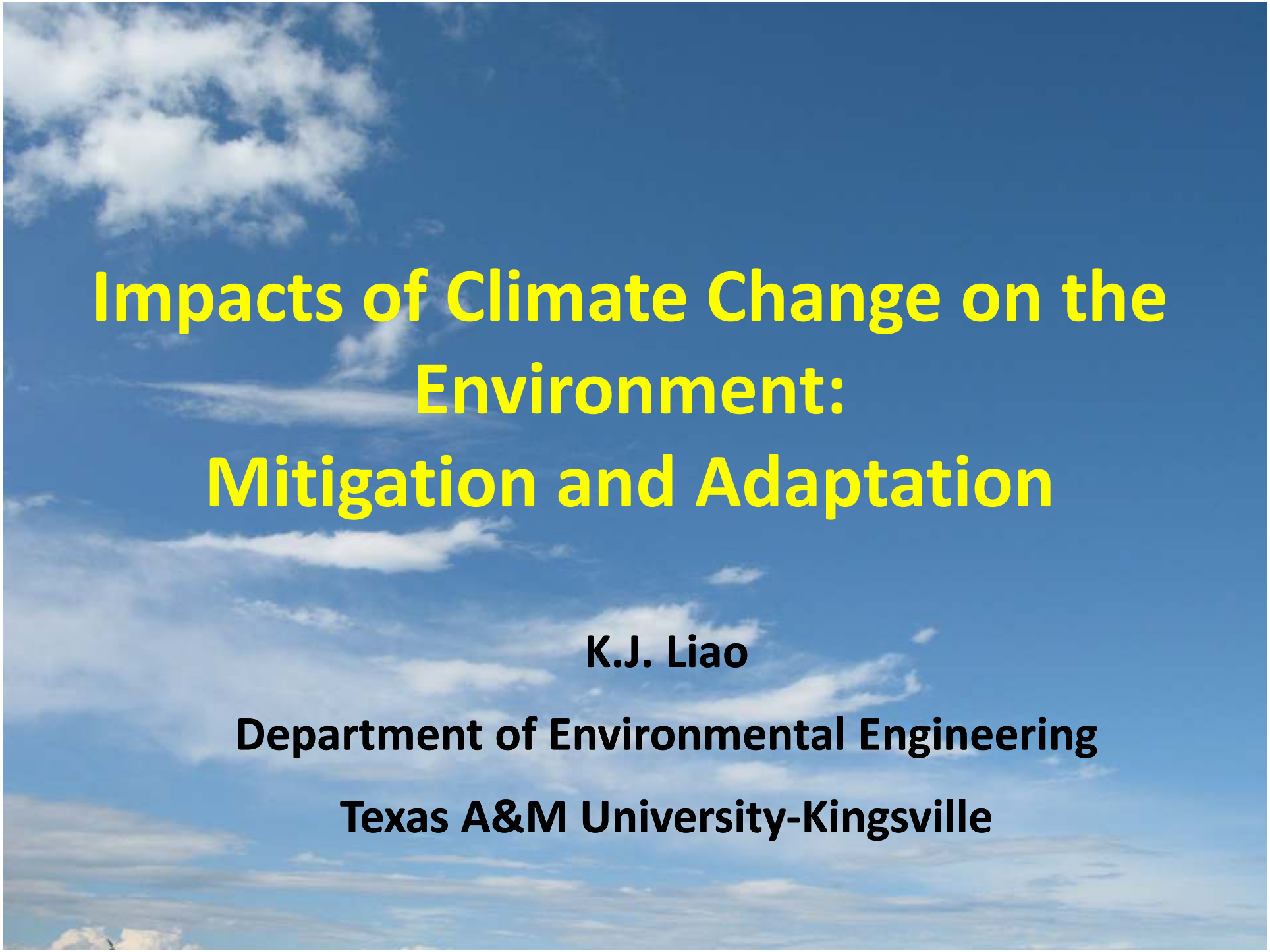
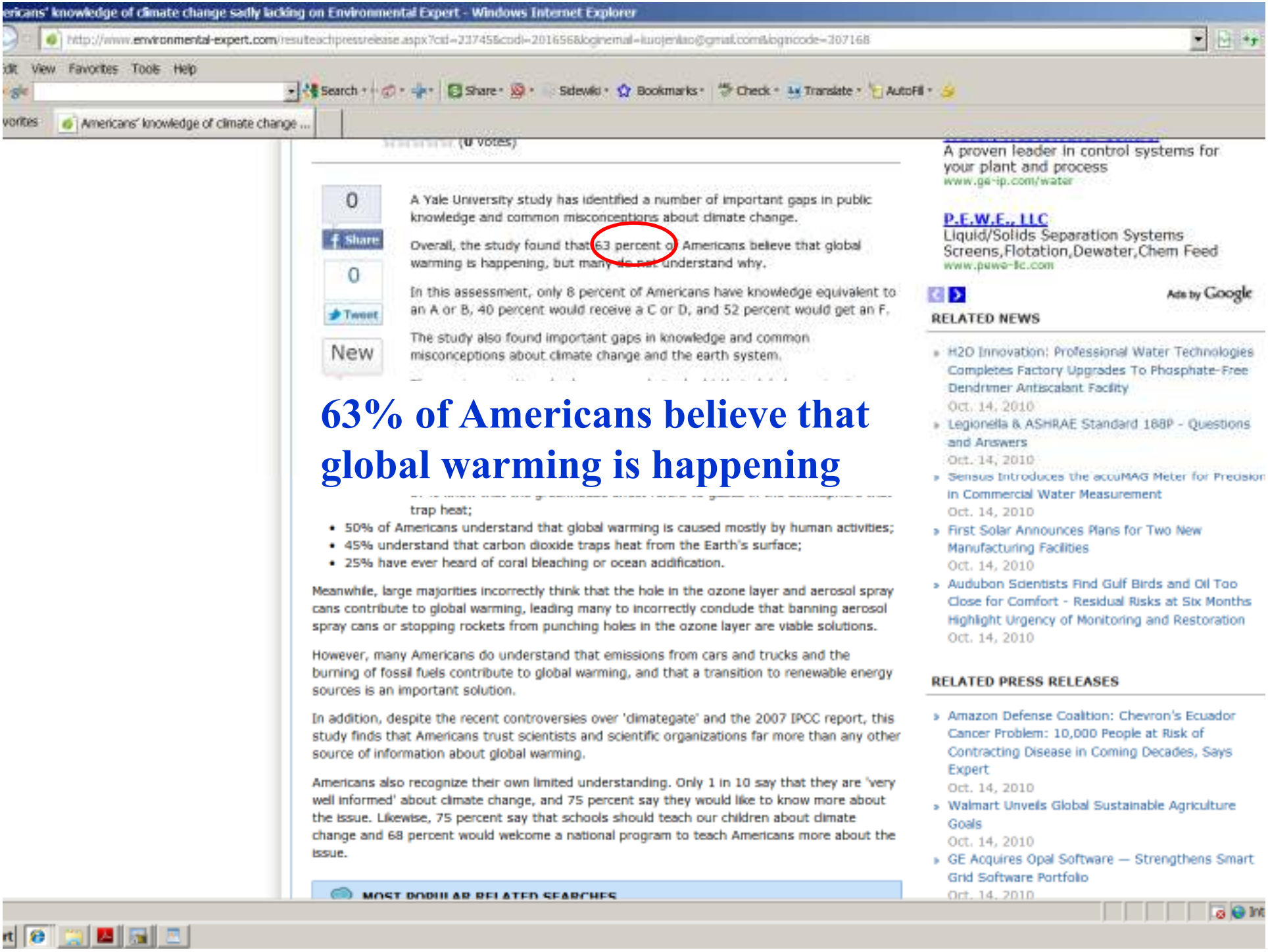


Impacts of Climate Change on the Environment: Mitigation and Adaptation

K.J. Liao

Department of Environmental Engineering

Texas A&M University-Kingsville


ericans' knowledge of climate change sadly lacking on Environmental Expert - Windows Internet Explorer
http://www.environmental-expert.com/resultsarchpressrelease.aspx?cid=23745&codi=201656&loginemail=kuojenlao@gmail.com&logincode=207168
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vorites Americans' knowledge of climate change ...
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New
A Yale University study has identified a number of important gaps in public knowledge and common misconceptions about climate change.
Overall, the study found that 63 percent of Americans believe that global warming is happening, but many do not understand why.
In this assessment, only 8 percent of Americans have knowledge equivalent to an A or B, 40 percent would receive a C or D, and 52 percent would get an F.
The study also found important gaps in knowledge and common misconceptions about climate change and the earth system.
63% of Americans believe that global warming is happening
trap heat;
50% of Americans understand that global warming is caused mostly by human activities;
45% understand that carbon dioxide traps heat from the Earth's surface;
25% have ever heard of coral bleaching or ocean acidification.
Meanwhile, large majorities incorrectly think that the hole in the ozone layer and aerosol spray cans contribute to global warming, leading many to incorrectly conclude that banning aerosol spray cans or stopping rockets from punching holes in the ozone layer are viable solutions.
However, many Americans do understand that emissions from cars and trucks and the burning of fossil fuels contribute to global warming, and that a transition to renewable energy sources is an important solution.
In addition, despite the recent controversies over 'climategate' and the 2007 IPCC report, this study finds that Americans trust scientists and scientific organizations far more than any other source of information about global warming.
Americans also recognize their own limited understanding. Only 1 in 10 say that they are 'very well informed' about climate change, and 75 percent say they would like to know more about the issue. Likewise, 75 percent say that schools should teach our children about climate change and 68 percent would welcome a national program to teach Americans more about the issue.
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The Intergovernmental Panel on Climate Change (IPCC)

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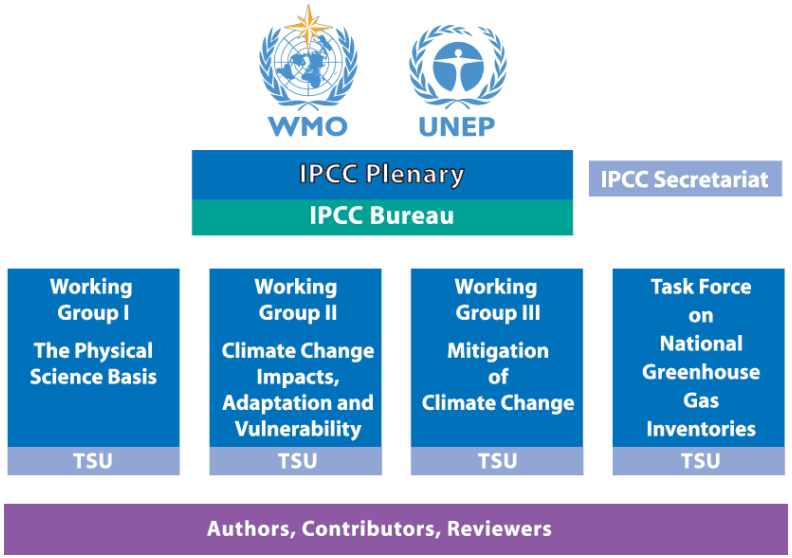
IPCC honoured with the 2007 Nobel Peace Prize

