mini lecture

Alternative Hypotheses for Global Warming

Can anything else besides greenhouse gas changes have caused 20th century warming?

References

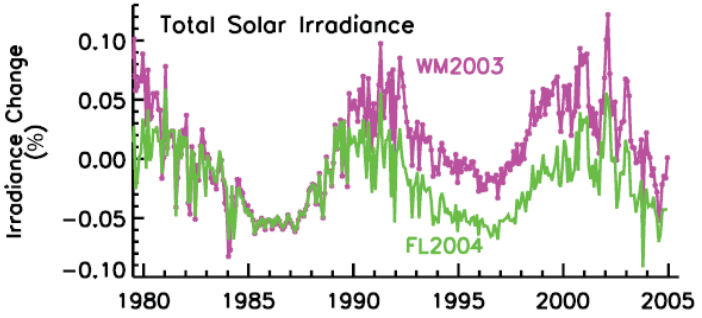
Ch 2: Changes in Atmospheric Constituents and in Radiative Forcing

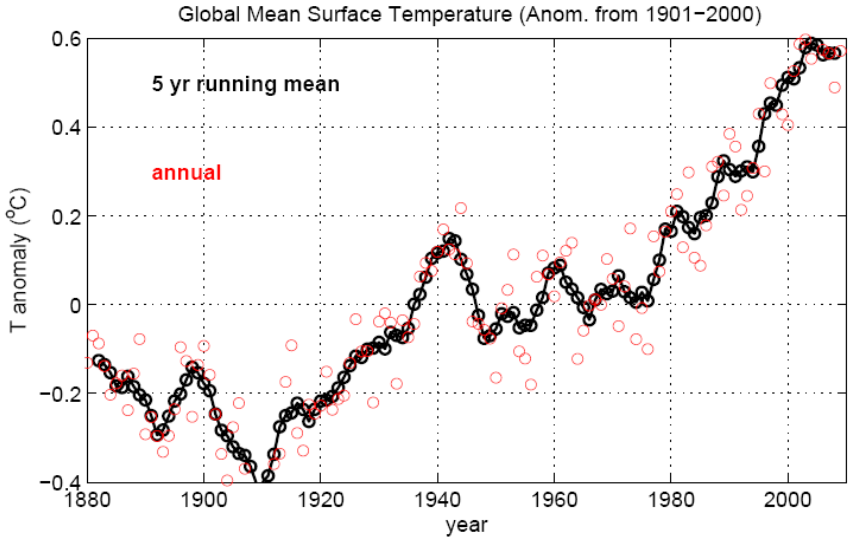
Semenov *et al* (2010, *J. Clim.*)

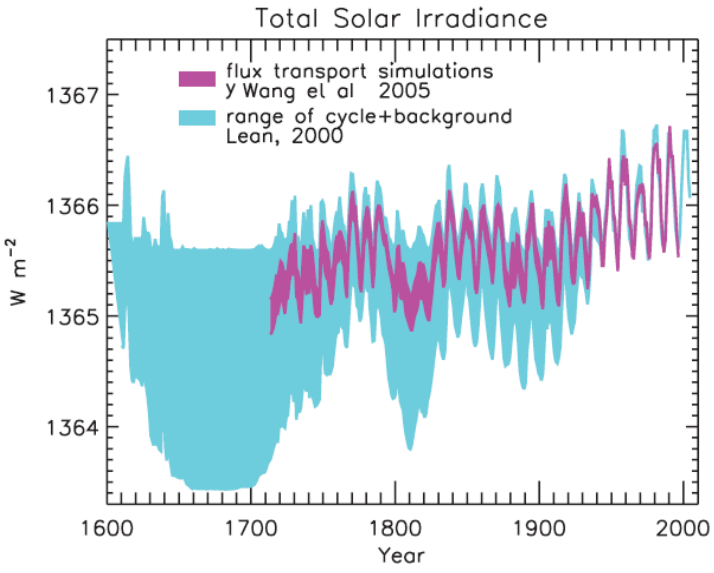
DelSole *et al* (2011, *J. Clim.*)

Solar Variability

Changes in total insolation:
in the past, may have been
a significant factor
BUT not consistent with recent trend

