GOSAT & GOSAT-2 status

Kei Shiomi (JAXA)

shiomi.kei@jaxa.jp
Level 1
TOA (top of atmosphere) radiance

Level 2
Column-averaged dry air mole fraction of CO₂ and CH₄

Level 3
CO₂ and CH₄ emissions and sinks

Level 4
CO₂ flux (64 areas)
CH₄ flux (43 areas)

The typical accuracy of retrieved column-averaged dry air mole fractions of CO$_2$ and CH$_4$ are 2ppm or 0.5% and 13ppb or 0.7%, respectively.
### GOSAT 10-year operation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar paddle incident</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unstable Pointing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switching Pointing mechanism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cryocooler suspend</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDMS incident</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Paddle incident</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FTS Nominal Pointing Pattern</th>
<th>5p-CT</th>
<th>3p-CT</th>
<th>1, 3 p-CT</th>
<th>3p-CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTS Pointing Mechanism</td>
<td>Primary</td>
<td></td>
<td>Secondary</td>
<td></td>
</tr>
<tr>
<td>FTS interferogram</td>
<td>No bias</td>
<td>800 fringes bias</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTS Operation</td>
<td>SWIR (S) and TIR (T)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FTS L1B V161.161**
- Re-processing (no geometry correction)
- Old version

**FTSL1B V201.202**
- Re-processing (pointing error, biased interferogram corrected)
- Older version

**FTSL1B V210.210**
- Re-processing (completed)

**FTSL1B V220.220**
- Sample products now available. Official release will be soon.

**CAI L1A V130.131**
- Latest version

---

10th anniversary of GOSAT on orbit operation.

July-Aug, 2018 3rd Inclination Maneuvering control.

New v220.220 of L1B will be improved the TIR band and be released in soon. SWIR is applied same processing as before.
GOSAT radiance degradation

- RDF for 10 years from annual vicarious calibration campaigns. The relative curves show the model derived from the onboard solar diffuser data.
- The Latest FTS v210.210 records the best estimated radiance after degradation correction.

http://www.eorc.jaxa.jp/GOSAT/calibration_1.html
GOSAT XCO$_2$ and XCH$_4$ validation with TCCON stations

<table>
<thead>
<tr>
<th>Group</th>
<th>Version</th>
<th>XCO$_2$</th>
<th>XCH$_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bias[ppm]</td>
<td>STD[ppm]</td>
</tr>
<tr>
<td>NIES-FP</td>
<td>v2.21-v02.60</td>
<td>-0.48</td>
<td>2.27</td>
</tr>
<tr>
<td>NIES-PPDF-S</td>
<td>V02.21-v02.40</td>
<td>0.73</td>
<td>1.83</td>
</tr>
<tr>
<td>ACOS (bias correction)</td>
<td>B3.5</td>
<td>0.1</td>
<td>1.7</td>
</tr>
<tr>
<td>RemoTeC-FP (bias correction)</td>
<td>v2.3.8</td>
<td>0.02</td>
<td>1.91</td>
</tr>
<tr>
<td>BESD</td>
<td>v1.02</td>
<td>-0.38</td>
<td>2.04</td>
</tr>
<tr>
<td>U-Leicester-Proxy</td>
<td>CH4 v4</td>
<td>4.80</td>
<td>13.44</td>
</tr>
</tbody>
</table>

NIES-FP: Uchino et al., 2017  
NIES-PPDF-S: Iwasaki et al., 2017  
ACOS: Lindqvist et al., ACP, 2015, Univ. Leicester: Parker, AMT, 2015  
RemoTeC: ESA-CCI SVR RemoTeC, 2016  
BESD: Heyman et al., 2015

- For long-term consistency, comparison of seasonal and annual trend around TCCON sites is performed in the recent papers. (Lindqvist, ACP, 2015 etc.)
Inter-comparison between GOSAT, OCO-2 and GOSAT-2, OCO-3

2008 09 10 11 12 13 14 15 16 17 18 19

Radiometric calibration

Prelaunch X-CAL

Annual Vicarious Calibration at the desert playa in Nevada

CO₂ & CH₄ profile

In situ CO₂ and CH₄ on AJAX

XCO₂ & XCH₄

Column with EM-27 FTS

Coincident Target

Calibrated GOSAT and OCO-2 radiance spectra agrees within 5% for all bands.
Optimization of GOSAT observation pattern

