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Development and Application of a Global Satellite Database of Wind and Wave Conditions

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Presentation Overview

Aims:

- Compile global database from all long term platforms
- Wind and wave conditions
- Fully calibrated and independently validated
- Cross-validated between platforms

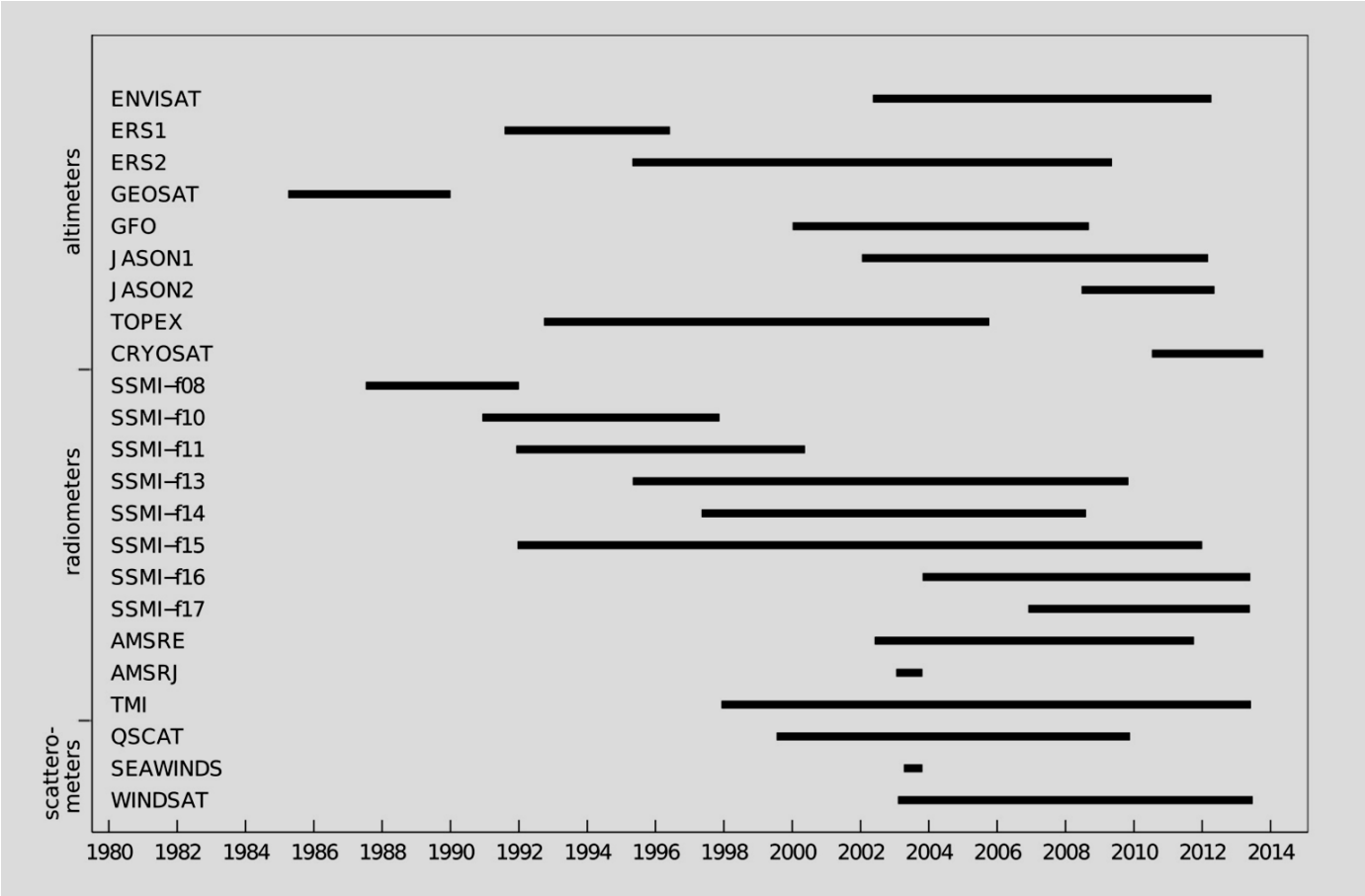
Uses

- Global climatology
- Long terms trends (30 years)
- Extreme value estimation

  eg. 1:100 year estimates
- Trends in extremes?

