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	2014
Project Title:	Wind stress in coupled wave-atmosphere models: storms and swells
Computer Project Account:	tpfa
Principal Investigator(s):	Fabrice Ardhuin and Jean-Luc Redelsperger
Affiliation:	Ifremer, France and CNRS, France
Name of ECMWF scientist(s) collaborating to the project (if applicable)	Jean-Raymond Bidlot and Peter Janssen
Start date of the project:	April 1st 2013
Expected end date:	December 2015

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)	NA	NA	2800000	27079
Data storage capacity	(Gbytes)	NA	NA	8000	101.784 Gbytes

Summary of project objectives
(10 lines max)

The better performance of Meteo-France's operational wave model (MFWAM) in many regions of the world ocean (e.g. around Hawaii) shows that ECMWF wave forecasts can probably be improved by using different parametrizations for wind-wave generation and dissipation. However, MFWAM results are not consistent with expect wind stress variability. Our objective is thus to develop wave and boundary layer parametrizations to arrive at a consistent treatment of the both wave evolution and wind stress, leading to improved forecast capabilities in the context of the coupled atmosphere-waves IFS system. Wet considers both high wind conditions in extra-tropical storms of the North Atlantic, for which the stress at a given wind speed is expected to decrease with wave age, and low wind conditions on the global scale for which swells are known to modify the air-sea momentum flux. The first effect that is already taken into account in the IFS, but its magnitude is still debated. The swell effect will probably require a modification of the boundary layer parametrization.

Summary of problems encountered (if any)
(20 lines max)
The transfer to the new computers as well as a delayed integration of the “MFWAM” version of the wave model parameterizations in perforce has delayed the analysis of the impact of that parameterization. As a result, progress has been limited to an investigation of alternative parameterizations in academic cases.

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. Understanding the performance of forecasting systems with respect to winds and waves.

a. Starting point of the project

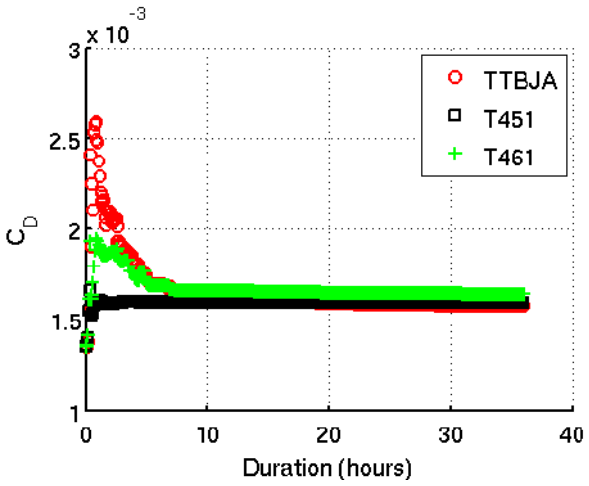
Prior knowledge on wave and atmosphere model behaviour was based on the monthly reports compiled for JCOMM by J.R. Bidlot. Because the forecasting systems use many different components, it is very difficult to determine the beneficial effect of any of these components on the final results. For example, although ECMWF, Meteo-France (MF) and SHOM-Ifremer (Previmer) all use the ECMWF analysed and forecast winds for their wave forecasts, but they use different resolutions, different assimilation procedures and physical parameterizations:

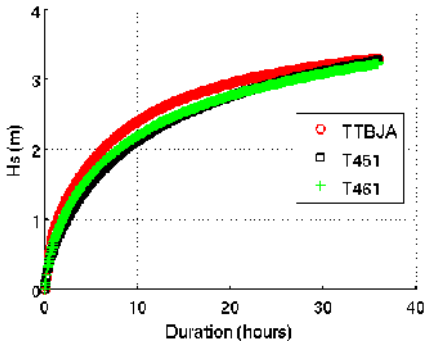
- ECMWF uses Janssen (1994) with later adjustements by Bidlot et al. (2005) and Bidlot (2012).
- MF uses Ardhuin et al. (2010) as modified by Rascle and Ardhuin (in press)
- Previmer uses the same parametrization as MF but in a different numerical setting (use of the WAVEWATCH III (WW3) code with different spatial propagation schemes and time integration schemes) and no data assimilation.

