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A Dynamical Recipe for the World's Largest Ocean Current

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Abstract

The Southern Ocean is home to the strongest winds, the biggest waves and the largest ocean current on Earth. The Antarctic Circumpolar Current (ACC) carries about 150×10^6 m^{3}s^{-1} from west to east around the Antarctic continent, roughly equivalent to 150 times the combined flow of the world's rivers. The strong eastward flow of the Antarctic Circumpolar Current (ACC) connects the ocean basins, allowing the existence of a global-scale overturning circulation that dominates ocean heat transport. Hence, the circulation of the Southern Ocean is of particular relevance for climate.

For many years, the dynamics of the current have puzzled oceanographers. Dynamical theory that explained the circulation in closed basins did not apply in the zonally-unbounded channel of the Southern Ocean. In the last decade, however, remarkable progress has been made, built on advances in ocean observations, numerical simulations, and theory.

The core ingredients of the dynamical recipe for the ACC are becoming clear. The tilting of density surfaces associated with the geostrophic flow of the ACC brings dense water to the surface at high latitudes. Water mass transformations where these layers outcrop link the upper and lower limbs of the global overturning circulation. The ACC and overturning circulations are therefore dynamically linked. Wind and buoyancy forcing act together to drive a strong, deep-reaching eastward flow made up of multiple zonal jets; instabilities of the jets spawn eddies with horizontal length scales of O(100 km); the eddies transport heat, momentum, vorticity and other tracers across the ACC, generally opposing the directly wind-driven circulation cell; and topography structures both the mean flow and the eddy field.