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Individual particle compositions and aerosol mixing states at different altitudes over the ocean in East Asia

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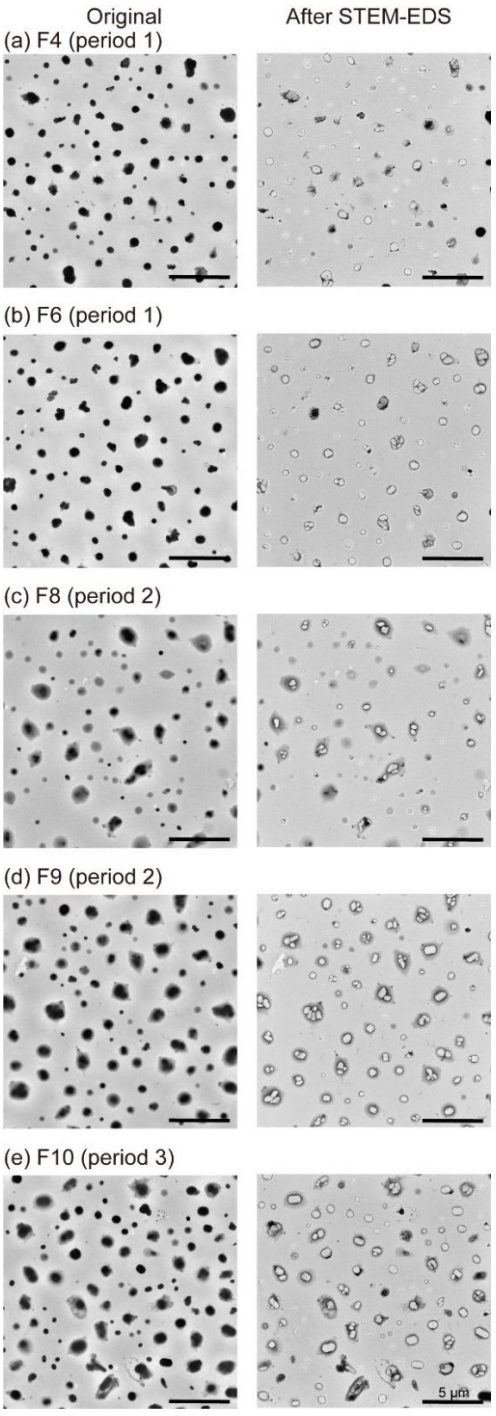

Figure S1. Examples of TEM images before (left) and after (right) the STEM-EDS particle measurements of the airborne samples. All scale bars are 5 μm.

