

New H₂¹⁶O measurements of line intensities around 1300 cm⁻¹ and 8800 cm⁻¹

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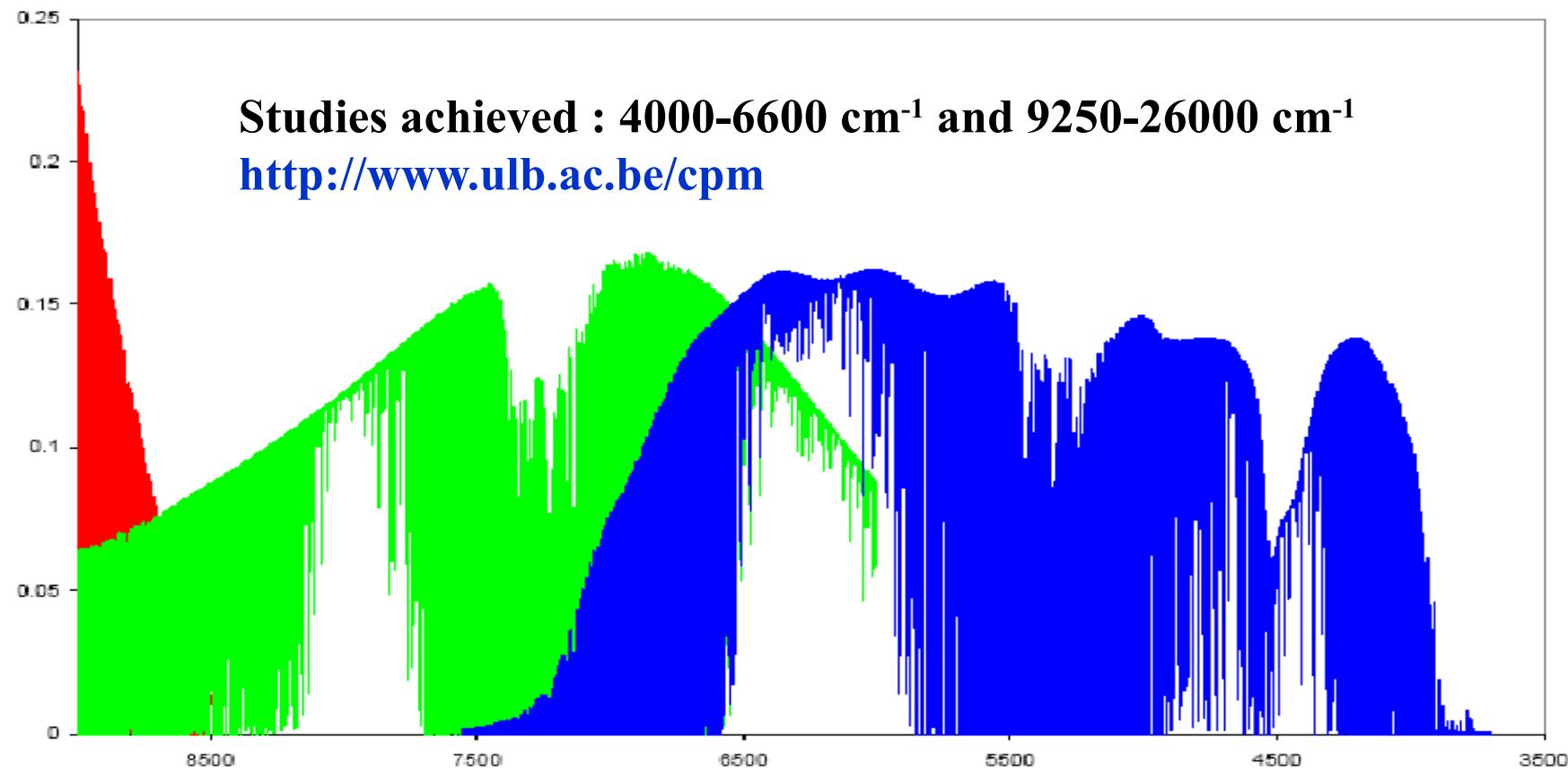
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Introduction

Our laboratory is engaged since many years in the study of H_2^{16}O vapor :



Fourier transform measurements of water vapor line parameters in the 4200–6600 cm^{-1} region

A. JENOUVRIER, L. DAUMONT, L. RÉGALIA-JARLOT, V. G. TYUTEREV, M. CARLEER, A. C. VANDAELE, S. MIKHAILENKO, S. FALLY

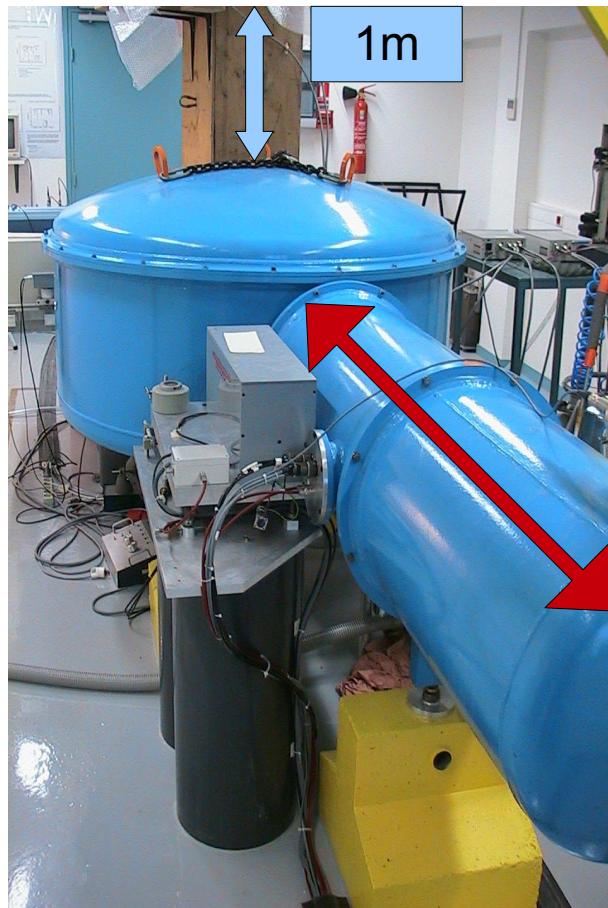
Journal of Quantitative Spectroscopy and Radiative Transfer, 105 (2007)

Green region : work in progress

Summary

- Brief presentation of GSMA's FTS and lastest improvements
- Study of H_2^{16}O around 1300 cm^{-1} ($10 \mu\text{m}$)
- Study of H_2^{16}O around 8800 cm^{-1} ($1.14 \mu\text{m}$)

GSMA's Fourier Transform Spectrometer



FTS with the 1-m White's cell

Step by step Fourier Transform Spectrometer (FTS) build in Reims

J.-J. Plateaux, A. Barbe, A. Delahaigue, Reims high resolution Fourier transform spectrometer. Data reduction for ozone. *Spectrochim. Acta 51A* (1995)

