

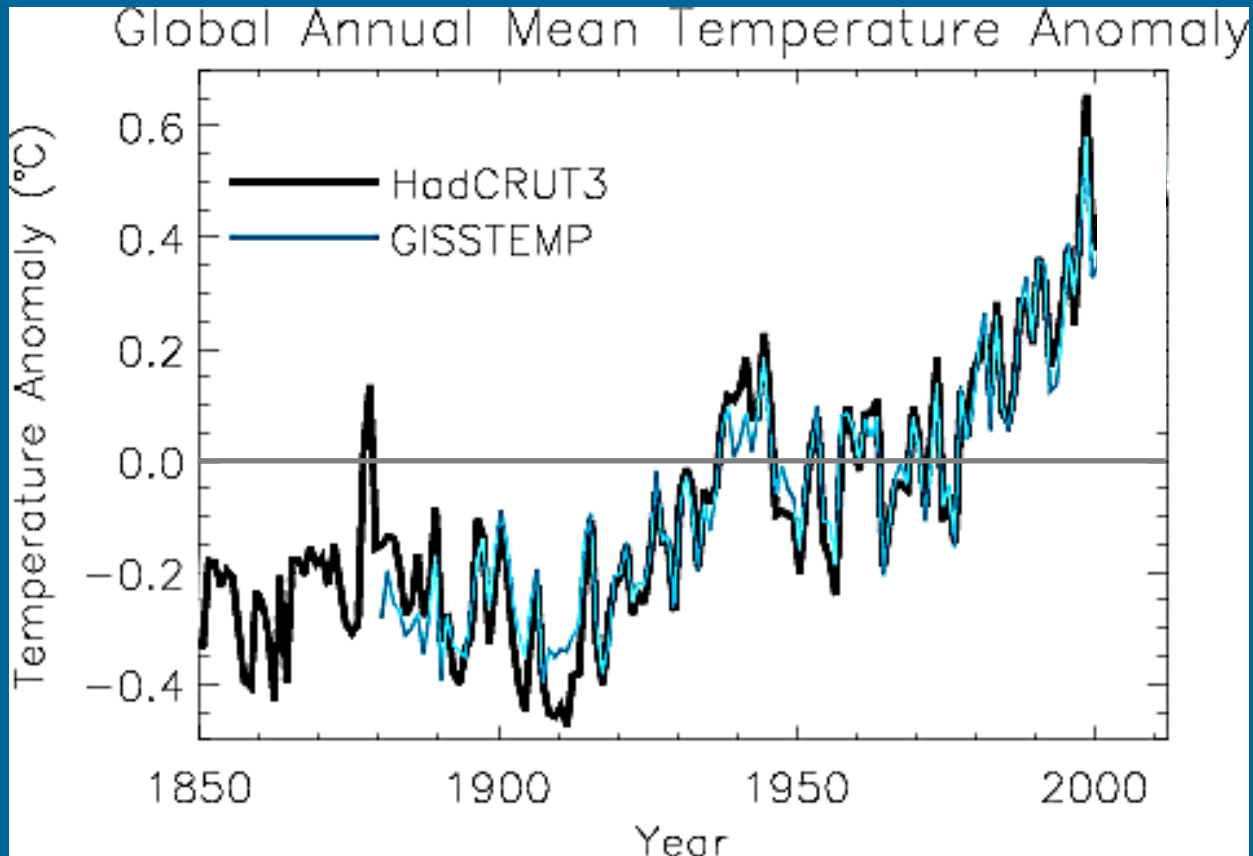
Where has the warming gone?

