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Interactive comment on "Interactions between the Somali Current eddies during the summer monsoon: insights from a numerical study" *by* C. Q. C. Akuetevi et al.

Anonymous Referee #1

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This study examines the interactions between the three major anticyclonic structures of the western Arabian Sea – Southern Gyre (SG), Great Whirl (GW) and Socotra Eddy (SE) – and their accompanying turbulence during the Southwest Monsoon. The use of 3 primitive equation numerical simulations run for decadal periods allow to identify different scenarii of interactions. The topic of investigation is of interest since there is no regional study focusing specifically on these interactions and the Arabian Sea regional dynamics is far to be fully understood. Specifically, although it has been evidenced that some mesoscale structures are permanent at seasonal scales (noticeably, SG, GW and SE), their robustness and variability at interannual scales is still debated and the use of long simulations is of particular interest in this perspective. However, even if the

objectives and outline of the paper follow an interesting and logical path, the depiction of different scenarii is too descriptive and deserves further dynamical diagnostics. For this reason, I recommend major revisions before publication. In section 1, I explain my point of view on possible weaknesses of the study and point out some suggestions for improving the science. In section 2, I list some issues that may deserve some rectifications. In section 3, I correct some typos and discuss some improvements for the figures.

1 General comments

1. The use of the 3 simulations is a bit wobbly since you don't clearly evidence their relative importance and how they are supposed to impact the dynamics. I suggest (i) not to use the 1/4° simulation, (ii) to investigate how the different physics of the models infer on the dynamics, and (iii) to compare the same 10 years (or more) simulated by the models, as interannual forcing variability in the region may be strong. About (i), the 1/4° simulation has a resolution of $\delta x \sim 25$ km which does not allow to resolve mesoscales : deformation radius at the latitude of the Socotra Eddy is ~ 70 km (Chelton et al., 1998) thus you are in an *eddy-permitting* regime (at least $10\ \delta x$ below the deformation radius are necessary to be *eddy-resolving*) that impedes the study of mesoscale dynamics. About (ii), you justify the use of different simulations to convince the reader on the robustness of the scenarii. I would say that it will make the reader more curious on how the dynamics is supposed to be changed by the model physics and forcing than making him/her comfortable with the results. Particularly, you mention the "tearing off from the boundary current of intense patches of positive vorticity". This process may be impacted by the boundary layer structure, thus by the friction and the slip condition. Another potential source of differences between simulations is the wind stress dataset used to force them. For instance, Beal and Donohue (2013)

suggest that the northern flank of the GW is aligned with the zero wind stress curl. I suggest that the authors build on those differences. About (iii), Beal et al. (2013) show that planetary waves generated in the Arabian Sea drive variability and feedback on the monsoon at interannual timescales. As such, it is worth comparing a same decade (or more than 10 years if available, that would better serve statistics) simulated by the models.

2. All scenarii are only based on sequences of snapshot maps and one section. This is pretty weak and lacks quantitative and more integrated diagnostics. Namely, quantifying eddy drift (you mention a SG drift of 1 m/s) requires an accurate eddy tracking (e.g., Morrow et al., 2004; Chelton et al., 2011). For instance, monitoring eddy statistics (vorticity, size, position, . . . , as done for the GW in Vic et al., 2014) as a function of time would bring quantitative aspects to go further than qualitative descriptions. Probability density functions (PDFs) of the eddy characteristics would allow to classify more precisely scenarii (e.g., PDF of spice in an eddy through years would indicate if merging occurs or not). I strongly encourage the authors to investigate statistically the eddy life cycles through eddy-tracking and statistics.

2 Specific comments

1. abstract : *these cyclones are identified as major actors in mixing water masses*. There is no clear evidence for mixing so you shouldn't say *major*.
2. p737,l1 : Precise which time of the year and introduce the wind stress features at this time; specifically, that the wind stress is upwelling favorable.
3. p737,l17 : You mention observations by Beal and Donohue (2013), idealized experiments by (Jensen, 1991; Wirth et al., 2002). You should add some recent

results by Vic et al. (2014) on the GW evolution (link with Rossby waves, intrinsic interannual variability, . . .)

