IMPACTS OF OCEAN MODEL PARAMETERIZATIONS AND ATMOSPHERIC INITIAL CONDITION PERTURBATIONS ON THE ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC) IN THE COMMUNITY EARTH SYSTEM MODEL (CESM)

Gokhan Danabasoglu, Laura Landrum, and Steve G. Yeager
National Center for Atmospheric Research, Boulder, CO, U.S.A.
Corresponding author e-mail: gokhan@ucar.edu

AMOC is presumed to play a major role in decadal and longer time scale climate variability and in prediction of the earth's future climate on these time scales. The primary support for such a prominent role for AMOC comes from coupled model simulations. They show rich AMOC variability, but time scales of variability and mechanisms differ substantially among models. Our previous studies with CESM showed that the ocean model's subgrid scale parameterizations play a role in creation of the Labrador Sea density anomalies that lead to changes in AMOC. Here, we present a systematic assessment of the impacts of several ocean model parameter choices on AMOC characteristics in CESM with the primary goal of identifying both robust and non-robust elements of AMOC variability and mechanisms. Our control is a new, 1500-year pre-industrial simulation. We branch off from this control and perform several 600-year simulations where some poorly-constrained parameter values in mesoscale, sub-mesoscale, vertical mixing, and lateral viscosity parameterizations in the ocean model are changed. The characteristics of AMOC from these simulations are compared with a three-member ensemble of 600-year perturbation experiments in which the initial atmospheric temperature field is slightly perturbed. A significant finding is that both the amplitude and time scale of AMOC variability differs considerably among all these experiments with dominant time scales of variability ranging from decadal to centennial. There are also substantial differences in the relative contributions of temperature and salinity anomalies to the positive density anomalies created in the model's deep-water formation (DWF) region prior to AMOC intensifications. Nevertheless, we identify some robust elements of AMOC variability mechanisms. These include: i) The Labrador Sea is the key region with upper-ocean density and boundary layer anomalies preceding AMOC anomalies; ii) Enhanced Nordic Sea overflow transports do not lead to an increase in AMOC maximum transports; iii) Persistent positive phase of the North Atlantic Oscillation plays a significant role in setting up the density anomalies that lead to AMOC intensification via surface buoyancy fluxes; and iv) After AMOC intensification, subsequent weakening is due to advection of positive temperature anomalies into the model's DWF region.