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The Prediction Of Extreme Value Wind Speeds And Wave Heights From Satellite Data

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Content

1 Introduction

2 Global estimates of Extremes

3 Satellite data set

4 Validation of Satellite Extreme Value Analysis

5 Global distribution of Extremes

6 Conclusion

1 Introduction

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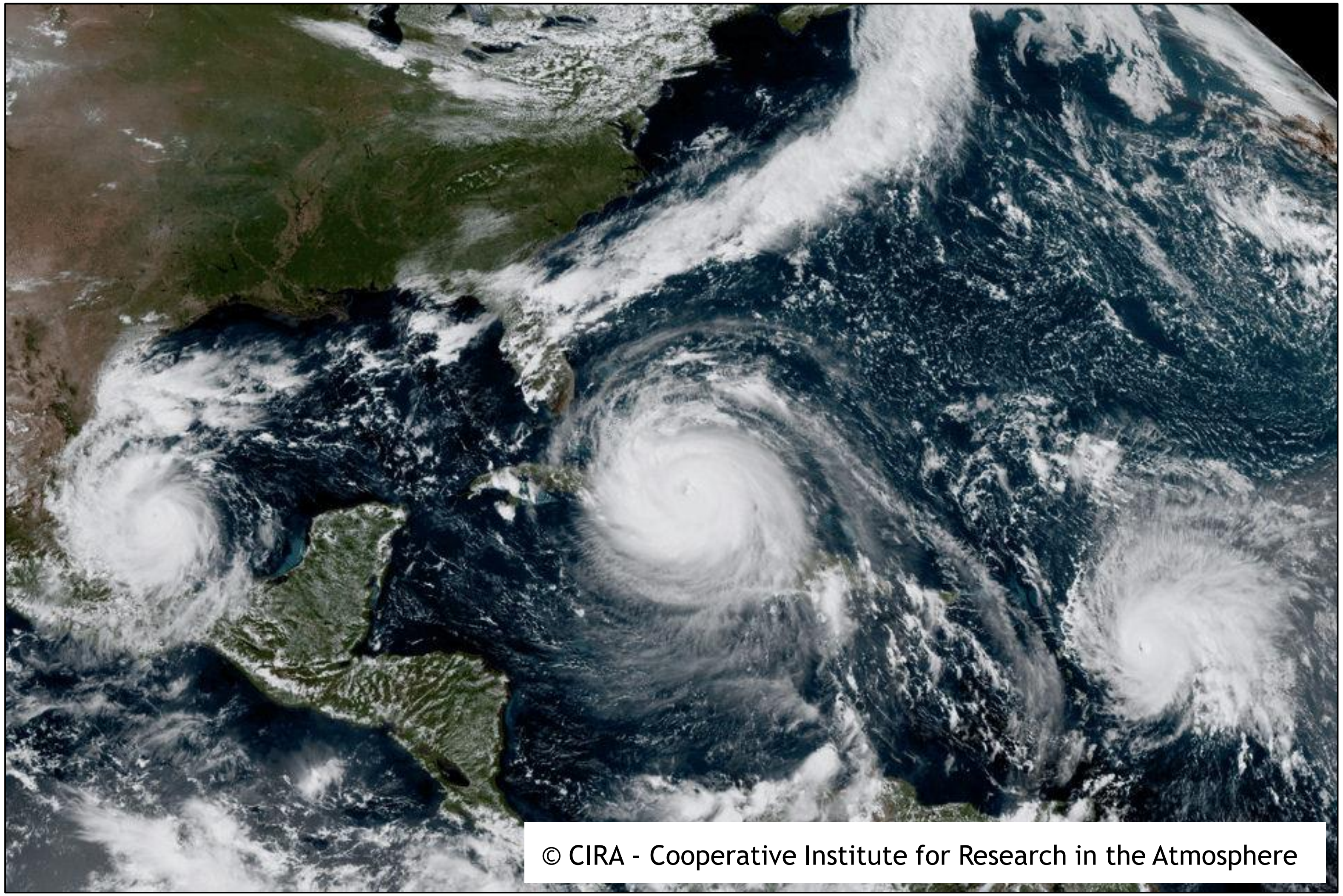

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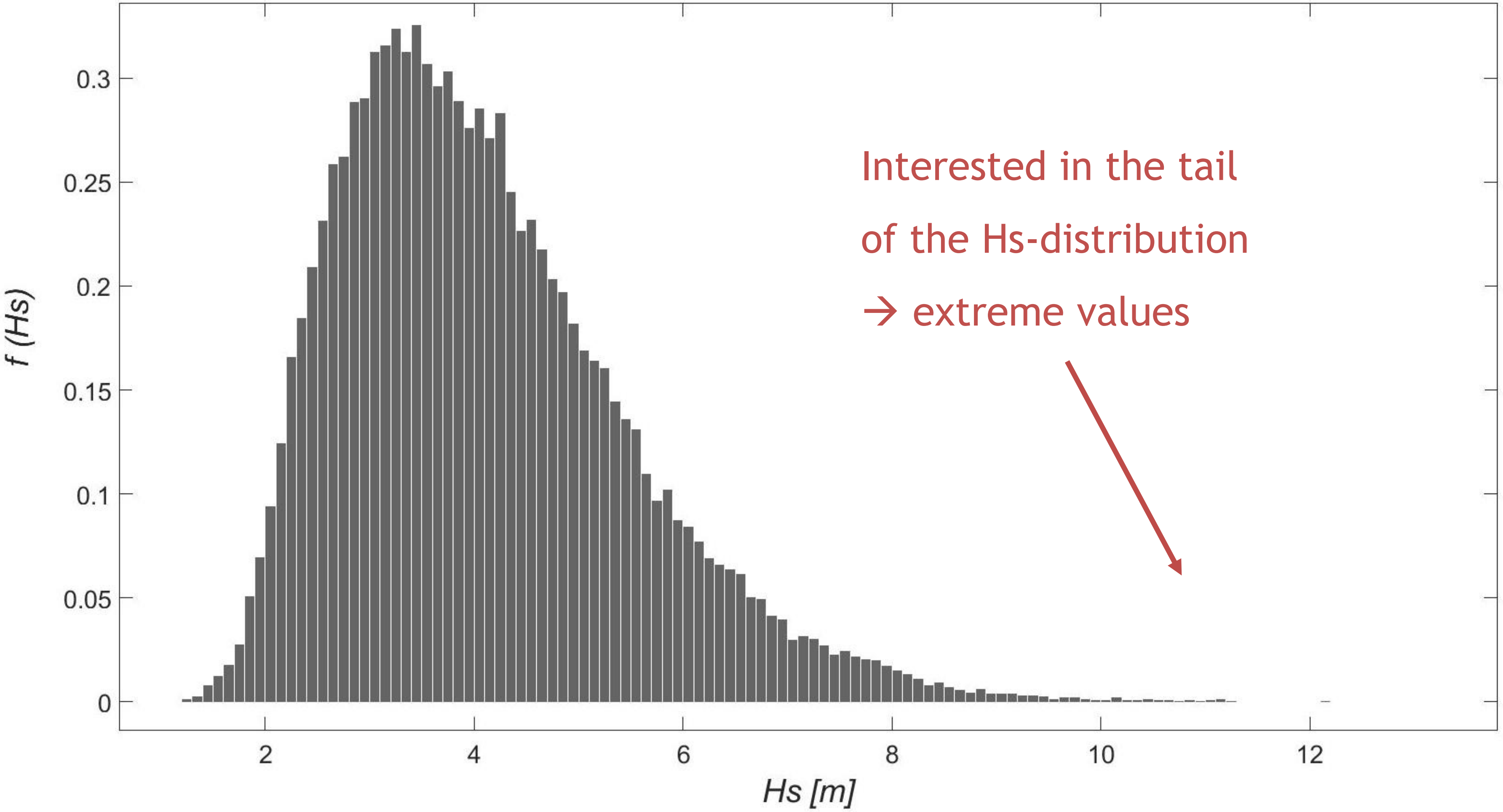
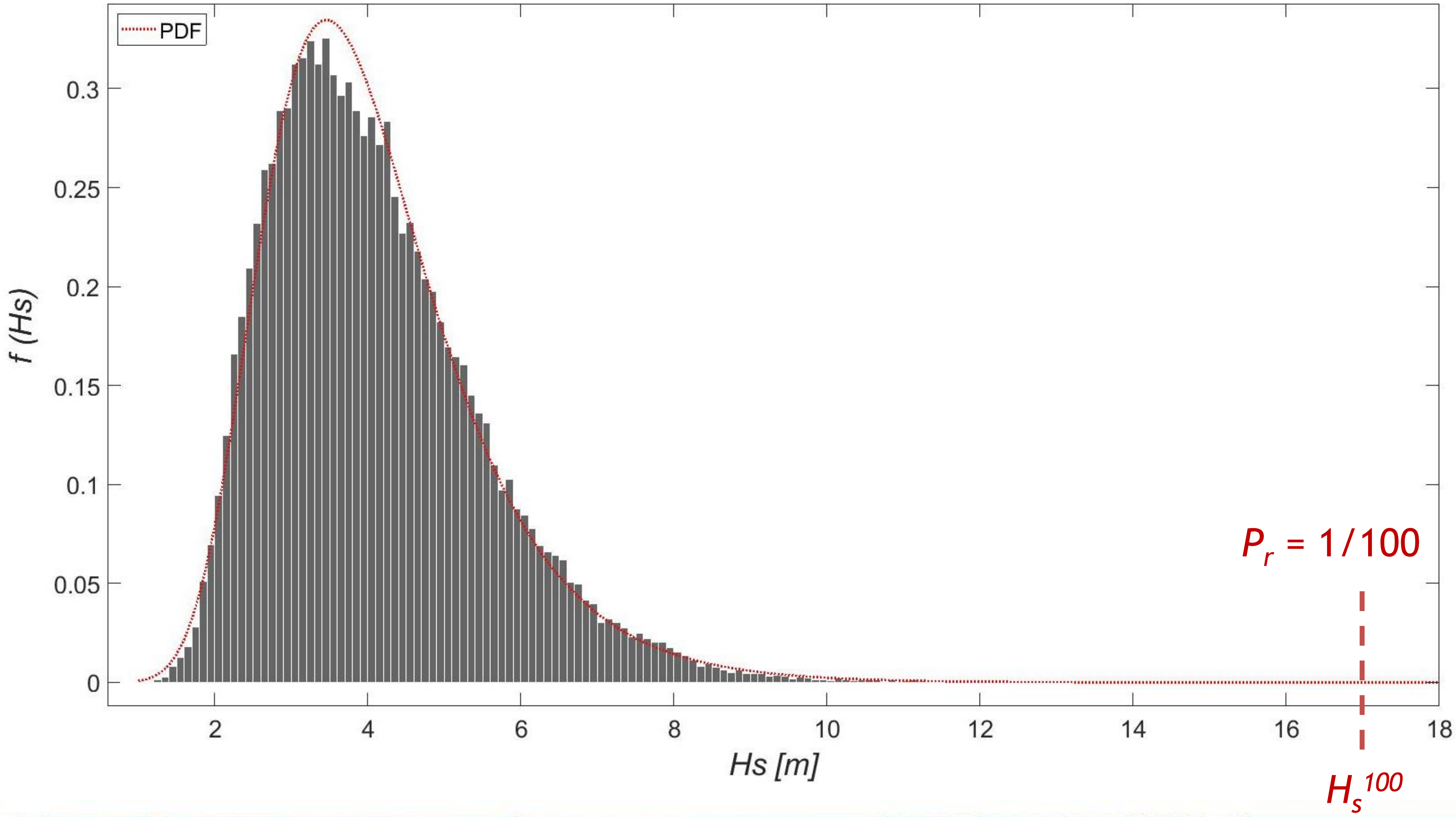
1 Introduction



