

## Review responses to OS preprint egusphere-2025-3112

### Reviewer #RC1:

**# 80: “The remaining thermal lag in the final dataset was found negligible, as the absolute difference between the mean of all climbs and dives in conservative temperature and absolute salinity at the thermocline was 0.04 °C and 0.015 g kg<sup>-1</sup>, respectively.”**

This difference is interpreted solely as the effect of thermal lag, but the glider is unlikely to sample exactly the same water masses during consecutive climbs and dives, and the observed differences could also reflect spatial variability, especially in such a frontal zone. I suggest that this point be acknowledged in the text, and that the authors provide an estimate of the typical horizontal distance between the end of a dive and the start of the subsequent climb, to put these differences into context. This mention could be mentioned in some clarification in the section 2.3.

# 80 Added: *‘Part of the climb–dive differences may also reflect spatial variability, especially in strong frontal regions.’*

Thank you for pointing out this. Indeed its important to highlight the difference in subsequent profiles being also from the strong lateral gradients the glider has travelled through.

# 98 changed from *‘To minimize the effect of glider advection, distance was calculated relative to the surrounding current. From this point onward, this will be referred to as “distance.”* to *‘To account for the spatial variability discussed in Sec. 2.1 and to minimize the effect of glider advection, distance was calculated relative to the surrounding current. From this point onward, this will be referred to as “distance”. After this correction, the cumulative distance was reduced to approximately half of the along-track distance.’*

**# 127: It should be specified, at least here when defining the terms, that the shear refers here to a “geostrophic shear”, to avoid confusion with any finer or smaller-scale shear that can be employed in the literature in mixing studies.**

Indeed, that's true.

We have changed the text to *‘... the vertical geostrophic shear is calculated from the thermal wind balance as ...’*

**#128, Eq(3) The term  $b_x$  should be detailed, with the  $dx$  that is applied (I guess 1.5 km, given in section 2.3 ?).**

This has been changed to *‘...  $b_x = \partial b / \partial x$  is the partial derivative of buoyancy in distance, with  $\partial x = 1.5 \text{ km}$  ...’*

**#143 Please define the terms (theta, rho, S etc...).**

Changed to

*‘... where  $\theta$  is the Conservative Temperature (°C),  $S$  is the Absolute Salinity (g kg<sup>-1</sup>),  $\rho$  is the potential density (kg m<sup>-3</sup>) referenced with the surface and ... the thermal expansion coefficient (K<sup>-1</sup>) and the saline contraction coefficient (g<sup>-1</sup> kg) ... ‘*

**#166** To help the reader be more familiar with FSLE diagnostics, please define the units of  $\delta\theta$  and  $\delta\theta_f$  (degrees ?), then please provide the correspondence (in meters) to help the reader understand the spatial scales.

This is a good point. Changed to ' $\delta\theta = 0.05^\circ$  ( $\sim 6$  km) and  $\delta\theta_f = 0.5^\circ$  ( $\sim 56$  km)'

