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The Characteristics of the Polar-night Jet Oscillation and its Relationship with the Arctic Oscillation (Extended Abstract)

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1. Introduction

In winter to spring, the variability of the stratosphere becomes very large due to the activity of the planetary waves propagation from the troposphere. As a result, there appears a coupled variability between the stratosphere and troposphere. The Polar-night Jet Oscillation (PJO) is one such variability. It is extracted from a slow variability of the anomalous zonal-mean zonal wind throughout cold season, and is characterized by the poleward and downward movement of the zonal-mean zonal wind (Kuroda and Kodera, 1999). Especially, the PJO in Northern Hemisphere shows a quasi-periodic nature, and the stratospheric sudden warming takes place and the Arctic oscillations (AO) appears in connection with the evolution of the PJO (Kodera *et al.*, 2000).

In this note, we shall introduce the characteristics of the PJO and how it is related with AO based on our recent works (Kuroda and Kodera, 1999 ; Kodera *et al.*, 2000).

2. Data

The data used in this analysis is based on the observational data of NMC/NCEP from 1979 to 1996. The stratospheric winds are calculated from a satellite-derived geopotential height as documented by Randel (1992). The tropospheric data below 100 hPa are due to the analysis of NMC/NCEP. Almost calculation are on monthly mean data except for those involving E-P flux, wave activity flux by Plumb (1985), which were performed on a 5 day-mean and then monthly averaged. Pentad-mean data are also supplementary used.

3. PJO

We have extracted the mode of variability (PJO) by means of the extended singular value decomposition (E-SVD) analysis between the zonal wind and vertical component of the E-P flux (Kuroda and Kodera, 1999). The three consecutive months we have considered are November to January, and December to February for every winter. Figure 1 shows the result of the mode of the zonal wind and E-P flux for consecutive three months. Contour denotes the regression of the zonal wind, and the arrow shows the E-P flux. The E-P flux is scaled by the reciprocal square root of the pressure for convenience.

It can be seen that the anomalous zonal wind at the 1st month shift poleward and downward

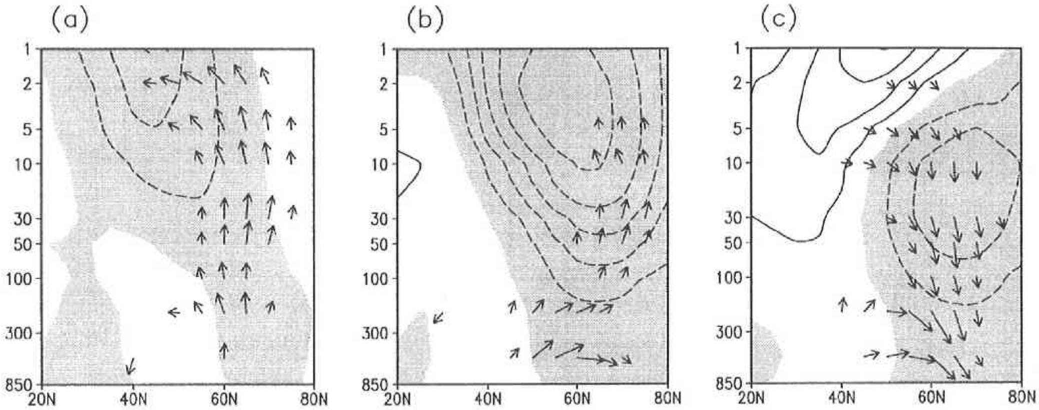

Fig. 1. Heterogeneous regression map of the leading E-SVD between the zonal-mean zonal wind (contour) and (the vertical component of) the E-P flux (vector). Meridional component of the E-P flux is constructed by the regression. Panels a, b and c correspond to the first, second and third months, respectively. The contour is 2 m/sec and the dashed lines indicate negative values. Zero contour line is omitted and negative values are shaded. The E-P flux is scaled by the reciprocal square root of pressure.

