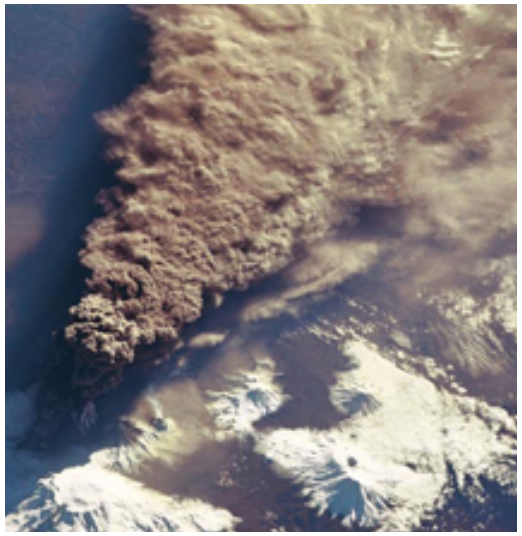
Lecture 1 – Climate Physics Primer



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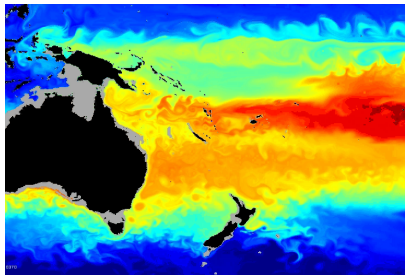
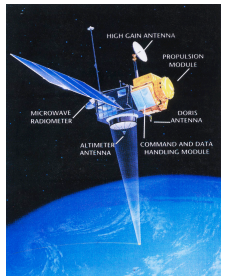
Climate Change Research Centre

Climate Change Research Centre

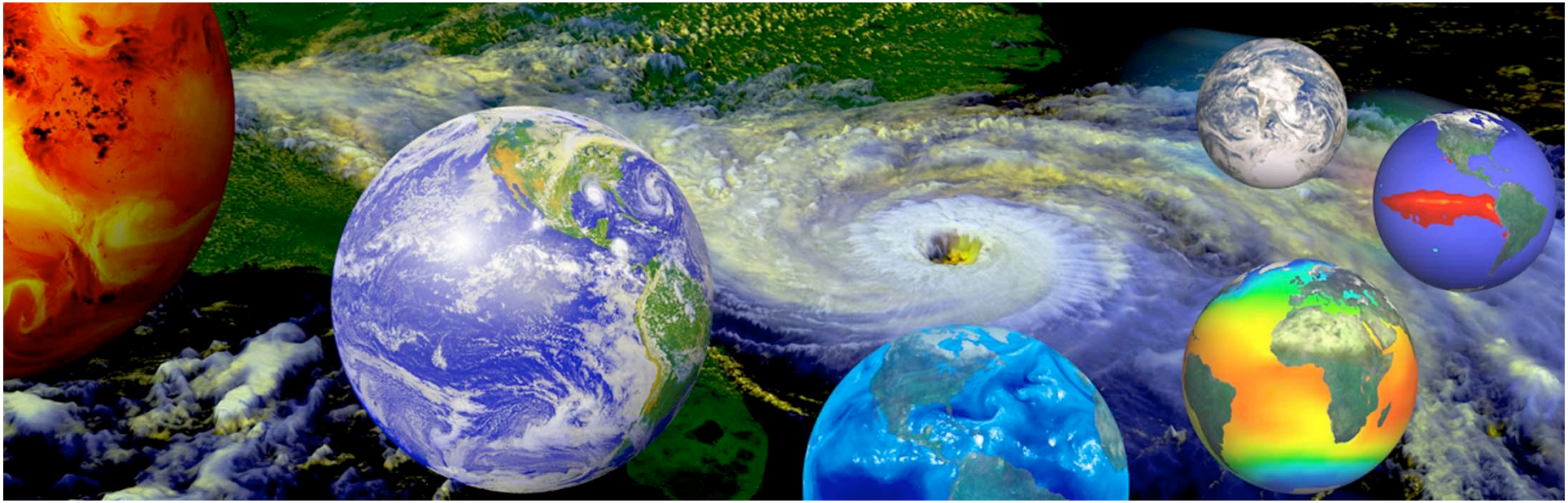
- Coordinating a climate research centre of 50 researchers
- Research: oceans role in climate
- Teaching ocean-atmosphere and climate courses
- Writing articles for scientific journals, reports, the media
- CLIVAR, WCRP, IPCC,…
- Policy statements & documents

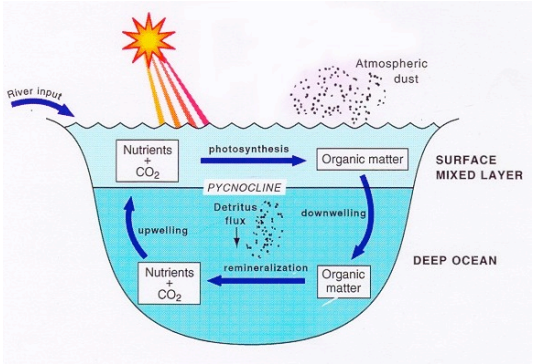
Physical oceanography, meteorology and climate science

The study of the physics, properties, and dynamics of the oceans, atmosphere and coupled climate system

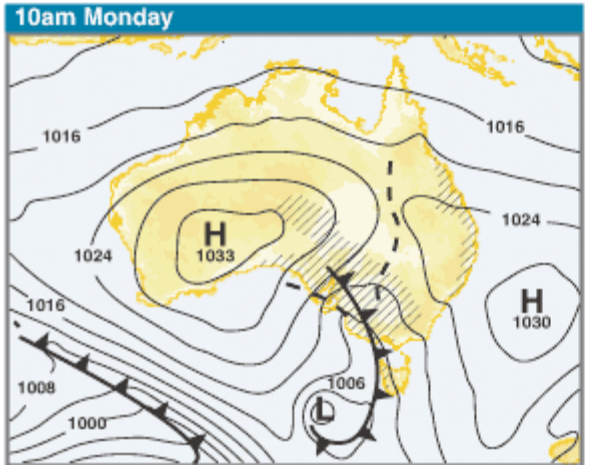


Applications

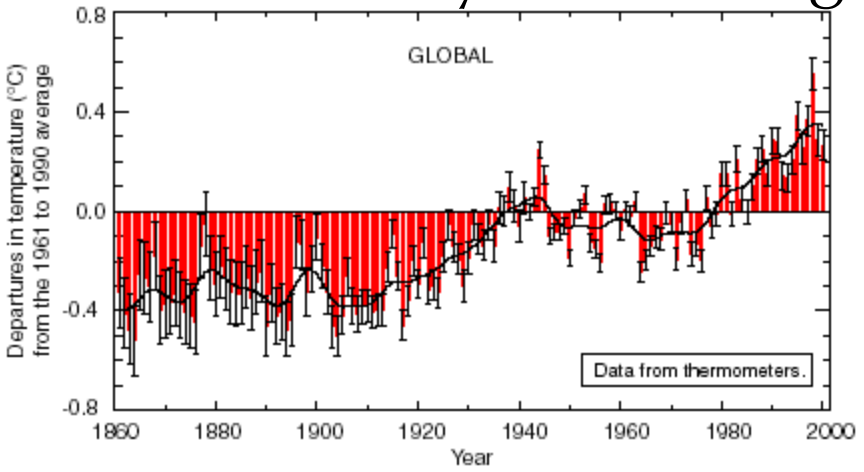
Biology and fisheries



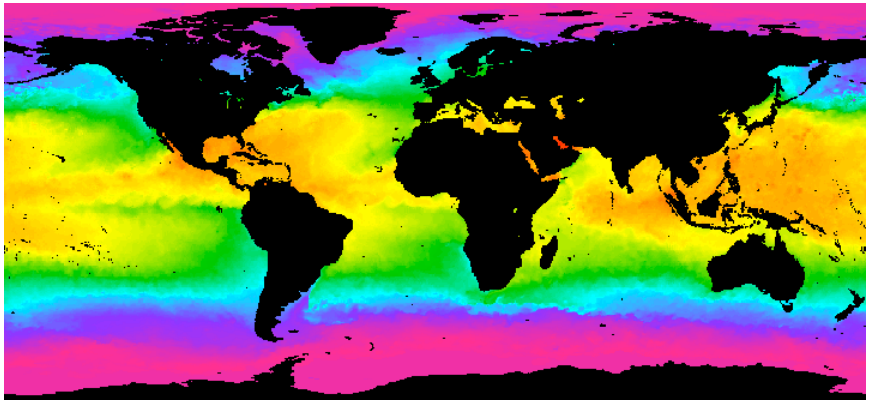
Weather prediction



Climate variability and change



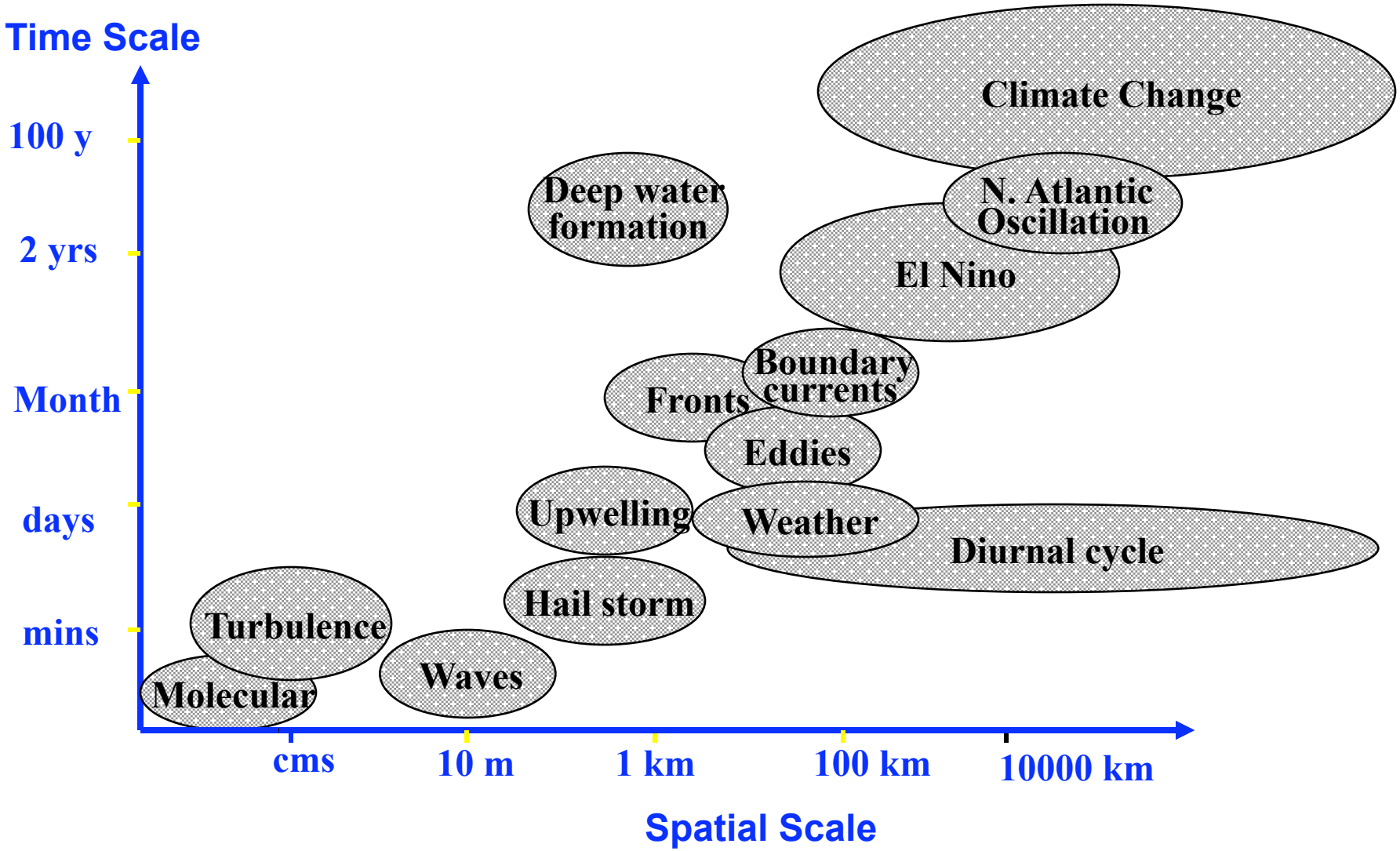
Ocean currents



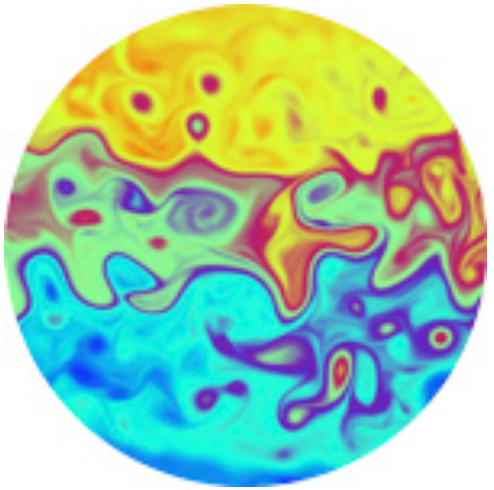
Navigation

Engineering, recreation, …

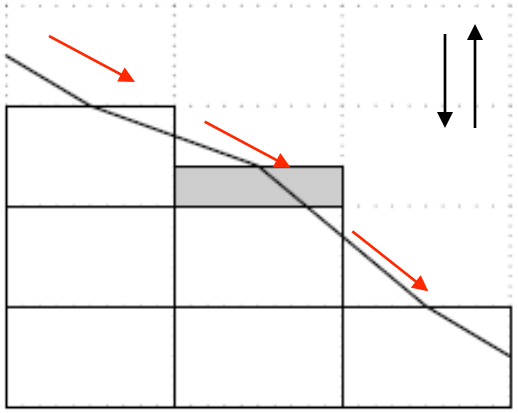
Oceanic and atmospheric phenomena



Research foci:



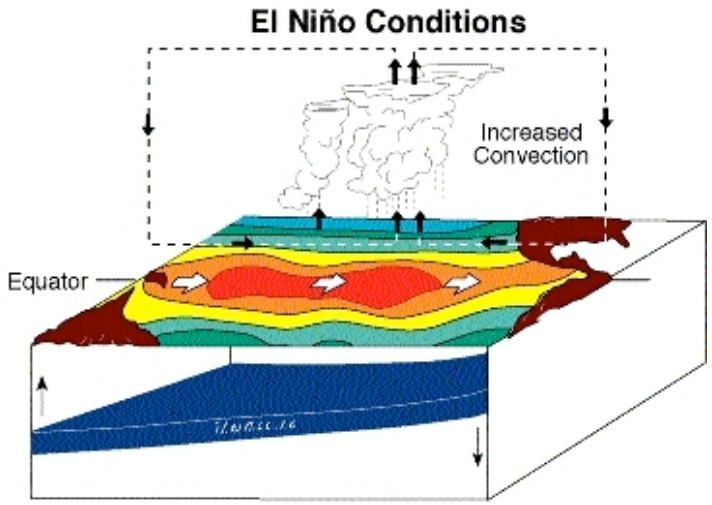
- **Model development**
  - subgrid-scale eddies, mixing
  - convection, gravity currents



- **Model evaluation**
  - tracers (CFCs, 14C,…)
  - water-masses

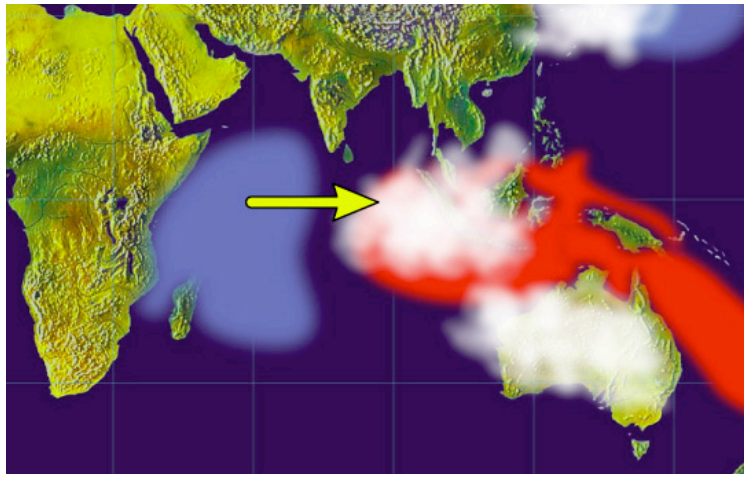
Research foci:

- OCEANS TO RAIN

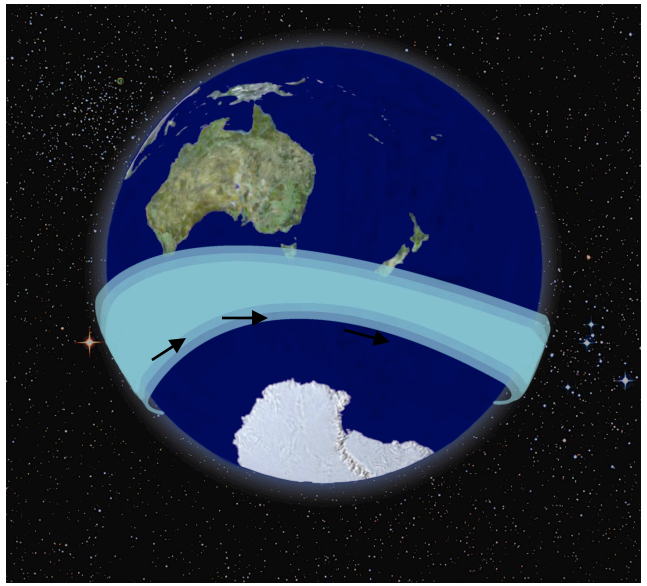


ENSO / Pacific Variability

Indian Ocean Variability / Change

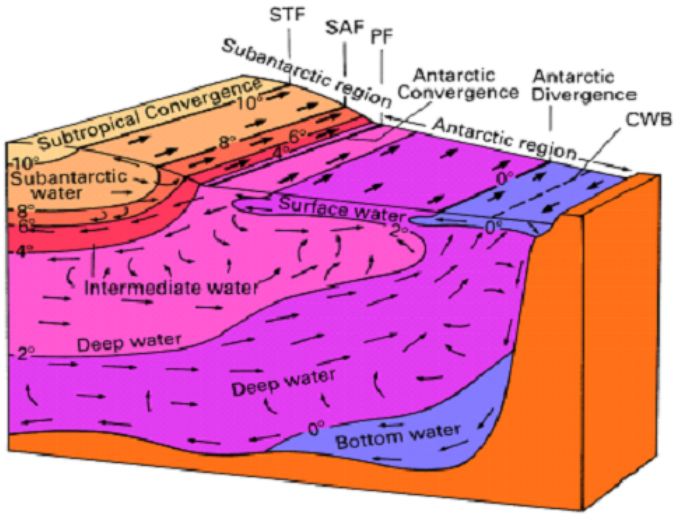


Southern Annular Mode

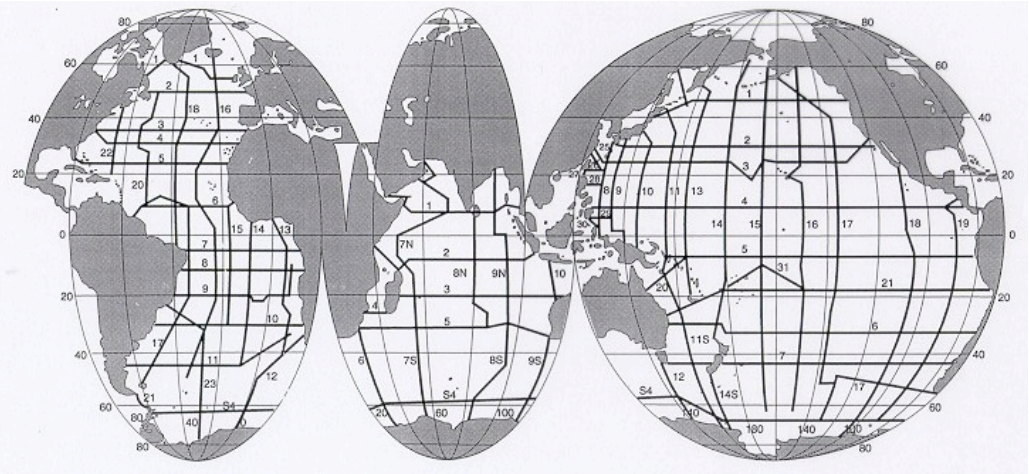


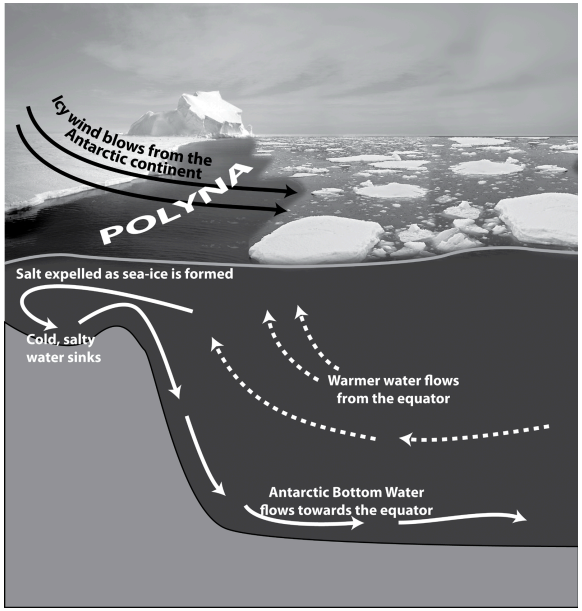
Research foci:

- Ocean thermohaline circulation
  - Water-masses
  - Variability
  - Stability / Change

