Supplement of Atmos. Chem. Phys., 20, 15285–15295, 2020
https://doi.org/10.5194/acp-20-15285-2020-supplement

Supplement of

Weaker cooling by aerosols due to dust–pollution interactions

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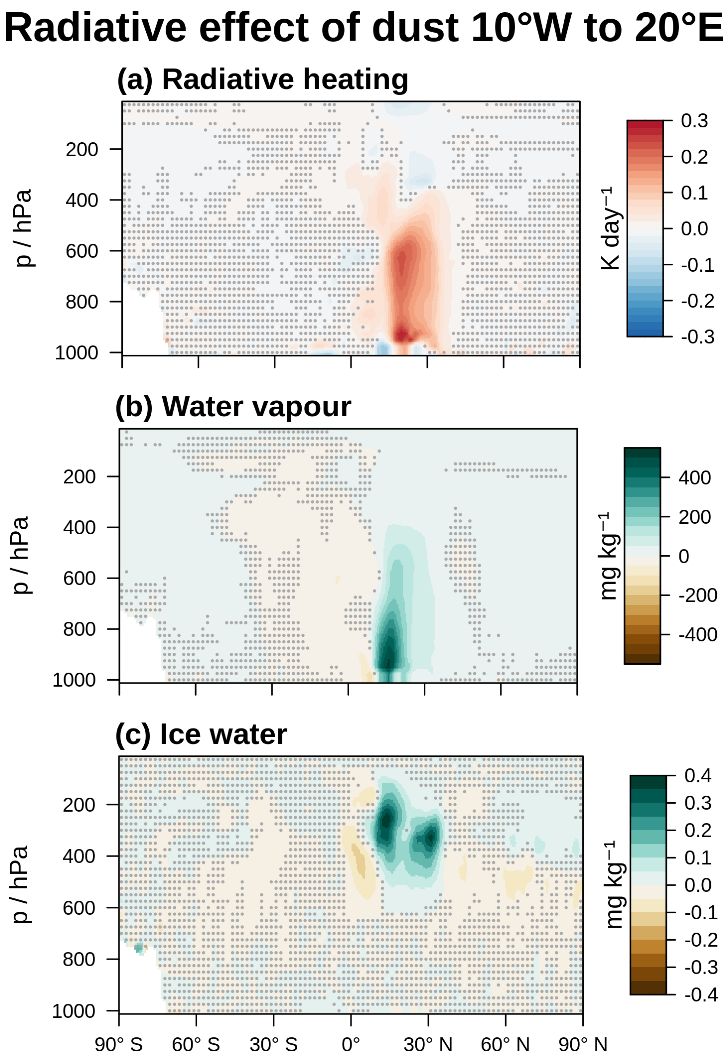

Figure S1: Difference between results from the nudged, pollution free simulations with and without dust ($\Delta_{\mathrm{dust}}x$), averaged from 10°W to 20°E. Mineral dust from the Sahara heats the atmosphere through aerosol-radiation coupling (a) increasing the vertical moisture transport (b) and the cloud ice water path (c). Where stippled, the results are consistent with zero at 2σ significance level.

