Relationship of the Atlantic Warm Pool with the AMOC and Link of the AMOC with Global Climate Model Biases

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This project has two major objectives. First, we examine and test a hypothesis: The Atlantic Warm Pool (AWP) plays a negative feedback role in the AMOC that acts to restore the AMOC after it is weakened or shut down. Second, we investigate common patterns of global SST biases in CMIP5 climate models which are commonly linked to the simulated AMOC.

Recent results

During the past year, we perform both diagnostic and modeling studies on the AMOC. The main findings and results are as follows:

- Our OGCM model experiments show that ocean response to the anomalous AWP-induced freshwater flux is primarily dominated by the basin-scale gyre circulation adjustments with a time scale of about two decades (Zhang et al. 2014). The positive (negative) freshwater anomaly leads to an anticyclonic (cyclonic) circulation overlapping the subtropical gyre. This strengthens (weakens) the Gulf Stream and the recirculation in the interior ocean, thus increases warm (cold) water advection to the north and decreases cold (warm) water advection to the south, producing an upper ocean temperature dipole in the midlatitude. As the freshwater (salty water) is advected to the North Atlantic deep convection region, the AMOC and its associated northward heat transport gradually decreases (increases), which in turn leads to an inter-hemispheric SST seesaw.
- Global SST biases in CMIP5 models are commonly linked to the AMOC simulations (Wang et al. 2014). We find that the cold SST bias in the North Atlantic is stronger when the AMOC is weaker, and vice versa, with an inter-model correlation of 0.85 between the SST bias and the AMOC index. The simulated SST bias in the North Pacific is linked to that in the North Atlantic. The mechanism is that the cold SST bias in the North Atlantic corresponds to a deepening of the Aleutian low and an intensification of the surface westerly winds in the North Pacific. The intensified westerly winds cool the North Pacific Ocean through enhanced latent heat flux and southward ocean advection associated with Ekman transports.

Most state-of-the-art climate models show warm SST bias in the tropical southeastern Pacific (SEP) and cold SST bias in the tropical North Atlantic (TNA). The cold SST bias in the TNA is associated with the AMOC: As the AMOC simulation is weaker, the cold SST bias in the TNA is larger. We perform coupled model experiments to show that as much as 30% of the warm SST bias in the SEP can be attributed to the cold SST bias in the TNA (Zhang et al. 2014). Our coupled model experiments also show that the cold SST bias in the TNA results in a weakening of the Hadley-type circulation from the TNA to the SEP. This meridional circulation reduces the South Pacific subtropical anticyclone and the associated subsidence, which in turn leads to a reduction of low clouds, a weakening of the easterly trade wind and thus an increase of the warm SST bias in the SEP.

Bibliography

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