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Determination of Oceanic Extremes using a Spatial Ensemble of Satellite Data

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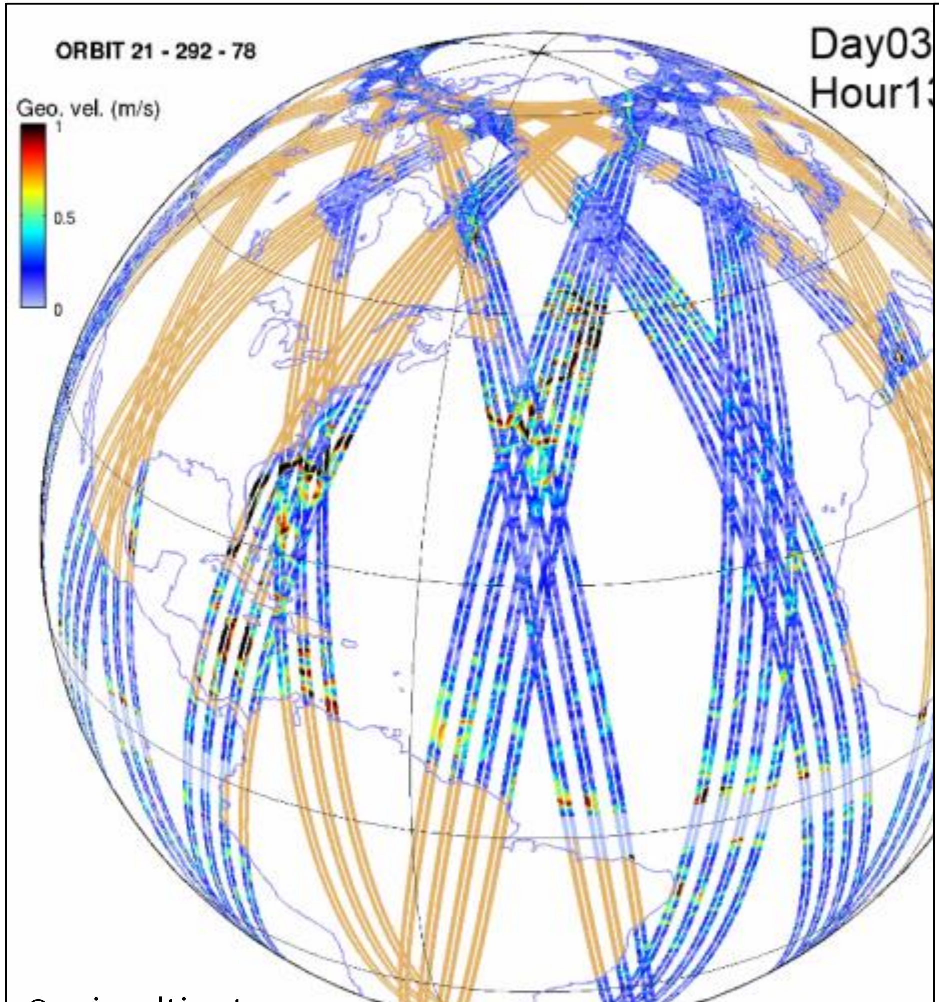
Content

1 Global distribution of extreme wave height and wind speed from satellite data (Takbash et al. 2019)

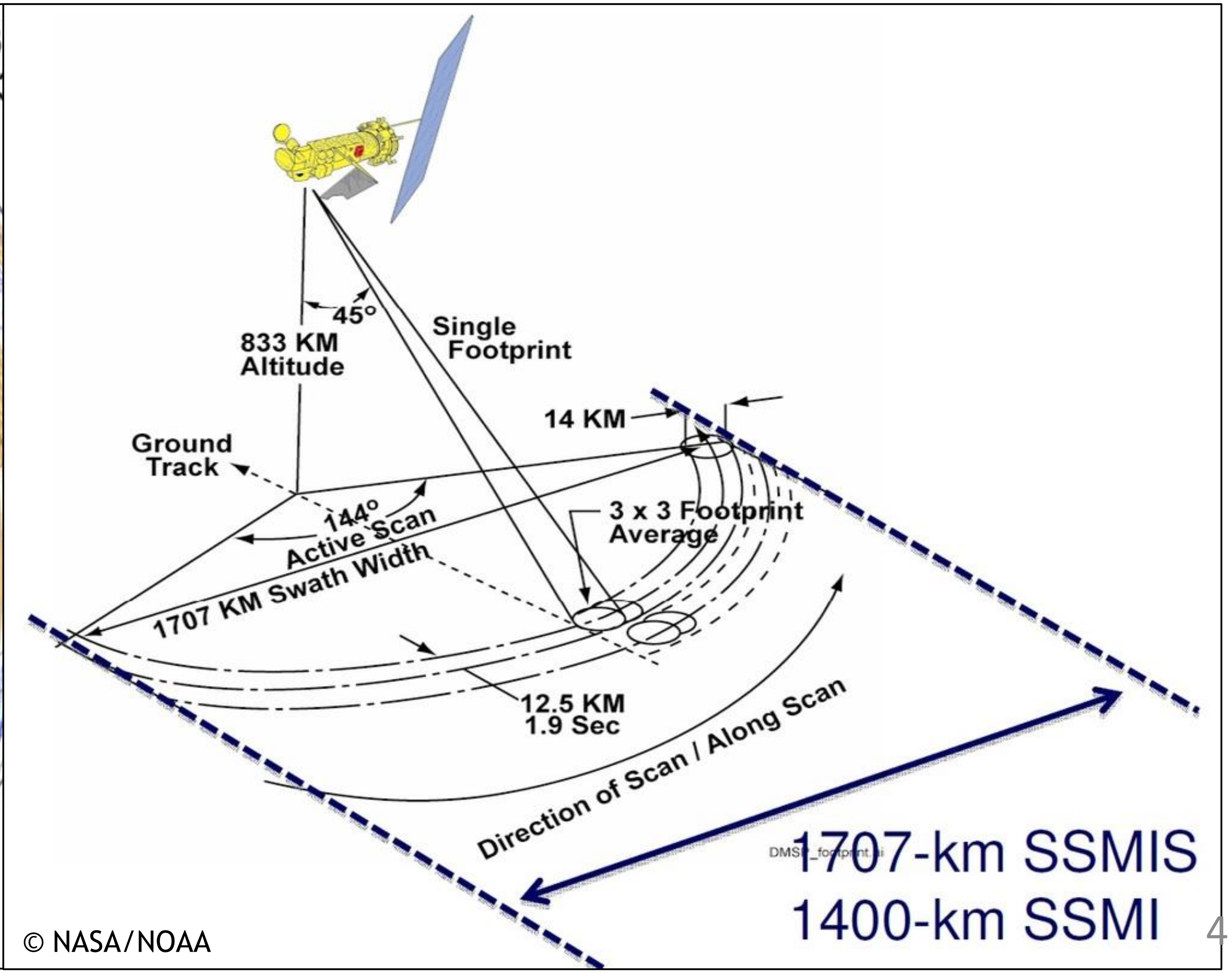
- Satellite data (Young et al., 2017):

  Altimeter/Radiometer → Long duration records & global coverage
- Two general approaches:
  - Initial Distribution Method (IDM) & Peaks over Threshold (PoT)
- Focus:
  - How well does the PDF fits the data?
  - How well is the tail of the PDF defined?

