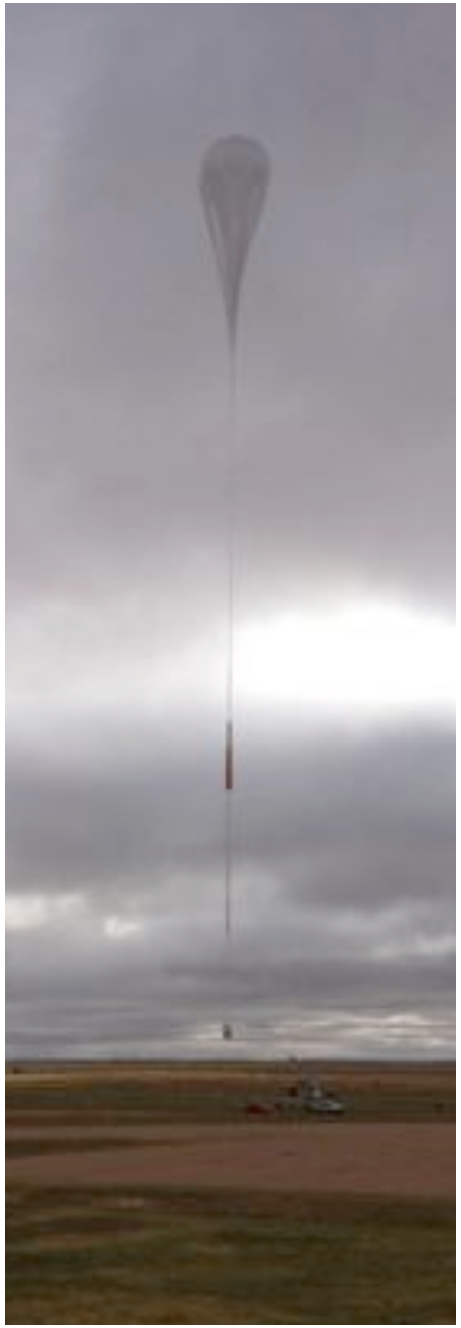

MkIV Balloon Flight

JPL sensors flew Sep 13-14, 2014 launched from Ft. Sumner, NM.

- MkIV Solar Occ FTS, G. Toon, PI mid-IR 650-5650 cm^{-1} at 0.01 cm^{-1} resolution
- Submillimeter Limb Sounder, R. Stachnik, PI 640 GHz heterodyne radiometer.

Continue trends since 1989 for GHG's, stratospheric H_2O, Br, Cl and F loading

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- Payload reached 40 km altitude, landing in Eastern Arizona after 24 hours aloft.
- Both instruments in excellent condition.
- Highly successful 23rd MkIV balloon flight (sunset+sunrise)
- Earliest MkIV launch for fall turn-around.
- Hopefully provide a closer coincidence with ACE than previous flights.
- Gas profiles available in a few weeks.

New Pseudo-Linelists (PLL)

C_3H_8:
- LWIR: from Sung et al. [2013]
- SWIR: from Harrison & Bernath [2010] lab measurements

CH_3OH: LWIR & SWIR both based on Harrison et al. [2012]

C_6H_6: Covering 640-710 cm^{-1} from lab measurements by Sung

mark4sun.jpl.nasa.gov/pseudo.html

Readme

Isotopomers	Fortran code	Data
C3H8/Propane (2560-3280 cm-1)	Readme.c3h8	c3h8_pll_2560_3280.101
C3H8/Propane (670-1550 cm-1)	Readme.c3h8	c3h8_pll_670_1550.101
CH3OH/Methanol	Readme.ch3oh	ch3oh_pll.101
CHF3/HFC-23	Readme.chf3	chf3.101
HCFC-141b	Readme.f141b	f141b.101
HNO3	Readme.hno3	Linelist
CH3CHO	Readme.ch3cho	Linelist
PAN	Readme.pan	Linelist
CH3CN	Readme.ch3cn	Linelist
HNO3	Readme.hno3	Linelist
C2H6 (1350-1496 cm-1)	Readme.c2h6_1350_1496	c2h6_1350_1496.101
C2H6 (2720_3100 cm-1)	Readme.c2h6_2720_3100	c2h6_2720_3100.101
N2O5		Linelist
ClNO3	Readme.clno3	Linelist
NF3	Readme.nf3	Linelist
CF4		Linelist
CFC-12		Linelist
CFC-11		Linelist
CCl4		Linelist
HCFC-22		Linelist
COCl2		Linelist
SF6		Linelist
CFC-113		Linelist
HCFC-142b		Linelist
CH3COOH		Linelist
Foreign collision-induced absorption	Readme.cia	FCIA-Linelist
Self collision-induced absorption		SCIA-Linelist

C_3H_8 Pseudo-Linelist 2560-3280 cm^{-1}

Based on laboratory measurements of Harrison & Bernath [2010]

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Infrared absorption cross sections for propane (C_3H_8) in the 3 μm region

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ABSTRACT

Infrared absorption cross sections for propane have been measured in the 3 μm spectral region from spectra recorded using a high-resolution FTIR spectrometer (Bruker IFS 125 HR). The spectra of mixtures of propane with dry synthetic air were recorded at 0.015 cm^{-1} resolution (calculated as 0.9/MOPD using the Bruker definition of resolution), at a number of temperatures and pressures appropriate for atmospheric conditions. Intensities were calibrated using two propane spectra (recorded at 278 and 293 K) taken from the Pacific Northwest National Laboratory (PNNL) IR database.

