Lower Stratospheric Cooling

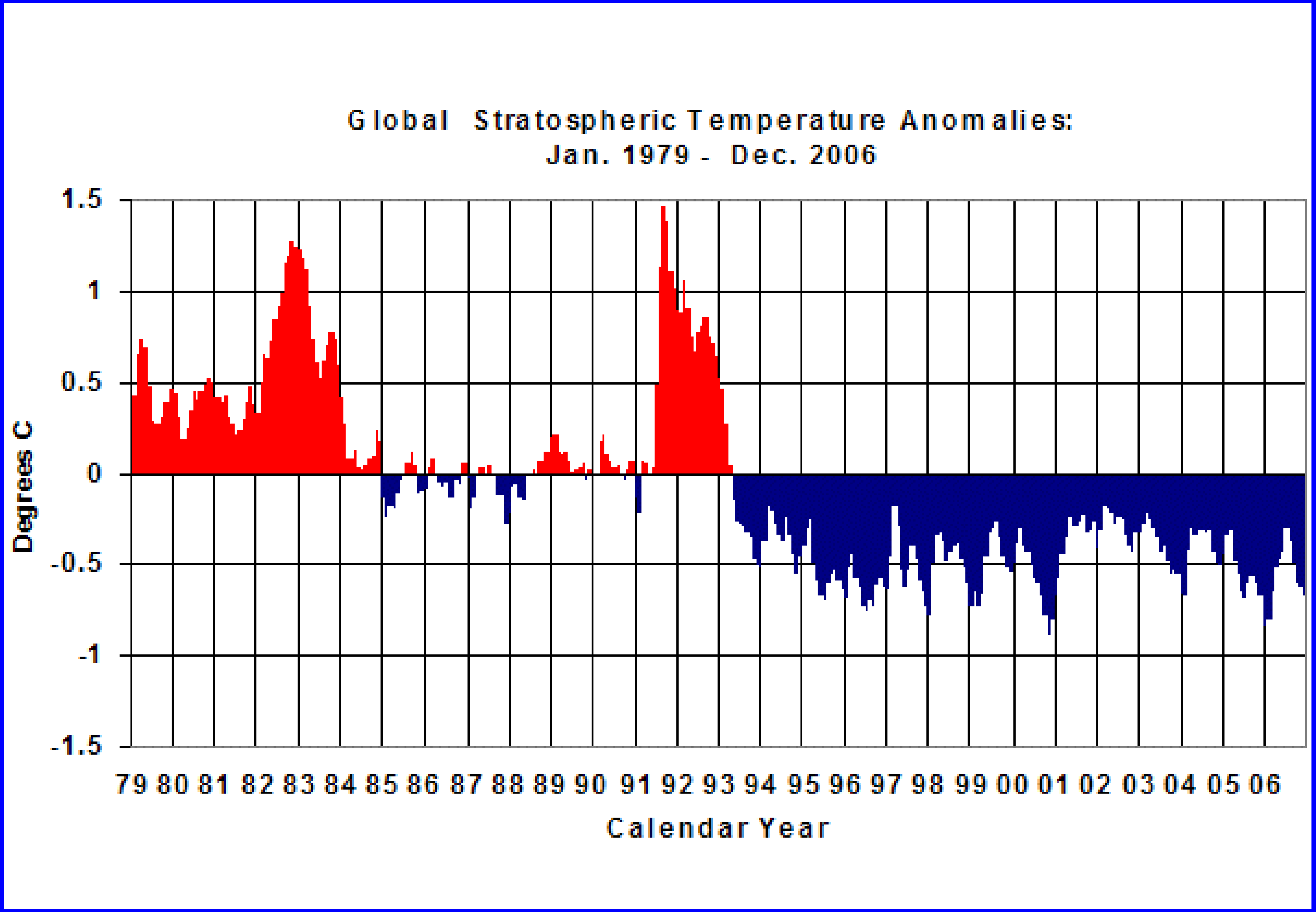
and

Abrupt Change in Arctic Sea Ice

Carl Drews
March 16, 2007

ATOC 7500-002 Human Influences on Weather and Climate
University of Colorado at Boulder
Dr. Roger Pielke Sr, Instructor

The Lower Stratosphere



http://www.ghcc.msfc.nasa.gov/MSU/msusci.html

There is a long-term cooling trend in the lower stratosphere. But the graph appears to show a ***stepwise*** response to volcanoes El Chicón in 1982 and Pinatubo in 1991.

