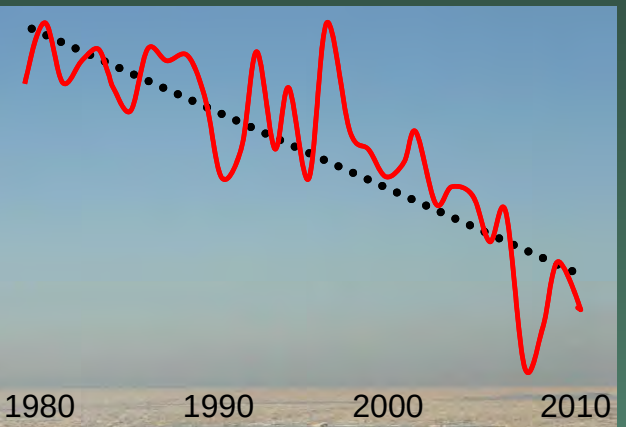
A review of 21st century Arctic sea ice projections



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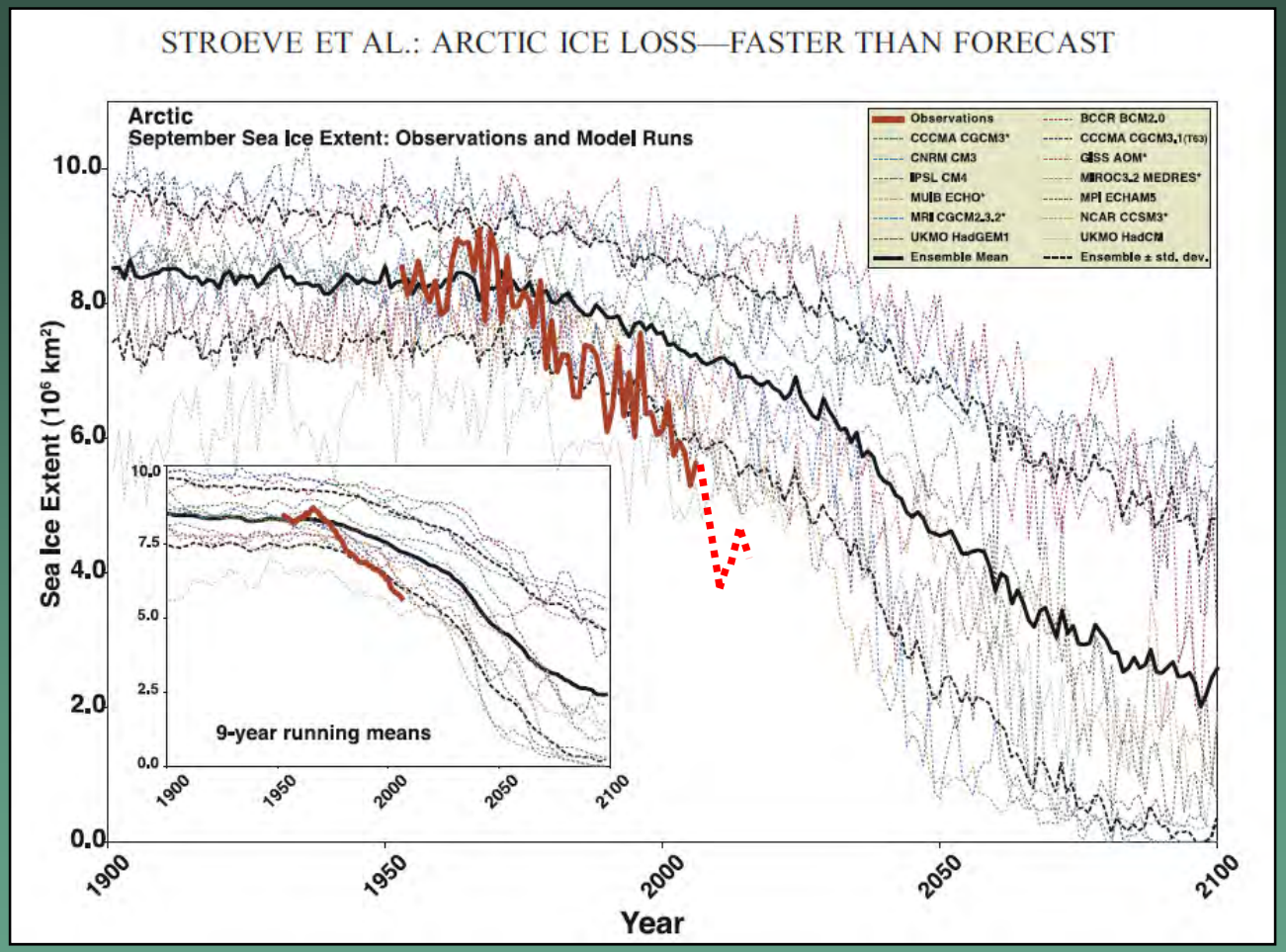
Observed ice decline is “faster than forecasted”



Stroeve, J., M. M. Holland, W. Meir, T. Scambos, and M. Serreze. 2007. Arctic sea ice decline: Faster than forecast. Geophysical Research Letters, dooi:10.1029/2007GL029703..

