Deriving a Global Dust Emission Dataset with an Inverse Analysis for Estimating Dust Impacts on Climate

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Abstract

Sedimentary records of dust indicate that atmospheric dust has increased ~55 % since the 1850s. Such increase is thought to be largely due to the historical land use–land cover change (LULCC) and climate change. However, state-of-the-art Earth system models (ESMs), such as those from the Coupled Model Intercomparison Project (CMIP6), simulated little historical change in dust. This poses challenges in assessing desert dust impacts on Earth's climate. To address this, we construct a globally gridded and decadally varying dust emission dataset (DustCOMMv1) spanning 1841–2000, by combining multiple sedimentary records of dust deposition with reanalyzed model constraints on the contemporary dust cycle using an inverse analysis. The derived emission dataset contains interdecadal variability of dust emissions as forced by sedimentary dust records across the globe. We evaluate the DustCOMM emission dataset and illustrate its effectiveness in enforcing a historical dust increase in ESMs by implementing it into the Community Earth System Model (CESM2) and by conducting a 1851–2000 dust cycle simulation. Simulated dust is in reasonable agreement with the sedimentary dust deposition records and with measured long-term dust concentration at ground-based sites. This contrasts with the CESM2 and other CMIP6 model simulations using process-based dust emission schemes, which show little to no secular dust trends. The DustCOMM emissions thus improves ESMs' representation of historical dust impacts on climate, such as via dust aerosol radiative forcings (RFs). Our CESM2 simulations estimate a 1990s minus 1850s historical direct RF of –0.10 W m^{-2} due to dust's scattering and absorbing radiation, accounting for ~20 % of historical total aerosol direct RF (of ~ –0.5 W m^{-2}). The DustCOMMv1 emission dataset is currently under use by various model intercomparison projects to improve the ESM representation of historical dust variability, such as the ongoing AeroCom phase III dust radiative forcing (DURF) experiment.

Early Career Scientist

YES, I am an early career scientist.

IGAC Activities

GEIA: Global Emissions Initiative