1 Global distribution of extreme wave height and wind speed from satellite data (Takbash et al. 2019)



© aviso altimetry



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Correction of the Radiometer data

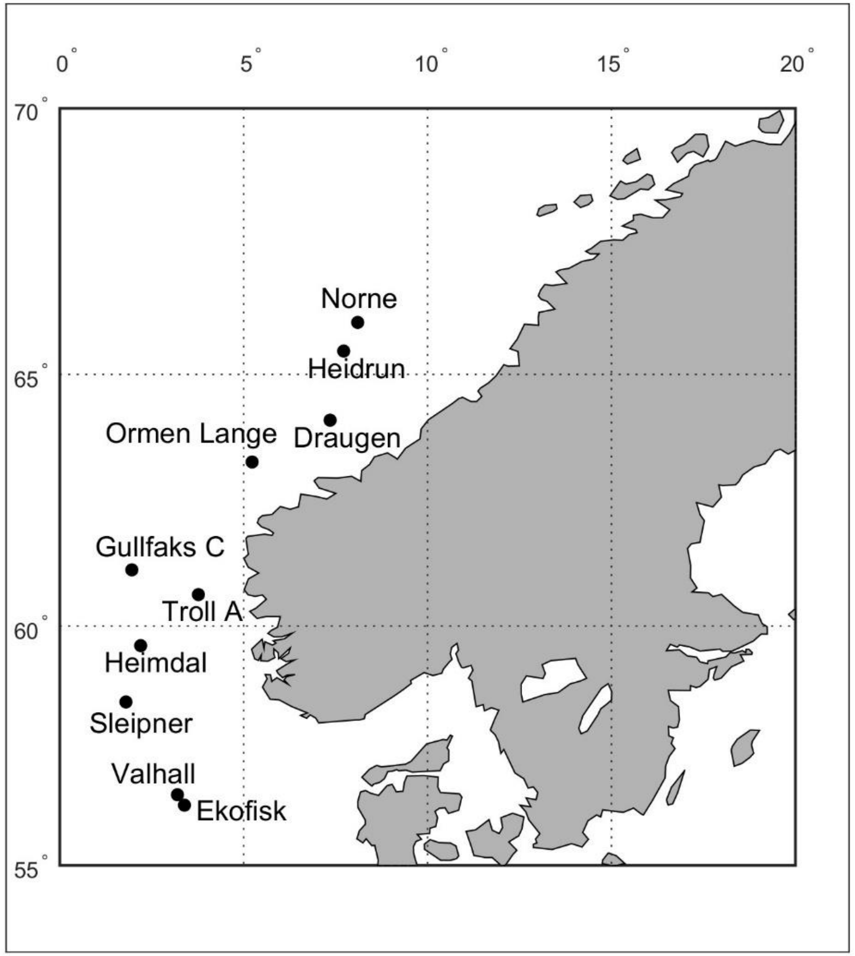


Figure 1 Locations of offshore platforms

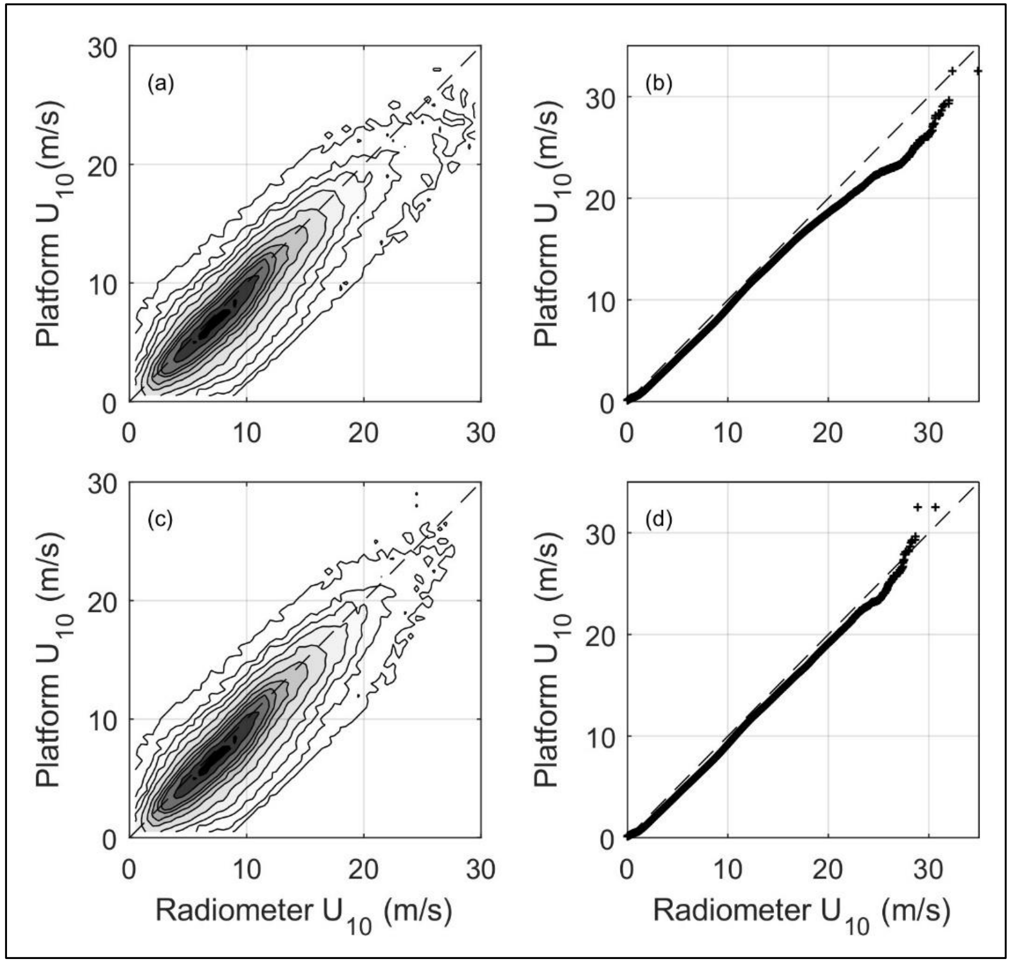
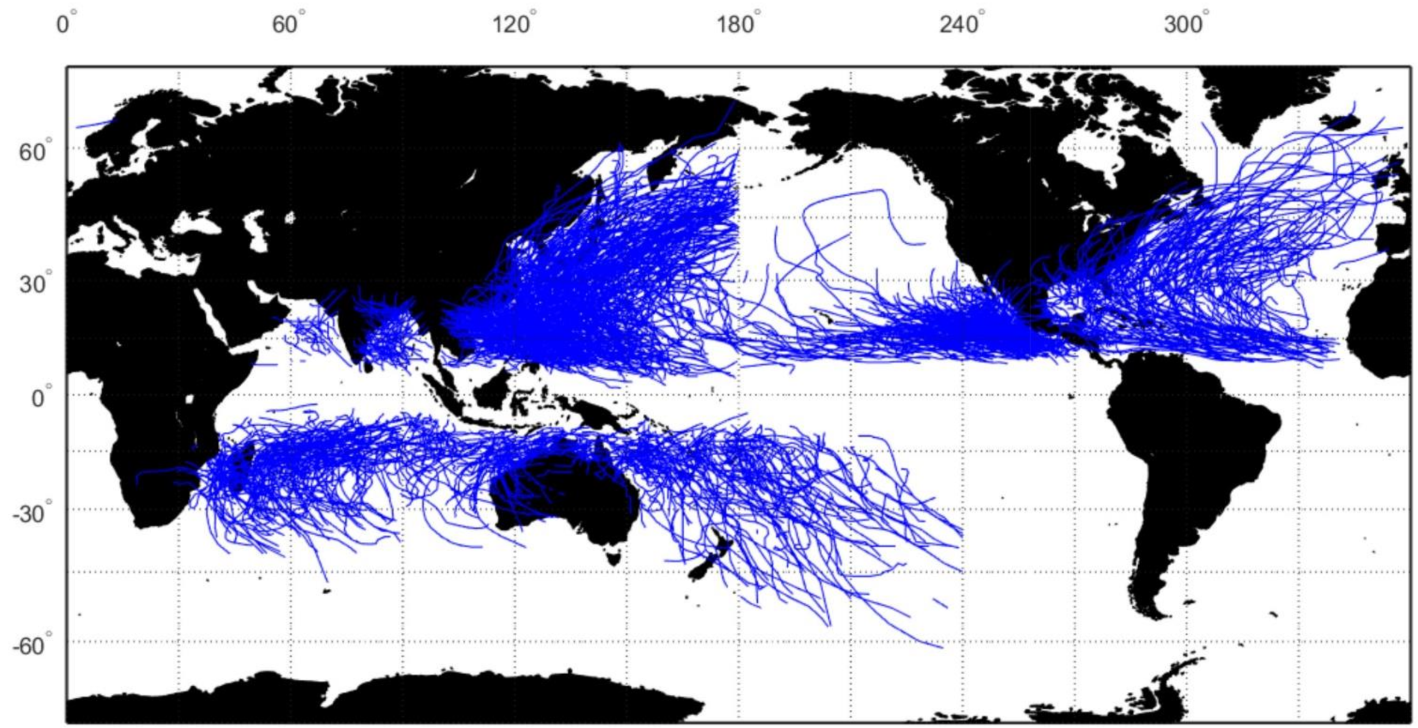