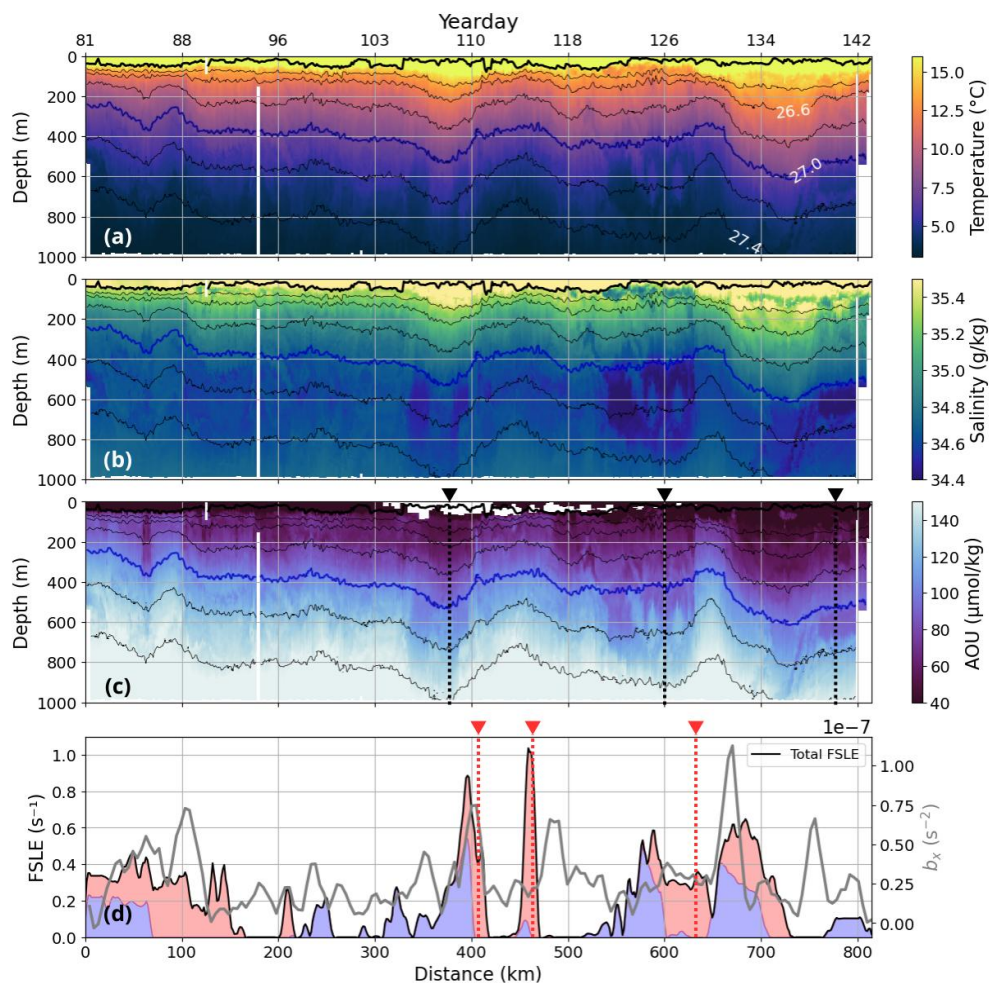
## #Section 2.5

The authors could anticipate the discussion about the difference between  $b_x$  and FSLE by recalling in the paragraph the spatial scales “sampled” by the glider. It could help the reader understand better the experimental design limitations, and anticipate the discussion about this later.