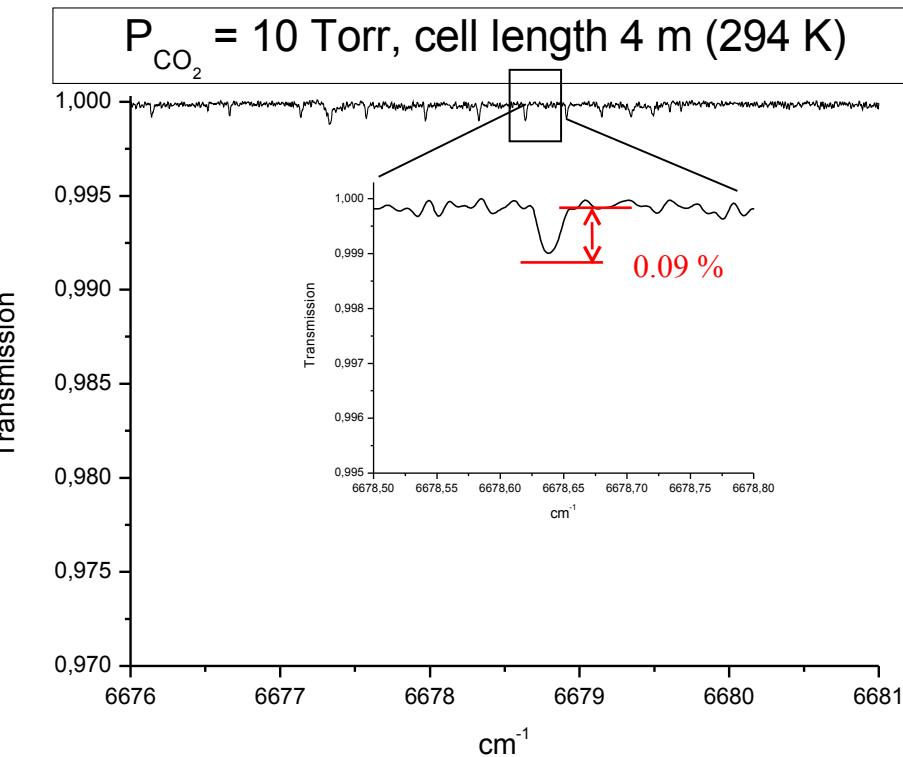
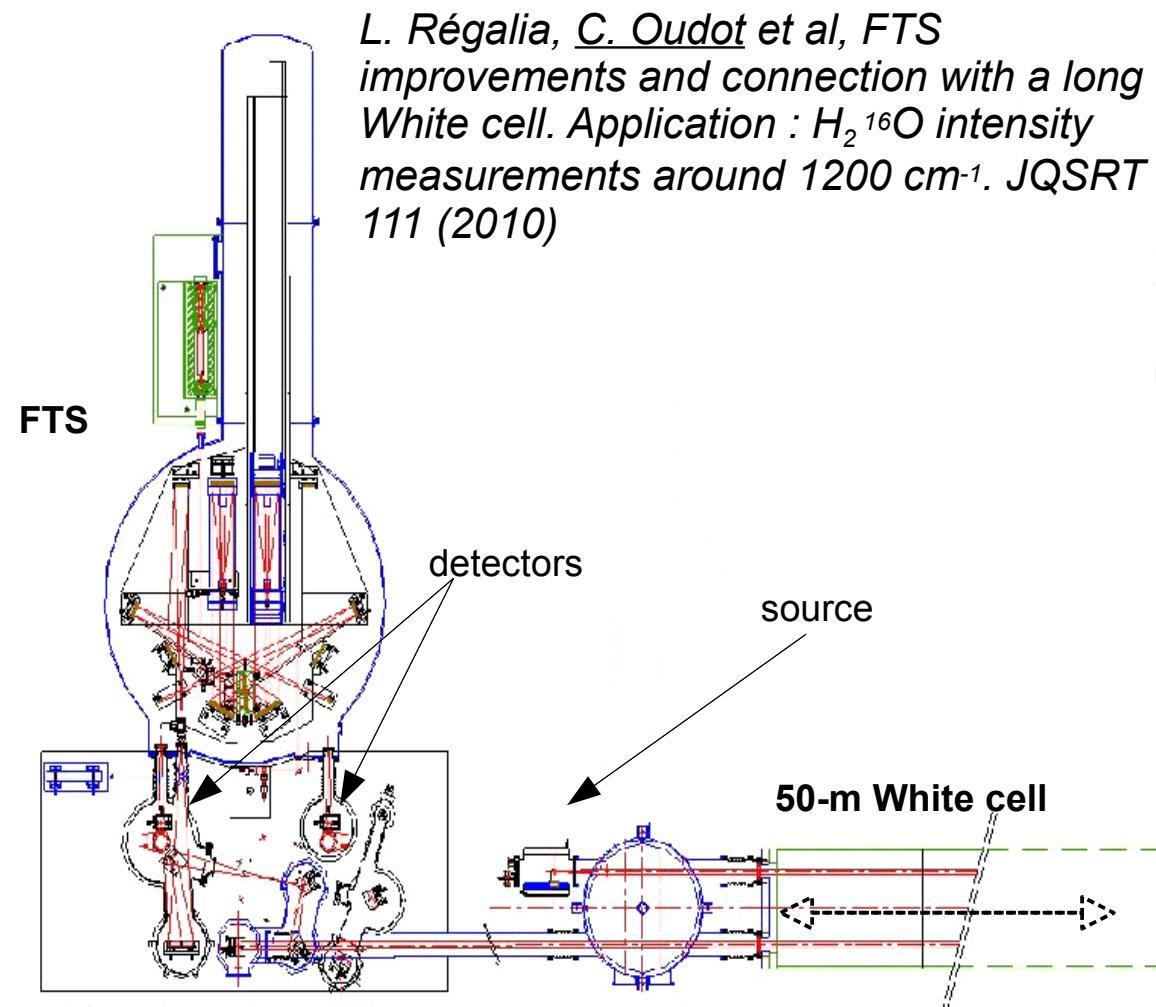
- DDM max : 3 meters
- Resolution n.a. $1.7 \times 10^{-3} \text{ cm}^{-1}$
- Spectral range : $900 \rightarrow 9000 \text{ cm}^{-1}$
- Beam splitter : ZnSe, CaF₂, SiO₂
- Detectors : HgCdTe, InSb, InGaAs
- Absorption cells
 - Simple path : 5, 10, 30, 50 and 60 cm
 - White cell : 1, 5 and 50 m

Multi-spectra software "MultiFiT" built in GSMA

J.-J. Plateaux, L. Régalia, C. Boussin, A. Barbe, Multispectrum fitting technique for data recorded by Fourier transform spectrometer: application to N₂O and CH₃D, *JQSRT*, 68 (2001)

Optical spectrometer improvement

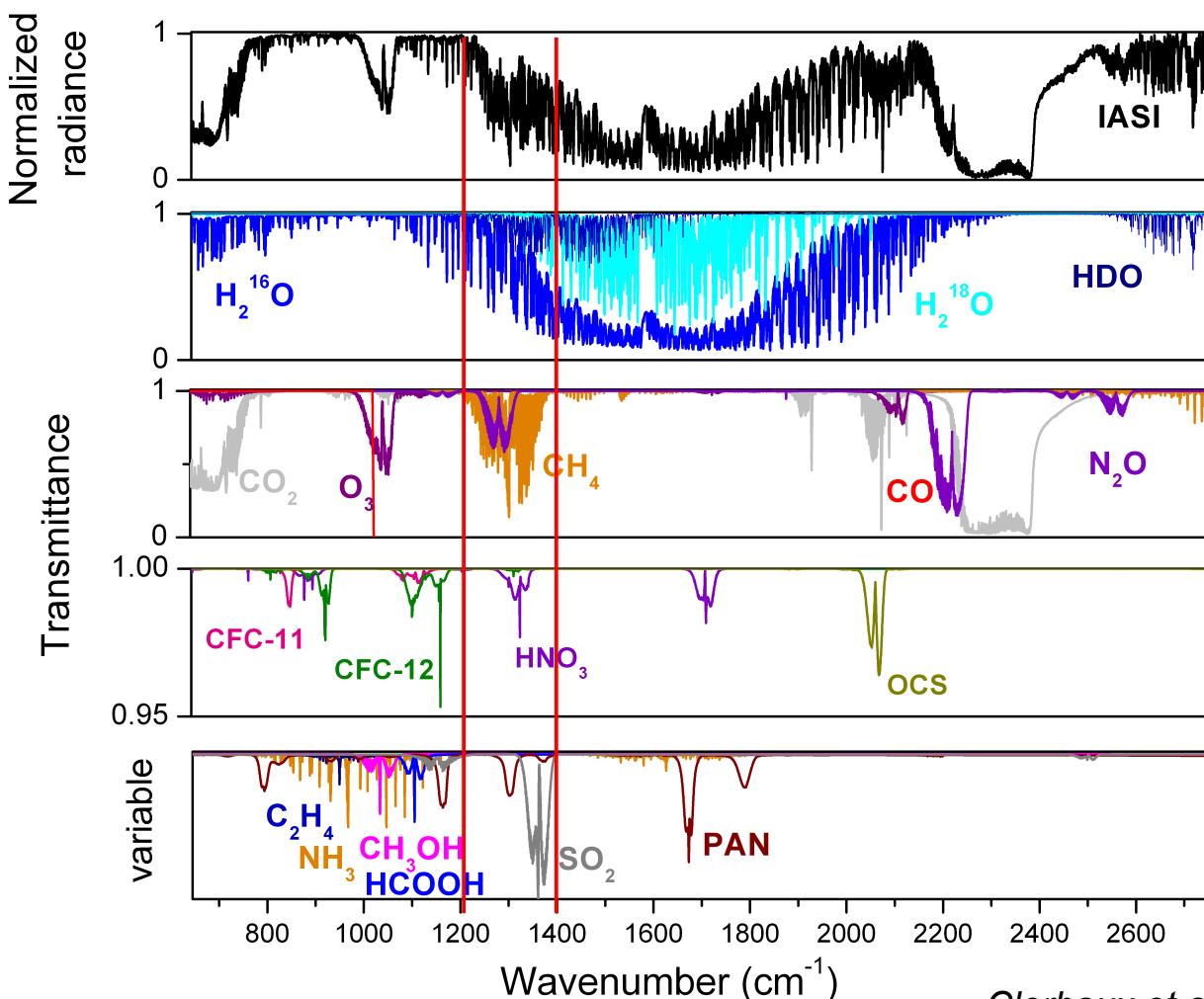
The 50-m White cell and the FTS were fitted in 2007.



