# In-Tandem Multi-Waveband Particulate Absorption and Size Observations Yield Substantial Increase in Radiative Forcing over Industrial Central China

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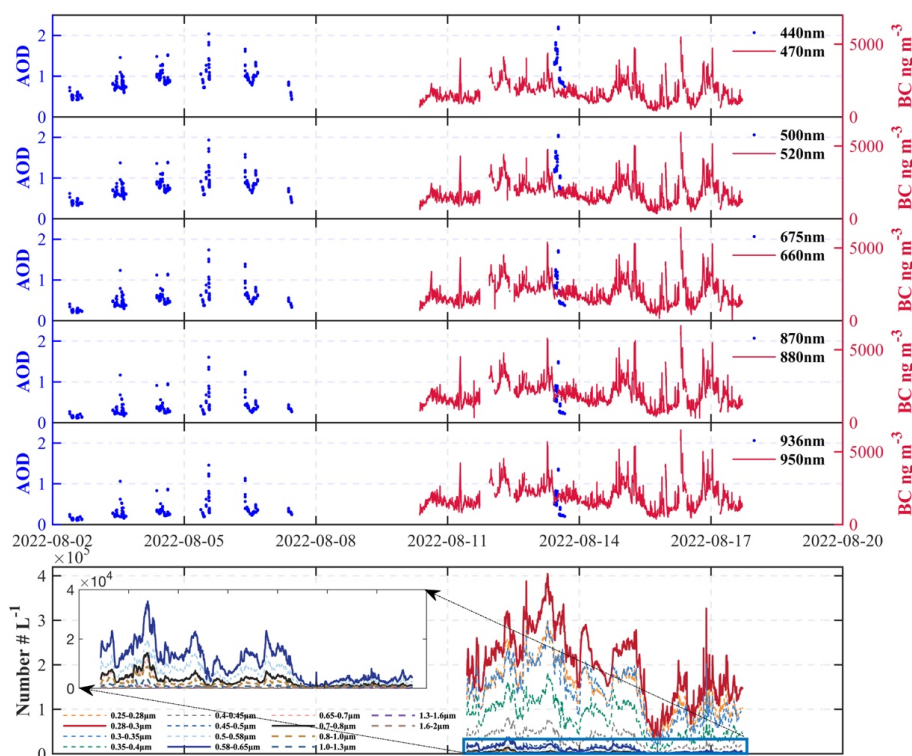
Figure S1: The measurements of field experiment campaign in August, 2022.

Figure S2: Photograph taken by Luoyao Guan in the study areas in August, 2022. These are typical scenes associated with black carbon, coal dust, and absorbing aerosol emissions. (a) the environment of coal mining areas; (b) coal-fired power plants; (c) coal transportation (d) coal storage.
