Development and Implementation of a Variational Cloud Retrieval Scheme for the Measurements of the SURFRAD Observation System

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The ESRL GMD Surface Radiation Budget Network (SURFRAD) provides continuous and accurate observations of both solar and infrared radiation at seven stations located across the continental United States. Through a combination of upward and downward viewing broadband irradiance measurements, these sites allow a rigorous, long-term characterization of the Earth's surface radiation budget. In addition to these broadband observations, each SURFRAD site also houses a Multi-Filter Rotating Shadowband Radiometer (MFRSR). This instrument, which measures direct and diffuse radiances in six distinct spectral bands in the visible and near-infrared regions, has been used primarily in context of the SURFRAD network to estimate aerosol optical depths via a Langley plot approach. Previous work, however, has suggested that these spectral MFRSR measurements also could be used to retrieve cloud properties. The goal of this work then was to develop and implement a variational cloud retrieval scheme based upon the measurements of the SURFRAD network. Instead of borrowing some pre-existing retrieval technique, however, the ideal combination of measurements for the retrieval scheme was determined through a rigorous error analysis of the surface-based cloud retrieval problem. The optimal retrieval scheme was applied both to synthetic data to determine our theoretical ability to retrieve cloud properties from these measurements and to SURFRAD radiance measurements to determine observed cloud properties with associated uncertainties at each station. These results were then compared to those from satellite-based observations such as MODIS from both a theoretical and observational perspective. In addition, to gain a better characterization of surface albedo and its effects on retrievals, a downward looking MFRSR was installed at the SURFRAD Table Mountain station to constrain the standard upward measurement. The figure below shows theoretical results for the expected retrieval accuracy of cloud visible optical depth as a function of cloud optical depth and effective radius from the SURFRAD MFRSR based upon an initial error analyses.

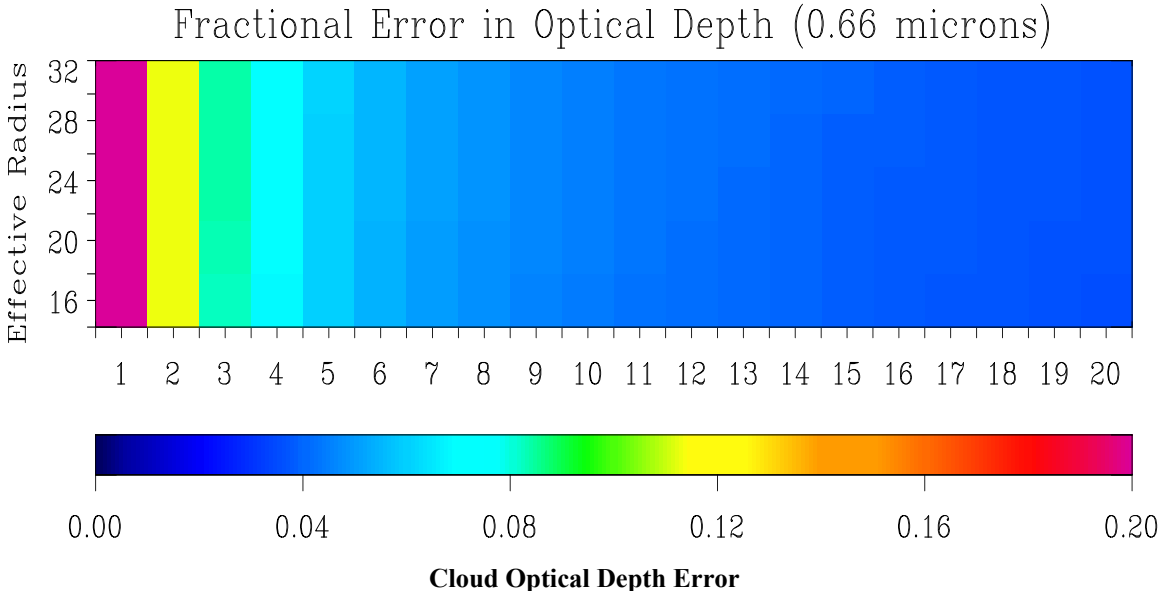

Figure 1. Theoretical results for the expected retrieval accuracy of cloud visible optical depth as a function of cloud optical depth and effective radius from the SURFRAD MFRSR based upon an initial error analyses