Three Signals

- Maybe the stratospheric temperature is a combination of three simpler curves:
  - Volcanic heating (short duration).
  - Long-term cooling from ozone or GHGs.
  - The 11-year solar cycle.

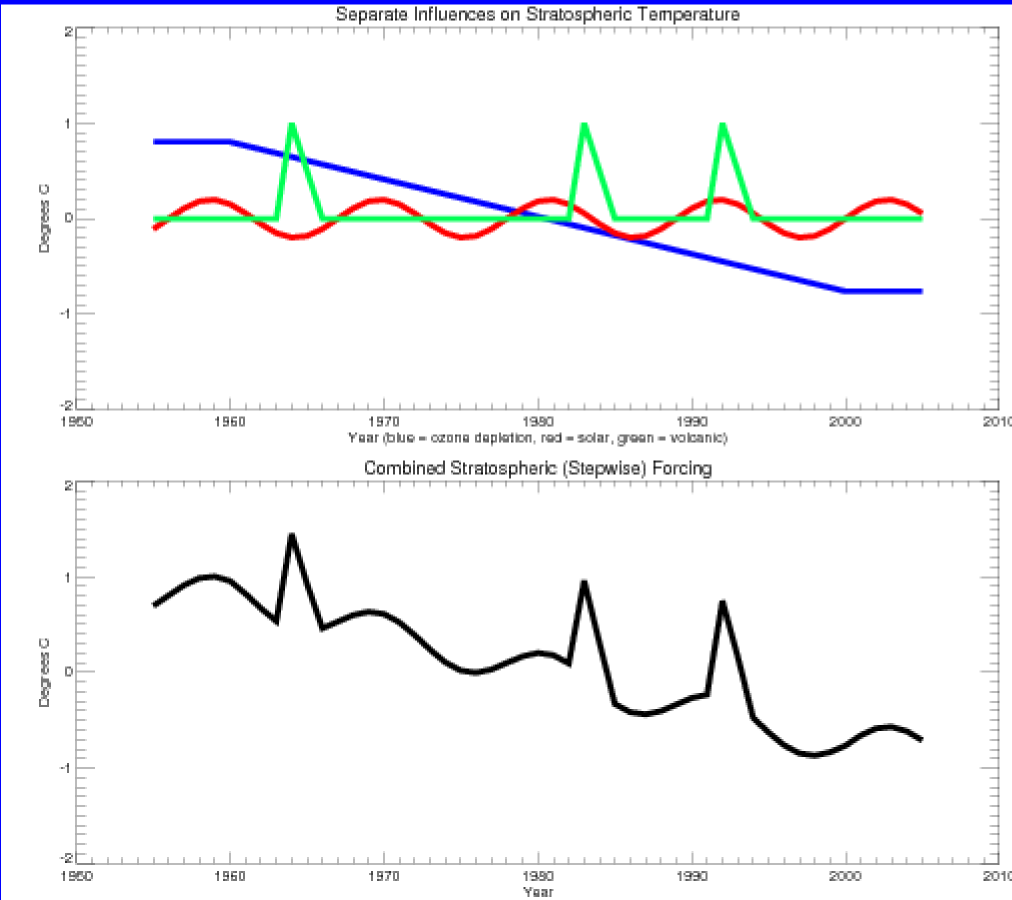
If we create these three signals, add them together, and display the result with IDL; it should exhibit the stepwise appearance . . .

