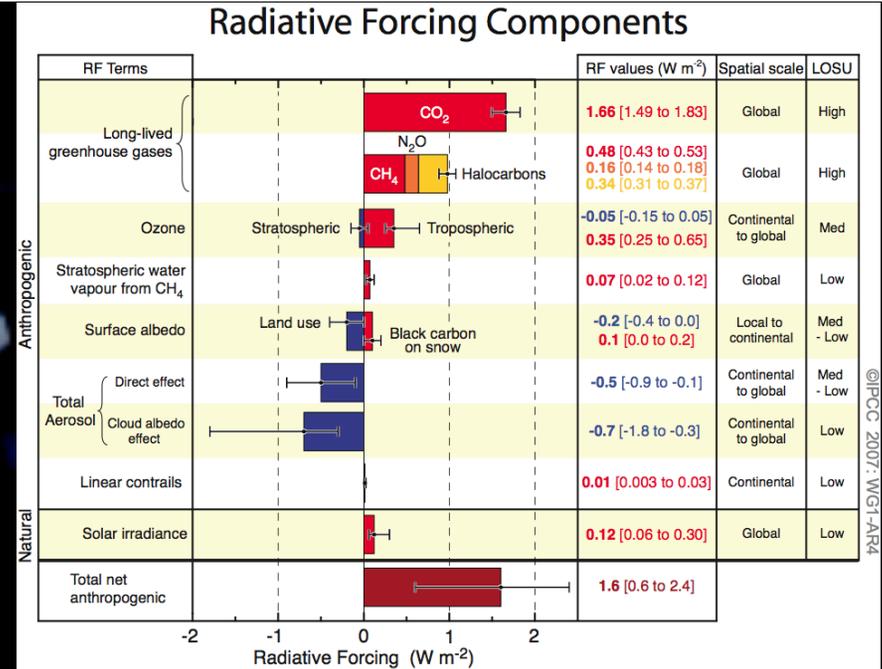


IPCC 4th Assessment Report 2007



● Present, Space-Era

- surface, troposphere and stratosphere
- .. ENSO, volcanic, solar and anthropogenic influences
- .. global and regional patterns
- GISS climate model simulations

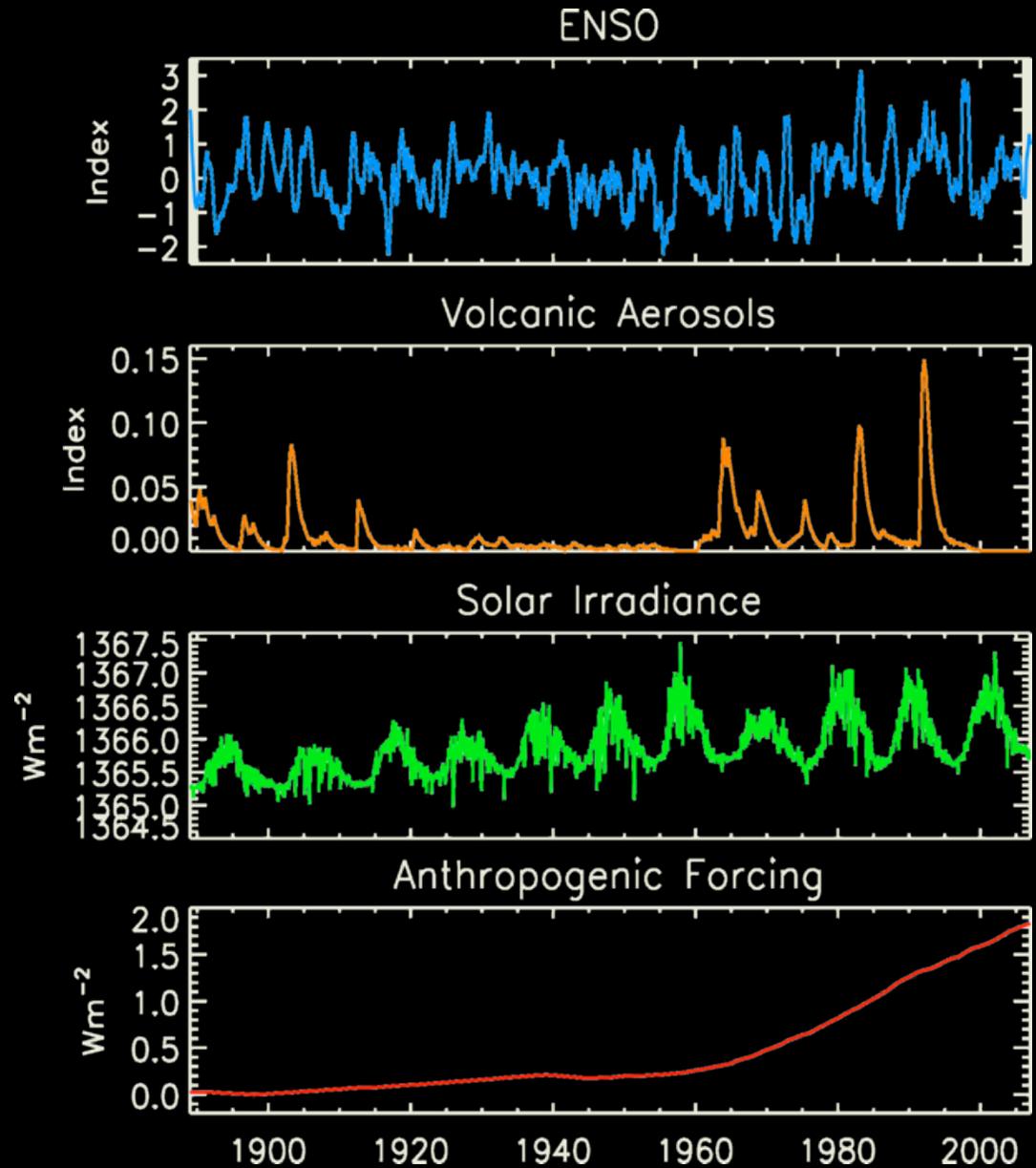
● Past

- instrumental surface temperatures, since 1880
- Holocene, proxies in the past 10,000 years

● Future Decades

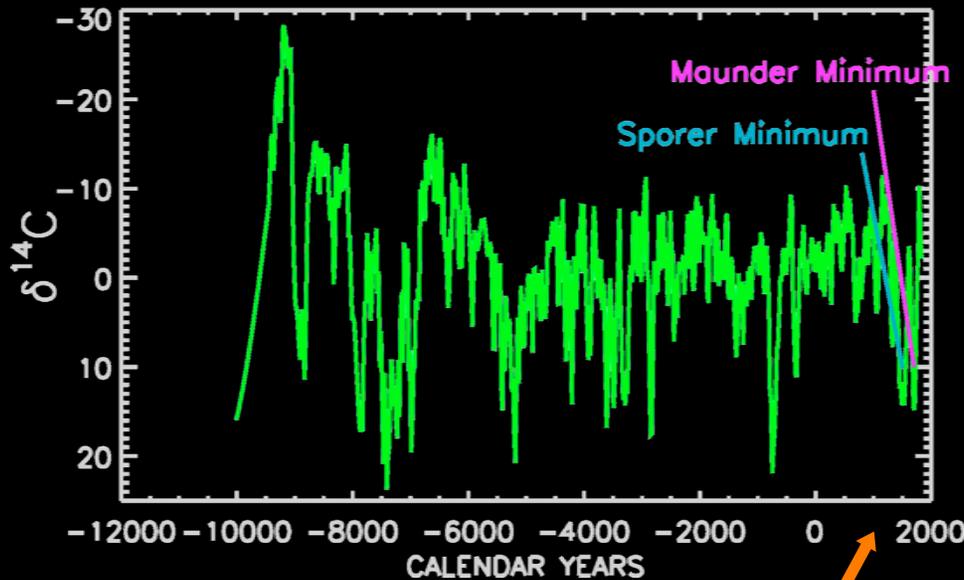
- forecasts of anthropogenic and solar influences
- scenarios for ENSO and volcanic influences

Natural and Anthropogenic Influences Since 1890



Centennial-Millennial Solar Variability

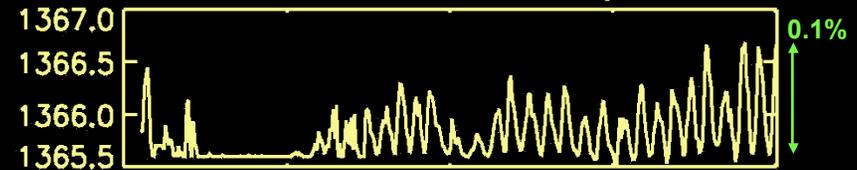
$\delta^{14}\text{C}$ in Tree-Rings:
Holocene Solar Activity Proxy



