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Cross spectral analysis of the AO index using the AOI equation

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Arctic Oscillation (AO) is explained as an atmospheric dynamical eigenmode. There is an argument, however, that the AO is a statistical illusion by the EOF analysis. Tanaka and Matsueda (2005) showed AO mode as the most unstable standing mode in the barotropic atmosphere. In addition to the zero frequency of the mode, the growth rate becomes also zero for adequate frictional force and interaction with transient eddies. Such a mode can be amplified resonantly by quasi-situational forcing. This idea of the AO is called singular eigenmode theory. For the problem of missing correlation in surface pressure between the Pacific and Atlantic is explained by Suzuki and Tanaka (2007) by analyzing barotropic height instead of the surface pressure. The barotropic height indicates significant correlation between the two regions. The missing correlation is thus explained by the baroclinic component of the atmosphere. We support the singular eigenmode theory, but a further analysis is required by the data analysis of the AO index. In this study we derived an equation called AOI equation from the definition of the AOI differentiated with respect to time, and substituting the primitive equation. According to the analysis result of the NCEP/NCAR reanalysis for 62 years of data, it is found that the AOI time series is proportional to the linear term of the AOI equation. The nonlinear term and external forcing term indicate inverse correlation with the AOI, which tend to damp the AOI to the normal. The fact that the linear term of the primitive equation is proportional to the AO structure, i.e., $L*x = a*x$ implies that the AO is an eigensolution of the dynamical system. The present study supports the singular eigenmode theory from the data analysis using the AOI equation.

Keywords: Arctic Oscillation, Global warming, Low-frequency variability, Singular eigenmode theory, Normal mode, Barotropic instability