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Is the dust cycle more sensitive to climate changes than thought? Insights from an improved model for mineral dust emission

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Simulations of the global dust cycle by atmospheric circulation models rely on an accurate parameterization of the vertical dust flux at emission. However, existing parameterizations either do not sufficiently account for differences in erodibility among soils, or require parameters that are unavailable on regional or global scales. To address these problems, we present a physically-based theory for the vertical dust flux that is based on the concept that dust emission is a threshold effect. The theory yields a straightforward expression for the vertical dust flux that depends only on the wind friction speed, the soil's threshold friction speed, and the soil's clay content, and can therefore be readily implemented into models. We show that our parameterization is supported by a compilation of high-quality dust flux measurements, and that it reproduces field measurements with a factor of $\sim$3 less scatter in log-space than existing parameterizations. An important insight from the parameterization is that the effect of increases in the threshold friction speed on the dust flux has been substantially underestimated in models. Variations in the threshold speed are partially driven by variations in soil moisture, which is determined by the balance between precipitation and evaporation. Consequently, our results indicate that the global dust cycle is more sensitive to changes in climate than previously thought.