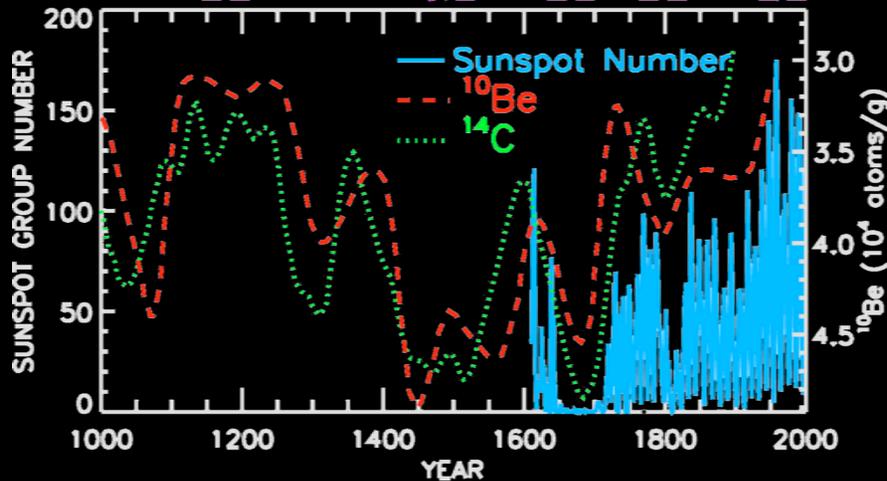
cosmogenic isotope changes
- ^{14}C in tree-rings, ^{10}Be in icecores -
imply long-term solar activity

... do they also imply long-term
solar irradiance variations?

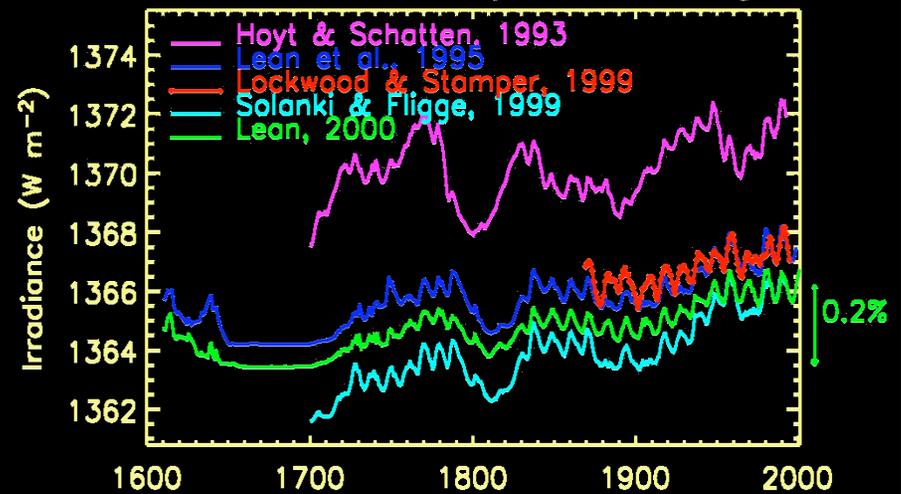
Total Solar Irradiance Cycle



Medieval Maximum
Sporer Minimum
Mouder Minimum
Dalton Minimum
Modern Maximum

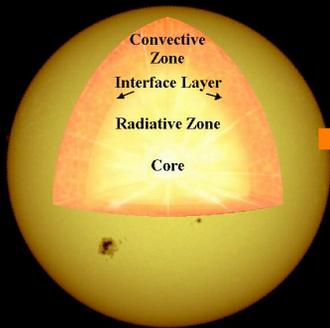


Total Solar Irradiance Cycle and Background

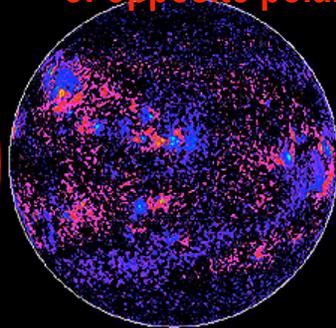


Estimating Long-Term Solar Variability

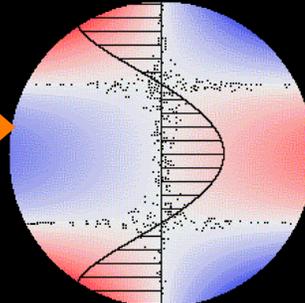
sub-surface dynamo



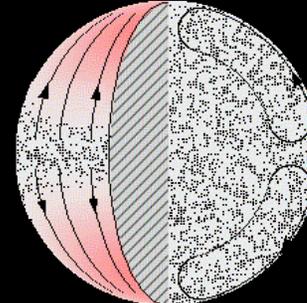
surface magnetic fields of opposite polarity



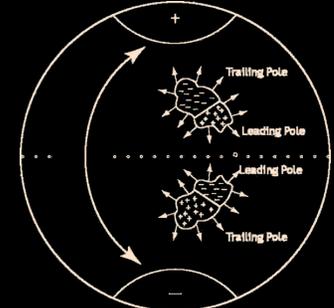
transported by... differential rotation,



