Some Associations between Arctic Sea Level Pressure and Remote Phenomena Seen in Daily Data

Richard Grotjahn
Dept. of Land, Air, & Water Resources, University of California, Davis
AMSR two-channel reconstruction of Arctic sea ice cover, 28 Sept. 2003 – 10 May 2004
by Tom Agnew, (Meteorological Service of Canada, Toronto; CRB)
Review: SLP – CCM 3.6

General pattern similar to observations
Error pattern has rings of higher and lower SLP error has effect on wind
SLP – similar error as before

CCM 3.6 vs eul_d50amip (T42) 1979-1999 OBS

Ring pattern similar
Shift of loc over Arctic.

1 mb interval
SLP eul_d50amip (T42) 1979-1999 OBS
(similar error still present)
SrFc Winds eul_d50amip (T42) 1979-1999 OBS
Review: 850mb meridional heat flux
Monthly Data – Correlations with Max SLP
Higher SLP w/ less at Pacific storm track end
High pass eddy fluxes used by Hoskins and Valdes are similar in location and strength. Compare >10 mK/s regions:
(L) thick dashed line (1979-84)
(R) pink (1979-2004)
Review: Hoskins & Valdez results overlaid on model SLP error fields qualitatively similar to N. Pacific linear response
1-pt correlations SLP v transient heat fluxes not compelling for high pass. When longer frequencies allowed longwave T trough pattern.
Hoskins & Valdes 1990
high pass eddy heat flux & response fields

Atlantic

Pacific

Stream function at 0.889 sigma level
Monthly data eofs

Ambaum et al. 2001, J. Climate

Fig. 1. First two EOFs [(a) EOF1 and (b) EOF2] for the DJFM mean sea level pressure. These EOFs explain 25% and 14% of the variance, respectively. The contour interval is 0.5 hPa.
NAO + and –

http://www.ldeo.columbia.edu/NAO/

Positive

Negative
Ambaum & Hoskins (2002) mechanism

links midlatitude storm tracks and polar pressure fields through the stratosphere

$$EP \text{ flux } = (F_y, F_p)$$

$$F_y = -[u'v']$$

$$F_p = f \frac{[v'\theta']}{(d[\theta]/dp)}$$

FIG 1. Schematic of the connections between modulations in the NAO, the height of the tropopause, and the strength of the stratospheric jet. If the NAO index increases, associated with it the cyclonic circulation over Iceland (IC) enhances (circular arrow at IC) and the tropopause (thick solid line) lowers with associated positive potential vorticity anomaly (+); upward-propagating Rossby waves (wavy lines) refract more toward the equator and break less in the stratospheric jet; the stratospheric jet enhances (large circular arrow) with associated positive potential vorticity anomaly (+); the tropopause below this anomaly rises and stretches (vertical arrows) the tropospheric column leading to an enhanced cyclonic circulation over the North Pole (circular arrow at NP).
Transient eddy momentum flux weak correlations even after low-pass filtering
\[ ZI = U_{35} - U_{55} \text{ @200 hPa opposite variation from mean as AO} \]

**Atlantic sector**

- \( AO < 0 \Rightarrow U_{35} - U_{55} > 0 \) (Low index)
- \( AO > 0 \Rightarrow U_{35} - U_{55} < 0 \) (High index)

**Pacific sector**

- \( AO < 0 \Rightarrow U_{35} - U_{55} >> 0 \) (Low index)
- \( AO > 0 \Rightarrow U_{35} - U_{55} > 0 \) (High index)

AO>0: Jet Strengthened In Atlantic (high index)

AO>0 Jet Weakened In Pacific (high index)

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Fig. 6. Climatological mean of zonal winds in the Atlantic sector (60°W-0°) for an AO index of (a) -1 std dev and (b) +1 std dev. (c) and (d) The same as (a) and (b), but for the Pacific sector zonal winds (150°E-120°W).
Panel "a)" selected from each of these figures whose captions are below.

