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Interactive comment on “Mesoscale eddies and submesoscale structures of Persian Gulf Water off the Omani coast in Spring 2011” by P. L’Hégaret et al.

P. L’Hégaret et al.

pierre.lhegaret@univ-brest.fr

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1]Pierre L’Hégaret ¹ 1]Xavier Carton 2]Stephanie Louazel 1]Guillaume Boutin [1]Laboratoire de Physique des Océans/UMR6523, UBO, 6 avenue Le Gorgeu CS93837, 29238 Brest cedex 3, France [2]Service Hydrographique et Oceanographique de la Marine, 13 rue de Chatellier CS92803, 29228 Brest cedex 2, Brest, France

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Mesoscale eddies and submesoscale structures of Persian Gulf Water off the Omani coast in Spring 2011, answer to referee #2

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1 General comments

The authors discuss the properties of mesoscale eddies and sub-mesoscale structures that are created by the outflow of dense saline water from the Persian Gulf based on in-situ measurements. The material, exclusively based on field observations, can be of interest to the scientific community. Overall it is rather difficult to follow the text. While the authors name some structures in the text as C1 or A2, for instance, these identifiers are not shown in the actual figures, only in the captions. I suggest that each individual structure referred to in the text should carry some consistent identifier that is also displayed in graphs. According to the introduction, one of the objectives of the paper is to describe the structure of sub-mesoscale fragments and to explore their

* pierre.lhegaret@outlook.com

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recurrence. I don't see that the authors achieve this objective. For instance, statistical methods could have been used to derive typical length scales etc. Overall I believe that the material presented is publishable in Ocean Science, but the manuscript requires substantial revision.

We thank the referee for reading this article. The text and figures will be revised to make it easier to follow. More explanations will be given on the choice of parameters and why they are use in this article. We will also provide more details about the sub-mesoscale structures observed during the experiment but it is difficult to study the recurrence and formation of the submesoscale structures with our database. Therefore we will temperate our objectives in the introduction: in this article, we will provide a preliminary and partial view of the formation and recurrence of submesoscale features using also ARGO float data.

2 Specific comments

Major points

1. Introduction. What is the significance of these structures in the broader context such as the oxygen budget or carbon fluxes in the northern Indian Ocean? Why is it important to study them?

The mesoscale eddies induce strong horizontal transports whereas the submesoscale structures induces high vertical velocities, mixing the deeper water masses and providing nutrient, oxygen and carbon. We will add references about these budgets.

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2. Okubo-Weiss quantity. What is the main difference between deformation- and vorticity-dominated structures? The authors show give specific reasons as to why this parameter is used in the work. The authors derive this quantity from instant measurements. Do such snapshots tell us anything about the hysteresis of structures over seasons?

This parameter is principally used to show the structures dominated by high concentrations of potential vorticity, which are assumed to be more robust when submitted to external straining or shearing flows and to point out their sustainability. Furthermore, this parameter indicates the location of the main vortex structures in the basin, for each season; this can further be compared with information from previous studies.

3. Spiciness. The authors need to provide a reference for their spiciness formula. Isn't spiciness defined as the potential temperature θ and salinity S of sea water at a given isopycnal surface (e.g., Veronis, 1972; Munk, 1981; Flament, 2002; Huang, 2011). I don't see the causal link between this definition and how spiciness is used in this work. Please explain and add references.

We used the definition of Smith and Ferrari (2009) to focus on the sub mesoscale structures observed at the periphery of the eddies. This parameter allows us to have a clear difference between the salty waters trapped inside the mesoscale eddies and the patches surrounding them. We were then able to estimate their formations via the shear and strain induced by the eddies. We will add the references, and specify more precisely how spiciness can be used to track the water masses when advected on isopycnals, around or below vortex structures.

4. Give specific reasons for the use of two-dimensional Ertel potential vorticity.

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2D Ertel PV was used because high resolution data (Seasoar hydrology and VM-ADCP currents) were available along vertical cross sections; a similar resolution was not available perpendicularly to these sections. The calculation of the Ertel potential vorticity was made by using the classic formulation but projected on two dimension through the measurements of salinity, temperature and velocity.

5. What are ADCP currents used for in this work? I understand that most of dynamic properties are derived from the (corrected) TS climatology. Please clarify.

The ADCP current are used to derive all the different parameters such as the Ertel potential vorticity and Okubo-Weiss. Comparisons between the ADCP currents and geostrophic velocity are made for each sections but are not essential for this study; we will delete the figures showing the geostrophic currents.

6. In Section 5.2. the authors state: "Since a strong shear and strain is necessary to break the PGW outflow and to form lens and filaments, it is logical to observe fewer submesoscale PGW structures during the summer monsoon". Yes, this seems to be logical, but you still need to have conclusive evidence in support of this hypothesis. Without any evidence, this section should be removed.

The evidence is made in an article of Vic (2015) using an high resolution model, but we do not have enough in situ measurements to support this evidence using observational date. We will remove this section, and simply add a paragraph about the different mechanisms able to break the PGW, either the strong strain and shear, the baroclinic instability of the current.

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7. Figure 9: Can the authors please explain why the geostrophic flow field looks so different from the ADCP flow field? Is there a mistake? Perhaps the geostrophic flow field was plotted upside-down? Figure 14: Can the authors explain the fundamental difference between the geostrophic and ADCP flow fields? Is there something wrong here?

We will remove the figures of the geostrophic velocities since their derivation depends of the level of reference. Here we used the surface velocity calculated via altimetry (AVISO), but inside the Sea of Oman the derivation has strong biases due the the 1/4° resolution of altimetry and to the proximity of the coasts.

Minor points

1. In the abstract, the authors state: "As well, recirculation of the PGW is observed, thus having the presence of salty nearby patches with two densities". What is meant by two densities? Please clarify.

We will implement this correction by moving out this part off the abstract. We will also explain in the description of the region, that the recirculation of the PGW in its eastern part can lead to the presence of two patches of PGW at close position but with two strongly different densities, one being recent and the other being mixed.

2. What is an isospice? Provide a definition. Has this been used before?

An isospice is a line of equal spiciness, we will implement it.

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3. Figure 8: The terms salty & fresh injections are not used anywhere else in the text. So, why are they used in the legend?

We will delete these points.

Technical comments

1. In the abstract that authors state: "The different mechanisms leading to its formation and presence are assessed here." "Assessed" is probably not to correct word here. "Examined" is probably a better word choice, although the authors only provide some suggestions in the end.

We will implement this change.

2. In the introduction the authors state: "Second, to concentrate on the submesoscale fragments detached from or by the mesoscale eddies, and then on the nature, structure, recurrence and possible role of such fragments". This sentence is confusing and incomplete. Role in what? Perhaps this sentence should read: "Second, we focus on submesoscale fragments detached from or embedded in mesoscale eddies to describe their typical structure and recurrence."

We will implement this correction.

3. In the results section the authors write: "This will be evidenced now with the PhysIndien experiment data". "Will" and "now" don't make sense in the same sentence. Better: This feature is now also documented with observational data from the PhysIndien survey.

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We will implement this correction.

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