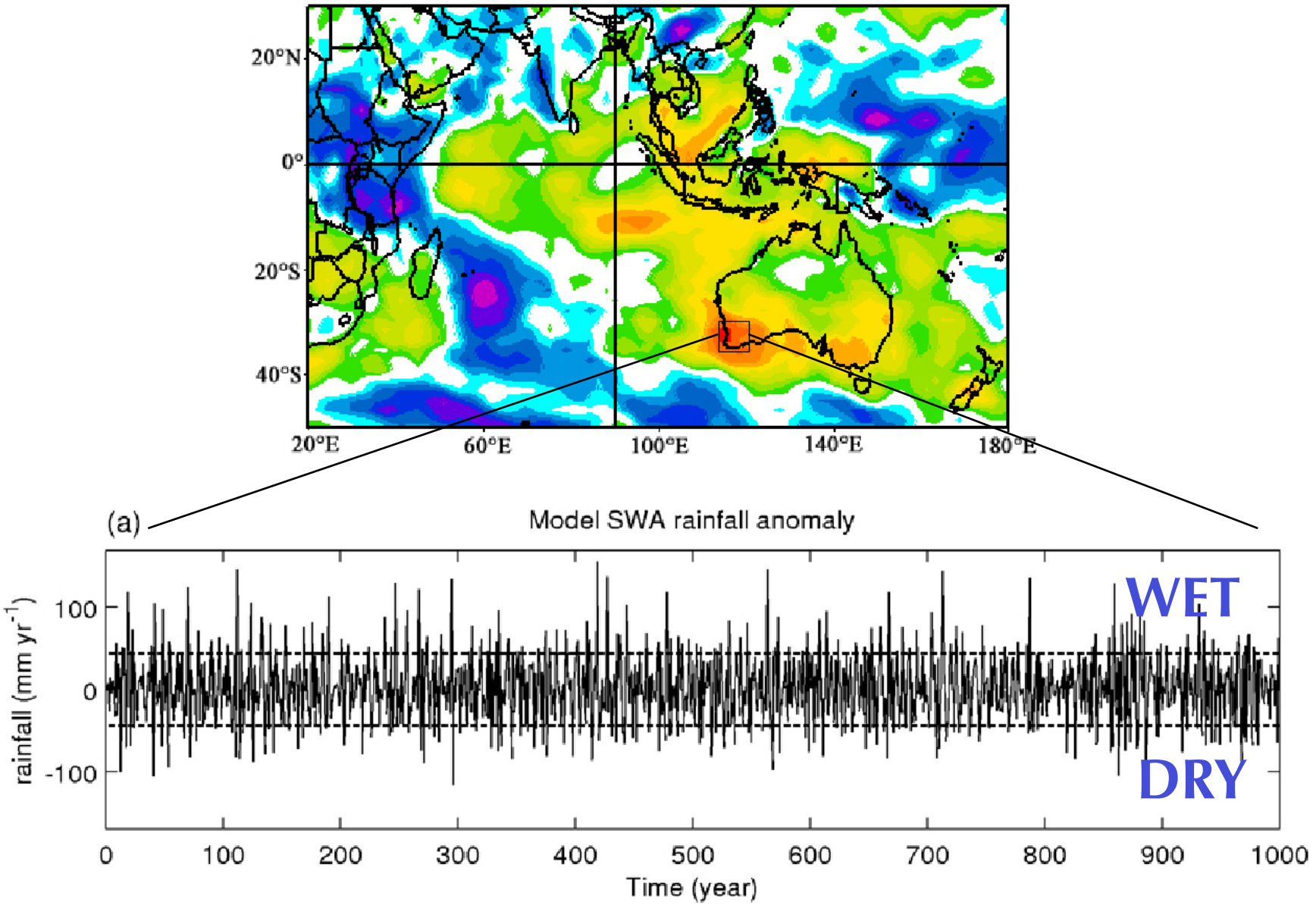


World Ocean Circulation Experiment / CLIVAR



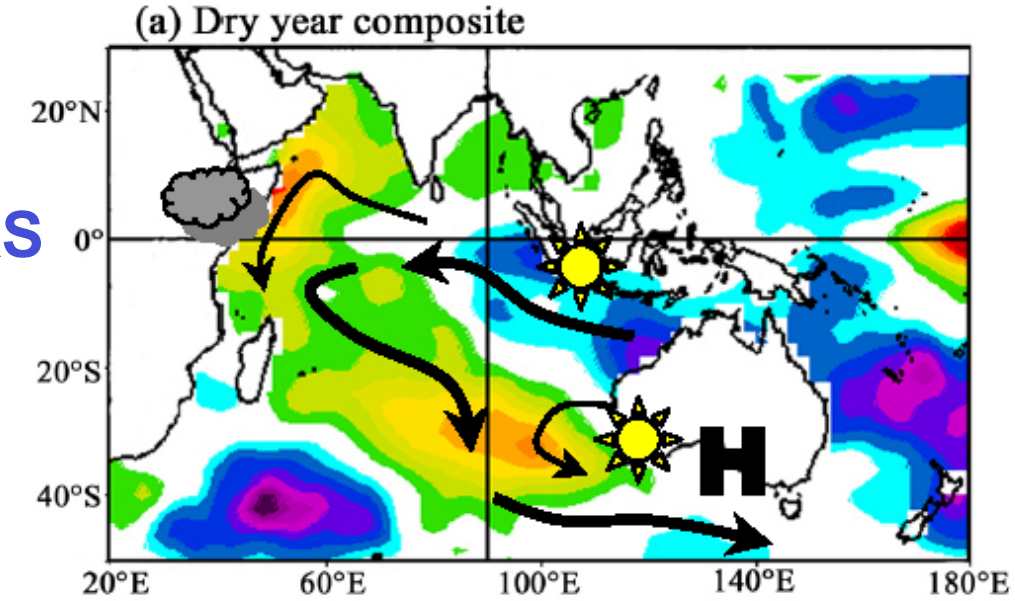


Southwestern Australia Rainfall – an Indian Ocean link?

