Pointing parameters and CO$_2$ vertical profile retrieval

From ACE-FTS limb occultation measurements

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Introduction

Objectives

- Determination of ACE-FTS pointing parameters independently from CO$_2$ a priori data

  \[ \text{N}_2 \text{ collision-induced absorption continuum at } 4\mu\text{m} \]

- Retrieving averaged CO$_2$ vertical profiles with a 2ppm accuracy

  \[ \text{CO}_2 \text{ lines sensitivities and constraint} \]

Interests

- Tropo/strato transport and interaction : Models improvement
- Carbon cycle fluxes
- Biomass fire and plume detection
Summary

- Retrieving ACE-FTS Pointing parameters:
  - Retrieval strategy
  - Selection of N_2 continuum spectral mw
  - Results

- CO_2 retrieval:
  - CO_2 mw selection
  - Constraint
  - Results
Pointing parameters retrieval

**Optimal estimation**: iterative and non linear fit of N₂ continuum spectral windows under constraint

**Target parameters**: Tangent altitudes at “measurement levels” and temperature profile at “grid levels”

**Retrieval error**: Random noise, non target species and model uncertainties
N$_2$ continuum spectral pre-selection(1)

N$_2$ continuum base-line : high dynamic in the 5-20km altitude range  

High sensitivity to altitude

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{n2_continuum.png}
\caption{N$_2$ continuum in function to geometric tangent heights}
\end{figure}

\begin{itemize}
\item 20.5km
\item 5km
\end{itemize}
N₂ continuum spectral pre-selection (2)

N₂O and CO₂ far wings contributions: select N₂ continuum contamination-free spectral domains
N$_2$ continuum spectral selection (3)

Optimization of N$_2$ spectral microwindows width: case of a micro window centered at 2500.7 cm$^{-1}$ for the 10-15km altitude range

Total error

model error: Far wings

Smallest error for a spectral width of 3.2cm$^{-1}$

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Synthetic results

Results from synthetic occultations with random noise (averaged over 25 occultation)

- Retrieved Error standard deviation ~ 50m
ACE-FTS tangent heights retrieval

Examples of 6 real occultations from different latitude bands:
- Good agreement in the 5-15km altitude range
- Spectroscopy bias?
- Clouds detected in the tropic (purple curve)

South Pole  North Pole  Mid Lat N  Mid Lat S  Tropic  Cloud

Difference between ACE level2 altitudes and retrieved altitude (N₂ continuum)
CO₂ retrieval

Selection of CO₂ lines main issue: Temperature sensitivity

Example of 4 different microwindows at 12 km

Low transition lower state energy E’’:
Positive temperature sensitivity

Transmission

T sensitivity (1K)

1924 cm⁻¹  E’’=43

1954 cm⁻¹  E’’=273

CO₂ sensitivity (1ppm)

2611 cm⁻¹  E’’=7

2632 cm⁻¹  E’’=220

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CO₂ retrieval : mw selection

Optimization of each individual mw and of total set.
Impact of:
  Random noise
  Temperature uncertainties
  Interfering species uncertainties

➢ 30 micro windows selected

<table>
<thead>
<tr>
<th>number of mw</th>
<th>CO₂ spectral domain (cm⁻¹)</th>
<th>altitude range (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1920-1955</td>
<td>9-20</td>
</tr>
<tr>
<td>6</td>
<td>2010-2030</td>
<td>8-20</td>
</tr>
<tr>
<td>8</td>
<td>2600-2635</td>
<td>5-20</td>
</tr>
<tr>
<td>4</td>
<td>3150-3205</td>
<td>6-20</td>
</tr>
<tr>
<td>5</td>
<td>3315-3355</td>
<td>7-20</td>
</tr>
</tbody>
</table>

\(^a\) not all microwindows of each family are used for the same altitude range
Constraint

Regularization Matrix (R) : CO$_2$ covariance matrix ($S_a$) from MOZART v2 air-transport and chemistry model

$$R = \alpha S_a^{-1}$$

Choice of $\alpha$
initial requirements :
- Vertical resolution
  2.5km
- Spurious oscillation
  < 5ppm (one shot)
- Accuracy (averaged)
  ~ 2ppm
- Bias from a priori data
  < 1ppm
**CO₂ synthetic retrieval**

For each case: Results averaged on 25 retrievals with the same true and a priori profiles. Random noise + T noise (1K): 25 drawings

Mean Averaged absolute error < 1ppm

Mean Dispersion ~ 2ppm

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Future work

- Article in preparation

- Temperature and tangent heights retrieval currently under refinement: Model, N₂ spectroscopy...

- Systematic Temperature, tangent heights and CO₂ retrieval from ACE-FTS occultations