CarbonTracker Asia 2016 : an Estimation of CO_2 Fluxes Centering on Asia

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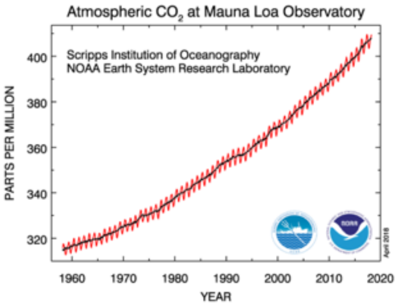
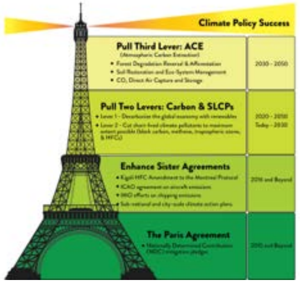
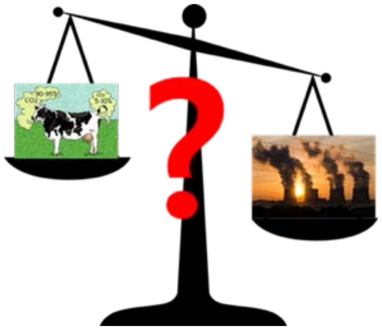
ESRL/GMD Annual Conference 2018, 22 May 2018







https://www.ersl.noaa.gov/gmd/ccgg/trends/

CO_2 in atmosphere keeps increasing

↓

We need a tool quantitatively estimating CO_2 flux

↓

But, the dynamics are not well known !

↓

TM5 met EnSRF then, they turned into the CarbonTracker (by NOAA ESRL)!

↓

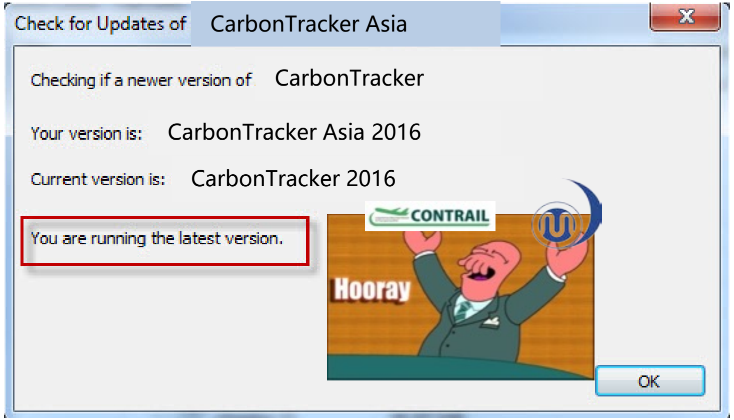
An Asian variation : CT Asia

Lord Kelvin

I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind.

AZ QUOTES

Today I will show you ..



- The latest update of the CT-Asia
- The impact of observation data (JMA & CONTRAIL which are only assimilated in the CTA)
- Demonstration of the CTA2016
- What to do next in order to visit here again
- The vision of NIMS in the CTA Development

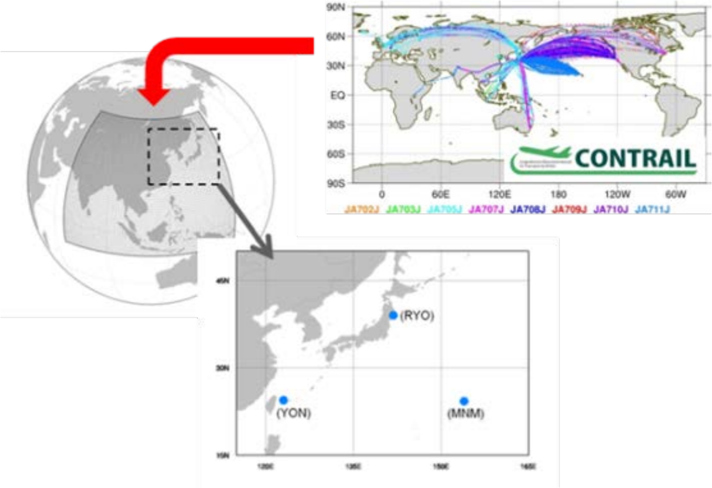
Inverse modeling for CO_2 flux estimation

