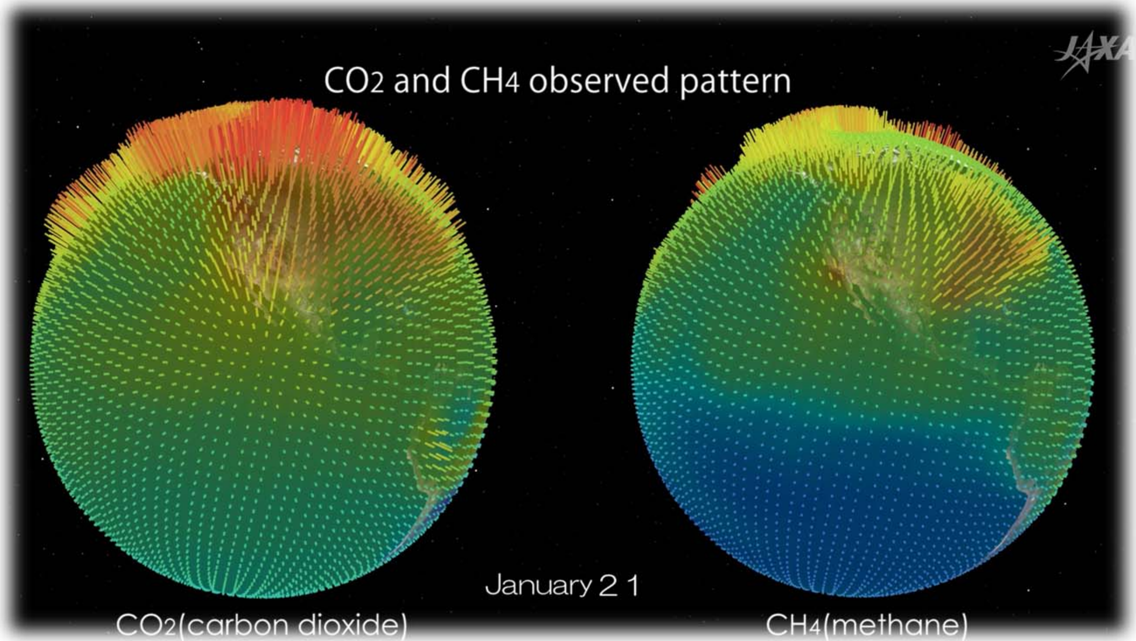
JAXA GOSAT program status

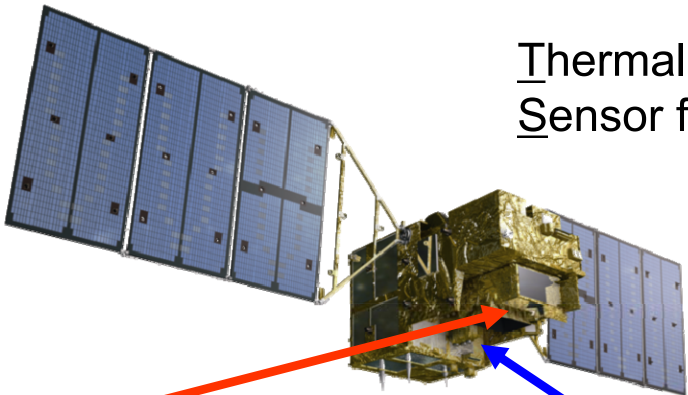


Akihiko KUZE (JAXA EORC)
June 15, 2017

Launch Vehicle and Orbit
GOSAT Satellite Configuration

Size	Main body	3.7m(H) x1.8m(W) x 2.0m(D)(Except attachment)
	Wing Span	13.7 m
Mass	Total	1,750 kg
Power	Total	3.8KW(EOL)
Design Life	5 years	
Orbit	Sun Synchronous Orbit	
	Local time	13:00±0:15 (February 2015 - January 2016) 12:46-12:52
	Altitude, inclination, period, revisit	666±0.6 km, 98.0±0.1 deg, 98.1 min, 3 days (44 rotations)
Launch	Vehicle, date	H-IIA, Jan. 23, 2009