Richard Allan

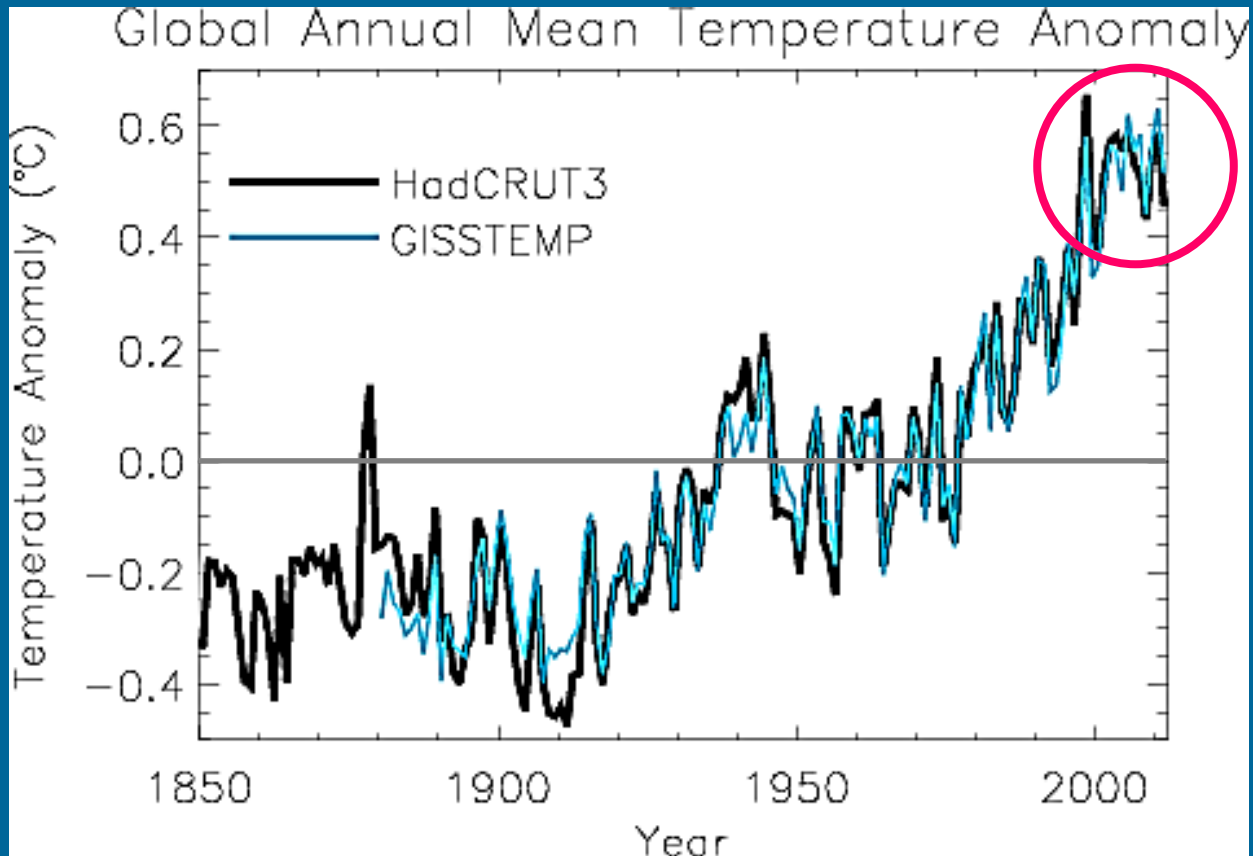
University of Reading/NCAS climate

Collaborators: Norman Loeb (NASA, USA), Greg Johnson (NOAA, USA),
John Lyman (NOAA, USA), Brian Soden (Univ Miami, USA)

