Response to the Topic Editor

Additional private note (visible to authors and reviewers only):
Dear Authors,

Please address the comments of the referee, especially the colour scales and description.

I also apologise for the delay, as from March last week to the first week of June, I was on medical leave following a major emergency.

Regards,
Topic Editor

Dear Topic Editor,

We hope you have fully recovered and you are doing well. We have carefully addressed all the additional comments raised by Reviewer 2. In line with your recommendation, particular attention was given to the harmonization of the colour scales across the figures of eddy diffusivity and to the improvement of the description in the manuscript. A detailed point-by-point response to the reviewer's comments is provided in the response letter.

Best regards,
Lucia Gualtieri
(on behalf of all authors)

Response to reviewer #2

I thank the authors for their revisions and for addressing my previous questions. The manuscript has improved and the sensitivity experiments provide useful information on the role of vertical mixing schemes and convective adjustment in this Mediterranean configuration. However, I still have several concerns regarding the interpretation and presentation of the results, as well as some aspects of the methodology. Please see my detailed comments below.

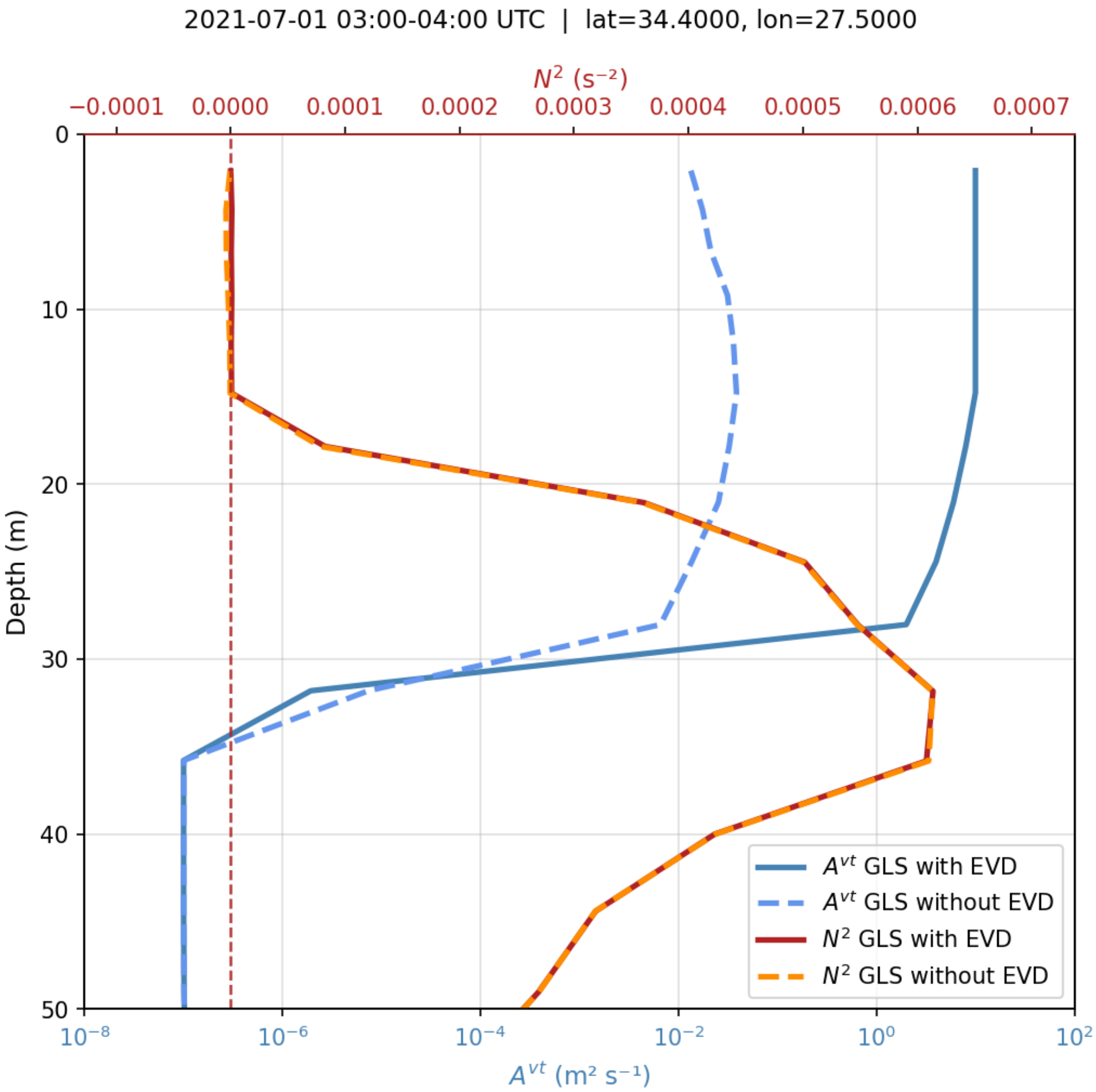
We thank the reviewer for these additional thoughtful comments. We have addressed the points raised and implemented the requested revisions throughout the paper.

A detailed response and explanation are provided below (reviewer's questions are in blue, our answers in black). Line numbers refer to the revised manuscript with track changes enabled (in No Markup view).

