Evaluation of Methane Flux from Natural Gas Transportation System from Satellite

- ◎ Methane column concentration observation from GOSAT
- ◎ Validation of GOSAT Data

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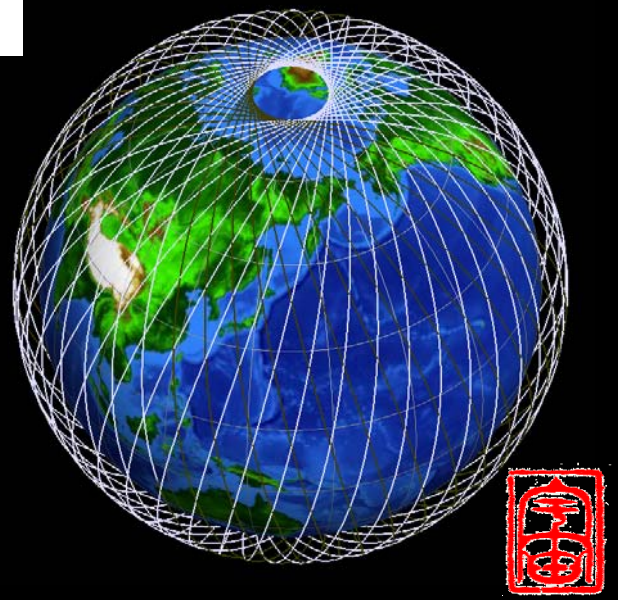
GOSAT