Observed ice decline is “faster than forecasted”

Findings of Stroeve et al. (2007)

September 1953-2006

- observed trend: -7.8 ± 0.6% / decade
- modeled trend: -2.5 ± 0.2% / decade (max: -5.4 ± 0.4%)

September 1979-2006

- observed trend: -9.1 ± 1.5% / decade
- modeled trend: -4.3 ± 0.3% / decade

September 1995-2006

- observed trend: -17.9 ± 5.9% / decade
- modeled trend: -6.6 ± 0.6% / decade

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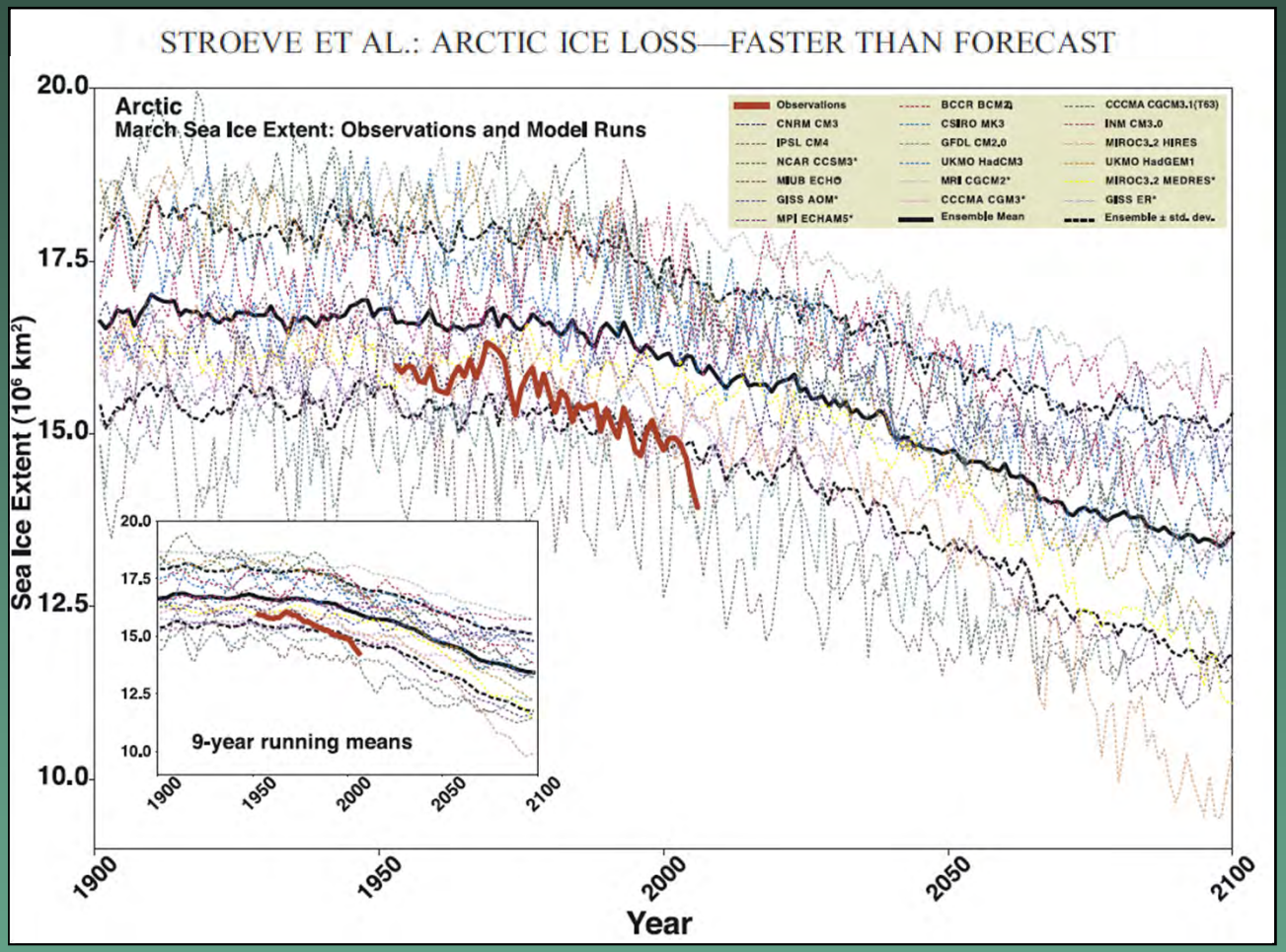
Observed ice decline is “faster than forecasted”



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Observed ice decline is “faster than forecasted”

Findings of Stroeve et al. (2007)

March 1953-2006

- observed trend: -1.8 ± 0.1% / decade
- modeled trend: -0.6 ± 0.1% / decade

March 1979-2006

- observed trend: -2.9 ± 0.3% / decade
- modeled trend: -1.2 ± 0.2% / decade

Trends and discrepancies are not as dramatic, but still occur

With increasing GHG loading all models show declining March ice

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Observed ice decline is “faster than forecasted”

Conclusions of Stroeve et al. (2007)

Current (2006) summer minima are 30 years ahead of model forecasts

The role of GHGs:

1953-2006

- 33-38% of observed trends are externally forced

1979-2006

- 47-57% of observed trends are externally forced

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Two concerns regarding the use of general circulation models to project sea ice are:

1) Are the correct forcing parameters applied and in the correct amount, and;
2) What is the temporal variability that can be expected when we look at trends of variable lengths.

