Atmos. Chem. Phys. Discuss., 13, C6718–C6722, 2013
www.atmos-chem-phys-discuss.net/13/C6718/2013/

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Retrieval of methane source strengths in Europe using a simple modeling approach to assess the potential of space-borne lidar observations" *by* C. Weaver et al.

Anonymous Referee #2

Received and published: 9 September 2013

The discussion paper "Retrieval of methane source strengths in Europe using a simple modeling approach to assess the potential of space-borne lidar observations" by C. Weaver et al. aims to analyze the sensitivity of future space-borne LIDAR instruments, such as the planned DLR/CNES MERLIN (MEthane Remote LIdar MissioN) instrument and the NASA Methane Sounder, to changes in methane emissions. In the first part of the study, the authors analyze European CH_4 emissions using the FLEXPART model and observations from 9 European surface monitoring stations, and then apply in the second part their modeling system to calculate column averaged mixing ratios (XCH_4)

for a reference case and a case with assumed 50% reduction of CH_4 emissions over Germany and the Netherlands, and compare the calculated difference in XCH_4 with the expected measurement precision. Unfortunately, this sensitivity analysis is based on forward simulations of XCH_4 for only 2 days, and is missing important elements such as the expected spatial and temporal coverage of the satellite data. Furthermore, a severe limitation of the analysis is that it takes into account only the vertical column between the surface and 400hPa, i.e. ignoring 40% of the total column. Although most of the CH_4 variability is indeed expected in the boundary layer, the upper troposphere and stratosphere may also contribute to variations of the CH_4 mixing ratios averaged over the total column, which needs to be further analyzed. I assume that the column averaged mixing ratios shown in Fig. 7 represent just the average between the surface and 400hPa. If this is the case, the signal in XCH_4 from the surface emissions averaged over the total column (i.e. between the surface and the top of the atmosphere) would be 40% lower. The paper completely lacks any discussion of vertical sensitivity (averaging kernels), expected spatial and temporal data coverage and potential systematic errors of the LIDAR instruments. The authors only compare their calculated relatively small signal in daily XCH_4 of the assumed 50% reduction of CH_4 emissions over Germany and the Netherlands ($\sim$3 ppb) with the expected instrument precision ($\sim$14 ppb), and estimate that at least monthly averaged measurements would be required for detecting the emission reduction, assuming a reduction of the random error by $1/\sqrt(N)$, while not discussing any systematic errors which might become limiting. Furthermore the signal in the monthly average XCH_4 might be smaller than in the shown daily maps. Overall, the presented very short analysis is not sufficient to quantitatively assess the sensitivity of the space-borne LIDAR measurements to changes in surface emissions. A much more detailed analysis would be required which should also include Observing System Simulation Experiments (OSSEs) taking into account the major aspects of the instrument (and the inverse modeling system), especially vertical sensitivity, expected spatial/temporal data coverage and systematic errors of the LIDAR instruments (as well as systematic errors of the modeling system), as e.g. performed for SCIAMACHY

[Meirink et al., 2006]. Because of these severe deficiencies of the presented discussion paper I cannot recommend the paper for publication in ACP.

Further comments:

Although the presented analysis of European CH_4 emissions based on the inversion of measurements from 9 surface stations is capable to identify some major CH_4 emission regions (Netherlands, and coal mining areas in Poland), the derived emissions per 'tile' and 45 day time step seem to have considerable noise (i.e. very large variations between the time steps, which are probably not very realistic), which is a common problem of many inverse modeling systems. It would be useful to better analyze these fluctuations and try to better separate the signal from the noise (e.g. by analyzing averages over larger areas and longer time periods).

The analysis of only 7.5 months is very short. At least one full year should be simulated to allow clearer conclusions about the contribution of seasonally varying emissions from wetlands.

A significant limitation of the presented inverse modeling system seems to be the treatment of the background, which is assumed to vary linearly over 45 days, and which therefore is not capable to account for variations in the background concentrations on shorter timescales. It seems likely that the general rather poor model performance for the mountain stations (e.g. observations at Jungfraujoch and Plateau Rosa are often several 10 ppb below model simulations / retrieved baseline; Fig.4) is largely due to variations of the background concentrations, which are not properly simulated. Furthermore, it is noted that the retrieved baselines show considerable discontinuities between the 45 day-periods (Fig. 4). The simulations could be significantly improved by using background fields from global CH_4 inversions (see e.g. [Rödenbeck et al., 2009]).

The CH_4 inversions from the MACC project are not a very good reference for the specific purpose of this paper (since the MACC inversions, aiming mainly on the global

scale, have been performed on coarse model resolution and do not assimilate European surface observations). It would be more appropriate to compare with CH_4 inversions on higher spatial resolution based on European surface measurements (e.g. [Bergamaschi et al., 2010; Manning et al., 2011]). None of the existing regional inversion studies is cited or discussed in the paper (beside the mentioned European inversions, there are also many inverse modeling studies for the US (e.g. [Kort et al., 2008]).

In many parts to the paper the discussion seems not very well elaborated. E.g. on page 19569 the authors state "This will definitely be an improvement over the current passive satellite instruments.", without giving any reference.

According to Table 1 the measurements from Kollumerwaard are reported on the NIST scale, while all other measurements are reported on the NOAA04 scale. It is not discussed in the paper, if and how the data have been converted to a common CH_4 calibration scale.

References

Bergamaschi, P., et al. (2010), Inverse modeling of European CH_4 emissions 2001-2006, J. Geophys. Res., 115(D22309), doi:10.1029/2010JD014180.

Kort, E. A., J. Eluszkiewicz, B. B. Stephens, J. B. Miller, C. Gerbig, T. Nehrkorn, D. B.C., J. O. Kaplan, S. Houweling, and S. C. Wofsy (2008), Emissions of CH_4 and N_2O over the United States and Canada based on a receptor-oriented modeling framework and COBRA-NA atmospheric observations, Geophys. Res. Lett., 35(L18808), doi:10.1029/2008GL034031.

Manning, A. J., S. O'Doherty, A. R. Jones, P. G. Simmonds, and R. G. Derwent (2011), Estimating UK methane and nitrous oxide emissions from 1990 to 2007 using an inversion modeling approach, J. Geophys. Res., 116(D02305,), doi:10.1029/2010JD014763.

Meirink, J. F., H. J. Eskes, and A. P. H. Goede (2006), Sensitivity analysis of methane emissions derived from SCIAMACHY observations through inverse modelling, Atmos. Chem. Phys., 6, 1275-1292.

Rödenbeck, C., C. Gerbig, K. Trusilova, and M. Heimann (2009), A two-step scheme for high-resolution regional atmospheric trace gas inversions based on independent models, Atmos. Chem. Phys., 9, 5331–5342.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 19559, 2013.