The Science of Climate Change

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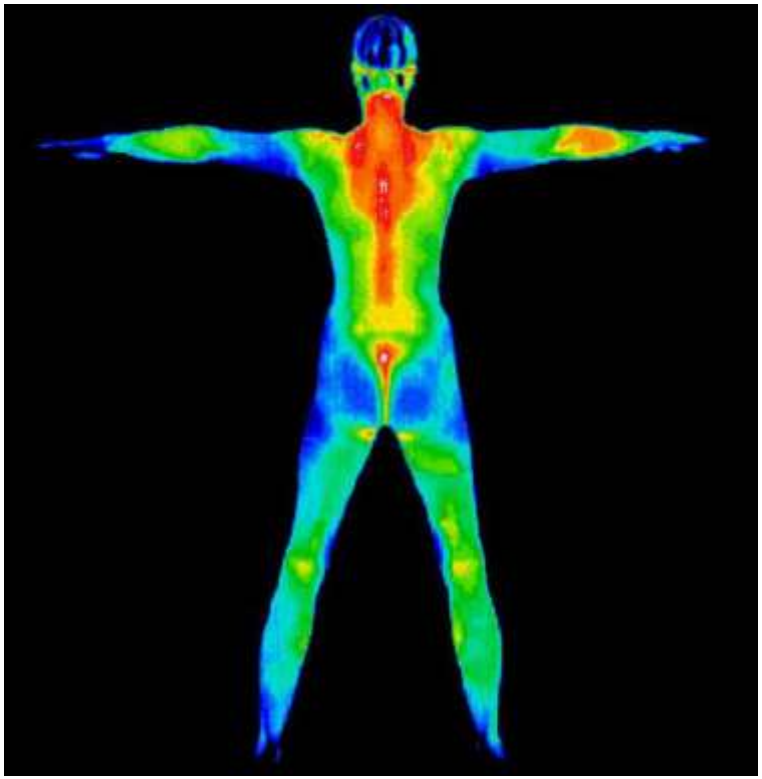
Climate Outreach Day, 17th January 2018

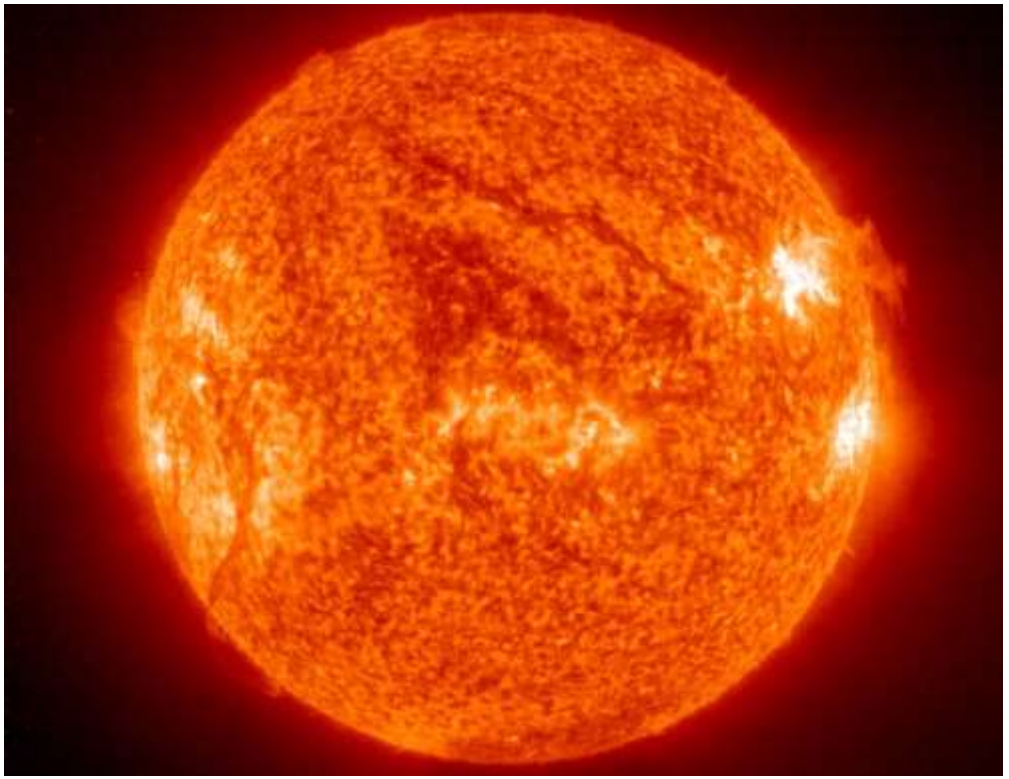
University of Reading

What Causes Climate Change?

