Reply to Reviewers' comments- Currents Generated by the Sea Breeze in the Southern Caspian Sea

Reply to Reviewers' comments- Currents Generated by the Sea Breeze in the Southern Caspian Sea

Authors: Masoud, Pawlowicz

We thank the reviewers for their constructive comments. Most of the issues they bring up are relatively minor and were easily addressed, and we go through them all below.

1. Main comments

This is a comment on the revised manuscript and how the authors responded to the reviewer comments on the original OSD version. The manuscript analyses in detail the sea breeze over the southern Caspian Sea, especially as represented in the WRF model, and the response in currents and sea level especially a few kilometres from the coast, as measured and as represented in an idealised model (two layers, uniform in depth and alongshore). Overall I think there should be minor modifications in respect of the following: Apart from the specific context, publication in Ocean Science should be on account of some new understanding. The text should make this clearer; at present there is much citation of literature with similar findings and any novelty in the present work is somewhat "buried". Perhaps a brief "conclusions" section would help (it could include the new paragraph at the end of the Discussion).

[This and the following comment reinforce the first comment of Reviewer 2. Along with most potential readers, I am not an expert on sea breezes to discern the novelty without help.]

There are sections in the "Discussion" especially which might have been better merged in the Introduction. The Discussion is for discussing the present findings; their relation to the existing literature is certainly in place here but literature cited should be quickly related to the present work. I agree with the authors regarding analysis for S1. As well as the reasons given in their response, "tidal" analysis would impose a sinusoid and so not fully represent a typical daily cycle of the sea breeze. A mean over all days as in the manuscript is preferable. However, the manuscript is vague about how much of the variance is in the daily cycle attributable to sea breeze; see the detailed comment below in respect of Table 2 and associated text. I have no strong view regarding component rotary versus along- and across-shore spectra. I would not have termed the reviewer comment "puzzling" but the authors give reasonable justification for retaining rotary components.

In the main comments, the reviewer suggests:

1- Modifications on the citation: In lines 25, 54, 58 and 413, we cite references related to sea breeze studies in the Caspian Sea including Khalili, 1971,khoshhal, 1997, Azizi, 2010 and Karimi,2016. We removed Khalili,1971 reference, since its results are the same as Khoshhal, 1997. We have added "atmospheric" when we talked about these references

in the discussion to clarify that the findings of these references are about weather system over the Caspian Sea not about the ocean response to the sea breeze system. However, there are other places including lines 17, 19 and 417, that we cite all of studies about ocean response to the sea breeze system in other case studies. Since all of the references in these line are based on observational studies in different case studies and we used all of these references to show their unique finding related to our results throughout the paper, we still think we need to keep them.

2- Emphasising on novelty of our work: We deliberately kept the introduction short as a stylistic preference. However we added a new paragraph in the introduction as follows: We find that the water column response to the sea breeze is measurable and widespread, occurring over the entire southern Caspian shelf year-round. However, the coupling between atmosphere and the ocean is a strongly local phenomenon, with changes in the timing of the daily cycle of currents responding to changes in the timing of the cycle of winds directly overhead, with no sign of propagation effects along-shore (unlike the case for lower frequency current variations). Analytical solutions to a new coupled two-layer rotating wind-driven shallow-water model are compared with observations and show good agreement. Model dynamics also explain the nature of the local response. We also added some words throughout the paper to emphasis on the novelty of our work.

3- Emphasise on the variance of daily cycle: See our explanations in the detailed comments.

2. Detailed comments

- Table 1. The caption refers to ". . brackets for Astara and Roodsar" but in fact the details of a deeper ADCP are simply in a second column for these locations. Corrected.

- Table 2. It should be stated in the caption that these "ratios" are percentages. Is this strictly "diurnal variance" or variance in a (narrow?) band around diurnal frequency? The text (lines 101-102) suggests that it may be quite a wide band; the caption should be clear about what is shown. The same question arises again in lines 383-385; exactly what is "two-thirds of high-frequency variance in winds".

  Percentage added in the caption. We modified the caption of table 2 to: Ratio of diurnal variance (band-passed filter with removing periods less than 6 hours and more than 30 hours) to high-frequency variance (frequencies higher than 1cpd) for alongshore and cross-shore wind stress and bottom current. line 384: Since we added an explanation about daily cycle and high frequency in the caption of table 2, we think there is no need to change this sentence in line 384 and it is clear now as we refer to table 2 in this sentence.

