Climate Change

Why we have to get off the carbon intensive gravy train

14 August 2009

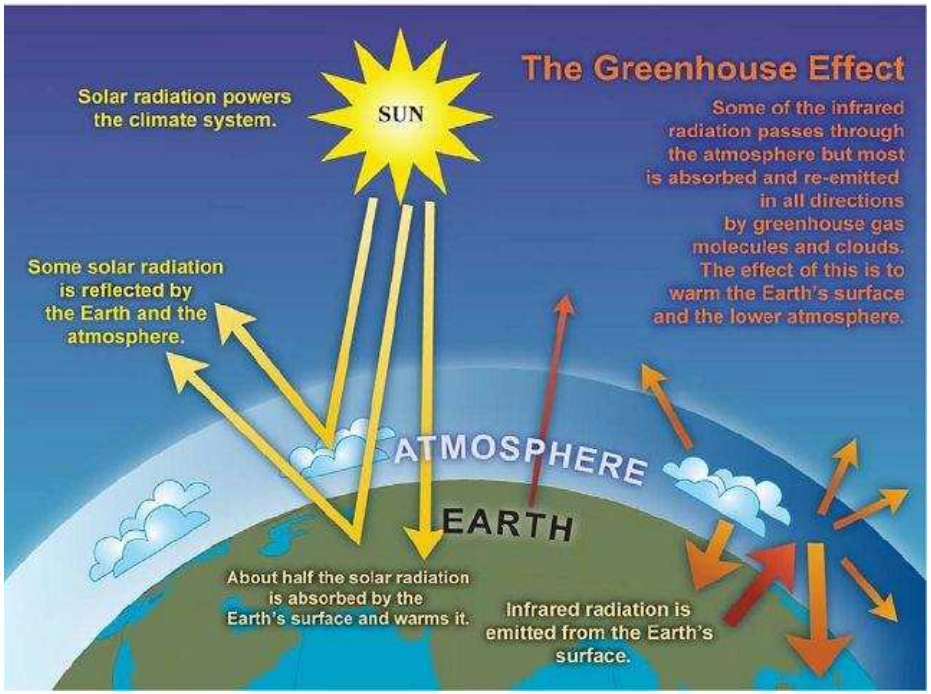
THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Outline

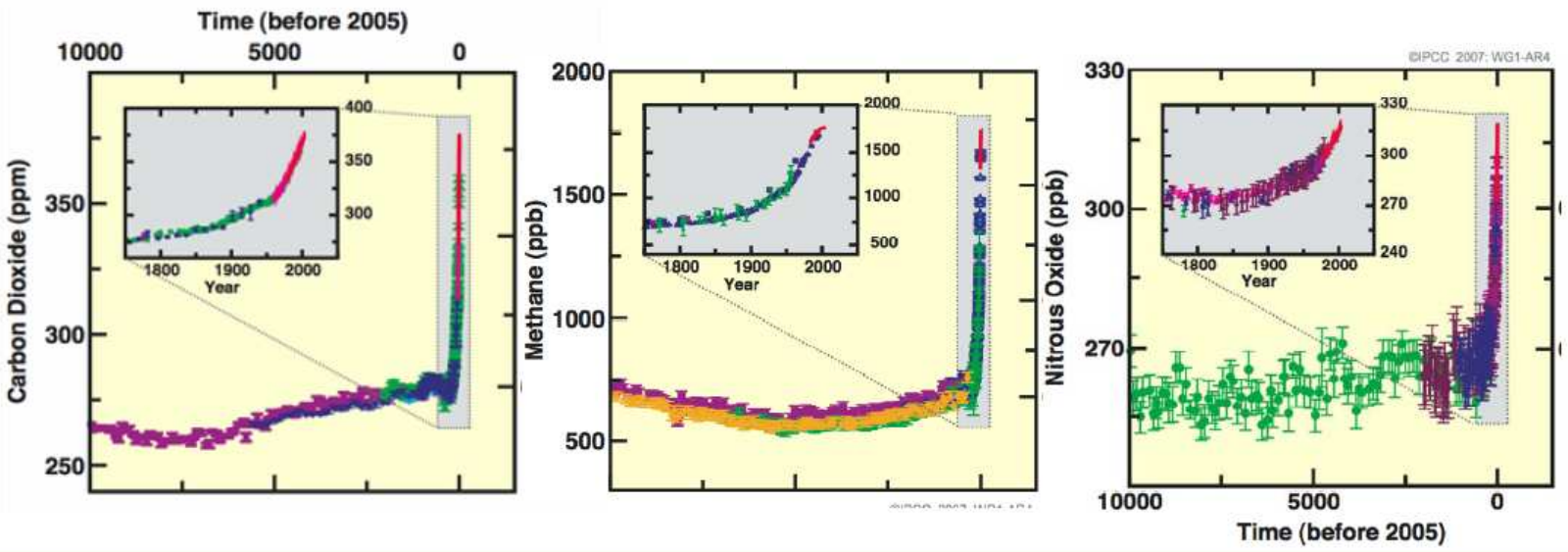
- The greenhouse effect and climate change
- Observed climate
- Impacts of climate change
- Climate scenarios for the future
- Impacts
- Why it is urgent

The greenhouse effect

- Long-term balance controlled by:
  - Amount & distribution of sunlight (nature)
  - Greenhouse gas concentrations (man & nature)
- Atmosphere is 0.04% CO_2
  - Difference between +15°C and -18°C

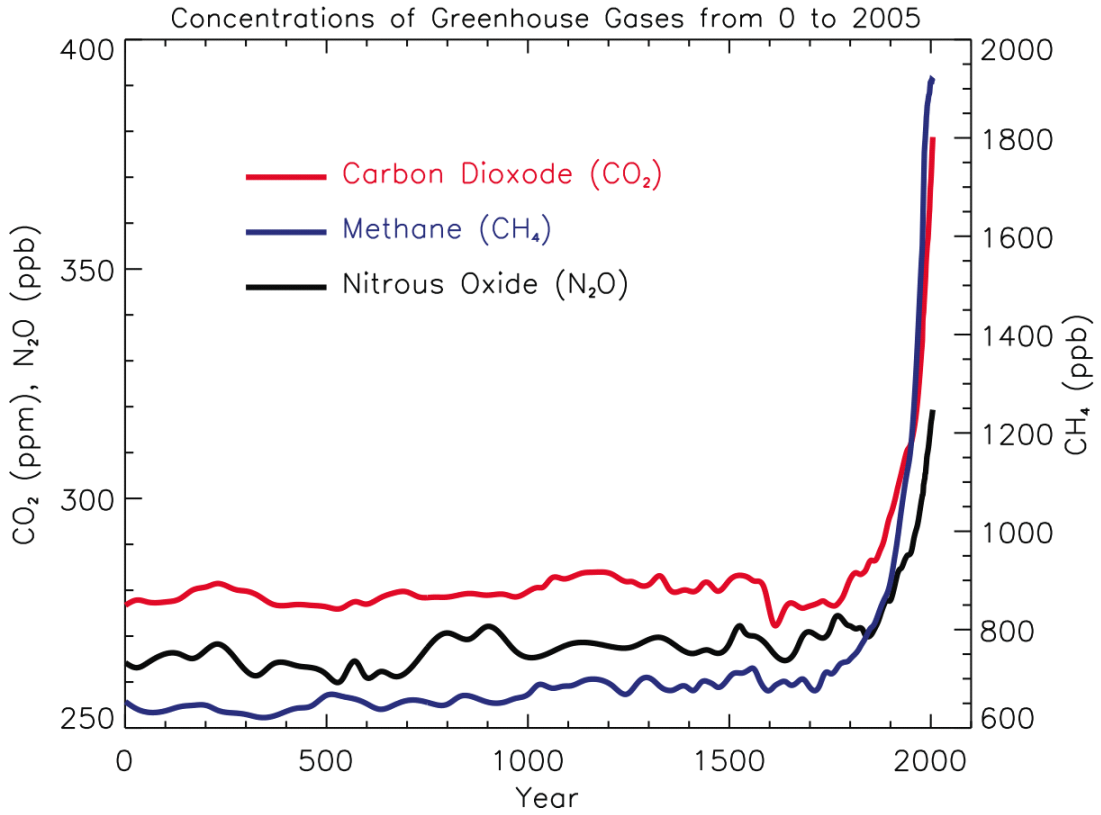


The greenhouse effect



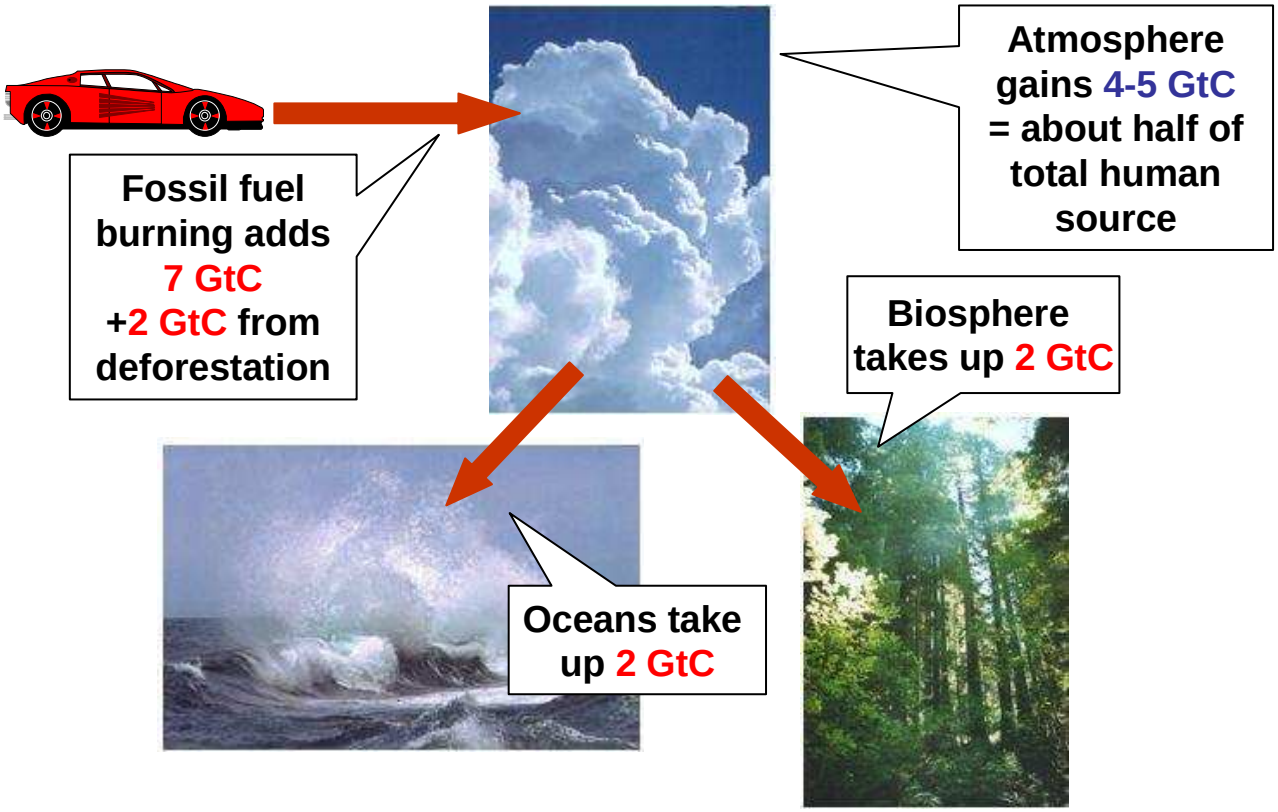
Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased marked as a result of human activities since 1750, and now far exceed values for at least the last 650,000 years.

The greenhouse effect



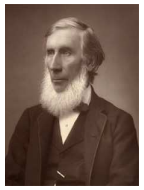
- Lots more greenhouse gas recently

Humanity & the carbon cycle



- Human inputs are about 10% of the natural (balanced) cycle
  - Net gain to atmosphere over time significant (~100 year lifetime)
  - Inputs increasing faster than expected, sinks becoming weaker (BAS)
  - We are important players in the climate system

CO_2 and Temperature Change



- IPCC Fourth Assessment Report, 2007
  - CO_2 doubling best estimate 3°C (2.0 - 4.5°C)
  - "business as usual" CO_2 doubling 2050–2100

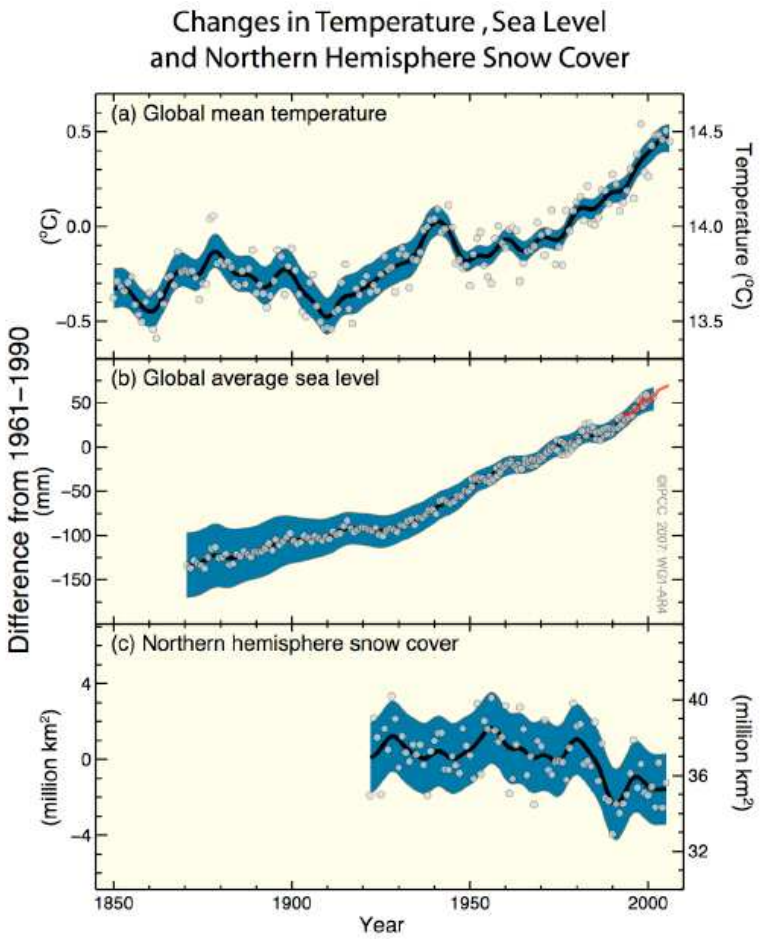
CO_2 concentration now 36% above pre-industrial

Half that increase in last 30 years

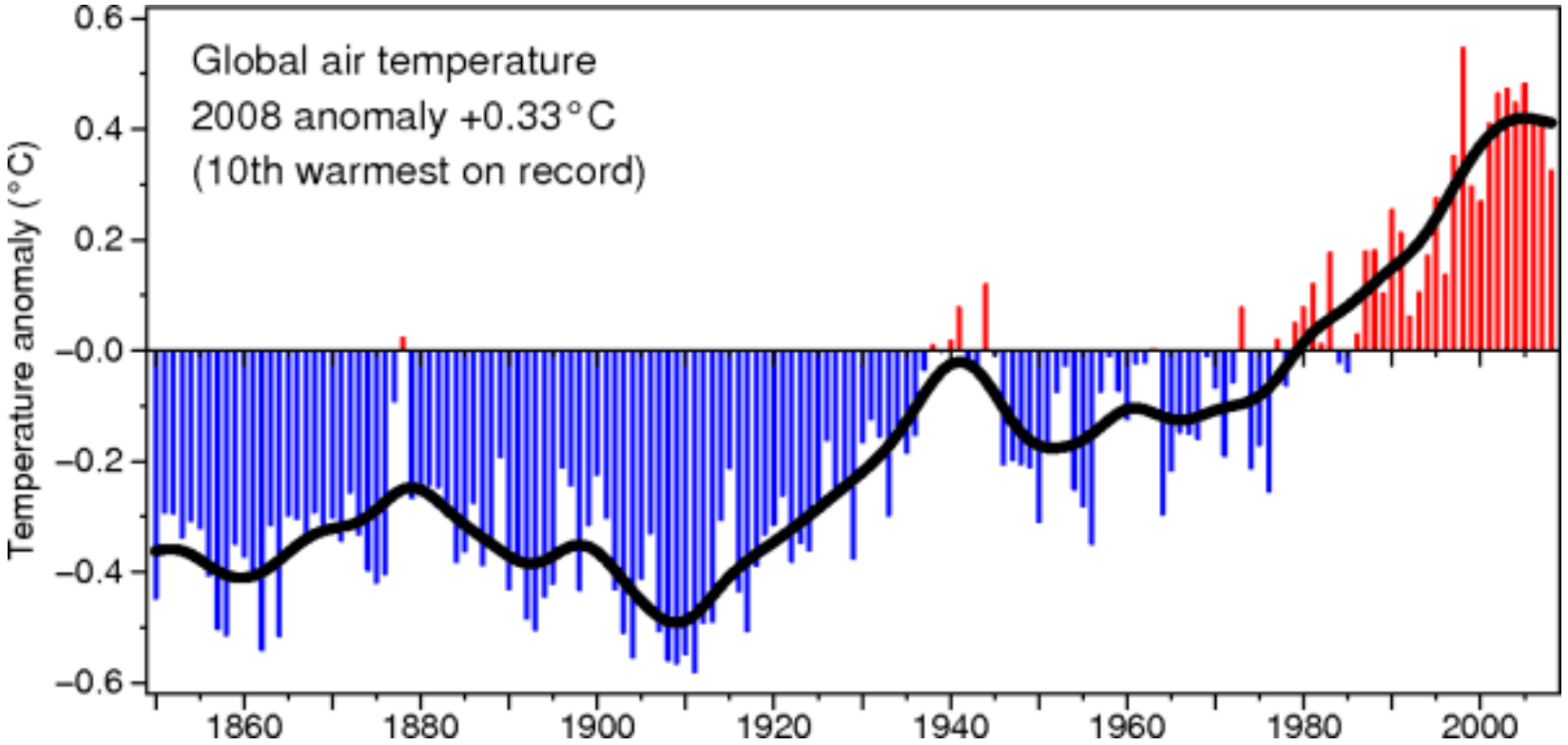
…and, we know it's from burning, since oxygen decreasing!

