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Inverse modelling on the basis of remote sensing to determine emission rates

KLAUS SCHÄFER, INA STEINECKE*, STEFAN EMEIS, MARTINA STOCKHAUSE, RALF SUSSMANN, THOMAS TRICKL, OLIVER REITEBUCH, KARSTEN HOECHSTETTER, ACHIM SEDLMAIER, Garmisch-Partenkirchen, GEORG DEPTA, ANDREAS GRONAUER, Freising, JENS SEEDORF, JÖRG HARTUNG, Hannover

Summary. Inverse modelling with a Gaussian dispersion model is used to determine emission rates of diffuse sources. The path-integrated gaseous concentrations of an exhaust are measured downwind of the source by FTIR absorption spectroscopy. Results of emission investigations from slurry spreading and a livestock building are discussed.

Inverse Modellierung auf der Grundlage der Fernerkundung zur Bestimmung von Emissionsraten

Zusammenfassung. Die inverse Modellierung mit einem Gaußschen Dispersionsmodell wird zur Bestimmung von Emissionsraten diffuser Quellen eingesetzt. Mit der FTIR-Absorptionsspektroskopie werden längengemittelte Konzentrationen von Spurengasen in der Abluftfahne der Quelle gemessen. Die Ergebnisse der Emissionsuntersuchungen bei der Gülleausbringung und an Stallanlagen werden diskutiert.

Introduction

The emission rates of diffuse and heterogeneous emission sources are not easily to determine because a single or point measurement in or above a source is not representative. To quantify these emission rates a technique with inverse dispersion modelling on the basis of remote sensing was developed.

The measurements are performed downwind of the emission source in distances where relevant parts of the exhaust plume are caught. Simultaneously, background concentrations and meteorological parameters are recorded. By inversion of an adapted dispersion model for the exhaust plume the emission rates of the source are determined.

Description of method

By means of the multi-components Fourier-transform infrared (FTIR) spectroscopy technique the absorption of light (from an artifical radiation source) within an exhaust plume is measured near the ground (open-path) perpendicular to the plume axis. No sampling of exhaust gases is necessary. Simultaneous measurements on different paths through the plume are carried out. The influences of turbulence-induced variations of plume dispersion can be minimized by sufficient optical path lengths and time integration during steady-state meteorological conditions. The absorption paths had typically a length of 150 to 300 m and were installed at altitudes from 1 up to 20 m above ground. The accuracy of FTIR absorption spectroscopy for the trace gases NH_3, CH_4, N_2O, CO and CO_2 is around 5 % (HAUS et al. 1994).

Gaussian and Eulerian dispersion models were investigated for inverse modelling to determine emission rates (LEHNING et al. 1994). Particularly attractive are Gaussian models because their inversion is rather simple (CARTER et al. 1993). An application to strongly inhomogeneous sources needs in certain cases iterative corrections. Eulerian and Lagrange models are expected to yield better results if the dispersion is influenced by buildings and pronounced orography and are currently tested.

The impact of agricultural emission sources on the environment and also on the climate has been grossly underestimated. The emissions are highly variable due to very different kinds of sources and require well adapted measurement techniques. Remote sensing on the basis of FTIR spectroscopy is suitable and further developed for this task.

Experimental results

Results from two field experiments will be presented. One experiment was made in order to estimate the area emission strength from meadows after slurry spreading in October 1996, the other experiment was made in order to verify the inverse modelling method by application to the emissions

* now: Cottbus.

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