4. p738,l18 : Why do you mention *fast dynamics*? compared to what? you should give scales for the variability. (also in p751,l20 and p753,l19)
5. p739,§2 : Why does the coarsest simulation have more vertical levels than the higher resolution simulations?
6. p739,l21 : This paragraph is useless and should be removed, it confuses the reader.
7. p740,l17 : Why is the validation performed only on the coarsest simulation? I must say that the validation does not make the reader feel at ease with the simulation as no observational dataset is used! Maybe you should present some validation against Aviso EKE or surface currents.
8. p740,l26 : Why currents are shown at 100 m depth and not at the surface as you focus on surface features in the article?
9. p741,l22 : *very good agreement* : if so, why not comparing surface currents and show it?
10. p742,l6 : *minimum sea surface temperature* : on which area? Is there a threshold value to qualify wedges as *cold*?
11. p742,l7 : Give the formula for spiciness.
12. p742,l16 : Again, why currents are at 50 m ?
13. p743,l6 : *detachments of positive vorticity* : It may have to do with the generation of a frictional boundary layer. A same phenomenon occurs on the shoreside of the Gulf Stream (Gula et al., 2015). Shedding of cyclones also occur. Do you

have those formation of eddies with the no slip and free slip simulations? How are eddy characteristics changed (vorticity range, size, . . .)?

14. p744,l6 : scenario i : I don't see the merging between a cyclone and the GW (anticyclone). How can you infer that from the maps?
15. p744,l12 : *This process is responsible for the mixing* : Fig. 5 shows a different scenario : collision between GW and SG. You should show exactly the same snapshots than Fig. 3 for spiciness.
16. p744,l19 : *clearly influences* : not so clear... You should show climatological mean and standard deviation of spice to see the water masses properties and variability to infer on mixing efficiency.
17. p745,l1 : $1/4°$ simulation is useless in this discussion since it is not designed to resolve mesoscales.
18. p745,l12 : *The intensification of the southwest monsoon during June amplifies the intensity of the GW* : you should be more precise, Vic et al. (2014)Ââshow that the action of the wind stress curl intensifies the GW.
19. p745,l16 : *migration at a speed of 1 m/s* : This estimate is based on snapshots shifted for more than 1 month. You should use the 5-day outputs to give a more accurate estimate. Again, tracking the eddy center would allow to be more precise.
20. p745,l19 : You should provide the frequency of events in this part.
21. p745,l24 : Scenario ii has not been described in literature and is the most frequent in your simulations. Can you extend on that?
22. p746,l19 : How does the physics of the simulations change the frequency of events?

23. p748,l22 : *it challenges the collapse interpretation based on the collapse of the two cold wedges.* Do you have a reference for that? What does *collapse of the two cold wedges* mean?
24. p749,l26 : Can you compare the shield of the vortex to the situation in Valcke and Verron (1997)?
25. p750,l23 : *they result from different ways of interaction of the GW with the topography of the Socotra Island.* : This is a strong statement and you didn't mention it before. Could you give arguments supporting that the GW interacts with the topography of Socotra Island?
26. p751,l5 : *fine-scale*. It's not precise enough, you're talking about *mesoscale*.
27. p751,l23 : *topographically constrained* : it's currently not supported by your analysis so you should not mention it, or if it's a well known feature, give a reference.
28. p752,l16 : *main drivers of the mixing* : At this time in the manuscript, we're not sure they are the main drivers. Be more cautious.

3 Technical corrections

In the following, (xxx) means "remove xxx".

1. abstract : allows (us)
2. abstract : encounterS
3. p736,l24 : (our) -> Fig. 1
4. p738,l6 : sentence is too long and elusive : *The lack of understanding. . .*

5. p738,l17 : (in space and time) -> spatio-temporal
6. p738,l24 : A section does not perform: In section 4 we perform
7. Table 1 : change the name of simulations to more convenient ones. We don't know what MJM95,MAL84 and MAL95 stand for.
8. p740,l25 : (a)
9. p741,l12 : (month of)
10. p741,l19 : (no figure shown) -> not shown
11. p742,l19 : parallel to THE coast
12. p742,l19 : (It is noteworthy to mention ...) -> Note that ...
13. p743,l7 : precise 'Western Boundary Current' as it is not written before.
14. All figures : fontsize is too small
15. Map figures : time should increase from left to right and top to bottom, as in usual text reading.
16. vorticity maps : should be non-dimensionalized by the Coriolis frequency to give an approximate Rossby number, useful to quantify the non-linearity of the dynamics.
17. p745,l6 : (unravel) -> untangle
18. p746,l14 : (At rare occasions) -> Occasionally
19. p747,l13 : (ζ plot) -> Fig.5 a-d
20. p747,l15 : (shooting) -> protruding

21. p750,l9 : (more or less)
22. p751,l8 : (permitted) -> allowed
23. p751,l9 : (give more light) -> shed light
24. p752,l15 : (detached) -> detach

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