Observed climate

- observations of increases in global average air and ocean temperatures with warmest years recently
- oceans warming and sea levels rising
- northern hemisphere snow cover decreasing
- less frosts, more heatwaves

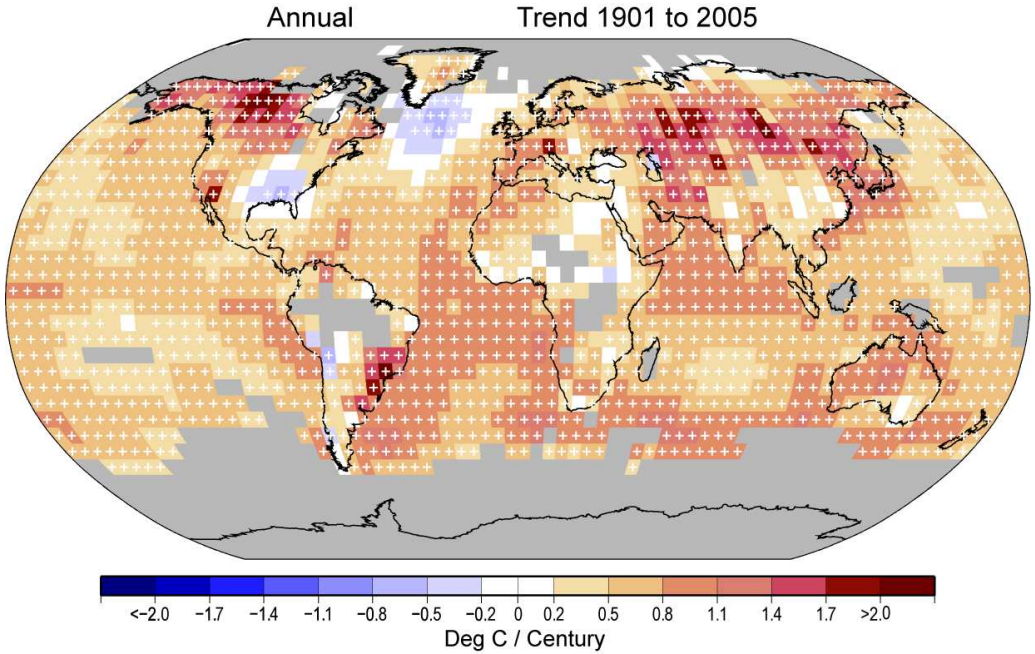


Observed climate

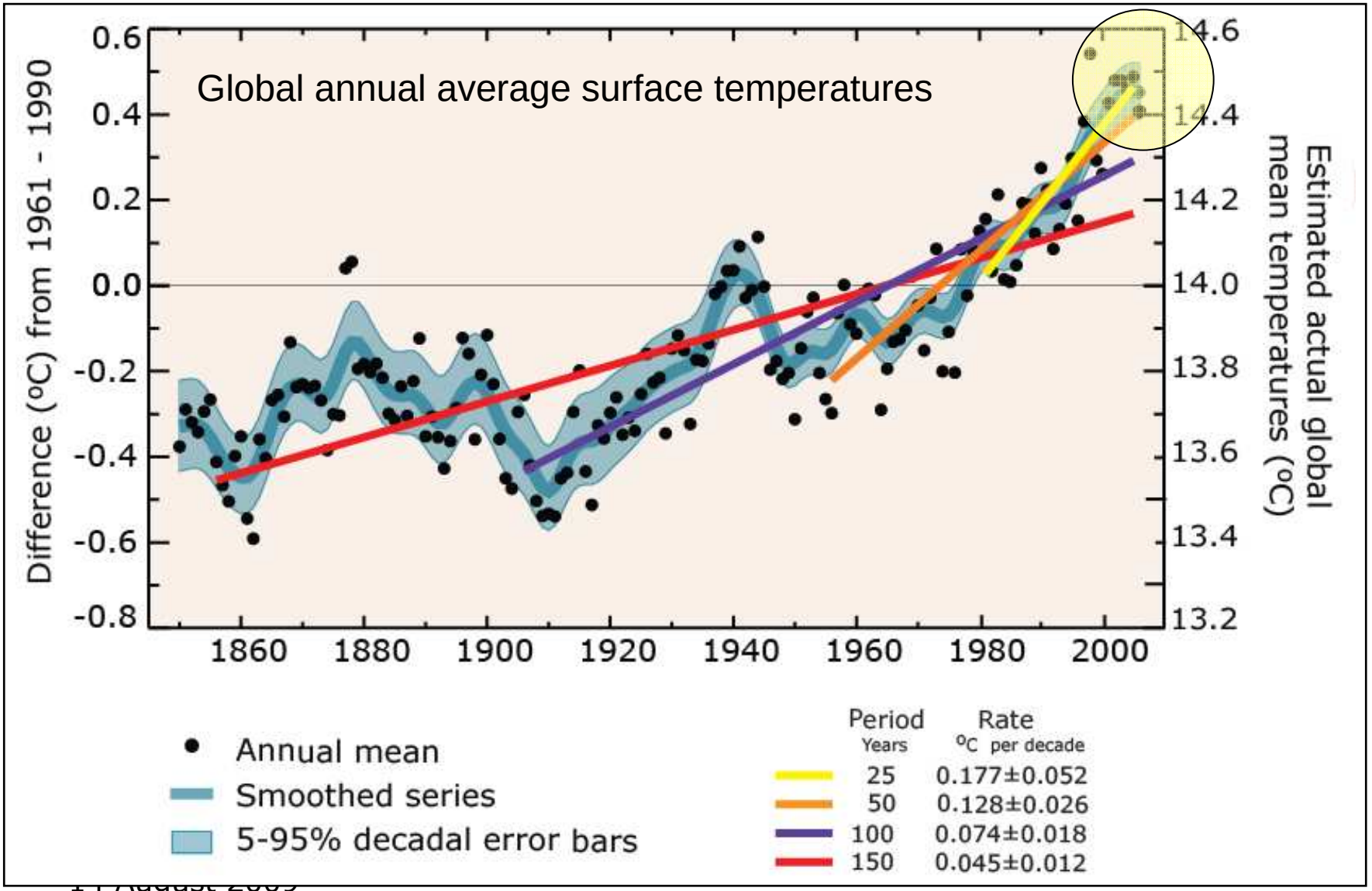


Observed climate

- Land warming faster than ocean
- Ocean heat content increasing
  - All the way down...
  - Oceans taken over 90% of total heating
- Southern Ocean/Antarctic not warming, yet...



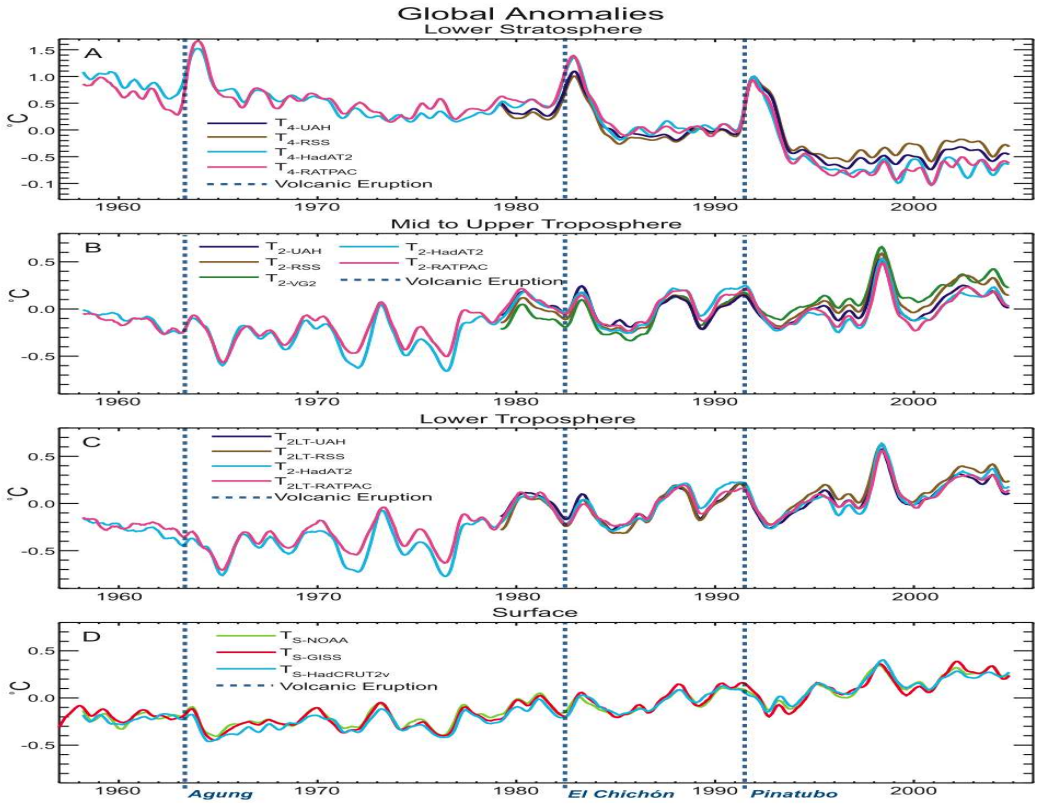
Observed climate



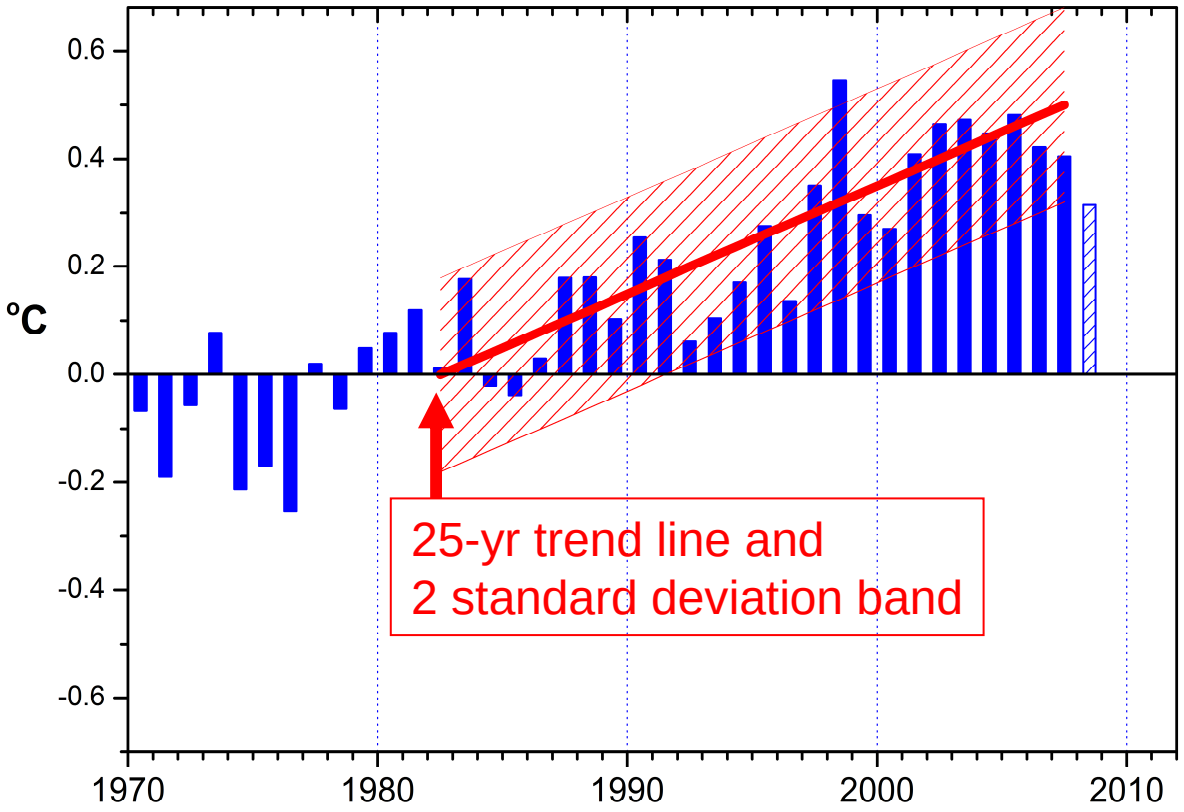
IPCC, WG I, 2007

Observed climate

- The upper atmosphere is cooling
- The lower atmosphere is warming
- Trends from weather balloons and satellite sensed temperatures are similar



Observed climate



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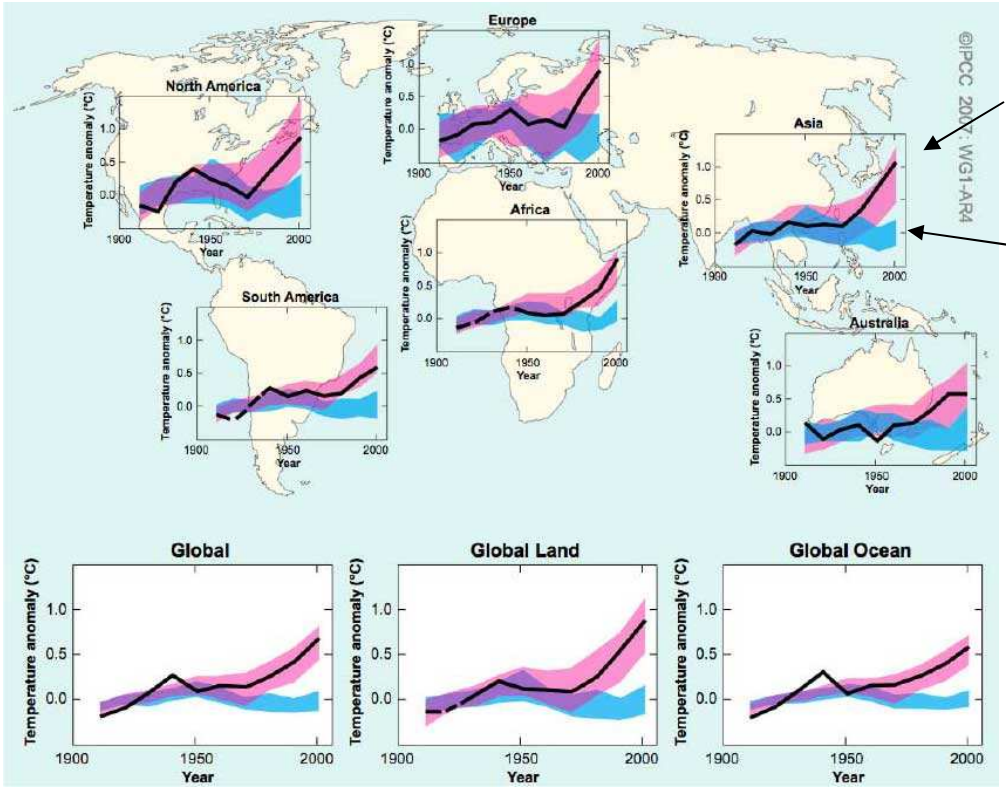
Observed climate

