Climate Change

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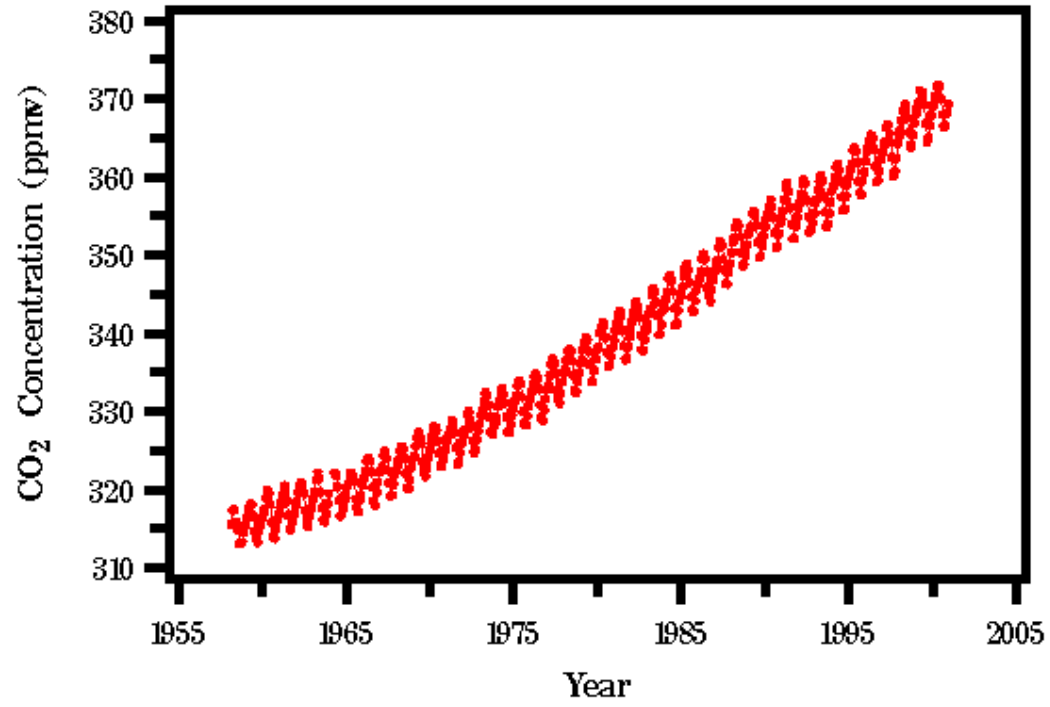
April 25, 2001

280 ppm preindustrial

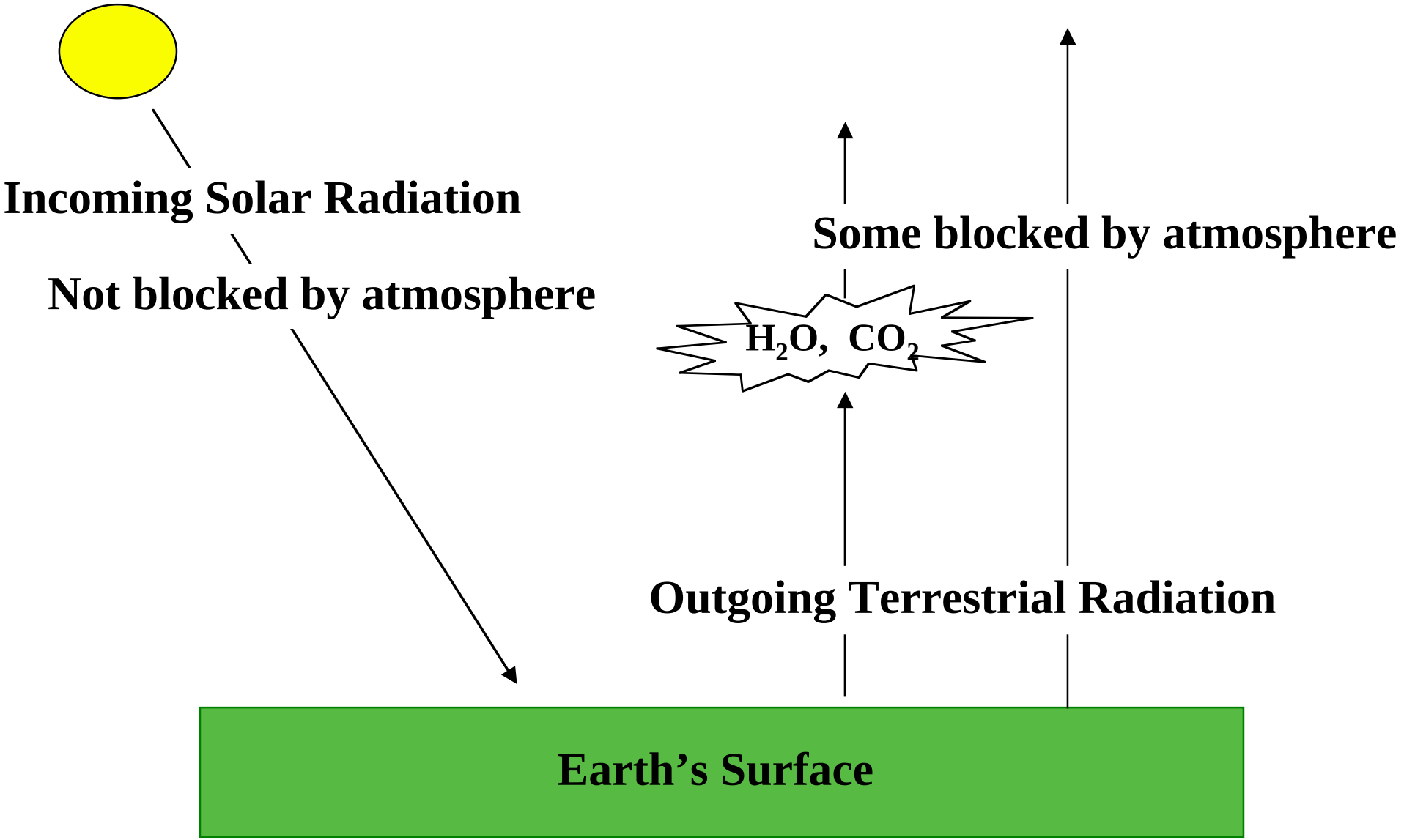
Main Points for Today

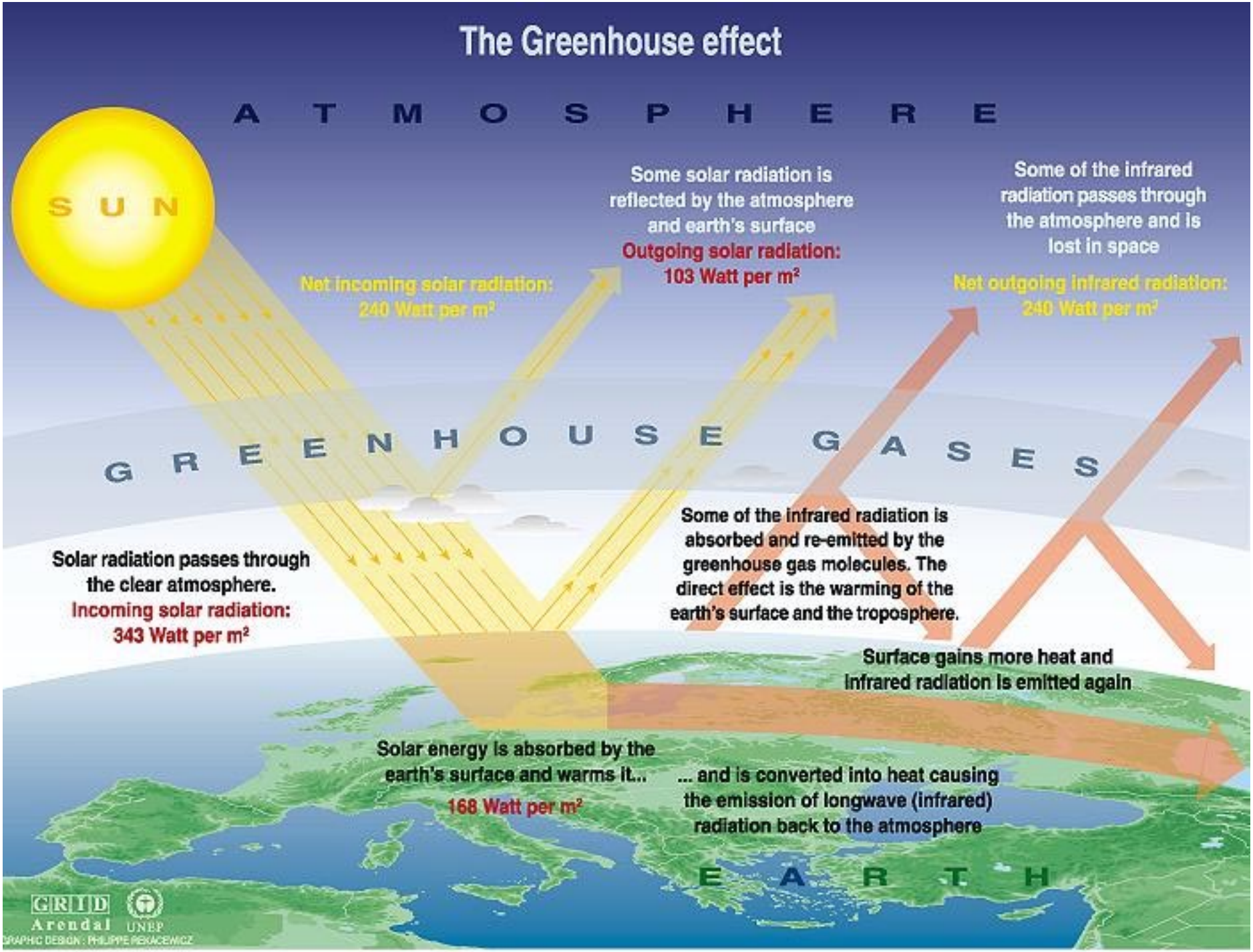
- **Physics of Global Change**
- **Evidence of Change**
- **Consequences of Change**
- **Impact of Changing our Habits**



Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)