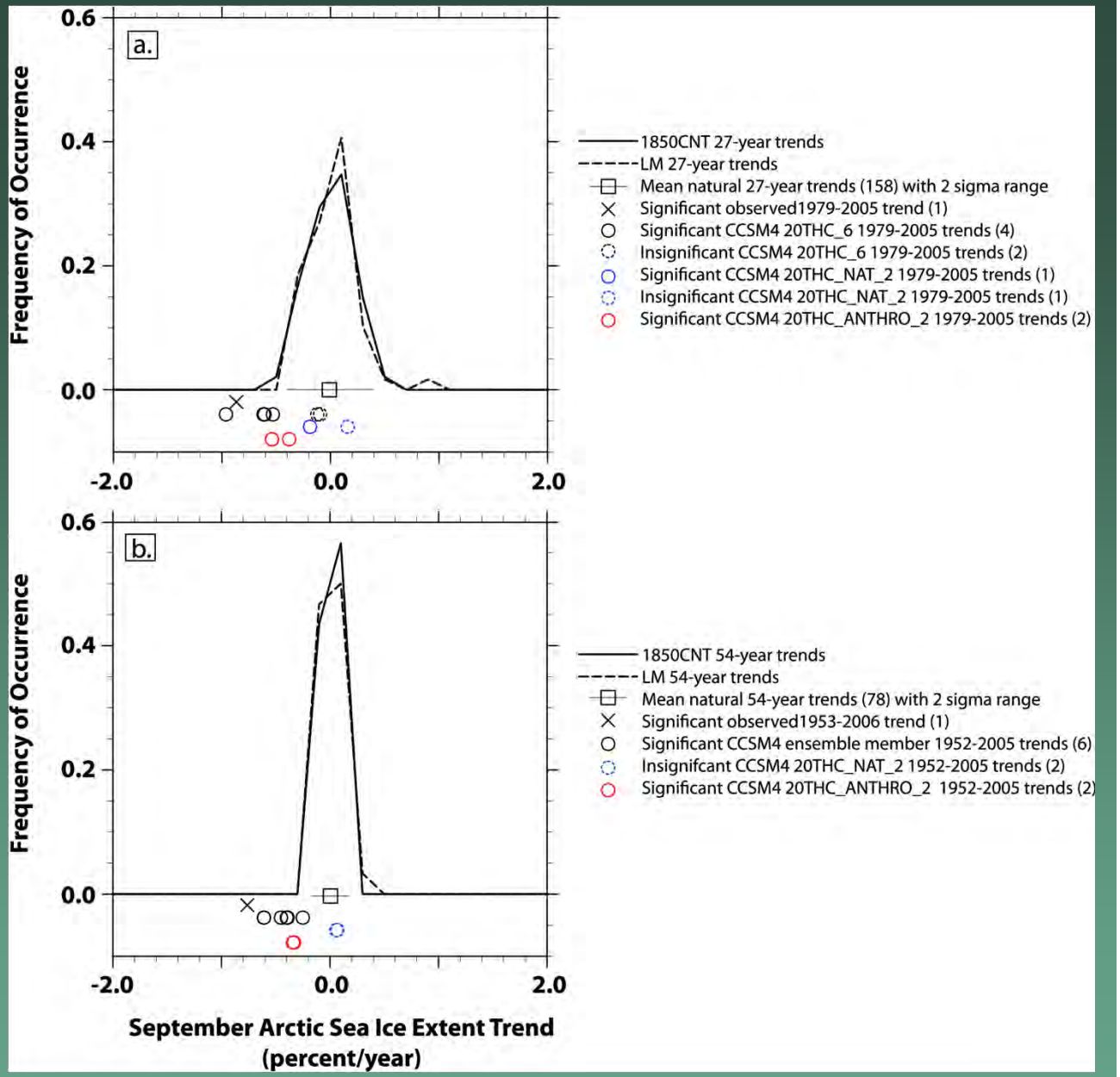
How much of the observed trend can be attributed to natural variation versus anthropogenic sources (i.e., GHGs, aerosols, and ozone).

Kay, J. E., M. M. Holland, and A. Jahn. 2011. Inter-annual to multi-decadal Arctic sea ice extent trends in a warming world. Geophysical Research Letters, doi:10.1029/2011GL048008.