Everything emits radiation energy

units: Watts per square metre (Wm^{-2})



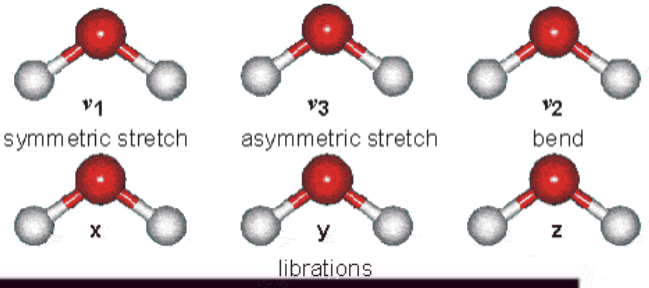


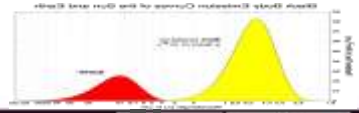
Cool things: long wave-length or thermal radiation, e.g. us ~300 K

Hot things: short wave-length radiation, e.g. the sun ~6000 K

Temperature in Kelvin = Temperature in ^{o}C + 273.15

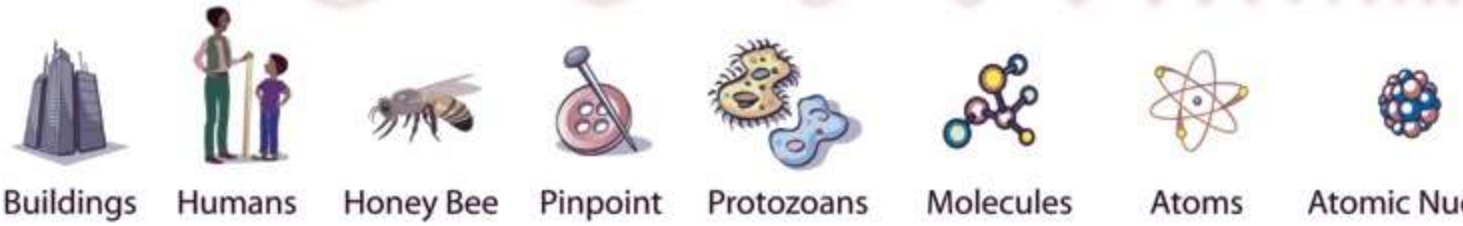
The Electromagnetic Spectrum



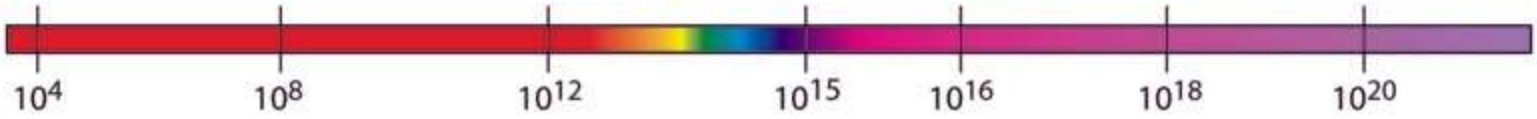


Penetrates Earth Atmosphere?

Wavelength (meters)



Frequency (Hz)



Temperature of bodies emitting the wavelength (K)

