Preliminary Results of CO2 Retrievals from Ground-based Solar Absorption FTIR Spectrometer and its Validation

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What is FT-IR?

◆ FT-IR (from wikipedia)

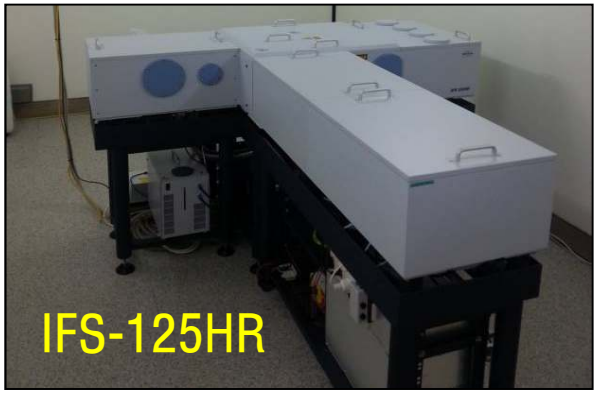
- Fourier Transform InfraRed spectroscopy is a technique which is used to obtain an infrared spectrum of absorption, emission, photoconductivity or Raman scattering of a solid, liquid or gas. An FTIR spectrometer simultaneously collects spectral data in a wide spectral range.

Atmospheric Emitted Radiance Interferometer

IFS-125HR with solar tracker

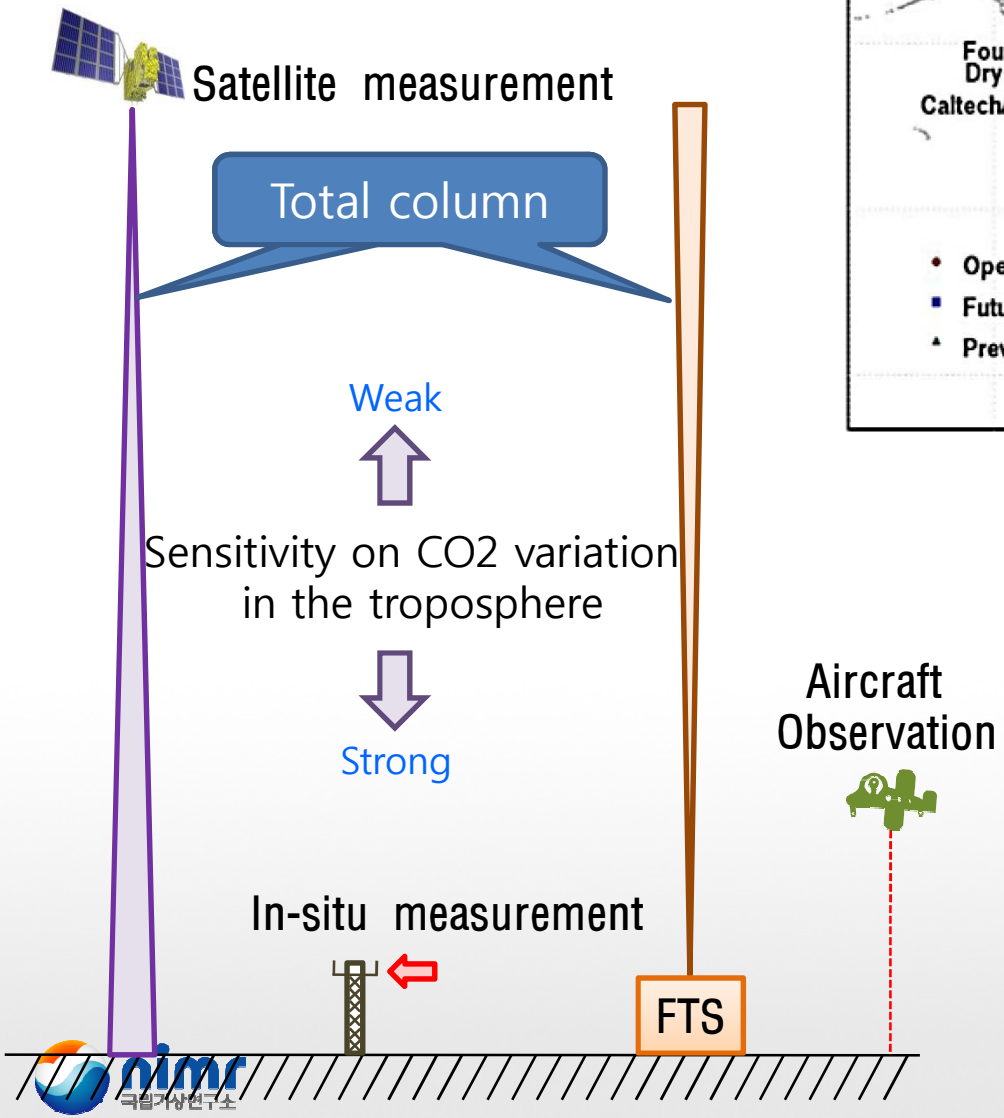
Goal

◈ Validation of satellite-based greenhouse gases by using ground-based solar absorption FT-IR



