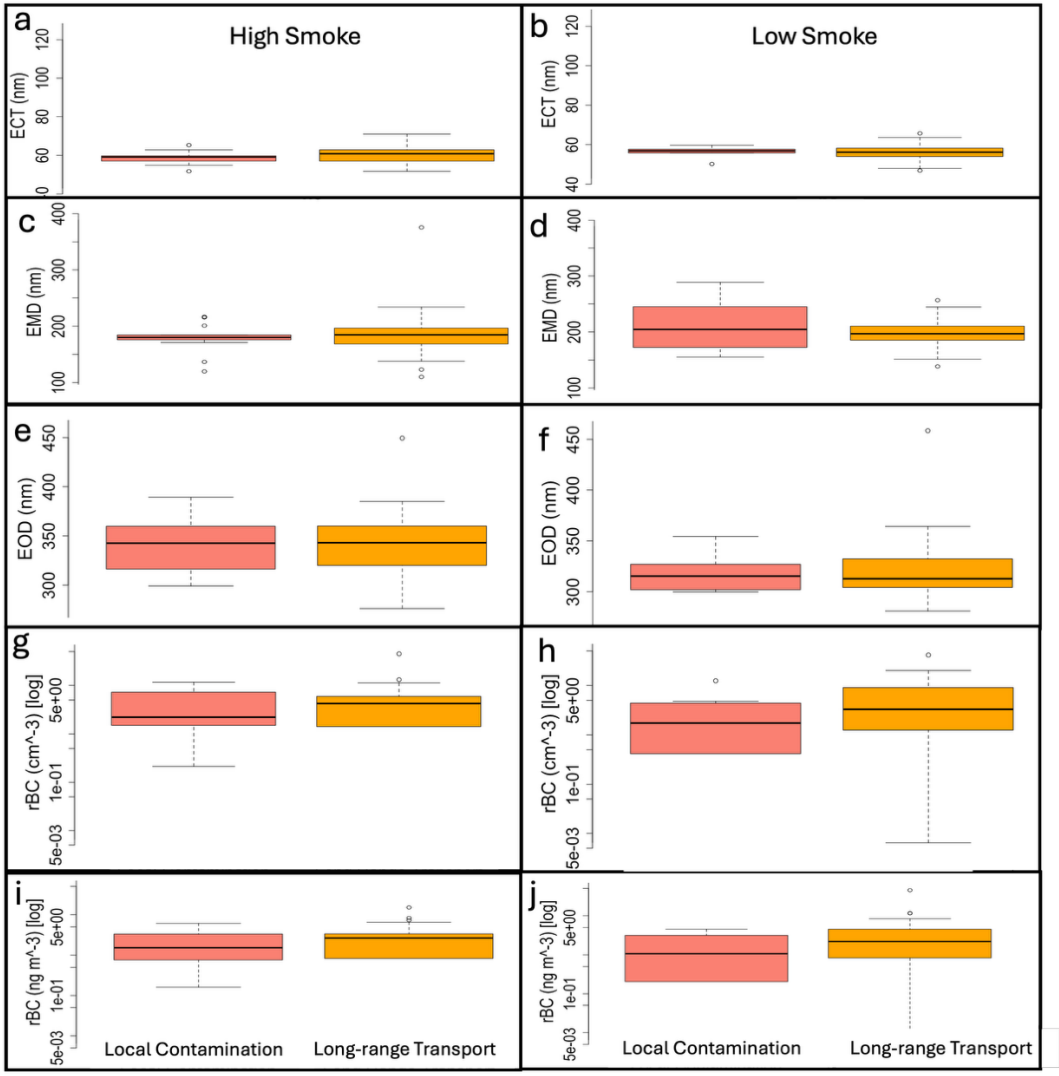


Figure S1: Comparison of SP2-XR aerosol variables categorized by high-smoke and low-smoke baseline scenarios derived from the NAAPS-RA reanalysis. No statistically significant differences were observed between the scenarios ($p \geq 0.05$, ns). Solid horizontal lines indicate median values, box boundaries represent the interquartile range (IQR), and whiskers extend to 1.5×IQR.

