

Supplement of Biogeosciences, 17, 1293–1308, 2020  
<https://doi.org/10.5194/bg-17-1293-2020-supplement>  
© Author(s) 2020. This work is distributed under  
the Creative Commons Attribution 4.0 License.



*Supplement of*

## **Leveraging the signature of heterotrophic respiration on atmospheric CO<sub>2</sub> for model benchmarking**

**Samantha J. Basile et al.**

*Correspondence to:* Samantha J. Basile (sjbasile@umich.edu)

The copyright of individual parts of the supplement might differ from the CC BY 4.0 License.

Table S1: Marine Boundary Layer (MBL) stations within the NOAA Earth System Research Laboratory CO<sub>2</sub> sampling network (ESRL). These sites were selected for obtaining at least 50% data coverage over the analysis period of 1982 to 2010.

Region	Station	Acronym	Lat	Lon
60°–90°N	Alert, AK	ALT	82.5	-62.5
	Ny-Ålesund, Svalbard	ZEP	78.9	11.9
	Barrow, AK	BRW	71.3	-156.6
	Stórhöfði, Iceland	ICE	63.4	-20.0
23°–60°N	Mace Head, Ireland	MHD	53.3	-9.9
	Shemya, AK	SHM	52.7	174.1
	Terceira Island, Azores	AZR	38.8	-27.4
	Tudor Hill, Bermuda	BMW	32.3	-64.9
	Sand Island, Midway	MID	28.2	-177.4
	Key Biscayne, FL	KEY	25.7	-80.2
	Pacific Ocean, 25°N	POCN25	25.0	-135.0
0°–23°N	Pacific Ocean, 20°N	POCN20	20.0	-139.0
	Cape Kumukahi, HI	KUM	19.5	-154.8
	Pacific Ocean, 15°N	POCN15	15.0	-143.0
	Mariana Islands, Guam	GMI	13.4	144.8
	Ragged Point, Barbados	RPB	13.2	-59.4
	Pacific Ocean, 10°N	POCN10	10.0	-147.0
	Pacific Ocean, 5°N	POCN05	5.0	-151.0
	Christmas Island	CHR	1.7	-157.2
0°–23°S	Seychelles	SEY	-4.7	55.2
	Pacific Ocean 5°S	POCS05	-5.0	-159.0
	Ascension Island	ASC	-8.0	-14.4
	Pacific Ocean 10°S	POCS10	-10.0	-163.0
	Tutuila American Samoa	SMO	-14.2	-170.6
	Pacific Ocean 15°S	POCS15	-15.0	-167.0
	Pacific Ocean 20°S	POCS20	-20.0	-171.0
23°–60°S	Pacific Ocean 25°S	POCS25	-25.0	-174.0
	Pacific Ocean 30°S	POCS30	-30.0	-177.0
	Cape Grim, Australia	CGO	-40.7	144.7
	Crozet Island	CRZ	-46.5	51.9
60°–90°S	Palmer Station, Antarctica	PSA	-64.0	-64.0
	Syowa Antarctica	SYO	-69.0	39.6
	Halley Bay, Antarctica	HBA	-75.6	-26.5
	South Pole	SPO	-90.0	-24.8

Table S2: Coefficient of variation for flux variables by latitude zone. All variables have been detrended using a third-order polynomial fit. For NEP, a negative sign represents flux into land and a positive sign represents a flux to the atmosphere from land.