	IFS-125HR	GOSAT-FTS
Band	9000~16,000 cm^{-1} (Si Diode Detector)	12,900~13,200 cm^{-1} (Si Diode Detector)
	3,800~12,800 cm^{-1} (InGaAs Detector)	5,800~6,400 cm^{-1} (InGaAs Detector)
		4,800~5,200 cm^{-1} (InGaAs Detector)
Spectrum Resolution	0.2 cm^{-1}	0.2 cm^{-1}
Temporal Resolution	Every 2~3 min.	Every 3 days

Background



Total Carbon Column Observing Network (TCCON)

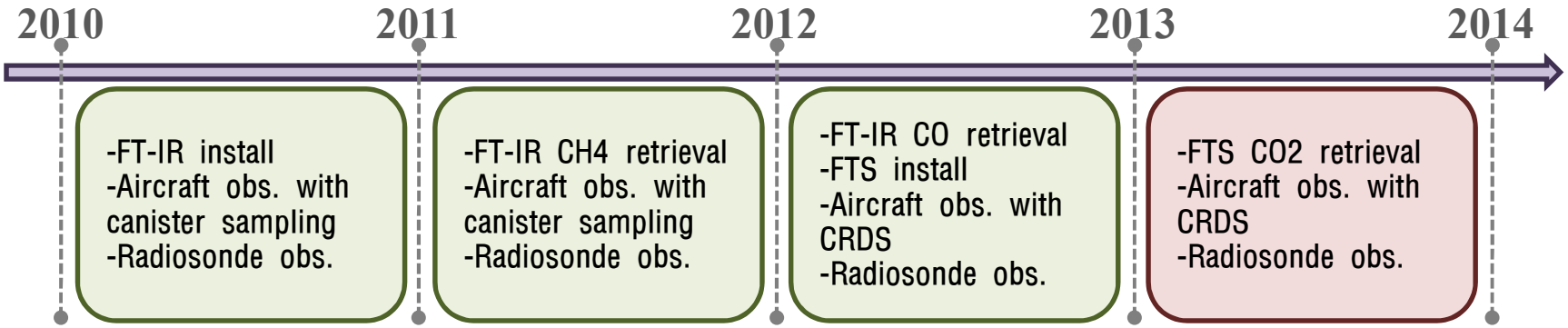
✓ In-situ measurement has high accuracy and sensitivity on CO2 concentration in the troposphere. But special resolution is not enough.
✓ Satellite-based CO2 has global coverage but its total column measurement is insensitive to large CO2 variability.

✓ It is difficult to obtain significant results from direct validation between satellite and in-situ measurements.
✓ In this regard, ground-based FTS, which has similar optics and sensors to those of CO2 observing satellite, is the best way to validate satellite-based CO2.

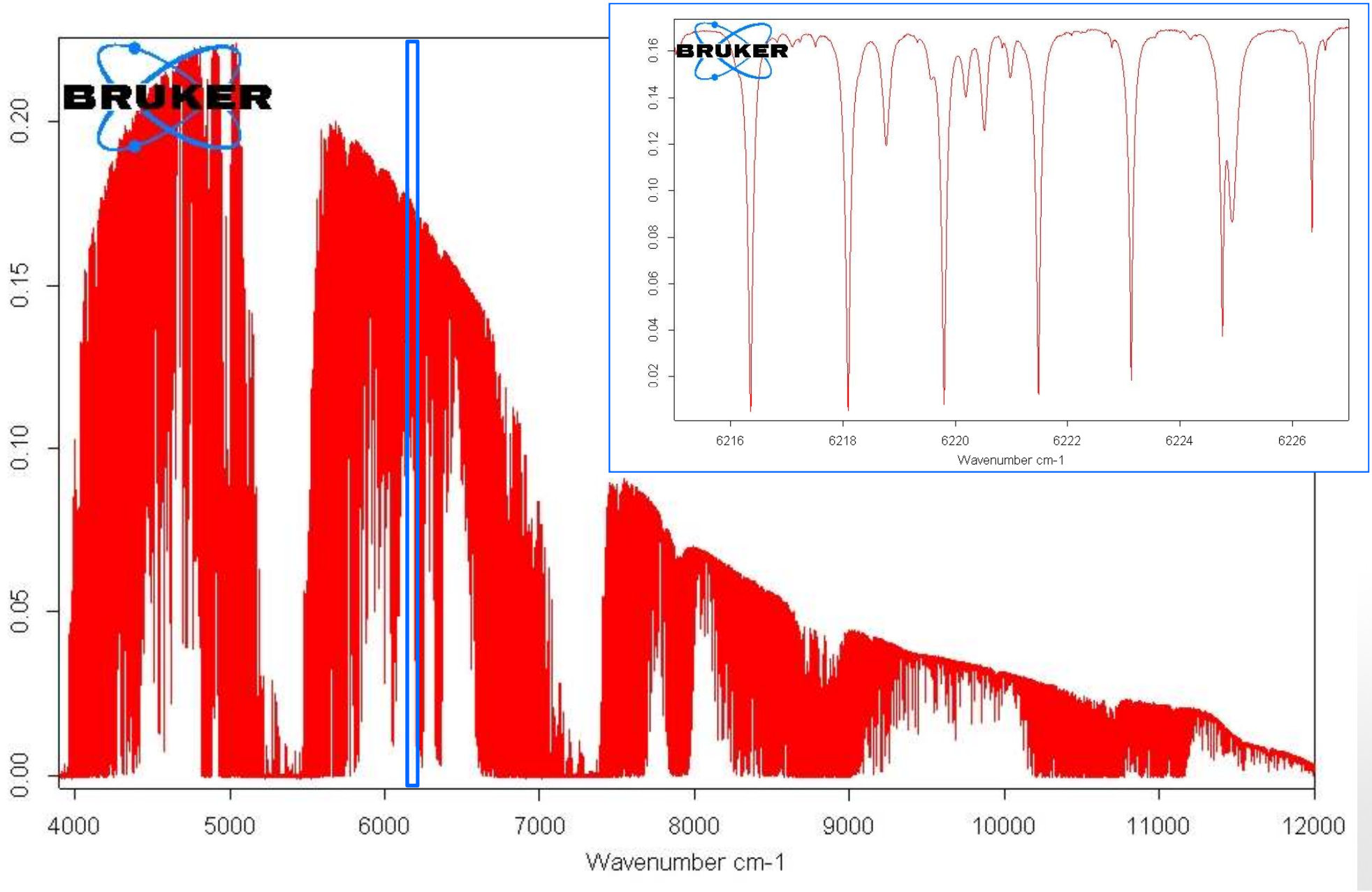
✓ It is necessary to calibrate FTS CO2 using aircraft observation in order to compensate for insensitivity on CO2 variation in the troposphere.

