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Interactive Comment

Interactive comment on "Investigating Alaskan methane and carbon dioxide fluxes using measurements from the CARVE tower" *by* A. Karion et al.

Anonymous Referee #3

Received and published: 19 January 2016

Overview:
The paper of Karion et al. reports measurements of atmospheric mole fractions of CO_2, CH_4 and CO from the CARVE tall tower in central Alaska. The measurements, mainly from the highest of the three avaialble heights, are used to infer fluxes of CO_2 and CH_4 and a regional budget of CH_4. The work forms part of the US Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) and draws on modelling methods and results from other papers published on the project.

The simultaneous measurements of CO, a tracer for combustion emission sources, allow the authors to identify and eliminate events, which are associated with anthro-

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pogenic emissions or biomass burning and thus determine the natural fluxes of CO_2 and CH_4. The WRF-STILT modellling framework, with a priori maps of CO_2 and CH_4 fluxes, is used to calculate the modelled mole fraction enhancements. Very good agreement is obtained between the modelled and measured CO_2 enhancements using fluxes taken from the POLAR-VPRM regression model. The performance for CH_4 is poorer, which the authors attribute to the simpler CH_4 flux models used with their much coarser spatial resolution and lack of temporal variability. A key finding is the significant biospheric fluxes of both CO_2 and CH_4 during the autumn and winter, which is supported by the cited paper of Zona et al.

Overall, the paper reads well and should be published, after addressing the specific and technical comments below.

Specific Comments:

Abstract I found a slight disconnect in the sentence (page 34873, line 21) "CO_2 signals at the tower are larger than predicted, with significant respiration occurring in the fall that is not captured by PolarVPRM" with the "remarkably good agreement with tower observations" in the previous sentence. It seems to undermine the "remarkably good agreement". Perhaps, "However" or similar qualifier is needed at the start of the sentence beginning "CO_2 signals".

Modelling The WRF-STILT modelling uses 500 particles per timestep (p 34880, line 13). There is no information provided in this or the cited paper by Henderson et al. as to why this number of particles is used. I am familiar with the UK NAME Lagrangian particle dispersion model, which appears to use far more particles: 20,000 (Ganesan et al., Atmos. Chem. Phys, 2015) to 33,000 particles (Manning et al., J. Geophys. Res.,2011). What is the reason for the difference? Is it to do with spatial resolution or a computational issue? What effect does using more or less particles have, e.g., on the uncertainty?

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Local source mixing I did not altogether find the discussion on the influence of (very) local sources convincing (p.34886 , lines 22-25). For CH_4, the authors argue that the measurements from the highest level of the CARVE tower are decoupled from the ground "despite its low height a.g.l., *the tower (my insertion)* is elevated above the surrounding area and likely is not affected by very local CH4 sources, such as wetlands". In the very next sentence on CO_2, the tower "is surrounded by trees and other vegetation" and these cause a larger CO_2 cycle. These statements seem to contradict. If I have misunderstood this, the text needs to be rewritten.

CH_4 flux models The CH_4 models are denoted as "uniform land-based flux" and "elevation-based". The cited paper of Chang et al. (2014) provides information on the "elevation model" and its use of four ecosystem/ land cover categories: Highlands (plateaus and uplands); Lowlands (plains, lowlands, and flats); the North Slope (Arctic coastal plain and Arctic foothills); and Mountains (ranges and mountains). It was not obvious from Chang et al what the uniform land-based model was (constant in time and spatially across these categories?). The elevation model gives a marginally better performance, which is to be expected as it does represent, to a certain extent, where wetlands and associated methane emissions are located. More information is needed in the present paper on these models.

Background concentrations The determination of the background is a key factor in the analysis. With the focus of the CARVE project on the carbon-cycle and natural fluxes of CO_2 and CH_4 in Alaska, I can see why a background based on clean air masses from the Pacific was chosen. However, as also noted by Referee 1, this impacts on the data capture, especially in the winter when the winds are predominantly from the East (Fig 4). Given that the uncertainty in the background concentration is the major term, I also endorse referee 1's comment about the robustness of the flux estimates for methane, especially in the autumn and winter and the conclusion about the significance of the autumn/winter fluxes for the annual CH_4 budget.

Context This paper forms part of a series of papers on the CARVE project and the reader is referred to these. I note that the main project description paper (Miller et al., 2015) is in preparation. The introduction clearly refers to the carbon-cycle but this context becomes lost later in the paper. As also noted by referee 1, it would be useful to be more explicit about the CO_2 and CH_4 sources earlier (and which are relevant to this study). This would then explain why anthropogenic sources and biomass burning were not of interest (but could be) and hence excluded. The leakage of CH_4 from oil and gas facilities is currently very topical.

Technical comments:

Throughout the paper, R^2 is said to be the correlation coefficient. Formally, it is the coefficient of determination and not the (Pearson product-moment) correlation coefficient, which is R (see, for example, http://stattrek.com/statistics/dictionary.aspx?definition=coefficient_of_determination). This occurs on p. 34892, line 12 and also in Table 1 and Figures 7 and 8.

There are a number of typographical other comments:

- There is no reference to Figure 4, which presumably should be in Section 4.2.
- p. 34874, lines 2, 11, 14: Check the date order of citations (e.g., should be Schuur et al., 2008, 2009, 2015)
- p. 34874, line 3: Remove "in" from "focused on in its ...."
- p. 34876, line 9: Insert comma after "2011" in "October 2011 17 km north of Fairbanks, AK,"
- p. 34876, line 16: remove "out" from "to change out flask packages". This also occurs in the Acknowledgements (page 34894, line 21)

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- p. 34882, line 11: Longitude in "tagged with the mole fraction from the Pacific boundary curtain at their exit latitude, longitude, and time" should be "altitude"
- p. 34890, line 26: Insert "in the" in "any improvement (in the) correlations"
- p. 34892, line 1: Suggest rephrasing to "not only low-lying wetlands and forests, but also extensive upland and mountain regions"
- p. 34892, line 8: Insert "in origin" after "biogenic"
- p. 34892, line 22: Insert "results" after "The model"
- p. 34892, line 23: Replace "that repeated all three years" with "that was repeated in all three years"
- p. 34892, line 27: Insert as indicated "to have fluxes from interior Alaska in its observation footprint" or similar
- p. 34893, line 20: Insert as indicated "fluxes in this region are likely to be highly heterogeneous"

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 34871, 2015.

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