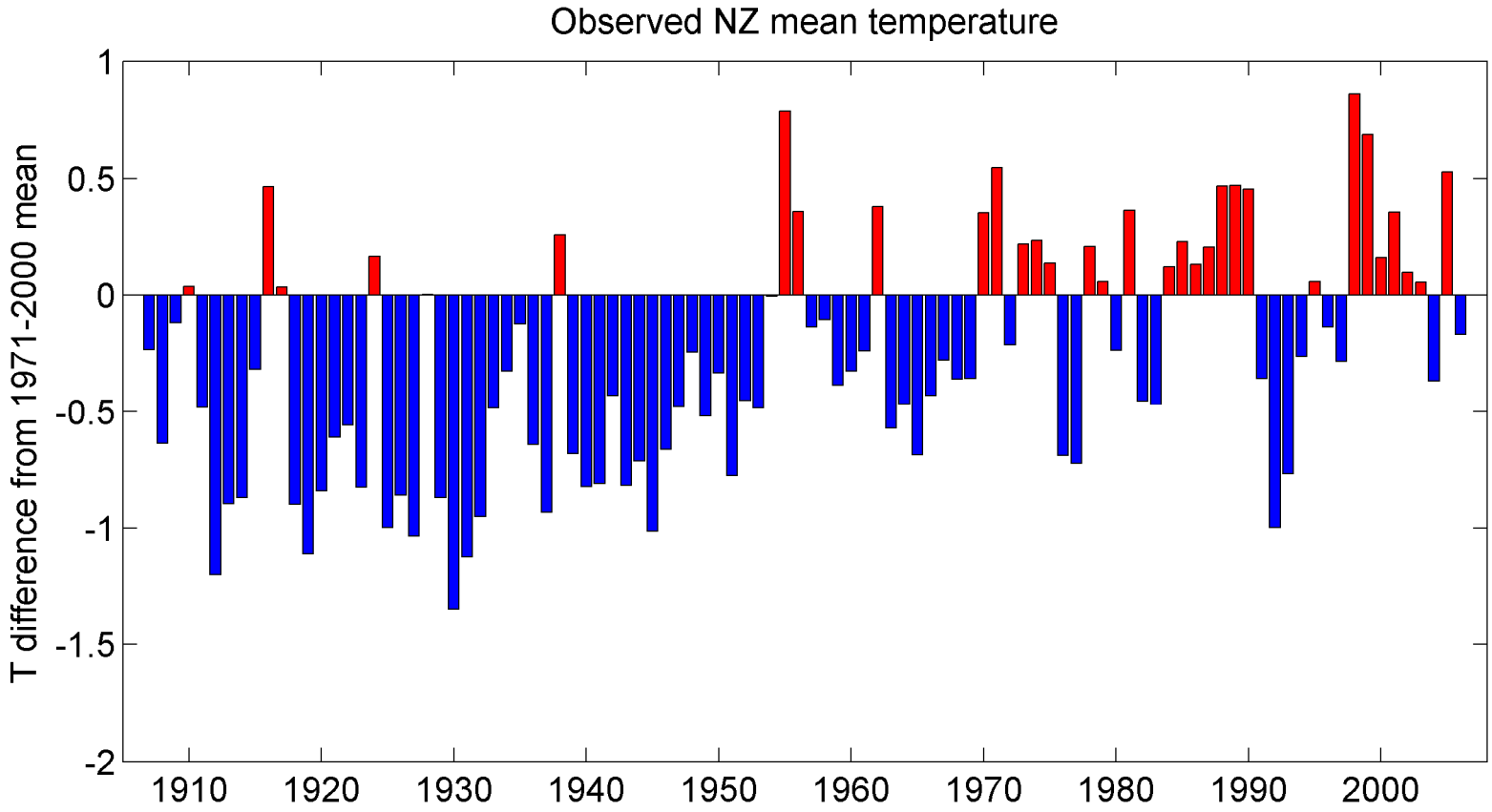


MODELS

All drivers

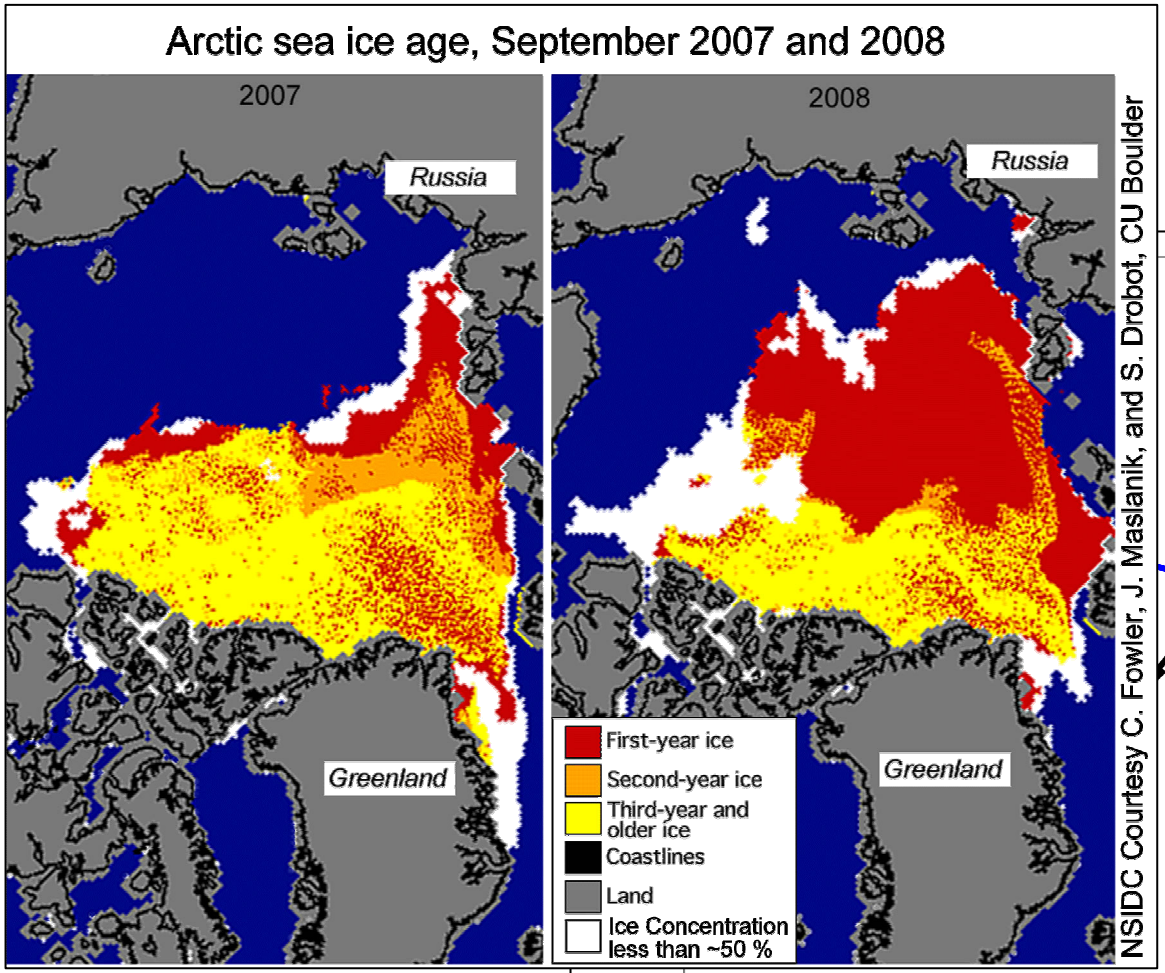
Natural drivers only

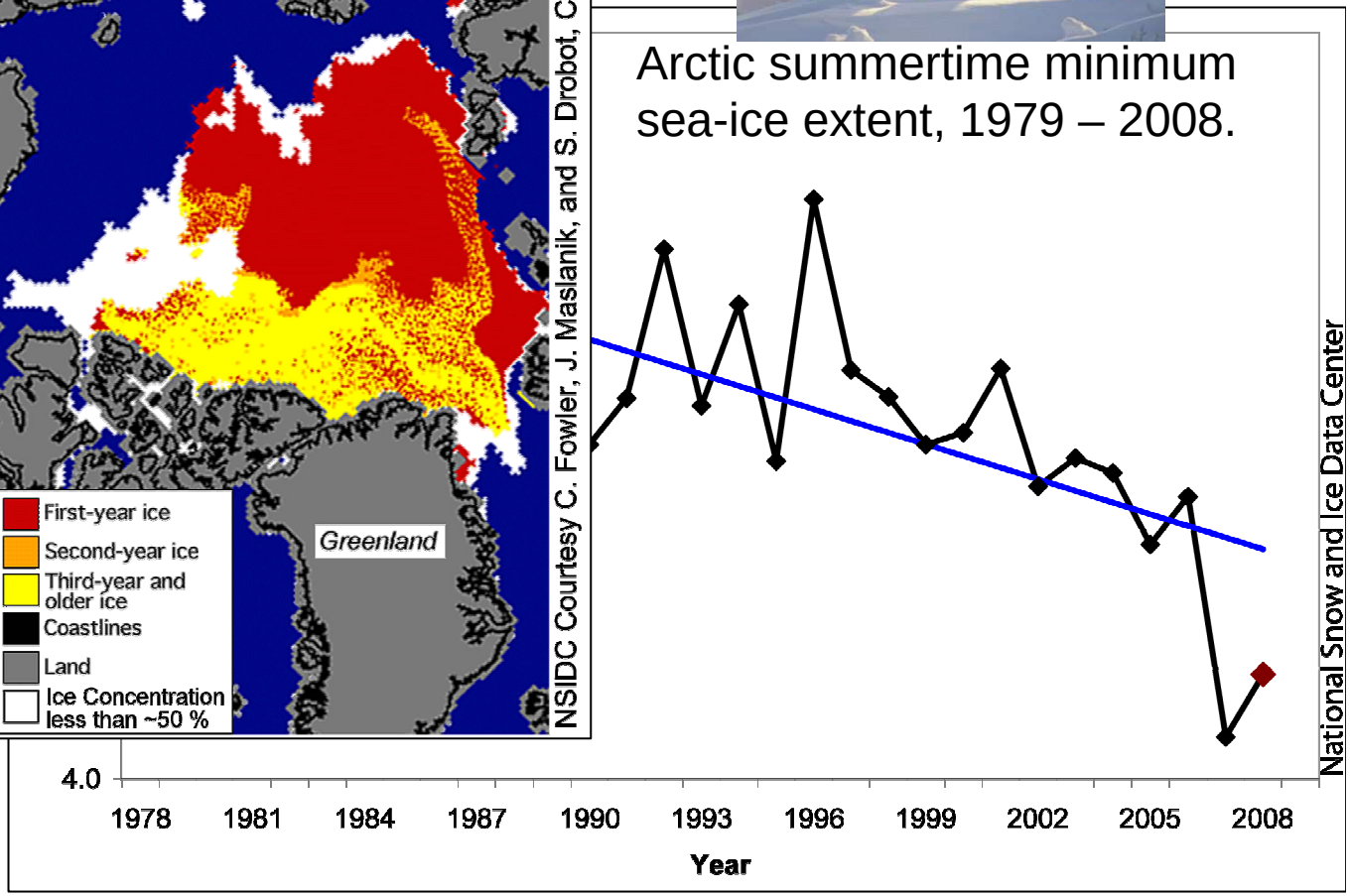
Observed climate



- 100-year change & year to year change both about 1°C

Arctic sea ice





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National Snow and Ice Data Center, http://nsidc.org

Alpine Response

Solid line total volume change of alpine ice volume

- Southern Alps ice volume has decreased 11% from 55 to 49 km^3 1976 - 2005
- This equates to 0.2 km^3/yr
- Only 9% comes from mass balance volume changes
- Long term volume loss due to calving and trunk down wasting of 12 large glaciers

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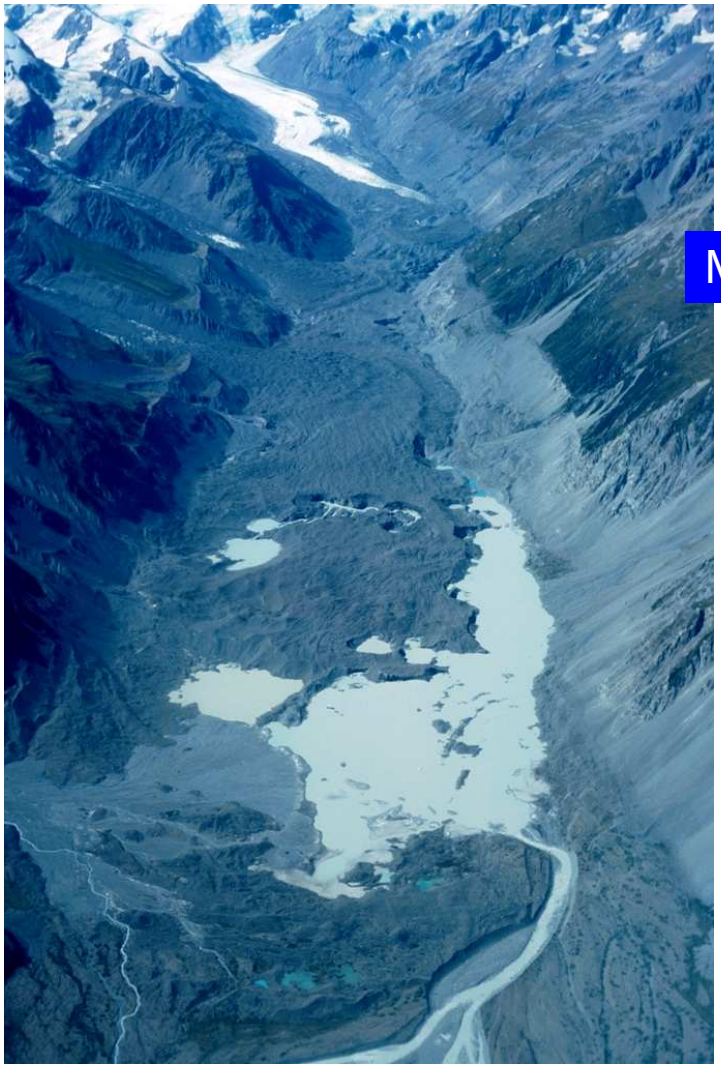
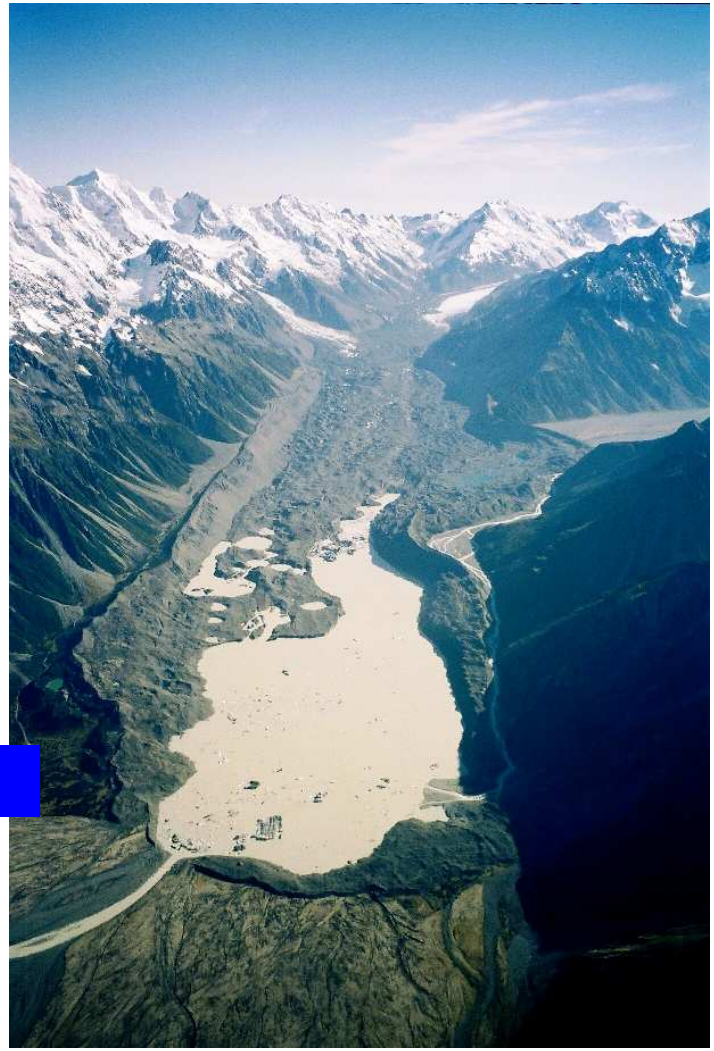
Alpine Response



