We would like to thank the reviewer for the time and effort spent reading our manuscript, and for the comments which have improved the manuscript significantly. A detailed response to all comments can be found below, where the blue text indicates our response to the reviewers' comments, which are denoted in black. Line numbers correspond to the revised manuscript.

Comments by the reviewer:
This paper tackles the worthwhile problem of identifying and characterizing double-diffusive staircase structures in ocean temperature and salinity profiles. Unfortunately there are fundamental shortcomings of the work.

Without seeing representative profiles (from different regions), it is impossible to determine the extent to which the algorithm works. Figure 6b provides clues that it maybe appropriate sometimes for the identification of salt-finger layers, although there are profile regions that appear to indicate steps which are not colored red (and it is unclear why). It would be helpful to be given some information about where the profiles are, and shown the detailed T-S structure.

The algorithm does detect thermohaline staircases not only using profiles of conservative temperature, but also using potential density and absolute salinity. Therefore, it is not always clear from conservative temperature profiles why a step is disregarded. To be more transparent about this selection, we added 3 figures in the Appendix of the revised paper with representative profiles of three well-known formation regions: the Arctic Ocean, the Mediterranean Sea, and the western tropical Atlantic Ocean. In these figures, we show the different steps of the algorithm. We also added the figures at the end of this reply.

Figure 6a is clearly showing that the algorithm is not working. The algorithm appears to have picked up the thermohaline intrusions underlying the double-diffusive staircase. One can see this immediately because of the regions that are deeper than the temperature maximum are marked blue. I would encourage the reviewers to examine some papers on the Arctic staircase and compare and validate their results against those. Similarly, the reader needs to see detailed profiles and validation.

Apparently, the algorithm was not clearly explained in the original paper and we use this comment to better explain the working and results of the algorithm (below and in the revised paper).

The algorithm detects stepped structures from vertical profiles of conservative temperature and absolute salinity. This implies that the algorithm can also detect mixed layers arising from thermohaline intrusions. Therefore, we added a paragraph to the introduction to discuss the origin of thermohaline staircases:

> *Lines 17-23:*
> *'It is still a topic of discussion how double-diffusive convection leads to the formation of thermohaline staircases in oceanic environments (Merryfield, 2000). For example, Stern (1969) argued that small-scale mixing processes trigger the formation of internal waves. On the other hand, variations in the turbulent heat and salt fluxes (Radko, 2003) or in the counter-gradient buoyancy fluxes that sharpen density gradients (Schmitt, 1994) could also lead to the formation of thermohaline staircases.*

Lastly, subsurface mixed layers can also arise from thermohaline intrusions (Merryfield, 2000). Although it remains unclear how these staircases arise, these studies agree that the formation of these subsurface mixed layers are related to double-diffusive processes.'

We also added a sentence to highlight the benefit of using a detection algorithm based on the vertical structure, such that the Turner angle can be used for validation:

Lines 74-75:
'The benefit of using the vertical structure, instead of using assumptions based on the Turner angle, is that we can use this angle to verify the results.'

We want to emphasize that our results show that most detected staircases are within double-diffusive regimes (Fig. 6). This suggests that we predominantly detect double-diffusive thermohaline staircases. However, similar to any other detection of thermohaline staircases, we cannot determine whether the origin of a subsurface mixed layer in double-diffusive regimes arises from thermohaline intrusions or from double-diffusive mixing. We added a paragraph to Section 3 and rephrased two sentences in the abstract and introduction to clarify this.

Line 1:
'Thermohaline staircases are associated with double-diffusive mixing.'

Lines 12-14:
'They are associated with double-diffusive processes, which in turn result from a two orders of magnitude difference between the molecular diffusivity of heat and that of salt (Stern, 1960).'

