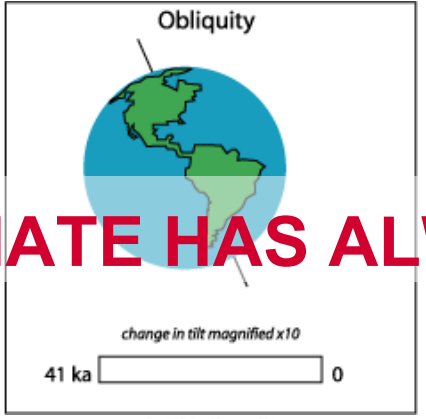
Department of Meteorology

University of Reading

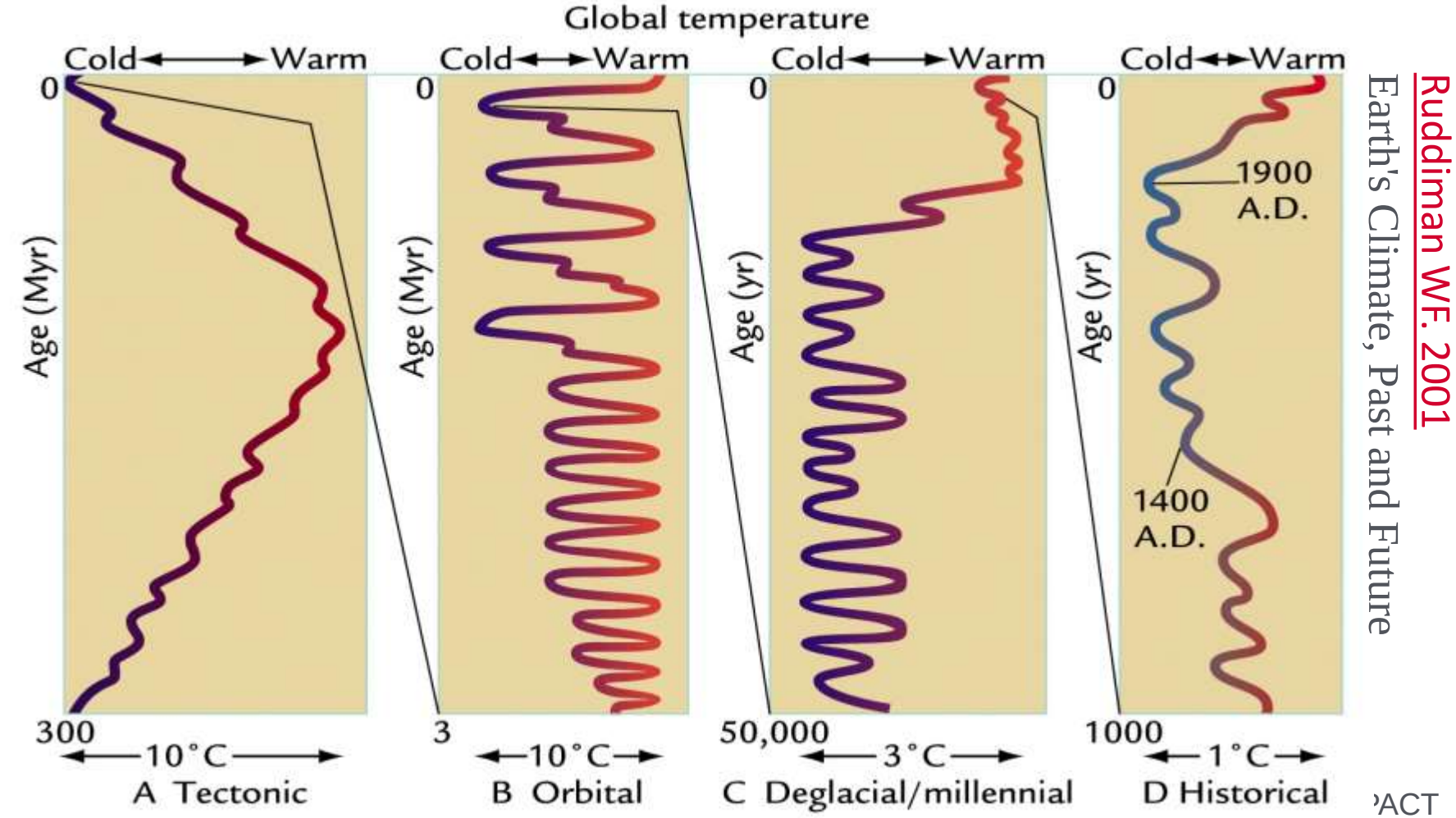
THE SCIENCE OF CLIMATE CHANGE

Professor Richard Allan @rpallanuk r.p.allan@reading.ac.uk

Northcote Lodge School, Wandsworth, 24th January 2018



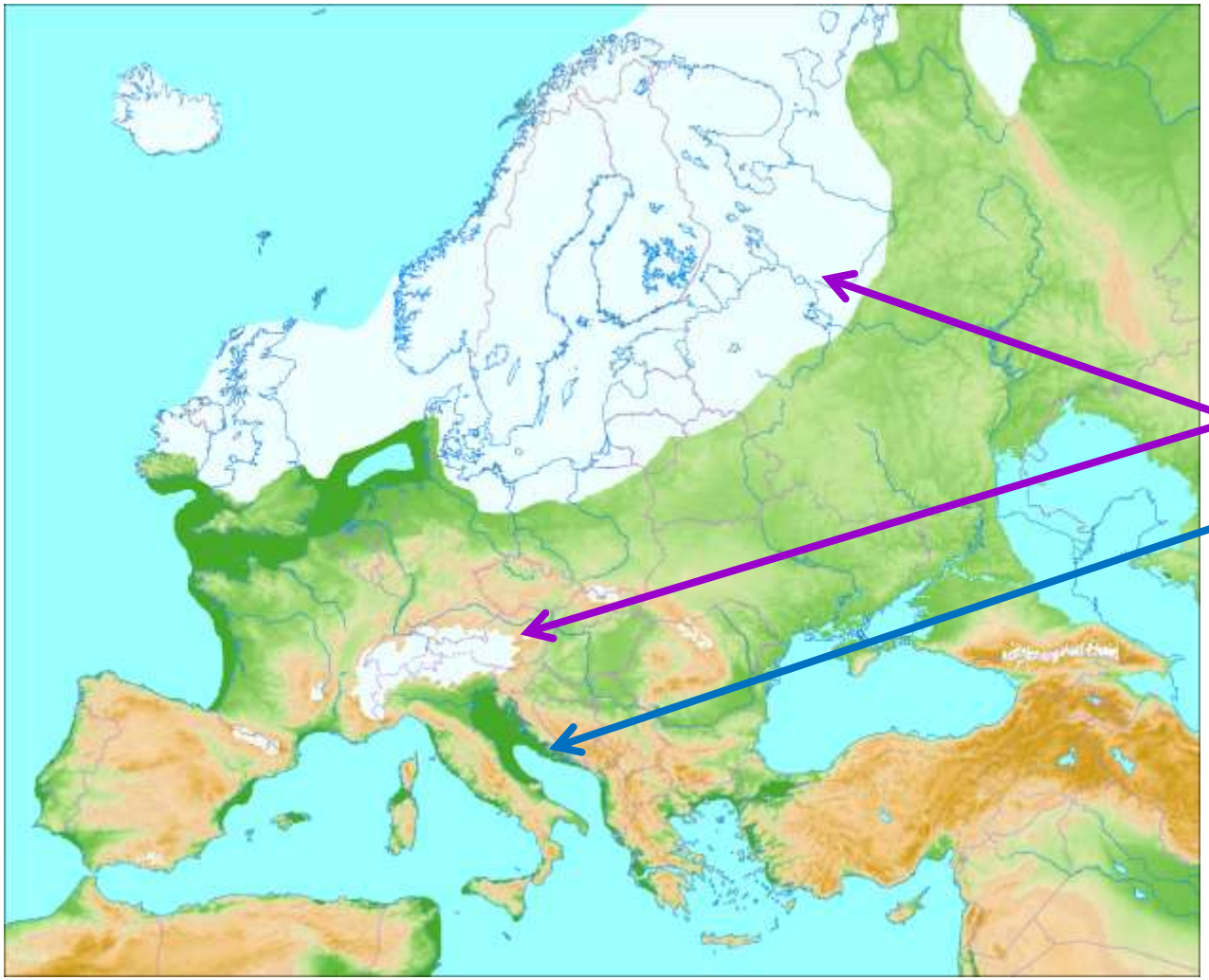
EARTH'S CLIMATE HAS ALWAYS BEEN CHANGING



