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Tracer-based investigation of organic aerosols in marine atmospheres from marginal seas of China to the northwest Pacific Ocean

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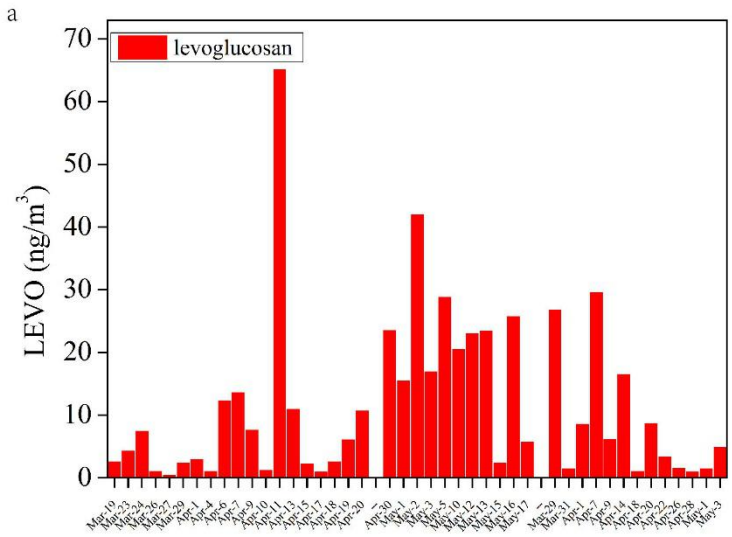
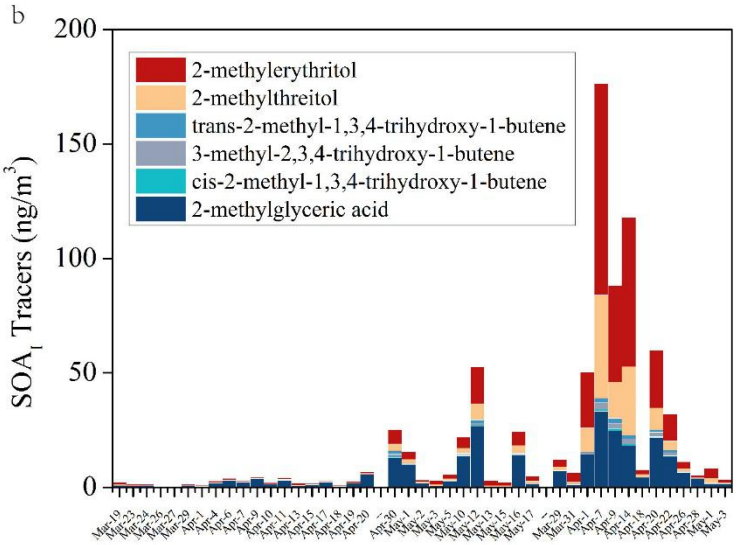
Section S1. Conversion between monoterpene SOA tracers measured in this study (HGA, HDMGA, MTBCA) and total monoterpene SOA tracers measured by Kleindienst et al. (2007). The SOA tracer method applies laboratory-determined ratios of the sum of specific SOA tracers to the total mass of SOA ($\frac{\sum SOA\ tracers}{total\ mass\ of SOA}$) to SOA tracers measured in the field (Kleindienst et al., 2007). Nine tracers, including pinonic acid, pinic acid, 2-hydroxy-4-isopropyladipic acid, 3-hydroxyglutanic acid (HGA), 3-hydroxy-4,4-dimethylglutaric acid (HDMGA), 3-isopropylpentanedioic acid, 3-acetylpentanedioic acid, 3-acetylhexanedioic acid and 3-(2-hydroxy-ethyl)-2-,2-dimethyl-cyclobutane-carboxylic acid, were used to estimate monoterpene SOA (Kleindienst et al., 2007). However, only three monoterpene SOA tracers were measured in this study, HGA, HDMGA and MBTCA, with two common tracers (HGA, HDMGA) used in both analyses in this study and Kleindienst et al. (2007). The correlation between the sum of these two common tracers and the sum of the nine tracers used in their study was measured. A strong correlation between the two common tracers (HGA+HDMGA) and the sum of all nine tracers indicated that they could be converted using a ratio of 0.32 (the slope, Fig. S4). Therefore, the total tracers $\Sigma_{tracers}$ and HGA+HDMGA values were converted using the formula (HGA+HDMGA) = 0.32* $\Sigma_{tracers}$. Thus, the f_{SOC} value for monoterpenes was scaled up by 3.1 based on laboratory observations, with the two tracers accounting for 2/9 of the total tracer level for monoterpenes (Kleindienst et al., 2007).

