



Supplement of

Formation of marine atmospheric organic aerosols associated with the spring phytoplankton bloom after sea ice retreat in the Sea of Okhotsk

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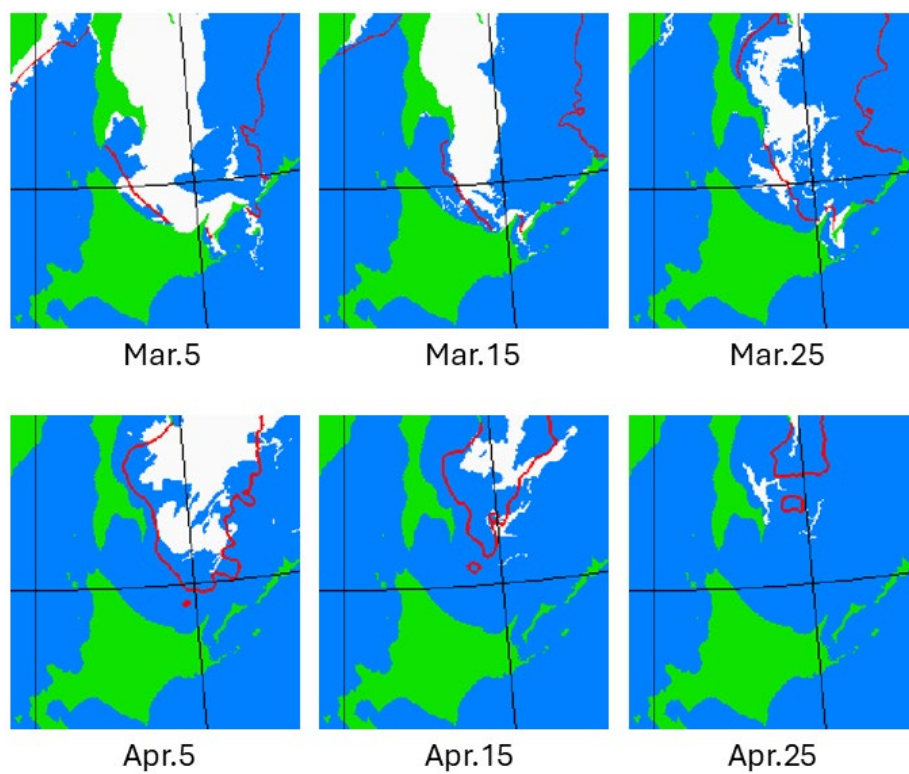


Figure S1: Sea ice extent (in white) in the Sea of Okhotsk in 2021. The red line in images indicates 1981 to 2010 average extent for the day shown. Source: Japan Meteorological Agency website https://www.data.jma.go.jp/kaiyou/db/seaice/archive/c_1/okhotsk_monthly/seaiceindex.html