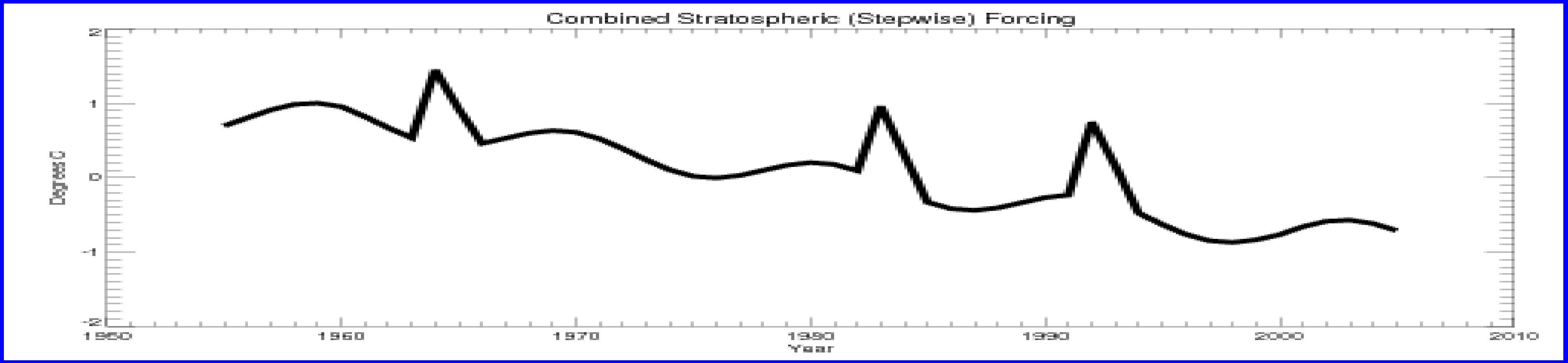
Blue = ozone

Green = volcanoes

Red = solar cycle

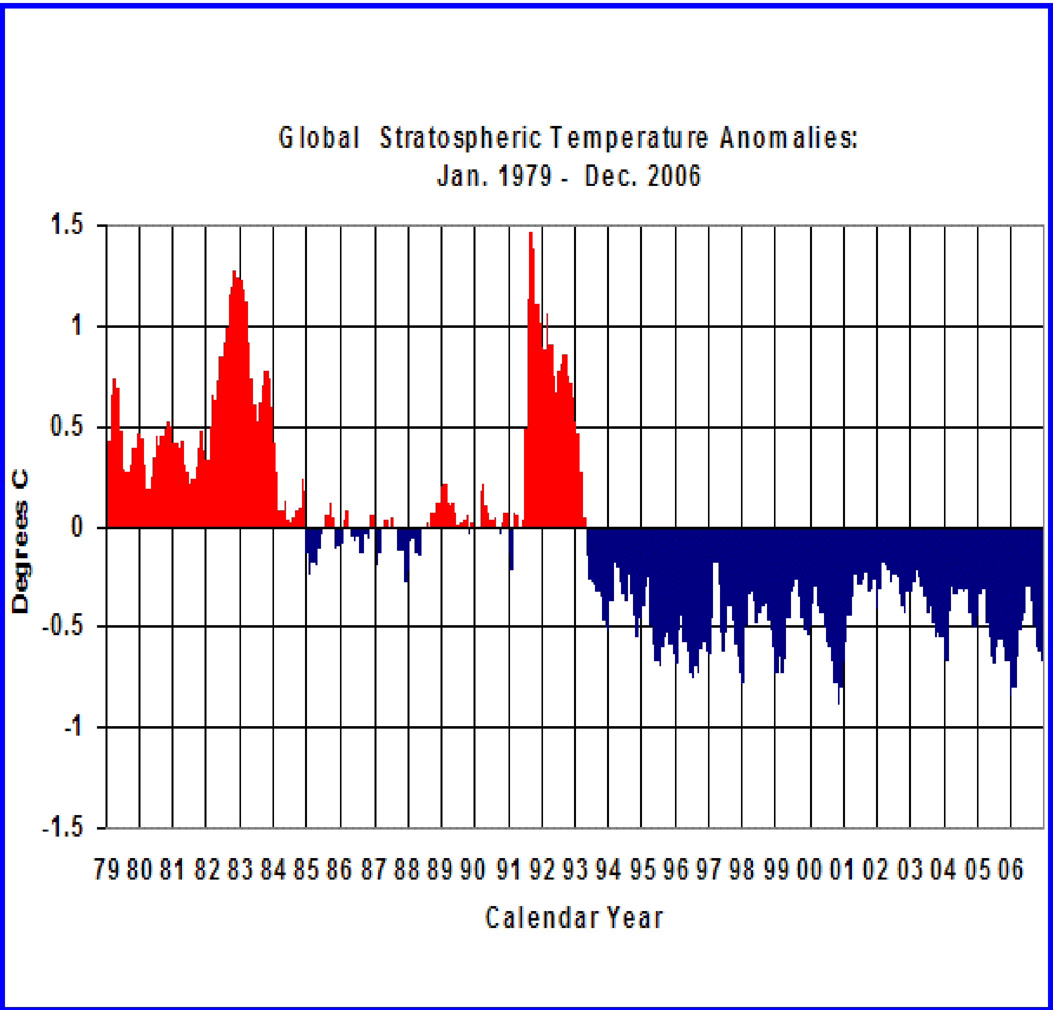
