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HOW SALINITY AFFECTS THE WIND-DRIVEN OCEANIC CIRCULATION

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The two main components of the oceanic circulation, the wind-driven circulation of the ventilated thermocline in the upper ocean, and the deep thermohaline circulation, both involve meridional over-turning and poleward heat transport. The sinking of surface waters depends critically on salinity in the second component, but in the first sinking is induced by the winds over subduction zones. Salinity nonetheless has a strong influence on the wind-driven circulation and hence on its transport of heat. Today that transport is less than it would be in the absence of salinity variations because the northward surface density gradient created by the decrease in surface temperature with latitude is countered by the decrease in salinity. (Surface salinities are high in low latitudes regions of strong evaporation, and are low in the rain belts of higher latitudes.) To explore these matters we use an idealized ocean general circulation model that captures the main aspects of the thermocline ventilation and employs simple parameterizations of surface heat and salt fluxes. Our calculations show that a freshening of the surface waters in the extra-tropics, and the associated reduction in the meridional density gradient at the surface, can reduce the poleward heat transport and deepen the equatorial thermocline. As the freshwater forcing at the surface in high latitudes approaches a critical value, certain aspects of the wind-driven circulation change radically: the horizontal heat transport in the ocean approaches zero, the heat budget becomes balanced locally everywhere, and the equatorial thermocline becomes practically horizontal so that permanent El Nio conditions prevail in the tropics. At that stage the wind-stress at the equator is balanced by salinity gradients in the upper ocean. Earlier than three million years ago oceanic conditions were apparently similar to these.