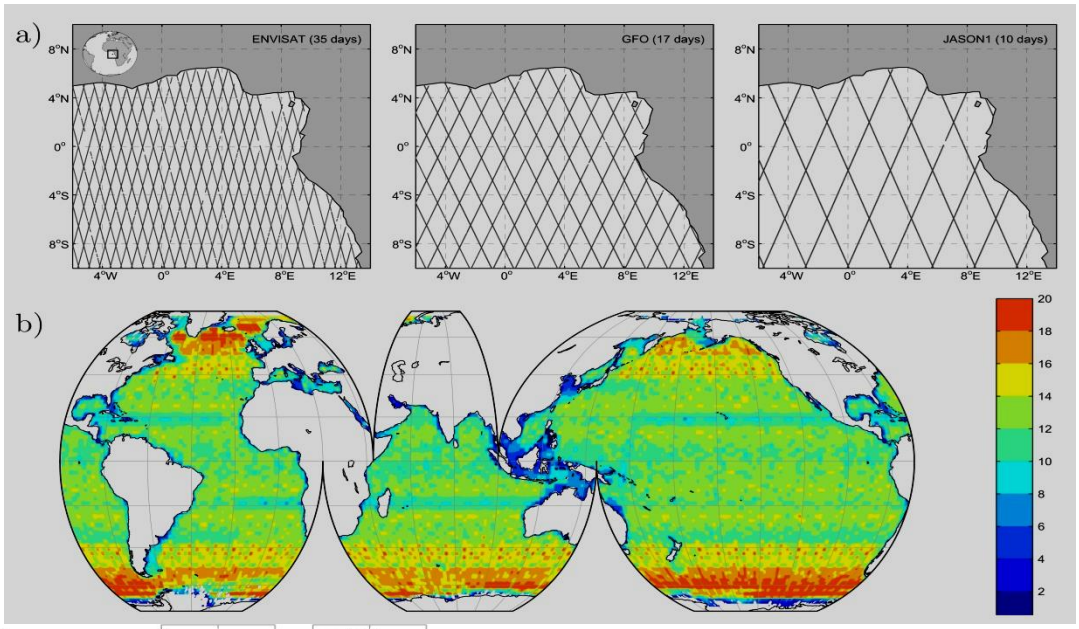
Period of data coverage

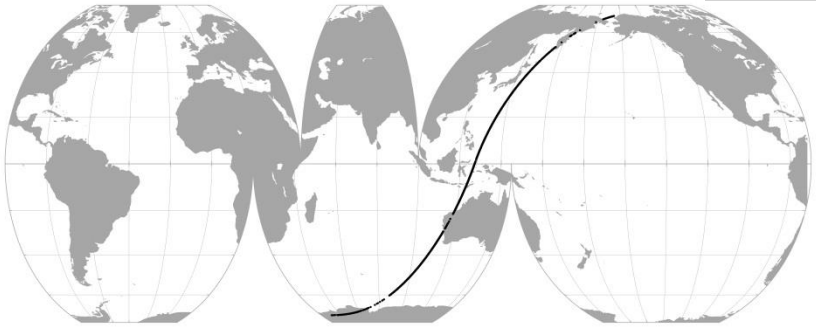
Combined dataset of 30 years duration

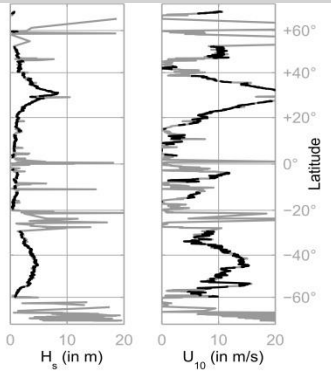


Satellite data coverage

Satellite Data Coverage - Altimeter

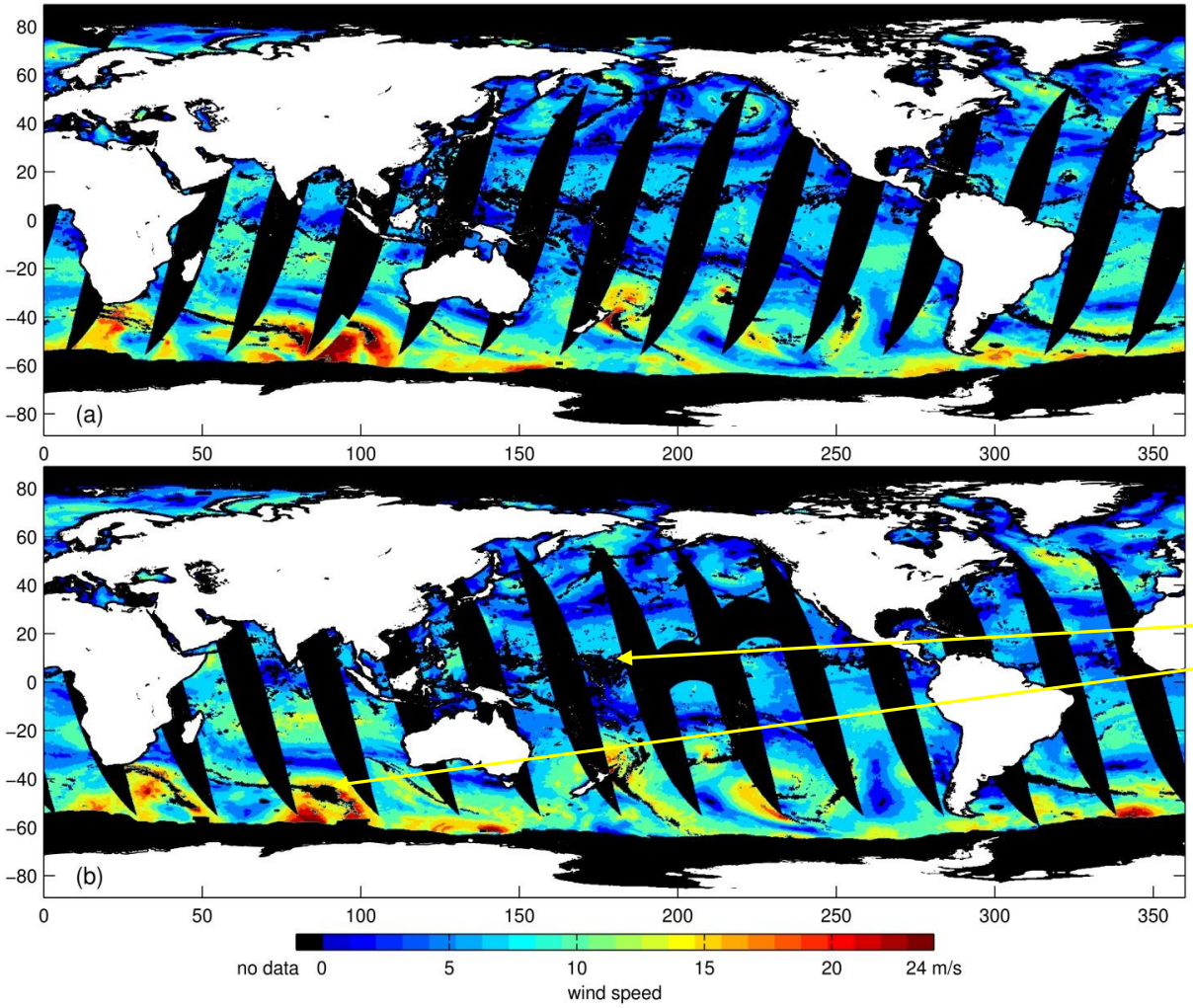






Satellite data coverage

Satellite Data Coverage – Radiometer/Scatterometer

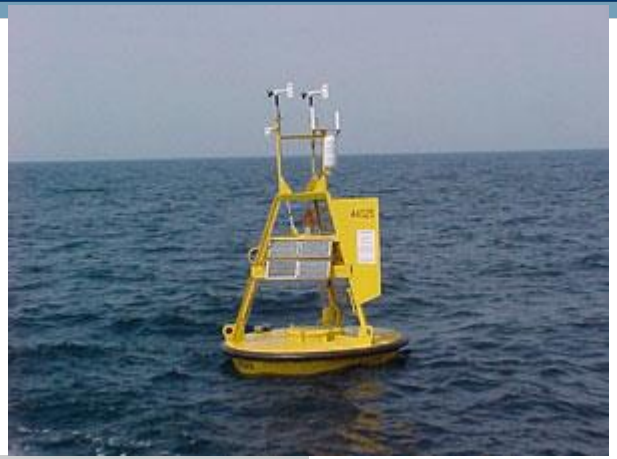


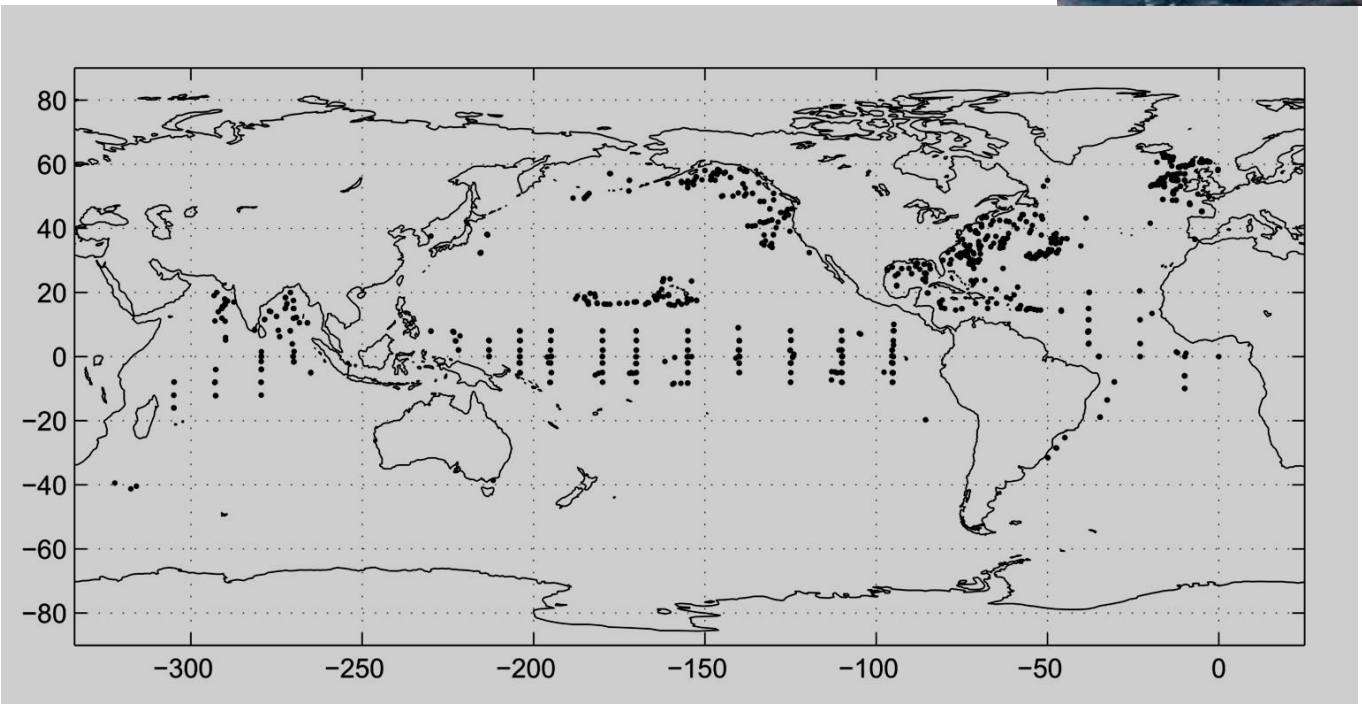
Data “holes” under rain

Insitu calibration buoys

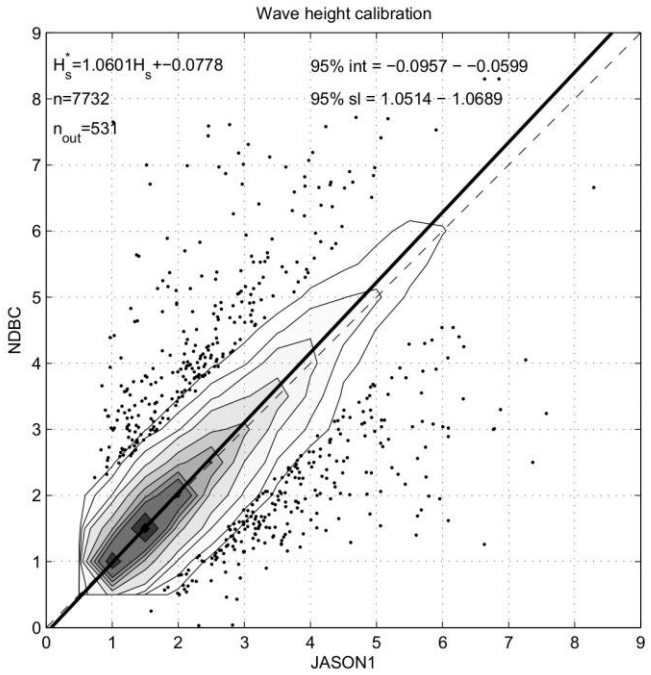
Two data sets

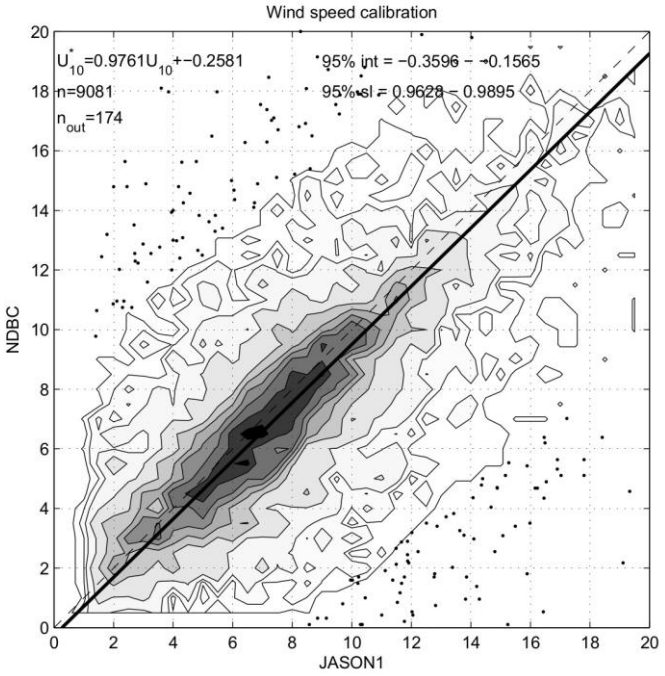
- NDBC
- ECMWF composite data





Altimeter calibration

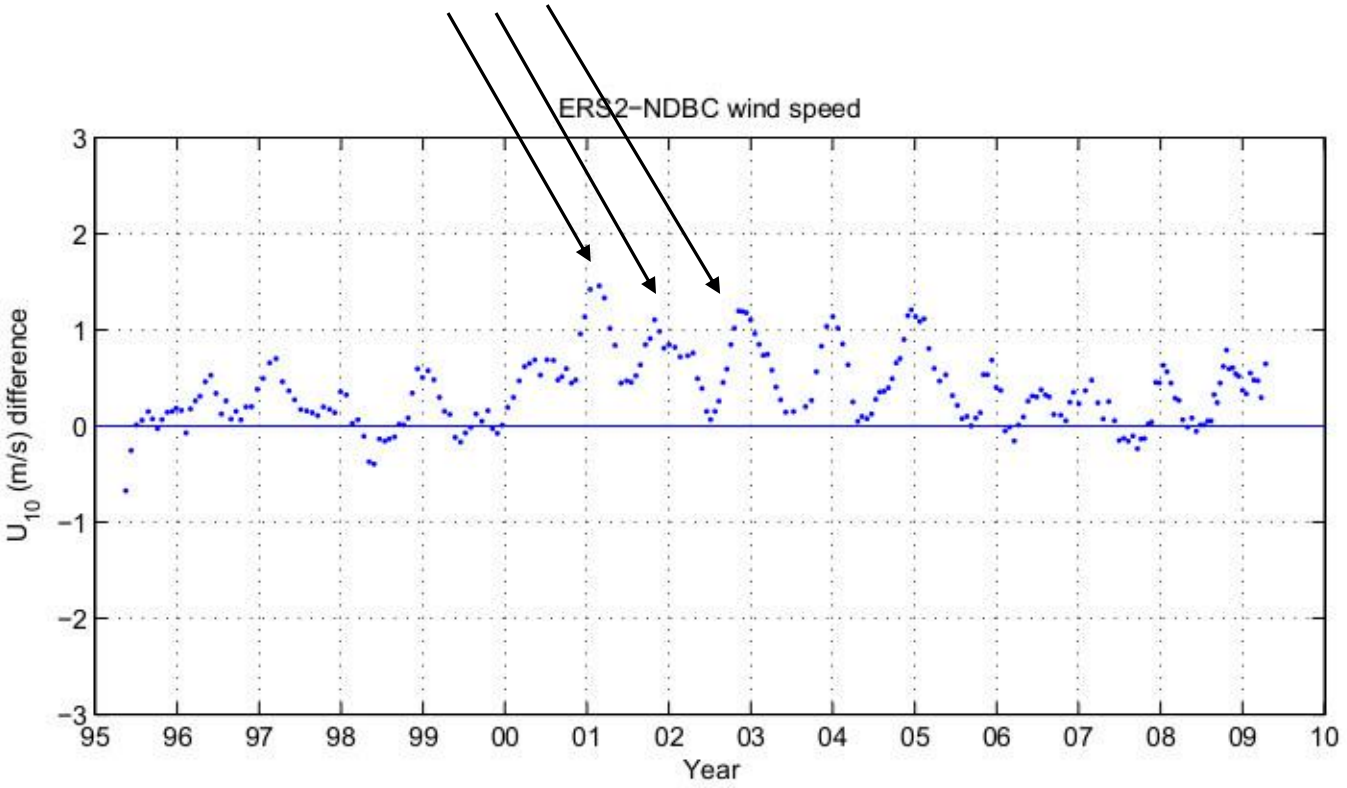




Greater scatter for wind speed

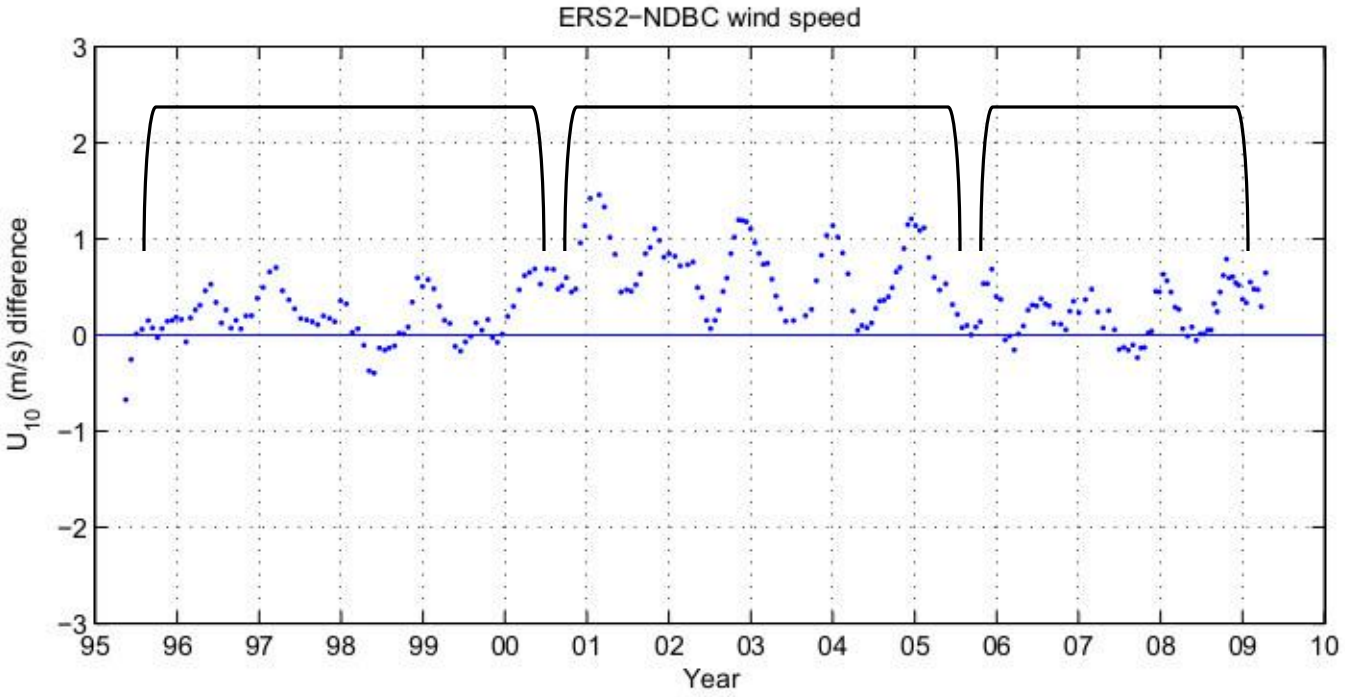
Altimeter long term stability

Annual cycle as NDBC buoys in Northern Hemisphere
Most likely due to changes in atmospheric stability



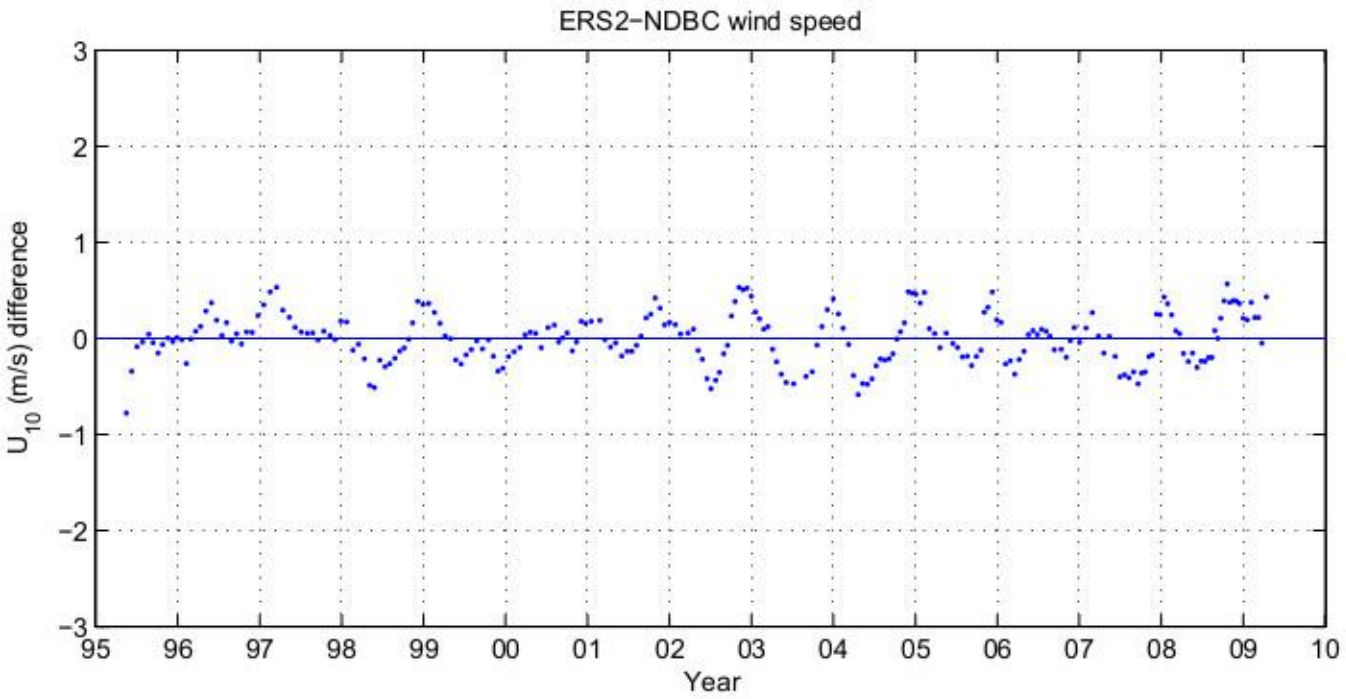
Altimeter long term stability

Apparent discontinuities in time
Piecewise calibration for each section separately