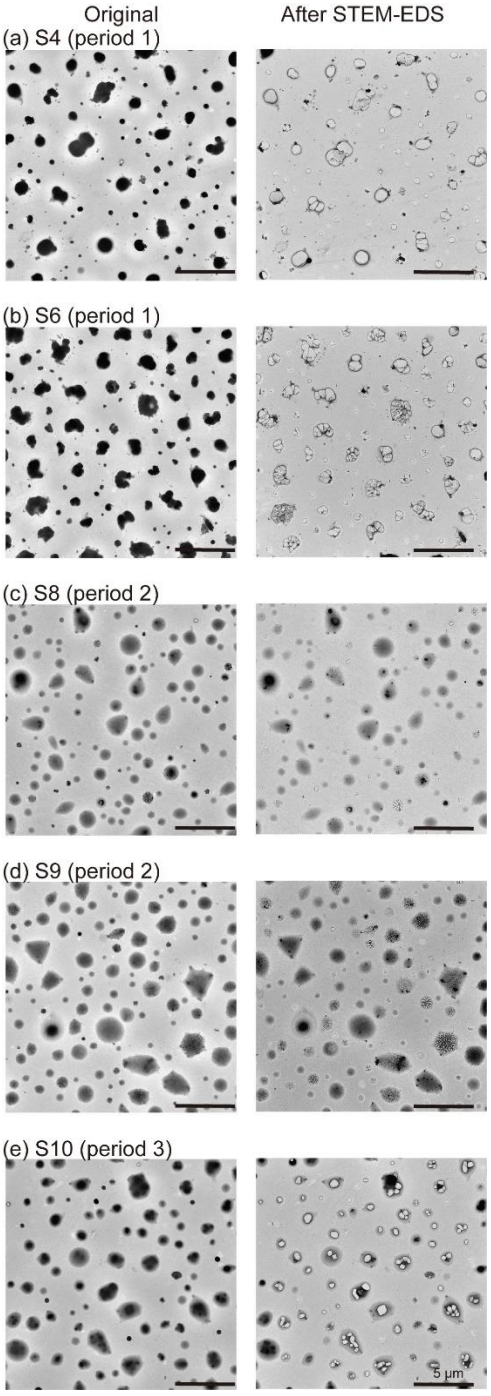

Figure S2. Examples of TEM images before (left) and after (right) STEM-EDS particle measurements of the shipboard samples. All scale bars are 5 µm. (a)-(e): Shipboard samples corresponding to airborne samples with the same flight number. These samples were collected at 5:00 UTC (a-d) and 3:00 UTC (e) when the aircraft was over or near the ship.

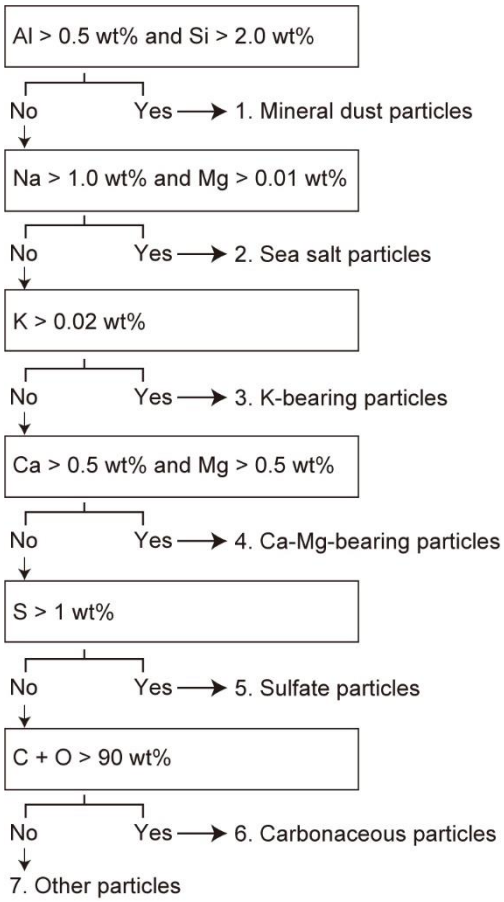

Figure S3. A flow chart for classifying individual particles into seven categories based on the STEM-EDS measurements.

