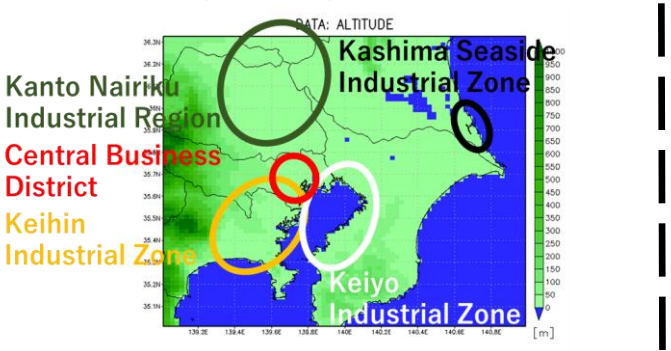
Estimation of anthropogenic CO2 emission from Kanto region, include Tokyo

Y. Arai(1), R. Imasu(1), Q. Wang(1), H. Kondo(2)

1:Atmosphere and Ocean Research Institute (AORI), The University of Tokyo, 2:National Institute of Advanced Industrial Science and Technology (AIST)

About CO_2 emission sources and sinks in Kanto region



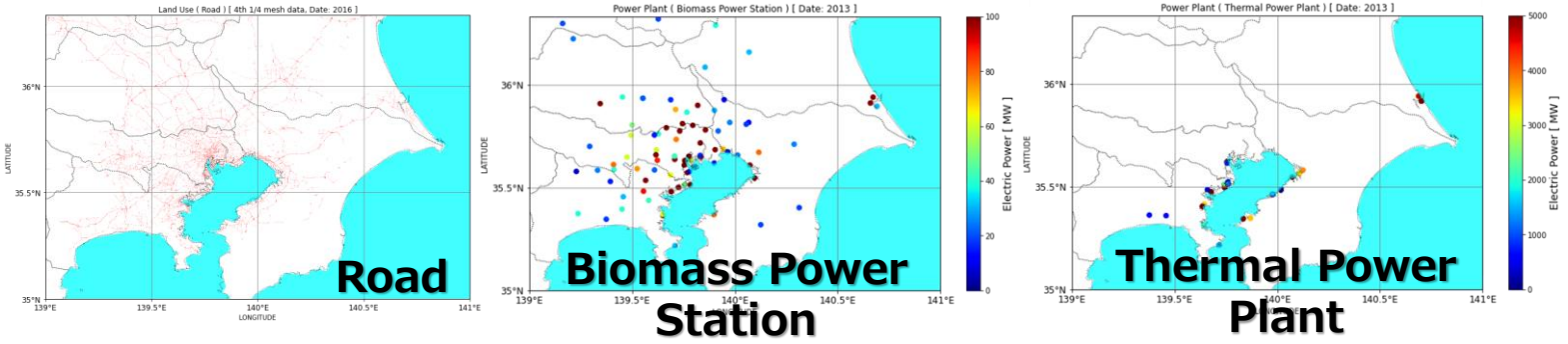


Fig.1: Main anthropogenic CO_2 emission sources

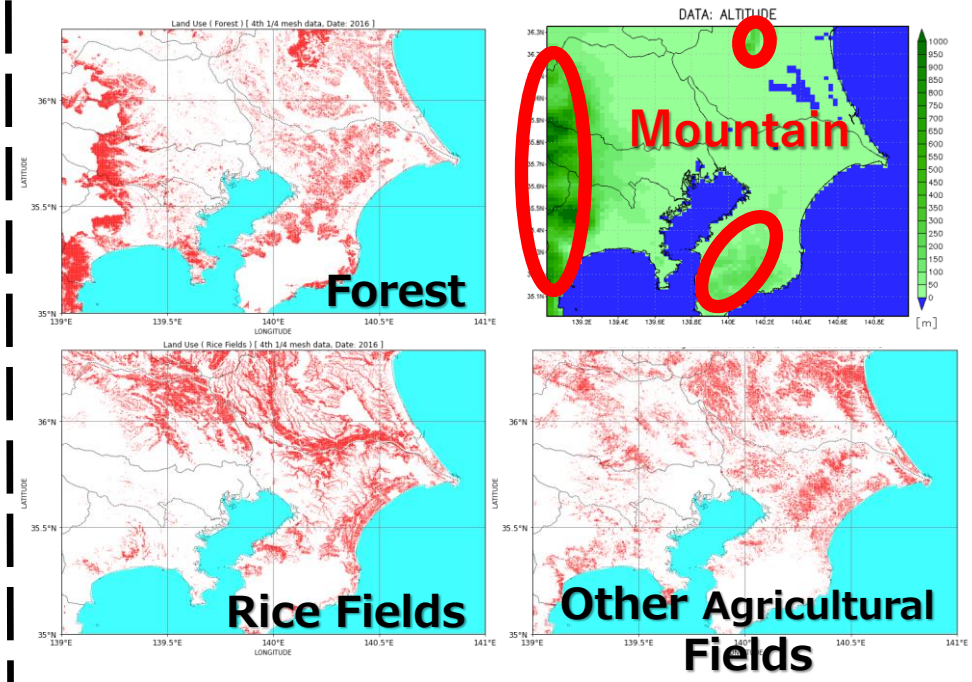


Fig.2: Main CO_2 emission sources and sinks from plant activities

- In Kanto region, CO_2 emissions from anthropogenic and plant activities are complicated (Fig.1, Fig.2).
- It has been reported that there are problems with CO_2 emission sources and sinks for many models.
- Attempts have already been made to improve the emission sources and sinks of CO_2 from plant activity (Wang et al., 2021).
- This study focuses on improving anthropogenic CO_2 emissions.