Conclusions of Kay et al. (2011)

Observed and modeled sea ice trends are forced by both natural and anthropogenic factors

Observed and modeled sea ice trends are greater than either natural variability-only or human-forced-only models

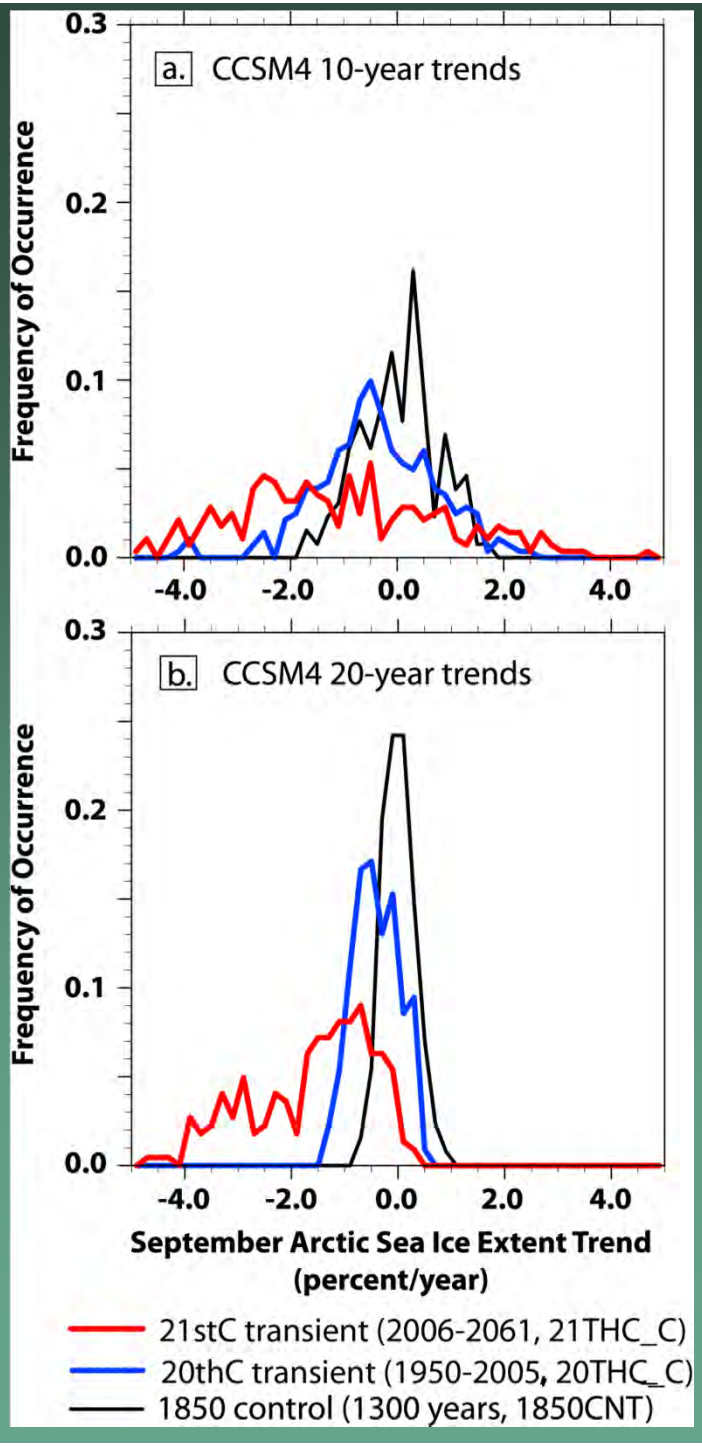


Kay, J. E., M. M. Holland, and A. Jahn. 2011. Inter-annual to multi-decadal Arctic sea ice extent trends in a warming world. Geophysical Research Letters, doi:10.1029/2011GL048008.

Conclusions of Kay et al. (2011)

Variability is greatest when trends are examined over relatively short (i.e, < 20 year) time frames. However, there are more negative than positive trends in the 21st century.

Observed and modeled sea ice trends >= 20 years show a greater frequency of negative trends.



Kay, J. E., M. M. Holland, and A. Jahn. 2011. Inter-annual to multi-decadal Arctic sea ice extent trends in a warming world. Geophysical Research Letters, doi:10.1029/2011GL048008.

Kay et al (2011) concluded that:

1) Observed and modeled late 20th century sea ice loss cannot result from natural variability alone. In fact, 56% of sea ice trends were due to anthropogenic forcing;
2) Internal variability, however, exerts a strong influence on sea ice trends, and this is especially evident on time scales < 20 years.
3) As climate warms, multi-decadal negative sea ice trends increase.
4) As climate warms, trend variability on 2-10 year timeframes increases.
5) As climate warms, positive sea ice trends on 2-10 year windows occur throughout the first half of the 21st century.

Kay, J. E., M. M. Holland, and A. Jahn. 2011. Inter-annual to multi-decadal Arctic sea ice extent trends in a warming world. Geophysical Research Letters, doi:10.1029/2011GL048008.

