A Brief History of Earth's Climate Change

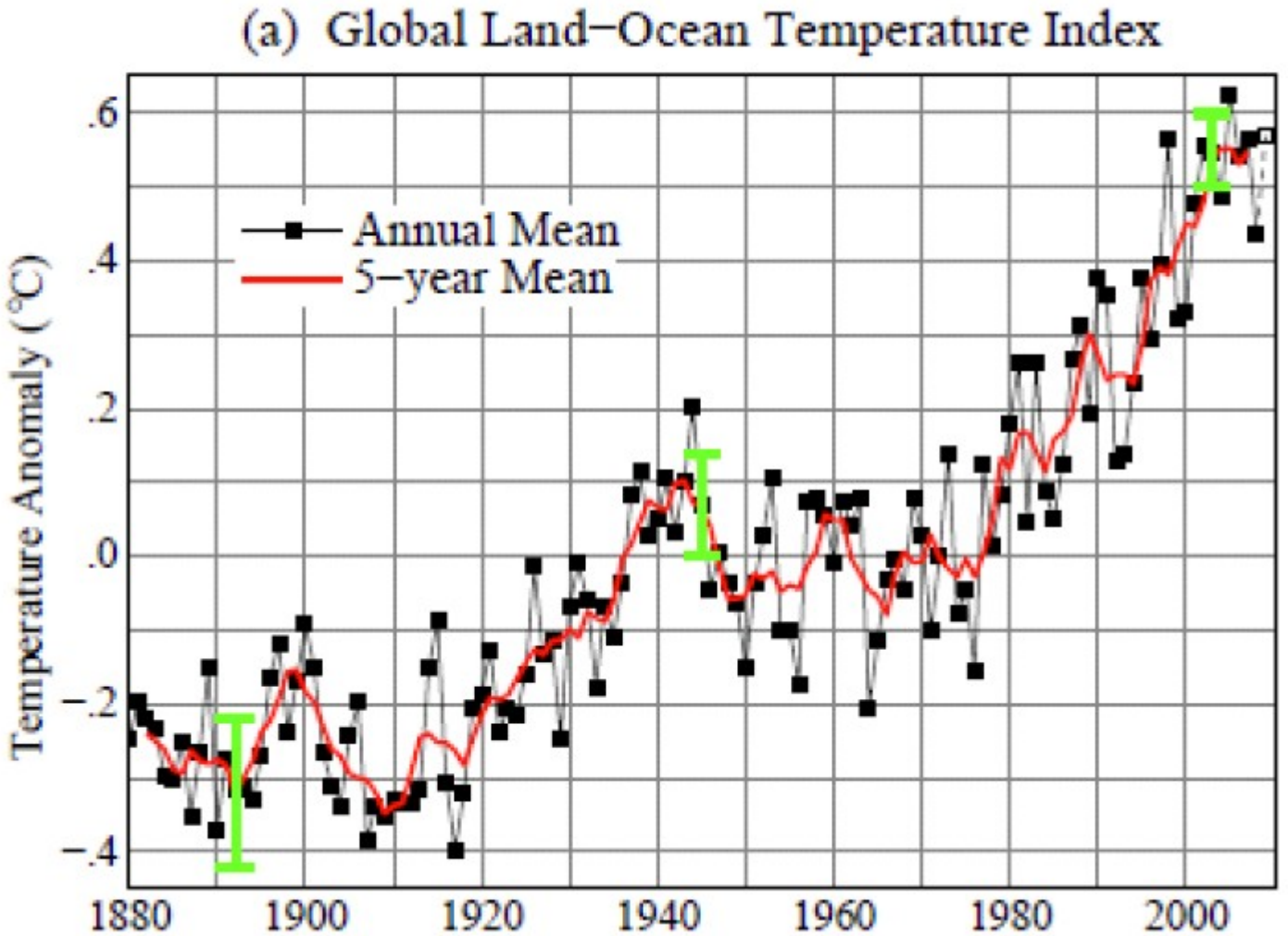
Invited Talk
Youth Leadership Dialogue
Australian American Leadership Dialogue
Stanford University
January 13, 2010

Dr. Larry Smarr
Director, California Institute for Telecommunications and Information Technology
Harry E. Gruber Professor,
Dept. of Computer Science and Engineering
Jacobs School of Engineering, UCSD

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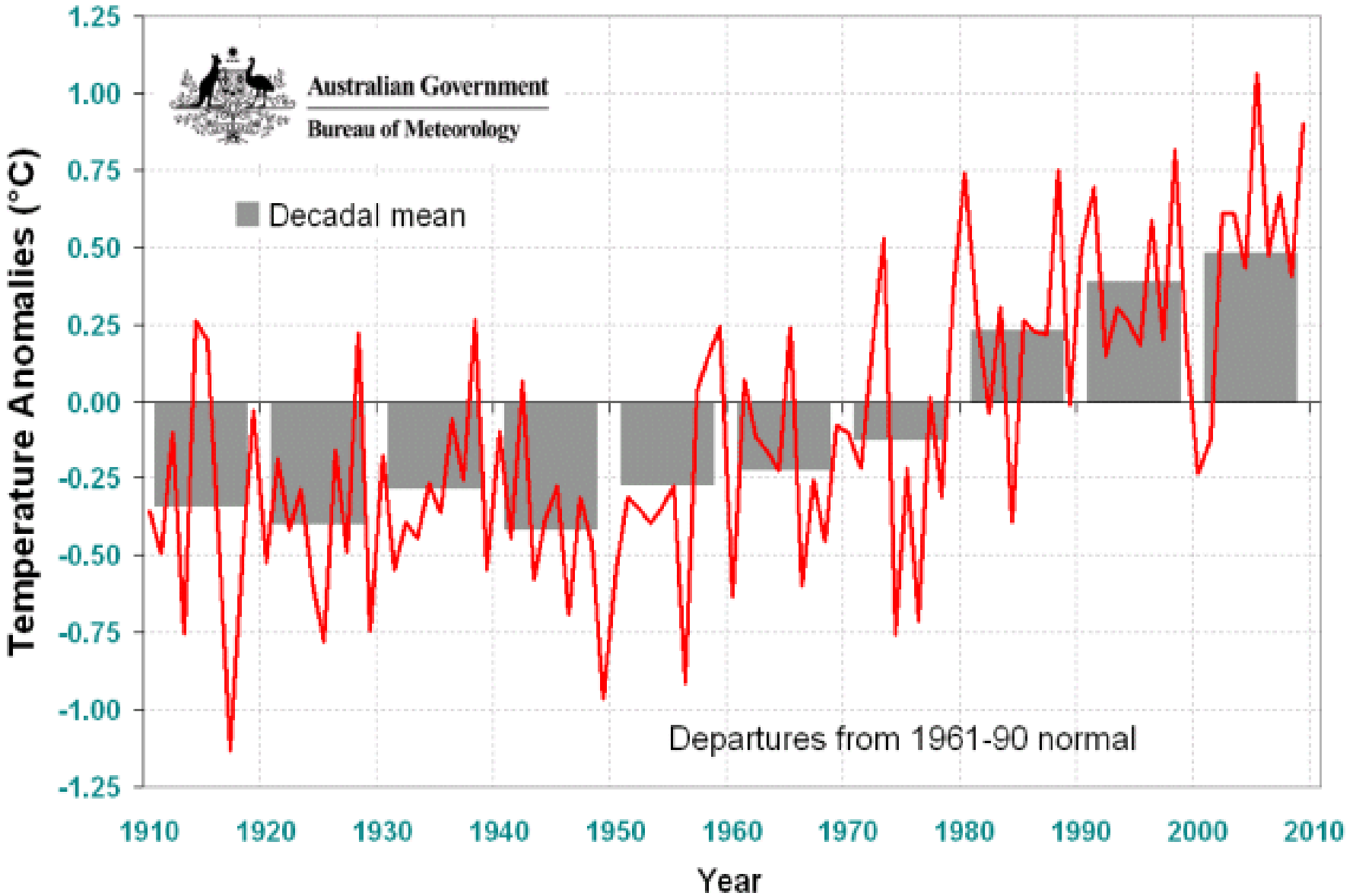
it²

Houston, We Have a Problem…



www.columbia.edu/~jeh1/mailings/2009/20091216_TemperatureOfScience.pdf

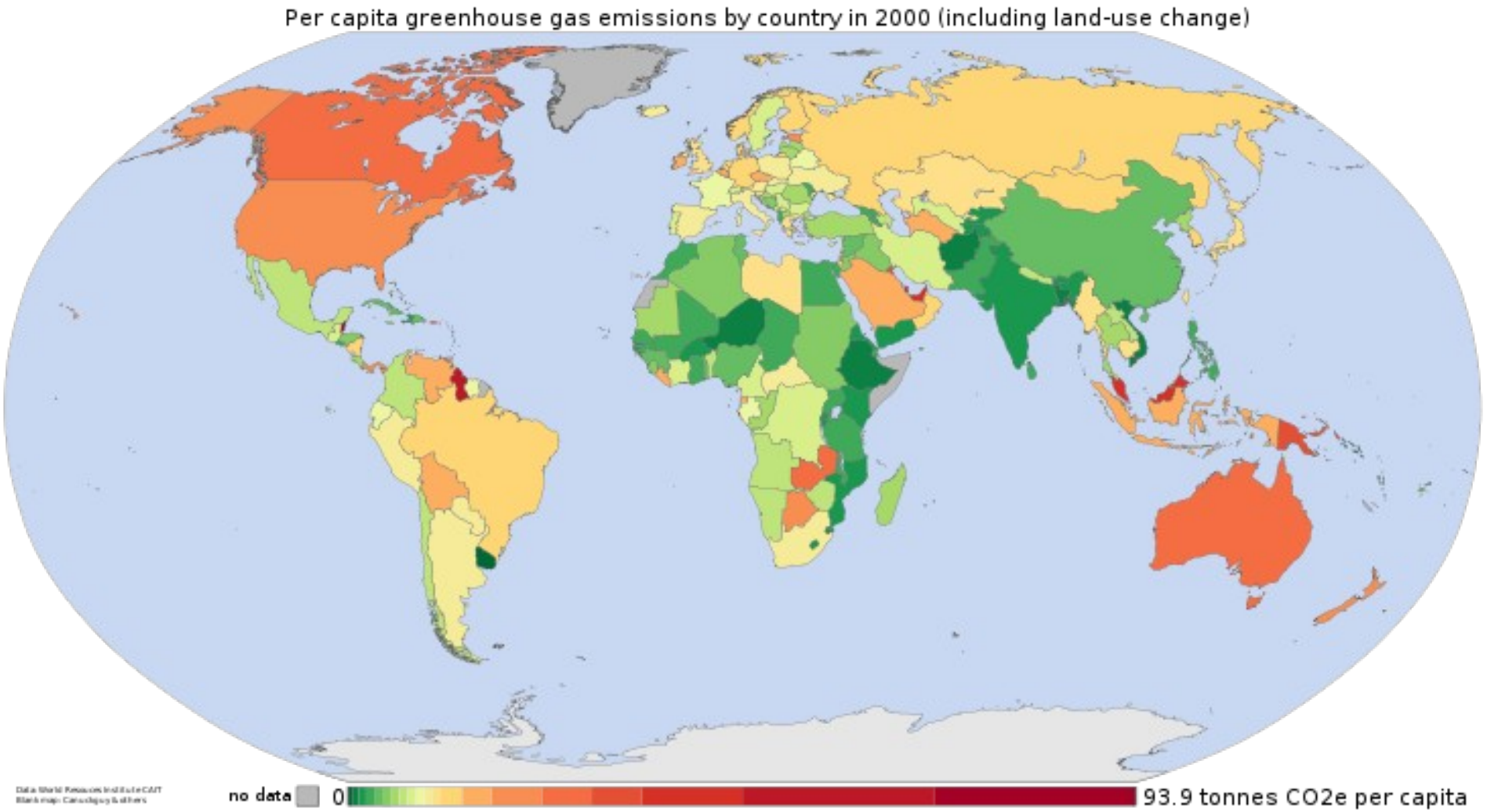
Annual and Decadal Mean Temperature Anomalies for Australia



