

## ***Interactive comment on “Sensitivity of the Mediterranean sea level to atmospheric pressure and free surface elevation numerical formulation in NEMO” by P. Oddo et al.***

**P. Oddo et al.**

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*(1) The model runs are from 7 January 2004 to 31 December 2012, yet all comparisons are done with tide gauge data from July 2010 to July 2012. Comparison should be done with tide gauge data covering the whole of studied interval. There is not much point in discussing spectral energy at periods longer than 200 days, when there are only 2-3.5 oscillations of these period in the modeled time series. These tide gauge data (at least at a hourly sampling interval) are certainly available for a number of the Mediterranean stations. If there is a problem with using longer time series because of model spin up time (but is it 6.5 years?), I either suggest starting model earlier, or*

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*refraining from discussing too much these long periods.*

- To our knowledge tide-gauge stations data spanning the entire period covered by model runs can be retrieved only through the Permanent Service for Mean Sea-Level (PSMSL, 2014; Holgate, 2014), as monthly or annual time-series. In general, for the Mediterranean area, higher frequency long time-series data availability is an issue. In this study high frequency data (1 day or 1hr) have been obtained from the MyOcean Mediterranean Med-MFC only since 2010. However, also in this case, most of the recorded series have gaps potentially affecting the statistics. The selected stations are the only ones providing long enough series without significant data gaps.

Moreover, we agree with the Referee2 about the sampling error and potential differences deriving from the time coverage in particular analyzing the lower frequencies. In order to evaluate potential sampling problems deriving from the relatively short time interval analyzed a preliminary analysis have been carried out. A dedicated spectral analysis has been carried out considering the entire model runs period. Basin averaged time-series have been considered. The power spectra obtained (Figure 1 of this document) are similar and comparable with those shown in Figure 3 (of the submitted manuscript) in terms of the energetic content associated to the annual (360 days) and semi-annual (180 days) frequencies, and those that characterize the medium frequencies processes (i.e. from 120 to 15 days). A sentence will be included in the manuscript.

Similar results have been obtained also for the Gibraltar Transport Spectra. It is also worth to mention that using longer time-series we obtained smaller confidence intervals ensuring the correctness of the results presented in the manuscript. However we think is important to focus on the comparison with the observations available.

*(2) I fully agree with reviewer 1 that periods shorter than 12 hours should not be analyzed due to aliasing problems; and would also, to be on a safe side, suggest*

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*cutting analysis at least at the 24 hours period. In any case, I suggest the authors to create spectra for the modeled time series at three selected stations for the whole modeling time interval for periods shorter than 48 hours, and to check whether or not they get some spurious spikes which could be due to aliasing. E.g. all of your spectra of model time series have strong peaks at 4 hours, likely at 2.5 hours also, and at some other periods as well. Also whatever you reproduce at the Adriatic has a spectral peak centered at 23-24 hours, and not at 21 hours.*

See answer to Referee1 about the possibility to model spectra of oceanic phenomena with frequency higher than the atmospheric forcing. Moreover previous manuscripts (Leder and Orlic 2004) have already proved the possibility to study high frequency oceanic processes in the Mediterranean analyzing hourly frequency time series shorter than one month. We agree with the Referee2 that spectral analysis spanning longer temporal windows could provide additional and more robust information, however we believe that the current analysis clearly show the differences between the different numerical schemes and the effect of the atmospheric pressure which is the main scope of the manuscript. Since the strong peaks mentioned by the Referee2 are often in agreement with the observations we think that the suggested additional analysis would not bring additional info and the major manuscript results will be unchanged.

We therefore prefer to maintain the current temporal windows for the high frequency spectral analysis having overlap with observations in order to better validate the model results.

For what concerns the Adriatic seiches peaks, we have redone the figures changing the X/Y aspect ratio and filtered the spectra partially following the Referee suggestion. It is easier now to read the exact peaks period which is 21 hr. The new figure has been provided in the answers to the Referee1 and will substitute the present one.

*(3) Analysis of water mass transport through Gibraltar is interesting. But this should be compared with some measurements, or, if these are not available, at least with*

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*existing literature. What is real amplitude of seasonal oscillations of transport through the Gibraltar strait?*

We thank the Referee for this positive comment. To our knowledge few studies focused on the annual frequencies of the Gibraltar transport mostly due to the scarcity of long enough observation time series. One of the few and most recent papers addressing the issue and providing estimates of the investigated quantity is Lafuente et al. 2002. Our results fit within the confidence interval provided by the Authors. The reference will be included in the text and the manuscript modified accordingly.