meridional flow,

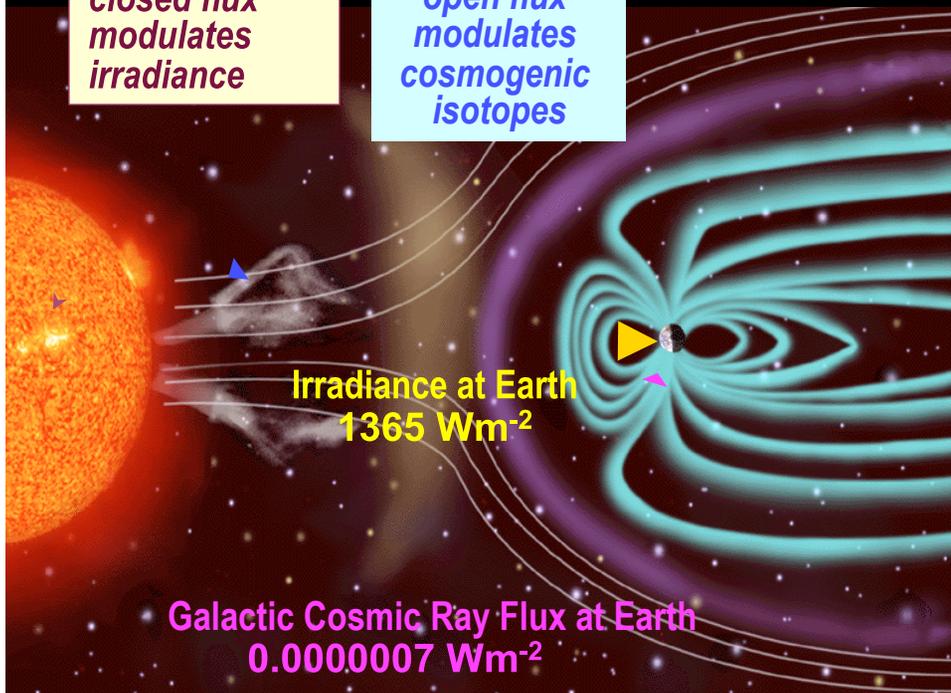


diffusion



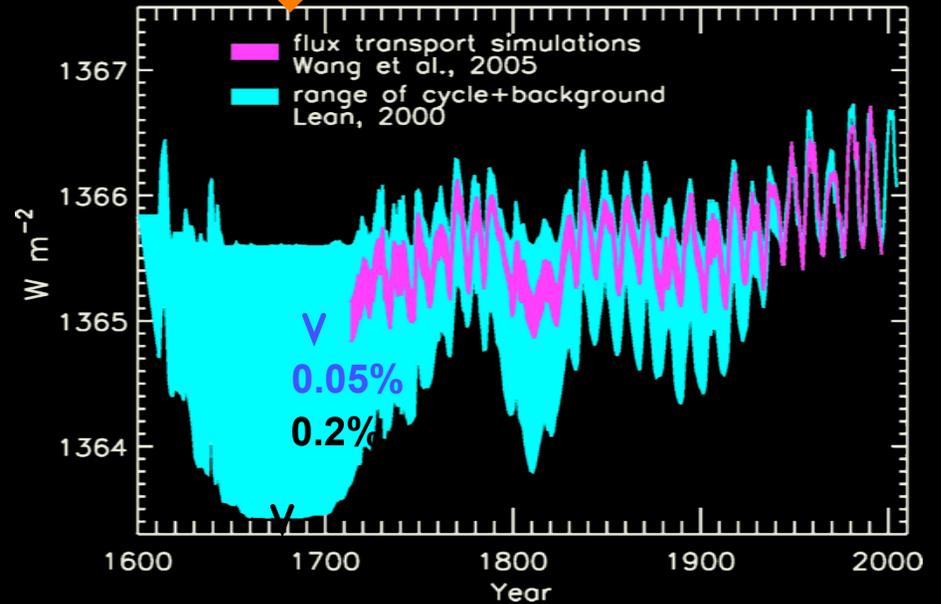
closed flux modulates irradiance

open flux modulates cosmogenic isotopes

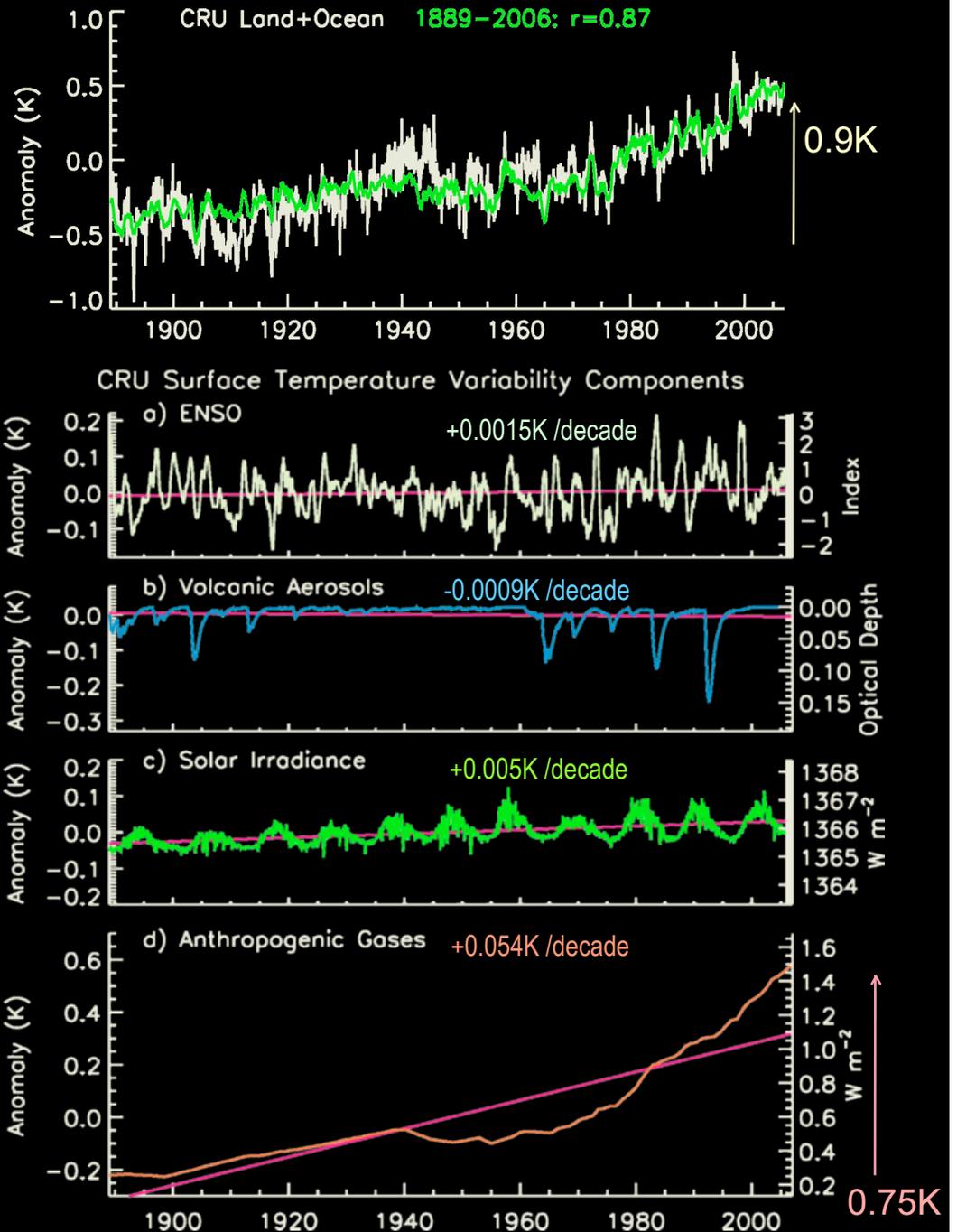


NRL Flux Transport Model

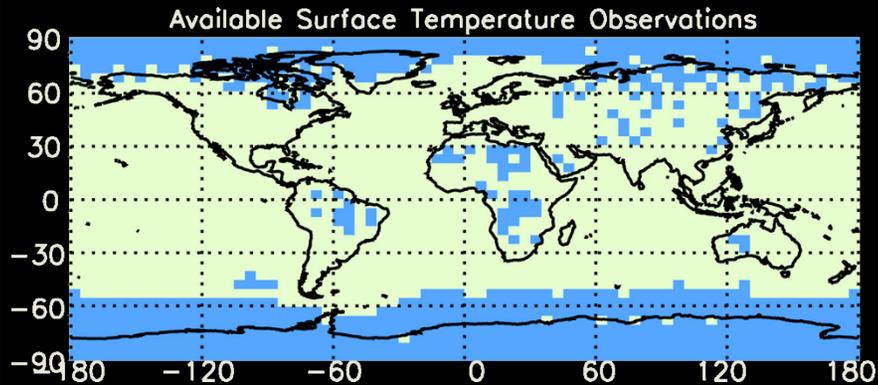
Total Solar Irradiance



Earth's Surface Temperature Change Since 1890



Surface Temperature Regional Response Patterns

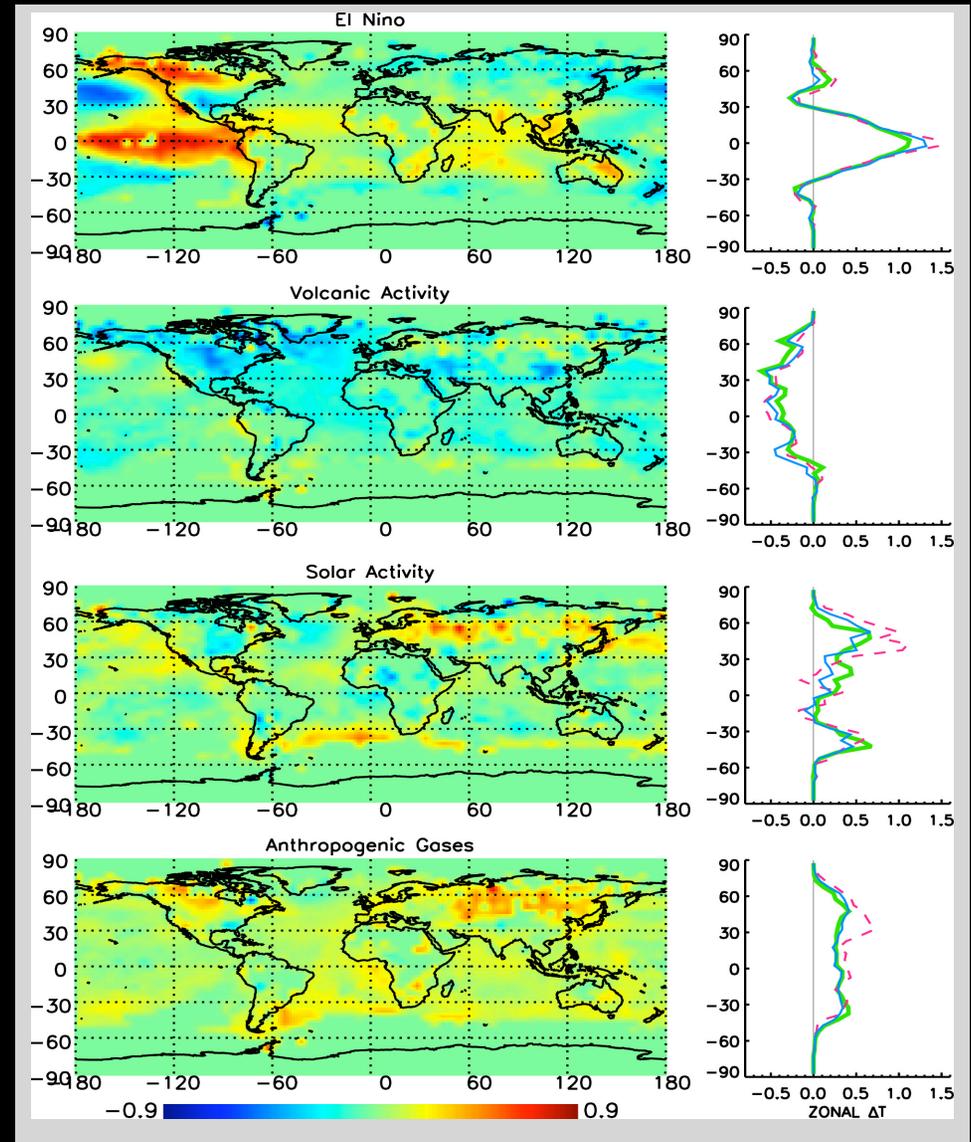


What (really) is the polar amplification?

