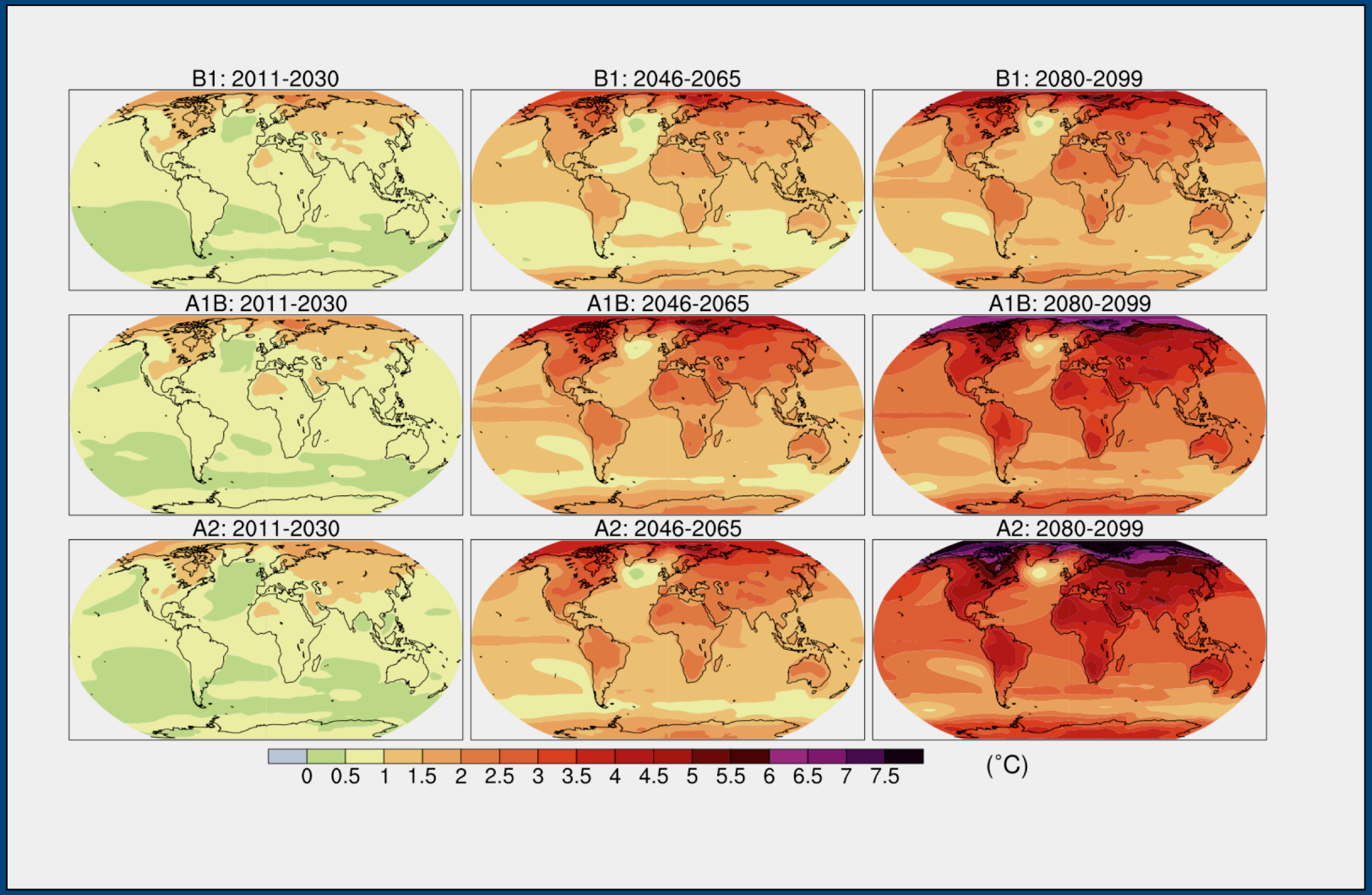
National Snow and Ice Data Center
Supporting Cryospheric Research Since 1976

Predictability of the Arctic Air Temperature Field

Mark Serreze, Andy Barrett
Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder