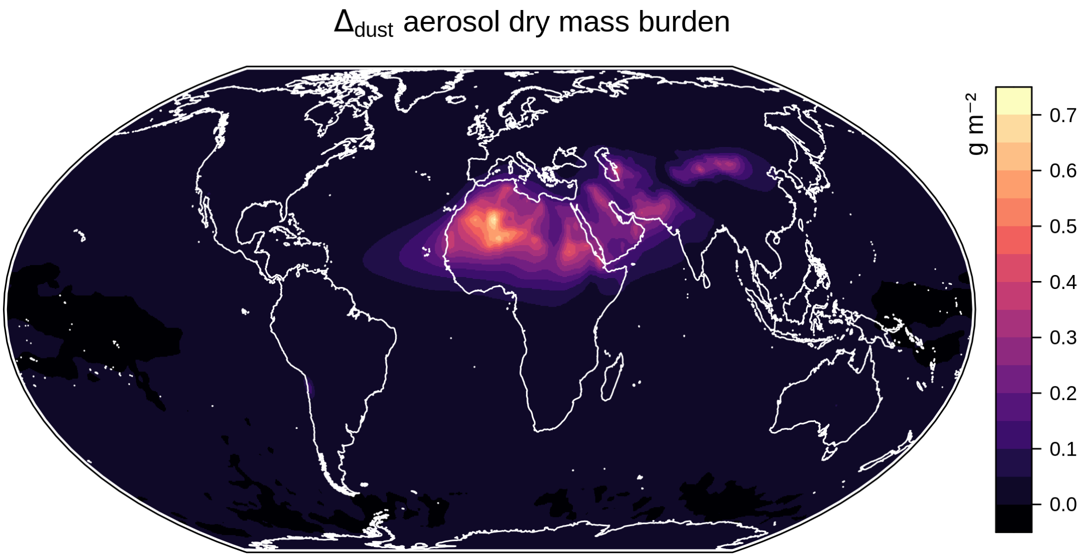

Figure S2: The aerosol dry mass burden from mineral dust emissions.

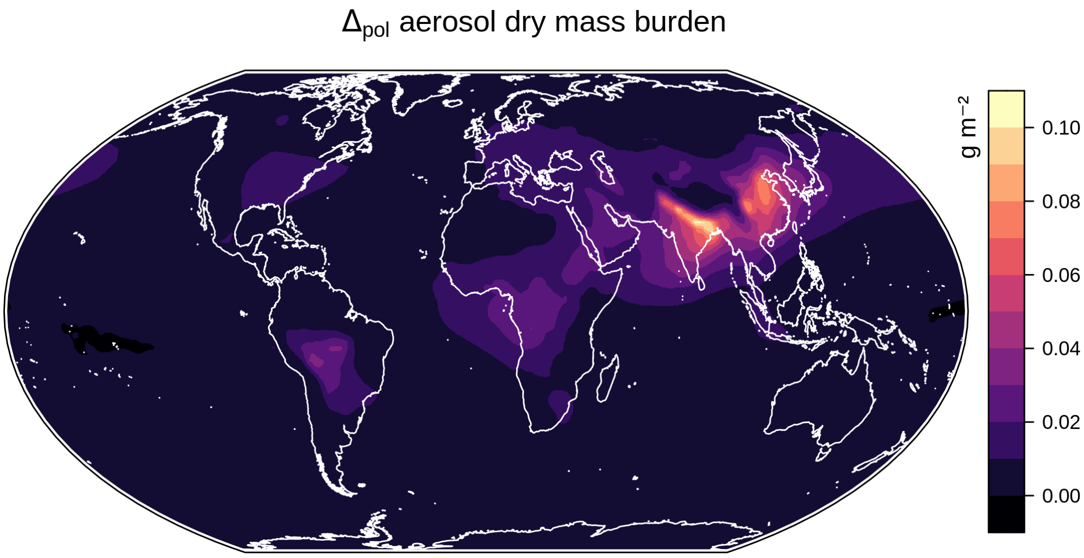

Figure S3: The aerosol dry mass burden from anthropogenic pollution.