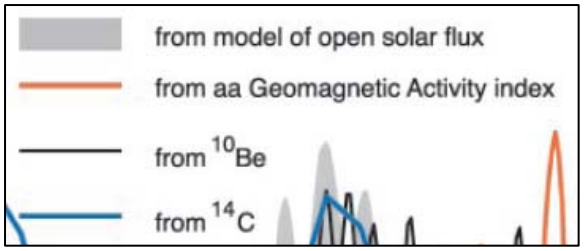


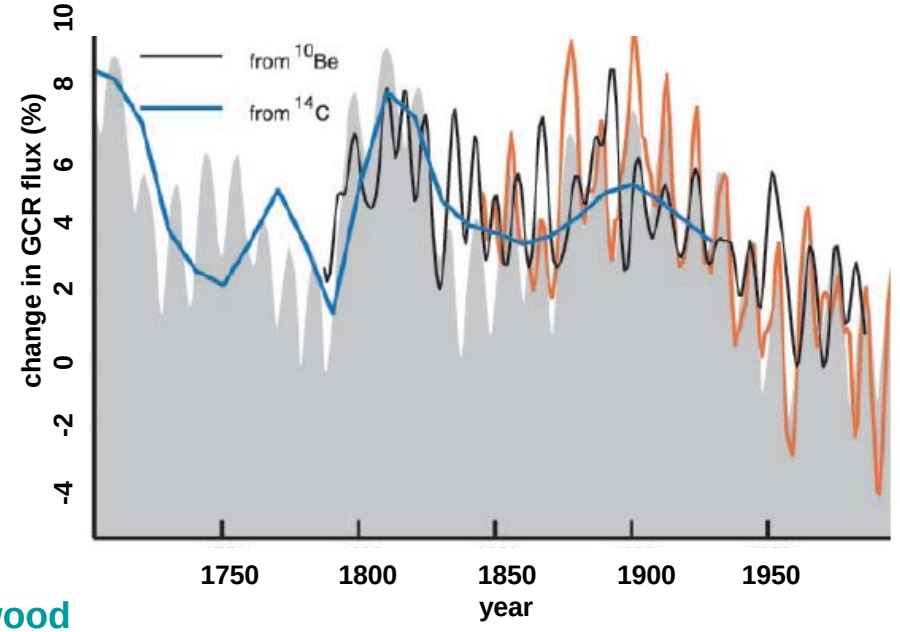




Solar Variability and Cosmic Rays

cosmic rays: high energy particles from space
from supernovae? from galactic-center black holes?
high solar activity
➔ changes interaction between solar wind & Earth's magnetosphere
cosmic rays are charged (electrons & protons)
➔ interact with magnetosphere
➔changes in solar activity cause changes in cosmic ray flux in atmosphere





Carslaw *et al* (2002, *Science*), after Lockwood

Climate Connection?

cosmic rays generate ions in atmosphere
these act as cloud condensation nuclei
not clear how important effect is in atmosphere
- **attempts to correlate solar cycle w/ clouds inconclusive**
- **also contaminated by insolation effects**

