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Numerical Simulations to Explore Deviations from the Beer-Lambert-Bouguer Law in a Correlated Random Medium

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The Beer-Lambert-Bouguer Law of exponential attenuation is ubiquitous in the study of atmospheric radiative transfer. However, previous work has shown that adherence to the classical Beer-Lambert-Bouguer law requires the scatterers in the medium to be spatially uncorrelated. As particulates in the atmosphere are often statistically correlated/clustered, it is useful to identify the magnitude of the deviation from the classical expectation under different degrees of spatial clustering.

Measuring this deviation is difficult in an experimental setting both because it is challenging to measure the spatial clustering and the deviations from the classical expectation are expected to be modest. Thus, we approach this question through a simplified “ballistic-photon” computational simulation.

Here, we use a simplified numerical model to track the extinction of a collimated light source through correlated random media. The geometry is taken to mimic a sub-volume of the Michigan Technological University Pi Chamber, and the scatterers (cloud droplets) are explicitly resolved using a variety of increasingly realistic techniques for a frozen-field representation of the particle positions.

We report on the anticipated deviations from the classical Beer-Lambert-Bouguer law through examination of the resulting intensity of the illumination leaving through different walls of the simulation domain.