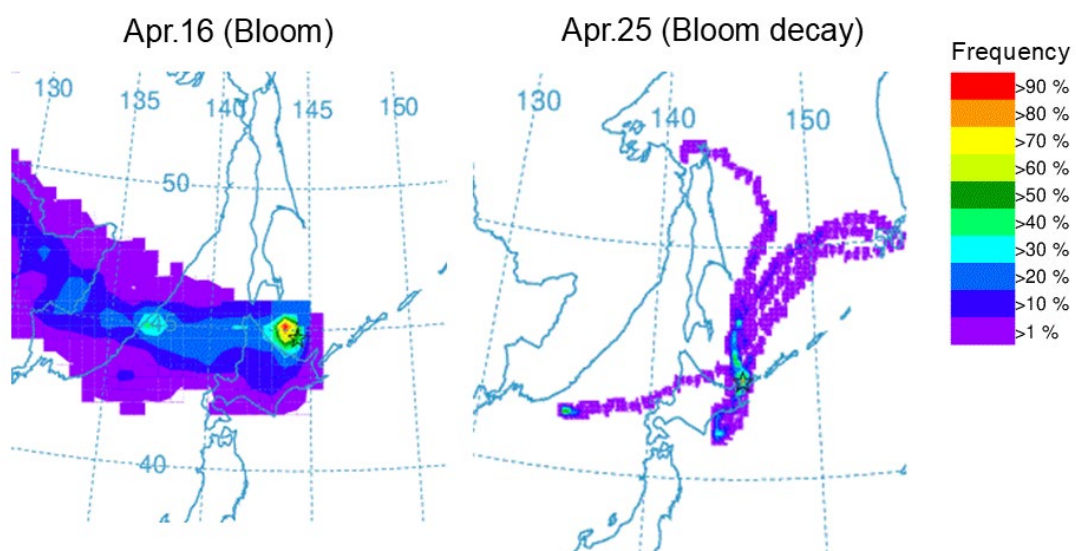


Figure S2: Typical 48-hour backward trajectory frequencies calculated from the sampling points for the bloom and bloom-decay periods.