Created by processing 「National Land Information（Urban area land use subdivision mesh data, Power generation facility data）」（Ministry of Land, Infrastructure, Transport and Tourism of Japan）
（https://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-L03-b-u.html, https://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-P03.html）

About anthropogenic CO_2 emissions

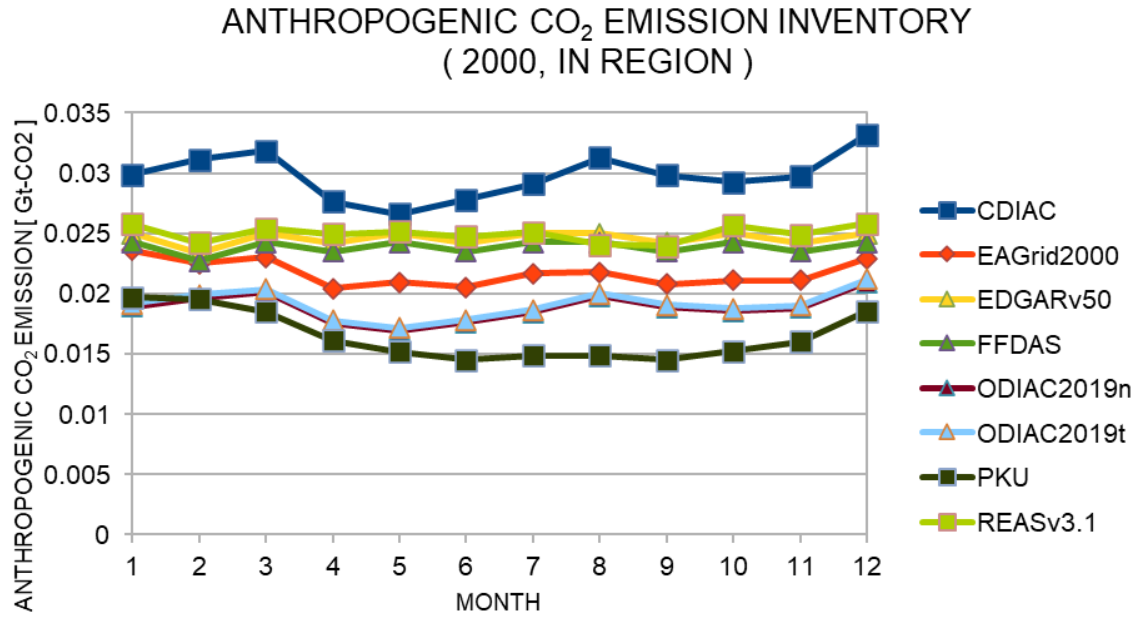


Fig.3: Monthly anthropogenic CO_2 emissions within the model area

- The time scale of emissions differs depending on the each inventory (such as monthly average emissions, annual average emissions) (Fig.3).
- Grid size depends on each inventory (Fig.4).

↓

- ODIAC (v2019, TIFF) has the most detailed grid size. However, since ODIAC is monthly average data, EAGrid 2000 JAPAN, which is the amount of emissions for each month and each time, had been used in this study.

EAGrid: The East Asian Air Pollutant Emissions Grid Database (Kannari et al.,2007)

