Reply to Referee #3

The manuscript analyses a temperature and salinity dataset, obtained from a mooring in the southern Adriatic, at seven depth levels from surface to bottom, from November 2014 to October 2019. With the help of additional data from ECMWF and Copernicus and the profiles of an Argo float, the authors describe the evolution of thermohaline properties in the water column, relating them to heat fluxes at the air-sea surface, and analyzing them towards other variables, such as mixed layer depth, relative vorticity and Turner angle.

Unfortunately, the study contains improper generalizations and some inaccuracies, already highlighted in particular by reviewer 2. Among these, the most serious is the recurring confusion between "predisposition to" and "occurrence of" salt fingering process, and a somewhat forced use of the Turner angle, compared to its original definition (Ruddick, 1983). Many arguments are based on this confusion and are therefore far from being proven valid.

Referee #3 (Ref. 3) is right when she/he says that with our vertically coarse mooring data only allows us to determine the "predisposition to" and not the "occurrence of" salt-fingering. However, to the best of our knowledge there is no long-term (multi-year), fine-resolution spatial and temporal data that could provide a definitive answer. Ref. 3 also refers to the work of Ruddick (1983), but Ruddick (1983) cites regions that are “salt fingering” when Turner angle (Tu) indicates this. Furthermore, Ruddick (1983) begins in line 2 with "The single most important external parameter that indicates the relative strength of double-diffusion is the gradient ratio ..." (the Tu is an amelioration of the gradient ratio and directly linked to it). In the rest of his work, especially in the last paragraph, Ruddick (1983) does not distinguish between "predisposition to" and "occurrence of". In our work, we are more cautious, corroborating our results with a high mixing coefficient, found in Cardin et al. (2020) and with staircase observations in the ARGO float data. We also complement Tu with vector length (VL), suggesting that salt fingering at high VL values are more prone to effectively produce salt fingering.
To acknowledge the comments of Ref. 3, we have now changed the assumption of occurrence to “favorable”, “predisposition” or “possible” conditions for salt fingering occurrence.

In my opinion, for possible publication, the work requires further analysis or a new goal setting, considering that double diffusion processes, and SF in particular, are the core theme of the present study.

Thank you for the feedback. We now consider that the Turner angle will point favorable or predisposing conditions of determined double-diffusion regime. We remain confident that the goal mentioned in the title: analyzing the SF and showing a tipping in 2017, is well argued in our paper.

Below are some comments in addition to what the other two reviewers have already noted.

Line 7. **The opening sentence of the abstract contains a dubious generalization. Perhaps salinity was confused with density?**

Thank you for pointing this. We are referring to double-diffusion processes that occur due to differences in the diffusivity coefficients, not general instability caused by density gradients. We rephrased the sentence.

Line 7: "In double-diffusive mixing, whenever salinity and temperature decrease with depth, the water column is either unstable or favorable to a state called salt fingering (SF)…"

Line 41. **Durante et al. (2019) did not use Argo data but CTD profiles from cruises. A more appropriate reference for this topic is Taillandier et al. (Biogeosciences 17, 3343–3366. doi: 10.5194/bg-17-3343-2020) who used CTD and ARGO profiles, from the Tyrrhenian Sea and the Algerian Basin.**

Thank you for pointing this mistake. We fixed the text and included the new reference.

Line 43: Durante et al. (2019) used a longer time series of CTD casts and Menna et al. (2021) analyzed years of Argo data profiles in the Tyrrhenian and Ionian/Levantine Seas, respectively, with the temporal resolution of the analyzed data ranging from weeks to months. Taillandier et al. (2020) used a combination of about 700 CTD and Argo floats profiles collected from 2013 to 2017 to study thermohaline staircases related to double-diffusion in the Western Mediterranean sea.

Line 93. "In order to explore if the water column was undergoing double-diffusive convection and its related local stability we estimated the Turner angle". Wrong approach: with Tu you only evaluate whether the water column is inclined to a given regime and do not demonstrate its actual presence.

The Turner angle is the principal indicator to determine if a predisposition to SF exists, so our approach is correct. We agree that the wording was not precise and now changed the sentence to:

Line 98: In order to explore if the water column was favorable to double-diffusive regimes and its related local stability possible condition we estimated the Turner angle (Tu) defined following Eq.(1):

Line 95. Equation 2: missing brackets make the formula incorrect

$$Tu = tan^{-1}\left(\frac{\alpha\partial\theta}{\partial z} - \frac{\beta\partial S}{\partial z}, \frac{\alpha\partial\theta}{\partial z} + \frac{\beta\partial S}{\partial z}\right);$$

Thank you. Fixed.

Line 106. A reference is missing for the vector length (VL). If it is your original introduction of a new analysis parameter you must explain it better.

Thank you, we consider VL a new analysis parameter. It was and is written in the paper:

Line 114: "To the best of our knowledge the VL has not been discussed in connection with stratification and the Tu."

we now added:

Line 116: A water mass is characterized by (θ, S), its potential temperature and salinity. The variables (Tu, VL) are simply the polar coordinates in (θ, S) space. It is Tu that determines the stability regime and VL the significance.

Lines 118-120. **Can you explain better how you calculate geostrophic velocities and RV? Which dataset do you use? Perhaps something should be guessed from the figures A2-A7, but these also require some explanation.**

The surface geostrophic velocities were obtained from the Copernicus Marine Service, SEALEVEL_EUR_PHY_L4_MY_008_068 product. We added to the text.

Line 125: Surface relative vorticity was defined following Eq. (3):

($RV = \frac{\partial v}{\partial x} - \frac{\partial u}{dy}$),

where u and v are surface geostrophic velocities (SEALEVEL_EUR_PHY_L4_MY_008_068 product; Copernicus Marine Service) in an area limited by the isobath of 1150 dbar. The RV is the average of 18 grid points around the mooring position with 0.125° spatial resolution.

Line 263. **Instead of Durante et al. (2019), I would cite Durante et al. (2021, Front. Mar. Sci. 8:672437. doi: 10.3389/fmars.2021.672437) which is more appropriate in the context of fluxes.**

Thank you and we accepted the suggestion.