GOSAT two years operation on orbit and its follow-on program

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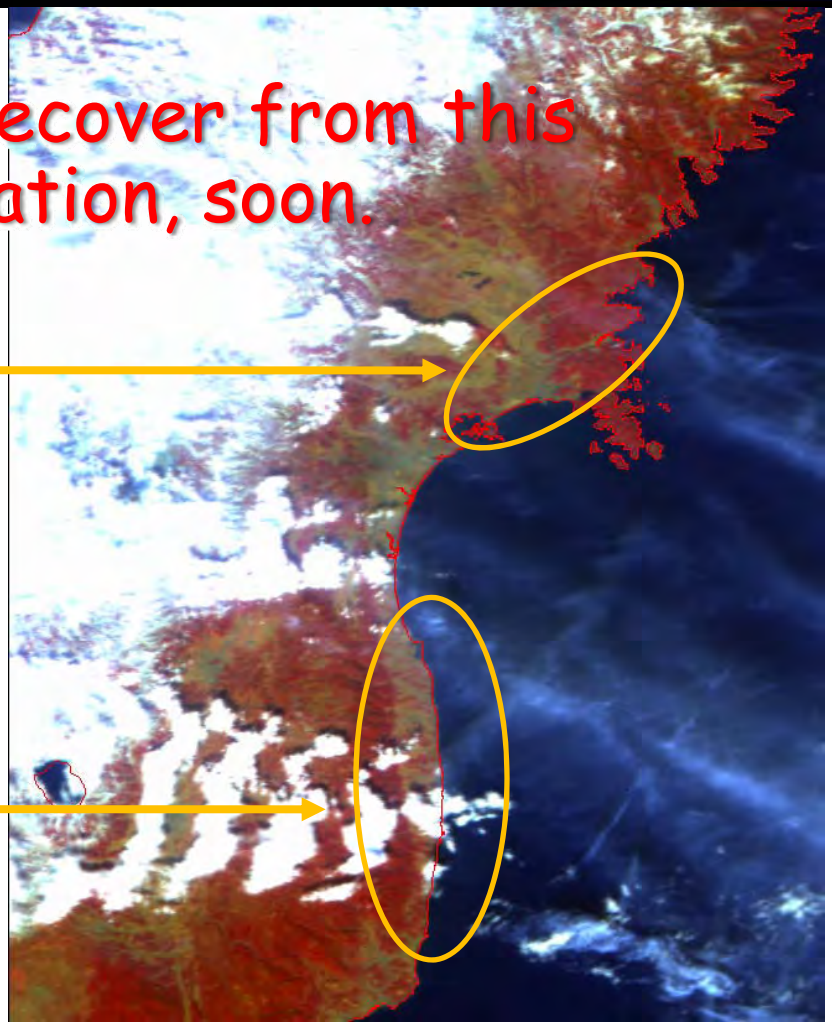
2011 EGU General Assembly, Vienna

Great Tohoku Earthquake

We hope we will recover from this serious situation, soon.

2011/03/14 (after Earthquake)

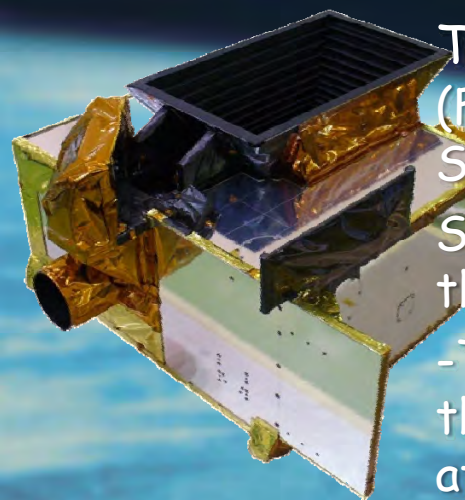


2011/02/27

TANSO onboard GOSAT

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

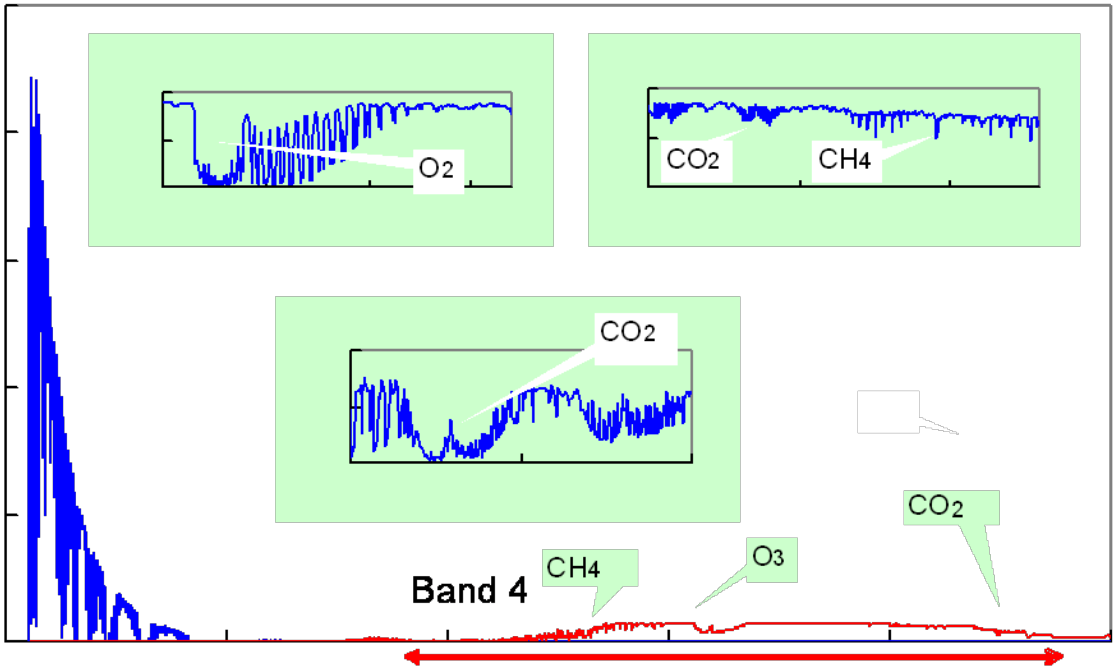
TANSO=Thermal And Near infrared Sensor for carbon Observation