Ruddiman WF. 2001
Earth's Climate, Past and Future

University of Reading

THE LAST GLACIAL MAXIMUM

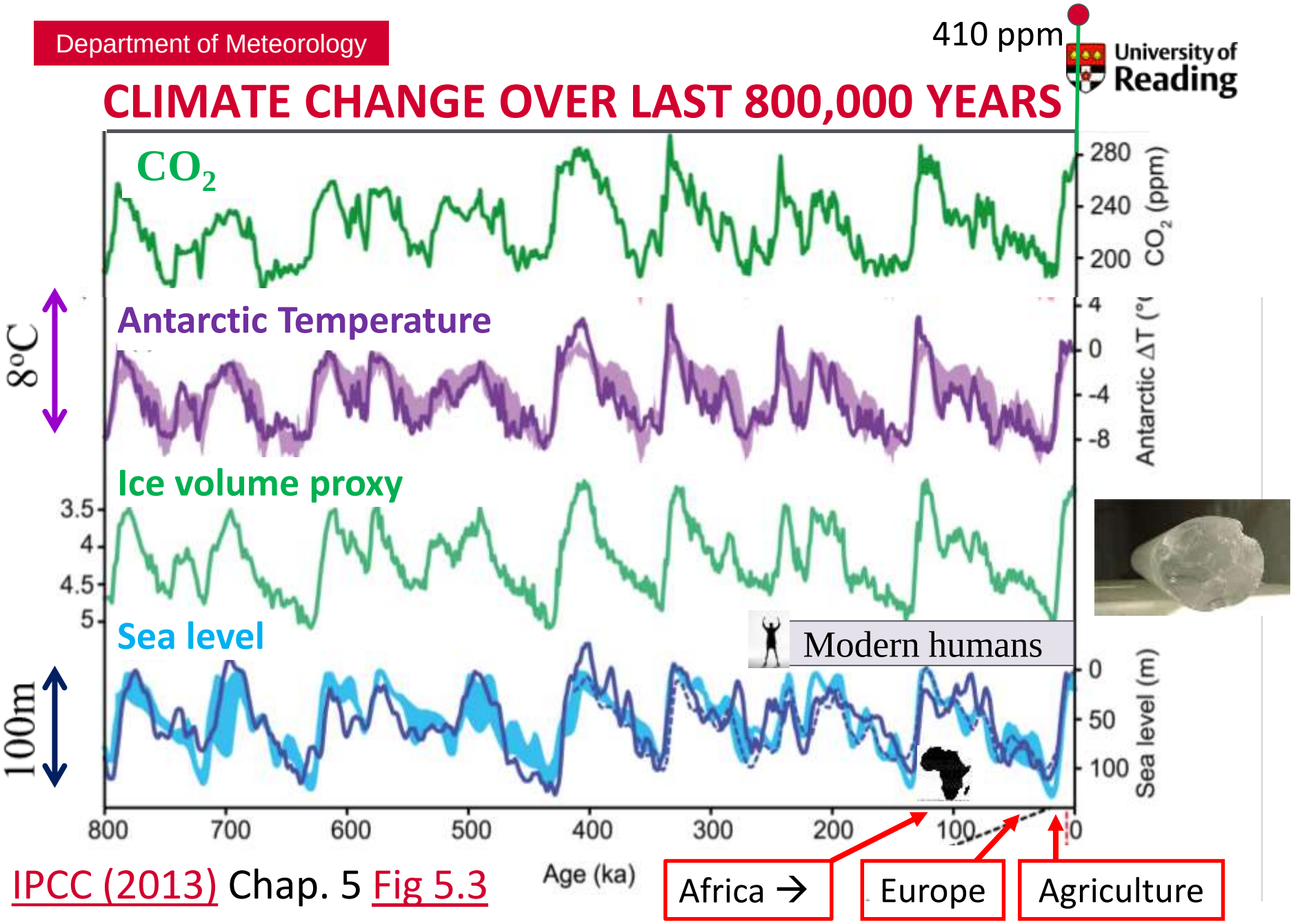


About 20,000 years ago…

- Northern Britain was covered by an ice sheet
- Sea level was 100 metres lower

University of Reading

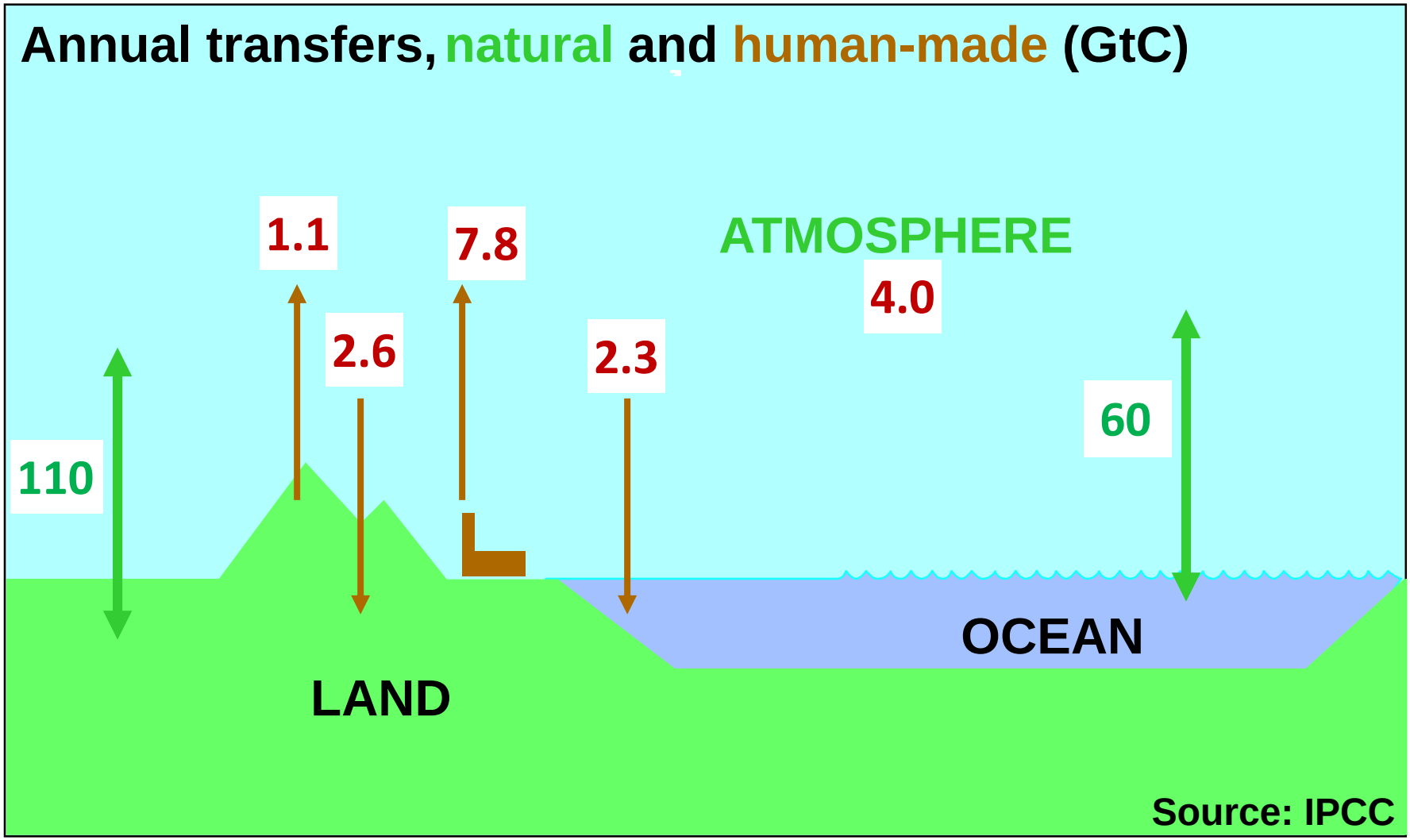
CLIMATE CHANGE OVER LAST 800,000 YEARS



IPCC (2013) Chap. 5 Fig 5.3

University of Reading

NATURAL & MAN-MADE CARBON CYCLES



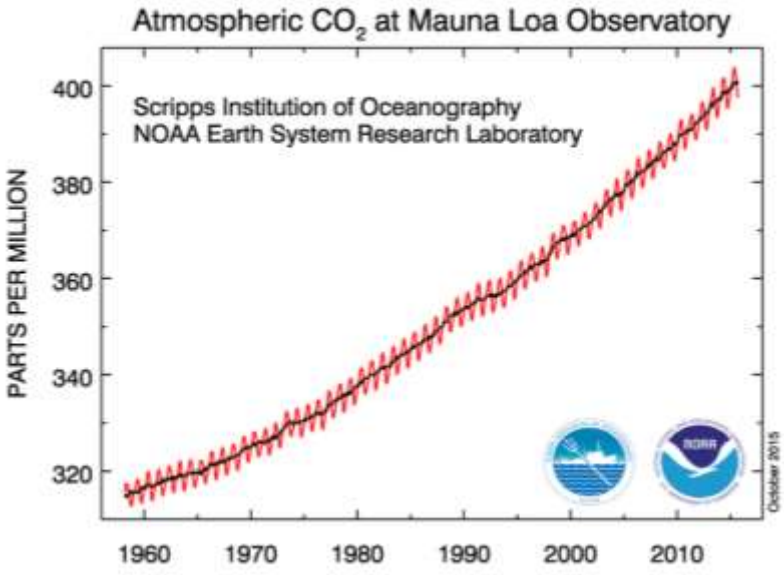
Values in billions of tonnes of Carbon per year from IPCC (2013) Fig. 6.1

University of Reading

CO_2 EMISSIONS ARE HEATING PLANET

- Increases in greenhouse gases heat the planet by reducing how easily Earth can cool to space through infra-red emission
- More small pollutant "aerosol" particles cool the planet by reflecting sunlight
- More energy is arriving than leaving: Earth is heating up…

Currently energy is accumulating at rate equivalent to every person currently alive using 20 kettles (2kW) each to boil oceans (or about 300 trillion watts) Allan et al. (2014)

