An Update on Climate-Change Science and Its Implications for Action

John P. Holdren

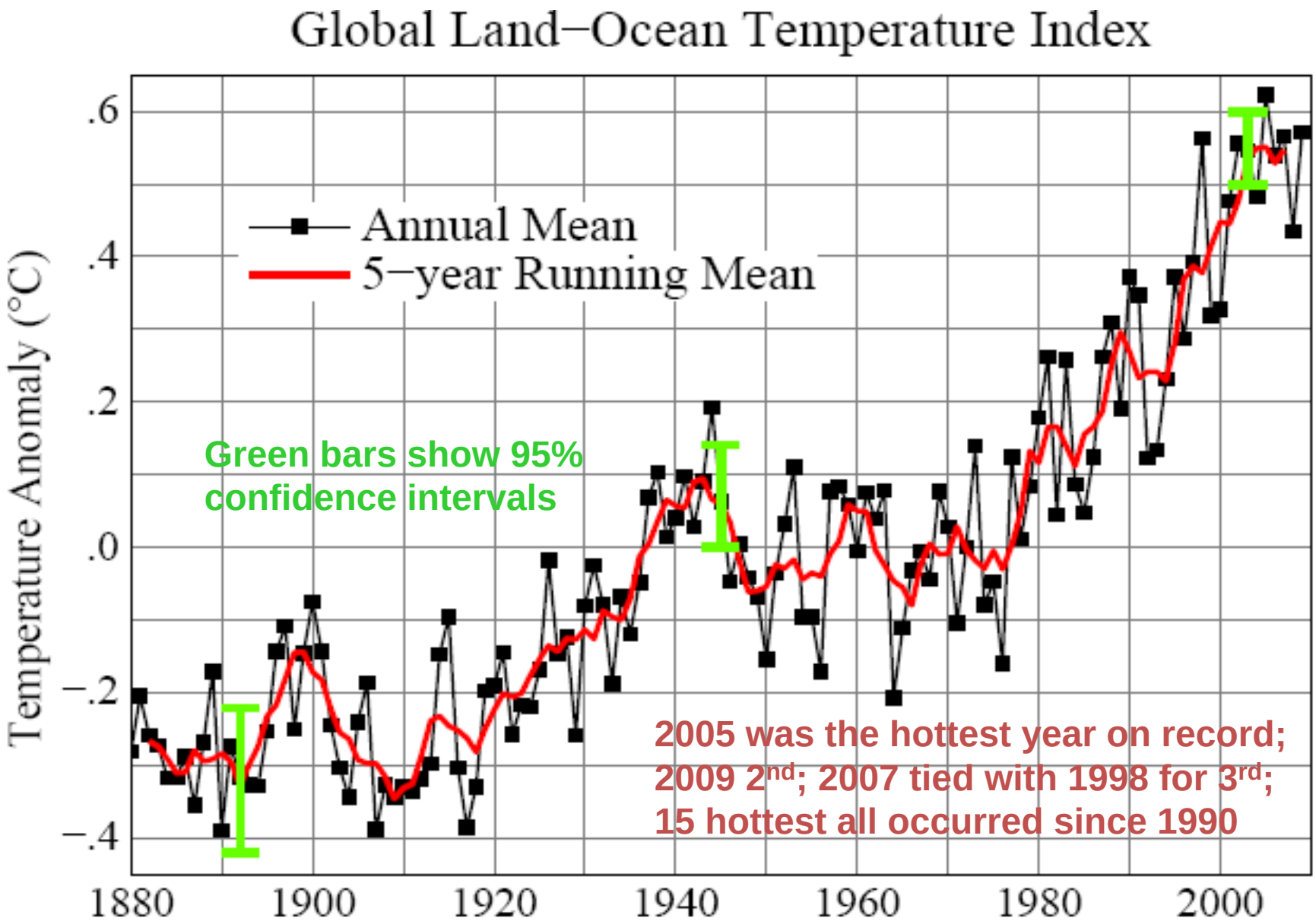
Assistant to the President for Science and Technology
and Director, Office of Science and Technology Policy
Executive Office of the President of the United States

Keynote Speech

US-China Climate Change Science Seminar

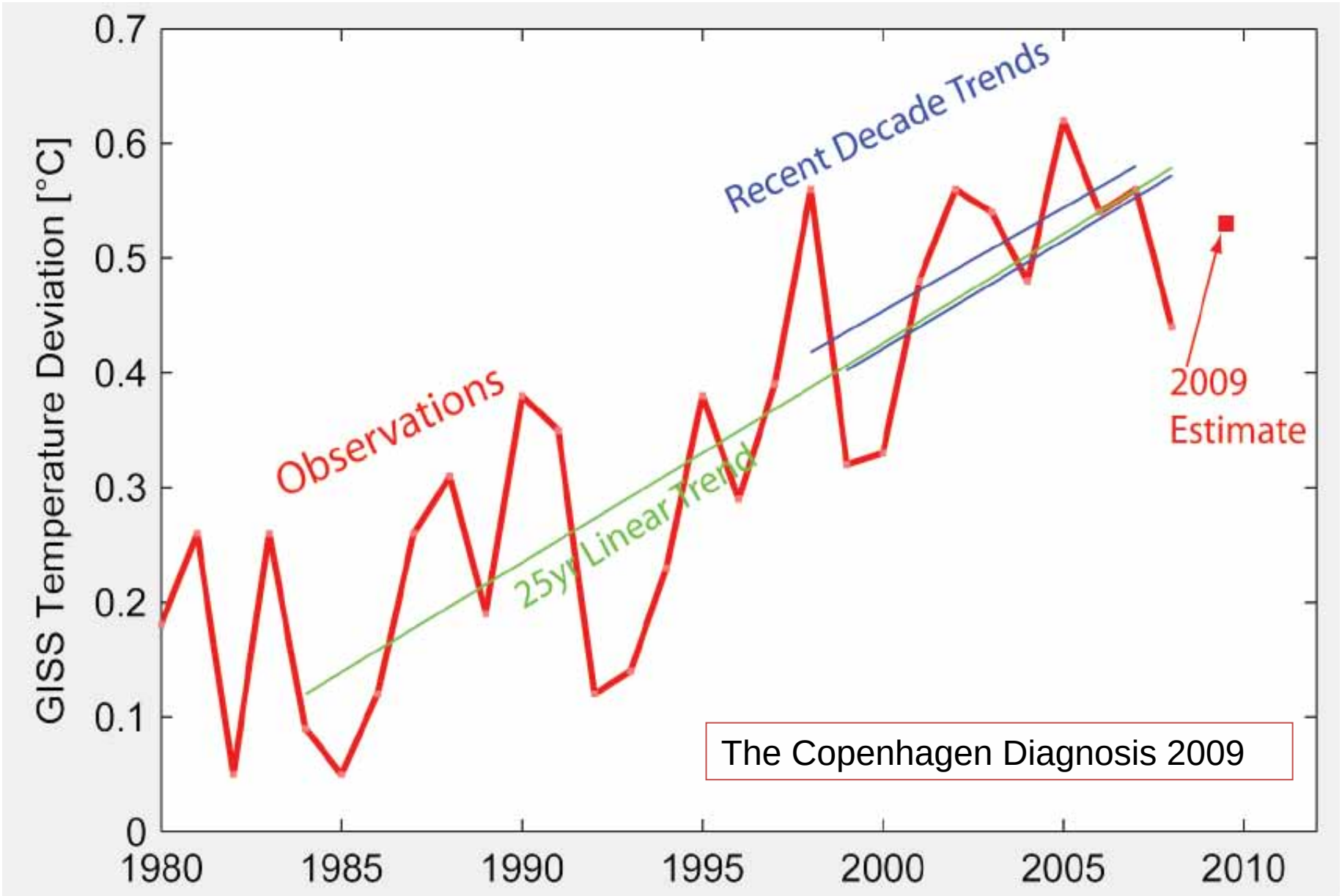
Tsinghua University • Beijing • 26 May 2010

The Earth is still warming: the thermometer record



http://data.giss.nasa.gov/gistemp/graphs/

The heating is not slowing signficantly



Average temperature isn't the whole story

Climate = weather patterns, meaning averages, extremes, timing, spatial distribution of…

