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Ocean Science
Discussions

Interactive comment on "Dynamics of North Balearic Front during an autumn Tramontane and Mistral storm: air–sea coupling processes and stratification budget diagnostic" *by* Léo Seyfried et al.

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Response to Referee #1

Authors' Answer: The paper has been revised according to the comments from the reviewers and we thank both reviewers for their very helpful comments and suggestions. Our point-by-point response is inserted in the reviewer's comments.

Reviewer's Comment: The Northwestern Mediterranean is an important region for the Mediterranean Overturning Circulation through the formation of Western Mediter-

ranean Deep Water. The authors provide an original study of the north Balearic front, bordering the open-ocean deep convection area of the Western Mediterranean. They combine observations and a realistic air-sea coupled model to analyse the thermal and dynamical air-sea coupling for different wind regimes in the north Balearic front region. Particularly, they highlight the importance of the adiabatic Ekman buoyancy flux in destratifying the frontal zone during strong wind event (three times greater than the air-sea buoyancy flux). I really enjoyed reading this manuscript which I think was clearly written and well structured. I was particularly amazed by the excellent agreement between the coupled model system and the met-ocean observations. I think the work is significant and deserve prompt publication. I have however a few comments I would like the authors to address before the manuscript is considered for publication.

Minor comments:

RC: p5,l 12: By looking fig 6c), the MLD doesn't seem to deepen only by a few meters, it looks like it deepened from ∼25m to ∼40m. To avoid this interpretation problem, you should indicate the MLD on the different profiles of the figure, particularly because you mentioned it in the text.

AA: The MLD have been added to the Fig 6c. The MLD deepen from ∼25 to ∼40m. The text has been modified accordingly.

RC: P5, l14: slight is not very quantitative can you be more accurate?

AA: "slight" has been replaced by a MLD deepening of about 20 meters.

RC: P7, l3-4: Any explanation why these small-scale structures were not observed?

AA: The filament structure simulated (see Fig. 4g) is not positioned at the same place in the reality.

RC: P7, l8: can you quantify how much smaller (10%, 100%,...)? p7, l 10-11: What about the large 0.2 bias between model and obs in Oct. 26? Is it also due to the fact that the modelled profile was not in the same region/regime? Adding small maps

on fig6, with the modelled and observed SST, zooming on the location of the profiles, would help understand if the profile were taken from the same type of region.

AA: This paragraph p7 l7-11 was modified : “At the end of the strong wind event, the simulation showed a decrease of temperature and an increase in salinity, density and MLD. The temperature decrease was smaller than in the observations, 3.3°C compared to 5.3°C. Whereas the salinity increase was more important in the simulation than in the observations, 0.15 compared to 0.05.The increase of density and MLD were smaller than in the observations, 1 km m-3 and 15 m compared to 1.32 kg m-3 and 25 m, respectively. However, it is worth to note that the observed profile is located to the north of the NBF whereas the corresponding one in the simulation is within the frontal zone. When the comparison is made with a simulated profil located slightly further east (41.8°N -5.15°E, green dashed line in Fig. 6), the simulation results are much closer to the Argo observations.” The Argo profiles positions are now available on Figure 4.

RC: P9, l2: “the density does not increase” → the density appears to increase when looking the position of the isopycnal and the colorbar.

AA: Modified

RC: p9, l11: when you speak about correlation you should give the correlation coefficient in the text, otherwise you should find another term.

AA: Modified

RC: P10, l22: E and P are not variables shown in the equation E (4). You should rather introduce Qnet and Fw.

AA: Done

RC: P11, l2: Can you give the origin or the kind of processes which are part of R? Later on, you speak about advective processes, you should also introduce it here.