C_3H_8 Pseudo-Linelist (PLL)

Covers 2765 – 3080 cm^{-1} at 0.005 cm^{-1} spacing (63001 lines) based on Harrison's lab measurements.

[This is different from the pseudo-linelist covering 690-1550 cm^{-1} described by Sung et al. [2013], which was based on Sung's own lab measurements.]

Assumes:

- ABHW = 0.07
- SBHW = 0.14

Line intensities and E"s are retrieved.

Assumed partition function following Sung et al. [2013]

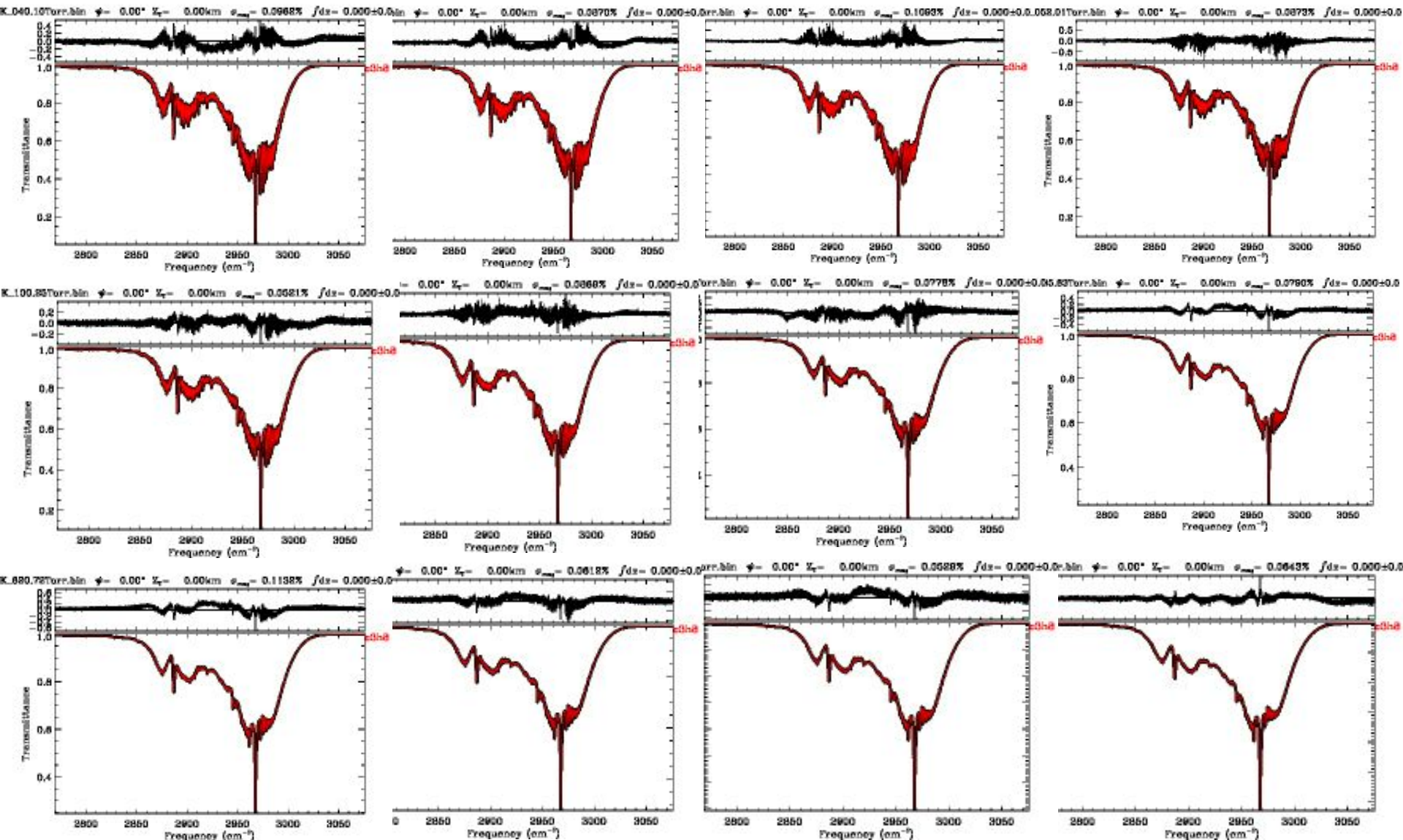
- Vibrational: Used 25/27 vibrational modes (dropping the torsional modes at 216 & 268 cm^{-1})
- Rotational: $(296/T)^2$