Indeed, this would be a good addition. We have responded to this point in the response #225 found below.

**#194** Low AOU discussed in the paragraph could be pre-pointed on the Figure 2 using the same kind of markers as in the Fig. 2d.

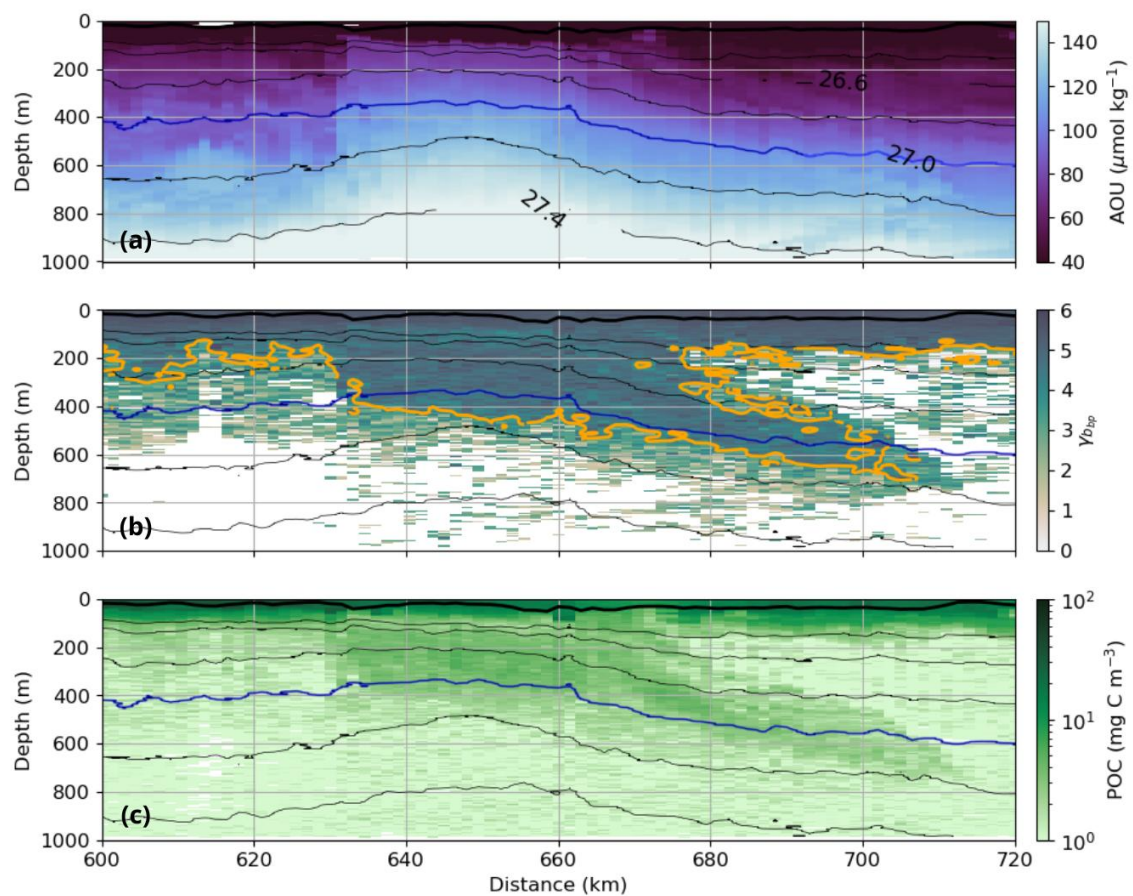
Low AOU values that are referred to in the text are now indicated with the same type of marker in black and referred to in the text.

