ENERGY FLOWS IN EARTH'S CLIMATE SYSTEM

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IMPORTANCE

Accurate knowledge of energy flows in Earth's climate system is essential to evaluation of representations of these flows in models of climate and climate change.

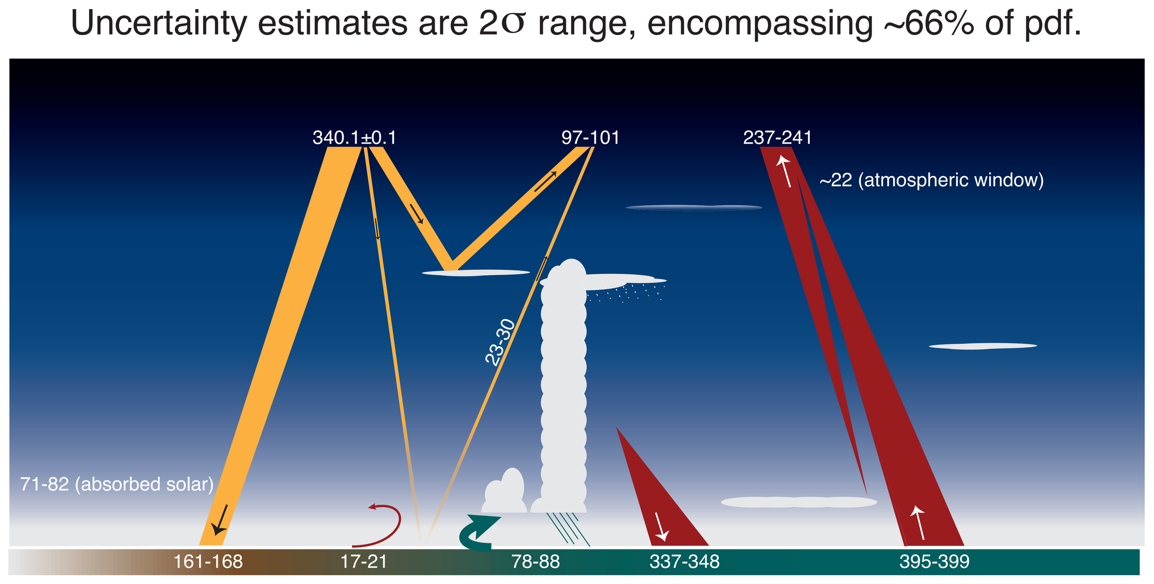
This poster presents key results from our recent survey of energy flows between the surface and the atmosphere and between the atmosphere and space and points out key remaining uncertainties.

Reference. Stevens B. and Schwartz S. E. Observing and Modeling Earth's Energy Flows. *Surveys Geophys*. In press, 2012. http://www.ecd.bnl.gov/steve/pubs.html#preprints

SUMMARY

Global, annual average energy flows, W m^{-2}

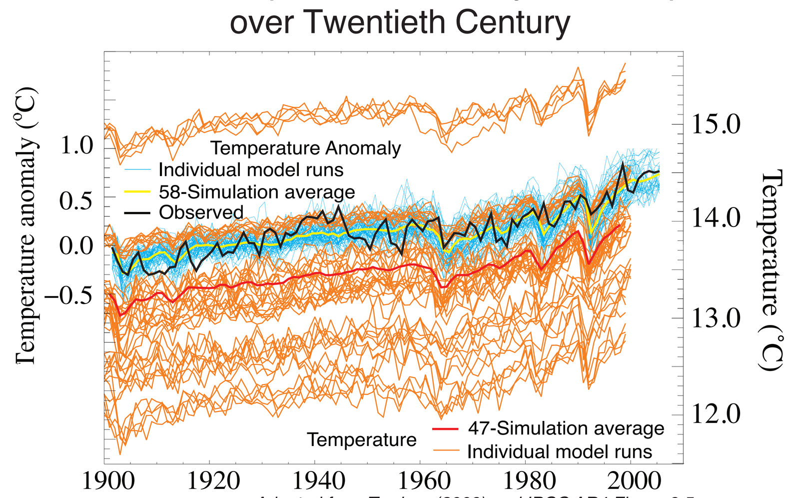
Uncertainty estimates are 2σ range, encompassing ~66% of pdf.



