

Supplement of Atmos. Chem. Phys., 21, 1963–1985, 2021  
<https://doi.org/10.5194/acp-21-1963-2021-supplement>  
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*Supplement of*

## **Regional CO<sub>2</sub> fluxes from 2010 to 2015 inferred from GOSAT XCO<sub>2</sub> retrievals using a new version of the Global Carbon Assimilation System**

**Fei Jiang et al.**

*Correspondence to:* Fei Jiang ([jiangf@nju.edu.cn](mailto:jiangf@nju.edu.cn))

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**Table S1.** The 28 layers for 3-D meteorological variables selected from ERA-Interim data sets

Layers in MOZART	Layers in ERA-Interim	a [Pa]	b	pf [hPa]	Geopotential Altitude [m]
1	8	298.495789	0.000000	2.6664	40294.73
2	14	1094.834717	0.000000	9.8925	31127.02
3	17	2082.273926	0.000000	18.8146	26880.84
4	19	3196.421631	0.000000	28.8816	24094.12
5	21	4906.708496	0.000000	44.3350	21342.15
6	23	7306.631348	0.000000	66.6233	18755.37
7	24	8765.053711	0.000076	80.3968	17563.62
8	25	10376.126953	0.000461	95.9781	16440.20
9	27	13775.325195	0.005081	132.7577	14382.89
10	29	16819.474609	0.020678	177.1176	12554.62
11	31	19027.695313	0.051690	228.8387	10930.02
12	32	19755.109375	0.073534	257.3558	10175.26
13	34	20429.863281	0.130023	319.6307	8737.51
14	36	20097.402344	0.202476	388.2700	7395.38
15	38	18864.750000	0.288323	461.8996	6154.67
16	39	17961.357422	0.335155	500.0000	5574.58
17	41	15706.447266	0.433963	577.3754	4498.91
18	43	13043.218750	0.535710	654.2732	3539.96
19	44	11632.758789	0.586168	691.7515	3105.35
20	46	8802.356445	0.683269	763.2045	2327.04
21	48	6144.314941	0.771597	828.0468	1670.26
22	49	4941.778320	0.811253	857.3419	1387.12
23	50	3850.913330	0.847375	884.2660	1133.73
24	52	2063.779785	0.907884	930.3702	713.97
25	53	1385.912598	0.931940	949.3494	546.06
26	55	467.333588	0.967645	979.0633	288.55
27	57	65.889244	0.988270	998.3854	124.48
28	60	0.000000	1.000000	1012.0494	10.00

**Table S2.** The meteorological variables selected from ERA-Interim data sets

Variable	Full Name	Unit	Dimension
t	air temperature	K	3-D
q	specific humidity	kg/kg	3-D
u	U component of wind	m/s	3-D
v	V component of wind	m/s	3-D
CI	Sea ice cover		2-D
SP	Surface pressure	Pa	2-D
SD	Snow depth	m	2-D
SSHF	Surface sensible heat flux	W/m <sup>2</sup> /s	2-D
U10M	10 metre U wind component	m/s	2-D
V10M	10 metre V wind component	m/s	2-D
T2M	2 metre temperature	K	2-D
D2M	2 metre dewpoint temperature	K	2-D
SSRD	Surface solar radiation downwards	W/m <sup>2</sup> /s	2-D
STRD	Surface thermal radiation downwards	W/m <sup>2</sup> /s	2-D
EWSS	East/West surface stress	N/m <sup>2</sup> /s	2-D
NSSS	North/South surface stress	N/m <sup>2</sup> /s	2-D
IE	Instantaneous moisture flux	kg/m <sup>2</sup> /s	2-D

