Review of the paper "Tracers confirm downward mixing of Tyrrhenian Sea upper waters associated with the Eastern Mediterranean Transient" by W. Roether and J. E. Lupton

by Stefania Sparnocchia (Referee)
stefania.sparnocchia@ismar.cnr.it

General comments

The paper by Roether and Lupton is a contribution to the understanding of recent changes observed in the Tyrrhenian Sea as a consequence of more general changes induced by climatic variation, affecting primarily the Eastern Mediterranean Sea. The paper confirms, first, what was already evidenced by other authors but with a novel approach, never applied in this basin before, and based on analysing isotope tracers. From this analysis an estimate of the time scale of deep sea mixing is also given. This is what makes the paper interesting for publication in Ocean Science, what I recommend, providing the following changes are done. I cannot objectively evaluate the methods applied, since my expertise doesn't include the chemistry and use of isotopes in marine circulation studies.

Specific comments

1) The cited observations of cascading (eg. pages 1536 line 11, 1545 line 11) on the northern slope of Sicily in the southern Tyrrhenian up to about 2000 m and related analysis of the mixing with resident water, commented by Millot (1999) in his review of circulation patterns in the Western Mediterranean, is from Sparnocchia et al. (1999, same volume of Millot's review) and should be corrected. The full reference is the following:

   Sparnocchia, S., Gasparini, G.P., Astraldi, M., Borghini, M., and Pistek. P.: Dynamics and mixing of the Eastern Mediterranean Outflow in the Tyrrhenian basin. J. Mar. Syst., 20, 301-317, 1999.

2) A few more words should be spent on the hydrological data in the "Data and Methods" section. For instance, the type of CTD in each cruise considered, if data are from vertical profiles or from bottles. Generally, using profiles is preferred than using bottle data, if/when they are available. Please, justify why in some cases they are not used/available. Also, the availability of CFC-12 data is not specified.

3) Fig. 3 is hard to read. To help the reader comparing different stations, I suggest to mark the same depth levels (e.g. 500, 750, 1000, 1250, 1500, …, bottom) at least in the stations where profile data are referred to in the text.

4) I agree with Artale's comment regarding the reference to a staircase structure in the caption of Fig. 3. The reference here is not clear, why exactly do the authors highlight this feature? and what does it mean in term of their mixing considerations? It seems they are noting the staircase structure in the 2007 CTD profile as an anomaly, but staircases are very common in this area, especially far from the area of ingression of the water from the Strait of Sicily. Probably, if they look at the CTD Temperature and Salinity profiles in station 786/87, they will also find staircases there. We have found a staircase structure in our measurements made in 1993 (Sparnocchia et al., 1999) downslope the cascading path. Unfortunately, we didn't show any profile in that paper, so I'm including at the end of this letter a Figure showing this structure.