1 Introduction



1 Introduction

Challenges:

1. How to reduce the extend of the required extrapolation?
2. How well is the tail of the PDF defined?
3. How well does the PDF fits the data?

1 Introduction – Choice of data set

1. How to reduce the extend of the required extrapolation?

- Traditional approach is to use buoy/offshore platform data

  !! Locations limited

  !! Long duration records not at all sites

- Alternative approaches:
  - Numerical model data

    !! As good as the model physics / performance under extreme condition

  - Satellite data

    !! Global coverage; Long duration records (Young et al., 2017)

1 Introduction – Extreme Value Theory

2. How well is the tail of the PDF defined?

3. How well does the PDF fits the data?

- Assumption of i.i.d.
- Three general approaches:
  - Initial Distribution Method (IDM)

    e.g. Goda (1998; 1992); Vinoth and Young (2011)
  - Peaks Over Threshold (POT)

    e.g. Goda (1992); Vinoth and Young (2011)
  - [Annual Maximum Method (AMM); e.g. Coles (2001)]

2 Global estimates of Extremes - IDM

! No theoretical approach for the choice of an appropriate distribution

→ Cumulative distribution function (CDF) that fits the whole PDF:

- Gumbel distribution

$$F(x) = \exp\left[-\exp\left(-\frac{x-A}{B}\right)\right] \quad (1)$$

- The Weibull three-parameter distribution

$$F(x) = 1 - \exp\left[-\left(\frac{x-A}{B}\right)^k\right] \quad (2)$$

$P(x < x^{100}) = 1\text{-}D/T_{100}$

(Tucker, 1991; Cooper and Forristall, 1997; Teng, 1998)

2 Global estimates of Extremes – POT

1. A threshold is set (objectively) and data above this threshold considered
   [e.g. 90th or 95th percentile (Alves and Young, 2003; Vinoth and Young, 2011)]

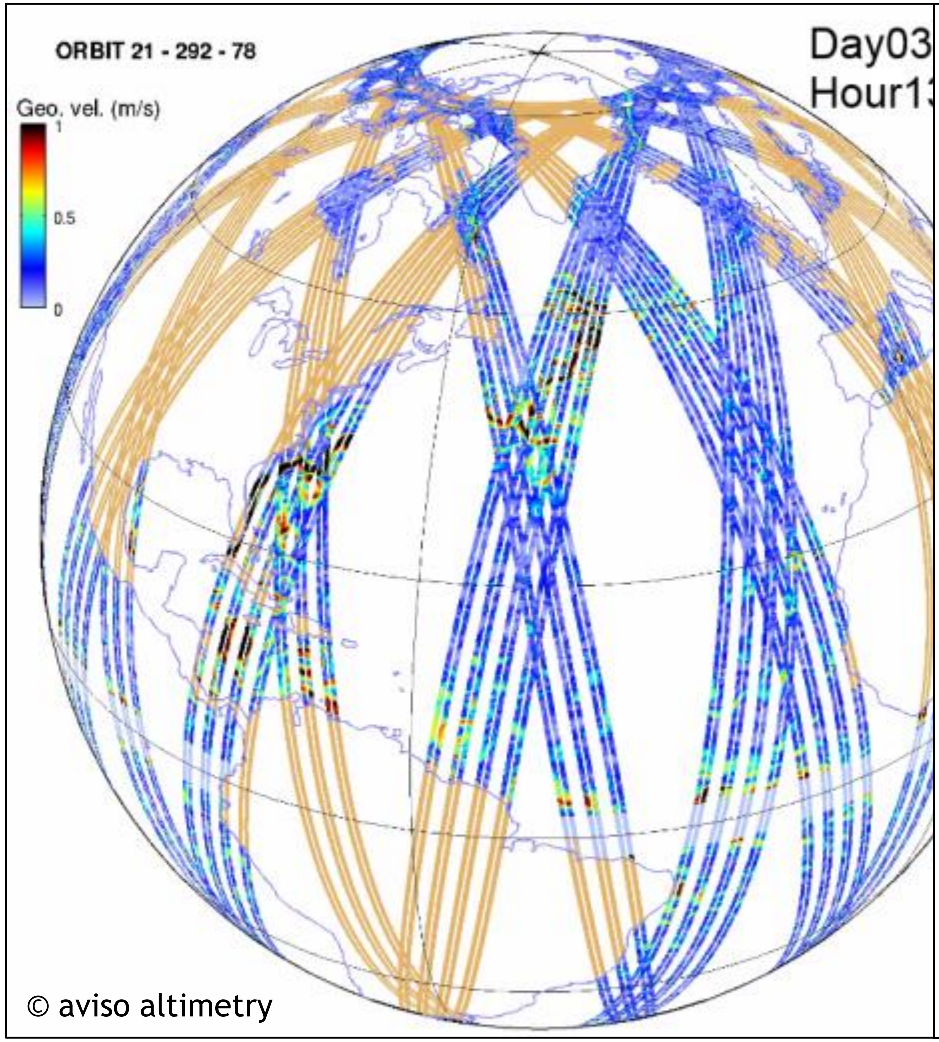
2. These exceedances will follow a Generalized Pareto distribution (GPD)

$$F(x) = 1 - \left[1 + k\left(\frac{x-A}{B}\right)^{-\frac{1}{k}}\right] \qquad (3)$$

