Climate Change:
It's Not Just for Scientists

50th Anniversary of the Global CO_2 Record Symposium and Celebration

November 28-30, 2007
Kona, Hawaii

Ralph J. Cicerone, President
National Academy of Sciences

OUTLINE

The Rise of Carbon Dioxide

Other Greenhouse Gases

Human Energy Usage Drives Climate Change

Changing Temperatures, Ice Losses, Sea Level Rise

Mitigation and Adaptation

Defining "dangerous"

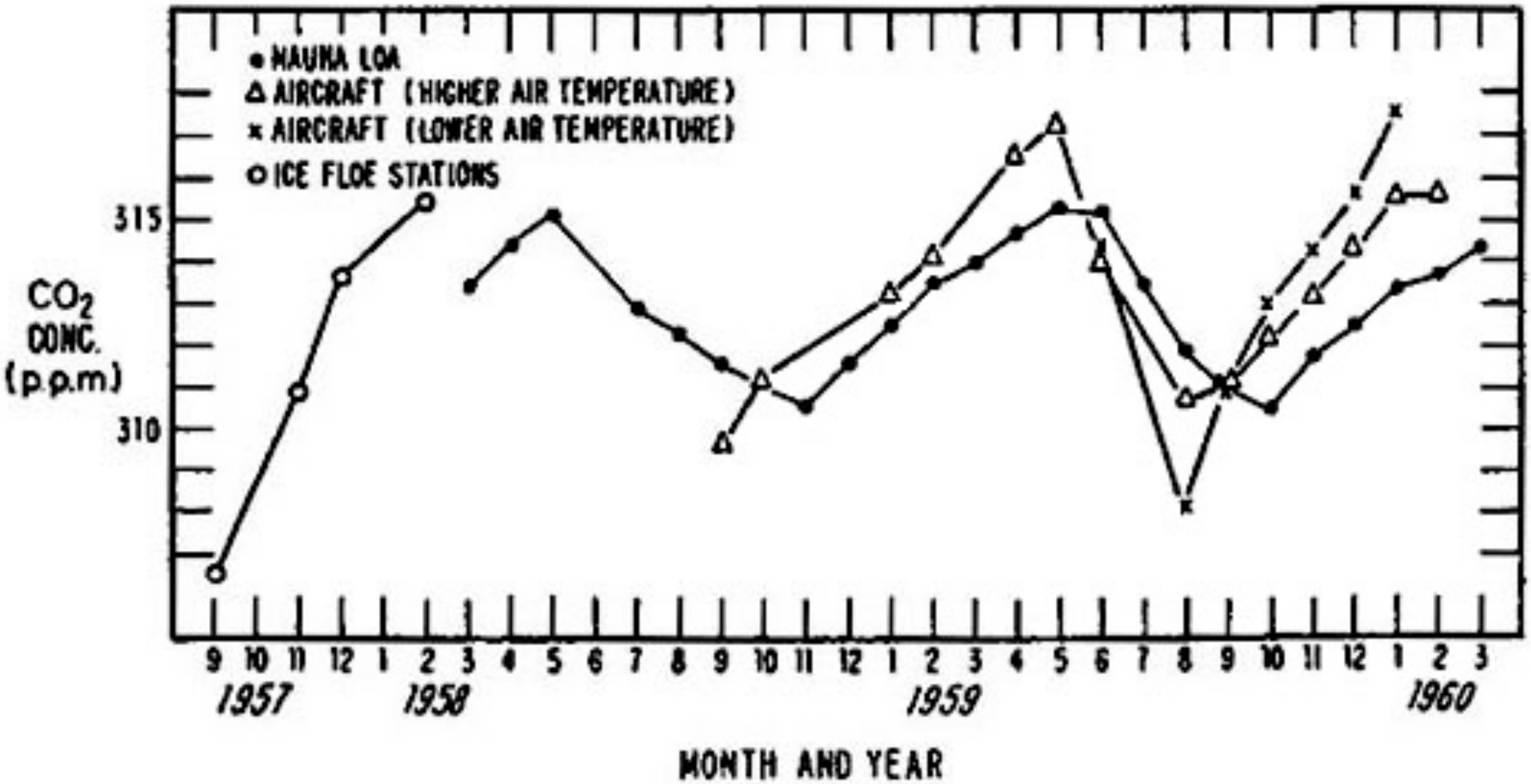
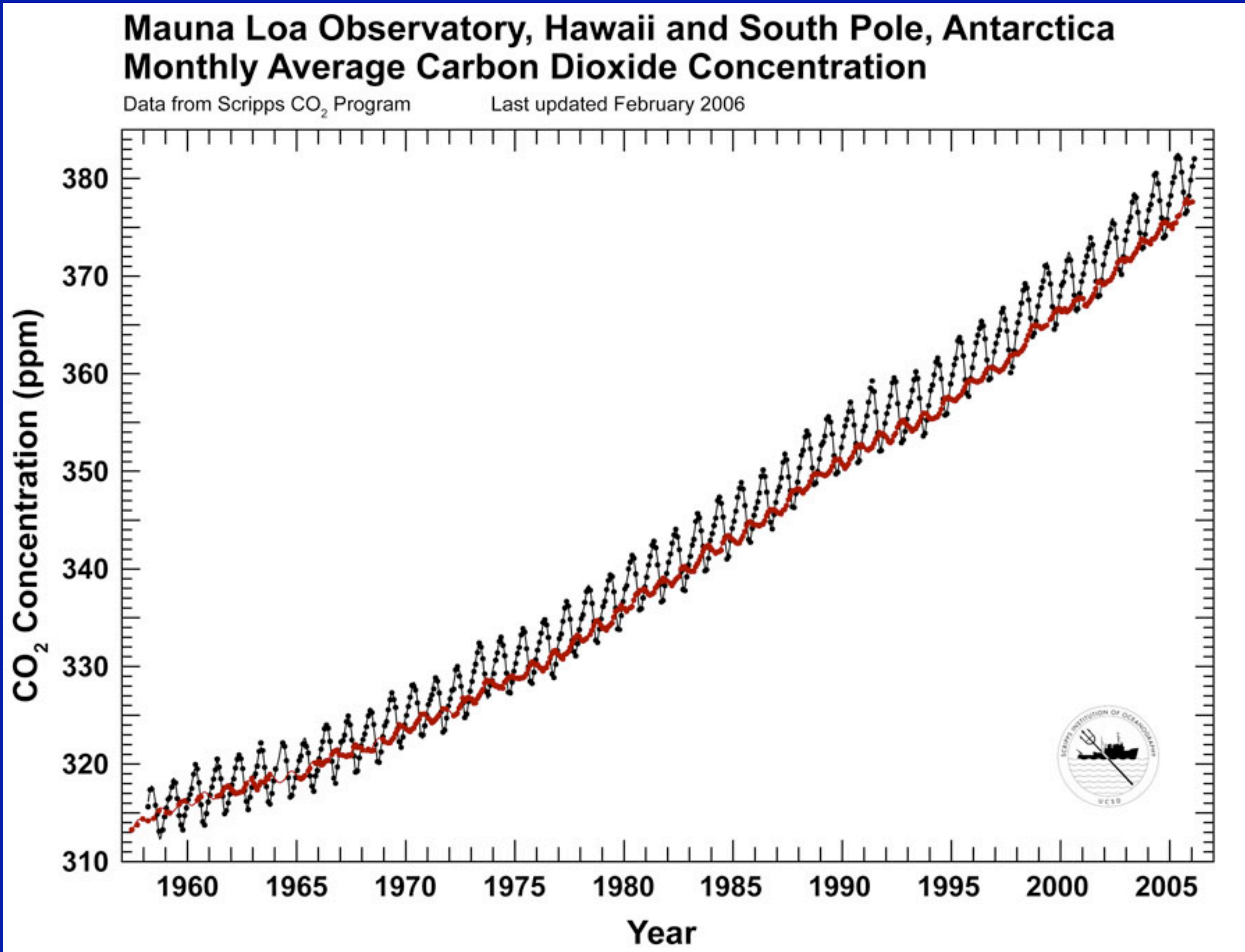
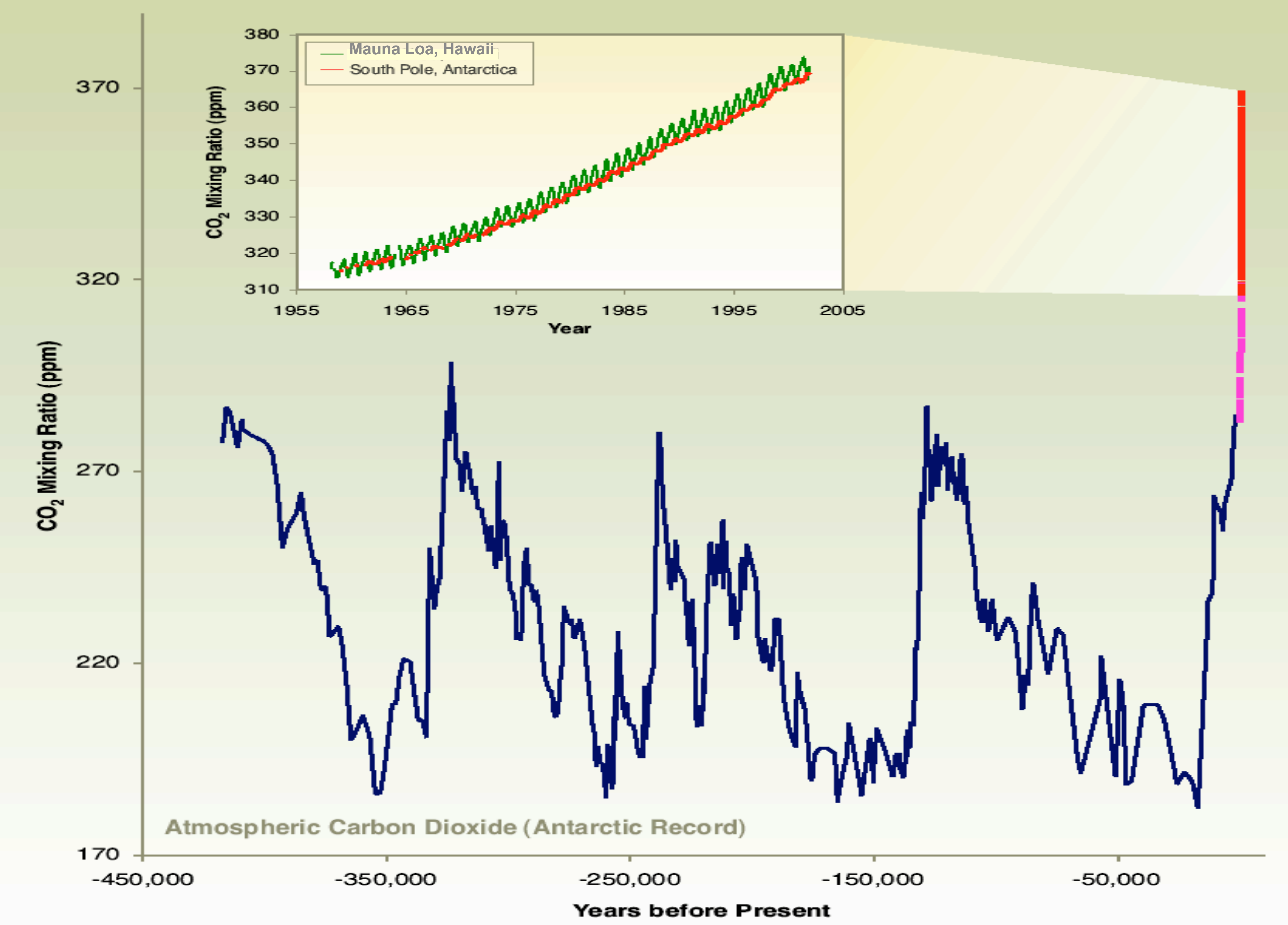


Fig. 1. Variation in concentration of atmospheric carbon dioxide in the Northern Hemisphere.

Tellus XII (1960), 2

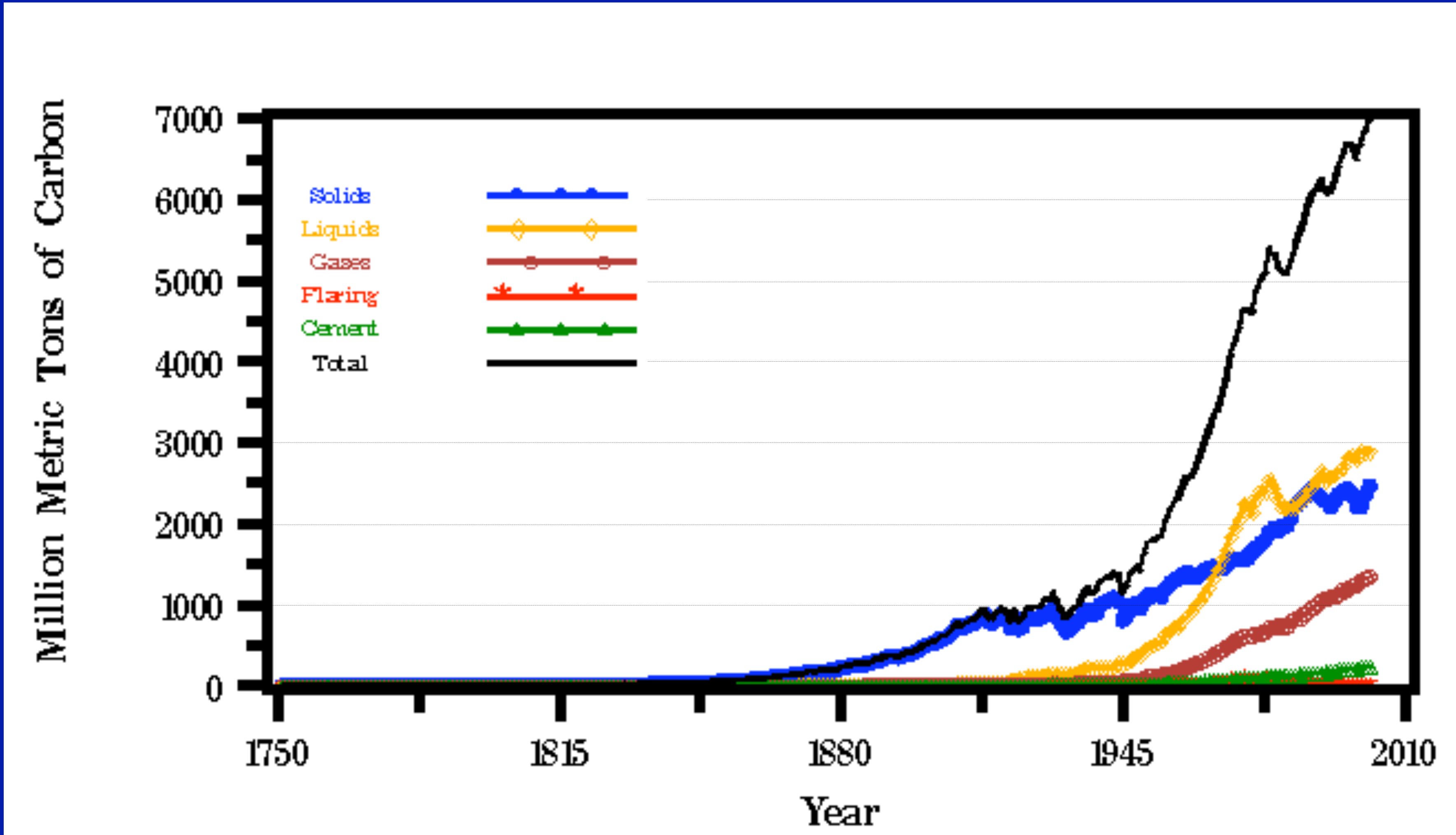
C. D. Keeling


Mauna Loa Observatory, Hawaii and South Pole, Antarctica
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO_2 Program
Last updated February 2006
CO_2 Concentration (ppm)
310
320
330
340
350
360
370
380
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year



