Atlas of Absorption Lines From 0 to 17 900 cm\(^{-1}\)

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DESCRIPTION OF THE ATLAS

This atlas is a pictorial representation of atmospheric absorption line parameters contained in the AFGL (Air Force Geophysics Laboratory) major-gas and trace-gas compilations currently available on magnetic tape (Rothman 1981, Rothman et al. 1981). It is a revised edition of the atlas previously published by Park (1977), which had been based on an earlier version of the AFGL major-gas compilation (McClatchey et al. 1973) and trace-gas line parameters collected at NASA Langley Research Center. This earlier publication has become very useful as a quick reference for researchers in the fields of molecular spectroscopy and atmospheric remote sensing. Since new, extensively revised versions of the AFGL line parameter compilations have recently been released, the authors felt that a new edition of the atlas was necessary.

In the atlas are presented plots of the logarithm (base 10) of absorption line strength (S in atm⁻¹·cm⁻²) at 296 K versus wavenumber (in cm⁻¹) for atmospheric gases (see table I). The atlas covers the spectral range of the AFGL compilations.

### Table I.- List of Gases Shown in the Atlas

<table>
<thead>
<tr>
<th>AFGL Gas Code</th>
<th>Gas name</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>H₂O</td>
</tr>
<tr>
<td>2</td>
<td>CO₂</td>
</tr>
<tr>
<td>3</td>
<td>O₃</td>
</tr>
<tr>
<td>4</td>
<td>N₂O</td>
</tr>
<tr>
<td>5</td>
<td>CO</td>
</tr>
<tr>
<td>6</td>
<td>CH₄</td>
</tr>
<tr>
<td>7</td>
<td>O₂</td>
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<tr>
<td>8</td>
<td>NO</td>
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<td>9</td>
<td>SO₂</td>
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<td>10</td>
<td>NO₂</td>
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<tr>
<td>11</td>
<td>NH₃</td>
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<tr>
<td>12</td>
<td>HNO₃</td>
</tr>
<tr>
<td>13</td>
<td>OH</td>
</tr>
<tr>
<td>14</td>
<td>HF</td>
</tr>
<tr>
<td>15</td>
<td>HCl</td>
</tr>
<tr>
<td>16</td>
<td>HBr</td>
</tr>
<tr>
<td>17</td>
<td>HI</td>
</tr>
<tr>
<td>18</td>
<td>ClO</td>
</tr>
<tr>
<td>19</td>
<td>OCS</td>
</tr>
<tr>
<td>20</td>
<td>H₂CO</td>
</tr>
<tr>
<td>(a)</td>
<td>N₂</td>
</tr>
<tr>
<td>(a)</td>
<td>CH₃Cl</td>
</tr>
<tr>
<td>(a)</td>
<td>Solar CO</td>
</tr>
</tbody>
</table>

*a* Indicates data not in 1980 AFGL compilations. O₂ quadrupole lines near 6.3 µm are also not included in the 1980 major-gas tape.
(0 to 17 900 cm\(^{-1}\)). Line parameters for all gases are taken from the 1980 versions of the AFGL major-gas and trace-gas compilations, and additional data are included for the electric quadrupole lines of O\(_2\) (Rothman and Goldman 1981) and of N\(_2\) (obtained from S. E. Keddy, Memorial University of Newfoundland, 1981) and for the \(v_4\) band of CH\(_3\)Cl (Margolis 1978). Solar CO lines at 6000 K, calculated by C. P. Rinsland in 1981, are also shown for the fundamental and first overtone sequences. The solar CO line strengths were calculated with the dipole moment function of Kirschner et al. (1977) following Tipping (1976) with terrestrial isotope ratios assumed. All isotopic bands contained in the AFGL compilation are included in this atlas, as well as the \(v_4\) bands of both CH\(_3\)Cl\(^{35}\) and CH\(_3\)Cl\(^{37}\) and the main isotopes of O\(_2\) and N\(_2\) for the quadrupole transitions. As in the AFGL compilation, intensities of all bands are scaled according to the terrestrial abundance of each isotopic species.

