Climate anomalies in the southern high latitudes associated with the Subtropical Dipole Mode

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Abstract Climate anomalies in the southern high latitudes associated with the Subtropical Dipole Mode (SDM) are investigated using a 23-year database consisting of SLP (sea level pressure), surface air temperature (SAT) and sea surface temperature (SST). The analysis depicted the spatial variability in the relationship of the above variables with the Subtropical Dipole Mode Index (SDI). It suggests that the SDM signal exists in the southern high latitudes and the correlation fields exhibit a wavenumber pattern around the circum-polar Southern Ocean. Lead-lag correlation analysis used the SLP, SAT, and SST anomalies with the SDI time series at the positive and negative correlation extremes shows that the southern high latitude climate responses to SDM almost instantaneously proposing the connection is by atmospheric and not by oceanic propagation.

Keywords southern high latitudes climate anomaly subtropical Dipole mode

1 Introduction

Enough has been said about the teleconnection of ENSO (El Niño-Southern Oscillation) in the tropical Pacific Ocean and the climate in the southern high latitudes (Fletcher et al. 1982, Smith and Steams 1993, Simmons and Jacka 1995, Liu et al. 2002, Kwok and Comiso 2002). In recent years, much attention was focused on the Indian Ocean (Webster 1999, Saji 1999, Swadhin and Toshiro 2001) suggesting the Indian Ocean plays a very active role in the global climate system. The relationship between the Indian Ocean, especially the subtropical Indian Ocean, and the climate in the southern high latitudes has not been discussed in the literature. Are there any signals of the subtropical Indian Ocean in the southern high-latitude climate anomalies? The present study is to explore the relation-
ship through analyzing the linear correlation of the Subtropical Dipole Mode Index (SDI) (Swadhin and Toshio 2001) with the polar climate anomalies.

2 Data analysis and results

Monthly SLP, SAT are got from the National Centers for Environmental Prediction—National Center for Atmospheric Research (NCAR-NCEP) reanalysis output (Kalnay 1996). The SST data are from dataset GISSST 2.2b of the British Atmospheric Data Center (BADC) (Rayner et al. 1996). At each grid point monthly anomalies of each variable were found by the method that subtracting the climatological seasonal cycle from each monthly mean value.

The anomalies fields in the global NECP 2.5° × 2.5° grids and GISSST 1° × 1° grid are resampled onto a polar stereographic grid for better visualization over the circumpolar Southern Ocean. The datasets used here all span a 23-year period from January 1981 to December 2002.

Based on the definition of the Subtropical Dipole Mode Index (Swadhin and Toshio 2001), it is obtained by computing the SST anomaly difference between the western (55-65°E, 37-27°S) and eastern (90-100°E, 28-18°S) subtropical Indian Ocean. In the following analysis, three-month running average of the SDI as shown in Fig. 1, is employed in order to avoid a significant portion of the noise due to small-scale and transient phenomena which are not associated with the large-scale coherent SDI signal.

![SDM Index vs Year](image)

Fig. 1 The Subtropical Dipole Mode Index time series from Nov 1981 to Mar 2003. The line shows the 3-month moving average of the time series.

2.1 Correlation analysis

In this section, we will examine the polar climate anomalies associated with the SDI.
time series. The correlation coefficients between the time series of SLP, SST, SAT anomalies and SDM time series are computed. The resulting correlation fields are shown in Fig. 2. The correlation maps show distinct centers of action (positive and negative extremes of the correlation coefficient). Most striking from the figure is that all of the correlation maps exhibit a wave number 3 pattern around the circum polar Southern Ocean. We are interested in the whole areas of the southern ocean except the southern Indian Ocean where SDM locates. There are two positive correlation centers of action in the following regions: the northern of Weddell Sea and the southern of Australian land along 50°S. There are also two negative correlation centers in the northern of the Bellingshausen Sea and in the southern-western Atlantic Ocean. Furthermore, we can find that the most positive and negative correlation values of SST are higher than SAT and SLP. The locations of the action center and the corresponding correlation coefficients are showed in Table 1.

2.2 The lead-lag correlation analysis

The lead-lag correlation analysis is used to study the response time scale of the correlation. We examine only areas with strong correlation where we have an interest. The plots of lead-lag correlation between the time series of SDI and the climate anomalies at the locations of strongest positive and negative correlation south of 40°S are shown in Fig. 3. The longitude and latitude of the selected locations have been showed in Table 1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Correlation Coefficient</th>
</tr>
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<tbody>
<tr>
<td>SLP</td>
<td>175°W, 50°S</td>
</tr>
<tr>
<td></td>
<td>0.24</td>
</tr>
<tr>
<td>SAT</td>
<td>22.5°W, 45°S</td>
</tr>
<tr>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td>SST</td>
<td>15°W, 45°S</td>
</tr>
<tr>
<td></td>
<td>0.48</td>
</tr>
<tr>
<td>SDI</td>
<td>92.5°W, 65°S</td>
</tr>
<tr>
<td></td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>130°W, 55°S</td>
</tr>
<tr>
<td></td>
<td>-0.26</td>
</tr>
<tr>
<td></td>
<td>110°W, 50°S</td>
</tr>
<tr>
<td></td>
<td>-0.34</td>
</tr>
</tbody>
</table>

Table 1: Locations of the action center and the corresponding correlation coefficients on the correlation maps of SLP, SAT, and SST anomalies with SDI time series (1981-2003).
Fig 2  Correlation maps of SLP, SAT, and SST anomalies with SDI time series (1981-2003) and the location of the positive (black X) and negative (black rectangular) extremes on the correlation maps. The correlation levels associated with the observed correlations are shown in a correlation map.
As seen in the lead-lag correlation plots the spatial peaks are also distinct in time and the broad correlation structure shows its similarity to the autocorrelation signature of the large-scale coherent SDI signals. There is no observable leading and lagging between SDI and the SST anomalies at the location of the negative and positive peaks. An approximate 3-month lead with the SLP and the SAT anomalies lagging the SDI is evident at the positive and negative peaks. Martinson and Iannuzzi (2003) and Liu et al. (2002) implied an atmospheric mechanism of the propagation between ENSO in the tropical Pacific Ocean and the climate anomalies in the southern high latitudes through the instantaneous correlation results. So from the above analysis we can see that the climate anomalies in the southern high latitudes respond the SDM almost instantaneously. So it can be suggested the fact that the propagation of the connection proceeds fast implies not oceanic but atmospheric mechanism.

3 Conclusions and Discussion

Through our analysis by correlation analysis to investigate the relationship between SDM and climate anomalies in the southern high latitudes, it is clear that

(1) evident teleconnection between SDM and SLP, SAT and SST anomalies in the southern high latitudes

Fig 3 Lead-lag correlation plots of the SLP, SAT, and SST anomalies with the SDI time series at the positive and negative correlation extremes (positive indicates SDI leads). The autocorrelation of the SDI time series is also shown.
exists Correlation fields exhibit a wavenumber-3 pattern around the circum polar Southern Ocean (2) the climate anomalies in the southern high latitudes responses the SDM almost instantaneously suggesting the teleconnection proceeds not by oceanic but atmospheric mechanism.

Now we can conclude that not only ENSO signals in the tropical Pacific Ocean but also subtropical Dipole Mode signals are found in the southern high latitudes Peterson and White ( 1998), in a case study, show ENSO can be a possible source of the inter-annual anomalies for sustaining the ACW in the western subtropical South Pacific. More studies on investigating whether the subtropical Dipole Mode can also be a source of ACW will be done in the future.

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References