Five Decades of Mean Temperature Rise

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Australia, the U.S., and Canada Share a Problem: Top 3 Developed Countries For Per Capita GHG Emission

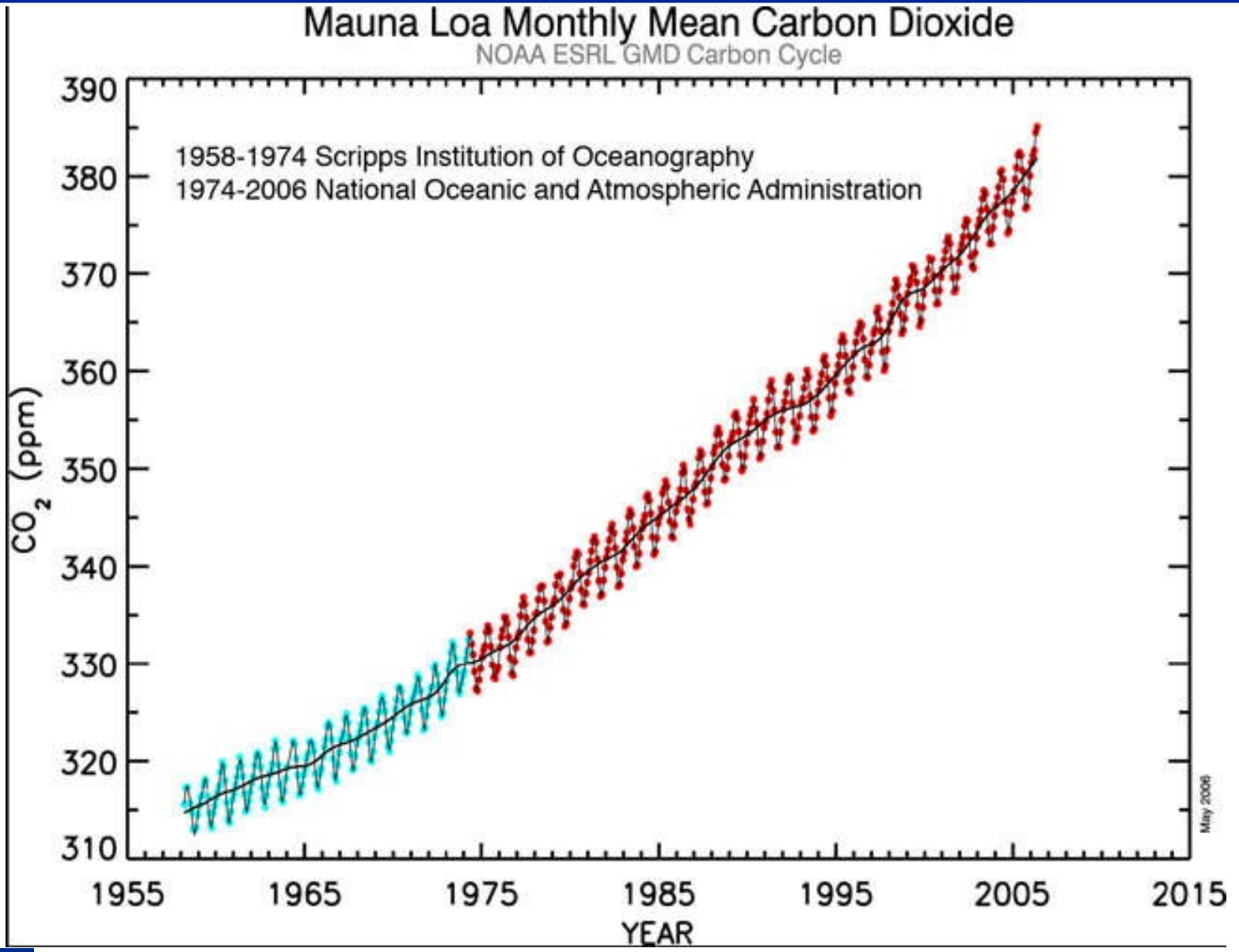


"Australia's Total Emissions Exceed Those of France and Italy"
--Australia Institute

http://en.wikipedia.org/wiki/File:GHG_per_capita_2000.svg

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The Unrelenting Climb of CO_2



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1965: White House document

RESTORING THE QUALITY
OF
OUR ENVIRONMENT



Report of The
Environmental Pollution Panel
President's Science Advisory Committee

THE WHITE HOUSE
NOVEMBER 1965

APPENDIX Y4

Atmospheric Carbon Dioxide

ROGER REVELLE, *Chairman*

WALLACE BROECKER
HARMON CRAIG
C. D. KEELING
J. SMAGORINSKY

CONCLUSIONS AND FINDINGS

Through his worldwide industrial civilization, Man is unwittingly conducting a vast geophysical experiment. Within a few generations he is burning the fossil fuels that slowly accumulated in the earth over the past 500 million years. The CO_2 produced by this combustion is being injected into the atmosphere; about half of it remains there.

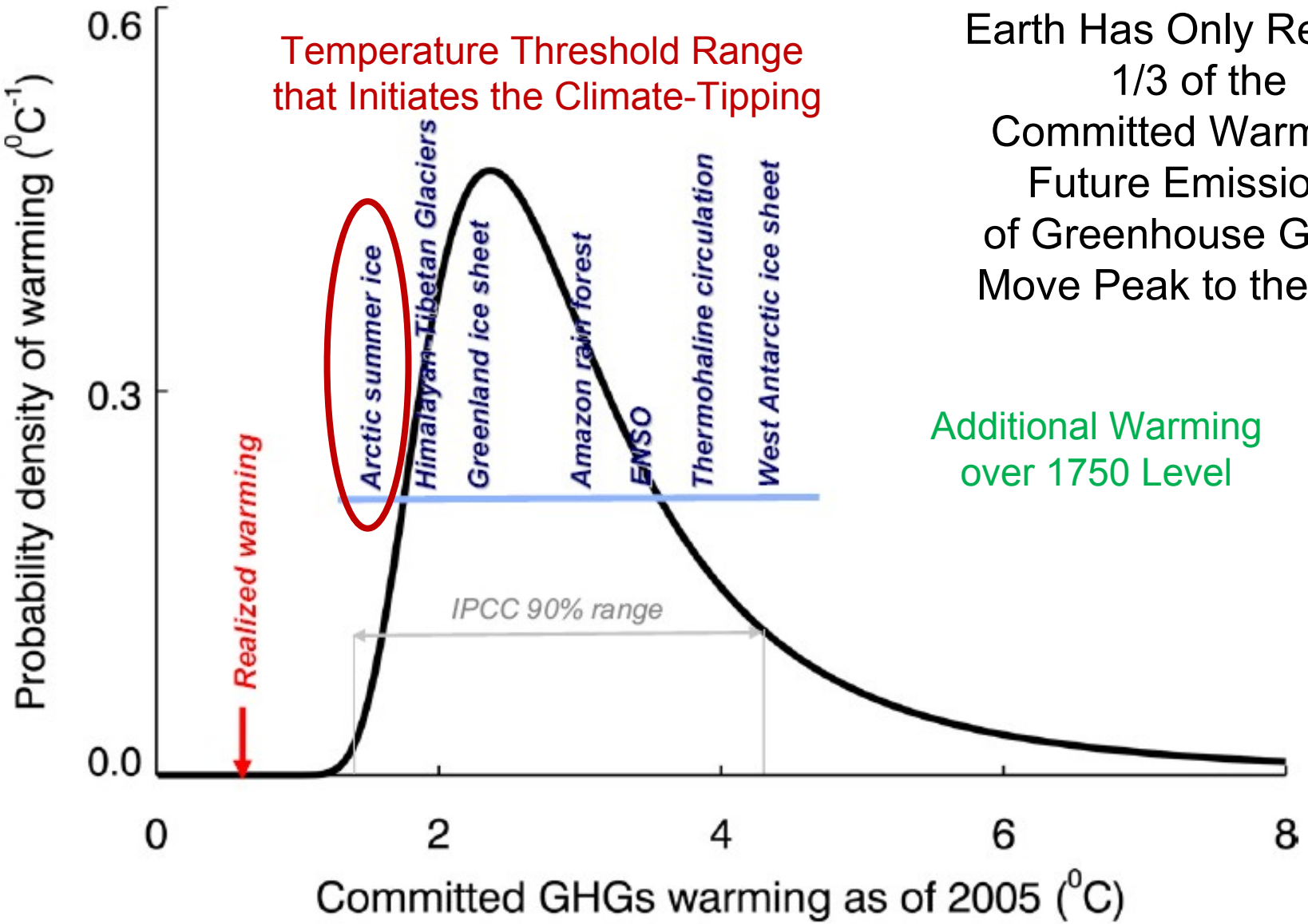
By the year 2000 the increase in atmospheric CO_2 will be close to 25%.