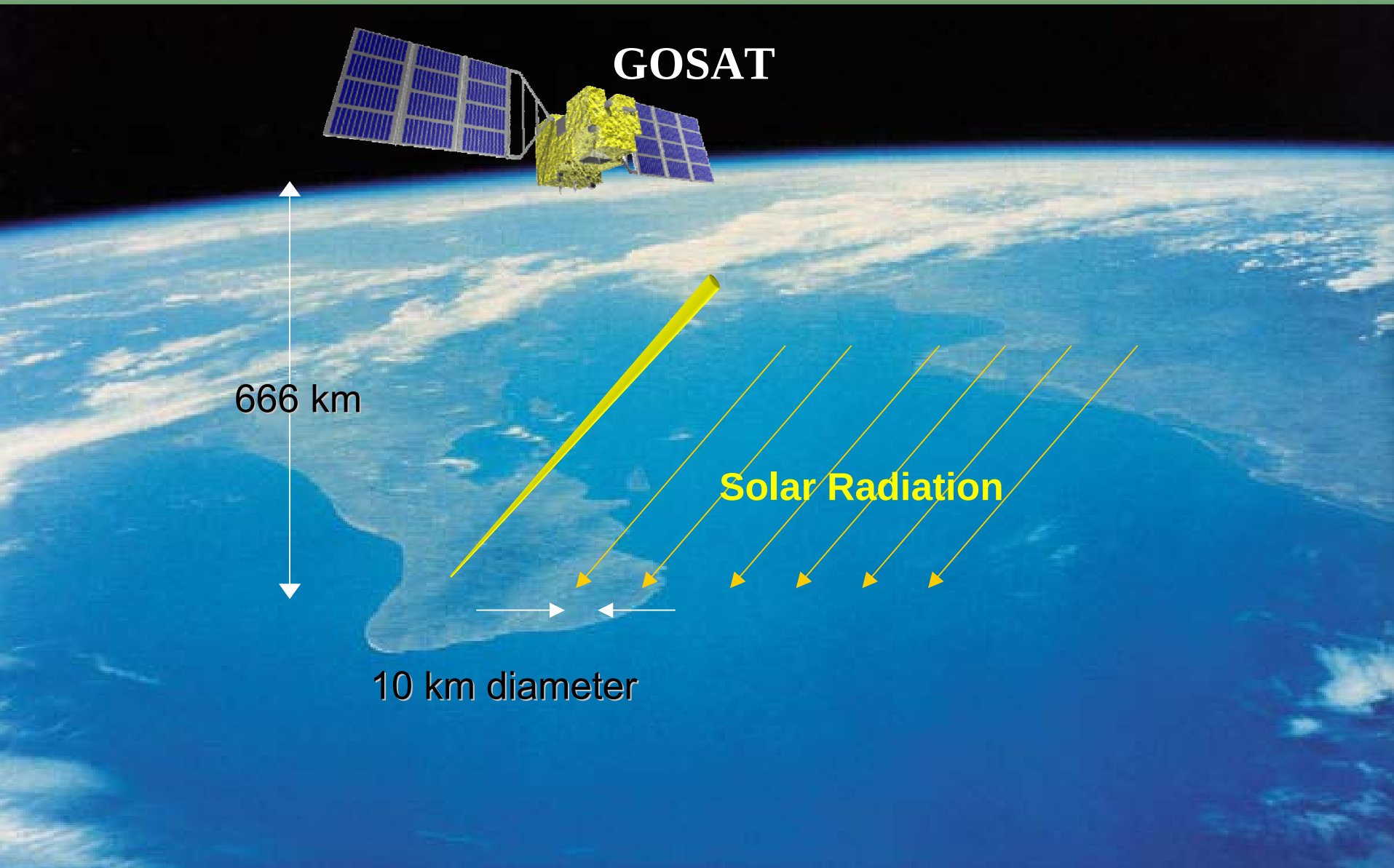
Greenhouse gases Observing SATellite

- Principle of Operation

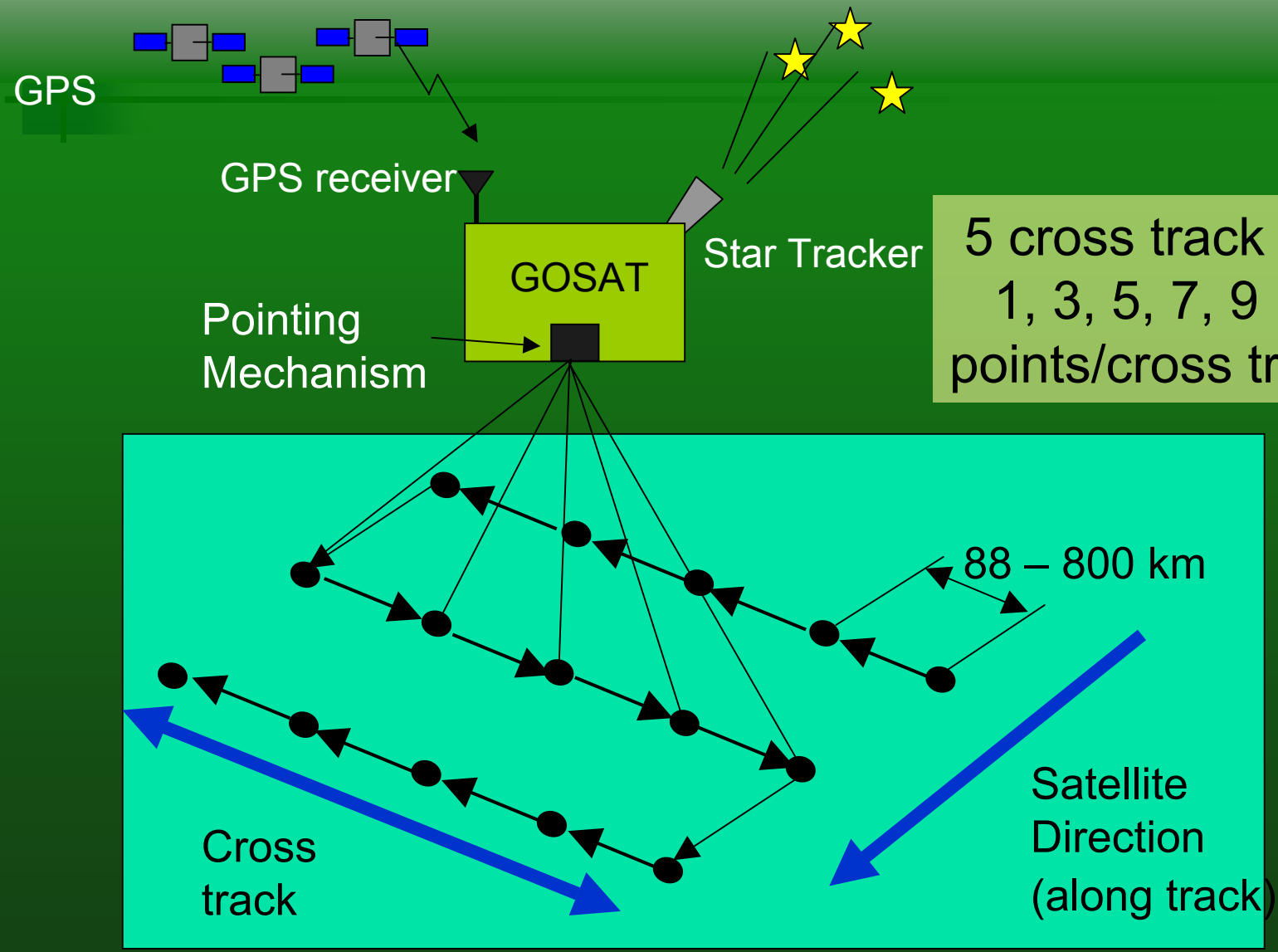


Launched in 2008

Inage of GOSAT observation

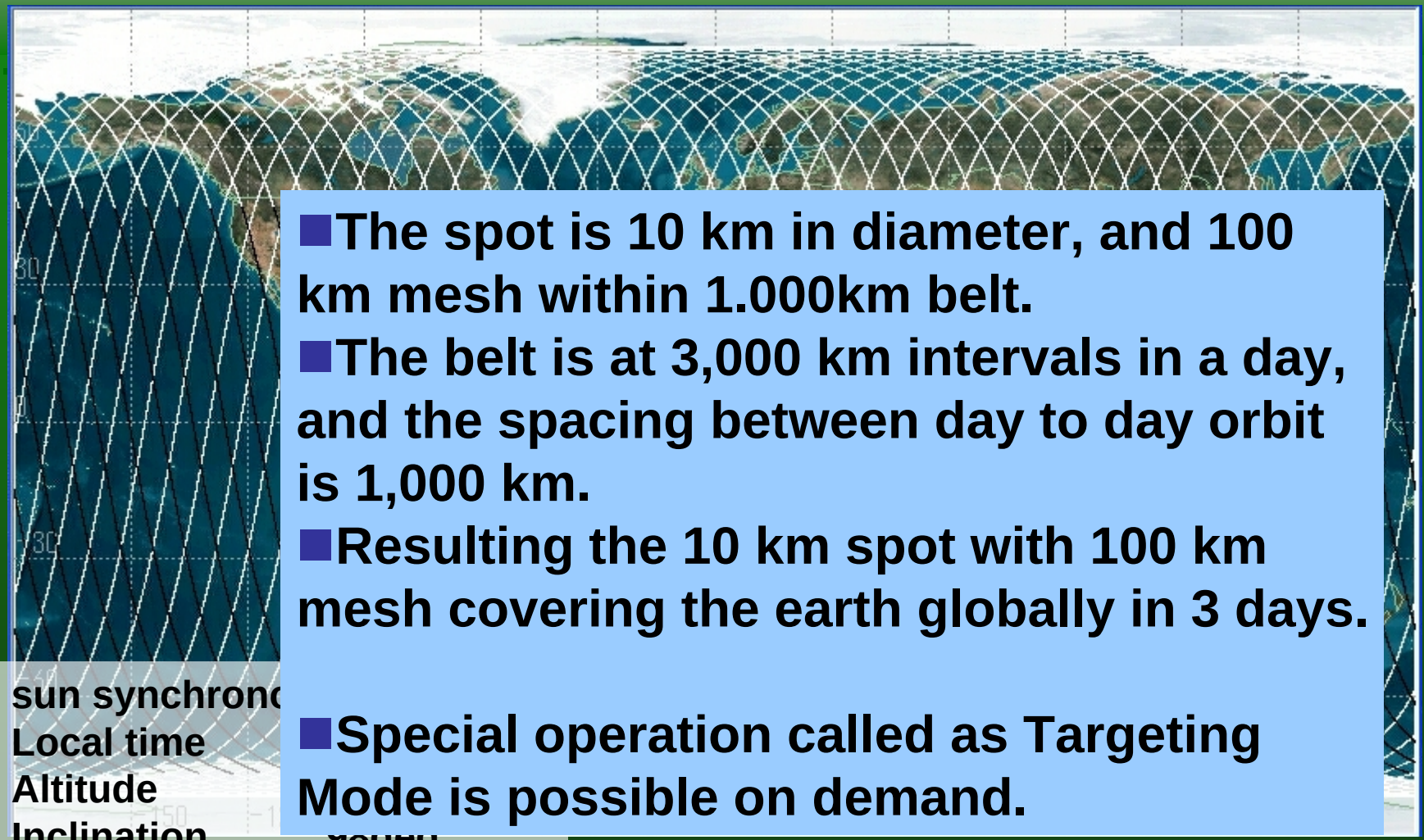


Footprints



5 cross track patters
1, 3, 5, 7, 9
points/cross track scan

Three-days Revisit

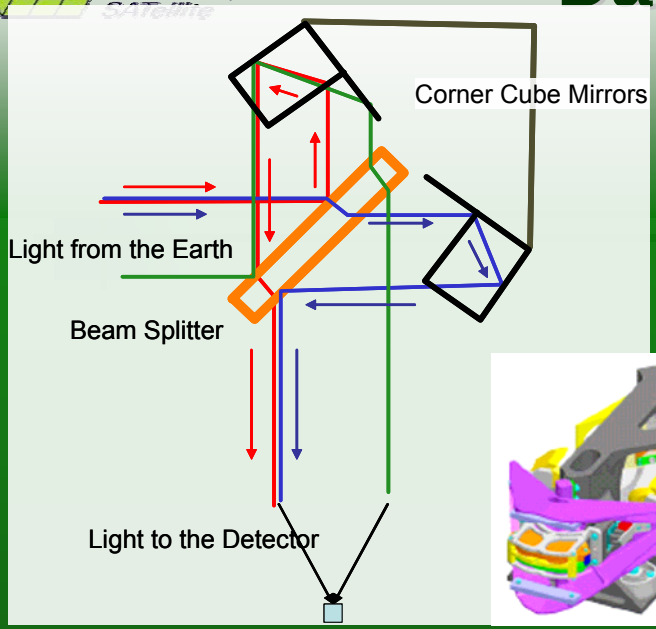


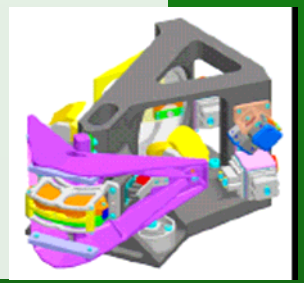
- The spot is 10 km in diameter, and 100 km mesh within 1.000km belt.
- The belt is at 3,000 km intervals in a day, and the spacing between day to day orbit is 1,000 km.
- Resulting the 10 km spot with 100 km mesh covering the earth globally in 3 days.

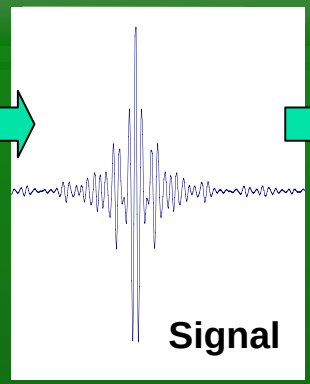
- Special operation called as Targeting Mode is possible on demand.

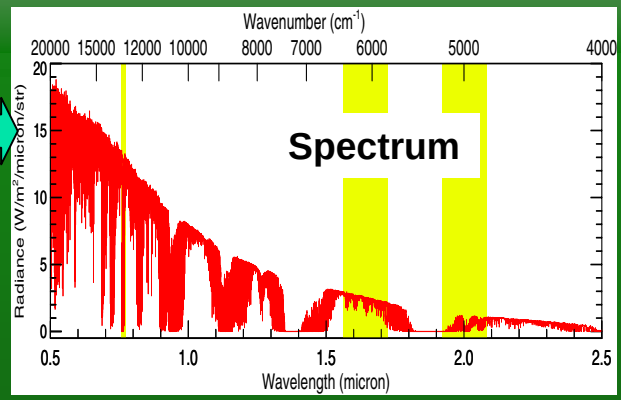
sun synchron	
Local time	
Altitude	
Inclination	98deg
Re-visit	3 days

