



View angle dependence of microwave and optical cloud liquid water path retrievals

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We investigated the view angle dependence of cloud liquid water path (CLWP) retrievals in one year of collocated AMSR-E microwave and MODIS optical satellite observations averaged down to a 25-km domain scale. The cross-swath variation of AMSR-E CLWP and that of MODIS cloud optical thickness, droplet effective radius, liquid cloud fraction, and CLWP were determined as a function of cloud heterogeneity and solar zenith angle. Our goal was to identify the cloud scenes and sun/view geometries for which 3D effects might introduce significant biases in domain-mean plane-parallel MODIS retrievals. Microwave CLWPs were generally consistent at all view directions, the view angle dependence of optical parameters, however, strongly depended on scene heterogeneity and sun angle. Liquid cloud fraction always exhibited a U-shape, that is, a consistent increase with view zenith angle, but with a slight forward/back scatter asymmetry depending on heterogeneity and solar zenith angle. Cloud optical thickness usually showed a slight/moderate decrease with view angle, especially in the forward scattering direction. In the most heterogeneous scenes and at very low sun, however, optical thickness also had a distinct U-shape, that is, a considerable increase towards swath edges. Droplet effective radius, on the other hand, always increased with view angle, particularly strongly in heterogeneous scenes and at low sun. The increase in droplet effective radius towards swath edges also tended to be asymmetric, with significantly larger values in the forward than in the back scatter direction. The overall view angle dependence of MODIS CLWP was, in turn, the result of the complex interplay among the sometimes opposite cross-swath variations of optical thickness, effective radius, and cloud fraction. MODIS CLWP could also show strong and usually U-shaped cross-swath variations in the most heterogeneous clouds at oblique sun; however, such cases represented only a small fraction of all retrievals. The most striking difference between microwave and optical CLWPs was not their view angle dependence, but the very strong increase of optical CLWPs with solar zenith angle, which was lacking in microwave retrievals.