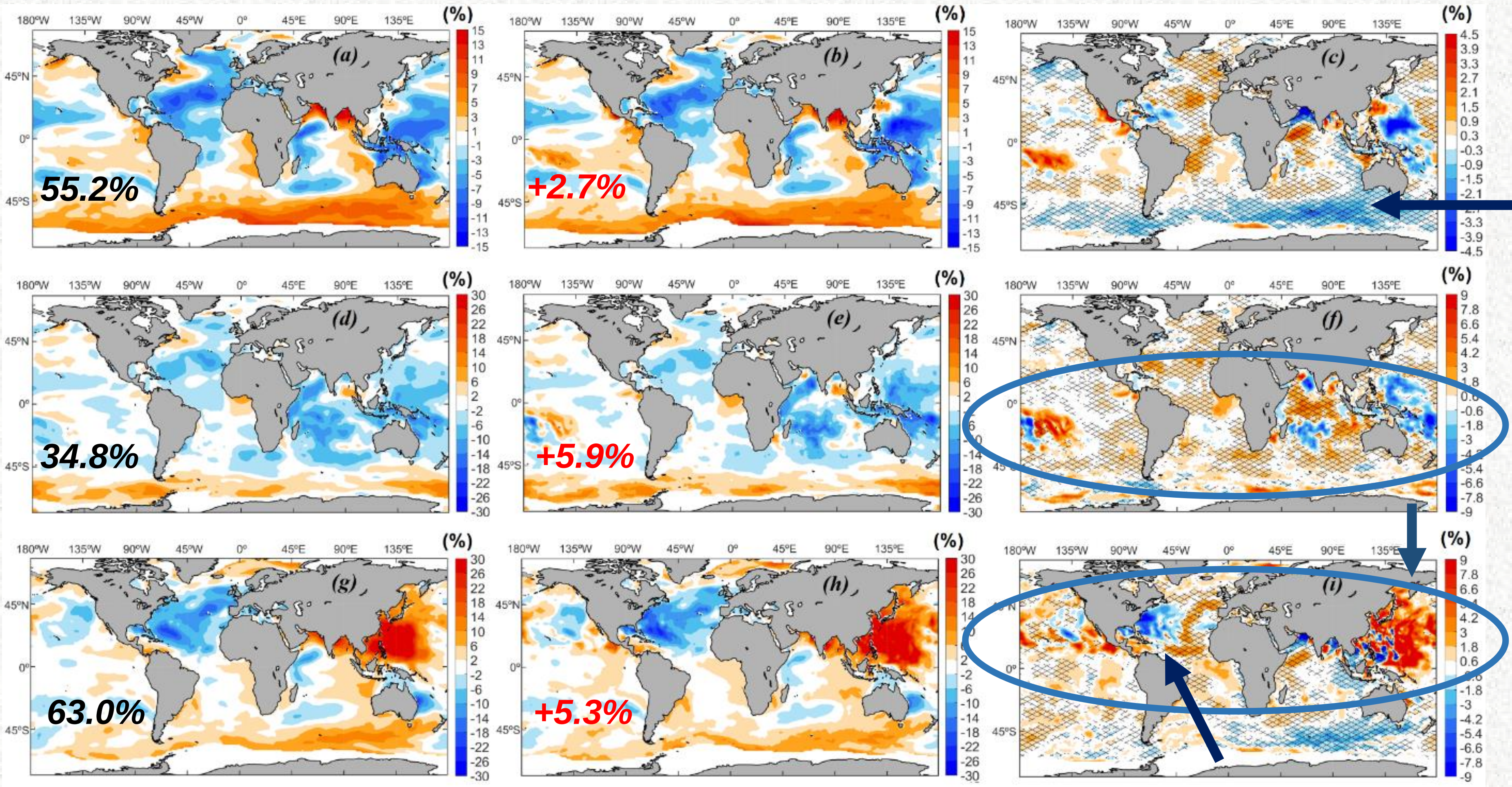
North Pacific (western & tropical eastern) **(3%-15%)**