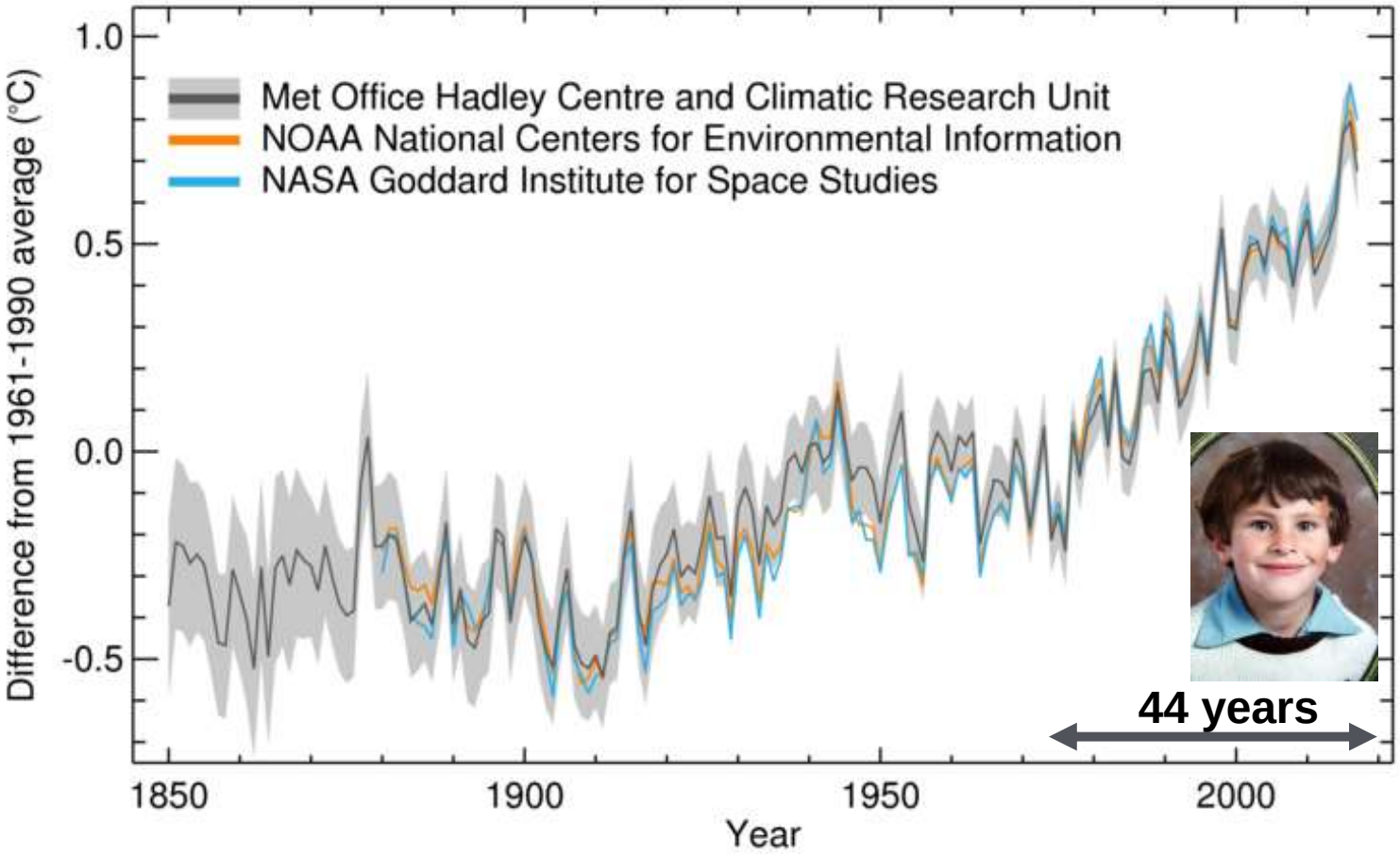


University of Reading

THE PLANET IS WARMING

Met Office

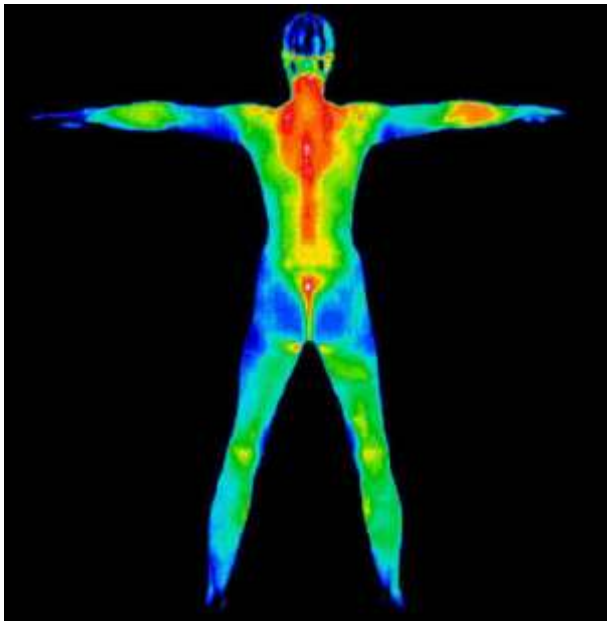
Global average temperature anomaly (1850-2017)



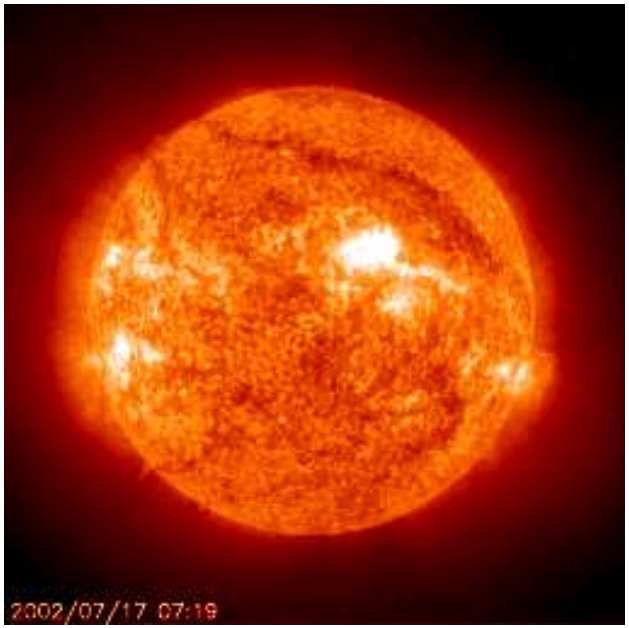
www.metoffice.gov.uk/research/monitoring/climate/surface-temperature

University of Reading

EVERYTHING EMITS RADIATION ENERGY UNITS: WATTS PER SQUARE METRE (Wm^{-2})



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



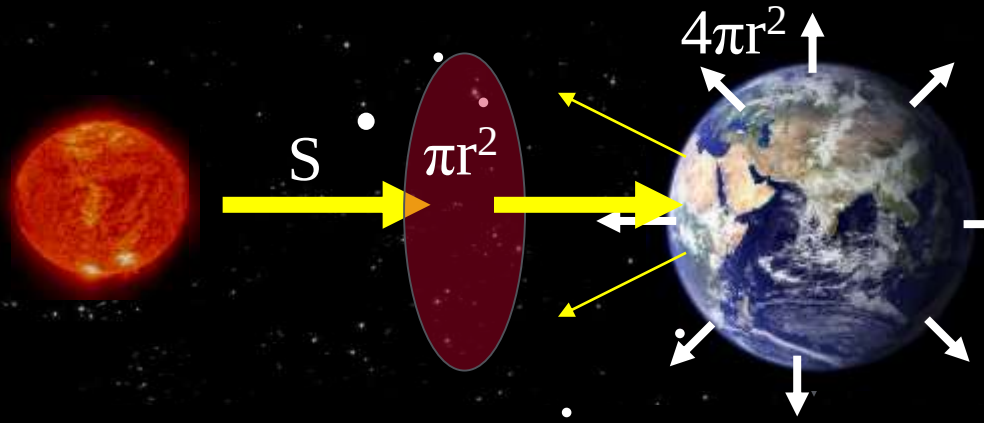
Hot things: short wave-length radiation, e.g. the sun ~6000 K

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

IR thermometer activity

EARTH'S RADIATIVE ENERGY BALANCE IN SPACE

University of Reading



S is the solar constant (about 1361 Watts per square metre, W/m^2)

30% of incoming sunlight is reflected back to space by clouds, tiny aerosol particles and bright surfaces (e.g. deserts).

So absorbed sunlight is (S/4) x (1 - 0.3) = (1361/4)x0.7 = 238 W/m^2

This is balanced by infrared cooling to space to give us our planet's average temperature of around 15^{o}C. But rising concentrations of greenhouse gases such as carbon dioxide are reducing the infrared cooling so more energy is arriving than leaving and the planet is heating up.

