RESPONSE TO REFEREES & REVISION DETAILS

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Title: A coupled wave-3D hydrodynamics model of the Taranto Sea (Italy): a multiple-nesting approach.

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Note: Page/Line/Figure numbers in the fields "Response" and "Revisions in manuscript" refer to the revised version of the manuscript.

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Anonymous Referee #1

In Fig. 9 a reference vector would help more than the color scale.

Response: Following your suggestions in the revised version of the manuscript, Fig. 9 a was improved, with the inclusion of a reference vector for the velocity distribution.

Revisions in manuscript: Fig. 9 a was revised in Pag.22.

Also in the area of Mar Grande (i.e. Figure 9 a) a figure with significant wave height distribution could be added.

Response: Following your suggestions, Fig. 9 b was added, adding a map of the significant waves in the area of Mar Grande.

Revisions in manuscript: Fig. 9 b was added in Pag. 22 and the text in Page 10 modified as "Figure 9 shows the colormaps of the surface velocity field (top) and of the significant wave height (bottom) in the area of Mar Grande. In particular, the values represent the average occurring in the interval from 10:00 am to 12:00 pm of the day 5 October 2014; the first two layers' depth-averaged (up to -2 m of water depth) of the 3D velocity results were obtained in order to compare the numerical outputs with the average observed trajectories of each drifter group (black arrows in the top panel)."

Anonymous Referee #2

Main concerns refer to the overall manuscript structure and to the quantification of the model accuracy.

As a first, I suggest to separate the methodological sections from the results sections. In the present version the sections 3.1 and 4.1 describing the different models setups are included into that part of the paper should be dedicated to the description and discussion of the model results. The Section 2.1 could be split into Model Description (2.1) and Model setup or Nesting Procedure or similar (2.2) including all the informations (including the Sections 4.1 and 4.3) needed to understand the different numerical experiments you performed. The Section 2.2 should describe only the field data, a specific Site Description Section could be included after the Introduction and before the methods.

…

Regarding the results… As a first, you should merge them into a unique Section (Model Results) at least divided into 2 sub/sections.

Response: -

Revisions in manuscript: Under your suggestion, the structure of the manuscript was revised as following:

1. Introduction
2. Multiple-nesting approach and model description
3. Case study
    3.1 Description of the investigated area
    3.2 Field data collection
4. Model set-up
    4.1 2D model of the Gulf of Taranto
    4.2 3D model of the Taranto Sea
5. Model results and discussion
    5.1 Coupled wave–2D hydrodynamics model of the Gulf of Taranto
    5.2 Coupled wave–3D hydrodynamics model of the Taranto Sea

6 Conclusions

The figures order was properly modified in the manuscript in order to follow this new revised structure.

Regarding the content of the methodological sections, you have to strongly reduce and try to clarify them. In particular, it is not necessary to describe the modifications you carried out to the model codes e.g. page 5 " In order to …. " This can be deleted it is not relevant to the scope of a research paper. "

Response: -

Revisions in manuscript: The text in the manuscript was reduced and modified (Pg. 3-4) as "In order to implement the proposed multiple-nesting approach, the authors properly modified each of the aforementioned modules in order for them to be able to read space-time varying conditions. A detail of the forcings of the adopted models is reported in Table 2, describing the initial conditions (IC), boundary conditions (BC) and surface boundary conditions (SBC) of the modelled variables." Table 2 was added in Pg. 16.

Again, it is not necessary the author mentions and describes the "fractional steps method" page 8 as well as cites the names of any Fortran files or similar.

Response: -

Revisions in manuscript: Description of the "fractional steps method", as well as cites the names of any Fortran files or similar, were removed in the manuscript.

The equation 1 is pretty alone in this context. Its presence is not necessary to deepen the results discussions. I think you can just refer to TEL3D documentation ….

Response: -

Revisions in manuscript: Eq. 1 was removed in the manuscript.

The table 1 is not clarifying too much the different nesting procedures. I suggest to enrich this table with the proper informations to clarify the different approaches.

Response: Table 2 was added to describe the nesting procedure in terms of forcings in the different implemented models. Table 1 just reported general information on the implemented models, in terms of simulated periods, grid sizes and spin-up times.

Revisions in manuscript: Table 2 was added in Pg. 16.

For each different model accuracy analysis I suggest to quantitatively describe both the real measurements, by providing some statistics about the data (e.g. extremes and averages), and the differences with the model results, at least through RMSE computation or similar.

Response: Analysis on the data and on the numerical results was included in the manuscript. In particular, harmonic analysis of the water elevation on an hourly basis was added for the most important semidiurnal and diurnal constituents (M2, K1) of the tide in Taranto, and results were compared with observations; RMSE and BIAS were calculated for velocity data, both for transects and for vertical profiles and the accuracy in computations was discussed.

Revisions in manuscript: the text was revised in Pg. 9-11, focusing on the description of the new analysis results.*"*

I think the paper can be valorised also by a revision of the English language and grammar.