Surface fluxes are much more uncertain than TOA fluxes.

SURFACE LONGWAVE FLUX

Global Mean Temperature Anomaly and Temperature over Twentieth Century



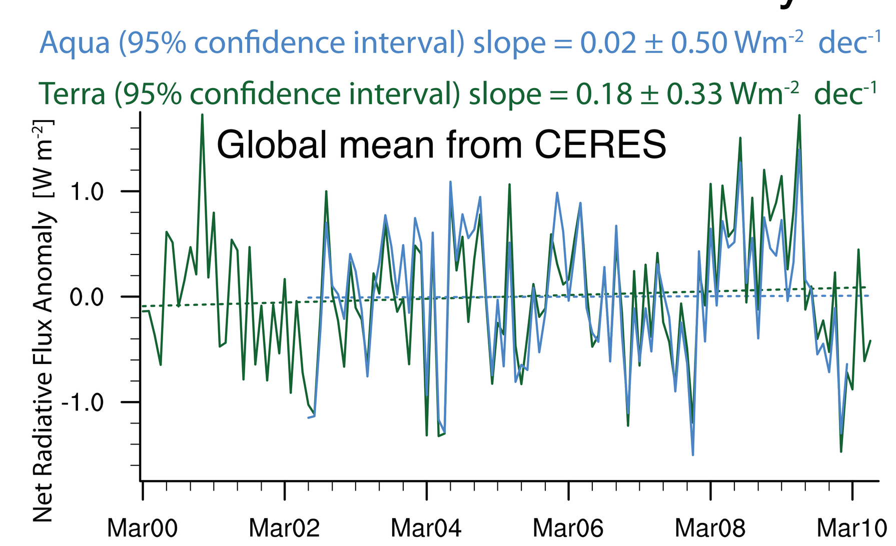
1 K error in temperature corresponds to error in emitted longwave radiation at surface of 3.4 W m^{-2}.

Despite differences in temperature models accurately represent increase in temperature over 20th century.

Surface emitted longwave flux is commonly evaluated as σT^4, where σ is the Stefan-Boltzmann constant and T is the near-surface (2 m) air temperature. However, emissivity in the thermal infrared can be as low as 0.9, depending on material. Further, the surface temperature can differ appreciably from that of air, e.g., by radiative cooling. Both effects can lead to ***substantial errors in calculated longwave fluxes***.