Scratch Energy Balance Activity

Earth's annual mean energy balance

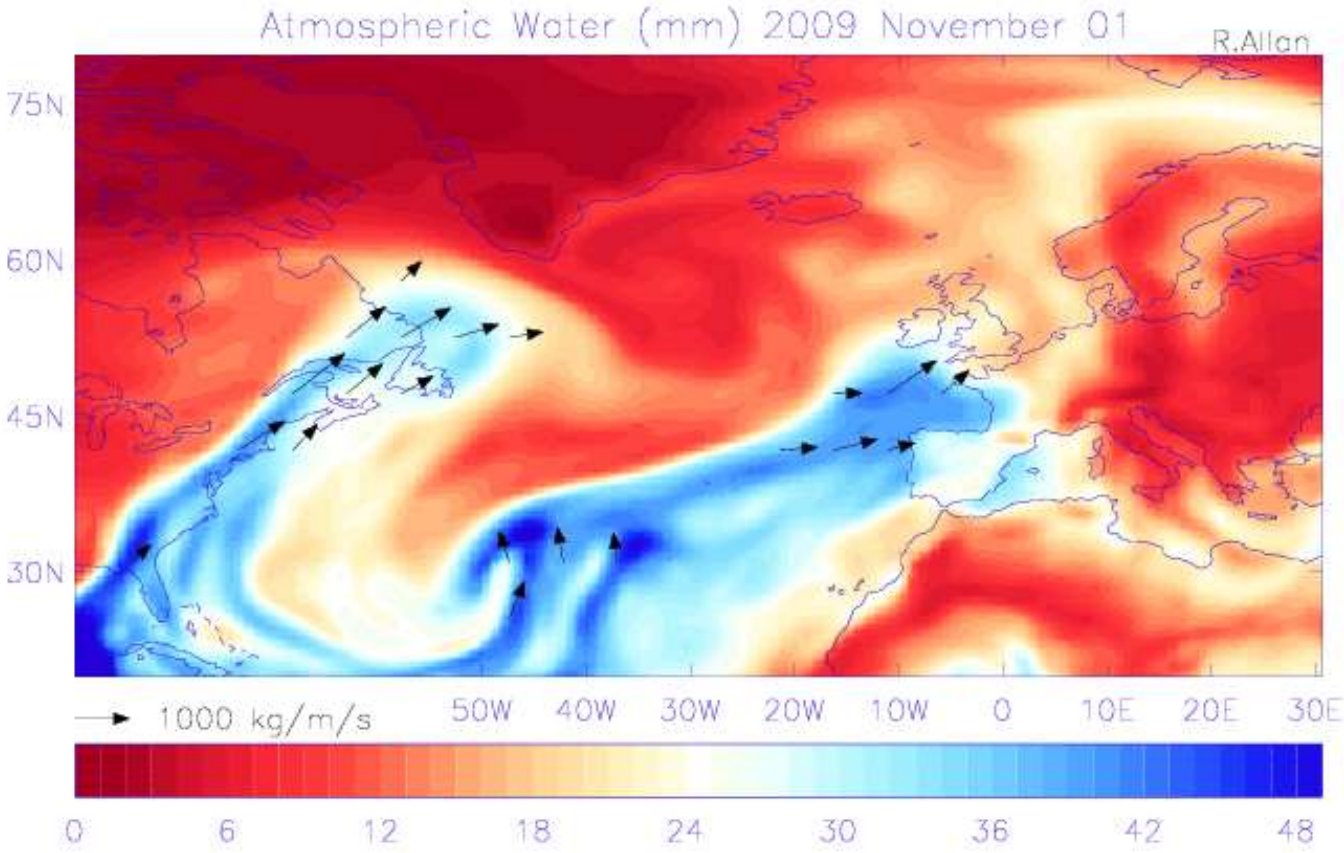
University of Reading

- Clouds affect radiation fluxes
- Radiation fluxes affect clouds

Feedback demonstration

University of Reading

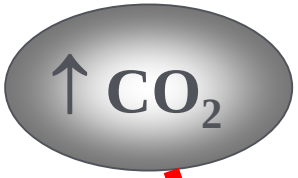
WATER VAPOUR & CLIMATE

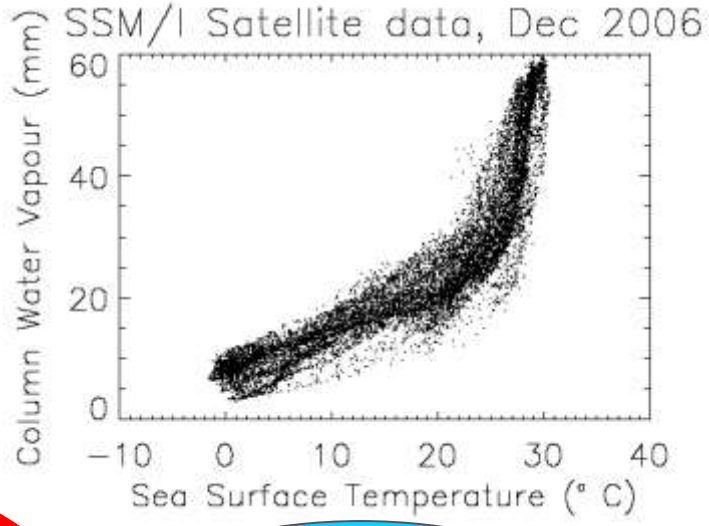


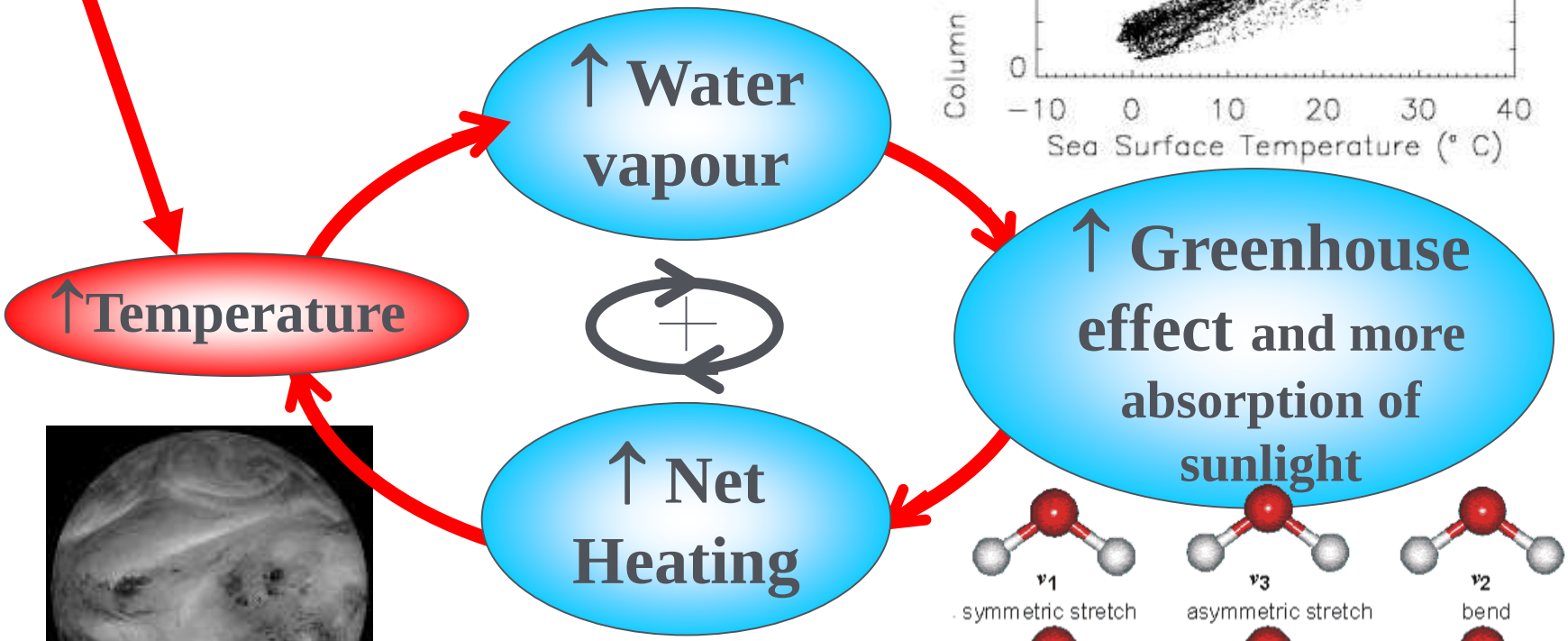
University of Reading

WATER VAPOUR AMPLIFIES CLIMATE CHANGE