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

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

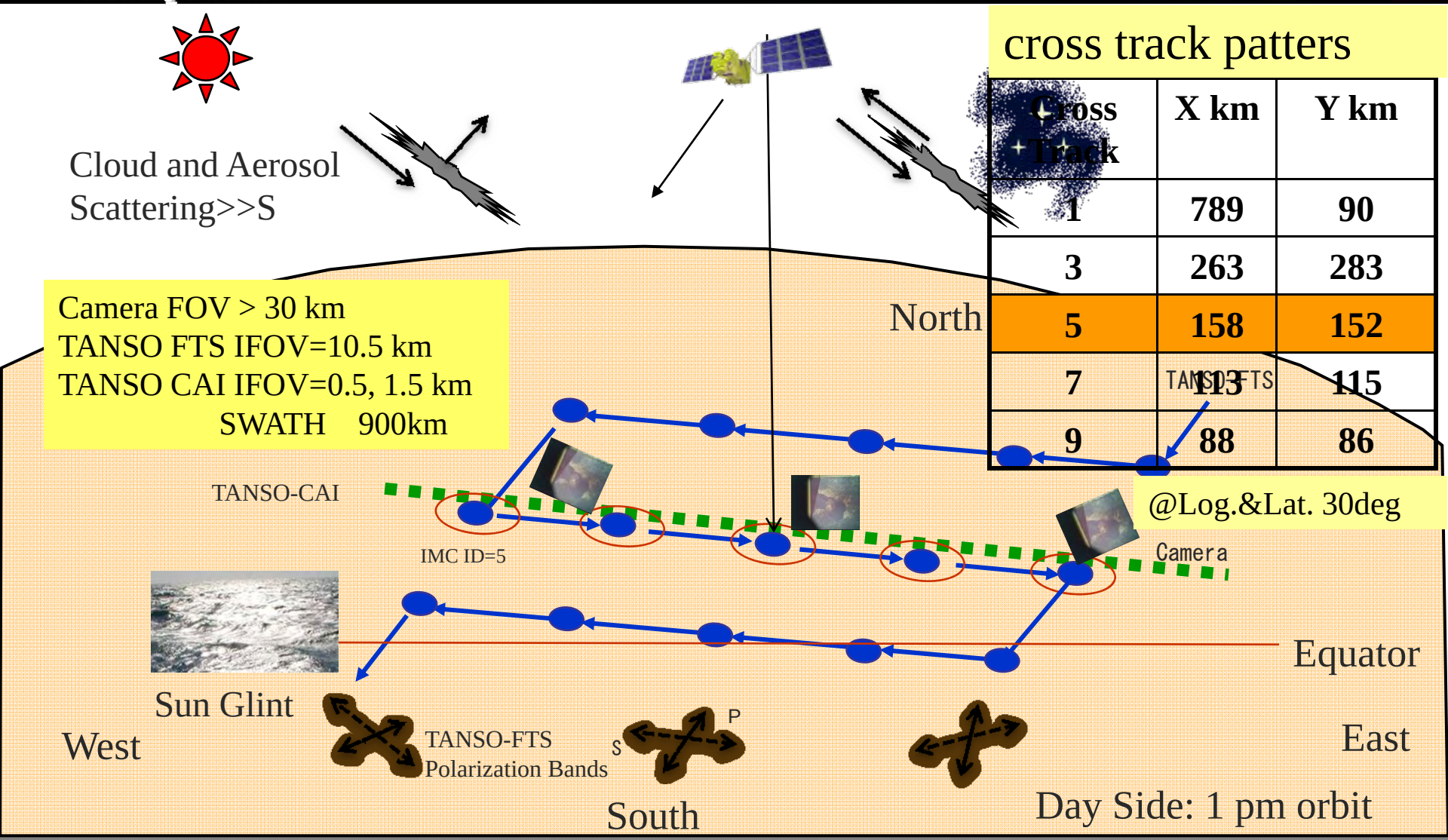
Spectral Coverage and Absorption Lines



- 3 narrow NIR bands
  - 0.76 micron
  - 1.6 micron
  - 2 micron
- A wide TIR band
  - 5.5 – 14.3 micron
- Spectral Resolution:
  - Band 1: 0.5 cm^{-1}
  - Bands 2-4: 0.2 cm^{-1}

- CO_2 column density mainly retrieved from absorption lines near 1.6 μm (Band 2)
  - 1.6 μm region most sensitive to CO_2 and has least interference by other molecules.
  - 1.67 μm region used for CH_4 column abundance retrievals
- O_2 A band absorption at 0.76 micron used to estimate optical path length.
- 2.06 micron (Band 3) provides additional constraints on CO_2, clouds, and aerosols.