Line CO₂: 6678.638671 cm⁻¹,
Intensity: $1.039 \cdot 10^{-25} \text{ cm/molec}$ (296 K)

Study of H₂¹⁶O line intensities in the 1200 – 1400 cm⁻¹ spectral region

This instrument is embarked on the satellite Metop and record spectra of the Earth's atmosphere.



- Precise measurement of water vapor proportion for meteorology predictions

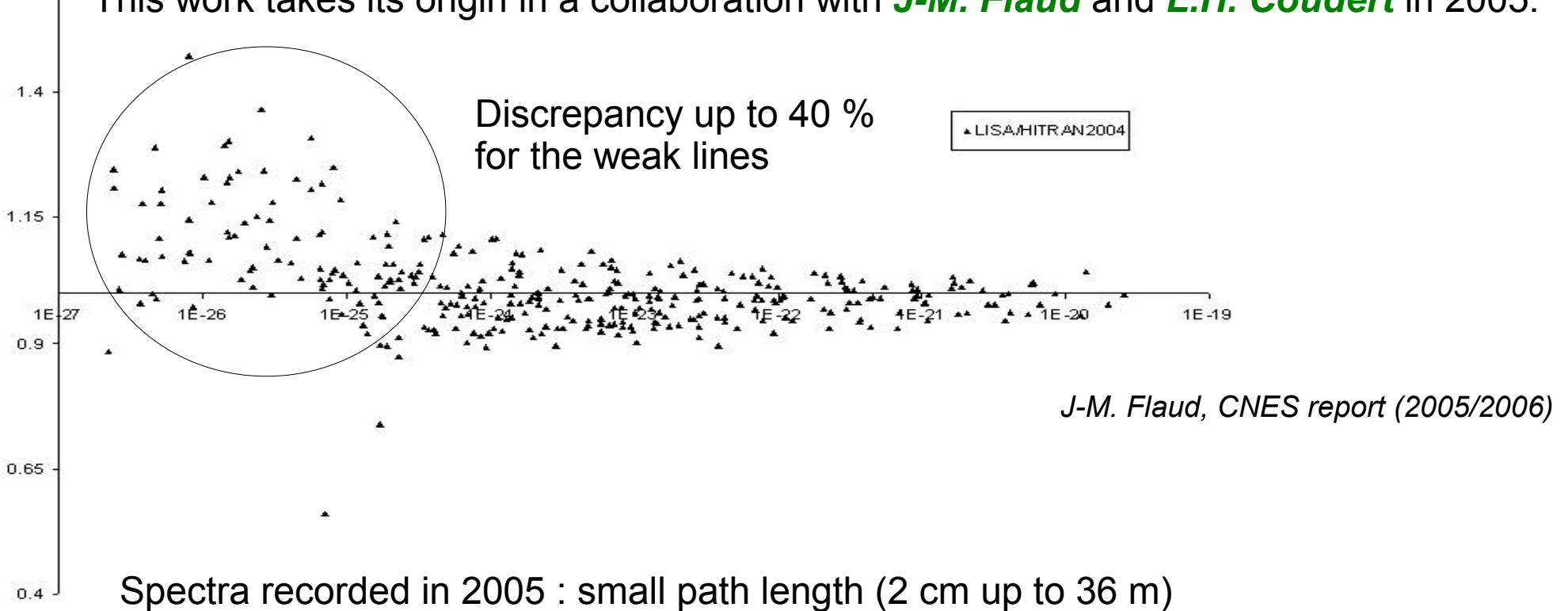
- Measure and survey of trace gas in the atmosphere.

The H₂¹⁶O absorptions are rather strong in this spectral region.

The inversion of IASI's spectra need precise spectroscopic parameters.

What database for the inversion of IASI spectra?

This work takes its origin in a collaboration with **J-M. Flaud** and **L.H. Coudert** in 2005.



Those spectra provide new measurements for the strongest lines, but didn't permit to make a conclusion for inversion of IASI's spectra.

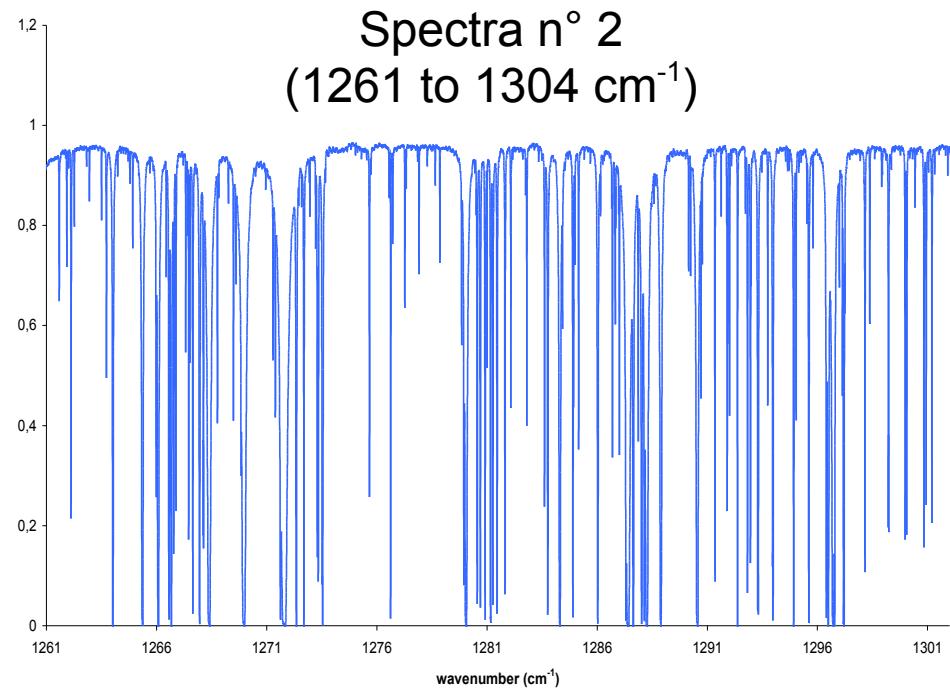
New measurements are needed for the lines under 1×10^{-25} cm/molec !

Experimental conditions

Spectra were recorded with the GSMA's FTS,
using sample of water vapor in natural
abundance :

Spectra	T (Kelvin)	H ₂ O Pressure (mbar)	Absorption Length (m)
1	290.0	13.38	201.34
2	289.4	13.51	602.32
3	289.2	14.17	1002.82

Spectra recorded in 2009 using the 50-m
White cell.



