Summary of NI ES GOSAT Project: Activities Over the Past Seven Years and Plans for the Next Five Years

T. Yokota (NIES GOSAT Project Acting Leader)

Center for Global Environmental Research (CGER)
National Institute for Environmental Studies (NIES), Japan
Contents

- Seven years of the NIES GOSAT project
  - Observation of columnar CO$_2$ & CH$_4$ amounts
  - Many versions of GOSAT data products
  - Monthly regional flux estimation of CO$_2$ and CH$_4$ by using GOSAT data for three/four years
- Next five-year plan of GOSAT data processing and distribution at NIES GOSAT DHF
TANSO onboard GOSAT

TANSO = Thermal And Near infrared Sensor for carbon Observation

**TANSO (炭素) = Carbon**

### Specifications

<table>
<thead>
<tr>
<th>Size</th>
<th>Main body</th>
<th>3.7 m x 1.8 m x 2.0 m (Wing Span 13.7 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>Total</td>
<td>1750 kg</td>
</tr>
<tr>
<td>Power</td>
<td>Total</td>
<td>3.8 kW (EOL)</td>
</tr>
<tr>
<td>Life Time</td>
<td></td>
<td>5 years</td>
</tr>
<tr>
<td>Orbit</td>
<td></td>
<td>sun synchronous orbit</td>
</tr>
<tr>
<td>Local time</td>
<td></td>
<td>13:00 +/- 0:15</td>
</tr>
<tr>
<td>Altitude</td>
<td></td>
<td>666 km</td>
</tr>
<tr>
<td>Inclination</td>
<td></td>
<td>98 deg</td>
</tr>
<tr>
<td>Repeat</td>
<td></td>
<td>3 days</td>
</tr>
<tr>
<td>Launch Vehicle</td>
<td></td>
<td>H-IIA</td>
</tr>
<tr>
<td>Schedule</td>
<td></td>
<td>Jan. 23 2009</td>
</tr>
</tbody>
</table>

### Instruments

- **TANSO-CAI** (Cloud and Aerosol Imager)
  - Ultraviolet (UV) (0.38 micron), visible (0.67 micron), NIR (0.87 micron), and SWIR (1.6 micron)

- **TANSO-FTS** (Fourier Transform Spectrometer)
  - SWIR reflected on the earth’s surface
  - TIR radiated from the ground and the atmosphere

(Courtesy of JAXA)
Mission promoted by JAXA, MOE, and NIES.

**MOE**
Ministry of the Environment

Sensor develop. (partly)  
Validation funding,  
Policy making

**JAXA**
Japan Aerospace Exploration Agency

Rocket launch, Satellite and Sensor development & operation, Data acquisition,  
Calibration, L1 data processing,  
Data distribution to major organizations (NASA, ESA, ...)

**NIES**
National Institute for Environmental Studies

Developing & improving GHG retrieval algorithms,  
L2 and higher level data processing, Data validation, Estimating carbon fluxes, Data product distribution
Objectives of the GOSAT Project

1. To obtain the **global distributions** of greenhouse gas (GHG) concentrations (CO$_2$ and CH$_4$) and their **temporal variations**
   - To **visualize** changing GHG global distributions
   - To fill out the gaps in the network of ground monitoring stations

2. To improve accuracy of the carbon flux (net sources and sinks) estimation on a sub-continental scale

3. To develop technologies for future GHG observing satellites ⇒ GOSAT-2
09/2002: Decision of the GOSAT project in Japan
04/2003: JAXA organized the GOSAT project team
04/2004: GOSAT virtual team was settled in the CGER/NIES
01/2009: GOSAT was launched successfully.
01/2014: GOSAT Nominal Operation Period ended, and GOSAT Extended Operation Period started.
★ 05/2014: One of the two solar paddles stopped.
★ 01/2015: JAXA switched the GOSAT Pointing mechanism of the TANSO-FTS from the main system to the sub-system due to occurrence of the unstable pointing.
★ 08/2015: GOSAT thermal Infrared observation was suspended due to the cryo--cooler anomaly. TANSO-FTS SWIR and TANSO-CAI observations were nominal. The cryo-cooler restarted on Sept. 14, and the TIR measurement has been recovered.
**TANSO-FTS SWIR Level 2 (Vers. 02.21, 02.31, 02.40, 02.50, 02.60) XCO₂ & XCH₄**

