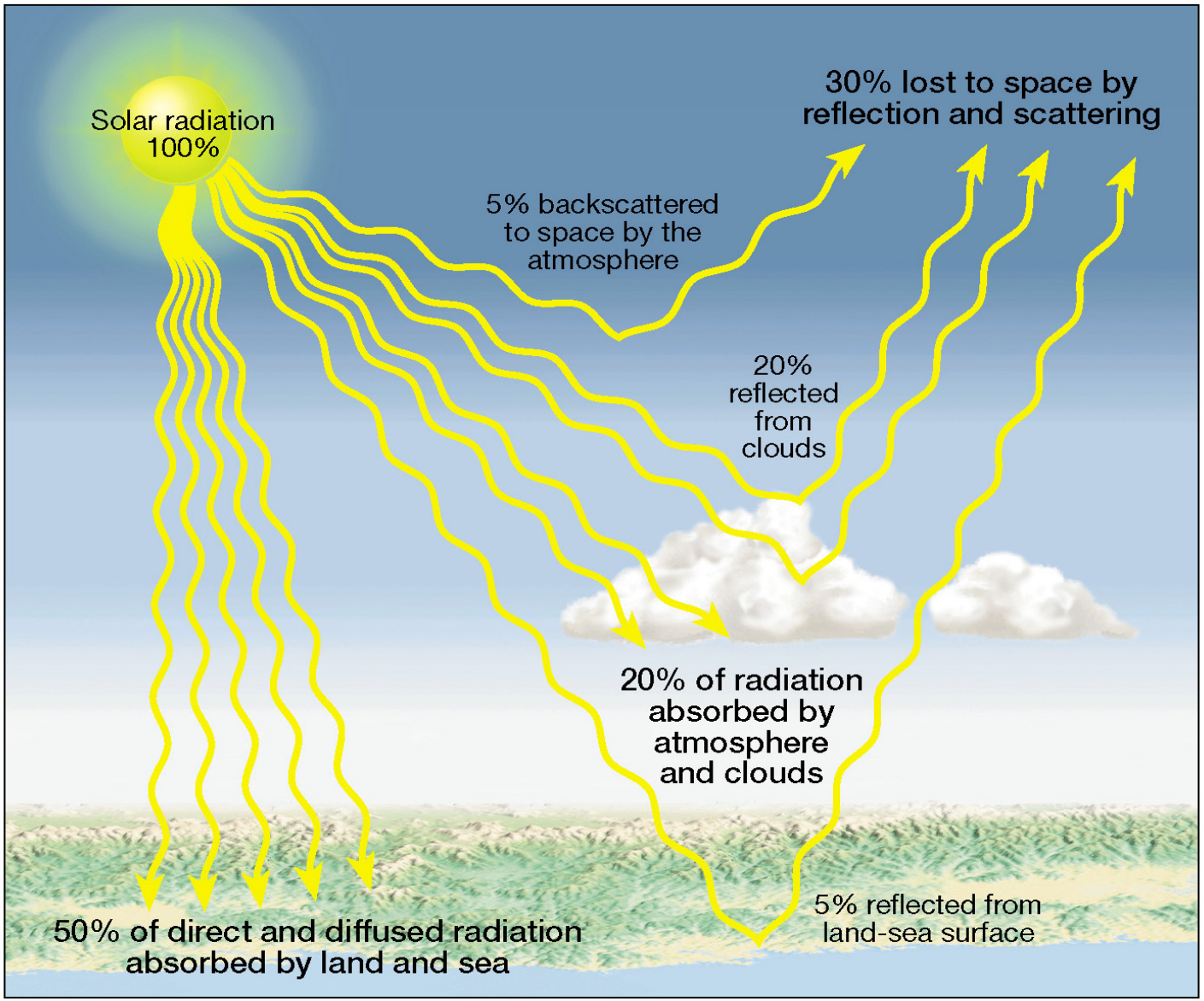
Global Sustainability Issues

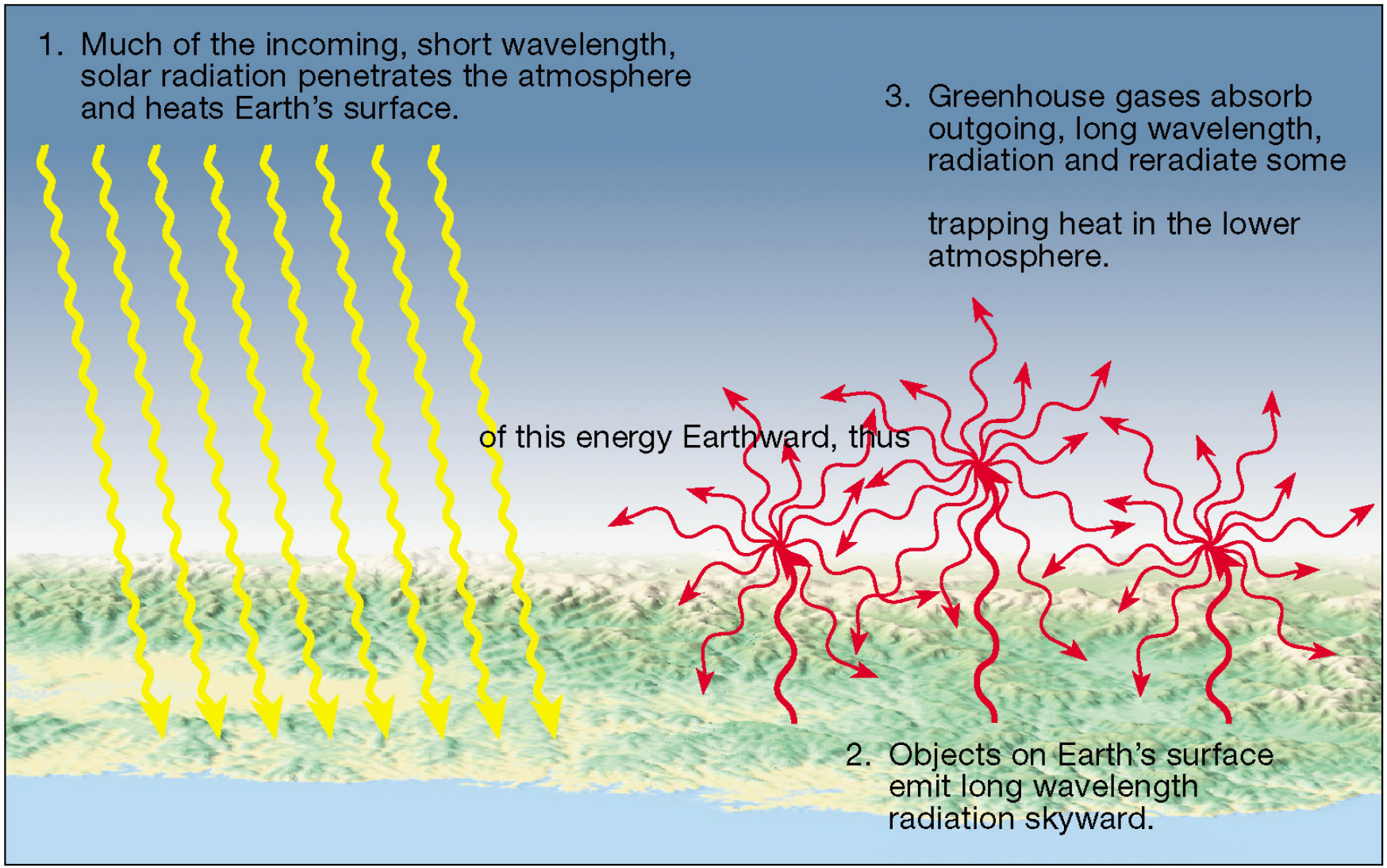
Let’s start with the biggie…..

Sunlight



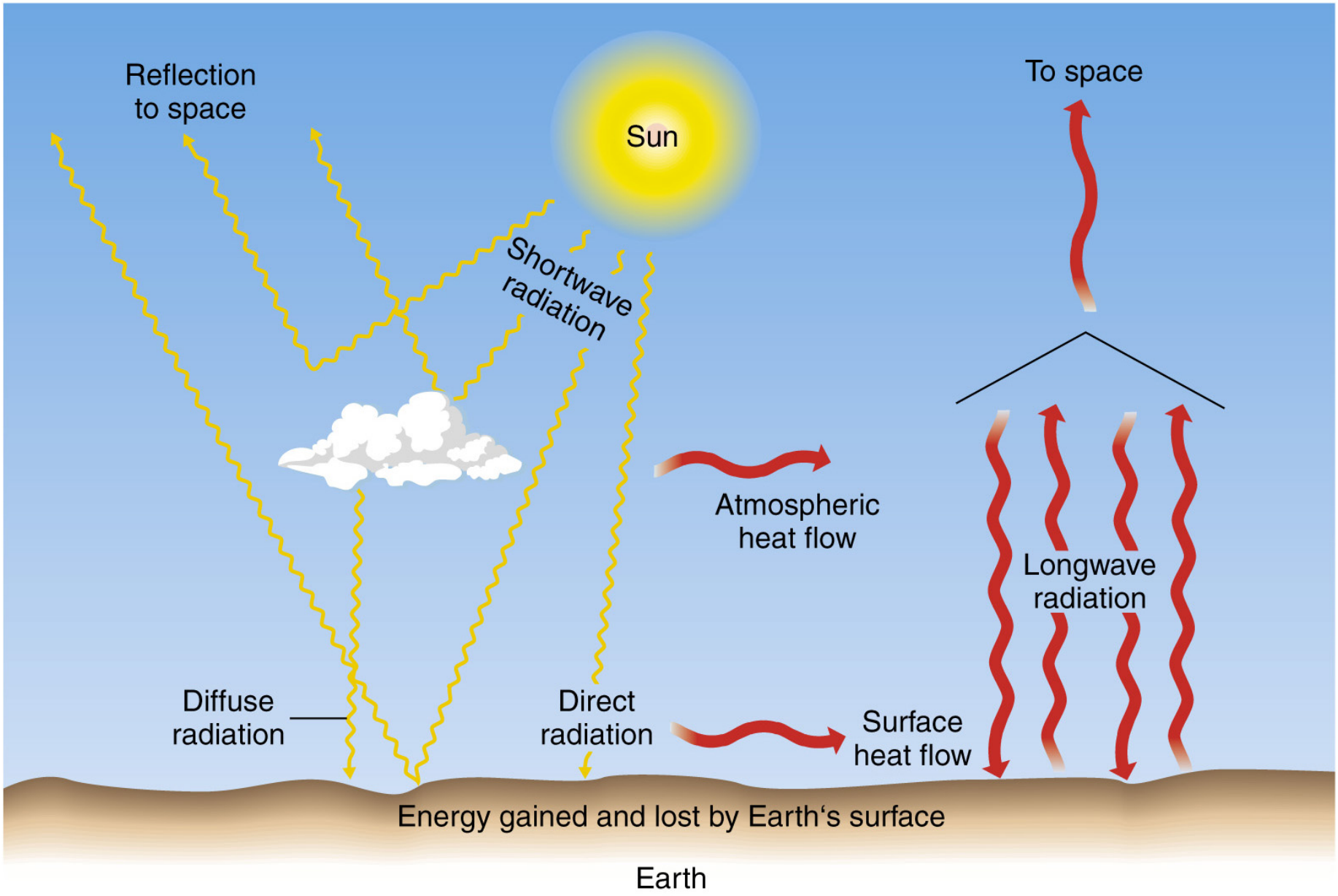
Lutgens and Tarbuck, The Atmosphere

Earth's energy balance



Lutgens and Tarbuck, The Atmosphere

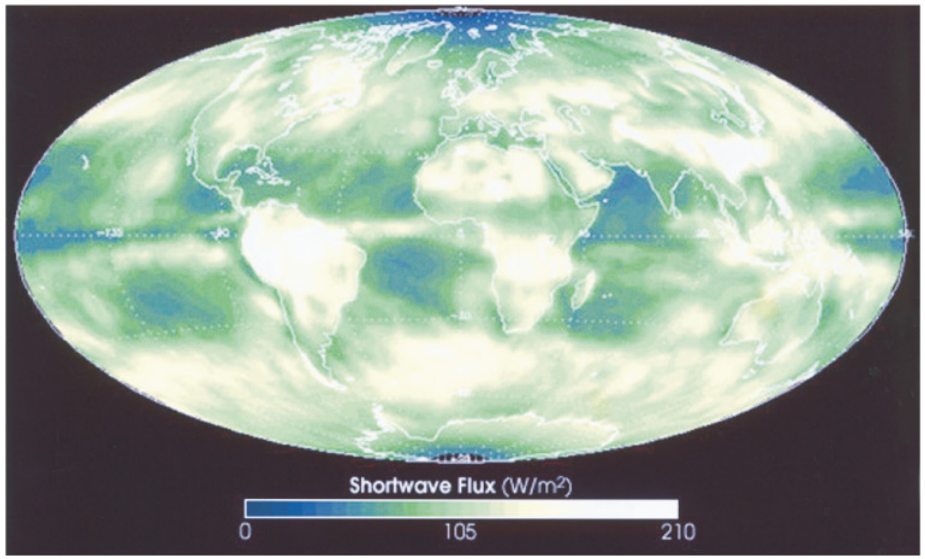
Energy Pathways



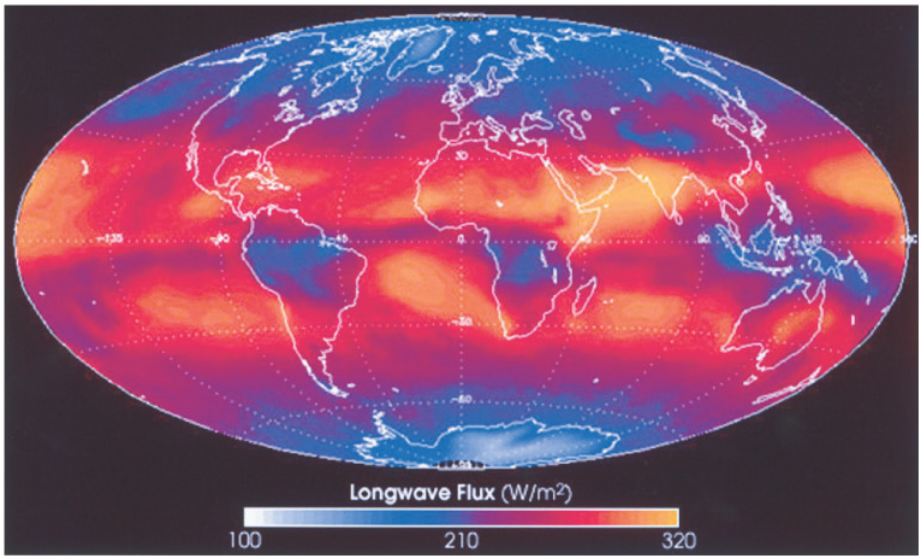
Christopherson: Geosystems

Figure 4.1

Shortwave and Longwave Energy

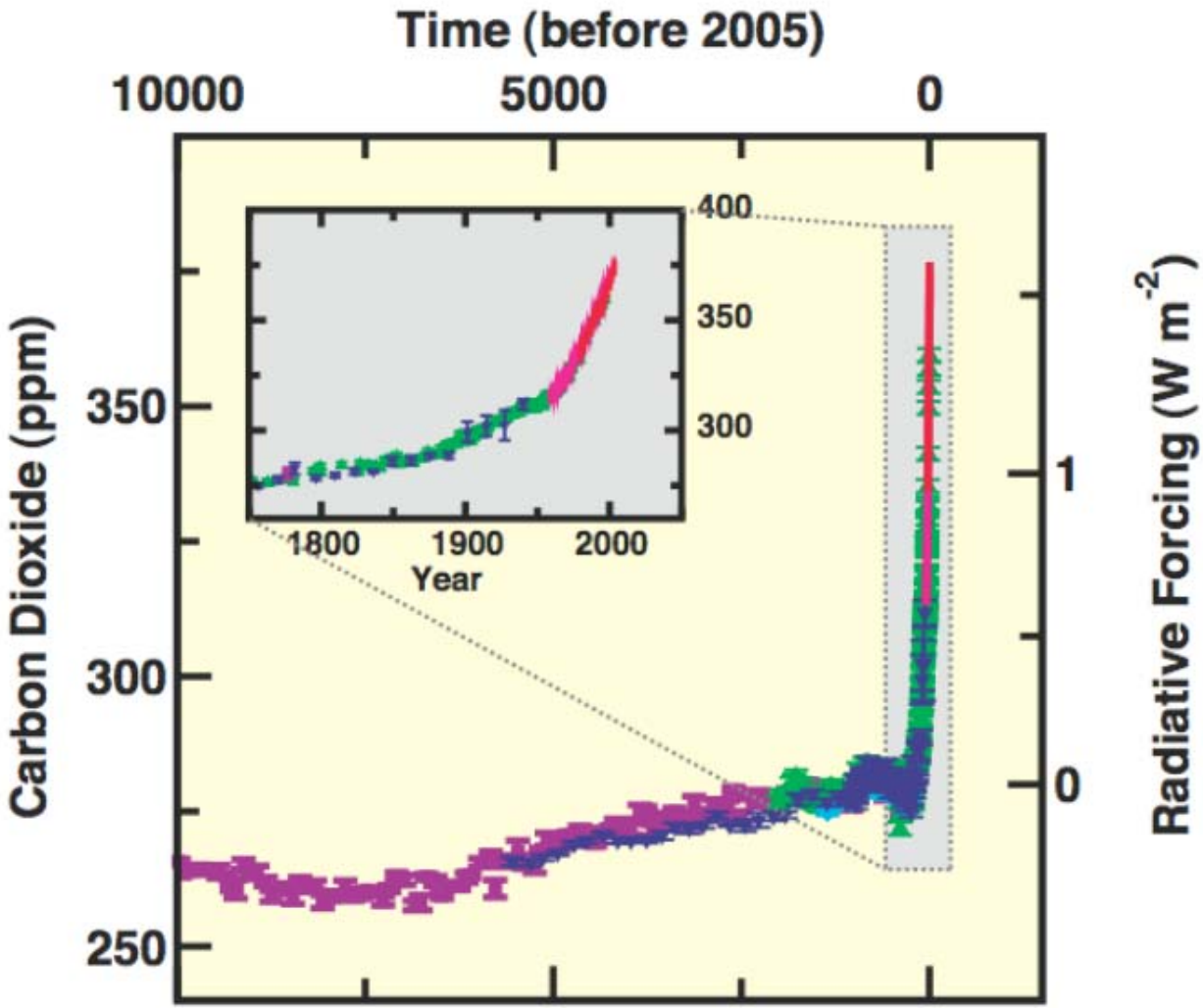


(a) Outgoing shortwave – Earth's albedo.



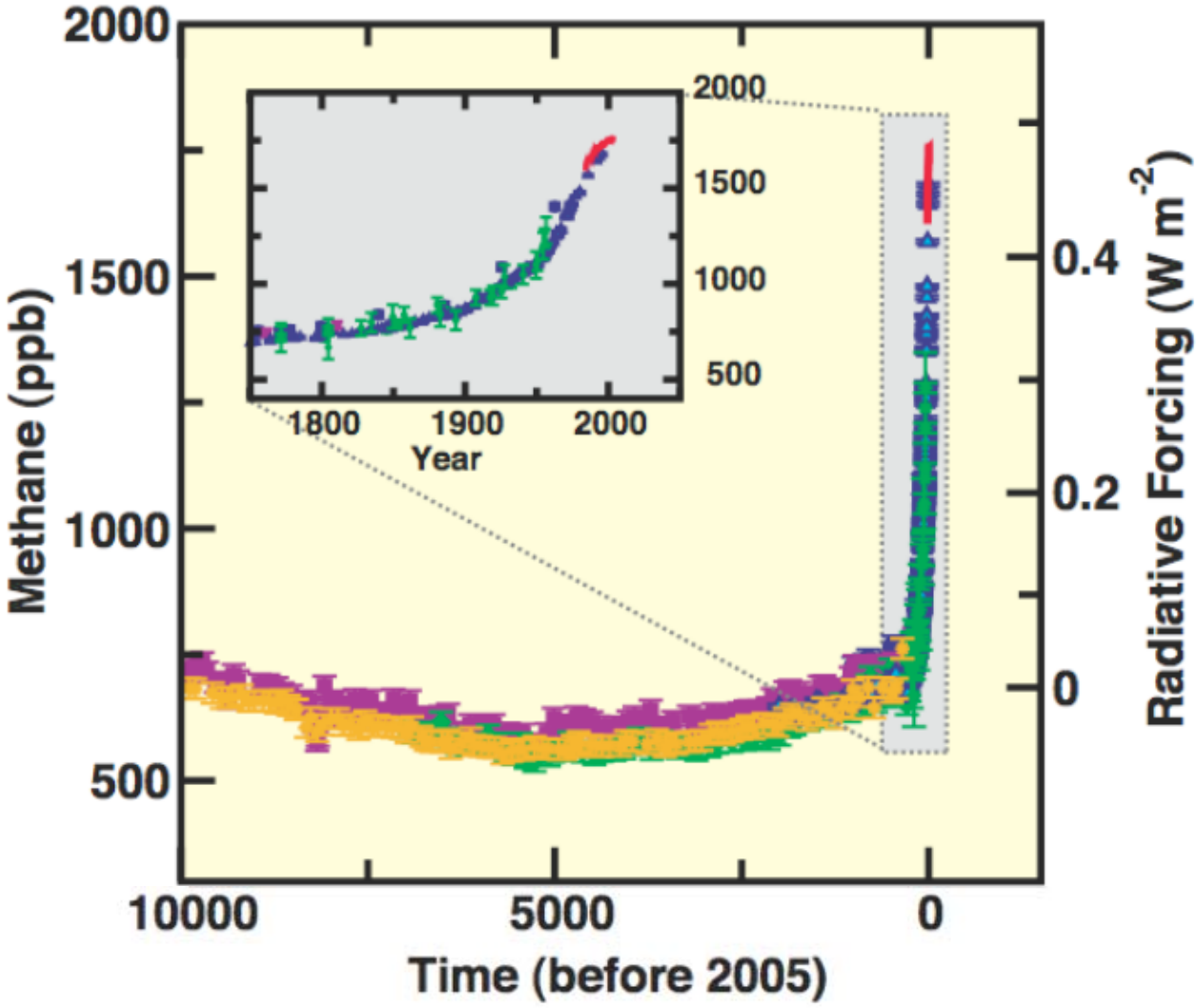
(b) Longwave energy flux to space.