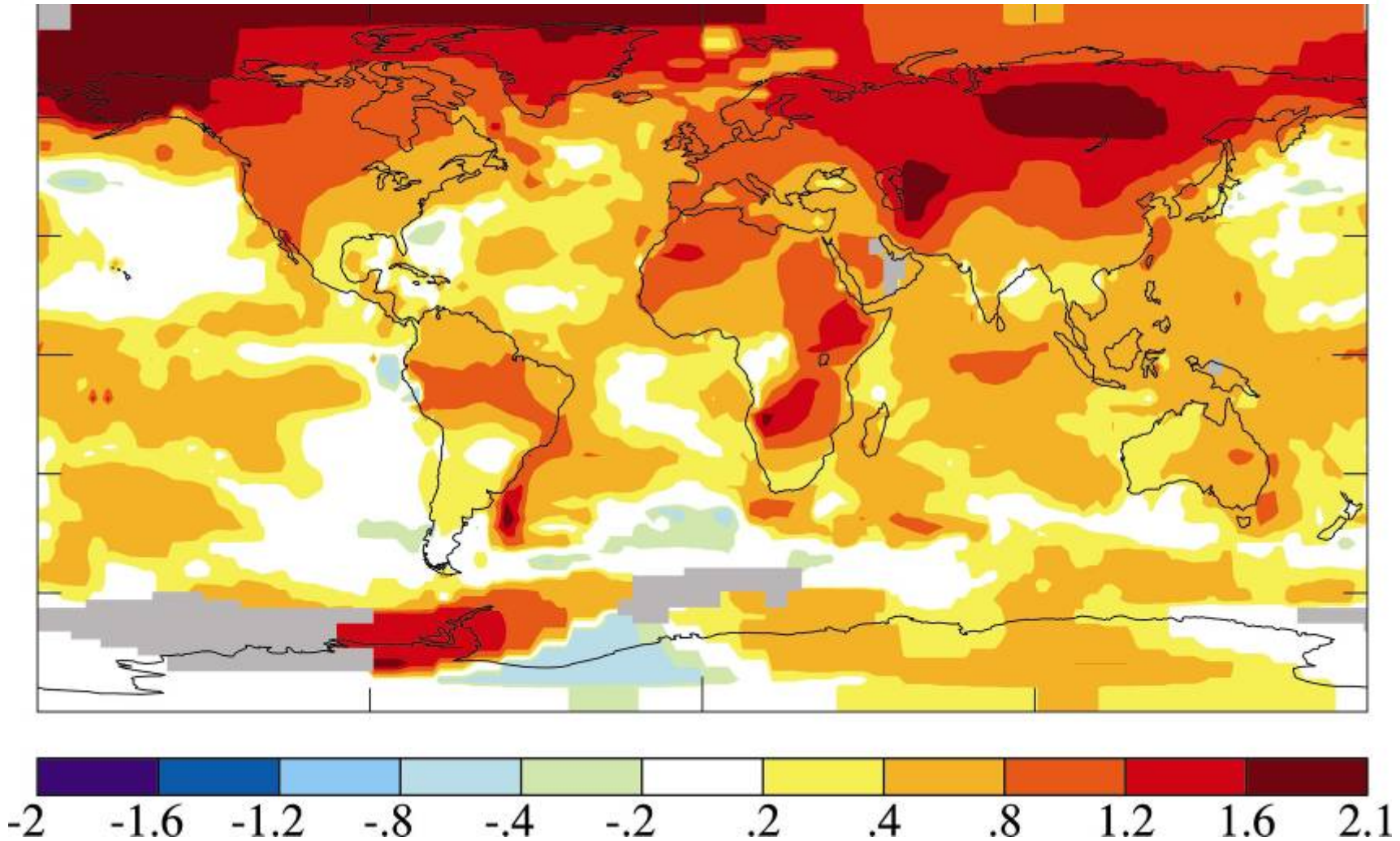
- hot & cold
- cloudy & clear
- humid & dry
- drizzles & downpours
- snowfall, snowpack, & snowmelt
- breezes, blizzards, tornadoes, & typhoons

Climate change means disruption of the patterns.

Global average temperature is just an index of the state of the global climate as expressed in these patterns. Small changes in the index → big changes in the patterns.

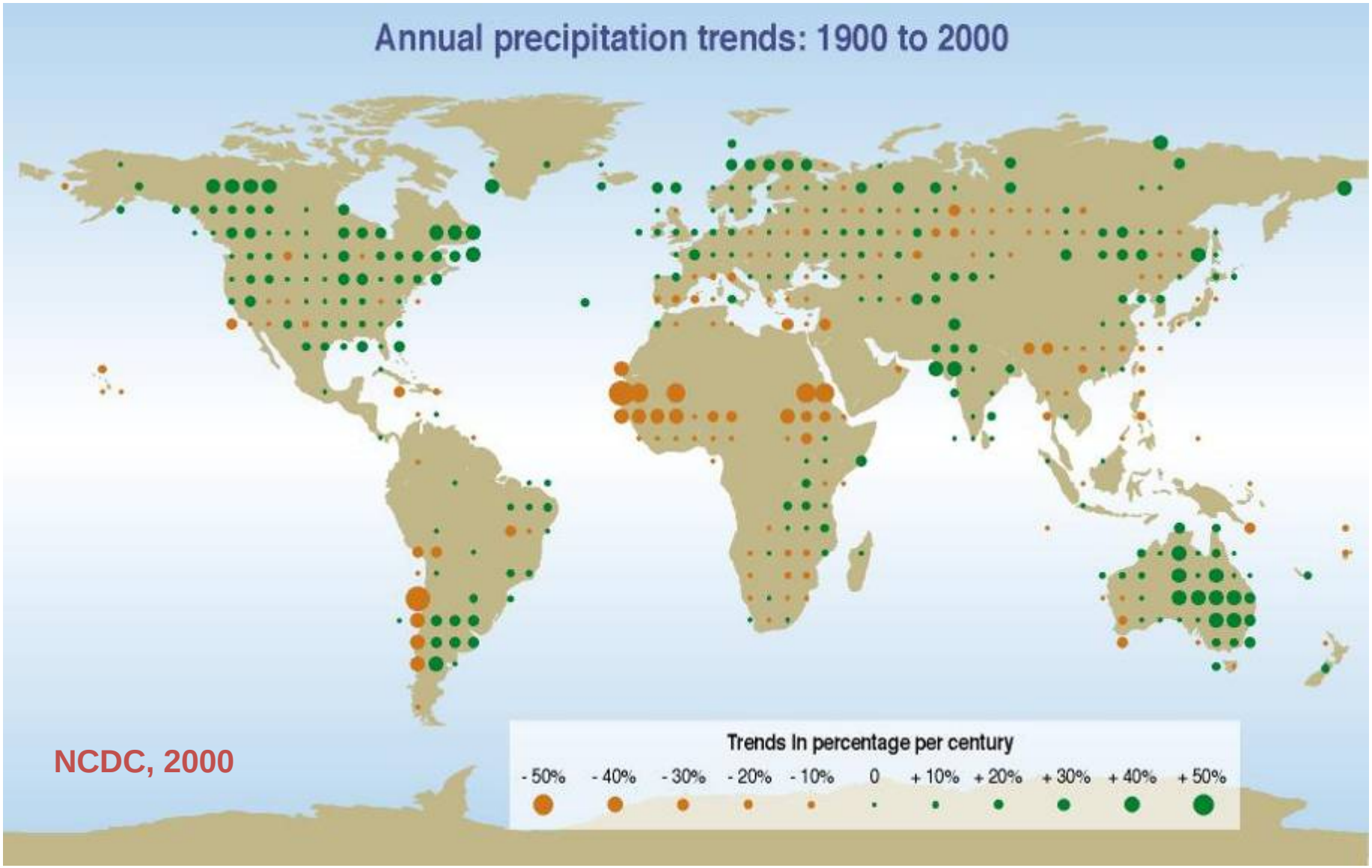
The heating is not uniform geographically

Surface T in 2001-2005 *vs* 1951-80, averaging 0.53ºC increase



J. Hansen et al., *PNAS 103*: 14288-293 (2006)

Other climate indicators are changing apace



This too is not uniform; most places getting wetter, some drier.

