Asian Dust Signatures at Barrow: Observed and Simulated

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Atmospheric aerosols affect the Earth's radiation budget directly through interactions with solar and terrestrial radiation and indirectly as cloud condensation and ice nuclei. Because polar atmospheres are generally very clean, small increases in aerosol concentrations can perturb radiative fluxes significantly. Recently, dust storms from the desert in China and Mongolia were tracked over the Arctic, suggesting that such remote regions are not immune to the dispersion of Asian dust. Corroborating evidence for transport of dust to the Arctic is provided by increased aerosol optical depths and by lidar measurements at Barrow, Alaska, in conjunction with trajectory analyses and dust transport. Here, a variety of measurements and model results are employed to characterize the radiative properties associated with a dust layer for a particular occurrence during the first half of April 2002.

Barrow spectral aerosol optical depth measurements were used to infer the size distribution of the dust layer; Mie scattering theory was used to determine the optical properties of the dust, and these were then ported into MODTRAN4, an AFRL radiative transfer algorithm. AFRL/VS recently developed a set of MODTRAN-based capabilities addressing energy deposition within the lower atmosphere (<70 km), providing flux values and heating/cooling rates for solar and thermal spectral regimes. From this combination of CMDL measurements and specifications for the required MODTRAN inputs and calculations, an energy budget for the dust event was produced, leading to an estimated forcing associated with the dust layer (Figure 1). Analytic calculations of the surface forcing as a function of aerosol optical depth (AOD) can then be compared with empirical results obtained using CMDL's suite of radiometers at Barrow.

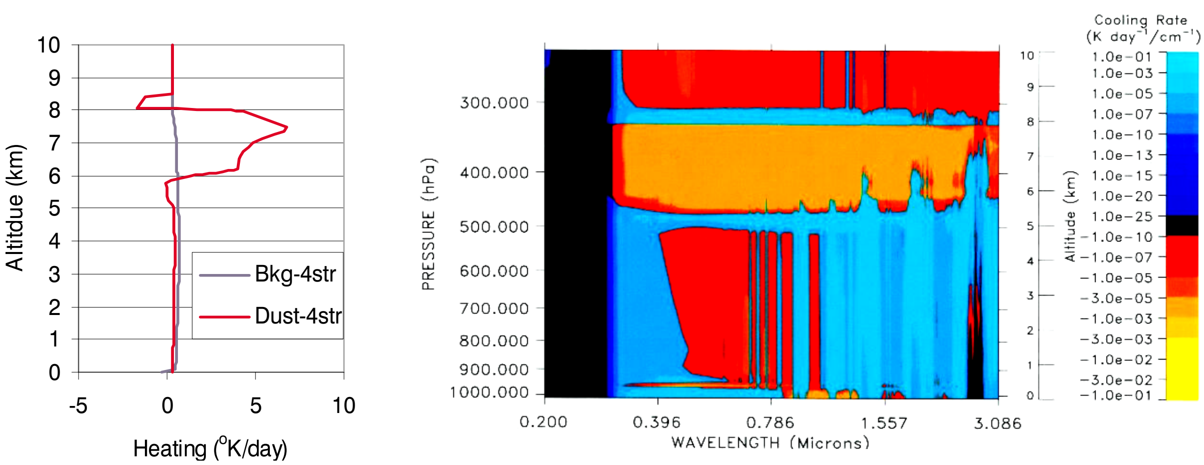

Figure 1. Left: Spectrally integrated heating rates. Against a very low background aerosol, the introduction of the Asian dust layer between 6 and 8 km produces a preliminary estimate of ~7 K peak heating, when compared with the background aerosol levels. Right. The spectrally resolved differences in cooling rates (dust layer–background), due to the introduction of the same layer (x-axis is logarithmic). The opacity between 0.2 and 0.3 µm is due to O_3 Hartley-Huggins bands. Other molecular features impact the energy deposition, e.g., O_2 at 0.76 µm; H_2O at 0.82, 0.94, 1.13, 1.38, and 1.88 µm; and CO_2 at 2.2 and 2.7 µm.