"How PRAGMA Can Help Save the Planet"

Banquet Keynote Speech
Pacific Rim Applications and Grid Middleware Assembly (PRAGMA) 18
Birch Aquarium, Scripps Institution of Oceanography, UCSD
March 3, 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

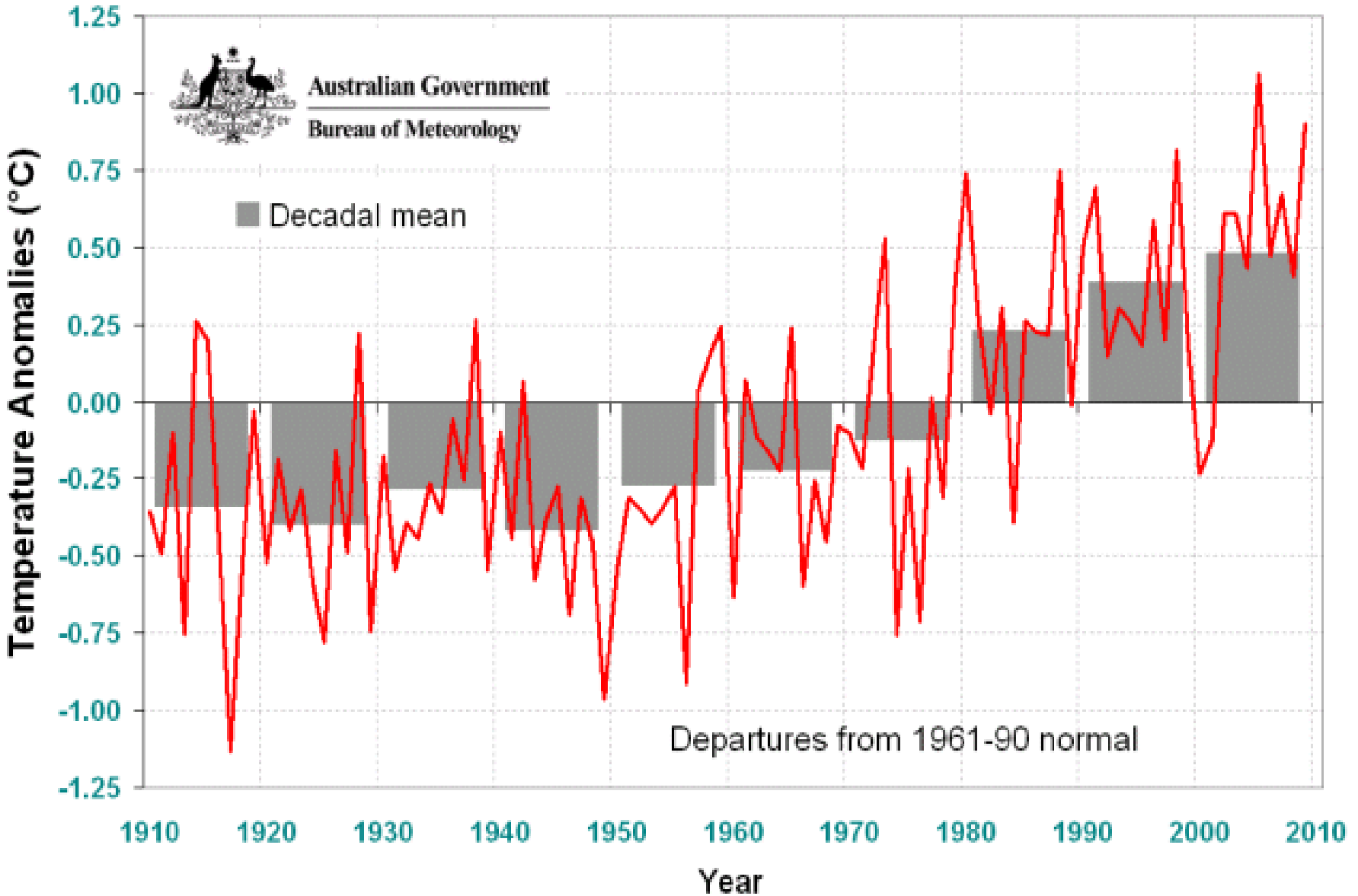
lsmarr@twitter.com

GreenLight Project

Abstract

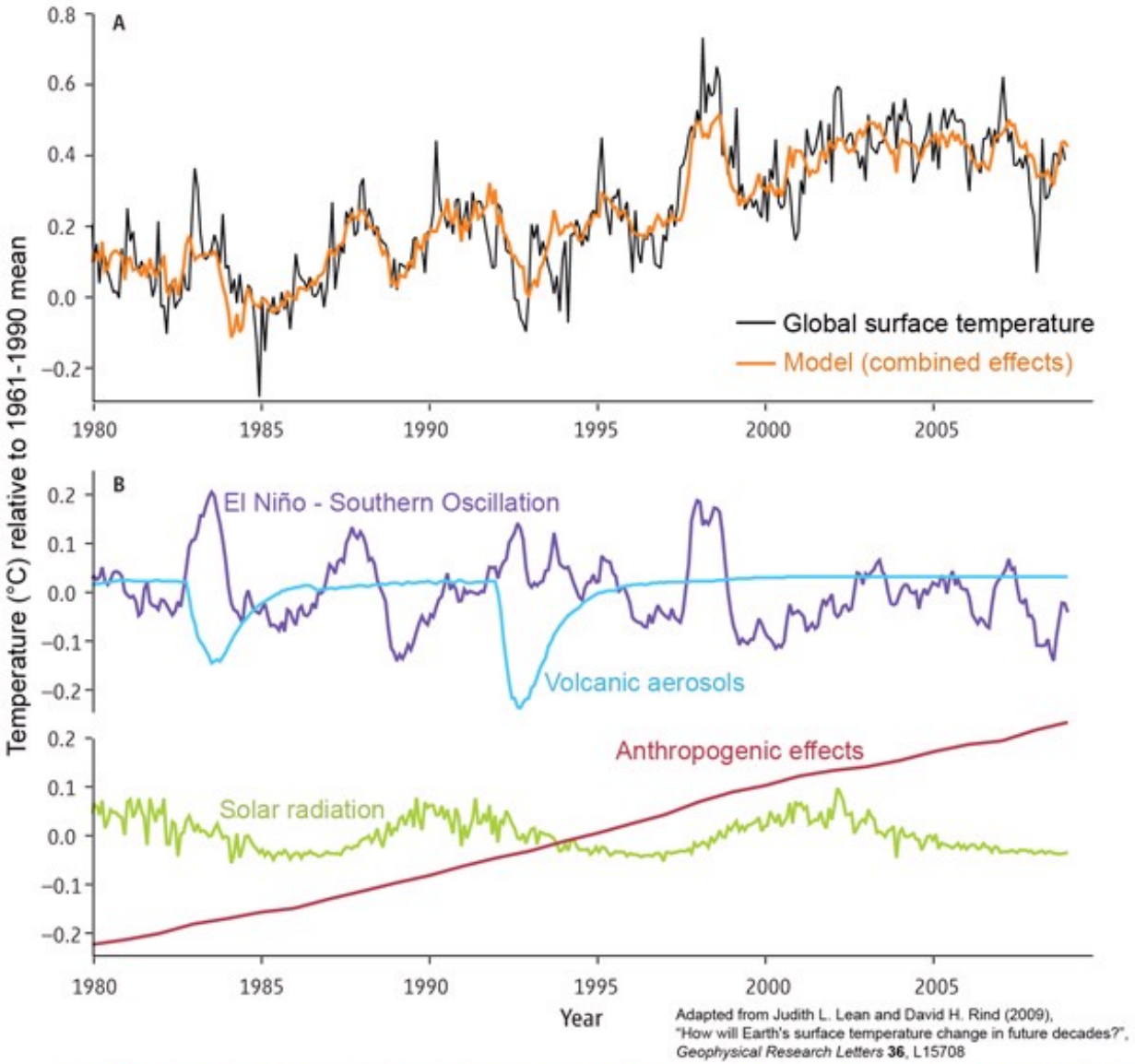
I will review the evidence that global greenhouse gas emissions are causing an impulse to the nonlinear Earth climate system on a scale not seen for millions of years. It is essential that global reduction of such emissions be undertaken immediately. PRAGMA is in an important position to help, because the development and use of Green IT and telecom can provide a near term slowing of the emission rates. The Smart2020.org report shows that much of the opportunity lies in the Pacific Rim, where PRAGMA could be a leader toward a low carbon economy.

Annual and Decadal Mean Temperature Anomalies for Australia



Five Decades of Mean Temperature Rise

Climate Models Match Past Temperature Variations, Combining Both Natural and Anthropogenic Effects



Adapted from Judith L. Lean and David H. Rind (2009), "How will Earth's surface temperature change in future decades?", *Geophysical Research Letters* **36**, L15708

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"The warmest year on record, 1998, coincides with the 'super-El Nino' of 1997-98," points out Lean. "The ESNO is capable of producing significant spikes in the temperature record."

Solar minimum has the opposite effect: "A 0.1% decrease in the sun's irradiance has counteracted some of the warming action of greenhouse gases from 2002 - 2008," she notes.

"This is the reason for the well-known 'flat' temperature trend of recent years."