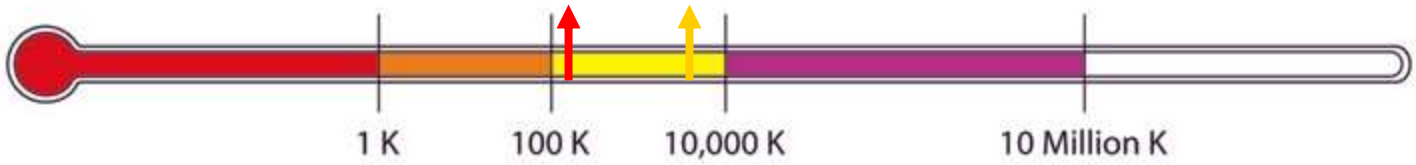
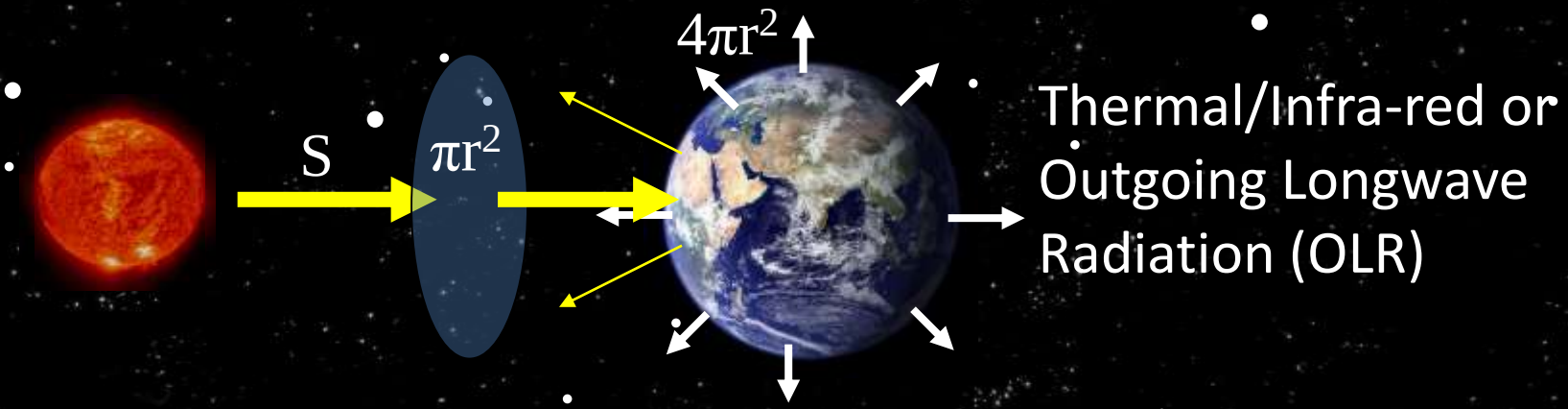


Figure from NASA.

IR thermometer activity

Earth's Radiation balance in space



Absorbed Solar or Shortwave Radiation $\frac{S}{4}X(1-\alpha)$

α is "albedo" – the proportion of incoming solar radiation reflected back

- There is a balance between heating from absorbed sunlight and cooling to space through thermal/longwave radiative energy
- $\frac{S}{4}(1-\alpha) = OLR$ S ≈ 1361 Wm^{-2}, α ≈ 0.3, OLR ≈ 239 Wm^{-2}
- How does it balance? Why is Earth's average temperature ~15°C?
- Scratch Energy Balance Activity

Forcing and response: a natural experiment


29/3/06 11.05am
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29/3/06 12.26pm
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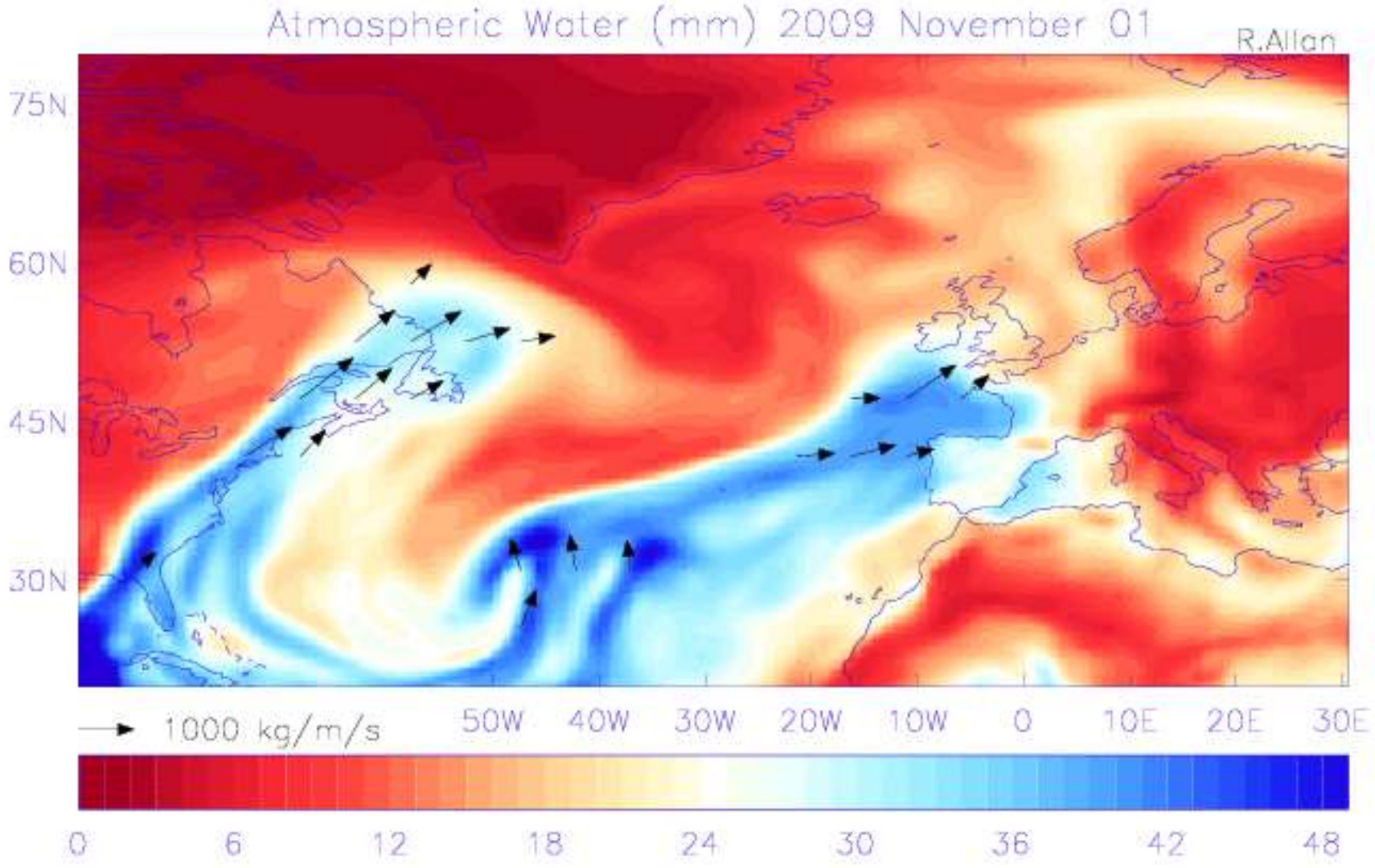
Clouds affect radiation fluxes

