**ENERGY FLOWS IN EARTH’S CLIMATE SYSTEM**

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**IMPACT**

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.


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**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.

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**SURFACE LONGWAVE FLUX**

Global Mean Temperature Anomaly and Temperature over Twentieth Century

Surface emitted longwave flux is commonly evaluated as σT⁴, 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.

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**EARTH’S ENERGY IMBALANCE**

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.

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**TOP OF ATMOSPHERE**

**Net Radiative Flux Anomaly**

Aqua (95% confidence interval slope = 0.02 ± 0.50 W m⁻², dec⁻¹

Terra (95% confidence interval slope = 0.18 ± 0.33 W m⁻², dec⁻¹

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.

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**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.

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**Cloud Shortwave Radiative Effect**

Aqua (95% confidence interval slope = -0.10 ± 0.13 W m⁻², dec⁻¹

Terra (95% confidence interval slope = 0.16 ± 0.23 W m⁻², dec⁻¹

Difference in trends: real or artifact?