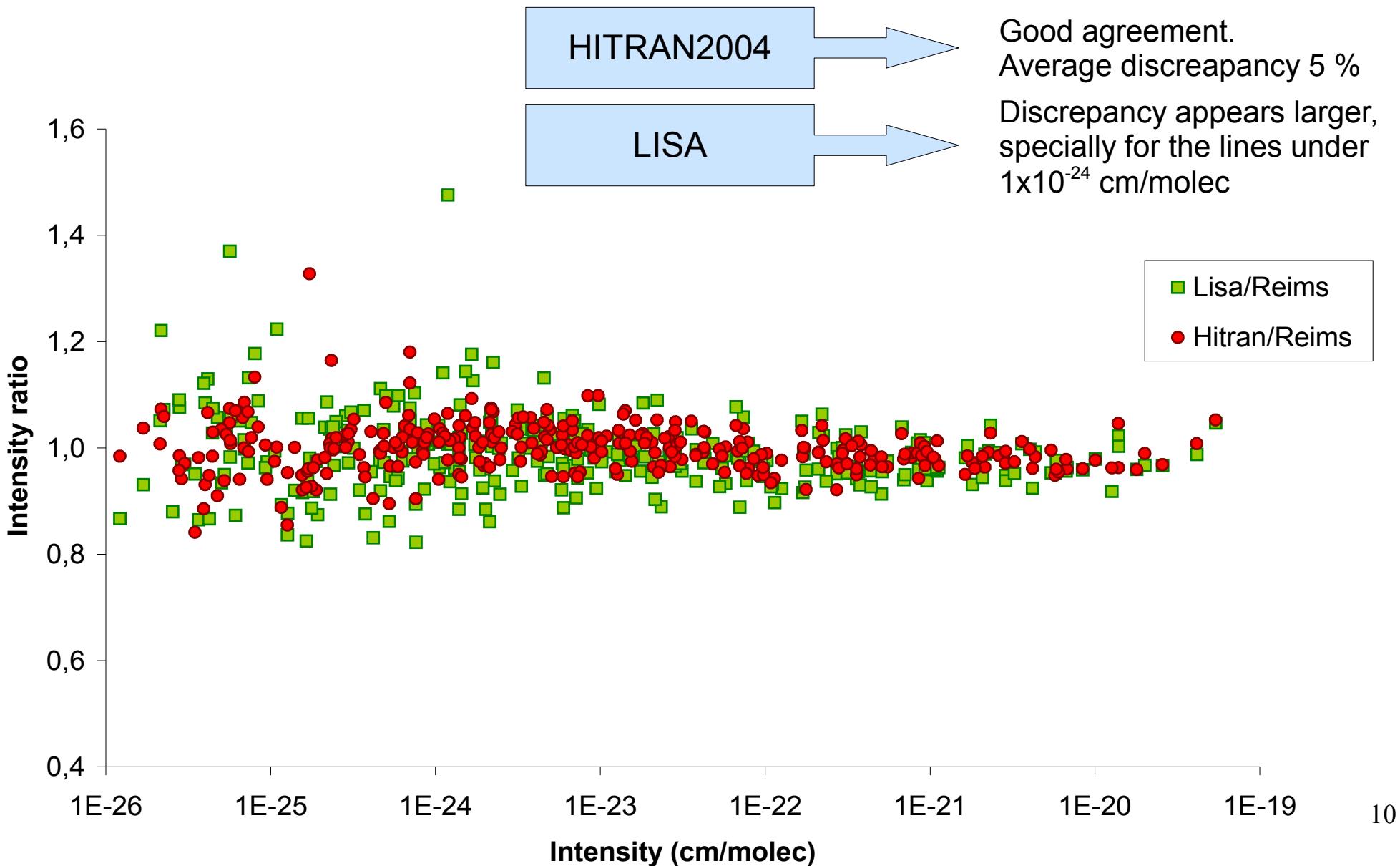
Our study focuses on H₂¹⁶O lines intensities for the spectral range of 1200 to 1400 cm⁻¹:

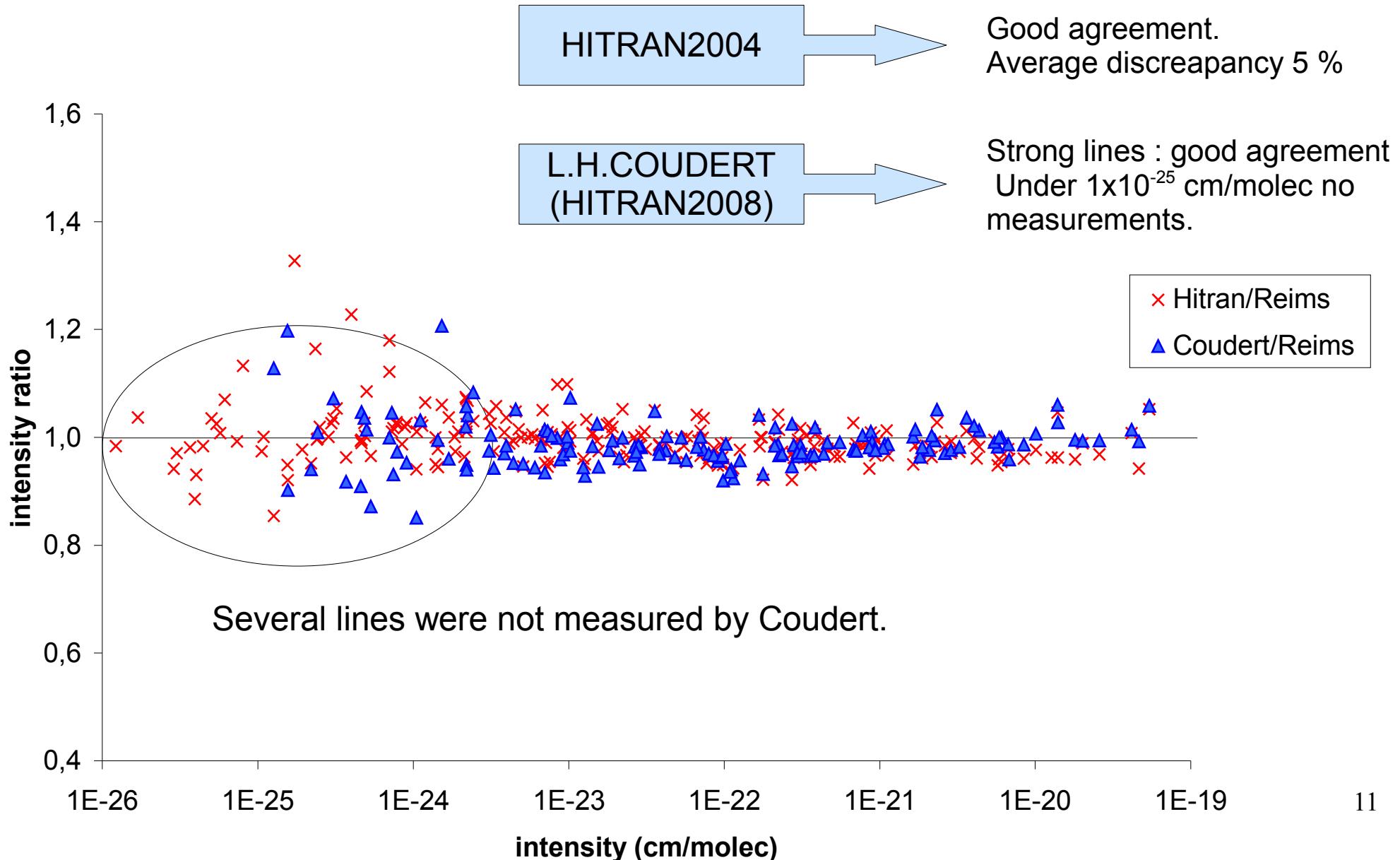
- intensity range measured 1x10⁻²⁶ to 1x10⁻¹⁹ cm/molec

- Comparisons

HITRAN2004, the LISA database, L.H Coudert et al. (2008)

