Global Climate Change

'Fiction, Facts, Uncertainties & Challenges'

David D. Houghton

Atmospheric & Oceanic Sciences

UW – Madison

Email: ddhought@facstaf.wisc.edu

Space Place – November 12, 2002

GLOBAL CLIMATE CHANGE

1. Introduction
2. What the unconvinced people are saying
3. Facts
4. Uncertainties
5. Challenges
6. What can we personally do about climate change

GLOBAL CLIMATE CHANGE

What the unconvinced people are saying…

1. "Theory remains entirely unproved."
2. "One-in-three chance … that experts are wrong."
3. "Models are incapable of handling … water vapor."
4. "Troposphere should be warming faster than the surface."
5. "If the weather folk can't figure out what's happening for the rest of the week, how can they tell us what the climate will be for the next 50 years?"
6. "Guess what? Antarctica's getting colder, not warmer."
7. "Global warming is still just a theory."

Facts…

1. Global mean temperature has been going up in the last 140 years.
2. The magnitude of this variability does not exceed natural variability.
3. Concentration of carbon dioxide has been going up as well as other greenhouse gases.
4. Radiative theory of atmospheric gases (greenhouse) and aerosols is important.
5. Climate change involves the entire “earth system” not just the atmosphere.
6. Future projections face uncertainties in emission production, modeling, and impacts.
7. Several thousand scientists from +40 countries all over the world have been involved.

GLOBAL CLIMATE CHANGE

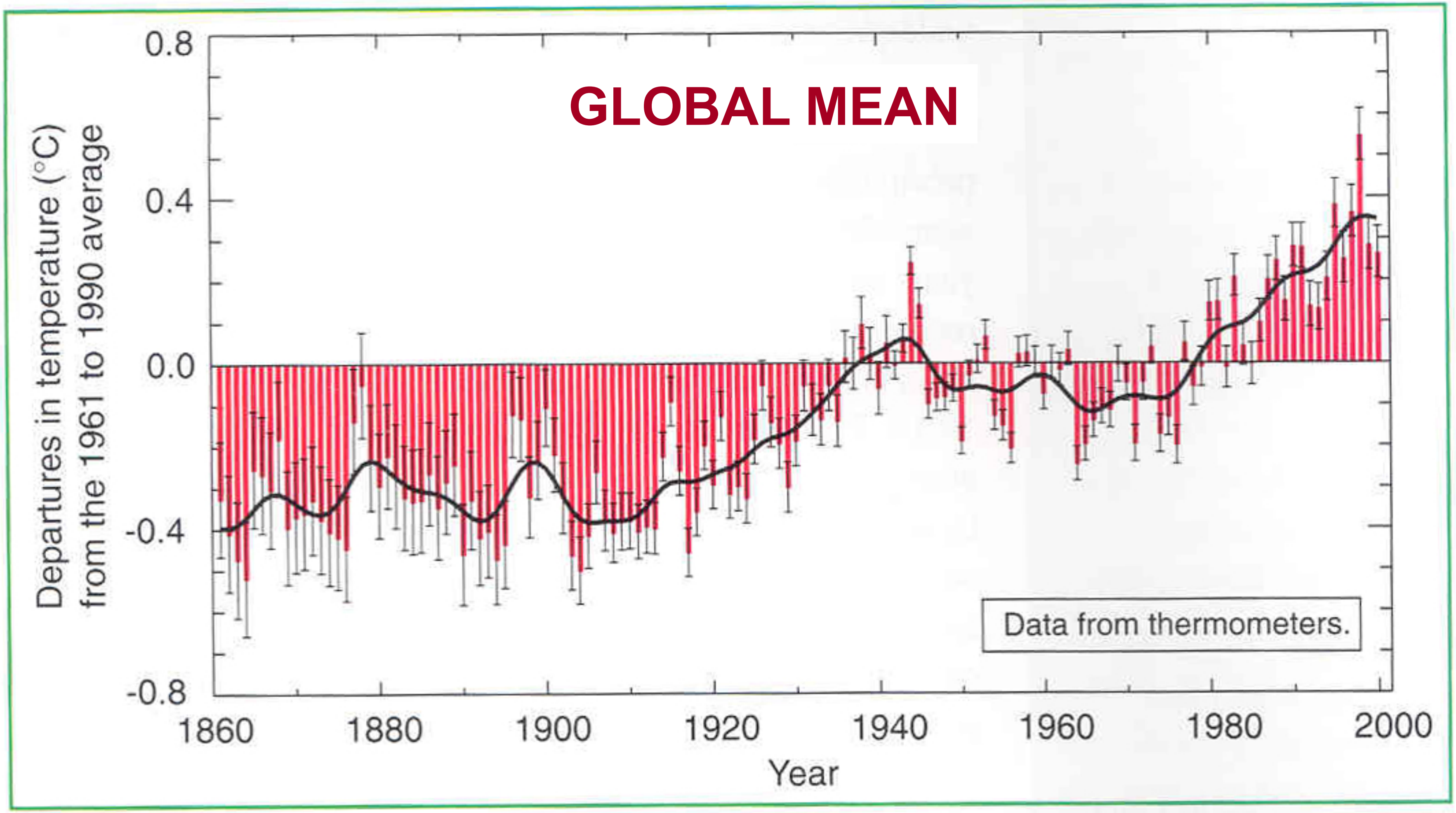


Figure 2: Combined annual land-surface air and sea surface temperature anomalies (°C) 1861 to 2000, relative to 1961 to 1990. Two standard error uncertainties are shown as bars on the annual number. [Based on Figure 2.7c]

