REQUEST FOR A SPECIAL PROJECT 2016–2018

MEMBERSTATE: France

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Project Title: Improvement of wind stress parameterization in coupled wave-atmospheric models

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SPFRARDH**	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2016	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2016-2018: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2018.)	**2016**	**2017**	**2018**
High Performance Computing Facility (units)	3,000,000	3,000,000	3,000,000
Data storage capacity (total archive volume) (gigabytes)	8	10	10

*An electronic copy of this form **must be sent** via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): June 30th 2015

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

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Extended abstract

It is expected that Special Projects requesting large amounts of computingresources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and thetechnical characteristics of the code to be used.The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

1) Challenge and objectives

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.

2) State of art

The wind stress in numerical models is parameterized using a drag coefficient, which may or not depend on the waves through a variable Charnock parameter (e.g. directly derived from a wave model).

The influence of the wave age on this drag coefficient has been demonstrated by several studies using in situ wind stress observations (Smith et al., 1992; Drennan et al., 2003). At very strong wind (>30 m/s), in situ or basin observations have shown a saturation, then decrease of the drag coefficient with increasing wind (Powell et al., 2003; Donelan et al., 2004; Jarosz et al., 2007; Holthuijsen et al., 2012). Numerous formulations of drag coefficients are currently available for use in numerical models (Charnock, 1955; Smith and Banke, 1975; Large and Pond, 1981; Wu, 1982; Janssen, 1991; Makin, 2005; Moon et al., 2007…), some of them taking into account the wave effect (Fairall et al. 2003).

Despite over 20 years of research on this topic, and even if the effect of the waves on the drag coefficient has been shown by several studies using in situ observations, there is still no clear consensus on the precise influence of waves. This is partly related to the lack of observations by high winds (typically > 20 m/s) and various sea conditions. As a consequence, there is still large uncertainties on the drag parameterization, which can easily reach 50% by strong wind, and up to 200% in cyclonic conditions.

2) Drag coefficient from WAM

Works in the framework of precedent Special Project "Wind stress in coupled wave-atmosphere models: storms and swell" show that values are probably overestimated for high winds (Figure 1). Modelled drag coefficient reaches 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). Ardhuin et al.

(2010) have proposed a parameterization that generally gives a better variability of the high wavenumber tail, compared to Janssen (1991). This parameterization will be tested (underway).

These first results show that parameterizations will probably have to be revisited.

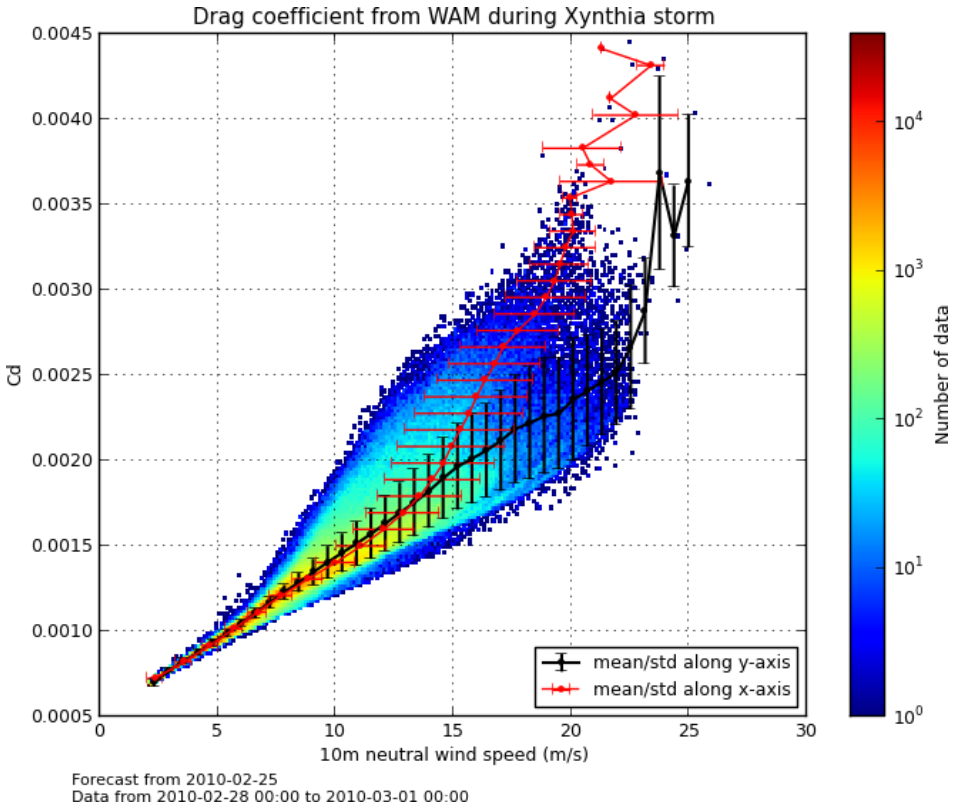

Figure 1: Drag coefficient during Xynthia storm (2010-02-28)

3) Proposed work

We propose to evaluate the impact of different wind stress parameterizations on atmospheric forecasts. Work will be based on Integrated Forecasting System (CY41r1) at a resolution T511 coupled to the coupled to the 55 km resolution WAM using 24 directions and 30 frequencies.

Different wave-dependant drag formulations will be tested, and the best parameterization selected based on comparisons between forecasts (typically beyond the 5 day horizon) and analyses, or on comparison with satellite data. Sensitive study should allow optimizing the dependence of the drag on the wave age. A particular study will also focus on the effect of spray, by very high winds.

The project will focus on mid-latitude storms, with a particular interest on North Atlantic winter the last 10 years. Forecasts to a range of 5 days will be performed for at least 20 cases.

For all cases, the model accuracy will be verified using 500 mb geopotential correlations, significant wave heights and mean periods, and wind speeds.

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