Annular modes
Regressions on the annular modes (in meters)

Fig. 1. (top) Zonal-mean geostrophic wind and (bottom) lower-tropospheric geopotential height regressed on the standardized indices of the annular modes (the AO and its SH counterpart) based upon monthly data, Jan 1958–Dec 1997. Left panels are for the SH, right panels are for the NH. Units are m s$^{-1}$ (top) and m per std dev of the respective index time series (bottom). Contour intervals are 10 m ($-15$, $-5$, $5$, $\ldots$) for geopotential height and 0.5 m s$^{-1}$ ($-0.75$, $-0.25$, $0.25$) for zonal wind.
Regressions of zonal-mean zonal wind on the annular modes

Fig. 1. (top) Zonal-mean geostrophic wind and (bottom) lower-tropospheric geopotential height regressed on the standardized indices of the annular modes (the AO and its SH counterpart) based upon monthly data, Jan 1958–Dec 1997. Left panels are for the SH, right panels are for the NH. Units are m s$^{-1}$ (top) and m per std dev of the respective index time series (bottom). Contour intervals are 10 m ($-15$, $-5$, $5$, . . .) for geopotential height and 0.5 m s$^{-1}$ ($-0.75$, $-0.25$, $0.25$) for zonal wind.

Fig. 2

Thompson and Wallace, J. Climate, 2000
**Fig. 3** As in Fig. 1, but regression maps are based on the standardized leading PC time series of the zonal-mean geopotential height field (1000–50 hPa; 20°–90°).
‘Variance explained’ by leading modes

**Table 2.** Percentage of variance explained by the leading modes in EOF expansion of monthly mean fields for the region poleward of 20°, based on data for all calendar months: mode 1 (2, 3).

<table>
<thead>
<tr>
<th>Zonally varying SLP (NH) and $Z_{850}$ (SH)</th>
<th>Zonal-mean geopotential height (1000 to 50 hPa)</th>
<th>Zonal-mean zonal wind (1000 to 50 hPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH</td>
<td>20 (10, 10)</td>
<td>45 (17, 12)</td>
</tr>
<tr>
<td>SH</td>
<td>27 (12, 9)</td>
<td>47 (27, 10)</td>
</tr>
</tbody>
</table>

*Fig. 4*
The standardized seasonal mean AO index during cold season (blue line) is constructed by averaging the daily AO index for January, February and March for each year. The black line denotes the standardized five-year running mean of the index. Both curves are standardized using 1950-2000 base period statistics.
Power spectrum is similar to that of a red-noise process

Fig. 6

**Fig. 4.** Power spectra for the intraseasonal ZI time series for (a) the NH winter, (b) the NH summer, (c) the SH winter, and (d) the SH summer. The corresponding red noise spectra and 95% confidence levels are also shown.
MSU2LT data regressed on the JFM NAM index (top) and the SAM index (bottom). Contour interval 0.1 K/std.

Wallace, *On the Arctic and Antarctic Oscillations*, 2000

**Fig. 7**

Lower-tropospheric temperature patterns associated with annular modes.
Summary of AO in its high index state: anomalous eddy momentum fluxes and Ferrel cell help maintain the high index state for a while.

Wallace, On the Arctic and Antarctic Oscillations, 2000
## Blocking and severe winter weather modulated by AO

### Number of JFM days 1958-97 marked by blocking events

<table>
<thead>
<tr>
<th>Location</th>
<th>Total</th>
<th>High AO</th>
<th>Low AO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>389</td>
<td>46</td>
<td>98</td>
</tr>
<tr>
<td>(140°W-180°W; 65°N-75°N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Atlantic</td>
<td>350</td>
<td>0</td>
<td>195</td>
</tr>
<tr>
<td>(20°W- 50°W; 55°N-65°N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>428</td>
<td>32</td>
<td>85</td>
</tr>
<tr>
<td>(50°E-70°E; 60°N-70°N)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Wallace, On the Arctic and Antarctic Oscillations, 2000*
### Blocking and severe winter weather modulated by AO

Number of JFM days 1958-97 with minimum temperatures $< \text{Location}$  |  Total | High AO | Low AO |
---|---|---|---|
$< -15\,^\circ C$ in Yakima, WA. | 116 | 17 | 41 |
$< -20\,^\circ C$ in Chicago, Il. | 181 | 12 | 50 |
$< -1\,^\circ C$ in Orlando, Fl. | 108 | 11 | 27 |
$< -5\,^\circ C$ in Paris, France | 142 | 8 | 54 |
$< -33\,^\circ C$ in Novosibirsk | 120 | 7 | 46 |
$< -20\,^\circ C$ in Beijing, Ch. | 141 | 11 | 41 |
$< -2\,^\circ C$ in Tokyo, Japan | 140 | 7 | 40 |

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Wallace, *On the Arctic and Antarctic Oscillations*, 2000

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**Fig. 10**
the feedback between the baroclinicity and the baroclinicity. In this case, we assumed that (i) the fluxes of heat as a function of the baroclinicity expression for the time rate of change of the eddy momentary materials). Equation 1 was then linearized (flux of wave activity and the eddy flux of heat of the eddy flux of heat, and (ii) variations in the rate of baroclinic waves (the left-hand side of baroclinic zone. We assumed that (i) the growth model based on linearized versions of Eq. 1 and suggests that the BAM is associated with two-way thermodynamic energy equation. The period imme-
ward heat fluxes persist for several days (Fig. 2A)
steady state where
We then applied two simplifying assumptions To develop the model, we first applied two
By construction, the regression map in Fig. 
Table 1. Correlations between the BAM index (the fields indicated regressed onto the BAM index time series (resulting equation was subsequently linearized fact that the changes in the Eady growth rate (solid contours) that peak around lag 0. The pole-
noise
Correlations are base
〈b〉
\frac{T}{a_t\delta t_e T_{tot}}\text{ precipitation derived from ERA-Interim [black} and AMSR-E [red }
Precipitation
Spatial signatures of the BAM
A EKE 300
C V*T* 700
E Precipitation
Fig. 11
Thompson & Barnes, Science, 2014
SAM resembles a red-noise process

BAM exhibits periodic variability (~25 days)

Fig. 12. Power spectra of the SAM and BAM indices. See text for details of the calculations.
Fig. 13

Regressions on SAM (shading) and zonal wind (contours)

Regressions on BAM

[\mathbf{u'v'}] (shading) and eddy kinetic energy (contours)

Temperature (shading) and mass stream function (contours)

Results are based on zonal-mean, daily-mean data. Regression coefficients are based on contemporaneous values of the data, except in the cases of $u'v'$ and $v'T'$, in which the fluxes lead the SAM and BAM indices by 1 day. Contours are (a),(b) 20.5, 0.5, 1.5, ..., ms$^{-2}$; (c),(d) 20.5, 0.5, 1.5, ..., 3*10^9 kg m$^{-2}$ s$^{-2}$; and (e),(f) 2, 3, 9, ..., m$^{-2}$ s$^{-2}$.
Regressions on Southern Hemisphere mean \([V^* T^*]\)

\([V^* T^*]\) (contours) and baroclinicity (shading) averaged 250-950 hPa

Strong baroclinicity, followed by strong heat flux, followed by weak baroclinicity

Fig. 14

Thompson & Barnes, Science, 2014
Comparison of simple stochastic model with ERA-interim for power spectrum of heat flux

Fig. 15

Thompson & Barnes, Science, 2014