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The Planet is Already Committed to a Dangerous Level of Warming



Earth Has Only Realized
1/3 of the
Committed Warming -
Future Emissions
of Greenhouse Gases
Move Peak to the Right

Additional Warming
over 1750 Level

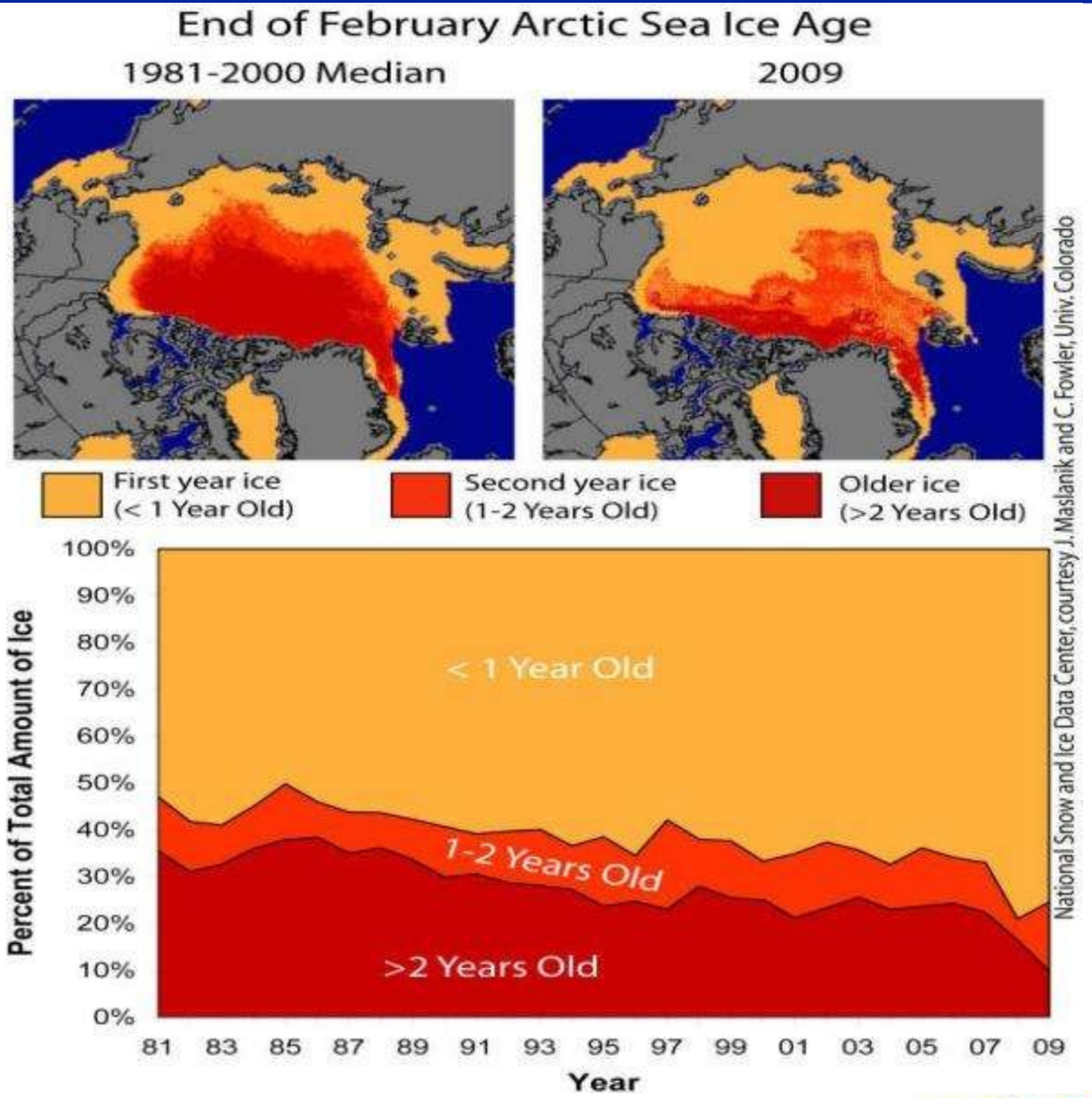
V. Ramanathan and Y. Feng, Scripps Institution of Oceanography, UCSD
September 23, 2008
www.pnas.org/content/105/38/14245.full.pdf+html

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Global Climatic Disruption Early Signs: Arctic Summer Ice is Rapidly Decreasing

"We are almost out of multiyear sea ice in the northern hemisphere--I've never seen anything like this in my 30 years of working in the high Arctic." --David Barber, Canada's Research Chair in Arctic System Science at the University of Manitoba October 29, 2009

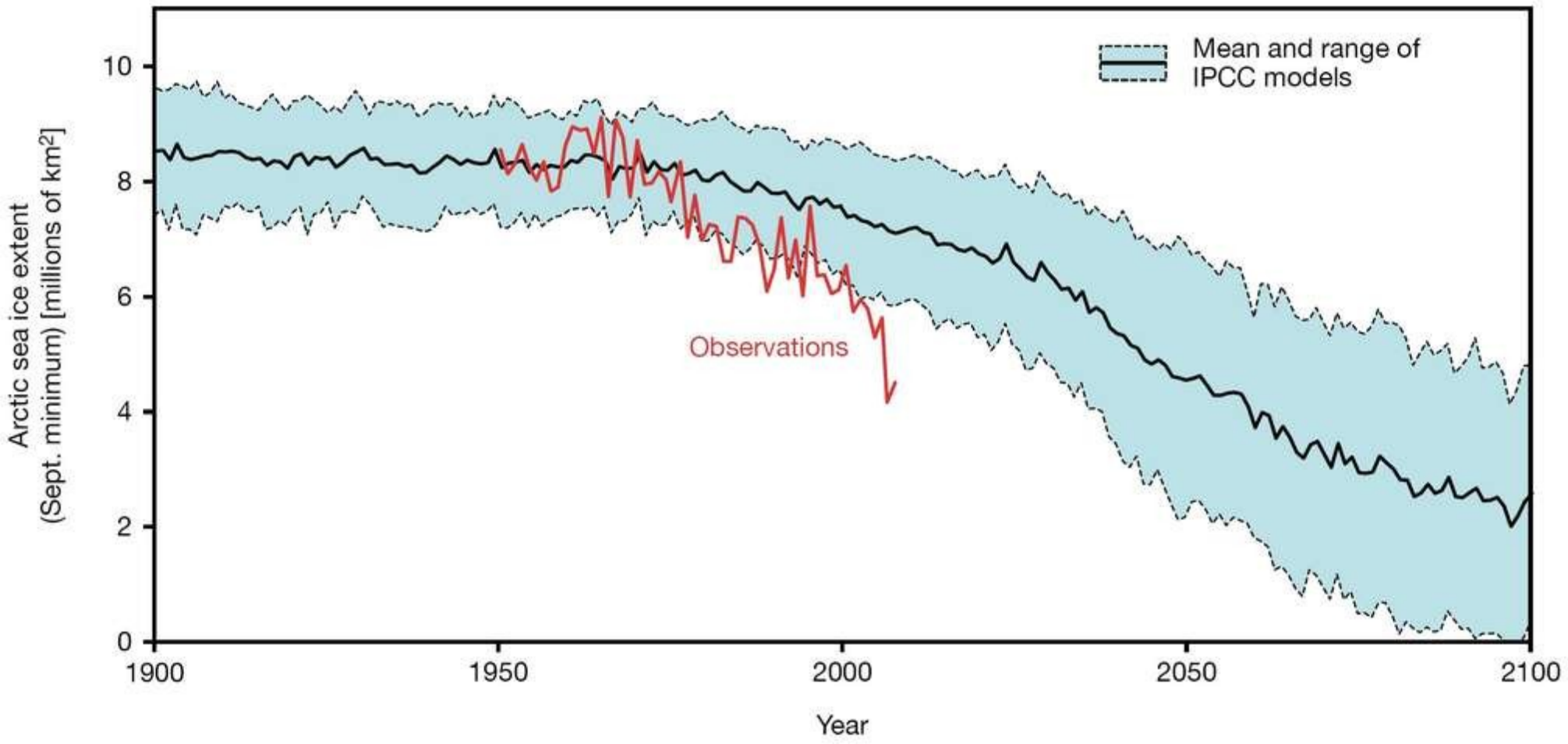
http://news.yahoo.com/s/nm/20091029/sc_nm/us_climate_canada_arctic_1



http://news.cnet.com/8301-11128_3-10213891-54.html

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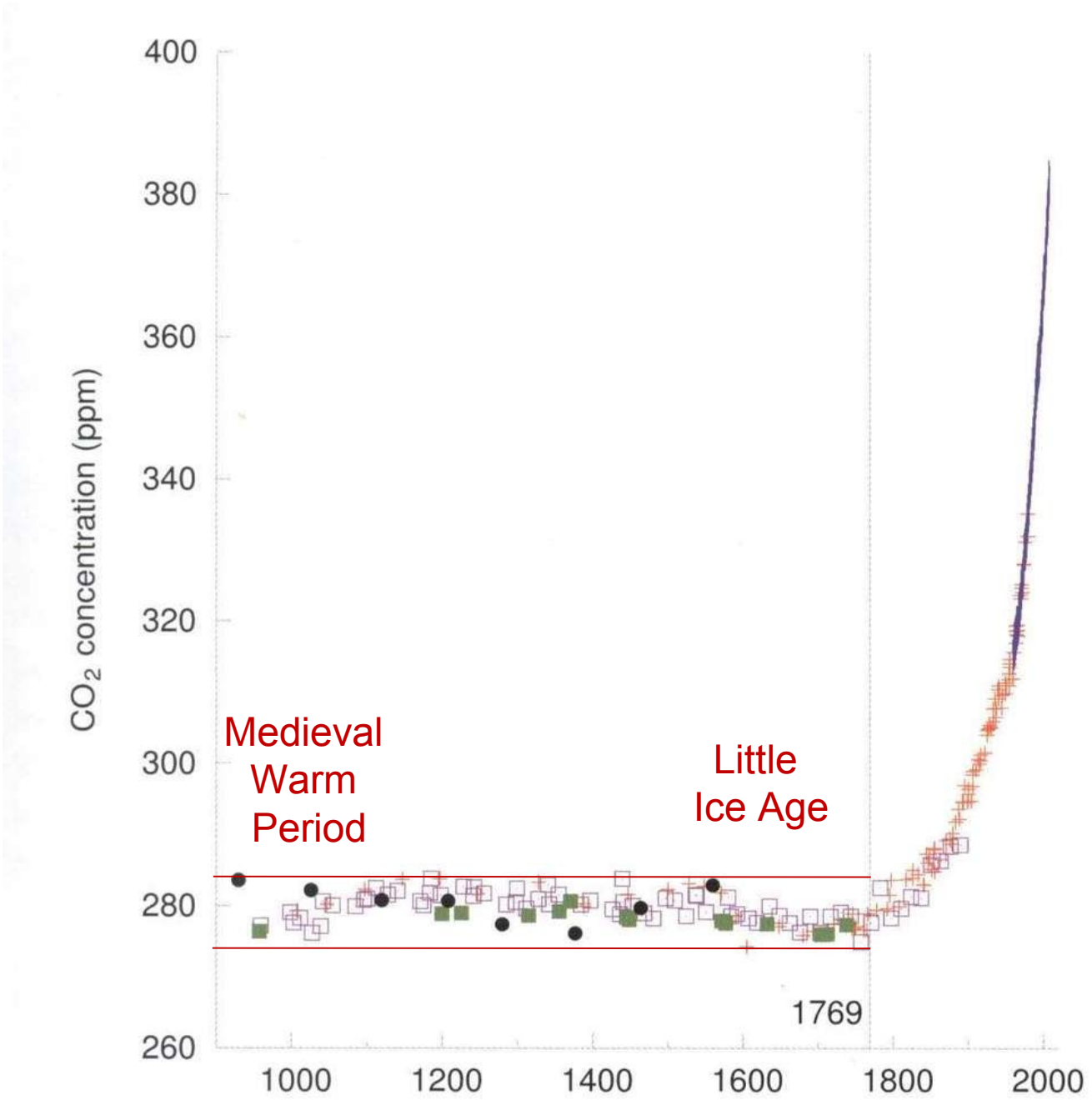
Arctic Summer Ice Melting Accelerating Relative to IPCC 2007 Predictions