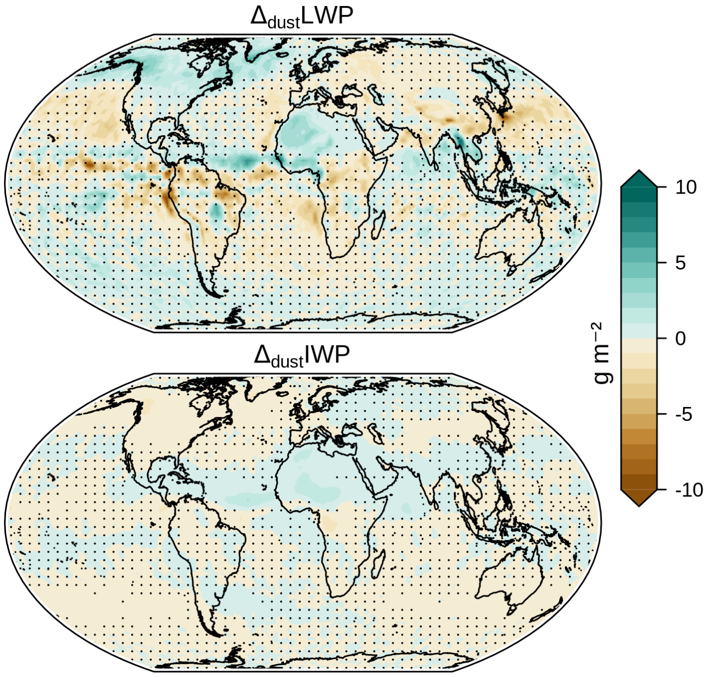

Figure S4: The effect of mineral dust on the cloud liquid water path (LWP) and ice water path (IWP).

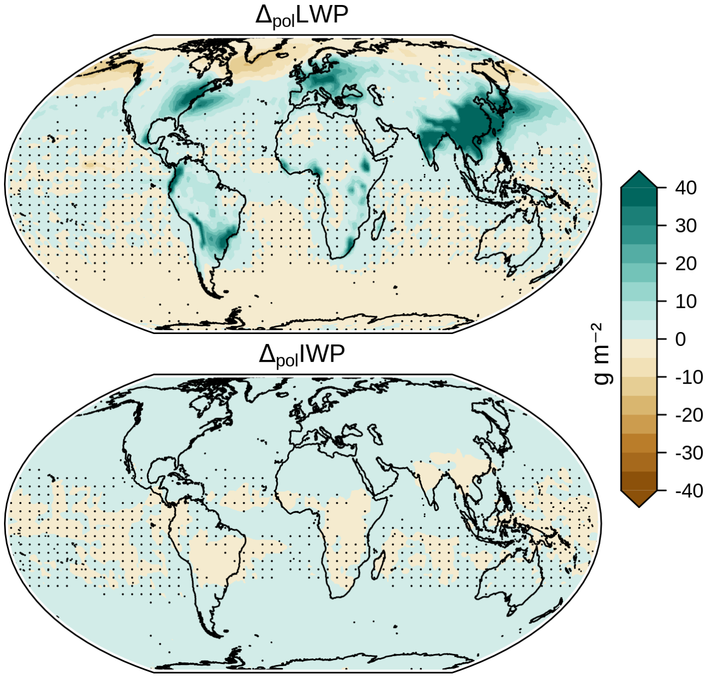

Figure S5: The effect of anthropogenic pollution on the cloud liquid water path (LWP) and ice water path (IWP).

