

Response to editor

Thank you for your review of this work, we appreciate the time and effort put into it. Here we have addressed each of your comments in turn. We have included your entire review in *blue italics*, with our responses in black and specific changes to the text in *red*.

Dear authors,

thank-you for your patience while I found an opportunity to consider the review of your latest manuscript. As you will have seen, although the review was positive about many aspects of the paper, the overall assessment was that the paper needed major revisions or perhaps such a substantial rewrite that it should be rejected and resubmitted.

I do not think this is necessary, and that although there is some further work required for publication it is relatively minor. The reviewer has made several suggestions for further work, but I think that these can be left for the future. It is better to publish the work that has already been done and ensure it is available for others. There will always be more that can be done and more ways to present such a complex data set. Of course if you agree with the reviewer and wish to do more then you may do so, but if you consider the changes unnecessary I am happy to proceed with substantially the same paper (with a few exceptions, please see below).

For now I will select "minor revisions", which will trigger a short automated deadline. If you need more time then please just ask the editorial office to push the deadline back as required.

Thank you for this feedback. We found some of the reviewer's comments very useful and will certainly consider them in future work. We added a paragraph to the end of the conclusion to describe possible future work directly, to acknowledge what was not done in this work, and to motivate future work in this area.

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The following clarifications and changes are necessary:

Please ensure that if there are caveats about the strength of the evidence that tides cause the mixed depth changes (eg that are in the main text in Section 5), they are also in the conclusions and abstract. It would help to clarify to have a specific subheading for caveats in the conclusions.

We added a sentence to the conclusion to emphasise this point: "It should be noted that although an increased mixed layer depth is one conditioning element for dense water formation, other concomitant processes are needed for deep water formation events to occur (Marshall and Schott, 1999; Pinardi et al., 2022).", and in the abstract, we changed the last sentence to "Tides increase the mixed layer depth in the Mediterranean Sea, particularly in the deep and intermediate water formation areas of the Western and Eastern basins. The addition of tides, the cases considered, does also enhance Western Mediterranean Deep Water formation."

Additional references in the introduction are not necessary, there is no need to cite every paper. We added some of the citations suggested by the reviewer, such as Hilt et al. (2020).

Regarding the 12h peak (line 140), I interpret this as being not just a sharp 12h peak but a discussion of a broad semi-diurnal frequency range that arises from spatial averaging over the basin. Is that correct? If so, please ensure it is clear but I agree with your physical explanation. If not then there is a problem with confusing frequencies.

There are several explanations for the broad peak, and the true reason is likely a combination of several of the following: firstly the combination of the peaks of the four semidiurnal tidal components in this model, and their blurring due to both spatial averaging and the temporal resolution of the experiment output being only hourly and not more frequent. Secondly, we have the amplification of basin/regional modes at 11.4h and 12h and their interactions with the tides, and thirdly there are further possible interactions of tides with other mesoscale phenomena in the Mediterranean Sea, particularly eddies. We can't confirm the exact interactions with this plot alone, but we begin to discuss these ideas in this paragraph. I think some of the frequencies did get mixed up here when we changed things after the first review. We edited this paragraph, both to address your later comment regarding line 144*, and to also highlight the possibility of interactions between tides and other mesoscale phenomena as a further reason for the broad peak: *"In the semidiurnal range, the tidal model introduces a broad peak around 12 hours, as well as peaks at the individual tidal component frequencies. This is due to the amplification by tides of the basin modes near and at these frequencies. We argue that the broad 12h energy peak in Figure 2 in the tidal run is composed of the amplified 11.4h Mediterranean Sea basin mode energy (Schwab and Rao, 1983) and the 12h Adriatic/Aegean seas mode (Lozano and Candela, 1995). Moreover, interactions between internal tides and other mesoscale phenomena such as eddies could be affecting the internal tidal kinetic energy, as discussed in Guo et al. (2023), but a dedicated analysis would be required to confirm whether this is the case in the Mediterranean Sea. Furthermore, the spatial and temporal averaging of model outputs has likely blurred these peaks slightly."*

Fig 2, caption: This must be the spatial average of the point-wise energy spectrum, not the energy spectrum of the spatial average? Be precise.