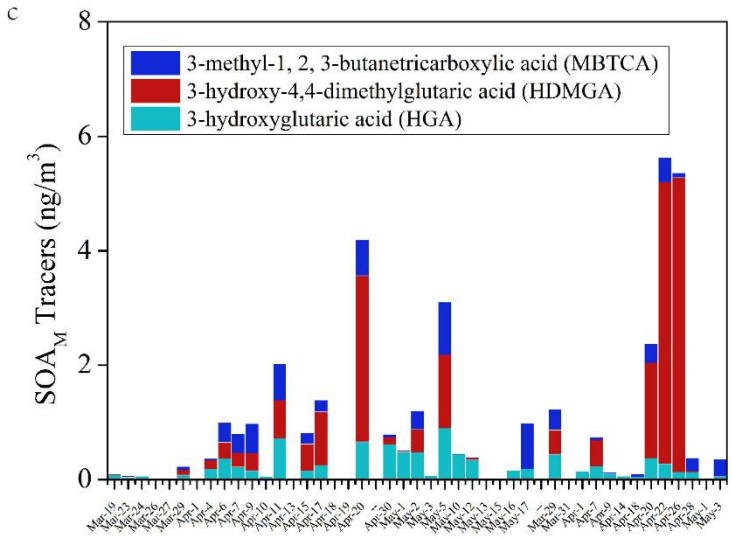
Section S2. Uncertainty of tracer-based SOC calculation

Both the quantification of SOA in ambient air and modeling of SOA remain challenging due to the variety of VOC sources and the complexity of SOA formation processes in the atmospheres of different environments (Hallquist et al., 2009). Under the assumptions that these organic tracers are stable in ambient air and that the tracer/OC conversion factors remain the same as those obtained from source samples or chamber simulations, the

uncertainty of the SOA tracer method could be determined from analyses of the organic tracers and estimation of the appropriate conversion factors. The uncertainties in tracer analyses were less than 20% (Ding et al., 2008). The uncertainties of f_{SOC} was previously reported to be 25% for isoprene, 48% for monoterpenes, 22% for β-caryophyllene, and 33% for aromatics (Lewandowski et al., 2013). Considering these factors, the uncertainty in the estimated SOC values was calculated through error propagation. The relative standard deviations were 32% for SOC_I, 52% for SOC_M, 30% for SOC_C, and 39% for SOC_A.


a
levoglucosan
LEVO (ng/m3)
0
10
20
30
40
50
60
70


b
2-methylerythritol
2-methylthreitol
trans-2-methyl-1,3,4-trihydroxy-1-butene
3-methyl-2,3,4-trihydroxy-1-butene
cis-2-methyl-1,3,4-trihydroxy-1-butene
2-methylglyceric acid
SOA_I Tracers (ng/m3)
0
50
100
150
200


c
3-methyl-1, 2, 3-butanetricarboxylic acid (MBTCA)
3-hydroxy-4,4-dimethylglutaric acid (HDMGA)
3-hydroxyglutaric acid (HGA)
SOA_M Tracers (ng/m3)
0
2
4
6
8

