CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

HITRAN2020: Practicality, Accuracy, Completeness, Traceability (PACT)

Iouli Gordon, Laurence Rothman, Robert Hargreaves, Eamon Conway, Ekaterina Karlovets, Robab Hashemi, Frances Skinner, Artem Finenko, Roman Kochanov, Yan Tan, Christian Hill

and

HITRAN contributors and validators world wide

Metrology for Climate Action, Online, September 2022

HITRANonline

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Home | Data Access | Documentation | Conferences | Links | About

- Line-by-line
- Absorption Cross Sections
- Collision Induced Absorption
- Aerosol Properties
- HITEMP
- HAPI
- Supplemental

The HITRAN Da

HITRAN is an acronym smission molecular absorption database. HITRAN is a copic parameters that a variety of computer codes use the transmission and emission of light in the atmosph

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Tutorials

News

Sep 2022 | **25000 users milestone**

Oct 2021 | **The data on this website corresponds to the HITRAN2020 edition**

Apr 2021 | **History of HITRAN by Dr. Laurence S. Rothman**

Apr 2020 | **HITEMP now includes methane**

Jul 2015 | **All inquiries can be made to HITRAN's support team at *info@hitran.org***

Database Updates

Aug 2022 | **Updated broadening parameters for CO_2 and H_2**

May 2022 | **H_2O line list update above 4340 cm^{-1}**

Nov 2021 | **Lines of $^{16}O_3$ in 850-980 cm^{-1} region restored**

www.hitran.org

New quadrennial edition

Journal of Quantitative Spectroscopy & Radiative Transfer 277 (2022) 107949

Contents lists available at ScienceDirect

Journal of Quantitative Spectroscopy & Radiative Transfer

journal homepage: www.elsevier.com/locate/jqsrt

- Article describing the HITRAN2020 edition is in Open Access in JQSRT

The HITRAN2020 molecular spectroscopic database

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Summary:

- 88 authors
- 82 pages
- 909 references

Available at: https://doi.org/10.1016/j.jqsrt.2021.107949

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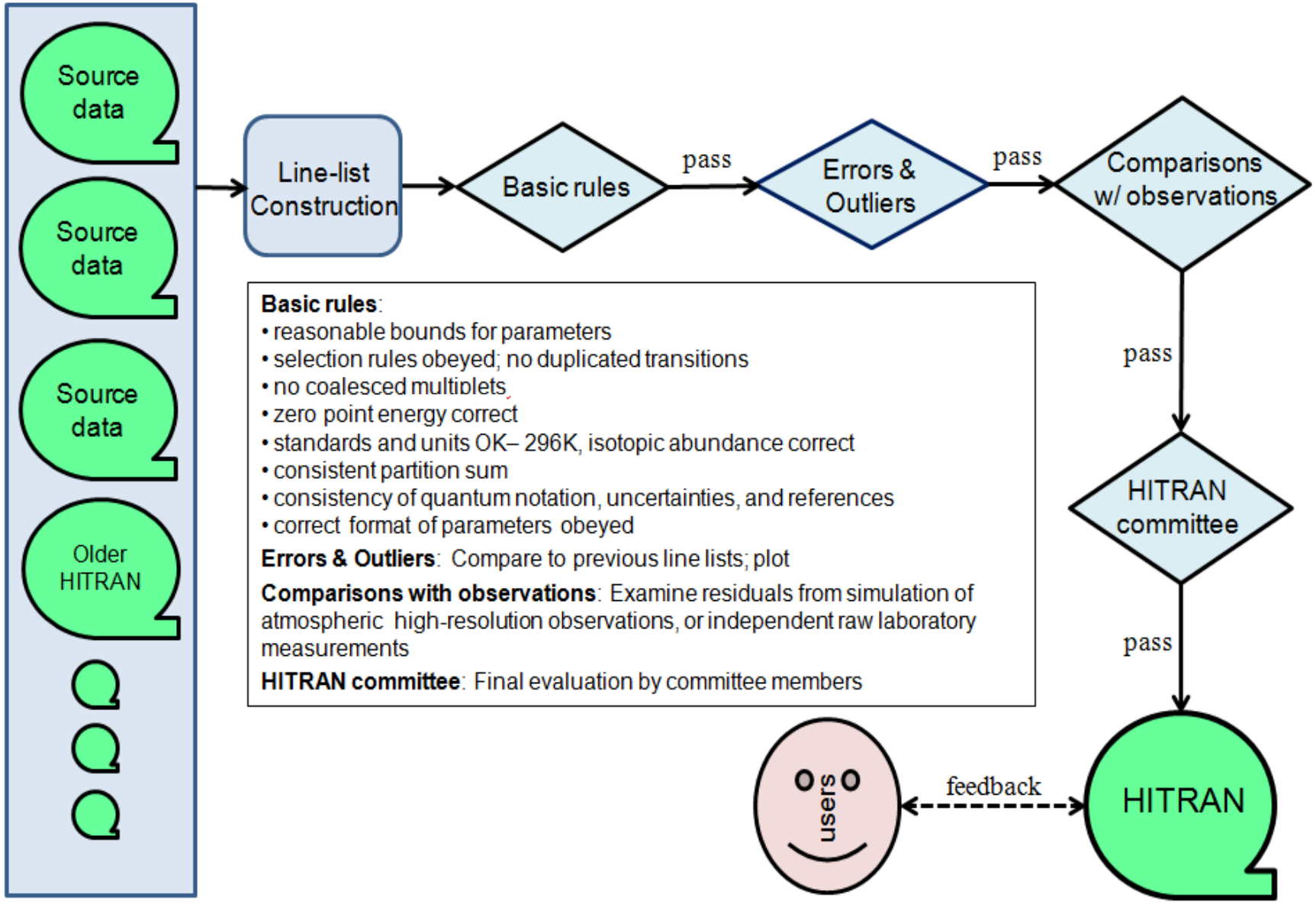
Scheme for Construction



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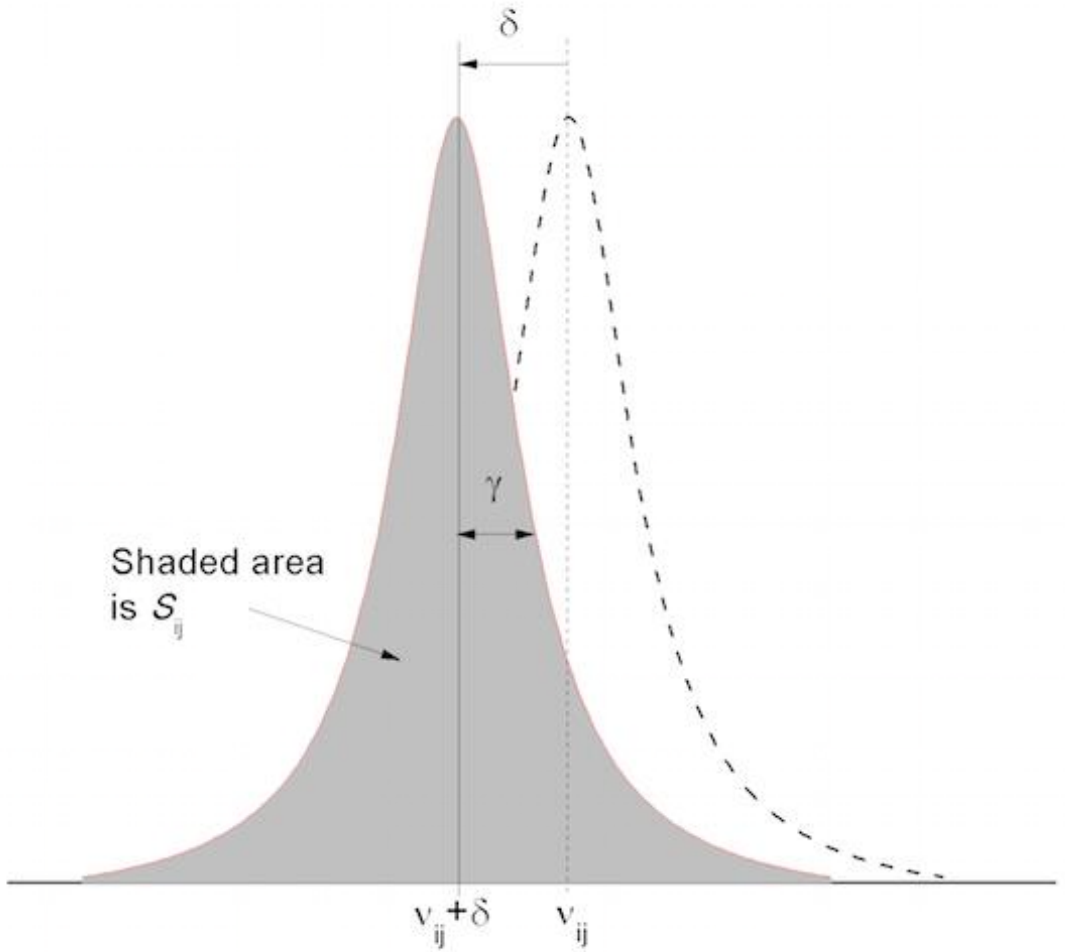

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HITRAN2020 line-by-line section (55 molecules)

Molecules (isotopologues) in the line-by-line portion of HITRAN						
H_2O (7)	**SO_2 (4)**	HI (2)	H_2O_2 (1)	HO_2 (1)	CH_3CN (1)	$COCl_2$(2)
CO_2 (12)	**NO_2 (2)**	ClO (2)	**C_2H_2 (3)**	O (1)	CF_4 (1)	**SO (3)**
O_3 (5)	**NH_3 (2)**	**OCS (6)**	**C_2H_6 (3)**	$ClONO_2$ (2)	C_4H_2 (1)	**CH_3F (1)**
N_2O (5)	HNO_3 (2)	**H_2CO** (3)	**PH_3 (1)**	NO^+ (1)	**HC_3N (1)**	**GeH_4 (4)**
CO (6+3) 	**OH (3)**	HOCl (2)	COF_2 (2)	HOBr (2)	**H_2 (2)**	**CS_2 (4)**
CH_4 (4)	HF (2)	N_2 (2)	**SF_6 (1)**	C_2H_4 (2)	CS (4)	**CH_3I (1)**
O_2 (3)	HCl (4)	**HCN (3)**	**H_2S (3)**	CH_3OH (1)	SO_3 (1)	**NF_3 (1)**
NO (3)	HBr (4)	CH_3Cl (2)	**HCOOH (1)**	CH_3Br (2)	C_2N_2 (1)	

Molecules for which the line lists were updated/extended with respect to HITRAN2016 are in bold

New molecules or increased amount of isotopologues for existing molecules are highlighted in red;

Updates in the line by line section

- Improved quality of the existing parameters

For many molecules in the database, but some are particularly important for the spectroscopy of the atmosphere.

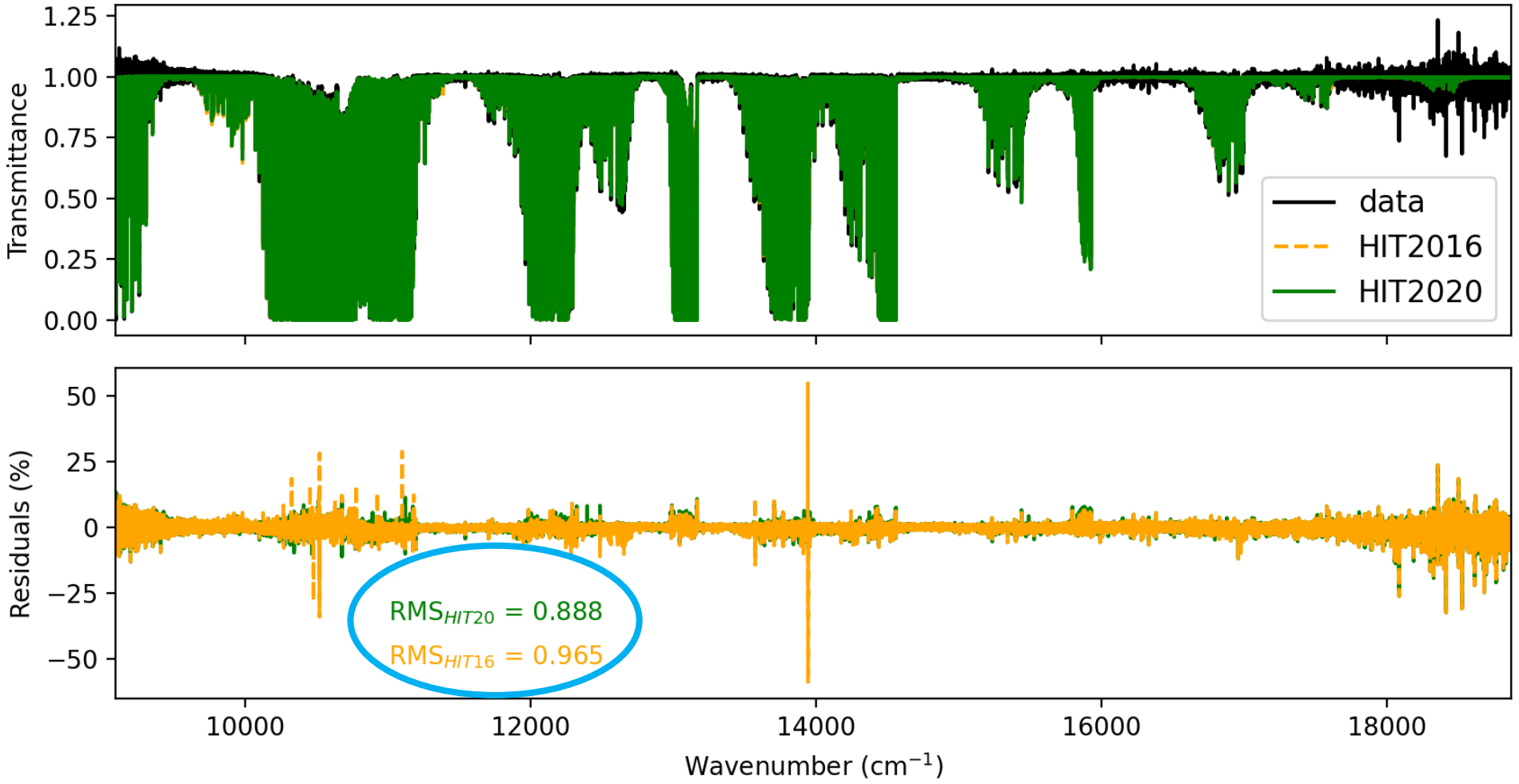
- Many added bands for most species in the database
- Partition sums are (re)calculated for all species (Gamache et al. JQSRT 271 (2021) 107713)

- Line shapes:
  - VP updated form many molecules
  - SDV parameterization (incl. CO_2, CO, N_2O)
  - Additional broadening by various perturbers (incl. H_2O)

Validations of H_2O in HITRAN2020

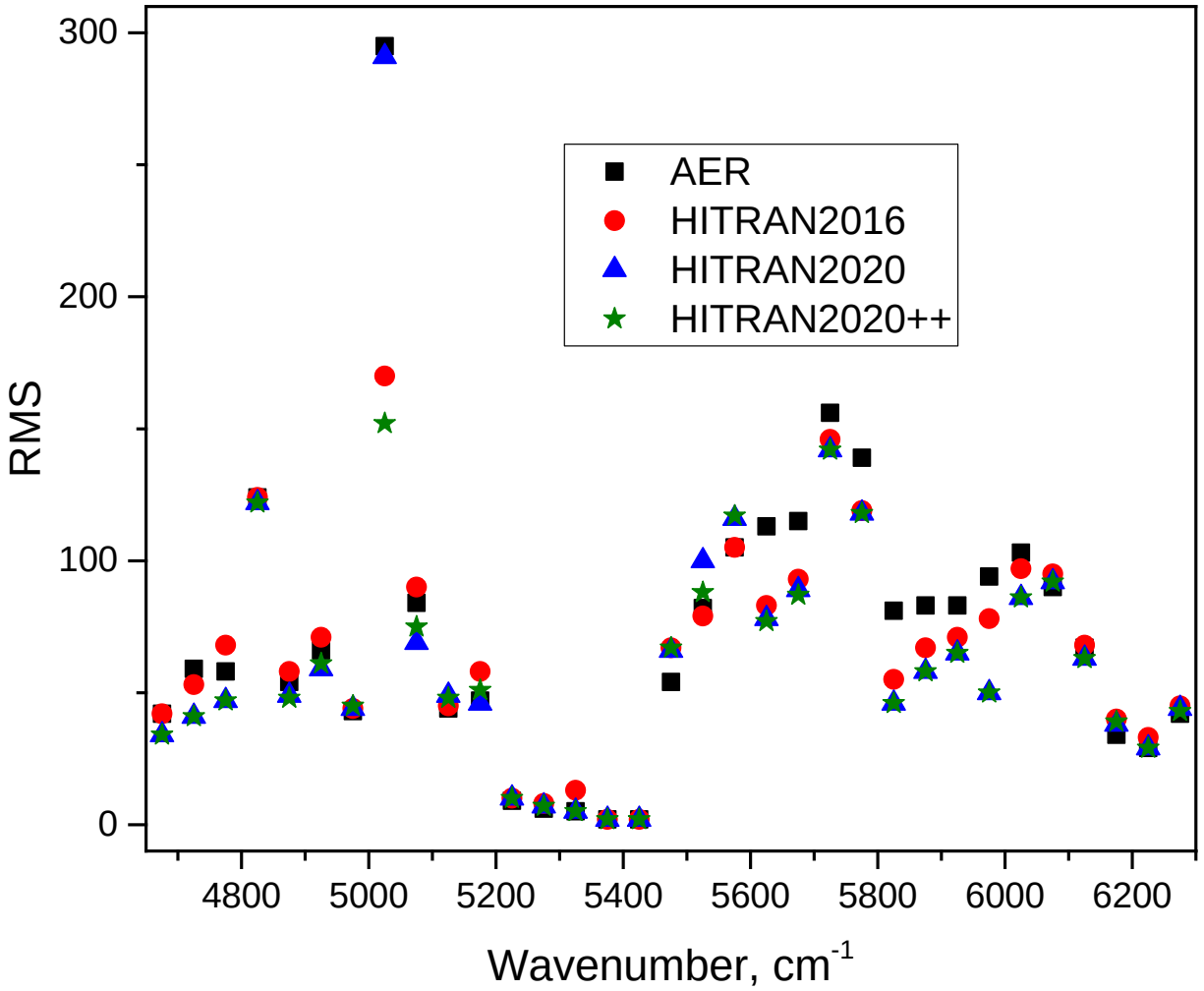
HITRAN2020 and HITRAN2016 compared at modelling the atmospheric transmittance. Compared to high-resolution solar spectrum Baker et al. ApJ 2020

