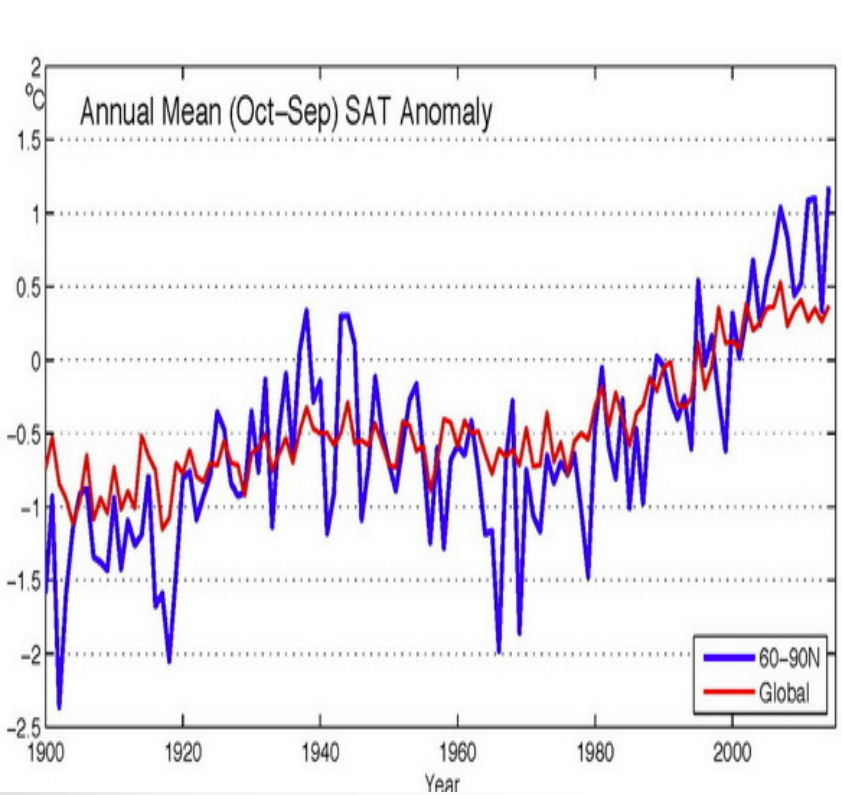
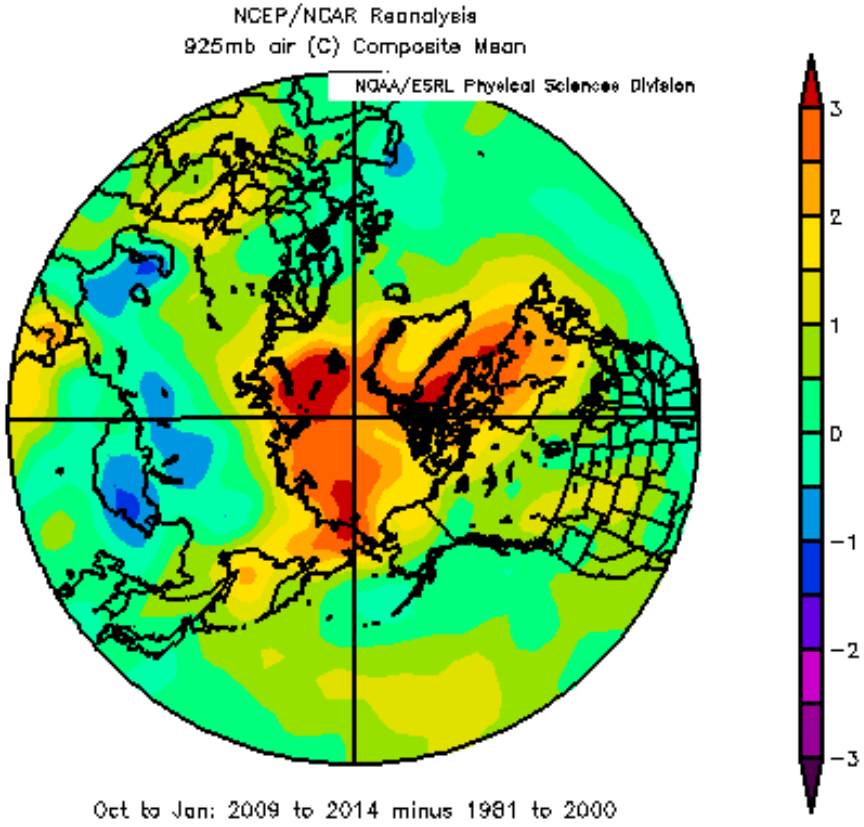
Large Arctic Climate Changes