Murchison Lake

Tasman Lake



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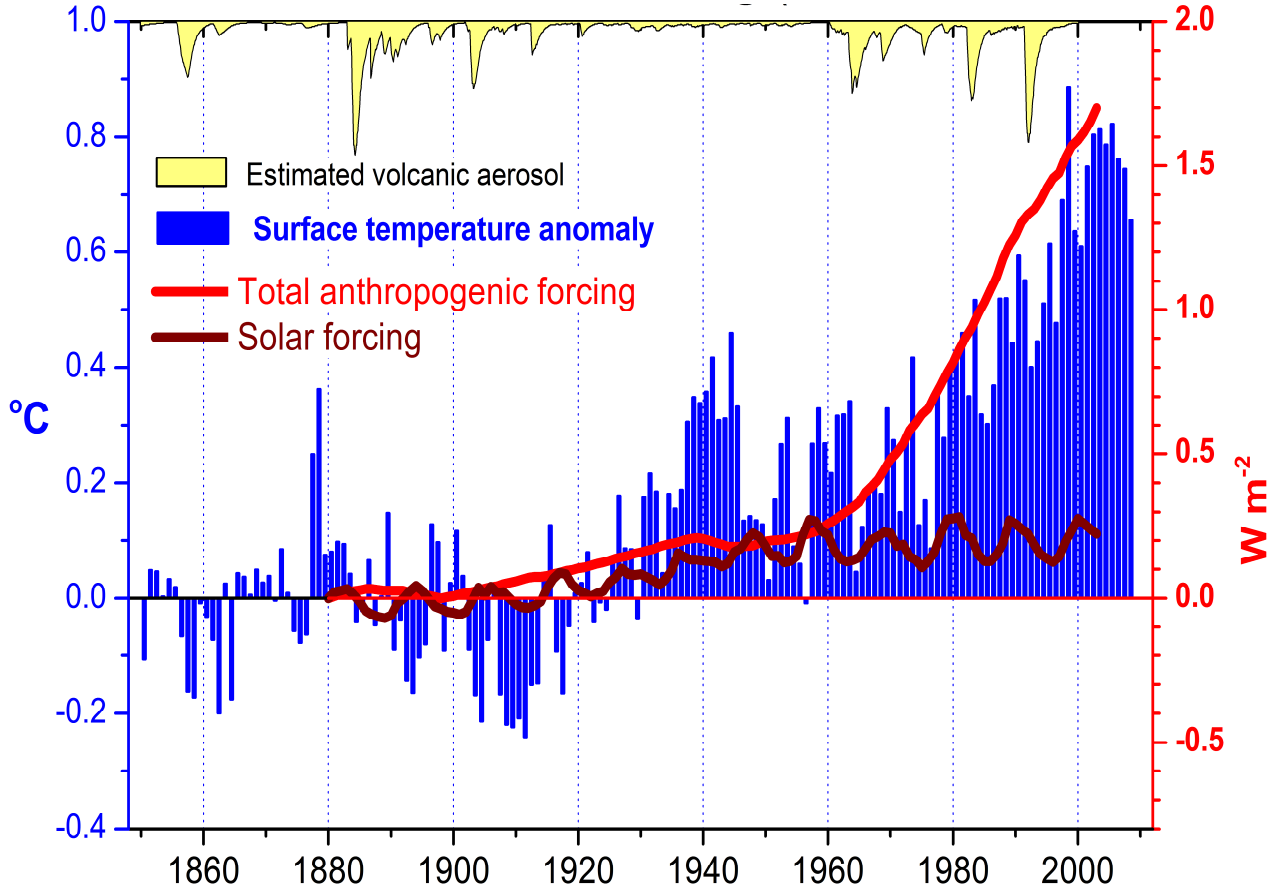
Global temperatures and radiative forcing



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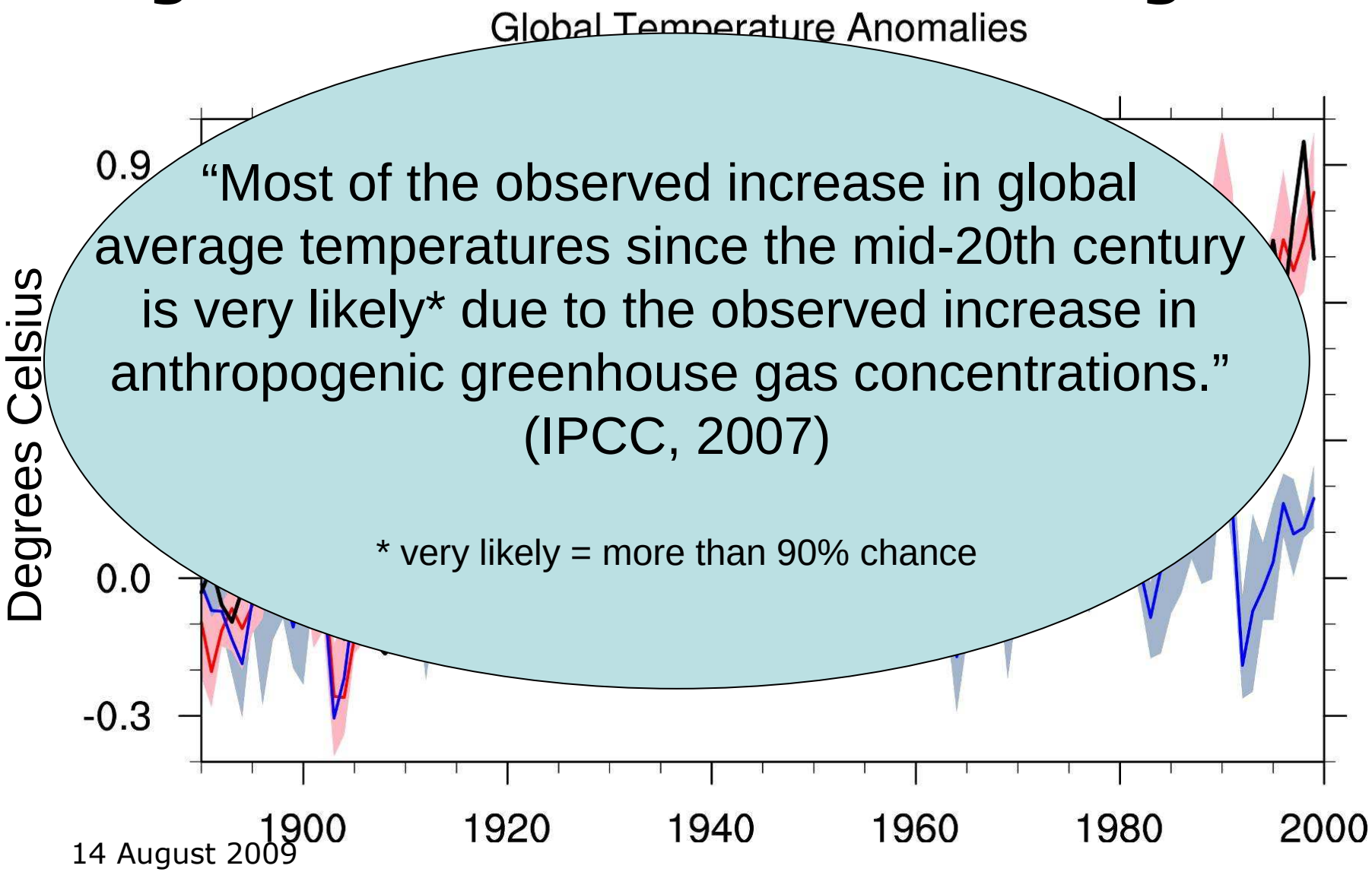
Diagnosis of actual climate change



"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." (IPCC, 2007)

* very likely = more than 90% chance

G. Meehl, NCAR, 2007

Impacts of climate change

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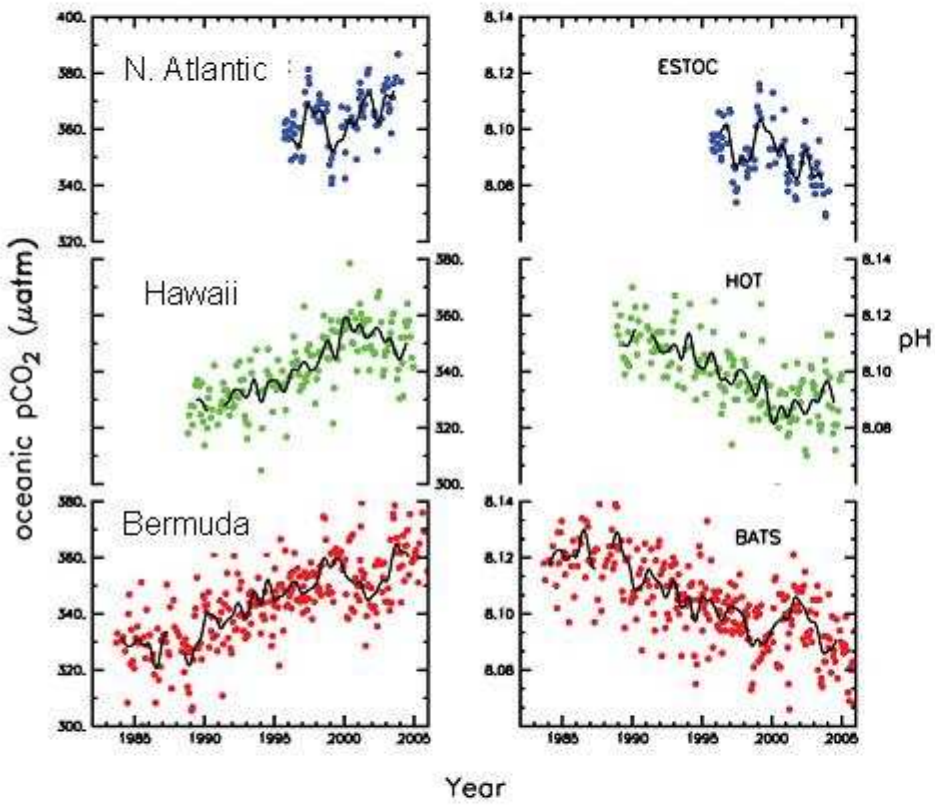
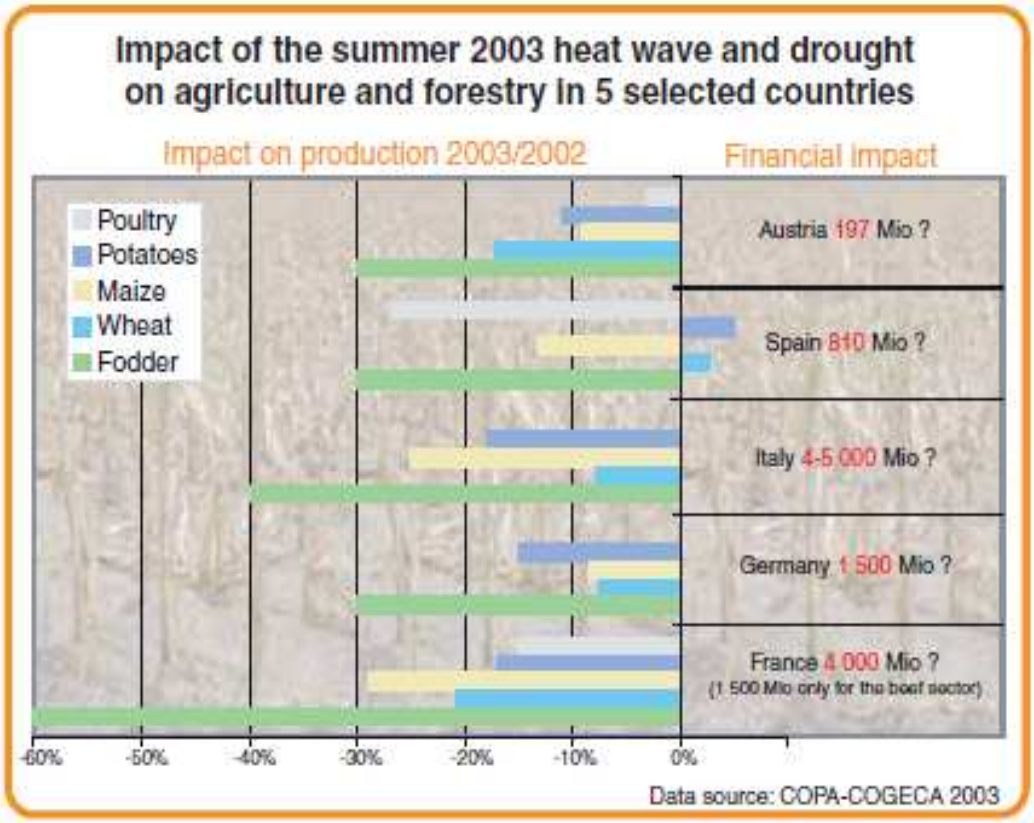
Ocean acidification



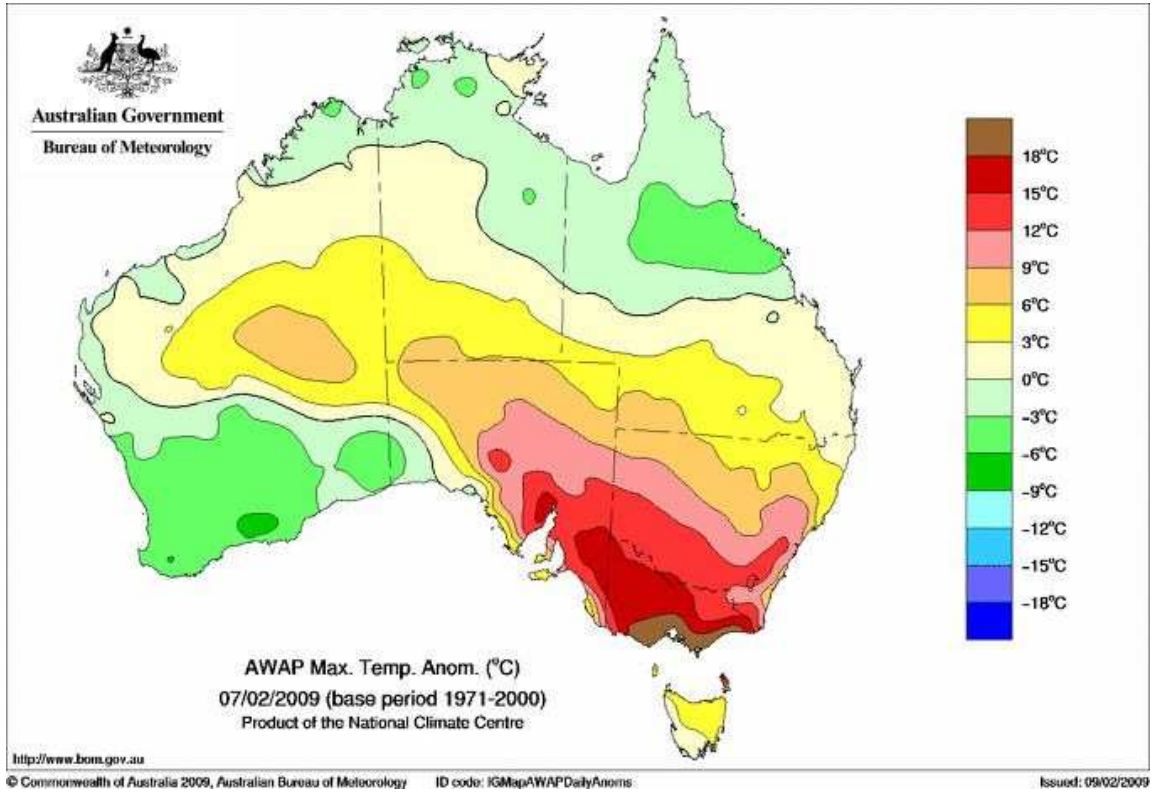
- 0.1pH unit decrease observed
- Another 0.3pH unit decrease this century
  - Unprecedented for over 20 million years
- Affects corals, shell formation, plankton growth
- May damage whole food chain in the oceans
  - **Regardless of "global warming"**

European 2003 heatwave



Over Europe, the main sectors hit by the extreme climate conditions were the green fodder supply, the arable sector, the livestock sector & forestry. Drought affects the state of vegetation by lowering photosynthetic activity leading to a reduction in productivity, in particular for crops & fodder. It also affects forests, weakening trees & making them vulnerable to diseases & insect attacks.