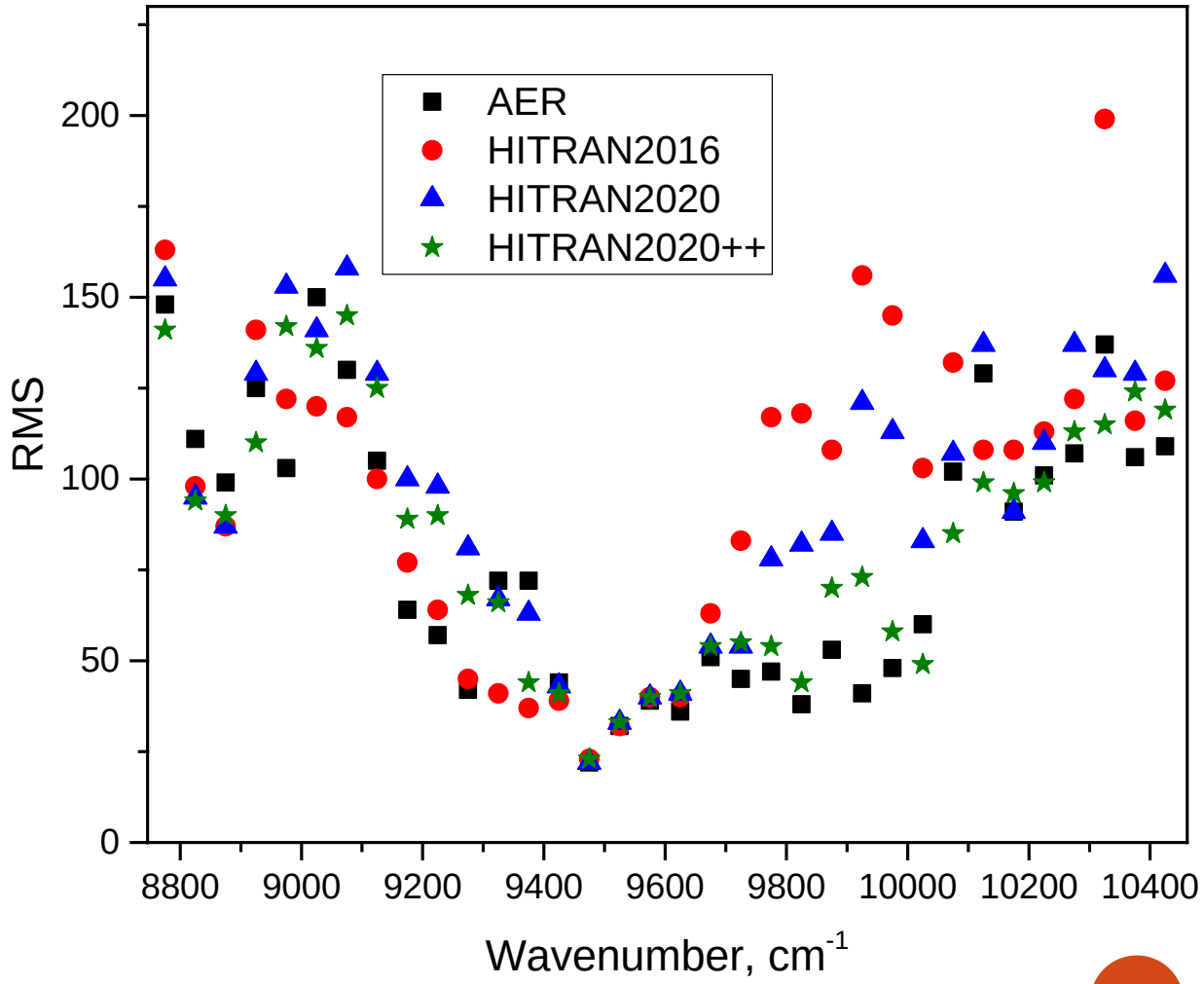
Figure credit: A. Baker (Caltech)



Further Validations of H_2O in HITRAN2020 Using TCCON

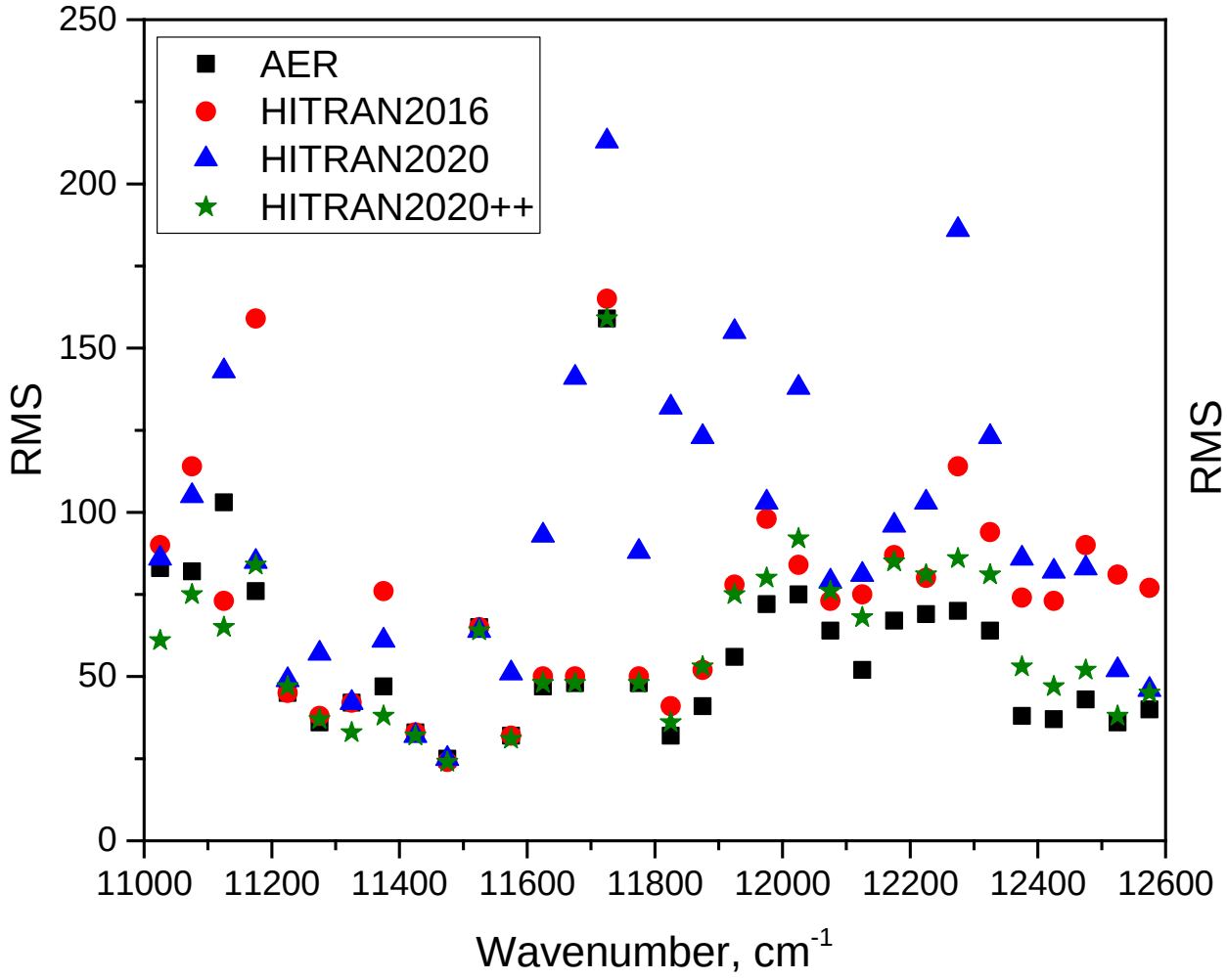
∆ Eli Mlawer and Mike Iacono (AER)

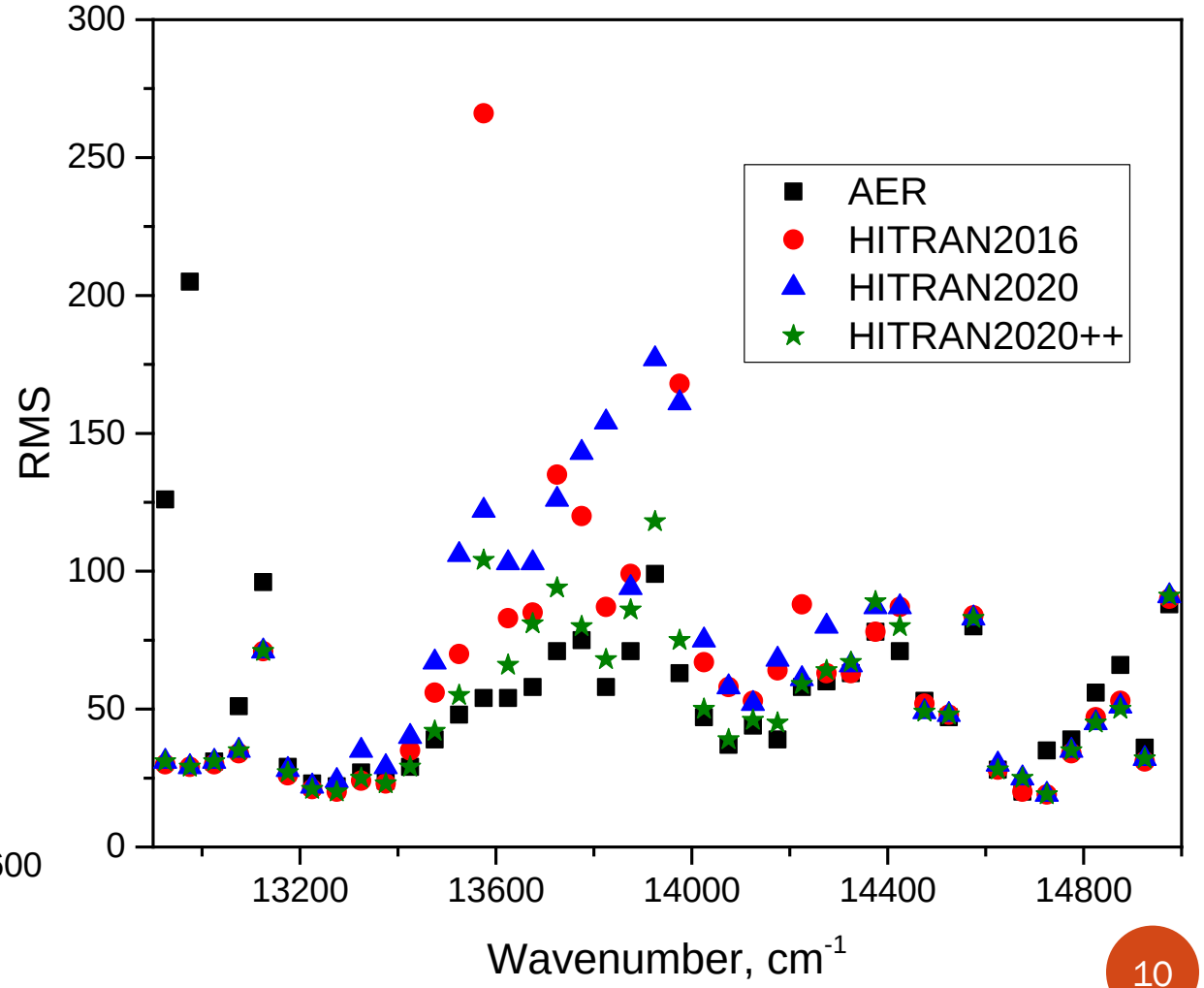




Major culprit: broadening and shifts

Further Validations of H_2O in HITRAN2020 Using TCCON





Δ Eli Mlawer and Mike Iacono (AER)

Example: ozone improvements

- Major overhaul of the O_3 line list and cross-sections from MW to UV.

MW
- ❖ In the region of pure rotational transitions, the values from the JPL catalogue were chosen

FIR
- ❖ Below 1180 cm^{-1} the DLR line list (which includes new broadening). https://dx.doi.org/10.5281/zenodo.4428825

MIR
- ❖ Above 1180 cm^{-1} and up to 5791 cm^{-1} new S&MPO line list partially described in Tyuterev et al., (2021) JQSRT, 272, 107801 is used except for the 2975-3205 cm^{-1} region, where UCL/Paris line list is used (Jacquemartet al., (2021) JQSRT 269, 107651)

NIR
- ❖ Above 5791 cm^{-1} HITRAN2016 line list is retained for HITRAN2020

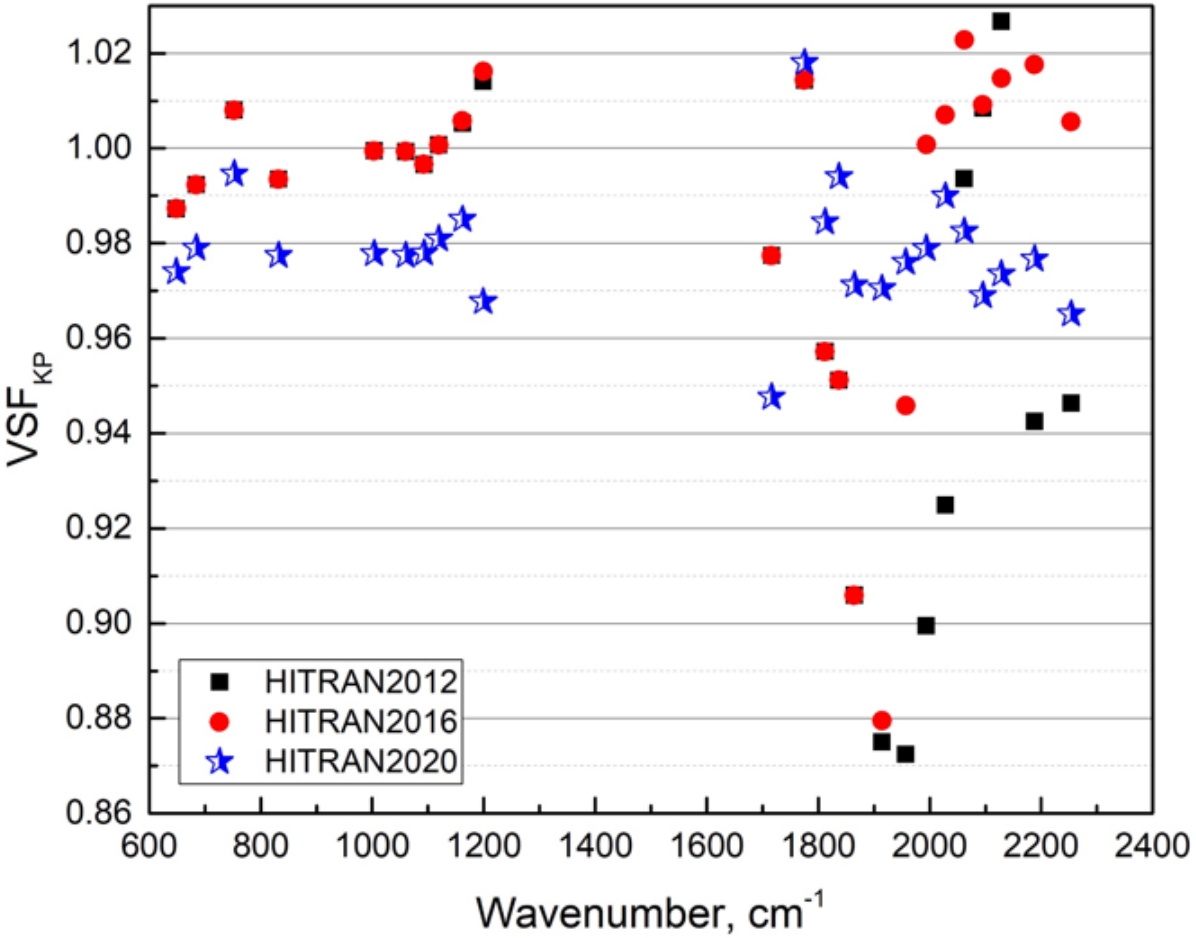
UV
- ❖ UV cross-sections are coming from the new measurements from DLR

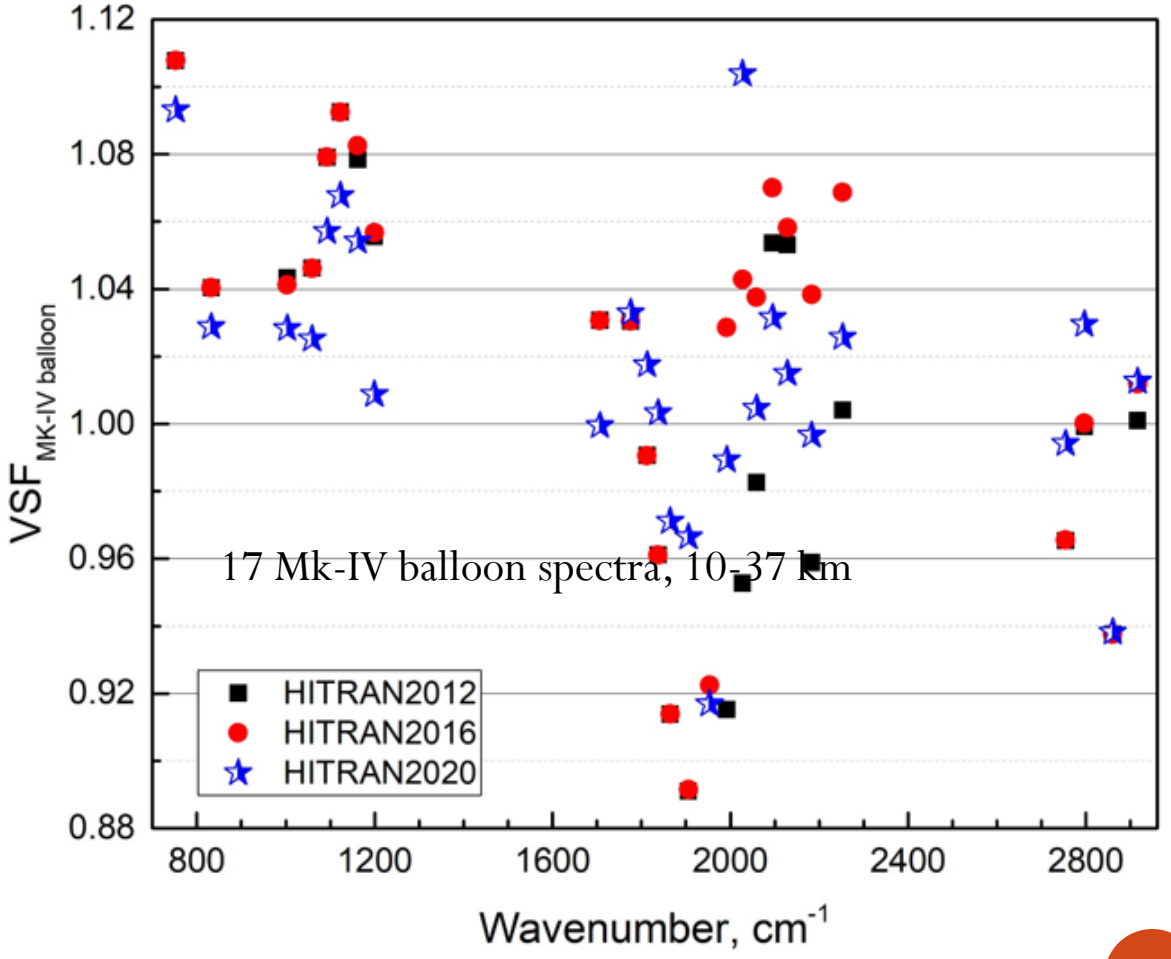
Detailed evaluations against laboratory and atmospheric spectra carried out by Geoffrey Toon (JPL)

https://mark4sun.jpl.nasa.gov/report/O3_Spectroscopy_Eval_2021_07_14.pdf

Ozone (contd..) consistency in the IR bands

Effectively the intensities of bands in the MW, 5 and 10 μm regions are increased by **2.8-3.8%**. While different effective scaling factors are observed elsewhere.





