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A theory of deep stratification and overturning circulation in the ocean

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A theory of the deep stratification and overturning circulation in an idealized single-basin ocean with a circumpolar channel is presented. The theory demonstrates the importance of the Southern Ocean in setting the deep stratification and overturning circulation of the world's oceans. The theory includes the effects of wind, eddies, and diapycnal mixing, and predicts the deep stratification and the rate of the overturning circulation in terms of the surface forcing and other problem parameters.

The theory shows that the dynamics of the deep stratification and overturning circulation can be characterized by two limiting regimes, corresponding to weak and strong diapycnal mixing. In the limit of weak diapycnal mixing, typical for the mid-depth ocean, deep stratification throughout the ocean is produced by wind and eddies in a circumpolar channel. The overturning circulation across the deep stratification is driven by the diapycnal mixing in the basin away from the channel but is sensitive, through changes in stratification, to the wind and eddies in the channel. In the limit of strong diapycnal mixing, of relevance to abyssal ocean, deep stratification is set by eddies in the channel and diapycnal mixing in the basin away from the channel, with the wind over the circumpolar channel playing a secondary role.

The theory is tested with a coarse-resolution ocean general circulation model configured in an idealized geometry. Results from a series of sensitivity experiments compare well with predictions from the theory.