Supplementary Materials for

Identifying the most (cost-)efficient regions for CO_2 removal with Iron Fertilization in the Southern Ocean

Lennart T. Bach*, Veronica Tamsitt, Kimberlee Baldry, Jeffrey McGee, Emmanuel C. Laurenceau-Cornec, Robert F. Strzepek, Yinghuan Xie, Philip W. Boyd

*Corresponding author. Email: lennart.bach@utas.edu.au

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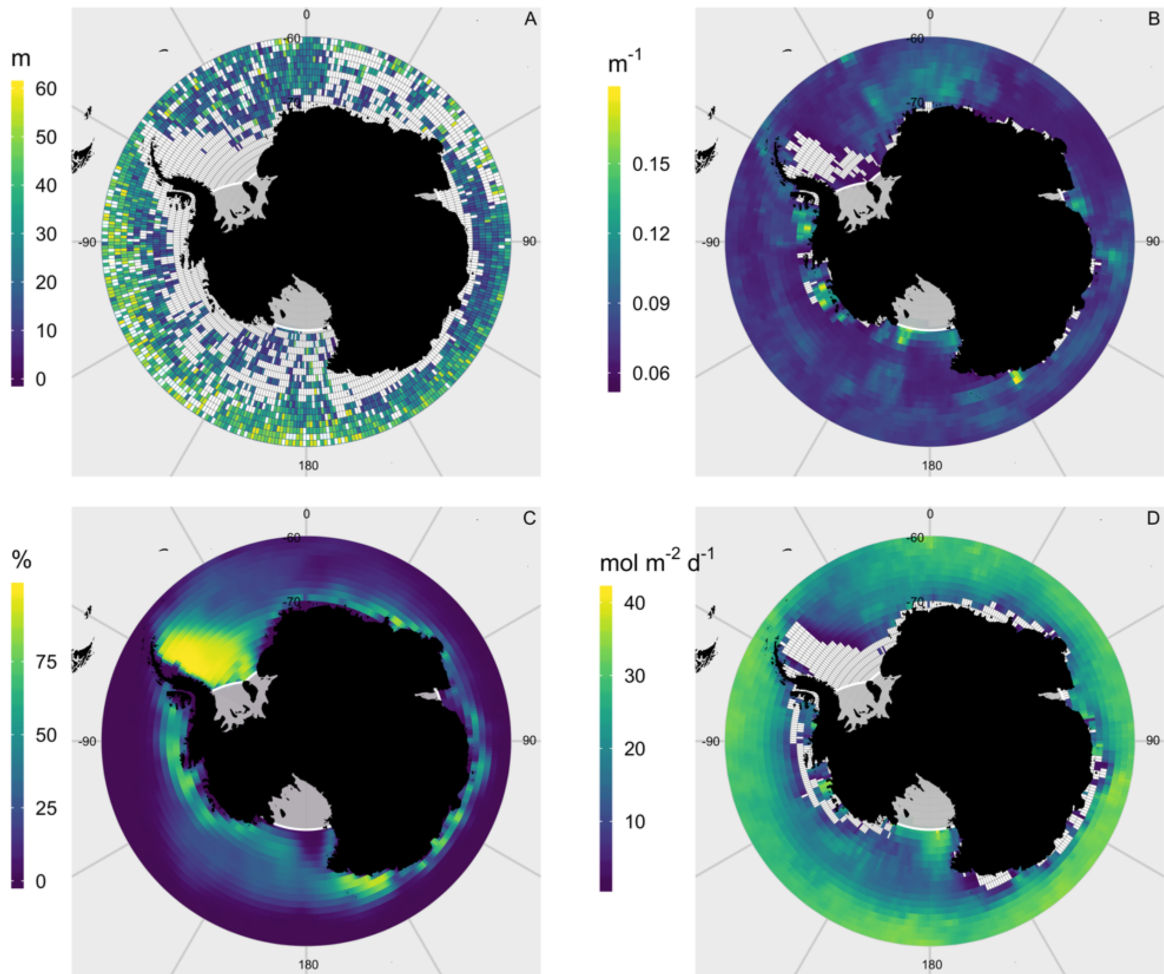

Fig. S1.

The four parameters used to calculate austral summer (December-February) I_{MLD}. (A) Mixed layer depth (h). The attenuation of PAR (K_d). (C) Ice cover (IC). (D) Incoming photosynthetically available radiation just below the sea surface ($PAR_{belowsurf}$).

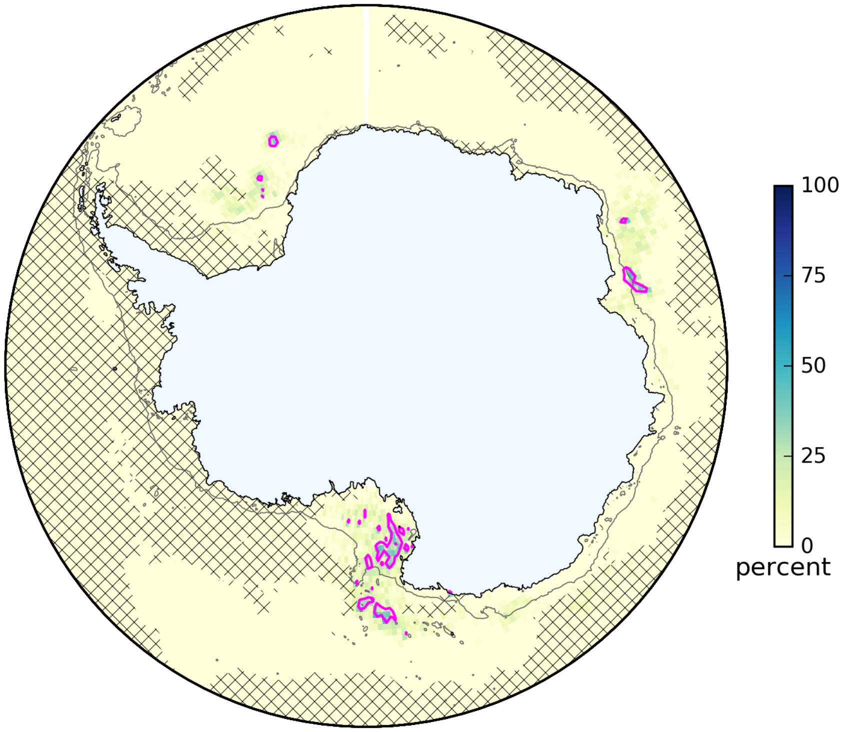

Fig. S2.

Physical downwelling of neutrally-buoyant virtual particles in the virtual particle release experiment. Particles were seeded uniformly in each grid cell of the MOM01 model at the sea surface on January 3rd and are considered to be exported when they are entrained in Dense Shelf Water (σ_1>32.56) and reach below 750 m within a year after particle release. The percent values give the likelihood for particles seeded within each 0.5° latitude by 1° longitude bin. The pink contours enclose areas where the percentage is ≥25%.