- Line 113. You mean "clockwise motion" when you say "negative frequencies" which is best avoided.

  Modified to: There is both clockwise and anti-clockwise motions in diurnal frequencies, although the clockwise motions is stronger everywhere except at AmirAbad ...

- Lines 129-131. This is a little confusing; there are four cases (cross-shore, alongshore wind) x (cross-shore, alongshore current) but they are not discussed systematically.

We removed this part since we did not talk about it later and we did not show any plots or numbers related to this.

- Lines 134, 137. Is "band-passed" as described in lines 101-102? Yes, and we add the following sentence to clarify it more: we will analyze only band passed data (removing data with periods less than 6 hours and more than 30 hours) from now on.

- Lines 136-137. "Winds rotate in the clockwise direction" except at Amir Abad according to figure 3a. In this part, we are talking about 4-day typical data of the summer shown in figure 4, which demonstrates that winds rotate clockwise in AmirAbad in this time period. When we talked about the spectra of whole data shown in figure 3, we mention that AmirAbad is an exception with both clockwise and anti-clockwise rotation.

- Lines 139-140 (for observations) and lines 149-152 (defining sea-breeze days) differ regarding the timings between onshore and offshore; this may decrease the number of sea-breeze days identified. Is this related to the comment on line 170: " the sea breeze day selection algorithm appears to be overly conservative". We define sea breeze days according to the observations in line 140 as follows: At all locations the wind blows onshore in the early afternoon, starting at about 5 hours after sunrise, and the onshore direction changes to offshore around sunset, remaining in that direction until late morning. The sunrise is around 5 am in summer (most of the sea breeze days occur in summer) so 5 after sunrise will be around 10am. So we picked this time as sea breeze direction (onshore direction) in our algorithm. And then in line 150: We pick sea breeze days for the sea breeze selection algorithm as follows: Here, a sea breeze day is counted when 1) the wind direction during the day (from 10 am to 11 pm) is from the sea breeze direction (onshore), but the wind overnight (from 11 pm to 10 am) is not from the same direction and 2) the wind direction in the afternoon and morning are both from the sea breeze direction (onshore), but afternoon (noon to 11 pm) wind speed is larger than wind speed in the morning (10 am to noon). The time of onshore and offshore direction is picked approximately based on figure 5 and it is true that the algorithm is conservative.

- Figure 7 caption, line 4. Do you mean Amir Abad or Noshahr? AmirAbad

- Line 198. "do very" → "vary" Corrected.

- Figure 8 caption, Table 1 and line 202 should agree about the water depth. In caption of figure 8, we added 31 m for Astara and 32 m for Roodsar. same for line 202

- Figure 9. What is the value of sigma used for these plots, c.f. discussion in lines 367-371. We add "$(\sigma = 0)$" after "inviscid".

- Figure 10 needs a colour scale. What are the units? Individual panels show time-and-spatial-dependence; "sensitivity" (to sigma) applies overall and should be better explained in the caption. 10b, 10e headings and caption disagree on value of sigma. The color scale is added to figure 10. The units added too. The label for

figure 10b and 10e is corrected now. Also one sentence added in the caption to clarify that this is a sensitivity analysis against σ.

- Lines 377-378. The "agreement" is not so good at Anzali where the observations have a significant (tidal?) semi-diurnal component. The reviewer is right that the modeled water level is not quite in agreement with the observations in Anzali. So we will mention this in line 380 as follows: Although the amplitude of the modeled water level is in a good agreement with the observed one in Anzali, the phase of the modelled response does not catch the semi-diurnal tidal component in this station.

- Lines 468-469. It is not immediately clear what "one" and "the other" refer to. Please specify. Modified to: The magnitude of the response is also affected by α, so to some extent changes in either bottom friction or α can compensate for changes in magnitude of the response.

- Lines 500-501. ". . , and . . response." needs a verb to have meaning. Modified to: Note that the sea breeze response is inherently local, as shown by the evanescent response of the model, and by the existence of strong local correlations between the phase and magnitude of wind forcing with the phase and magnitude of the ocean response.