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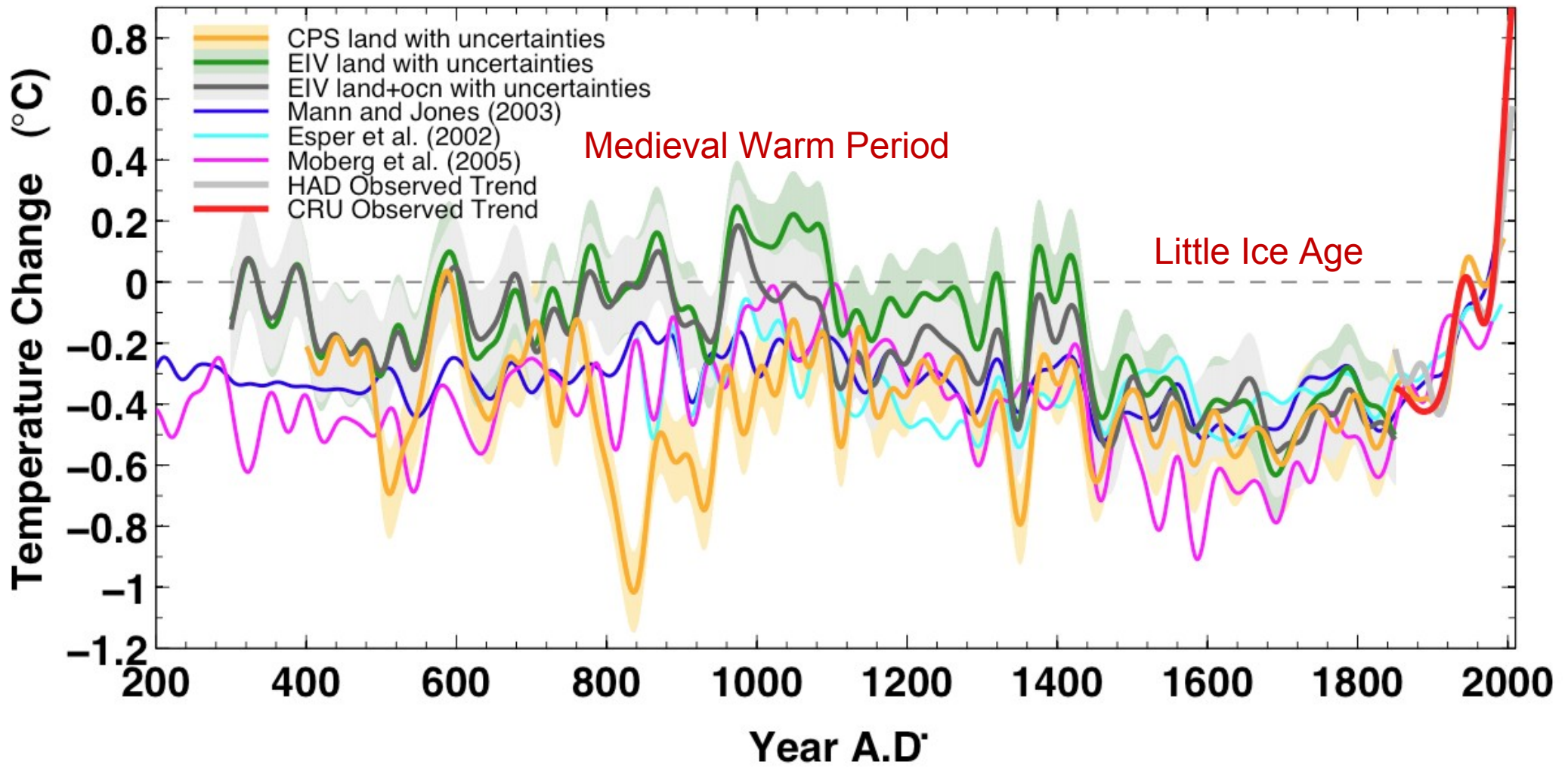
Rapid Increase in the Greenhouse Gas CO_2 Since Industrial Era Began



388 ppm in 2010

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Examining Natural Climate Change: 1000s of Years



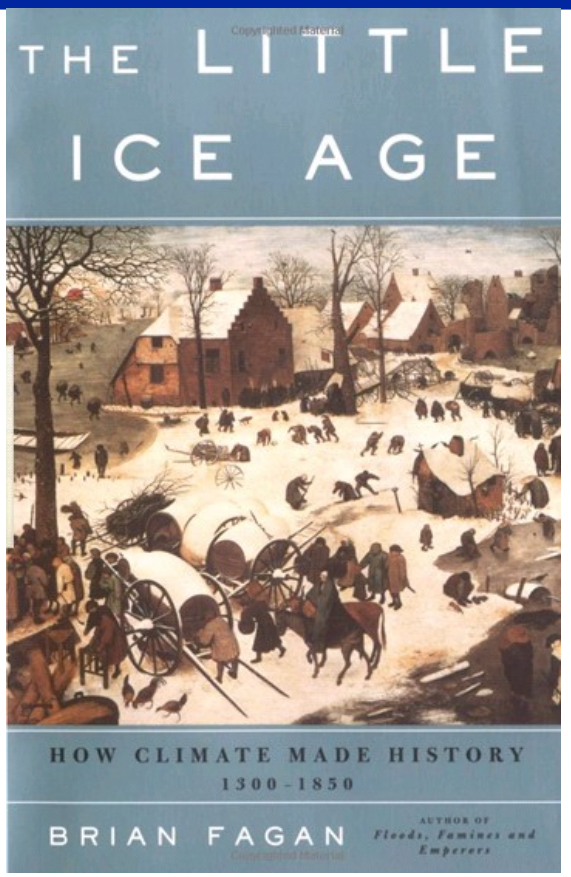
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Mann, et al., PNAS 105, 13252–13257 (2008)

it²

The Little Ice Age: The Climate State Earth is Emerging From





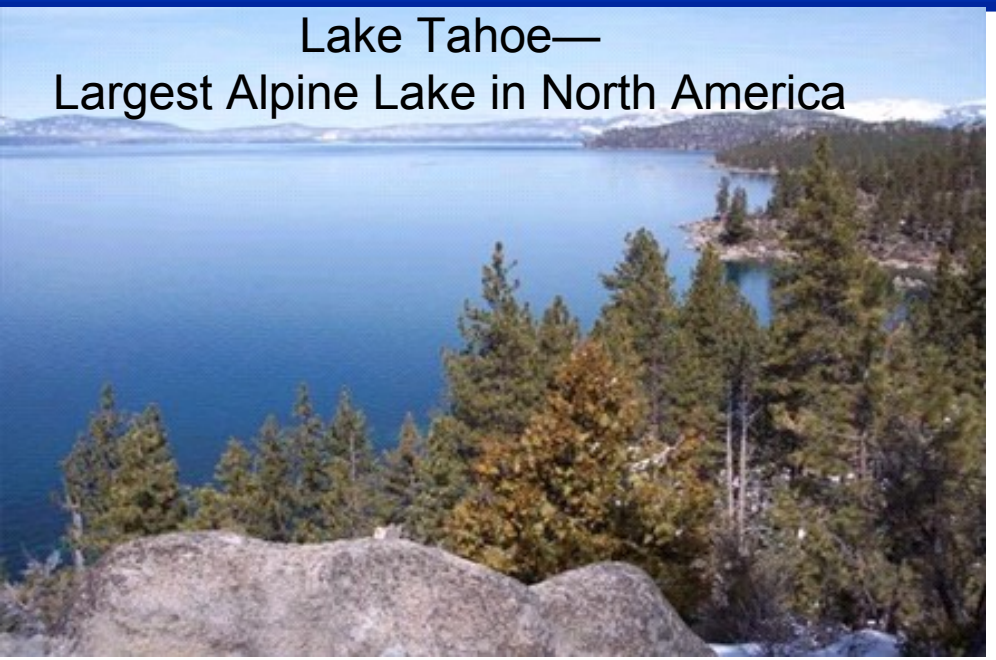
At Jamestown, the colonists had the bad fortune to arrive at the height of the driest seven-year period in 770 years. No fewer than 4,800 of the 6,000 settlers who arrived between 1607 and 1625 perished.
-- The Little Ice Age, Brian Fagan

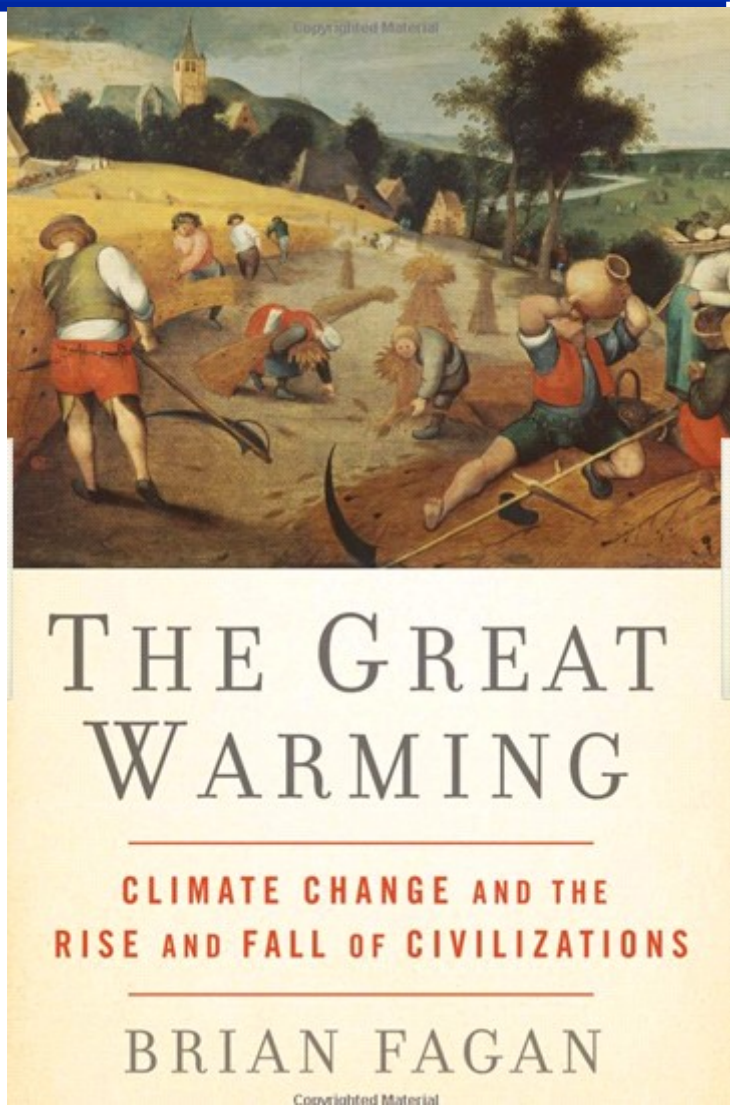
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http://reference.findtarget.com/search/Little%20Ice%20Age/