IPCC
Phone: +41-22-730-8208 /84/54
Email: IPCC-Sec@wmo.int



On 23 June 2010 the IPCC announced that **831 Authors and Review Editors** have been selected for the IPCCs Fifth Assessment Report, including:

- **IPCC WG I AR5 Authors List (258 experts)**
- **IPCC WG II AR5 Authors List (302 experts)**
- **IPCC WG III AR5 Authors List (271 experts)**

AR5 SCHEDULE, OUTLINES AND RELEVANT GUIDANCE DOCUMENTS

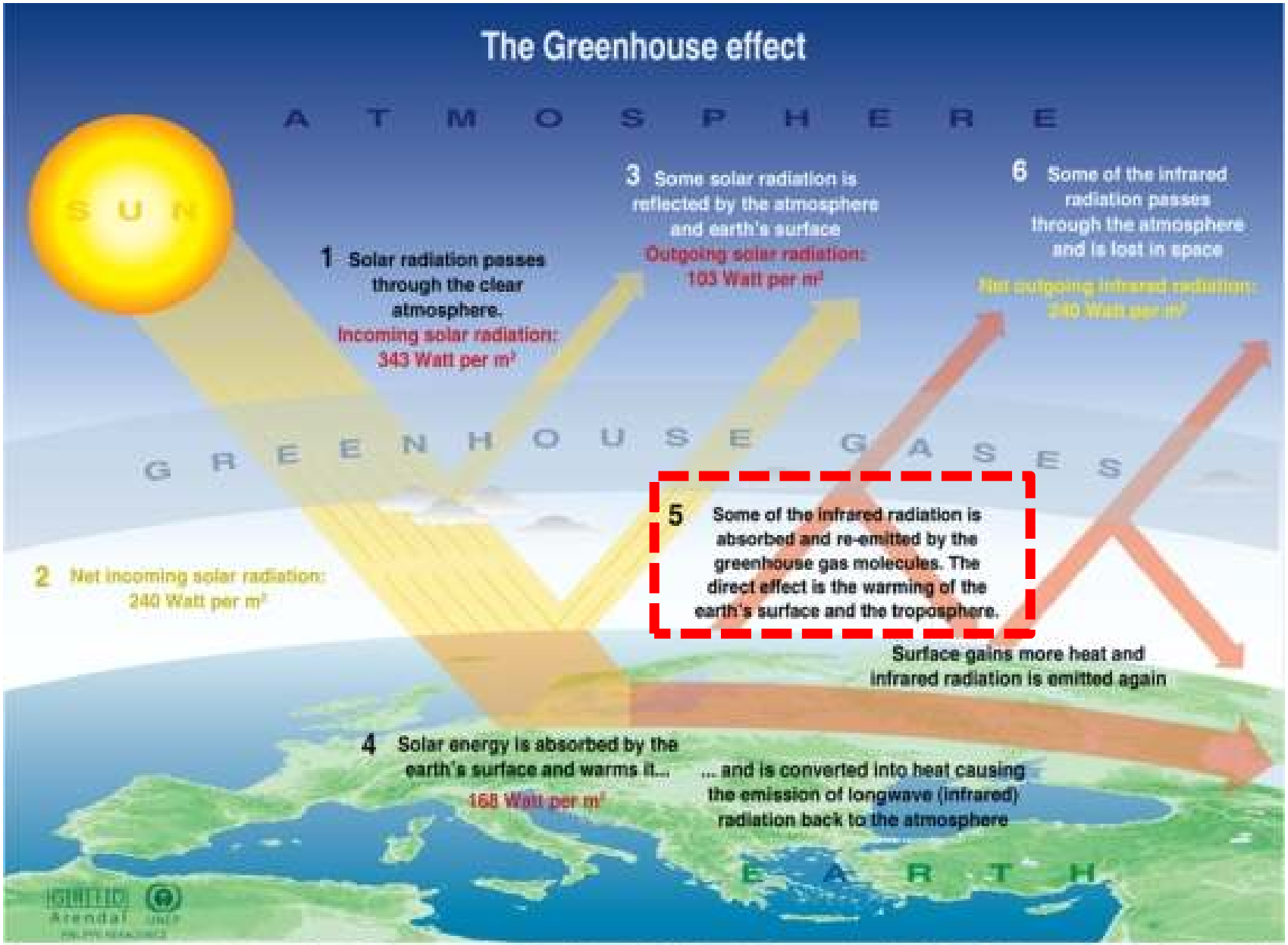
- Working Group I Outline: The Physical Science Basis (PDF)
- Working Group II Outline: Impacts, Adaptation, Vulnerability (PDF)
- Working Group III Outline: Mitigation of Climate Change (PDF)
- Concept notes on cross-cutting issues agreed by the Panel (PDF)
- AR5 Expert Meetings and Workshops planned in support of the assessment process (PDF)

The Working Group I report is scheduled to be finalized in September 2013, the Working Group II report in March 2014 and the Working Group III report in April 2014. The scope and content of the AR5 Synthesis Report will be developed in the course of the year 2010. The Synthesis Report is scheduled to be finalized in September 2014.

A short summary description of the AR5 outline, as well as of new features and areas of emphasis is provided in this AR5 leaflet (PDF).

Further information about the AR5 scoping process and other Panel decisions can be found in documentation for and reports of recent Panel Sessions.

Special Reports



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

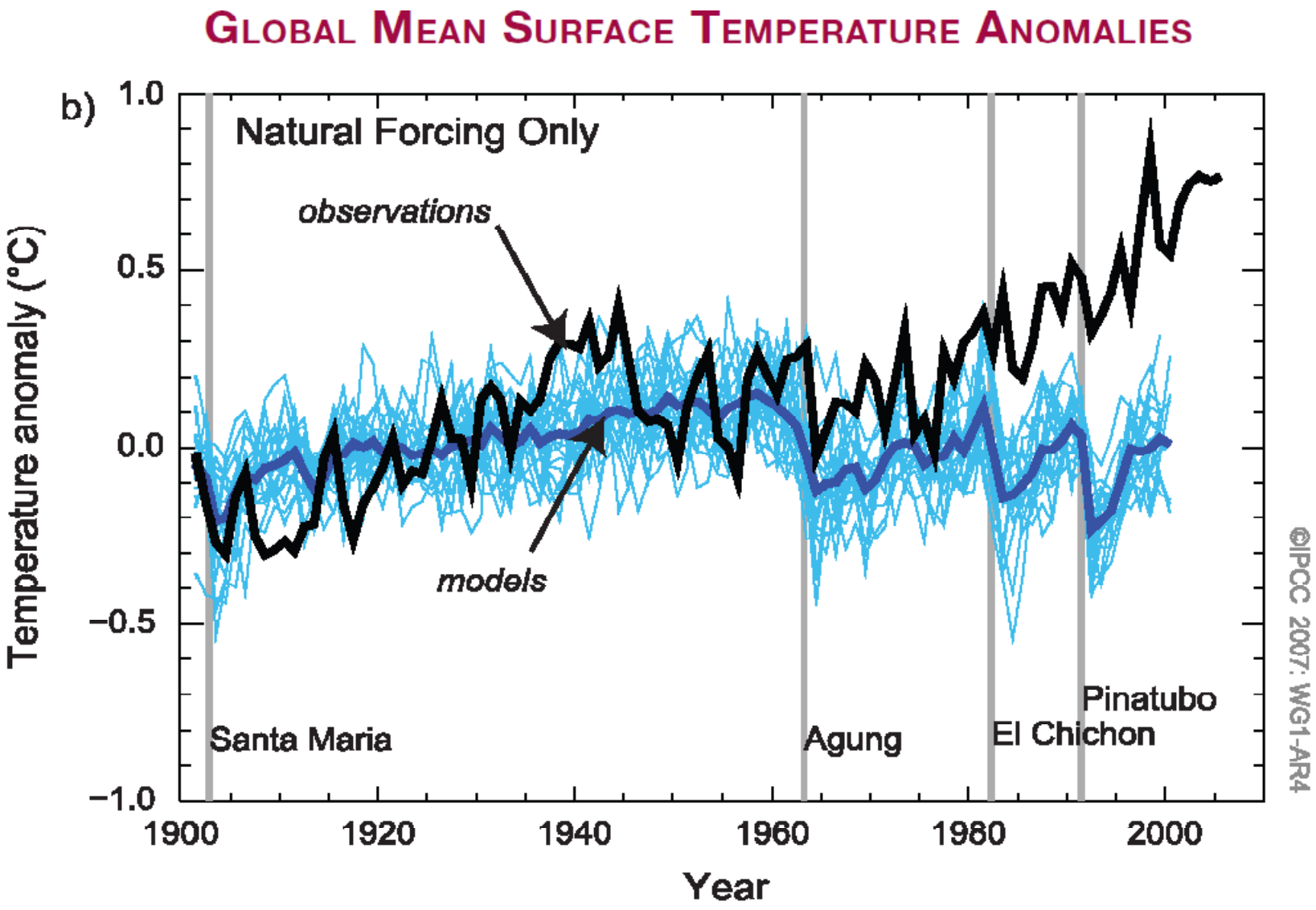
Climate Change or Global Warming?