$P(x < x^{100}) = 1\text{-}N_y/100\ N_{PoT}$

(Vinoth and Young, 2011)

3 Satellite data set



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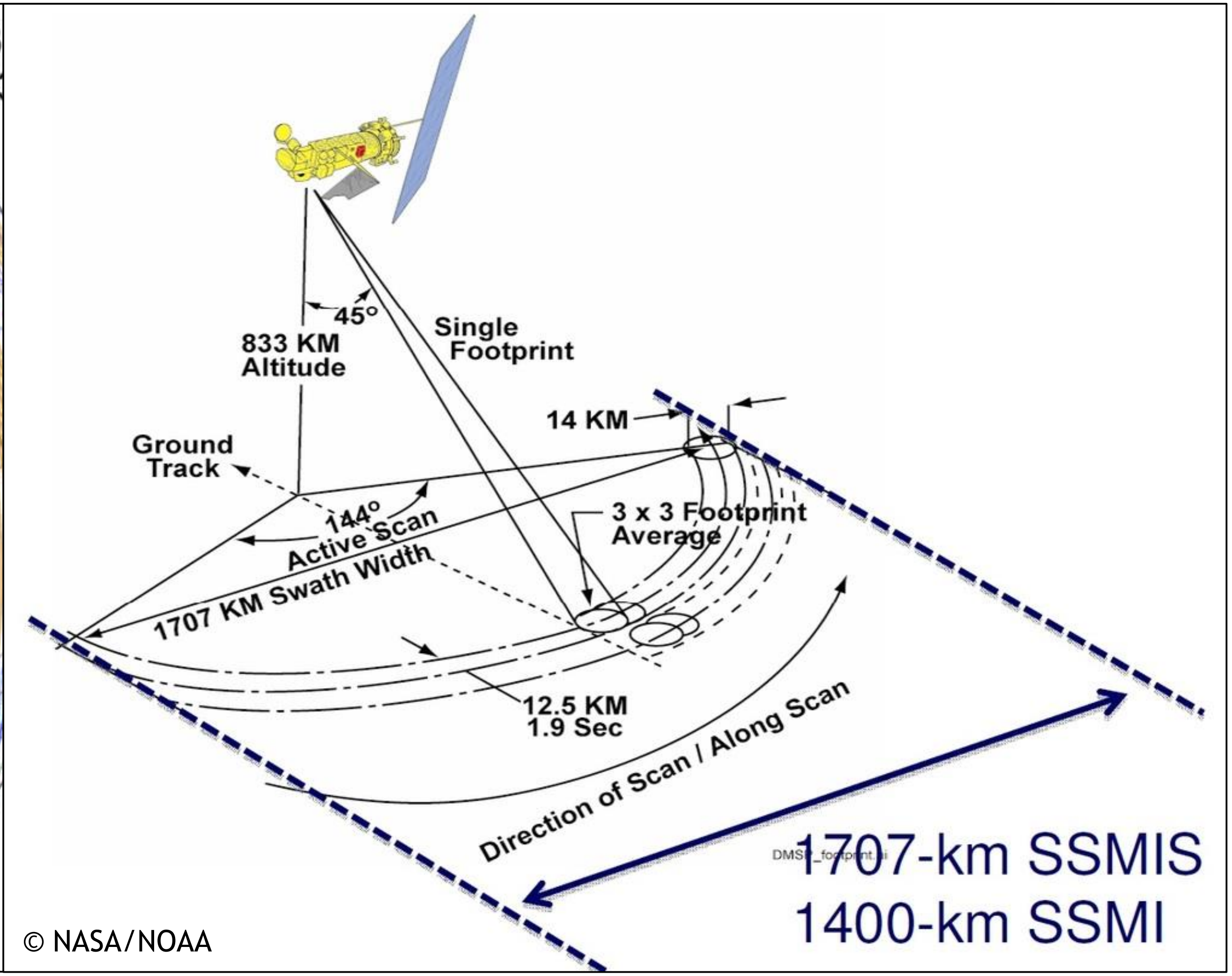

