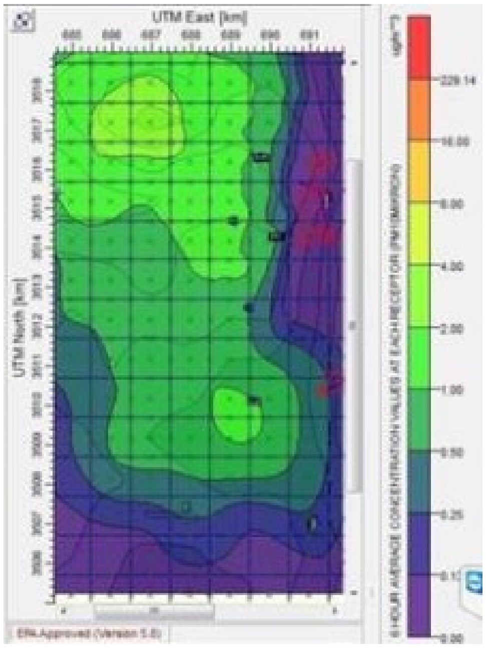
Dispersion of particle emissions from quarries in complex terrain

Quarrying and surface mining operations are area sources of dust (suspended particles) that may cause considerable air pollution. Such sources, by their nature, are characterized by lack of detailed information about the location of the mobile mining equipment (bulldozers, loaders, graders, etc.), which makes it difficult to determine reliably the location, duration and strength of the dust emission sources in quarries and surface mines.

AERMOD and CALPUFF are two common computer models (software) that predict dispersion and concentrations of pollutants in the air. There are some important differences between the two models, among others, in the way they represent the wind profile, uneven terrain, account for area sources and deposition of the airborne particles.

Previous studies mostly considered emissions from point sources (usually stacks higher than 100 m). To date, only few studies evaluated AERMOD and CALPUFF for area sources (mostly not quarries or open mines), and almost all of them did it for flat terrain conditions. In general, the results of the previous studies did not show a clear advantage of any of the models. Moreover, these studies used only measured meteorological data and did not examine the effect of using modeled meteorological data, obtained using meteorological models that account for topographical and land cover features at different spatial scales. A typical example for such a model is WRF – one of the most widely used prognostic meteorological models. Such meteorological models can produce the missing on-site meteorological data by establishing a pseudo meteorological station at a specified location, thus providing wind field estimates in a format that can be directly used for dispersion calculations.



In our research, we studied dust dispersion from quarries located in mountainous areas in two geographical regions, accounting, among others, for (a) varying distances between the meteorological station, the emission site and the receptor points where concentrations are required/measured; (b) WRF-modeled vs. observed meteorological data; (c) dispersion of different size fractions of the airborne particles (with the smaller fractions considered to be more hazardous than the larger ones); and (d) particle deposition. We compared predictions of AERMOD and CALPUFF to dust concentrations measured round the quarries and judged their reliability by different performance metrics, including the modeled-to-measured average concentration ratio. We found that AERMOD predicted ambient concentrations of quarries' related emissions more accurately than CALPUFF, and attributed this to the different representation of area sources in the two models and to the different parametrization of particle deposition rates. As could be expected, the smaller the distance between the meteorological station, the emission source and the receptor point, the better the predictions of both AERMOD and CALPUFF were. In contrast, using WRF-modeled meteorological data for mountainous terrain, dispersion estimates were, in general, less accurate than when using (even remote) meteorological observations.

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