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High-Resolution WRF simulations of the Mediterranean Sea Breeze penetration into the Dead Sea valley: Sensitivity tests and optimal model configuration

Pavel Kunin, Dorita Rostkier-Edelstein, and Pinhas Alpert

The Mediterranean Sea breeze (MSB) originates at the Mediterranean coast and is very pronounced during the spring and the summer. During the day the MSB flows up the Judean hills, then, it drops into the DS valley in the early evening hours. Hence, this flow descends about 1200 m from the Judean Mountains to the DS at about -430 m below MSL. This significant descent, enhanced by the density current, speeds up the wind and the adiabatic heating warms and dries the DS area.

We used WRF model to analyze and better understand the complex processes in and around the DS area, e.g., the MSB structure and its propagation into the DS Valley. A pre-requisite for relying on model simulations to analyze atmospheric processes is to verify their skill with respect to observations.

WRF was configured with four nested domain with 30, 10, 3.3 and 1.1 km grid spacing. The model sensitivity was checked for: (1) landuse/vegetation databases, (2) PBL schemes, (3) number of vertical levels, (4) atmospheric and soil initial and lateral boundary conditions from different global models (IC/BC), (5) initial conditions for the finest domain, (7) initialization time of finest domain.

Model simulations were verified against unique very high-resolution (HR, both vertical and temporal) observations first conducted in the DS valley as part of the Virtual Institute DEad SEa Research Venue (DESERVE) project using the KITcube instruments (a ground-based microwave radiometer, two wind lidars and radiosoundings) along with Energy Balance Stations. These provided horizontal and vertical winds, temperature, humidity, pressure, radiation, and visibility data.

Evaluation of model simulations against observations was made for seven parameters that were used to analyze the atmospheric dynamics of the MSB penetration into the DS valley: surface specific humidity, temperature and wind; vertically integrated water vapor; time evolution of horizontal and vertical-wind and profile; and time of MSB arrival to the DS valley.

Our sensitivity study shows that the surface variables and the temporal evolution of the horizontal and vertical wind were most sensitive to the PBL scheme and IC/BC from global models. Vertically integrated water vapor was most sensitive to the PBL scheme. The time of arrival of the MSB to the DS valley was most sensitive to IC/BC from global models.
The best simulation includes landuse/vegetation from MODIS 15-seconds resolution dataset, the Mellor-Yamada-Janjic PBL scheme, 40 vertical levels, IC/BC from NCEP/GFS global model for all nested domains, and later initialization time of the of the finest domain with respect to the coarser ones by 24 hours. In our presentation, we will discuss physical and numerical factors responsible for the most favorable outcomes.