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Interactive comment on "Modelling wave–current interactions off the east coast of Scotland" *by* A. D. Sabatino et al.

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Dear reviewer,

Thanks for your time and your patience for reviewing our manuscript. I think that all of the points raised in your review are extremely interesting and will improve our manuscript. First we acknowledge that wave-currents interactions is a challenging topics and is very difficult to estimate their magnitude. I also acknowledge that in the paper there are some points in which there was a lack of clarity.

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Discussion Paper

First: the one-way coupling. MIKE by DHI does not allow a real-time coupling, so this means that the results of the flow model have to be fed into the wave model and there is not the possibility to make an online coupling. In MIKE by DHI software the two-way coupling as in *Michaud et al.* (2012) and *Bennis et al.* (2011), would be possible evaluating by the radiation stress due to waves from the wave model, feeding this information in the flow model and using the results from the flow model for forcing the wave model. This could be the next step for a future work on this model: however in this study we were more interested on how the general tidal- and wind-driven circulation were affecting the wave field rather than how the waves were affecting the currents. One of the reason of this is that we do not have any current observation nearshore or in the surface that could validate the effect of this coupling, since this effect is stronger nearshore and near the free-surface. However, we acknowledge that not implementing the two-way coupling introduces an error that is going to be discussed in a more in detail Discussion section of the paper. The other limitation due to the absence of the two-way coupling (more precisely the absence of an online coupling between these two models) is that the wave set-up is not considered. However both of these phenomena are more important on the sealevel/current rather than on the wave field itself. We believe that your suggestion could be implemented in the near future considering a development of the model in this direction for a future study.

Secondly: the rms average differences between waves in the coupled and the uncoupled model are consistent with previous studies in different areas. In particular *Osuna and Monbaliu* (2004), who studied the Southern North Sea found a difference based on the rms on one months period of about 3% for the H_s and an rms of 20% for T_m (Table 3 and 4 of *Osuna and Monbaliu* (2004)). This is consistent with the results showed in Table 4. However, in order to see if there is an improvement we will add

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in the revised manuscript in Table 4 the difference between the directional spreading, the peak period and the wave direction recorded in the wave gauges with the model output. We'll also add some 2D spectrum analysis during stormy periods and compare the spectra with and without WCIs.

Larger deviations are only cited and not showed in the manuscript: to address this comment we will add to the paper a contour plot with the maximum, positive and negative variation on the considered period due to the wave-currents interactions. The results are quite high but are consistent with previous studies, such as the Adriatic Sea (*Benetazzo et al.*, 2013). In addition, those results were computed by the model in nearshore shallow areas in strong tidal- and/or wind-driven current conditions, such as storms or spring high/low tides.

About the contour plots: we are going to change them in order to keep the colour consistent between different plots in the same figures. We will also change, in difference contour plot the colours in order to show negative difference with blue-scale colours and red-scale colours for positive difference, in order to fit into the journals requirements. We will also include, as suggested, a plot with the timeseries of the H_s and the T_m or T_p in coastal locations, where the model was predicting higher results (as Figure 9).

The swell and windsea waves in the MIKE 21 SW model are differentiated using the *Donelan et al.* (1985) criterion, that is based on a wave-age based criterion, from empirical wave measurements in wave tanks and in Lake Ontario field measurements. From *Donelan et al.* (1985) swell waves are the components fulfilling the following relation:

$$\frac{U_{10}}{c_p}\cos(\theta - \theta_w) < 0.83 \quad (1)$$

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where U_{10} is the wind speed at 10 m, c_p is the phase speed, θ is the wave propagation direction and θ_w is the direction of the wind. MIKE 21 SW has a second method for the discrimination of the windsea with the swell waves, that is a dynamic threshold function, in which the threshold frequency is based on the ratio between the total wave energy of a Pierson-Moskowitz spectrum (E_{PM}) and the total wave energy of the model spectrum (E_{Model}):

$$f_{threshold} = \alpha f_{p,PM} \left(\frac{E_{PM}}{E_{Model}} \right)^{\beta} \quad (2)$$

where $f_{p,PM}$ is the peak frequency of the Pierson-Moskowitz spectrum, and α = 0.7, β = 0.31 are two constant. However, most of the studies about windsea and swell waves used the *Donelan et al.* (1985) relation, so we decided to use this relation instead of the other relation. We acknowledge that for a more scientific discussion of the results obtained in this manuscript it is important to have a section on how the swell and the windsea waves are obtained. For this reason we will add a subsection in the Materials and Methods describing the above criteria.

Inconsistencies in wave period definition: I would like to thank the reviewer for spotting an error between the supporting material and the Table 4: in the supporting material it should read T_m instead of T_p. It will be corrected in the reviewed version. The output mean wave period is the T_{m01} that is defined from the spectrum as (*Rice*, 1944):

$$T_{m01} = 2\pi \frac{m_0}{m_1} \quad (3)$$

where m_0 and m_1 are the 0-th and the first spectral moment respectively. We will add all in the paper this information as suggested by the reviewer in the final version. The peak period was only used for the analysis of the final model output and not for the validation, since the T_p reported in the supporting material was only a typo. As was highlighted by the reviewer the peak period is everytime very difficult to estimate.

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We will add into the Discussion section some comments about the peak wave period estimation uncertanties (see eg *Serio et al.* (2005) or *Young* (1995)). We'll also add in the Methods a discussion about the uncertanties from satellite data observations as suggested by the reviewer (*Gommenginger et al.*, 2003).

Model setting and configuration not well documented: we acknowledge, reading again the document, that some details about the calibration and about the model setting are missing, such as the number of frequencies or the number of directions included into the model, or such as all the calibration parameters and their values, that should separated from the Methods sections and should be put into the validation and calibration section. For the γ parameter: the calibration was carried out based on the best agreement between model and data and the calibration parameters were the γ, the C_{Dis} and the δ of the white-capping formulation. For the γ the approach was to vary its value by steps of 0.1 in the range 0.6-1.2 and then refining. The best agreement between data and model was found after the calibration for γ = 0.6. This is a value that is lower than the 0.73 used as default value for SWAN and WAVEWATCH III models (and also for the MIKE 21 SW as well) and found as average by (*Battjes and Stive*, 1985), however is worth noticing that different values were of the γ based on experimental studies were found throughout the years, such as *Battjes and Janssen* (1978) that found values of γ who 0.6-0.73, or *Stive* (1985) 0.62-0.82, as well as *Kaminsky and Kraus* (1993) 0.6-1.79, with an average of 0.79.

We will expand the Discussion section as well as the Results and Methods section in order to document better the points that were raised by the reviewer, and also we will change the caption of figures and tables in order to make them standing on their own.

The water depth of the Aberdeen wave gauge is 10 m (referred to the mean sea level). Apologies for not specifying it.

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About minor comments: Thanks for noticing the error of the phase, while S was south, not H_s: we will change S and write 'south' instead.

In conclusion we thanks the anonymous reviewer 1 for the corrections and suggestions that will surely help to improve the paper. If Reviewers 1 have any other comments, we will be happy to discuss them and to modifying the paper accordingly.

Thanks!

Alessandro D. Sabatino

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