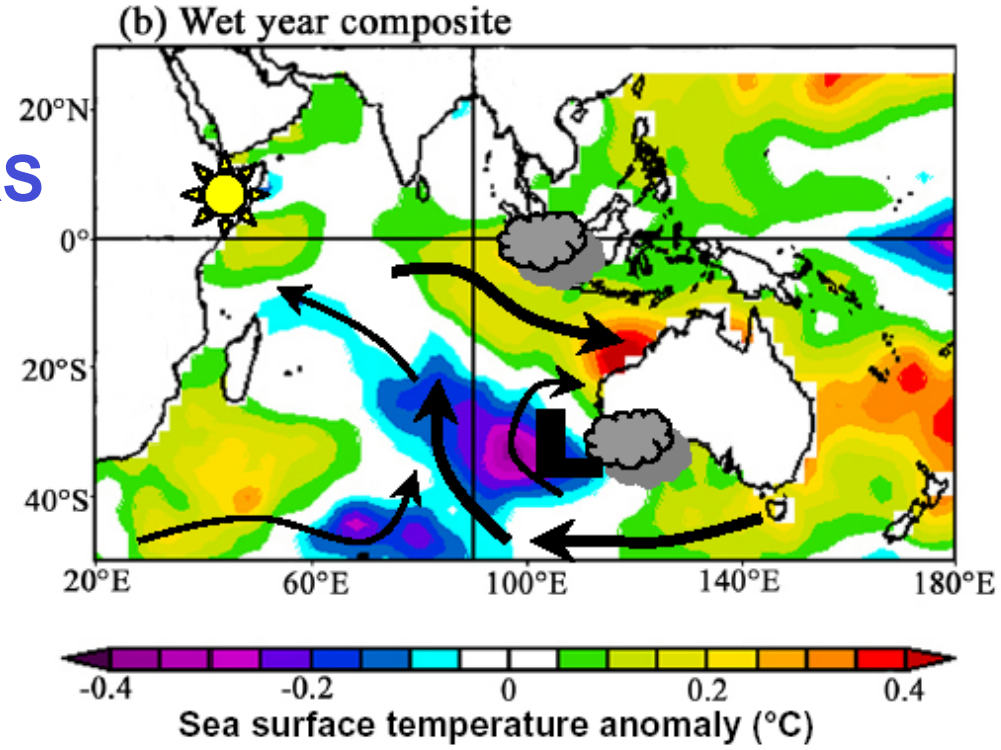


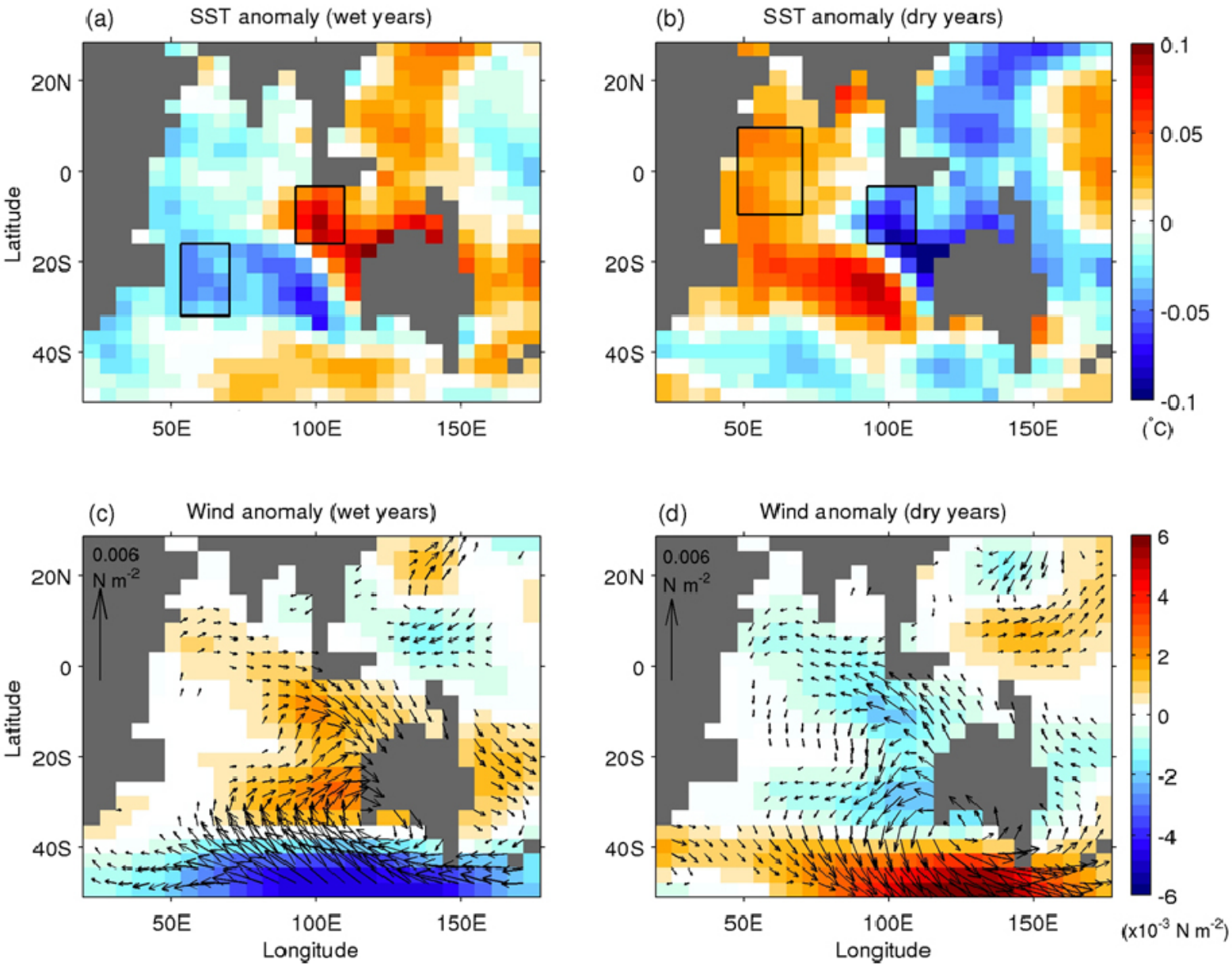
England et al., J. Climate

DRY YEARS



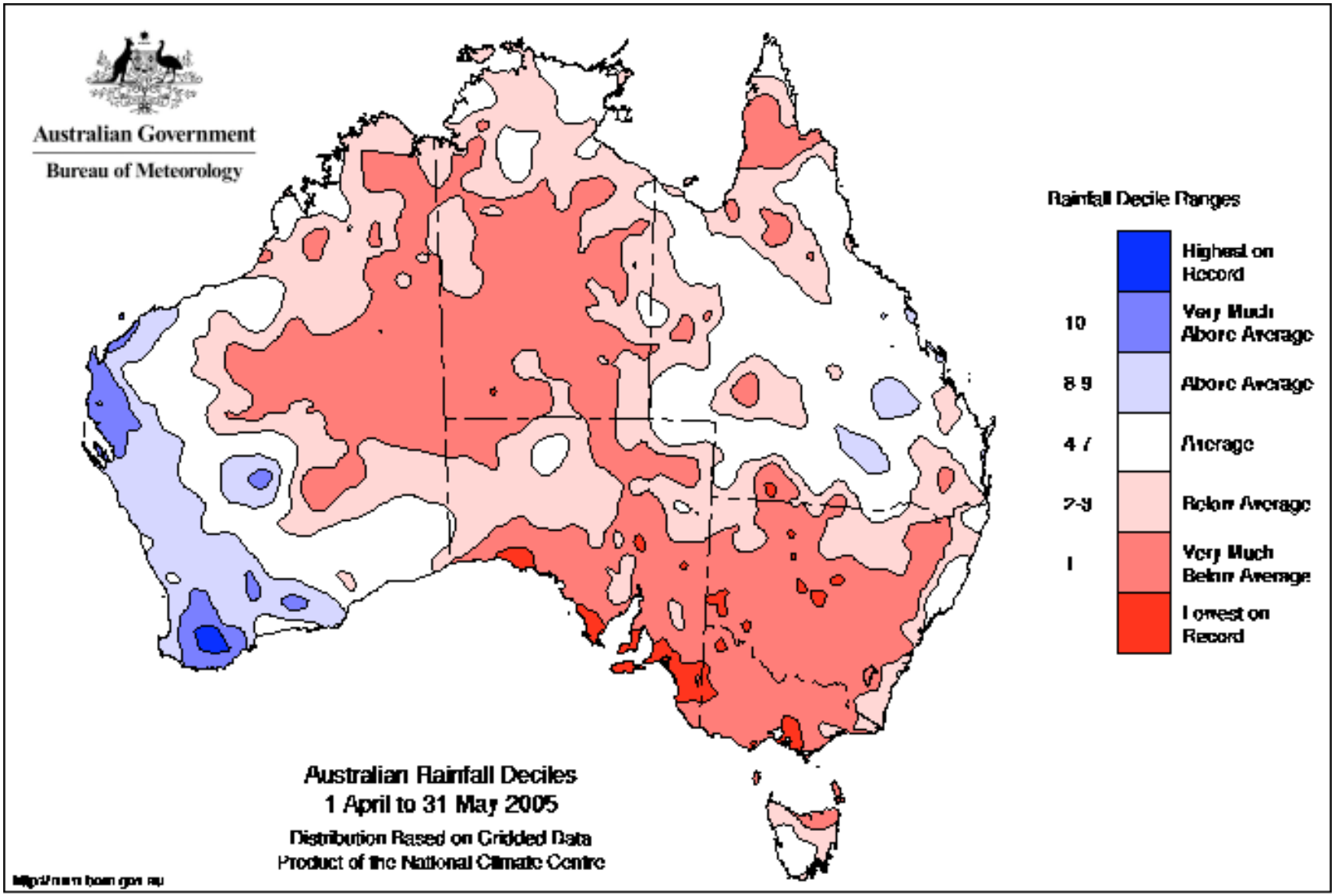
WET YEARS



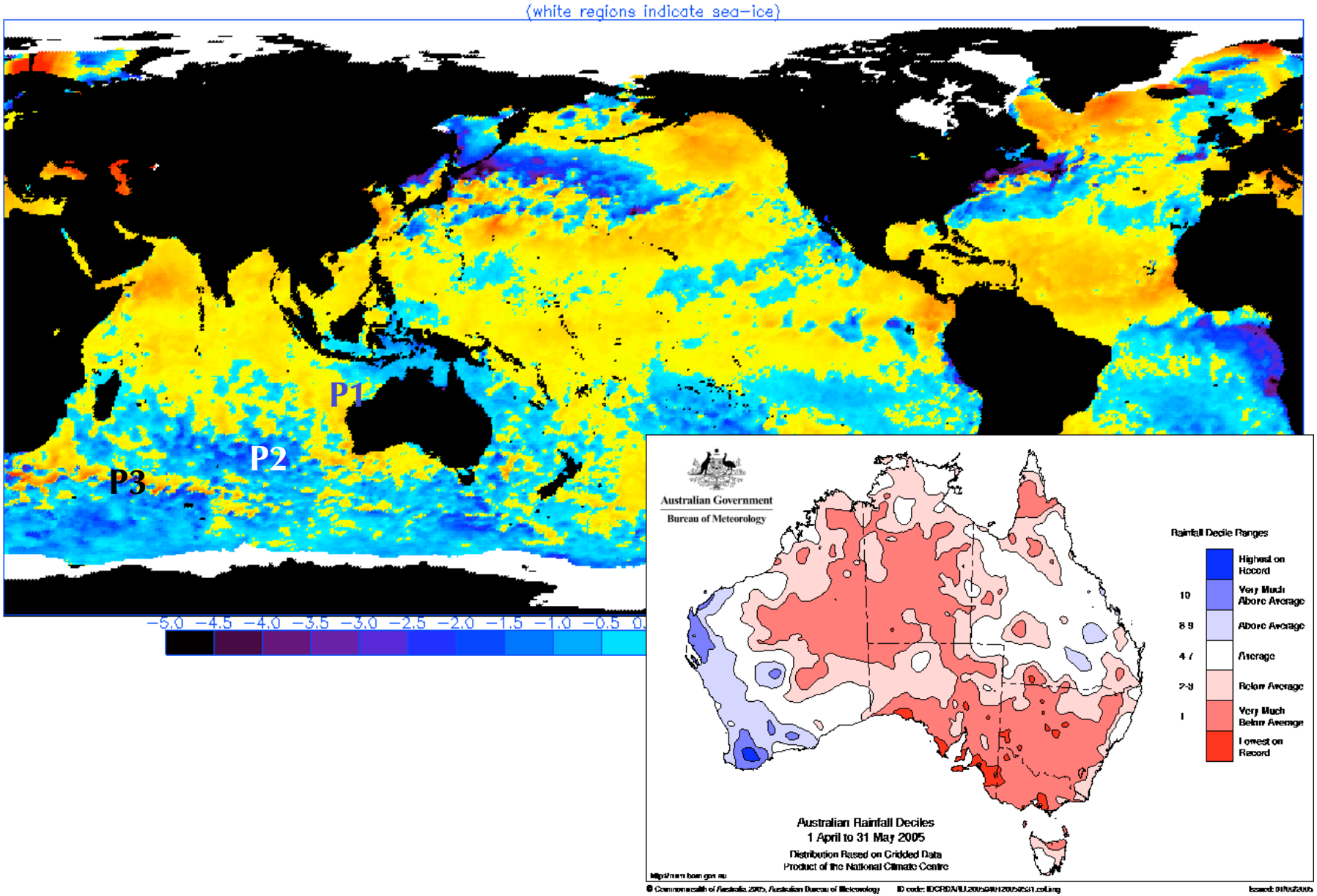


England et al., J. Climate

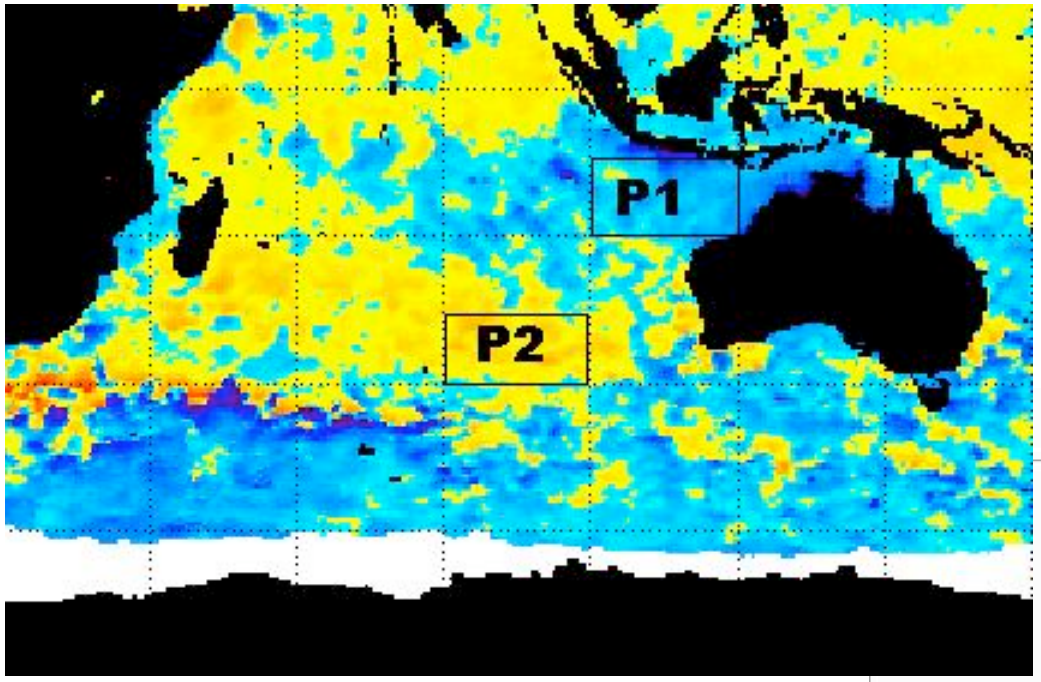
Rainfall deciles; April-May 2005



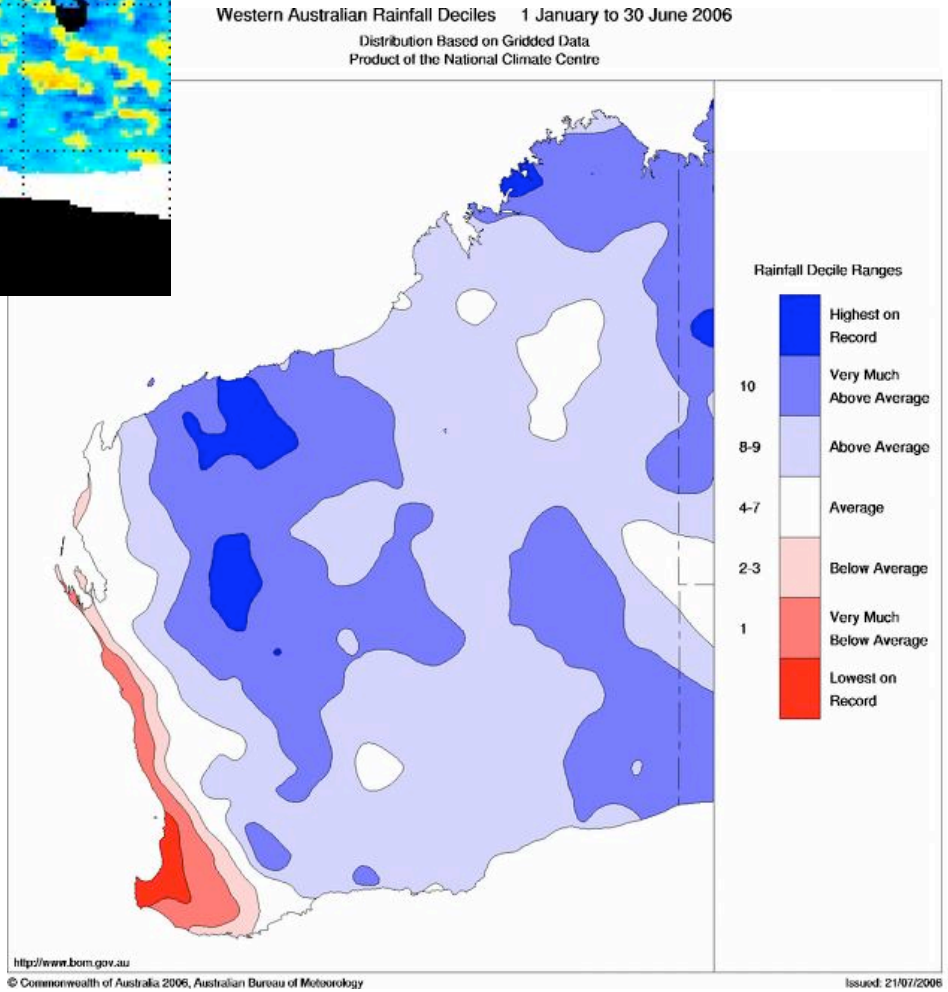
Global SST anomalies – April 2005



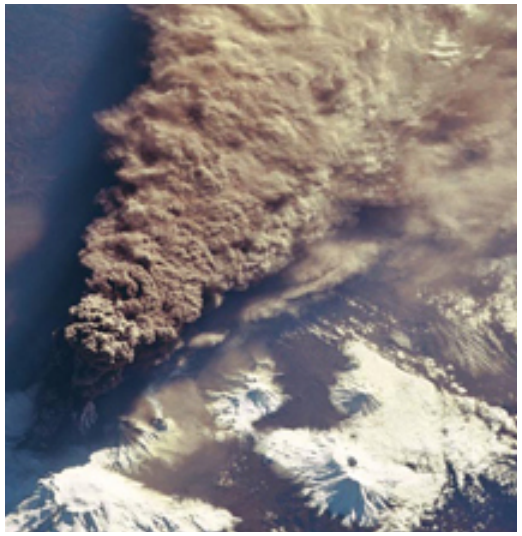
Update in 2006



SST *anomalies in April 2006 (blue = cool anomalies, red = warm anomalies).*



Lecture 1 – Climate Physics Primer



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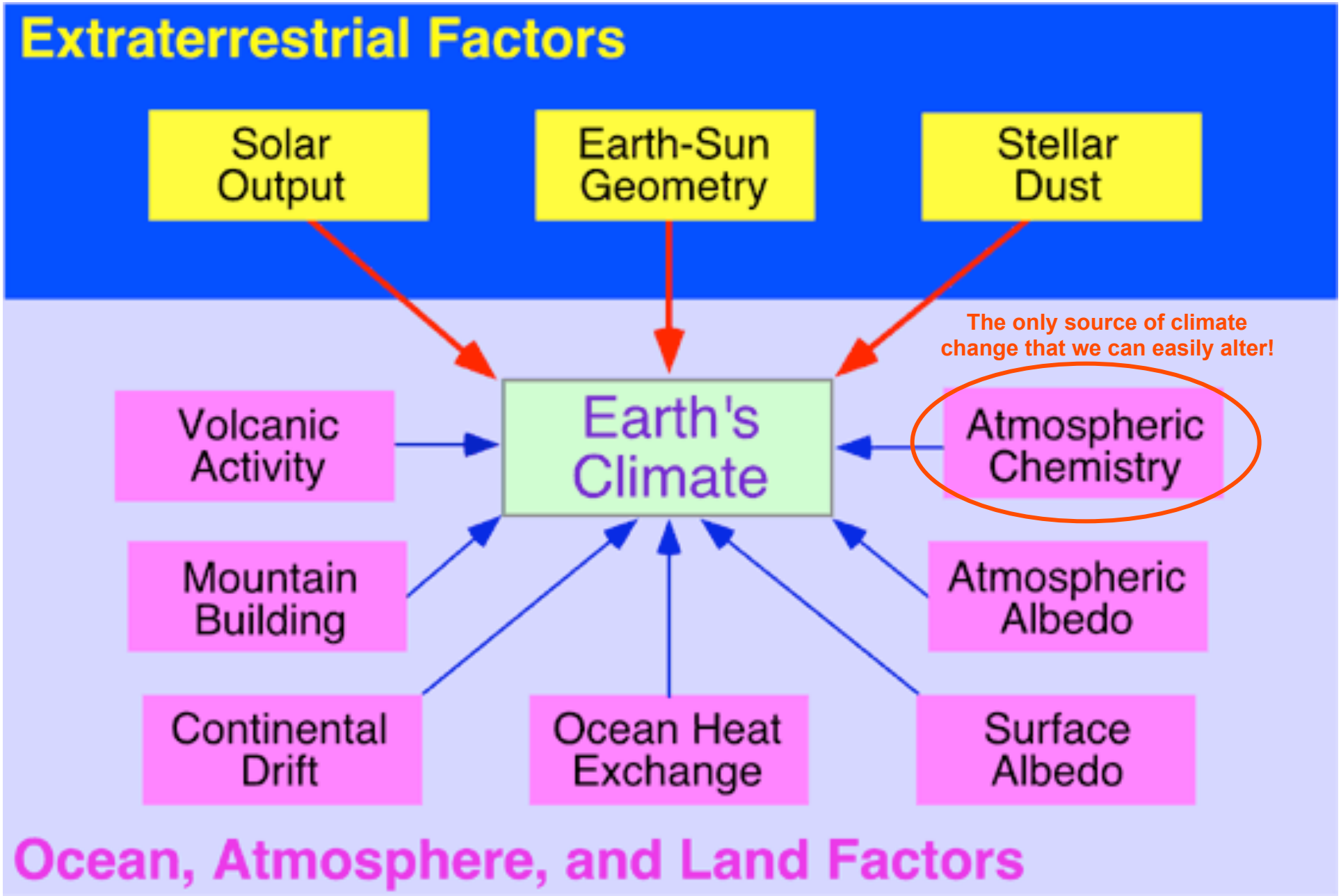
Climate Change Research Centre

Climate Physics Primer

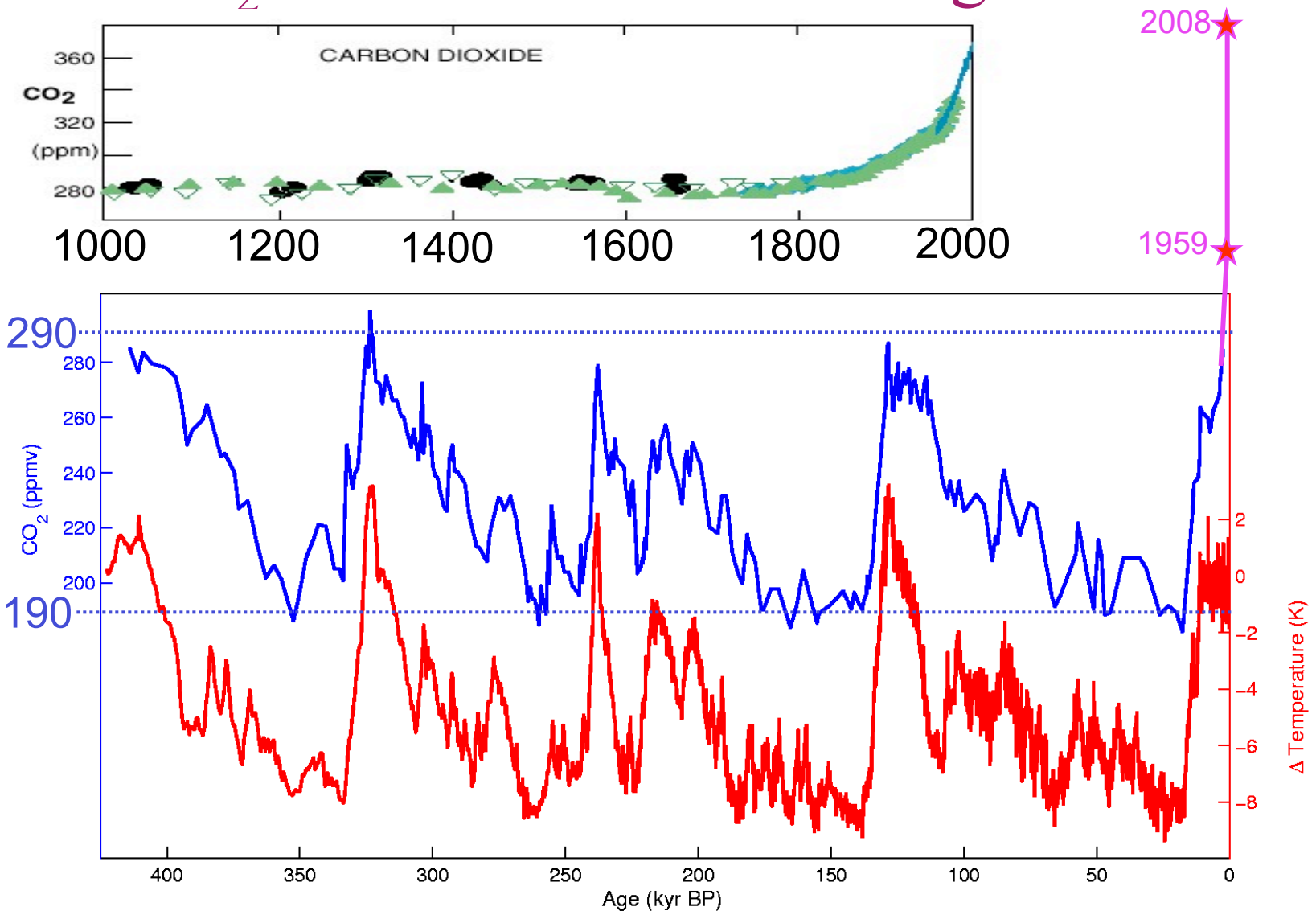


- What causes the Earth's climate to change?
- Why are we concerned about greenhouse gases?
- Has much changed in the past century?
- What's in stall for the coming decades?

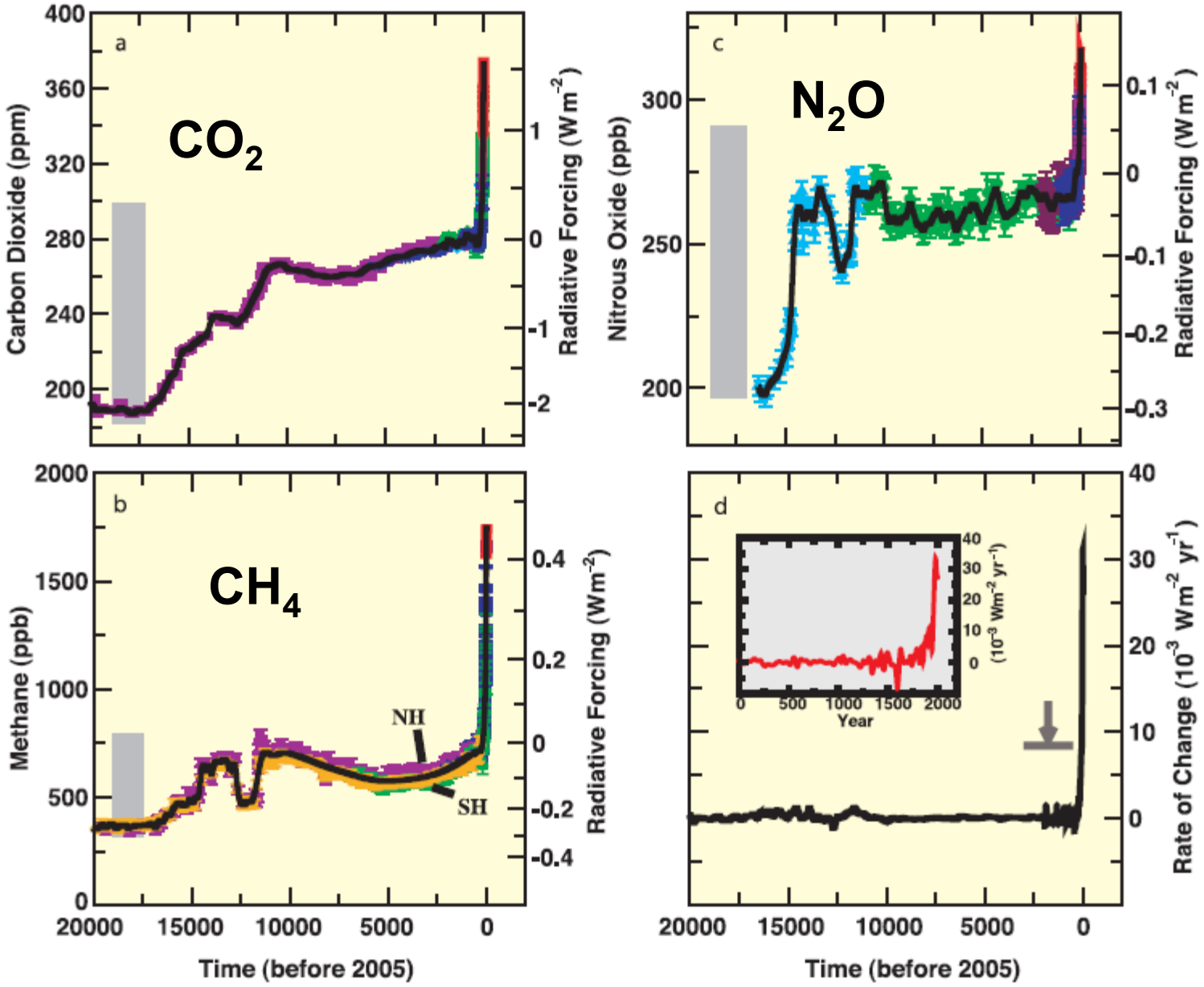
Causes of climate change



CO_2 Concentration is Rising

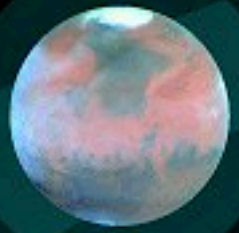


Changes in Greenhouse Gases from Ice Core and Modern Data



Planets and atmospheres

Mars
Thin atmosphere
(Almost all CO_2 in ground)
Average temperature : - 50°C



Earth
0,03% of CO_2 in the atmosphere
Average temperature : + 15°C

Venus
Thick atmosphere
containing 96% of CO_2
Average temperature : + 420°C

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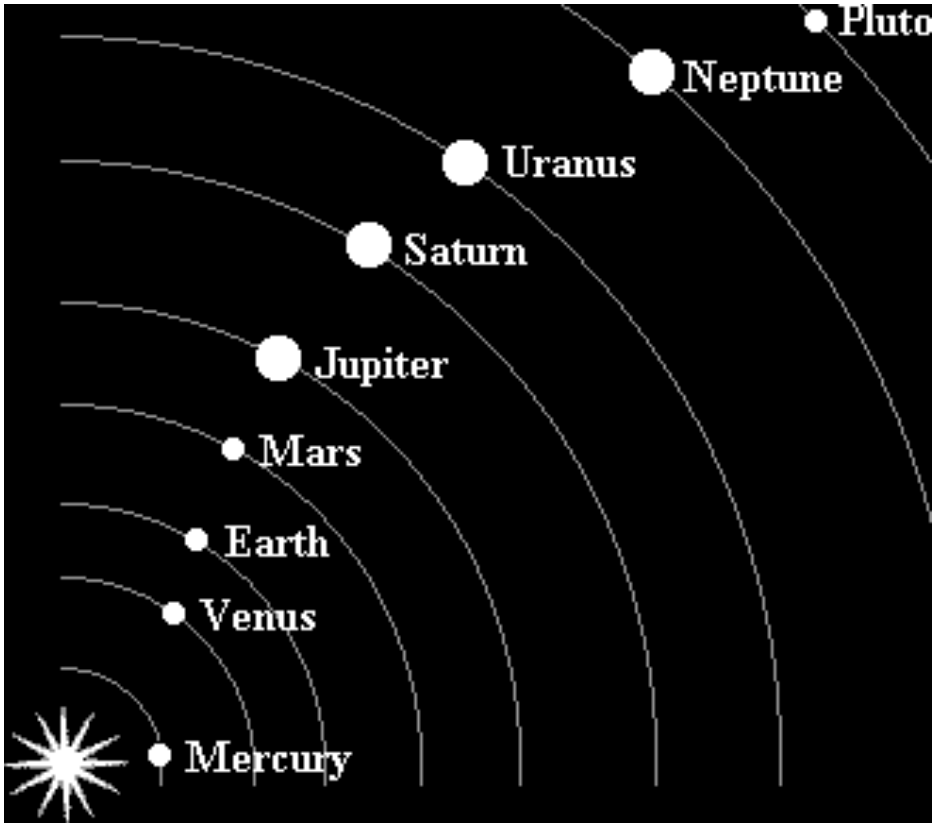
GRAPHIC DESIGN : PHILIPPE REKACEWICZ

Sources: Calvin J. Hamilton, Views of the solar system, www.planetscapes.com; Bill Arnett , The nine planets, a multimedia tour of the solar system, www.seds.org/billa/tnp/nineplanets.html

Why is Venus hotter than Mercury?



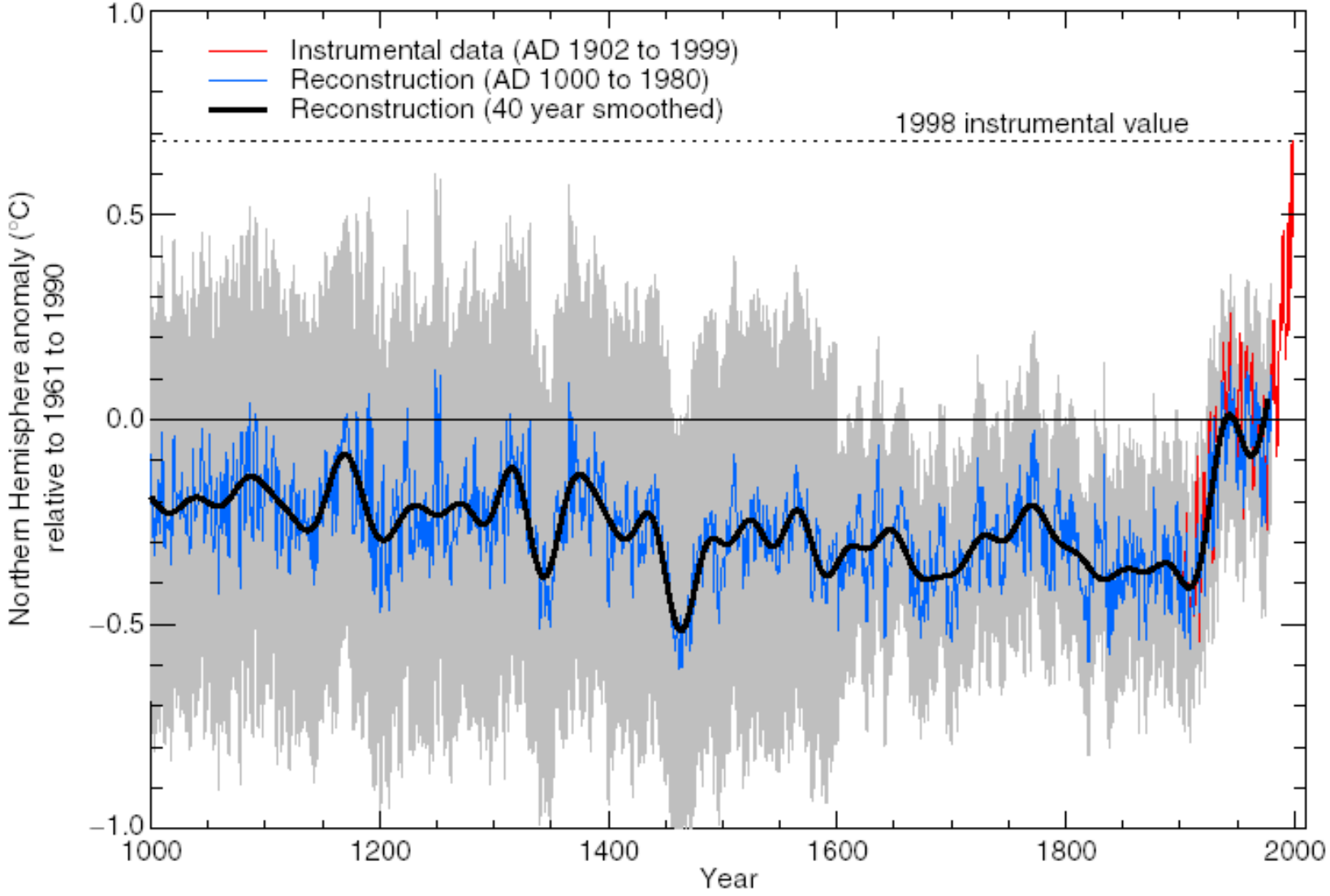
Mercury temperature = ~85°C

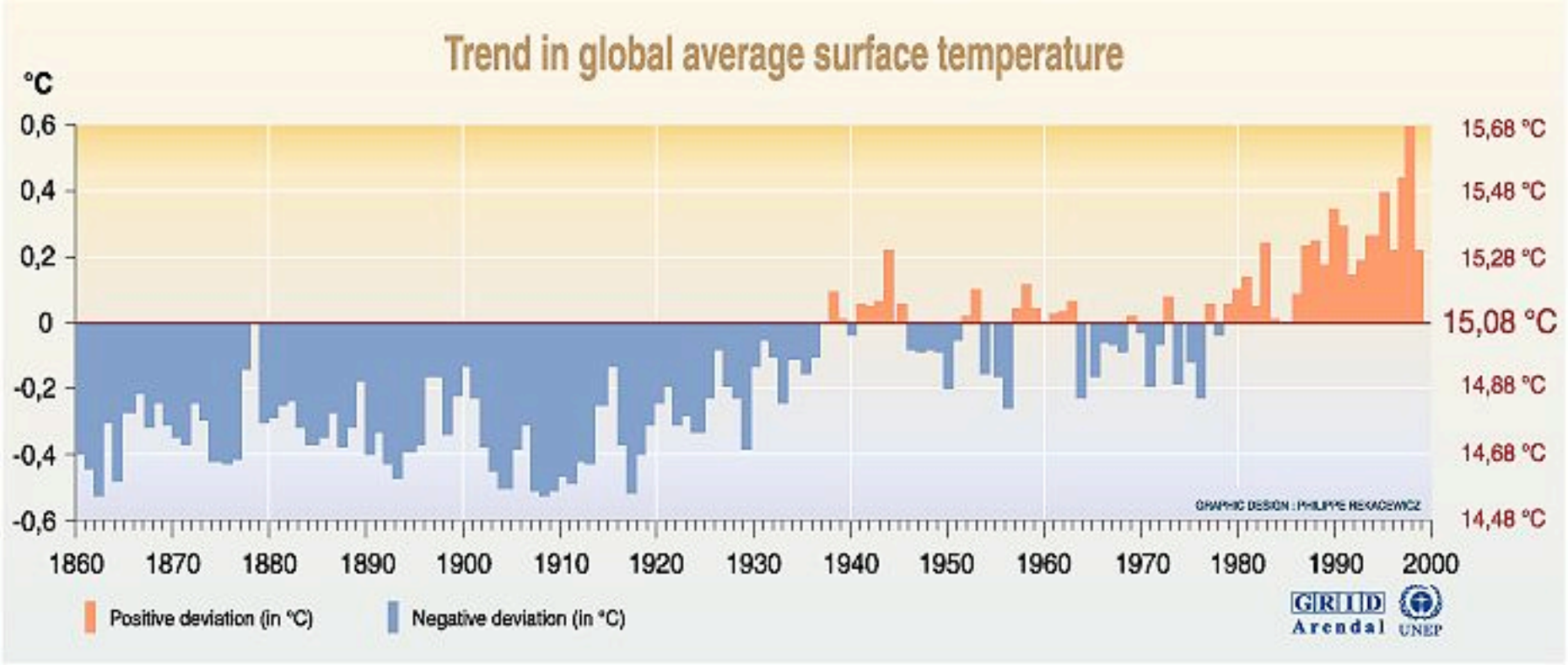
Venus temperature = 500 °C

Answer -

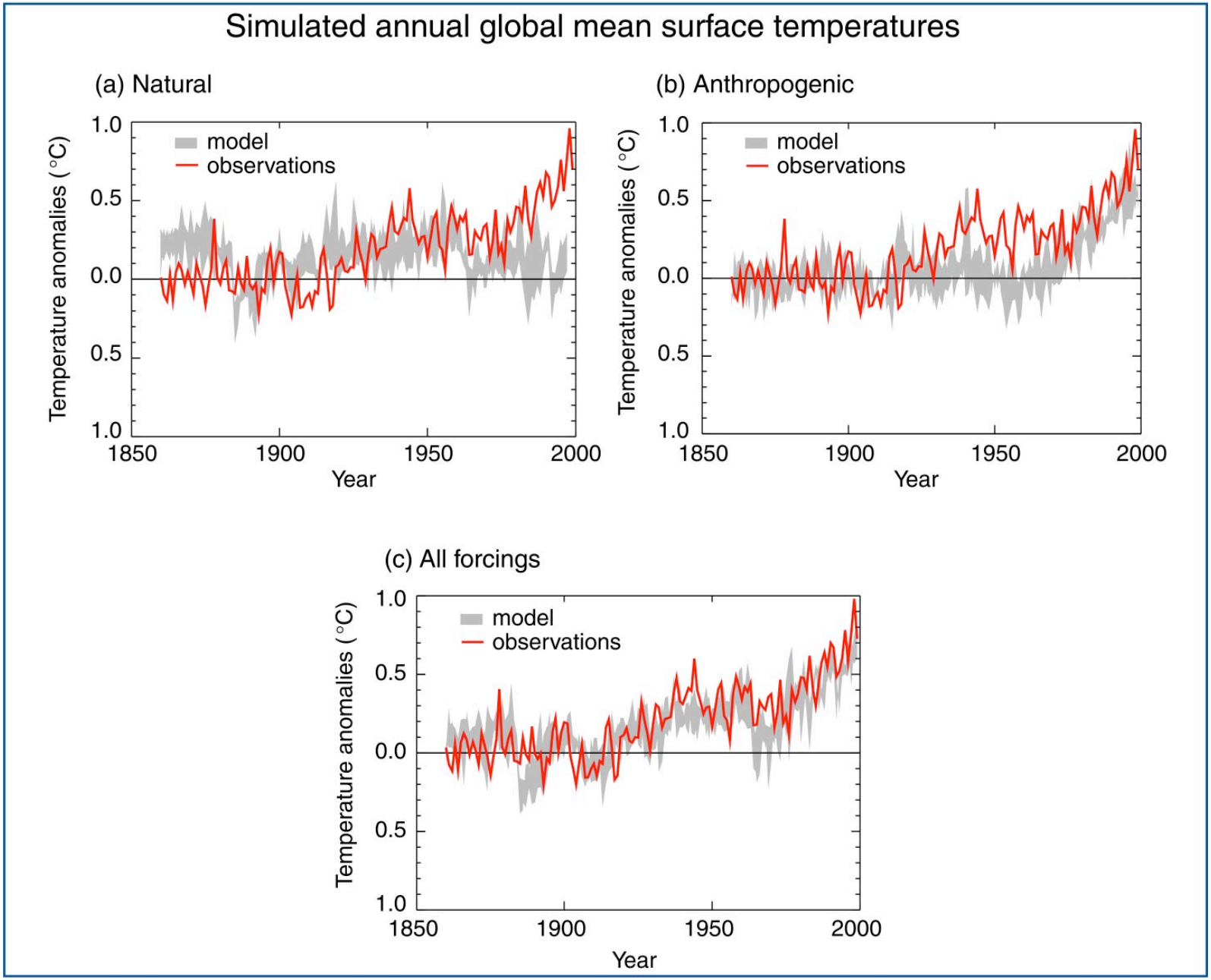
The Greenhouse Effect

NH air temperatures since 1000 A.D.