From Petite et al (1999), Fischer et al (1999) and Figure 4 (inset)

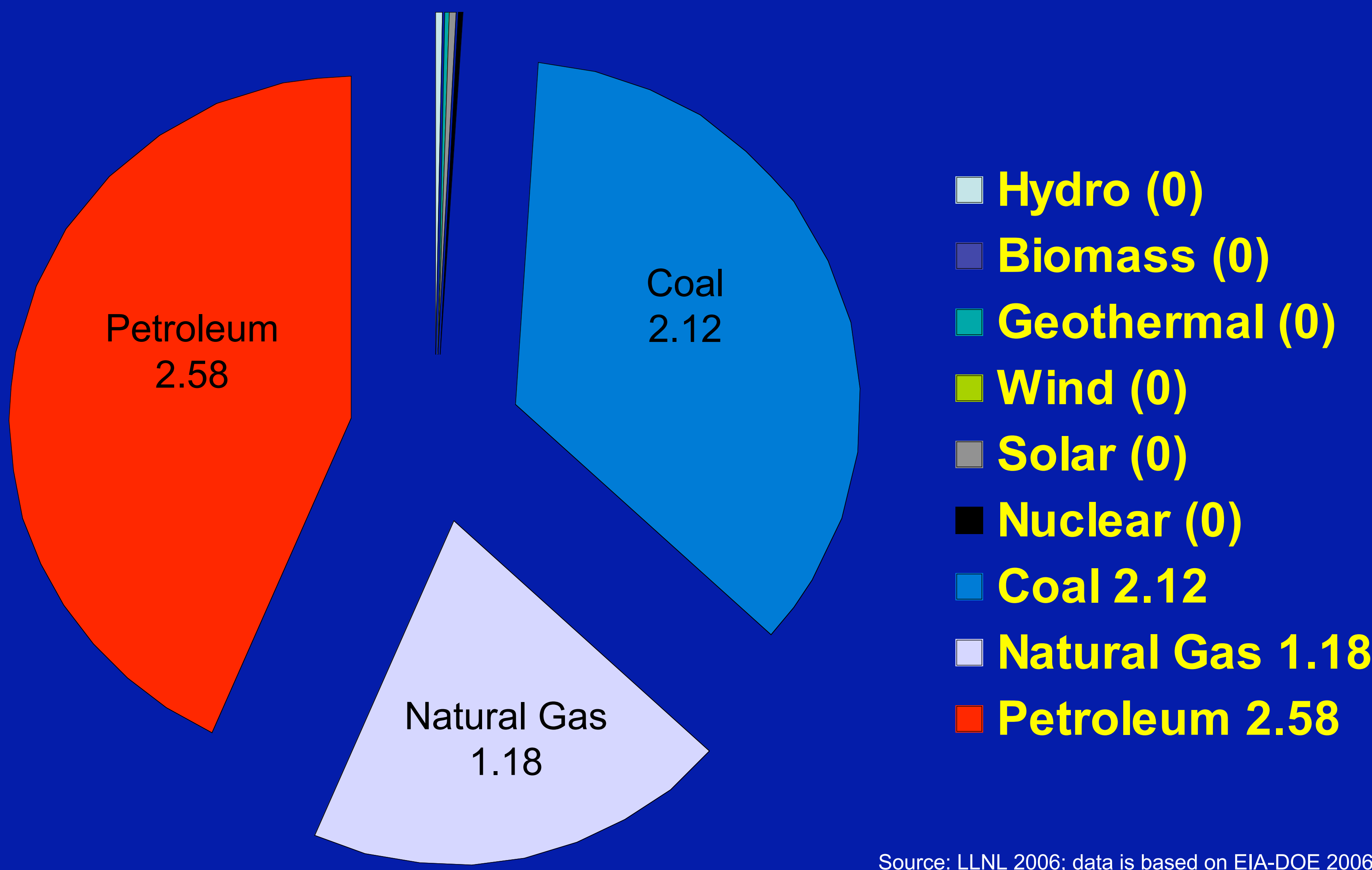
Global, Regional, and National CO_2 emissions



Global CO_2 emissions from fossil fuel burning, cement production, and gas flaring for 1751-2002

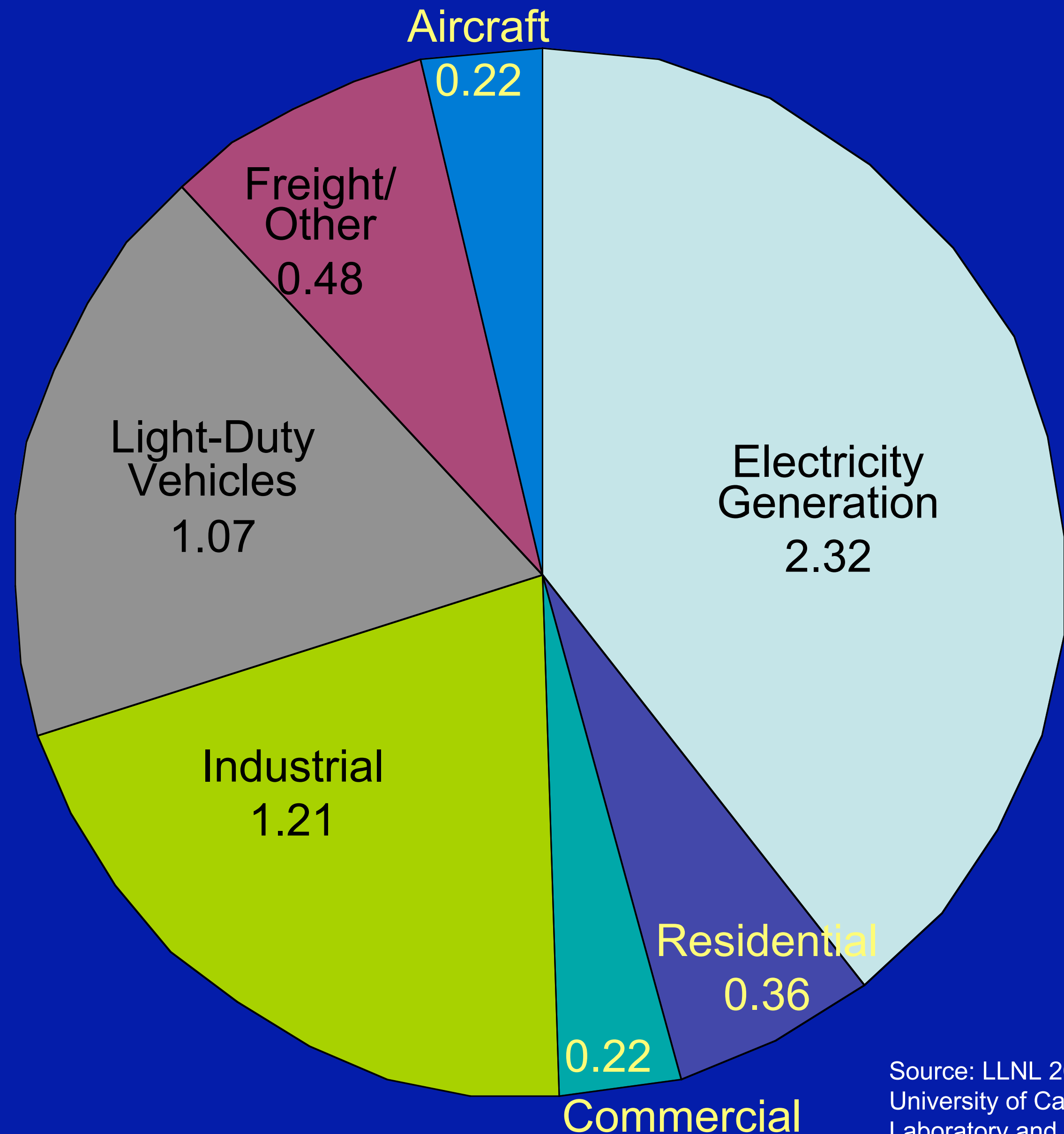
http://cdiac.esd.ornl.gov

U.S Carbon Dioxide Emissions From Energy Consumption by Source (in billion metric tons CO_2)

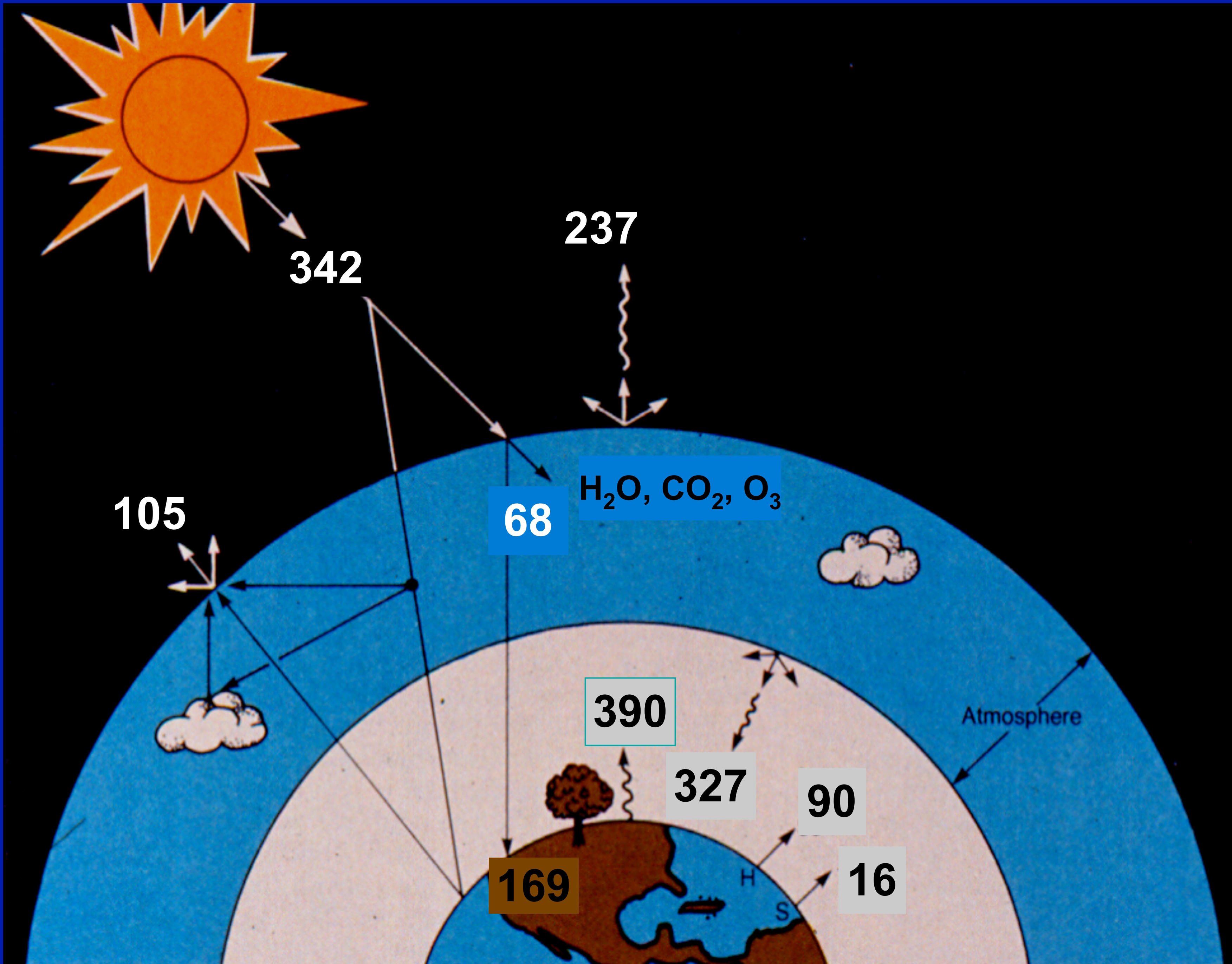


Source: LLNL 2006; data is based on EIA-DOE 2006b.
University of California, Lawrence Livermore National Laboratory and the Department of Energy

