What controls the oceanic conveyor?

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The deep meridional overturning circulation of the ocean is one of the most poorly understood aspects of the oceanic general circulation. Observational evidence has indicated that the North Atlantic Deep Water (NADW) flows southward along the Americas at the depths of roughly 2000-3000 m, enters the Southern Ocean, which encircles Antarctica, and flows into the Indian and Pacific Oceans. There the water upwells (becomes lighter) by diffusion and eventually returns to the northern North Atlantic as lighter surface and/or intermediate waters. This global circulation is sometimes called the ``great ocean conveyor.'' Although this picture is generally accepted, it is not know why it must be so.

As an attempt to gain insight into the mechanisms controlling this global circulation, I examine results of a realistic ocean general circulation model (OGCM) and an idealized OGCM. The control experiment of the realist world ocean model has a realistic bathymetry and boundary conditions. The equilibrium state is very successful in simulating the deep and bottom circulation. In particular, detailed analyses show that the circulation attains a form of the ``conveyor'' circulation. NADW does not upwell much in the Atlantic, but it does in the Indian and Pacific basins.

The idealized model has two rectangular basins representing the Atlantic and the Pacific connected by a channel representing the Southern Ocean. Salinity is held constant and uniform, and the boundary condition of temperature is a simplified zonally uniform distribution. Windstress is also simplified and zonally uniform. The standard run of this simple model reproduces a ``conveyor'' circulation. As a sensitivity study, the Pacific basin is closed; then the circulation of NADW is much weakened.

This effected is simulated in the realistic world ocean model by reducing the vertical diffusivity in the Indian and Pacific Oceans rather than by closing those basins. The reduction of vertical diffusivity leads to the reduction in upwelling in the Indian and Pacific, which in turn leads to the weakening of the NADW overturning cell. These results indicates that the ``conveyor'' circulation is controlled by diffusive upwelling in the Indian and Pacific basins. I also propose that one of the reasons why NADW does not upwell much in the Atlantic Ocean is the presence of the final northward branch, the return flow, of the NADW cell. The deep water that has upwelled in the Indian and Pacific returns to the Atlantic from the south. This near-surface flow acts as an insulator to prevent the underlying deep water from gaining buoyancy.