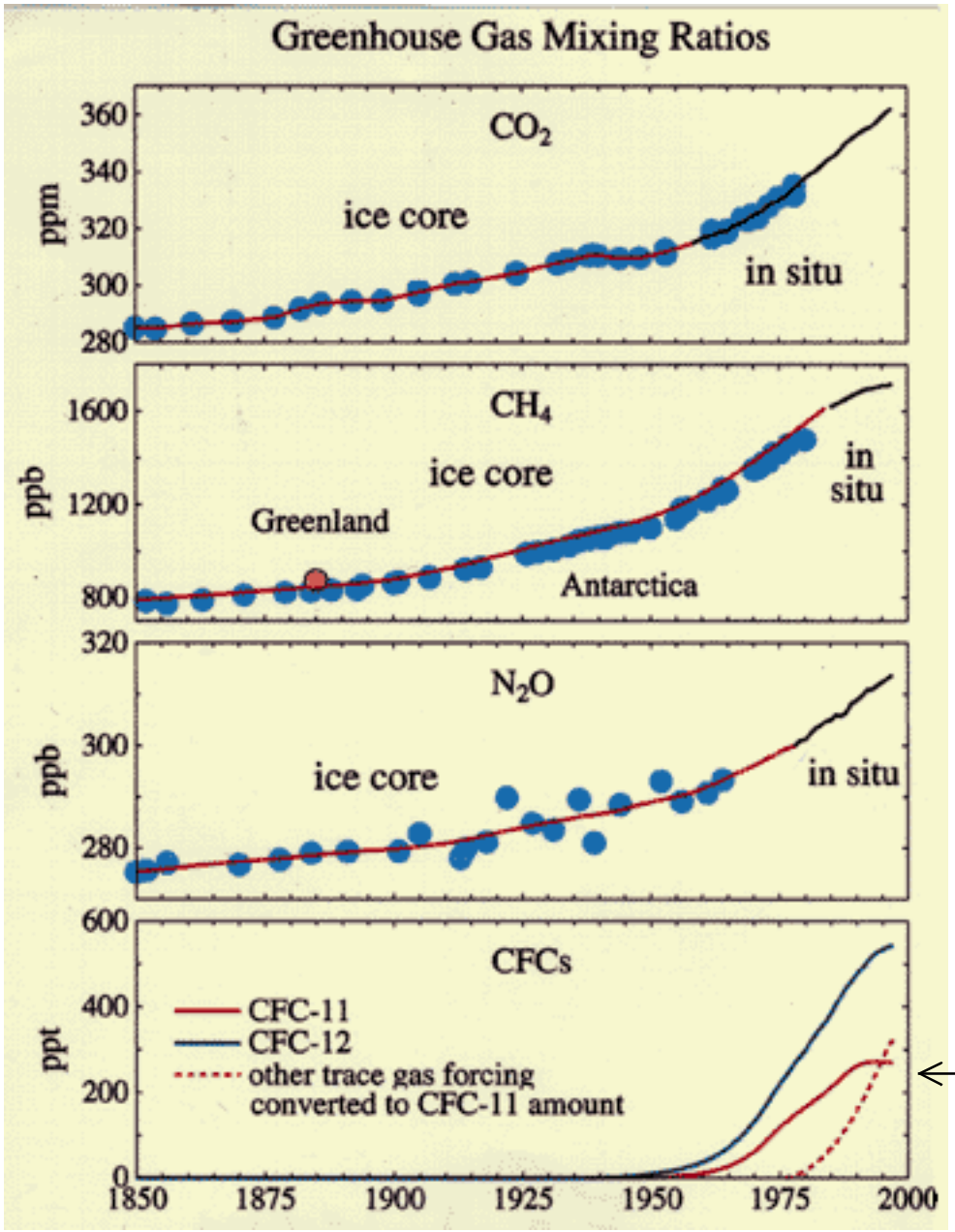
Review of Global Climate





Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change

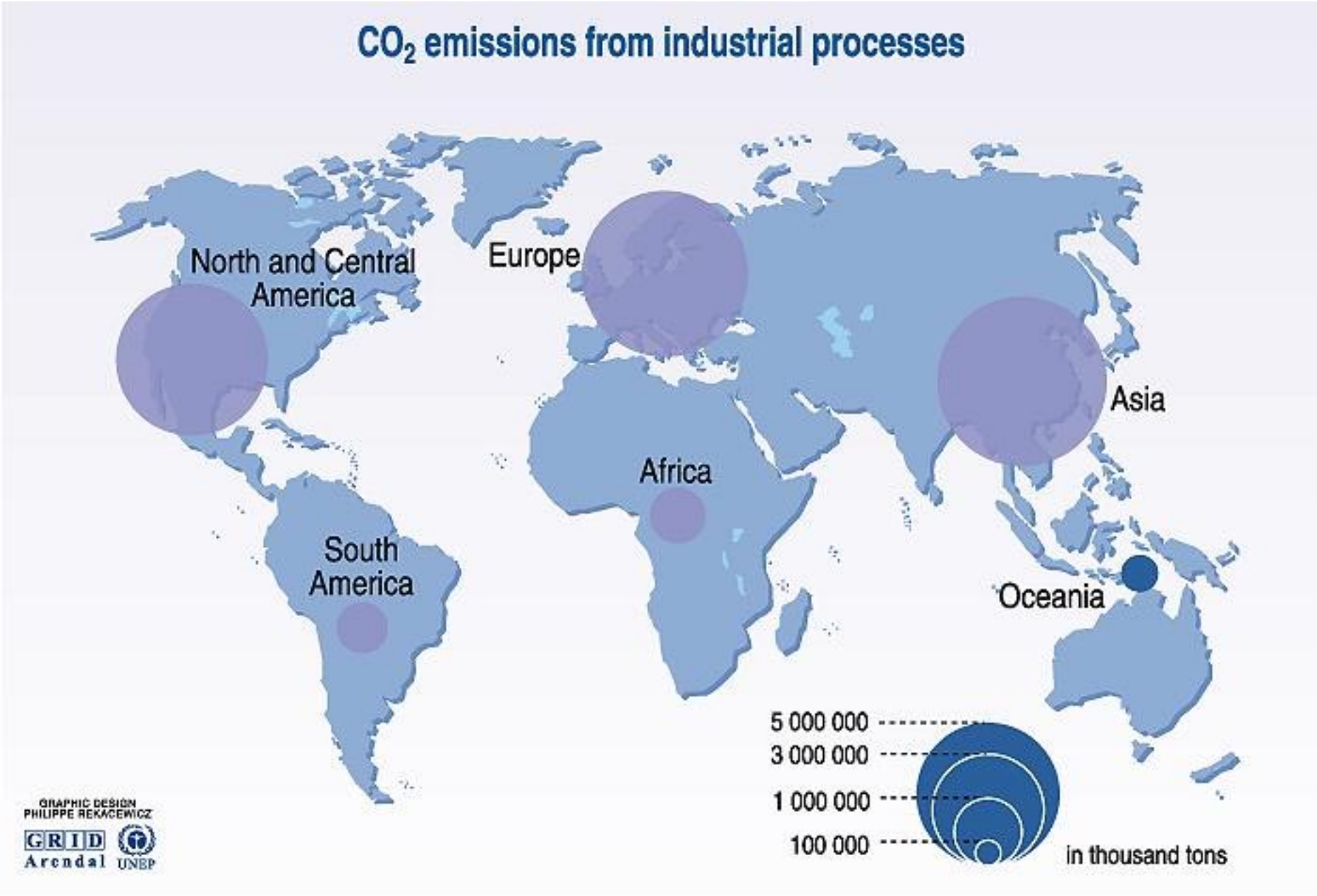
Trends in Greenhouse Gas Amounts in Atmosphere



Measurements
Black- in situ observations
Dots - from ice cores

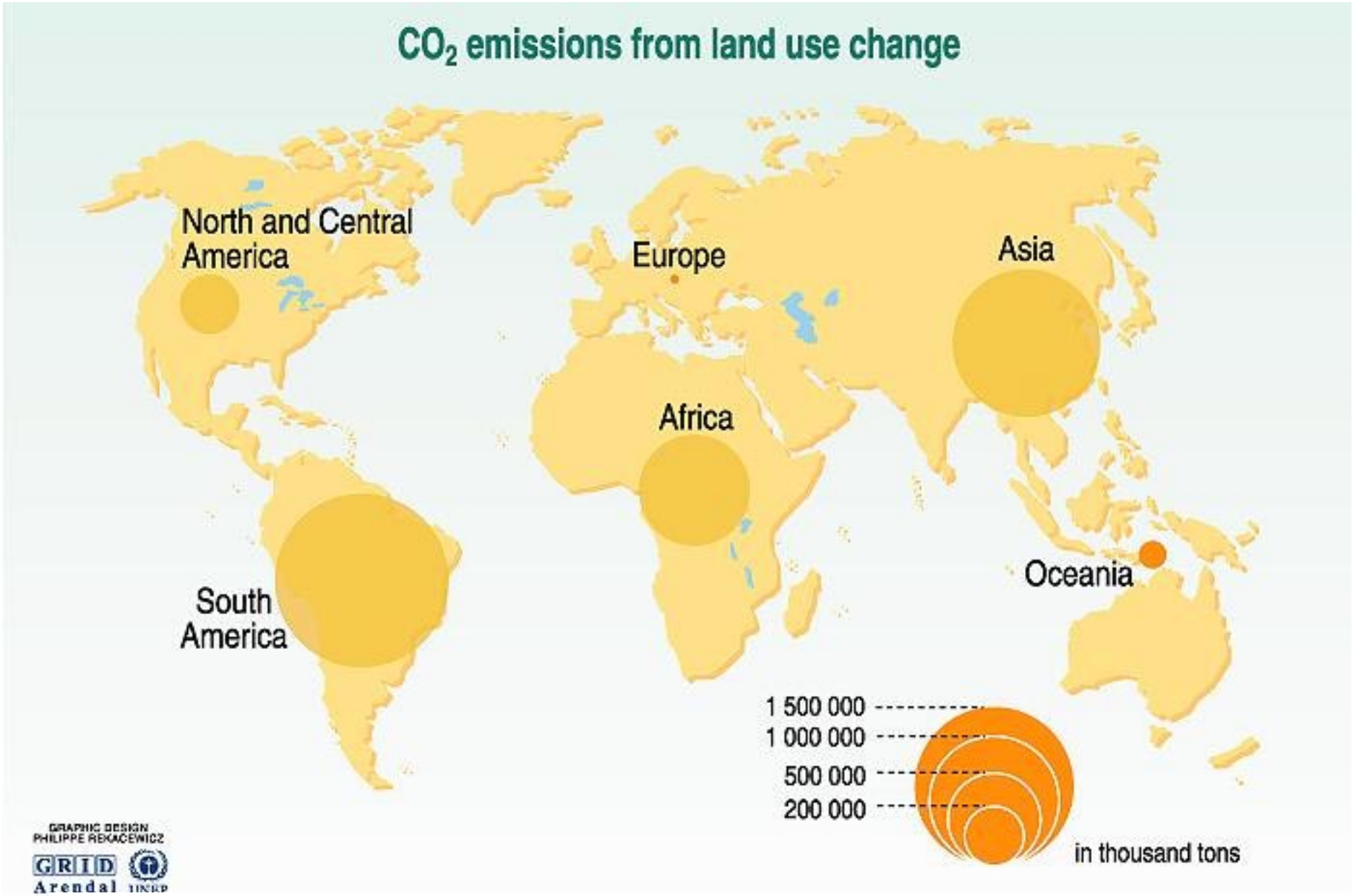
CFCs - in situ since 1977, before that estimated from industrial production and lifetimes

Leveling off ☺



Source: United Nations framework convention on climate change (UNFCCC).