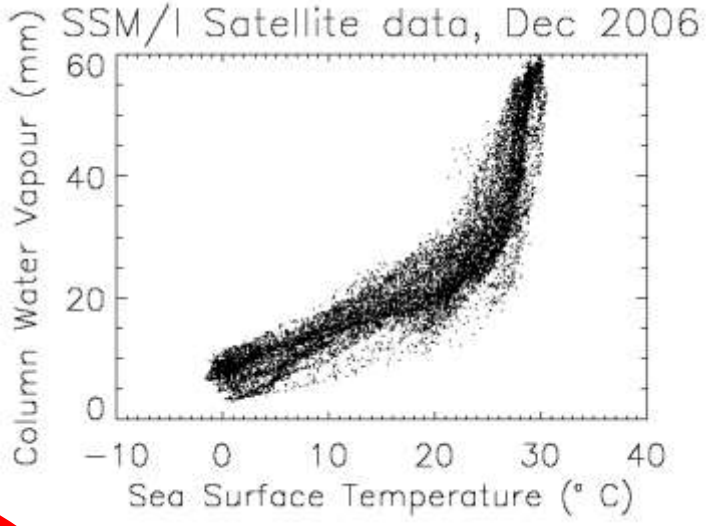
Radiation fluxes affect clouds

Feedback/response activity

Water vapour and climate



Water Vapour causes an amplifying positive Feedback loop



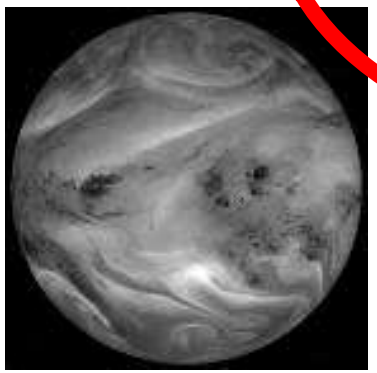
↑ CO_2

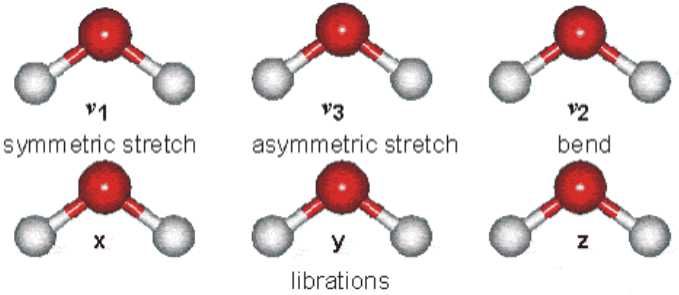
↑ Water vapour

↑ Greenhouse effect and more absorption of sunlight

↑ Net Heating

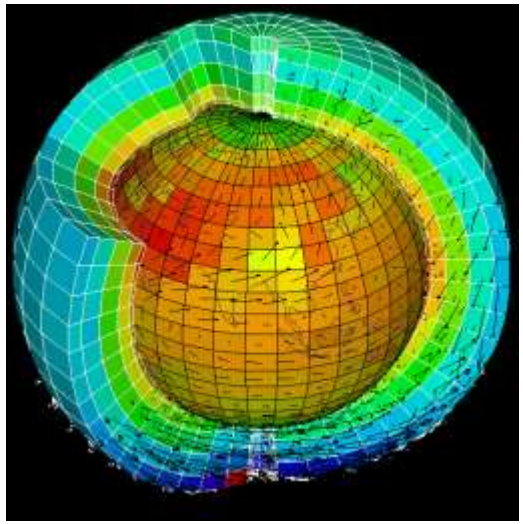
↑ Temperature

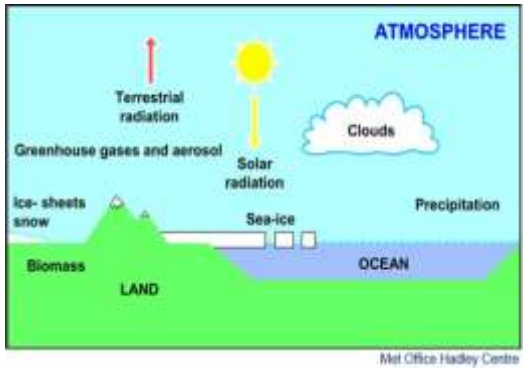




Climate simulations

- Scientists put all the physics of the atmosphere, oceans and land into complex computer simulations
- Many millions of lines of code are used to calculate the equations and pass information between grid cells
- These simulations are used to:
  - understand why climate has changed in the past
  - project how climate will change over future decades and centuries