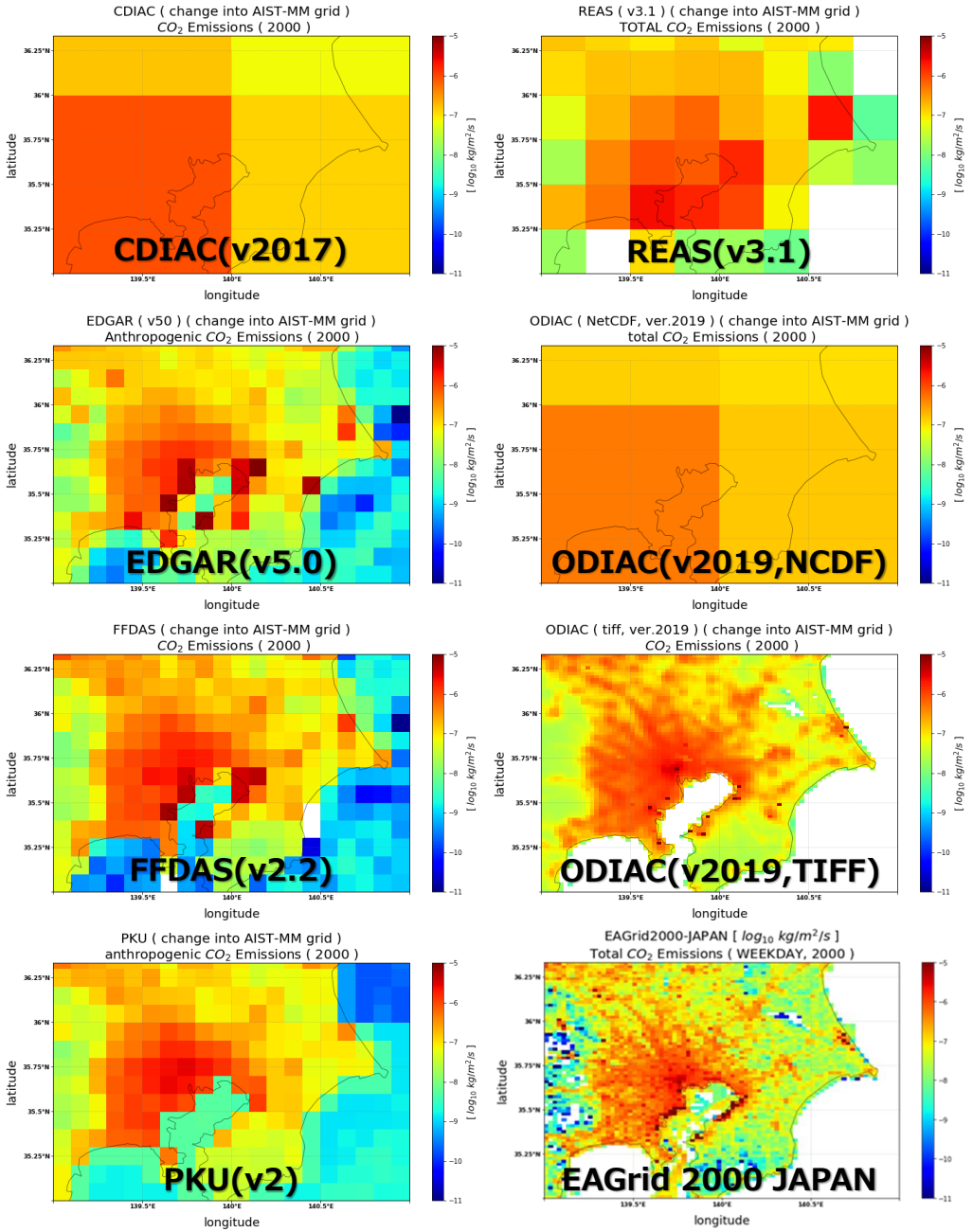


Fig.4: The currently available CO_2 emission inventories in 2000 for model calculation

