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Analysis of the sensitivity of thermal infrared nadir satellite observations to the chemical and micro-physical properties of upper tropospheric-lower stratospheric sulphate aerosols

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Secondary sulphate aerosols are the predominant typology of aerosols in the upper troposphere/lower stratosphere (UTLS), and can have an important impact on radiative transfer and climate, cirrus formation and chemistry in the UTLS. Despite their importance, the satellite observation at the regional scale of sulphate aerosols in the UTLS is limited. In this work, we address the sensitivity of the thermal infrared satellite observations to secondary sulphate aerosols in the UTLS. The absorption properties of sulphuric acid/water droplets, for different sulphuric acid mixing ratios and temperatures, are systematically analysed. The absorption coefficients are derived by means of a Mie code, using refractive indexes taken from the GEISA (Gestion et Etude des Informations Spectroscopiques Atmosphériques : Management and Study of Spectroscopic Information) spectroscopic database and log-normal size distributions with different effective radii and number concentrations. IASI (Infrared Atmospheric Sounding Interferometer) and SEVIRI (Spinning Enhanced Visible and Infrared Imager) pseudo-observations are generated using forward radiative transfer calculations performed with the 4A (Automatized Atmospheric Absorption Atlas) radiative transfer model, to estimate the impact of the absorption of idealized aerosol layers, at typical UTLS conditions, on the radiance spectra observed by these simulated satellite instruments. We found a marked spectral signature of these aerosol layers between 700 and 1200 cm^{-1}, due to the absorption bands of the sulphate and bi-sulphate ions and the undissociated sulphuric acid, with absorption peaks at 1170 and 905 cm^{-1}. Micro-windows with a sensitivity to chemical and micro-physical properties of the sulphate aerosol layer are identified, and the role of interfering species, and temperature and water vapour profile is discussed.