Department of Meteorology

University of Reading

WEATHER AND CLIMATE SCIENCE FOR SOCIETY

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Virtual Open Day, 23rd May 2018

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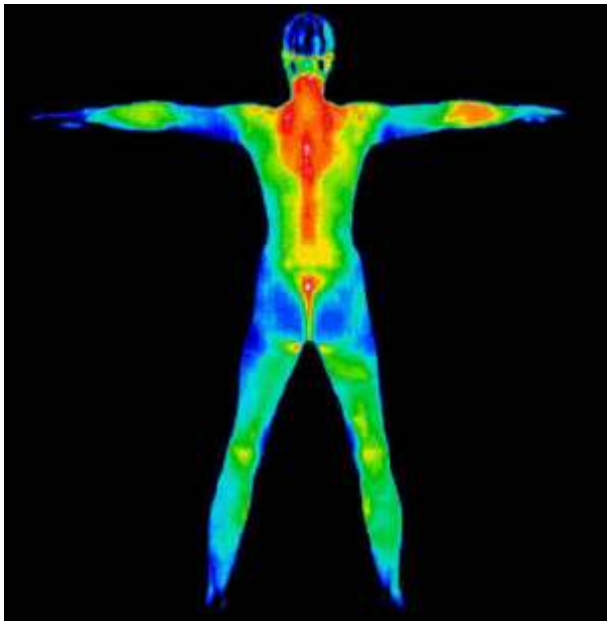
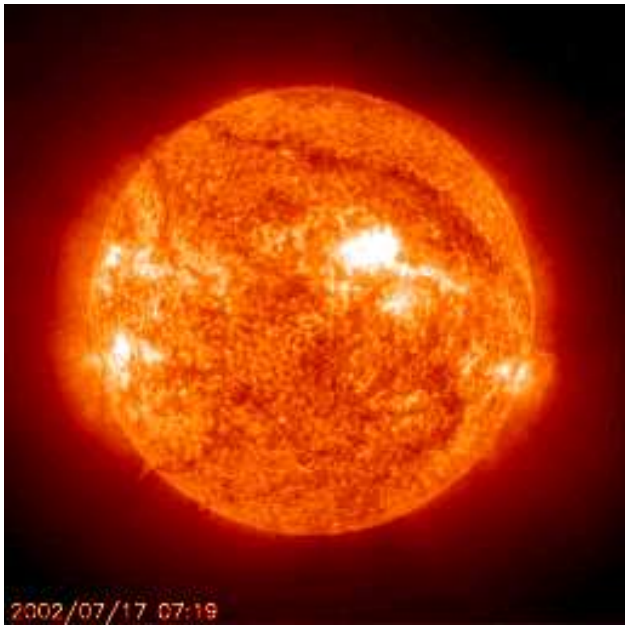
EVERYTHING EMITS RADIATION ENERGY UNITS: WATTS PER SQUARE METRE (Wm^{-2})



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

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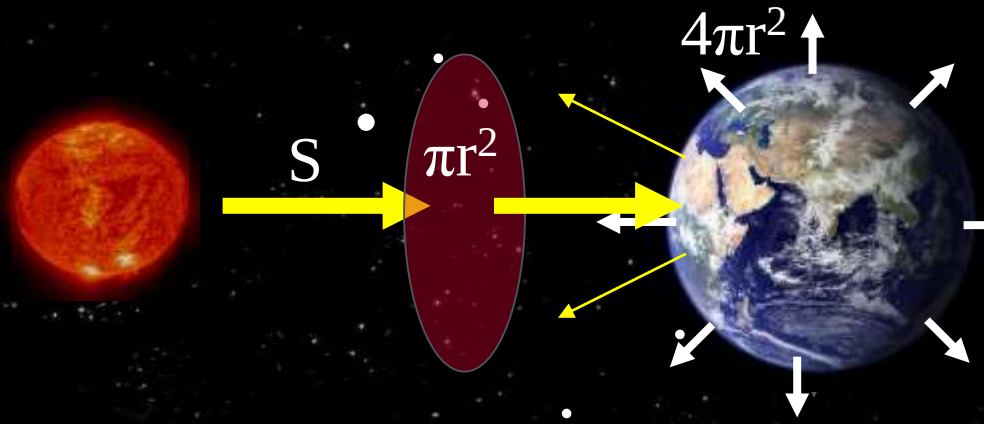