Activities on Remotely-sensed CO2/CH4 Validation

- Period/Site: 2010~present / Anmyeondo (KGAWC)
- Instruments: Emission FT-IR, Absorption FTS
- Observations: Aircraft observation with CRDS, Radio sonde



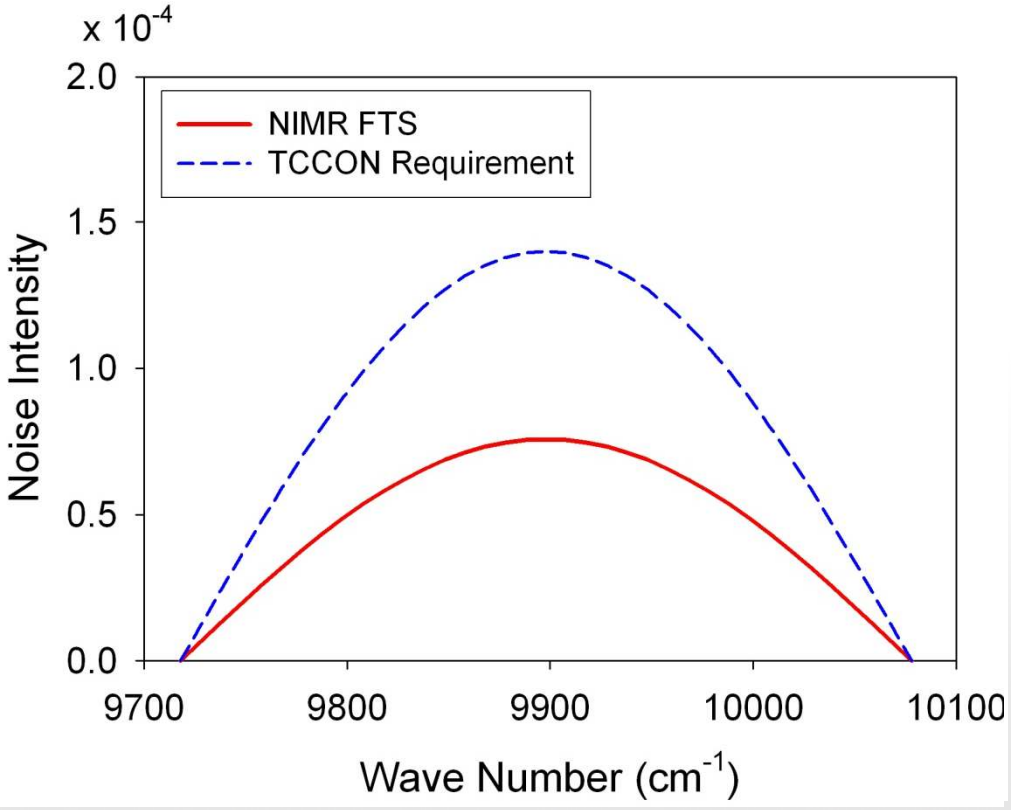
Measured spectra

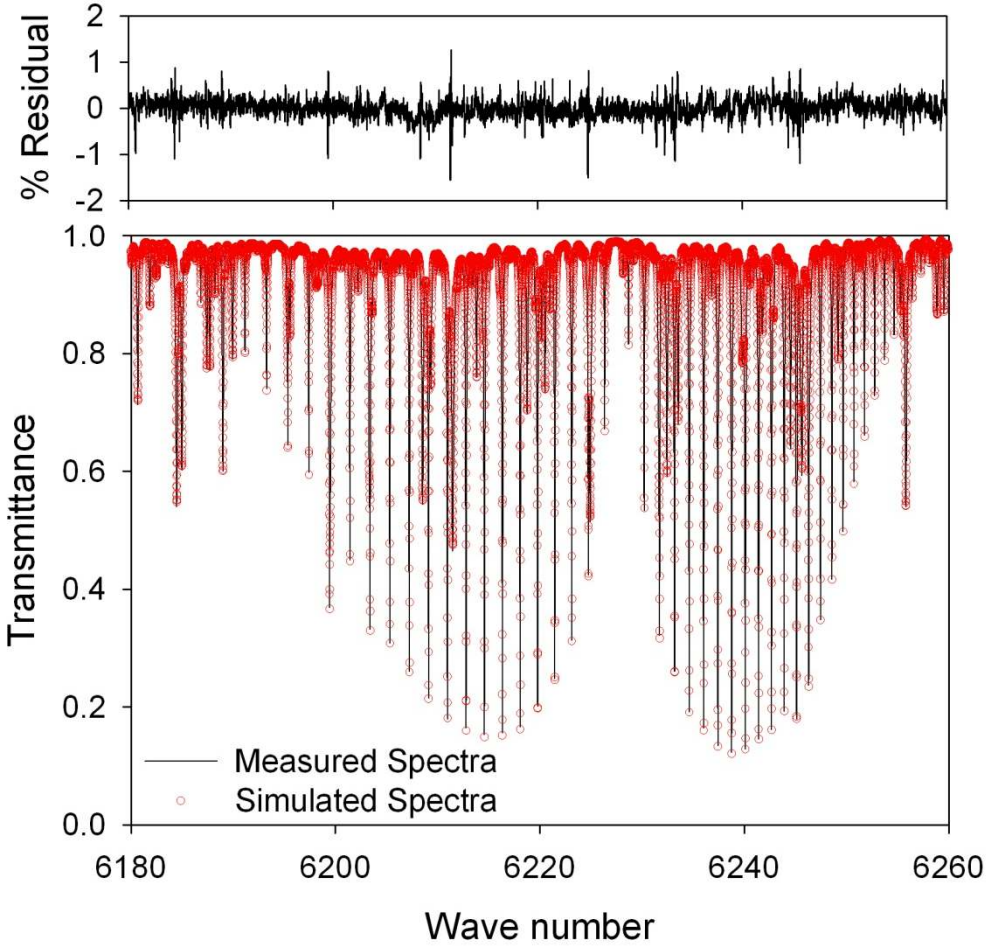


Modulation Efficiency (ME) and Spectrum Fitting

- ME ≥ 98% indicates measurement CO2 error ≤ 0.1%.
- ME=99.2% at the OPD of 45 cm^{-1} is corresponding to the error of 0.035%.
- Spectrum fitting
  - Good agreement between measured and simulated spectra

