Building an efficient gaseous absorption database for the Eradiate radiative transfer model

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The absorption coefficient of atmospheric gas mixtures—in contrast to the radiative properties of clouds and aerosols—is a fast-varying function of the spectral coordinate, notably in the infrared region of the electromagnetic spectrum where most molecule absorption lines are located. Modelling gaseous absorption accurately is critical because it can significantly improve the quality of aerosol retrieval from satellite observations when spectral bands overlap with gas absorption bands (e.g. [1]).
The most straightforward unbiased approach to compute gaseous absorption for satellite observation simulation is the so-called line-by-line method wherein absorption lines are resolved by integrating over thousands of monochromatic calculations. The prohibitive computational cost of this approach led to the development of numerical methods such as the correlated *k*-distribution method [2, 3]. It consists in performing radiation calculation in heterogeneous atmospheres over a broad spectral range while still working within the context of monochromatic radiative transfer theory and has become very popular in radiative transfer models for Earth observation applications.
We present our method to build an absorption coefficient inverse cumulative distribution database suitable for use in atmospheric radiative transfer simulations within the correlated *k*-distribution method. The database tabulates the inverse cumulative distribution of the absorption coefficient—*k(g)*—on variable *g*-points, gas molecule volume fractions, temperature and pressure meshes in fixed-width wavenumber intervals within the solar reflective spectral region. Line-by-line absorption spectrum calculations, from which the inverse cumulative distributions are derived, were performed using the Radiative line-by-line Solver (RADIS) [4, 5] using the latest version of the HITRAN spectroscopic parameters database [6]. The correlated *k*-distribution method assumes that absorption spectra at different altitudes are correlated in wavenumber space which is not rigorously valid in realistic atmospheres [7]. As a result, the method is not exact and its accuracy depends on the spectral interval and the quadrature *g*-points number. For this reason, the database also tabulates its accuracy in being able to reproduce the atmosphere average transmittance for a "US Standard" atmospheric profile [8]. We also present how this database is exploited within the Eradiate open-source 3D radiative transfer model [9].

Keywords: gas absorption modelling, correlated k-distribution method.

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