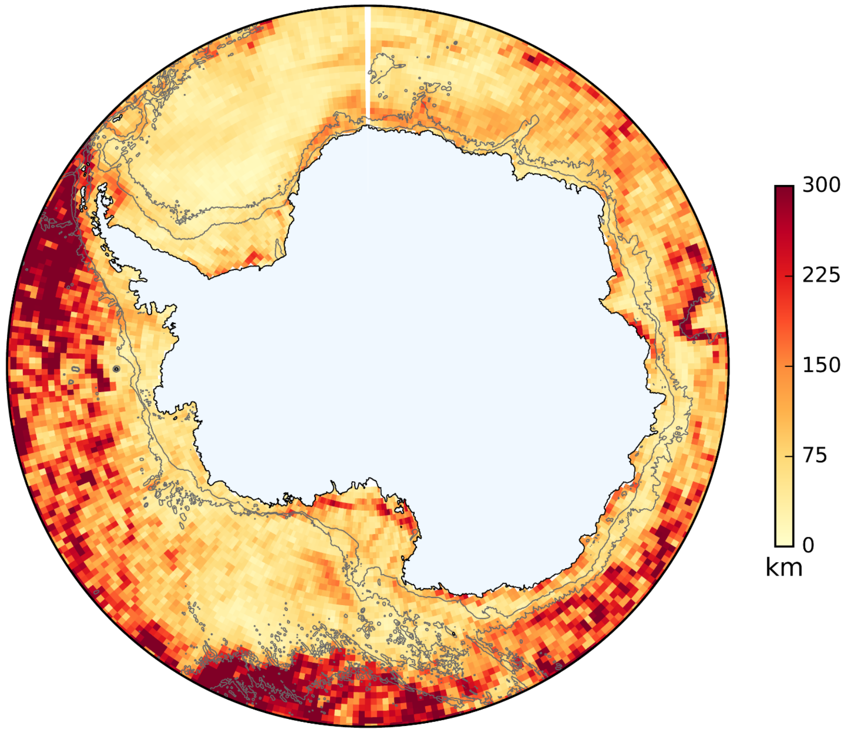

Fig. S3.
Mean net distance neutrally-buoyant particles seeded in January drift horizontally within 1 month from release. Particles are binned in 0.5° latitude by 1° longitude bins by starting location and the color indicates the average distance traveled (net horizontal distance in km) from the starting location of all particles released within each bin. Distances are large in the Antarctic Circumpolar Current (ACC) but generally shorter in the Weddell and Ross Gyres and coastal areas, except for some faster coastal currents.

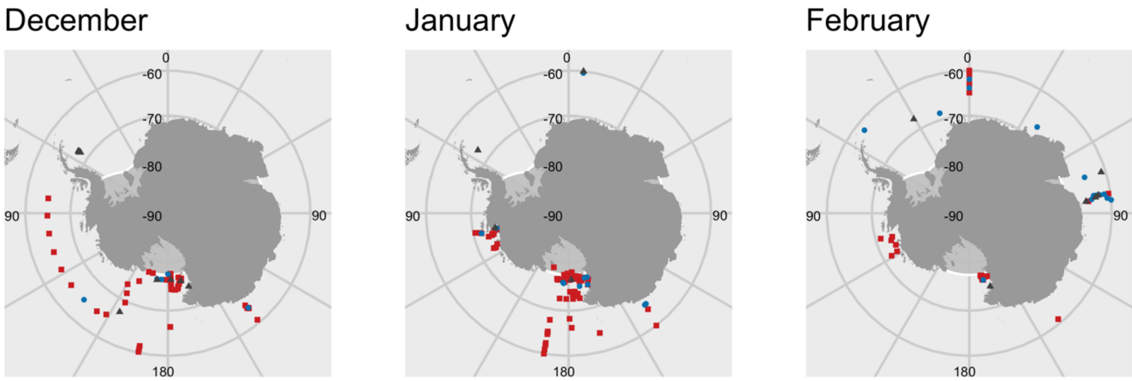

Fig. S4.

Monthly surface (0-100 m) DFe surface concentrations. Red squares = 0 – 0.25 = “limited”; Blue circles = >0.25 – 0.5 nM = “mildly-limited”; Grey pyramids = >0.5 = non-limited).

Table S1.

Summary of the literature analysis to constrain the onset of Iron limitation. Lon. is longitude. Lat. is latitude. Depth is the depth from where the incubated communities were collected (in m). DoE are the days of experiment. V. is the incubation volume (in L). Incub. indicates whether communities were incubated on the deck of a research vessel or in its laboratories. PAR is the photosynthetically active radiation the communities were exposed to during the experiments. Numbers are either given in µmol m^{-2} s^{-1} or as percentage of ambient light provided. L:D is the light/dark cycle (hour:hour) during a day. Ambient indicates an L:D cycle at the position of the research vessel during the experiment. T is the incubation temperature in °C. Ambient indicates a temperature at the position of the research vessel during the experiment. DFe, N, P, and Si are the background concentrations of dissolved iron, nitrate, phosphate, and silicate, in the batch of the incubated water when it was collected. Meth. indicates how growth rates were measured (chla = increase of chlorophyll a concentration; POC = increase of particulate organic carbon concentrations; NO3 = decrease of nitrate concentrations). μ_{+Fe} are the community growth rates in the +Fe treatment. μ_{-Fe} are the community growth rates in the un-amended controls. μ_{+Fe}/μ_{-Fe} is the fold-change in community growth rates due to Fe enrichment.

Reference	Lon.	Lat.	Depth	DoE	V.	Incub.	PAR	L:D	T	DFe	N	P	Si	Meth.	μ_{+Fe}	μ_{-Fe}	μ_{+Fe}/μ_{-Fe}
(Coale et al. 2003)	178.00	-76.50	25	8	20	Deck	120%	amb.	amb.	0.03	21.6	1.64	71	chla[a]	0.230	0.137	1.683
(Coale et al. 2003)	176.00	-74.30	25	13	20	Deck	120%	amb.	amb.	0.04	26.9	1.9	63.5	chla[a]	0.207	0.096	2.153
(Coale et al. 2003)	170.00	-62.30	50	18	20	Deck	120%	amb.	amb.	0.1	31.1	2.06	45.9	chla[a]	0.250	0.146	1.717
(Coale et al. 2003)	170.00	-59.30	50	16	20	Deck	120%	amb.	amb.	0.06	26.8	1.83	15.2	chla[a]	0.110	0.053	2.065
(Coale et al. 2003)	170.10	-67.80	20	15	20	Deck	120%	amb.	amb.	<0.03	25.1	1.56	59.8	chla[a]	0.260	0.071	3.646
(Coale et al. 2003)	170.10	-62.00	25	16	20	Deck	120%	amb.	amb.	0.11	22.6	1.43	4.9	chla[a]	0.120	0.036	3.337
(Bertrand et al. 2007)	-179.38	-74.43	5-8	6	1.1	Deck	20%	amb.	amb.	0.31	19.89	1.36	63.64	chla[b]	0.228	0.110	2.077
(Bertrand et al. 2007)	179.11	-76.00	5-8	9	1.1	Deck	20%	amb.	amb.	0.11	20	1.33	62	chla[c]	0.254	0.095	2.686