Absorbed Solar or Shortwave Radiation $\frac{S}{4}X(1-\alpha)$

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

Earth's annual mean energy balance

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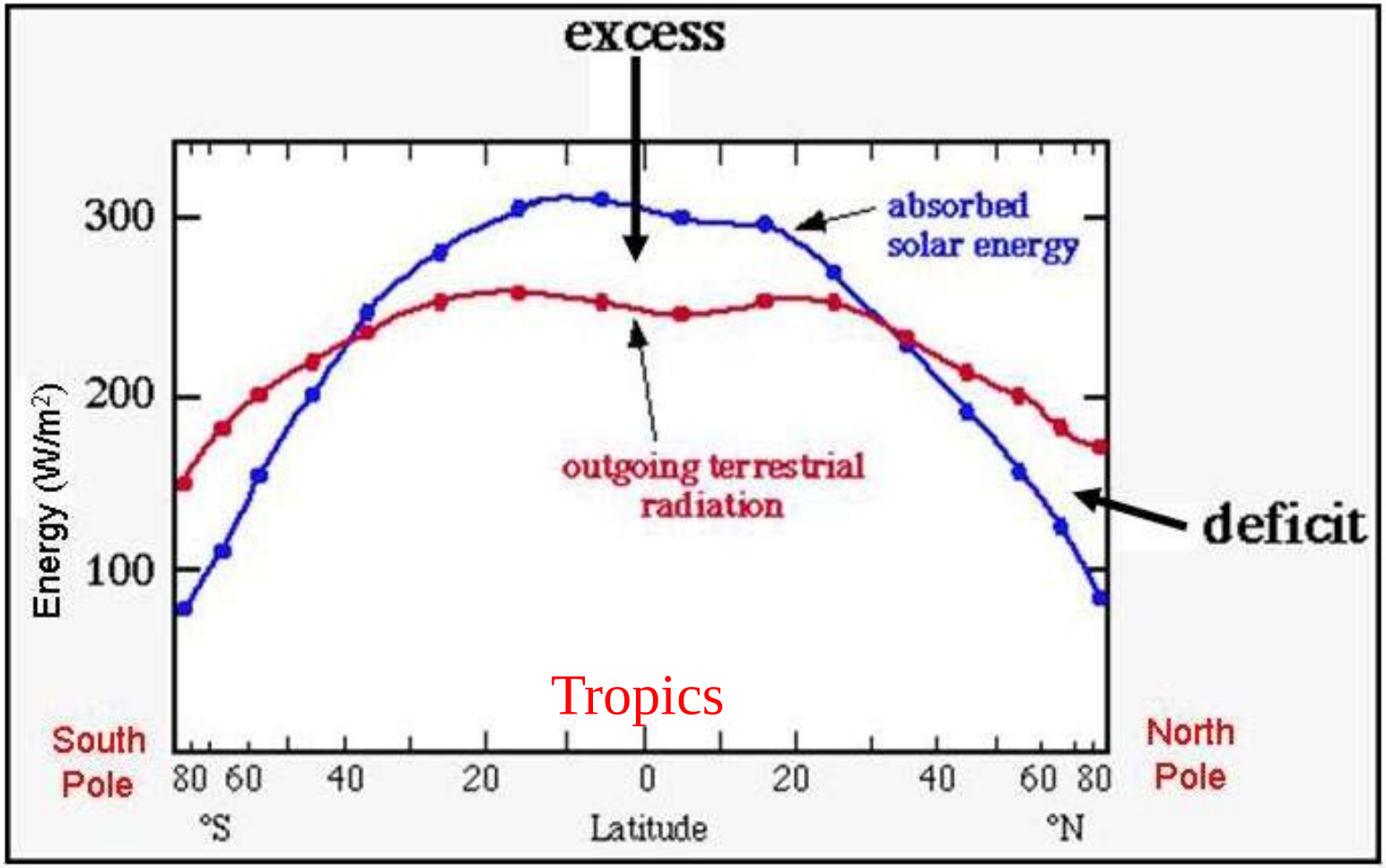
EARTH'S RADIATIVE ENERGY BALANCE



Click for movie

Why doesn't the tropics keep getting hotter and hotter?

