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Recent Advances in Observing Earth's Radiation Budget

N.G. Loeb (1), G.L. Stephens (2), S. Kato (1), D.R. Doelling (1), and M. Wild (3)

(1) NASA Langley Research Center, Hampton, VA, United States (norman.g.loeb@nasa.gov), (2) Jet Propulsion Laboratory/NASA, Pasadena, CA, United States, (3) Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

Observing Earth's energy flows is a challenge because it involves a range of time and space scales and encompasses both radiative and non-radiative energy exchanges between the sun, atmosphere, cryosphere, land and the entire depth of the ocean. The radiative energy balance between the solar or shortwave (SW) radiation absorbed by Earth and the thermal infrared or longwave (LW) radiation emitted back to space is fundamental to climate. An increase in the net radiative flux into the system (e.g., due to external forcing) is primarily stored as heat in the ocean, and can resurface at a later time to affect weather and climate on a global scale. The associated changes in the components of the Earth-atmosphere such as clouds, the surface and the atmosphere further alter the radiative balance, leading to further changes in weather and climate. At the surface, Earth's radiation balance constrains the global hydrological cycle, and its geographical distribution drives circulations in the atmosphere and ocean.

The availability of multiple years of data from improved passive instruments launched as part of the Earth Observing System, active instruments belonging to the A-Train constellation, and the Argo global array of profiling floats measuring the temperature of the upper 1,800 m of the ocean has led to significant improvements in our ability to observe Earth's radiation budget. At the top-of-atmosphere (TOA), there have been marked improvements in the accuracy of TOA radiative fluxes through improved instrument calibration, improved representation of the angular dependence of TOA radiation, and improved diurnal sampling through fusion of data from sun-synchronous and geostationary satellite instruments. Based upon combined observations from the Clouds and the Earth's Radiant Energy System (CERES) and in-situ ocean heat content anomaly data from Argo, Earth's radiative imbalance is observed to be 0.54 ± 0.43 Wm–2 (uncertainties at the 90% confidence level), suggesting that energy is continuing to accumulate in the sub-surface ocean. The new observations also refute earlier claims of "missing energy" in the system.

Because surface radiative fluxes are not directly measured from satellite, they are much more uncertain than at TOA. However, significant advances have been made due to the availability of global observations of vertical cloud and aerosol profiles from CALIPSO and Cloudsat active sensors. This has led to improved estimates of the effects of clouds on both the surface and atmospheric energy balance, and a marked increase in downward LW radiation at the surface. The latter result is independently confirmed through comparisons with surface flux measurements over land from the Global Energy Balance Archive and the Baseline Surface Radiation Network. The increased estimate of downward LW radiation suggests a need to increase the estimate of global mean latent heat flux by 10% over that inferred from GPCP global mean precipitation.