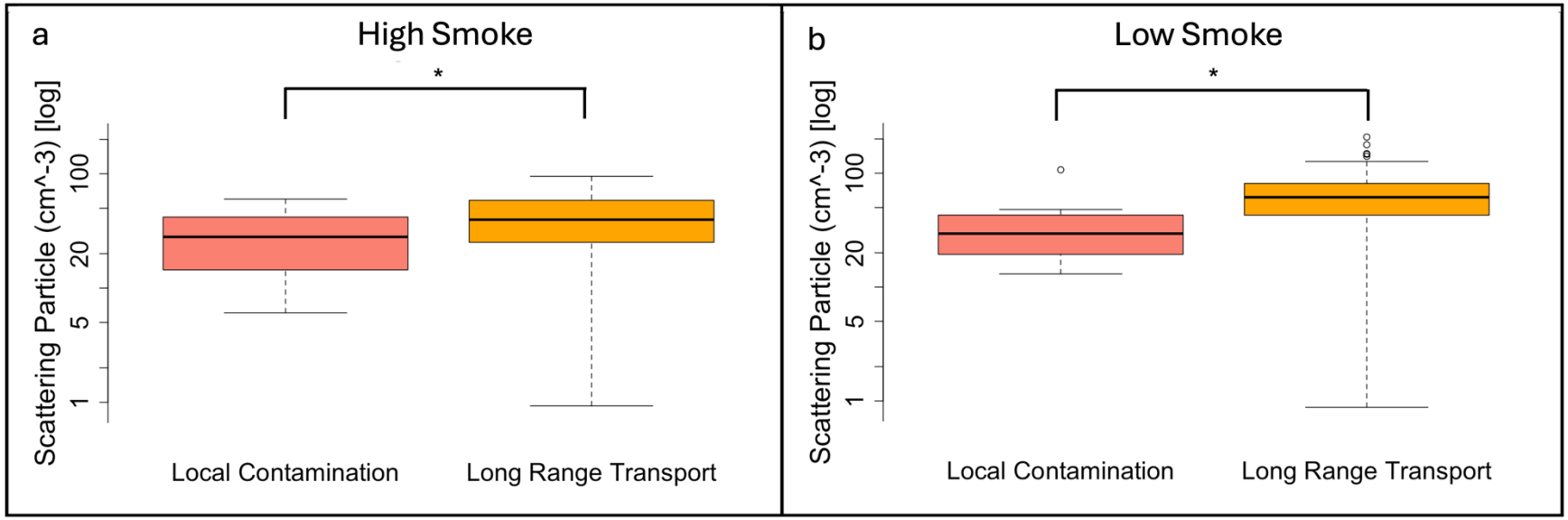


Figure S2: SP2-XR scattering particle number concentration (cm^{-3}) categorized by high-smoke and low-smoke baseline scenarios derived from the NAAPS-RA reanalysis. A statistically significant difference was observed between local and long-range scenarios ($p<0.05$). Solid horizontal lines indicate median values, box boundaries represent the interquartile range (IQR), and whiskers extend to 1.5×IQR.

