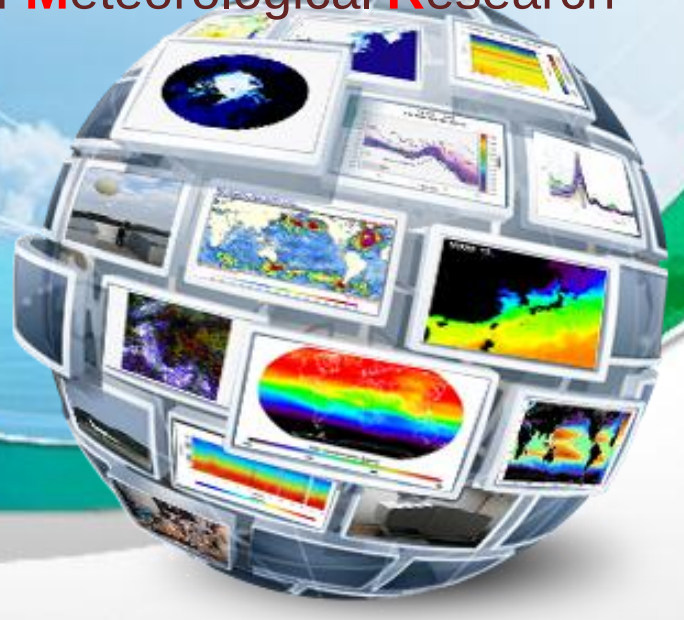
Introduction of Anmyeondo FTS Station as a New TCCON Site

Tae-Young GOO, Young-Suk OH, Jin-Ho Shin,
Mi-Lim OU, and Chun-Ho CHOI

Global Environment System Research Division
National Institute of Meteorological Research



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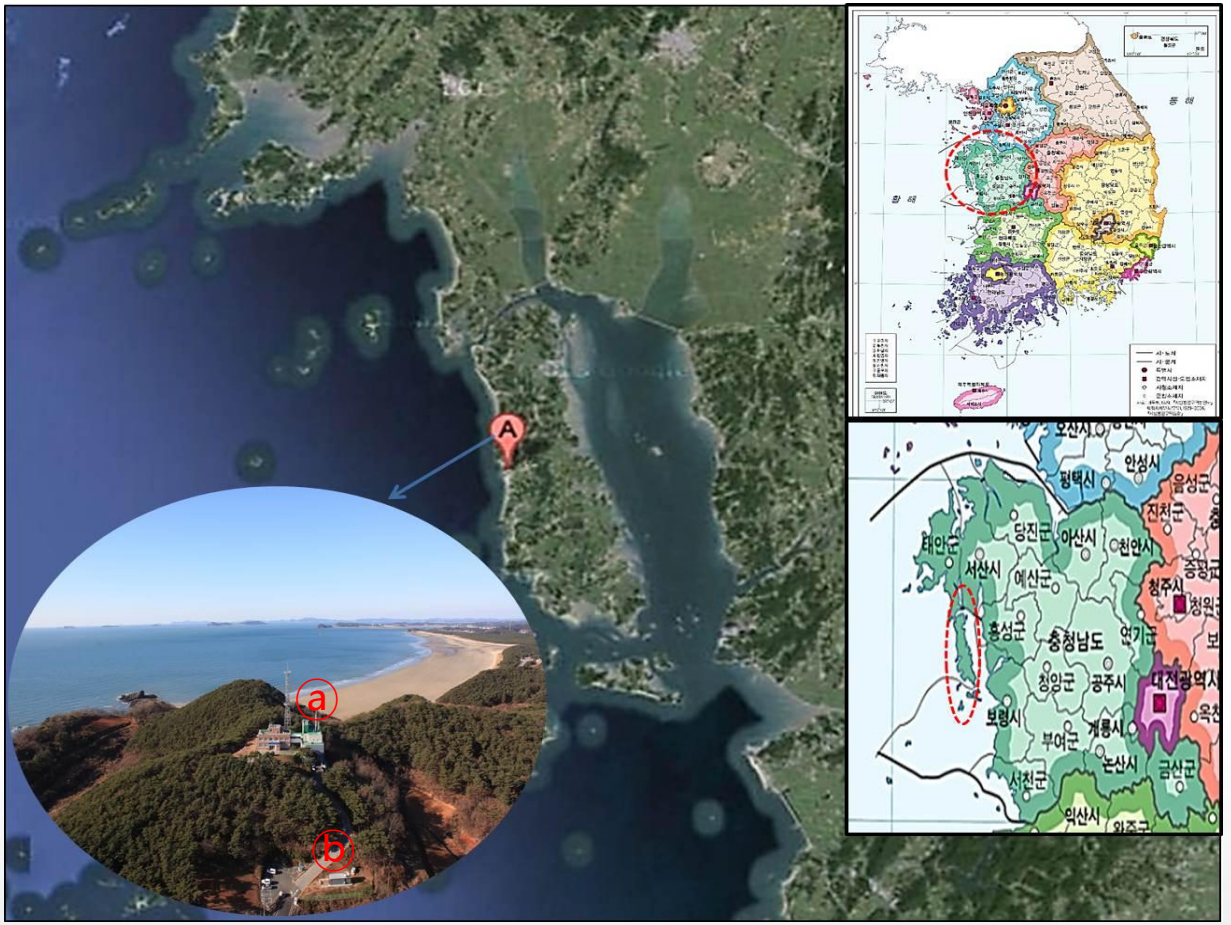
Where is the site?

- Latitude: 36°32N
- Longitude: 126°19E
- Altitude: 25 masl
- WMO Regional GAW station of the KMA
- ⓐ FT-IR, ⓑ FTS
- FTS station is a designated site of the TCCON



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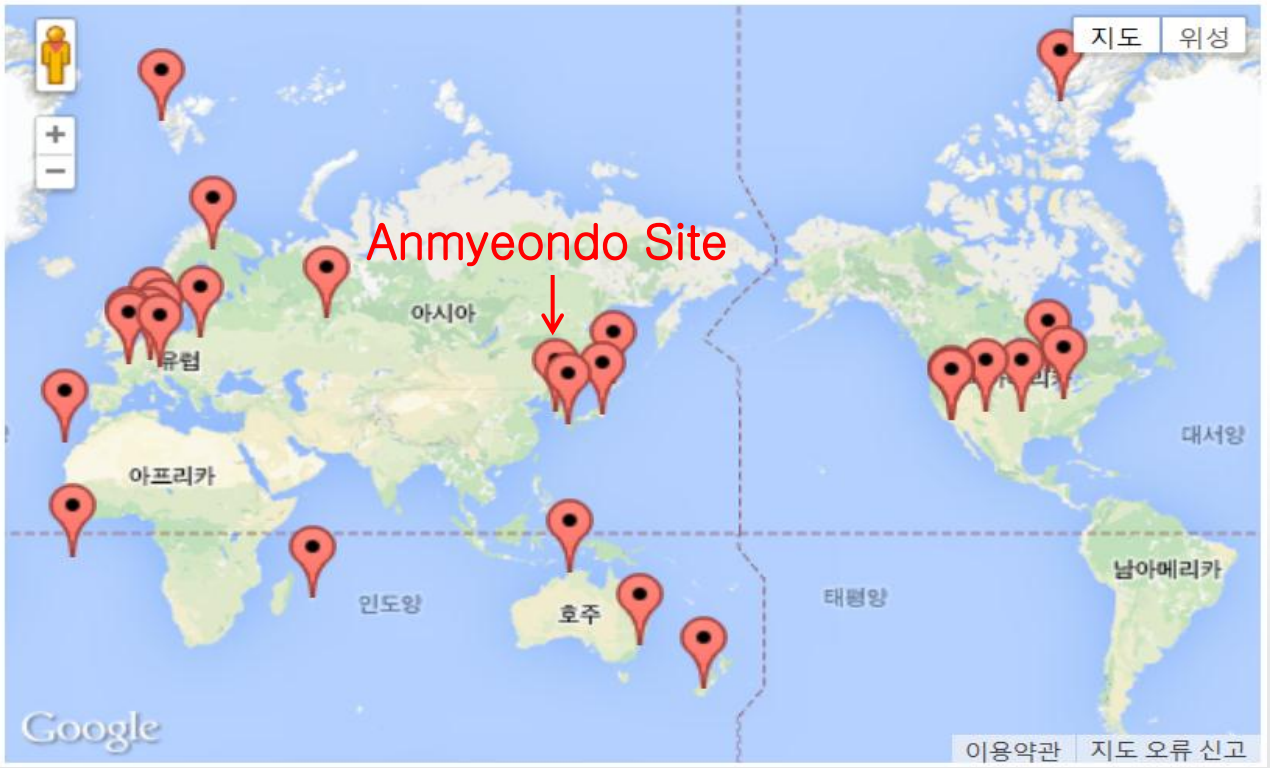
What is the TCCON?