Australian heatwave 2009



It has been a truly unbelievable event and the climate change implications are very clear - it was the hottest day on record in the midst of the longest heatwave on record with 2009 having the driest start to a year on record in a 12 year drought which has been our hottest, longest and driest on record.

Dr David Jones
Bureau of Meteorology

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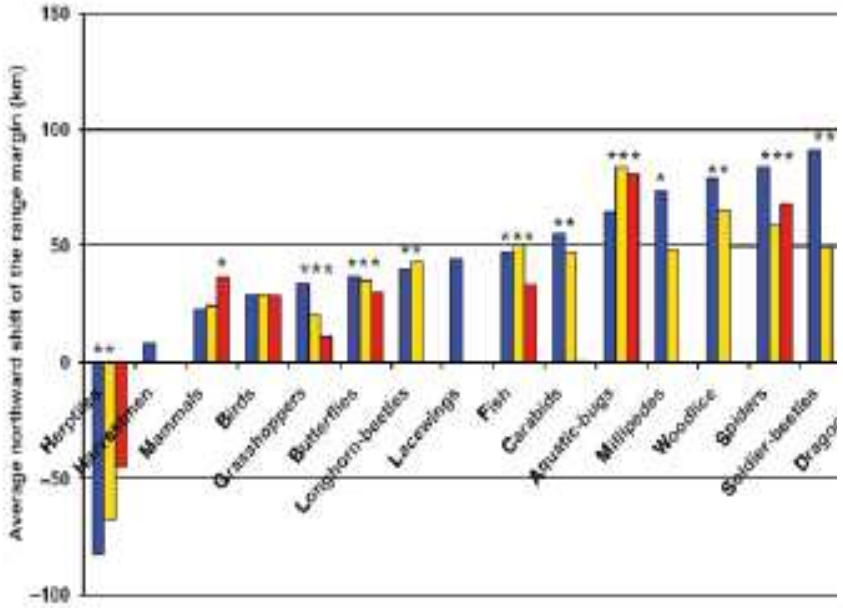
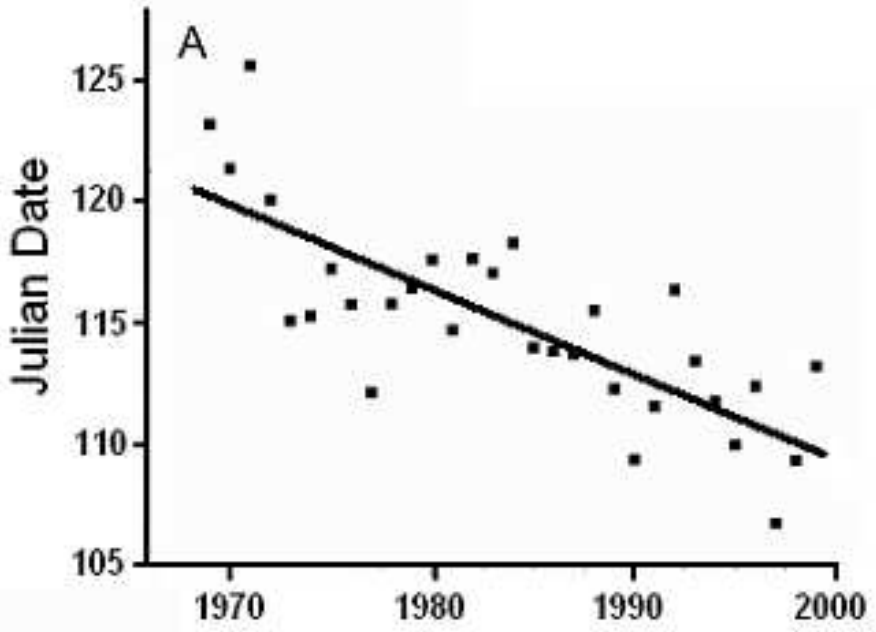
Observed impacts on natural systems

- Cryosphere melting
  - Enlargement and increased numbers of glacial lakes, with increased risk of outburst floods
- Permafrost
  - Decrease in travel days of vehicles over frozen roads in Arctic, number of lakes/ponds increasing
  - More ice/rock avalanches in mountain regions
- Hydrology
  - Spring peak discharge occurring earlier in rivers affected by snowmelt
  - Lakes and rivers are warming

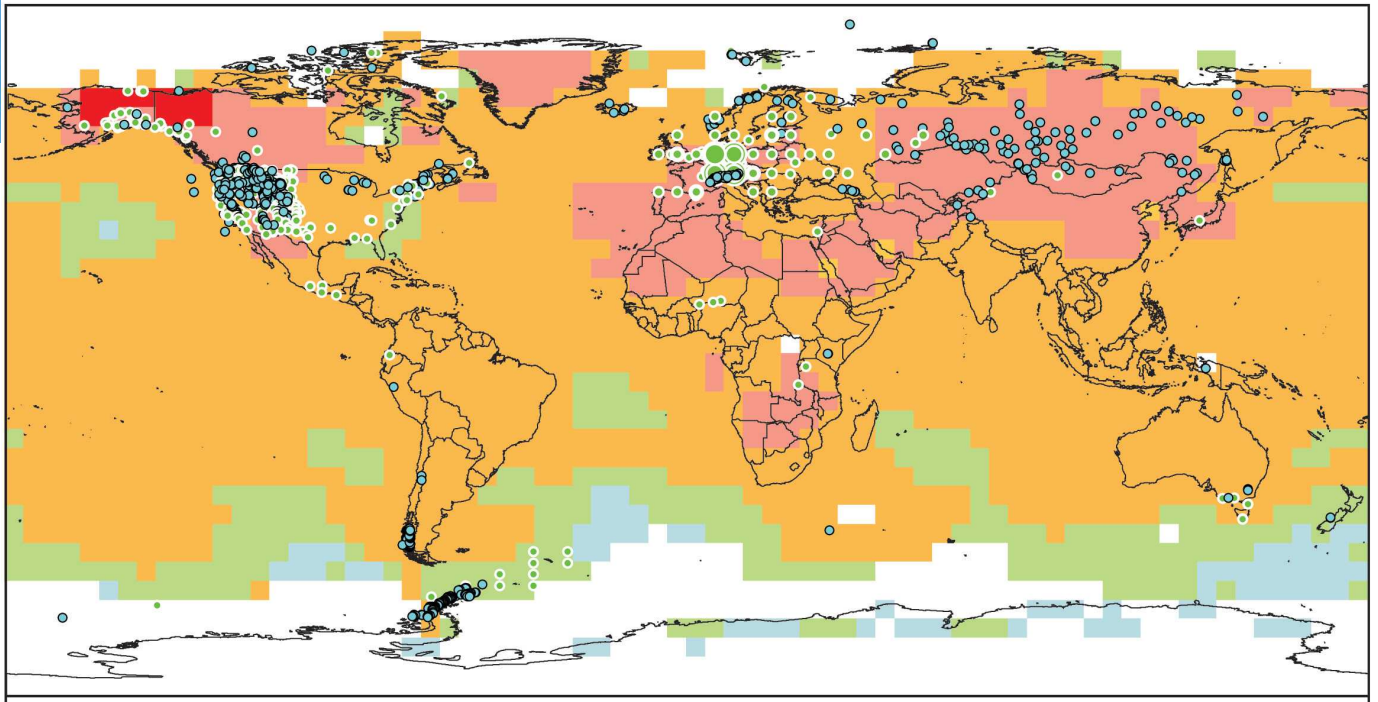
Observed impacts on natural systems





- Terrestrial species
  - Earlier timing of spring events (leaf emergence, bird migration, egg-laying)
  - Poleward and upward shift of species ranges

Changes in physical and biological systems and surface temperature 1970-2004



	NAM	LA	EUR	AFR	AS	ANZ	PR*	TER	MFW**	GLO
			28,115					28,586		28,671
Physical	355	53	119	5	106	6	120	764	1	765
Biological	455	5		2	8	0	24		85	
Physical	94%	98%	94%	100%	96%	100%	91%	94%	100%	94%
Biological	92%	100%	89%	100%	100%	–	100%	90%	99%	90%

Observed data series

- Physical systems (snow, ice and frozen ground; hydrology; coastal processes)
- Biological systems (terrestrial, marine, and freshwater)

Physical	Biological
Number of significant observed changes	Number of significant observed changes
Percentage of significant changes consistent with warming	Percentage of significant changes consistent with warming

Europe ***

○	1-30
○	31-100
○	101-800
○	801-1,200
○	1,201 -7,500

Temperature change °C
1970-2004

-1.0 -0.2 0.2 1.0 2.0 3.5

* Polar regions include also observed changes in marine and freshwater biological systems.

** Marine and freshwater includes observed changes at sites and large areas in oceans, small islands and continents. Locations of large-area marine changes are not shown on the map.

*** Circles in Europe represent 1 to 7,500 data series.

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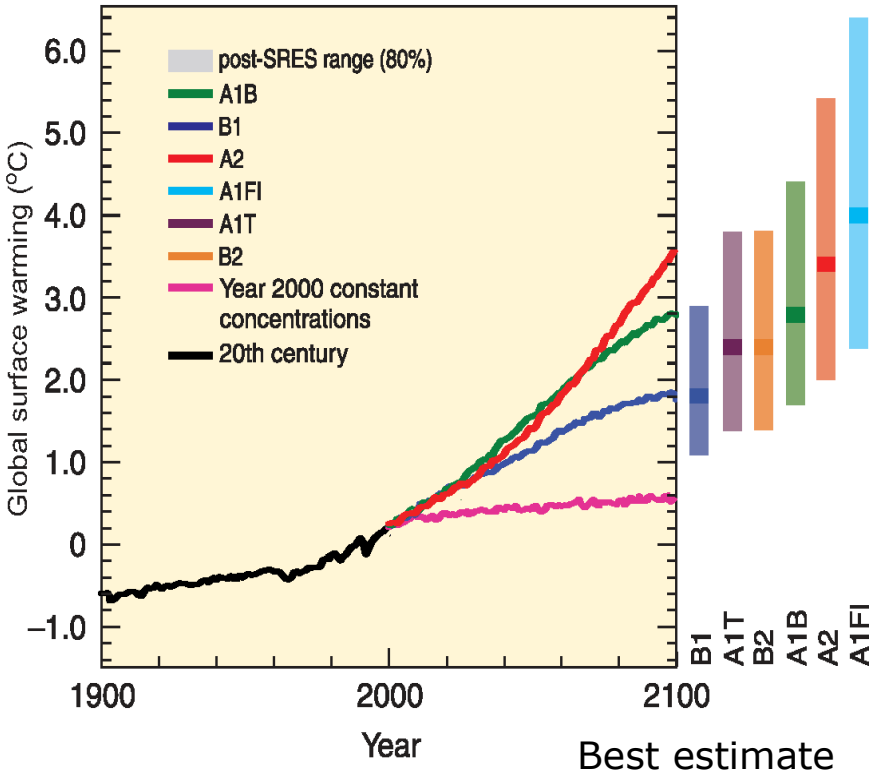
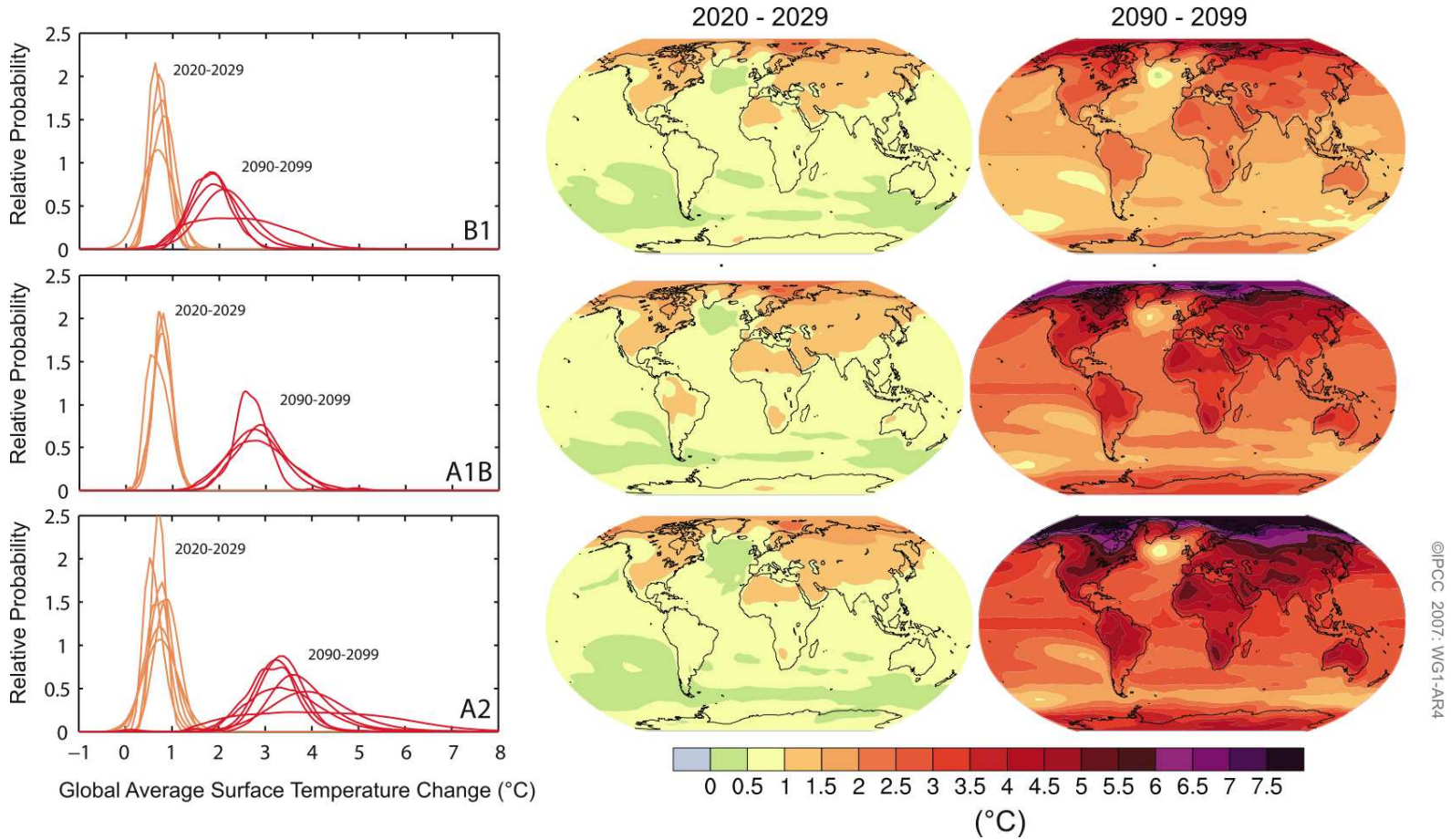
Climate scenarios

- The range of projections (Table SPM.1) is broadly consistent with the TAR.
  - However, high end of range is larger than in TAR.
  - Broader range of available models suggests stronger climate-carbon cycle feedbacks.
- Sea level rise projections for the 21st century are also consistent with the TAR.
  - However, uncertainty hinders making reliable estimates of the upper bound.