About AIST-MM model and the method to estimate CO_2 emission

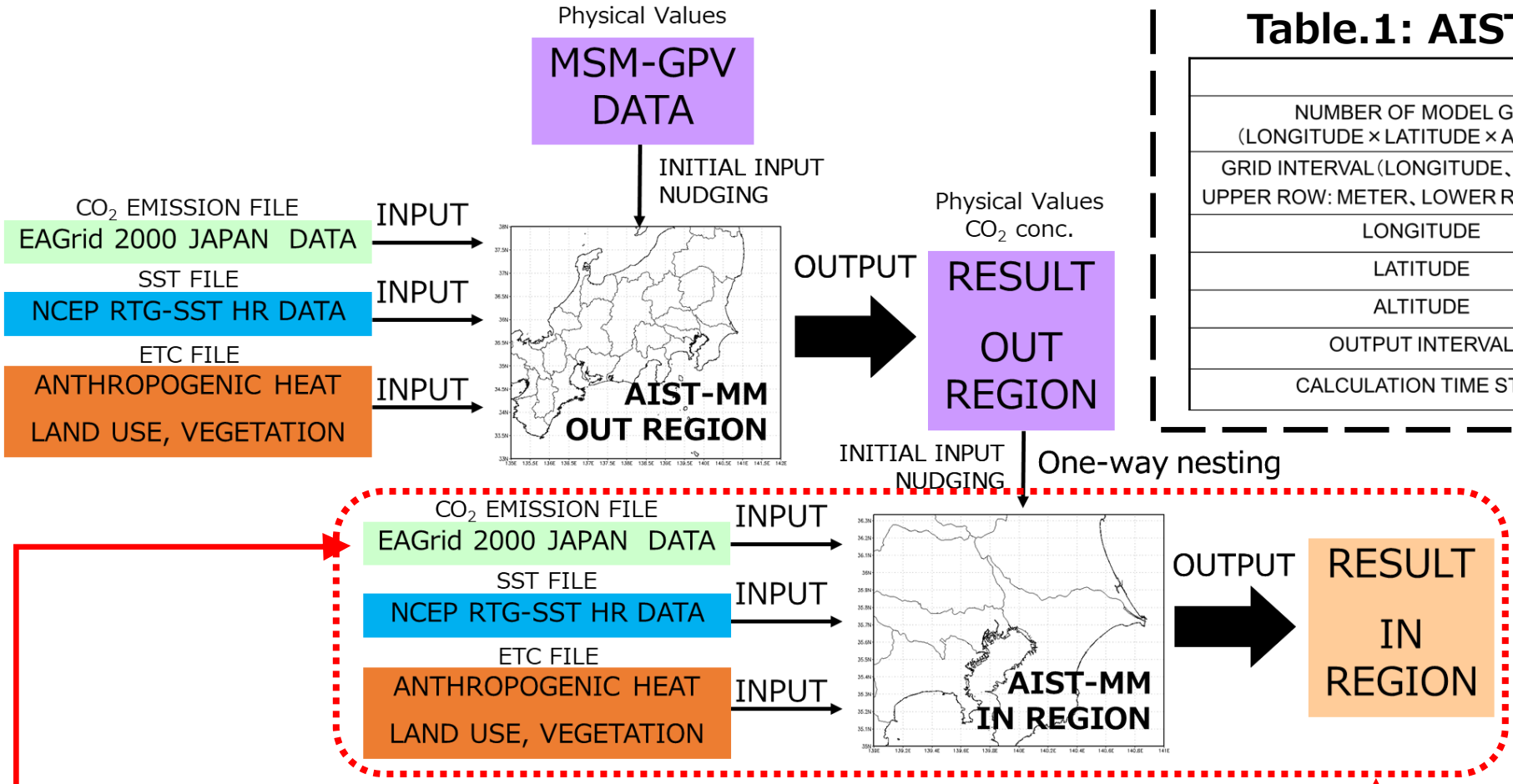


Fig.5: AIST-MM calculation flow

Table.1: AIST-MM setting information

	OUT REGION	IN REGION
NUMBER OF MODEL GRID (LONGITUDE × LATITUDE × ALTITUDE)	56 × 60 × 35	80 × 80 × 35
GRID INTERVAL (LONGITUDE、LATITUDE)	11310 [m]、9260 [m]	2775 [m]、2608 [m]
UPPER ROW: METER、LOWER ROW:DEGREE	0.125° 、0.08333°	0.025° 、0.01666°
LONGITUDE	135.0 E～142.0 E	139.0 E～141.0 E
LATITUDE	33.0 N～38.0 N	35.0 N～36.333 N
ALTITUDE	0～5400 [m]	0～5400 [m]
OUTPUT INTERVAL	1 [hour]	30 [minute]
CALCULATION TIME STEP	30 [second]	10 [second]

Table.2: LETKF setting

ENSEMBLE MEMBERS	20	
LOCALIZATION SIZE	20 km	
OBSERVATION ERROR	IN-SITU WDCGG	1 ppm
	CONTRAIL	1 ppm
	SATELLITE	1.5 ppm
COVARIANCE INFLATION	2 %	

The error model for each member was created by anthropogenic CO_2 emission which was given about ± 10% error.

LETKF method was adapted in this calculation part.

AIST-MM: National Institute of Advanced Industrial Science and Technology - Mesoscale Model (Kondo et al., 2001),
MSM-GPV: MesoScale Model-Grid Point Value, ANTHROPOGENIC HEAT (Kayaba et al.,2010; Hokari et al., 2015),
NCEP: National Centers for Environmental Prediction, RTG SST HR: Real-Time Global Sea Surface Temperature High Resolution (Gemmill et al., 2007),
LETKF: Local Ensemble Transform Kalman Filter (Miyoshi et al., 2007), WDCGG: The World Data Centre for Greenhouse Gases
CONTRAIL: Comprehensive Observation Network for TRace gases by AIrLiner (Machida et al., 2008)

Assimilation using GOSAT observation, DATE: 2018/03/25 13:00 (JST)