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



Thermal And Near infrared Sensor for carbon Observation

TANSO-FTS

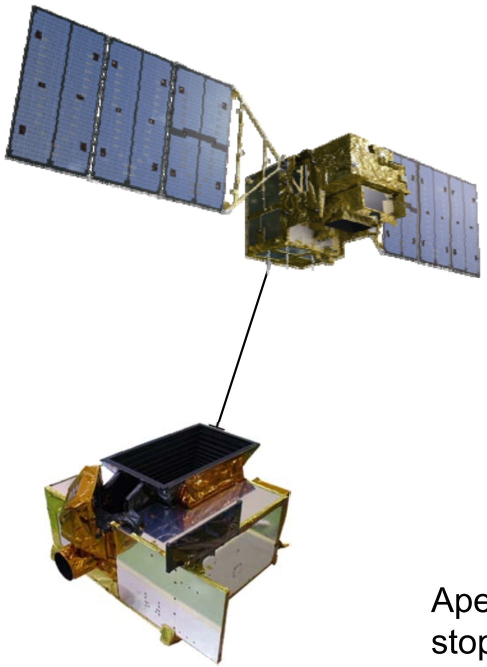
SWIR/TIR FTS

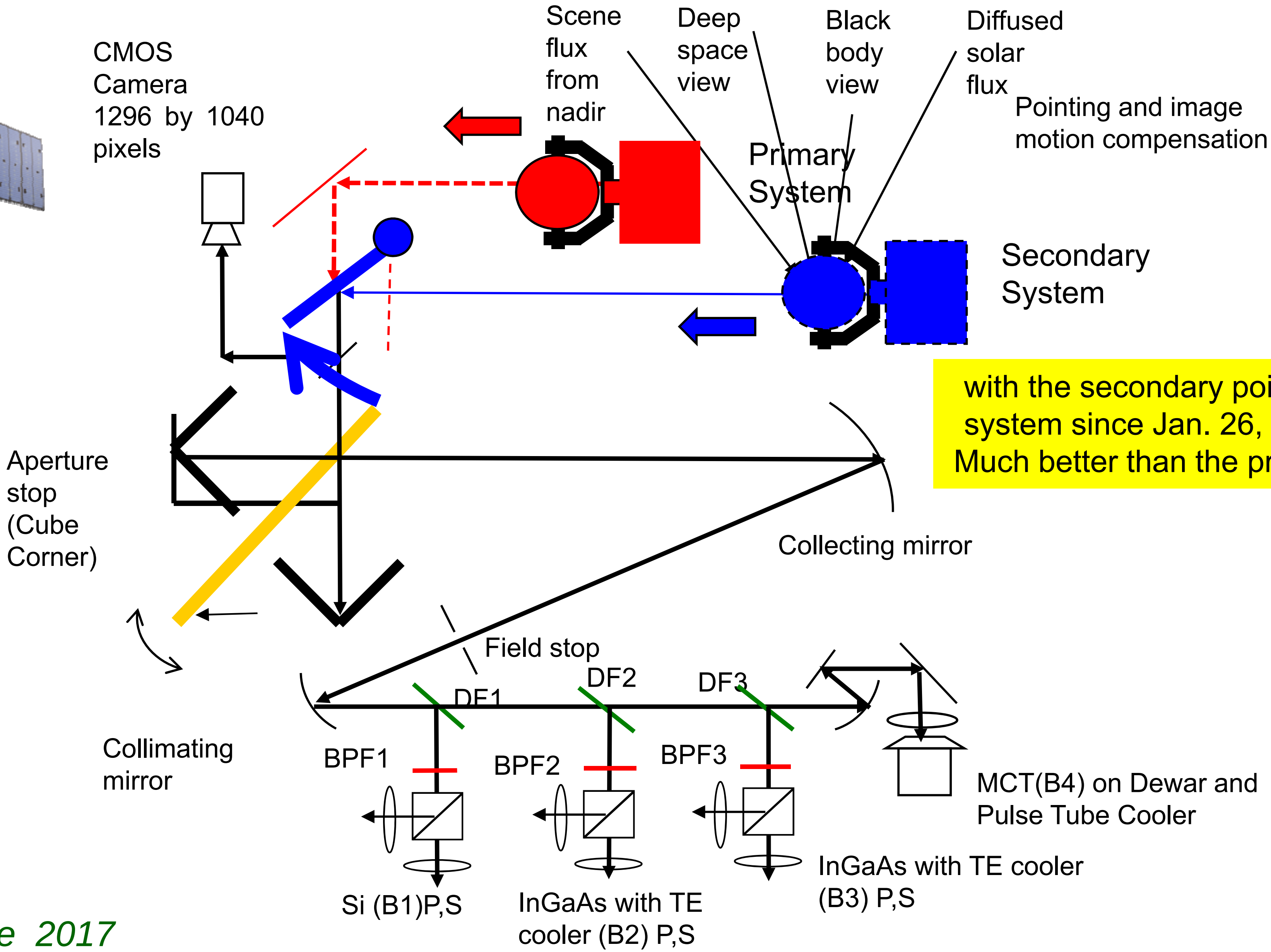
TANSO-CAI

UV, Visible, SWIR Imager

Combination of Pointing System and Spectrometer

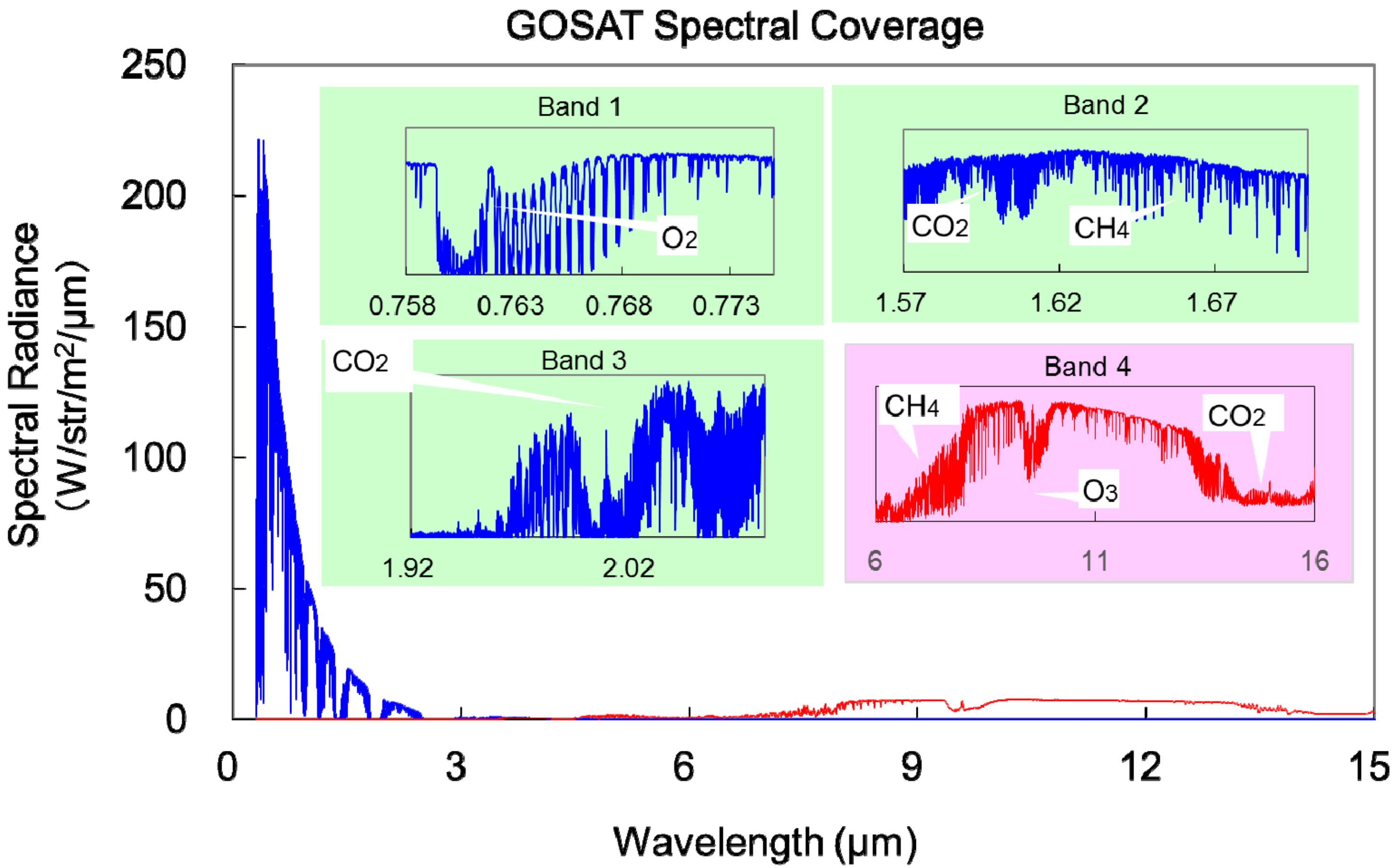
FTS multiplex advantage: exact the same IFOV: SWIR, TIR, 2 linear polarization





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

Wide Spectral Coverage with a FTS



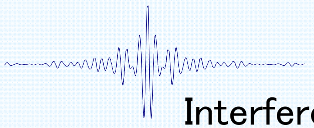
- Solar Reflected light
  3 narrow bands
  - 0.76 μm
  - 1.6 μm
  - 2.0 μm
- Thermal Radiation
  A wide band
  - 5.5 – 14.3 μm
- With 0.2cm^{-1} spectral resolution (interval)

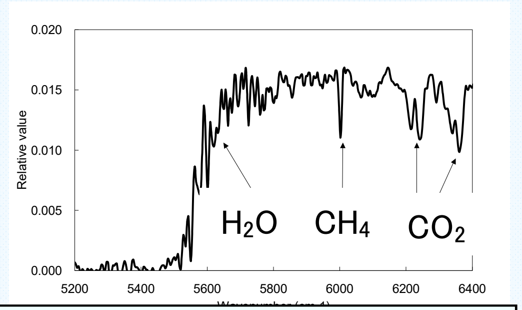
- Column averaged density of CO_2 is mainly retrieved by using the absorption lines between 1.6 μm region.
  - The intensities of these lines are less temperature dependent and not interfered by other molecules.
- O_2 A band absorption at 0.76 μm: Dry air column

