SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2016……………………………………………………….
Project Title:	Improvement of wind stress parameterization in coupled wave-atmospheric models ……………………………..…… …………………………………………………………..……
Computer Project Account:	SPFRARDH
Principal Investigator(s):	Fabrice Ardhuin……………………………………..…… …………………………………………………………..……
Affiliation:	LOPS (Laboratoire d'Océanographie Physique et Spatiale), CNRS
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Jean Bidlot…………………………………………..…… …………………………………………………………..……
Start date of the project:	2016
Expected end date:	2018

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	n/a	n/a	3,000,000	1,562,172
Data storage capacity	(Gbytes)	n/a	n/a	10	

Summary of project objectives

(10 lines max)

Wind stress is a key parameter for ocean-atmosphere mechanical exchanges. As such, its realistic parameterization in atmospheric models is of special interest. In particular, it may significantly influence evolution of storms, both hurricanes and extra-tropical storms (e. g. Emanuel 2003). This research work aims at better representing the wind stress in numerical models, leading to an improved parameterization of turbulent fluxes, namely momentum flux, sensible and latent heat fluxes. This study will be based on experiments using Integrated Forecasting System (IFS) coupled with Wave Model (WAM).

The objective is to define an optimal wind stress parameterization, based on a more physical approach, taking into account (1) the wave influence, especially dependence of the drag on the wave age, by moderate to strong winds, (2) the spray influence by very high winds.

Summary of problems encountered (if any)

(20 lines max)

The only problem encountered was the migration to Cray Broadwell Nodes, but it has been fixed quite quickly thanks to Paul Burton indications and Jean Bidlot help.

Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

1. Introduction

We propose to evaluate the impact of different wind stress parameterizations on atmospheric forecasts. Work is based on Integrated Forecasting System (CY41r1) at a resolution T1279 coupled to the 0.25° resolution WAM using 24 directions and 30 frequencies. Different wave-dependant drag formulations are tested. We focus on mid-latitude storms, with a particular interest on North Atlantic winter the last 10 years. Forecasts to a range of 5 days are performed.

Works in the framework of precedent Special Project “Wind stress in coupled wave-atmosphere models: storms and swell” allowed to test on 10 events, five parameterizations:

- uncoupling WAM/IFS,
- coupling WAM/IFS with ECMWF default parameterization (Janssen 1991),
- coupling WAM/IFS with MFWAM parameterization (Ardhuin et al. 2010),
- coupling WAM/IFS with wave age dependant parameterization (Oost et al. 2002),
- coupling WAM/IFS with empirically-derived Charnock parameterization.

Results showed that drag values are probably overestimated for high winds, reaching 0.0045, whereas observed drag coefficient for high wind speeds in tropical cyclones are lower than 0.003 (Powell et al.; 2003). This could be due to an excess of energy level in the high wavenumber tail of the wave spectrum (Bidlot et al.; 2015). Empirically-derived Charnock parameterization allows clearly confining drag to lower values, leading to higher winds.

2. Comparisons with satellites

Modelled winds have been compared to observations from satellites: radiometer AMSR2 (Figure 1), radiometer WindSat and scatterometer ASCAT. Simulations have been led during Kaat and Lilli storms, from 23rd to 27th January 2014 (one of the 10 events, selected in precedent Special Project). Forecasts have been made from analyses every 24h.

Correlations between models (ECMWF default parameterization) and satellites are presented Figure 2. Results show good quite correlation with ASCAT, whereas high modelled winds seem strongly underestimated by radiometers AMSR2 and WindSat. Biases for each satellite and each parameterization are presented Figure 3; empirically-derived Charnock parameterization allows clearly reducing bias, compared with other parameterizations (except uncoupling).