AA: The origin of processes which are part of R are now introduced p10 l23: ”The strat-

ification index variation at depth H (with H =250 m, H>MLD) between times T1 and T2 can be approximated by the integral of buoyancy mass flux between times T1 and T2 (Eq 5). In order to evaluate the competing roles of the diabatic and Ekman buoyancy fluxes on stratification variation, these two term are diagnosed and compared to the stratification variations. Finally, to close our stratification budget diagnosis we evaluate the residual term corresponding to other potential sources of horizontal and vertical advection of buoyancy (geostrophic circulation, frontogenesis, Ekman pumping, ...) that are not directly diagnosed in this study”.

RC: P11, l15-16: you could precise that the stratification fain is of the same order of magnitude than the cumulated EBF effect.

AA: Done

RC: P12, l14: in the BNF zone → in the eastern part of the NBF (down-front wind)

AA: Done

RC: p13, l25: “This process is not reproduced in our real case study.” → Do you have an explanation why?

AA: We explain that by the fact that the front is not constrained by the bathymetry.

Typos/ spelling mistakes:

RC: p1,l5: ... modelling system and focused... → modelling system. We focused

AA: Done

RC: p1,l9: I will split the sentence l8-l10 in two, I found it hard to follow.

AA: Done

RC: p4, l19: ‘..., the horizontal resolution of which is about’ →..., with an horizontal resolution of

AA: Done

RC: p6, l12: (of all the .... → from all the ?

AA: Done

RC: P7, l4: marked → intense?

AA: Modified

RC: P7, l7: was shown by the model on October 26th

AA: Corrected

RC: P7, l8: ... an increase in salinity and density [...], except for salinity. → something is not clear, can you double check the meaning?

AA: This section has been modified.

RC: P7, l15: obviously → slightly?

AA: Modified

RC: P7, l22: red → yellow-red?

AA: Modified

RC: P7, l28: less strong → reduced?

AA: Modified

RC: P8, l17: and after IOP16 (blue lines in fig 8)

AA: Modified

RC: p8, l27: The EW section (Fig. 8.b) before IOP16, which crosses the meander (Fig. 7c), intersects the NBF → The EW section (Fig. 8.b) crosses the meander (Fig. 7c) before IOP16. It intersects the NBF

AA: Modified

RC: p9, l1: in the heart → in the core?

AA: Corrected

Figures: RC: fig3: You should add the ticks for all the time mentioned in the text (e.g. 18 UTC on October 27). Did you display the ticks for 0000UTC or 1200UTC?

AA: The figure 3 has been modified to be more readable.

RC: fig4. Drawing the NBF position on figure 4 would help to follow the text (p7,l9)

AA: Done

RC: fig5: - Can you add an indication of the period of strong wind mentioned in the text (e.g. by an horizontal line on top of the sections?) - The tick labels cannot be seen clearly. Can you make sure to make them visible? You should also plot the MLD on figure (d)-(g) as you discuss it in the text, but it's difficult to locate it on the suplots.

AA: The figure 5 has been modified to be more readable.

RC: Fig6: You should need the MLD on all profiles and add the criterion used (density based?), for example by a small horizontal line on obs and model profiles.

AA: The MLD for all profiles was added to the density profile.

RC: It's difficult to clearly localised the green dash profile location on figure 4. Could you a subplot where you indicate the position of argo profiles in Oct. 26th for both model and obs SST maps? (by zooming on a box such as 42.5N-42.2N / 4.5E-5.5E). Can you also do it for the locations of the 2 profiles taken in October 31 st? It could help understanding why the profiles doesn't exactly match.

AA: The dash profile location has been added on figure 4.

RC: Fig7: - l4: line (a-c) → do you mean (a-b)? - You should keep a numbering consistent between all figures (increasing from left to right and top to bottom)

AA: Done

RC: Fig8: This figure is difficult to read. - For clarity, you should leave more horizontal and vertical spaces between the colorbar and vertical sections. - Can you add axe labels for plots and colorbar? - Do we need to see all these isopycnals? The superposition of isopycnal doesn't make the figure easy to read. What about keeping the 27 and 28 isopycnals as plain lines and the other as small dash lines? Could you also make sure that the contour labels are visible? (by adding them manually in the middle of the contour line for example?) Can you indicate the surface position of the front on the 25/10 and on 30/11 on top of the section by a specific marker (e.g. reverse triangle, arrow, ...) ? You could indicate the cyclonic gyre extension you are mentioning in the text.