※%Residual = Residual x 100

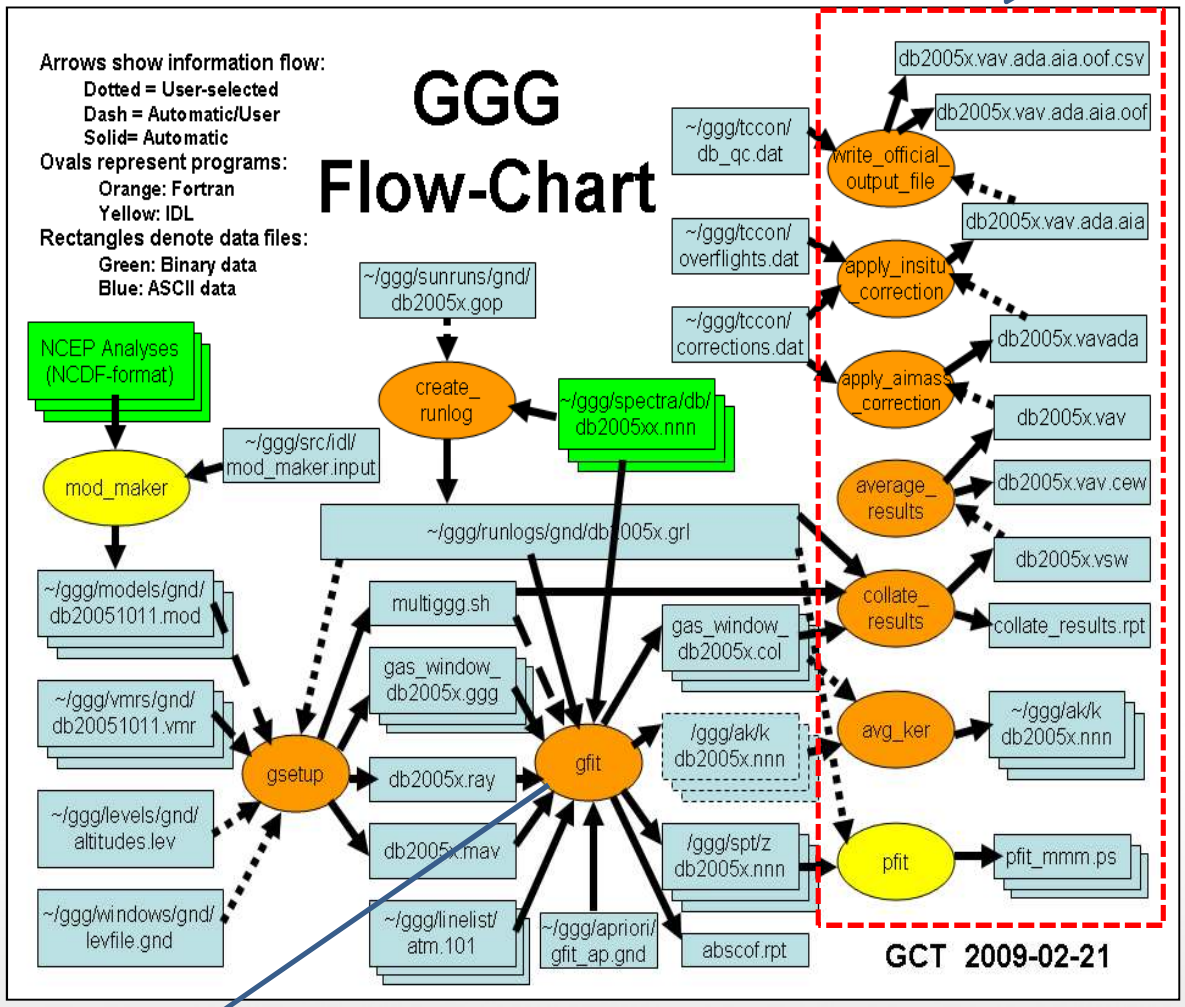




CO2 Retrieval Algorithm

Gas	Center Frequency [cm^{-1}]	Window Width [cm^{-1}]	Spectral Region [cm^{-1}]	Interfering Gases
O_2	7885.00	240.00	7765 – 8005	H_2O
CO_2	6220.00	80.00	6180 – 6260	H_2O, HDO, CH_4
	6339.50	85.00	6297 – 6382	H_2O, HDO

