

The global impact of thermohaline staircases

Double diffusive mixing results in the formation of thermohaline staircases that consist of a sequence of mixed layers that are separated by gradient layers (Fig. 1).

Although approximately 44% of the ocean is susceptible to double diffusive mixing, the contribution of double diffusive mixing to the global mixing energetics remains unknown.

We developed an algorithm to detect thermohaline staircases and used it to obtain a global overview of regions where double diffusive mixing dominates over turbulent mixing.

Using this overview, we estimate the contribution of double diffusion to the global energy budget. We find that the enhanced mixing by double diffusion has a minor contribution to the global mixing energetics. Despite this limited contribution, we also find new 'staircase regions', which potentially impacts the global circulation.

In this document, we explain the detection algorithm. Please contact us if you have any questions regarding the algorithm or results of this study.

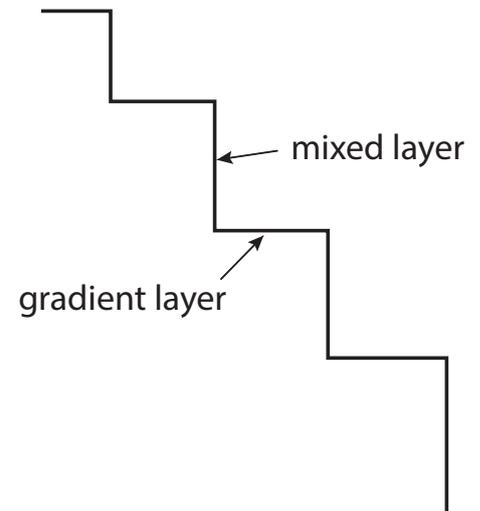


Figure 1: Schematic of a vertical temperature profile with a thermohaline staircase.

Staircase detection algorithm:

The goal of the detection algorithm is to identify stepped staircase structures in the vertical profiles (Fig. 2).

Algorithm steps:

1. Identify mixed layers
2. Identify gradient layers
3. Identify double diffusion regime
4. Sequences of mixed layers

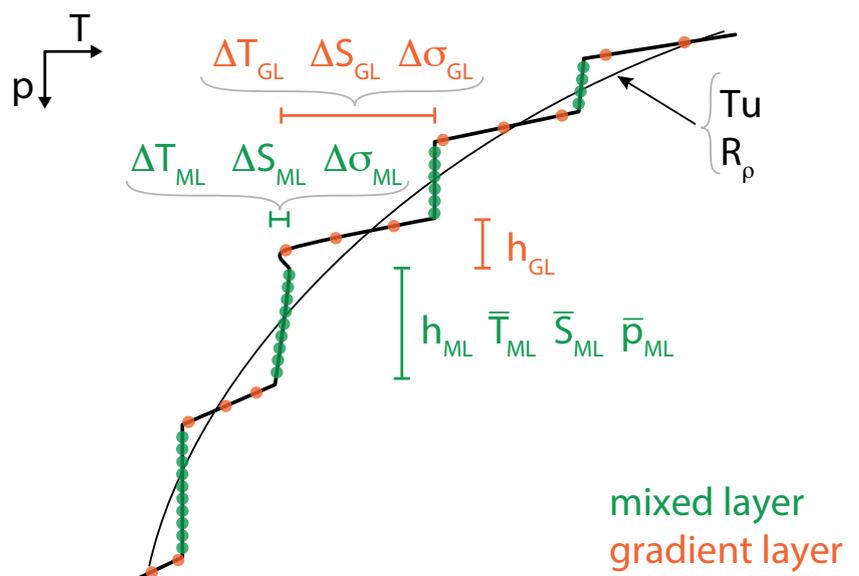


Figure 2: Schematic of staircase detection scheme and saved variables

Global dataset:

To obtain a global dataset, we apply the staircase detection algorithm to Argo floats and Ice Tethered Profilers from 2002-2020. In total, 483.301 profiles are analysed (Fig. 3), of which 10 percent contains thermohaline staircases. (Fig. 4). Some examples are shown in Figure 5.

