The interdecadal AMOC mode related to westward propagation of temperature anomalies – in theory and in CMIP5 models

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The CMIP5 coupled models show a broad variety of AMOC variability with the leading modes exhibiting different amplitudes, periods, and spatial characteristics and driving mechanisms. Simple theoretical models and ocean GCMs suggest that on interdecadal timescales this variability can be controlled by an internal (damped) mode of the AMOC associated with westward propagation of depth-integrated temperature (density) anomalies in the North Atlantic ocean. The quadrature phases of this mode correspond to the strengthening of the AMOC followed by the emergence of a broad warm temperature anomaly in the northern Atlantic. Here, we investigate whether this mode operates in the CMIP5 models and what role it may play in climate. Out of the 25 models investigated, we find that roughly one third to one half of the models exhibit variability consistent with this mode (e.g. IPSL-CM5A-LR, GFDL-CM3, GFDL-ESM2M). The most relevant modal features include statistically significant peaks in the frequency band between 15 and 30 years, the westward propagation of density anomalies at depths of 200-500m correlated with AMOC variations, and the prevailing effect of temperature on density anomalies with a small compensation from salinity. However, very few models exhibit the phase lag between variations in the east-west and north-south temperature differences suggested by some theories. On the whole, CMIP5 provides a strong evidence for this interdecadal mode in coupled models. Moreover, the models in which this mode is dominant typically show a strong effect of the AMOC on climate as seen in the correlation between AMOC and SST variations in the North Atlantic.