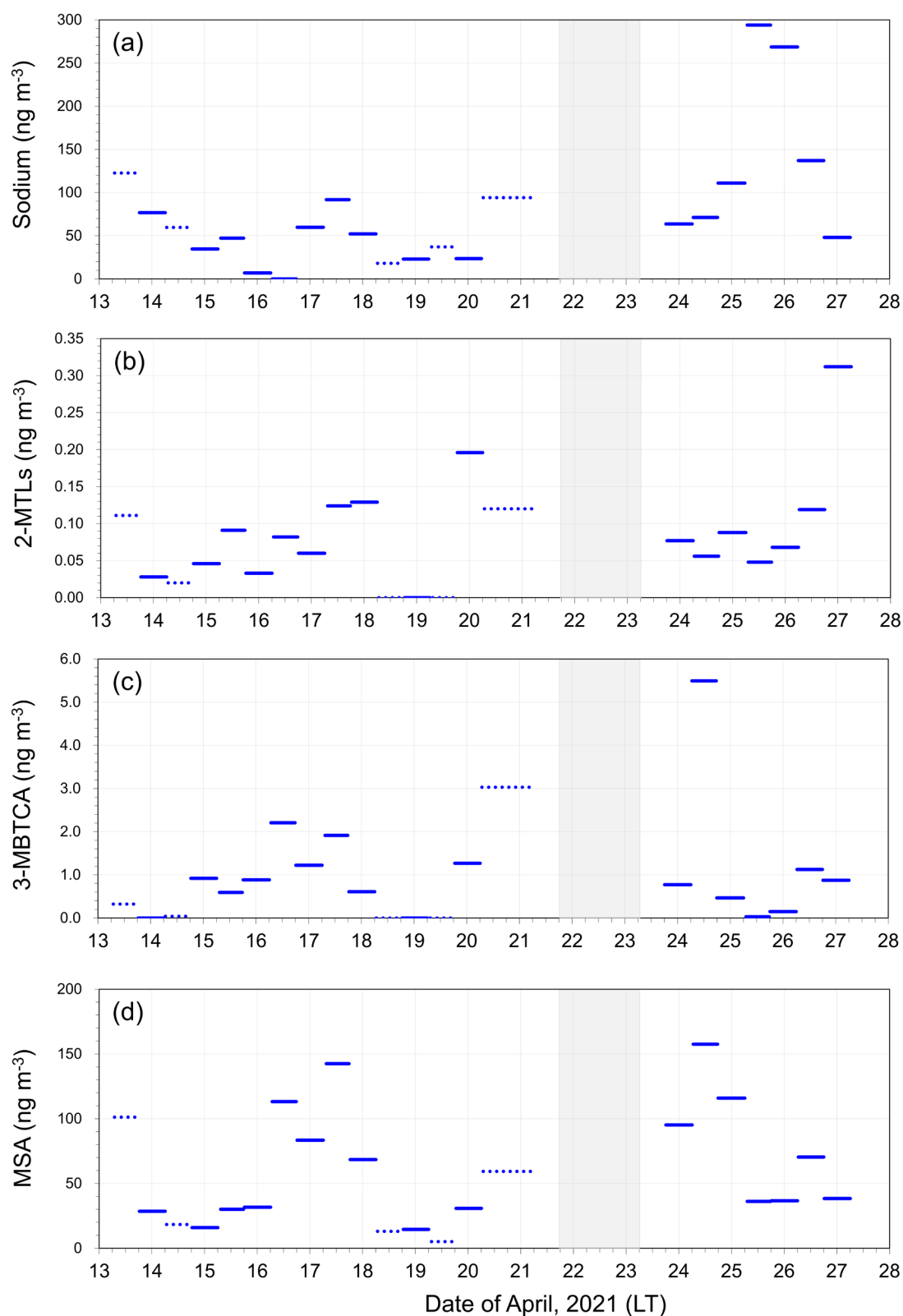


Figure S3: Timeseries of the mass concentrations of (a) sodium, (b) 2-methyltetrols (2-MTLs), (c) 3-methyl-1,2,3-butanetricarboxylic acid (3-MBTCA), and (d) MSA in submicrometer aerosols.

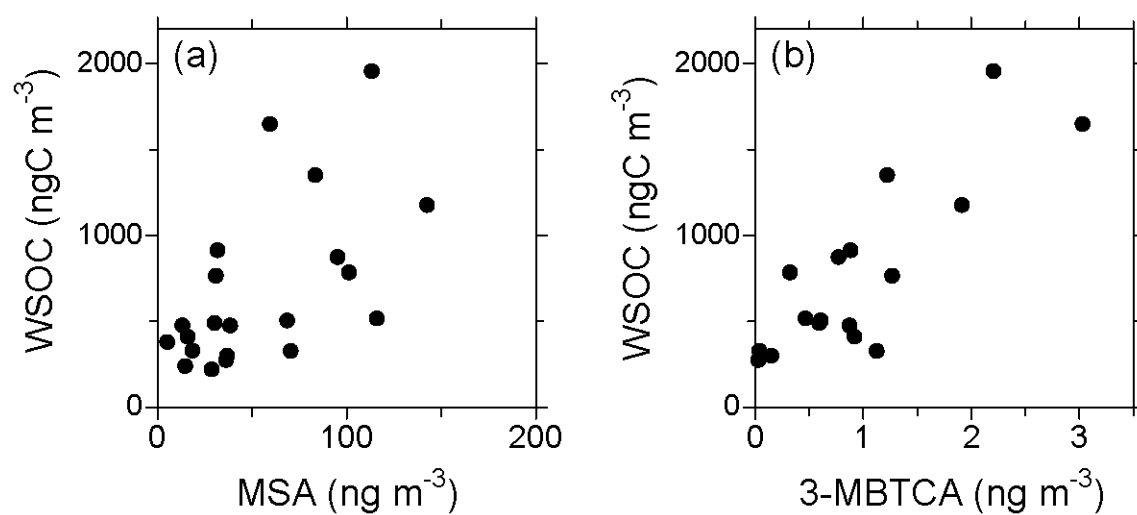


Figure S4: Scatter plots between (a) WSOC and MSA, and (b) WSOC and 3-MBTCA in submicrometer aerosols.

Table S1: Average concentration of each parameter in aerosol of marine origin and Chl *a* in surface seawater during the pre-bloom period in the Oyashio region (Mar. 2015; Miyazaki et al., 2018; 2020) and the bloom and bloom-decay periods in the Sea of Okhotsk. Shown are average values and standard deviations.

	Pre-bloom period	Bloom period	Bloom-decay period
WSOC (ngC m ⁻³)	545±332	803±555	447±208
WSON (ngN m ⁻³)	10.1±25.6	346±240	130±189
WSOC:WSON	15±47	2.6±1.5	8.5±6.8
3-methyl-1,2,3- butanetricarboxylic acid (3-MBTCA)	0.6±0.8	0.9±0.7	1.3±1.9
MSA	46±40	51±45	79±47
Chl <i>a</i> (mg m ⁻³)	1.02±0.75	5.58±2.05	4.00±1.77

Table S2: Concentrations of each chemical parameter in aerosol sample. The numbers in the parenthesis are the lower detection limits (LODs) for the direct measurements of mass concentrations. The numbers −9.9, −9.99, and −9.999 indicate that the concentration was below the LOD.

