COMMENTS ON TOVS TRANSMITTANCES

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1. TOVS Transmittance Calculations

Assuming that a substantial improvement of TOVS results, if possible at
all, can only be achieved by improved physical methods, we have started with a
comparison of line-by-line and TOVS transmittances in the 15 µm region. These
comparisons are restricted insofar as the exact spectral response functions of
the HIRS spectral channels are generally not known by the user community. We
demonstrate the effect that an undefined spectral response function has in
Figure 1 for the worst case (Spönkuch and Dohler, 1979), the center channel
(HIRS channel 1), taking the figures for central wavenumber and half-power
bandwidth quoted by Schwalb (1978). Table 1 shows the line-by-line
calculations corresponding to procedure 1. The differences in transmittances
are about 0.01 for a central wave number shift from 668.5 cm⁻¹ to 667.92 cm⁻¹
and about 0.1 for an increase in the half-power bandwidth from Δν = 3 cm⁻¹ to
Δν = 4 cm⁻¹. For the other channels, the differences are considerably smaller
but they still are .005 to .01 larger for line-by-line than TOVS
transmittances (McMillin et al., 1980). To determine the influence of the
uncertainty of spectroscopic line data and of the numerical approximations
used, two different line-by-line procedures and spectroscopic sources were
applied for the midlatitude summer standard atmosphere. Their main
characteristics are summarized in Table 1.

The differences in transmittances from the top of the atmosphere to the
pressure levels of the ordinate are shown in Figure 2 for HIRS channel 6 (ν
at 733.20 cm⁻¹) for zero zenith angle. The differences are larger than .01°
within the whole troposphere and, hence, an order of magnitude larger than for
the technique used in producing TOVS transmittances (Weinreb et al., 1981).
Table 2 gives the mean absolute (averaged for all pressure levels) and the
maximal absolute differences between the two line-by-line procedures for other
15 µm HIRS channels together with the lower pressure level concerning the last
one.

2. Conclusion

In conclusion, the differences in line-by-line calculations of atmospheric
transmittances are larger than in the McMillin-Fleming (1976) approximation.
Therefore, if there is a need for improvements in atmospheric transmittances,
priority should be given to basic spectroscopic investigations as initiated by
the IRC WG on Remote Sensing (Spectroscopy).

References

dioxide absorption lines between 12 and 20 µm. Technical Report
036350-4-T, Univ. of Michigan.


Spünkuch, D., W. Dohler, 1979: Accuracy requirements for spectral band passes of satellite infrared sounders with high spectral resolution. In: H.J. Bolle (ed.): Remote sounding of the atmosphere from space. COSPAR Advances in Space Exploration Vo. 4, 139-142.


Table 1: Spectroscopic line data and details of line-by-line calculation

<table>
<thead>
<tr>
<th></th>
<th>Procedure 1</th>
<th>Procedure 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>line data</td>
<td>Drayson 1973</td>
<td>AFGL 1976</td>
</tr>
<tr>
<td>half-width/</td>
<td>const.</td>
<td>variable</td>
</tr>
<tr>
<td>$\nu$ [cm$^{-1}$]</td>
<td>$\alpha_{Lo}$ [cm$^{-1}$]</td>
<td>line profile</td>
</tr>
<tr>
<td>660-662</td>
<td>0.08</td>
<td>$f_\nu$</td>
</tr>
<tr>
<td>662-671</td>
<td>0.07</td>
<td>$f_\nu$</td>
</tr>
<tr>
<td>671-708</td>
<td>0.08</td>
<td>$f_\nu$</td>
</tr>
<tr>
<td>708-715</td>
<td>0.07</td>
<td>$f_{BKM}$</td>
</tr>
</tbody>
</table>

Integration: .01 for $p < 100$ mbar, const = .005 cm$^{-1}$

step: .02 for $100 \leq p \leq 500$ mbar, for all pressure levels $[cm^{-1}]$ .04 for $p > 500$ mbar

cut-off: 10 cm$^{-1}$ from the interval border independent of $p$

Maximum cut-off 15 cm$^{-1}$

$\alpha_{Lo}$: Lorentz half-width at normal conditions, $f_\nu$: Voigt profile, $f_{BKM}$: Benedict profile with constant corresponding to Kunde and Maguire (1974).

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Table 2: Mean absolute and maximal absolute differences in line-by-line transmittances, calculated corresponding to the procedures of Table 1. (p is the lower pressure level for the maximum differences).

<table>
<thead>
<tr>
<th>Central wave number $\nu_0$/cm(^{-1})</th>
<th>half power bandwidth/cm(^{-1})</th>
<th>$\Delta \tau$</th>
<th>$\Delta \tau_{\text{max}}$</th>
<th>p/mbar/</th>
</tr>
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<tbody>
<tr>
<td>679.21</td>
<td>10</td>
<td>.007</td>
<td>.0185</td>
<td>100</td>
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<td>691.56</td>
<td>12</td>
<td>.002</td>
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<td>704.63</td>
<td>16</td>
<td>.001</td>
<td>.0034</td>
<td>300</td>
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<td>715.05</td>
<td>16</td>
<td>.009</td>
<td>.0357</td>
<td>200</td>
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<td>733.16</td>
<td>16</td>
<td>.008</td>
<td>.0163</td>
<td>500</td>
</tr>
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</table>
FIGURE 1. Line-by-line calculation of atmospheric transmittance for HIRS channel 1 for different spectral response characteristics. Zero zenith angle. Procedure 1 (see Table 1).
FIGURE 2. Differences $\Delta T$ in transmittances using different spectroscopic data and numerical procedures corresponding to Table 1, for HIRS channel 6 ($\nu_o = 733.20 \text{cm}^{-1}$). Zero zenith angle.
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