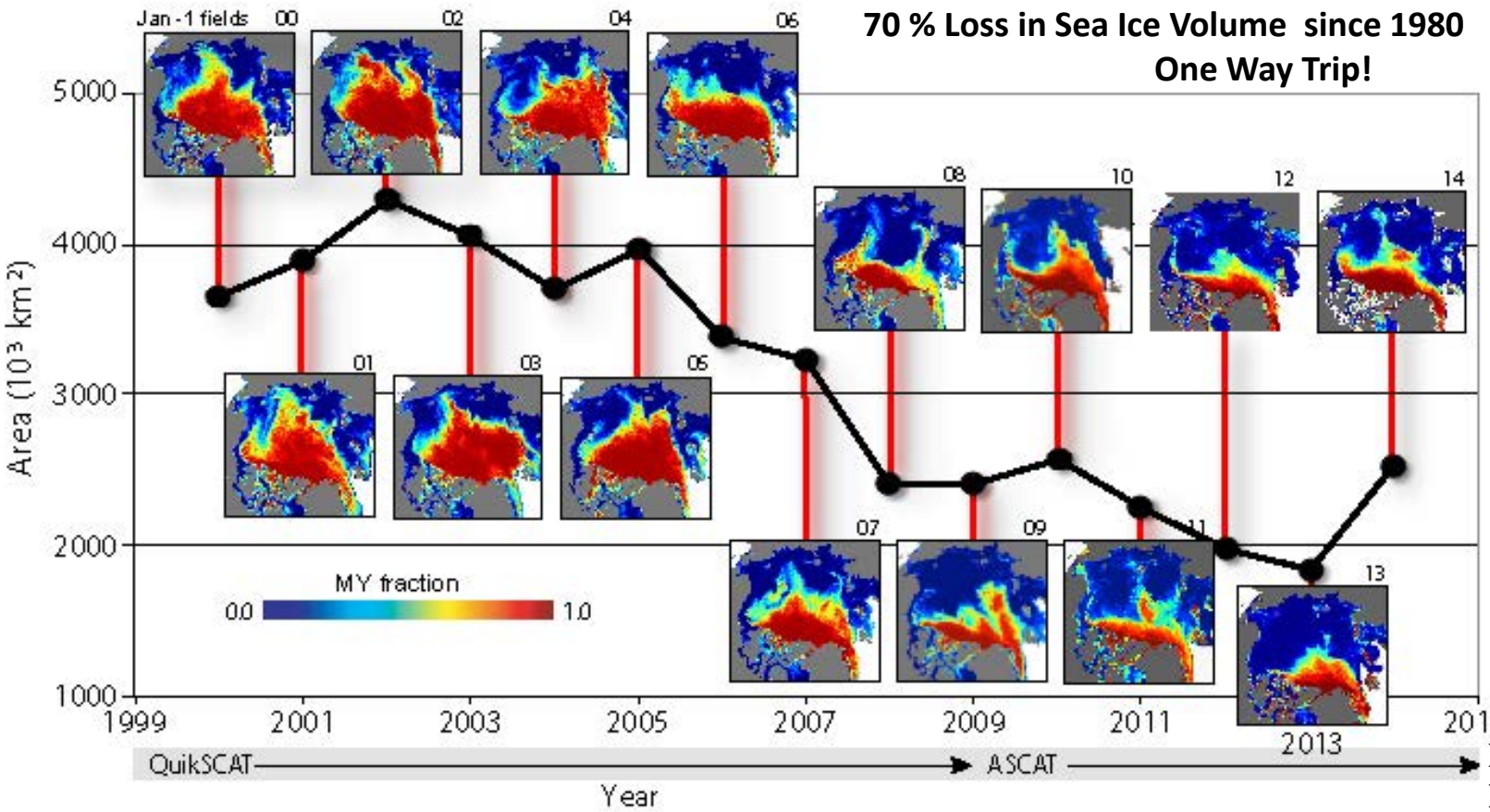
James Overland and Muyin Wang
NOAA/PMEL

Arctic (temperature) Amplification: 2-3 times changes in Mid-latitudes





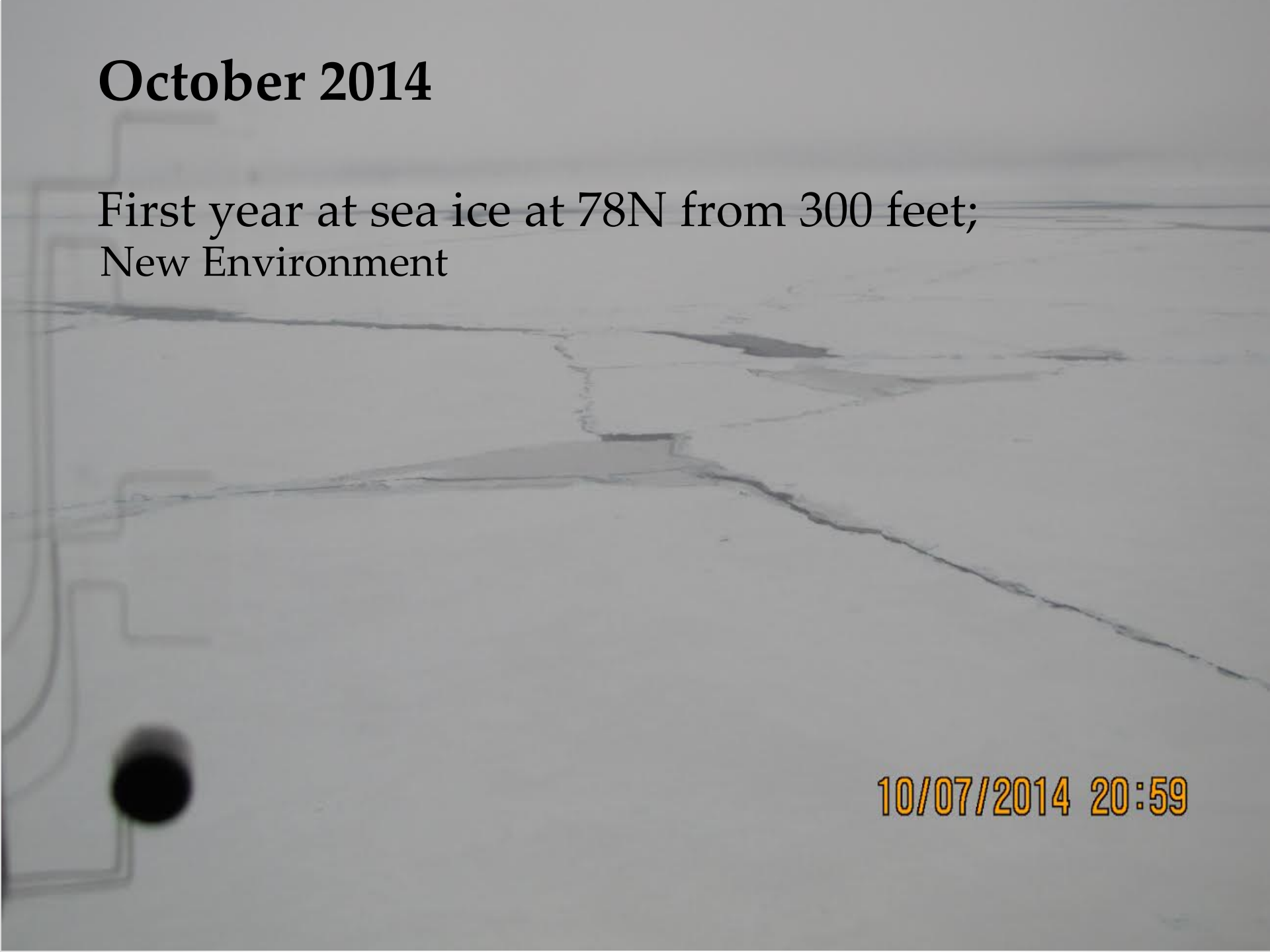
Decline in Arctic Multiyear Sea Ice Coverage 40 % Since 1980 (Red)
Arctic is Now Mostly First Year Sea Ice(Blue)



R. Kwok

October 2014

First year at sea ice at 78N from 300 feet;
New Environment



On land, there is additional evidence of the impact of the persistent warming trend.

Tundra

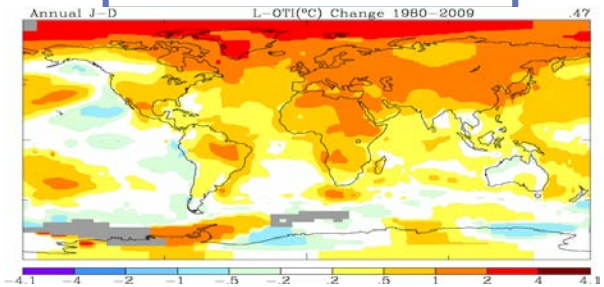
- Between 1982 and 2013, the tundra biomass increased by 20 percent.

Greenland

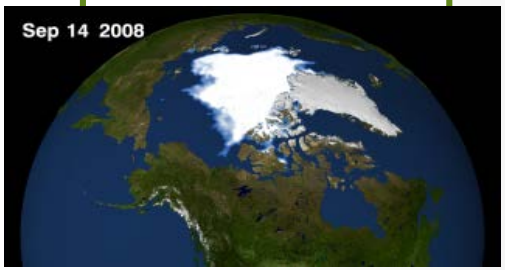
- The number of days of melting in June and July 2014 exceeded the 1981–2010 average over most of the ice sheet.