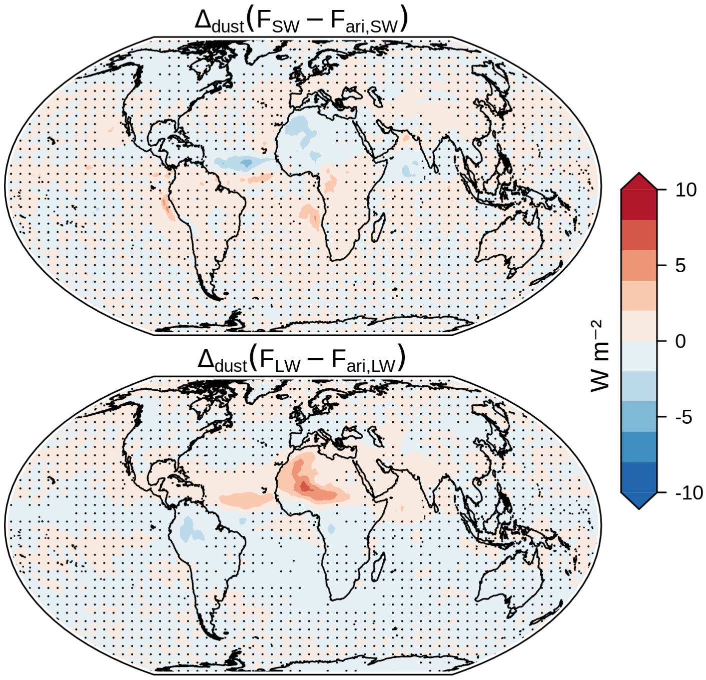

Figure S6: The indirect radiative effect of mineral dust at the TOA in the solar (SW, top) and terrestrial (LW, bottom) spectrum.

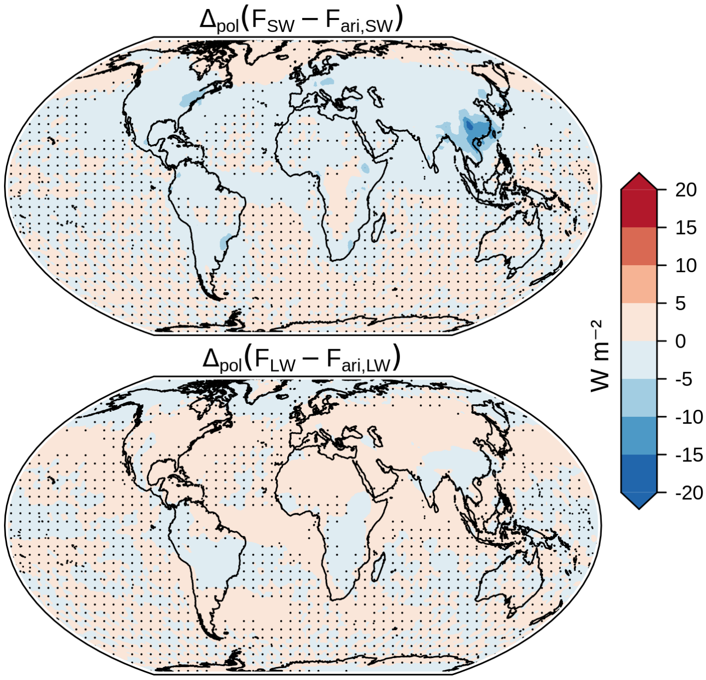

Figure S7: The indirect radiative effect of anthropogenic pollution at the TOA in the solar (SW, top) and terrestrial (LW, bottom) spectrum.