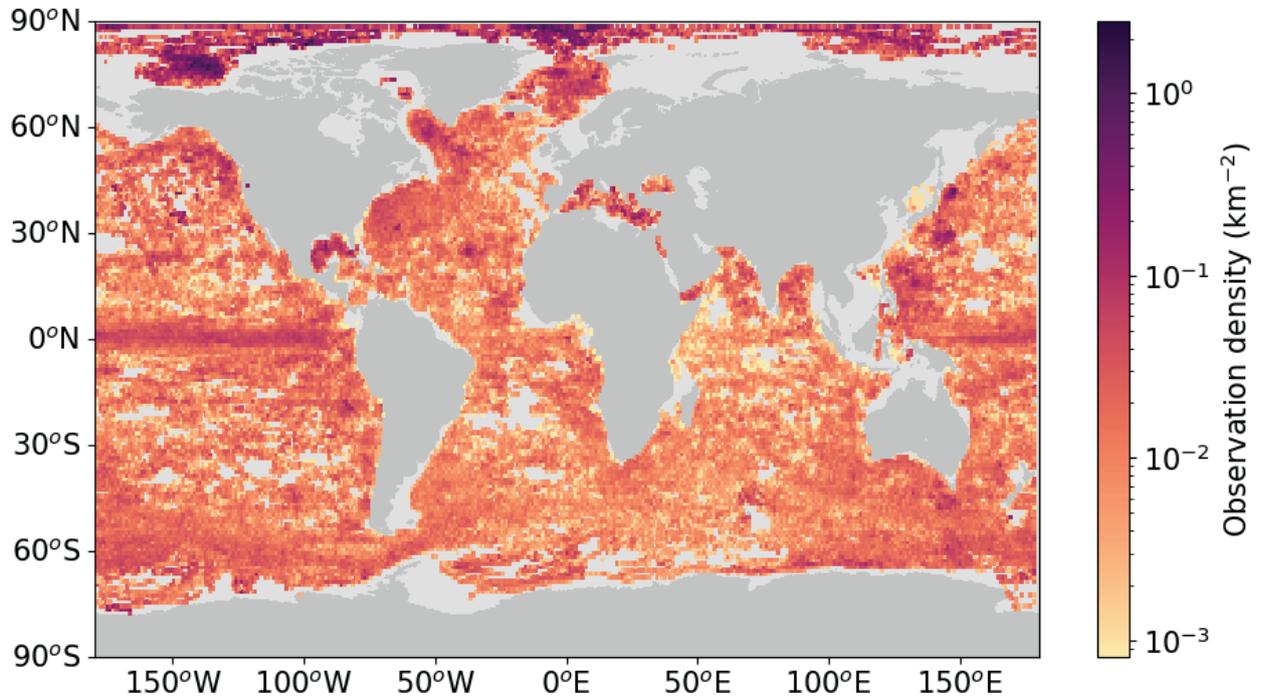


Figure 3: Number of observations per km². All values are averaged per degree². Note the logarithmic scale.

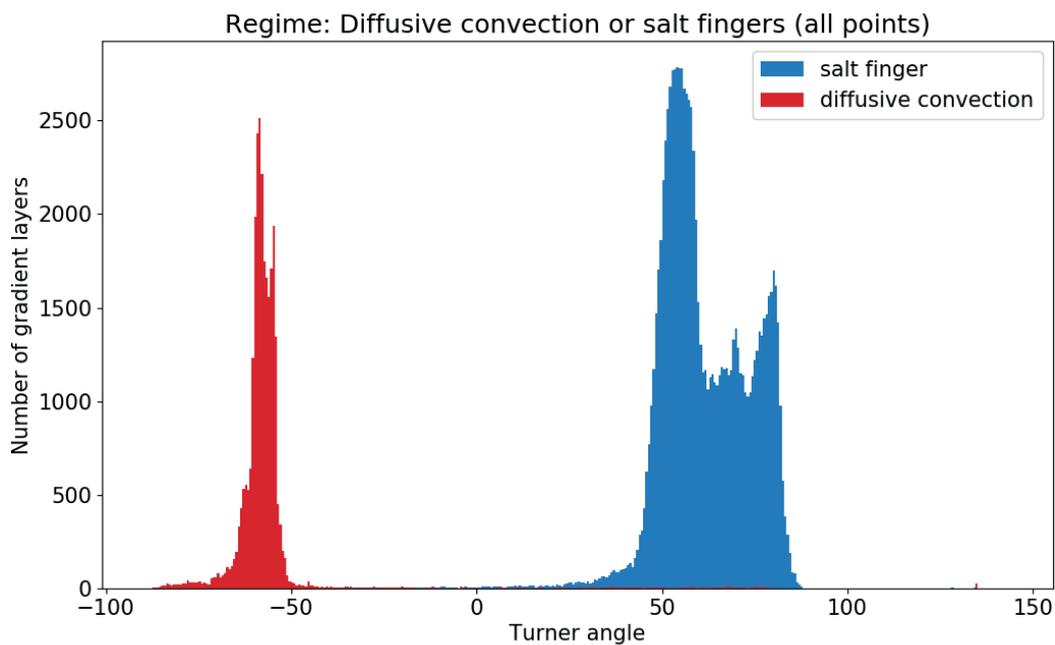


Figure 4: Mixed layers that are identified by the staircase detection algorithm as a function of the Turner angle.

