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Dimethyl sulfide (DMS) climatologies, fluxes, and trends – Part 2: Sea–air fluxes

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Supplementary Tables :

Table S1: Monthly binned and averaged in situ Flux data at 1°×1° resolution.

Month	Year	Latitude	Longitude	In Situ DMS Flux (μmol m^{-2} d^{-1})	References
9	1991	0	160	1.6	(Marandino et al., 2007)
9	1991	5	126	0.8	
9	1991	13	160	0.6	(Marandino et al., 2008)
9	1991	17	130	3	
9	1991	20	127	1	(Marandino et al., 2009)
9	1991	27	136	2.2	
9	1991	28	147	0.7	(Yang et al., 2011)
9	1991	29	147	2.4	
10	1991	20	-155	0.8	(Bell et al., 2015)
2	1994	16	146	1.4	
2	1994	136	147	1.5	(Blomquist et al., 2017)
3	1994	1	146	1.9	
11	1995	-54	159	0.4	(Omori et al., 2017)
11	1995	-53	138	1.3	
11	1995	-48	137	0.6	(Smith et al., 2018)
11	1995	-47	146	1.2	
11	1995	-44	151	2.6	(Shon et al., 2001)
11	1995	-41	144	6.6	
12	1995	-51	157	3.5	(Leck and Persson, 1996)
12	1995	-50	148	2.8	
12	1995	-47	151	2.6	(Sharma et al., 1999)
12	1995	-46	146	2.2	
12	1995	-46	149	2.2	(Land et al., 2014)
12	1995	-45	144	2.75	
12	1995	-42	142	2.4	
12	1995	-41	139	0.9	
6	2000	41	-71	6.2	
11	2003	-8	-109	11.4	
11	2003	-8	-108	8.72	
11	2003	-8	-107	9.08	
11	2003	-8	-106	6.6	
11	2003	-8	-105	7.85	

11	2003	-8	-104	6.54
11	2003	-8	-103	9
11	2003	-8	-102	8.08
11	2003	-8	-101	7.675
11	2003	-8	-100	6.1
11	2003	-8	-99	7.94
11	2003	-8	-98	8.125
11	2003	-8	-97	6.64
11	2003	-8	-96	7.275
11	2003	-8	-95	6.64
11	2003	-7	-95	8.5
11	2003	-6	-95	6.22
11	2003	-5	-95	4.2
11	2003	-4	-95	5.35
11	2003	-3	-110	5.5
11	2003	-3	-95	7.233333
11	2003	-2	-110	3.716667
11	2003	-2	-95	2.7625
11	2003	-1	-110	2.4
11	2003	-1	-95	1.1
11	2003	0	-110	2.1
11	2003	0	-100	7.1
11	2003	0	-95	7.084615
11	2003	1	-95	8.236364
11	2003	1	-94	6.1
11	2003	1	-93	4.25
11	2003	1	-92	4.9
11	2003	2	-110	9.5
11	2003	2	-95	9.7625
11	2003	2	-92	5.25
11	2003	2	-91	6.975
11	2003	2	-90	7.25
11	2003	3	-110	12.5
11	2003	3	-95	7.844444
11	2003	3	-90	10.35
11	2003	3	-89	13.925
11	2003	3	-88	15.6

11	2003	4	-110	16.64
11	2003	4	-95	6.3875
11	2003	4	-88	16.65
11	2003	4	-87	9.72
11	2003	4	-86	7.35
11	2003	5	-110	5.68
11	2003	5	-95	3.52
11	2003	7	-95	4.566667
11	2003	8	-110	2.25
11	2003	8	-109	2.95
11	2003	8	-107	4.2
11	2003	8	-106	1.7
11	2003	8	-96	3.9
11	2003	8	-95	2.15
5	2004	5	168	1.105333
5	2004	5	169	1.66
5	2004	6	165	3.913333
5	2004	6	166	9.78
5	2004	7	161	3.083333
5	2004	7	162	3.925
5	2004	7	163	4.835
5	2004	8	159	2.4425
5	2004	8	160	2.4425
5	2004	9	155	3.36
5	2004	9	156	3.432857
5	2004	9	157	2.06
5	2004	10	155	4.705
5	2004	12	147	2.535
5	2004	12	148	1.43
6	2004	0	-166	9.3
6	2004	0	-165	8.403333
6	2004	1	-167	8.67
6	2004	1	-165	6.3325
6	2004	1	-164	10.33
6	2004	2	-164	8.845
6	2004	2	-163	10.495
6	2004	4	-162	8.215

6	2004	4	-161	6.26
6	2004	4	-156	3.64
6	2004	5	-160	8.005
6	2004	6	-160	10.6
6	2004	7	-157	6.67
6	2004	8	-158	5.31
6	2004	21	-156	6.05
6	2004	22	-157	3.85
6	2004	23	-155	2.89
6	2004	25	-154	4.605
6	2004	26	-155	4.675
6	2004	28	-154	2.92
6	2004	45	-144	2.19
7	2004	29	-75	1.7
7	2004	29	-74	4.42
7	2004	29	-73	5.1
7	2004	29	-64	7.236
7	2004	29	-63	6.022222
7	2004	30	-73	5.433333
7	2004	30	-72	4.48
7	2004	30	-71	5.8
7	2004	30	-70	6.95
7	2004	30	-66	6.4
7	2004	30	-65	6.465517
7	2004	30	-64	6.2
7	2004	31	-69	5.5
7	2004	31	-66	7.030303
7	2004	31	-65	5.696429
8	2004	28	-71	7.775
8	2004	28	-70	6.3
8	2004	28	-69	9.5
8	2004	29	-69	7.35
8	2004	29	-68	17.05
8	2004	29	-67	4.45
8	2004	29	-66	5.85
8	2004	29	-65	4.5
8	2004	29	-64	2.8

8	2004	30	-60	6.2
1	2006	-35	-103	5.8
1	2006	-34	-103	6.505
1	2006	-33	-103	4.35
1	2006	-28	-103	1.48
1	2006	-27	-103	1.135
1	2006	-26	-103	1.17
1	2006	-24	-103	3.165
1	2006	-23	-103	2.46
1	2006	-19	-105	8.08
1	2006	-18	-105	5.48
1	2006	-16	-106	43.4
1	2006	-15	-107	36.15
1	2006	-12	-108	37.55
1	2006	-11	-109	15.1
1	2006	-11	-108	19.4
1	2006	-10	-109	7.52
1	2006	-9	-110	6.48
1	2006	-7	-110	5.88
1	2006	-6	-110	12.3
1	2006	-4	-110	11.4
1	2006	-3	-110	7.925
1	2006	-2	-110	7.385
1	2006	-1	-110	8.82
6	2007	43	-18	4.516364
6	2007	44	-18	3.2
7	2007	42	-18	1.657576
7	2007	42	-17	1.738462
7	2007	42	-16	1.314286
7	2007	43	-65	9.643333
7	2007	43	-64	3.18
7	2007	43	-18	2.565
7	2007	43	-17	1
7	2007	43	-16	2.356452
7	2007	44	-63	0.475
7	2007	44	-62	2.29
7	2007	44	-61	2.855