**XCO₂**

April 2009 - February 2016

One paddle stopped

Pointing mirror switched

**XCH₄**

**XCO₂, XCH₄:** Column-averaged volume mixing ratios are the ratio of the total amount of CO₂ or CH₄ to the total amount of dry air contained in a vertical column from ground surface to the top of the atmosphere.
## GOSAT Standard Data Products

<table>
<thead>
<tr>
<th>Product Level</th>
<th>Sensor / Band</th>
<th>Product Designation</th>
<th>Description</th>
<th>Product Provision Unit</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1</strong></td>
<td>FTS</td>
<td>FTS L1B data</td>
<td>Radiance spectral data obtained by performing Fourier transform on interferogram data</td>
<td>per FTS scene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAI</td>
<td>CAI L1B data</td>
<td>Radiance data (band-to-band and geometric corrections applied / data mapping not performed)</td>
<td>per CAI frame</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td>L1B+</td>
<td>CAI L1B+ data</td>
<td>Radiance data (band-to-band and geometric corrections applied / data mapping performed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td>FTS SWIR</td>
<td>L2 CO₂ column amount (SWIR)</td>
<td>CO₂ column abundance data retrieved from SWIR radiance spectral data</td>
<td>can be selected</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>L2 CH₄ column amount (SWIR)</td>
<td>CH₄ column abundance data retrieved from SWIR radiance spectral data</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FTS TIR</td>
<td>L2 CO₂ profile (TIR)</td>
<td>CO₂ vertical profile data retrieved from TIR radiance spectral data</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>L2 CH₄ profile (TIR)</td>
<td>CH₄ vertical profile data retrieved from TIR radiance spectral data</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAI</td>
<td>L2 cloud flag</td>
<td>Cloud coverage data</td>
<td>per CAI frame</td>
<td></td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
<td>FTS SWIR</td>
<td>L3 global CO₂ distribution (SWIR)</td>
<td>CO₂ column-averaged mixing ratio data projected on a global map</td>
<td>per month (global)</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L3 global CH₄ distribution (SWIR)</td>
<td>CH₄ column-averaged mixing ratio data projected on a global map</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FTS TIR</td>
<td>L3 global CO₂ distribution (TIR)</td>
<td>Monthly-averaged CO₂ concentration at each vertical level projected on a global map</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>L3 global CH₄ distribution (TIR)</td>
<td>Monthly-averaged CH₄ concentration at each vertical level projected on a global map</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAI</td>
<td>L3 global radiance distribution</td>
<td>Global radiance distribution data (3 days worth, including data for cloudy segments)</td>
<td>per 3 days (global)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>L3 global reflectance distribution (clear sky)</td>
<td>Clear-sky radiance data (composed only of clearsky segments selected from a month worth of data)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>L3 global NDVI</td>
<td>Vegetation index global distribution data (cloudy segments excluded)</td>
<td>per 15 days $30° × 60°$ (lat. × lon.)</td>
<td></td>
</tr>
<tr>
<td><strong>Level 4</strong></td>
<td>L4A</td>
<td>L4A global CO₂ flux</td>
<td>CO₂ flux per each of the 64-divided global regions (monthly average)</td>
<td>per year (64 regions)</td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>L4B</td>
<td>L4B global CO₂ distribution</td>
<td>Three-dimensional, global distribution of CO₂ concentration</td>
<td>per month $2.5° × 2.5°$ grid (lat. × lon.)</td>
<td>NetCDF</td>
</tr>
</tbody>
</table>

Settled in 2005
## GOSAT Standard Data Products

### Level 1

<table>
<thead>
<tr>
<th>Product Level</th>
<th>Sensor / Band</th>
<th>Product Designation</th>
<th>Description</th>
<th>Product Provision Unit</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1B</td>
<td>FTS</td>
<td>FTS L1B data</td>
<td>Radiance spectral data obtained by performing Fourier transform on interferogram data</td>
<td>per FTS scene</td>
<td>HDF5</td>
</tr>
<tr>
<td>L1B+</td>
<td>CAI</td>
<td>CAI L1B+ data</td>
<td>Radiance data (band-to-band and geometric corrections applied / data mapping performed)</td>
<td>per CAI frame</td>
<td>HDF5</td>
</tr>
</tbody>
</table>