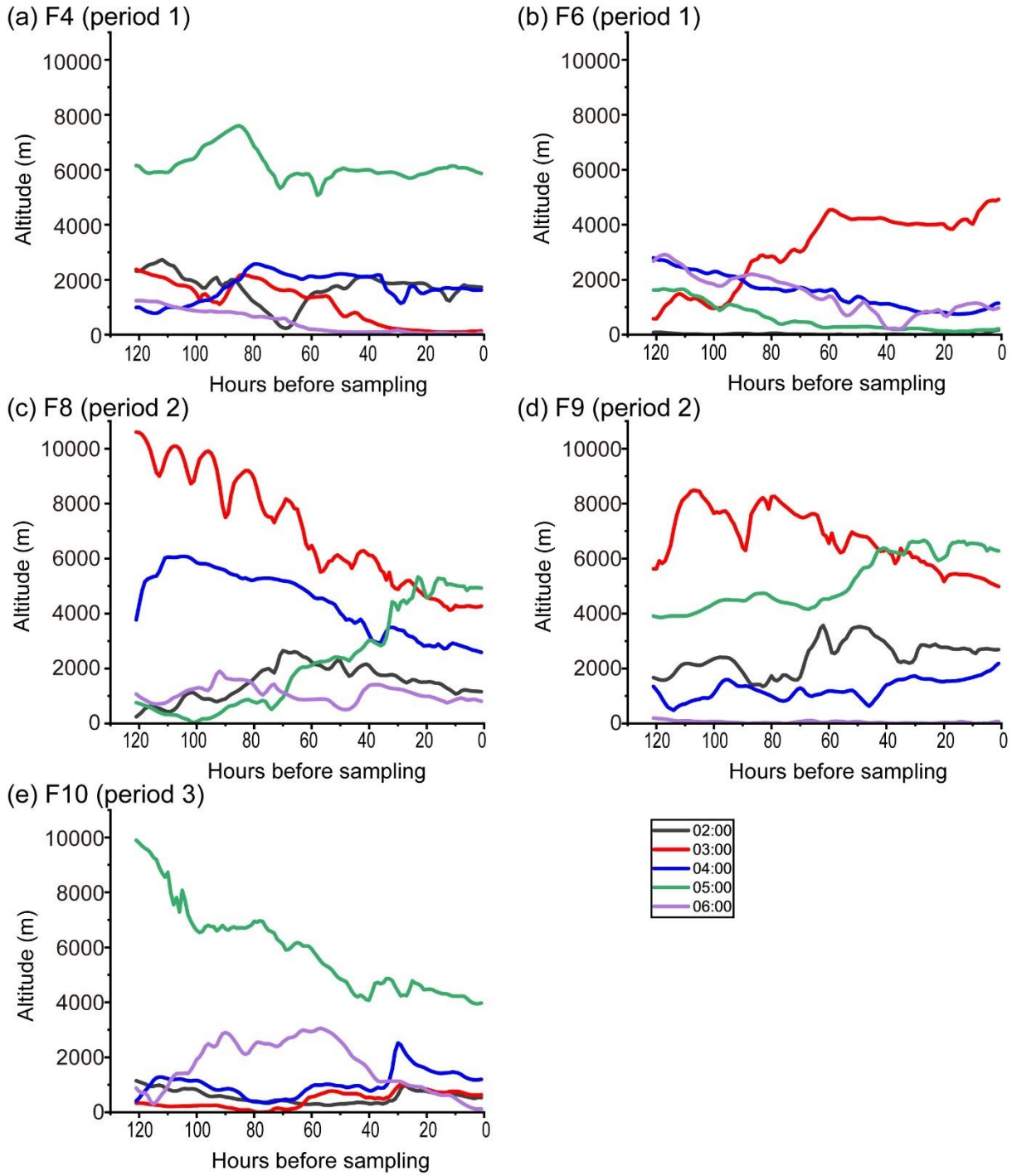

Figure S4. Back trajectories (altitudes) of sampled air parcels during each flight. The trajectories (120 h) start every hour (UTC). The trajectories with latitude and longitude are shown in Figure 2.

