Dear Prof. Kantha,

We want to thank you for the review of the paper and we hope that this last revision of the manuscript will fulfill your requests in order to consider it satisfactory for publication. You can find below our answer to your specific comments and a revised version of the Conclusions is added.

Best Regards

Debora Bellafiore

Topic Editor Decision: Publish subject to minor revisions (Editor review)

(27 Nov 2015) by Prof Lakshmi Kantha

Comments to the Author:

It appears to me that the real goal of this modeling exercise was to select one of the two models used in the study for possible future use (perhaps for operational purposes). However the authors' bias toward the finite element model SHYFEM becomes quite evident. It is normally the practice in such inter-comparisons to run each model in its best possible configuration and with identical forcing and boundary conditions to assess the relative performance. Clearly that was not done in this study. Instead different heat flux and wind stress formulations were used. This strategy dilutes the utility of the study. This point was picked up by both the reviewers and in my opinion, was not addressed satisfactorily by the authors except for their statement that that should be done in a future study. Nevertheless, the reviewers did not recommend that the paper be rejected and I have taken that into consideration in my decision. However, I would like the authors to state explicitly in the Conclusions that this was an oversight that will be corrected in a future study.

The most significant findings of the study are that a hydrostatic model is adequate for studying a DWF event in shallow waters of the coast. The finding that proper treatment of riverine influence is important is quite obvious. However equally obvious is the need for proper initial conditions, and surface forcing by wind stress and heat flux. I don't believe the authors have done a thorough investigation of these aspects. I would like the authors to amend/include statements in the Conclusions alluding to this.

With these minor revisions, I accept the paper for publication in OS.

Authors' reply: The work proposed in the submitted paper had the main aim to investigate, by means of different modeling tools, the capability to reproduce coastal vertical processes in the Adriatic Sea. This aim was devoted to the process study reproduction, as well as the identification of modeling tools for operational purposes.

The recent literature about modeling implementations in the study area does not provide an agreed upon position on the best possible configuration for models, in terms of heat flux treatment, wind stress formulation and specific datasets to be used to force and initialize the model runs. Therefore the authors decided, applying the same datasets (meteorological fields, lateral bc) to force the two models, to start the investigation from the state of the art implementations (SHYFEM and MITgcm), as a first step in examining their capability in process studies in the NAS. To chose one of the two configurations would have been arbitrary as well. The authors totally agree on the fact that common setups for the treatment of surface forcings and for specific parameterization would have provided a clearer picture and we agree on mentioning this aspect in the conclusions, referring to future development of the present work.

No bias was applied toward SHYFEM, the authors are users and developers of both the models and there was no attempt to lead the interpretation of conclusions in a particular direction, but only state the ability/limitations of each modeling choice. However, probably some of the wording in the conclusion could have been misinterpreted as the topic editor suggested and, in order to clarify our intentions, we tried to rephrase some part of the conclusions that arose from the models' intercomparison, specifically, the point on the different resolutions in the two models.

What concerns the main outcomes of the paper, we agree with the topic editor in emphasizing the fact that non-hydrostatic processes seem not to be relevant in the DW event evolution in the NAS is a significant finding. We also think that identifying the minimum resolution needed to reproduce the larger window of processes, along the coast and more offshore, is, as well, an interesting finding. In order to give further emphasis on the above mentioned points, we removed the comment of the availability of correct datasets for realistic modeling connected with river input, as suggested by the topic editor.

The text added in the conclusion is underlined:

CONCLUSIONS

The coastal zone of the NAS is characterized by a number of hydrodynamic processes that interact and evolve on different spatial and temporal scales. The present work demonstrates the complexity of modeling these specific processes and identifies a number of issues needed for choosing the most suitable modeling strategy for this typology of study.

The main findings are listed below.

– The two models use different bulk formulas for surface latent and sensible heat, accordingly to their state of the art setups already tested in the area. This leads to different heat transfer at the surface, giving rise to an overall different energy balance. Lower convective dynamics over the water column is reproduced in the case of MITgcm relative to SHYFEM. Therefore the choice of suitable bulk formulas, specifically in the coastal zone, is a central point for modeling implementations.

– There are differences in the small scale hydrodynamic structure in the offshore area of NAS that are connected with higher resolution over the whole domain in MITgcm. However, these fine scale features in MITgcm have little impact on the overall reproduction of the dense water formation; therefore the presented implementation identifies the spatially variable minimum resolution adequate to reproduce the investigated processes, that span from less than 500 m in the nearshore area up to 1-2 kilometers offshore. Higher resolutions do not add information on the main investigated dynamics.

– A highly resolved coastal zone, with the possibility to reproduce the complex morphology connected with lateral freshwater inputs, can provide the correct momentum injection into the system and affects the capability to reproduce buoyant processes in the coastal area.

– Nonhydrostatic processes have little impact on the coastal features seen on the shelf of the NAS, suggesting that the hydrostatic models are adequate for simulating DW formation in the shallow areas of the basin.

There are a number of outstanding issues that are not tackled in this present work. In this paper we used different wind stress formulation and bulk formulas which lead to substantial differences pointing to the need of a thorough investigation of their effects. Particularly, for the latter, further studies can be considered, using the option to directly force the system with heat and mass fluxes provided by meteorological models. Other open questions not considered in this work are the effects that different horizontal advection, mixing

and turbulence closure schemes have on coastal hydrodynamic processes, such as the dense water event considered here. Such a study would require using a single model with different implementations of these schemes to precisely characterize and attribute their impact on the coastal dynamics. Also, here we found that nonhydrostatic processes have little impact in the shallow coastal shelf of the NAS, though there were differences from the hydrostatic case seen in the deeper part of the basin. Exploring the entire Adriatic basin may reveal if the nonhydrostatic dynamics plays any part in the wider propagation of dense water through the basin, particularly in the Southern Adriatic Pit.

Despite these outstanding questions, this work provides some clarity on the chosen setups that were already used for implementations in the Adriatic Sea , giving suitable suggestions for improvements. These modeling implementations, mainly devoted to process investigations, can be used to guide choices made for possible future operational products.