Indicators: mountain glaciers are shrinking

Indicators: coastal glaciers are receding

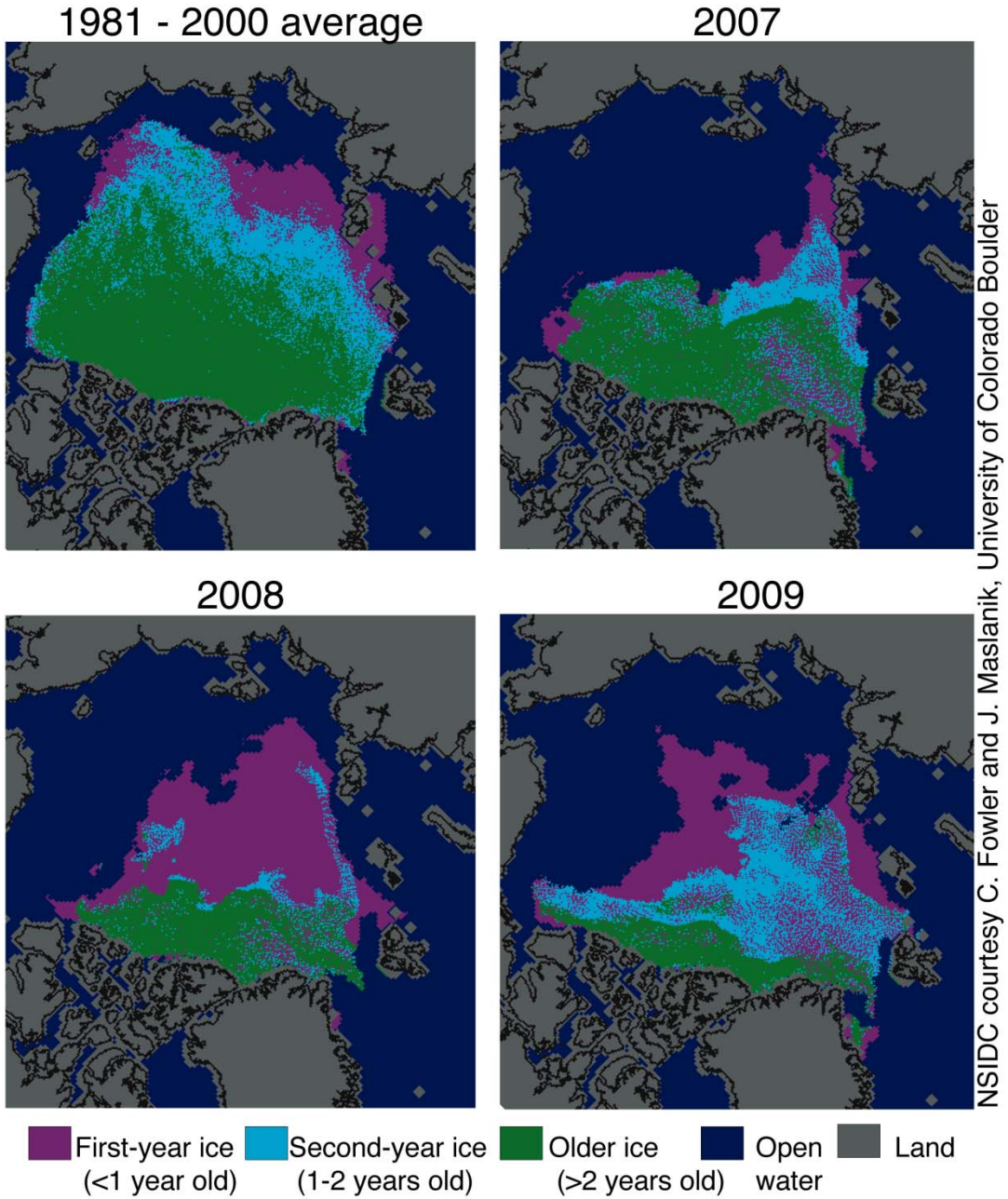
Muir Glacier, Alaska

August 1941

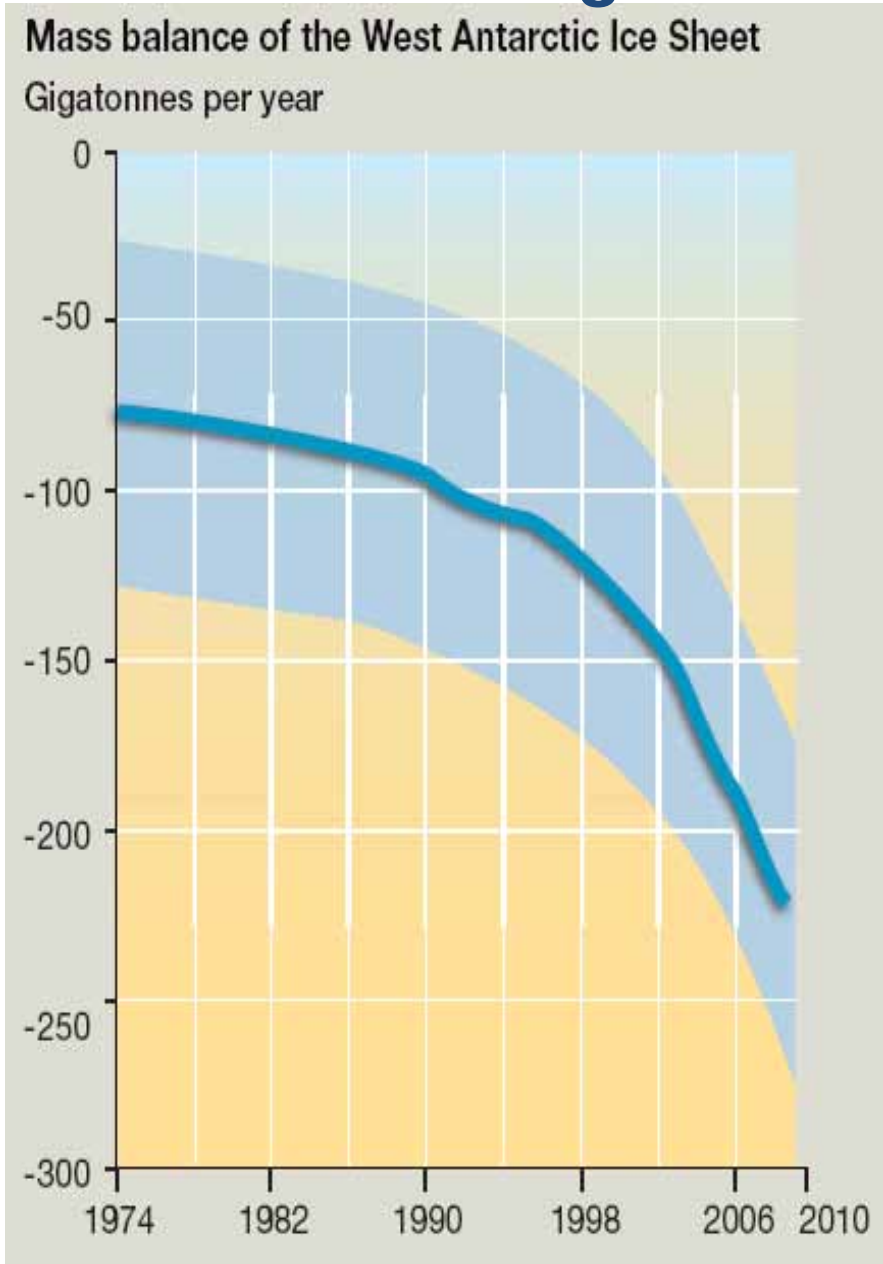
August 2004

NSIDC/WDC for Glaciology, Boulder, compiler. 2002, updated 2006. *Online glacier photograph database.* Boulder, CO: National Snow and Ice Data Center.

Indicators: Arctic sea ice shrinking & thinning

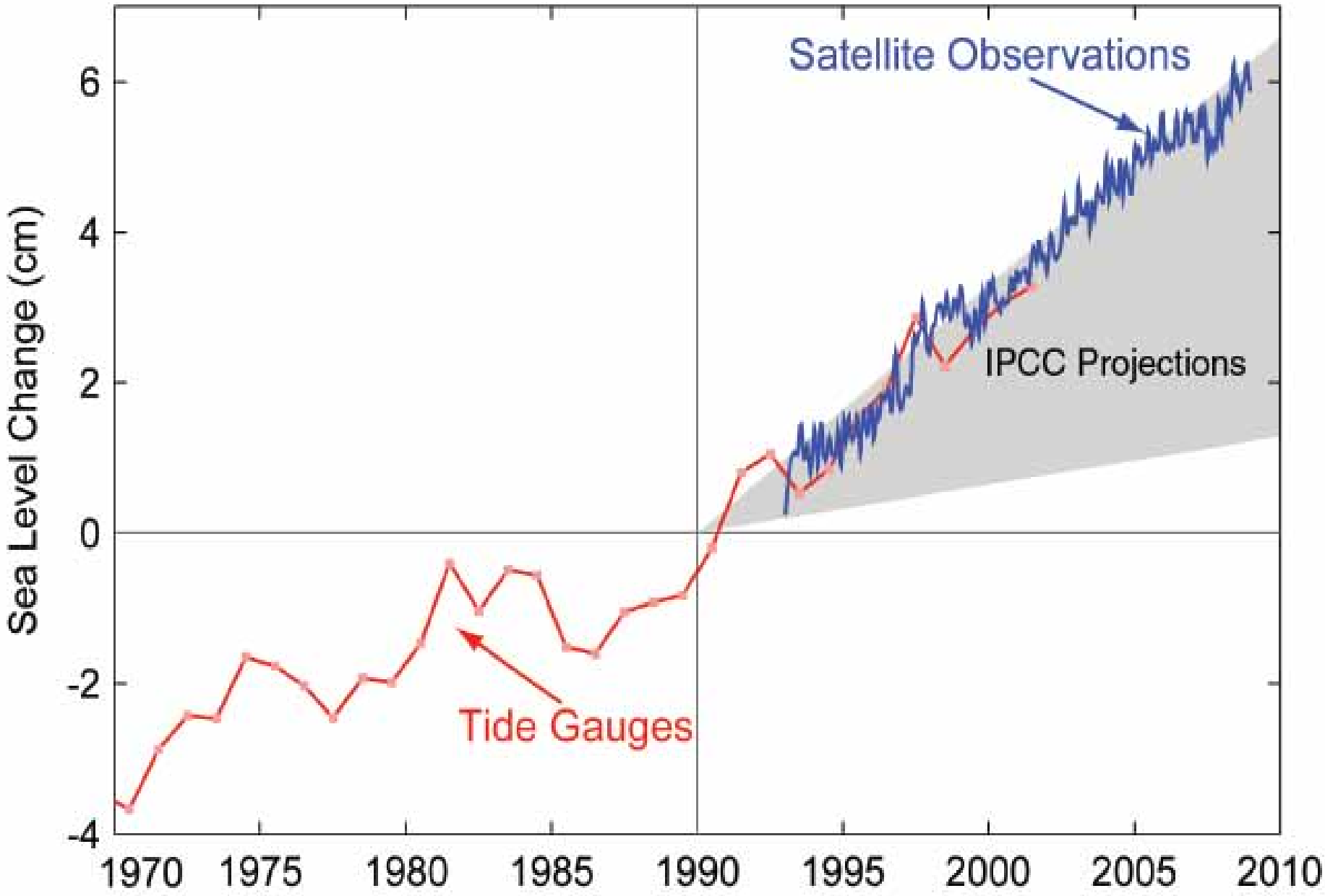


Indicators: Greenland & Antarctic ice losing mass



The Copenhagen Diagnosis, 2009

Indicators: sea level is rising



Humans are the main cause

Human vs natural influences 1750-2005 (watts/m^2)

