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Global potential of dust devil occurrence

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Mineral dust is a key constituent in the climate system. Airborne mineral dust forms the largest component of the global aerosol budget by mass and subsequently affects climate, weather and biogeochemical processes. There remains large uncertainty in the quantitative estimates of the dust cycle.

Dry boundary-layer convection serves as an effective mechanism for dust uplift, typically through a combination of rotating dust devils and non-rotating larger and longer-lived convective plumes. These microscale dry-convective processes occur over length scales of several hundred metres or less. They are difficult to observe and model, and therefore their contribution to the global dust budget is highly uncertain. Using an analytical approach to extrapolate limited observations, Koch and Renno (2006) suggest that dust devils and plumes could contribute as much as 35%. Here, we use a new method for quantifying the potential of dust devil occurrence to provide an alternative perspective on this estimate.

Observations have shown that dust devil and convective plume occurrence is favoured in hot arid regions under relatively weak background winds, large ground-to-air temperature gradients and deep dry convection. By applying such known constraints to operational analyses from the European Centre for Medium Range Weather Forecasts (ECMWF), we provide, to the best of the authors' knowledge, the first hourly estimates of dust devil occurrence including an analysis of sensitivity to chosen threshold uplift.

The results show the expected diurnal variation and allow an examination of the seasonal cycle and day-to-day variations in the conditions required for dust devil formation. They confirm that desert regions are expected to have by far the highest frequency of dry convective vortices, with winds capable of dust uplift. This approach is used to test the findings of Koch and Renno (2006).

Koch J., Renno N. (2006). The role of convective plumes and vortices on the global aerosol budget. Geophys. Res. Lett., L18806.