Observation of Enhanced Water Vapor in the Asian Dust Layer and Its Effect on Atmospheric Radiative Heating and Cooling Rates

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Wind-blown mineral dust causes significant atmospheric radiative heating in solar wavelengths (SW; 0.3 ~ 4.0 μm) and cooling in long wavelengths (LW; 4.0 ~ 40 μm). This effect of dust on radiative heating and cooling rates can affect the temperature profile and atmospheric thermodynamics. This study investigates the effect of mineral dust aerosol and its associated water vapor (WV) on atmospheric radiative heating rates using ground-based lidar, aircraft, radiosonde measurements, and a radiation model (SBDART) during Asian dust events in the spring of 2001 and 2002.

Figure 1 shows the vertical profiles of the aerosol extinction coefficient and water vapor mixing ratio at 0000 UTC as well as the calculated instantaneous (0000 UTC) and diurnally averaged radiative heating rates at Gosan, Korea, on April 17, 2001. We found enhanced levels of WV within the dust layer (DL) relative to the atmospheric layer above and below the DL. This WV led to an increase in the net radiative heating rate within the DL, changing the heating rate vertical structure. A net cooling was calculated above the DL as a result of low aerosol and drier conditions. Our finding suggests that the presence of WV within the DL acts to maintain a warmer DL, potentially influencing the atmospheric static stability. This finding is supported by an increase in the potential temperature at the top and bottom of the DL.

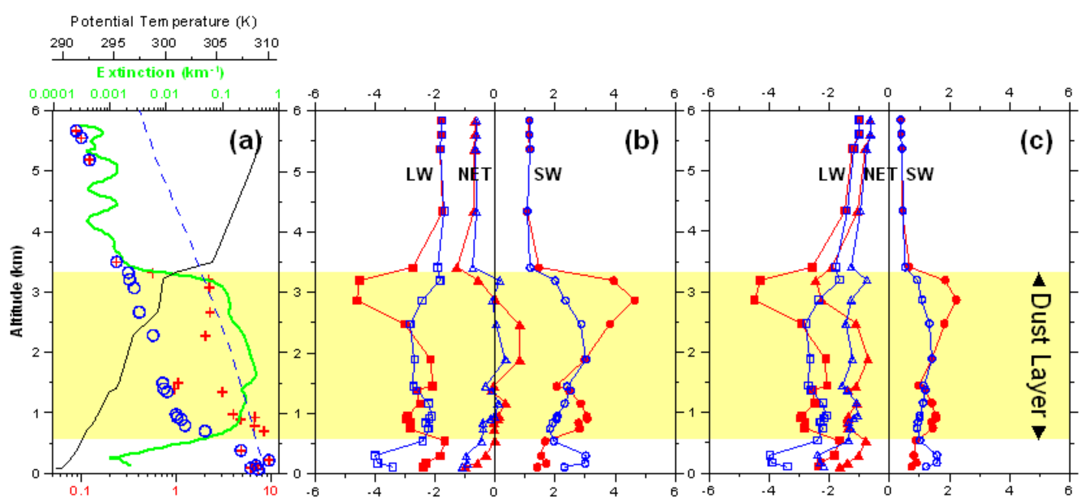

Figure 1. Vertical profiles of (a) measured micropulse lidar aerosol extinction coefficient (green line), water vapor mixing ratio (WVMR, cross) and potential temperature (black line) at 00UTC, (b) and (c) calculated instantaneous (00UTC, 54° solar zenith angle) and diurnal averaged solar (circles), infrared (squares) and net (triangles) radiative heating rates for the presence (closed red symbol) and the absence (opened blue symbol) of water vapor in the dust layer at Gosan on April 17, 2001. The blue circles in (a) are the assumed WVMR profile, which excludes water vapor in the dust layer, for a sensitivity test. The dashed line in (a) represents the standard atmospheric WVMR profiles, which is the average of model-given mid-latitude summer (July, 45°N) and winter (January, 45°N) profiles taken from the MODerate Resolution Atmospheric TRANsmittance and Radiance Code (MODTRAN) standard atmosphere. This average was intended to represent the spring atmospheric properties.