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Assessment of SO_2 pollution in the Middle East using MERRA-2, CAMS reanalyses and the high-resolution WRF-Chem simulations

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Oil recovery, power generation, water desalination, gas flaring, and traffic are the main contributors to SO_2 emissions in the Middle East (ME). The main SO_2 sources are located near urban centers often in the vicinity of the Red Sea or Arabian Gulf and maritime oil platforms. High SO_2 concentrations in combination with intense solar radiation, high relative humidity, and temperature provide unique conditions for the tropospheric photochemistry and air pollution formation in the ME that have not been yet adequately investigated. In addition, satellite observations reveal currently unaccounted SO_2 emission sources in the ME. This study aims at evaluating all available SO_2 emissions datasets over ME and testing (on regional bases) the high-resolution model simulations and meteorology/chemistry reanalyses, MERRA-2 and CAMS, with the satellite and available ground-based air-quality observations.

We employ WRF-Chem v3.7.1 regional meteorology-chemistry model with the GOCART aerosol module coupled with the RACM chemical mechanism driven by MERRA-2 meteorological and chemical boundary conditions. We conduct simulations for 2015-2016 with 10 km grid spacing using HTAP v2.2 emission datasets and a new one based on the combination of the near-surface SO_2 emissions taken from the HTAP v2.2 inventory with the strong (>30 Kt/year) SO_2 point sources obtained from the satellite Ozone Monitoring Instrument (OMI) observations.

We found that MERRA-2 and CAMS emission inventories (EDGAR v4.2 and MACCity, correspondingly) incorporate inaccurate locations of the strong SO_2 sources in the ME and significantly underestimate SO_2 emissions in the Arabian Gulf. Therefore, the WRF-Chem run with the new combined (HTAP v2.2 and OMI) emissions improves comparisons with surface SO_2 observations. Our simulations show that daily averaged SO_2 surface concentrations in the major cities of Saudi Arabia frequently exceed World Health Organization air quality limit. Annually averaged geographical distribution of SO_2 surface concentrations peak at the highly populated western and eastern coasts of Saudi Arabia, Eastern Iraq, and Arabian Gulf. This indicates the urgent necessity in effective control over the SO_2 emissions in the ME region to reduce the harmful effect of anthropogenic pollution on human health and environment.