- **Climate change** refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer).
- **Global warming** is an average increase in the temperature of the atmosphere near the Earth's surface.
- National Academy of Sciences:

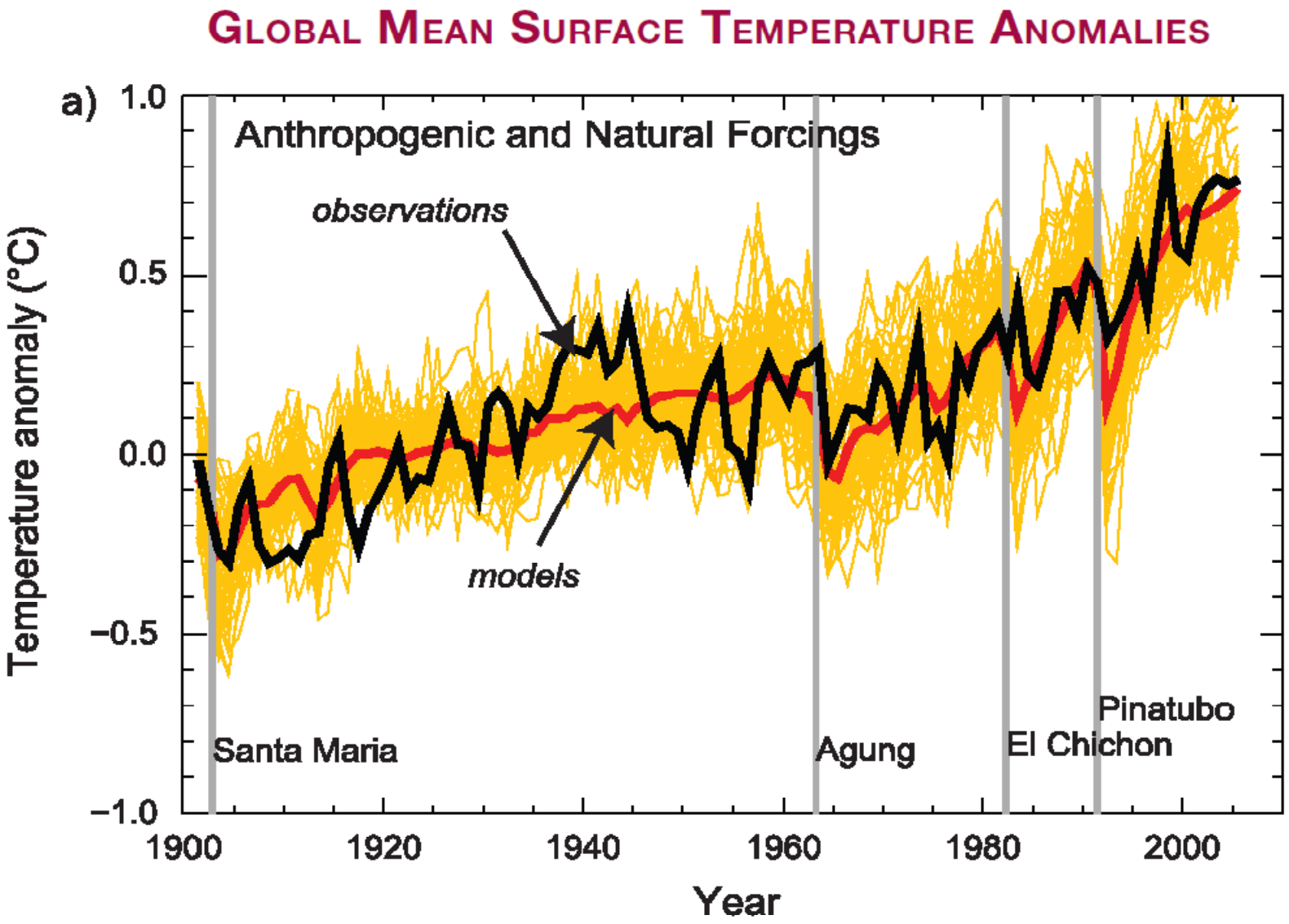
  "*the phrase '**climate change**' is growing in preferred use to '**global warming**' because it helps convey that there are [other] changes in addition to rising temperatures*"

Causes of Climate Change

- **Natural factors**, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun;
- **Natural processes within the climate system** (e.g. changes in ocean circulation);
- **Human activities** that change the atmosphere's composition (e.g. through burning fossil fuels) and the land surface (e.g. deforestation, urbanization, etc.)

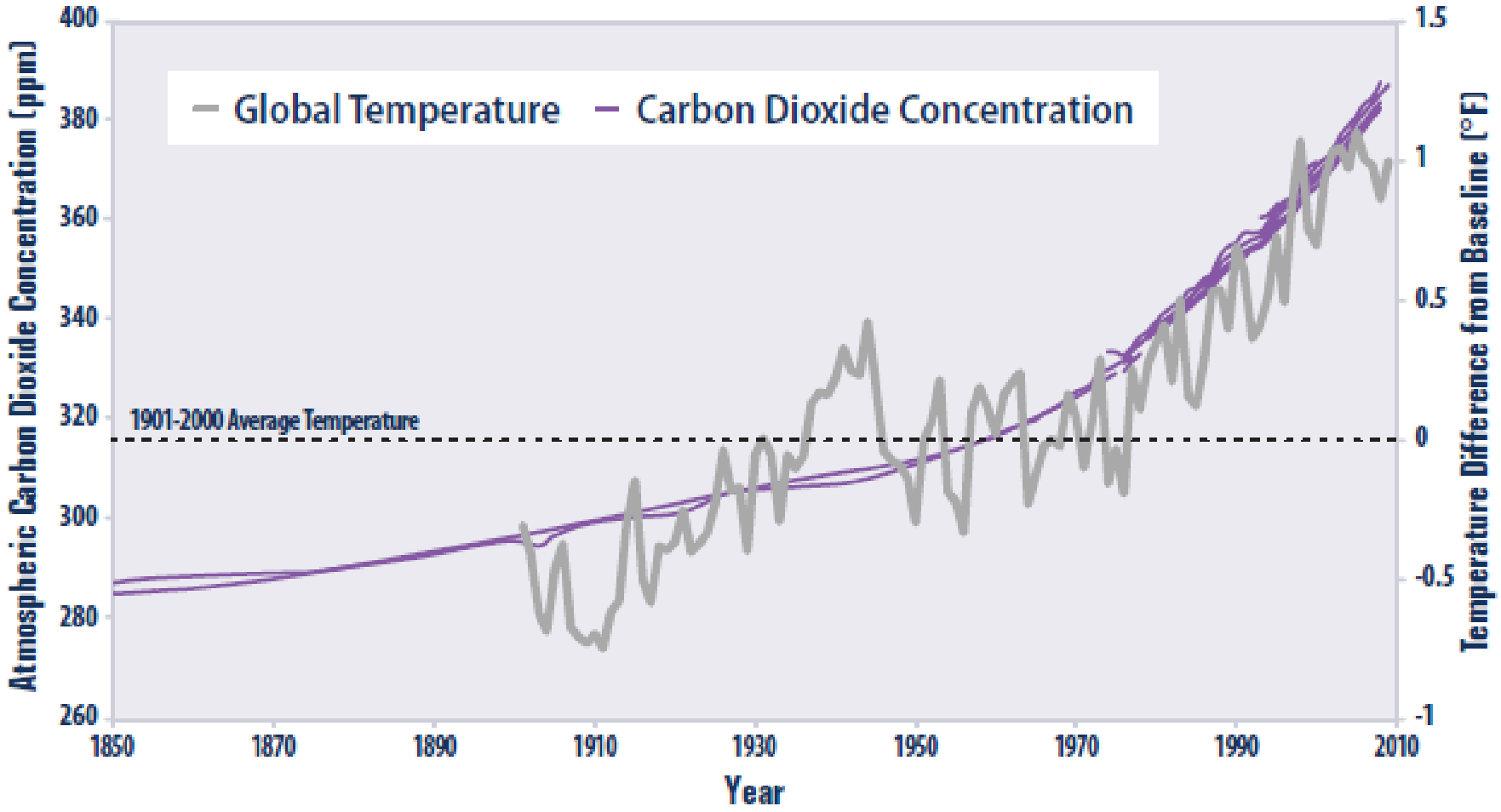


IPCC AR4 Simulations (from 13 different climate models from around the world)



IPCC AR4 Simulations (from 13 different climate models from around the world)

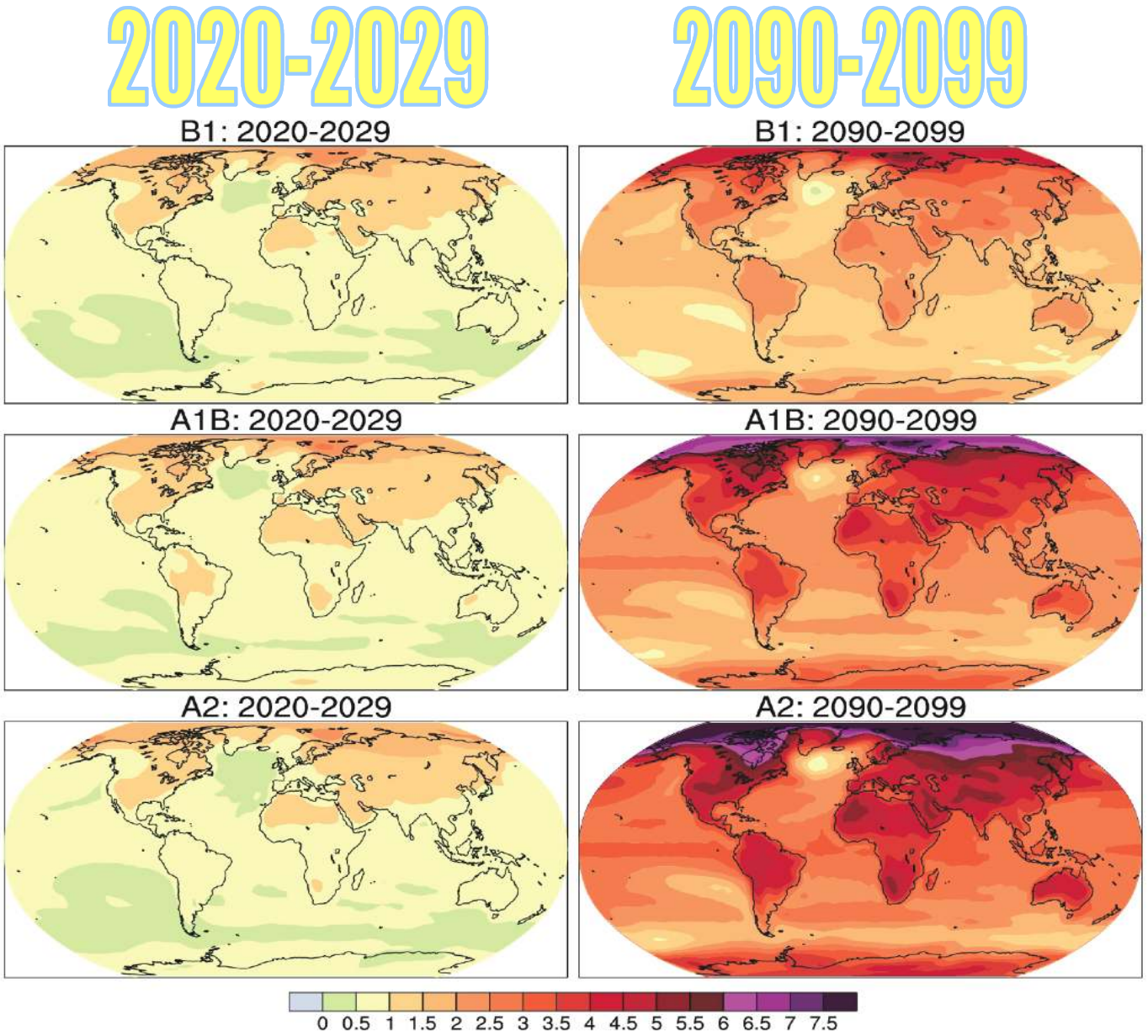
The Link Between Greenhouse Gases and Temperature, 1850–2009