7	2007	44	-60	3.345
7	2007	44	-59	0.555
7	2007	44	-18	3.35
7	2007	44	-16	3.6
7	2007	44	-15	1.6
7	2007	45	-59	3.42925
7	2007	45	-58	5.342
7	2007	45	-57	0.698
7	2007	45	-56	0.785333
7	2007	45	-20	5.2
7	2007	46	-56	1.0135
7	2007	46	-55	2.39
7	2007	46	-54	4.677143
7	2007	46	-53	2.85
7	2007	47	-52	1.77
7	2007	47	-51	2.32
7	2007	47	-15	0.2
7	2007	48	-51	2.756667
7	2007	48	-50	4.53
7	2007	48	-49	3.62
7	2007	49	-49	7.515833
7	2007	49	-48	11.24333
7	2007	50	-48	13.4
7	2007	50	-47	16.16
7	2007	50	-46	9.953333
7	2007	51	-46	12.38333
7	2007	51	-45	7.863333
7	2007	51	-44	4.11
7	2007	52	-44	2.56
7	2007	52	-43	4.972857
7	2007	52	-42	5.46
7	2007	52	-15	15.1
7	2007	53	-42	5.613333
7	2007	53	-41	17.77
7	2007	53	-40	9.71
7	2007	53	-15	19.86667
7	2007	53	-14	33.4

7	2007	54	-14	19.2
7	2007	54	-13	19.88571
7	2007	54	-12	8.866667
7	2007	55	-12	18.4
7	2007	55	-11	16.05
7	2007	55	-10	10.36667
7	2007	55	-9	6.5
3	2008	-54	-37	1.484615
3	2008	-53	-37	0.7
3	2008	-52	-38	2.35
3	2008	-52	-37	2.15
3	2008	-51	-39	2.630435
3	2008	-51	-38	4.568376
3	2008	-51	-37	2.811864
3	2008	-51	-36	0.6
3	2008	-50	-39	5.26
3	2008	-50	-38	3.65
3	2008	-50	-37	2.933333
4	2008	-52	-37	1.7
4	2008	-51	-38	0.7
4	2008	-51	-37	1.326667
4	2008	-50	-40	2.9
4	2008	-46	-46	1.2
4	2008	-45	-47	1.55
4	2008	-45	-46	2.175
10	2008	-20	-86	2.873684
10	2008	-20	-85	4.696154
10	2008	-20	-84	7.38
10	2008	-20	-83	8.42
10	2008	-20	-82	7.86
10	2008	-20	-81	8.86
10	2008	-20	-80	10.08
10	2008	-20	-79	5.116667
10	2008	-20	-78	4.32
10	2008	-20	-77	3.9
10	2008	-20	-76	5.64
10	2008	-20	-75	3.805

10	2008	-19	-86	8.3
10	2008	-19	-85	6.175
10	2008	-18	-85	4.16
10	2008	-17	-85	4.383333
10	2008	-16	-85	4.98
10	2008	-15	-85	2.76
10	2008	-14	-85	1.92
10	2008	-13	-85	3.5
10	2008	-12	-85	5.52
10	2008	-11	-85	5.366667
10	2008	-10	-85	6.4
10	2008	-9	-85	2.9
10	2008	-8	-85	0.883333
10	2008	-7	-85	2.9
10	2008	-7	-84	1.8
10	2008	-6	-84	2.828571
10	2008	-5	-84	1.84
10	2008	-4	-84	1.3
10	2008	-4	-83	1.725
10	2008	-3	-83	16.56
10	2008	-2	-83	14
10	2008	-1	-83	3.3
11	2008	-22	-80	3.4
11	2008	-22	-74	1.92
11	2008	-22	-72	2.9625
11	2008	-22	-71	0.45
11	2008	-22	-70	0.6
11	2008	-21	-85	2.43913
11	2008	-21	-84	2.844444
11	2008	-21	-83	3.441667
11	2008	-21	-82	3.364286
11	2008	-21	-81	1.933333
11	2008	-21	-80	2.263636
11	2008	-21	-79	5.1
11	2008	-21	-75	3.675
11	2008	-21	-74	1.8
11	2008	-20	-85	2.016667

11	2008	-20	-84	3.495455
11	2008	-20	-78	5.38
11	2008	-20	-77	2.62
11	2008	-20	-76	1.91875
11	2008	-20	-75	2.773913
11	2008	-20	-73	2
11	2008	-20	-72	1.718182
11	2008	-19	-84	2.155556
11	2008	-19	-81	1.2
11	2008	-19	-80	6.1
11	2008	-19	-79	2.633333
11	2008	-19	-76	4.1
11	2008	-19	-75	3.175
11	2008	-19	-74	0.8
11	2008	-19	-73	1.02
11	2008	-19	-72	1.56
11	2008	-19	-71	1.715385
12	2008	-21	-71	1.5
12	2008	-21	-70	0.9
1	2012	-30	-107	5.2
1	2012	-23	-120	12.1
1	2012	-23	-100	6.6
1	2012	-20	-100	26.1
2	2012	-46	173	8.749756
2	2012	-46	174	9.959917
2	2012	-45	174	9.940588
2	2012	-45	175	19.82411
2	2012	-44	174	19.03833
2	2012	-44	175	26.07352
2	2012	-44	176	14.77714
2	2012	-44	177	21.17849
2	2012	-44	178	7.062713
2	2012	-44	179	5.921477
2	2012	-44	180	9.729116
2	2012	-44	181	3.49889
2	2012	-43	175	4.986496
2	2012	-43	179	5.614133

2	2012	-43	180	9.145043
3	2012	-45	175	6.297276
3	2012	-44	-180	7.5
3	2012	-44	173	9.406773
3	2012	-44	174	11.11755
3	2012	-44	175	17.04101
9	2012	43	-133	14.8
9	2012	47	-180	9.8
9	2012	47	170	7.4
10	2013	53	-49	0.258138
10	2013	53	-48	0.140438
10	2013	53	-47	0.116901
10	2013	53	-46	0.274299
10	2013	53	-45	0.42615
10	2013	53	-44	0.330985
10	2013	53	-43	0.186145
10	2013	54	-47	0.328994
10	2013	54	-46	0.435587
10	2013	54	-45	0.529874
10	2013	54	-44	0.272545
10	2013	55	-46	0.259339
10	2013	56	-46	0.152437
10	2013	57	-46	0.109785
10	2013	58	-46	0.292686
10	2013	58	-45	0.734069
10	2013	59	-50	0.372846
10	2013	59	-45	0.369968
10	2013	60	-51	0.148186
10	2013	61	-51	0.143013
10	2013	62	-52	0.116265
10	2013	62	-51	0.173884
10	2013	63	-52	0.116019
11	2013	41	-65	0.790641
11	2013	41	-64	0.859507
11	2013	41	-63	0.672312
11	2013	42	-64	0.778588
11	2013	42	-63	0.136175