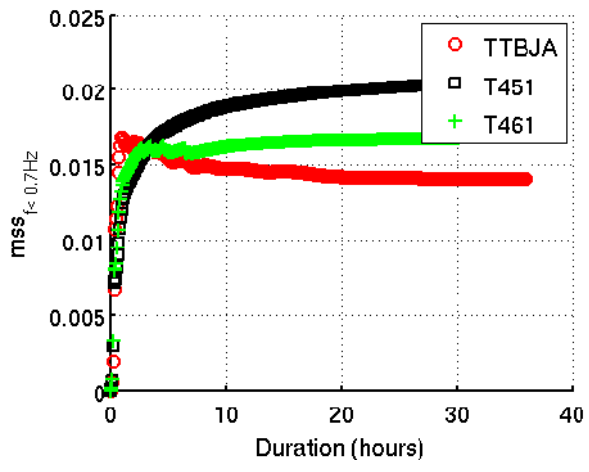
Also the JCOMM validation is only performed with buoy data.

b. Investigation of alternative formulations for the high frequency tail and impact on wind stress

The overestimation of the energy level at high frequencies with the parameterization by Ardhuin et al. (2010) and Rascle & Ardhuin (2013) is problematic and we have thus finally put back a fixed tail, before a more physical term can be found.







These three panels show the variation of the drag coefficient, wave height and mean square slope (integrated up to 0.7 Hz) for a uniform ocean with a constant wind of 12 m/s. Compared to the "BJA" (Bidlot et al. 2005 or later revisions) and "T451" (Rascle & Ardhuin 2013), the update "T461" uses a fixed tail similar to BJA and a saturation dissipation similar to T451. It is able to give an (relatively weak) increase of mss with wave age, associated with a (relatively weak) decrease of drag.

The free IFS (WAM) results confirm that random errors and biases against altimeter are indeed larger

This gives an updated parameterization that is capable of reproducing some of the expected decrease of the wind stress with increasing wave age (see above). The new parameterization has been validated at global scales with a better performance for short fetches, related to this enhanced drag and wave growth.

The analysis of the drag variability caused by the sea state was recently found to be overestimated when using the Janssen parameterization (Bakhoday-Paskyabi et al. 2013) using eddy-correlation data from the ASIS Tower off Martha's Vineyard. This analysis has to be confirmed with more data, and it will be interesting to see what can be the impact of a reduced or enhanced drag variability in the coupled IFS calculations.

There has been no progress yet on the additional issue of swell impact on the ABL.

5. References

Ardhuin, F., Rogers, E., Babanin, A., Filipot, J.-F., Magne, R., Roland, A., van der Westhuysen, A., Queffeulou, P., Lefevre, J.-M., Aouf, L., and Collard, F., "Semi-empirical dissipation source functions for wind-wave models: part I, definition, calibration and validation," J. Phys. Oceanogr., 40, 9, 1917–1941, 2010.

Bidlot, J., Janssen, P., and Abdalla, S., "A revised formulation for ocean wave dissipation in CY25R1," Tech. Rep. Memorandum R60.9/JB/0516, Research Department, ECMWF, Reading, U. K., 2005.

Bidlot, J.-R., "Present status of wave forecasting at E.C.M.W.F.," in Proceedings of ECMWF workshop on ocean wave forecasting, 25–27 June, 1–16, 2012.

Bakhoday Paskyabi, M., M. Flügge, J. B. Edson, J. Reuder, Wave–induced Characteristics of Atmospheric Turbulence Flux Measurements, Energy Procedia, Volume 35, 2013, Pages 102-112, ISSN 1876-6102, http://dx.doi.org/10.1016/j.egypro.2013.07.163.

List of publications/reports from the project with complete references

No publication/report has yet been completed.

Summary of plans for the continuation of the project

(10 lines max)

The next steps to be taken are :

- the analysis of the forecasts with coupled and uncoupled waves, in order to identify interesting cases and understand better the adjustment to roughness (change in stress, wind speed, SLP …)
- The evaluation of alternative wave model parameterizations (e.g. Ardhuin et al. 2010)
- The implementation of a surface upward momentum flux in the PBL and 1D simulations

A visit by F. Ardhuin (and MN Bouin) to ECMWF will probably take place between October 2014 and April 2015.