On each page of the atlas, the plots of log (S) versus wavenumber for all gases having absorption lines in the same 50 cm\(^{-1}\) interval are presented in order of the integer gas codes given in table I. For the major gases (H\(_2\)O, CO\(_2\), O\(_3\), N\(_2\)O, CO, CH\(_4\), and O\(_2\)), all lines having strengths within 10\(^{-6}\) of the maximum value for that interval are shown; and for the trace gases, all lines having strengths within 10\(^{-4}\) of the maximum are included, because the maximum and minimum line strengths are redetermined for each 50 cm\(^{-1}\) interval, sudden changes may appear in the line strength scale from one plot to another, and some weak lines on the AFGL tape are not plotted in this atlas. Isolated weak bands may also appear, at first glance, to be much stronger than expected. Since the number of gases appearing simultaneously in any single 50 cm\(^{-1}\) interval is significantly reduced at wavenumbers higher than 5000 cm\(^{-1}\), plots of log (S) versus wavenumber for two consecutive intervals are presented on the same page from 5000 to 10 000 cm\(^{-1}\), and three consecutive intervals are plotted together from 10 000 to 17 900 cm\(^{-1}\).

At the bottom of each page for intervals from 0 to 5000 cm\(^{-1}\), also presented are plots of the lower-state energy values (E" in cm\(^{-1}\)) for lines of the strongly absorbing gases H\(_2\)O, CO\(_2\), O\(_3\), and CH\(_4\). These energy values are plotted as an aid to quickly judge the strength of atmospheric absorption by these gases at temperatures different from 296 K. Energy values greater than 1500 cm\(^{-1}\) are plotted as 1500 cm\(^{-1}\); in the few cases of unassigned transitions, where the energies are given as \(-1\) on the AFGL tape, they are plotted as 0 cm\(^{-1}\) in the atlas. At wavenumbers higher than 5000 cm\(^{-1}\), plots of E" versus wavenumber are omitted.

Updated versions of this atlas are planned when major revisions of the AFGL line parameter compilations are released.

Langley Research Center
National Aeronautics and Space Administration
Hampton, VA 23665
October 9, 1981
REFERENCES


H₂O

CH₄

O₂

CO SUN

H₂O

CO₂

N₂O

CH₄

HBr

N₂

WAVENUMBER

H₂O

CO₂

CH₄
cm⁻¹
Wavenumber

μm

H₂O

CO₂

N₂O

OH

CO SUN

Wavenumber

H₂O

CO₂
<table>
<thead>
<tr>
<th>Wavenumber (cm⁻¹)</th>
<th>H₂O</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>3400-3450</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3400</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>3405</td>
<td>1500</td>
<td></td>
</tr>
<tr>
<td>3410</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>3415</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td>3420</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>3425</td>
<td>3500</td>
<td></td>
</tr>
<tr>
<td>3430</td>
<td>4000</td>
<td></td>
</tr>
<tr>
<td>3435</td>
<td>4500</td>
<td></td>
</tr>
<tr>
<td>3440</td>
<td>5000</td>
<td></td>
</tr>
<tr>
<td>3445</td>
<td>5500</td>
<td></td>
</tr>
<tr>
<td>3450</td>
<td>6000</td>
<td></td>
</tr>
</tbody>
</table>

The graph shows the logarithmic intensity (log(S)) of various molecules (H₂O, CO₂, N₂O, O₁₁, HF, CO) across different wavenumbers.
H₂O
N₂O
CO
HF
CO SUN

