**Abstract**

Atmospheric low-frequency anomalies, also known as teleconnection patterns, are most energetic in the Northern Hemisphere during the winter season. These teleconnections have a far-reaching impact on weather and climate that spans the Northern Hemisphere. In this study, the teleconnections of the wintertime North Pacific are examined from the continuum perspective with self-organizing map (SOM) analysis. Using daily ERA-Interim reanalysis data for the 1979-2011 period, we found that most of the North Pacific teleconnections can be grouped into several Pacific/North America (PNA)-like, Western Pacific (WP)-like, and East Pacific (EP)-like SOM patterns. Each of the SOM patterns has an e-folding time scale of 7 to 10 days. The WP-like SOM patterns undergo a decline in their frequency from early to late winter, and vice versa for the EP-like SOM patterns, corresponding to an eastward seasonal shift of the North Pacific teleconnections. It is shown that the interannual variability of the PNA, WP, and EP can be interpreted as arising from interannual changes in the frequency of the corresponding SOM patterns. The seasonal shift and interdecadal trend of these teleconnections are found to be associated with corresponding changes in sea ice and precipitation.

**Results**

In general, the WP-like patterns undergo a seasonal decline in their frequencies, while the EP-like patterns show an increase in their frequencies (Table 3). There are also seasonal changes in the PNA pattern: A stronger southern (northern) center is detected in late (early) winter.

The correlations between the seasonal mean SOM frequency and PC time series are 0.93, 0.86, and 0.78 for the PNA, WP, and EP patterns, respectively. The PNA underwent a significant downward trend, WP, and EP didn’t show a significant trend.

**Conclusion**

In conclusion, using SOM analysis, we have examined the dominant North Pacific teleconnection patterns from the continuum perspective. This has enabled us to more accurately determine the spatial structure of the teleconnection patterns than with previous methods, and has helped us to learn new features of the seasonal variation of the teleconnection patterns. Furthermore, because our findings show that interannual variability of the dominant North Pacific teleconnections can be interpreted as arising from the interdecadal variability in the frequency of the corresponding SOM patterns, a SOM approach may also shed light onto the processes that drive climate variability.

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**Figures**

- Fig. 1: (Left) EOF1 spatial patterns for (a) the entire winter (Nov - Mar), (b) early winter (Nov - Dec), and (c) late winter (Jan - Mar). (Right) Same as the left column except for EOF2. Warmer colors denote positive values and colder colors negative values. Contour interval is 0.6.
- Fig. 2: SOM patterns of the anomalies 250-hPa zonal wind for NDJFM. Percentages on the top left of each map describe the occurrence frequency in early winter (MD) and late winter (FM).
- Fig. 3: Group-averaged winter mean occurrence frequencies for the (a) PNA-like SOMs, (b) WP-like SOMs, and (c) EP-like SOMs. Principal component for the (d) winter mean EOF1 in NDJFM, (e) early winter mean EOF2 in MD, (f) late winter mean EOF2 in FM.
- Fig. 4: (Left) Group-composite anomalous sea-ice cover based on PNA-like (top), WP-like (middle), and EP-like (bottom) SOMs (High). An left column except for the 10-meter wind vector (green) and 2-meter temperature (orange).

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**Table 1**

<table>
<thead>
<tr>
<th>SOM</th>
<th>PNA (Early)</th>
<th>PNA (Late)</th>
<th>WP</th>
<th>WP (Early)</th>
<th>WP (Late)</th>
<th>EP</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 (11)</td>
<td>9 (10)</td>
<td>8 (9)</td>
<td>7 (8)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The PNA, WP, and EP-like SOMs, their polarity and occurring frequency in early and late winter. The last column shows the e-folding time scale for each SOM (167 days). Values in parenthesis are the e-folding time scale obtained from the EOF time series.