An amplifying (positive) feedback loop involving water vapour

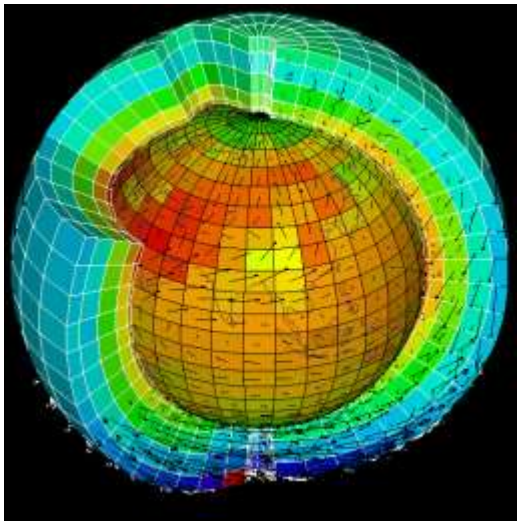


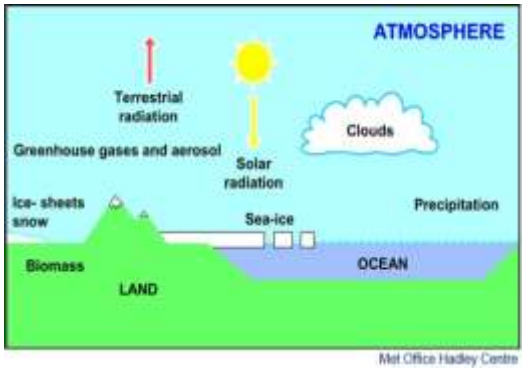




WHAT ARE THE PREDICTIONS?

- What's a prediction?
- Scientists use observations and experiments to understand the physics of the environment
- The physics of the atmosphere/oceans/land are coded in complex computer simulations
- They are used to:
  - understand past climate change
  - project how climate will change over future decades and centuries