Pointing and Footprints



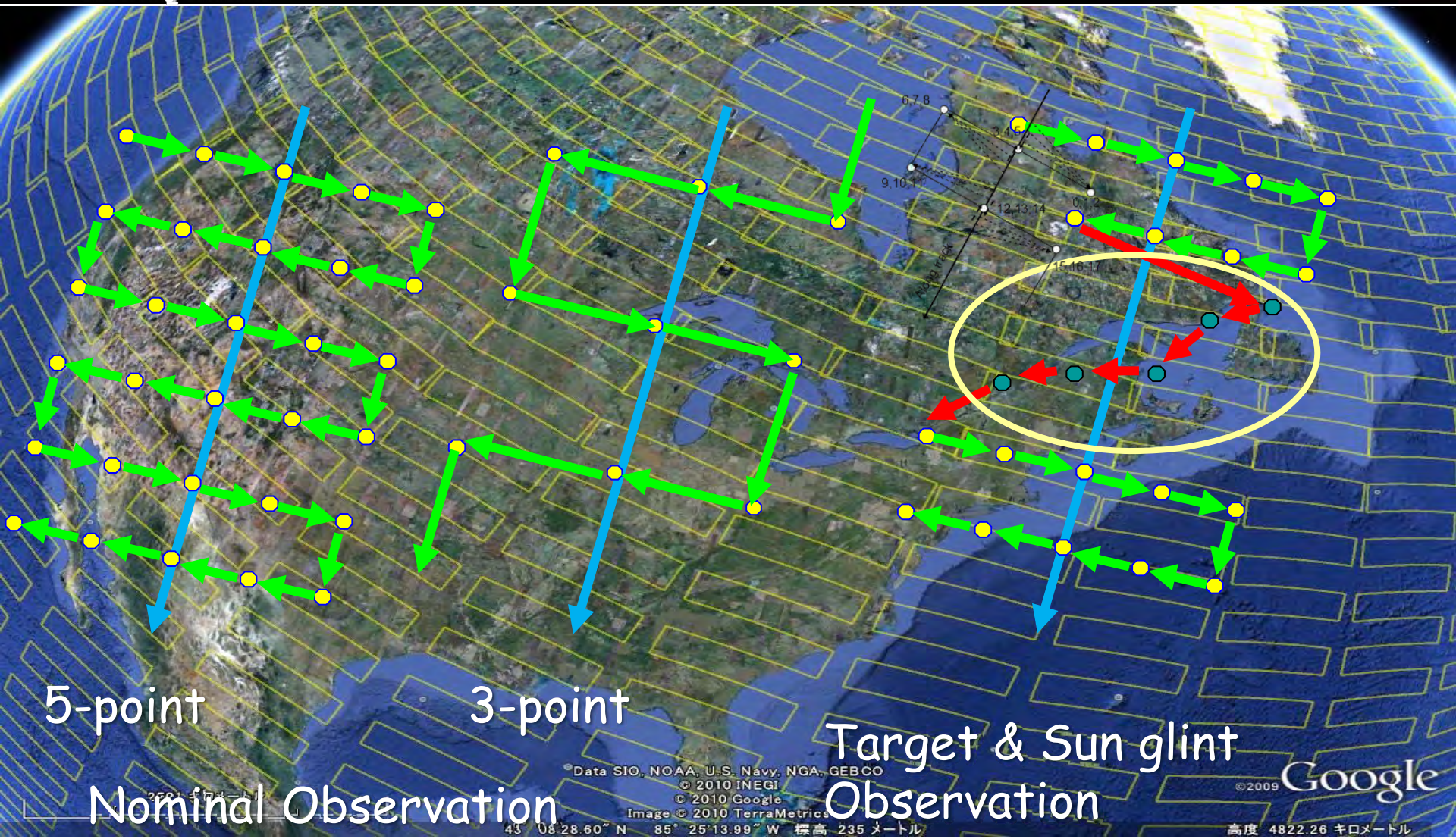
cross track patters

Cross Track	X km	Y km
1	789	90
3	263	283
5	158	152
7	113	115
9	88	86

@Log.&Lat. 30deg

Spatial Sampling: Scan Patterns

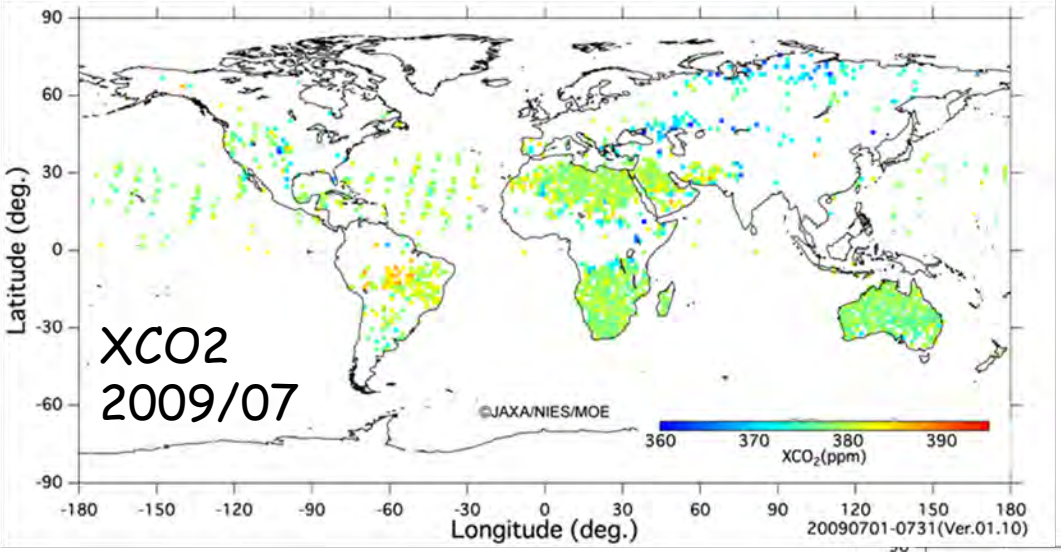
Greenhouse gases Observing SATellite



How well has it performed ?

- GOSAT was successfully launched from Tanegashima Space Center on a H-IIA Launch vehicle on 23 January 2009
- "First Light" images and spectra taken on 9 February 2009
- Initial Cal/Val completed an routine operations started in July 2009
  - First global maps collected in April 2009
- First Level 2 X_{CO2} and X_{CH4} products released in February 2010
- 3 Research Announcements released
  - 106 proposals have been selected
  - Next RA Meeting: 19-20 May, Edinburgh, U.K.