Sample ID	Start date&time	End date&time	OC	WSOC	WIOC	WSOM	WIOM	OM	MSA	Cl [−]	NO ₂ [−]	Br [−]	NO ₃ [−]	SO ₄ ^{2−}	Na ⁺	NH ₄ ⁺	K ⁺	Ca ²⁺	Mg ²⁺	2-MTLS	3-MBTCA	WSON	Glucose	Pinic acid	Pinonic acid	δ ¹³ C
<i>HIV-DN-</i>	LT	LT	ngC m ^{−3} (40.0)	ngC m ^{−3} (15.0)	ngC m ^{−3}	ng m ^{−3}	ng m ^{−3}	ng m ^{−3}	ng m ^{−3} (0.1)	ng m ^{−3} (0.1)	ng m ^{−3} (0.1)	ng m ^{−3} (0.1)	ng m ^{−3} (0.1)	ng m ^{−3} (0.1)	ng m ^{−3} (0.5)	ng m ^{−3} (0.5)	ng m ^{−3} (0.5)	ng m ^{−3} (0.5)	ng m ^{−3} (0.5)	ng m ^{−3} (0.005)	ng m ^{−3} (0.005)	ngN m ^{−3}	ng m ^{−3} (0.005)	ng m ^{−3} (0.005)	ng m ^{−3} (0.005)	‰
05	2021/4/13 7:00	2021/4/13 17:46	1085.8	784.5	301.3	1412.0	361.6	1773.6	101.2	150.7	41.3	1.3	136.7	1480.3	122.7	702.3	51.7	36.7	17.8	0.111	0.323	404.5	0.219	3.951	2.179	−23.87
06	2021/4/13 18:18	2021/4/14 6:03	504.4	221.1	283.3	398.0	339.9	738.0	28.6	33.6	1.8	0.4	25.3	621.7	76.7	238.4	7.6	7.5	8.8	0.028	−9.999	122.9	−9.999	−9.999	1.533	−20.24
07	2021/4/14 6:44	2021/4/14 17:49	389.1	329.8	59.3	593.6	71.2	664.8	18.4	30.3	0.9	1.0	46.0	680.8	59.6	298.8	10.6	9.4	11.1	0.020	0.039	83.3	−9.999	−9.999	1.313	−23.20
08	2021/4/14 18:18	2021/4/15 6:02	728.1	410.8	317.3	739.4	380.8	1120.2	15.9	19.3	6.5	1.2	48.1	1001.5	34.6	436.2	19.8	6.4	4.7	0.046	0.920	204.0	−9.999	3.563	0.529	−20.64
09	2021/4/15 7:20	2021/4/15 17:44	1353.4	491.2	862.2	884.1	1034.7	1918.8	30.1	14.1	3.3	0.9	74.3	1066.4	47.2	463.1	20.4	11.4	7.1	0.091	0.593	227.0	0.083	0.529	1.602	−21.72
10	2021/4/15 18:10	2021/4/16 6:04	1429.0	913.6	515.5	1644.4	618.5	2262.9	31.7	−9.9	2.2	1.0	177.8	1179.7	6.9	637.7	44.7	20.4	2.8	0.033	0.884	340.7	0.324	0.022	0.909	−19.13
11	2021/4/16 6:47	2021/4/16 17:46	2475.8	1954.7	521.1	3518.4	625.4	4143.8	113.2	42.7	5.5	1.9	646.6	1987.0	−9.9	1149.4	138.3	74.0	12.7	0.082	2.206	874.5	1.033	7.921	3.391	−18.50
12	2021/4/16 18:09	2021/4/17 6:04	1871.3	1350.5	520.8	2431.0	624.9	3055.9	83.4	66.2	3.2	1.8	247.0	1978.8	59.8	1006.3	88.9	34.3	7.9	0.060	1.222	497.7	0.272	0.160	1.990	−18.58
13	2021/4/17 7:26	2021/4/17 17:46	1635.1	1176.0	459.1	2116.8	550.9	2667.7	142.5	104.3	2.4	1.4	117.4	2178.7	91.8	932.5	100.2	27.1	14.3	0.124	1.914	547.0	0.652	−9.999	2.142	−17.84