1965: White House document

APPENDIX Y4

Atmospheric Carbon Dioxide

ROGER REVELLE, *Chairman*

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

RESTORING THE QUALITY OF OUR ENVIRONMENT

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

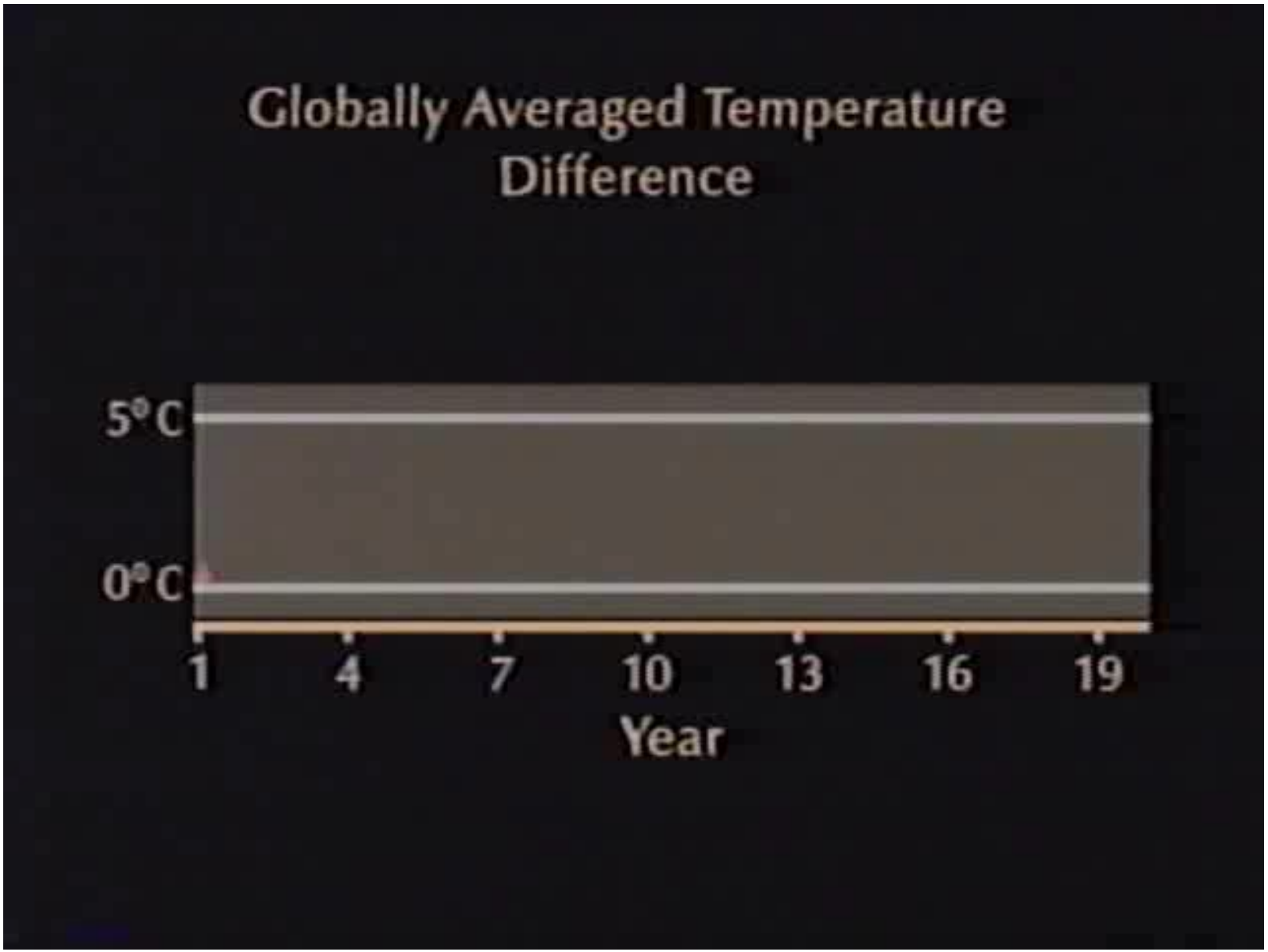
THE WHITE HOUSE
NOVEMBER 1965

CONCLUSIONS AND FINDINGS

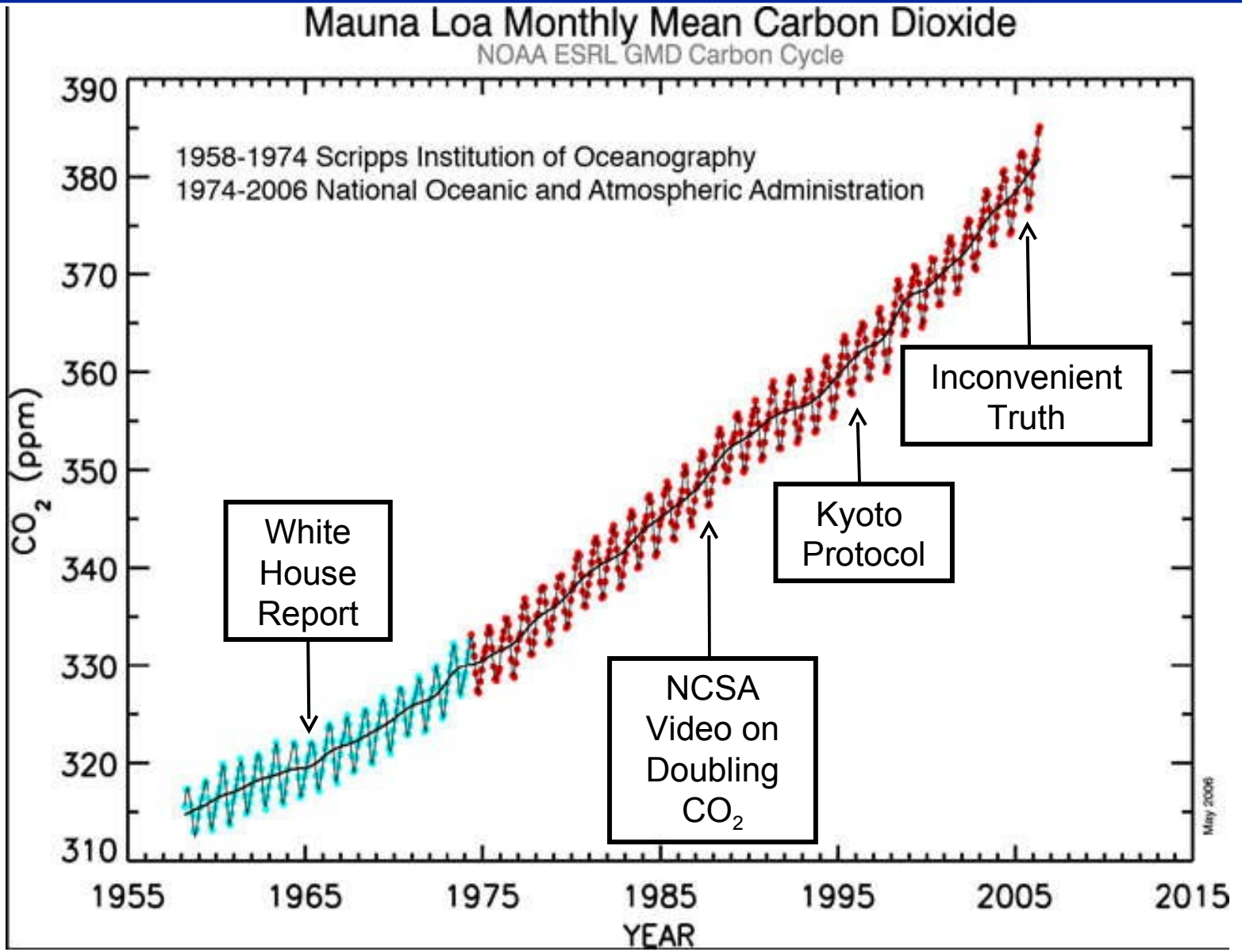
Through his worldwide industrial civilization, Man is unwittingly conducting a vast geophysical experiment. Within a few generations he is burning the fossil fuels that slowly accumulated in the earth over the past 500 million years. The CO_2 produced by this combustion is being injected into the atmosphere;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

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

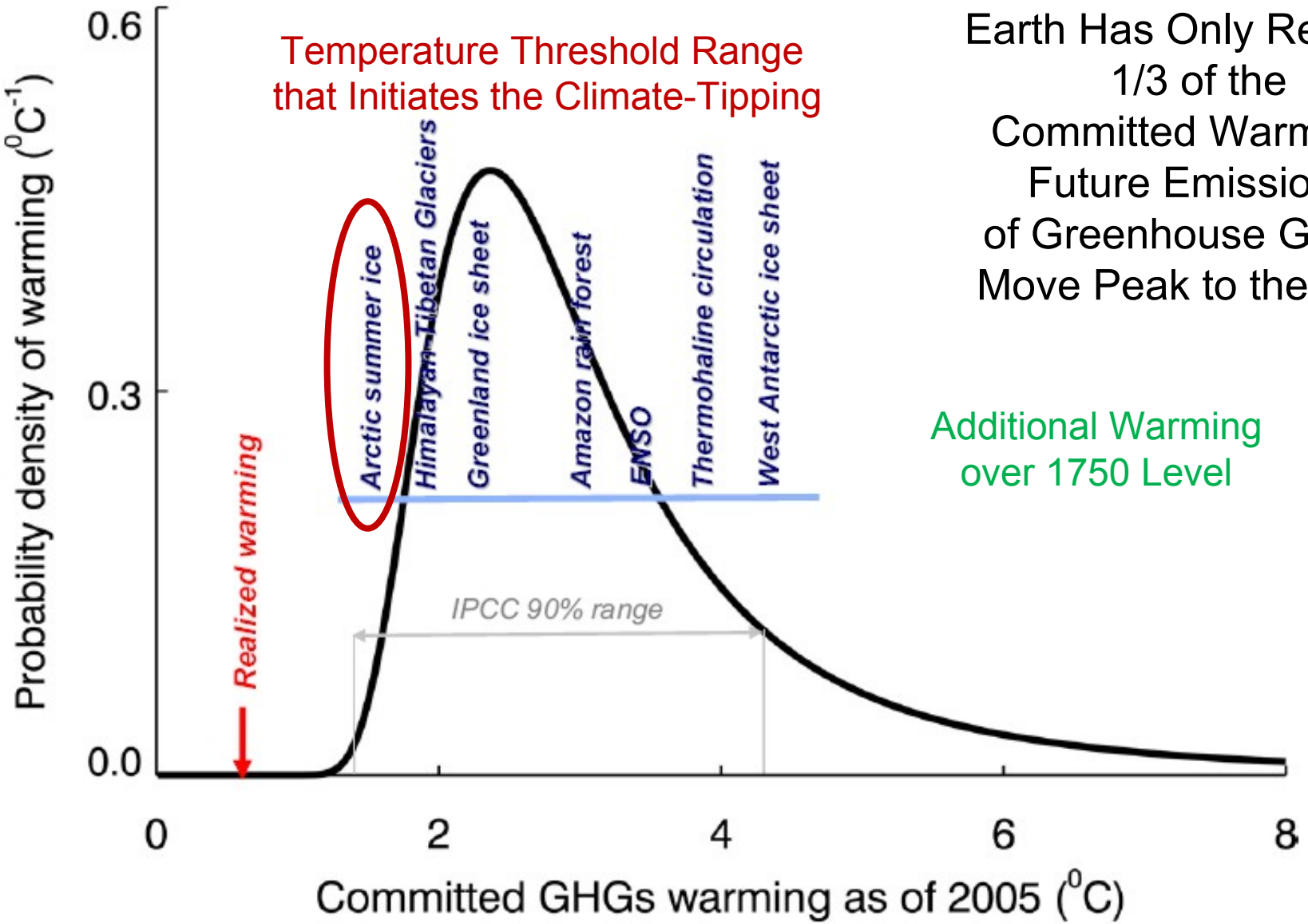
NCSA Visualization of a Doubling of CO_2 Warren Washington NCAR Simulation 1988