11	2013	43	-63	0.208599	
11	2013	43	-62	0.119829	
11	2013	44	-62	0.131688	
11	2013	44	-61	0.168166	
11	2013	45	-61	0.12096	
11	2013	45	-60	0.238417	
11	2013	46	-60	0.239039	
11	2013	46	-59	0.20804	
11	2013	47	-60	0.440808	
11	2013	47	-59	0.184634	
11	2013	48	-60	0.305009	
11	2013	49	-60	0.237817	
11	2013	49	-59	0.334803	
11	2013	50	-58	0.289316	
11	2013	51	-57	0.3235	
11	2013	52	-57	0.191453	
11	2013	52	-56	0.188311	
11	2013	52	-55	0.2374	
11	2013	52	-54	0.346499	
11	2013	52	-53	0.411235	
11	2013	52	-52	0.371889	
11	2013	52	-51	0.374102	
11	2013	52	-50	0.391167	
11	2013	52	-49	0.357335	
11	2013	52	-48	0.229348	
11	2013	52	-47	0.294404	
11	2013	53	-47	0.316976	
11	2013	53	-46	0.258824	
1	2014	33	-175	11.1	

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Table S2. : Seasonal maximum positive and negative differences of DMS flux values in µmol m^{-2} d^{-1} at different ocean regions. There are some rows where both maximum positive or negative differences are not shown. This is due to N00b shows higher flux values than respective parametrization methods and hence those differences are not present.

Parameterization	**Season**	**Maximum Difference in µmol m^{-2} d^{-1}**	**Ocean Region**
N00b - LM86	DJF	8.10	Weddell Sea
	MAM	5.15	Caribbean Sea
	JJA	14.29	Indian Ocean
	SON	6.11	Indian Ocean
N00b - E93	DJF	-38.93 / 8.18	Weddell Sea / Caribbean Sea
	MAM	-14.48 / 6.32	Gulf of Finland / Caribbean Sea
	JJA	-11.32 / 18.45	Gulf of Alaska / Indian Ocean
	SON	-10.61 / 6.81	Weddell Sea / Indian Ocean
N00b - N00a	DJF	3.40	South Pacific Ocean
	MAM	2.47	Caribbean Sea
	JJA	6.12	Indian Ocean
	SON	2.98	Indian Ocean
N00b - Ho06	DJF	-10.59 / 1.86	Ross Sea / Indian Ocean
	MAM	-4.32 / 1.50	North Sea / Caribbean Sea
	JJA	-3.92 / 2.37	North Atlantic Ocean /Arabian Sea
	SON	-5.67 / 1.81	Southern Ocean / Bay of Bengal
N00b - GM12	DJF	5.93	Caribbean Sea
	MAM	4.37	Caribbean Sea
	JJA	16.17	Caribbean Sea
	SON	4.94	Indian Ocean
N00b - W14	DJF	4.12	Ross Sea
	MAM	2.59	North Sea
	JJA	4.52	Caribbean Sea
	SON	2.93	Indian Ocean

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Table S3. : Monthly and annual maximum values of σ_{DMS}, σ_k, σ_{wind} and σ_{total} in μmol m^{-2} d^{-1} at the different oceanic regions.

Month	Max. σ_{DMS} at Ocean Region (μmol m^{-2} d^{-1})	Max. σ_k at Ocean Region (μmol m^{-2} d^{-1})	Max. σ_{wind} at Ocean Region (μmol m^{-2} d^{-1})	Max. σ_{total} at Ocean Region (μmol m^{-2} d^{-1})
January	34.64 South Atlantic Ocean	21.70 Weddell Sea	6.64 Southern Ocean	22.66 Weddell Sea
February	23.41 South Atlantic Ocean	6.99 Weddell Sea	4.58 Southern Ocean	16.20 South Atlantic Ocean
March	15.58 North Atlantic Ocean	3.17 South Atlantic Ocean	1.90 Southern Ocean	12.68 South Pacific Ocean
April	16.54 North Atlantic Ocean	6.67 Guld of Finland	1.54 Alboran Sea	13.29 North Atlantic Ocean
May	20.55 Arabian Sea	9.12 Sea of Okhotsk	2.74 Gulf of Alaska	17.17 North Atlantic Ocean
June	21.68 North Atlantic Ocean	7.49 Indian Ocean	2.82 South Pacific Ocean	19.18 North Atlantic Ocean
July	23.87 Arabian Sea	8.86 Indian Ocean	3.12 Gulf of Aden	24.60 Arabian Sea
August	21.86 Arabian Sea	5.75 Indian Ocean	2.12 Caribbean Sea	21.97 Arabian Sea
September	13.38 Arafura Sea	6.12 Indian Ocean	2.51 Indian Ocean	13.39 Arafura Sea
October	12.10 Indian Ocean	2.93 Bay of Bengal	2.86 Philippine Sea	9.05 Argentine Sea
November	18.40 South Atlantic Ocean	10.43 Weddell Sea	6.13 Southern Sea	16.47 South Atlantic Ocean
December	28.76 South Atlantic Ocean	17.00 Weddell Sea	6.98 Southern Ocean	18.91 South Atlantic Ocean
Annual	**11.42 South Atlantic Ocean**	**5.35 Weddell Sea**	**2.62 Southern Ocean**	**8.55 North Atlantic Ocean**

Supplementary Figures :