Line 167-174:
'Figure 7a also indicates that the deepest mixed layer of some thermohaline staircases is located at the temperature maximum, which suggests that this lowest layer might be the result of thermohaline intrusions (Ruddick and Kerr, 2003). There, the algorithm identified a mixed layer, because temperature and salinity stratification were weak enough (see Section 3.1). Furthermore, both conservative temperature and absolute salinity in this mixed layer are larger than in the mixed layer above. While both are typical for a staircase in the diffusive-convective regime, the algorithm does not detect whether this mixed layer is a temperature maximum, which could indicate that arose from thermohaline intrusions. Note that this only concerns the deepest mixed layers of the staircases, and that only the characteristics of the interfaces in between mixed layers are labelled as part of a staircase by the algorithm.'

Furthermore, we would like to note that it is difficult to design a staircase detection algorithm that is optimized for all staircase regions, due to large variations in the height of the mixed layers and temperature and salinity steps of the interfaces. In this global dataset, we aimed to optimize the global detection, such that we detect thermohaline staircases in all well-known formation regions. To show this in a transparent way, we added figures of representative profiles (Figure A1, A2, A3), and added a paragraph to the conclusions to discuss this issue.

Lines 260-268:

'We optimized the input of the algorithm such that it provides a global overview and limits the number of detected false positives. As a result, the regional verification in Section 5 indicated that the data pre-processing and data analysis have some limitations. For example, the vertical resolution of 1 dbar in the profiles is too course to capture all staircase steps in the Arctic Ocean. In the Mediterranean, the Argo floats did not dive deep enough to capture the full depth of the staircase region. However, the fact that (i) the algorithm detects thermohaline staircases at realistic depth ranges, with (ii) conservative temperature and absolute salinity steps across the interfaces, and in (iii) the same double-diffusive regime as previous studies (Table 3-Table 5), indicates that the algorithm itself performs well. Therefore, when considering an individual staircase region, we recommend optimizing the input variables of the algorithm for that specific region and applying the algorithm on additional data, for example high-resolution CTD or microstructure profiles, where available.'

(As an aside, potential temperature should be used when ex-amining step structures in deep water and the authors ought to compare profiles of potential temperature and temperature through deep staircases.)

It is not entirely clear to us why the reviewer insists that potential temperature should be used when examining step structures in deep water. We prefer to use conservative temperature over potential temperature, because thermohaline staircases are predominantly studied for their heat and salt fluxes through the interfaces. In contrast to potential temperature, conservative temperature can be regarded as a conservative variable and can be accurately used for computations regarding the heat content (Graham and McDougall, 2013). For further details on the conservative temperature, we refer to Graham and McDougall (2013):

Graham, F. S., & McDougall, T. J. (2013). Quantifying the nonconservative production of Conservative Temperature, potential temperature, and entropy. Journal of Physical Oceanography, 43(5), 838-862. https://doi.org/10.1175/JPO-D-11-0188.1

To clarify that we use conservative temperature instead of potential temperature, we replaced 'temperature' by 'conservative temperature' and 'salinity' by 'absolute salinity' throughout the manuscript.

Furthermore, we added a sentence to motivate the usage of conservative temperature:

Line 63-64:
'Note that we use conservative temperature as this is more accurate than potential temperature in computations concerning heat fluxes and heat content (Graham and McDougall, 2013).'