Black = sum of those

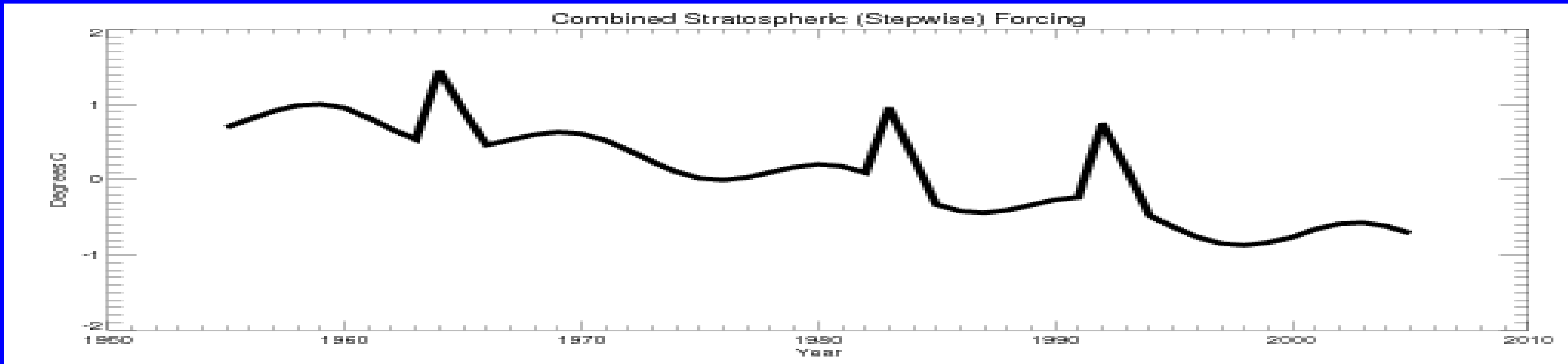




Um – yes, the graphs match (sort of).