Example: O_2

1.27 μm band

New model based on separation of magnetic dipole and electric qudrupole contributions thanks to recent data from Grenoble:

Konefał et al., JQSRT(2020) 241, 106653,

Tran et al., (2020) 240, 106673.

and NIST:

Fleurbaey ., JQSRT(2021) 261, 107495

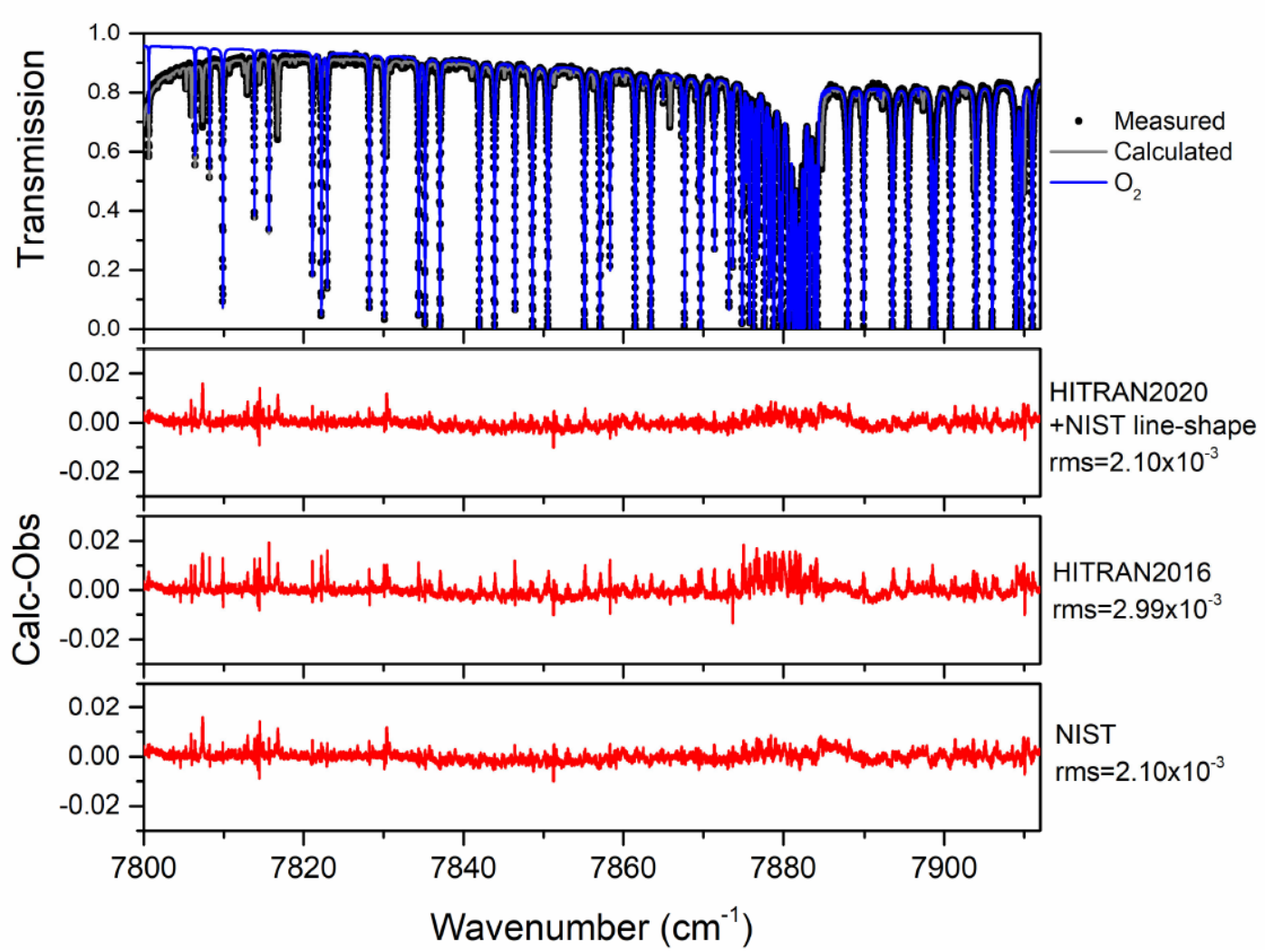
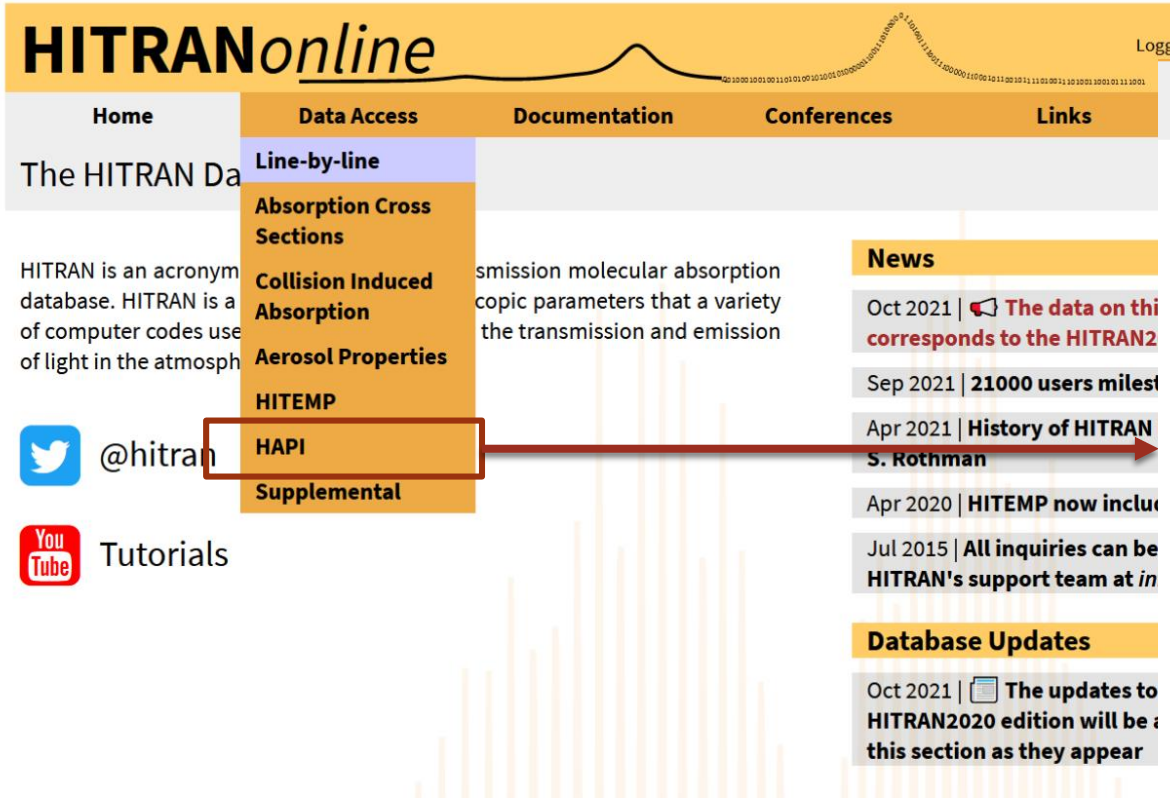


Figure credit: Ha Tran (LMD, Paris)

Modern structure and interface at www.hitran.org



HAPI: The HITRAN Application Programming Interface

Introduction

The *HITRAN Application Programming Interface* (HAPI) [1] is a set of routines in Python which aims to provide remote access to functionality and data provided by HITRAN*online*. At the present time, the API can download, filter and process line-by-line transition data.

The main purpose of this API is to extend the functionality of the main site, in particular, for the calculation of spectra using several types of line shape, including the flexible HT (Hartmann-Tran) profile [2] and optionally accounting for instrumental functions. Each feature of the API is represented by a Python function taking a set of arguments which describe the parameters defining the task.

The current version of HAPI and user manual is available for download using the following links:

- hapi.py V.1.1.1.0
- hapi_manual.pdf

In addition, the HAPI project and version history are available on Github:

- https://github.com/hitranonline/hapi

HAPI is described in Ref. [1], and futher suggestions and comments are welcome: please email rkochanov@cfa.harvard.edu.

Citation

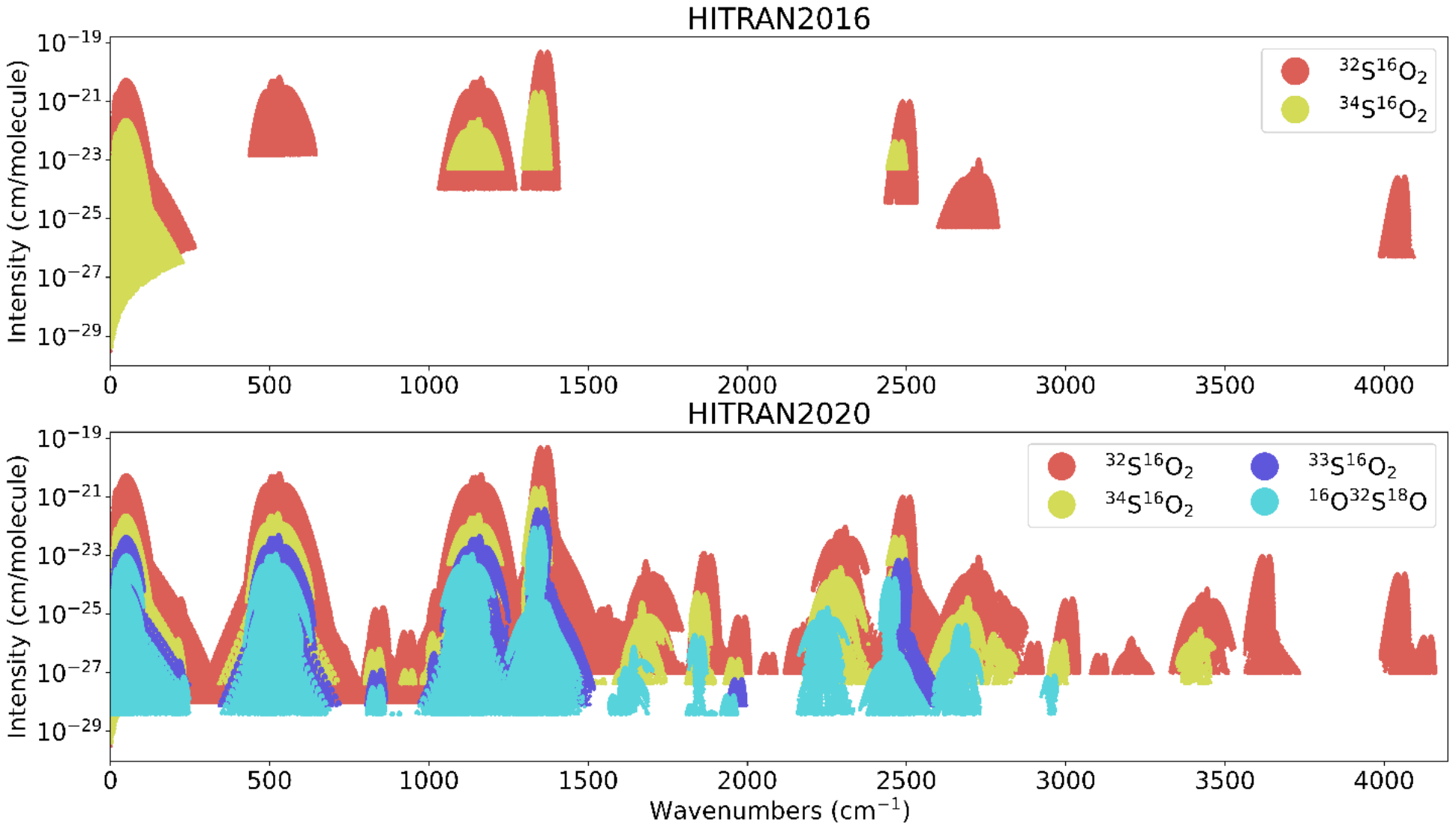
If you use HAPI in your research or software development, please cite it using the following reference:

- R.V. Kochanov, I.E. Gordon, L.S. Rothman, P. Wcislo, C. Hill, J.S. Wilzewski, HITRAN Application Programming Interface (HAPI): A comprehensive approach to working with spectroscopic data, *J. Quant. Spectrosc. Radiat. Transfer* **177**, 15-30 (2016) [Link to article] [ADS].

To make a reference to particular version of HAPI, use corresponding DOI from the Zenodo community in addition to the reference given above.

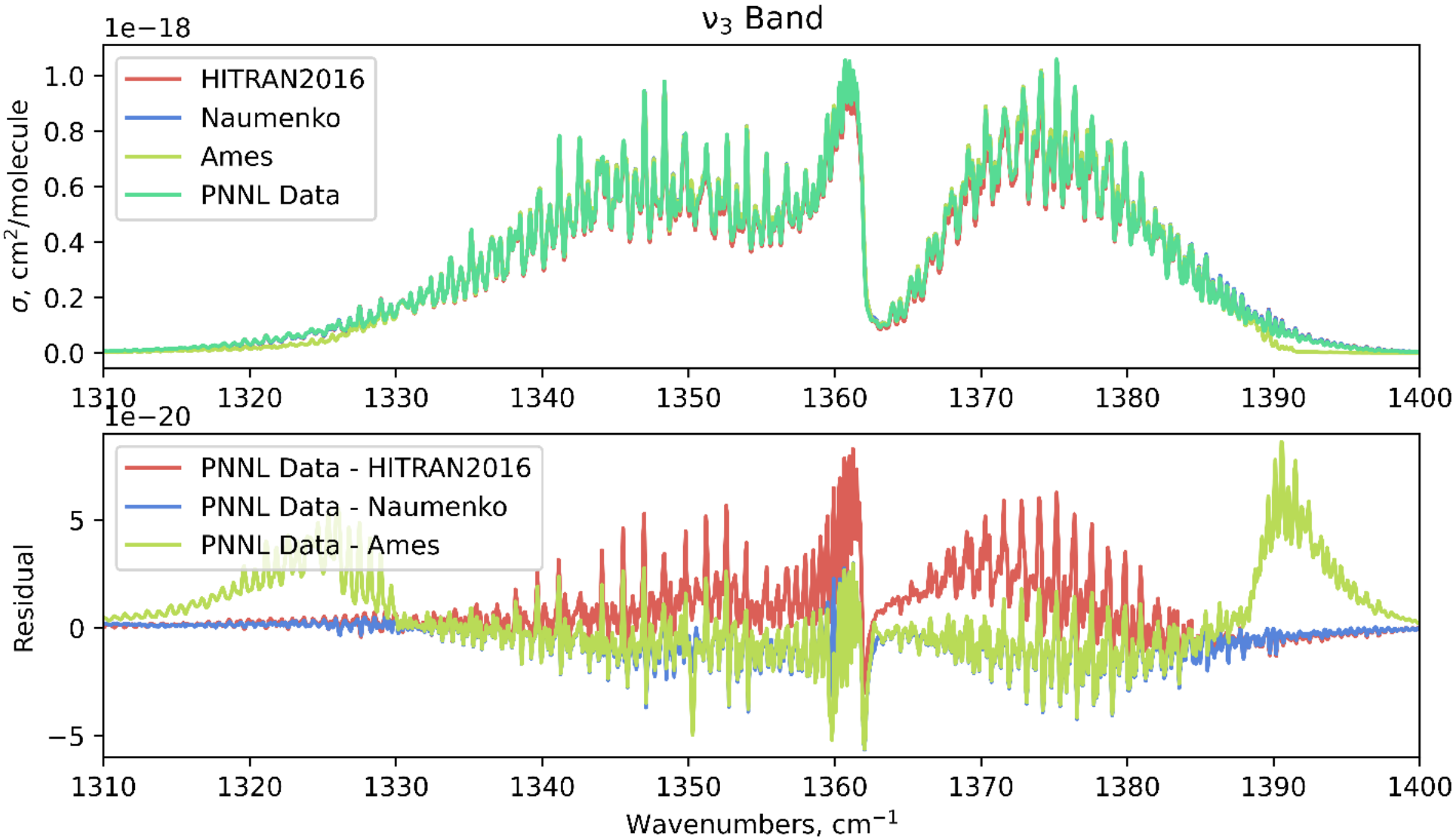
www.hitran.org/hapi

Improved parameters, new bands, isotopologues



Other examples include NO, NO_2, OCS, HCN, HCOOH etc…

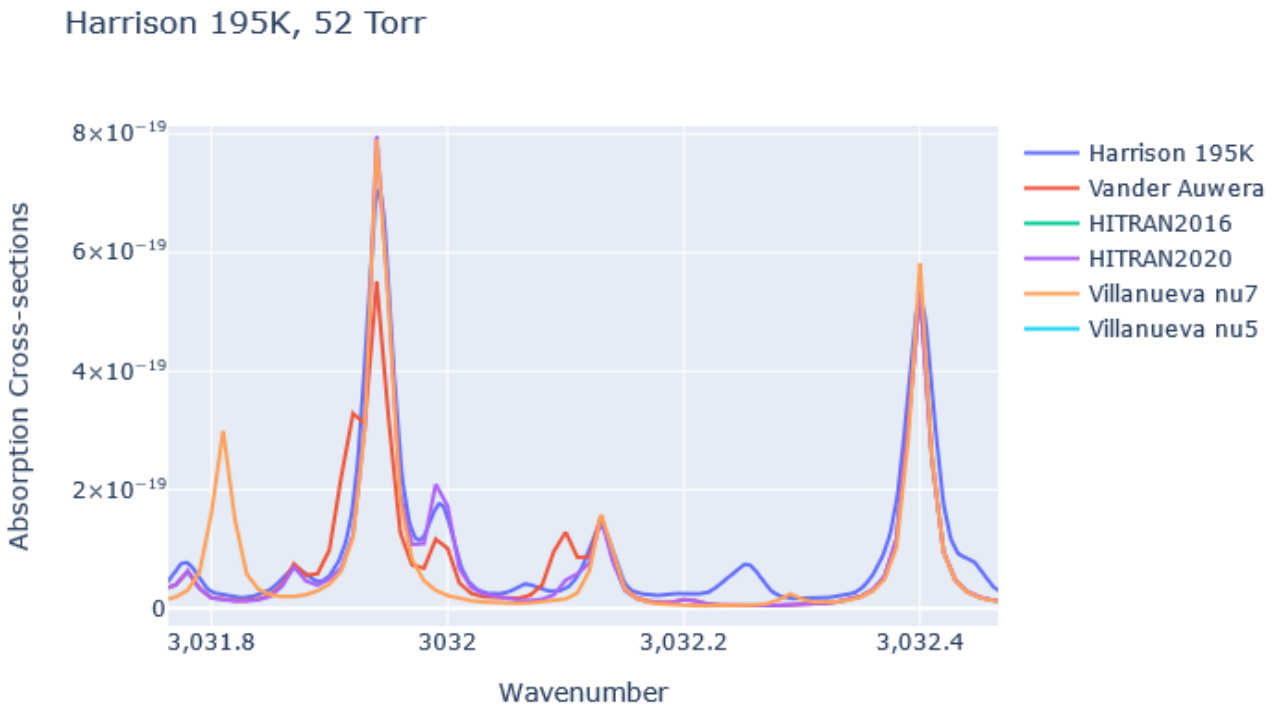
Improved parameters, new bands, isotopologues