“Arctic Amplification”: Global Warming +Multiple Feedbacks

Global Warming

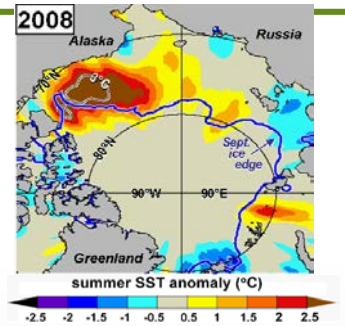


Reduction of Arctic sea Ice

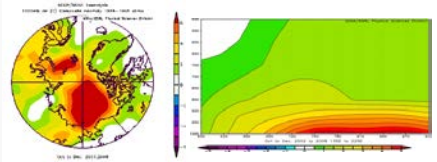


Sept Sea Ice Extent

Ocean absorbs more heat

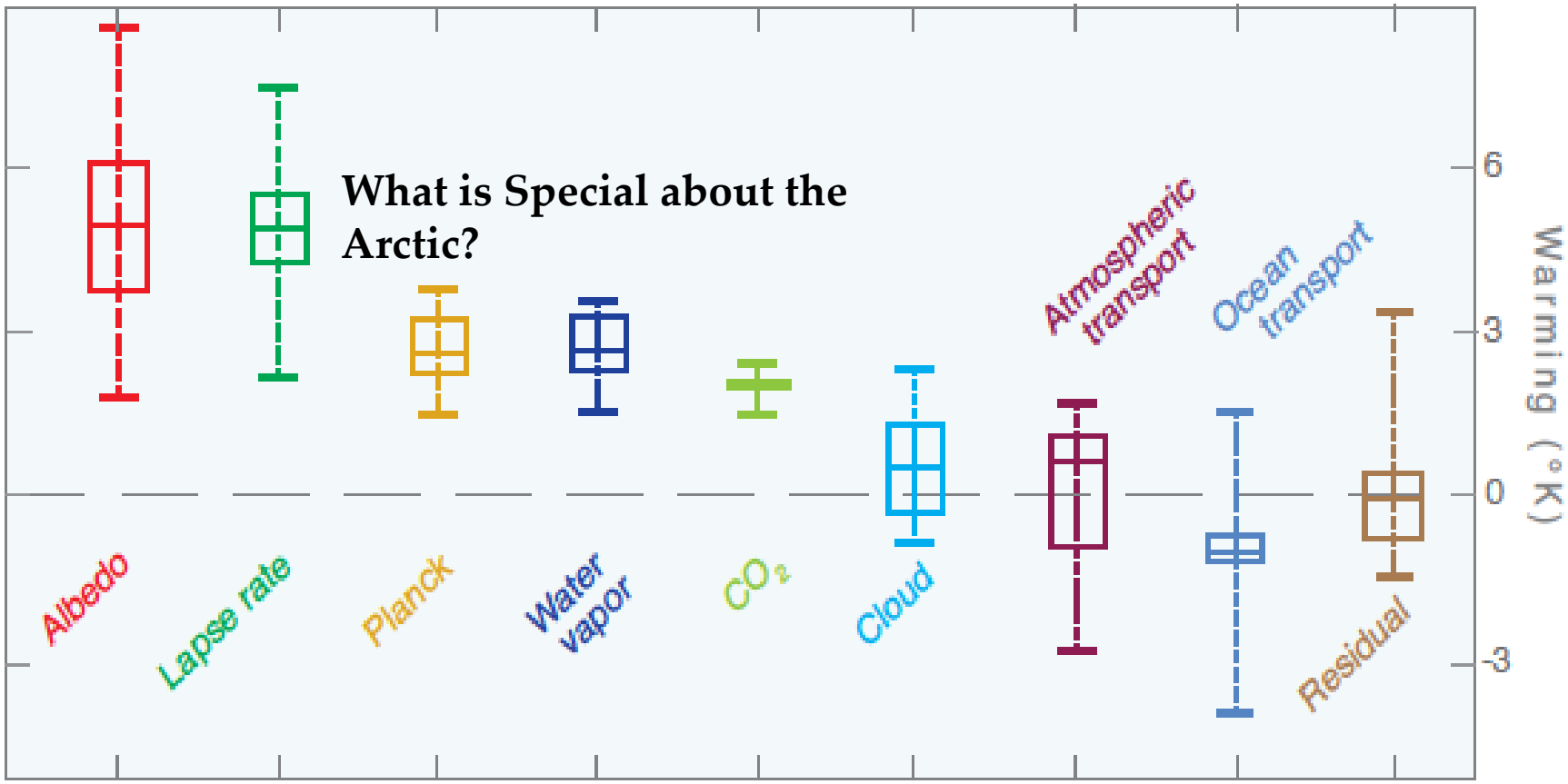


Atmosphere warming



OND Temp Anomaly

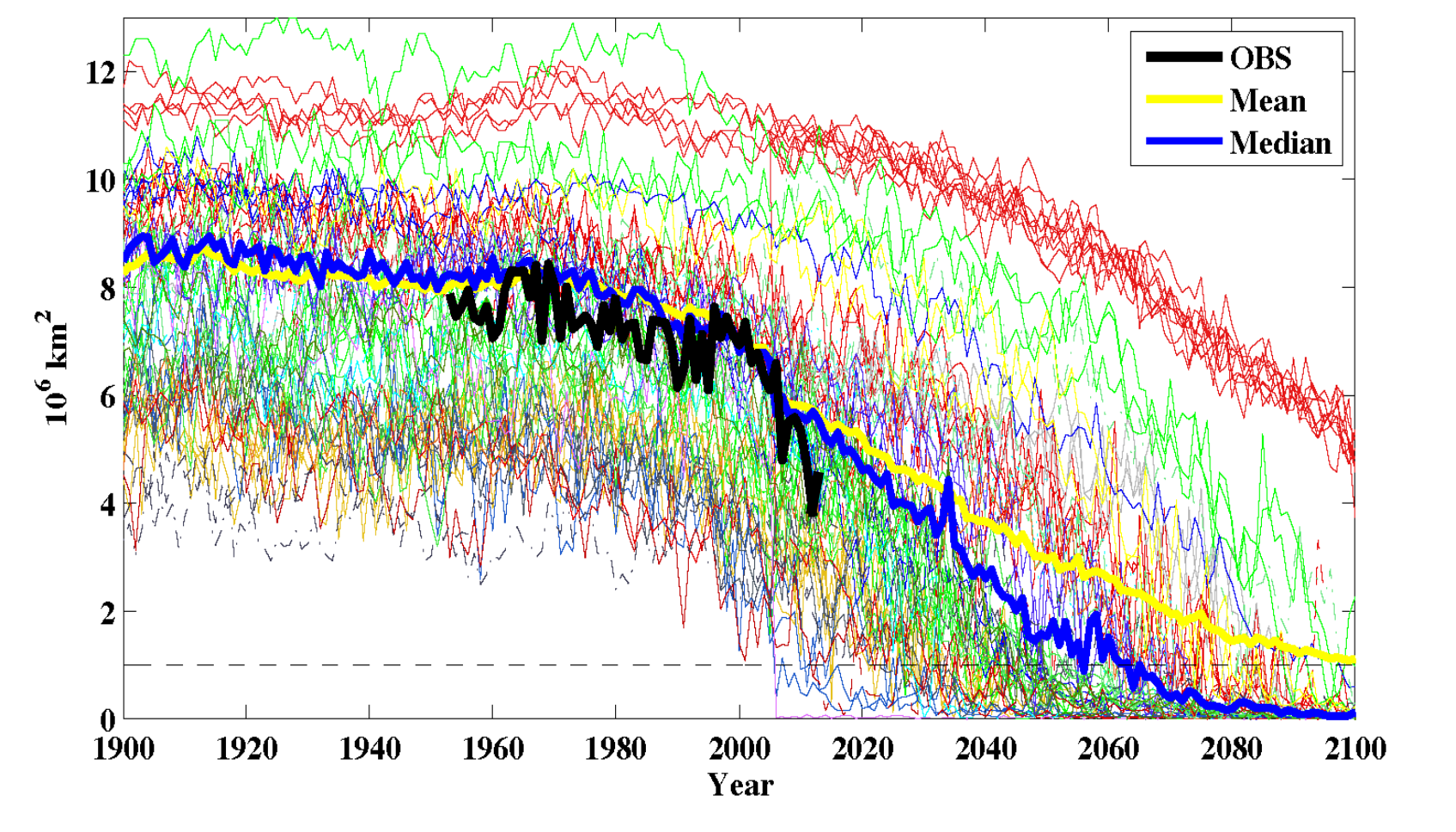
Contributions of various feedbacks to total Arctic warming in climate models