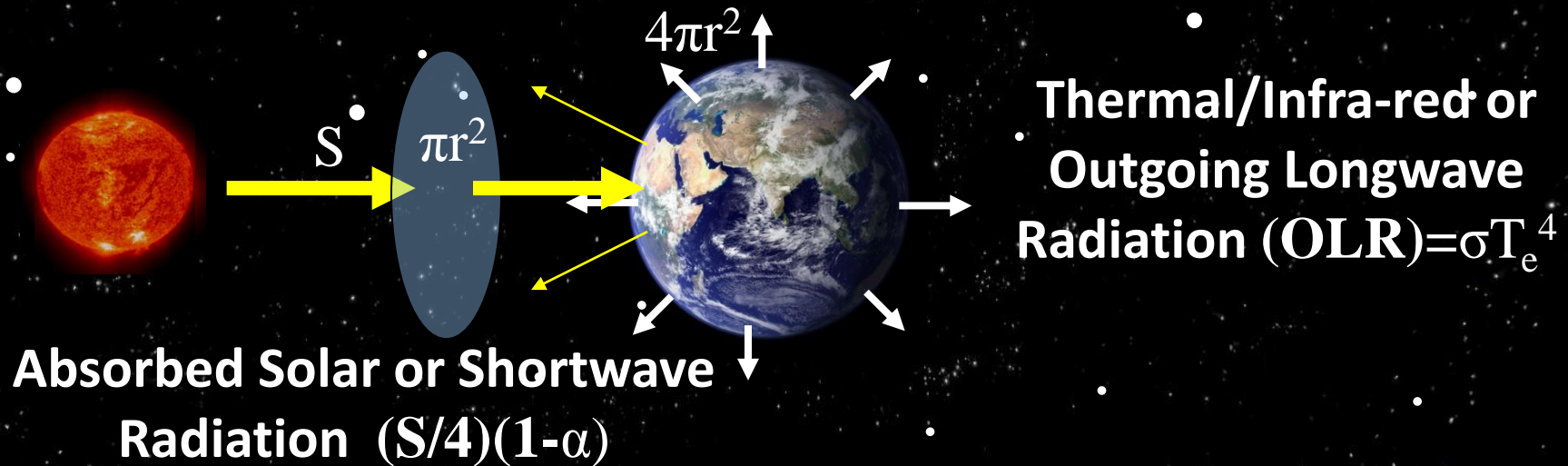
Global Warming...



Global Warming ?



Earth's energy balance in space

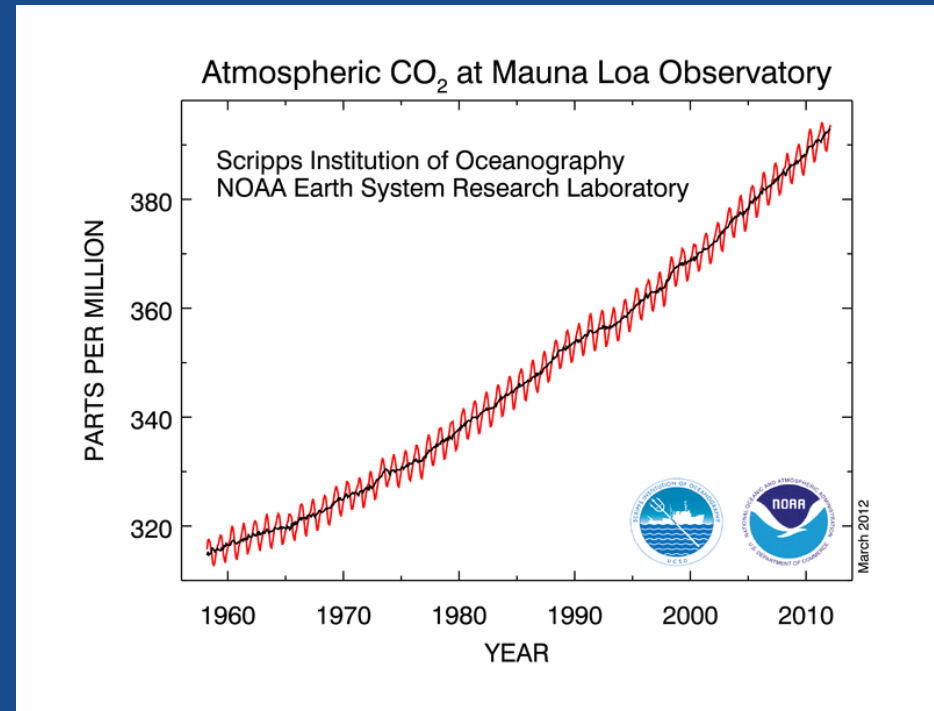


- There is a balance between the absorbed sunlight and the thermal radiative cooling of the planet

