Generalized radiative transfer models for subpixel spatial & spectral variabilities in optically thin scattering media: application to aerosol profiling with the Oxygen A-band

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Generalized radiative transfer (GRT) theory was originally developed as a rigorous formalism for predicting spatial/ensemble average radiances and fluxes in stochastic 3D optical media dominated by scattering using a new homogenization [1,2]. Phenomenological precursors of GRT explained a slew of real-world observations of the cloudy atmosphere from the ground up (Ref. [3], and references therein). In parallel, the basic tenet of GRT, namely, substitution of the standard exponential (a.k.a. Beer's) direct transmission function with a power-law form, was proposed to address the perennial problem of efficient spectral integration across molecular absorption bands where cross-sections vary over many orders-of-magnitude [4]. We recently unified these two applications of GRT [5], established the validity of the spectral version from first physical principles [6], and illustrated the two purposes with analytical solutions for media that are optically thin as far as the scattering goes.

We will survey these recent developments in GRT theory and dual applications, and tie them to a current problem in aerosol profiling from space-based using passive imaging sensors that exploit the unique properties of the O_2 A-band (759–772 nm), as opposed to active lidar sensors that may have exquisite vertical resolution but no swath—only a "curtain" of data is provided. NASA's upcoming PACE mission and MAIA investigation will benefit from this new capability.

References

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