MIPAS database: New HNO$_3$ line parameters at 7.6 µm derived from laboratory intensity measurements and MIPAS satellite measurements

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Preparation of IASI-New Generation (2020)

Goal for IASI-NG: to enable simultaneous detection of HNO$_3$ both at 11 µm & 7.6 µm using MIPAS spectra.
The source for the line positions & relative intensities parameters for HNO$_3$ @7.6 μm in the HITRAN-2012 database:


The « bad quality » of the HNO$_3$ parameters in HITRAN or GEISA at 6.3 μm … originates from « our imperfect 1989-1993 linelist»
A. Perrin: « New Analysis of the $\nu_3$ and $\nu_4$ bands of HNO$_3$ in the 7.6 $\mu$m region 


- FTS spectra recorded at high resolution in the 7.6 $\mu$m, 11 $\mu$m and 22 $\mu$m regions.
- New theoretical model $\Rightarrow$ the $\nu_3$ and $\nu_4$ cold bands, and four dark bands (the $2\nu_6$, $3\nu_9$, $\nu_5+\nu_9$, $\nu_7+\nu_8$)
- First observation of the $\nu_3+\nu_9-\nu_9$ hot band

A 2013 **preliminary** linelist for H$^{14}$NO3 ($\nu_3$ and $\nu_4$ cold bands, four dark bands ($2\nu_6$, $3\nu_9$, $\nu_5+\nu_9$, $\nu_7+\nu_8$) and the $\nu_3+\nu_9-\nu_9$ hot band
Strategy:

- As a starting point, we use the 2013 preliminary list of line positions and relative line intensities at 7.6 µm.

- We kept the 11 µm band line parameters as they are in GEISA or HITRAN.

- We performed the intercalibration of the new 7.6 µm parameters (line positions and relative intensities) relatively to those at 11 µm.

Strategy for the 11\( \mu \)m and 7.6 \( \mu \)m regions (HNO\(_3\))

We used and **combined** three sets of experimental data:

- A list of laboratory experimental (individual) line intensities measured in the 7.6 \( \mu \)m region using FTS spectra recorded in 2004 at Giessen (a)
- The Pacific Northwest Laboratory (PNNL) cross sections ([https://secure2.pnl.gov/nsd/nsd.nsf/Welcome](https://secure2.pnl.gov/nsd/nsd.nsf/Welcome)) (b)
- MIPAS spectra (orbit 04712 from 24 January 2003)

Here we present the **final** 7.6 \( \mu \)m database « **MIPAS-2015** » which is a compromise resulting from these 3 studies.

**References:**
A set of ~ 350 line intensities were measured for well isolated lines in the 7.6 µm region using the program “WSpectra” (ULB Belgium software)

(FTS spectra recorded in Giessen)

Ratio $R = \frac{\text{MIPAS-2015}}{\text{Measured line intensities}}$

$R_{\text{mean}} = 0.949(\pm 0.180)$
(2) The Pacific Northwest Laboratory cross sections
(https://secure2.pnl.gov/nsd/nsd.nsf/Welcome)
The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) was a FTS spectrometer for the detection of limb emission spectra in the middle and upper atmosphere. On ENVISAT (died in 2012)

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Obs (MIPAS orbit 04712 24 January 2003)

(P branch of the $v_3$ band and R branch of the $v_4$ band of HNO$_3$)

Limb radiance (nW/(cm$^2$ sr cm$^{-1}$))

Wavenumber in cm$^{-1}$

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Obs (MIPAS orbit 04712 24 January 2003)

(Q branch of the $\nu_3$ band of HNO$_3$)

Limb radiance (nW/(cm$^2$ sr cm$^{-1}$))

Wavenumber in cm$^{-1}$

- Obs
- MIPAS-2015
- GEISA or HITRAN

(Obs-Calc)
Obs (MIPAS orbit 04712 24 January 2003)

(R band of the $v_3$ band of HNO$_3$)

Limb radiance (nW/(cm$^2$ sr cm$^{-1}$))

Wavenumber in cm$^{-1}$

- Obs
- MIPAS-2015
- GEISA or HITRAN

$\nu_3 + \nu_9 - \nu_9$

(Obs-Calc)

- MIPAS-2015
- GEISA or HITRAN

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HNO₃ concentration profile (v.s. altitude) using the «old» database…

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HNO$_3$ concentration profile (v.s. altitude) using the « new » database.

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Conclusion

Improved line positions and intensities have been generated for the 7.6 µm spectral region of nitric acid. They were obtained relying on:

A recent reinvestigation of the nitric acid band system at 7.6 µm, followed by calibration of the intensities using:
• Line intensity measurements in laboratory conditions
• Validation using the PNNL cross sections
• Comparisons of HNO$_3$ concentration profiles retrieved from “Michelson Interferometer for Passive Atmospheric Sounding” (MIPAS) limb mission radiances in the 11 and 7.6 mm domains.

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Orbits 24/01/2003, DB-HIT12, AVG HNO3 from MWs @11um(A) and MWs @7.6um(B)

HNO$_3$ concentration profile vs. altitude

With GEISA or HITRAN

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HNO$_3$ concentration profile v.s. altitude

Orbits 24/01/2003, DB-V4.43, AVG HNO3 from MWs @11um(A) and MWs @7.6um(B)

With the new « MIPAS-2015 »

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### Hamiltonian matrix

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A.Perrin: ASA-HITRAN 2012