How much solar radiation does atmospheric mineral dust absorb, and how much do climate models simulate?

Mineral dust particles account for approximately a third of the shortwave radiation scattered and absorbed by all aerosols in the atmosphere. As such, they have substantial radiative impacts on the Earth’s climate system. But despite their radiative impacts, the amount of shortwave radiation absorbed by atmospheric dust remains largely unclear. This is because knowledge of dust absorption properties, characterized by the dust aerosol absorption optical depth, primarily depends on the dust size distribution and the complex refractive index, which are difficult to observe from remote-sensing platforms. As a result, climate model simulations rely on certain assumptions about dust properties that have led to significant uncertainties in their estimation of the global dust absorption optical depth. In this talk, I will describe a framework that leverages dozens of in-situ measurements of the dust size distribution and single-scattering albedo to obtain a more accurate constraint on the dust absorption optical depth at 550-nm wavelength. I will show that atmospheric dust is much coarser with substantial spatial variability in the imaginary refractive index than represented in most climate models. Consequently, I will show that the amount of solar radiation absorbed by dust in the atmosphere differs substantially from what climate models simulate. Finally, I will discuss the critical implications of this model bias to our estimates of dust impacts on the Earth’s climate system.