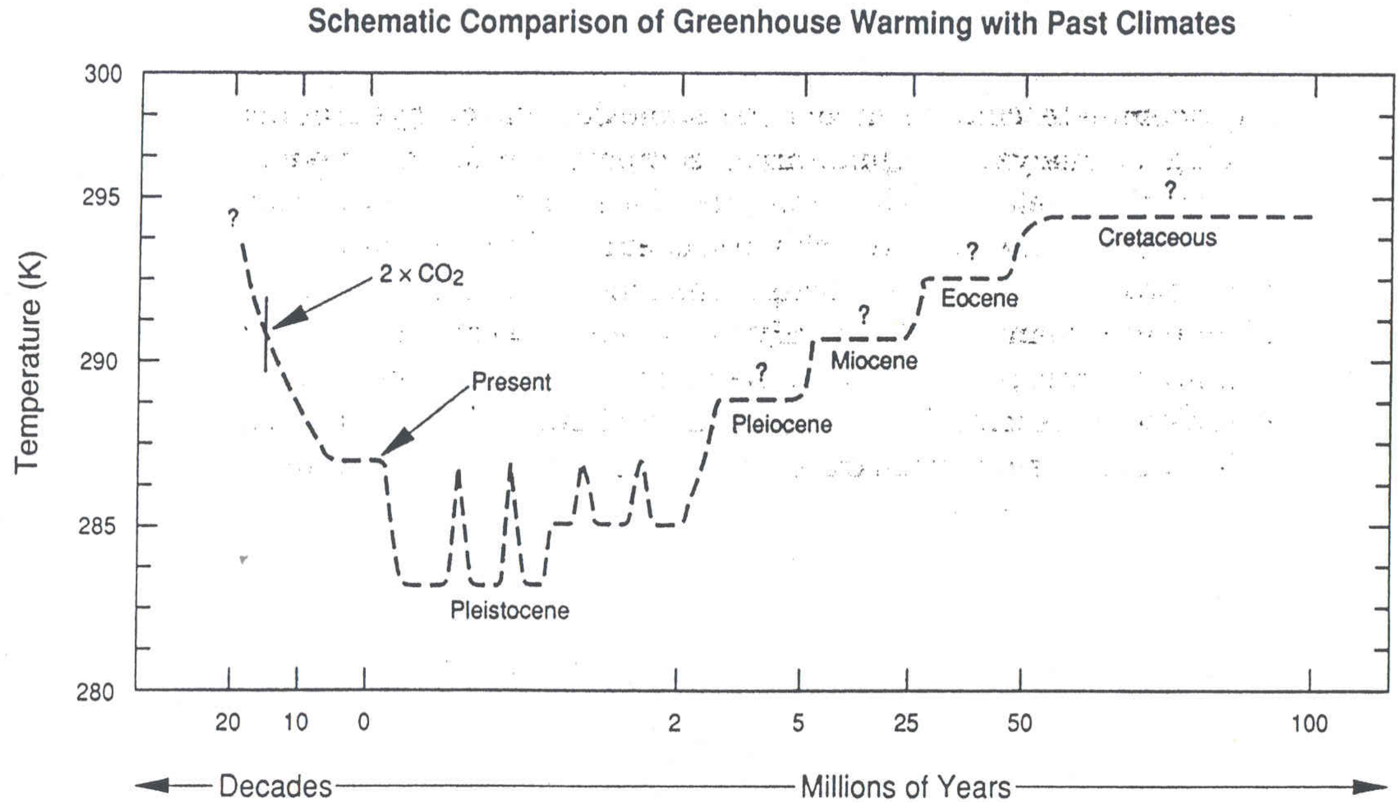
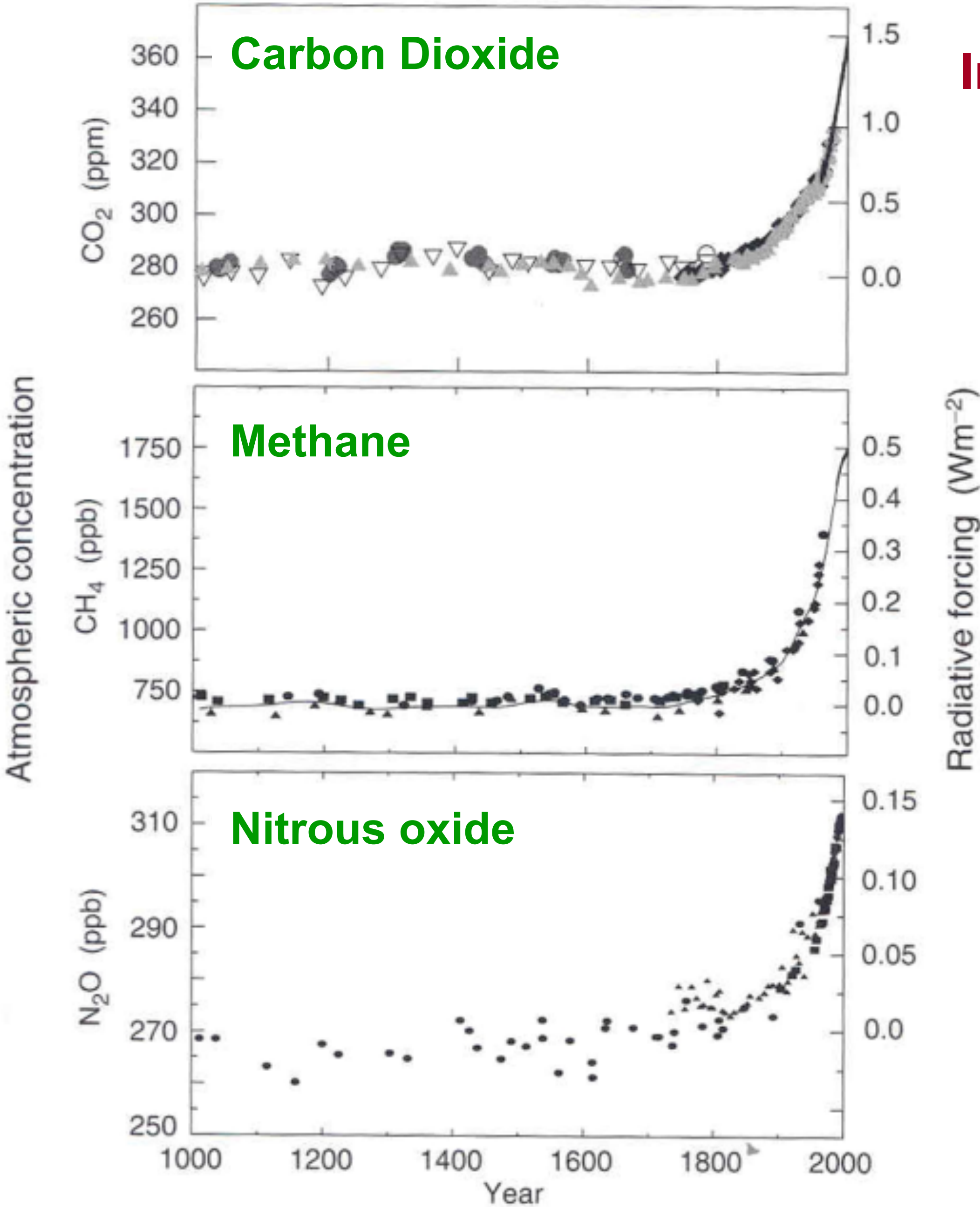


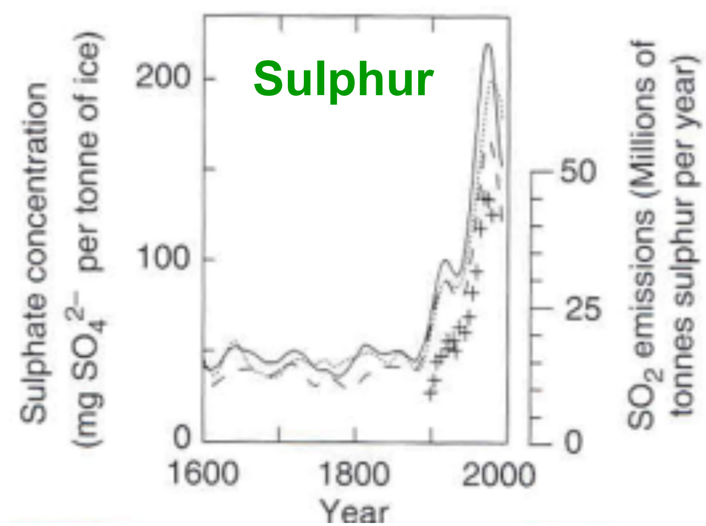
Fig. 21.2 Schematic comparison of possible future greenhouse warming with estimates of past changes in temperature. Pleistocene glacial–interglacial cycles are more numerous than shown. The characteristic amplitude of global temperature change during glacial–interglacial cycles is 3–4 K. Note that pre-Pleistocene changes are not well fixed in magnitude, but their relative warmth is approximately correct. Maximum warming in the Cretaceous is based on estimates by Barron and colleagues. Time intervals in between have been scaled accordingly. (Crowley, 1989).

Indicators of the human influence on the atmosphere during the Industrial Era

(a) Global atmospheric concentrations of three well mixed greenhouse gases



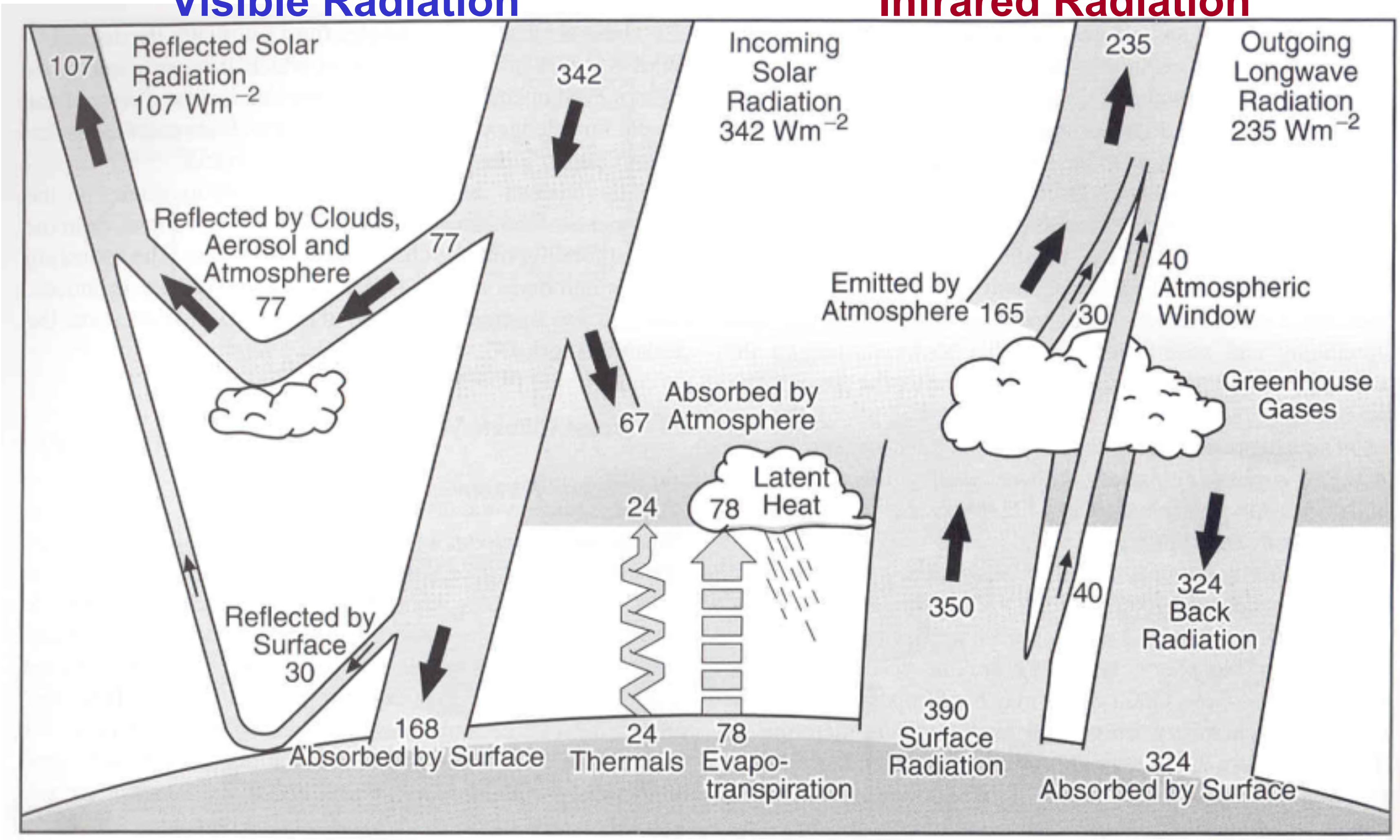
(b) Sulphate aerosols deposited in Greenland ice