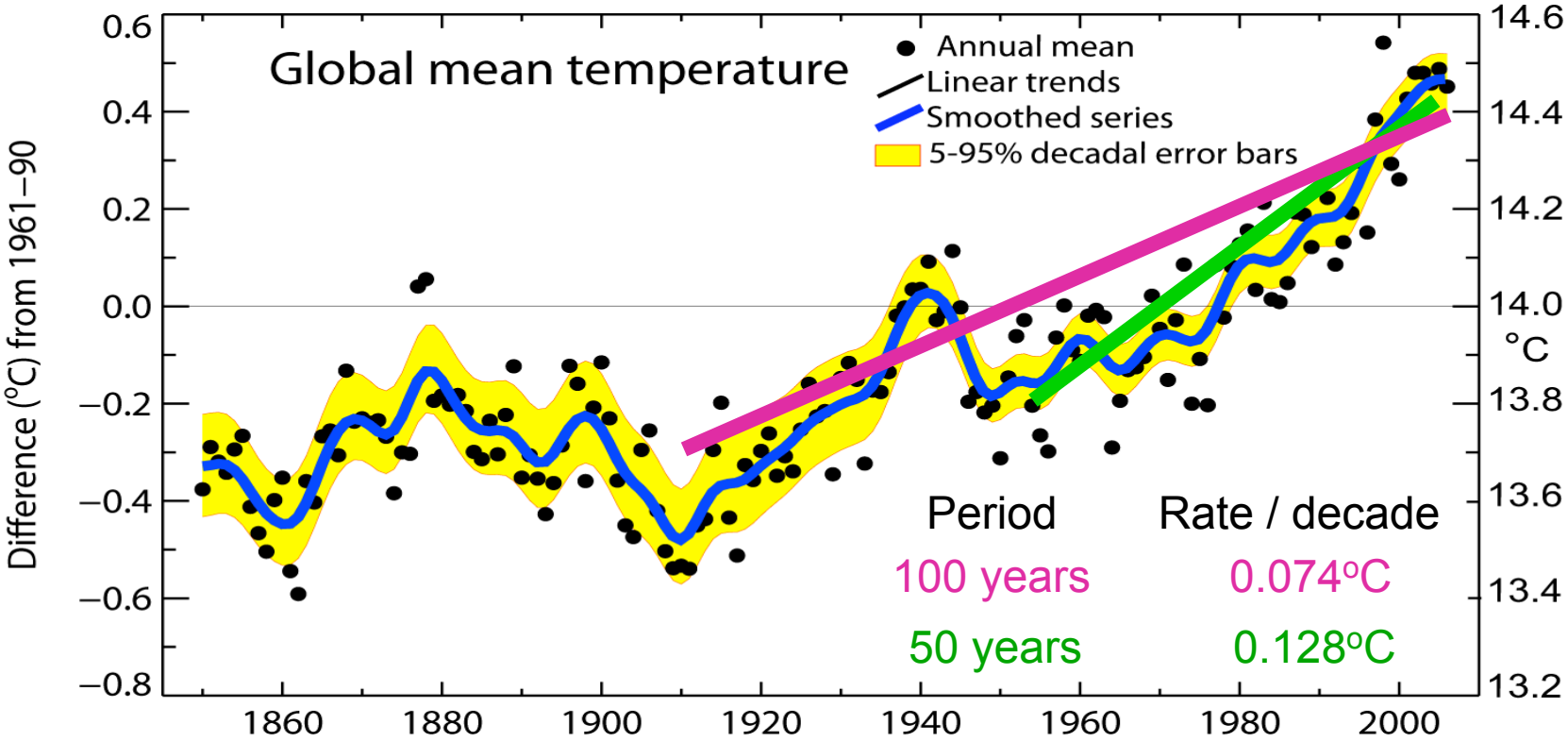




Source: School of environmental sciences, climatic research unit, university of East Anglia, Norwich, United Kingdom, 1999.

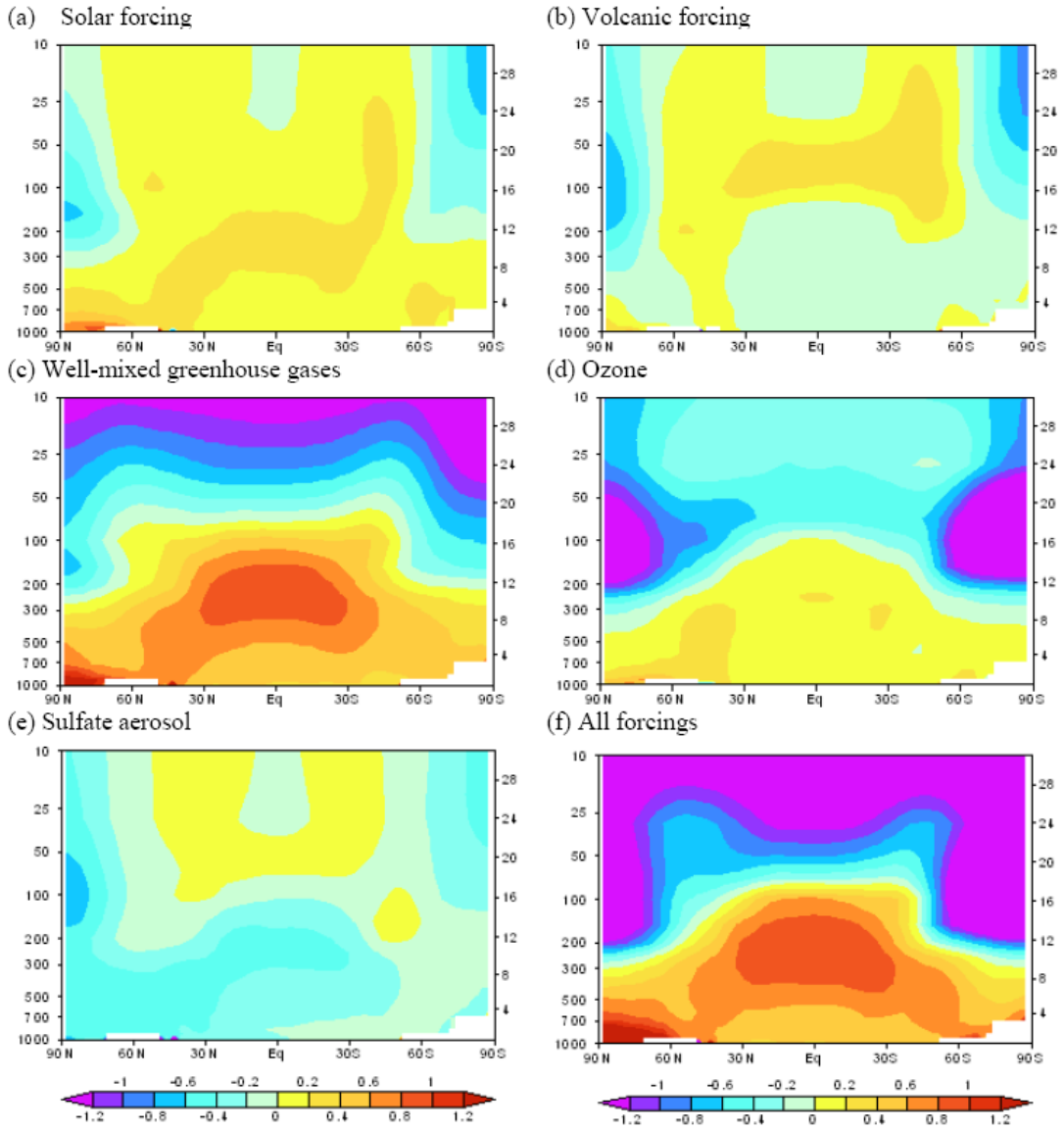

Simulated annual global mean surface temperatures
(a) Natural
(b) Anthropogenic
(c) All forcings
model
observations
Temperature anomalies (°C)
Year
1.0
0.5
0.0
0.5
1.0
1850
1900
1950
2000

Changes in global average surface temperature



Eleven of the last twelve years rank among the twelve warmest years in the instrumental record of global surface temperature

The Greenhouse Fingerprint unambiguously matches the 20th Century atmospheric temperature trend...



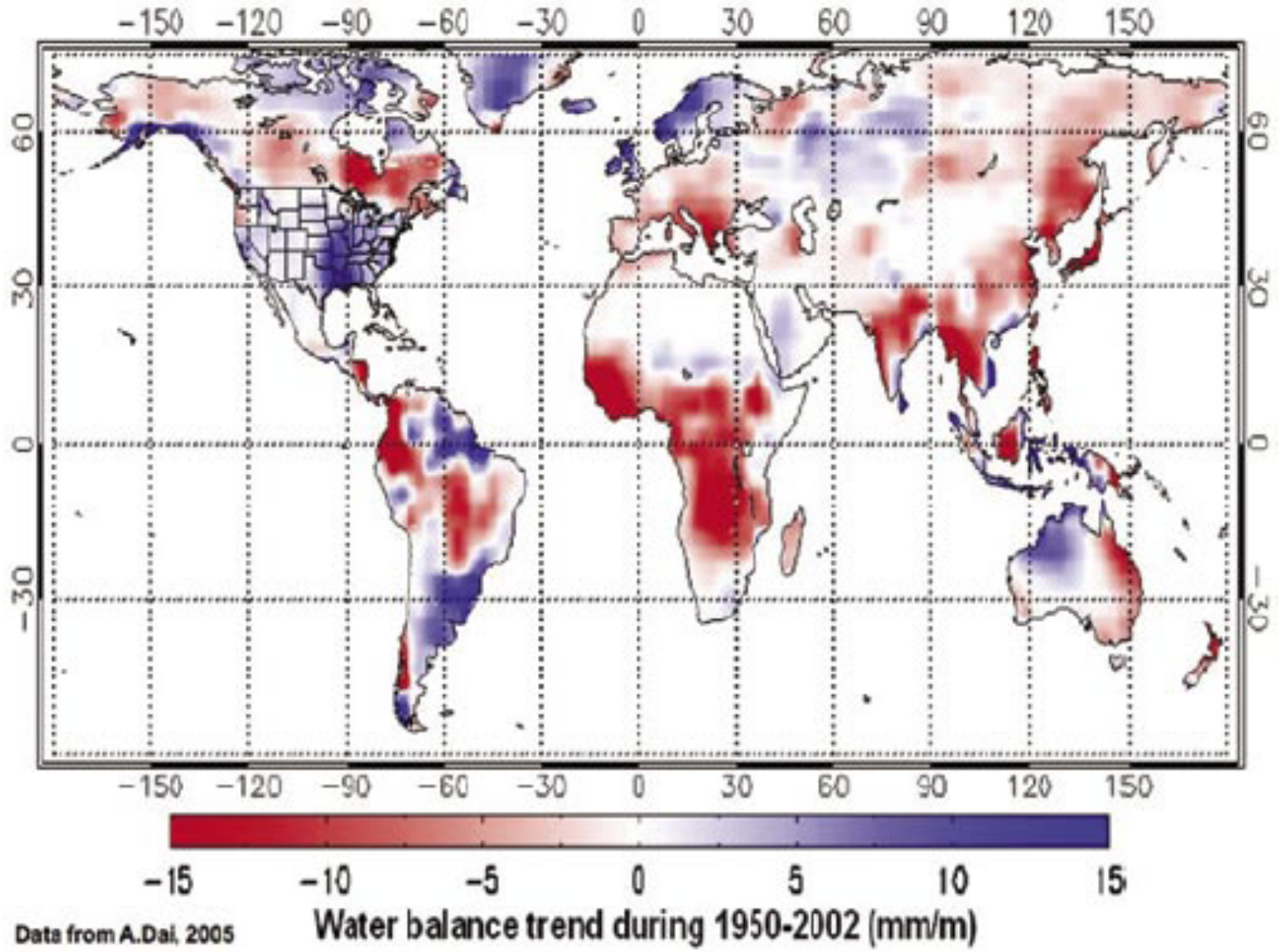
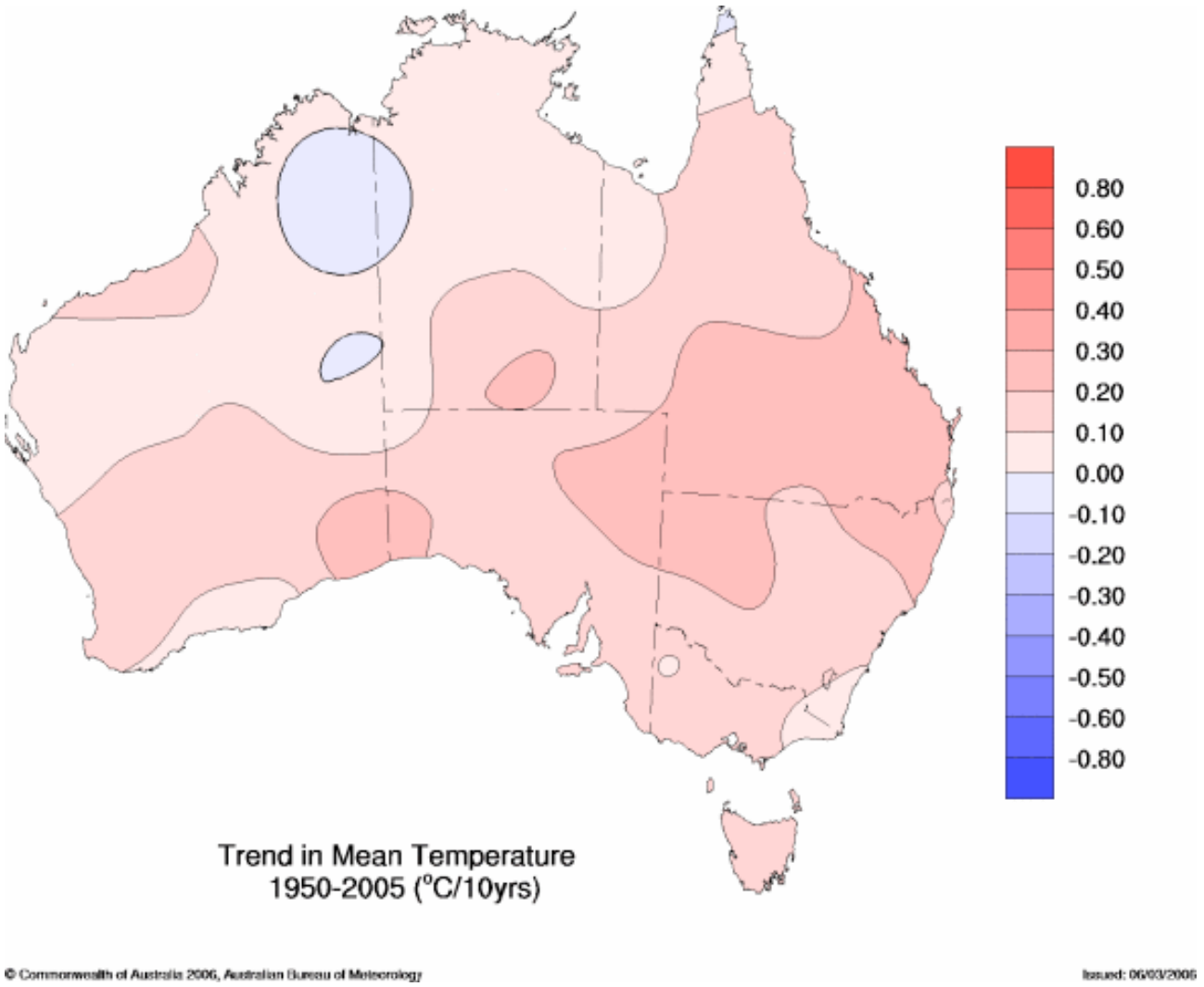
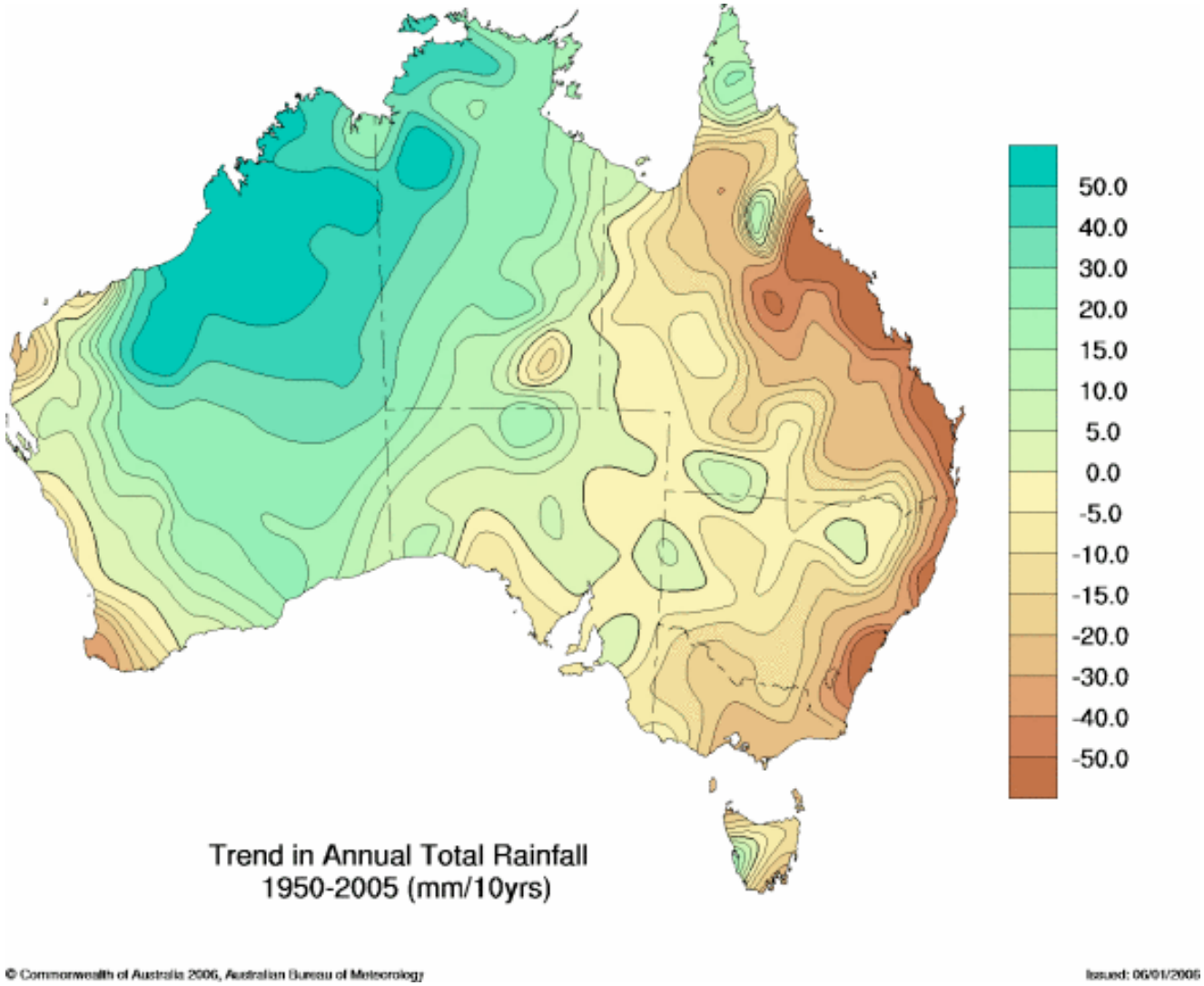


FIGURE 20: Global drying and wetting trends over the past half-century as estimated by the change in water balance (in mm per month) (A. Dai, National Center for Atmospheric Research, USA, and Dai et al. 2005).