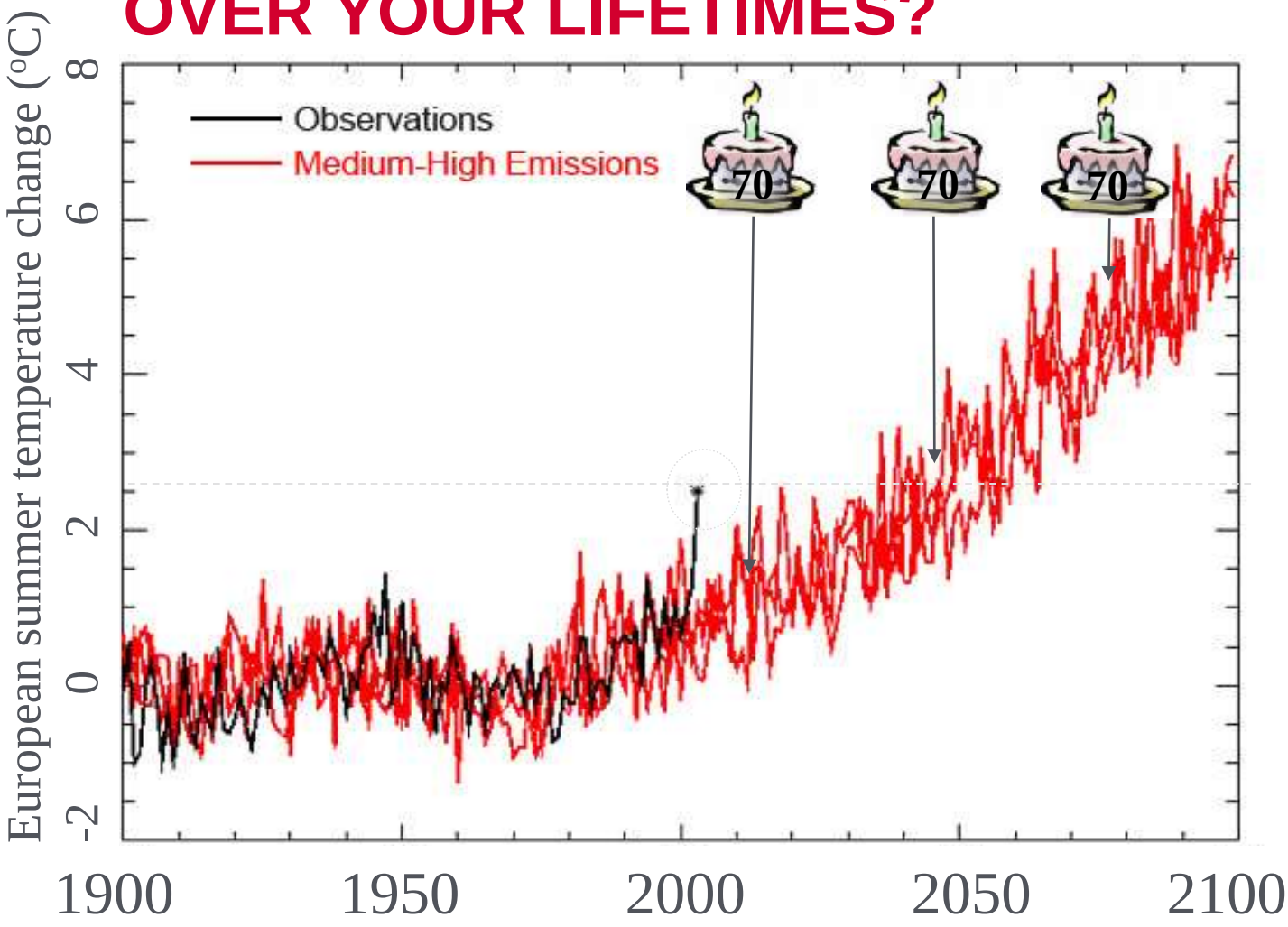




climate model animation

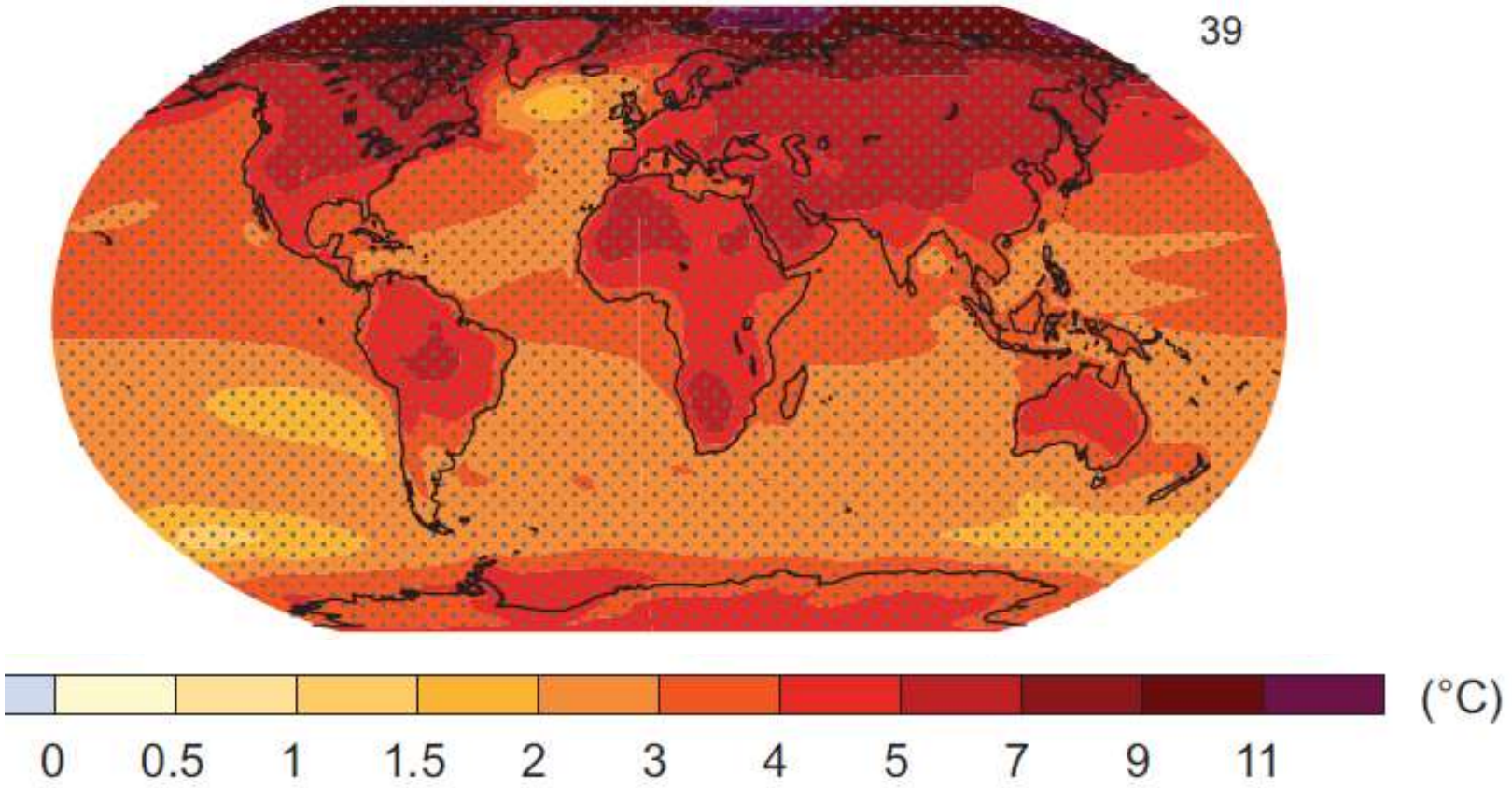
University of Reading

HOW WILL CLIMATE CHANGE OVER YOUR LIFETIMES?



