Mineral dust and residual biomass ash aerosols: experimental complex refractive indices retrieval

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ABSTRACT

Hyperspectral and high spectral resolution infrared instruments such as AIRS and IASI have shown their efficiency in determining chemical and microphysical aerosol information. However, these techniques require accurate information about the optical properties, specifically the complex refractive index (CRI) $m(\bar{\upsilon}) = n(\bar{\upsilon}) + i\, k(\bar{\upsilon})$. Previous retrieval techniques of CRI, whether pellet or bulk, modify the microphysical properties of the studied aerosol, in turn modifying the retrieved data and where over limited spectral ranges.

In this project, we present a new retrieval methodology allowing high spectral-resolution extinction spectra measurement (up to 0.5 cm^{-1}) from far infrared (FIR) (50 µm /200 cm^{-1}) up to UV (0.25 µm /40,000 cm^{-1}) and the recording of the size distribution of particles in suspension. Introducing these experimental measurements in a numerical iterative process, the real and imaginary parts of the CRI are retrieved using an optimal estimation method (OEM) associated to scattering theories and the single subtractive Kramers-Kronig (SSKK) relation. Using this methodology, we were able to accurately determine CRI, from FIR to UV for kaolinite[1], one of the main clays found in dust.

The same methodology is used in our laboratory with residual ash from wood combustion. Biomass burning aerosols are one of the largest sources of absorbing aerosols but little is known about their optical properties. For the first time, the extinction spectra of suspended residual ashes have been measured from FIR to UV. The main FIR and IR bands can be assigned to oxidised compounds (mainly $CaCO_3$ and K_2SO_4) which was confirmed by chemical analysis measurements of the particles. These laboratory studies pave the way for the synergy of the FORUM and IASI-NG space instruments.

[1] M. Chehab, H. Herbin, A. Deguine, S. Gosselin, V. Bizet, and D. Petitprez. First complex refractive indices retrieval from FIR to UV: application to kaolinite particles. Aerosol Science and Technology, 58:5, 498-511, DOI: 10.1080/02786826.2024.2318371.