Industrial Nations Produce the most Carbon Dioxide



Source **Due to changes in land use, rainforests cut down, leading to urbanization, roads, and grassland which can hold less carbon.**

Greenhouse Gas Amounts in Atmosphere: Preindustrial & 1994

The main greenhouse gases

Greenhouse gases	Chemical formula	Pre-industrial concentration	Concentration in 1994	Atmospheric lifetime (years)***	Anthropogenic sources	Global warming potential (GWP) *
Carbon-dioxide	CO_2	278 000 ppbv	358 000 ppbv	Variable	Fossil fuel combustion Land use conversion Cement production	1
Methane	CH_4	700 ppbv	1721 ppbv	12,2 +/- 3	Fossil fuels Rice paddies Waste dumps Livestock	21 **
Nitrous oxide	N_2O	275 ppbv	311 ppbv	120	Fertilizer industrial processes combustion	310
CFC-12	CCl_2F_2	0	0,503 ppbv	102	Liquid coolants. Foams	6200-7100 ****
HCFC-22	$CHClF_2$	0	0,105 ppbv	12,1	Liquid coolants	1300-1400 ****
Perfluoromethane	CF_4	0	0,070 ppbv	50 000	Production of aluminium	6 500
Sulphur hexa-fluoride	SF_6	0	0,032 ppbv	3 200	Dielectric fluid	23 900

Note : pptv= 1 part per trillion by volume; ppbv= 1 part per billion by volume, ppm v= 1 part per million by volume

* GWP for 100 year time horizon. ** Includes indirect effects of tropospherico zone production and stratospheric water vapour production. *** On page 15 of the IPCC SAR. No single lifetime for CO_2 can be defined because of the different rates of uptake by different sink processes.**** Net global warming potential (i.e., including the indirect effect due to ozone depletion).

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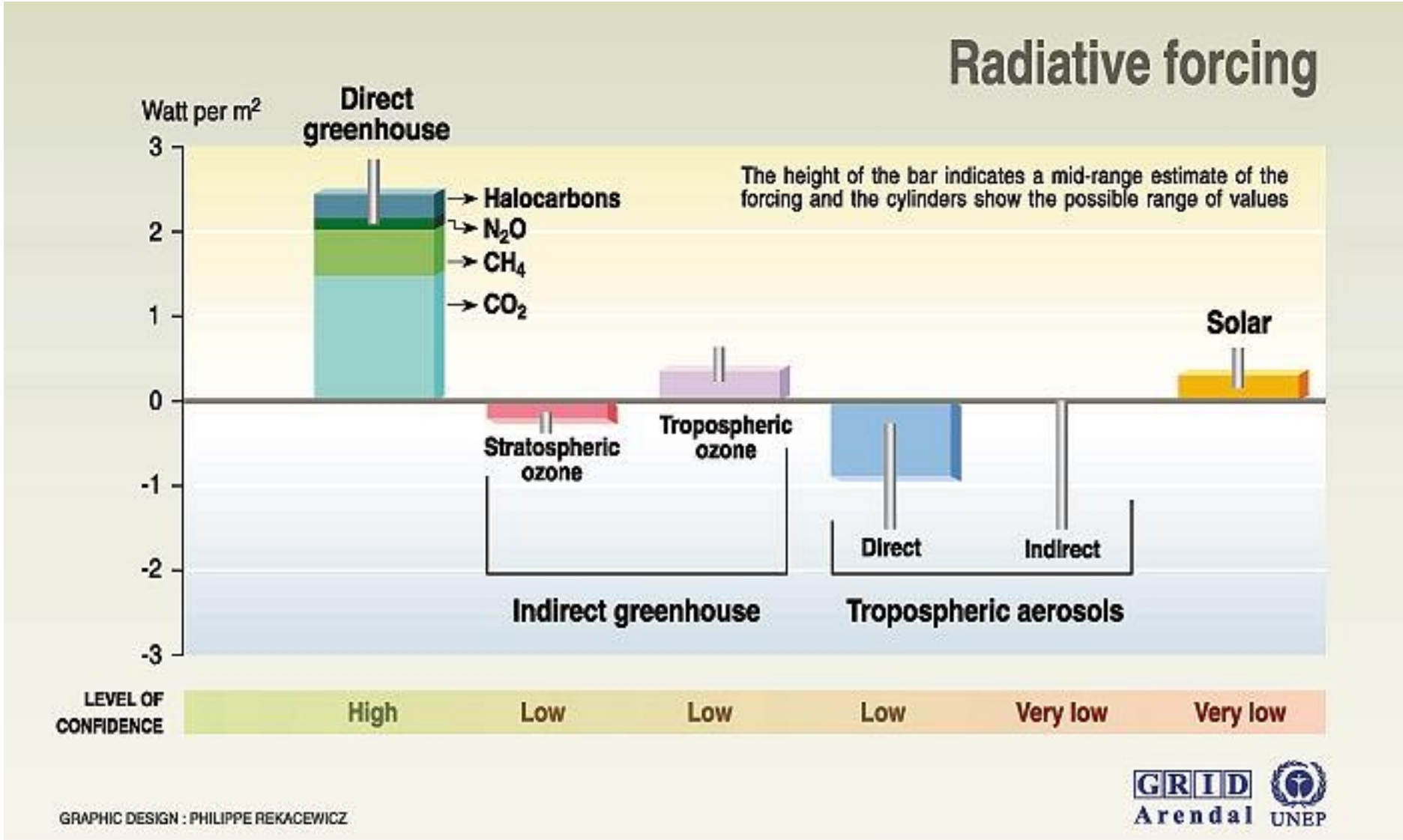
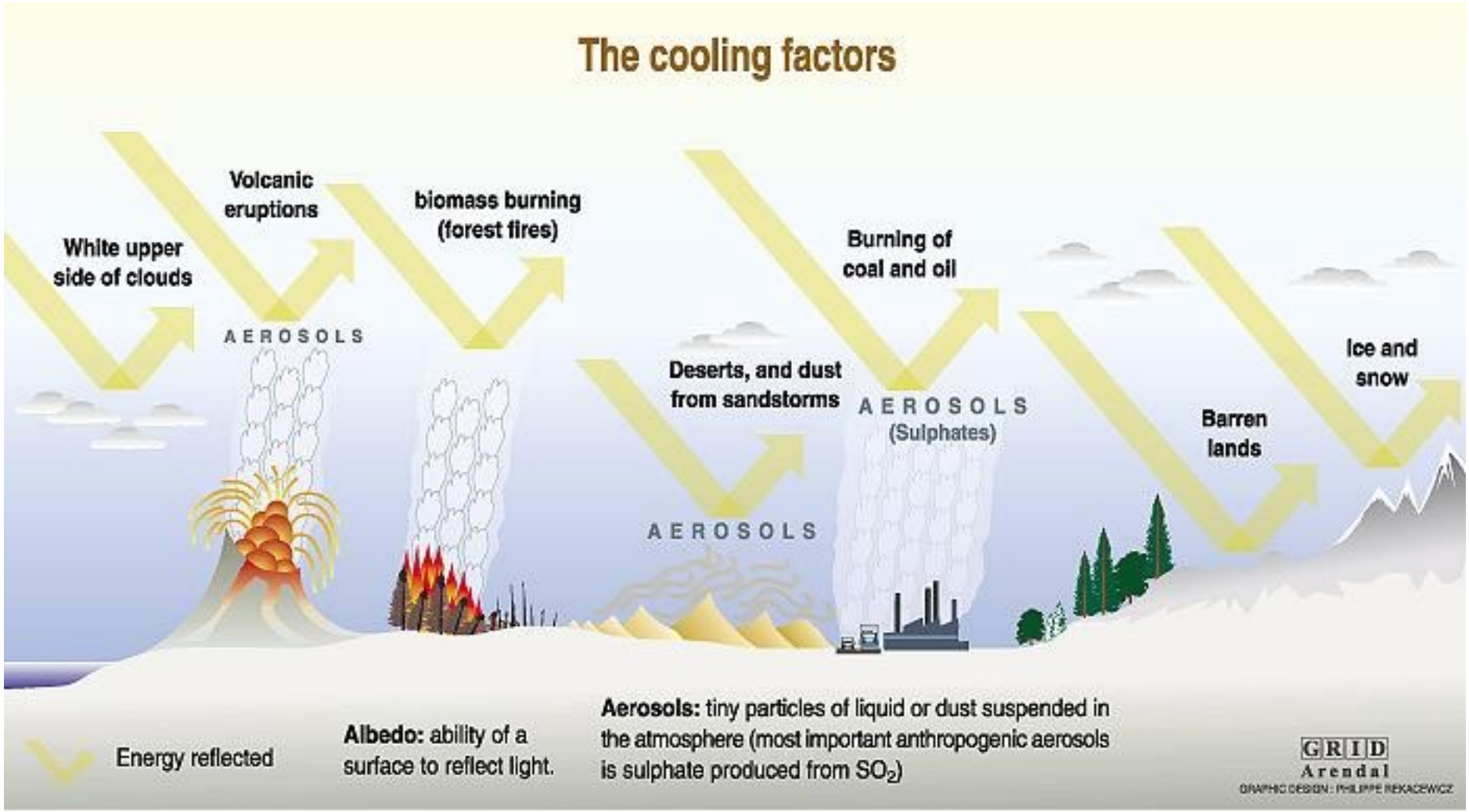
Source: IPCC radiative forcing report ; Climate change 1995, The science of climate change, contribution of working groupe 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.



Source: 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.

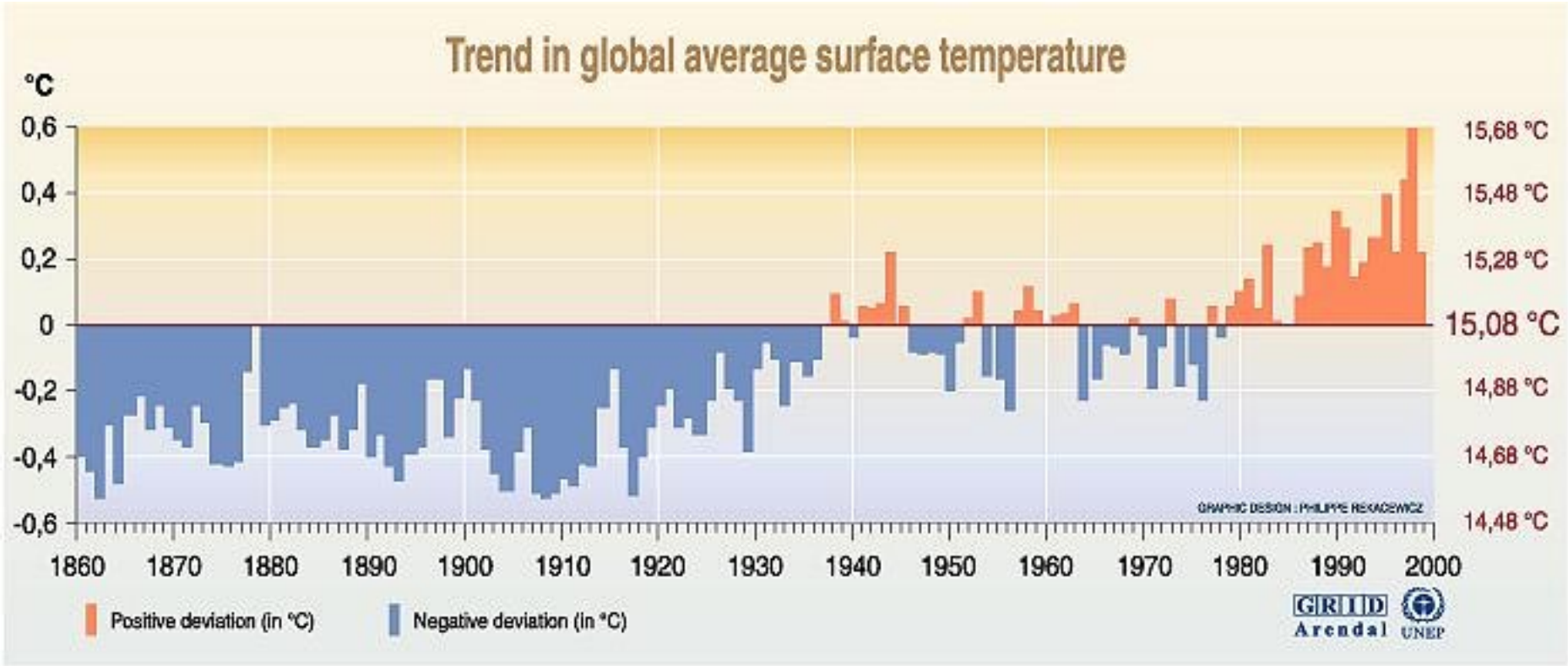
Indirect - change in cloud properties due to aerosols (cloud nucleation)