Figure 2 Radiometer-platform comparisons

Global distribution of Extremes – Altimeter PoT



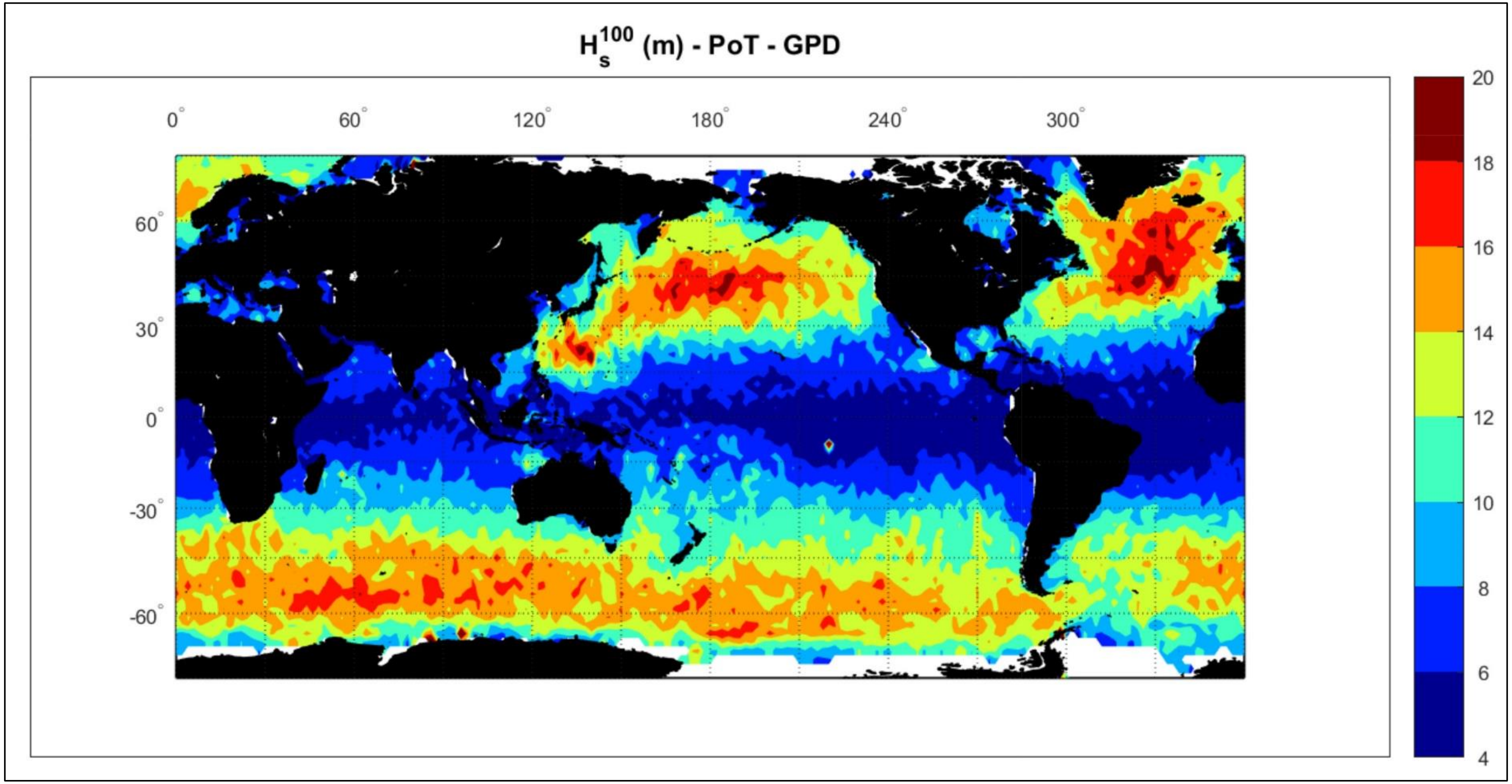
Knapp et al., 2010

	Altim.		Radiom.	
	PoT	IDM	PoT	IDM
U_{10}	GPD			
H_s				

16 – 40 m/s

Figure 3a
Global values of extreme wind speed – Altimeter/PoT-GPD

Global distribution of Extremes – Altimeter PoT

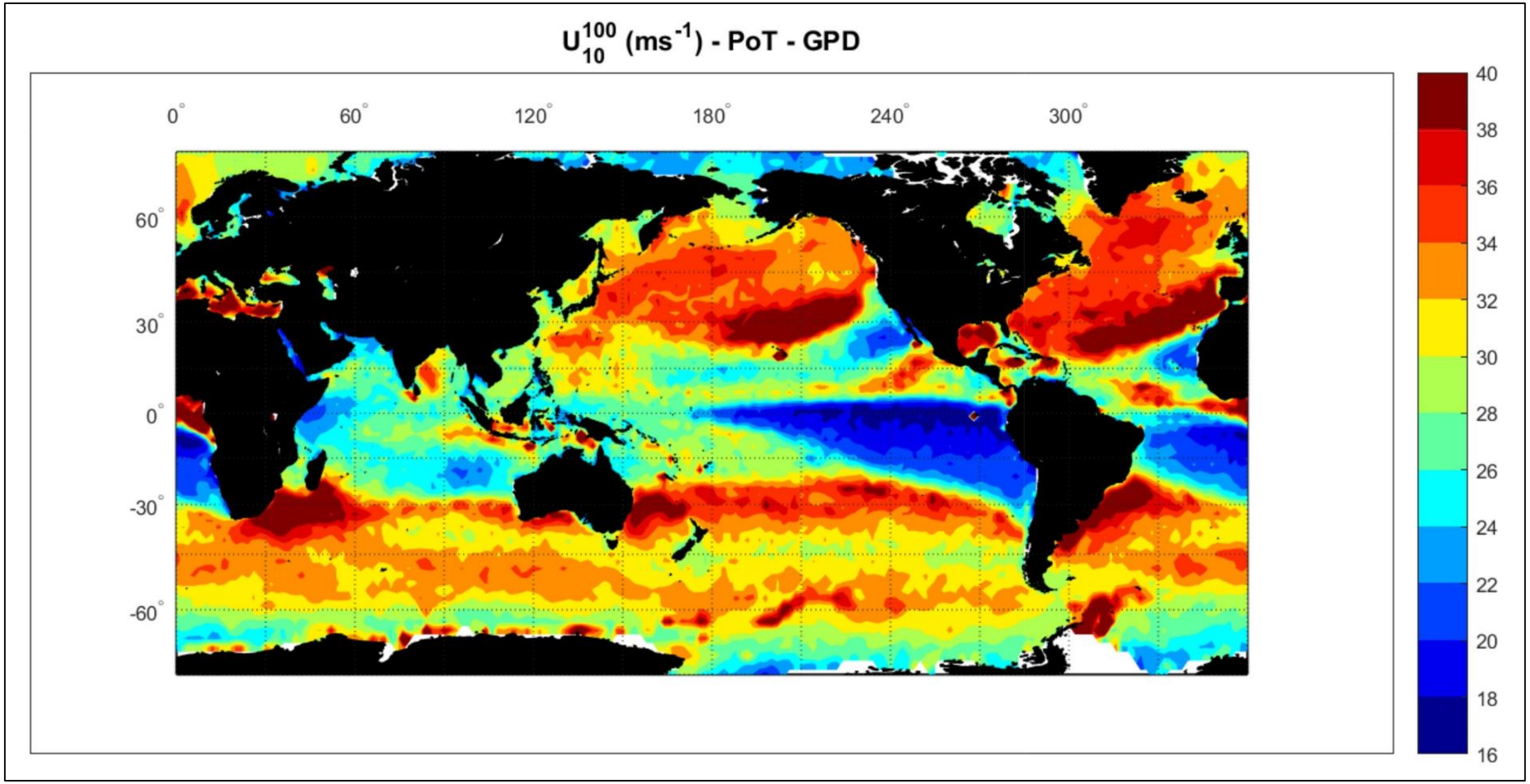


	Altim.		Radiom.	
	PoT	IDM	PoT	IDM
U_{10}				
H_s	GPD			

4 – 20 m

Figure 3b
Global values of extreme wave height – Altimeter/PoT-GPD

Global distribution of Extremes – Radiometer PoT

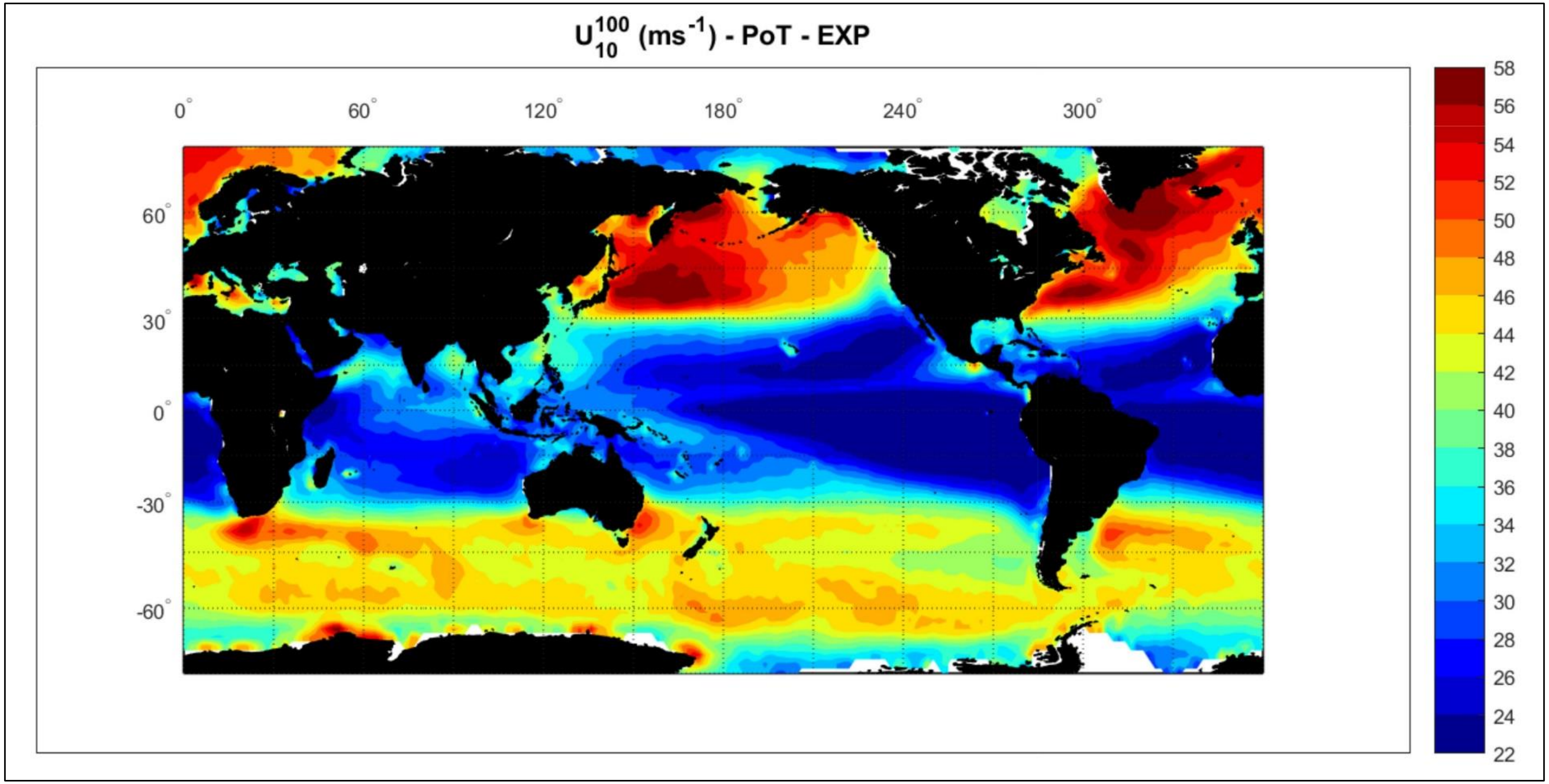


	Altim.		Radiom.	
	PoT	IDM	PoT	IDM
U_{10}			GPD	
H_s				

16 – 40 m/s

Figure 4
Global values of extreme wind speed – Radiometer/PoT-GPD

Global distribution of Extremes – Radiometer PoT

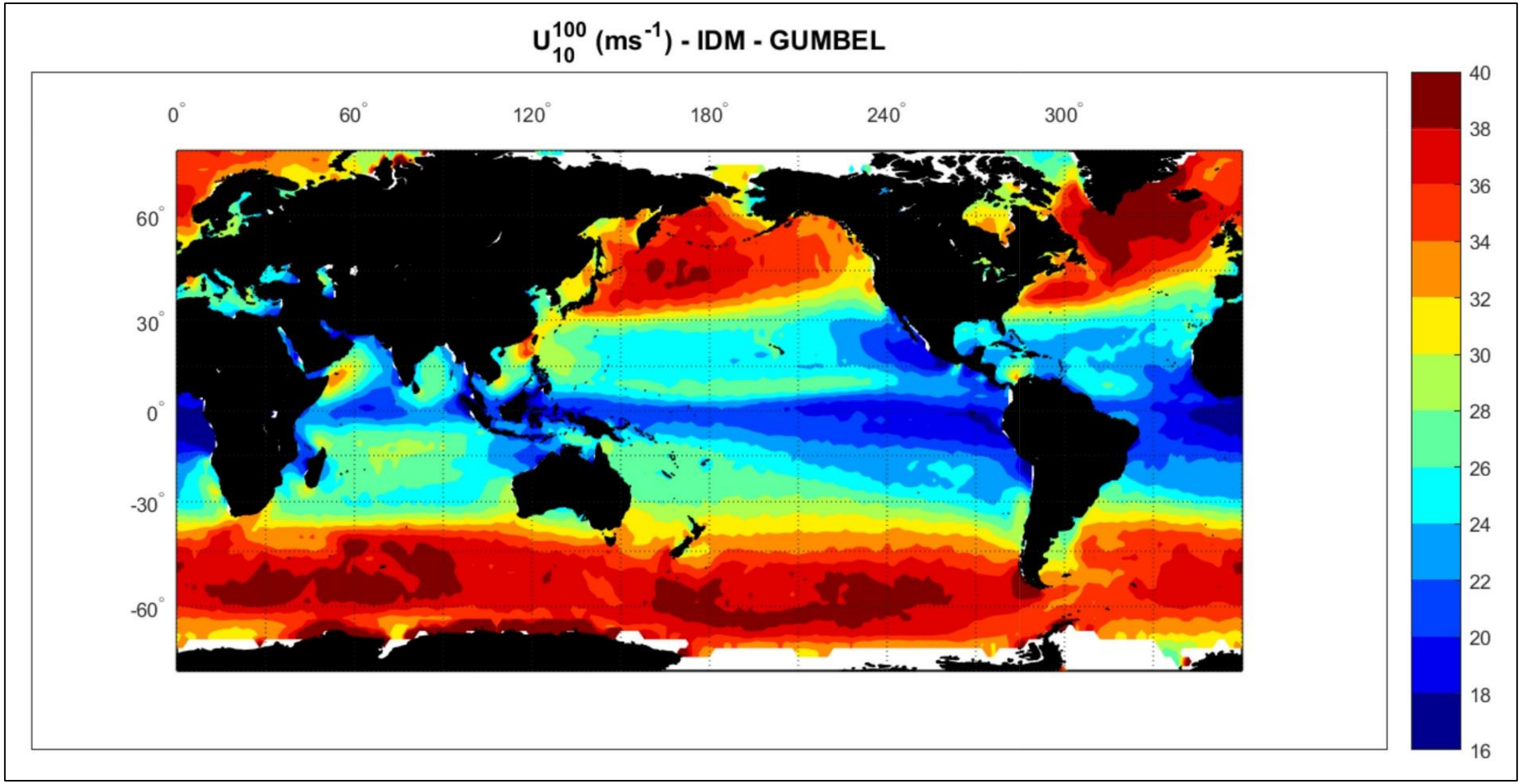


	Altim.		Radiom.	
	PoT	IDM	PoT	IDM
U_{10}			EXP	
