JAXA GOSAT program status

Akihiko KUZE (JAXA EORC)
June 15, 2017
## GOSAT Satellite Configuration

<table>
<thead>
<tr>
<th>Size</th>
<th>Main body</th>
<th>3.7m(H) x 1.8m(W) x 2.0m(D) (Except attachment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wing Span</td>
<td>13.7 m</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>Total</td>
<td>1,750 kg</td>
</tr>
<tr>
<td>Power</td>
<td>Total</td>
<td>3.8KW (EOL)</td>
</tr>
<tr>
<td>Design Life</td>
<td>5 years</td>
<td></td>
</tr>
<tr>
<td>Orbit</td>
<td>Sun Synchronous Orbit</td>
<td></td>
</tr>
<tr>
<td>Local time</td>
<td>13:00±0:15 (February 2015 - January 2016) 12:46-12:52</td>
<td></td>
</tr>
<tr>
<td>Altitude, inclination, period, revisit</td>
<td>666±0.6 km, 98.0±0.1 deg, 98.1 min, 3 days (44 rotations)</td>
<td></td>
</tr>
</tbody>
</table>

Launch Vehicle, date: H-IIA, Jan. 23, 2009

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One of the two solar paddles stopped its rotation. (June 2014) Still providing enough power for decade long observation

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**TANSO-FTS**

- **TANSO-CAI**
  - UV, Visible, SWIR Imager

**SWIR/TIR FTS**
Combination of Pointing System and Spectrometer

FTS multiplex advantage: exact the same IFOV: SWIR, TIR, 2 linear polarization

CMOS Camera
1296 by 1040 pixels

Pointing and image motion compensation

Scene flux from nadir
Deep space view
Black body view
Diffused solar flux

Primary System

Secondary System

with the secondary pointing system since Jan. 26, 2015
Much better than the primary

Collecting mirror

Field stop

Collimating mirror

Aperture stop (Cube Corner)

BPF1
BPF2
BPF3

DF1
DF2
DF3

Si (B1)P,S
InGaAs with TE cooler (B2) P,S
InGaAs with TE cooler (B3) P,S

MCT (B4) on Dewar and Pulse Tube Cooler
Column averaged density of CO$_2$ is mainly retrieved by using the absorption lines between 1.6 μm region. The intensities of these lines are less temperature dependent and not interfered by other molecules.

O$_2$ A band absorption at 0.76 μm: Dry air column
GOSAT Data Products and Distribution

**JAXA**
- Measurement
- Interferogram
- Level 1 processing
  - processing to spectra
  - calibration

**NIES**
- Level 4 Processing
  - estimate the global net flux
- Level 2 and 3 Processing
  - to produce the global distribution map for CO₂ and CH₄
  - validation

Data distribution
- Public
- Regional Flux

**Data distribution**
GOSAT Operation and Research Progress since Launch

Frequent and global CO₂ distribution

2011 Butz et al.
the accuracy of 2 ppm or 0.5% for CO₂ and 13 ppb or 0.7% for CH₄

Global flux inversion (b)

2011 Joiner et al. and Frankenberg et al.
Solar induced Chlorophyll Fluorescence

Long term CO₂ and CH₄ (c)

2015 Turner et al. (d)
North American CH₄ emissions using prior information on source locations <aggregation, emission source classification>

Flux Emission from CH₄ point sources

Goal
City level CO₂ flux estimation with source classification

Instrument
Feb. 2009
The first very-high spectral resolution spectrometer to measure column-averaged dry air mole fractions of CO₂ and CH₄ globally

Data Processing
Non linearity corrections

Jul. 2014
OCO-2 launch

Pointing mechanism switched to the secondary (Jan. 2015)
2-axis agile pointing system effectively collects science data over regions and areas of special interest.

Level 1 V201 (2015)
Long-term uniform quality data set
Flexibility with Target Observation

Optimized sampling pattern for flux estimation with an agile pointing system

WAS: Mar. 2011 Grid & Specular Reflection

NOW: Mar., 1 2016

Extending glint region over ocean by tracking principal plane

2-Axis pointing system
Up to 1000 custom target observations per day by uploading commands every day.
NASA GES DISC
The CMS Methane (CH₄) Flux for North America data set contains estimates in North America based on an inversion of the GEOS-Chem chemical transport model constrained by GOSAT.