### Level 2

<table>
<thead>
<tr>
<th>Sensor / Band</th>
<th>Product Designation</th>
<th>Description</th>
<th>Product Provision Unit</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTS SWIR</td>
<td>L2 CO₂ column amount (SWIR)</td>
<td>CO₂ column abundance data retrieved from SWIR radiance spectral data</td>
<td>can be selected</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td>L2 CH₄ column amount (SWIR)</td>
<td>CH₄ column abundance data retrieved from SWIR radiance spectral data</td>
<td>can be selected</td>
<td>HDF5</td>
</tr>
<tr>
<td>FTS TIR</td>
<td>L2 CO₂ profile (TIR)</td>
<td>CO₂ vertical profile data retrieved from TIR radiance spectral data</td>
<td>can be selected</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td>L2 CH₄ profile (TIR)</td>
<td>CH₄ vertical profile data retrieved from TIR radiance spectral data</td>
<td>can be selected</td>
<td>HDF5</td>
</tr>
<tr>
<td>CAI</td>
<td>L2 cloud flag</td>
<td>Cloud coverage data</td>
<td>per CAI frame</td>
<td>HDF5</td>
</tr>
</tbody>
</table>

### Level 3

<table>
<thead>
<tr>
<th>Sensor / Band</th>
<th>Product Designation</th>
<th>Description</th>
<th>Product Provision Unit</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTS SWIR</td>
<td>L3 global CO₂ distribution (SWIR)</td>
<td>CO₂ column-averaged mixing ratio data projected on a global map</td>
<td>per month (global)</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td>L3 global CH₄ distribution (SWIR)</td>
<td>CH₄ column-averaged mixing ratio data projected on a global map</td>
<td>per month (global)</td>
<td>HDF5</td>
</tr>
<tr>
<td>FTS TIR</td>
<td>L3 global CO₂ distribution (TIR)</td>
<td>Monthly-averaged CO₂ concentration at each vertical level projected on a global map</td>
<td>per month (global)</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td>L3 global CH₄ distribution (TIR)</td>
<td>Monthly-averaged CH₄ concentration at each vertical level projected on a global map</td>
<td>per month (global)</td>
<td>HDF5</td>
</tr>
<tr>
<td>CAI</td>
<td>L3 global radiance distribution</td>
<td>Global radiance distribution data (3 days worth, including data for cloudy segments)</td>
<td>per 3 days (global)</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td>L3 global reflectance distribution (clear sky)</td>
<td>Clear-sky radiance data (composed only of clear-sky segments selected from a month worth of data)</td>
<td>per 3 days (global)</td>
<td>HDF5</td>
</tr>
<tr>
<td></td>
<td>L3 global NDVI</td>
<td>Vegetation index global distribution data (cloudy segments excluded)</td>
<td>per 15 days 30°×60° (lat. × lon.)</td>
<td>HDF5</td>
</tr>
</tbody>
</table>

### Level 4

<table>
<thead>
<tr>
<th>Product Level</th>
<th>Product Designation</th>
<th>Description</th>
<th>Product Provision Unit</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>L4A</td>
<td>L4A global CO₂ flux</td>
<td>CO₂ flux per each of 64 global regions (monthly average)</td>
<td>year (global)</td>
<td>Text/NetCDF</td>
</tr>
<tr>
<td></td>
<td>L4A global CH₄ flux</td>
<td>CH₄ flux per each of 43 global regions (monthly average)</td>
<td>year (global)</td>
<td>Text/NetCDF</td>
</tr>
<tr>
<td>L4B</td>
<td>L4B global CO₂ distribution</td>
<td>Three-dimension global distribution of CO₂ concentration</td>
<td>month (global) 2.5°×2.5°grid (lat. × lon.)</td>
<td>NetCDF</td>
</tr>
<tr>
<td></td>
<td>L4B global CH₄ distribution</td>
<td>Three-dimension global distribution of CH₄ concentration</td>
<td>month (global) 2.5°×2.5°grid (lat. × lon.)</td>
<td>NetCDF</td>
</tr>
</tbody>
</table>
## GOSAT Standard Data Products

### Level 1
- **L1B**
  - **FTS**: FTS L1B data
  - **CAI**: CAI L1B data
  - Description: Radiance spectral data obtained by performing Fourier transform on interferogram data
  - Product Provision Unit: per FTS scene
  - Data Format: HDF5

### Level 2
- **L1B+**
  - **CAI**: CAI L1B+ data
  - Description: Radiance data (band-to-band and geometric corrections applied / data mapping not performed)
  - Product Provision Unit: per CAI frame
  - Data Format: HDF5

### Level 2
- **L2**
  - **FTS SWIR**: L2 CO₂ column amount (SWIR)
  - **L2 CH₄ column amount (SWIR)**
  - **L2 H₂O column amount (SWIR)**
  - **L2 CH₄ profile (TIR)**
  - **L2 cloud flag**
  - Description: CH₄ vertical profile data retrieved from TIR radiance spectral data
  - Product Provision Unit: per month (global)
  - Data Format: HDF5