Aerosols Cool the Atmosphere



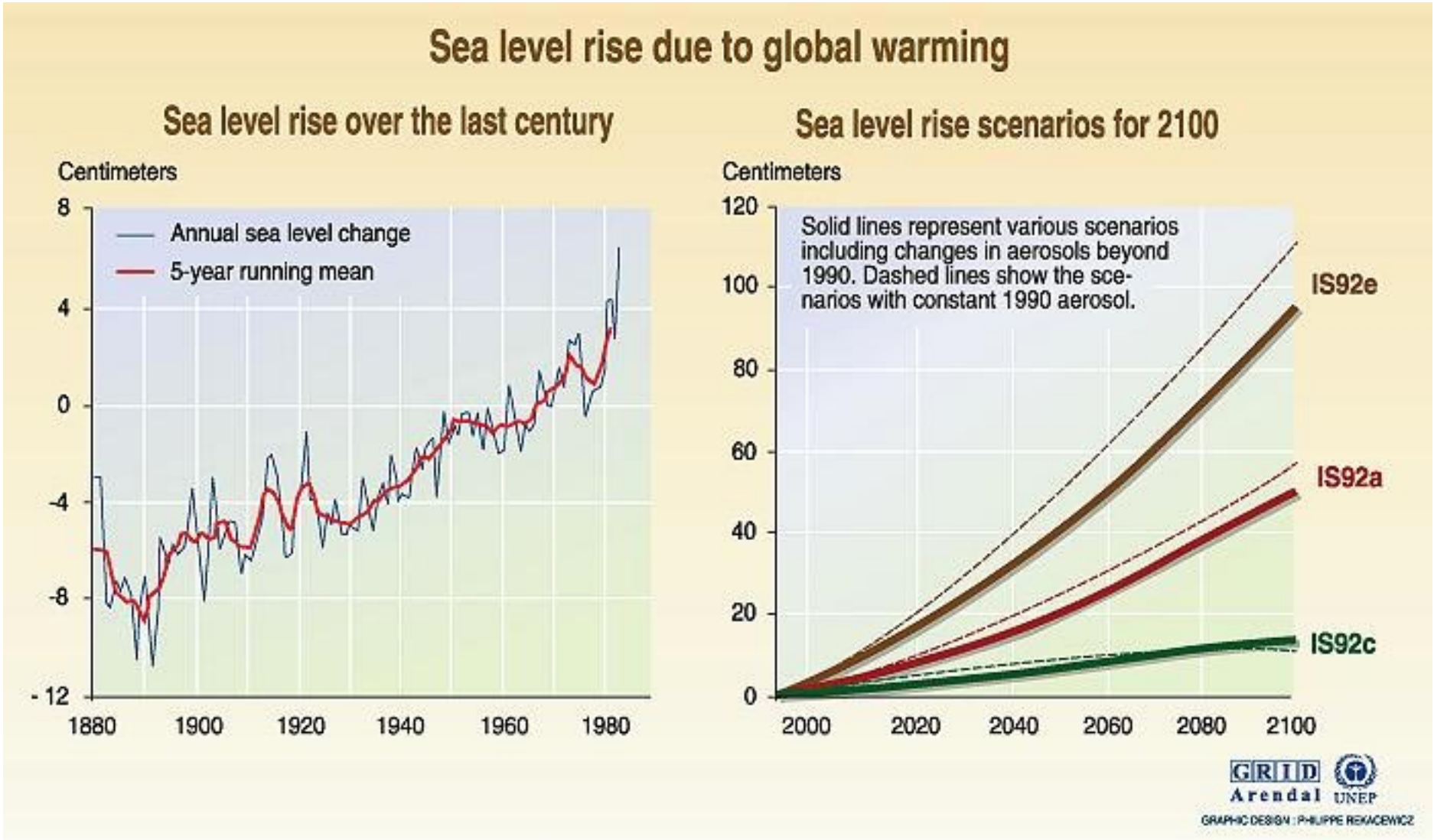
Sources: Radiative forcing of climate change, the 1994 report of the scientific assessment working group of IPCC, summary for policymakers, WMO, UNEP; L.D. Danny Harvey, Climate and global environmental change, Prentice Hall, pearson Education, Harlow, United Kingdom, 2000.

Observed Trends in Surface Air Temperature



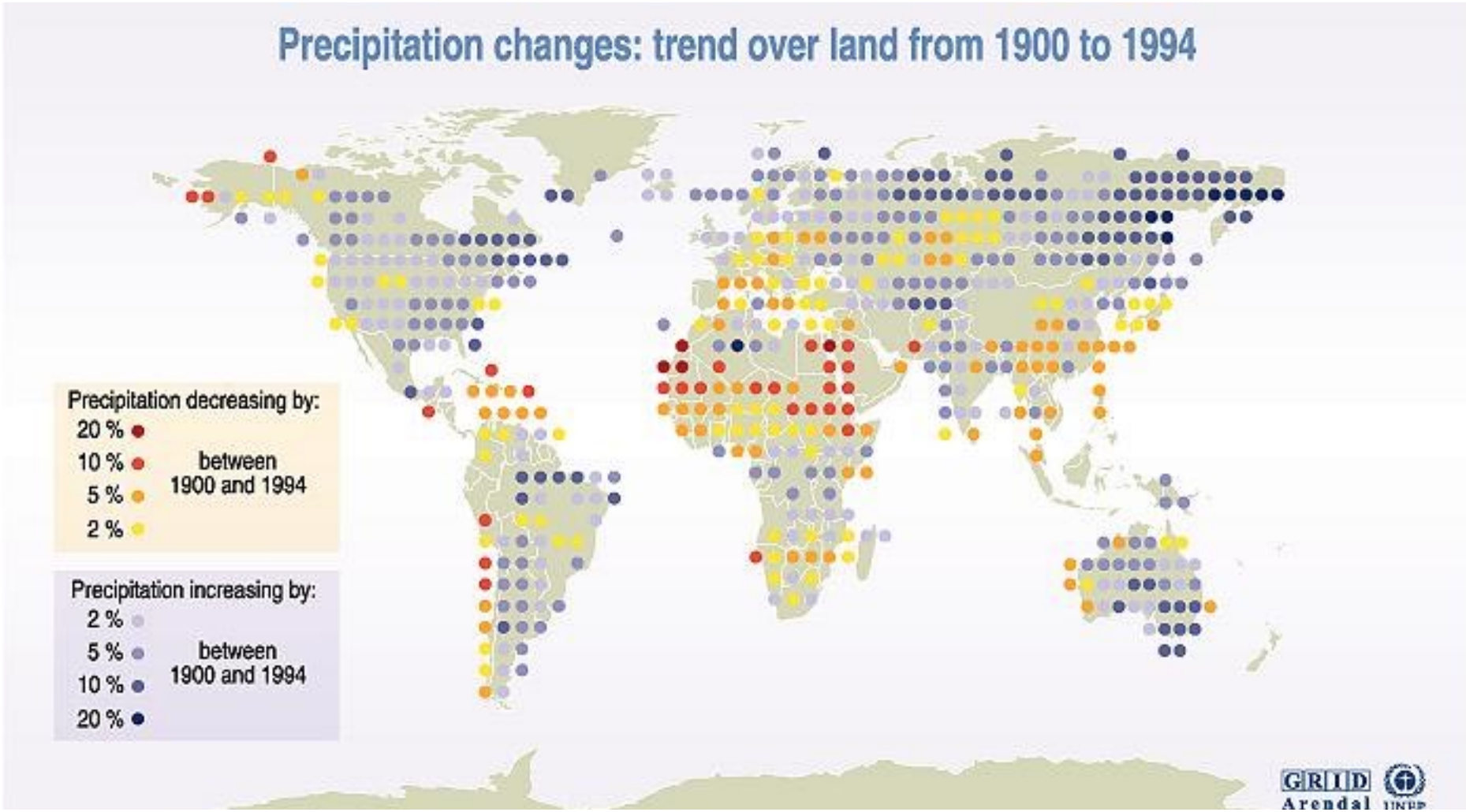
Source: School of environmental sciences, climatic research unit, university of East Anglia, Norwich, United Kingdom, 1999.

- The mean global surface temperature has increased by about 0.3 to 0.6°C since the late 19th century and by about 0.2 to 0.3°C over the last 40 years.
- The recent warming has been greatest between 40°N and 70°N



Source: 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; Sea level rise over the last century, adapted from Gornitz and Lebedeff, 1987.

- Info is derived mainly from tide-gauge data
- Over last 100 years, the global sea level has risen by ~10 - 25 cm
- 2-7 cm due to thermal expansion and 2-5 due to glacier melt



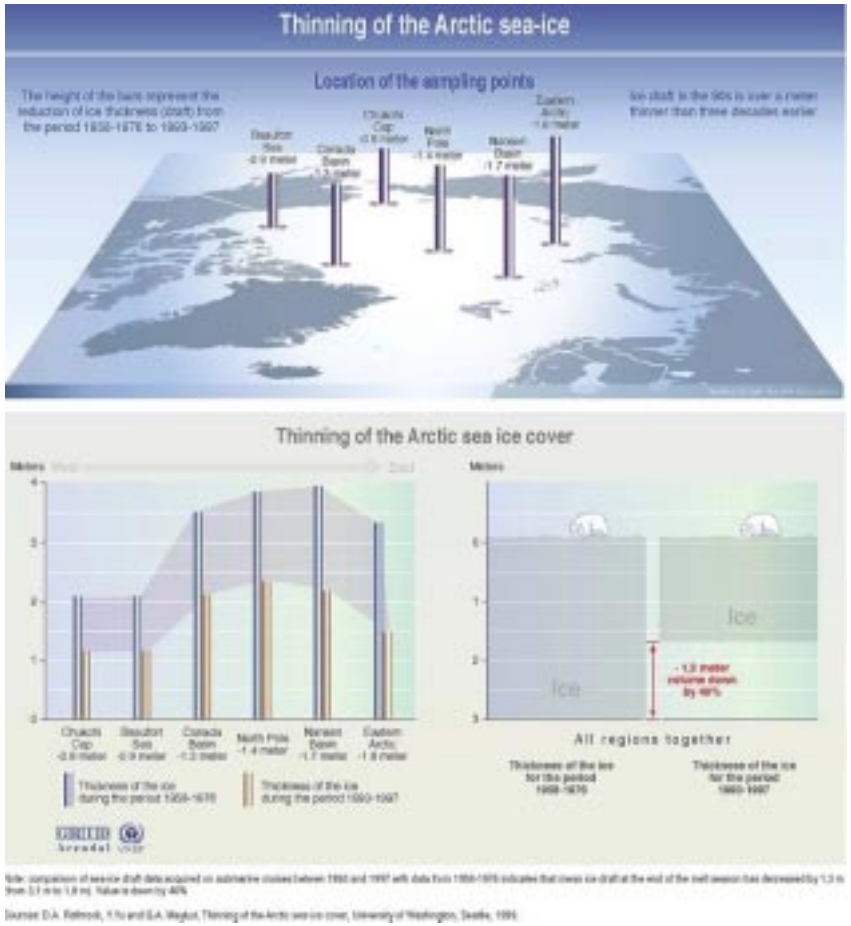
•Precipitation has increased over land at high latitudes of the Northern Hemisphere, especially during the cold season.

