Weaker cooling by aerosols due to dust-pollution interactions

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Motivation

Anthropogenic aerosols cool the climate by increasing the planetary albedo directly through aerosol-radiation interactions and indirectly through cloud adjustments

→ Important contribution to the radiation budget, partially masking the greenhouse warming

Anthropogenic pollutants interact with natural aerosols, in particular with aeolian dust:

- particulate pollutants coagulate with dust particles
- dust particles are exposed to chemical ageing
- dust particles limit the activation of pollution particles

We study the impact of these dust-pollution interactions on the aerosol radiative effect

Methods

- Global ECHAM/MESSy atmospheric chemistry-climate model (EMAC)
- Horizontal grid spacing ≈ 1.9°, 31 vertical levels (T63L31)
- 4 emission configurations:

	default	“dust”	“pol”	“0”
Dust emissions	☑	☑	☐	☐
Pollution emissions*	☑	☐	☑	☐

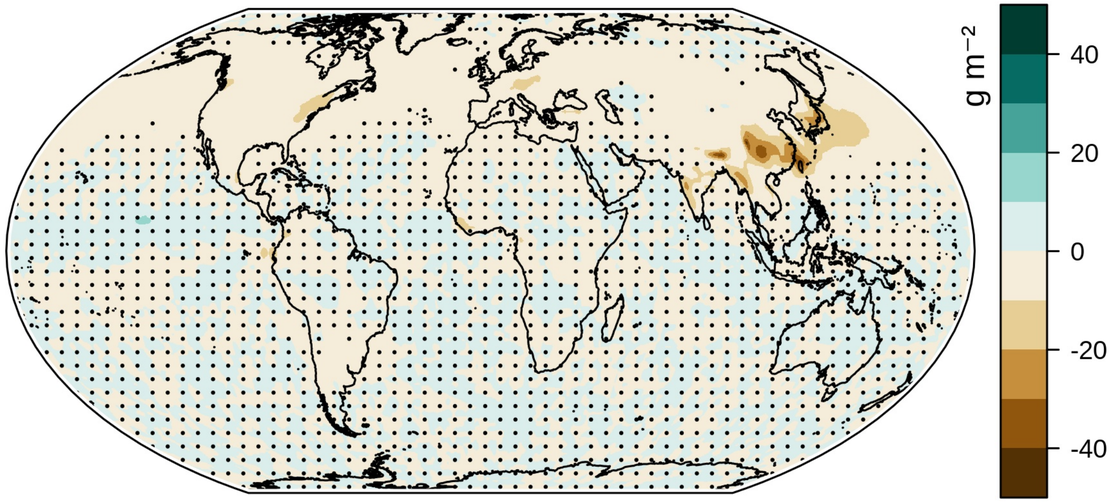
The effect of dust-pollution interactions on result x (e.g. cloud water path) is given by $x - x_{dust} - x_{pol} + x_0$

- Nudged simulations for regional analysis (10 years, 2006 to 2015)
- SST simulation ensembles for global forcings (16 × 1 year, 2010)

*EDGARv4.3 + 90 % GFEDv3.1 biomass burning; same GHGs in all configurations

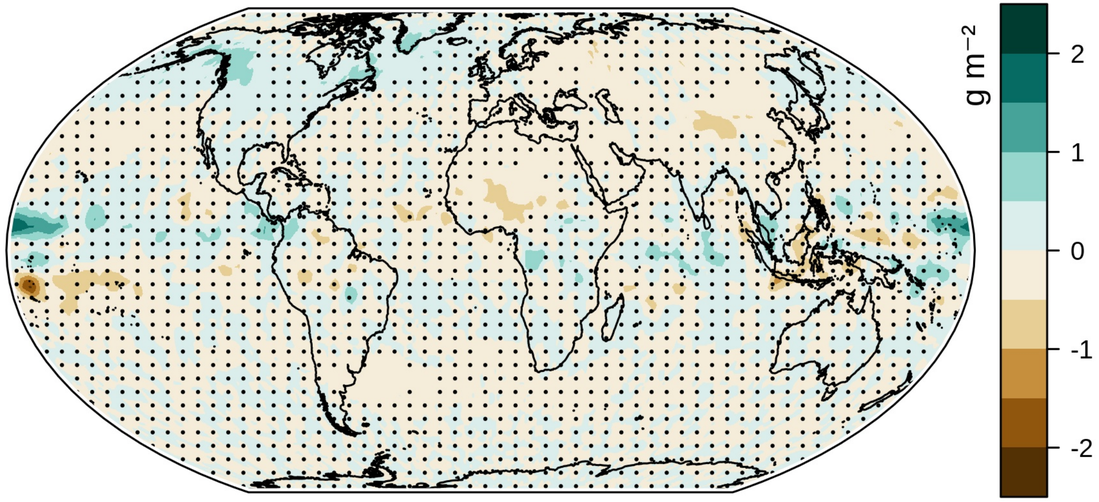
Dust-pollution interaction effect on clouds