Retrieved VMR Scale Factors

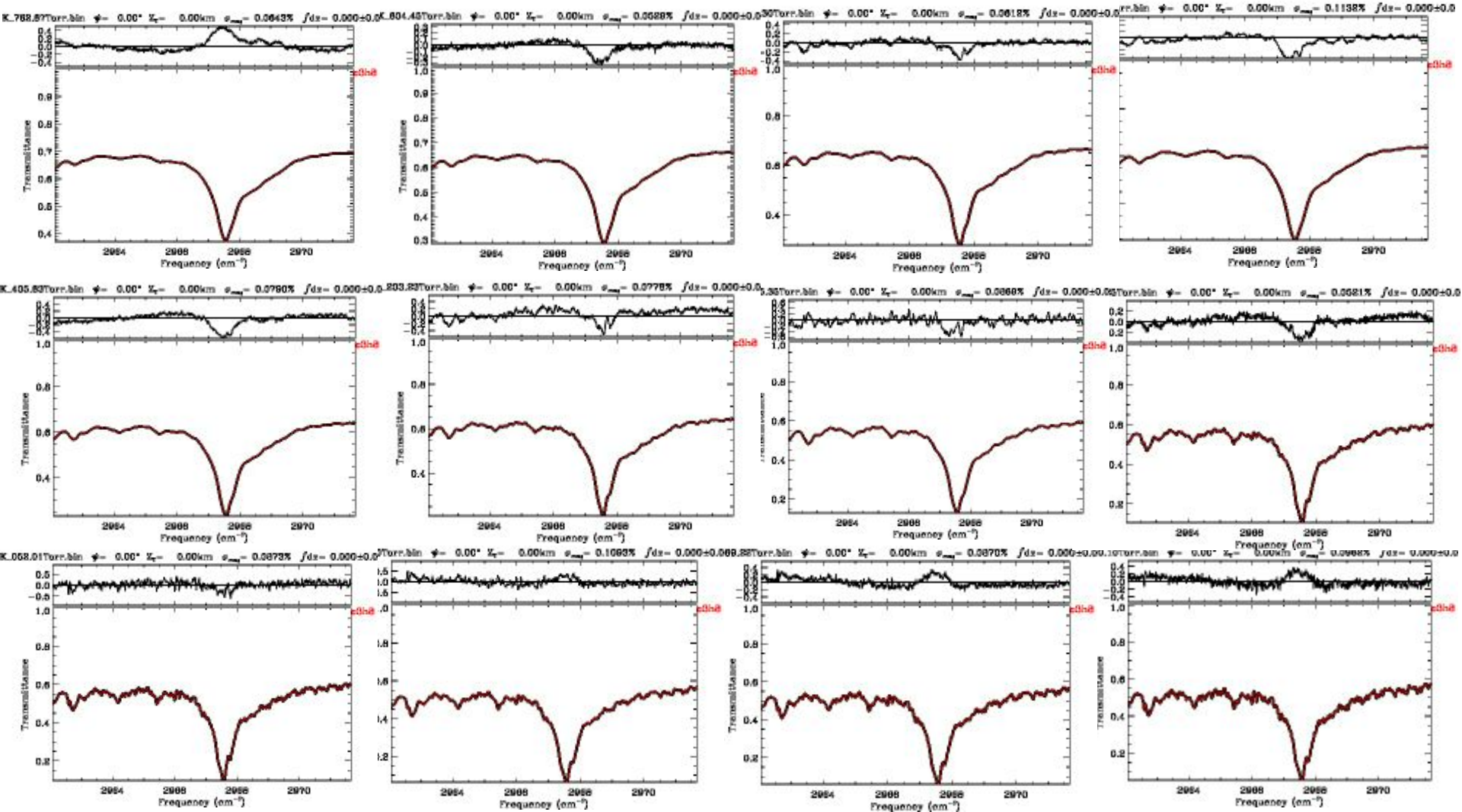
Spectrum	RMS %	VSF	VSF_error
C3H8_195K_040.10Torr.bin	0.0962	1.0263	2.9E-03
C3H8_195K_069.22Torr.bin	0.0870	1.0260	2.6E-03
C3H8_195K_098.30Torr.bin	0.1093	1.0267	3.3E-03
C3H8_215K_052.01Torr.bin	0.0873	0.9776	2.6E-03
C3H8_215K_100.25Torr.bin	0.0521	0.9782	1.6E-03
C3H8_215K_275.35Torr.bin	0.0869	0.9789	2.6E-03
C3H8_252K_203.23Torr.bin	0.0778	0.9632	2.3E-03
C3H8_252K_405.63Torr.bin	0.0790	0.9668	2.4E-03
C3H8_250K_620.72Torr.bin	0.1132	0.9644	3.4E-03
C3H8_269K_369.30Torr.bin	0.0612	0.9837	1.8E-03
C3H8_269K_604.45Torr.bin	0.0529	0.9828	1.6E-03
C3H8_296K_762.67Torr.bin	0.0643	1.0373	1.9E-03

C_3H_8 scale factors are all self-consistent within 4% (and 2% rms)

