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Ocean Science Discussions

Interactive comment on "A high resolution free surface model of the Mediterranean Sea" *by* M. Tonani et al.

M. Tonani et al.

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We thank the reviewer for pointing out missing elements in our model solution analysis. We think we have answered all the comments and the paper is improved. We start with answering the general comment and then the specific comments. A revised manuscript has been submitted to OS.

GENERAL COMMENT Reviewer: ...The paper does not, however, emphasize the new insights and improvements due to the high resolution, in comparison with existing lower resolution simulations. This is a key element, which is missing in the assessment of the 2 simulations, that should be developed.

Answer: We have added figure 1 and its discussion at line 9, pag 215. "Figure 1 shows a comparison between the vertical resolution of a CTD profiles of salinity by the 72

levels (panel a) and the 31 levels model (panel b). The continuous line is the CTD profile from the bottom down to 300m and the dots are the positions of the vertical levels of the model. It is clear that with only few levels (panel b) all the small scales are missed and moreover the depth of the sub-superficial minimum is displaced. Several of this comparison between data and model level distribution have been perform in a preliminary phase in order to decide the number of levels of the vertical grid of the model."

Reviewer: ...However, authors do not mention how the free surface influences the Med Sea dynamic, in comparison with previous rigid lid simulation...

Answer: We thank the reviewer for pointing out this missing information. We have added now the following explanation at page 226: "Furthermore free surface models in the Mediterranean Sea allow for an important improvement in the realism of the simulations permitting a net water influx at Gibraltar to compensate for the positive water losses at the air-sea interface. Rigid lid models in fact cannot have a net transport at Gibraltar and this is a missing feature of all the previous high resolution simulations. Figure 2 shows a comparison between the dynamic topography (panel a) and the steric component (panel b) between the rigid lid 1/8°x1/8° horizontal resolution model and the free surface 1/16°x1/16° model. The comparison has been done for year 1999. The low resolution rigid lid model is not able to well simulate the seasonal variability of the dynamic topography and has a really smooth shape, respect the free surface and high resolution model. The dynamic topography has been computed from the sea surface pressure for the rigid lid model and from the sea surface high for the free surface one. Panel b) shows the variability of the sea level high due to the steric effect. We have compute this variabillity from the climatological data of MEDATLAS and from the two model simulations. It is clear from figure 2 that the low resolution model has a higher variability that could be due to the low vertical resolution of the model that is not adequate to represent the seasonal variability of the characteristics of the water column. The high resolution model on the contrary has a variability much more closer

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to the steric component of the climatology, therefore it seems to be more efficient in the simulation of the water column properties variability due to the seasonal variability."

Reviewer: In summary, authors should emphasize the impact on their simulations of the 2 new elements of their model: i.e. the high resolution and the implicit free surface, and provide elements of assessment showing how those 2 new elements allow improving/changing the realism of the simulation.

Answer: We think we have answered in the previous two points

Reviewer: The authors also spend too much time in section 2 presenting the equations of the model, which are usual equation from Madec et al. (1998). Refering to Madec et al. (1998) is enough. If you really want to keep some of the equations in the text, please state why (How does it differ from Madec et al. ?). In summary, most of the equations from section 2 should be removed.

Answer: For section 2.1, we have re-written Madec et al. (1998) equations for a regular lat, long grid and to show the exact form of the relaxation forcing in the T,S equations for the Atlantic box. We believe this is necessary to make clear how a Mediterranean Sea model has to be set up to work properly. The formulas of section 2.2 and 2.3 instead are specific to our model, they indicate the choice in values of the model free parameters, the air-sea physics, the bottom boundary layer stress formulation, the heat and salt flux corrections. In section 2.4 and 2.5 we show the parameterization of the Atlantic box which has never been written before and we show the water flux correction to keep a constant free surface in a closed basin but with large water losses in part of it. We believe that a model is defined on the basis also of these choices, not only the basic equations. However, we agree with the reviewer for the formulas on KE, wind stress curl and transport which are now deleted.

Reviewer: Moreover, the language is often not precise and not fluent. Some sentences should be rephrased.

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Answer: We have had a native English language speaker revise the entire text.

SPECIFIC COMMENT (1) in the abstract, it is said the implicit free surface is used for the 1st time in the Mediterranean Sea. This is not really true, as the Mercator-Ocean global simulation (with data assimilation) is also using the free surface in the Mediterranean Sea. The Mercator simulation is however, not a free simulation, neither a model dedicated to the Mediterranean Sea. It is also said that the free surface enhances the model capability to simulate the SSH variability. This is not demonstrated in the present paper and this sentence should be removed.

Answer We have corrected now the abstract and changed the text as follows: ...The model considers... This means that it is not the only one but we now show that the model improves both the SLA and the Gibraltar transport realism as shown in the two new pictures added in the paper.