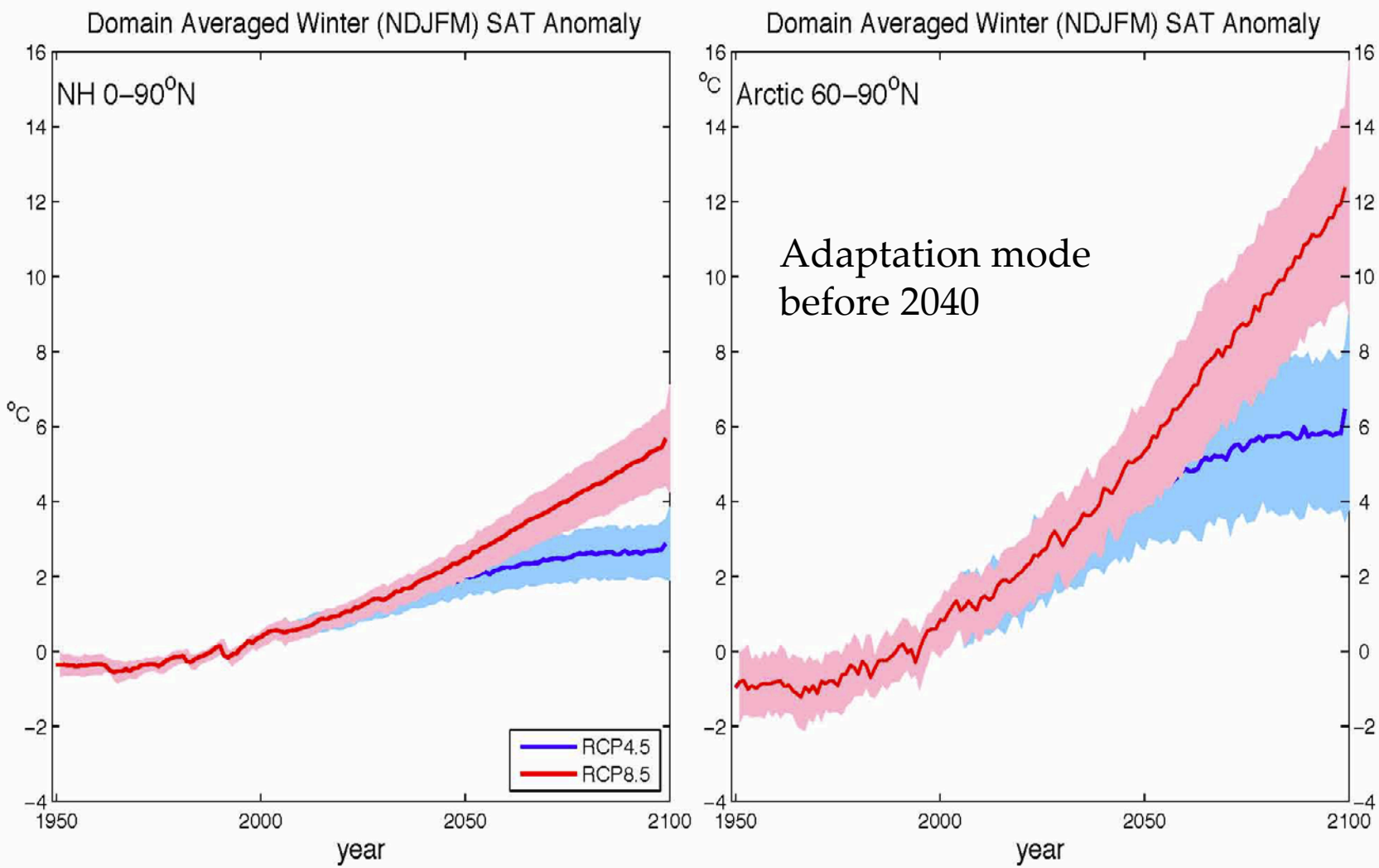
Pithan and Mauritsen, 2014, Nature Geoscience

Future Sea Ice loss Occurring Faster than Projected

Wide Range of September Sea Ice Extent Hindcasts and Predictions from IPCC



89 ensemble members from 36 CMIP5 models under strongest (RCP8.5) emissions scenario Overland and Wang (2013)

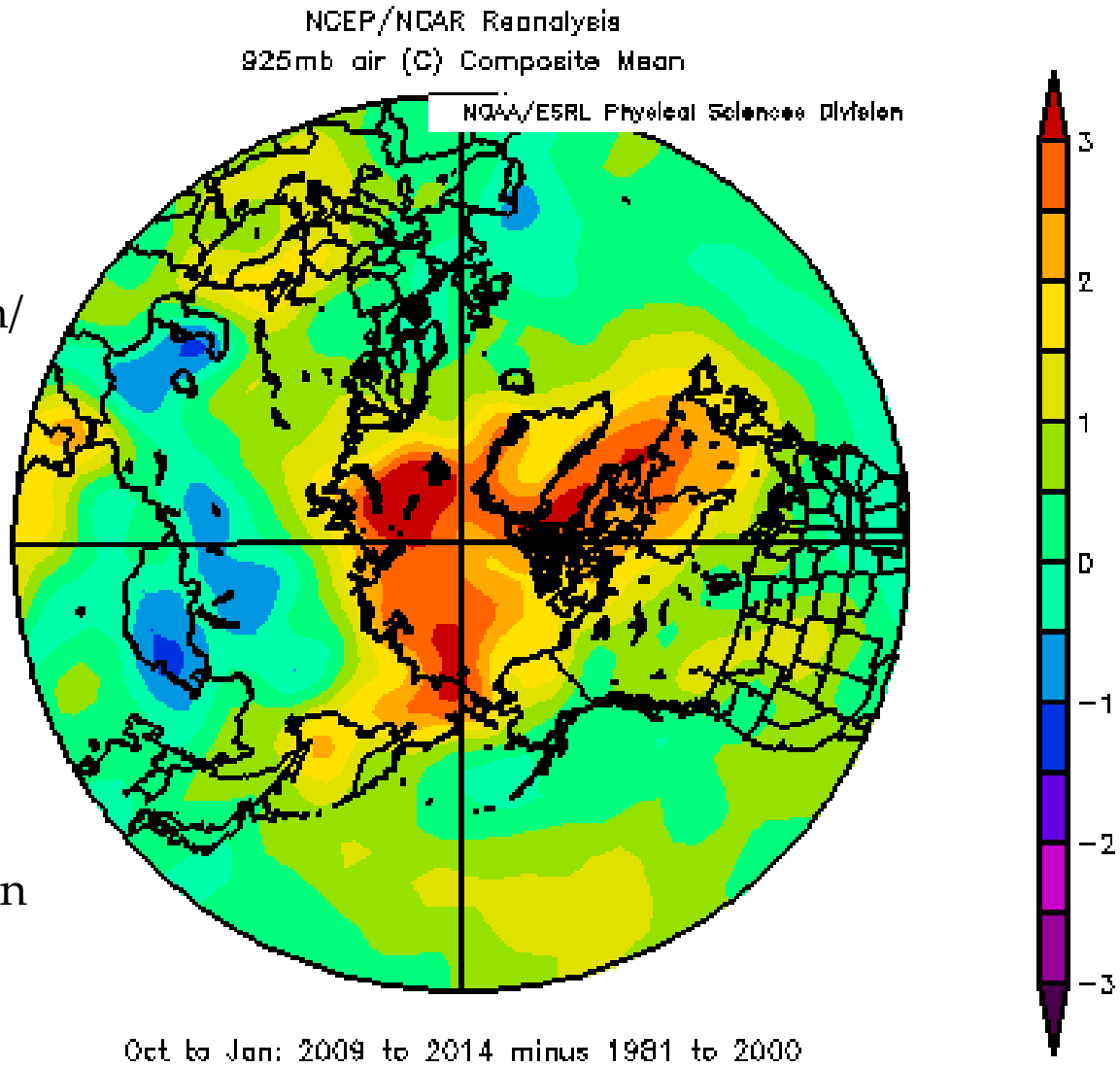

Domain Averaged Winter (NDJFM) SAT Anomaly
NH 0–90°N
°C
16
14
12
10
8
6
4
2
0
−2
−4
1950
2000
2050
2100
year
RCP4.5
RCP8.5
Domain Averaged Winter (NDJFM) SAT Anomaly
Arctic 60–90°N
°C
Adaptation mode
before 2040
year

