Recent Improvement of NUCAPS CH$_4$ from CrIS FSR Data

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Recent Improvements in CH\textsubscript{4} Retrievals from CrIS FSR Data

- Sensitivity (mid-upper troposphere) and Requirement of CH\textsubscript{4} products (based on total amount) --- need a good CH\textsubscript{4} firstguess in the lower troposphere;
- Optimization: First guess, Channel Selection, and tuning;
- Quality control (CH\textsubscript{4}QC) – to be added soon;

Validation:
Comparison of CrIS CH\textsubscript{4} profiles with model, AIRS and TCCON data;

Examples:
- Monitoring the leakage of CH\textsubscript{4} from California Aliso Canyon Oil Field and Gas Storage Facility;
- Monitoring the CO plume from 2016 Fort McMurray wildfire; Monitoring the CO plume from Indonesia Fires (9/20-11/8, 2015);

Summary and Future works
## Requirements of Trace Gases Products from CrIS

### Ozone

- **EDR Attribute**: Total Column
- **Vertical Coverage**: Total Column
- **Horizontal Resolution**: 100 km
- **Mapping Uncertainty, 3 sigma**: 25 km
- **Measurement Range**: 0 – 200 ppbv
- **Measurement Precision**: 15%
- **Measurement Accuracy**: ±5%
- **Refresh**: 24 h

### Methane

- **EDR Attribute**: Total Column
- **Vertical Coverage**: Total Column
- **Horizontal Resolution**: 100 km
- **Mapping Uncertainty, 3 sigma**: 25 km
- **Measurement Range**: 300 – 500 ppmv
- **Measurement Precision**: 0.5% (2 ppmv)
- **Measurement Accuracy**: ±1% (4 ppbv)
- **Refresh**: 24 h

### CH₄

- **EDR Attribute**: Total Column
- **Vertical Coverage**: Total Column
- **Horizontal Resolution**: 100 km
- **Mapping Uncertainty, 3 sigma**: 25 km
- **Measurement Range**: 1100 – 2250 ppbv
- **Measurement Precision**: 1% (~20 ppbv)
- **Measurement Accuracy**: ±4% (~80 ppbv)
- **Refresh**: 24 h

**Note**
Sensitivity of CrIS to CH$_4$

- Major sensitivities are in the mid-upper troposphere – not near the surface where the variation is impacted by emissions;
- Sensitivities in the polar are lower than tropics and mid-latitude
Assuming 5% error of CH4 profile in lower troposphere (below 800 hPa), the error in total amount is about 1.2%.

- to meet the requirement of total amount in 1% (accuracy) is hard;
- It requires a very good a priori
CH$_4$ First-guess Update

(about +2.5%)

--- Old fg is the one used in AIRS-V7 and NOAA IASI system
Continued Optimization: Channel Selection (1)

Current one – delivered in July

Updated one – to be delivered in Oct/Nov
Continued Optimization(2): Re-tuning to CH\textsubscript{4} bands

- CH\textsubscript{4} is very sensitive to upstream temperature and water vapor products;
- Cloud-clearing is a good thing to the yield of retrievals but could be poisonous to trace gases products;
Method of Re-tuning to CH$_4$ bands

1) Using SARTA to simulate the global radiance with inputs
   - T,Q profiles from NUCAPS retrievals;
   - CH$_4$, N$_2$O and CO$_2$ from model simulations;
2) read CCR and applied QC (MW+IR) = 0;
3) Computed the difference of \([R_{\text{simu}} - R_{\text{CCR}}]\);
4) Modified the tuning file in CH$_4$ bands ONLY (from 1200-1360 cm$^{-1}$) → no impact to T & q products;

One day data (45°S-45°N) on 2/17/2015 is used;
Comparison of CH$_4$ from AIRS, IASI and CrIS (20160508, @515hPa) – NO QC to CrIS CH$_4$ products
Examples of Quality Control (CH$_4$QC)

- For two granules
- Left panels: red lines are from current version and black lines are from updated retrievals;
- Right panels: Profiles from new version and after using CH$_4$QC
Example of CH$_4$ map with the CH$_4$QC
Yields after using CH$_4$QC