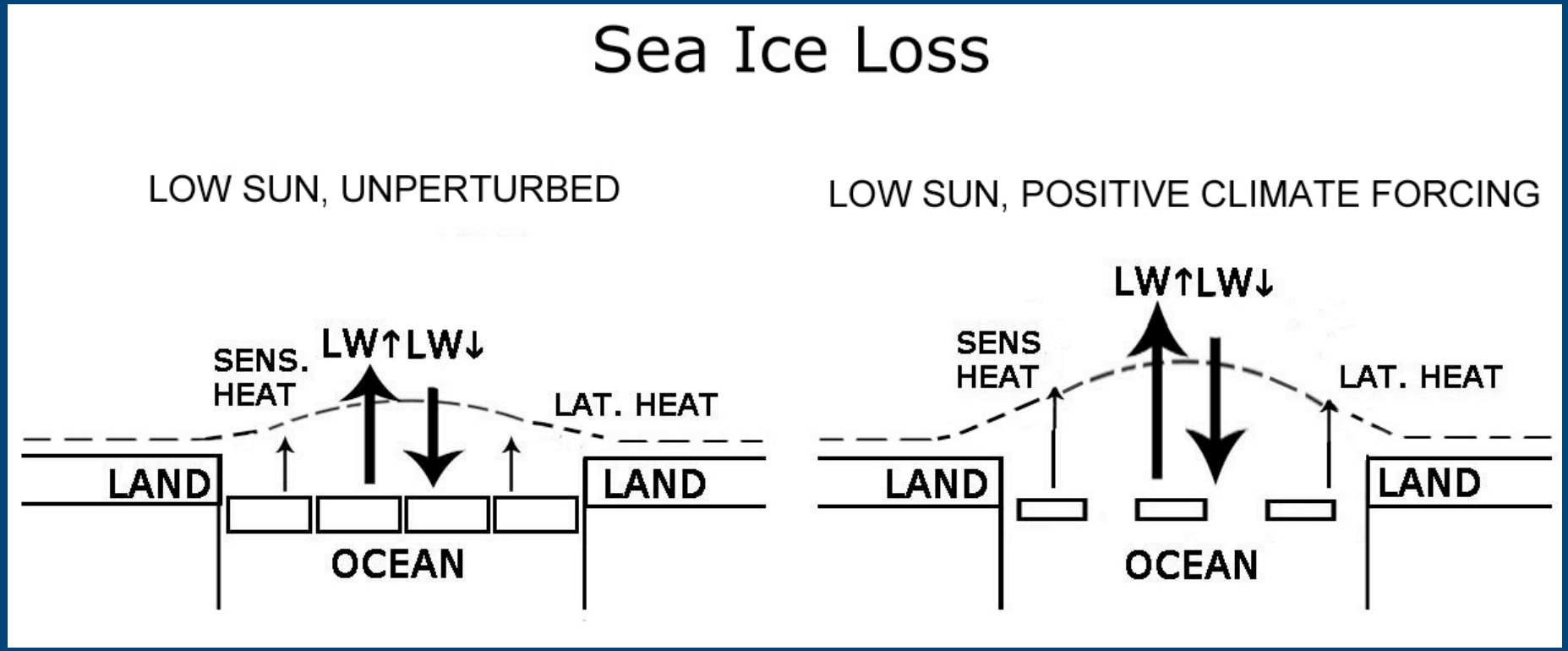

Evolution through the 21st century

Projected changes in annual averaged surface air temperature relative to the late 20th century.