Multi-model median sea ice projections

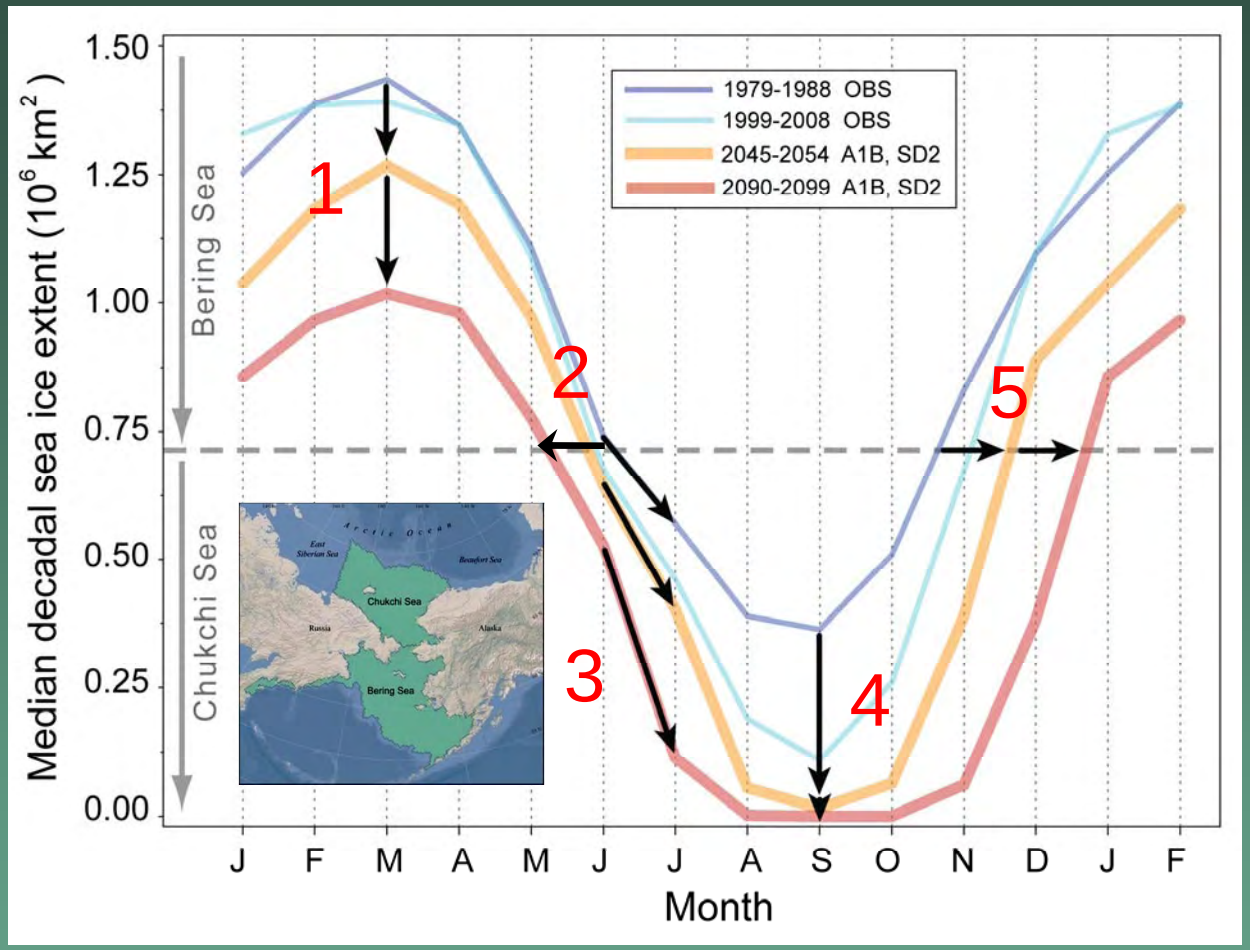
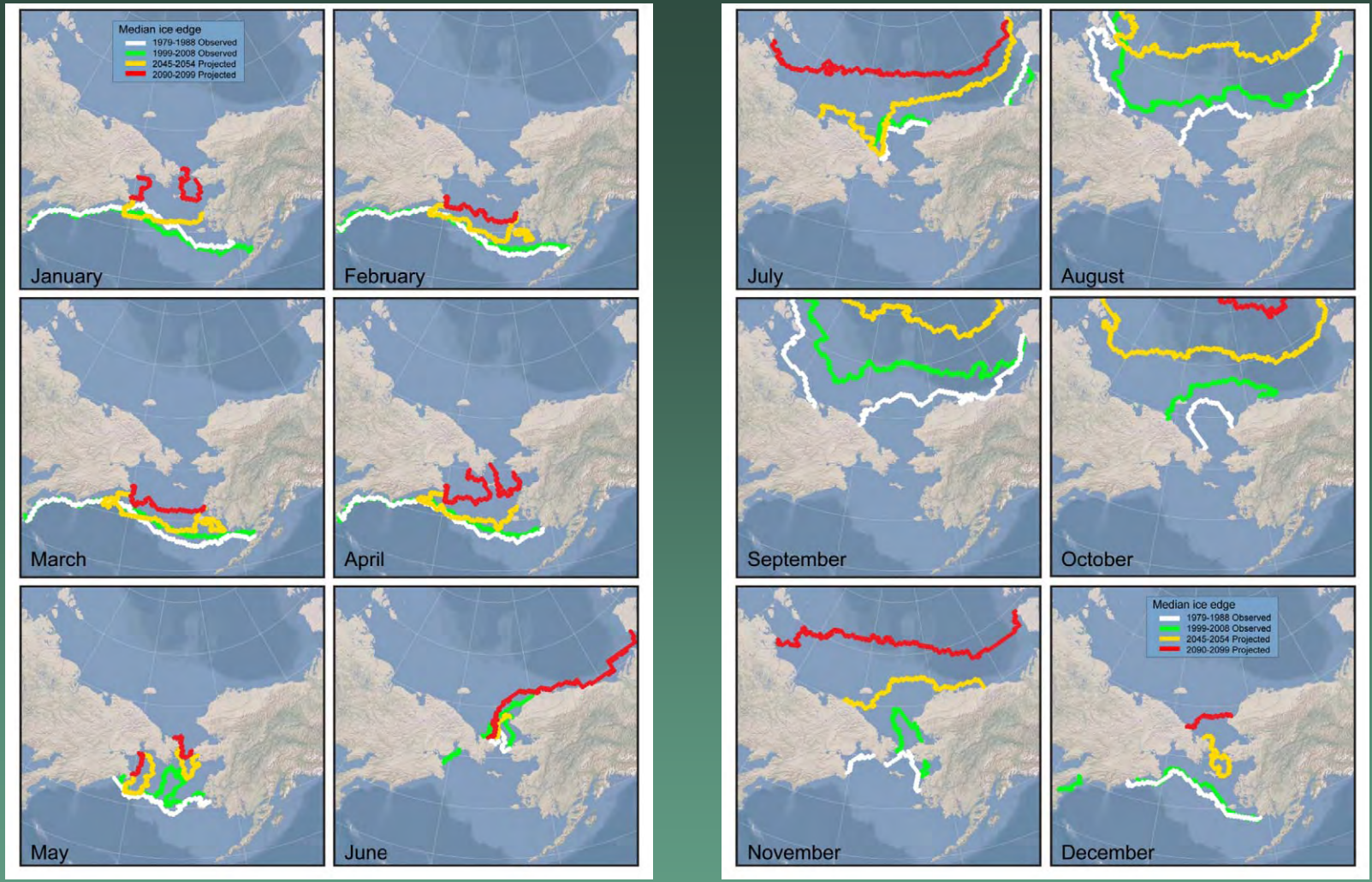