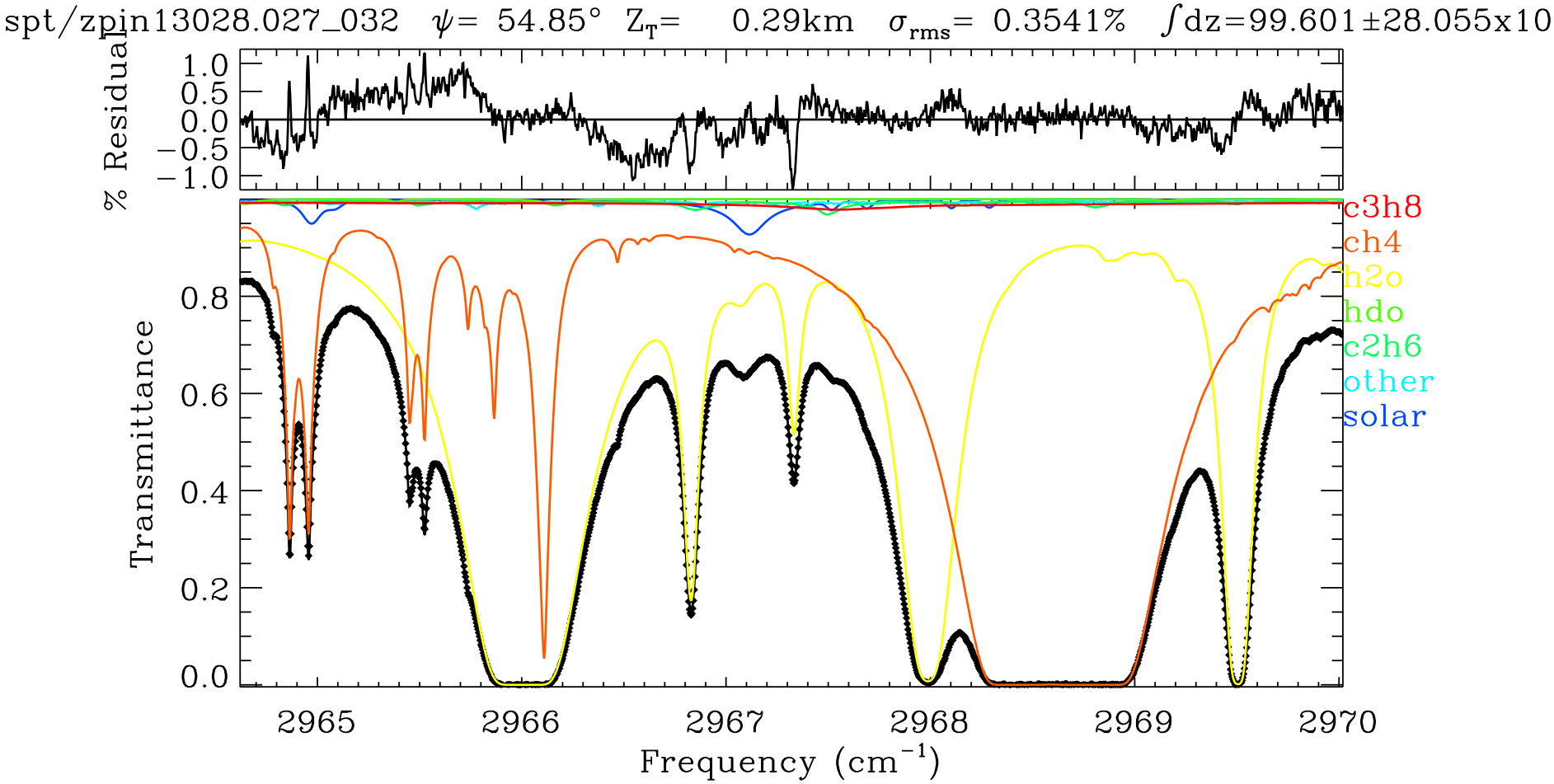
Fits to Lab spectra: Full Band



Fits to lab spectra: Q-branch

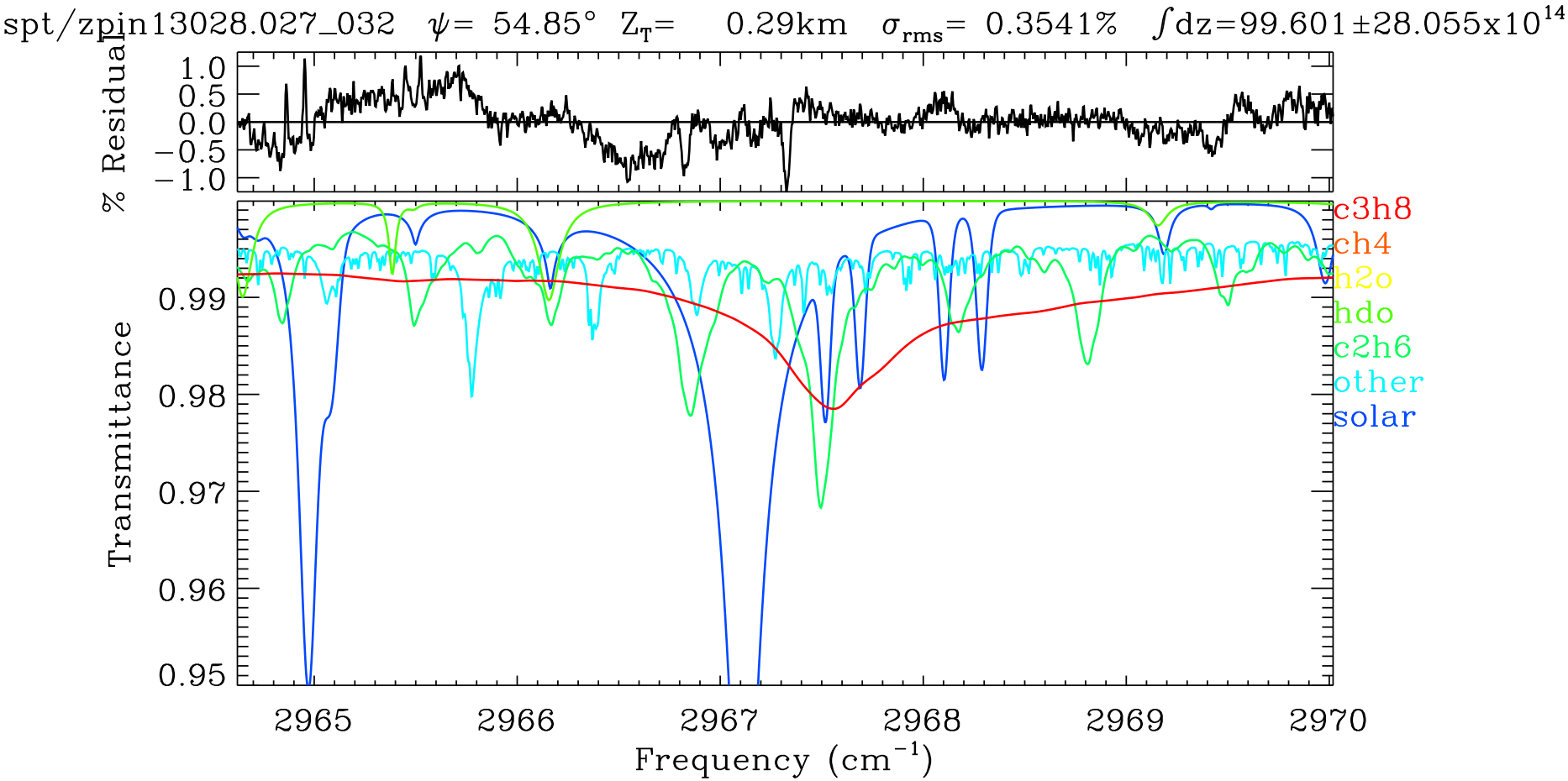


Fits to MkIV ground-based



C_3H_8 Q-branch lies in wings of strong CH_4 lines at 2968-2969 cm^{-1} and so the retrieved C_3H_8 is very sensitive to assumptions about CH_4 widths, pressure shifts, and line mixing.

Fits to MkIV ground-based



Same as previous figure, but y-zoomed to see the C_3H_8 absorption contribution

C_3H_8 Summary

Developed a PLL for C_3H_8 based on lab measurements of Harrison & Bernath [2010].

Matches lab measurements very well.

Unable to detect C_3H_8 in MkIV balloon measurements (too clean, too high)

Can measure C_3H_8 in ground-based measurements made from Pasadena (part of the Los Angeles basin) under polluted/smoggy conditions.

Interestingly, Los Angeles emits more C_3H_8 than C_2H_6 (natural gas leaks), so although globally C_2H_6 far exceeds C_3H_8, this is not necessarily true in LA.

