Yonsei CArbon Retrieval Algorithm: Validation and its Application to OCO-2 satellite

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Introduction

GOSAT and OCO-2 have been providing hyperspectral measurements of reflected near-infrared sunlight. We developed the OE-based XCO2 retrieval algorithm using GOSAT spectra and validated with TCCON observations. We also developed retrieval algorithm using OCO-2 spectra, characterized by use of aerosol data from MODIS and CALIOP, and cloud screening by MODIS Cloud Mask product. The preliminary results are shown here.

GOSAT TANSO-FTS

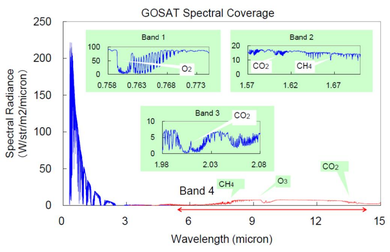

Figure 1. TANSO-FTS radiance spectra(NIES)

Scanning frequency	0.25, 0.5, or 1 interferogram/second			
	SWIR			TIR
Band	1	2	3	4
Polarization	applicable	applicable	applicable	N/A
Wavenumbers (cm^{-1})	12,900 -13,200	5,800 - 6,400	4,800 - 5,200	700 -1,800
Wavelength (μm)	0.75 - 0.78	1.56 -1.72	1.92 - 2.08	5.5 -14.3
Resolution (cm^{-1})	0.2 cm^{-1} (scan on both sides) (MOPD +/-2.5 cm)			

Table 1. TANSO-FTS Specifications(NIES)

CO_2 Retrieval Algorithm

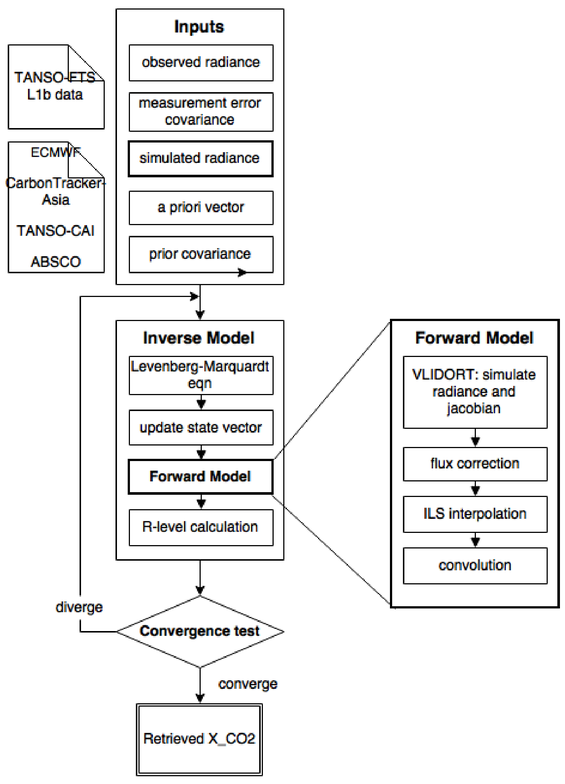

Figure 2. Flow chart of the YCAR algorithm

The Yonsei Carbon Retrieval algorithm, YCAR, is developed to retrieve column-averaged dry air mole fraction of atmospheric CO2 (XCO2) and based on the Optimal Estimation (OE) method.

State Vector	a priori	Parameters	No. of Elements
CO_2	CT-Asia	20 levels	20
Water Vapor Multiplier	1	multipied to H_2O profile	1
Aerosol Optical Depth	pre-defined	19 levels	19
Temperature Shift	0	added to temperature profile	1
Surface Pressure	ECMWF	scalar	1
Albedo	from Spectra	2 x 3 bands	6
Wavenumber Dispersion	0	2 x 3 bands	6
Zero Level Offset	0	scalar	1

Table 2. Elements of state vector of the YCAR algorithm

YCAR-A

Changes in the composition of aerosol-related variables

19 layes of AOD → Parameterization of AOD profile and oprical properties

YCAR-CAI

Use of near-real time AOD a priori value and cloud mask from GOSAT/TANSO-CAI data to minimize the uncertainty of cloud and aerosol information