observation

$$x^a = x^p + \left(HP^bH^T + R\right)^{-1} P^bH^T\left(y - Hx^p\right)$$

TM5 presents

$$F = \lambda_r\left(F_{bio} + F_{ocn}\right) + F_{ff} + F_{fire}$$

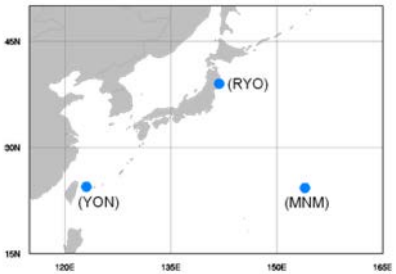


The CarbonTracker Asia 2016

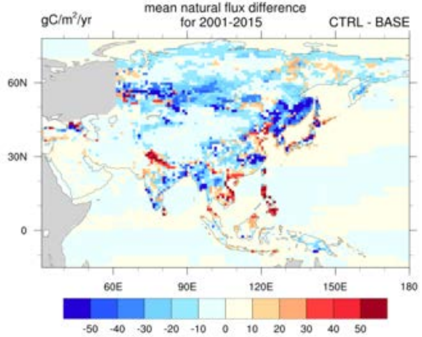
- Transport model : **TM5**
- Model-data mismatch Covariance(R) is known
- Background error covariance (P^b) is calculated by TM5
- Adopting nested grid(1°×1°) in Asia[1)]
- JMA continuous observation and CONTRAIL data were assimilated

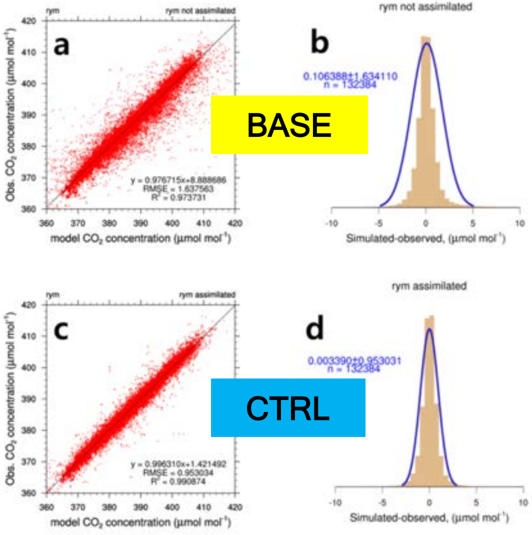
1) Kim, Jinwoong, Hyun Mee Kim, and Chun-Ho Cho. "The effect of optimization and the nesting domain on carbon flux analyses in Asia using a carbon tracking system based on the ensemble Kalman filter." Asia-Pacific Journal of a mospheric Sciences 50.3 (2014): 327-344.

The impact of JMA observation



Exp. name	Obs.	period	Grid
BASE	Same as CT-NOAA (adoptive mdm)	1.Jan.2000~ 27.Nov.2015	Global 3°×2° Asia 1°×1°
CRTL	ryo, yon, mnm **continuous** data (with fixed mdm 3) added		

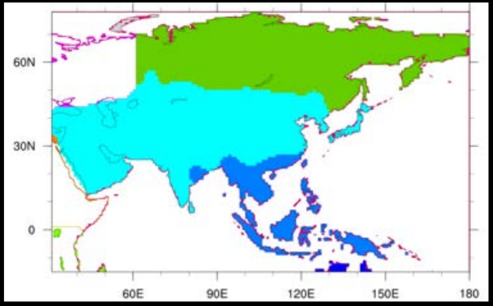




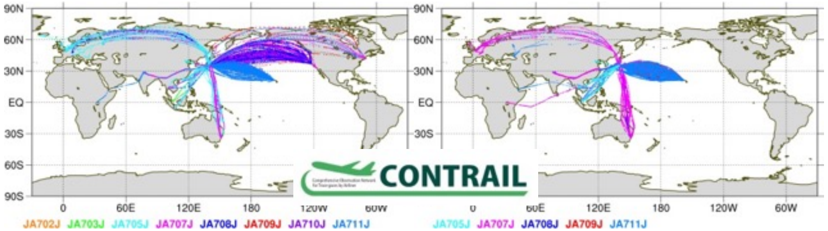
NO RYM ASSI	Bias	RMSE	R^2
RYO	0.85	4.08	0.87
YON	-0.18	1.76	0.97
MNM	0.05	0.79	0.99