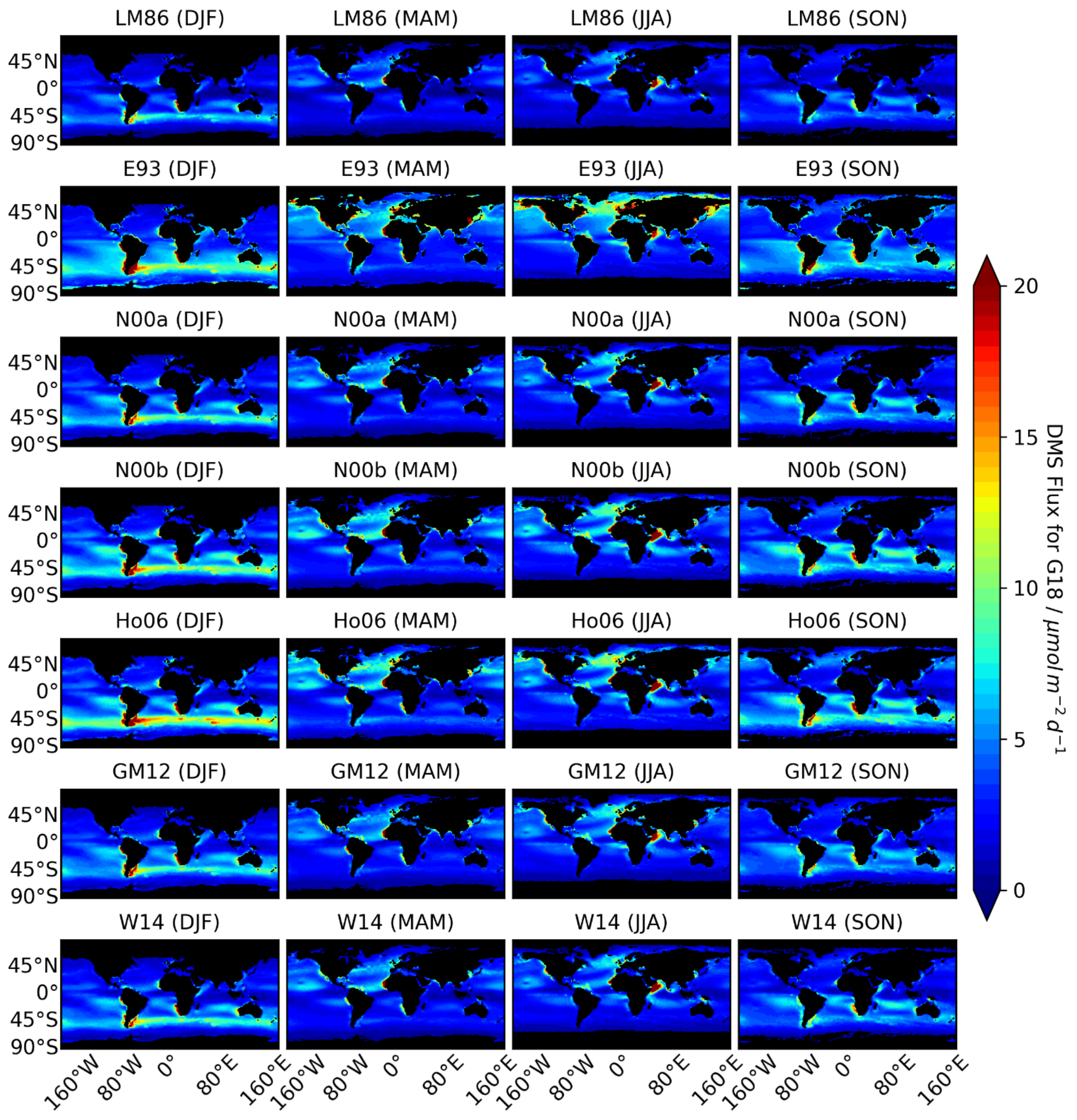


Figure S1: DMS flux estimation using seven different parameterizations for different seasons using the G18 climatology. In the June-July-August (JJA) season, the maximum flux of 44.75 μmol m^{-2} d^{-1} is calculated in Arabian with N00b. In December-January-February (DJF) season, the highest value of 49.34 μmol m^{-2} d^{-1} in the South Atlantic Ocean with Ho06 is calculated.

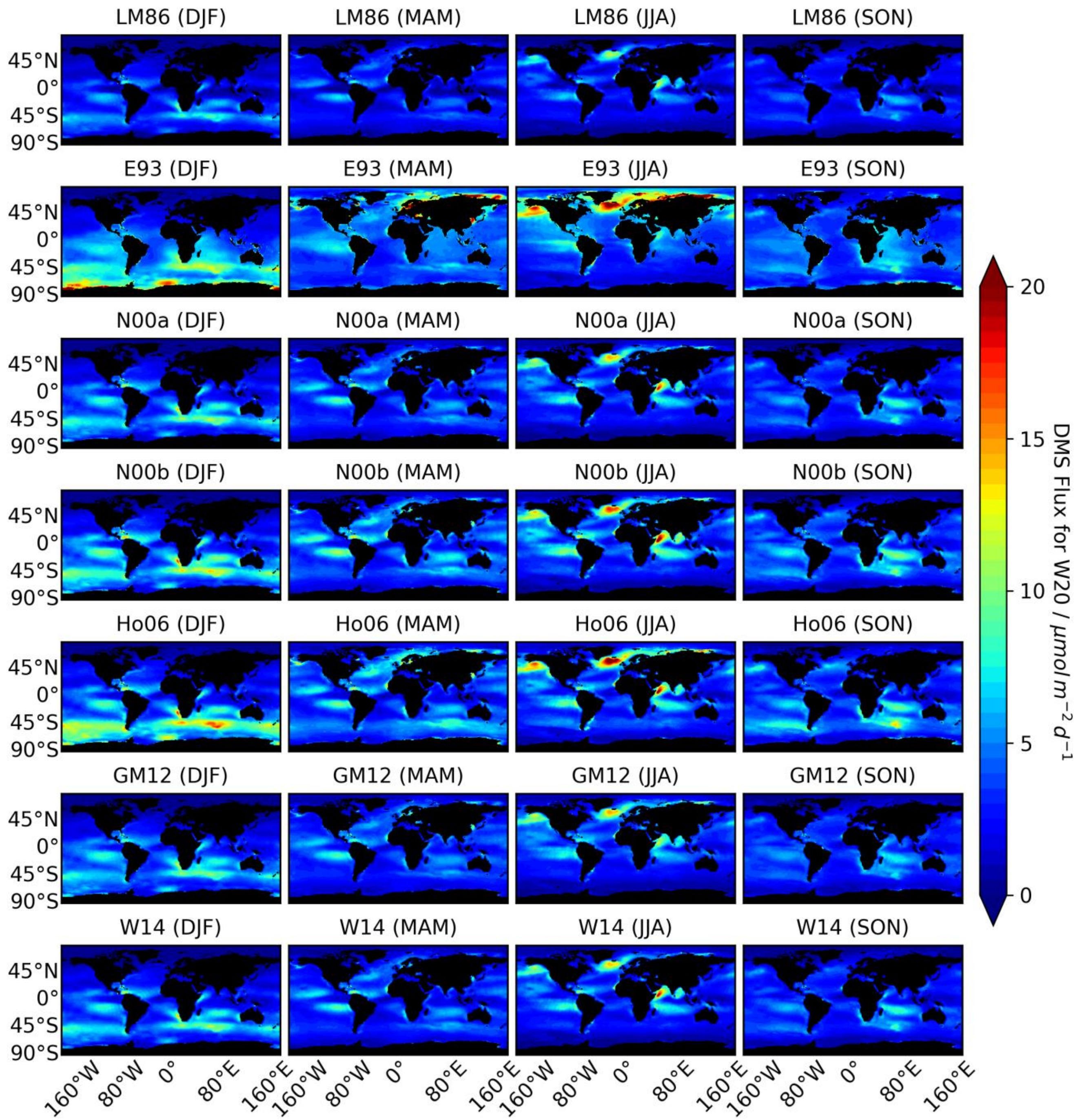


Figure S2: DMS flux estimation using seven different parameterizations for different seasons using the W20 climatology. In December-January-February (DJF) E93 calculates the highest flux value of 27.86 μmol m^{-2} d^{-1} near Antarctic coastal region. In June-July-August (JJA) season E93 calculated highest flux of 44.94 μmol m^{-2} d^{-1} in Kara Sea.