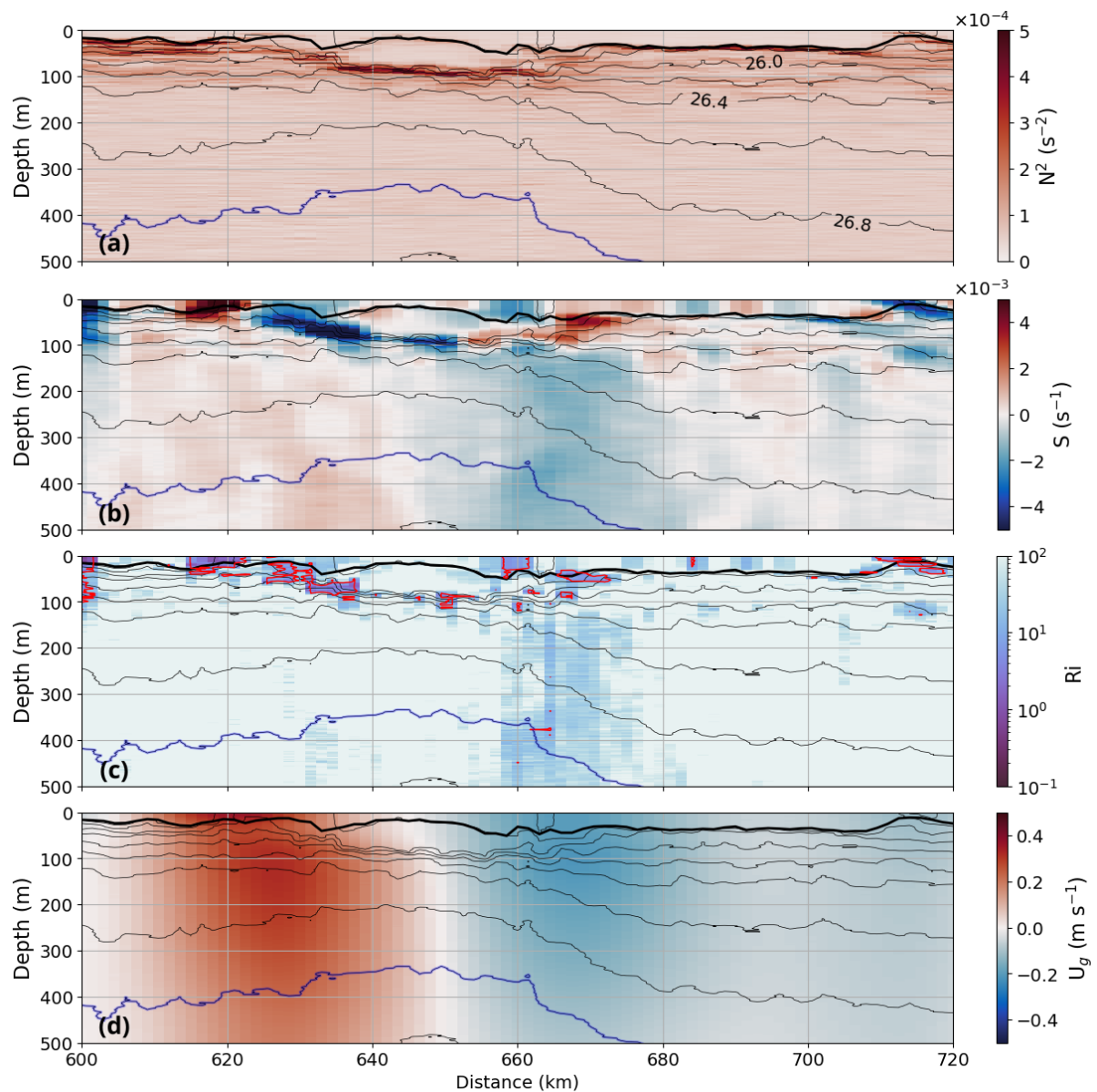


### #Figure 2, Figure 4, and Figure 5

The authors could plot some reference isopycnal in bold (e.g.,  $27 \text{ kg.m}^{-3}$ ), to better orient the reader during the description between Figures 2,4,5. The description could be defined backward from the Figure 6 that identifies the isopycnal of interest (e.g. the “barrier-27”, or the 26.5 too regarding POC, or the 26.25 for spiciness/AOU/POC).

Thats a neat idea. Indeed, this will help with orientation and following description in the text too. We have added a blue bold contour line at the -27.0 isopycnal which is included in all the relevant figures.





**# 224, FSLE: If the FSLE is scale-dependent, maybe you could better justify the choice of  $\delta t$  and  $\tau$  ?**

**Would smaller-scale choices (e.g.  $\tau$  of 3 days ...) shift the FSLE sensitivity toward faster, smaller-scale deformation — i.e., closer to what the glider sees in terms of sharp fronts and subduction ? Or maybe just adding noise to the estimates ?**

**This could be anticipated in the methods and then recalled there.**

These are good points to clarify in the methods. We have added the following description to the methods: *The initial separation  $\delta_0$  is set close to the altimetry grid spacing ( $1/8^\circ$ ) and smaller than the regional first-baroclinic Rossby radius ( $\sim 25$  km) (Chelton et al., 1998) to resolve meso- to submesoscale frontal features. The final separation  $\delta_f$  is set so that  $\delta_f = 10 \delta_0$ , following the method of Sudre et al. (2023). This choice ensures that FSLE captures the growth of submesoscale frontal features into larger mesoscale structures, representing the overall strain field. The time integral  $\tau$  is chosen to align with typical mesoscale mixing timescales observed in*

the Cape Basin (Kersalé, M. et al., 2018; Capuano et al., 2018). The chosen parameters represent the lower limits permitted by the resolution of altimetry, bringing the FSLE fields closer to glider-scale observations. Parameter sensitivity tests indicate that further reductions in  $\tau$  or  $\delta_0$  predominantly enhance noise rather than reveal additional coherent structures.

Added to # 224: Although the FSLE parameters were chosen at the lower limits permitted by altimetry to better approach glider scales (Sec. \ref{sec:2.5}), the temporal and spatial resolution of the FSLE field remain coarser than the glider resolution. As a result, it may not fully resolve sharper, short-term frontal structures observed by the glider or capture immediate short-term surface dynamics.