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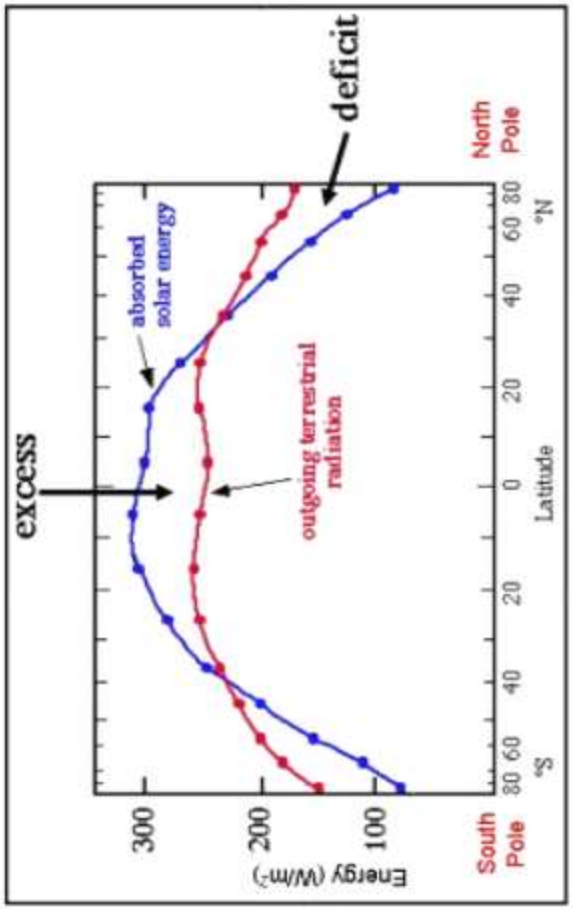