Greenhouse Gases



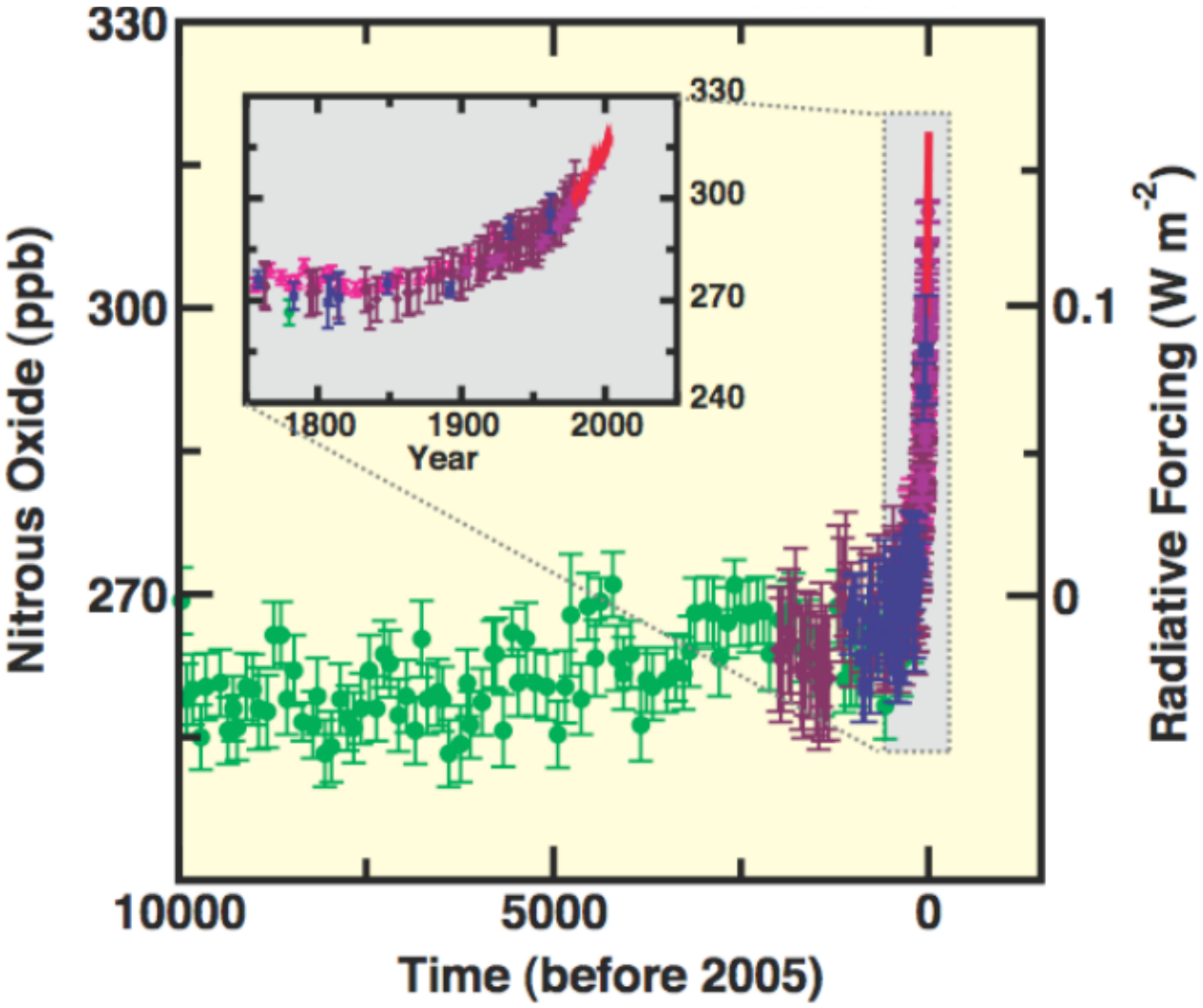
Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University Press. http://www.ipcc.ch

Greenhouse Gases



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University Press. http://www.ipcc.ch

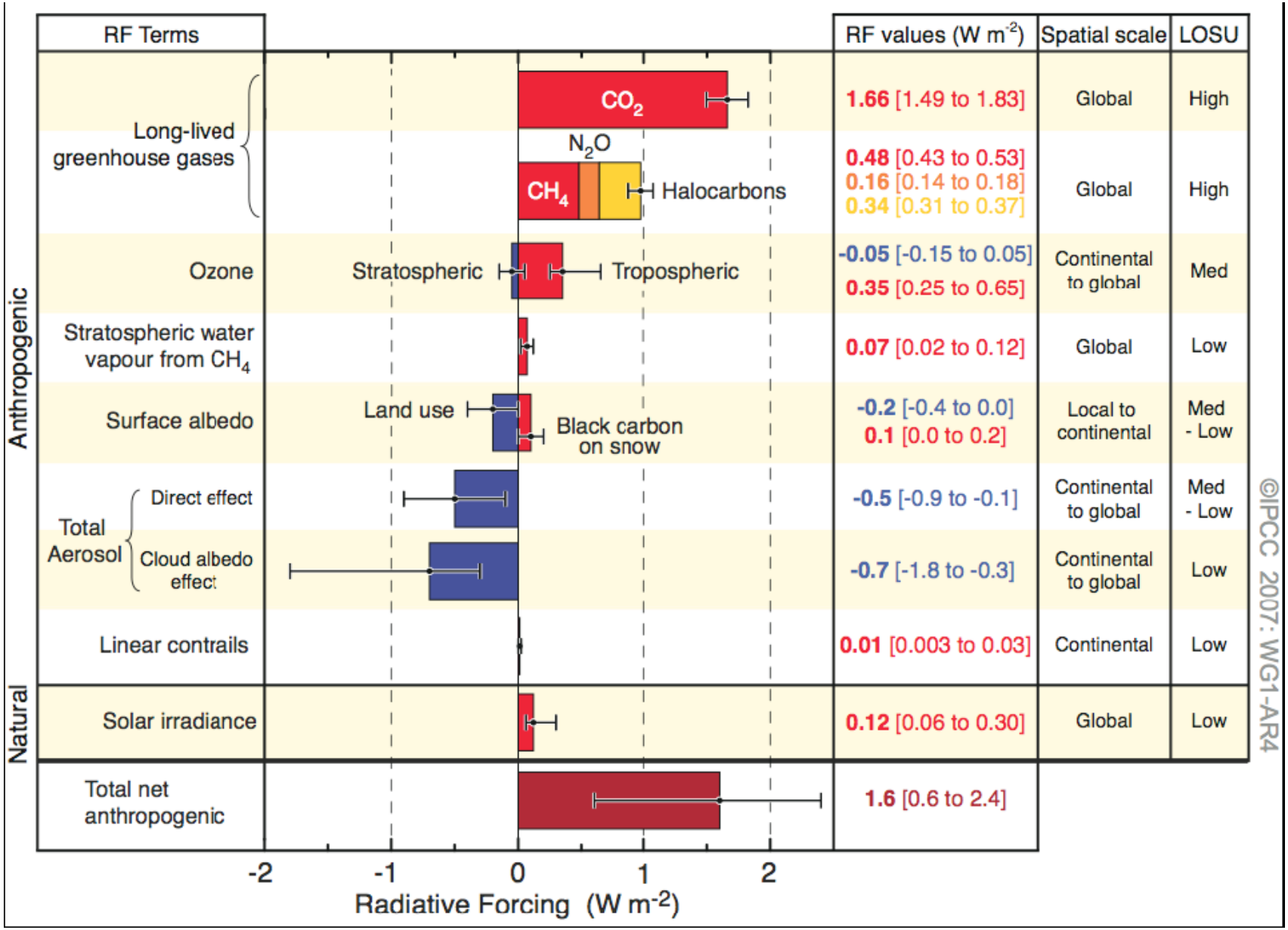
Greenhouse Gases



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University Press. http://www.ipcc.ch

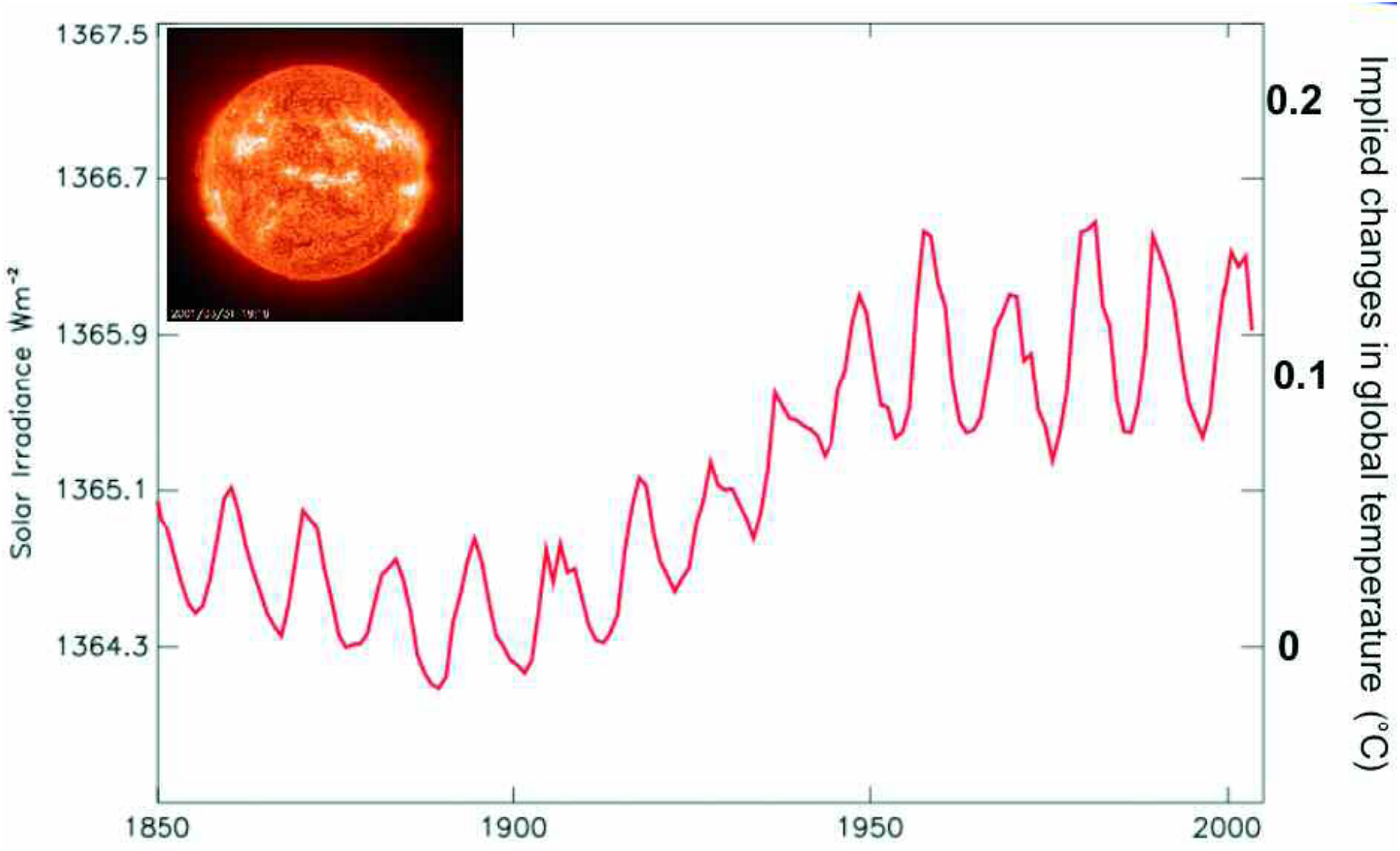
Surely it’s not only GHGs –
What other things control our climate?

Components of Radiative Forcing, 2005



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University Press (in press, 2007). http://www.ipcc.ch

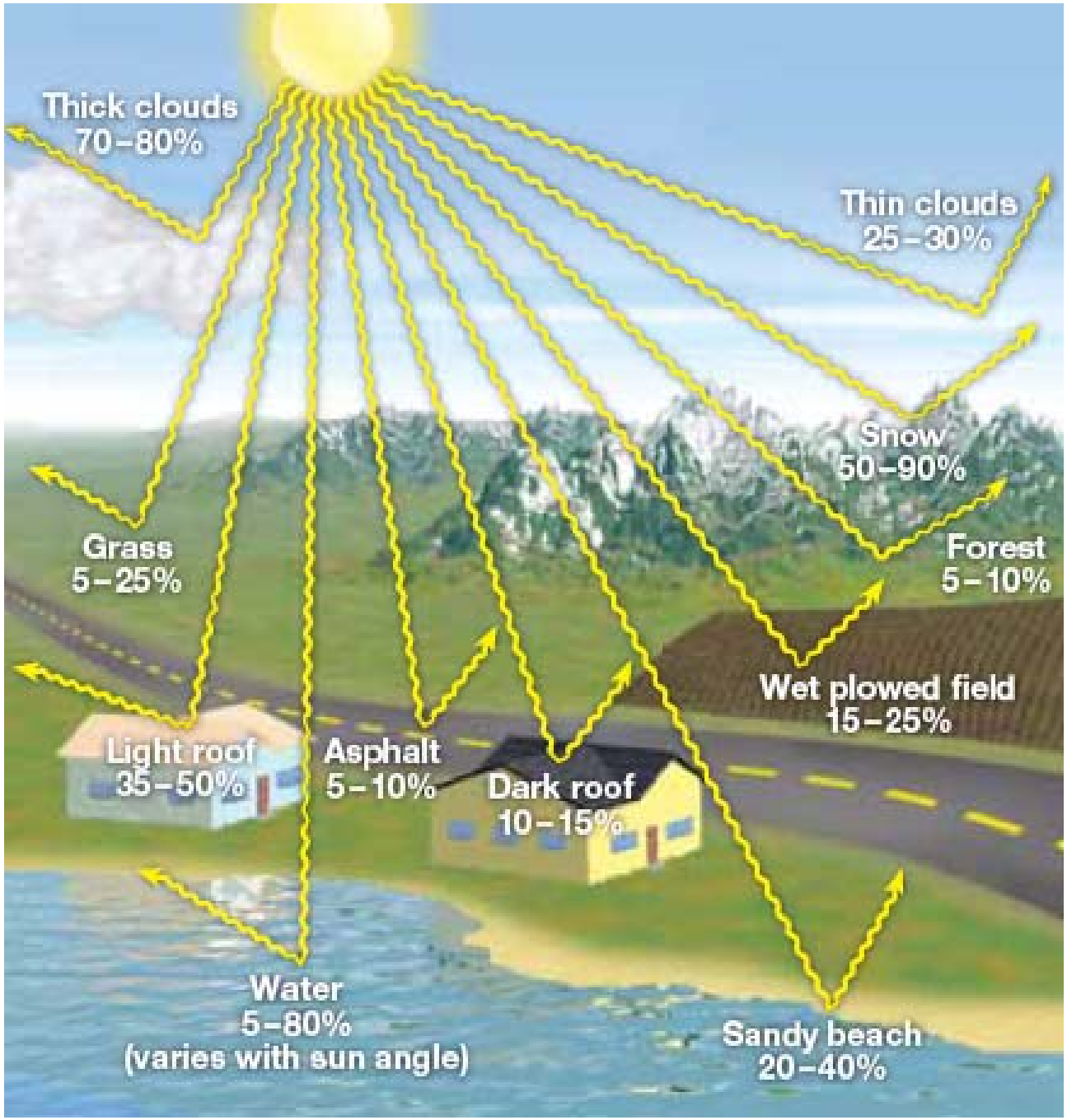
Changes in Solar Irradiance



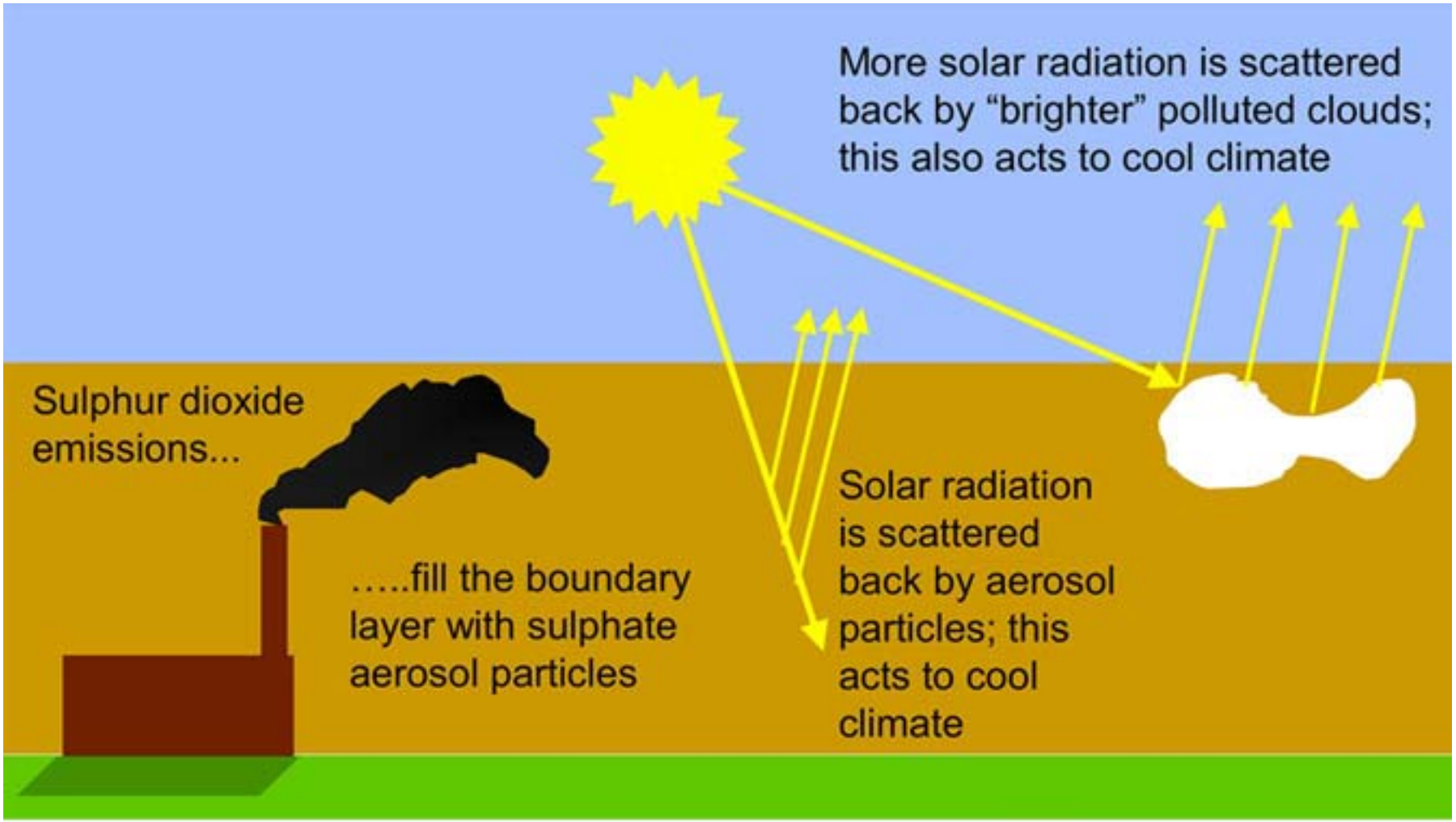
Lean, 2003

Hadley Centre for Climate Prediction and Research

Albedo


Thick clouds
70–80%
Thin clouds
25–30%
Snow
50–90%
Forest
5–10%
Grass
5–25%
Wet plowed field
15–25%
Light roof
35–50%
Asphalt
5–10%
Dark roof
10–15%
Water
5–80%
(varies with sun angle)
Sandy beach
20–40%

Sulphur aerosols cool climate directly and indirectly



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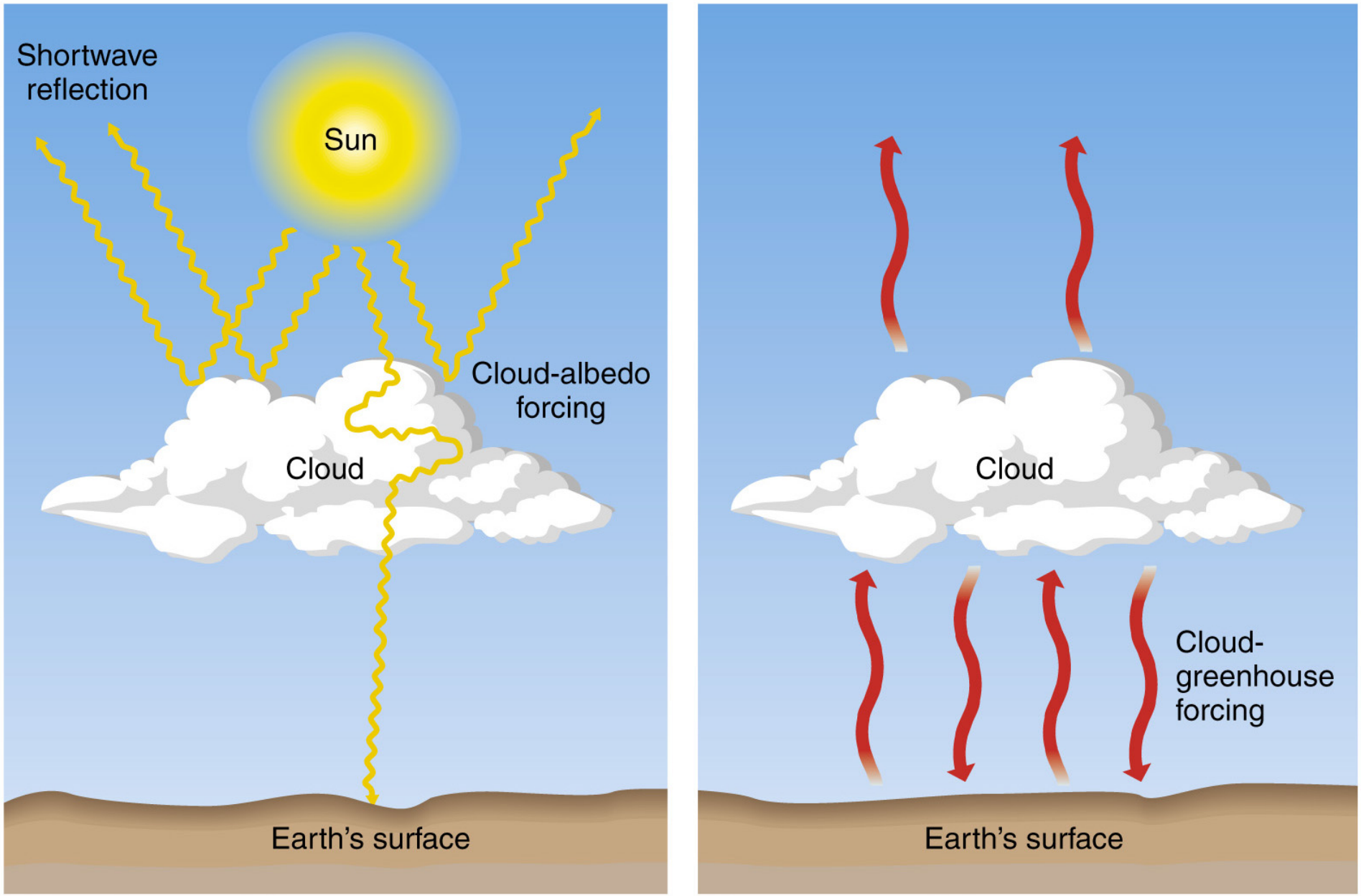
Clouds and Albedo