“Radiative forcing” of climate



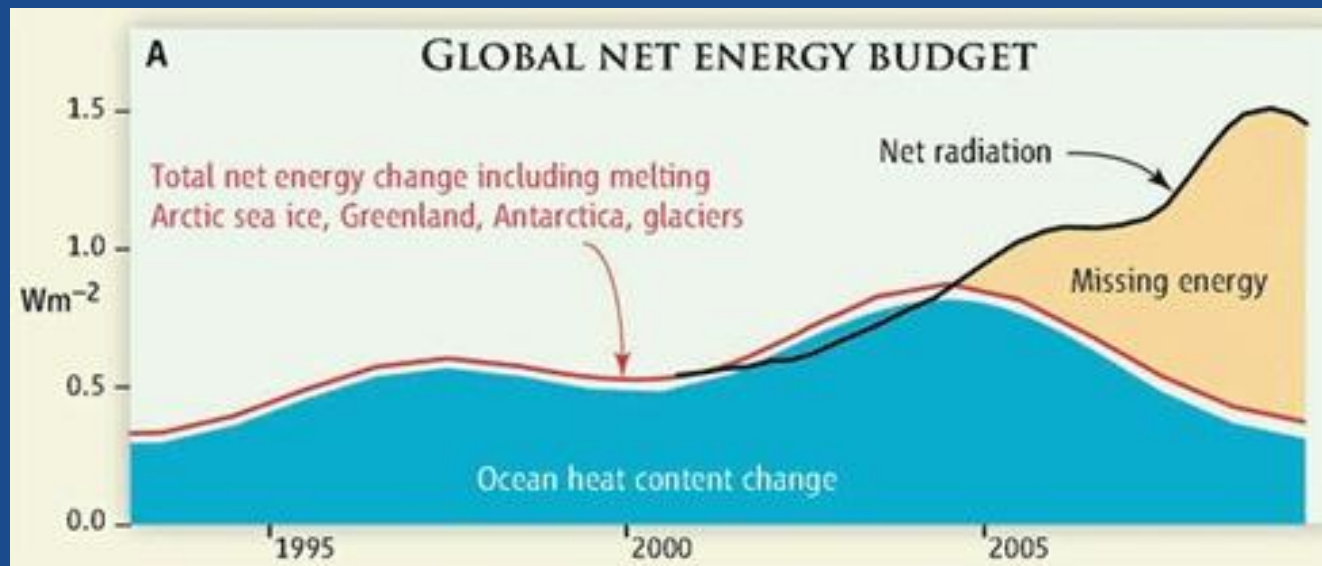
- Increases in greenhouse gases heat the planet by trapping heat
- Small pollutant particles (aerosols) cool the planet by reflecting sunlight
- If more energy is arriving than is leaving the planet, Earth should warm...



Missing energy?