AA: The figure 8 has been modified to be more readable.

RC: Fig 14: Could you indicate, on figure 13 for example, the area chosen for the two regions a and b?

AA: Done

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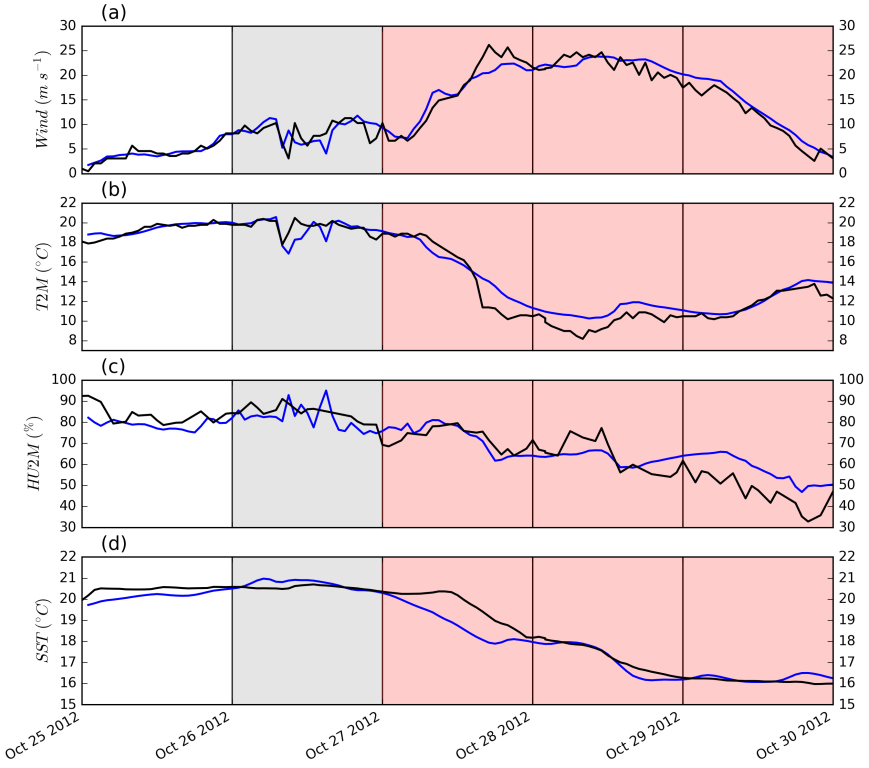

Fig. 1. Time series at the Lion meteorological buoy of (a) the 10 m wind speed, (b) the 2 m air temperature, (c) the 2 m air humidity and (d) the Sea Surface Temperature. Observations in black and simulations