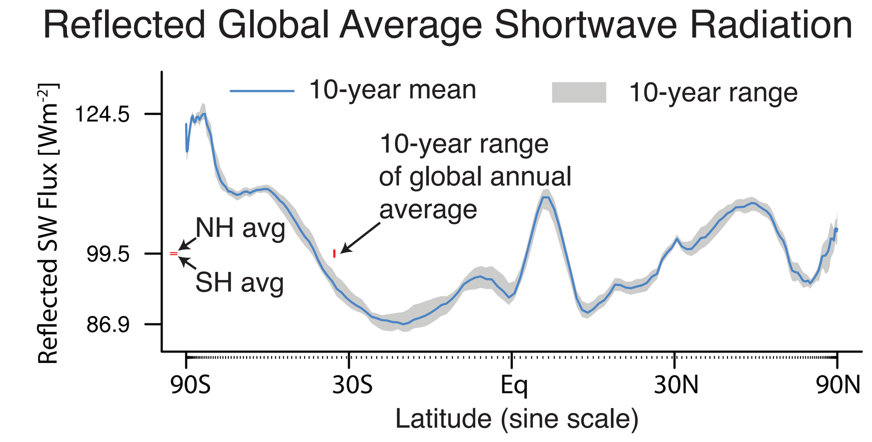
TOP OF ATMOSPHERE

Net Radiative Flux Anomaly



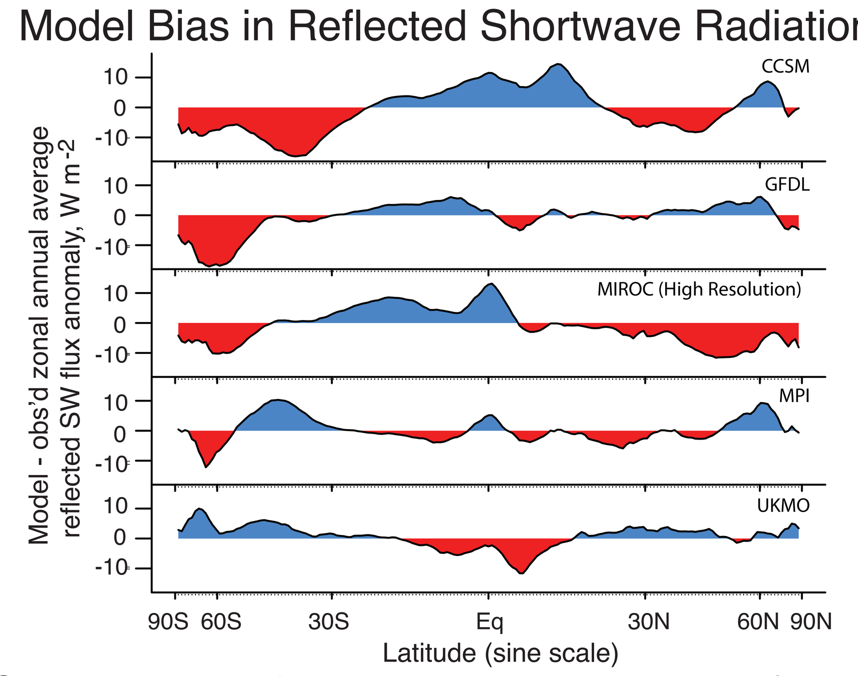
Average planetary radiative imbalance is near constant.
Fluctuations ~±1 W m^{-2} are real and a property of Earth's climate system.
Fluctuations need to be understood and represented in models.

Reflected Global Average Shortwave Radiation



Reflected shortwave irradiance is nearly constant with time and, on average, nearly equal between hemispheres.
By implication absorbed shortwave and emitted longwave are similarly constant.
This constancy needs to be understood and represented in models.

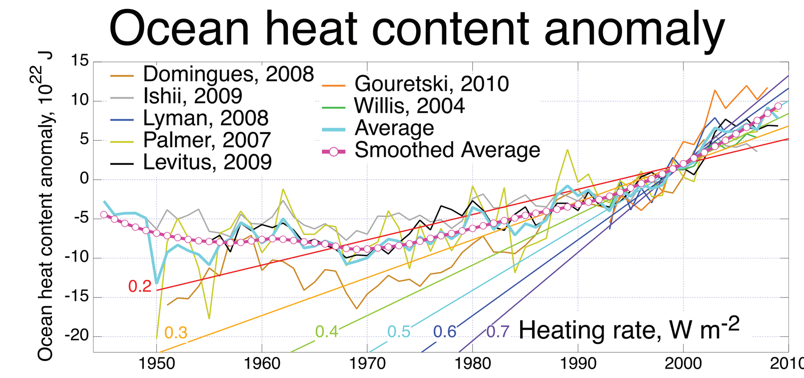
Model Bias in Reflected Shortwave Radiation



Current climate models systematically misrepresent reflected SW radiation.