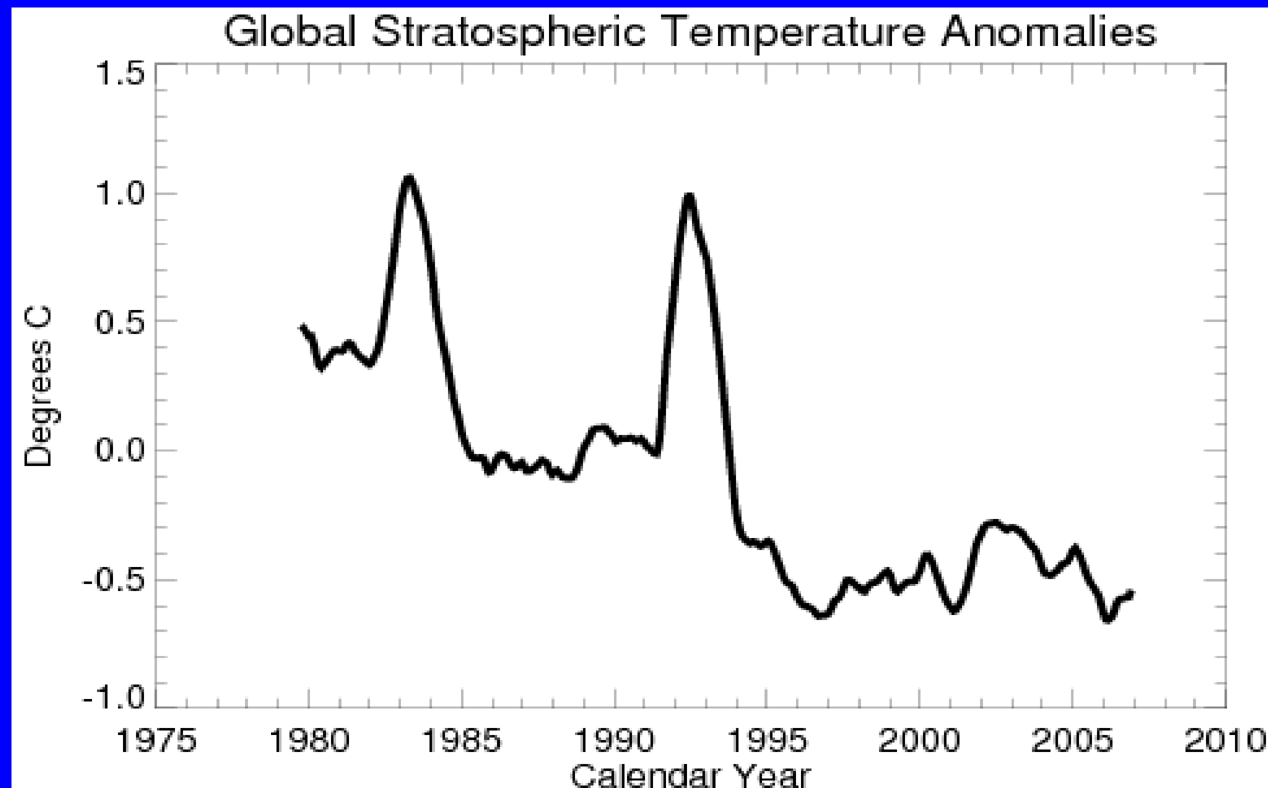
Try smoothing the raw data . . .





Eureka!

Archimedes Thoughtful by Fetti (1620)