GLOBAL CLIMATE CHANGE

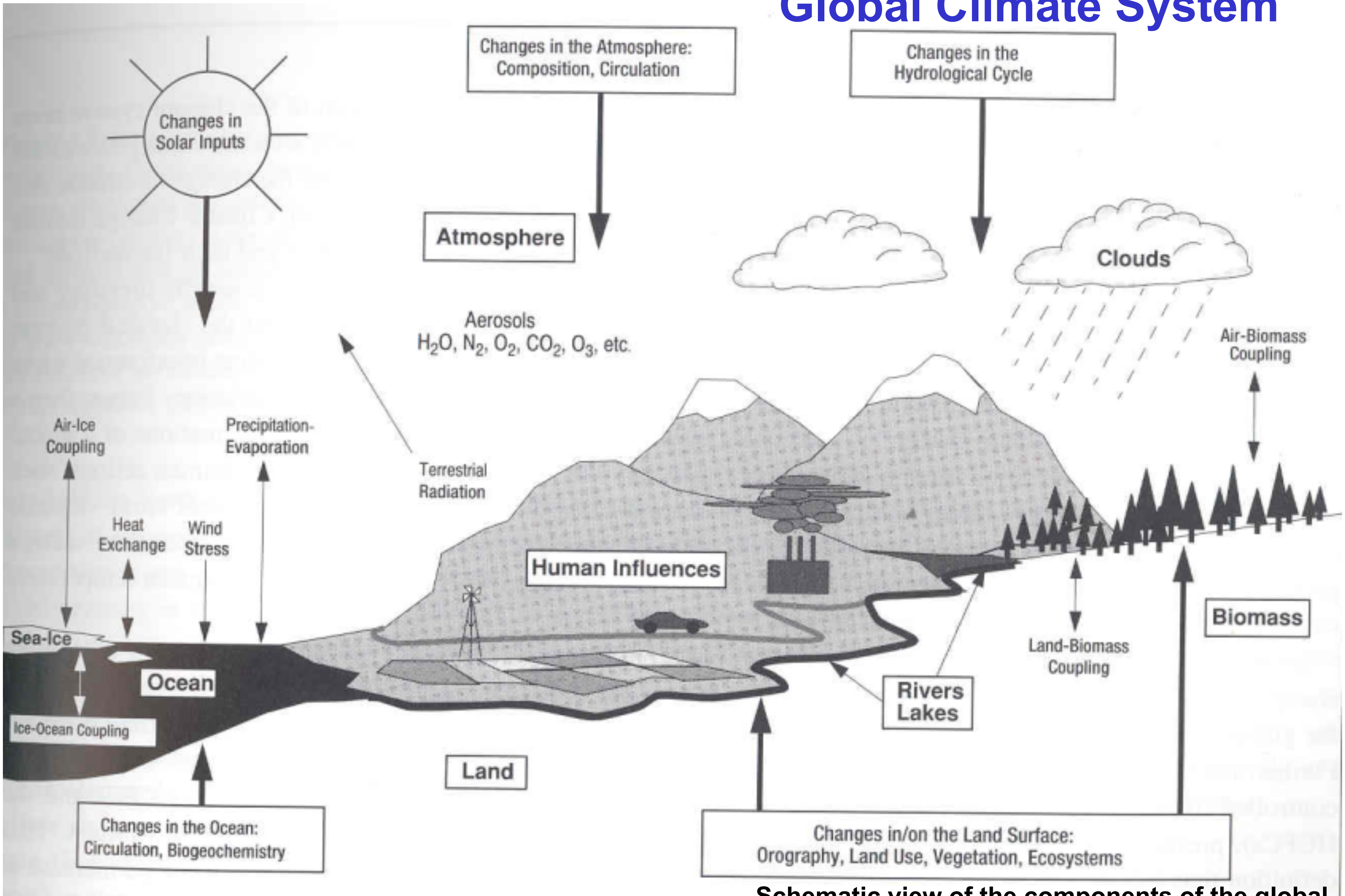
Visible Radiation

Infrared Radiation



The Earth's annual and global mean energy balance. Of the incoming solar radiation, 49% (168 WM^{-2}) is absorbed by the surface. The heat is returned to the atmosphere as sensible heat, as evapotranspiration (latent heat) and as thermal infrared radiation. Most of this radiation is absorbed by the atmosphere, which in turn emits radiation both up and down. The radiation lost to space comes from cloud tops and atmospheric regions much colder than the surface. This causes a greenhouse effect.
Source: Kiehl & Trenberth, 1997: Earth's Annual Global Mean Energy Budget, *Bull. Am. Met. Soc*. 78, 197-208.

Global Climate System



Schematic view of the components of the global climate system (bold), their processes and interactions (thin arrows) and some aspects that may change (bold arrows).

GLOBAL CLIMATE CHANGE

Uncertainties…

1. Human induced forcing changes to present
2. Future emissions scenarios

   [Special Report on Emission Scenarios (SRES) study]