(2) line 10 to 15, pp219: It is not true to say that no operational models are available to drive the Atlantic box boundary conditions, as the FOAM, TOPAZ and MERCATOROcean models could provide operational boundary conditions in this area. Please remove this sentence. Which climatology is used for the Atlantic Box relaxation?

Answer When we started the modelling effort the operational oceanography community did not have the networking necessary for the nesting in the Atlantic. However, we realise now this sentence is not true and we have removed the sentence from the text. The climatology used for the Atlantic Box is WOA98 (Levitus, 1998) as described in the Appendix.

(3) line16, pp216 "verson 8.1" : the 8.1 OPA version does not include implicit free surface. It is rather 8.2 that does include free surface (Roullet et al.). Please provide explanation on how you have implemented the free surface in the 8.1 version.

Answer This is a typing error, the version used is 8.2 not 8.1.

(4) the discussion pp228 is interesting, but hard to read, as the sentences are usually

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too long and not to the point. please, repharse some of it.

Answer The discussion has been rewritten and the language corrected by a native English language speaker: "XBT and ARGO vertical profiles were collected over years 2003 and 2004 within the MFSTEP framework. The rms error between data and model have been computed at different depths (30, 150 and 300m) and then averaged over each month. Panel a) of figure 12 shows the rms for temperature from XBT. The rms has values with a high variability, especially at the surface, and it could be due to the scarcity in space of the data. The rms with the ARGO (Panel b)), on the other hand, shows values lower than 0.5° C, except in the summer, when the error is much larger at the depth of 30m. This could be due to the misplacement of the seasonal thermocline in the model simulation. This situation is present also in panel c), which shows the rms for the salinity (Dobricic et al. 2007). The rms at 30m is generally about 0.08psu in September of both 2003 and 2004, and could reach a value of 1.6-1.8 psu. At 150 and 300m the rms does not have this fluctuation. The rms at 150m has values close to 0.08psu with oscillation that could reach values of 1.2 psu or decrease down to 0.02psu. At 300m the rms is about 0.04psu. Panel d) shows the rms of the density computed from temperature and salinity data from ARGO versus model. These values are well consistent with the results of salinity and temperature discussed above. We can now try to understand the differences in late summer-autumn in figure 11. This is due mainly to two factors: 1) the wrong water flux during summer, which lacks the high evaporative fluxes during late summer and autumn; 2) the upper mixed layer physics, which does not correctly reproduce the relatively deep, hot and salty mixed layer during the summer-autumn period. This interpretation is supported by the results of both figure 11 and figure 12, which show that the model has large model errors in the upper seasonal thermocline."

TECHNICAL COMMENTS

(3) line 7-8, pp220: "These modification...". This sentence should be at the beginning of the paragraph.

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Answer We have rephrase the lines 1-8: "Some modifications are necessary at the Strait of Gibraltar to avoid an unrealistic values of the transport at this strait. The horizontal viscosity is laplacian in the region between 6.25°W and 5.125°W while in the rest of the basin in bilaplacian. The diffusivity in this area is 10 times larger than in the rest of the model. In the same geographical area the bottom friction drag coefficient is linear and ten times larger then in the other parts of the model. Out of the Strait of Gibraltar..."

(4) line 16, pp220: refer to "Eq. (13)" rather than to "(13)". Same remark is applied to all the references to equations.

Answer We have taken into account this remark for all the equations.

(5)line 3, pp221: this sentence does not have any subject. I guess "Eq(20)" is missing at the beginning of the sentence.

Answer Thanks for the remark, the text has been corrected.

(6)line 15, pp221: do not use abbreviation "doesnt" but write "does not". Same remark applies to all other abbreviation in the text.

Answer Thanks for the remark, the text has been corrected.

(7) line 17-18, pp221: "A new...": I do not understand this sentence. please rephrase.

Answer We have removed the sentence.

(8) line (3) pp222: please use another abbreviation for the perpetual year experiment as "P" was already used to defined Precipitation earlier in the text.

Answer Thanks for the remark, the abbreviation "P" has been substituted with "PYE";

(9) equation (24): sensible heat flux is missing in the equation.

Answer The sensible heat flux has been added.

(10)line 4, pp223: "re-emitted"

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Answer Corrected.

(11) line 11, pp223: typo error for short wave Qs

Answer Corrected.

(12)line 20, pp223: do not give definition of Kinetic energy as it is a common knowledge. do not use KE acronym, as it adds confusion to the text. In general, try not to use too many acronyms. same remark for wind stress and wind stress Curl where WC and WS acronyms should be removed.

Answer The definition and acronym of Kinetic energy has been removed as well for the wind stress and wind stress curl.

