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Interactive comment on "Coupling of wave and circulation models in coastal-ocean predicting systems: a case study for the German Bight" *by* J. Staneva et al.

Anonymous Referee #2

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The paper represents a consistent study of the wave-current interaction effects in the tidal dominated water, with focus on the North Sea and the Wadden Sea. Its results demonstrate the significance of model coupling and confront the widespread understanding in operational forecasting that the coupling of wave-and-ocean circulation model leads only to complex, computational demanding model systems, which under normal conditions exhibit only weak interaction effects. This paper analyses high impact scenarios as well a normal conditions and calm seasons. Model results are validated and systematically compared with observations from tide gauge stations, wave buoys and ADCP's. Positive impacts on the model forecasting quality are demonstrated statistically.

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Interactive Discussion
Discussion Paper

I recommend to accept the paper for publication in Ocean Science after revision of the manuscript. The good model study and validation work is to some extend reduced by a sometimes unclear use of terminology, notations and references. Please find a more detailed description at the beginning of the detailed review. However, the model study is well designed and great efforts have been made to evaluate the coupling effects by model comparison with observations. The presented results are substantial and support the conclusion. The models seem to have been set-up correctly and the coupling mechanisms seem to have been implemented in the correct way. Adequate numbers of references have been provided to put a frame around the developments of the recent years. The methods are valid and clearly outlined. What is somewhat missing, is a discussion of the processes and methods, and why some were selected over others. The amount of supplementary material is appropriate.

Detailed review

The authors should be more clear and specific about names and notations. Different names are used to describe similar terms. So are wave dependent stress, wave stress and radiation stress used to describe the same coupling parameter, and sometimes are even thrown together with the wave force, i.e. the divergence of the radiation stress. Parameters and concepts are rarely introduced, even when they are ambiguous (e.g. wave stress) or not commonly accepted (e.g. wave force). The whole paper should receive a work through to make its terminology explicit and consistent.

P-page, L-line P3170, L1: WAM, which has been used in this study is not only a wind wave model, but it is also a model for swell prediction.

P3170, L7: Tidal currents in the North Sea might be one, but not the only effect that affects wind-wave generation and propagation. I assume that the authors refer to tidal variations of water level in general and consider its impact on depth dependent wave propagation in the shallow regions of the Wadden Sea. Furthermore, waves do not feedback onto tidal currents, but onto the mean currents. Waves also affect the water level (wave set-up), which again is affecting wave propagation.

P3170, L10: produce instead of producing

P3170, L11: maybe combined effect instead of collective role

P3170, L14-17: Processes should be indicated more clearly and expected impacts should be presented. I assume that wave-dependent stress is actually the Radiation-stress. It is not clear if wave breaking is affecting the turbulent mixing. It is also unclear what the authors mean when they speak about different parameterizations of the wave effects on the ocean circulation. (On page 3173, L6-7 the authors write that the impact of different parameterizations are not subject of this paper.)

P3171, L9: The processes that are listed here are affecting the interface between the ocean and the atmosphere, which is not subject of this paper. The authors should add the processes that are studied, i.e. momentum exchange between waves and mean currents and dissipation processes in the water column (turbulent mixing) and at the sea bed (bottom friction).

P3171, L14 and in the entire document: The authors seem absolutely clear that the tidal impacts on the wave dynamic are mainly a consequence of the tidal currents, and not a result of the water level variation due to tides. This had to be proven, by reference, or by running a tidal driven model (no wind forcing) and only using the tidal currents, but not the tidal variation of water level to force the wave model WAM. The results of this run had to be compared with the fully coupled model, including the effects of varying water level (water depth), wave induced water level variations and surges.

P3171, L13 to P3173, L2: This part of the document provides an overview of relevant publications and studies. Starting with a more general overview over coupling processes, the reader is confronted with a multitude of processes which could be organized a more structured. The literature review continues with a list of publications that are dealing with the model physics of coupled ocean-and-wave models (although this is not made clear). The comprehensive, but rather uncommented sweep through the publications makes it difficult to understand the authors view and motivation to select one alternative approach over the other. It remains unclear why Mellor 2008 (radiation stress divergence, i.e. wave force) was selected for this study and not one of the alternative approaches. The discussion between Mellor and Bennis & Ardhuin focused on the instantaneous and time integrated effect of topographical gradients, which are present in the Wadden Sea, although they might not be significant enough to influence the results significantly.

Furthermore, the description remains incomplete, as the introduction is only dealing with the momentum exchange between wave-and-ocean circulation model. Wave dependent bottom friction parameterizations and TKE input due to wave breaking and dissipation is described in paragraph 2.3. The process description could be more harmonized. Furthermore, the method of ocean circulation-to-wave model coupling should be explained in this paper as well. It is not presented in chapter 2.3 on page 3175. The link to the publication Wahle et al. (2015) is not available yet (see comment P3175,L26).

The general discussion in the introduction could cover additional points like how much model coupling is needed for operational model applications. Are the selected processes the major ones? What would be the next level? Does operational model have to go to 200m resolution (GETM high resolution grid) to cover the scales needed for model coupling? Most basin scale, operational ocean models feature a coarser resolution.