Original Projections ***Corrected Projections*** ***Differences***

A

DJF

JJA



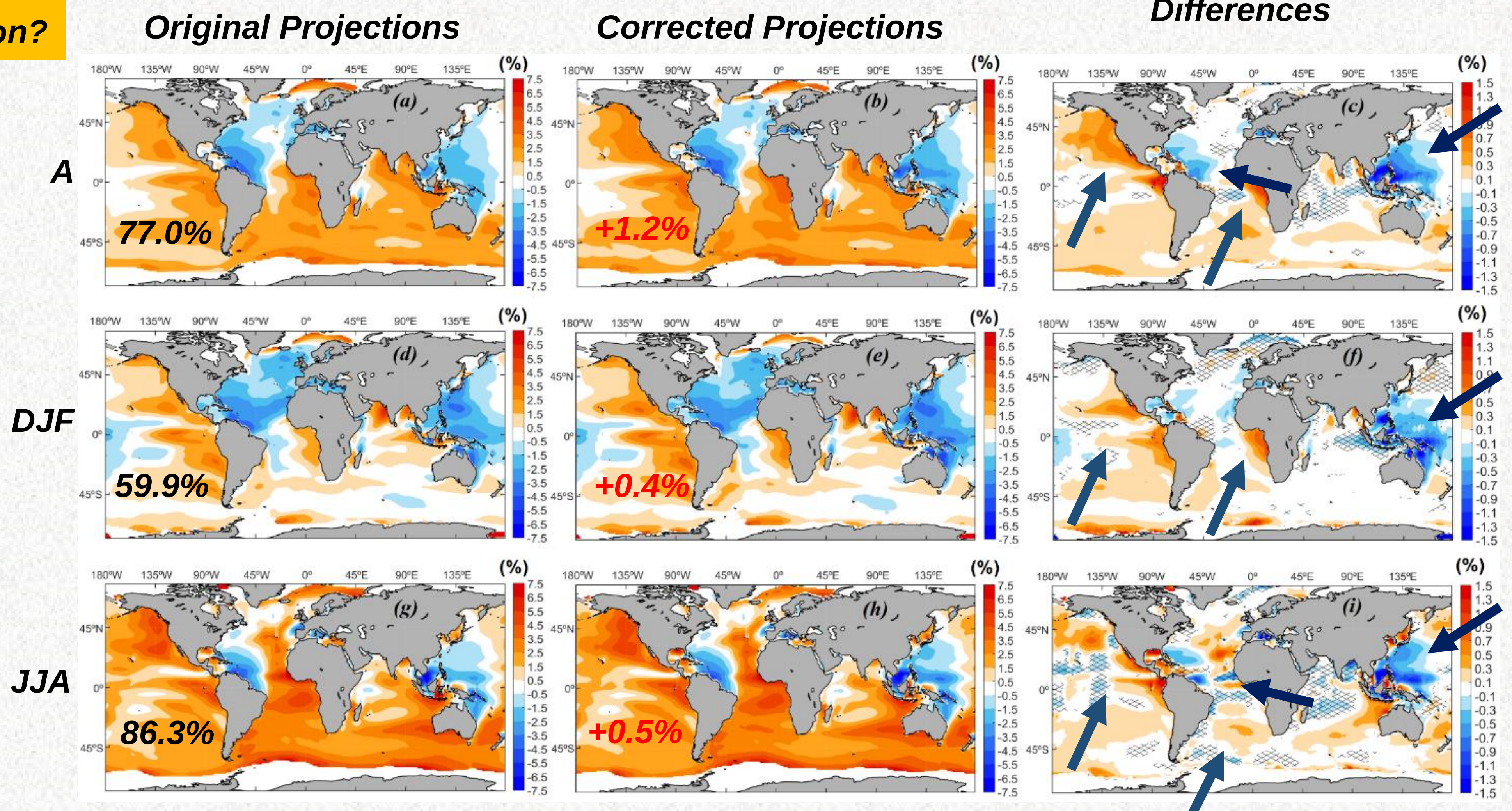
Mean T_m

Where did the magnitudes of the projected changes increase with bias correction?

Western North Atlantic **(~ 1%)** & Pacific (Philippines Sea) **(~ 2%)**
Swell pools & NE Pacific **(1%)**

SW Pacific, Indonesia **(~ 1%)**
Swell pools (Atlantic and Pacific) **(~ 1%)**

Tropical to subtropical latitudes of the North Atlantic & Philippines Sea **(~ 1%)**
Swell pools & North Atlantic / Pacific **(~ 1%)**