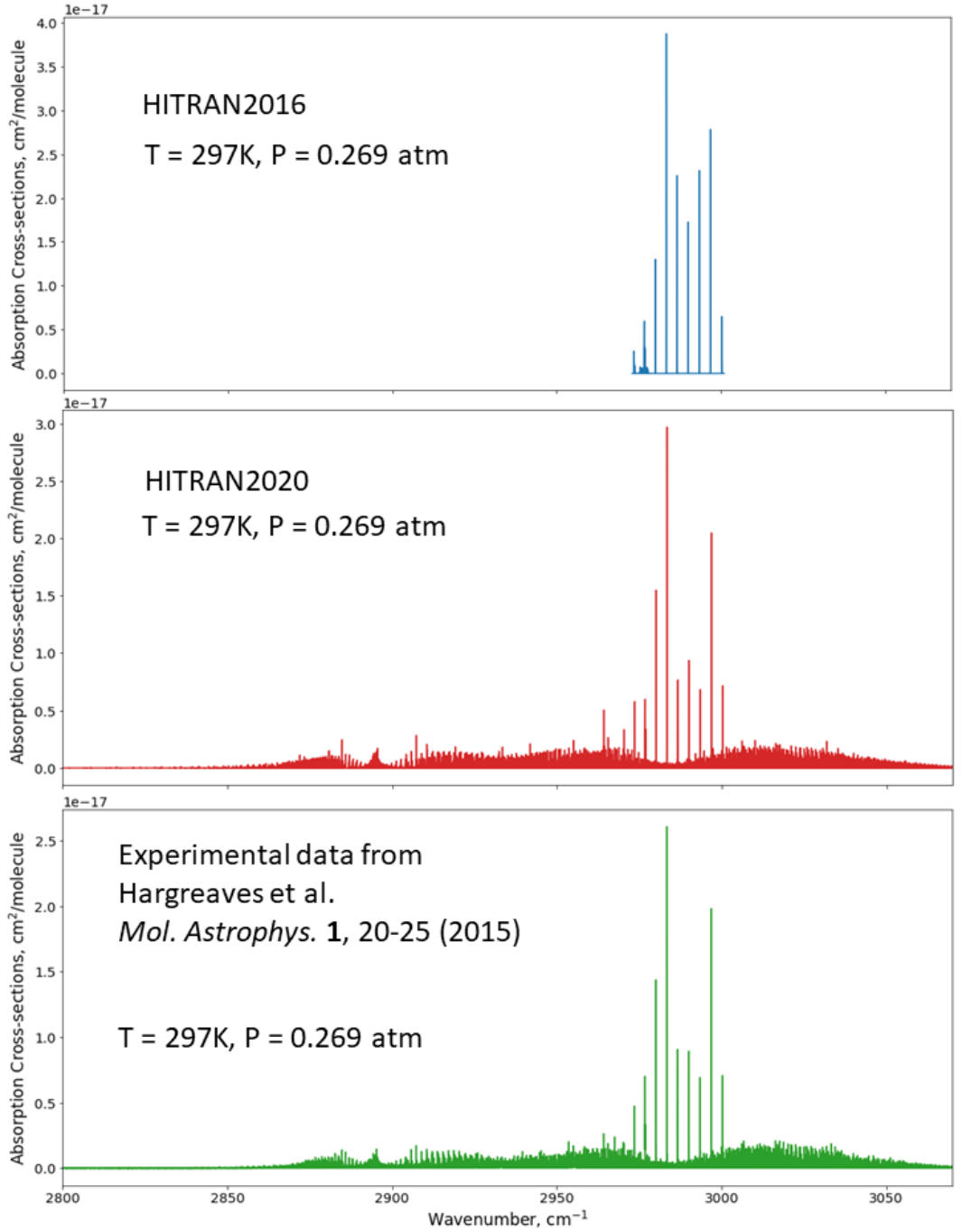


- Validated against PNNL and other laboratory spectra

Naumenko data used for HITRAN2020 in this region

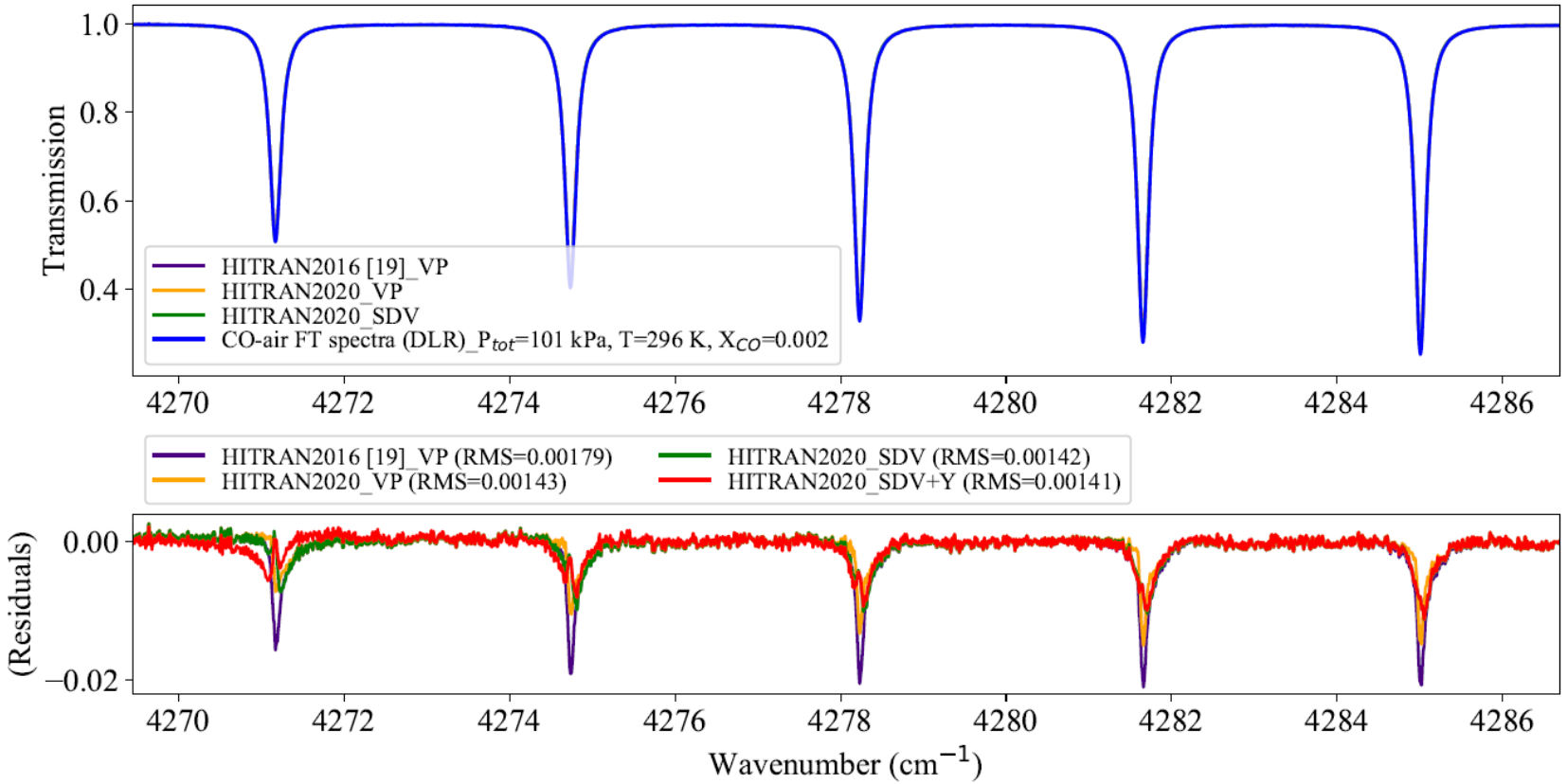
Improved parameters, new bands (e.g. C_2H_6)





Non-Voigt line shapes

- Apart from Voigt HITRAN accommodates Hartman-Tran, SDV and Galatry profiles
- Example: every line of CO_2, N_2O and CO now has speed-dependent Voigt and first order line mixing parameters.

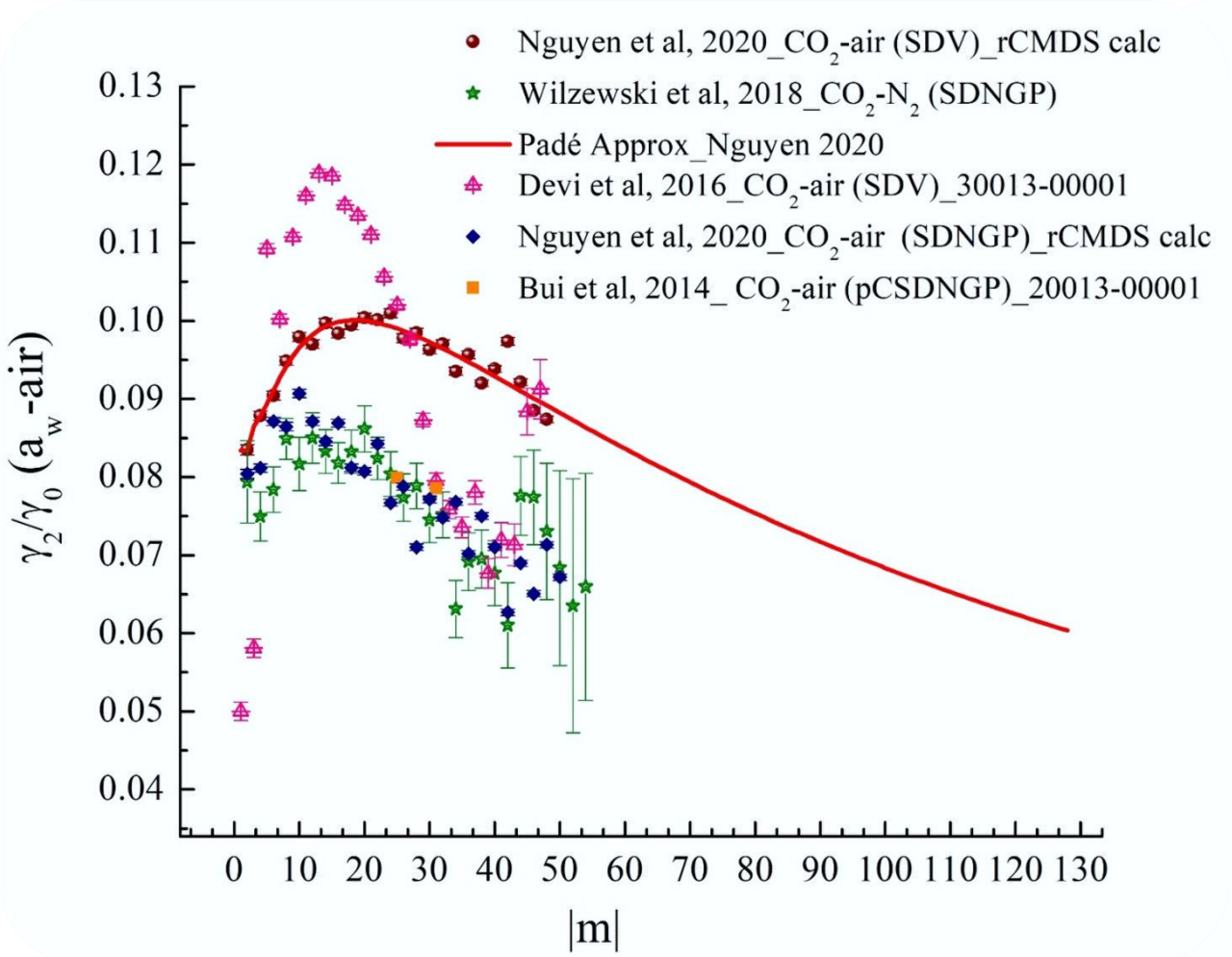


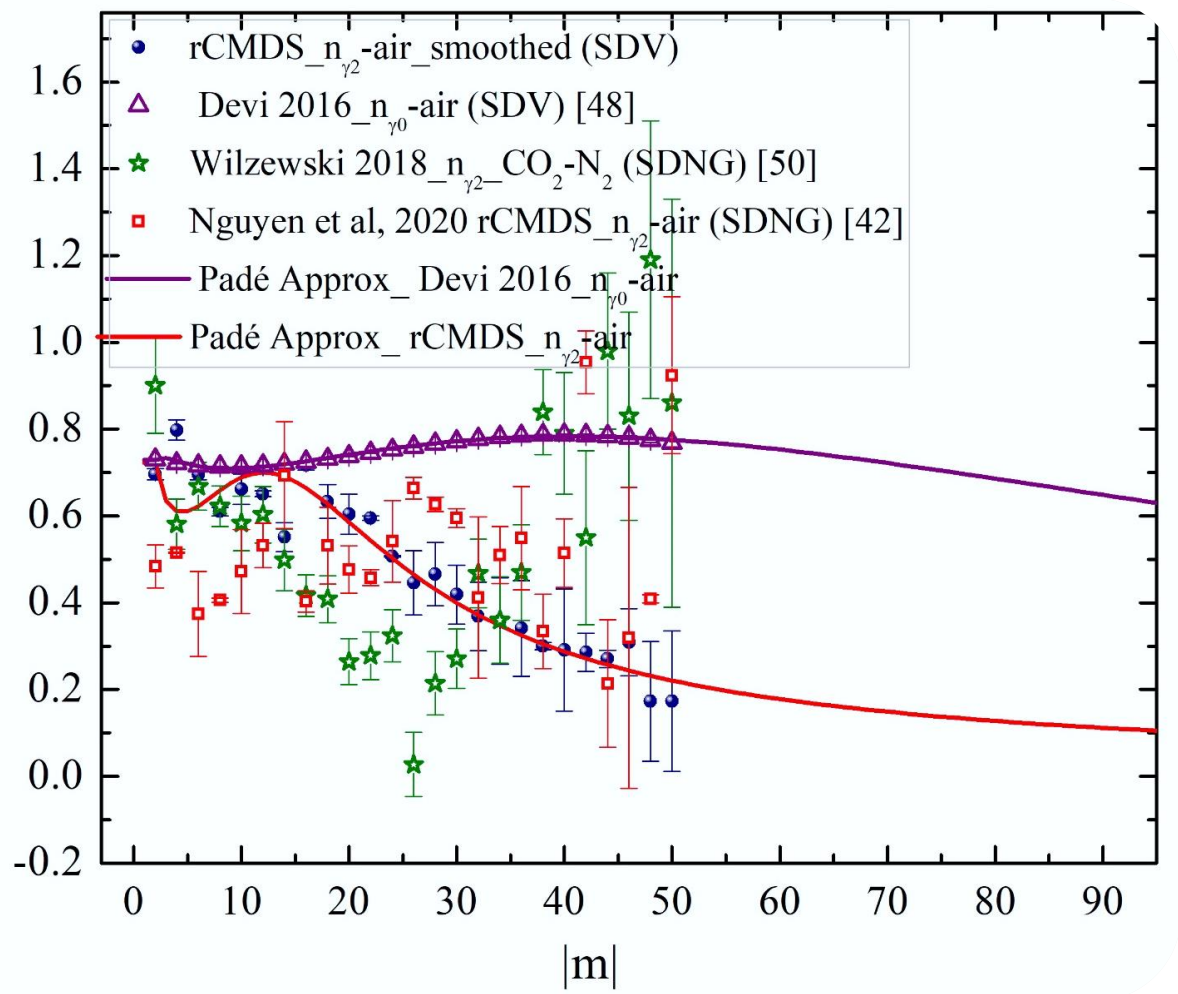
SDV parameters[b]	Common notation
Half-widths	γ_0-air(SDV)
	γ_0-self(SDV)
Temp. dep. half-widths	n_{γ_0}-air(SDV)
	n_{γ_0}-self(SDV)
Speed dep. half-widths	γ_2-air(SDV)
	γ_2-self(SDV)
Temp. dep. speed dep.	n_{γ_2}-air(SDV)
	n_{γ_2}-self(SDV)
Line shifts	δ_0-air(SDV)
	δ_0-self(SDV)
First-order line-mixing	Y_{air}(SDV)
	Y_{self}(SDV)
Temp. dep. first-order	n_Y-air(SDV)
line-mixing	n_Y-self(SDV)

Hashemi et al., JQSRT(2020) 107283.
Hashemi et al., JQSRT(2021) 107735.

SDV and/or HT parameters are available for H_2 selected transitions of H_2O and O_2

Non-Voigt line shapes (CO_2)





Nguyen et al, JQSRT,242 (2020) 106729.
Bui et al, JCP, 141 (17) (2014) 174301
Devi et al, JQSRT, 177 (2016) 117-144 .

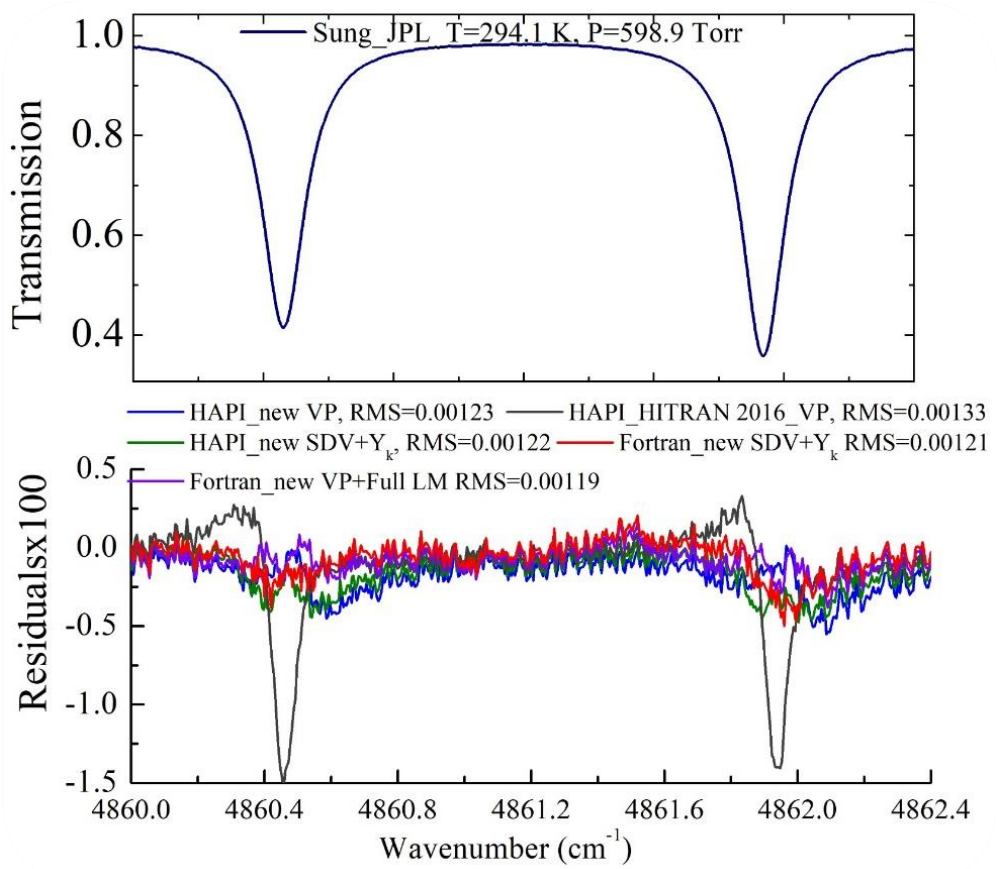
Wilzewski et al, JQSRT, 206 (2018) 296-305.
Birk et al, 2021, JQSRT (2022)
Daneshvar et al, JQSRT, 2014;149:258-74