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3 Satellite data set

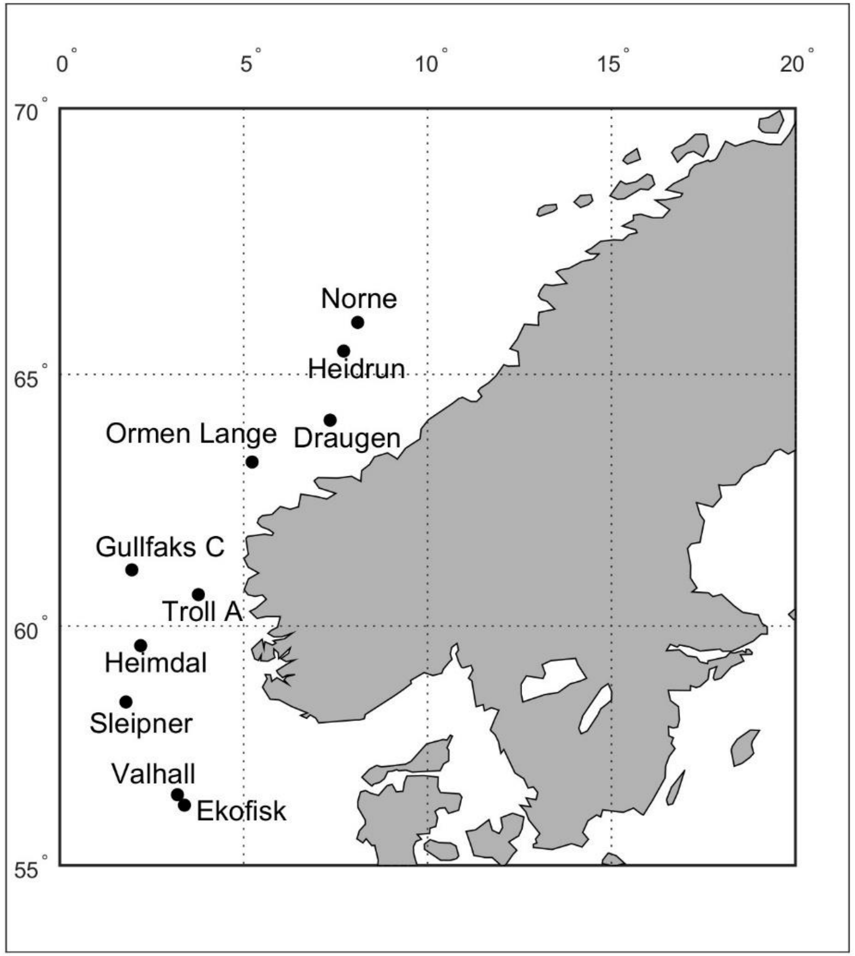

Figure 1 Locations of offshore platforms

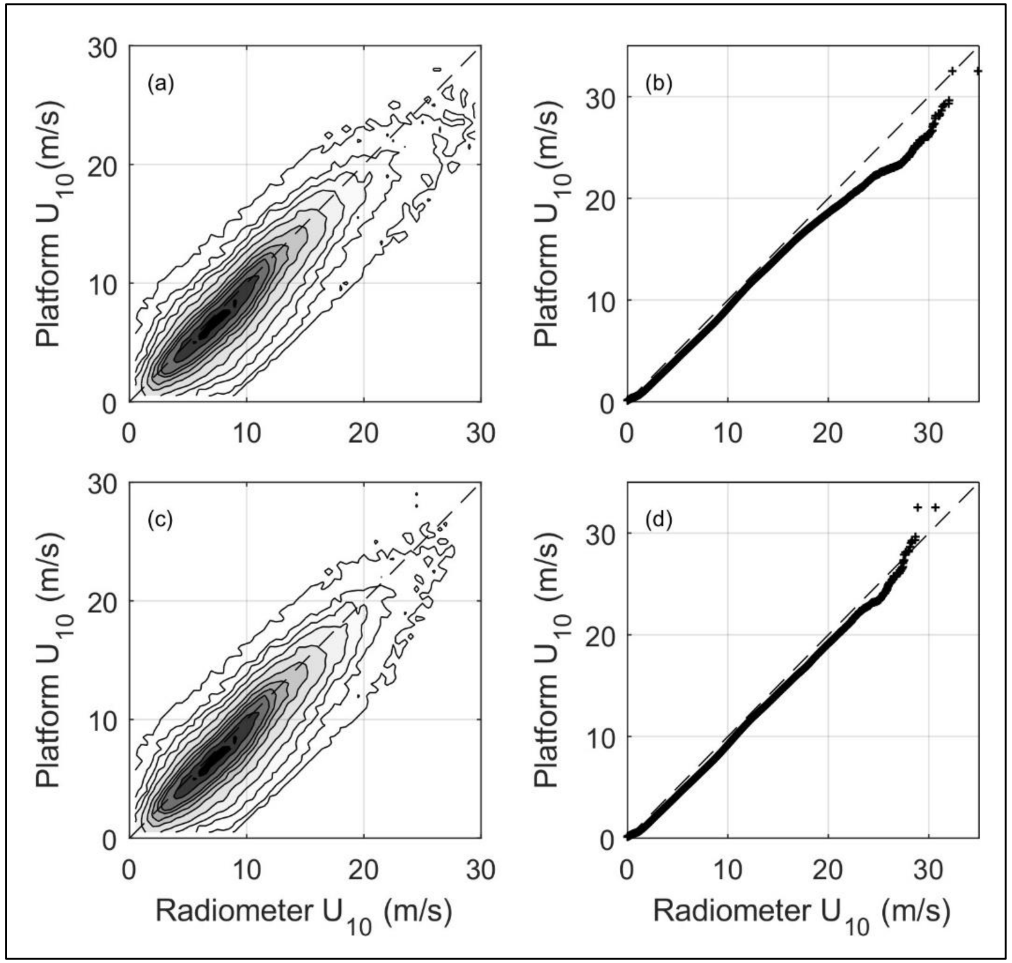

Figure 2 Radiometer-platform anemometer comparisons

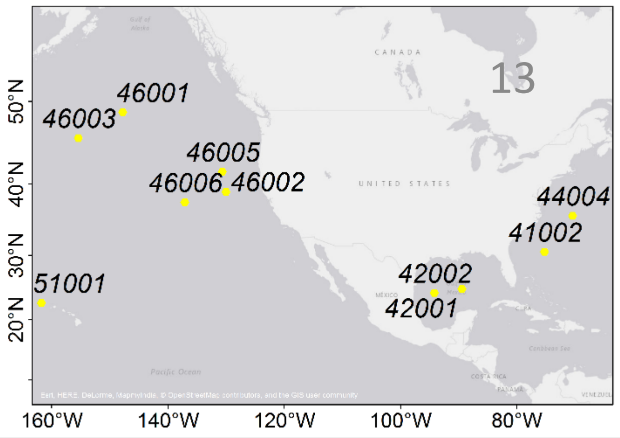

Figure 3 Locations of NDBC buoy

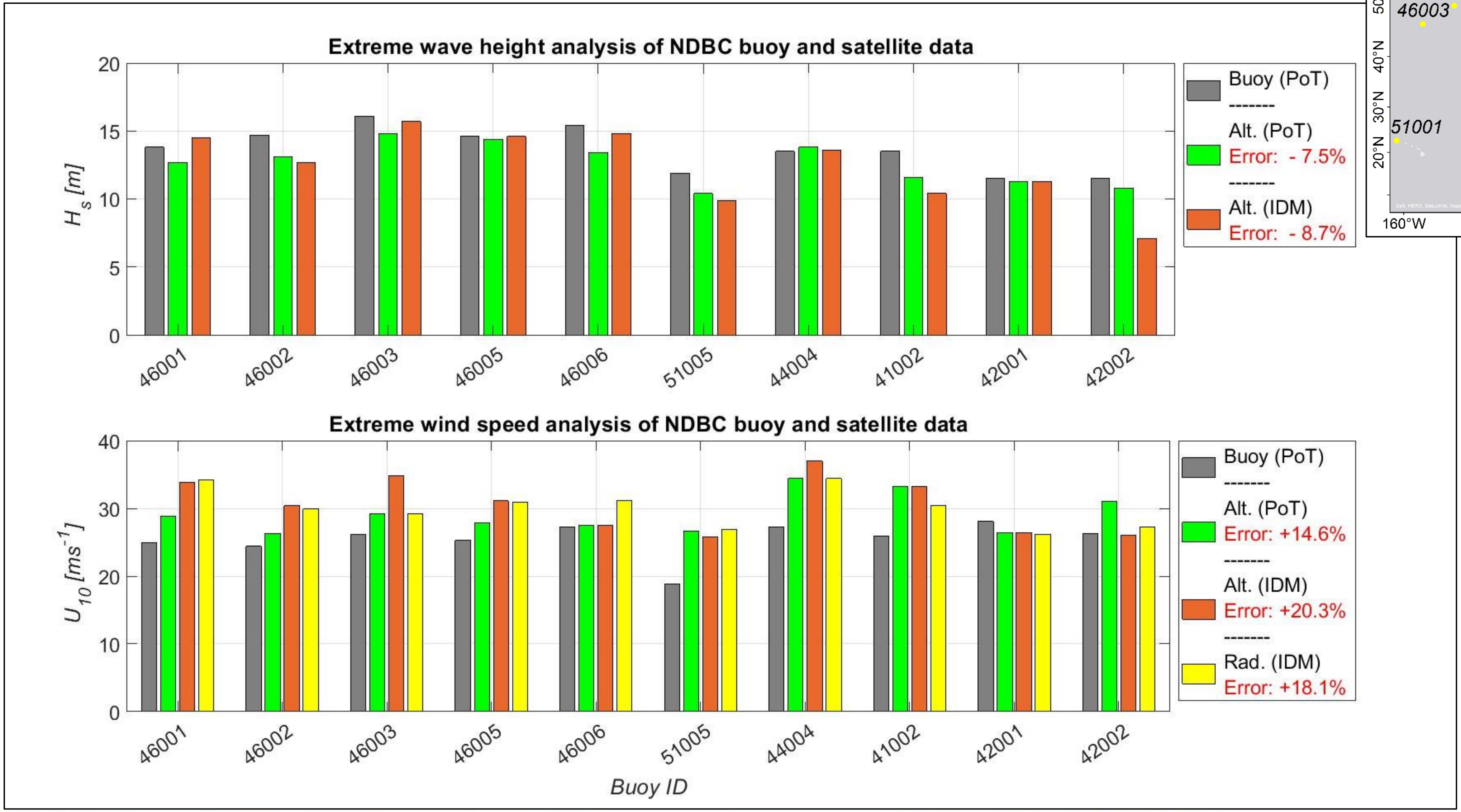