H_s				

!! 22 – 58 m/s

Figure 5
Global values of extreme wind speed – Radiometer/PoT-EXP

Global distribution of Extremes – Altimeter IDM

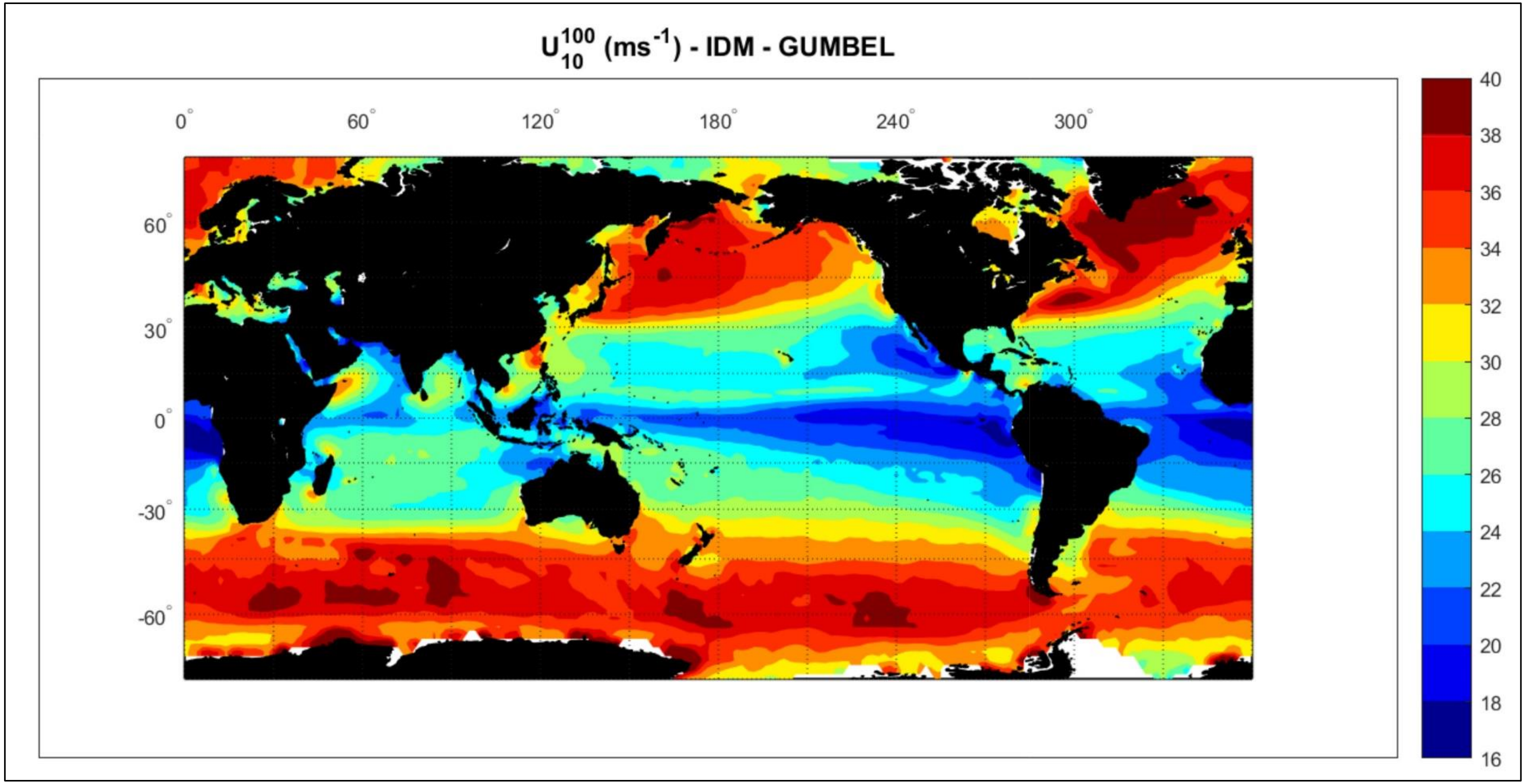


	Altim.		Radiom.	
	PoT	IDM	PoT	IDM
U_{10}		Gbl		
H_s				

16 – 40 m/s

Figure 6
Global values of extreme wind speed - Altimeter/IDM-Gumbel

Global distribution of Extremes – Radiometer IDM

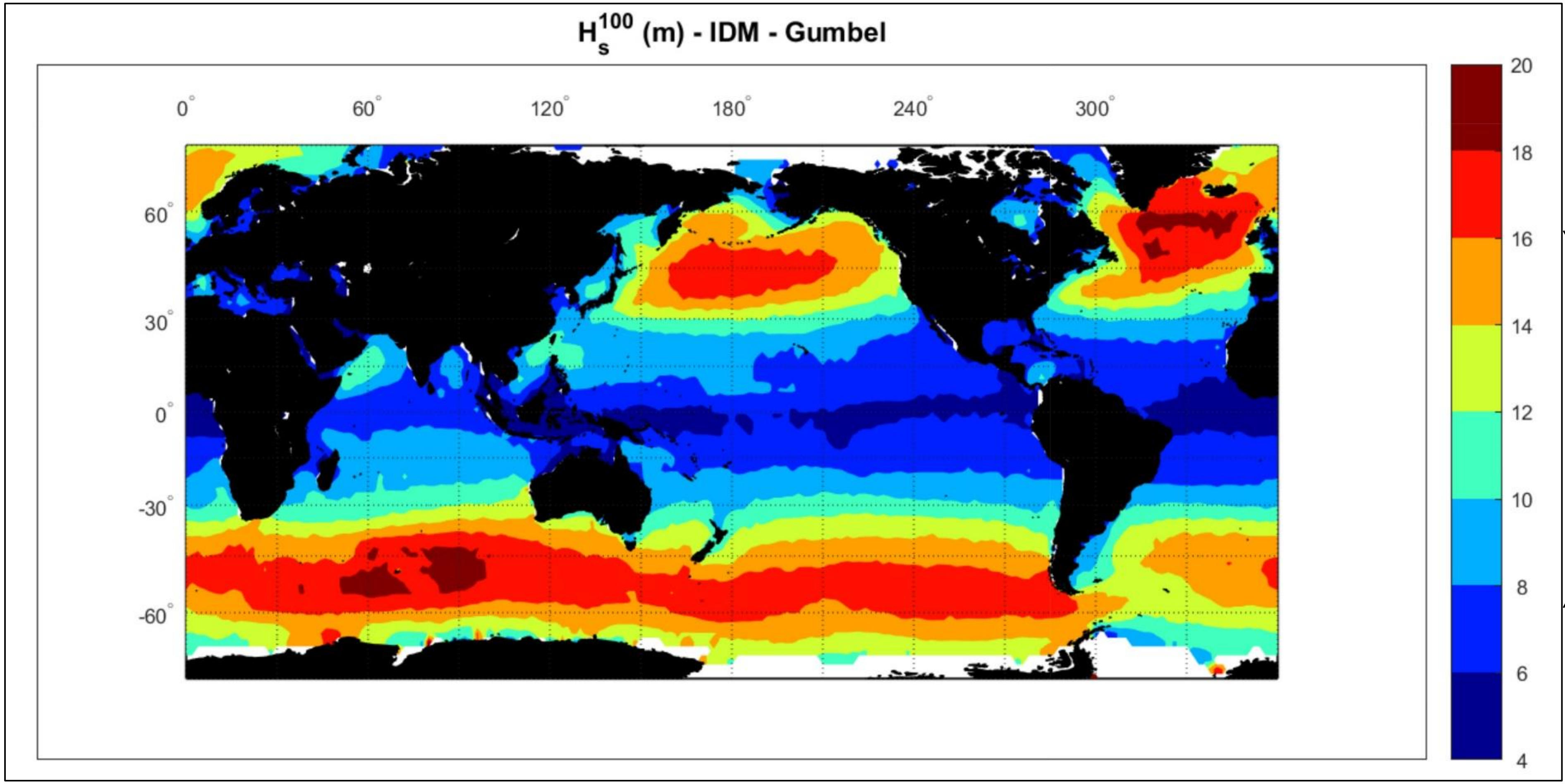


	Altim.		Radiom.	
	PoT	IDM	PoT	IDM
U_{10}				Gbl
H_s				

16 – 40 m/s

Figure 7
Global values of extreme wind speed – Radiometer/IDM-Gumbel

Global distribution of Extremes – Altimeter IDM



	Altim.		Radiom.	
	PoT	IDM	PoT	IDM
U_{10}				
H_s		Gbl		

4 – 20 m

Figure 8
Global values of extreme wave height – Altimeter/IDM-Gumbel

2 Conclusion

- ❑ The new Satellite data enables **PoT analysis for the first time for**
  - **Altimeter**:

    - Values consistent with buoy and previous numerical model data