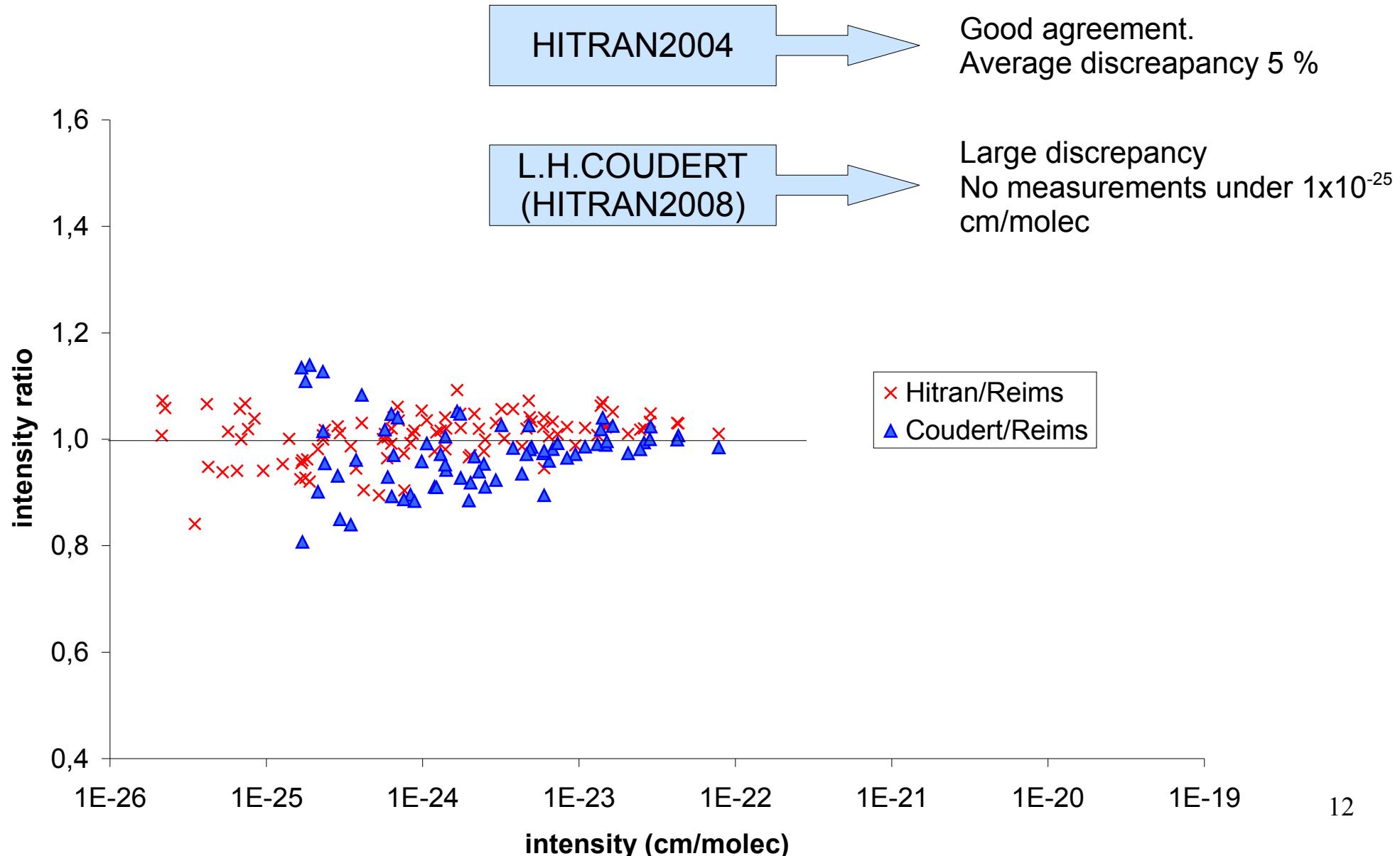
Comparison : Reims to HITRAN2004 and the LISA database





2v₂ – v₂ band

Comparison : Reims to HITRAN2004 and L.H.Coudert



Conclusion

The spectra recorded with the 50-m White cell allowed us to reach the small absorption lines of H₂¹⁶O between 1200 and 1400 cm⁻¹.

- **330 lines measured**
- **105 lines measured more than the linelist published by L.H. Coudert**

L.H. Coudert et al, the H₂¹⁶O molecule: Line position and line intensity analyses up to the second triad,
J.Mol.Spectrosc. 251 (2008)

- Reims values in better agreement with the HITRAN database.

***FTS improvements and connection with a long White cell.
Application : H₂¹⁶O intensity measurements around 1200 cm⁻¹.***

*L. Régalia, C. Oudot, X. Thomas, P. Von der Heyden, D. Decatoire
JQSRT 111, issue 6 (2010)*

Study of H_2^{16}O lines in the spectral region around 8800 cm^{-1}

Review of the H₂¹⁶O HITRAN database

The 8800 cm⁻¹ spectral region still relies to the studies of **J-Y. Mandin** (1988)

	6600 – 8000 cm ⁻¹	8000 – 9250 cm ⁻¹	9250 – 10 000 cm ⁻¹
Hitran91/92	Unchanged from previous version	Mandin et al (1988)	Chevillard et al (1989)
Hitran96	Toth (1994)	Unchanged	Unchanged
Hitran2000	Unchanged	Intensity correction by Giver et al (1999)	Brown et al (2002)
Hitran2004	Toth	Unchanged	Unchanged
Hitran2008	Unchanged	Unchanged	Mix of new result of Tolchenov and Tennyson and data from Brown et al (2002)

Even if a correction of conversion of temperature was made by **Giver et al**, several studies still point out a line intensity problem in the HITRAN database.

J.-Y. Mandin, J.-P. Chevillard, J.-M. Flaud, C. Camy-Peyret, H₂¹⁶O: Line positions and intensities between 8000 and 9500 cm⁻¹: the second hexad of interacting vibrational states: {(050), (130), (031), (210), (111), (012)}, Can. J. Phys., (1988) 66

J.-Y. Mandin, J.-P. Chevillard, J.-M. Flaud, C. Camy-Peyret, N₂-broadening coefficients of H₂¹⁶O lines between 8500 and 9300 cm⁻¹, J. Mol. Spectrosc., (1988) 132

L.P. Giver, C. Chackerian, P. Varanasi, Visible and near-infrared H₂¹⁶O line intensity corrections for HITRAN-96, JQSRT, (2000) 66

J. Bailey, A comparison of water vapor line parameters for modeling the Venus deep atmosphere, Icarus (2009) 201

Experimental study of Tolchenov and Tennyson

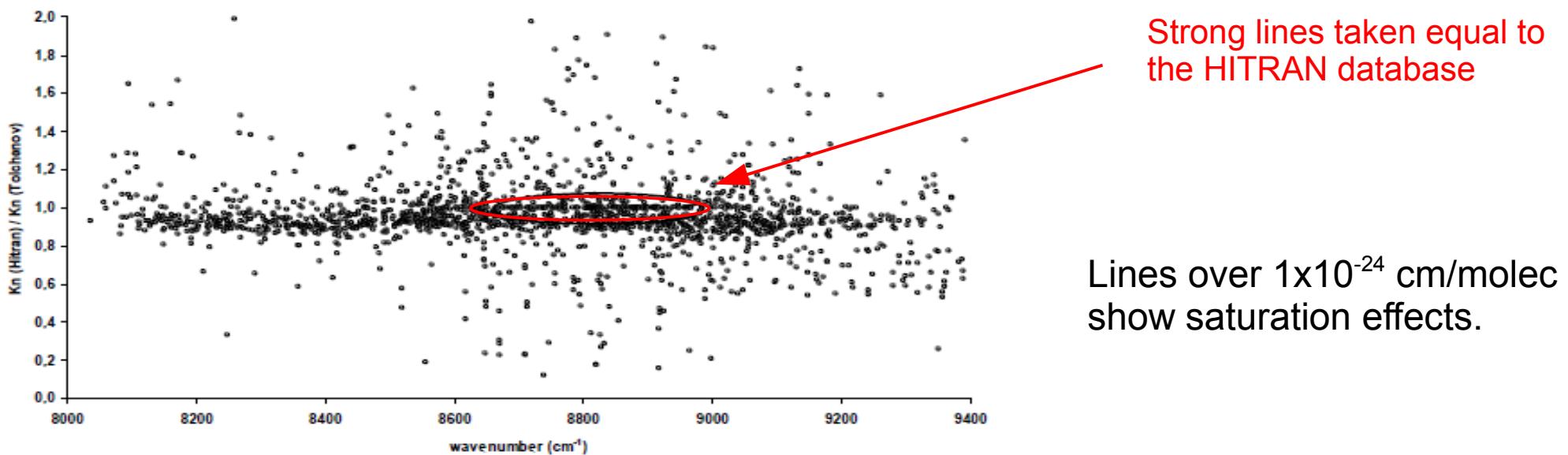
Experimental study of water vapor in the spectral region 7400 to 9600 cm⁻¹.

R. N. Tolchenov, J. Tennyson, *Water line parameters for weak lines in the range 7400- 9600 cm⁻¹*, J. Mol. Spectrosc., (2005) 231

Only one spectrum recorded by **Schermaul**, in the following experimental conditions : temperature of $294,4 \pm 0,7$ K, pressure of 20 hPa and path length $480,6 \pm 0,6$ m.

