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Interactive comment on “Observations of new western Mediterranean deep water formation using ARGO floats 2004–2006” by R. O. Smith and H. L. Bryden

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We are grateful for the positive replies and thoughtful comments received from all referees to help improve our paper. We provide below responses to each of the main comments expressed by the referees. All minor comments and technical corrections have been made directly in the revised manuscript.

1) I believe that the manuscript is a bit long and some parts could be omitted or reduced to improve readability.

Although we have added text to make the required corrections, the manuscript word count has been reduced slightly from 9300 to 9035 words. We have also eliminated the section describing the float trajectories and shortened considerably the first section

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of the discussion, as discussed below.

2) First part of Discussion (753, 754 and down to 755, 22) reiterates findings in the previous section and could be shortened substantially. Discussion could be more focused by dividing it under subtitles as Introduction is well organised.

We have done our best to reduce the length of the manuscript by eliminating those descriptions that were felt unnecessary (such as the Argo float trajectories) and avoiding a reiteration of the results section at the beginning of the discussion. We have also revised parts of the Discussion by re-ordering sections into a more logical format to improve readability. In removing a description of the Argo float trajectories we instead point the reader toward figure 2 during the section titled 'Data'.

3) Maybe it would be better to explain here why these two cells are selected, although it is made evident later throughout the manuscript Discussion.

We agree that a description of why the two NCEP/NCAR cells were selected is more appropriately placed in the data section to assist the reader in later understanding our results and discussion sections.

4) Mismatch between the descriptions in the text and legend and the colour-coded trajectories in Fig. 2. Please check float WMO numbers and colour coding for the tracks.

We can confirm there was a mismatch in the both the colour coding for the Argo float transects and that the incorrect trajectory for float 6900291 was plotted instead of float 6900292. Neither error affected the subsequent description of deep water formation in the western basin and both have been corrected in a revised version of figure 2. Thank you for pointing out these errors.

5) It is shown, from this and other authors analysis that in 2004-2005 nWMDW was formed in the Catalan subbasin and probably also in a large area around the Gulf of Lyons. After the sinking and spreading phase, this nWMDW should be present in the

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deep layers of the western Mediterranean. Is there a clear explanation for this not including the Ligurian, as it is evidenced by the deep casts before March 2006?

We did not detect nWMDW produced in the 2004-2005 winter within the deep layers of the Ligurian subbasin in the following winter. We think that the new deepwater found a level of neutral buoyancy below 2000m, beyond the sampling capability of both the Argo floats and the DYFAMED time series. However, we could not find any conclusive evidence for this to be the case, beyond noting that the density of the 2004-2005 nWMDW is higher than historical WMDW which was present at 2000m depth in the Ligurian and DYFAMED profiles in the winter of 2005-2006, suggesting any nWMDW would be in the deeper layers of the western basin.

6) I would say that from the data of the 14 March profile it is not possible to infer that the detected nWMDW was formed in 2006 probably outside the MEDOC area rather than it is just the signature of the nWMDW formed there the previous winter.

We agree that relying only on data from 14th March 2006 from Argo float 6900292 does not provide sufficient evidence for nWMDW formation in or surrounding the MEDOC region. Although we cannot be sure where and when this nWMDW was formed, we provide two plausible explanations: 1) Homogeneous vertical temperature and salinity profiles were observed down to 700m prior to 14th March 2006 and it is possible that if the Argo float has profiled to 2000m in the days/weeks prior to March 14th we may have observed deep mixed layers 'connected' to the surface waters. 2) The nWMDW present in March 2006 represents a signature of the new deep water known to have been produced during the 2004-2005 winter in the western basin (Font et al., 2007).

7) Air-sea fluxes. A better general picture of the situation would appear if NCEP/NCAR heat fluxes were provided for both regions for the two winters. It would help understanding not only the differences between the nWMDW formed in both areas but also why there was or not dense water formation in a specific area in a specific winter.

We have now included NCEP/NCAR heat fluxes from both re-analysis locations for

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the two winters as suggested by the referee, and have highlighted the differences in surface forcing acting in the two subbasins along with the interannual variability noted within the heat flux time series. The revised figure and interpretation assist greatly in evidencing the relationships between location, surface heat fluxes, water column structure and the occurrence of dense water formation. Thank you for the suggestion.

8) Add a definition or reference for the heat content.

We have added a definition of what we have termed heat content change within this paper along with a reference to the literature this was taken from: "We define the heat content change computed from Argo float data as the time derivative of heat content (Levitus et al., 2000) integrated over a fixed depth layer (0-200m) between successive Argo float profiles".

9) I don't understand why the authors conclude that "else the Catalan subbasin could not have undergone the pre-conditioning required for deep convection" in 2004-2005. This appears to be contradictory with the rest of the paper.

This conclusion has been revised to aid clarity and now reads:

"These studies are of interest because combined with data presented in this investigation, they show deepwater production during the 2004-2005 winter occurred in numerous regions of the western basin and was not constrained to the MEDOC region. This suggesting therefore that surface water densities exceeded 28.8 kg m-3 over a wider region than 'typically' observed (Marshall & Schott, 1999) during the pre-conditioning phase of winter 2004-2005, ultimately leading to an enlargement of the deep convective regime of the western basin during this winter (Salat et al., 2007)."

10) The authors should clarify whether they indicate by nWMDW the newly formed deep water in every winter, or a distinguishable water mass formed in 2005 and 2006 that had markedly different characteristics than the 'usual' deep water, the latter being indicated by oWMDW, as supported by other authors.

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As this section discusses interannual variability between deep water produced in every winter we have clarified our terminology with nWMDW representing the new deep water that is typically produced each winter in the western basin.

11) The doubt on previous ship surveys having neglected the regions where WMDW formation was documented in this paper by Argo floats can be solved by looking at other available data sources, e.g. the DYFAMED time series or some campaigns mentioned by other authors. There are evidences of the 2005 convection in the Catalan subbasin being part of an unusually wider dense water formation area, both from in-situ data or numerical simulations.

We thank the referee for this comment as it highlighted a previously neglected method in which we could investigate whether the nWMDW produced in the 2004-2005 winter was subsequently detected in the Ligurian subbasin (when it would be expected to be present in either/both Argo float data and the DYFAMED time series data). We have included a reference to the DYFAMED campaign to assist the reader in locating other hydrographic data from the western basin along with references to the papers suggested, which evidence dense water formation in the western basin during the 2004-2005 winter.

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