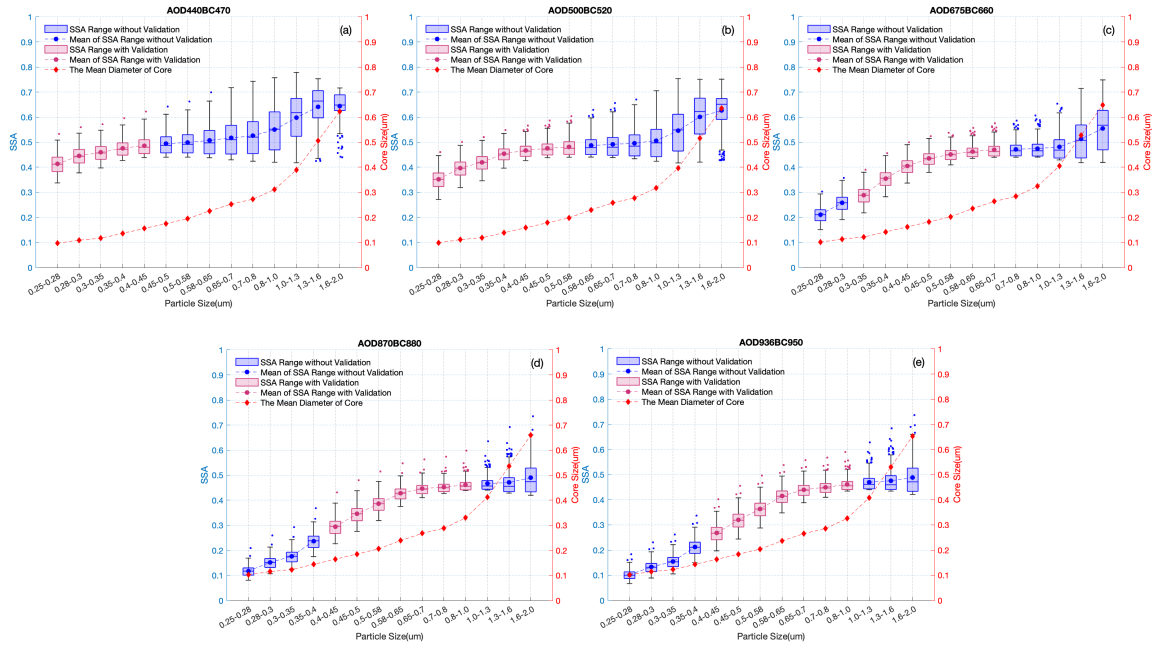

Figure S3: Multi-wavelength SSA simulation results under non-uniform assumption and ISSIZE distribution. Convex hull (pink) represents the particle size range where AAE theory is applicable, while concave hull (blue) indicates the non-applicable region, when computed using observations at (a) 470 nm; (b)520 nm; (c)660 nm; (d)880 nm; and (e)950 nm respectively.
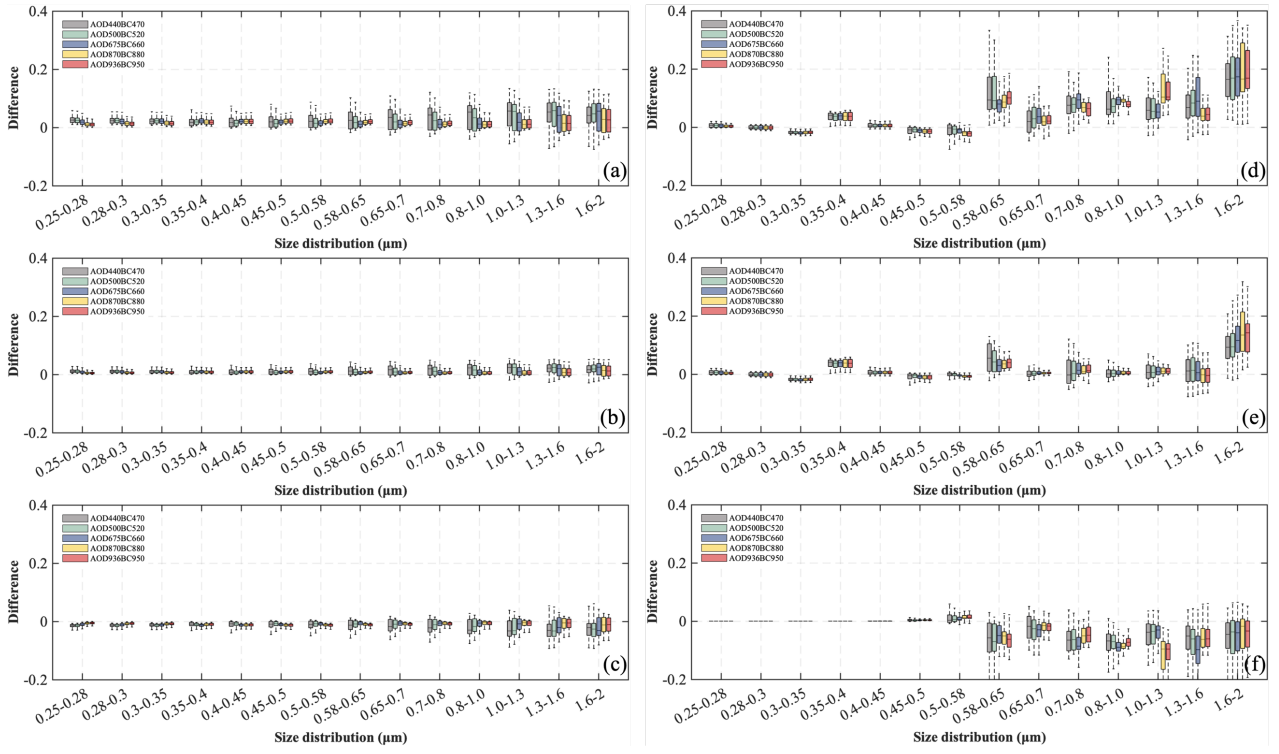
