Variability and Trends in the Southern Hemisphere High Latitude, Quasi-Stationary Planetary Waves

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Monthly Mean
500 hPa Height Field from the
ERA-Interim Reanalysis
The Variability of the Amplitudes With Latitude

Variation of 500hPa GPH mean amplitude by wavenumber and latitude

Mean amplitudes of waves 1-10 over 30 – 90 S. 1979 - 2013
The Mean Amplitudes of Waves 1 to 4

<table>
<thead>
<tr>
<th>Wave number</th>
<th>Summer (DJF)</th>
<th>Fall (MAM)</th>
<th>Winter (JJA)</th>
<th>Spring (SON)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>71.4 (18.4)</td>
<td>80.0 (19.1)</td>
<td>100.5 (22.8)</td>
<td>81.5 (17.3)</td>
<td>83.3 (13.1)</td>
</tr>
<tr>
<td>2</td>
<td>32.9 (10.9)</td>
<td>40.5 (12.1)</td>
<td>44.4 (12.9)</td>
<td>41.7 (11.2)</td>
<td>39.8 (6.2)</td>
</tr>
<tr>
<td>3</td>
<td>36.3 (8.1)</td>
<td>44.8 (11.1)</td>
<td>48.4 (12.6)</td>
<td>38.9 (12.3)</td>
<td>42.1 (4.4)</td>
</tr>
<tr>
<td>4</td>
<td>20.6 (6.4)</td>
<td>19.4 (7.4)</td>
<td>17.0 (4.6)</td>
<td>13.6 (4.3)</td>
<td>17.6 (2.9)</td>
</tr>
</tbody>
</table>

Over 55-65 S for 1979 – 2013. SD in parentheses
The 1979 – 2014 Mean Winter 500 hPa Height

Wave 1 ridge

Wave 1 trough

The Amundsen Sea Low
The Annual Cycle of Wave Number 1 Amplitude

1979 – 2013
The Annual Cycle of Wave Number 1 Phase

1979 – 2013
The Winter Amplitude of Wave Number 1

1979 – 2013
Extremes of Winter Wave Number 1 Amplitude

Small amplitude 1983

Large amplitude 1995
The correlation of annual mean 1.5 m air temperature with the annual mean amplitude of wave number 1 for 1979-2013. Areas where the correlations are significant at $p < 0.05$ are enclosed by a bold line.
Forcing of the Wave Number 1 Amplitude

Correlation of the annual mean amplitude of wave number 1 with annual mean SSTs
Tropical Influences

During El Nino events a wave train is established to the Amundsen – Bellingshausen Sea


Deeper ASL – SAM positive and/or La Nina

Weaker ASL – SAM negative and/or El Nino
Forcing of the Wave Number 1 Phase

Correlation of the annual mean phase of wave number 1 with annual mean SSTs
The Annual Cycles of Wave Number 3

Amplitude

Phase
The forcing of wave number 3 phase

The correlation of wave 3 phase and 500 hPa zonal wind. Annual.
The Trends in the Amplitudes of the Waves

<table>
<thead>
<tr>
<th>Wave number</th>
<th>Summer</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.82</td>
<td>-4.77</td>
<td>-5.81</td>
<td>-4.47</td>
<td>-3.64*</td>
</tr>
<tr>
<td>2</td>
<td>-0.46</td>
<td>0.75</td>
<td>-0.35</td>
<td>1.83</td>
<td>0.58</td>
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<tr>
<td>3</td>
<td>2.29</td>
<td>-2.61</td>
<td>-0.50</td>
<td>1.36</td>
<td>0.11</td>
</tr>
<tr>
<td>4</td>
<td>-0.28</td>
<td>-1.64</td>
<td>-0.47</td>
<td>1.12</td>
<td>-0.15</td>
</tr>
</tbody>
</table>
The Trends in Annual Mean SSTs

1979 - 2013
# The Trends in the Phases of the Waves

<table>
<thead>
<tr>
<th>Wave number</th>
<th>Summer</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.17</td>
<td>0.62</td>
<td>1.39</td>
<td>2.57</td>
<td>1.08</td>
</tr>
<tr>
<td>2</td>
<td>4.38</td>
<td>9.15</td>
<td>0.82</td>
<td>4.63</td>
<td>4.24</td>
</tr>
<tr>
<td>3</td>
<td>0.54</td>
<td>0.32</td>
<td>1.46</td>
<td>2.81</td>
<td>1.06</td>
</tr>
<tr>
<td>4</td>
<td>-0.19</td>
<td>-1.58</td>
<td>-2.69*</td>
<td>2.81</td>
<td>-0.31</td>
</tr>
</tbody>
</table>

1979 - 2013
The Trend in Annual Mean 500 hPa Height

1979 - 2014
Conclusions

• Wave Number 1 has the largest amplitude of the planetary waves and its amplitude is strongly influenced by tropical SSTs and especially the ENSO cycle.
• The amplitude is greater during the El Nino phase because of the strong teleconnection to the Amundsen Sea where the wave 1 ridge is located.
• There are significant influences of wave 1 variability on the Antarctic surface temperature field.
• Wave 3 is strongly influenced by the strength of the westerlies over the Southern Ocean and therefore the ozone hole and the SAM.
• Since 1979 the amplitude of wave number 1 has decreased, which is consistent with the slight cooling (La Nina phase) of temperatures across the central Pacific. However, natural/intrinsic variability of the waves is large and may have played a major role.
Thank you