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Satellite-based radiative forcing by light-absorbing particles in snow across the Northern Hemisphere

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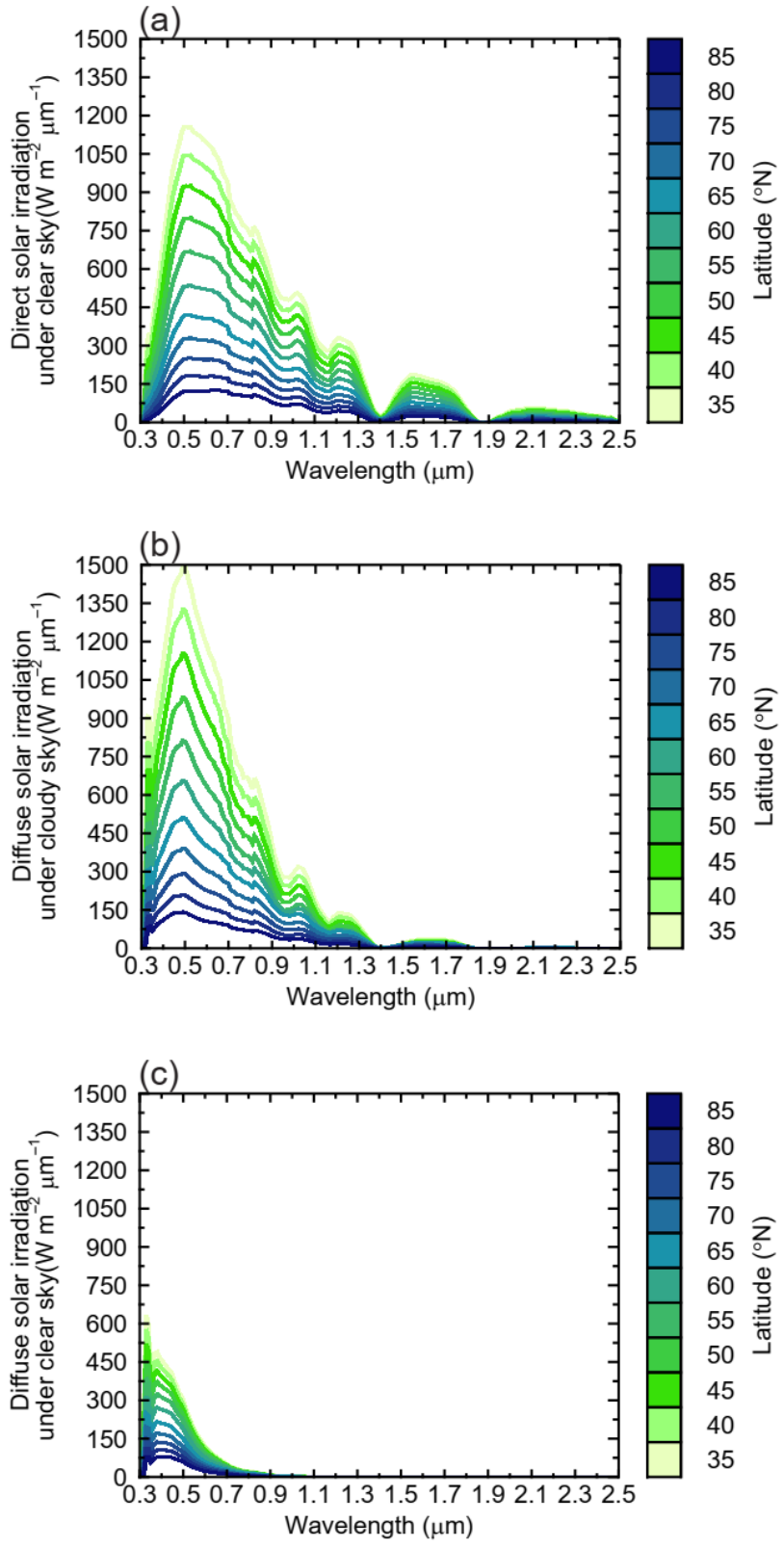

Figure S1. (a) Average December-May incident direct solar spectra for latitudes 35°–85°, derived from the SBDART model during clear-sky conditions. (b) Same as (a), but for diffuse solar irradiance. (c) Same as (a), but for cloudy-sky condition.