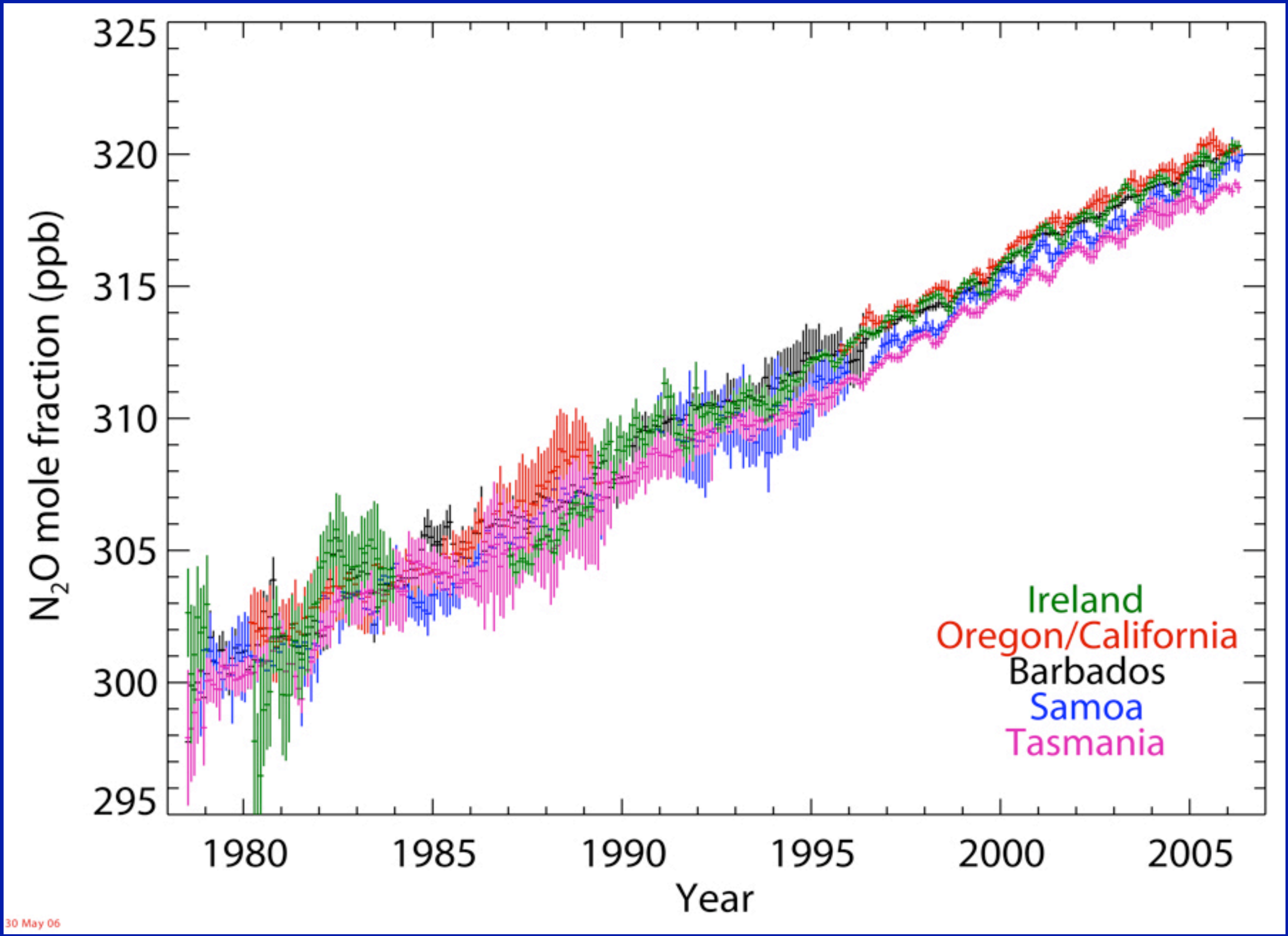
U.S Carbon Dioxide Emissions From Energy Consumption by Usage (in billion metric tons CO_2)



Source: LLNL 2006; data is based on EIA-DOE 2006b. University of California, Lawrence Livermore National Laboratory and the Department of Energy

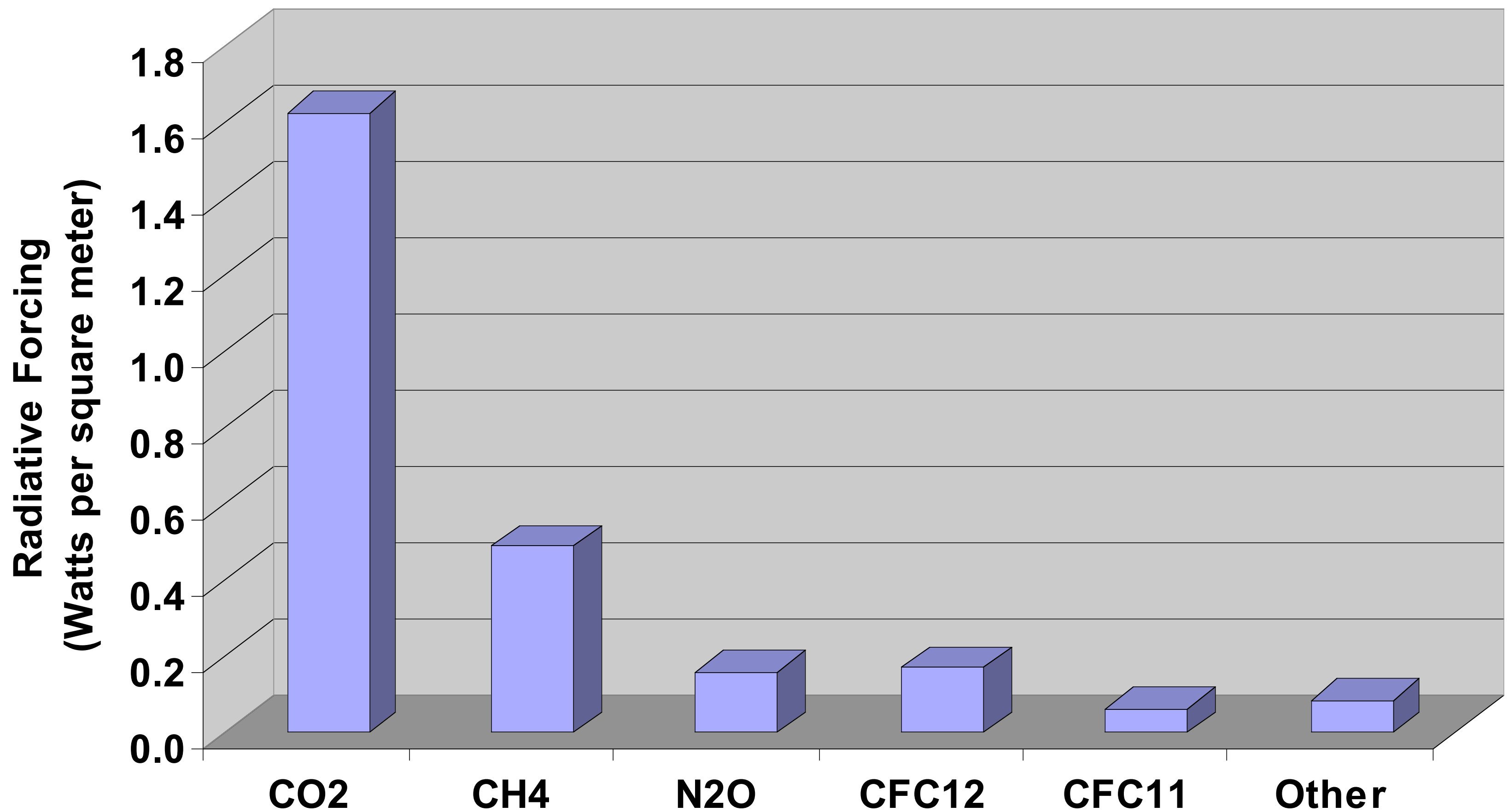


237
342
105
68
H_2O, CO_2, O_3
390
327
90
16
169
H
S
Atmosphere



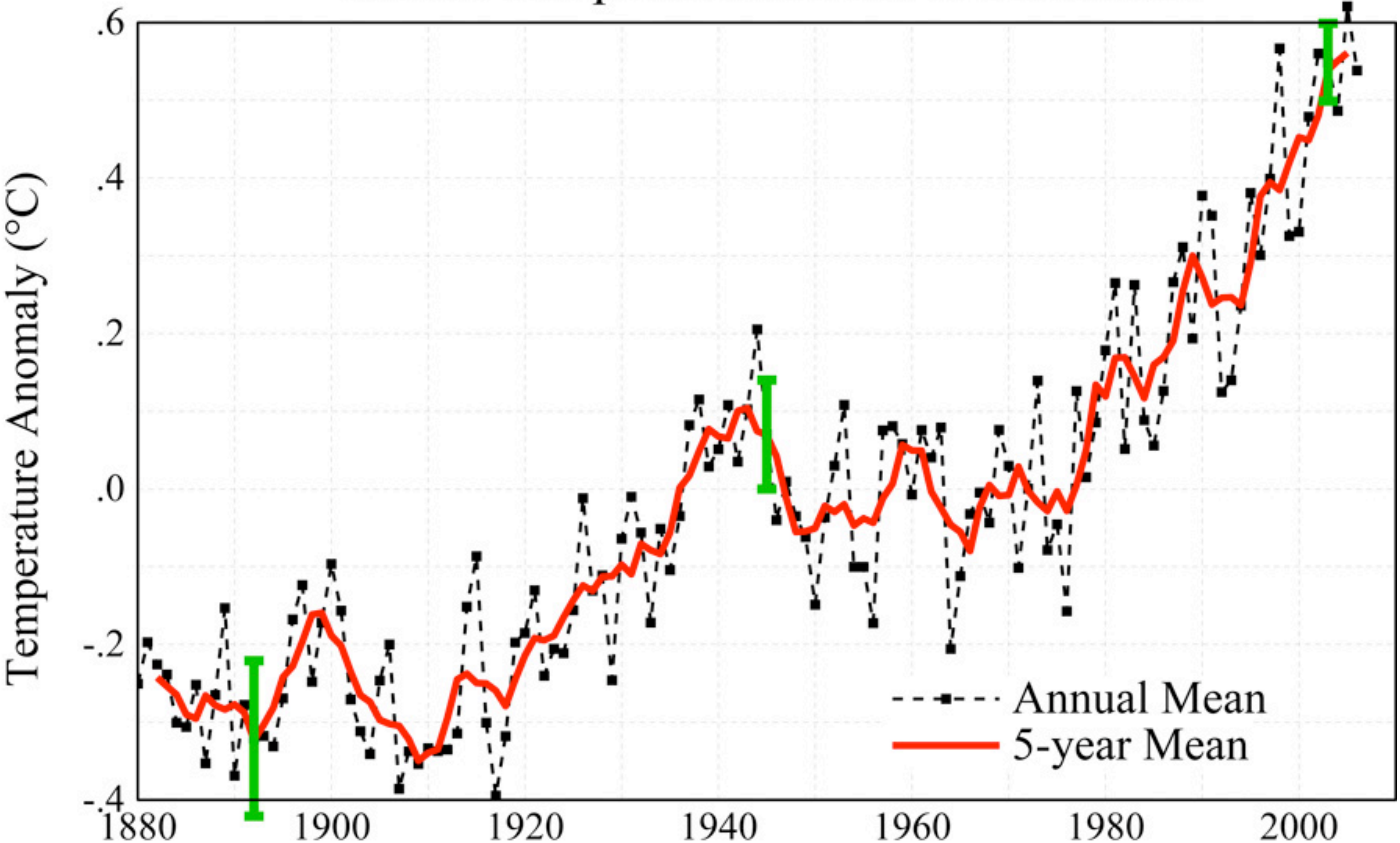
http://agage.eas.gatech.edu

2004 Radiative forcing from well-mixed greenhouse gases



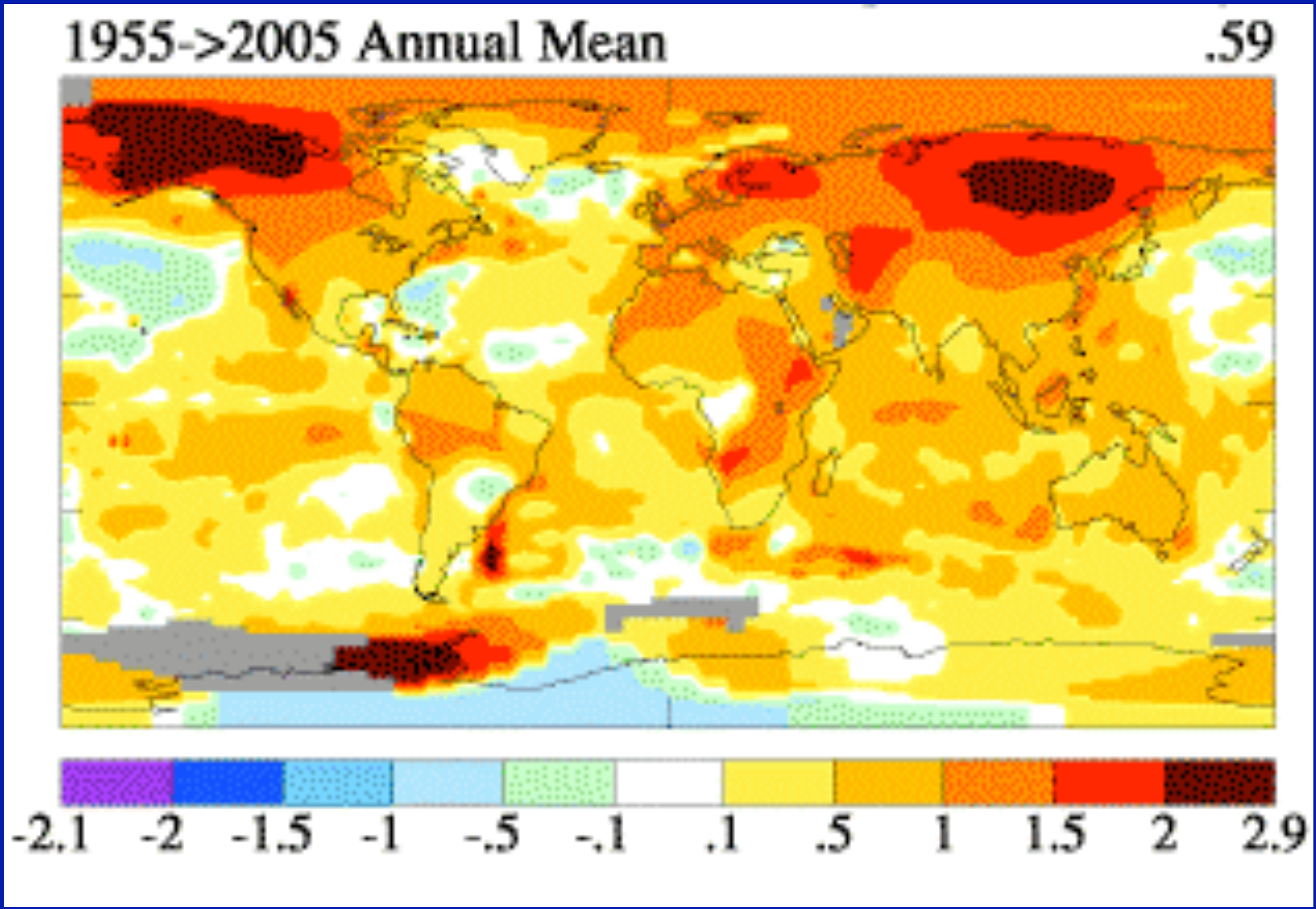
Source: NOAA ESRL Global Monitoring Division