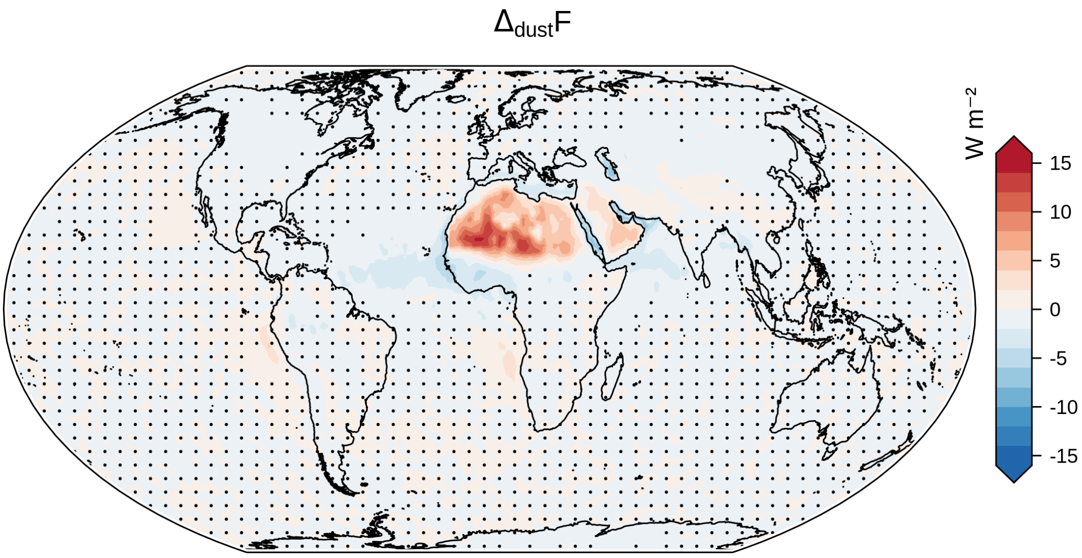

Figure S8: The effect of mineral dust on the radiative net flux at the TOA.

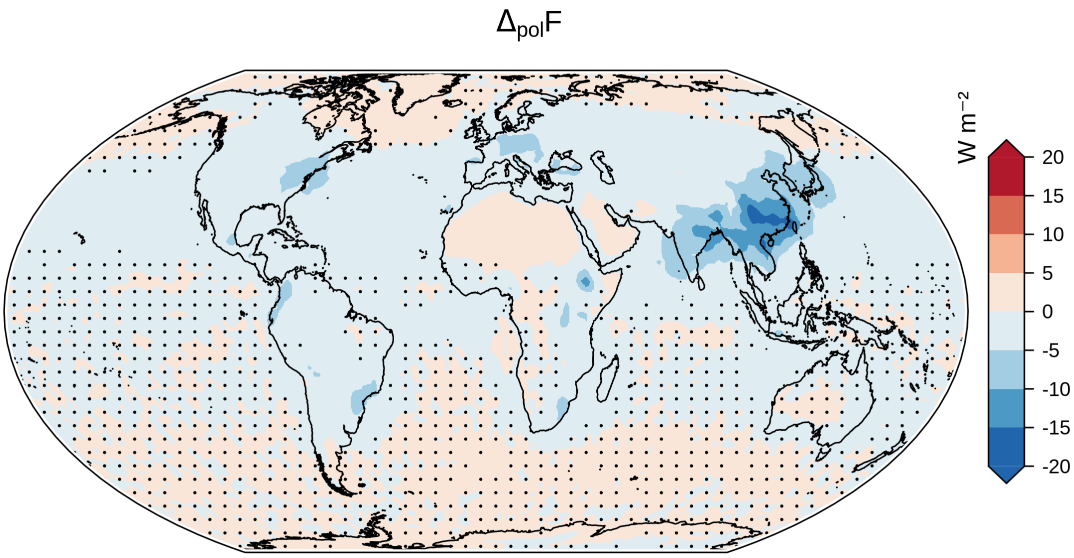

Figure S9: The effect of anthropogenic pollution on the radiative net flux at the TOA.

Table S1: Accommodation coefficients

Gas-phase species	Accommodation coefficient	References
Sulfuric acid (H_2SO_4)	0.3 (on insoluble particles)	M7 (Vignati et al., 2004), Raes and Van Dingenen (1992)
	1 (on soluble particles)	M7 (Vignati et al., 2004)
Nitric acid (HNO_3)	0.1	GMXe (Pringle et al., 2010a,b), Hanisch and Crowley (2003)
Hydrochloric acid (HCl)	0.064	GMXe (Pringle et al., 2010a,b), Van Doren et al. (1990)
Ammonia (NH_3)	0.097	GMXe (Pringle et al., 2010a,b), Feng and Penner (2007)
Water (H_2O)	0.3 (on insoluble particles)	GMXe (Pringle et al., 2010a,b)
	1 (on soluble particles)	GMXe (Pringle et al., 2010a,b)