    - Much greater fine scale structure
  - **Radiometer**:

    - Unacceptable “fair-weather” bias

    → **Unusable for PoT**
- ❑ IDM yield quite biased estimates of extremes and their spatial distribution

  → Comparing to PoT, **little reason to use IDM in the future**!

3 Global extreme wave height from spatial ensemble data (Takbash and Young 2019)

Aim:

reduce potential errors and **the size of confidence limits** on the resulting estimates of extremes when applying the **PoT approach** to **altimeter** data

→ Potential method: **increase the amount of data points** by combining data from adjacent regions

→ **spatial ensemble** of aggregated (pooled) data

- Equivalent to a longer duration time series!
- Method has been tested by Breivik et al. (2013; 2014) in the time domain

3 Global extreme wave height from spatial ensemble data (Takbash and Young 2019)

Two criteria must be satisfied:

1. The areas must be far enough apart that the data points of these areas are **independently distributed** (i.e. uncorrelated)
2. The areas must still be representative of a similar wave climate by showing a **common parent distribution**

→ Assessment: ERA-Interim reanalysis data (continues in spatial/time domain)

3 Global extreme wave height from spatial ensemble data (Takbash and Young 2019)

To satisfy the **first criterion**:

Determine the **spatial coherence of wave height** on a global basis using the Pearson correlation coefficient

- Removed the **monthly variation** (monthly mean)
    - Deseasonalised time series
    - Irregular variations (storms and long-term trend)

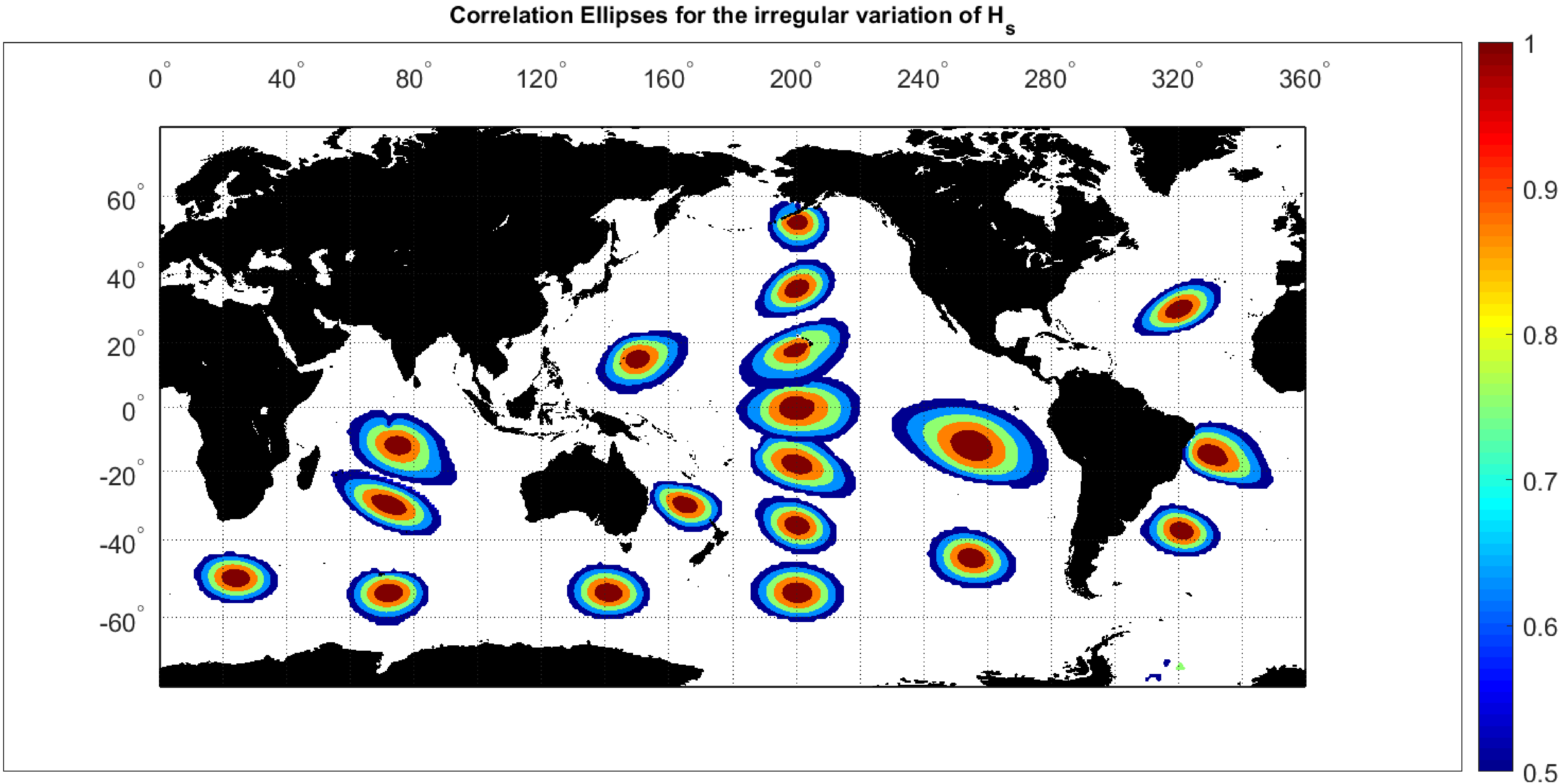


Figure 9 Correlation Ellipses – irregular variation of H_s [monthly means subtracted from the time series]

