Anomalous East Asian Winter Monsoon
in Relation to
Symbolic Eurasian Blocking Patterns

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Abstract

This study attempts to examine the anomalous state of the East Asian Winter Monsoon (EAWM) in relation to spatial and temporal features of atmospheric blocking over Eurasia at the upstream of the climatological Siberian high region. Atmospheric blocking is identified by geopotential height gradients (zonal indices) over the extratropics. Surface air temperature is used to assess the impact of blocking on the EAWM region. Generally, there are two spatially independent blocking patterns of an omega shape with the ridge centered over the Ural-Siberia region and the European continent respectively. The impact is significant if the downstream cyclonic vortex of the blocking system forms a dynamic contact with the Siberian high, which is more confined to the former case. On the whole, the impact can be viewed from the perspective of a single event and a whole season.

Establishment of a blocking high over Ural-Siberia involves interaction between the Siberian high and an upstream cyclone. Three temporal features of the blocking high are investigated: duration, intensity and extension. Firstly, the tropospheric warm-core structure is maintained by which the kinetic energy of the thermal ridge is converted to the potential energy of the blocking ridge. The warm ridge extending poleward induces cold advection to promote sustained development of the Siberian high. Secondly, the amplification of the blocking ridge is dependent on the amount of incoming anticyclonic vorticity advection. The advection can be determined by the zonal pressure gradient between the upstream cyclone and the Siberian high, which tightens when the cyclone is located right to the west of the Siberian high. However, this dynamic factor is not deterministic for the thermodynamic evo-
olution of the Siberian high. Thirdly, the extension may be related to the size of pre-existing cold anomalies over western Siberia. Intense cold air masses tend to tighten the pressure gradient and to amplify the upper-tropospheric trough aloft the upstream cyclone. The thermodynamic feedback from Siberia perhaps supports the blocking high to stay for longer time. Therefore, a long-lasting cold period may take place as a consequence of a long-lasting blocking event.

The blocking-EAWM relationship is close (weak) when outstanding blocking frequency is over Ural-Siberia (Europe). These upstream blocking activities may be regarded as a response to a combined signal of the Arctic Oscillation (AO) and El Niño/Southern Oscillation (ENSO). Weakened (strengthened) meridional flow in the positive (negative) phase of the AO is unfavorable (favorable) for blocking high formations. As the AO shows a close relationship with the North Atlantic Oscillation (NAO), the teleconnection between the AO and the Eurasian blocking activity may exist in the form of an eastward propagating wave-train signal generated over the North Atlantic Ocean. Be that as it may, the transmission of a signal across East Asia may be disturbed by the external effect of the ENSO, which probably suppresses (enhances) the sinking motion near Siberia in its positive (negative) phase. In short, the blocking-EAWM linkage is stronger (weaker) when the AO and ENSO are in phase (out of phase). If both the AO and ENSO attain their positive (negative) phase, the blocking frequency is distinctly low (high) over Ural-Siberia and uniform warming (cooling) would be observed in East Asia. Rather, if they are out of phase, the blocking signal would not be clear over Ural-Siberia and the monsoonal flow in northern (southern) East Asia would be stronger in negative AO (negative ENSO).
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<td>Arctic Oscillation</td>
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<td>AOI</td>
<td>Arctic Oscillation index</td>
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<tr>
<td>BI</td>
<td>Blocking intensity of a blocking region</td>
</tr>
<tr>
<td>BI&lt;sub&gt;max&lt;/sub&gt;</td>
<td>Maximum blocking intensity of a blocking event</td>
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<tr>
<td>BI&lt;sub&gt;mean&lt;/sub&gt;</td>
<td>Mean blocking intensity of a blocking event</td>
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<tr>
<td>CPC</td>
<td>Climate Prediction Center</td>
</tr>
<tr>
<td>DJF</td>
<td>December through February</td>
</tr>
<tr>
<td>EAWM</td>
<td>East Asian winter monsoon</td>
</tr>
<tr>
<td>EAWMI</td>
<td>East Asian winter monsoon index</td>
</tr>
<tr>
<td>ENSO</td>
<td>El Niño/Southern Oscillation</td>
</tr>
<tr>
<td>EOF (n)</td>
<td>(The n-th leading) Empirical orthogonal function</td>
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<tr>
<td>Ext</td>
<td>Extension of a blocking region</td>
</tr>
<tr>
<td>Ext&lt;sub&gt;max&lt;/sub&gt;</td>
<td>Maximum extension of a blocking event</td>
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<td>GHGN</td>
<td>Geopotential height gradient in the north</td>
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<tr>
<td>GHGS</td>
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<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<td>IPCC AR4</td>
<td>The fourth assessment report of IPCC</td>
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<td>PC</td>
<td>Principal component</td>
</tr>
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<td>PCA</td>
<td>Principal component analysis</td>
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<td>PC (n)</td>
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<td>PDO</td>
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<td>NAO</td>
<td>North Atlantic Oscillation</td>
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<td>NCAR</td>
<td>National Center for Atmospheric Research</td>
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<tr>
<td>NCC</td>
<td>National Climate Center</td>
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<tr>
<td>NCEP</td>
<td>National Centers for Environmental Prediction</td>
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<tr>
<td>NDJFM</td>
<td>November through March</td>
</tr>
<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
</tr>
<tr>
<td>QG</td>
<td>Quasi-geostrophic</td>
</tr>
<tr>
<td>SLP</td>
<td>Sea level pressure</td>
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<tr>
<td>SST</td>
<td>Sea surface temperature</td>
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<td>WAF</td>
<td>Wave activity density flux</td>
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<td>B06</td>
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\( \nabla \) Gradient operator
\( \nabla^2 \) Laplacian
\( - \nabla_h \cdot T \) Horizontal temperature advection
\( - \nabla_p \cdot T \) Vertical temperature advection due to adiabatic heating
\( \phi \) Latitude
\( \phi_N \) Northernmost latitude of a blocking region
\( \phi_S \) Southernmost longitude of a blocking region
\( \eta_g \) Absolute geostrophic vorticity
\( \lambda \) Longitude
\( \lambda_E \) Easternmost longitude of a blocking region
\( \lambda_W \) Westernmost longitude of a blocking region
\( \lambda_k \) Explained variance of the k-th EOF
\( \theta \) Potential temperature
\( \rho \) Density
\( \psi' \) Perturbation stream-function
\( \zeta \) Relative vorticity
\( f_0 \) Planetary vorticity at 45°N
\( c_p \) Specific heat capacity under constant pressure
\( q_{0.25} \) Lower quartile (25\textsuperscript{th} percentile)
\( q_{0.75} \) Upper quartile (75\textsuperscript{th} percentile)
\( N^2 \) Static stability
\( R \) Gas constant
\( T(p) \) Temperature (at p-hPa isobaric level)
\( U(p) \) Zonal wind (at p-hPa isobaric level)
\( U_g \) Zonal component of geostrophic wind
\( V(p) \) Meridional wind (at p-hPa isobaric level)
\( V_g \) Meridional component of geostrophic wind
\( W(p) \) Vertical velocity (omega) (at p-hPa isobaric level)
\( Z(p) \) Geopotential height (at p-hPa isobaric level)
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