Projections of Climate Change (IPCC, 2007)

greatest over land & at most high N latitudes

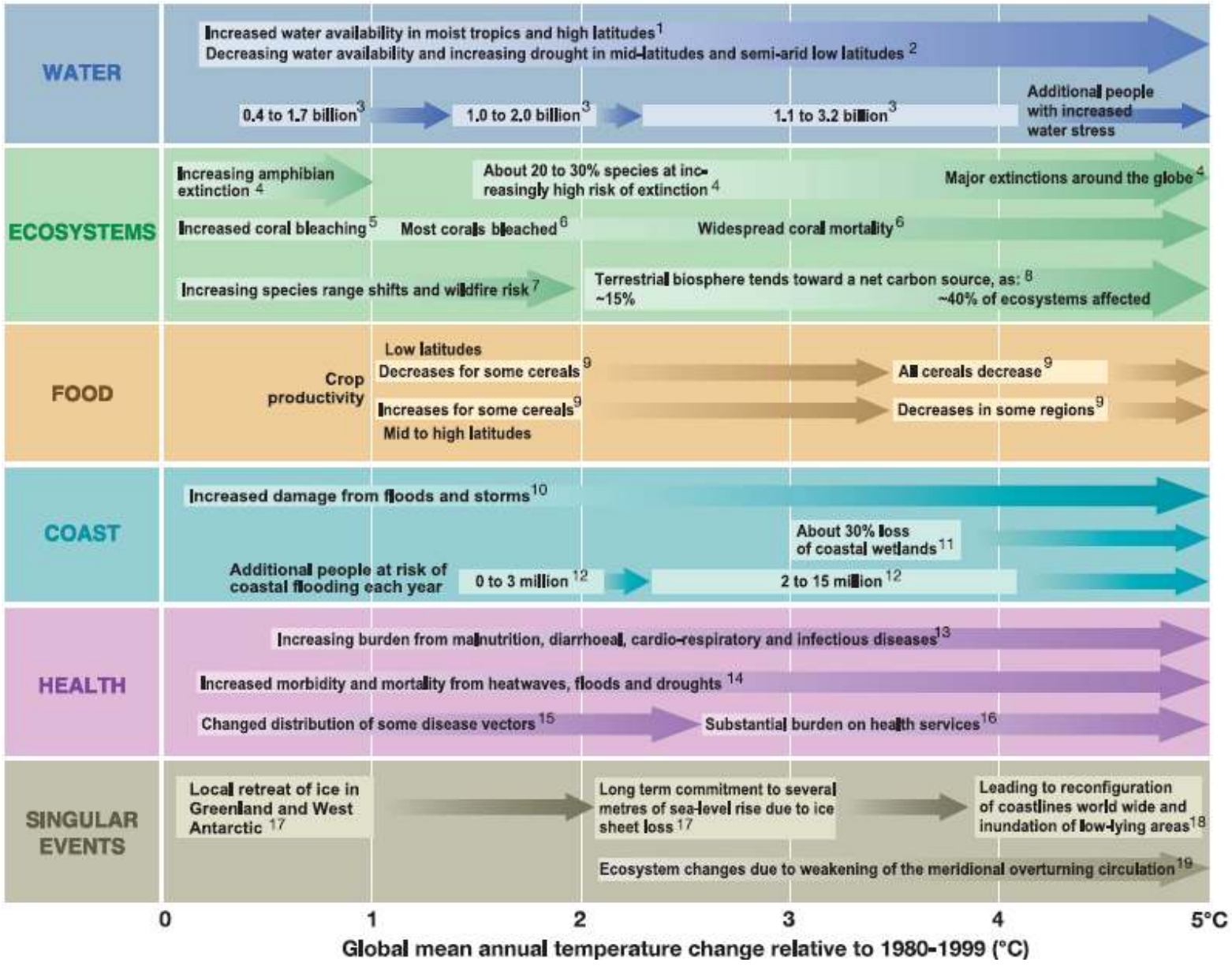
and least over the south, Ocean & parts of the N Atlantic Ocean



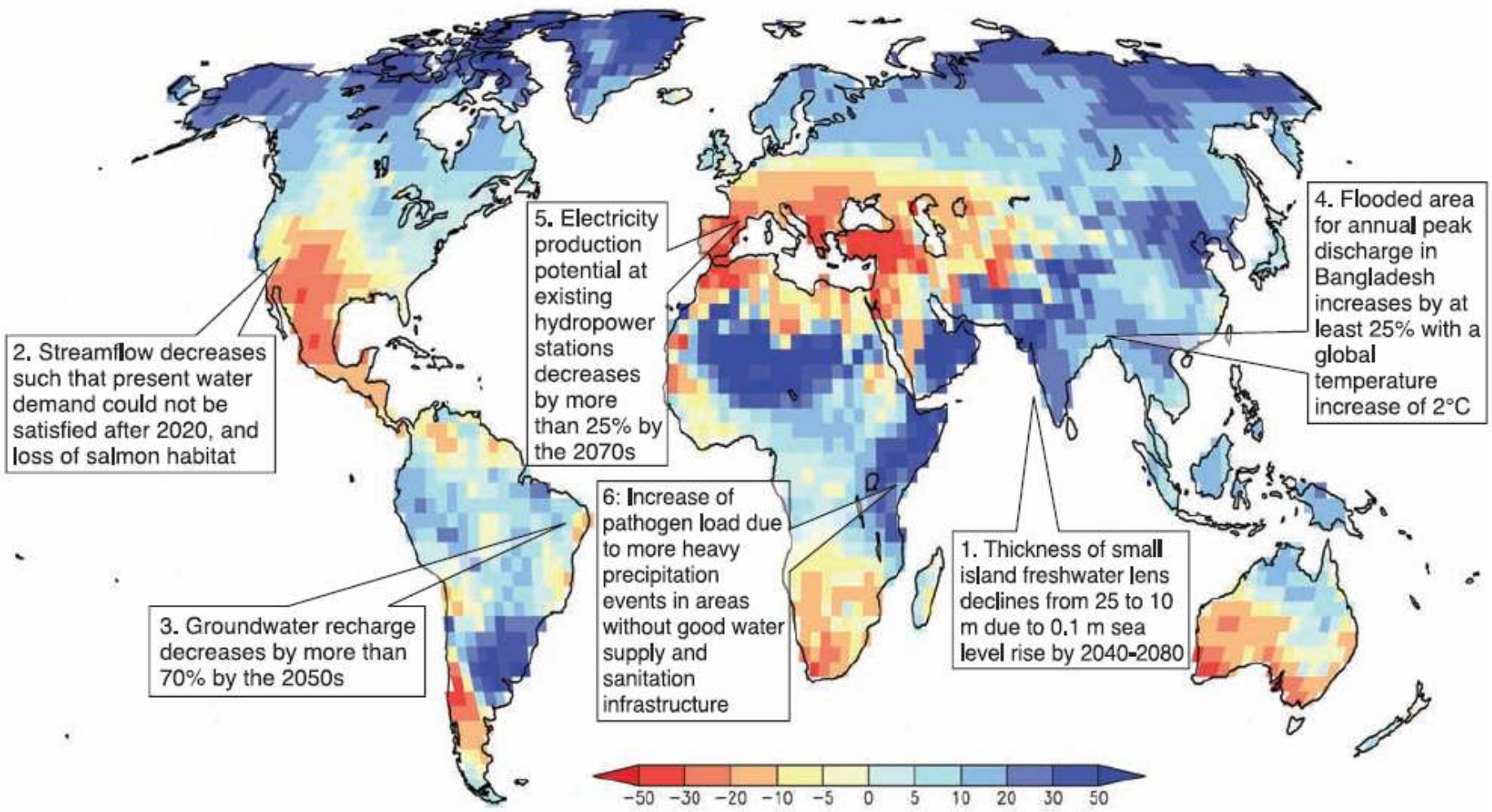
Ken Salazar, Secretary of the Interior, December 10, 2009

"Climate change is affecting every corner of the American continent. It's making droughts drier and longer, floods more dangerous, and hurricanes more severe."