Fit to 15-enriched NO_2 lab spectrum

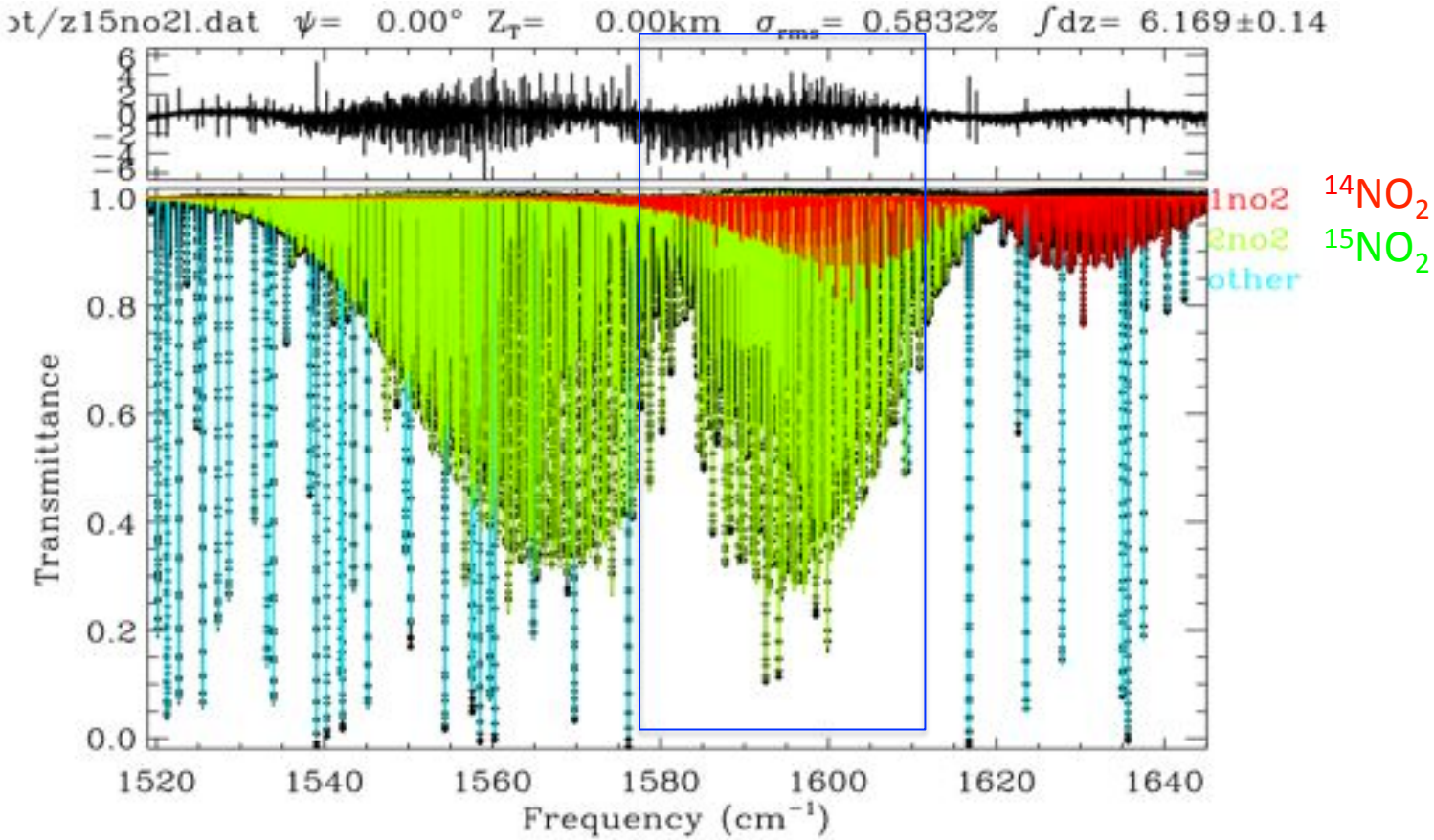


Figure N. *Fit to the 0.2 mbar, 296K, laboratory spectrum of $^{15}NO_2$. The black points represent the measured lab spectrum. The black line the fitted calculation. The residuals are the difference (meas-calc). The colored lines represent the contributions of the various gases.*

Measured by Orphal et al. [2000]