Global Temperature: Land-Ocean Index

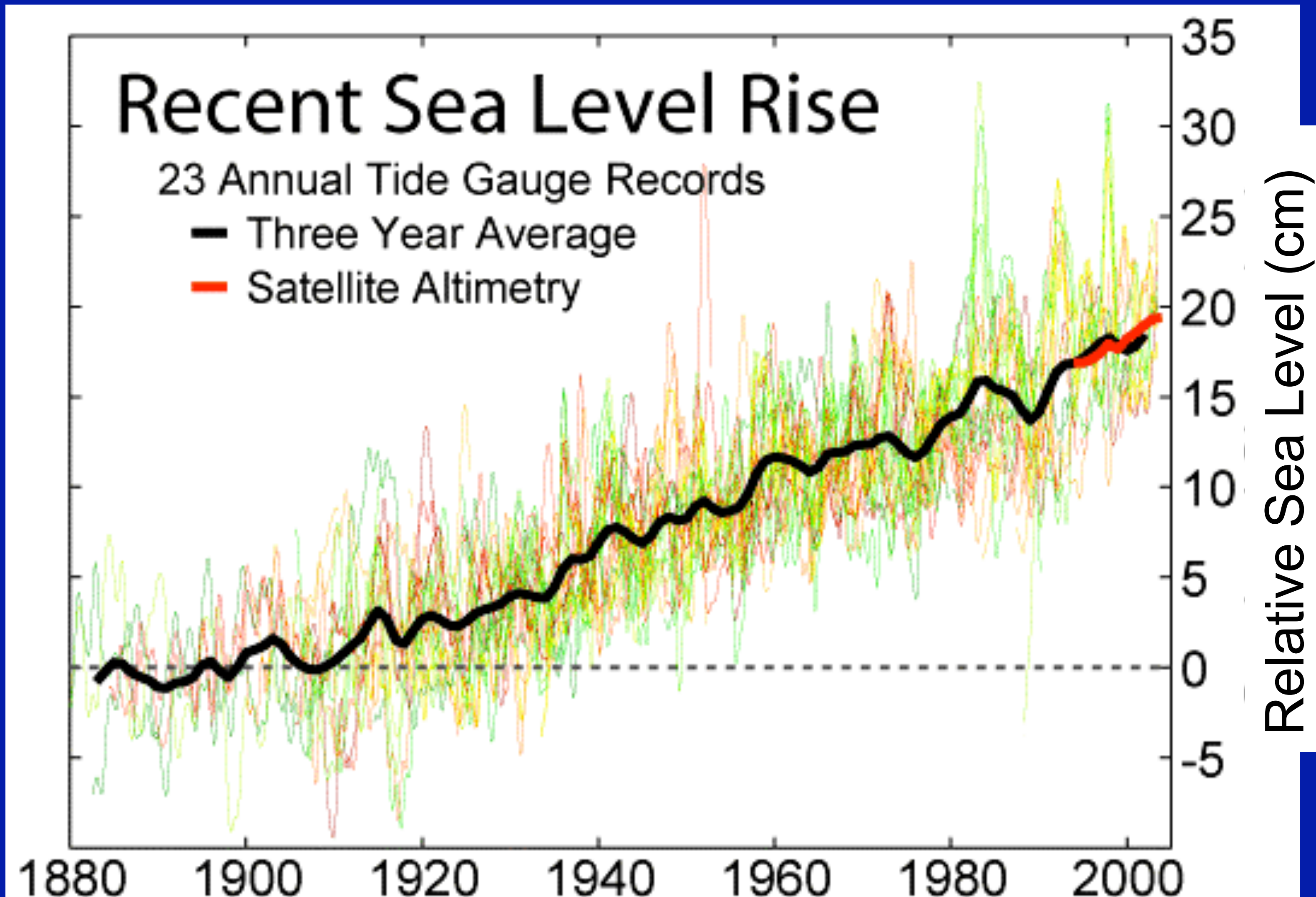


www.giss.nasa.gov/gistemp
(updated from Hansen et al., 2001)

Last 50 Years Surface Temperature Change Based on Linear Trends (°C)



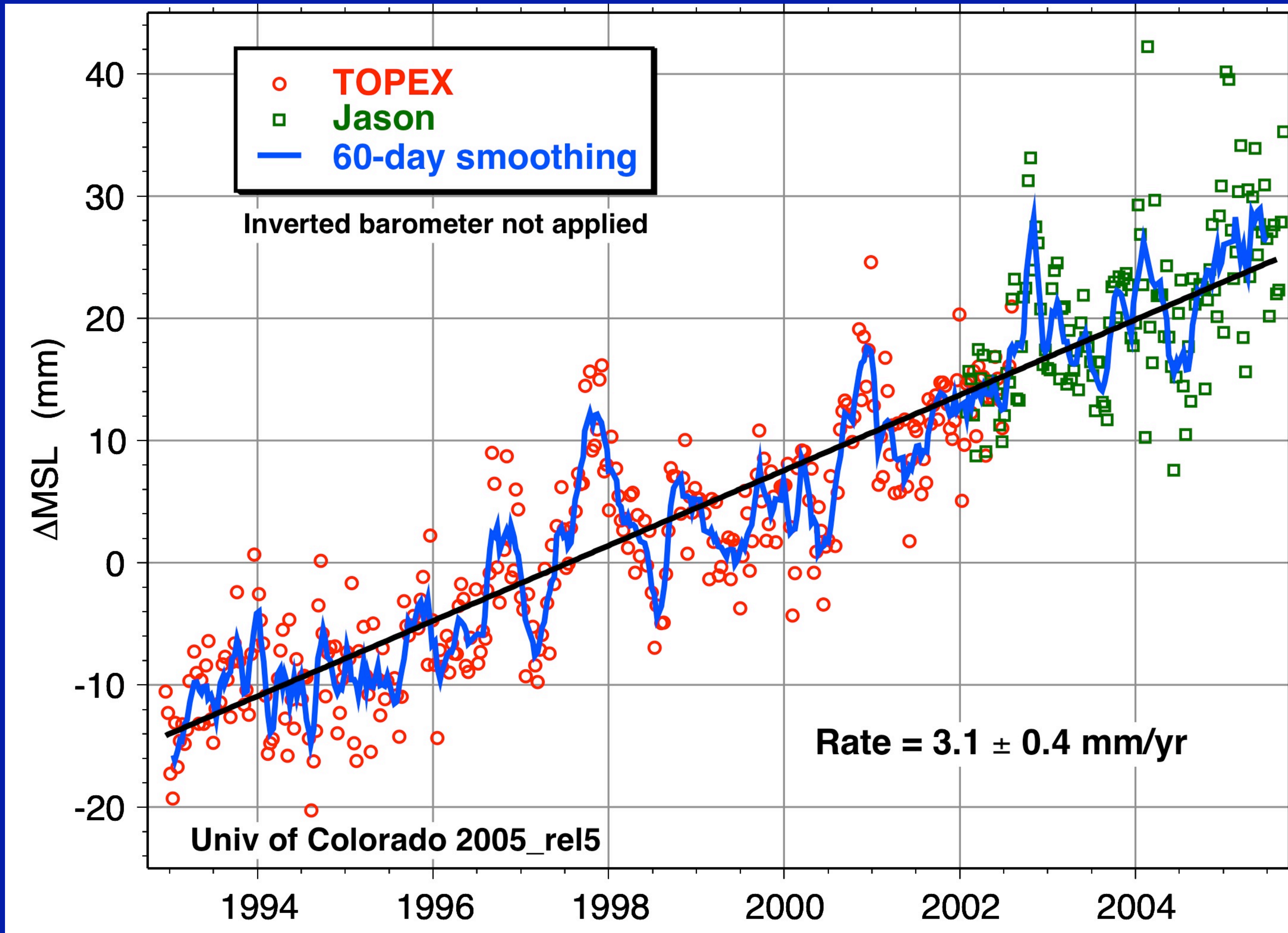
www.giss.nasa.gov/gistemp (updated from Hansen et al (2001))



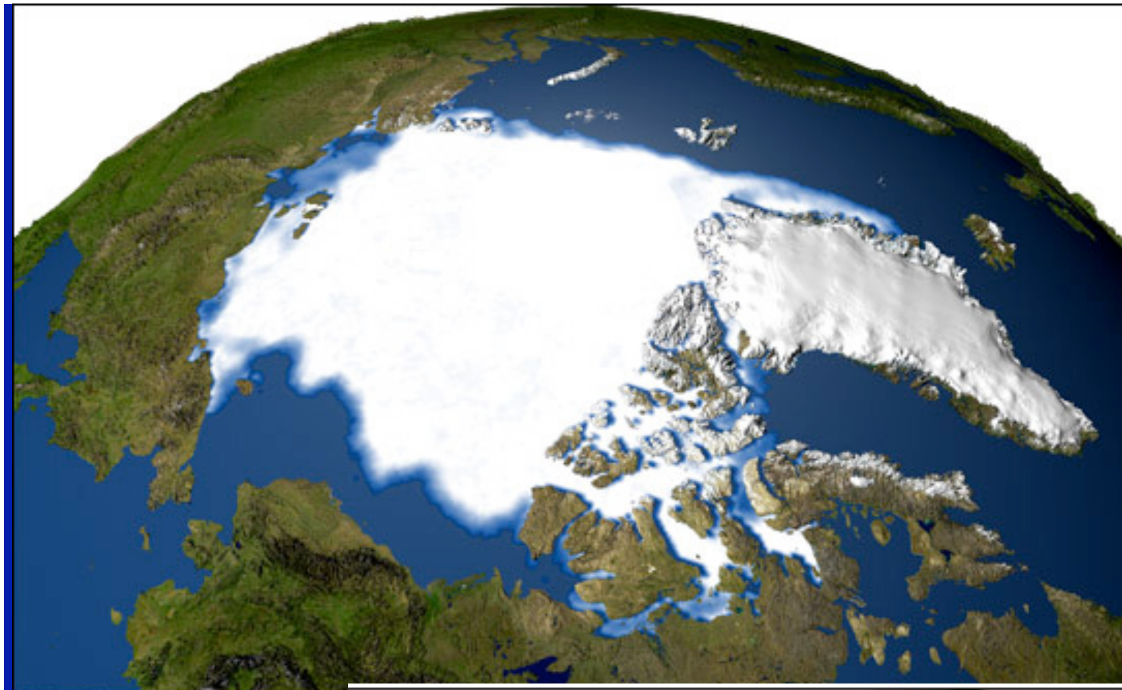
1882-2005 sea level rise based on Permanent Service for Mean Sea Level (PSMSL) tide gauge data from 23 sites selected by Douglas (1997)

This figure was prepared by Robert A. Rohde

http://www.globalwarmingart.com/wiki/Image:Recent_Sea_Level_Rise.png



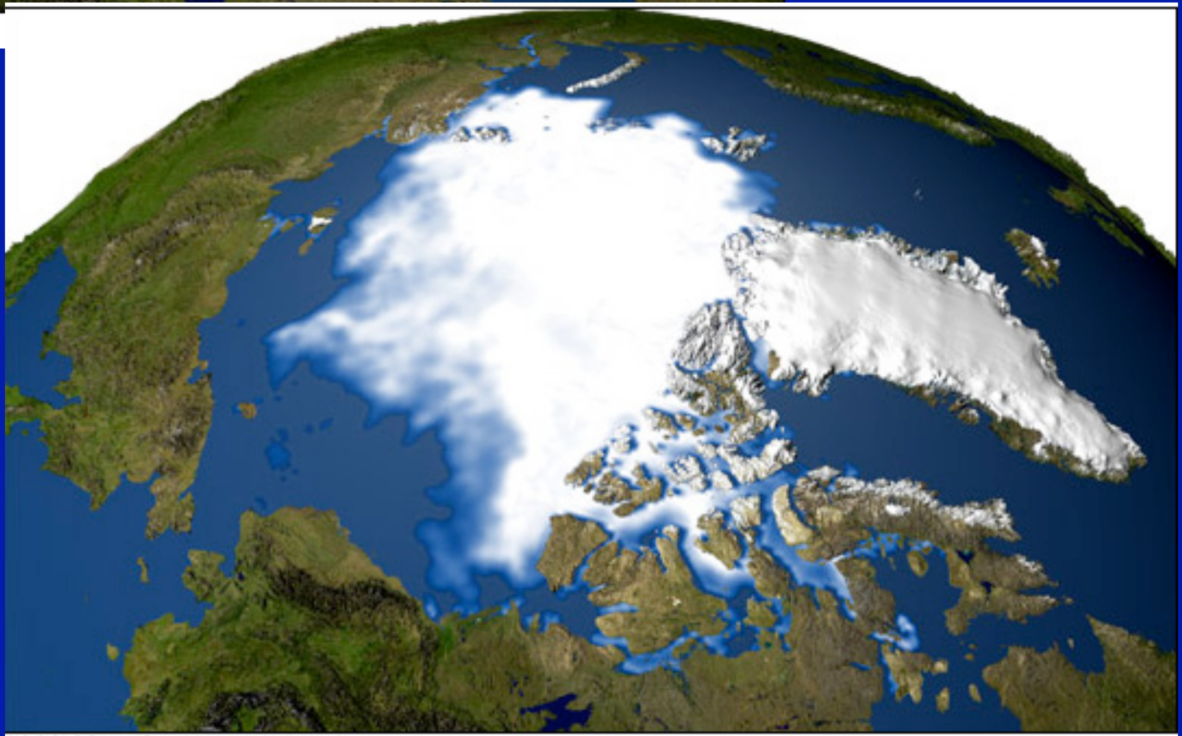
1992-2006 sea level rise observed by satellite altimetry
(Leuliette et al 2004, updated at http://sealevel.colorado.edu)



1979 SSMI Composite Data

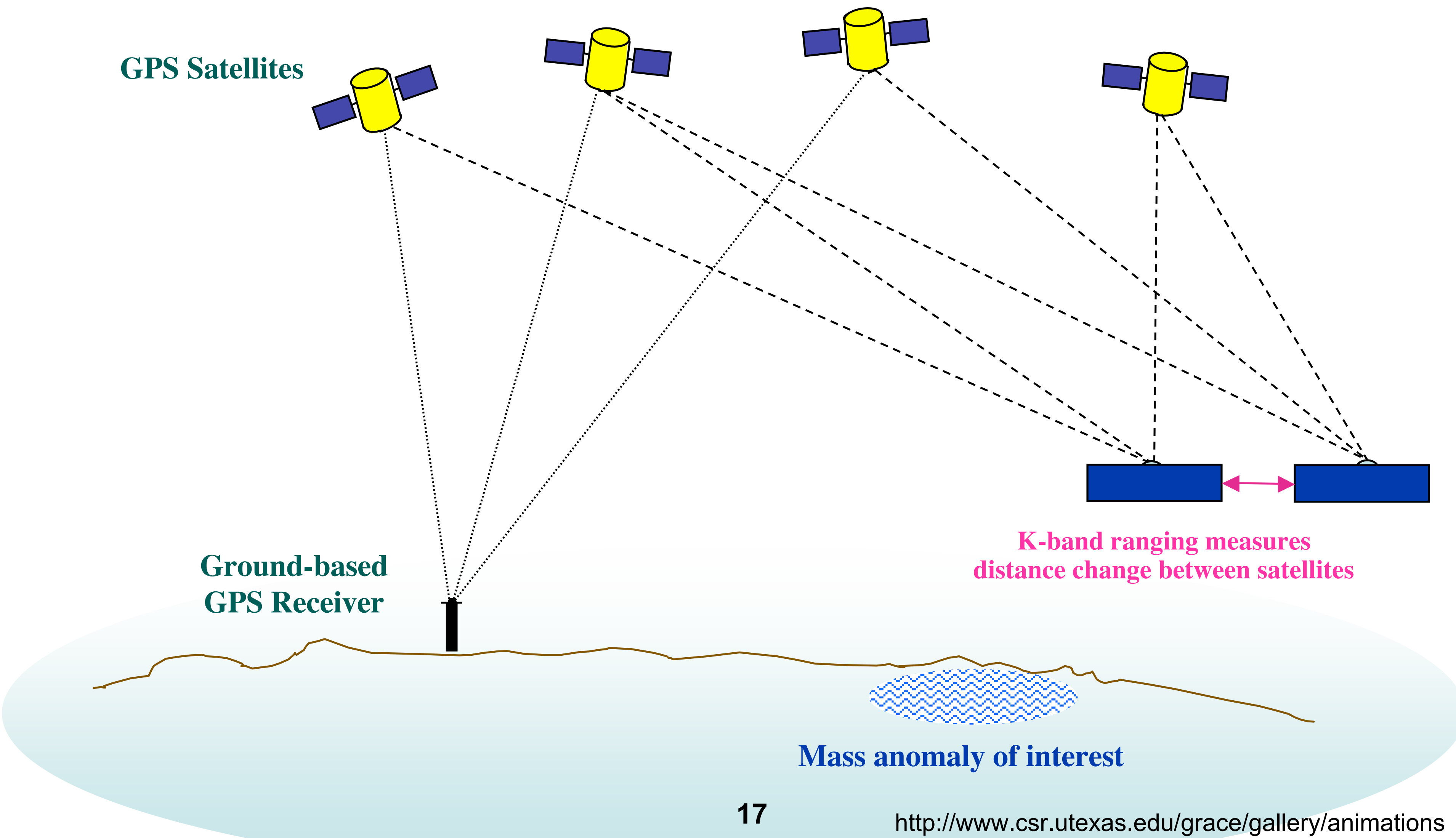
Northern Hemisphere Sea Ice Extent (1979 versus 2003)