July 2010
https://mirador.gsfc.nasa.gov/

CH₄ emission (Gg/year)

Contents
Long term
CO₂, CH₄, SIF, AOD
Solar-induced chlorophyll fluorescence
Aerosol optical depth

To be added
City distribution map
Aeronet site
4 Level 2 products intercomparison
OCO-2 match up
Surface wind speed
Ground validation data
Toward GHG satellites constellation
Inter-comparison between GOSAT and OCO-2

Radiometric calibration

Annual Vicarious Calibration at the desert playa in Nevada

CO$_2$ & CH$_4$ profile

In situ CO$_2$ and CH$_4$ on NASA AMES AJAX

XCO$_2$ & XCH$_4$

Column with a compact FTS

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

Retrieved
Parameter
Comparison over match up points

2014/09 ~ 2016/02
Level2 matchup : 715 points
Agreement: <0.14 ppm over Ocean

### GOSAT-2

#### TANSO-FTS-2

- **Characteristics**
  - **Life**: 5 years
  - **Orbit**: Sun-Synchronous (628 km)
  - **Mass**: About 2 t
  - **Launch**: FY 2018
  - **Observation Valuables**
    - CO₂, CH₄, and CO
    - **Accuracy**: 0.5 ppm (CO₂) and 5 ppb (CH₄) at 500-km mesh over earth’s surface

#### TANSO-CAI-2

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

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**Table: Band Characteristics**

<table>
<thead>
<tr>
<th>Target Gases</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
<th>Band 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td>0.75-0.77</td>
<td>1.56-1.69</td>
<td>1.92-2.33</td>
<td>5.5-8.4</td>
<td>8.4-14.3</td>
</tr>
<tr>
<td>CO₂, H₂O</td>
<td>1.92-2.33</td>
<td>5.5-8.4</td>
<td>8.4-14.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂, CH₄, CO₂, H₂O</td>
<td>4,200-5,200</td>
<td>1,188-1,800</td>
<td>700-1,188</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table: Spectral Coverage (nm)**

<table>
<thead>
<tr>
<th>Spectral Coverage (nm)</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
<th>Band 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>333-353</td>
<td>433</td>
<td>664</td>
<td>859</td>
<td>1585</td>
<td>1675</td>
</tr>
<tr>
<td>453</td>
<td>684</td>
<td>879</td>
<td>1675</td>
<td></td>
<td></td>
</tr>
<tr>
<td>684</td>
<td>879</td>
<td>1585</td>
<td>1675</td>
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</tbody>
</table>

**Table: Spectral Resolution (nm)**

<table>
<thead>
<tr>
<th>Spectral Resolution</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
<th>Band 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>333-353</td>
<td>118</td>
<td>236</td>
<td>472</td>
<td>944</td>
<td>1888</td>
</tr>
<tr>
<td>453</td>
<td>684</td>
<td>879</td>
<td>1585</td>
<td>1675</td>
<td></td>
</tr>
<tr>
<td>684</td>
<td>879</td>
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<td>1675</td>
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**Table: Spatial Resolution**

<table>
<thead>
<tr>
<th>Spatial Resolution</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
<th>Band 5</th>
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</thead>
<tbody>
<tr>
<td>460 m</td>
<td>920 m</td>
<td>460 m</td>
<td>920 m</td>
<td>920 m</td>
<td>920 m</td>
</tr>
</tbody>
</table>

**Table: Tilt**

<table>
<thead>
<tr>
<th>Tilt</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
<th>Band 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>+20 deg (Forward viewing)</td>
<td>333-353</td>
<td>433</td>
<td>664</td>
<td>859</td>
<td>1585</td>
</tr>
<tr>
<td>+20 deg (Backward viewing)</td>
<td>370-390</td>
<td>540</td>
<td>664</td>
<td>859</td>
<td>1585</td>
</tr>
</tbody>
</table>

**Table: Swath**

<table>
<thead>
<tr>
<th>Swath</th>
<th>Band 1</th>
<th>Band 2</th>
<th>Band 3</th>
<th>Band 4</th>
<th>Band 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>920 km</td>
<td>460 m</td>
<td>920 m</td>
<td>460 m</td>
<td>920 m</td>
<td>920 m</td>
</tr>
</tbody>
</table>
Conclusion and Future Plan

1. The first high spectral resolution FTS from 0.76 to 15 μm with two linear polarization has contributed to understand radiative transfer in the Earth’s atmosphere.

2. With updated molecular spectroscopy and retrieval of light path modification from O₂A band, precise and accurate XCO₂ and XCH₄ has been achieved. Uncertainty in global flux has been reduced.

3. Frequent updates in non-linearity correction in level 1 processing has improved consistent data set from dark to bright desert target.

4. International collaboration on calibration, validation, and retrieval algorithm has demonstrated the effectiveness of the GHG monitoring from space.

5. The agile pointing system and daily observation planning has been maximizing good quality data. However, further modification is needed to optimize the sampling pattern for CO₂ and CH₄ flux estimation.

6. Simultaneous measurement of short-lived spices such as NO₂ and CO, and imaging capability, wind speed information will improve anthropogenic GHG emission estimation.

7. Solving puzzles to estimate emission amount of individual emission sources will provide effective GHG anthropogenic reduction.