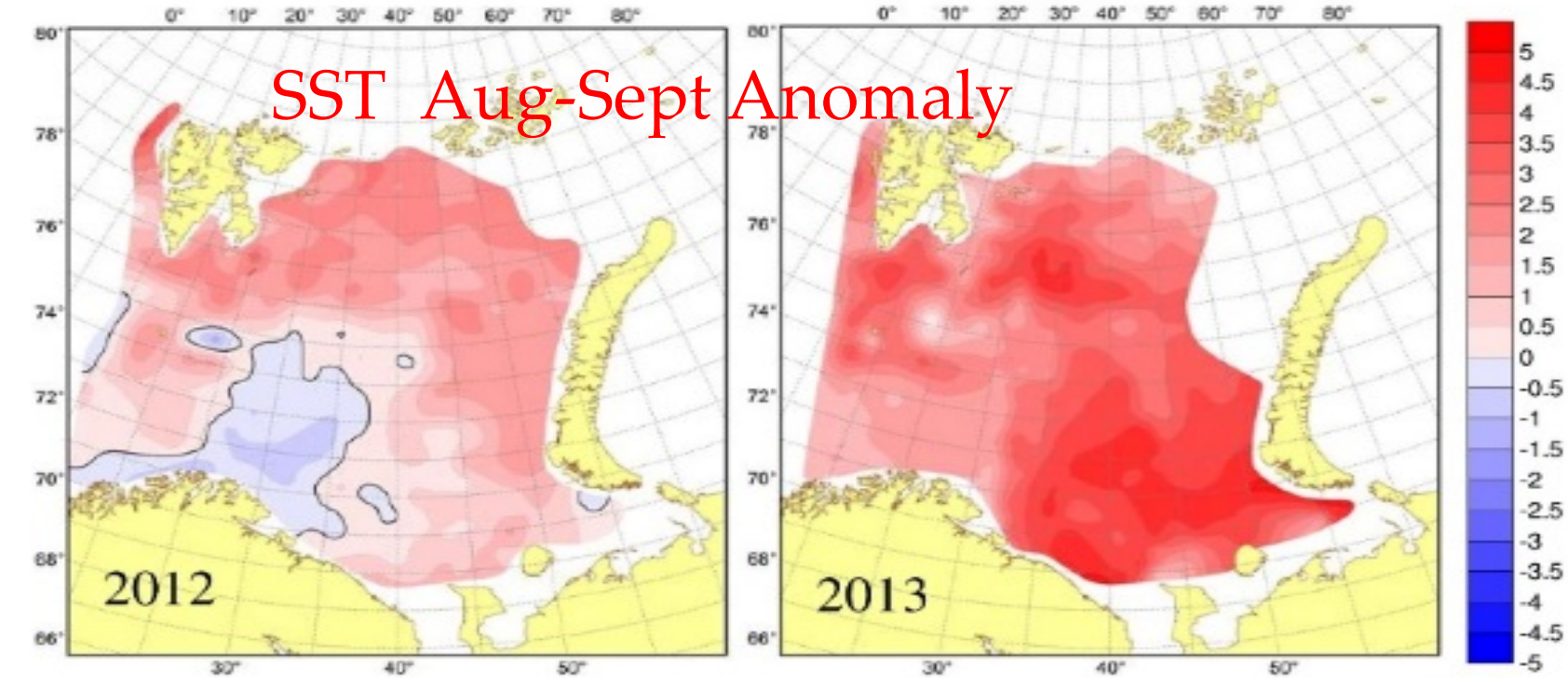
Three Patterns of Arctic/Subarctic Climate Variability

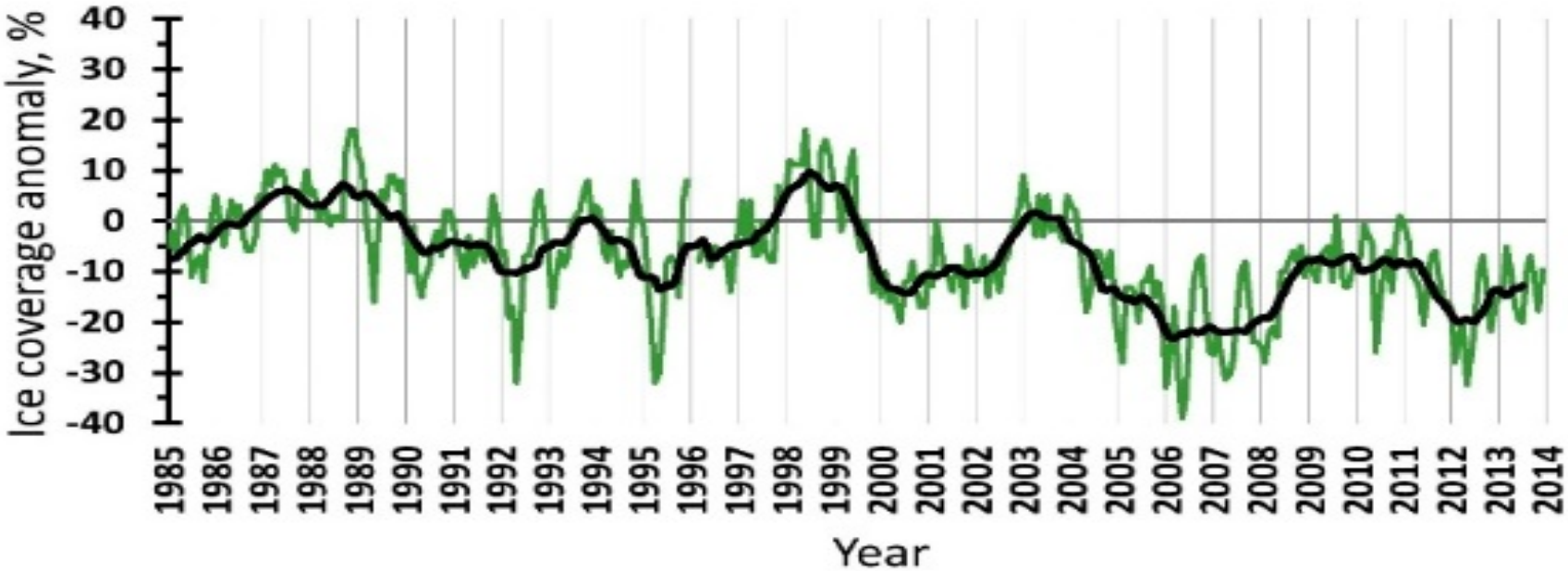
Arctic Warming Pattern

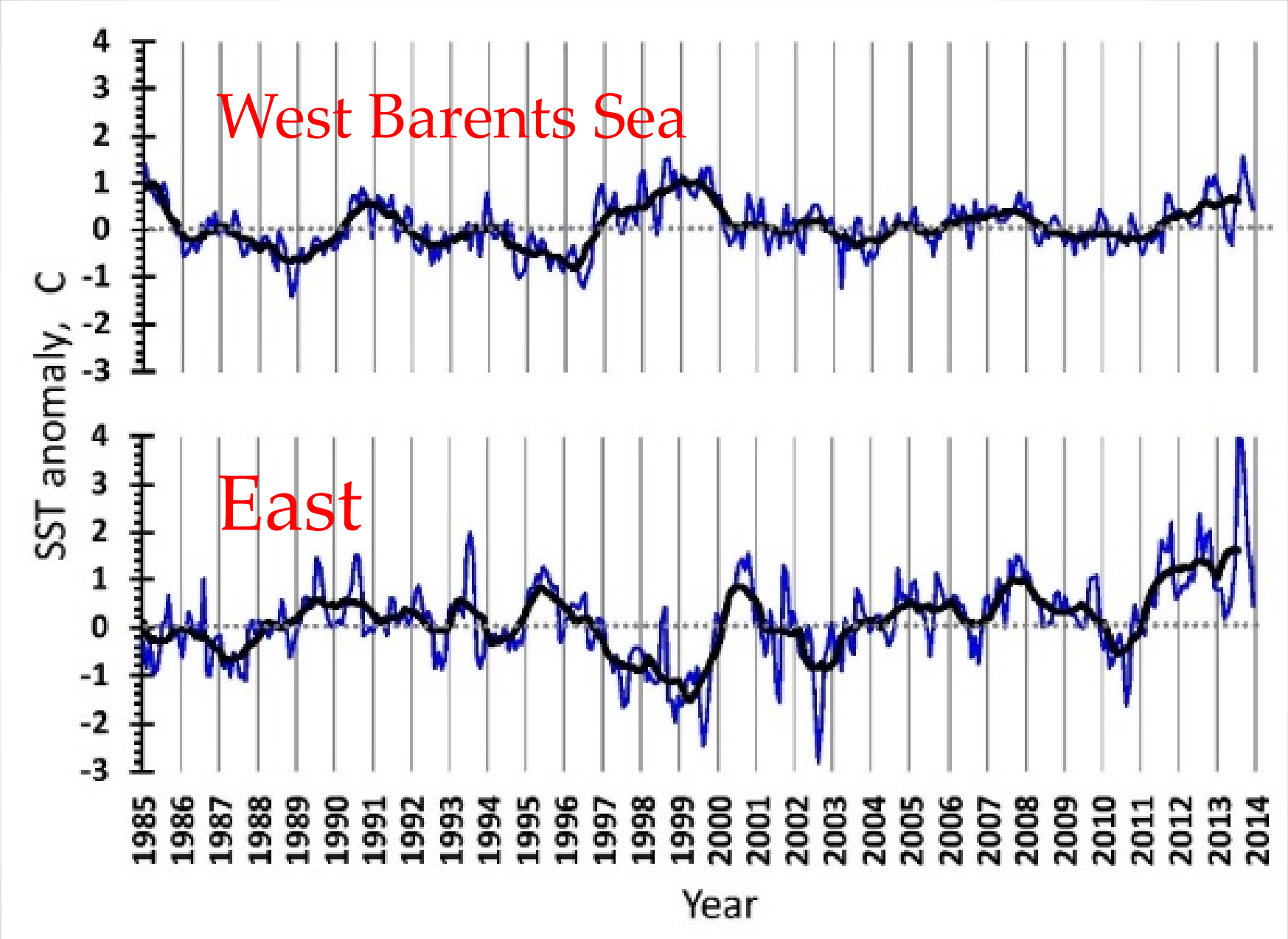
Arctic Oscillation/ North Atlantic Oscillation (AO/NAO)