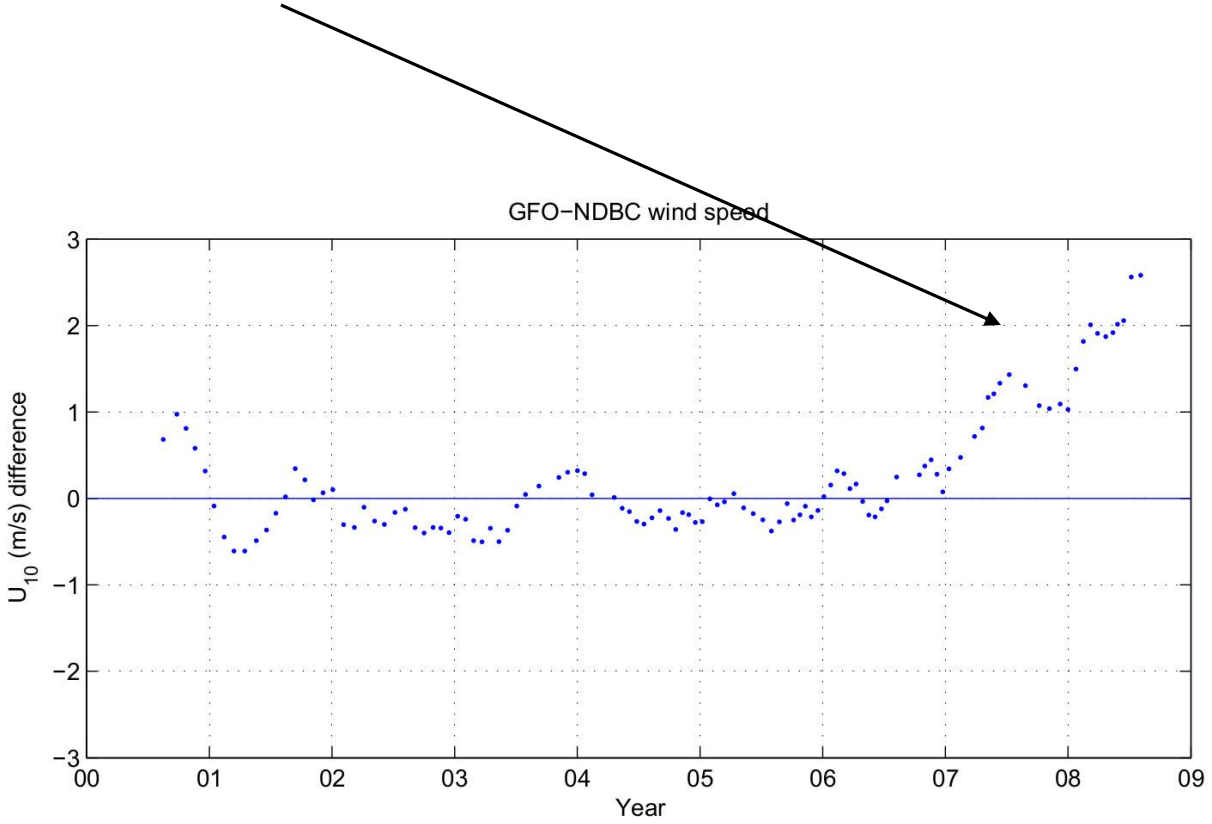
Altimeter long term stability

Discontinuities removed



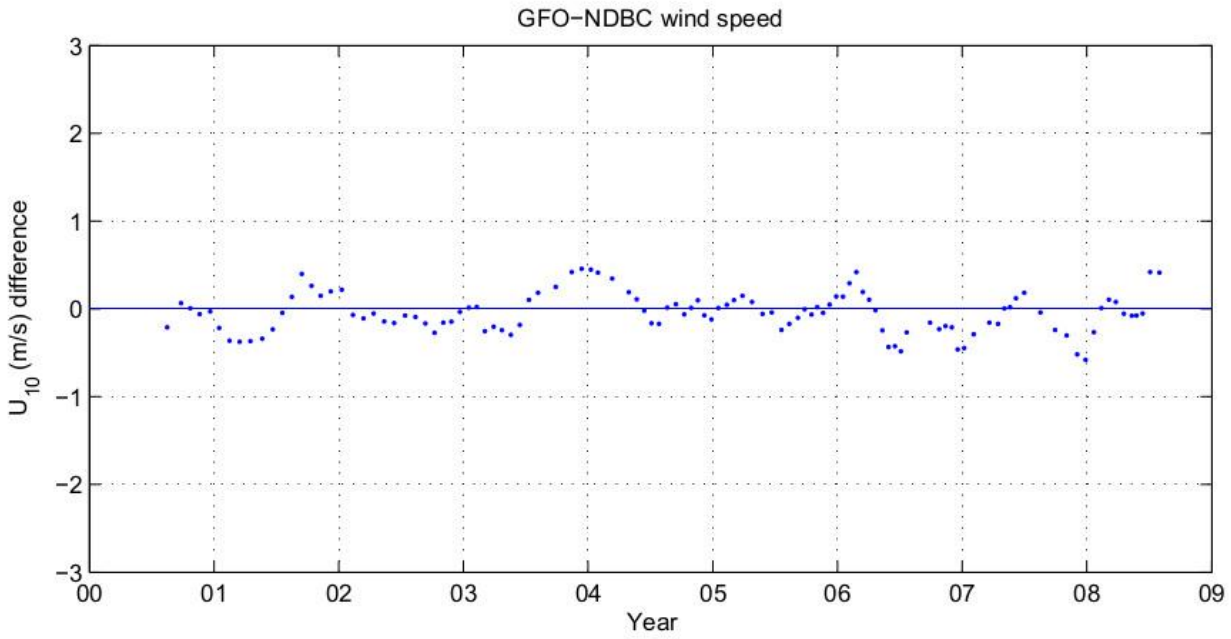
Altimeter long term stability

Drift removed by fitting a function



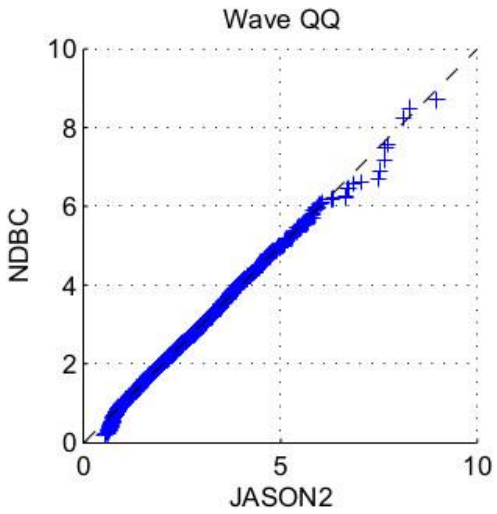
Altimeter long term stability

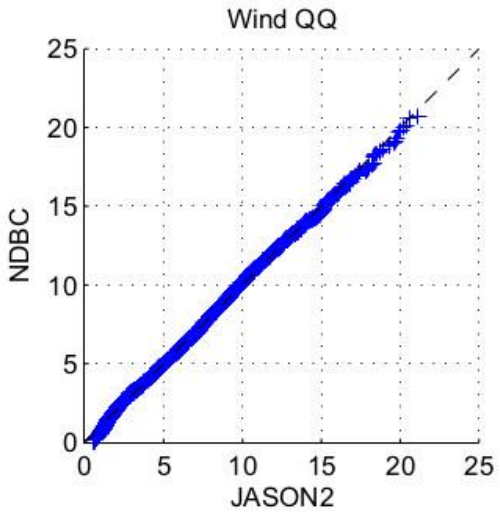
Difference plot after drift removed



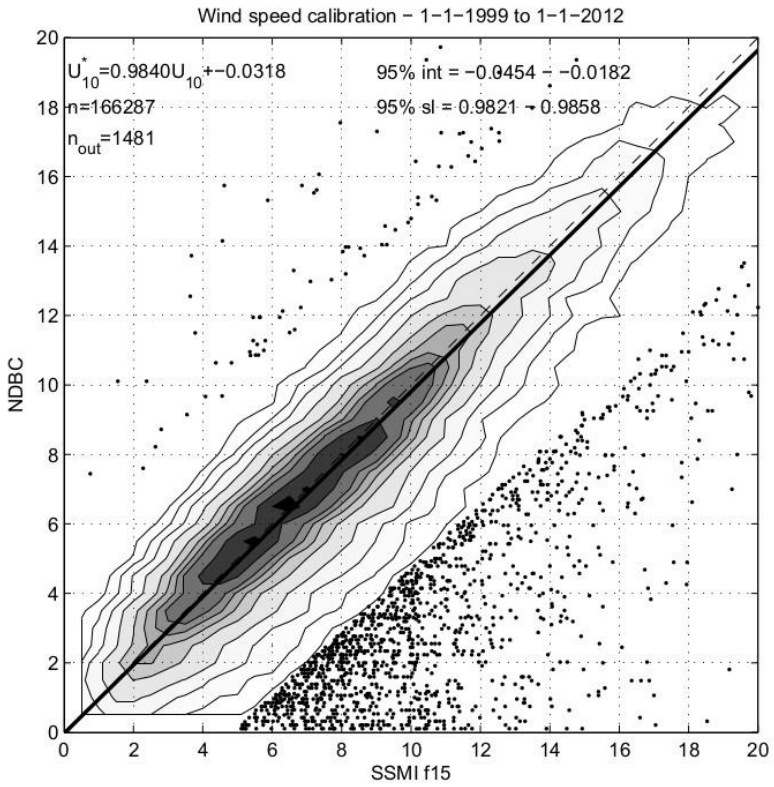
Buoy – altimeter PDF comparisons

- Altimeter wind speed and wave height both reproduce PDF of buoy data
- Confidence in measurements across available data range





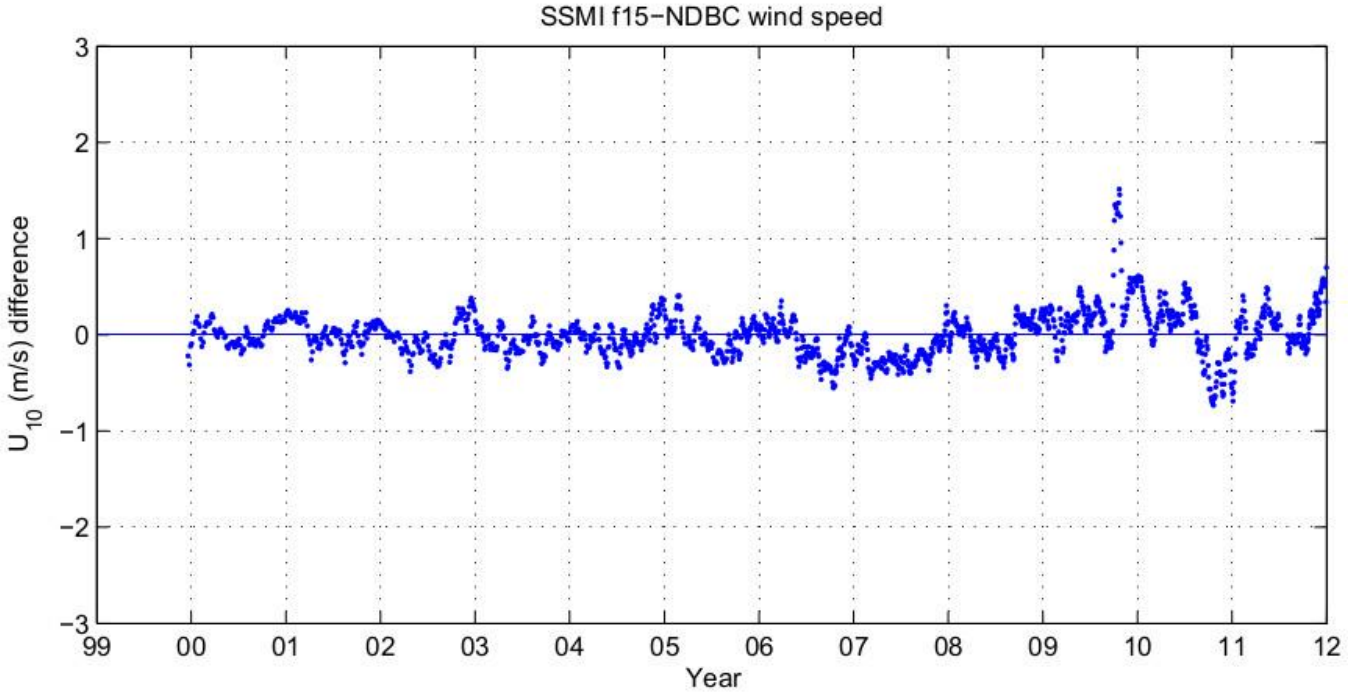
Radiometer Calibration



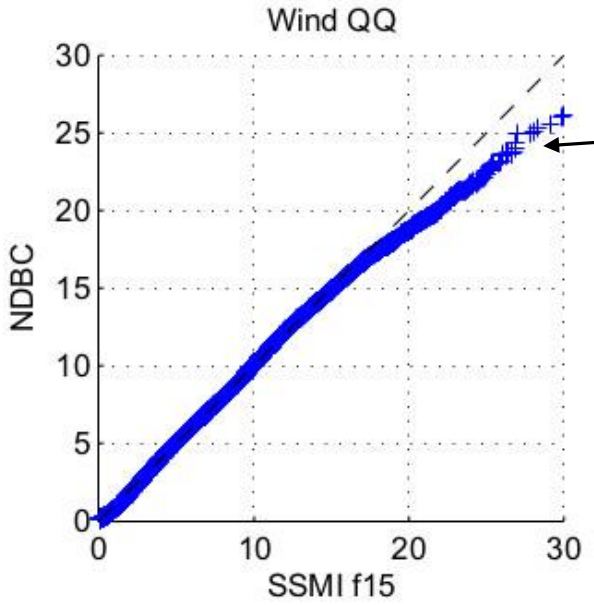
Order of magnitude more match-ups than altimeter
Less scatter than altimeter

Radiometer long-term stability

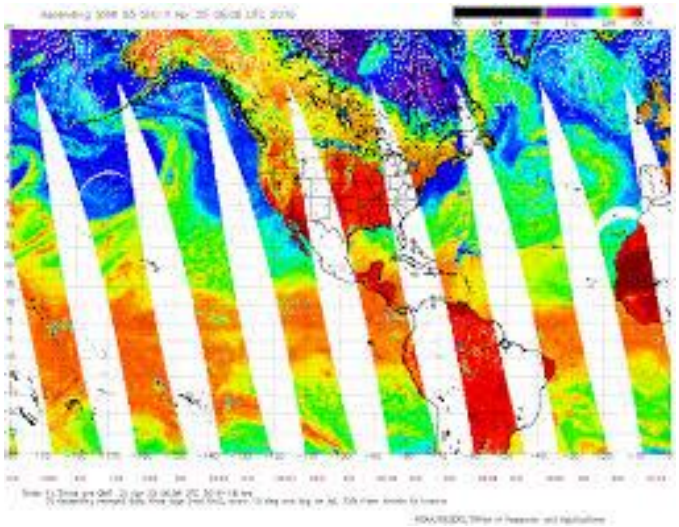
- No major discontinuities
- Slightly less scatter the altimeter



Buoy – Radiometer PDF comparisons

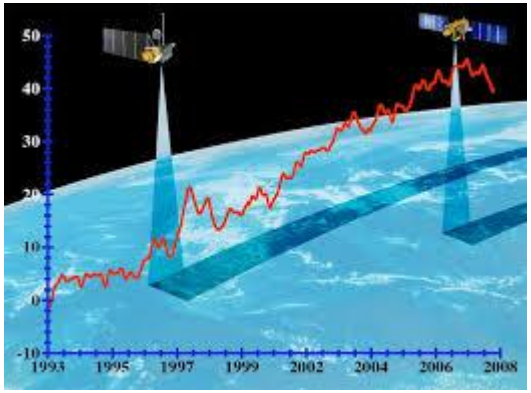


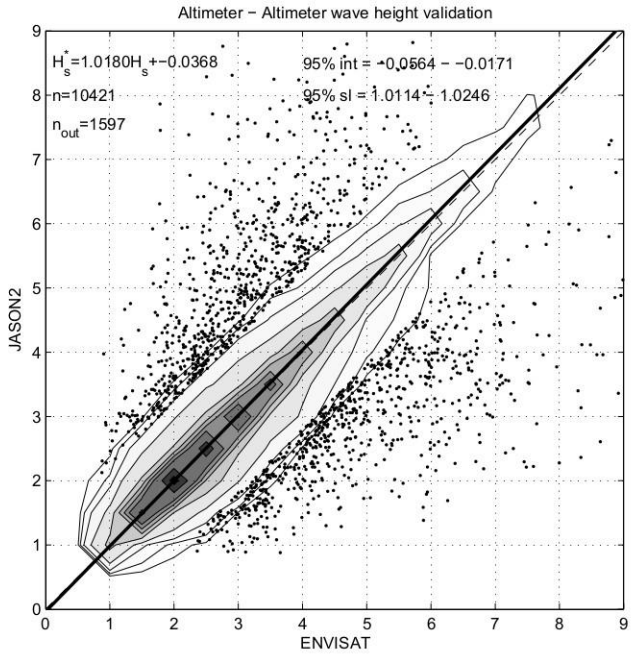
- Radiometer overestimates high winds
- Scatterometer has same response

