Paragraph about your final project due Tuesday May 17 by email to me

New paper to read for next week posted Wednesday

Homework 3 due Thursday

Why does the model print the variance of the ice volume? What good is it?
Is there an Arctic Paradox?

Cold Arctic Air Blankets U.S./Europe
Arctic Paradox:
Warming Arctic May Mean Colder Winter for Some

CLIMATE CENTRAL
Bundle Up, It’s Global Warming

By JUDAH COHEN
Published: December 25, 2010
A striking example of the accuracy of the new method happened in the winter of 2002-03. Based on extensive Siberian snow cover during the fall, Cohen correctly forecasted cold weather in the eastern U.S., while most other forecasters predicted warm weather for the northern half of the U.S., based mainly on El Niño conditions. Similarly, Cohen's forecast for the winter of 2003-04 indicated cold conditions in the northeastern U.S., while other forecasts anticipated an equal

The predicted winter surface temperature anomalies (differences from normal) for the United States Jan-Feb-Mar 2010 in degrees Celsius. The prediction was made in December 2009. The predictions make use of October Siberian snow cover, sea level pressure anomalies and equatorial Pacific sea surface temperature anomalies (the JFM predicted value of Nino 3.4).

Credit: Judah Cohen, AER, Inc.
Atmosphere

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March 7, 2011

See [Warm Arctic-Cold Continents website](#)

Summary

While 2009 showed a slowdown in the rate of annual air temperature increases in the Arctic, the first half of 2010 shows a near record pace with monthly anomalies of over 4°C in northern Canada. There continues to be significant excess heat storage in the Arctic Ocean at the end of summer due to continued near-record sea ice loss. There is evidence that the effect of higher air temperatures in the lower Arctic atmosphere in fall is contributing to changes in the atmospheric circulation in both the Arctic and northern mid-latitudes. Winter 2009-2010 showed a new connectivity between mid-latitude extreme cold and snowy weather events and changes in the wind patterns of the Arctic; the so-called Warm Arctic-Cold Continents pattern.
SIT changes from 3-4 m to 0.5-1 m in winter and 2.5-3m to <0.5m in summer. ΔSIT is relatively uniform all year.
ΔSIC is not uniform all year
\( \Delta \text{fluxes} \) is not uniform all year (all are positive up here) and the annual change differs among the fluxes. Turbulent fluxes change most in winter, LW in Fall, and SW in summer (see red stars).
Fig. 3. Seasonal cycle of the turbulent energy flux ($Wm^{-2}; \Delta SH + LH$; thin solid curve), longwave radiative flux ($\Delta LW$; dotted curve), and shortwave radiative flux ($\Delta SW$; dashed curve) responses area averaged over the Arctic Ocean. The net surface energy flux response is given by the thick solid curve, and the SIC changes (%) are indicated by the gray bars (note the inverted scale). Fluxes are positive upward.
ΔAir Temperature peaks in winter, as for Δnet surface flux
Black contour shows regions with T inversion

Decreases most in OND

FIG. 7. Geographical distributions of the strength of the December low-level inversion ($T_{850}\text{hPa} - T_{1000}\text{hPa} > 0\,^\circ\text{C}$) during (left) 1980–99 and (right) 2080–99. Values <1.5°C not shown.
ΔAir Temperature peaks in winter, as for Δnet surface flux. Black contour shows regions with T inversion.
Horizontal heat transport by <monthly variab.
Horizontal heat transport by >monthly variab.
Condensation heating
Vertical and Horizontal Diffusion (aka turbulence)
Longwave Heating
Feb 500hPa response resembles the (negative) NAO pattern, but otherwise the patterns are unlike major modes of atmospheric variability.
Baroclinic response over Arctic Ocean and Equivalent Barotropic (amplifying with height) ridge over Russia and trough over Bering Sea.

Baroclinic Response is linear due to loss of sea ice
Barotrophic Response is nonlinear from storm feedbacks via transient eddy momentum flux
Speculates that lack of 1000hPa response over Arctic Ocean is cancellation from baroclinic and barotropic response
“Linear theory” response to surface heating anomaly is baroclinic (wind has vertical shear and temperature varies in the horizontal). This is the fast response (a few days), and it is has a planetary wave-train-like response. See Hoskins and Karoly (1981). This means eddy flux terms that contain v’T’ and u’v’ terms are ignored.

The initial response modifies transient eddy activity (storms), which also propagate the response downstream causing teleconnections and amplification with height (equivalent barotropic). The pattern may resemble the circulation that caused the initial heating anomaly, in which case there is a positive feedback and therefore the process becomes nonlinear. This occurs in storm tracks. See Lau and Holopainer (1984).
converging and diverging v’T’ enhance the pattern of H and L at 300 mb and therefore increases the jet aloft from A to B.
Magnusdottir et al 2004

Found prescribed SST anomaly of ~5 deg had a smallish effect on 500hPa height but removing a similar sized area of sea ice (which results in ~20 deg surface temperature anomaly) had a much bigger effect, albeit with the opposite sign.  

500 hPa height response patterns
Terrestrial warming has same mean annual cycle but it is ~3 deg C greater in CCSM3

High latitude precipitation increase is much greater in CCSM3 but the greater warming means less falls as snow

SLP (shown below) CCSM3 has response in summer, which therefore must not be a direct response of the sea ice loss
Response of CESM1 with CAM5 physics to increasing absorbed shortwave radiation in sea ice

Sea ice Area in $10^6$ km$^2$

Control

Increased Sea Ice Absorbed SW

Month

Month
Response of CESM1 with CAM5 physics to increasing absorbed shortwave radiation in sea ice

\( \Delta \text{OND Temperature Profile in } ^\circ\text{C} \)
Response of CESM1 with CAM5 physics to increasing absorbed shortwave radiation in sea ice.

Absorbed Shortwave W m$^{-2}$
Response of CESM1 with CAM5 physics to increasing absorbed shortwave radiation in sea ice

95% significance denoted with dots south of 65N
Response of CESM1 with CAM5 physics to increasing absorbed shortwave radiation in sea ice

95% significance shaded, Z500 contour interval is 10m, SLP contour interval is 1hPa
Response of CESM1 with CAM5 physics to increasing absorbed shortwave radiation in sea ice

Δ OND Zonal Wind in m/s (looks same in JFM)
Δ OND Zonal Wind in m/s

OND Zonal Wind in m/s