- Total Carbon Column Observing Network (26 sites over the world)
  - a network of ground-based Fourier Transform Spectrometers recording direct solar spectra in the near-infrared spectral region.
  - From these spectra, accurate and precise column-averaged abundance of CO2, CH4, N2O, CO, H2O, HF, and HDO are retrieved.
- TCCON provides an essential validation resource for the Orbiting Carbon Observatory (OCO), Sciamachy, and GOSAT.



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Overview of Instruments

Remotely-sensed Obs.

◈ FT-IR (Fourier Transform InfraRed)

-Model: AERI-003
-Manufacture: ABB (Canada)
-Period: 2010.6.~present
-Range: **550~3,000 cm^{-1}**
-Resolution: **1 cm^{-1}**
-Time Interval: 7~8 min.
-Measurement: Downward infrared spectra
-Retrievals: **T/q, CH4, CO**

◈ FTS (Fourier Transform Spectrometer)

-Model: IFS-125HR
-Manufacture: Bruker (German)
-Period: 2013.3.~present
-Range: **3,800~16,000 cm^{-1}**
-Resolution: **~0.0063 cm^{-1}**
-Time Interval: 2~3 min.
-Measurement: Solar absorption spectra
-Retrievals: **CO2, CH4**

Obs. for Validations

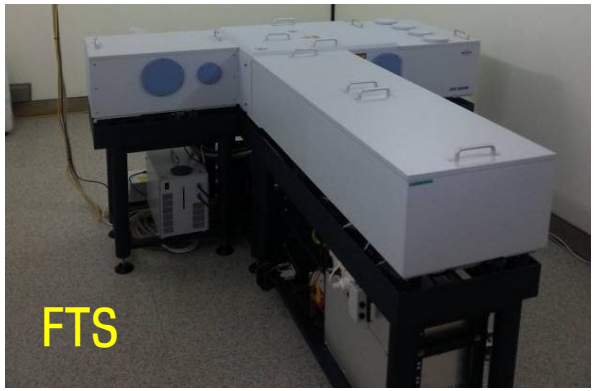
◈ Radio Sonde

-Manufacture: Graw (German)
-Period: 2010~present
-Num.: 72 launches so far
-Altitude range: ~30 km
-Measurement: **T, P, Humi.**, Wind dir. and speed
-Launch time: at the time of aircraft obs. and satellite overpassing

◈ Airborne CRDS

(Cavity Ring-Down Spectroscopy)
-Manufacture: Picarro (USA)
-Period: 2012~present
-Altitude range: **~5 km**
-Measurement: **CO2, CH4, CO, H2O**
-Resolution: 0.3 sec.
-Aircraft Obs. 2010-2011
·Canister sampling(23 flights)
·CO2, CH4, N2O, SF6, CO

Instrument Configurations



	FTS(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)
Spec. Res.	0.2 cm^{-1}	0.2 cm^{-1}
Time. Res.	Every 2~3 min.	Every 3 days

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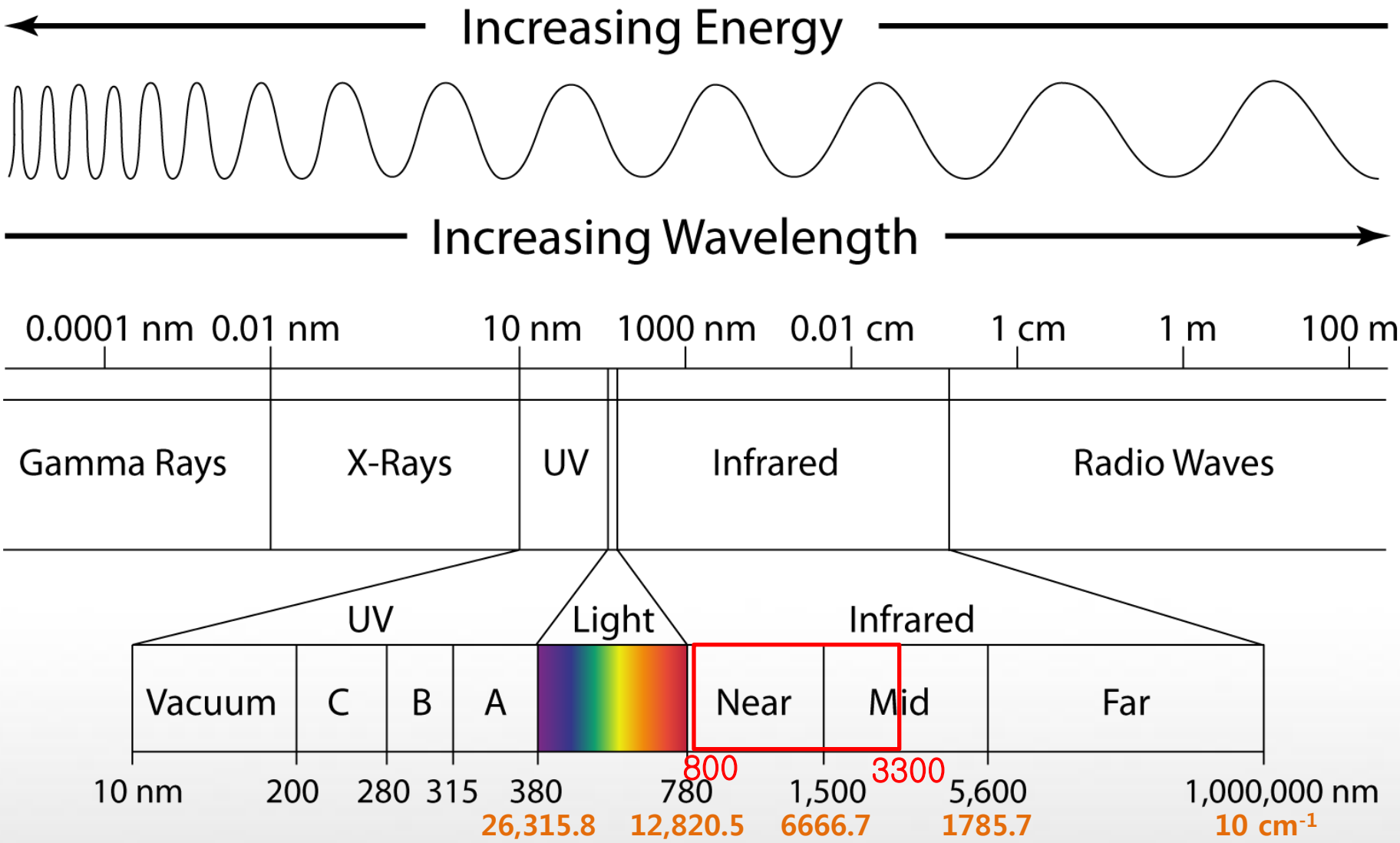
Electromagnetic Spectrum