**Table S3.** Statistical results for the prior and posterior CO<sub>2</sub> mixing ratios at the 52 flask sites

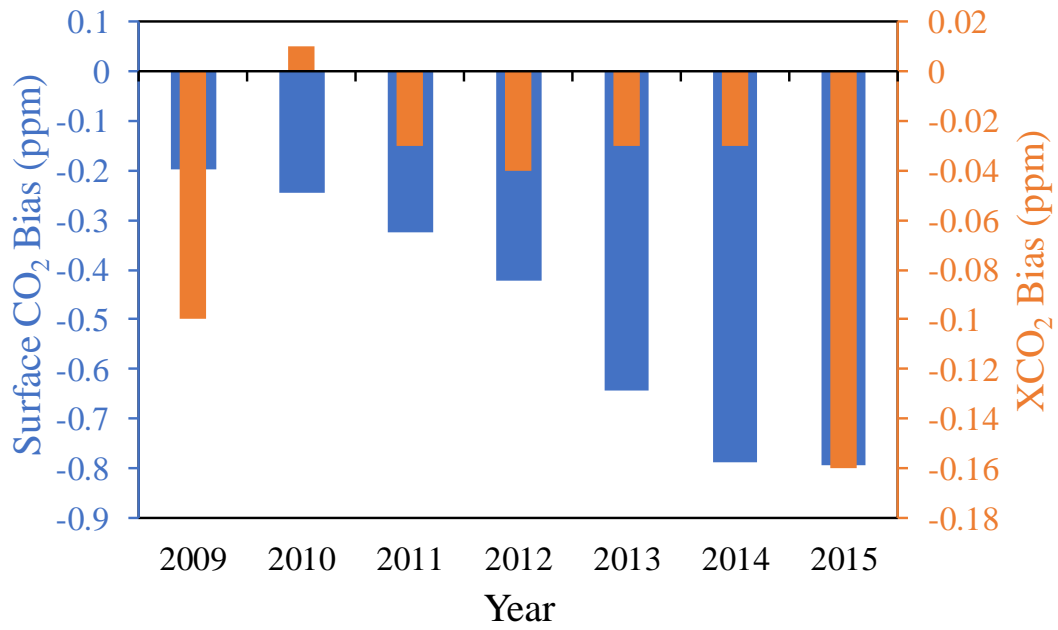
Site Code	Lat	Lon	BIAS (ppm)		RMSE (ppm)		CORR	
			Prior	Posterior	Prior	Posterior	Prior	Posterior
alt	82.45	297.49	2.01	-0.28	2.73	1.54	0.96	0.98
asc	-7.97	345.6	1.68	-0.35	1.86	0.72	0.98	0.99
ask	23.26	5.63	1.47	-0.88	1.8	1.13	0.98	0.99
azr	38.77	332.62	1.39	-1	2.46	1.94	0.91	0.94
bhd	-41.41	174.87	0.94	-0.93	1.53	1.45	0.96	0.97
bkt	-0.2	100.32	2.79	0.77	3.56	2.41	0.92	0.92
bmw	32.26	295.12	2.87	0.4	3.21	1.47	0.95	0.95
brw	71.32	203.39	1.78	-0.84	3.26	3.93	0.95	0.93
cba	55.21	197.28	0.84	-1.35	2.41	2.6	0.94	0.95
cgo	-40.68	144.69	1.25	-0.64	1.4	0.82	0.99	0.99
chr	1.7	202.85	1.75	-0.38	2.03	1.04	0.95	0.95
cib	41.81	355.07	0.72	-1.83	2.89	3.16	0.87	0.9
crz	-46.43	51.85	1.29	-0.52	1.41	0.71	0.99	1
dsi	20.7	116.73	2.97	1.17	3.67	2.4	0.93	0.94