$$XCO_2 = \frac{\left[\frac{CO_{2(6220)} + CO_{2(6339)}}{2}\right]}{O_{2(7885)}} \times 0.2095 \times 10^6$$



o Spectrum fitting module
- MkIV spectra(balloon, aircraft, ground-based obs.), ATMOS spectra
- Ground-based FT-IR spectra analysis

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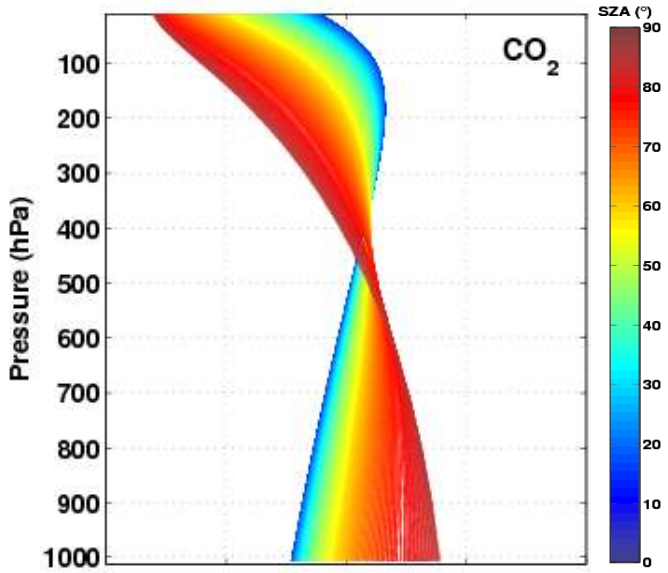
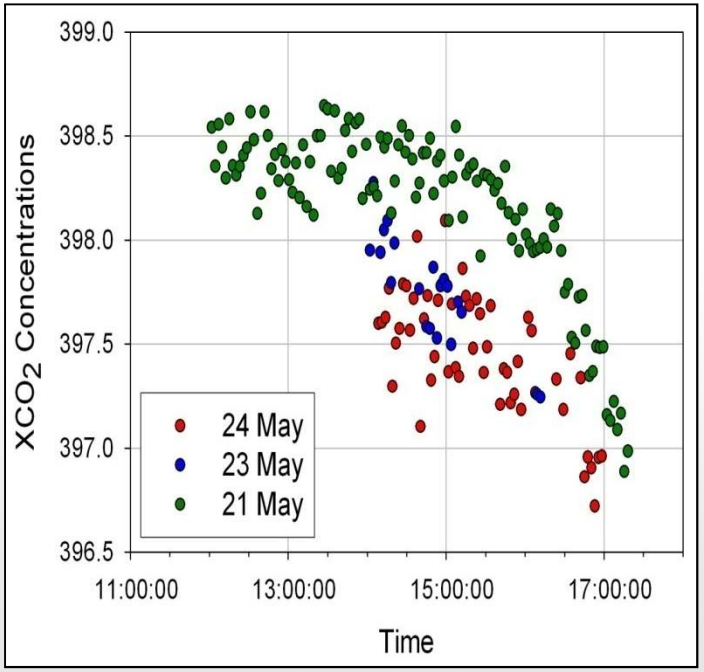
Data