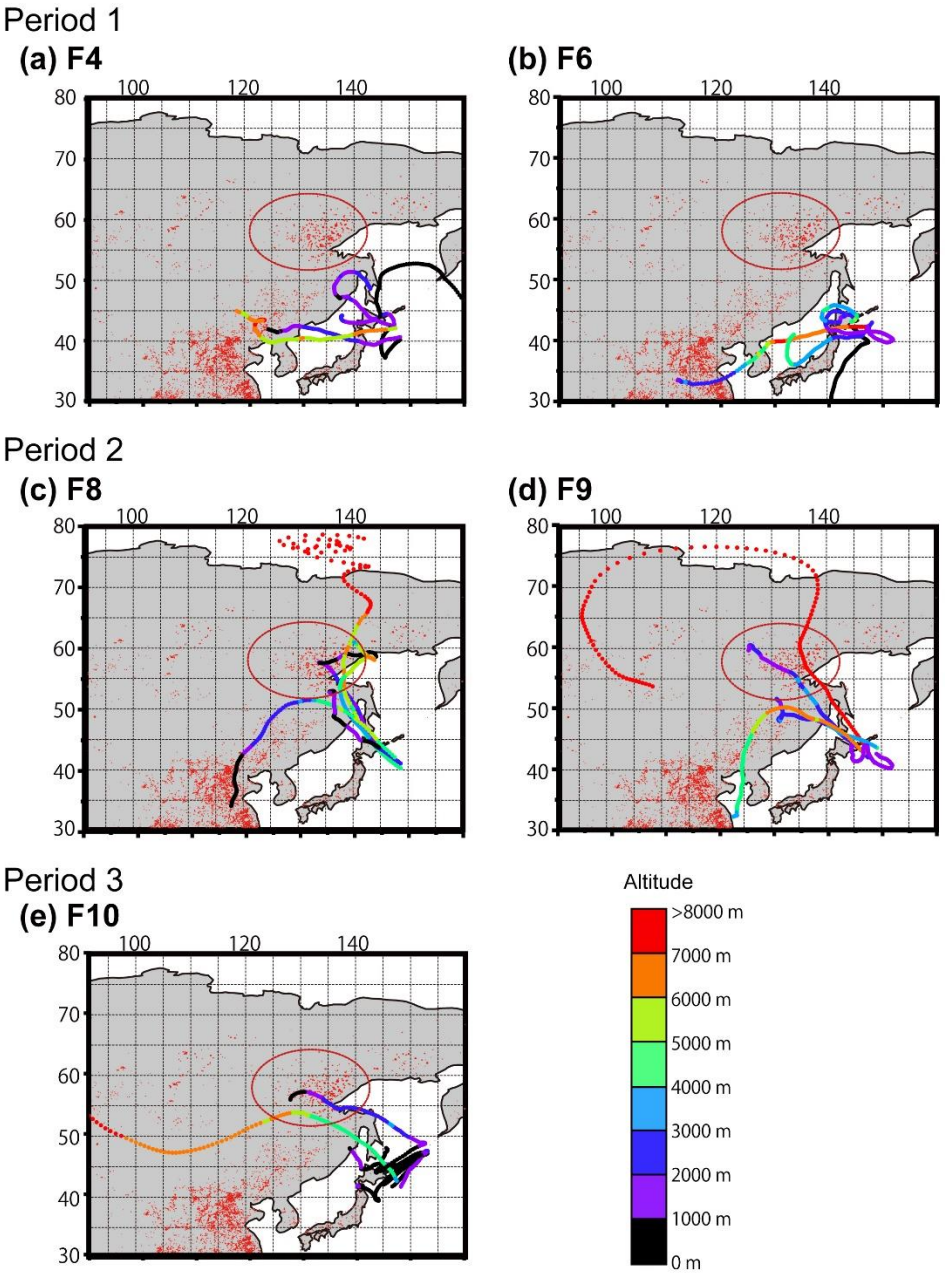

Figure S5. Back trajectories of sampled air parcels during each flight with larger area than that in Figure 2. The trajectories (120 h) start every hour (UTC). Colors along the trajectories indicate altitudes. Red dots indicate active fires during the sampling period (from July 22 to August 1, 2022) from NASA's Fire Information for Resource Management System (NASA FIRMS, 2025). The area of biomass burning in the Siberian Forest is shown as a red circle.