Australian temperature trend, 1950 – present day



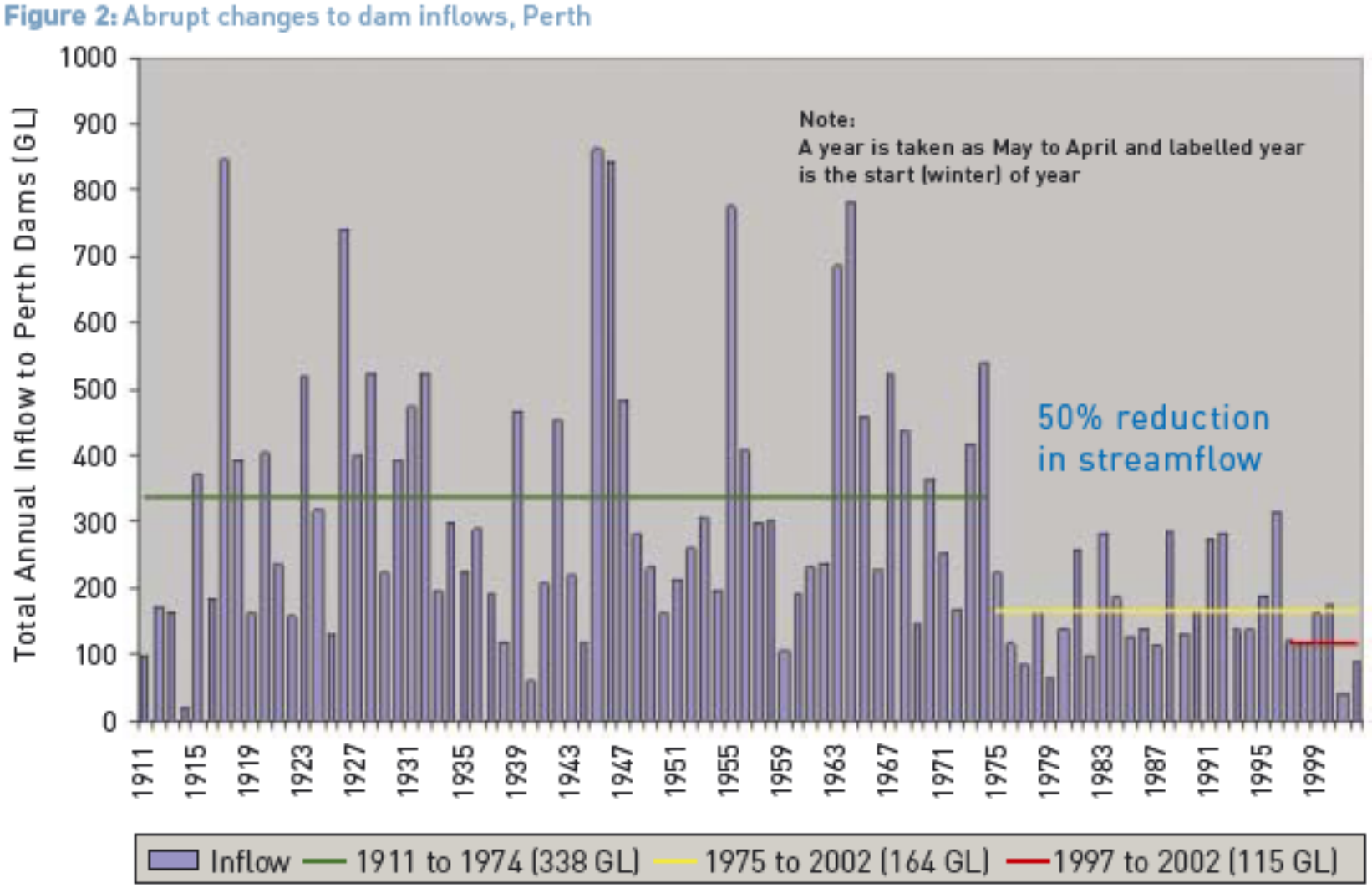
Australian rainfall trend, 1950 – present day



Southern Annular Mode


Southern Hemisphere Jet Stream

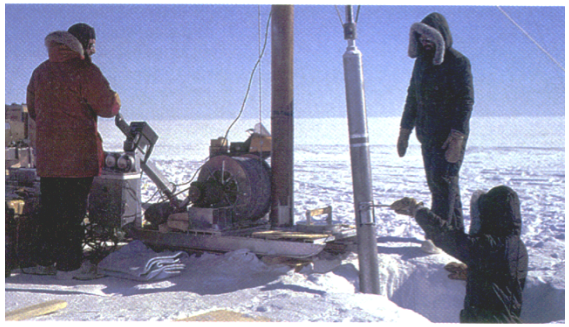
Total annual inflow into Perth Dams

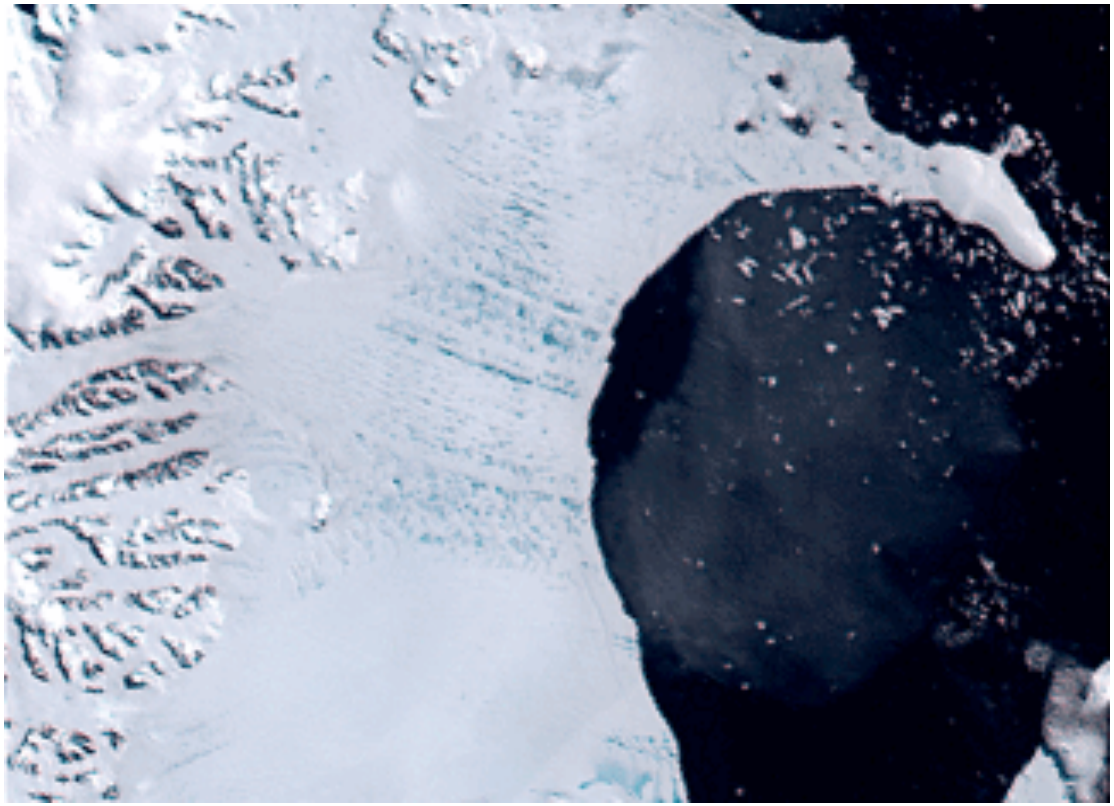


IPCC-WG2 [2007]

Is the Antarctic changing?

… observations

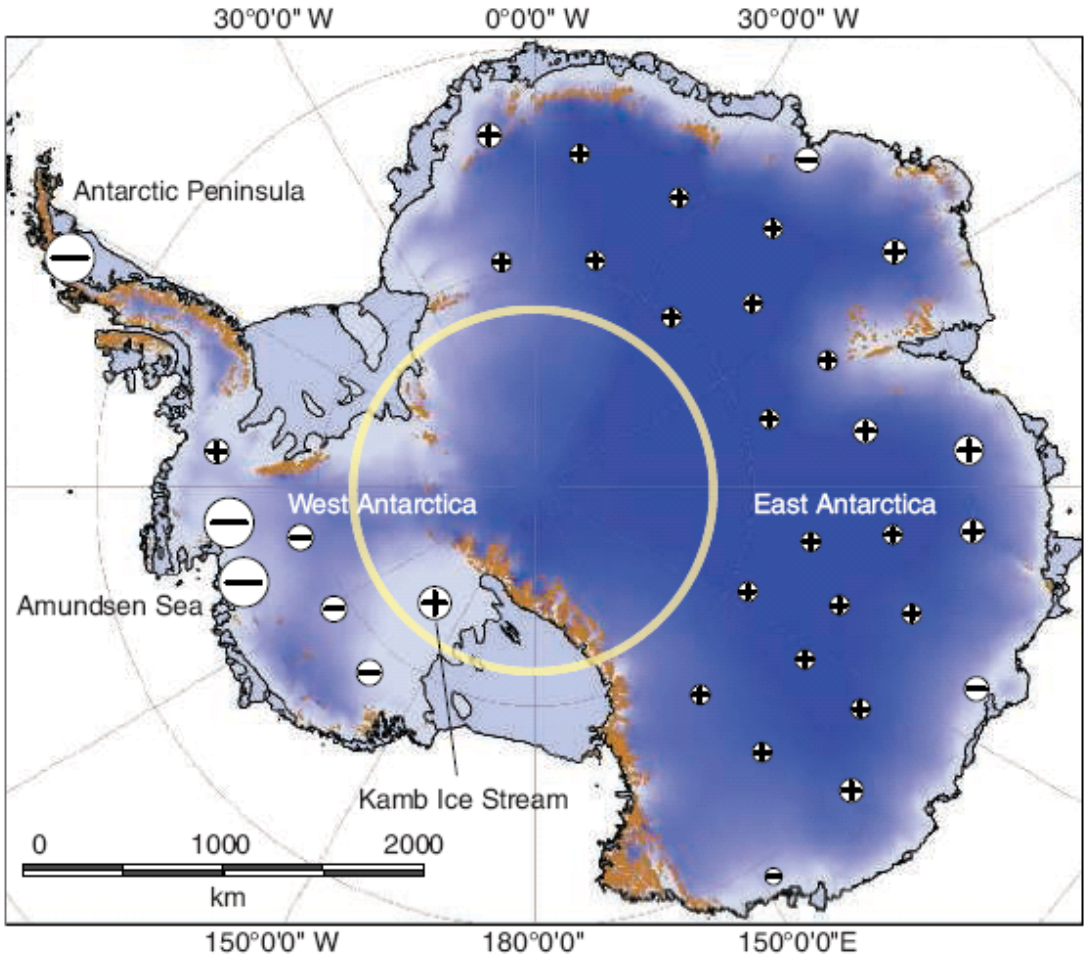




Larsson-B Ice Shelf Collapse 31 January to 7 March 2002

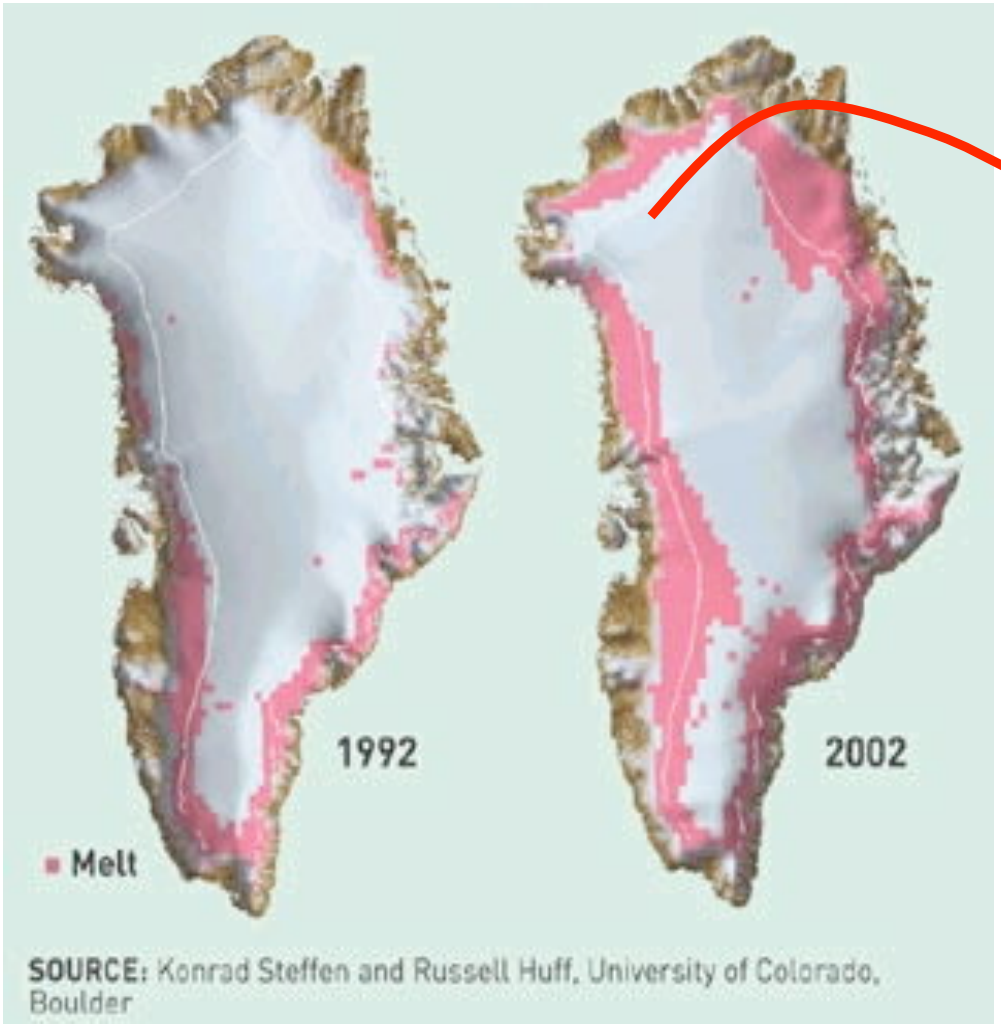
http://nsidc.org/iceshelves/larsenb2002/animation.html

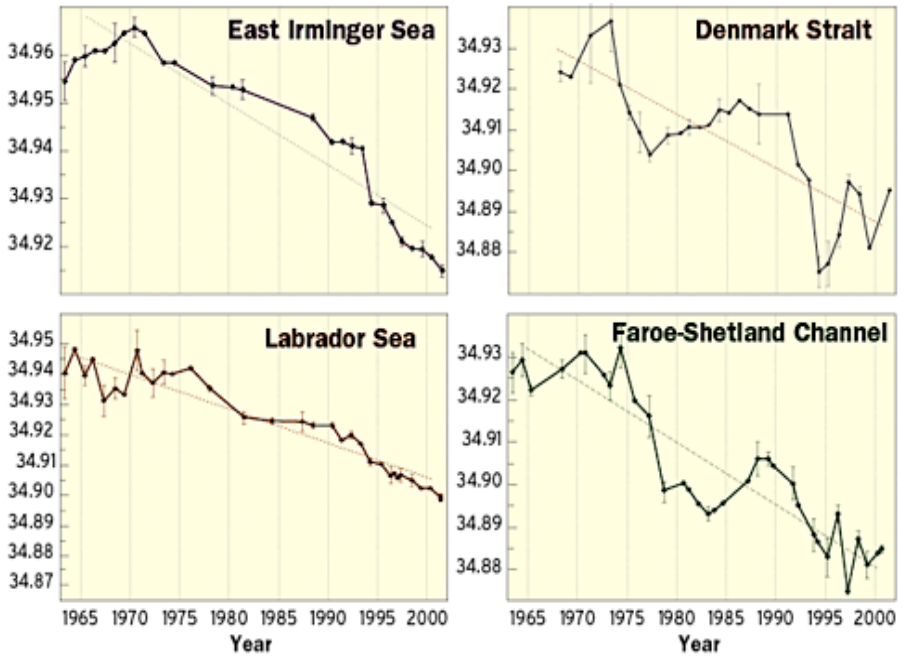
Twentieth Century Land-Ice Changes



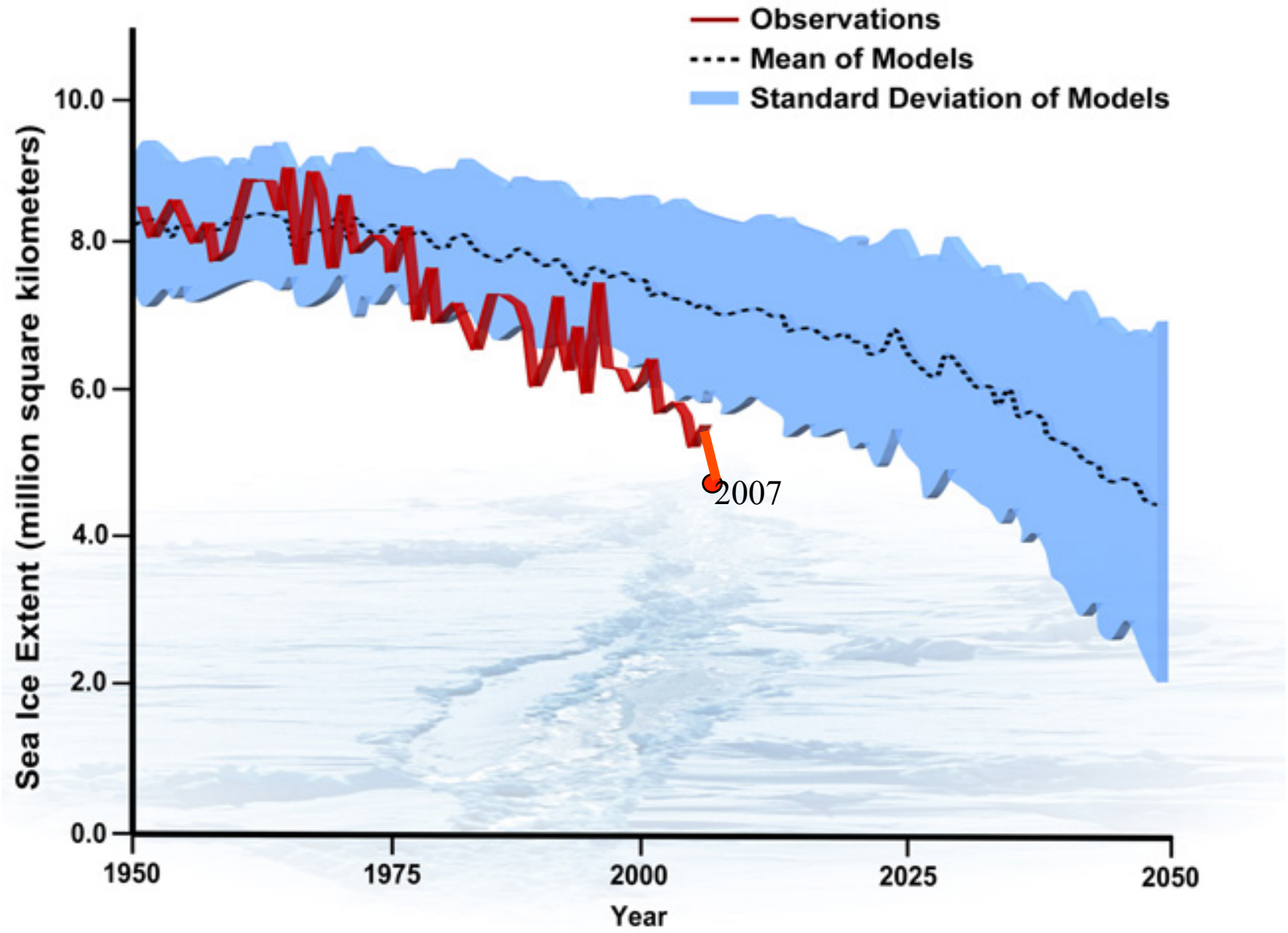
Davis et al., Vaughan; Science, 2005

Melting of the Greenland Ice-sheet



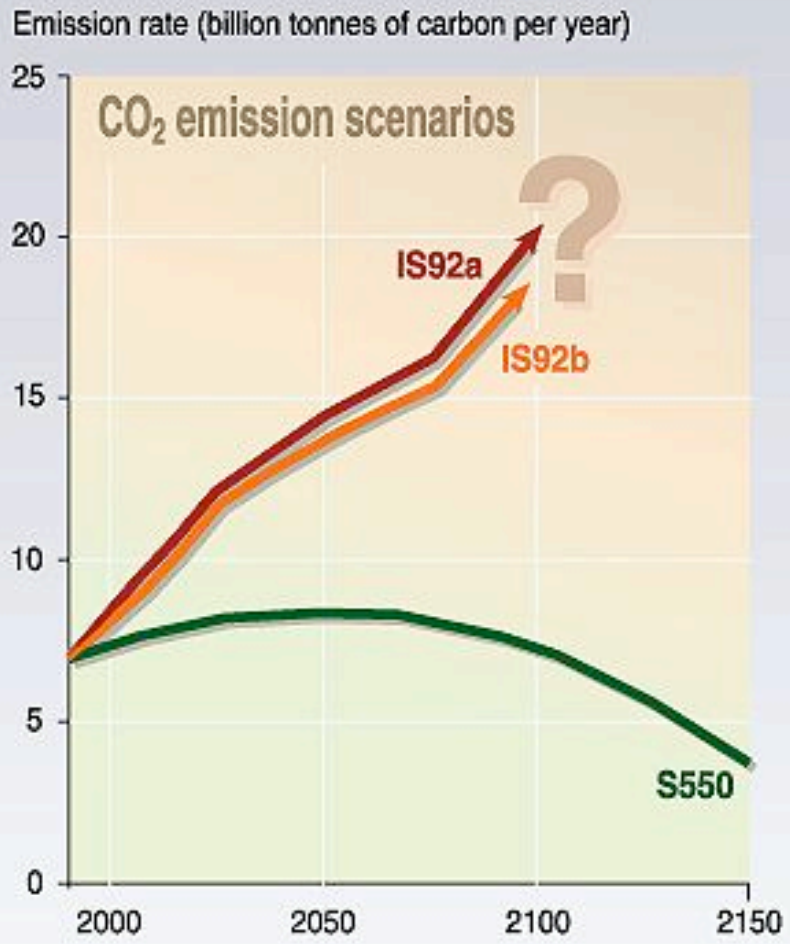


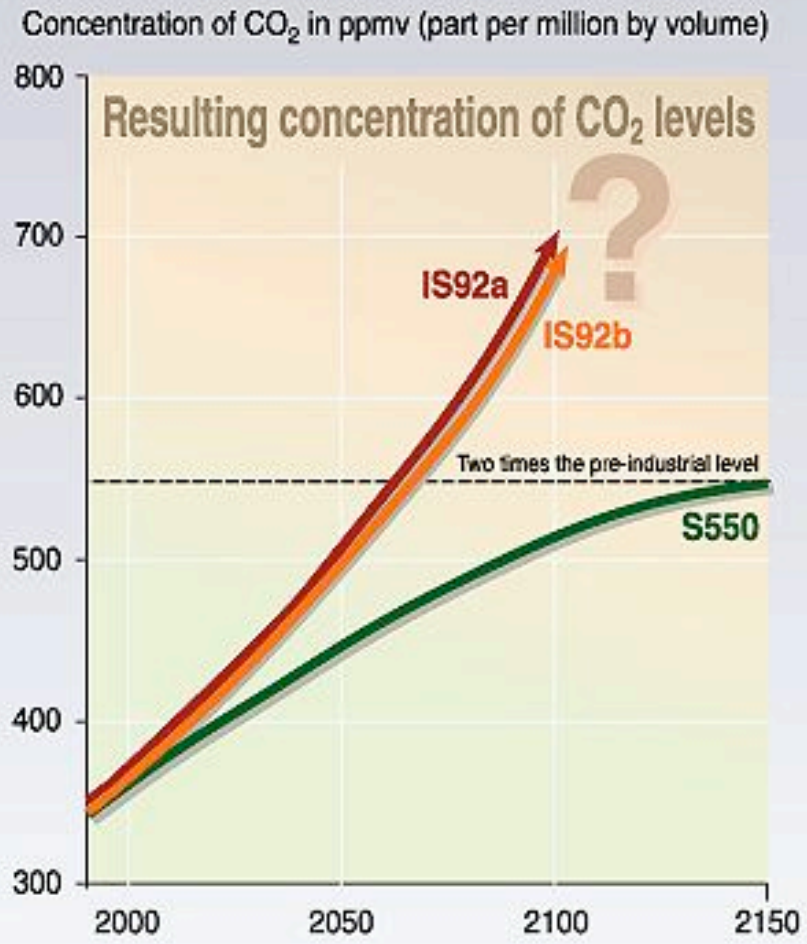
Minimum Arctic sea ice extent



Stroeve et al. GRL 2007

Projected changes in CO_2 and climate: summary of assumptions in the IPCC 1992 alternative scenarios