“The Consequences Of Not Knowing Low- And High-latitude Climate Sensitivity”

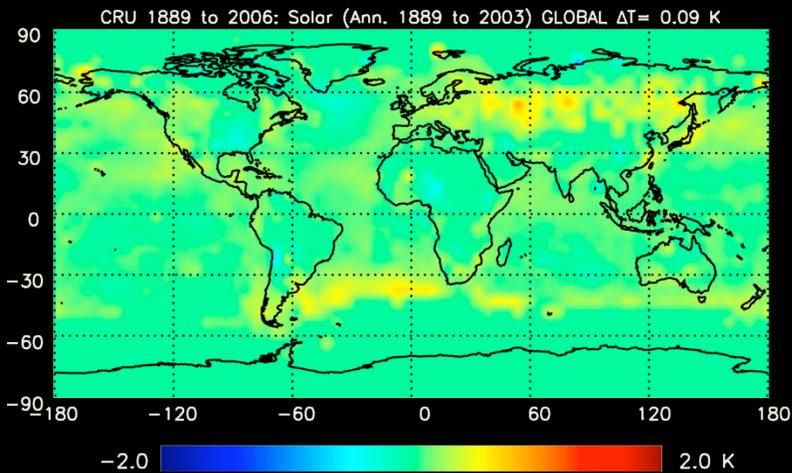
David Rind, BAMS, 2008

normalized to 0.1 K global change



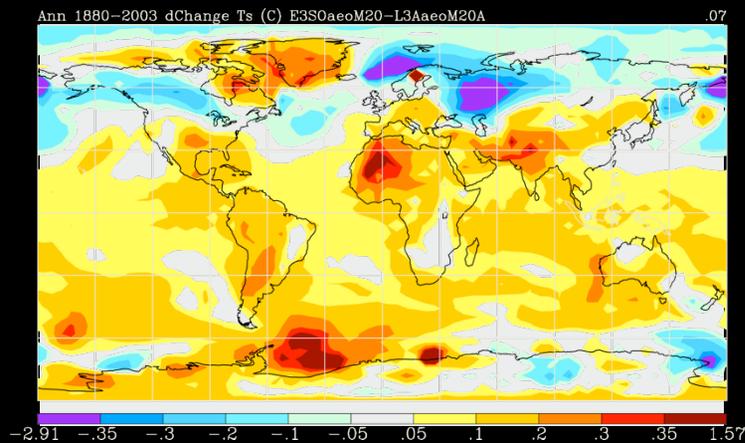
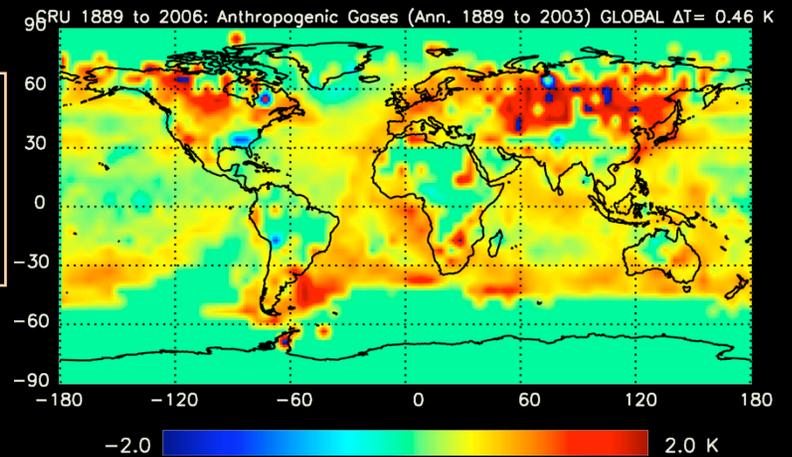
Regional Surface Air Temperature Change Annual 1889 – 2003

SOLAR IRRADIANCE

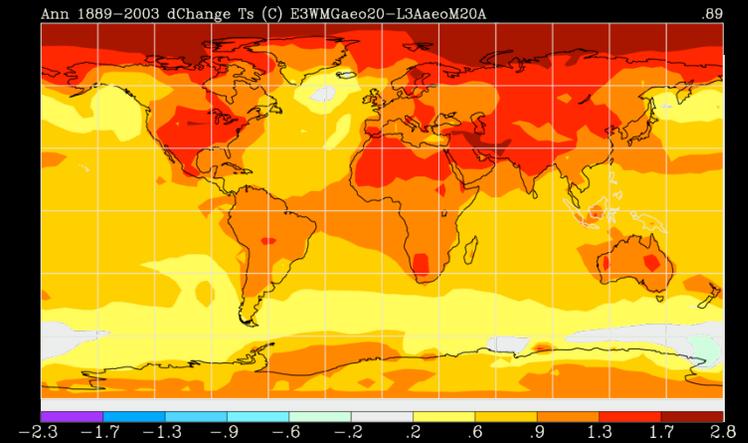


CRU
Empirical
Analysis for
1889-2006

ANTHROPOGENIC



GISS
ModelE



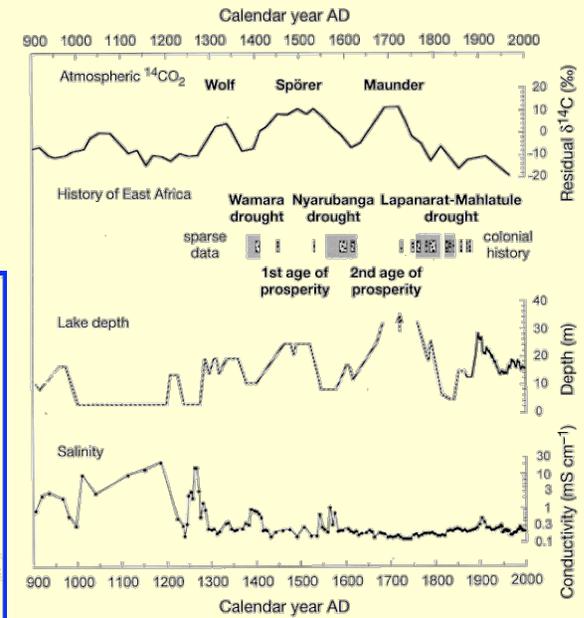
4° (lat) × 5° (long) M20 Schmidt et al., 2006 <http://www.giss.nasa.gov>

Centennial Climate Change, Drought and Culture

- semi-arid regions are particularly vulnerable to hydrological changes
- severity of past droughts exceeds contemporary events

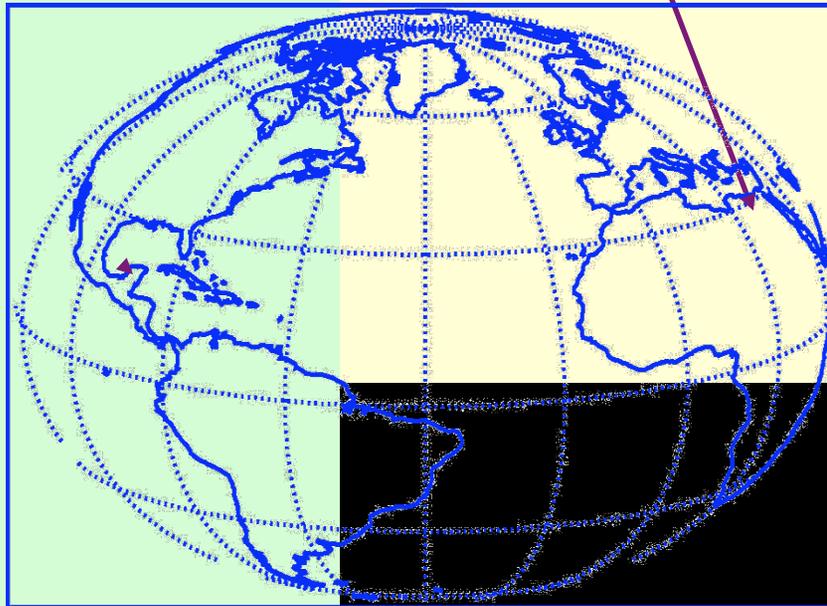
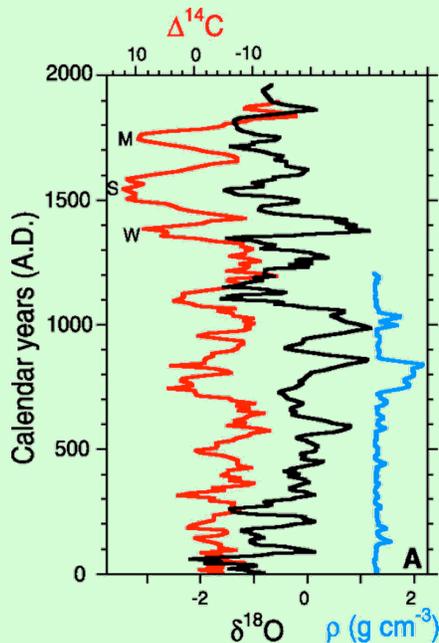
Equatorial East Africa