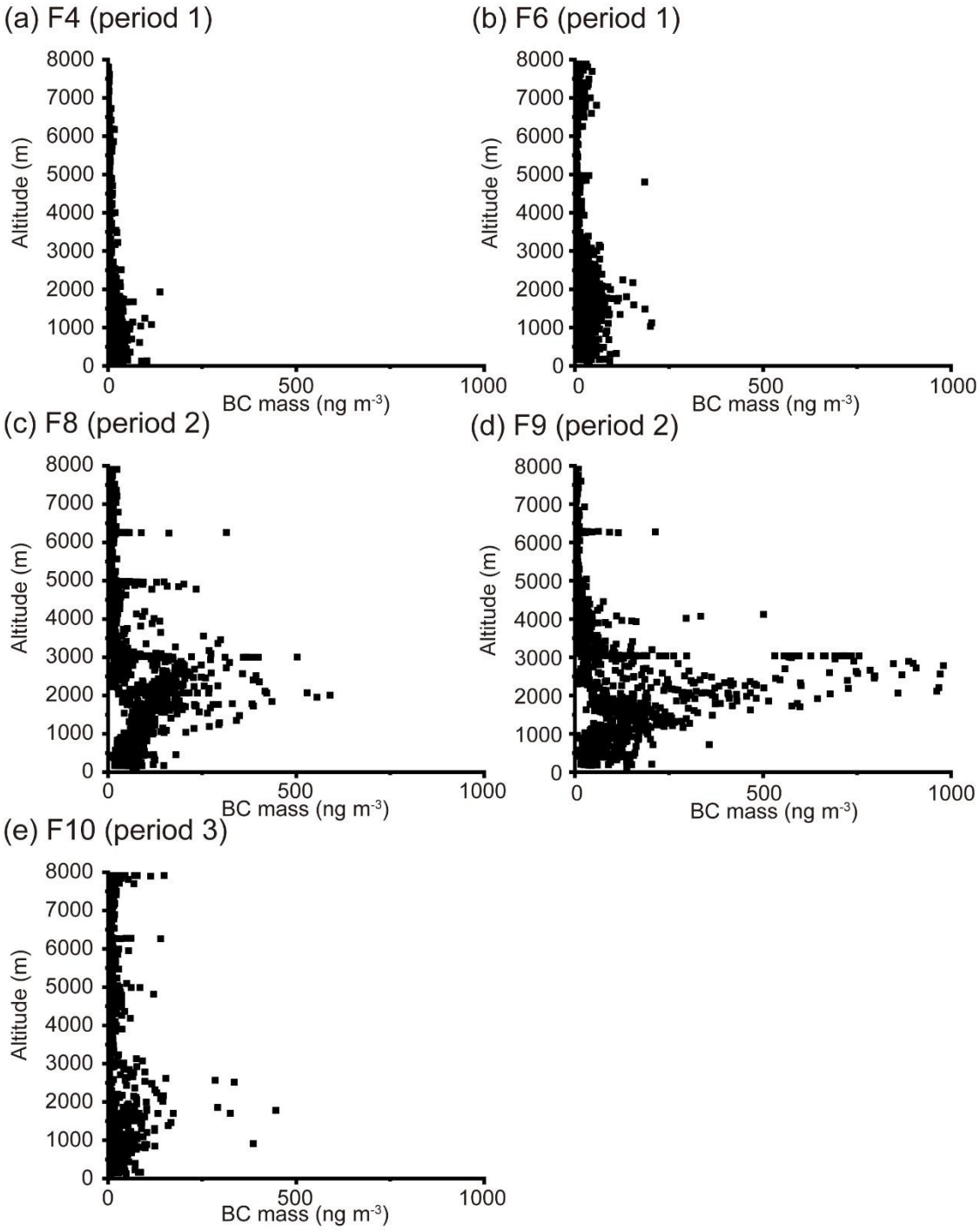

Figure S6. Black carbon (BC) mass concentrations over flight altitudes measured with a single particle soot photometer (SP2). Each plot represents a 10-second average.