Global Impacts of Climate Change



Future Climate Impacts on Freshwater

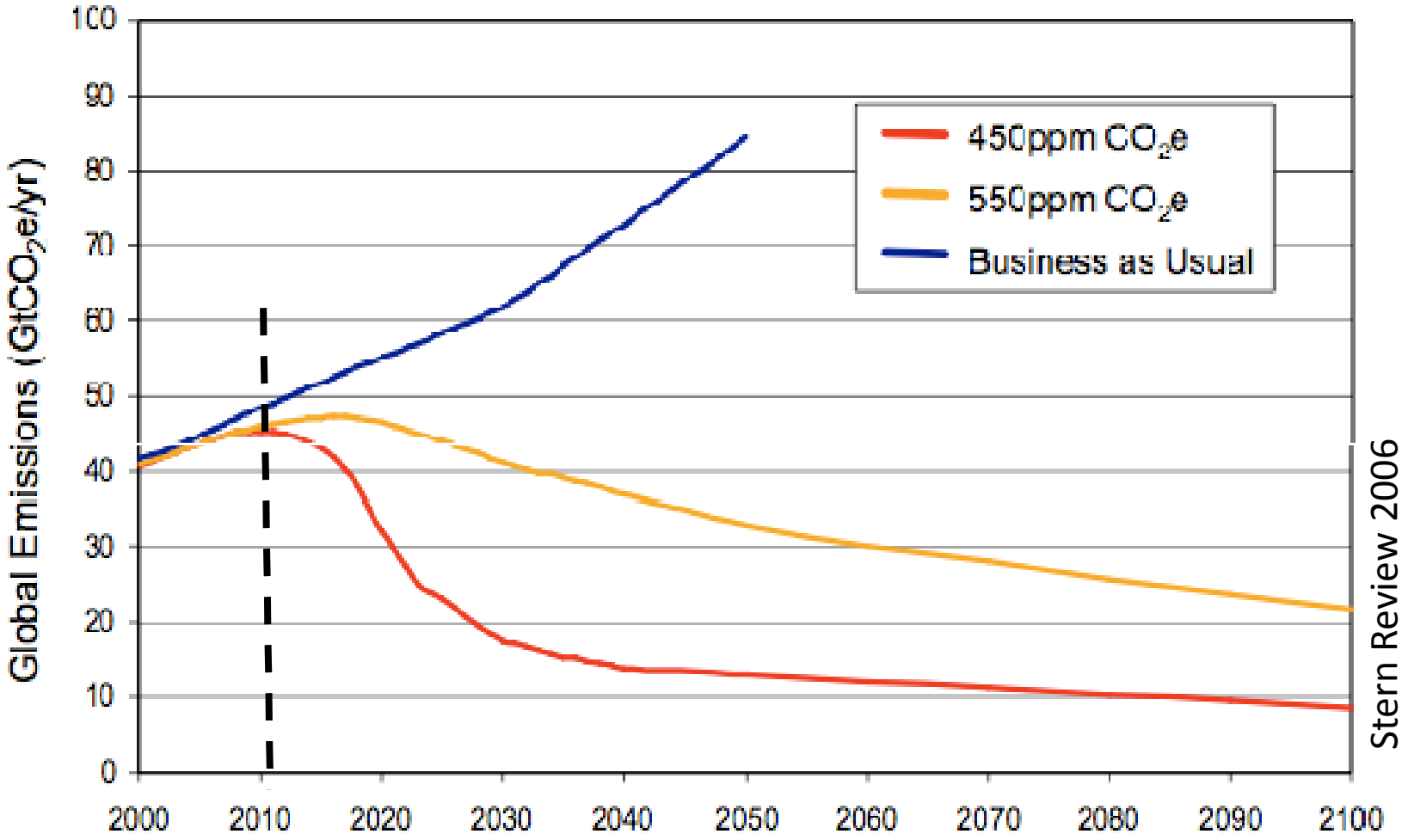


IPCC, WG2, 2007

Human Responses to Climate Change

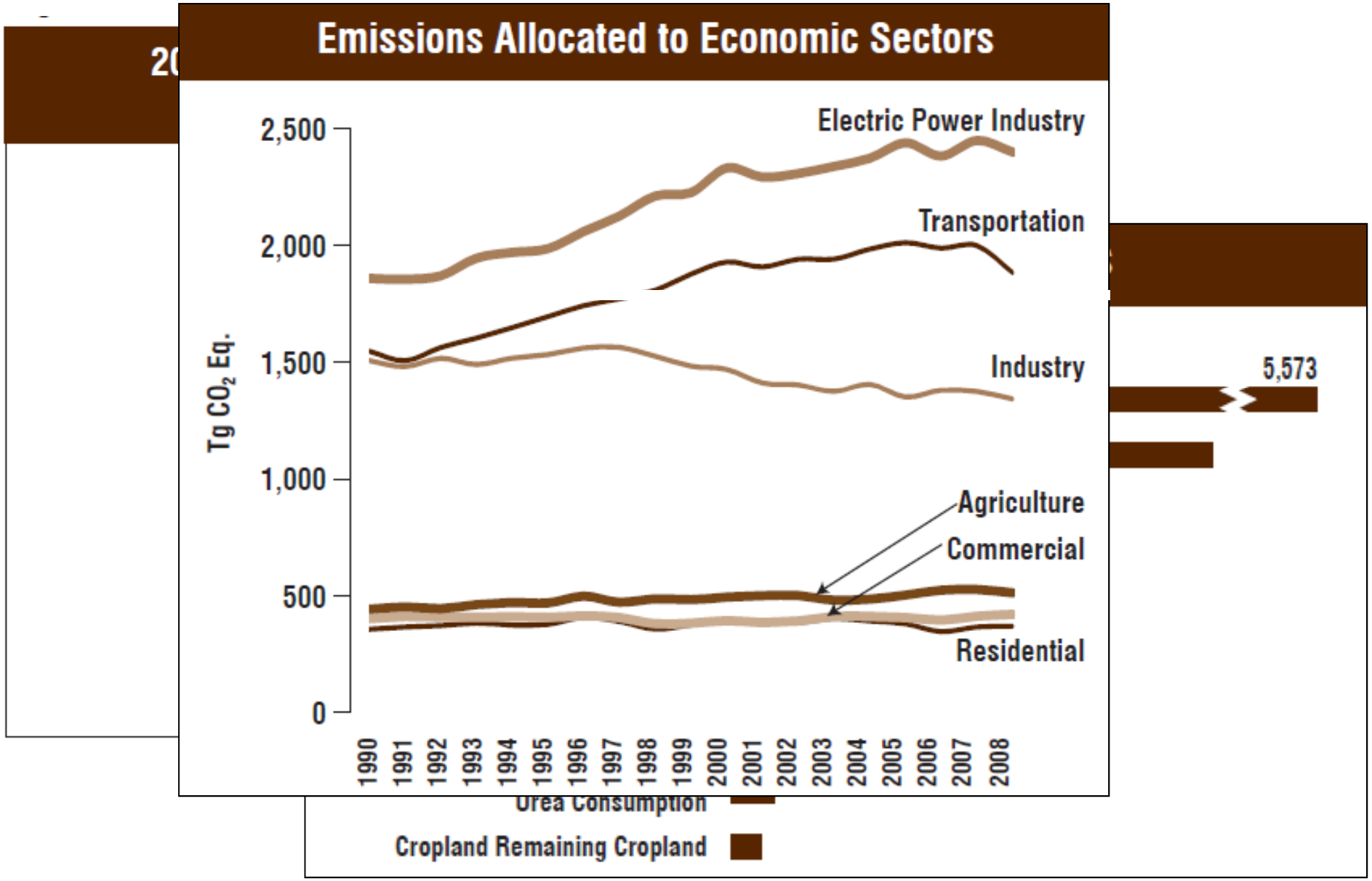
- ***Mitigation***: Actions to reduce greenhouse gas emissions.
- ***Adaptation***: Actions by individuals or systems to avoid, withstand, or take advantage of current and projected climate changes and impacts.

Emissions Paths to Stabilisation



Strong action is needed urgently

US GHG Emissions



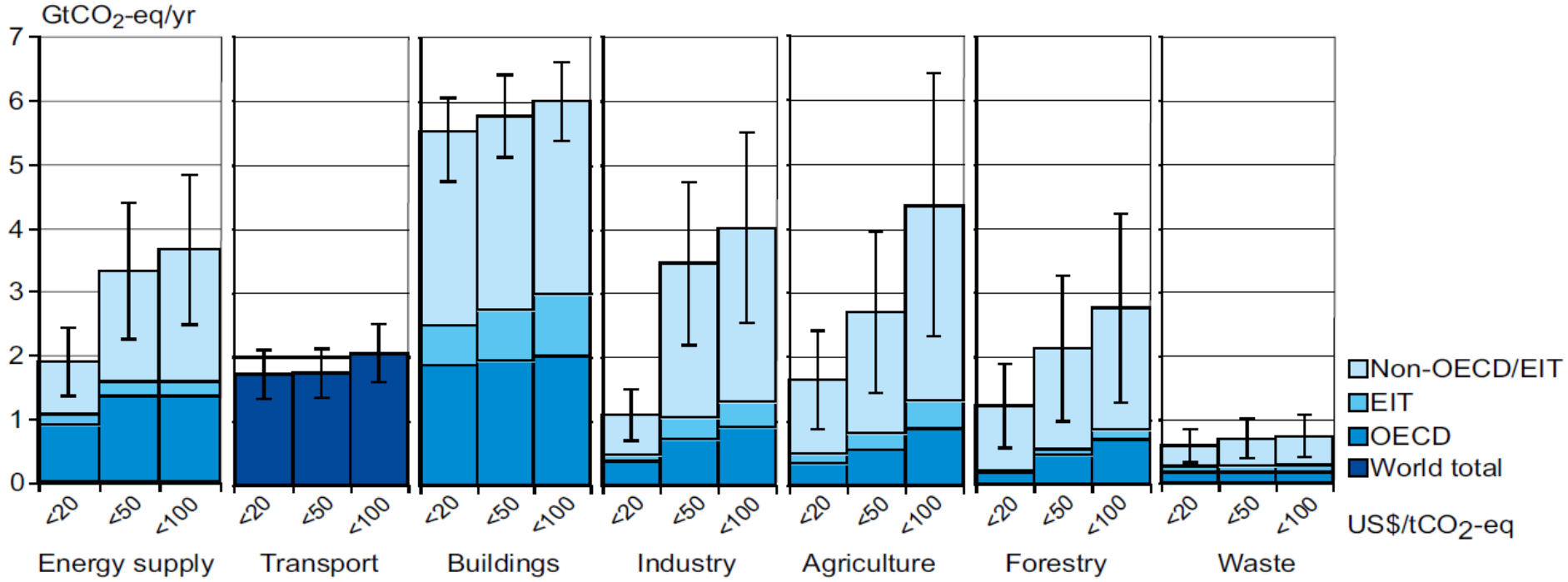
Potential for Climate Change Mitigation

- **Market potential** is the mitigation potential based on private costs and private discount rates.
- **Economic potential** is the amount of GHG mitigation, which takes into account social costs and benefits.
- **Technical potential** is the amount by which it is possible to reduce GHG emissions by implementing a technology or practice that has already been demonstrated.