climate model animation

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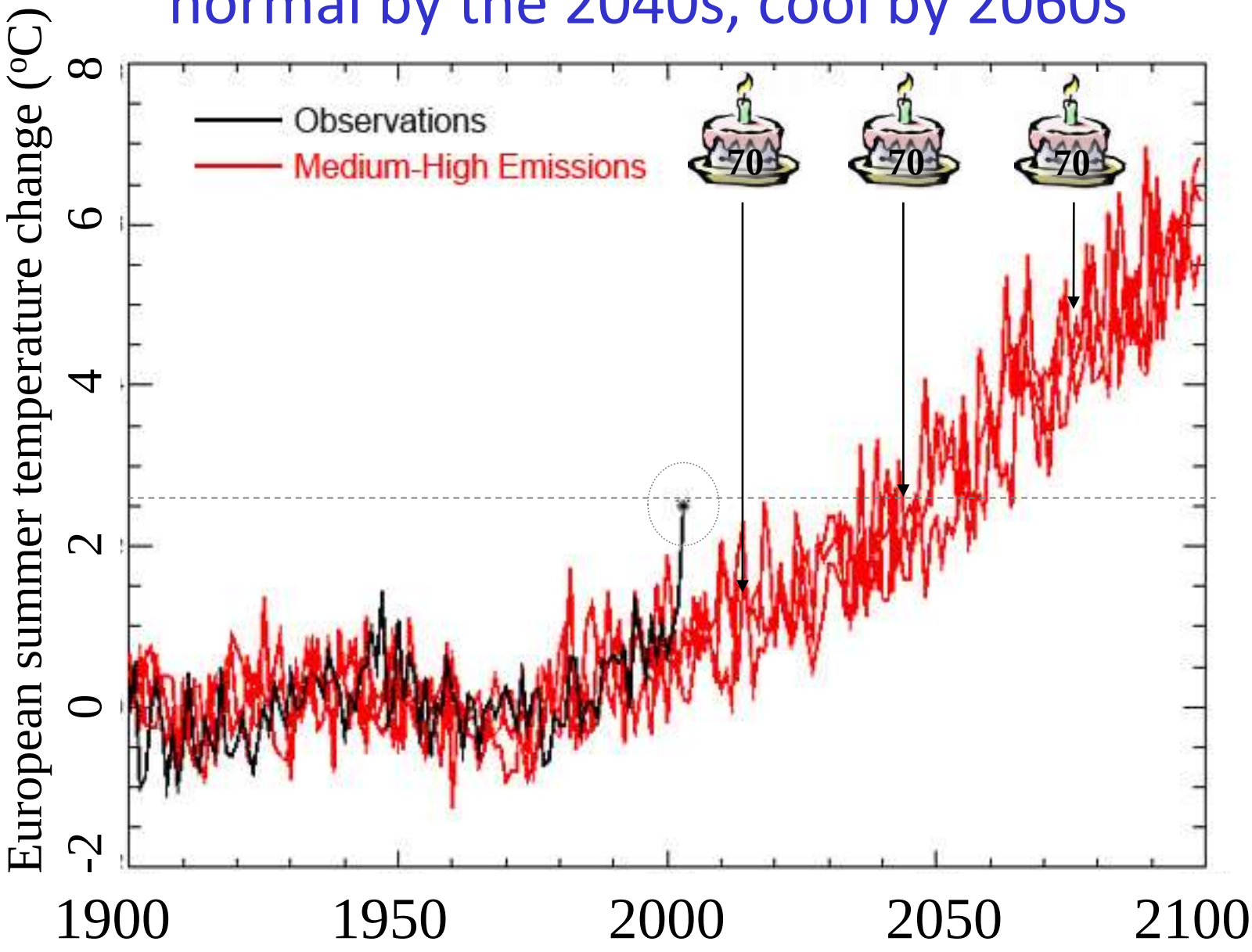
