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Modeling of extreme dust pollution in the complex terrain of the Dead Sea Valley

Pavel Kishcha (1), Daniel Rieger (2), Jutta Metzger (2), Boris Starobinets (1), Max Bangert (2), Heike Vogel (2), Ulrich Schaettler (3), Ulrich Corsmeier (2), Pinhas Alpert (1), and Bernhard Vogel (2)

(1) Tel Aviv University, Department of Geosciences, Tel Aviv, Israel (pavel@cyclone.tau.ac.il), (2) Karlsruhe Institute of Technology (KIT), Institute of Meteorology and Climate Research, Karlsruhe, Germany, (3) Deutscher Wetterdienst (DWD), Offenbach, Germany

The area of the Dead Sea valley is often affected by mineral dust. This study focuses on an extreme dust episode occurring on March 22, 2013, where near surface dust concentrations of up to 7000 μg m-3 were encountered in the Dead Sea region. This near surface dust concentration was two orders of magnitude higher than the annual averaged surface dust concentration in the Dead Sea valley. The event was driven by a Cyprus low and its frontal system, causing favorable conditions for long-range transport to the investigation area. It was accompanied by high wind speeds and a gust front that rapidly passed the Judean Mountains on 22 March 2013. Wind was even accelerated on the lee side of the Judean Mountains leading to a severe downslope wind. We simulated this situation with the comprehensive online-coupled weather forecast model COSMO-ART. Reasonable agreement was found between the simulated meteorological variables and the observations. The model also reproduced the spatio-temporal distribution of near surface dust concentration, consistent with available measurements, in the Dead Sea valley and the surrounding areas. With respect to the time of the maximum near surface dust concentration in the Dead Sea valley, the model captured it almost perfectly when compared with the observed TSP concentrations. COSMO-ART showed that the high near surface dust concentration in the Dead Sea valley was mainly determined by local emissions. These emissions were caused by strong winds on the lee side of the Judean Mts. The model showed that an ascending airflow in the Dead Sea valley lifted dust particles (originated mainly from the upwind side of the Judean Mts.) up to approximately 7 km. These dust particles contributed to the pronounced maximum in modeled dust aerosol optical depth (AOD) of approximately the value of three over the valley. This highlights an important point that the maximum dust AOD was reached in the eastern part of the Dead Sea valley, while the maximum surface dust concentration was reached in the western part of the valley. Therefore, our study indicates the difficulties in using satellite-based AOD for initializing dust concentration within numerical forecast systems over a region with complex terrain. Numerical model experiments with different domains and dust sources (both local and remote ones) permitted us to quantify the contribution of various source regions to the pronounced maximum of dust AOD in the Dead Sea valley. Specifically, the model showed that 30% of the maximum dust AOD stems from local emissions and about 70% from more remote ones from the upwind side of the Judean Mountains.