Figure 7.

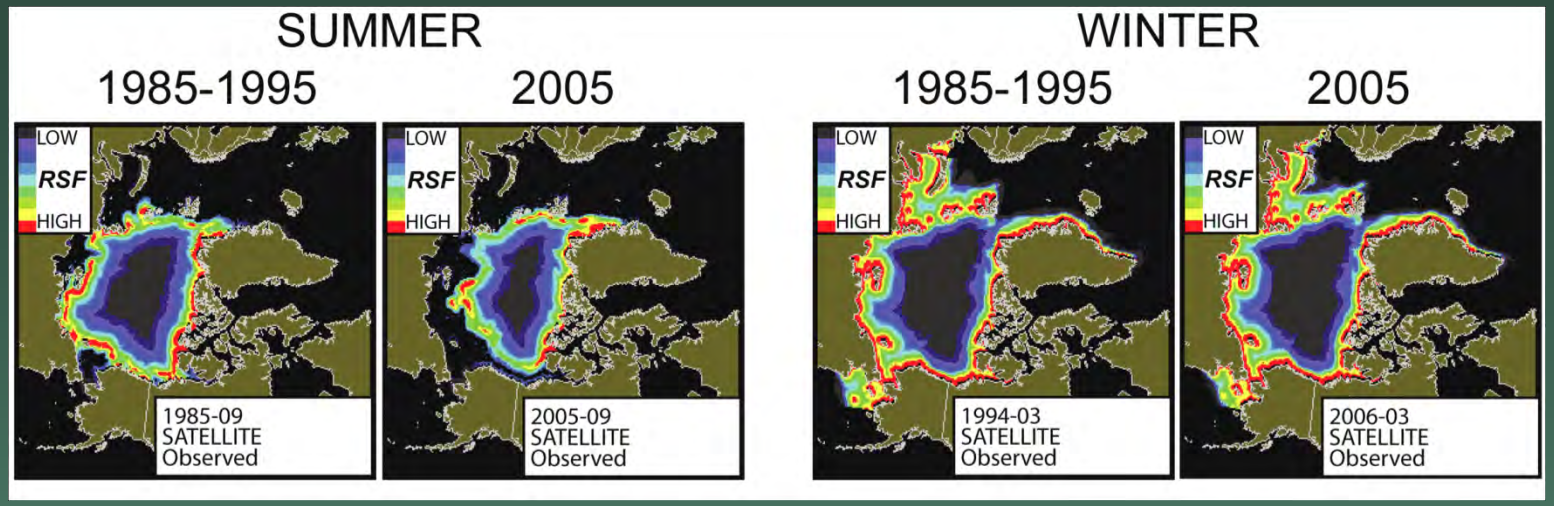
Douglas, D.C., 2010, Arctic sea ice decline: Projected changes in timing and extent of sea ice in the Bering and Chukchi Seas: U.S. Geological Survey Open-File Report 2010-1176, 32 p. http://pubs.usgs.gov/of/2010/1176