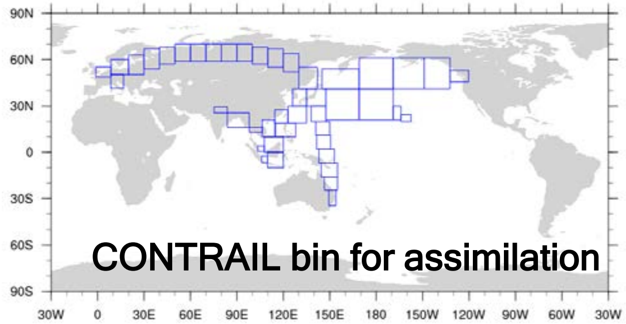
RYM ASSI	Bias	RMSE	R^2
RYO	0.03	1.88	0.97
YON	-0.17	1.42	0.98
MNM	0.01	0.69	1.00

- MDM values of them are set to **3.0** (for a continuous site)
- Hourly averaged data were assimilated
- There is an prominent flux difference **before** and **after** assimilation
- Bias, RMSE, and R^2 at Ryori are highly improved
- Fluxes around Japan seem to be estimated better !



The impact of CONTRAIL observation





CONTRAIL bin for assimilation

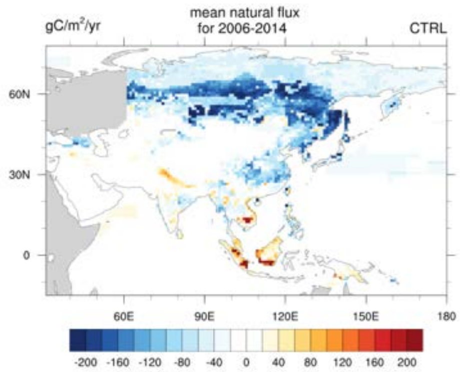
Exp. Name	Observation	MDM	Assimilation period
CRTL	Surface only (RYM added)	CT-NOAA : adoptively ryo, mnm, yon : 3 ppm	2005.11.05~ 2014.12.31
CONT	Surface (RYM added) + CONTRAIL	same as CTRL for surface 2 ppm for CONTRAIL	

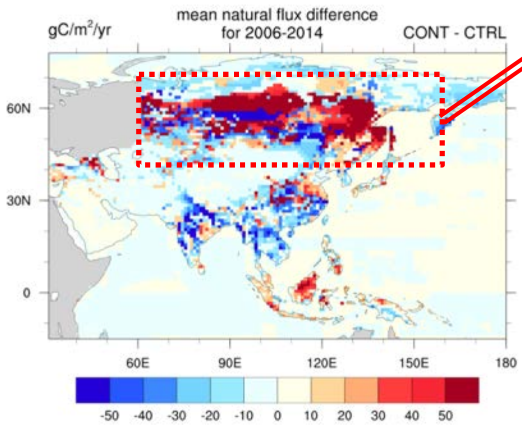
- CONTRAIL data[1)] are assimilated in CTA-2016
- For each bin, observation values are spatially and temporally(**daily**) averaged
- Referred to H. F. Zhang et al[2)]
- Developed based on CT-2013B by YSU
- Modified to CT-2016 by NIMS

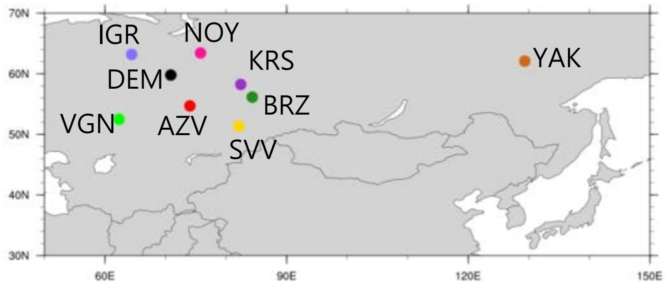
1) Machida, T., H. Matsueda, Y. Sawa, et al., (2008), Worldwide measurements of atmospheric CO2 and other trace gas species using commercial airlines. J. Atmos. Oceanic. Technol., 25 (10), 1744-1754, DOI: 10.1175/2008JTECHA1082.1.

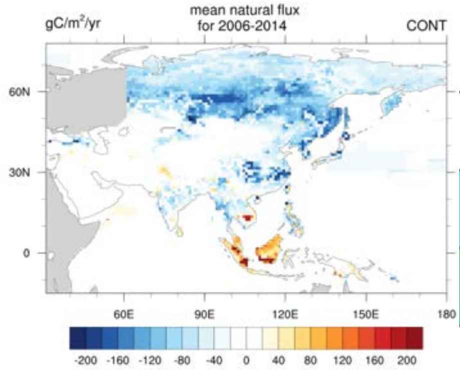
2) Zhang, H. F., Chen, B. Z., van der Laan-Luijk, I. T., Machida, T., Matsueda, H., Sawa, Y., ... & Yan, J. W. (2014). Estimating Asian terrestrial carbon fluxes from CONTRAIL aircraft and surface CO 2 observations for the period 2006–2010. Atmospheric Chemistry and Physics, 14(11), 5807-5824.