The Unrelenting Climb of CO_2
In Spite of Clear Understanding of the Problem



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

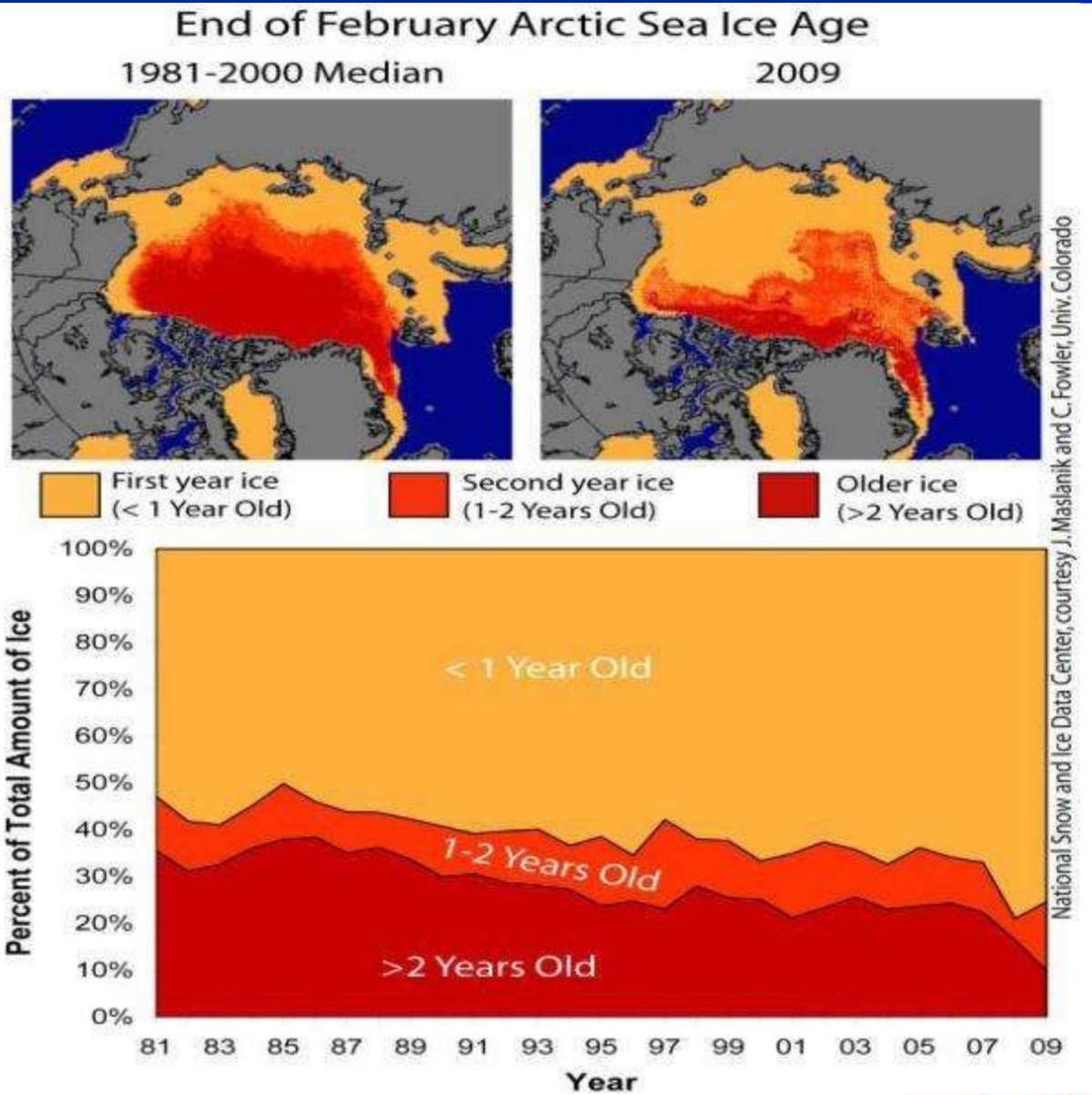
Additional Warming
over 1750 Level

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

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

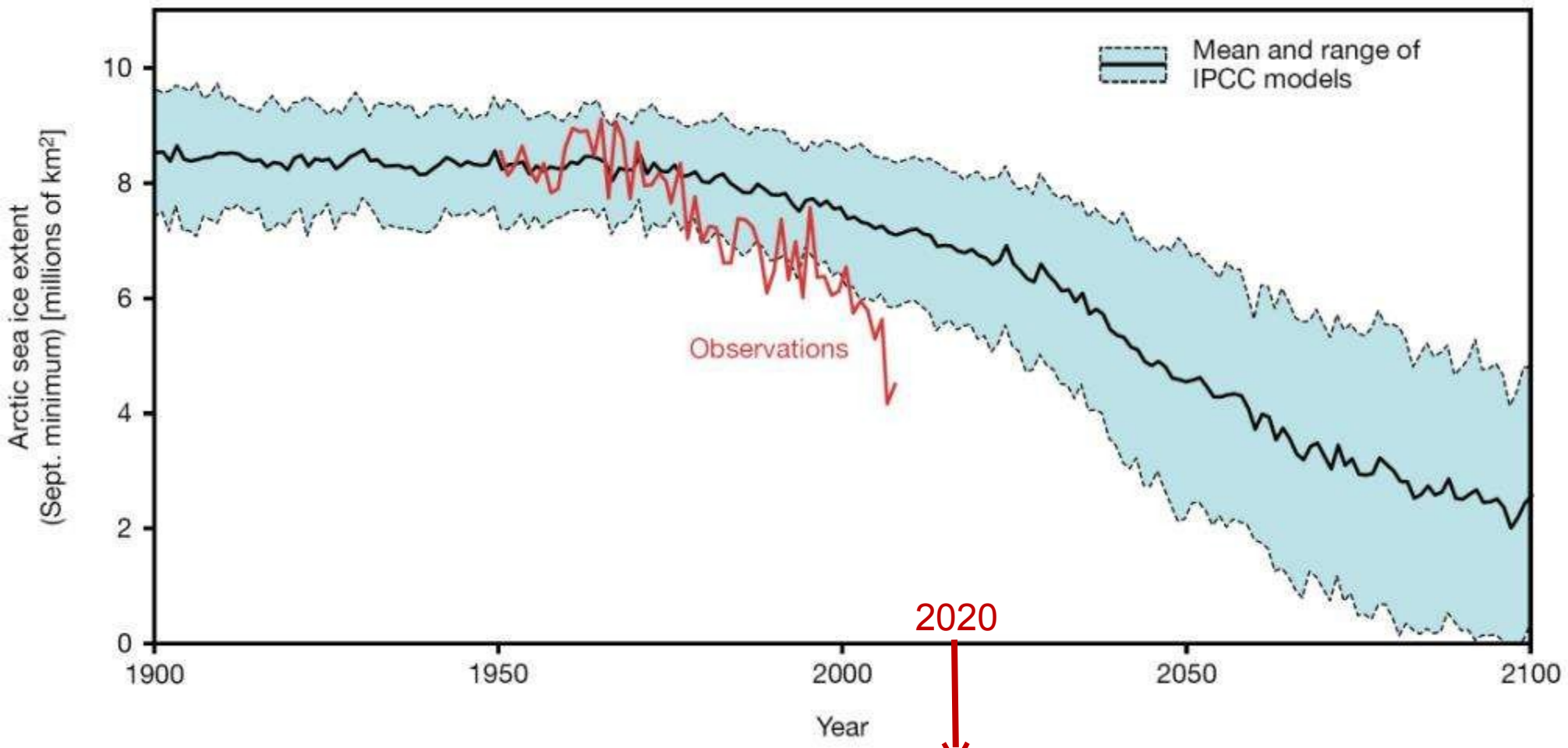
"We are almost out of multiyear sea ice in the northern hemisphere--I've never seen anything like this in my 30 years of working in the high Arctic." --David Barber, Canada's Research Chair in Arctic System Science at the University of Manitoba October 29, 2009

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



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

Arctic Summer Ice Melting Accelerating Relative to IPCC 2007 Predictions

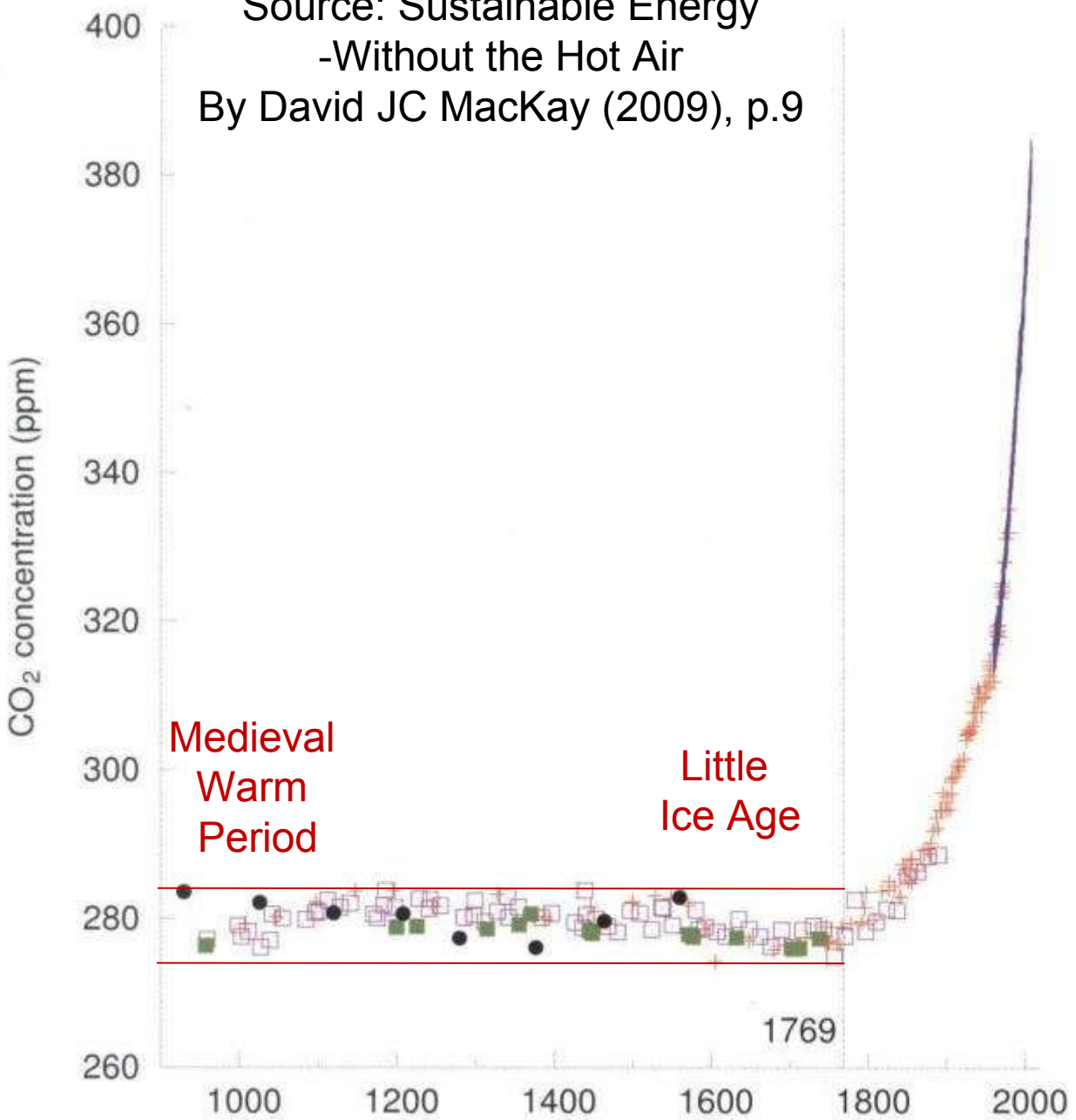


Potentially Volume of Arctic Summer Ice Goes to Zero:
Talk by NPS's Wieslaw Maslowski at AAAS San Diego Feb. 2010
http://aaas.confex.com/aaas/2010/webprogram/Paper1505.html

Rapid Increase in the Greenhouse Gas CO_2 Since Industrial Era Began

Source: Sustainable Energy
-Without the Hot Air
By David JC MacKay (2009), p.9

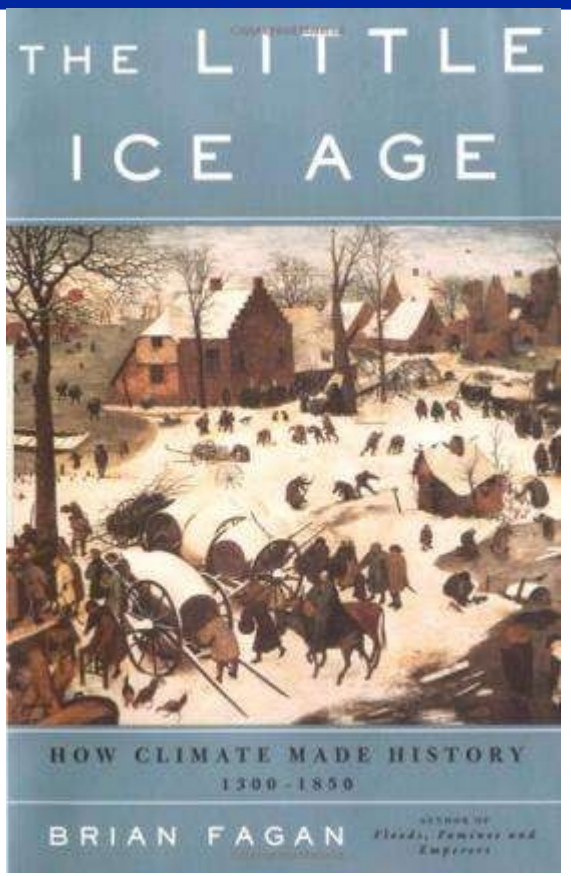
388 ppm in 2010



GreenLigh

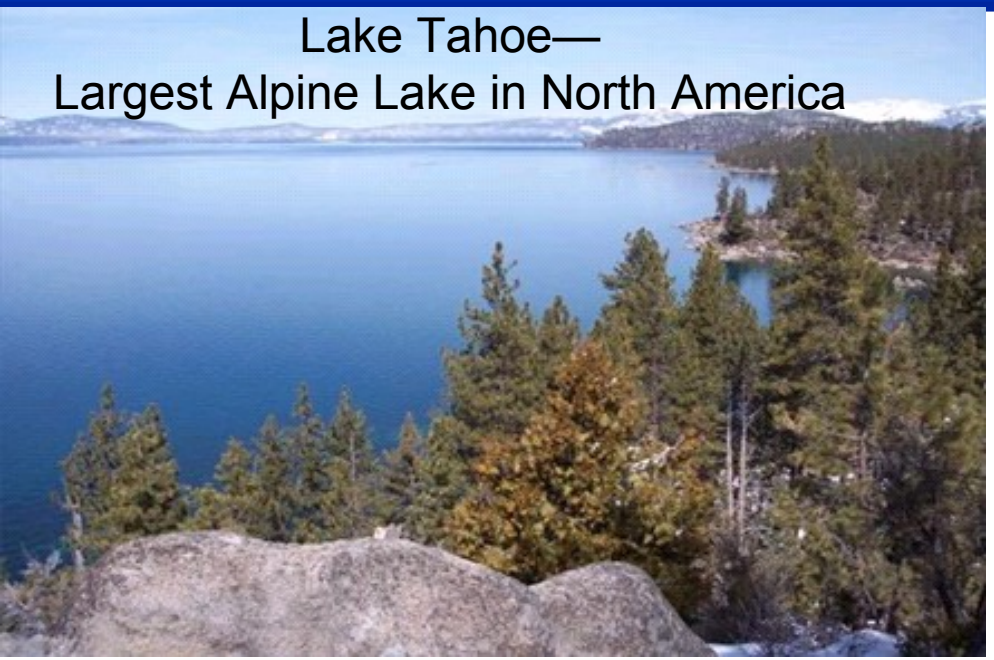
The Little Ice Age: The Climate State Earth is Emerging From