Data Processing



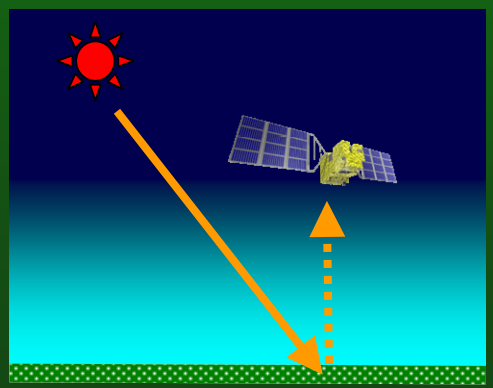


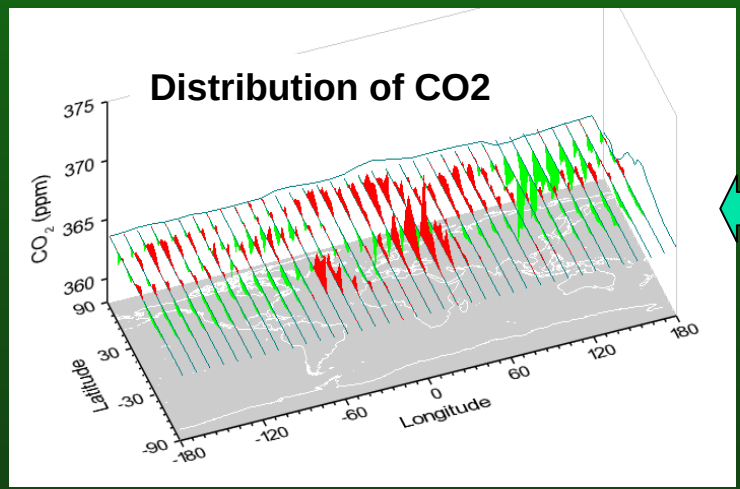


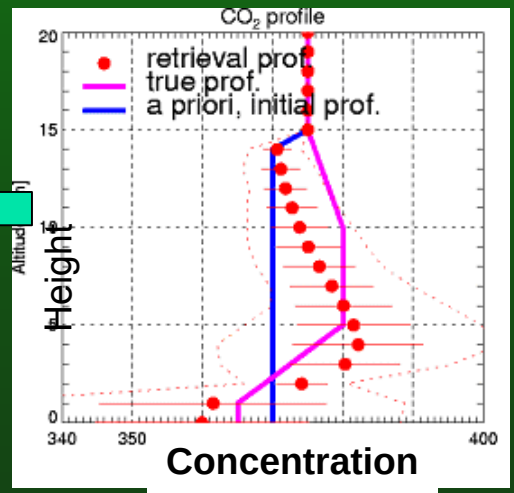


JAXA

NIES/MOE