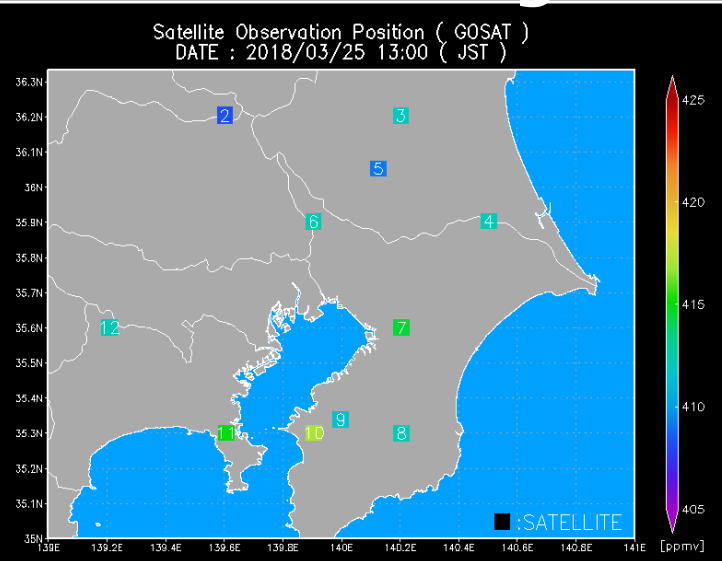


Fig.6: GOSAT Observation

Assimilation

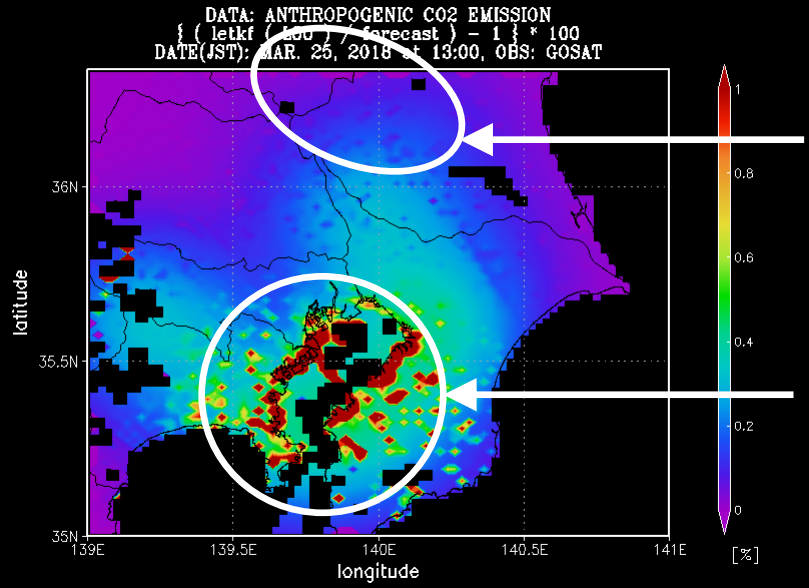


Fig.9: CO_2 emission correction rate

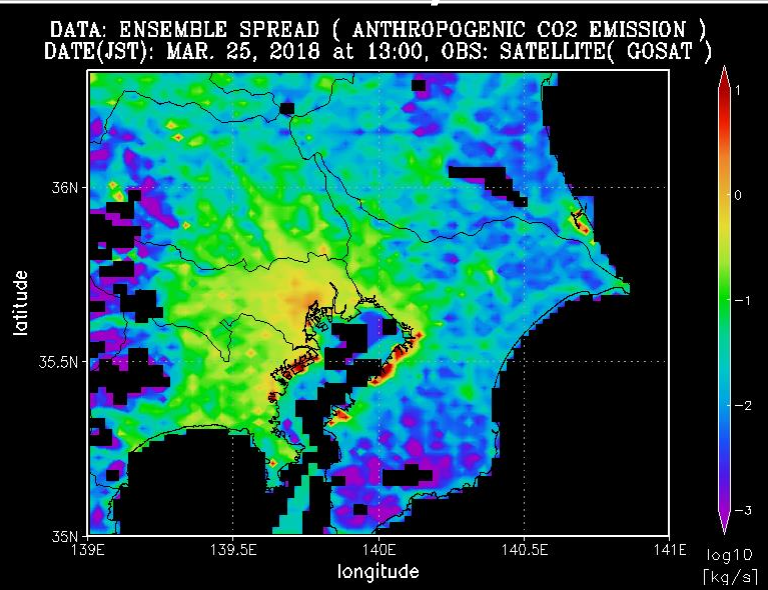


Fig.7: Eesemble spread
(anthropogenic CO_2 emission)