Human emissions leading to increases in…	
atmospheric carbon dioxide	+ 1.7
methane, nitrous oxide, CFCs	+ 1.0
net ozone (troposphere ↑ , stratosphere ↓)	+ 0.3
absorptive particles (soot)	+ 0.3
reflective particles (sulfates, etc.)	- 0.7
indirect (cloud forming) effect of particles	- 0.7
Human land-use change increasing reflectivity	- 0.2
Natural changes in sunlight reaching Earth	+ 0.1

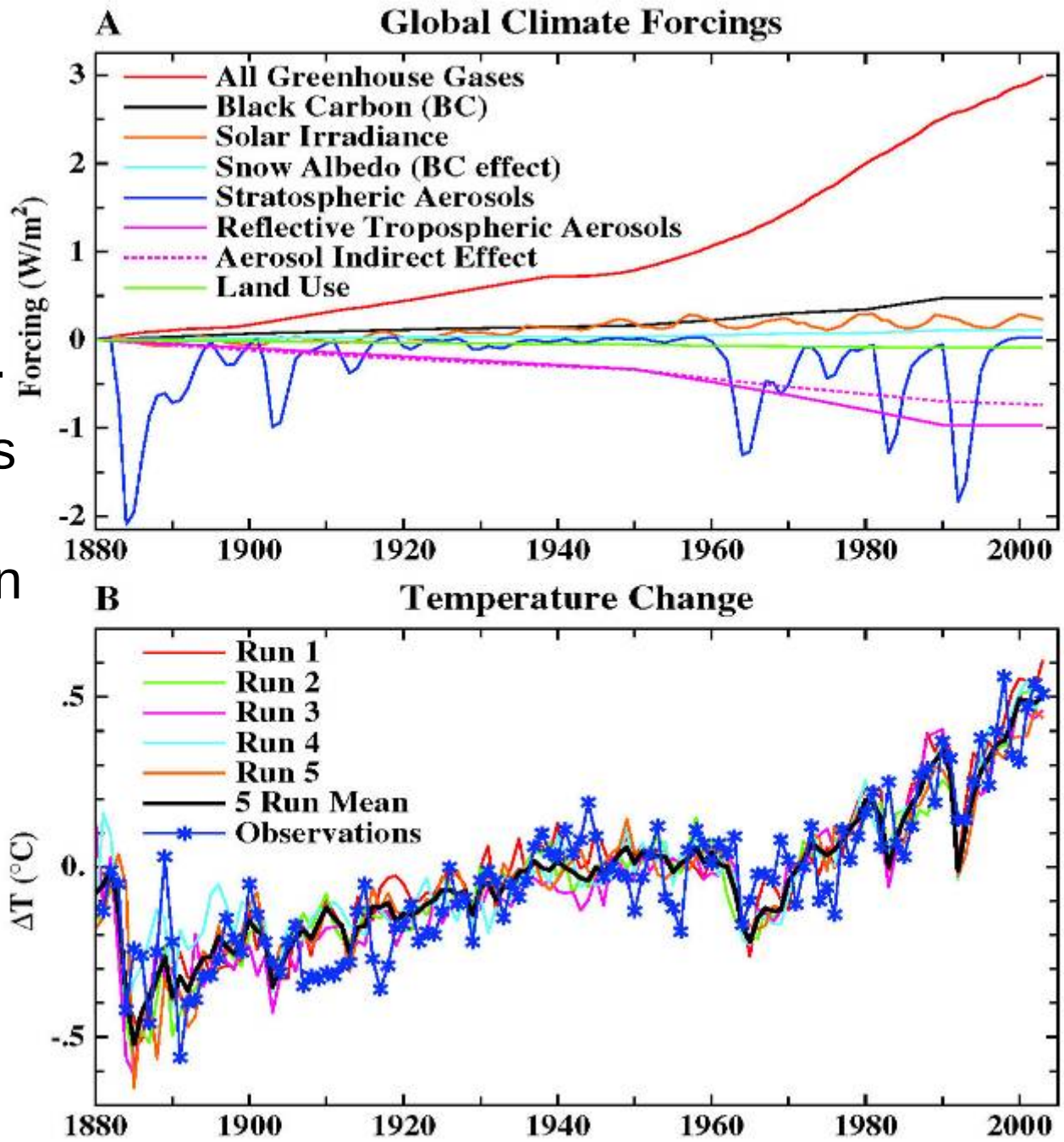
The warming influence of anthropogenic GHG and absorbing particles is ~30x the warming influence of the estimated change in input from the Sun.

IPCC AR4, WG1 SPM, 2007

Humans are the main cause (cont)

Top panel shows best estimates of human & natural forcings 1880-2005.

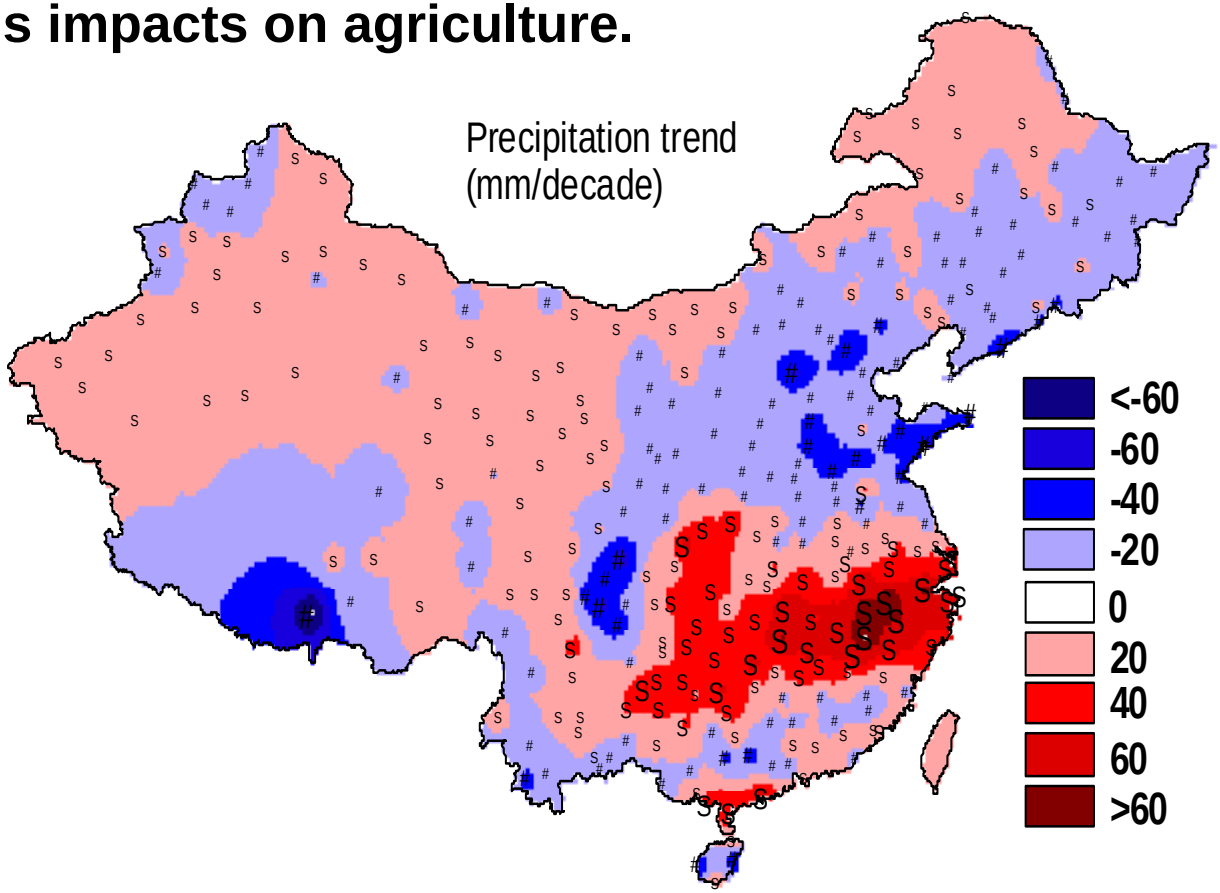
Bottom panel shows that state-of-the-art climate model, when fed these forcings, reproduces almost perfectly the last 125 years of observed temperatures.



Source: Hansen et al., *Science 308*, 1431, 2005.

