AIRS Mid-Tropospheric CO$_2$ Climatology Product

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Agenda

• AIRS Mid-tropospheric CO$_2$ climatology dataset created
• Product uncertainties included
• Product validation underway
  – This talk examines the seasonal cycle
  – Results: NH Dampening and Phase Lag, SH Reversal

• Conclusions
AIRS Retrieves CO$_2$ in the Mid to Upper Troposphere

- **AIRS Sensitivity**
  - Peak sensitivity altitude varies slightly with latitude and season:
    - Tropics: 285 hPa
    - Poles: 425 hPa
  - Width at half-maximum is ~400 hPa, spanning:
    - Tropics: 120 hPa to 515 hPa
    - Poles: 235 hPa to 640 hPa
  - Tails of averaging kernels intrude into stratosphere, where air is older than in troposphere by an amount that varies with latitude (~1 yr in tropics; ~5 yrs at poles).
  - Impact: ~3 ppm increase in retrieved CO$_2$ near the poles if correction is applied.
AIRS Mid-Tropospheric CO₂ Climatologies

- AIRS CO₂ Climatology: Average of AIRS L3 Monthly CO₂ over years 2003-2010

\[ D_{\downarrow ijm} = \sum_{k=1}^{18} N_{\downarrow ijm} D_{\downarrow ijm} / \sum_k \]

**Simple Monthly Climatology**
- V5 L3 Monthly CO₂ for Years: 2003-2010
- QC on -9999
- Detrend CO₂ using linear fit to all years for each grid cell
- Average CO₂ values for individual months (e.g. all January’s. Gives 12 files)
- Preserve Grid of input L3

Standard deviation and number of samples for each month from all years is combined into single value

**July Climatology Statistics**

a) Uncertainty, $\sigma_{ij7}$

b) Number of Data Points included in the mean, $N_{ij7}$

\[ \sigma_{ijm} = \sqrt{\sum_{k=1}^{8} N_{ijklm} [D_{ijklm}]^2} \]

\[ N_{ijm} = \sum_{k=1}^{8} N_{ijklm} \]
Zonal average of AIRS CO$_2$ climatologies show many features

- Higher variability in polar regions
- Higher amplitude of seasonal cycle in NH
- Persistent low in SH subtropics (See Xun’s Talk)
## Comparison of Seasonal Cycle Datasets

<table>
<thead>
<tr>
<th>Comparison Product</th>
<th>Instrument</th>
<th>Level</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-Trop CO$<em>2$, T$</em>{500mb}$, T$_{surf}$</td>
<td>AIRS</td>
<td>L3</td>
<td>GES/DISC</td>
</tr>
<tr>
<td>Surface CO$_2$</td>
<td>In-Situ/Flask</td>
<td>N/A</td>
<td>NOAA ESRL*</td>
</tr>
<tr>
<td>EVI, T$_{surf}$ (for GPP)</td>
<td>MODIS</td>
<td>L3</td>
<td>GES/DISC</td>
</tr>
</tbody>
</table>

Seasonal Cycle Revealed in Zonal Averages

Monthly climatology made for each product by combining L3 from 2003-2010

Zonal averages made of each climatology in 20 degree bins
Mid-tropo CO$_2$
NH: Damped seasonal amplitude compared to surface

SH: Higher seasonal amplitude. Inter-hemispheric transport?
Mid-tropo CO$_2$

NH: Lags the surface due to mixing

SH: Leads the surface due to interzonal transport?
AIRS CO$_2$ Shows Significant Influence of Surface in addition to Atmospheric Transport

High Correlation of CO$_2$ and GPP for July in NH Boreal Forests

40N-50N $
ewline$ C = 0.80
Summary and Future Work

• Summary
  – AIRS mid-tropospheric CO₂ monthly climatology generated
  – Recently reprocessed for 2003-2014
  – Climatology available at co2.jpl.nasa.gov this summer
  – Distinctive seasonal cycle seen in the mid-tropospheric CO₂ from AIRS
    • Amplitude damped in NH relative to surface flask measurements
    • Phase lag relative to surface flask in NH
    • Phase precedes, and amplitude higher than surface in SH
  – Influence of boreal forest drawdown in summer seen in spatial variability
    of AIRS mid-tropospheric CO2

• Future work
  – Climatology with Version 6 to increase yield and accuracy

• Acknowledgements
  – Dr. Mous Chahine (CO2 VPD Algorithm, AIRS Science Team Lead to 2011)
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AIRS CO$_2$ Climatology Animation

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