   A1FI: fossil fuel intensive energy system

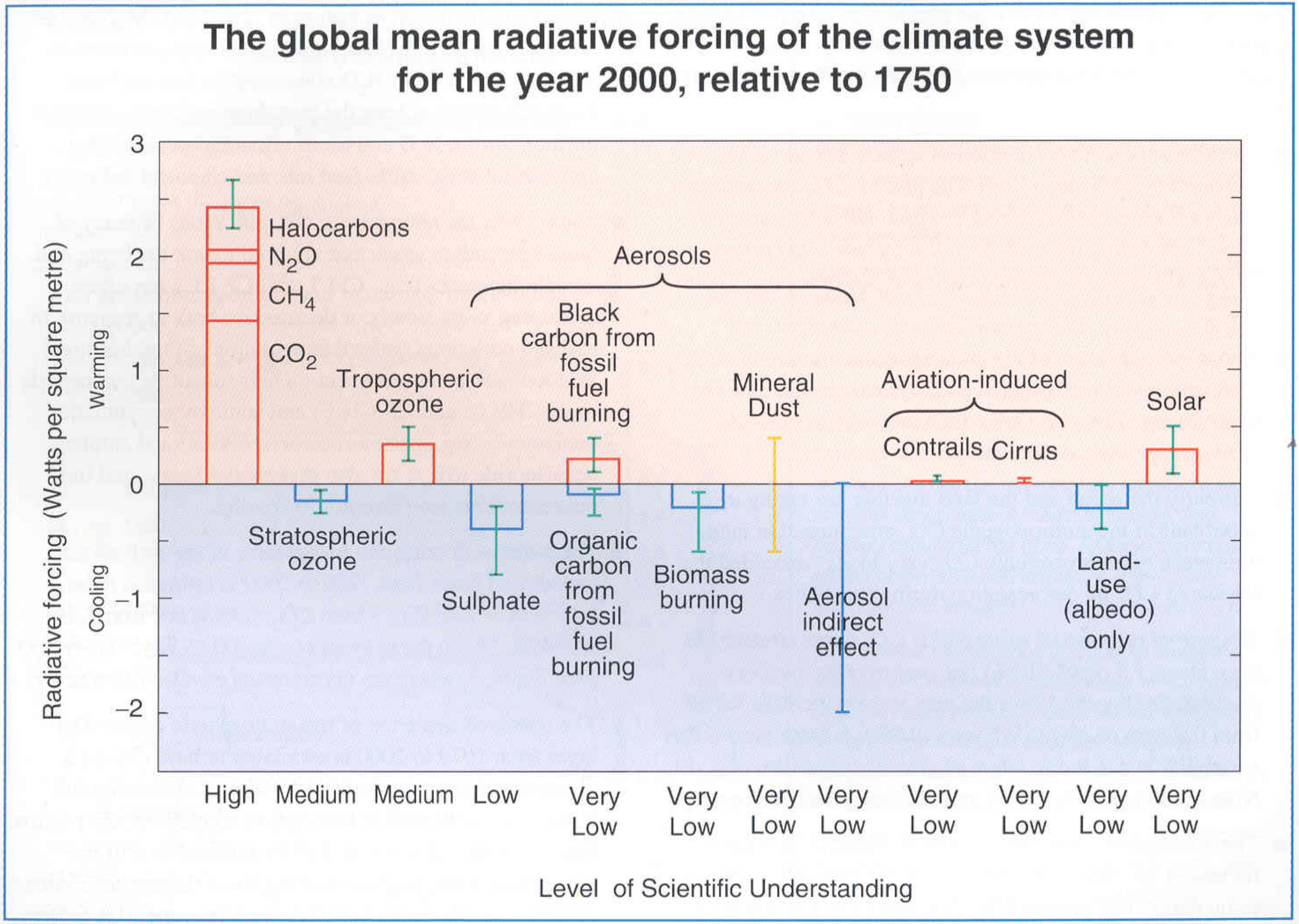
   A1T: non-fossil fuel intensive energy system

   A1B: no one energy source relied on

   A2: self-reliant economy, preservation of local identities

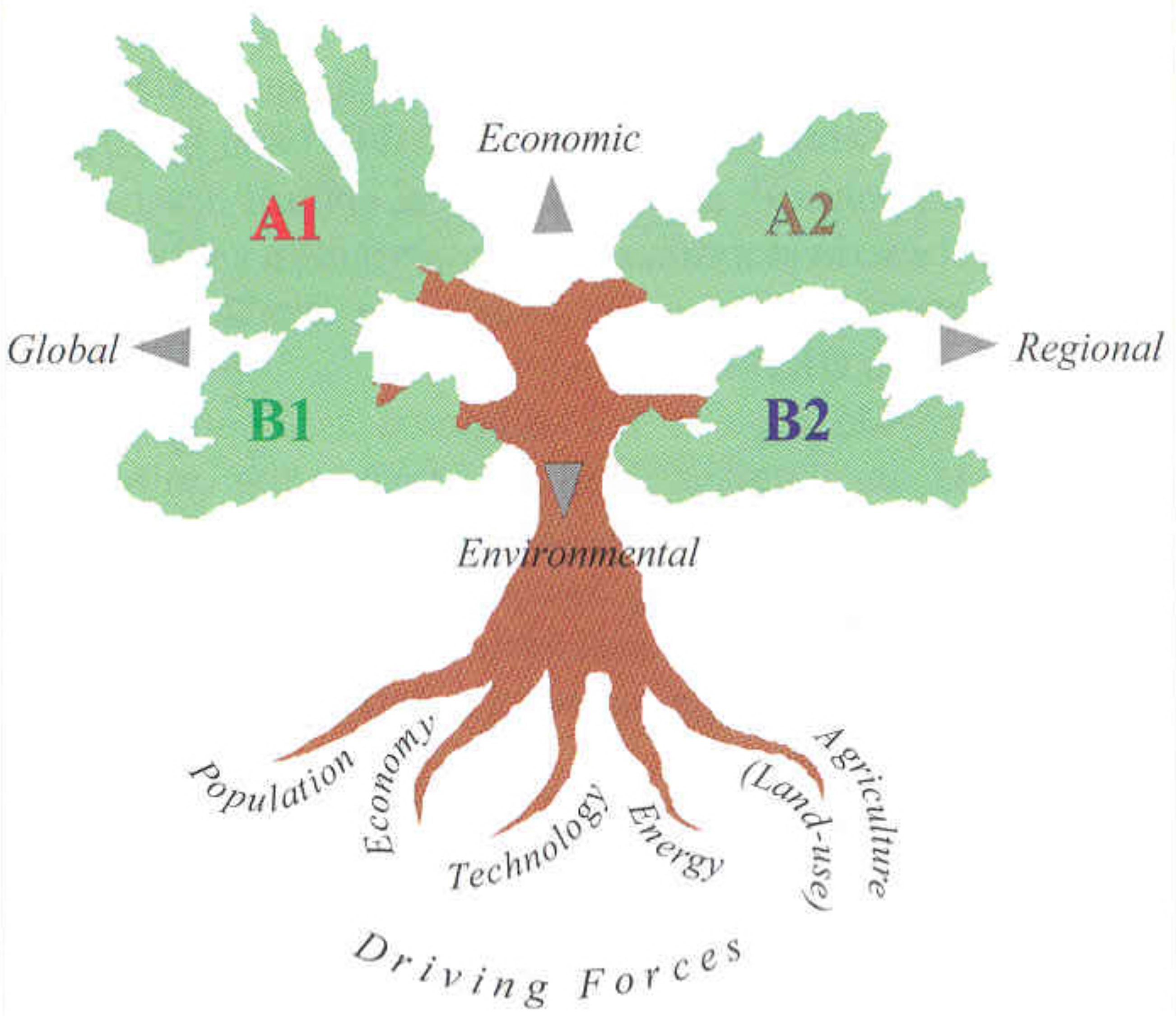
   B1: service and information economy, clean technology, global solutions

   B2: B1 with local solutions, increasing population, less technology
3. Model predictions – global mean
4. Model predictions – local conditions
5. Impacts