Harm is already occurring: China precipitation

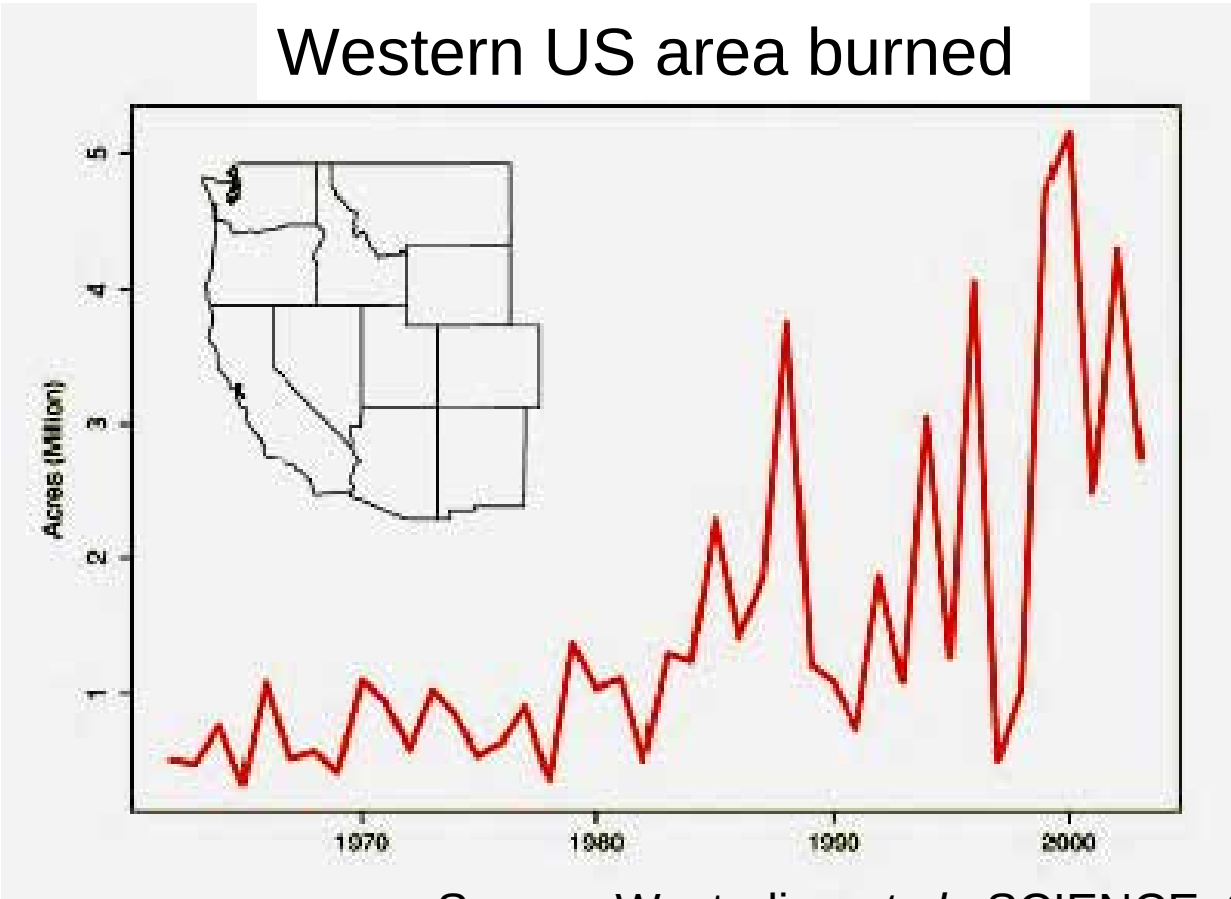
30-year weakening of East-Asia monsoon – attributed to global climate change -- has meant less moisture flow South to North, producing increased flooding in South, drought in North, with serious impacts on agriculture.



Qi Ye, Tsinghua University, May 2006

Harm is already occurring: US wildfires

Wildfires in the Western USA have increased 6-fold in the last 30 years. Similar trends are evident in other fire-prone regions.



Source: Westerling *et al*., SCIENCE, 2006

Harm is already occurring: pest outbreaks

Pine bark beetles, with a longer breeding season courtesy of warming, devastate trees weakened by heat & drought in Colorado

USGCRP 2009

Harm is already occurring: Melting permafrost

Norwegian Polar Institute, 2009

Harm is already occurring: coastal erosion

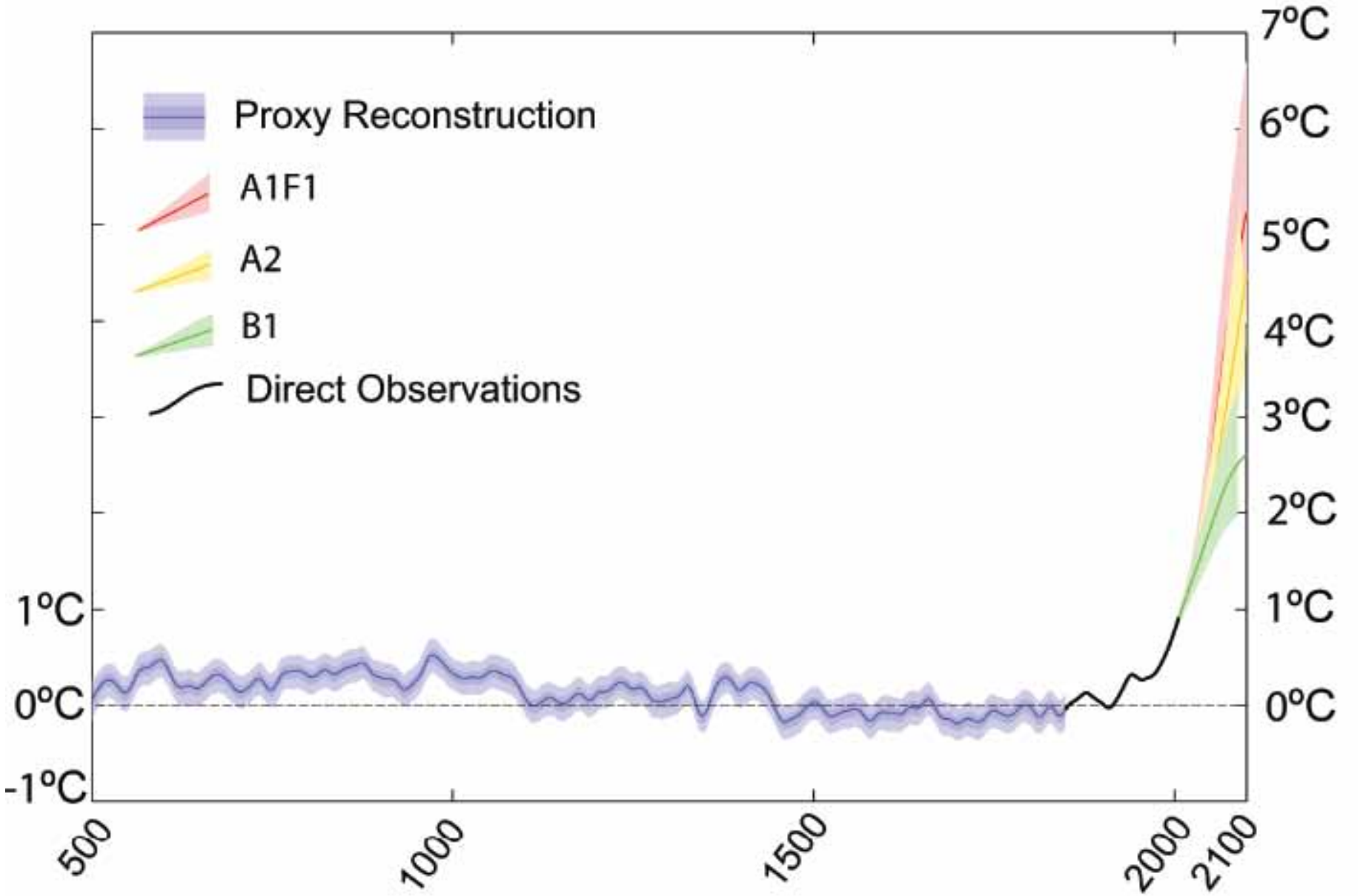
Harm is already occurring widely

Worldwide we're seeing, variously, increases in

- floods
- wildfires
- droughts
- heat waves
- pest outbreaks
- coral bleaching events
- power of typhoons & hurricanes
- geographic range of tropical pathogens