FTS observation in June 22-24, 2016

- Grid observation
- Target observation

- West US for emission targets
- Expanding glint observation
- Tracing islands for covering land area
- Dithering among cloudy area

Calibration Site (Idaho, Nevada)

Validation Site in desert (AFRC)

Upwind

Oil Field (Bakersfield)

Cattle Feedlots (Chino)

Urban Validation Site (Caltech)
GHG trend viewer of total & 2-layer partial column

http://www.eorc.jaxa.jp/GOSAT/CO2_monitor/index_ACOS_B73.html

GOSAT measures both solar reflected light from the Earth’s surface (SWIR) and thermal emission from the Earth’s atmosphere (TIR) providing CO₂ partial-column densities of UT and LT.


Long-term trend of ACOS, NIES, RemoTeC CO₂, CH₄, SIF, AOD
Solar-induced chlorophyll fluorescence
Aerosol optical depth

http://www.eorc.jaxa.jp/GOSAT/CO2_monitor/index_ACOS_B73.html
**TANSO-FTS-2**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>TANSO-FTS-2</th>
<th>TANSO-CAI-2 (radiometer)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Gases</strong></td>
<td><strong>333 - 353</strong></td>
<td><strong>370 - 390</strong></td>
</tr>
<tr>
<td></td>
<td><strong>433 - 453</strong></td>
<td><strong>540 - 560</strong></td>
</tr>
<tr>
<td></td>
<td><strong>664 - 684</strong></td>
<td><strong>664 - 684</strong></td>
</tr>
<tr>
<td></td>
<td><strong>859 - 879</strong></td>
<td><strong>859 - 879</strong></td>
</tr>
<tr>
<td></td>
<td><strong>1585 - 1675</strong></td>
<td><strong>1585 - 1675</strong></td>
</tr>
<tr>
<td><strong>Spectral Band (nm)</strong></td>
<td>++20 deg. (Forward viewing)</td>
<td>-20 deg. (Backward viewing)</td>
</tr>
<tr>
<td><strong>Tilt</strong></td>
<td>460 m</td>
<td>460 m</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>920m</td>
<td>920m</td>
</tr>
<tr>
<td><strong>Swath</strong></td>
<td>920 km</td>
<td></td>
</tr>
</tbody>
</table>

**Observation Valuables**
- CO₂, CH₄ and CO
- Accuracy: 0.5 ppm (CO₂) and 5 ppb (CH₄) at 500-km mesh over earth’s surface

**Characteristics**
- **Life**: 5 years
- **Orbit**: Sun-Synchronous (628km)
- **Mass**: About 2 t
- **Launch**: FY 2018

1. Simultaneous CO (carbon monoxide) measurement
2. All target mode capability
3. Cloud-avoiding pointing with onboard camera (Intelligent pointing)

GOSAT-2 was launched on October 29, 2018
Over-land soundings are taken after re-point system toward less cloud by quick processing of on-board camera image.
Inter-comparison of GOSAT, GOSAT2 and OCO2
Summary

(1) GOSAT operation
   • Successful fully operation of FTS and CAI over 10 years since 2009

(2) GOSAT products
   • Latest FTS L1 V210.210 and CAI L1 V130.131 are available in whole observation term.
   • NIES L2 XCO2 and XCH4 v02.80 are available for the latest L1 V210.210.
   • NIES L3 and L4 are also available corresponding to the latest L2.
   • GOSAT L2 are also produced by other organization algorithms (ACOS, RemoTeC, BESD, Leicester, Yonsei etc.)

(3) Calibration, validation and inter-comparison with GOSAT, GOSAT-2 and OCO-2
   • Railroad valley campaign collaboration with OCO-2
   • XCO2 and XCH4 long-term validation with TCCON data
   • Inter-comparison of GOSAT, GOSAT-2 and OCO-2 in spectra and XCO2

(4) GOSAT-2 operation
   • GOSAT-2 was launched on 29 October, 2019 and is now operated in cal/val phase.
   • Adding CO channel and aerosol UV imager