The impact of CONTRAIL observation









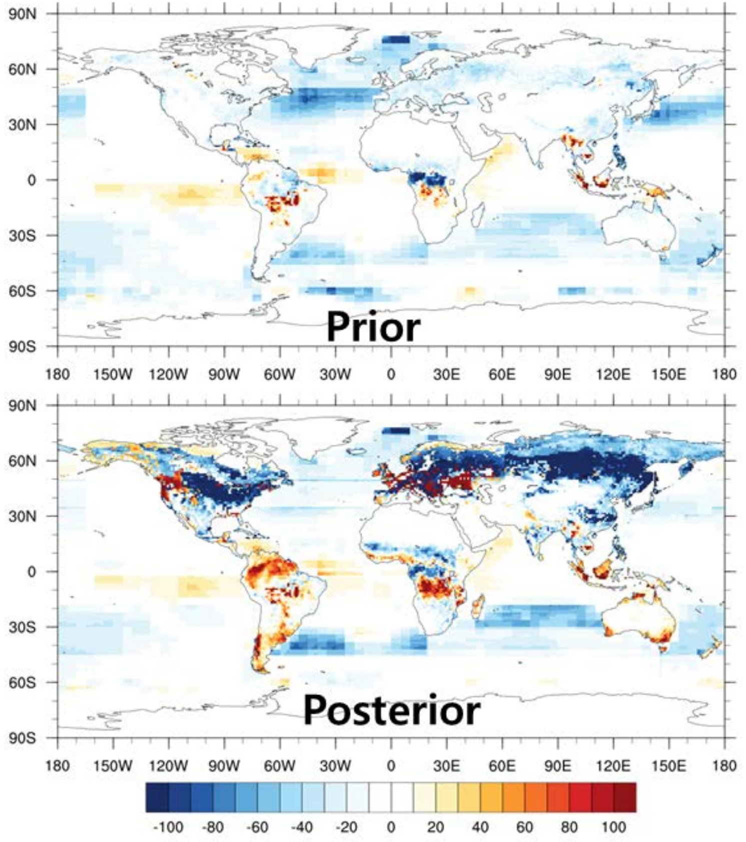
Terrestrial biosphere flux during the period ($PgCyr^{-1}$)

Exp. name	Period	Eurasia Boreal	Eurasia Temperate	Tropical Asia
CTRL	2006 ~2014	-1.47±0.96	-0.45±0.73	-0.09±0.19
CONT		-1.35±0.82	-0.58±0.59	-0.09±0.37

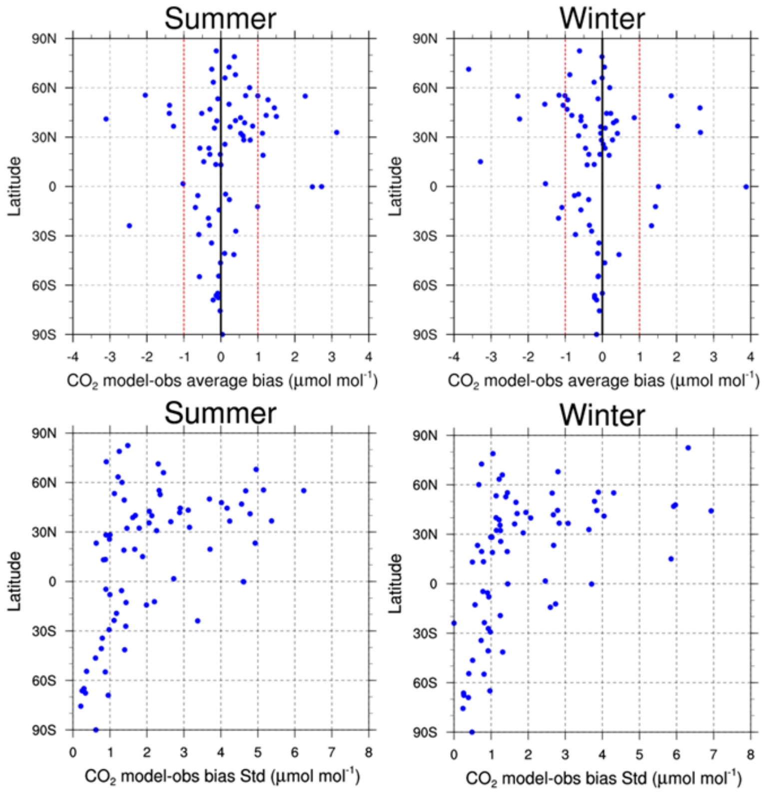
	CTRL			CONT		
	RMSE	R^2	bias	RMSE	R^2	bias
AZV	5.16	0.83	-0.34	4.83	0.85	-0.54
BRZ	4.94	0.84	-0.50	4.94	0.84	-0.40
DEM	4.91	0.84	-0.85	4.78	0.85	-0.96
IGR	8.04	0.68	-3.06	7.51	0.71	-2.72
KRS	5.22	0.84	-1.26	5.15	0.85	-1.29
NOY	5.03	0.84	-1.55	5.18	0.82	-1.45
SVV	5.80	0.77	-1.02	5.60	0.76	-0.81
VGN	5.38	0.84	1.16	5.16	0.84	1.09
YAK	7.37	0.71	-2.56	6.45	0.77	-1.72