Verschuren et al.,
Nature, 2000



Maya Lowlands

Hodell et al.,
Science, 2001



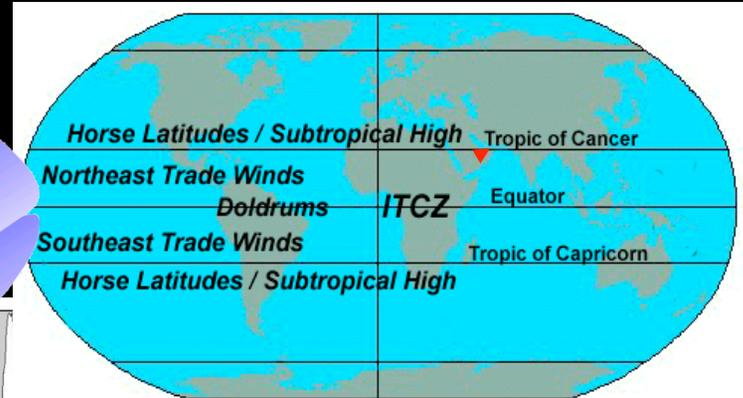
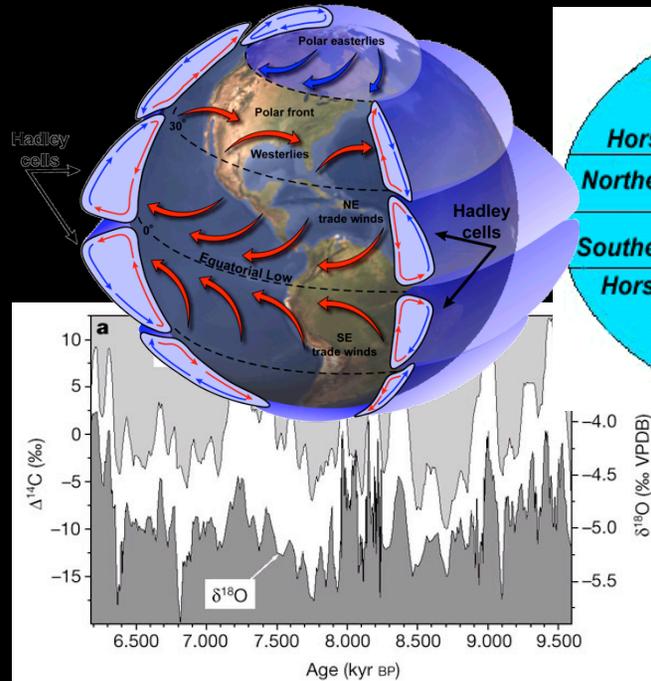
high solar activity \rightarrow low $\Delta^{14}\text{C}$ \rightarrow high $\delta^{18}\text{O}$ \rightarrow
increased drought \rightarrow cultural collapse
206-208 yr components of $\Delta^{14}\text{C}$ and $\delta^{18}\text{O}$ vary in phase

Holocene Sun-Climate Connections

INTERTROPICAL CONVERGENCE ZONE

$\delta^{18}\text{O}$ in stalagmites in Oman track $\delta^{14}\text{C}$ for 3,000 years in mid-Holocene

Neff et al., Nature, 2001



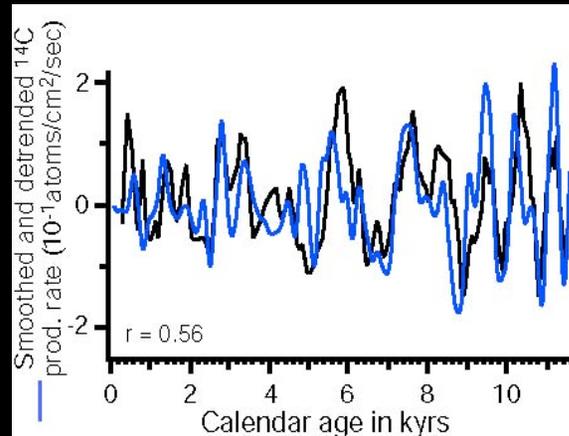
high solar activity \blacktriangleright low $\delta^{14}\text{C}$
 \blacktriangleright low $\delta^{18}\text{O}$ \blacktriangleright high rainfall

high solar activity \blacktriangleright low $\delta^{14}\text{C}$
 \blacktriangleright less drift ice southward

NORTH ATLANTIC CLIMATE

surface winds and ocean hydrography affected by solar variability --
 North Atlantic Deep Water may amplify solar signals

Bond et al., Science, 2001



Paleo Sun–Climate Synopsis

...when solar activity is high....

increased temperature & moisture
SW Alaska
Sheng et al., 2003

drought
Western US
Cook et al., 2001

warming
North Atlantic
Bond et al., 2000

stronger monsoon
Wangxiang cave
Zhang et al., 2008

Mayan drought
Cariaco Basin
Hodell et al., 2001
Haug et al., 2003

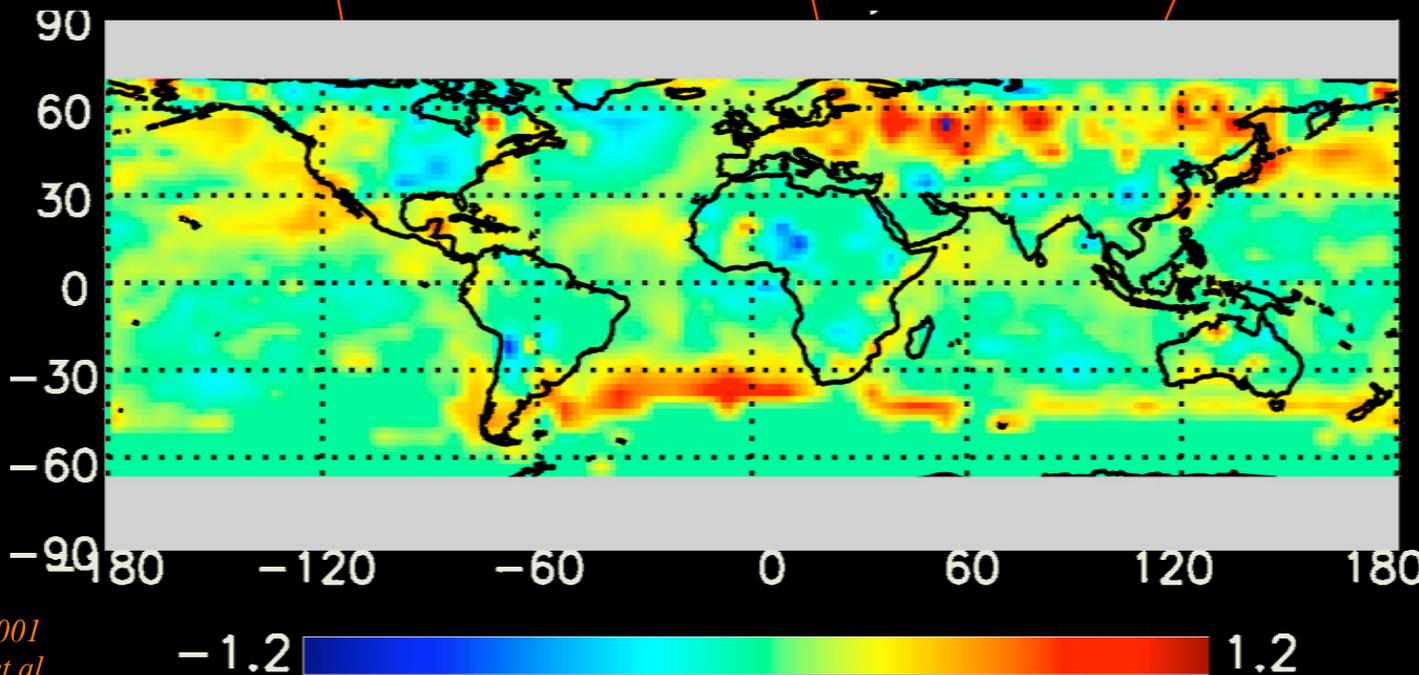
weakened upwelling and trade winds (warmer SSTs)
Cariaco Basin
Black et al., 1999