Fourier Transform Spectrometer

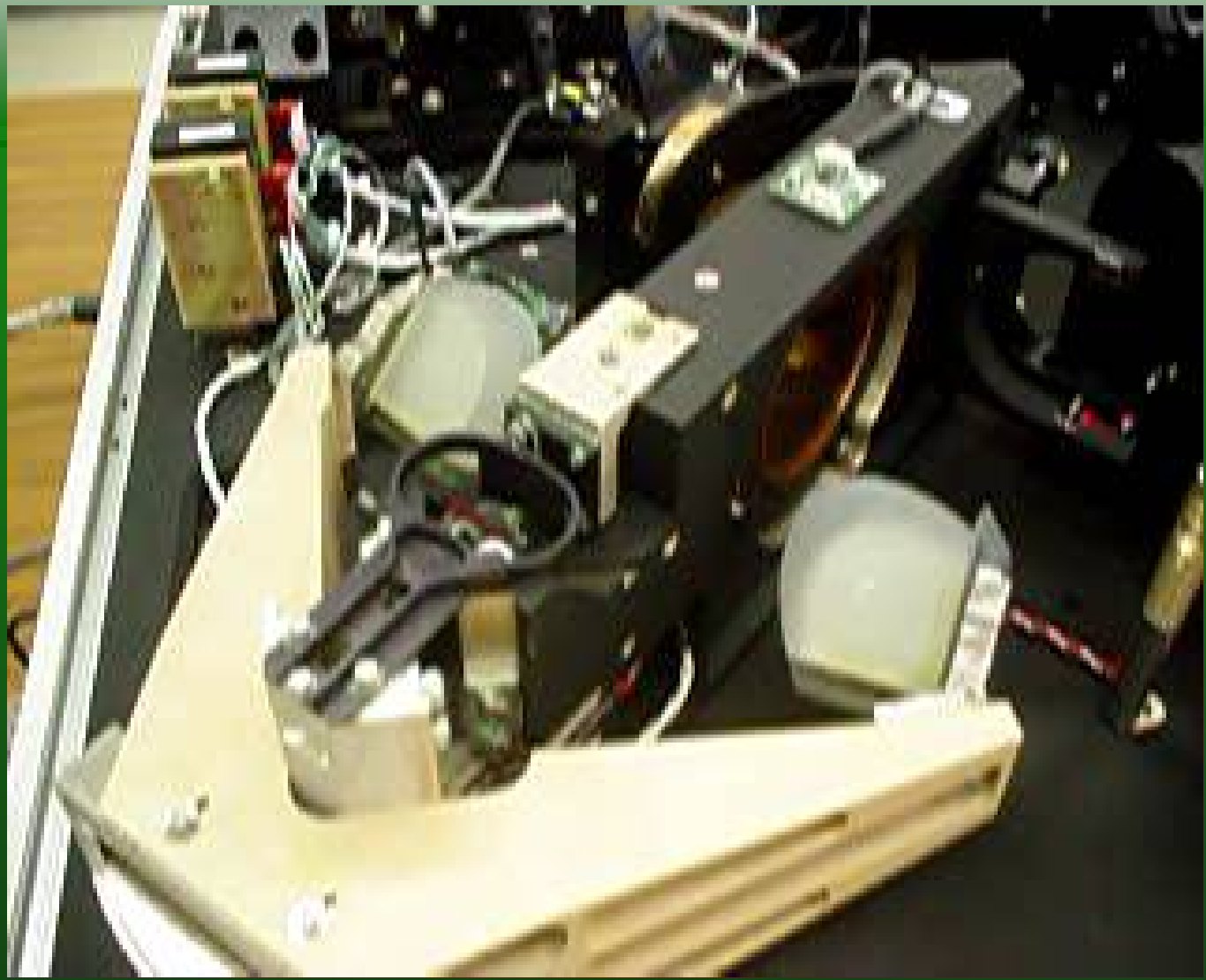
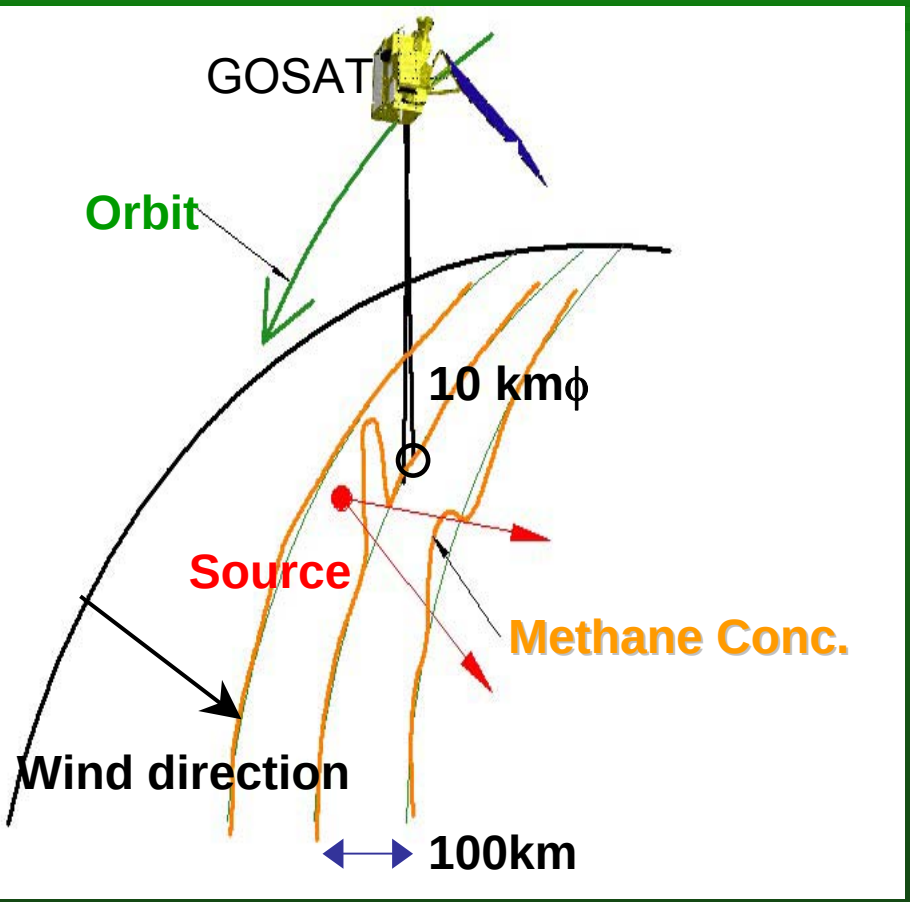
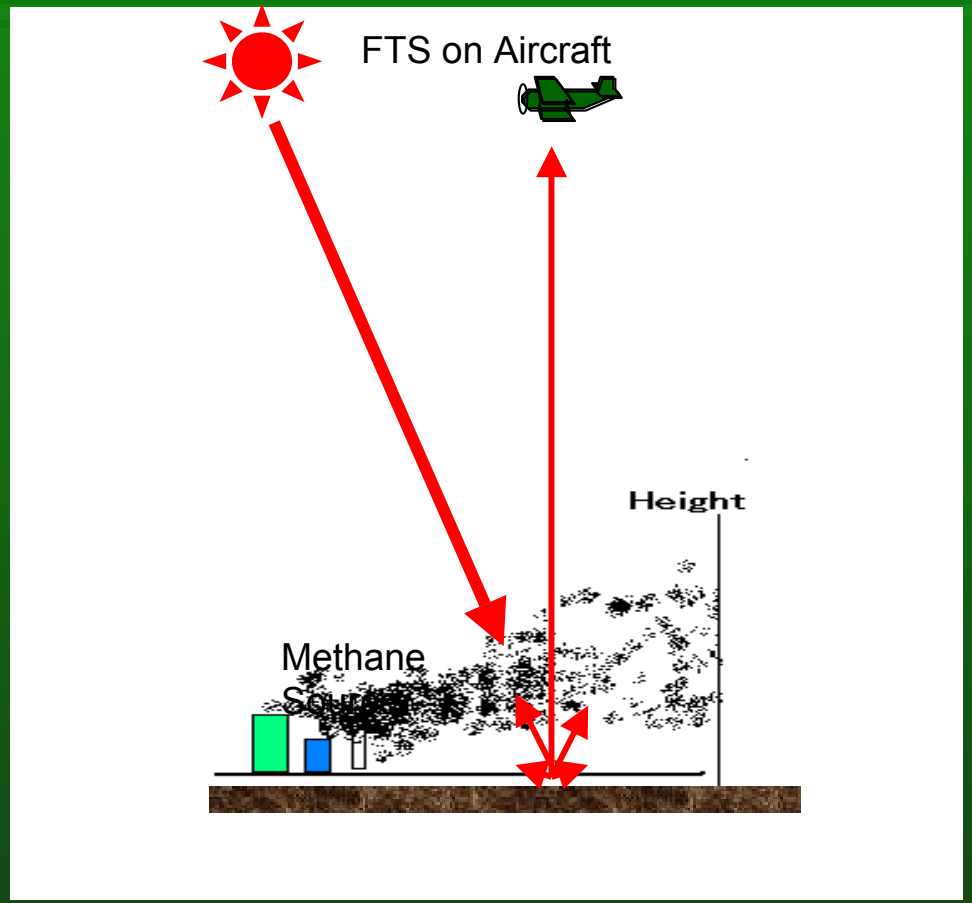
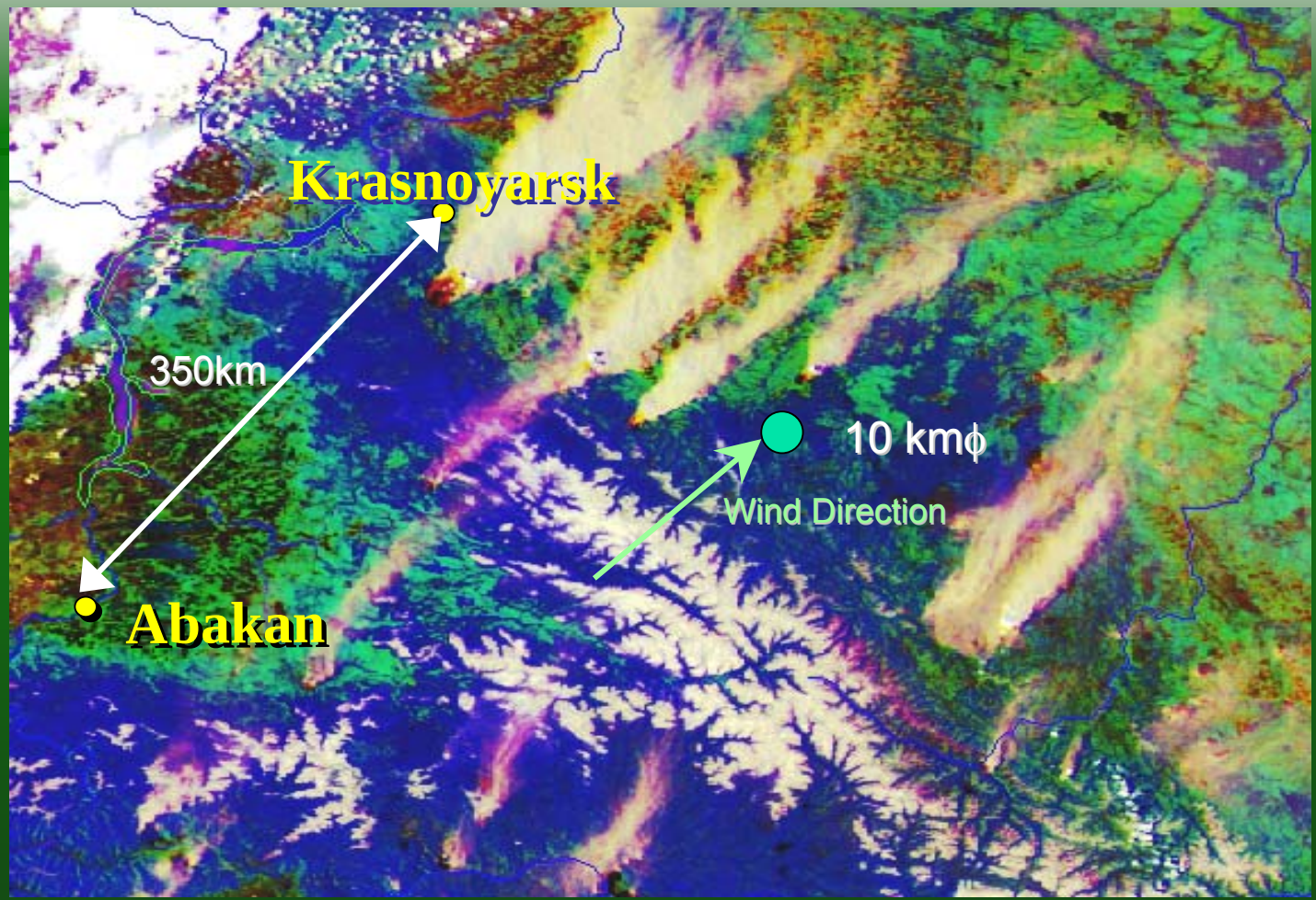


