

Global trends in wind speed and wave height over the past 25 years

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Introduction

Studies of climate change typically consider measurements of temperature change over extended period of time. Climate, however, is much more than temperature. Over the oceans, changes in wind speed and the surface gravity waves, generated by such winds, play an important role. In addition to being themselves an indicator of climate change, winds and waves play important roles in the design and operation of offshore shipping and structures, as well as controlling the flux of energy from the atmosphere to the ocean and potentially upper ocean mixing. Thus, they significantly influence the mechanisms of air-sea interaction.

This presentation investigates changes in global wind speed and wave height over the past 25 years, using a consistently calibrated and validated altimeter data base for this period.

Altimeter database

Zieger et al (2009) have considered observations of significant wave height and radar cross-section (wind speed) from all altimeter missions in the period 1985-2008. Each mission was calibrated against insitu buoy data over this period. Each data set from the various missions was then cross-validated against other satellites operating at the same time. In this way, periods of altimeter drift or discontinuities were identified and corrected. The resulting data set represents a high quality data set with global coverage over an extended period of time.

Trend determination

Our aim is to determine the linear trend in the data set for the mean, 90th and 99th percentile values of both wind speed and wave height. The determination of trend has been extensively considered in the literature, the aim being to determine the linear increase/decrease in the mean of the time series in the presence of seasonal variation and data gaps. Five different methods were considered, each was tested against synthetic data sets and their error characteristics determined. Ultimately, the Seasonal Kendall Test (Hirsh et al. 1982) was adopted.

Data accuracy

Altimeter data has been previously used to determine mean wind and wave climatology. However, as we intend to consider extreme values at the 90th and 99th percentile, it is necessary to demonstrate that the altimeter can accurately measure such value. Fig. 1 shows a percentile-percentile (Q-Q) plot comparing buoy and altimeter for both wind speed and wave height. Excellent agreement is demonstrated at all values up to the 99th percentile (most extreme value in the plot).

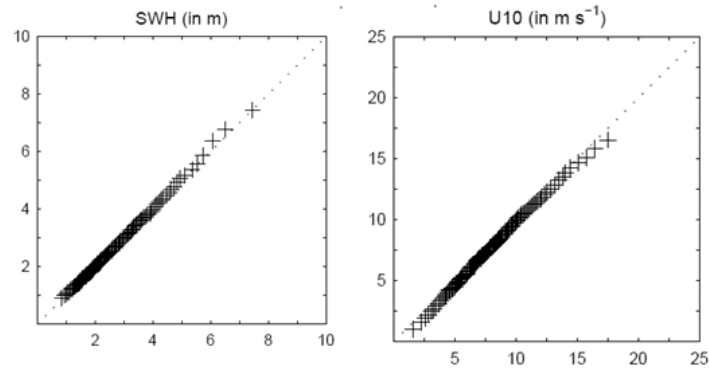


Fig. 1 Percentile-percentile plot between buoy (vertical axis) and altimeter (horizontal axis) at NDBC buoy 46005. Significant wave height is shown as the top panel and wind speed as the lower panel.

Such comparisons were conducted at all NDBC buoy locations. In each case, the altimeter data was capable of accurately determining 90th and 99th percentile values.

Global trends

The data was binned into 2 degree by 2 degree regions and the trend analysis applied to each bin. This process was repeated for each of wind speed and wave height at the mean, 90th and 99th percentile levels. The mean values show a weak global trend of increasing values of both wind speed and wave height. This positive trend becomes progressively stronger at the 90th and 99th percentile. Fig. 2 shows the trend values, expressed as a percentage increase/decrease per year for the 99th percentile. The positive trend is clear.

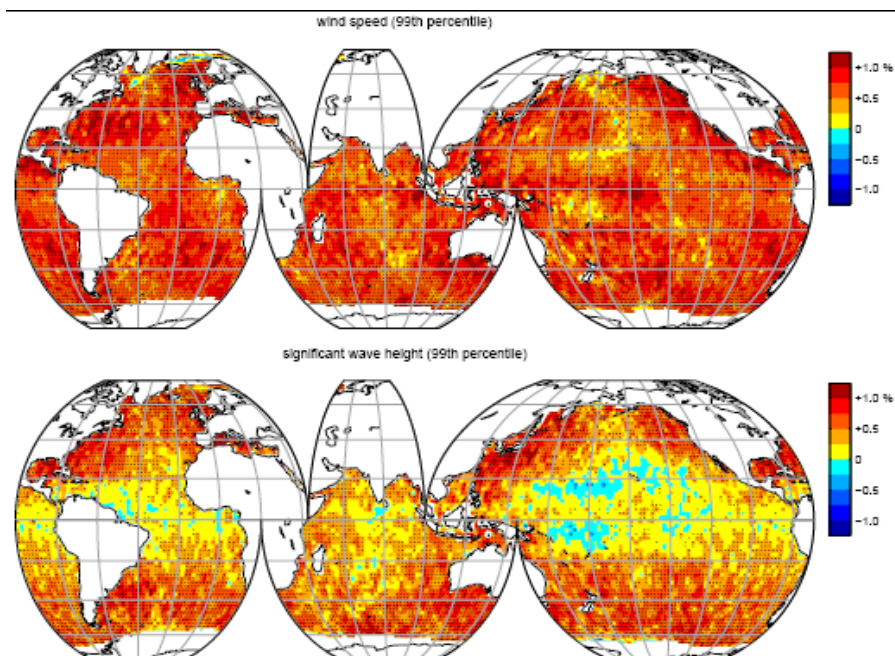


Fig. 2 Trend (percentage increase/decrease per year) for wind speed (top) and significant wave height (bottom) at the 99th percentile. Both quantities show an overall global increase, with a stronger trend for wind speed.

References

Hirsh, R.M., Slack, J.R. & Smith, R.A. 1982. Techniques of trend analysis for monthly water quality data. *Water Resour. Res.*, 18, 107-121.

Zieger, S., Vinoth, J. and Young, I.R. 2009. Joint calibration of multi-platform altimeter measurements of wind speed and wave height over the past 20years. *J. Atmos. & Ocean. Tech.*, 26, 2549-64.