Region	Model Flux	Mean Flux [Pg C yr <sup>-1</sup> ]	Flux Standard Deviation (STD) [Pg C yr <sup>-1</sup> ]	STD : Flux [%]
61°-90°N	CASA HR	3.94	0.08	2
	CORPSE HR	4.52	0.23	5
	MIMICS HR	3.96	0.09	2
	CASA NPP	4.07	0.09	2
	CASA NEP	-0.13	0.05	40
	CORPSE NEP	0.45	0.16	35
	MIMICS NEP	-0.11	0.08	76
24°-60°N	CASA HR	22.73	0.24	1
	CORPSE HR	23.06	0.31	1
	MIMICS HR	22.88	0.48	2
	CASA NPP	23.15	0.28	1
	CASA NEP	-0.42	0.40	96
	CORPSE NEP	-0.09	0.46	505
	MIMICS NEP	-0.27	0.66	245
1°-23°N	CASA HR	10.63	0.08	1
	CORPSE HR	10.63	0.10	1
	MIMICS HR	10.57	0.22	2
	CASA NPP	10.66	0.44	4
	CASA NEP	-0.03	0.48	1428
	CORPSE NEP	-0.03	0.47	1571
	MIMICS NEP	-0.09	0.62	732
0°-23°S	CASA HR	14.26	0.10	1
	CORPSE HR	14.30	0.12	1
	MIMICS HR	14.24	0.29	2
	CASA NPP	14.52	0.57	4
	CASA NEP	-0.27	0.61	232
	CORPSE NEP	-0.22	0.58	262
	MIMICS NEP	-0.28	0.84	296
24°-90°N	CASA HR	3.72	0.05	1
	CORPSE HR	3.74	0.07	2
	MIMICS HR	3.74	0.08	2
	CASA NPP	3.77	0.26	7

CASA NEP	-0.05	0.26	518
CORPSE NEP	-0.03	0.24	810
MIMICS NEP	-0.03	0.33	1135

---

Table S3: Multiple linear regression coefficients ( $\gamma$ ) and  $R^2$  are used to model interannual variability in heterotrophic respiration as a function of interannual variability in temperature,

NPP, or preceding year NPP. All variables have been detrended and deseasonalized. We list statistically significant predictors of HR IAV, as determined by p-values from ANOVA.

Region	Model IAV	HR IAV Regression		
		CASA-CNP Temperature IAV [Pg C y <sup>-1</sup> K <sup>-1</sup> ]	CASA-CNP NPP Current year IAV [--]	CASA-CNP NPP Preceding year IAV [--]
61°-90°N	CASA HR	<b>0.16</b> , 0.64	<b>0.74</b> , 0.67	-0.14, 0.02
	CORPSE HR	<b>0.42</b> , 0.54	<b>2.22</b> , 0.77	-0.23, 0.01
	MIMICS HR	<b>0.13</b> , 0.32	<b>0.63</b> , 0.40	0.06, 0.00
	CASA-CNP NPP	<b>0.15</b> , 0.43		
24°-60°N	CASA HR	<b>0.78</b> , 0.58	0.2, 0.05	0.33, 0.15
	CORPSE HR	<b>1.00</b> , 0.57	-0.28, 0.06	0.32, 0.08
	MIMICS HR	<b>1.74</b> , 0.70	<b>-0.90</b> , 0.27	0.05, 0.00
	CASA-CNP NPP	-0.38, 0.10		
1°-23°N	CASA HR	0.17, 0.14	<b>-0.10</b> , 0.26	<b>0.12</b> , 0.45
	CORPSE HR	0.00, 0.00	-0.06, 0.07	<b>0.17</b> , 0.61
	MIMICS HR	<b>1.03</b> , 0.68	<b>-0.40</b> , 0.60	-0.03, 0.00
	CASA-CNP NPP	<b>-1.57</b> , 0.42		
0°-23°S	CASA HR	<b>0.24</b> , 0.17	<b>-0.07</b> , 0.17	<b>0.12</b> , 0.41
	CORPSE HR	-0.01, 0.00	-0.01, 0.00	<b>0.17</b> , 0.61
	MIMICS HR	<b>1.50</b> , 0.87	<b>-0.46</b> , 0.79	0.03, 0.00
	CASA-CNP NPP	<b>-2.65</b> , 0.72		
24°-90°N	CASA	0.00, 0.00	0.03, 0.03	<b>0.12</b> , 0.32
	CORPSE	-0.07, 0.04	0.09, 0.13	<b>0.17</b> , 0.36
	MIMICS	<b>0.32</b> , 0.42	<b>-0.26</b> , 0.65	-0.08, 0.04
	CASA-CNP NPP	<b>-1.11</b> , 0.52		

\*bolded values are statistically significant (p < 0.05)

