Sensitivity to wind stress formulation in a coupled wave-atmosphere model

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WHY ?

Wind stress significantly influences modelling of oceanic processes such as waves, breakers, surges, surface/coastal circulation, upwellings and modelling of atmospheric processes. Large wave heights tend to be underestimated in wave models (Rascle & Ardhuin 2013, Hanafin et al. 2012), as well as storm surges in ocean models (Muller et al. 2014). This could be partly due to underestimated high wind speeds in atmospheric models, and inappropriate representation of wind stress in numerical models.

The objective is to define a more appropriate wind stress parameterization (i.e. generating values closer to observations), taking into account the wave influence by moderate to strong winds.

Coupled wave-atmosphere model

The study is based on ECMWF global atmosphere model IFS (Integrated Forecasting System), which is coupled to ECWMF (ECMWV Wave Model), with spatial resolution of 16 km for the atmosphere and 28 km for the waves.

Tested parameterizations

Sensitivity study focused on 5 parameterizations (see table). Empirically-derived Charnock parameterization has been developed in order to reach more physical drag coefficient values for high wind speeds (i.e. more consistent with measurements, Powell et al. 2003).

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RESULTS

Comparisons with observations

Sensitivity study shows that strong winds in the models are underestimated compared with satellites and platforms. MFWAM [3] and wave-age dependant [4] parameterizations tend to give larger drag coefficients and lower wind speed than the operational setting [2], with negative biases compared with observations. Empirically derived Charnock parameterization results in a reduced bias. However, further validation is needed.

Biases between observations

For strong winds, ASCAT and buoys observations agree well with each other, giving the lowest wind speed values. AMSR2, SMOS and platforms are also coherent with each other, giving higher wind speed values. ASCAT strong winds seem to be underestimated compared to other data.

There is a clear bias between buoys and platforms, underlying that strong winds from buoys could be underestimated.

Impact on different parameterizations on atmosphere

A larger Charnock parameter leads to larger roughness length, higher drag coefficient, higher wind stress, and then lower wind speed and higher surface pressure in the storm center.

Impact of different parameterizations (uncoupling, ECMWF default parameterization, empirically-derived Charnock parameterization)

WHERE ?

For this study, we focus on North East Atlantic mid-latitudes storms. The case study has been selected from analyses of ERA-Interim winds and mean sea-level pressures during the last 10 years. Selected events are Kaat and Lilli storms, which crossed North Atlantic from 23th to 27th January 2014, with wind speed above 35 m/s.

References & Acknowledgement

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Wind biases between model and observations computed from 23th to 27th of Jan. 2014 on North East Atlantic