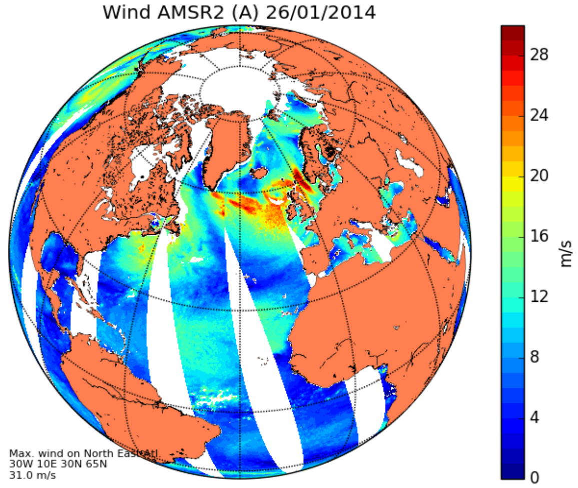


Figure 1: Wind data from AMSR2 the 26th January 2014

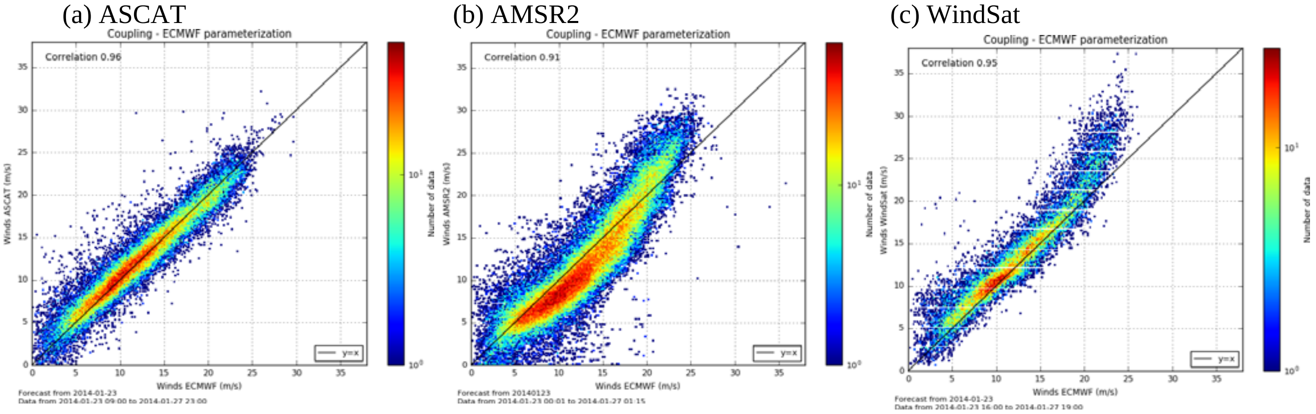

(a) ASCAT
(b) AMSR2
(c) WindSat

Figure 2: Wind correlation from 23rd to 27th of January 2014 between ECMWF default parameterization and (a) ASCAT, (b) AMSR2 and (c) WindSat

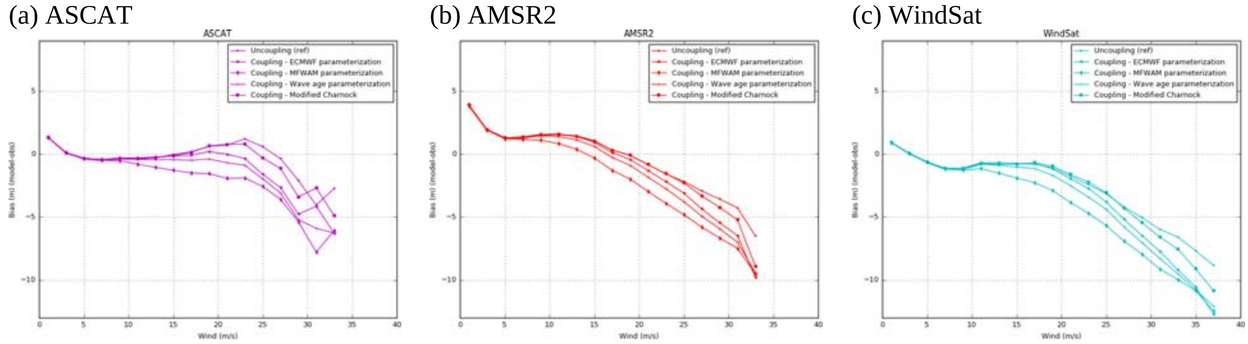

(a) ASCAT
(b) AMSR2
(c) WindSat

Figure 3: Wind biases, computed from 23rd to 27th of January 2014, between (a) ASCAT, (b) AMSR2, (c) WindSat and model (five parameterizations)

3. Comparisons with buoys and platforms

Modelled winds have also been compared to in situ observations: 76 buoys and 12 platforms (Figure 4), during Kaat and Lilli storms, from 23rd to 27th January 2014. Forecasts have been made from analyses every 24h.

Correlations between models (ECMWF default parameterization) and buoys and platforms are presented Figure 5. Results show good quite correlation with platforms (R=0.93), whereas data are more scattered with buoys. Biases are presented Figure 6; as for satellites, empirically-derived Charnock parameterization allows clearly reducing bias, compared with other parameterizations (except uncoupling).