(13) line 7 pp224: "could be considered" " as"

Answer Corrected

(14) line 8 pp224: "sections", "WE" "show..."

Answer Corrected

(15)line 11, p224: figure 4 and not figure04. Later in the text, use "figure" instead of "fig"

Answer Corrected.

(16)line 13, pp224: "does has"...2 verbs, one too much!

Answer Corrected.

(17) line 7, pp225: "with respect" "TO" . In the sentence " the 1st 3 year", please state whether this apply to (I) or (P).

Answer Corrected. The sentence " the 1st 3 year" has been corrected, the sentence refers to (I).

(18) Top panel of figure5 is not commented. only middle and lower panels are used.

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please remove top panel in Fig5.

Answer The top panel of figure5 is commented into the text but not correctly referred. The text has been corrected at line 22, pp225.

(19) line 15 pp225 "sector and positive"...you already said just before it is positive. rephrase.

Answer The sentence has been rephrased: "The curl is positive over a vast area of the northern part of the basin, with the exception of the western part of the Gulf of Lion. While the curl is mainly negative in the southern part of the Meduterranean";

(20) line 19, pp225: "with large departure" from what?

Answer "with large departure" has been removed.

(21) line 10 pp225: "we might say" this is not precise scientific language. same for "more or less" line13 pp226. same for "ca" line 1, pp226. It should be replaced by "approximately" or ""

Answer Corrected.

(22) line 1 pp226: please specify how many grid points of the model you have to resolve the Gibraltar strait.

Answer 2 , it is added also into the text (line 1, pag 226)

(23) line 2 pp226 "have " "BEEN" "developped"

Answer Corrected.

(24) line 14 pp226: "It's not evident...": I do not understand the english, please rephrase.

Answer The sentence has been rephrased: "The eastward and westward transport at the Strait of Gibraltar have approximately the same fluctuation with no clear evidence of a seasonal signal. The variability of the eastward and westward transport is strictly

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related to the wind stress, as it is already pointed out in other works (Beranger et al. 2005)."

(25) line 10 pp226: capital letter for March.

Answer Corrected.

(26)line 19 pp226: replace "how much" by "that"

Answer Corrected.

(27)line 20 pp 226: replace "then" by "than"

Answer Corrected.

(28) pp226,line 20: I do not see the WS in figure 7, only WC. But you comment it in the text. please change figure7 accordingly.

Answer Figure 7 has been modified.

(29)line 3 pp227 "transport" not "thansport"

Answer Corrected.

(30)line 5 pp227 "and for values..." please rephrase as I do not understand the meaning. Answer The sentence has been rephrased: "The westward and eastward components have a high variability with high values of transport in winter and lower in summer. The time variability is in good agreement with observations done during years 1999-2001 (Beranger et al., 2004) and also the values of the maximum transport simulated by the model have values comparable with the observed ones."

(31)line 8 pp227 "seems..." this is not precise scientific language.

Answer The sentence has been rephrased: "The model over estimates the minimum..."

(32)line 8 pp227: "which" instead of "wich"

Answer Corrected.

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(33)line 11 pp227: you compare model with satellite, no the other way round. please rephrase.

Answer Rephrased.

(34) line 5 pp228: "coming" "TO"

Answer Corrected.

(35) line 13, pp228: you place the thermocline at 30m. I guess you are talking about the seasonal thermocline, not the permanent one. Please, precise. use "larger" instead of "bigger".

Answer Corrected.

(36)line 18 pp228: "which oscillation..." rephrase as I do not understand.

Answer "which oscillation" has been corrected, "with oscillation";

(37)line 9 pp229 :" even do"..."EVENTHOUGH"???

Answer Corrected.

(38)line 10 pp229 :"improved"??? instead of "performed"

Answer Corrected.

(39)line 13 pp229 :"deep" what do you mean by deep? 30 meters deep?

Answer "deep" has been removed from the sentence.

(40)line 14 pp229 :WITH respect TO

Answer Corrected.

(41)line 21, pp230: RoseNstein

Answer Corrected.

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(42)For all the figures, captions should be rephrased as some information is missing. provide units as well. provide a) b) c) separation if many panels. Fig 5,7,9, and 10 are too small, and the legend bearly readible. Figure4: provide the same X axis for the 2 panels (years). Figure2: provide X axis in english, not italian.

Answer All the figures has been revised and all the captions have been rephrased.

(43)line20, pp216: please remove sentence " this implementation is named MFS1671" as the reader do not care about this information.

Answer This sentence has been removed.

(44) line 3 and line 4, pp200 "larger" instead of "bigger" same for line 13, pp228.

Answer Corrected.

Interactive comment on Ocean Sci. Discuss., 4, 213, 2007.