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Observations of artificially released SO_2 puffs using a tomographic setup of six UV cameras

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A passive scalar injected into a turbulent atmospheric flow exhibits complex dynamical behaviour, which can depart substantially from Gaussian behaviour. This behaviour is quite difficult to capture with models. Therefore, atmospheric tracer experiments are needed for constraining dispersion parameters. The COMTESSA project (Camera Observation and Modelling of 4D Tracer Dispersion in the Atmosphere) is the first attempt at using UV camera observations to study 4D tracer dispersion in the atmospheric boundary layer.
For this, during a three week campaign in Norway in July 2017, the passive tracer SO_2 was artificially released in continuous plumes and discrete puffs from a 10 m tower. The SO_2 column densities were observed simultaneously with six ultraviolet cameras positioned at a circle around the release point. Such SO_2 cameras are widely used to monitor SO_2 emissions from volcanoes. Based on the absorption of back-scattered sunlight by SO_2 molecules, the cameras capture the SO_2 column densities with sampling rates of several Hertz and spatial resolution of few centimeters. In this way, we could collect a data set of spatially and temporally resolved tracer column densities from six different directions. In addition, Eddy covariance measurements were performed at the release, and two additional towers.
As a first study, the dispersion of the SO_2 puffs was analysed. The two-dimensional, horizontal trajectories of the center of mass of the puffs were reconstructed based on the tomographic setup enabling a pixel-to-distance mapping of the camera images at the position of the puff. That, in turns, made it possible to retrieve the puff spread in the individual image planes, which, depending on the camera's orientation towards the wind direction, directly corresponds to the puff spread in along-wind, cross-wind and vertical direction. The consistency of the trajectories was checked by monitoring the total (conserved) SO_2 mass of the puffs. Here, we report on the applied methods and the results for single, artificially released puffs within a short time interval, while in the future the same methods will be applied on an extended data set to retrieve statistical insights of the turbulent flow in the atmospheric boundary layer.
The first COMTESSA field campaign demonstrated that a simplified tomographic setup of SO_2 cameras can be successfully used to retrieve dispersion parameters from artificially released SO_2 puffs. This is the first step towards a complete tomographic reconstruction of the puffs. Such a reconstruction of the conditions in the atmospheric boundary layer will be invaluable for the modelling of atmospheric dispersion.