Stratosphere-tropospheric coupling:
we are asking the wrong questions.

Mark P. Baldwin
(From Baldwin and Dunkerton, *Science* 2001)
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Observed Average Surface Pressure Anomalies (hPa)

60 days following weak stratospheric winds

60 days following strong stratospheric winds

From Baldwin et al., Science 2001
Northern Annular Mode
Composite surface maps for high and low NAM index.
(From Thompson and Wallace, *Science* 2001)
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1) the surface pressure pattern associated with variations in the strength of the polar vortex looks like the NAM/NAO.

2) the maximum surface response is near the North Pole.

3) the relationship between stratospheric vortex strength and the NAM is linear.
Baldwin and Dunkerton (1999) suggested that the redistribution of mass in the stratosphere, in response to changes in wave driving, may be sufficient to influence the surface pressure significantly, consistent with the theoretical results of Haynes and Shepherd (1989).
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• Ambaum and Hoskins (2002) used “PV thinking” to explain how stratospheric PV anomalies affect surface pressure.
Anomalous wave drag leads to variations in vortex strength

January Zonal-Mean Wind

“Wave Driven Pump”

Wave Drag
FIG. 4. Schematic of the bending of isentropic surfaces (labeled $\theta_0$, $\theta_1$, and $\theta_2$) toward a positive potential vorticity anomaly. The arrows represent winds associated with the potential vorticity anomaly, becoming weaker away from the anomaly.

Diagram from Ambaum and Hoskins *J Climate* (2002).
Create an index of vortex strength as defined by PV at 600K (20-25 hPa).
From Baldwin and Birner, *Nature Geosci.*, under revision
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Composite Anomalous Pressure, 33 Weak Vortex events

PV index at 600K

Pressure Anomaly, 7 hPa between ticks

Lag (days)
Correlation during winter (JFM) between the 600K PV index and zonal-mean temperature. The JFM daily correlation between PV530 and polar cap tropopause T anomalies is 0.90.

From Baldwin and Birner, Nature Geosci., under revision
A simple “model”

[Diagram: Two cylinders, one with labeled "Mass" and "Higher pressure and temperature".]
A simple “model”
50-hPa Annular Mode
Northern Annular Mode
Plunger

Polar Cap Pressure Anomaly

km

Pressure (hPa)
A guess at tropospheric pressure change

Polar Cap Pressure Anomaly

- wave driven pump
- modest tropospheric effect?
Actual Data

Regression between PV600K index and Polar Cap $p'$

ERA-40 observations
Actual Data

Regression between PV600K index and Polar Cap $p'$

Polar Cap Pressure Anomaly

ERA-40 observations

Tropospheric amplification
Actual Data

Regression between PV600K index and Polar Cap $p'$

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Tropospheric amplification

This diagnostic can be made for any model or data set.
Conclusions
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