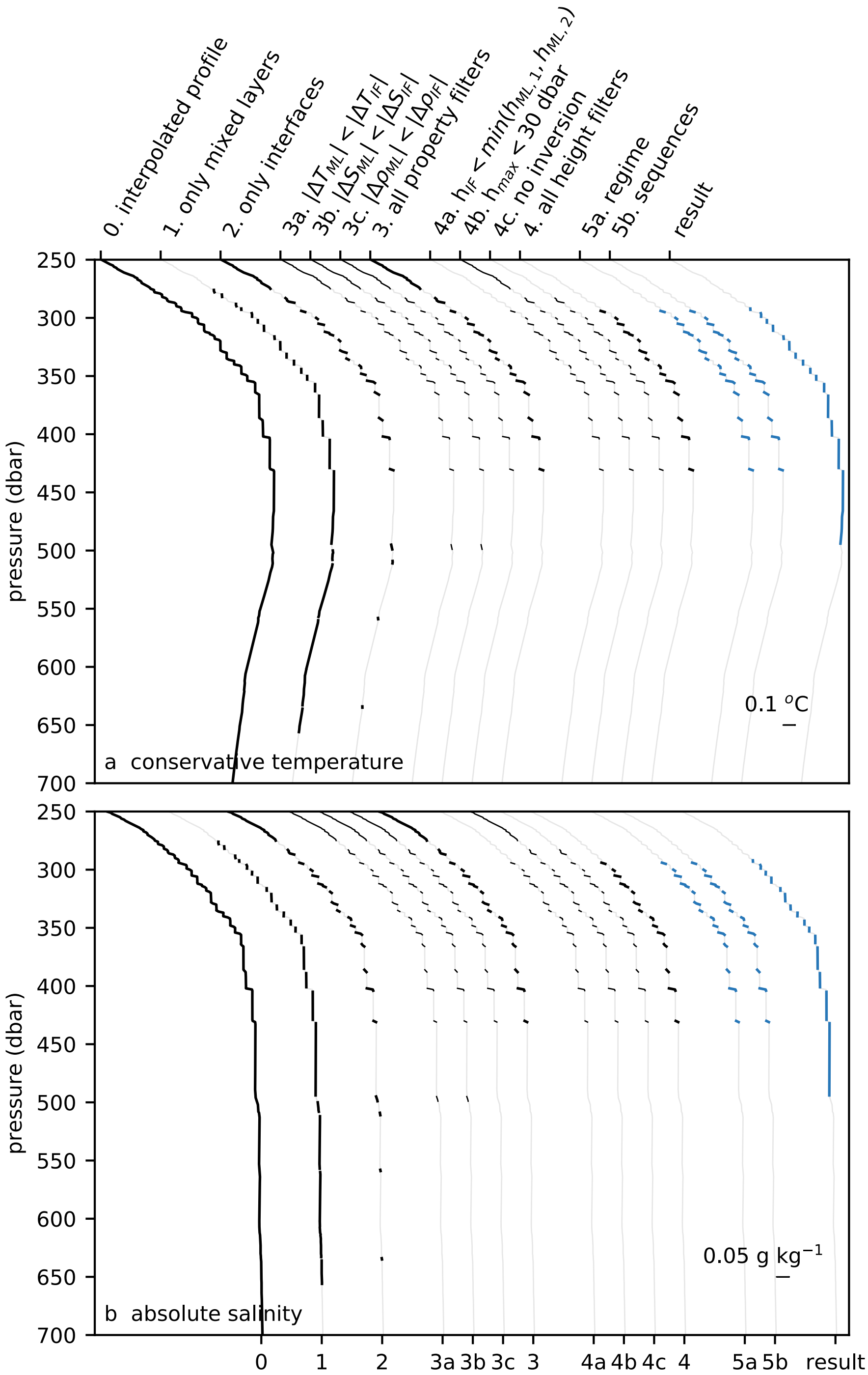

Figure A 1 Steps of the detection algorithm applied on a profile in the Arctic Ocean, where steps are indicated on separate (a) conservative temperature and (b) absolute salinity profiles. Each profile is shifted for clarity. Similar to Figures 3-5, an interface is not considered by the detection algorithm when the interface characteristics did not meet the requirements of a previous step. Original profile is taken from Ice-Tethered-Profiler ITP64 at 137.8°W and 75.2°N on 29 January 2013. The details of the pre-processing and the algorithm steps are discussed in Section 2 and Section 3, respectively.