Pacific Decadal Oscillation/ Pacific North American Pattern (PDO/PNA)




SST Aug-Sept Anomaly
2012
2013
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5

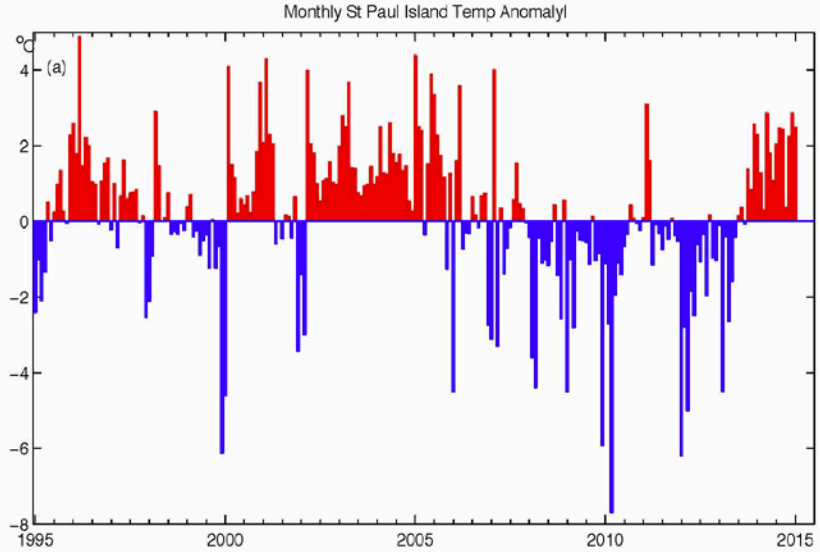

Ice coverage anomaly, %
40
30
20
10
0
-10
-20
-30
-40
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year


West Barents Sea
East
SST anomaly, C
4
3
2
1
0
-1
-2
-3
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Year

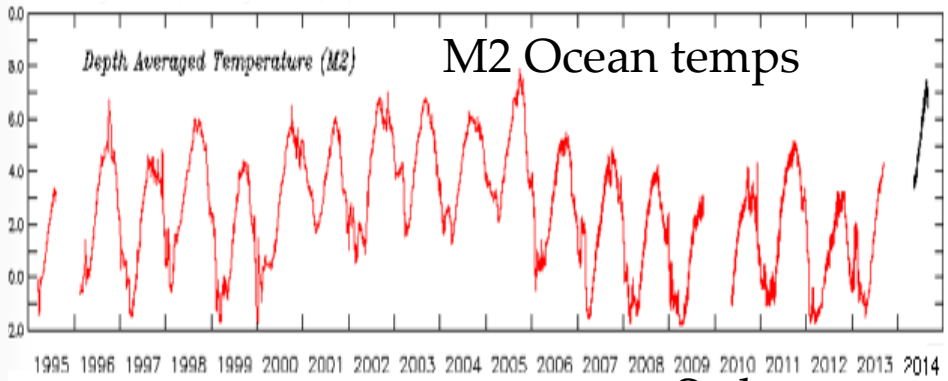
Prediction of sea ice loss and open water duration is difficult for Barents Sea because Atlantic current is too weak in climate models,