GOSAT Data Products and Distribution

JAXA

Measurement





Receive and Record

Level 1 processing
- processing to spectra
- calibration

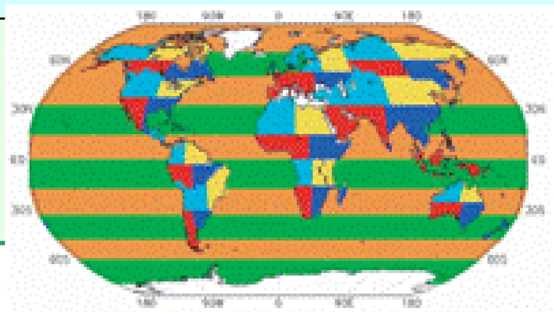
esa DLR JPL cnes

Data distribution

Level 1 Data

NIES

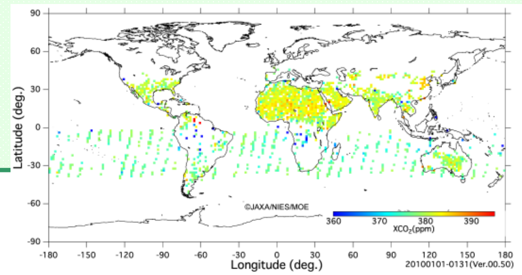
Level 4 Processing
- estimate the global net flux



Level 2 and 3Processing
- to produce the global distribution map for CO_2 and CH_4
- validation

Data distribution
Public

Regional Flux



GOSAT Operation and Research Progress since Launch

Launch

Frequent and global CO_2 distribution

2011 Butz et al.
the accuracy of 2 ppm or 0.5% for CO_2 and 13 ppb or 0.7% for CH_4

Global flux inversion (b)

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

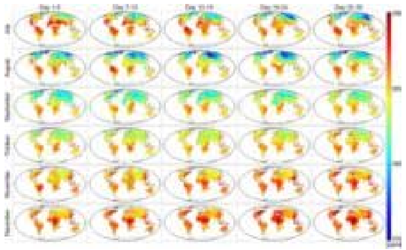
Long term CO2 and CH4 (c)

2015 Turner et al. (d)
North American CH_4 emissions using prior information on source locations <aggregation, emission source classification>

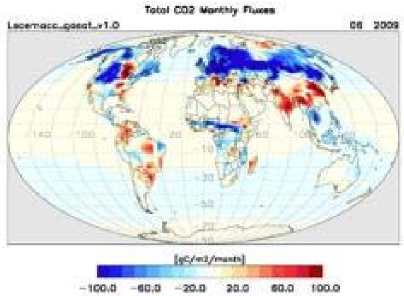
Flux Emission from CH_4 point sources

Goal
City level CO_2 flux estimation with source classification

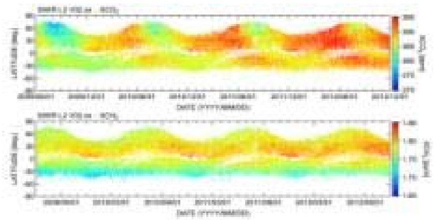
2017



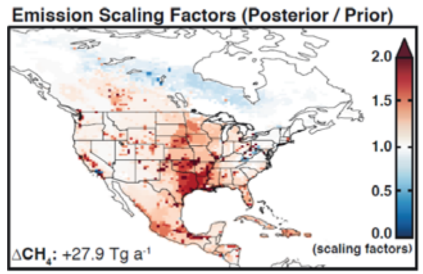
(a) Hammerling et al.



(b) Houweling et al.



(c) NIES/JAXA/MOE



(d) Turner et al.

Instrument

Feb. 2009
The first very-high spectral resolution spectrometer to measure column-averaged dry air mole fractions of CO_2 and CH_4 globally

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.