drought
Equatorial East Africa
Verschuren et al., 2000

high rainfall
Oman
Neff et al., 2001

warming
Beijing
Tan et al., 2004

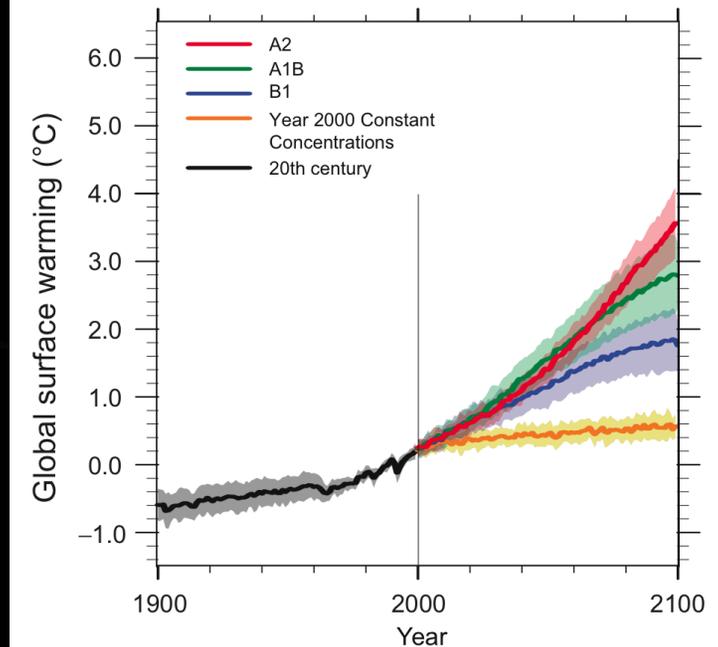
tree-rings
Chile
Roig et al., 2001
Nordemann et al.



warming
Tasmania
Hill et al., 2007

significant local changes do not imply global changes of equal magnitude

IPCC 4th Assessment Report 2007
... 0.2°C per decade for the next
two decades
... 0.6 to 4°C in 21st Century



● Present, Space-Era

- *surface, troposphere and stratosphere*
 - .. *ENSO, volcanic, solar and anthropogenic influences*
 - .. *global and regional patterns*
- *GISS climate model simulations*

● Past

- *instrumental surface temperatures, since 1880*
- *Holocene, proxies in the past 10,000 years*

● Future Decades

- *forecasts of anthropogenic and solar influences*
- *scenarios for ENSO and volcanic influences*



Climate change: The next ten years

- › 13 August 2008 by [Fred Pearce](#) and [Michael Le Page](#)
- › Magazine issue [2669](#). [Subscribe](#) and get 4 free issues.
- › For similar stories, visit the [Climate Change](#) Topic Guide

WHAT's going to happen to the climate over the next 10 years or so? Is it time to buy that air conditioner you considered during the last heatwave? Should you rip up your garden and replant it with drought-resistant plants, or can you expect more rain - perhaps even floods - in your part of world? The other possibility, of course, is that your local climate will change little in the near future.

On the one hand we have weather predictions for the next few days. On the other we have climate forecasts for the very distant future. But what happens in the middle? Why don't we have forecasts for, say, 2010 or 2018? Knowing how temperature and rainfall will change over the next few years would be invaluable to many people, from farmers to the tourism industry to those in charge of our water supplies. Yet while you might think predicting how the climate will change over the next few years would be a lot easier than saying what it will be like in 2030 or 2050, it's actually harder.



PRINT



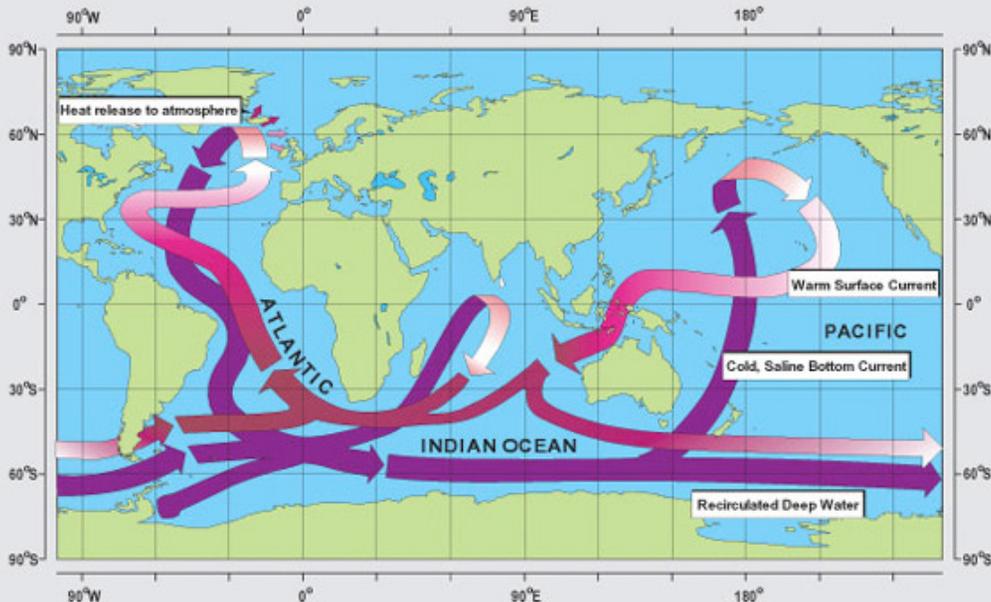
SEND



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Decadal Forecasting using Models of Ocean Meridional Overturning Circulation



Improved Surface Temperature Prediction for the Coming Decade from a Global Climate Model

Smith et al., Science, 2007

...internal variability will partially offset the anthropogenic global warming signal for the next few years.

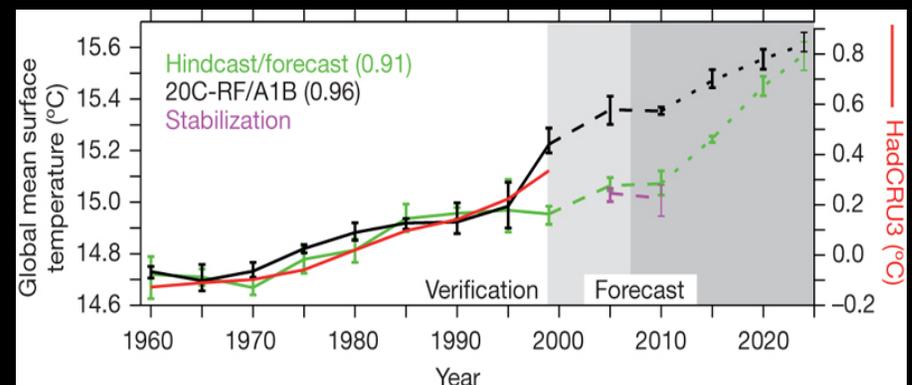
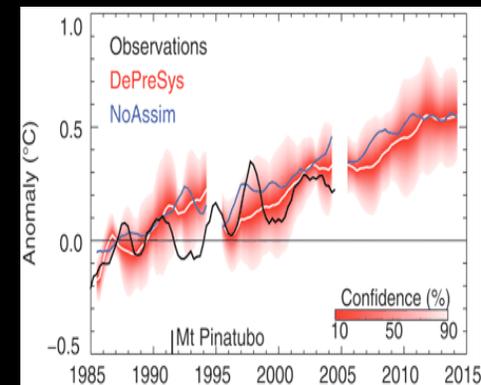
... climate will continue to warm, with at least half of the years after 2009 predicted to exceed the warmest year currently on record..... $\Delta T = 0.3^{\circ}\text{C}$ from 2004-2014

Advancing decadal-scale climate prediction in the North Atlantic sector

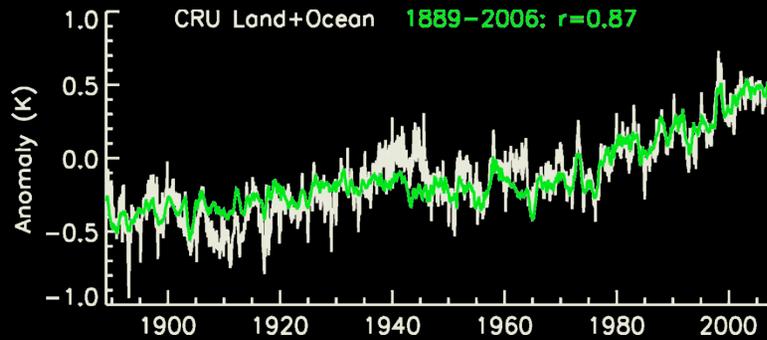
Keenlyside et al., Nature, 2008

... over the next decade ...North Atlantic SST and European and North American surface temperatures will cool slightly

....global surface temperature may not increase over the next decade, as natural climate variations in the North Atlantic and tropical Pacific temporarily offset the projected anthropogenic warming.



How – and Why - will Climate Change in the Future?