(Bertrand et al. 2007)	173.30	-75.00	5-8	8	1.1	Deck	20%	amb.	amb.	0.13	22.98	1.63	62	chla[c]	0.465	0.215	2.165
(Bertrand et al. 2007)	168.96	-76.65	10	7	0.0 6	Deck	20%	amb.	amb.	0.09	13.37	1.49	74.75	chla[c]	0.360	0.240	1.500
(Takeda 1998)	140.70	-64.20	10-15	7	12	Deck	40%	amb.	amb.	0.16	22.8	1.24	18.7	chla	0.430	0.130	3.308
(Takeda 1998)	140.70	-64.20	10-15	7	12	Deck	2.60 %	amb.	amb.	0.16	22.8	1.24	18.7	chla	0.400	0.130	3.077
(Cullen et al. 2003)	-170.10	-67.80	20	10.7	20	Deck	120%	amb.	amb.	0.03	25.1	1.54	60	chla	0.280	0.150	1.867
(Öztürk et al. 2004)	6.00	-56.5	15	13	12	Deck	50%	amb.	amb.	0.47	29		60	chla	0.323	0.236	1.368
(Sedwick et al. 2000)	179.95	-76.48	0.3	6	1.2	Deck	50%	amb.	amb.	0.82	27.5			chla[b]	0.167	0.306	0.545
(Sedwick et al. 2000)	170.73	-76.50	0.4	7	2.2	Deck	50%	amb.	amb.	2.2	26			chla[b]	0.335	0.335	1.000
(Van Leeuwe et al. 1997)	-6.20	-57.3			20	Lab	100	16:8	1	0.6	repl.	repl.	repl.	chla[d]	0.197	0.230	0.857
(Van Leeuwe et al. 1997)	-6.00	-48.82			20	Lab	100	16:8	1	0.5	repl.	repl.	repl.	chla[d]	0.280	0.215	1.302
(Van Leeuwe et al. 1997)	-6.00	-47			20	Lab	100	16:8	1	3.5	23	1.6	14	chla[d]	0.450	0.350	1.286
(Van Leeuwe et al. 1997)	-6.27	-59			20	Lab	100	16:8	1	0.5	repl.	repl.	repl.	chla[d]	0.385	0.345	1.116

(Sedwick et al. 2007)	173.23	-73.4	0.3		1	Deck	15%	amb.	0	0.38	20	1.5	55	chla[c]	0.390	0.386	1.008
(Sedwick et al. 2007)	173.23	-73.4	0.3		1	Deck	15%	amb.	0	0.38	20	1.5	55	chla[c]	0.210	0.179	1.169
(Timmermans et al. 1998)	-91.83	-67.21	40	3	20	Lab	80	8:16	3.5	0.31	24.72	1.73	14.22	chla	0.003	0.005	0.531
(Rose et al. 2009)	177.36	-75	surface		4.5	Deck	18%	amb.	0	0.15	25.8	1.9	68	chla	0.296	0.142	2.087
(Kustka et al. 2015)	178.00	-74.5	33-44	10	8	Lab	40	24:0	1.5	0.235	18.6		56.9	chla	0.258	0.099	2.606
(Kustka et al. 2015)	178.50	-72.58	25-35	9	8	Lab	40	24:0	1.5	0.188	27.7		58.5	chla	0.242	0.118	2.051
(Kustka et al. 2015)	176.65	-74.14	30-40	9	8	Lab	40	24:0	1.5	0.12	27.6		66	chla	0.262	0.105	2.495
(Kustka et al. 2015)	178.75	-74.20	25-35		8	Lab	40	24:0	1.5	0.127	22.4		61.4	chla	0.365	0.160	2.281
(Hopkinson et al. 2007)	-57.70	-60.5	20	7-14	4	Lab	218	24:0	2.5	0.14				chla	0.320	0.150	2.133
(Hopkinson et al. 2007)	-57.70	-60.5	85	7-14	4	Lab	37	24:0	2.5	0.12				chla	0.340	0.140	2.429
(Hopkinson et al. 2007)	-54.10	-59.6	25	7-14	50	Lab	185	24:0	2.5	0.09				chla	0.240	0.110	2.182
(Hopkinson et al. 2007)	-54.90	-59.4	20	11	4	Lab	139	24:0	2.5	0.11	22			chla	0.230	0.080	2.875

(Hopkinson et al. 2007)	-54.90	-59.4	50	7-14	4	Lab	34	24:0	2.5	0.31				chla	0.340	0.170	2.000
(Hopkinson et al. 2007)	-58.00	-61.2	20	7-14	4	Lab	218	24:0	2.5	1.74				chla	0.210	0.190	1.105
(Hopkinson et al. 2007)	-54.40	-60.9	20	14	4	Lab	218	24:0	2.5	1.59	28			chla	0.420	0.370	1.135
(Viljoen et al. 2018)	0.00	-65	30		2.4	Lab	25	amb.	0	0.19	25.2		74.3	chla[e]	0.230	0.130	1.769
(Viljoen et al. 2018)	0.00	-65	30		2.4	Lab	65	amb.	0	0.19	25.2		74.3	chla[e]	0.260	0.150	1.733
(Wu et al. 2019)	166.67	-77.85		7	0.3	Lab	80	24:0	0.5	1.01				chla	0.221	0.126	1.752
(Wu et al. 2019)	166.67	-77.85		8	0.3	Lab	80	24:0	0.5	0.47				chla	0.172	0.190	0.903
(Alderkamp et al. 2019)	177.51	-77	10.2	6	2	Deck	3%	amb.	-0.5	0.086	20.3	1.45	71.7	POC	0.180	0.124	1.452
(Alderkamp et al. 2019)	177.51	-77	10.2	6	2	Deck	30%	amb.	-0.5	0.086	20.3	1.45	71.7	POC	0.225	0.169	1.331
(Alderkamp et al. 2019)	177.50	-77.32	9.97	6	2	Deck	3%	amb.	-0.5	0.067	23.2	1.61	70.8	POC	0.208	0.141	1.475
(Alderkamp et al. 2019)	177.50	-77.32	9.97	6	2	Deck	30%	amb.	-0.5	0.067	23.2	1.61	70.8	POC	0.245	0.168	1.458
(Alderkamp et al. 2019)	171.00	-77	25.01	6	2	Deck	3%	amb.	-0.5	0.09	21.7	1.53	70.1	POC	0.120	0.092	1.304