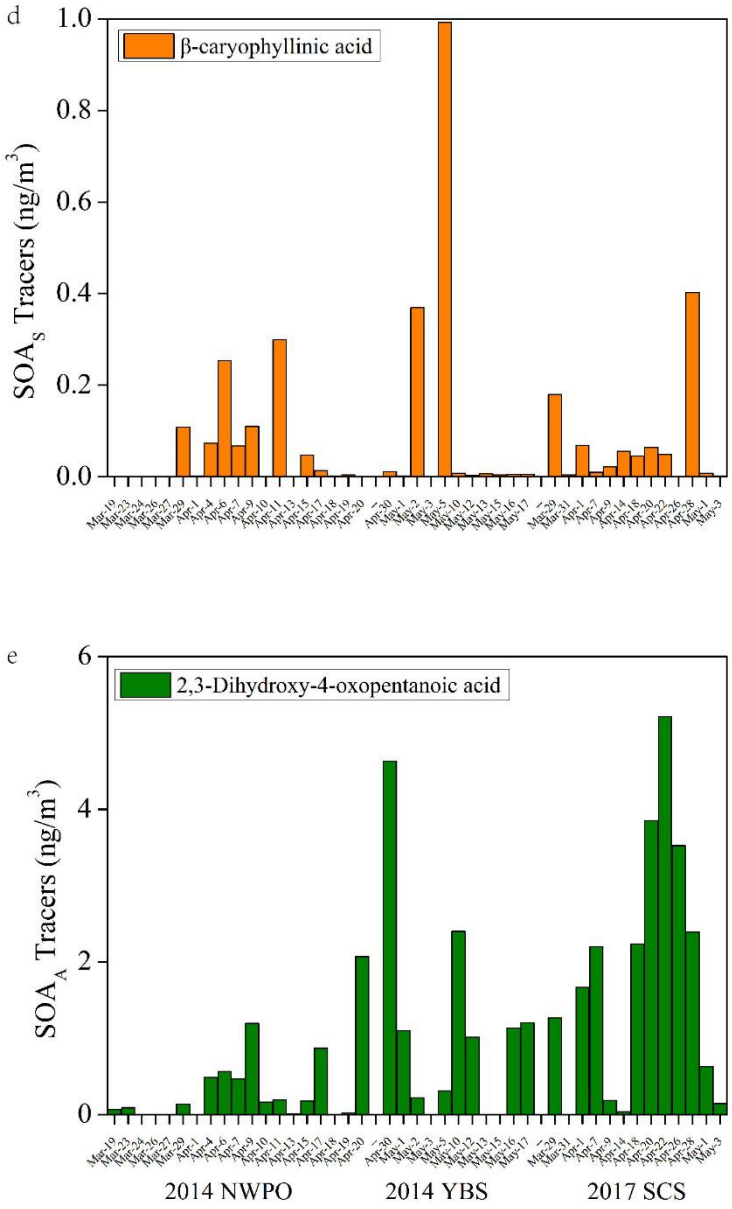


Figure S1. Concentration of primary and secondary organic tracers over the NWPO, YBS and SCS.

