Dynamical understanding and the prediction of the Arctic Oscillation

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The Arctic Oscillation (AO) is a north-south seesaw of the atmospheric mass between the Arctic region pole-ward of 60N and a surrounding zonal ring in the mid-latitudes. The AO is defined as the EOF-1 of the time variation in sea-level pressure, which is dynamically related to the time variation of the barotropic component of the atmosphere. For this reason, the essential features of the AO are contained in the barotropic component of the atmosphere governed by the 2D fluid mechanics, which characterizes the low-frequency variability. According to our study, it is demonstrated that the singular eigenmode of the dynamical system emerges resonantly as the AO in response to the arbitrary forcing under a moderate linear damping. However, it is still unclear why the atmospheric low frequency variability shows almost no correlation between the Pacific and Atlantic sectors. The purpose of this study is to examine the one point correlation between the barotropic heights at the Atlantic and Pacific sectors in the model atmosphere. The results are compared with that of the barotropic heights in the observed atmosphere.

Moreover, 60-day ensemble predictions are attempted in this study using the barotropic S-model developed at the University of Tsukuba. By the theoretical deduction, the Arctic Oscillation may be understood as a singular eigenmode of the global atmosphere induced by steady forcing. The singular eigenmode is amplified resonantly by the steady forcing because the eigenvalue is zero for this mode. If this is the case, the time mean bias near the initial condition of the time integration is essential for the long-term prediction in a monthly range. Based on this hypothesis, we constructed an ensemble prediction model for the AO index for 60 days using various biases in the external forcing averaged for 10 to 60 days before the initial condition. The results are compare with the actual AOI by the observations in the past.

According to the result, it is demonstrated that the one point correlation maps for the AO agree between the model and real atmospheres. The one point correlation shows perfect mach with the AO pattern in the model. In addition to this fact, the one point correlation in the observed atmosphere shows similar correlation between the Pacific and Atlantic sectors, although the correlation is weaker than that in the model atmosphere.

Based on the know performance of the barotropic S-model developed at the University of Tsukuba, ensemble predictions are attempted for the AO index up to 60 days into the future. By a deduction from the singular eigenmode theory, the Arctic Oscillation is amplified resonantly by the steady forcing anomaly. If this is the case, the time mean bias near the initial condition for the time integration is essential for the long-term prediction in a monthly range. Based on this hypothesis, we have constructed an ensemble prediction model for the AO Index for 60 days using various biases in the external forcing averaged for 10 to 60 days before the initial condition. It is found that the prediction (hindcaste) for the past winter was mostly successful. As the first real trial, the AO index for the winter of 2006/2007 is predicted from the initial condition in November 2006. The result indicates that the AO index is large positive, suggesting warm winter in Japan. Although the prediction must be confirmed many times, the result suggests a possible predictability for the monthly range by the barotropic S-model.