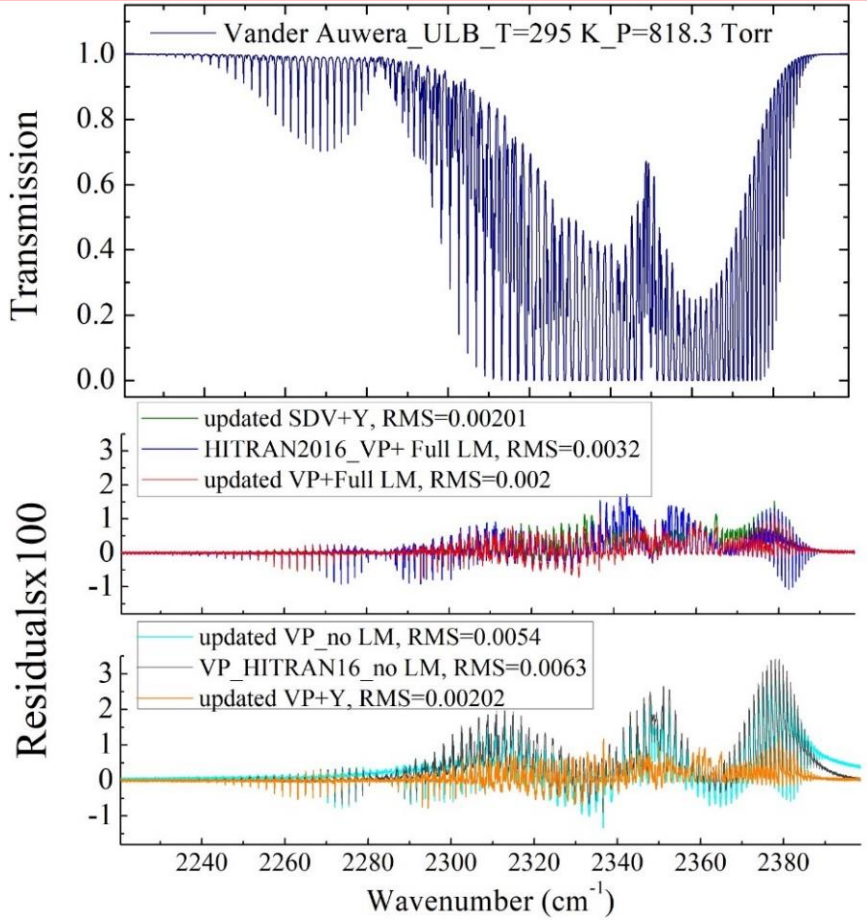
Update of the CO_2 LM package

The line mixing package for CO_2 was updated. The approach by Lamouroux et al. (2015) is used for predicting the line-mixing effect in all the bands of CO_2 either accounting for the full line mixing (W) or the first-order approximation (Y):

1) VP+ first order LM
2) VP+ full LM
3) SDV+ first-order LM. This Fortran package is available at HITRAN*online*: https://hitran.org/supplementary/

Validation using laboratory spectra





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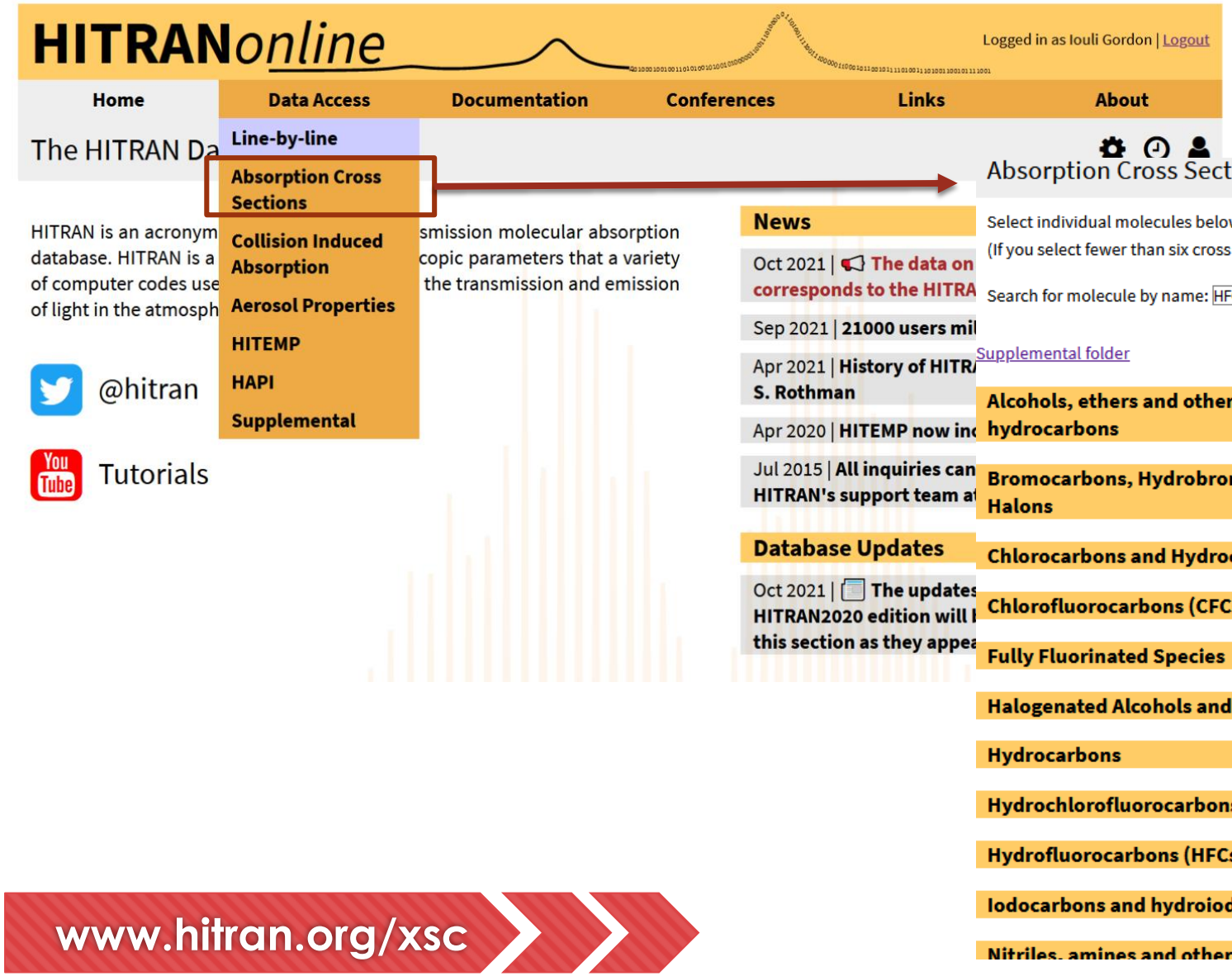
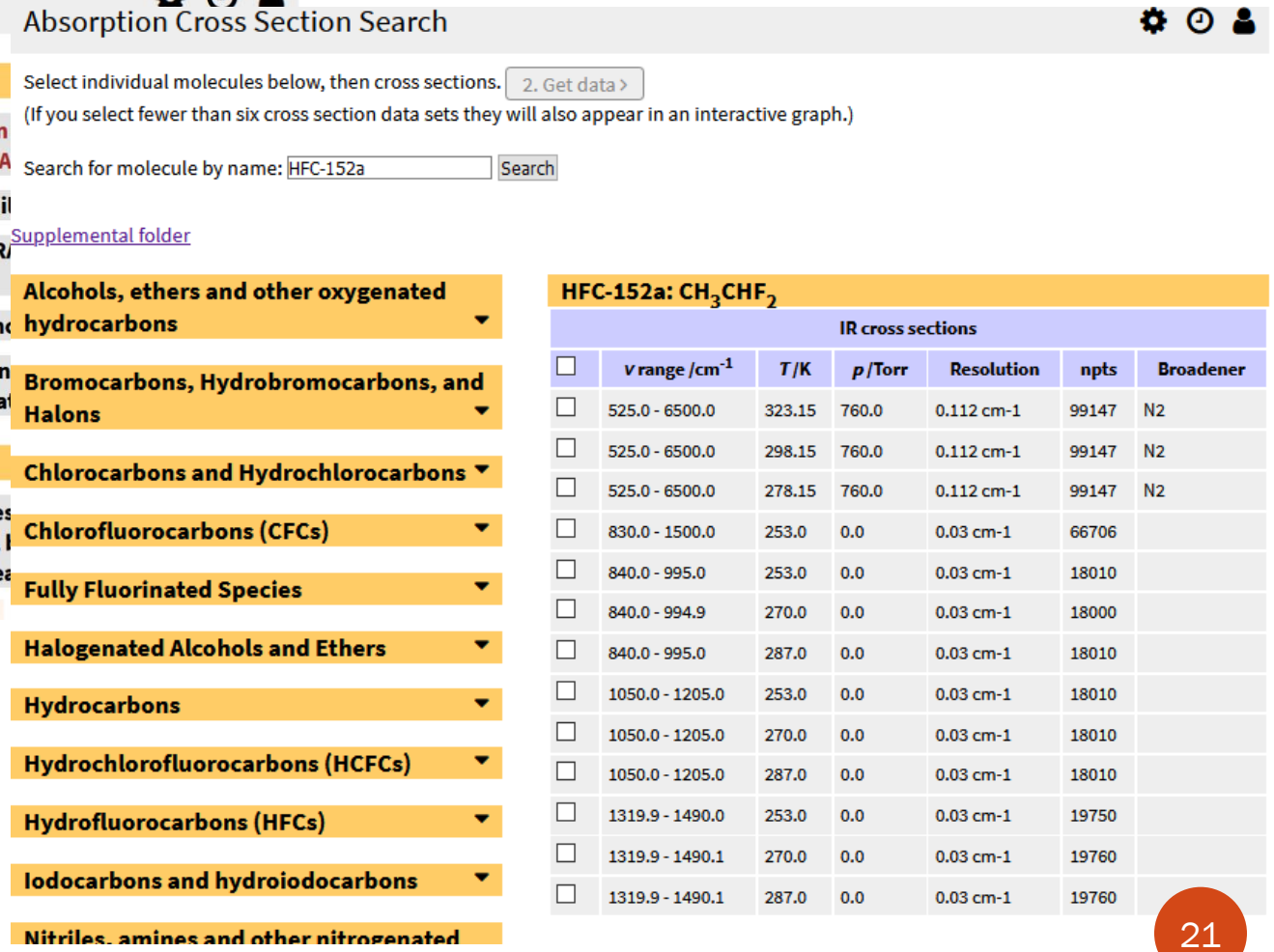




	ν range /cm-1	T/K	p/Torr	Resolution	npts	Broadener
☐	525.0 - 6500.0	323.15	760.0	0.112 cm-1	99147	N2
☐	525.0 - 6500.0	298.15	760.0	0.112 cm-1	99147	N2
☐	525.0 - 6500.0	278.15	760.0	0.112 cm-1	99147	N2
☐	830.0 - 1500.0	253.0	0.0	0.03 cm-1	66706	
☐	840.0 - 995.0	253.0	0.0	0.03 cm-1	18010	
☐	840.0 - 994.9	270.0	0.0	0.03 cm-1	18000	
☐	840.0 - 995.0	287.0	0.0	0.03 cm-1	18010	
☐	1050.0 - 1205.0	253.0	0.0	0.03 cm-1	18010	
☐	1050.0 - 1205.0	270.0	0.0	0.03 cm-1	18010	
☐	1050.0 - 1205.0	287.0	0.0	0.03 cm-1	18010	
☐	1319.9 - 1490.0	253.0	0.0	0.03 cm-1	19750	
☐	1319.9 - 1490.1	270.0	0.0	0.03 cm-1	19760	
☐	1319.9 - 1490.1	287.0	0.0	0.03 cm-1	19760	

www.hitran.org/xsc

Cross sections (.xsc)

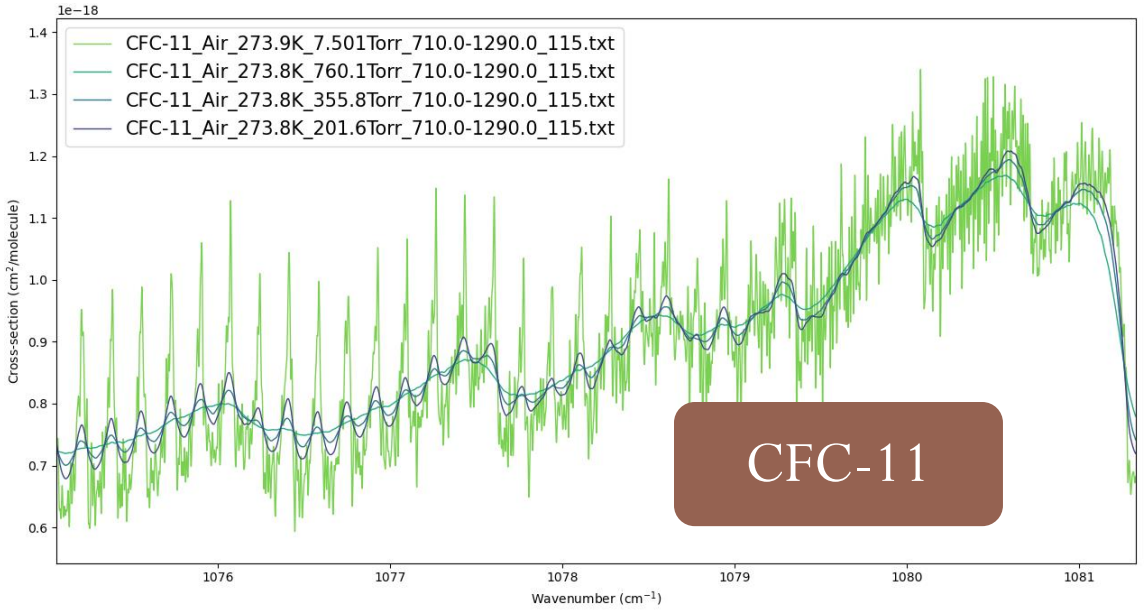
Molecule	Temperature range (K)	Pressure range (Torr)	Number of P,T sets	Spectral range (cm^{-1})
CCl_3F (CFC-11)	192 – 293	7.5 – 760	30	710 – 1290
CH_3CCl_2F (HCFC-141b)	188 – 295	7.5 – 761	30	705 – 1280
SF_6	189 – 294	7.5 – 751	37	780 – 1100
CF_4 (CFC-14)	190 – 296	7.5 – 760	34	1190 – 1336

