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Properties of the Okhotsk High as a Dynamical Mode in Northeast Asia in Midsummer (Extended Abstract)

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1. Introduction

Midsummer weather over Japan is strongly affected by pressure anomalies like a stationary Rossby wave on the subtropical jet. On the other hand, there are some patterns like a blocking, which are closely related to the pressure anomalies in the midlatitudes. They are centered in the subarctic area, where absolute vorticity gradient is small. In this study, we select a pattern closely related to the high latitudes, and then its dynamical properties are examined.

2. Detection of anomaly patterns

An EOF analysis was performed for 250 hPa height anomaly around Japan (25-80°N, 80°E-160°W) for midsummer (July 21-August 20) in 1979-1995. As a result, an anomaly pattern which seems to propagate from the high latitudes was obtained as the first mode. The first principal component (PC 1) correlates well with the temperature anomaly in northern Japan. Some linkages are expected between PC 1, and the Okhotsk high or the

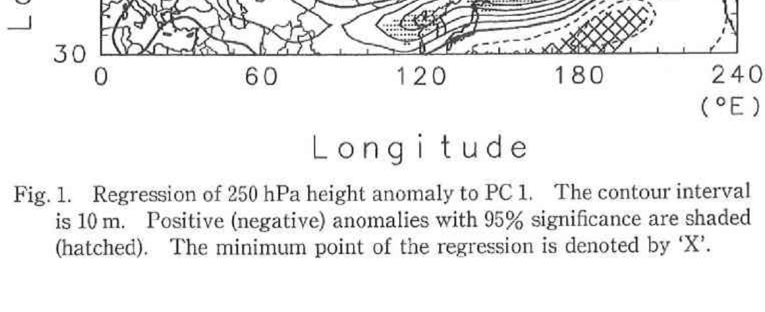

Fig. 1. Regression of 250 hPa height anomaly to PC 1. The contour interval is 10 m. Positive (negative) anomalies with 95% significance are shaded (hatched). The minimum point of the regression is denoted by 'X'.

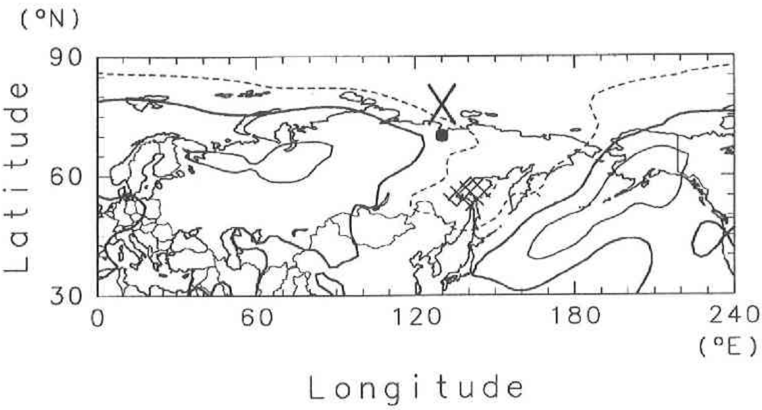

Fig. 2. Regression of SLP to PC 1. The contour interval is 0.5 hPa. Positive (negative) anomalies with 95% significance are shaded (hatched).

related 'Yamase' wind. The regression of 250 hPa height anomaly in the Northern Hemisphere (NH) to PC 1 is shown in Fig. 1. This anomaly can be recognized not only just as a simple Rossby wave propagation from northwest to southeast, but also as a vorticity anomaly which stays near 60–70°N where the gradient of absolute vorticity is small. Further, a similar mode is obtained as the second mode, by another EOF analysis for an annular region at 30–60°N concerning the whole NH midlatitudes. This anomaly pattern can be considered to be a peculiar one to this range of longitude.