(Alderkamp et al. 2019)	171.00	-77	25.01	6	2	Deck	30%	amb.	-0.5	0.09	21.7	1.53	70.1	POC	0.206	0.159	1.296
(Alderkamp et al. 2019)	171.00	-76.5	23.5	6	2	Deck	3%	amb.	-0.5	0.061	17.7	1.06	57.4	POC	0.067	0.024	2.792
(Alderkamp et al. 2019)	171.00	-76.5	23.5	6	2	Deck	30%	amb.	-0.5	0.061	17.7	1.06	57.4	POC	0.156	0.091	1.714
(Alderkamp et al. 2019)	10.03	-53.01	24	10-15	4	Lab	30	24:0	3	0.23	24.6	1.6	32.1	NO3[f]	0.052	0.031	1.692
(Endo et al. 2017)	140.05	-59	15	3.3	9	Lab	100	17:7	3.6	0.043	24.96	1.59	11.11	chla	0.351	0.103	3.400
(Endo et al. 2017)	110.00	-60	15	3.7	9	Lab	100	18.5: 5.5	2.5	0.052	25.82	1.61	29.54	chla	0.405	0.084	4.816
(Endo et al. 2017)	138.08	-60.35	15	4	9	Lab	100	19.25 :4.75	1	0.024	25.7	1.65	39.75	chla	0.482	0.462	1.042

[a]data extracted from plots except for the control.
[b]data extracted from plots. t_{end} was the value before N, P, or Si were limiting.
[c]data extracted from plots.
[d]the authors excluded the lag phase that occurred directly after the Fe addition
[e]the authors also measured POC based growth and these values were different to the chla based values. We chose their chla based values for consistency with most other datasets.
[f]the authors diluted the experiment multiple times. We used only values before the first dilution.

Table S2.

Summary of the literature analysis for growth vs. irradiance curve of Southern Ocean phytoplankton. I is the growth irradiance in µmol m^{-2} s^{-1}. L:D is the light:dark cycle of the incubation in hour:hour. PAR is the photosynthetically active radiation the communities were exposed to in mol m^{-2} d^{-1}. T is the incubation temperature in °C. Ambient indicates a temperature at the position of the research vessel during the experiment. N, P, and Si are the concentrations of dissolved nitrate, phosphate, and silicate during incubations. Rel. µ is the growth rate normalized to the maximum growth rate observed in a growth vs. irradiance curve. Exp. indicates that data belongs to the same growth vs. irradiance curve.

Authors	I	L:D	PAR	T	N	P	Si	Species	Rel. µ	Exp
(Strzepek et al. 2012)	570	24:0	49.2	3.0	300	10	100	*Phaeocystis antarctica*	0.82	1
(Strzepek et al. 2012)	400	24:0	34.6	3.0	300	10	100	*Phaeocystis antarctica*	1.00	1
(Strzepek et al. 2012)	98	24:0	8.5	3.0	300	10	100	*Phaeocystis antarctica*	0.61	1
(Strzepek et al. 2012)	57	24:0	4.9	3.0	300	10	100	*Phaeocystis antarctica*	0.64	1
(Strzepek et al. 2012)	34	24:0	2.9	3.0	300	10	100	*Phaeocystis antarctica*	0.45	1
(Strzepek et al. 2012)	18	24:0	1.6	3.0	300	10	100	*Phaeocystis antarctica*	0.42	1
(Strzepek et al. 2012)	8	24:0	0.7	3.0	300	10	100	*Phaeocystis antarctica*	0.21	1
(Strzepek et al. 2012)	3	24:0	0.3	3.0	300	10	100	*Phaeocystis antarctica*	0.15	1
(Strzepek et al. 2012)	100	24:0	8.6	3.0	300	10	100	*Phaeocystis antarctica*	1.00	2
(Strzepek et al. 2012)	70	24:0	6.0	3.0	300	10	100	*Phaeocystis antarctica*	0.97	2
(Strzepek et al. 2012)	30	24:0	2.6	3.0	300	10	100	*Phaeocystis antarctica*	0.91	2

(Strzepek et al. 2012)	10	24:0	0.9	3.0	300	10	100	*Phaeocystis antarctica*	0.67	2
(Strzepek et al. 2012)	3	24:0	0.3	3.0	300	10	100	*Phaeocystis antarctica*	0.47	2
(Strzepek et al. 2012)	100	24:0	8.6	3.0	300	10	100	*Proboscia inermis*	1.00	3
(Strzepek et al. 2012)	70	24:0	6.0	3.0	300	10	100	*Proboscia inermis*	0.92	3
(Strzepek et al. 2012)	30	24:0	2.6	3.0	300	10	100	*Proboscia inermis*	0.75	3
(Strzepek et al. 2012)	10	24:0	0.9	3.0	300	10	100	*Proboscia inermis*	0.44	3
(Strzepek et al. 2012)	3	24:0	0.3	3.0	300	10	100	*Proboscia inermis*	0.22	3
(Strzepek et al. 2012)	100	24:0	8.6	3.0	300	10	100	*Eucampia antarctica*	1.00	4
(Strzepek et al. 2012)	70	24:0	6.0	3.0	300	10	100	*Eucampia antarctica*	1.00	4
(Strzepek et al. 2012)	30	24:0	2.6	3.0	300	10	100	*Eucampia antarctica*	0.72	4
(Strzepek et al. 2012)	10	24:0	0.9	3.0	300	10	100	*Eucampia antarctica*	0.74	4
(Strzepek et al. 2012)	3	24:0	0.3	3.0	300	10	100	*Eucampia antarctica*	0.55	4
(Arrigo et al. 2010)	5	24:0	0.4	2.0	300	10	repl.	*Fragilariopsis cylindrus*	0.55	5
(Arrigo et al. 2010)	25	24:0	2.2	2.0	300	10	repl.	*Fragilariopsis cylindrus*	0.91	5
(Arrigo et al. 2010)	65	24:0	5.6	2.0	300	10	repl.	*Fragilariopsis cylindrus*	1.00	5
(Arrigo et al. 2010)	125	24:0	10.8	2.0	300	10	repl.	*Fragilariopsis cylindrus*	0.82	5
(Arrigo et al. 2010)	5	24:0	0.4	2.0	300	10		*Phaeocystis antarctica*	0.26	6