### Level 3
- **L3**
  - **FTS TIR**: L3 global CO₂ distribution (TIR)
  - **L3 global CH₄ distribution (TIR)**
  - **L3 global radiance distribution**
  - **L3 global reflectance distribution (clear sky)**
  - **L3 global NDVI**
  - Description: Monthly-averaged CO₂ concentration at each vertical level projected on a global map
  - Description: Monthly-averaged CH₄ concentration at each vertical level projected on a global map
  - Product Provision Unit: per 3 days (global)
  - Data Format: Text/NetCDF

### Level 4
- **L4A**
  - **L4A global CO₂ flux**
  - **L4A global CH₄ flux**
  - Description: CO₂ flux per each of 64 global regions (monthly average)
  - Description: CH₄ flux per each of 43 global regions (monthly average)
  - Product Provision Unit: year (global)
  - Data Format: Text/NetCDF

- **L4B**
  - **L4B global CO₂ distribution**
  - **L4B global CH₄ distribution**
  - Description: Three-dimensional global distribution of CO₂ concentration
  - Description: Three-dimensional global distribution of CH₄ concentration
  - Product Provision Unit: month (global)
  - Data Format: 2.5°×2.5° grid (lat. × lon.)
GOSAT Data Processing

Registered Users

Researchers

JAXA

Level 1 Data

Observation Requests

Level 1 Data

Observation Plan

Data Transfer

Level 1 Data

GOSAT Data Handling Facility (NIES/GOSAT DHF)

Computing Facilities

Processed data

Data Storage

GOSAT Computer System

Reference Data Providers

Reference Data

Standard Data Products

Observation Requests

(GIES) GOSAT L2 (FP)
(NIES/UTYO) PPDF-S

ACOS (OCO-2)

ACOS GOSAT B3.5

RemoTeC

UoL FP/Proxy

Bremen U. BESD

ESA
55-month-long GOSAT XCO$_2$ and XCH$_4$ (June 2009 – December 2013)

- Above movies are 1-month-moving average GOSAT XCO$_2$ and XCH$_4$ with three-day interval. The mesh size is 2.5 degree.
- Various interesting features are shown in these movies such as annual and seasonal variations of XCO$_2$ and localized anomalies of XCH$_4$.
- GOSAT obtained XCO$_2$ and XCH$_4$ data for more than 6 years. Validation results suggest that relative accuracies (variations) of XCO$_2$ and XCH$_4$ are $\approx 2$ ppm ($\approx 0.5\%$) and $12$ ppb ($\approx 0.7\%$), respectively.
Schematic illustration of the GOSAT validation

**Ground-based high-resolution FTS**

A worldwide network of ground-based FTS (TCCON; over 20 sites in the world)

- **Aircraft measurements**
- **Morino et al. (2011, AMT)**
- **Yoshida et al. (2013, AMT)**

**In-situ instrument onboard the airplane**
- Concentration measurement at various altitudes

**Ground-based high-resolution FTS**
- Laser beam
- Aerosols
- Scattered light

**Sky radiometer**
- Lidar

**Tsukuba, Rikubetsu, Saga**

**in NIES (Tsukuba)**
Validation of GOSAT (TANSO-FTS SWIR) Level 2 Data with TCCON data (Ver.02.21)

- Slightly lower values (negative biases) of GOSAT
- Standard Deviation is lower than 1%, respectively

(by I. Morino & O. Uchino (NIES))
Contribution of satellite data to carbon flux
Monthly CO₂ Flux Estimates and Uncertainties

Top: monthly-mean CO₂ data (input to flux estimation)
Squares: GOSAT XCO₂ gridded to 5° × 5° cells
Circles: GLOBALVIEW data (212 sites)
Bottom: Flux uncertainty
Time series of monthly regional flux estimates

Green: Prior estimate
Red: Posterior estimate by GV only
Blue: Posterior estimate by GV + GOSAT

Unit: gC m⁻² day⁻¹
Gray bar: Flux uncertainty reduction (%)

Red: Flux unc. (GV-only estimate)
Blue: Flux unc. (GV + GOSAT estimate)
GOSAT L4B Data Product (V02.03)
Model-simulated CO₂ concentration

◆ (6hr-step, 0.925 sigma-level (~ 800m), 2.5° × 2.5° grid )

