Potential importance of midlatitude oceanic frontal latitude on the atmospheric annular mode variability as revealed from aqua-planet experiments

Abstract

The annular mode variability in the extratropical atmosphere is manifested as latitudinal displacement of an eddy-driven polar front jet (PFJ) and an associated stormtrack. Recent observational and modeling studies indicate PFJ in climatological-mean state forms in the vicinity of a midlatitude oceanic front that maintains a surface baroclinic zone by countering poleward eddy heat transport. The present study reveals strong sensitivity of the meridional structure of the annular mode to the latitude of an oceanic front, through a set of “aqua-planet” experiments with an atmospheric general circulation model with zonally uniform sea-surface temperature (SST) prescribed at the model lower boundary with frontal SST gradient whose latitude varies from one experiment to another. The simulated low-frequency variability in each of the experiments represents meridional displacement of PFJ with a high degree of zonal symmetry, as observed in the Southern Annular Mode (SAM). The nodal latitude of westerly anomalies associated with the annular mode tends to shift together with the
The positive phase of the model annular mode is characterized by eddy-driven PFJ situated poleward of the SST front, and its axis shows unambiguous sensitivity to the frontal latitude. In the negative phase, by contrast, PFJ form near 40° latitude insensitively to the latitude of the SST front in any of the experiments. The particular latitude nearly corresponds to the climatological-mean PFJ axis that is realized in an experiment where the midlatitude frontal SST gradient is smoothed out and therefore atmospheric internal dynamics through eddy-mean flow interactions dominates over thermodynamic effects by the underlying SST. The results suggest that the annular mode may be interpreted as a manifestation of low-frequency shifts of the atmospheric general circulation between a dynamical regime dominated by the thermodynamic influence of frontal SST gradient and that by atmospheric internal dynamics. Such an atmospheric “regime-like” behavior is also found from the observations over Southern Indian and Pacific oceans.