Image of observation





Wildfires with smoke plumes

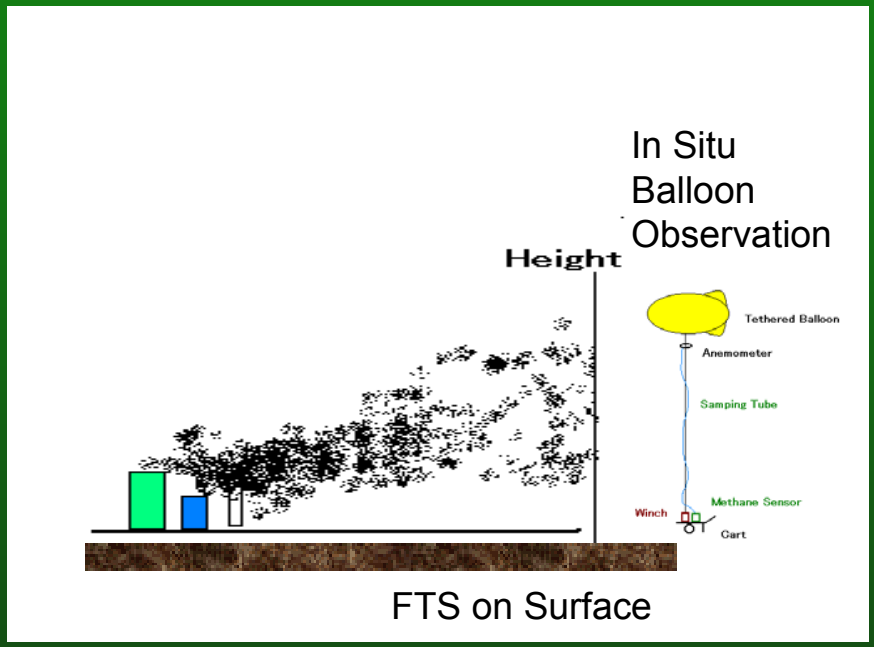


Krasnoyarsk territory, 25, May 1999

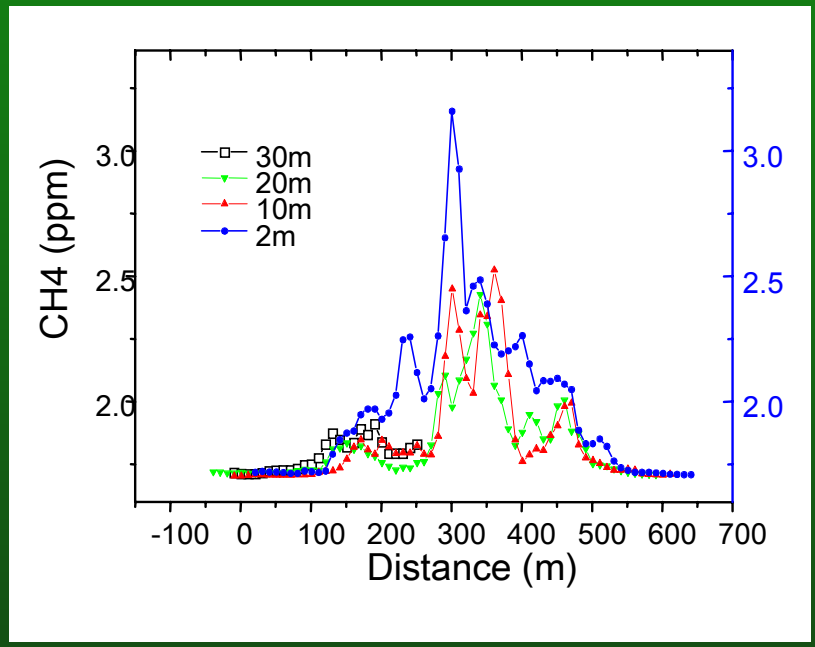
Ground observation of CH4 leakage from compressor station

Flux = Concentration x Wind speed

Continuous leak rate observed in East Europe



FTS on Surface



The flux, Q, estimated from CH4 concentration, C_{CH4} and Wind velocity, v, is

$$Q = \int (C_{CH4} - C_0) \times v \, ds$$

= 11800 ppm CH4·m3/s = 1020 m3 CH4/s

= 730 kg CH4/s=73tCH4/day

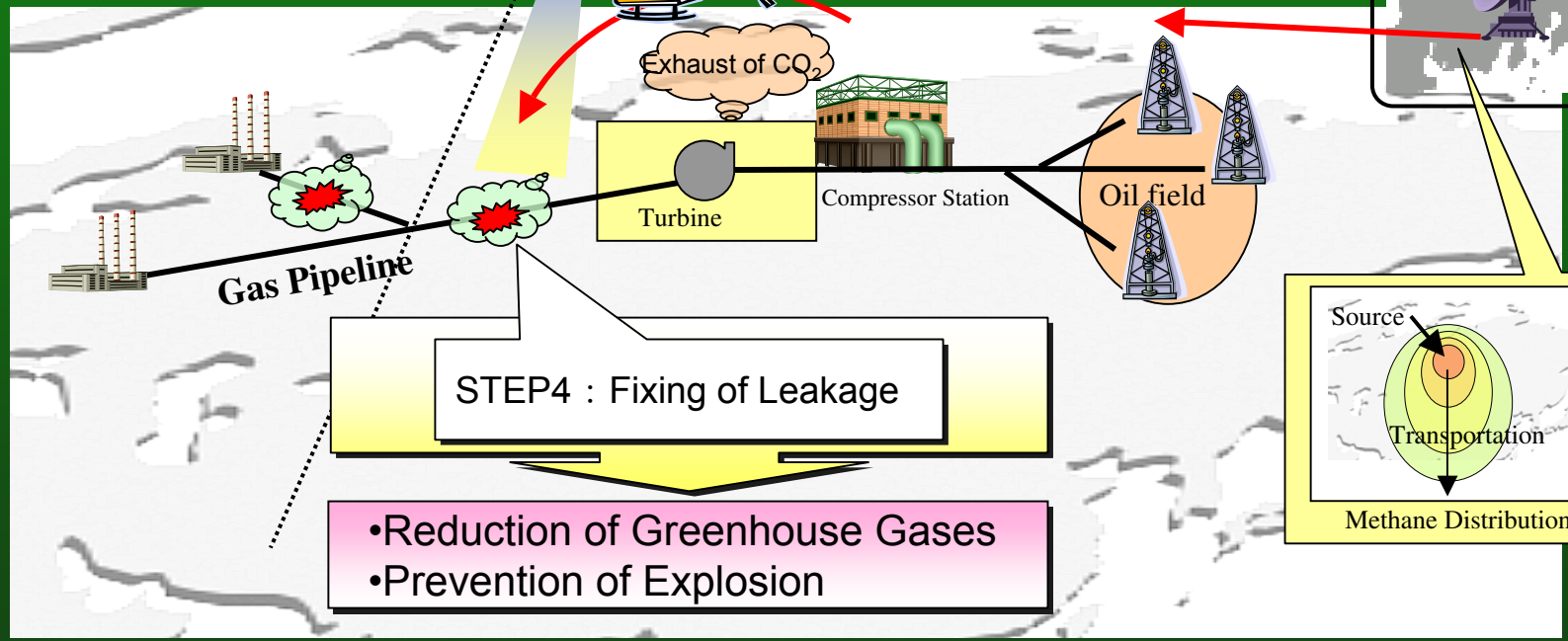
Procedure of CH4 emission reduction

Spectrometer on GOSAT
- Polar Orbit
  (Once per three days)
- 10km resolution
- Detectable limit: : 1.3tH_4/Day