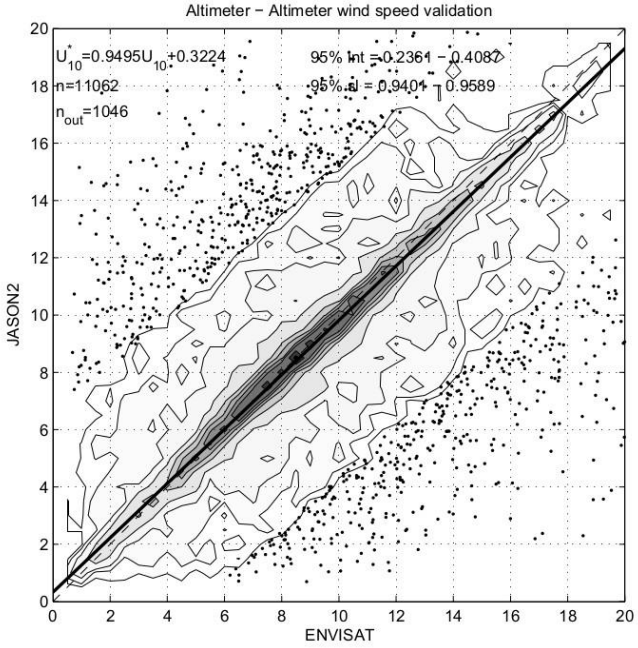


Altimeter – Altimeter cross-validation

- Scatter similar to buoy comparisons
- Calibrated data regression within 3 to 5%

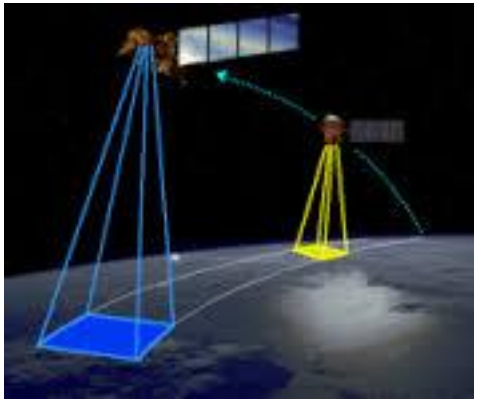


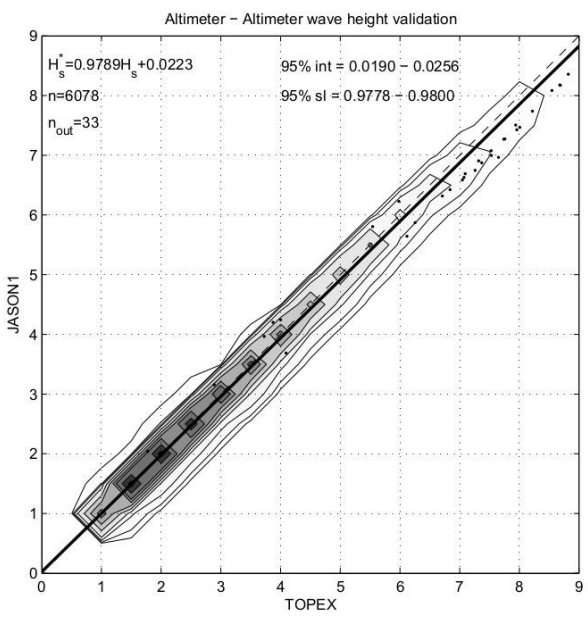


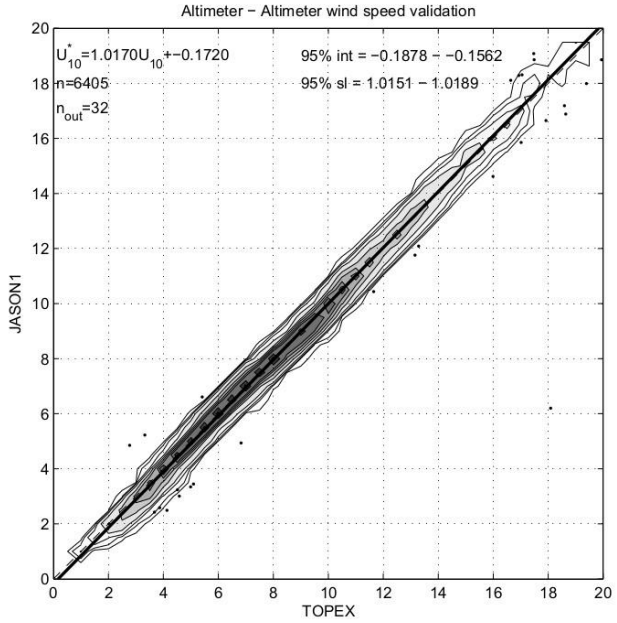


Altimeter – Altimeter scatter

- Scatter removed for satellites in same orbit
- Scatter mainly due to match-up criteria

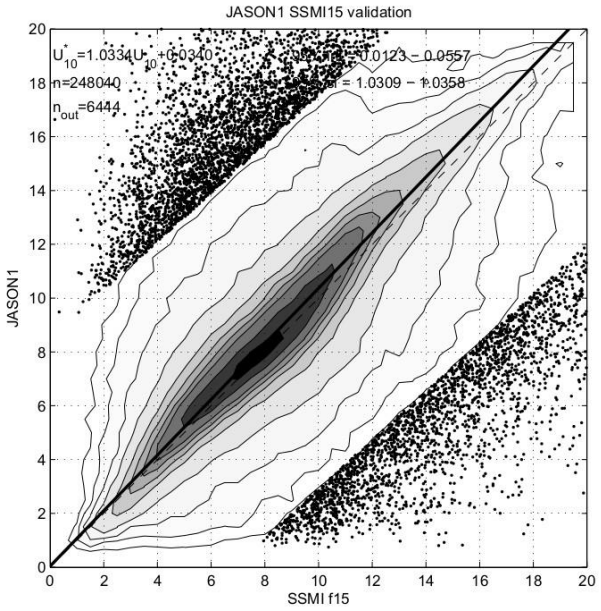


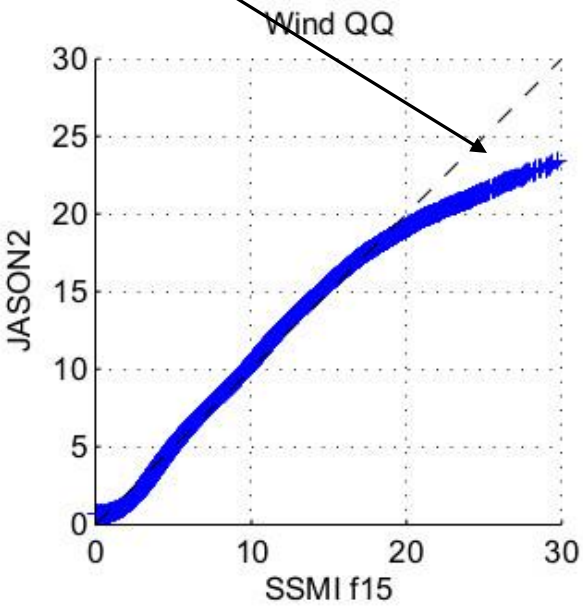




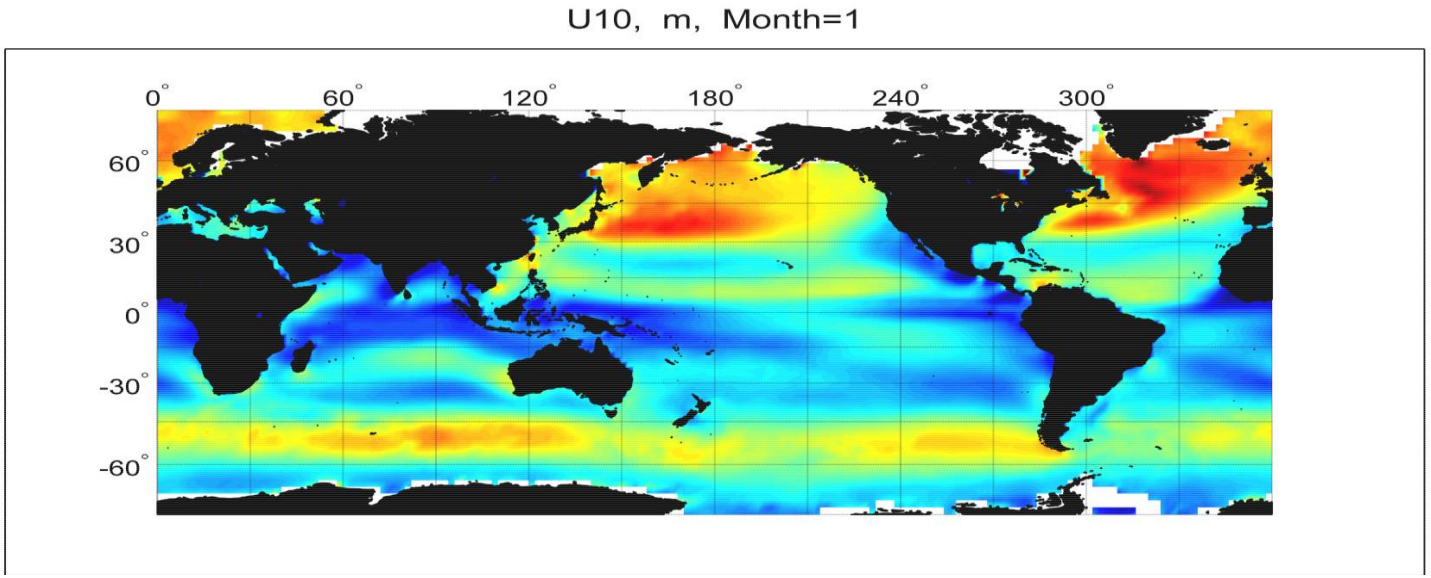
Altimeter – Radiometer cross-validation

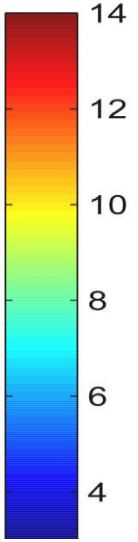
- Very large number of match-ups
- As indicated by buoys, radiometer overpredicts at high wind-speed
- Same response for scatterometer



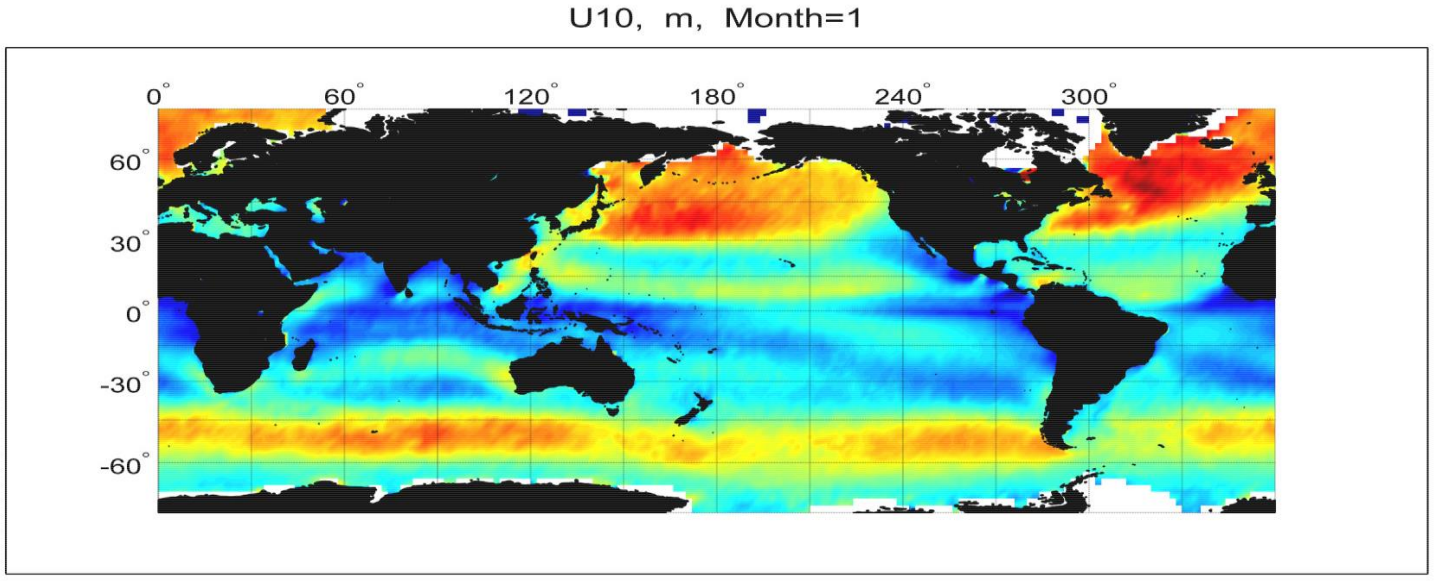


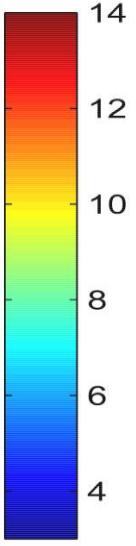
Global climatology – January U_{10} Monthly means