WAVENUMBER

μm

H₂O
N₂O
CO
HF
CO SUN

WAVENUMBER

H₂O

cm⁻¹
CO SUN

WAVENUMBER

H₂O
CO
CH₄
HF
HI
CO SUN

WAVENUMBER

H₂O
CH₄

cm⁻¹
The image contains a graph with the x-axis labeled as 'Wavenumber' ranging from 4800 to 4850 cm⁻¹, and the y-axis labeled as 'log(10)' with values ranging from 500 to 1200. The graph displays three different spectra: one for H₂O, one for CO₂, and one for HBr. Each spectrum is represented by a series of vertical lines and bars, indicating peaks and troughs in the absorbance at various wavenumbers. The graph also features a scale on the right side marked in microns (μm) with values from 2.083 to 2.062 μm.
The image contains three graphs showing spectral data for various compounds. The graphs are labeled with the compounds H₂O, CO₂, and HCl. The x-axis represents wavenumber in cm⁻¹, while the y-axis shows logarithmic intensity (log(S)). The graphs display a range of wavenumbers from 5500 to 5600 cm⁻¹, with specific peaks indicating the absorption frequencies of the compounds. The data is presented in a natural scientific format, suitable for analysis and discussion.
The graph depicts the absorption spectra of water vapor (H₂O), carbon dioxide (CO₂), and hydrochloric acid (HCl) in the near-infrared region between 1.75 and 1.74 μm and the mid-infrared region between 1.739 and 1.724 μm. The x-axis represents the wavelength in cm⁻¹, and the y-axis represents the logarithm of the signal intensity (log(S)). The spectra show distinct absorption bands for each gas, with the water vapor spectrum being the most prominent in both regions.
1.515 1.514 1.513 1.512 1.511 1.509 1.508 1.507 1.506 1.505 1.504

,.,r--~..,.......1.,.........,....,.,..,....,,,,,,,,.,., ..*,........., w-n

1:
G -8 -
-9 H
-10 -11 i

WAVENUMBER

6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650

WAVENUMBER

1.504 1.503 1.502 1.500 1.499 1.498 1.497 1.496 1.495 1.494 1.493

H_2O

CO_2

WAVENUMBER

6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700

WAVENUMBER

120
1.370 1.369 1.368 1.367 1.366 1.365 1.364 1.363 1.362 1.361

\[ \text{H}_2\text{O} \]

1.361 1.360 1.359 1.358 1.357 1.356 1.355 1.354 1.353 1.352

\[ \text{H}_2\text{O} \]

1.351

\[ \text{HBr} \]
\[ \text{WAVENUMBER} \]

\[ \text{cm}^{-1} \]
1.183 1.183 1.182 1.181 1.181 1.180 1.179 1.179 1.178 1.177 1.176

H₂O

HCl

HI

8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450

WAVENUMBER cm⁻¹

1.180 1.180 1.180 1.180 1.179 1.179 1.178 1.178 1.177 1.177 1.177

H₂O

HCl

HI

8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500

WAVENUMBER cm⁻¹
\begin{align*}
\log(S) & \quad \text{WAVENUMBER}\quad \mu m \\
.943 & .943 .943 .942 .942 .941 .941 .940 .939 .939 \\
10600 & 10605 10610 10615 10620 10625 10630 10635 10640 10645 10650 \\
\text{cm}^{-1} & \\
\log(S) & \quad \text{WAVENUMBER}\quad \mu m \\
.939 & .939 .938 .938 .937 .937 .936 .936 .935 .935 \\
10650 & 10655 10660 10665 10670 10675 10680 10685 10690 10695 10700 \\
\text{cm}^{-1} & \\
\log(S) & \quad \text{WAVENUMBER}\quad \mu m \\
.935 & .934 .934 .933 .933 .932 .932 .931 .931 .930 \\
10700 & 10705 10710 10715 10720 10725 10730 10735 10740 10745 10750 \\
\text{cm}^{-1} & \\
\end{align*}
WAVENUMBER