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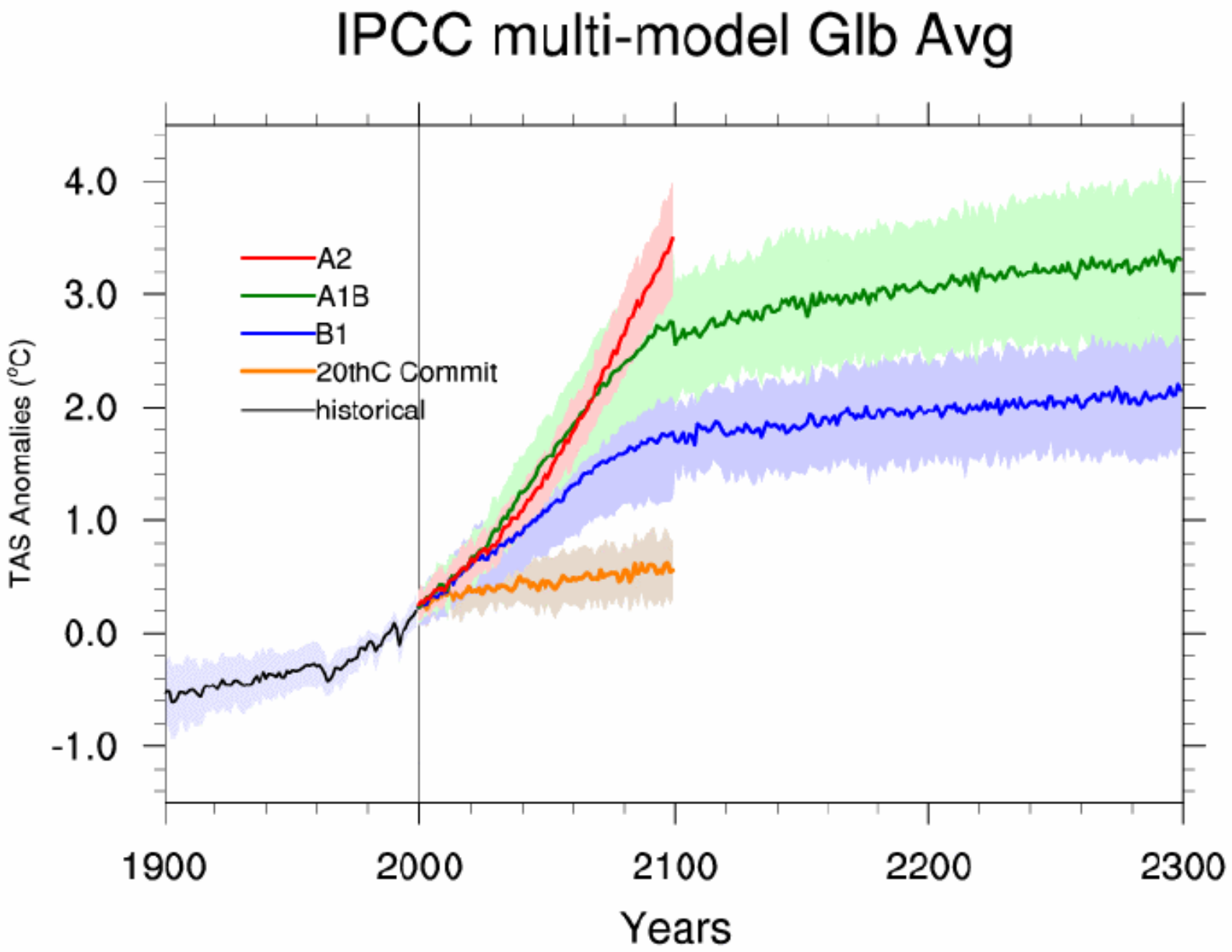
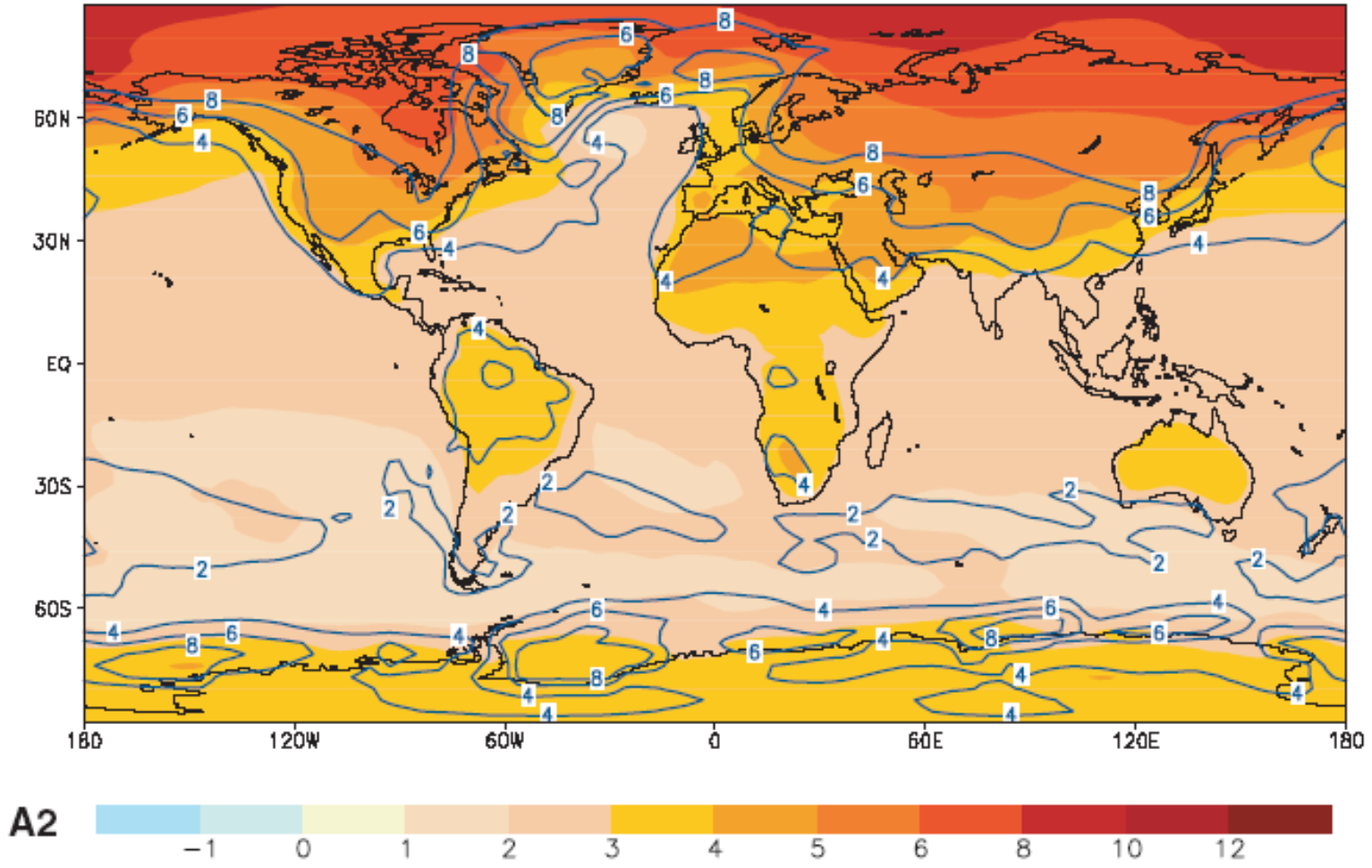
GRAPHIC DESIGN : PHILIPPE REKACEWICZ

Sources: 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 press university, 199; Hadley center for climate prediction and research, United Kingdom, in Climate change information kit, Information unit for convention (IUC), UNEP, Geneva, 1997.


IPCC multi-model Glb Avg
TAS Anomalies (°C)
4.0
3.0
2.0
1.0
0.0
-1.0
A2
A1B
B1
20thC Commit
historical
1900
2000
2100
2200
2300
Years

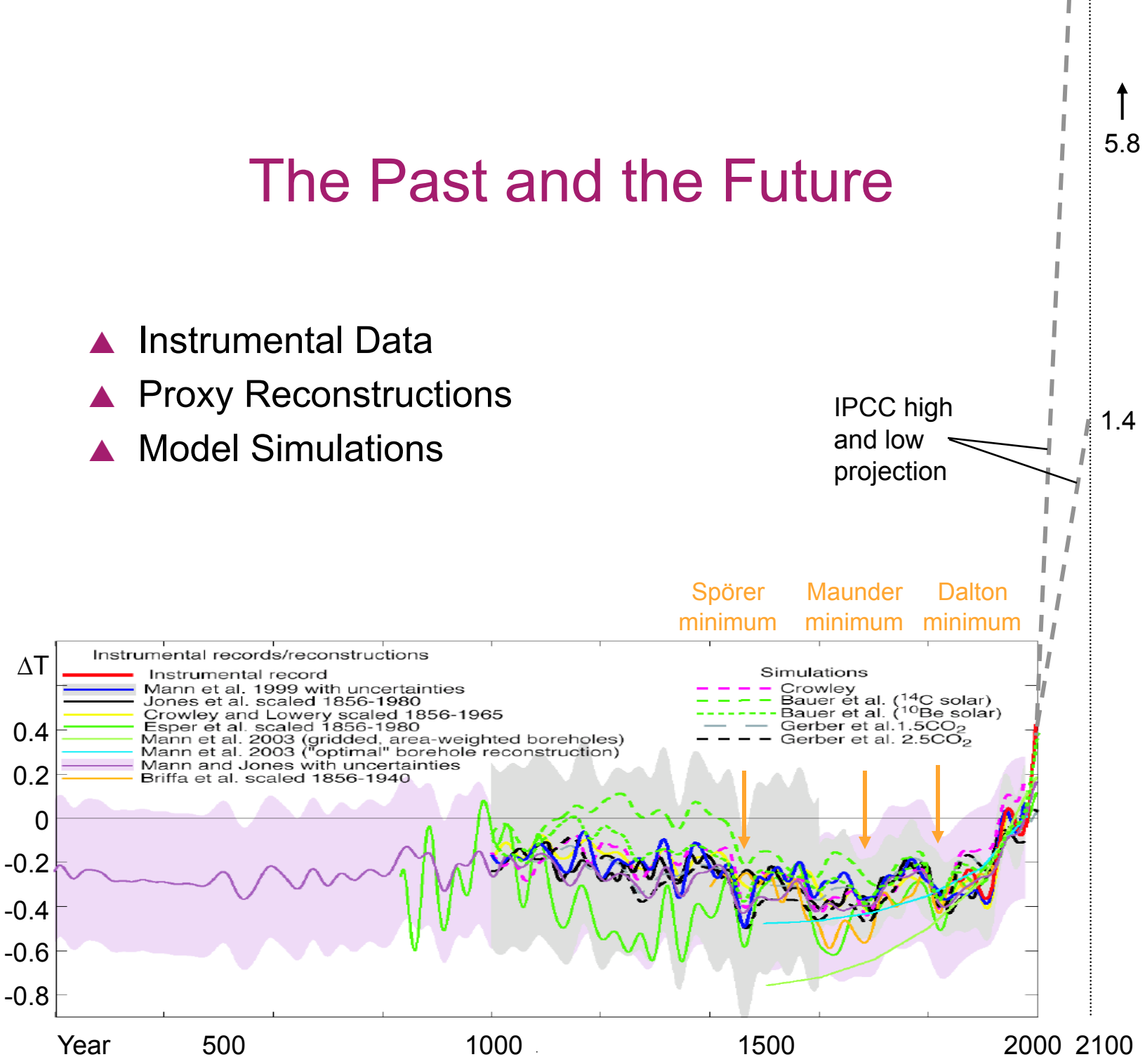
Annual-mean temperature change predicted for 2070-2100 in IPCC Third Assessment Report models



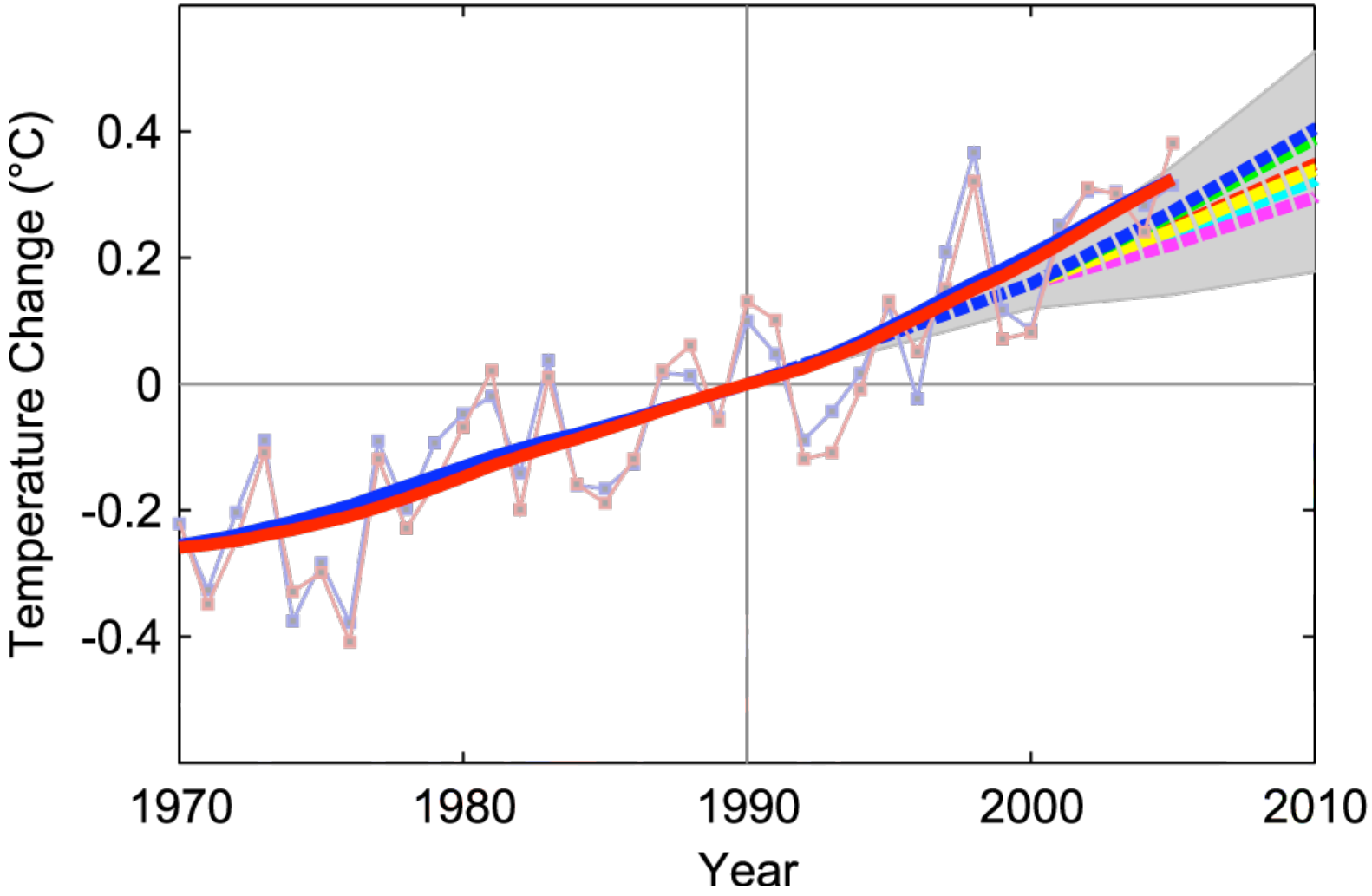
Annual mean change in temperature (colour shading) and its range (isolines) (Unit: °C) for the SRES scenario A2, showing the period 2071 to 2100 relative to the period 1961 to 1990.

The Past and the Future

- Instrumental Data
- Proxy Reconstructions
- Model Simulations

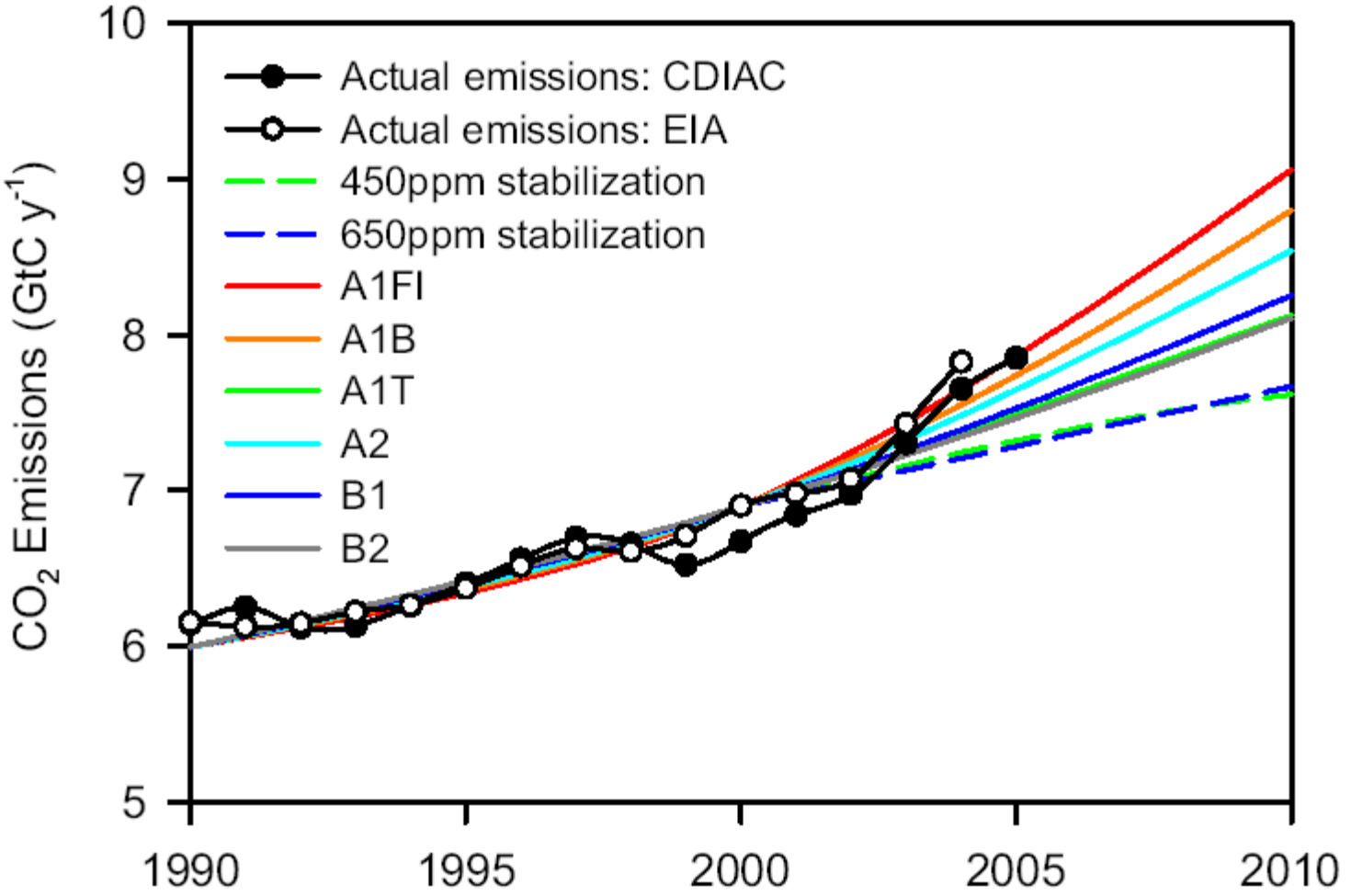


We are currently tracking at the very high end of emission scenarios and temperature projections



Rahmstorf et al. (2007)

We are currently tracking at the very high end of emission scenarios – beyond what the IPCC thought possible



Raupach et al. (2007)