but Barents is part of Arctic Warming Pattern, so expect major changes by 2030

Southeastern Bering Sea Variability much larger than Global Warming contribution

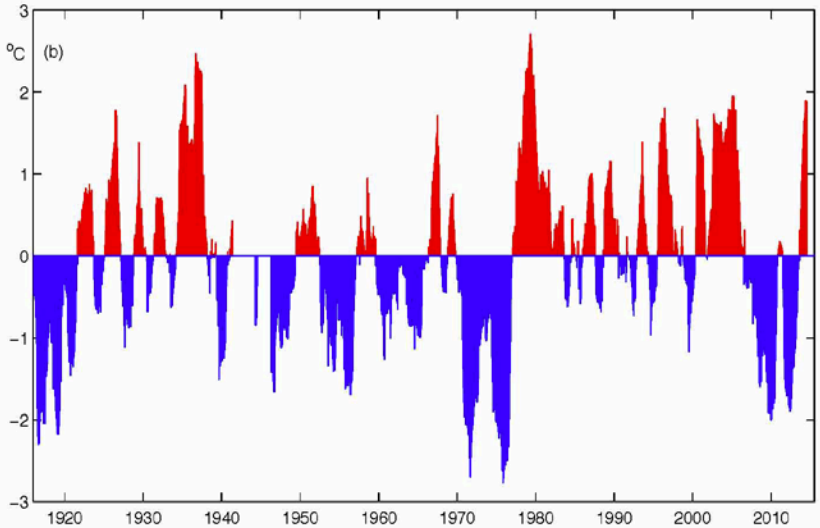


2000 2015

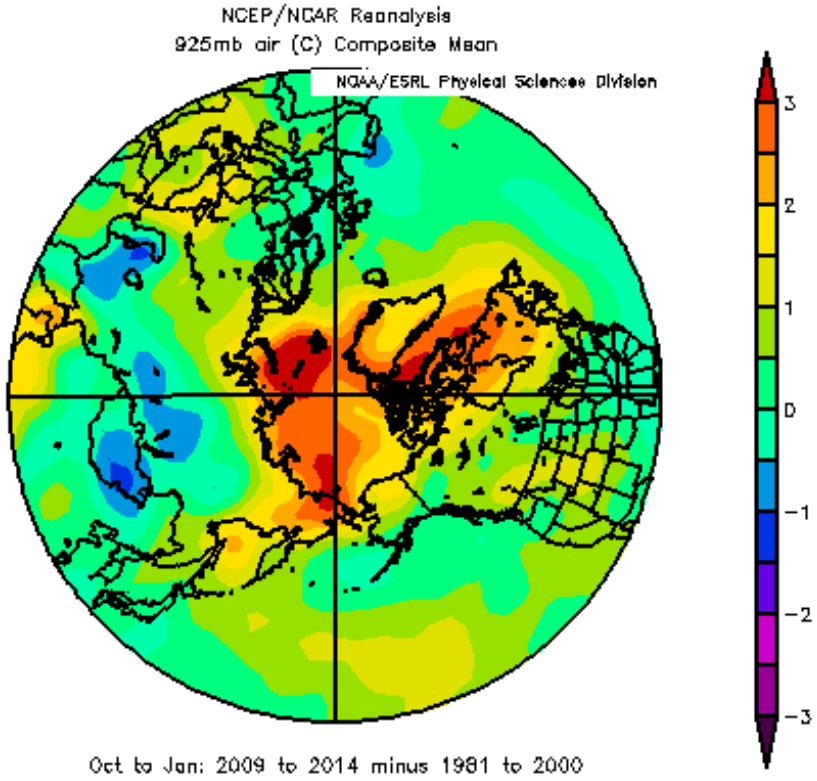


Stabeno

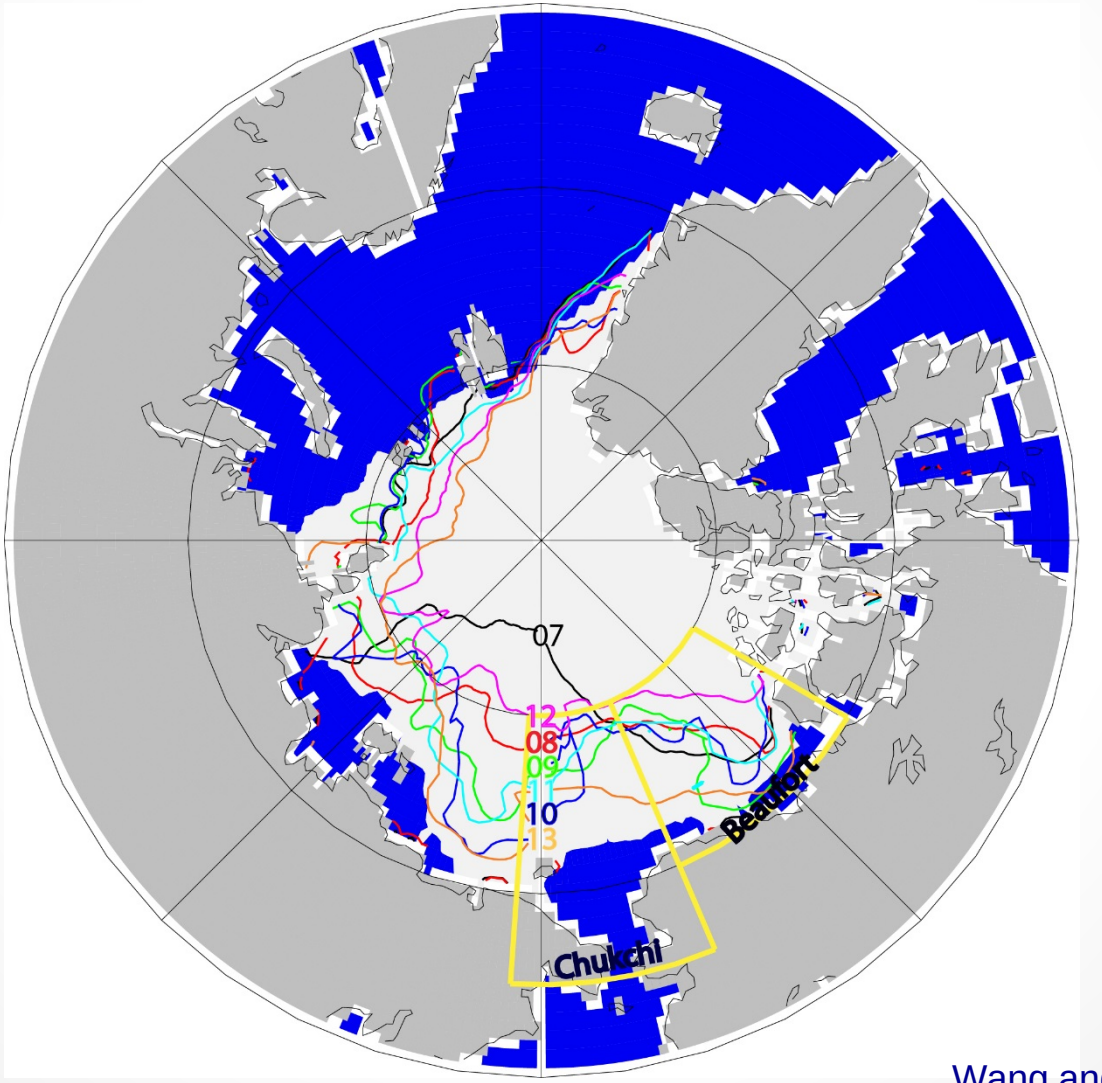
St Paul air temperatures



1970 2000



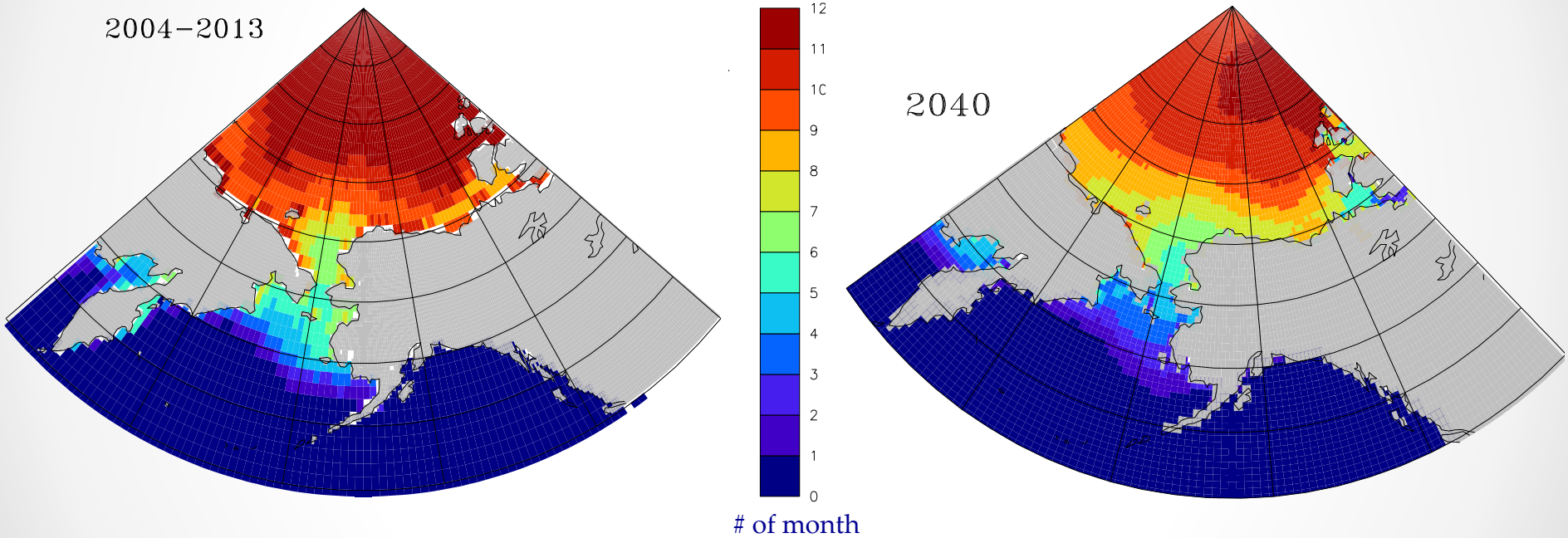
September Sea Ice Minimums



Wang and Overland, 2015

Future Sea Ice Duration in Alaska Arctic

Still have a winter wall of freezing temperatures



Observations (72 N)