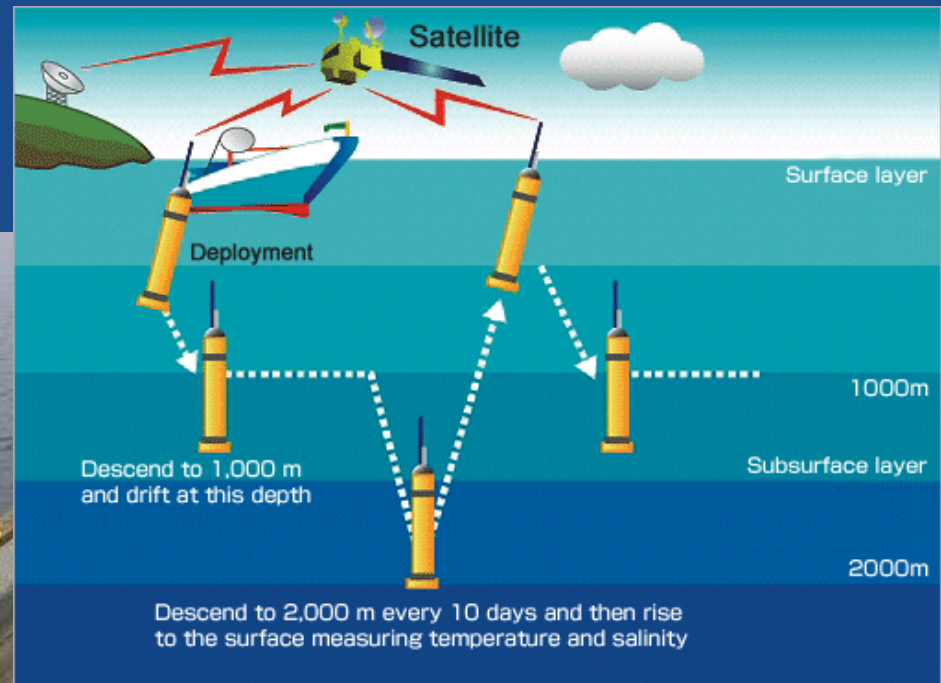
- Scientists had previously highlighted a large discrepancy between energy arriving at our planet and heat entering the ocean

Heating Rate in
Watts per square metre



Measuring Earth's energy flows

- Satellite instruments measure energy arriving and leaving our planet
 - Sunlight & thermal radiation
- Automated floats measure heating of the ocean