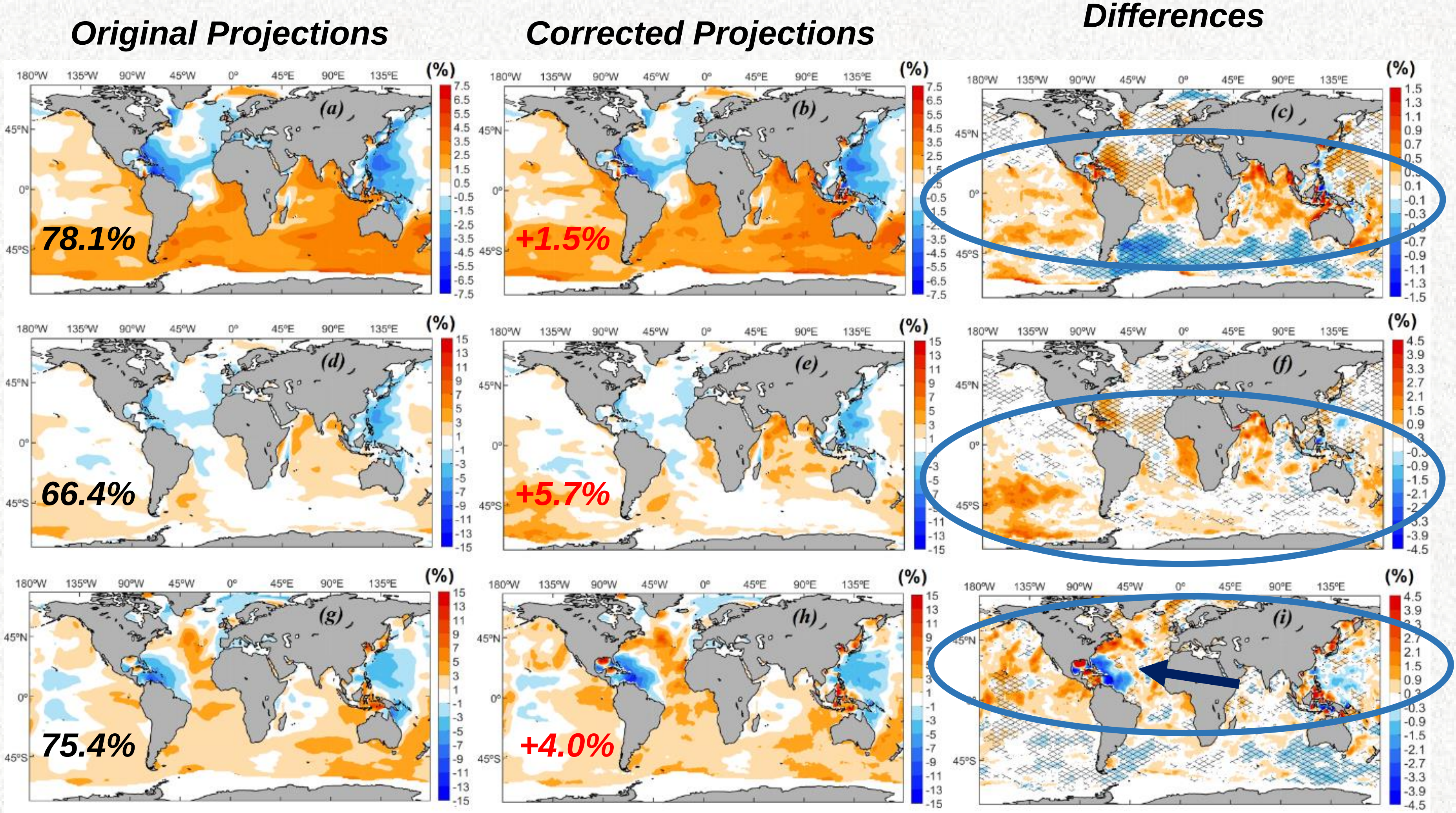
Extreme mean T_m (> p99)

Where did the magnitudes of the projected changes increase with bias correction?

Tropical to subtropical latitudes of both hemispheres: swell pools **(1%-2%)**

Southern Hemisphere (generalized) **(2%-4%)**

Tropical to subtropical latitudes of the North Atlantic **(~ 5%)** & Philippines Sea **(~ 2%)**
Northern Hemisphere (generalized) **(1%-3%)**



Extreme mean P_w (> p99)

$$P_w \overset{m}{=} T_m H_S^2$$

Where did the magnitudes of the projected changes increase with bias correction?

