EGU21-12751
https://doi.org/10.5194/egusphere-egu21-12751
EGU General Assembly 2021

Estimating coal mine methane emissions using ground-based FTIR spectrometry, WRF driven Lagrangian dispersion modelling, and a regularized inversion approach

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Methane (CH_4) emissions from coal production are one of the main sources of anthropogenic CH_4 in the atmosphere. Poland is the second largest hard coal producer in the European Union with the Polish area of the Upper Silesian Coal Basin (USCB) as a part of it. Emission estimates for CH_4 from USCB for individual coal mine ventilation shafts range between 0.03kt CH_4/yr and 25.9kt CH_4/yr, amounting to a basin total of roughly 465kt CH_4/yr (E-PRTR database, 2014). During CoMet (Carbon Dioxide and Methane Mission 2018) four ground-based, portable FTIR (Fourier transform infrared) spectrometers EM27/SUN were deployed in the USCB. We arranged these instruments in fixed locations in the North, East, South, and West of the USCB in approx. 50km distance to the center of the basin. This set-up ensures both, upwind and downwind measurements of CH_4 for the prevailing wind directions. Subtracting upwind from downwind XCH_4 observations gives the net methane enhancement of the region in between two selected instruments. These enhancements are also modeled with the Lagrangian particle dispersion model Flexpart. The model is driven by WRF wind simulations calculated in a nested domain using data assimilation of 3D wind-lidar data measured at three locations in the area of interest. The residuals between modeled and measured enhancements are minimized with a Phillips-Tikhonov regularized, non-negative least squares approach using the E-PRTR inventory data as a-priori information. The regularization parameters are graphically chosen via L-curve determination. Simulation uncertainty is expressed through an ensemble of different model runs, each with altered, basic meteorological parameters. The model generally matches the E-PRTR inventory data within it's error range for a small number (6 to 10) of coal mine ventilation shafts, whereas it suggests higher emission rates than the E-PRTR for more

involved point sources (>30).