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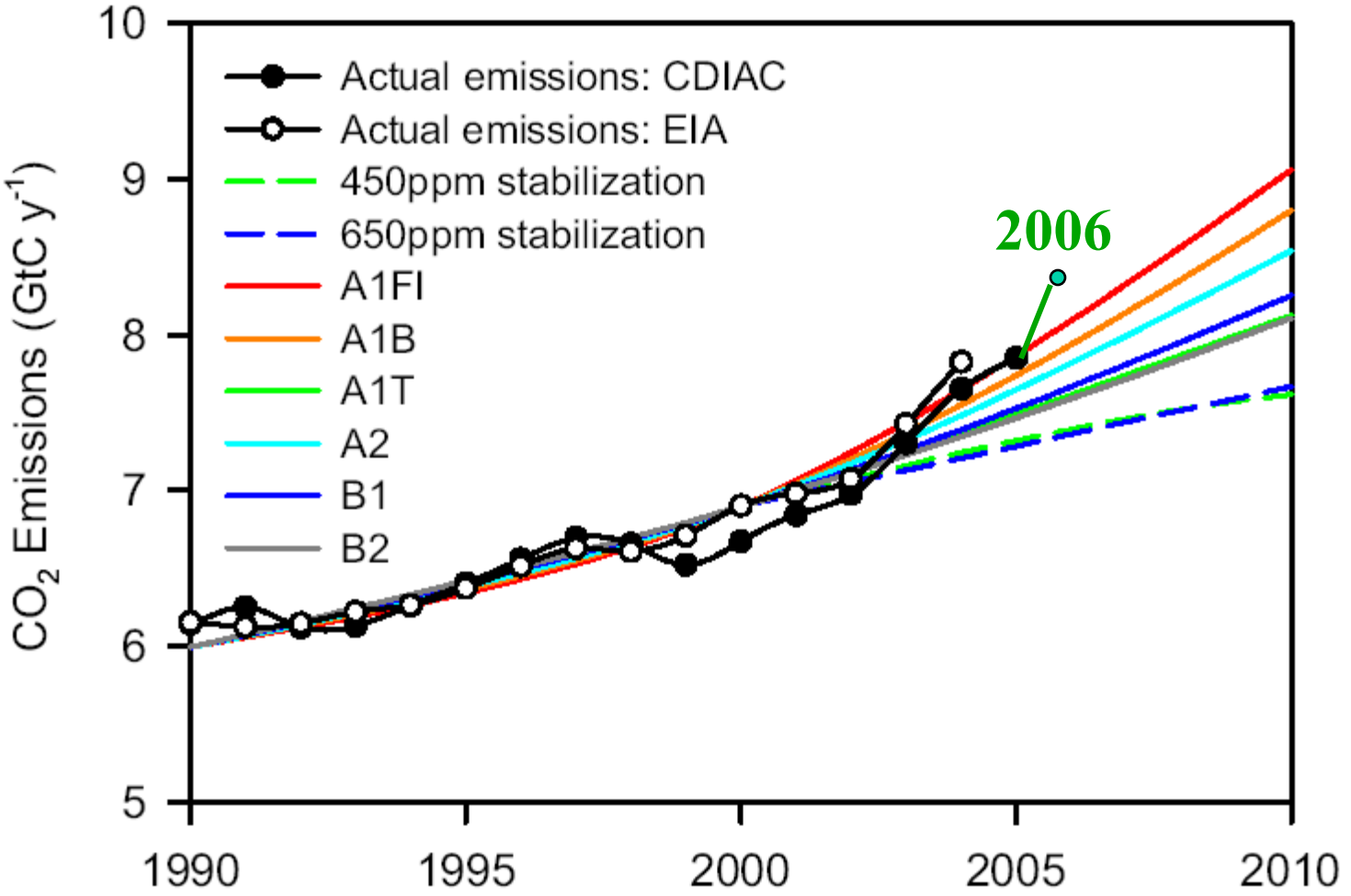
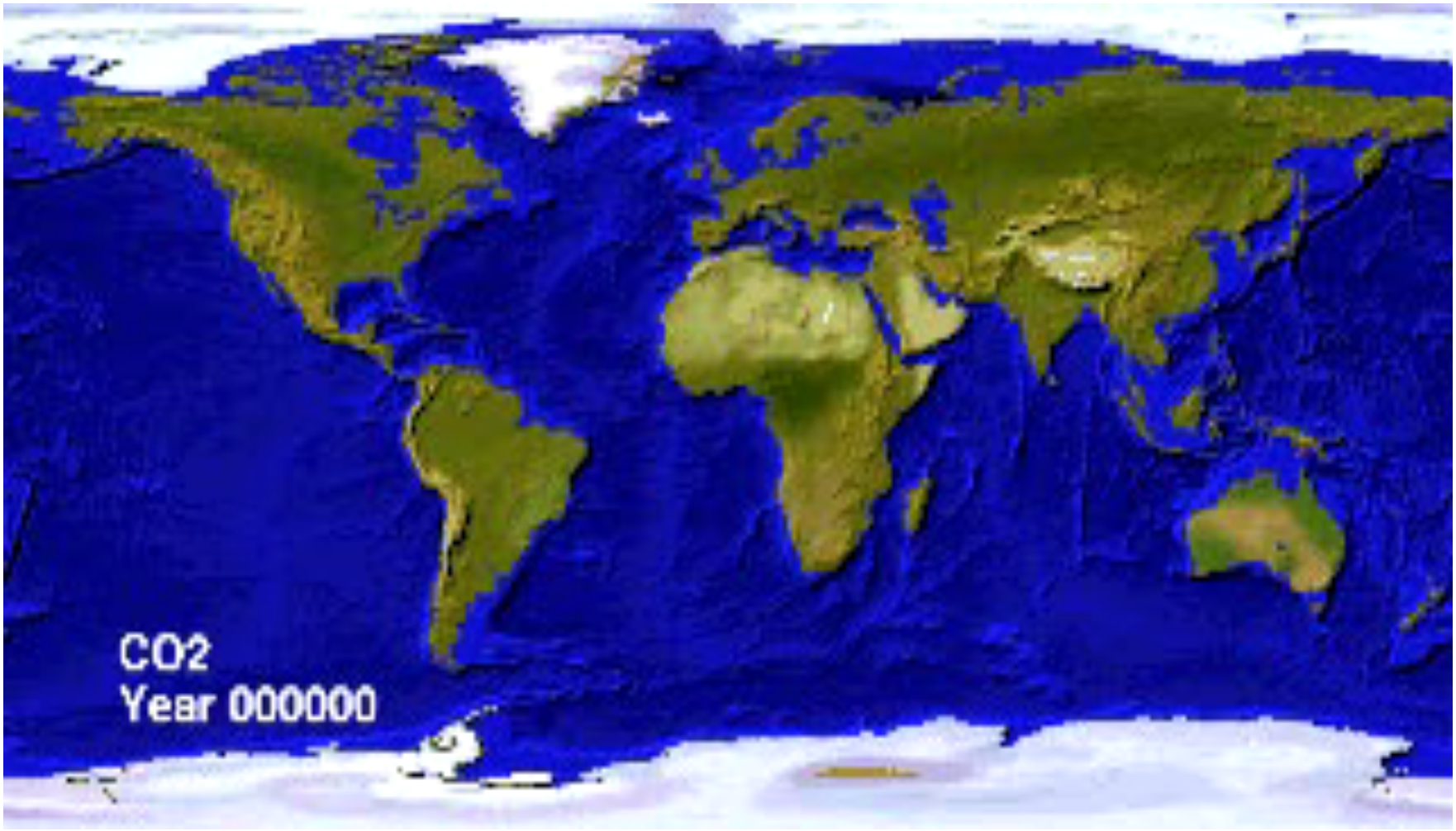


Raupach et al. (2007)

Climate Change simulation to year 2054



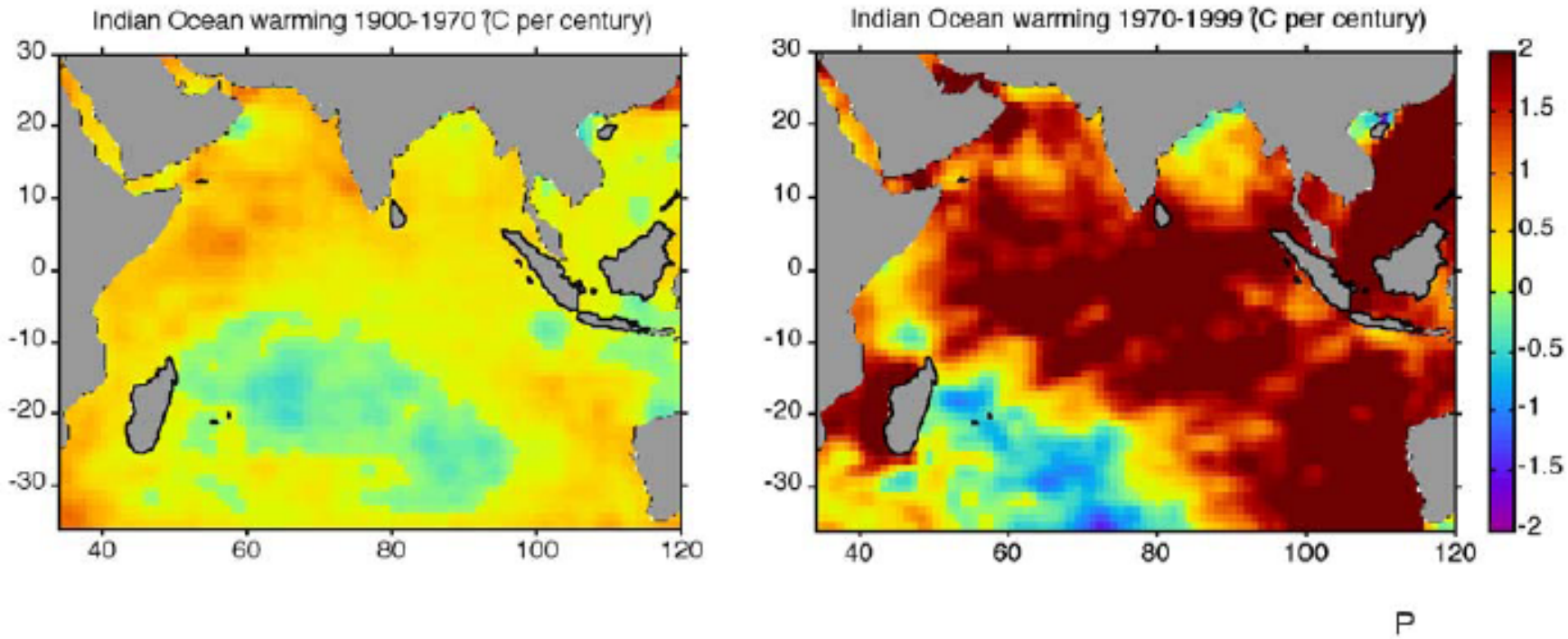
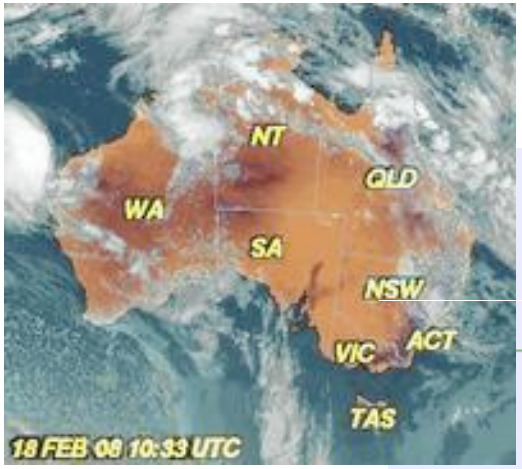
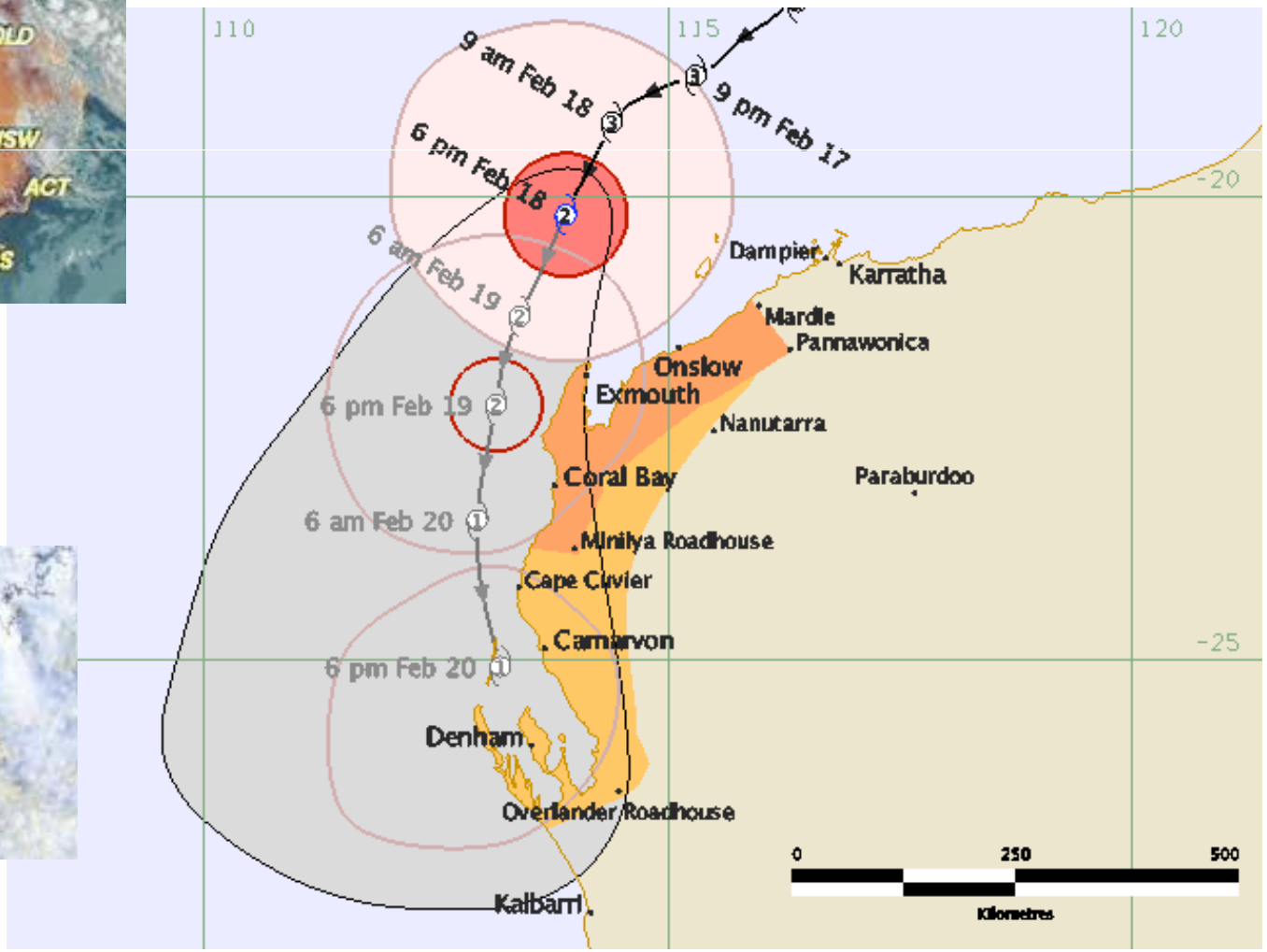


Figure 5.3.5. Linear trend of SST in the Indian Ocean for (a) 1900–1970 and (b) 1970–1999 estimated from the HADISST temperature data (after Rayner *et al.*, 2003).

Tropical Cyclone Nicholas, 18 February, 2008





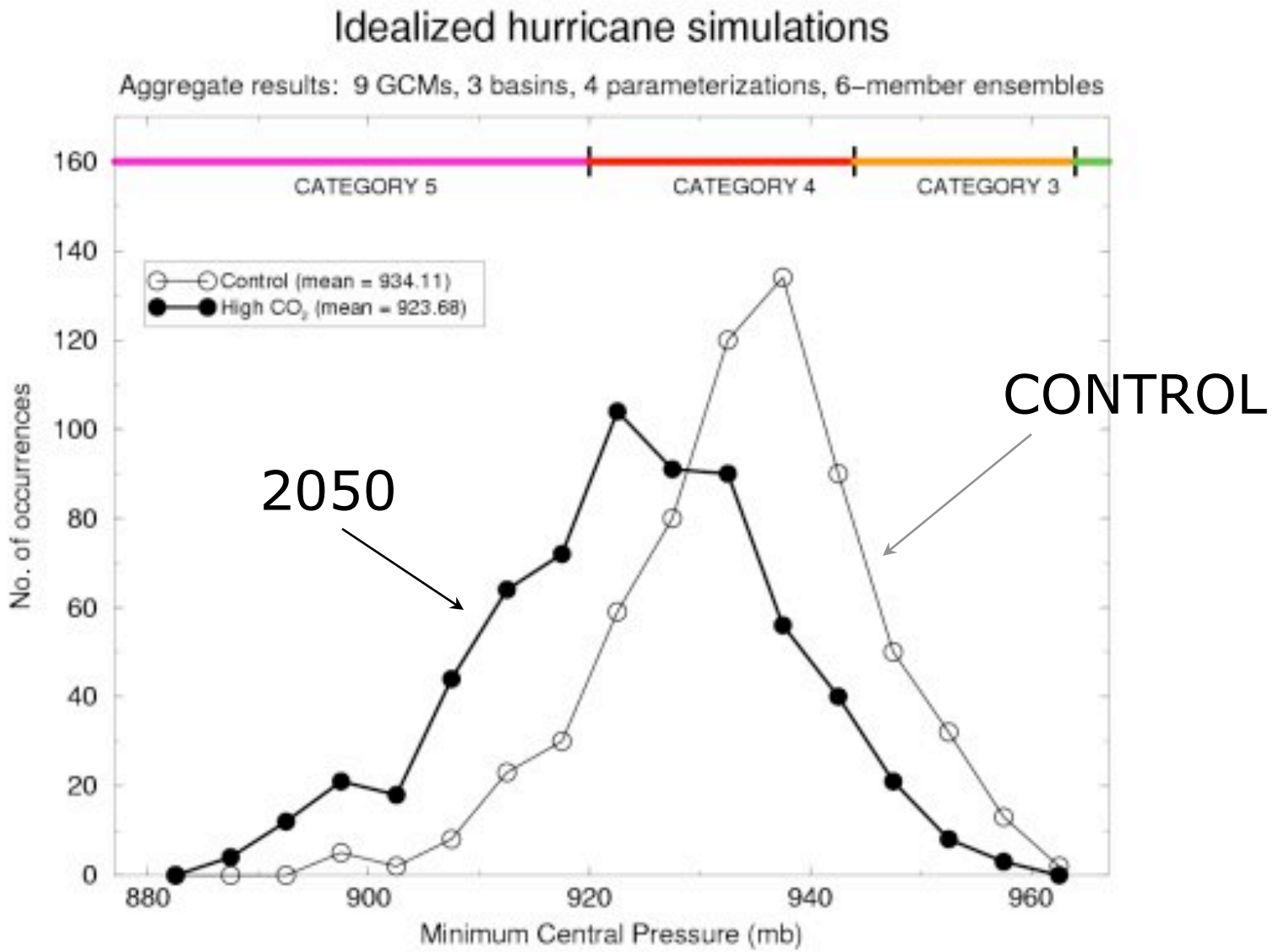
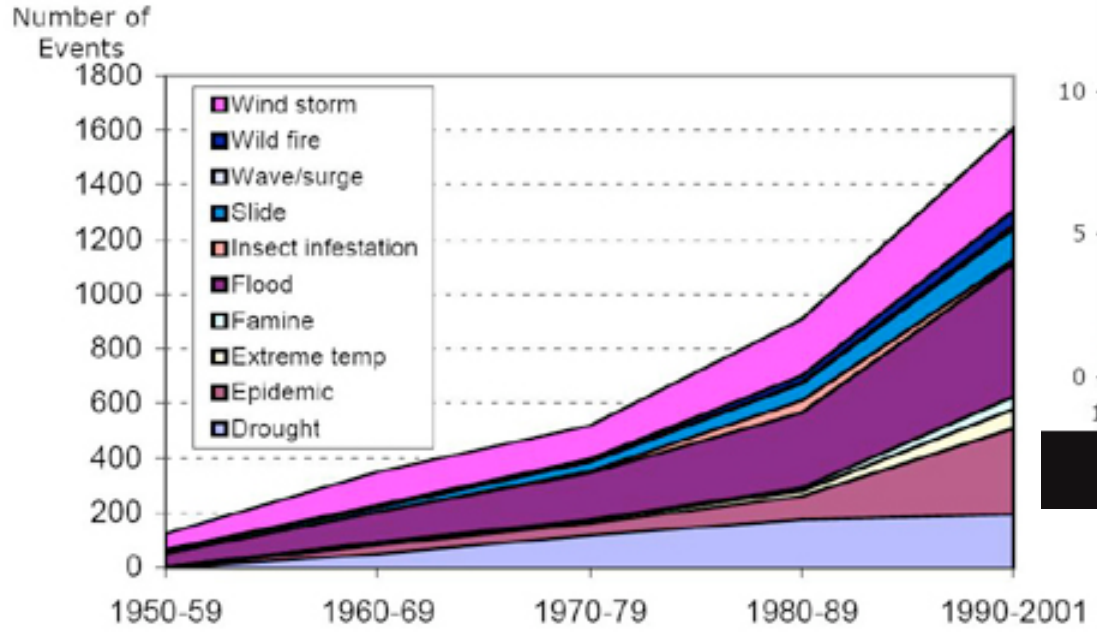


Figure 1. Model Simulation of Trend in Hurricanes (from Knutson et al, 2004)

Increases in severe storms and extreme climatic events?



Source: Center for Research in the Epidemiology of Disasters (CRED)

Increase and Mix of Weather Climate Disasters

Weather Related Insurance

CONCLUSIONS

- The planet has seen substantial climate change in the past century

- These changes cannot be explained by known modes of natural variability (i.e., solar cycles, …)

- A manifestation of climate change can easily be found in air temperatures, rainfall, ocean properties, land-ice, sea-level, winds, storm tracks, …

- These changes will accelerate over the coming decades/century unless we adopt aggressive response strategies

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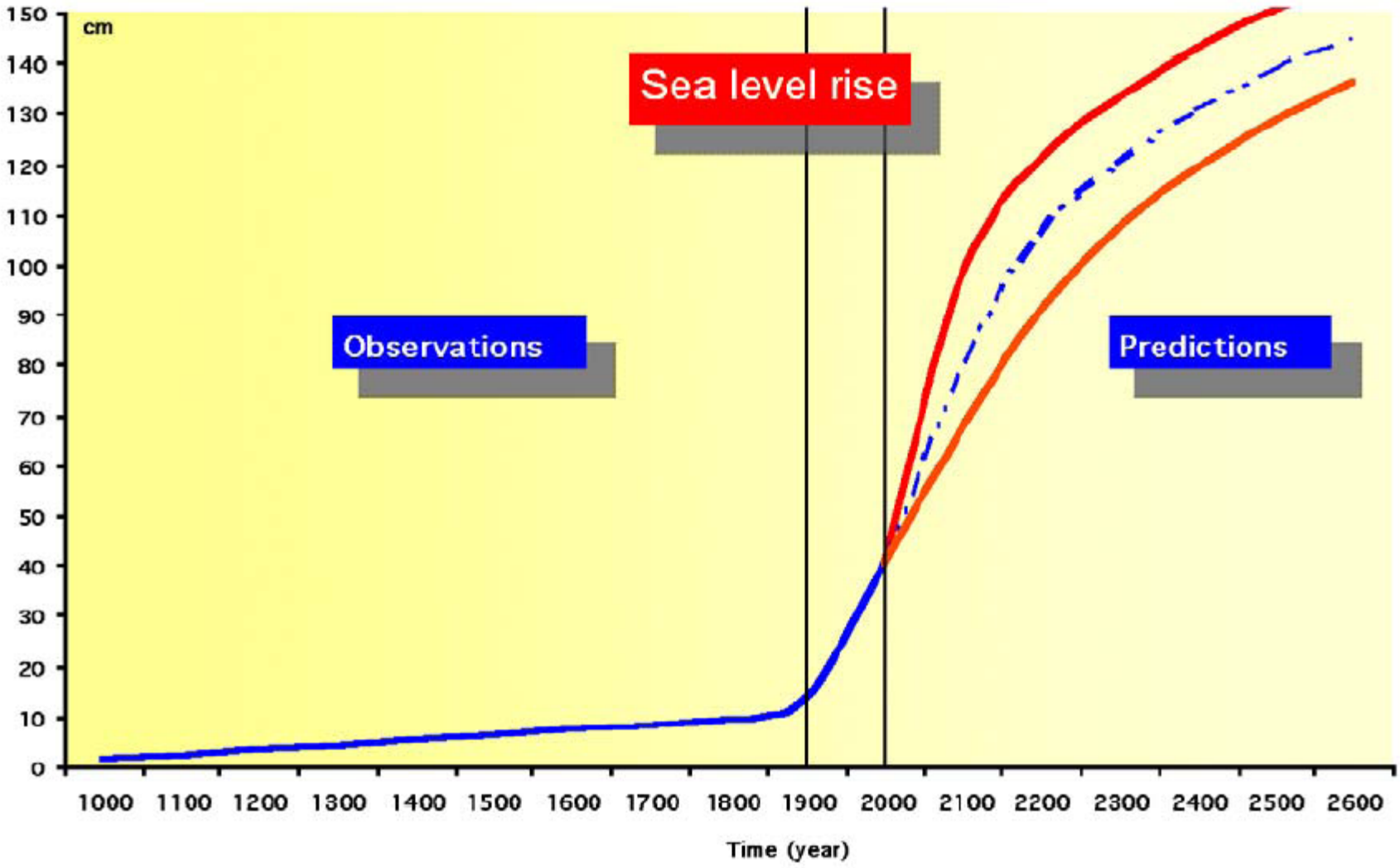
Climate change and human rights

- Displacement of populations
- Water supply
- Food supply
- Human health
- Socio-economic context

