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2-D reconstruction of atmospheric concentration peaks from horizontal long path DOAS tomographic measurements: parametrisation and geometry within a discrete approach

A. Hartl, B. C. Song, and I. Pundt
Institute of Environmental Physics, University of Heidelberg, Germany

Abstract. In this study, we theoretically investigate the reconstruction of 2-D cross sections through Gaussian concentration distributions, e.g. emission plumes, from long path DOAS measurements along a limited number of light paths. This is done systematically with respect to the extension of the up to four peaks and for six different measurement setups with 2-4 telescopes and 36 light paths each. We distinguish between cases with and without additional background concentrations. Our approach parametrises the unknown distribution by local piecewise constant or linear functions on a regular grid and solves the resulting discrete, linear system by a least squares minimum norm principle. We show that the linear parametrisation not only allows better representation of the distributions in terms of discretisation errors, but also better inversion of the system. We calculate area integrals of the concentration field (i.e. total emissions rates for non-vanishing perpendicular wind speed components) and show that reconstruction errors and reconstructed area integrals within the peaks for narrow distributions crucially depend on the resolution of the reconstruction grid. A recently suggested grid translation method for the piecewise constant basis functions, combining reconstructions from several shifted grids, is modified for the linear basis functions and proven to reduce overall reconstruction errors, but not the uncertainty of concentration integrals. We suggest a procedure to subtract additional background concentration fields before inversion. We find large differences in reconstruction quality between the geometries and conclude that, in general, for a constant number of light paths increasing the number of telescopes leads to better reconstruction results. It appears that geometries that give better results for negligible measurement errors and parts of the geometry that are better resolved are also less sensitive to increasing measurement errors.

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