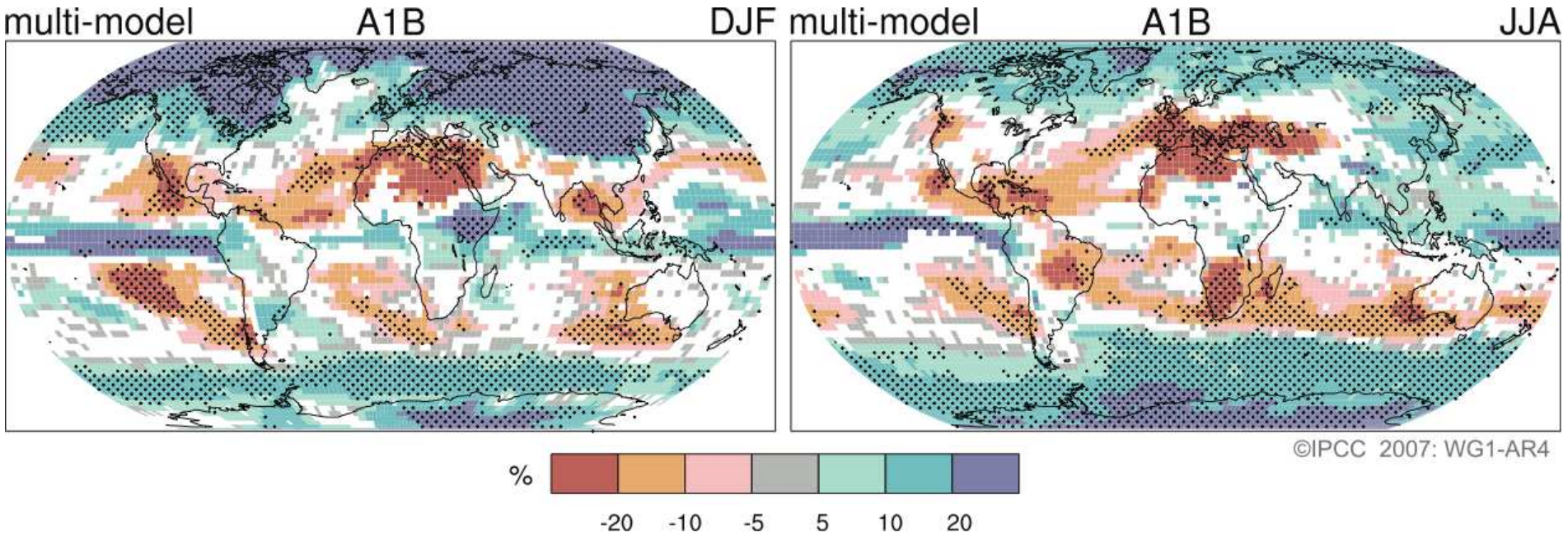


Best estimate and *likely* uncertainty range at 2100

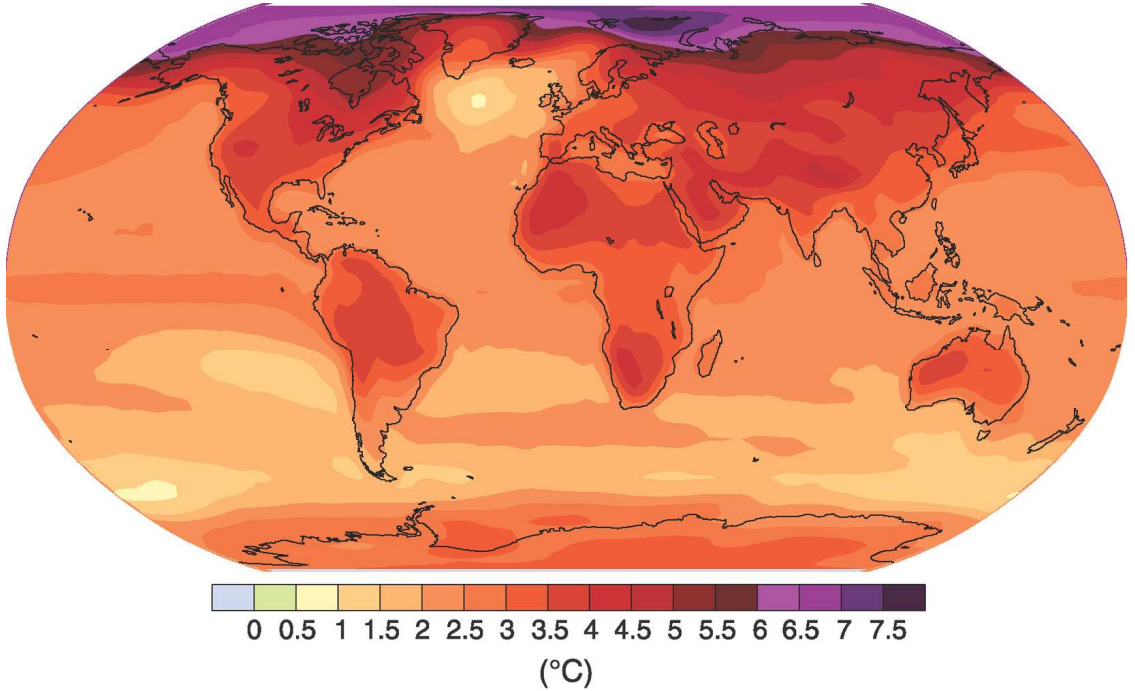
Future climate : 30 & 100 years



Climate projections : Precipitation



Impacts of climate change



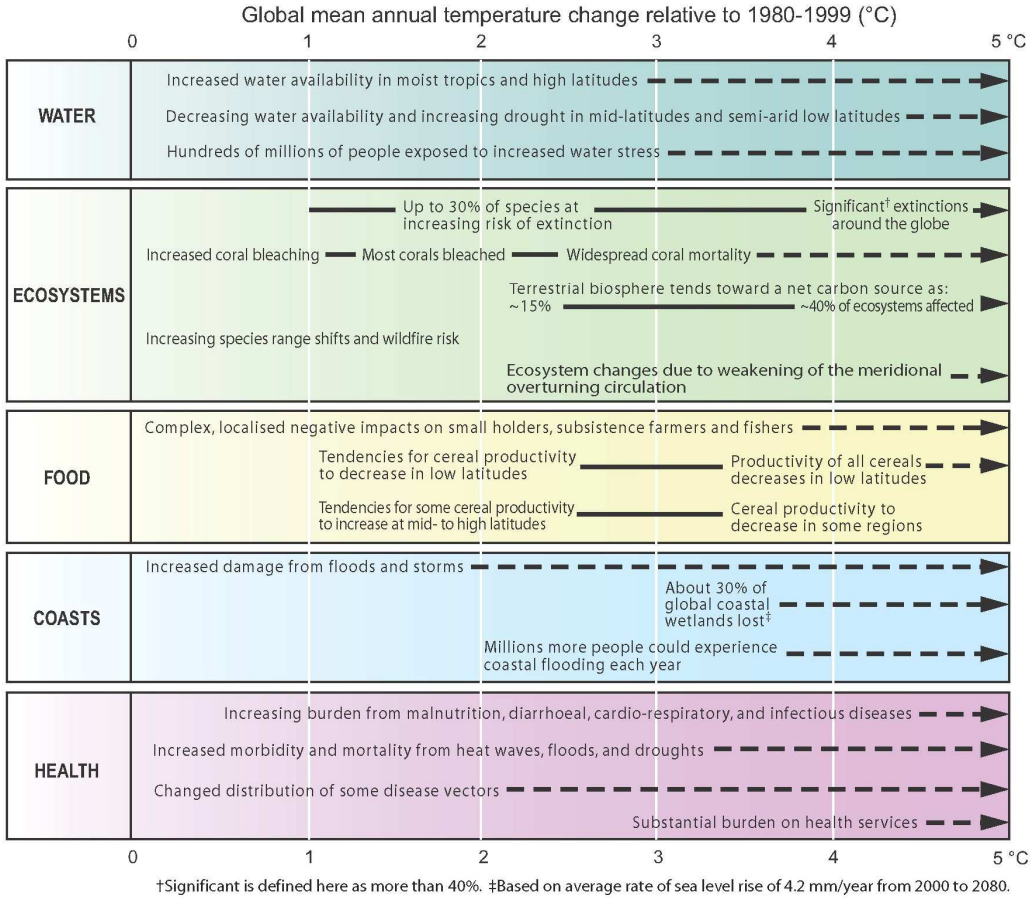
- Warming greatest over land and at most high northern latitudes and least over Southern Ocean and parts of the North Atlantic Ocean

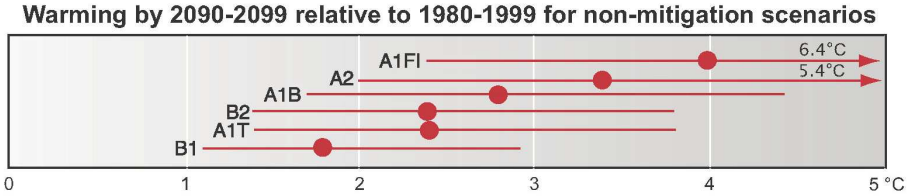
Impacts of climate change

- *Very likely* increase in frequency of hot extremes, heat waves, and heavy precipitation
- *Likely* increase in tropical cyclone intensity; less confidence in global decrease of tropical cyclone numbers
- Poleward shift of extra-tropical storm tracks with consequent changes in wind, precipitation, and temperature patterns
- *Very likely* precipitation increases in high latitudes and *likely* decreases in most subtropical land regions, continuing observed recent trends

Impacts of climate change

More systematic understanding of the timing and magnitude of impacts related to differing amounts and rates of climate change.





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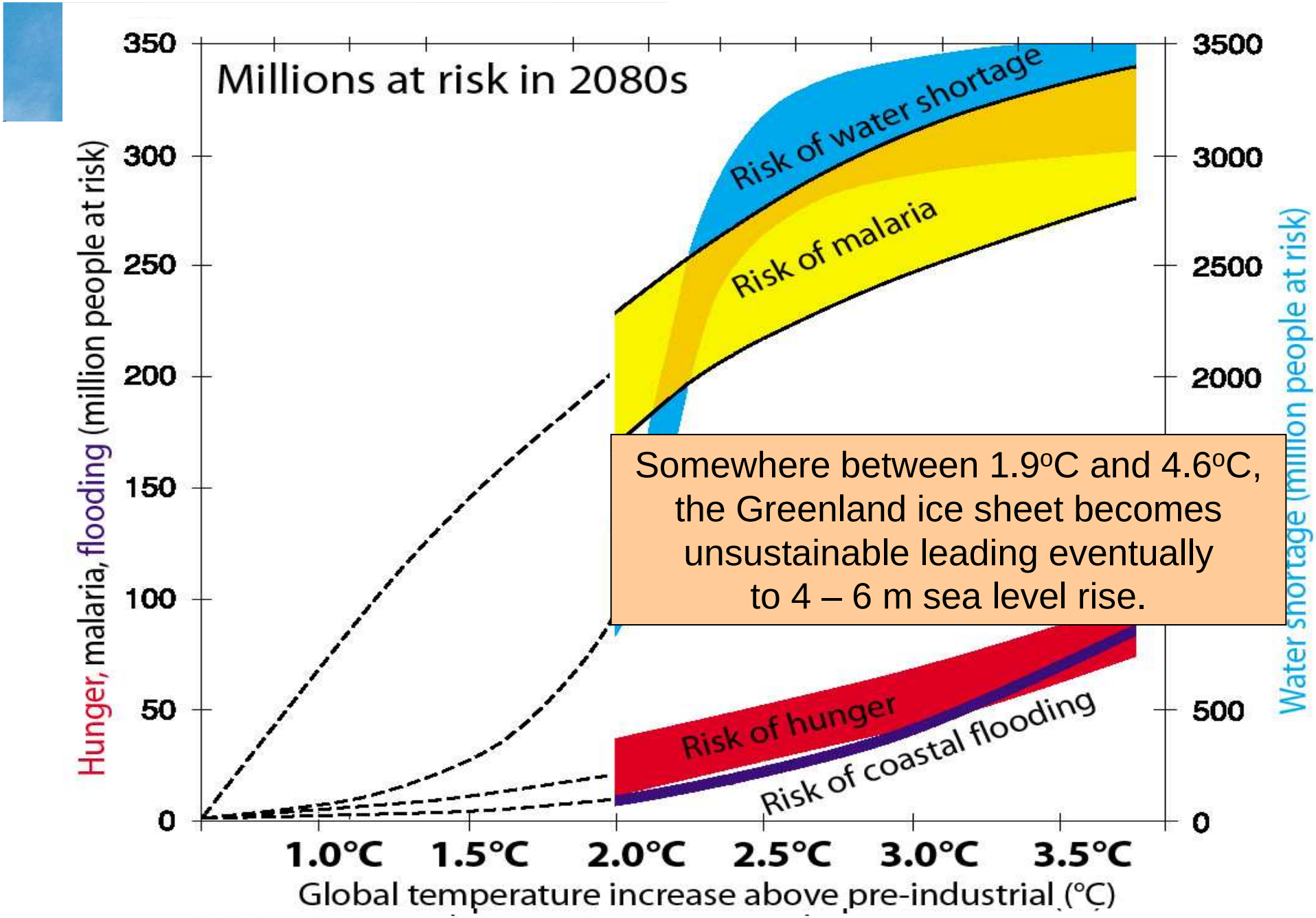


Parry et al, Global *Environmental Change*, 2001

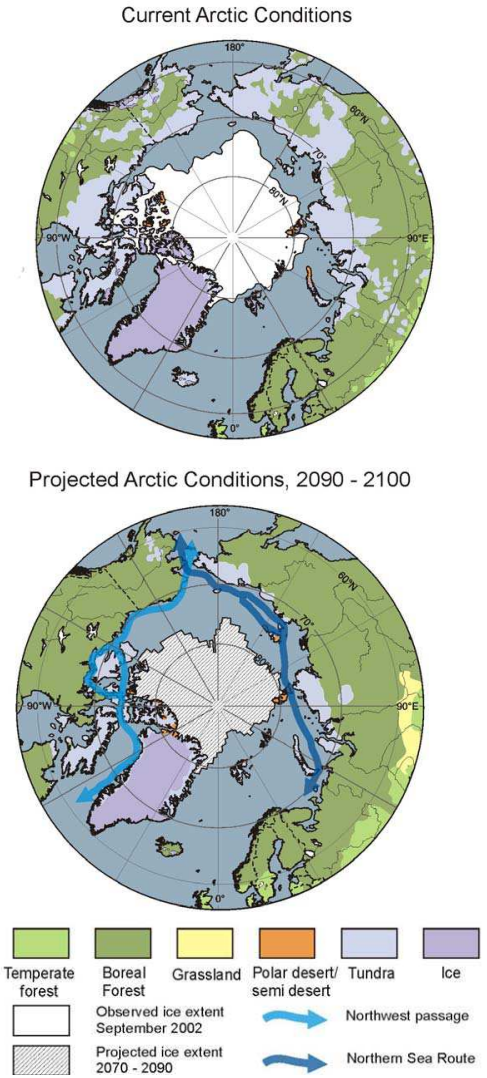
Impacts of climate change

- Arctic
  - High rates of warming on natural systems
  - Arctic sea ice 20 – 30% less by 2100
  - Permafrost significantly decreased
  - Large scale forest fires & outbreaks of tree-killing insects