R. Schermaul, et al, *Weak Line Water Vapor Spectra in the Region 13 200–15 000 cm⁻¹*, J. Mol. Spectrosc, 211 (2002)

H₂¹⁶O intensity of Tolchenov compare to the HITRAN2008 database :

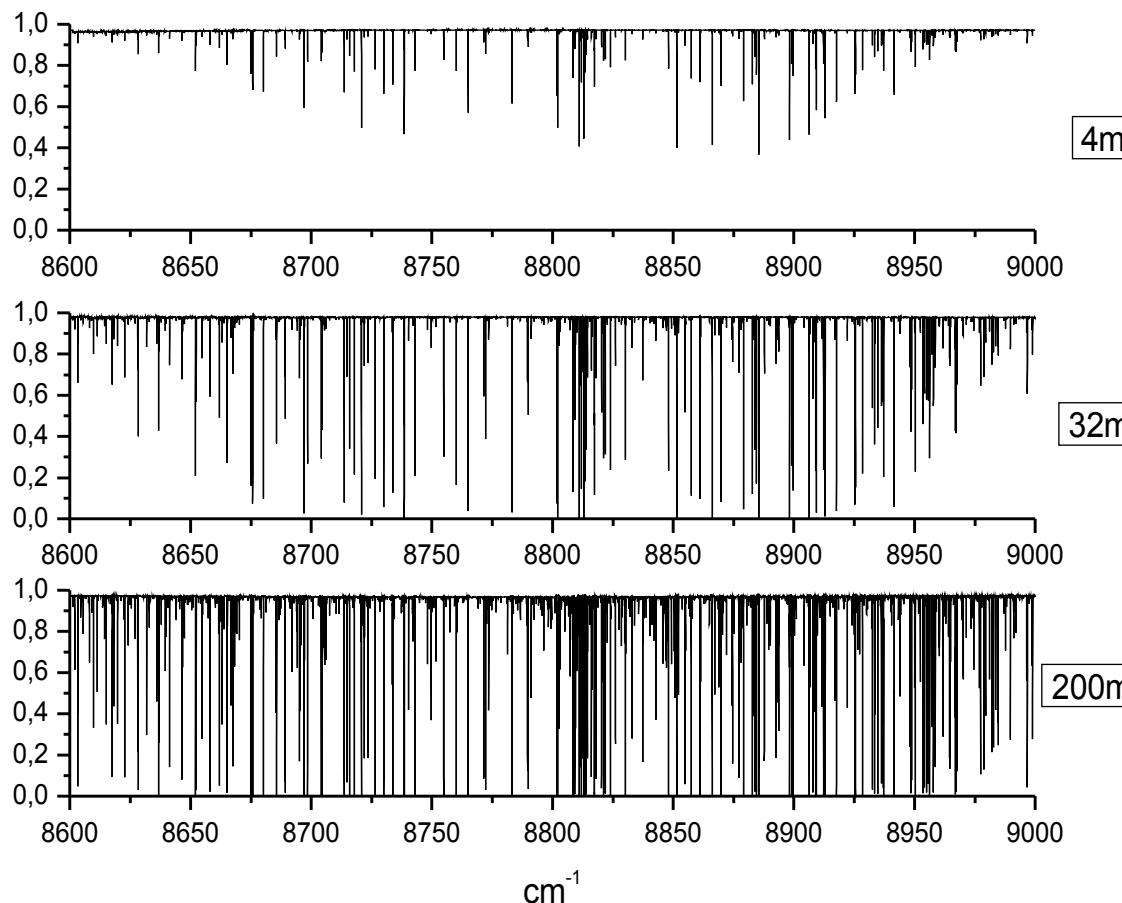


Average of discrepancy 10 %

Experimental conditions

This study focuses on the H₂¹⁶O relative strong lines listed and assigned in the HITRAN2008 database.

Sample of water vapor in natural abundance were used for record the spectra.



Spectra	Path lenght (m)	Pressures (hPa)
Series 1	4.17	20.10 ; 9.90 ; 4.80 ; 2.32
Series 2	12.18	20.10 ; 9.90 ; 4.81 ; 2.33
Series 3	32.21	20.18 ; 9.90 ; 3.56 ; 2.32
Series 4	201.48	13.74 ; 6.90 ; 2.67
Series 5	602.32	13.75 ; 6.65 ; 2.71
Series 6	1203.04	13.82 ; 6.70 ; 2.79

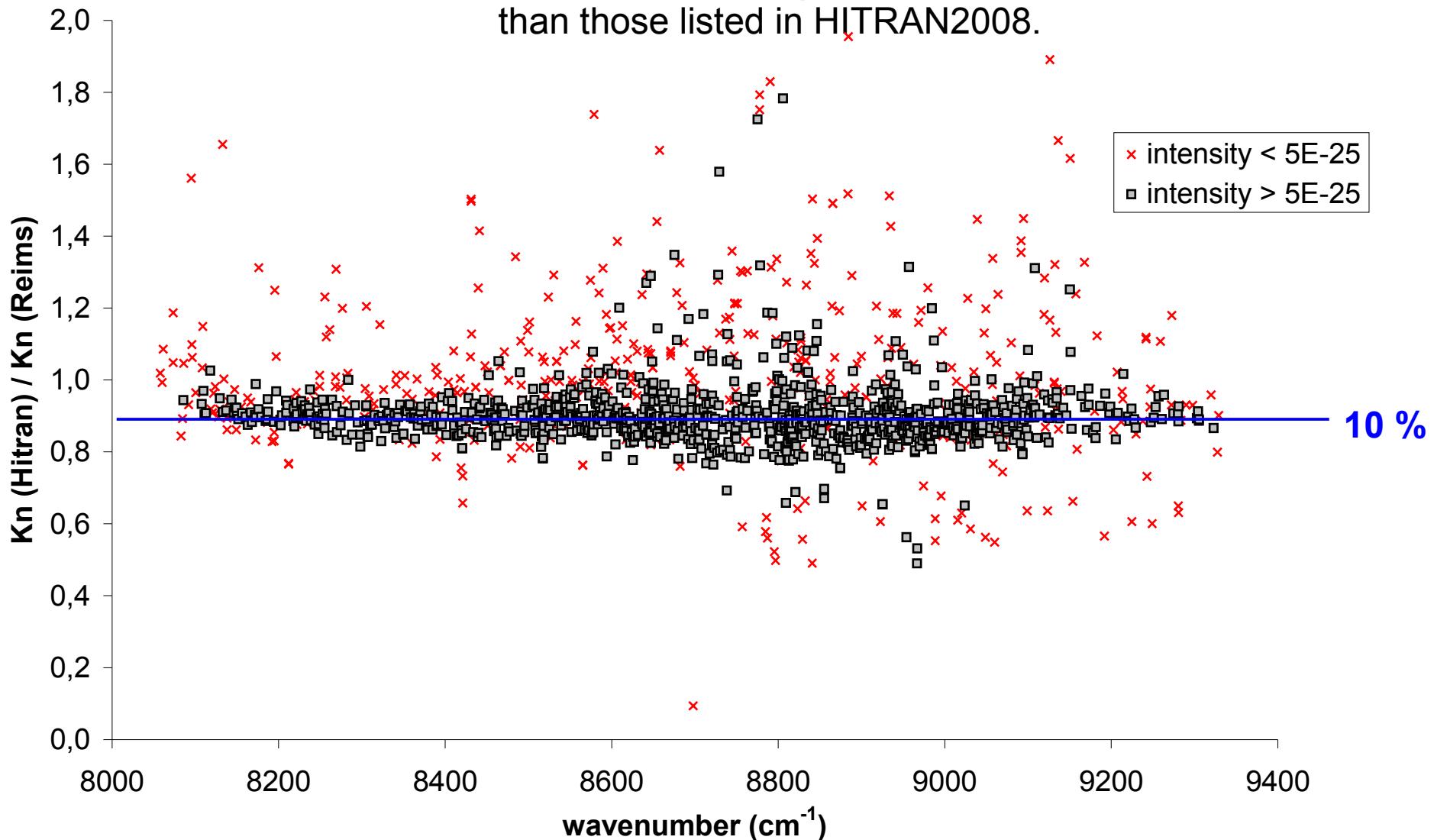
Spectra of series 1, 2 and 3 were recorded with a 1-m White cell and the others with the 50-m White cell.

Spectra recorded at 2.5 hPa with 3 different path absorption lengths.