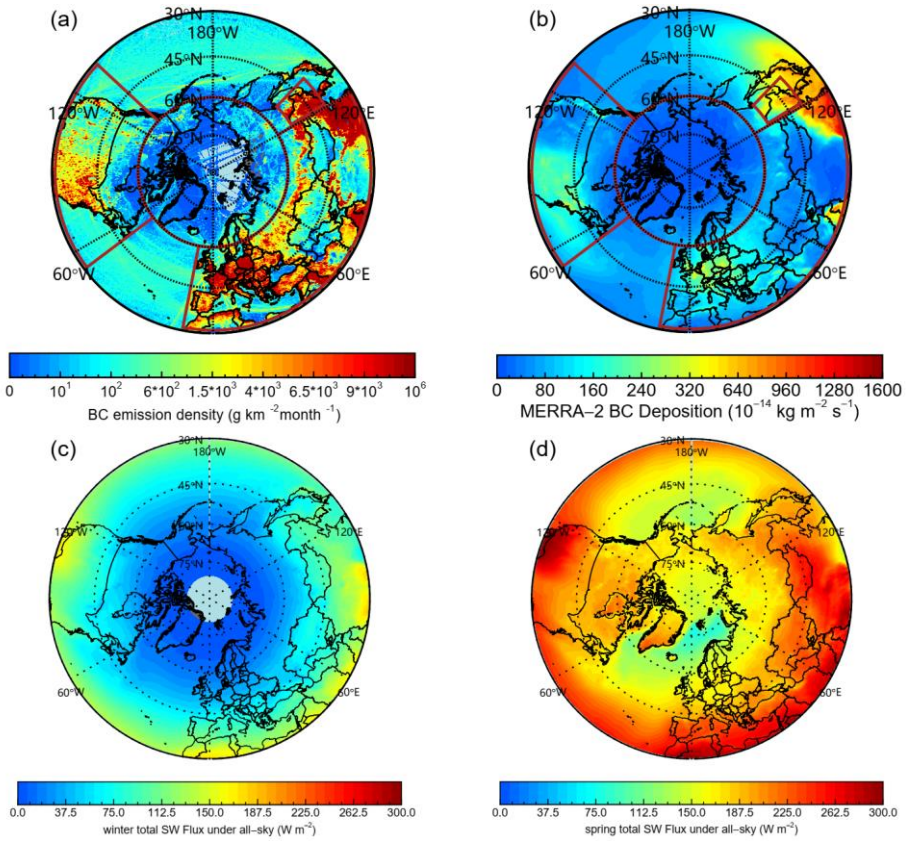

Figure S2. Spatial distributions of average (a) BC emissions density, (b) BC deposition from MERRA-2, (c) winter and (d) spring total downward shortwave flux at the surface in from CERES. BC emissions density is for the period 2003–2014 and from the research group at Peking University (Wang et al., 2014), while other data were collected for the period 2003 and 2018.

