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Improvements in cloud and aerosol remote sensing from hyperspectral shortwave observations

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The application of shortwave (solar), spectrally resolved, continuous, near-full solar spectrum measurements for cloud and aerosol remote sensing and radiative energy budget evaluation has increased over the past decade and will continue to do so in future satellite and aircraft missions. Enhancing spectral resolution and range is key to resolving a number of outstanding science questions because of the added information content in the measurements. We demonstrate this with a number of examples from airborne field campaigns conducted over the past five years. In contrast to space-borne applications where the energy-related quantities have to be derived from radiance or radiance-based cloud and aerosol retrievals, airborne measurements can be used to derive cloud and aerosol properties and to quantify the radiative energy budget, circumventing an artificial separation between remote sensing and energy budget assessment that often leads to systematic biases. In one example, we show how a new irradiance-based retrieval of single scattering albedo, asymmetry parameter, and surface albedo, applied to MILAGRO data, simultaneously provides top- and bottom-of-layer radiative forcing. Throughout the experiment, the direct aerosol effect is tightly constrained which may appear surprising given the wide range of the associated spectral aerosol properties. A second example, from the TC4 experiment, shows that attribution of errors in the transition from cloud optical thickness and effective radius to shortwave cloud forcing and absorption can only be achieved by using spectral information. A model-measurement case study from the GoMACCS experiment demonstrates that clouds immersed in an aerosol layer have a spectrally distinct forcing, different from that of the cloud field alone. This talk will also feature a quantitative analysis of information content in hyperspectral shortwave measurements, and we apply multivariate analysis to SCIAMACHY data to demonstrate improvements in trend detection and attribution. In conclusion, we point out the wide applicability of spectral techniques ranging from aerosol layers, heterogeneous clouds, cloud-aerosol scenes, and surface characterization. This may prove useful as we move beyond the A-Train era towards future missions such as CLARREO.