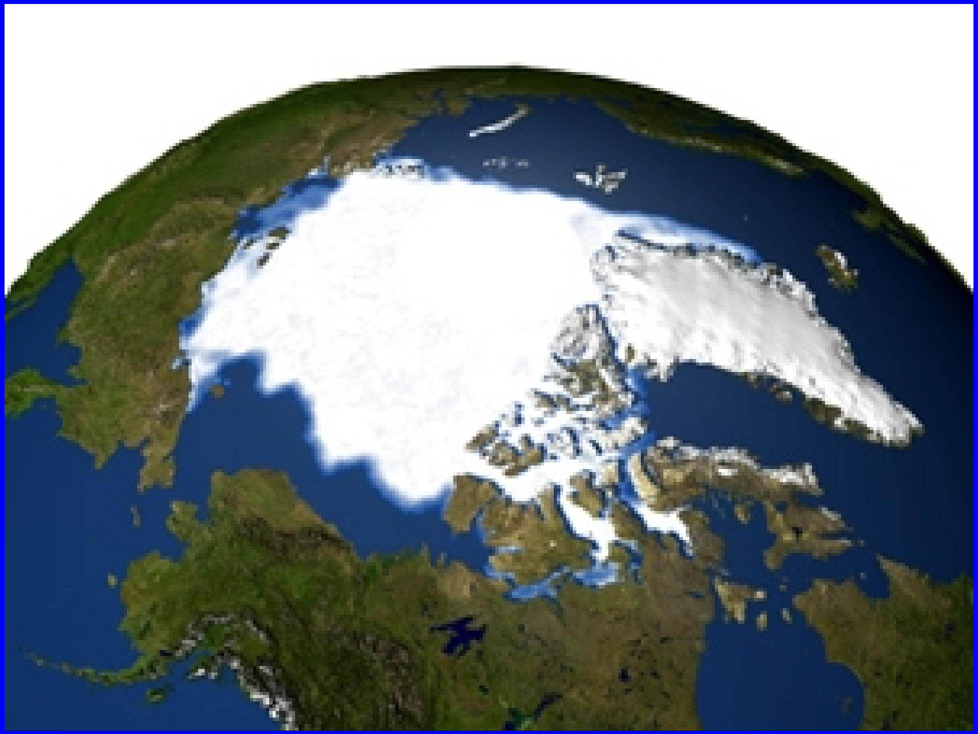
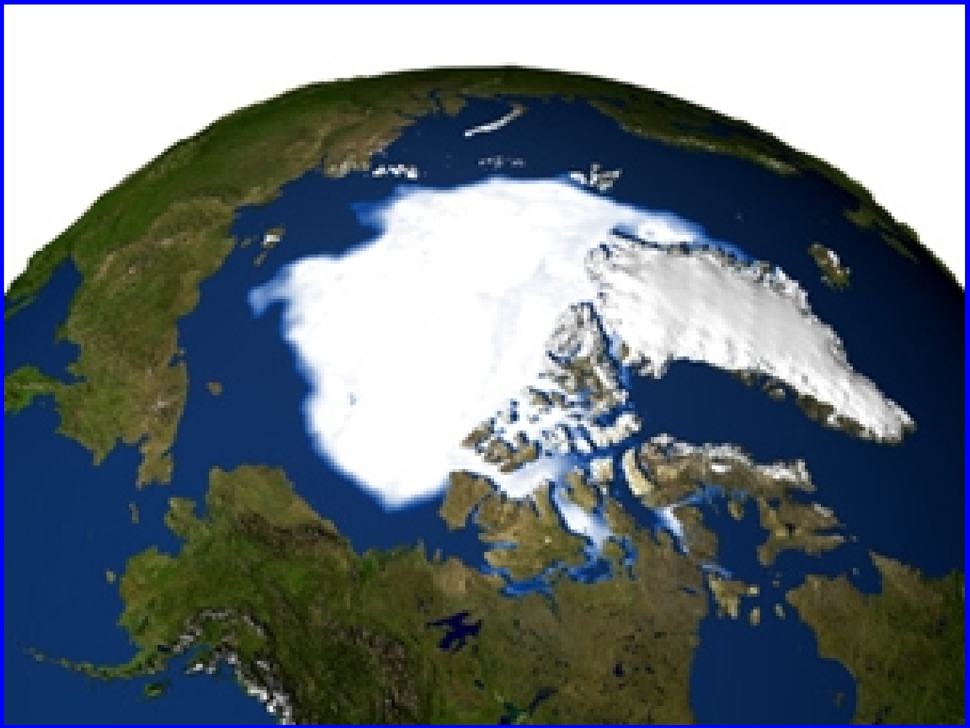


12-month running average

The data decreases after 2003, just like the solar cycle should.

Abrupt Change in Arctic Sea Ice

- Seminar by Marika Holland at NCAR on March 8, 2007.
  - Abrupt change can also be described as a "tipping point".
  - CCSM3 simulations. Various scenarios.
  - Satellite measurements of sea ice extent since 1979.
  - 8% loss of extent per decade, and accelerating.
  - Big polynya (open area) in the Beaufort Sea.
  - Warming happens in pulses; sudden increases followed by periods of relative stability.

These images show the extent of sea-ice coverage in September 1979 (left) and 2005 (right). (Images courtesy NASA.)

http://www.ucar.edu/communications/quarterly/winter0506/permafrost.jsp

Projections of Ice Extent

- Ice free in 15 years? 2025? Or 2040.
- Arctic could move from 80% to 20% coverage in a single decade, during the summer months only. Winter Arctic will always have ice.
- As the ice thins, vertical melting is more efficient at producing open water.
  - Abrupt change happens then.
- Non-linear, large response to positive feedback.
- There is an increase in ocean heat transport to the Arctic. OHT is the trigger to abrupt change, and the pulses are natural.