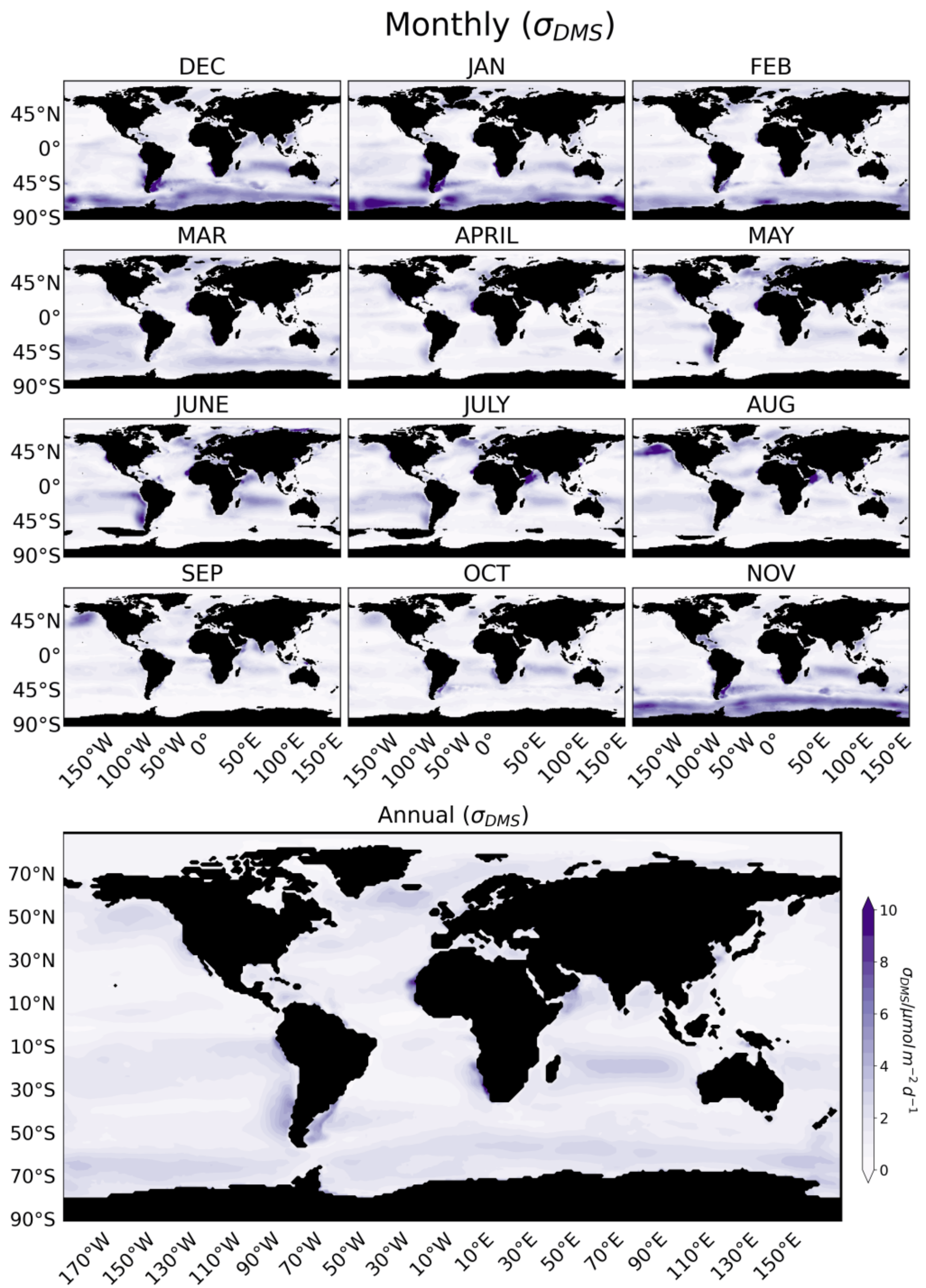


Figure S3: Standard deviation in DMS flux due to the standard deviation in seawater DMS concentration. In December-January-February (DJF), a maximum deviation of 34.64 µmol m^{-2} d^{-1} in the South Atlantic Ocean in January is calculated. In the March-April-May (MAM) season, the maximum deviation of 20.55 µmol m^{-2} d^{-1} in the Arabian Sea is calculated in May. In the June-July-August (JJA) season, it is 23.87 µmol m^{-2} d^{-1} in the Arabian Sea in July. In the September-October-November (SON) season, the maximum deviation of 18.40 µmol m^{-2} d^{-1} in the South Atlantic Ocean during November is calculated. On an annual scale, the maximum deviation calculated is 11.42 µmol m^{-2} d^{-1} in the South Atlantic Ocean. The complete summary of maximum values is listed in Table S3.