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<th>Descending</th>
<th>Yield (%)</th>
<th>Percentage relative to NO CH$_4$QC (%)</th>
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<td>QC=2</td>
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<table>
<thead>
<tr>
<th>Ascending</th>
<th>Yield (%)</th>
<th>Percentage relative to NO CH$_4$QC (%)</th>
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</thead>
<tbody>
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<tr>
<td>QC=2</td>
<td>45.2</td>
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</tr>
</tbody>
</table>
Some Results

**Validation:** comparison with model, AIRS and TCCON data;

**Examples:**

- Monitoring the leakage of CH$_4$ from California Aliso Canyon Oil Field and Gas Storage Facility;
- Monitoring the CO plume from 2016 Fort McMurray wildfire;
- Monitoring the CO plume from Indonesia Fires (9/20-11/8, 2015);
Comparison with model CH$_4$ – improvement is obvious but accuracy is large than 1%
Comparison of CrIS and AIRS CH$_4$

Total amounts of CH$_4$ from AIRS

AIRS CH$_4$ at 515 hPa
Comparison of CrIS xCO/xCO₂/xCH₄ with TCCON Measurements

- Data of 10 days is used;

- This is a simple comparison by averaging TCCON data within 1 hours of satellite overpass and satellite data within 200 km over the ground site;

- Better agreement can be achieved if using of averaging kernels
Example: Largest leakage in U.S. history
Aliso Canyon Gas Leakage (10/23/2015-2/18/2016)

Surface Measurements
Can CrIS Capture the Leakage of CH$_4$?

In daytime the retrieved CH$_4$ is larger than in the night time;
There are
Can CrIS Capture the Leakage of CH$_4$ – cont’d?
Example of CO: 2016 Fort McMurray Wildfire

MODIS/Aqua captured smoke from the Ft. McMurray wildfire and other Canadian wildfires billowing across the Atlantic Ocean.

Huff and Kondragunta, EOS, V98, 6, 2017

Wildfire Smoke map, 4:30 p.m. May 8, 2016, from Weatherunderground,

Brownish-gray smoke obscured the island of Borneo from MODIS in October 19, 2015. Image from NASA Earth Observatory.
Summary

1. The major sensitivity of CrIS is in the mid-upper troposphere but it is very small in the lower troposphere, so CrIS cannot capture the surface emission. 5% error of the firstguess in the lower troposphere will lead to 1.2% error in the total amount – making it hard to meet the requirement in 1% accuracy.

2. Cloud-clearing is a great part from NUCAPS but we have to be very careful to set QC for all trace gases;

3. Recent improvements (firstguess, channel selection, tuning and CH$_4$QC) are promising, but more works need to be done, particularly we need more profile validation using aircraft measurements.

4. The examples show some promising results to use CrIS to observe the CO plume from wildfires, and the possibility to capture the CH$_4$ leakage from Aliso Canyon Oil Field and Gas Storage Facility in California.
Future Works

- Trace gases maturity review will be made in Nov/Dec., and this is the deadline for us to finalize the update to trace gases algorithms; Another delivery will be delivered by that time frame;

- In addition to the operational system, I will use an offline system with more update to trace gases retrievals to reprocess SNPP CrIS FSR data since Dec.4, 2014 to present. Any update with new sciences can be considered, and these work will help our future update to NUCAPS operational system.

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Questions/Suggestions

Thanks

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Increase of spectral resolution by 4X in SLW greatly benefits CO retrieval; Not used for CO2 (so far) Increase of spectral resolution by 2X in MLW benefits CH4 retrieval;
CrIS (old) vs AIRS CH$_4$

**Total amounts from AIRS**

**CH$_4$ @ 515hPa**
CrIS started to operate in the full spectral resolution (FSR) mode since Dec. 4, 2014, with spectral resolution of 0.625 cm$^{-1}$ for all three bands, thus has 2211 channels as compared to 1305 channels in normal mode;

FSR data is generated from IDPS since March 8, 2017, and history data back to 12/4/2014 can be obtained from STAR.

S-NPP CrIS switched to FSR mode.