(a) Shortwave radiation

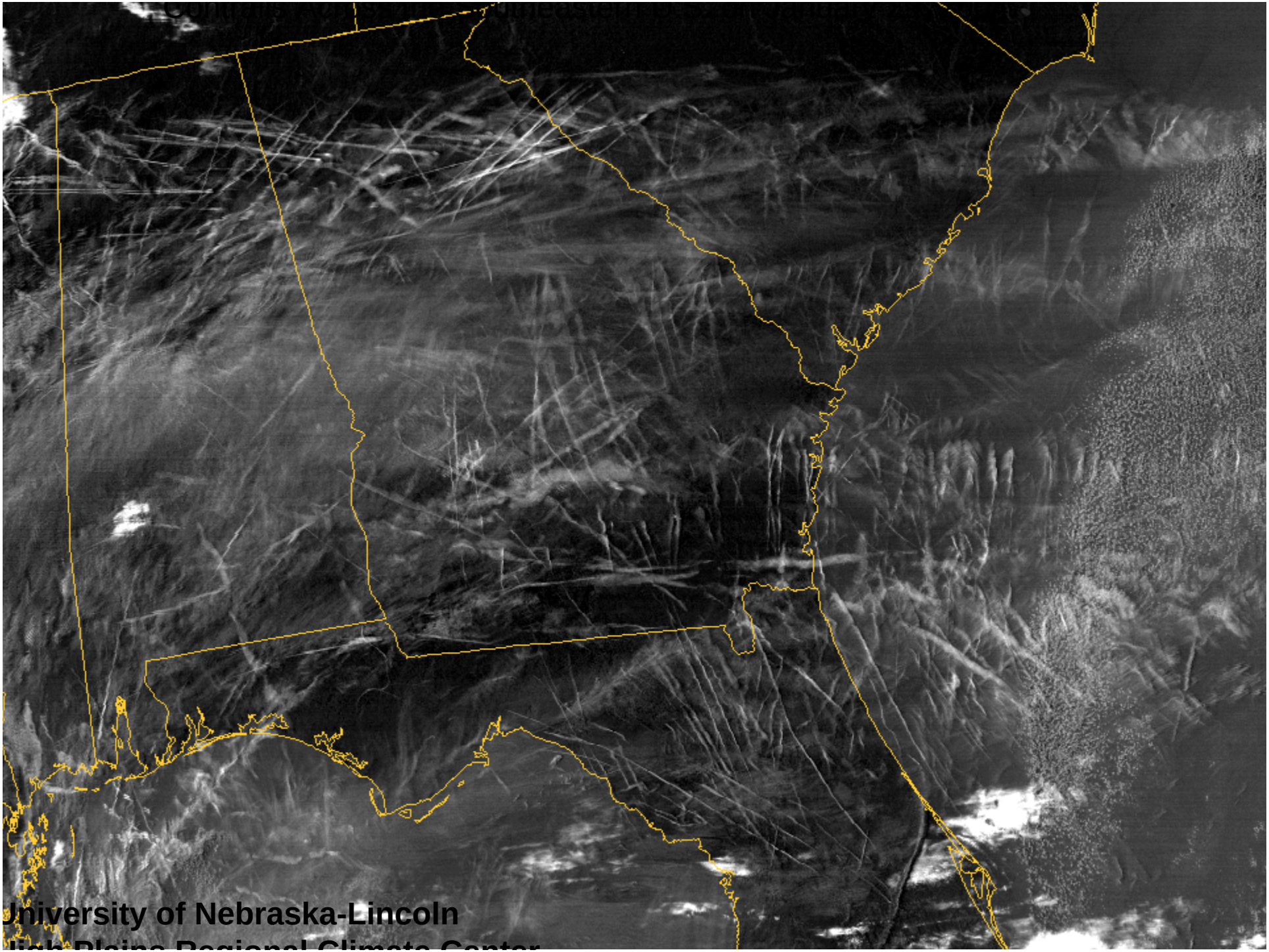
(b) Longwave radiation

Figure 4.7

Clouds

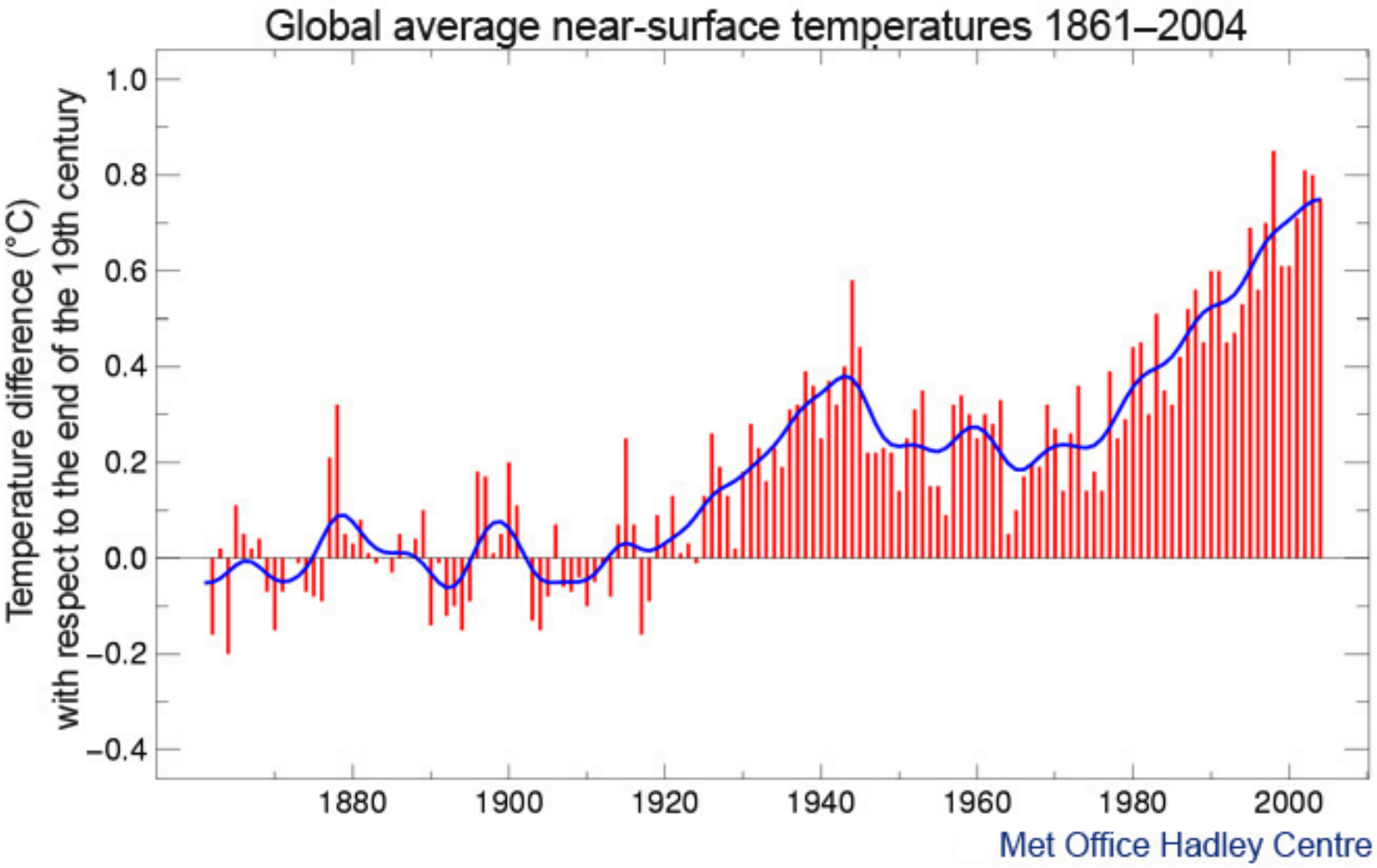
Low clouds cool climate

High clouds warm climate


University of Nebraska-Lincoln

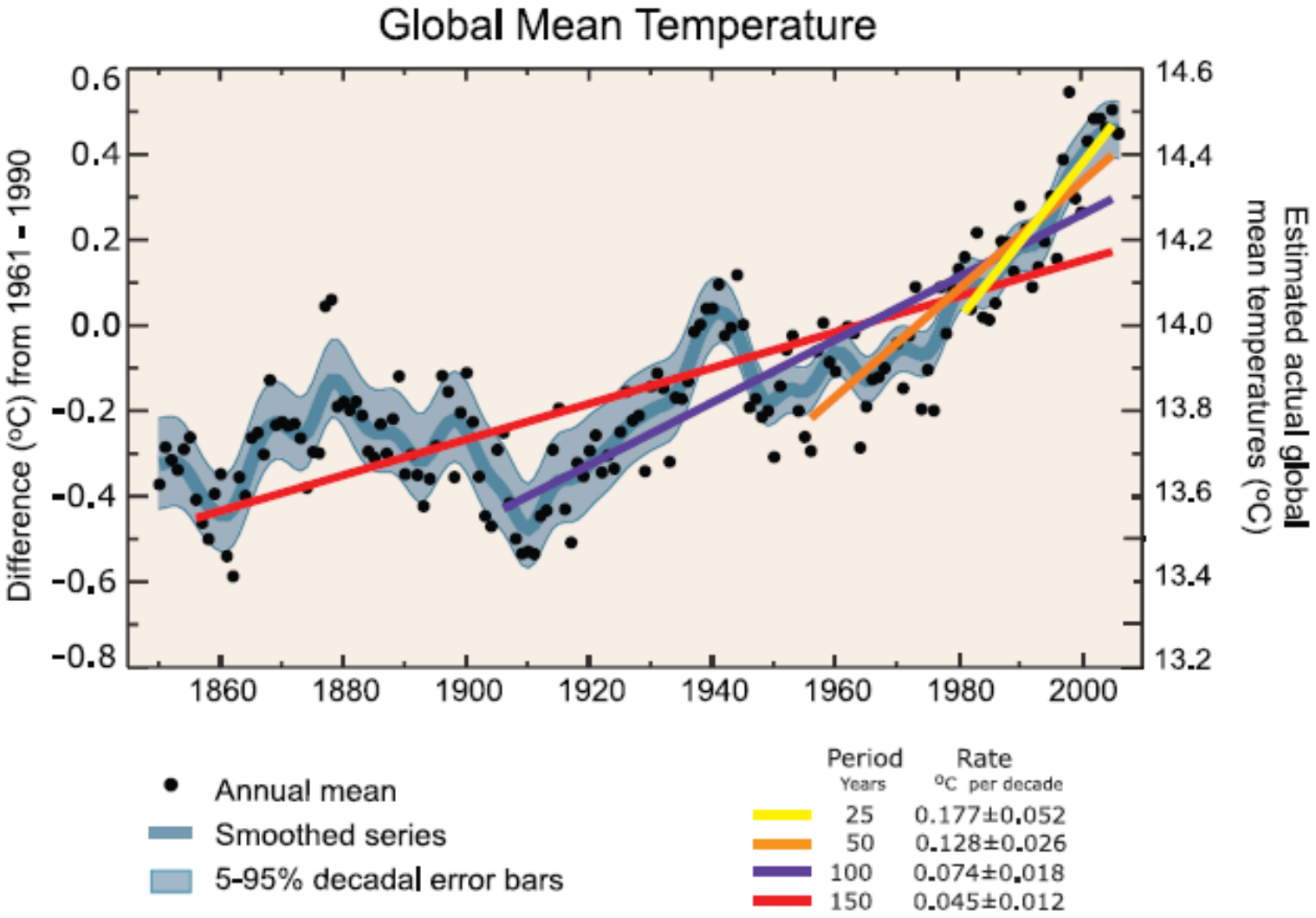
Where’s the evidence?

Observed Global Warming



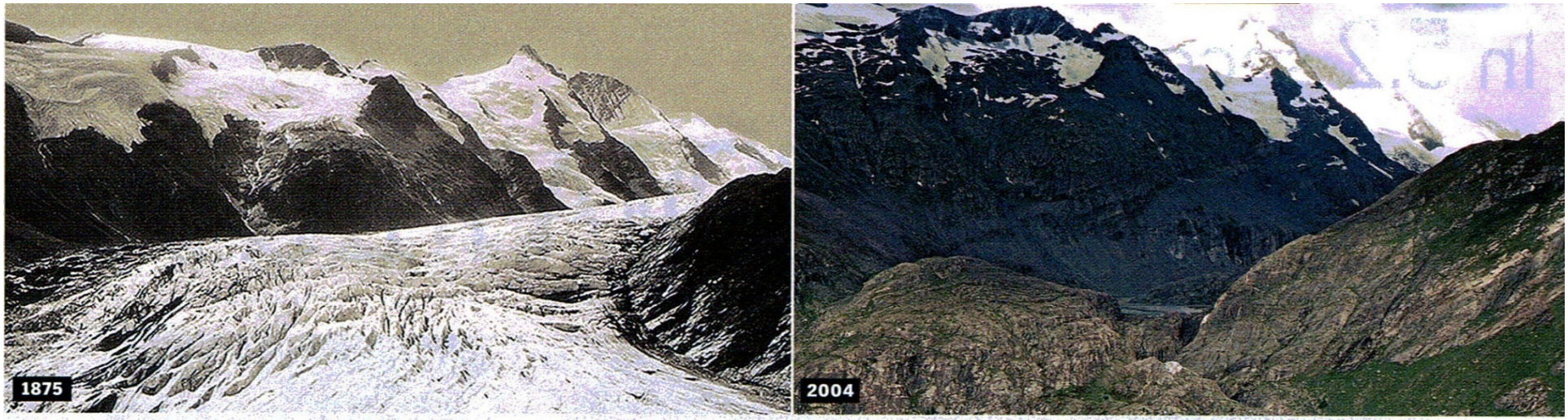
Hadley Centre for Climate Prediction and Research

Observed Global Warming

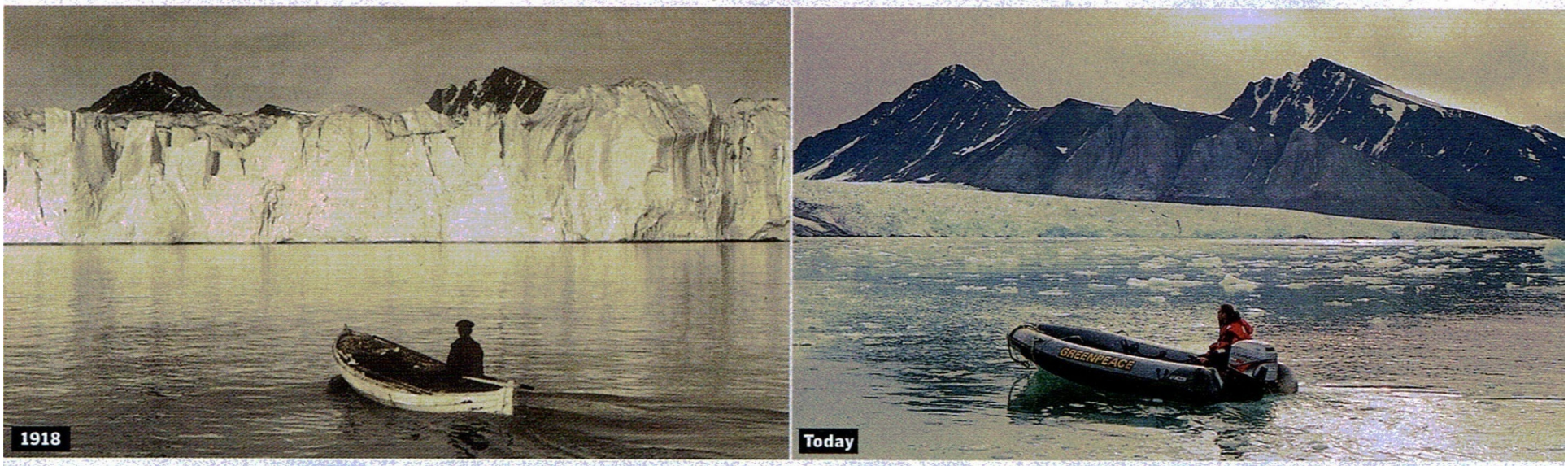


Trenberth et al., 2007

Evidence for global warming?



Glaciers all over the planet are disappearing at faster rates than scientists expected. Austria's Pasterze glacier (above) has retreated almost two miles already.

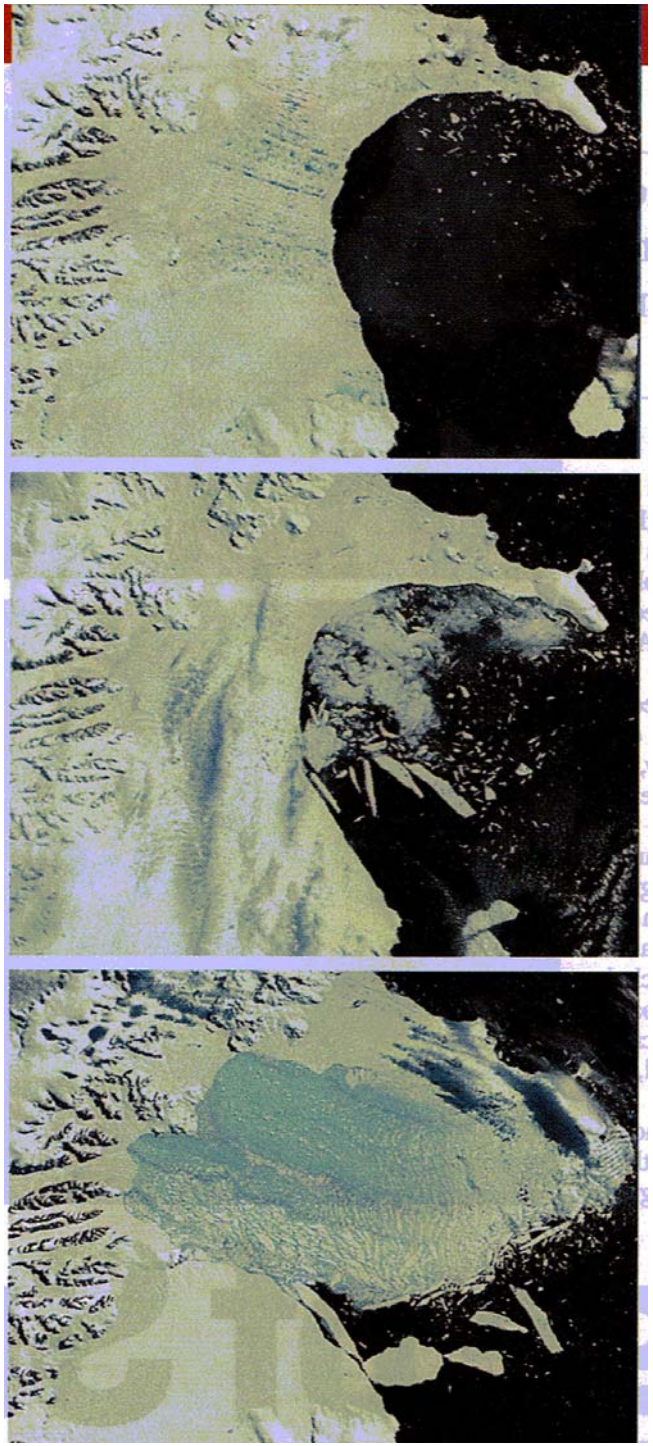


The accelerated melting of glaciers, such as the Kongsfjorden in Norway (above), increases the rate at which sea levels rise.

Evidence for global warming?

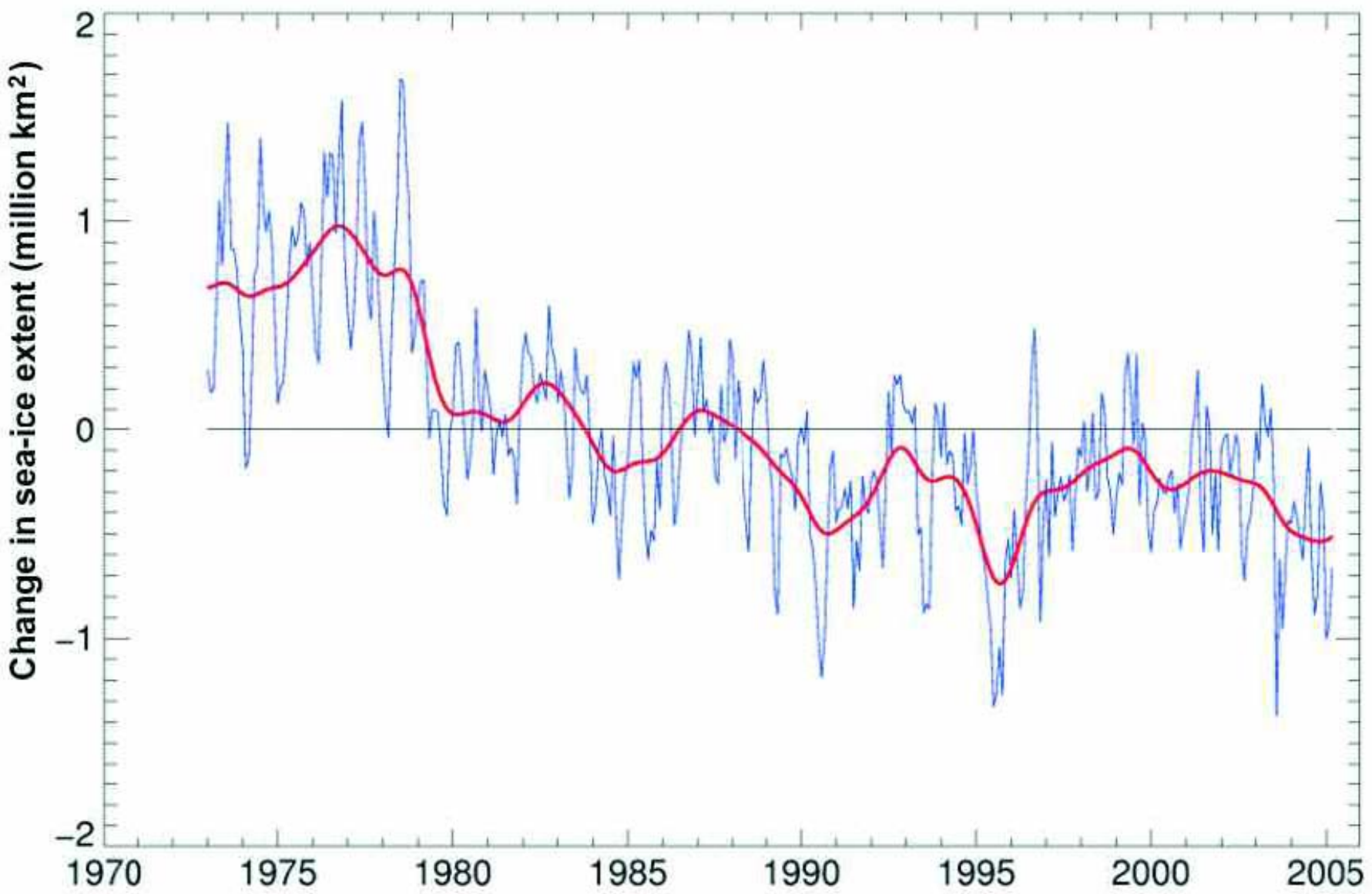
The Larsen B ice shelf disintegrates, setting thousands of ice bergs adrift in the Weddell Sea in 2002.

720 billion tons of ice!



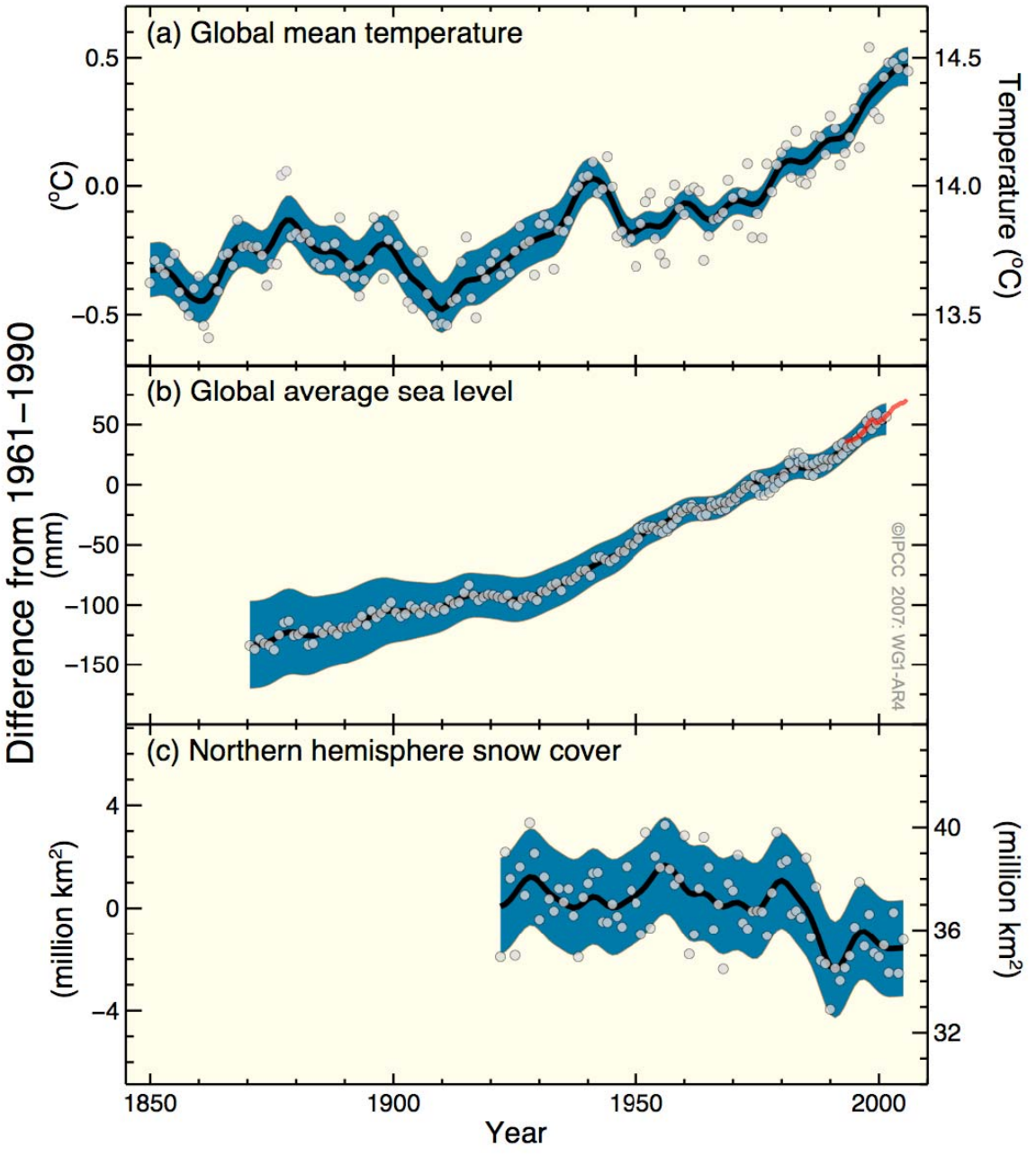

© EnviroZine

Decrease in Arctic Sea-Ice



Hadley Centre for Climate Prediction and Research

Observed Changes in Sea Level, Temperature and N.H. Snow Cover

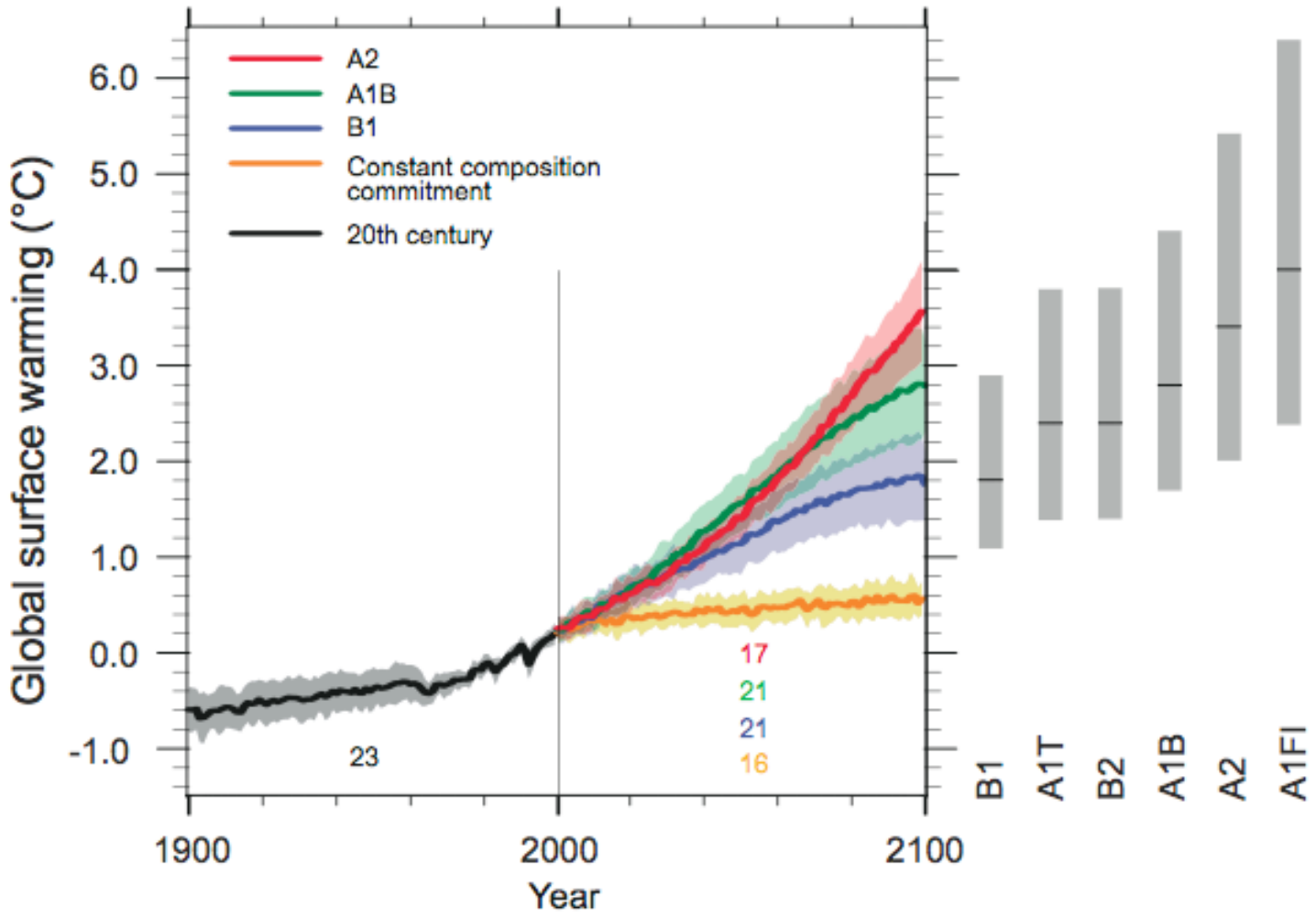


Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University press, 2007). http://www.ipcc.ch

What’s the future?