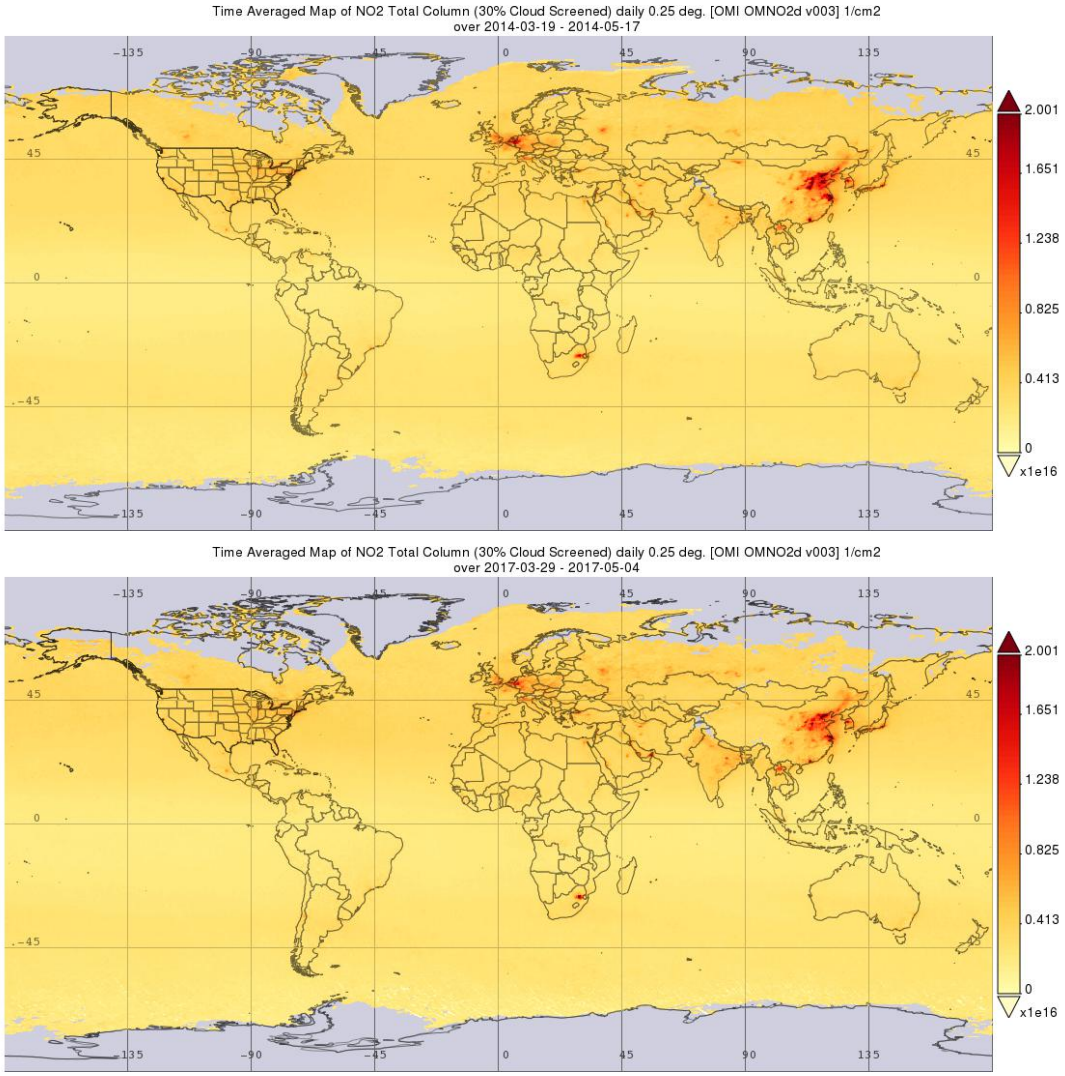


Figure S2. Average NO_2 distribution estimated globally using satellites in springtime during the sampling cruises in 2014 (upper panel) and 2017 (lower panel). Data are from https://giovanni.gsfc.nasa.gov/giovanni.