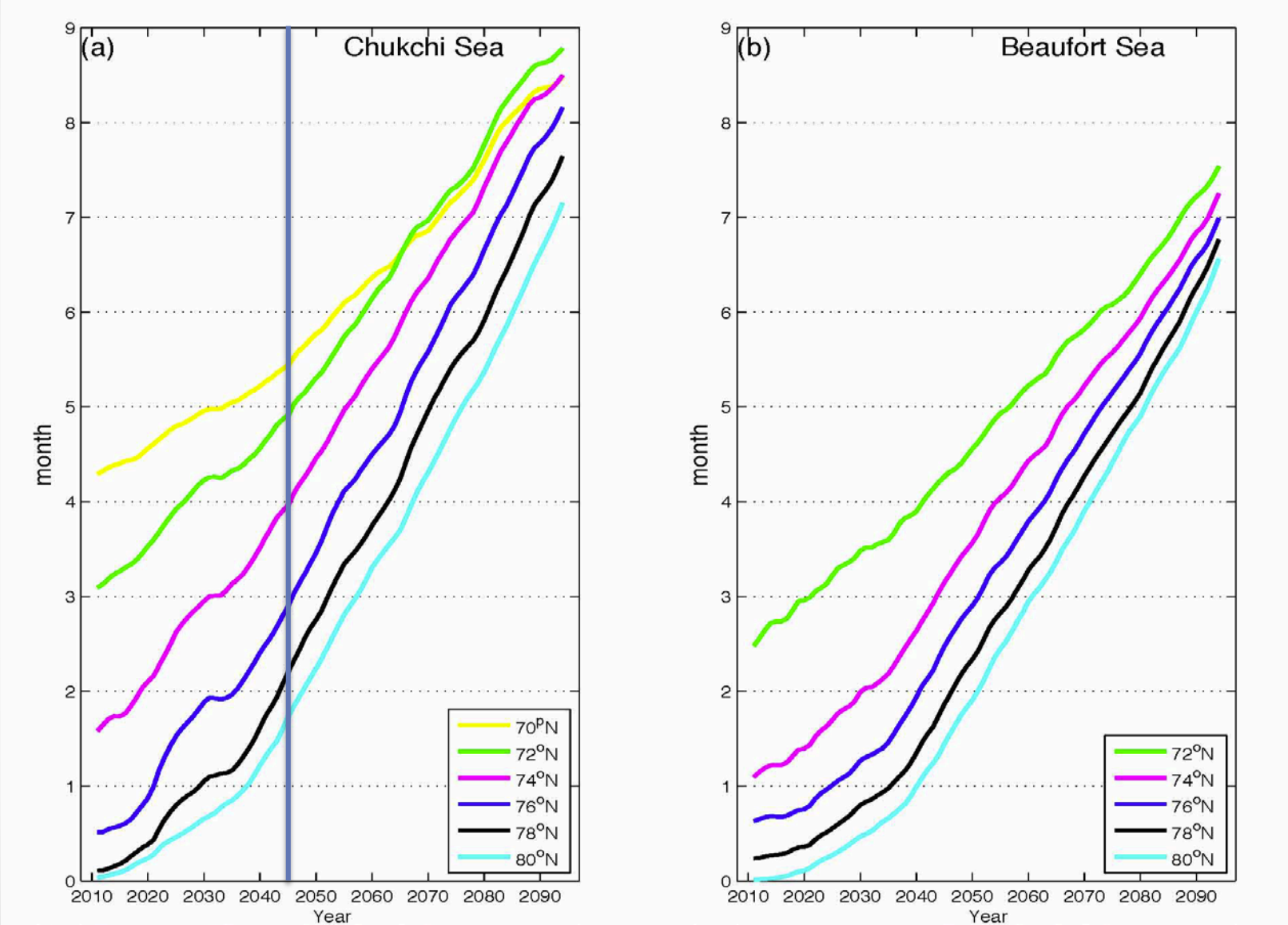
3 months Open Water Now

Ensemble mean of 12 CMIP5 models

5 months Open Water by 2040

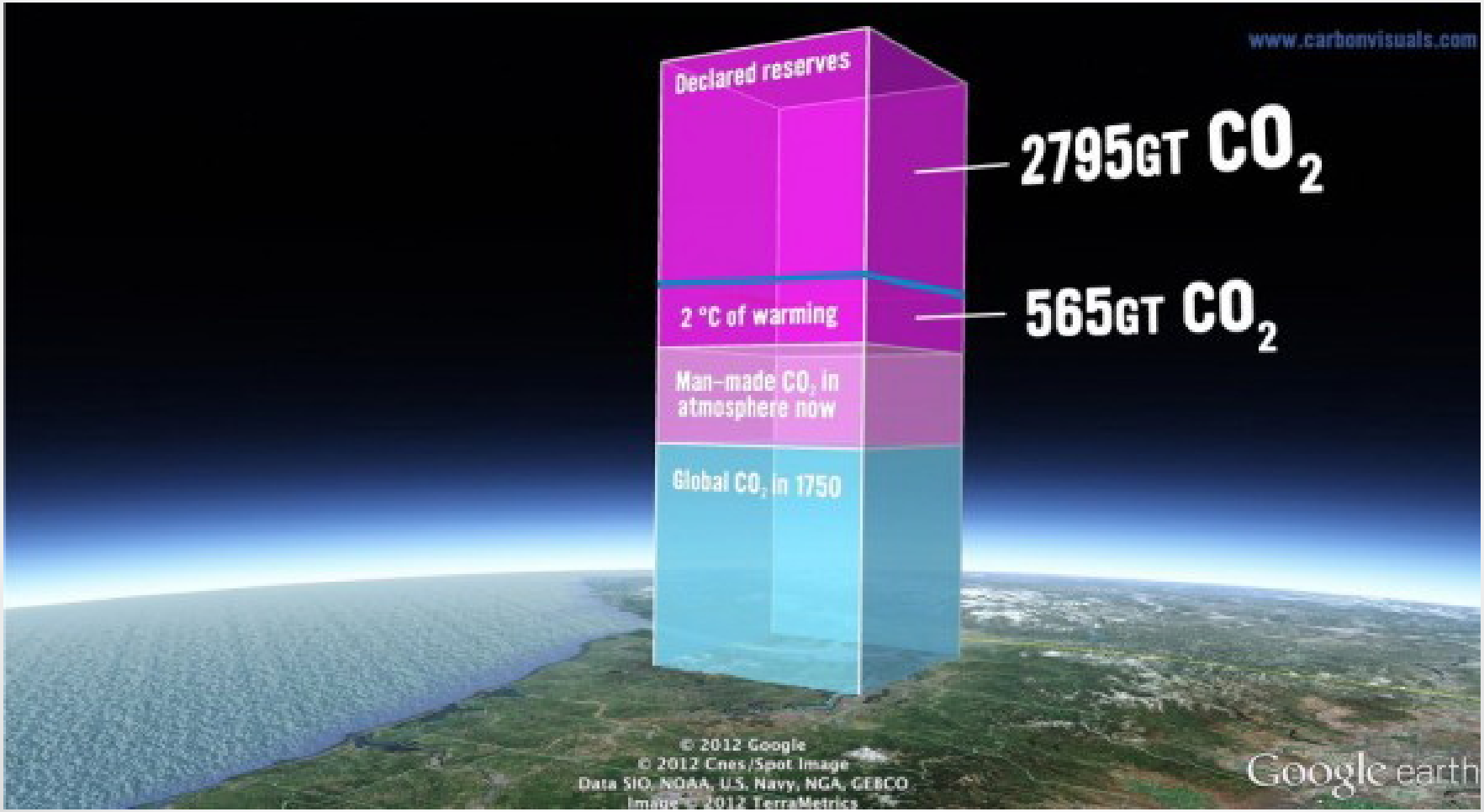
Wang and Overland, 2015

Zonal Mean Distribution of Ice Free Months



Wang and Overland, 2015

Modest Global Warming + Large Arctic Amplification = Adaptation in next 20 Years



Predictions

- Arctic already has new normal.
- The Arctic climate has shifted from thick multi-year-old sea ice to mostly first-year sea ice. Difficult to return to old system. One-Way Trip over next three decades!
- Winter still wins! Future extended periods of newly open water will be seasonally limited to summer and early fall.