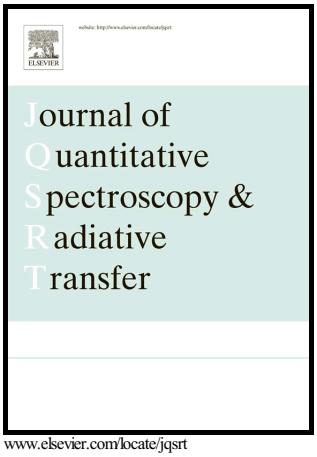

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Alexander Berk, Fred Hawes

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Validation of MODTRAN®6 and its Line-By-Line Algorithm

Alexander Berk* and Fred Hawes

Spectral Sciences, Inc. (SSI), 4 Fourth Avenue, Burlington, MA 01803

*Corresponding Author: lex@spectral.com

ABSTRACT

A new line-by-line (LBL) algorithm has been developed for use within the MODTRAN®6[1] atmospheric radiative transfer model. The model computes both emitted and scattered line-of-sight radiances utilizing a spherical refractive geometry package and the DISORT discrete ordinate model to solve the 1-D scattering problem. The MODTRAN6 LBL method distinguishes itself from most other monochromatic models in that the radiative transfer problem is solved at arbitrarily fine spectral resolution within disjoint and contiguous 0.1 cm^{-1} steps, marching through the user-specified band pass. The advantage of this approach is that the predominantly Lorentzian, temperature and pressure dependent contributions to each 0.1 cm^{-1} spectral bin from molecular transitions centered more than 0.05 cm^{-1} from the bin can be summed off-line and fit to a simple analytic form. The line-shape of each molecular transition is explicitly modeled on-the-fly only over a narrow 0.2 cm^{-1} sub-region. The challenge of this approach is to ensure that spectral discontinuities do not arise at spectral bin edges, where the method for modeling absorption from individual molecular lines changes abruptly. Interpolations based on the radiative transfer physics of the pre-computed *line tail* data are introduced to produce a smooth transition across these edges. Spectral validations against LBLRTM verify the fidelity of the approach. The new MODTRAN LBL algorithm is used to quantify the accuracy of the MODTRAN band model and correlated-*k* statistical approaches under varying conditions. Future upgrades to the MODTRAN band model, correlated-*k* and LBL methods are also discussed.

Key Words: Radiative Transfer, Line-by-line, Voigt function, Band Model, Correlated-*k*, Spectral Transmittance

1. INTRODUCTION

The original MODTRAN statistical band model (BM) was developed in the 1980's [1, 2] to provide a spectral resolution bridge between the Air Force Geophysics Laboratory (AFGL) low-altitude, coarse (20 cm^{-1}) resolution LOWTRAN code [3-10] and the computationally time intensive high resolution line-by-line (LBL) FASCODE algorithm [11-14]. MODTRAN introduced the use of temperature-dependent absorption coefficient $\langle S/d \rangle$ and line spacing $\langle 1/d \rangle$ *line center* statistical BM parameters into the suite of AFGL models. The $\langle S/d \rangle$ parameter insures that the total integrated strength of molecular transitions centered in the BM spectral bin is conserved, and the chosen BM form for the distribution of lines within that bin is defined as a function of the $\langle 1/d \rangle$ parameter. The MODTRAN BM also introduced the partitioning of spectral bin molecular absorption into three distinct components: (1) lines centered in each spectral bin, (2) *line tail* contributions from neighboring molecular transitions out to 25 cm^{-1}, and (3) continua for lines centered beyond 25 cm^{-1} from the spectral bin. For a number of years, the three AFGL

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