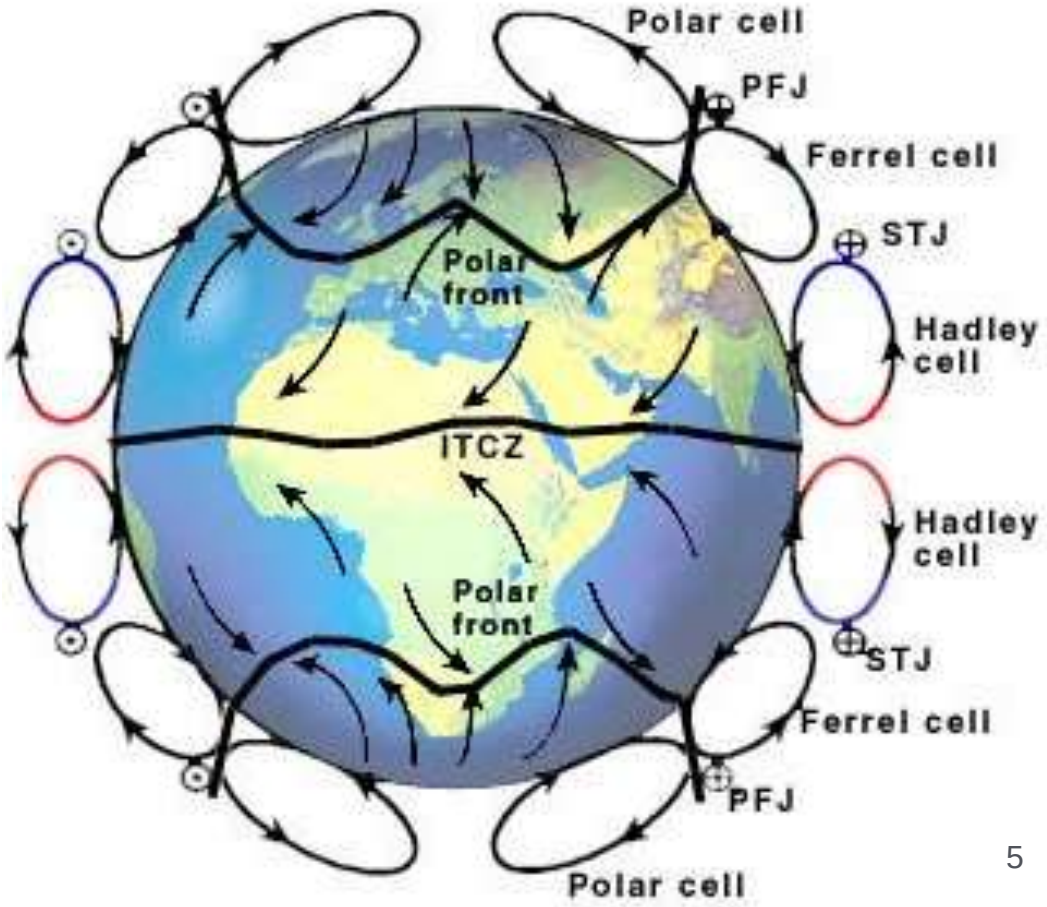
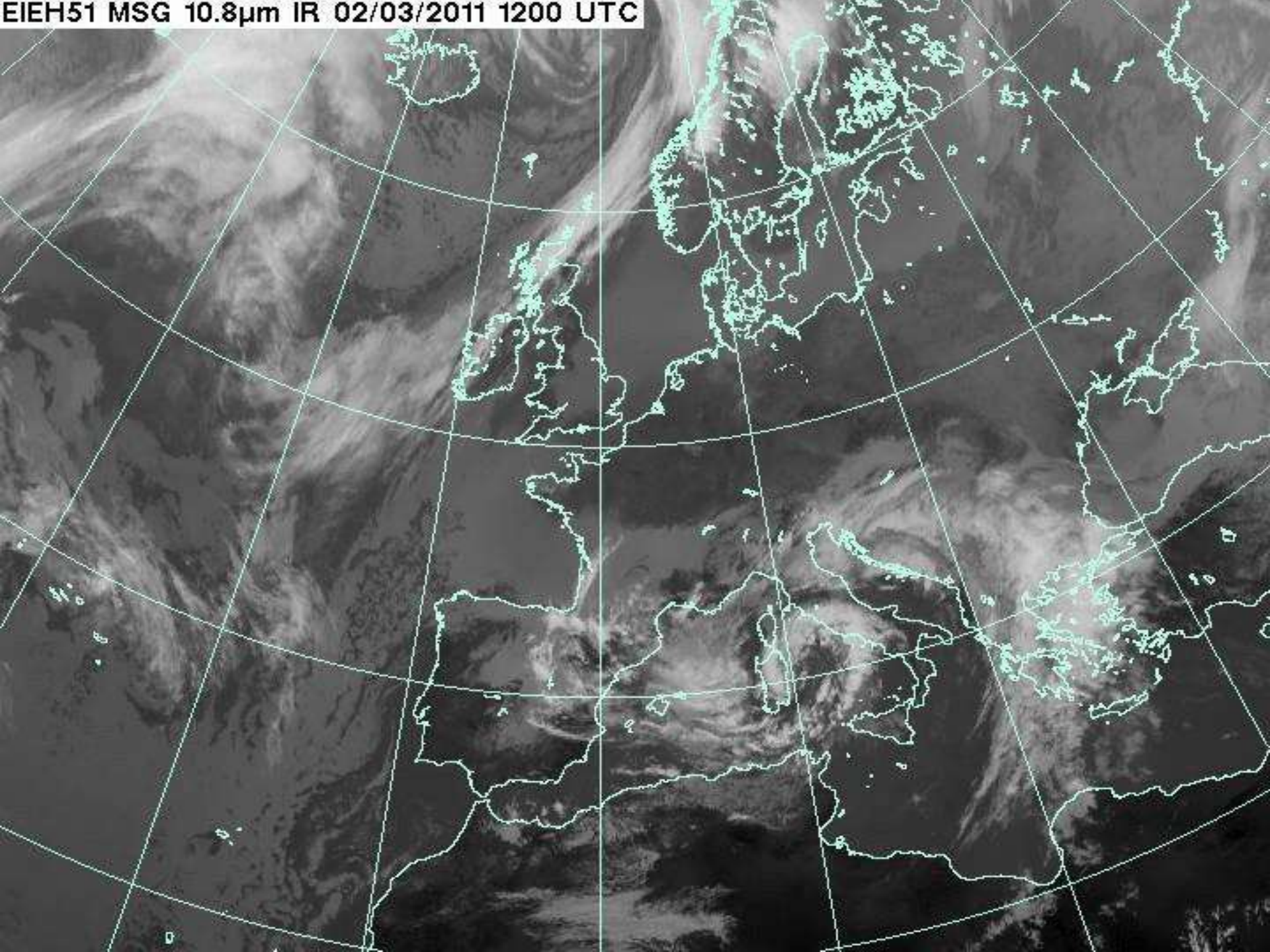