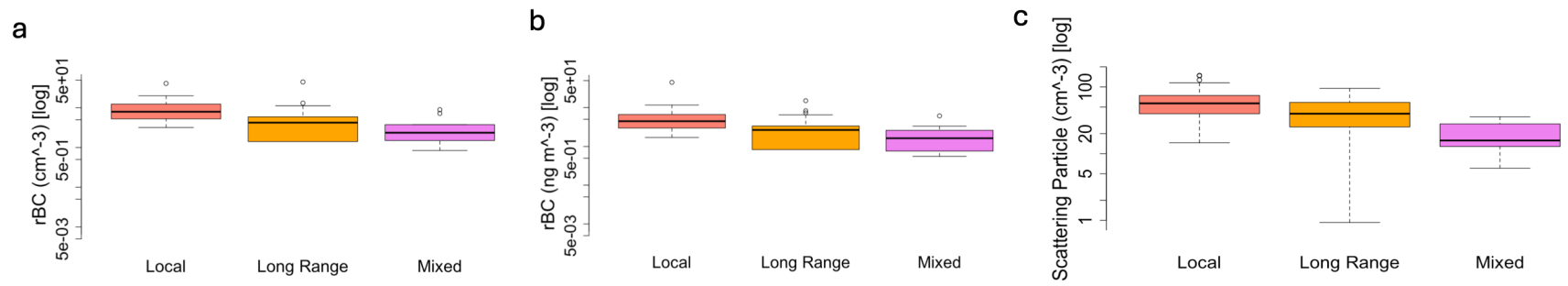


Figure S3: Box plots comparing SP2-XR measured properties across local, long-range, and mixed transport scenarios: a) refractory black carbon number concentration (rBC, cm^{-3}; log scale), b) refractory black carbon mass concentration (rBC, ng m^{-3}; log scale), and c) scattering particle number concentration (cm^{-3}; log scale). Solid horizontal lines indicate median values, box boundaries represent interquartile ranges (IQR), whiskers denote 1.5 × IQR, and open circles indicate individual outliers.

Table S1. Descriptions of directly measured variables from the SP2-XR.

	Average Incandescence number concentration	**Average Scattering-only number concentration**	**Average rBC_{mass} concentration**	**Average rBC_{total} mass**
Units	cm^{-3}	cm^{-3}	ng m^{-3}	fg
Measurement Type (Direct or Derived)	Direct	Direct	Direct, based on calibration	Direct, based on calibration
Description	Average concentration of rBC	Average concentration of scattering particles (e.g. dust)	Average mass concentrations of incandescing particles derived from mass calibration	Average mass of all incandescing particles
Calculation			Mass of each particle/sec (fg/m^3) converted to ng/m^3	Sum of each particle mass

Table S2. Descriptions of derived variables from the SP2-XR.

	Avg Diameter of rBC	**Avg Diameter of scattering Particles**	**Avg Volume-weighted Diameter of Scat. Particles (EOD)**	**Avg Volume-weighted Diameter of rBC (EMD)**	**Equivalent Coating Thickness (ECT)**
Units	nm	nm	nm	nm	nm
Measurement Type (Direct or Derived)	Derived	Derived	Derived	Derived	Derived
Description	Average equivalent mass diameter of incandescent particles	Average equivalent optical diameter of scattering particles	Average of the median volume diameter of scattering particles	Average of the median volume diameter of incandescent particles	This is a metric that is used to represent the fraction of rBC mixed with other material
Calculation/Derivation	$Sum(C_i*D_i)/Sum(C_i)$	$Sum(C_i*D_i)/Sum(C_i)$	$Sum(C_i*D_i^4)/Sum(C_i*D_i^3)$	$Sum(C_i*D_i^4)/Sum(C_i*D_i^3)$	This is the difference between the optical radius and rBC radius

Table S3: SP2-XR and NAAPS-RA data from three case studies depicted in Figure 6. The case studies include a local contamination event between September 25 and 27, a high smoke deposition long-range transport event that occurred between August 12 and 18, and a suspected mixed aerosol transport between August 22 and 27. ECT refers to Equivalent Coating Thickness defined in Table 2-SI.

Aerosol Transport Scenario	**# Days**	**NAAPs Cumulative Smoke Concentration ($\mu g\ m^{-3}$)**	**NAAPs Cumulative ABF Concentration ($\mu g\ m^{-3}$)**	**Mean rBC concentration (cm^{-3})**	**Mean rBC ($ng\ m^{-3}$)**	**Mean Total rBC Particle Mass (fg)**	**Mean EOD (nm)**	**Mean EMD (nm)**	**Mean ECT (nm)**
Local 2024-09 25th to 27th	3	0.1	0.55	21	8	12	315	193	48
Long Range 2024-08 12th to 18th	7	4.76	1.12	9	4	7	355	183	61
Mixed 2024-08 22nd to 27th	6	4.49	1.7	3	2	4	353	162	59