EARTH'S ENERGY IMBALANCE

Ocean heat content anomaly

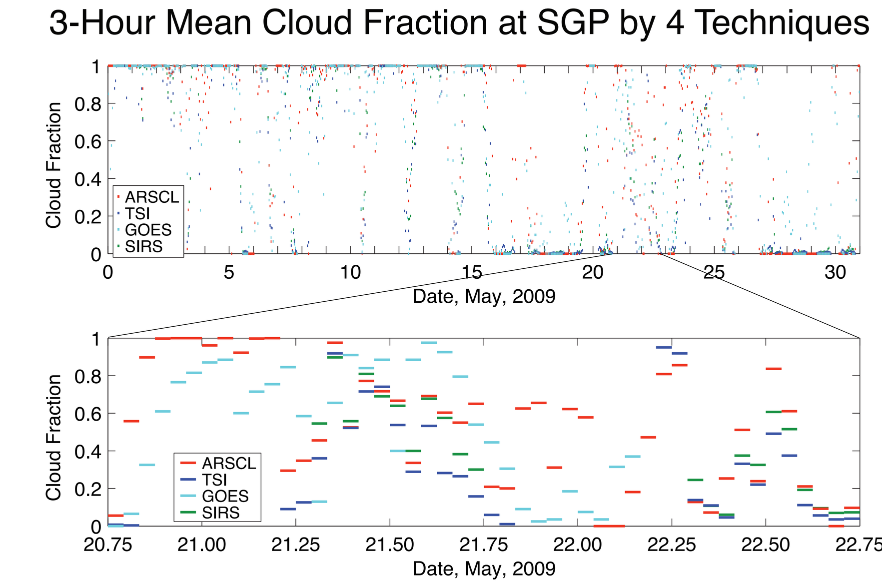


Earth's energy imbalance, determined from rate of increase of ocean heat content, augmented by other heat sinks, is estimated as 0.9 ± 0.3 W m^{-2}. This low imbalance implies that most warming from incremental greenhouse gases is already realized, ***not largely "in the pipeline"*** as indicated by many climate model calculations.

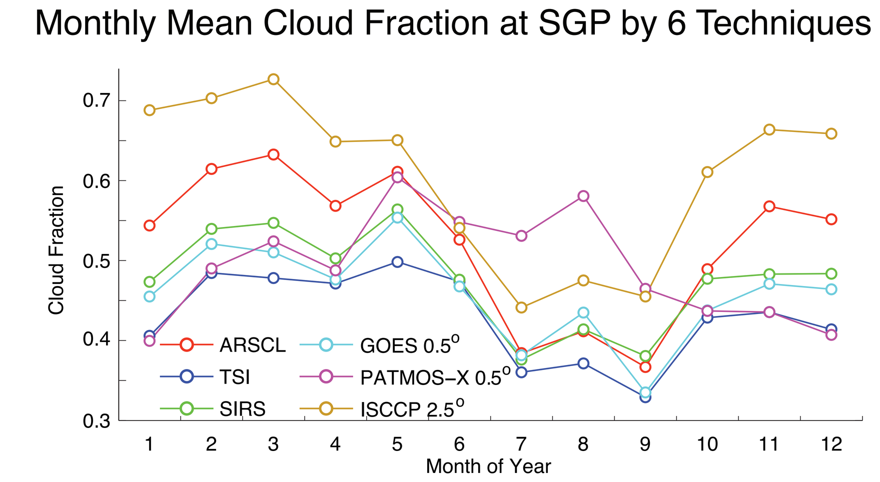
CLOUD FRACTION

Cloud fraction is widely used in interpretation of cloud effects on radiation, in measurement and models. However as cloud fraction depends on threshold and resolution, ***different measurement techniques yield very different values***. Nonetheless models continue to use this quantity and model evaluations are based on comparison with observations. The inability to define a cloud limits the ability to determine cloud radiative effects on short- and longwave irradiance.

