Two Types of Arctic Oscillation and Their Associated Rossby wave propagations

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In this study, the dynamical evolutions of two types of Arctic Oscillation (AO) on the intraseasonal time scale, the stratospheric (S) type and the tropospheric (T) type, have been investigated in terms of the transient eddy feedback forcing and the three-dimensional Rossby wave propagation. The S-Type (T-type) event is featured by the anomalous stratospheric polar vortex that is in phase (out-of-phase) with its tropospheric counterpart. About one third of all AO events are identified as the T-type event in both the positive and negative phase.

In the troposphere, the transient eddy feedback forcing is primarily responsible for the meridional seesaw structure of both the S- and T-type event, with additional contributions from the Rossby wave propagation. For the T-type of AO event, the formation and maintenance of stratospheric positive anomalies over the polar cap are associated with the upward propagation of Rossby wave packets originated from the near-tropopause altitude over northeastern Asia (Figure 1d, 1h, 1l). In addition to the upward propagation, the Rossby waves also propagate downward back into the troposphere over the North Atlantic, which contributes the formation of the height anomalies over the Iceland. But such upward/downward propagating features disappear for the S-type event, implying that the propagations of the planetary waves might act as an important role in the formation of S-type AO event. Therefore, the underlying dynamical features that can differentiate itself from the S-type event lie in the vertical propagation of zonally confined Rossby waves.

Clearly shown in Figure 2, two vertical waveguides that extend throughout the troposphere and stratosphere exist over the North Asia/North Pacific region and over the North Atlantic. The former exhibits a somewhat westward-tilting structure with altitude. Therefore, once some circulation anomalies are developed and sustained in the upper troposphere/lower stratosphere over the Northeast Asia, the Rossby wave packets emanate from this region and propagate upward and eastward into the stratosphere. Before the peak pentad of the T-type event, the circulation anomalies over Northeast Asia are generally formed, and they tend to facilitate the Rossby wave packets to propagate upward, which contributes to the formation of anomalies centered over North America with the opposite sign. There is another vertical waveguide over the North Atlantic with relatively large k_s in the troposphere. Therefore, if some circulation anomalies persist on over North America in the stratosphere, the zonally confined Rossby waves might be continually refracted back into the troposphere along the local waveguide. Thus, the vertical waveguide over the North Atlantic could be responsible for the locally downward injection of the Rossby wave packets that occurred in the T-type event.

Therefore, the local waveguide structure well-explains the geophysical inclination of the vertical propagation of Rossby wave packets in the T-type event.

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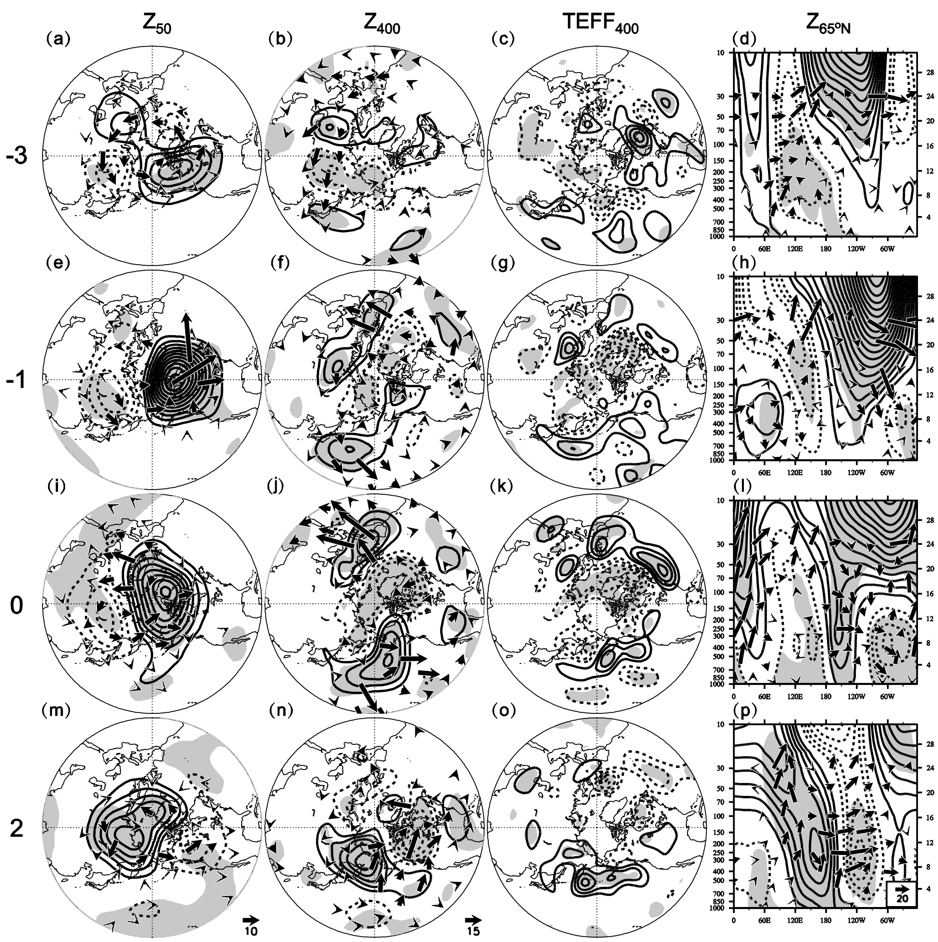

Figure 1 Composite time evolution of anomalous Z_{50}, Z_{400}, transient eddy feedback forcing at 400 hPa ($TEFF_{400}$) and zonal-height section of height anomalies at 65°N ($Z_{65^{\circ}N}$) associated with

the 10 T-type AO events. Contour intervals are 40 m, 35 m, 4 m/day and 40 m for Z_{50}, Z_{400}, $TEFF_{400}$ and the cross-section, respectively. Arrows ($m^2\ s^{-2}$) are wave activity flux based on the composite anomalies and they have been normalized with pressure. Shading marks the region of 90% confidence level.

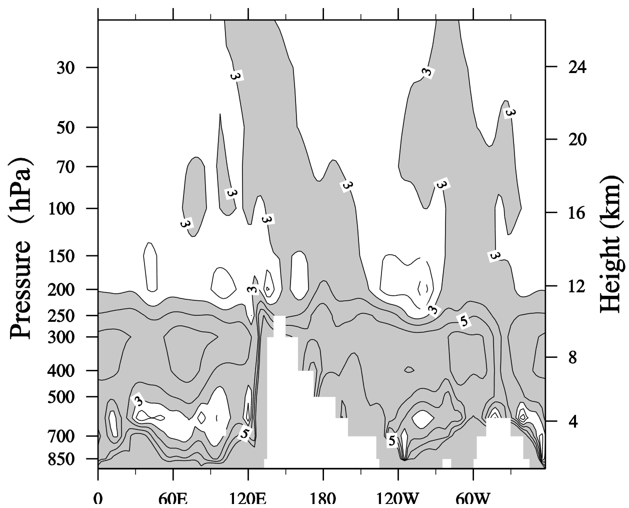

Figure 2. Meridional section of total stationary Rossby wavenumber, k_s, at 65°N, based on the climatological-mean state in the expanded winter. The k_s has been represented as the "equivalent zonal wavenumber." Only the k_s exceeding 3 are shaded.