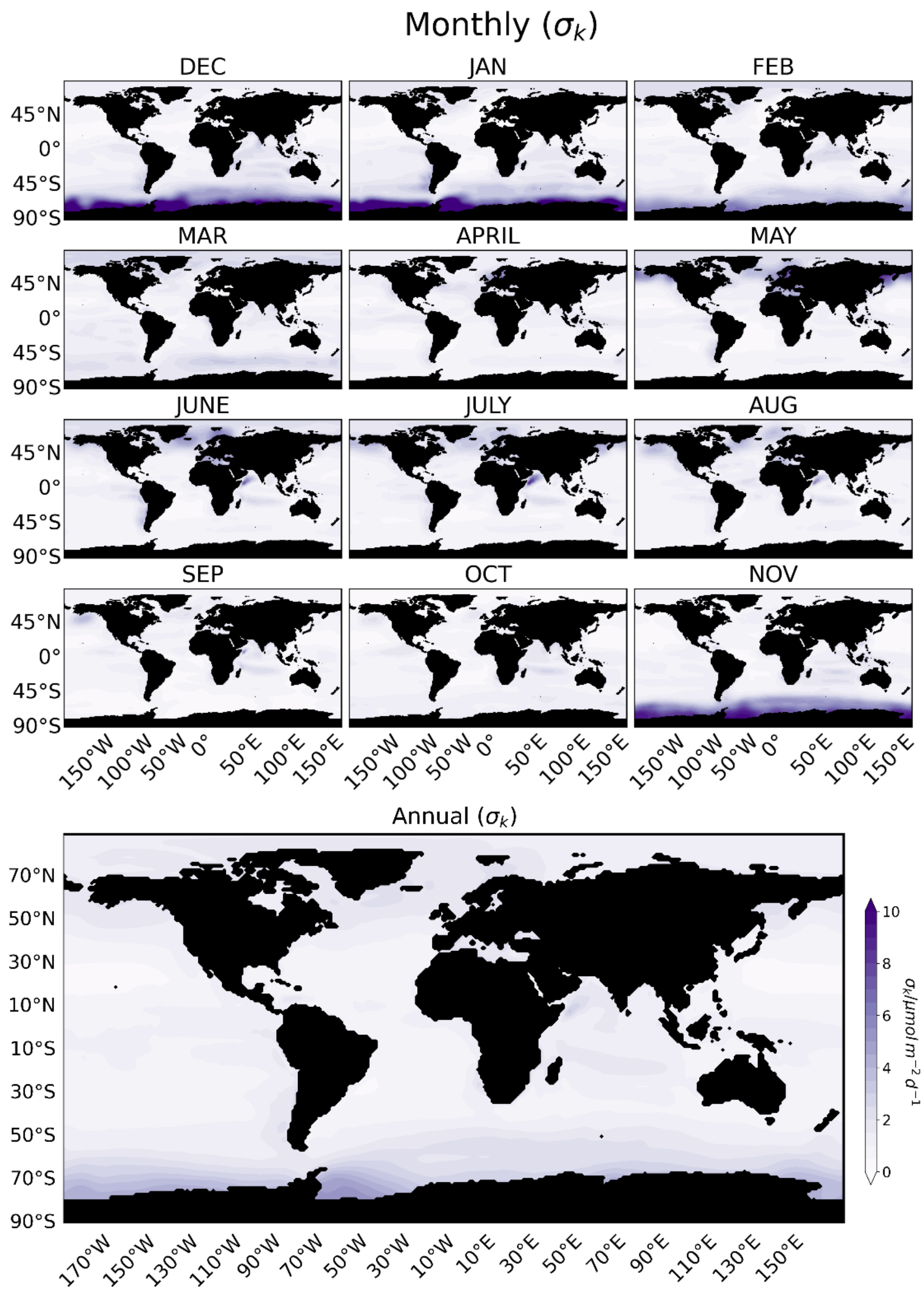


Figure S4: Standard deviation in DMS flux due to the standard deviation between different flux parameterizations. In December-January-February (DJF), a maximum deviation of 21.70 μmol m^{-2} d^{-1} in the Weddell Sea is calculated in January. In the March-April-May (MAM) season, the maximum deviation of 9.12 μmol m^{-2} d^{-1} is calculated in the Sea of Okhotsk during May. In the June-July-August (JJA) season, the maximum is 8.86 μmol m^{-2} d^{-1} in the Indian Ocean is calculated in July. In the September-October-November (SON) season, the maximum deviation of 10.43 μmol m^{-2} d^{-1} is calculated in the Weddell Sea. On an annual scale, the maximum deviation calculated is 5.35 μmol m^{-2} d^{-1} in the Weddell Sea. The complete summary of maximum values is listed in Table S3.

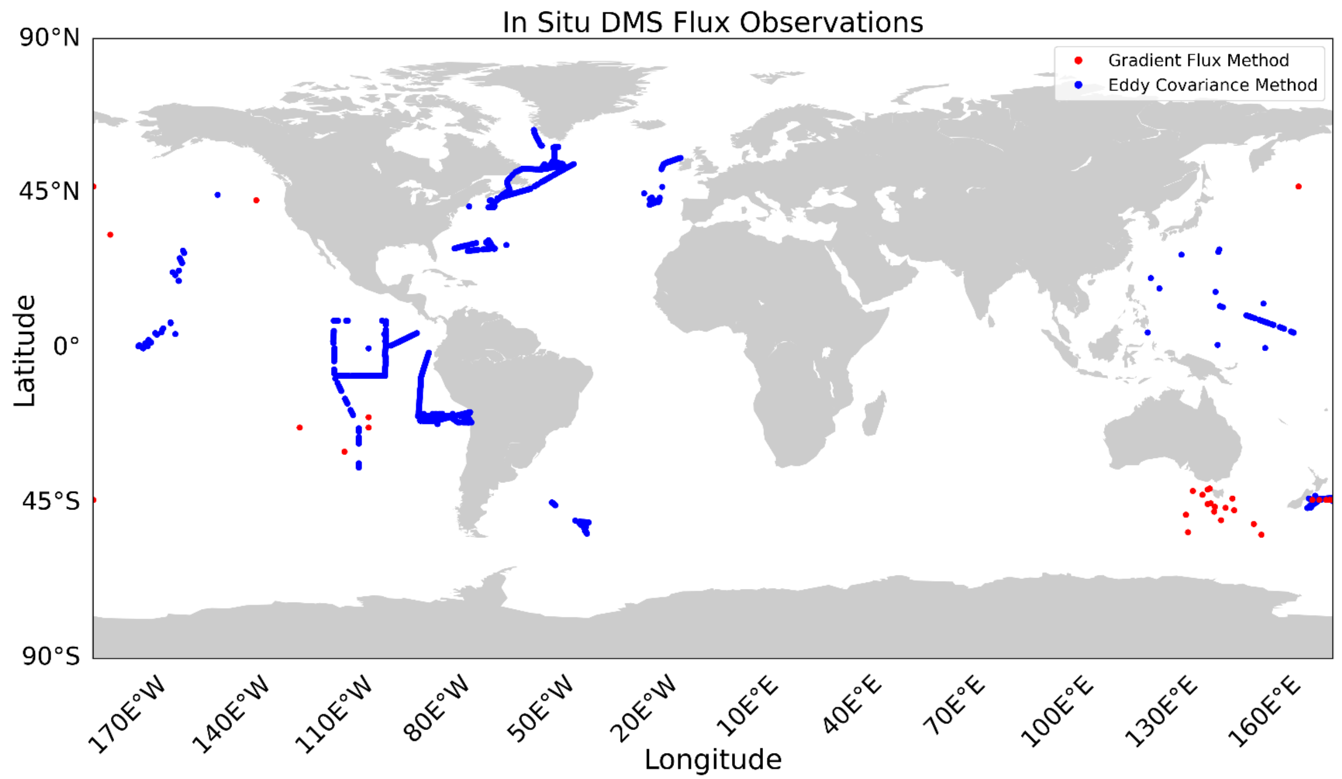


Figure S5: Global locations of in situ DMS flux observations. The fluxes are calculated either by Eddy Covariance or Gradient Flux Method.