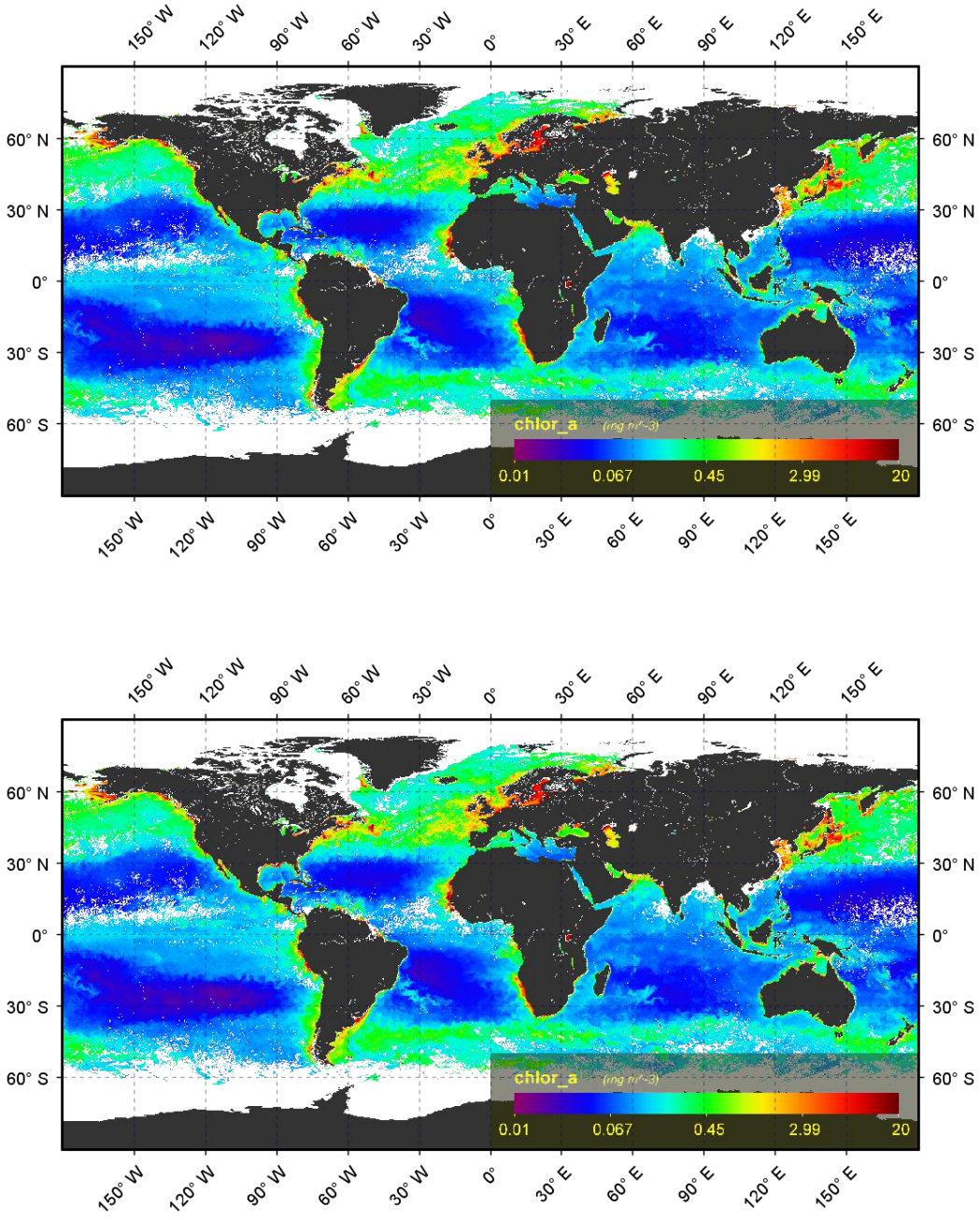


Figure S3. Monthly average marine chlorophyll-a distribution estimated globally using satellites in springtime (April) during the sampling cruises in 2014 (upper panel) and 2017 (lower panel). Data are from **https://oceancolor.gsfc.nasa.gov**.

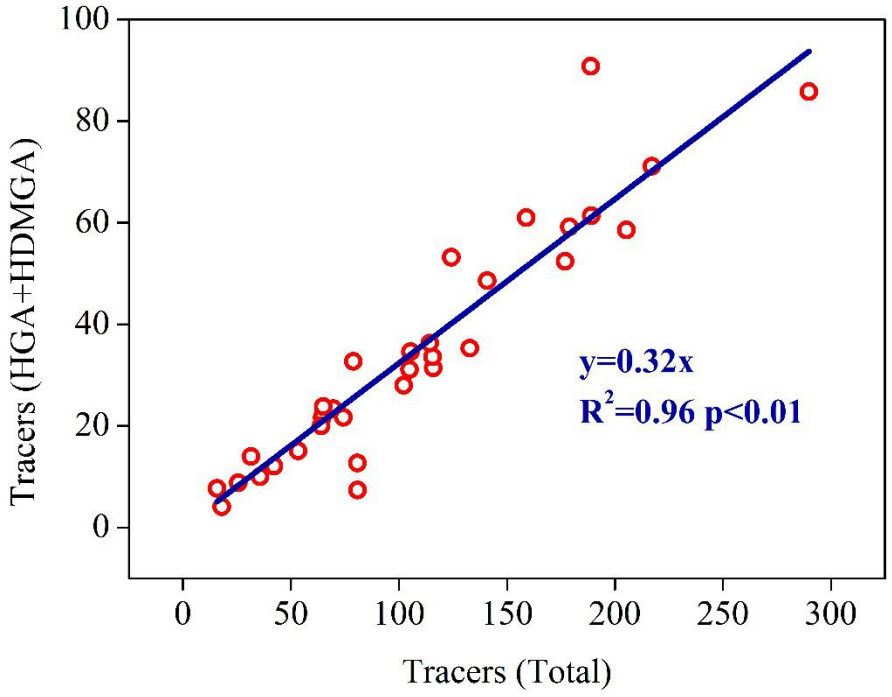


Figure S4. Linear correlation between two monoterpene SOA tracers (HGA+HDMGA) and nine monoterpene SOA tracers measured previously (Kleindienst *et al.*, 2007).