(Arrigo et al. 2010)	25	24:0	2.2	2.0	300	10		*Phaeocystis antarctica*	0.86	6
(Arrigo et al. 2010)	65	24:0	5.6	2.0	300	10		*Phaeocystis antarctica*	1.00	6
(Arrigo et al. 2010)	125	24:0	10.8	2.0	300	10		*Phaeocystis antarctica*	0.63	6
(Arrigo et al. 2010)	5	24:0	0.4	2.0	300	10		*Phaeocystis antarctica*	0.20	7
(Arrigo et al. 2010)	25	24:0	2.2	2.0	300	10		*Phaeocystis antarctica*	0.34	7
(Arrigo et al. 2010)	65	24:0	5.6	2.0	300	10		*Phaeocystis antarctica*	0.71	7
(Arrigo et al. 2010)	125	24:0	10.8	2.0	300	10		*Phaeocystis antarctica*	0.63	7
(Timmer mans et al. 2007)	15	16:8	0.8	4.0	80	5	80	*Chaetoceros brevis*	0.00	8
(Timmer mans et al. 2007)	18	16:8	1.0	4.0	80	5	80	*Chaetoceros brevis*	0.58	8
(Timmer mans et al. 2007)	38	16:8	2.2	4.0	80	5	80	*Chaetoceros brevis*	0.71	8
(Timmer mans et al. 2007)	45	16:8	2.6	4.0	80	5	80	*Chaetoceros brevis*	0.86	8
(Timmer mans et al. 2007)	65	16:8	3.7	4.0	80	5	80	*Chaetoceros brevis*	0.91	8
(Timmer mans et al. 2007)	78	16:8	4.5	4.0	80	5	80	*Chaetoceros brevis*	0.92	8
(Timmer mans et al. 2007)	100	16:8	5.7	4.0	80	5	80	*Chaetoceros brevis*	1.00	8
(Timmer mans et al. 2007)	12	16:8	0.7	4.0	80	5	80	*Thalassiosira antarctica*	0.01	9
(Timmer mans et al. 2007)	14	16:8	0.8	4.0	80	5	80	*Thalassiosira antarctica*	0.53	9
(Timmer mans et al. 2007)	30	16:8	1.7	4.0	80	5	80	*Thalassiosira antarctica*	0.68	9

(Timmer mans et al. 2007)	40	16:8	2.3	4.0	80	5	80	*Thalassiosira antarctica*	0.71	9
(Timmer mans et al. 2007)	70	16:8	4.0	4.0	80	5	80	*Thalassiosira antarctica*	0.86	9
(Timmer mans et al. 2007)	103	16:8	5.9	4.0	80	5	80	*Thalassiosira antarctica*	1.00	9
(Baumann et al. 1994)	4	24:0	0.3	-1.6	29	2	75	*Phaeocystis antartica*	0.20	10
(Baumann et al. 1994)	17	24:0	1.5	-1.6	29	2	75	*Phaeocystis antartica*	0.44	10
(Baumann et al. 1994)	51	24:0	4.4	-1.6	29	2	75	*Phaeocystis antartica*	0.65	10
(Baumann et al. 1994)	100	24:0	8.7	-1.6	29	2	75	*Phaeocystis antartica*	0.83	10
(Baumann et al. 1994)	161	24:0	13.9	-1.6	29	2	75	*Phaeocystis antartica*	0.95	10
(Baumann et al. 1994)	351	24:0	30.3	-1.6	29	2	75	*Phaeocystis antartica*	1.00	10
(Baumann et al. 1994)	5	24:0	0.4	1.0	29	2	75	*Phaeocystis antartica*	0.45	11
(Baumann et al. 1994)	19	24:0	1.6	1.0	29	2	75	*Phaeocystis antartica*	0.62	11
(Baumann et al. 1994)	52	24:0	4.5	1.0	29	2	75	*Phaeocystis antartica*	0.63	11
(Baumann et al. 1994)	101	24:0	8.7	1.0	29	2	75	*Phaeocystis antartica*	0.78	11
(Baumann et al. 1994)	161	24:0	13.9	1.0	29	2	75	*Phaeocystis antartica*	0.87	11
(Baumann et al. 1994)	353	24:0	30.5	1.0	29	2	75	*Phaeocystis antartica*	1.00	11

(Baumann et al. 1994)	4	24:0	0.3	-1.6	29	2	75	*Chaetoceros socialis*	0.13	12
(Baumann et al. 1994)	18	24:0	1.6	-1.6	29	2	75	*Chaetoceros socialis*	0.28	12
(Baumann et al. 1994)	50	24:0	4.3	-1.6	29	2	75	*Chaetoceros socialis*	0.43	12
(Baumann et al. 1994)	100	24:0	8.7	-1.6	29	2	75	*Chaetoceros socialis*	1.00	12
(Baumann et al. 1994)	160	24:0	13.8	-1.6	29	2	75	*Chaetoceros socialis*	0.50	12
(Baumann et al. 1994)	350	24:0	30.2	-1.6	29	2	75	*Chaetoceros socialis*	0.15	12
(Baumann et al. 1994)	5	24:0	0.4	1.0	29	2	75	*Chaetoceros socialis*	0.23	13
(Baumann et al. 1994)	19	24:0	1.7	1.0	29	2	75	*Chaetoceros socialis*	0.43	13
(Baumann et al. 1994)	52	24:0	4.5	1.0	29	2	75	*Chaetoceros socialis*	0.88	13
(Baumann et al. 1994)	101	24:0	8.8	1.0	29	2	75	*Chaetoceros socialis*	0.91	13
(Baumann et al. 1994)	162	24:0	14.0	1.0	29	2	75	*Chaetoceros socialis*	1.00	13
(Baumann et al. 1994)	352	24:0	30.4	1.0	29	2	75	*Chaetoceros socialis*	0.95	13
(Baumann et al. 1994)	3	24:0	0.3	-1.6	29	2	75	*Nitzschia curta*	0.16	14
(Baumann et al. 1994)	18	24:0	1.5	-1.6	29	2	75	*Nitzschia curta*	0.37	14
(Baumann et al. 1994)	50	24:0	4.4	-1.6	29	2	75	*Nitzschia curta*	1.00	14

(Baumann et al. 1994)	99	24:0	8.6	-1.6	29	2	75	*Nitzschia curta*	0.58	14
(Baumann et al. 1994)	160	24:0	13.8	-1.6	29	2	75	*Nitzschia curta*	0.37	14
(Baumann et al. 1994)	350	24:0	30.3	-1.6	29	2	75	*Nitzschia curta*	0.36	14
(Baumann et al. 1994)	5	24:0	0.4	1.0	29	2	75	*Nitzschia curta*	0.25	15
(Baumann et al. 1994)	18	24:0	1.6	1.0	29	2	75	*Nitzschia curta*	0.63	15
(Baumann et al. 1994)	51	24:0	4.4	1.0	29	2	75	*Nitzschia curta*	1.00	15
(Baumann et al. 1994)	100	24:0	8.6	1.0	29	2	75	*Nitzschia curta*	0.93	15
(Baumann et al. 1994)	159	24:0	13.8	1.0	29	2	75	*Nitzschia curta*	0.91	15
(Baumann et al. 1994)	350	24:0	30.2	1.0	29	2	75	*Nitzschia curta*	0.91	15
(Baumann et al. 1994)	4	24:0	0.4	-1.6	29	2	75	*Thalassiosira tumida*	0.00	16
(Baumann et al. 1994)	18	24:0	1.5	-1.6	29	2	75	*Thalassiosira tumida*	0.27	16
(Baumann et al. 1994)	52	24:0	4.5	-1.6	29	2	75	*Thalassiosira tumida*	0.74	16
(Baumann et al. 1994)	101	24:0	8.7	-1.6	29	2	75	*Thalassiosira tumida*	1.00	16
(Baumann et al. 1994)	160	24:0	13.8	-1.6	29	2	75	*Thalassiosira tumida*	0.94	16
(Baumann et al. 1994)	351	24:0	30.3	-1.6	29	2	75	*Thalassiosira tumida*	0.74	16