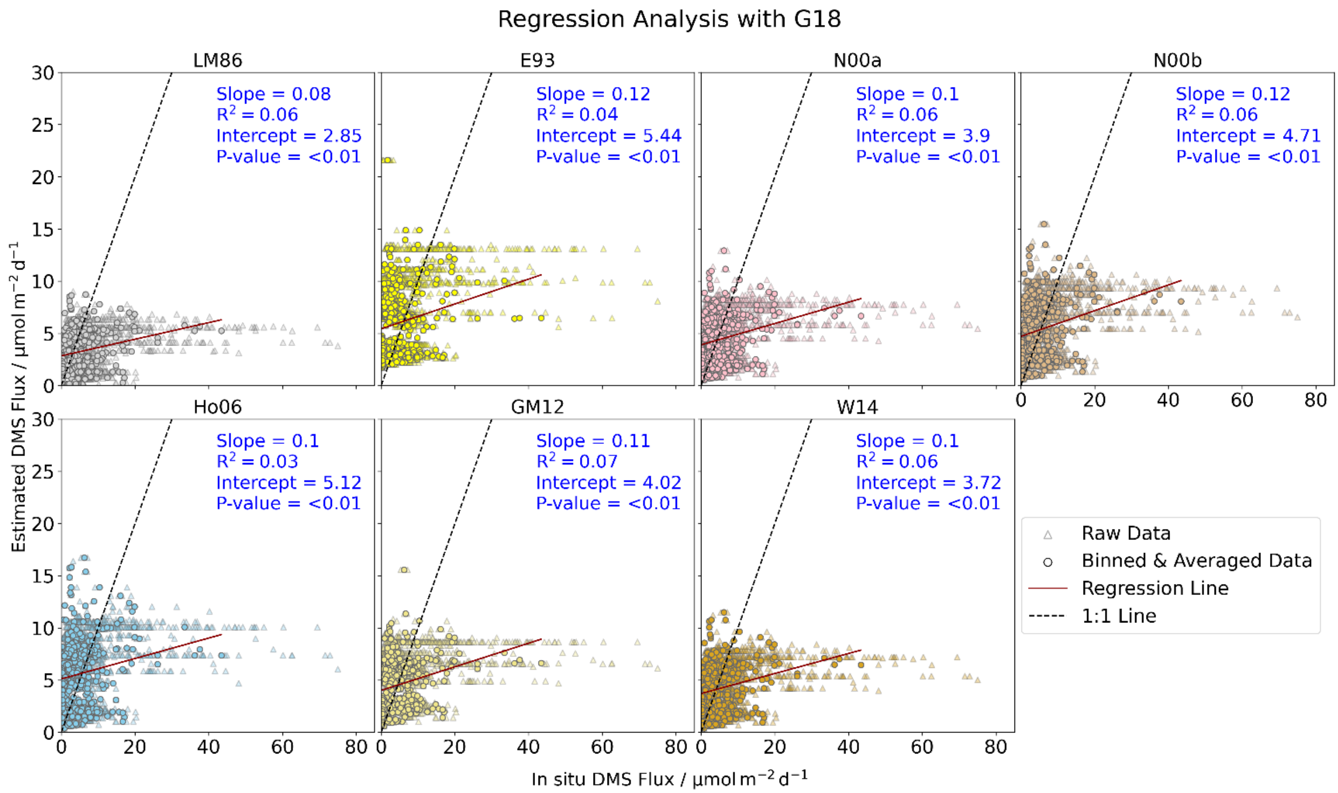
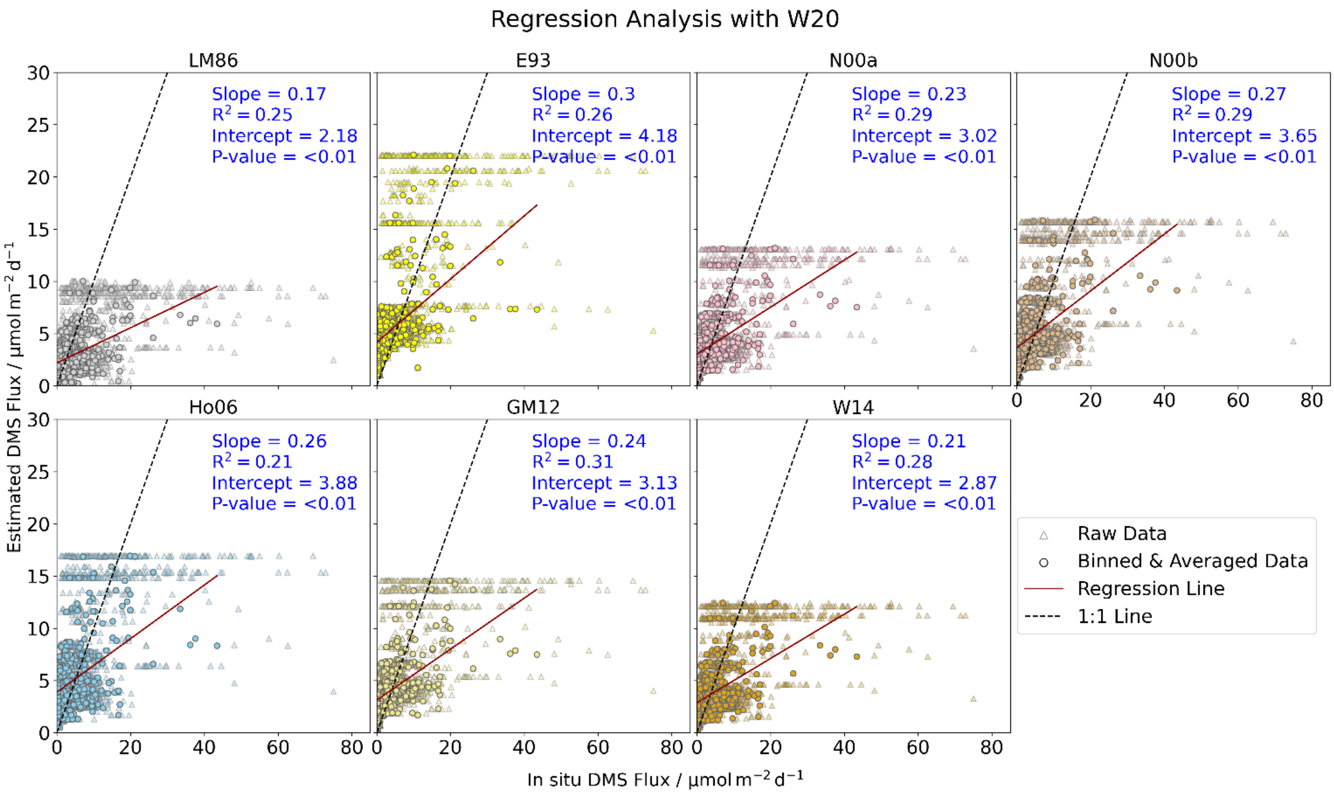


Figure S6: The regression between the in situ and estimated DMS fluxes using G18 with the N00b parameterization and the other six parameterizations show that regression with in situ data seems to be poor with R^2 values ranging from 0.03 to 0.07. Dark red line is the regression between binned and averaged in situ DMS flux and estimated DMS flux points. Black dash-line is the 1:1 representation between in situ flux points and estimated flux points.



70 **Figure S7:** The regression between the in situ and estimated DMS fluxes using W20 with the N00b parameterization and the other six parameterizations show that regression with in situ data seems to be poor with R^2 values ranging from 0.21 to 0.31. Dark red line is the regression between binned and averaged in situ DMS flux and estimated DMS flux points. Black dash-line is the 1:1 representation between in situ flux points and estimated flux points.