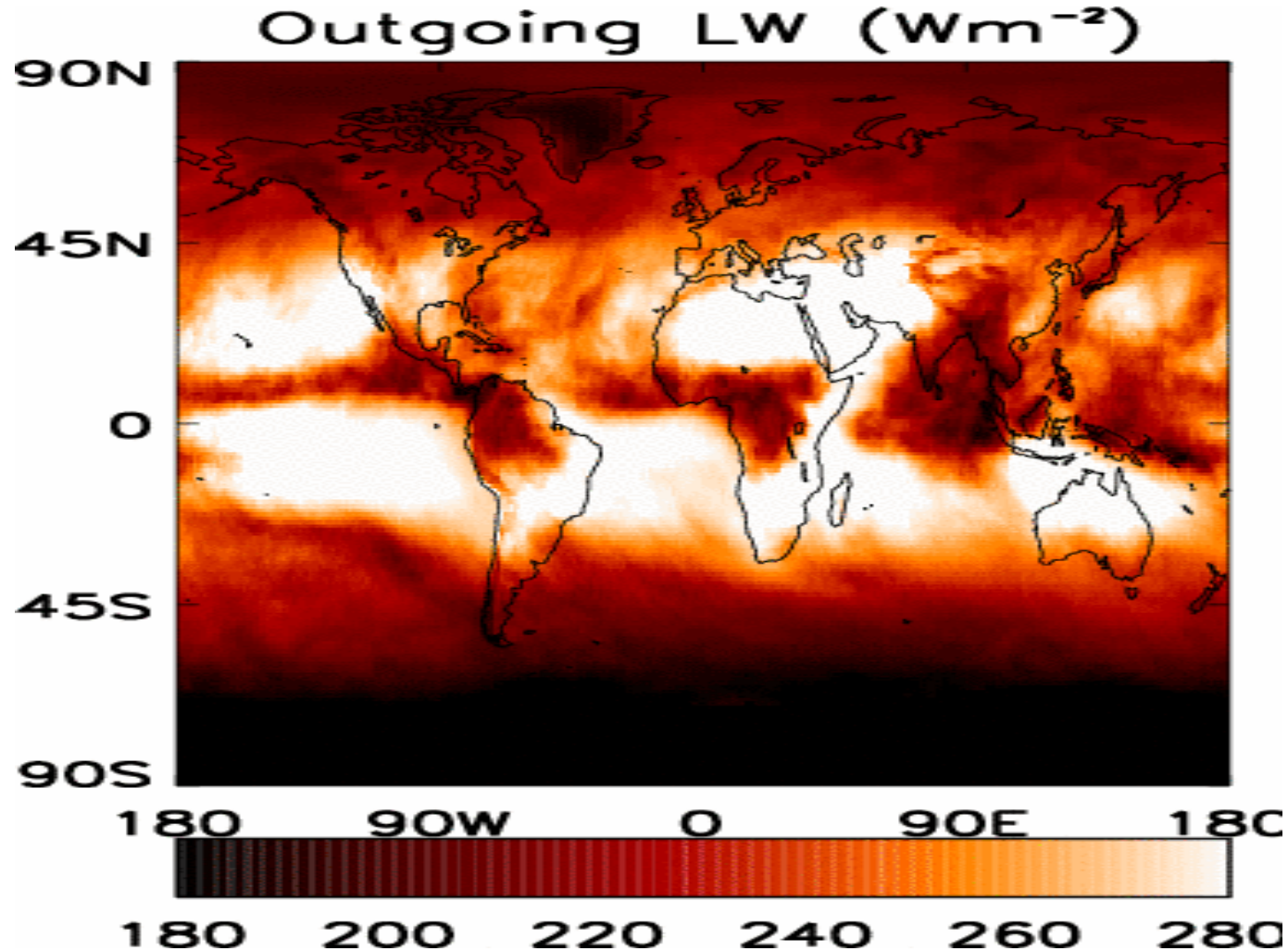


ARGO floats →



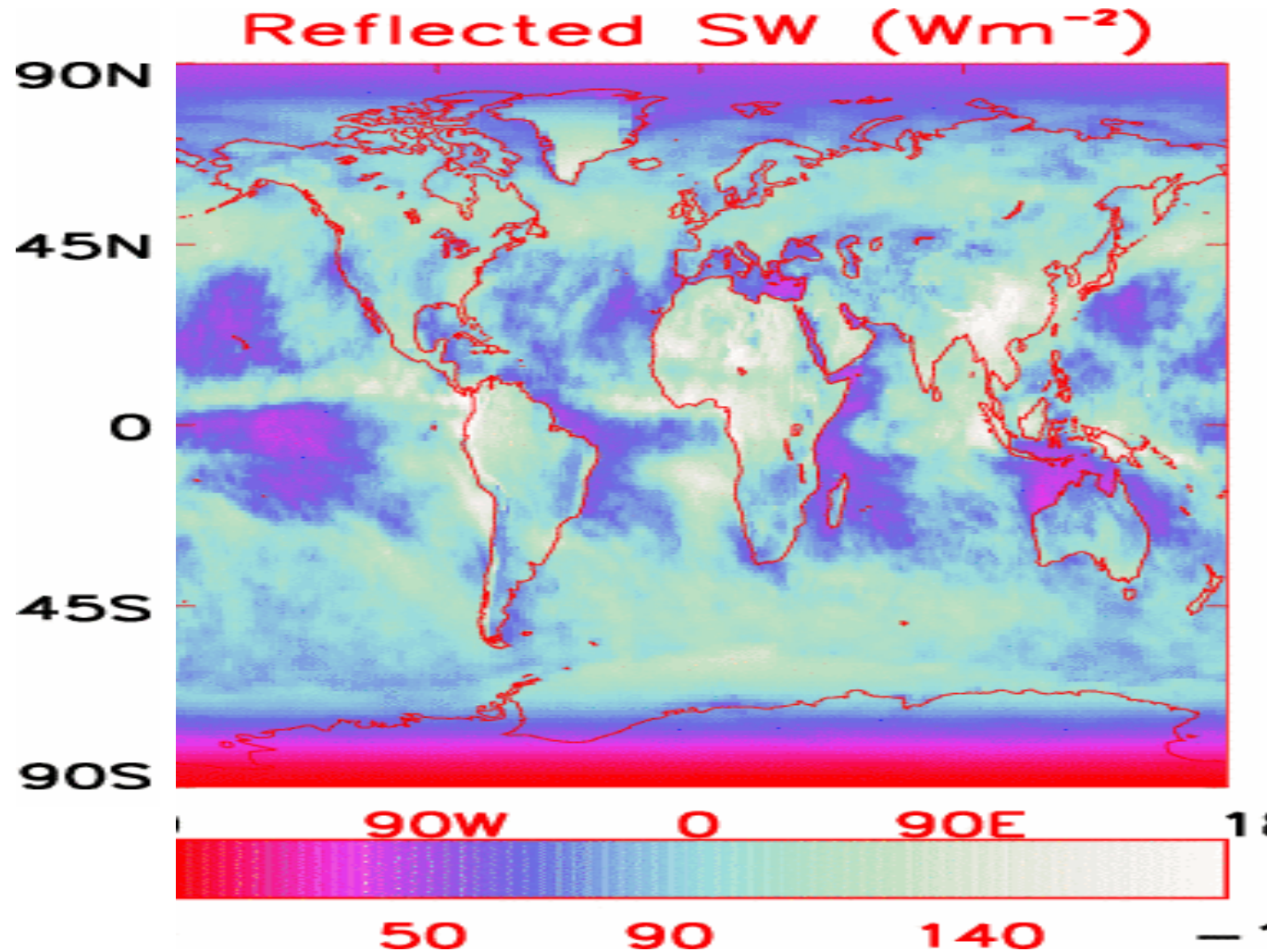
Top of Atmosphere Radiative Energy Fluxes