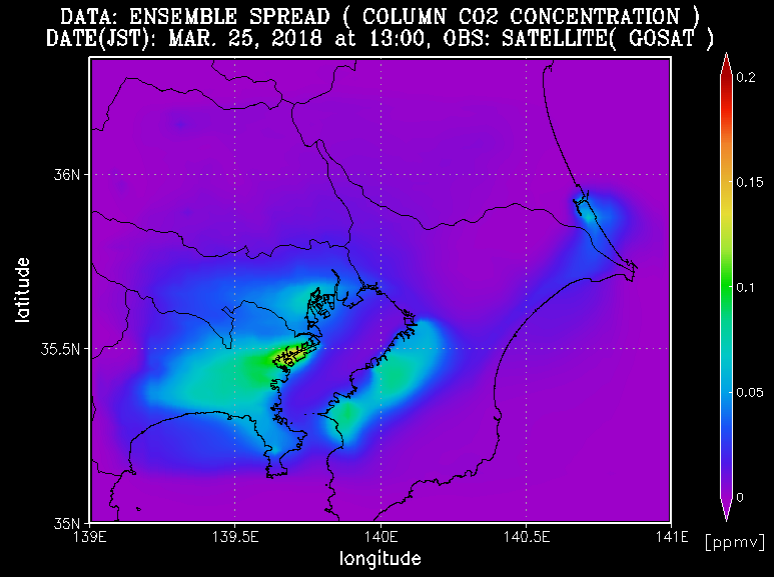


Fig.8: Eesemble spread
(CO_2 column mass)

GOSAT observations exist in the northern part of the region (Fig.6), but anthropogenic CO_2 emissions were hardly improved due to the small spread of CO_2 column mass concentration errors (Fig.8).

Anthropogenic CO_2 emission correction rate around Tokyo Bay has been larger than other area due to the relationship among observation position (Fig.6) and the spread of anthropogenic CO_2 emission errors (Fig.7) and the spread of CO_2 column mass concentrations errors (Fig.8).

Assimilation using OCO-2 observation, DATE: 2018/03/14 13:00 (JST)