(Baumann et al. 1994)	4	24:0	0.3	1.0	29	2	75	*Thalassiosira tumida*	0.10	17
(Baumann et al. 1994)	18	24:0	1.5	1.0	29	2	75	*Thalassiosira tumida*	0.47	17
(Baumann et al. 1994)	50	24:0	4.3	1.0	29	2	75	*Thalassiosira tumida*	0.89	17
(Baumann et al. 1994)	100	24:0	8.7	1.0	29	2	75	*Thalassiosira tumida*	1.00	17
(Baumann et al. 1994)	160	24:0	13.8	1.0	29	2	75	*Thalassiosira tumida*	0.99	17
(Baumann et al. 1994)	351	24:0	30.4	1.0	29	2	75	*Thalassiosira tumida*	0.89	17

Table S3.
Sources of the required mean climatologies for salinity, temperature, dissolved oxygen, phosphate, silicate, nitrate, total alkalinity (TA), pCO_2, wind speed, and sea-ice concentration for the Southern Ocean south of 60°S. Daily mean climatologies were generated for sea-ice concentration, wind speed, temperature and salinity for calculations of air-sea gas exchange. Coarser, monthly mean climatologies were used for carbonate parameters, as the spatiotemporal variability of these data has a small influence on CO_2 equilibration time-scales (Jones et al. 2014). Mean climatologies were bi-linearly interpolated along MOM01 particle trajectories (position saved every 5 days), without linear interpolation between months to avoid significant data loss due to sea-ice coverage.
WOA https://www.nodc.noaa.gov/OC5/woa18/woa18data.html
CCMP http://data.remss.com/ccmp/v02.0
NSIDC https://nsidc.org/data/seaice_index/archives
OISST https://www.ncdc.noaa.gov/oisst

Variable	Time period	Source	Resolution
surface salinity	All data	WOA (0-10m average) (Boyer et al. 2018)	1x1 degree, monthly
dissolved oxygen	All data	WOA (0-10m average) (Boyer et al. 2018)	1x1 degree, monthly
phosphate	All data	WOA (0-10m average)	1x1 degree, monthly

		(Boyer et al. 2018)	
silicate	All data	WOA (0-10m average) (Boyer et al. 2018)	1x1 degree, monthly
nitrate	All data	WOA (0-10m average) (Boyer et al. 2018)	1x1 degree, monthly
temperature	2010-2018	NOAA OISST (Huang et al. 2021)	0.25x0.25 degree, daily
$pCO_{2\ sea}$	2010-2016	(Gregor et al. 2019)	1x1 degree, monthly
wind speed	2010-2018	CCMP reanalysis (Wentz et al. 2015)	0.25x0.25 degree, daily
sea-ice	2010-2018	NSIDC (Maslanik and Stroeve 1999)	25 km x 25 km, daily

Table S4.

Export-ratios compiled for all available data from the Southern Ocean south of 60°S. Export-ratios were calculated as the ratio of particulate organic carbon (POC) flux at 100 m to net primary productivity (NPP) integrated over the euphotic zone. Flux data and locations were extracted from the given references. The applied method (Sediment trap or Thorium-based) is provided in the "Method" column. The NPP data were satellite-derived, using a 8 day climatology calculated with the CAFE algorithm (Silsbe et al. 2016) available at http://sites.science.oregonstate.edu/ocean.productivity/index.php. NPP values were spatially averaged over a 0.25 x 0.25° box centered on the location of flux measurements, and temporally averaged over 16 days in case of Thorium-based fluxes (^{234}Th residence time; (Henson et al. 2011)) or over the duration of trap deployments to better account for horizontal advection and export time-lags (Laws and Maiti 2019). Six export-ratios exceeding 1 (i.e. export flux > NPP) were removed from the analysis.

Reference	**Latitude**	**Longitude**	**Date**	**Method**	**Export-ratio**
(Asper and Smith 1999)	-77.1	173.1	23/11/94	Trap	0.179
(Asper and Smith 1999)	-76.6	173	6/12/94	Trap	0.088

(Asper and Smith 1999)	-76.5	172.9	18/11/94	Trap	0.054
(Asper and Smith 1999)	-76.5	171.8	24/12/95	Trap	0.180
(Asper and Smith 1999)	-76.5	170.8	27/12/95	Trap	0.148
(Asper and Smith 1999)	-76.5	165	2/1/96	Trap	0.160
(Asper and Smith 1999)	-76.5	177.6	7/1/96	Trap	0.177
(Asper and Smith 1999)	-76.5	165	12/1/96	Trap	0.166
(Cochran et al. 2000)	-76.5	-175.6	19/1/97	Thorium	0.204
(Cochran et al. 2000)	-76.5	-175.6	1/1/97	Thorium	0.707
(Cochran et al. 2000)	-76.5	-175.6	14/2/97	Thorium	0.294
(Cochran et al. 2000)	-76.5	165.8	13/1/97	Thorium	0.230
(Cochran et al. 2000)	-76.5	165.8	8/2/97	Thorium	0.962
(Cochran et al. 2000)	-76.5	165.8	18/2/97	Thorium	0.758
(Cochran et al. 2000)	-76.5	-175.6	19/1/97	Thorium	0.120
(Cochran et al. 2000)	-76.5	-175.6	1/2/97	Thorium	0.557
(Cochran et al. 2000)	-76.5	-165.8	13/1/97	Thorium	0.399
(Asper and Smith 1999)	-75	173	27/11/94	Trap	0.230
(Langone et al. 1997)	-74.7	175	13/12/94	Trap	0.007
(Langone et al. 1997)	-74	175	12/12/94	Trap	0.005
(Cochran et al. 2000)	-73.5	-175.4	24/1/97	Thorium	0.269
(Rodriguez y Baena et al. 2008)	-70.5667	-9.0333	20/12/03	Thorium	0.168
(Rodriguez y Baena et al. 2008)	-70.4667	-9.2	20/12/03	Thorium	0.051
(Rodriguez y Baena et al. 2008)	-70.3667	-9.3333	19/12/03	Thorium	0.025
(Rutgers van der Loeff et al. 2011)	-69.4	0	11/3/08	Thorium	0.240
(Rutgers van der Loeff et al. 2011)	-69.05	-17.35	15/3/08	Thorium	0.183