University of Reading

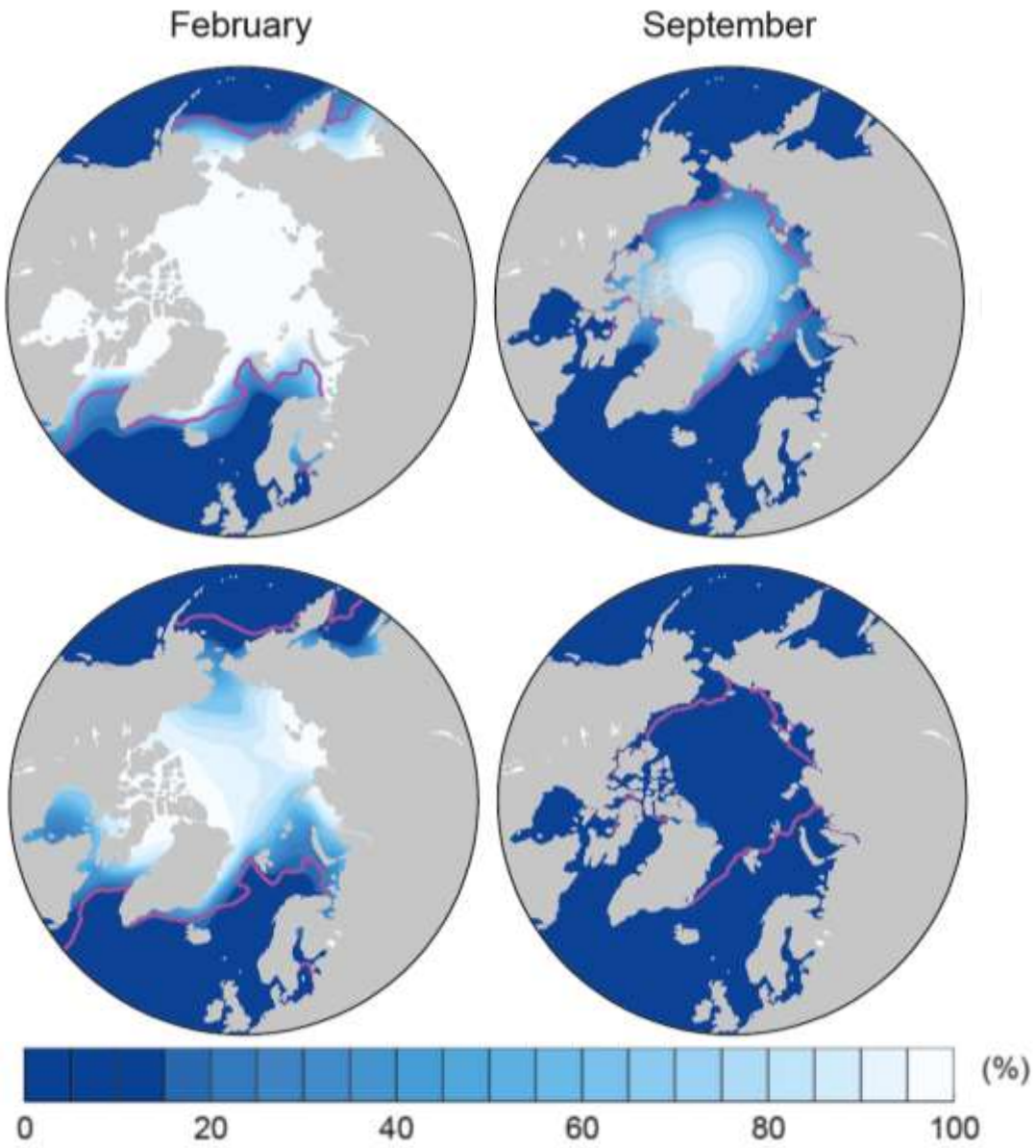
WARMING WILL BE GREATER OVER THE LAND AND GREATEST IN THE ARCTIC



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

University of Reading

PROJECTIONS: ARCTIC SEA ICE EXTENT DECLINE IN 21ST CENTURY



- **94% decrease in September**
- **34% decrease in February**

high emissions scenario

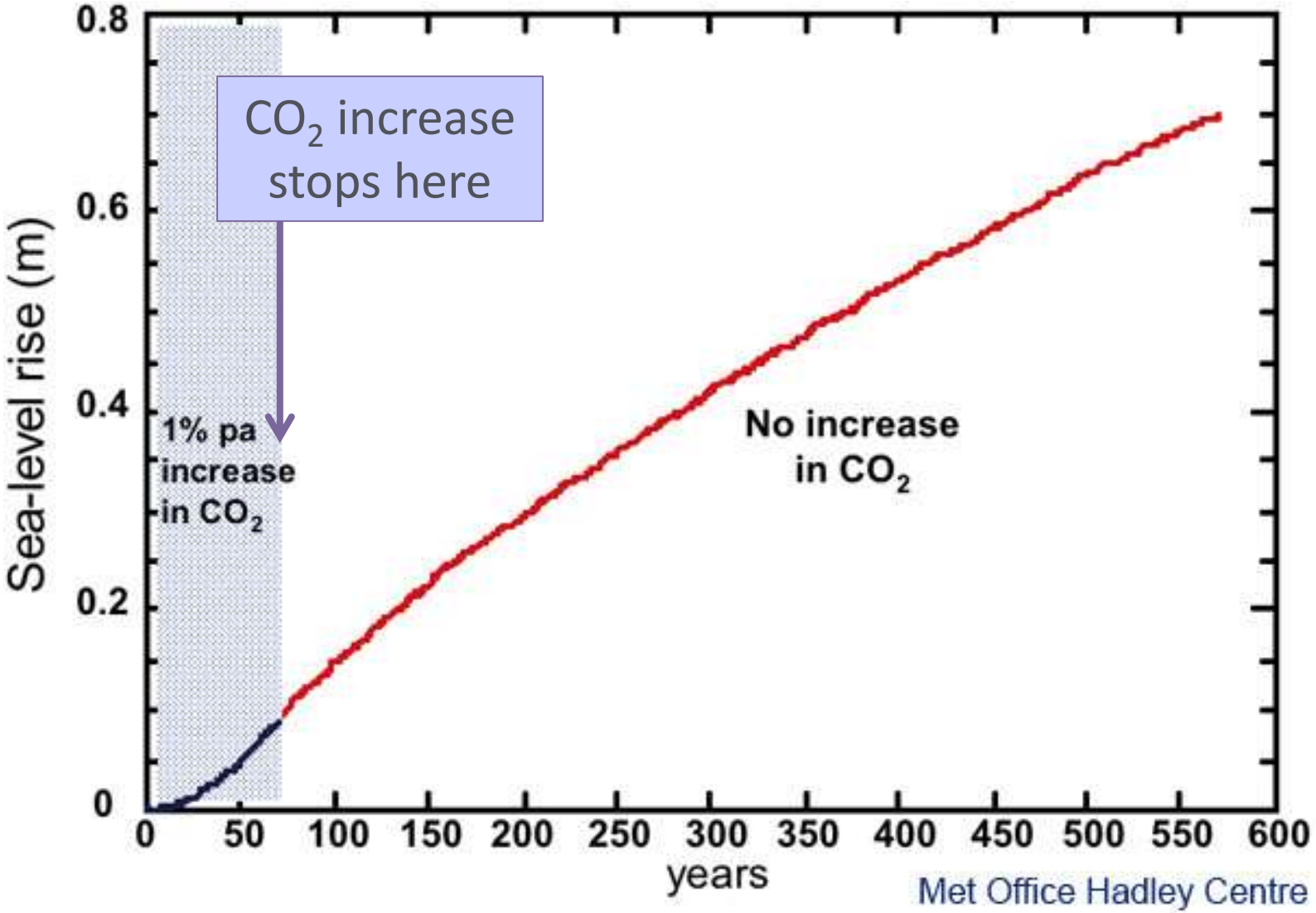
IPCC (2013)
WG1 Fig. 12.29

University of Reading

INTENSIFICATION OF HEAVY RAINFALL

University of Reading

SEA-LEVEL WILL RISE FOR CENTURIES



CLIMATE CHANGE

- 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?

University of Reading

COP21 PARIS CLIMATE DEAL

source: http://www.carbonbrief.org/analysis-the-final-paris-climate-deal

- **Target**: global temperature well below 2°C; efforts to limit to 1.5°C
- **Mitigation**: pursue policies aiming to achieve INDC climate pledges; subsequent pledges progressively more ambitious; global stocktake 2018 & then every 5 years; peak global greenhouse gas emissions “as soon as possible”; “balance” between emissions & sinks 2050-2100
- **Adaptation**: $100bn/yr fund for developing countries: new collective quantified goal by 2025; periodic review of adaptive planning of Loss & damage has its own Article in the agreement — now on par with mitigation & adaptation; liability/compensation excluded.
- **Transparency:** "facilitative, non-intrusive, non-punitive” system of review will track countries’ progress; emissions trading allowed; aviation/shipping not included
- **Treaty:** deal enters force once 55+ parties, covering at least 55% of global emissions have signed up

University of Reading

DEGREES IN METEOROLOGY AND CLIMATE

- BSc Meteorology & Climate (BB physics and maths)
- MMet Meteorology & Climate with a year in Oklahoma (AA physics and maths)
- BSc Mathematics & Meteorology (AAB-ABB including A in Maths)
- MMath Mathematics & Meteorology (AAB-ABB including A in Maths)
- BSc Physics of the Environment (ABB-AAC from three A levels including Mathematics & Physics, one of which must be at grade A)

Modules: *Atmospheric physics, dynamics, numerical methods, energy exchange, differential equations & calculus, Aran field course, dissertation, boundary layer, optional extra physics, weather forecasting, climate change, remote sensing, oceanography, environmental chemistry, global circulation, atmospheric electricity, …*

- More information at www.reading.ac.uk/met/undergraduate-courses
- Work Experience Programme (February 2019): https://research.reading.ac.uk/meteorology/work-experience/