Figure 4 Extreme value analysis of NDBC buoy and satellite data

5 Global distribution of Extremes - Altimeter POT

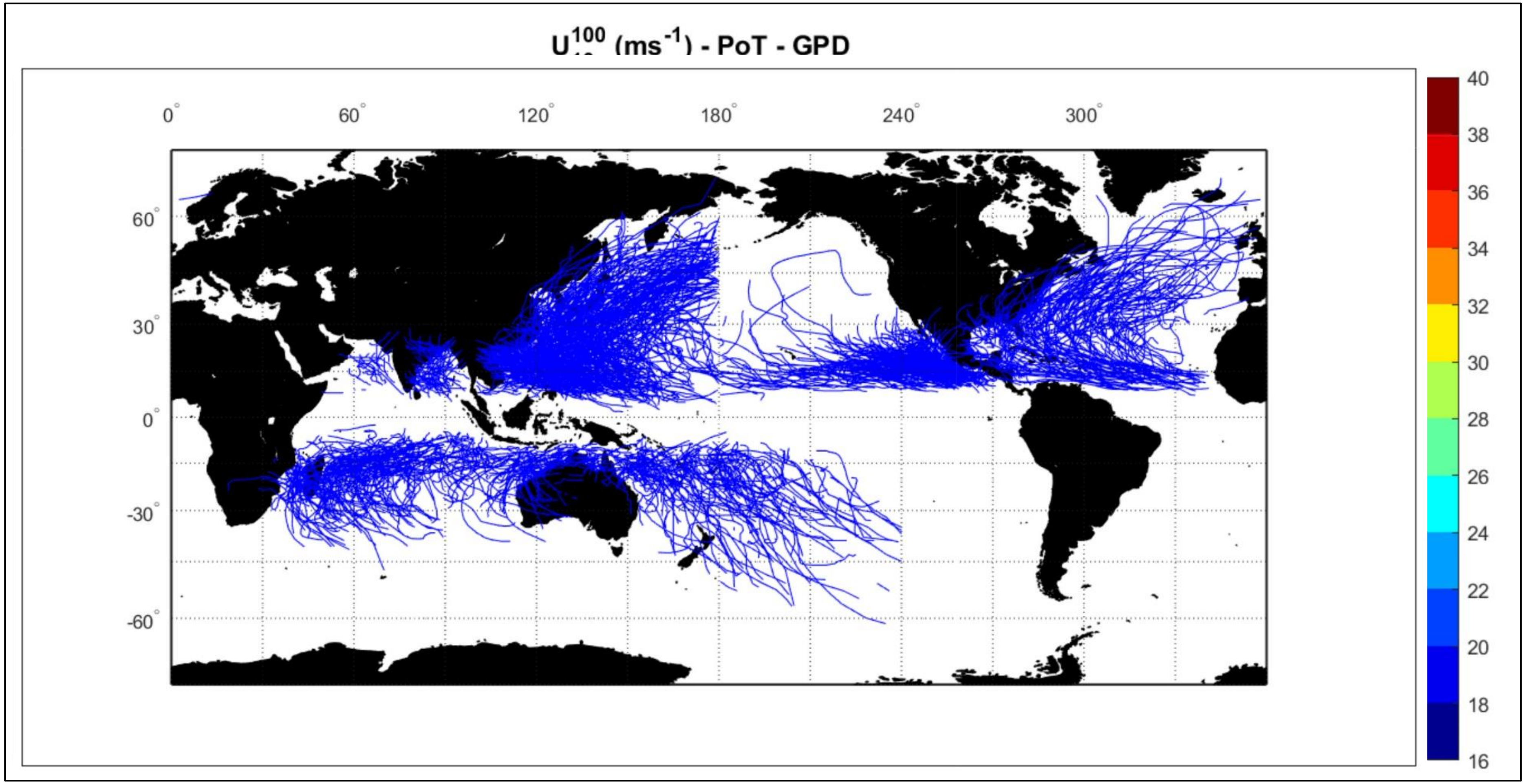

Figure 5a Global values of extreme wind speed – Altimeter/POT-GPD

5 Global distribution of Extremes - Altimeter POT

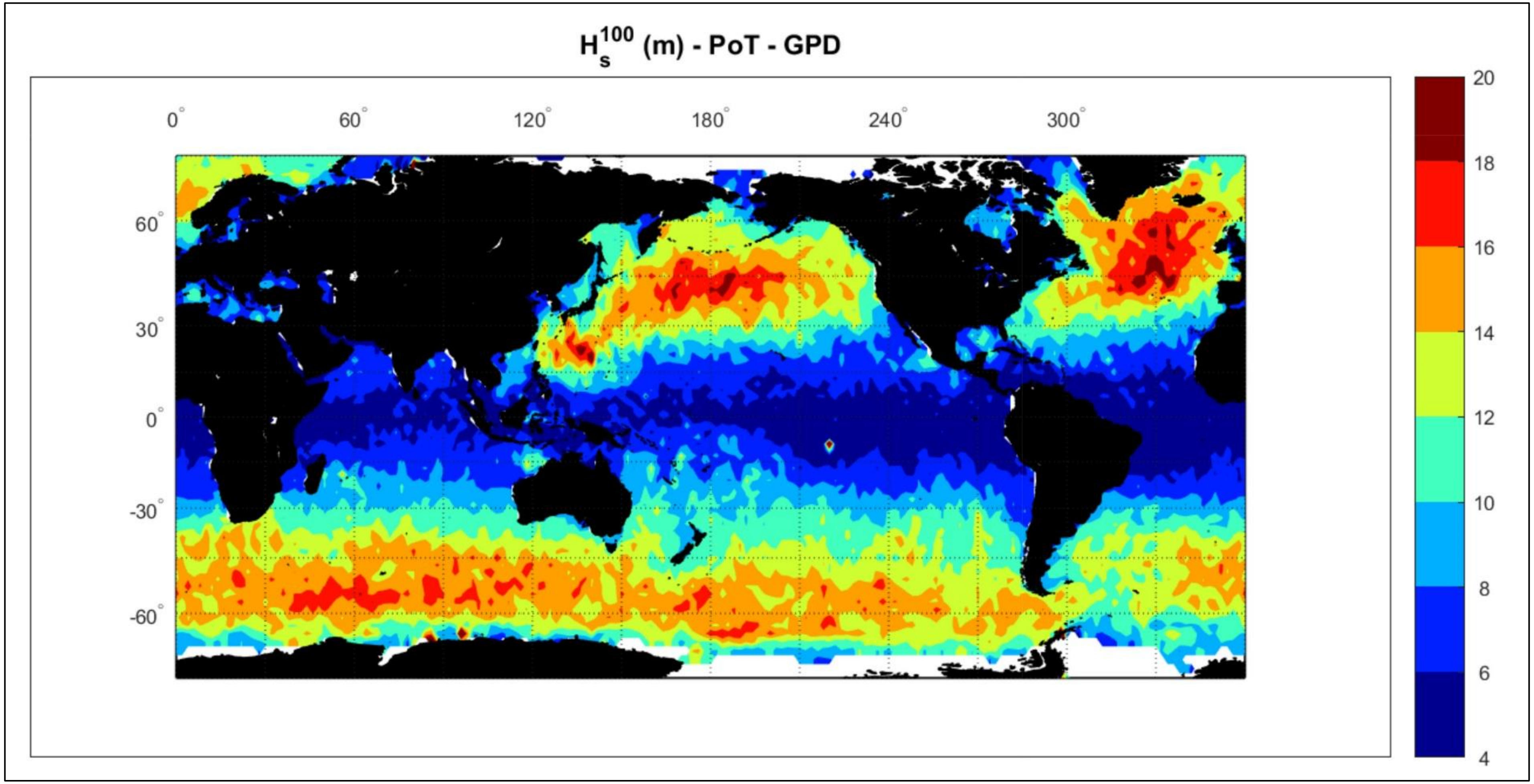

Figure 5b Global values of extreme wave height – Altimeter/POT-GPD