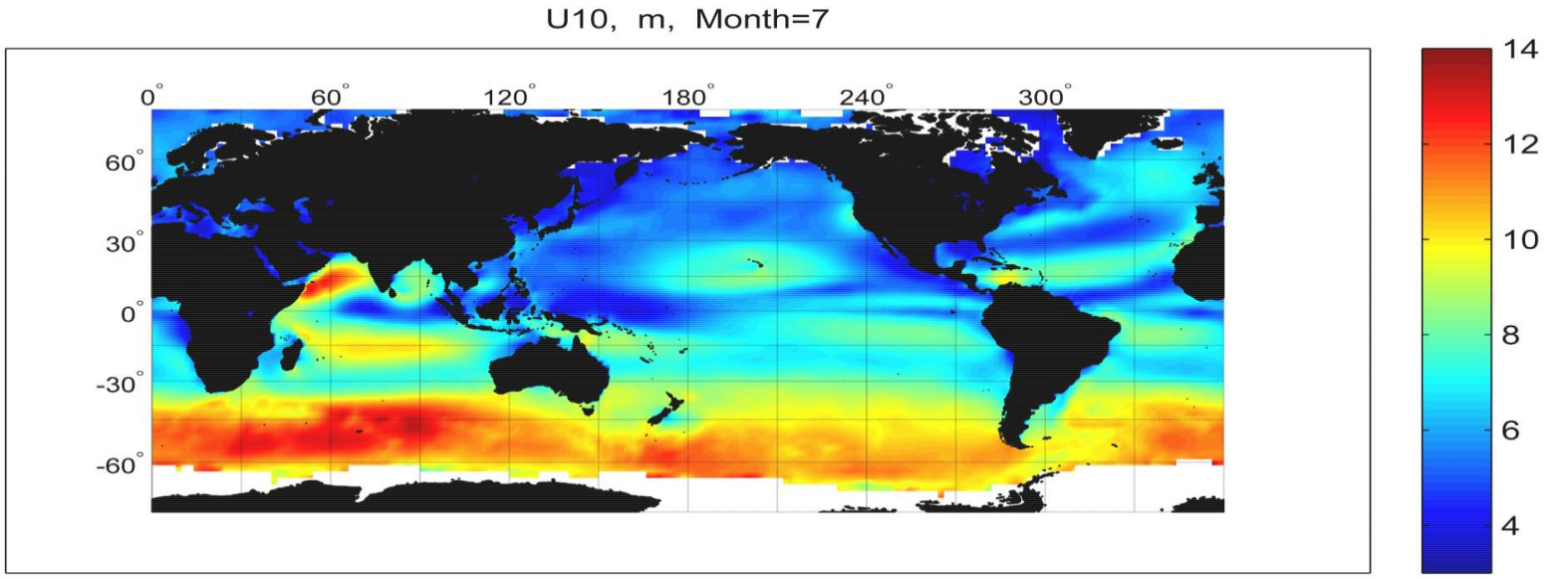
SSMI/ Scat



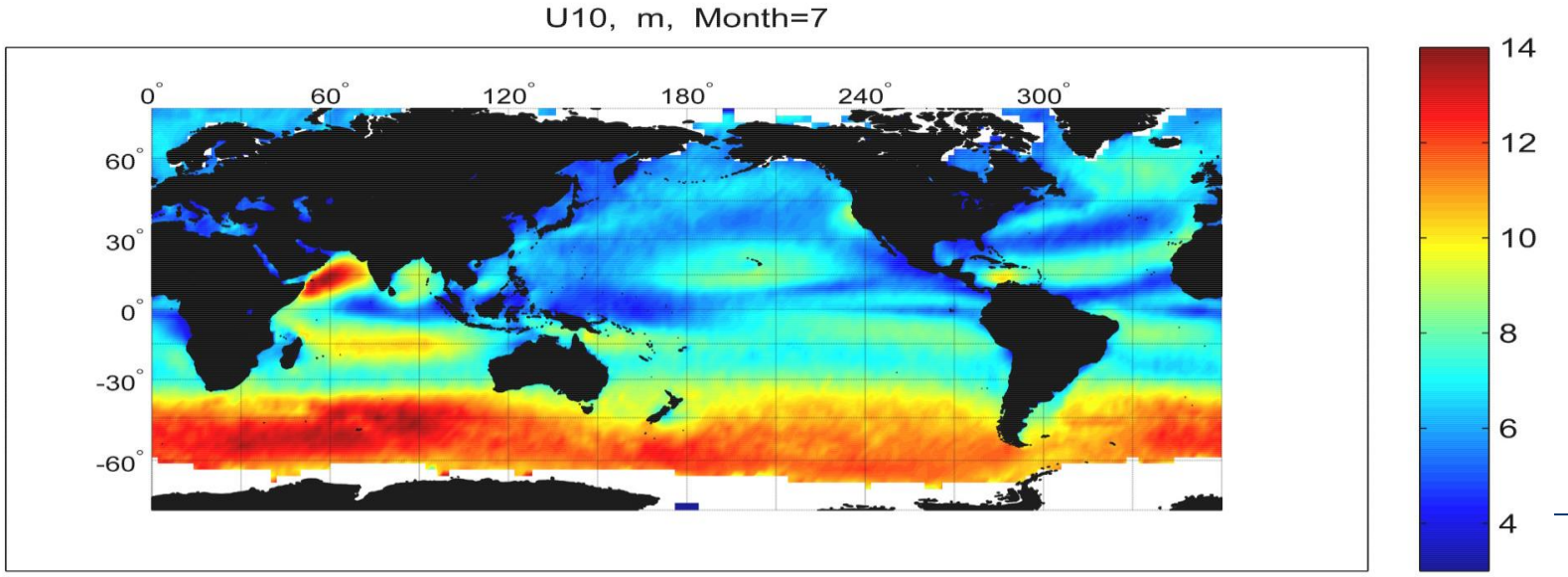


Altimeter

Global climatology – July U_{10} Monthly means

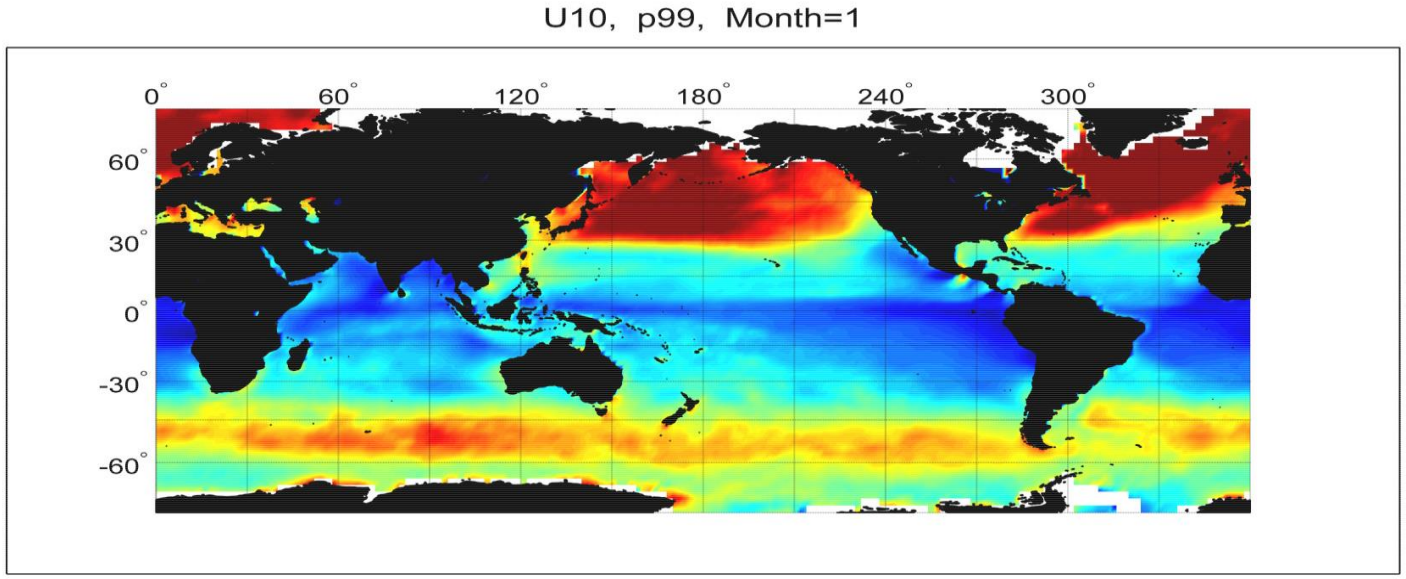


SSMI/ Scat

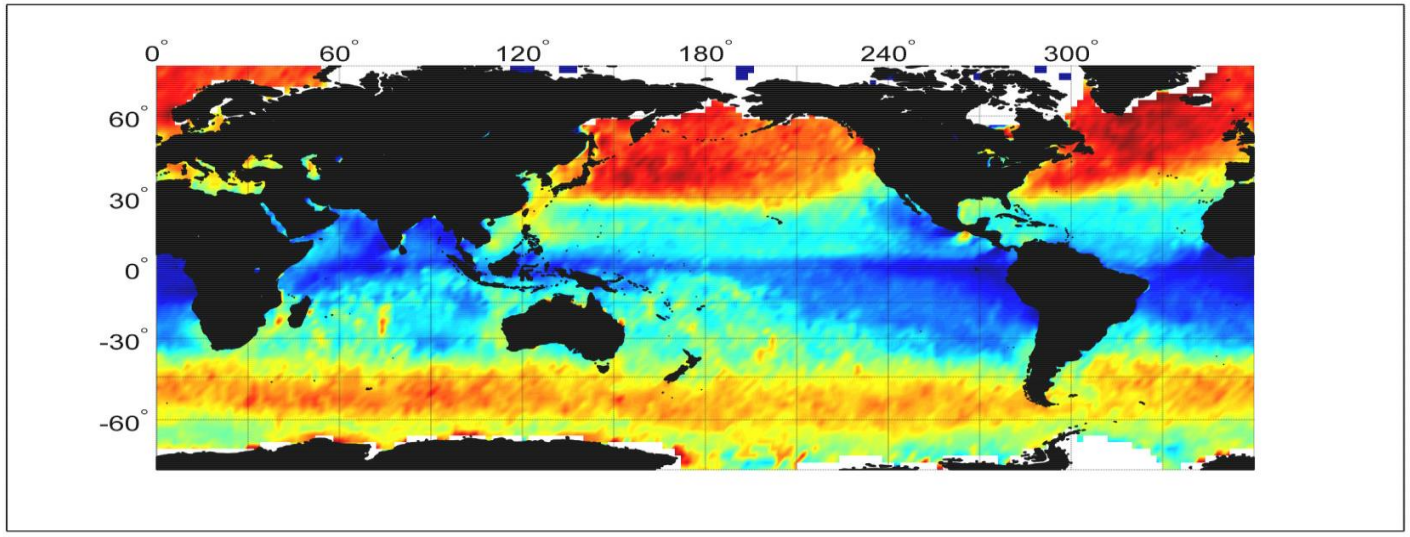


Altimeter

Global climatology – January U_{10} 99th percentile

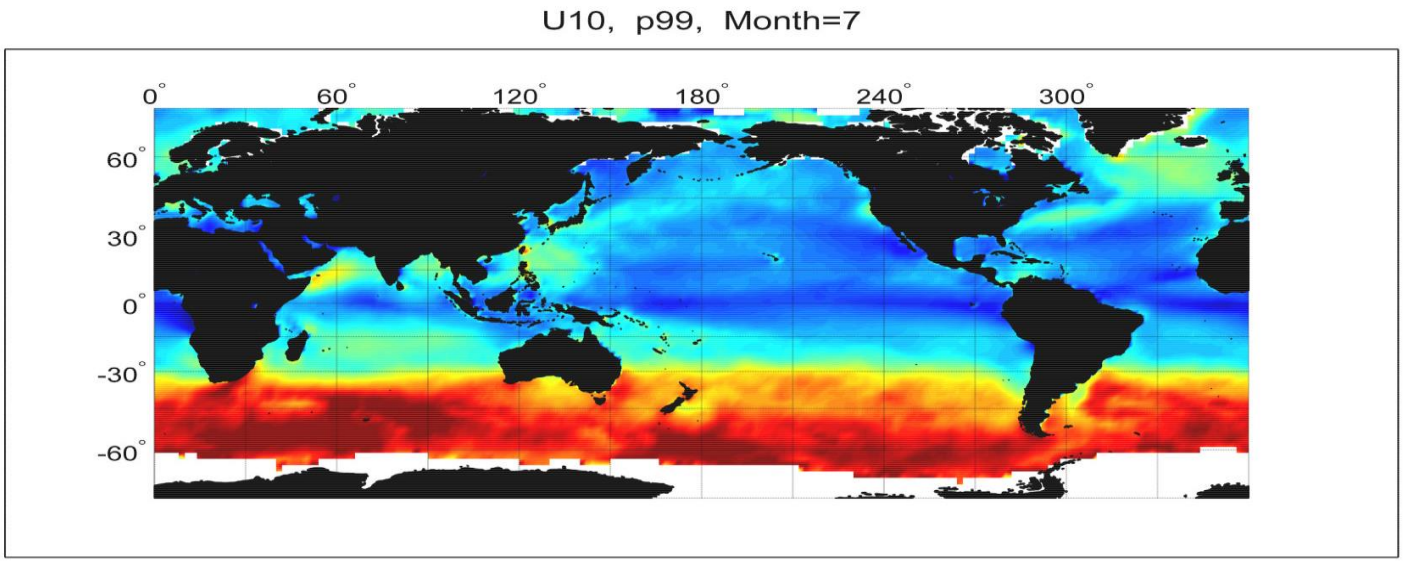


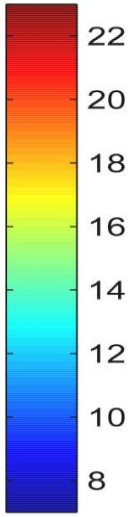
SSMI/ Scat



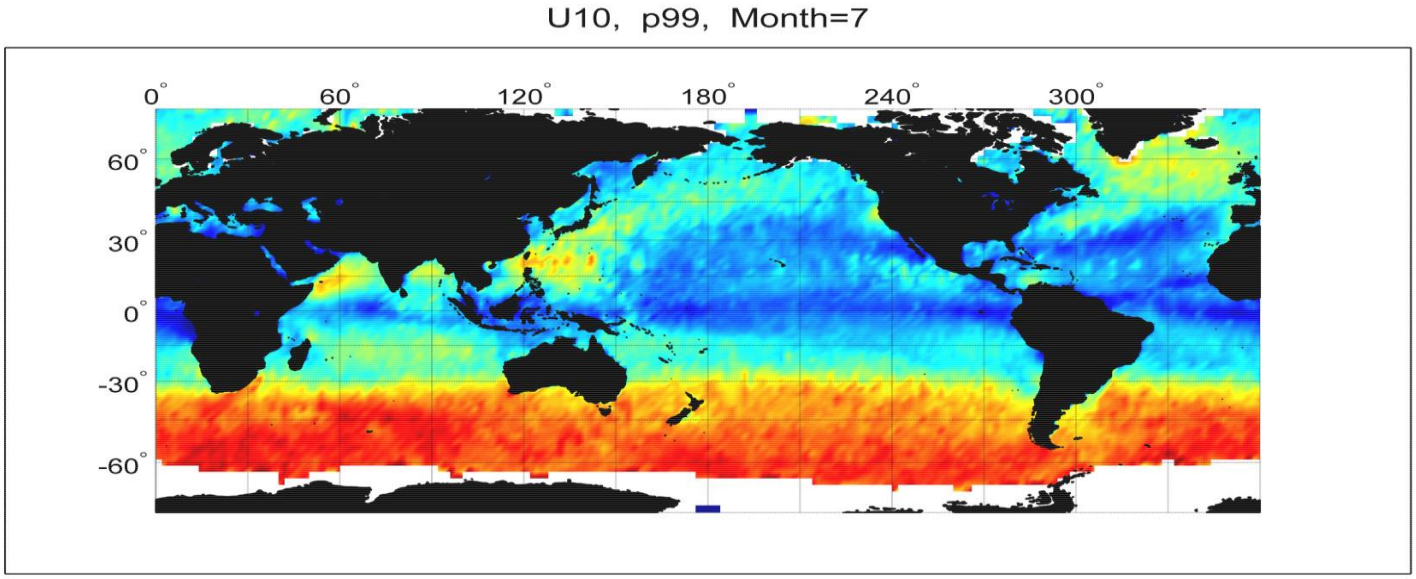
Altimeter

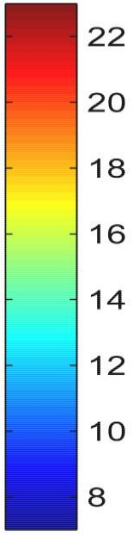
Global climatology – July U_{10} 99th percentile