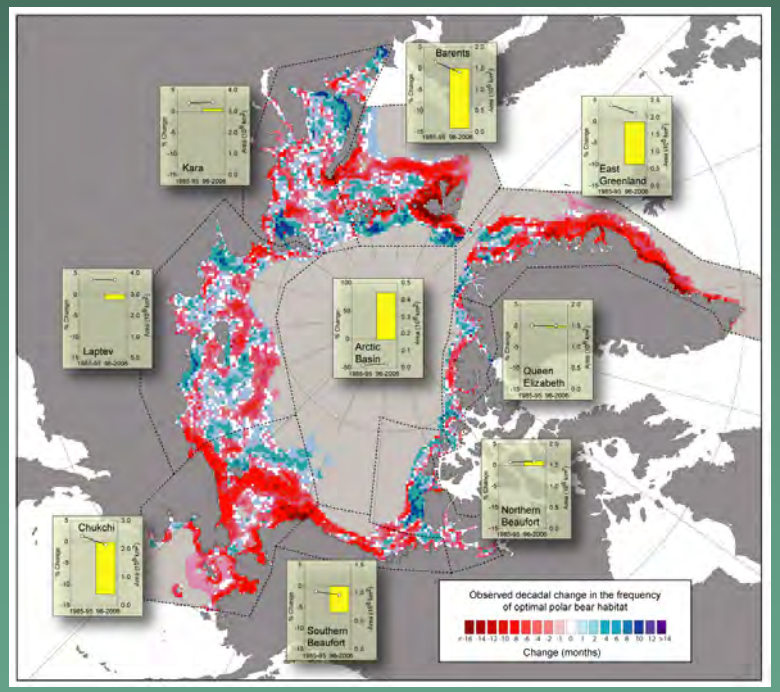


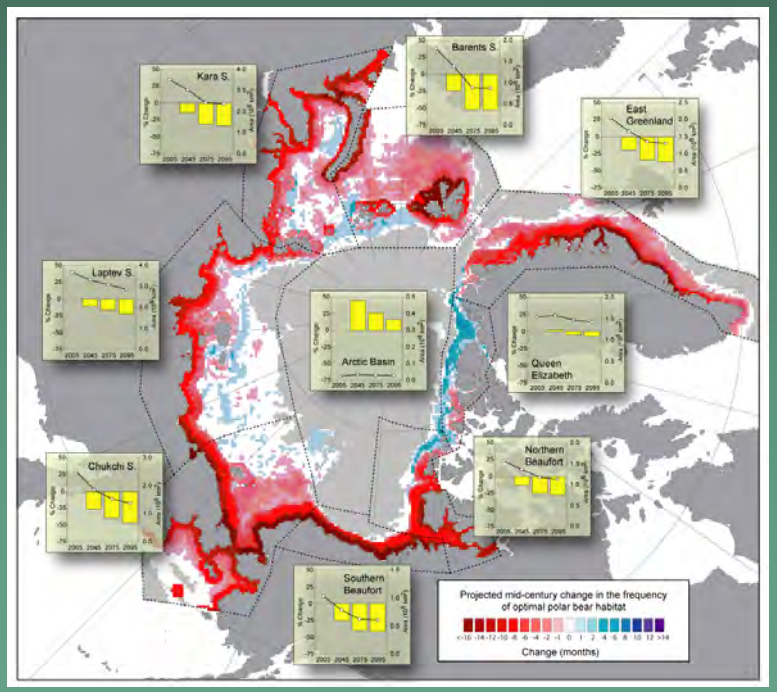
Median ice edge
- 1979-1988 Observed
- 1999-2008 Observed
- 2045-2054 Projected
- 2090-2099 Projected

Figure 9.

Douglas, D.C., 2010, Arctic sea ice decline: Projected changes in timing and extent of sea ice in the Bering and Chukchi Seas: U.S. Geological Survey Open-File Report 2010-1176, 32 p. http://pubs.usgs.gov/of/2010/1176







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Habitat: 1996-2006 minus 1985-1995

Habitat: 2041-2050 minus 2001-2010

Durner et al. 2009

In conclusion

- The observation of “faster than forecast” continues to be realized.
- “Faster than forecast” is becoming faster
- Eventually there will be better quantification of the forcing elements of CGM sea ice projections
- Also, there will be better quantification of the temporal variation in GCM sea ice projections
- Despite this, it is unlikely that GCM sea ice projections and habitat projections will change with newer GCM models