Mitigation Options for Energy Sector

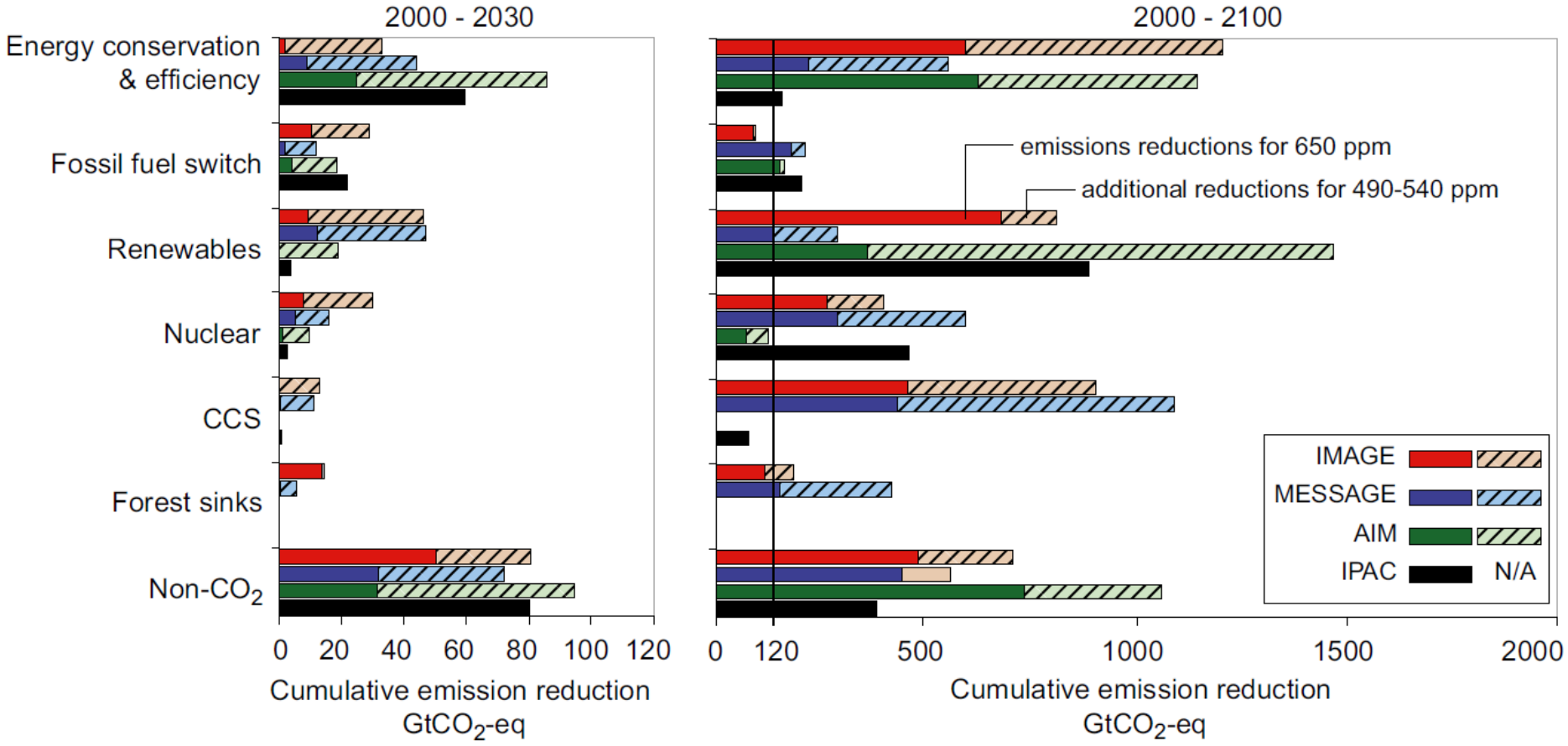
Sector and mitigation options	**Potential SD synergies and conditions for implementation**	**Potential SD trade-offs**
Energy supply and use: Chapters 4-7		
Energy efficiency improvement in all sectors (buildings, transportation, industry, and energy supply) (Chapters 4-7)	- Almost always cost-effective, reduces or eliminates local pollutant emissions and consequent health impacts, improves indoor comfort and reduces indoor noise levels, creates business opportunities and jobs and improves energy security - Government and industry programmes can help overcome lack of information and principal agent problems - Programmes can be implemented at all levels of government and industry - Important to ensure that low-income household energy needs are given due consideration, and that the process and consequences of implementing mitigation options are, or the result is, gender-neutral	- Indoor air pollution and health impacts of improving the thermal efficiency of biomass cooking stoves in developing country rural areas are uncertain
Fuel switching and other options in the transportation and buildings sectors (Chapters 5 and 6)	- CO_2 reduction costs may be offset by increased health benefits - Promotion of public transport and non-motorized transport has large and consistent social benefits - Switching from solid fuels to modern fuels for cooking and heating indoors can reduce indoor air pollution and increase free time for women in developing countries - Institutionalizing planning systems for CO_2 reduction through coordination between national and local governments is important for drawing up common strategies for sustainable transportation systems	- Diesel engines are generally more fuel-efficient than gasoline engines and thus have lower CO_2 emissions, but increase particle emissions. - Other measures (CNG buses, hybrid diesel-electric buses and taxi renovation) may provide little climate benefit.
Replacing imported fossil fuels with domestic alternative energy sources (DAES) (Chapter 4)	- Important to ensure that DAES is cost-effective - Reduces local air pollutant emissions. - Can create new indigenous industries (e.g., Brazil ethanol programme) and hence generate employment	- Balance of trade improvement is traded off against increased capital required for investment - Fossil fuel-exporting countries may face reduced exports - Hydropower plants may displace local populations and cause environmental damage to water bodies and biodiversity
Replacing domestic fossil fuel with imported alternative energy sources (IAES) (Chapter 4)	- Almost always reduces local pollutant emissions - Implementation may be more rapid than DAES - Important to ensure that IAES is cost-effective - Economies and societies of energy-exporting countries would benefit	- Could reduce energy security - Balance of trade may worsen but capital needs may decline

Sectoral Economic Potential for Global Mitigation



IPCC, WG3, 2007

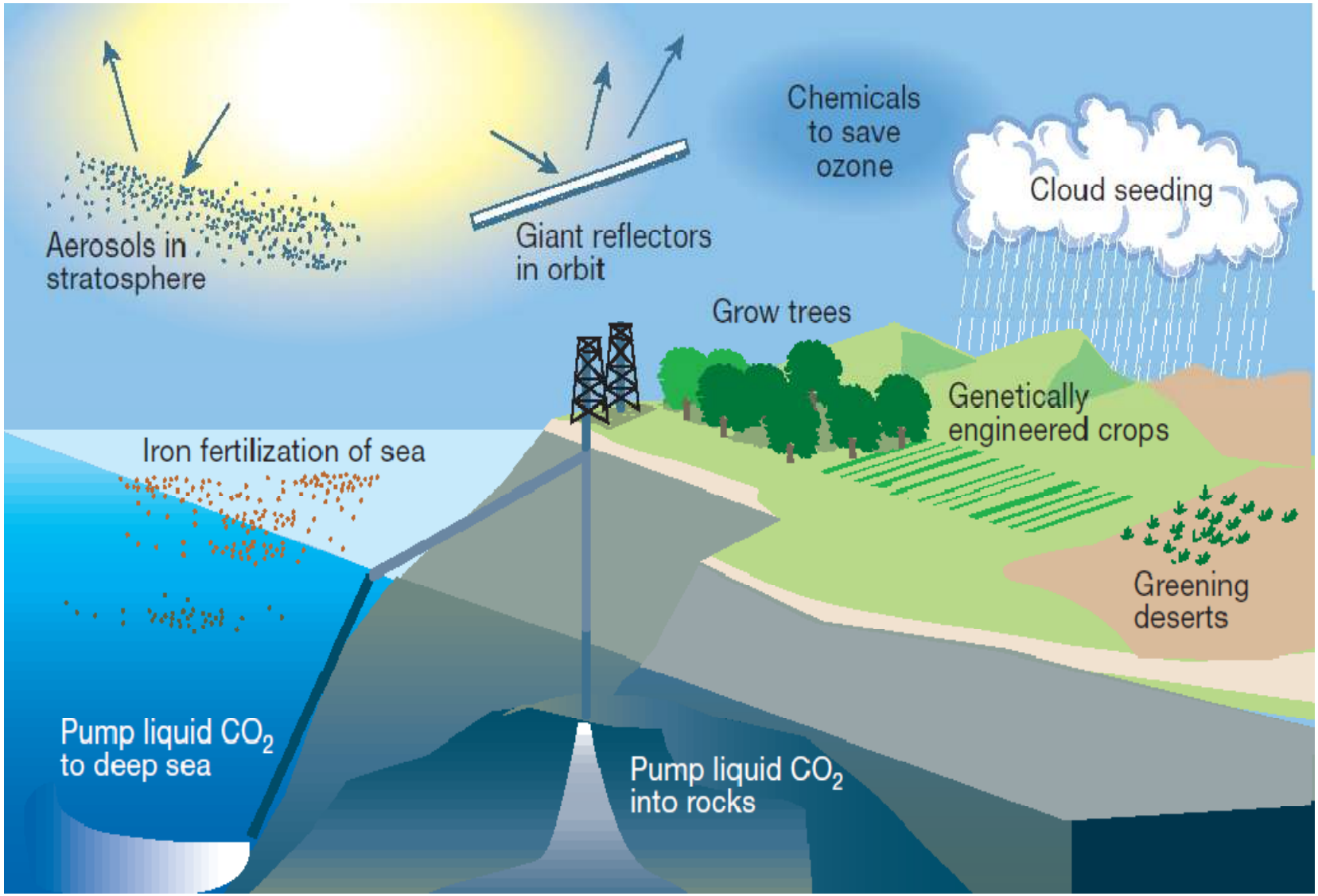
Cumulative Emission Reductions for Alternative Mitigation Measures



IPCC, 2007

Earth-Engineering for Climate Change Mitigation

Keith, David, 2001: Geoengineering, *Nature*, **409**, 420.



Stratospheric Geoengineering

Benefits

1. Cool planet
2. Reduce or reverse sea ice melting
3. Reduce or reverse ice sheet melting
4. Reduce or reverse sea level rise
5. Increase plant productivity
6. Increase terrestrial CO_2 sink

Risk

1. Drought in Africa and Asia
2. Continued ocean acidification
3. Ozone depletion
4. No more blue skies
5. Less solar electricity generation
6. Degrade passive solar heating
7. Environmental impact of implementation
8. Rapid warming if stopped
9. Cannot stop effects quickly
10. Human error
11. Unexpected consequences
12. Commercial control
13. Military use of technology
14. Conflicts with current treaties
15. Whose hand on the thermostat?
16. Ruin terrestrial optical astronomy
17. Ruin stargazing
18. Ruin satellite remote sensing

Robock, Alan, 2008: 20 reasons why geoengineering may be a bad idea. *Bull. Atomic Scientists*, **64**, No. 2, 14-18, 59, doi:10.2968/064002006.