better | worse | So so

Results



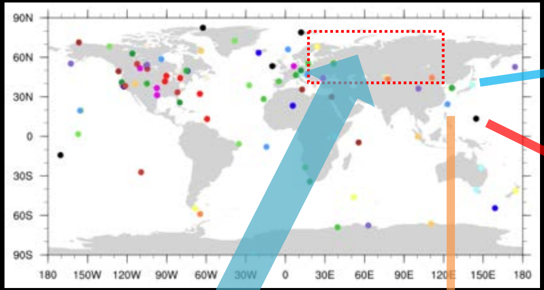
Global natural (bio+fires+ocean) fluxes averaged over 2001-2015 [gC/m²/yr]

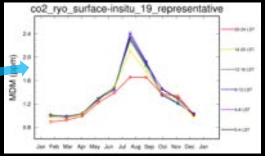


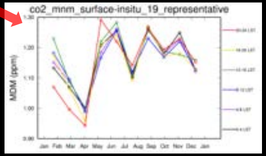
Latitudinal distribution of the averaged posterior for flask observation residuals and their standard deviations (Summer & Winter)

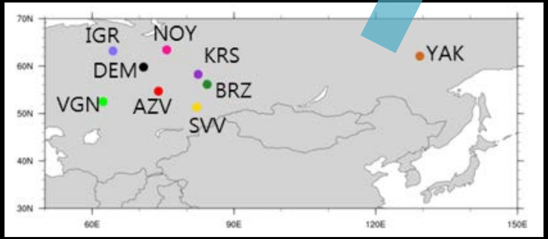
Conclusion

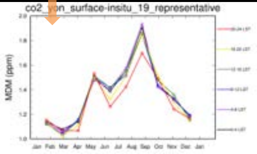
- The CTA has been updated !
- The impact of JMA and CONTRAIL observation data is presented
- We demonstrated the new version of CTA : The CarbonTracker Asia 2016
- Siberia observation data assimilation for CTA-2016 in progress[1)]
- adaptive MDM is applied to JMA, CONTRAIL, and JR siberia data
- CTA-2017 will be released
- Webpage for CTA will be updated