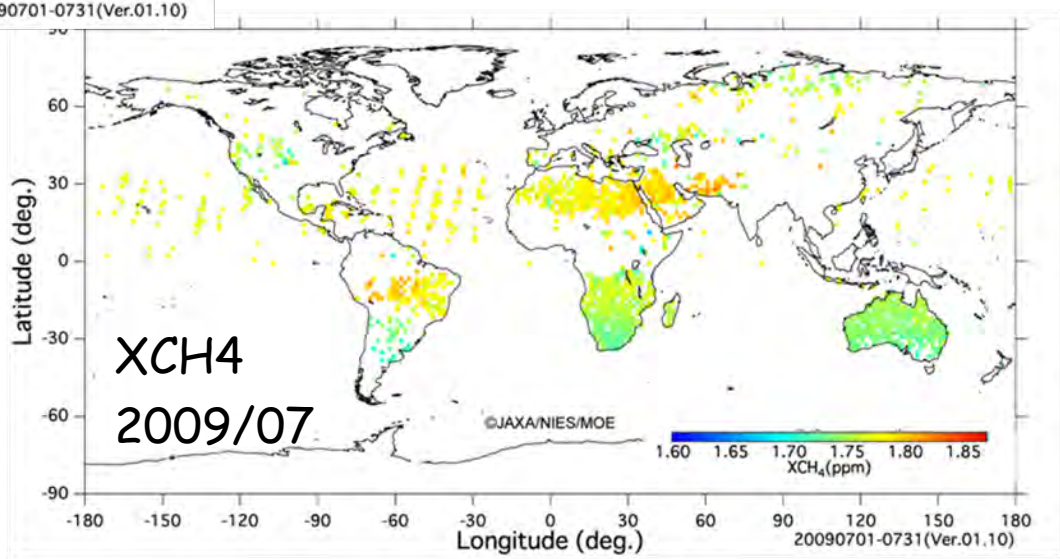
Global Map for GHG



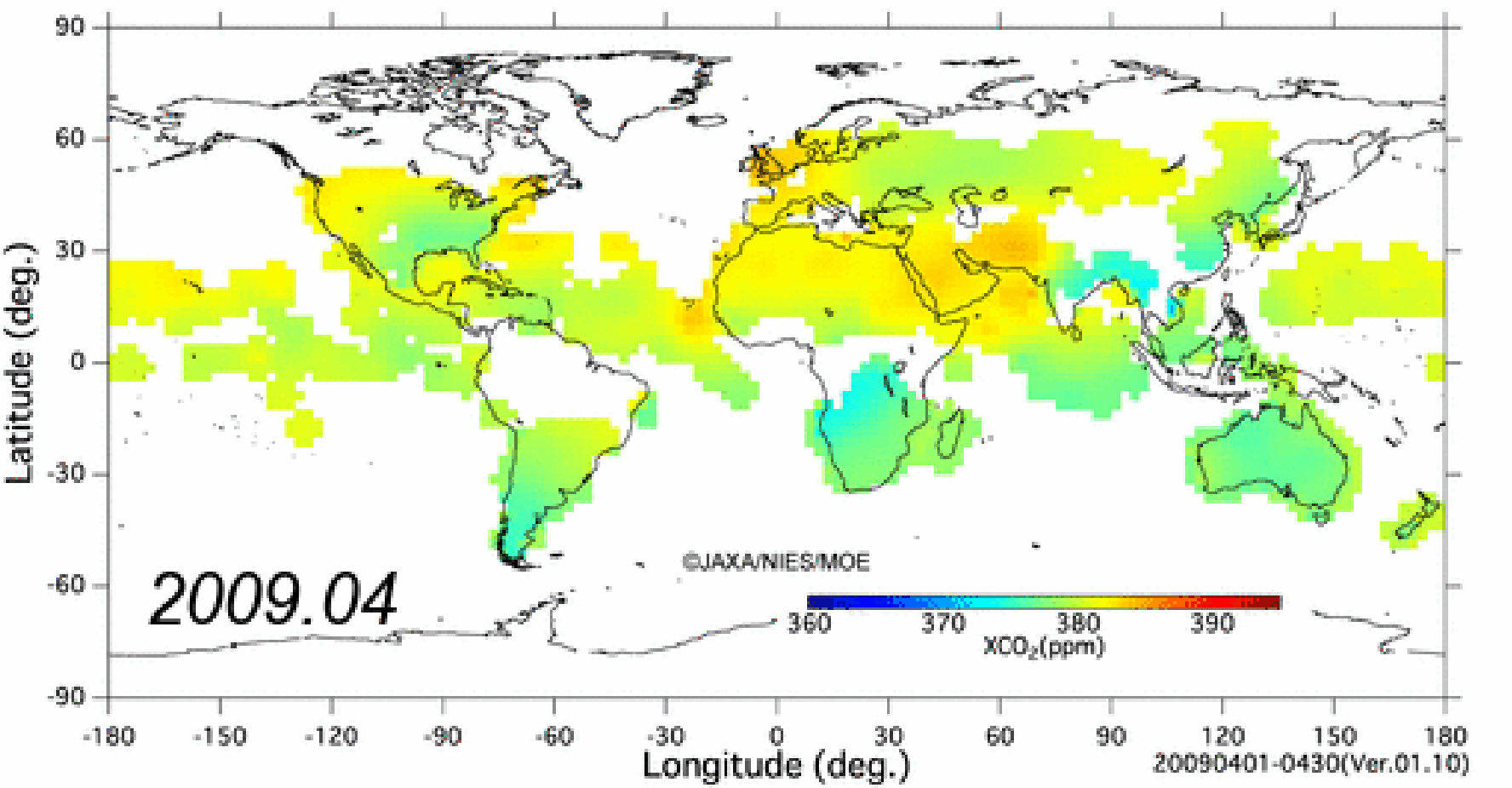
NIES is using the GOSAT measurements to retrieve X_{CO2} and X_{CH4}

These data have biases (+8.9 ppm for CO_2, +0.02ppm for CH_4), and are affected by dust aerosols, however, the overall data distribution trend is reasonable.

The retrieved results will be revised as the instrument calibration and retrieval algorithms improve.



Global Map for GHG



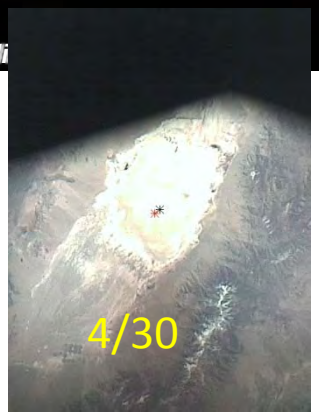
Level 3 data provided by NIES

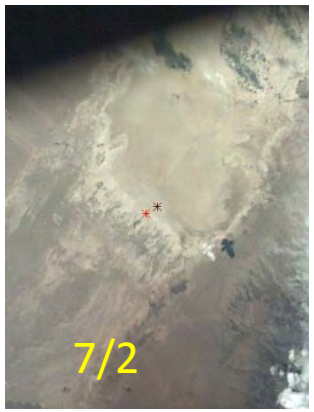
TANSO Measurement Anomalies

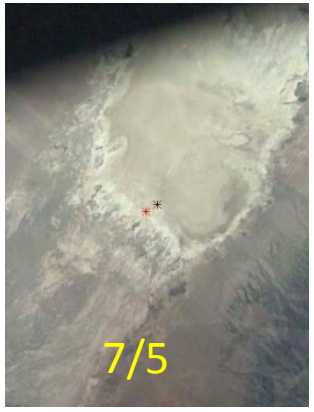
A few anomalies have been identified and are under investigation

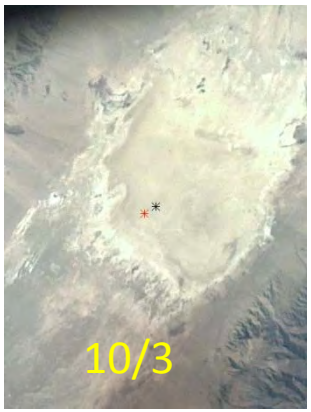
- 10-20 % of recorded interferograms have anomalous fluctuations.
  - Can be distinguished by checking level 1 data quality flag.
- TANSO-FTS Zero Path Difference (ZPD) shift
  - Problem mitigated by resetting FTS once every 2 weeks
- Sampling laser signal level decreases very slowly due to misalignment
  - No impact on performance (small wavelength shift).
- TANSO-FTS onboard camera data detected a few km pointing offset .
- Radiometric response degradation has been observed
  - The largest impacts seen at the shortest wavelengths
- TANSO-FTS Band 1 Nonlinearity – Currently under investigation

