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Modification of the Baroclinic Instability associated with AO Index: A Theoretical Proof of the Positive Feedback

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The modification of the baroclinic instability associated with positive and negative Arctic Oscillation Index (AOI) is theoretically investigated using a linearized 3D spectral primitive equation model.

According to the observational analysis, the AOI tends to be positive due to the enhanced northward eddy momentum flux by the transient baroclinic waves which intensify the polar jet in high latitudes and weaken the subtropical jet. Conversely, the AOI tends to be negative when the eddy momentum flux becomes southward in high latitudes causing weaker polar jet and stronger subtropical jet.

In this study the baroclinic instability problem is solved for zonal mean basic states for AOI positive and negative cases by adding and subtracting AO patterns of the zonal mean winds onto the normal basic state. The linear instability analysis shows that the most unstable Charney mode M_C changes its structure to intensify or weaken the polar jet by the eddy momentum flux associated with the positive or negative AOI. More importantly, the meridionally dipole Charney mode M_2 is modified into the monopole Charney mode M_1 (see Tanaka and Tokinaga 2002) to transport eddy momentum flux northward under the positive AOI condition. It is found that this modification is essential to intensify the polar jet during the AOI positive phase. Hence, we have theoretically confirmed that there are positive feedbacks between the baroclinic instability waves and the Arctic Oscillation characterized by the intensity of the polar jet.

Keywords: Arctic Oscillation, Baroclinic Instability, 3 dimensional normal mode