**#301 and #311: “Sharp SST gradients”: Please report some value in the text to support the statement .**

#301 changed to

*‘The glider is passing through a region with significant SST variability and sharp SST gradients of approximately  $0.4\text{ }^{\circ}\text{C km}^{-1}$ , as indicated by the dashed contour lines in (Fig. 7b). These surface gradients also extend to depth (Fig. 2a).’*

#311 changed to ‘.... that is aligned with sharp SST gradients of approximately  $0.6\text{ }^{\circ}\text{C km}^{-1}$ . ’

**#351 “In some instances, the glider may cross into a different water mass, making it difficult to precisely locate the source of the ventilated waters. It is possible that these waters have been recently ventilated through surface processes in a neighboring region and are subsequently advected into the observed area.” ...**

**This part is the occasion to discuss more the localized ventilation at approximately 80 km along the glider’s track, mentioned at the line #201, that was not much discussed and could be highlighted there.**

We have added the following description as suggested: ‘Localized features, such as the subsurface eddy described in Sec. \ref{subsec:3.1}, can trap and transport recently ventilated waters to depth over small horizontal scales. While this event reflects ventilation associated with the eddy, it is also possible that these waters were ventilated through surface processes in a neighboring region and subsequently advected into the observed area.’

**# Shear driven vs front induced, in section 3.4 and 4.1**

**In Sections 3.4 and 4.1, I found it difficult to understand the criteria used to distinguish the processes at 630 km and 660 km, given that both locations are associated with low  $Ri$  and high FSLE. Is the distinction based on the weaker POC signal at depth for the front-induced case (Fig. 8b), or more simply due to the geometry of the glider path (e.g., more cross-front sampling at 630 km vs. more along-flow sampling at 660 km) ? I suggest clarifying this distinction in Section 3.4, so that the discussion in Section 4.1 is more clearly aligned with the synthesis presented in Fig. 8.**

Thank you. To to clarify and align the messaging we have added the following pieces of text:

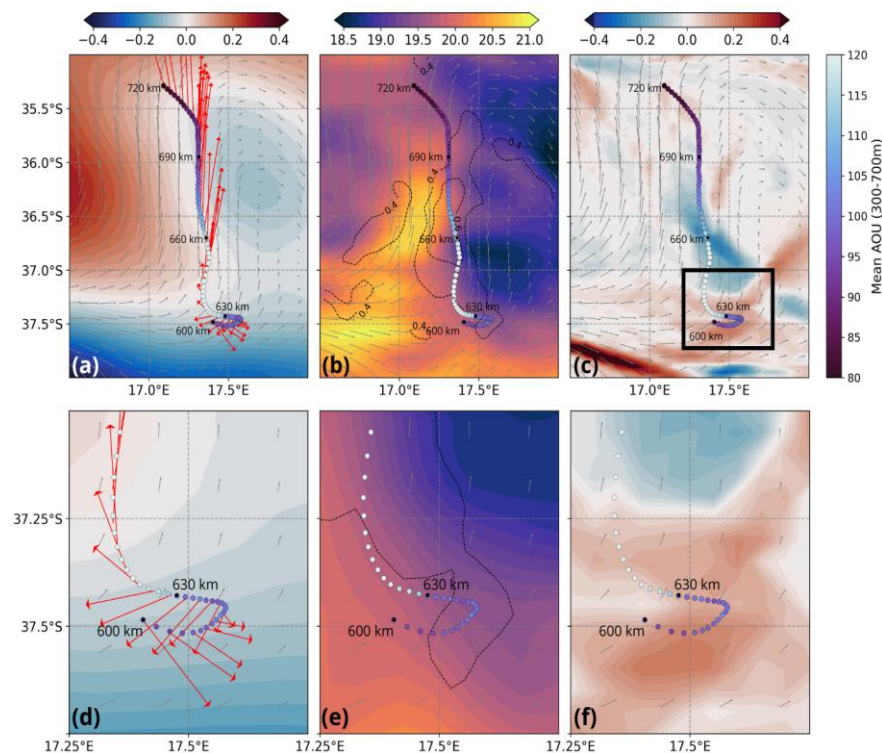
added: *‘The glider samples across sharp SST gradients of approximately  $0.6\text{ }^{\circ}\text{C km}^{-1}$ , as indicated by the dashed contour lines in (Fig. 7b), crossing the edges of small-scale cyclones and anticyclones.’*

added: *‘This cross-structure sampling captures vertical transport of tracers across density layers  $25.7$  to  $26.5\text{ kg m}^{-3}$  (Fig. 6), consistent with shear instabilities driving localized diapycnal transport (Fig. 5).’*

added: *‘In contrast, beyond  $660\text{ km}$ , the glider primarily follows the edge of a mesoscale eddy and moves along the front. In this regime, vertical tracer transport occurs primarily along tilted isopycnals, rather than through across-isopycnal mixing. The glider is following a path along the edge of the secondary cyclone that is aligned with sharp SST gradients of approximately  $0.6\text{ }^{\circ}\text{C km}^{-1}$ , as indicated by the dashed contour lines in (Fig. 7b).’*