Image courtesy of NASA-Goddard Space Flight Center



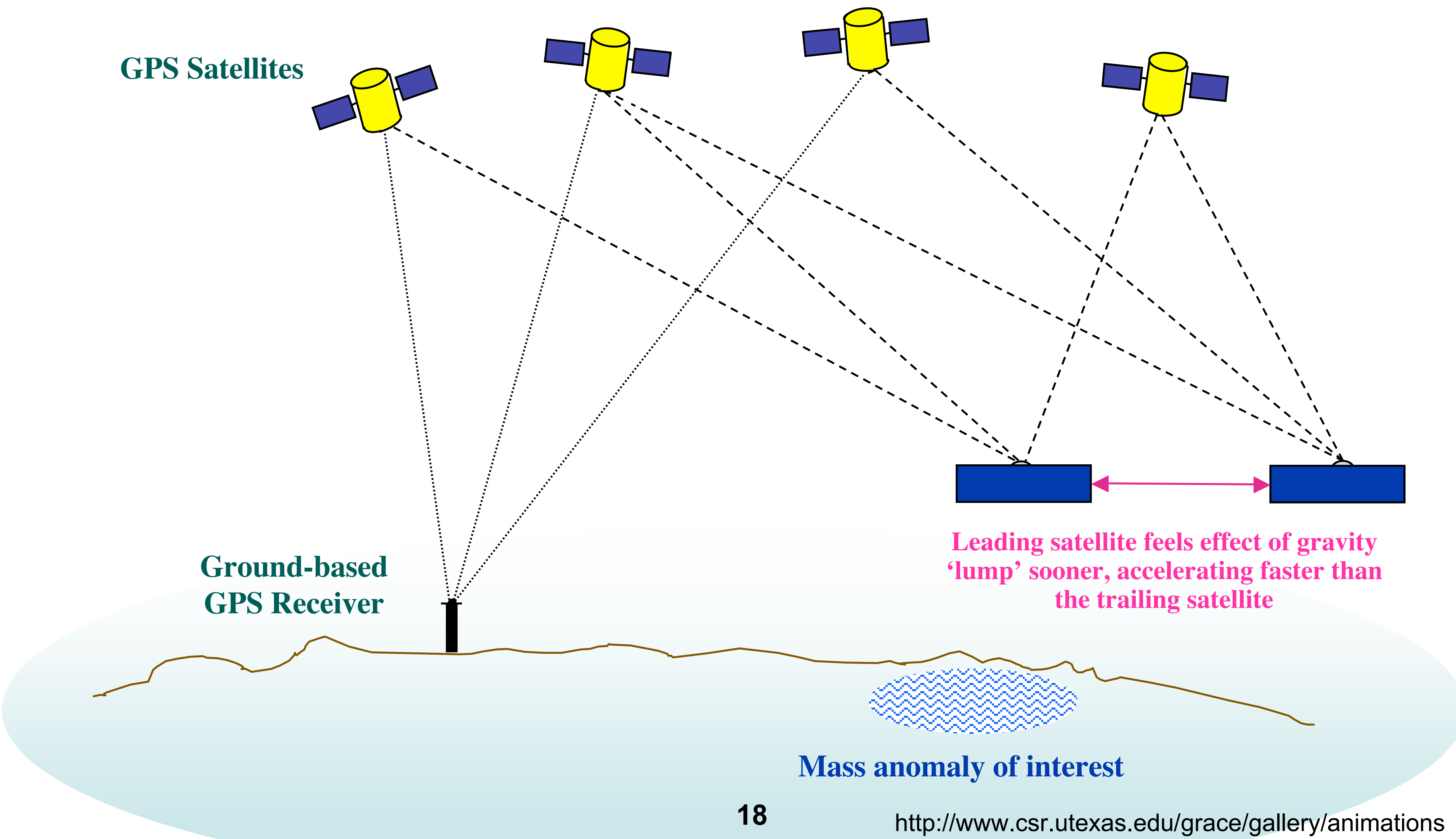
2003 SSMI Composite Data

GRACE: Mission Concept



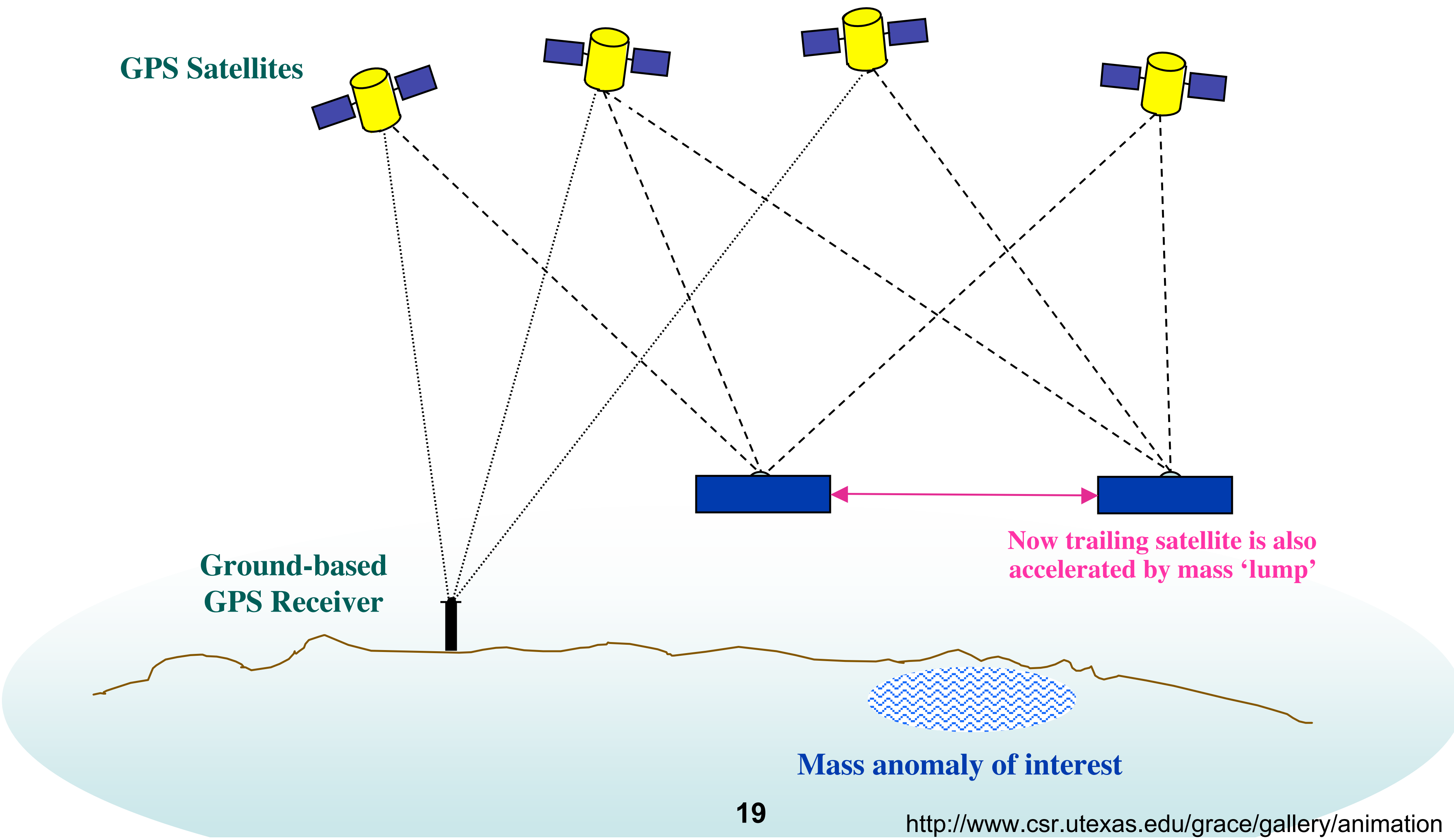
http://www.csr.utexas.edu/grace/gallery/animations

GRACE: Mission Concept



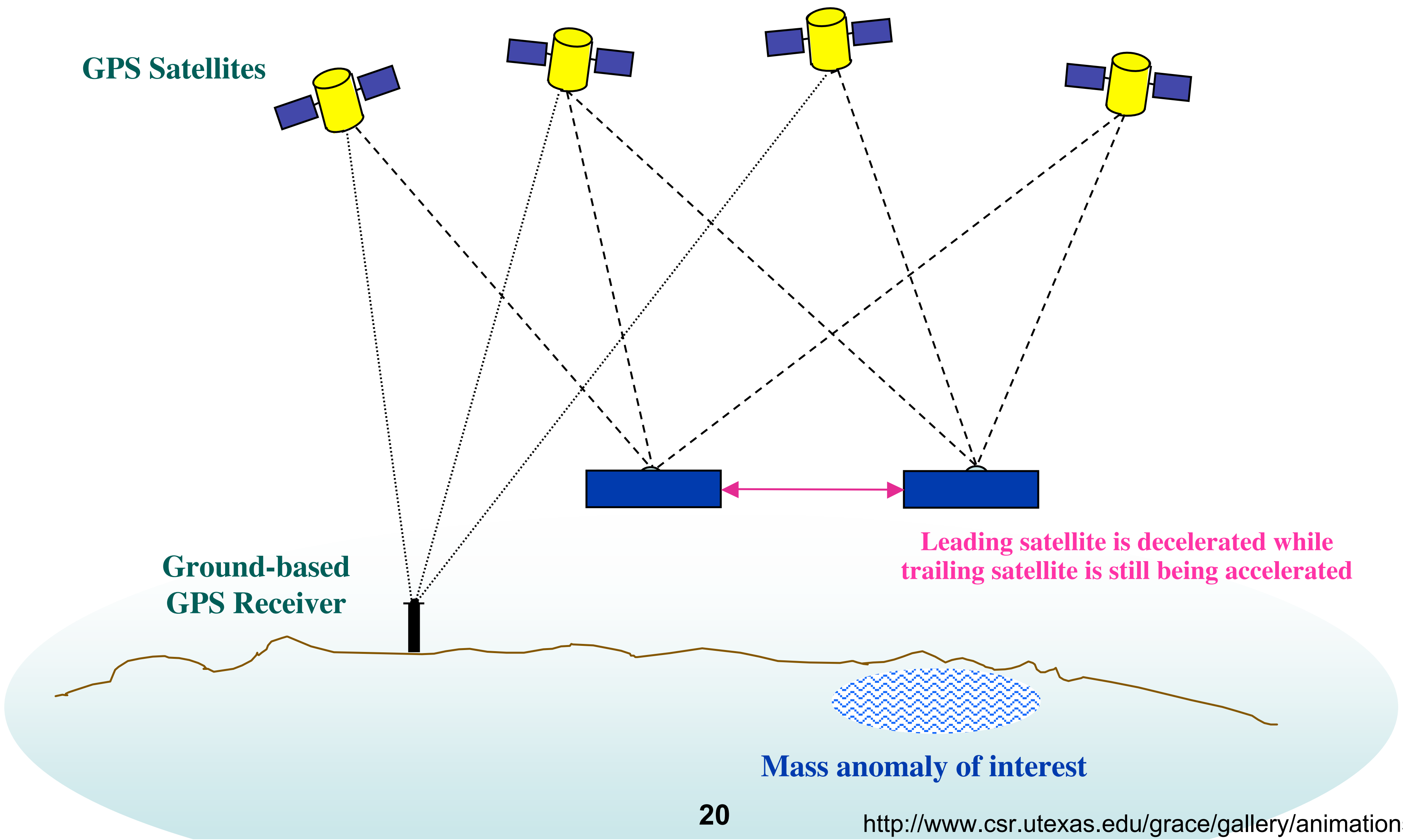
http://www.csr.utexas.edu/grace/gallery/animations