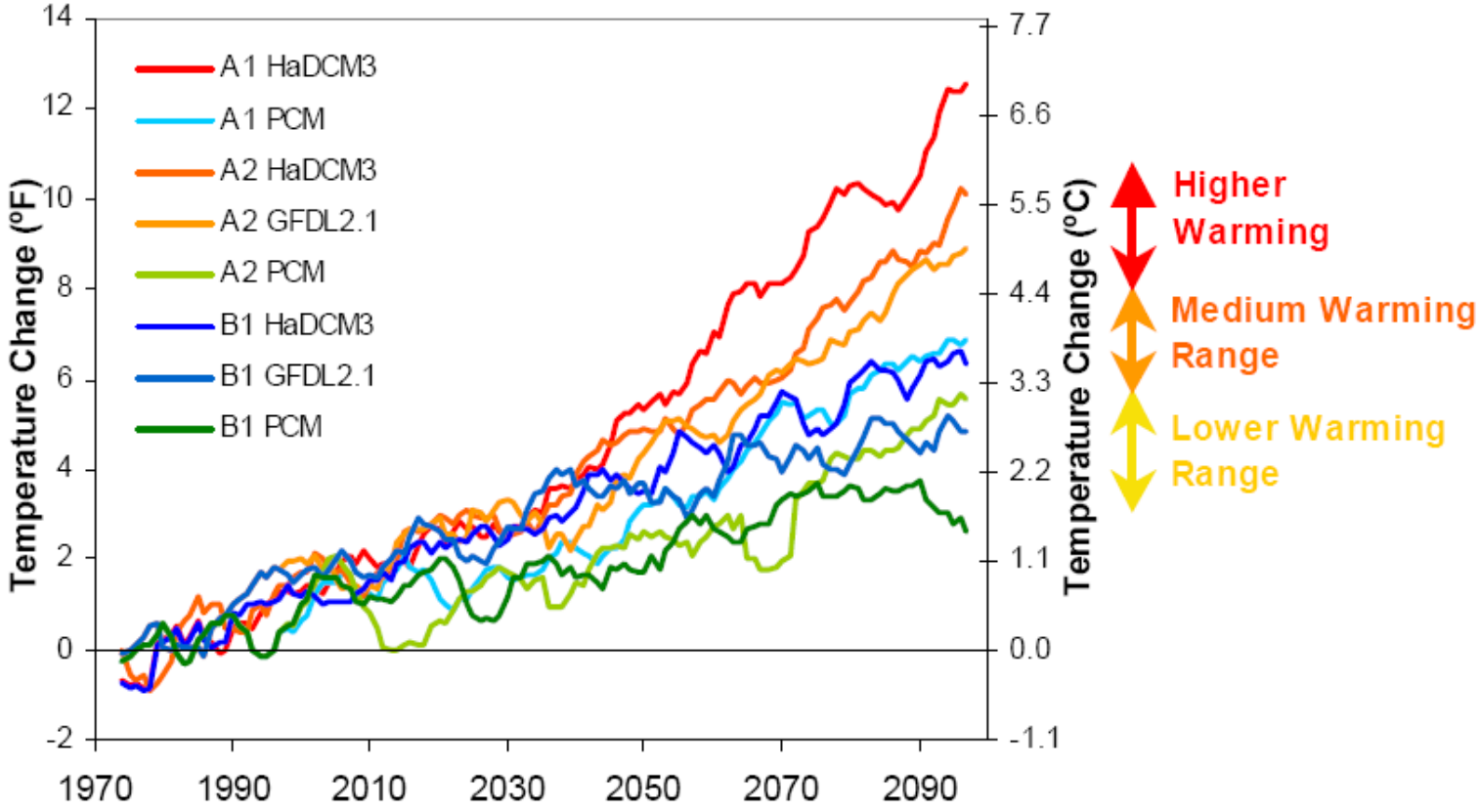
Global Averages of Surface Warming

(relative to 1980-99)



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University press, 2007). http://www.ipcc.ch

Predicted Climate Changes in California: Temperature



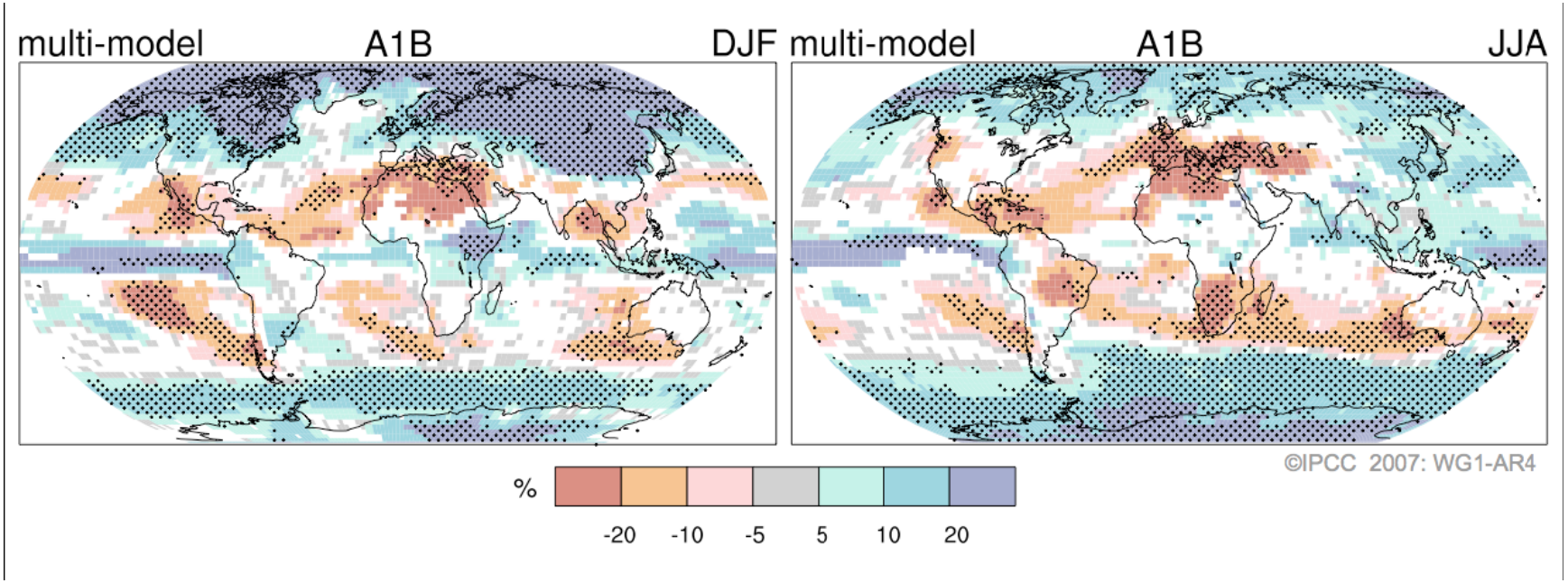
Low range: 3.0°F – 5.4°F
Medium range: 5.5°F – 7.8°F
High range: 8.0°F – 10.4°F

Greater warming in summer than winter

Cayan et al., 2006:CEC-500-2005-186-SF

Projected Changes in Precipitation

(for 2090-2099 relative to 1980-1999)



Intergovernmental Panel on Climate Change (IPCC), WGI Fourth Assessment Report *2007: Summary for Policymakers,* Cambridge University press, 2007). http://www.ipcc.ch

Is it an impending disaster?

Who do we believe?

“Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.”

“Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations. Discernible human influences now extend to other aspects of climate, including ocean warming, continental-average temperatures, temperature extremes and wind patterns.”

“Palaeoclimatic information supports the interpretation that the warmth of the last half century is unusual in at least the previous 1,300 years. The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 m of sea level rise.”

“For the next two decades, a warming of about 0.2°C per decade is projected for a range of SRES emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected.”

IPCC, 2007

Who do we believe?

Farmer's Almanac, 2009

1895

"Geologists think that the world may be frozen up again."

–The New York Times

1912

"The human race will have to fight for its existence against cold."

–Los Angeles Times

The *Titanic* strikes an iceberg and sinks. "An ice age is encroaching."

–The New York Times

1923

"The Ice Age is Coming Here"

–The Washington Post

"Scientist Says Arctic Ice Will Wipe Out Canada and parts of Europe and Asia, and Switzerland Would be Entirely Obliterated"

–Chicago Tribune

1930s

Searing heat and drought turn the nation's midsection into a "Dust Bowl."

1933

"America is in longest warm spell since 1776, with temperatures in a 25-year rise."

–The New York Times

1939

". . . weathermen have no doubt that the world, at least for the time being, is growing warmer."

–TIME

(CONTINUED)

Early to mid-1950s

North America experiences above-normal temperatures, droughts, and, on the East Coast, devastating hurricanes.

1952

Melting glaciers are the trump card of global warming.

–The New York Times

1960s

Brutal cold prevails worldwide.

1970s

The chill continues. *TIME* and *Newsweek* magazines report on the coming ice age.

1976–79

The United States and many other parts of the Western Hemisphere experience the coldest contiguous winters on record.

1979

"Plan for the Study of Dome Over Town Is Approved" [Winooski, Vermont; to protect the city from cold]

–The New York Times

1980

A brutal summer heat wave occurs in much of the United States. (Residents of Winooski realize that they would have fried to death under a dome.)

1980–2000

Temperatures rise globally, interrupted only by the cooling effects of major volcanic eruptions: El Chichón in Mexico (1982) and Pinatubo in the Philippines (1991).

1988

Record heat and drought in eastern and central United States cause over $40 billion in crop losses.

1991

"Volcano's Eruption in Philippines May Counteract Global Warming"

–The New York Times

1997–98

A super El Niño results in the warmest temperatures on record worldwide.

1998

"Earth Temperature in 1998 Is Reported at Record High"

–The New York Times

2007

"First Major Snow in Buenos Aires Since 1918"

–International Herald Tribune

Australia records its coldest June ever and Chile experiences its toughest winter in 50 years. Johannesburg, South Africa, gets its first significant snow in a half-century. Despite the bitter cold throughout much of the Southern Hemisphere, NASA's James Hansen declares 2007 the second-warmest year on record.

2008

"Snow Day in Baghdad"

–International Herald Tribune

The coldest weather since 1964 hits the Middle East, while China experiences unusually heavy snow and freezing temperatures.

Who do we believe?

“In my opinion, it is still feasible to solve the global warming problem before we pass tipping points that would guarantee disastrous irreversible climate change. But urgent strong actions are needed. Failure to achieve the actions needed to stabilize global climate will result in great intergenerational injustice.”

“Our global climate is nearing tipping points. Changes are beginning to appear, and there is a potential for rapid changes with effects that would be irreversible – if we do not promptly slow fossil fuel emissions during the next few decades.”

“Tipping points are fed by amplifying feedbacks. As Arctic sea ice melts, the darker ocean absorbs more sunlight and speeds melting. As tundra melts, methane a strong greenhouse gas, is released, causing more warming. As species are pressured and exterminated by shifting climate zones, ecosystems can collapse, destroying more species.”

“Such a level of atmospheric CO_2 (450 ppm) and global warming imply that we would hand our children and grandchildren a condition that would run out of their control, a situation that should be unacceptable to humanity.”

James Hansen (atmospheric scientist):

Who do we believe?

James Lovelock (atmospheric scientist):

Your work on atmospheric chlorofluorocarbons led eventually to a global CFC ban that saved us from ozone-layer depletion. Do we have time to do a similar thing with carbon emissions to save ourselves from climate change?
Not a hope in hell. Most of the "green" stuff is verging on a gigantic scam. Carbon trading, with its huge government subsidies, is just what finance and industry wanted. It's not going to do a damn thing about climate change, but it'll make a lot of money for a lot of people and postpone the moment of reckoning. I am not against renewable energy, but to spoil all the decent countryside in the UK with wind farms is driving me mad. It's absolutely unnecessary, and it takes 2500 square kilometres to produce a gigawatt – that's an awful lot of countryside.

What about work to sequester carbon dioxide?
That is a waste of time. It's a crazy idea – and dangerous. It would take so long and use so much energy that it will not be done.

Do you still advocate nuclear power as a solution to climate change?
It is a way for the UK to solve its energy problems, but it is not a global cure for climate change. It is too late for emissions reduction measures.

So are we doomed?
There is one way we could save ourselves and that is through the massive burial of charcoal. It would mean farmers turning all their agricultural waste – which contains carbon that the plants have spent the summer sequestering – into non-biodegradable charcoal, and burying it in the soil. Then you can start shifting really hefty quantities of carbon out of the system and pull the CO_2 down quite fast.

Would it make enough of a difference?
Yes. The biosphere pumps out 550 gigatonnes of carbon yearly; we put in only 30 gigatonnes. Ninety-nine per cent of the carbon that is fixed by plants is released back into the atmosphere within a year or so by consumers like bacteria, nematodes and worms. What we can do is cheat those consumers by getting farmers to burn their crop waste at very low oxygen levels to turn it into charcoal, which the farmer then ploughs into the field. A little CO2 is released but the bulk of it gets converted to carbon. You get a few per cent of biofuel as a by-product of the combustion process, which the farmer can sell. This scheme would need no subsidy: the farmer would make a profit. This is the one thing we can do that will make a difference, but I bet they won't do it.

Do you think we will survive?
I'm an optimistic pessimist. I think it's wrong to assume we'll survive 2 °C of warming: there are already too many people on Earth. At 4 °C we could not survive with even one-tenth of our current population. The reason is we would not find enough food, unless we

Who do we believe?

IQ2 Debate: Global Warming Is Not a Crisis - Richard Somerville (atmospheric scientist)

IQ2 Debate: Global Warming Is Not a Crisis - Phillip Stott (biogeographer)

What are the impacts?

Predicted Climate Changes in California: Impacts on Agriculture

Temperature – heat stress, number of chill hours, milk production

Pests and weeds – warmer winters lead to increase

Spring snowpack may be reduced by as much as 70 – 90% by the end of the century.

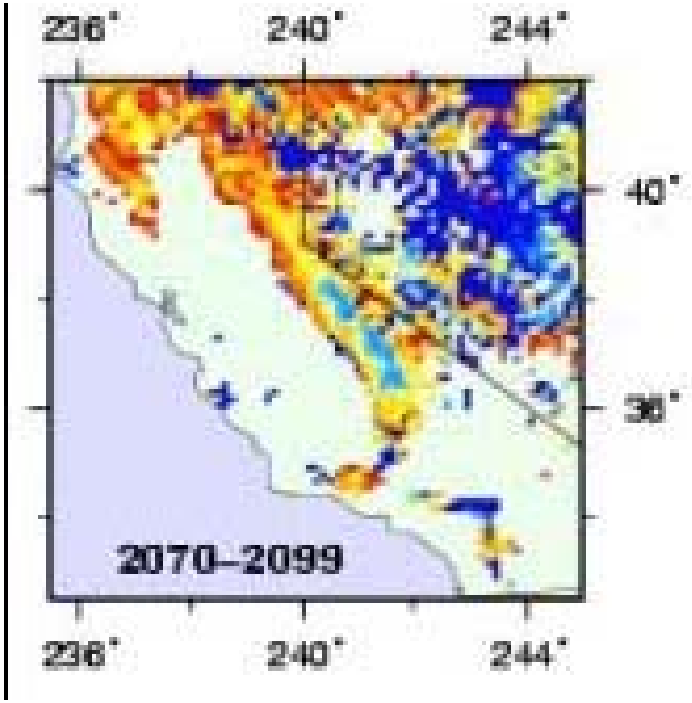
Need to build more storage capacity (maximum runoff will occur earlier – snowpack currently stores half the amount of the man-made reservoirs in California).

More demand for water from agriculture due to higher evaporation rates.

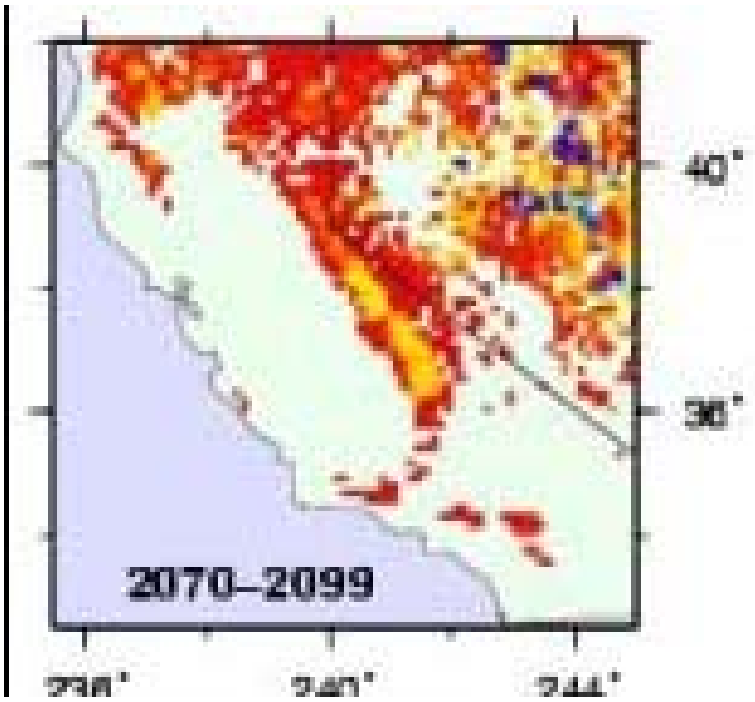
Cayan et al., 2006:CEC-500-2005-186-SF

Predicted Climate Changes in California: Snowpack and Water Supply

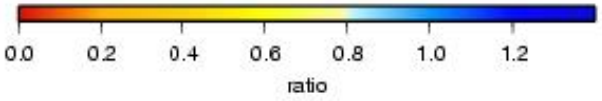
Low Temperature Scenario



Medium Temperature Scenario



April 1 snow water equivalent 2070–2090 fraction of 1961–1990.

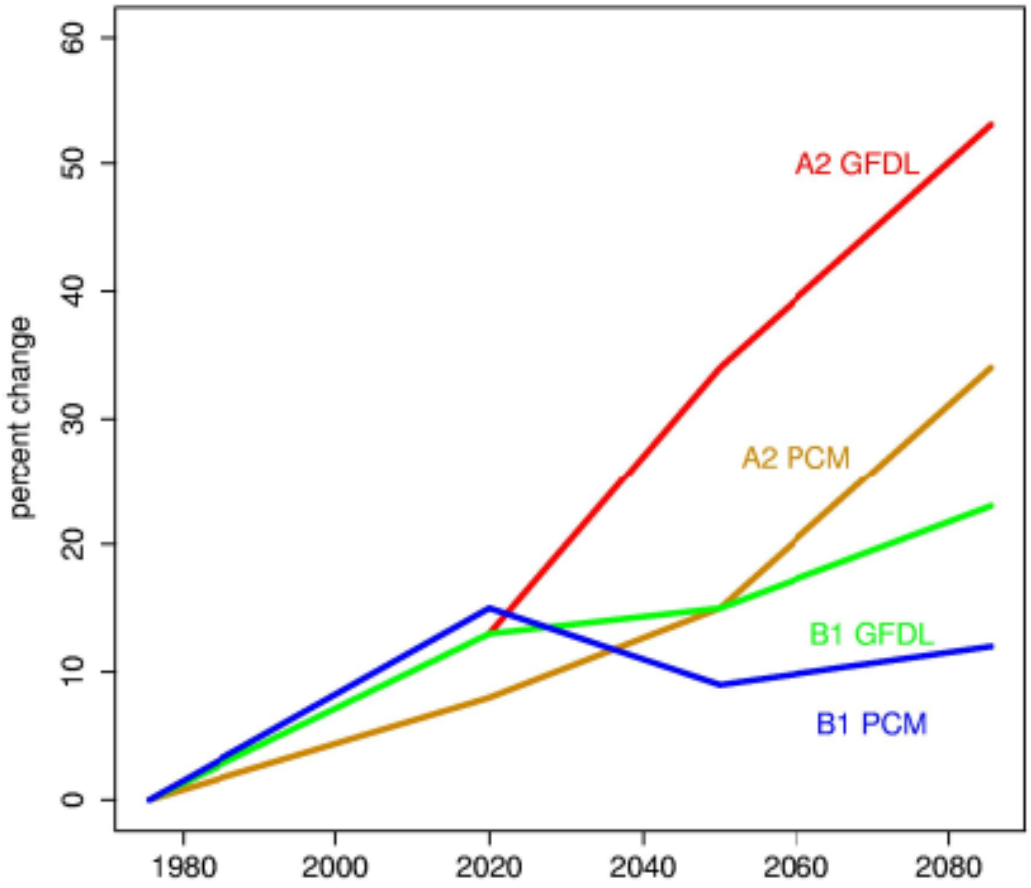


Cayan et al., 2006:CEC-500-2005-186-SF

Predicted Climate Changes in California: Fires

The risk of large fires could rise by as much as 55% by the end of the century and increase associated damage costs by as much as 30% (Westerling and Bryant, 2006).

