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Discussions

Interactive comment on "Wave-current interaction during Hudhud cyclone in the Bay of Bengal" *by* Volvaiker Samiksha et al.

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RESPONSE SHEET - REVIEW COMMENTS

Interactive comment on "Wave-current interaction during Hudhud cyclone in the Bay of Bengal" byVolvaiker Samiksha et al.

Anonymous Referee #1 Received and published: 30 May 2017

Comment – 1:

The manuscript has a subject that is appropriate to the NHESS publication and shouldbe of interest to readers of the journal. The paper is reasonably well written, logicallyorganised, structured and illustrated. The authors present an interesting set

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of simulationsto assess the mutual affects of waves and currents during the passage of theVery Severe Cyclonic Storm Hudhud. The principal results are: (1) Waves contributed0.25 m to the total water level during the event, which agrees with measurements atVisakhapatnam; (2) Current speed increased from 0.5 to 1.8 m/s for a short time duringthe event; (3) the two-way coupling increased the current magnitude by 0.25 m/salong the track; (4) The use of wave-ocean coupling increases Hs in 2 m comparedto wave model only; (5) waves decrease due to currents when they travel normal tothe coast after crossing the shelf area (right side of track) and increased on the leftside of track when currents oppose wave direction. Cyclonic systems currently poseone of the most challenging and important meteo-oceanographic phenomena for theearth science community and the study is a valuable contribution. However I havefundamental objections that I believe should be addressed before final publication.

Response: The authors thank the reviewer for thoroughly reviewing our manuscript, appreciating the work and providing valuable suggestions to improve the manuscript. The fundamental objections raised by the reviewer have been addressed in the following paragraphs.

Comment – 2:

My main concern is related to the overall content and discussions. In the end of introduction,the authors state that "The present study primarily aims at quantifying theimpact of wave-current interaction on waves during the Hudhud cyclone". The analysishowever seems to be equally focused on the effects of waves on currents and waterlevel. I presume they do so because the only data source available is of a Wave Riderbuoy. No current data is available. However, there is no clear discussion on whetherthe inclusion of current improves wave simulation at the buoy location. The authorsjust mention the differences in model results show the plots of comparison of modeland measurement and let the readers draw their own conclusion. The coupling systemincrease wave height (0.2 m) at the wave height peak moment. But wave height isdecreased before this moment and model actually agrees better with data without theinclusion of currents. Wave period is also slightly better represented in the simulationwithout currents. If the main goal of the paper is "quantifying" the effect of wave-currentinteractions on waves, this must be discussed also in terms of improvement and/or deteriorationof simulations compared to measurements. At least an attempt should bemade. It is an interesting opportunity to address some limitations of these models andif currents are actually beneficial to wave modelling (and vice-versa).

Response: The authors appreciate the reviewer comments and agree that this study focus not only on the quantification pertaining to the impact of wave-current interaction, but also on: (i) impact of wave-current interaction on water level, (ii) impact of wave-current interaction on waves and (iii) impact of wave-current interaction on currents. Accordingly, the last paragraph in the Introduction section has been modified, and relevant references were added as follows:

From literature review, it is evident that most of the studies carried out with storm surge models for the Indian coast used standalone models (Rao et al., 2012; Bhaskaran et al., 2014; Gayathri et al., 2015; Gayathri et al., 2016, Dhana Lakshmi et al., 2017). A comprehensive review on the coastal inundation research and an overview of the processes for the Indian coast was also reported by Gayathri et al. (2017). One can find very few studies reported using a coupled model (ADCIRC with SWAN) for the Indian seas (Bhaskaran et al., 2013; Murty et al., 2014, 2016; Poulose et al., 2017) for extreme weather events. These studies examined the performance of coupled models and role of improved wind forcing on waves and hydrodynamic conditions. The present study is a comprehensive exercise that aims to study the following interaction during the Hudhud event: (i) impact of wave-current interaction on water level, (ii) impact of wave-current interaction on waves, and (iii) impact of wave-current interaction on currents. This involves simulation of winds, tides, storm surges, currents and waves in the study domain during this extreme weather event using the coupled ADCIRC and SWAN models. Only the measured wave and water level data was available for the verification of model results (which happened to be very close to the cyclone track).

