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Enhancing WRF Model Forecasts by Assimilating High-Resolution GPS-Derived Water-Vapor Maps combined with METEOSAT-11 Data

Yuval Reuveni[1,2,3], Anton Leontiev[4], and Dorita Rostkier-Edelstein[5,6]
[1]Department of Physics, Ariel University, Ariel, Israel
[2]Eastern R&D Center, Ariel, Israel
[3]School of Sustainability, Interdisciplinary Center (IDC) Herzliya, Herzliya, Israel
[4]Department of Electrical Engineering, Ariel University, Ariel, Israel
[5]Department of Environmental Physics, Israel Institute for Biological Research, Ness-Zyiona, Israel
[6]The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University, Jerusalem, Israel

Improving the accuracy of numerical weather predictions still poses a challenging task. The lack of sufficiently detailed spatio-temporal real-time in-situ measurements constitutes a crucial gap concerning the adequate representation of atmospheric moisture fields, such as water vapor, which are critical for improving weather predictions accuracy. Information on total vertically integrated water vapor (IWV), extracted from global positioning systems (GPS) tropospheric path delays, can enhance various atmospheric models at global, regional, and local scales. Currently, numerous existing atmospheric numerical models predict IWV. Nevertheless, they do not provide accurate estimations compared with in-situ measurements such as radiosondes. In this work, we demonstrate a novel approach for assimilating 2D IWV regional maps estimations, extracted from GPS tropospheric path delays combined with METEOSAT satellite imagery data, to enhance Weather Research and Forecast (WRF) model predictions accuracy above the Eastern Mediterranean area. Unlike previous studies, which assimilated IWV point measurements, here, we assimilate quasi-continuous 2D GPS IWV maps, augmented by METEOSAT-11 data, over Israel and its surroundings. Using the suggested approach, our results show a decrease of more than 30% in the root mean square error (RMSE) of WRF forecasts after assimilation relative to the standalone WRF when verified against in-situ radiosonde measurements near the Mediterranean coast. Furthermore, substantial improvements along the Jordan Rift Valley and Dead Sea Valley areas are achieved when compared to 2D IWV regional maps. Improvements in these areas suggest the importance of the assimilated high resolution IWV maps, in particular when assimilation and initialization times coincide with the Mediterranean Sea Breeze propagation from the coastline to highland stations.