CARBON DIOXIDE MONITORING FROM THE GOSAT SATELLITE

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ABSTRACT:

The Greenhouse gases Observing SATellite (GOSAT) is design to monitor the global distribution of carbon dioxide (CO_2) from orbit. It is a joint project of Japan Aerospace Exploration Agency, the Ministry of Environment (MOE), and the National Institute for Environmental Studies (NIES). JAXA is responsible for the satellite and instrument development, MOE is involved in the instrument development, and NIES is responsible for the satellite data retrieval. It is scheduled to be launched in 2008. As existing ground monitoring stations are limited and still unevenly distributed, the satellite observation has advantages of global and frequent observations. The objective of the mission is response to COP3 (Kyoto Protocol): Observation of Green House Gases (GHGs) including CO_2 with 1% relative accuracy in sub-continental spatial resolution and to identify the GHGs source and sink from the data obtained by GOSAT in conjunction with the data from the ground instruments, with simulated models. In order to detect the CO_2 variation of boundary layers, the technique to measure the column density and the retrieval algorithm to remove cloud and aerosol contamination are investigated. The simultaneous observation of methane (CH_4), which is the second largest contribution molecule, is studied. The spectrometer with high optical throughput and spectral resolution has been designed. The performance demonstration with flight-like instrument from air planes will be presented. The camera to retrieve cloud and aerosol properties will also be borne on GOSAT.

1. INTRODUCTION

The Greenhouse gases Observing Satellite (GOSAT) is a satellite to monitor the carbon dioxide (CO_2) globally from orbit as illustrated in Figure 1, and it aims to contribute to the international efforts to prevent global warming, such as the Kyoto Protocol. It is a joint project of Japan Aerospace Exploration Agency (JAXA), the Ministry of Environment (MOE) and National Institute for Environmental Studies (NIES). JAXA is responsible for satellite development, launch and satellite operation. JAXA and MOE are in charge of the sensor development. MOE and NIES are responsible for satellite data utilization. It is scheduled to be launched in early 2008.

Figure 1. Image of GoSat on orbit.

2. GOSAT MISSION OBJECTIVES

(1) Mission Objectives

The objectives of the GOSAT mission are to contribute to Japanese environmental administration by estimating the Green House Gases (GHGs) source and sink in Sub-continental scale and verifying the reduction of GHG's emission which is required by the Kyoto Protocol and to advance earth observation technologies for future missions.

(2) Mission Targets

The targets of the mission are observation of CO_2 density in 3-month average with 1% (4ppmv) relative accuracy in sub-continental spatial resolution during the first commitment period (2008 to 2012) of the Kyoto Protocol and reducing errors by half in identifying the GHGs source and sink in Sub-continental scale with the data obtained by GoSat in conjunction with the data gathered by the ground instruments.

3. GOSAT ONBOARD SENSORS

The greenhouse gases sensor, which is to be accommodated on GOSAT, is a Fourier Transform Spectrometer with high optical throughput and spectral resolution. The instrument detects the interferogram of solar short wave infrared spectra (SWIR) reflected on the earth's surface and thermal infrared spectra (TIR) radiated from the ground and the atmosphere. The interferogram then are transformed with the fast Fourier transformation (FFT) algorithm into spectra, which include the absorption spectra of GHGs. Table 1 show the specification of the greenhouse gases observation sensor. Figure 2 illustrate the instrument configuration and Figure 3 shows the optical layout which consist of the pointing mechanism, relay optics, 2 FTSs, and detectors. The 2 FTSs cover the wide spectral range from 0.76 to 15 micron as shown in Figure 4.

To monitor greenhouse gases, it is essential to measure the troposphere where the greenhouse effect occurs. In general, it is more difficult to measure the troposphere from space than the stratosphere. Nadir-looking measurement is the only feasible way to measure the flux that passes through the lower troposphere. Figure 5 and 6 show the geometry of nadir-looking measurements and the concept of the GOSAT altitude control and pointing system, respectively.

An imager to detect and correct the cloud and aerosol effect is also borne together with the FTS. With the spectra, image data, and the retrieval algorithm to remove cloud and aerosol contamination, the column density of the gases can be calculated.

Figure 7 shows the breadboard model of the FTS, which has been tested and its performance demonstration from air planes is planned. The measured data on the ground, shown as a sample in Figure 8, certainly detected the CO_2 and CH_4 spectra with 0.2 cm^{-1} spectral resolution.

Table 1. The specification of the Greenhouse gases Sensor.

Ground Pointing Mechanism and Fore optics	Configuration	2-axes scanner (fully redundant)				
	Scanning	Cross Track (±35 deg□ Along Track (±20deg)				
	Field of view	IFOV 8 km□ 88 km (Interval) 790 km (scan width) (latitude of 30 deg)				
Fourier Transform Spectrometer	Speed	0.7□1 (Interferogram)/sec				
	Spectral band	1	2	3	4	5
	Coverage (cm^{-1})	12900-13200	5200-6400	4800-5200	2000-2500	660-2000
	resolution (cm^{-1})	0.5	0.2	0.2	0.1	0.1
	Detector	Si	InGaAs	InGaAs	InSb	PC-MCT
	Calibration	Solar Irradiance, Deep Space, Moon			Blackbody, Deep space	

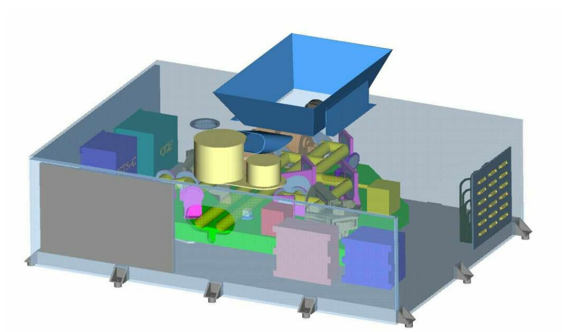

Figure 2. Instrument configuration.