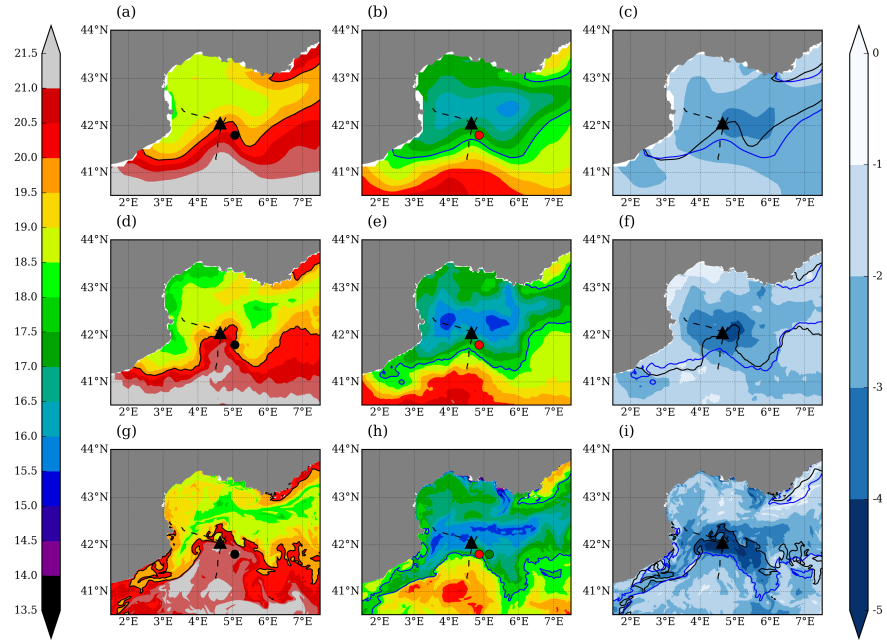

Fig. 2. Sea Surface Temperature analysis from the OSTIA product (a-c), from the Mediterranean Copernicus product (d-f), and from the coupled simulation (g-i) at 0000 UTC on 25 October (a, d and g), at 0000 UT

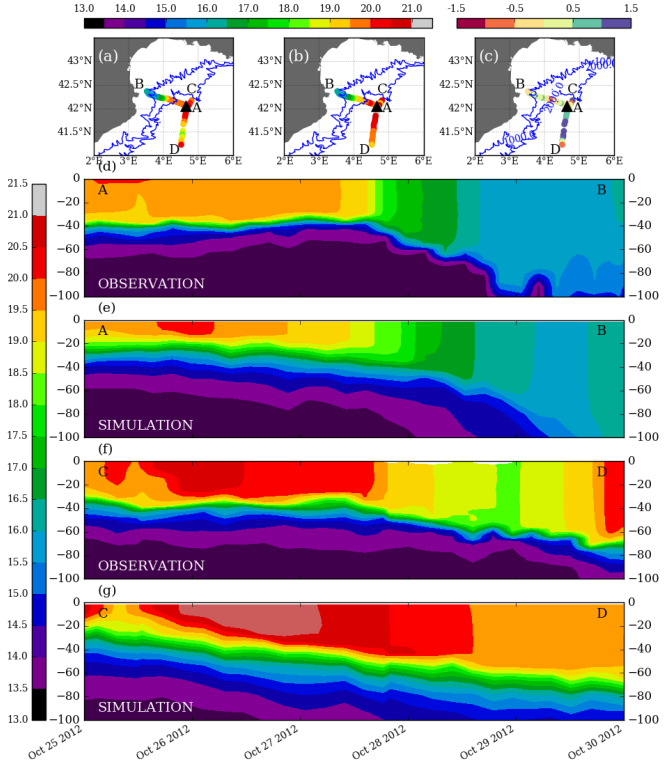

Fig. 3. SST measurement (a), simulation (b) and bias of the simulation (c), along the trajectory of the glider Eudoxus (moving westward) and Campe (moving southward). Vertical section of potential temperature