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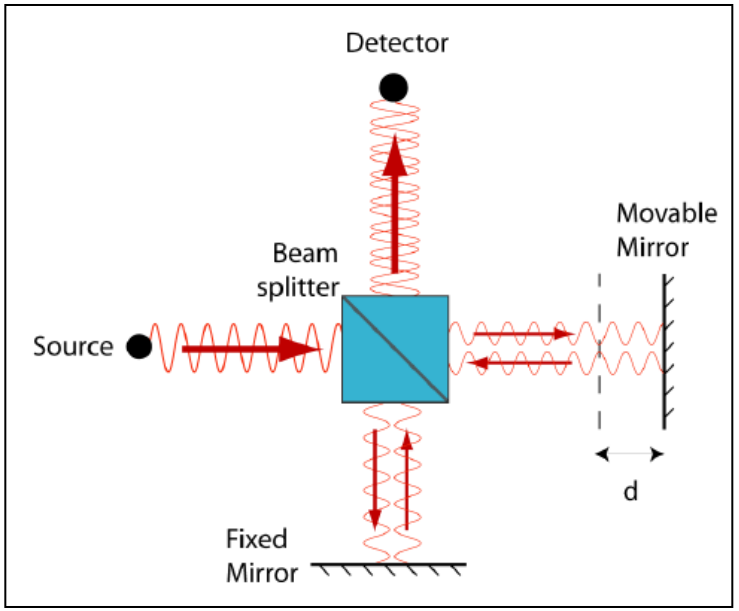
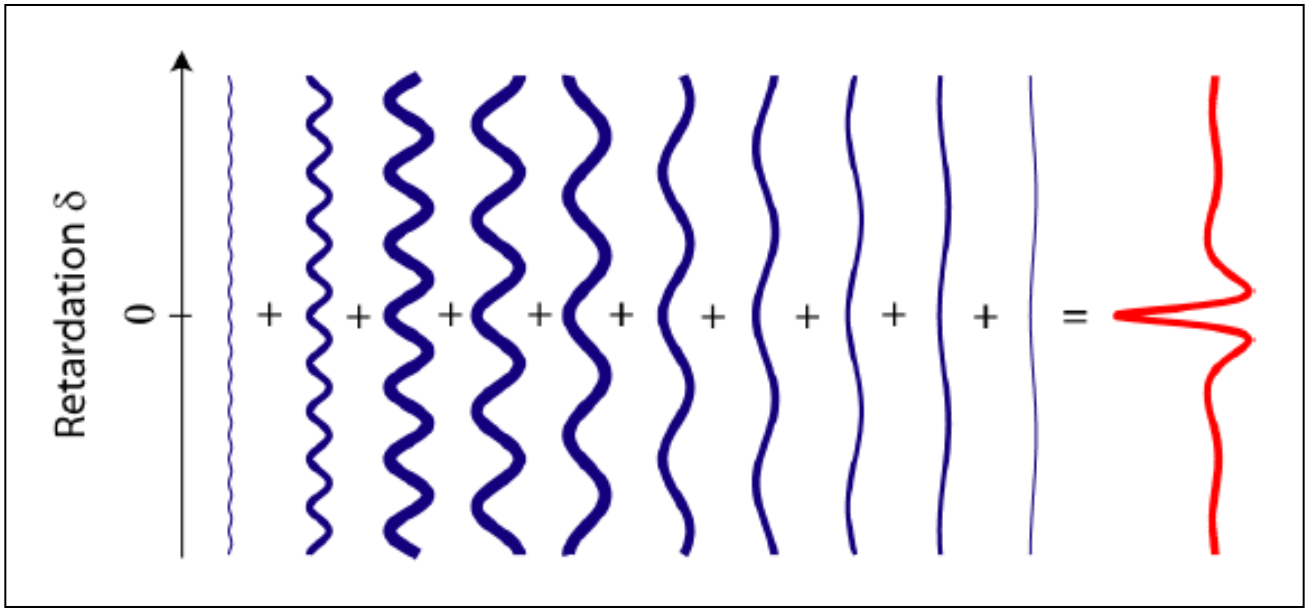
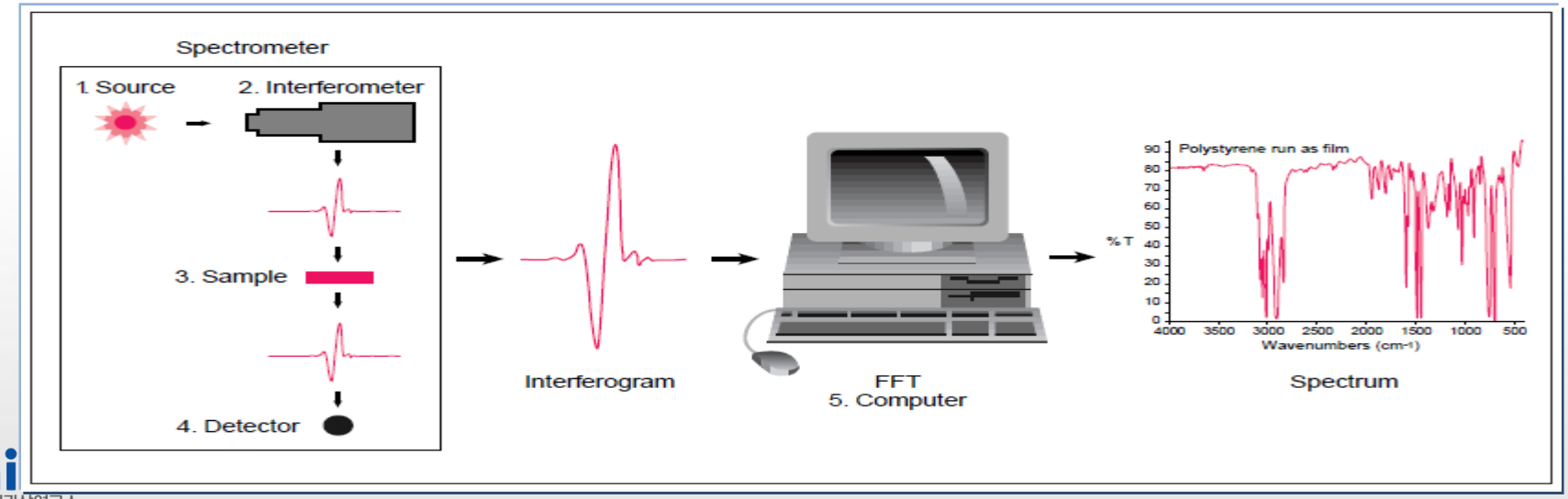
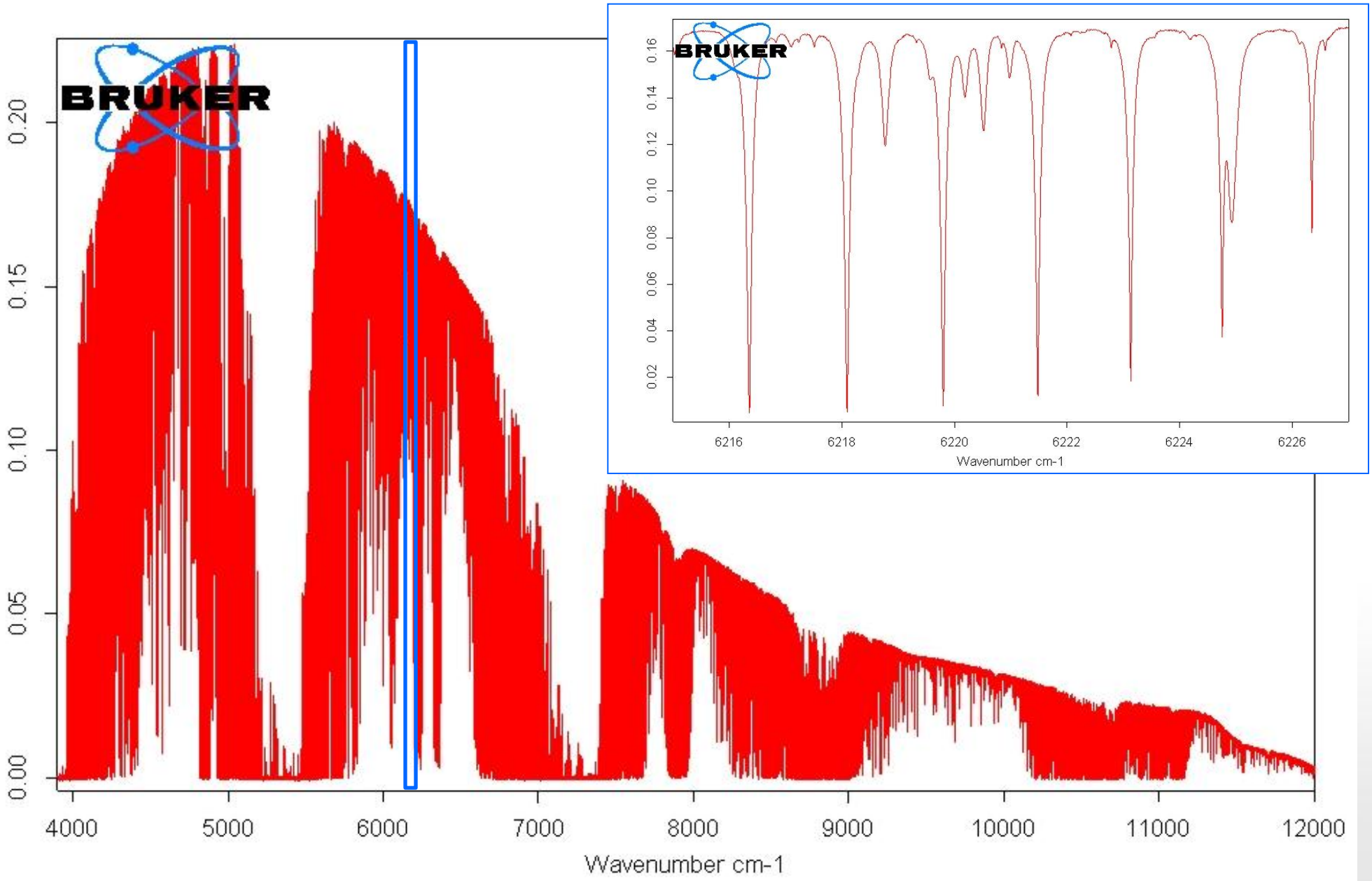
Interferometer and FFT





