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Sensitivities in Satellite-Based Estimates of Cirrus Cloud Radiative Forcing

Erica K. Dolinar (), Scott C. Ozog (2), Simone Lolli (3), John E. Yorks (4), and James R. Campbell (5)

(1) American Society of Engineering Education c/o Naval Research Laboratory, Monterey, California, USA, (2) University of Maryland, College Park, Maryland, USA, (3) CNR-IMAA, Istituto di Metodologie per l'Analisi Ambientale, Tito Scalo, Italy, (4) NASA Goddard Space Flight Center, Greenbelt, Maryland, USA, (5) Naval Research Laboratory, Monterey, California, USA

In this paper, we describe a unique experiment conducted in the summer of 2017 using the NASA high-altitude WB-57 aircraft. Flying well above typical jet aircraft altitudes, we profiled cirrus clouds below the aircraft using the nadir-oriented NASA Cloud Physics Lidar (CPL) while simultaneously measuring visible and infrared cloud top radiances using radiometers mounted to the underbelly of the airframe. On 11 August, the WB-57 underflew the NASA Cloud Aerosol Transport System (CATS) lidar flying aboard the International Space Station while profiling cirrus clouds formed in thunderstorm outflow over central Texas in the southern United States. The purpose of this flight was to understand sensitivities in resolving cirrus cloud radiative properties from the satellite versus the higher-resolution depiction available with the aircraft. We therefore compare estimates of top-of-the-atmospheric (TOA) forcing solved using the Fu-Liou-Gu radiative transfer model using the satellite-derived CATS extinction coefficient profile versus that of CPL. We vary resolutions with the satellite to understand its impact on the forcing estimates. We apply the radiometers as a closure constraint to both estimates.

Cirrus are the only cloud genera that can induce a positive or negative daytime TOA forcing, depending on a host of variables such as cloud and surface temperature, particle size, surface albedo and solar zenith angle. This unique sensitivity translates to an equally unique net TOA daytime forcing contribution by cirrus clouds to the climate budget that our group has shown oscillates between +/- 2 W/m2 in absolute terms depending on latitude. Therefore, it is critical that we understand how well satellite lidar measurements perform in resolving these optically-thin and tenuous clouds, and quantify what potential biases may be present in satellite-based TOA forcing estimates due to undersampling and/or misrepresentation of their structure. We further look at sensitivities to our model estimates by comparing results derived with classical single-scattering optical parameterizations versus newer models. The overall goal of the presentation is to describe a holistic look at satellite versus near in-situ profiling of cirrus clouds and the sensitivity in TOA cloud forcing induced by what proves the most common cloud in the earth atmosphere.