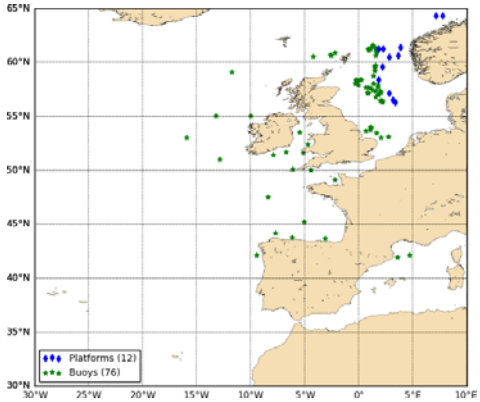
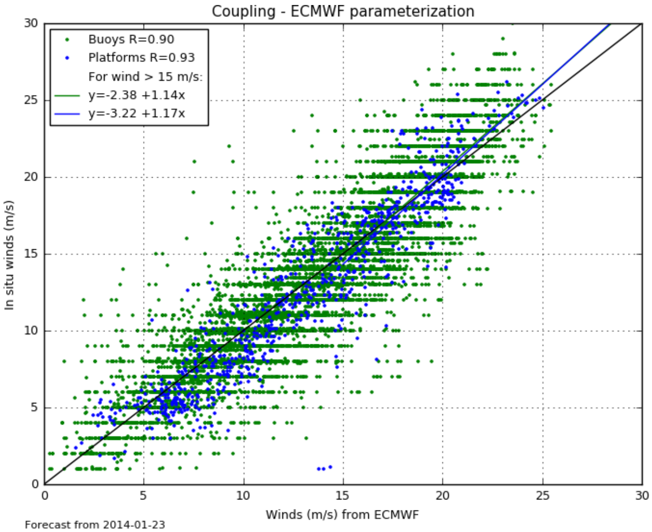


Figure 4: Map of available buoys and platforms



Forecast from 2014-01-23
Data from 2014-01-23 to 2014-01-27

Figure 5: Wind correlation from 23rd to 27th of January 2014 between ECMWF default parameterization and buoys (green) and platforms (blue)

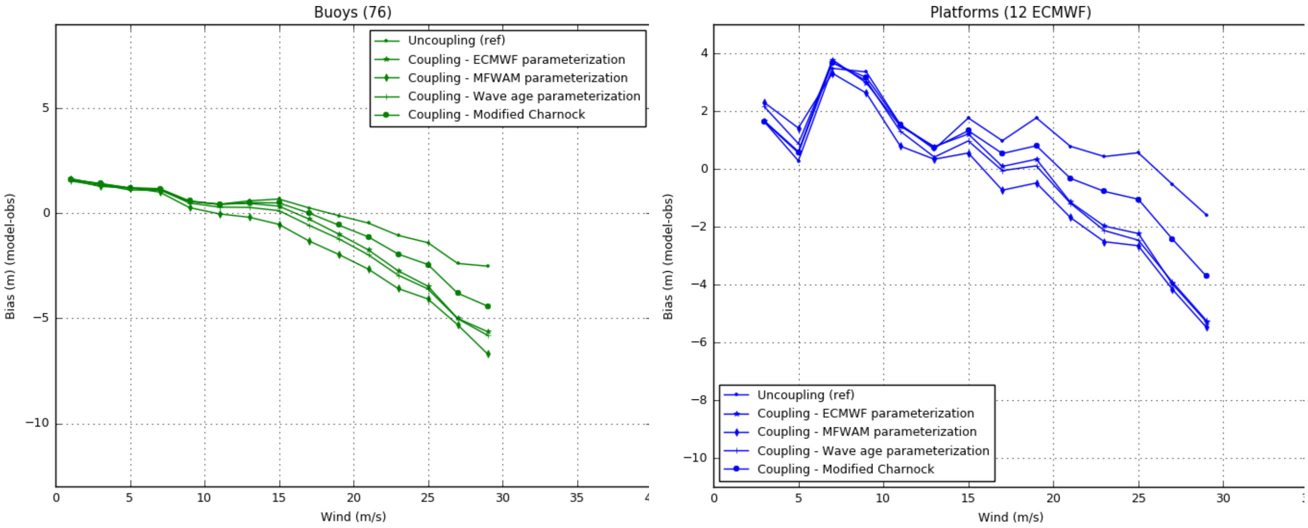


Figure 6: Wind biases, computed from 23rd to 27th of January 2014, between (a) buoys (b) platforms and model (five parameterizations)

4. Bias synthesis with buoys, platforms and satellites

Synthesis of bias between model with ECMWF default parameterization and observations (buoys, platforms and satellites AMSR2, ASCAT, WindSat) is presented Figure 7. Biases show that modelled low winds (<5 m/s) seem slightly overestimated compared with observations, medium winds (5 - 20 m/s) are quite coherent with observations, whereas modelled high winds (>20 m/s) seem to be underestimated compared with observations, with biases reaching more than 10 m/s for wind higher than 35 m/s. Further investigations have to be conducted, to analyse how these observations are independent – or not (for example, buoys are used to calibrate satellites). Errors associated with observations should also be taken into account. It is also important to precise that these results are associated to a single event, and study should be extended to other events.