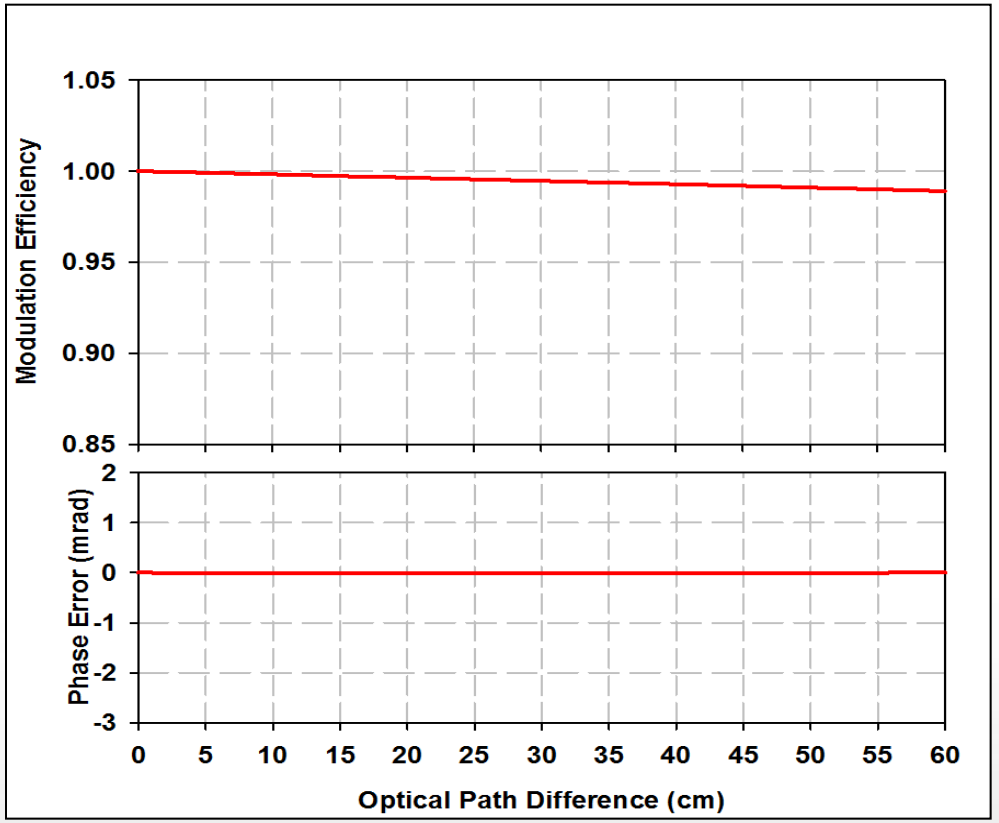


Measured spectra

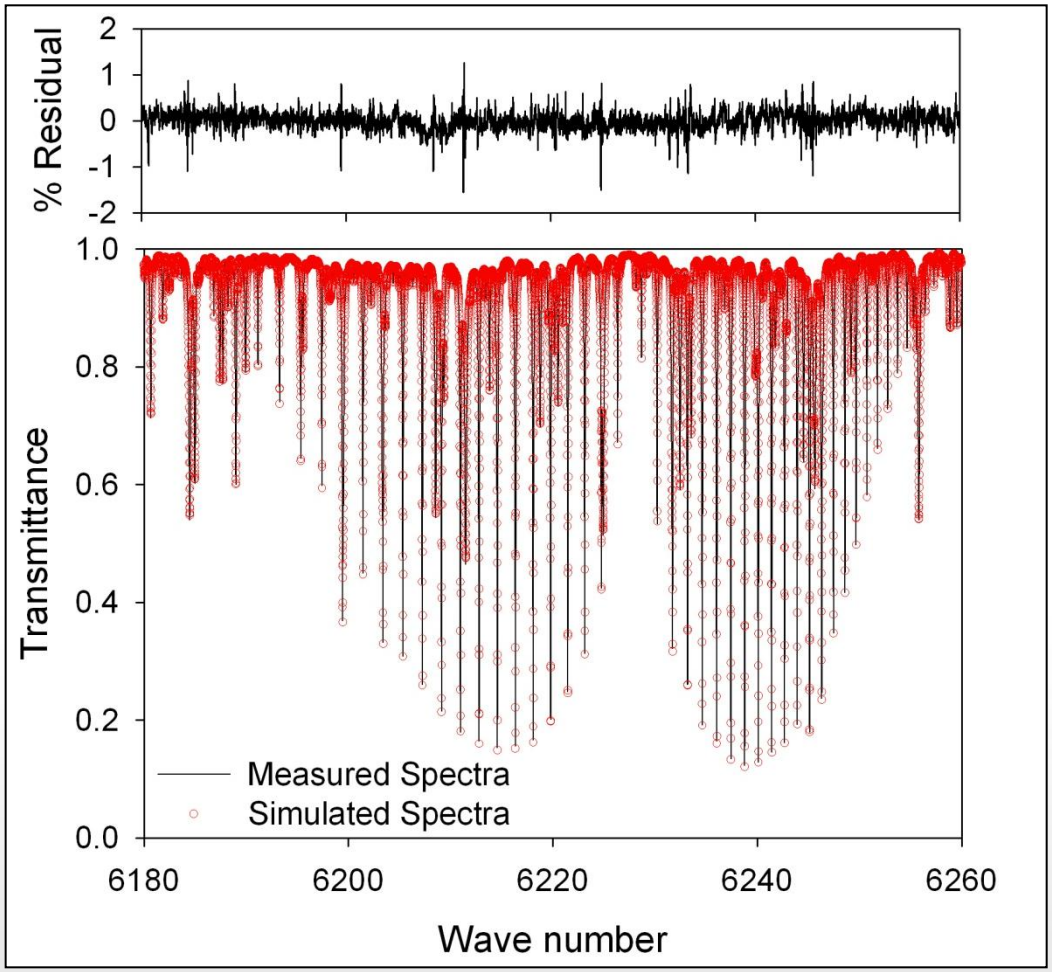


Measurement Accuracy

Modulation Efficiency



Spectra Comparison



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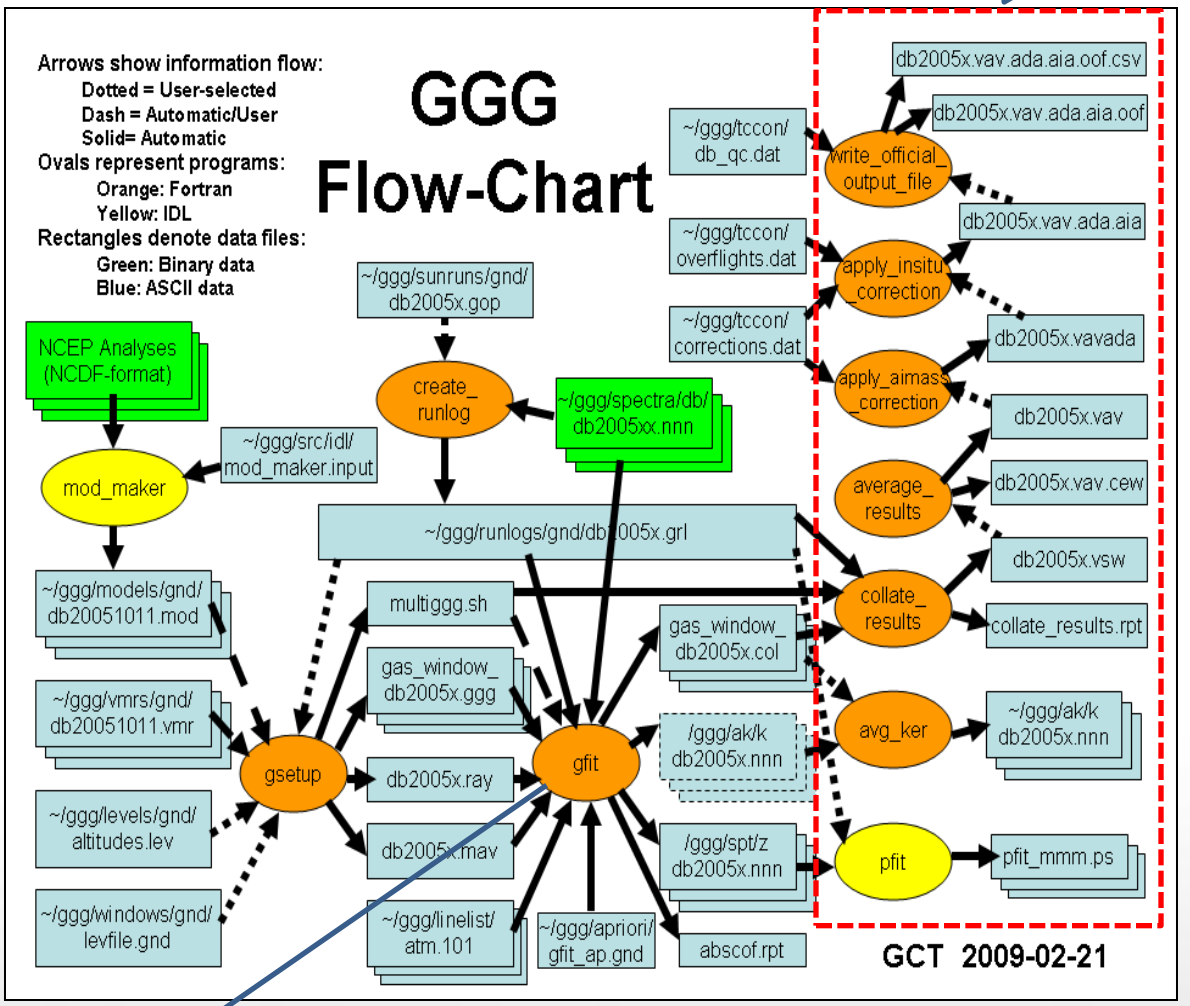
CO2 Retrieval Algorithm

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