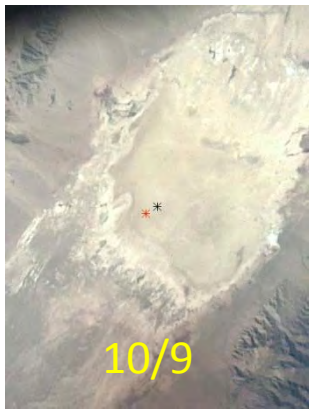
Pointing Offset

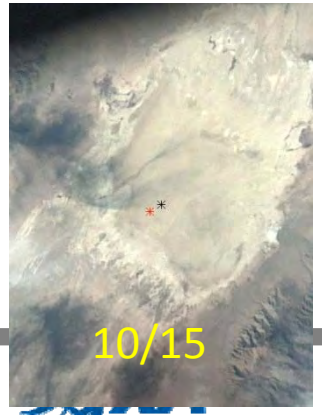


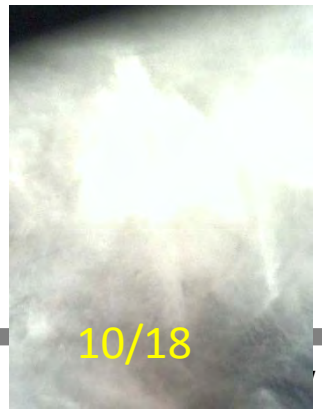






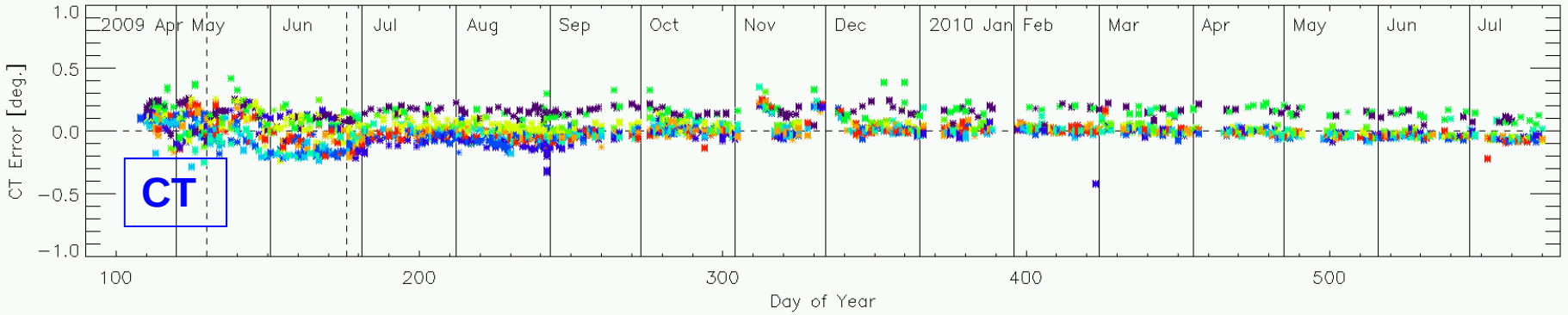


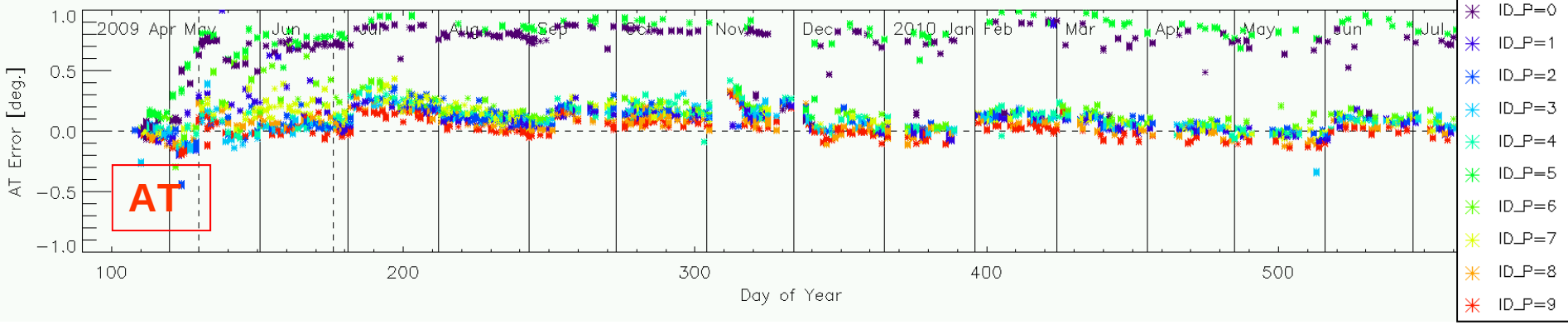




Pointing Offset (5 point mode)