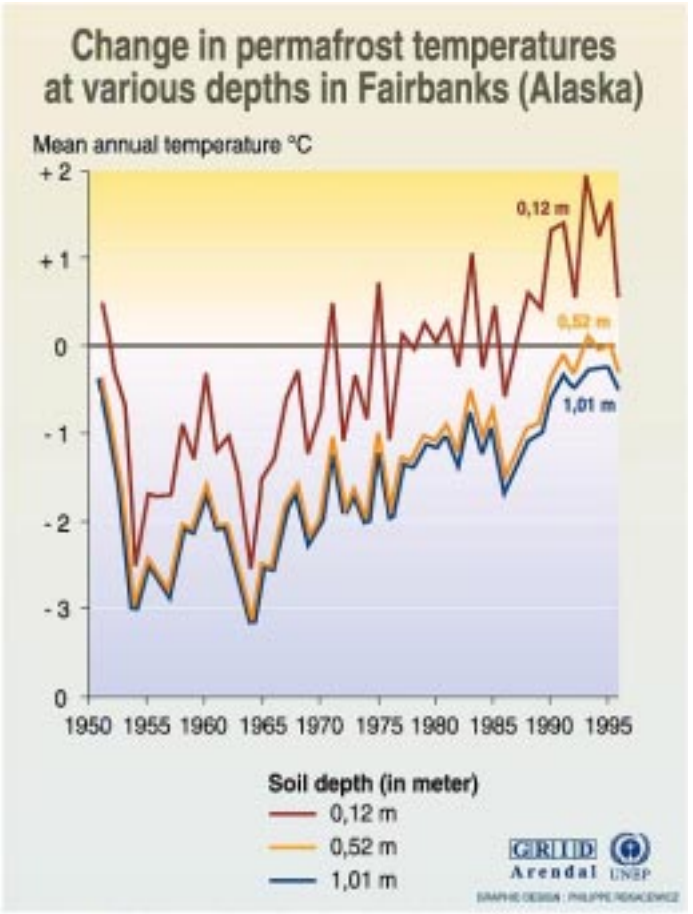
•Precip decreased in steps after the 1960s in subtropics & tropics

•Precip over land increased 1900-1960, but decreased since ~1980

• No good record of precip over the ocean

Trends Arctic Ice Thickness & Fairbanks Permafrost Temperature





Source: Romanovsky, in Impacts of global climate change in the Arctic regions, IASC, Tromsø, April 1999.

☹ Release Methane
Damage Roads and Buildings

Changes in River Ice Breakup in Finland and in Nenana

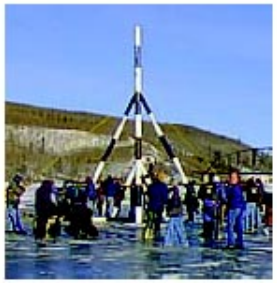


Fig. 1. Townspeople of Nenana, Alaska, raise the tripod on the frozen Tenana River, 4 March 2001. [Photo by J. Coghill (9)]

Science 2001

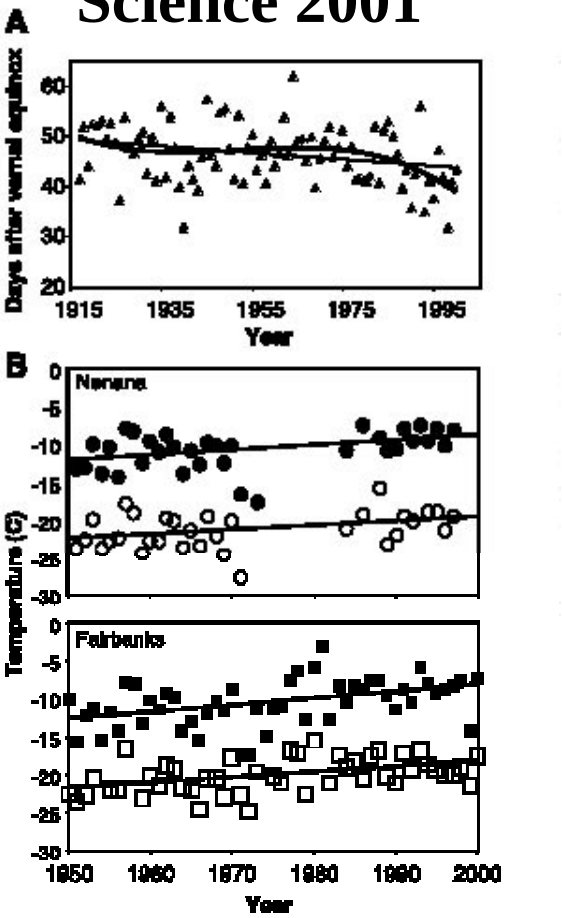
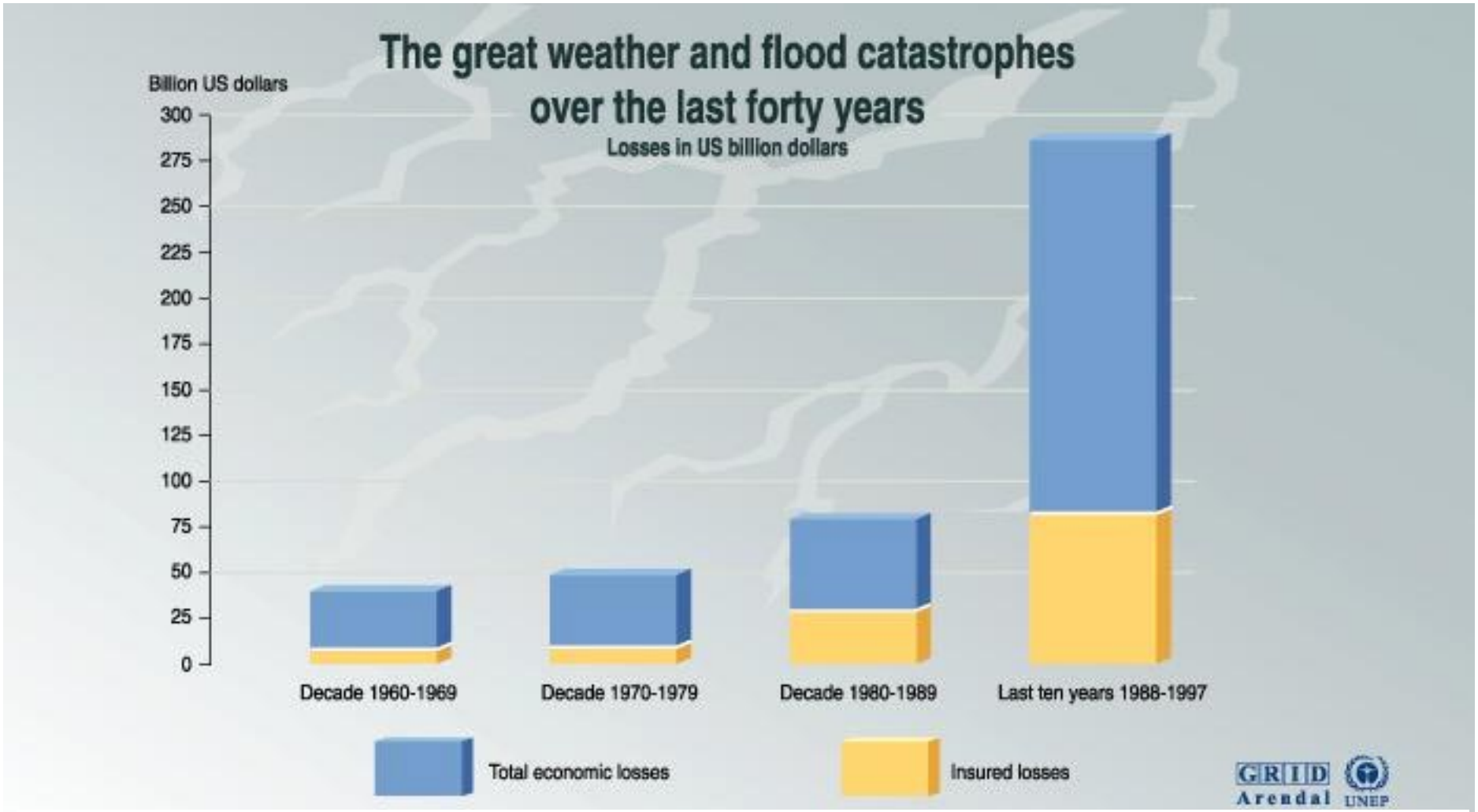


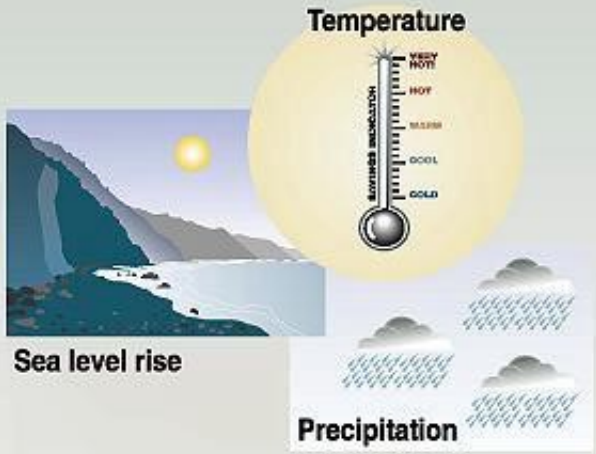
Fig. 2. (**A**) Ice breakup trends on the Tenana River. Breakup occurs between calendar dates 20 April and 20 May. Light line: linear regression (slope = −0.07, t = −2.53, P = 0.01, R^2 = 0.07). Heavy line: third-order polynomial regression (ice break = −1E-04 year^3 + 0.59 year^2 + 1144 year + 744660, F = 4.18, P = 0.008, adjusted R^2 = 0.10). (**B**) Temperature data for Nenana and Fairbanks, Alaska. ● and ■, TMAX; ○ and □, TMIN.

Economic Costs that have increased from weather events

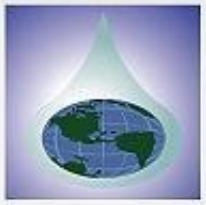


- Caution ==> Increase in cost partially due to more people
- Fewer frosts in several widespread areas
- Increase in the proportion of rainfall from extreme events over Lower 48

Potential climate changes impact



Impacts on...