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

Post process



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

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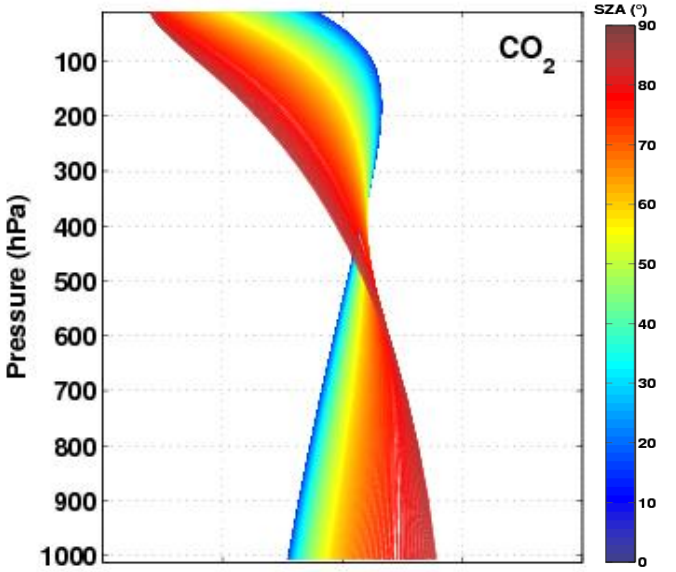
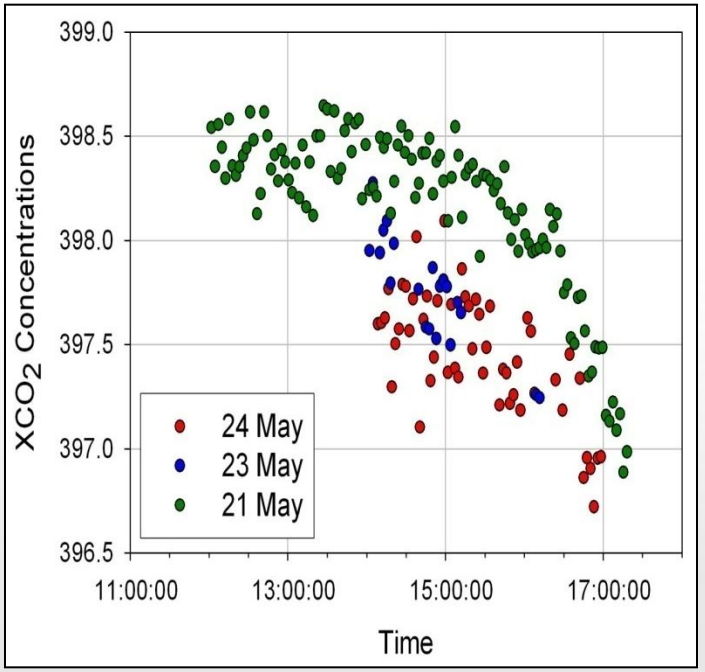
Data

- 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)