**Fig. 5.** Regressions of the December–February geostrophic zonal wind upon (a) the zonal wind index (b) the equatorial SST index. Anomalies are defined by multiplying the regressive coefficients at each grid point by the appropriate index standard deviation: 2.7 m s⁻¹ for the UI and 0.6°C for the SSTI. The indicated phase is that associated with a westerly phase of UI and a positive phase of ENSO as in (b). The corresponding standard error is shown in the right side panels. The contour interval is 1 m s⁻¹, and negative contours are dashed.

**Fig. 6.** Same as in Fig. 5 except for the sea level pressure. The corresponding zonal-mean surface temperature is shown in the right side panels. The contour interval is 6.5 mb, and negative contours are dashed.

**Fig. 7.** Standard deviation of 500 mb NH stationary wave geopotential heights that is linearly related to (a) the zonal-mean zonal wind index, (b) the equatorial SST index, and (c) the combination of the UI and the SST index. The contour interval is 5 gpm.

Source: Ting et al 1996.
-Zonal index: $U_{55} - U_{35}$ Sectors

Pacific sector: $-ZI > 0$ w/ weaker Aleutian low (as expect)
Atlantic sector: $-ZI > 0$ w/ deeper Icelandic low (as expect)
Neither has much signal for Arctic SLP
Back to Basics: U100 vs SLP
Stronger SLP with weaker, broader Stratospheric vortex
CAM3.x $U_{200}$ bias vs observed $U_{100}$ correlations

Reverse sign
Review: Temperature @ 300, 850
Monthly Means for DJF
Review: Temperature @ 300, 850

SLP pt where Model bias >0

SLP pt where Model bias <0. (reverse Sign shown)
CAM3.x bias vs 1-pt observed correlations: T
vert. ave. daily T correl. More like T_{200} bias than T_{850}
Net mass flux
mass flowing from Beaufort into the Kara Sea
when SLP higher at mouth of Ob river
Early Conclusions (after 1 month)

- AMIP run with CAM3.x at T42 has similar SLP error as CCM 3.6
- Sea ice responds to daily changes
- Attempts to link Arctic SLP to midlatitude cyclone activity in 3 ways:
  1. high pass transient VT based on linear stationary wave solutions
  2. transient daily UV based on EP flux argument
  3. zonal wind index ZI based on connection to AO
- None of these three quantities showed convincing link to Arctic SLP
- Attempts were made to compare the model biases in T and zonal wind to observed links between those variables and SLP.
  1. Model biases were consistent with the observed correlations
  2. Seems to alter the long wave pattern, amplify wave# 1; reduce wave# 2
- Daily “mass fluxes” (pressure integral of divergent wind):
  1. Possible mass flow from W. Beaufort towards Kara sea consistent with model bias
  2. Max SLP looks like flow around a high
Future Work

• Consult with collaborators
• Additional observational work: diabatic heating, composites
• Better eddy flux information, possibly with filtering
• Further comparison of model fields to parallel the observational work
• Test stationary wave model response to prescribed anomalous: eddy fluxes, diabatic heating (“stationary wave model”)
• Test what anomalous eddy fluxes arise from an anomalous stationary wave pattern (“storm track model”)
• Model variations (topography, surface stress, etc.)
Storage
CAM3.x bias vs 1-pt observed correlations: $T_{850}$
daily $T_{850}$ correl. vs model bias $T_{850}$ – poor match
CAM3.x bias vs 1-pt observed correlations: $T_{200}$

daily $T_{200}$ correl. vs model bias
Review: SLP autocorrelation

Monthly Data – obs on left, ccm3.6 on right

CCM3.6 sees Pacific more strongly than the obs
Net mass flux
mass flowing around the mean location of the high

Meridional component

Zonal component
ECMWF model performance

cy26r1 T_95L60 – Jung & Tompkins, 2003

Mean: thin contours in dam
Difference: is shaded in dam

(a) Z1000 Difference Cy26r1-ERA40 (Dec-Mar 1962-2001)
ECMWF model performance

cy26r1 $T_L95L60$ – Jung & Tompkins, 2003

(a) Vector Wind 1000hPa ERA40 (Dec-Mar 1962-2001)

(b) Vector Wind Error 1000hPa Cy26r1-ERA40 (Dec-Mar 1962-2001)