A Radiative Transfer Model for the Wavelength Region of 2500-4000 cm^{-1}

Motivation and Purpose

Characteristics of Wavelength Region:

- interaction of thermal and solar radiation
- aerosol scattering is still relevant, esp. in cases of smoke, dust, (volcanic) ash, clouds
- emission by molecules and aerosols

Instruments:

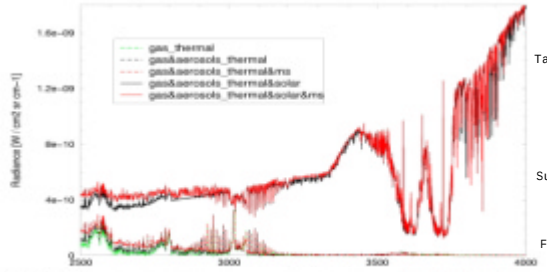
Instrument	nr. of channels	spectral range [cm^{-1}]	res. [cm^{-1}]
SCIAMACHY	8 (2)	4200-42000	0.5
MIPAS	5 (1-2)	685-2410	<0.04
FOCUS-MIRROR	1	650-3000	0.2
MODIS	36 (6)	700-2730 7200-7350	--
BIRD	MIR	2400-2900	--

Requirements of a new Model

- comprise Planck- and Solar Source Term
- model molecular absorption throug Line-by-Line calculation
- include aerosol scattering and -absorption
- consider sphericity of atmosphere (ability of limb viewings)

Estimation of Sensitivity – MODTRAN Calculations

To get a first estimation of the influences of the different terms – aerosols in emitting atmosphere, solar single scattering, multiple scattering – some MODTRAN calculations were done. Fig. [1] shows all the terms in different combination while Fig. [2] and [3] deal with the influence of multiple scattering in special.



Limbpath
Tangent H. 20km
US Standard
Standard Background Aerosols
Sun Zenith 60°
Sun Azimuth 50°

Fig. [1]

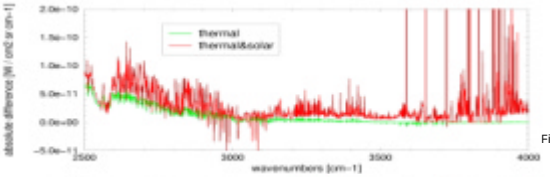


Fig. [2]

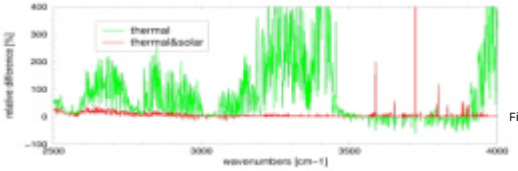


Fig. [3]

Basic Ideas

Pseudospherical 1d-Radiative Transfer Model

- Source Function Integration Method, that means calculate intensity I_0 at observer by piecewise integrating the source terms along the line of sight

$$I_{n-1} = I_n \cdot T_n^{n-1} + \int J_{n'} \cdot T_{n'}^{n-1} dn' \quad \text{with} \quad J_n = J_n^B + J_n^{SS} + J_n^{MS}$$

- Planck term J^B and Solar Single Scattering term J^{SS} are calculated in a spherical shell atmosphere
- Multiple Scattering Term J^{MS} is derived using a pseudospherical model (solving RT-problem in planparallel layered atmosphere, but with solar source transmitting trough a spherical shell atmosphere)

$$J^{MS} = \frac{b}{4p} \int P(\nu, \nu') \cdot I_{ps} d\nu'$$

based on existing modules

- SDISORT (by Stamnes, Kylling et al.) as pseudospherical model to calculate I_{ps} for J^{MS}
- Parts of Line-by-Line-RT-Code MIRART (by Schreier) to compute molecular absoption coefficients
- OPAC (by Hess et al.), a database of optical properties of aerosol components and clouds and software package to „mix“ your own atmosphere, to get aerosol properties from

Open Problems

- huge number of wavenumber gridpoints, which means e.g. huge number of runs of monochromatic SDISORT – k-distribution methods? ω_0-dependend neglecting of Multiple Scattering and even Solar Single Scattering Term?
- modelling of local/regional events (e.g. clouds) – use different 1d-atmospheres for J^{MS} and define nonsymmetrical limbpaths?
- Overestimation (?) of surface emitted radiation single scattered into the line of sight

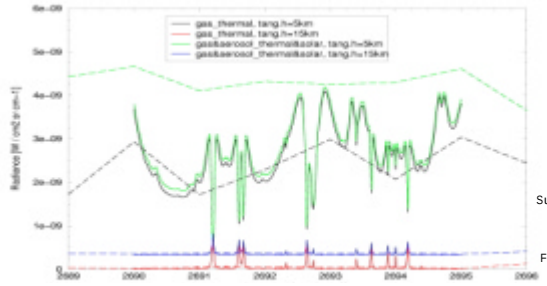
First Results

MIRART with Solar Single Scattering

As a „pre“-step Solar Single Scattering (SSS) was implemented in MIRART, a code for high spectral resolution RT-claculations in a pure gaseous atmosphere driven by Planck Source Term. For that aerosol properties, taken from precalculated OPAC outputfiles, were added as well as sunspectra (from MODTRAN) and further geometry tools.

Examples

Fig. [4] and [5] show results of MIRART_SSS calculations compared to MODTRAN results with a similar setup. Calculations at Fig. [4] were done in a window region while Fig. [5] shows intensity in presence of narrow spectral lines.



MIRART & MODTRAN
Limbpath
US Standard
Standard Background Aerosols
Sun Zenith 60°
Sun Azimuth 70°

Fig. [4]

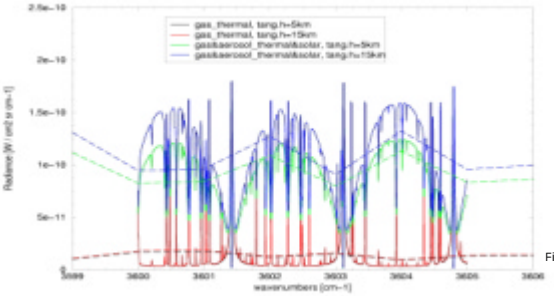


Fig. [5]

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