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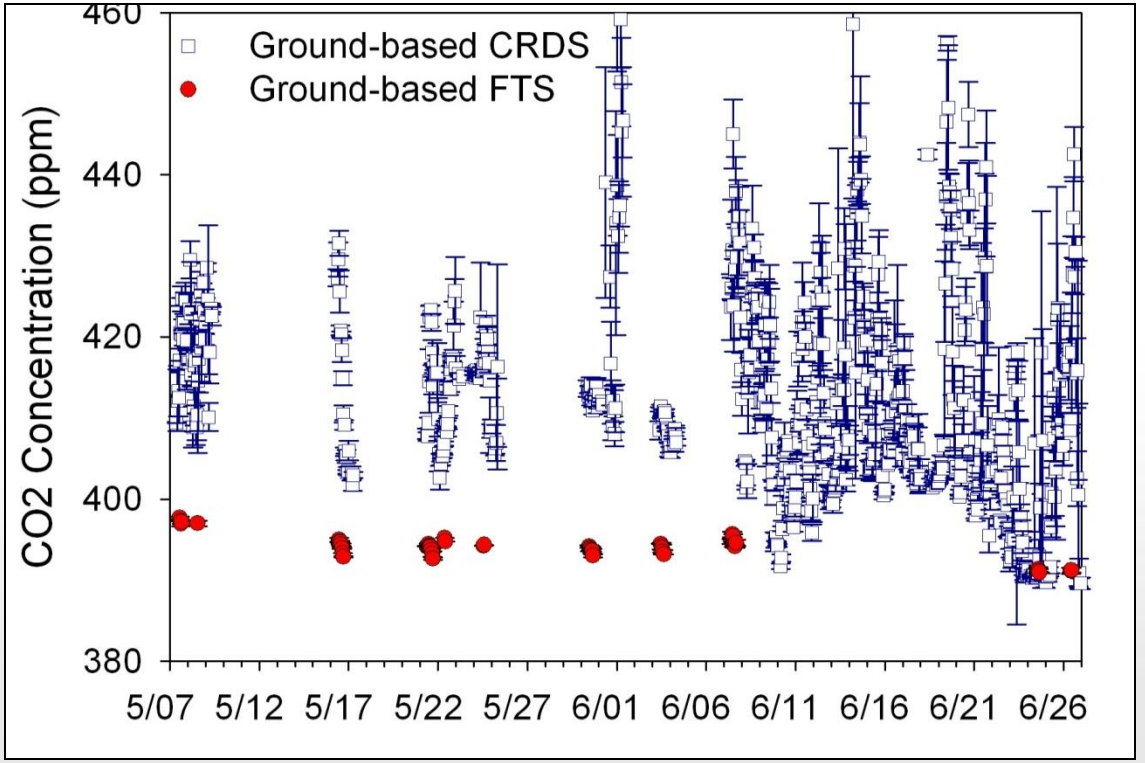
CO2 Comparison of FTS and CRDS

❖ Period: May to June 2013
❖ FTS CO2 is a retrieved estimation from the measured spectra.
  - Daily variation: Small / - Concentration: Low
❖ CRDS CO2 is a measured observation
  - Daily variation: Large / - Concentration: High
※ CRDS (Cavity Ring-Down Spectroscopy analyzer)



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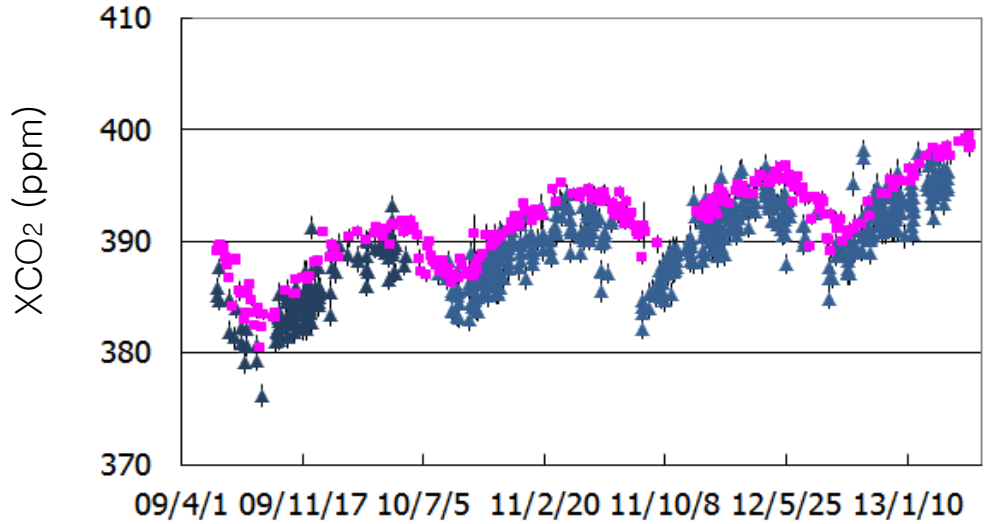
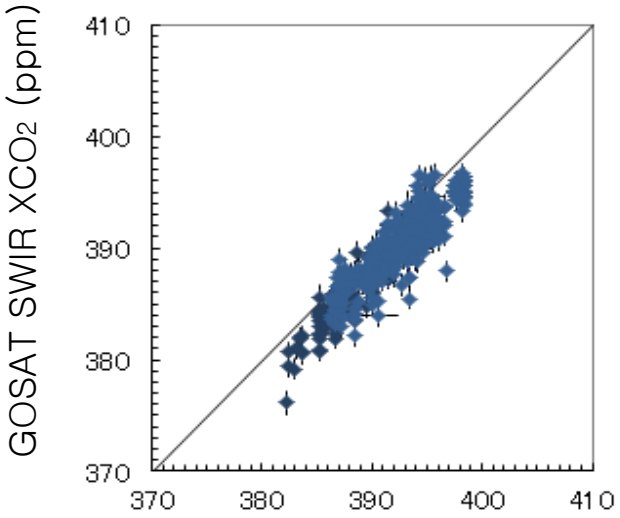
...me series of GOSAT SWIR and TCCON FTS XCO2 and XCH4 and their scatter diagrams for Lamont

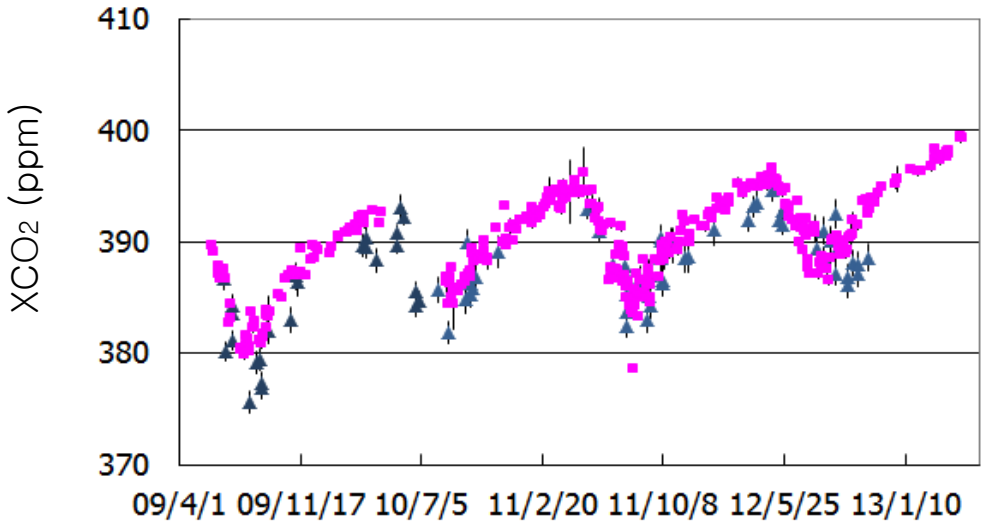
Lamont

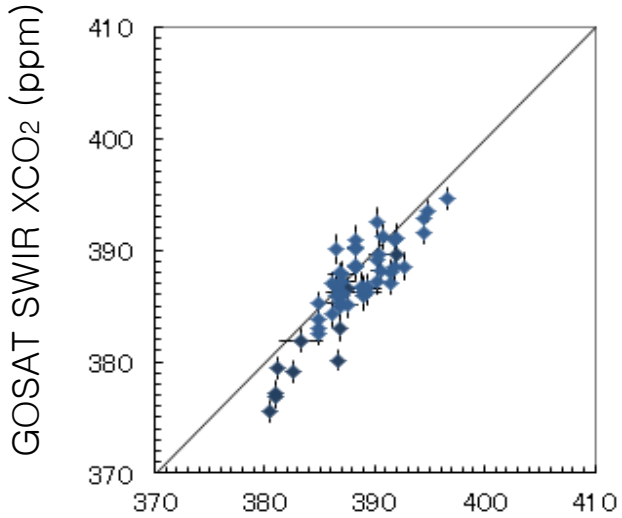




[Mean values within ±30 min. of GOSAT overpass]