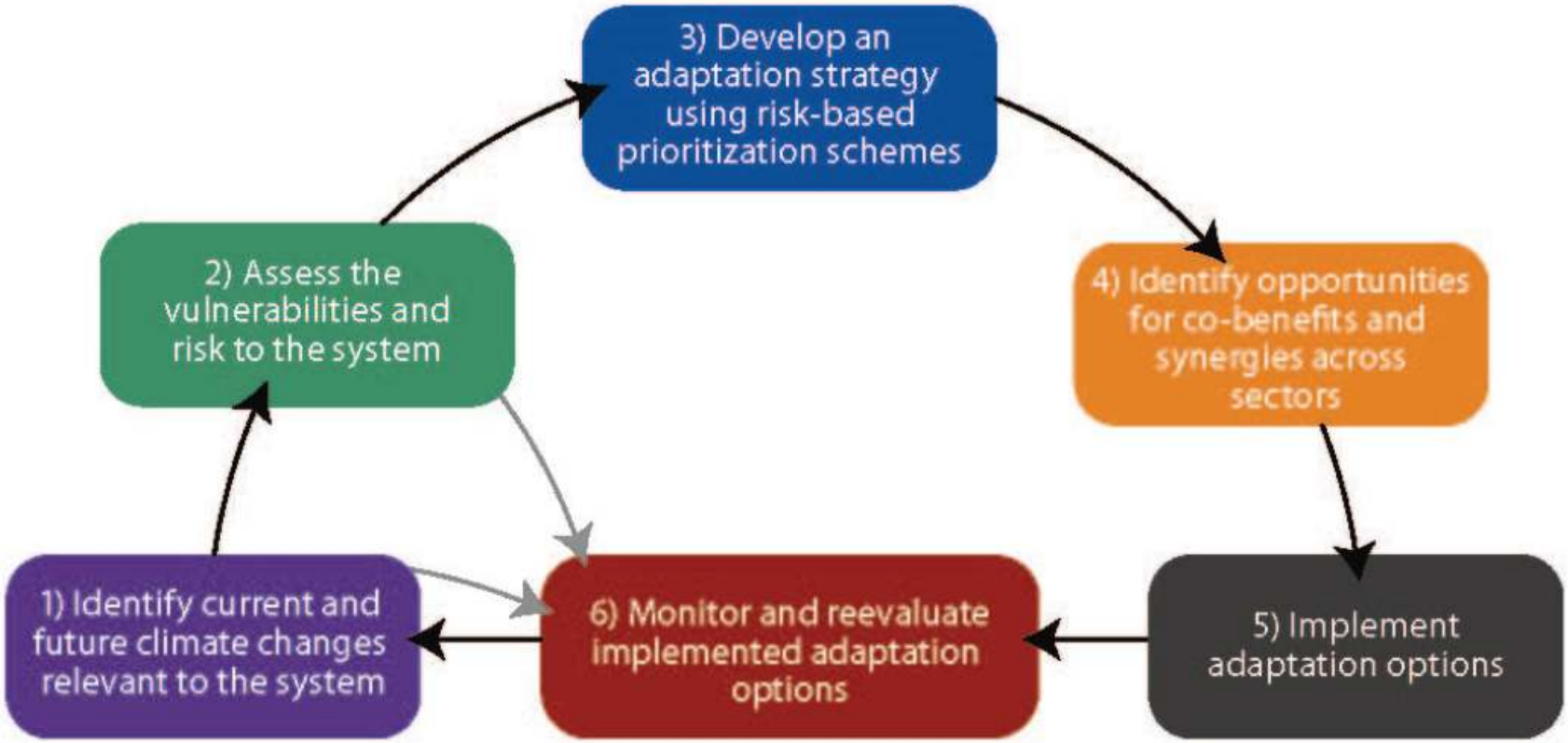
But……is mitigation the only solution to climate change?

No!

Adaptation

- Since climate change is inevitable and some degree of the changes will occur and affect the environment regardless of future mitigation of climate change, some actions should be taken in order to minimize the climate-induced risks to the environment, human health, society and economics.
- Such reactions are usually called "*adaptation*" and they are defined as the *adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities* (IPCC, 2007)

Adaptation Planning Process



NRC, 2010

Key Factors for Adaptation Capacity

- **Adaptive Capacity:** A system's inherent ability to adapt to climate change impacts.

Factors	Examples
Economic resources	Wealth of individuals and localities.
Technology	Localized climate and impact modeling to predict climate change and variability; efficient irrigation systems to reduce water demand.
Information/awareness	Species, sector, and geographic-based climate research; population education and awareness programs.
Skills/human resources	Training and skill development in sectors and populations; knowledge-sharing tools and support.
Natural resources	Abundant levels of varied and resilient natural resources that can recover from climate change impacts; healthy and inter-connected ecosystems that support migration patterns, species development and sustainability.
Infrastructure	Systems that provide sufficient protection and enable efficient response (e.g., wireless communication, health systems, air-conditioned shelter).
Institutional support/governance	Governmental and non-governmental policies and resources to support climate change adaptation measures locally and nationally.

Adaptation Research

- Adaptation to the climate change effects has been widely discussed and focused on:
  - **Agriculture** (Howden et al., 2007; Karing et al., 1999; Mendelsohn and Dinar, 1999)
  - **Water Resources** (de Loe et al., 2001; Dessai and Hulme, 2007)
  - **Ecosystems** (Richards et al., 2008; Vos et al., 2008)
  - **Human Health** (Ebi and Burton, 2008).

Example of Adaptation Initiatives

REGION Country *Reference*	Climate-related stress	Adaptation practices
AMERICAS		
Canada ***(1) Ford and Smit (2004)*** ***(2) Mehdi (2006)***	(1) Permafrost melt; change in ice cover	Changes in livelihood practices by the Inuit, including: change of hunt locations; diversification of hunted species; use of Global Positioning Systems (GPS) technology; encouragement of food sharing.
	(2) Extreme temperatures	Implementation of heat health alert plans in Toronto, which include measures such as: opening of designated cooling centres at public locations; information to the public through local media; distribution of bottled water through the Red Cross to vulnerable people; operation of a heat information line to answer heat-related questions; availability of an emergency medical service vehicle with specially trained staff and medical equipment.
United States ***Easterling et al. (2004)***	Sea-level rise	Land acquisition programmes taking account of climate change (e.g., New Jersey Coastal Blue Acres land acquisition programme to acquire coastal lands damaged/prone to damages by storms or buffering other lands; the acquired lands are being used for recreation and conservation); establishment of a 'rolling easement' in Texas, an entitlement to public ownership of property that 'rolls' inland with the coastline as sea-level rises; other coastal policies that encourage coastal landowners to act in ways that anticipate sea-level rise.
Mexico and Argentina ***Wehbe et al. (2006)***	Drought	Adjustment of planting dates and crop variety (e.g., inclusion of drought-resistant plants such as agave and aloe); accumulation of commodity stocks as economic reserve; spatially separated plots for cropping and grazing to diversify exposures; diversification of income by adding livestock operations; set-up/provision of crop insurance; creation of local financial pools (as alternative to commercial crop insurance).

Adaptation Options to Climate Change

	Food, fibre and forestry	Water resources	Human health	Industry, settlement and society
Drying/ Drought	*Crops*: development of new drought-resistant varieties; intercropping; crop residue retention; weed management; irrigation and hydroponic farming; water harvesting *Livestock*: supplementary feeding; change in stocking rate; altered grazing and rotation of pasture *Social*: Improved extension services; debt relief; diversification of income	Leak reduction Water demand management through metering and pricing Soil moisture conservation e.g., through mulching Desalination of sea water Conservation of groundwater through artificial recharge Education for sustainable water use	Grain storage and provision of emergency feeding stations Provision of safe drinking water and sanitation Strengthening of public institutions and health systems Access to international food markets	Improve adaptation capacities, especially for livelihoods Incorporate climate change in development programmes Improved water supply systems and co-ordination between jurisdictions
Increased rainfall/ Flooding	*Crops*: Polders and improved drainage; development and promotion of alternative crops; adjustment of plantation and harvesting schedule; floating agricultural systems *Social*: Improved extension services	Enhanced implementation of protection measures including flood forecasting and warning, regulation through planning legislation and zoning; promotion of insurance; and relocation of vulnerable assets	Structural and non-structural measures. Early-warning systems; disaster preparedness planning; effective post-event emergency relief	Improved flood protection infrastructure "Flood-proof" buildings Change land use in high-risk areas Managed realignment and "Making Space for Water" Flood hazard mapping; flood warnings Empower community institutions
Warming/ Heatwaves	*Crops*: Development of new heat-resistant varieties; altered timing of cropping activities; pest control and surveillance of crops *Livestock*: Housing and shade provision; change to heat-tolerant breeds *Forestry*: Fire management through altered stand layout, landscape planning, dead timber salvaging, clearing undergrowth. Insect control through prescribed burning, non-chemical pest control *Social*: Diversification of income	Water demand management through metering and pricing Education for sustainable water use	International surveillance systems for disease emergence Strengthening of public institutions and health systems National and regional heat warning systems Measures to reduce urban heat island effects through creating green spaces Adjusting clothing and activity levels; increasing fluid intake	Assistance programmes for especially vulnerable groups Improve adaptive capacities Technological change
Wind speed/ Storminess	*Crops*: Development of wind-resistant crops (e.g., vanilla)	Coastal defence design and implementation to protect water supply against contamination	Early-warning systems; disaster preparedness planning; effective post-event emergency relief	Emergency preparedness, including early-warning systems More resilient infrastructure Financial risk management options for both developed and developing regions

Impacts on Agriculture (IPCC, 2007)

- Increases in drought and flood frequency are projected to affect local crop production negatively
- Warmer and more frequent hot days and nights will increase insect outbreaks impacting agriculture, forestry and ecosystems.
- In many African regions, area suitable for agriculture, the length of growing seasons and yield potential are expected to decrease.
- In drier areas of Latin America, climate change could lead salinization and desertification of agricultural land. Productivity of important crops is projected to decrease and livestock productivity to decline.