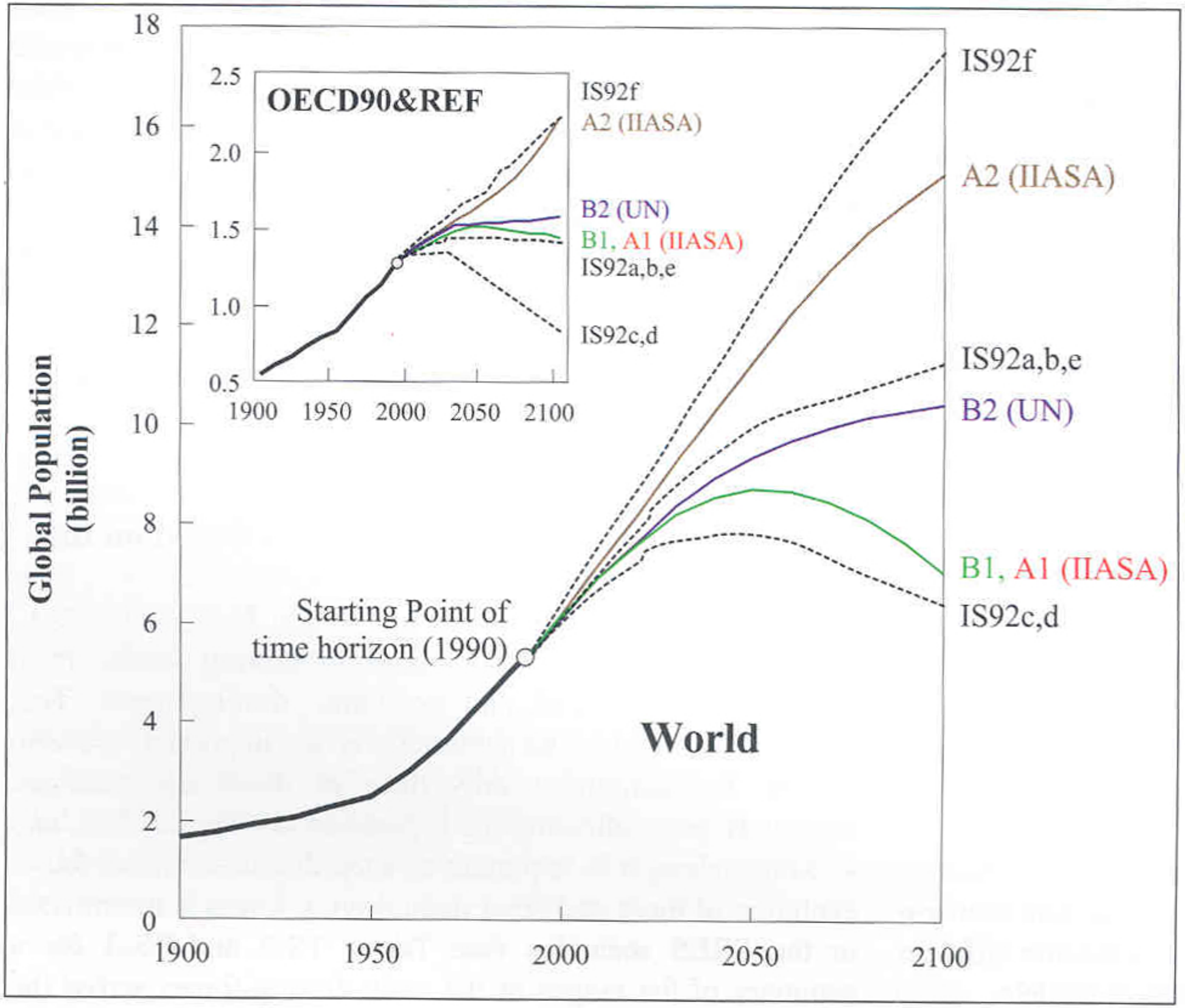


GLOBAL CLIMATE CHANGE

SRES Scenarios for Emissions



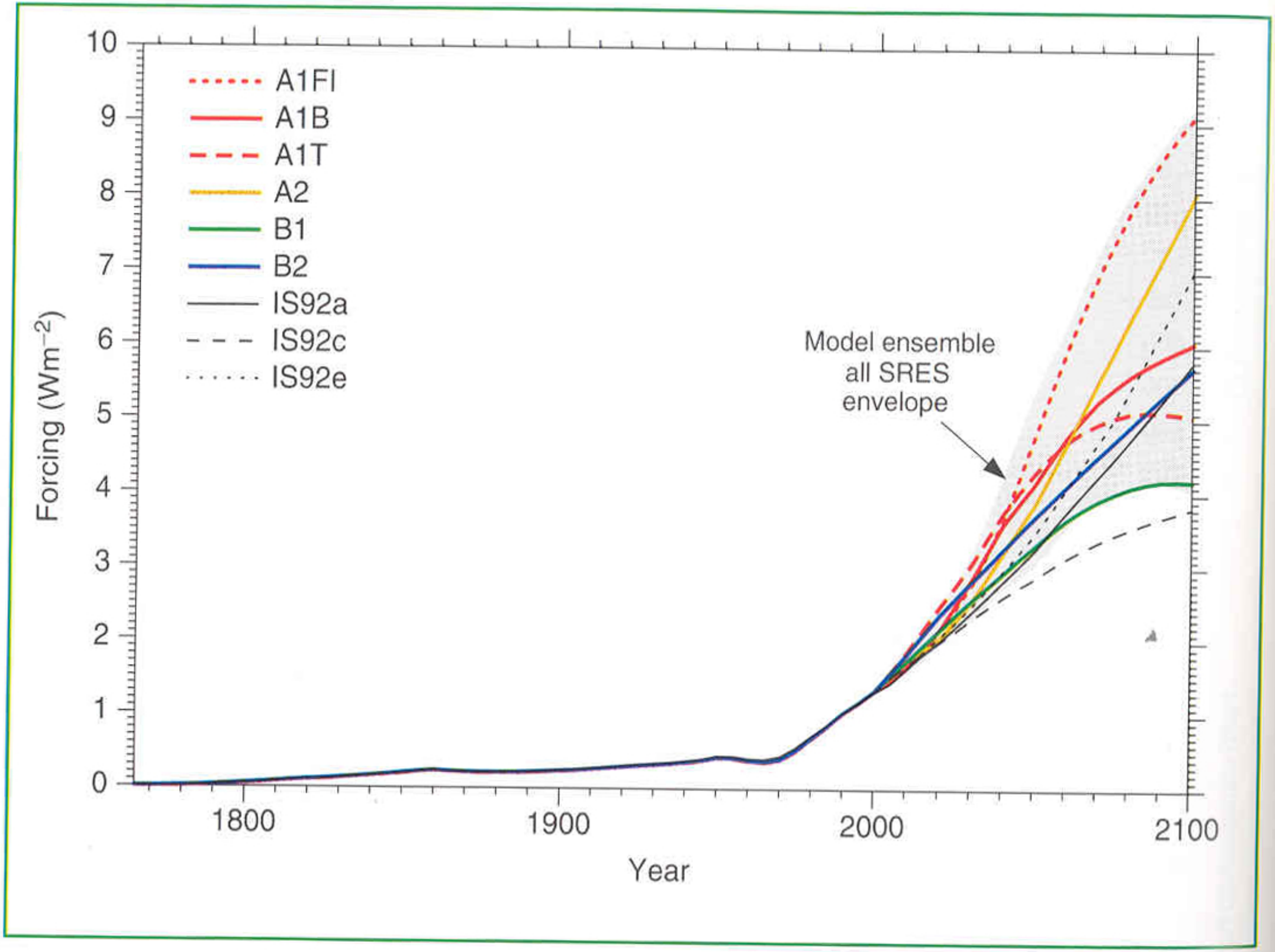
Population Projections



Population Projections

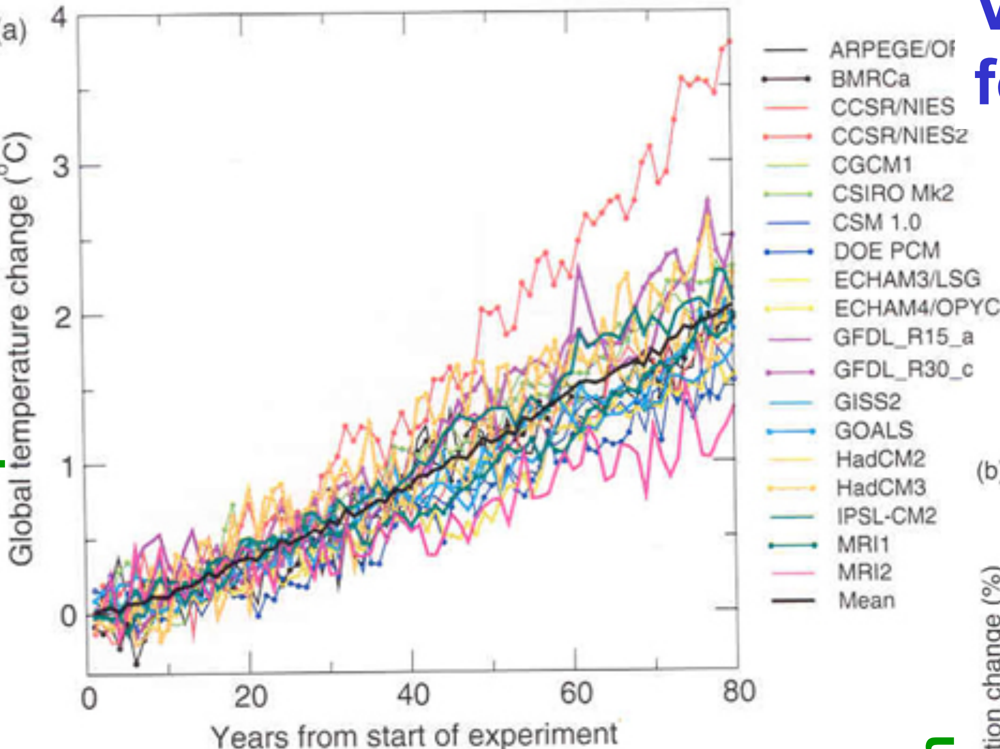
Historical data from 1900 to 1990 (based on Durand, 1967; Demeny, 1990; UN, 1998, for medium) and IPCC IS92 scenarios (Leggett *et al*., 1992; Pepper *et al*., 1992) from 1990 to 2100.