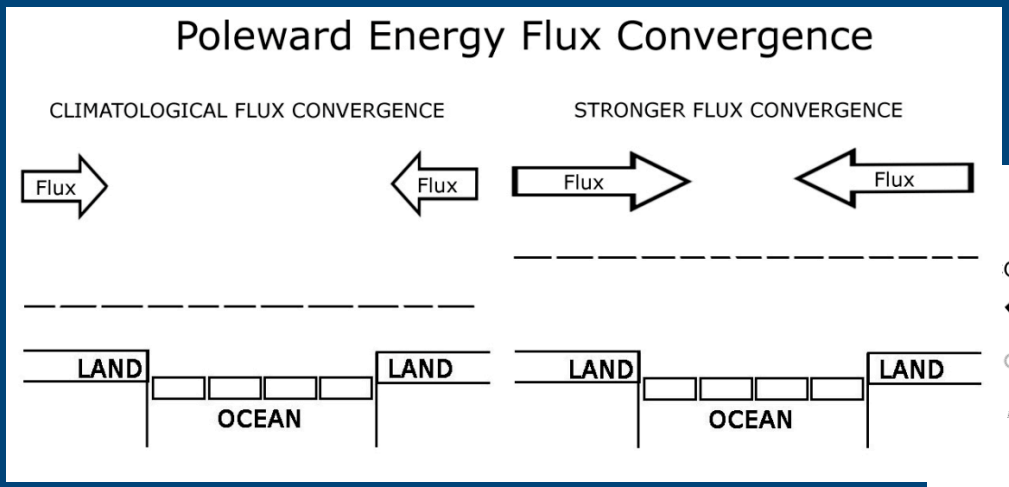
IPCC AR-4

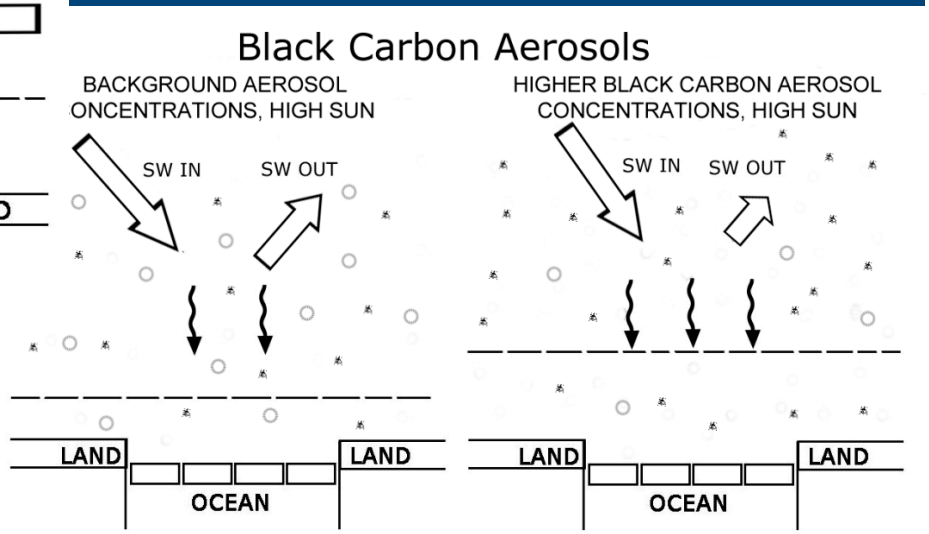
Sea ice loss is especially important

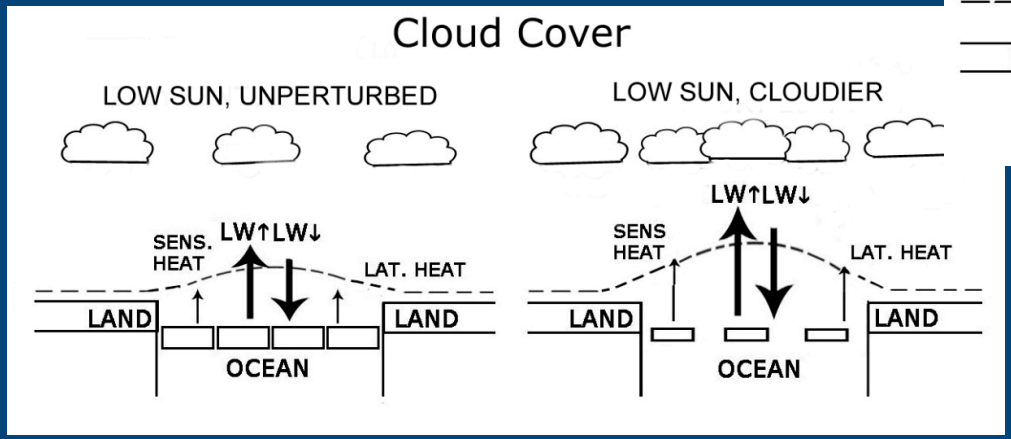


- Ocean picks up more heat in summer
- Releases more heat back to the atmosphere in autumn and winter

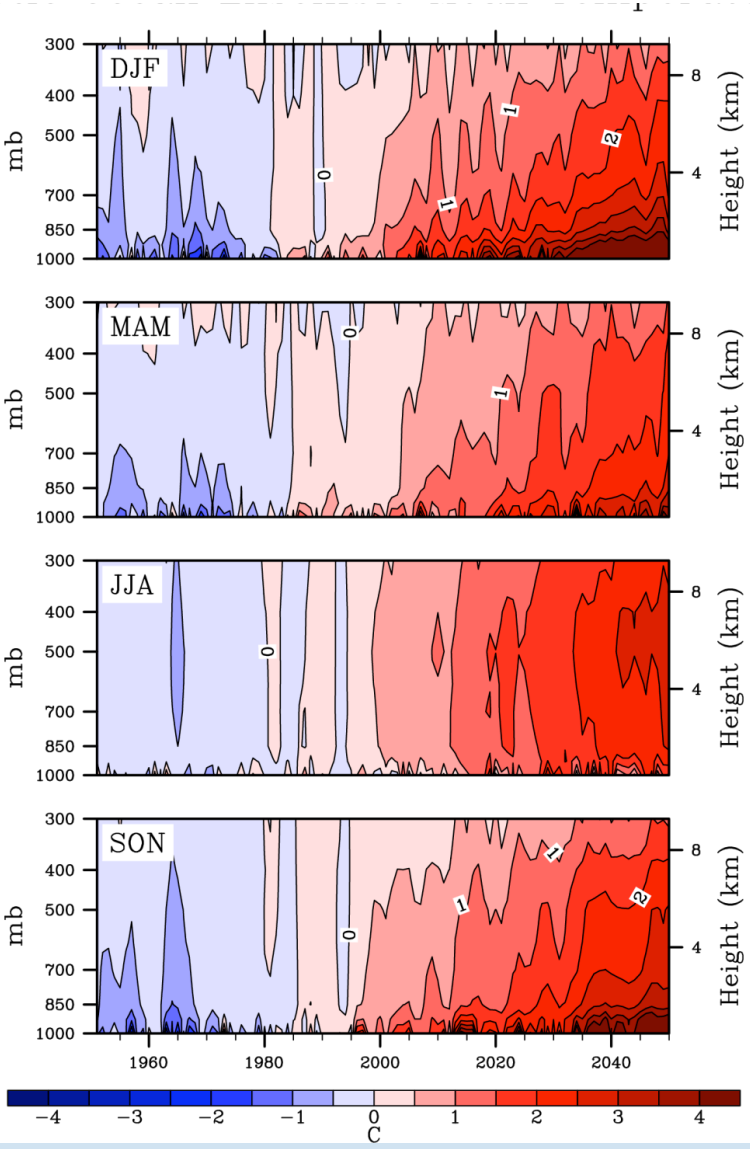
Other factors contributing to Arctic amplification