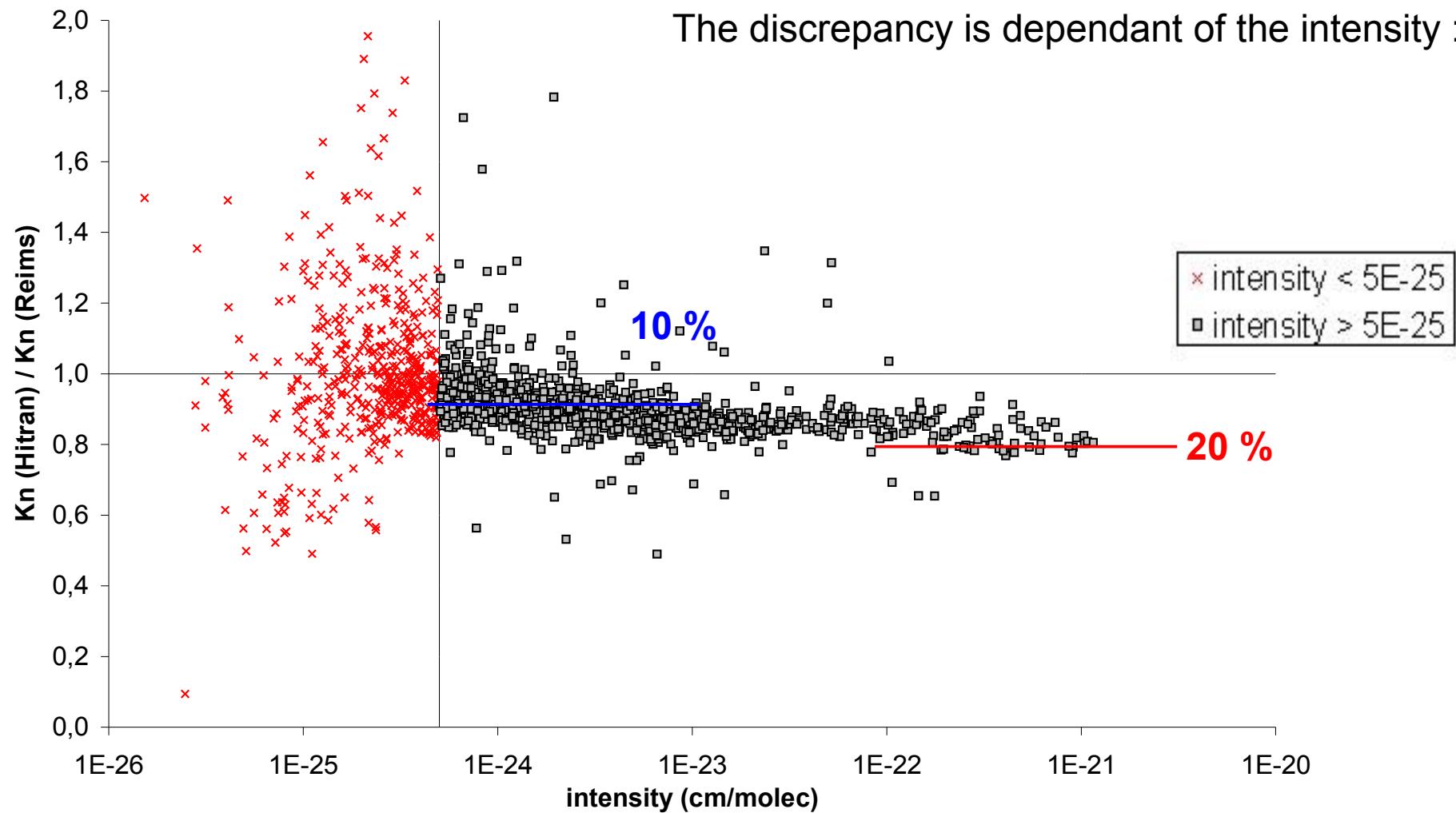
In average we find than our intensities values are

10% higher

than those listed in HITRAN2008.



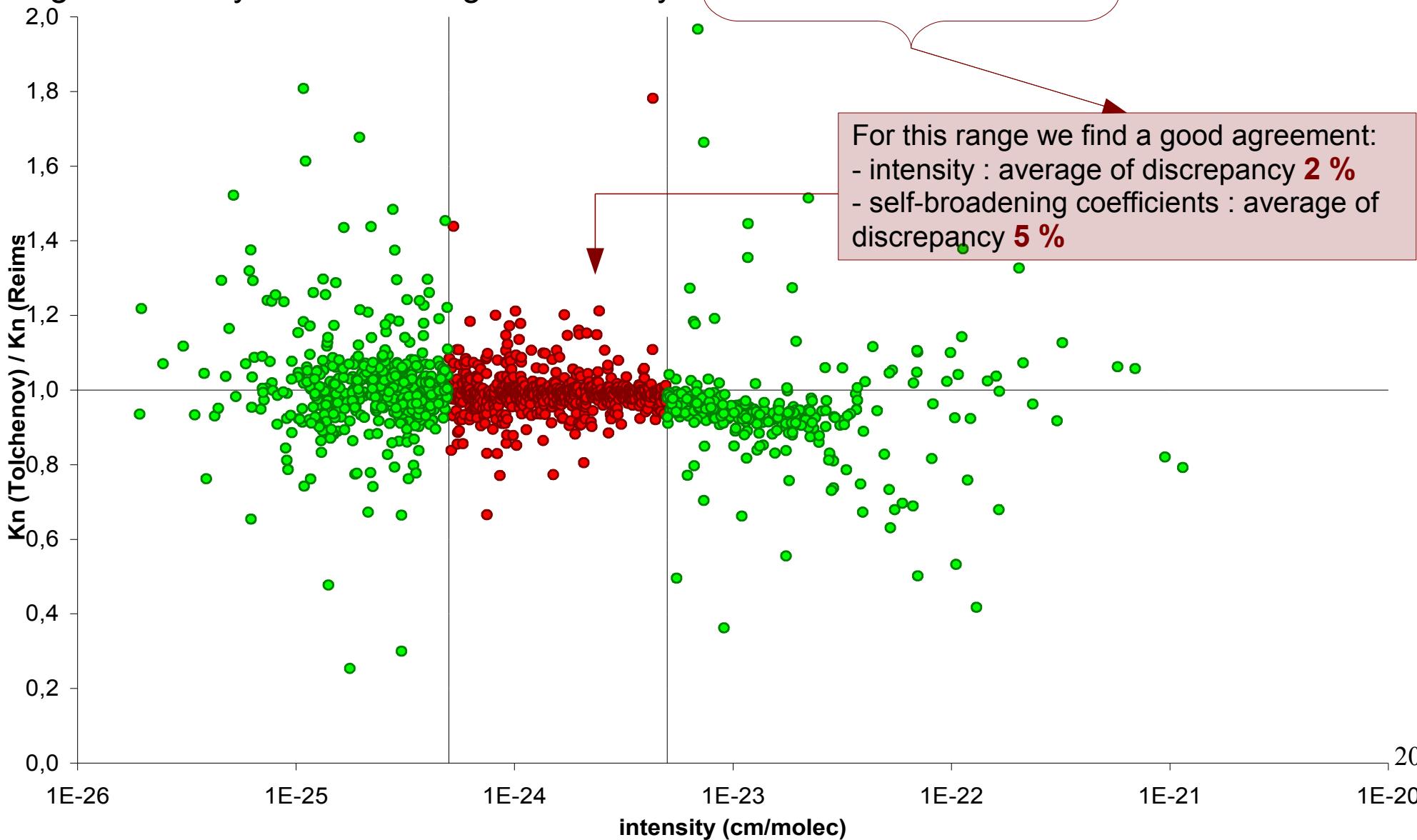
Comparison : Reims to the HITRAN2008 database (2)