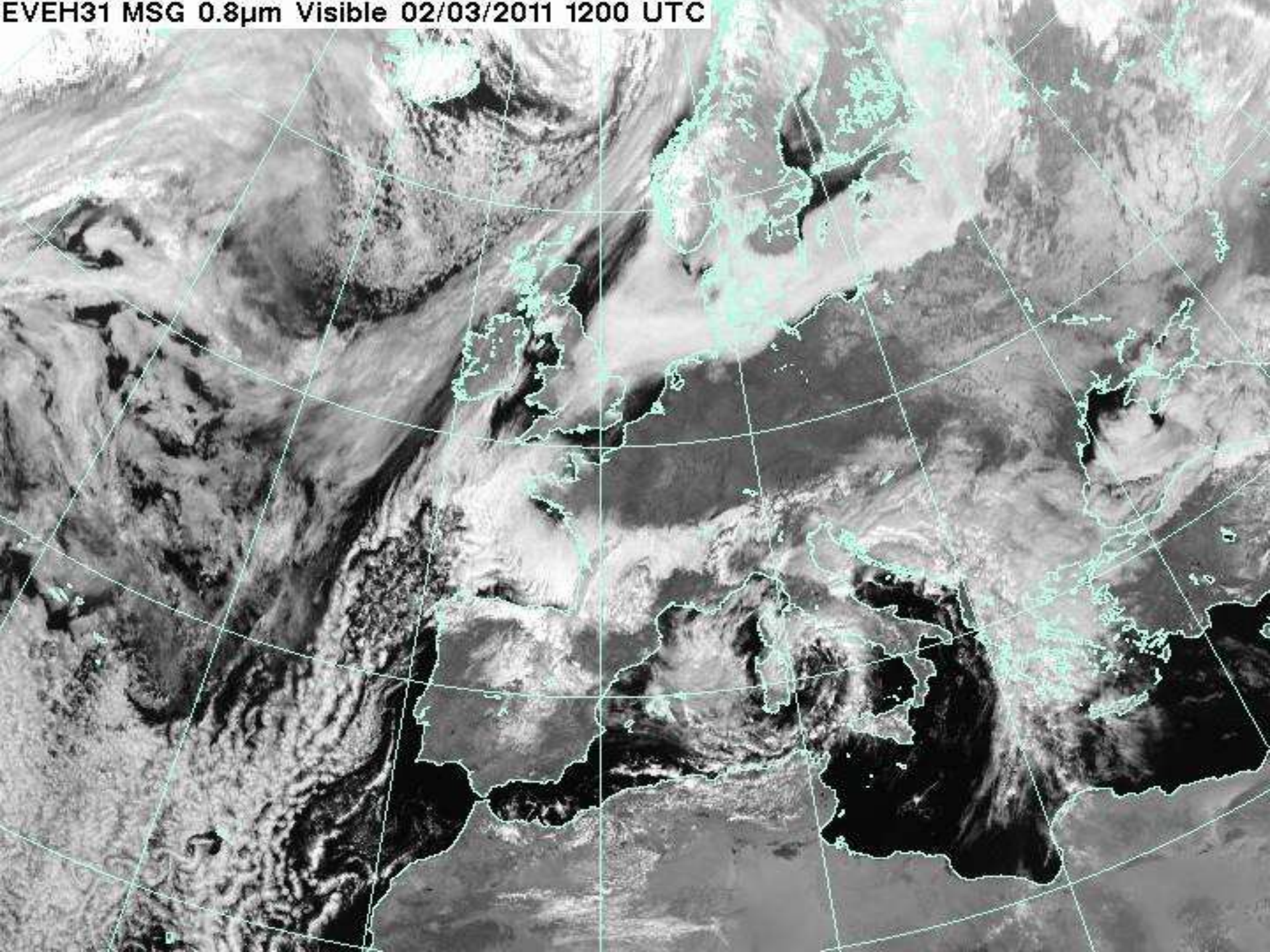
EARTH'S ENERGY BUDGET AND ATMOSPHERIC CIRCULATION