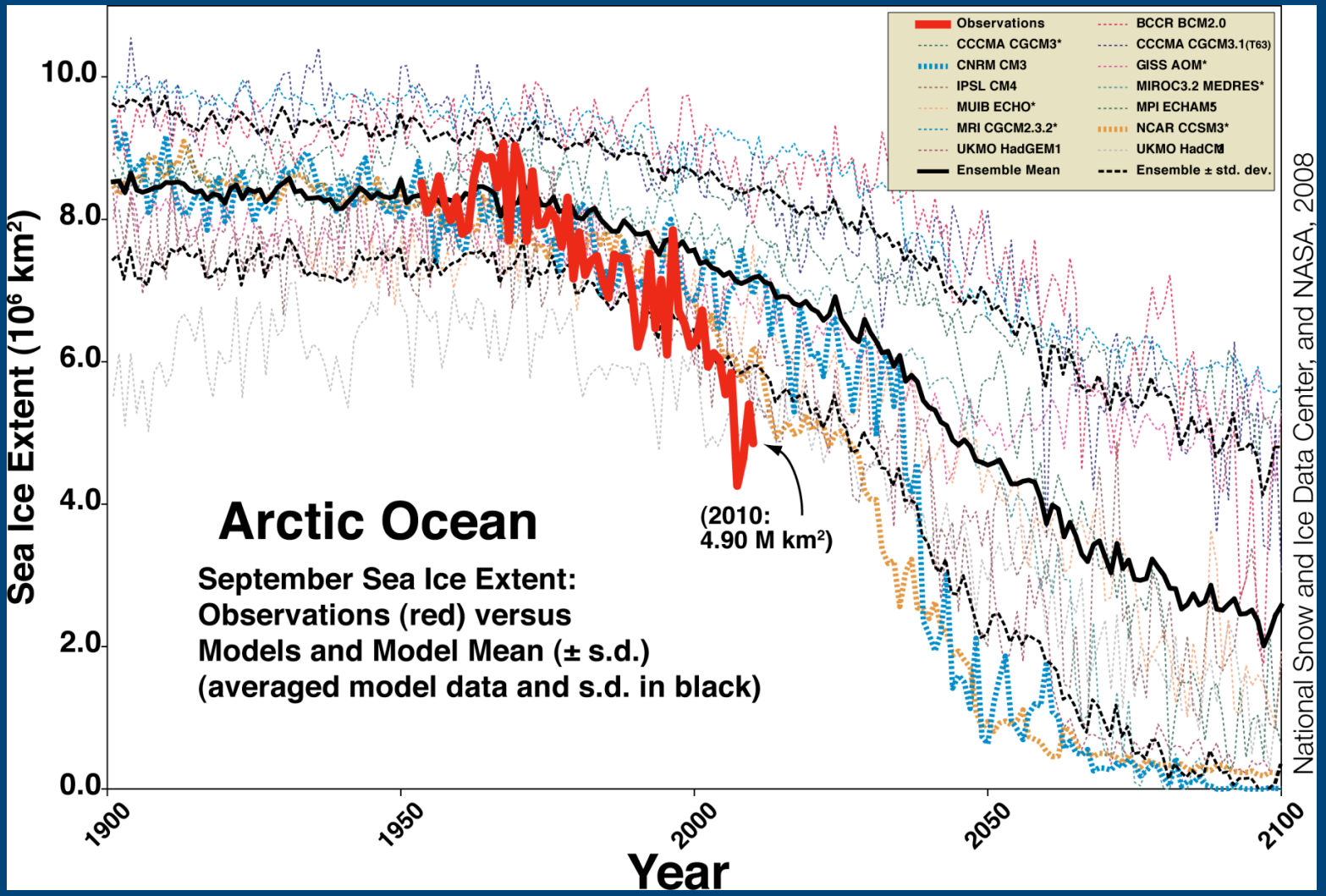


Projected evolution of temperature change



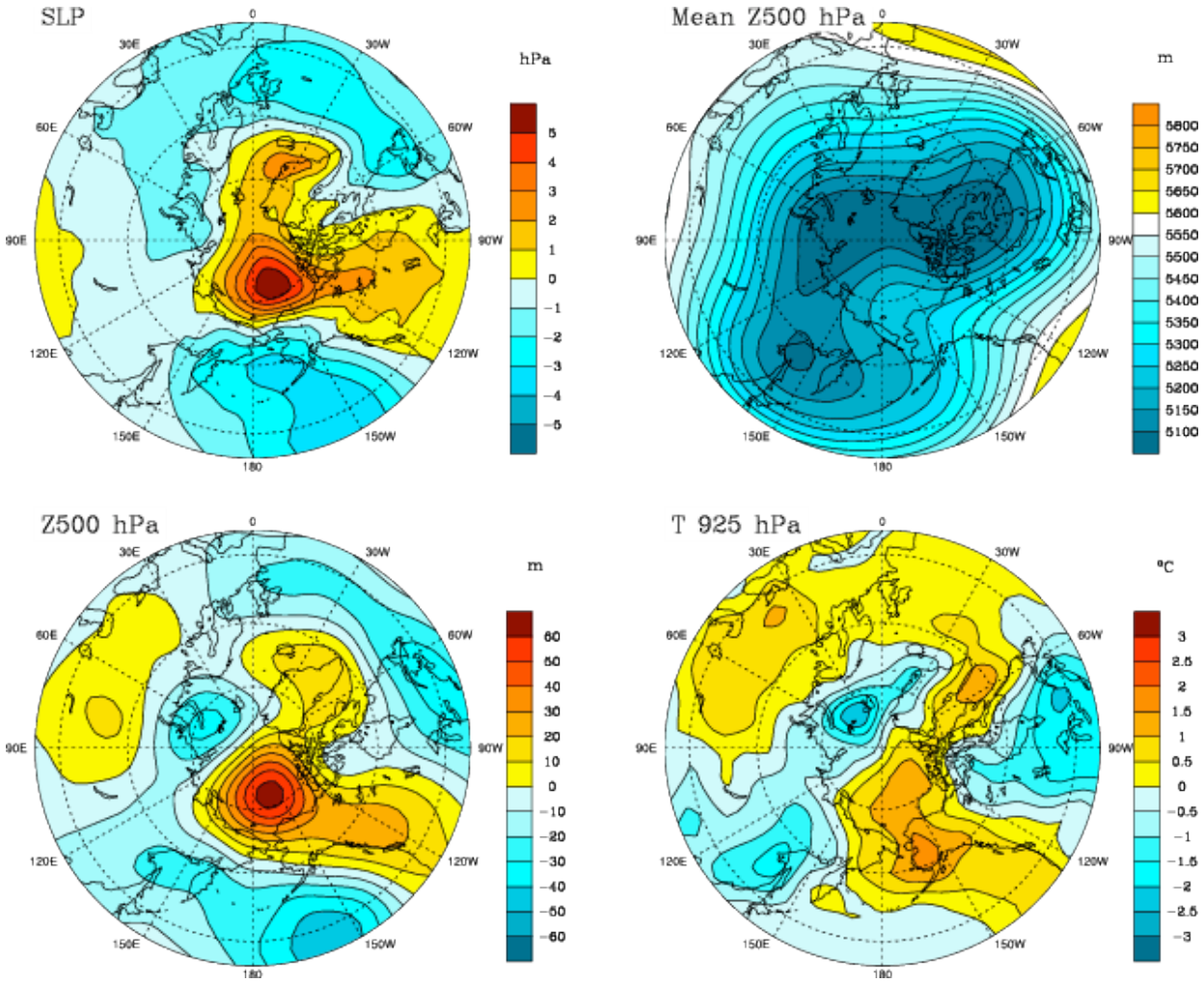
Evolution of Arctic Ocean temperature anomalies, 1950-2050, from a multi-model ensemble (CCSM3, PCM1, HADCM3 MIROC3.2-HIRES) based on observed climate forcing through 2000 and the A1B emissions scenario for the 21st century. Values are expressed as temperature anomalies with respect to 1970-1999 