AGU PUBLICATIONS

Journal of Geophysical Research Atmospheres

Supporting Information for

Fusion of MISR Stereo Cloud Heights and Terra-MODIS Thermal Infrared Radiances to Estimate Multi-layered Cloud Properties

Arka Mitra[1], Jesse Ray Loveridge[1] and Larry Di Girolamo[1]

1. *Department of Atmospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, IL*

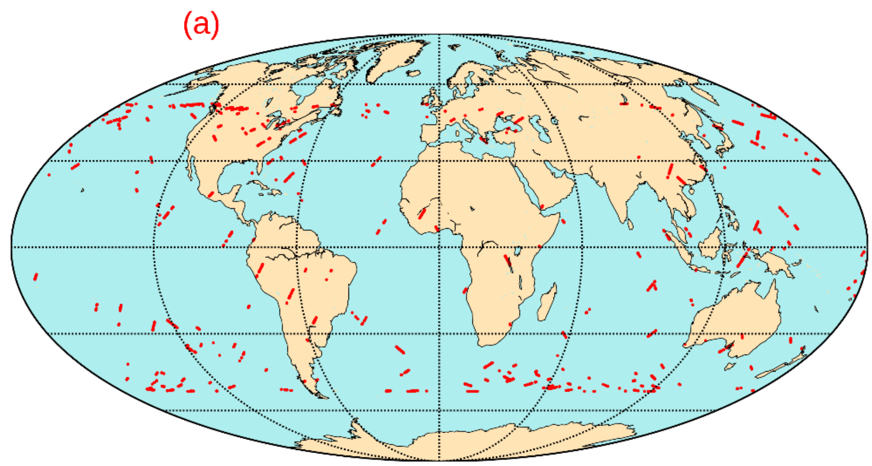
Contents of this file

Introduction

In the following two sections, we will provide some supporting information that will aid the reader in understanding the main manuscript better. In Section S1, we present the geographical distribution of CATS, MISR and MODIS collocated pixels that were deemed worthy for our main analysis (Section 4.1 of main manuscript). In Section S2, we present further details of the radiative transfer simulations used to determine the estimates of longwave cloud radiative effect (CRE) biases resulting from the application of a 1-alyered CO2-slicing, that has been presented in the Section 5 of the main manuscript.

Text S1. *Spatial distribution of collocated CATS, MISR and MODIS pixels where MODIS-MISR CTH difference > 1 km and MODIS employed CO_2-slicing for Cloud-top Detection*

As in Mitra et al. (2021), CATS, MISR and MODIS samples were selected only if they are collocated (< 1 km) and coincident (< 5 minutes), for robust statistical analysis. Such collocated pixels are restricted to latitudes traversed by the ISS orbit (±52° in either hemisphere), from which the CATS lidar operated.



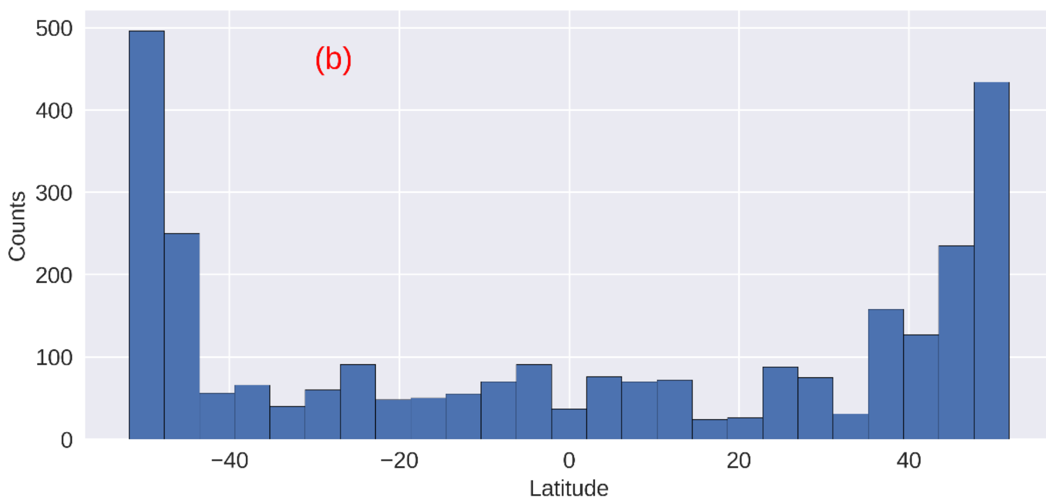


Figure S1. Spatial distribution of collocated CATS, Terra-MODIS and MISR pixels between 2015-17 (a) globally and (b) binned zonally.

