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Estimating hourly benzene concentrations in a highly-complex topographical environment in northern Spain using RAMS and the CALPUFF modeling system

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The RAMS-CALMET-CALPUFF modeling system together with observations has been used to analyse the hourly benzene impacts of a coke plant in a nearby urban area in a region of very complex topography (a mountainous region near the coast) in northern Spain. The air flow in this region is strongly influenced by the local topography and, specially under anticyclonic conditions, important daily changes in stability, wind velocity and wind direction occur almost every day, which directly affect the dispersion of pollutants in the area. The aim of this study was to set up a methodology suitable for dispersion studies in very complex areas, where pollutants dynamics is highly affected by mesoscale meteorological processes.

Two ten-day periods have been modeled. High spatio-temporal resolution meteorological simulations have been performed with the non-hydrostatic mesoscale meteorological model RAMS. A configuration of four nested grids has been used. 4D assimilation has been performed using NCEP and ERA-Interim data. The RAMS meteorological output has been downscaled from a 1 km to a 250 m resolution with the CALMET diagnostic model. Observational meteorological data have been assimilated into CALMET. The results of the meteorological simulations have been validated both against data recorded by a network of surface stations and by a wind profiler radar (WPR) located near the coast. The already validated meteorological fields have been input into the CALPUFF nonsteady-state puff dispersion model. For the dispersion simulations, benzene emission data have been obtained from the Spanish E-PRTR Register. Predicted impacts have also been compared with observations.

Comparisons of the RAMS simulated wind fields against the WPR profiles have revealed inaccurate NCEP reanalysis data for one of the simulated periods. Initialization with ECMWF-Interim data have improved the results. The main flows that affect dispersion in the area have been mostly well captured by the modeling system, for which the assimilation of meteorological observations into CALMET has shown of prime importance. This data assimilation has been crucial to reproduce the nocturnal drainage flows on some days and hence, for a subsequent simulation of the actual daily cycles of benzene concentrations by CALPUFF. These cycles has been captured by the model; however, concentration levels are underestimated, probably due to an underestimation of the registered benzene emissions.

The availability of good meteorological observations in the area to assess the model reliability, and good emission data are of key importance to improve the model evaluations.