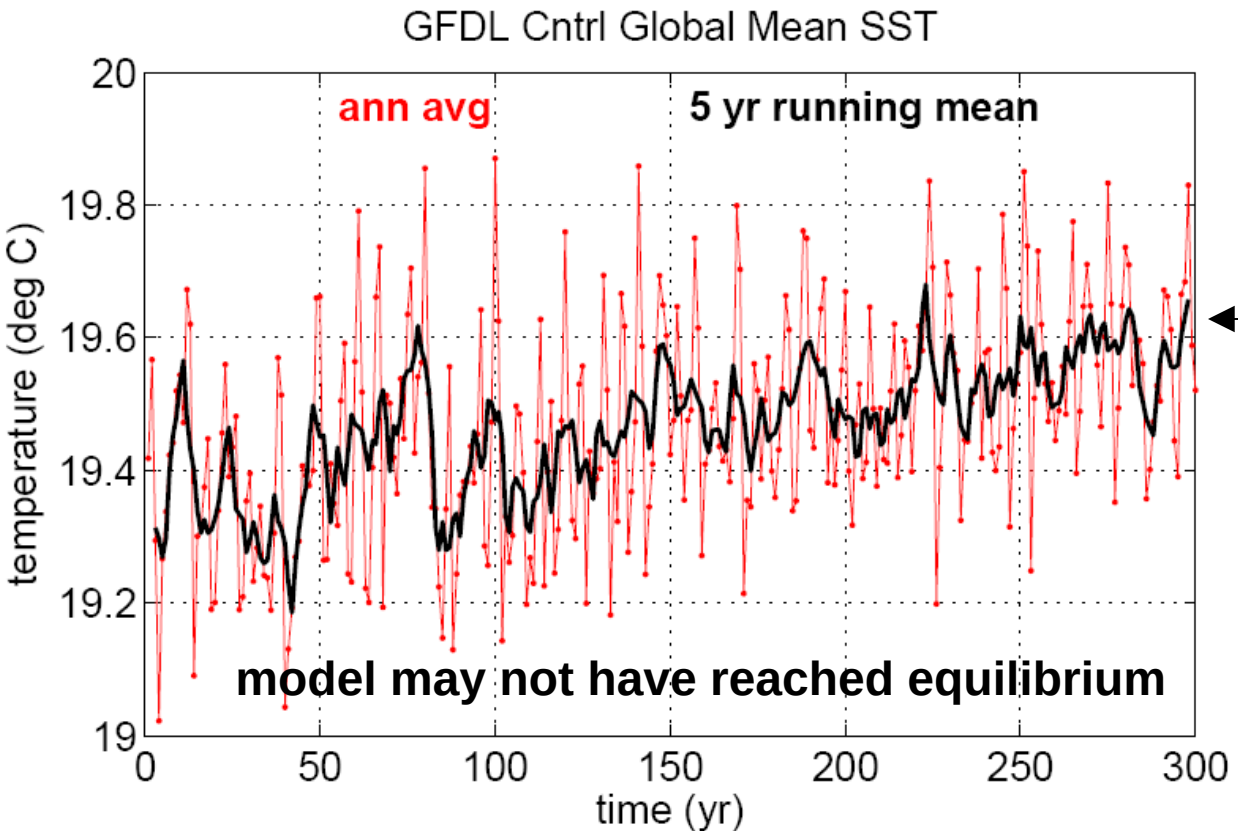
Solar Variability of UV

UV constitutes about 1% of solar insolation
UV variability (15%) much bigger (as percent) than total variability
UV variations affect ozone concentrations
correlated changes in stratospheric T up to >1C at 50km
trends?
connections to troposphere??

Internal Variability

It's possible that internal modes:
- **affect global mean T and related climate parameters**
- **aren't reproduced by current climate models**
- **have multi-decadal to centennial time scales**

So this is a possible alternative explanation for global warming, but based on little evidence!



coupled models don't produce O(1C) centennial variations in temperature from internal variations

AMV? [not exactly alternative – more like compliment]

eg Semenov Latif Dommenget Keenlyside Stehz Martin Park (2010, *J. Clim.*):

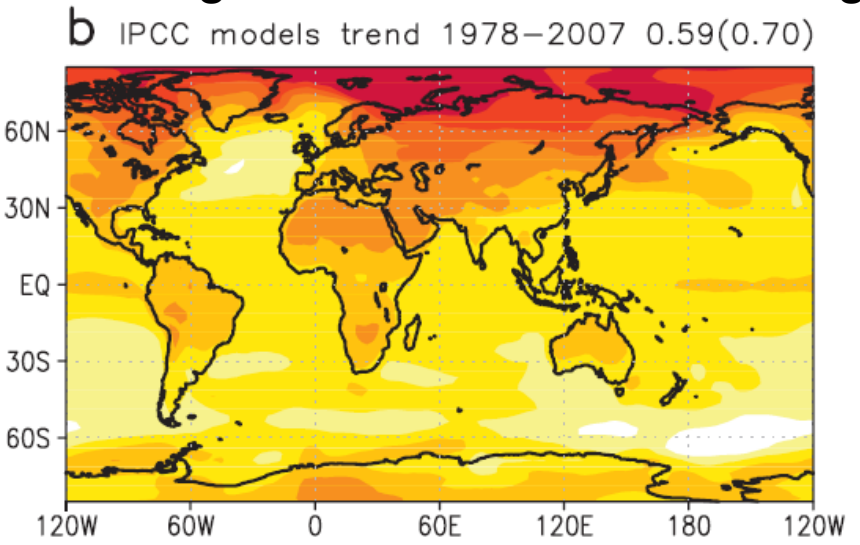
Atlantic Multidecadal Variability (AMV) SST may be driven by variability of Atlantic Meridional Overturning Circulation