Figure S4: Differences of multiband SSA under different assumptions and size distributions. (a) ISSIZE and Log₁ under the non-uniform assumption; (b) ISSIZE and Log₁₂₃ under the non-uniform assumption; (c) Log₁ and Log₁₂₃ under the non-uniform assumption; (d) ISSIZE and Log₁ under the uniform assumption; (e) ISSIZE and Log₁₂₃ under the uniform assumption;(f) Log₁ and Log₁₂₃ under the uniform assumption.
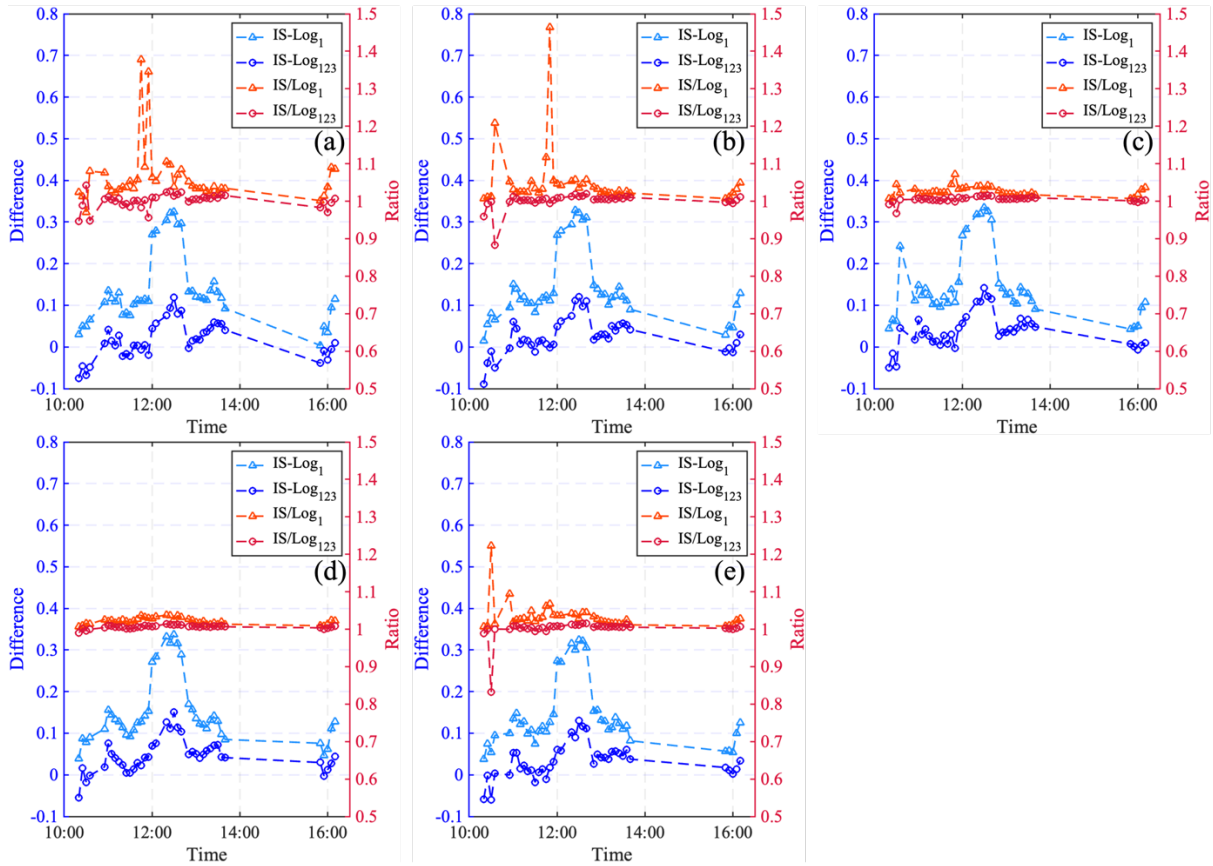

Figure S5: Differences of multiband radiative forcing and ratio with uniform assumption between different size distributions. (a) 470nm; (b)520nm; (c)660nm; (d)880nm; (e)950nm.

