Geosci. Model Dev. Discuss., 8, C1907–C1912, 2015
www.geosci-model-dev-discuss.net/8/C1907/2015/

Geoscientific Model Development Discussions

Interactive comment on "A fully coupled Atmosphere–Ocean Wave modeling system (WEW) for the Mediterranean Sea: interactions and sensitivity to the resolved scales and mechanisms" *by* P. Katsafados et al.

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Received and published: 7 September 2015

A) I'm really torn by this paper. I'm all in favor in showing the impact of coupling but I was extremely disappointed that the authors have barely acknowledged that the work they present here has already been done and has been at the core of the operational forecasting system from the European Centre for Medium-range Weather Forecasts (ECMWF) since 1998. Peter Janssen and his team have shown through the years the beneïňĄt of such approach. Peter even has a book dedicated to that (Janssen 2004: The Interaction of Ocean Waves and Wind, Cambridge University Press). Moreover,

Peter was awarded this year the Nanssen medal in physical oceanography, in greater part because of his work on this topic. Even more disappointing is to note that this work was carried out during the MyWave project, in which Peter was also involved in showing that coupling waves to the ocean circulation (on top of the wave-atmosphere coupling) was also beneïňĄcial (Oyvind Breivik, Kristian Mogensen, Jean-Raymond Bidlot, Magdalena Alonso Balmaseda, Peter A.E.M. Janssen, 2015:Surface Wave Effects in the NEMO Ocean Model: Forced and Coupled Experiments Journal of Geophysical Research:Oceans 04/2015; DOI:10.1002/2014JC010565).

Reply:

The main aim of this manuscript is to present the approach adopted to develop a fully coupled atmosphere-ocean wave model for supporting regional research and operational activities. Obviously there are many other similar works published during the last decades at global scale (ECMWF, NOAA/GFDL, CNRM-CM5) or at regional scale (coupling with limited area models). In particular, ECMWF has developed an advanced, state-of-the-art system based on a two-way coupling of the IFS spectral atmospheric model and the ECMWF version of WAM ocean wave model (ECWAM). Its superiority has been proved through a number of publications for a decade or even more. Following reviewer's comment we added an extensive paragraph describing the development and the main features of the ECWAM. We could not include the work of Breivik et al. (2015) because it was published after manuscript initial submission in the GMD (March 2, 2015). However, it is included in the revised version of the manuscript.

B) The description of the method used to couple the wave model to the atmospheric model does not indicate anything really novel with respect to what was done by ECMWF. The model parallelisation is different but the essence is still the same.

Reply:

The method used to couple the wave model to the atmospheric model is based on the Multiple Program Multiple Data (MPMD). We decided to follow MPMD

because it handles on a flexible way the two modelling components and it is very efficient and manageable with the load balancing on the processors. However, the OASIS coupler (versions 3 and 4), which is used to support the UK Met Office Unified Model and having as components the UM atmosphere, the NEMO ocean and the CICE sea-ice models, is also based on the MPMD architecture (https://wiki.cc.gatech.edu/CW2013/index.php/Experiences_and_Decisions_in_Met_Office_
As for the physics of coupling we admit that we followed a method very similar to ECMWF approach but with a totally different atmospheric model implemented on a very high resolution domain.

C) Moreover, it looks to me that the WAM code used does not contain certain adjustment to the numerical code that was necessary when the original WAM code was adapted at ECMWF (see ECMWF IFS documentation Chapter 7 and Bidlot J.-R. 2012: Present status of wave forecasting at ECMWF.Proceeding from the ECMWF Workshop on Ocean Waves, 25-27 June 2012. ECMWF, Reading, United Kingdom), now called ECWAM.

