Salt feedbacks in the quasi-adabatic overturning circulation

by Christopher L. Wolfe and Paola Cessi

Scripps Institution of Oceanography - UCSD

The adiabatic overturning circulation is the part of the meridional overturning circulation that persists in the limit of vanishing diffusivity. Two conditions are required for the existence of the adiabatic overturning circulation: a high-latitude zonally-reentrant channel subject to surface westerlies and a set of outcropping isopycnals which are shared between the channel and the opposite hemisphere. This paper examines how different buoyancy forcing regimes, and in particular freshwater flux, affect the surface buoyancy distribution and thus the strength of the adiabatic overturning circulation. If the effect of freshwater is ignored, the size of the shared isopycnal window is effectively fixed by the surface forcing, due to the strong coupling between atmospheric and sea surface temperatures. Precipitation is not coupled to sea surface salinity; thus, in a freshwater-forcing ocean, the sea surface buoyancy (and thus the size of the shared isopycnal window) is not specified by the atmospheric state alone. It is found that a salt-advection feedback leads to a surface buoyancy distribution which increases the size of the isopycnal window and strengthens the adiabatic overturning circulation. The strength of the feedback is controlled by processes in the southern channel, where the surface salinity is determined by a balance between freshwater input from the atmosphere, salt input from upwelling deep water, and freshwater export in the surface Ekman layer. A simple calculation allows this surface salinity, and---ultimately---the size of the isopycnal window, to be estimated without detailed knowledge of the interior circulation.