3. Vertical structure and heat budget of the pressure anomaly

A comparison between Fig. 1 and Fig. 2 showing sea level pressure (SLP) anomaly reveals that this anomaly pattern has a baroclinicity and corresponds well to the appearance of the Okhotsk high with opposite sign. It was shown, by the analyses of heat budget, that the cooling effect by the advection of zonal temperature gradient by anomalous wind is strong in the middle and lower troposphere in this region. This cooling effect is balanced by the advection of the temperature anomaly by the mean wind in the middle layer, and by the vertical wind and thermal forcing in the lower layer. It can be noted that the anomalous thermal forcing is not a significant trigger for the formation of the anomaly pattern shown in Figs. 1 and 2, since the thermal forcing is damping the temperature anomaly. Form these results, we can consistently understand this pattern by considering the effect of advection of the temperature gradient in the basic field by the anomalous wind corresponding to the vorticity forcing in the upper layer.

4. Abrupt development of the anomaly by barotropic energy conversion

The temporal evolution of the pressure anomaly over Siberia is examined, by

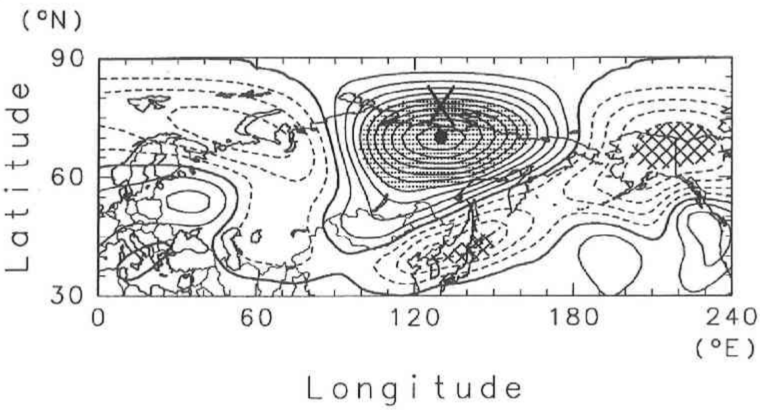

Fig. 3. Regression of 250 hPa height to the normalized 250 hPa height anomaly at point X. The contour interval is 10 m. Positive (negative) anomalies with 95% significance are shaded (hatched).

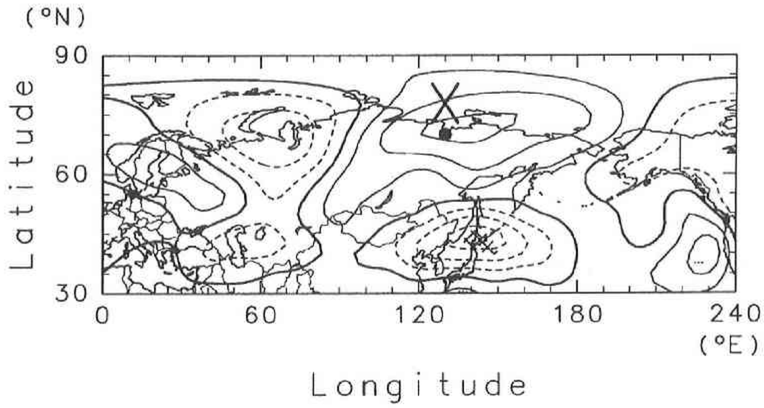

Fig. 4. The same for Fig. 3, except the lagged regression for 10 days before.

calculating the regression of 250 hPa height anomaly to the anomaly at point X (70.0°N, 130.0°E) where the value of the regression is lowest in Fig. 1. Figure 3 shows the simultaneous regression, while Fig. 4 the lagged regression at $t=-10$ days. The wave-like pattern propagating from the west to Siberia is not significant enough. The appearance of the predominant vorticity anomaly in the upper troposphere over Siberia may be recognized as an abrupt development of vorticity anomaly in western Siberia, rather than as a wave propagation from the west, when statistical temporal evolutions are concerned shown in Figs. 3 and 4.

