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Interpretation of Atmospheric CO_2 Measurements in Mexico City

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The French-Mexican project Mexico City's Regional Carbon Impacts (MERCI-CO_2) is building a CO_2 observation network in the Metropolitan Zone of the Valley of Mexico (ZMVM). The project investigates the atmospheric signals generated by the city's emissions on total column and surface measurements, aiming at reducing the uncertainties of CO_2 emissions in ZMVM and evaluating the effects of policies that had been implemented by the city authorities.

A nested high-resolution atmospheric transport simulation based on the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) is performed to analyze the observed CO_2 mixing ratios during dry and wet seasons over Mexico City and its vicinity. Both anthropogenic emissions (UNAM 1-km fossil fuel emissions) and biogenic fluxes (CASA 5-km simulations) are taken into account. The model configuration, with a horizontal resolution of 1km and using the Single-Layer urban canopy Model (SLUCM), has been evaluated over two weeks in January 2018 using meteorological measurements from 26 stations set by the Air Quality Agency of Mexico City (Secretary of the Environment of Mexico City - SEDEMA). The reconstruction of meteorological conditions in the urban area shows better performances than suburban and mountainous areas. Due to the complex topography, wind speeds in mountain areas are 2-3 m/s over estimated and wind direction simulations in some stations are 90° deflected, especially in southern mountains.

Two high-precision CO_2 analyzers deployed in urban and rural areas of Mexico City are used to evaluate the WRF CO_2 1-km simulations. The model reproduced the diurnal cycle of CO_2 mixing ratios at the background station but under-estimates the nighttime accumulation at the urban station. Mean absolute errors of CO_2 concentrations range from 6.5 ppm (background station) to 27.1 ppm (urban station), mostly driven by the elevated nocturnal enhancements (up to 500 ppm at UNAM station). Based on this analysis, we demonstrate the challenges and potential of mesoscale modeling over complex topography, and the potential use of mid-cost sensors to constrain the urban GHG emissions of Mexico City.