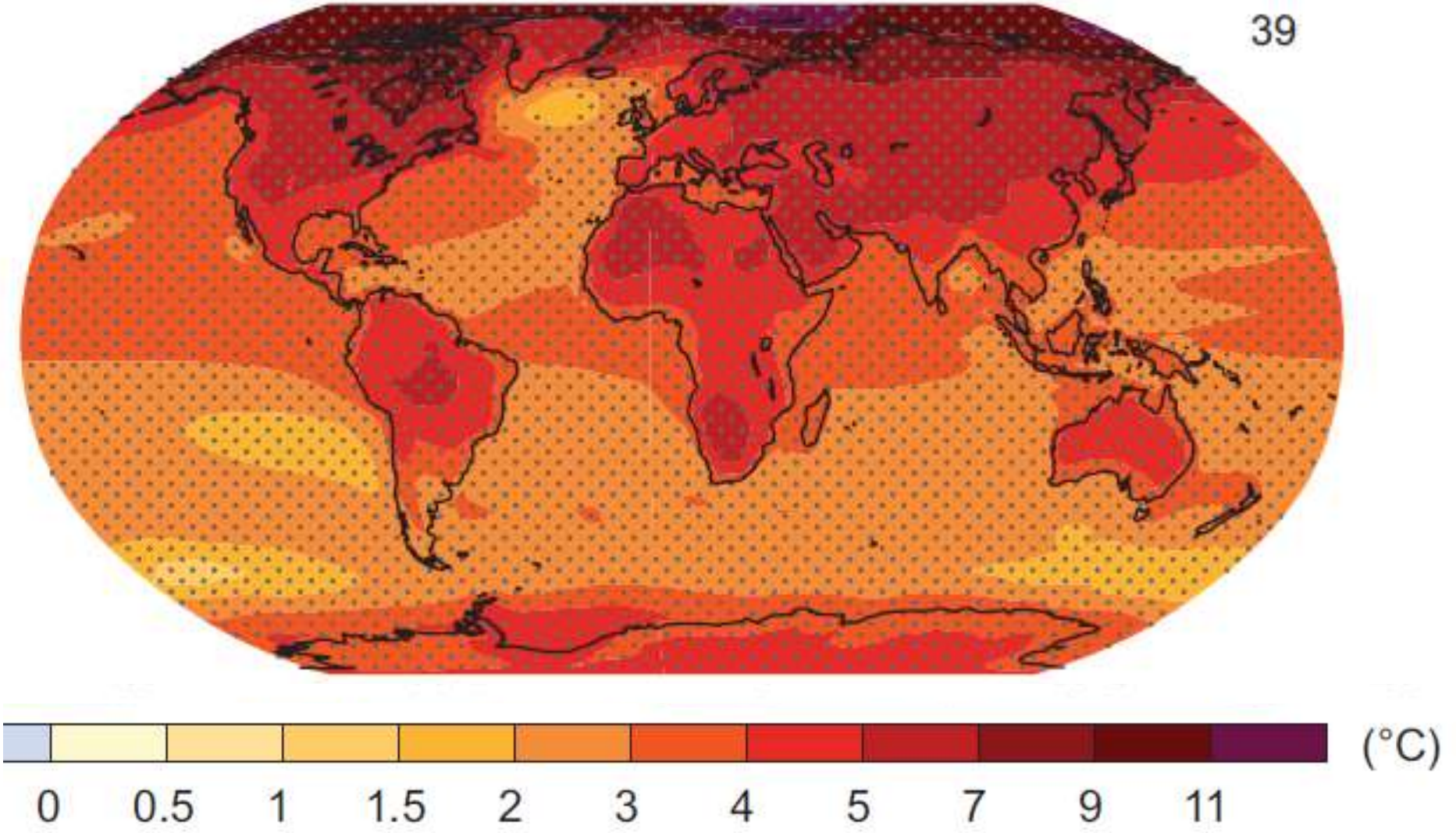
How will climate change over your lifetimes?