- Spectra measured from FTS
- 6 hourly NCEP Reanalysis
  - 2.5 x 2.5 grid, 17 pressure levels
  - Temperature, Geopotential height, Specific humidity, Pressure on the tropopause
- Pressure on the level of FTS
- a priori CO2 profile
  - based on MkIV balloon and ACE profile (30~40N, 2003~2007)
  - replaced an empirical model based on fits to GLOBALVIEW data (~10 km)
  - an age-dependent profile in the stratosphere
- Averaging Kernel
- Spectroscopy
  - Many atmospheric line lists come from HITRAN 2004 and 2008
  - CO2 line lists in 4300~7000 cm^{-1} (Toth et al. 2008)





FTS CO2 against In-situ CO2 (1)

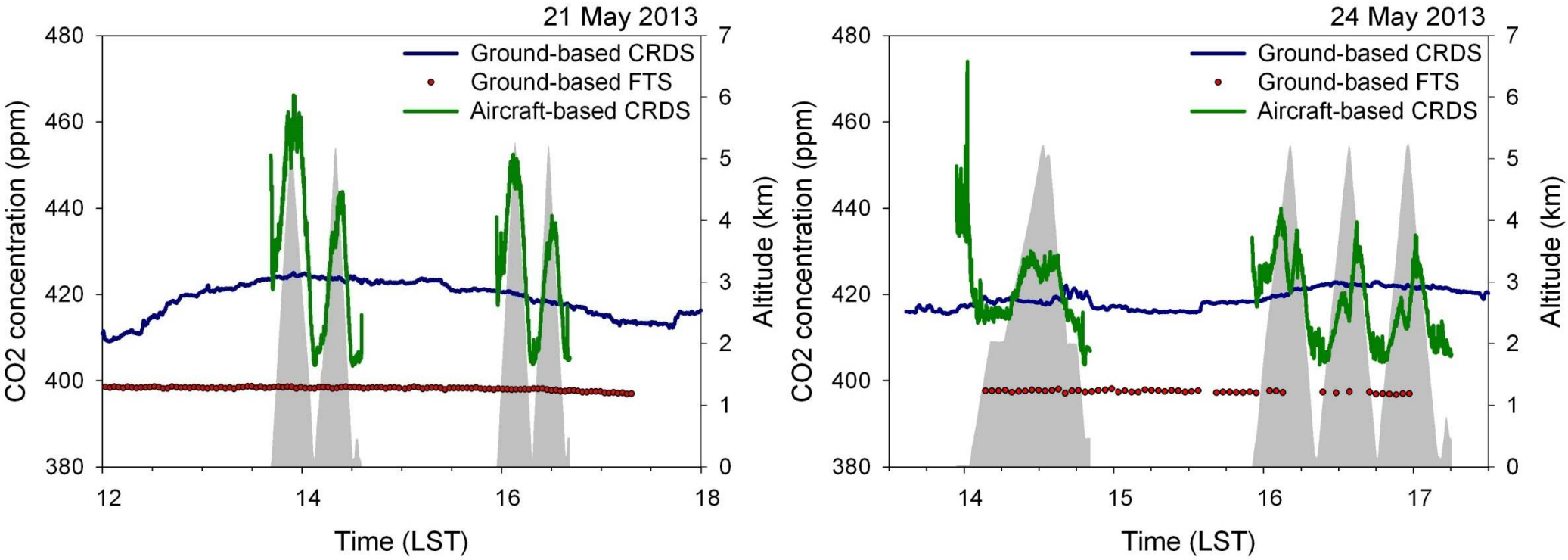
◈ Period: 24 May 2013

◈ Data Descriptions

- In-situ CO2 at the KGAWC (CRDS, 5 seconds)
- Aircraft-based CO2 (CRDS, 0.15~5 km, 0.3 seconds)