Response: -

Revisions in manuscript: After consulting a native English speaker colleague, silent changes in the use of English were made throughout the text.

Anonymous Referee #3

Major comments

1- On the basis of Figs. 11 and 12, it was concluded that the "combined effects of (i)...have led to a better representation of the circulation regime inside Mar Grande by the proposed modelling approach" in comparison with SANIFS predictions. But "this better representation" does not appear so well on these two figures. Indeed, the present modelling system predicts higher amplitudes of velocities than SANIFS reducing initial differences with in-situ measurements (Fig. 11). Nevertheless, strong differences still remain. In particular numerical results from TEL3D+TOM are found to overestimate observed velocities by 50 % on 6 October 2014. Taking into account these differences, it is very difficult to conclude that "the overall agreement of computations is quite good" here. What is more, whereas predictions from TEL3D+TOM provide better representation of daily-averaged vertical profiles of current at the Mar Grande station on 6 and 7 October 2014, a better agreement appears to be obtained with SANIFS on 5 October (Fig. 12).

Response: In the revised manuscript, the comparison with SANIFS results was discussed in more detail. In particular, and in addition to the current magnitude values measured at MEDA station, the mean flux directions through the Mar Grande openings with the open-sea were compared, as well as the dynamics inside the basin. The comparison with the field measurements (i.e. ADCP transects and drifter trajectories) revealed the accurate reproduction of the current patterns by TEL3D+TOM model, although SANIFS seems to be producing an opposite circulation pattern. In addition, the main discrepancies regarding the 2D velocity and the daily-averaged vertical profiles between the current computations at the Mar Grande station and the observations may be related, as discussed in the manuscript, to the underestimation in wind forcings on 6 October and in current at lower layers on 5 October due to the spin-up period.

Revisions in manuscript: The text was modified from Pg. 10 - l. 27 to Pg. 11 – l.5, as: "The presented results also agree, as well as with the available measurements, with the findings by De Pascalis et al. (2015), that described the 2013-averaged fields of Mar Grande, while SANIFS outputs in Federico et al. (2016) reported opposite circulation and fluxes. The time series of currents and the vertical profiles at the point of the Mar Grande station are presented in Figs. 11 and 12, respectively: in both panels, the numerical results from the TEL3D+TOM run are compared with the observations and the SANIFS outputs. The overall agreement of computations is acceptable, with a mean error in the depth-averaged velocity magnitude equal to 24% and 33% for TEL3D+TOM and SANIFS runs, respectively. Vertical profiles of velocity at the Mar Grande station are also well captured by the model: the daily-averaged values in the period from 5 to 7 October 2014 show a good agreement with observations, with decreased velocity BIAS values for TEL3D+TOM results, especially after the day 6 October."

2- Whereas the evaluation of models predictions is of major interest in this research study, significant improvement of the quality of this manuscript will be gained by extending the discussion of results obtained here. For instance, numerical predictions may be exploited to gain further insights about the hydrodynamics of the Mar Grande area exhibiting major forcings and the dominant interactions including effects of currents on waves.

Response: The description of the proposed operational strategy for the development of a multiscale modelling system, based on a multiple-nesting approach and open-source numerical models was the main objective of the paper. The implementation of this approach for the representation – at the highest resolution – of the dynamics of the Mar Grande Area in the Sea of Taranto, also due to the particular scientific interest of the area dynamics and the availability of field data for the models' calibration/validation. Discussion on the hydrodynamics of the area and further insights on effects of currents on waves and vice versa will be the aim of a dedicate manuscript (in preparation), that will focus with more details on the shallow water area and the Mar Piccolo dynamics.

Revisions in manuscript: The text was modified in Pg. 2 - l. 24, as: “The objective of the present paper is the description of an operational strategy for the development of a multiscale modelling system, based on a multiple-nesting approach and open-source numerical models, and its implementation -at the highest resolution- of the dynamics of the Mar Grande Area in the Sea of Taranto (South Italy). Section 2 reports the methodology of proposed multiple-nesting approach, describing the four levels of downscaling and the features of the adopted numerical models. The case study of the Taranto Sea is described in Section 3, together with the available field measurements, used to calibrate and validate the adopted numerical models, thus confirming the validity of the proposed approach. In Section 4.1, simulation results of 2D wave-current interactions for the entire Gulf of Taranto are showed to provide the offshore boundary conditions in terms of wave forcings for the small-scale 3D model of the Taranto Sea. The computed current pattern developing in Mar Grande and the evaluation of flux exchanges with the open sea are discussed in Subsection 4.2, in comparison to the collected field data.”

Minor comments

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p.2 - l. 10 = Are all the references cited compared predictions with in-situ observations? I am not sure of it. You may only include references which exhibit such comparisons (for instance, effects of currents on the significant wave height...).