(Rutgers van der Loeff et al. 2011)	-69	-6.9	13/3/08	Thorium	0.109
(Rutgers van der Loeff et al. 2011)	-68.5	0	10/3/08	Thorium	0.081
(Buesseler et al. 2001)	-67.8	-170.1	17/1/98	Thorium	0.321
(Buesseler et al. 2003)	-67.8	-170	16/1/98	Thorium	0.357
(Shimmield et al. 1995)	-67.6	-84.9	7/12/92	Thorium	0.392
(Buesseler 1998)	-67.6	-84.9	15/11/92	Thorium	0.288
(Buesseler et al. 2001)	-67	-170	28/1/98	Thorium	0.347
(Buesseler et al. 2001)	-67	-170	15/2/98	Thorium	0.543
(Rutgers van der Loeff et al. 2011)	-66.93	-25.28	17/3/08	Thorium	0.160
(Rutgers van der Loeff et al. 2011)	-66.46	0	8/3/08	Thorium	0.123
(Buesseler et al. 2001)	-66.1	-168.7	28/2/98	Thorium	0.690
(Buesseler et al. 2003)	-66.1	-170	26/2/98	Thorium	0.713
(Buesseler et al. 2005)	-66	-172.5	29/1/02	Thorium	0.041
(Buesseler et al. 2005)	-66	-172.5	30/1/02	Thorium	0.082
(Buesseler et al. 2005)	-66	-172.5	3/2/02	Thorium	0.235
(Buesseler et al. 2005)	-66	-172.5	13/2/02	Thorium	0.304
(Buesseler et al. 2005)	-66	-172.5	19/2/02	Thorium	0.150
(Buesseler et al. 2005)	-66	-172.5	20/2/02	Thorium	0.376
(Rutgers van der Loeff et al. 2011)	-66	-32.76	20/3/08	Thorium	0.114
(Buesseler et al. 2001)	-65.2	-170.1	28/1/98	Thorium	0.903
(Buesseler et al. 2003)	-65.2	-170	27/1/98	Thorium	0.894
(Buesseler et al. 2001, 2003)	-65.167	-170.1	28/1/98	Thorium	0.903
(Rutgers van der Loeff et al. 2011)	-65.11	-40.31	22/3/08	Thorium	0.133
(Buesseler et al. 2001, 2003)	-64.833	-170.1	18/1/98	Thorium	0.597

(Buesseler et al. 2001)	-64.8	-170.1	18/1/98	Thorium	0.593
(Buesseler et al. 2003)	-64.8	-170	17/1/98	Thorium	0.694
(Rutgers van der Loeff et al. 2011)	-64.78	-42.88	23/3/08	Thorium	0.258
(Buesseler et al. 2001)	-64.7	-169.2	18/12/97	Thorium	0.302
(Buesseler et al. 2001)	-64.7	-169.3	8/3/98	Thorium	0.553
(Buesseler et al. 2001, 2003)	-64.7	-169.333	8/3/98	Thorium	0.556
(Buesseler et al. 2003)	-64.7	-170	17/12/97	Thorium	0.310
(Buesseler et al. 2003)	-64.7	-170	7/3/98	Thorium	0.557
(Buesseler et al. 2001, 2003)	-64.673	-169.186	18/12/97	Thorium	0.302
(Rutgers van der Loeff et al. 2011)	-64.48	0	28/2/08	Thorium	0.123
(Buesseler et al. 2001)	-64.2	-169.2	16/12/97	Thorium	0.136
(Buesseler et al. 2003)	-64.2	-170	16/12/97	Thorium	0.122
(Buesseler et al. 2001, 2003)	-64.153	-169.186	16/12/97	Thorium	0.139
(Rutgers van der Loeff et al. 2011)	-64.03	-48.26	25/3/08	Thorium	0.155
(Buesseler et al. 2001)	-63.5	-170	25/12/97	Thorium	0.250
(Buesseler et al. 2001)	-63.5	-170	28/1/98	Thorium	0.533
(Buesseler et al. 2001)	-63.5	-170	15/2/98	Thorium	0.312
(Rutgers van der Loeff et al. 2011)	-63.46	-52.1	28/3/08	Thorium	0.280
(Le Moigne et al. 2016)	-63.45	-25.28	3/2/13	Thorium	0.210
(Rutgers van der Loeff et al. 2011)	-63.35	-52.85	29/3/08	Thorium	0.199
(Buesseler et al. 2001)	-63.1	-169.2	19/12/97	Thorium	0.288
(Buesseler et al. 2001)	-63.1	-169.9	24/2/98	Thorium	0.581
(Buesseler et al. 2003)	-63.1	-170	18/12/97	Thorium	0.293
(Buesseler et al. 2003)	-63.1	-170	23/2/98	Thorium	0.601

(Buesseler et al. 2001, 2003)	-63.087	-169.186	19/12/97	Thorium	0.288
(Buesseler et al. 2001, 2003)	-63.083	-169.883	24/2/98	Thorium	0.582
Charette unpublished	-62.553	-59.348	24/1/06	Thorium	0.097
(Buesseler et al. 2001)	-62.5	-170	4/11/97	Thorium	0.518
(Buesseler et al. 2003)	-62.4	-170	27/10/97	Thorium	0.587
(Buesseler et al. 2001, 2003)	-62.317	-170.003	28/10/97	Thorium	0.604
Charette unpublished	-62.254	-62.997	16/1/06	Thorium	0.241
Charette unpublished	-62.25	-58.002	24/1/06	Thorium	0.208
(Buesseler et al. 2001, 2003)	-62.033	-170.1	20/1/98	Thorium	0.532
(Buesseler et al. 2001)	-62	-170.1	20/1/98	Thorium	0.532
(Buesseler et al. 2001)	-62	-170.1	25/1/98	Thorium	0.278
(Buesseler et al. 2001, 2003)	-62	-170.1	25/1/98	Thorium	0.278
(Buesseler et al. 2003)	-62	-170	24/1/98	Thorium	0.262
(Buesseler et al. 2003)	-62	-170	19/1/98	Thorium	0.524
Charette unpublished	-61.999	-54.998	23/1/06	Thorium	0.190
Charette unpublished	-61.749	-59.029	19/1/06	Thorium	0.066
Charette unpublished	-61.748	-57.007	21/1/06	Thorium	0.290
Charette unpublished	-61.748	-55.752	22/1/06	Thorium	0.215
Charette unpublished	-61.747	-62	17/1/06	Thorium	0.646
(Buesseler et al. 2001)	-61.7	-168.8	14/12/97	Thorium	0.194
(Buesseler et al. 2001)	-61.7	-170.1	11/3/98	Thorium	0.185
(Buesseler et al. 2003)	-61.7	-170	13/12/97	Thorium	0.197
(Buesseler et al. 2003)	-61.7	-170	9/3/98	Thorium	0.177
(Buesseler et al. 2001, 2003)	-61.667	-168.833	14/12/97	Thorium	0.194