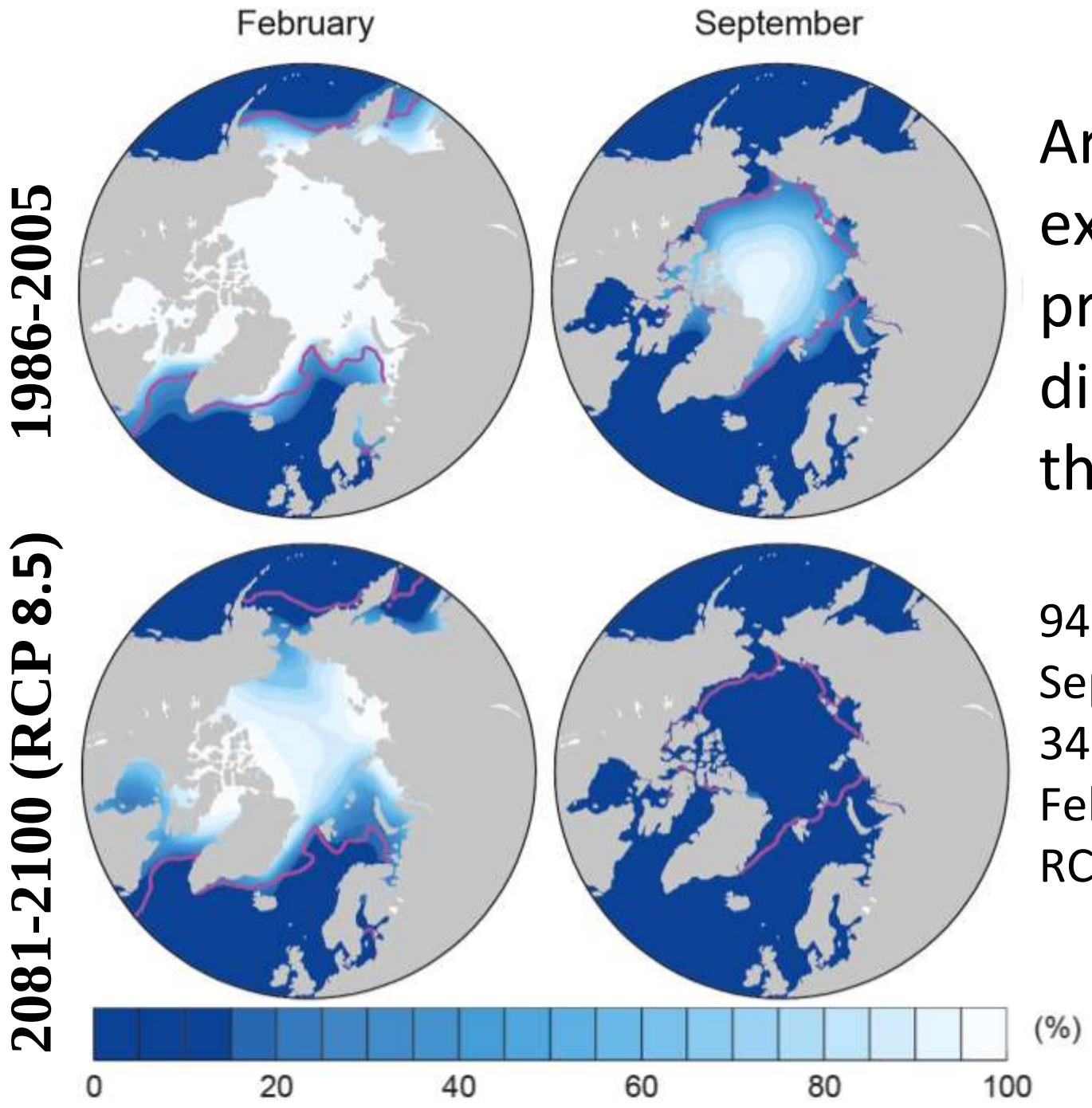
Summer 2003 European heatwave temperatures normal by the 2040s, cool by 2060s