Emission Scenarios



Variations Among Models for one Emission Condition

Temperature



Precipitation

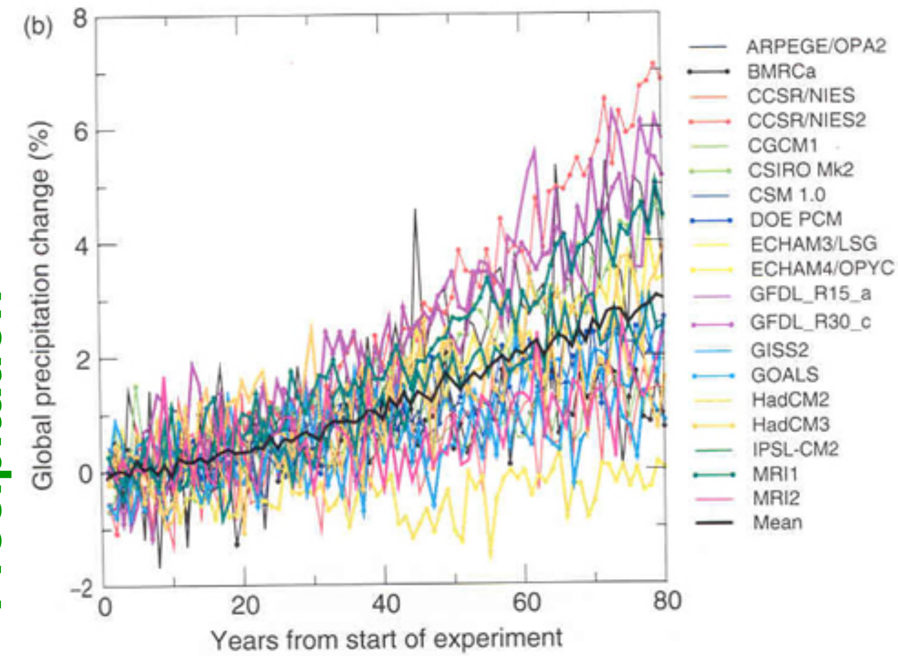
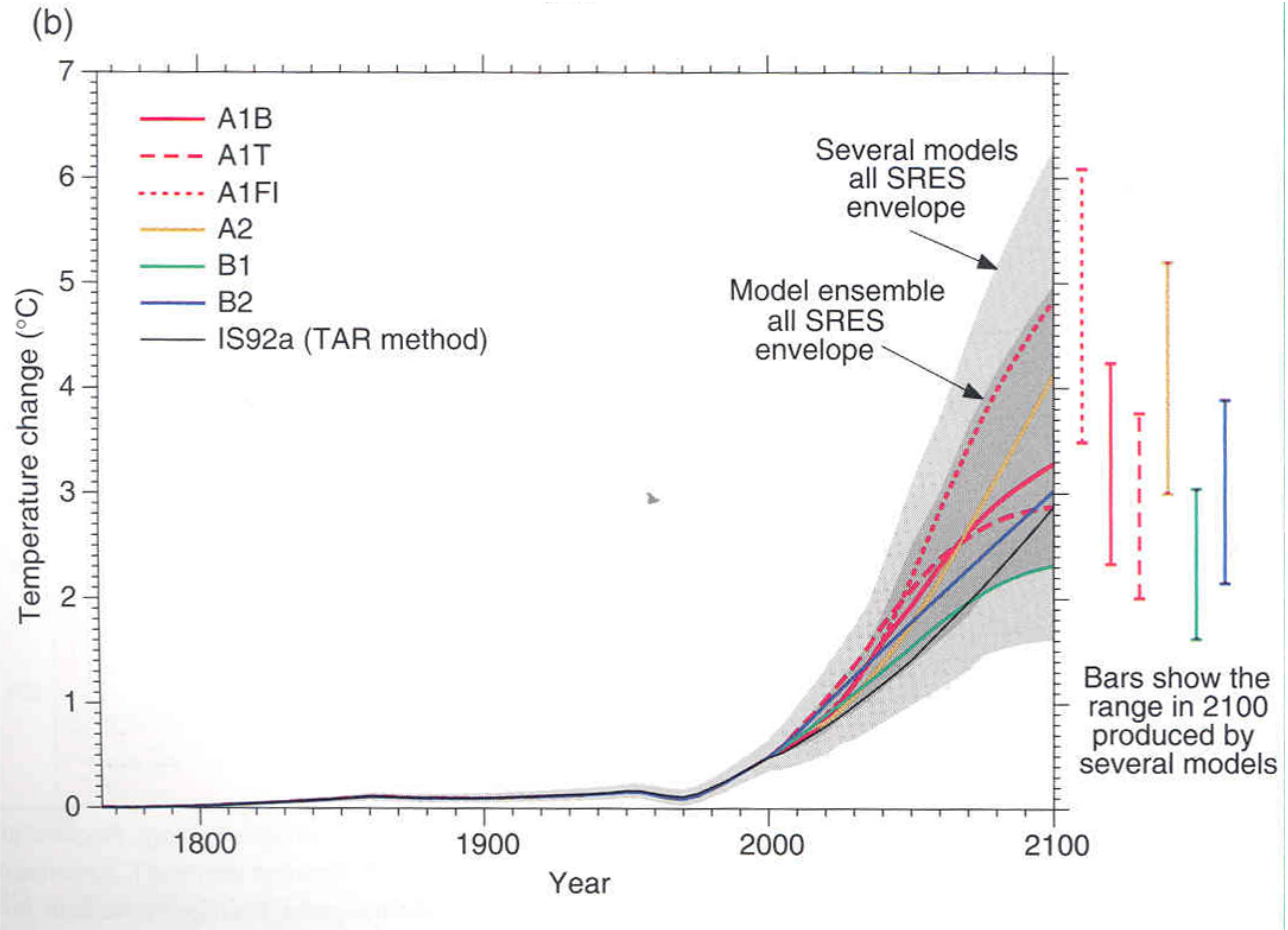


Figure 9.3: The time evolution of the globally averaged (a) temperature change relative to the control run of the CMIP2 simulations (Unit: °C). (b) ditto. for precipitation. (Unit: %). See Table 9.1 for more information on the individual models used here.

Overall Predictions for Future Temperature Change



Climate Change Impacts on Humans & the Environment

A. Terrestrial ecosystems
- Agriculture
- Forests
- Desert and desertification
- Hydrology and water resources

B. Ocean systems
1. Sea level
2. Coastal zones and marine ecosystems

C. Human "systems"
1. Settlements, energy and industry
2. Economic, insurance, and other financial services
3. Human health
   a. Vector borne diseases
   b. Water-borne and food-borne diseases
   c. Food supply
   d. Air pollution
   e. Ozone and ultraviolet radiation

Climate Change Impacts on Humans & the Environment

D. Atmospheric systems
   1. Weather
   2. Storms
   3. Floods and droughts
   4. Extremes

Table 13-5: Selected crop studies for South and Southeast Asia.

Study	Scenario	Geographic Scope	Crop(s)	Yield Impact (%)	Other Comments
Rosenzweig and Iglesias (eds.), 1994[1]	GCMs	Pakistan	Wheat	-61 to +67	UKMO, GFDL, GISS, and +2°C, +4°C, and ±20% precip; range is over sites and GCM scenarios with direct CO_2 effect; scenarios w/o CO_2 and w/ adaptation also were considered; CO_2 effect important in offsetting losses of climate-only effects; adaptation unable to mitigate all losses
		India	Wheat	* -50 to +30 *	
		Bangladesh	Rice	-6 to +8	
		Thailand	Rice	-17 to +6	
		Philippines	Rice	-21 to +12	
Qureshi and Hobbie, 1994	average of 5 GCMs	Bangladesh	Rice	+10	GCMs included UKMO, GFDLQ, CSIRO9, CCC, and BMRC; GCM results scaled to represent 2010; includes CO_2 effect
		India	Wheat	decrease	
		Indonesia	Rice	-3	
			Soybean	-20	
			Maize	-40	
		Pakistan	Wheat	-60 to -10	
		Philippines	Rice	decrease	
		Sri Lanka	Rice	-6	
			Soybean	-3 to +1	
			Coarse Grain	decrease	
			Coconut	decrease	
Parry *et al.*, 1992	GISS	Indonesia	Rice	approx. -4	Low estimates consider adaptation; also estimated overall loss of farmer income ranging from $10 to $130 annually
			Soybean	-10 to increase	
			Maize	-65 to -25	
		Malaysia	Rice	-22 to -12	
			Maize	-20 to -10	Maize yield affected by reduced radiation (increased clouds); variation in yield increases; range is across seasons
			Oil Palm	increase	
			Rubber	-15	
		Thailand sites	Rice	-5 to +8	
Matthews *et al.*, 1994a, 1994b	3 GCMs	India	Rice	-3 to +28	Range across GISS, GFDL, and UKMO GCM scenarios and crop models; included direct CO_2 effect; varietal adaptation was shown to be capable of ameliorating the detrimental effects of a temperature increase in currently high-temperature environments
		Bangladesh		-9 to +14	
		Indonesia		+6 to +23	
		Malaysia		+2 to +27	
		Myanmar		-14 to +22	
		Philippines		-14 to +14	
		Thailand		-12 to +9	

Table 18-3: Major tropical vector-borne diseases and the likelihood of change of their distribution with climate change.