14	2021/4/17 18:19	2021/4/18 6:02	836.2	505.0	331.2	908.9	397.5	1306.4	68.5	5.1	0.3	1.0	24.1	1541.8	52.2	603.3	32.1	8.5	6.0	0.129	0.608	355.7	0.251	−9.999	0.570	−18.15
15	2021/4/18 6:48	2021/4/18 17:46	1206.2	476.8	729.4	858.3	875.3	1733.5	13.1	−9.9	1.9	0.7	9.1	534.7	18.1	112.5	1.8	12.2	2.1	−9.999	−9.999	62.3	0.070	−9.999	0.047	−23.54
16	2021/4/18 18:30	2021/4/19 6:02	261.8	240.8	21.0	433.5	25.2	458.7	14.6	−9.9	−9.9	−9.9	13.4	49.7	23.0	16.6	0.6	3.7	2.5	−9.999	−9.999	68.8	−9.999	−9.999	0.465	−17.07
17	2021/4/19 7:23	2021/4/19 18:02	629.6	380.1	249.5	684.2	299.4	983.6	5.1	−9.9	0.2	−9.9	13.6	55.8	37.1	11.4	−9.9	6.5	3.4	−9.999	−9.999	−9.9	−9.999	−9.999	0.201	−99.99
18	2021/4/19 18:32	2021/4/20 6:05	840.2	765.6	74.6	1378.1	89.5	1467.6	30.8	−9.9	4.3	0.6	90.6	677.2	23.5	348.3	17.5	12.3	3.3	0.196	1.268	222.8	0.531	4.760	10.47	−21.17
19	2021/4/20 6:55	2021/4/21 6:19	3016.6	1647.4	1369.2	2965.3	1643.1	4608.4	59.4	65.8	4.3	1.5	239.3	1468.0	94.1	583.3	83.9	42.3	16.6	0.120	3.030	245.2	2.320	3.129	7.972	−24.57
23	2021/4/23 18:07	2021/4/24 6:03	2430.8	873.63	1557.2	1572.5	1868.6	3441.1	95.2	71.9	2.4	0.5	503.7	2056.1	63.7	1035.7	27.4	21.7	11.6	0.077	0.772	286.7	0.228	2.615	6.046	−21.39
24	2021/4/24 6:33	2021/4/24 17:38	1409.3	359.38	1049.9	646.9	1259.9	1906.8	157.5	88.3	2.8	0.6	1000.1	2037.6	71.2	1267.6	39.1	19.2	13.6	0.056	5.493	494.3	0.240	3.633	6.071	−21.92
25	2021/4/24 17:53	2021/4/25 6:04	1795.9	516.78	1279.1	930.2	1534.9	2465.1	115.9	110.9	0.4	0.6	89.2	721.1	111.0	351.5	20.8	10.6	14.5	0.088	0.466	71.1	0.070	−9.999	1.449	−17.15
26	2021/4/25 7:10	2021/4/25 17:46	397	275.52	121.5	495.9	145.8	641.7	36.2	398.9	−9.9	0.5	102.6	387.8	294.0	115.3	13.2	21.3	43.8	0.048	0.030	13.3	0.260	−9.999	0.510	−14.86
27	2021/4/25 18:06	2021/4/26 6:03	688.6	300.39	388.2	540.7	465.9	1006.6	36.7	224.2	0.2	1.3	104.2	669.9	268.6	181.9	16.1	27.0	37.7	0.068	0.149	−9.9	−9.999	−9.999	0.182	−14.66
28	2021/4/26 6:26	2021/4/26 18:00	653.9	327.83	326.1	590.1	391.3	981.4	70.4	31.2	1.1	0.9	68.2	652.4	137.0	196.3	9.8	15.0	17.2	0.119	1.125	9.8	−9.999	0.109	0.608	−21.57
29	2021/4/26 18:14	2021/4/27 6:05	519.1	475.94	43.2	856.7	51.8	908.5	38.4	−9.9	2.5	0.7	89.6	534.5	48.0	252.5	5.7	9.7	5.2	0.312	0.874	32.5	−9.999	2.989	3.712	−19.87