Both these data sets were utilized in this study. Unfortunately, no measured current data was available for verification of the model-computed currents. The coupled model (ADCIRC+SWAN) has demonstrated its efficacy in predicting storm surge and water level elevation as compared to the standalone ADCIRC model. For example, considering the 2013 Phailin cyclone event (Murty et al., 2014), the difference in residual water level between standalone and coupled versions at Paradeep in Odisha coast were about 0.3m, and the coupled model performed relatively better than standalone model. In addition, for the 2011 Thane cyclone, good performance of coupled parallel ADCIRC-SWAN model was reported by Bhaskaran et al. (2013). The overall performance of waves and currents during Thane event validated against HF Radar observations and with satellite tracks of ENVISAT, JASON-1, JASON-2 and wave rider buoy observations very clearly show that coupled model performed reasonably well. During extreme weather events like cyclones, the interaction between waves and currents is a highly non-linear process, and the transfer and exchange of energy between them is a very complex process. Along the nearshore regions, the non-linear interaction process is highly complex and to a larger extent, it is controlled by the local water depth and coastal geomorphological features. There can be instance wherein the computed results using a coupled model may be under-estimated considering the influence of currents. However, in this case the role of bottom characteristics and water level needs a separate detailed study. Also, including fine resolution bathymetry and cyclonic winds will further enhance the accuracy of the model.

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Comment – 3:

The exact location of the wave rider buoy must be plotted,possibly on the map of figure 1a, so that the reader can know where the validationof the wave model was performed for.

Response: The authors appreciate the reviewer comments. Accordingly as suggested, the buoy location is marked in Figure 1a.

Comment – 4:

Very little detail is given about wave measurements. Although section 2 is entitled“Data and Methodology” it is basically about the modelling configuration. What is thesampling time of wave information, how is it obtained (spectral method, record length)?

This information together with the aforementioned plot of the buoy location may be of interest to readers.

Response: The authors appreciate the reviewer comments. The wave data used in this study was obtained from the National Institute of Ocean Technology, Chennai. As suggested by the reviewer, the details of wave measurements and data analysis are now added in the revised manuscript as follows:

Wave data was obtained from the directional wave rider buoy deployed off Visakhapatnam (17.63ïĆřN; 83.26ïĆřE) at 15 m water depth. The measurement range is -20 m to 20 m, with an accuracy of 3%. The in situ data was recorded continuously at 1.28 Hz and the recording interval for every 30 min was processed as one record. At every 200 seconds, a total number of 256 heave samples were collected and a Fast Fourier Transform (FFT) was applied to obtain a spectrum in the frequency range 0 to 0.58 Hz having a resolution of 0.005 Hz. Eight consecutive spectra covering 1600 seconds were averaged and used to compute the half-hourly wave spectrum. Significant wave height (H_m0) or 4√(m_0) was obtained from the wave spectrum. The nth order spectral moment (mn) is given by: m_n=∫ _0∞âŰŠãĂŰf^n S(f)dfãĂŮ, where S(f) is the spectral energy density at frequency f. The period corresponding to the maximum spectral energy (i.e., spectral peak period (T_p) is estimated from the wave spectrum. The wave direction (D_p) and directional width corresponding to the spectral peak is estimated based on the circular moments (Kuik et al.,1988).

Comment – 5:

Why do the authors decide for the set of physics of growth and dissipation fromCavaleri and Malanotte-Rizzoli (1981) and Komen et al. (1984)? These old parameterisationsand especially the Komen et al. dissipation form are proven to not be adequatein nonstandard conditions, as in opposing currents, for example (see Ardhuin et al JPO(2012) and Rapizo et al (JGR 2017)). The dissipation form in Westhuysen et al (2007)shows better performance than the Komen et al. term in adverse currents (Rapizoet al, 2017).