Park Falls





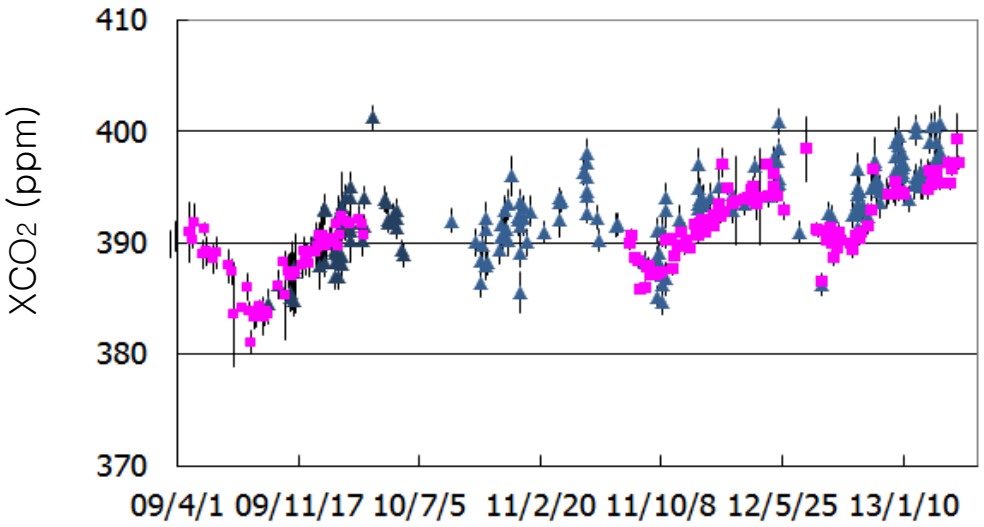
[Mean values within ±30 min. of GOSAT overpass]

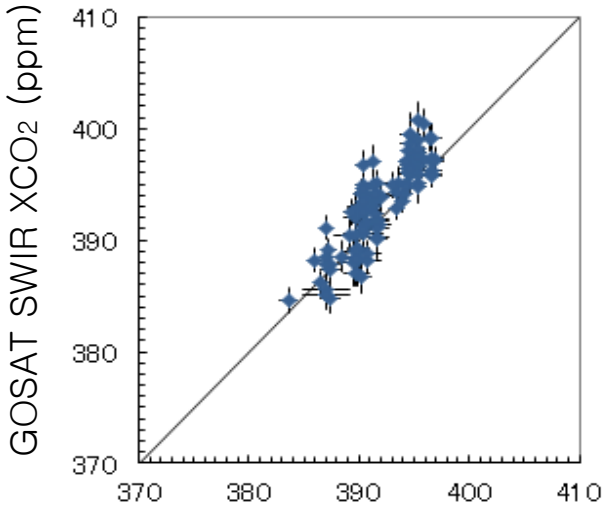
▲ GOSAT SWIR V02.xx with screening for GU

■ Mean values within ±30 min. of GOSAT overpass (GGG2012)

Time series of GOSAT SWIR and TCCON FTS XCO2 and XCH4 and their scatter diagrams

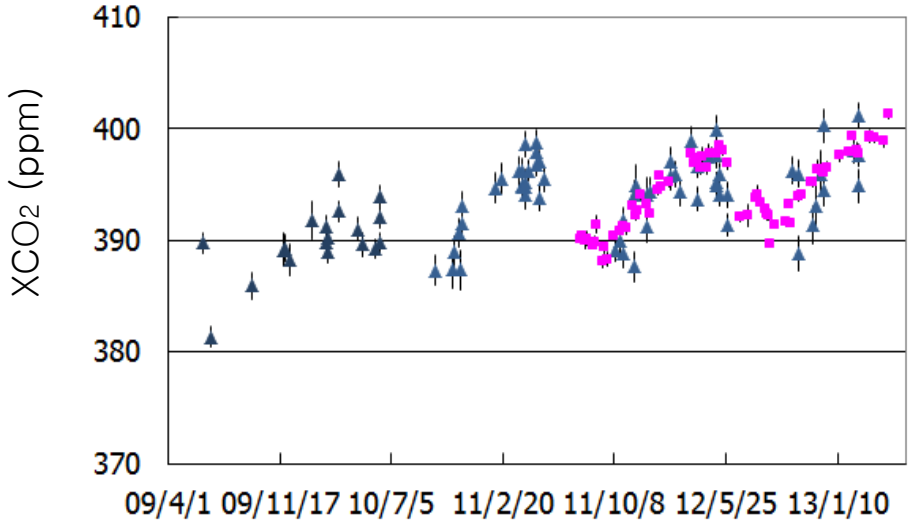
Tsukuba

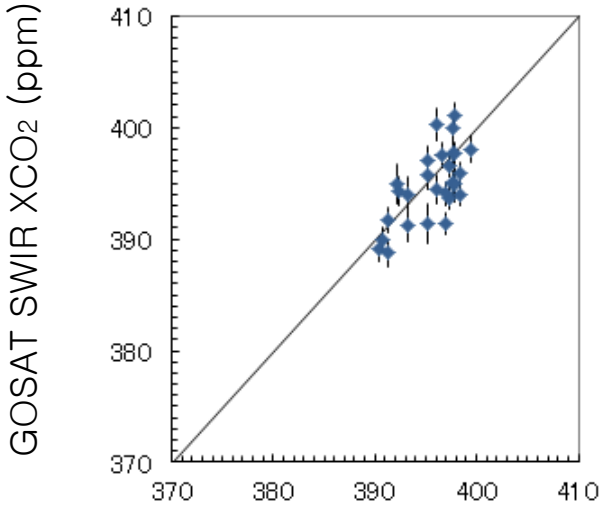




[Mean values within ±30 min. of GOSAT overpass]

Saga





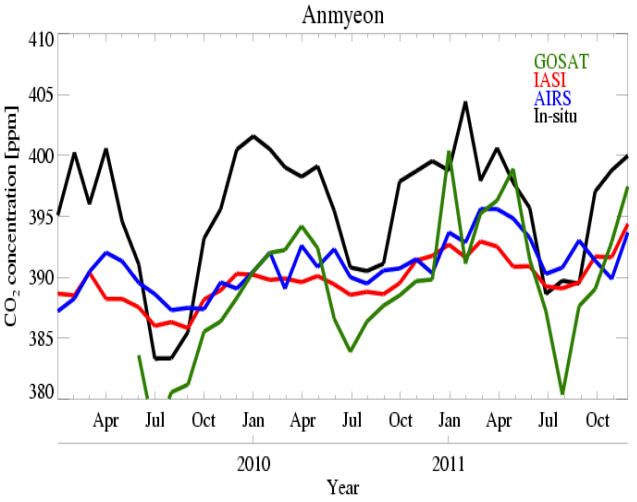
[Mean values within ±30 min. of GOSAT overpass]

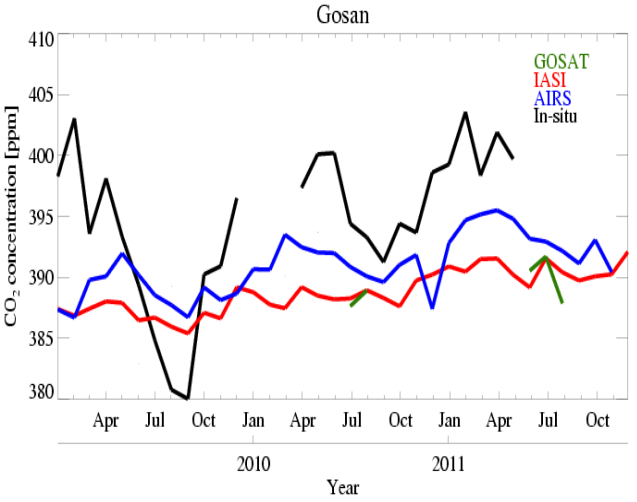
▲ GOSAT SWIR V02.xx with screening for GU