The image at left, based on simulations produced by the Community Climate System Model, shows the approximate extent of Arctic sea ice in September. The model indicates the extent of this late-summer ice could begin to retreat abruptly within several decades. By about 2040 (image at right), the Arctic may be nearly devoid of sea ice during the late summer unless greenhouse gas emissions are significantly curtailed. (Illustrations ©UCAR.)

Note reference to greenhouse gases.

http://www.ucar.edu/news/releases/2006/arcticvisuals.shtml

Time Series of Ice Extent

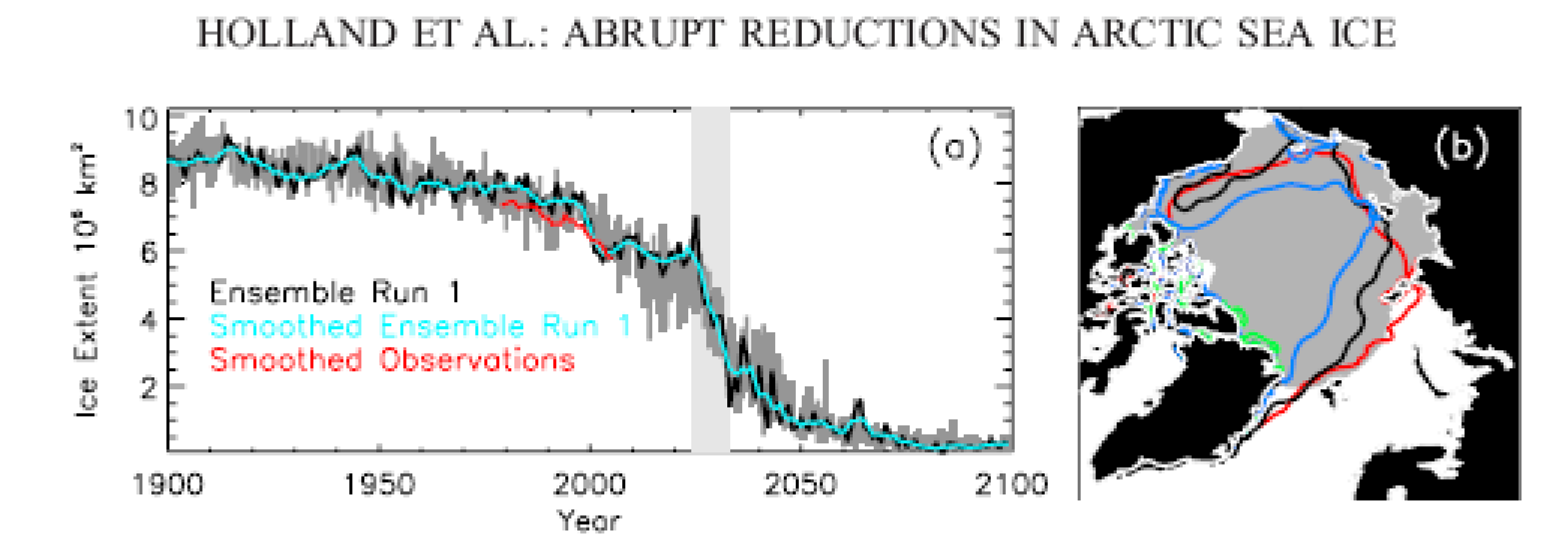


Figure 1. (a) Northern Hemisphere September ice extent for Run 1 (black), the Run 1 five-year running mean (blue), and the observed five-year running mean (red). The range from the ensemble members is in dark grey. Light grey indicates the abrupt event. (b) The Run 1 (black) and observed (red) 1990s averaged September ice edge (50% concentration) and Run 1 conditions averaged over 2010–2019 (blue) and 2040–2049 (green). The Arctic region used in our analysis is shown in grey.

Future abrupt reductions in the summer Arctic sea ice

Marika M. Holland,1 Cecilia M. Bitz,2 and Bruno Tremblay3,4

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L23503, doi:10.1029/2006GL028024, 2006

Mechanism Driving Abrupt Change

- 1. Thinning of the ice cover.
- 2. A trigger pulse from ocean heat transport.
- 3. Positive feedback from albedo of open water.