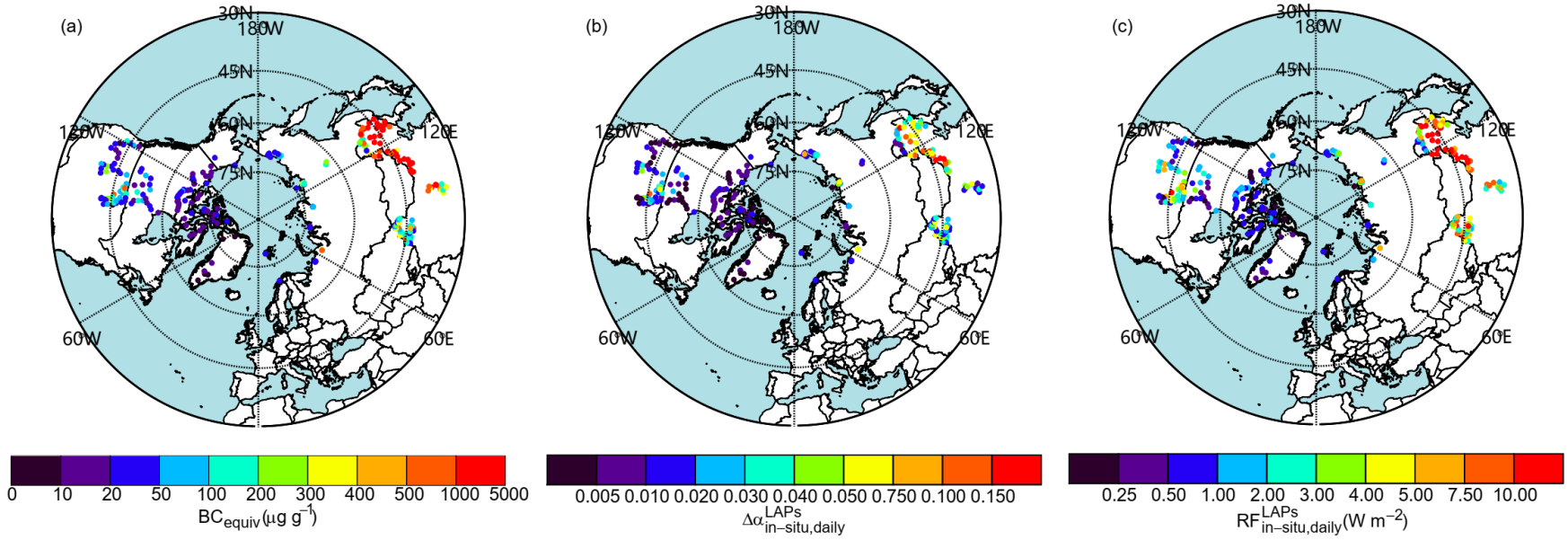

Figure S3. Spatial distribution of (a) in-situ measurements of BC_{equiv} and (b) the in situ snow albedo reduction and (c) radiative forcing. The snow albedo reduction and radiative forcing were calculated by SNICAR using measured BC_{equiv}.