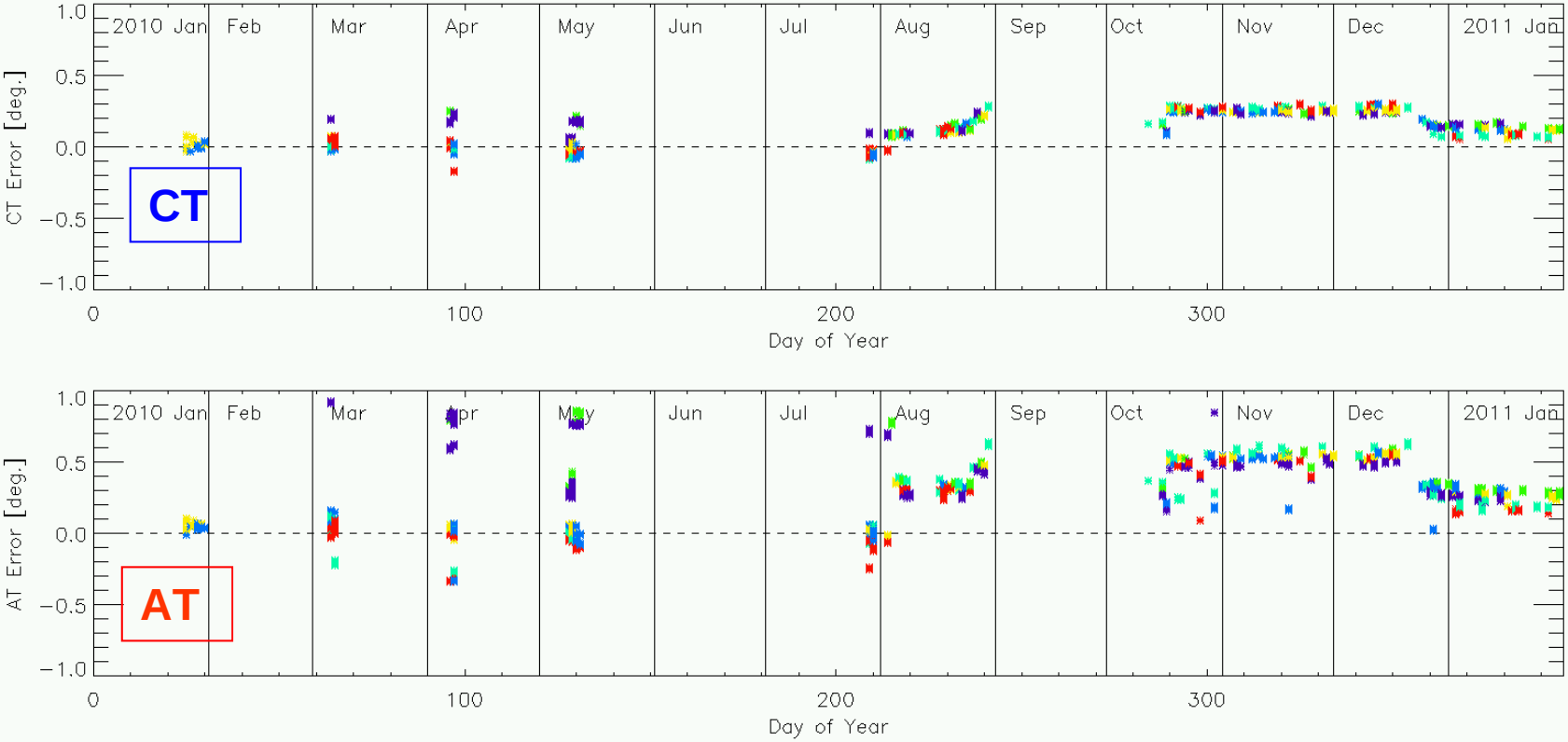
- Pointing target position error was analyzed applying onboard Camera image.
- Pointing has systematic offset values that are changing with time.
  - Along-track (AT) values show greater offsets than Cross-track (CT)



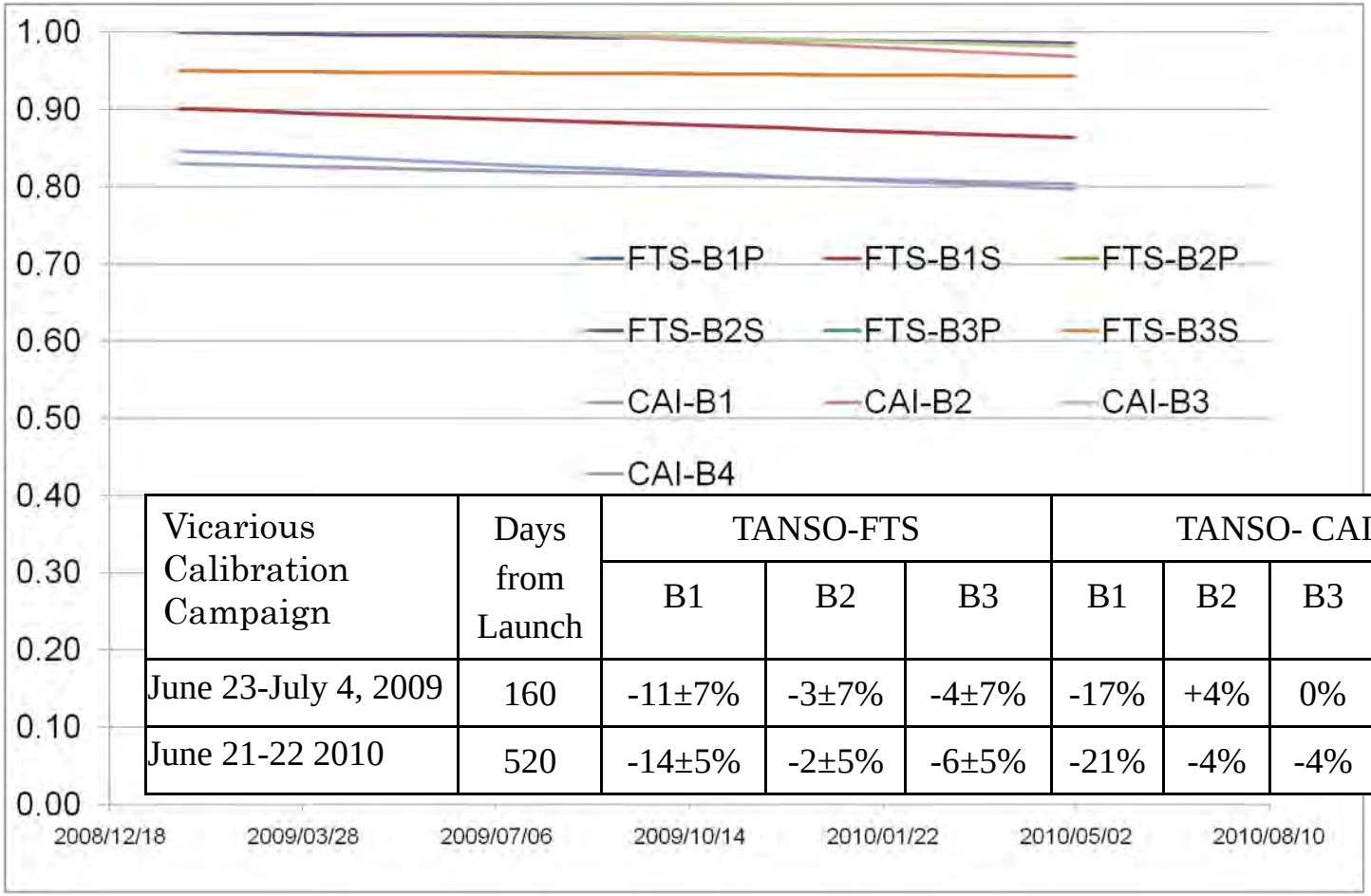


Pointing Offset (3 point mode)

- Pointing target position error was analyzed using onboard Camera images.
- Pointing still has systematic offsets that change with time, but both amplitude of offset and variability are substantially smaller in 3-point mode