GRACE: Mission Concept



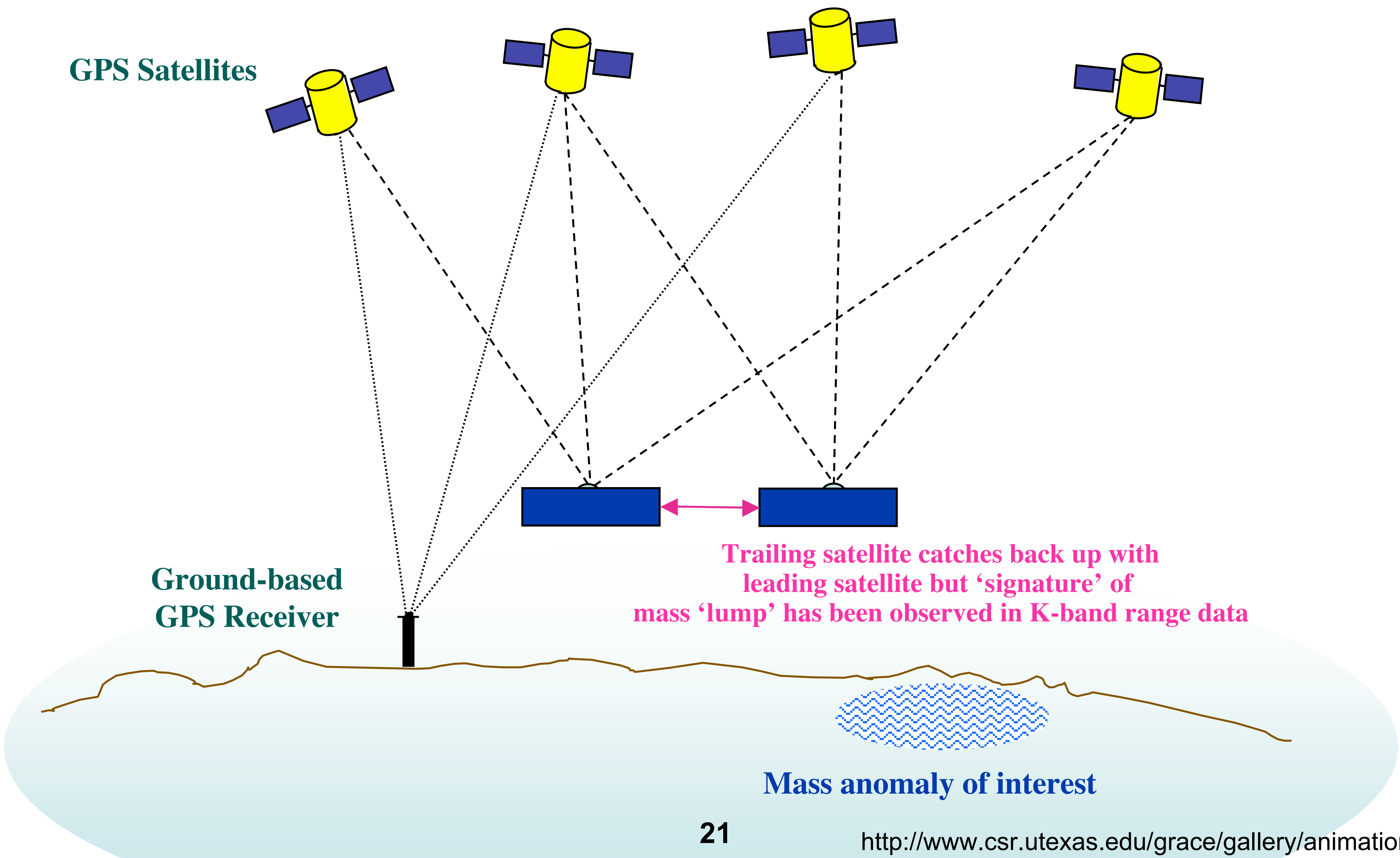
http://www.csr.utexas.edu/grace/gallery/animation

GRACE: Mission Concept

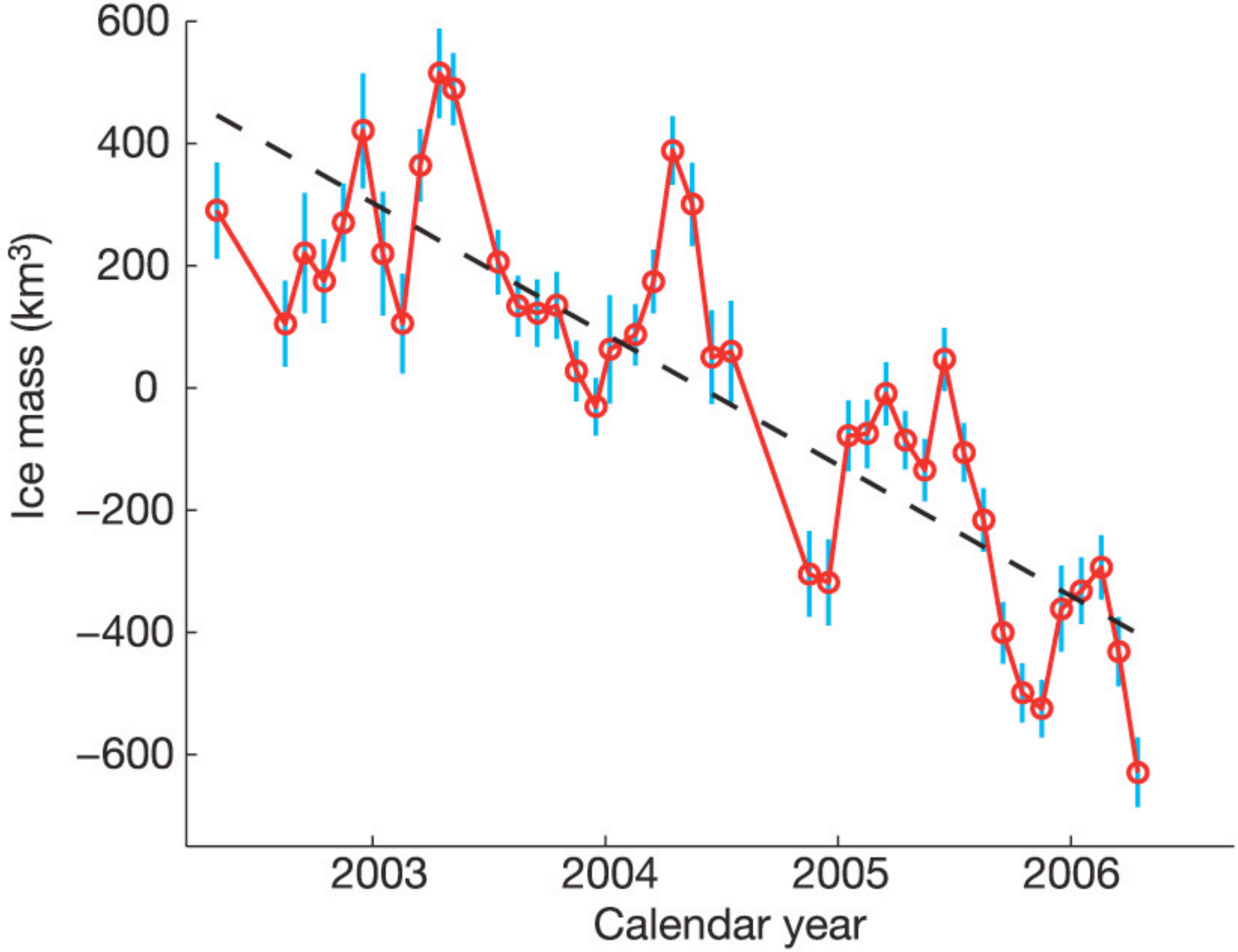


http://www.csr.utexas.edu/grace/gallery/animations

GRACE: Mission Concept

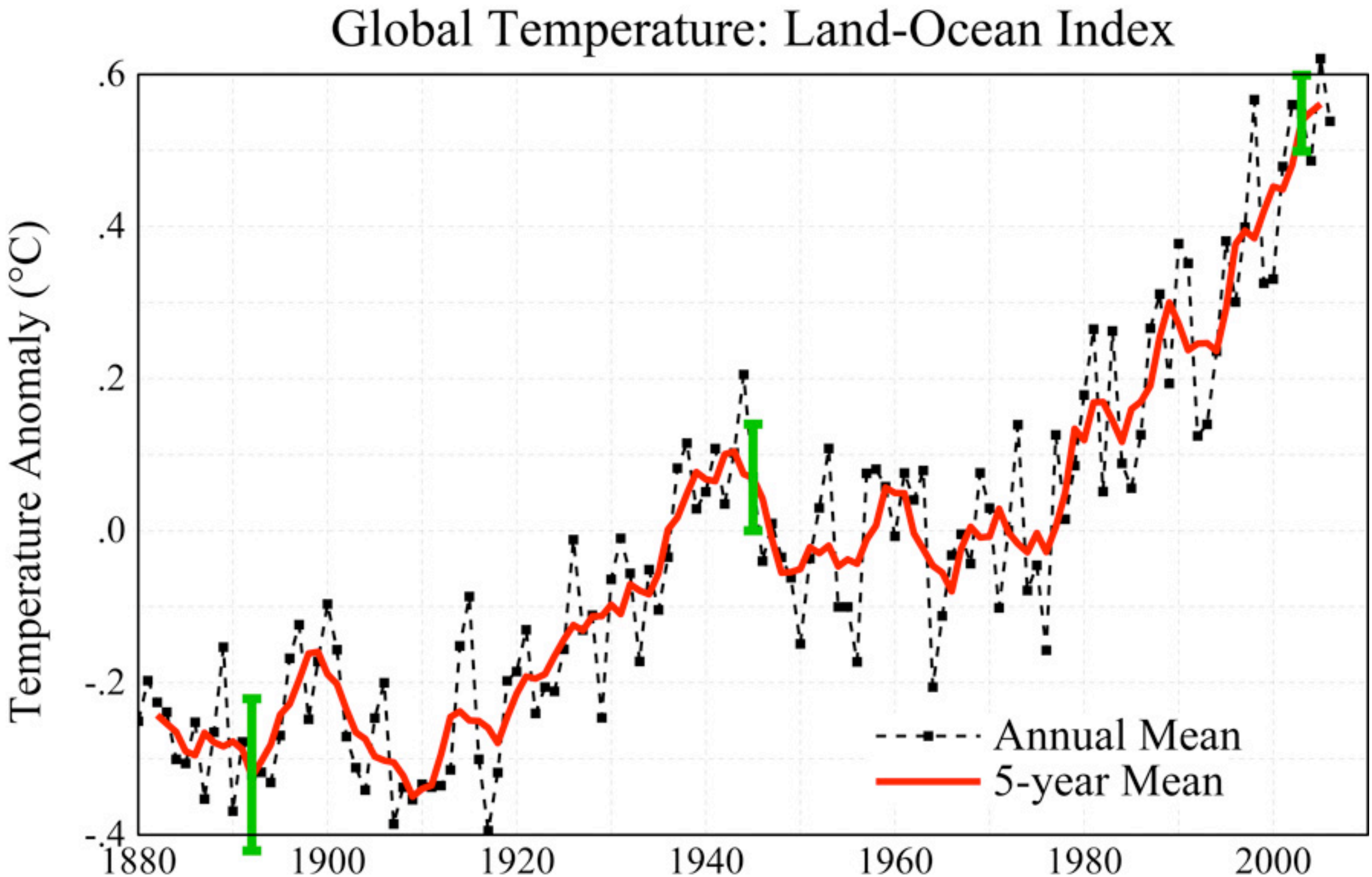


http://www.csr.utexas.edu/grace/gallery/animations



Greenland Grace monthly mass solutions. For the entire Greenland ice sheet, for April 2002 to April 2006, after scaling the results and removing the mean. The blue error bars include only the contributions from uncertainties in the GRACE gravity fields.

Isabella Velicogna & John Wahr 2006b



www.giss.nasa.gov/gistemp
(updated from Hansen et al., 2001)

Frohlich and Lean (2005): Recent analyses of satellite measurements do not indicate a long-term trend in solar irradiance (the amount of energy received from the sun)

