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What determines the position of the transition zone between alpha and beta regions in the ocean? A model study.

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The stratification is primarily controlled by the temperature in subtropical regions (alpha ocean), and by salinity in subpolar regions (beta ocean). Between these two regions lies a transition zone where intense frontal systems are usually found, either in the Southern Ocean or in the North Atlantic and North Pacific basins. Transition zones are often characterized by deep mixed layers in winter responsible for the ventilation of intermediate layers. Here we want to investigate what determines the latitudinal position of the transition zone. It is generally assumed that this position is set by the wind stress pattern forcing Ekman downwelling, however the position of the transition zone does not match so well the wind stress convergence zone in the observations. Another possibility would be that it is controlled by the distribution of air-sea fluxes. The equation of state (EOS) for seawater determines the relative impact of heat and freshwater forcing on the buoyancy forcing. A key property of seawater is that the density becomes less sensitive to temperature at low temperatures (caused by an important nonlinearity of the EOS), increasing the effect of salinity on the stratification in polar region. We hypothesize that the decreasing of the relative influence of temperature on density is a major component in setting the position of the transition zone. To test this hypothesis, we developed an idealized triple-gyre configuration with the ocean global circulation model NEMO (Nucleus for European Modelling of the Ocean). A range of simplified EOS have been ran to test the effect of the buoyancy forcing on the position of the transition zone and the convective area. Under restoring conditions for the temperature and the salinity, augmenting or reducing the sensitivity of the density to the temperature is used as a way to modify the relative contribution of temperature and salinity to the buoyancy forcing. We show that the position of the convective area corresponds to a surface density maximum and is not directly related to the Ekman pumping zone. Moreover, alpha - beta ocean distinction becomes possible because the EOS is nonlinear. The first order influence of the forcing evolution on setting the localization of the transition zone and the associated deep water formation challenges the classical theories of thermocline ventilation by Ekman pumping.