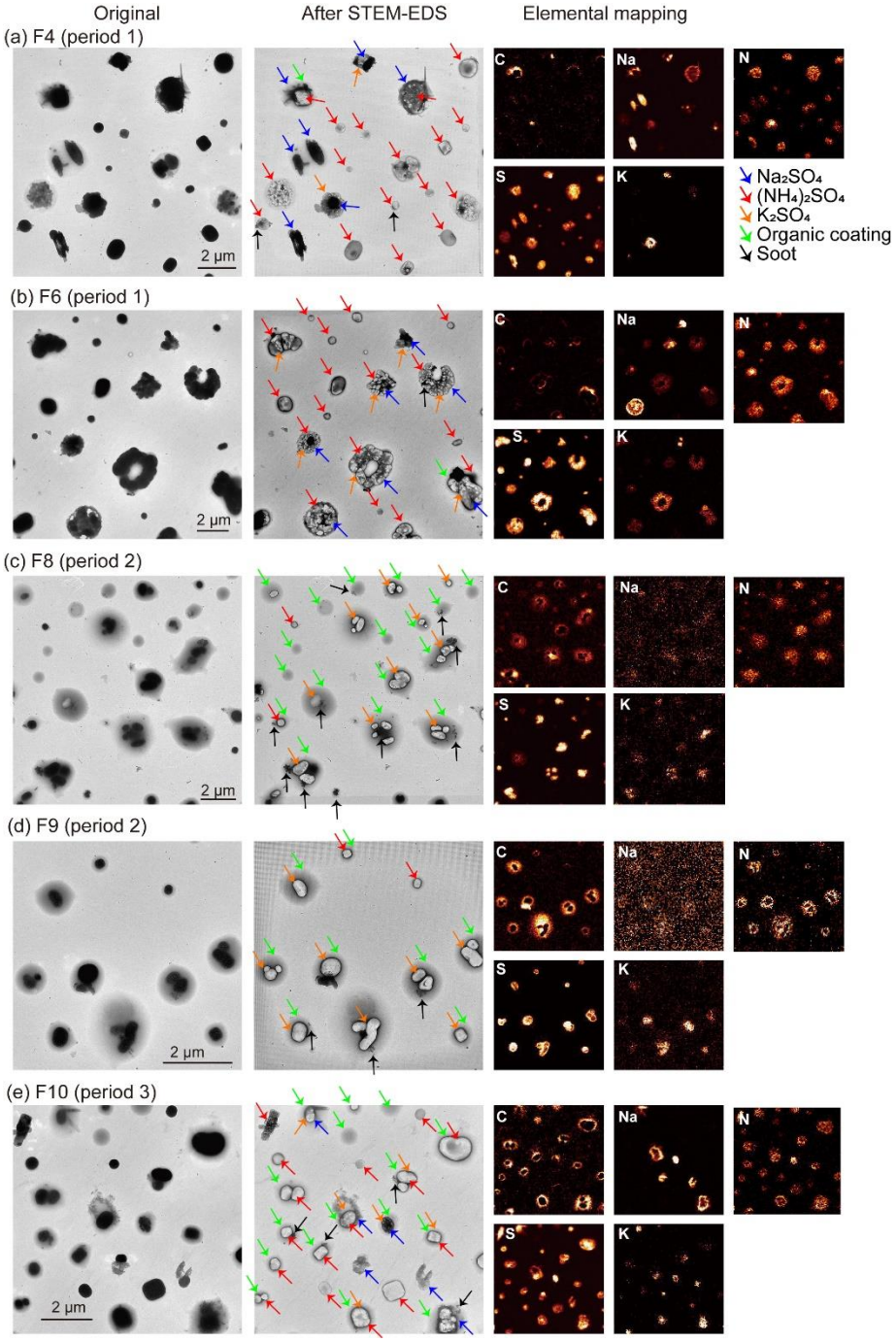

Figure S7. Possible aerosol species in Fig. 3 are indicated by arrows.