Table S3: Concentrations of each parameter in surface seawater sample.

Sample ID	Sampling time	DOC	DN	DON
	LT	µgC L ⁻¹	µgN L ⁻¹	µgN L ⁻¹
F1	2021/4/13 7:30	880.83	94.27	86.50
F2	2021/4/13 8:00	883.00	105.33	103.50
F3	2021/4/13 8:30	924.72	92.65	78.91
F4	2021/4/13 9:00	886.25	106.89	99.52
F5	2021/4/13 9:30	942.05	101.99	86.05
F6	2021/4/13 13:45	871.08	88.68	61.04
F7	2021/4/13 14:15	914.42	105.27	94.64
F8	2021/4/13 14:45	981.61	117.41	101.43
F9	2021/4/13 15:18	1012.49	119.52	88.02
F10	2021/4/13 15:45	998.95	113.68	92.59
F11	2021/4/13 16:15	1003.28	99.92	89.73
F12	2021/4/13 16:45	987.57	124.32	97.05
F13	2021/4/13 17:15	1010.87	110.98	98.45
St.11	2021/4/14 5:25	931.78	140.06	115.60
Opt2	2021/4/14 11:00	930.95	134.77	105.59
St.9	2021/4/14 13:09	871.95	123.97	80.67
St.7	2021/4/14 17:41	876.89	151.97	103.29
St.5	2021/4/14 21:35	958.67	98.49	75.47
St.3	2021/4/15 1:05	977.89	107.54	98.11
St.1	2021/4/15 4:00	975.14	91.47	78.97
Opt3	2021/4/15 11:00	954.60	232.89	156.15
St.18	2021/4/16 19:35	961.42	145.97	95.93
St.20	2021/4/16 21:23	1053.63	113.26	94.41
St.25	2021/4/17 1:38	1028.38	102.98	101.03
St.23	2021/4/17 4:37	967.46	142.92	79.24
Opt4	2021/4/17 11:00	839.03	140.49	102.35
St.16	2021/4/17 17:12	1054.73	146.00	90.65
St.14	2021/4/17 22:36	1081.63	148.55	103.21
St.12	2021/4/18 3:22	1148.59	106.64	89.02
Bio(Opt.) - 5	2021/4/18 11:00	869.67	124.90	124.90
F14	2021/4/19 7:02	957.23	160.33	102.62
F15	2021/4/19 7:30	1013.57	148.73	94.30
F16	2021/4/19 8:00	975.11	127.99	71.12
F17	2021/4/19 8:30	1029.29	99.08	87.85
F18	2021/4/19 9:00	1069.382	141.7867	115.10
Opt6	2021/4/19 11:00	974.49	126.91	108.10
F19	2021/4/19 11:30	1047.167	94.44854	90.95
F20	2021/4/19 12:00	1024.953	91.98395	83.56
F21	2021/4/19 12:30	853.0812	63.6393	56.17
F22	2021/4/19 13:00	841.0681	77.63088	60.91
F23	2021/4/19 13:30	856.3575	73.80299	62.66
F24	2021/4/19 14:00	865.0943	77.76287	65.27

F25	2021/4/19 14:30	871.6469	71.39407	63.36
F26	2021/4/19 15:00	903.3178	78.68685	66.50
F27	2021/4/19 15:30	886.3902	93.89939	71.97
F28	2021/4/19 16:00	968.2977	172.272	138.06
F29	2021/4/19 16:30	1019.08	94.72436	84.22
F30	2021/4/19 17:10	983.0411	89.87351	74.37
Opt7	2021/4/20 11:00	911.06	91.34	64.29
St.30	2021/4/23 15:45	1098.10	101.72	99.09
St.28	2021/4/23 17:16	1031.68	131.97	103.69
St.26	2021/4/23 19:47	1134.32	117.44	114.51
St.104	2021/4/24 5:50	1006.98	183.54	92.60
Opt8	2021/4/24 11:00	913.75	304.97	111.80
F31	2021/4/26 14:00	918.0611	76.31092	74.54
F32	2021/4/26 14:30	937.7189	134.2242	127.41
F33	2021/4/26 15:00	901.1336	179.8288	178.34
F34	2021/4/26 15:30	728.0357	192.4344	66.56
F35	2021/4/26 16:00	629.7467	177.6178	45.09
F36	2021/4/26 16:30	750.4238	128.4823	72.66
F37	2021/4/26 17:00	830.6931	168.8731	79.58
F38	2021/4/26 17:30	786.4631	61.98935	60.62
F39	2021/4/26 18:00	712.2003	97.36428	31.67
F40	2021/4/26 18:20	710.0161	138.844	21.83