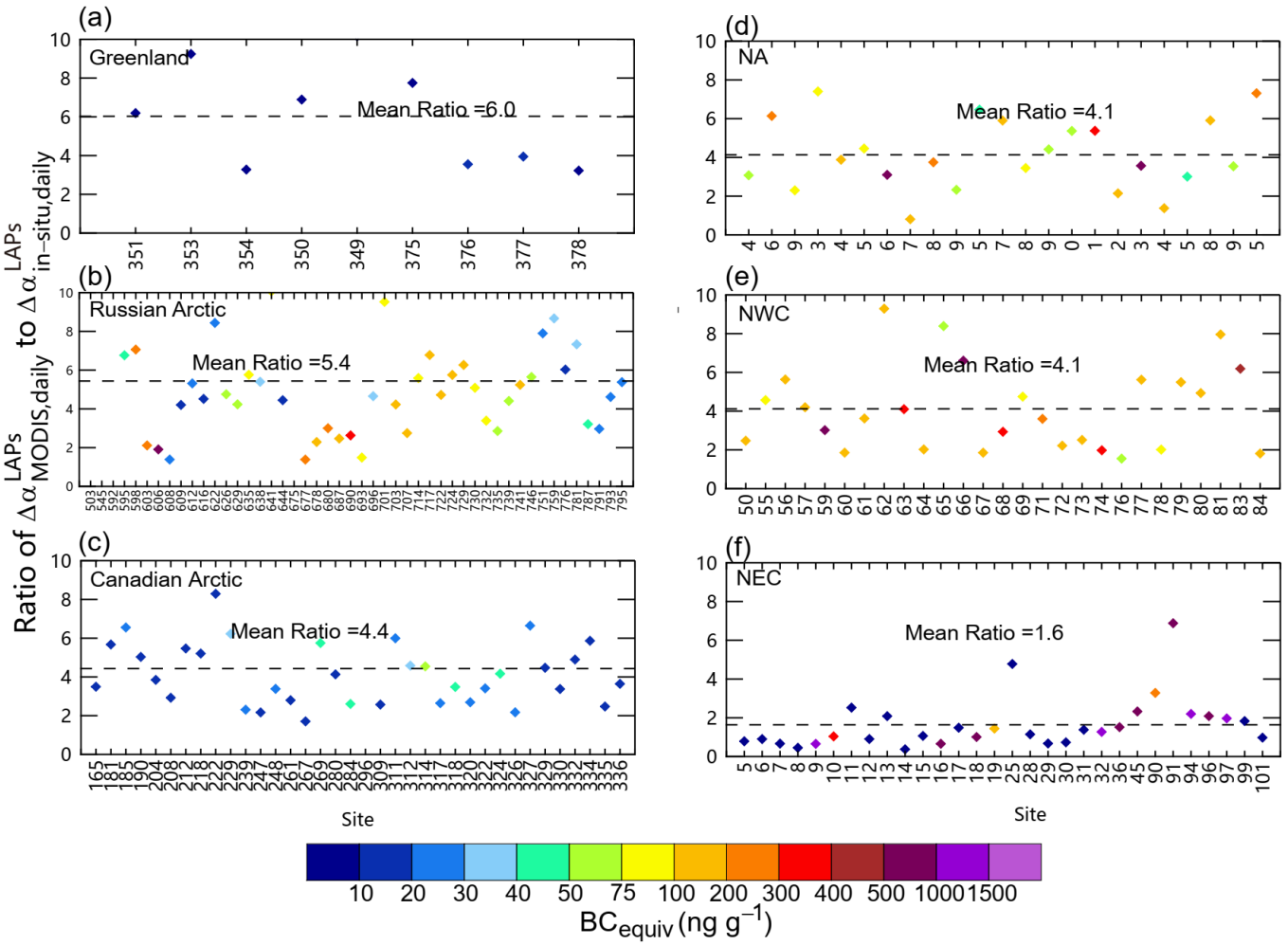

Figure S4. Ratio of $\Delta\alpha_{MODIS,ins}$ to $\Delta\alpha_{in-situ,ins}$. Panels (a)–(f) represent the snow samples collected in Greenland, Russian Arctic, Canadian Arctic, NA, NWC, and NEC, respectively.