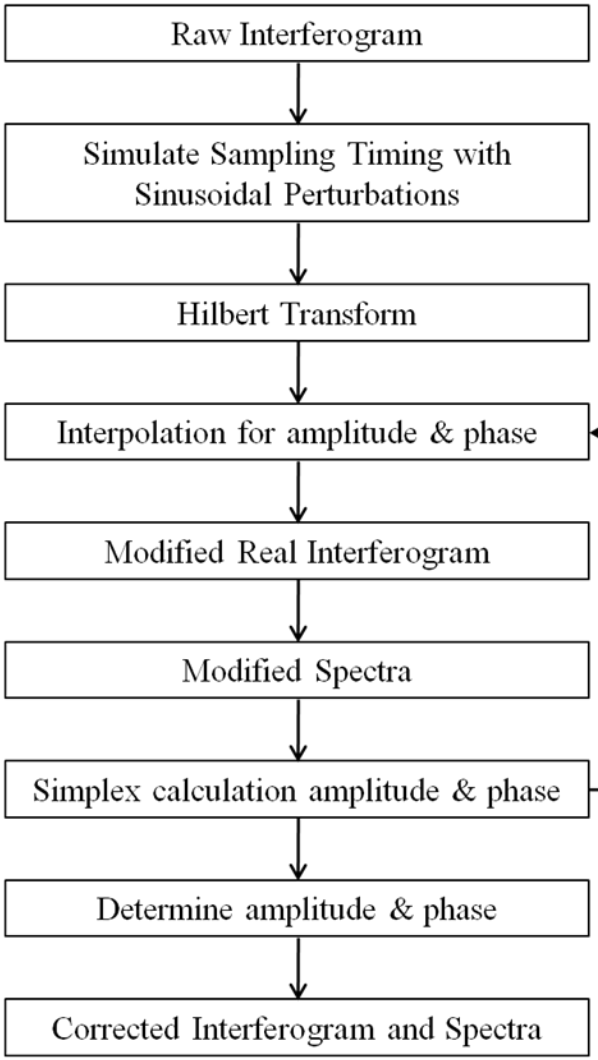
Radiometric Degradation



Vicarious Calibration Campaign	Days from Launch	TANSO-FTS			TANSO- CAI			
		B1	B2	B3	B1	B2	B3	B4
June 23-July 4, 2009	160	-11±7%	-3±7%	-4±7%	-17%	+4%	0%	-18%
June 21-22 2010	520	-14±5%	-2±5%	-6±5%	-21%	-4%	-4%	-20%

Band1 FTS and CAI degradation may have occurred just after launch or may be due to a pre-launch calibration error.

Scan-Fluctuation Correction for Band1 Gain M Data



$$T_{ZC\_Meas} = t_{fringe} \cdot n + \sum_{i=1}^{2} \left\{ T_{Delay} \cdot \left(1 + A_i \cos(2\pi f_i t + \phi_i)\right) \right\}$$