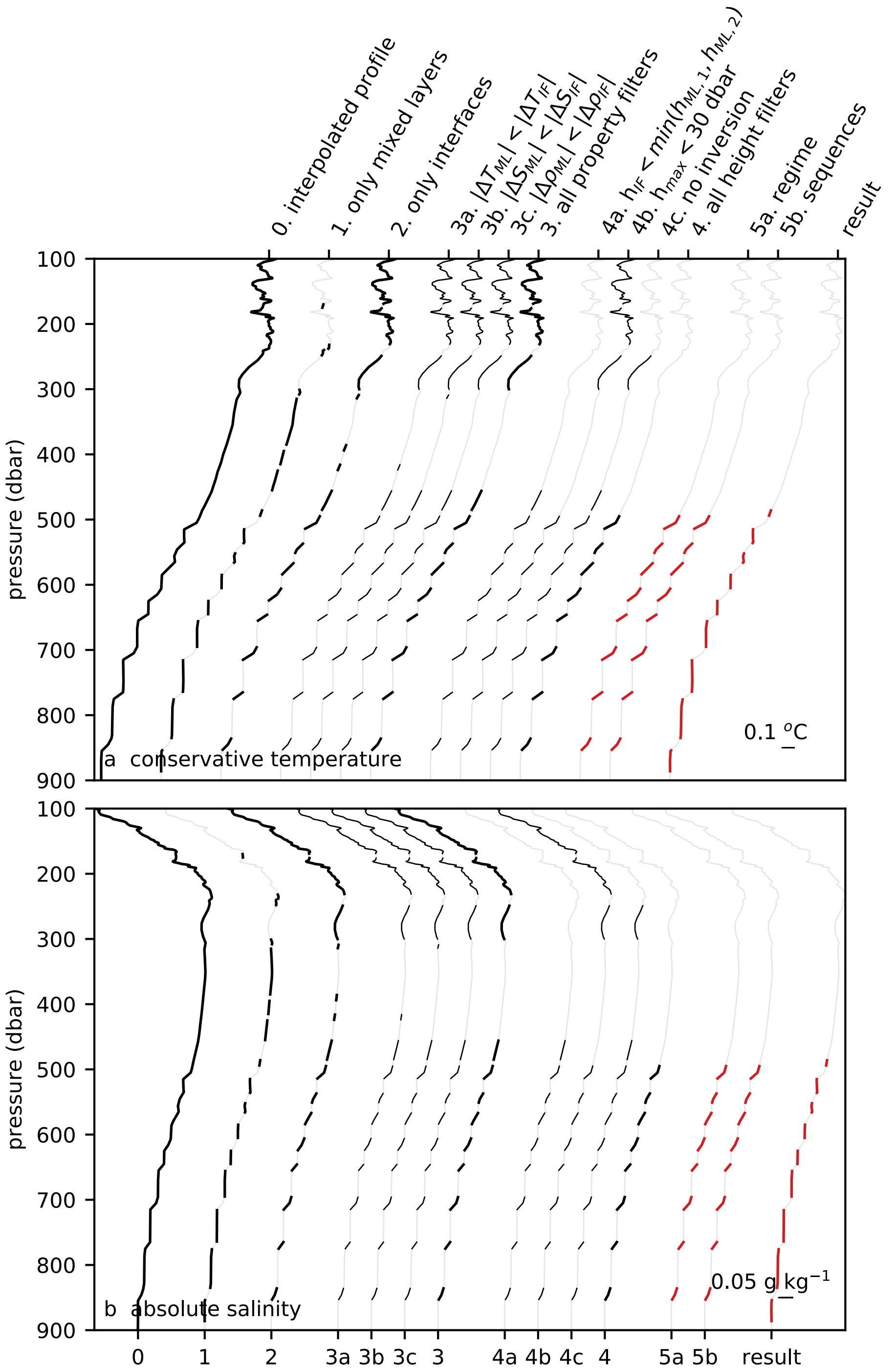

Figure A 2 as Figure A1, but for a profile in the Mediterranean Sea. Original profile is taken from Argo float 6901769 at 8.9°E and 37.9°N on 31 October 2017.