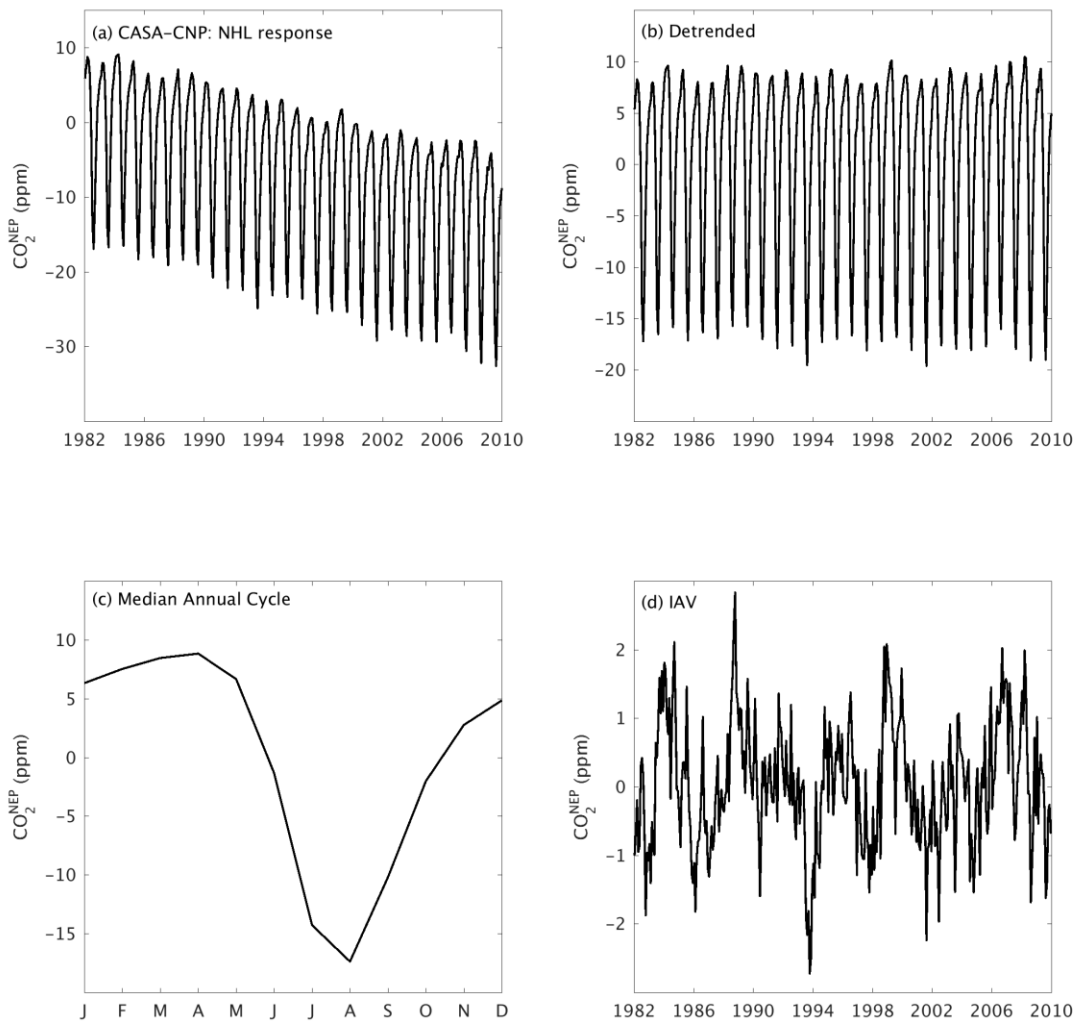


Figure S1: Depiction of interannual variability (IAV) calculation. (a) Multi-site mean CASA-CNP CO<sub>2</sub><sup>NEP</sup> in the Northern Hemisphere high latitudes (NHL) region for 1982 to 2010 (CO<sub>2</sub><sup>NEP</sup> = CO<sub>2</sub><sup>HR</sup> + CO<sub>2</sub><sup>NPP</sup>). (b) Detrended CASA-CNP CO<sub>2</sub><sup>NEP</sup> timeseries after removing a third-order polynomial fit. (c) Climatological annual cycle calculated using the median of monthly values over the analysis period. (d) CASA-CNP CO<sub>2</sub><sup>NEP</sup> interannual variability calculated from removing the climatological annual cycle from each year in the detrended timeseries.