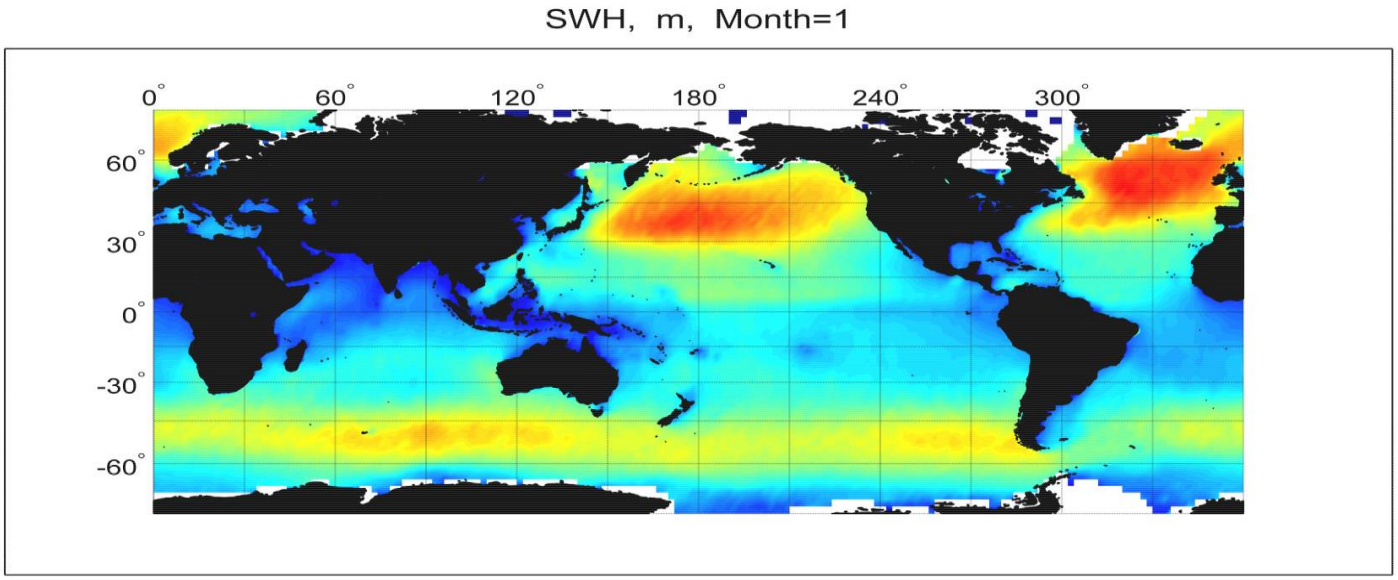
SSMI/ Scat

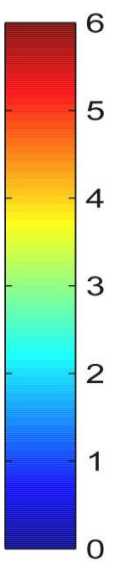




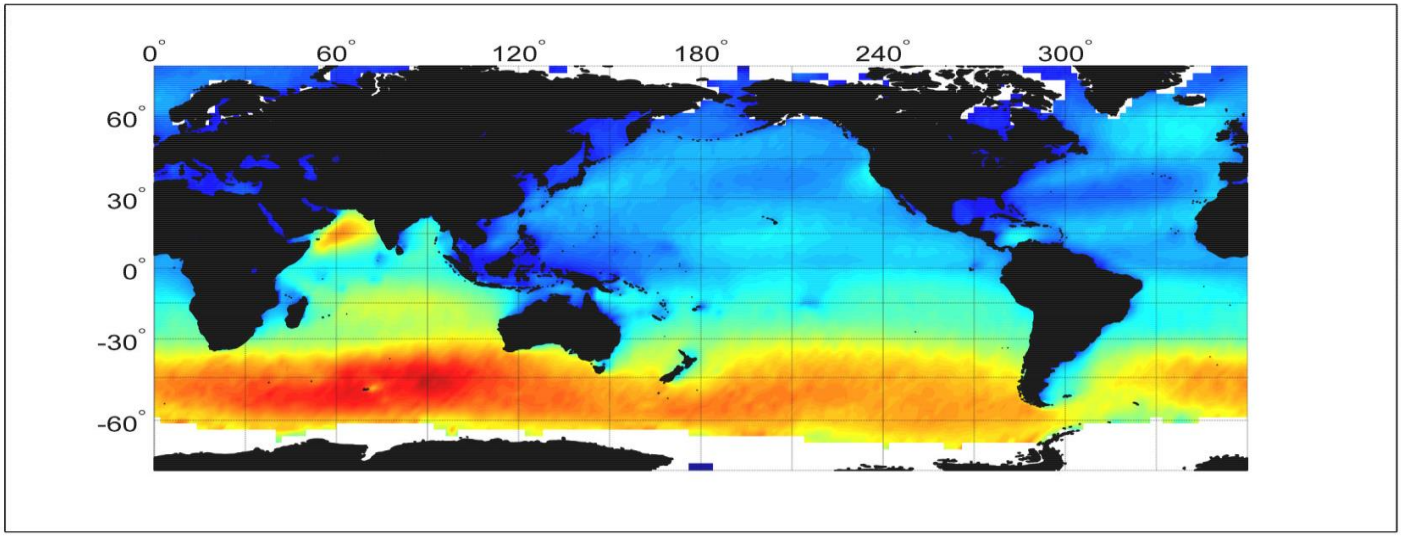
Altimeter

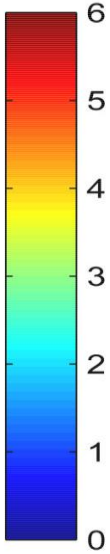
Global climatology – Hs Mean monthly - altimeter





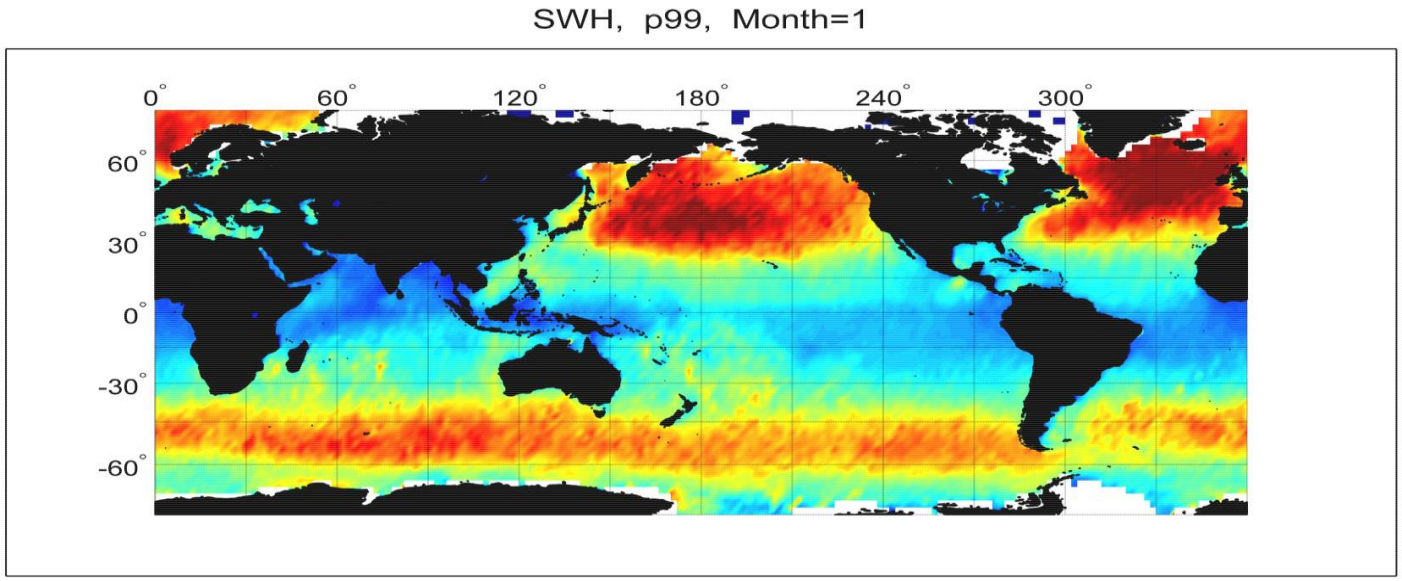
January



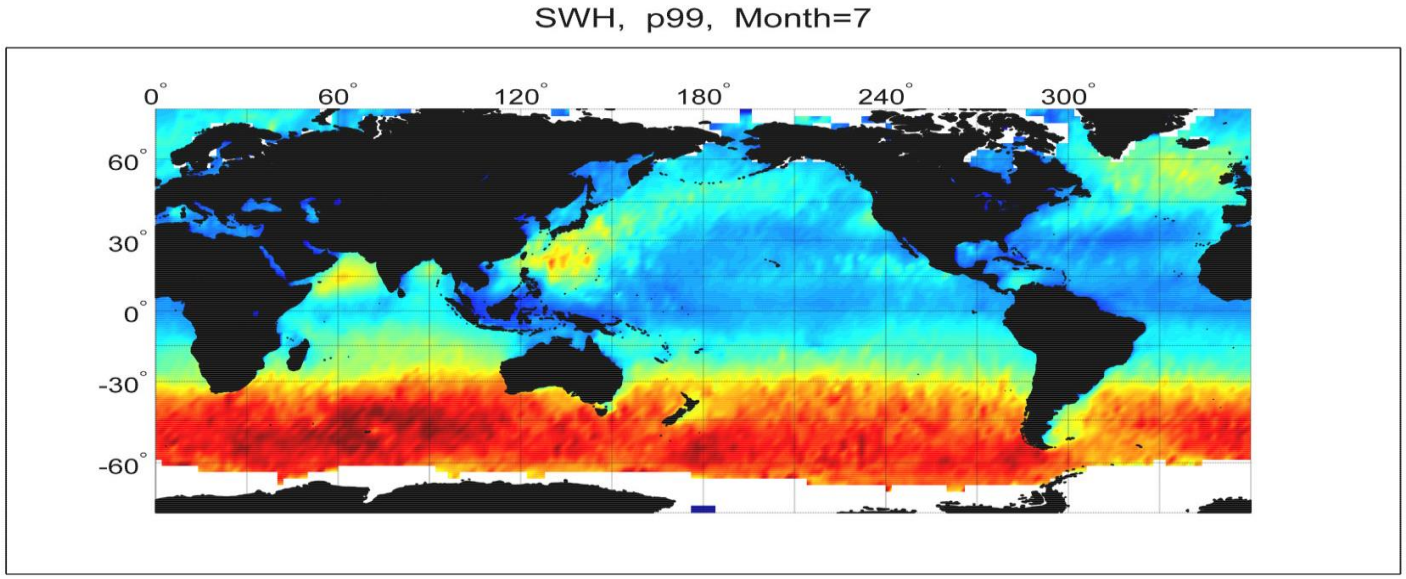


July

Global climatology – Hs 99% percentile - altimeter



January

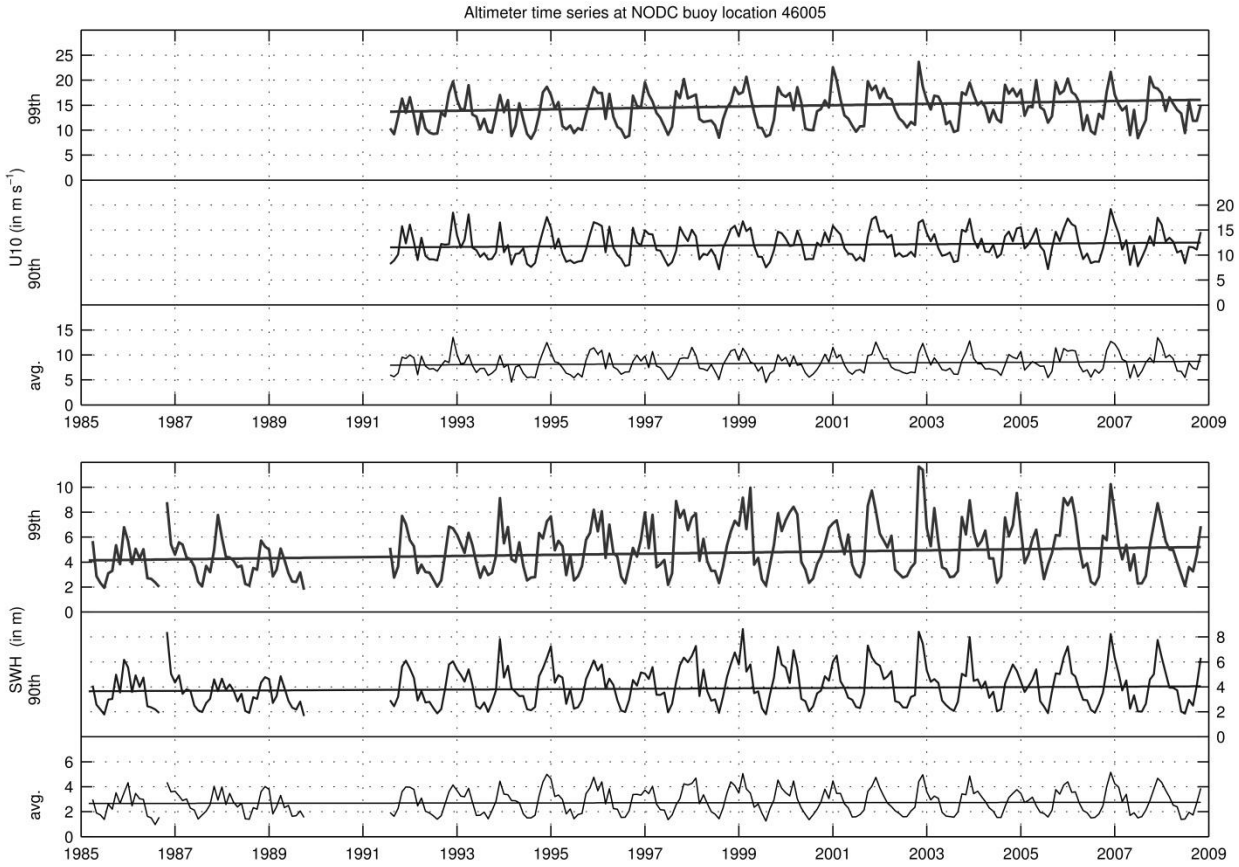


July

Global Trends

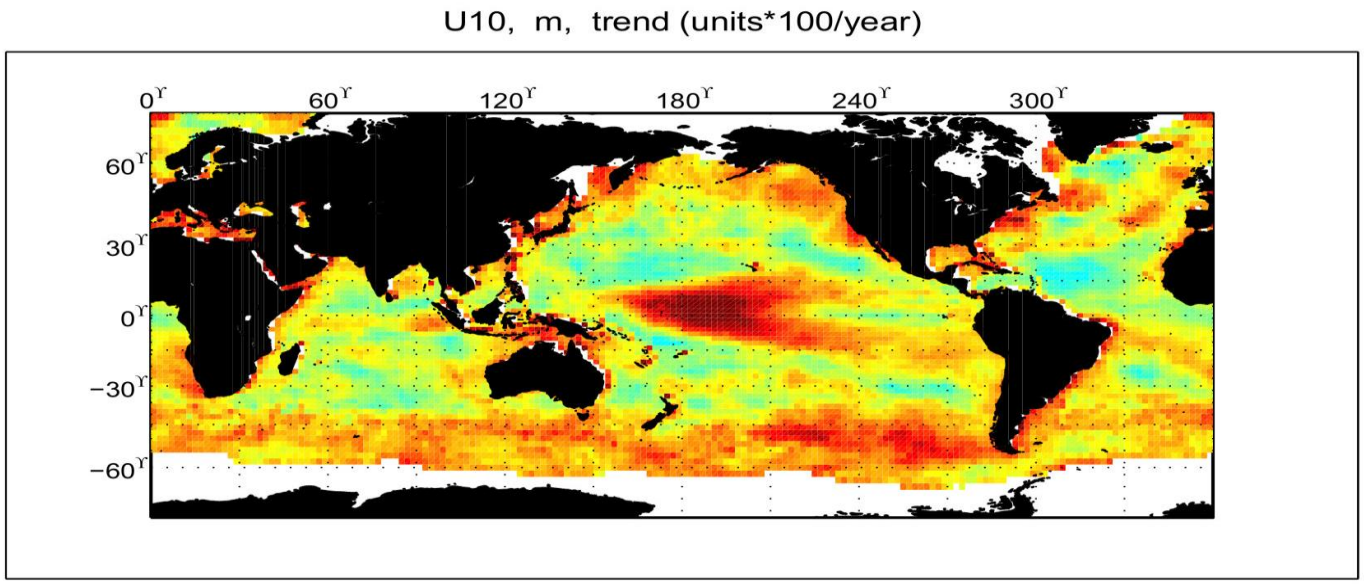
Aim is to determine long term trend in the presence of large seasonal signal