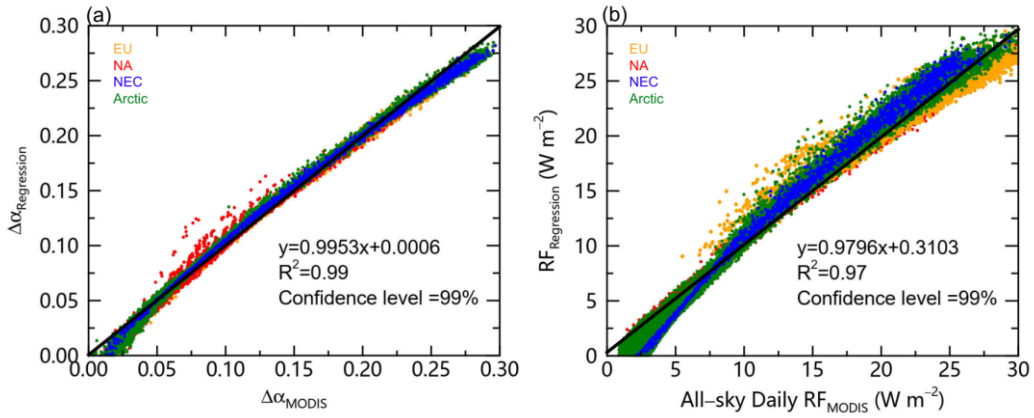

Figure S5. Comparisons of (a) $\Delta\alpha_{MODIS}$ and fitted albedo reduction ($\Delta\alpha_{Regression}$), and (b) RF_{MODIS} and fitted radiative forcing ($RF_{Regression}$). Different colors represent different regions.

