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# Estimation of Swiss methane emissions by near surface observations and inverse modeling

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On a global scale methane ($CH_4$) is the second most important long-lived greenhouse gas. It is released from both natural and anthropogenic processes and its atmospheric burden has more than doubled since preindustrial times. Current $CH_4$ emission estimates are associated with comparatively large uncertainties both globally and regionally. For example, the Swiss national greenhouse gas inventory assigns an uncertainty of 18% to the country total anthropogenic $CH_4$ emissions as compared to only 3% for anthropogenic $CO_2$ emissions. In Switzerland, $CH_4$ is thought to be mainly released by agricultural activities (ruminants and manure management >80%), while natural emissions from wetlands and wild animals represent a minor source (~3 %). The country total and especially the spatial distribution of CH4 emission within Switzerland strongly differs between the national and different European scale inventories. To validate the “bottom-up” Swiss $CH_4$ emission estimate and to reduce its uncertainty both in total and spatially, “top-down” methods combining atmospheric $CH_4$ observations and regional scale transport simulations can be used.

Here, we analyse continuous, near surface observations of $CH_4$ concentrations as collected within the newly established CarboCountCH measurement network (http://www.carbocount.ch). The network consists of 4 sites situated on the Swiss Plateau, comprising a tall tower site (217 m), two elevated (mountaintop) sites and a small tower site (32 m) in flat terrain. In addition, continuous $CH_4$ observations from the nearby high-altitude site Jungfraujoch (Alps) and the mountaintop site Schauinsland (Germany) were used. Two inversion frameworks were applied to the $CH_4$ observations in combination with source sensitivities (footprints) calculated with the regional scale version of the Lagrangian Particle Dispersion Model FLEXPART. One inversion system was based on a Bayesian framework, while the other utilized an extended Kalman filter approach. The transport model was driven by analysis fields from the non-hydrostatic numerical weather predication model COSMO at horizontal resolutions of up to 7 km x 7 km. As a result spatially resolved, annual mean $CH_4$ fluxes for Switzerland were obtained. In general total Swiss $CH_4$ emission remained close to the “bottom-up” estimates, while considerable shifts in the regional distribution of the emissions were obtained. Reductions in $CH_4$ emissions, as compared to the prior estimates, were established in regions with large emissions from ruminants, while increases resulted in the Western part of the Swiss Plateau, which is dominated by mixture of large water bodies and crop and vegetable farming. Sensitivity inversions were applied to assess the overall robustness and the uncertainty of the inversion system.