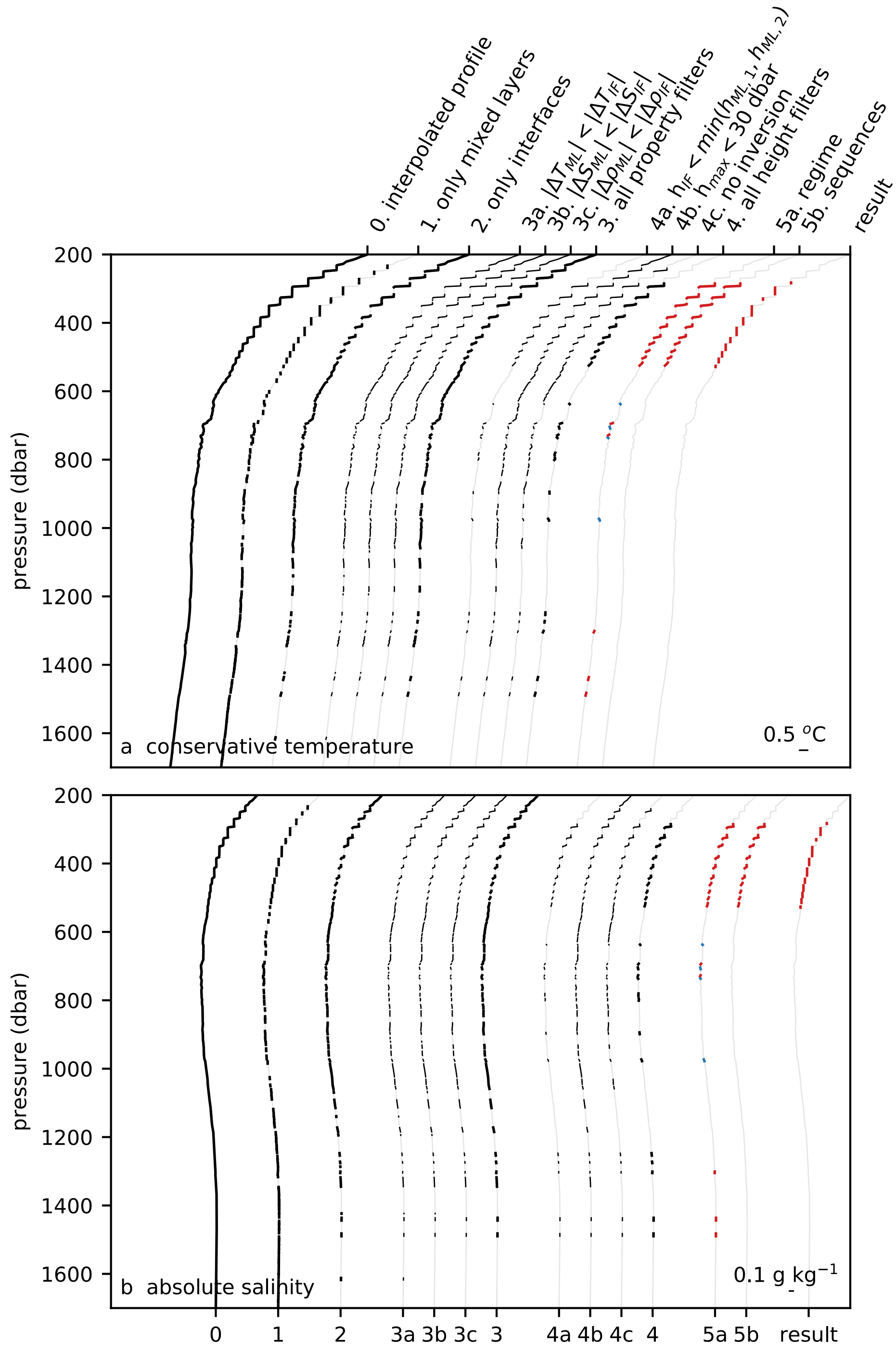

Figure A 3 as Figure A1, but for a profile in the western tropical North Atlantic. Original profile is taken from Argo float 4901478 at 53.3°W and 11.6°N on 9 August 2014.