STEP 1 :
Observation of CH4 Spectrum

STEP 2 :
Data transmission, Analysis

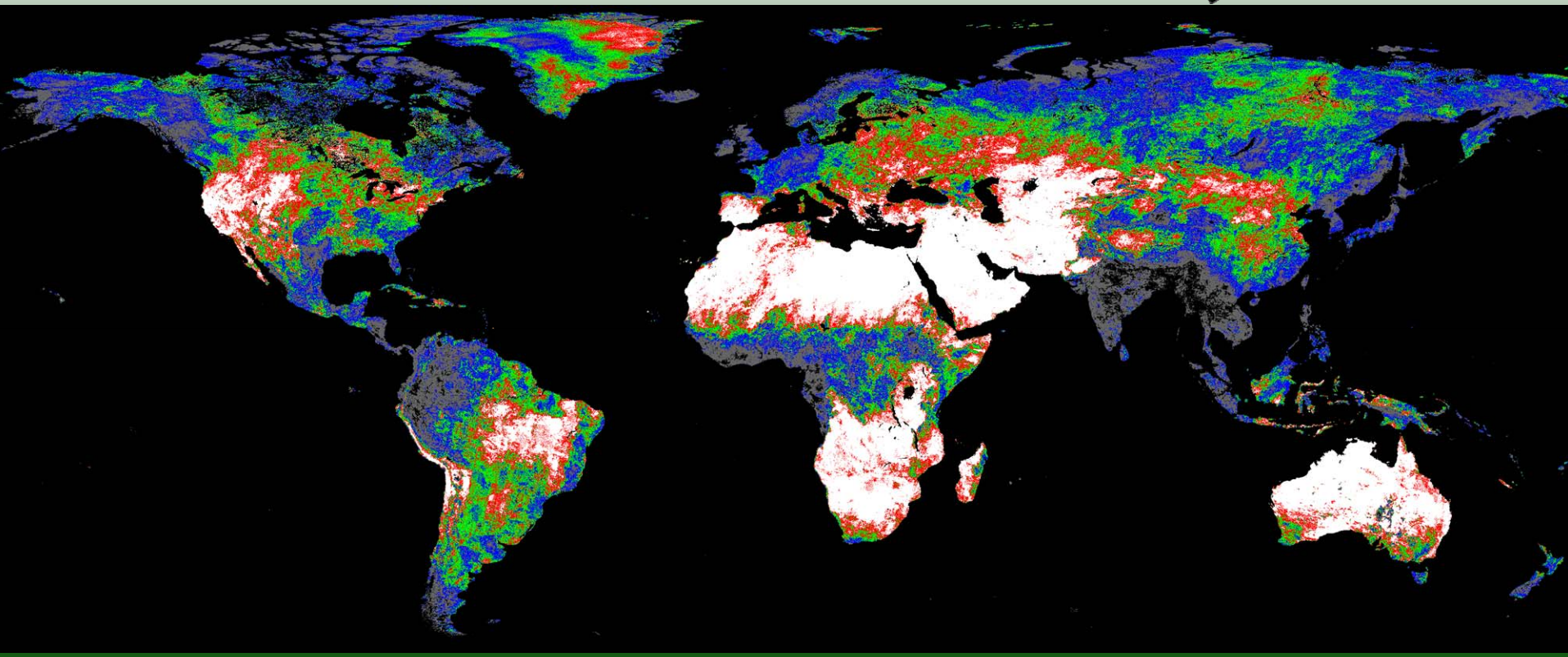
STEP 3 :
Ground truth



STEP4 : Fixing of Leakage

- Reduction of Greenhouse Gases
- Prevention of Explosion

Cloud coverage in July, 2002



Clear Sky Probability
(from MODIS)

- 0
- 0.0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0

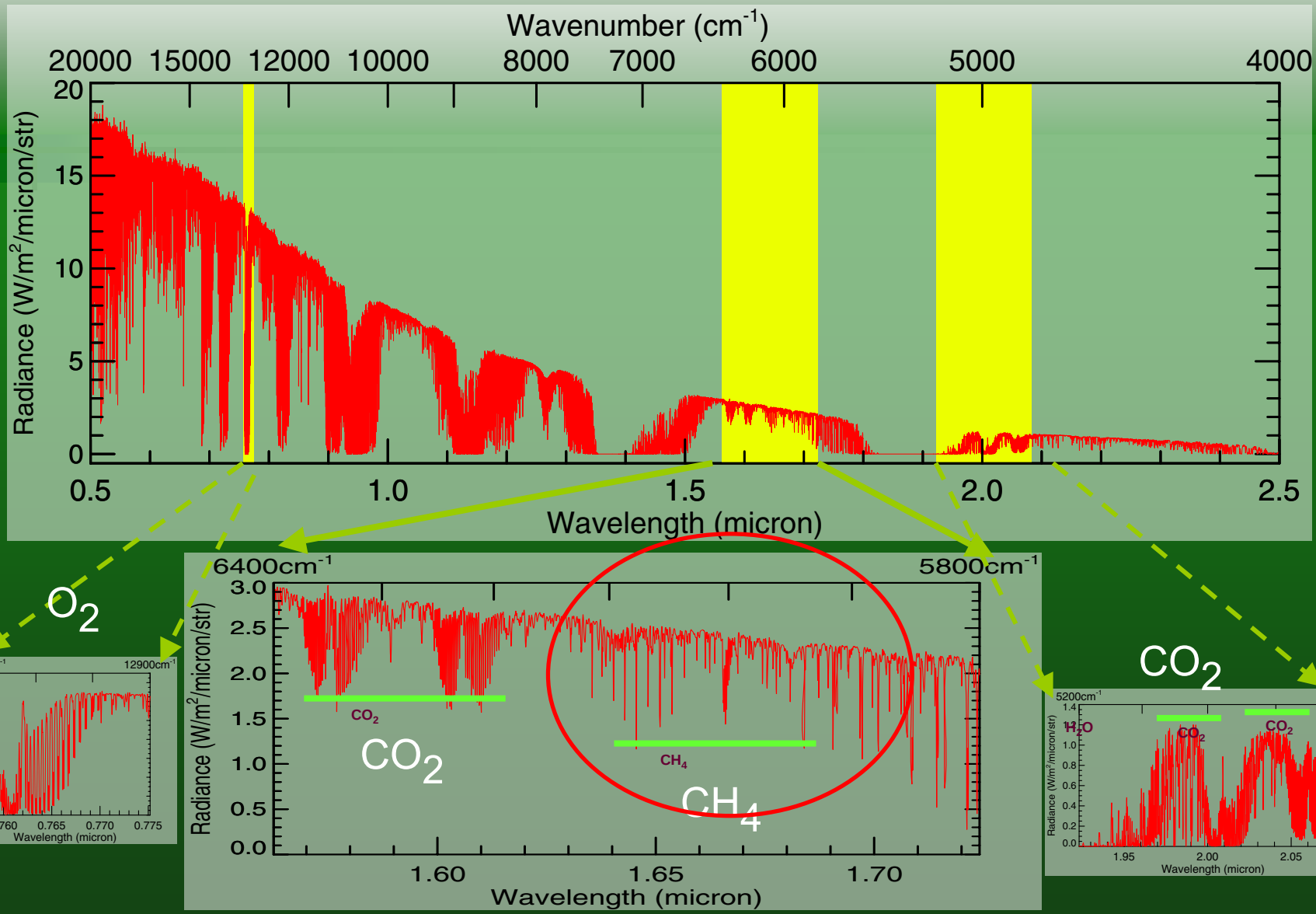
Ocean is set at 0 because of small reflectance at 1.6 and 2.0 μm

GOSAT

Greenhouse gases Observing SATellite

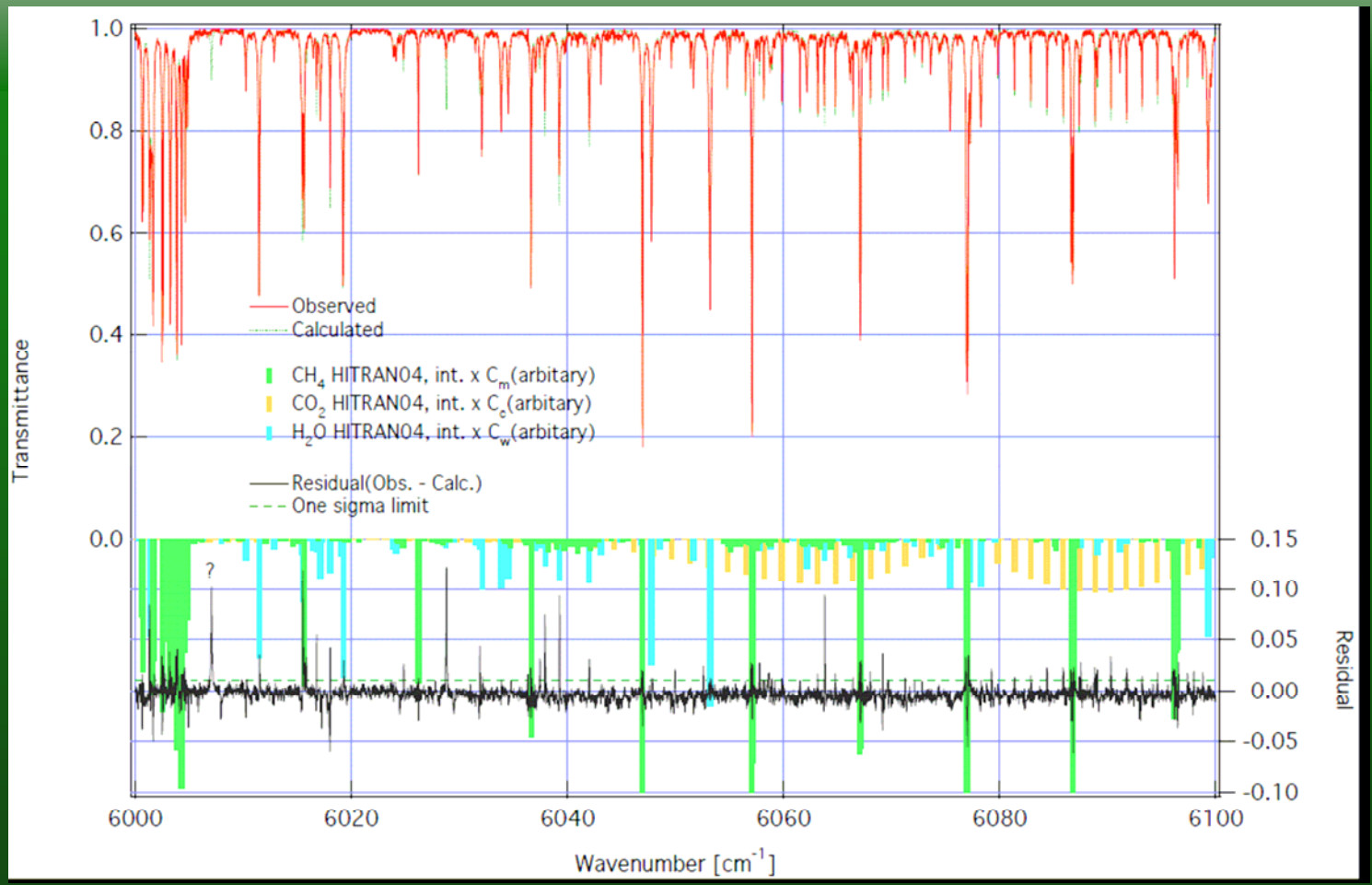
- Principle of Operation
- Precision of Measurement