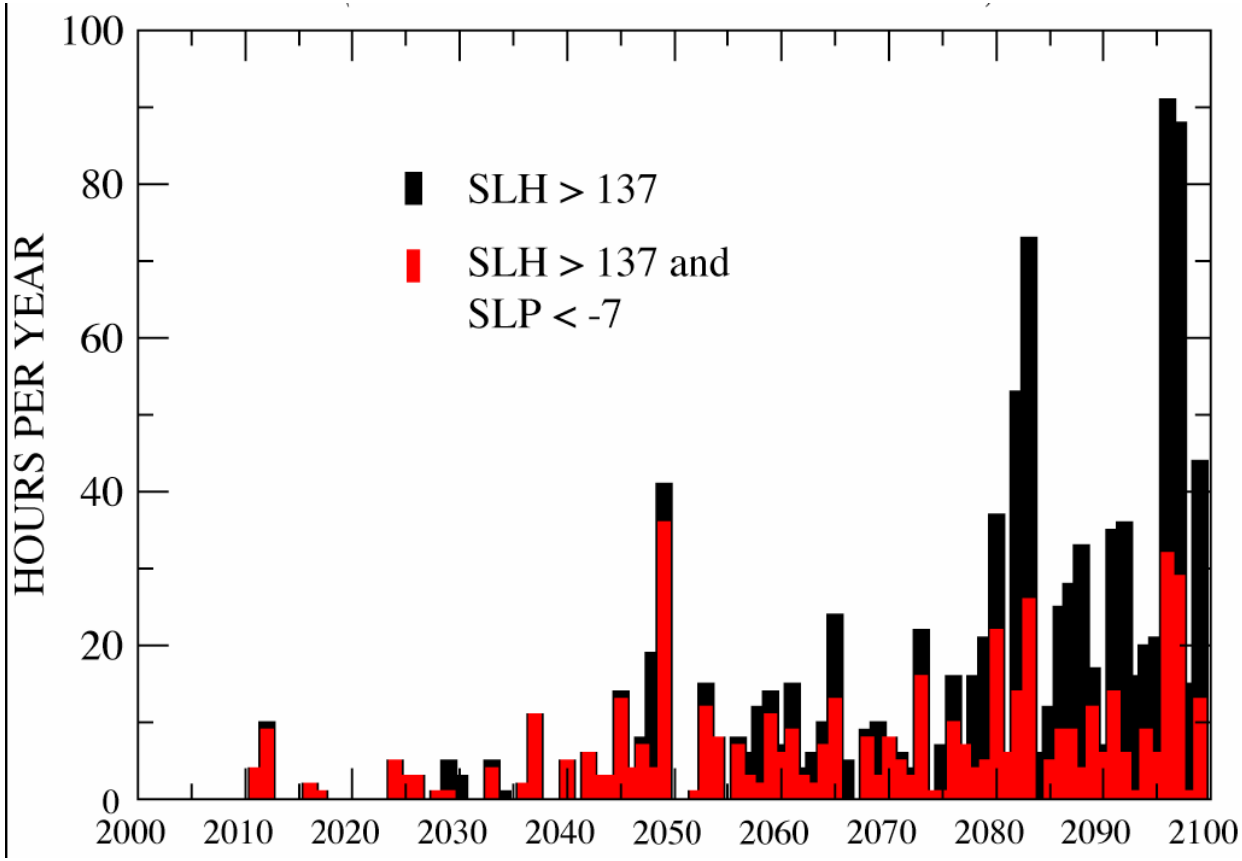
In addition, wildfires add significantly to atmospheric carbon dioxide emissions, so that the expected increase in their frequency will further accelerate global warming (Running, 2006).



Cayan et al., 2006:CEC-500-2005-186-SF

Predicted Climate Changes in California: Coastal Sea Level

Projected exceedences of SF hourly sea level height above historical 99.99 percentile (black). Coincidences with storms (red)



Biggest impacts will be the result of the combined higher sea level with high tides and winter storm surges which bring heavy surf and wind-driven waves with them.

The frequency of these extreme events is expected to escalate.

Cayan et al., 2006:CEC-500-2005-202-SF

What are the impacts?

FRONTLINE Heat: Watching the world change (PBS)

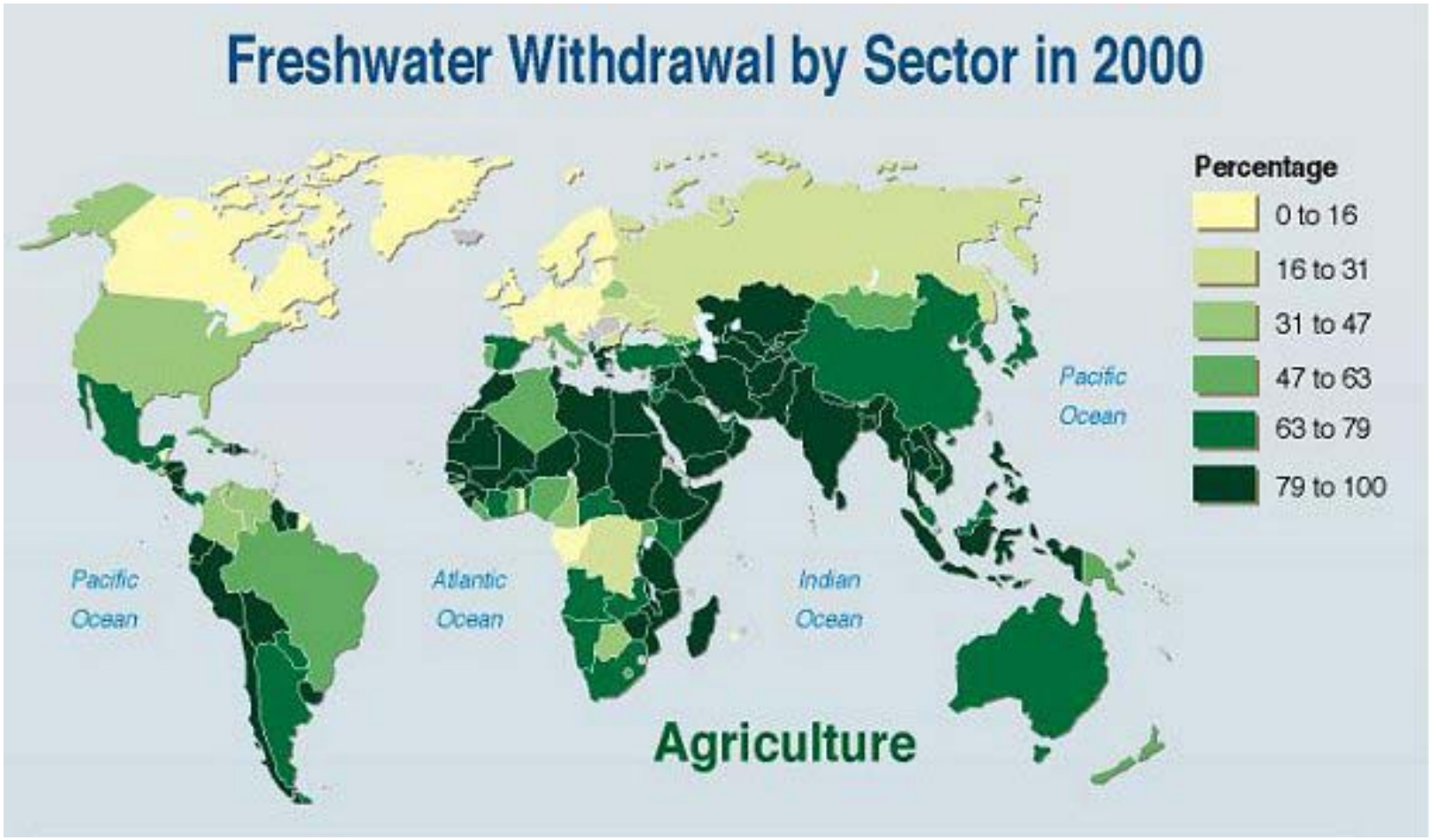
Water Scarcity

Agricultural activities consume most water on a worldwide basis - due to the enormous amounts needed to produce food.

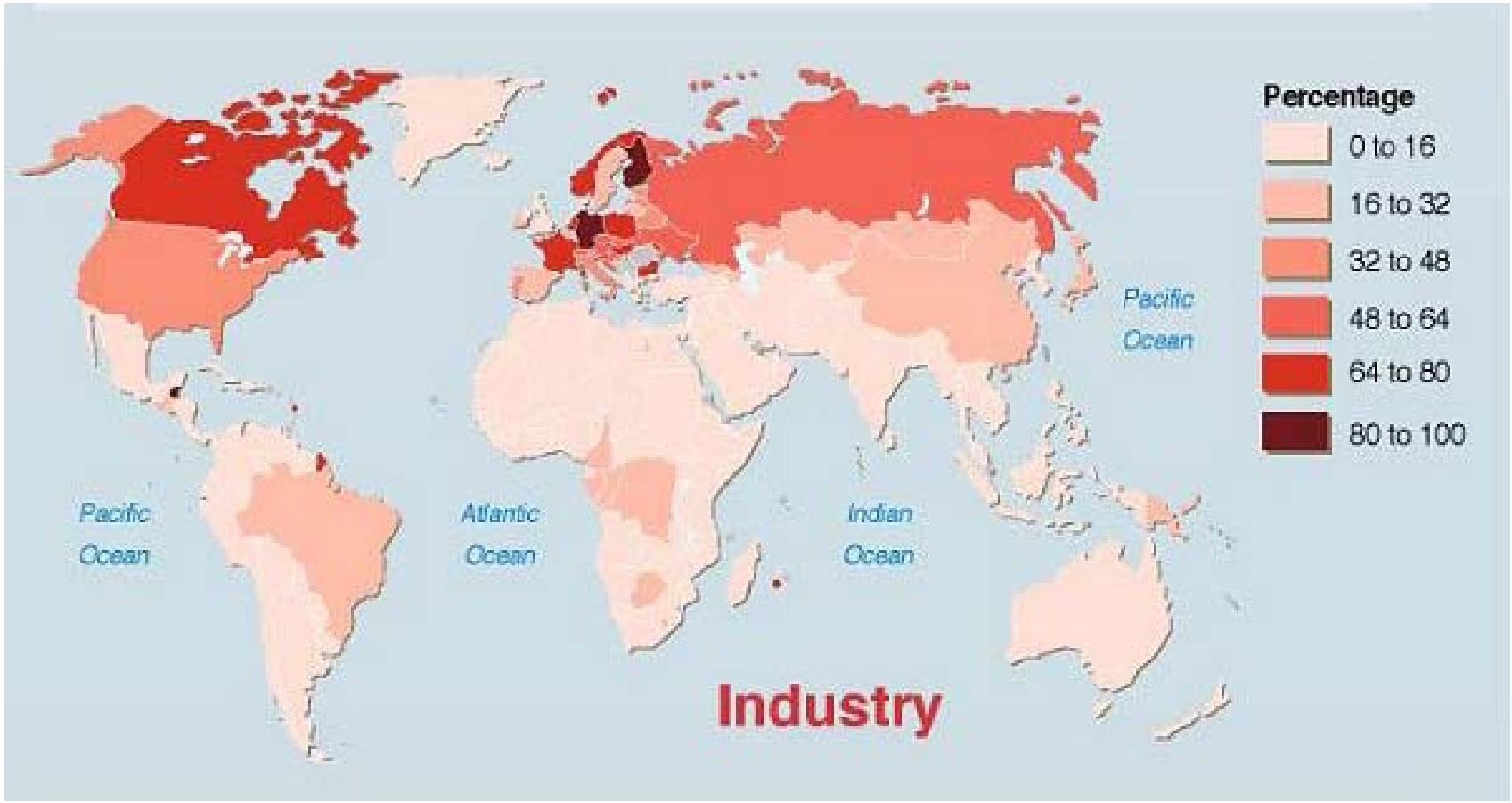
Economic water scarcity occurs due to a lack of investment and is characterised by poor infrastructure and unequal distribution of water.

Physical scarcity occurs when the water resources cannot meet the demands of the population. Arid regions are most associated with physical water scarcity. But there is a trend in artificially-created scarcity - even in areas where water is apparently abundant. This is largely due to overuse; agriculture uses up to 70 times more water to produce food than is used in drinking and other domestic purposes, including cooking, washing and bathing. The results are desiccated and polluted rivers, declining groundwater and problems of allocation, in which some people win out in access to water over others.

Comprehensive Assessment of Water Management in Agriculture, 2006



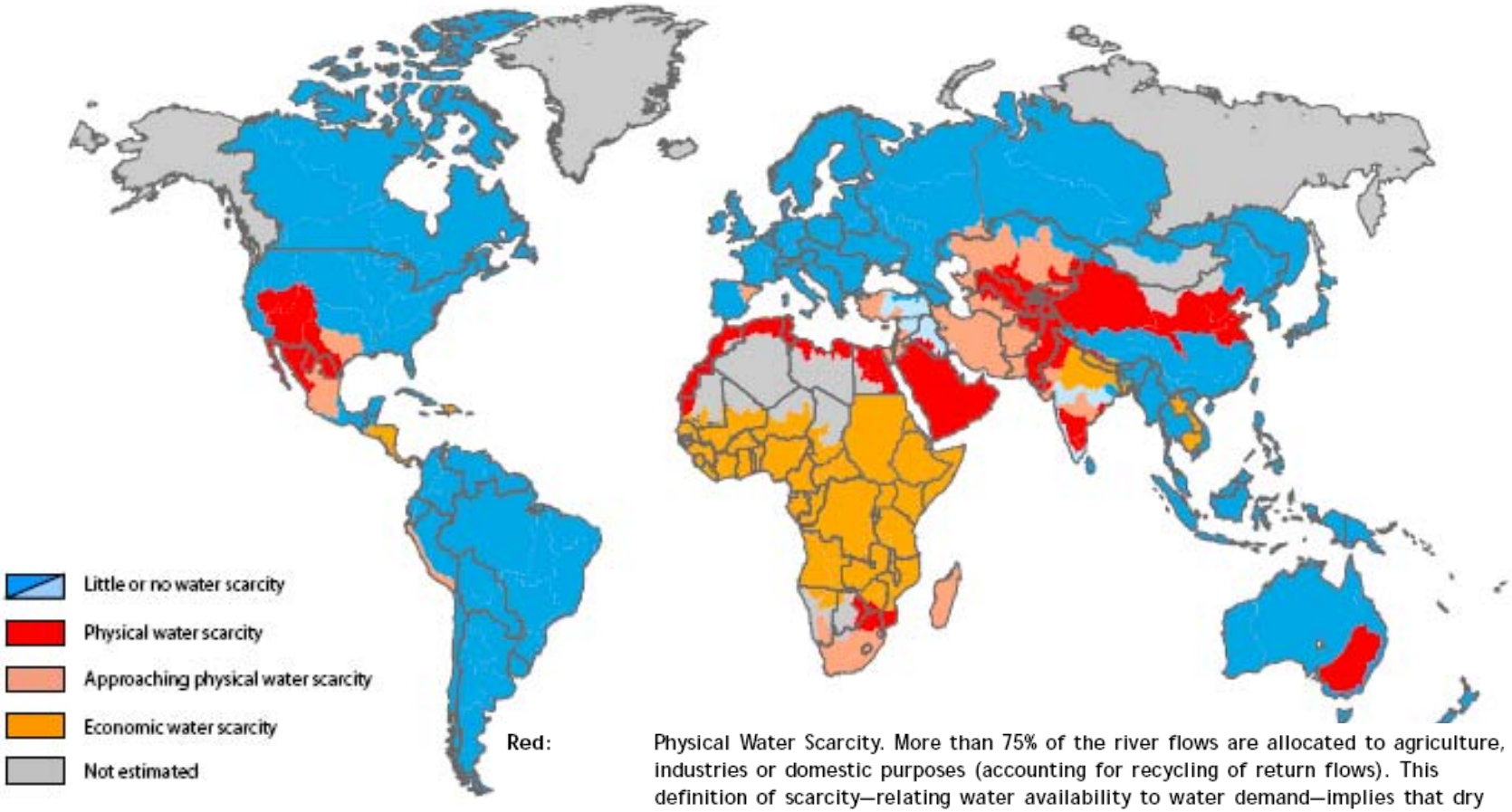
World Resources 2000-2001, WRI, Washington DC



World Resources 2000-2001, WRI, Washington DC

World Resources 2000-2001, WRI, Washington DC

Water Scarcity



Red: Physical Water Scarcity. More than 75% of the river flows are allocated to agriculture, industries or domestic purposes (accounting for recycling of return flows). This definition of scarcity—relating water availability to water demand—implies that dry areas are not necessarily water-scarce. For example, Mauritania is dry but not physically water-scarce because demand is low.

Light Red: More than 60% of river flows are allocated. These basins will experience physical water scarcity in the near future.

Orange: Economic Water Scarcity. Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists. These areas could benefit by development of additional blue and green water, but human and financial capacity are limiting.

Blue: Abundant water resources relative to use: less than 25% of water from rivers is withdrawn for human purposes.

Comprehensive Assessment of Water Management in Agriculture, 2006

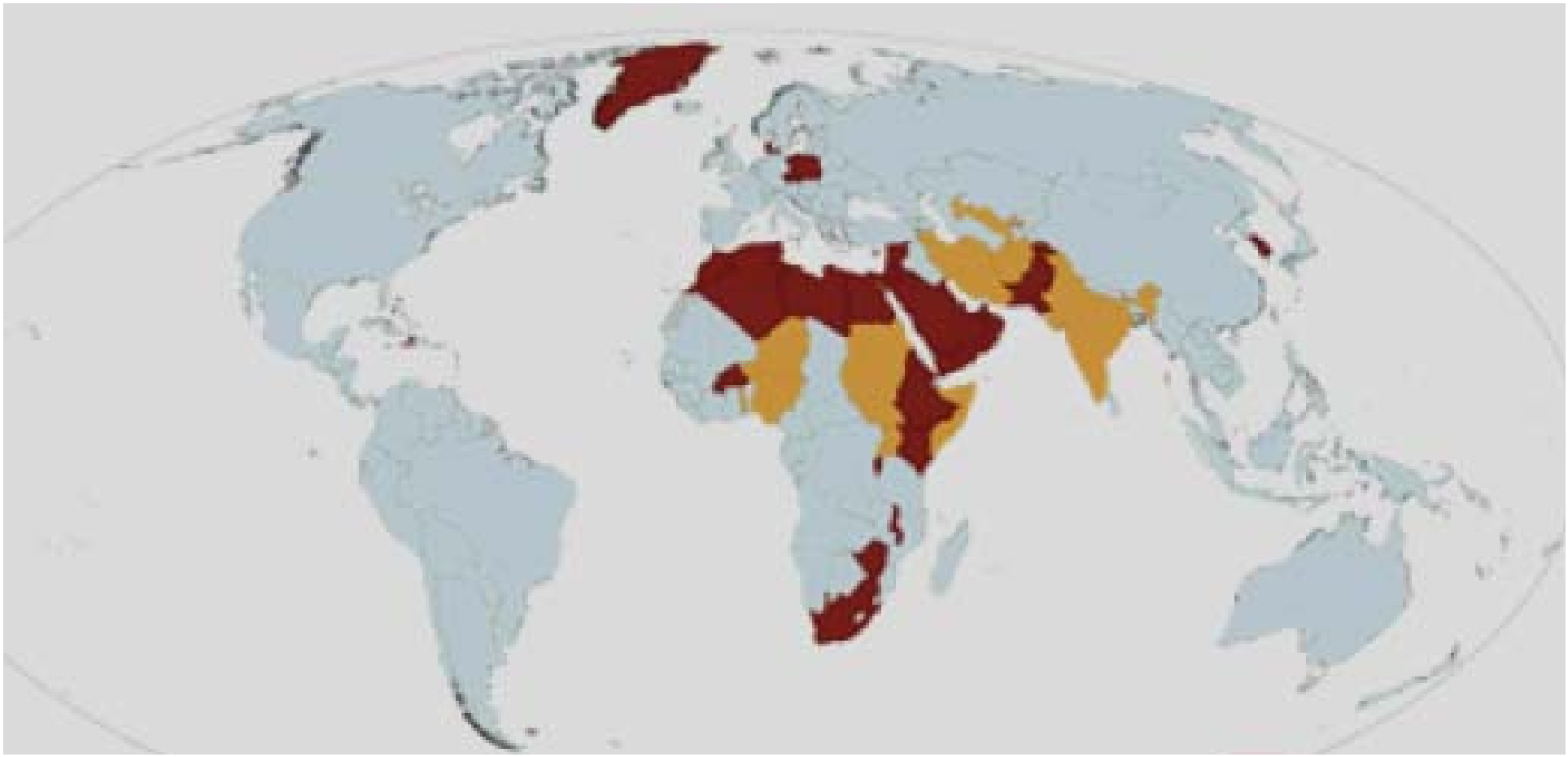
Water Scarcity

Egypt imports more than half of its food because it does not have enough water to grow it domestically. Australia is faced with major water scarcity in the Murray-Darling Basin as a result of diverting large quantities of water for use in agriculture. The Aral Sea has shrunk to a quarter of its original volume And the shrunken Aral Sea remains one of the most visible examples where massive diversions of water to agriculture have caused widespread water scarcity, along with an environmental catastrophe.

"It is possible to reduce water scarcity, feed people and address poverty, but the key trade-off is with the environment".

“One quarter of the world's population live in river basins where water is physically scarce. Another one billion people live in river basins where water is economically scarce. As a result, many people around the world dependent on rivers, lakes and other wetlands risk falling into poverty.”

Water-Short Countries in 2005 and 2025



Water-scarce or water-stressed countries in 2005

Additional water-scarce or water-stressed countries by 2025

Neither water-stressed nor water-scarce in either year

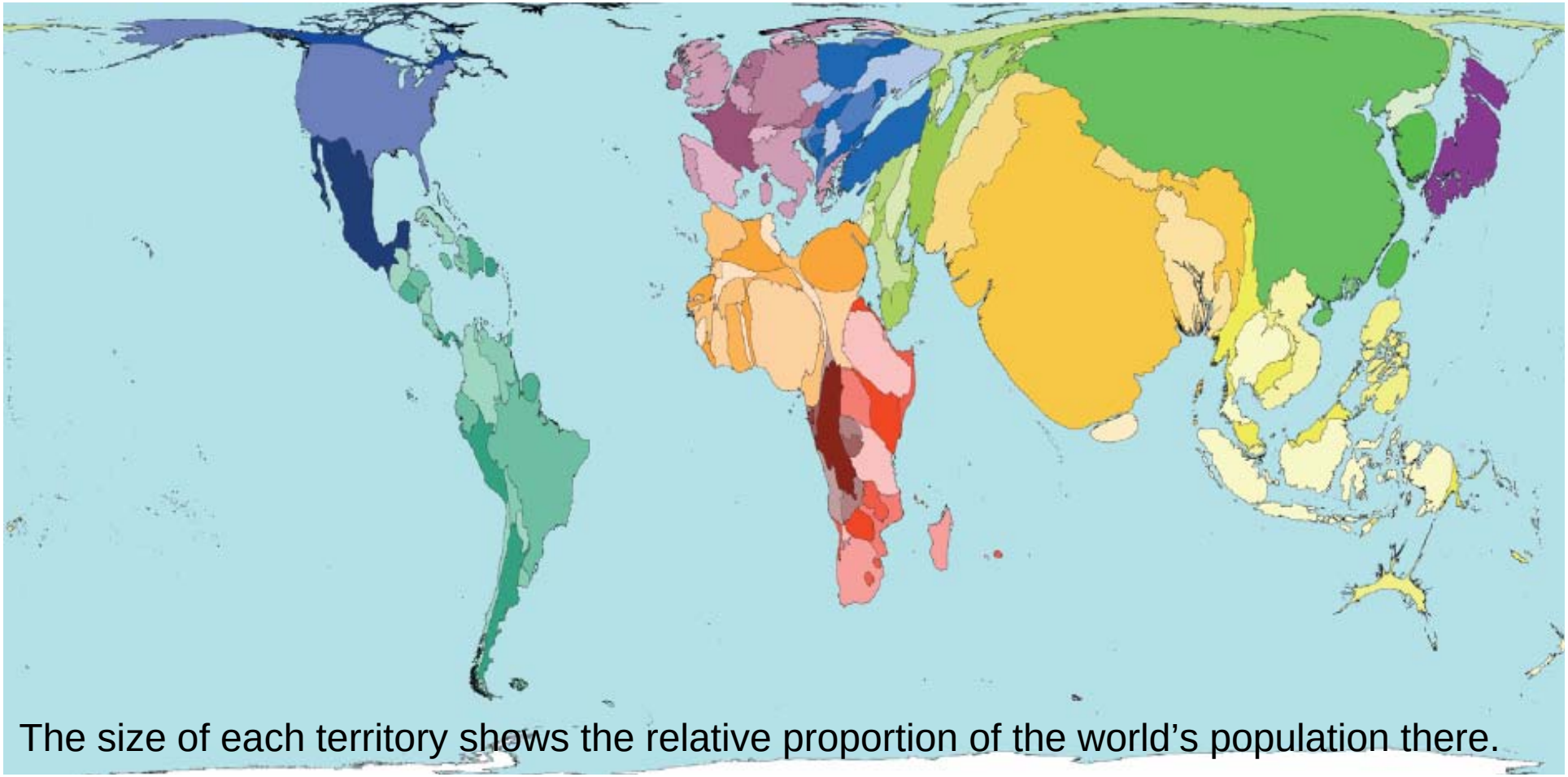
No data

www.populationaction.org/mappingthefuture

www.ccsr.columbia.edu/population/map

The other biggie?