Probably just #1 and #3 can produce abrupt change, but #2 really gets things moving!

Ensemble Members

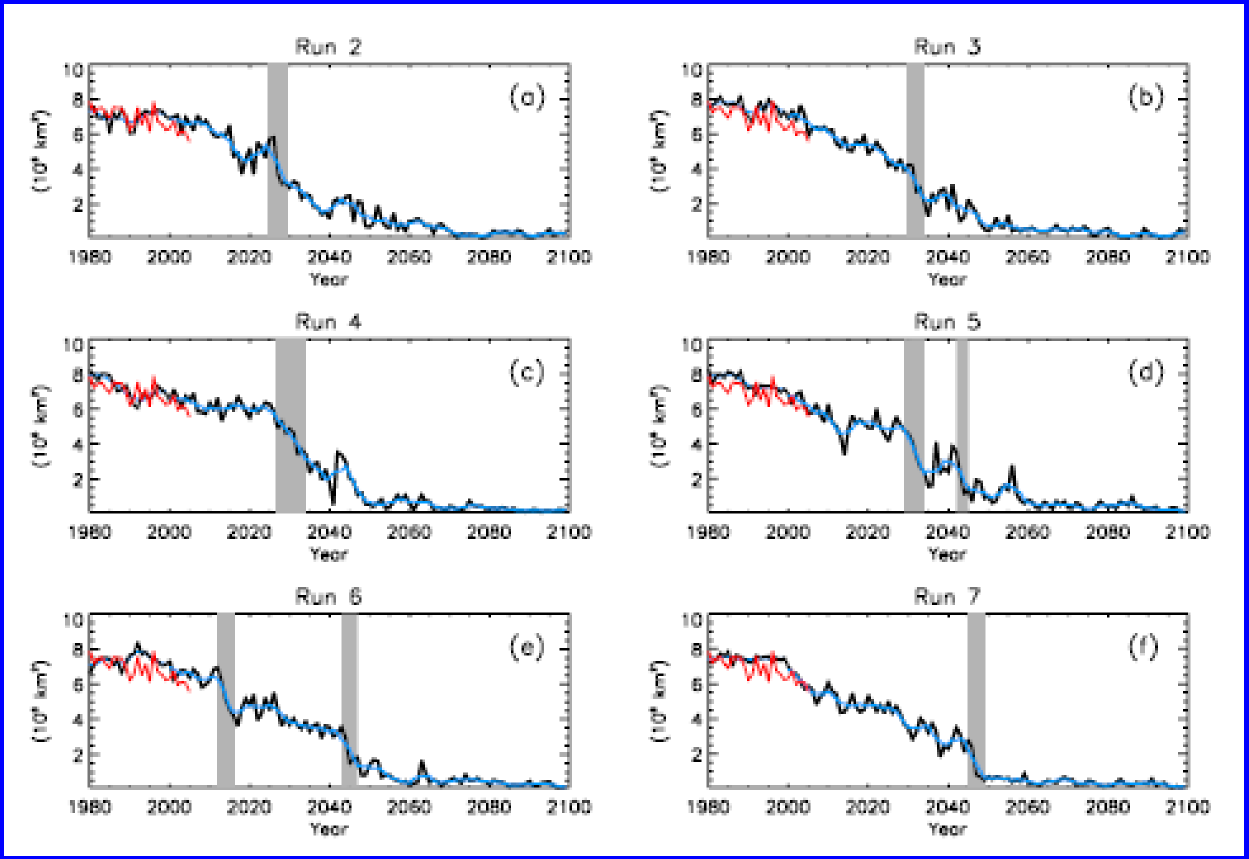


Figure 4. The Northern Hemisphere September ice extent from six additional CCSM3 A1B ensemble members. The five-year running mean (blue) and observed extent (red) are also shown. Grey shading indicates an abrupt transition as defined in the text.

Future abrupt reductions in the summer Arctic sea ice

Marika M. Holland,1 Cecilia M. Bitz,2 and Bruno Tremblay3,4

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L23503, doi:10.1029/2006GL028024, 2006

Questions?

Comments?

Reactions?