



Horizontal convection and Sandström's postulate revisited

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On the basis of laboratory experiments with a source of heating and of cooling in a tank of water, Sandström (1908, 1916) concluded that a convectively-driven circulation could only exist if the geopotential level of the heat source is below the level of the cooling source. This conclusion has since been commonly interpreted to mean that the meridional gradient of heating of the ocean surface cannot on its own generate a global-scale vertical overturning of the oceans. However, Sandström's reported observations are at odds with the vigorous circulation observed in more recent laboratory experiments and numerical simulations of 'horizontal convection', where the circulation in a box is driven by a gradient of temperature or heat flux along one horizontal boundary (Rossby 1965, 1998; Mullarney et al. 2004; Wang & Huang 2005).

Here we revisit Sandström's experiments in an attempt to resolve this discrepancy. Contrary to his observations, we clearly see a convective circulation occupying the full depth of the box when the sources of heating and cooling are at the same level, and even when the heating source is situated above the cooling source. We present velocity and density profiles, discuss the governing physics and offer an interpretation of Sandström's conclusions that is consistent with the observed vigorous circulation in horizontal convection. We conclude by returning to the question of the role played by surface buoyancy fluxes in the global overturning circulation of the oceans.