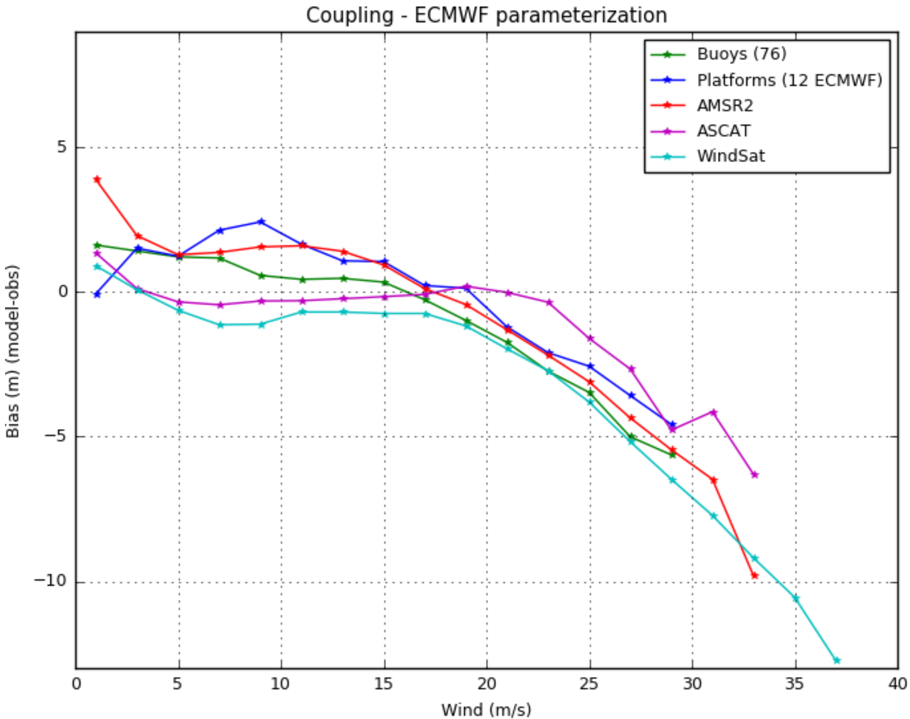


Figure 7: Wind biases, computed from 23rd to 27th of January 2014, between model (ECMWF default parameterization) and observations (buoys, platforms, AMSR2, ASCAT and WindSat)

5. References

Ardhuin F, Rogers E, Babanin AV, Filipot J, Magne R, Roland A, van der Westhuysen A, Queffeulou P, Lefevre J, Aouf L, Collard F (2010). Semi empirical dissipation source functions for ocean waves. Part I: definition, calibration, and validation. J Phys Oceanogr 40:1917–1941. doi:10.1175/2010JPO4324.1, 2418, 2425, 2431, 2441.

Bidlot J.-R., Breivik Ø., Mogensen K., Alonso Balmaseda M., Janssen P. (2015). ECMWF Coupled Ocean-Wave-Atmosphere forecast system. Marine Environmental Monitoring, Modelling and Prediction Colloquium, 4th - 8th May 2015, Liège, Belgium.

Janssen, P. A. E. M. (1991). Quasi-linear theory of wind-wave generation applied to wave forecasting. J. Phys. Oceanogr., 21, 1631–1642

Oost, W. A.; Komen, G. J.; Jacobs, C. M. J.; et al. (2002). New evidence for a relation between wind stress and wave age from measurements during ASGAMAGE. Boundary-Layer Meteorology, vol. 103, Issue 3, p.409-438

Powell, M., Vickery, P. & Reinhold, T. (2003). Reduced drag coefficient for high wind speeds in tropical cyclones. Nature, 422, 279-283.

List of publications/reports from the project with complete references

No publication/report has yet been completed, but a paper is in preparation.

Summary of plans for the continuation of the project

(10 lines max)

We will go on further in comparisons between model and observations, particularly extending comparisons with SMOS (Soil Moisture Ocean Salinity) satellite data.

Tests have been conducted on a specific event (Kaat and Lilli storms), they will have to be extended to others selected events (about 10), to have a more statistic approach.

First results show that some parameters still have to be adjusted for MFWAM parameterization.