Satellite Estimates of Aerosol Species Contributions to Global Aerosol Direct Effects

Alexander Matus and Tristan L'Ecuyer | **contact:** amatus@wisc.edu

Department of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison

Motivation

Aerosols affect climate by scattering and absorbing solar energy, which remains a significant source of uncertainty in our ability to predict future climate.

Methods

Improving upon previous techniques, CloudSat's new multi-sensor radiative fluxes and heating rates data product leverages the ability of CloudSat and CALIPSO active sensors to retrieve vertically-resolved cloud and aerosol properties critical for accurate assessment of aerosol direct effects. Upwelling and downwelling radiative fluxes from this product are used to compute the shortwave aerosol direct radiative effects (DRE), defined as the net flux perturbation due to the presence of aerosols, which are sorted by CALIPSO aerosol type classification.

$$DRE = \left(F^{\downarrow} - F^{\uparrow}\right)_{aero} - \left(F^{\downarrow} - F^{\uparrow}\right)_{noaero} \quad (1)$$

Inputs

Cloud properties:	CloudSat, CALIPSO, MODIS
Aerosol properties:	CALIPSO
Surface reflectance:	MODIS, AMSR-E
Temperature, humidity:	ECMWF reanalysis

Algorithm

Two-stream, adding-doubling radiative transfer model

- 6 shortwave, 12 longwave bands
- 125 levels (0 – 30 km)

Outputs

1. Vertical profiles of radiative flux (Wm^{-2})
2. Vertical profiles of heating rates ($K\ day^{-1}$)

Figure 1: Flowchart of the 2B-FLXHR-LIDAR algorithm.

Aerosol Species Contributions to DRE

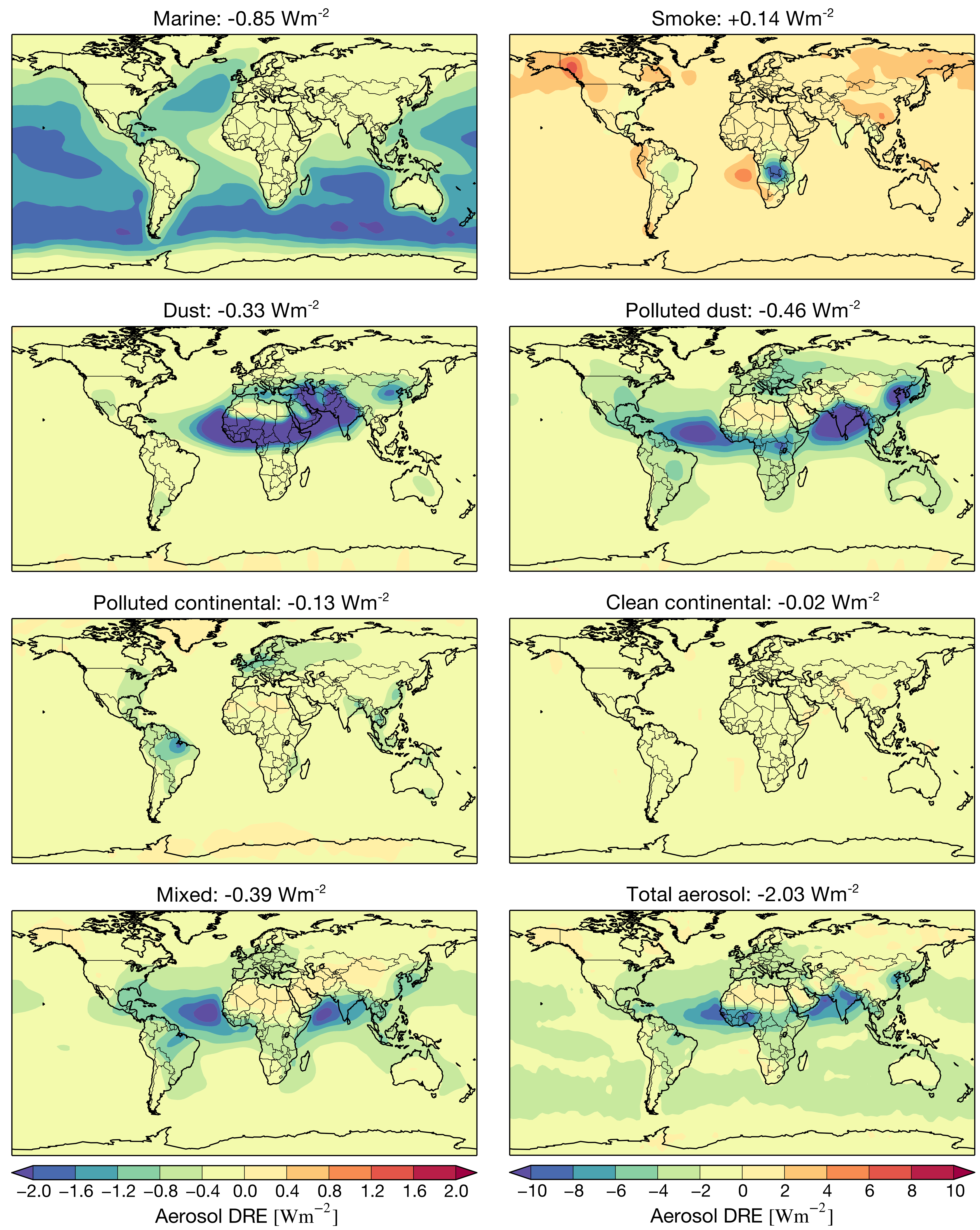

Figure 2: Annually-averaged aerosol DRE as sorted by CALIPSO aerosol types.

Global DRE Estimates

Table 1: Global annually-averaged DRE [Wm^{-2}]

	Clear-sky	Cloudy-sky	All-sky
Marine	-0.92	-0.69	-0.85
Dust	-0.38	-0.25	-0.33
Poll. Cont.	-0.20	-0.08	-0.13
Clean Cont.	-0.04	0.00	-0.02
Poll. Dust	-0.57	-0.31	-0.46
Smoke	-0.09	+0.55	+0.14
Mixed	-0.55	-0.19	-0.39
Global	-2.74	-0.97	-2.03

Assessing the contributions of aerosol species to global aerosol direct effects lends valuable insight into the complex role of aerosols on climate. Using the 2B-FLXHR-LIDAR dataset, we:

- Evaluate the role of cloud cover on absorbing versus scattering aerosol species; and
- Quantify the global distribution of DRE from both natural and anthropogenic sources.

The Big Picture

Multi-sensor A-Train satellite observations provide key observational constraints necessary to evaluate and improve climate model simulations of aerosol direct effects from different emission sources and under a range of atmospheric conditions.

Have a smartphone? Scan the QR code for more on this study: bit.ly/ams2014

References

[1] D. Chand, R. Wood, T. L. Anderson, S. K. Satheesh, R. J. Charlson, Nature Geoscience, **2**, 181-184 (2009).

[2] D. Henderson, T. L'Ecuyer, G. Stephens, P. Partain, and M. Sekiguchi, JAMC, **52**, 853-871 (2013).

[3] D. Shindell et al., Atmo. Chem. Phys., 2939-74 (2013).

[4] H. Yu et al., Atmo. Chem. Phys., **6**, 613-666 (2006).