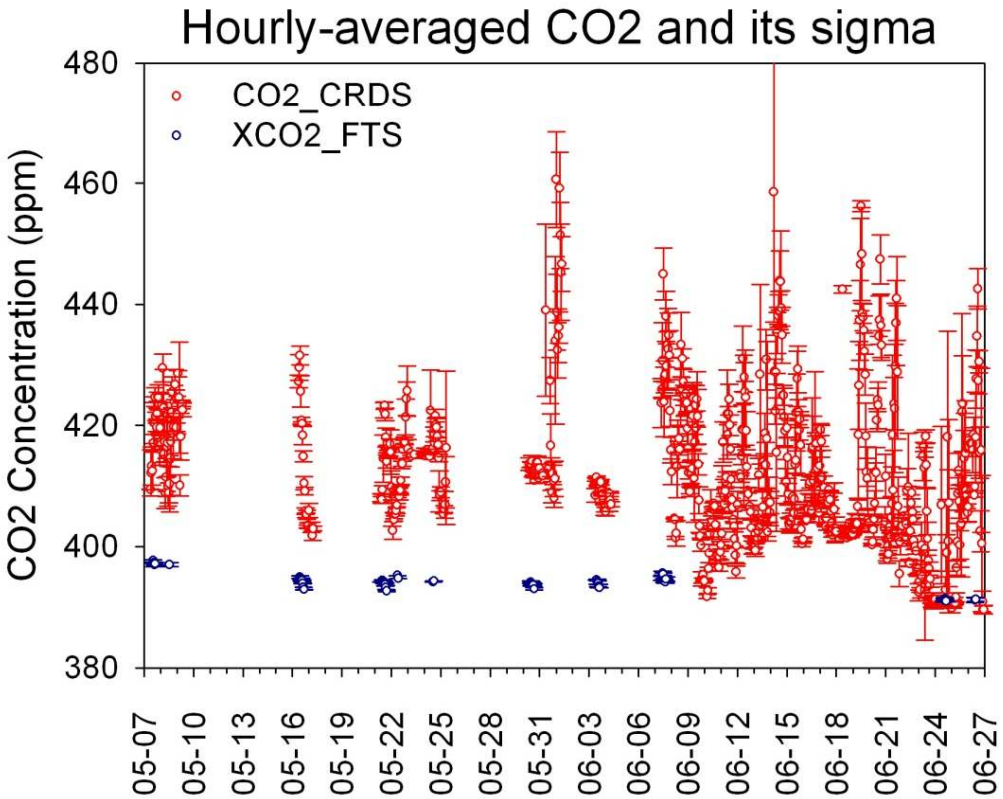
◈ Results

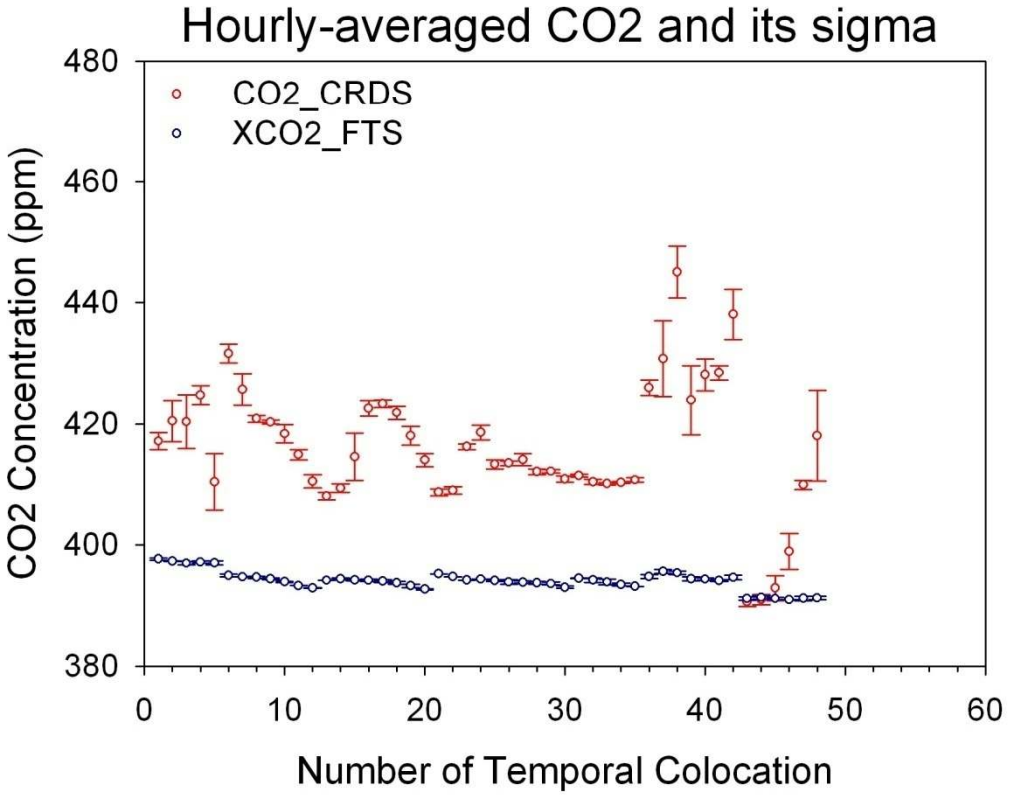
- While in-situ measurements show considerably large CO2 variability, FTS CO2 doesn't as expected.



FTS CO2 against In-situ CO2 (2)

- Period: May~June 2013
- Data: hourly-averaged CO2 and its sigma
- Results
  - Large differences were found even though hourly-averaged CO2 has small standard deviation.