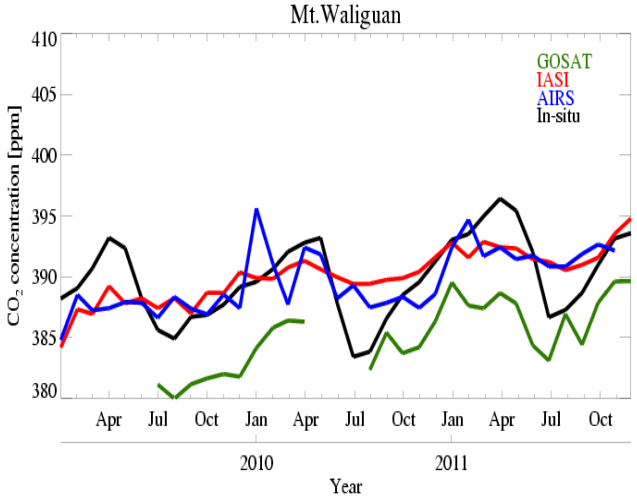
■ Mean values within ±30 min. of GOSAT overpass (GGG2012)

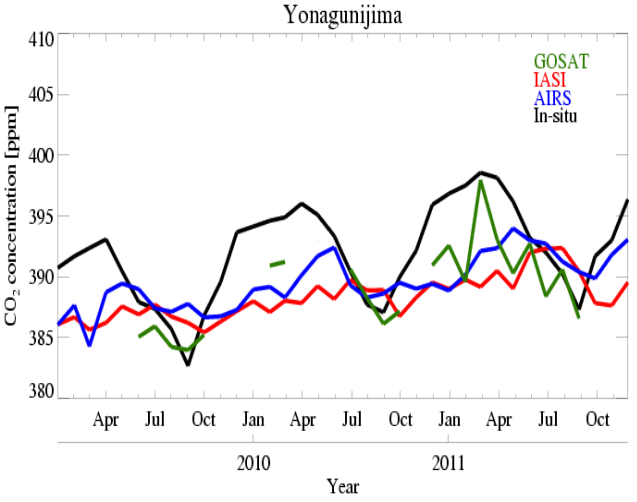
CO2 Comparisons of Sat. and In-situ Measurement

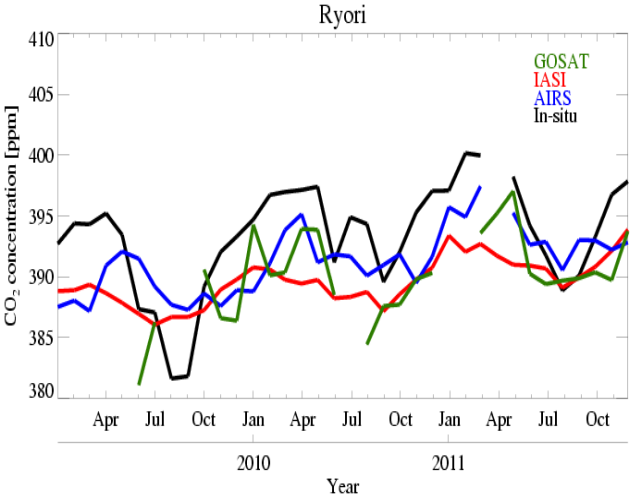
- **GOSAT (v.2xx)**
  (Greenhouse gas Observing SATellite)
- **MetOp/IASI**
  (Infrared Atmospheric Sounding Interferometer)
- **Aqua/AIRS**
  (Atmospheric Infrared Sounder)
- **In-situ data from WDCGG**
  (World Data Center of Greenhouse Gases)











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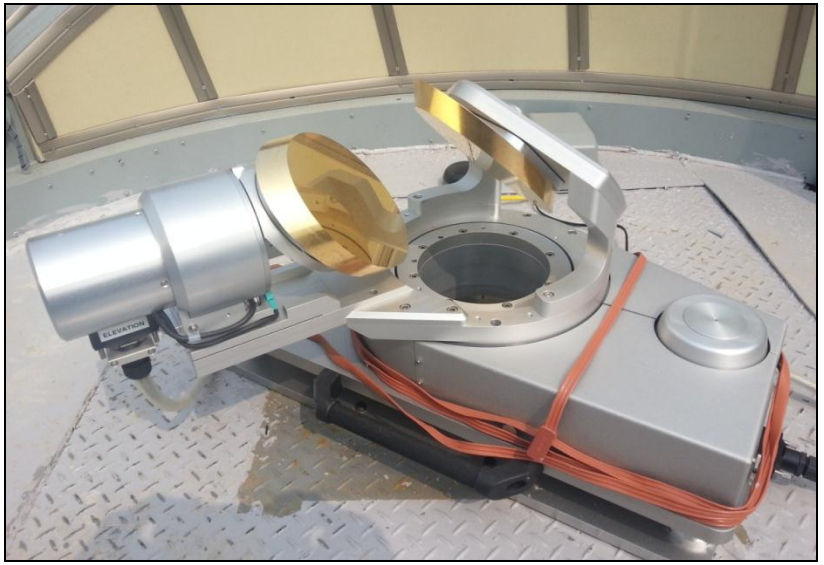
Summary

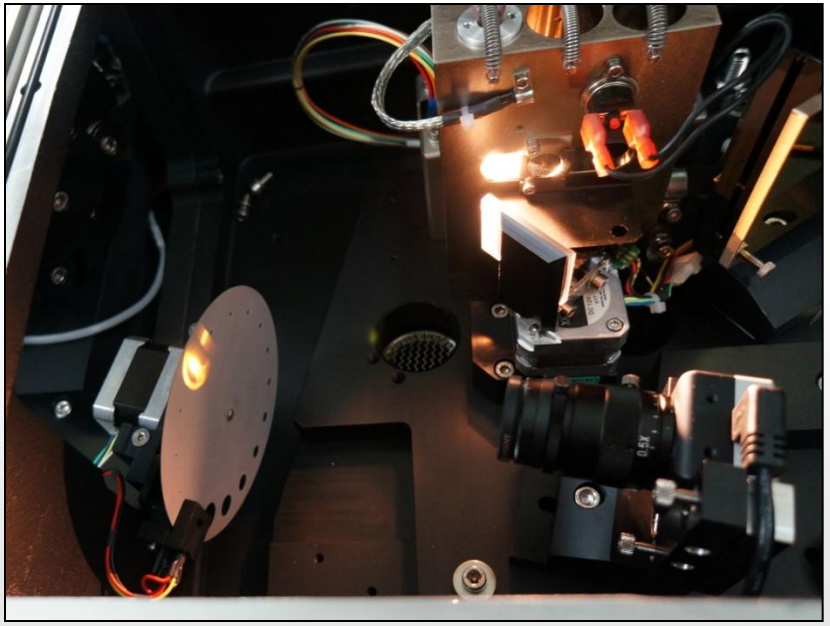
- IFS-125HR was installed at Anmyeondo on 12 December 2012.
- Operation has begun since 29 March 2013.
- NIMR FTS station is a new TCCON site
- ILS sensitivity and ghost measurements look fine though, regular test results are needed for longer period.
- Decreasing pattern of XCO2 and insitu CO2 look similar but large difference of XCO2 and insitu CO2 concentration was found.
- Recently FTS CH4 was retrieved and preliminary study was carried out.
- Aircraft measurements are necessarily needed to correct retrieval algorithm.
  - CO2 and CH4 vertical profiles have obtained by the NIMR aircraft observations since 2010.

- **Acknowledgements**

This study was supported by "Development and Application of Methodology for Climate Change Prediction (NIMR 2012-B-2)" at National Institute of Meteorological Research.

A547N solar tracker





- Azimuth: 0°~320°
- Elevation: -10°~85°
- Tracking accuracy: ± 2 min of arc
- Tracking speed: 1.5°/sec maximum
- Camtracker