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.

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 **23rd to 27th January 2014**, with wind speed above 35 m/s.

Storm tracks for Kaat and Lilli storms, Jan. 2014
In black dotted line, schematic of principal tracks for lower tropospheric storm track activity (Hoskins & Hodges, 2002)

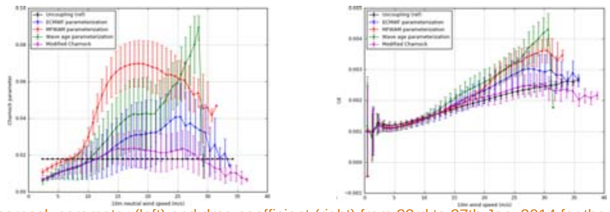
HOW ?

Coupled wave-atmosphere model

The study is based on ECMWF global atmosphere model IFS (Integrated Forecasting System), which is coupled to ECWAM (ECMWF 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).

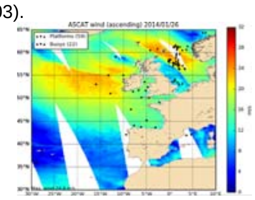


Charnock parameter (left) and drag coefficient (right) from 23rd to 27th Jan. 2014 for the five parameterizations

Parameterization	Reference
[1] Uncoupling WAM/IFS	
[2] Coupling WAM/IFS with ECMWF default parameterization	Janssen 1991
[3] Coupling WAM/IFS with MFWAM parameterization	Ardhuin et al. 2010
[4] Coupling WAM/IFS with wave-age dependant parameterization	Oost et al. 2002
[5] Coupling WAM/IFS with empirically-derived Charnock parameterization	

Observations

Wind data from satellites (**ASCAT** scatterometer, **AMSR2**, **WindSat**, **SMOS** radiometers), 22 **buoys** and 59 **platforms** have been exploited in this study.

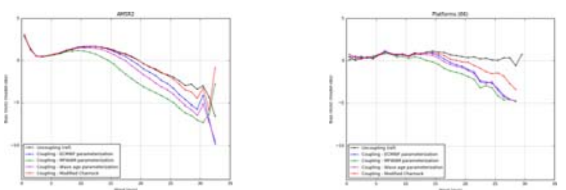


Wind on Jan. 26, 2014, estimated from ASCAT ascending passes

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.

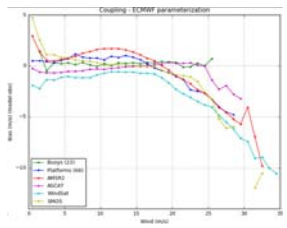


Wind biases between AMSR2 (left), platforms (right) and model (five parameterizations), computed from 23rd to 27th of Jan. 2014 on North East Atlantic

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.

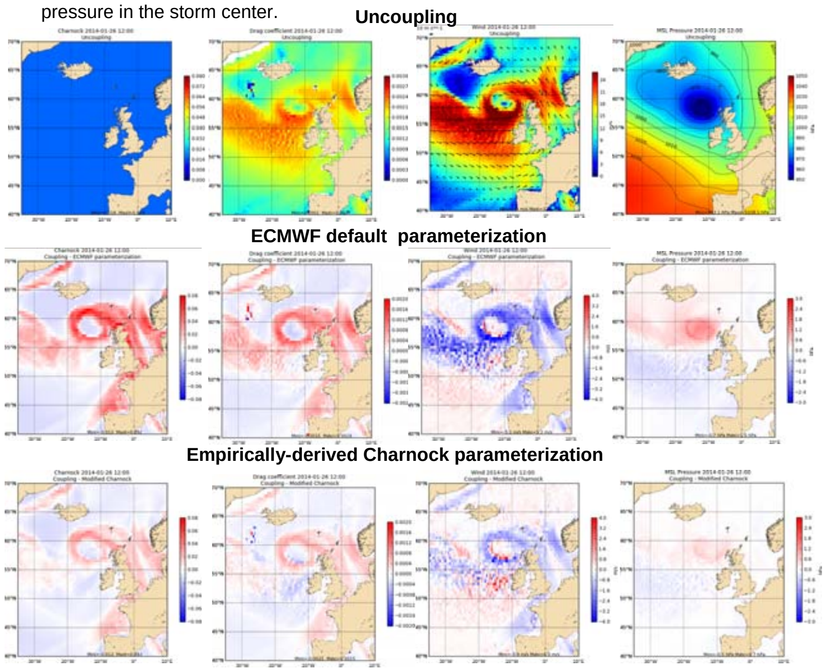
There is a clear **bias between buoys and platforms**, underlying that strong winds from buoys could be underestimated.



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

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 parameteization, empirically-derived Charnock parameterization) on Charnock, drag coefficient, wind and MSL Pressure

References & Acknowledgement

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Ardhuin et al. (2010). Semi empirical dissipation source functions for ocean waves. Part I: definition, calibration, and validation. J Phys Oceanogr.
Hanafin et al. (2012). Phenomenal sea states and swell from a North Atlantic Storm in February 2011: a comprehensive analysis. Bulletin Of The American Meteorological Society.
Hoskins & Hodges (2002). New perspectives on the Northern Hemisphere winter storm tracks. J Atmos Sci.
Janssen (1991). Quasi-linear theory of wind-wave generation applied to wave forecasting. J. Phys. Oceanogr.
Muller et al. (2014). Atmospheric storm surge modeling methodology along the French (Atlantic and English Channel) coast. Ocean Dynamics.
Powell et al. (2003). Reduced drag coefficient for high wind speeds in tropical cyclones. Nature.
Oost et al. (2002). New evidence for a relation between wind stress and wave age from measurements during ASGAMAGE. Boundary-Layer Meteorology.
Rascle & Ardhuin (2013). A global wave parameter database for geophysical applications. Part 2: Model validation with improved source term parameterization. Ocean Modelling.

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