Retrieval of Trace Gases using CrIS Full Spectrum Data

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Outline

Part I: Lessons Learned from AIRS and IASI Trace Gases Retrievals

- AIRS and IASI provide measurements of trace Gases (O_3, CO_2, CO, CH_4, N_2O since 2002);
- Valuable information of gases distribution in Mid-Upper troposphere can be observed (examples):
  1) Enhancement of upper troposphere CH_4 over south Asia during Monsoon season;
  2) Stratospheric Intrusion and its impact to CH_4 and O_3;
- One more study to examine the possibility to combine AIRS and IASI data to make a long-term product;

Part II: Preliminary Assessment to CrIS Trace Gases Retrievals and Improvements

1) Preliminary assessment to current trace gases retrieval in NUCAPS (DOF, Averaging Kernels) and Improvements;
2) Monitoring the leakage of CH_4 from California Aliso Canyon Oil Field and Gas Storage Facility;

Summary and Future Works
CO$_2$, CO and CH$_4$ are listed as Level-1 requirement of products of JPSS.
1. AIRS Observed CH$_4$ Enhancement over South Asia During Monsoon Season (JJAS)

CARIBIC aircraft measurements proved significant increase of CH₄ as AIRS observed in the same time over South Asia

Courtesy of Angela Baker and Tanja Schuck (Schuck et al., 2010, ACP)
2. AIRS Observed the Impact of Stratospheric Intrusion to CH$_4$ and O$_3$

Aircraft Measurements


One more study: to make a long-term product by combing AIRS and IASI CH₄ Products

South Asia: repeatable increase of CH₄ during Monsoon Season

Arctic: similar seasonal cycles from AIRS and IASI but has large difference in the cold season

Xiong et al., 2016, Comparison of Atmospheric Methane Retrievals from AIRS and IASI, IEEE JSTARS, 10.1109/JSTAR.2016.2588279
The above examples shows that AIRS and IASI can be used to observe gases distribution in Mid-Upper troposphere, and it is likely to combine AIRS and IASI data to make a long-term product;

CrIS started to operate in the full spectral resolution (FSR) mode since Dec.4, 2014 making it possible to retrieve trace gases.
CrIS Normal Resolution and Full Resolution SDR

CrIS FSR data are available from NOAA/NESDIS/STAR, and it has 2211 channels as compared to 1305 channels in normal mode.


<table>
<thead>
<tr>
<th>Frequency Band</th>
<th>Spectral Range (cm(^{-1}))</th>
<th>Number of Channel (unapodized)</th>
<th>Spectral Resolution (cm(^{-1}))</th>
<th>Effective MPD (cm)</th>
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<td>LWIR</td>
<td>650 to 1095</td>
<td>713* (717)</td>
<td>0.625</td>
<td>0.8</td>
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<tr>
<td>MWIR</td>
<td>1210 to 1750</td>
<td>433* (437)</td>
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<tr>
<td>SWIR</td>
<td>2155 to 2550</td>
<td>159* (163)</td>
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<tr>
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<td></td>
<td>633* (637)</td>
<td>0.625</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Red: Full resolution

![Graph showing brightness temperature vs. wavenumber for CH\(_4\), CO, and CO\(_2\).](image-url)
Part 2: Preliminary Assessment to CrIS Trace Gases Retrievals and Improvements

- First check to NUCAPS trace gases retrieval averaging kernels and DOFs indicated the DOFs are much lower than AIRS and IASI;

- Improvements can be made after re-selection of channels, as well as the update to QC;

- Historically largest gas leakage in California provides a good case to test if NUCAPS can capture this leakage;
Averaging Kernels and Degree of Freedoms (DOFs) before and after Improvement for CO

Major Sensitivity: 300-650 hPa

DOFs increase after the re-selection of channels
Averaging Kernels and DOFs Changes for CH$_4$

Major sensitivity: 200-550 hPa

DOFs increase after the re-selection of channels
Averaging Kernels and DOFs – CO$_2$

More works need to be done for CO$_2$
Changes of CH$_4$ Distribution after the re-selection of channels and update of QC (+10 ppb)
Change of CO distribution after re-selection of channels and update of QC
Aliso Canyon Gas Leakage (10/23/2015-2/18/2016)

- Historically largest gas leakage -- a good case to test if NUCAPS can capture this leakage;
- CrIS retrievals for two days before the leakage (10/23/2015) and 1 week after have been made in this analysis;

CH$_4$ increase from ground measurement
CH$_4$ from Ascending Node — enhanced CH$_4$
started in Oct.22, 2015

Unknown sources
CO from Ascending Node – similar transport of CO, but sources are unknown

Unknown sources
CH₄ from 10/21 – 10/29/2015
CO from 10/21 – 10/29/2015
CO$_2$ from Ascending Node
Summary and Future Works

1. CrIS full spectrum data can be used to retrieve trace gases with similar DOFs as AIRS and IASI, with its major sensitivity in the *mid-upper troposphere*; however, to combine these three sensors to make a consistent product from 2002 to beyond need more works (larger disparity existed in the Arctic between AIRS and IASI retrievals);

2. It is promising to use CrIS full Spectrum data to detect the leakage of CH$_4$ during the historically largest Gas leakage from *Aliso Canyon Oil Field and Gas Storage Facility in 2015*. However, more checks to other possible uncertainties need to be done (cloud-clearing, transport);

3. Preliminary improvements in channels selection and QC have been made, which show positive impacts to the retrieval products;

4. Validation is a key step but hampered due to lack of the measurements of trace gases profiles. Improvement to QC will be one focus of future works.
Questions/Suggestions

Thanks
3. Monitoring of N$_2$O trend using AIRS

Validation: one Key step to evaluate the trace gases products

AIRS-V6 CH₄

Locations of Validation Profiles

- 272–343 hPa
  - R = 0.73
  - Bias = −1.35%
  - rms = 1.88%

- 343–441 hPa
  - R = 0.77
  - Bias = −0.76%
  - rms = 1.56%

- 441–575 hPa
  - R = 0.87
  - Bias = −0.05%
  - rms = 1.16%

- 575–777 hPa
  - R = 0.95
  - Bias = 0.270%
  - rms = 0.87%
Change of CO$_2$

More works need to be done for CO$_2$
Day-night Difference

20151024, Latitude > 30 °

Daytime CH4 and CO2 are larger than night time, but not CO