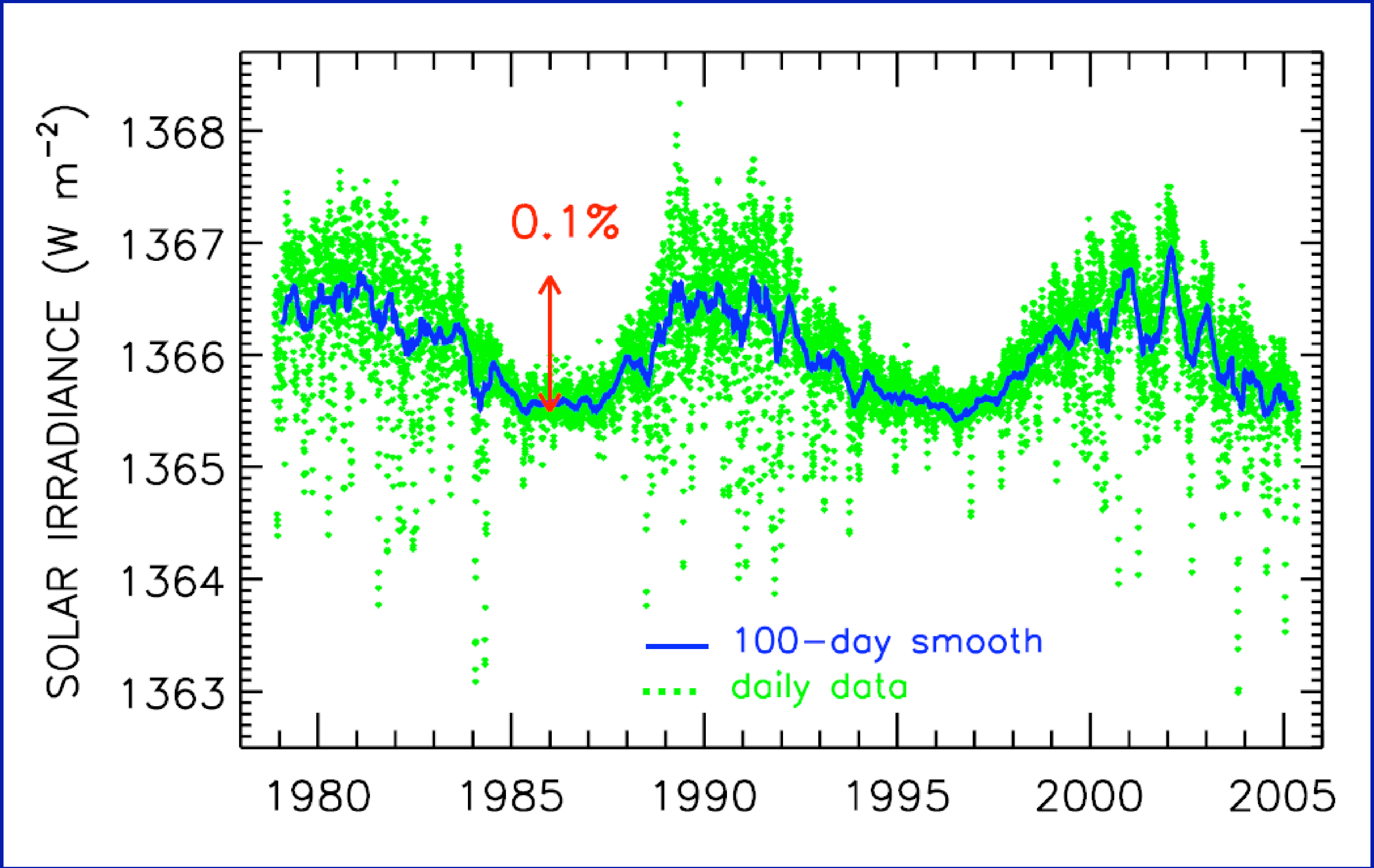
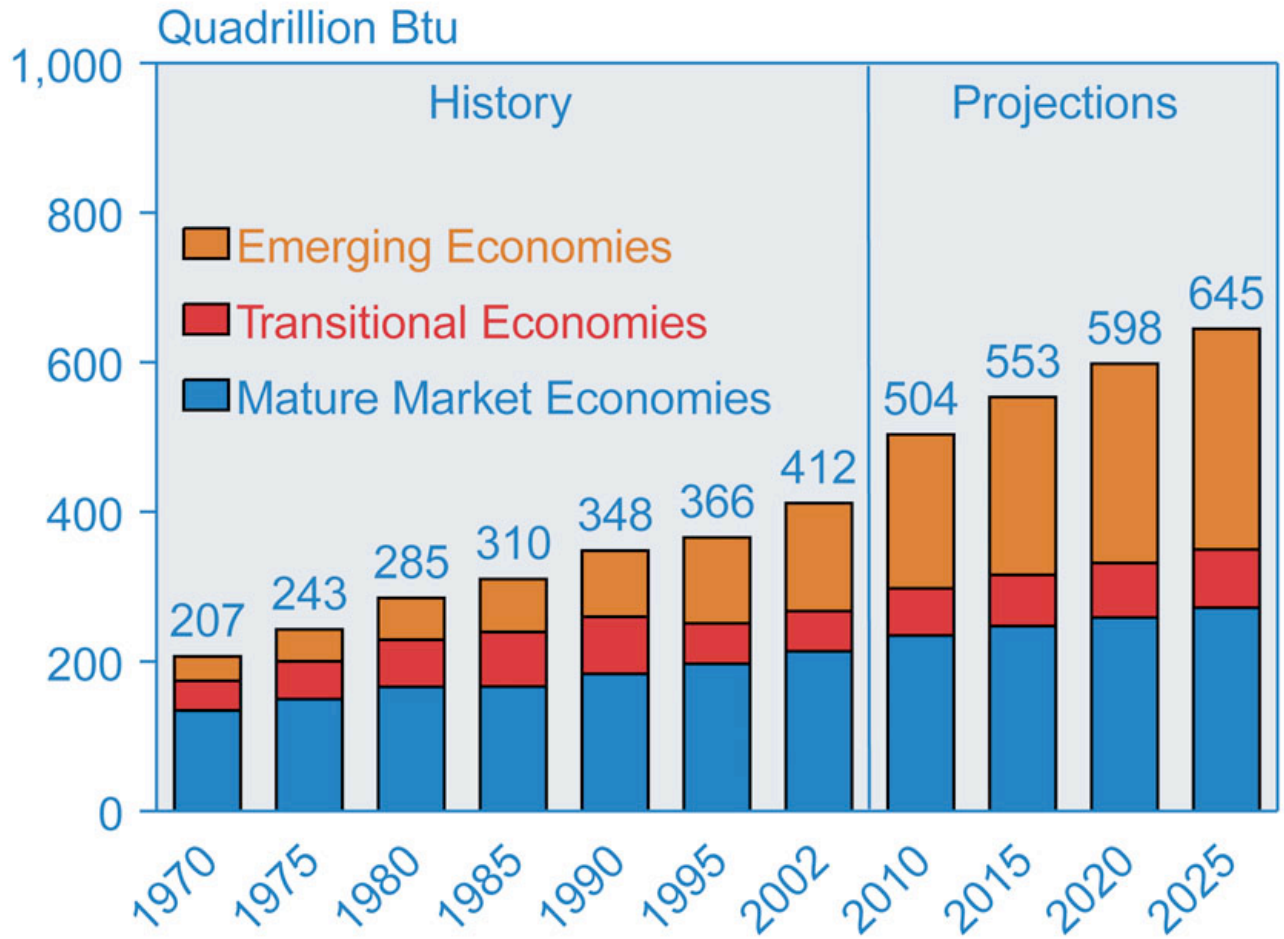
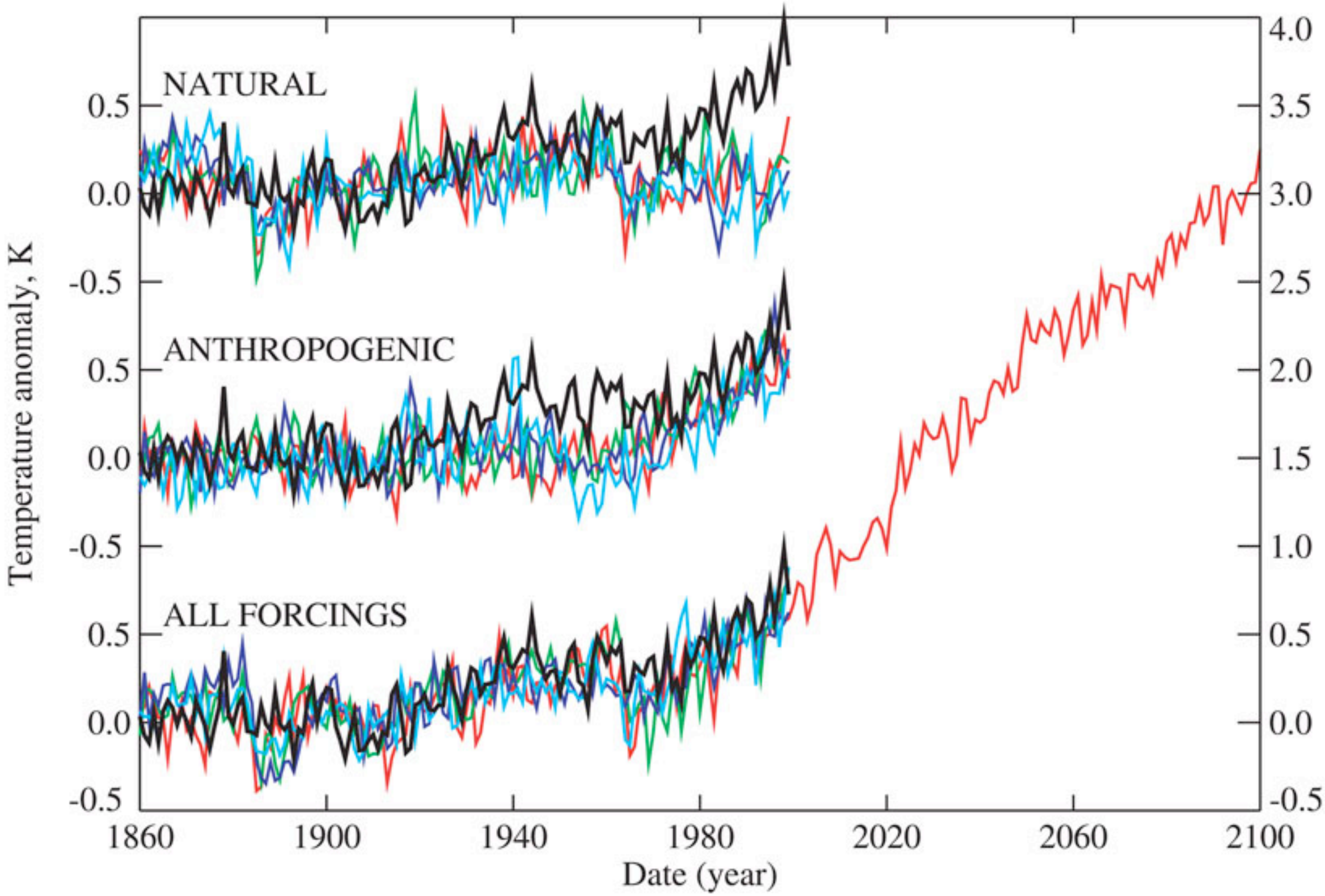


Figure 1. World Marketed Energy Consumption by Region, 1970-2025



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).



Computed and Observed Temperatures

Stott et al (2000)

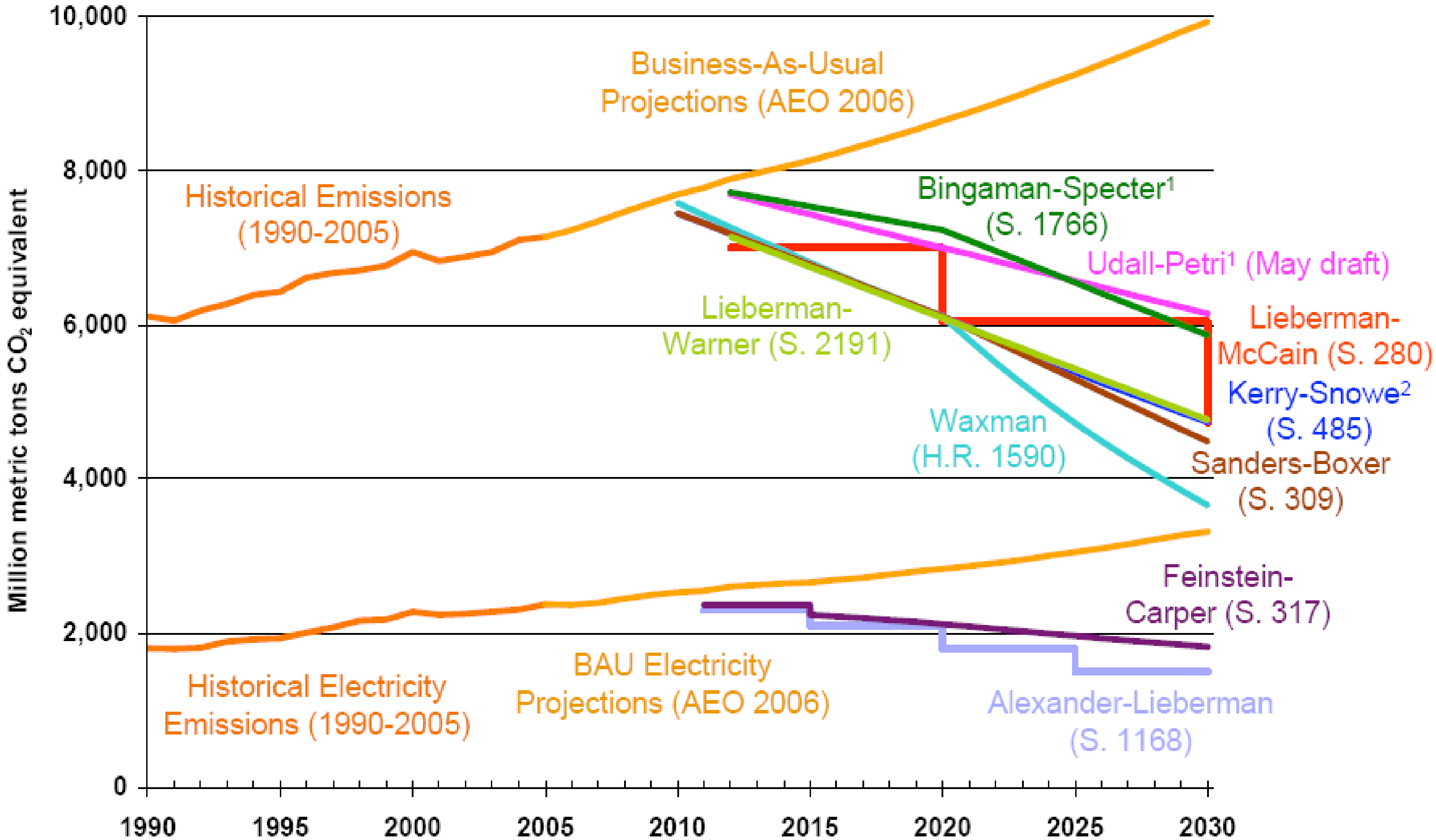
Summary of Market-Based Climate Change Bills Introduced in the 110th Congress

Draft as of October 29, 2007 (See companion figure for target levels.)

	Who's Regulated	Allowance Allocation	Price Stability	Offsets	Technology	Competitiveness
Lieberman-Warner (S. 2191)	Economy-wide cap: large sources downstream at emitter; transport emissions at refinery; F-gas producers and importers. (75% of US GHG emissions covered.)	40% free to industry (including electric generators; with phase out); 10% to electricity consumers; 24% auctioned to fund technology deployment, transition assistance, and adaptation; 12% set aside for CCS and sequestration; 9% to states; 5% for early action.	"Climate Fed" with discretion to increase use of borrowing and offsets and temporarily expand cap. Borrowing: up to 15% of allowances, for no more than 5 years.	Up to 15% of obligation can be met with domestic sequestration, and another 15% through international allowances and credits.	Technology deployment incentives for zero- and low-carbon generation, advanced coal, cellulosic biomass, and advanced vehicles (55% of auction revenues)	Bulk, energy-intensive imports from countries w/o comparable policy require permits after 2020.
Bingaman-Specter (S. 1766)	Economy-wide cap: coal and process emissions at emitters; oil refiners, NG processors, and oil/NG importers; and F-gas producers and importers.	53% free to industry (with phase out); 24% auctioned to support R&D, transition assistance, adaptation; 14% set aside for CCS and sequestration; 9% to states.	\$12/metric ton CO_2 safety valve, rising at 5% per year above inflation.	Unlimited domestic offsets including methane and SF_6. Limits on international offsets (10% of cap) and domestic agricultural offsets (5% of cap).	Detailed technology development programs funded from allowance auction revenues (12-26% of auction revenues).	Bulk, energy-intensive imports from countries w/o comparable policy require permits after 8 years.
Udall-Petri (May draft and staff talks)	Economy-wide cap: primarily upstream sources (e.g., producers and importers of fuels).	20% free to industry. 80% auctioned to support RD&D; developing country engagement; adaptation, dislocation aid; sequestration; debt reduction.	\$12/metric ton CO_2 safety valve, rising at 2-8% per year above inflation.	Unlimited geological sequestration offsets. 5% of allowances set aside to fund biological sequestration and 1% for CCS projects.	Establishes ARPA-E to fund technology advancement projects (24% of auction revenues).	Inaction by developing countries can justify delay in safety valve escalation.
Lieberman-McCain (S. 280)	Economy-wide cap: large downstream at emitter; transport emissions regulated at refinery.	Discretion of EPA, with guidance for some free allocation and an auction to fund R&D, transition assistance, adaptation measures.	Borrowing: up to 25% of allowances, for no more than 5 years.	Up to 30% of obligation can be met with domestic sequestration projects and international offsets.	Revenues from some auctioned allowances used for RD&D.	No provisions.
Kerry-Snowe (S. 485)	Economy-wide cap: point of regulation at discretion of EPA.	Discretion of the President with guidance from the EPA.	No provisions.	USDA sets rules for domestic biological sequestration.	Vehicle emission rules; efficiency & renewable standards for electric generation; additional bill-specific mandates.	
Waxman (H.R. 1590)				No provisions.		
Sanders-Boxer (S.309)	Economy-wide cap: EPA has discretion to implement a market-based allowance program to achieve cap.					
Feinstein-Carper (S. 317)	Electricity-sector cap: power plants. (S. 1168 also covers utility SO_2, NO_x, and mercury emissions.)	85% free to industry, based on generation (updated annually), and phased out by 2036.	Borrowing up to 10%, for no more than 5 years.	International offsets up to 25% of cap; extensive domestic biological offsets.	Distributes auction revenues to multitude of technology programs.	
Alexander-Lieberman (S. 1168)		75% free to industry, based on heat input.	No provisions.	Domestic offsets in five categories, including methane, SF_6, efficiency, and forest sequestration.	NSPS for CO_2 emissions from new electric generation units.	
Stark (H.R. 2069)	Economy-wide tax: fossil fuels taxed by CO_2 content at the point of production and import.	100% revenues to US Treasury.	\$3/metric ton CO_2, rising \$3 annually.	Tax refunds for fuel CO_2 sequestered downstream: CCS, plastics.	No provisions.	Tax applied to fossil fuel imports; fossil fuel exports are exempt.
Larson (H.R. 3416)		1/6 of revenues to R&D, 1/12 to industry transition assistance (with phase out), remainder to payroll tax rebates.	\$16.5/metric ton CO_2, rising 10% plus inflation annually.	Tax refunds for domestic sequestration and HFC destruction projects.	1/6 of tax revenues up to \$10 billion annually goes to clean energy technology R&D.	
Dingell (Summary of draft)	Economy-wide tax: fossil fuels taxed by CO_2 content at point of production and import. Also, tax on gasoline (but diesel exempt).	Revenues used to expand EITC and help fund entitlement programs. Gas tax revenues go to highway trust fund (40% mass transit, 60% roads).	\$15/metric ton CO_2, rising at inflation. \$0.5/gallon gasoline tax (in addition).	No provisions.	No provisions.	