WAVENUMBER

WAVENUMBER

WAVENUMBER
This image contains a graph showing the logarithm of the intensity (log(S)) against wavenumber (cm⁻¹) for water vapor (H₂O). The graph is divided into three sections with wavenumbers ranging from 816 to 810 cm⁻¹ and 12300 to 12400 cm⁻¹. The graph displays various peaks at different wavenumbers, indicating absorption bands for water vapor. The x-axis is labeled with wavenumbers and the y-axis is labeled with log(S) values.
WAVENUMBER

13000 13005 13010 13015 13020 13025 13030 13035 13040 13045 13050 

WAVENUMBER

13050 13055 13060 13065 13070 13075 13080 13085 13090 13095 13100 

WAVENUMBER

13100 13105 13110 13115 13120 13125 13130 13135 13140 13145 13150 

WAVENUMBER

174
WAVENUMBER

WAVENUMBER

WAVENUMBER

WAVENUMBER

176
\begin{align*}
\text{WAVENUMBER} & \quad \text{\(\mu m\)} & \quad \text{H}_2\text{O} \\
\text{WAVENUMBER} & \quad \text{\(cm^{-1}\)} & \quad \text{O}_2
\end{align*}

\begin{align*}
\text{WAVENUMBER} & \quad \text{\(\mu m\)} & \quad \text{H}_2\text{O} \\
\text{WAVENUMBER} & \quad \text{\(cm^{-1}\)} & \quad \text{O}_2
\end{align*}

\begin{align*}
\text{WAVENUMBER} & \quad \text{\(\mu m\)} & \quad \text{H}_2\text{O} \\
\text{WAVENUMBER} & \quad \text{\(cm^{-1}\)} & \quad \text{O}_2
\end{align*}
<table>
<thead>
<tr>
<th>Wave Number (cm⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16000 16005 16010 16015 16020 16025 16030 16035 16040 16045 16050</td>
</tr>
<tr>
<td>16050 16055 16060 16065 16070 16075 16080 16085 16090 16095 16100</td>
</tr>
<tr>
<td>16100 16105 16110 16115 16120 16125 16130 16135 16140 16145 16150</td>
</tr>
</tbody>
</table>

Wavelengths (λ cm⁻¹): 0.625, 0.625, 0.624, 0.624, 0.624, 0.624, 0.624, 0.623, 0.623, 0.623

Wavenumbers (cm⁻¹): 621, 621, 621, 621, 620, 620, 620, 620, 619, 619
<table>
<thead>
<tr>
<th>Wavenumber (cm(^{-1}))</th>
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</thead>
<tbody>
<tr>
<td>16150 - 16165</td>
</tr>
<tr>
<td>16200 - 16215</td>
</tr>
<tr>
<td>16250 - 16265</td>
</tr>
<tr>
<td>WAVENUMBER</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>cm⁻¹</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>WAVENUMBER</th>
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<tbody>
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<td>cm⁻¹</td>
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<thead>
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<td>cm⁻¹</td>
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<table>
<thead>
<tr>
<th>WAVENUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>cm⁻¹</td>
</tr>
</tbody>
</table>
Wave Number

H₂O

Wave Number

H₂O

Wave Number

H₂O
Plots of absorption line strength versus line position for wavenumbers from 0 to 17 900 cm\(^{-1}\) are shown for the 20 atmospheric gases (H\(_2\)O, CO\(_2\), O\(_3\), N\(_2\)O, CO, CH\(_4\), O\(_2\), NO, SO\(_2\), NO\(_2\), NH\(_3\), HNO\(_3\), OH, HF, HCl, HBr, HI, CIO, OCS, H\(_2\)CO), which appear in the 1980 Air Force Geophysics Laboratory major-gas and trace-gas compilations, and for N\(_2\) and CH\(_3\)Cl at 296 K and solar CO at 6000 K. Also shown are similar plots of lower-state energy values for absorption lines for the strongly absorbing atmospheric gases (H\(_2\)O, CO\(_2\), O\(_3\), and CH\(_4\)) for wavenumbers from 0 to 5000 cm\(^{-1}\).