World Population, 2002



The size of each territory shows the relative proportion of the world's population there.

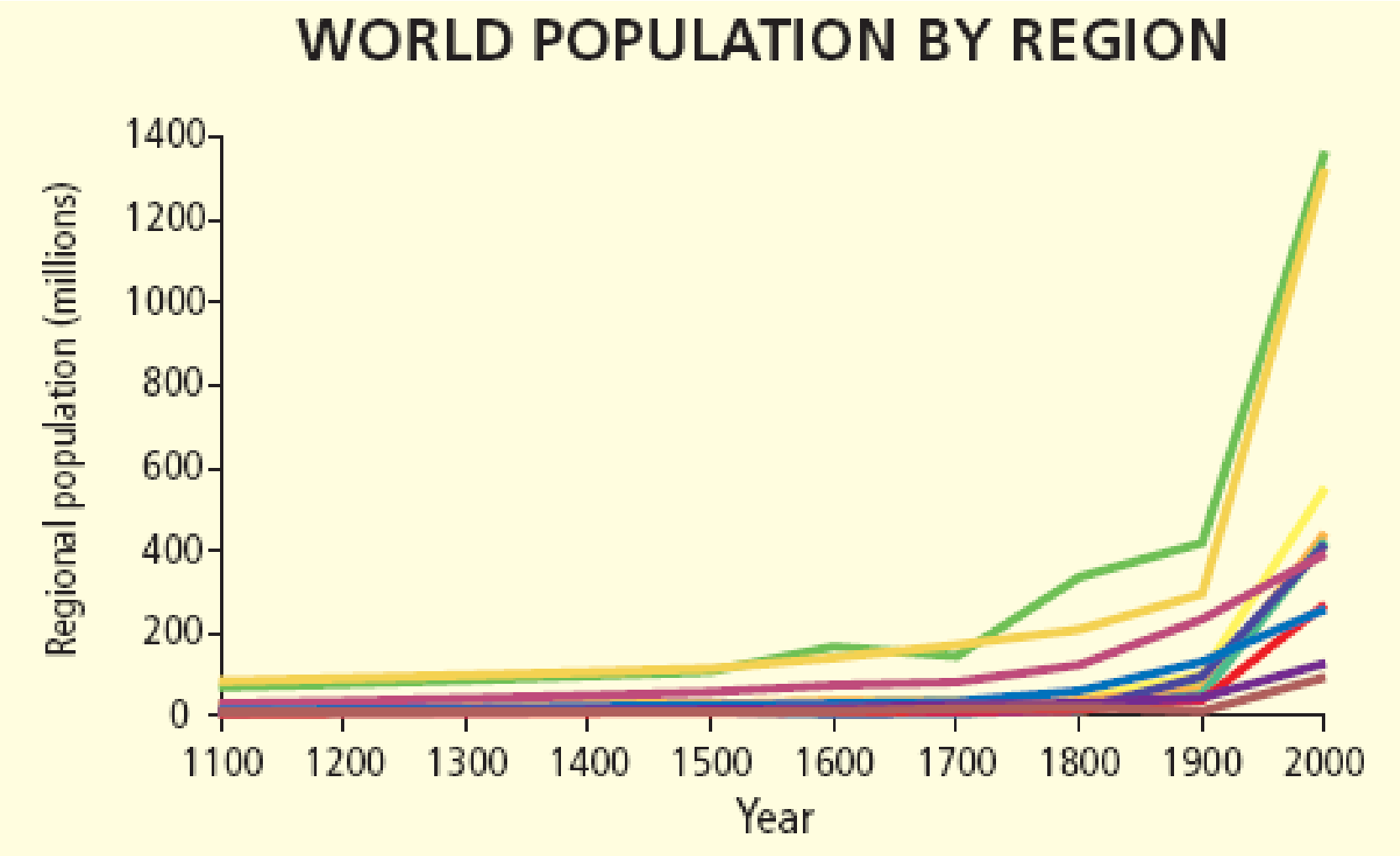
www.worldmapper.org

World's Most Populous Countries

Rank	Territory	Value
1	China	1295
2	India	1050
3	United States	291
4	Indonesia	217
5	Brazil	176
6	Pakistan	150
7	Russian Federation	144
8	Bangladesh	144
9	Japan	128
10	Nigeria	121

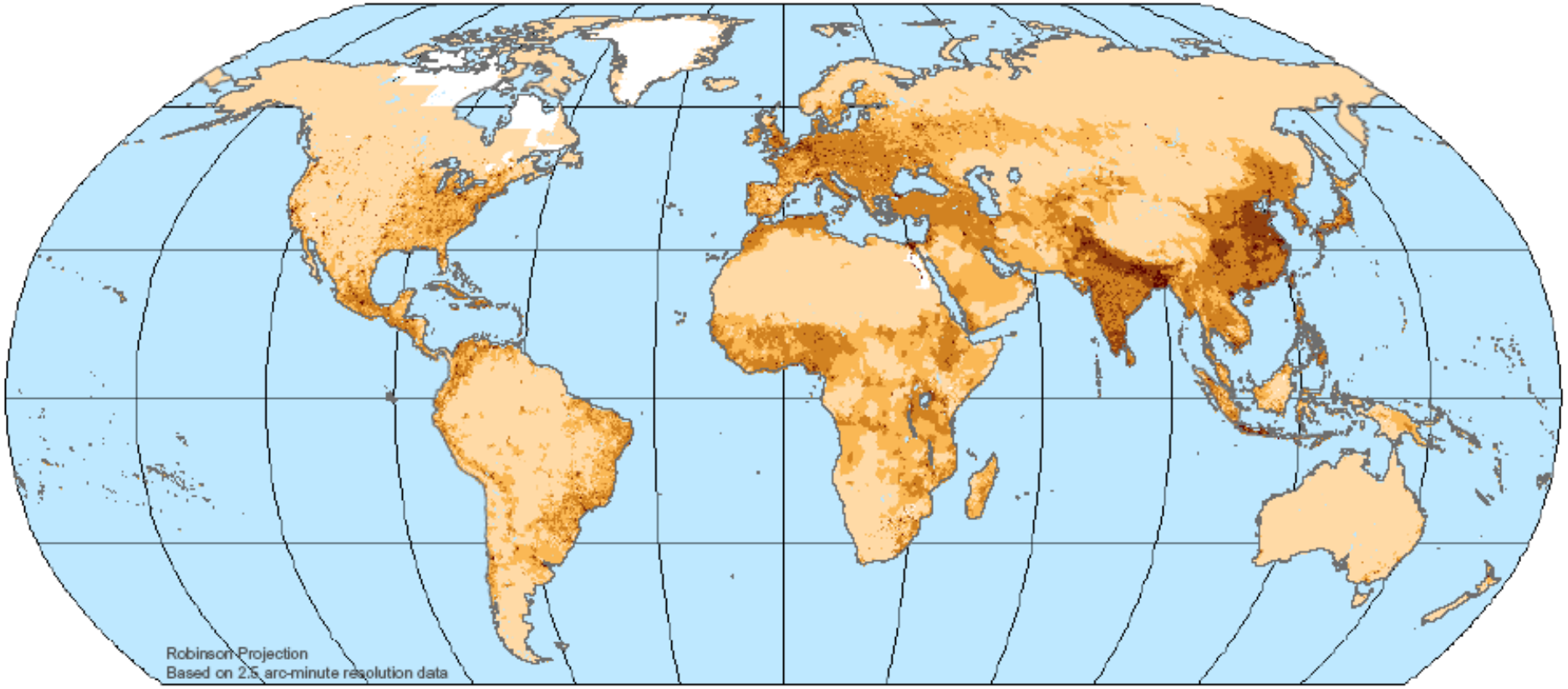
millions

www.worldmapper.org

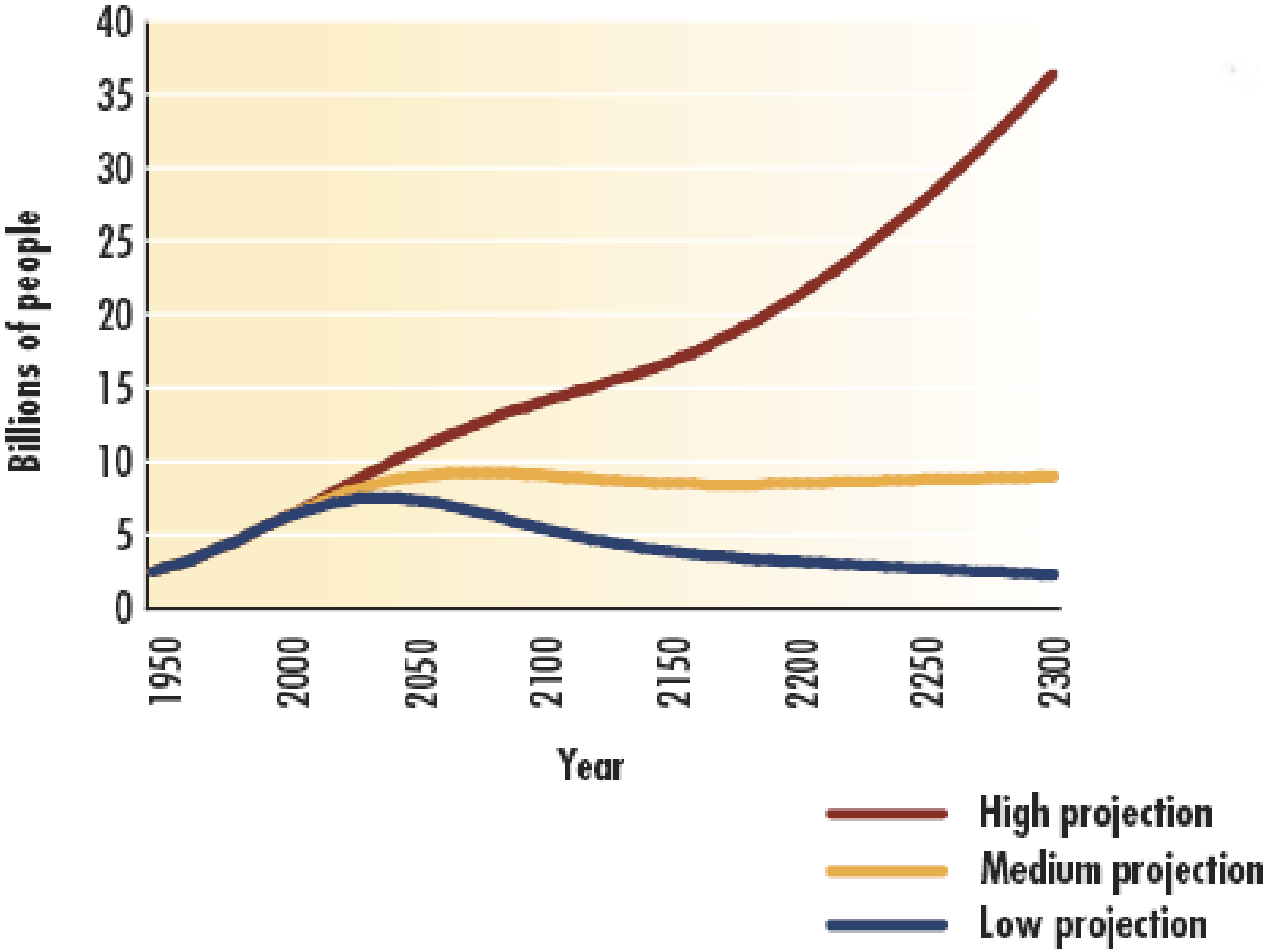


www.worldmapper.org

World Population Density, 2000

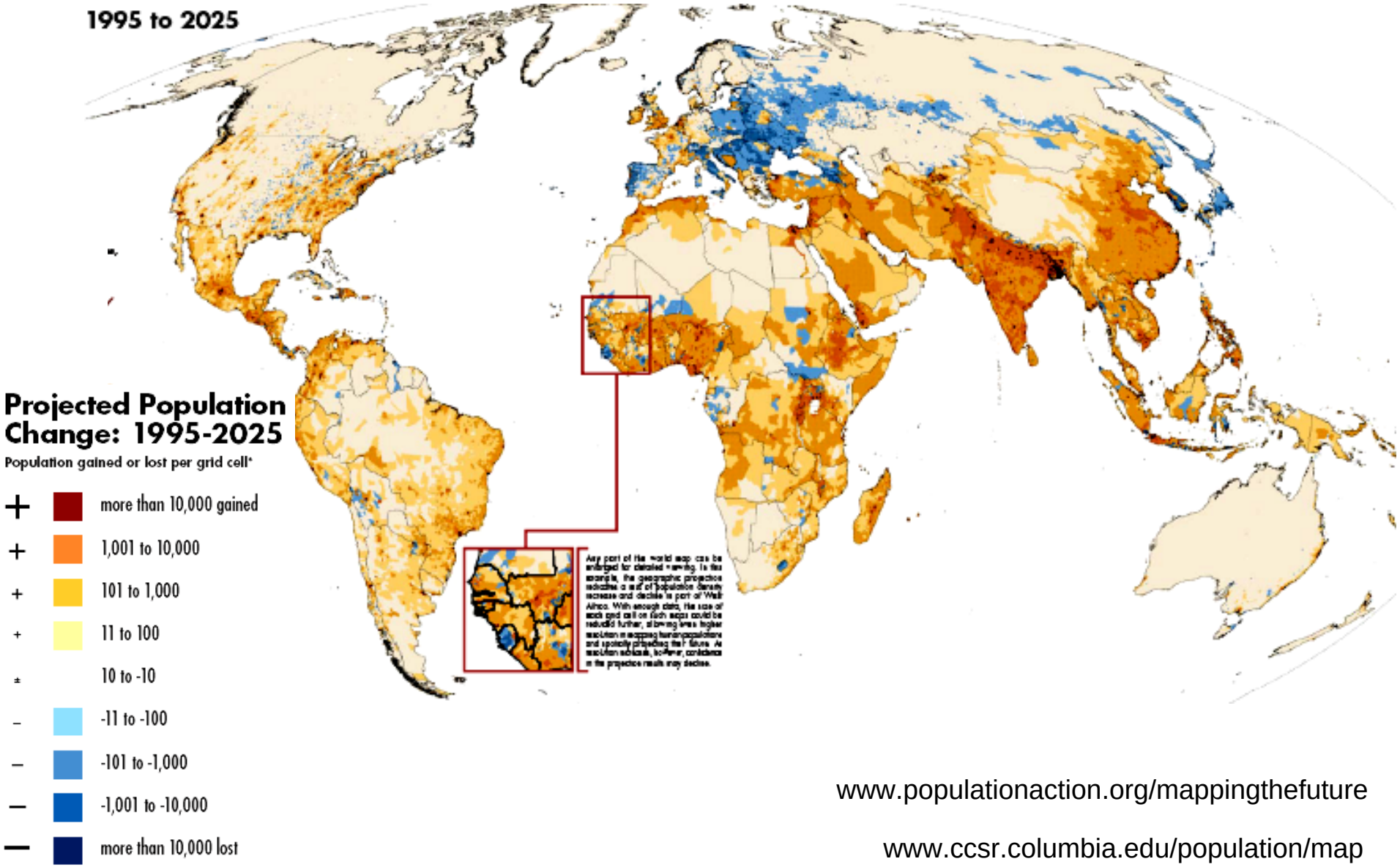


World Population Trends and Projections, 1950 – 2300



www.worldmapper.org

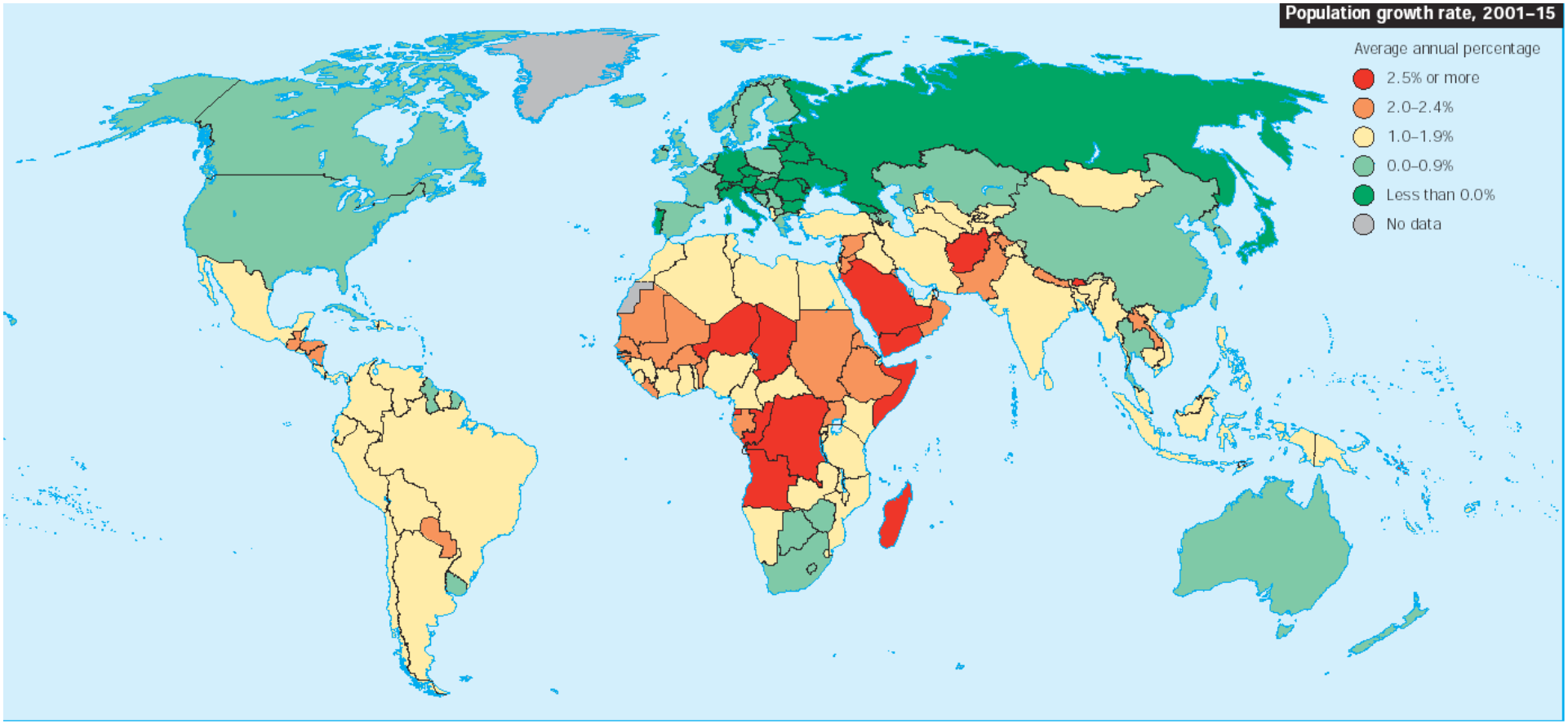
Projected Population Change, 1995 - 2025



www.populationaction.org/mappingthefuture

www.ccsr.columbia.edu/population/map

World Population Growth Rate, 2001 - 2015



What can be done about population?

Should anything be done?

Population Growth - Video

China’s solution?

China's one child policy was established in 1979 to limit China's population growth. The policy limits couples to one child. Fines, pressures to abort a pregnancy, and even forced sterilization accompanied second or subsequent pregnancies.
It is restricted to ethnic Han Chinese living in urban areas. Citizens living in rural areas and minorities living in China are not subject to the law.
The rule has been estimated to have reduced population growth in the country of 1.3 billion by as much as 300 million people over its first twenty years.

Singapore’s solution?

At its peak in 1957, the Total Fertility Rate reached more than **six children per woman.**

“Between 1969 and 1972, a set of policies known as "population disincentives" were instituted to raise the costs of bearing third, fourth, and subsequent children. Civil servants received **no paid maternity leave for third** and subsequent children; maternity hospitals charged progressively **higher fees for each additional birth**; and **income tax deductions** for all but the first two children were **eliminated**. Large families received no extra consideration in public housing assignments, and top priority in the competition for enrollment in the most desirable primary schools was given to only children and to children whose parents had been sterilized before the age of forty. Voluntary sterilization was rewarded by seven days of paid sick leave and by priority in the allocation of such public goods as housing and education. The policies were accompanied by publicity campaigns urging parents to "Stop at Two" and arguing that large families threatened parents' present livelihood and future security. The penalties weighed more heavily on the poor, and were justified by the authorities as a means of encouraging the poor to concentrate their limited resources on adequately nurturing a few children who would be equipped to rise from poverty and become productive citizens.”

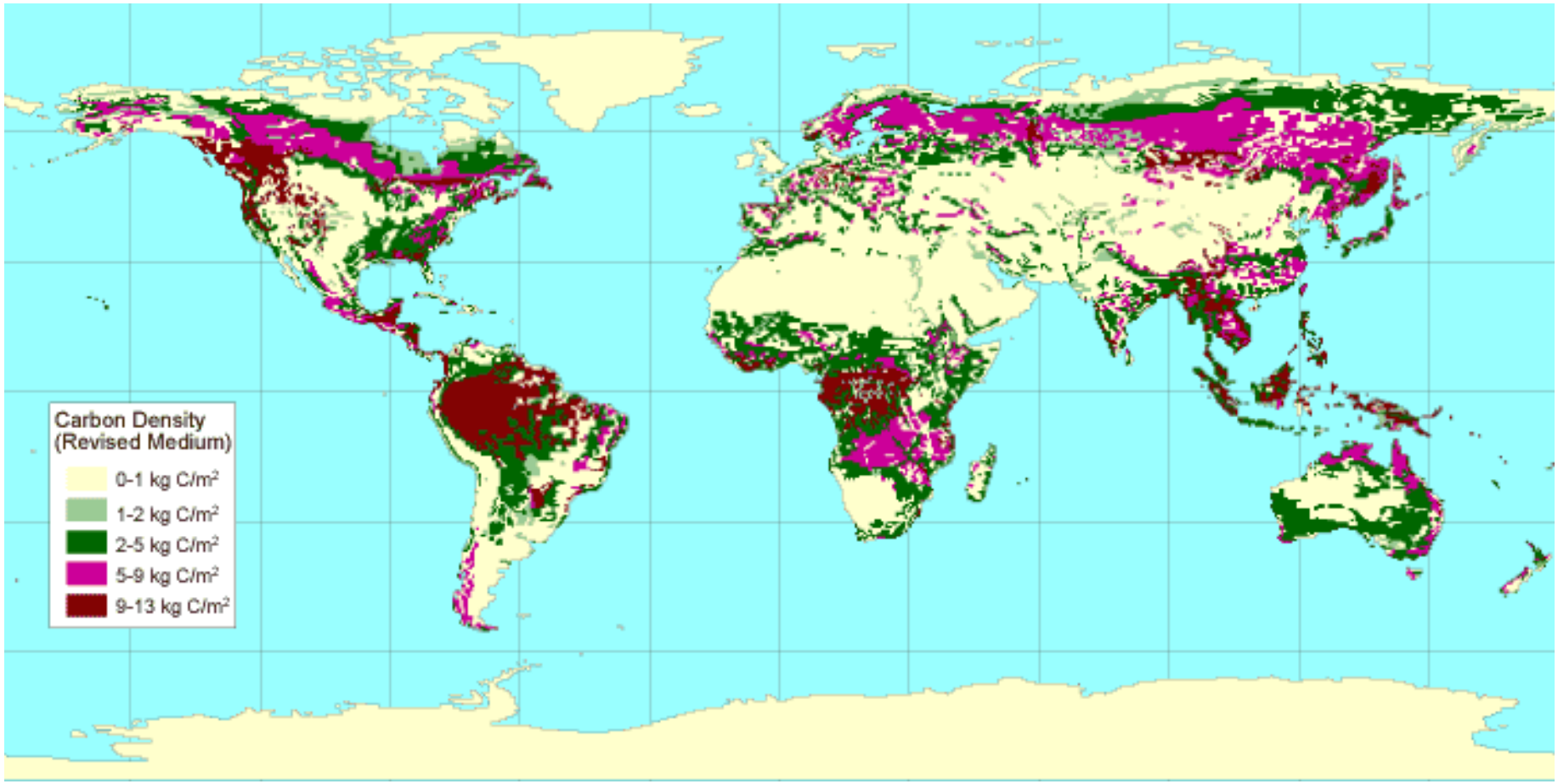
Fertility declined throughout the 1970s, reaching the replacement level of 1.006 in 1975, and thereafter declining below that level.

http://www.ipss.go.jp/webj-ad/WebJournal.files/population/2003_6/24.Yap.pdf

Other sustainability issues.

