Geophysical Research Abstracts
Vol. 20, EGU2018-7867, 2018
EGU General Assembly 2018

Effect of sea breeze circulation on aerosol mixing state and radiative properties in the Negev Desert of Israel

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Chemical composition, microphysical and optical properties of atmospheric aerosol deep inland in the Negev Desert of Israel are found to be influenced by daily occurrences of sea breeze flow from the Mediterranean Sea. Abrupt increases in aerosol volume concentration and shifts of size distributions towards larger sizes, which are associated with increase in wind speed and atmospheric water content, were systematically recorded during the summertime at a distance of at least 80 km from the coast. Chemical imaging of aerosol samples showed an increased contribution of highly hygroscopic particles during the intrusion of the sea breeze. Besides a significant fraction of marine aerosols, the amount of internally mixed marine and mineral dust particles was also increased during the sea breeze period. The number fraction of marine and internally mixed particles during the sea breeze reached up to 88 % and 62 % in the 1-2.5 μm and 2.5-10 μm size range, respectively. Additionally, numerous particles with residuals of liquid coating were observed by SEM/EDX analysis. Ca-rich dust particles that had reacted with anthropogenic nitrates were evidenced by Raman microspectroscopy. The resulting hygroscopic particles can deliquesce at very low relative humidity. Our observations suggest that aerosol hygroscopic growth in the Negev Desert is induced by the daily sea breeze arrival. The varying aerosol microphysical and optical characteristics perturb the solar and thermal infrared radiations. The changes in aerosol properties induced by the sea breeze, relative to the background situation, doubled the shortwave radiative cooling at the surface (from -10 to -20.5 Wm-2) and increased by almost three times the warming of the atmosphere (from 5 to 14 Wm-2), as evaluated for a case study. Given the large number of observed liquid coating on individual particles, we also examined the possible influence of the particle homogeneity assumption on the retrieval of aerosol microphysical characteristics. Numerical simulations suggest that sensitivity to the coating appears if backward scattering and polarimetric measurements are available for the inversion algorithm. This may have an important implication for retrievals of aerosol microphysical properties in remote sensing applications.