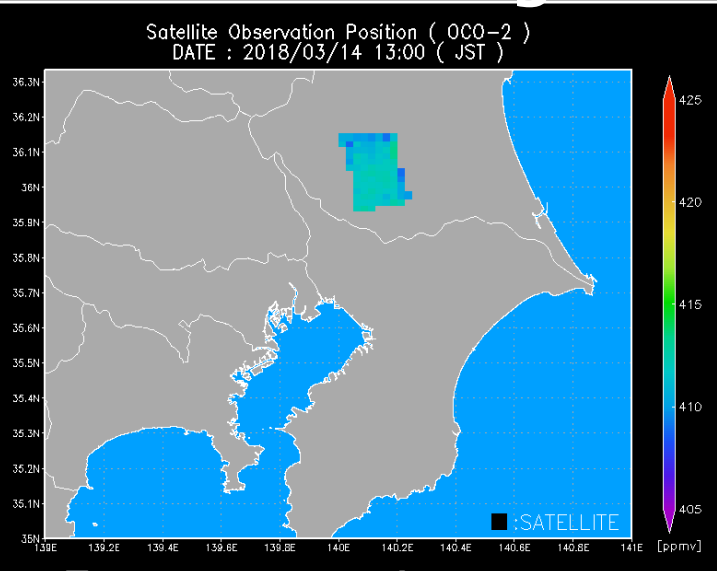


Fig.10: OCO-2 Observation

Assimilation

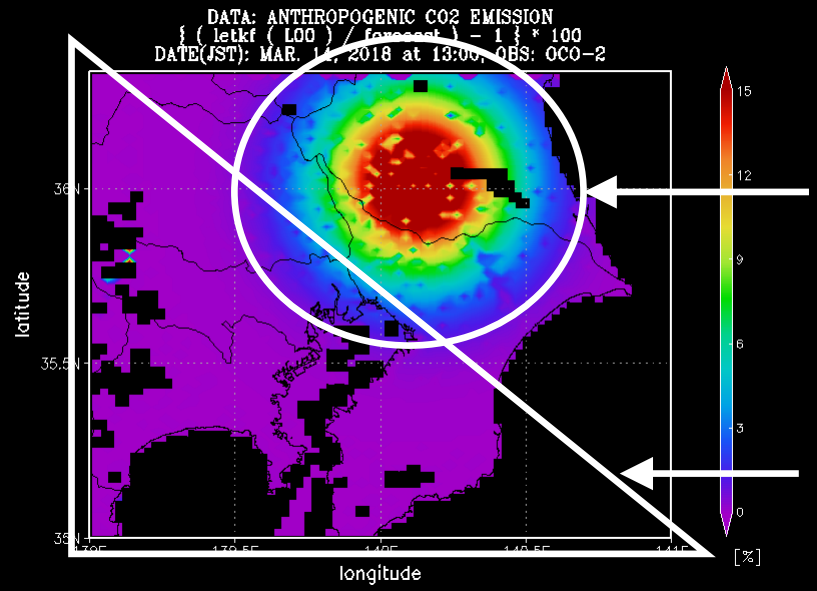


Fig.13: CO_2 emission correction rate

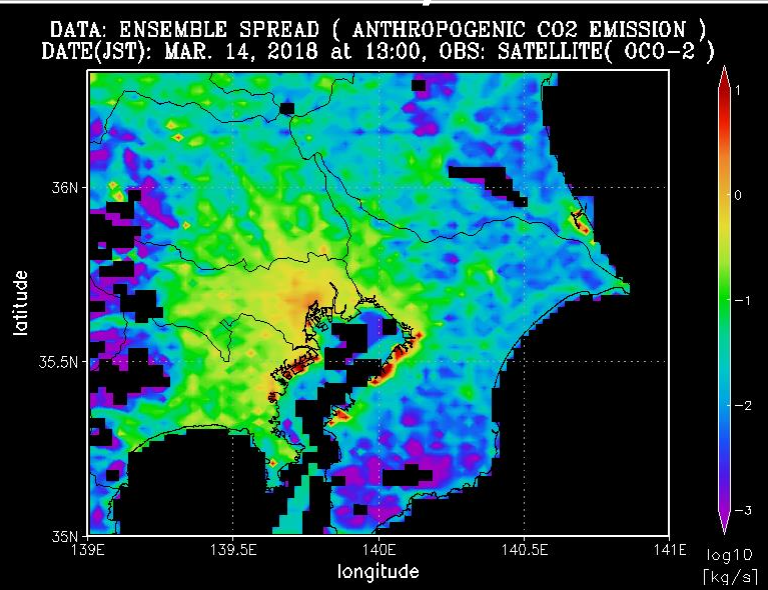


Fig.11: Eesemble spread
(anthropogenic CO_2 emission)

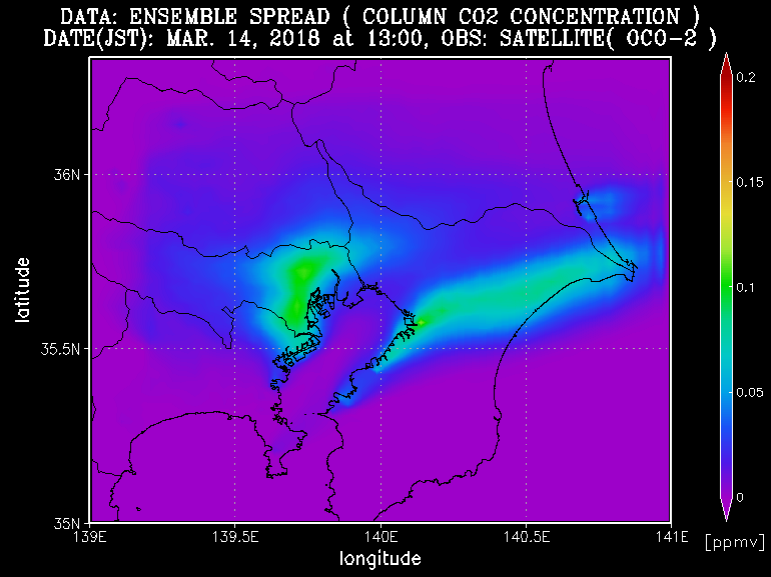


Fig.12: Eesemble spread
(CO_2 column mass)

Anthropogenic CO_2 emissions were improved due to the relationship among observation position (Fig.10) and the spread of anthropogenic CO_2 emission errors (Fig.11) and the spread of CO_2 column mass concentrations errors (Fig.12). Espeially, as there were many OCO-2 observation numbers, anthropogenic CO_2 emissions were improved strongly.

As OCO-2 observations didn't exist in the western and southern part of the region (Fig.10), anthropogenic CO_2 emissions in the area weren't improved.

Assimilation using CONTRAIL observation or in-situ observation, DATE: 2018/03/04 11:00 (JST)

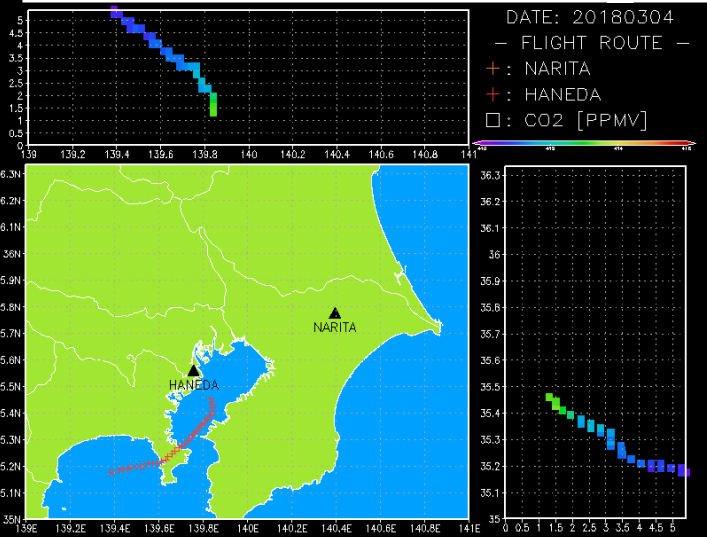


Fig.14: CONTRAIL Observation (Flight route and altitude)