5 Global distribution of Extremes - Radiometer POT

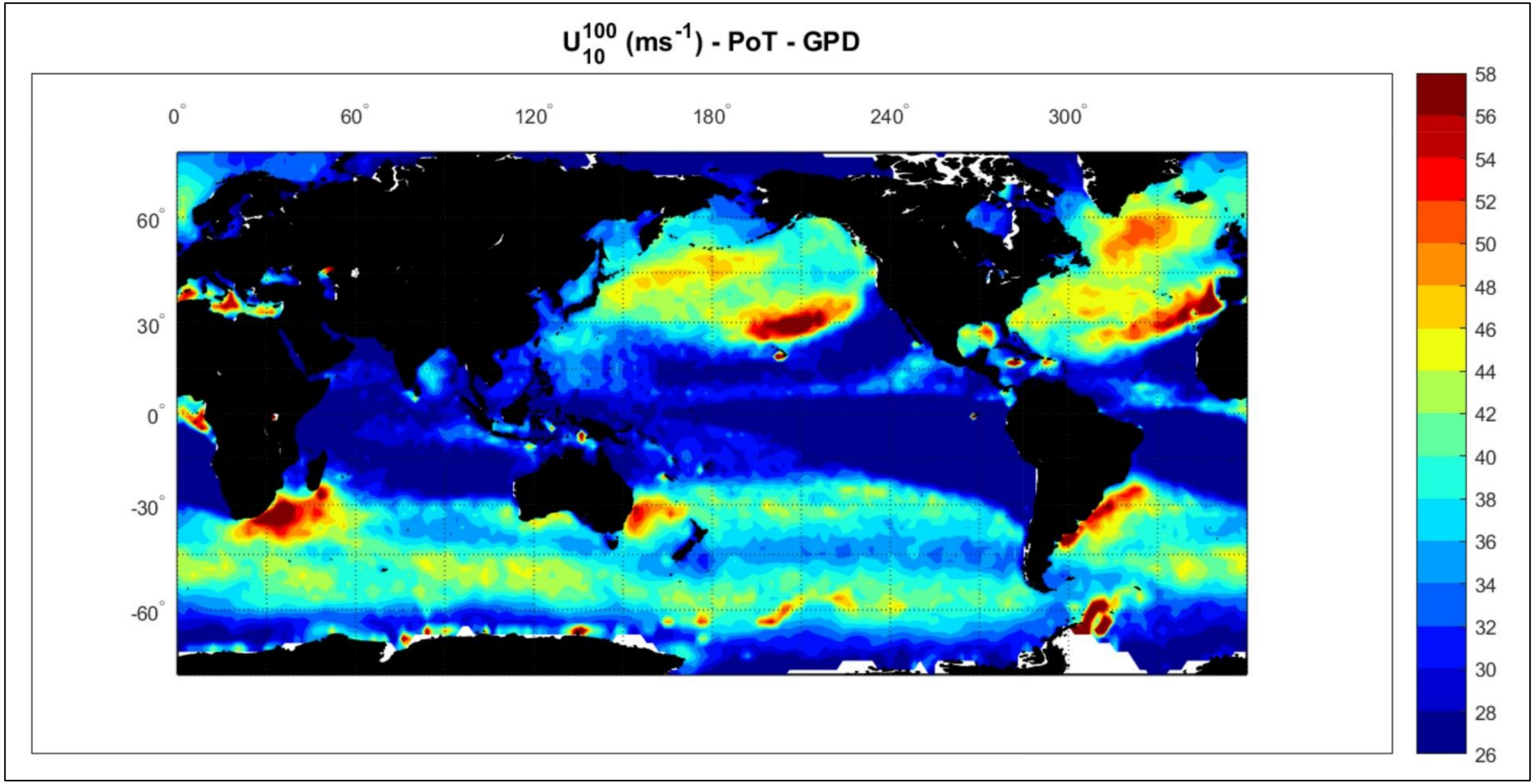

Figure 6a Global values of extreme wind speed – Radiometer/POT-GPD (no high wind speed correction)

5 Global distribution of Extremes - Radiometer POT

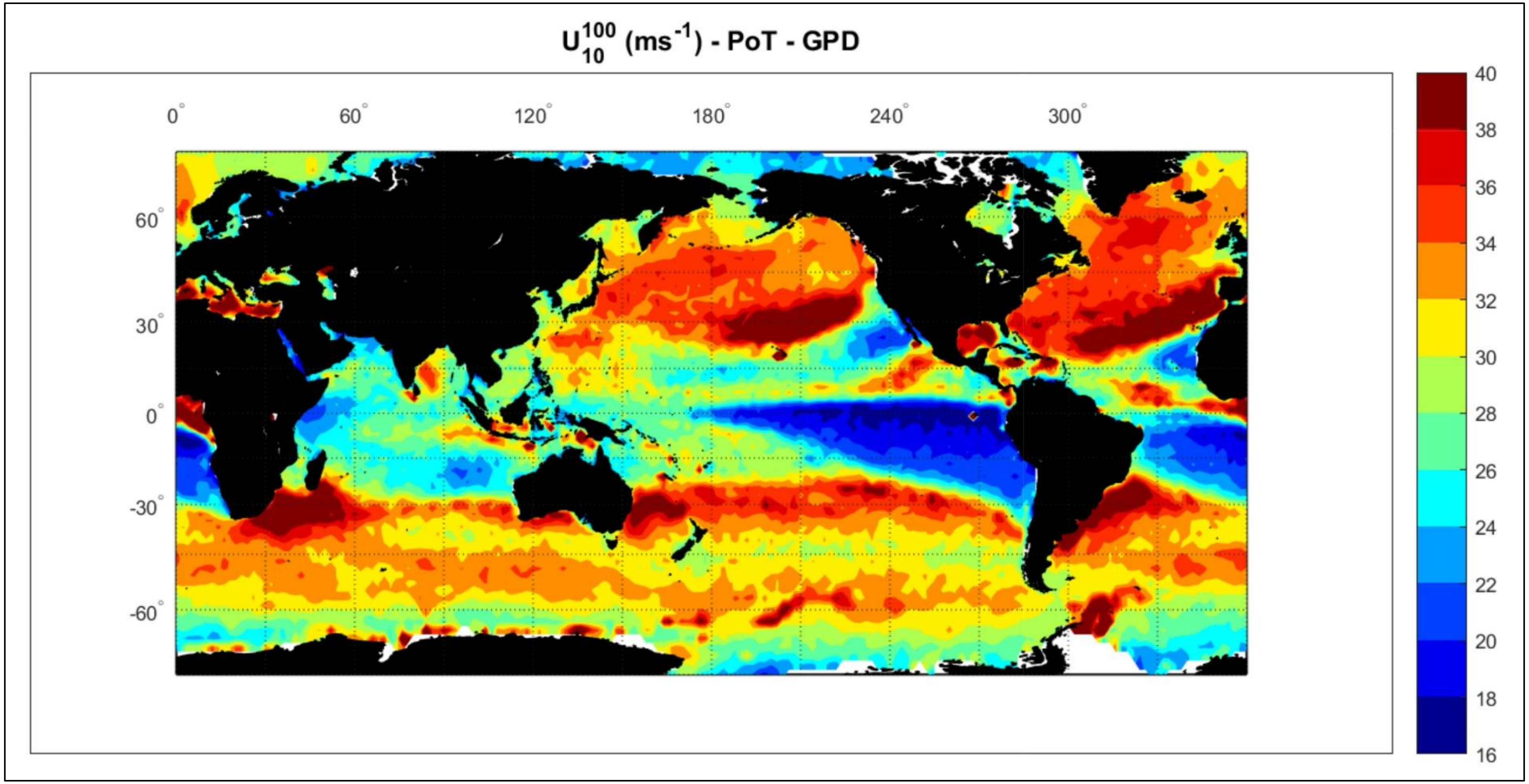

Figure 6b Global values of extreme wind speed – Radiometer/POT-GPD (with high wind speed correction)