There is a predominant divergence of wave activity flux to the west of the anticyclonic center over western Siberia in Fig. 3 (not shown). This result implies that the anomaly is strengthened over western Siberia, rather than that it is just formed by a

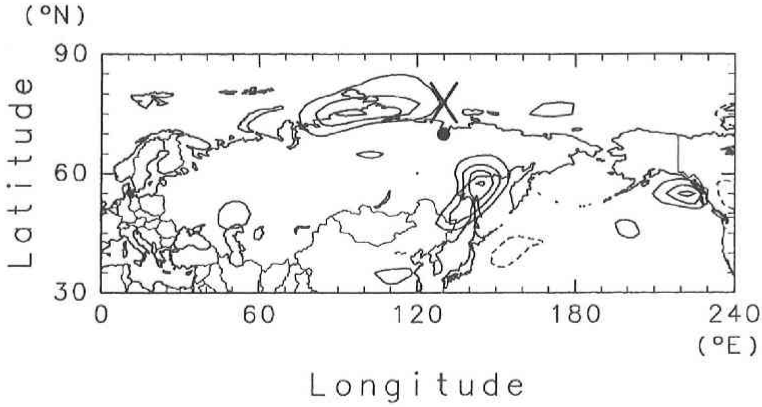

Fig. 5. Barotropic energy conversion associated with the anomalous fields shown in Fig. 3. The contour interval is $5.0\times10^{-5}\,m^2/s^3$. The zero contours are suppressed, and negative contours are broken.

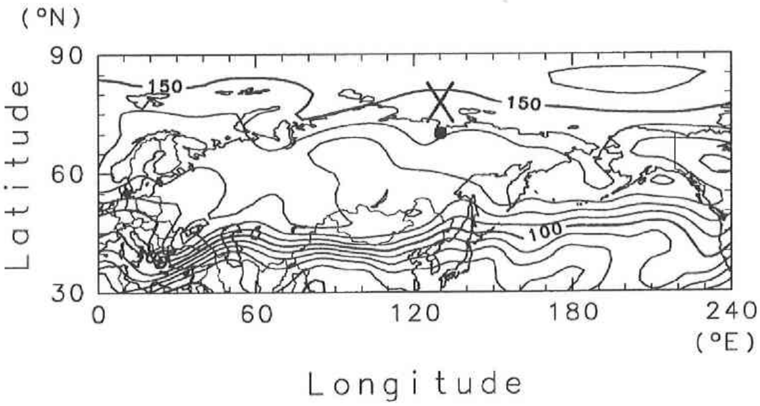

Fig. 6. Climatological absolute vorticity at 250 hPa for July 21 to August 20. The contour interval is $1.0\times10^{-5}/s$.

wave propagation. Concerning the result shown in Fig. 3, barotropic energy conversion was estimated as follows:

$$\left(\frac{\partial}{\partial t}+\bar{\boldsymbol{u}}\cdot\nabla\right)\left(\frac{u'^2+v'^2}{2}\right)=-u'^2\frac{\partial}{\partial x}\bar{u}-u'v'\frac{\partial}{\partial y}\bar{u}-u'v'\frac{\partial}{\partial x}\bar{v}-v'^2\frac{\partial}{\partial y}\bar{v}. \tag{1}$$

The result is shown in Fig. 5. The growth of the anomaly corresponds to barotropic energy conversion from the basic field to the anomaly field. The conversion does not appear when low-passed (smoothed) basic fields with components with a wavenumber equal to or smaller than 10 are used for the calculation instead of the original climatological fields shown in Fig. 6. In Fig. 6, a predominant distortion of the absolute vorticity field is seen over western Siberia, where a positive energy conversion was obtained in Fig. 5. From this result, we can conclude that the energy conversion is related to a localized distortion of absolute vorticity distribution of the basic field.

5. Conclusions

By EOF analyses, the anomaly pattern which is excited over Siberia and is associated with the formation of a cold Okhotsk high was obtained. This pattern has a baroclinicity and corresponds well to the appearance of the surface high over the Okhotsk Sea. We can consistently understand this pattern by considering the effect of advection of the temperature gradient in the basic field by the anomalous wind corresponding to the vorticity forcing in the upper layer. The appearance of the predominant vorticity anomaly in the upper troposphere over Siberia may be recognized as an abrupt development of vorticity anomaly in western Siberia, rather than as a wave propagation from the west in this analysis. It is revealed that the abrupt growth of the anomaly corresponds to the strengthening of anomaly by barotropic energy conversion from the basic field, associated with a distortion of the absolute vorticity distribution in western Siberia, to the anomaly field.