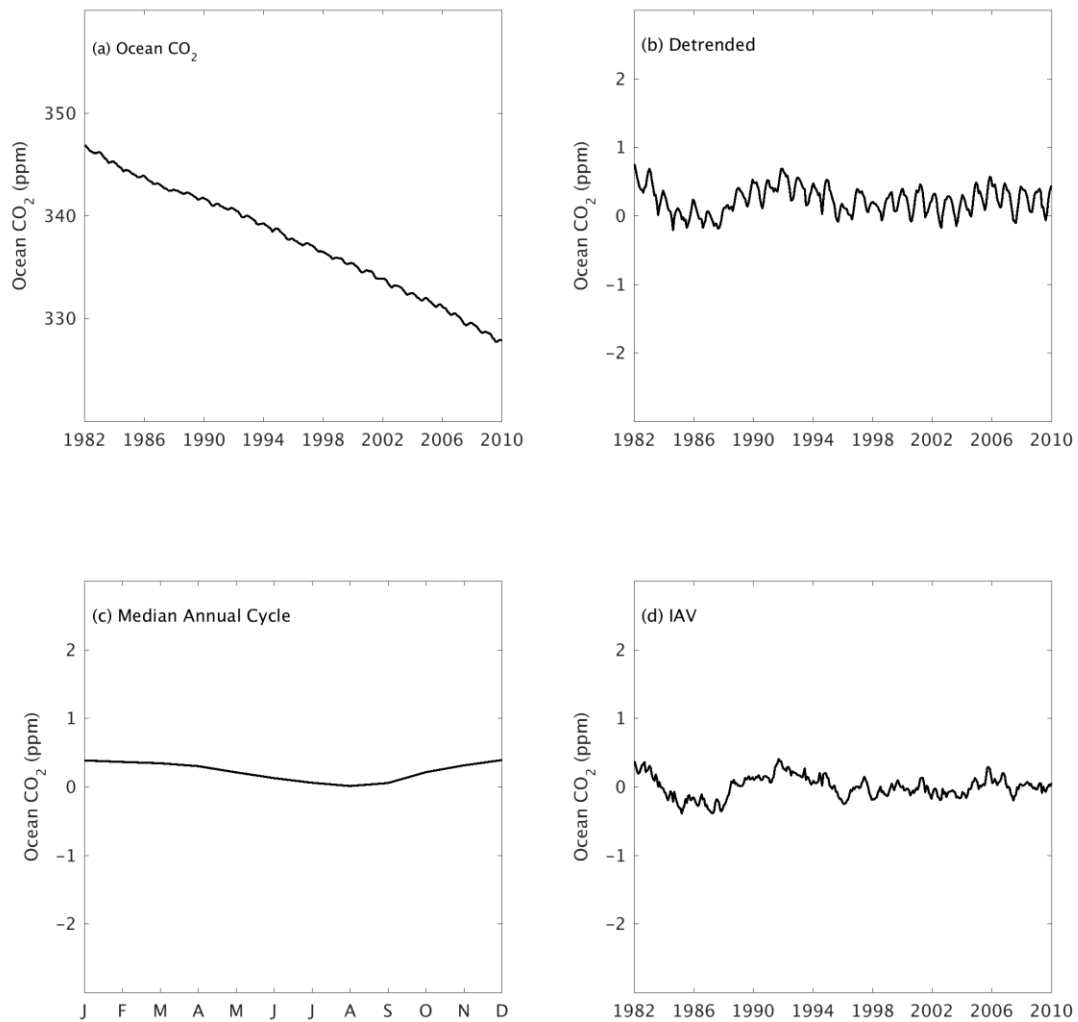


Figure S2: CO<sub>2</sub> concentrations from ocean fluxes. CO<sub>2</sub> output from GEOS Chem simulation forced by CO<sub>2</sub> CAMS inversion 17r1. (a) Averaged CO<sub>2</sub> in the Northern Hemisphere high latitudes (NHL) region for 1982 to 2010. (b) Detrended CO<sub>2</sub> timeseries after removing a third-order polynomial fit. (c) Climatological annual cycle calculated using the median of monthly values over the analysis period. (d) CO<sub>2</sub> interannual variability calculated from removing the climatological annual cycle from each year in the detrended timeseries.