*(4) Finally, if you are to discuss influence of including air pressure effect into numerical model, you should include tide gauge stations which are influenced by the largest horizontal pressure gradients into analysis - like Genoa (but here it's important to use periods shorter than 15 days), and then stations for which there are largest pressure differences between model runs (as seen from Figure 2).*

We thank the Referee for this important comment. Individual tide-gauge data analysis has been performed during our study. As also mentioned in the manuscript, it is evident that for period shorter than 15 days the response to the atmospheric pressure varies within the Mediterranean Basin, with some areas more sensitive to the forcing than others. Following the Referee suggestion we have analyzed the Genoa time-series (Fig.2 of this document) individually and produced an analysis equivalent to current Fig.3 of our manuscript. The analysis confirms that for frequencies lower than 15 days the behaviour is very similar to the current Fig.3 of the manuscript. For frequencies up to 5 days the atmospheric pressure effects become more evident and differences between model configurations' are significant. Further investigation of this issue produced a new Fig.3 where the abscissa now reaches 5 days showing the similarity between the model and the Genoa tide gauge station (even if less pronounced because other sta-

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tions have different behaviour). Therefore we suggest to modify the abscissa limit in Fig.3 (see Fig.3 in this document). We will also mention that the amplitude of the effect of the atmospheric pressure for period shorter than 15 days varies within the basin.

*More specific comments:*

*Figure 3. Is this data from all tide gauge stations? Authors should smooth their spectral estimates (using window averaging); all these peaks in the middle left figure are distressing. Also, level of confidence should be added to all spectral plots.*

We will better specify the data sources (all the tide-gauge stations) and we have already created new figures with smoothed spectra and level of confidence. The new figures will be used in the final manuscript version.

*Figure 4. Authors should add levels of confidence, and when crossing from left to right column in plots, authors should continue their plots where they've stopped them (at 72 hours period). X-label should be given (or written in Figure caption).*

The figure will be redrawn including levels of confidence and X-label provided in the corresponding Figure Caption.

*Figure 5. What is black line in middle plot, i.e. from which experiment is it originating from?*

The black line in the middle plot is the surface mass flux (Evaporation – Precipitation - Runoff) which is identical in all the experiments. The text will be modified accordingly, explaining that all the model experiments have identical mass flux at the air-sea interface.

*Figure 6-8. Restrict to periods longer than 24 hours (you can filter short periods out from tide gauge time series), estimate spectra for whole modeling interval, add confi-*

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dence levels. I would even do spectral analysis for periods of 1 - 360 days for selected stations.

Figures 6-8 will be modified (see previous answer) smoothing high frequencies and changing the X/Y axes aspect ratio to better identify peaks in the spectra. However, as also explained in the previous answers to Referee1, we think that the analysis at frequencies higher than 24 hr is appropriate and correct. Estimated spectra for the whole modelling interval would be difficult to validate due to the observational gap.//

References:

- Lafuente J. G., Delgado, J., Vargas, J. M., Sarhan, T., Vargas, M. and Plaza, F. Low frequency variability of the exchanged flows through the Strait of Gibraltar during CANIGO. Deep Sea Research, 49, 19, 4051-4067. 2002
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Interactive comment on Geosci. Model Dev. Discuss., 7, 3985, 2014.

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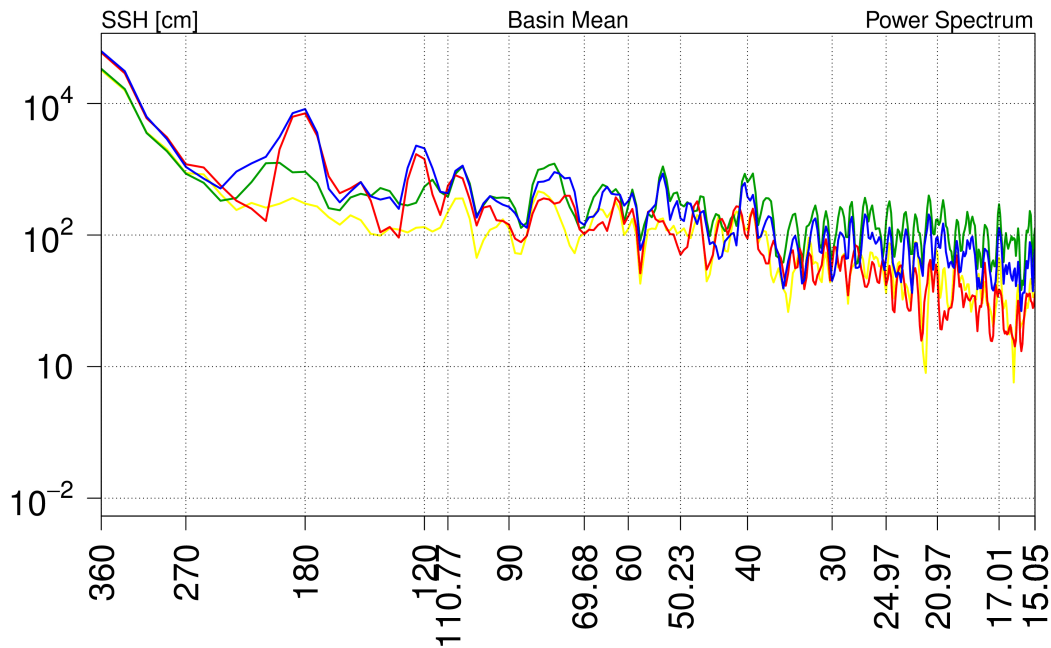
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**Fig. 1.** As Fig.3 but computed using the entire model run period.