means. There are 15 ensemble members for the 20th century (8 CCSM3, 4 PCM1, 2 HADCM3 and 1 MIROC3.2-HIRES) and 11 for the 21st century (7 CCSM3, 2 PCM1, 1 HADCM3, 1 MIROC3.2-HIRES).

Ice extent will almost certainly continue its downward trend



Updated from Stroeve et al. (2007)

We have to get the atmospheric circulation right



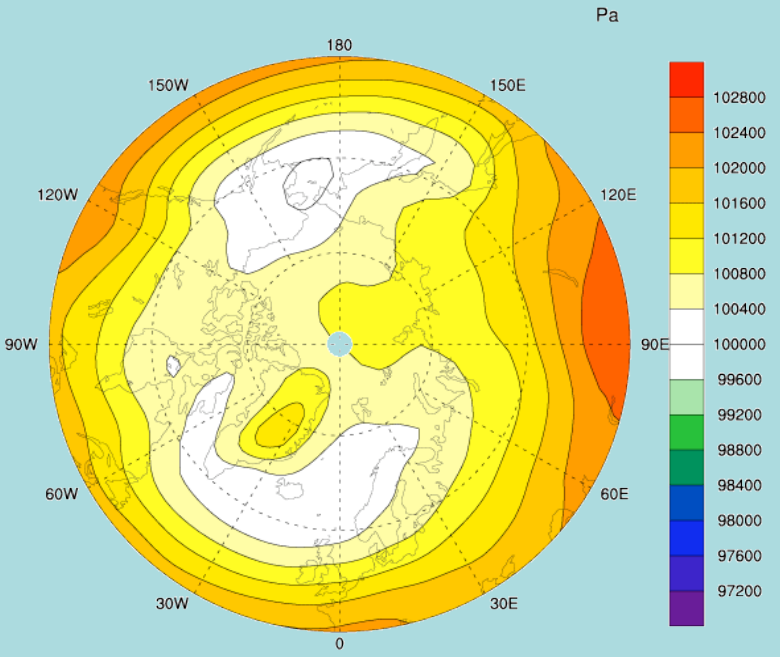
Winter signature of a strong BSH (top 20%)