CERES/TERRA, September 2004



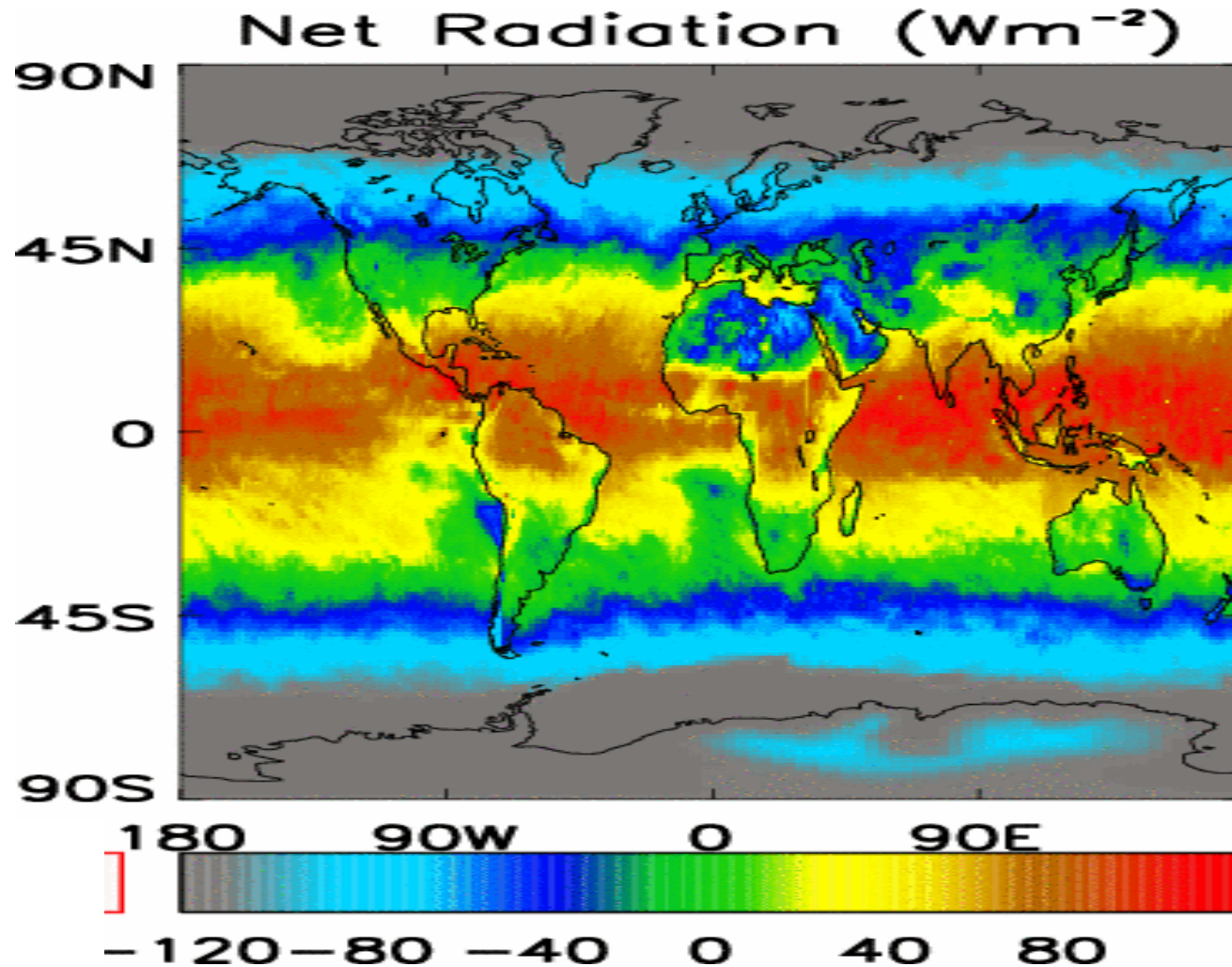
Top of Atmosphere Radiative Energy Fluxes