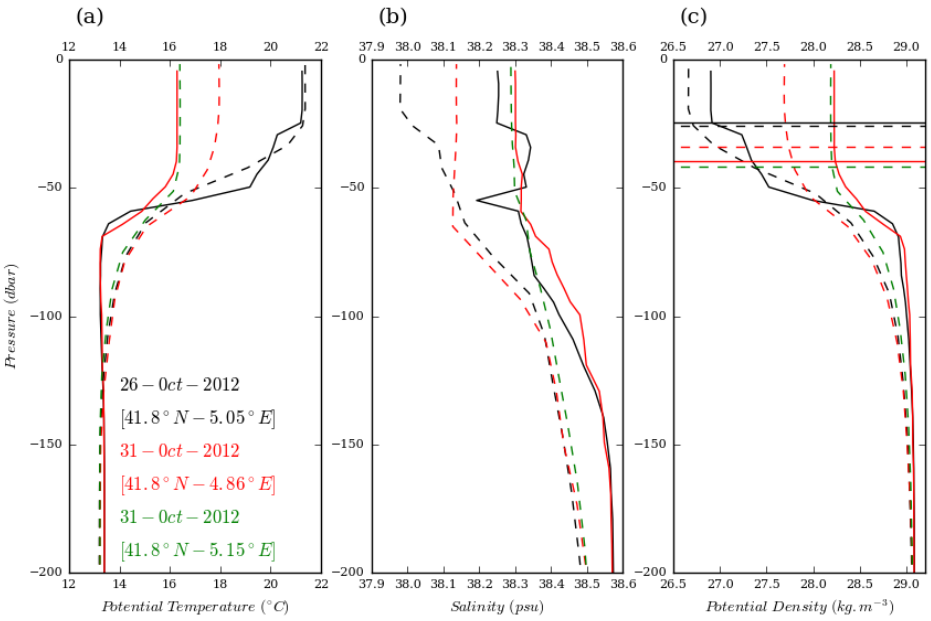

Fig. 4. Argo potential temperature (a), salinity (b) and potential density (c) measured (solid line) and simulated (dashed line) at the different dates indicated in the figure. For 31 October, only simulated

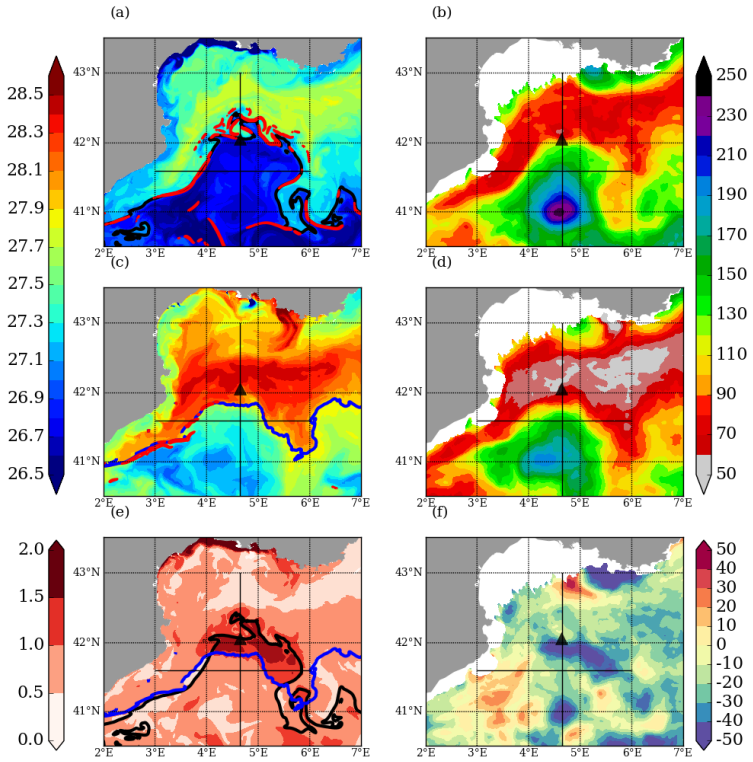

Fig. 5. Sea surface density in \unit{kg\ m^{-3}} (left column) and Stratification Index at 250 m in \unit{kg\ m^{-2}} (right column), at 0000 UTC on 26 October (a and d), at 0000 UTC on 30 October (b and e)