Reply:

Computer code: The source code of WAM has been extensively revised because it is initially based on the serial code of WAM Cycle 4, which is parallelized using OpenMP directives. To this end, a new MPI communicator has been defined in WAM in order to exchange information with the atmospheric model, which is fully MPI parallelized and using MPI_COMM_WORLD as a global communicator. The cross talking between the two models wasn't the only tricky milestone, since the two models have different grid structure, indexing, sea masks and domain edges. Therefore, numerous modules have been developed for homogenize and handle the data exchange between the atmospheric and the ocean-wave components. Physics: The reviewer is referring to the following adjustments introduced since CY38R1 version of IFS (IFS Documentation – Cy38r1). 1) Reduction of za value to 0.008 (from 0.011). We use 0.011 as it also appears in other versions of WAM model (for example WAM Cycle 4.5.4 available through

MyWave project web page). 2) Adjustment of the wave dissipation source function in order to obtain a proper balance at the high frequencies (Eq. 3.14 of IFS Documentation – Cy38r1). In the present version of WEW we use the original dissipation source term of WAM Cycle 4 (although this has been adjusted in WAM Cycle 4.5.4).

D) ECWAM contains the same sea state dependent Charnock parameterisation but also the impact of gustiness and air density on wave growth. One might argue that ECMWF focuses on global scale application, whereas this paper interest was the Mediterranean basin. But I will argue that all these effects might actually be more important over the Mediterranean Sea.

Reply:

WAM receives the near surface wind components from the atmospheric model and returns the Charnock parameter, similarly with ECWAM, for the estimation of the roughness length and the friction velocity in the surface layer parameterization scheme. The coupling frequency has been set on the WAM timestep which is 360 sec while the timestep of the atmospheric model is 15 sec. In the abovementioned paper of Breivik et al. (2015) the coupling timestep between IFS/ECWAM and NEMO model is 10800 sec. The coupling timestep of WEW is in line with its native horizontal resolution, which is 0.05x0.05 deg. Therefore WEW has the ability to resolve additional mesoscale features since the non-hydrostatic motions of the atmosphere become very important on a resolution of 0.05deg or even finer. In general, the atmospheric local circulations, the etesian winds, the sea breezes and the convective systems over an area with complex sea-land physiographic characteristics, such as the Aegean Sea or the Mediterranean Sea, can be resolved by regional non hydrostatic models on very fine horizontal resolutions. Additionally, the parameterization of the impact of gustiness and air density on wave growth has been introduced only to the ECWAM model and it is not freely available to the community of WAM users.

E) The paper would have constituted a nice contribution the ïňĄeld, had the authors

gone beyond reproducing what had already been done (by ECMWF and others). For instance explore the behavior of the heat and moisture ïňĆux on sea state Jassen 1997: Effect of surface gravity waves on the heat ïňĆux, ECMWF Technical Memorandum http://old.ecmwf.int/publications/library/do/references/show?id=83780 or ïňĆuxes speciïňĄcation for short fetches and/or under inïňĆuence of bora like winds,...

Reply:

We would like to thank the reviewer for his/her very interesting and challenging recommendation. It is clear that the work presented in this manuscript describes our efforts to develop a coupled atmosphere – wind waves modelling system and implemented in a very high resolution model domain. Our intention is to use this modelling tool to further study interactions at the air-sea interface and their possible impact on the sea state as the reviewer suggests. We are currently working on the development of a new hybrid surface layer parameterization based on the Mellor-Yamada-Janjic (MYJ) and the Janssen schemes that operate in the atmospheric and ocean wave components of the WEW respectively (Katsafados et al., 2015). In this case the roughness length depends on the wave age instead of the Charnock parameter following the formulation proposed by Vickers and Mahrt (1997). Moreover, the physical processes related to the rainfall and the droplet diameter impacts on the SWH and the ocean wave spume will be incorporated in the updated version of WEW by the end of this year.

On behalf of the authors,

Petros Katsafados

List of the works cited in our reply

Katsafados P., Papadopoulos A., Varlas G., and Korres G., 2015: “A hybrid surface layer parameterization scheme for the two-way fully coupled atmosphere-ocean wave system WEW”. European Geosciences Union (EGU), General Assembly 2015, 12-17 April 2015, Wien, Austria, 12752. Vickers D. and L. Mahrt, 1997: “Fetch limited drag

coefficients”. Bound.-Layer Meteor., 85, 53-79.

Interactive comment on Geosci. Model Dev. Discuss., 8, 4075, 2015.