Disease	Vector	Population at Risk (million)[a]	Number of People Currently Infected or New Cases per Year	Present Distribution	* Likelihood of Altered Distribution with Climate Change *
Malaria	Mosquito	2,400[b]	300–500 million	Tropics/Subtropics	+++
Schistosomiasis	Water Snail	600	200 million	Tropics/Subtropics	++
Lymphatic Filariasis	Mosquito	1,094[c]	117 million	Tropics/Subtropics	+
African Trypanosomiasis (Sleeping Sickness)	Tsetse Fly	55[d]	250,000–300,000 cases per year	Tropical Africa	+
Dracunculiasis (Guinea Worm)	Crustacean (Copepod)	100[e]	100,000 per year	South Asia/ Arabian Peninsula/ Central-West Africa	?
Leishmaniasis	Phlebotomine Sand Fly	350	12 million infected, 500,000 new cases per year[f]	Asia/Southern Europe/Africa/ Americas	+
Onchocerciasis (River Blindness)	Black Fly	123	17.5 million	Africa/Latin America	++
American Trypanosomiasis (Chagas' disease)	Triatomine Bug	100[g]	18 million	Central and South America	+
Dengue	Mosquito	1,800	10–30 million per year	All Tropical Countries	++
Yellow Fever	Mosquito	450	<5,000 cases per year	Tropical South America and Africa	++

+ = likely
++ = very likely
+++ = highly likely
? = unknown

Challenges

A. **Nature of climate system**
   1. Analysis must consider entire climate system and all of humanity
   2. Extensive natural climate variability
   3. Global connections for both climate forcing and climatic response
   4. Uncertainties in outcomes involve uncertainties in many components
   5. A small change in global means can translate to large changes in local means/extremes

B. **Needs for research**
   1. Improve data – longer data, error analysis, more global coverage
   2. Improve theory – radiation-aerosol, cloud drops-aerosol
   3. Improve models – parameterization for small scale components
   4. Separating naturally-induced fluctuations from human effects

Challenges (cont.)

C. Nature of people

1. Implement controls on human impacts on the environment
2. World cooperation
3. Look at ourselves

GLOBAL CLIMATE CHANGE

Uncertainties in Detection & Attribution of Climate Change

(Sept. 2002 paper – *Bull. Amer. Meteorological Society*)
Assessment by 19 experts (11 from the U.S.)

Evidence type:

1. **Century-long trend in global mean surface temperature**
2. **30-year trend in vertical pattern of temperature**
3. **30-year trend in geographical pattern of surface temp.**
4. **30-year trend in diurnal temperature range over land**

Mean assessment of probability of detection:

1. **95%**
2. **99%**
3. **80%**
4. **73%**

Mean expected fraction attributed to greenhouse forcing

1. **72%**
2. **20%**
3. **61%**
4. **45%**

GLOBAL CLIMATE CHANGE

What Can We Do About Climate Change?

1. Why should we care?
2. Modify our own life style
3. Mitigation and adaptation
4. Modify national and global practice
5. Influencing public policy

GLOBAL CLIMATE CHANGE

Estimated Net Energy Use in USA in 1972

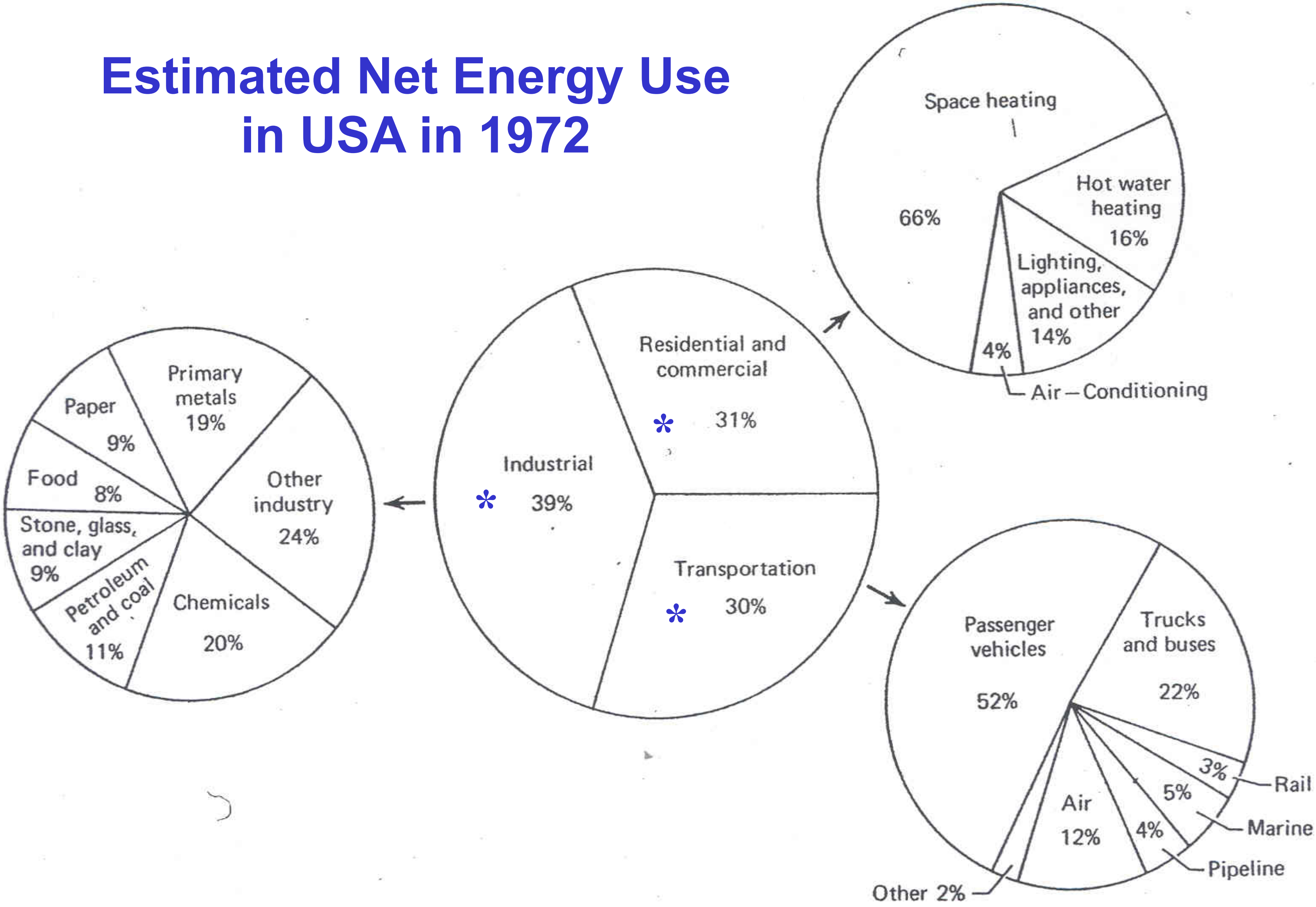


FIGURE 31.1 Estimated net energy use in 1972. (From FEA 1975.)