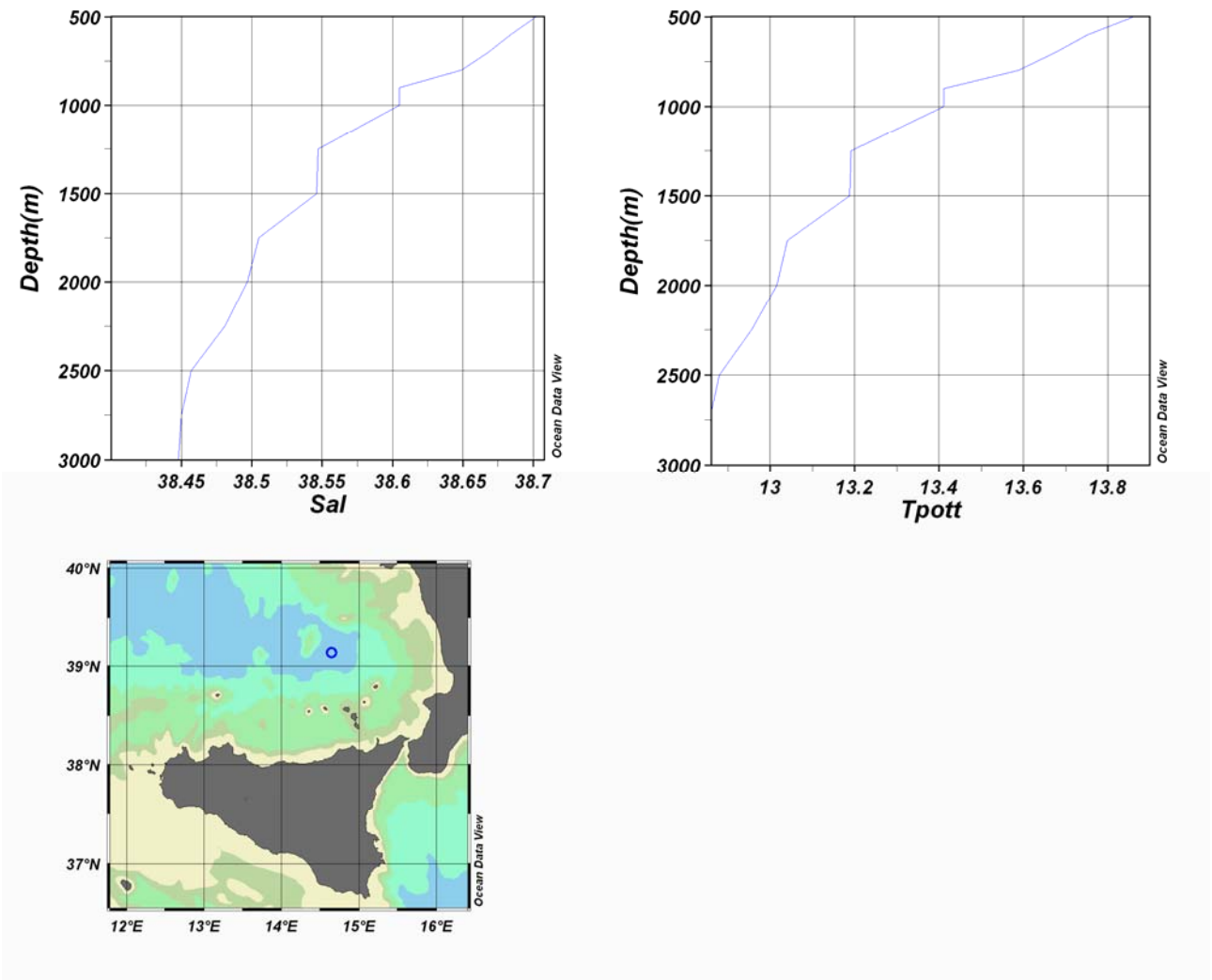
   In the same paper, we have discussed the along-path mixing of the vein coming from the Eastern Mediterranean and entering the Tyrrhenian Sea. In particular we have focused on two mixing phases. The first occurring during the cascading, immediately after the entrance in the basin and until the denser tEMDW reaches a buoyancy equilibrium above the underling resident TDW, when the second phase starts. The first phase accounts for the greater and faster changes in the T/S properties, and occurs in a zone where the bottom slope is very steep. These are mainly due to turbulent mixing of the deep vein with ambient water encountered along its path while cascading. The second phase was related to double diffusion processes between the warm and salty tEMDW and the colder and less salty TWD (salt fingering). Staircase structure in T/S profiles are typical expression of these last processes in action. Moreover, I think that the cascading at the entrance of the Tyrrhenian Sea is also a normal process there, more or less energetic depending on the density difference among the water coming from the Strait of Sicily, and the resident one. I suggest the authors take a look to our paper, too, and to use some more arguments on the processes working along-circuit in the cyclonic path in the Tyrrhenian Sea when they interpret their results in section 4.

5) I suggest to substitute the term “convection”, frequently used in section 4 to indicate the transfer of water along-slope by cascading in the deep layer of Tyrrhenian Sea, with a more general “mixing” associated with the cascading process (technically it can be termed a turbulent eddy-mixing).

6) Page 1537, line 9: Gasparini et al. (2005) estimated a mean value of 0.3 Sv in the period 1990-2000, and not in the period 1988-1994, as the authors are indicating. The following comment at page 1542, lines 1 to 7 needs also to be better explained.

Technical corrections

1) Page 1538, section 3 Data and methods, line 11: “5%/0.08 TU”, use “5% or 0.08 TU” as done in line 8.
2) Fig. 3, y-axis label: if you use Kg/m3, tick-marks are values+1000. You can use as label “density (Sigma_2-units)”, so thick-marks are correct.
3) Page 1536 line 11, insert a dot between 7 and 10^4.



Vertical profiles of Salinity and Potential Temperature in the southern Tyrrhenian sea measured during PRIMO93 cruise (Sparnocchia et al., 1999) showing a typical “staircases” structure.