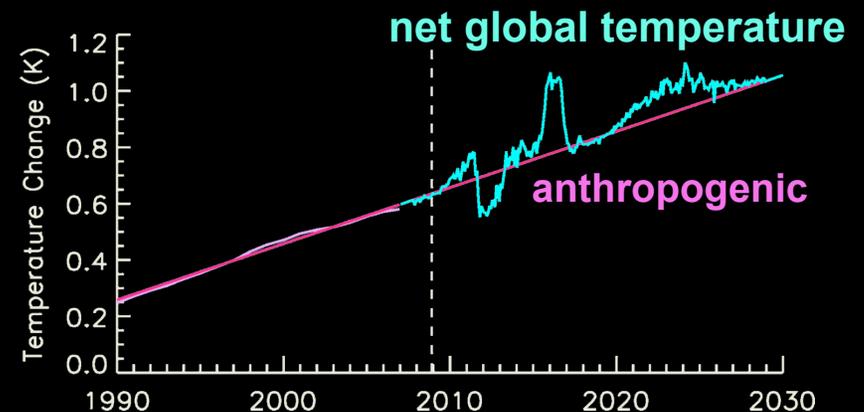
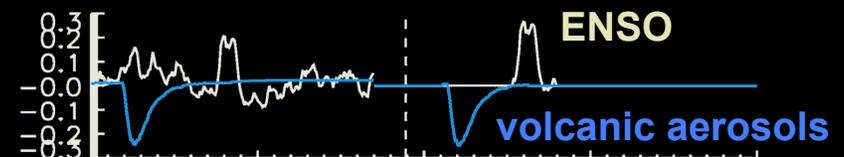
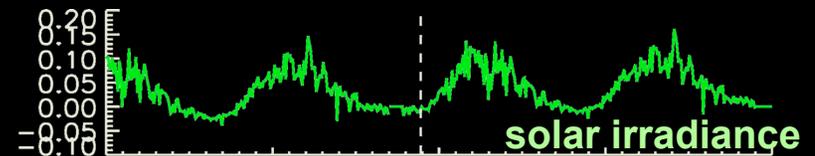
Nature, 25 May 2006

Currently, the Sun is at a solar minimum, and most predictions suggest that the next solar maximum in five or six years' time will be weak. ...

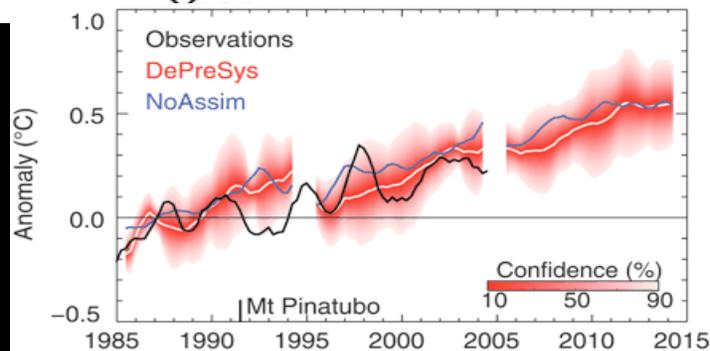
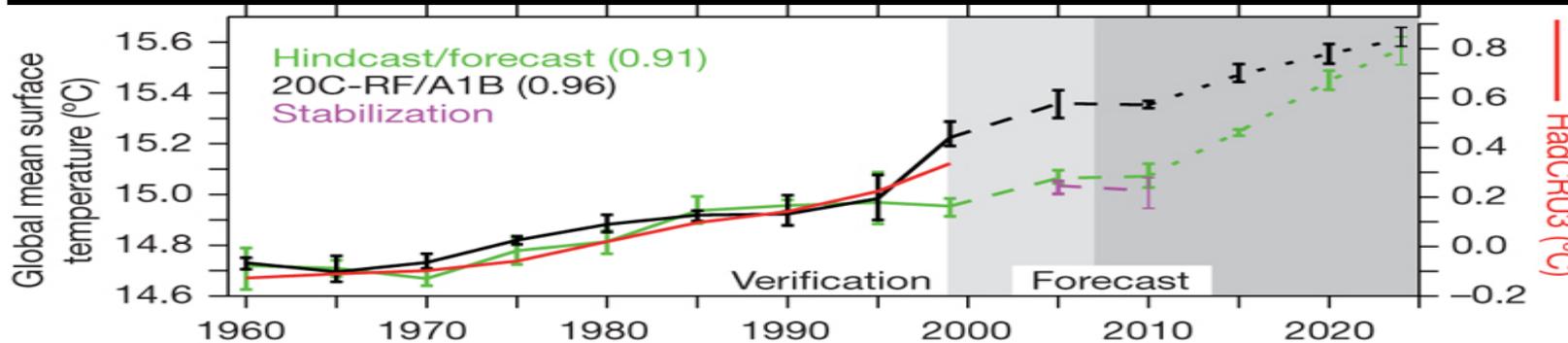
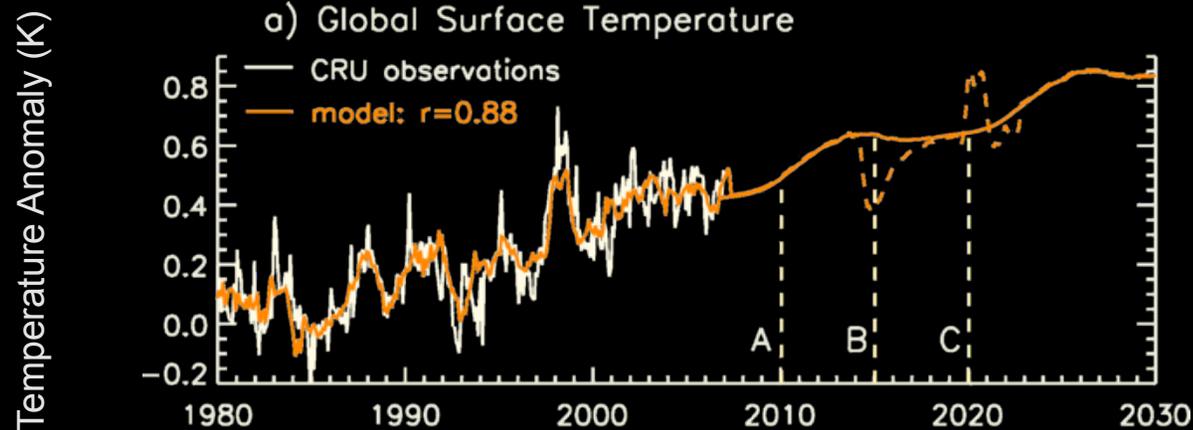
Climate skeptics who argue that human activities are not responsible for global warming have seized on these results....

So convinced are they that last year two Russian skeptics placed a \$10,000 bet that global temperatures will show an average fall for 2012–17 — on the assumption that the next solar cycle will be weak.

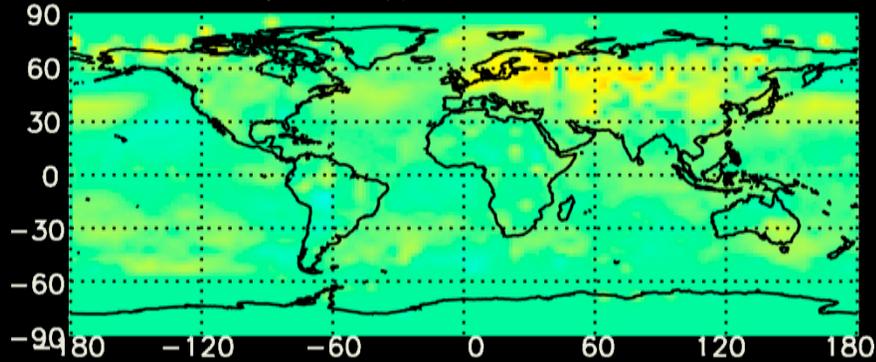
future near-term climate change depends on irradiance cycles and other natural influences relative to anthropogenic trends



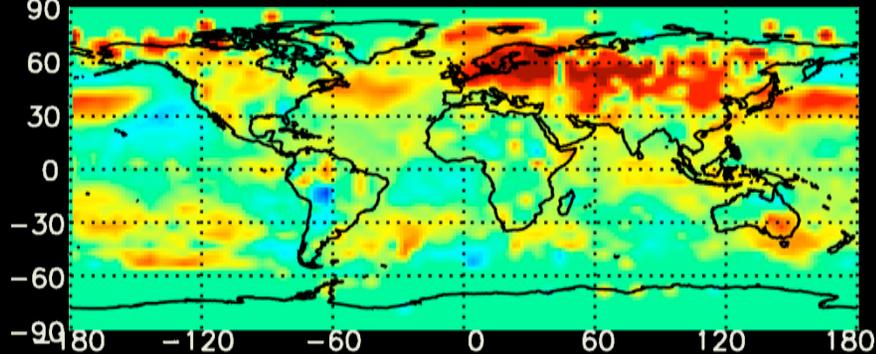
How will Earth's Surface Temperature Change in Future Decades?



