

Reviewer 1

The discussion in the paper is clear and well-organized, and the results should be of good practical use to other researchers using CTD data to estimate mixing. However, given the emphasis on validating the Thorpe scale, it seems a bit narrow in scope to limit the discussion only to one method. It would be useful to know how the Gargett and Garner validation method performs compared to the van Haren and Gostiaux (2014) criterion of the z/d ratio. Also, since temperature CTD data tend to be considerably less noisy than density, if good results could be achieved by identifying overturns in the temperature profiles rather than the density profiles, or if salinity compensation made such an approach impractical.

Thank you for letting us know the interesting new method of van Haren and Gostiaux (2014). In the revised version we have inserted a new subsection 5.1 where we compare the performance of this method in comparison with our approach. We have emphasized there that temperature profiles cannot be used in our case of the upper layer of the Antarctic zone where the temperature is unstably distributed due to the presence of the subsurface T_{min} at about 200 m and T_{max} at about 700 m.

5.1 Comparison with a displacement shape method

Recently, van Haren and Gostiaux (2014) suggested a new method of discriminating various overturns and intrusions via inspection of displacement (d) shapes in a d - z plane. They showed that depending on the displacement slopes z/d , the true overturns can be categorized into different types of vortex, such as most frequent half-turn Rankine vortices ($1/2 < z/d < 1$) and rather rare full-turn Rankine vortices ($z/d \sim 1$) or solid-body rotations ($z/d = 1/2$). These authors recommended to use temperature profiles rather than density profiles if salinity-compensating intrusions are negligible, because the density profiles are much noisier thus cause an overestimate of turbulence parameters. They mentioned also that more or less equivalent results (within a factor of 1.5) may be obtained with the density data only by imposing a limit of discarding density variations smaller than $1 \times 10^{-3} \text{ kg m}^{-3}$, twice the expected noise level.

In our case of the upper layer of the Antarctic zone the temperature is not an adequate parameter for investigating overturns because of its unstable vertical distribution, with a gradual temperature increase with depth from the Winter Water ($T_{min} < 2^\circ\text{C}$) centered at about 200 m to the Upper Circumpolar Deep Water ($T_{max} \sim 2.3^\circ\text{C}$) centered at about 700 m (Park et al., 2014). Then, we have tested the method using corrected density profiles after discarding density variations (relative to sorted density profiles) smaller than the proposed limit of $1 \times 10^{-3} \text{ kg m}^{-3}$ by van Haren and Gostiaux, (2014).

An example of the test is given in Fig. 7 for station A3-1 already discussed in Figs. 3 and 4 and where there exist four clear density spikes (red arrows). van Haren and Gostiaux (2014) previously remarked that discarding density variations $< 1 \times 10^{-3} \text{ kg m}^{-3}$ unfortunately limits the use of investigating the shape of displacements. Consistent with this remark, discriminating various types of overturns by inspection of displacement shapes does not appear very obvious (Fig. 7b). Nevertheless, we observe that the most significant displacements appear mostly in the vicinity of the above four density spikes, with a rather marked asymmetry between positive and negative displacements. As before, the mixing rates have been estimated using the Shih parameterization (Eq. 6) and the Thorpe scales L_T of identified overturns. The red line in Fig. 7c illustrates the resultant diffusivities averaged over intervals of 10 m, in comparison with those from our best approach of the Thorpe scale method (using intermediate density profiles and applying the overturn ratio criterion $R_o = 0.25$ and the Shih parameterization: black line) and the TurboMAP measurements (blue line). Note that the latter two lines are borrowed from Fig. 4c. Compared to our best approach and the

TurboMAP data, the displacement shape method yields in many places comparable diffusivities within a factor of 2, but with a great exception in the vicinity of the above four density spikes where we observe a significant overestimation (relative to the TurboMAP data) by as much as an order of magnitude. This indicates that in great contrast to our approach, the displacement shape method does not able to discriminate the false overturns associated with apparent density spikes (caused probably by a mismatch between the temperature and conductivity sensors), the major cause of most false overturns in the oceans (e.g., Galbraith and Kelley, 1996; Gargett and Garner, 2008).