AMV SST may contribute to global warming signal

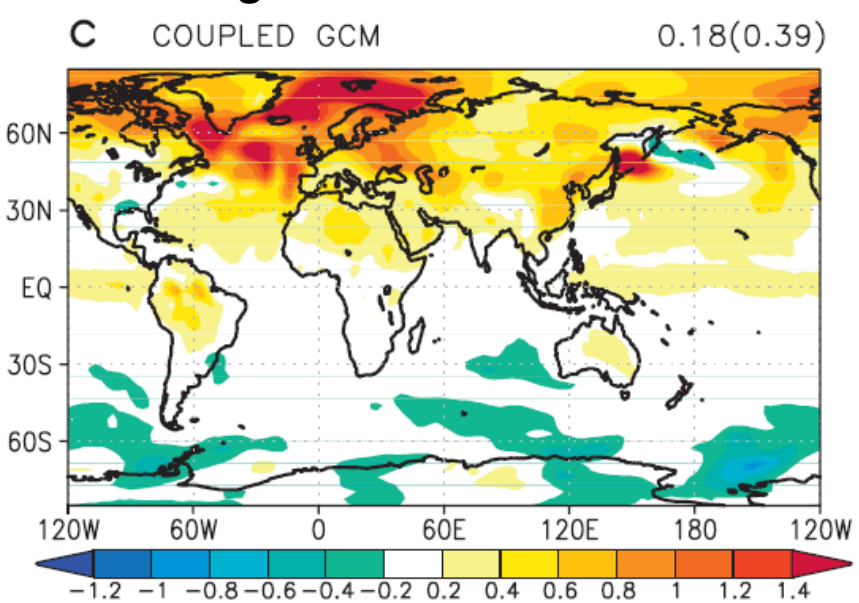
"twentieth-century Northern Hemisphere surface climate exhibits a long-term warming trend largely caused by anthropogenic forcing… natural internal multidecadal climate variability in the North Atlantic-Arctic sector could have considerably contributed to the Northern Hemisphere surface warming since 1980."

internal variability can also make system reach "tipping point" more quickly and hence amplify forced change

warming trend from radiative forcing



warming trend from AMV



Could AMV Account for all of global warming?

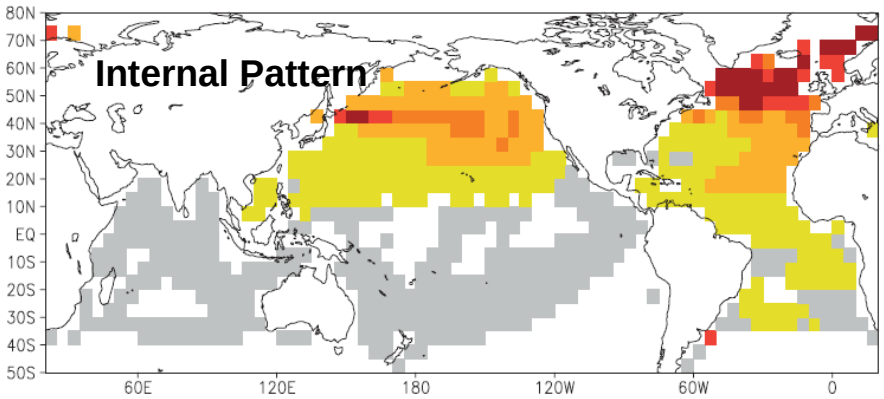
[see
DelSole Tippett Shukla (2011 *J Clim*)]

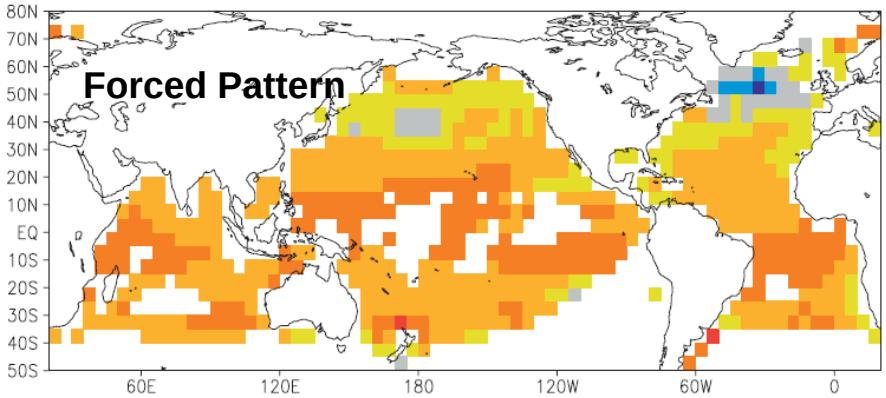
Used multi-model ensemble
of control and forced runs
Defined spatial SST patterns for
- internal variations
  (basically AMV)
- response to GHG forcing

note differences in patterns
Internal strongest in N Atl
Forced is negative in N Atl
& strongest in tropics

➔ AMV could NOT cause
observed global warming
(if model representation of
AMV is correct)

Multi-Model Patterns of SST Variability





Local Trend in HadSST2 1850–2005