(a) Liquid water path



Global mean: (-1.10 ± 0.03) g m^{-2}

(b) Ice water path

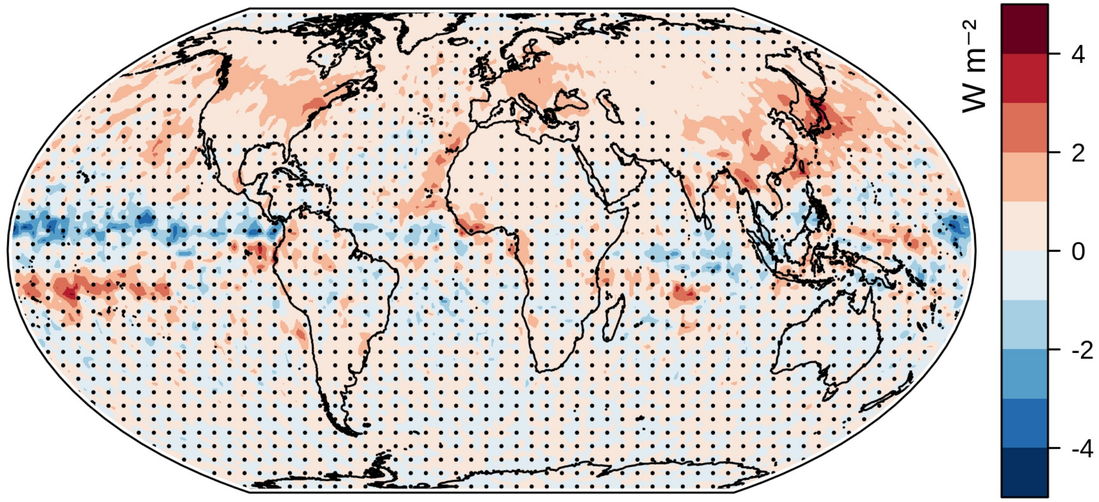


Global mean: (-0.027 ± 0.003) g m^{-2}

Annual mean effect of the dust-pollution interactions on the liquid (a) and ice (b) cloud water in the nudged simulations. Over stippled regions the results are consistent with zero at 2 σ significance level.

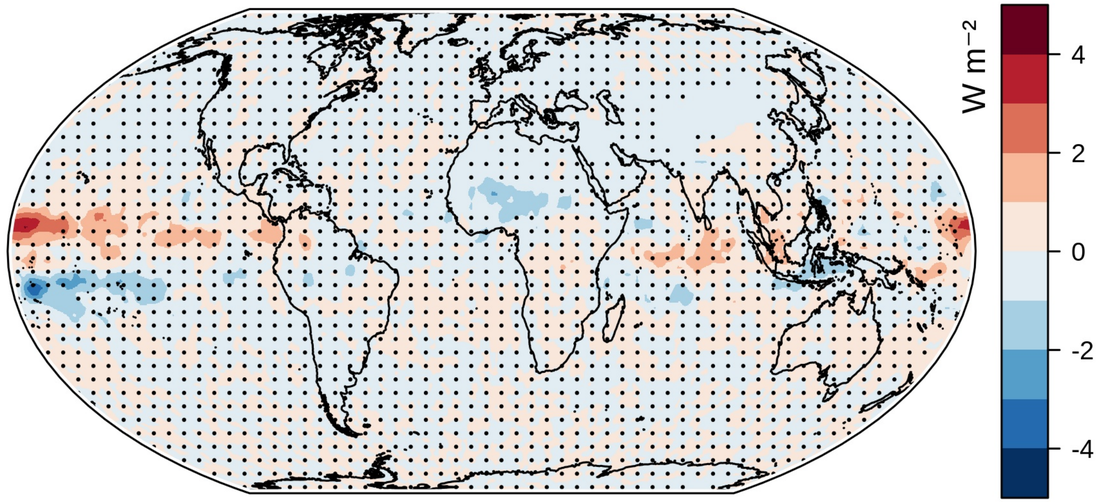
Dust-pollution interaction effect on the indirect aerosol TOA forcing