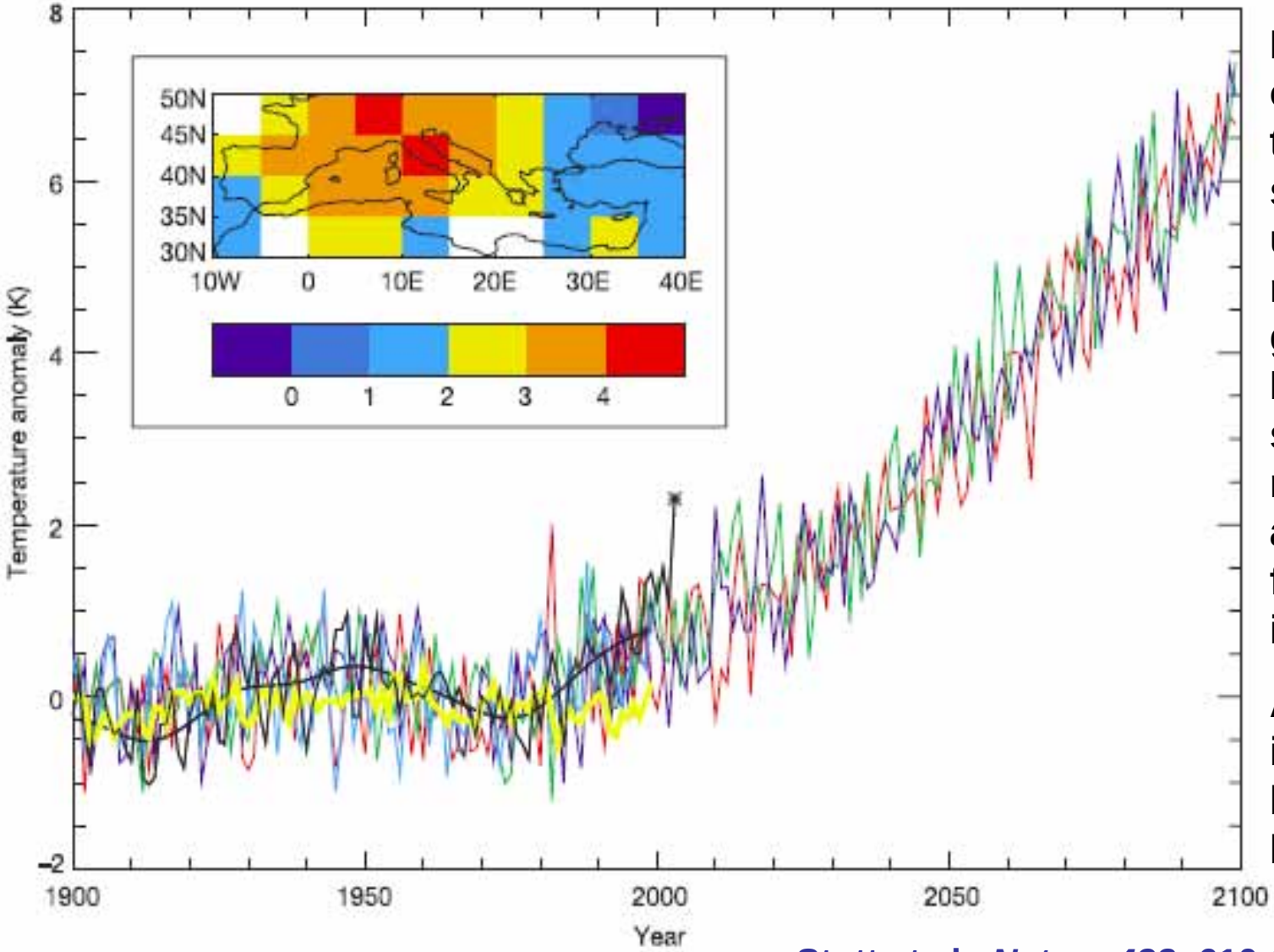
All plausibly linked to climate change by theory, models, observed "fingerprints"

Under business as usual, more harm is coming



More harm is coming: Heat waves

Extreme heat waves in Europe, already 2X more frequent because of global heating, will be "normal" in mid-range scenario by 2050



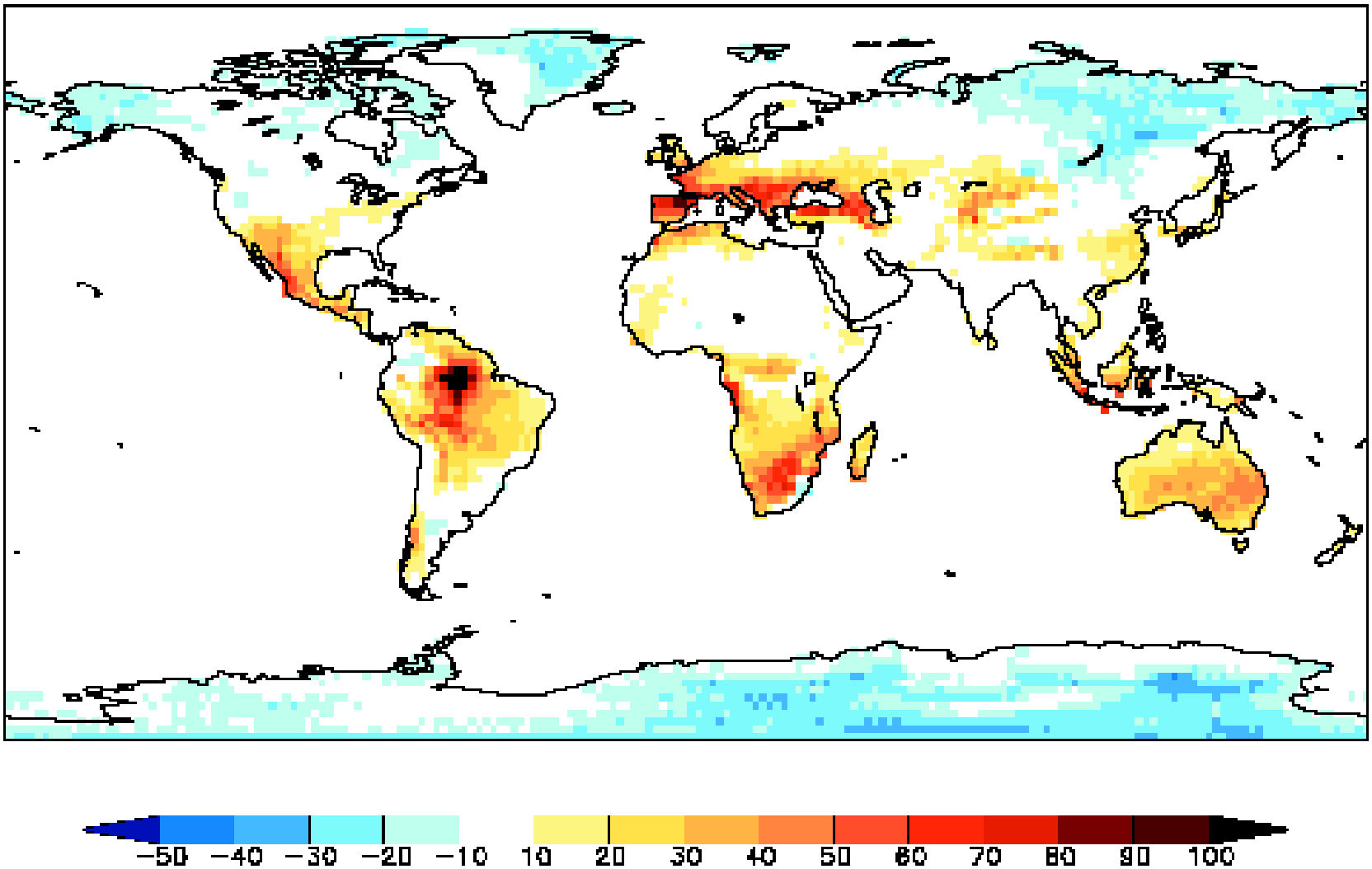
Black lines are observed temps, smoothed & unsmoothed; red, blue, & green lines are Hadley Centre simulations w natural & anthropogenic forcing; yellow is natural only.

Asterisk and inset show 2003 heat wave that killed 35,000.

Stott et al., *Nature 432*: 610-613 (2004)