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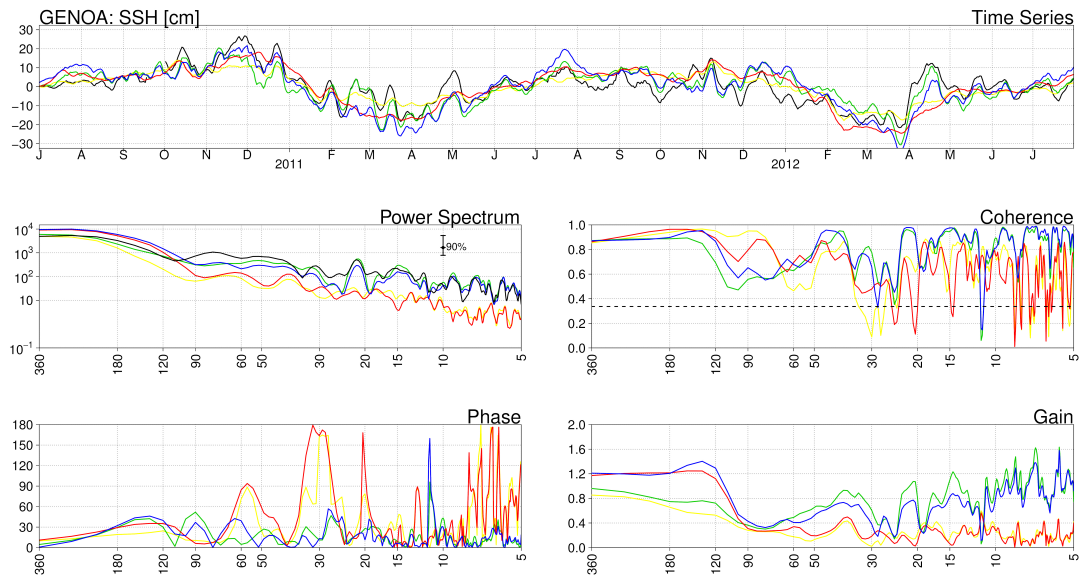


Fig. 2. Similar to Fig.3 but for Genoa station

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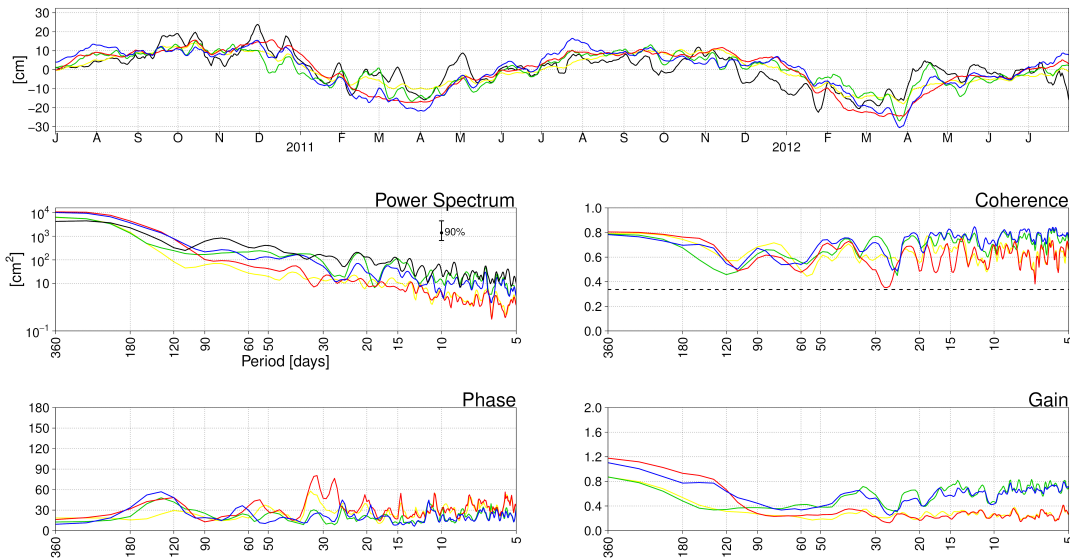


Fig. 3. New version of Fig.3 with smoothed spectra, confidence interval and X limit 5 days.

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