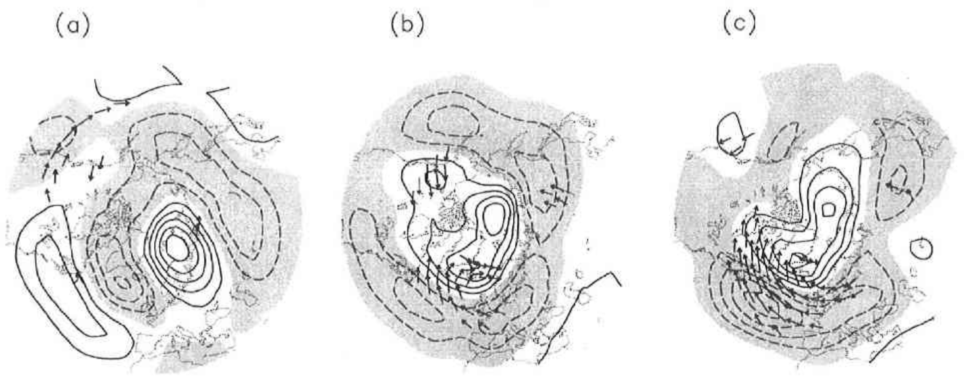

Fig. 2. The same as in Figure 1 except for the regression map of 500-hPa geopotential height (contour) and the wave activity flux (vector). Contour interval is 10 m.

as a time march. It is also noteworthy that the anomalous E-P flux is always directed toward the weaker zonal wind area. This suggests a close relationship between these quantities. At the 2nd month, the zonal wind shows meridional deep dipole structure from surface to the stratopause. At this time, the meridional propagation of the E-P flux is prominent in the troposphere. At the 3rd month, the positive zonal wind anomaly extends to the whole upper stratosphere, and the center of the negative wind anomaly shift down to the middle stratosphere. However the meridonal dipole structure at the troposphere is persistent.

To see the variability of the troposphere due to PJO, we have calculated the regression of the 500-hPa geopotential height and wave activity flux (Figure 2). At the 1st month, the pattern is that of east-west wave train. However, it becomes annular north-south seesaw at the 2nd month. This is just the AO pattern. So AO appears in connection with the formation of the meridional

