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Foehn-induced effects on dust pollution, frontal clouds and solar radiation in the Dead Sea valley

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The significant drying up of the Dead Sea over the past 40 years has led to an increase in an exposed area contributing to local dust pollution. Measurements show that, sometimes, in the Dead Sea valley, dust pollution can reach extreme concentrations up to several thousands of micrograms per cubic meters. Our analysis of a meteorological situation shows that a foehn phenomenon can be a causal factor for the aforementioned extreme local dust concentration. This foehn phenomenon creates strong warm and dry winds, which are accompanied by air turbulence and temperature inversion.

In our study, foehn-induced effects on dust pollution, frontal clouds and solar radiation were analyzed over the Judean Mountains ($\sim$1000 m) and over the Dead Sea valley (-420 m), using high-resolution numerical simulations and in-situ observations at meteorological stations located across the mountain ridge. An extreme dust episode occurring on March 22, 2013, was analyzed, which was characterized by measured surface dust concentrations of up to 7000 μg m-3 in the Dead Sea valley. We simulated this foehn phenomenon with the 3-km resolution COSMO-ART model. Our analysis has shown that the foehn phenomenon could be observed even over the relatively low Judean Mountains. This analysis was based on various meteorological, pyranometer, radar, and aerosol measurements together with high-resolution model data. In the Dead Sea valley, the maximum aerosol optical depth (AOD) did not coincide with the maximum surface dust concentration. This lack of coincidence indicates difficulties in using satellite-based AOD for initializing dust concentration within numerical forecast systems over this region with complex terrain. In the western Dead Sea valley, strong foehn winds of over 20 m/s were accompanied by maximal air turbulence leading to maximal local dust emissions. Thus, the model showed that, by creating significant turbulence, the foehn phenomenon intensified the saltation (bombardment) mechanism of local dust generation in the western Dead Sea valley. In addition, the foehn-induced pronounced temperature inversion trapped dust particles beneath this inversion. These two factors caused the measured extreme surface dust concentration in the Dead Sea valley on the specified day.

Radar data on March 22 showed a passage of multi-layer frontal cloudiness through the area of the Dead Sea valley leading to a sharp drop in noon solar radiation. The strong descending airflow over the downwind side of the Judean Mountains significantly influenced the frontal cloudiness leading to the formation of a cloud-free band over the Dead Sea valley.