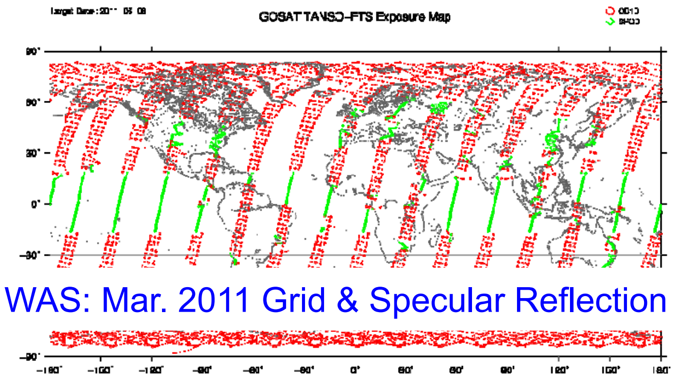
Data Processing

Non linearity corrections

Level 1 V201 (2015)
Long-term uniform quality data set

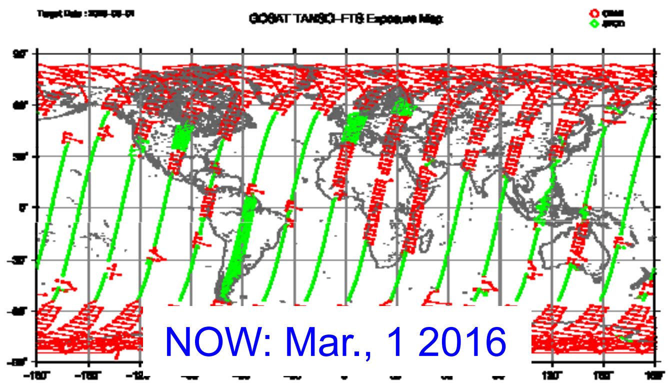
Flexibility with Target Observation

Optimized sampling pattern for flux estimation with an agile pointing system

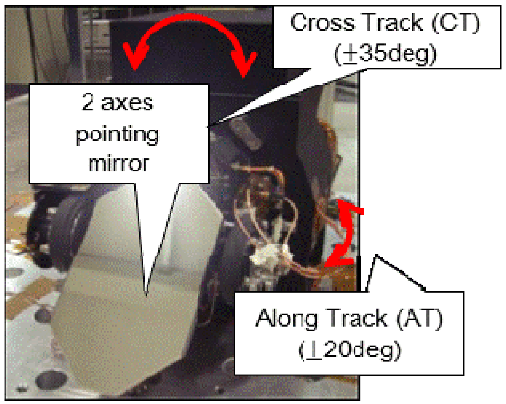


WAS: Mar. 2011 Grid & Specular Reflection

Extending glint region over ocean by tracking principal plane

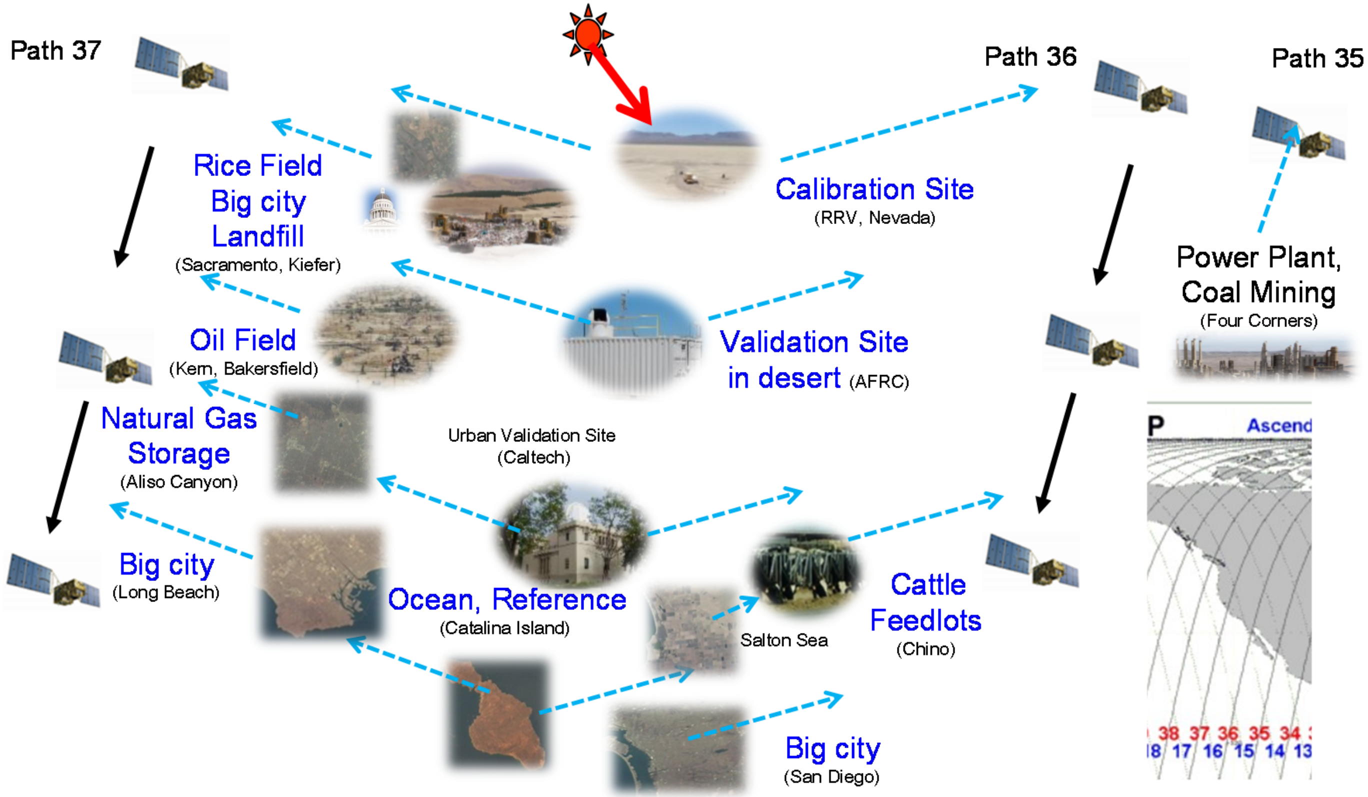


NOW: Mar., 1 2016



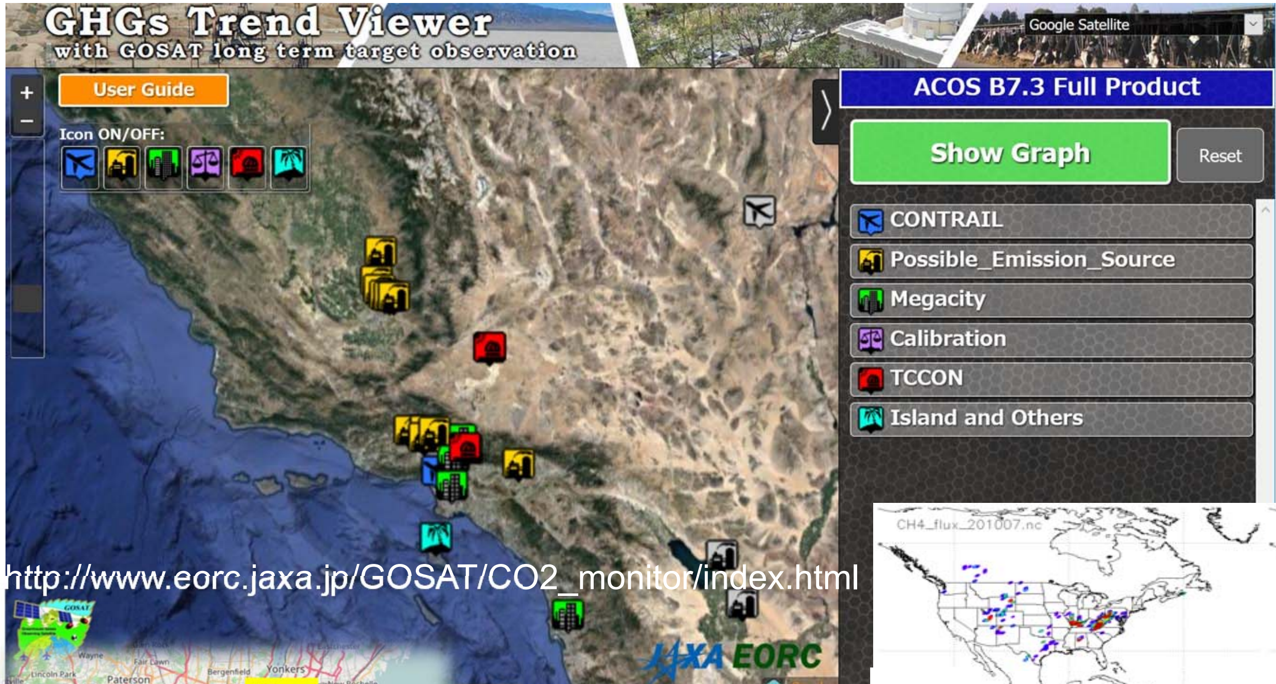
2-Axis pointing system

Up to 1000 custom target observations per day by uploading commands every day.



GHG Trend Viewer and NASA GES DISC

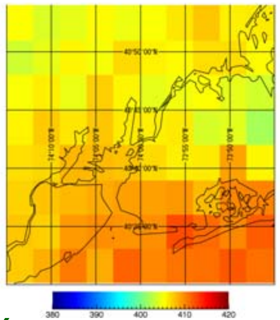
CMS (Carbon Monitoring System) Methane (CH_4) Flux for North America 0.5 degree x 0.667 degree



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

Contents
Long term
CO_2, CH_4, SIF, AOD
Solar-induced chlorophyll fluorescence
Aerosol optical depth

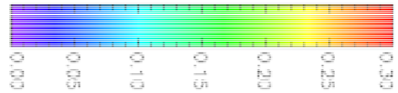
To be added
City distribution map
Aeronet site
4 Level 2 products intercomparison
OCO-2 match up
Surface wind speed
Ground validation data