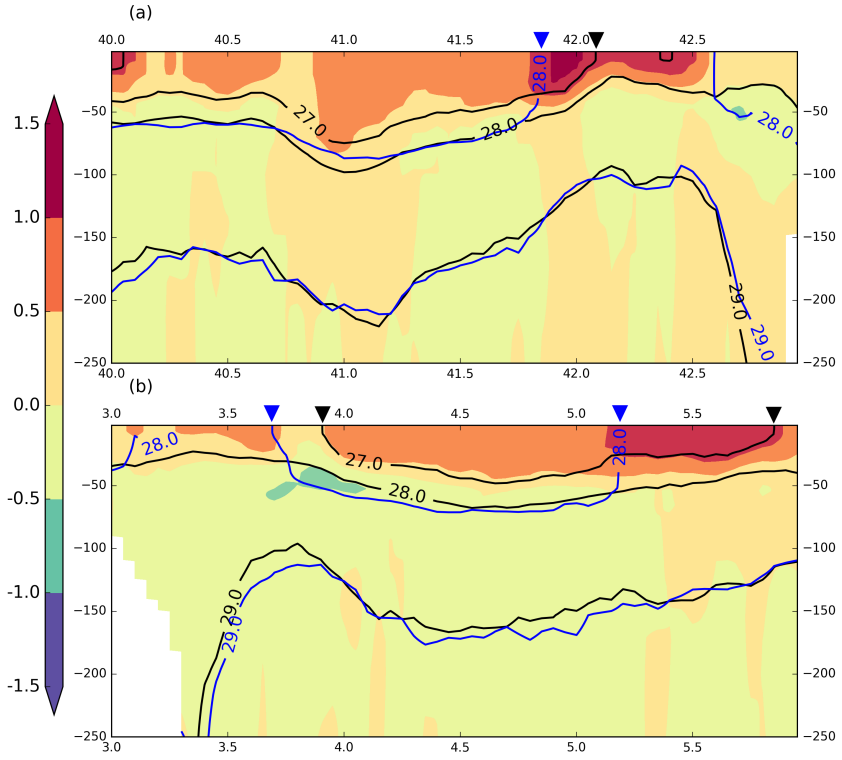

Fig. 6. (a) South-North section at 4.65\unit{^\circ E} and (b) West-East section at 41.7\unit{^\circ N} (see Fig. \ref{Fig7} for their positions) of the potential density difference between 0000 UTC on 30 Oct

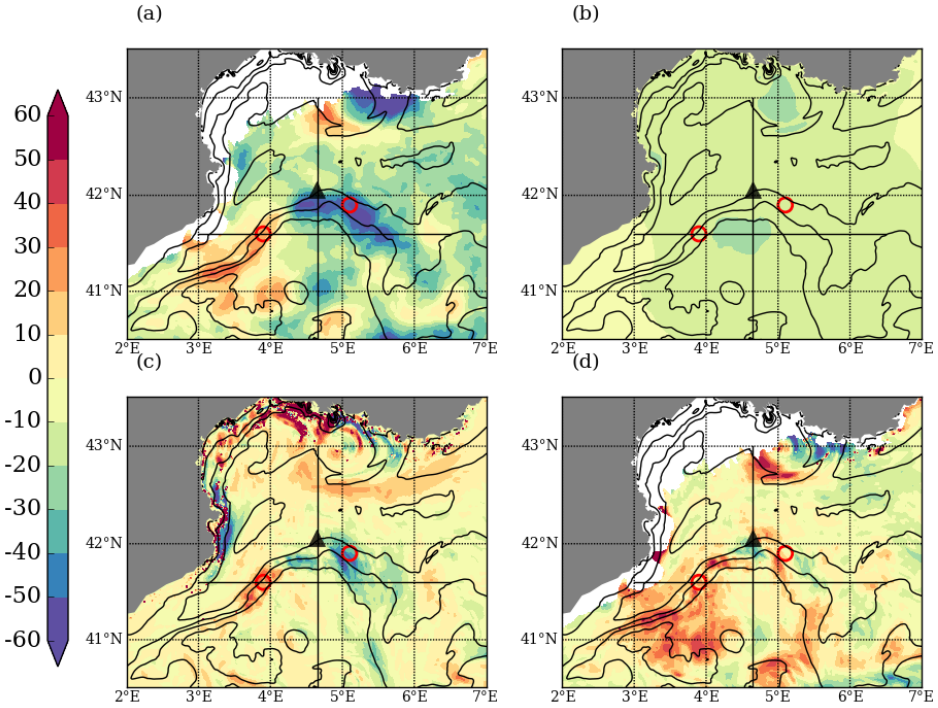

Fig. 7. Same figure as Fig. 12 for IOP16b.