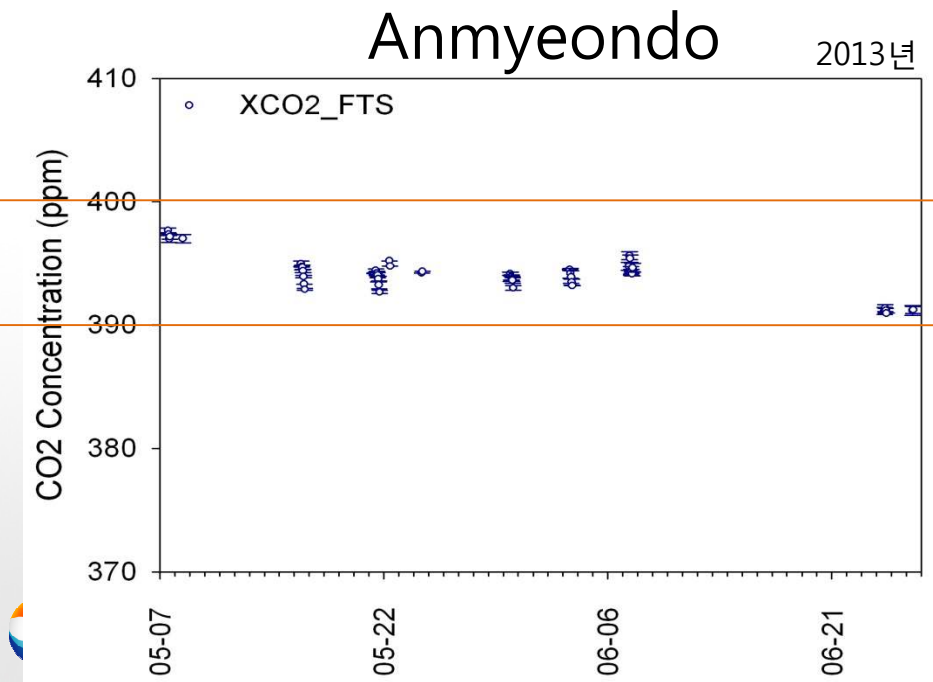


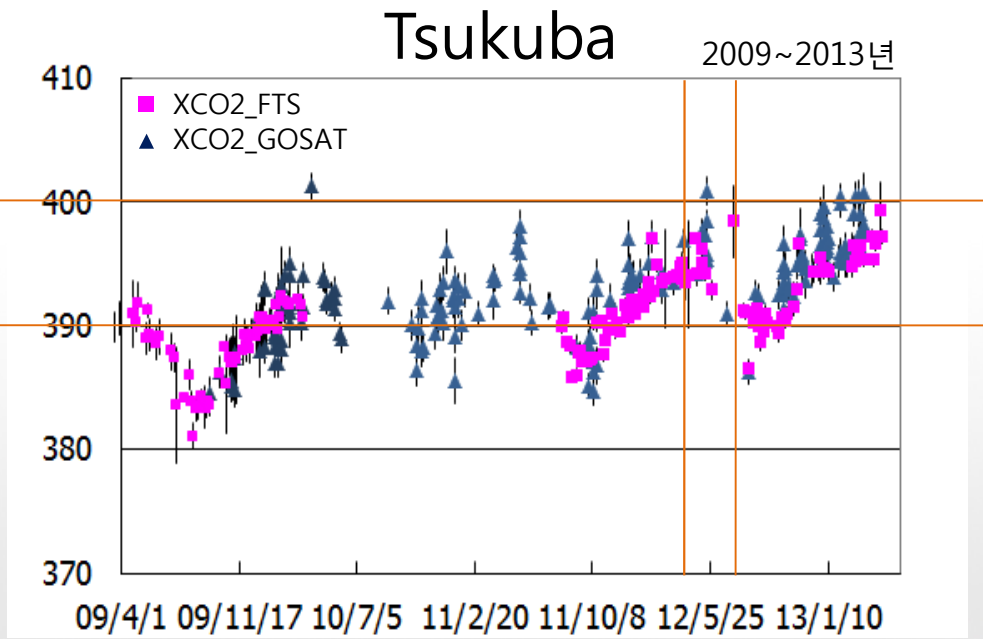


FTS vs FTS

◈ Data description
- FTS CO2 at Anmyeondo from May to June 2013
- FTS CO2 at Tsukuba from April 2009 to January 2013

◈ Results
- Time variation and concentration level of FTS CO2 at Anmyeondo look reasonable.





(From Morino et al., 2012 TCCON meeting)

Summary and Conclusion

- It is difficult to obtain significant results in the comparison of ground-based in-situ CO2 and remotely-sensed total column CO2 measurement because of their different sensitivities on CO2 variability in the troposphere.
- Nevertheless, in-situ CO2 measurements are necessary to assess the quality of remotely-sensed CO2 measurements.
- Long-term comparison of background CO2 concentration from the GAW station is desirable to validate FTS and satellite CO2.
- Although NIMR FTS CO2 needs correction for dependence of solar zenith angle and CO2 concentration in the troposphere, preliminary FTS CO2 looks reasonable concentration level and temporal variation so far.
- Aircraft observation plays a key role to compensate insufficient sensitivity of FTS CO2 in the troposphere.

Thank you for your attention

◆ Acknowledgement

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- In-situ CO2 observation data were produced by the Korea Global Atmosphere Watch Center.

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Instrument

- IFS-125HR with Solar Tracker (Bruker, Germany)
- Specification
  - Spectrum range: 16,000~3,800 cm^{-1} (0.63~2.63 ㎛)
  - Spectrum resolution: up to 0.0063 cm^{-1}
  - Temporal resolution: about 2 minutes
  - Detector/Beam splitter: InGaAs, Si-Diode / CaF2
  - Retrieval: CO2