1. The manuscript remains somewhat descriptive in its physical interpretation. Differences in (K_z) are often interpreted as differences in convective intensity, but (K_z) is a parameterized mixing coefficient rather than a direct diagnostic of convection. The authors should provide additional diagnostics, such as (N^2) and qualify these interpretations more carefully.

We thank the reviewer for this comment. The objective of this paper is to compare what each scheme produces in terms of mixing, and we believe that the eddy diffusivity coefficient (denoted hereafter A^{vt} as in the manuscript) is the most appropriate diagnostic for this purpose. While N^2 describes the background stratification and is influenced by the mixing, it is a less direct measure of the mixing response of each scheme compared to A^{vt}.

To further support this choice, we provide in this letter an additional figure (see below) showing vertical profiles of A^{vt} and N^2 for the GLS scheme with and without EVD at the same location as Figs. 12c and 12f (lat=34.40, lon=27.50) on 1 July 2021 at 03:00-04:00, during the convective event visible in those figures. The figure below clearly shows that A^{vt} and N^2 convey consistent information: negative N^2 values in the uppermost few meters coincide with A^{vt}=10 m^2s^{-1} in the case of EVD activated, confirming the link between the two by construction. In the absence of EVD, negative N^2 values are also present in the same layer, consistent with the large A^{vt} diagnosed by the mixing scheme alone according to its own formulation. However, A^{vt} provides a much clearer and more direct diagnostic, as it is the actual output of the mixing schemes and makes the convective events more readily visible.



2. The authors should briefly discuss whether the prescribed EVD coefficient is dependent on model resolution. In this study, convective adjustment is applied as a fixed vertical diffusivity of 10 $m^2\ s^{-1}$ wherever $N^2 < 0$. Since this coefficient is intended to represent unresolved convective overturning, its appropriate value may depend on resolution. As resolution increases, the amount of unresolved convective transport may change, so the same fixed EVD value may not be transferable to other model configurations. I do not suggest additional experiments, but the authors should clarify and acknowledge this scale dependence as a limitation in the discussion.

We agree that the EVD coefficient may depend on model resolution, as higher resolution configurations may explicitly resolve a larger fraction of convective overturning. This can potentially lead to a different value for EVD. Therefore, we have added a note on this aspect at the end of the subsection on convective adjustment (Subsection 2.2.2, lines 277-280) stating that:

> *It is worth noting that the appropriate value of the EVD coefficient may depend on model resolution. As resolution increases, a larger fraction of convective overturning may become explicitly resolved, potentially reducing the contribution of unresolved convective transport and, consequently, the optimal EVD coefficient may differ. The*

> *value adopted here is therefore calibrated for the present model configuration and may not be directly transferable to setups with different resolution.*

3. Figures 3 and 12 both show the vertical eddy diffusivity coefficient, but they use different color scales. This could be potentially misleading, because readers may visually compare the colors across figures and infer differences in mixing intensity that are partly caused by the colorbar choices rather than by the model results.

We thank the reviewer for this comment. We agree that using different color scales across Figures 3 and 12 and across panels within the same figure could be misleading when comparing mixing intensity. Both figures have been updated to use the same logarithmic color scale, which is now consistent across all subpanels within each figure and between the two figures, ensuring a fair visual comparison both across mixing schemes and between configurations with and without convective adjustment.

4. In the water-mass formation case studies of South Adriatic Pit and Rhodes Gyre, differences in LIW intrusion and sinking are mainly attributed to the local behavior of the vertical mixing schemes and EVD. However, after a period of numerical integration, the experiments may also differ in circulation, mesoscale structure, and lateral advection. The authors should clarify to what extent the diagnosed differences are caused by local vertical mixing rather than changes in background.

We thank the reviewer for this comment that allowed us to better clarify an important point. We agree that after more than a year of numerical integration, the experiments may differ not only in local vertical mixing but also in circulation, mesoscale structure, and lateral advection. However, these differences in background state are themselves a consequence of mixing and convection parameterization choices, since the six experiments differ solely in the choice of vertical mixing scheme and convective adjustment setting. This concept was already expressed in Section 3.3 (lines 540-550).

Following the reviewer's suggestion, we have made this point more explicit by expanding the preamble in Section 3.3 and adding a note in each of the two case studies (Subsection 3.3.1 and 3.3.2). The revised preamble now includes (lines 544-546):

> *This divergence, driven solely by the different mixing and convective adjustment configurations (Section 2.3 and Table 1), encompasses not only differences in local vertical mixing, but also in the large-scale circulation, mesoscale structure and lateral advection.*

In subsection 3.3.1, we have modified the following sentence (lines 599-601):

> *This behaviour is consistent with the formulation of the mixing schemes, which may have also produced, over the prior integration period, differences in lateral advection and mesoscale activity that contribute to the contrasting salinity structures.*

And in subsection 3.3.2 added (lines 631-634):

> *As discussed above, the spread among configurations reflects not only the direct effect of local vertical mixing, but also differences in background circulation, mesoscale structure, and lateral advection accumulated over the prior integration period under each vertical mixing and convective adjustment setting (Table 1).*