Can the salt advection feedback be detected in decadal AMOC variability?

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The sign of the freshwater transport across the southern boundary of the Atlantic Ocean by the overturning circulation (Fov) has been suggested as an indicator for the stability of the Atlantic meridional overturning circulation (AMOC). A northward freshwater flux would provide a negative feedback on AMOC changes, while a southward transport would provide a positive feedback – implying the possibility of an AMOC collapse. This salt-advection feedback mechanism critically depends on the AMOC strength impacting Fov, and Fov, in turn, influencing the AMOC. In this study, we examine whether we can find evidence for this feedback by examining decadal scale AMOC variability in two state-of-the-art global climate model (GCM) pre-industrial control simulations; namely the GFDL-ESM2M and Community Earth System Model (CESM1). We perform correlation and spectral analysis on time series of the AMOC and Fov.

We find that both GCMs have large salinity biases throughout the Atlantic, typical of most climate models. These salinity biases, occurring both in the upper ocean (above 800 m) and at depth (1.2-4 km) cause Fov to have a positive bias. The modeled decadal variability of Fov(y) (i.e., freshwater transport by the AMOC at any latitude) is dominated by variability in the salinity field rather than in the velocity field, except in the northern subtropics (20°-45°N) where the velocity variability dominates. Therefore, Fov decadal variability co-varies more with the region's salinity variability than with its AMOC variability. Similarly, we do not find any evidence that changes in Fov influence the strength of the AMOC on these time scales. We suspect that larger amplitude and longer period changes in the AMOC are necessary to detect the salt advection feedback as a control on AMOC variability and stability in the Atlantic Ocean.