- Africa
  - Especially sub-Saharan because of low adaptive capacity and drying

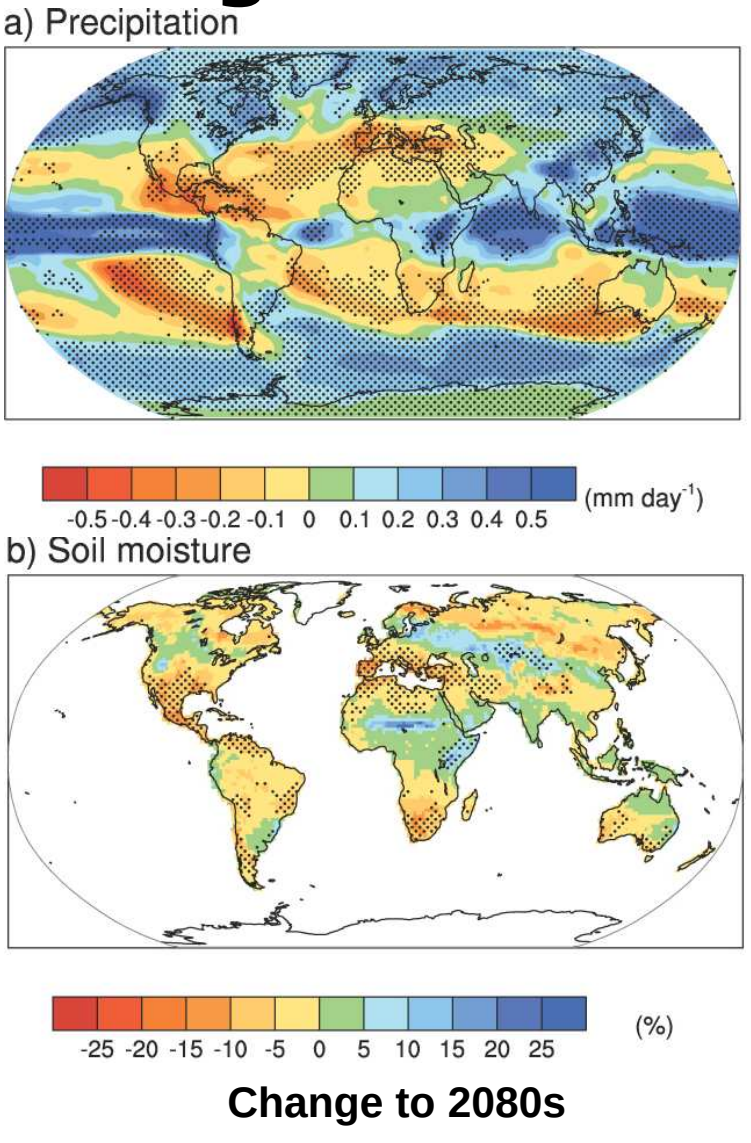
- Small Islands
  - High exposure of populations & infrastructure to risk of sea level rise & storm surge
  - Reduction in average rainfall is very likely to reduce the size of the freshwater lens

- Asian megadeltas
  - High exposure of populations & infrastructure to risk of sea level rise & storm surge



Impacts of climate change : Water

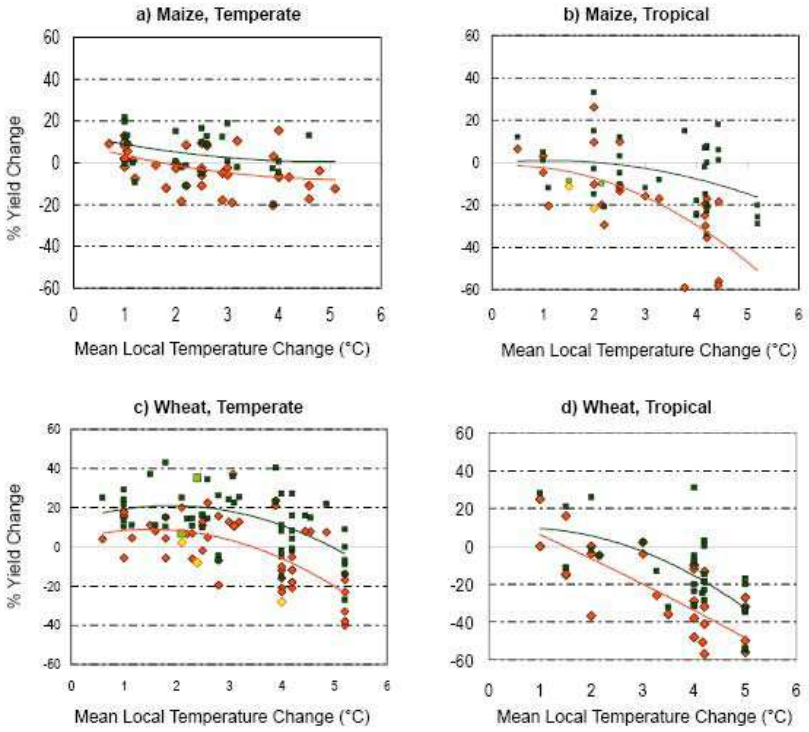
- Runoff and water availability
  - Very likely to increase at higher latitudes and in some wet tropics. Decrease over much of mid-latitudes and dry tropics
- Droughts and floods
  - Drought-affected areas likely to increase, extreme precipitation events also augmenting flood risk
- Cryosphere
  - Water volumes stored in glaciers and snow cover very likely to decline



Change to 2080s

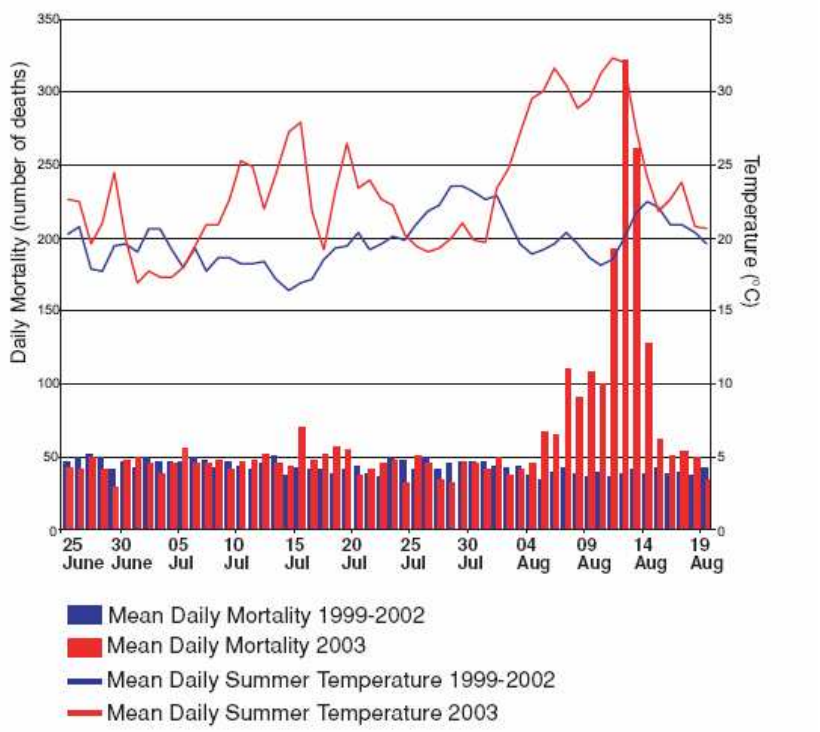
Impacts of climate change: Food

- Crop yield
  - Likely to increase at higher latitudes for global average temperature increases of 1 to 3°C, then decrease
  - At lower latitudes especially dry tropics likely to decrease
- Global production
  - Likely to increase up to about 3°C, then decrease
- Droughts and floods
  - Negative impacts, especially subsistence sectors at low latitudes



Impacts of climate change: Health

- Indirect effects
  - Projected climate change likely to affect millions of people, particularly those with low adaptive capacity through malnutrition and consequent disorders
- Malaria
  - Mixed effects due to expansion and contraction of range
- Beneficial effects
  - Some benefits to health such as fewer deaths from cold exposure

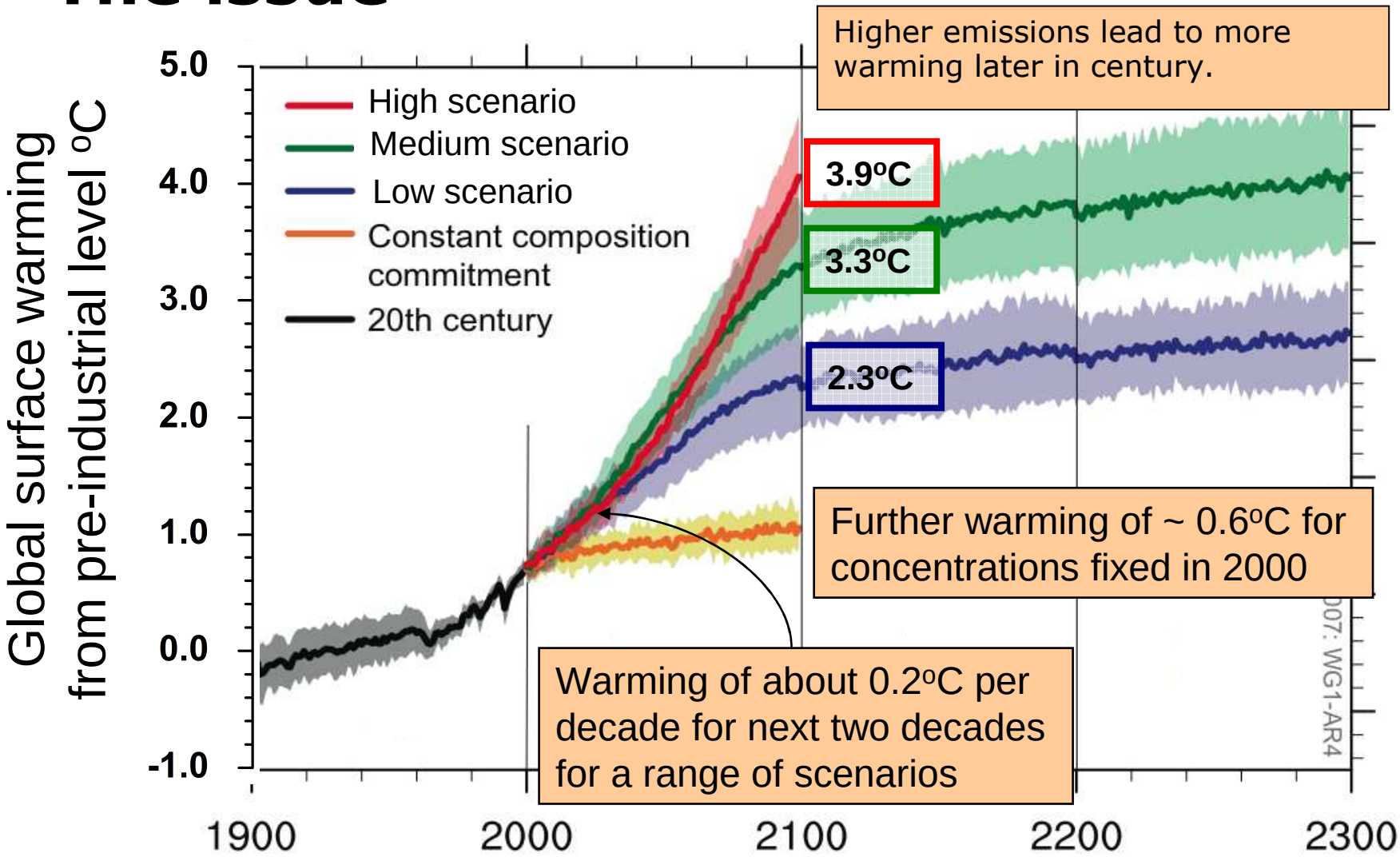


Vulnerable regions/sectors

Relative vulnerability of coastal deltas ro sea level trends to 2050

- Ecosystems
  - Tundra
  - Boreal forests
  - Mountain areas
  - Coasts
  - Coral reefs
  - Sea ice biomes
- Coasts
  - Low lying coasts due to threat of sea-level rise
- Water Resources
  - Middle and dry low-latitude regions due to decrease in rainfall and higher rates of evapotranspiration

The issue



Adapted from IPCC, WG I 2007

The Issue

- Currently above pre-industrial temperatures by … ~0.7°C
- Committed warming as oceans catch up with atmosphere … >0.6°C
  (IPCC, WG I, 2007)
- Minimum warming while energy infra-structure changes … ~0.8°C

- *(van Vuuren et al, PNAS, 2008)*

>2.1°C

Urgency

First we have to change our energy technology and infrastructure.

20 – 40 years

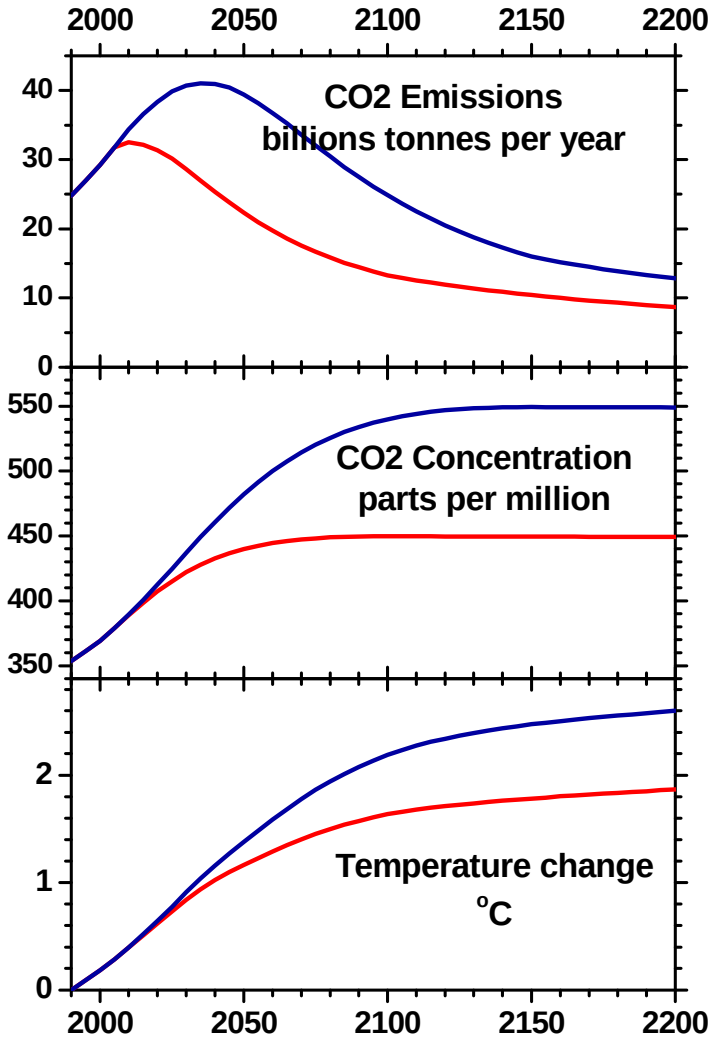
Then CO_2 emissions peak and decline.