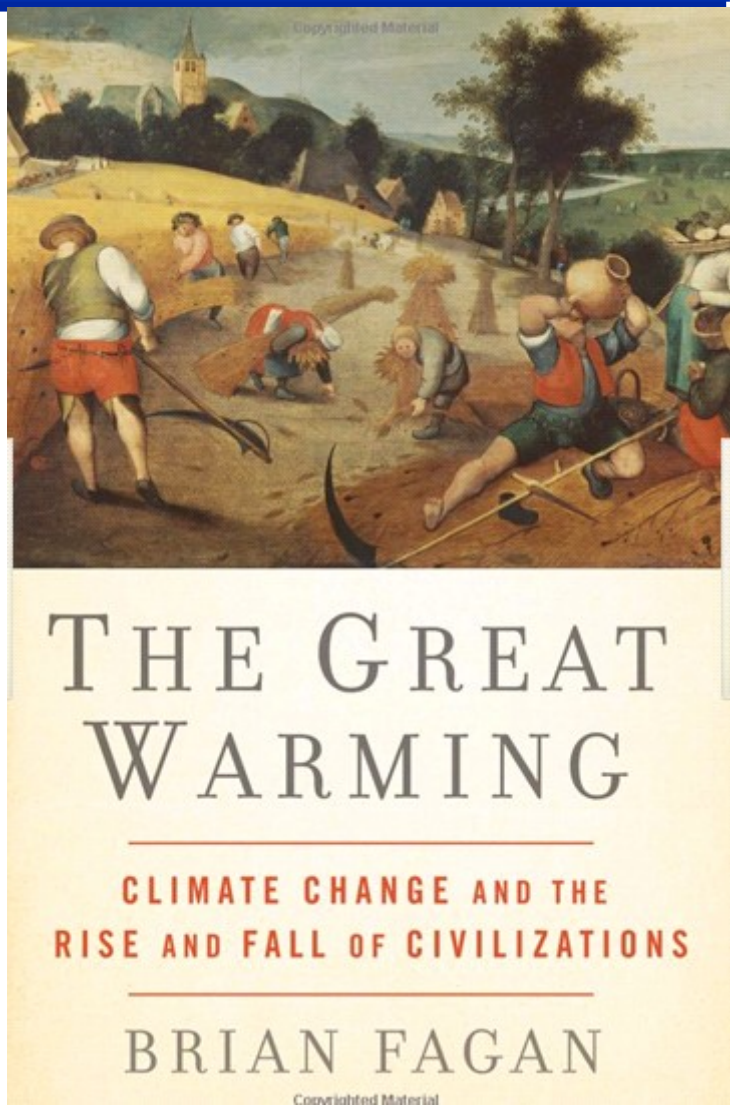




At Jamestown, the colonists had the bad fortune to arrive at the height of the driest seven-year period in 770 years. No fewer than 4,800 of the 6,000 settlers who arrived between 1607 and 1625 perished.
-- The Little Ice Age, Brian Fagan

The Medieval Warm Period
Last Time Global Temperatures Were This High





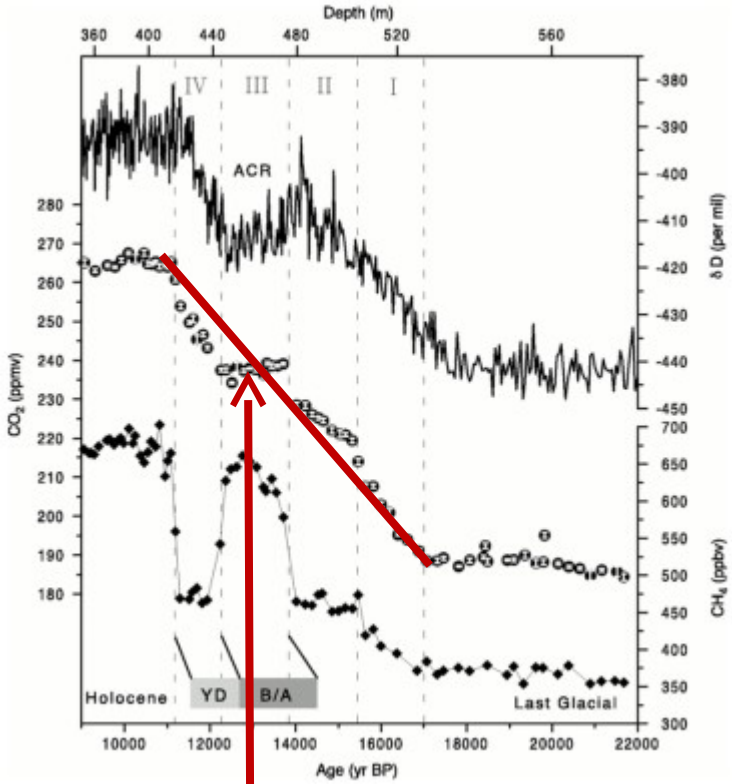
A 300 Year California Megadrought:
"Precipitation was <60% of normal
between 950-1250 AD.
Several trees were radiocarbon dated to ~1250 AD
and are positioned upslope a
~60 meter deep submerged paleoshoreline.
--Daniel Brothers Ph.D. Thesis UCSD SIO Dec 2009

But CO_2 in 1250AD was <290ppm;
Today ~390ppm

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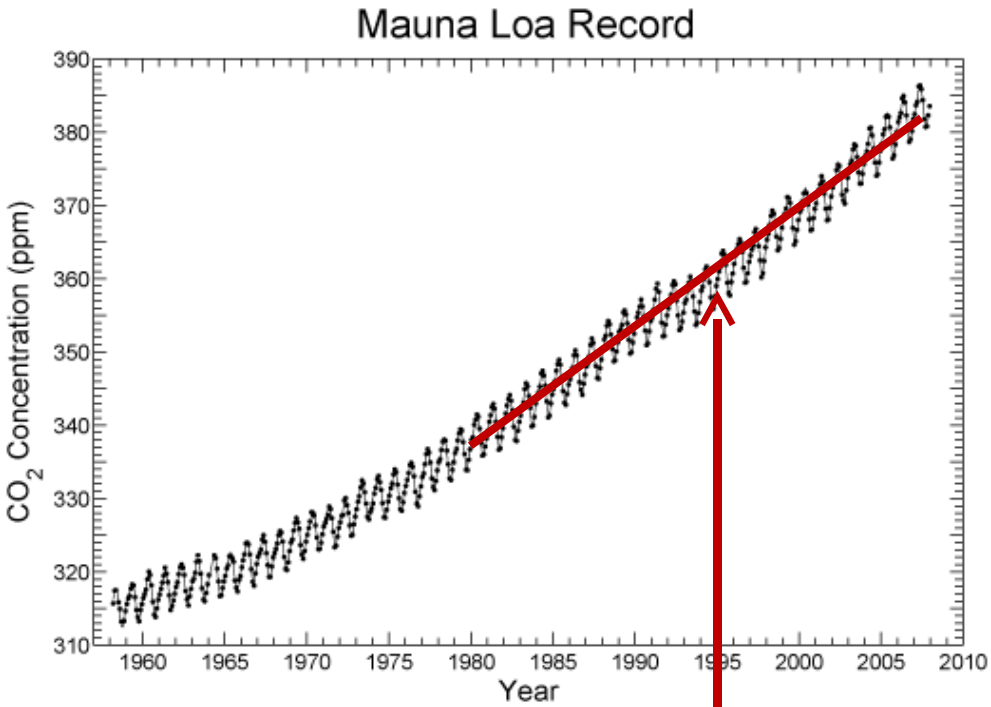
The Earth is Warming Over 100 Times Faster Today Than During the Last Ice Age Warming!

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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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



"China and India resisted signing up for a global goal of halving greenhouse gas emissions by 2050."
—Reuters July 8, 2009

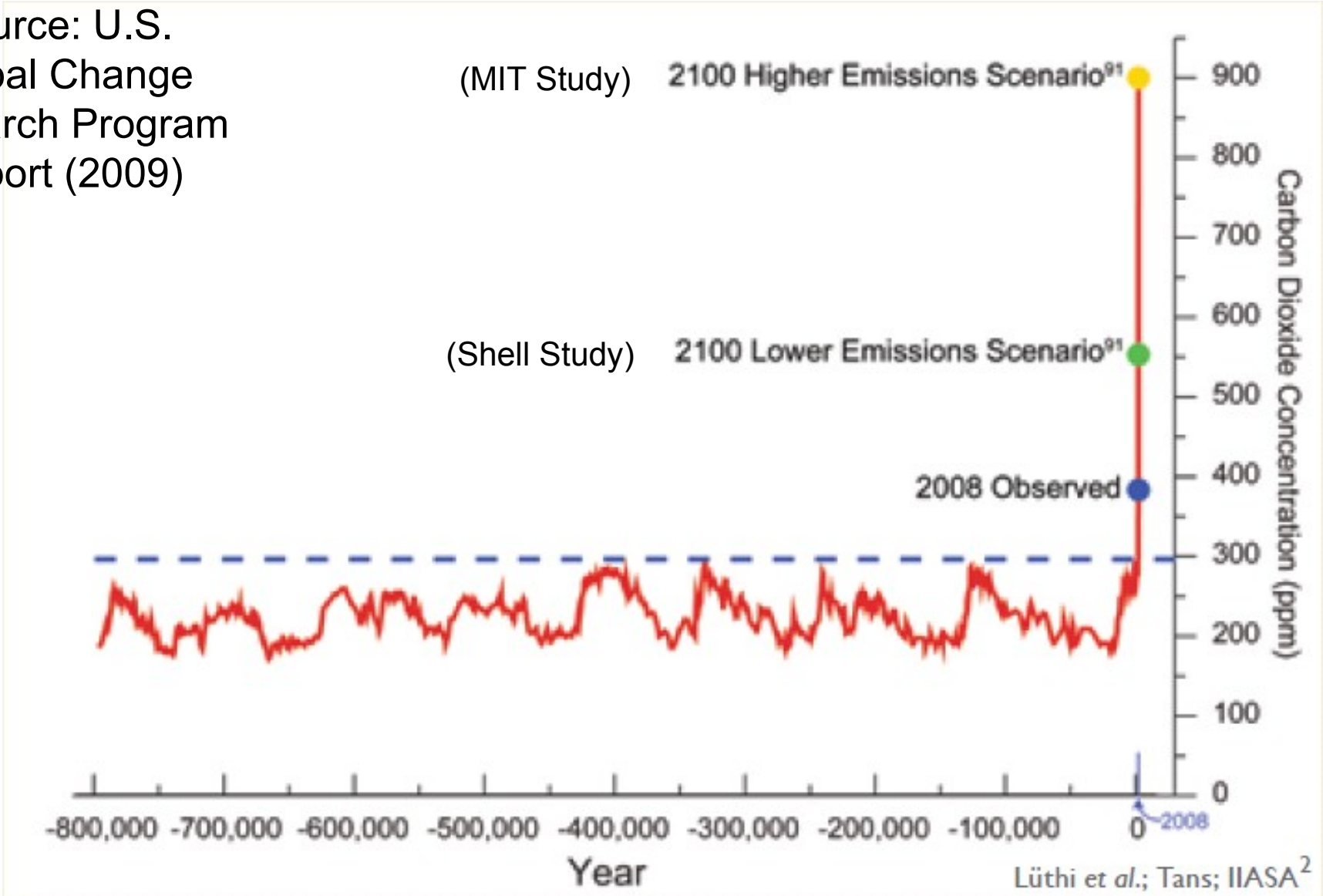
Estimated CO_2 Level in 2100 is 550ppm

Current CO_2 Level is 388 ppm

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Atmospheric CO_2 Levels for 800,000 Years And Projections for the 21st Century