EIEH51 MSG 10.8µm IR 02/03/2011 1200 UTC


EVEH31 MSG 0.8µm Visible 02/03/2011 1200 UTC

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

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WEATHER FORECASTS & CLIMATE PREDICTION

- What's a prediction?
- Scientists use observations and physics to forecast the weather and predict how climate will change
- This can make a difference to lives and wellbeing
- Budding forecasters and research scientists use physics and maths to make a difference to people

Ingredients:

- Observations, Experiments, Physics, Computer Simulation

Variables: $\{\mathbf{v}, p, T, \rho, q\}$

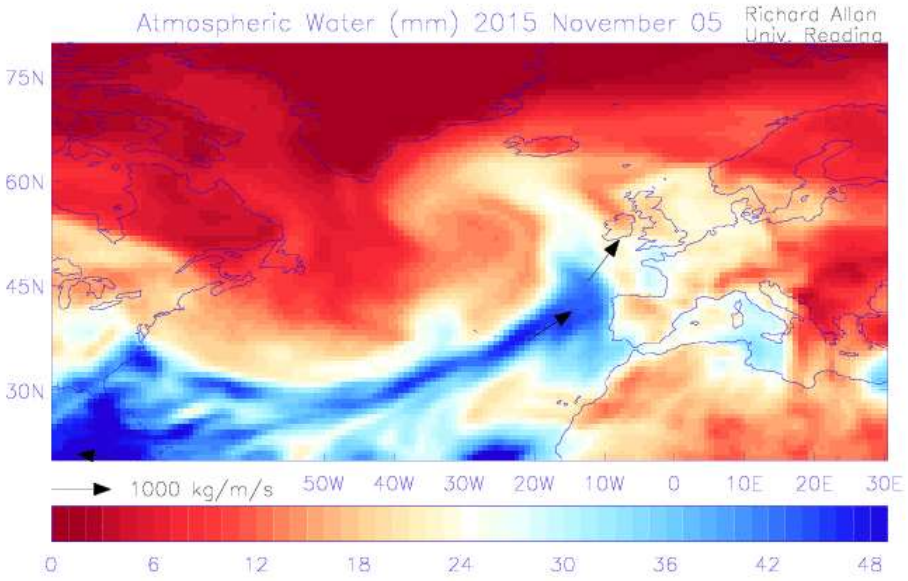
$$\frac{d}{dt}\mathbf{v} = -2\boldsymbol{\Omega} \times \mathbf{v} - \frac{1}{\rho}\nabla_3 p + \mathbf{g} + \mathbf{F}$$ Conservation of momentum (Navier-Stokes)

$$C_v \frac{d}{dt}(\rho q) + p\frac{d}{dt}\left(\frac{1}{\rho}\right) = J$$ Conservation of energy (1st Law of Thermodynamics)

$$\frac{\partial}{\partial t}(\rho) = -\nabla_3 \cdot (\rho \mathbf{v})$$ Conservation of air mass

$$\frac{\partial}{\partial t} = -\nabla_3 \cdot (\rho \mathbf{v} q) + \rho(E - C)$$ Continuity of water vapor mass

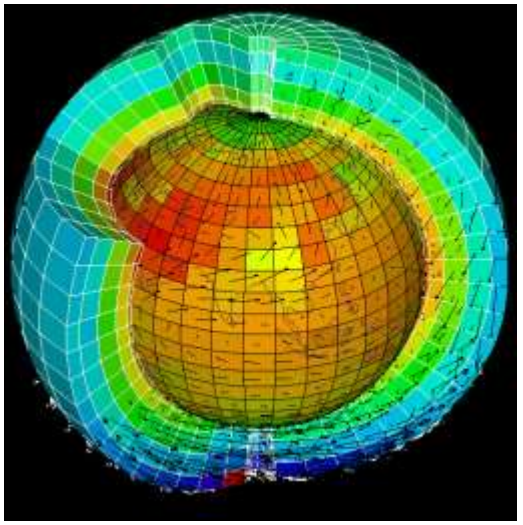
$$p = \rho R T$$ Equation of state (Ideal gas law)