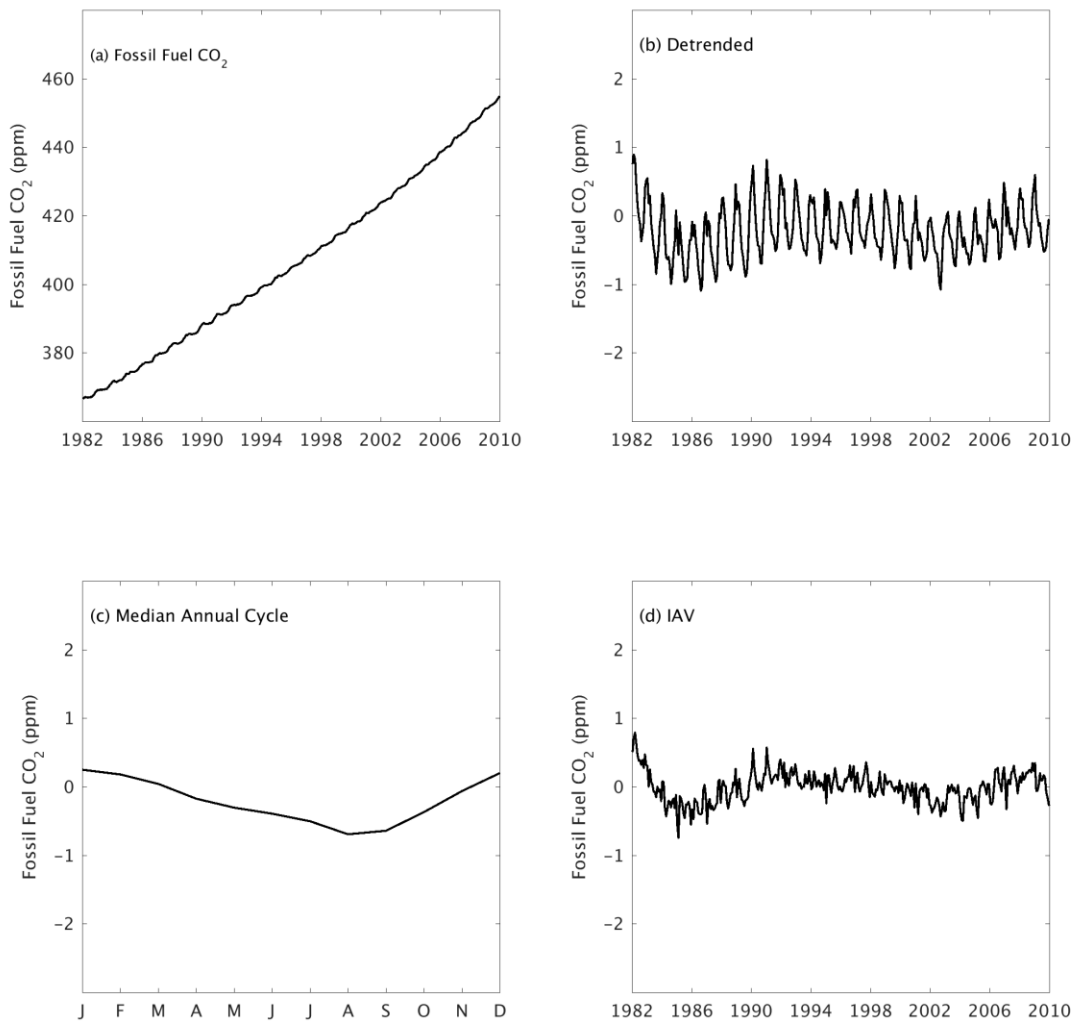


Figure S3: CO<sub>2</sub> concentrations from fossil fuel emissions. CO<sub>2</sub> output from GEOS Chem simulation forced by CO<sub>2</sub> CAMS inversion 17r1. (a) Averaged CO<sub>2</sub> in the Northern Hemisphere high latitudes (NHL) region for 1982 to 2010. (b) Detrended CO<sub>2</sub> timeseries after removing a third-order polynomial fit. (c) Climatological annual cycle calculated using the median of monthly values over the analysis period. (d) CO<sub>2</sub> interannual variability calculated from removing the climatological annual cycle from each year in the detrended timeseries.