(a) Solar spectrum (SW)



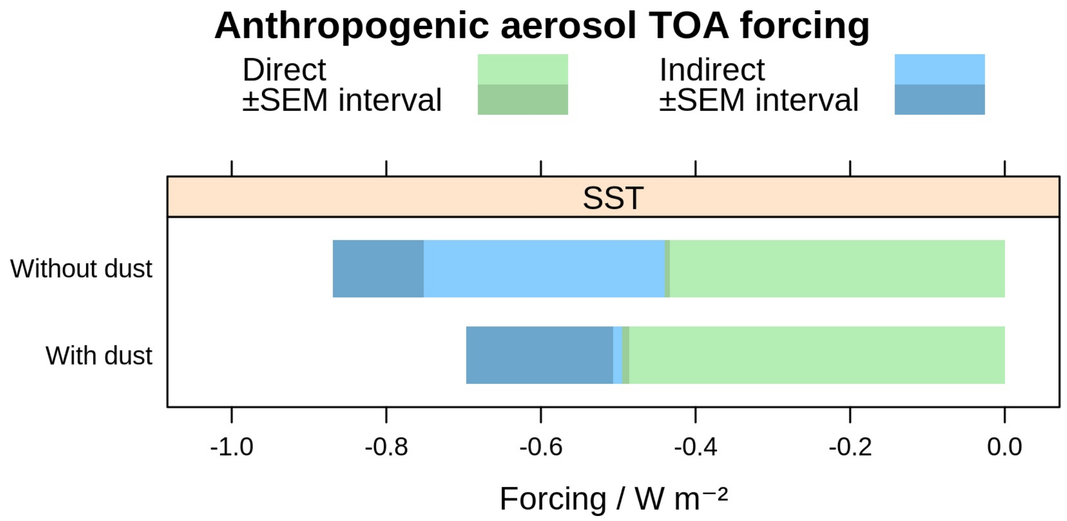
Global mean: (0.23 ± 0.01) W m^{-2}

(b) Terrestrial spectrum (LW)



Global mean: (-0.05 ± 0.01) W m^{-2}

Annual mean indirect effect of the dust-pollution interactions on the solar (a) and terrestrial (b) radiative forcing at the top of the atmosphere in the nudged simulations. Over stippled regions the results are consistent with zero at 2 σ significance level.



(0.2 ± 0.1) Wm^{-2}
Dust-pollution interactions

Estimates of the global anthropogenic aerosol forcing at the top of the atmosphere (TOA) from simulations with prescribed sea surface temperature (SST) in the presence or absence of aeolian dust. Darker colours represent the standard error of mean (SEM) of the direct (green) and indirect (blue) forcings.

Conclusions

- Dust-pollution interactions reduce the cloud water by moderating the cloud water increase caused by anthropogenic pollution

- The resulting decrease of solar radiation scattering dominates the total radiative effect of the dust-pollution interactions

- Dust-pollution interactions contribute $(0.2 \pm 0.1)\ \mathrm{Wm^{-2}}$ to the anthropogenic aerosol radiative forcing, significantly reducing the climate cooling effect of atmospheric aerosols

Details

K. Klingmüller, V. A. Karydis, S. Bacer, G. L. Stenchikov, J. Lelieveld, Weaker cooling by aerosols due to dust-pollution interactions, 2020 (in preparation)