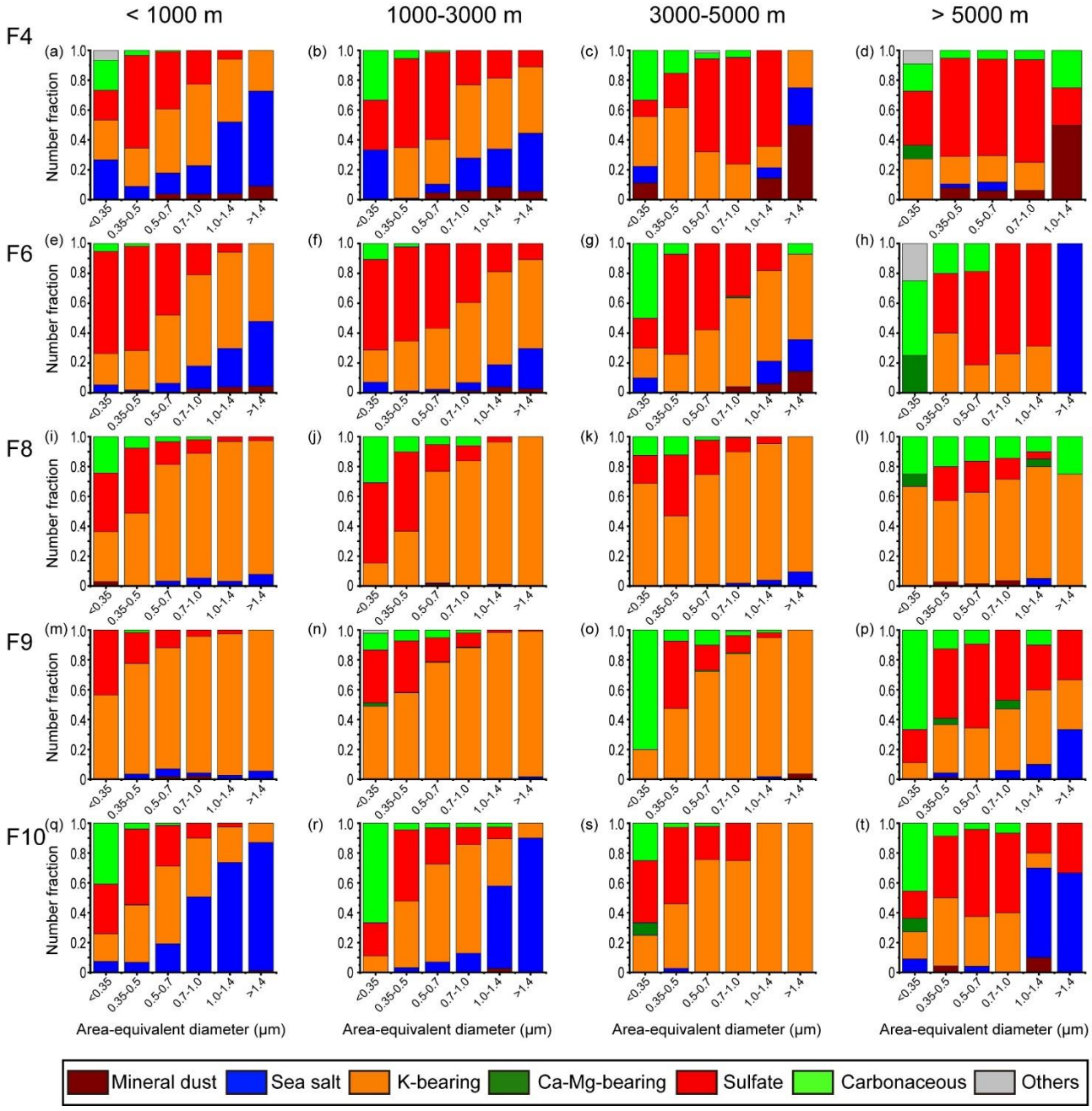

Figure S8. Size-dependent number fractions of airborne samples with different altitudes from each flight. Samples were classified based on the sampling altitudes of < 1000 m, 1000-3000 m, 3000-5000 m, and > 5000 m. The ranges of lognormal size bins are < 0.35, 0.35-0.50, 0.50-0.71, 0.71-1.0, 1.0-1.4, and >1.4 μm.