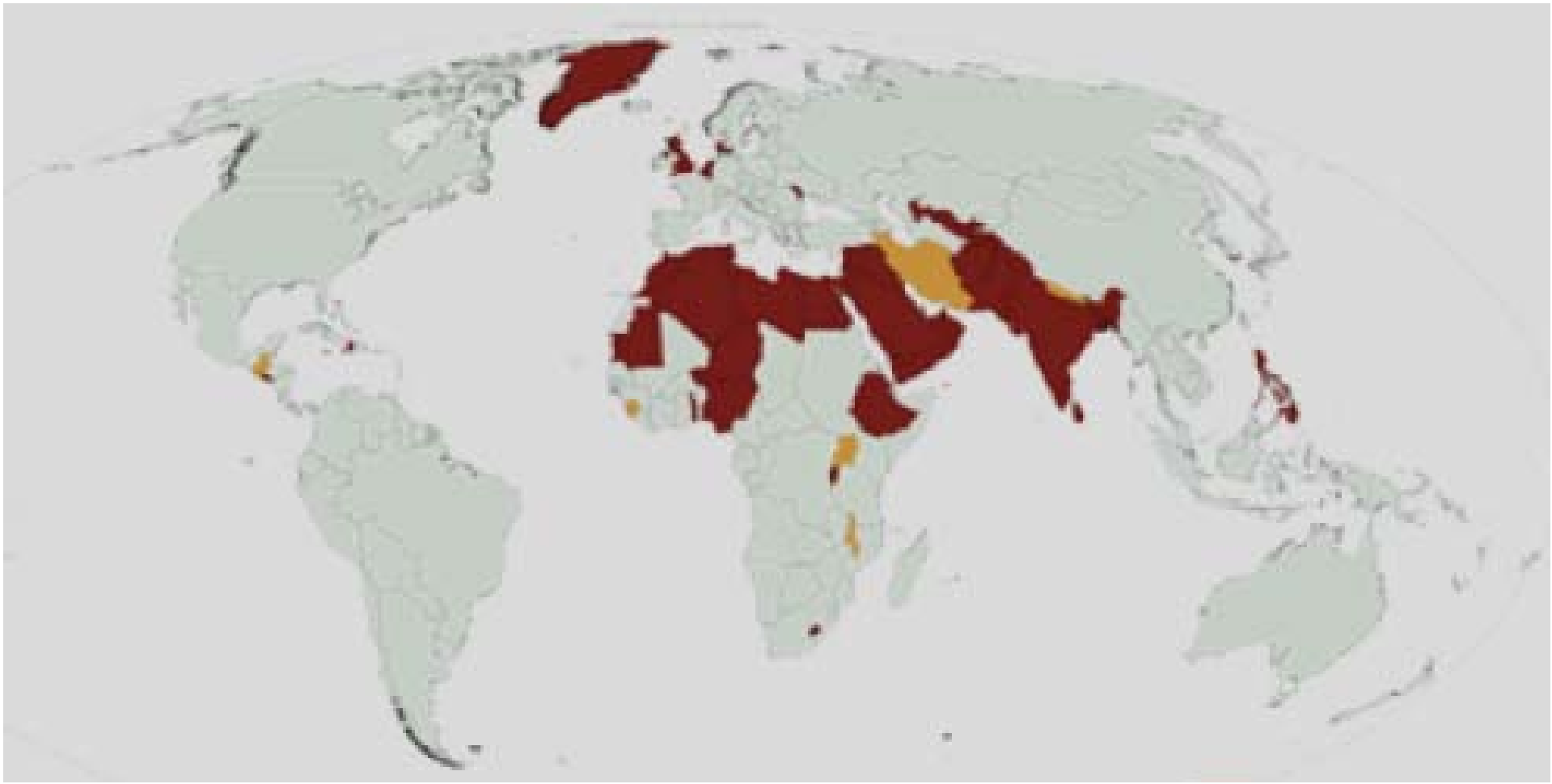
Deforestation and CO_2 storage/release

Major World Ecosystem Complexes Ranked by Carbon in Live Vegetation: A Database



Carbon Dioxide Information Analysis Center (CDIAC), http://cdiac.ornl.gov

Low Per Capita Forest Cover Countries in 2005 and 2025



Low forest cover countries in 2005

Additional low forest cover countries by 2025

Low forest cover not projected by 2025

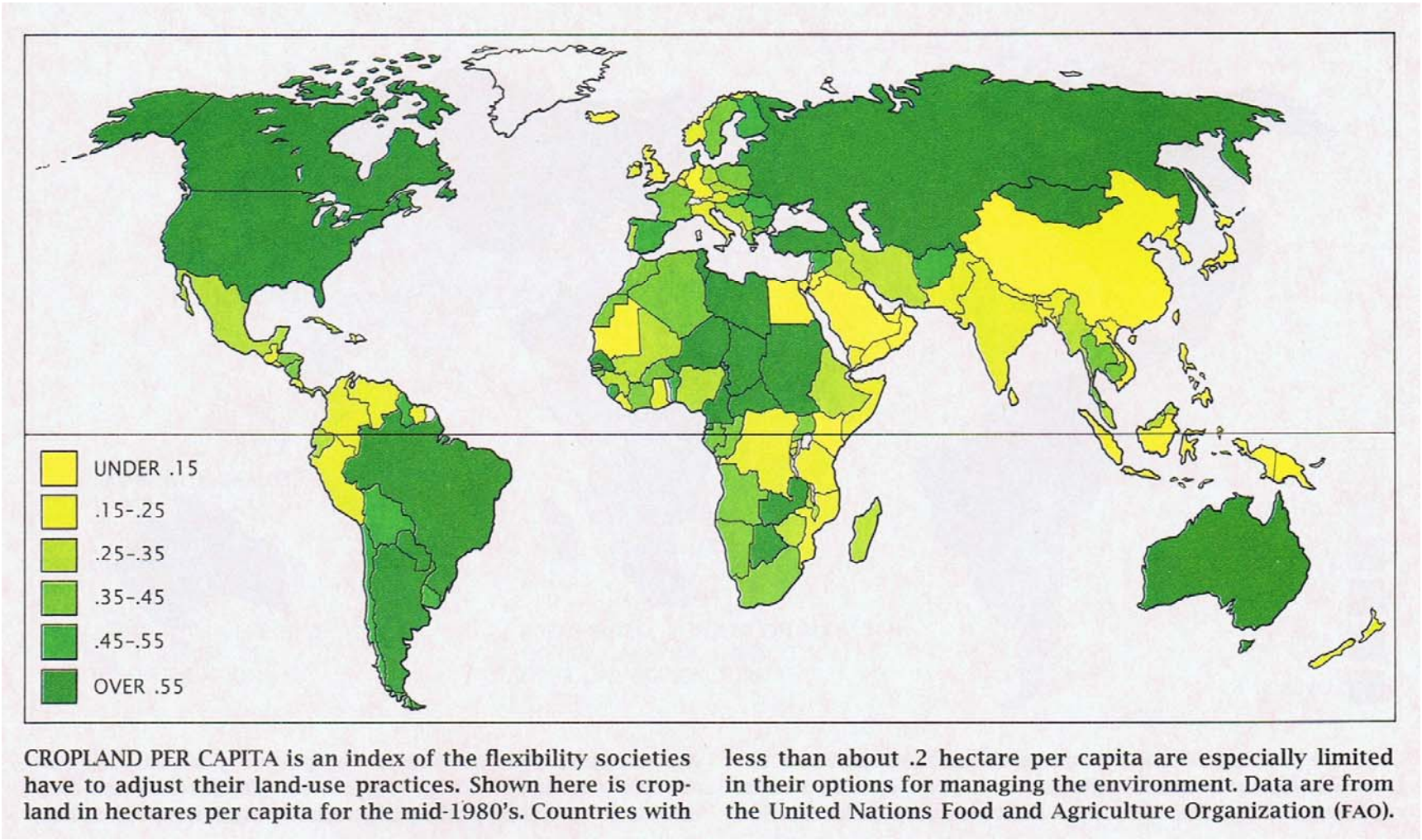
No data

www.populationaction.org/mappingthefuture

www.ccsr.columbia.edu/population/map

Available Cropland

Available cropland per capita (hectares)



CROPLAND PER CAPITA is an index of the flexibility societies have to adjust their land-use practices. Shown here is cropland in hectares per capita for the mid-1980's. Countries with less than about .2 hectare per capita are especially limited in their options for managing the environment. Data are from the United Nations Food and Agriculture Organization (FAO).

W.C. Clark, Sci Am, 261,3, 47-54, 1989

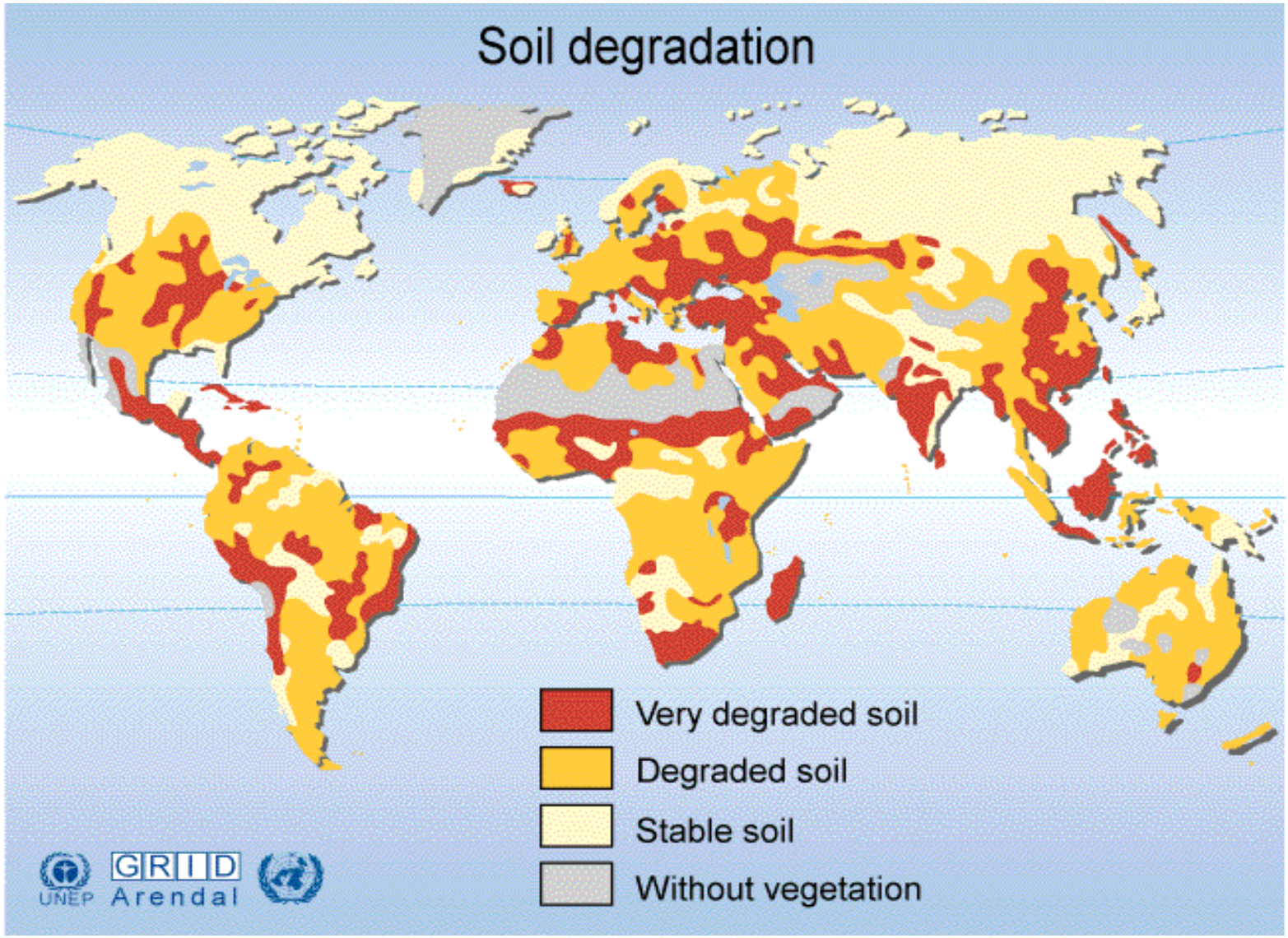
Soil degradation

Almost 75% of Central America's agricultural land has been seriously degraded as has 20% of Africa's and 11% of Asia's (Scherr, 1999).

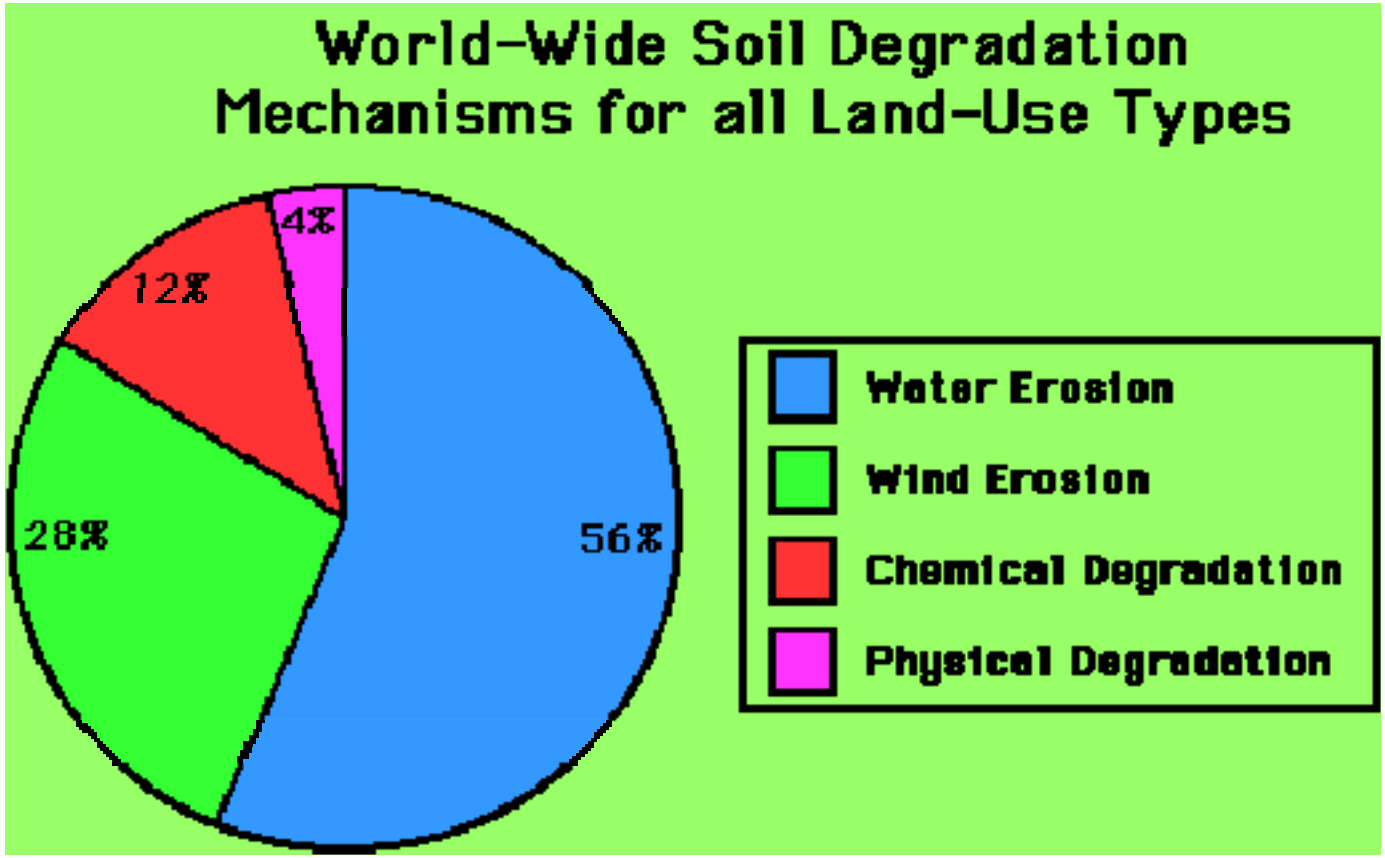
Rows of maize and sorghum abruptly end before chasm cut through field by rampaging runoff.

www.iita.org/info/ ar97/26-27.htm

Soil degradation worldwide



Soil Erosion



http://royal.okanagan.bc.ca/mpidwirn/agriculture/erosion.html

How sustainable agriculture can help - Intercropping

- Crops harvested at different times allows for better soil protection
- After-harvest residue allows for mulching

Loss of biodiversity

"although some degree of crop uniformity may have certain economic advantages, it has serious ecological drawbacks. History has shown that a huge area planted with a single crop species is highly vulnerable to changing climatic conditions of the emergence of a new, matching strain of a pathogen or pest"

Altieri 2000, p. 123

How sustainable agriculture can help - Intercropping

- Combining of two or more crops in field
- Alternating rows or bands
- Combine heavy feeders with nitrogen-fixing legumes

How sustainable agriculture can help - Use of canopy

Sustainable forestry

Combine trees for lumber or pulp with fruit or coffee trees

Intercrop with grains or legumes in early years before canopy is established

Impediments to change

Labor intensive

High profitability of export crops

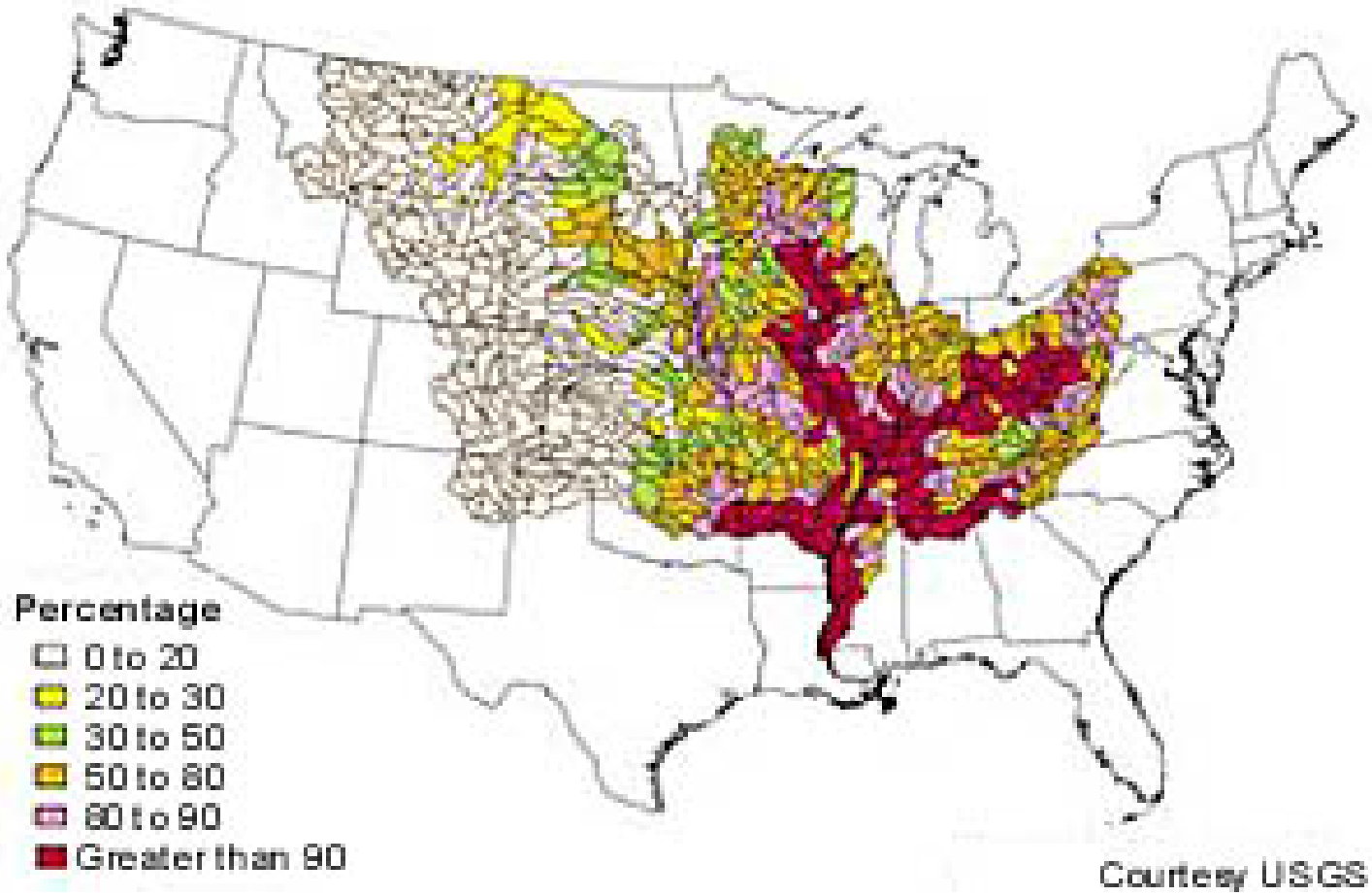
National agriculture policies

- Subsidies of fertilizer, pesticides

Farmers tend to be very conservative

Agribusiness has little incentive to change

Nitrogen run off



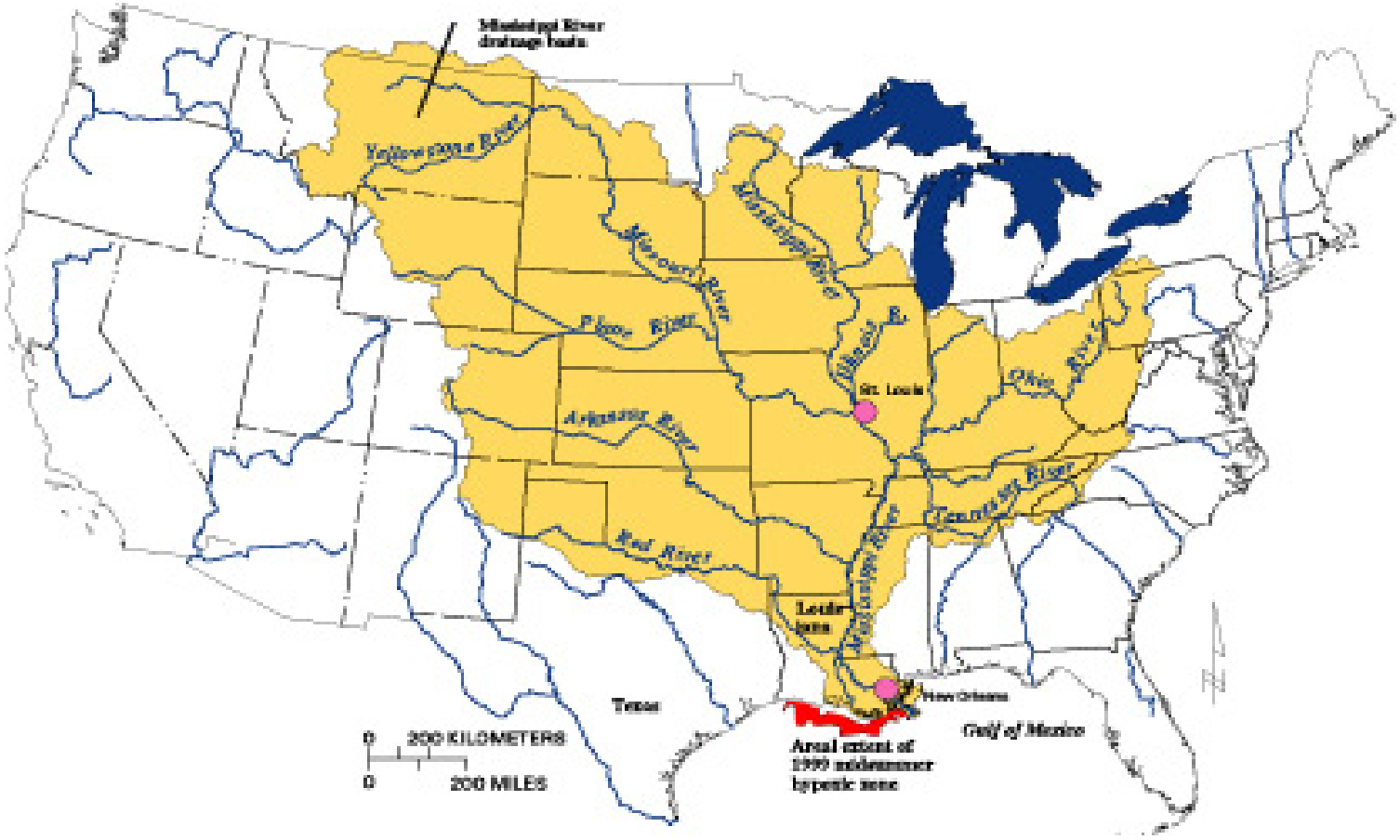
Nitrogen and other applied fertilizers run off fields to Mississippi River and into Gulf of Mexico. Presence of N creates algae blooms, hypoxia

Water Pollution: Eutrophication

Hypoxia (lack of oxygen) is caused by the presence of excess nutrients in water, which cause intensive growth of algae. A decrease in dissolved oxygen is caused by the degradation of dead plant material (algae), which consumes available oxygen. In many cases hypoxic waters do not have enough oxygen to support fish and other aquatic animals. The eutrophication of waters is caused by nutrients coming from many sources, such as fertilizers applied to agricultural fields, golf courses, and suburban lawns; deposition of nitrogen from the atmosphere; erosion of soil containing nutrients; and sewage treatment plant discharges.