**In addition, a zoomed-in view of Fig. 7 might help support the description. For example, by adding a subplot showing the  $35\text{--}37^{\circ}\text{ S}$  range on top and  $37\text{--}38^{\circ}\text{ S}$  below, or by using a variable latitudinal grid to expand  $37\text{--}38^{\circ}\text{ S}$ , or by including a supplementary figure.**

We have now included a zoomed-in view between  $37 - 38^{\circ}\text{ S}$  to support the description of the glider crossing sharp SST gradients  $600 - 630\text{ km}$  and edges of small-scale cyclones and anticyclones  $630 - 660\text{ km}$ . References in the text have been adjusted accordingly, and the subcaption has been updated.



**Figure 7.** Glider-mission averaged fields (6 May-16 June) of (a) SLA, with red arrows representing the glider depth-averaged current, (b) SST, where the dashed contour lines indicate the temperature gradient and (c) FSLE. Panels (d–f) show zoomed-in views of the black box indicated in panel (c). Geostrophic velocities are represented with the grey vector field. Dots represent the glider trajectory and the color indicates the mean AOU between  $300$  and  $700\text{ m}$  depth.

## **# Fate of the ventilation**

**The manuscript describes episodes of low AOU and enhanced POC at densities around 27 kg m<sup>-3</sup> (~400 m depth), but it is not clear what their fate is further downstream across the basin. Could the authors elaborate on whether these water masses interact with other water mass types, and how (or if) they eventually connect to a branch of the AMOC?**

We have altered and added some text to make this more clear.

*‘As ventilated waters are advected downstream along isopycnals, the cumulative anomalies of high POC and low AOU are gradually reduced by remineralization and respiration. While this process is taking place, they can interact with surrounding water masses and contribute to the transport of heat, salt, and tracers toward other parts of the Atlantic, potentially influencing intermediate-depth circulation and branches of the AMOC (Beal et al., 2011; Capuano et al., 2018; R  hs et al., 2022).’*

**Some discussion of the potential spatial influence of these ventilation/export events would be valuable. For example, is there a region where FSLE signals are systematically more intense, indicating a persistent hotspot of this mechanism?**

*added ‘Regions of consistently high FSLE, as shown in Fig. 1c, coincide with elevated EKE and mark persistent ‘hotspots’ where strong mesoscale stirring and fronts are likely to subduct and ventilate waters, highlighting this particular area (the Cape Basin and particularly just west of the Agulhas Retroflection) as a region of potentially enhanced vertical transport.’*

**Is the process observed here specific to the Cape Basin, or does it occur more widely in the surrounding South Atlantic?**

*added ‘Although this study focuses on the Cape Basin, similar processes might occur in other regions with strong frontal dynamics, such as the Brazil–Malvinas Confluence. These areas remain the focus of active research. Integrating observational datasets with high-resolution models and emerging satellite missions, such as SWOT, might provide a more holistic view of ventilation and carbon fluxes across the South Atlantic.’*

**Finally, the manuscript could benefit from a short statement on the likely fate of the cumulative POC and oxygen anomalies generated by these events.**

*We have modified the text as per the comment (# Fate of the ventilation) above: ‘As ventilated waters are advected downstream along isopycnals, the cumulative anomalies of high POC and low AOU are gradually reduced by remineralization and respiration. While this process is taking place, they can interact with surrounding water masses and contribute to the transport of heat, salt, and tracers toward other parts of the Atlantic, potentially influencing intermediate-depth circulation and branches of the AMOC (Beal et al., 2011; Capuano et al., 2018; R  hs et al., 2022).’*

## **#142, Section 2.4.4**

**Please use Spiciness instead of Spice.**

Changed Spice to Spiciness

**#341**

**Tipo (double parenthesis for the citation to be corrected).**

Corrected, thank you.

**References section:**

**Some DOIs have inconsistent formatting.**

all double <https://doi.org/> are corrected