CERES/TERRA, September 2004

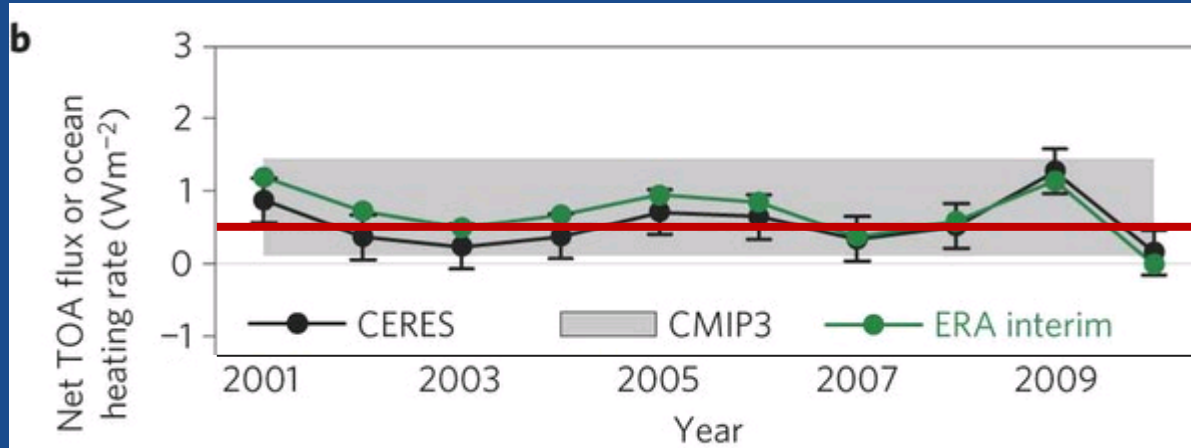


Top of Atmosphere Radiative Energy Fluxes

CERES/TERRA, September 2004



Combining satellite measurements with ocean observations...



- We found that heat is continuing to accumulate
- The rate of heating is 0.5 Watts per square metre (this is equivalent to the heat of 250 billion 1 kilo-Watt electric heaters distributed over the planet)