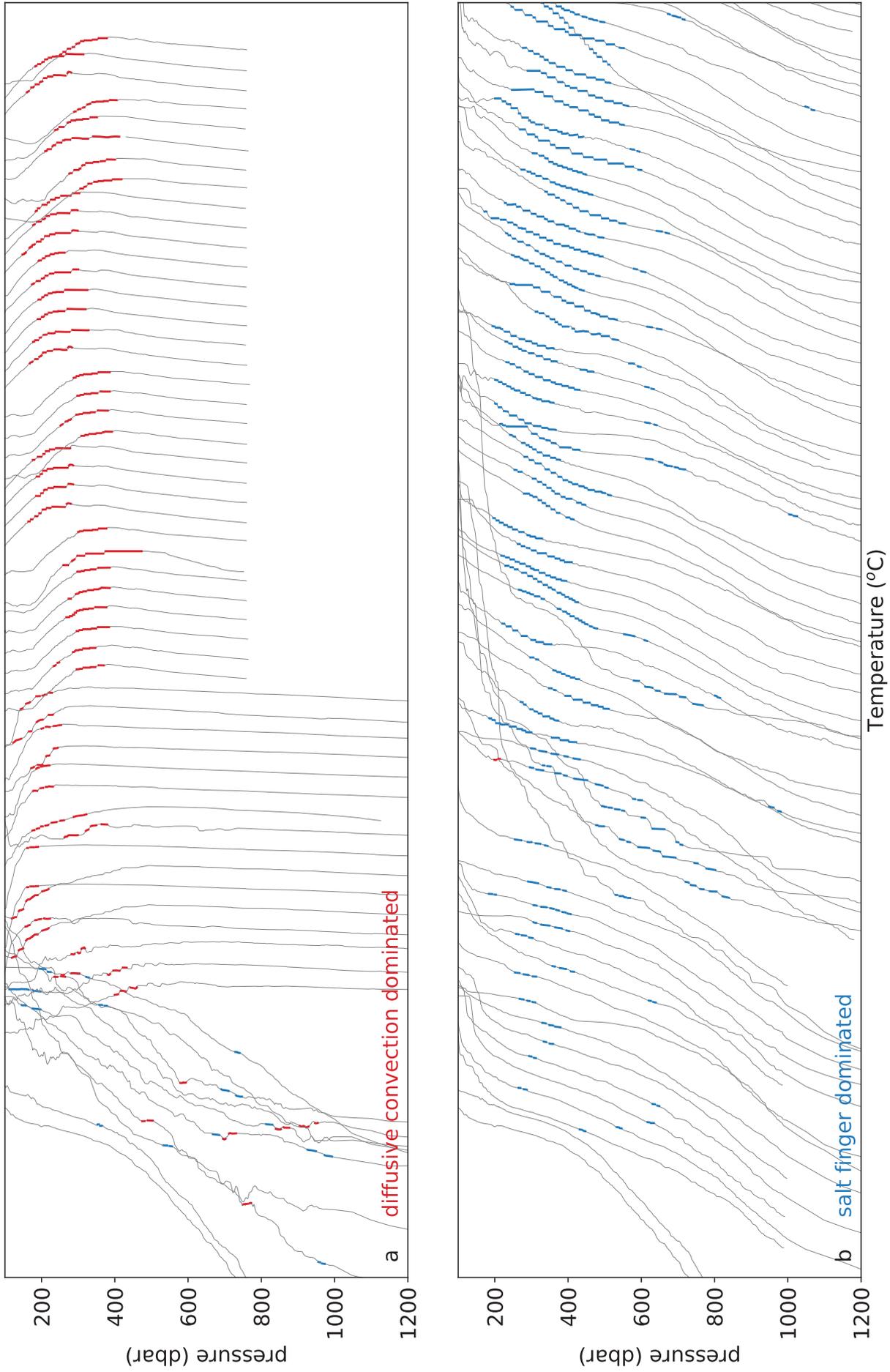


Figure 5: Some examples of temperature profiles with thermohaline staircases. The detected mixed layers are highlighted in red (diffusive convection regime) and blue (salt-finger regime). The profiles are shifted and sorted from no staircases to staircases with a high number of mixed layers.