Validation with TCCON

2011~2012, Tsukuba, Japan

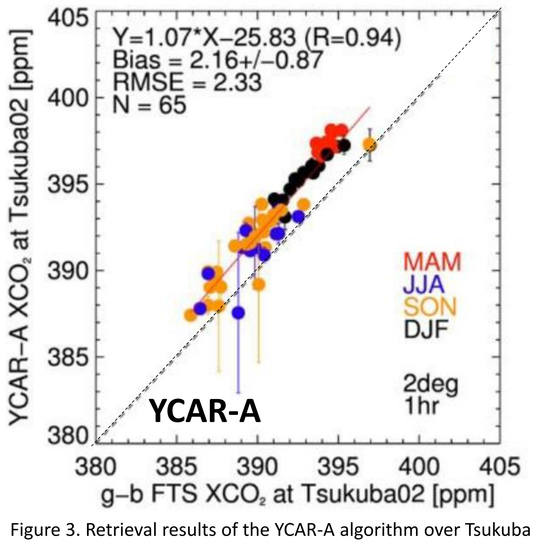

Figure 3. Retrieval results of the YCAR-A algorithm over Tsukuba

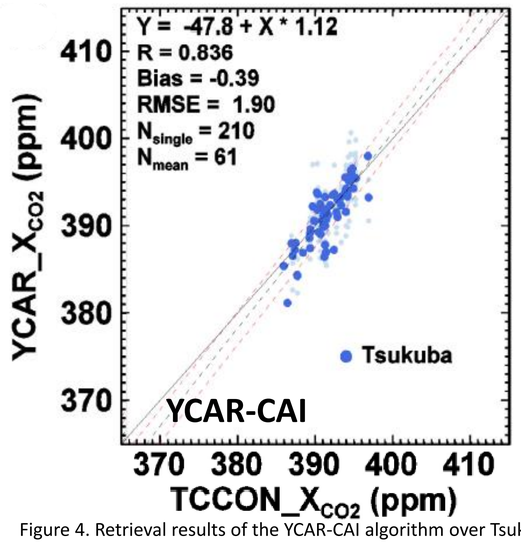

Figure 4. Retrieval results of the YCAR-CAI algorithm over Tsukuba

Application to OCO-2

State Vector	a priori	Parameters	No. of Elements
CO_2	CT-NA	20 levels	20
Water Vapor Multiplier	1	multipied to H_2O profile	1
Aerosol Loading Parameters	MODIS CALIOP	Total AOD Peak Height FWHM	3
Temperature Shift	0	added to temperature profile	1
Surface Pressure	ECMWF	scalar	1
Albedo	from Spectra	2 x 3 bands	6
Wavenumber Dispersion	0	2 x 3 bands	6
Solar Induced Fluorescence	0	Fluorescence at 755nm and its spectral slope	2

Table 4. Elements of state vector of the YCAR-OCO algorithm

- As the OCO-2 satellite belongs to the A-train, we used near-real time data from MODIS/Aqua and CALIOP/CALIPSO. YCAR-OCO algorithm is based on YCAR-A, and utilizes MODIS and CALIOP data, which enables to consider real atmospheric information.
- Utilization of IQU polarization is added in the algorithm
- O2 A-band Solar Induced Fluorescence (SIF) and its spectral slope are included in state vector

MODIS/Aqua Cloud Mask L2	Near-real time cloud mask
MODIS /Aqua Aerosol Daily L3	a priori value of total AOD
CALIOP Lidar L2 5km Cloud and Aerosol Product	Near-real time a priori value of peak height and FWHM of aerosol profile

- We categorized 4 aerosol types by data of ~100 AERONET sites in 2014, East Asia, by the method suggested by Lee et al.(2010)
- We calculate the cost function assuming each 4 aerosol types, and a priori values of aerosol optical properties(refractive index, size distribution, etc.) are determined by the aerosol type generating the lowest cost function.

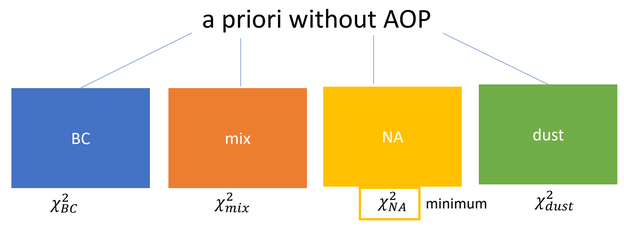

Figure 5. An illustration of the scheme determining aerosol type

Preliminary Results of YCAR-OCO

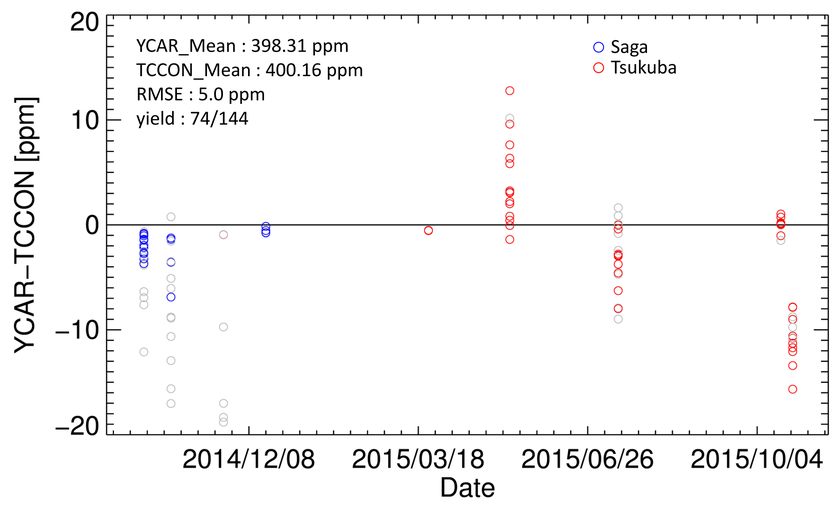

Figure 6. Comparison of early results of YCAR-OCO algorithm with TCCON measurements

- The results shows overall under-estimation of XCO2, except one scene.
- Biases and variations are highly dependent on scenes.
- Low initial values of albedo are suspected to be a cause of error, yet we need to investigate other ones.

Further Study

- Include aerosol optical properties in state vector and retrieve simultaneously, instead of using fixed aerosol types
- PCA-based RT calculation speed-up
- global retrievals to characterize error of the algorithm
- Bias correction, quality control

Reference & Acknowledgement

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This work was supported by the National Institute of Meteorological Research [Meteorological work support technology development research] "Climate change prediction support and application research(KMA2018-00321)"