P3174, L8: 200m

P3174, L8: This is just a comment. Strong wave impacts on the ocean conditions are expectable at the North-Frisian islands, due to prevailing westerly winds. Why are the grids structured so as to better resolve the south-eastern North Sea?

P3174, L25, and following: There is no figure indicating the coverage of the WAM grid. Ideally one figure should represent both set-ups, i.e. the coupled WAM-GETM set-up. For operational applications it would also be helpful to learn more about the spectral discretization and the time steps for source integration that have been used. The definition of the grid resolution is presented with rather high resolution. It should be done in the same way as with GETM. The terms delta phi and delta lambda are strictly speaking undefined.

P3175, L12, L14: The term "wave force" is not generally accepted and unambiguous. It is used and defined in the WAM manual as the divergence of the radiation stress.

P3175, L13-14: I don't quite understand this sentence. What do you get when you subtract the Stokes drift (a velocity) from the wave force (a force)? I understand that the wave force was added to the momentum equation to calculate the dynamic of the mean currents, the sum of the Stokes drift and the Eulerian drift (Mellor, 2008, eqn. 11a). Maybe the Stokes Drift was subtracted from the mean currents to get the Eularian drift. That would make sense. But if this is true, than I would like to know what the Eulerian drift was used for?

P3175, L24: The coupling processes described above, take only wave effects on the ocean circulation into consideration. The description is therefore incomplete. Circulation model feedback mechanisms of varying depths, currents and ice concentrations are not described.

P3175, L26: I could not find the link to Wahle et al. (2015). The paper must be still in print. The paper is used as a reference for the in-detail description of the coupling technique. I could only find a link to a presentation at the GODAE workshop 2014. The coupling technique: circulation-to-wave-model is not described either.

P3177, L1: "both runs", the two runs are not defined yet. Furthermore, figure2 does not show results for both runs. Instead it shows the ratio of the standard deviation of the coupled run to the mean value of the uncoupled run (which works because Hs and tm1 are strictly positive).

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P3177, L3: Why did the authors analyze the coupling effects only for calm wind periods, and not for storm scenarios as well? Wave induced sea level variation, i.e. the wave setup is noticeable only during storm scenarios, and coupling effects are more pronounced.

P3177, L7: One "coastal areas" to many

P3177, L11-17: Comment: The connection between the further analysis of a station at the entrance to the Jade Bay and the high SD value of tm1 should be made clearer. I had to read the paragraph twice to understand this.

P3177, L14: SDT or SD

P3177, L16: Southerly winds means winds from the south (meteorological convention) or winds in southerly direction (mathematical convention)? The reason for this question is, that I don't understand why waves that have been generated inside the Jade Bay could have longer effective fetch than waves coming from the North, i.e. waves that have crossed some distance of North Sea.

P3177, Chapter 3.2: The model validation chapter could be presented before the analysis chapter 3.1 and 4.

P3177, L28: which two model simulations.

P3178, L2: Please see my comment to P3171, L14. I don't argue that current refraction does not play a role, but it is not the only player. Tidal water level variations and depth refraction plays a strong role tidal dominated seas like the North Sea.

P3178, L3: I think the authors mean the difference of the SD and not the SD between measured and simulated values, which is the RMS error?

P3178, L22: I can't find the locations for the buoys T1-T4 in figure1. Throughout the paper, figure1 is references when it comes to indicate individual locations and transections, but none of these locations is presented in the figure.

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Interactive Comment

P3178, L20 to P3179, L12 It is interesting that the additional wave force during storms does not lead to exaggerated sea level predictions, as it usually does, when the wave force (divergence of the radiation stress) is directly applied to the momentum equation, without additional penance due to mixing or reduced wind stress. This would be interesting point to elaborate on.

P3179, L21 (see also previous point): Increased water levels of 10 to 15 cm during calm situations are rather significant. Operational circulation models and set-ups are highly tuned. The annual miss rate, i.e. the percentage of time with water level forecasts that are exceeding a range of 20cm is about 3% to 5%. High water events have a tendency to be slightly over-predicted. Additional 10 to 15cm, or even 30cm during storms, would lead to exaggerated water levels. My assumption would be that the authors used a somewhat lower drag coefficient than operationally is used, to avoid water level over-prediction.

P3179, L18: Clear use of terminology: This is the first time that term radiation stress is used. The radiation stress is also not increasing the water level, but the wave force (divergence of the radiation stress tensor) is, when applied to the momentum equation.

P3180, L2: What is the SLE amplitude?

P3180, L7-16: What is the reason for the TKE increase? Figure7 indicates that depth induced wave breaking under normal meteorological conditions leads to an increase of TKE in the surf zone (where the waves break). Under storm conditions and high water levels the zone where waves break extends entirely over the shallows regions. The manuscript remains unclear about the reasons for this increase. Is it because of enhanced wave propagation, refraction, stronger wave growth under strong wind conditions or maybe other reasons.

P3180, L18 and the following: Figure8, lower right panel (zonal velocity difference). Why is there a shift in time between the maximum of the significant wave height and the maximum of the current velocity difference? It seems that while the waves are still growing, the difference between the zonal currents is already reducing.

P3181, L2: The positions are not plotted in figure1

Interactive comment on Ocean Sci. Discuss., 12, 3169, 2015.

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