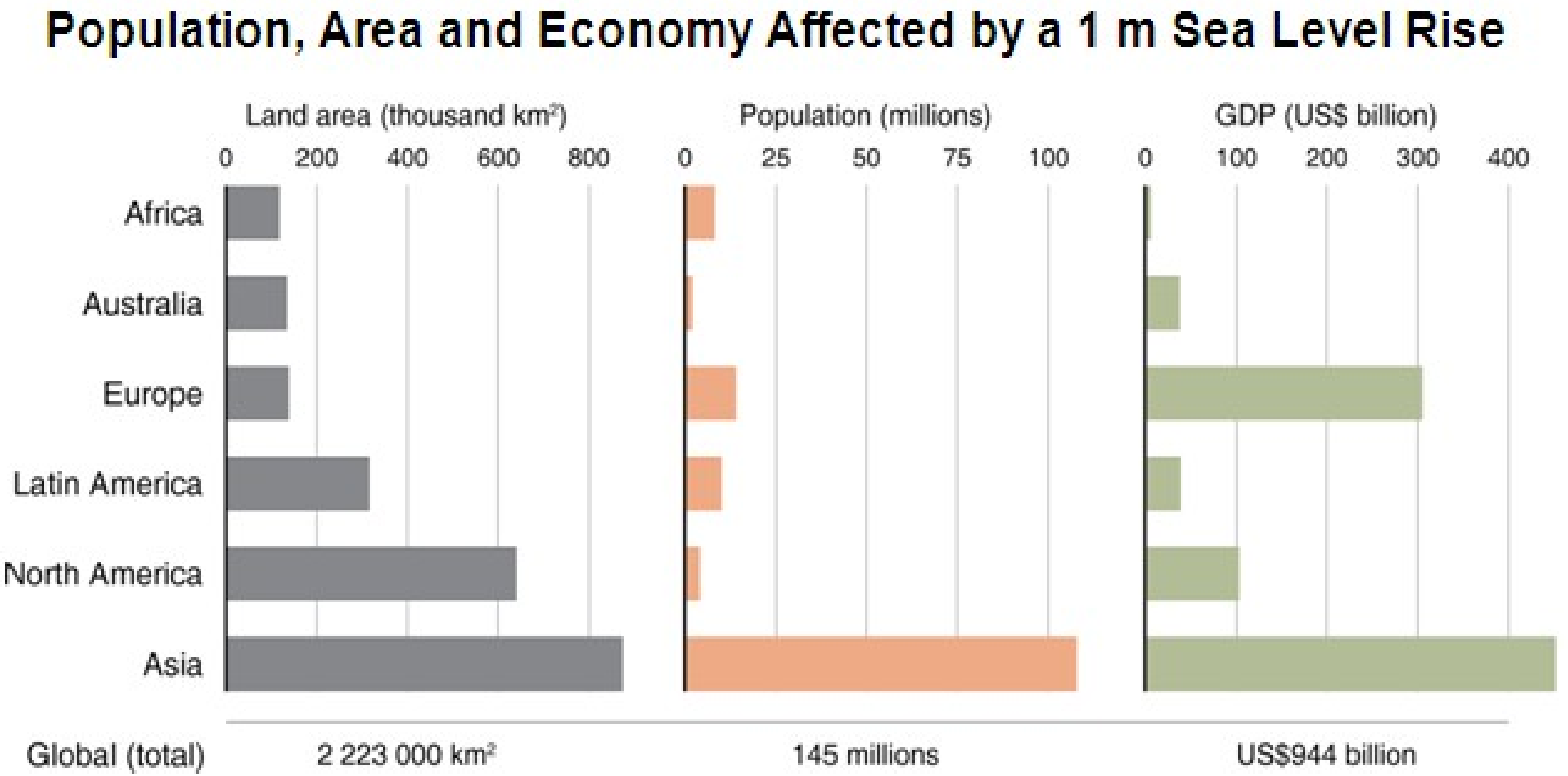
Source: U.S. Global Change Research Program Report (2009)



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www.globalchange.gov/publications/reports/scientific-assessme
/us-impacts/download-the-report

Sea Level Rise Will Impact 150 Million People by 2100 —The Vast Majority in Asia



http://maps.grida.no/go/graphic/population-area-and-economy-affected-by-a-1-m-sea-level-rise-global-and-regional-estimates-based-on-

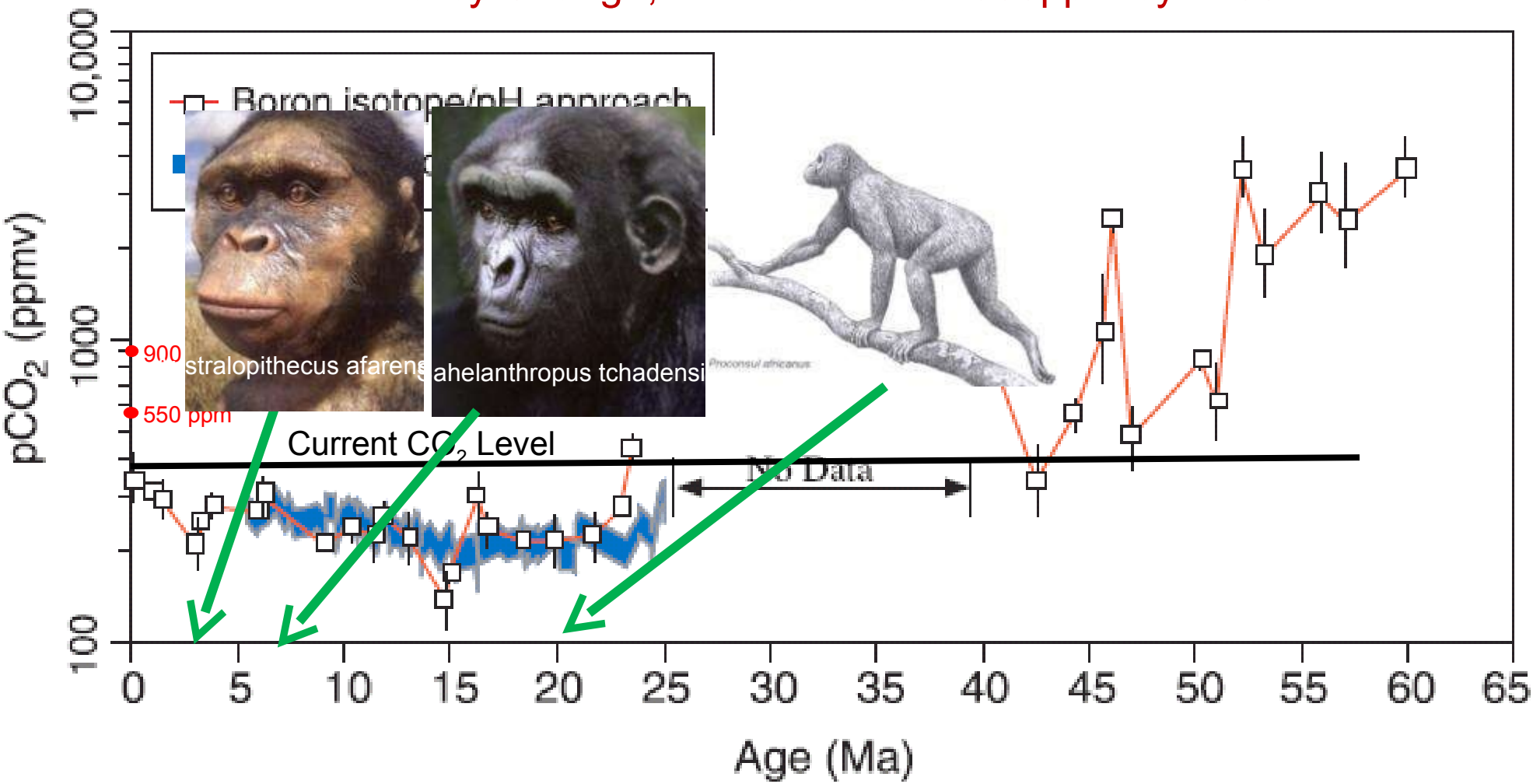
UNEP GRID ARENDAL
Environmental Knowledge for Change

Martin Vermeer and Stefan Rahmstorf,
PNAS, v. 106, 21527–21532 (2009)

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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

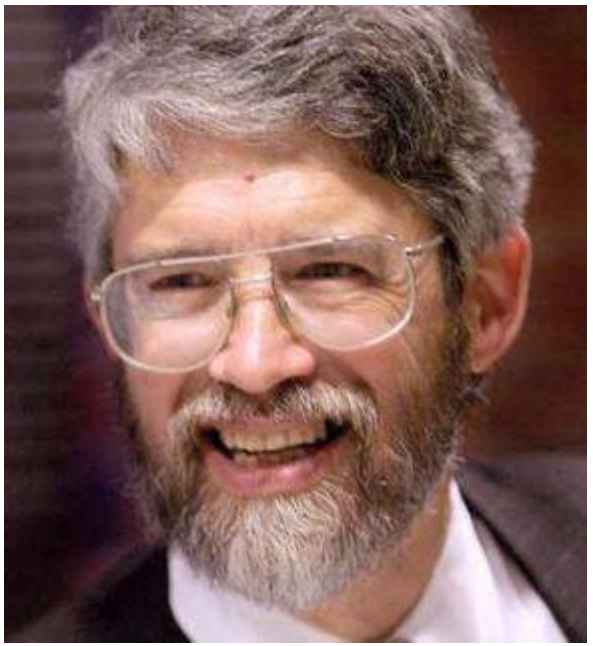
Homonid Images: *The Last Human*, G.J. Sawyer and V. Deak

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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:

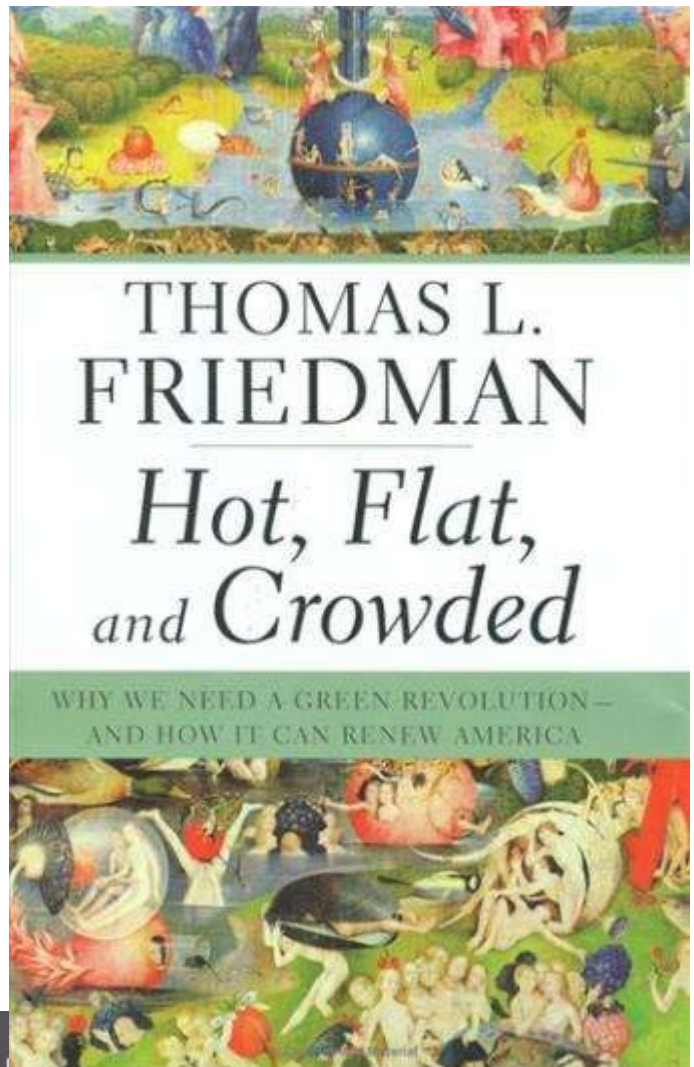
- Real without doubt
- Mainly caused by humans
- Already producing significant harm
- Growing more rapidly than expected"

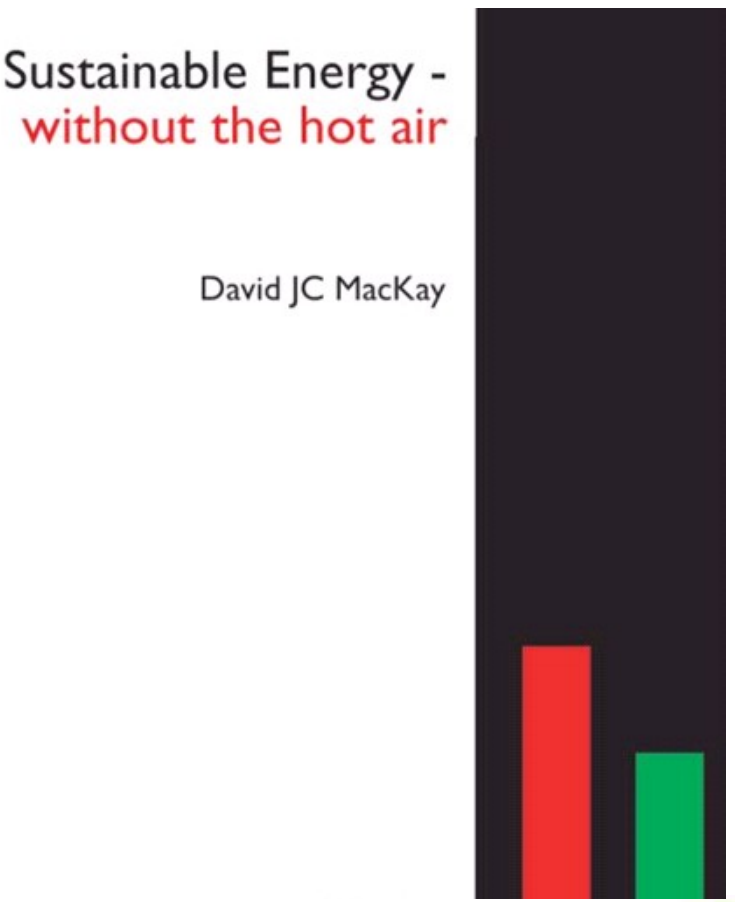
-- John Holdren, Director Office of Science and Technology Policy
June 25, 2008

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

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"





How Can PRAGMA Research Help Slow Down the Increasing Greenhouse Gas Emissions?