The newly implemented in SWAN and recently released 'ST6' physics(Rogers et al, 2012) performs best in conditions of effective currents Rapizo et al (JGR2017), which is the subject of investigation here. If the old physics are used instead, ajustification must be given.

Response: The authors appreciate the reviewer comments. The authors have conducted this study in 2015 using the unstructured version of SWAN (version 40.85) implementing an analog to the four-direction Gauss-Seidel iteration technique with unconditional stability (Zijlema, 2010). However, Rapizo et al (2017) reported the good performance of SWAN in tidal current regime (ebb and flood flows) very recently (2017) only. It may kindly be noted that, the co-author of this work, Bhaskaran and his team has carried out a few studies (Bhaskaran et al., 2014; Gayathri et al., 2015; Gayathri et al., 2016, Dhana Lakshmi et al., 2017; Bhaskaran et al., 2013; Murty et al., 2014, 2016; Poulose et al., 2017) using the same formulation of Komen et al. (1984) for cyclones that occurred in the Indian Ocean region, and found that SWAN with this scheme performed well for extreme weather events also. Keeping this in view, in the present study the authors have gone ahead with using the same formulation of Komen et al to study the wave-current interaction during the Hudhud event. However, the authors appreciate the reviewer comments and shall use the scheme of Roger et al (2012) in SWAN and study the wave-current interaction in tidal as well in cyclonic conditions as a separate study in future.

Comment – 6:

I find it hard to analyse the differences in current speed shown in Fig. 5 (especiallyfor figure (b)). Although it is interesting to see the pattern produced by the cyclonelandfall, all figures show similar patterns. I suggest here to plot (b) and (c) as currentspeed differences (similar to Fig. 10 bottom panels).

Response: The authors appreciate the reviewer comments. As suggested one more Figure (5d) is added to show the difference in current speed similar to Fig. 10 in the revised manuscript.

Comment – 7:

Other minor points: Line 22: “Studies show that waves contribute to local currents,water level and mixing.” By mentioning “Studies” I feel at least one reference is neededhere.

Response: The authors appreciate the reviewer comments. As suggested the following three references are added to this statement in the revised manuscript:

Kudryavtsev et al., 1999; Davies and Lawrence, 1995; McWilliams et al., 2004. These studies show that waves contribute to local currents, water level and mixing.

Comment – 8:

Line 24-26: “Several studies have been carried out relating to individual processes,but not many on interaction between the processes. Therefore, we need to take intoaccount different processes that impact a specific process.” Very confusing, manyrepetitions of word “process”. Rephrase.

Response: The sentence is rephrased as follows in the revised manuscript: ‘Several studies have been carried out relating to individual processes, but not on the interactions between them’.

Comment – 9:

Line 34: “effected” => “affected”

Response: The correction made accordingly in the revised manuscript.

Comment – 10:

Line 37: “The wave processes that impact the coastal environment are:” There aremany other wave-related processes that impact the coastal environment other thanthe ones listed (wave set-up, wave-current interactions and breaking-induced mixing).The

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first phrase should be rephrased to something like: “Some of the relevant waveprocesses that impact the coastal environment are as follows:”

Response: The sentence is modified as follows in the revised manuscript: Some of the wave processes that impact the coastal environment are as follows: wave set-up, wave-current interactions and breaking-induced mixing.

Comment – 11:

Line 55: SWAN stands for Simulating Waves Nearshore, not "in Nearshore".

Response: The correction is made accordingly in the revised manuscript.

Comment – 12:

Line 93: Buoy coordinates are wrong. (same for legend in Fig. 4, 6 and 8)

Response: The authors appreciate the reviewer comments. As suggested, the corrections are made (17.63ïĆřN; 83.26ïĆřE) in the revised manuscript.

Please note that two figures are included in supplement file.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-11/nhess-2017-11-AC1-supplement.pdf

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2017-11, 2017.