More harm is coming: droughts

Drought projections for IPCC‘s A1B scenario



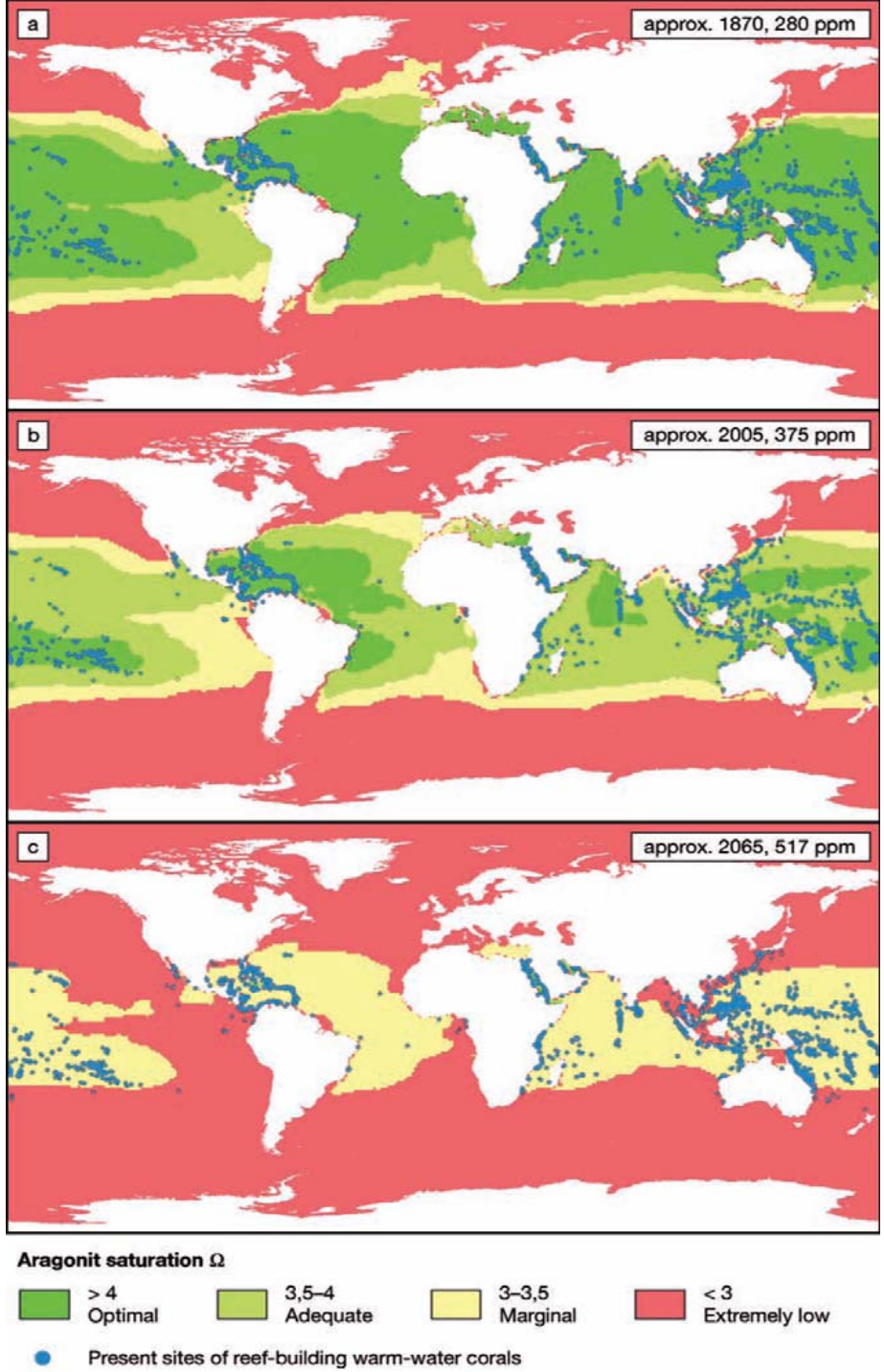
Percentage change in average duration of longest dry period, 30-year average for 2071-2100 compared to that for 1961-1990.

More harm is coming: acidifying the oceans

About 1/3 of CO_2 added to atmosphere is quickly taken up by the surface layer of the oceans (top 80 meters).

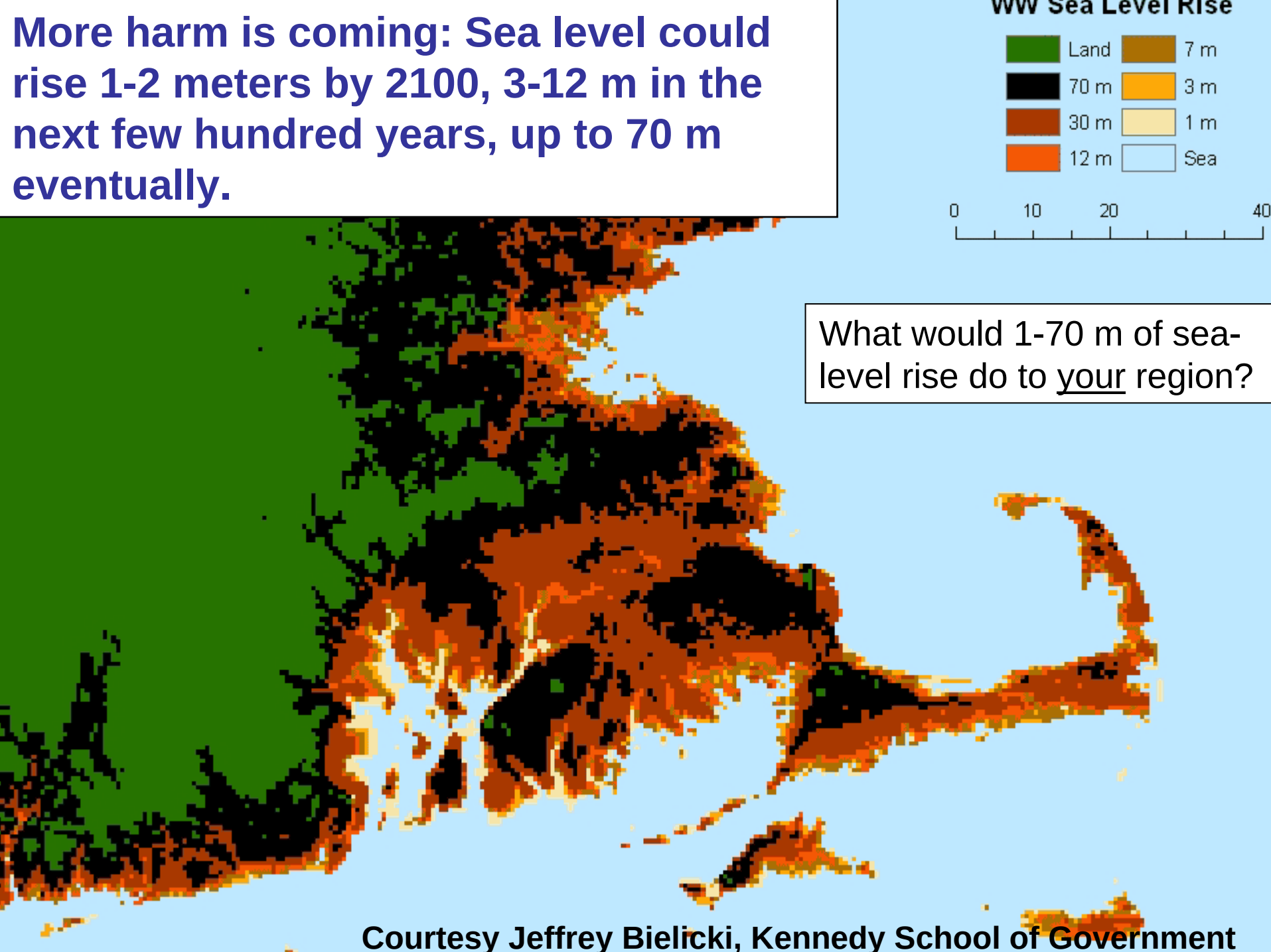
This lowers pH as dissolution of CO_2 forms weak carbonic acid ($H_2O + CO_2 \rightarrow H_2CO_3$).

Increased acidity lowers the availability of $CaCO_3$ to organisms that use it for forming their shells & skeletons, including corals.



Steffen et al., 2004

More harm is coming: Sea level could rise 1-2 meters by 2100, 3-12 m in the next few hundred years, up to 70 m eventually.



What would 1-70 m of sea-level rise do to <u>your</u> region?

Courtesy Jeffrey Bielicki, Kennedy School of Government

Do recent disclosures about e-mails and IPCC missteps cast doubt on these conclusions?

- E-mails show climate scientists are human, too; more efforts at openness & transparency are warranted

- IPCC missteps show need for increased rigor in adhering to organization's strict review procedures; but errors discovered so far are few & unimportant.

- IPCC isn't the source of scientific understanding of climate, just a messenger. Sources are the global community of climate scientists & mountain of peer-reviewed research they've produced over decades.

Recent disclosures (contined)

- Nothing in e-mails or IPCC controversies rises to a level that would call into question the core understandings about global climate disruption.

- All science is contingent; there are always uncertainties & needs for refinement. And there's always a chance that new observations & analyses will not just refine but overturn previous conclusions.

- But overturning is very unlikely when the body of data & analysis supporting the generally accepted conclusions is extensive & much reviewed.

Recent disclosures (continued)

- Body of data & analysis supporting generally accepted conclusions about climate disruption is immense.
- Because of their relevance to policy choices of great importance, key findings from climate science have been subjected to unprecedentedly extensive peer review.
- It's therefore highly unlikely that new data or insights will alter these findings in a fundamental way.
- Policy makers should not bet the public's welfare against such long odds – i.e., bet that the science is wrong.

What are our options?

- There are only three options:
  - mitigation
  - adaptation
  - suffering
- We're doing all three now & will do more of all three; what's up for grabs is the mix.
- To minimize suffering, we need enough mitigation to avoid an unmanageable degree of climate change & enough adaptation to manage what we don't avoid.
- The mitigation & adaptation measures we need are likely to be far less costly than the suffering that will result from inaction.

Mitigation possibilities include…

(CERTAINLY)

- Reduce emissions of greenhouse gases & soot from the energy sector
- Reduce deforestation & increase reforestation
- Modify agricultural practices to reduce emissions of greenhouse gases & build up soil carbon

(CONCEIVABLY)

- “Scrub” greenhouse gases from the atmosphere technologically (“artificial trees”)
- “Geo-engineering” to create cooling effects offsetting greenhouse heating (white roofs…)

Adaptation possibilities include…

- Changing cropping patterns
- Developing heat-, drought-, and salt-resistant crop varieties
- Strengthening public-health & environmental-engineering defenses against tropical diseases
- Building new water projects for flood control & drought management
- Building dikes and storm-surge barriers against sea-level rise
- Avoiding further development on flood plains & near sea level

Many are “win-win”: They’d make sense in any case.

