Radiative transfer computations in estimating surface and in-atmosphere radiation budget of Earth at a global scale

Seiji Kato[a,*], Norman G. Loeb[a], Fred G. Rose[b], and David A. Rutan[b]

[a]*NASA Langley Research Center, Hampton, VA 23681-2199, USA*
[b]*Science Systems and Applications, Inc., Hampton, VA, USA*

[*]*Presenting author (seiji.kato@nasa.gov)*

The NASA's Clouds and the Earth's Radiant Energy System (CERES) project provides earth radiation budget data products. Top-of-atmosphere irradiances are derived from broadband radiance observations [1]. Surface and in-atmosphere irradiances are derived using a radiative model [2]. In order to understand radiation budget at a global scale, surface and in-atmosphere irradiances need to be estimated with a radiative transfer model.

Shortwave (solar) and longwave (emitted by the earth) irradiances are computed separately. The atmosphere is divided into ~50 vertical layers. Spectral region is separated into smaller spectral regions and absorptions by water vapor, ozone, carbon dioxide, and other trace gases are treated with the correlated-*k* approximation. Scattering by air molecules, aerosols and clouds are treated by two- and four-stream approximations applied to the integro-differential equation of radiative transfer. It is assumed that aerosol and cloud particles scatter radiation incoherently. Polarization state is ignored. Most inputs to the radiative transfer model come from observations, including temperature, humidity profiles, cloud and aerosol properties. Specifically, cloud and aerosol properties used in the computations are derived from satellite observations of radiances measured at discrete wavelengths.

Despite many approximations and assumptions made in the algorithm, computed surface irradiances agree to within the uncertainty of surface irradiance observations taken at 36 land sites and 46 ocean buoys distributed globally when top-of-atmosphere irradiances are constrained by irradiances derived from broadband radiance measurements by CERES instruments.

In this talk we summarize the method to compute surface and in-atmosphere irradiances, and how these irradiance estimates contribute to the understanding of the energy budget of the Earth and energy transport and hydrological cycle within the system.

References

[1] Loeb, N. G., D. R. Doelling, H. Wang, W. Su, C. Nguyen, J. G. Corbett, L. Liang, C. Mitrescu, F. Rose, and S. Kato, 2018: Clouds and the Earth Radiant Energy System (CERES) Energy Balanced and Filled (EBAF) Top-of-Atmosphere (TOA) Edition-4.0 data product. *J. Climate* **31**, 895–918.

[2] Kato, S., F. G. Rose, D. A. Rutan, T. J. Thorsen, N. G. Loeb, D. R. Doelling, X. Huang, W. L. Smith, W. Su, and S.-H. Ham, 2018: Surface irradiances of Edition 4.0 Clouds and the Earth's Radiant Energy System (CERES) Energy Balanced and Filled (EBAF) data product. *J. Climate* **31**, 4501–4527.

Mode of presentation: Invited