Table S1. Concentration of primary and secondary organic tracers (unit: ng/m^3); OC, EC (μg C/m^3) over the NWPO, YBS and SCS.

	galactosan	mannosan	levoglucosan	2-methylglyceric acid	cis-2-methyl-1,3,4-trihydroxy-1-butene	3-methyl-2,3,4-trihydroxy-1-butene	trans-2-methyl-1,3,4-trihydroxy-1-butene	2-methylthreitol	2-methylerythritol	3-hydroxyglutaric acid	3-hydroxy-4,4-dimethylglutaric acid	3-methyl-1,2,3-butanetricarboxylic acid	β-caryophyllinic acid	2,3-Dihydroxy-4-oxopentanoic acid	OC	EC
2014 NWPO																
Mar-19	0.07	0.12	2.64	0.92	0.004	0.06	0.012	0.28	0.92	0.08	0.01	0.01	0.001	0.07	2.49	0.59
Mar-23	0.22	0.24	4.32	0.62	0.002	0.02	0.002	0.19	0.38	0.04	0.004	0.02	0.0002	0.09	1.49	0.31
Mar-24	0.24	0.30	7.49	0.91	nd	nd	nd	0.13	0.27	0.05	nd	nd	nd	nd	2.59	0.90
Mar-26	0.08	0.06	1.10	nd.	0.001	0.01	0.0004	0.06	0.17	0.001	0.001	nd	nd	nd	1.47	0.16
Mar-27	0.04	0.02	0.52	0.003	nd.	0.004	0.003	0.10	0.20	0.001	0.0001	nd	nd	0.001	1.27	0.35
Mar-29	0.15	0.17	2.44	0.88	0.002	0.01	0.003	0.14	0.32	0.08	0.09	0.06	0.11	0.14	2.62	1.76
Apr-1	0.20	0.20	2.95	0.21	0.001	0.02	0.001	0.24	0.49	0.00	0.00	0.00	0.002	0.00	1.21	0.13
Apr-4	0.09	0.05	1.13	1.76	0.001	0.03	0.003	0.34	0.69	0.19	0.15	0.03	0.07	0.49	0.91	0.23
Apr-6	0.61	0.64	12.38	2.98	0.002	0.02	0.004	0.29	0.59	0.37	0.28	0.34	0.25	0.56	1.16	0.13
Apr-7	0.68	0.70	13.61	2.35	0.004	0.02	0.003	0.20	0.42	0.22	0.25	0.33	0.07	0.47	2.15	0.30
Apr-9	0.19	0.26	7.65	3.72	nd	nd	nd	0.20	0.39	0.15	0.31	0.52	0.11	1.19	3.88	0.52
Apr-10	0.07	0.08	1.30	1.35	0.003	0.01	0.001	0.17	0.36	0.05	0.00	0.01	nd	0.17	1.23	0.24
Apr-11	3.60	3.64	65.18	3.07	0.009	0.03	0.011	0.32	0.67	0.72	0.66	0.64	0.30	0.19	4.25	0.55
Apr-13	0.88	0.86	11.02	0.61	0.005	0.05	0.002	0.37	0.76	nd	nd	nd	nd	0.01	3.59	0.57
Apr-15	0.12	0.15	2.27	1.11	0.002	0.02	0.002	0.24	0.50	0.16	0.46	0.20	0.05	0.18	1.80	0.16