Fit to MkIV balloon spectrum

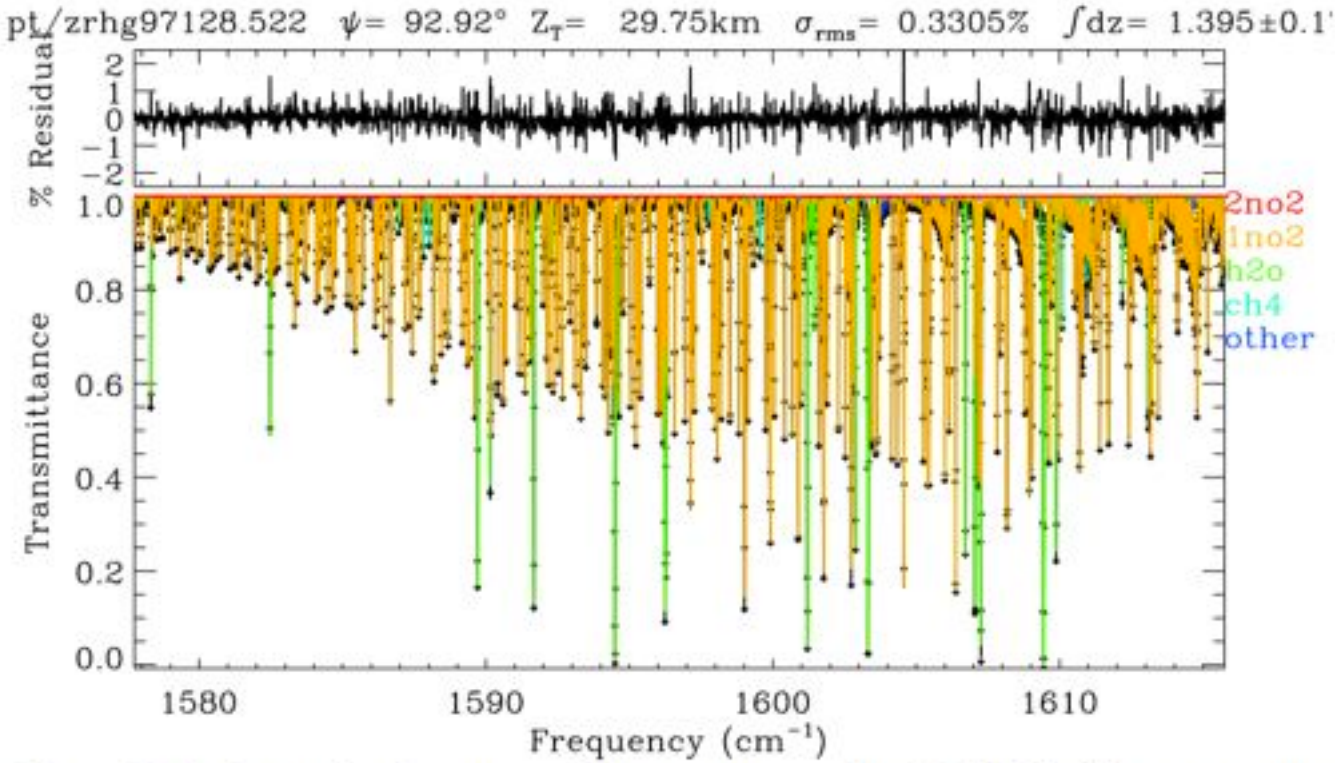


***Figure N+1**. Example of a spectral fit to an atmospheric MkIV balloon spectrum measured at 30 km tangent altitude. The main absorbers in this region are H_2O and $^{14}NO_2$. Weaker absorbers include CH_4, O_2, and $^{15}NO_2$.*

Fit to MkIV balloon spectrum

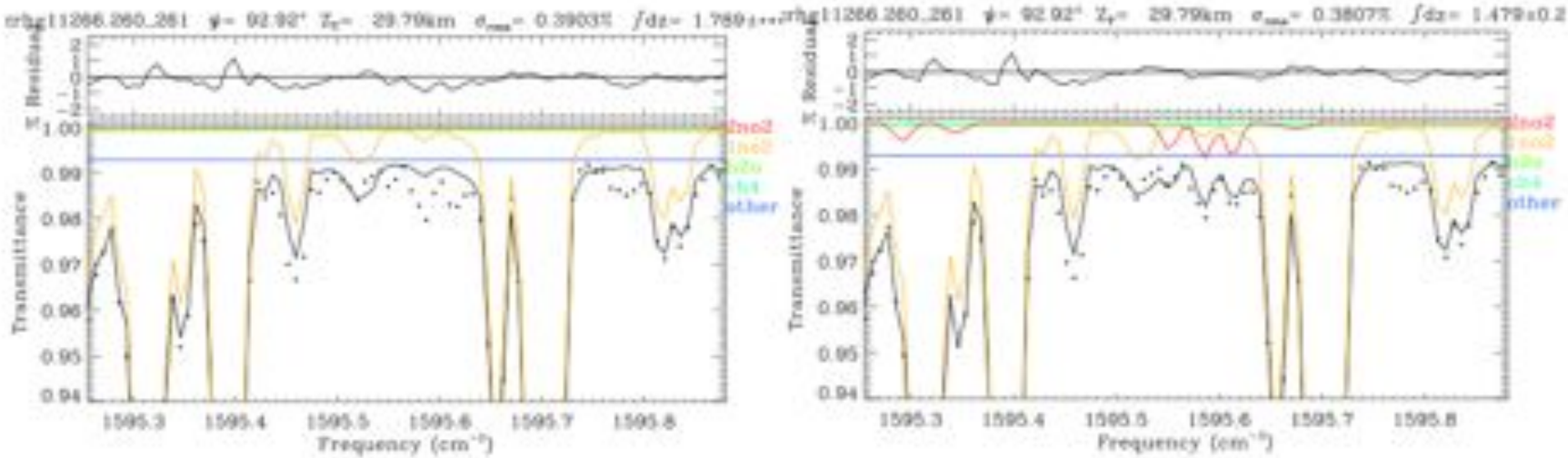


***Figure N+2**. Zoom into a spectral fit of a MkIV balloon spectrum at 30 km tangent altitude with (right) and without (left) the new $^{15}NO2$ linelist. Three $^{15}NO2$ absorption features (red trace) are clearly visibly in the center of the right-hand panel. These fill in the dips in the residuals seen in the left-hand panel. The red trace in the right panel represents the $^{15}NO_2$ contribution to the calculated transmittance. The orange trace represents the $^{14}NO_2$ contribution, green H_2O, cyan CH_4, and blue mainly O_2.*