Spectra of GOSAT sensor



(1) 0.76 μm band (2) 1.6 μm band (3)

Spectra of Methane

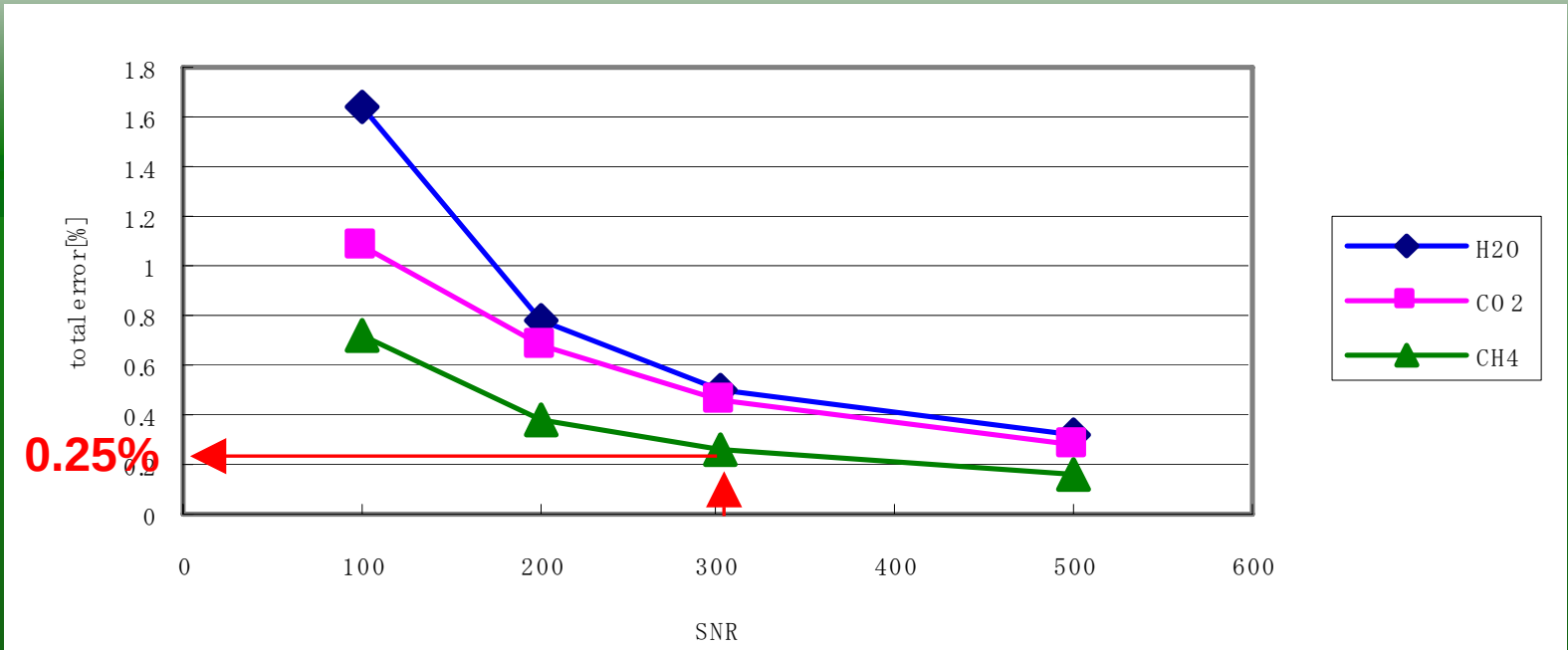


Ground Observation Data

Position of CH4,CO2 and H2O absorption

Difference between Observation and Analysis

Precision of Measurement



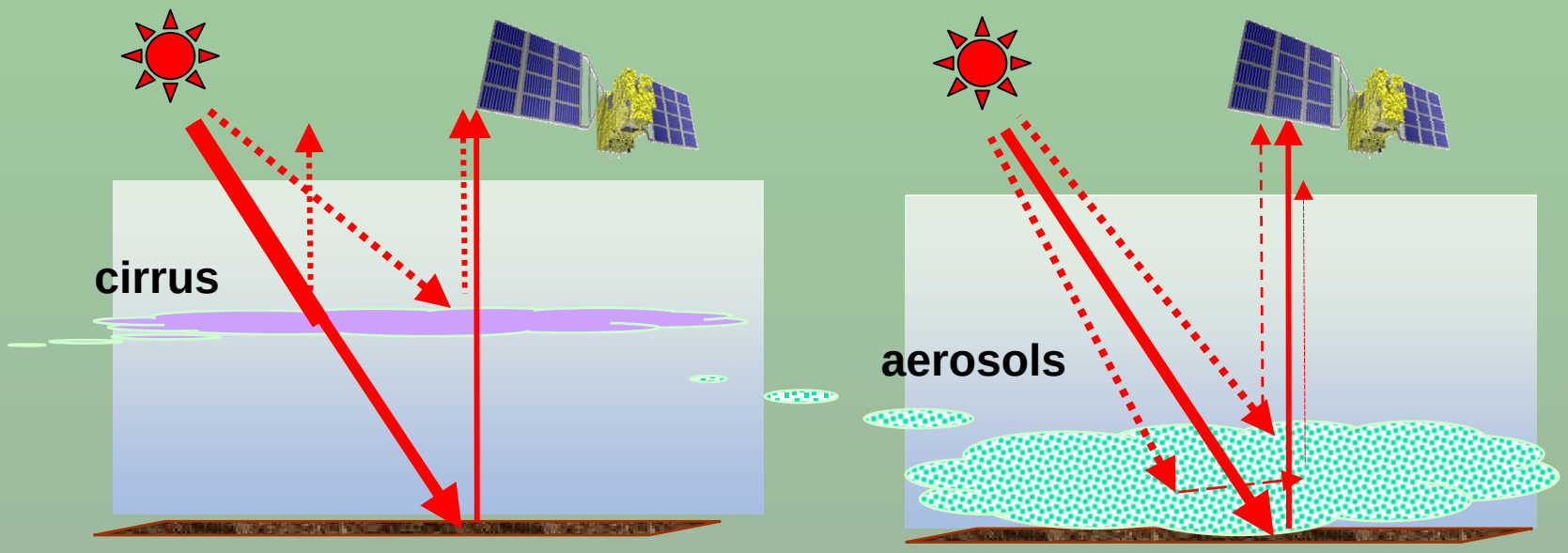
- Precision is dependent on the Signal to Noise Ratio and the Spectral Resolution.
- In case of GOSAT, SNR > 300, and $\Delta\nu$ = 0.2 cm-1
- Precision of **4 ppb** or better is expected.