Health	Agriculture	Forest	Water resources	coastal areas	Species and natural areas
					
Weather-related mortality Infectious diseases Air-quality respiratory illnesses	Crop yields Irrigation demands	Forest composition Geographic range of forest Forest health and productivity	Water supply Water quality Competition for water	Erosion of beaches Inundation of coastal lands additional costs to protect coastal communities	Loss of habitat and species Cryosphere: diminishing glaciers

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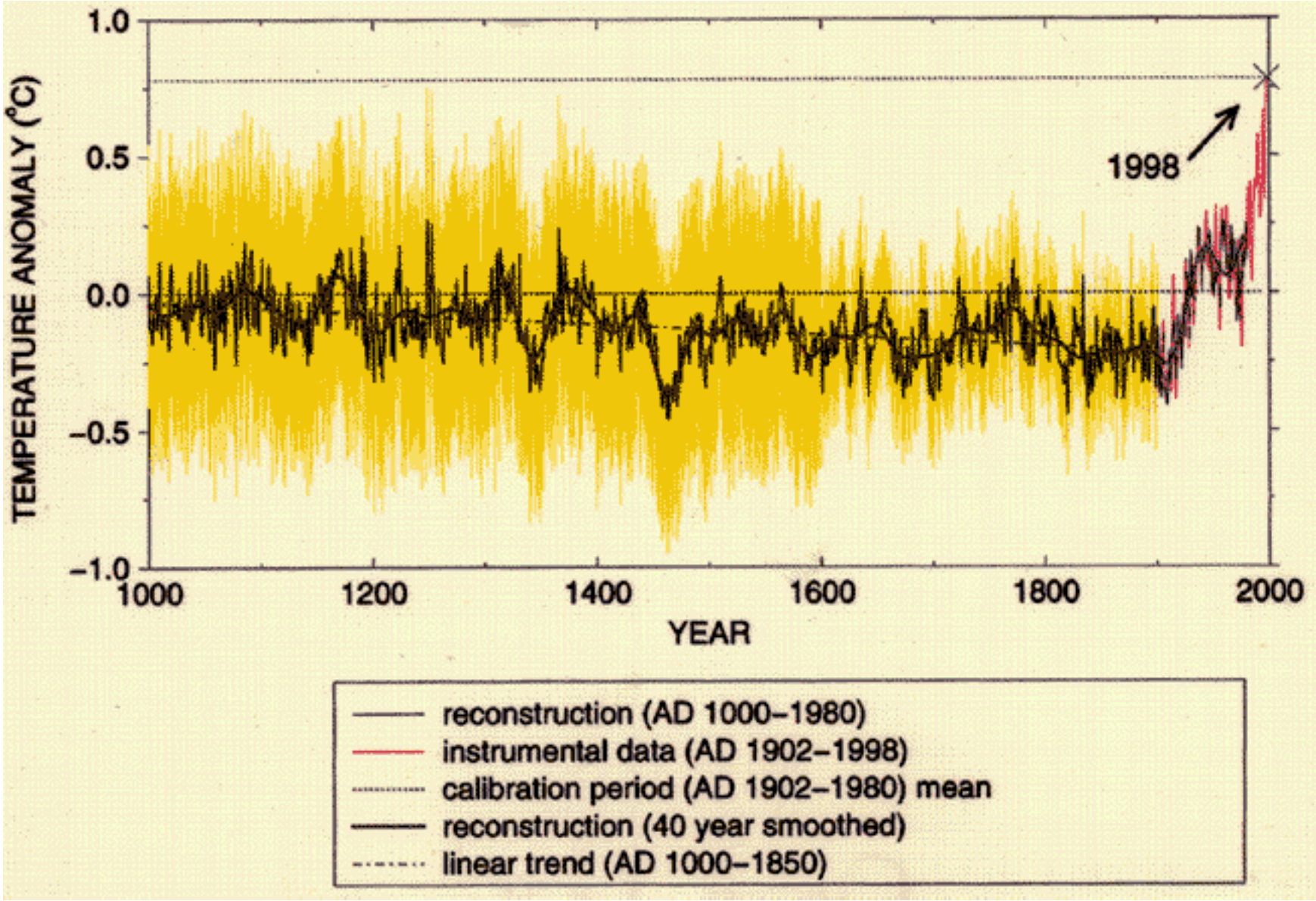
GRAPHIC DESIGN : PHILIPPE REKACEWICZ

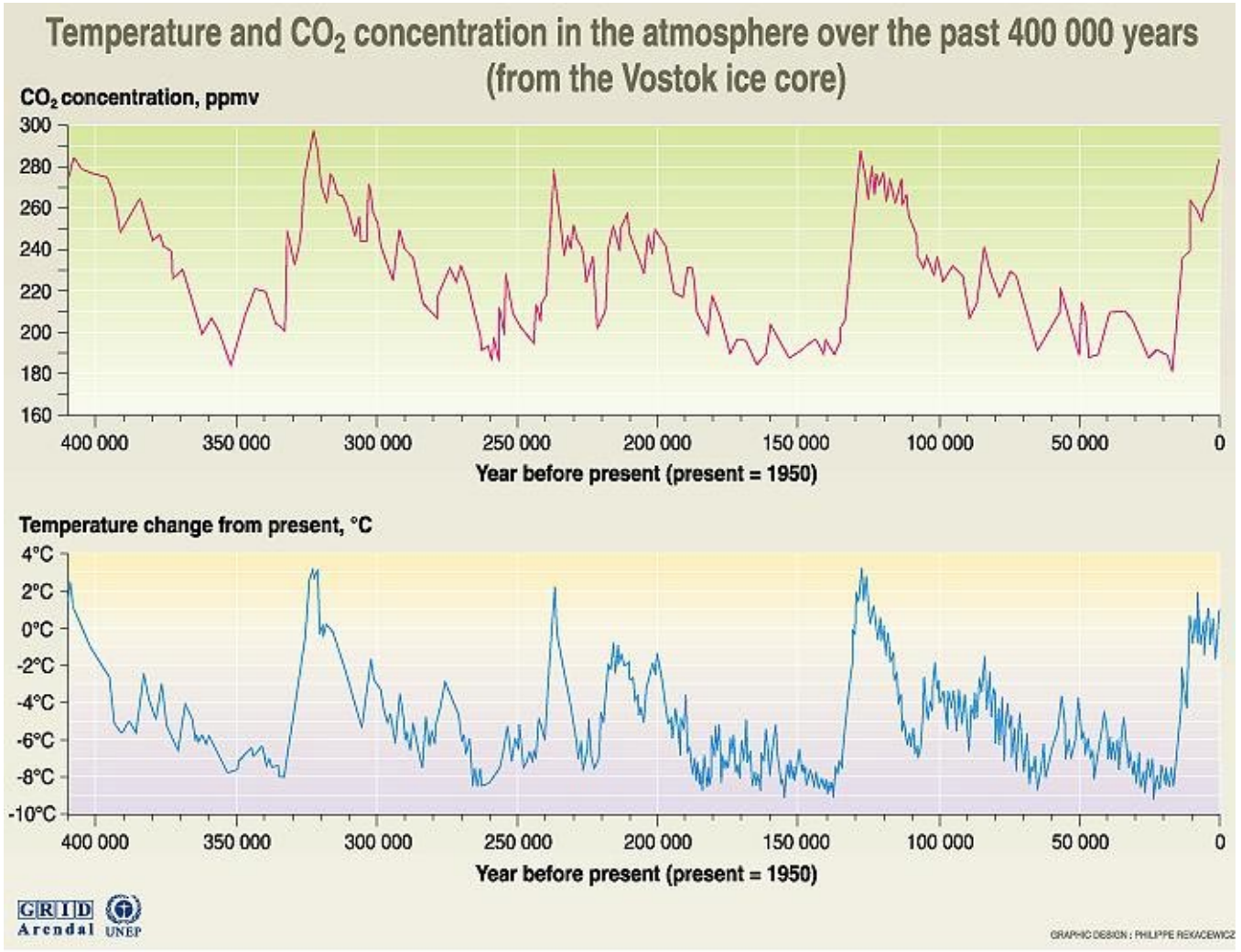
Source: United States environmental protection agency (EPA).

1000 year temperature reconstruction



• dendroclimatic, coral, and ice-core proxy records as calibrated by instrumental measurements

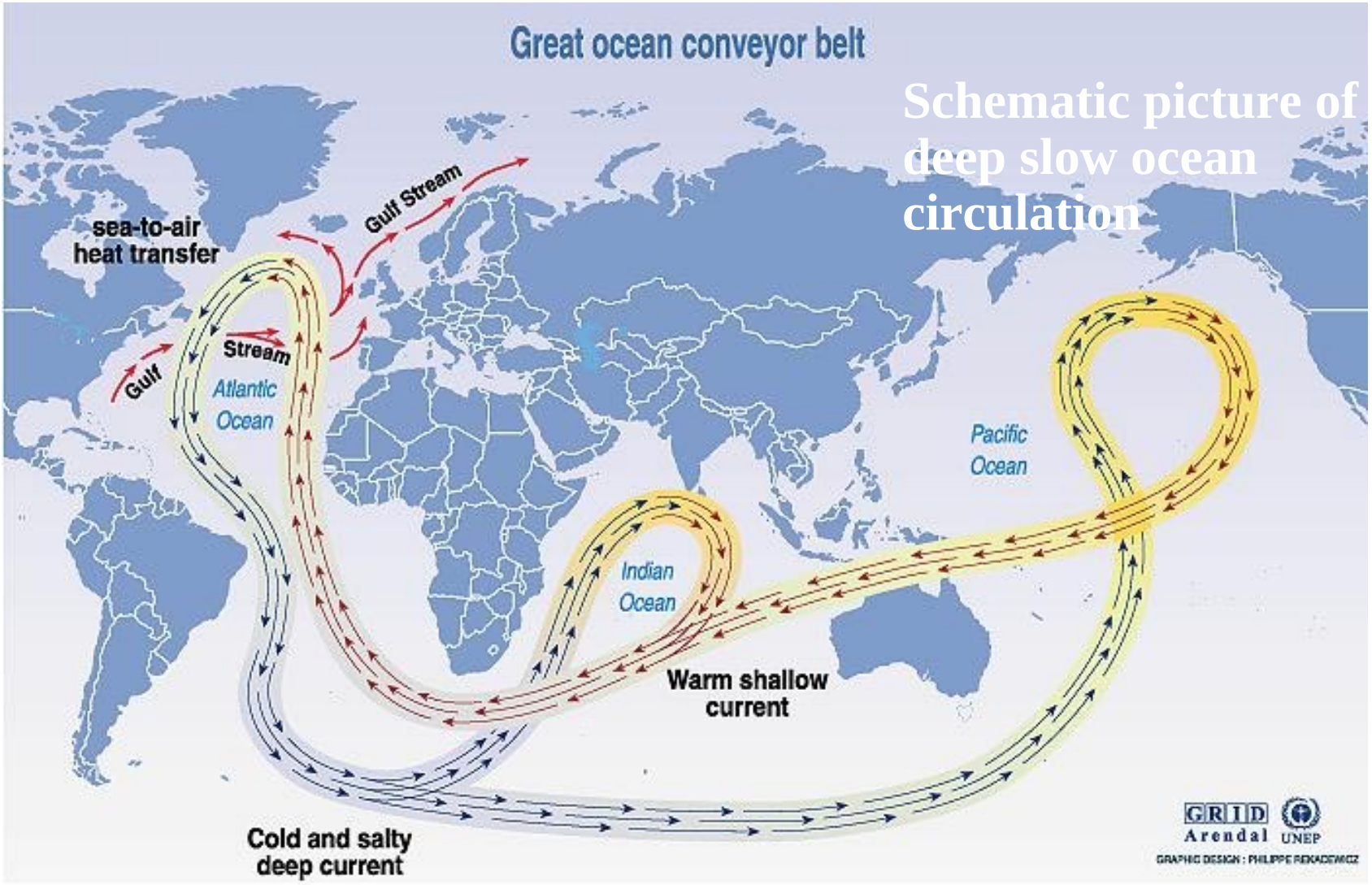
Paleoclimate Record shows increase in CO_2 and Temperature