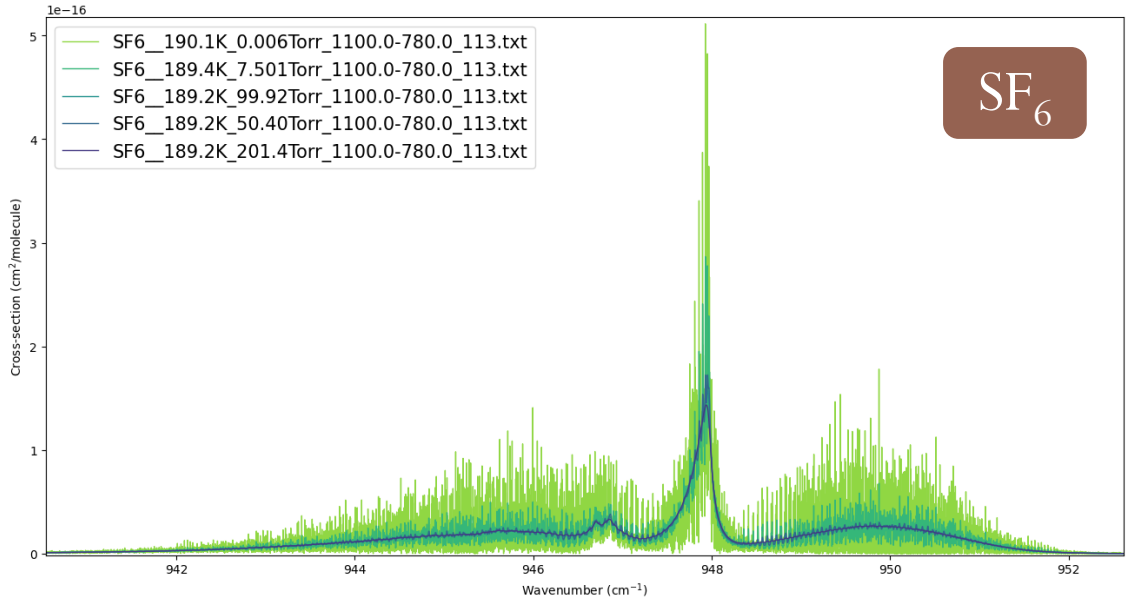
Harrison (2018), AMT 11, 5827-5836

Harrison (2019), JQSRT 238, 106489

Harrison (2020), JQSRT 254, 107202

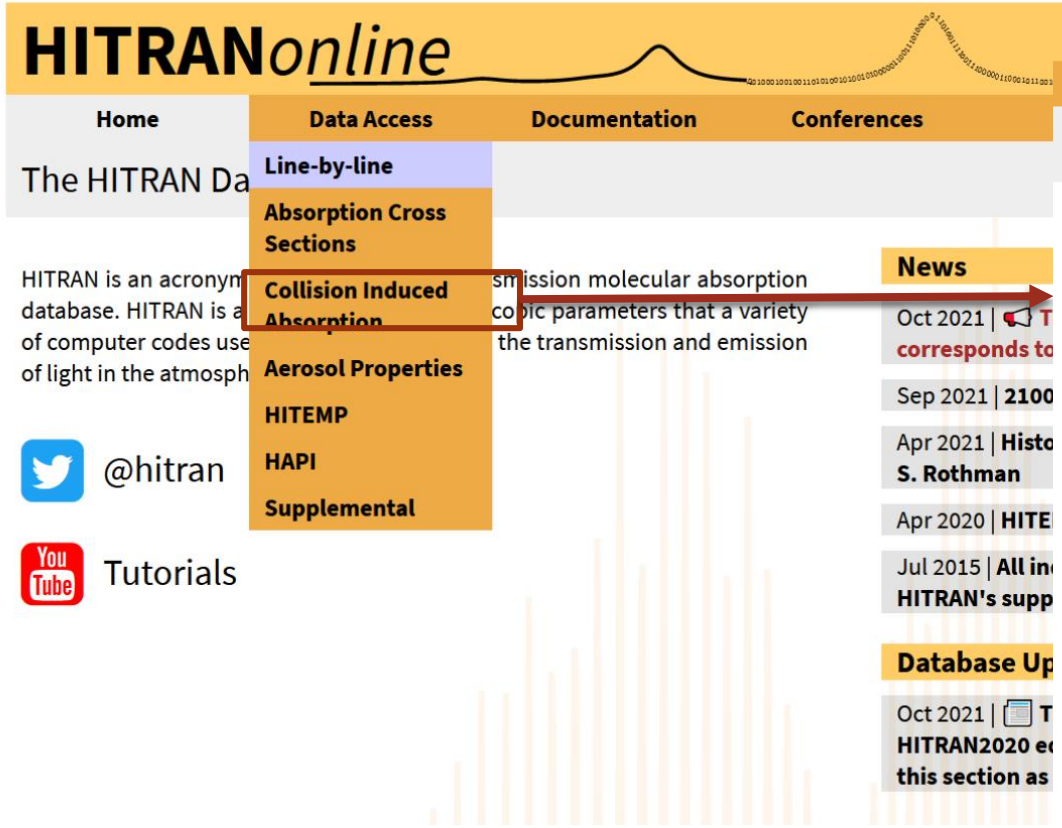
Harrison (2021), JQSRT 260, 107432

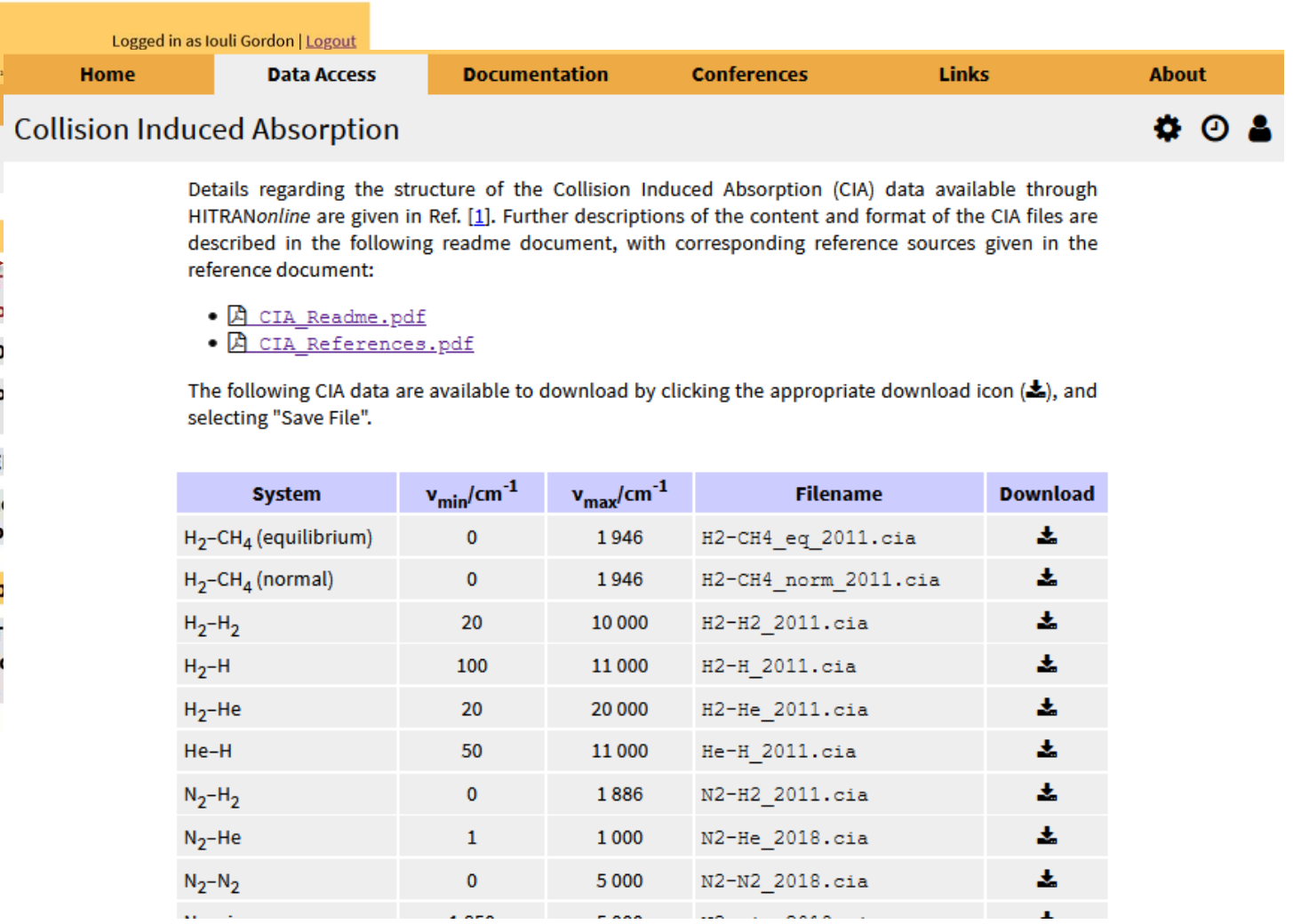




- Also added UV and planetary relevant cross-sections

Modern structure and interface at www.hitran.org

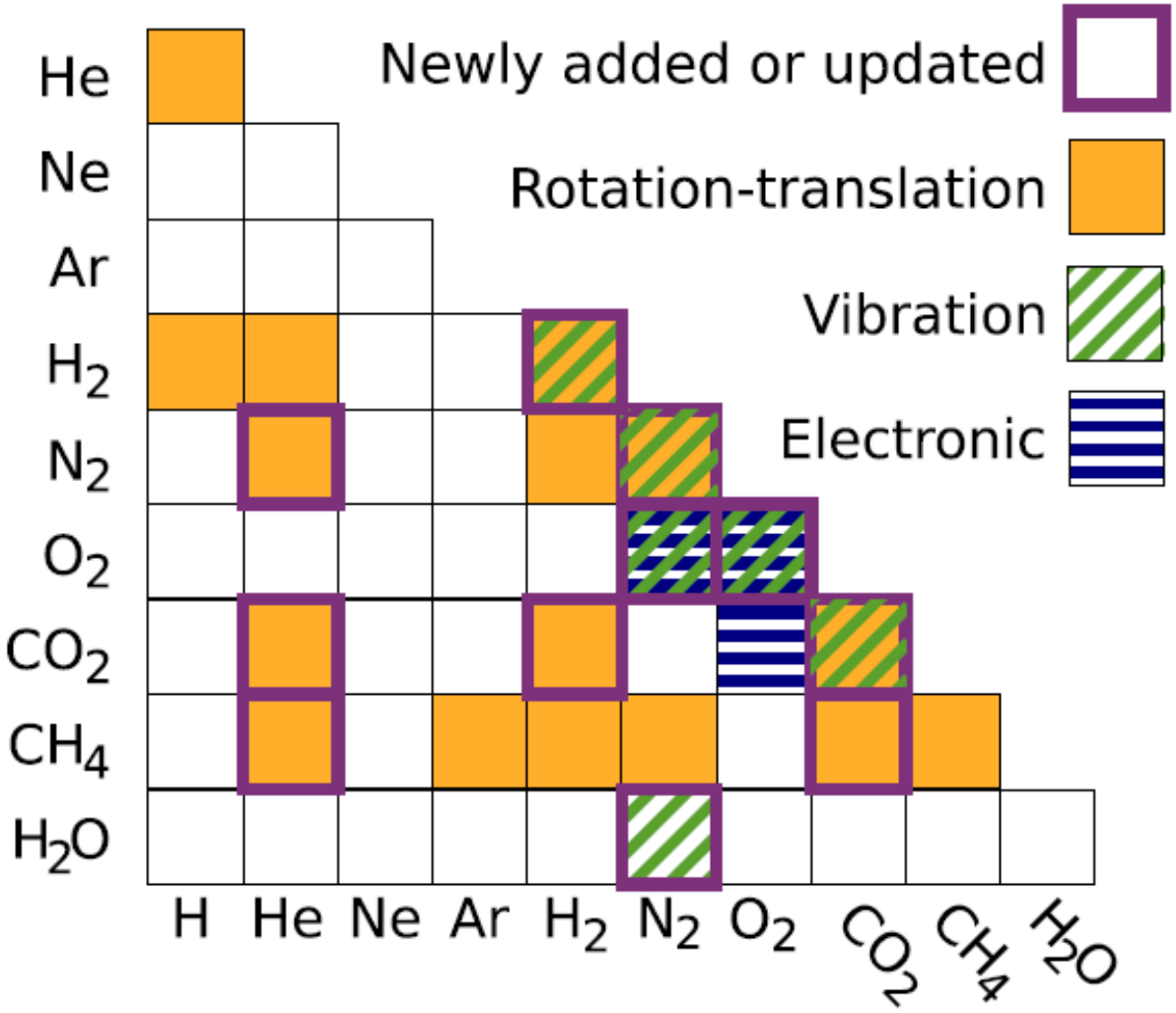


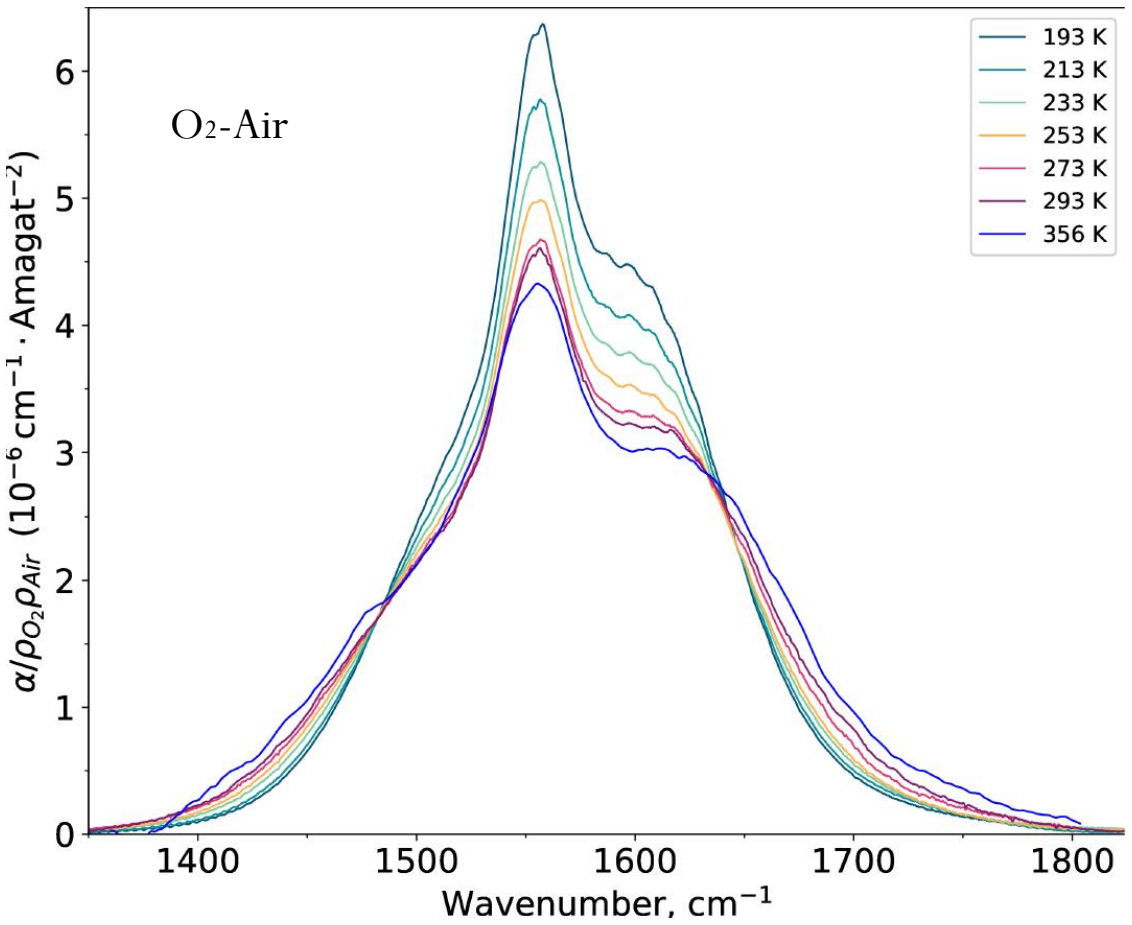


System	ν_{min}/cm^{-1}	ν_{max}/cm^{-1}	Filename	Download
H_2-CH_4 (equilibrium)	0	1 946	H2-CH4_eq_2011.cia	
H_2-CH_4 (normal)	0	1 946	H2-CH4_norm_2011.cia	
H_2-H_2	20	10 000	H2-H2_2011.cia	
H_2-H	100	11 000	H2-H_2011.cia	
H_2-He	20	20 000	H2-He_2011.cia	
He-H	50	11 000	He-H_2011.cia	
N_2-H_2	0	1 886	N2-H2_2011.cia	
N_2-He	1	1 000	N2-He_2018.cia	
N_2-N_2	0	5 000	N2-N2_2018.cia	

www.hitran.org/cia

Update of the CIA section





Update to update

Karman, *et al.*, "Update of the HITRAN collision-induced absorption section", *Icarus* 328 (2019) 160-175.

Referencing the original sources

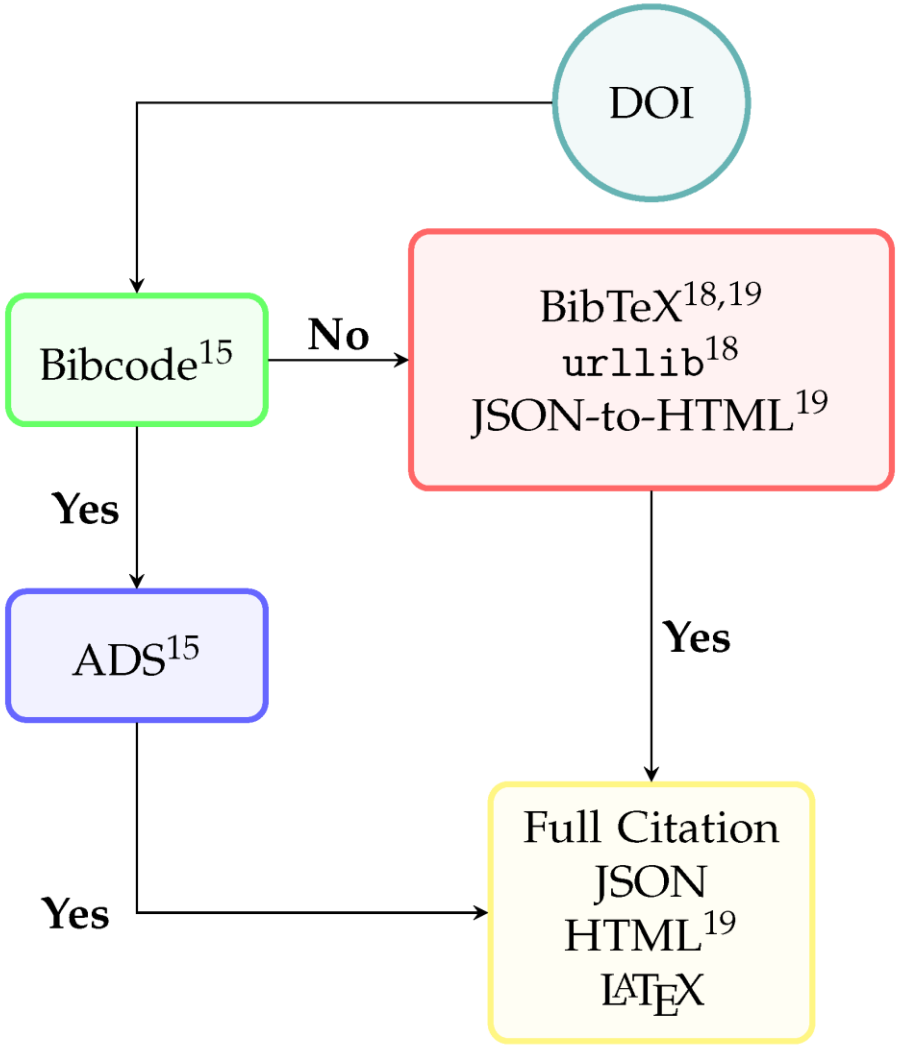
Open Access | Editor's Choice | Article

Referencing Sources of Molecular Spectroscopic Data in the Era of Data Science: Application to the HITRAN and AMBDAS Databases

by Frances M. Skinner [1,2,*], Iouli E. Gordon [1,*], Christian Hill [3,*], Robert J. Hargreaves [1], Kelly E. Lockhart [4] and Laurence S. Rothman [1]

1 Atomic and Molecular Physics, Center for Astrophysics|Harvard & Smithsonian, Cambridge, MA 02138, USA
2 Undergraduate Chemistry Department, University of Massachusetts Lowell, Lowell, MA 01854, USA
3 Nuclear Data Section, International Atomic Energy Agency, Vienna International Centre, PO Box 100, A-1400 Vienna, Austria
4 The SAO/NASA Astrophysics Data System (ADS), Center for Astrophysics|Harvard & Smithsonian, Cambridge, MA 02138, USA
* Authors to whom correspondence should be addressed.

Atoms **2020**, *8*(2), 16; **https://doi.org/10.3390/atoms8020016**



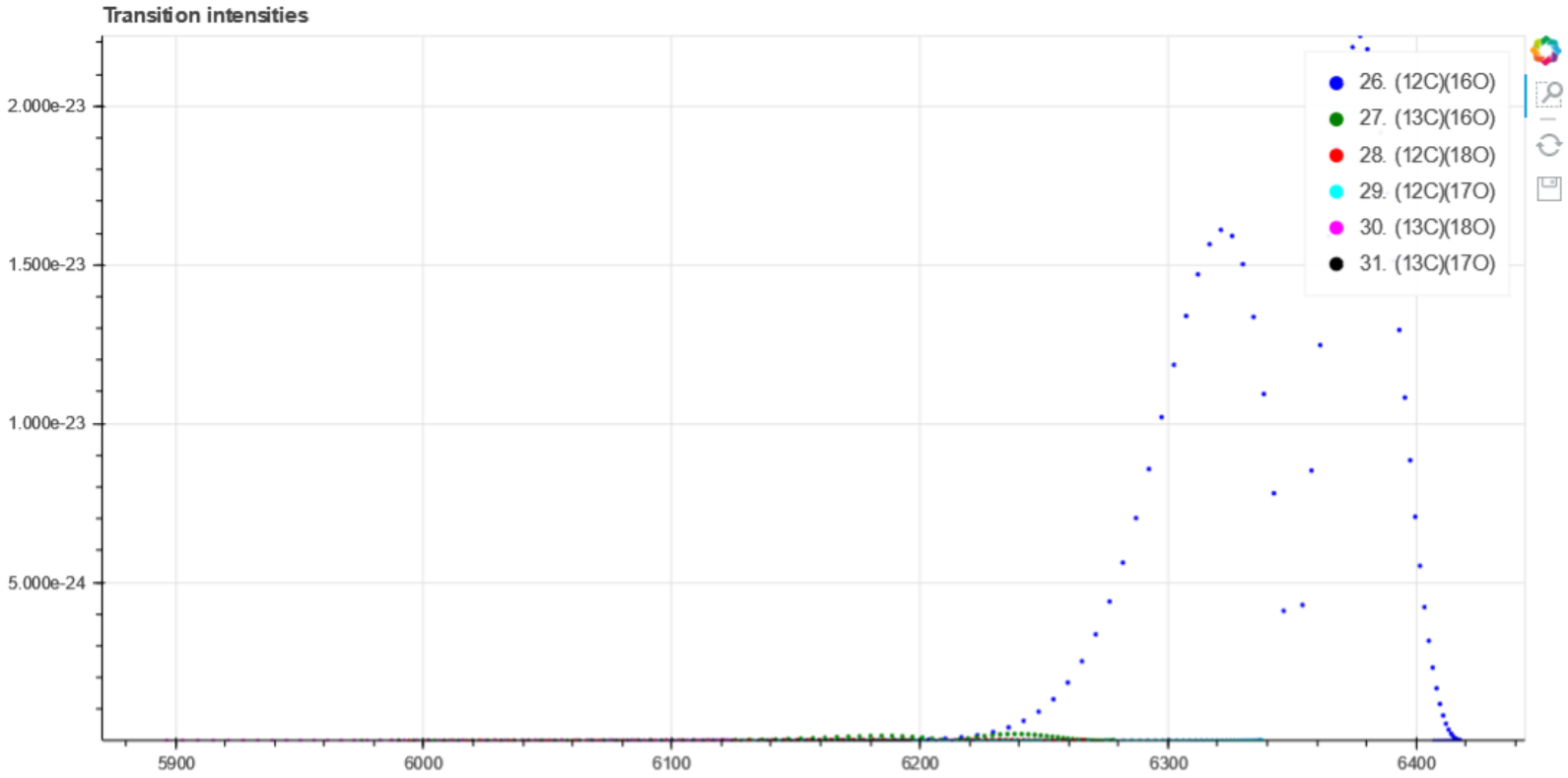
Search Results

708 transitions written in 4.02 secs (query time: 0.05 secs).

Downloads

3 output files were generated using the output format *.par (160 chars)*.