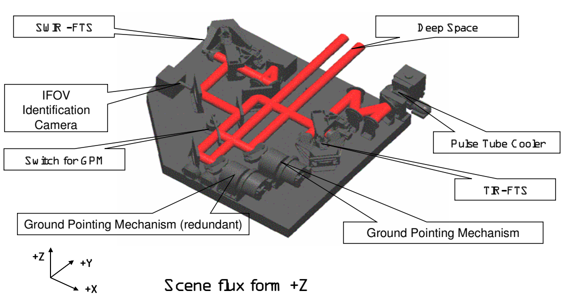

Figure 3. The FTS optical layout

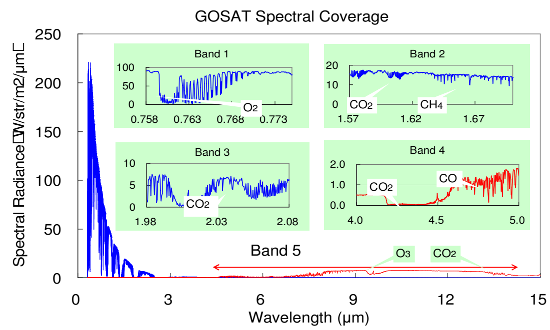

Figure 4. The spectral coverage of the GOSAT FTS.

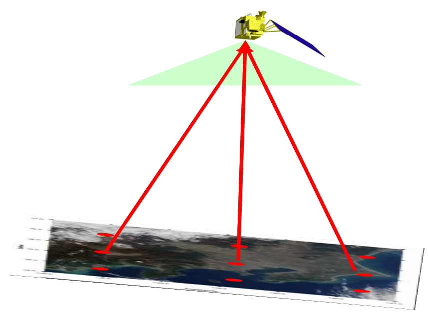

Figure 5. Observation image.

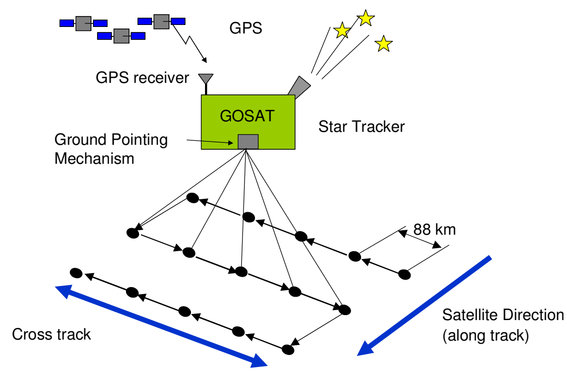

Figure 6. Altitude control and pointing.

Figure 7. GOSAT FTS bread board model.

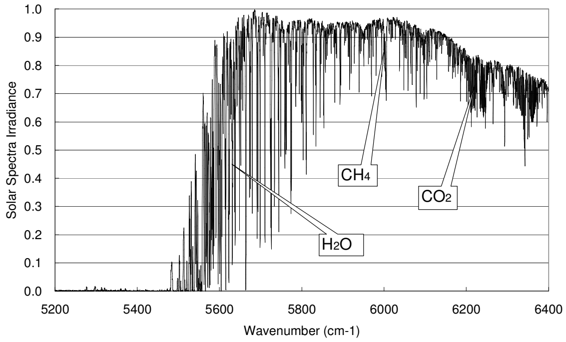

Figure 8. Sample of the spectra measured on the ground with the bread board model.

4. SPACECRAFT

GOSAT is a medium-size satellite which weighs 1650kg. It will be launched by H-IIA rocket of JAXA in early 2008. Figure 9 illustrate the image of GOSAT on orbit and table 2 shows the summary of the GOSAT satellite.

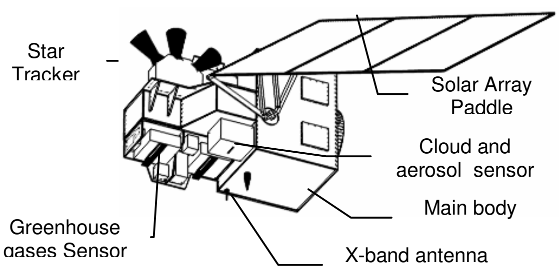

Figure 9. GOSAT on orbit.

Table 2. GOSAT characteristics.

Size	Main body	1.5 x 2 x 3.2 m
Mass	Total	1650kg
Power	Total	3319W (@β=0°)
Life Span	5 years	
Orbit	Altitude	618km
	Inclination	65deg
Telemetry and Command	□S band) Command □1[kbps] HK telemetry□32.8[kbps □X band□Mission Telemetry□120 [Mbps]	
Launch	Vehicle	H-IIA
	Schedule	Feb.2008

5. CONCLUSION

GOSAT project finished its internal project readiness review (PRR) in November 2003, and has started its phase-B study. The bread board model results provided the feasibility of nadir-looking scattered light measurements for monitoring greenhouse gases (CO_2 and CH_4) globally with 0.2 cm^{-1} spectral resolution in the SWIR region.

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