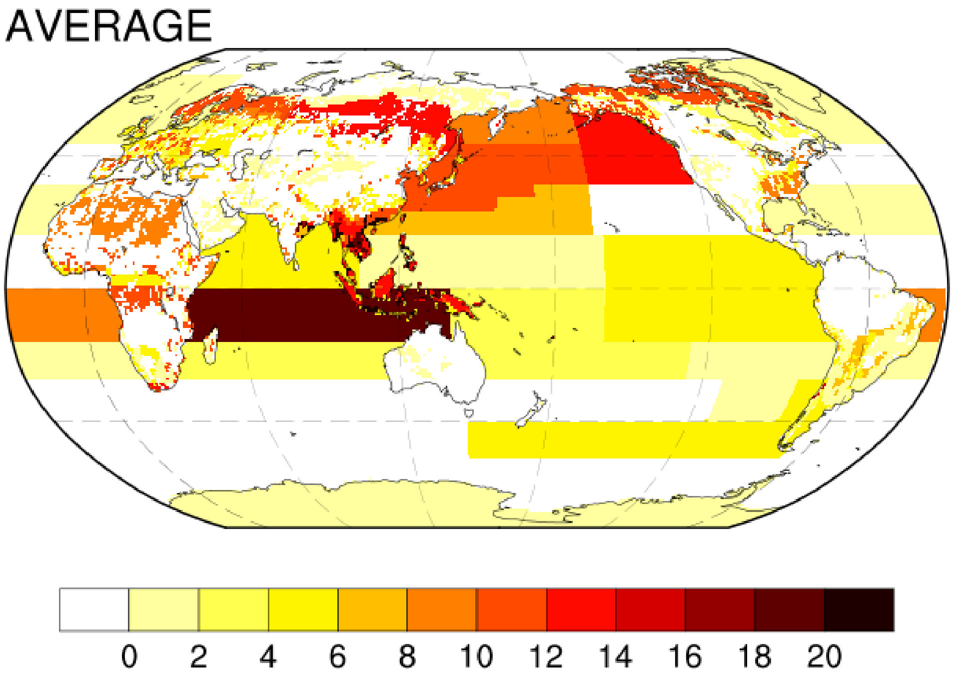




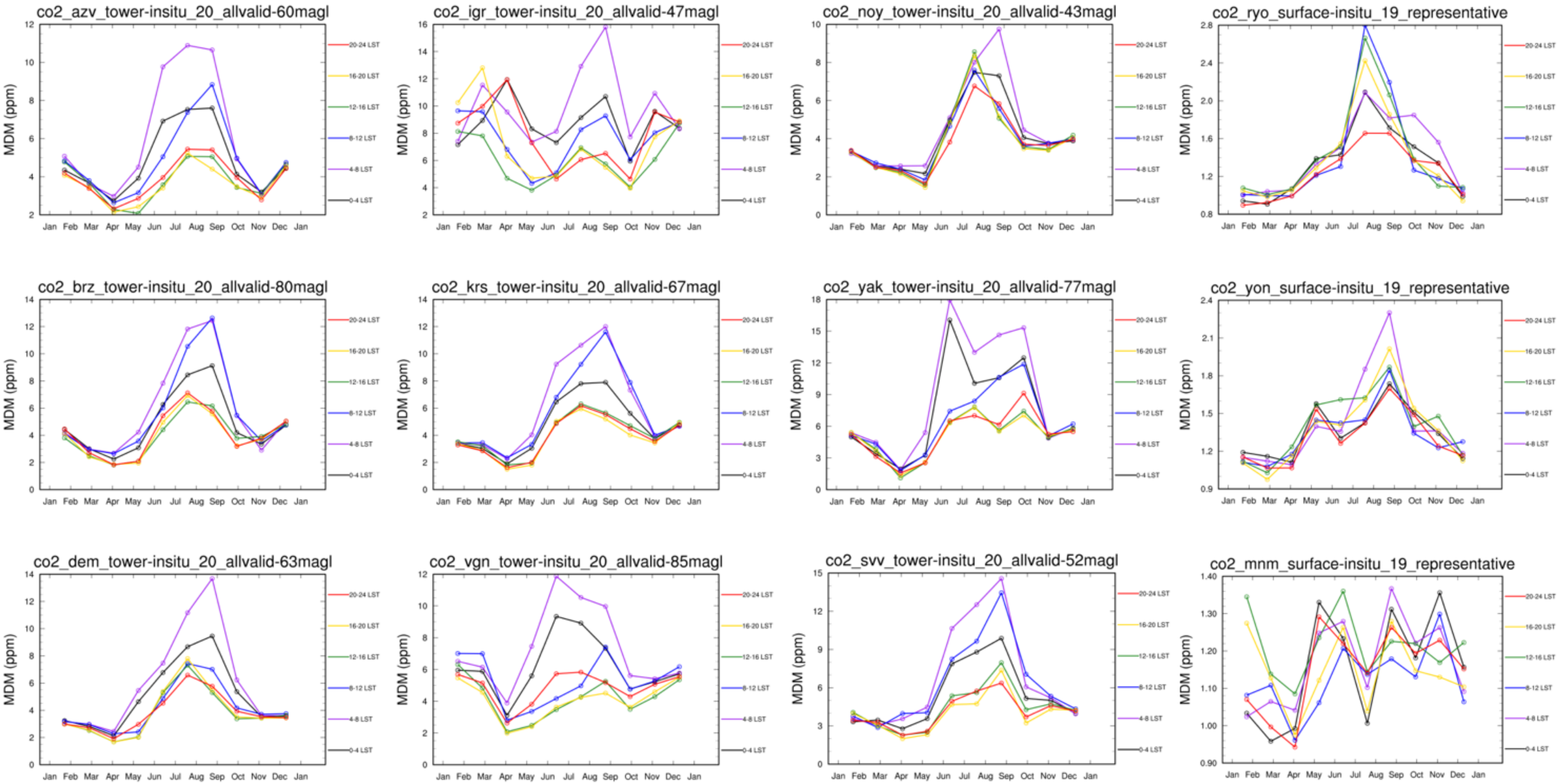


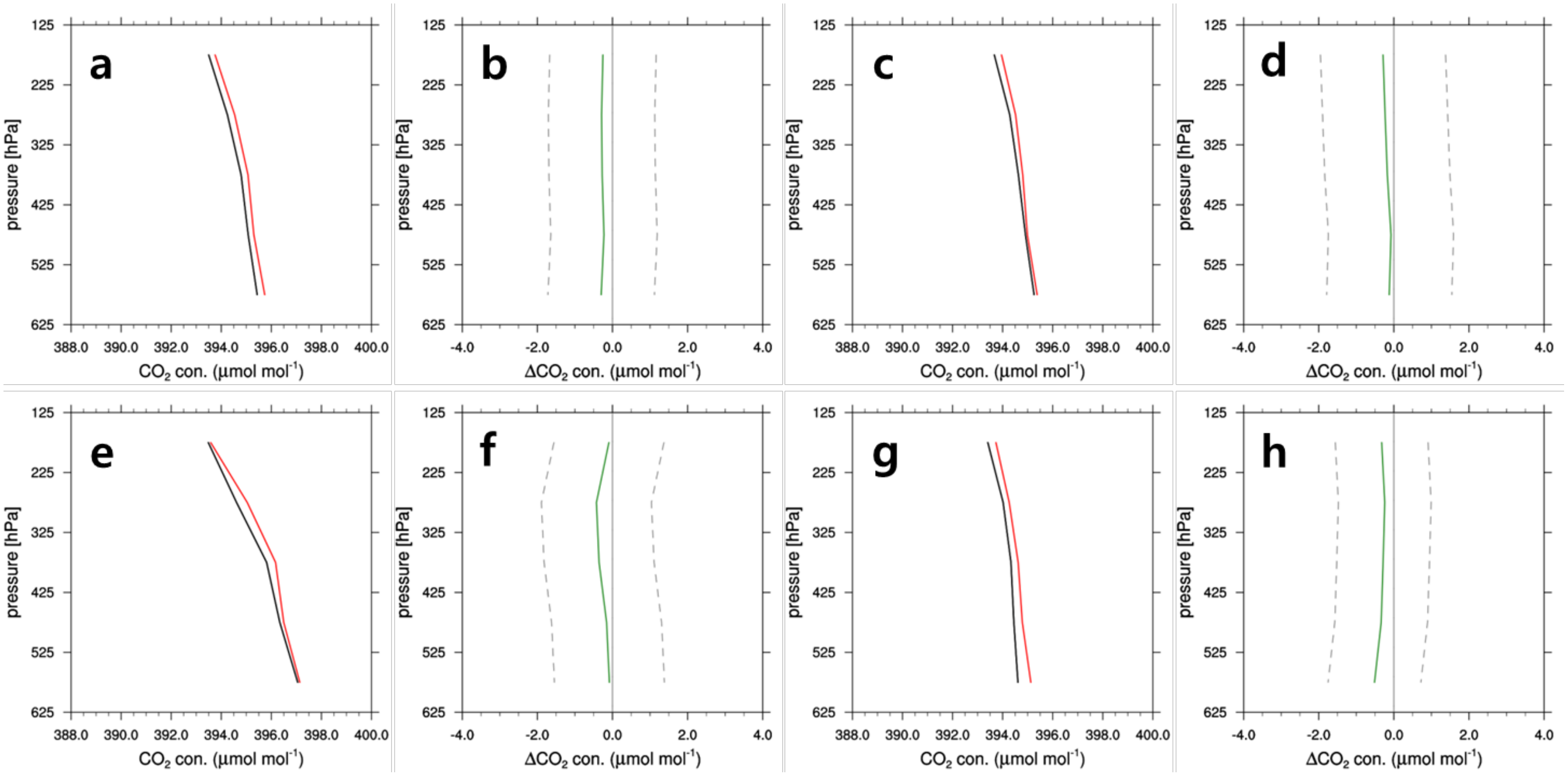
1) Kim, J., Kim, H. M., Chun-Ho, C., Boo, K. O., Jacobson, A. R., Sasakawa, M., & Fedoseev, N. (2017). Impact of Siberian observations on the optimization of surface CO 2 flux. Atmospheric Chemistry and Physics, 17(4), 2881.