6167df73.par	[112.0 KB]	view in browser	Output transitions data (160-character .par format)
6167df73.bib.html	[8.9 KB]	view in browser	List of sources (html format)
6167df73.bib	[4.8 KB]	view in browser	List of sources (BibTeX format)



Hover the mouse pointer over parameters below for citation and notes.

Isotopologue	ν	S	A	γ_{air}	γ_{self}	E''	n_{air}	δ_{air}	J'	J''
$^{13}C^{18}O$	5896.4479	1.219e-31	0.003468	0.0432	0.046	1953.1202	0.67	-0.009	32	33
$^{13}C^{18}O$	5902.7851	2.084e-31	0.003514	0.0438	0.046	1838.582	0.67	-0.009	31	32
$^{13}C^{18}O$	5909.0354	3.501e-31	0.00356	0.0443	0.047	1727.4728	0.67	-0.009	30	31

Referencing Multiple Sources

$^{12}C^{18}O$	6140.6839	1.337e-26	0.005193	0.0553	0.059	384.2612	0.72	-0.007	13	14
$^{12}C^{17}O$	6141.6383	4.729e-29	0.004659	0.0471	0.05	1312.6581	0.67	-0.008	25	26
$^{13}C^{17}O$	6141.6494	4.207e-29	0.005023	0.0712	0.077	10.7362	0.74	-0.005	3	2
$^{13}C^{16}O$	6141.8175	4.83e-26	0.005089	0.0538	0.058	499.5146	0.7	-0.008	15	16
$^{12}C^{18}O$	6141.9807	5.238e-30	0.02402	0.0651	0.071	2128.4137	0.74	-0.006	5	4
$^{12}C^{17}O$	6143.0759	5.324e-31	0.02364	0.0569	0.062	2405.8643	0.74	-0.007	11	12
$^{13}C^{16}O$	6143.5520	1.317e-29	0.02055	0.0757	0.081	2099.7101	0.75	-0.005	2	1
$^{12}C^{16}O$	6144.8286	2.448e-29	0.02102	0.0477	0.051	3378.9537	0.67	-0.008	24	25
$^{13}C^{17}O$	6144.8503	5.389e-29	0.00528	0.0677	0.074	21.472	0.74	-0.006	4	3
$^{12}C^{16}O$	6144.8924									
$^{12}C^{18}O$	6145.0227									
$^{12}C^{18}O$	6145.6023									
$^{13}C^{16}O$	6146.9004									
$^{13}C^{16}O$	6146.9495									
$^{12}C^{16}O$	6147.0017									
$^{12}C^{17}O$	6147.8670									
$^{12}C^{17}O$	6147.8924									
$^{13}C^{17}O$	6147.9565									
$^{12}C^{18}O$	6147.9662									
$^{12}C^{16}O$	6149.7093									
$^{13}C^{16}O$	6150.1502									
$^{12}C^{18}O$	6150.4248									
$^{12}C^{18}O$	6150.8113									
$^{13}C^{17}O$	6150.9677									
$^{12}C^{16}O$	6151.1146	3.767e-29	0.02131	0.0483	0.051	3284.0846	0.67	-0.008	23	24
$^{13}C^{16}O$	6151.9853	7.522e-26	0.005251	0.0553	0.059	385.7275	0.72	-0.007	13	14
$^{12}C^{17}O$	6152.6093	6.876e-31	0.02448	0.0586	0.064	2320.5079	0.75	-0.007	9	10
$^{13}C^{16}O$	6153.3014	2.911e-29	0.0243	0.0651	0.071	2132.4969	0.74	-0.006	5	4
$^{12}C^{18}O$	6153.5578	6.259e-30	0.02638	0.0595	0.065	2222.7523	0.75	-0.006	9	8

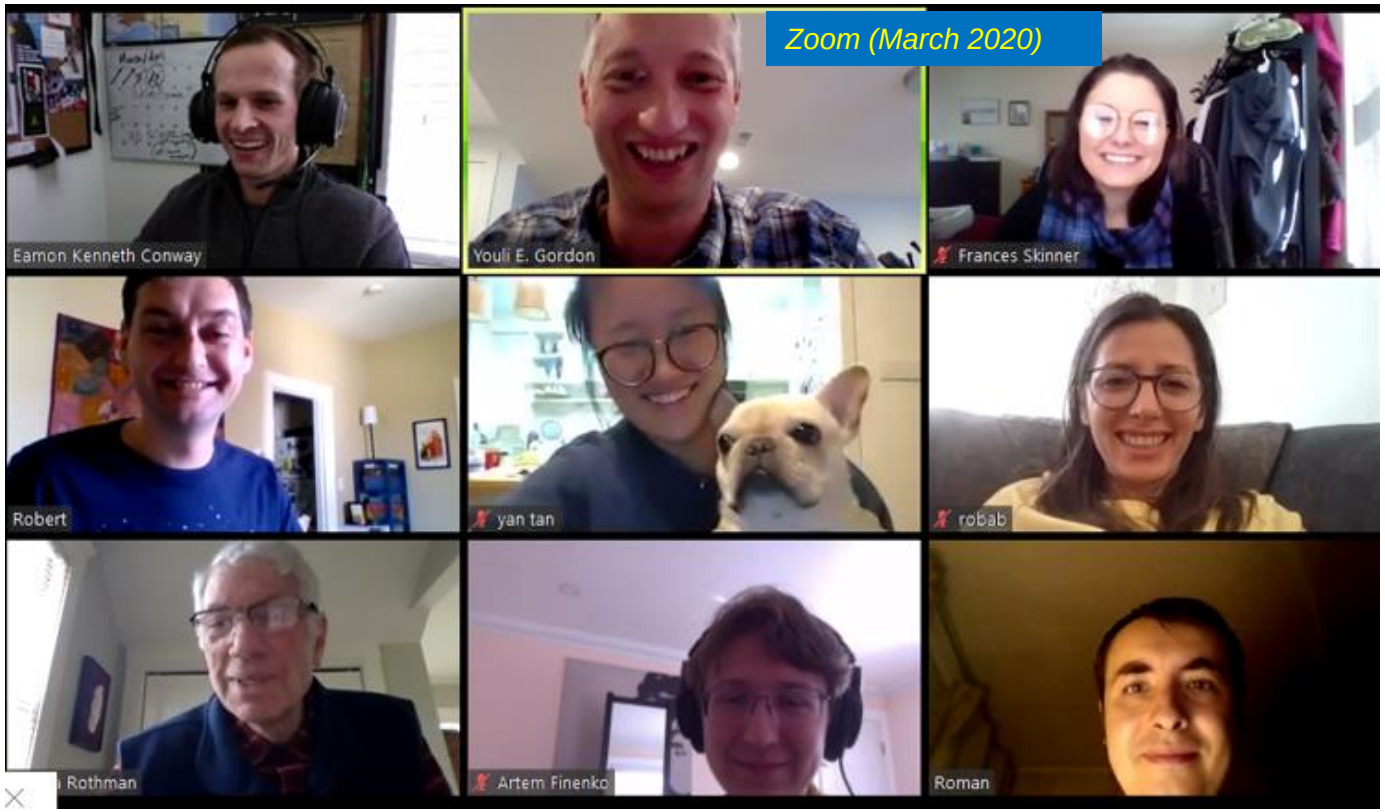
1326. I.E. Gordon (2020). Intensities of the bands with Δv=3 from Ref. [1326a] were multiplied by a factor 1.026 based on the experimental works from Ref. [1326b] and Ref. [1326c]..

- 1326a. G. Li, I.E. Gordon, L.S. Rothman, Y. Tan, S.-M. Hu, S. Kassi, A. Campargue, E.S. Medvedev, "Rovibrational Line Lists for Nine Isotopologues of the CO Molecule in the $X^1\Sigma^+$ Ground Electronic State", *The Astrophysical Journal Supplement Series* **216**15 (2015). [link to article] [ADS]
- 1326b. A. Cygan, P. Wcisło, S. Wójtewicz, G. Kowzan, M. Zaborowski, D. Charczun, K. Bielska, R. S. Trawiński, R. Ciuryło, P. Masłowski, D. Lisak, "High-accuracy and wide dynamic range frequency-based dispersion spectroscopy in an optical cavity", *Optics Express* **27**21810 (2019). [link to article] [ADS]
- 1326c. Y. Borkov, A. Solodov, A. Solodov, T. Petrova, E. Karlovets, V. Perevalov, "Fourier transform CO spectra near 1.6 μm", *Journal of Quantitative Spectroscopy and Radiative Transfer* **253**107064 (2020). [link to article] [ADS]

Future Updates

- Adding continuum absorption by water vapor. Working with Eli Mlawer's group at AER on parametrizing both self and foreign continuum to be included in HITRAN
- New trace species. More isotopologues for existing molecules
- More bands for trace gases, especially in the FIR/TIR
- More lines with sophisticated line shapes. The new requirements for spectral uncertainties have been reduced to 0.1%!
- More CIA and laboratory cross-sections (got permission to get the rest of PNNL). Wider temperature regimes
- Increase user engagement

Acknowledgments:



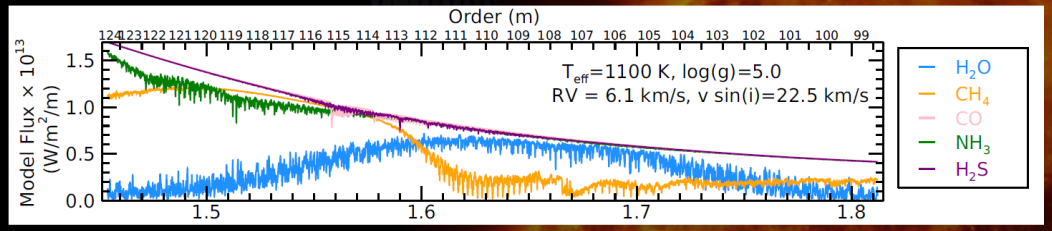
We would like to thank all the contributors and collaborators who have worked towards the HITRAN2020 edition and validated the data. It was not easy in the times of pandemic.

Development of HITRAN2020 was supported through the NASA grants: NNX17AI78G, NNX16AG51G, 80NSSC20K0962, 80NSSC20K1059.

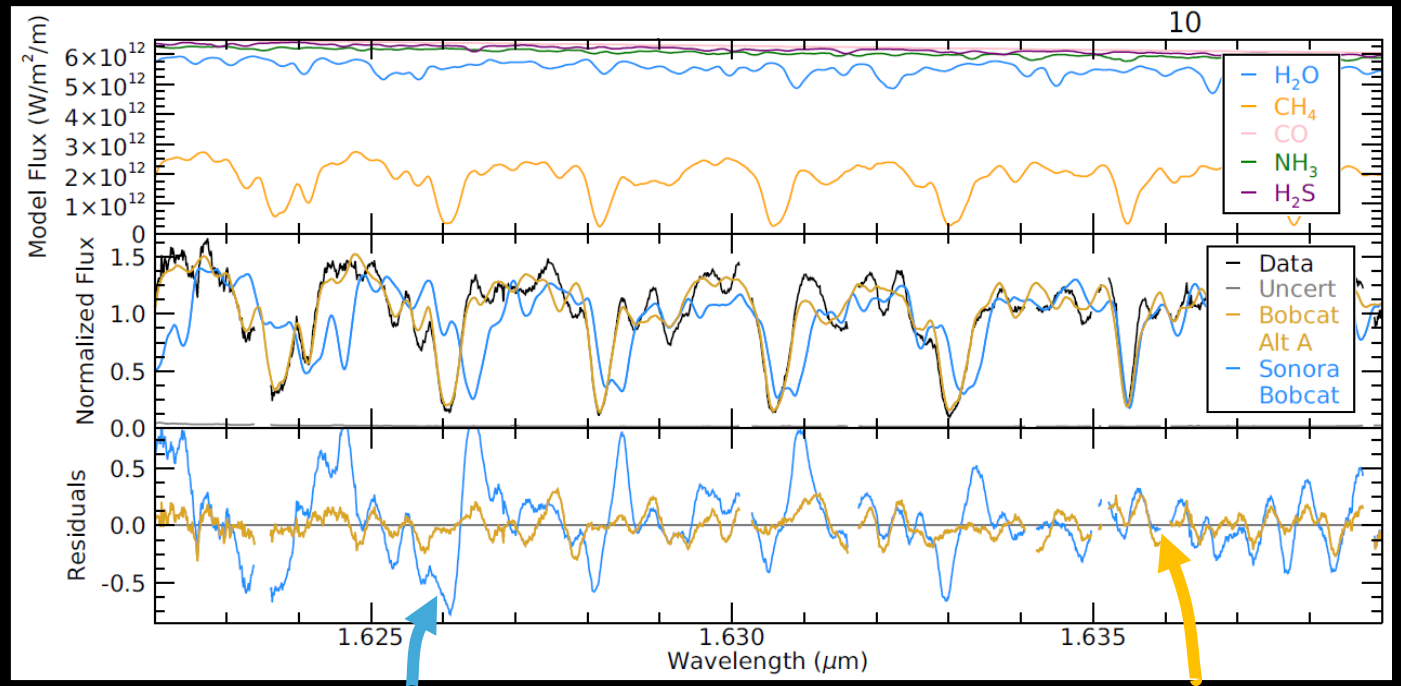
HITEMP FOR BROWN DWARFS

- T-class brown-dwarfs often referred to as “methane” dwarfs due to onset of CH_4 absorption
- *H* and *K* spectral bands used for classification

▼ H band overview from Tannock et al. (2022), MNRAS, *in press*



▼ from Tannock et al. (2022), MNRAS, *in press*



Model with ExoMol CH_4

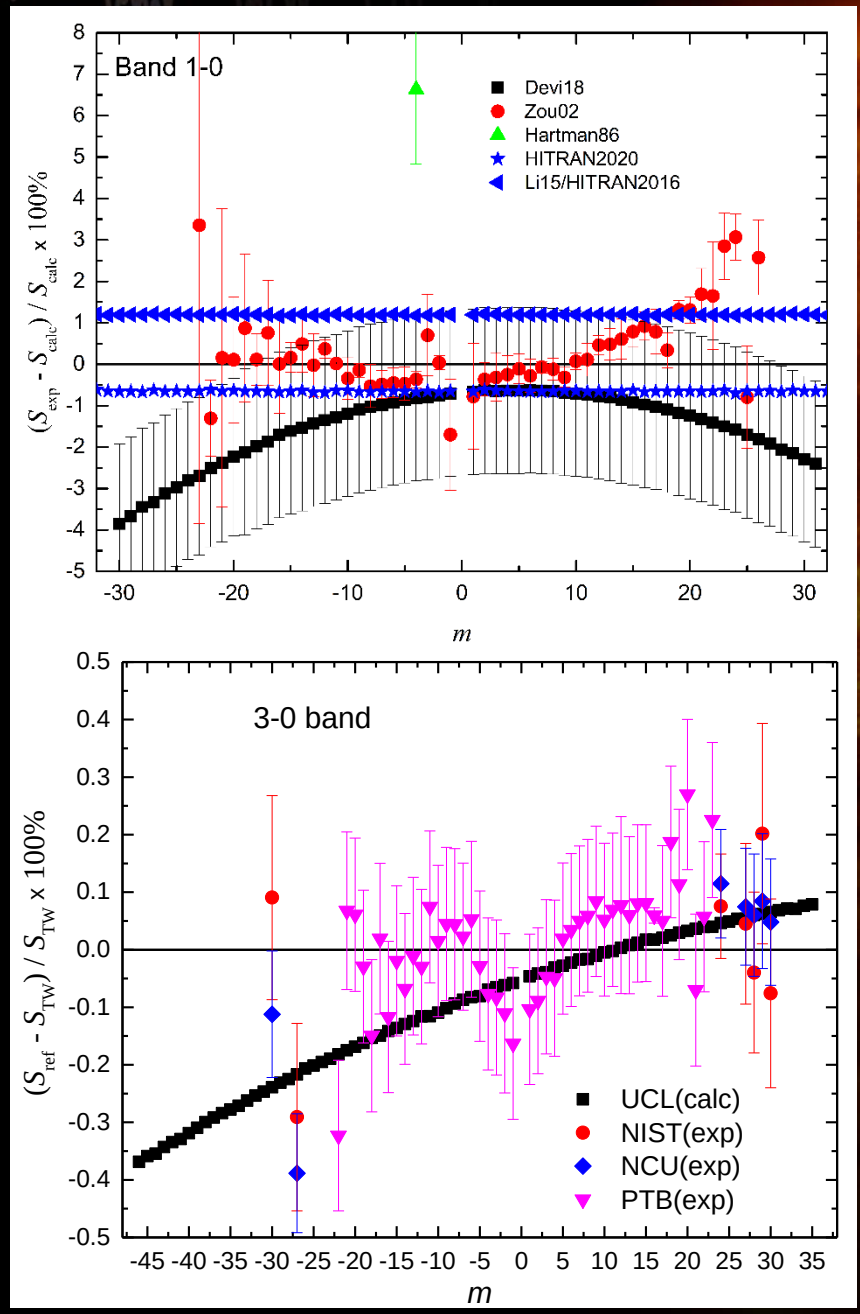
Model with HITEMP CH_4

- Tannock et al. (2022), *in press*
- 1.46–2.48 μm measurements
  - T6 (1060 K)
  - *R*=45,000 (Gemini South/IGRINS)
- **CH_4 HITEMP** list provides clear improvement for brown dwarfs models
  - “Bobcat Alt A” model

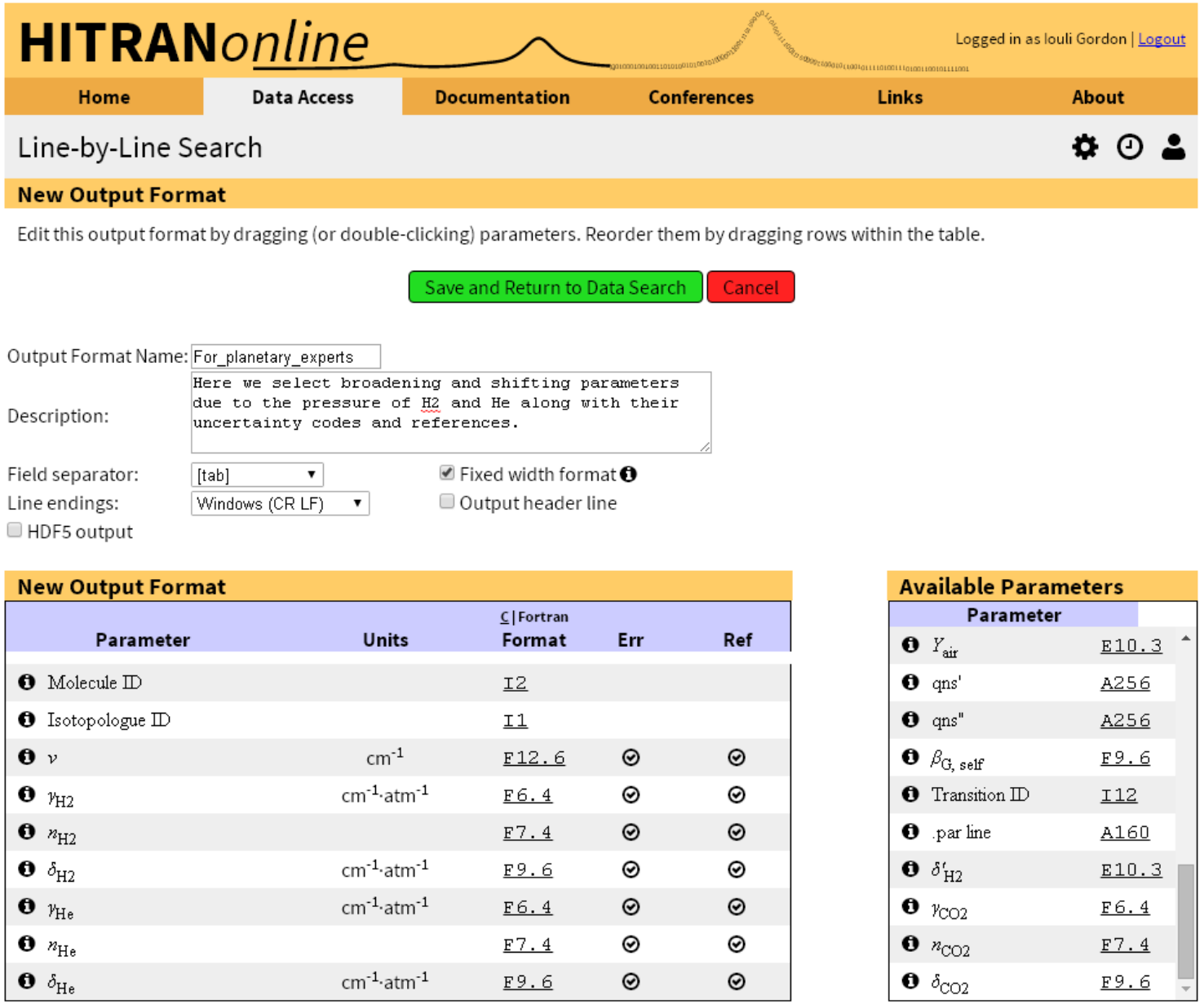
CO IMPROVEMENTS

- CO in HITEMP originates from Li et al. (2015)
- HITRAN2020 contained intensity scaling for some bands to make more consistent with modern observations
  - Not carried over to HITEMP
- New *ab initio* data from Meshkov, et al. (2022), *JQSRT* 280,108090
  - Positions and intensities can be used for updating HITRAN and HITEMP
  - Improvements shown for 1-0 and 3-0 bands
  - The 3-0 band comparison with very highly accurate experiments from Bielsja et al. (2022) Phys Rev Letters