eic	-27.16	250.57	1.66	-0.35	1.91	1.07	0.98	0.98
gmi	13.39	144.66	1.77	-0.3	2.13	1.25	0.96	0.96
hba	-75.61	333.79	1.54	-0.35	1.64	0.59	0.99	1
hpb	47.8	11.02	1.92	0.06	3.42	3.27	0.93	0.91
hsu	41.02	235.45	1.19	0.51	3.6	3.13	0.9	0.87
hun	46.95	16.65	1.89	0.33	3.58	4.34	0.96	0.91
izo	28.31	343.5	1.82	-0.52	2.18	1.05	0.96	0.98
key	25.67	279.84	1.93	-0.45	2.44	1.29	0.94	0.96
kum	19.52	205.18	1.28	-0.93	2.05	1.66	0.94	0.96
lln	23.47	120.87	2.36	0.28	3.13	2.04	0.91	0.92
lmp	35.52	12.62	2.45	-0.03	3.28	1.85	0.92	0.94
mex	18.98	262.69	2.43	0.16	2.84	1.25	0.94	0.96
mhd	53.33	350.1	1.84	-0.62	2.63	1.54	0.95	0.98
mid	28.21	182.62	1.93	-0.26	2.55	1.34	0.94	0.96
mlo	19.54	204.42	1.52	-0.69	1.83	1.08	0.97	0.98
nat	-5.8	324.81	1.49	-0.73	1.85	1.28	0.95	0.96
nmb	-23.58	15.03	0.67	-1.14	1.22	1.44	0.96	0.98
nwr	40.05	254.41	1.27	-0.89	2.16	1.77	0.93	0.95
oxk	50.03	11.81	0.88	-1.21	3.06	3.2	0.9	0.9
pal	67.97	24.12	1.38	-0.85	2.76	2.96	0.96	0.95
psa	-64.92	296	1.41	-0.45	1.56	0.74	0.99	0.99
rpb	13.16	300.57	1.63	-0.7	1.92	0.97	0.97	0.99
sey	-4.68	55.53	1.62	-0.31	1.82	0.75	0.98	0.99
sgp	36.61	262.51	1.18	-1.5	2.97	4.09	0.87	0.82
shm	52.71	174.13	1.1	-0.96	2.75	2.43	0.94	0.96
smo	-14.25	189.44	1.7	-0.44	1.81	0.73	0.99	0.99
spo	-89.98	335.2	1.52	-0.34	1.61	0.53	0.99	1
sum	72.6	321.58	2.03	-0.28	2.71	1.47	0.96	0.98
syo	-69.01	39.59	1.51	-0.37	1.6	0.57	0.99	1
tap	36.74	126.13	2.11	0.61	3.42	3.47	0.92	0.87
thd	41.05	235.85	-0.39	-1.43	2.48	2.73	0.91	0.9
tik	71.6	128.89	1.85	-0.65	3.1	2.69	0.95	0.96
ush	-54.85	291.69	0.97	-0.17	1.19	0.81	0.93	0.86
uta	39.9	246.28	2.06	-0.01	2.81	1.9	0.92	0.92
uum	44.45	111.1	0.98	-1.09	3.03	3.44	0.91	0.9
wis	29.97	35.06	1.51	-0.83	2.82	2.19	0.91	0.93
wlg	36.29	100.9	1.24	-0.96	2.39	2.33	0.93	0.93
zep	78.91	11.89	2.33	-0.05	3	1.78	0.96	0.97