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Table S1: The statistic of radiative forcing through all five bands with uniform assumption, the mean values of RF are given in bold, the standard deviations are given in parentheses, the last two rows are RMSE between different size distribution.

	470 nm	520 nm	660 nm	880 nm	950 nm
ISSIZE	**3.1**(*1.9*)	**4.5**(*2.0*)	**6.1**(*2.3*)	**6.9**(*2.2*)	**5.7**(*2.4*)
Log_1	**3.0**(*1.9*)	**4.4**(*2.0*)	**5.9**(*2.3*)	**6.8**(*2.1*)	**5.5**(*2.3*)
Log_{123}	**3.1**(*1.9*)	**4.5**(*2.0*)	**6.0**(*2.3*)	**6.9**(*2.1*)	**5.6**(*2.3*)
RMSE(ISSIZE-Log_1)	0.16	0.16	0.18	0.17	0.16
RMSE(ISSIZE-Log_{123})	0.05	0.05	0.06	0.06	0.05

Table S2: The statistic of two first-order linear/non-linear models with uniform assumption through all five wavelengths, the coefficient of determination is given in bold, the RMSE, and weighted RMSE are given in parentheses (W m^{-2}).

|	470 nm	520 nm	660 nm	880 nm	950 nm
ISSIZE (SSA)	**0.79**(*4.44, 0.09*)	**0.76**(*4.39, 0.09*)	**0.73**(*4.28, 0.09*)	**0.71**(*4.20, 0.10*)	**0.74**(*4.34, 0.09*)