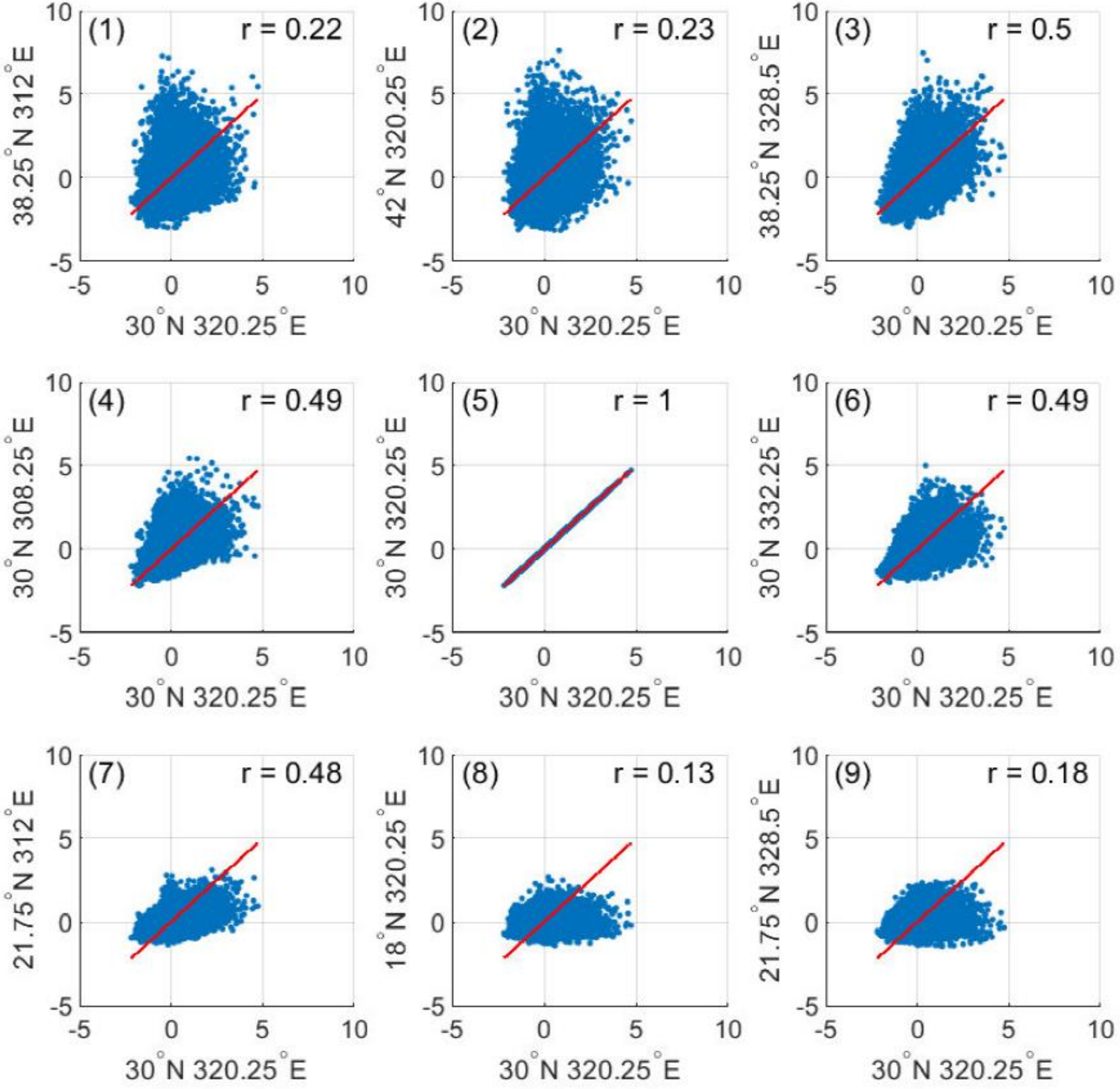


Figure 10 Scatter plots of deseasonalised H_s between a location at 30°N, 320.25°E (North Atlantic) and surrounding locations (12° radius)

3 Global extreme wave height from spatial ensemble data (Takbash and Young 2019)

→ Assessment of spatial coherence between **areas in zonal direction**!

Second criterion:

The **relative percentage difference (RPD)** between

- monthly means (averaged over the duration of the records)
- averaged monthly 99th percentile values

→ Wave climate is similar when **RPD is less than 10 %** for both parameter!

$$\overline{\mathrm{RPD}}(i,j) = \frac{1}{12}\sum_{k=1}^{12}\frac{|\overline{H}_s(i,k) - \overline{H}_s(j,k)|}{\overline{H}_s(i,k)},$$

$$\mathrm{RPD}^{99}(i,j) = \frac{1}{12}\sum_{k=1}^{12}\frac{|H_s^{99}(i,k) - H_s^{99}(j,k)|}{H_s^{99}(i,k)}.$$

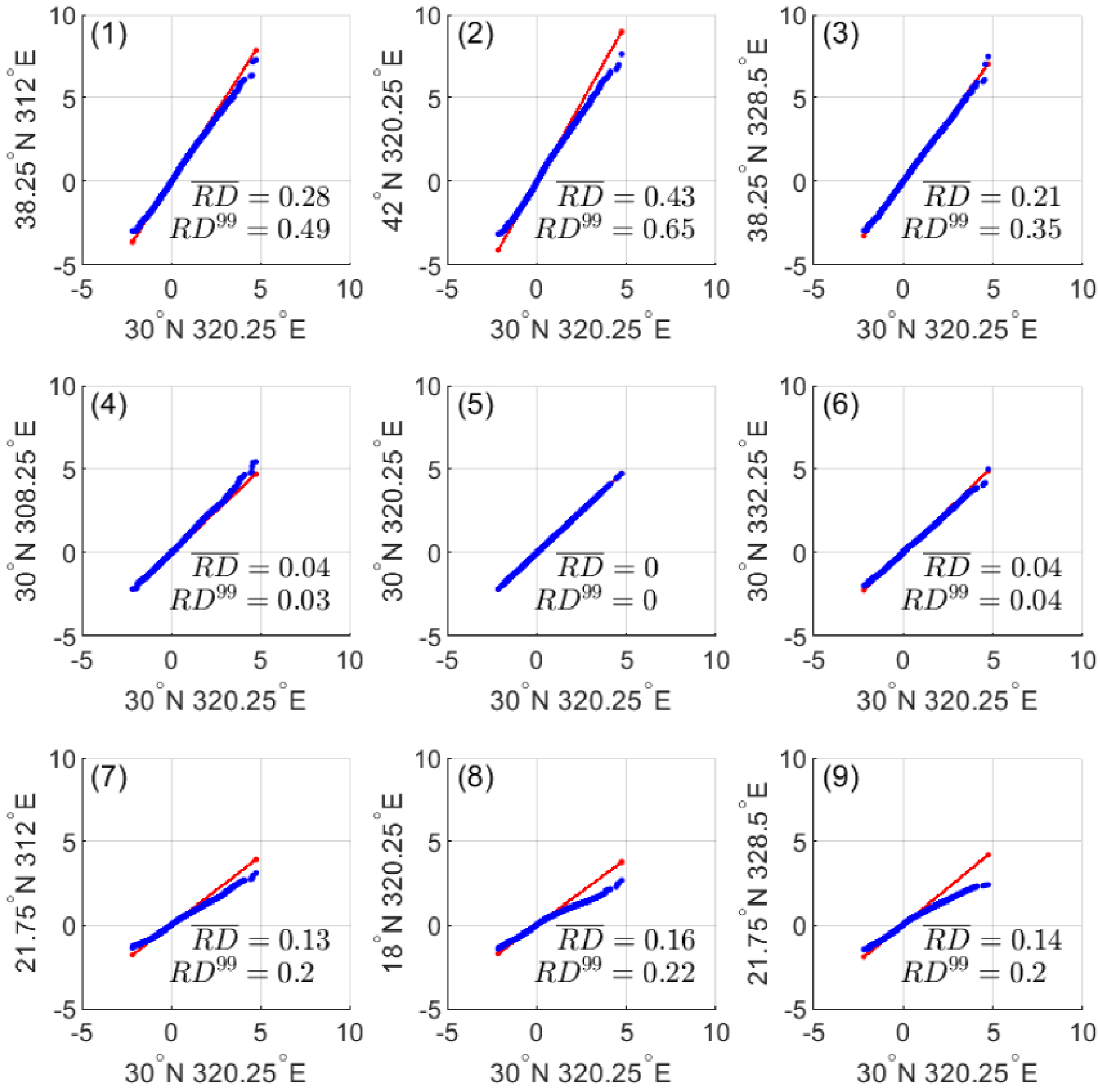


Figure 11 QQ plots of deseasonalised H_s between a location at 30 °N, 320.25 °E (North Atlantic) to surrounding locations (12° radius)