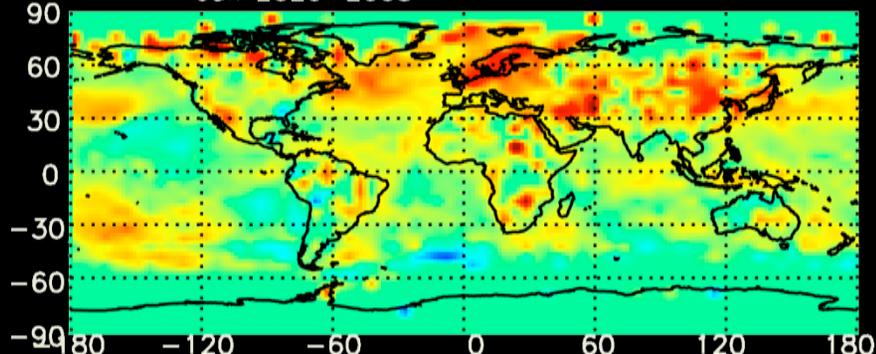
Solar and Anthropogenic Influences
Jan 2010–2008



Jan 2015–2008



Jan 2020–2008

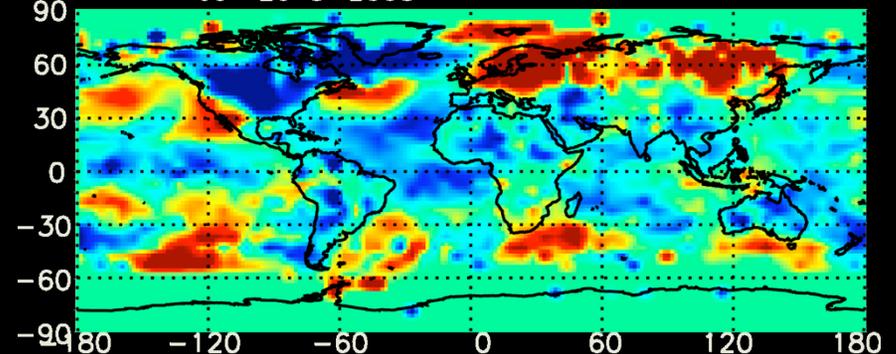


-1.0 1.0°C

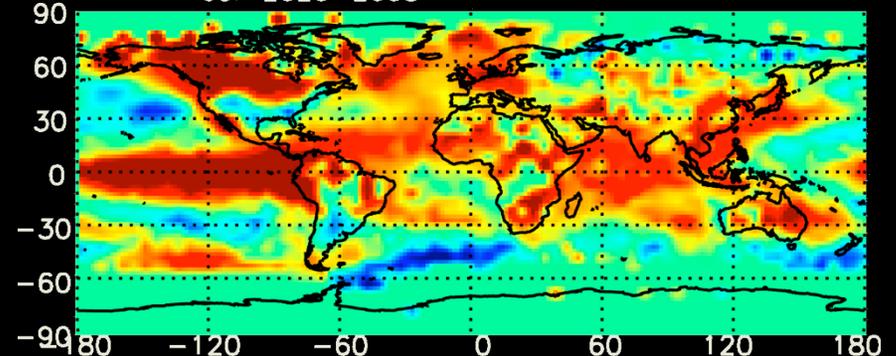
Phil Jones, UEA

The GISS group average surface T data into 80 equal area boxes across the world. The UK group (CRU/MOHC) grid the data into 5 by 5 degree lat/long boxes, as does NCDC. These griddings don't allow so much extrapolation of data - no extrapolation beyond the small grid box.

Jan 2015–2008 + Volcano

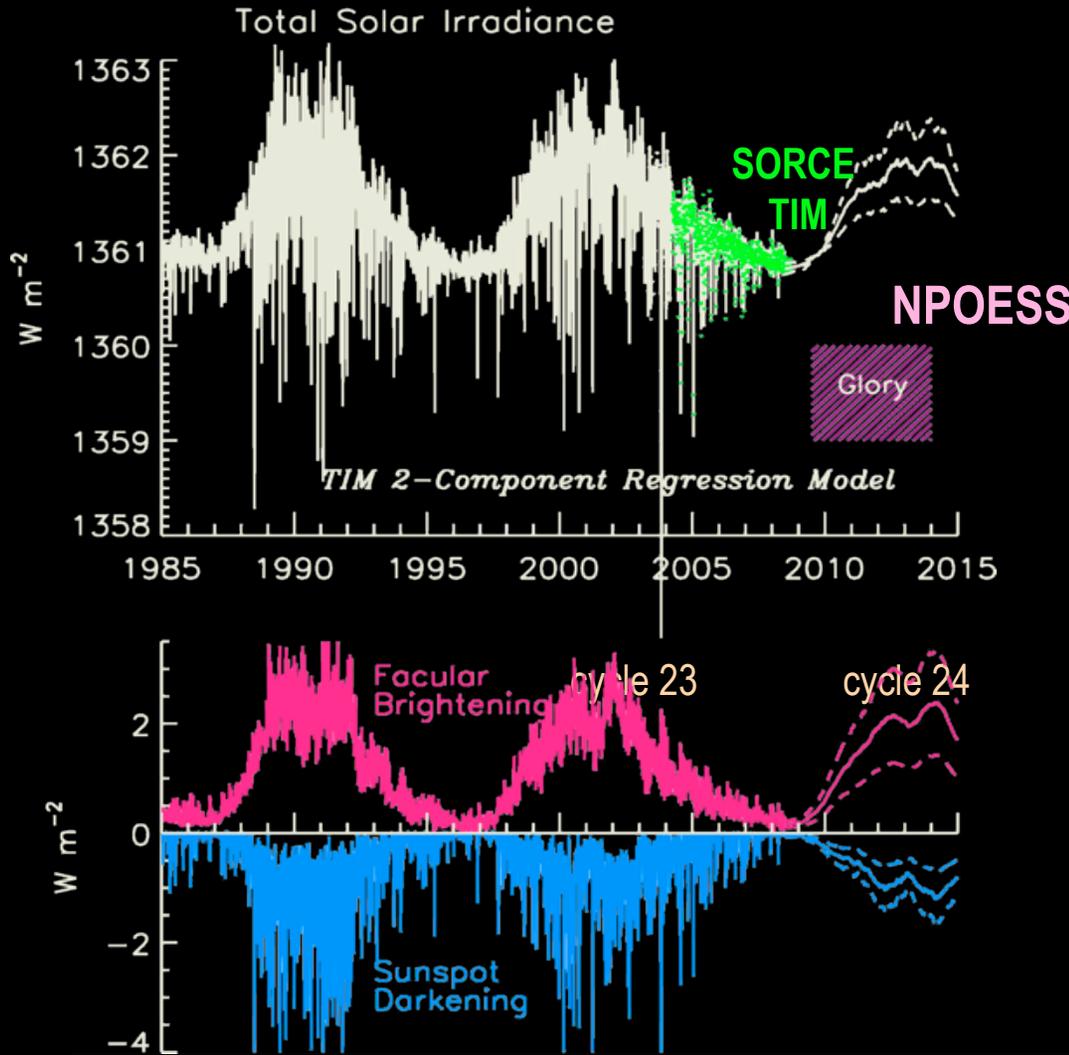


Jan 2020–2008 + ENSO



-1.0 1.0°C

How – and Why - will Solar Irradiance Change in the Future?



How active will solar cycle 24 be?

- 40% higher than cycle 23
(Dikpati et al, 2005)
- less active than cycle 23

Are we entering a protracted solar minimum? (unlikely)

- there were no sunspots from Jan to Sept 2008
- some solar and geomagnetic indices are historically (over decades) low
- cycle 21 & 22 length was 10.6 years
- cycle 23 length is 12 years
- cycle 20 was 13 years
- new-cycle spots have appeared

An accurate, precise, long solar irradiance record is crucial to constrain solar-driven climate change.

Natural and Anthropogenic Influences on Earth's Surface Temperature: SUMMARY

- **Natural climate change occurs simultaneously with anthropogenic influences**
... solar & volcanic influences, internal modes (ENSO, QBO), greenhouse gases, aerosols
- **Surface and atmospheric temperatures respond to the individual influences with complex spatial patterns**
... dynamical as well as thermal responses
- **Model simulations and empirical results have different spatial patterns and magnitudes of change**
- **Natural climate change will both accelerate and mitigate global warming in the next two decades**
... accelerated warming 2008-2015 from solar and anthropogenic increases
... minimal warming 2015-2020 when solar cancels anthropogenic increase
... Europe will warm the most, even with volcanic activity
- **Past and future solar irradiance changes are uncertain**
... continuous monitoring will advance understanding