5 Global distribution of Extremes - Radiometer POT

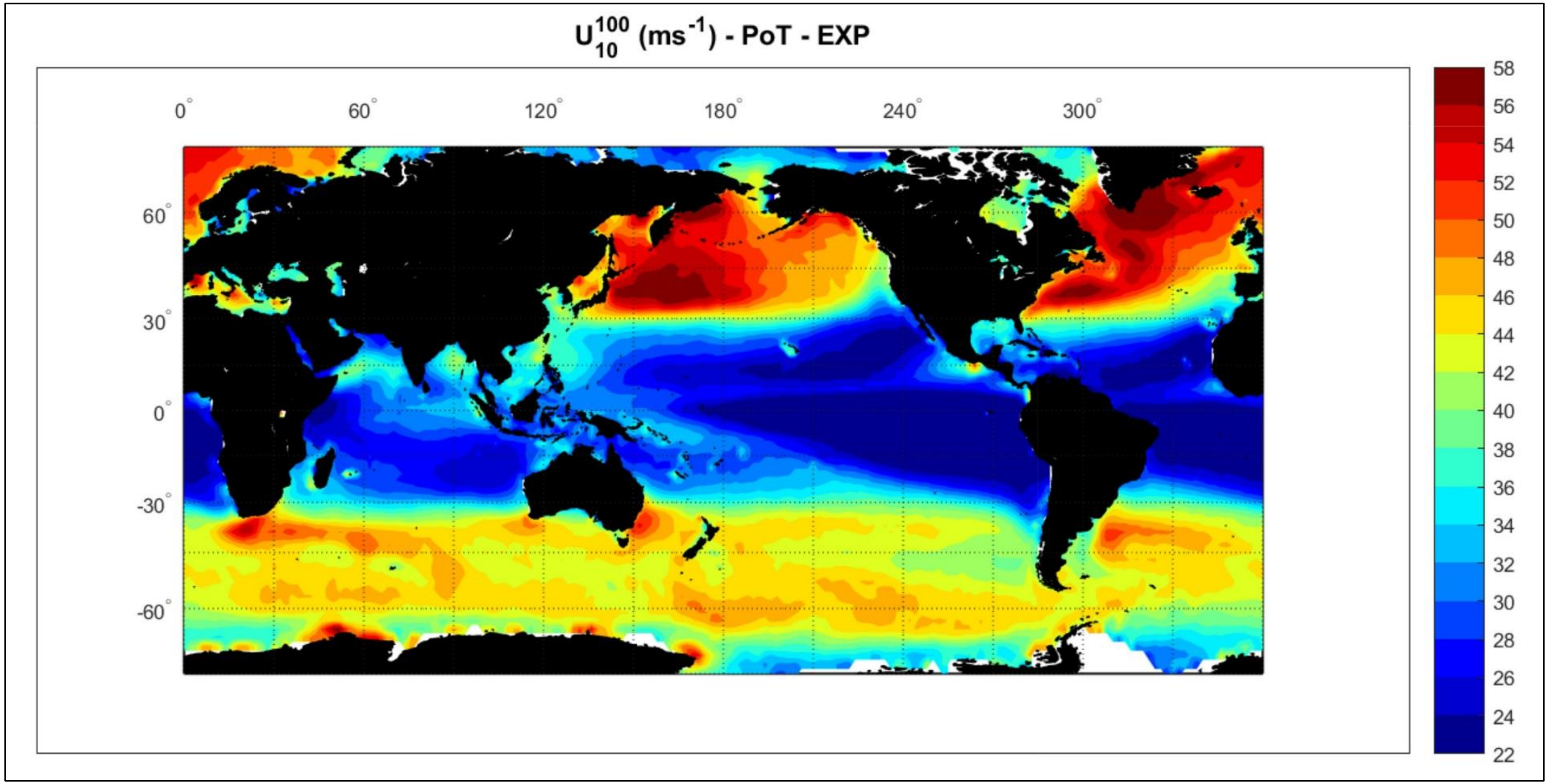

Figure 7 Global values of extreme wind speed – Radiometer/POT-EXP (with high wind speed correction)

5 Global distribution of Extremes – Altimeter IDM

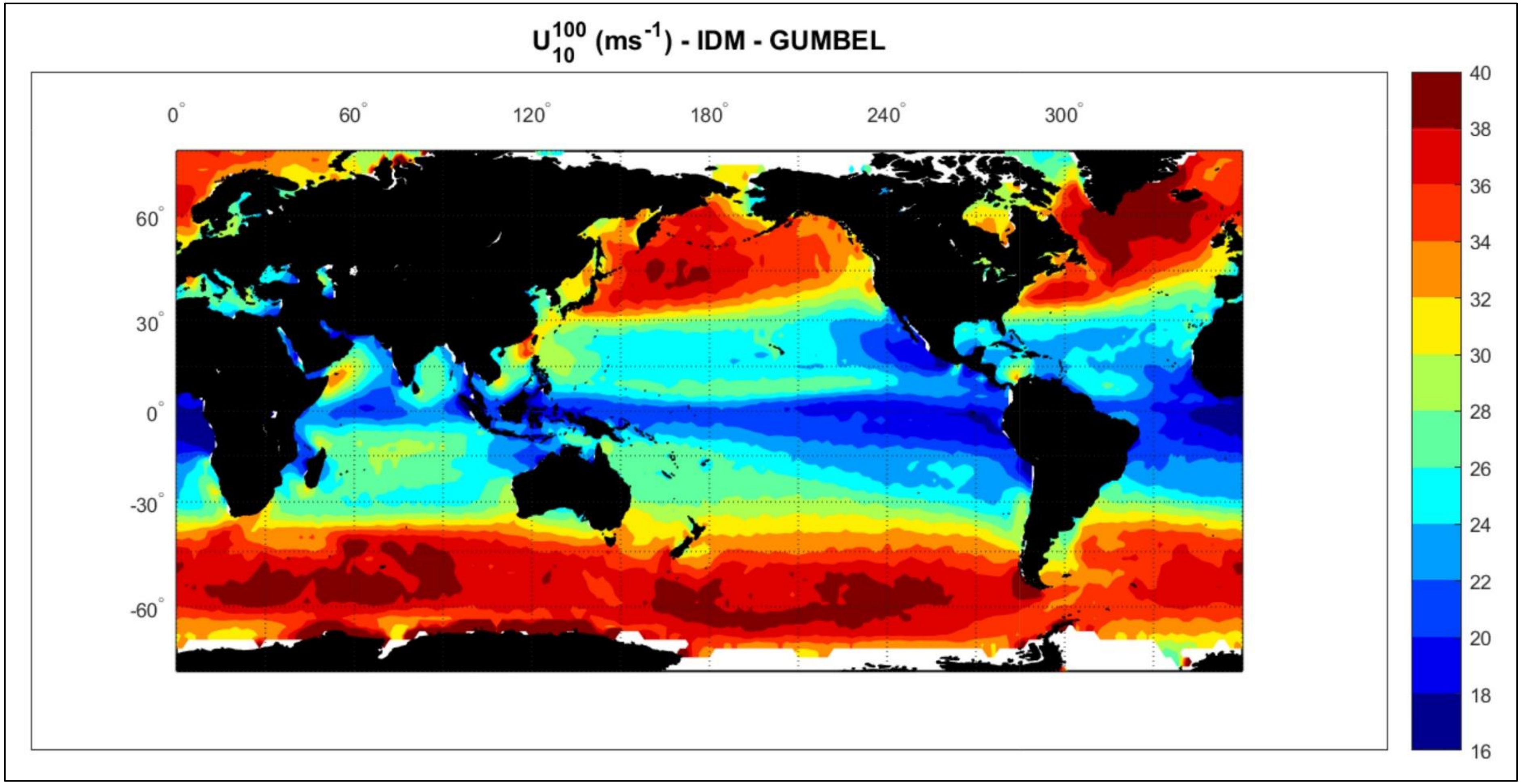

Figure 8a Global values of extreme wind speed – Altimeter/IDM-Gumbel (with high wind speed correction)

