Spatial scales of 3-D cloud radiative smoothing: what the spatial variability of multi-angular and multi-spectral features can reveal about multiple scattering in cloudy atmospheres

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To facilitate the passive remote sensing of cloud properties it is typical to approximate the inhomogeneous 3-D structure of real clouds into a simplified 1-D model such that radiative transfer can be efficiently simulated in a closed form. As a consequence it is assumed that each resolved cloudy pixel is independent of its neighbors and there is no net horizontal transport of light across pixel boundaries – the independent pixel assumption. This study examines the impact of resolved inhomogeneous 3-D effects – cases that break the independent pixel assumption. One characteristic of resolved 3-D radiative effects is known as radiative smoothing – whereby inhomogeneous cloudy features are smoothed out as a result of the horizontal transport of light from brighter/thicker clouds to darker/thinner cloudy pixels. One important aspect of radiative smoothing is the scale break – the scale or pixel resolution above which the smoothing due to 3-D effects is no longer resolved from pixel to pixel. This scale break, which for conservative scattering regimes occurs at approximately 300–500 meters, has been used to constrain and define spatial resolutions of satellite imaging radiometers such as MODIS and VIIRS. However the scale break is dependent on how much multiple scattering contributes to the observed signal and thus depends on viewing and solar zenith angles, the single scattering albedo, and droplet size.

In this study we will examine radiative smoothing in a multi-angular and multi-spectral context using both simulated data and observations from the airborne Research Scanning Polarimeter. Airborne platforms can often have ground-registered spatial resolutions on the order of tens of meters, well below the scale break, and therefore resolve 3-D effects associated with radiative smoothing. The impact of cloud radiative smoothing in regimes with strong absorption (e.g., the shortwave infrared) has been underexplored. Additionally, it also offers the first opportunity to explore radiative smoothing in a different radiative regime, namely polarized reflectances, which have markedly different 3-D radiative processes due to limited multiple scattering.

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