We added a sentence to the caption to detail the calculation of the spectrum: *"The basin-mean spectrum is calculated as an area-weighted mean of the periodogram at each gridpoint in the Mediterranean Sea."*

Line 144: I agree with the reviewer that the 10.7h signal is missing from the Adriatic in figure 3a, please check.

* See above

Line 147: the wording needs to be clearer about the separate 8.4h, 8.2 and 8h peaks.

We have rewritten this paragraph to improve precision: “Peaks are also seen at 8h and 6h, which correspond to the kinetic energy frequencies in the Sicily Strait, noted by Palma et al. (2020) where these peaks were considered to come from non-linear effects of tides. Further peaks that are enhanced by tides align with the Western Mediterranean basin mode of 8.4h discussed in Schwab and Rao (1983), and the Gulf of Gabes mode at 8.2h (Lozano and Candela, 1995). Schwab and Rao (1983) also noted a fourth Mediterranean mode at 7.4h and the third Adriatic mode at 6.7h, but these are not visible in the basin-mean spectrum of Fig. 2 and are not affected by tides. Overall, there are many oscillations in the Mediterranean Sea that are interacting with tides leading to their enhancement, although not every barotropic oscillation mentioned in the literature is affected by tides.”

Line 152: I agree with the reviewer that the 6.7hour Adriatic mode does not appear to be enhanced by tides, please check.

We have rewritten this paragraph: “In the Adriatic Sea (Fig. 3a), the sea level energy peaks at the frequencies of the barotropic modes of the Adriatic Sea at 10.7 hours and 12 hours (Lozano and Candela, 1995) are enhanced by tides, whereas the mode at 6.7 hours (Schwab and Rao, 1983) has a similar energy density in both experiments. This is evidenced by the different amplitudes of the 10.7 and 12-hour peaks in the non-tidal case compared to the tidal one, unlike the 6.7-hour peak which remains the same. The peaks at 12 hours and 10.7 hours are also visible in the model without tides, but with lower energy, thus confirming that these peaks are due to amplification of existing modes forced by winds and atmospheric pressure.”

Fig 6f. There's no sign of the 6.7 hour period here, which is surprising in comparison to figure 5b. It is in fig 6e too. I think this may be an artefact of the colour choice, because even in the tidal run the energy around 6 hours is much lower than at the longer periods. Is there is a better way to show this, for example normalising with frequency?

We changed the colourbar on this figure to ensure the 6 hour peak is visible. As you said, it's there, but it's a few orders of magnitude lower than the tidal peaks.

Figs 7, 8, 9 and in supplementary mat., since the depth axis is logarithmic, is it necessary to also have separate panels for depth ranges? Could you reduce clutter by combining them? Not essential, just a suggestion.

We chose to separate the panels in order to demonstrate the differences between the layers of the Mediterranean (upper Atlantic water, intermediate Mediterranean water, and deep Mediterranean water), since we also refer to these layers in the text. Moreover, even with the logarithmic scale, it was easier to see the features this way than in a single panel.

Section 6: I accept your previous reply to the reviewers about retaining section 6, if a little peripheral to the main paper.

Line 214, "Assessing [...] is evidence of" doesn't make sense, reword.

We changed this sentence to the following: “Assessing the impact of tides on the mixed layer depth can provide indirect evidence for the impact of internal tides on the vertical mixing and vertical motion.”

Almost all figures: I have already flagged this, but many of the figures MUST be more legible before publication compared to the latest full manuscript. Please ensure numbers and text are large enough to read on every figure when the paper is printed on A4. (If you have good eyesight, I suggest checking it by printing at half size! Also check the detailed requirements in the instructions to authors.) The publication charges at this journal do not increase with bigger figures.

We have updated all of the figures, increasing the font size in most of them and increasing their size to take up the full width of the page where appropriate. We also made the checks by printing the paper at half size as you suggested: everything is clearer now.

All data should be available, please refer to the author instructions on data provision.

We have made the data available on Zenodo (link: <https://zenodo.org/records/10911630>), and also submitted this link on the journal website along with the revised manuscript.

Regards,

Dr Joanne Williams, editor.