Log_1 (SSA)	**0.85**(*4.31, 0.10*)	**0.85**(*4.1, 0.11*)	**0.85**(*3.97, 0.12*)	**0.83**(*4.07, 0.12*)	**0.86**(*3.92, 0.11*)
Log_{123} (SSA)	**0.82**(*4.40, 0.09*)	**0.81**(*4.35, 0.09*)	**0.79**(*4.30, 0.11*)	**0.77**(*4.32, 0.11*)	**0.80**(*4.28, 0.10*)
ISSIZE (SSA, AOD, size)	**0.93**(*2.73, 0.06*)	**0.93**(*2.61, 0.07*)	**0.93**(*2.5, 0.07*)	**0.93**(*2.39, 0.07*)	**0.93**(*2.56, 0.06*)
Log_1 (SSA, AOD, size)	**0.93**(*2.98, 0.12*)	**0.93**(*2.73, 0.07*)	**0.94**(*2.57, 0.07*)	**0.93**(*2.57, 0.08*)	**0.94**(*2.57, 0.07*)
Log_{123} (SSA, AOD, size)	**0.93**(*2.87, 0.14*)	**0.93**(*2.72, 0.15*)	**0.92**(*2.55, 0.16*)	**0.92**(*2.49, 0.15*)	**0.93**(*2.51, 0.07*)
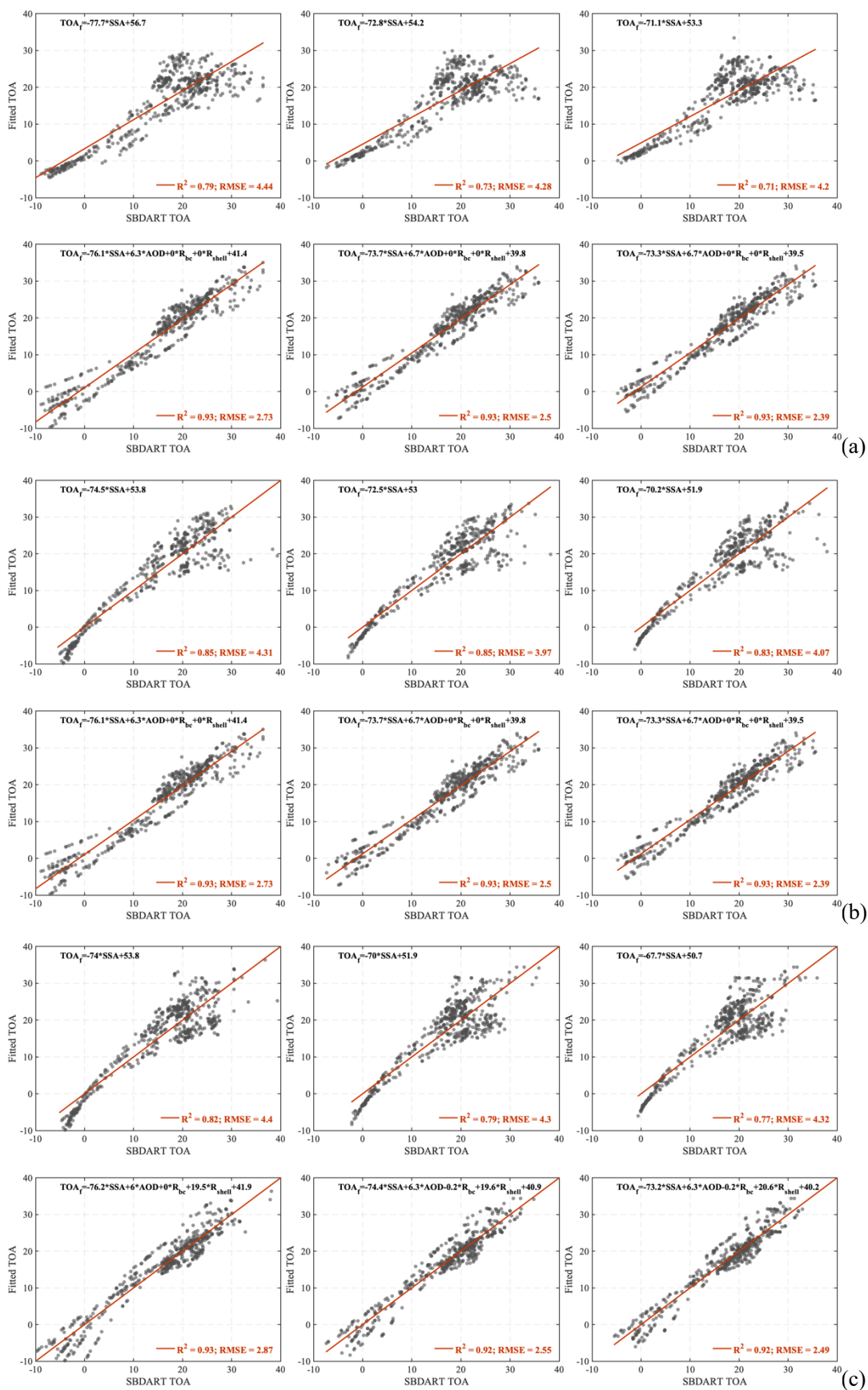
Figure S6: Deriving adjusted TOA using two different linear models with uniform assumption, the first row in each subfigure is linear model only including SSA, the second row is linear model including the effects of BC core, sulfate shell and AOD as additional variables, the first to the third column for each subfigure is 470nm, 660nm and 880nm. (a) ISSIZE measurements; (b)Log₁ distribution; (c)Log₁₂₃ distribution.