Table S2: MESSy submodels used in the present study

Submodel	Domain	Reference
AEROPT	Aerosol optical properties	Lauer et al. (2007); Klingmüller et al. (2014)
AIRSEA	Air-sea exchange	Pozzer et al. (2006)
CLOUD	Cloud physics	Jöckel et al. (2006)
CLOUDOPT	Cloud optical properties	Dietmüller et al. (2016)
CONVECT	Convection	Jöckel et al. (2006)
CVTRANS	Convective transport	Jöckel et al. (2006)
DDEP	Dry deposition	Kerkweg et al. (2006a)
GMXe	Aerosol microphysics	Pringle et al. (2010b)
JVAL	Photolysis	Sander et al. (2014)
LNOX	Lightning NO_x	Tost et al. (2007)
MECCA	Gas-phase chemistry	Sander et al. (2019)
OFFEMIS	Offline emissions	Kerkweg et al. (2006b)
ONEMIS	Online emissions	Kerkweg et al. (2006b)
ORACLE	Organic aerosol composition and evolution	Tsimpidi et al. (2014)
RAD	Radiative transfer	Dietmüller et al. (2016)
SCAV	Scavenging	Tost et al. (2006)
SEDI	Sedimentation	Kerkweg et al. (2006a)
SURFACE	Surface parametrisations	
TNUDGE	Tracer nudging	Kerkweg et al. (2006b)

Table S3: Globally averaged annual mean cloud properties and contributions thereto, based on the nudged simulations. "Total" represents the simulation with all emissions, "Mineral dust" and "Anthropogenic pollution" include the effect of dust-pollution interactions ($\Delta_{\text{dust}}x + \Delta_{\text{int}}x$ and $\Delta_{\text{pol}}x + \Delta_{\text{int}}x$), "Dust-pollution interactions" are given by the interaction term $\Delta_{\text{int}}x$.

	Total	Mineral dust	Anthropogenic pollution	Dust-pollution interactions
Droplet number / m^{-2}	$(5.36 \pm 0.01) \times 10^{10}$	$(-2.01 \pm 0.03) \times 10^{9}$	$(4.79 \pm 0.06) \times 10^{9}$	$(-2.06 \pm 0.03) \times 10^{9}$
Liquid water path / (g m^{-2})	79.2 ± 0.3	-1.16 ± 0.03	1.72 ± 0.03	-1.10 ± 0.03
Ice water path / (g m^{-2})	15.01 ± 0.03	-0.0694 ± 0.0009	0.494 ± 0.004	-0.027 ± 0.003

Table S4: Globally averaged annual mean TOA radiative effects in W m^{-2}, based on the nudged simulations. "Mineral dust" and "Anthropogenic pollution" include the effect of dust-pollution interactions ($\Delta_{\text{dust}}x + \Delta_{\text{int}}x$ and $\Delta_{\text{pol}}x + \Delta_{\text{int}}x$), "Dust-pollution interactions" are given by the interaction term $\Delta_{\text{int}}x$.

		Mineral dust	Anthropogenic pollution	Dust-pollution interactions
Net	Total	-0.01 ± 0.01	-0.84 ± 0.01	0.15 ± 0.02
	Direct	-0.198 ± 0.004	-0.520 ± 0.005	-0.026 ± 0.002
	Indirect	0.19 ± 0.01	-0.32 ± 0.01	0.18 ± 0.02
SW	Total	-0.05 ± 0.01	-0.952 ± 0.008	0.20 ± 0.01
	Direct	-0.308 ± 0.004	-0.560 ± 0.005	-0.028 ± 0.002
	Indirect	0.26 ± 0.01	-0.392 ± 0.008	0.23 ± 0.01
LW	Total	0.041 ± 0.008	0.11 ± 0.01	-0.05 ± 0.01
	Direct	0.111 ± 0.001	0.0396 ± 0.0002	0.0023 ± 0.0002
	Indirect	-0.070 ± 0.008	0.07 ± 0.01	-0.05 ± 0.01

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