▼ From Meshkov et al. (2022)

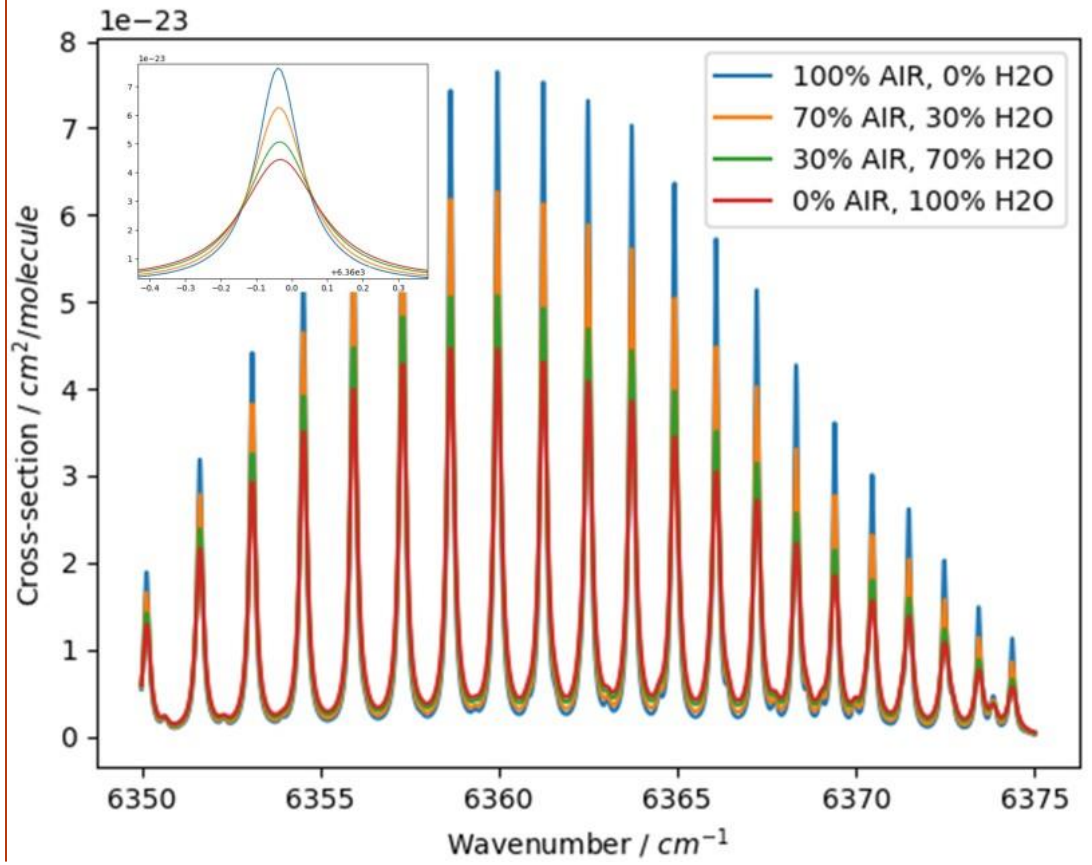


Access to different broadeners



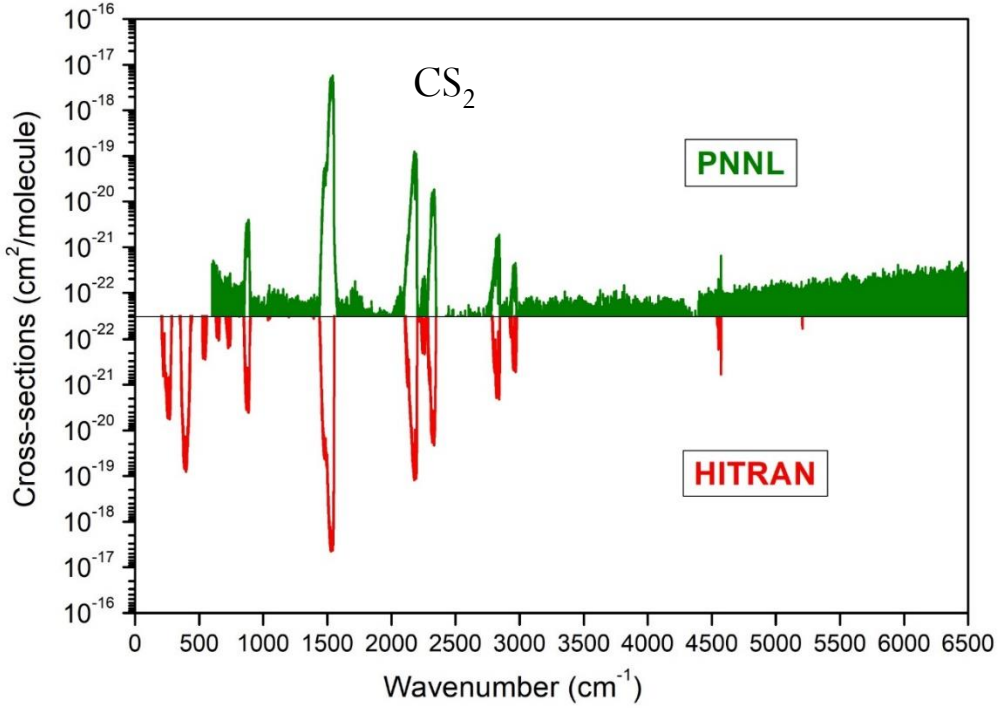
Broadening by H_2O added for the first time

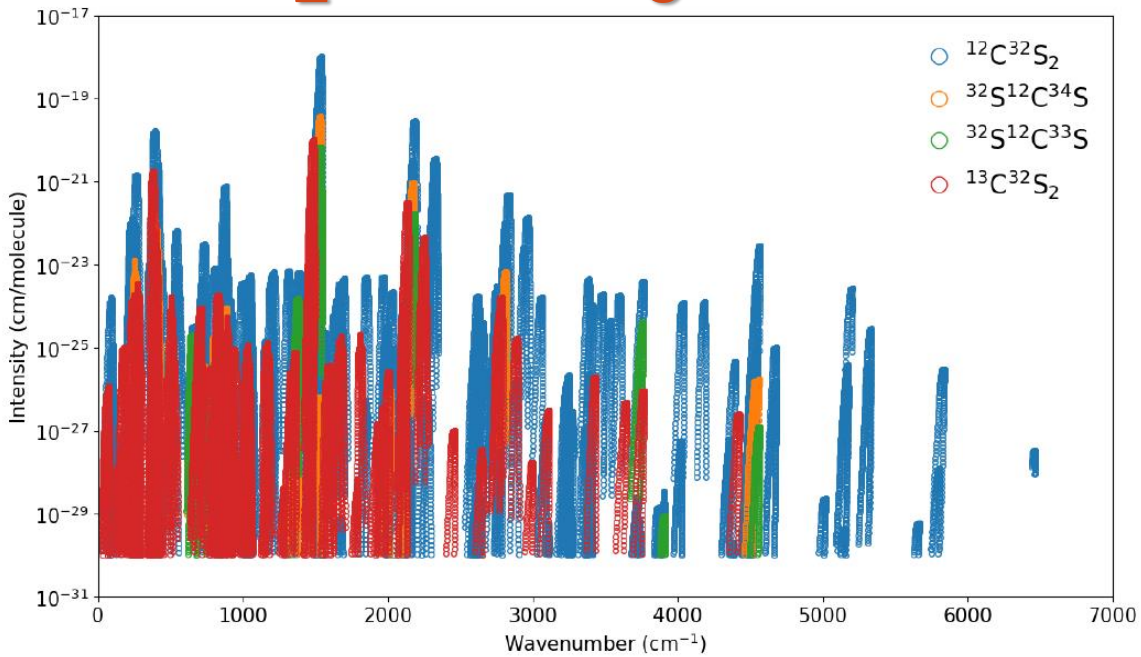
```
16  h.fetch('co2',2,1,6350.0,6375.0,
17          ParameterGroups=('voigt_h2o',))
18
19  mix = [
20          {'air':1.0,'h2o':0.0},
21          {'air':0.7,'h2o':0.3},
22          {'air':0.3,'h2o':0.7},
23          {'air':0.0,'h2o':1.0},
24      ]
25
26  leg = []
27  for d in mix:
28      leg.append(make_legend(d))
29      nu,xsc = h.absorptionCrossSection(
30          SourceTables='co2',
31          Diluent=d,
32          profile='Voigt',
33          WavenumberRange=[NUMIN,NUMAX],
34          )
35      pl.plot(nu,xsc)
```

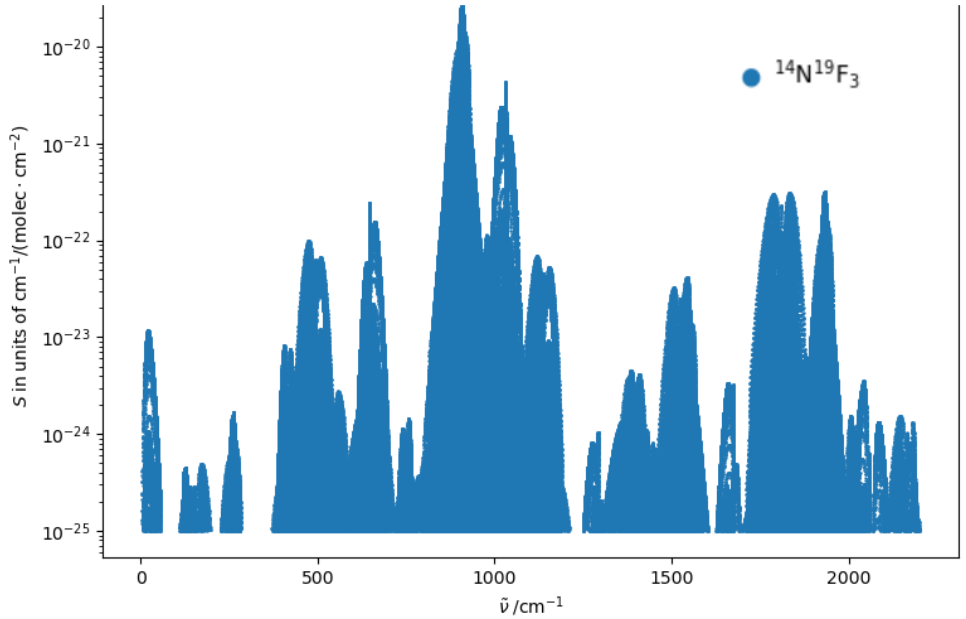


Already available: CO_2, N_2O, CO, CH_4, O_2, NH_3, and H_2S broadened by water.
Tan, et al., J. Geophys. Res. Atmos. 33 (2019) 2019JD030929

New molecules (examples CS_2 and NF_3)





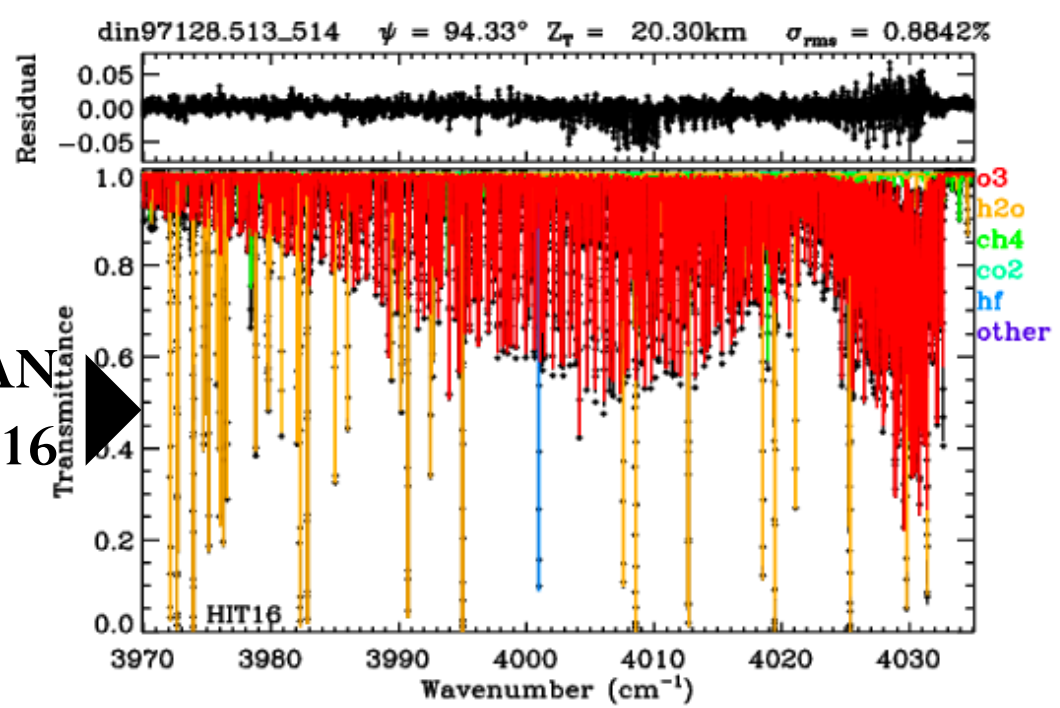


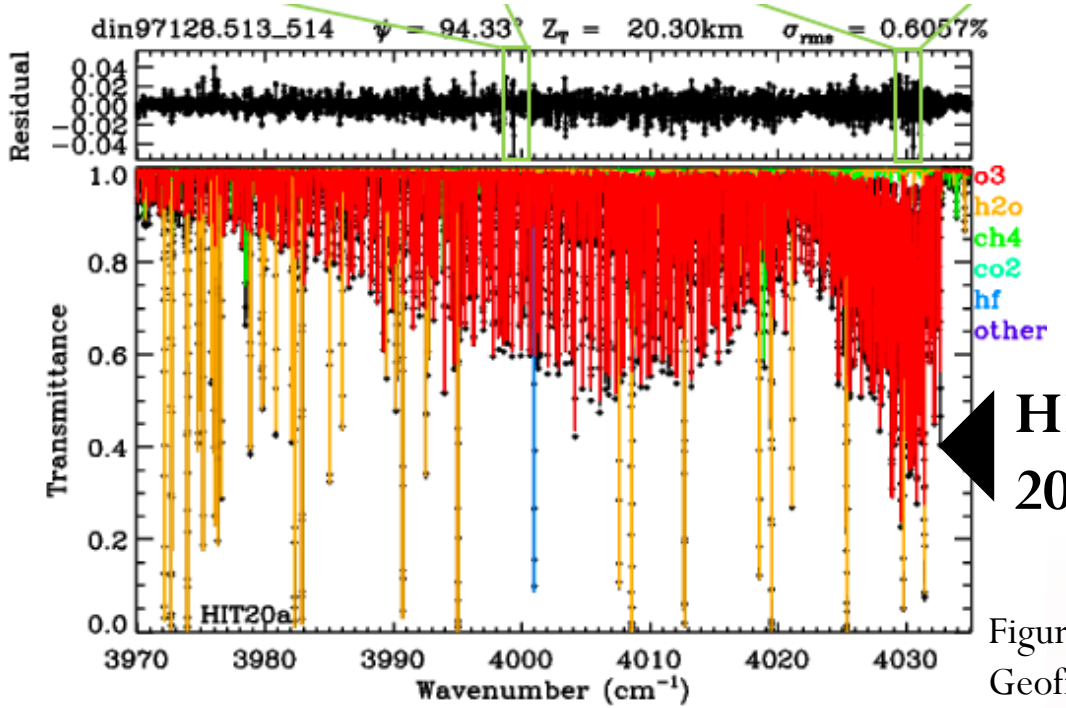
- CS_2 line list is based on Karlovets et al. (2020) JQSRT 258, 107275
- NF_3 line list is based on Egorov et al., JQSRT(2019) 239, 106668

Ozone (contd..) overall reduction of RMS

- The RMS values are reduced throughout the spectral regions. In particular, line positions are much improved. See validation with a balloon spectra below.

HITRAN 2016





HITRAN 2020

Figure credit: Geoff Toon (JPL)

Accessing HITRAN with HAPI

- **HAPI (HITRAN Application Programming Interface) [1]**
  - A free open source Python module (library) which provides a set of tools for working with structured spectroscopic data from different sources.

```
# Import HAPI functions for downloading the data:
from hapi import *

# Fetch the CH4 data for the main isotopologue, in the 2500-2600 wavenumber range:
fetch('ch4',6,1,2500,2600)

# Select the lines with and intnensity greater than 1.0x10e-21 cm/molecule:
select('ch4', DestinationTableName='ch4_strong', Conditions=('>','sw', 1e-21))

# Calculate absortption coefficeient:
nu_coeff= abscoef('ch4_strong')

# Repeat the fetching for other molecles and isotopologues in previous example:
fetch('ch4',6,2,2500,2600)
fetch('so2',9,1,2500,2600)
fetch('hf',14,2,2500,2600)

# Print a list of unique IDs:
getHelp(ISO_ID)

# Fetch the CH4 data for the two strongest isotopologues, in the 2500-2600
# wavenumber range, including the additional broadening parameters:
fetch_by_ids('ch4', [32,33], 2500, 2600, ParameterGroups=['160-char'], Parameters[
        'gamma_H2', 'delta_H2', 'gamma_He', 'delta_H2', 'gamma_CO2', 'delta_CO2', ... ])
```

Import HAPI library

Easy command to download data

Tools for working with the data

Many more options to include additional parameters, filtering etc.

www.hitran.org/hapi/

[1] R. V. Kochanov, et al. (2016), *JQSRT* 177, 15.

Upcoming:

- HAPI v2.0
  - Kochanov et al. (2021), *in prep*
- HAPIEST
  - Karns et al. (2021), *in prep*