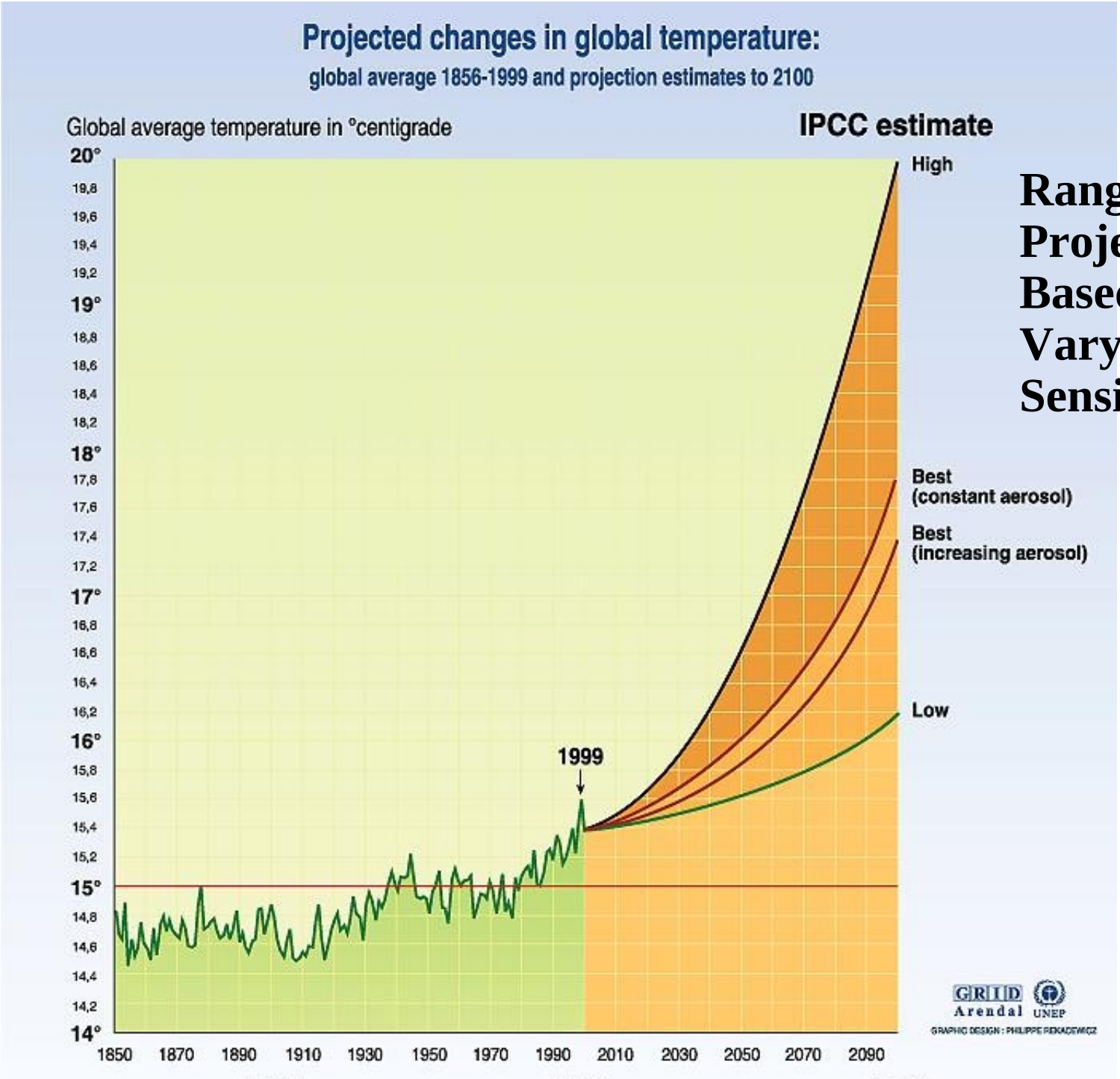
Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3JUne), pp 429-436, 1999.

- **Rapid changes in climate have occurred in the past 400,000 years**

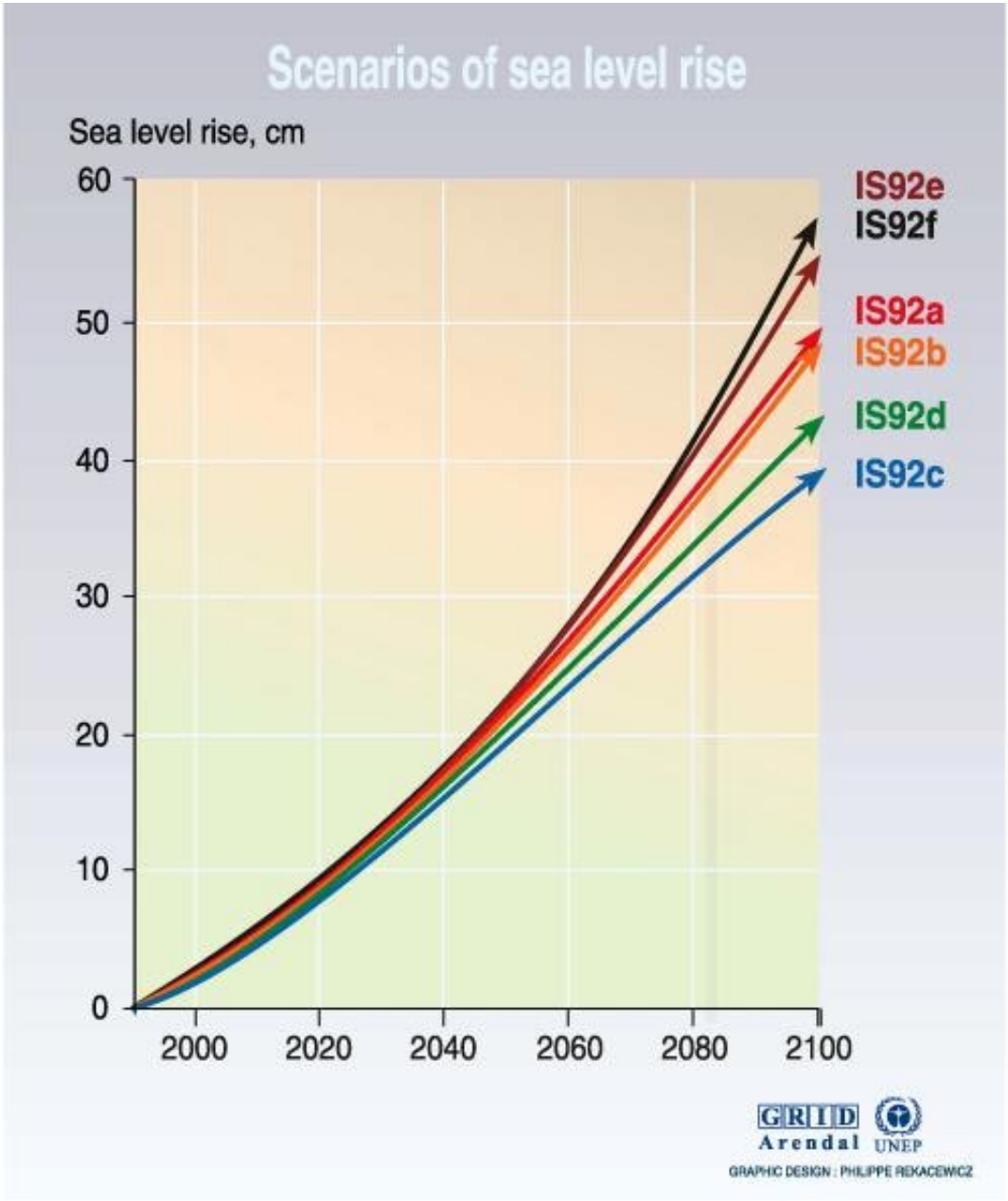
Ocean and Climate Change



- **Increase air temperature, warm ocean**
  - **stop this slow circulation (Halocline Catastrophe) + Feedback**

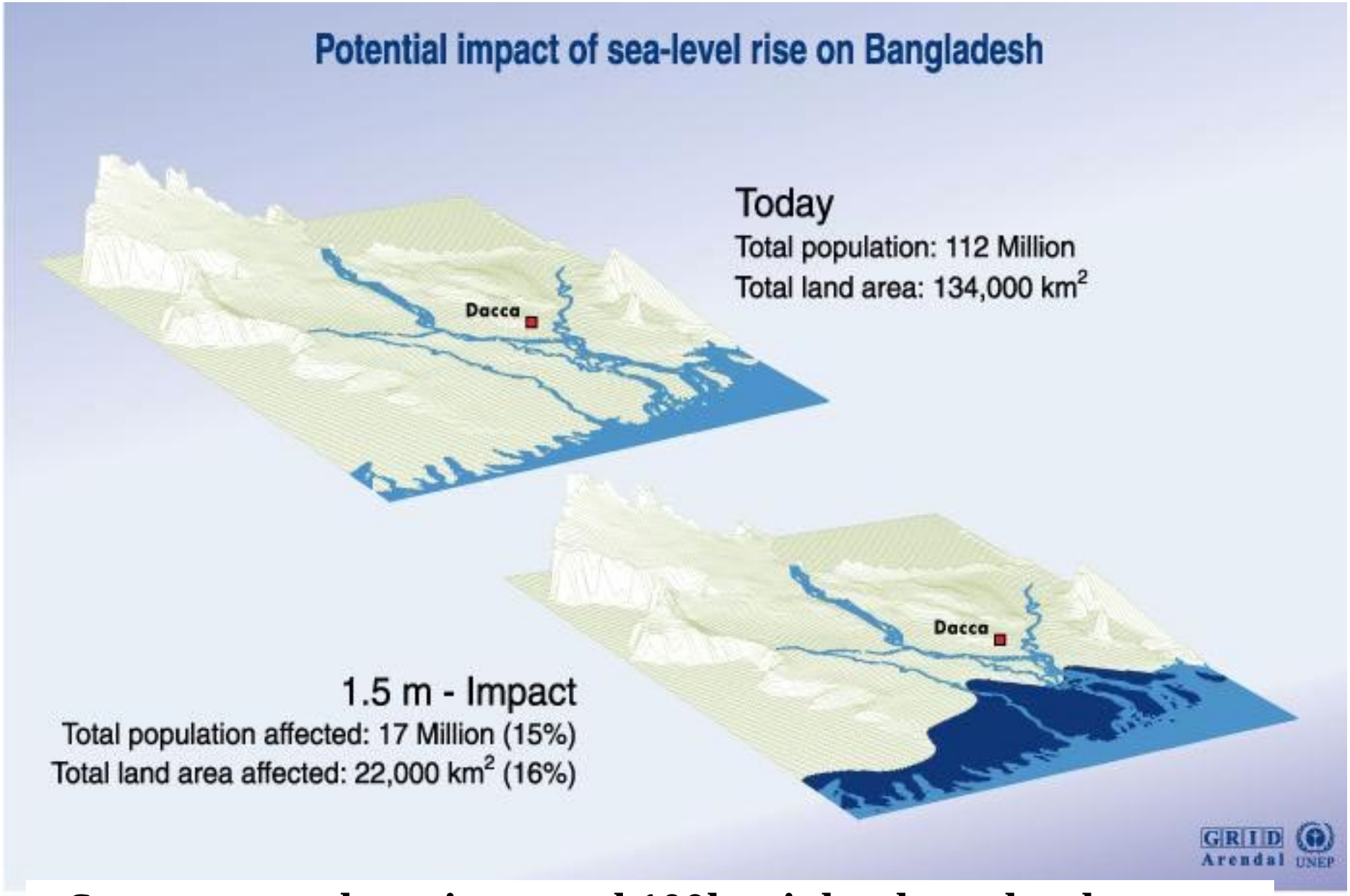


Range of Projections Based on Varying Sensitivities



Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of

increase in global mean sea level of between 13 and 94 cm.