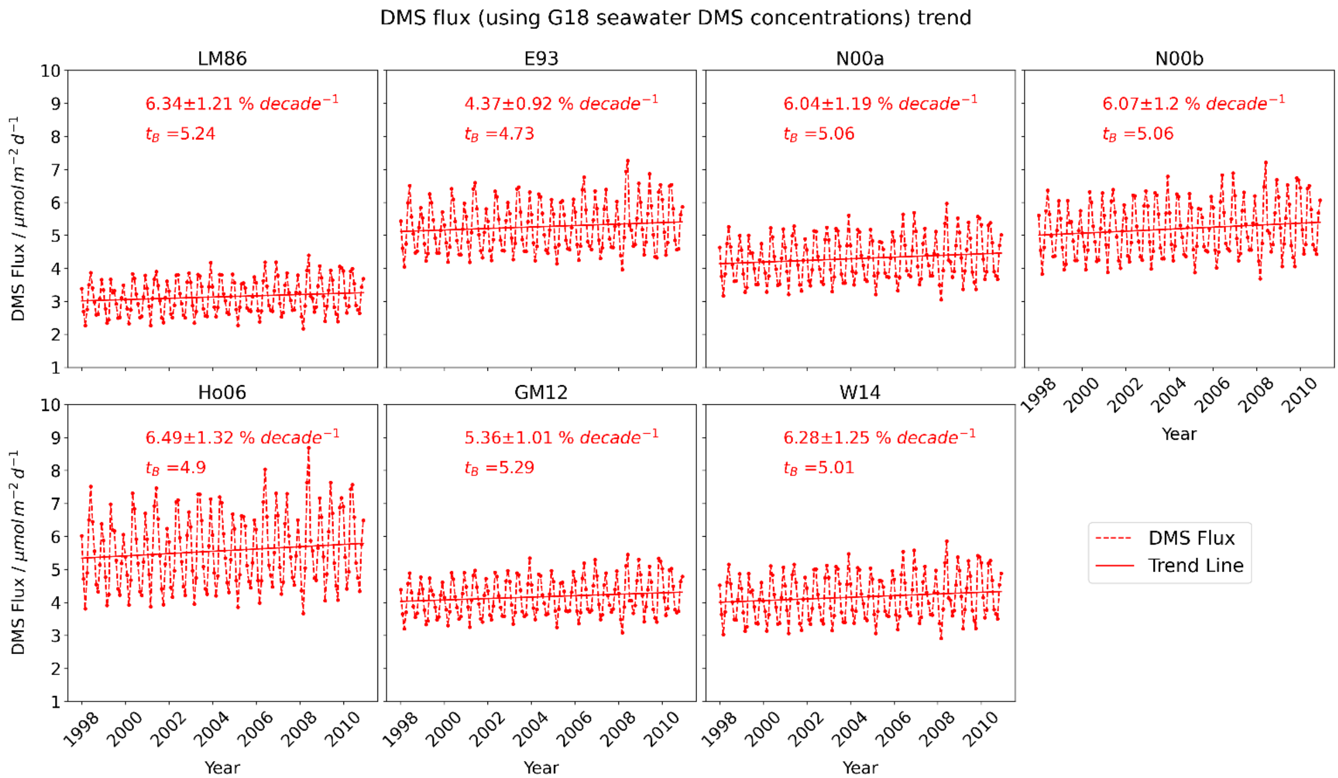


Figure S8 : DMS flux trend using seawater DMS concentrations of G18 for each parameterization method. Trend is calculated using bootstrap resampling method. The trend is significant if $t_B > 2$.

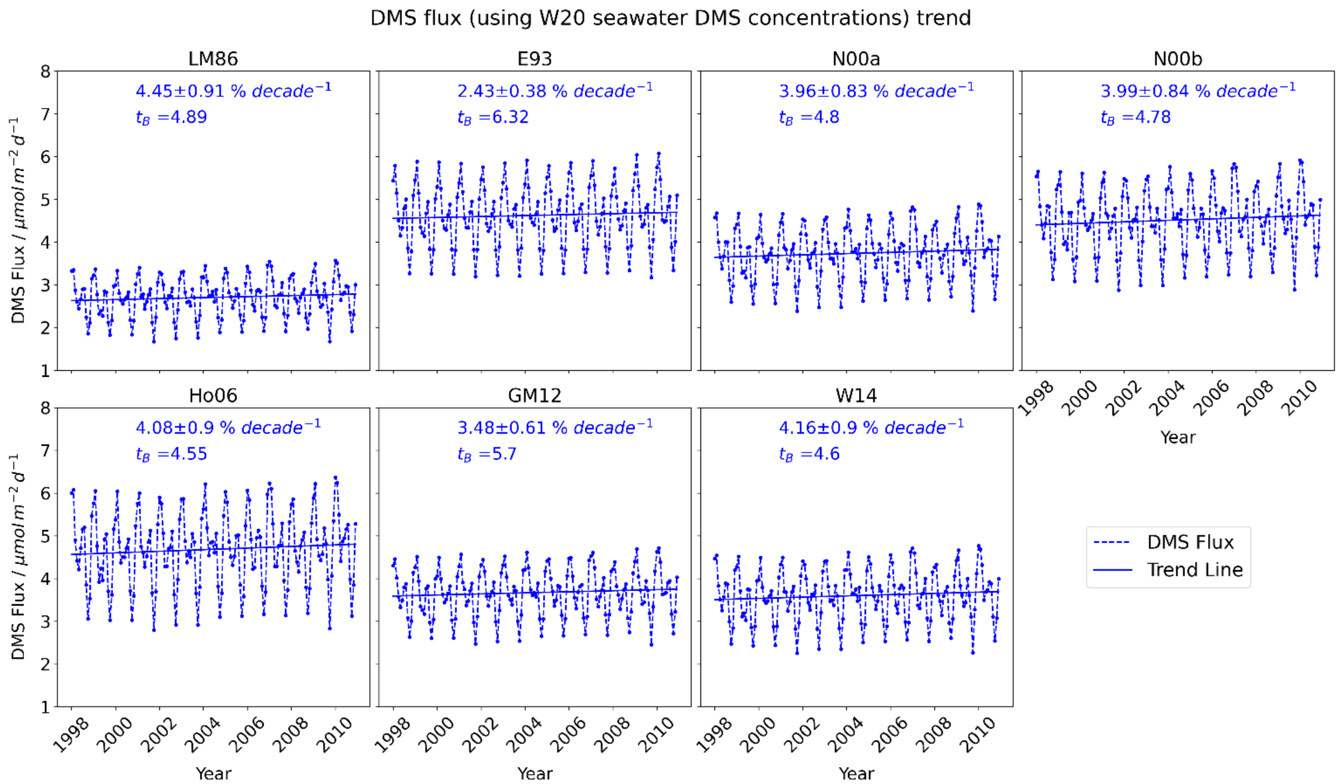


Figure S9 : DMS flux trend using seawater DMS concentrations of W20 for each parameterization method. Trend is calculated using bootstrap resampling method. The trend is significant if $t_B > 2$.

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