Original Projections ***Corrected Projections*** ***Differences***

A

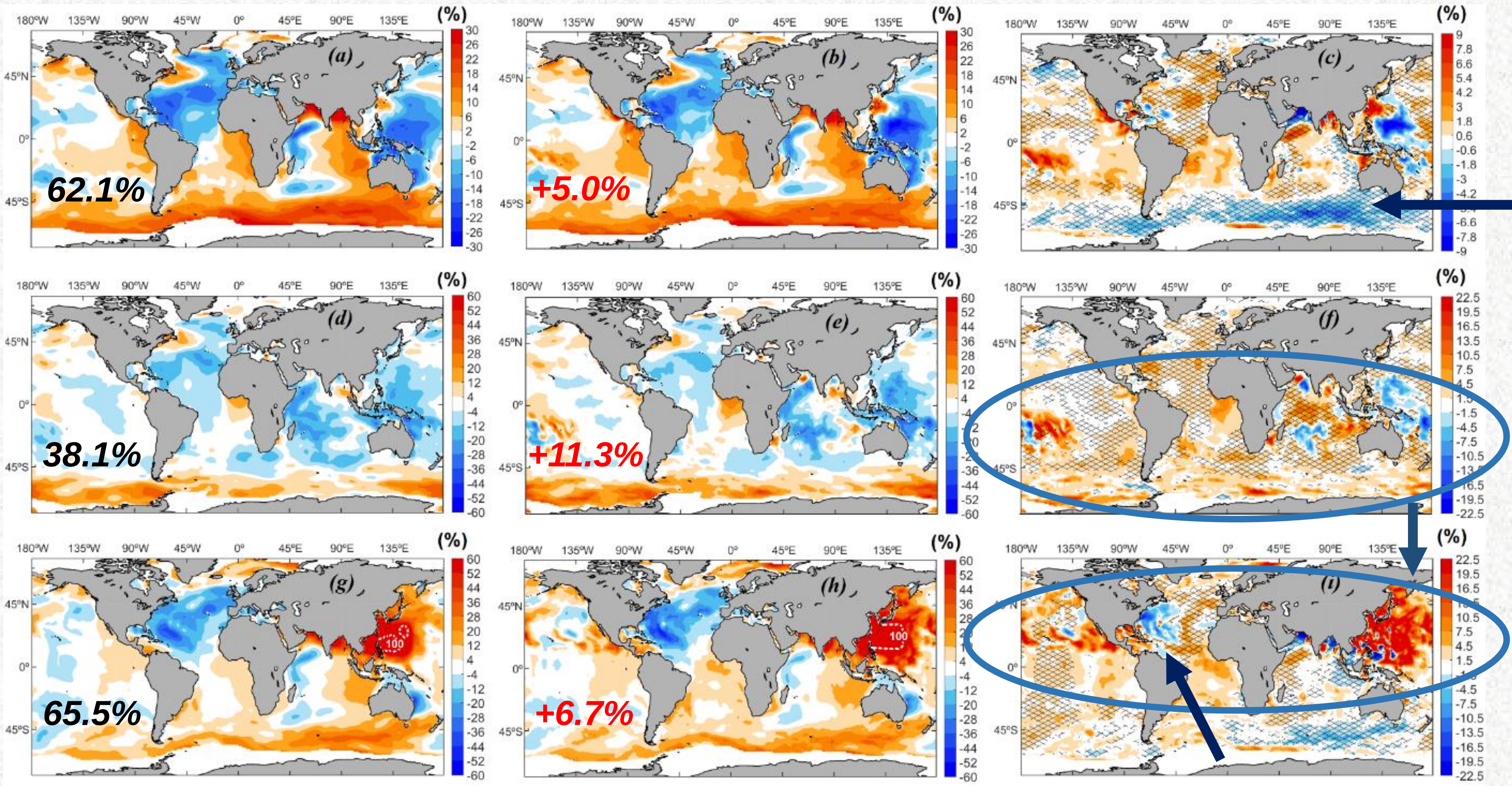
South Philippines Sea
(~ 10%)
Swell pools **(2%-9%)**

DJF

South Philippines Sea, Coral Sea & tropical Indian Ocean
(2%-10%)
High latitudes of the Southern Ocean **(5%-15%)**

JJA

Western North Atlantic
(5%-15%)
North Pacific (western & tropical eastern) **(15%-25%)**



➢ Summary and conclusions

- The **EGQM method** provided good results in reducing the biases with reference to ERA5.

  *(for both the **total** and **extreme** Hs / Tm / MWD – not shown)*

- The **differences** between the **original** and the **corrected** projected changes are higher at the tropical and subtropical latitudes of both hemispheres, possibly due to the widespread misrepresentation of local phenomena in these areas in PC20, namely:

  - *Tropical cyclones, misrepresented due to coarse spatial and temporal resolution (most visible for Hs)*
  - *Swell attenuation, misrepresented due to the parameterizations in the wave model (most visible for Tm)*
  - *The differences are more striking for the energy flux projections (Pw), since it receives input from both Hs and Tm.*

Ciências ULisboa

hidrográfico marinha-portugal · 60 ANOS DE CONHECIMENTO DO OCEANO

6as Jornadas de Engenharia Hidrográfica
1as Jornadas Luso-Espanholas de Hidrografia
3, 4 e 5 novembro 2020

THANK YOU

Bias Correction of a S… ing Dynamic Ensemble of Wave Climate Pro… wards the End of the 21st Century

Gil Lemos
FCUL / Instituto Dom Luiz, Lisbon, Portugal

grlemos@fc.ul.pt
Earthsystems PhD program

6ªs JEH / 1ªs JLEH, November 4th, 2020

Álvaro Semedo (IHE Delft)
Mikhail Dobrynin (DWD Hamburg)
Melisa Menendez (IH Cantabria)
Pedro Miranda (Lisbon University)