- **Storm surges have impacted 100km inland, sea level country**
- **Already a very poor country, 1.5m increase devastating**

Other evidence that supports climate has warmed

- **Tropical glaciers are melting fast**
  - **E. Africa, New Guinea, Andes**
  - **Kilimanjaro may be ice free by 2015**
  - **73% decrease from 1913-1989**

- **Arctic sea ice has retreated, particularly in summer**

Polar Climate Change Largest and Ice Albedo Feedback

Ice-albedo feedback
(more ice, more reflected Solar, cooler temperatures, more ice…...positive feedback loop)
High latitude thawing of permafrost==>methane!

Impact on Humans

- **Disease transmissions - Malaria**

- **Change in Variability - more extremes**
  - **more hurricanes**
  - **more El Niños**
  - **increased flooding of rivers in the US**

- **Permafrost thaws**

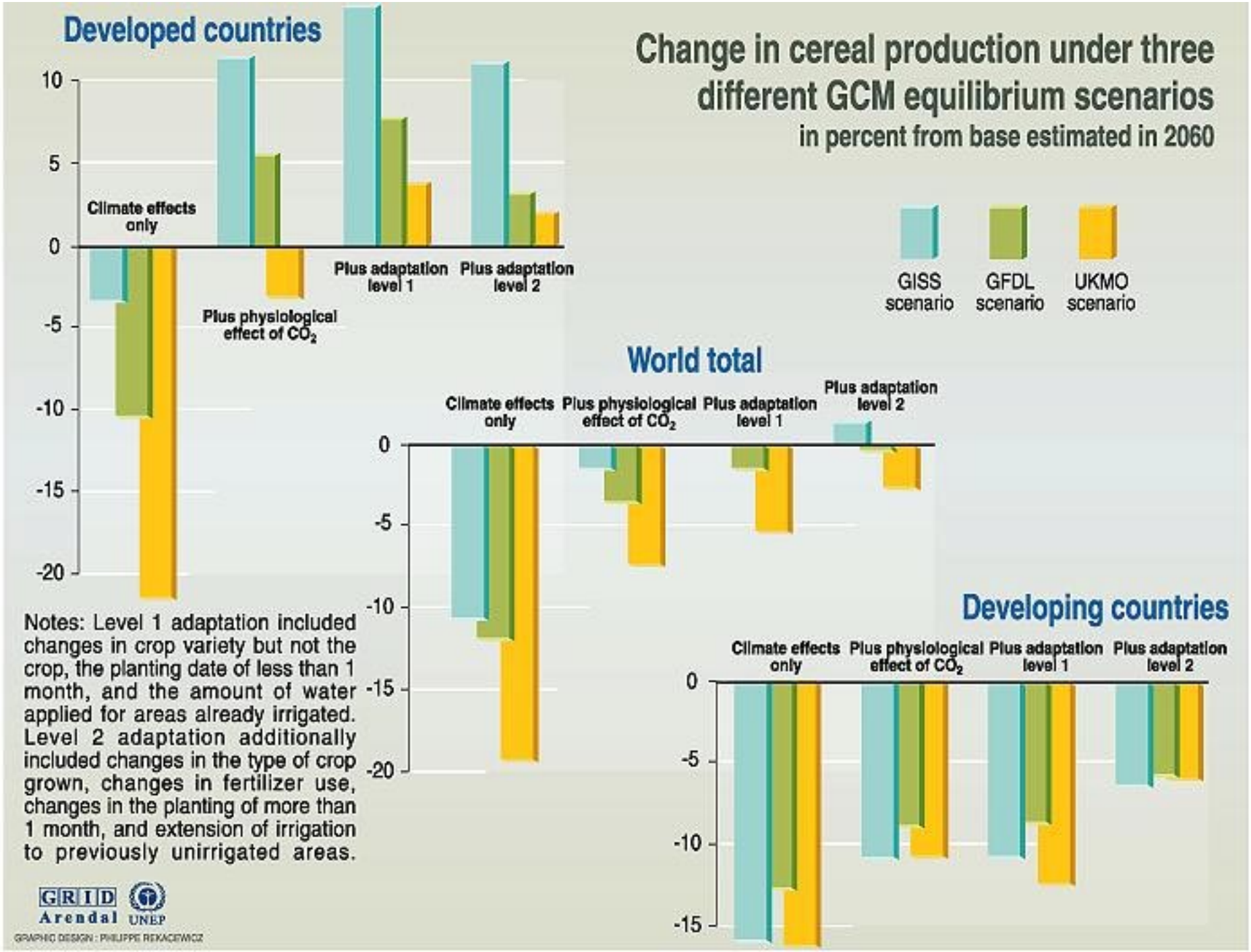
- **Sea level rises - ocean warms and expands**

Disease	Vector	Population at risk (million)[1]	Number of people currently infected or new cases per year	Present distribution	Likelihood of altered distribution
Malaria	Mosquito	2,400[2]	300-500 million	Tropics and Subtropics	
Schistosomiasis	Water snail	600	200 million	Tropics and Subtropics	
Lymphatic Filariasis	Mosquito	1 094[3]	117 million	Tropics and Subtropics	
African Trypanosomiasis (Sleeping sickness)	Tsetse fly	55[4]	250 000 to 300 000 cases per year	Tropical Africa	
Dracunculiasis (Guinea worm)	Crustacean (Copepod)	100[5]	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[6]	Asia, Southern Europe Africa, Americas	
Onchocerciasis (River blindness)	Black fly	123	17.5 million	Africa, Latin America	
American Trypanosomiasis (Chagas disease)	Triatomine bug	100[7]	18 million	Central and South America	
Dengue	Mosquito	1,800	10-30 million per year	All Tropical countries	
Yellow Fever	Mosquito	450	more than 5 000 cases per year	Tropical South America Africa	

1. Top three entries are population-prorated projections, based on 1989 estimates.
2. WHO, 1994.
3. Michael and Bundy, 1995

Highly likely Very likely Likely Unknown

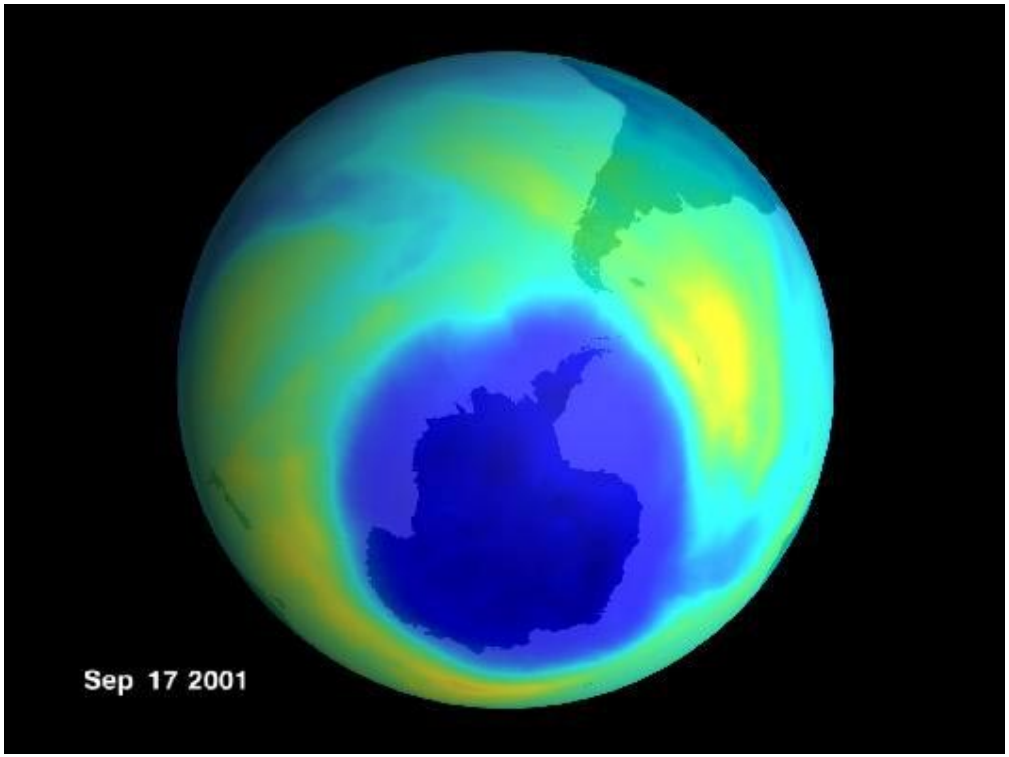
- **Vector Borne Diseases increase with warmer climate**
- **VBD cause significant numbers of deaths in tropics**
- **Malaria and other fun stuff to think about**



Source: Climate change 1995, Impacts, adaptations and miligation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental

2001 OZONE HOLE ABOUT THE SAME SIZE AS PAST 3 YEARS

October 16, 2001 - News Story



26 million square kilometers - size of North America, area and depth

Chlorine compounds leveling off due to decreased production

Summary

- Atmospheric greenhouse gases are increasing
- Atmospheric temperature increasing

- Past Climate evidence
  - Greenhouse gas increase goes with Temperature increase

- Impact on Humans
  - Due to climate change
  - Due to change in extremes

- Natural Variability
  - long time scales in ocean
  - solar variability

Global warming Web pages

- **IPCC** http://www.ipcc.ch/
- **ACIA, Arctic Climate Impact Assessment**
  http://www.acia.uaf.edu/
- **Climate Ark, Climate Change & Renewal Energy Portal**
  http://www.climateark.org/
- **UNEP site, many graphics from there**
  http://www.grida.no/climate/vital/17.htm

Anti-global warming of points of view

- http://www.junkscience.com/ **anti-environment web page**

- **Pat Michaels**

http://www.evsc.virginia.edu/faculty/people/michaels.shtml

- **Fred Singer**

http://www.sepp.org/bios/singer/biosfs.html