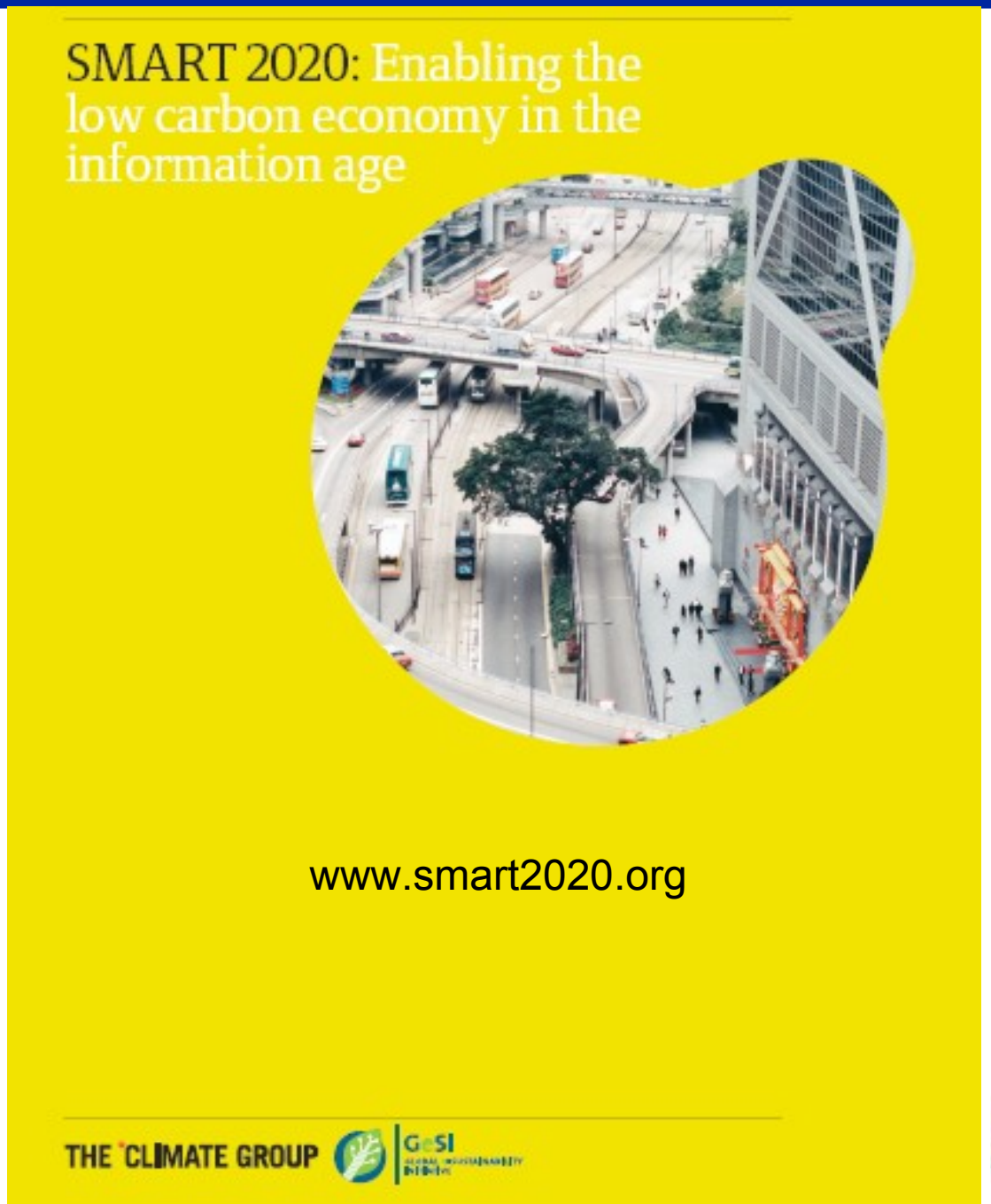
ICT is a Critical Element in Achieving Countries Greenhouse Gas Emission Reduction Targets

GeSI member companies:

- Bell Canada,
- British Telecomm.,
- Plc,
- Cisco Systems,
- Deutsche Telekom AG,
- Ericsson,
- France Telecom,
- Hewlett-Packard,
- Intel,
- Microsoft,
- Nokia,
- Nokia Siemens Networks,
- Sun Microsystems,
- T-Mobile,
- Telefónica S.A.,
- Telenor,
- Verizon,
- Vodafone Plc.

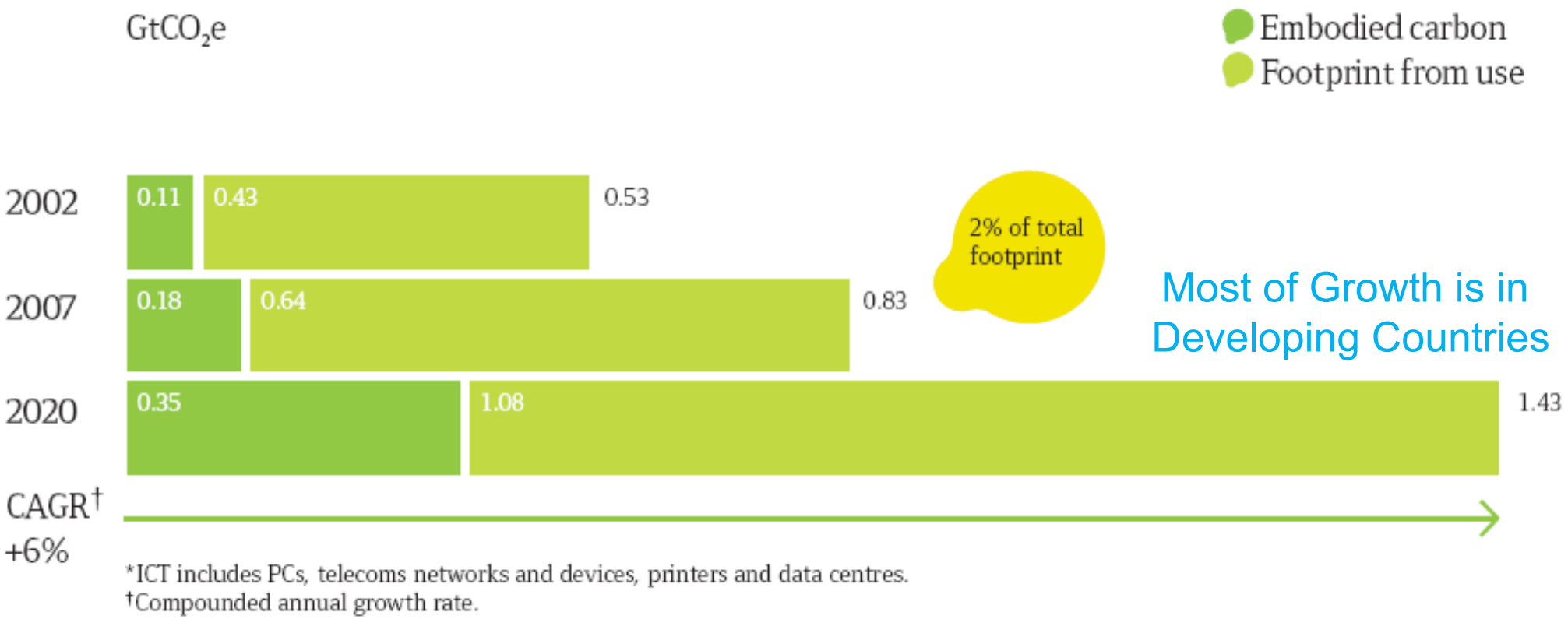
Additional support:

- Dell, LG.



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The Global ICT Carbon Footprint is Significant and Growing at 6% Annually!

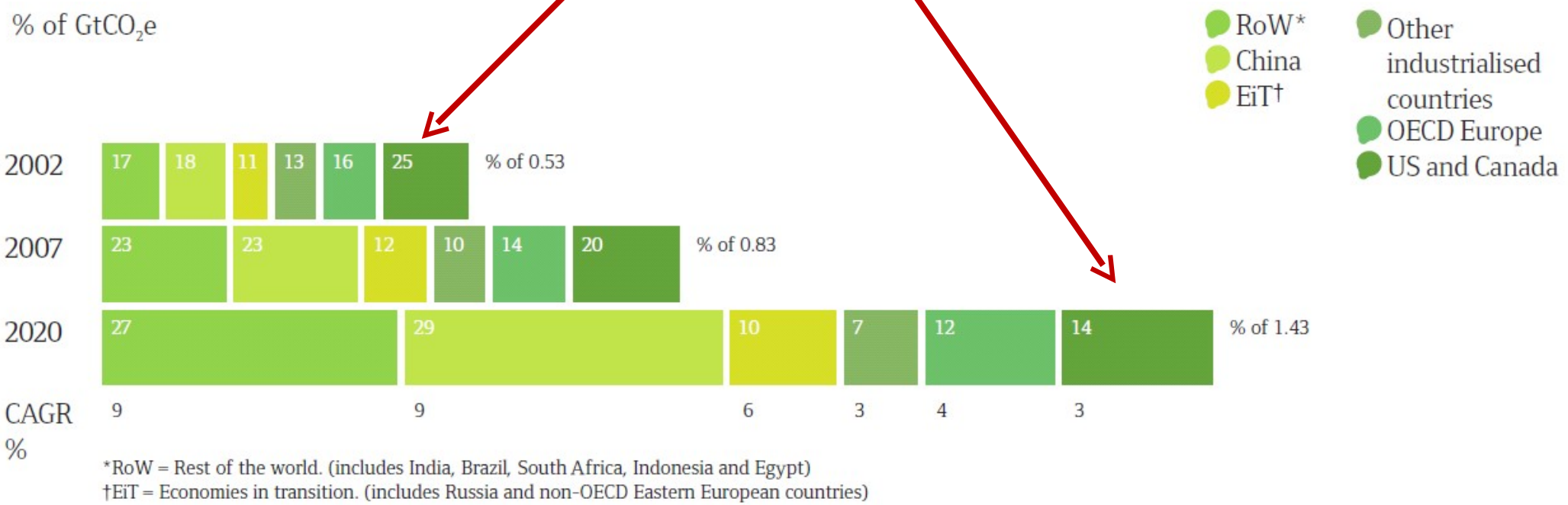


the assumptions behind the growth in emissions expected in 2020:

- takes into account likely efficient technology developments that affect the power consumption of products and services
- and their expected penetration in the market in 2020

Reduction of ICT Emissions is a Global Challenge – U.S. and Canada are Small Sources