Resources for the Future • kopp@rff.org, pizer@rff.org, aldy@rff.org

Comparison of Emission Reduction Goals in Legislative Proposals in the 110th Congress (as of October 29, 2007)



RESOURCES FOR THE FUTURE

This graph depicts emissions targets from some of the major climate change bills in Congress. Targets are based on comparison with historical year emissions. Kerry-Snowe, Sanders-Boxer, and Waxman specify future emissions as a percentage of 1990 emissions. For Lieberman-Warner, Lieberman-McCain, Udall-Petri, and Bingaman-Specter, emission targets for covered sectors are related to historical emissions for those sectors, and total emissions are assumed to match those in the corresponding historical year.

[1] Bill contains flexibility mechanisms which allow actual emissions to rise above the target.

[2] The Kerry-Snowe target is overlaid by others: it is nearly identical to Sanders-Boxer before 2020 and to Lieberman-Warner from 2020-2030.

Climate Change Mitigation and Adaptation

Mitigation = Reduce Amount of Climate Change
(slow it)

Adaptation = Reduce Impacts of Climate Change

[FULL COMMITTEE PRINT]

110TH CONGRESS
1st Session

HOUSE OF REPRESENTATIVES

REPORT
110–

DEPARTMENT OF THE INTERIOR, ENVIRONMENT, AND RELATED AGENCIES APPROPRIATIONS BILL, 2008

JUNE , 2007.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

Mr. DICKS, from the Committee on Appropriations, submitted the following

REPORT

together with

[To accompany H.R.]

The Committee on Appropriations submits the following report in explanation of the accompanying bill making appropriations for the Department of the Interior, the Environmental Protection Agency, and Related Agencies for the fiscal year ending September 30, 2008

COMMISSION ON CLIMATE CHANGE ADAPTATION AND MITIGATION

Appropriation enacted, 2007	$0
Budget estimate, 2008	0
Recommended, 2008	50,000,000
Comparison:	
Appropriation, 2007	+50,000,000
Budget estimate, 2008	+50,000,000

CLIMATE CHANGE COMMISSION

As noted in the introduction to this report, the Committee views global climate change as one of the great challenges facing our country. The recent reports of the Intergovernmental Panel on Climate Change (IPCC) have eliminated any lingering doubt about whether global warming is occurring. In fact, these reports make clear that global warming has already resulted in real and significant impacts. This was confirmed at hearings held by the Appropriations Committee in April during which witnesses from the land management agencies of the Interior Department and Forest Service described climate related changes already occurring in the national parks, wildlife refuges and on other public lands. These impacts included increased wildfires, changing precipitation and water availability patterns, increasing presence of invasive species, changing migratory patterns for many animals and birds, and significant loss of habitat for many species. The conclusions are clear. Climate change is real; its impacts are already present; and, irrespective of regulatory or technological changes put in place over the next few years, climate change will remain a reality for the foreseeable future. The challenge now is how to live with this reality.

To begin to address this reality, society must now initiate a new stage of the debate which focuses on effective steps to facilitate adaptation to and mitigation of climate change. This debate will take many forms and it will be a long process which may lead us in unknown directions. At the onset of this effort, we know, however, that science will be a key tool for monitoring climate change and for developing and testing different adaptation and mitigation strategies and tools. For this reason, the Committee has included $50 million in this bill to jump-start the scientific effort around the adaptation and mitigation challenges.

While the use of a commission or advisory committee to guide Federal science investment is not unusual, this Commission is atypical in two ways. First, it cuts across all areas of climate related science which might contribute to these challenges. Second, it may be unique in that money is included in this fiscal year 2008 bill to begin implementation of the Commission's recommendations during 2008. Of the $50 million included in the bill, $45 million will be transferred on July 1, 2008 by the Administrator of the EPA to various Federal science agencies for implementation of Commission recommendations. The amounts of the various transfers are to be based on the Commission's report. In short, this is a Commission which will actually have money to invest, making it at the same time both more credible and more effective.

The Commission will be comprised of science leaders both inside and outside government. Specifically, it will include the Administrator of the Environmental Protection Agency, the Director of the National Science Foundation, the Administrator of the National Aeronautics and Space Administration, the Director of the United States Geological Survey, the Undersecretary for Science of the Department of Energy, the Administrator of the National Oceanographic and Atmospheric Administration, the Chief of the United States Forest Service, the President of the National Academy of Engineering, the President of the National Academy of Sciences, and six additional members with appropriate expertise to be selected by the Chairman. The President of the National Academy of Sciences is designated as the Chairman by statute. The Commission will be housed within the Environmental Protection Agency for administrative and logistical support. The bill includes $5 million for support costs of the Commission. In addition to supporting employment of Commission staff directly, funds are provided for contractual support from the National Academy of Sciences.

Article 2, UN Framework Convention on Climate Change (1992)

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Questions from White House (2001)

- By how much will temperatures change over the next 100 years and where?
- What will be the consequences (e.g., extreme weather, health effects) of increases of various magnitudes?
- Has science determined whether there is a “safe” level of concentration of greenhouse gases?
- What are the substantive differences between the IPCC Reports and the Summaries?
- What are the specific areas of science that need to be studied further, in order of priority, to advance our understanding of climate change?

Defining "Dangerous"

Link Danger with Irreversibility

examples: sea-level rise, loss of biodiversity

Rate of Disruption > Rate at which we can adapt

Who Should Define "Dangerous" ?

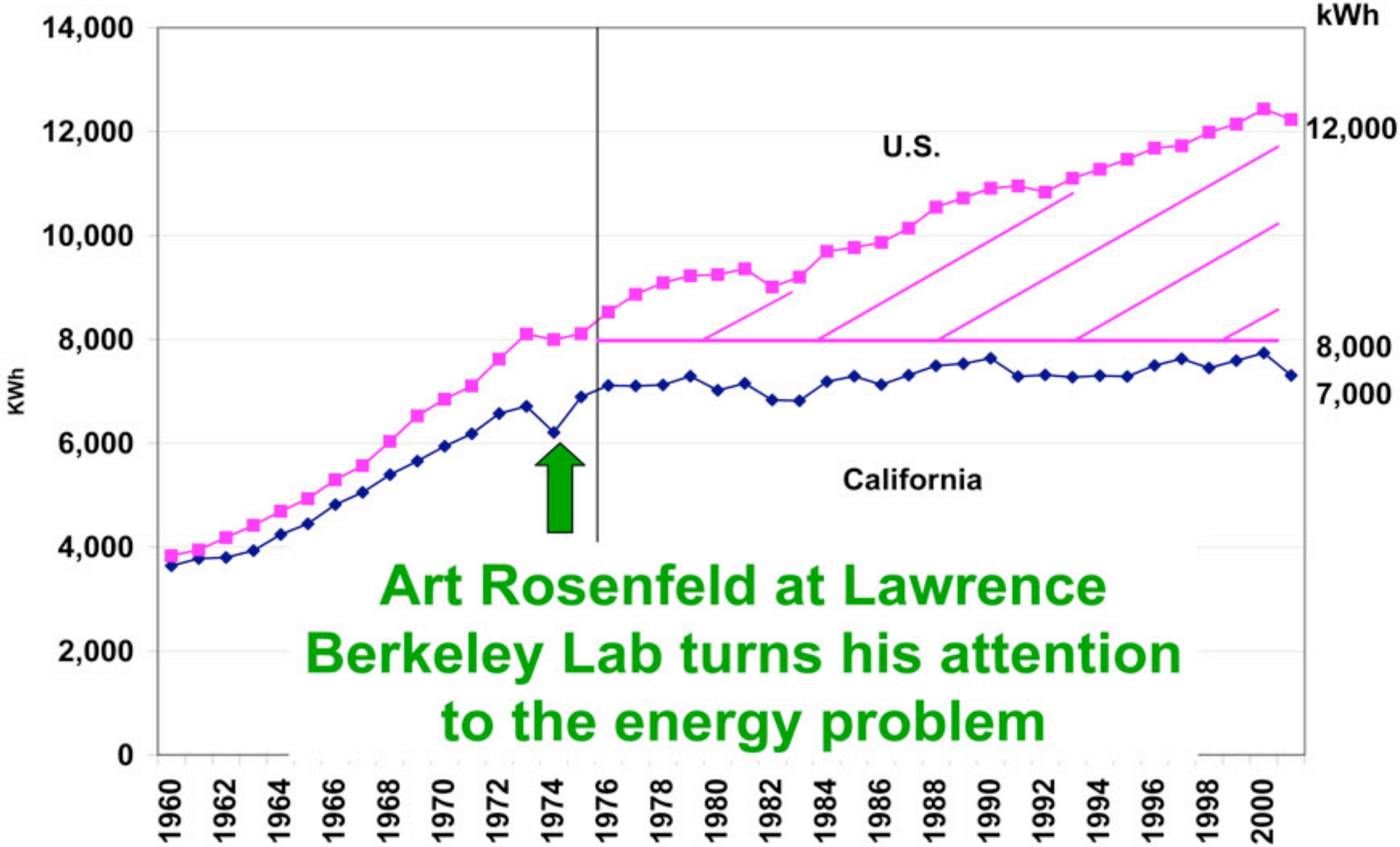
scientists?

elected leaders?

________________ ?

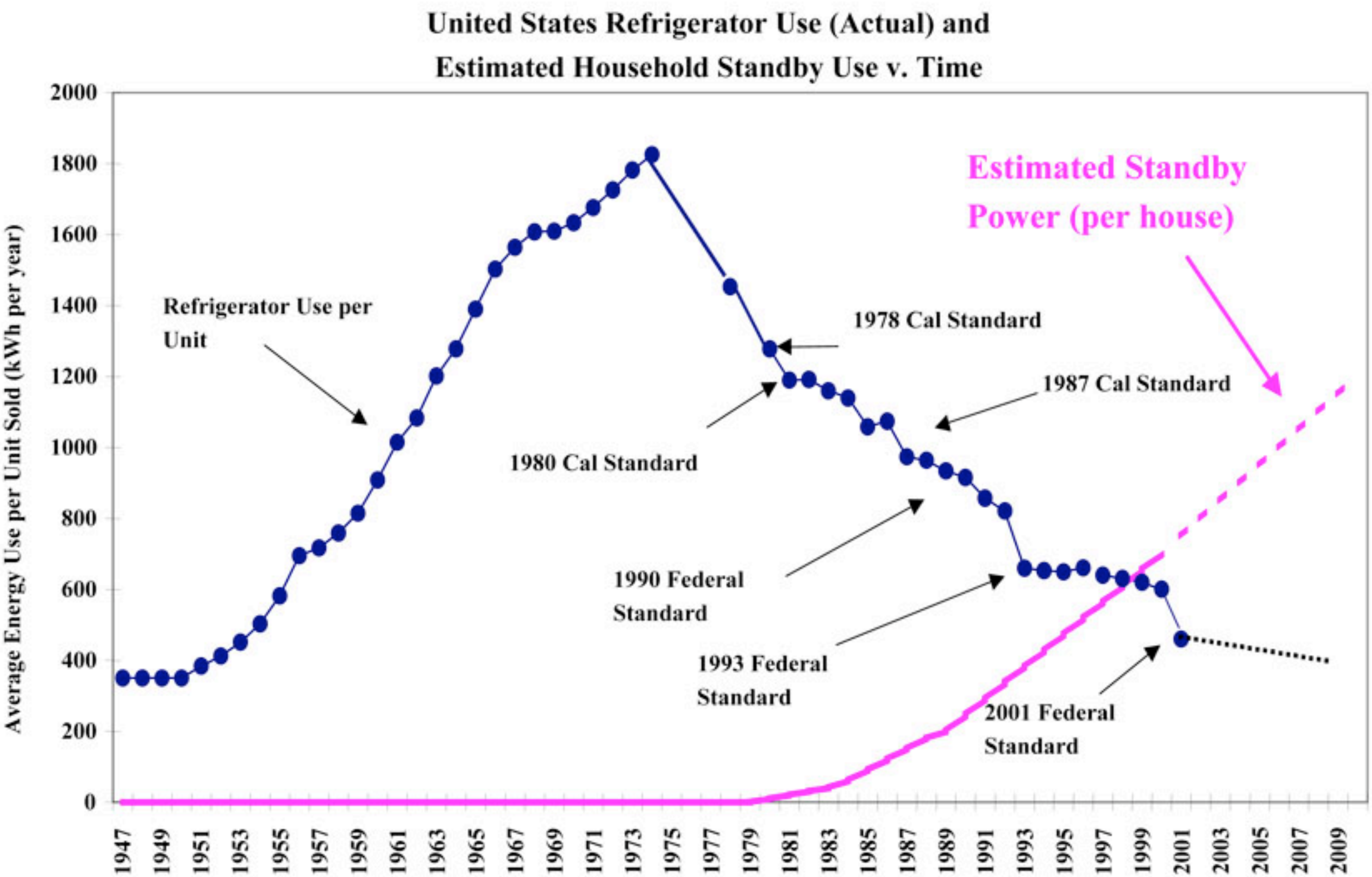
From Lawrence Berkeley Laboratory

Electricity Consumption/person in the US and California



The attack of the "vampire" drains on energy

From Lawrence Berkeley Laboratory



Immediate action with multiple benefits.

Energy efficiency would:

- decrease our dependency on foreign oil
- improve our national security
- decrease our trade deficit
- decrease local air pollution
- increase our national competitiveness
- encourage development of new products for global markets
- decrease household energy costs while also slowing the increases of CO_2 and CH_4 !