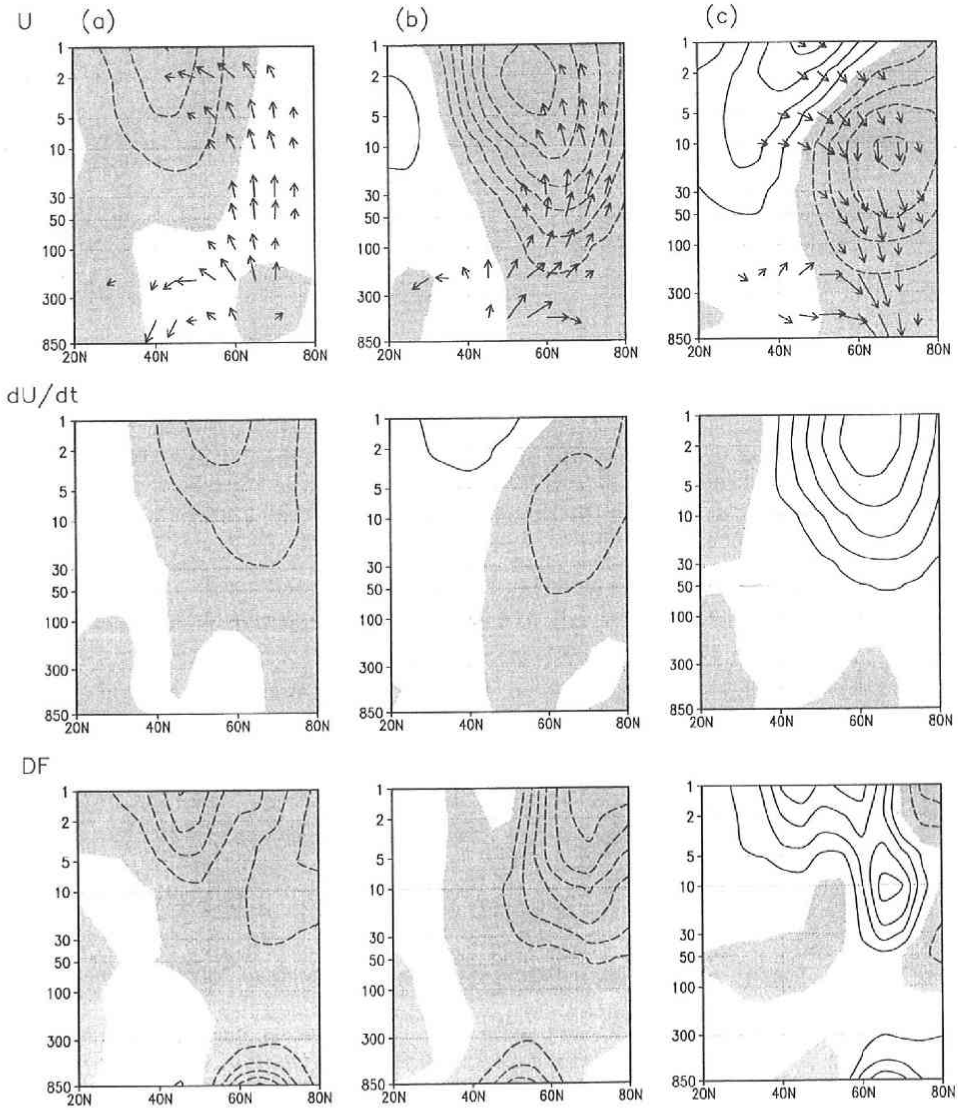

Fig. 3. (Top panels) The same as in Figure 1, but for the regression map of the leading E-SVD based on the pentad mean data. Panels a, b, and c display components of 4th, 10th, and 16th pentads, respectively. Middle and bottom panels are the same as in top panels, but for the zonal-mean zonal wind tendency and the wave forcing, respectively. Contour intervals are 2 m/sec (top panels), 0.2 m/sec/day (middle panels), and 0.5 m/sec/day (bottom panels).

deep dipole structure of zonal-mean zonal seen in Fig. 1. In this time, northward propagation of wave activity is prominent at the north Atlantic area, east Siberia and US. This annular pattern persists to the 3rd months but it changes the feature from annular mode to the local mode of NAO.

To get a finer time resolution for evolution of the PJO, we have repeated the similar analysis by the pentad mean data. Figure 3 shows the result of the analysis. The panels show selected results for 4^{th}, 10^{th} and 16^{th} pentad and they should correspond to 1^{st} to 3^{rd} month in the former analysis. As the data have fine time resolution, it is now possible to calculate zonal wind acceleration for each pentad. So we have compared the zonal wind acceleration and the wave forcing to investigate how PJO is made. It can be seen that the patterns of the zonal wind acceleration and the wave forcing are very similar though the magnitudes are different. This strongly suggests that the PJO is made through the wave-mean flow interaction. It is also found that the wave of zonal wavenumber one component is most important.

The PJO sometimes exists throughout cold season. Though we have shown only 3 consecutive months in early to mid-winter, we have examined the variability throughout cold season by the regression. It is found that the PJO shows quasi-periodic variability with a period of 4 to 5 months and the temperature at the polar area shows quasi-periodic downward propagation, though only about one cycle is achieved in winter to spring.

4. Summary

The PJO is extracted by the E-SVD analysis between zonal wind and the vertical component of the E-P flux of consecutive three months in winter. Anomalous zonal wind of PJO moves poleward and downward with seasonal march, with the changes of the E-P flux directed toward the negative zonal wind. The similarity between the zonal wind acceleration and the wave forcing suggests that the PJO is made through the wave-mean flow interaction (of especially zonal wavenumber 1 component). It is also found that AO appears in the troposphere when anomalous zonal wind of PJO shows meridional deep dipole structure.

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