Serreze and Barrett, State of the Arctic, Miami 2010

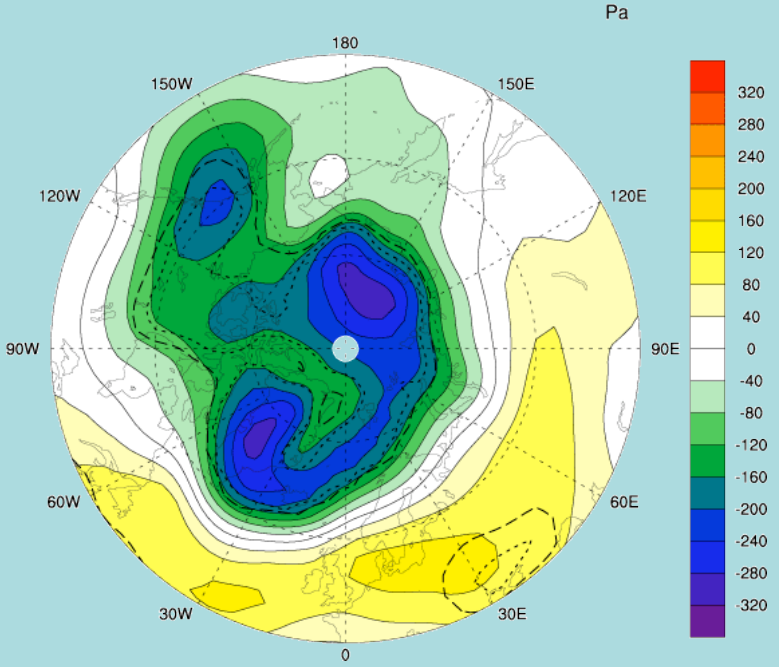
Will sea ice loss affect circulation patterns?

The NCAR Community Atmospheric Model (CAM) was used to perform two 30-year simulations, one with a climatological late 20th century seasonal cycle in sea ice fraction, and one using the 2007 seasonal cycle. Circulation differences were most prominent in autumn and winter.