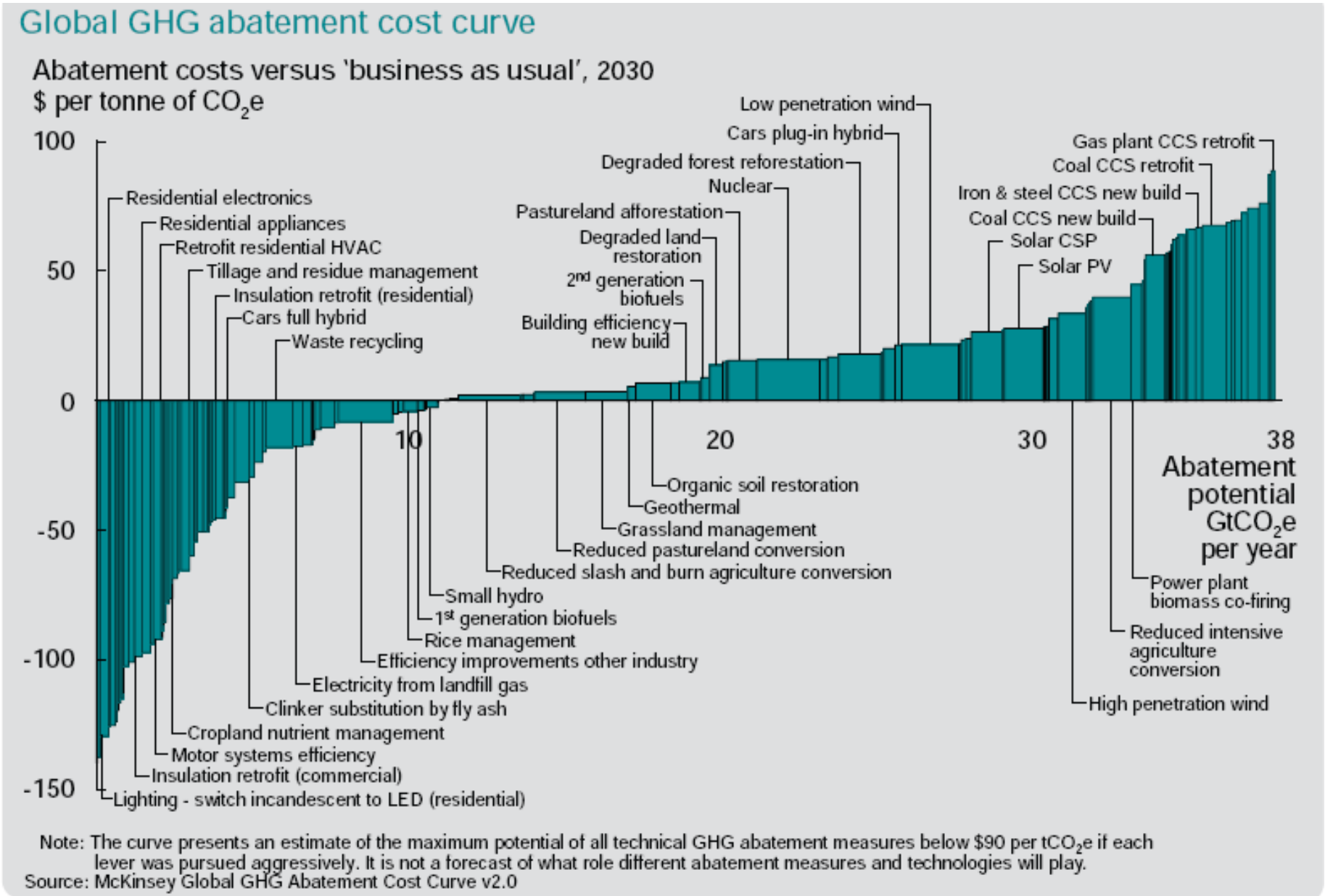
Delaying action is dangerous

- Several “tipping points” into disastrous change are thought to lurk between 1.5ºC and 2.5ºC above pre-industrial T_{avg}, e.g.
  - drastic alteration of ocean currents & thus regional climates
  - destruction of coral reefs & marine food webs by combination of above + heat stress, acidification
  - huge impacts of temperature extremes, droughts, & pest impacts on agriculture and forests
  - methane outpouring from warming northern soils, adding large additional T increases
  - rapid ice-sheet disintegration & sea-level rise

Delaying action is dangerous (continued)

- Limiting ΔT_{avg} to ≤2ºC is now considered by many the most prudent target that's still attainable.
  - EU embraced this target in 2002, G-8 & G-20 in 2009
- Just to have a 50% chance of staying below 2ºC
  - developed-country emissions must peak no later than 2015 and decline rapidly thereafter
  - developing-country emissions must peak no later than 2025 and decline rapidly thereafter.

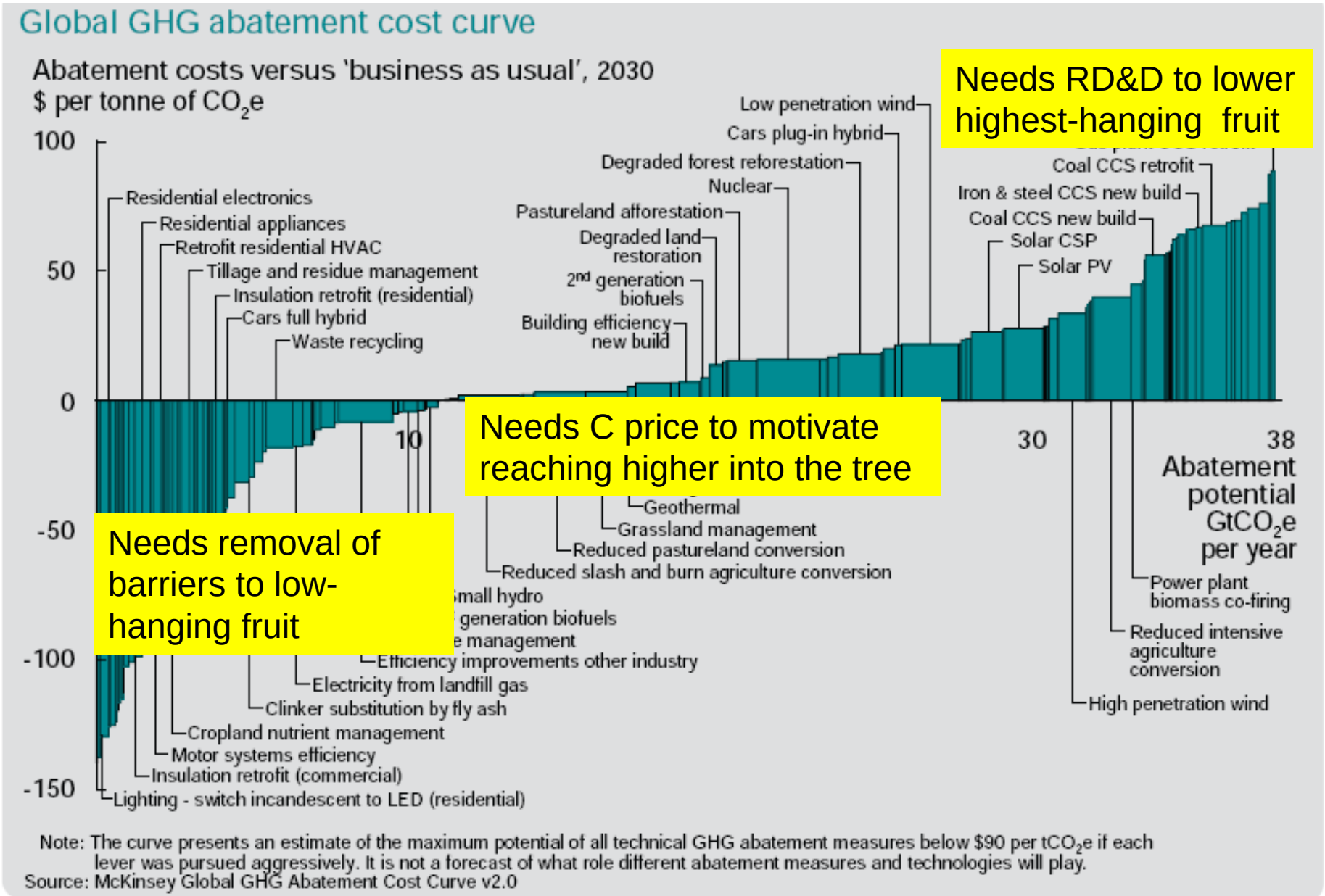
Options and costs for a 2°C emissions trajectory



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below $90 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

Source: McKinsey Global GHG Abatement Cost Curve v2.0

Policy needs for 2°C: the fruit-tree metaphor



Is the needed mitigation affordable?

- Rough calculations
  - Paying an average of $100/tC to avoid half of current world CO_2 emissions would cost $0.5 trillion/yr, under 1% of current GWP (much of it a transfer, not a “loss”).
  - Using McKinsey cost curve for what we’d need to be doing in 2030 to be on 450 ppmv stabilization trajectory shows net cost of only about $0.1 trillion/yr.
- Current econ models say mitigation to stabilize at 450 ppmv CO_2e probably means 2-3% GWP loss in 2030, 2100 (range 1-5%).
- World now spends 2.5% of GWP on defense; USA spends 5% on defense, 2% on env protection

Thank you!