©JAXA/NIES/MOE
Monthly CH₄ Flux Estimates and Uncertainties

Top: monthly-mean GOSAT XCH₄ data gridded to 2.5° x 2.5° mesh (input to flux estimation)
Middle: Monthly flux estimates (GOSAT Level 4A CH₄)
Bottom: Flux uncertainty

* Anthropogenic, natural, and biomass burning emissions are estimated separately for each region.
Model Intercomparison with international research groups

Single-system GOSAT inversion inter-comparison (Transcom 3 subject)

Five GOSAT $X_{CO_2}$ Datasets
- NIES Level 2 v02.11
- ACOS B3.4
- PPDF-S v02.11
- RemoTeC v2.11
- U. of Leicester v4

(Single-shot $X_{CO_2}$ retrievals used)

Five Regional Monthly Flux Estimates
- NIES Level 4 Inverse Modeling System
  - NIES-TM
  - Kalman Smoother

Inter-comparison
  - 19 mon.

64 Land/Ocean Regions

19-mon. time series: five fluxes estimated for Reg. 32

(by H. Takagi & S. Maksyutov (NIES))

These monthly spreads add up to > 1GtC/yr differences → not negligible!
GOSAT Research Promotion (International Research Collaboration)

◆ Research Announcement

➢ Research Topics

1) Calibration
2) Data Processing Algorithm
3) Validation
4) Carbon Balance Estimation and Atmospheric Transport Models
5) Data Application

➢ First announcement was issued in March 2008.

➢ 10 announcements were issued and 126 research subjects were adopted by now.

➢ 46 subjects have been completed.
<table>
<thead>
<tr>
<th>Country</th>
<th>1st RA</th>
<th>2nd RA</th>
<th>3rd RA</th>
<th>4th RA</th>
<th>5th RA</th>
<th>6th RA</th>
<th>7th RA</th>
<th>8th RA</th>
<th>9th RA</th>
<th>10th RA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>23</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>36</td>
</tr>
<tr>
<td>USA</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Germany</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>China</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Canada</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>France</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>UK</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Russia</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Finland</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Australia</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>India</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Korea</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Malaysia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Norway</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Belgium</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Beralus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Czech</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>NewZealand</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Singapore</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Taiwan, ROC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>52</td>
<td>36</td>
<td>18</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>126</td>
</tr>
</tbody>
</table>
## GOSAT Research Announcement (RA) Adopted Subject Topics

<table>
<thead>
<tr>
<th>Research Category</th>
<th>1st RA</th>
<th>2nd RA</th>
<th>3rd RA</th>
<th>4th RA</th>
<th>5th RA</th>
<th>6th RA</th>
<th>7th RA</th>
<th>8th RA</th>
<th>9th RA</th>
<th>10th RA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Data Processing Algorithm</td>
<td>11</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Data Validation</td>
<td>15</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Source and Sink Estimation</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>Data Application</td>
<td>16</td>
<td>14</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Data Application/Validation</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Data Application/Source and Sink Estimation</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>36</td>
<td>18</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>126</td>
</tr>
</tbody>
</table>
Rights and duty of the RA PIs

◆ Rights

1. To submit the GOSAT observation requests.
2. To request the delivery of standard and research products without any cost prior to their release to the general users.
3. To request to process FTS SWIR L2 data products without any screening criteria of the data quality.
4. To obtain additional information of the FTS SWIR L2 data products (column abundances of CO₂, CH₄, and H₂O (SWIR)), so-called the “sub-datasets” of the FTS L2 data products.
5. To participate in the GOSAT RA PI Meeting (closed meeting)

◆ Duty

1. To write a progress report and an interim report once in a year.
2. The final report and a summary report should be written after completion.
3. These reports will be evaluated by the GOSAT RA Selection and Evaluation Committee.
The 7th GOSAT RA PI Meeting, June 15, 2015 @ Caltech, Pasadena, CA USA
GOSAT-related Published Papers
(as of December 2015)

Total: 226 articles
At the first stage of the GOSAT project, we have designed the data handling facility (DHF) to process, re-process, store, distribute, and improve processing codes for 5-year nominal mission period.

But GOSAT is still operating, and now in 8th year operation. Therefore, we have prepared equipment to process for five years more, and will update the DHF system under the condition of keeping operation.

From this year, we will re-process the CAI data, minimum-surface reflectance, cloud flag, and then FTS SWIR L2 $X_{\text{CO}_2}$ and $X_{\text{CH}_4}$ by using an assimilation – SPRINTARS (aerosol transport model) for the data during April 2009 – May 2014.