Use Seasonal Mann-Kendall test for Trend



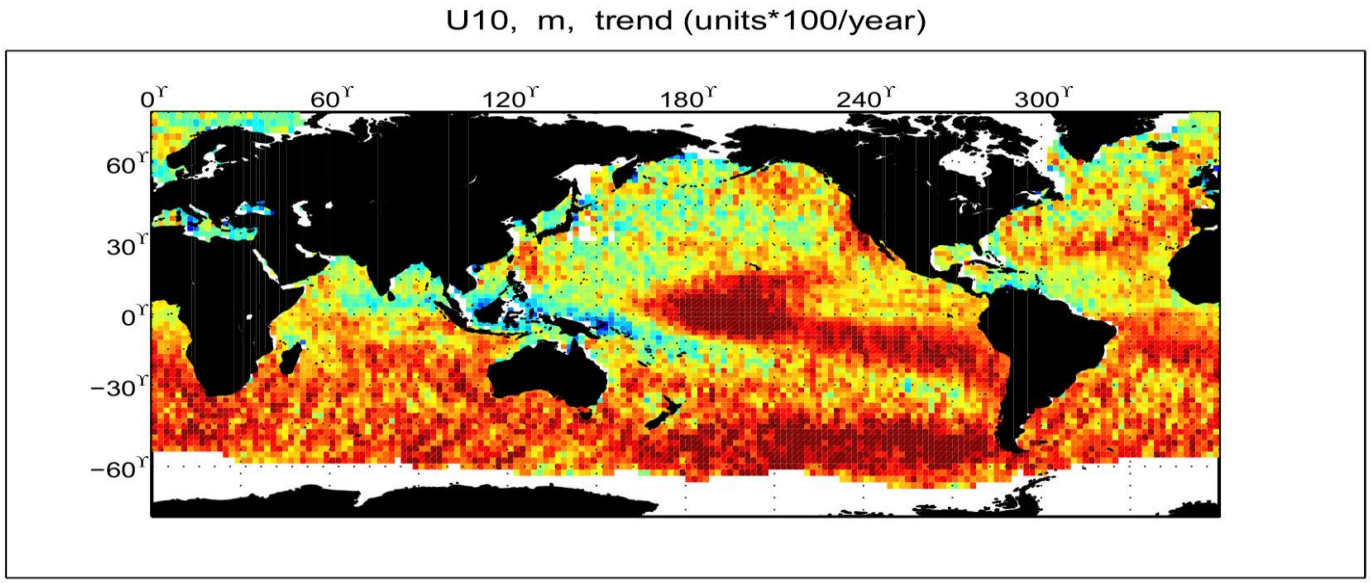
Young, Zieger and Babanin (2011), Science

Mean monthly U_{10} trends



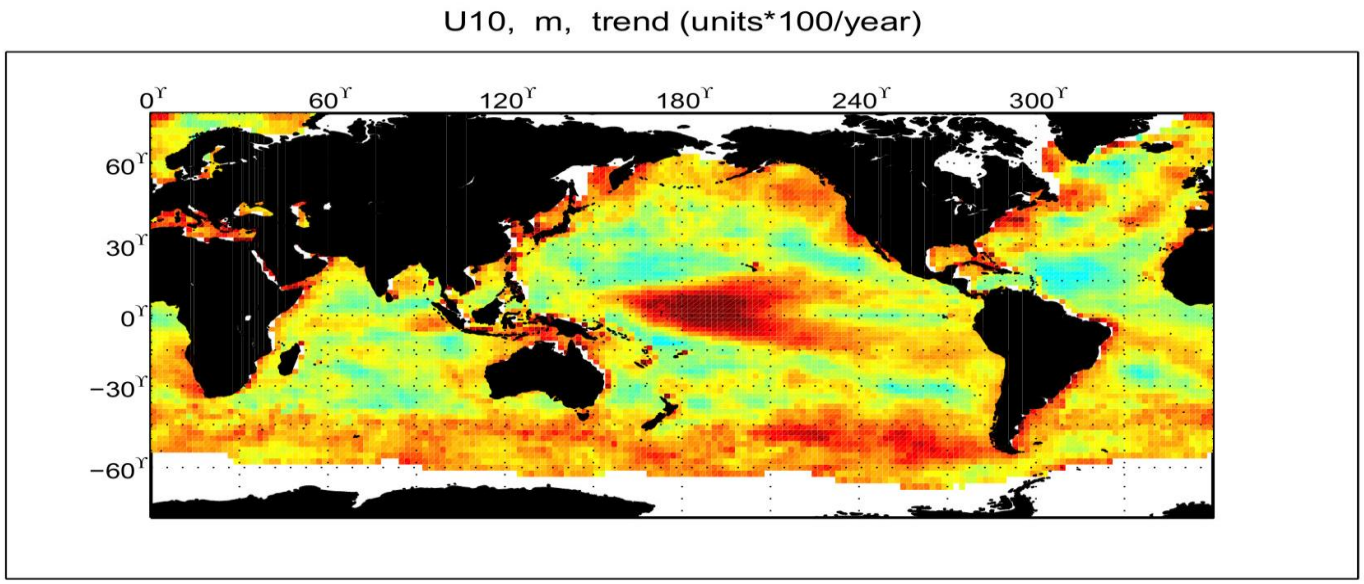
cm/s/yr

SSMI/ Scat

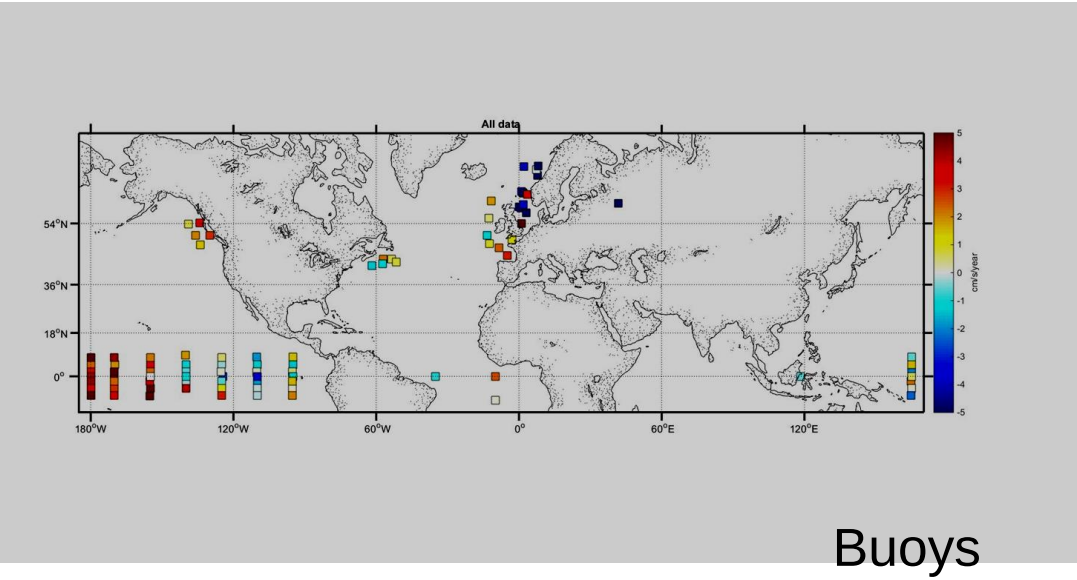


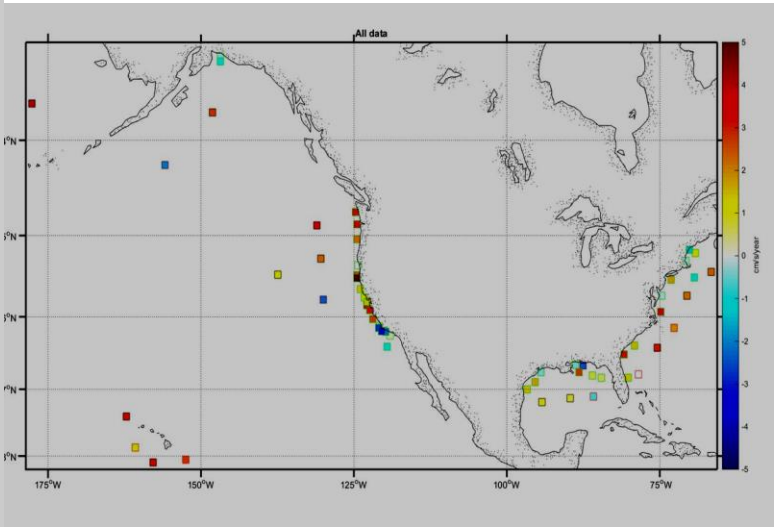
Altimeters

SSMI/Scat U_{10} trends compared to buoys



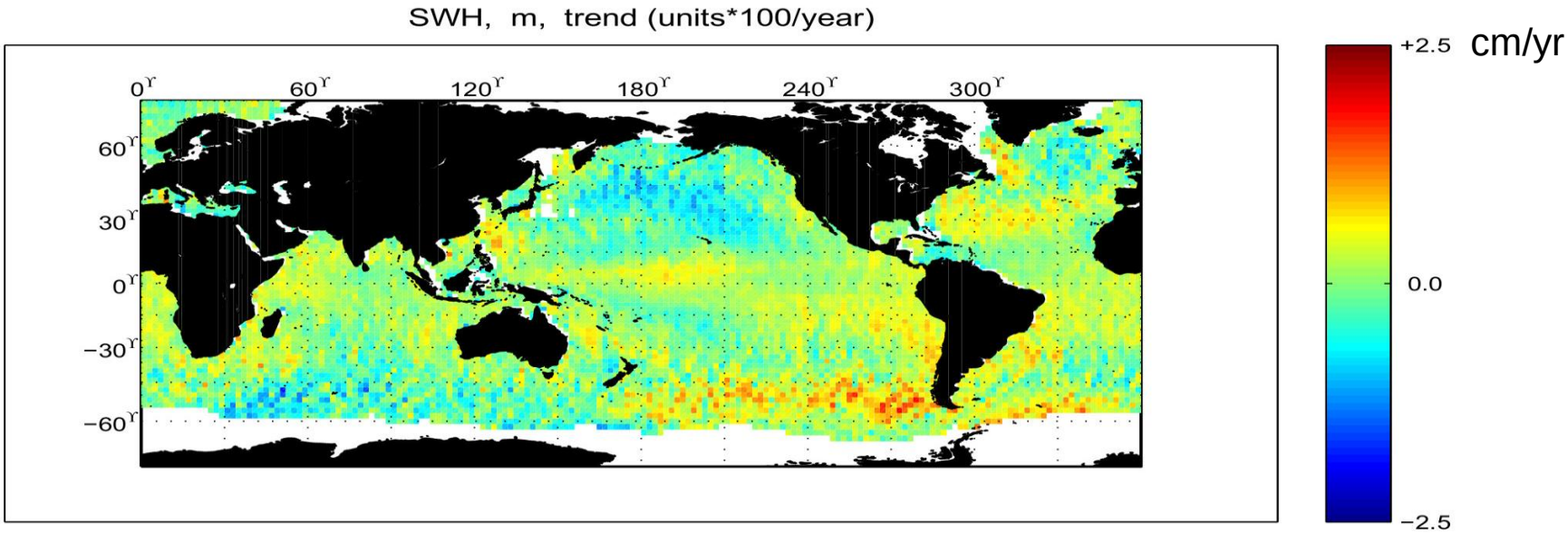
SSMI/ Scat





Buoys

Mean monthly H_s trends - altimeter



Extreme trends

Summary

- Database complete and fully validated
- Increasing trend in mean wind speeds and wave heights confirmed
- Differences between altimeter and SSMI/Scat wind speed trends much reduced
- Processes to estimate extreme percentiles need to be refined

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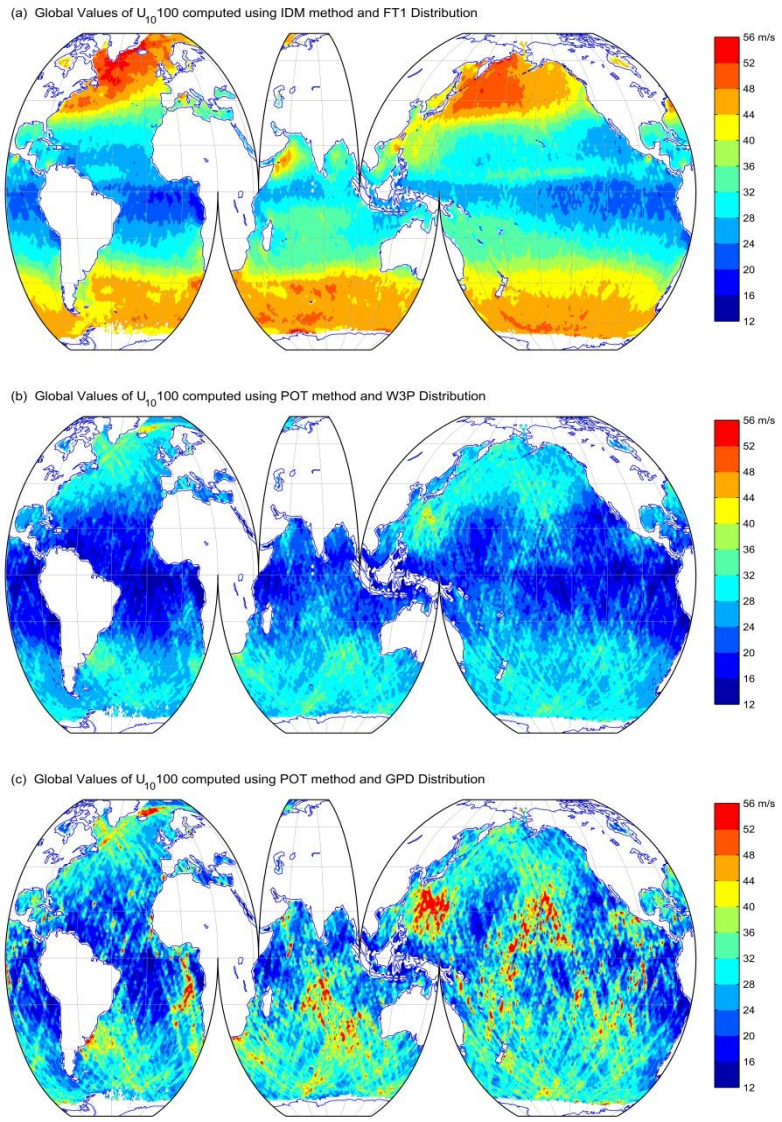
Global extreme values