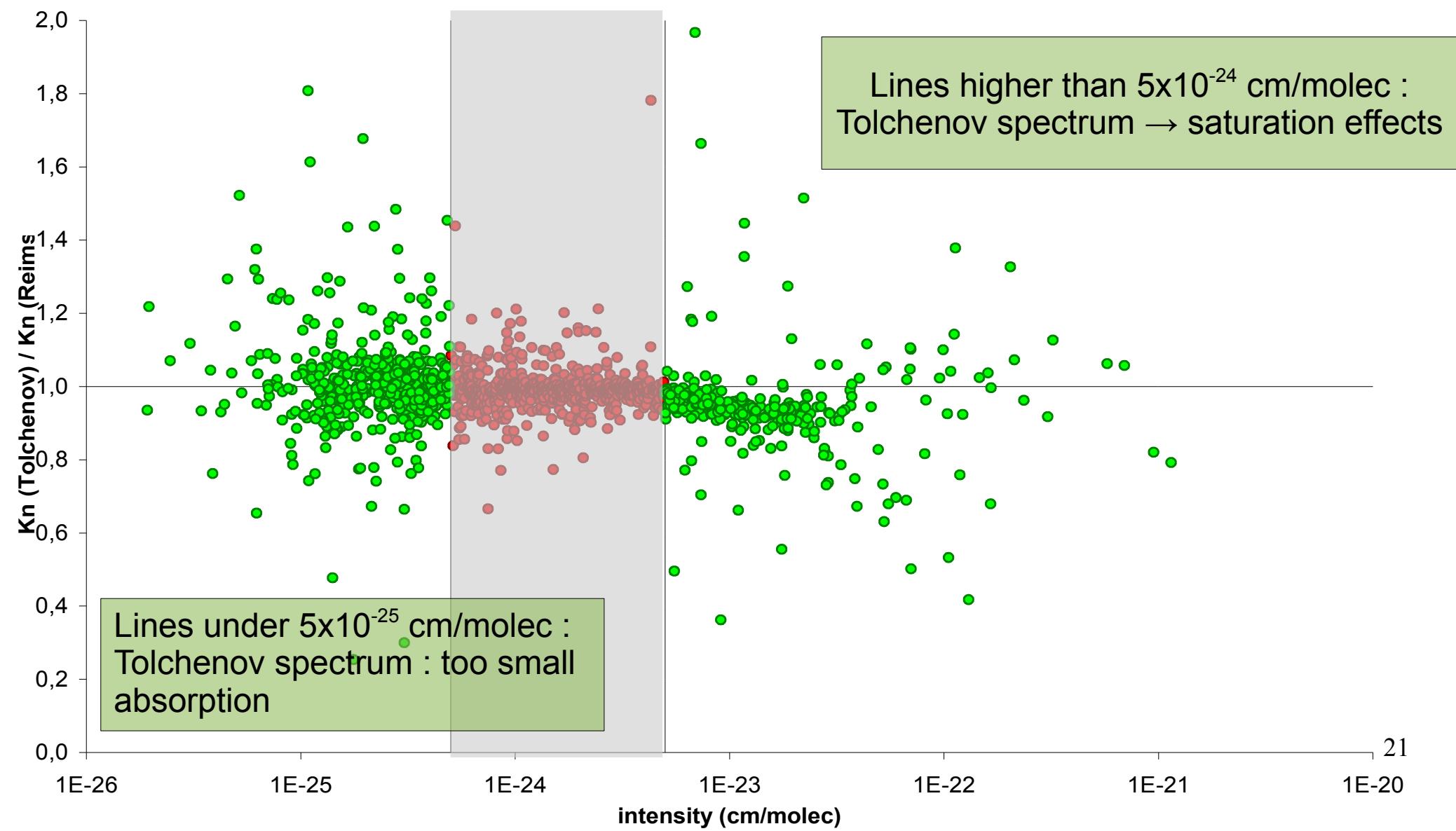
Approximately absorption path length chosen to obtain correct lines parameters

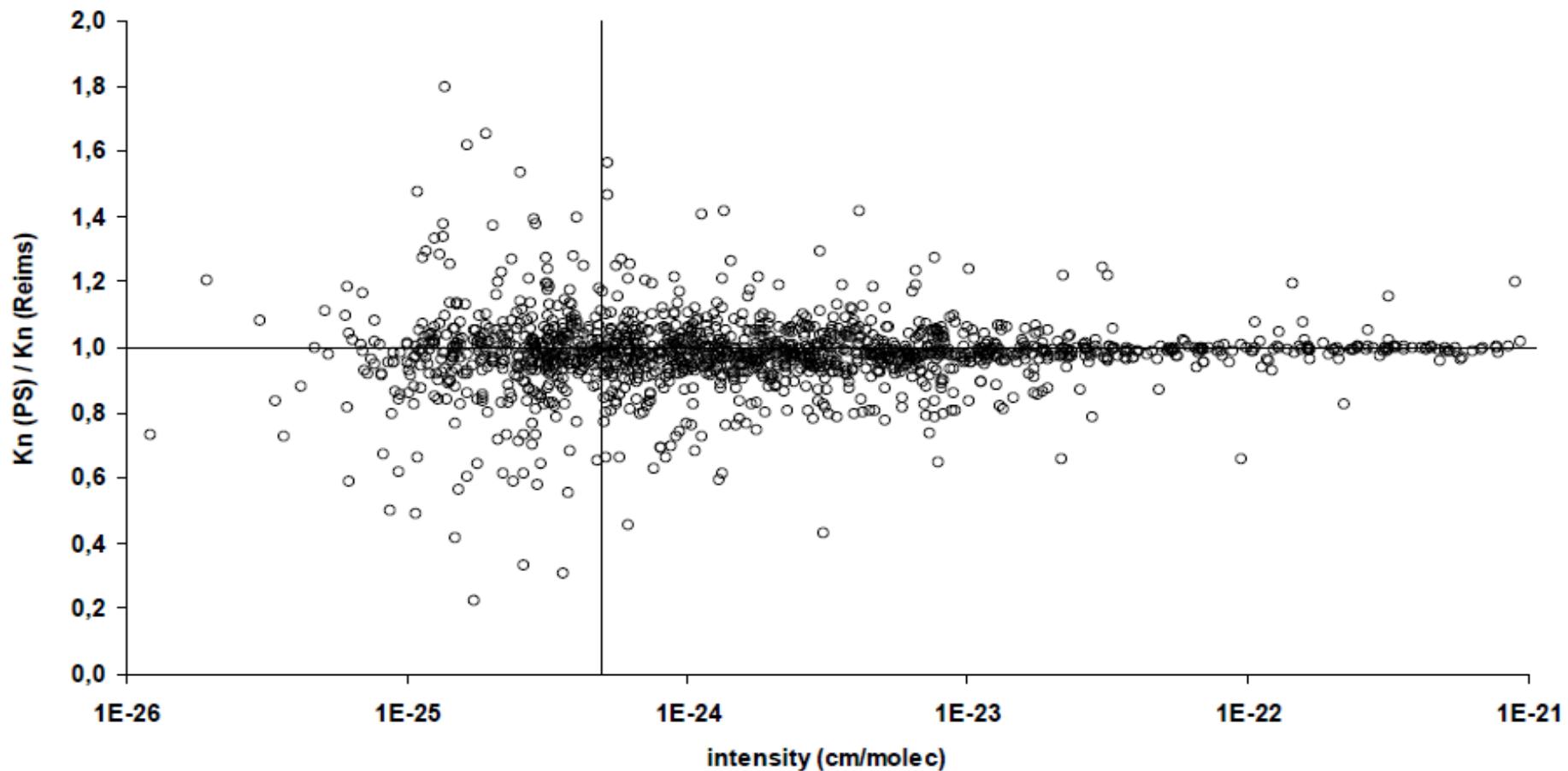
Comparison : Reims to Tolchenov and Tennyson (1)

Considering the experimental condition of the authors, the comparison with their result is significant only in a small range of intensity : 5×10^{-25} to 5×10^{-24} cm/molec.



Comparison : Reims to Tolchenov and Tennyson (2)





Linelist from Partridge and Schwenke were taken from the web database SPECTRA.
<http://spectra.iao.ru>

Conclusion

Our study brings **new measurements for the lines between 1×10^{-25} and 1×10^{-21} cm/molec**, our intensity values are in very good agreement with those measured by Tolchenov. Moreover, we measured the **strong lines**, that were not investigate since the measurements of Mandin. Those line intensities are **20% higher than HITRAN2008 values**.

***Intensity measurements of H₂¹⁶O lines in the spectral region
8000 – 9350 cm⁻¹***

***C. Oudot, Le Wang, X. Thomas, P. Von der Heyden, L. Daumont
and L. Régalia, J. Mol. Spectrosc. doi:10.1016/j.jms.2010.04.011***

The study of the line intensities of H_2^{16}O is in progress
in the spectral range of 6600 to 9350 cm^{-1} .

And we plan to study H_2^{18}O in the $10\mu\text{m}$ region