Land mask Methodology: CASA Soil Heterotrophic Respiration (HR)

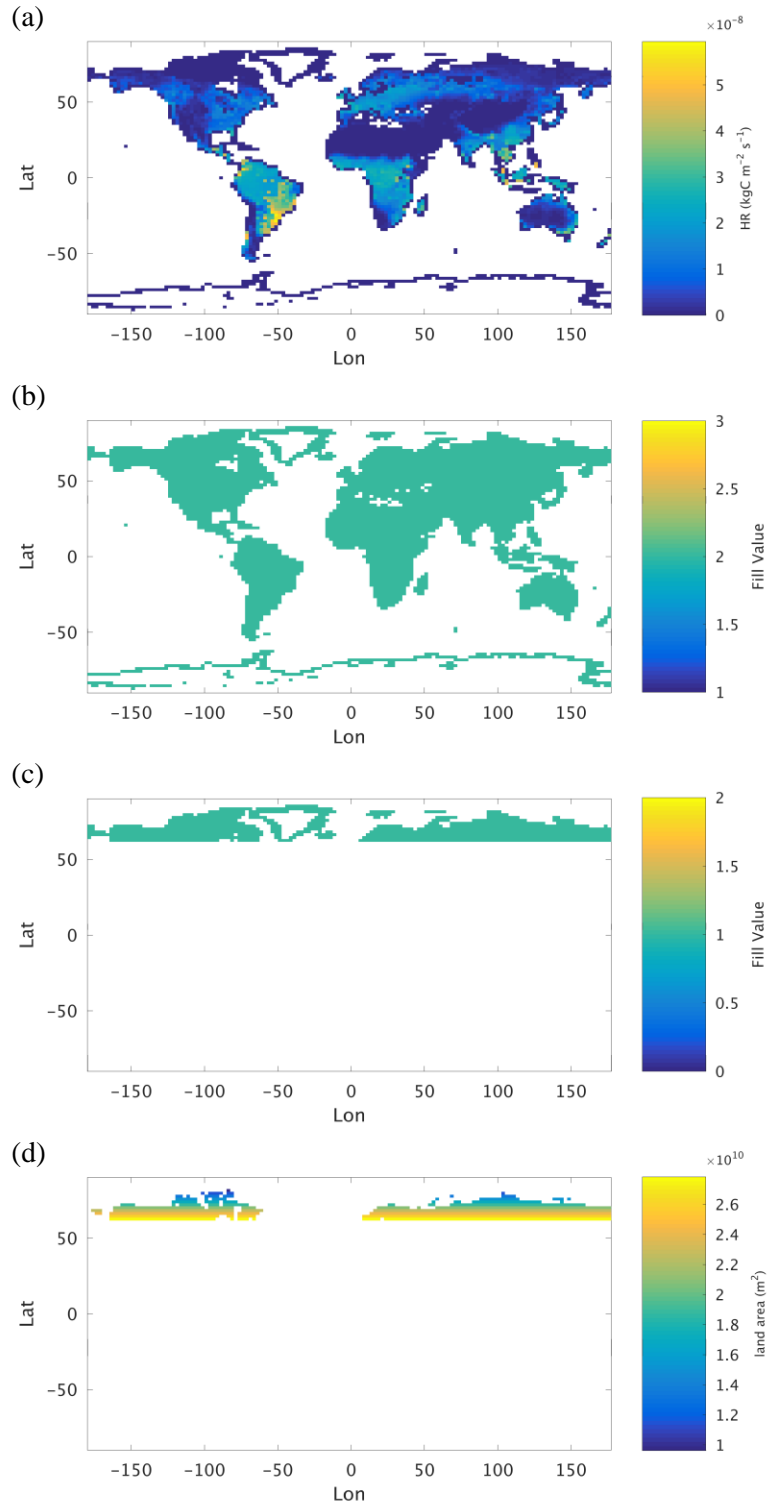


Figure S4: Example land mask for the Northern Hemisphere High Latitudes (NHL). (a) CASA-CNP soil heterotrophic respiration (HR) for January 1982. (b) Global land mask with land gridcells set to a constant fill value and ocean gridcells set to NaN. (c) Land mask after application of a separate NHL latitude band mask with values of 0 south of 61 °N. Land gridcells were reassigned a value of 1. (d) NHL land mask weighted by area with Greenland removed.