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Terahertz/Far-Infrared Remote Sensing of Ice Clouds - A Sensitivity Study

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Initiated by current developments in Terahertz (THz) sensor technology the application of instruments operating in the spectral region between 0.1 – 30 THz is recently considered for a number of remote sensing issues. Accounting for more than 50% of the outgoing longwave radiation (OLR) and with the major component of cirrus radiative forcing in the Far-Infrared (FIR) below 650 cm-1 (20 THz), satellite measurements in this spectral region will significantly support the determination of the radiation budget of the Earth. Furthermore, spanning the whole range of particle sizes found in tropospheric ice clouds, the THz region bears the potential to complement existing methods in measuring ice cloud properties including ice content and size distribution information. Exploring this spectral region might significantly improve our knowlegde and understanding of those clouds in the future.

In order to evaluate the feasibility of monitoring tropospheric ice clouds using passive THz/FIR observations, the sensitivity of the measurements concerning cloud properties and their natural range of variability is studied. This includes microphysical properties like particle size and shape, ice content and ice water path as well as macrophysical cloud properties (cloud altitude and thickness). The sensitivity to cloud properties is analyzed for a range of atmospheric conditions. In particular, separability from variations in the temperature and humidity profiles is focused on.

Good retrievals of ice cloud properties as well as the determination of the Earth's radiation budget require appropriately accurate radiative transfer calculations. Fundamental to that is a good knowledge of the input parameters to the radiative transfer models. In particular, this includes spectrally dependent properties of the molecular as well as particulate atmospheric matter, i.e., spectroscopic parameters of the molecular absorption lines and continua as well as the dielectric properties of aerosol and cloud particle material. Due to the lack of Terahertz light source and receiver technology in the past, measurements of these parameters have been sparse and the knowledge about them is rather poor. But, uncertainties in this parameters induce uncertainties in the retrieved cloud parameters and estimated total OLR, respectively. Using different spectroscopic databases (e.g., HITRAN and JPL), dry air and water vapor continua (e.g., Liebe and CKD) as well as ice refractive index models, we study the impact of their variability to cloud property retrievals and OLR calculations. From that, conclusions will be drawn on requirements for future experiments to measure spectroscopic and dielectric properties atmospheric constituents for geophysical applications in the THz/FIR spectral range.