Baroclinic Annular Mode in the Southern Hemisphere: Its Reproducibility and Sensitivity to Ocean Fronts assessed in Aqua-Planet Experiments

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Large-scale tropospheric variability in the extratropical Southern Hemisphere is characterized by two major and independent modes. One is the barotropic annular mode or the Southern Annular Mode (SAM), which represents meridional shifts of the eddy-driven polar front jet (PFJ; Thompson and Wallace, 2000). The other is the Baroclinic Annular Mode (BAM), which represents pulsing of stormtrack activity (Thompson and Woodworth, 2014).

In this study, the sensitivity of BAM to the midlatitude oceanic frontal zone is assessed through aqua-planet experiments in which, after the removal of landmasses, zonally symmetric distributions of sea-surface temperature (SST) are prescribed as the lower boundary condition of an atmospheric general circulation model AFES. In our control experiment, climatological SST profiles observed over the South Indian Ocean in austral summer and winter are prescribed in the model northern and southern hemispheres, respectively. The profiles are characterized by frontal SST gradient at 45˚ latitude. In our NF experiment, the frontal SST gradients are removed by raising SST artificially poleward of the front. The two experiments are both conducted over 3600 days under a perpetual condition with insolation fixed to the boreal summer solstice.
As in the observations, BAM signatures in the control experiment represent pulsing of the climatological stormtrack anchored in the vicinity of the oceanic front. By contrast, in the NF experiment without the oceanic frontal zone, BAM cannot be reproduced: BAM-associated anomalies of eddy kinetic energy and poleward eddy heat flux are reduced by ~30% and ~50%, respectively, and their peaks are displaced equatorward by ~5˚ from the oceanic frontal zone. Our experiments therefore suggest that the oceanic frontal zone enhances and anchors the BAM variability by strengthening stormtrack activity through maintaining near-surface baroclinicity. Specifically, anomalous sensible heat flux from the ocean acts to restore the meridional gradients in surface air temperature modified by anomalous meridional eddy heat flux associated with BAM, and this effect is greatly enhanced under the frontal SST gradient.

キーワード：環状モード、海洋前線帯、水惑星実験
Keywords: Annular mode, Oceanic frontal zone, Aqua-planet experiment