Global U_{10} (100)

Vinoth and Young (2011)
J. Climate



IDM – FT1 distribution

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

PoT – Weibull 3P

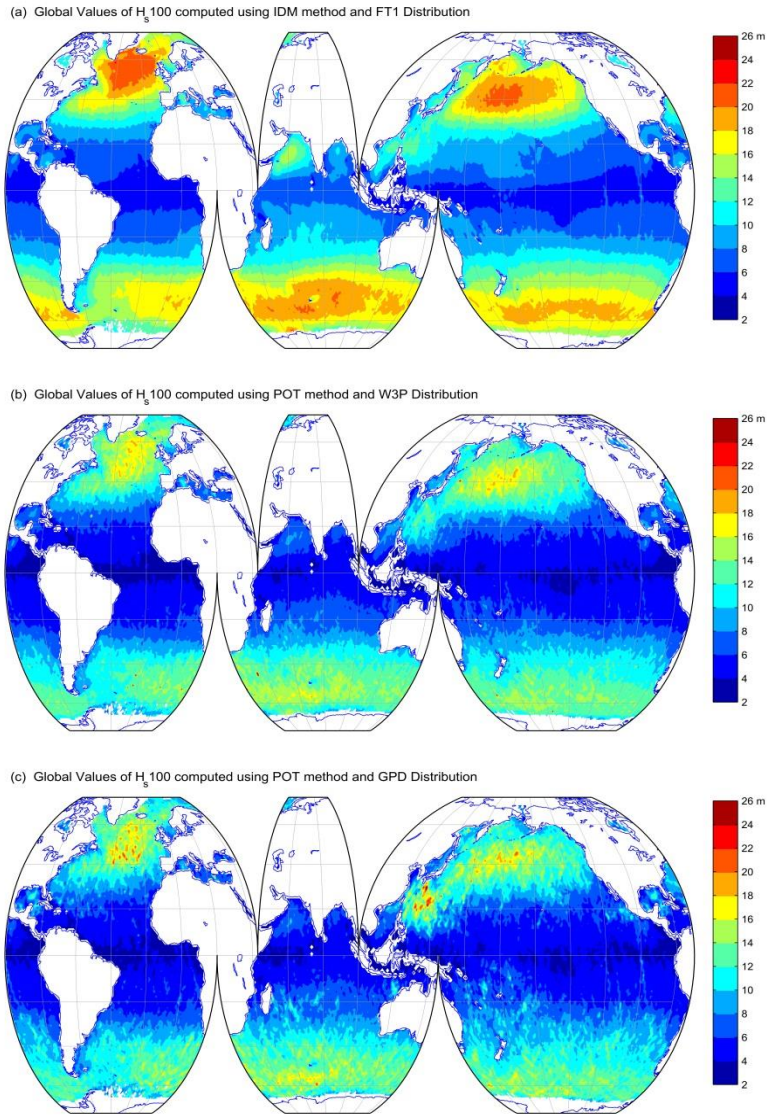
$$F(x) = 1 - \exp\left[-\left(\frac{x-A}{B}\right)^{k}\right]$$

PoT - GPD

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

Global extreme values

Global H_s (100)



IDM – FT1 distribution

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

PoT – Weibull 3P

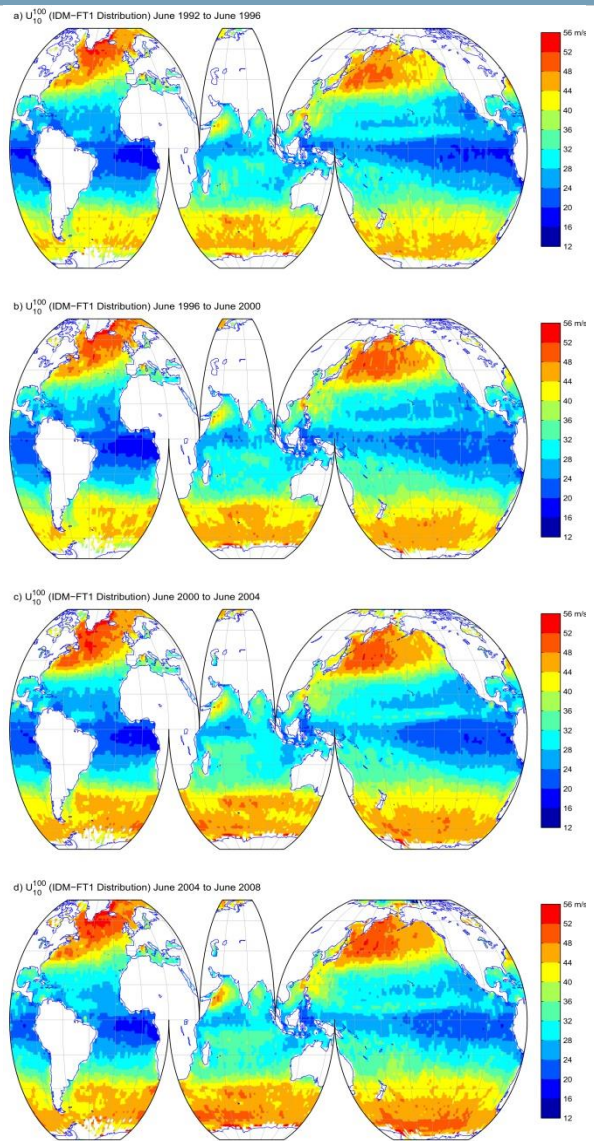
$$F(x) = 1 - \exp\left[-\left(\frac{x-A}{B}\right)^{k}\right]$$

PoT - GPD

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

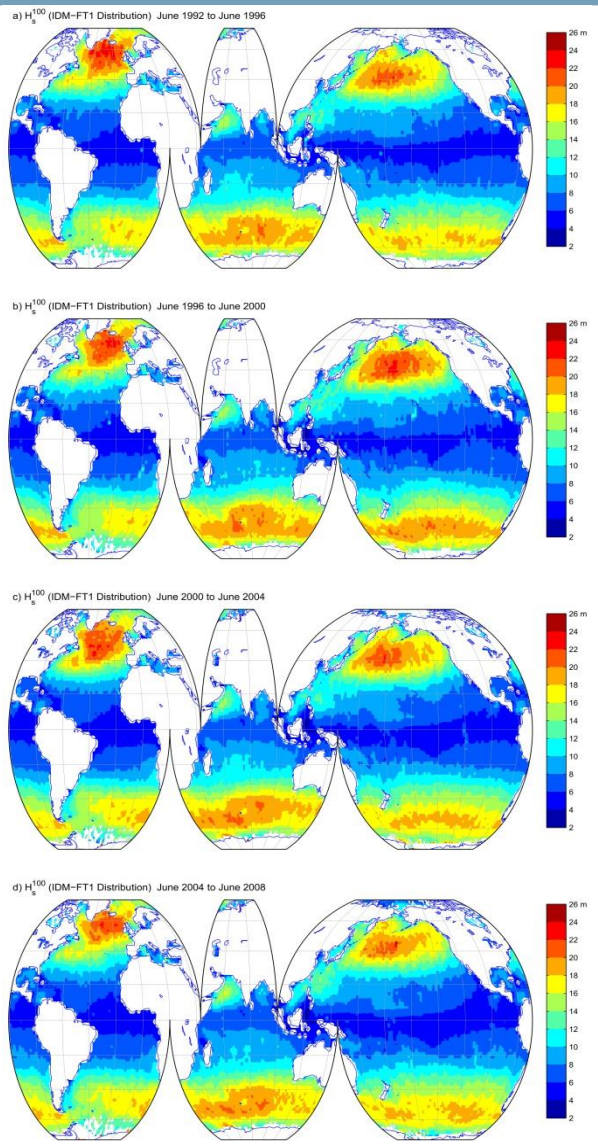
Global extreme trends

U_{10} (1:100)
Calculated in blocks



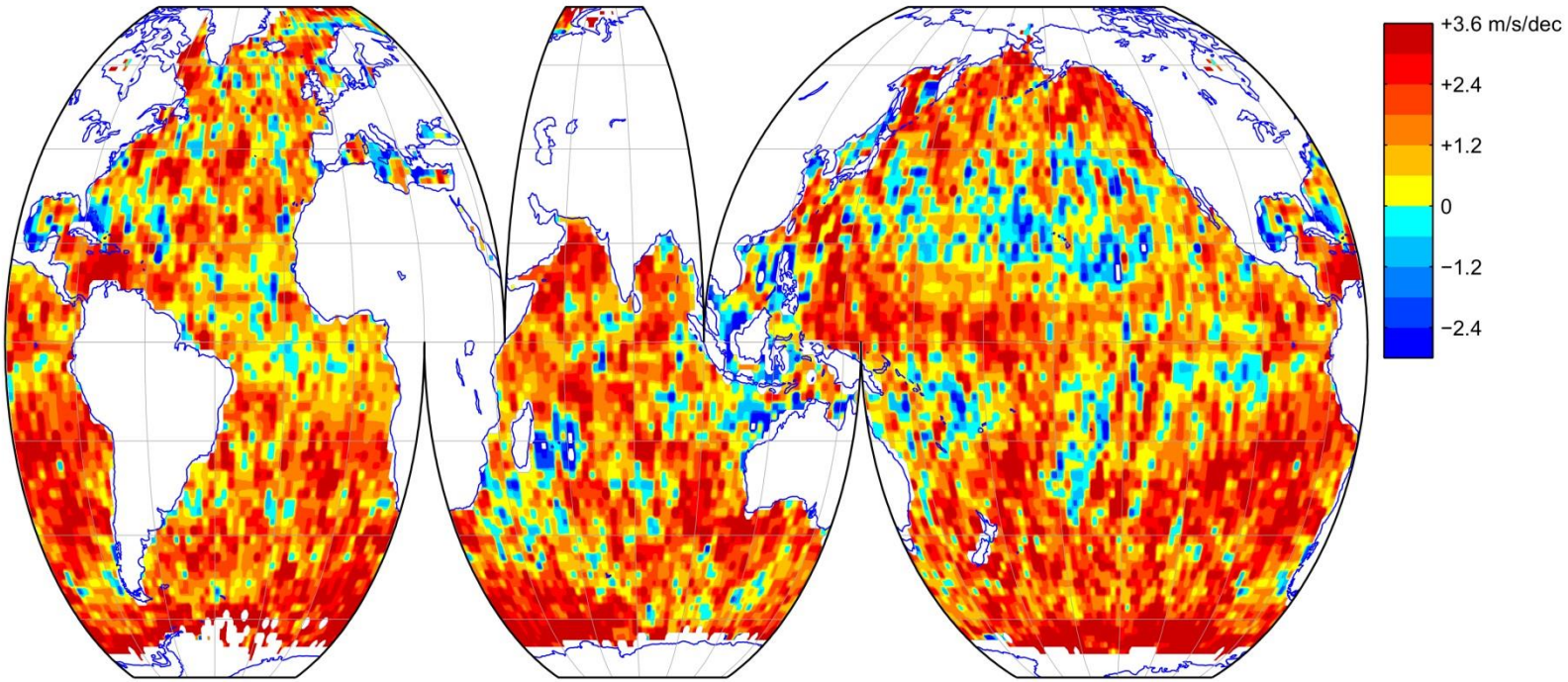
Global extreme trends

H_s (1:100)
Calculated in blocks



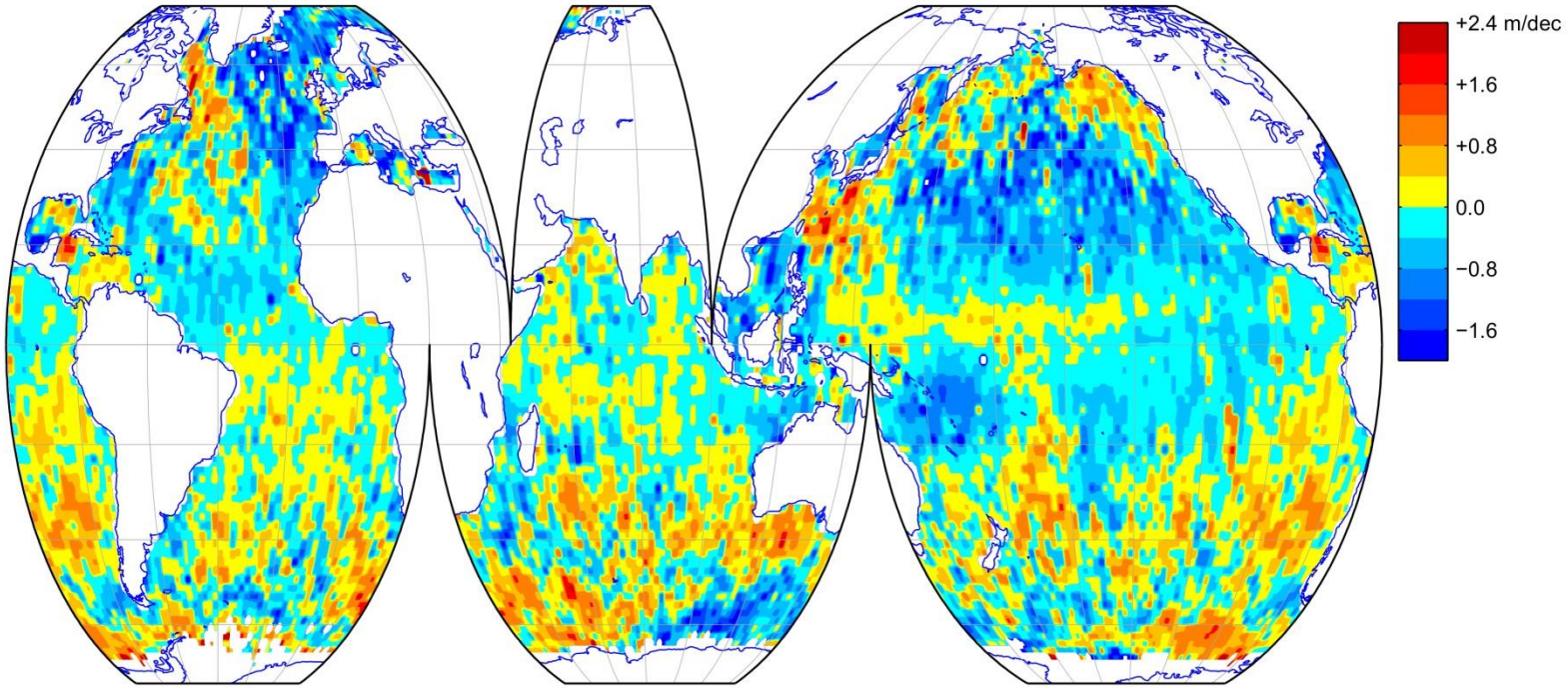
Global extreme trends

U_{10} (1:100) trend
Calculated from blocks



Global extreme trends

H_s (1:100) trend
Calculated from blocks



However, neither trend is statistically significant!

Conclusions

- Altimeter data can clearly give global
  - Climatology
  - Trends
  - Extremes

- Expanded dataset can:
  - Reconcile reported trend differences in SSMI and altimeter
  - Enhanced coverage for climatology and extreme values

- Further work:
  - Extreme values in undersampled datasets
  - Ensembles to expand length of time series
  - Nearshore data expansion by resampling
  - Need to understand why U_{10} trends stronger than H_s trends