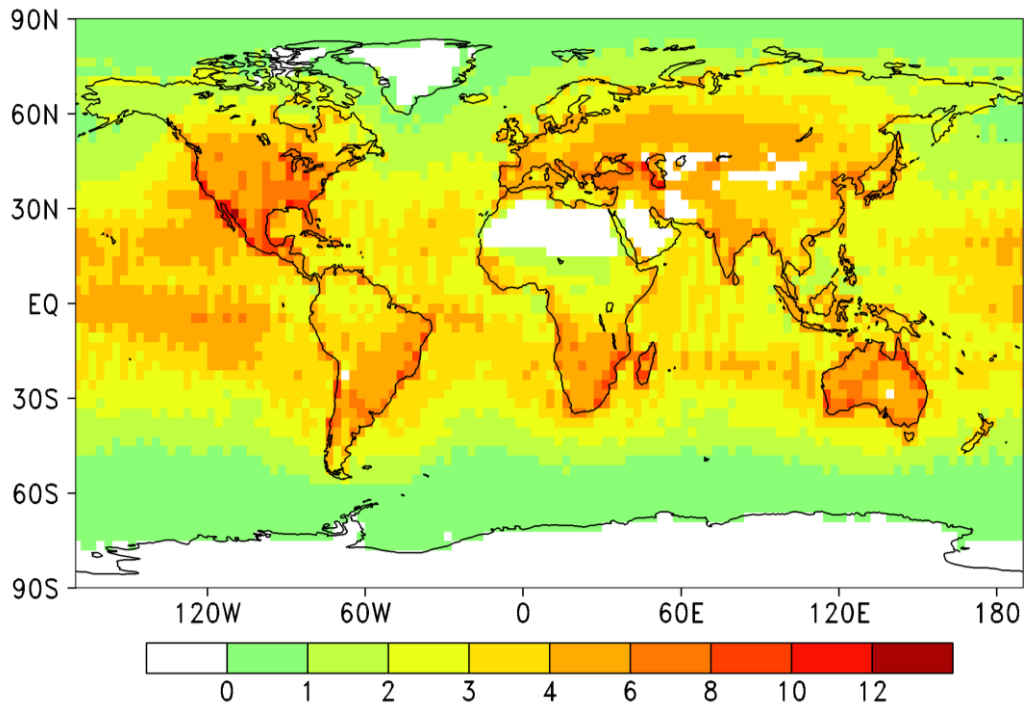
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**Table S4.** Results of sensitivity tests in the year of 2010 (1week, 2weeks and 4weeks are three experiments using 1 week, 2 weeks and 4 weeks assimilation window, respectively; Wfossil is an experiment that is based on 1week experiment, but with fossil fuel and cement production carbon emission also being optimized with a global uncertainty of 5%; Wnoise is another experiment that is based on 1week experiment, but with the spurious signals not being removed in each window)

		Prior	1week	2weeks	4weeks	Wfossil	Wnoise
Super Obs. Num. per window	Total	-	730	1039	1360	730	730
	Each grid	-	4	6	9	4	28
Global Flux (PgC yr <sup>-1</sup> )	BIO	-2.07	-4.16	-4.46	-4.49	-4.15	-4.31
	OCN	-2.08	-2.33	-2.32	-2.35	-2.31	-2.42
	FOSSIL	9.07	9.07	9.07	9.07	9.05	9.07
	Net	7.25	4.91	4.62	4.55	4.92	4.67
Regional BIO Flux (PgC yr <sup>-1</sup> )	North America Boreal	-0.29	-0.43	-0.41	-0.35	-0.44	-0.42
	North America Temperate	-0.42	-1.25	-1.75	-2.41	-1.21	-1.41
	Tropical South America	-0.17	-0.26	-0.32	-0.27	-0.27	-0.3
	Temperate South America	-0.24	-0.4	-0.36	-0.19	-0.41	-0.37
	Northern Africa	0.21	0.32	0.36	0.62	0.34	0.28
	Southern Africa	0.22	-0.3	-0.59	-1.04	-0.29	-0.42
	Boreal Asia	-0.4	-0.46	-0.3	0.11	-0.48	-0.33
	Temperate Asia	-0.3	-0.29	-0.15	-0.06	-0.27	-0.31
	Southeast Asia	-0.29	-0.23	-0.21	-0.2	-0.24	-0.27
	Australia Europe	-0.17 -0.19	-0.4 -0.41	-0.48 -0.21	-0.53 -0.12	-0.4 -0.43	-0.4 -0.28
Independent evaluation against flask obs. (ppm)	Global BIAS	1.43	-0.44	-0.4	-0.38	-0.43	-0.41
	Global MAE	1.92	1.37	1.39	1.51	1.35	1.4
	Global RMSE	2.36	2.11	2.18	2.39	2.08	2.2
Deviation from the observed AGR (PgC yr <sup>-1</sup> )		2.08	-0.26	-0.55	-0.62	-0.25	-0.5



**Figure S1.** Interannual variations of the global mean biases of simulated surface CO<sub>2</sub> and XCO<sub>2</sub> concentrations



**Figure S2.** Mean super-observation numbers within a DA window (1 week) and the localization scale (3000 km) during the May 2009–December 2015 period