SON SLP, Control



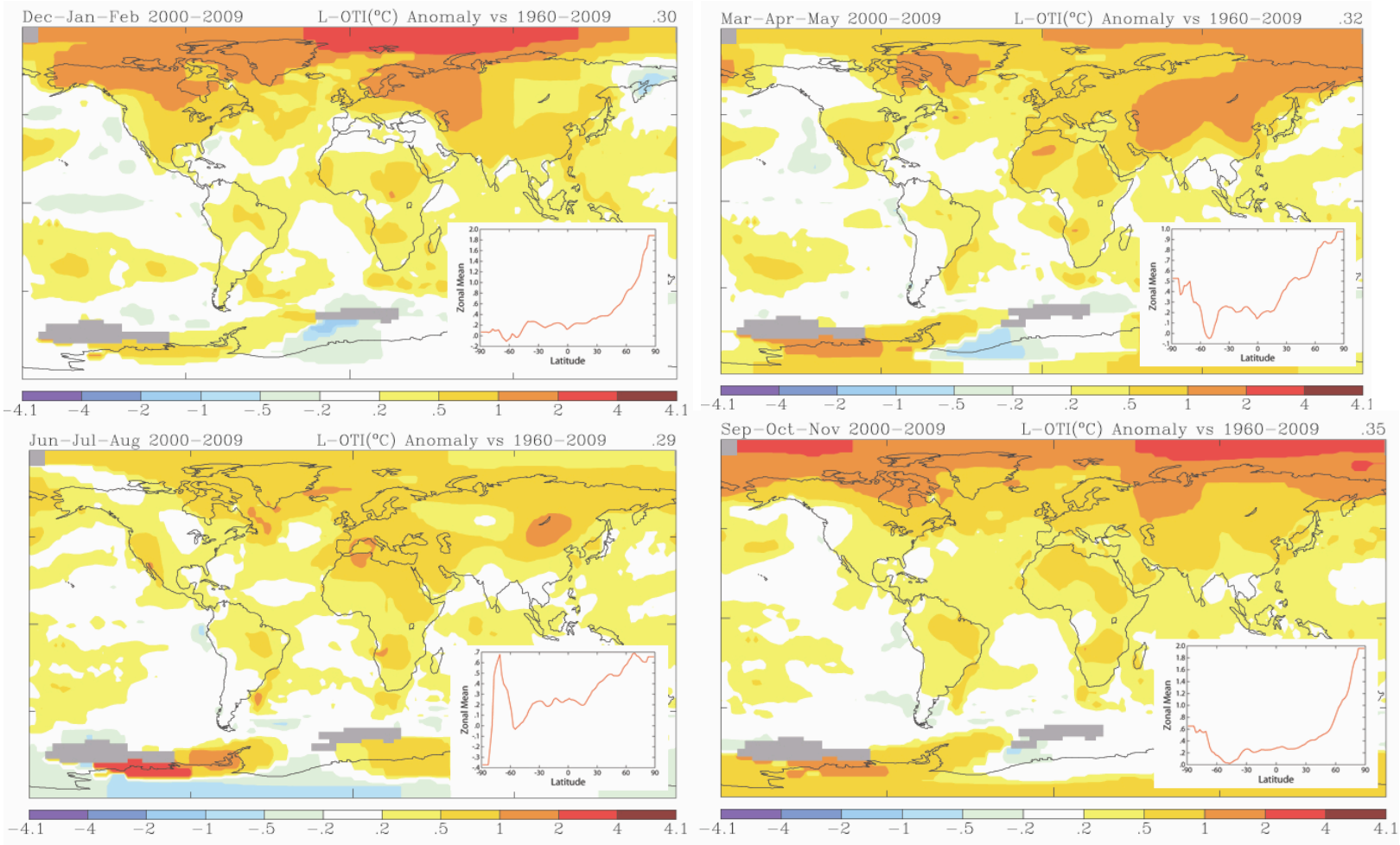
SON SLP, Experiment - Control



E. Cassano, J. Cassano and M. Higgins


Patterns of recent change illustrate some of these points

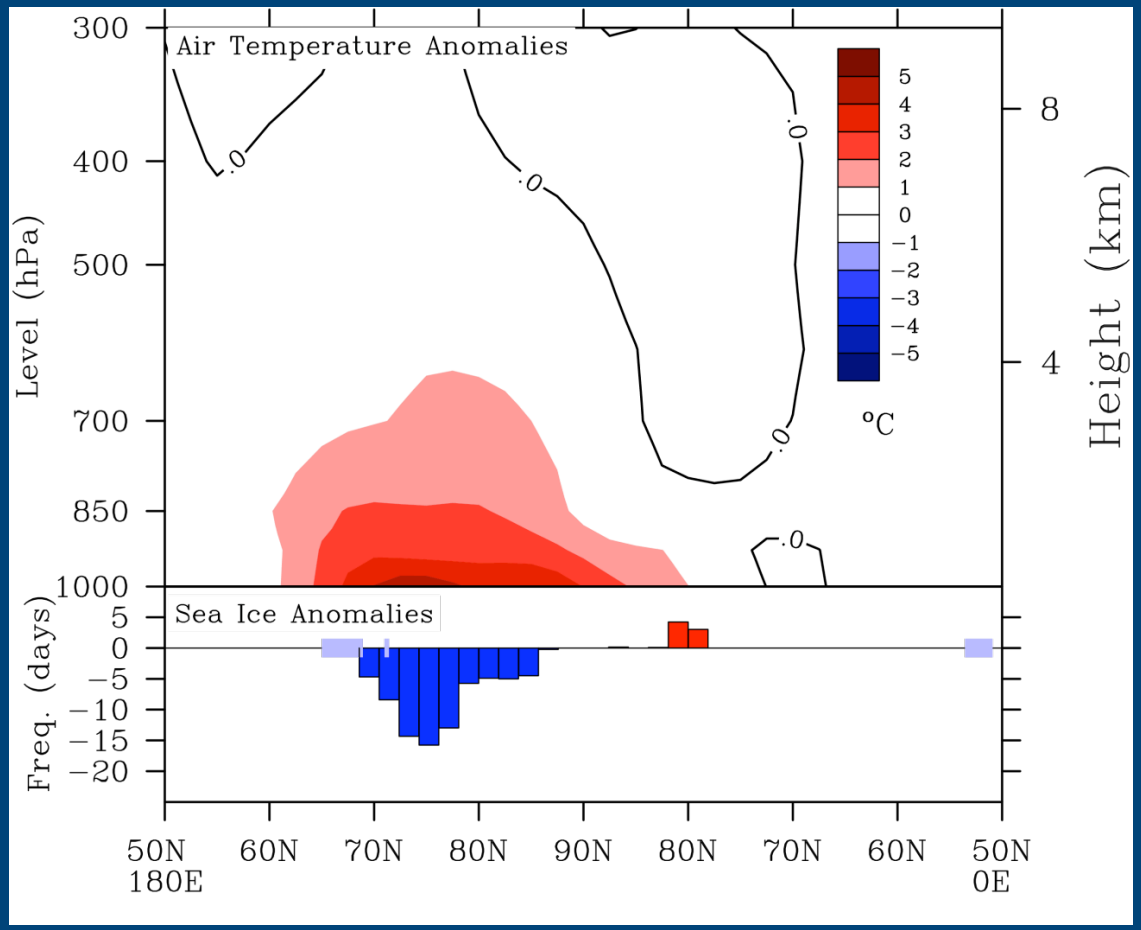
SAT anomalies, 2000-2009, from GISS analysis



Obvious Arctic amplification, with general autumn/winter maximum, but based on liberal interpolation over the Arctic Ocean

