Quantification of line-by-line parameter errors in the 183.31 GHz water vapour line
ITSC-21 / Darmstadt / Germany / December 2017

Emma Turner¹, William Bell², John Eyre¹, Roger Saunders¹, Stuart Newman¹, Peter Rayer¹a

Abstract
The rotational/transition of water vapour at 183.31 GHz is one of the most heavily utilised spectroscopic lines measured by current and future satellite instruments such as SAPHIR, MHS, ATMIS, SSMIS and ICI. The passbands of channels centred at this frequency typically span a wide frequency range (e.g., 24 GHz for SAPHIR channel 6) in order to profile tropospheric humidity. However, equivalent radiative transfer simulations of these satellite observations show errors that increase further away from the line centre. The Met Office microwave line-by-line model AMSUTRAN is used to investigate the sensitivity to the 183.31 line’s spectroscopic parameters by replacing the existing configuration with those from the latest HITRAN database, along with their associated range of uncertainties. The effect on top of atmosphere brightness temperatures is shown monochromatically and for satellite channels centred on the line. Channel differences can reach up to 1 K, and the uncertainties surrounding HITRAN parameters can add up to ±1 K around this. Differences decrease in channels further from the line centre but uncertainties can remain high.

Table 1. Spectroscopic parameters used to calculate 183.31 GHz line absorption. Intensities and half widths are calculated at a temperature of 296 K. HITRAN uncertainties are those quoted in the line record.

<table>
<thead>
<tr>
<th>Spectroscopic Parameter</th>
<th>AMSUTRAN</th>
<th>HITRAN 2016</th>
<th>HITRAN 2016 Uncertainty (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Frequency (GHz)</td>
<td>183.31074</td>
<td>183.31107</td>
<td>0.005</td>
</tr>
<tr>
<td>Line intensity (km/ºK)</td>
<td>2.39</td>
<td>2.35</td>
<td>1.5</td>
</tr>
<tr>
<td>Self-broadened half width (km/ºK)</td>
<td>29.49</td>
<td>29.35</td>
<td>3.5</td>
</tr>
<tr>
<td>T-D dependence of ABHW</td>
<td>0.77</td>
<td>0.76</td>
<td>15</td>
</tr>
<tr>
<td>Half-cell-broadened half width (km/ºK)</td>
<td>156.48</td>
<td>153.56</td>
<td>15</td>
</tr>
<tr>
<td>T dependence of ABHW</td>
<td>0.85</td>
<td>0.76</td>
<td>15</td>
</tr>
<tr>
<td>Frequency precision shift (GHz/kK)</td>
<td>0</td>
<td>-0.000796</td>
<td>20</td>
</tr>
</tbody>
</table>

Figure 1. a) Positions and intensities (at 246 K) of HITRAN 2016 lines for 7 isolines of water vapour. Line half widths are to scale. b) Level to space transmittance at 246 KPa calculated using AMSUTRAN’s standard configuration of 30 H2O lines (red), all available HITRAN H2O lines up to 1000 GHz (green). c) Alternating equal brightness temperatures for each of the 30 lines calculated using monochromatic transmittance simulations with one renormalised line profile located at TOA brightness temperature differences between AMSUTRAN (blue line in c), and each of the two HITRAN lines.

Conclusions
• Moving to HITRAN 2016 line parameters will alter TOA brightness temperatures up to 1 K. Kewellown 150 – 800 GHz.
• Larger differences are seen around line centres, beyond 800 GHz, and throughout the spectrum when more lines > 1000 GHz are included.
• The difference at the peak of the 183.31 GHz line is 1.25 K.
• The range of uncertainties in the HITRAN lines matches up to 1.5 K but still do not encompass the results from the existing AMSUTRAN configuration.
• Differences in satellite channels decrease further away from the line centre but uncertainties do not necessarily, in contrast to what is often observed in measurements.
• For comparison, errors in RTTOV generated BT’s are < 0.05 K with respect to the averaged line-by-line BT’s used in this study.

References