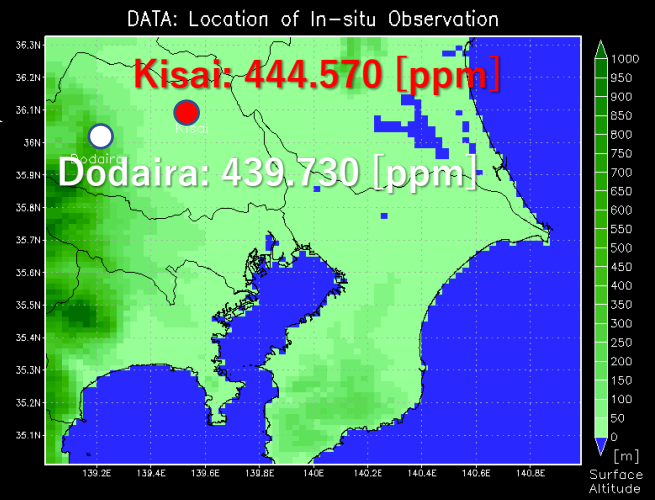


Fig.16: In-situ observation (WDCGG: Kisai, Dodaira)

Assimilation

Assimilation

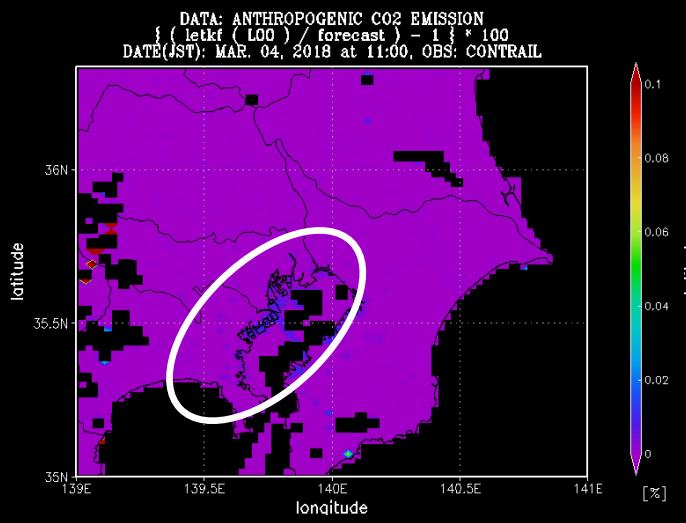


Fig.15: anthropogenic CO_2 emission correction rate

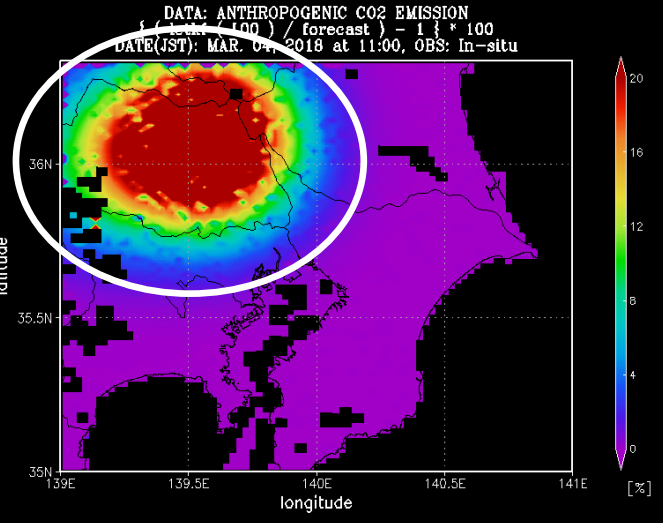


Fig.17: anthropogenic CO_2 emission correction rate

Anthropogenic CO_2 emissions were improved very weakly in case to use CONTRAIL observations (fig.14, fig.15).
Anthropogenic CO_2 emissions were improved very strongly in case to use in-situ observations (fig.16, fig.17).

It was because that anthropogenic CO_2 emissions, which were given errors, existed almost near ground surface. So the higher observation altitude was, the smaller the spread of the CO_2 concentration error was.

- It has become possible to estimate anthropogenic CO_2 emissions by assimilation calculation using various observations.
- The parameters used in the assimilation calculation must be adjusted.
- The AIST-MM model itself needs further improvement.