(Buesseler et al. 2001, 2003)	-61.667	-170.1	11/3/98	Thorium	0.185
Charette unpublished	-61.5	-60.491	18/1/06	Thorium	0.419
Charette unpublished	-61.5	-55.001	23/1/06	Thorium	0.152
Charette unpublished	-61.5	-54	23/1/06	Thorium	0.115
(Rutgers van der Loeff et al. 2011)	-61.48	0	27/2/08	Thorium	0.097
(Buesseler et al. 2001, 2003)	-60.917	-169.253	12/12/97	Thorium	0.415
(Buesseler et al. 2001)	-60.9	-169.3	12/12/97	Thorium	0.413
(Buesseler et al. 2003)	-60.9	-170	11/12/97	Thorium	0.420
(Buesseler et al. 2001)	-60.5	-169	1/11/97	Thorium	0.547
(Buesseler et al. 2001, 2003)	-60.5	-169	1/11/97	Thorium	0.548
(Buesseler et al. 2003)	-60.5	-170	31/10/97	Thorium	0.568
Charette unpublished	-60.261	-57.517	20/1/06	Thorium	0.123
Charette unpublished	-60.244	-57.01	21/1/06	Thorium	0.106
(Buesseler et al. 2001, 2003)	-60.233	-170.067	22/2/98	Thorium	0.478
(Buesseler et al. 2001, 2003)	-60.231	-170.071	10/12/97	Thorium	0.198
(Buesseler et al. 2001)	-60.2	-170.1	10/12/97	Thorium	0.198
(Buesseler et al. 2001)	-60.2	-170.1	22/2/98	Thorium	0.478
(Buesseler et al. 2003)	-60.2	-170	10/12/97	Thorium	0.194
(Buesseler et al. 2003)	-60.2	-170	20/2/98	Thorium	0.487
(Rutgers van der Loeff et al. 2011)	-60.1	-55.26	2/4/08	Thorium	0.490
(Buesseler et al. 2001)	-60	-170	4/11/97	Thorium	0.467
(Buesseler et al. 2001)	-60	-170	25/12/97	Thorium	0.274
(Buesseler et al. 2001)	-60	-170	15/2/98	Thorium	0.442
(Le Moigne et al. 2016)	-60	-29.48	5/2/13	Thorium	0.670

Table S5.

All available b-values compiled for the Southern Ocean south of 60°S. All data that were available and accessible in the peer-reviewed literature were considered for the calculations of a b-value. b-values were calculated based on carbon fluxes from at least 3 depth levels by fitting the power-law function (Martin et al. 1987) given in equation 5 in the main text to the flux data. Flux data were based on 3 different methods as indicated for each value (Sediment trap, Thorium-based, or estimated with underwater cameras (UVP)). We note that UVP-derived flux estimates have been validated before by Guidi et al. (2015), who found no statistical difference to thorium-derived flux estimates. All b-values are within a reasonable range (Berelson 2001), except for one outlier (3.95 (i.e., very high rates of POC flux attenuation) from (Asper and Smith 1999)) which we removed from the analysis.

Reference	Latitude	Longitude	Date	Method	b-value
(Cochran et al. 2000)	-76.5	-178	2/11/96	Thorium	1.37
(Cochran et al. 2000)	-76.5	-178	19/1/97	Thorium	1.22
(Cochran et al. 2000)	-76.5	-178	1/2/97	Thorium	0.51
(Cochran et al. 2000)	-76.5	165.9	13/1/97	Thorium	0.47
(Cochran et al. 2000)	-76.5	165.9	8/2/97	Thorium	1.58
(Guidi et al. 2015)	-58.83	-21.25	20/10/95	UVP	1.26
(Guidi et al. 2015)	-58.83	-21.27	20/10/95	UVP	1.28
(Guidi et al. 2015)	-58.83	-21.22	20/10/95	UVP	1.37
(Guidi et al. 2015)	-58.67	-28.62	23/10/95	UVP	0.90
(Guidi et al. 2015)	-58.67	-31.17	24/10/95	UVP	0.95
(Guidi et al. 2015)	-58.67	-31.2	24/10/95	UVP	0.76
(Asper and Smith 1999)	-76.5	168.5	17/11/94	Trap	3.95
(Asper and Smith 1999)	-77.1	173.1	23/11/97	Trap	1.38
(Asper and Smith 1999)	-75	173	27/11/94	Trap	0.97

(Asper and Smith 1999)	-76.6	173	6/12/94	Trap	1.30
(Asper and Smith 1999)	-76.5	171.8	24/12/95	Trap	1.02
(Asper and Smith 1999)	-76.5	170.8	27/12/95	Trap	1.97
(Asper and Smith 1999)	-76.5	165	2/1/96	Trap	0.74
(Asper and Smith 1999)	-76.5	-177.6	7/1/96	Trap	0.72
(Asper and Smith 1999)	-76.5	165	21/1/96	Trap	0.56
(Buesseler et al. 2005)	-66.34	-171.96	30/1/02	Thorium	0.96
(Buesseler et al. 2005)	-66.34	-171.96	30/1/02	Thorium	1.10
(Buesseler et al. 2005)	-65.91	-170.79	19/2/02	Thorium	0.25
(Berelson 2001)	-61.5	-170	spring/summer (1997-1998)	Thorium, Trap	0.88
(Berelson 2001)	-65.5	-170	spring/summer (1997-1998)	Thorium, Trap	0.77
(Berelson 2001)	-68	-170	spring/summer (1997-1998)	Thorium, Trap	0.86
(Cavan et al. 2015)	-60.97	-48.14	3/2/13	MSC	1.51
(Cavan et al. 2015)	-60.97	-48.14	4/2/13	MSC	1.89
(Cavan et al. 2015)	-60.97	-48.14	5/2/13	MSC	1.03
(Shimmield et al. 1995)	-67.6	-84.93	7/12/92	Thorium	0.31
(Langone et al. 1997)	-74	175	12/12/94	Trap	0.70
(Langone et al. 1997)	-74.7	175	13/12/94	Trap	0.58

Table S6.

Operational cost estimates of OIF ($US per km^2 of fertilized area) for different assumptions of fertilizer costs, daily ship costs, the distance to the OIF site, and the fraction of iron that becomes bioavailable (e.g. 0.8 means that 80% becomes bioavailable and 20% of the added Fe is lost due to inorganic particle sinking). The cost calculation equations are provided in the methods.

Fertilizer costs (US$ t^{-1})	**Ship costs ($US d^{-1})**	**Inorganic particle sinking (fraction from 0-1)**	**Operational costs ($US km^{-2})**
600	5000	0.2	101
600	5000	0.5	51
600	5000	0.8	39
600	7000	0.2	124
600	7000	0.5	65
600	7000	0.8	50
900	5000	0.2	121
900	5000	0.5	60
900	5000	0.8	44
900	7000	0.2	145
900	7000	0.5	74
900	7000	0.8	55

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