Transportation Energy Efficiency
USA Study 1974

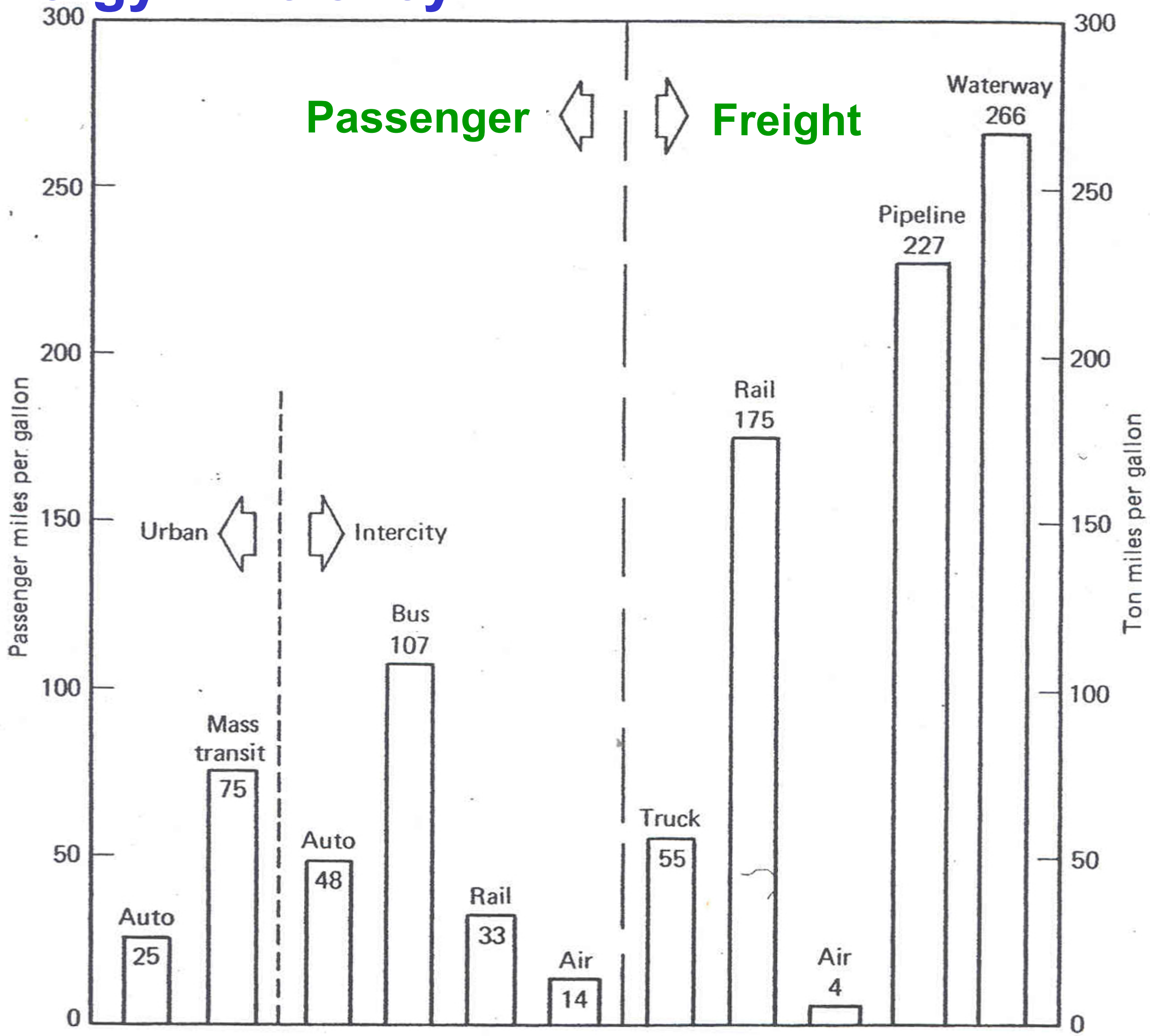


FIGURE 31.3 Transportation energy efficiency. All efficiencies shown are expressed in terms of gasoline equivalent (125,000 Btu/gal = 34,839,536.62 kJ m^{-3}. (Sources: FEA, *Project Independence Final Task Force Report,* 1974; FEA 1975.)

What Can We Do About Global Warming?

There are simple steps each of us can take that will help reduce our emissions of greenhouse gases. Just a few examples:

- **Recycling saves the energy required to manufacture new products.**
- **Give your family car a day off by riding your bike, taking the bus, or walking.**
- **Plant trees – they absorb carbon dioxide.**
- **Read and learn about global warming.**
- **Save electricity by turning off the TV and lights when you're through with them.**

(more on next slide)

GLOBAL CLIMATE CHANGE

What Can We Do About Global Warming?

(cont.)

- Go solar – a solar system to provide hot water can reduce your family's carbon emissions by about 720 pounds a year.

- Encourage others to take these simple actions.

- Preserve forests – they act as carbon dioxide "sinks" – in other words, they absorb carbon dioxide.

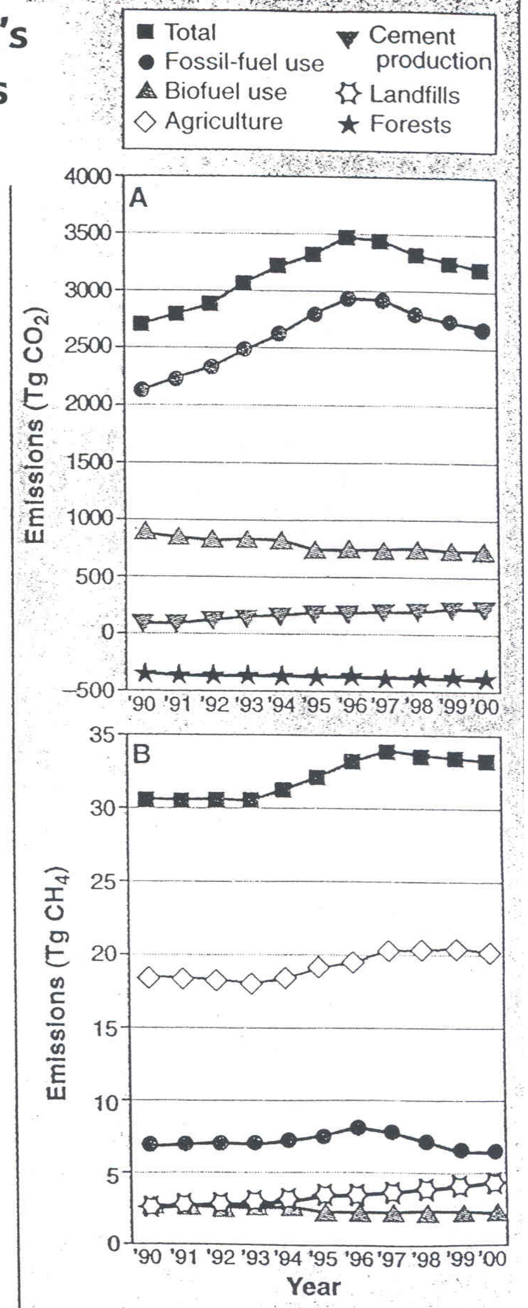
- Develop renewable energy technologies to reduce dependence on fossil fuels.

- Use energy more efficiently. For example, the federal government has a variety of voluntary partnership programs with industry to reduce greenhouse gas emissions by using energy more efficiently.

Recent Reductions in China's Greenhouse Gas Emissions

David G. Streets[1*], Kejun Jiang[2], Xiulian Hu[2], Jonathan E. Sinton[3], Xiao-Quan Zhang[4], Deying Xu[4], Mark Z. Jacobson[5], James E. Hansen[6]

Focusing only on CO_2 emissions from fossil fuel combustion, against which we can compare other countries, we calculate that China's emissions dropped from 2950 Tg (teragrams of CO_2, 1 Tg = 1 million tonnes) in 1996 to 2690 Tg in 2000, a reduction of 8.8%. This decrease, which China achieved while most other countries were increasing their emissions, represents about 1% of the global CO_2 emissions from fossil fuel combustion in 2000 of 25,300 Tg (*1*). In the period 1995 to 1999, CO_2 emissions from fossil fuel combustion in western Europe increased by 4.5%, in the United States by 6.3%, in Japan by 3.0%, and in India by 8.8% (*4*).



Trends in emissions of (A) CO_2 and (B) CH_4 in China, 1990 to 2000.

Global Climate Change

'Fiction, Facts, Uncertainties & Challenges'

David D. Houghton

Atmospheric & Oceanic Sciences

UW – Madison

Email: ddhought@facstaf.wisc.edu