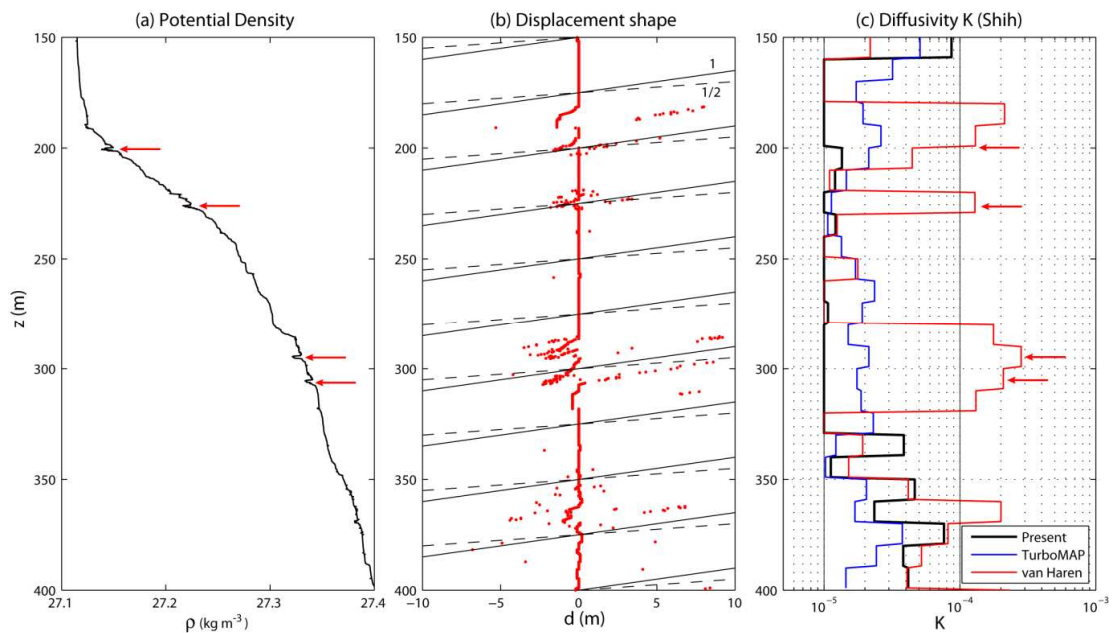


Fig.7. (a) Potential density profile in the 150-400 m layer at A3-1, with four clear density spikes being indicated by red arrows. (b) Displacement points (red dots) computed from corrected density data after discarding density variations smaller than $1 \times 10^{-3} \text{ kg m}^{-3}$. Displacement slopes $z/d = 1$ (solid) and $z/d = 1/2$ (dashed) are superimposed. (c) Diffusivity profile estimated from the displacement shape method (red) in comparison with those from our best approach (black) and TurboMAP data (blue), all using the Shih parameterization. See the text for more details. Red arrows indicate the location of the density spikes seen in (a).

Some minor technical edits:

Pg. 12143, Line 15: need the "The" in front of Gargett and Garner or the "s" after, but not both.

Yes, corrected as "The Gargett and Garner method". Thank you.

Pg. 12144, Lines 20-25: I found the wording here confusing. The text speaks of suspect overturns "passing" the $R_0=0.2$ and/or 0.25 criteria, which sounds as if the overturns were validated, when they were actually flagged as false. I'd say an overturn with $R_0 < \text{threshold value}$ fails the validation, not passes it.

We agree with you that the phrases we made are quite ambiguous. In the revision we have restated the phrases as following:

“The overturns associated with first two spikes near 200 and 225 m have R_o values between 0.2 and 0.25 (Fig. 3c), thus can be considered as false overturns according to the ($R_o =$) 0.25 criterion, whereas the 0.2 criterion might have validated them as true overturns. The third spike just above 300 m has a R_o value much smaller than 0.2, thus can be easily discriminated as a false overturn even by the more stringent 0.2 criterion. The fourth spike just below 300 m reveals a R_o value so close to 0.25 that the 0.25 criterion appears to be absolutely necessary for invalidating the prospect overturn.”

Pg. 12146, Line 14: no need for "the" in front of "unity". Line 17: should be "prevents detection of". Line 26: should be "much more reasonable agreement". Line 27: again, no "the" in front of "unity".

Yes, corrected.