30 + years

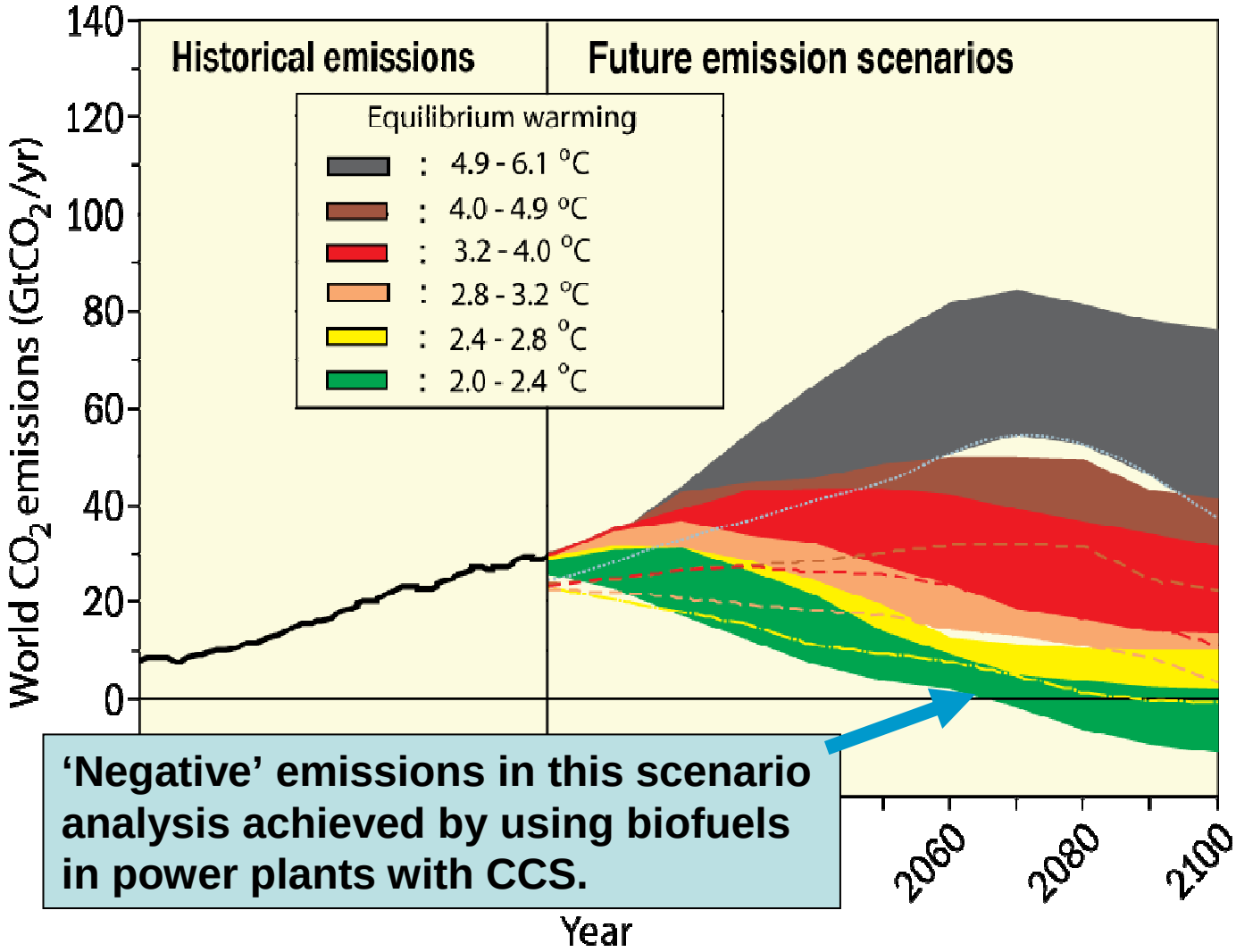
Then CO_2 in the atmosphere stabilises.

About 30 years

Then further warming stops.



Scenarios



2°C target requires keeping to bottom end of green range

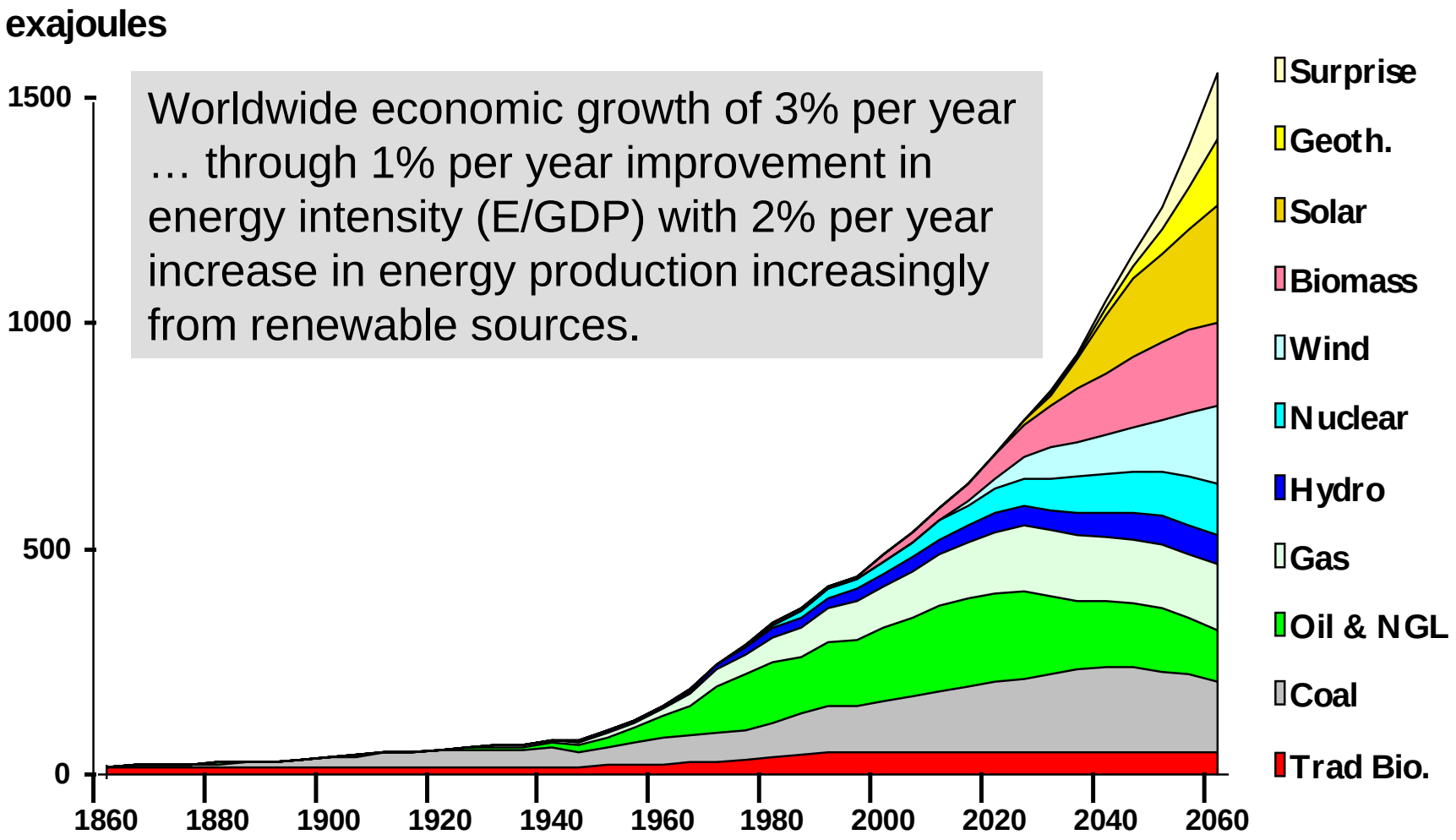
Global emissions need to peak by about 2020

And require negative emissions late in the century

'Negative' emissions in this scenario analysis achieved by using biofuels in power plants with CCS.

Adapted from IPCC, WG III, 2007

Shell International Ltd.
Sustained Growth Scenario from 1990s



Worldwide economic growth of 3% per year … through 1% per year improvement in energy intensity (E/GDP) with 2% per year increase in energy production increasingly from renewable sources.

IPCC Scenarios

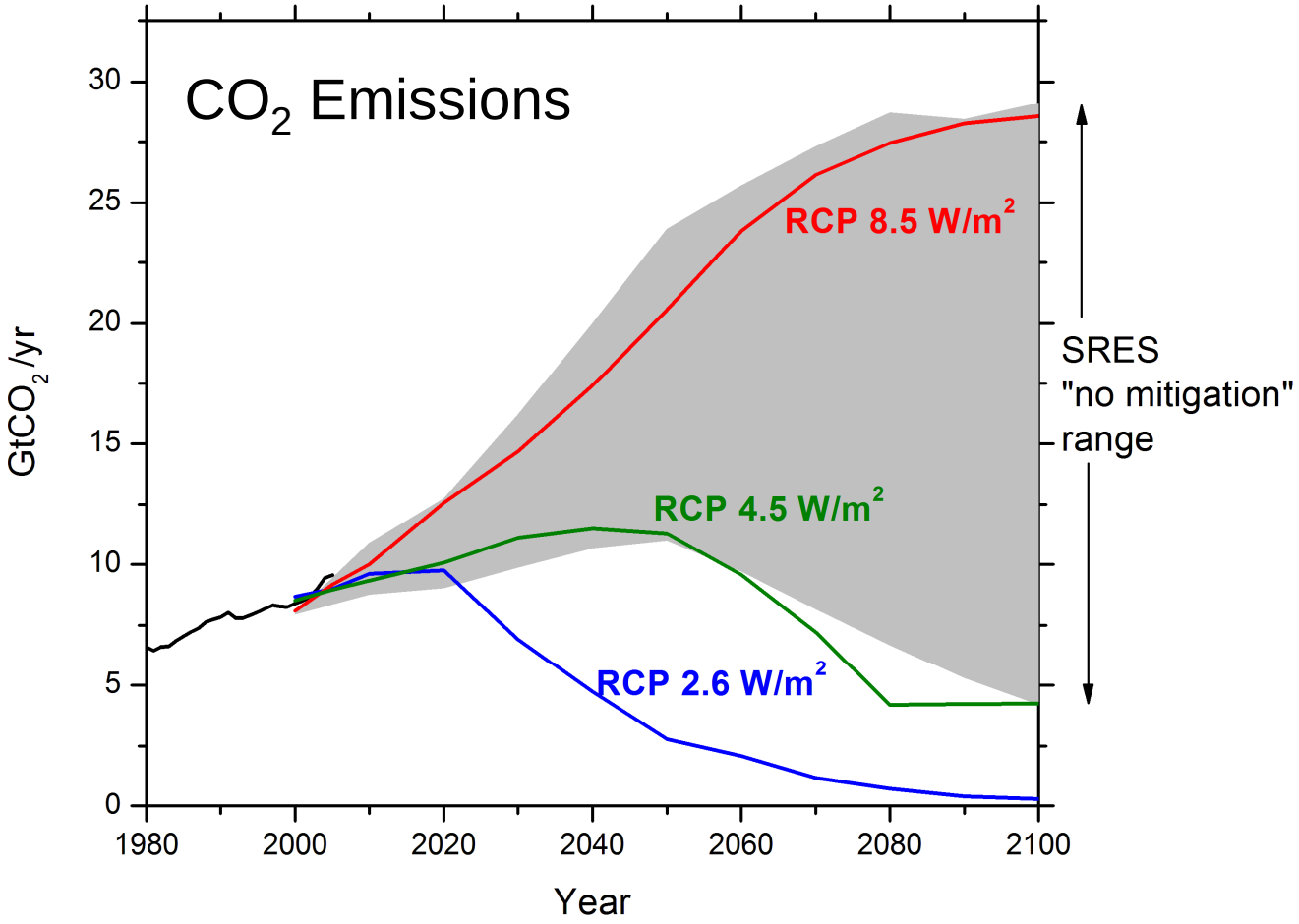
- Experts said the lowest emission scenario that is well established in the literature leads to 2.4°C warming.
- Policymakers said we need to achieve 2°C!
- Led to significant debate as t[illegible] include a 2°C scenario in t[illegible] Assessment.
- Waiting now to see of other [illegible] can confirm that biofuel ener[illegible] right magnitude.

"Overshoot scenarios":
A polite way of saying
we can't avoid dangerous climate change, … or

… Of passing the problem to our grandchildren to solve.

IPCC Scenarios

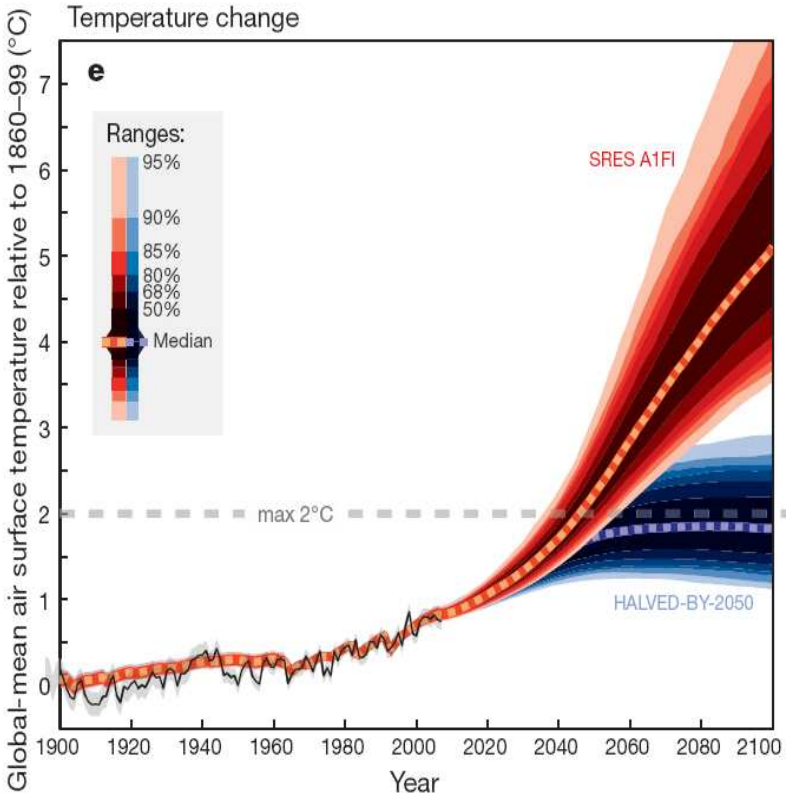
- Scenario development groups have discussed options for next IPCC assessment at great length.
- Decisions made public in May 2009.
- Climate modellers want extensions into following two centuries.



The next IPCC assessment

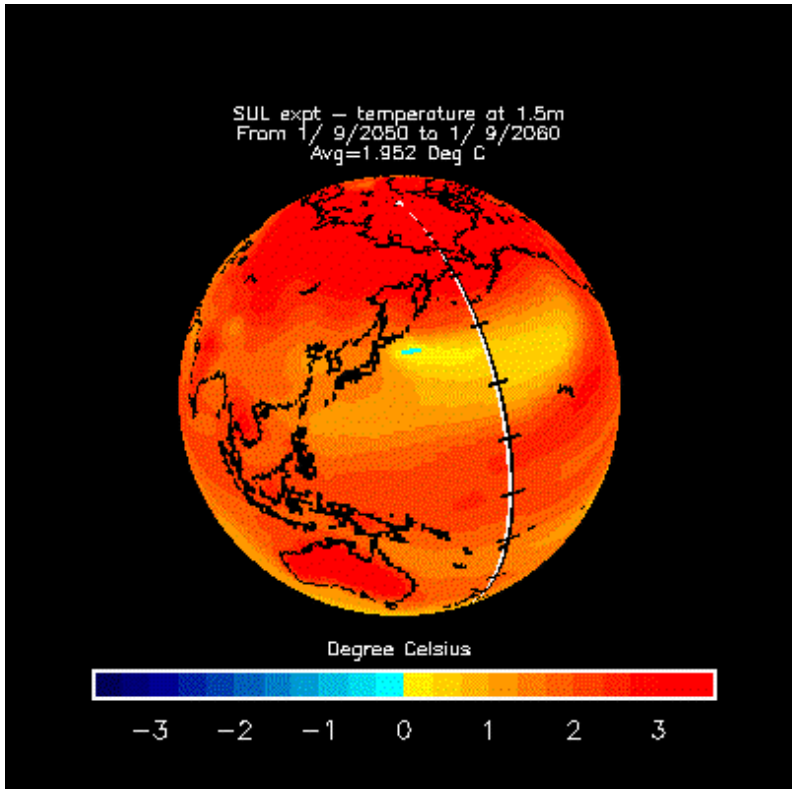
- Uncertainty range in warming for a given scenario still large.

- This from a paper by Malte Meinshausen et al in Nature (30 April 2009) arguing that emissions in the first half of this century are critical to outcomes.



Concluding remarks

- Increases in greenhouse gases are causing the climate system to warm
- Observations show unequivocal warming of the climate system
- New Zealand temperatures have warmed 0.8°C over 100 years
- Mean projections give 2 to 2.5°C for the 2090s



Concluding remarks

- Impacts of warming include massive reduction in ice volumes, melting of Arctic permafrost, earlier emergence of insects, birds and plants in spring, retreat of New Zealand glaciers and southward spread of agriculture
- Sea level rise likely to be much more than projected