Thank you for your attention !

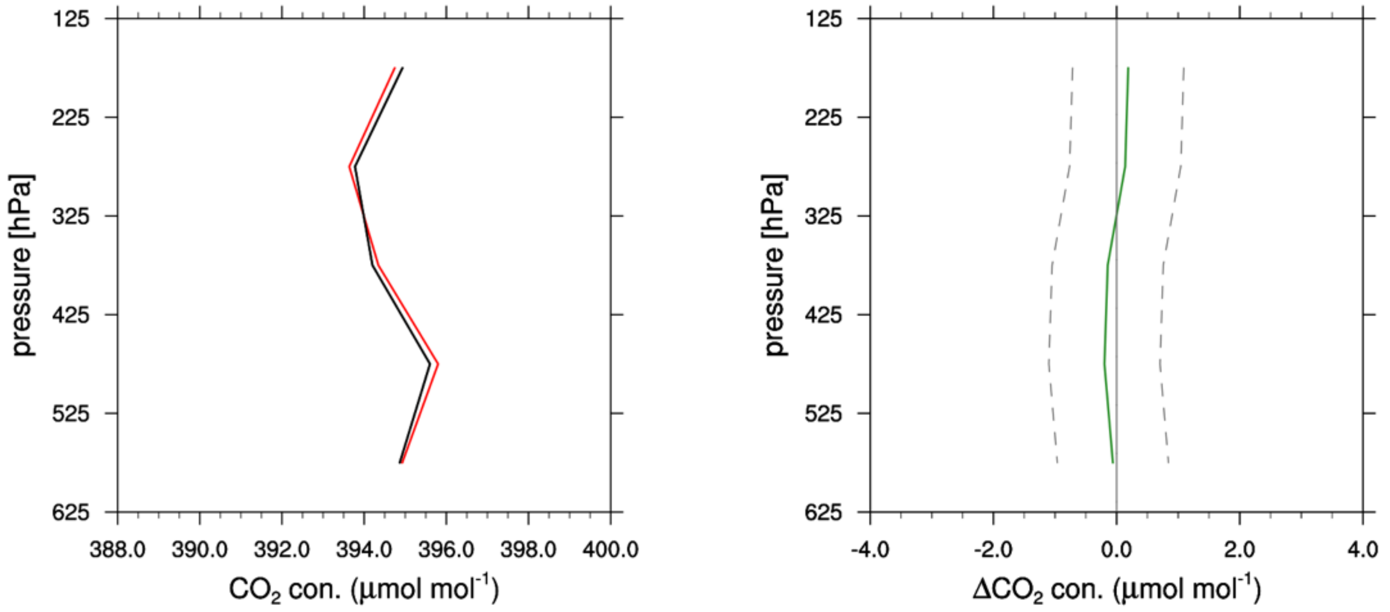


Uncertainty reduction (CONT vs CTRT)
Averaged for 2006~2014


co2_azv_tower-insitu_20_allvalid-60magl
co2_igr_tower-insitu_20_allvalid-47magl
co2_noy_tower-insitu_20_allvalid-43magl
co2_ryo_surface-insitu_19_representative
co2_brz_tower-insitu_20_allvalid-80magl
co2_krs_tower-insitu_20_allvalid-67magl
co2_yak_tower-insitu_20_allvalid-77magl
co2_yon_surface-insitu_19_representative
co2_dem_tower-insitu_20_allvalid-63magl
co2_vgn_tower-insitu_20_allvalid-85magl
co2_svv_tower-insitu_20_allvalid-52magl
co2_mnm_surface-insitu_19_representative
MDM (ppm)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
20-24 LST
16-20 LST
12-16 LST
8-12 LST
4-8 LST
0-4 LST



(a) Vertical profile of modeled (**black**) and observed (**red**) CO2 concentration for whole airports and their differences (green) with its 1-sigma range (dashed grey), (c) and (d) are same plot with (a) and (b) respectively at Haneda airport. (e) and (f) are at Narita airport. Then, (g) and (h) are results for the airports with exclusion of Haneda and Narita airports.



ICN vertical profile