it²

The Medieval Warm Period
Last Time Global Temperatures Were This High





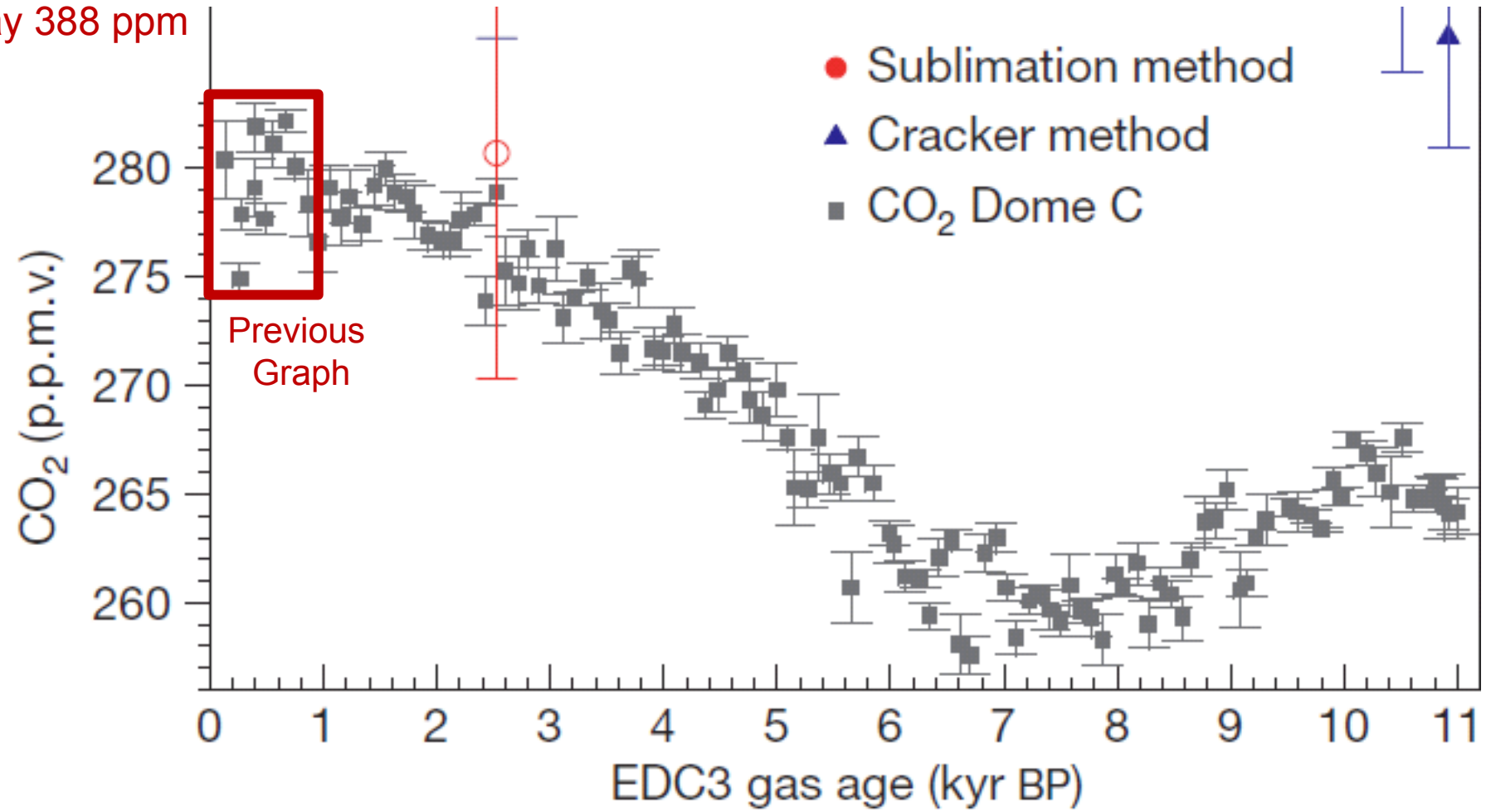
A 300 Year California Megadrought:
"Precipitation was <60% of normal
between 950-1250 AD.
Several trees were radiocarbon dated to ~1250 AD
and are positioned upslope a ~60 meter deep
submerged paleoshoreline.
--Daniel Brothers Ph.D. Thesis UCSD SIO Dec 2009

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But CO_2 was <290ppm; Today ~390ppm

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Slow Small Variation in Atmospheric CO_2 During Civilization Period



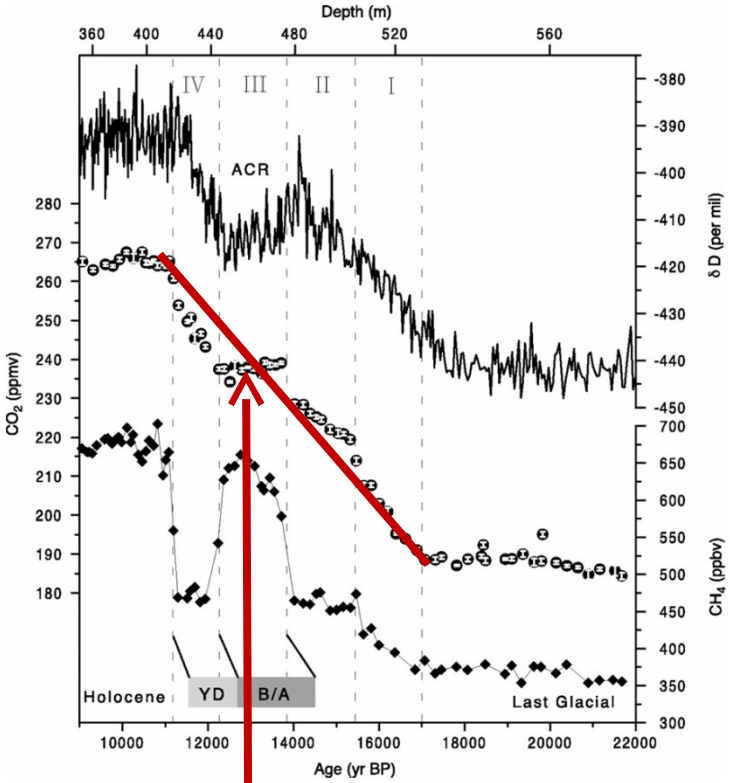
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Elsig, et al. Nature 461, 507-510 (Sept. 2009)

it²

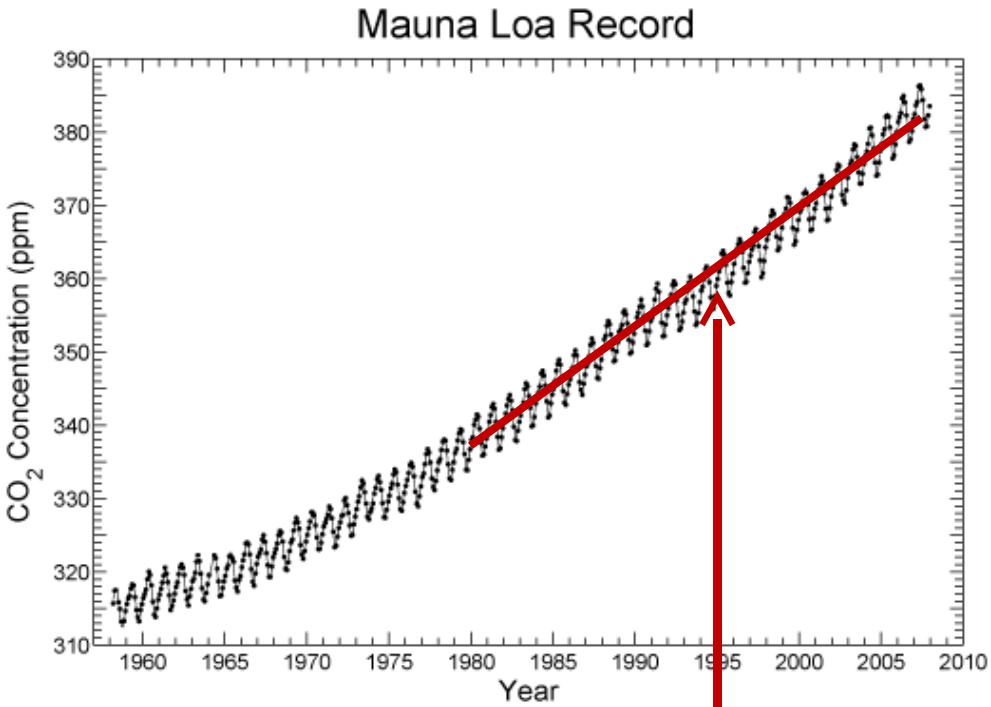
The Earth is Warming Over 100 Times Faster Today Than During the Last Ice Age Warming!

Monnin, et al., Science v. 291 pp. 112-114, Jan. 5, 2001.



CO_2 Rose From
185 to 265ppm (80ppm)
in 6000 years or
1.33 ppm per Century

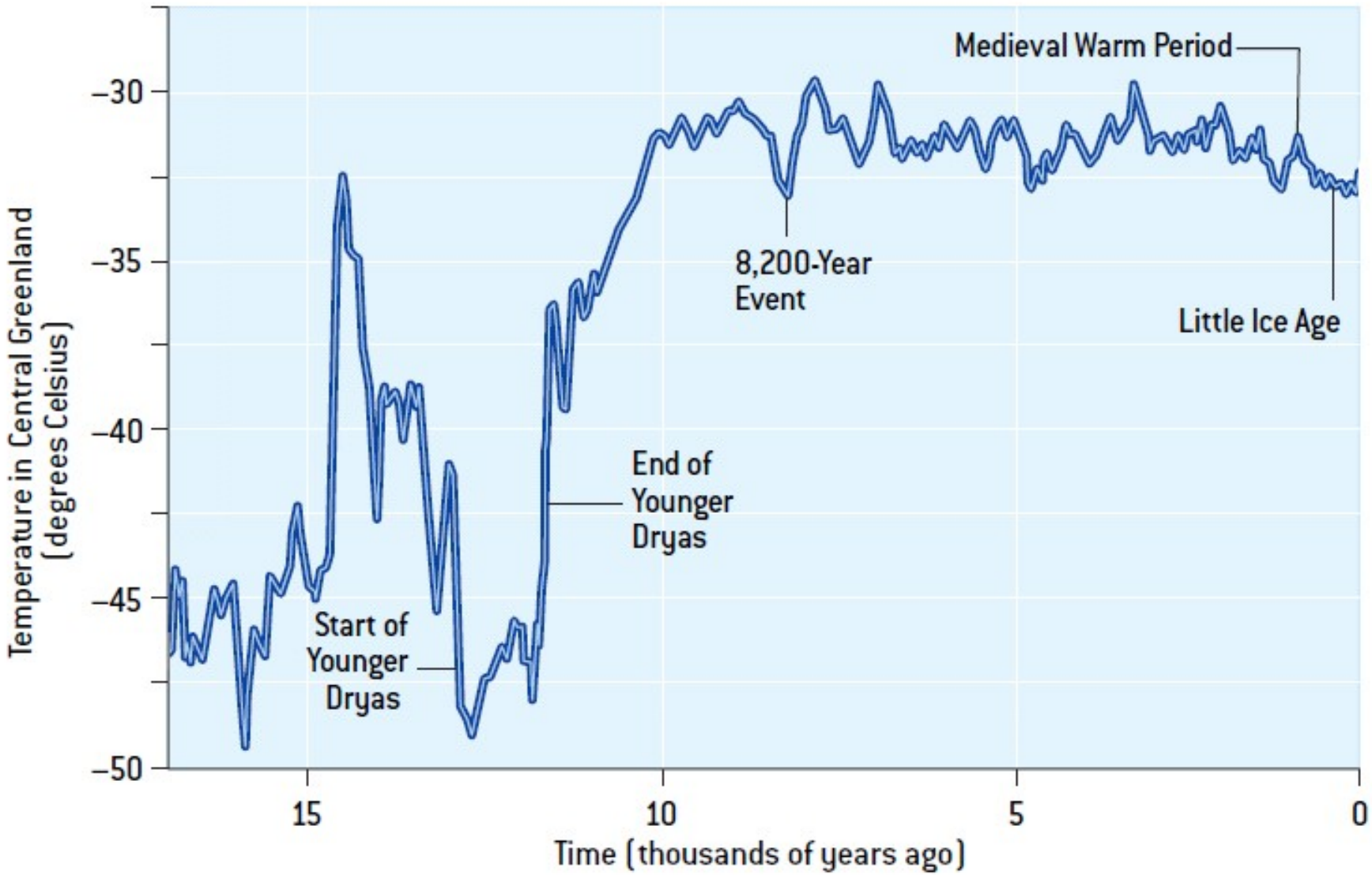
http://scrippsco2.ucsd.edu/program_history/keeling_curve_lessons.html