http://data.giss.nasa.gov/gistemp

A clear link with declining sea ice extent



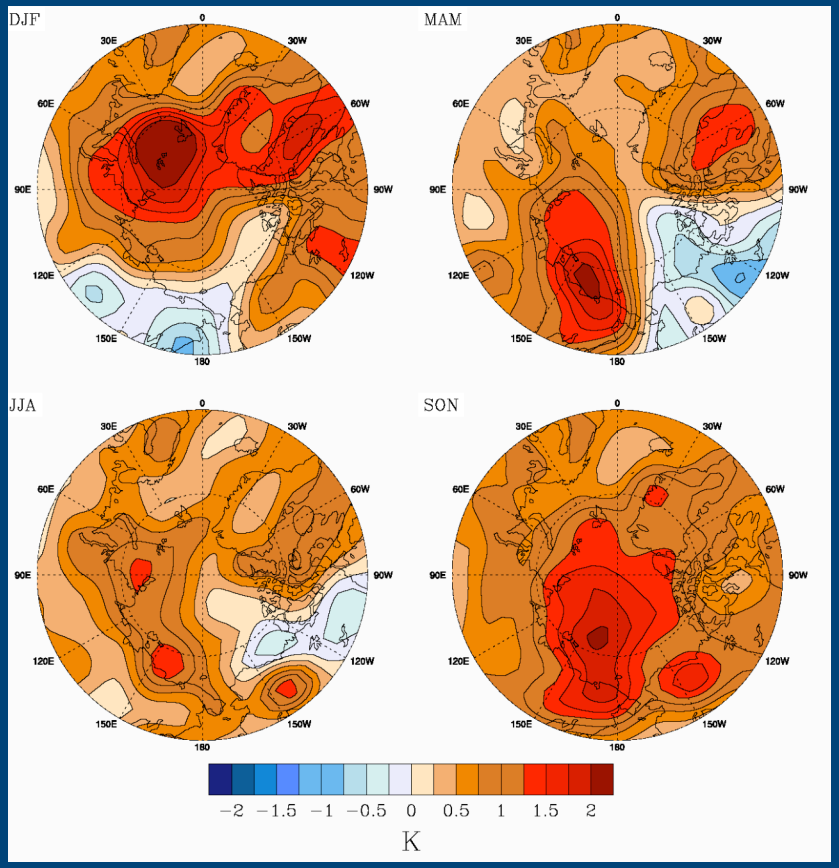
NCEP autumn (SON) temperature anomalies, 2003–2007 minus 1979–2007

Anomalies in ice-covered days from NCEP, 2003–2007 minus 1979–2007

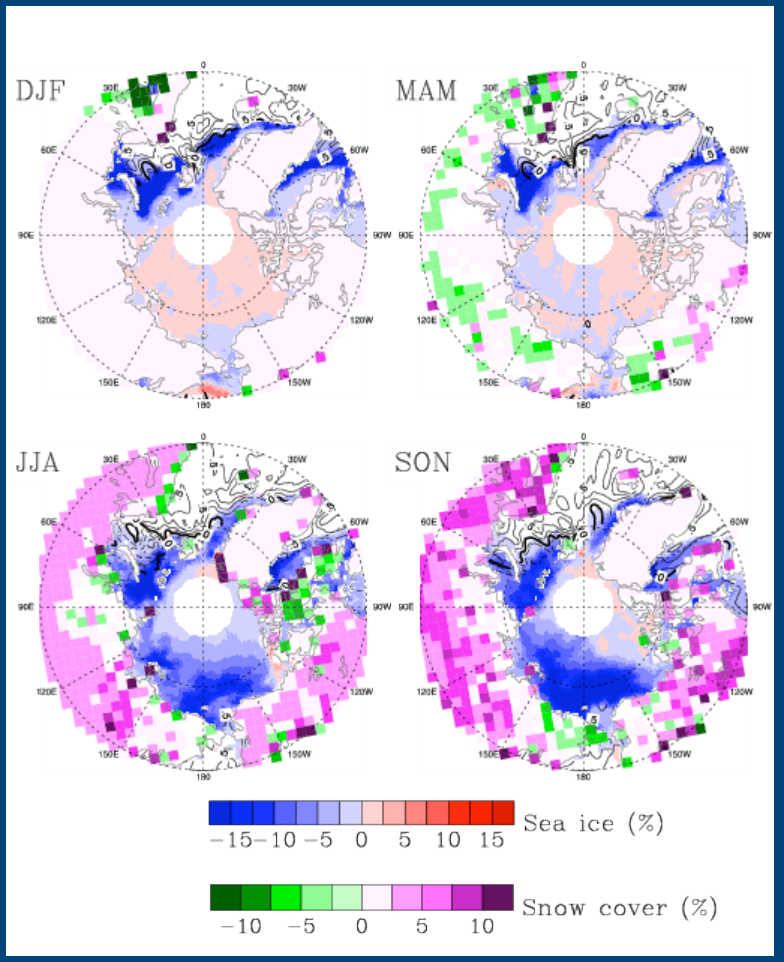
From Serreze et al., 2009

But there's more to the story……

NCEP 925 hPa temperature anomalies (2000-2009)



SIC, SST and snow cover anomalies (2000-2009)



Conclusions

Predicting Arctic temperature trends over the next 50 years is in part a problem of predicting changes in sea ice extent

Making viable predictions means getting the right large-scale patterns of atmospheric circulation. Wild card: how will ice loss affect atmospheric circulation patterns?

A key challenge in predicting temperatures over decadal and multi-decadal time scales is conflation of multiple and often interacting processes

- Background radiative forcing
- Changes in surface conditions, especially sea ice extent
- Changes in atmospheric circulation
  - Advection
  - Circulation anomalies forcing sea ice anomalies
- Changing relationships between winds and temperature
  - Winds spread out effects of anomalous surface heat sources

NSIDC

Thank You