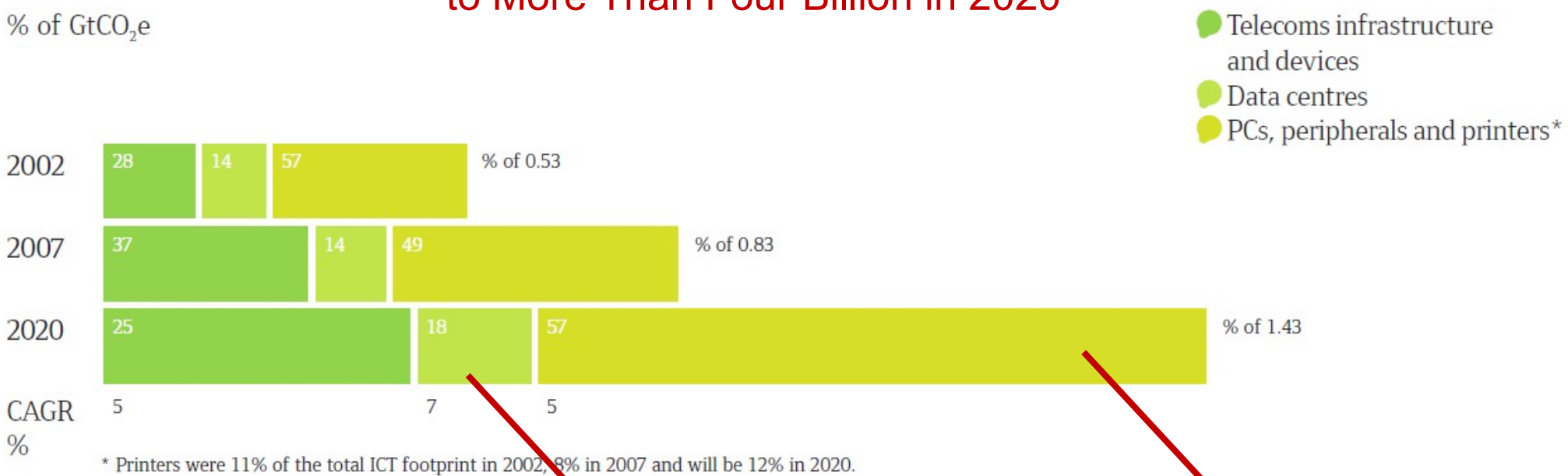
U.S. plus Canada Percentage Falls From
25% to 14% of Global ICT Emissions by 2020



*RoW = Rest of the world. (includes India, Brazil, South Africa, Indonesia and Egypt)
†EiT = Economies in transition. (includes Russia and non-OECD Eastern European countries)

The Global ICT Carbon Footprint by Subsector

The Number of PCs (Desktops and Laptops) Globally
is Expected to Increase
from 592 Million in 2002
to More Than Four Billion in 2020



Data Centers Are Rapidly Improving

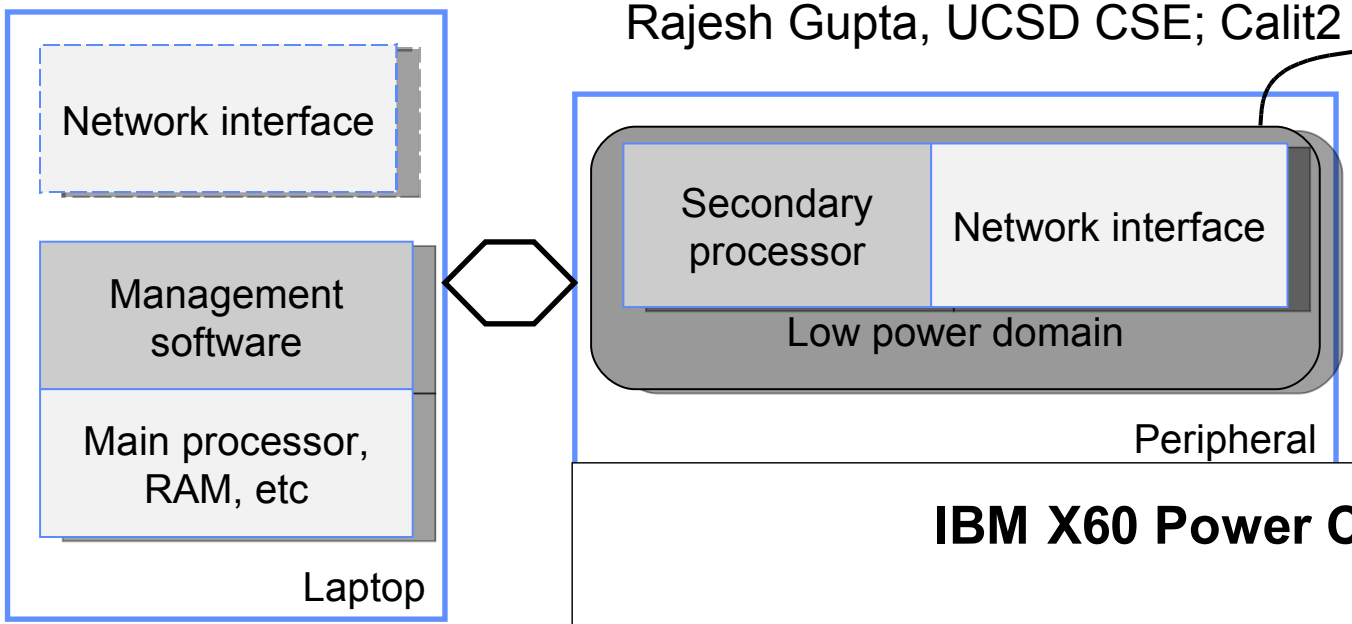
PCs Are Biggest Problem

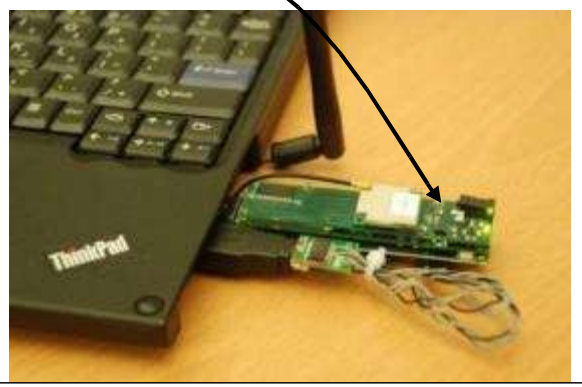
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www.smart2020.org

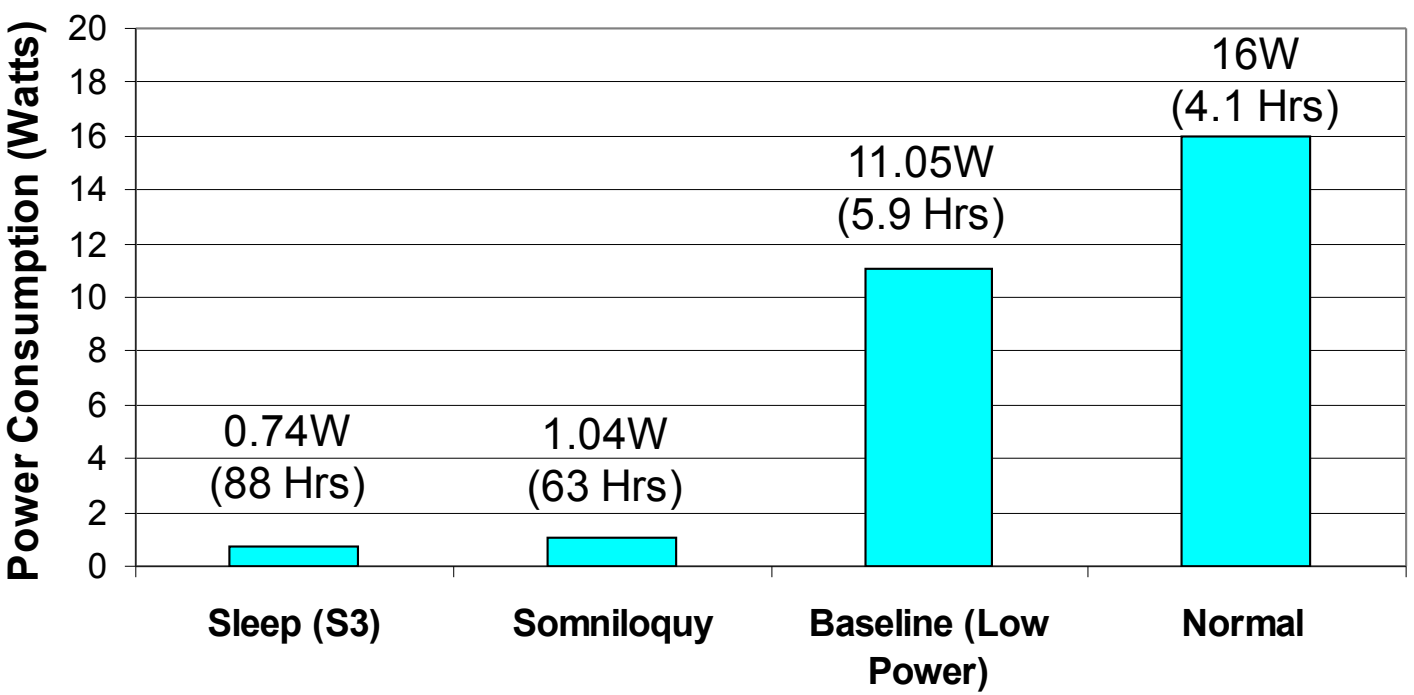
Increasing Laptop Energy Efficiency: Putting Machines To Sleep Transparently

Rajesh Gupta, UCSD CSE; Calit2





Somniloquy Enables Servers to Enter and Exit Sleep While Maintaining Their Network and Application Level Presence



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Application of ICT Can Lead to a 5-Fold Greater Decrease in GHGs Than its Own Carbon Footprint

While the sector plans to significantly step up the energy efficiency of its products and services, ICT's largest influence will be by enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020.

--Smart 2020 Report

Major Opportunities for the United States*

- **Smart Electrical Grids**
- **Smart Transportation Systems**
- **Smart Buildings**
- **Virtual Meetings**

*** Smart 2020 United States Report Addendum**

www.smart2020.org

Next Stage: Developing Greener Smart Campuses Calit2 (UCSD & UCI) Prototypes

- **Coupling the Internet and the Electrical Grid**
  - Choosing non-GHG Emitting Electricity Sources
  - Measuring Demand at Sub-Building Levels
  - Reducing Local Energy Usage via User Access Thru Web
- **Transportation System**
  - Campus Wireless GPS Low Carbon Fleet
  - Green Software Automobile Innovations
  - Driver Level Cell Phone Traffic Awareness
- **Travel Substitution**
  - Commercial Teleconferencing
  - Next Generation Global Telepresence

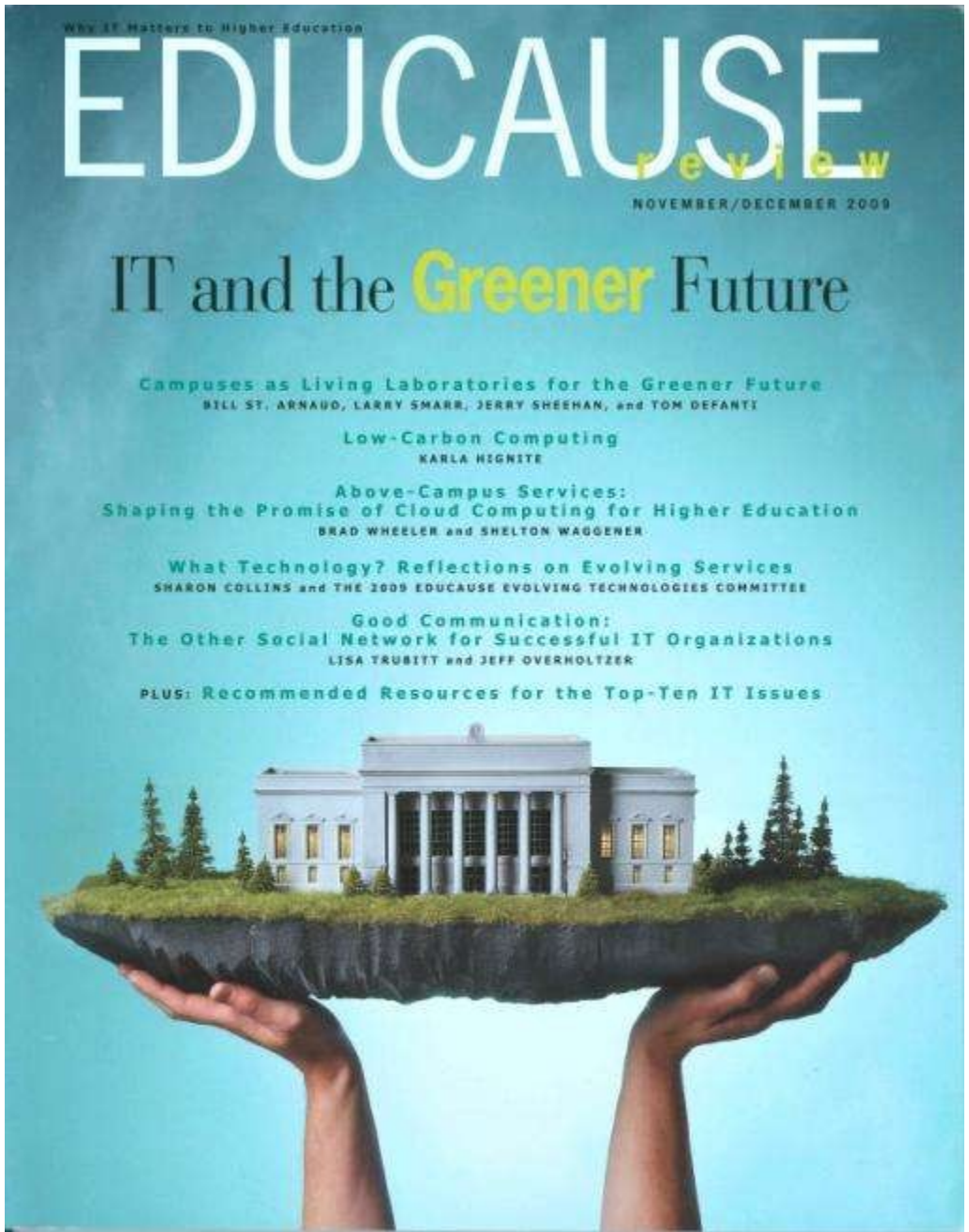
Student Video -- UCSD Living Laboratory for Real-World Solutions
www.gogreentube.com/watch.php?v=NDc4OTQ1 on UCSD

