Remote Measurement of Greenhouse Gases Under Cloud With the Atmospheric Emitted Radiance Interferometer (AERI) Fourier Transform Spectomereter (FTS) Instrument

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The remote measurement of tropospheric gas concentrations can be achieved by utilizing thermal emission under cloud. The cloud deck acts as a cold, optically thick, blackbody at the cloud base temperature. The emission features from the atmospheric gases below the cloud are superimposed on the cloud blackbody emission. In the thermal spectral region, there are bands and lines from ozone, carbon dioxide, water vapor, methane, nitrous oxide, chloroflurocarbons (CFC), nitric acid and many other gases.

Ozone is used as an example gas since it is both a major air pollutant and a strong greenhouse gas (GHG). The measurements made under cloudy conditions enable the radiative flux from tropospheric O_3 to be determined since the downward emission from the stratospheric ozone are blocked by the cloud layer. The measurement of the surface forcing irradiance flux from gases requires a well-calibrated high-resolution measurement of spectral radiance in the thermal infrared region from 700 to 2500 wave numbers (cm^{-1}): suitable measurements are conducted routinely with the AERI instruments at the Department of Energy Atmospheric Radiation Measurement (ARM) sites. Well-calibrated infrared spectral measurements of the downward infrared thermal radiation have been regularly taken by the robotic AERI instruments at the three main ARM sites for over 11 years with a 15-year record at the ARM South Great Plains site. The AERI instrument is an FTS which has internal blackbody calibration sources and is fully automated for long term operation.

Features from carbon dioxide, water vapor, ozone and several greenhouse gases are evident in zenith spectra of the radiance from clouds above the sites. Although the technique was designed for radiative forcing measurements of greenhouse gases, the conversion to mixing ratios is simple. Of particular interest is the measurement of ozone below cloud since the combination of the total column and the cloud base height yields a mean mixing ratio below the cloud base. Example measurements of the ozone mixing ratio in the lower troposphere are shown. A time series of the tropospheric ozone mixing ratio measurements will be displayed. Sample measurements of CFC11, CFC12 and HNO_3 mixing ratios will be demonstrated. Potential applications to the monitoring of GHG mixing ratios are discussed. Since AERI measurements are in the lower troposphere, these could augment the current ESRL GMD flask measurements and help assess the representativeness of the GMD gas mixing ratios. It would be highly desirable to have additional measurements of the average gas concentrations in the lower troposphere and at the surface since significant gradients have been observed in the gas profiles near large sources. Extra information could compensate for boundary layer effects on vertical profiles of gases. The combination of flask measurements and the AERI lower troposphere mixing ratio measurements could help assess the representativeness in these situations. AERI algorithms also provide a measurement of the temperature and humidity profiles from the surface up to cloud base.

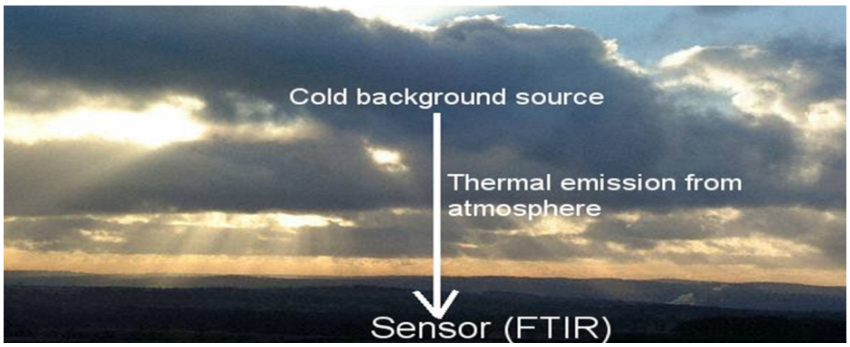

Figure 1. The concept for measurement of gases by thermal emission spectra under a cloud.