NASA GES DISC

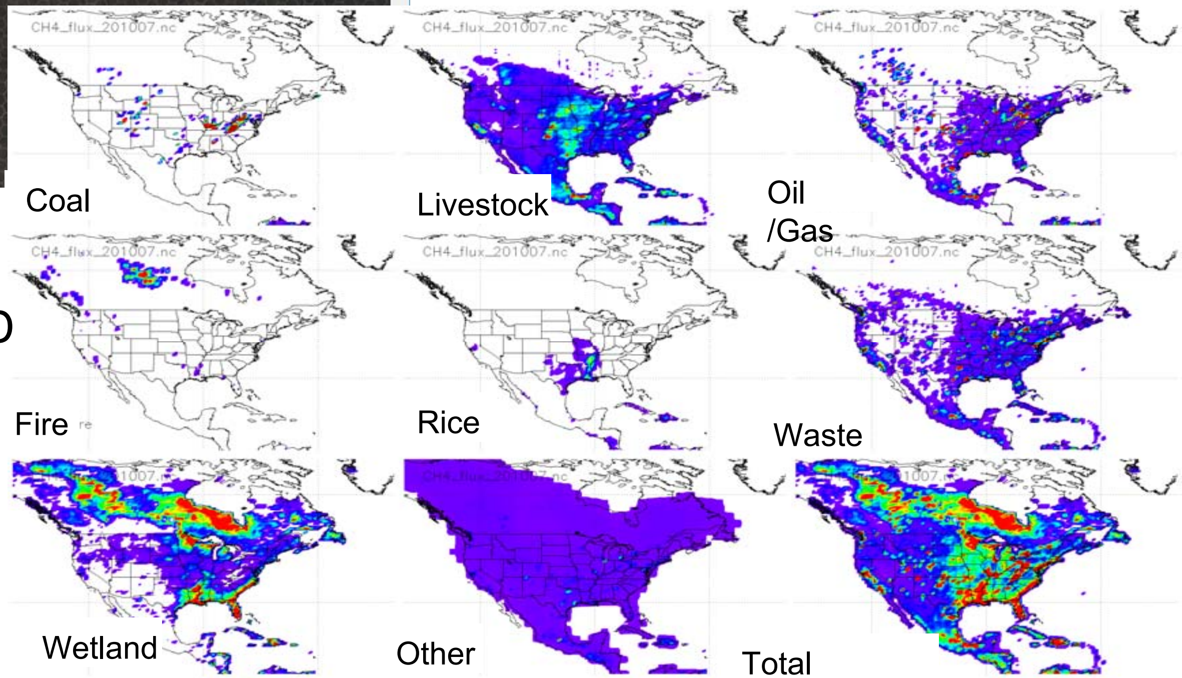
The CMS Methane (CH_4) Flux for North America data set contains estimates in North America based on an inversion of the GEOS-Chem chemical transport model constrained by GOSAT.

July 2010



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

CH_4 emission (Gg/year)