Warming will be greater over the land and greatest in the Arctic



Change in average surface temperature (1986–2005 to 2081–2100) RCP 8.5 Scenario



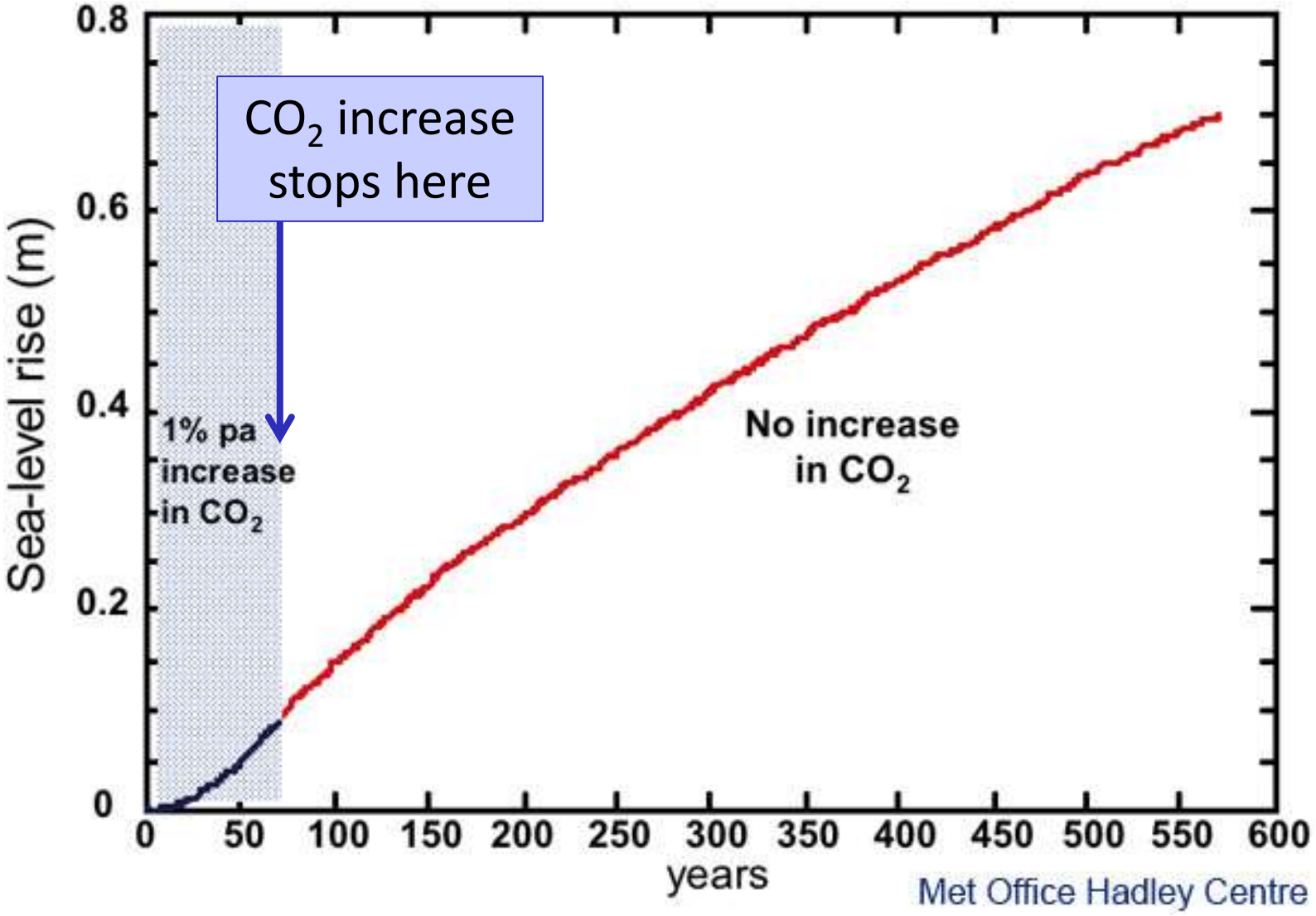
Arctic sea ice extent is projected to diminish over the 21st century

94% decrease in September and 34% decrease in February for the RCP8.5 scenario

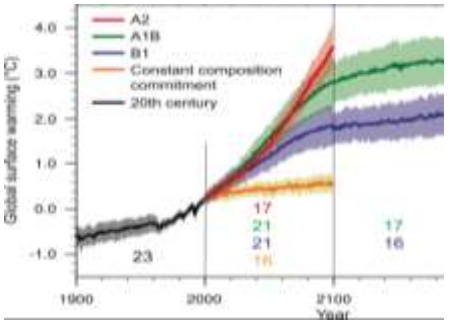
IPCC (2013)
WG1 Fig. 12.29

Intensification of heavy rainfall

Sea-level rise will continue to rise for centuries



Summary



- Climate has always changed
- Greenhouse gases such as carbon dioxide are at their highest levels for at least the last 800,000 years
- This pollution from human activity is amplifying the natural greenhouse effect
- This is heating the planet by impeding outgoing infrared cooling to space
- Substantial changes in global temperature and rainfall patterns are projected using computer simulations
- Predicting regional climate change is a challenge
- What can we do to avoid dangerous climate change?