Abstract

A wide body of modeling and theoretical scaling studies support the concept that changes to the Atlantic meridional overturning circulation (AMOC), forced by winds or buoyancy fluxes, can be understood in terms of a simple causative relation between the AMOC and an appropriately defined meridional density gradient (MDG) . The concept has been utilized in a multitude of simplified ocean models and in the interpretation of model output. Here we present two suites of experiments, performed using the MOM4 ocean model coupled to an energy-moisture balance model, in which the positive AMOC-MDG relation breaks down. In the first suite of seven runs the Southern Ocean winds are altered and it is found that increasing winds in the Southern Ocean causes an increase in overturning while the surface density difference between the equator and North Atlantic drops. In the second suite of eight runs the equation of state is manipulated so that the density is calculated at the model temperature plus an artificial increment ΔT that ranges from -3 to 9 ºC. An increase in ΔT results in increased sensitivity of density to temperature gradients. The AMOC in these runs drops as the MDG increases- regardless of whether the density difference is computed at the surface or averaged over the upper ocean. Traditional scaling analysis can produce this weaker AMOC if the scale depth decreases enough to compensate for the stronger MDG. The depth of the maximum overturning streamfunction does decrease to fulfill this requirement, but the more commonly used pycnocline depth increases. These two depth scales are usually assumed to be the same in theoretical models of the AMOC. It is suggested that the correlation between the MDG and AMOC breaks down in these runs because the AMOC is influenced strongly by remote forcing such as Southern Ocean winds and Antarctic Bottom Water formation.