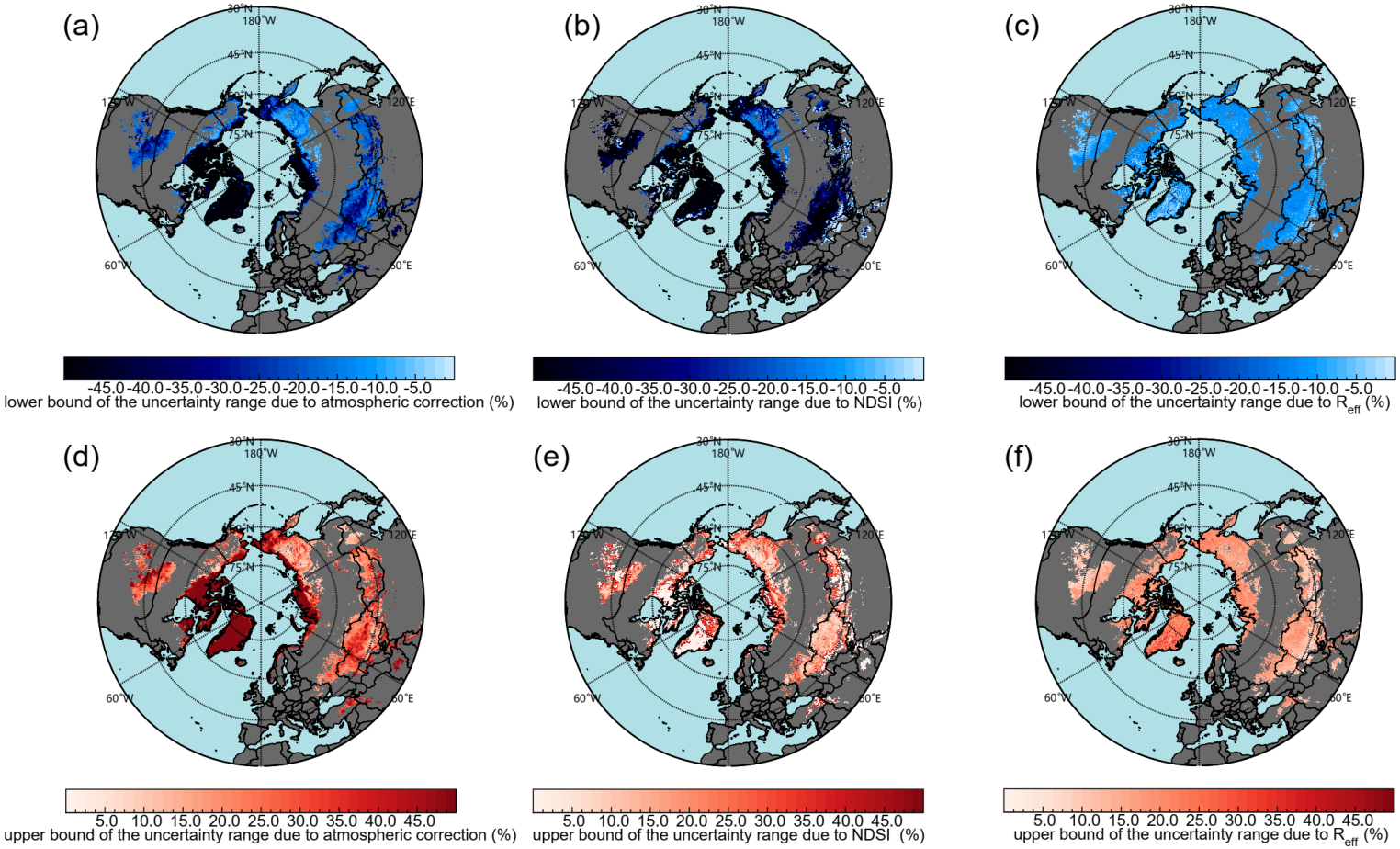

Figure S6. Spatial distributions of the lower bound of the uncertainty range due to (a) atmospheric correction, (b) snow cover fraction calculation and (c) snow grain size retrieval, respectively. (d)-(f) Same as (a)-(b), but for the upper bound of the uncertainty range.

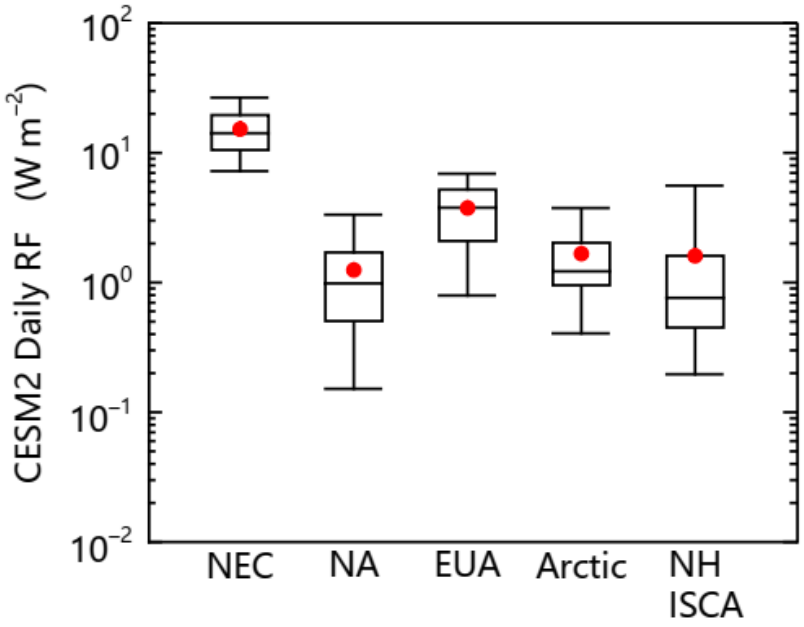

Figure S7. Statistics of daily radiative forcing, based on the CESM2 soot content of snow in December–May during the period 2003–2014. The boxes denote the 25th and 75th quantiles, and the horizontal lines represent the 50th quantiles (medians), the averages are shown as red dots; the whiskers denote the 5th and 95th quantiles.

Table S1. The mean absolute error (MAE), root mean square error (RMSE) and correlation coefficient of $\Delta\alpha^{LAPs}_{MODIS,corrected}$ relative to $\Delta\alpha^{LAPs}_{in-situ,daily}$

	Northeastern China	Northwestern China	NA	Canadian Arctic	Greenland	Russian Arctic
MAE	0.064	0.016	0.014	0.0038	0.0014	0.011
RMSE	0.088	0.020	0.024	0.0075	0.0016	0.016
Correlation coefficient	0.13	-0.22	0.25	0.53	0.37	0.27

References

Wang, R., Tao, S., Shen, H., Huang, Y., Chen, H., Balkanski, Y., Boucher, O., Ciais, P., Shen, G., Li, W., Zhang, Y., Chen, Y., Lin, N., Su, S., Li, B., Liu, J., and Liu, W.: Trend in global black carbon emissions from 1960 to 2007, Environ Sci Technol, 48, 6780-6787, 10.1021/es5021422, 2014.