CO_2 Has Risen From
335 to 385ppm (50ppm)
in 30 years or
1.6 ppm per Year

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Sudden Flip-Flops--an Unavoidable Element of Climate: The Younger Dryas Episode



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Richard Alley, Scientific American, Nov 2004

it²

Abrupt Climate Change Can Be Very Swift

Mini ice age took hold of Europe in months

- 11 November 2009 by Kate Ravilious
- Magazine issue 2734. Subscribe and get 4 free issues.
- For similar stories, visit the Climate Change Topic Guide

PRINT SEND SHARE

JUST months - that's how long it took for Europe to be engulfed by an ice age. The scenario, which comes straight out of Hollywood blockbuster *The Day After Tomorrow*, was revealed by the most precise record of the climate from palaeohistory ever generated.



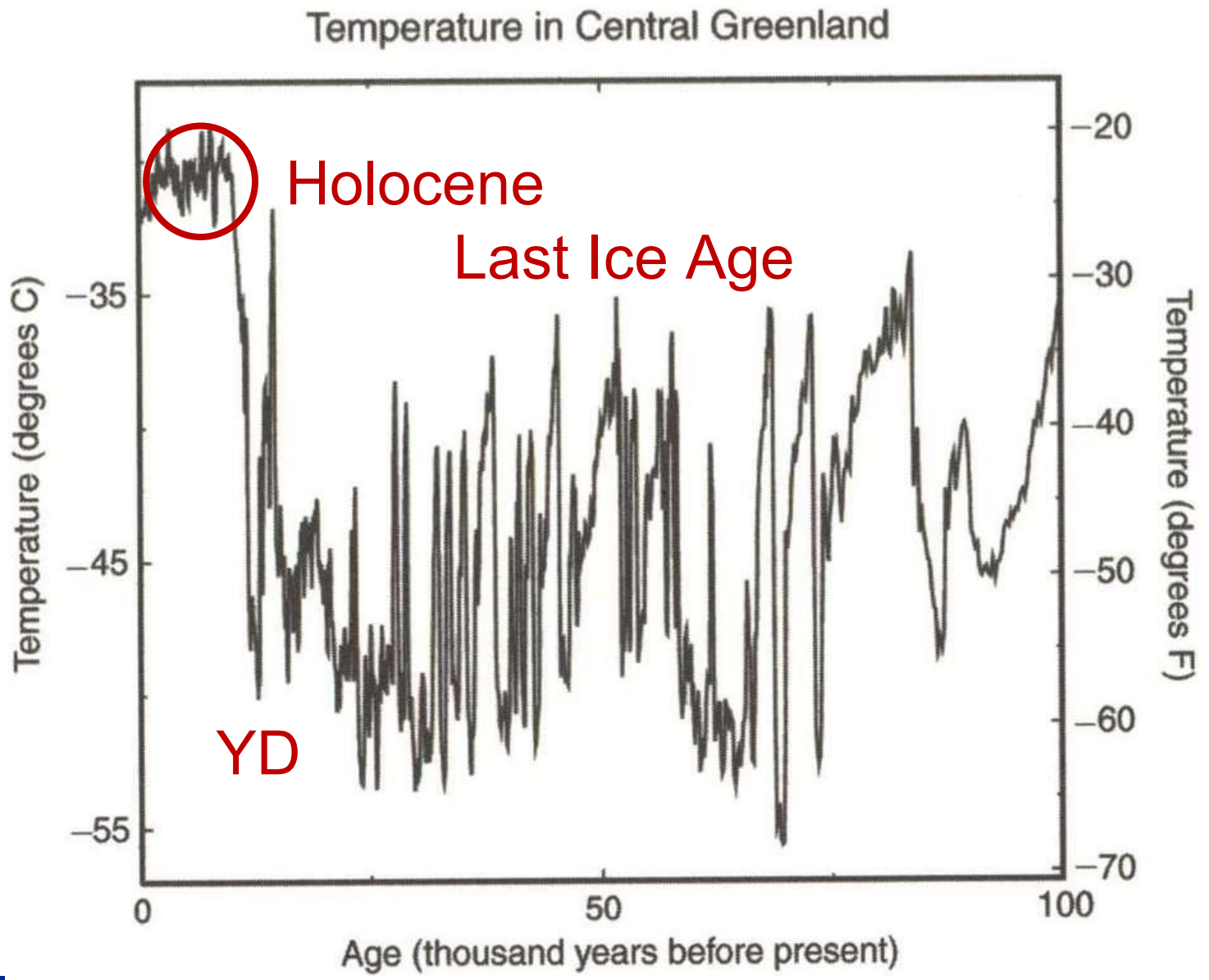
Around 12,800 years ago the northern hemisphere was hit by the Younger Dryas mini ice age, or "Big Freeze". It was triggered by the slowdown of the Gulf Stream, led to the decline of the Clovis culture in North America, and lasted around 1300 years.

Until now, it was thought that the mini ice age took a decade or so to take hold, on the evidence provided by Greenland ice cores. Not so, say William Patterson of the University of Saskatchewan in Saskatoon, Canada, and his colleagues.

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Our Last 10,000 Years Have Been Unusually Stable -- Abrupt Climate Change Has Been the Norm



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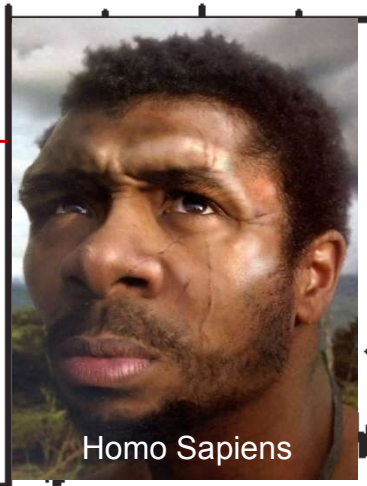
Richard Alley, The Two Mile Time Machine (2000), page 119

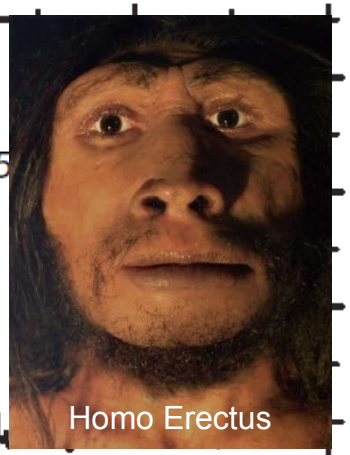
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Antarctic Ice Cores Show CO_2 and Temperature Have Oscillated For 800,000 Years in a Narrow Range

Today 388-

Vertical Range 170 to 300 ppm





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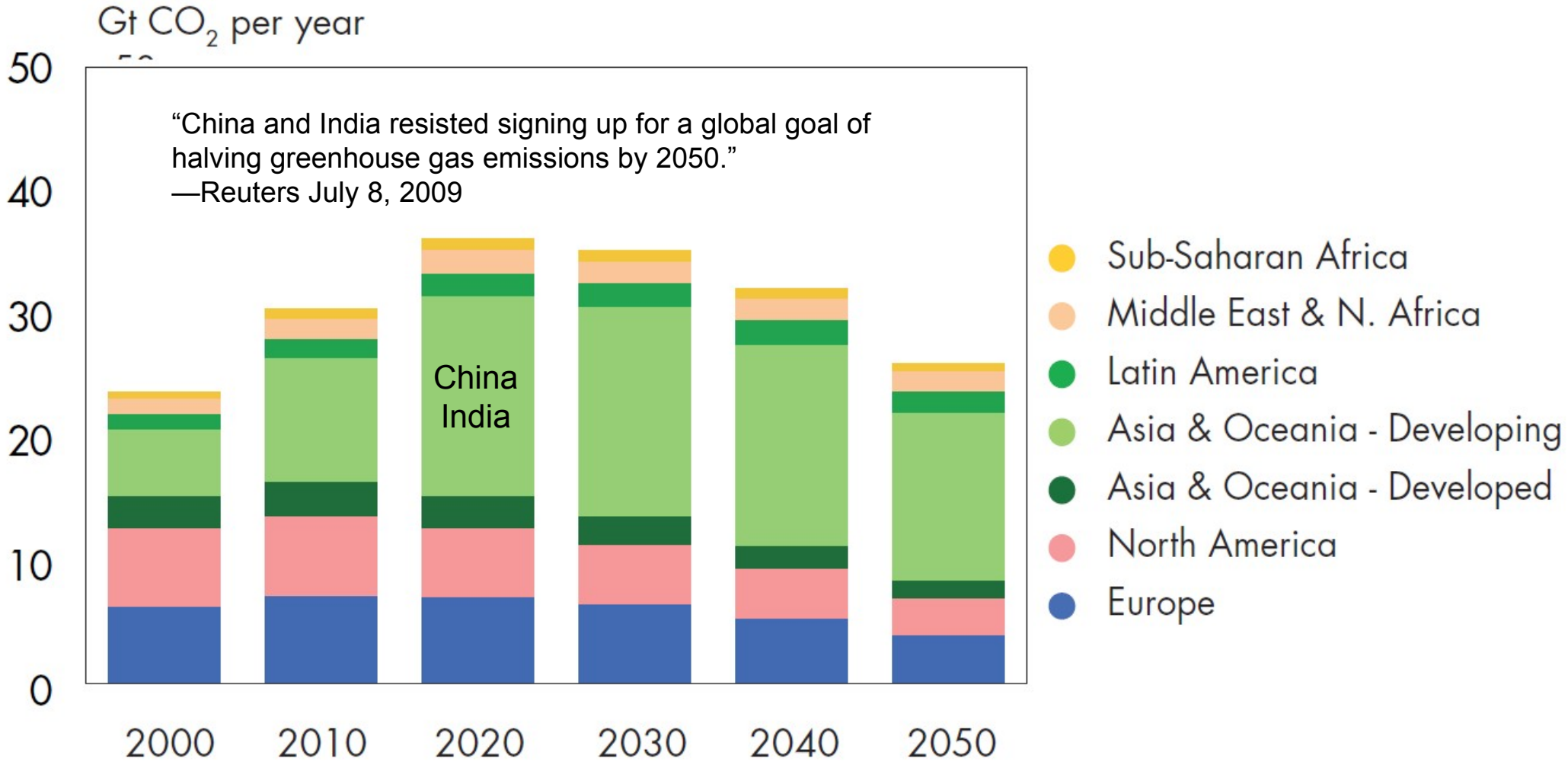
Ice Cores: Luthi, et al. Nature may 15, 2008 v. 453 pp379-82