The Gulf of Mexico dead zone is an area where water near the sea floor has hypoxic conditions. The hypoxic zone is caused by excess nitrogen delivered from the Mississippi River in combination with seasonal stratification of Gulf waters.

Fertilizer Run off



Nitrogen run off causes annual “Dead Zone” in the Gulf of Mexico, covering over 7,000 square miles. Oxygen levels are too low to support marine life within this zone. Summer storms disperse the nitrogen, but the Dead Zone returns annually.

http://co.water.usgs.gov/hypoxia/html/hyplarge.html

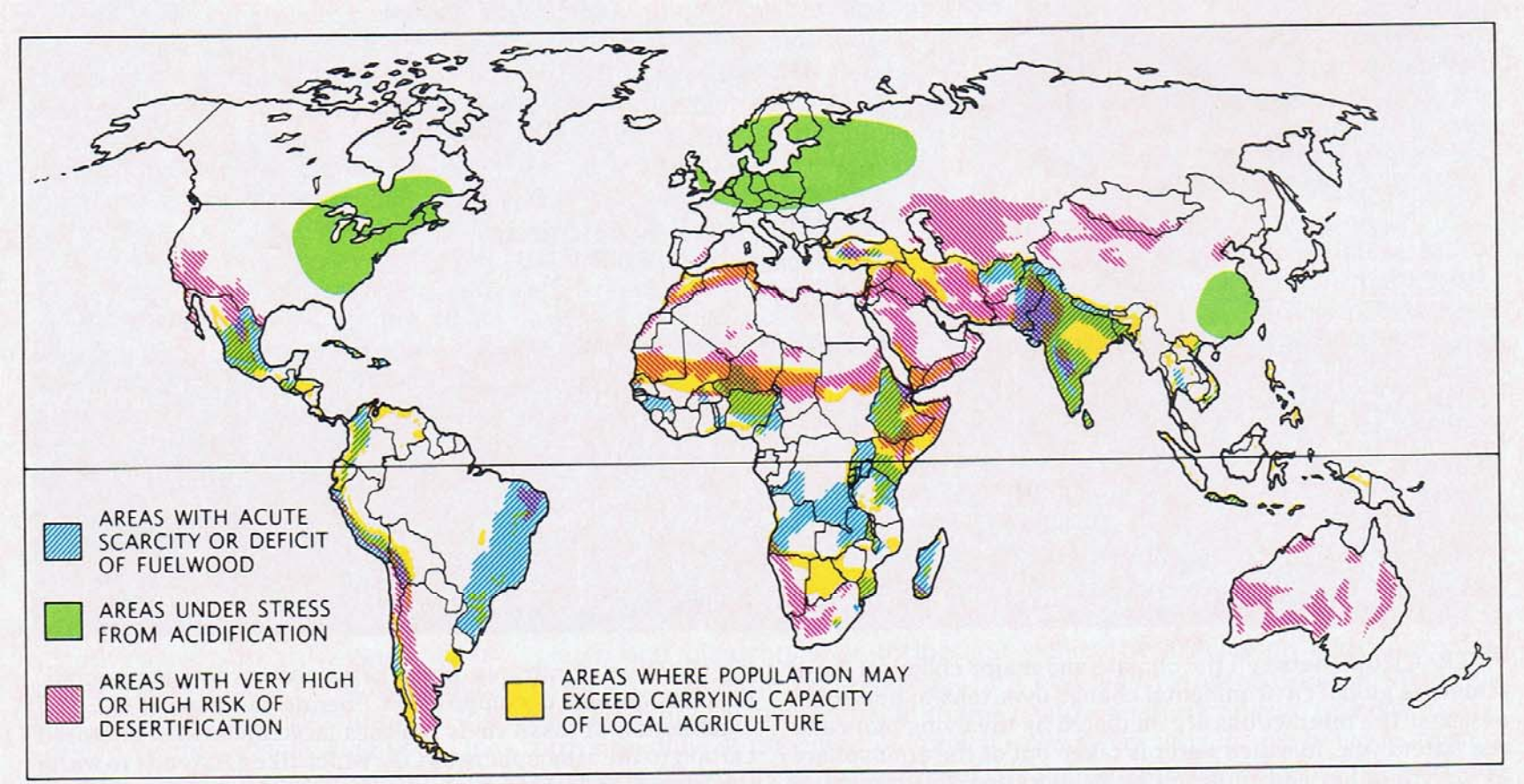
Water – Ocean acidification

Some of the additional CO_2 in the atmosphere is taken up by the ocean (dissolved). This makes the ocean water more acidic as the gas dissolves to create carbonic acid. An overall drop in the pH of the oceans from 8.16 to 8.05 has occurred over the past few decades.

This increased acidity can hamper the ability of a wide variety of marine organisms ranging from coral to abalone to form calcium carbonate shells and skeletal structures. It may be that at crucial stages in the larval and juvenile stages in the lives of many marine invertebrates, ocean acidification inhibits calcification, and also appears to affect reproduction and growth in some organisms.

Air Pollution: Acid Rain

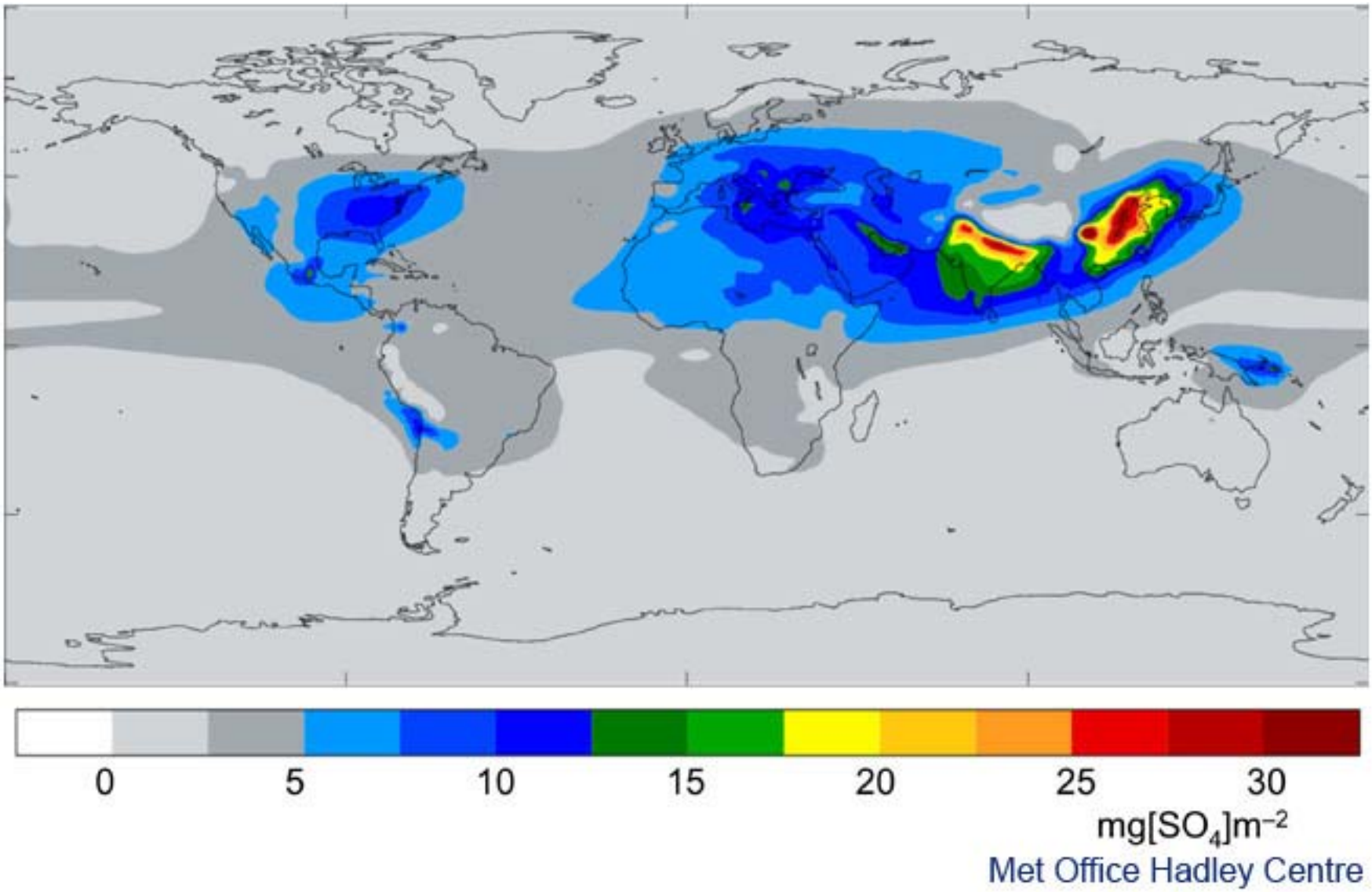
Land Degradation –
desertification, acid rain, overharvesting, stress on agriculture



LAND DEGRADATION results from a variety of human activities. Shown are regions threatened by desertification, overharvesting of firewood, acid rain and stress induced by efforts to feed more people than the land is actually able to support. The data are from the U.N.'s Food and Agriculture Organization and the Scientific Committee on Problems of the Environment.

W.C. Clark, Sci Am, 261,3, 47-54, 1989

Estimated burden of sulphate aerosol, in 1990s



Hadley Centre for Climate Prediction and Research

Acid Rain (U.S.)

The Acid Rain Program (ARP) was created under Title IV of the 1990 Clean Air Act (CAA). Amendments to reduce the adverse effects of acid deposition through reductions in annual emissions of SO_2 and NOx primarily from fossil fuel-burning electricity generation. The ARP employs two policies: a cap and trade program for SO_2 and a rate-based reduction program for NOx.

Acid Rain – SO_2

Since its inception in 1990, the cap and trade component of the ARP has reduced SO_2 emissions from power plants by more than 40 %. The program is on track to reach the cap—reducing 1980 emissions by 50 % at full implementation in 2010. EPA's cap and trade programs to date have delivered significant environmental results.

SO2 Emission Reductions from Acid Rain Program

The green dots on the map show emissions of SO_2 from power generating units greater than 25 MW (the largest being primarily coal burning). Note that at the program's inception in 1995, SO_2 emissions drop significantly and decrease further over time. The colored background is an isopleth map showing change in sulfate concentrations as measured by the air quality monitoring network.

http://www.epa.gov/captrade/maps/so2.html

Acid Rain - NOx

NOx contributes to acid deposition, as well as the formation of ground-level ozone, a pervasive air pollution problem—also known as "smog"—in many areas in the East

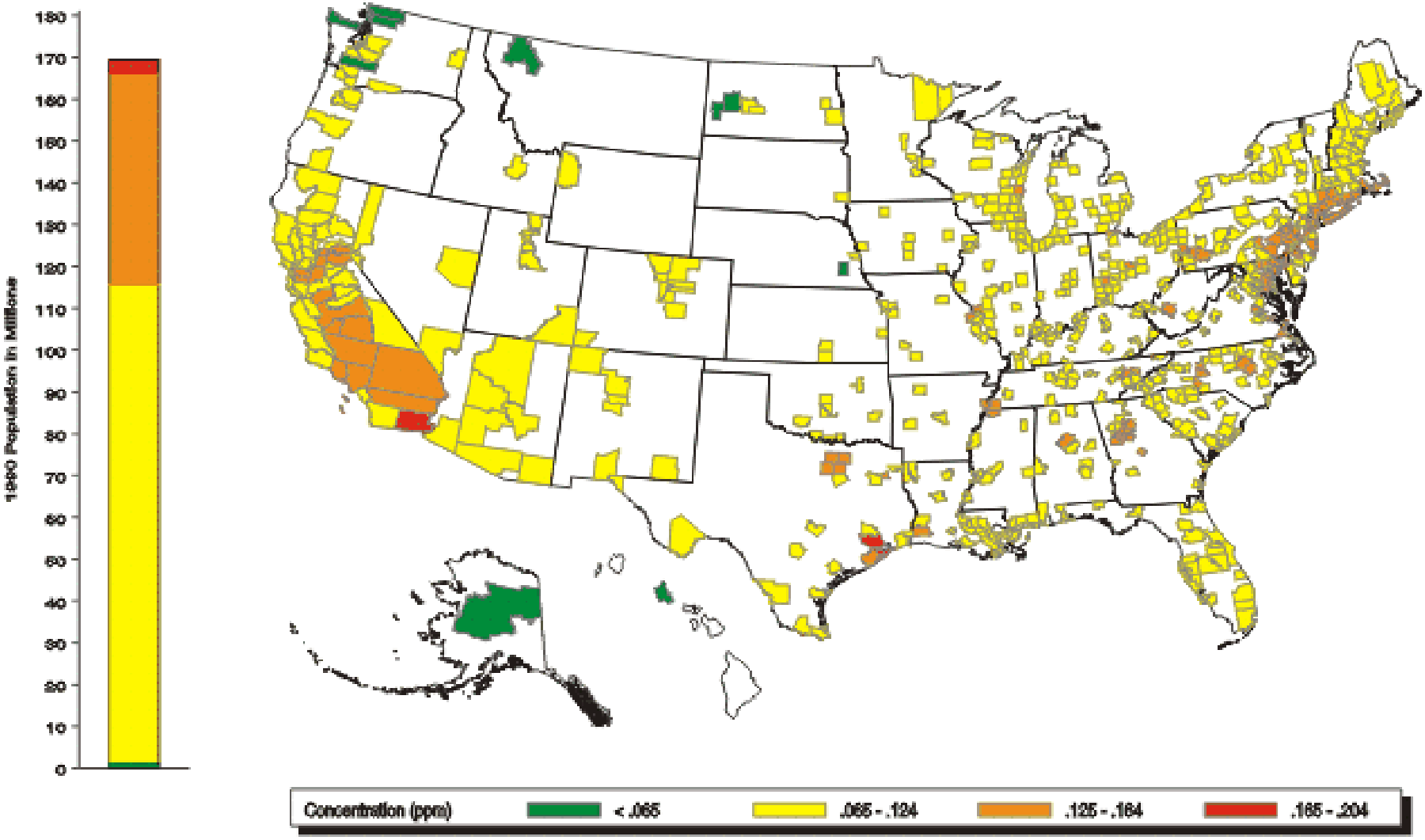
NOx Emission Reductions from Acid Rain Program

The orange dots in the map show the reductions in NOx emissions over time beginning in 1995 with the advent of the Acid Rain Program (ARP).

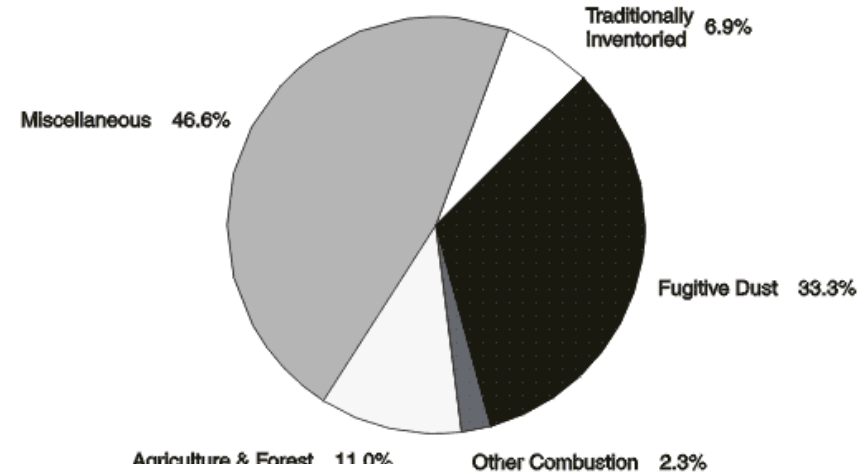
The colored background is an isopleth map showing the change in nitrate concentrations as measured by the air quality monitoring network. Since the inception of the ARP, total nitrate concentrations have declined by about 30 % in the eastern United States.

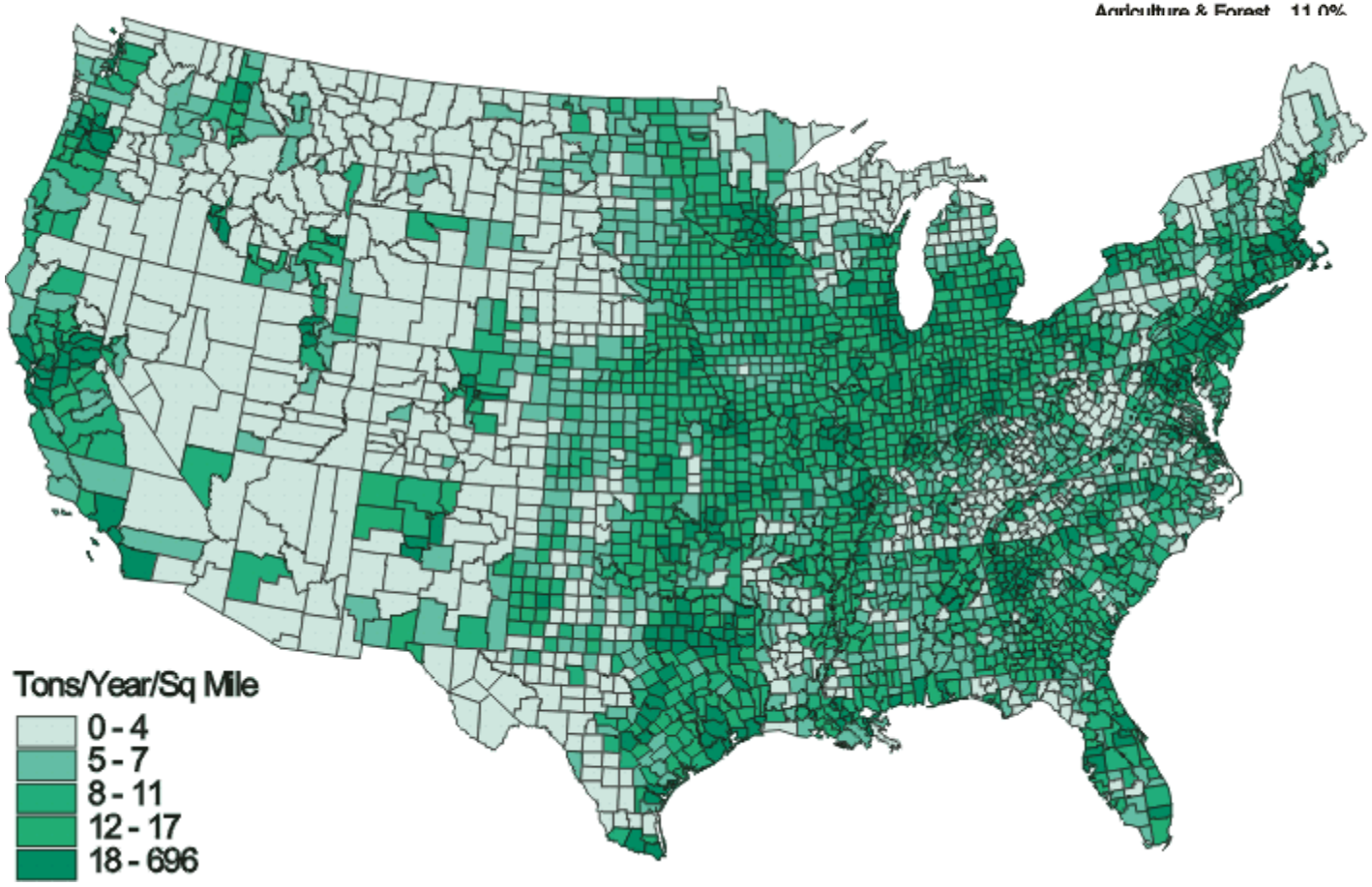
http://www.epa.gov/captrade/maps/nox.html

Air Pollution – Ozone, O_3. Maximum one-hour concentration.

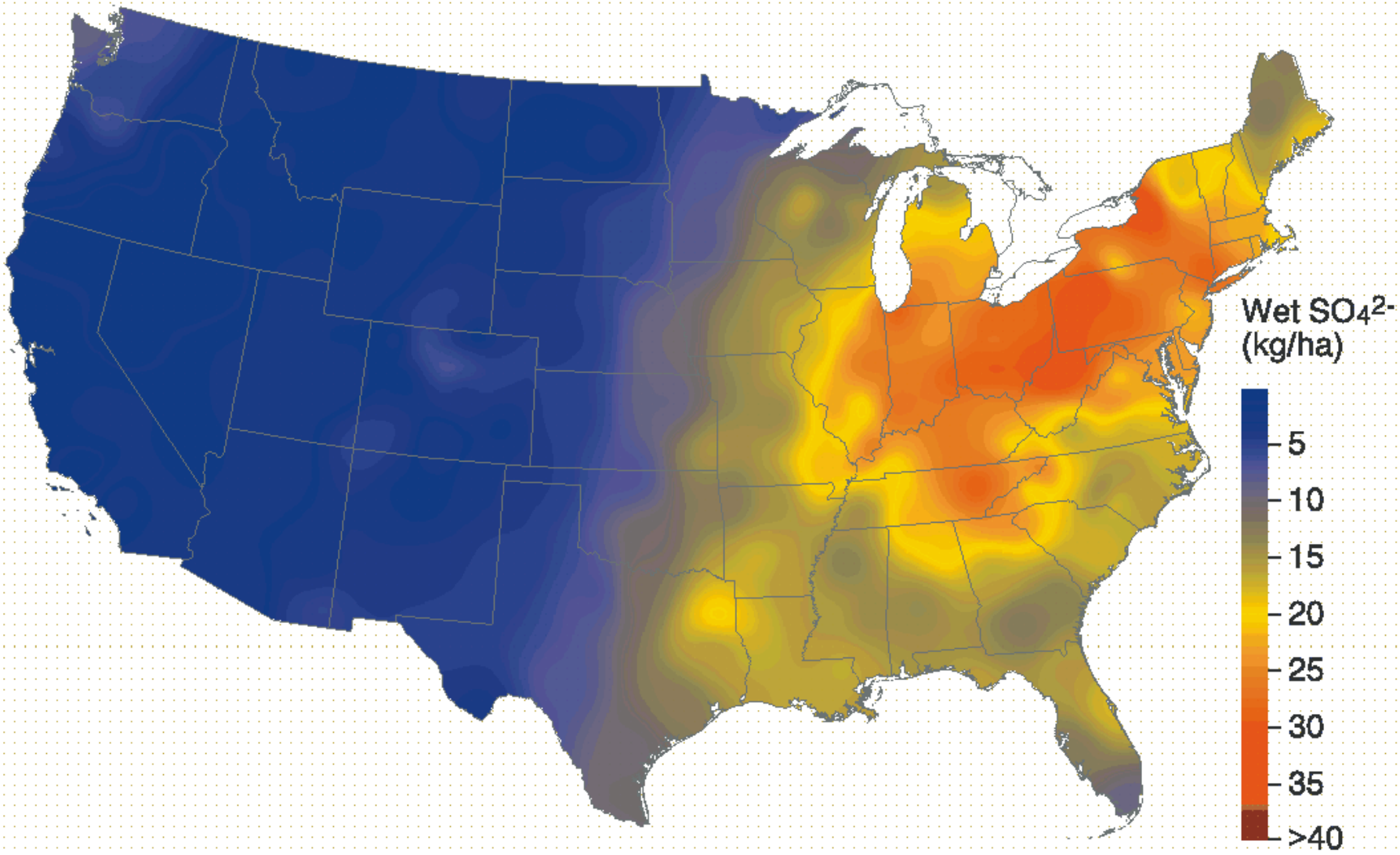


Air Pollution – Particulate Matter, PM10





Air Pollution – Sulfate deposition



Source: CASTNET & NADP/NTN

USEPA/CAMD 03/28/01

The End.

"Wait a minute! What about ye carbon footprint?"
Mostyn, David

Tarzan's trees being chopped down.
Mike Williams.