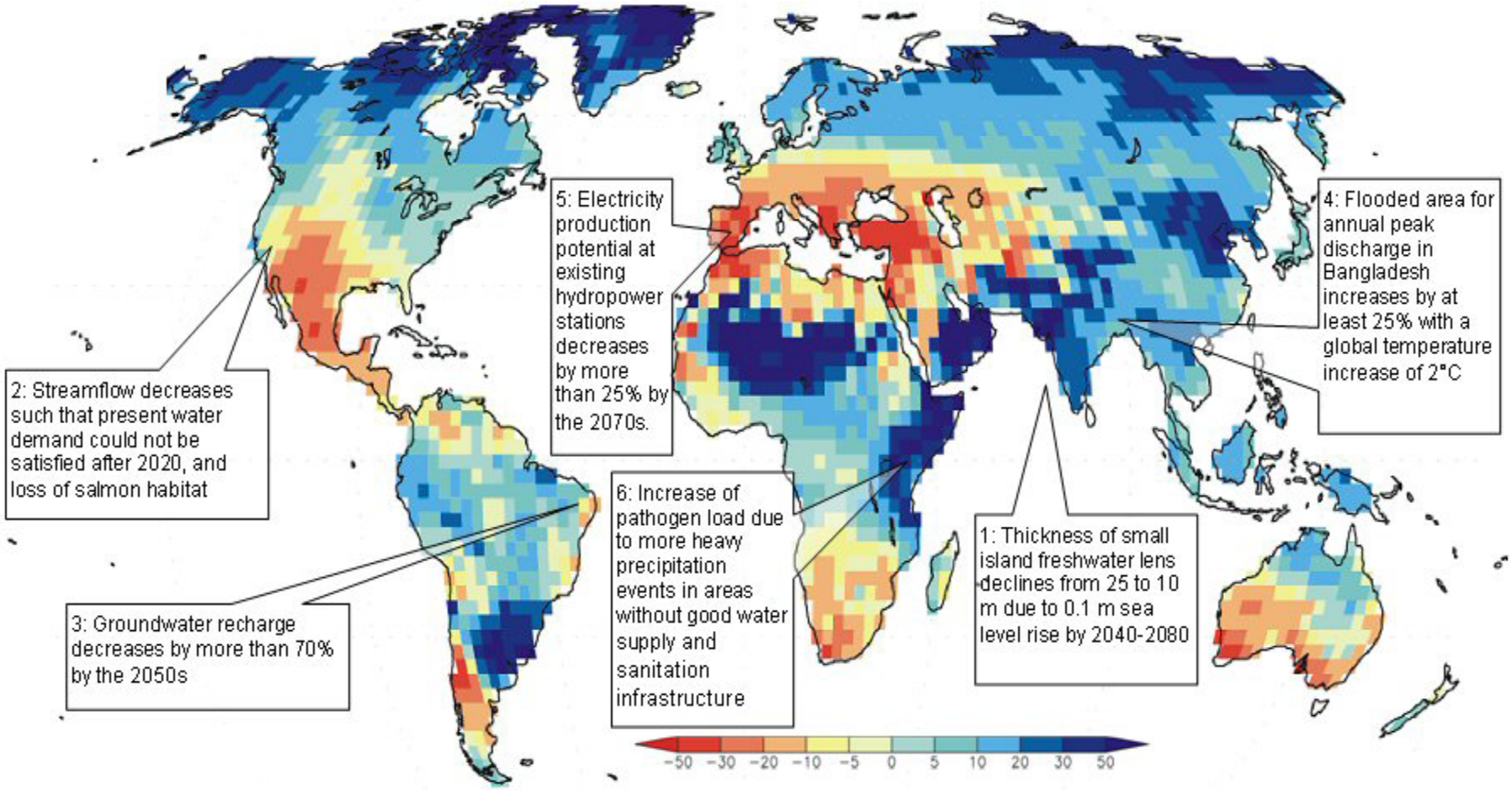


IPCC-WG1 [2007]

***Figure 6.6**: Relative vulnerability of coastal deltas as indicated by the indicative population potentially displaced by current sea-level trends to 2050 (Extreme ≥ 1 million; high =1 million - 50,000; medium 50,000 – 5000; following Ericson et al. (2006)).*

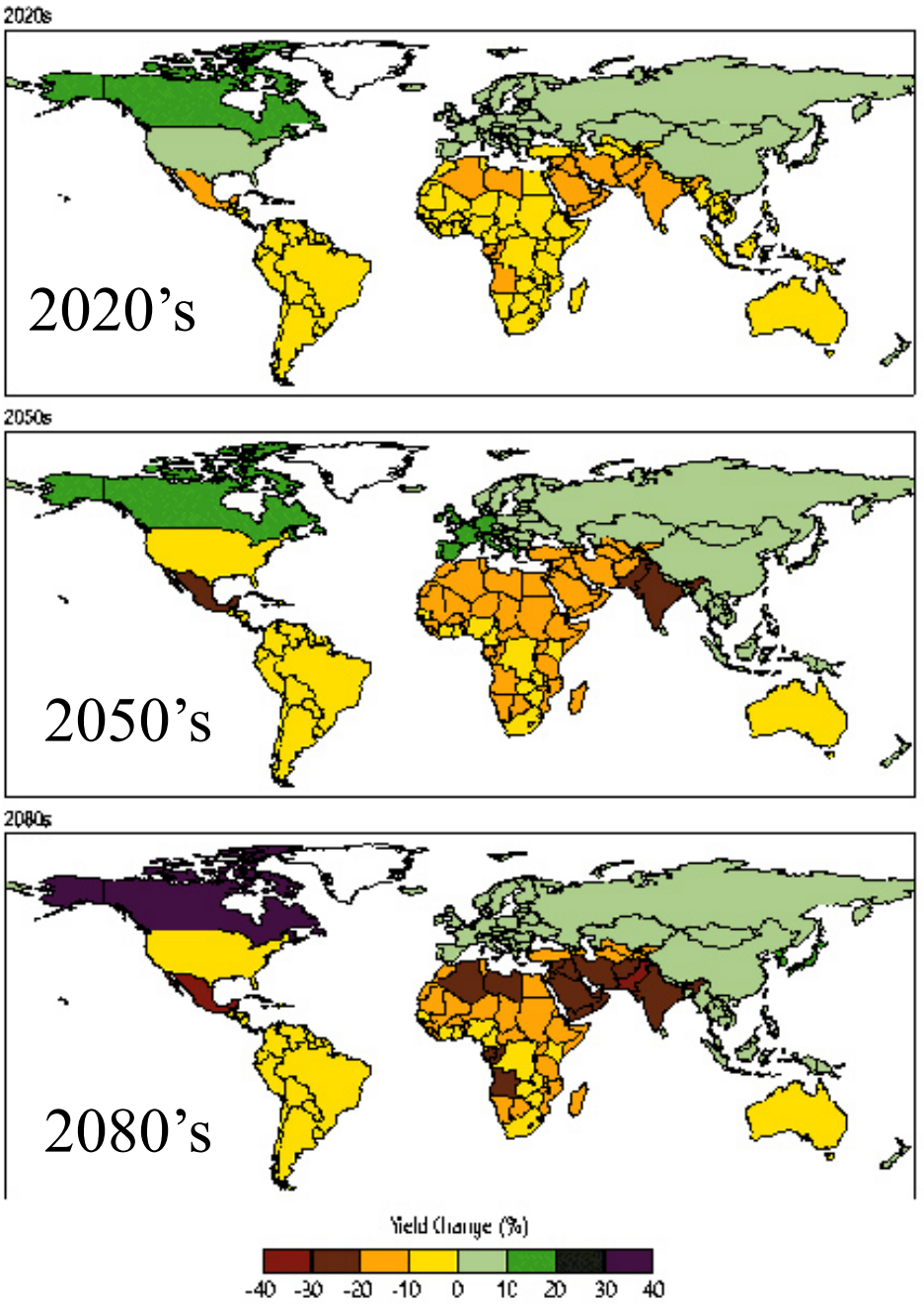
IPCC-WG2 [2007]

Projected run-off changes 2100 relative to 1981-2000



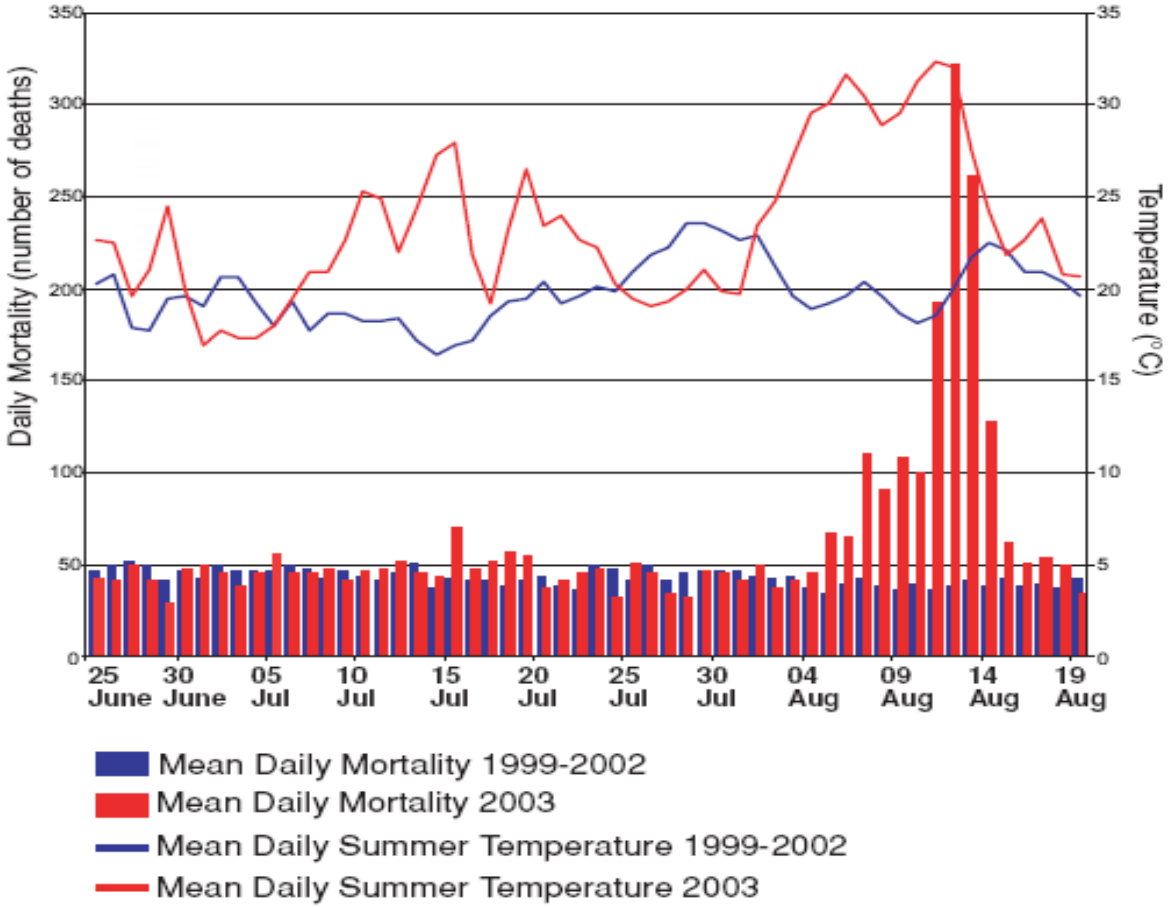
IPCC-WG2 [2007]

Crop yield changes projected relative to today aggregated by nation

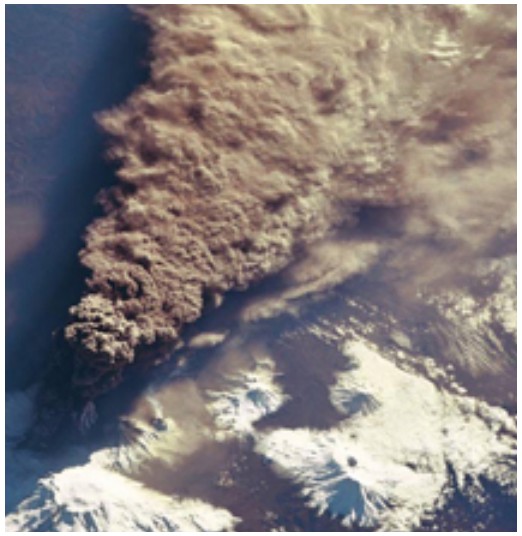


Source: Jackson Institute, University College London / Goddard Institute for Space Studies / International Institute for Applied Systems Analysis

Number of deaths in Paris in summer 2003



Lecture 1 – Climate Physics Primer



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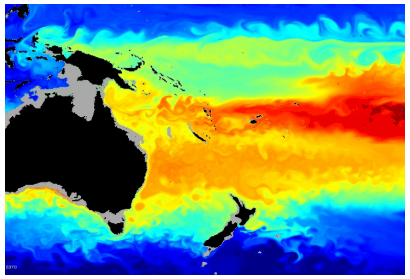
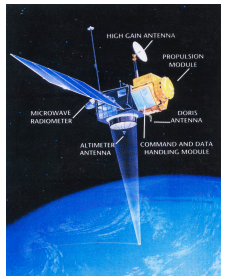
Climate Change Research Centre

Some issues re. climate science

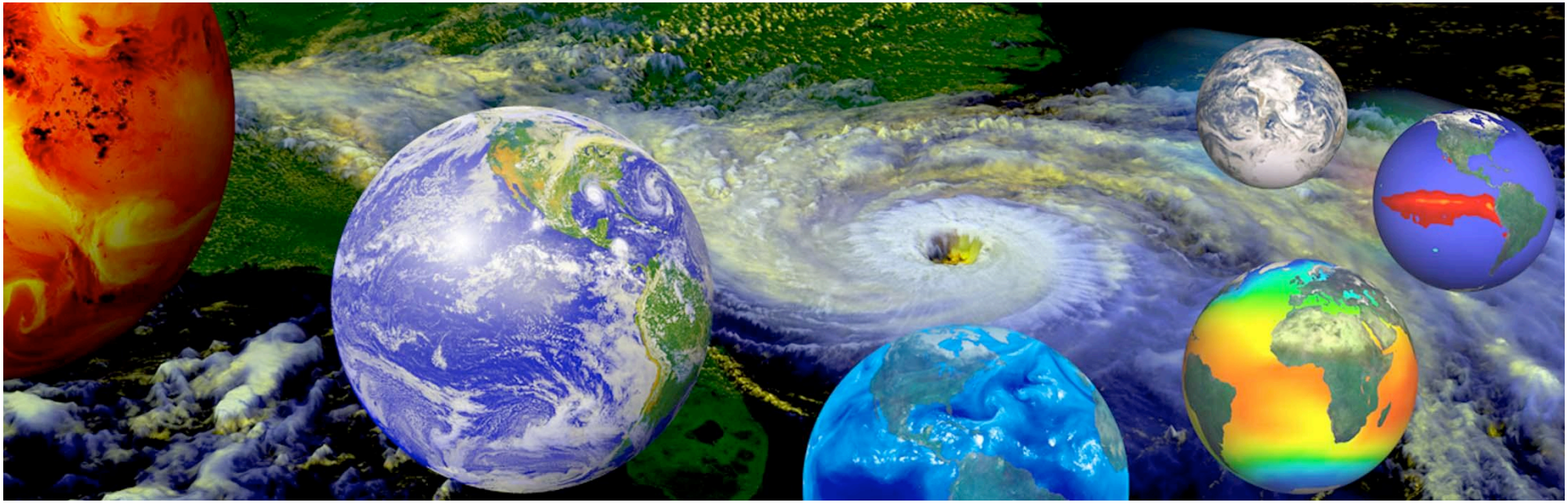
- **Climate scientists are well aware of natural variability**
  - Climate scientists have no "conflict-of-interest"
  - Climate science must undergo rigorous peer-review
    - Climate scientists do not prescribe policy
    - Inexpert debate - unlike any other science
  - Opportunities for innovation and economic growth
    - We have succeeded before: CFC's, …
- Climate scientists are your **best** source of information for climate science

Physical oceanography and climate science

The study of the physics, properties, and dynamics of the oceans and coupled climate system



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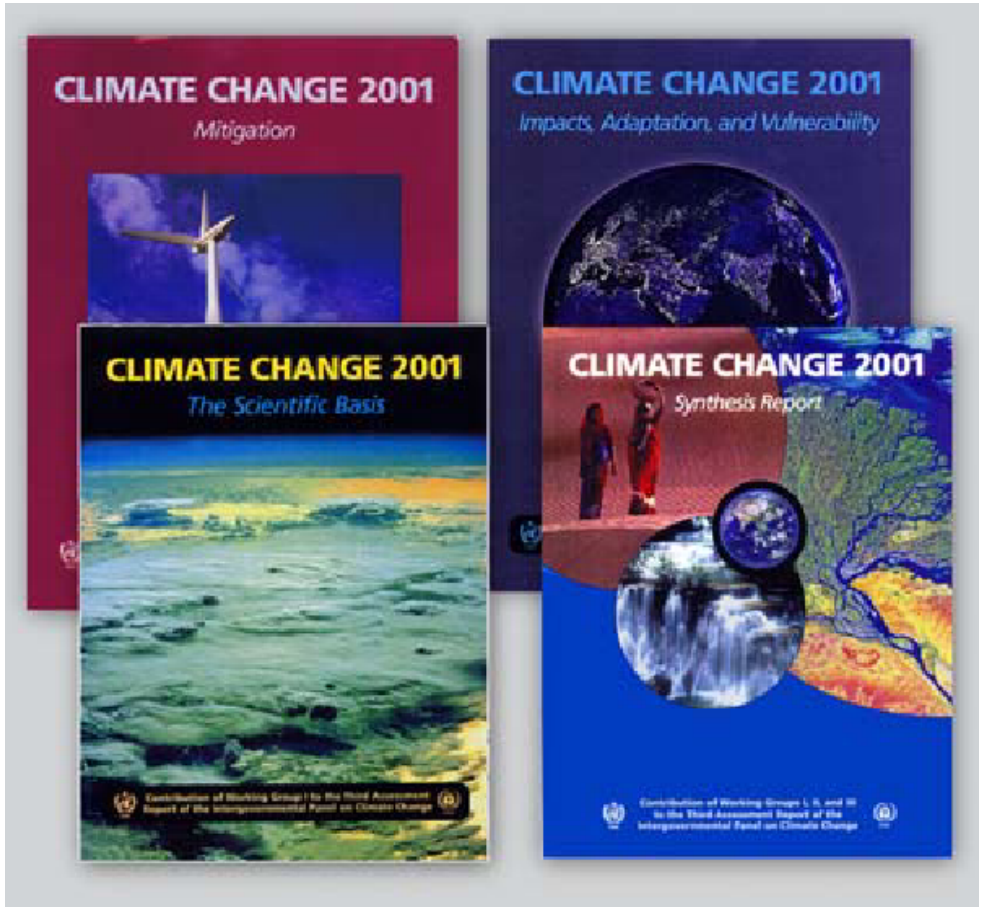
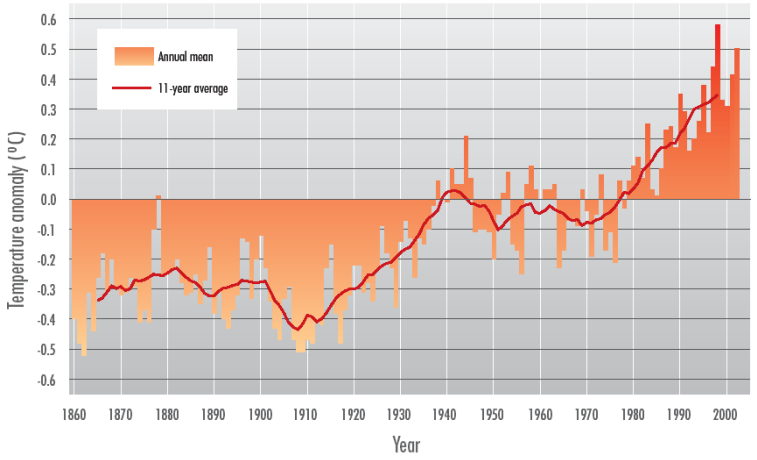
Intergovernmental Panel on Climate Change (IPCC)





http://www.ipcc.ch

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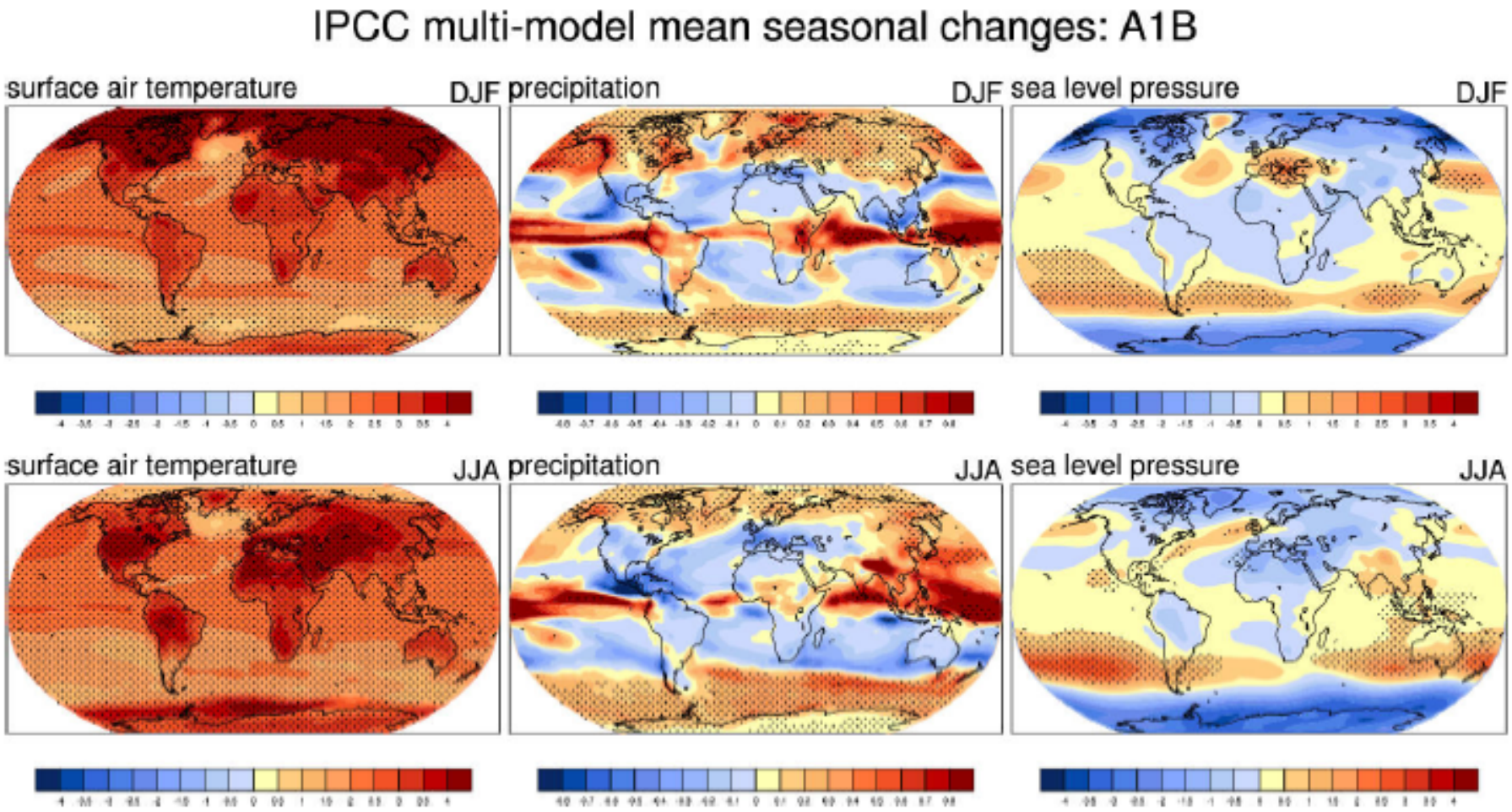

Figure 10.3.6. Multi-model mean change under the A1B scenario for 2080–2099 relative to 1980–1999, for DJF (top) and JJA (bottom). The variables are, from left to right, surface air temperature (°C), precipitation (mm/d), and sea level pressure (hPa). Stippling denotes areas where the magnitude of the multi-model ensemble mean exceeds the inter-model standard deviation.

IPCC-WG1 [2007]

Global 20th Century Temperature Trends