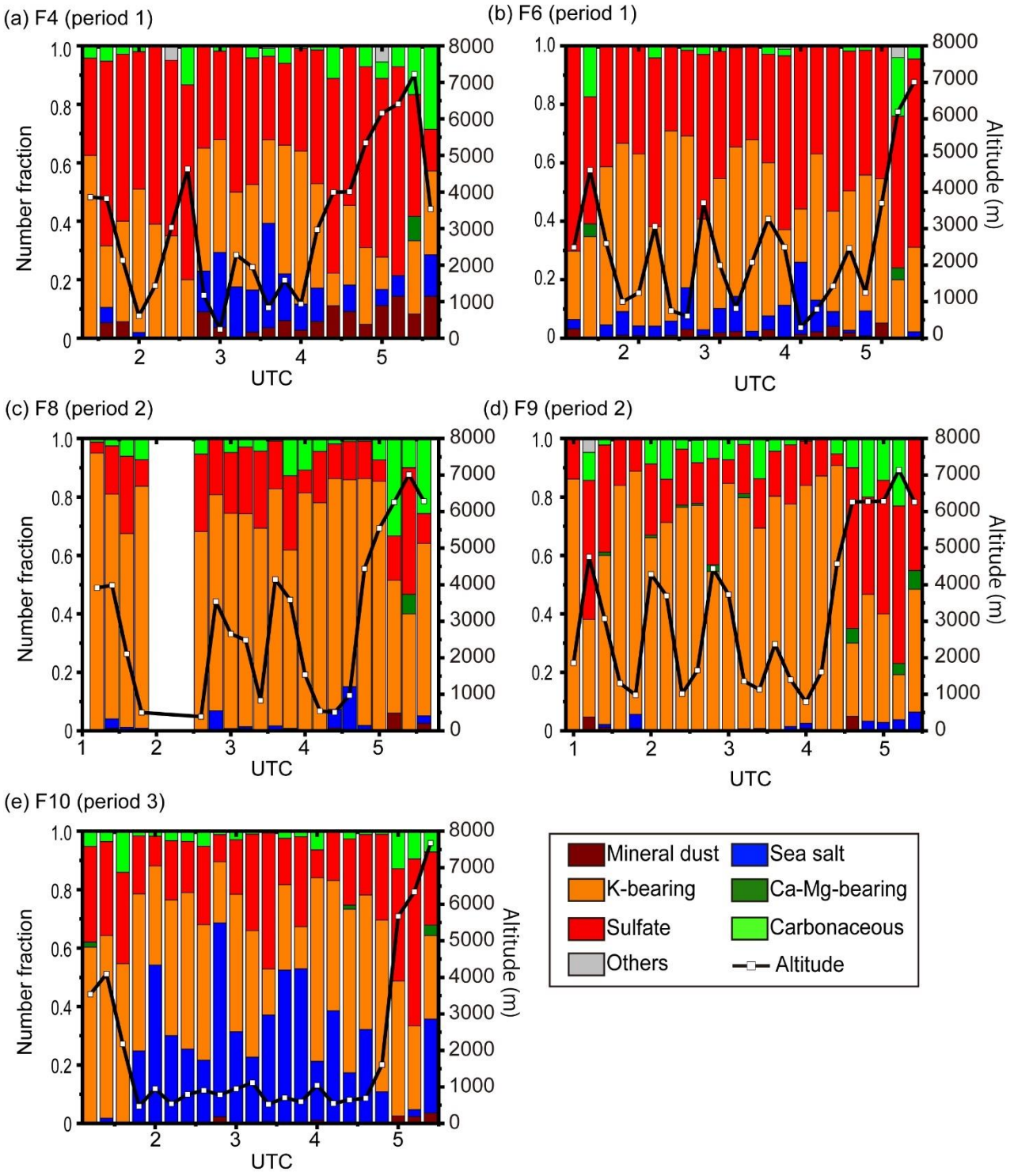

Figure S9. Number fractions of all airborne samples with averaged altitudes during each sampling period.

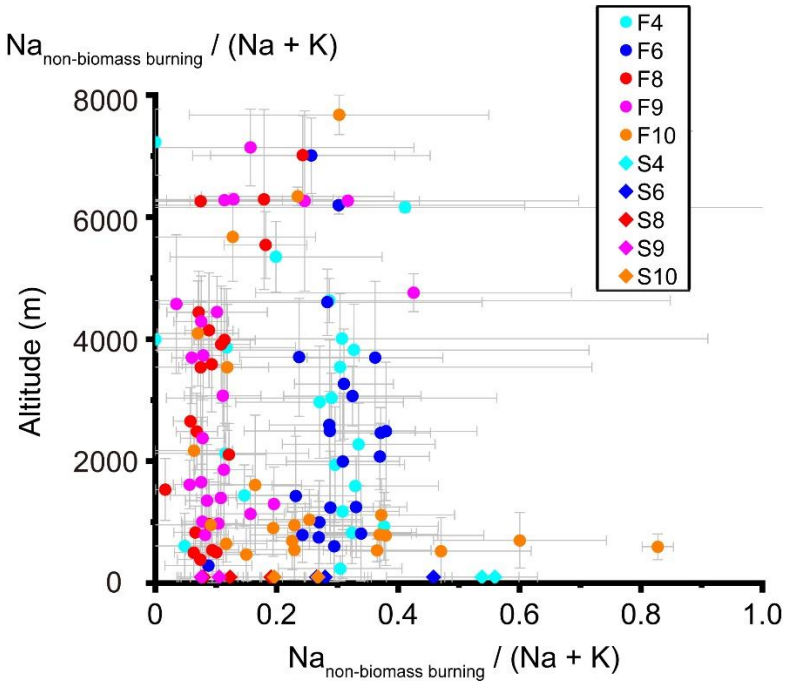

Figure S10. Comparison of the sodium fraction with consideration of the sodium contributions from biomass burning. This figure is the same as Fig. 7a but with modified sodium contributions from biomass burning based on an assumption by Adachi et al. (2025): $[Na_{non\text{-}biomass\ burning}] = [Na] - [K] \times 0.06$.

Table S1. The positions of the aircraft at each hour.

	UTC	Long (deg)	Lat (deg)	Height (m agl)
F4	0200	146.5589	42.5128	1732.6
	0300	148.0219	40.1481	134.9
	0400	148.0071	40.6131	1626.8
	0500	147.1833	42.0905	5864.5
	0600	144.16	43.8796	66.7
F6	0200	144.5813	42.0304	177.3
	0300	146.6322	42.2479	4922.2
	0400	147.9427	42.954	1143
	0500	147.1251	42.3443	209.6
	0600	144.4347	43.7994	968.9
F8	0200	147.0213	42.2252	1159.4
	0300	148.482	40.4313	4268.9
	0400	148.4498	41.2466	2586.1
	0500	147.3599	42.2196	4924.7
	0600	144.455	43.8511	809.2
F9	0200	147.2814	41.9291	2685.3
	0300	148.5012	41.0827	4982.4
	0400	148.9798	43.5075	2184.6
	0500	146.6079	42.6057	6280.7
	0600	144.16	43.8797	66.5
F10	0200	145.0106	41.6363	531
	0300	146.5894	41.3135	634.3
	0400	148.1675	41.2888	1194.9
	0500	147.3906	42.2311	3969.3
	0600	144.166	43.8654	117.4

References

Adachi, K., Sun, C., Onchang, R., and Takegawa, N.: Homogeneous Mixing of Sea Spray and Biomass Burning Tracer Elements Within Single Particles Observed Over Southeast Asia, Journal of Geophysical Research: Atmospheres, 130, 10.1029/2024jd042328, 2025.