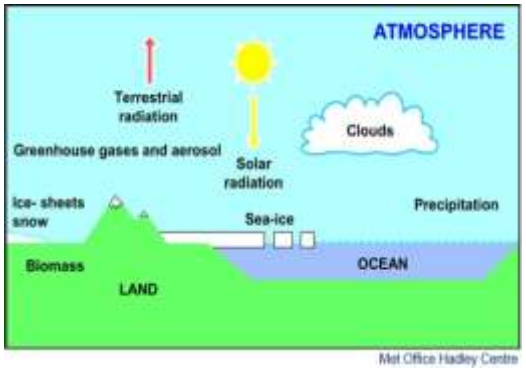


CLIMATE SIMULATIONS

- Scientists code all the physics of the atmosphere, oceans and land in complex computer simulations
- Many millions of lines of code are used to calculate physics equations & pass information between grid cells
- These simulations build on weather forecast simulations but add more physics (oceans, vegetation, chemistry, …)
- They are used to:
  - understand how past climate changed
  - project how climate will change over future decades and centuries

climate model animation





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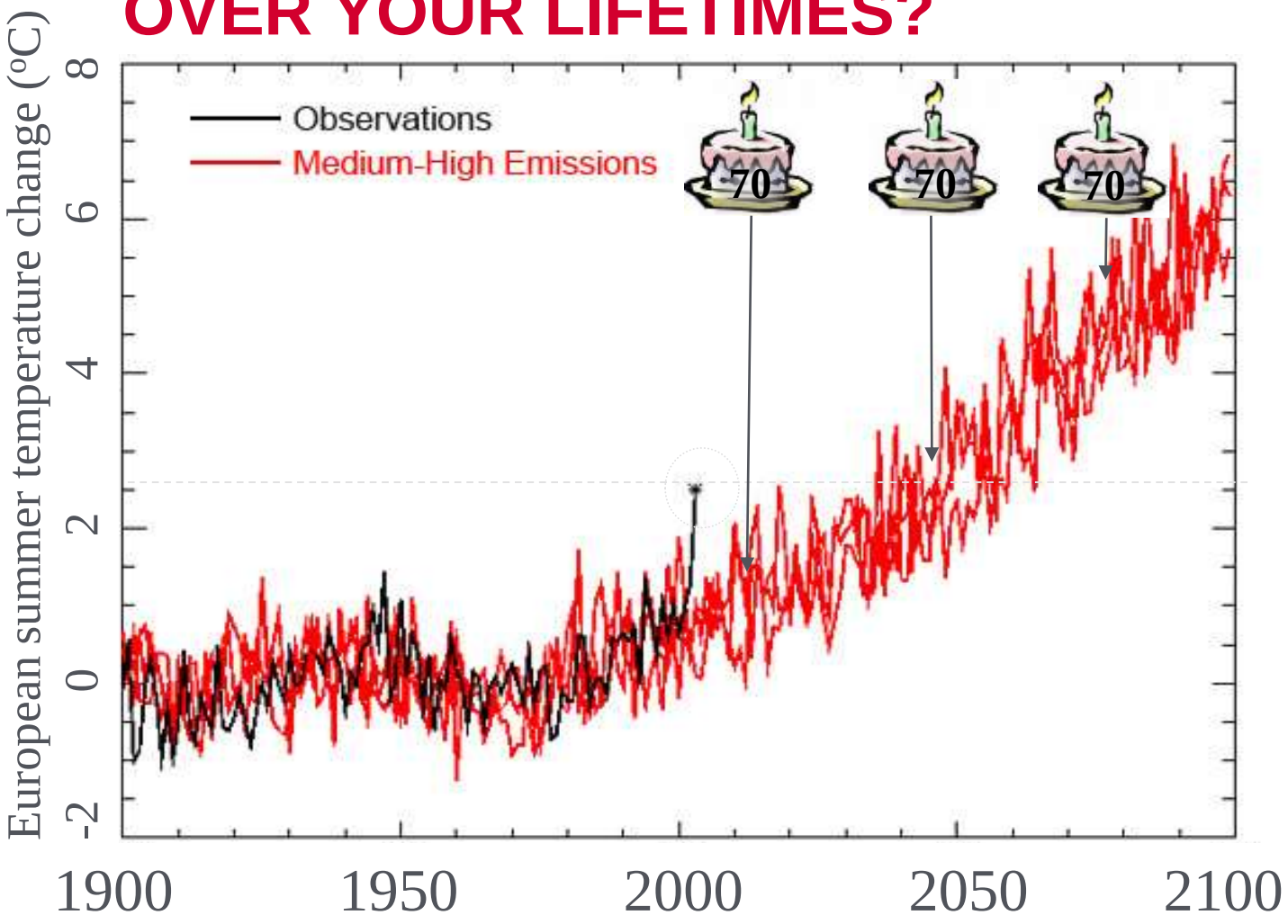
HOW WILL CLIMATE CHANGE OVER YOUR LIFETIMES?



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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/

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?

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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