Toward GHG satellites constellation

Inter-comparison between GOSAT and OCO-2

2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

Radiometric calibration

Prelaunch X-CAL

Annual Vicarious Calibration at the desert playa in Nevada

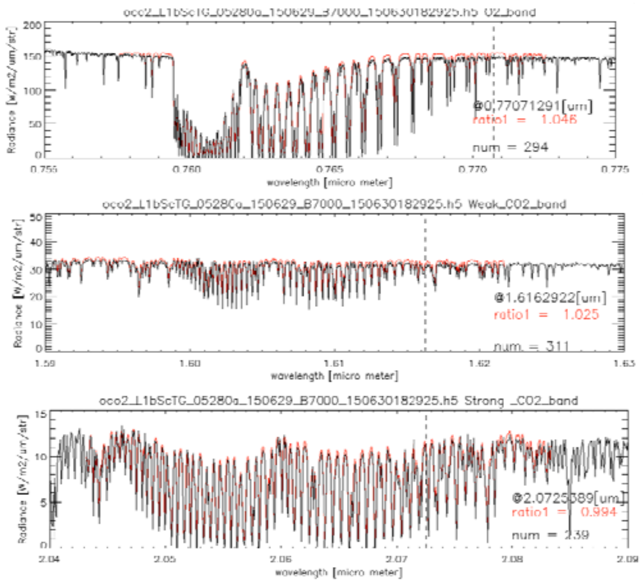
CO_2 & CH_4 profile

In situ CO_2 and CH_4 on NASA AMES AJAX

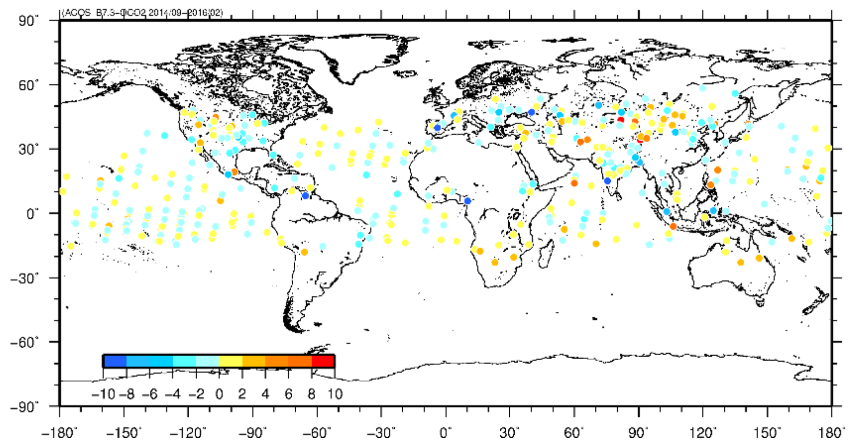
XCO_2 & XCH_4

Column with a compact FTS

Coincident Target



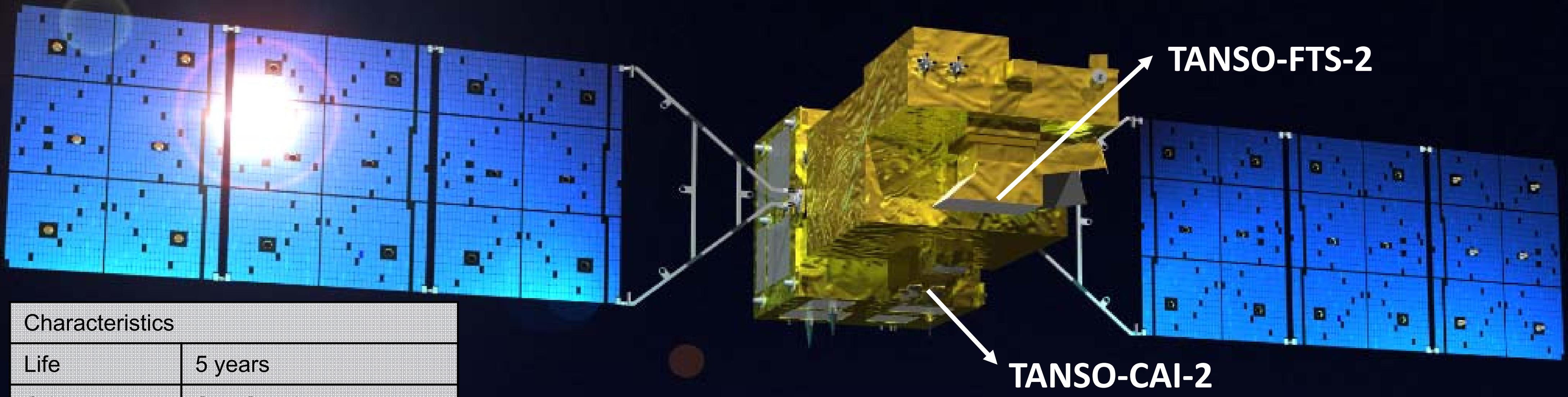
Calibrated GOSAT and OCO-2 radiance spectra agrees within 5% for all bands.



Retrieved Parameter Comparison over match up points

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

GOSAT-2



Characteristics	
Life	5 years
Orbit	Sun-Synchronous (628km)
Mass	About 2 t
Launch	FY 2018
Observation Valuables	CO_2, CH_4 and CO Accuracy: 0.5 ppm (CO_2) and 5 ppb (CH_4) at 500-km mesh over earth's surface

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

TANSO-FTS-2

	Band 1	Band 2	Band 3	Band 4	Band 5
Target Gases	O_2	CO_2, H_20	CO_2, CH_4, CO, H_20		
Spectral Coverage (μm)	0.75-0.77	1.56-1.69	1.92-2.33	5.5-8.4	8.4-14.3
Spectral Coverage (cm-1)	12,950 - 13,250	5,900 - 6,400	4,200 - 5,200	1,188 - 1,800	700 - 1,188
Spectral Resolution	0.2 cm^{-1}				
Exposure	4 sec				
IFOV	9.7 km				
Pointing	±40 deg. (Along track), ±35 deg. (Cross track)				
Polarimetry	Yes (P and S channels)			No	

TANSO-CAI-2 (radiometer)

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Spectral Band (nm)	333 - 353	433 - 453	664 - 684	859 - 879	1585 - 1675	370 - 390	540 - 560	664 - 684	859 - 879	1585 - 1675
Tilt	+20 deg. (Forward viewing)					-20 deg. (Backward viewing)				
Spatial Resolution	460 m				920m	460 m				920m
Swath	920 km									

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 O_2A band, precise and accurate XCO_2 and XCH_4 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 rom 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 CO_2 and CH_4 flux estimation.
6. Simultaneous measurement of short-lived spices such as NO_2 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.