RMS spectral fits to MkIV balloon spectra

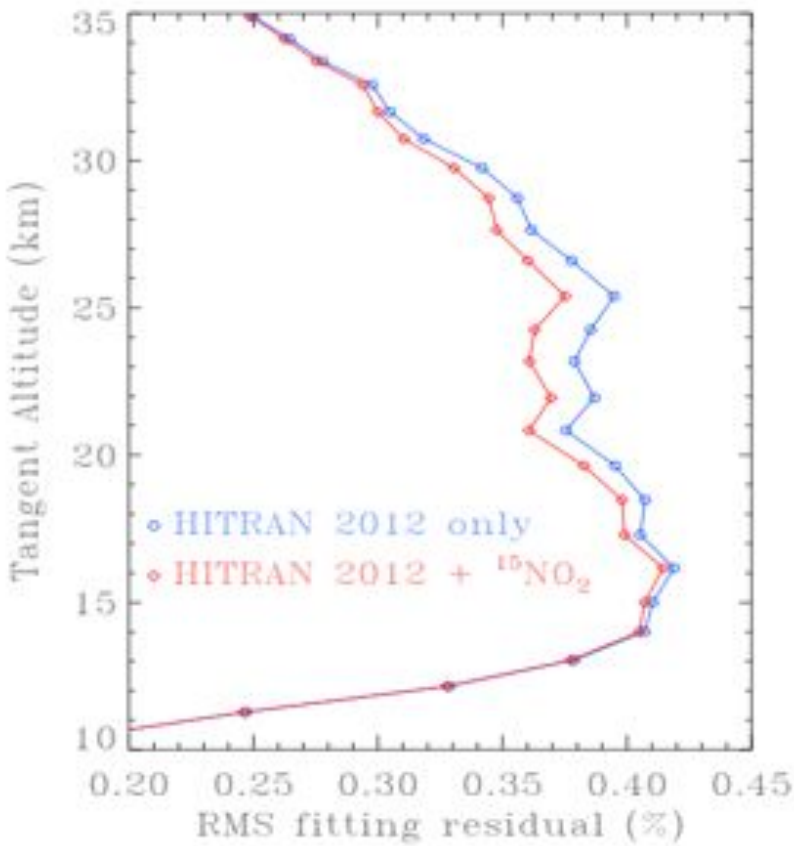


***Figure N+3**. Spectral fitting residuals (%) of MkIV balloon spectra plotted versus Tangent altitude with (red) and without (blue) the new $^{15}NO2$ linelist.*

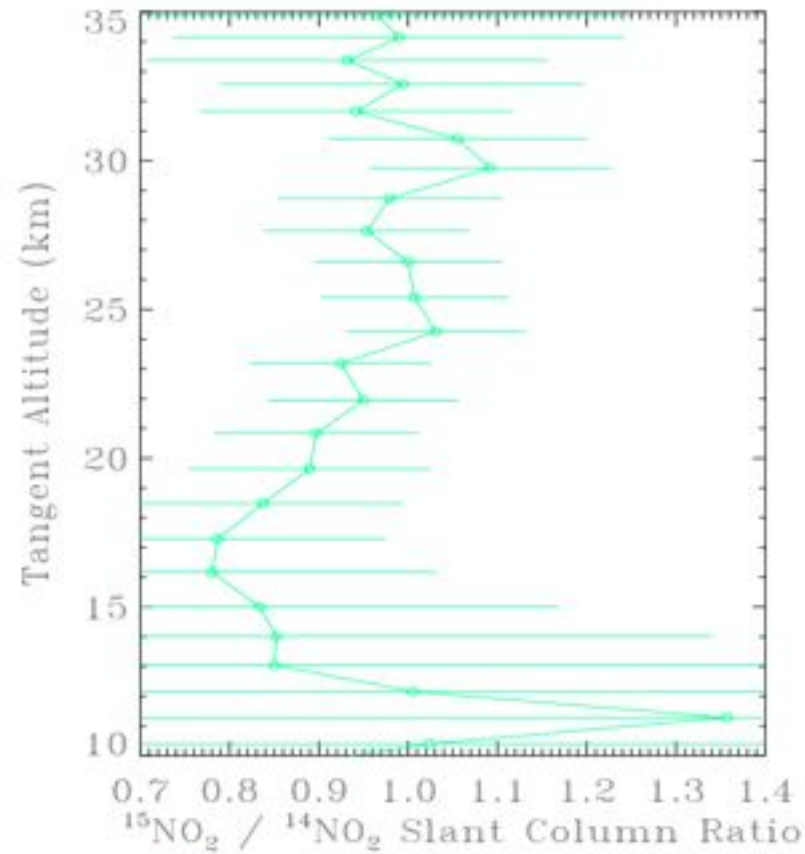


***Figure N+4**. Ratio of 15/14 NO_2 slant columns retrieved from MkIV balloon spectra.*

$^{15}NO_2$ Summary

$^{15}NO_2$ absorption features in the 1600 cm^{-1} region can reach 1% in depth in limb spectra.

But no $^{15}NO_2$ linelist in HITRAN yet, despite lab measurements having been reported by Orphal et al. [2000].

Motivated by the availability of a recently-improved $^{15}NO_2$ linelist, MkIV balloon spectra were fitted for $^{15}NO_2$.

Use of this linelist resulting in significantly improved spectral fits to MkIV (and MIPAS) spectra and an estimate of the 15/14 NO_2 fractionation

A paper describing this new linelist [Perrin et al., 2014] has been submitted to JQSRT and is undergoing revision.