GOSAT

Greenhouse gases Observing SATellite

- Principle of Operation
- Precision of Measurement
- Validation

Reflection from cirrus/aerosol



Wide coverage
Difficult to Identify
Height : 7,000～12,000 m
→ Influence to the column abundance seriously

Wide coverage
Difficult to Identify
(small scattering in Near Infrared)
Mainly in the mixing layer: ～3,000 m
→ Error may not serious in most cases

BBM Experiment
Nov 17, 2005

Mt. Tsukuba

Summit of Mt. Tsukuba
At the terminal of lope-way

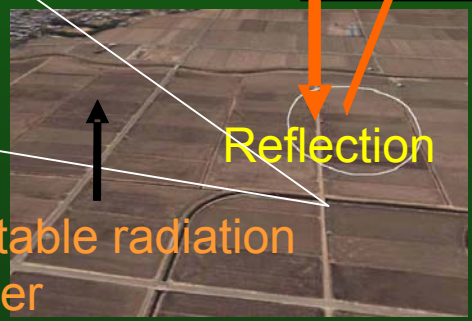
Direct solar

BBM

Observation of direct solar radiation by FTS (120HR)

In Situ Observation

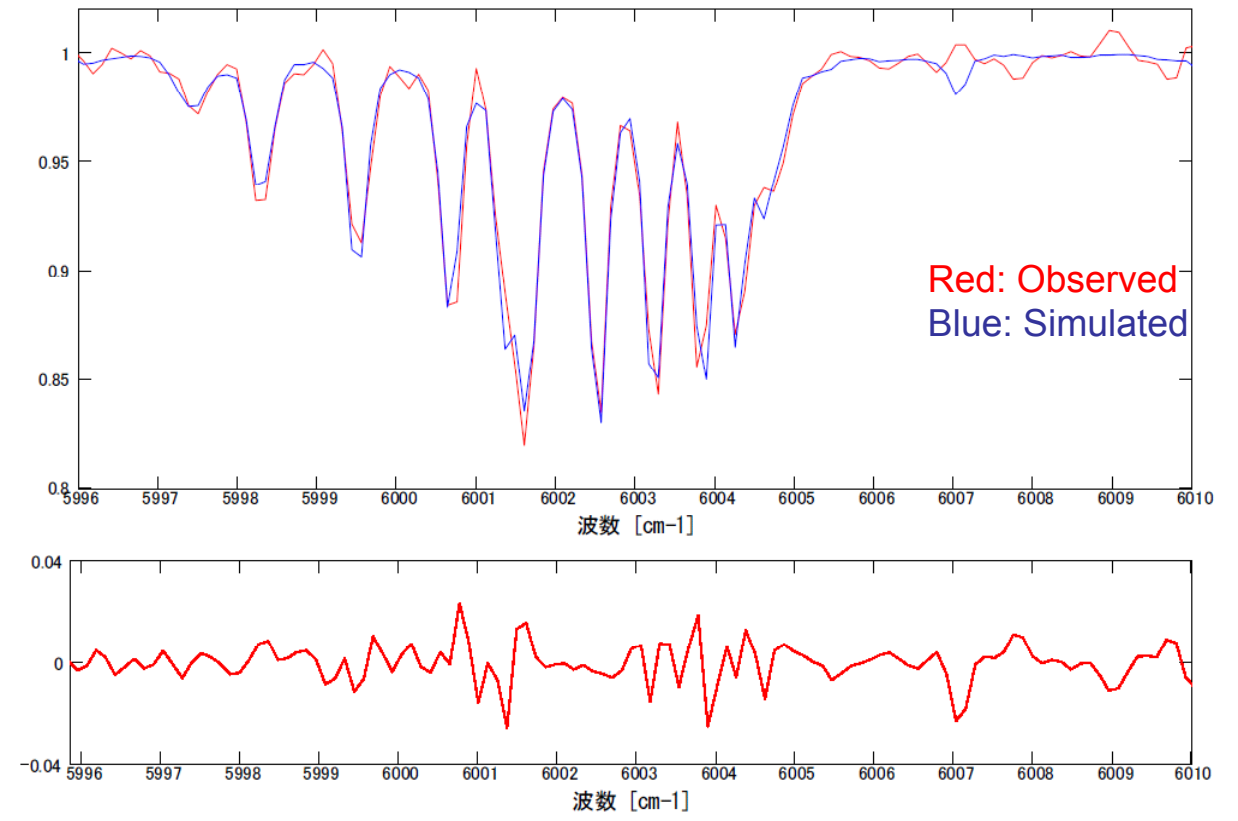
In situ observation



Portable radiation meter

In situ observation

Comparison between observed and simulated spectra



H_2O	6880 ±23 ppmv
CO_2	398 ±2.2 ppmv
CH_4	2.02 ±0.02 ppmv

Call for the cooperation

Evaluation of the precision

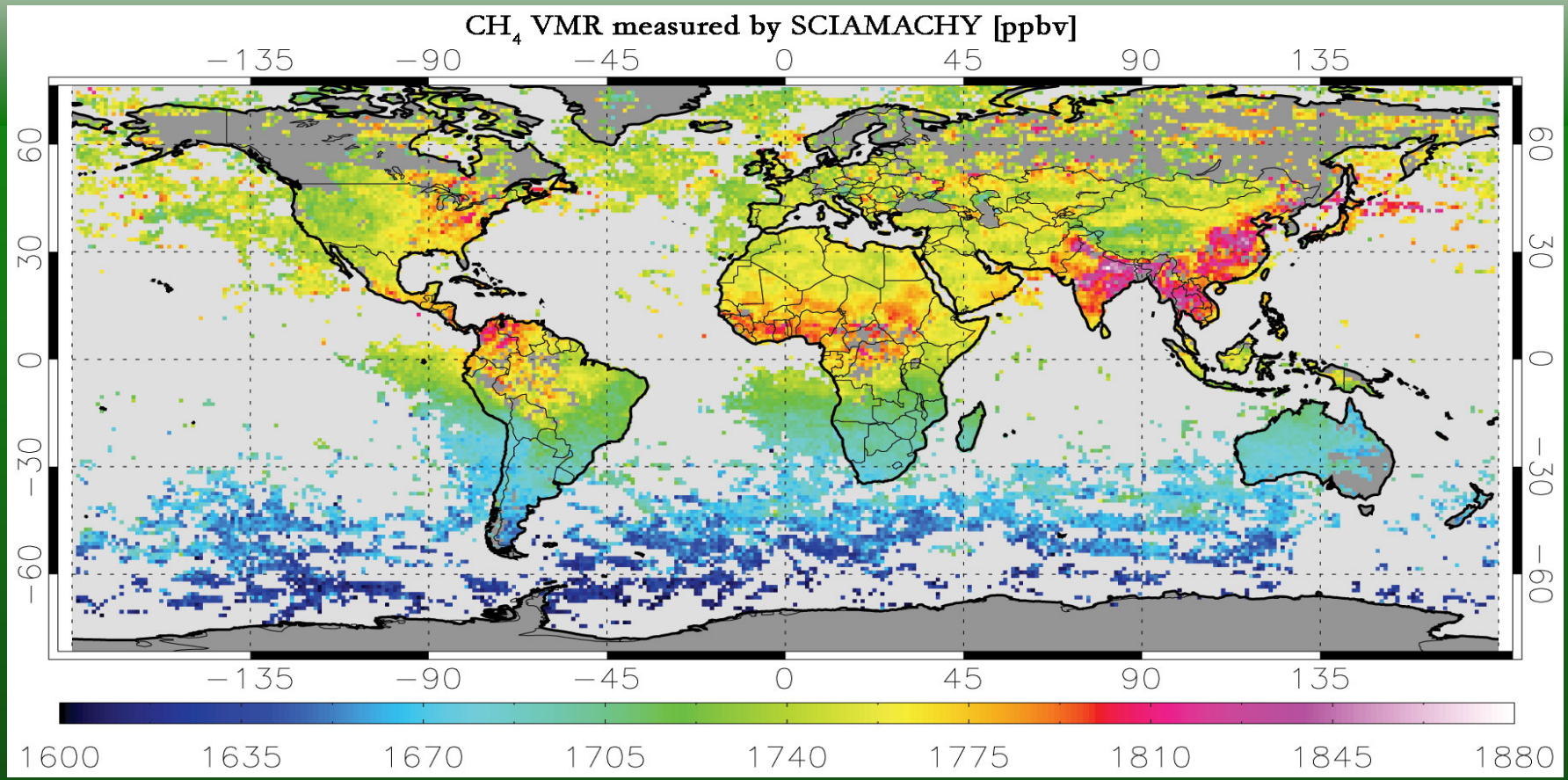
- Tsukuba Model : Almost identical with real satellite sensor designed for aircraft observation.
- Combination with in situ observation.
- Over a compressor station or Artificial leak of methane.
- International cooperation is welcomed sharing the results and future project.

Conclusion

- The observation of CH_4 in the precision of 0.25% means that the 4ppb difference in column can be detectable.
- If the field of view is 10 km$^{\phi}$, the total mass of air is 0.8x10(12)kg in it. The amount of 4 ppb corresponds to 3 tCH_4 in 10 km square. If the transportation is 100 km/day, the leak of 30 tCH_4/day is detectable. If it is calm, the minimum detectable leak rate decreases.
- There are the records of leakage 45, 79, or 0.73 tCH_4/day stationary at compressor stations in East Europe, and some of them are detectable.
- The leakage which is lead to explosion is more than this amount.

We need a test field !!

Observation by Europe Satellite



SCIAMACHY(6cm-1) 20 ppb resolution monthly base

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