Apr-17	0.07	0.08	1.02	2.31	0.003	0.01	0.001	0.15	0.33	0.25	0.93	0.20	0.01	0.87	1.09	0.12
Apr-18	0.08	0.14	2.68	0.20	nd	0.01	nd	0.19	0.42	nd	nd	nd	0.002	0.003	3.05	0.44
Apr-19	0.28	0.39	6.15	1.75	0.003	0.02	0.005	0.24	0.51	0.02	nd	0.004	0.004	0.02	8.88	3.59
Apr-20	0.40	0.63	10.76	5.66	0.014	0.05	0.015	0.31	0.65	0.66	2.91	0.63	nd.	2.07	6.65	0.74
2014 YBS																
Apr-30	0.86	1.70	23.53	13.03	0.62	0.81	1.58	2.88	6.32	0.62	0.12	0.05	0.01	4.63	8.95	2.26
May-1	0.98	1.90	15.53	9.91	0.09	0.32	0.26	1.67	3.30	0.48	0.01	0.01	0.002	1.10	8.63	1.19
May-2	3.16	5.98	42.03	1.90	0.01	0.01	0.03	0.45	0.86	0.48	0.40	0.33	0.37	0.22	10.42	1.99
May-3	2.54	3.88	16.96	0.52	0.01	0.02	0.01	0.72	1.63	0.07	nd	nd	nd	nd	7.46	1.04
May-5	3.20	4.48	28.86	2.79	0.03	0.10	0.05	0.91	1.69	0.90	1.28	0.92	0.99	0.31	9.84	2.56
May-10	1.23	2.16	20.55	13.80	0.22	0.46	0.48	2.23	4.79	0.44	nd	0.01	0.01	2.40	9.45	1.98
May-12	1.02	1.40	23.05	26.89	0.35	0.90	1.29	6.99	16.15	0.34	0.04	0.01	0.003	1.01	12.15	4.05
May-13	2.13	1.55	23.46	0.01	0.01	0.06	0.02	0.68	2.08	0.01	nd	0.0002	0.01	0.001	10.31	2.57
May-15	0.69	0.06	2.50	0.04	0.005	0.03	0.01	0.67	1.59	0.00	nd	0.001	0.004	0.002	16.29	6.36
May-16	1.14	1.62	25.77	14.00	0.04	0.40	0.54	3.32	5.97	0.16	nd	0.002	0.01	1.14	8.59	2.32
May-17	0.24	0.32	5.84	1.44	0.05	0.09	0.08	1.18	1.94	0.19	nd	0.80	0.01	1.20	8.53	1.87
2017 SCS																
Mar-29	nd	nd	26.79	7.17	0.05	0.14	0.09	1.56	3.17	0.44	0.42	0.36	0.18	1.27		
Mar-31	nd	nd	1.49	1.05	0.06	0.19	0.15	0.99	4.06	0.02	nd	nd	0.004	0.00		
Apr-1	nd	nd	8.60	14.32	0.07	0.89	0.27	10.35	24.32	0.14	nd	0.01	0.07	1.67		
Apr-7	nd	nd	29.61	33.15	0.83	2.98	2.02	44.99	92.48	0.23	0.46	0.05	0.01	2.20		

Apr-9	nd	nd	6.26	24.67	1.04	2.35	2.10	15.75	42.23	0.10	nd	0.02	0.02	0.18		
Apr-14	nd	nd	16.54	18.15	0.65	2.37	1.64	29.93	65.23	0.06	nd	nd	0.06	0.04		
Apr-18	nd	nd	1.06	4.35	0.03	0.09	0.08	0.98	2.04	0.04	nd	0.05	0.05	2.24		
Apr-20	nd	nd	8.71	21.74	0.47	1.91	0.97	9.68	25.01	0.37	1.67	0.32	0.06	3.85		
Apr-22	nd	nd	3.43	13.37	0.36	1.62	0.90	4.04	11.66	0.28	4.92	0.44	0.05	5.21		
Apr-26	nd	nd	1.61	6.54	0.09	0.33	0.16	1.18	2.91	0.13	5.15	0.08	nd	3.52		
Apr-28	nd	nd	1.00	3.83	0.02	0.07	0.04	0.38	0.85	0.13	0.02	0.23	0.40	2.39		
May-1	nd	nd	1.52	1.65	0.03	0.09	0.08	2.21	4.22	0.02	nd	nd	0.01	0.63		
May-3	nd	nd	4.95	1.54	0.03	0.09	0.08	0.45	1.32	0.05	nd	0.31	0.002	0.15		

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