Response: All the reported works of the cited references analysed the influence of coupling modelling in simulating waves, water levels and currents. Roland et al. (2009) simulated waves and water levels induced by the century storm in November 1966 in the regions of the Venice Lagoon. The obtained results have been compared to in situ measurements with respect to the wave heights and water level elevations, and the inclusion of the wave induced water level setup reduced the error in prediction. Wolf (2009) reviewed the existing capability for combined modelling of tides, surges and waves, their interactions and the development of coupled models, performing a simulation of coastal flooding in Myanmar in Irrawaddy River Delta. Hersbach and Bidlot (2008) analysed the effects of inclusion of ocean surface currents in the ECMWF analysis and forecast system. In Benetazzo et al., 2013, the winds and the computed waves were compared with observations at the CNR-ISMAR Acqua Alta oceanographic tower, located off the Venice littoral.

Revisions in manuscript: The sentence in Pg. 2 was modified as “Several authors have demonstrated that the coupling of wave and surge, tide (Holthuijesen, 2007; Roland et al., 2009; Wolf, 2009) and ocean currents (Hersbach and Bidlot, 2008; Benetazzo et al., 2013, Brando et al., 2015) is a key element influencing the accuracy in nearshore dynamics predictions.”

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p. 2 – l. 28 = in terms of wave forcings = only wave forcings?

Response: Only wave forcings resulting from the coupled TEL2D+TOM model were used as BC for the coupled TEL3D+TOM; the other boundary conditions were extracted by SANIFS and COSMO-ME models (see also Table 2).

Revisions in manuscript: Table 2 was added in Pg. 16.

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p. 3 = The last sentence has to be reviewed. It is not clear whether TELEMAC 3D is driven by predictions from TELEMAC2D or not.

Response: see previous response

Revisions in manuscript: The sentence in Pag. 3-I.28 was modified as "For the spectral module, the imposed waves at the offshore boundary are extracted from the TOM results of the 2D coupled model of the Gulf of Taranto (Fig. 1c); the hydrodynamics module TELEMAC3D (henceforth denoted as TEL3D, Hervouet, 2007), is driven by predictions extracted from SANIFS simulations (Fig. 1b) and COSMO-ME outputs (for 3D offshore boundary and surface conditions, as well as the 3D initial conditions)."

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p. 4 – I. 30 = Do you consider effects of wave and current bottom boundary layers? In particular effects of the apparent bottom roughness felt by the current above the wave boundary layer? See Grant and Madsen (1979). You may add a comment about it here.

Response: The TELEMAC 2D and 3D modules and the TOMAWAC module are directly coupled to represent wave–current interactions in both directions. TEL transfers to TOM the updated values of current velocities and water depths while TOMAWAC solves the wave action density conservation equation, and returns to TEL the updated values of the wave driving forces acting on the current (Hervouet, 2007). The effects of enhanced bottom fiction coefficient due to wave-current interaction, as also experienced by Grant and Madsen (1979), are not included in TELEMAC-TOMAWAC coupling. The increased friction due to waves and vertical mixing due to orbital velocities will be added in the next release of the model, as the code developers privately communicated to the authors.

Revisions in manuscript: The sentence in Pg. 4 - I. 29 was added as: "*When using the same horizontal discretization, the modules TEL2D and TEL3D can be directly coupled (two-way coupling) to the spectral module TOM in order to reproduce the dynamics of wave-driven currents: the gradients of the radiation stress induced by waves are computed using the theory of Longuet-Higgins and Steward (1964) as part of the hydrodynamics equations. The TELEMAC modules transfers to TOM the updated values of current velocities and water depths, while TOM solves the wave action density conservation equation, and returns to the hydrodynamics modules the updated values of the wave driving forces acting on the current (Hervouet, 2007). The effects of an enhanced bottom fiction coefficient due to wave-current interaction, as also experienced by Grant and Madsen (1979), are not included in the present release of the code*".

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p. 5 – I. 28 = Nautical charts are often corrected to overestimate shallow waters areas. Is it the case in the present data?

Response: The used nautical chart was commonly implemented in numerical models, correcting their reference level (generally corresponding to the minimum tidal elevation). A comparison of the used data with other available bathymetries (e.g. De Serio and Mossa, 2013) showed good correspondence also at shallow waters.

Revisions in manuscript: -

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p. 7 – I. 4 = The Crotone station does not appear in Fig. 1.

Response: -

Revisions in manuscript: the text in Pg. 7-I.10 was revised as: "TOM is driven by the wave components extracted every 30 min from the offshore buoy located in Crotone (black circle in the right panel of the following Fig. 5). "

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p. 7 – I. 18 = Wind drag coefficient and bottom friction appear to be corrected only for TEL2D and not for TOMAWAC. Please confirm it clearly in this paragraph.

Response: Wind drag coefficient and bottom friction were calibrated firstly in TEL2D, and then their final values (reported in the text) were also used in TOM.

Revisions in manuscript: The sentence in Pg. 7-l.27 was added as: "*The final values for these coefficients were also used in TOM module*."

For the other minor revisions from Referee #3, modifications were introduced in the text and in the figures.

The authors would like to thank the three anonymous referees for their constructive comments and suggestions leading to improve the discussion on the present research results.

On behalf of the authors
Maria Gabriella Gaeta