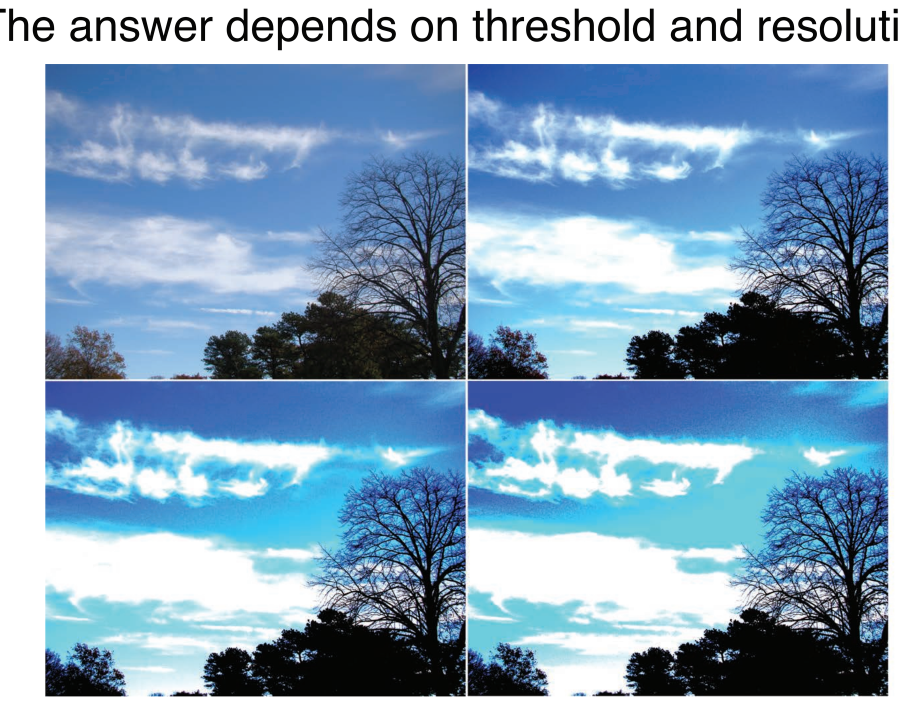
3-Hour Mean Cloud Fraction at SGP by 4 Techniques



Monthly Mean Cloud Fraction at SGP by 6 Techniques

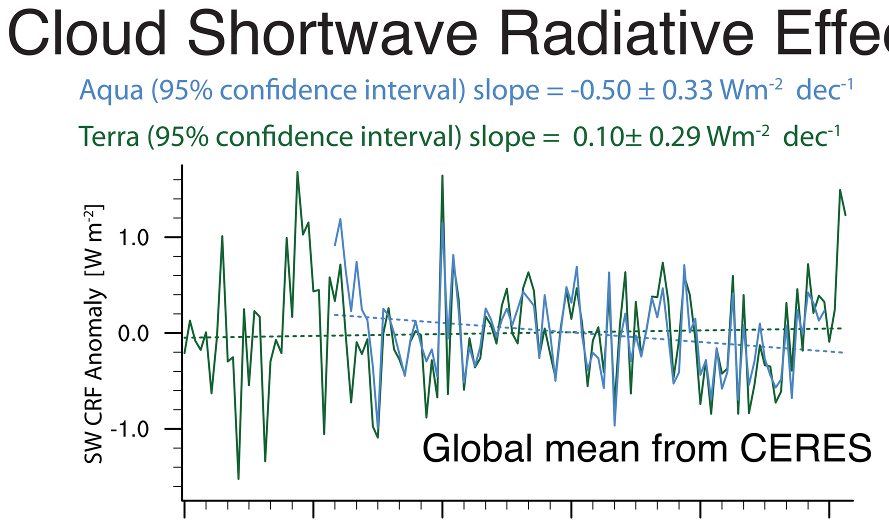


What is the Cloud Fraction?
The answer depends on threshold and resolution.



Contrast is increased in successive frames.

Cloud Shortwave Radiative Effect



Difference in trends: real or artifact?