5 Global distribution of Extremes - Radiometer IDM

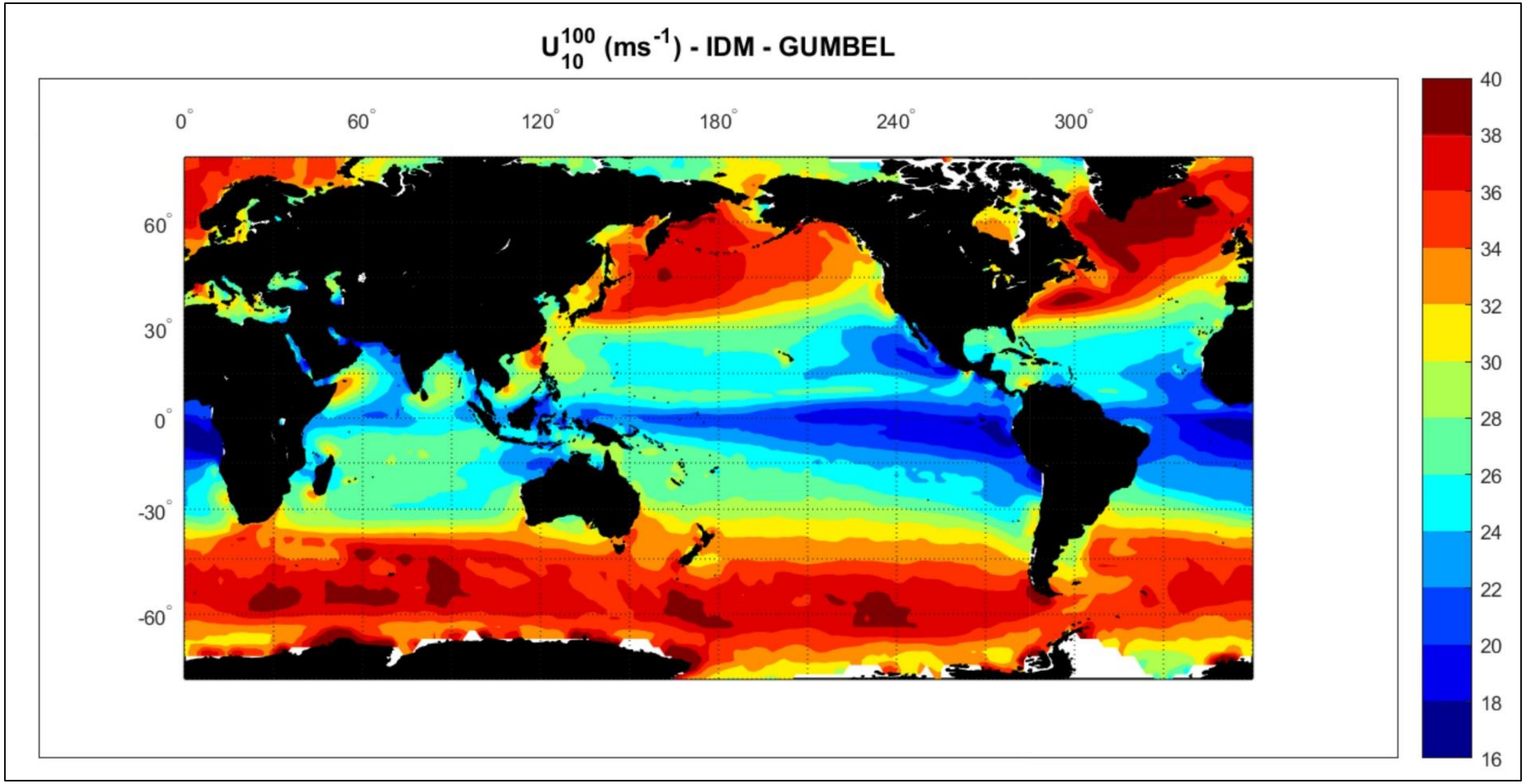

Figure 9 Global values of extreme wind speed – Radiometer/IDM-Gumbel (with high wind speed correction)

5 Global distribution of Extremes - Altimeter IDM

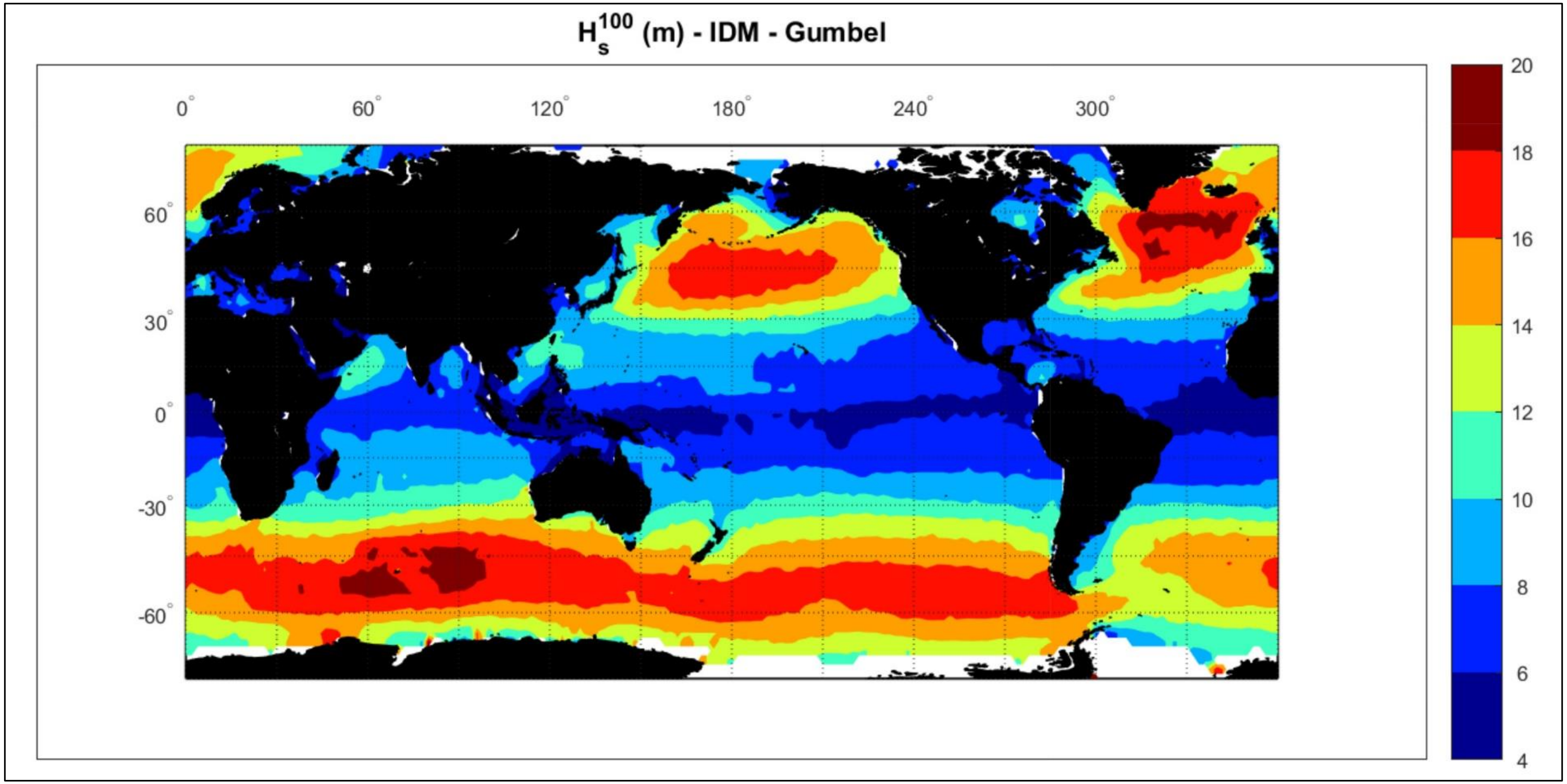

Figure 8b Global values of extreme wave height – Altimeter/IDM-Gumbel

6 Conclusion

- The new Satellite data enables POT analysis for the first time
  - Altimeter:

    !! Values consistent with buoy and previous numerical model data

    !! Much greater fine scale structure
  - Radiometer:

    !! Unacceptable “fair-weather” bias

    → Unusable for POT EVA
- IDM yield quite biased estimates of extremes and their spatial distribution

  !! Comparing to POT, little reason to use IDM in the future!

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