Homonid Images: *The Last Human*, G.J. Sawyer and V. Deak

it²

Future Estimates of CO_2 Emissions From Energy: An Aggressive CO_2 Emission Reduction Scenario

www-static.shell.com/static/public/downloads/brochures/corporate_pkg/scenarios/shell_energy_scenarios_2050.pdf



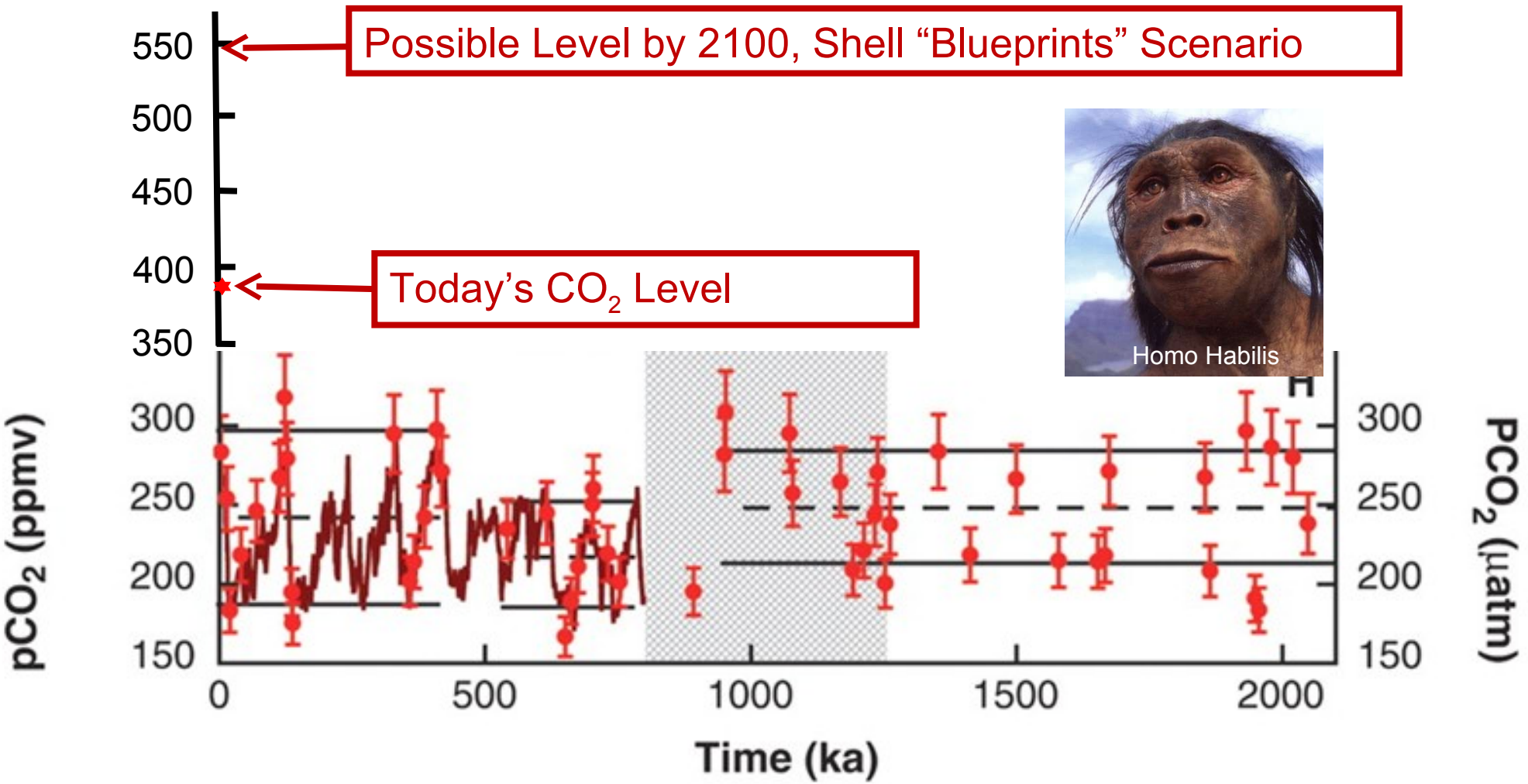
Estimated CO_2 Level in 2100 is 550ppm

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Current CO_2 Level is 388 ppm

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Ice Core Record Has Been Extended Using Plankton: Today's CO_2 is Higher Than in Last 2 Million Years!



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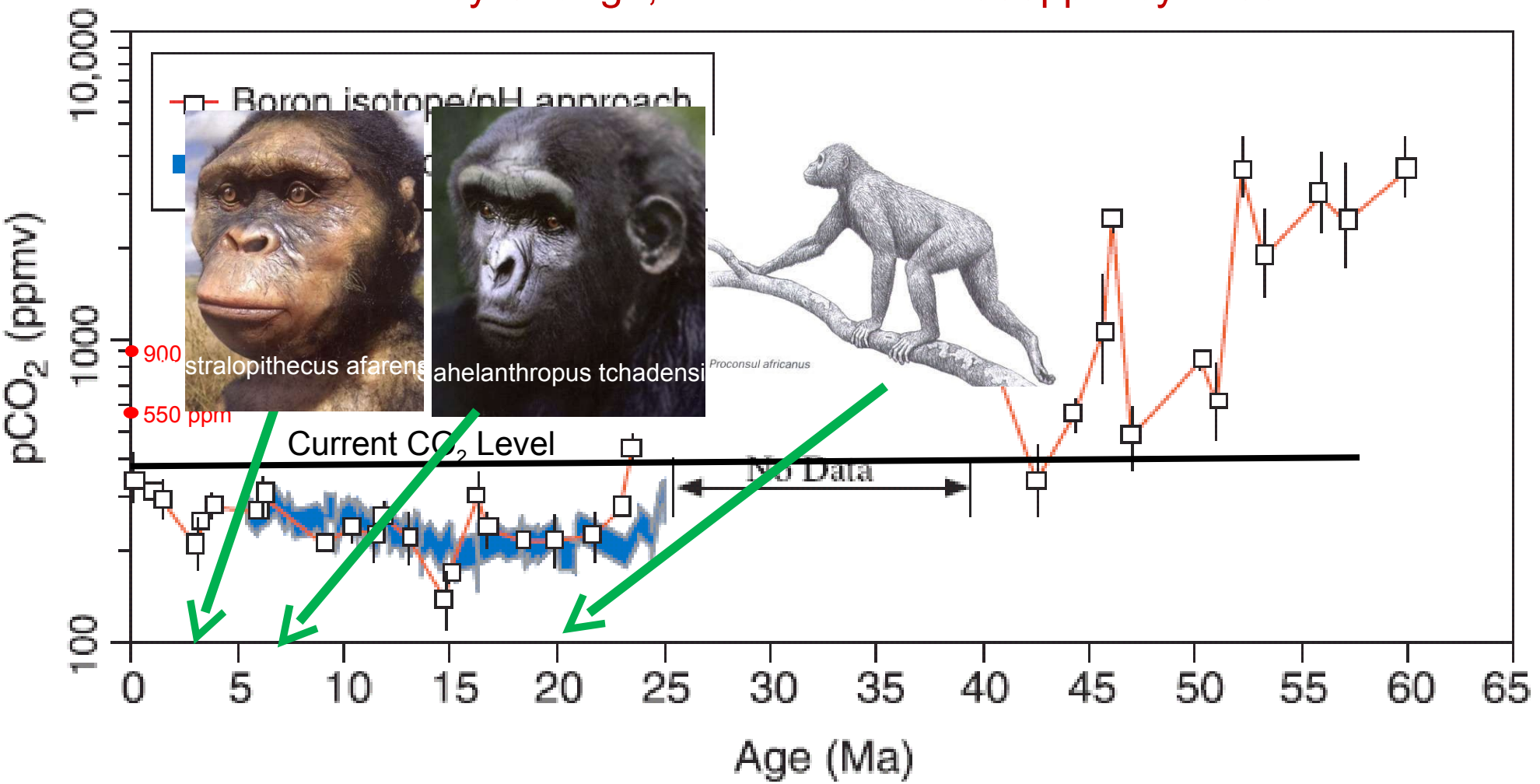
CO2: Hönisch, et al. Science 19 June 2009 Vol. 324. pp. 1551 - 1554

Homonid Images: *The Last Human*, G.J. Sawyer and V. Deak

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Earth's Climate Hasn't Seen the Current Level of CO_2 During the Entire Evolution of Homonids!

With No Policy Change, MIT Estimates ~900ppm by 2100



Estimates of Cenozoic atmospheric pCO_2 based on two independent proxies as measured in subtropical deep-sea sediment cores from the Pacific

CO_2: James Zachos, et al. Science v. 292 p. 686 27 Apr. 2001

Homonid Images: *The Last Human*, G.J. Sawyer and V. Deak

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Earth's Climate is Rapidly Entering a Novel Realm Not Experienced for Over 20 Million Years

"Global Warming" implies gradual, uniform, mainly about temperature, and quite possibly benign.

What's happening is rapid, non-uniform, affecting everything about climate, and is almost entirely harmful.



