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Dust-snow/ice interactions: a glacial cycle modulator and trigger?

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Dust emitted from low- and mid-latitudes deposits on ice and snow at mid- and high-latitudes, where absorbing impurities can trigger and amplify powerful ice-albedo feedbacks. We study the climate effects of dust using a general circulation model that treats previously neglected aerosol and snowpack radiative and thermodynamic processes and so captures new positive feedbacks. The simulations compare well with observed snow albedo evolution and impurity concentration.

We estimate the total (natural + anthropogenic) dust snowpack-forcing of +0.02 W m-2 warms present global climate 0.03-0.07 K. This is much smaller than the present forcing and temperature response to atmospheric dust, about -0.6 W m-2 and -0.3 K, respectively. These current-climate results are consistent with the commonly held view that atmospheric dust, on balance, cools climate. However, the climate change efficacy (surface temperature response per unit forcing) of dust aerosol in snow is 3-4 times that of CO2, and nearly ten times that of atmospheric dust. Strong dirty snow forcing efficacies (due to ice albedo feedbacks) have significant implications for dustier climates, such as the Last Glacial Maximum (LGM).

Our LGM simulations show that increased snowpack dust concentration from desert and glaciogenic sources may warm equilibrium climate 2 K. This exceeds the LGM climate cooling by atmospheric dust and suggests causal links between dust-ice interactions and glacial terminations: Gradual cooling and increasing dustiness during glacial phases can lead to a tipping point where dust deposited to snow/ice initiates

global atmospheric warming, moistening, and reduced dust emissions. We will describe one mechanism by which Dust-Accelerated Melt may occur on fast timescales and help to trigger abrupt climate change.