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UCI Named 'Best Overall' in Flex Your Power Awards
www.today.uci.edu/news/release_detail.asp?key=1859

Make All PRAGMA Campuses Living Laboratories for the Greener Future

www.educause.edu/EDUCAUSE+Review/EDUCAUSEReviewMagazineVolume44/CampusesasLivingLaboratoriesfo/185217



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Research Needed on How to Deploy a Green CI: PRAGMA as an International Green CI Testbed?



- **Computer Architecture**
  - Rajesh Gupta/CSE
- **Software Architecture**
  - Amin Vahdat, Ingolf Kruger/CSE
- **CineGrid Exchange**
  - Tom DeFanti/Calit2
- **Visualization**
  - Falko Kuster/Structural Engineering
- **Power and Thermal Management**
  - Tajana Rosing/CSE
- **Analyzing Power Consumption Data**
  - Jim Hollan/Cog Sci
- **Direct DC Datacenters**
  - Tom Defanti, Greg Hidley

Toward "Zero Carbon" ICT
Green Cloud Computing and Storage

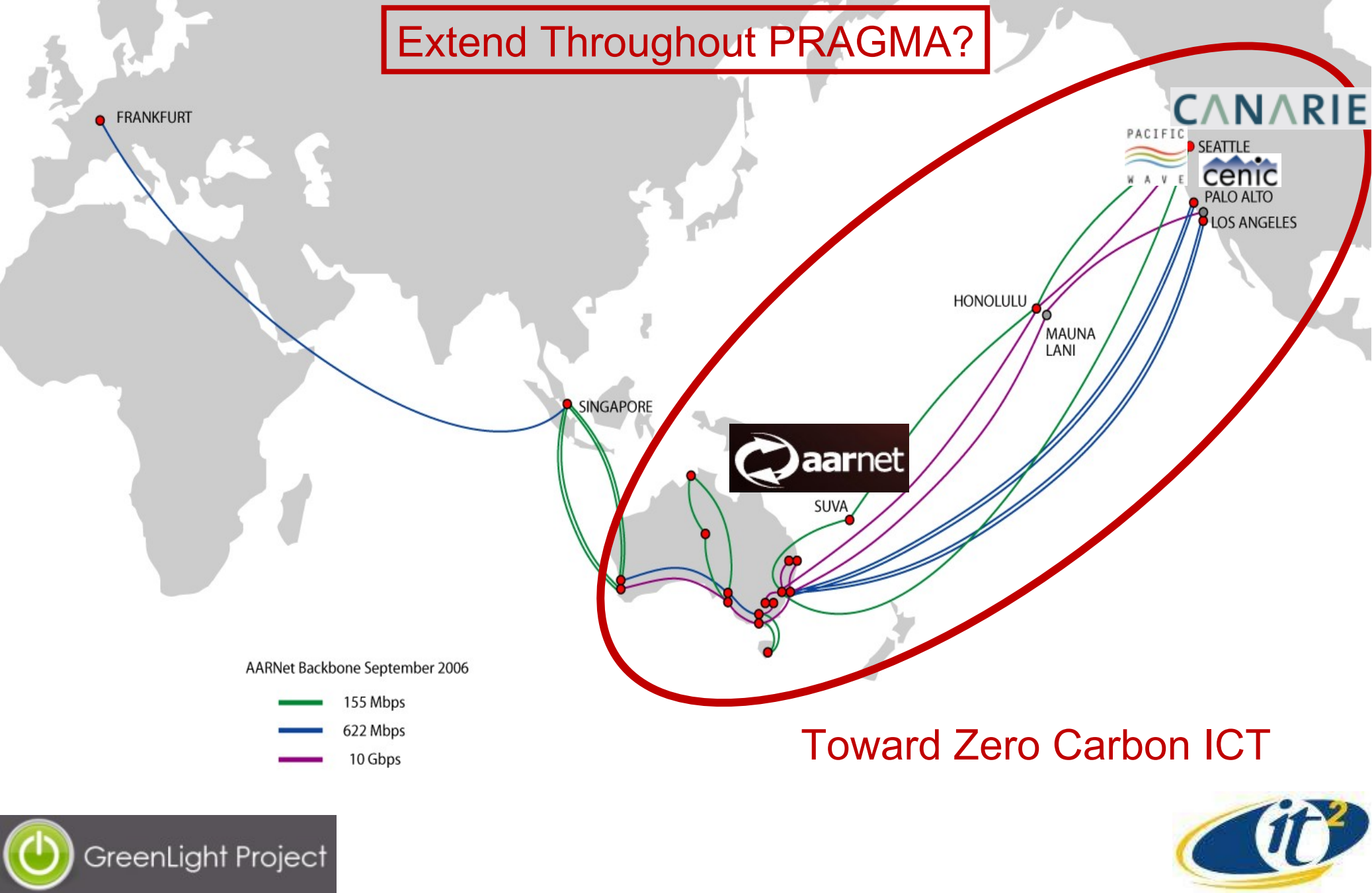
- **Purchasing Green Power Locally is Expensive with Significant Transmission Line Losses**
  - **Demand for Green Power Within Cities is Growing Dramatically**
  - **ICT Facilities Don't Need To Be Located In Cities**
- **But Most Renewable Energy Sites are Very Remote and Impractical to Connect to Electrical Grid**
  - **Can be Easily Reached by an Optical Network**
  - **Provide Independence from Electrical Utility**
  - **Savings in Transmission Line Losses (Up To 15% Alone)**
  - **Plus Carbon Offsets Can Pay for Moving ICT Facilities to Renewable Energy Site**
- **Calit2 is Discussing Partnering with Canada**
  - **Move a GreenLight Facility to Hydro Site in British Columbia**
  - **Link by 10Gbps Optical Fiber to Calit2—Offer to Remote Users**

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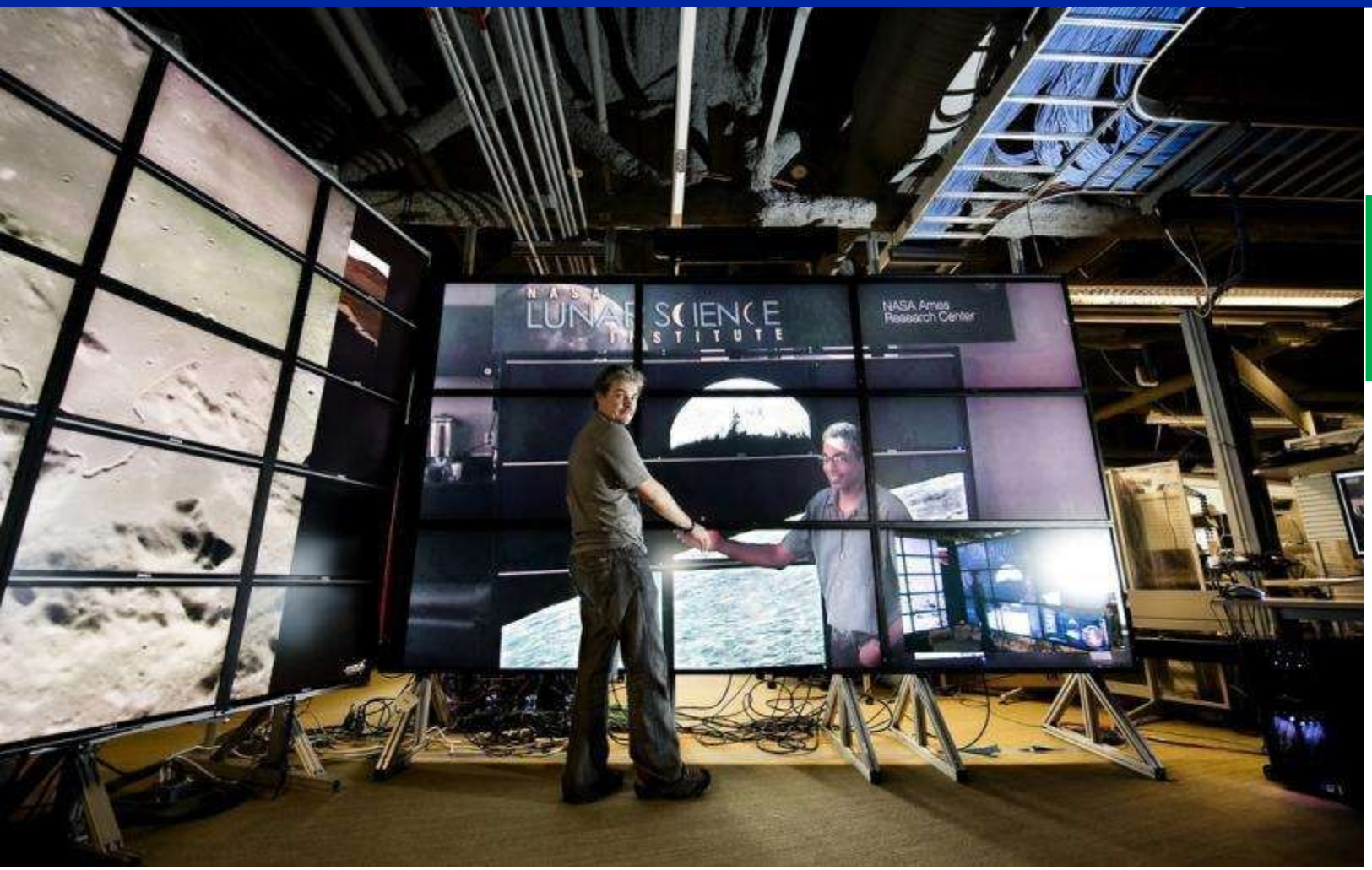
Source: Bill St. Arnaud, CANARIE, Canada

it²

Coupling AARNet - CENIC/PW - CANARIE Optical Nets: An Australian-U.S.-Canada Green Cloud Testbed



High Definition Video Connected OptIPortals: Virtual Working Spaces for Data Intensive Research



NASA Interest in Supporting Virtual Institutes

CGLX

LifeSize HD

NASA Ames
Lunar Science Institute
Mountain View, CA

Extend Throughout PRAGMA?

Source: Falko Kuester, Kai Doerr Calit2; Michael Sims, NASA

GreenLight Project

it²

PRAGMA Reducing Carbon Emissions Using Optical Networks and HD



GreenLight Project

You Can Download This Presentation at lsmarr.calit2.net



ABOUT LARRY SMARR

Larry Smarr is the founding Director of the California Institute for Telecommunications and Information Technology (Calit2), a UC San Diego/UC Irvine partnership, and holds the Harry E. Gruber professorship in Computer Science and Engineering (CSE) at UCSD's Jacobs School. At Calit2, Smarr has

WHAT I'M READING

Complete List of Larry's Recommendations

On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead (2008)

RECENT TWITTER POSTS

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Ismarr: Great GreenLight research meeting yesterday--lots of UCSD researchers exploring much greener