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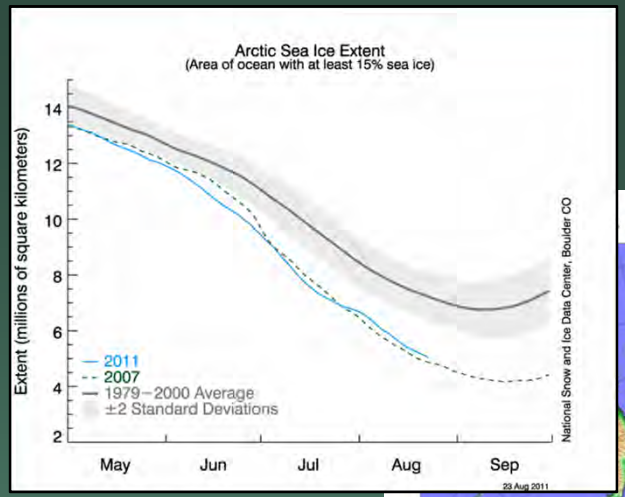
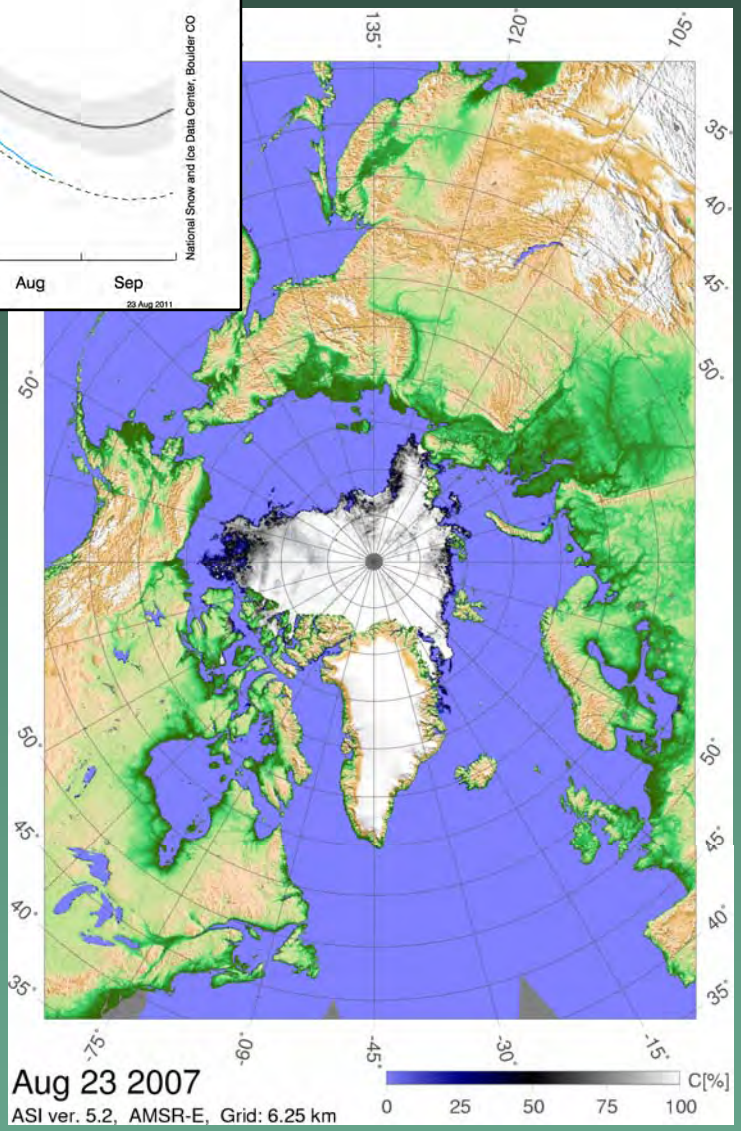
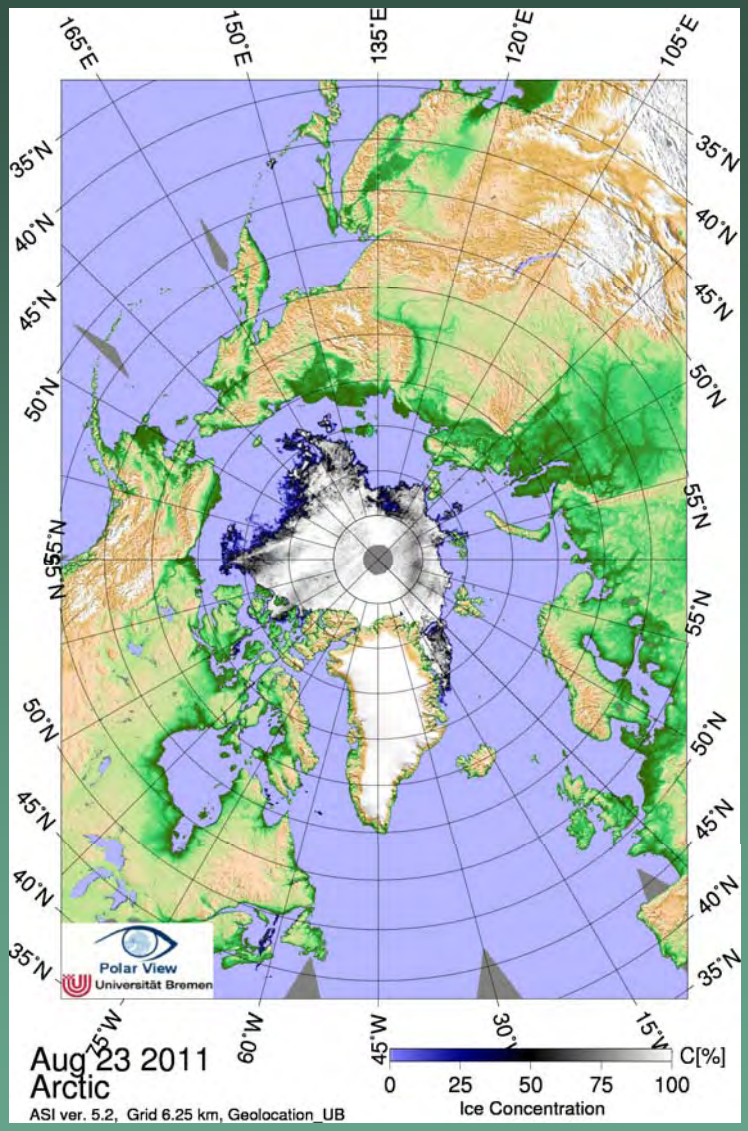
Thank you







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