Geophysical Research Abstracts
Vol. 21, EGU2019-13206, 2019
EGU General Assembly 2019

The Antarctic Polar Front arising from nonlinearities of the Equation of State of Seawater

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The Antarctic Polar Front is one of the most emblematic oceanic fronts, often used as a natural boundary for the Southern Ocean. The Antarctic Polar Front has traditionally been the subject of intense research because of its role in shaping the physical and biogeochemical environments of the Southern Ocean. Despite its central role, there is currently no clear consensus on what causes it to exist in the first place, let alone what controls its variability. Here we will first show that the Antarctic Polar Front forms a natural boundary between two distinct regimes of thermohaline stratification, as unraveled by an objective method of classification of vertical temperature and salinity profiles. More specifically, the Antarctic Polar Front marks the northern limit of the beta ocean, where salinity gradients control the stratification in the permanent pycnocline. We will then argue that this regime transition is primarily driven by nonlinearities of the Equation of State of Seawater, in the form of a temperature dependence of the thermal expansion coefficient which makes cold waters inherently more sensitive to salinity changes than warm waters. This hypothesis is illustrated in model sensitivity experiments in which the Antarctic Polar Front is found to vanish when the Equation of State is made linear.