Adaptation Strategies of Agricultural Sectors to Climate Change

- Changing planting dates (March -> Feb or Jan)
- Planting different varieties or crop species
- Development and promotion of alternative crops
- Developing new drought and heat-resistant varieties
- Better pest and disease control for crops;
- Implementing new or improving existing irrigation systems (Reducing water leakage, soil moisture conservation - mulching);

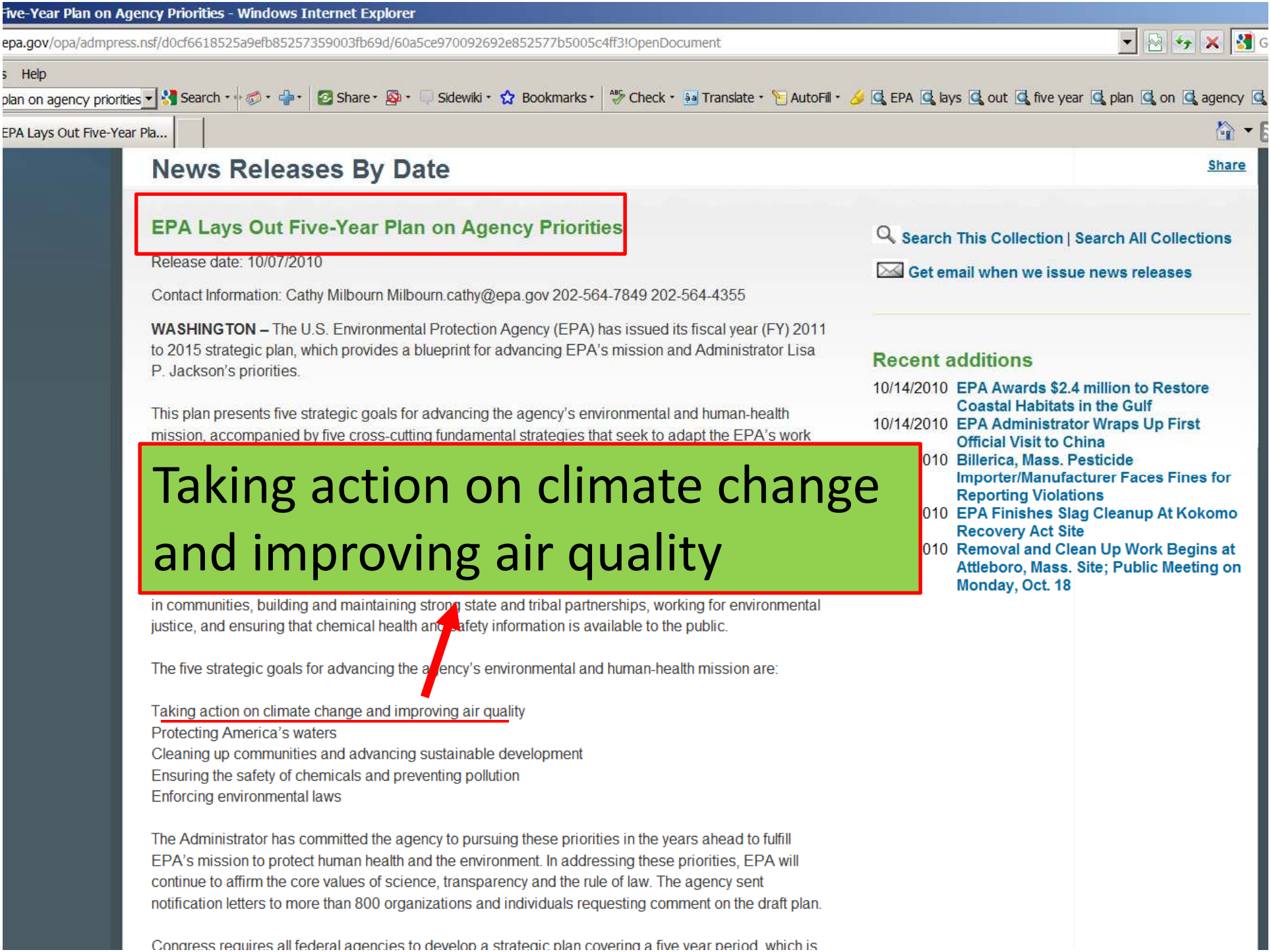
US Climate Change Adaptation Budgets

CLIMATE CHANGE ADAPTATION INITIATIVE

(dollars in millions)

Bureau	2010	2011	Change
BLM	15.0	17.5	+2.5
Reclamation	3.5	7.0	+3.5
USGS	67.5	77.9	+10.4
FWS	40.0	58.8	+18.8
NPS	10.0	10.0	+0.0
BIA	0.0	0.2	+0.2
TOTAL	**136.0**	**171.3**	**+35.4**

Climate Change Adaptation, Highlights of Departmental Interior, 2010


Five-Year Plan on Agency Priorities - Windows Internet Explorer
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EPA Lays Out Five-Year Plan on Agency Priorities
Release date: 10/07/2010
Contact Information: Cathy Milbourn Milbourn.cathy@epa.gov 202-564-7849 202-564-4355
WASHINGTON – The U.S. Environmental Protection Agency (EPA) has issued its fiscal year (FY) 2011 to 2015 strategic plan, which provides a blueprint for advancing EPA's mission and Administrator Lisa P. Jackson's priorities.
This plan presents five strategic goals for advancing the agency's environmental and human-health mission, accompanied by five cross-cutting fundamental strategies that seek to adapt the EPA's work
Taking action on climate change and improving air quality
in communities, building and maintaining strong state and tribal partnerships, working for environmental justice, and ensuring that chemical health and safety information is available to the public.
The five strategic goals for advancing the agency's environmental and human-health mission are:
Taking action on climate change and improving air quality
Protecting America's waters
Cleaning up communities and advancing sustainable development
Ensuring the safety of chemicals and preventing pollution
Enforcing environmental laws
The Administrator has committed the agency to pursuing these priorities in the years ahead to fulfill EPA's mission to protect human health and the environment. In addressing these priorities, EPA will continue to affirm the core values of science, transparency and the rule of law. The agency sent notification letters to more than 800 organizations and individuals requesting comment on the draft plan.
Congress requires all federal agencies to develop a strategic plan covering a five year period, which is
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10/14/2010 EPA Awards $2.4 million to Restore Coastal Habitats in the Gulf
10/14/2010 EPA Administrator Wraps Up First Official Visit to China
010 Billerica, Mass. Pesticide Importer/Manufacturer Faces Fines for Reporting Violations
010 EPA Finishes Slag Cleanup At Kokomo Recovery Act Site
010 Removal and Clean Up Work Begins at Attleboro, Mass. Site; Public Meeting on Monday, Oct. 18

DOE's Strategic Plans

Strategic Theme 1
Energy Security

Promoting America's energy security through reliable, clean, and affordable energy

GOAL 1.1 ENERGY DIVERSITY
Increase our energy options and reduce dependence on oil, thereby reducing vulnerability to disruptions and increasing the flexibility of the market to meet U.S. needs.

GOAL 1.2 ENVIRONMENTAL IMPACTS OF ENERGY
Improve the quality of the environment by reducing greenhouse gas emissions and environmental impacts to land, water, and air from energy production and use.

GOAL 1.3 ENERGY INFRASTRUCTURE
Create a more flexible, more reliable, and higher capacity U.S. energy infrastructure.

GOAL 1.4 ENERGY PRODUCTIVITY
Cost-effectively improve the energy efficiency of the U.S. economy.

Strategic Theme 3
Scientific Discovery & Innovation

Strengthening U.S. scientific discovery, economic competitiveness, and improving quality of life through innovations in science and technology

GOAL 3.1 SCIENTIFIC BREAKTHROUGHS
Achieve the major scientific discoveries that will drive U.S. competitiveness; inspire America; and revolutionize our approaches to the Nation's energy, national security, and environmental quality challenges.

GOAL 3.2 FOUNDATIONS OF SCIENCE
Deliver the scientific facilities, train the next generation of scientists and engineers, and provide the laboratory capabilities and infrastructure required for U.S. scientific primacy.

GOAL 3.3 RESEARCH INTEGRATION
Integrate basic and applied research to accelerate innovation and to create transformational solutions for energy and other U.S. needs.

Strategic Theme 5
Management Excellence

Enabling the mission through sound management

GOAL 5.1 INTEGRATED MANAGEMENT
Institute an integrated business management approach throughout DOE with clear roles and responsibilities and accountability to include effective line management oversight by both Federal and contractor organizations.

GOAL 5.2 HUMAN CAPITAL
Ensure that the DOE workforce is capable of meeting the challenges of the 21st Century by attracting, motivating, and retaining a highly skilled and diverse workforce to do the best job.

GOAL 5.3 INFRASTRUCTURE
Build, modernize and maintain facilities and infrastructure to achieve mission goals and ensure a safe and secure workplace.

GOAL 1.2 ENVIRONMENTAL IMPACTS OF ENERGY

Improve the quality of the environment by reducing greenhouse gas emissions and environmental impacts to land, water, and air from energy production and use.

GOAL 2.3 NUCLEAR PROPULSION PLANTS
Provide safe, militarily-effective nuclear propulsion plants to the U.S. Navy.

GOAL 4.2 MANAGING THE LEGACY
Manage the Department's post-closure environmental responsibilities and ensure the future protection of human health and the environment.

NOAA's Next-generation Strategic Plans

NOAA's Long-Term Goals:

Climate Adaptation and Mitigation:
An informed society anticipating and responding to climate and its impacts

Weather-Ready Nation:
Society is prepared for and responds to weather-related events

Healthy Oceans:
Marine fisheries, habitats, and biodiversity are sustained within healthy and p ecosystems

Resilient Coastal Communities and Economies:
Coastal and Great Lakes communities are environmentally and economically

The Copenhagen Accord

- In December 2009, The United Nations Climate Change Conference (COP15) in Copenhagen ended with an agreement, *The Copenhagen Accord*, which recognizes the importance of a two-degree increase in global temperatures for staving off the worst effects of climate change.
- According to *The Copenhagen Accord*, developed countries commit to a goal of mobilizing jointly **US$100 billion** a year by 2020 for developing countries to adapt to the environmental consequences of climate change (http://unfccc.int/meetings/cop_15/items/5257.php).

The AT&T Technology and Environment Awards Program - Connecting Minds for a Sustainable Future

Proposal title:

Development of an Air Pollution Alert System: Integrating an Air Quality Forecasting Model and Location-aware Mobile Devices

- Traditional ways: air pollution alerts are delivered to the public in three ways: 1) internet posting; 2) emails; and 3) broadcasting through media.

New approach: Integrating location-aware mobile devices into air quality alert systems