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\(_2\)O, Br, Cl and F loading

• 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-Linelist (PLL)

\( \text{C}_3\text{H}_8 \):  
- LWIR: from Sung et al. [2013]  
- SWIR: from Harrison & Bernath [2010] lab measurements

\( \text{CH}_3\text{OH} \): LWIR & SWIR both based on Harrison et al. [2012]

\( \text{C}_6\text{H}_6 \): Covering 640-710 cm\(^{-1}\) from lab measurements by Sung
C$_3$H$_8$ Pseudo-Linelist 2560-3280 cm$^{-1}$

Based on laboratory measurements of Harrison & Bernath [2010]
C₃H₈ 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

<table>
<thead>
<tr>
<th>Spectrum</th>
<th>RMS %</th>
<th>VSF</th>
<th>VSF_error</th>
</tr>
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<tr>
<td>C3H8_195K_040.10Torr.bin</td>
<td>0.0962</td>
<td>1.0263</td>
<td>2.9E-03</td>
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</tbody>
</table>

C₃H₈ scale factors are all self-consistent within 4% (and 2% rms)
Fits to Lab spectra: Full Band
Fits to lab spectra: Q-branch
$\text{C}_3\text{H}_8$ Q-branch lies in wings of strong CH$_4$ lines at 2968-2969 cm$^{-1}$ and so the retrieved $\text{C}_3\text{H}_8$ 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$_3$H$_8$ Summary

Developed a PLL for C$_3$H$_8$ based on lab measurements of Harrison & Bernath [2010].

Matches lab measurements very well.

Unable to detect C$_3$H$_8$ in MkIV balloon measurements (too clean, too high)

Can measure C$_3$H$_8$ in ground-based measurements made from Pasadena (part of the Los Angeles basin) under polluted/smoggy conditions.

Interestingly, Los Angeles emits more C$_3$H$_8$ than C$_2$H$_6$ (natural gas leaks), so although globally C$_2$H$_6$ far exceeds C$_3$H$_8$, 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 is 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$_2$O 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 $^{15}$NO$_2$ linelist. Three $^{15}$NO$_2$ 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$_2$O, 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 $^{15}$NO$_2$ linelist.

**Figure N+4.** Ratio of 15/14 NO$_2$ slant columns retrieved from MkIV balloon spectra.
\[15\text{NO}_2\text{ Summary}\]

\[15\text{NO}_2\] absorption features in the 1600 cm\(^{-1}\) region can reach 1\% in depth in limb spectra.

But no \[15\text{NO}_2\] linelist in HITRAN yet, despite lab measurements having been reported by Orphal et al. [2000].

Motivated by the availability of a recently-improved \[15\text{NO}_2\] linelist, MkIV balloon spectra were fitted for \[15\text{NO}_2\].

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.