Text S2. *Details on Radiative Transfer Modeling to understand the LW CRE bias due to a 1-layered CO_2-slicing (Section 5)*

To estimate broadband LW CRE we use radiative transfer simulations from the uvspec program in the version 2.0.4 libRadtran software package (Mayer & Kylling, 2005). The same climatological atmospheric and surface conditions are used as in Figure 1 (Section 3.2.1). We also use the values of CTP overestimations (and corresponding overestimations of effective emissivity) for Band 36/35 (the more widely applied solution) from Figure 1 in estimating cloud radiative effect (CRE) bias from a 1-layered CO_2-slicing in Fig. 5. This procedure described below is repeated for different combinations of high CTP between 150-600 hPa and low cloud CTP between 600-1000 hPa for 3 values of high cloud effective emissivity (0.1, 0.2 and 0.4).

Broadband longwave (LW) fluxes are calculated between 4-100 μm using the DISORT radiative transfer solver with 16 streams. Molecular absorption is calculated using the 'fu' parameterization scheme (Fu & Liou, 1992). For the 'True' LW CRE we define both a low and a high cloud layer. The low cloud has a homogeneous cloud liquid water content of 0.5 g m^{-3} and particle effective radius (R_e) of 10 μm with a geometric thickness of 500 m. Water cloud optical properties are calculated using the 'hu' scheme (Hu & Stamnes, 1993). For the high cloud, R_e is fixed at 40 μm and geometric thickness at 100 m. This higher cloud is deliberately chosen to be geometrically thin to mimic the infinitesimally thin condition in a CO_2-slicing forward model (Section 2).

The above software settings require ice water content (IWC) of the high cloud as input. In setting the IWC, we prescribe the 11.2 μm (MODIS Channel 31) emissivity of the upper layer. We convert this emissivity to an infrared optical depth (τ_{IR}) at 11.2 μm (MODIS channel 31). We use the 'baum' ice microphysical model (Baum et al., 2014) to calculate the required IWC from τ_{IR} (Figure S2). To calculate the 'effective' LW CRE we use CTP and emissivity from our 1-layered CO_2-slicing algorithm to define a single ice cloud layer (500 m thick). The same conversion described above is used to define the IWC of this cloud. The R_e of the retrieved cloud is assumed to be that of the upper cloud layer (40 μm).

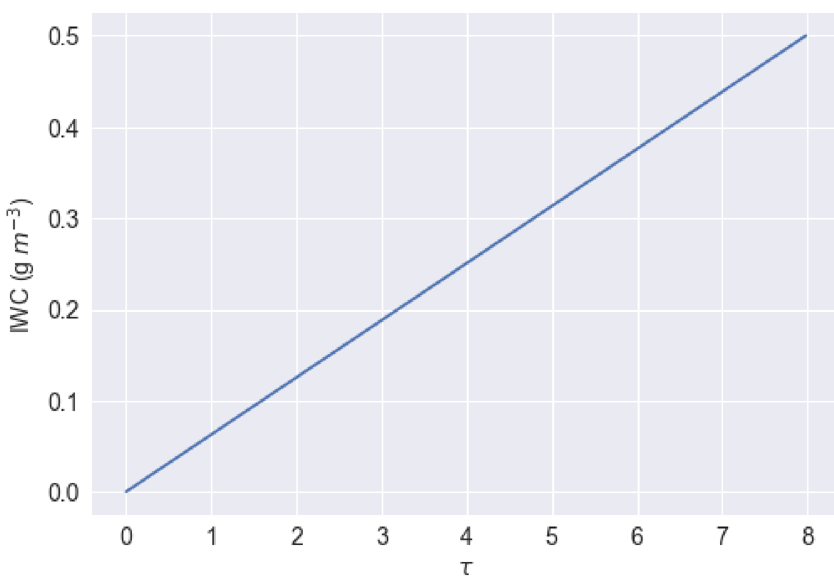


Figure S2. Variation of visible optical depth (τ) with ice-water content (IWC; g/m^3) for a 250 m thick ice-cloud at 10 km, with effective radius of ice particles = 40 μm and in a tropical climatological atmospheric profile.