where $n : 1, 2, \cdots N_{Total\_fringe}$

T_{Delay} : *Delay Time*

f_i : *Frequency of perturbation*

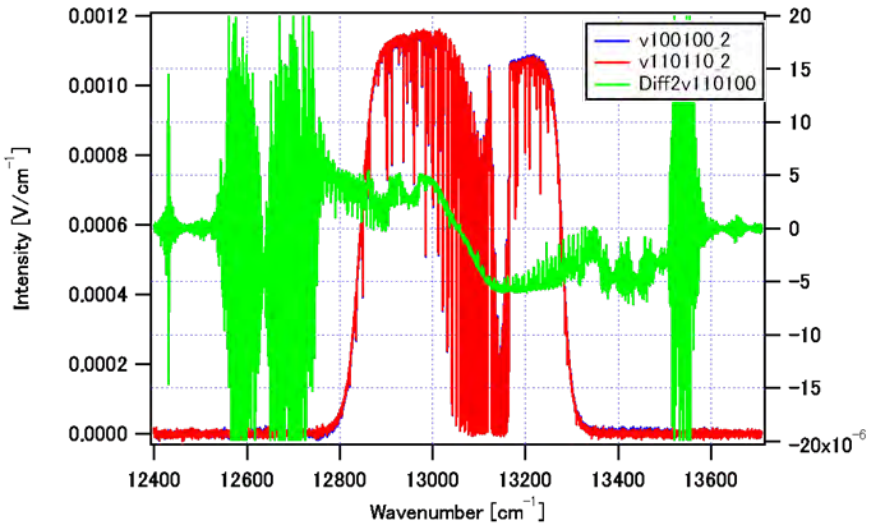
A_i : *Amplitude of perturbation*

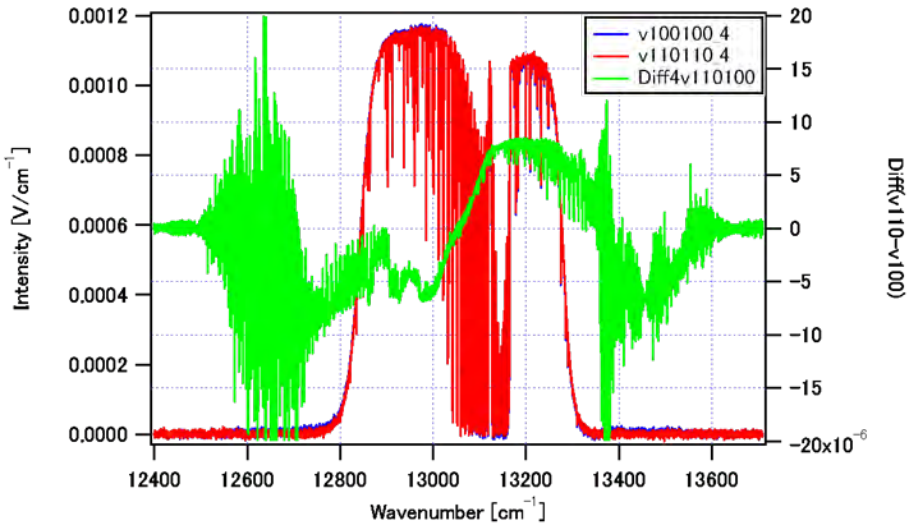
ϕ_i : *phase of perturbation*

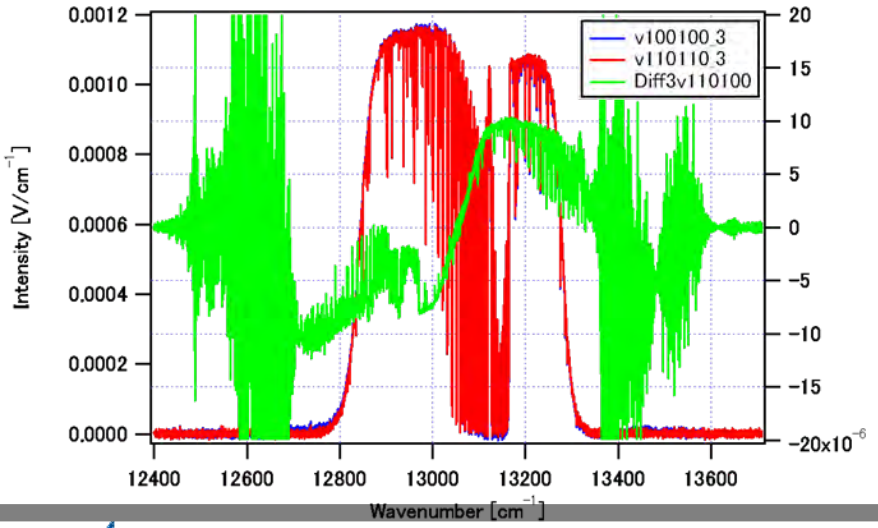
$$q = \sqrt{\frac{q_1}{q_{01}} + \frac{q_2}{q_{02}} + \frac{q_3}{q_{03}} + \frac{q_4}{q_{04}}}$$

- 12500 to 12750 cm^{-1} root-mean: q_1
- 13300 to 13600 cm^{-1} root-mean: q_2
- 12400 to 13700 cm^{-1} root-mean: q_3
- 12400 to 13700 cm^{-1} root-mean: q_4

Scan-Fluctuation Correction for Band1 Gain M Data







Items	unit	L2 Products (without correction)	Validation	L2 Products (with correction)	Validation	Ground Meas.
Height	m	1428	–	1428	–	1442
Latitude	deg	38.4941	–	38.4941	–	38.5044
Longitude	deg	−115.6567	–	−115.6567	–	−115.6919
Pressure	hPa	848.888	–	858.808	–	854.2
		865.645	−16.757	857.722	1.086	
		864.273	−15.385	859.174	−0.366	
xCO2	ppmv	384.623	–	383.768	–	
		378.363	6.26	381.039	2.729	
		379.614	5.009	381.384	2.384	
xCH4	ppmV	1.80016	–	1.79403	–	
		1.77781	0.02235	1.79554	−0.00151	
		1.77464	0.02552	1.78609	0.00794	

Summary of GOSAT Performance

- GOSAT has been successfully collecting global measurements needed to retrieve X_{CO2} and X_{CH4} since April 2009
- While a few instrument anomalies have been identified, their impacts on the GOSAT data products are being mitigated through
  - An on-orbit radiometric calibration program, incorporating
    - Direct observations of the lunar disk
    - Observations of reflected sunlight from primary and backup targets
  - An on-orbit geometric calibration program using internal cameras
  - Annual vicarious calibration campaigns in Railroad Valley, Nevada
  - Laboratory measurements using the GOSAT Engineering Model
- GOSAT Level 1B products can be obtained from:

  http://data.gosat.nies.go.jp/

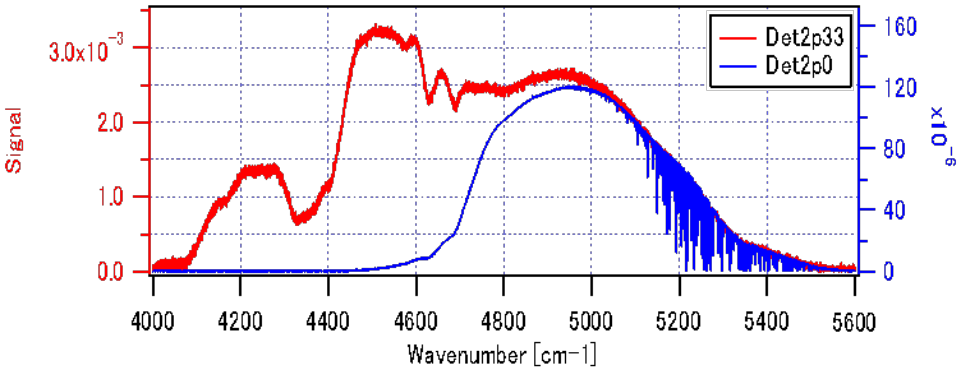
Feasibilities of Follow-on Mission

GHGs mission

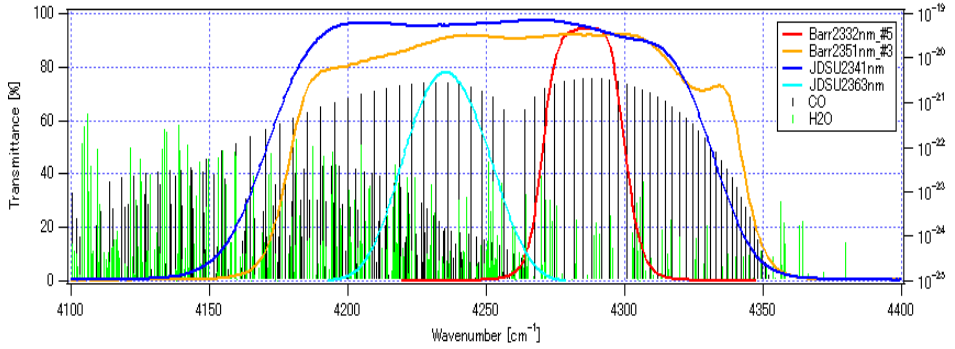
GOSAT TANSO (baseline)	(1) SNR=300 (Scan=4sec; CT=5points)	
Improvement element	(1) FTS upgrade High SNR (SNR=300; Scan< 4sec; CT=5-9 points)	x
	Mapping Capability (IFOV=2-3km, with discrete array Det.)	x
	(2) FTS robustness Robustness to micro-vibration disturbance	x
	(3) CAI upgrade Imaging Spectrometer in UV band	
Expansion of target	(1) CO	x

Study of 2.3 micron CO measurement

Long wave extended cut-off of the TANSO-FTS 2.0 micron detector response



Optimization of 2.3 micron BPF with wide and narrow band characteristics



Total sensitivity test by using CO gas cell with combination of 2.3 micron detector and BPF installed on the TANSO-FTS breadboard model.