The use of long-term satellite databases to study global wind and wave climate

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The study of global ocean wind and wave climatology can be addressed using two data sources – models or satellites

Satellites provide a measurement database but with some limitations

**Investigate**
- Climatology
- Extremes
- Trends
Combined dataset of 33 years duration
Insitu calibration buoys

Two data sets
• NDBC
• ECMWF composite data
Altimeter calibration

Matchups – 50km and 30 mins.

Greater scatter for wind speed
Global climatology – January $U_{10}$ Monthly means

**U10, m, Month=1**

**U10, m, Month=1**
Global climatology – July $U_{10}$ Monthly means

Rad.

Altimeter

$m/s$
• Determine probability distribution function (PDF) of wind speed and wave height
• Fit an extreme value distribution to the upper percentiles
• Peaks over threshold and Generalized Pareto distribution
• Extrapolate to extreme value level
  e.g. 1 in 100 years

Observed PDF

Generalized Pareto Distribution
To give 100 year estimates
Altimeter/Scatterometer – $U_{10}$ – PoT (GPD)

Takbash et al., 2019
Tropical Cyclone Tracks

![Map of Tropical Cyclone Tracks](image1)

![Map of Tropical Cyclone Tracks](image2)
Altimeter – $H_s$ - PoT (GPD)

Takbash et al., 2019
Data for trends

- Altimeter, radiometer, scatterometer
  - Calibrated against buoys
  - Validated against independent buoys
  - Discontinuities and drift removed
  - High wind speed/wave height checked and corrected
  - Corrected for boundary layer stability (climatological correction)

Young & Donelan, 2018
Wind speed $U_{10}$ trends

Altimeter $U_{10}$ mean trend (1985 - 2018) [cm/s/yr]

Altimeter $U_{10}$ p90 trend (1985 - 2018) [cm/s/yr]

Young & Ribal, 2019
Wind speed $U_{10}$ trends

Scatterometer $U_{10}$ mean trend (1992 - 2018) [cm/s/yr]

Scatterometer $U_{10}$ p90 trend (1992 - 2018) [cm/s/yr]

Young & Ribal, 2019
magnitude and distribution of trends comparable between completely different instruments

Altimeter and Radiometer Comparison

Young & Ribal, 2019
Wave Height $H_s$ trends

Young & Ribal, 2019
- Stronger trends in $U_{10}$ than $H_s$
- This is counter-intuitive, as for “fully developed” conditions $H_s \propto U_{10}^2$
- Therefore, might expect stronger trend for $H_s$
- Perhaps not “fully developed”
- Trend on mode of distribution, rather than mean

Young & Ribal, 2019
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Young & Ribal, 2019
• Consider how PDFs of wind speed and wave height have changed over time

![Wind speed PDF](A) with broadened distribution:
- Mean has increased
- Mode has increased

![Wave height PDF](B) with decreased mode:
- Mean hardly changed

Young & Ribal, 2019
Winds generate waves, so why does the wave height PDF behave so differently to the wind speed?

To generate waves far from land, need:
- Wind speed
- Wind duration

May have a wind increase but if the wind duration decreases may have no increase in wave height (or even a decrease)

As we have a broadening of the wind speed PDF, the strengthening winds may not have sufficient time to generate increased waves

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<th>$U_{10}$ (m/s)</th>
<th>$t$ (hrs)</th>
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<tr>
<td>5</td>
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Time to generate smaller waves
Insufficient time to generate larger waves
• Climatology consistent between all instruments
• Differences in wind speed due to atmospheric stability

• Consistent extreme value analysis results for altimeter and scatterometer wind speeds – altimeter does not appear to excessively under-sample extremes
• Radiometer unusable for extreme value analysis due to fair weather bias

• Reasonably consistent trends for wind speed across all three instruments
• Weaker trends in wave height than wind speed may be due to changes in duration of strong winds
• Consistency of trend results indicate that altimeters not significantly impacted by changing sampling density with more satellites in orbit in recent years