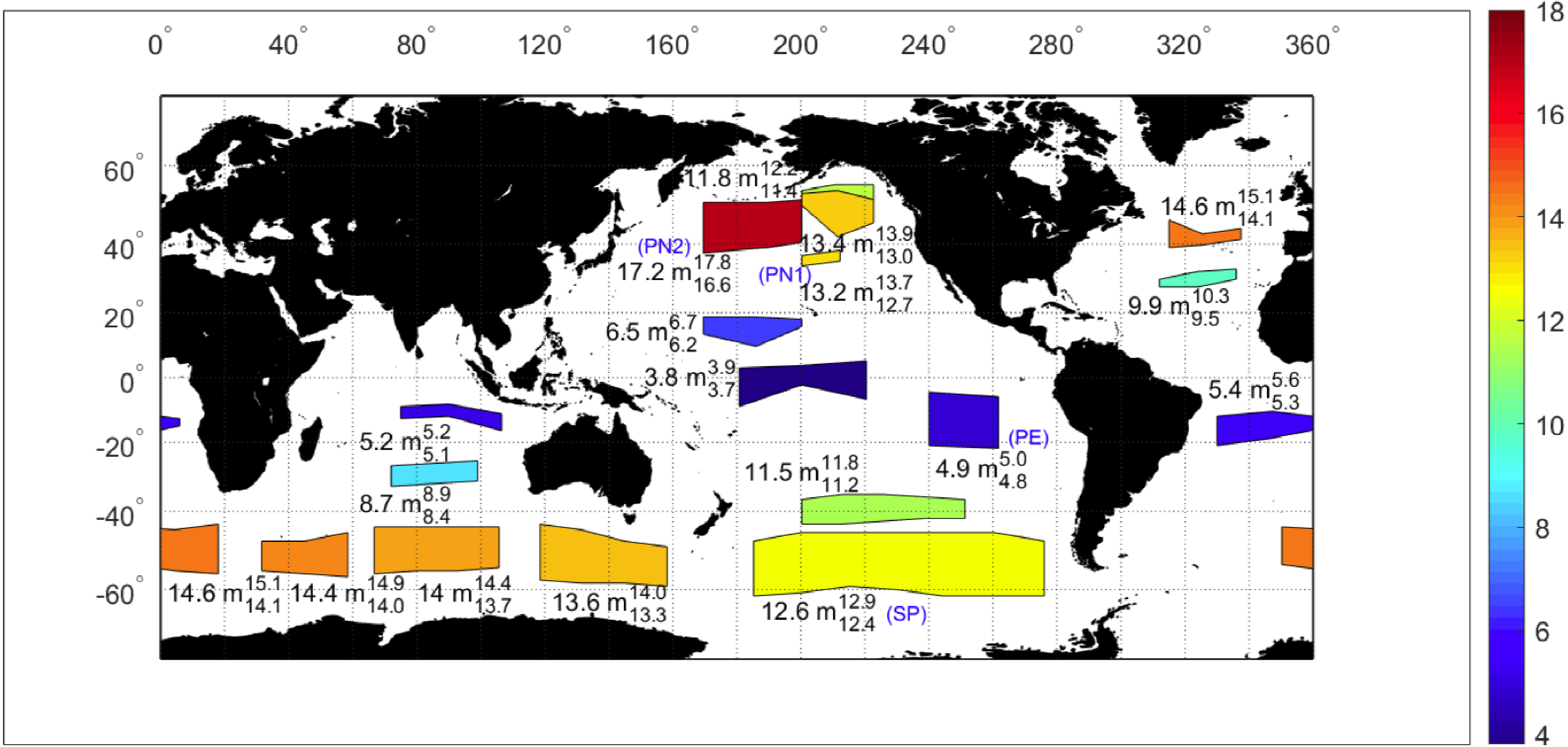


Figure 12 Ensemble spatial regions for **ERA-Interim** data

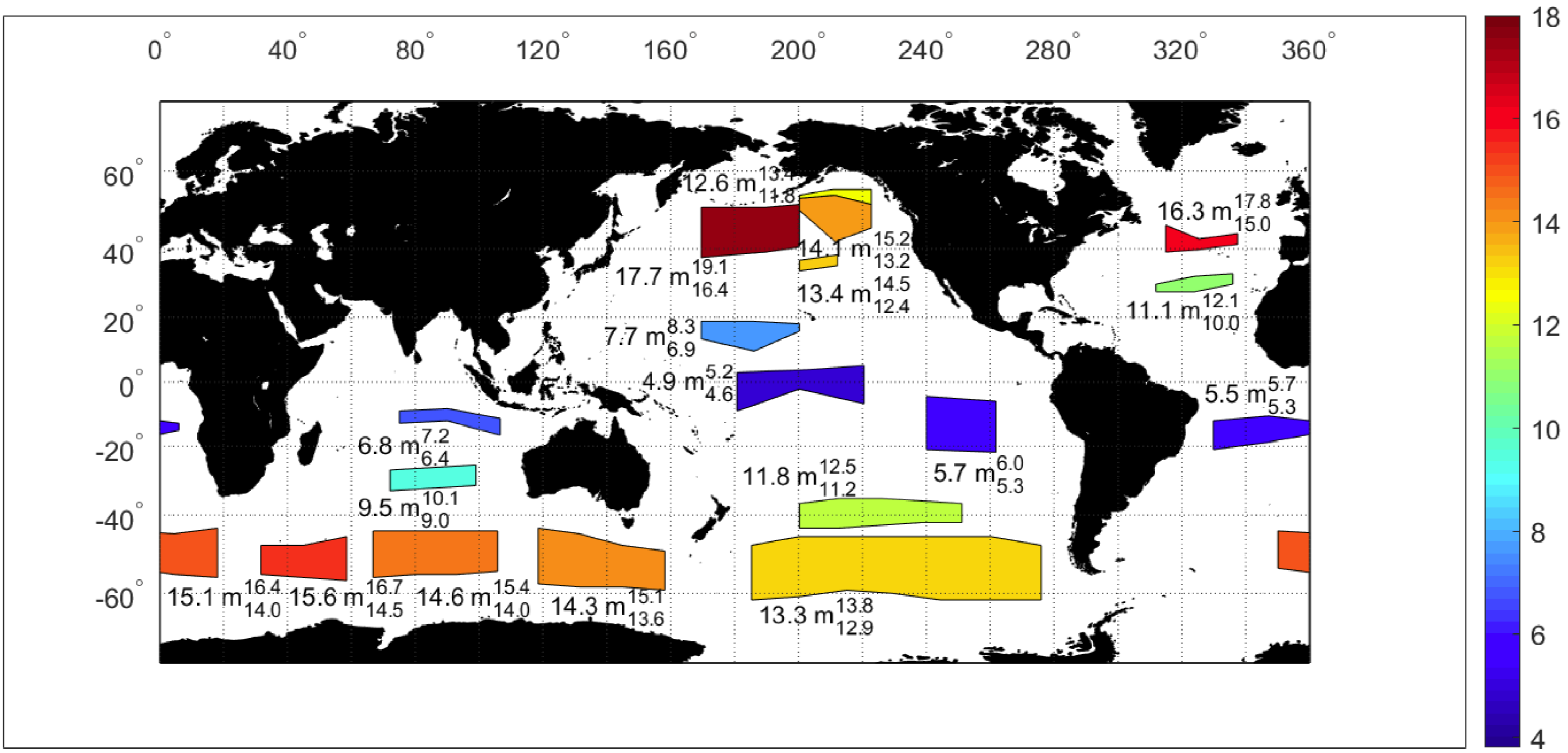


Figure 13 Ensemble spatial regions for **Altimeter** data

4 Conclusion

- ❑ For **ERA-Interim data** we created spatial ensemble equivalent to:

  60 yrs (N Pacific) to **210 yrs** (S Pacific)

- ❑ For **Altimeter data** we created spatial ensemble equivalent to:

  54 yrs (N Pacific) to **189 yrs** (S Pacific)

→ **Reduced size of the confidence interval by ~30% - 60%** depending on the size of the spatial ensemble data