A more accurate term is 'global climatic disruption'

This ongoing disruption is:

- Real without doubt
- Mainly caused by humans
- Already producing significant harm
- Growing more rapidly than expected"

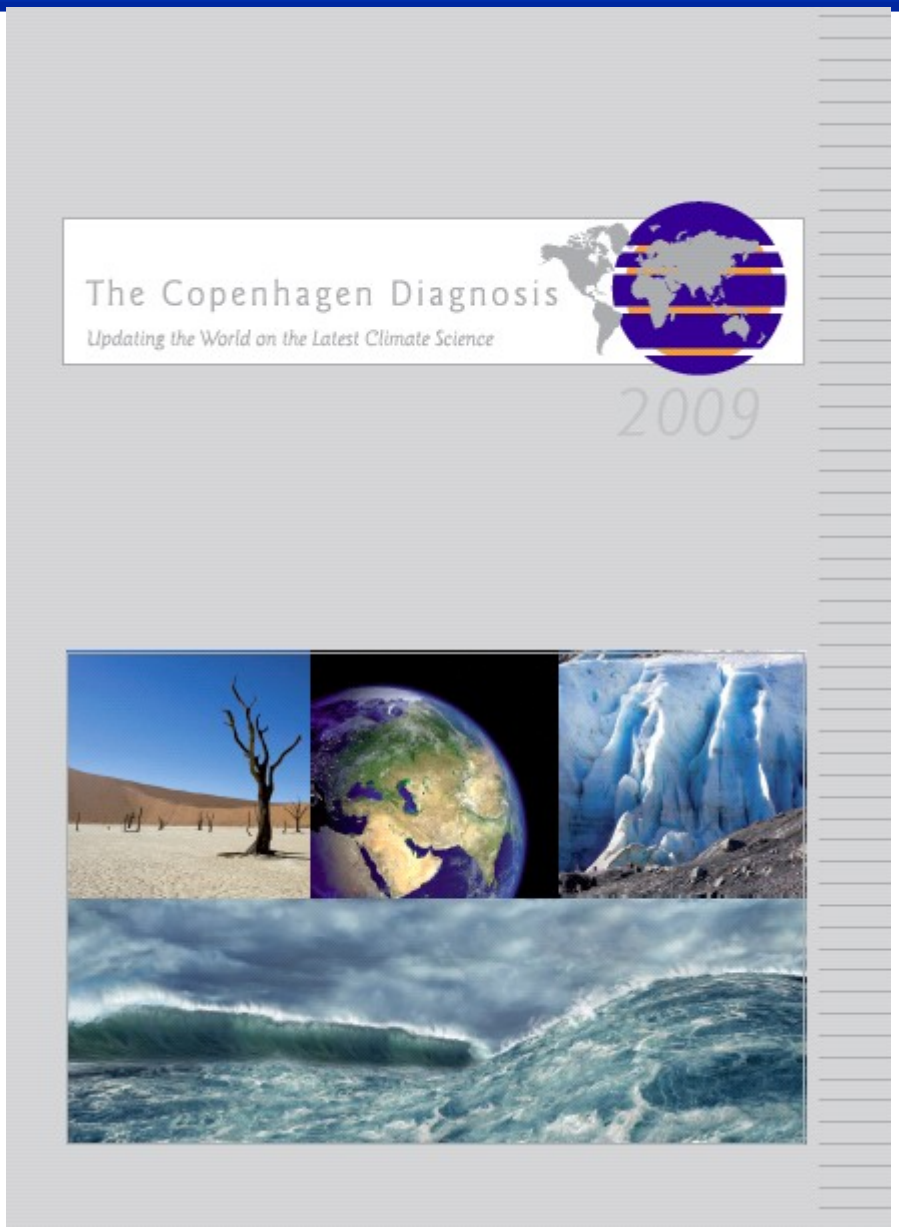
-- John Holdren, Director Office of Science and Technology Policy
June 25, 2008

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See Video Lecture: http://greenmonk.net/john-holdren-on-global-climatic-disruption/

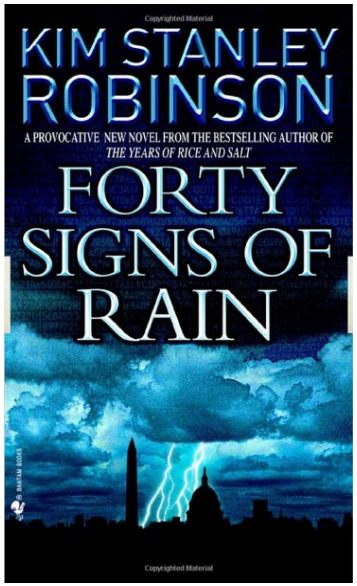
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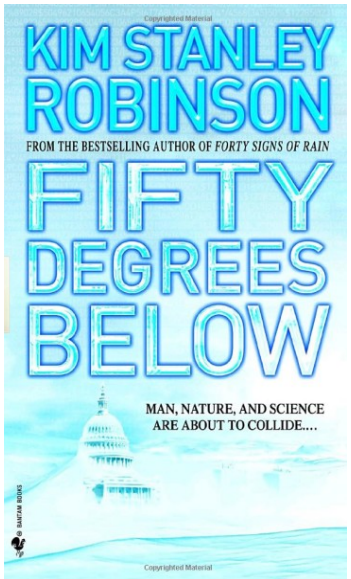
The Latest Science on Global Climatic Disruption
An Update to the 2007 IPCC Report

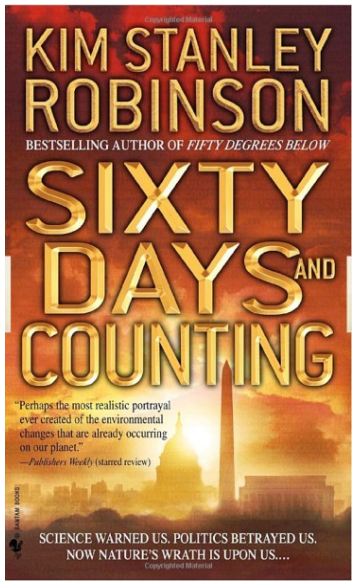


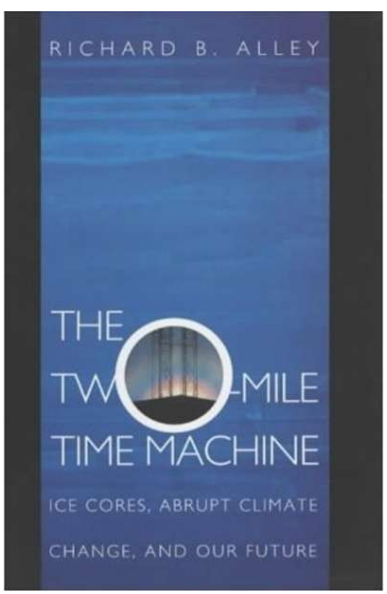
www.copenhagendiagnosis.org

My Recommendations for Further Reading

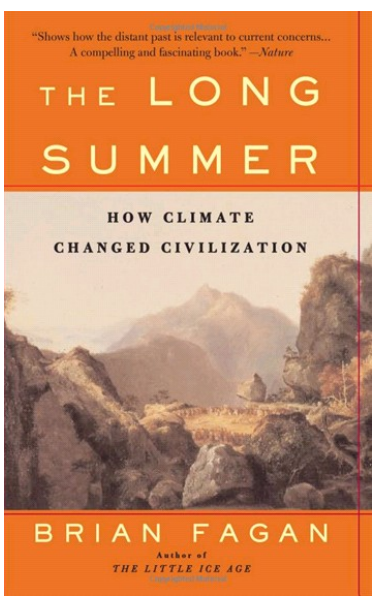










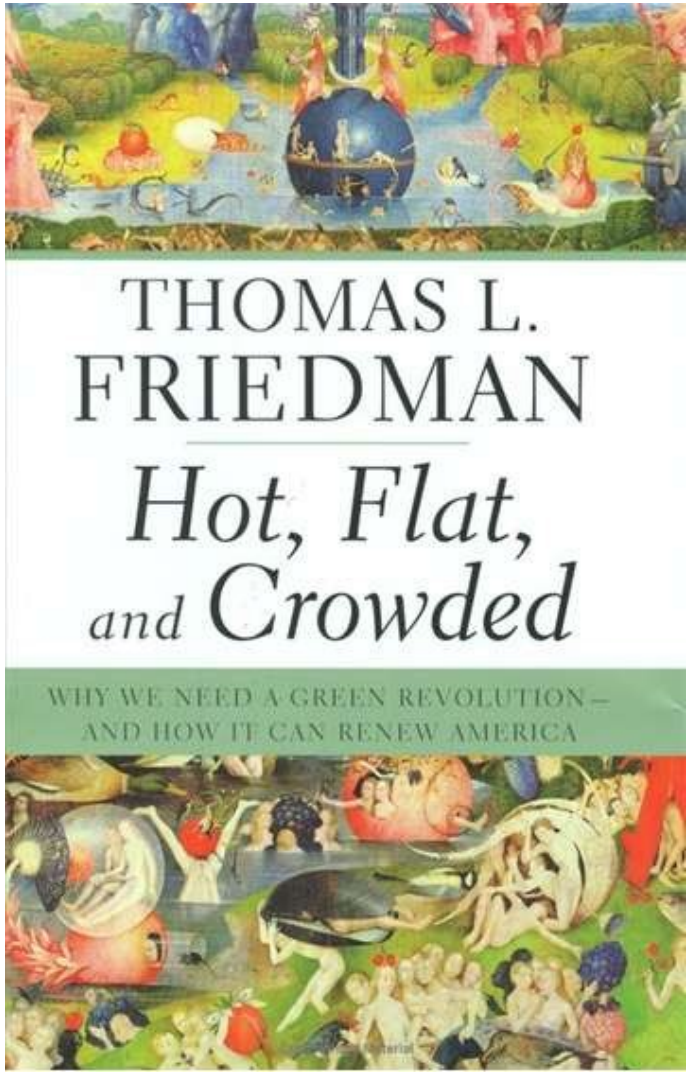


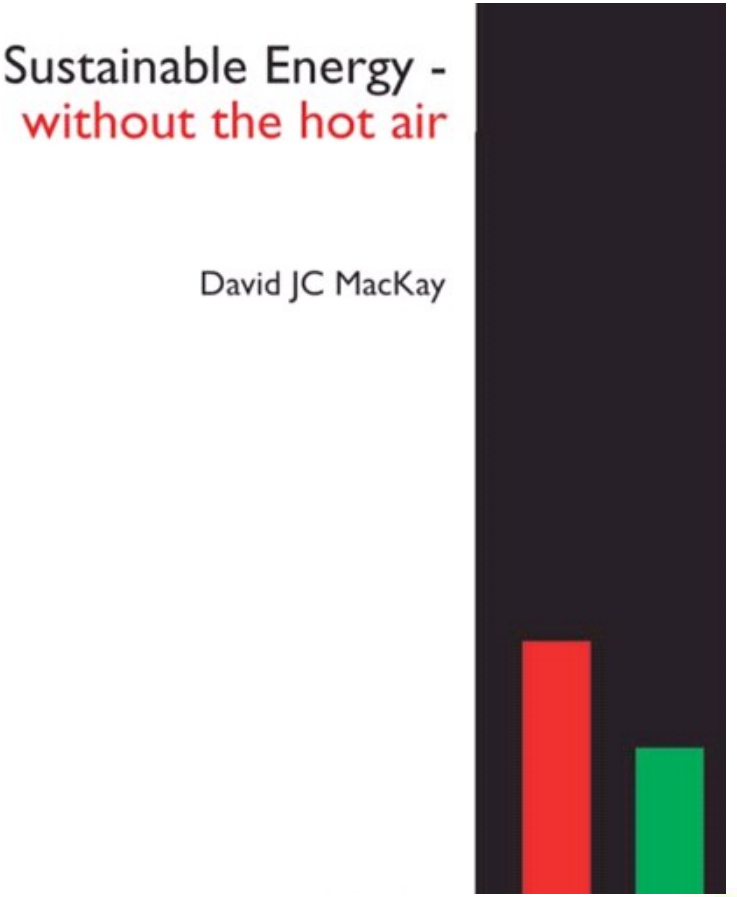
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What is Creating the Problem and What Can the World Do to Change?

"It Will Be the Biggest Single Peacetime Project Humankind Will Have Ever Undertaken"





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