

# ***Interactive comment on “Eddy covariance measurements of the net turbulent methane flux in the city centre – results of 2 years campaign in Łódź, Poland” by W. Pawlak and K. Fortuniak***

**Anonymous Referee #1**

Received and published: 9 March 2016

— General comments —

This is a new and important study, in which a long time-series (2 years) of methane fluxes is presented and analysed. The dataset represents the first of its kind in terms of duration, enabling annual total methane flux to be estimated for an urban area, as well as some consideration of inter-annual variability. The analysis focuses on the temporal patterns in the methane flux at various timescales (daily, weekly, monthly, seasonally and annually) and spatial patterns are explored too. In some places deeper analysis may offer additional insight.

The article is generally well written and thorough, but very repetitive in places. Sometimes use of unnecessary words obscures the meaning. I have made some specific

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suggestions below but the article as a whole would benefit from being more concise. Shorter (more) paragraphs would also improve readability.

Overall the quality of the work is high and I recommend this paper for publication in ACP following minor revisions.

– Specific comments –

1. Introduction: The introduction would be easier to read if it was more concise and less repetitive. Breaking the text up into smaller paragraphs would also help. I have made some suggestions below.

P2 L15-18: To improve readability delete unnecessary words: ‘In the first place’, ‘furthermore’, ‘the formation of’

P2 L27-8: Delete ‘, and methane is also the main component of natural gas’ as it is unnecessary given L28-9.

P3 L24 – P4 L8: This part is quite hard to follow, a bit repetitive and could benefit from rewording.

P4 L20-22: This sentence is not clear, please rephrase.

P5 L18: Delete ‘Furthermore’

P5 L19: Delete ‘in the following months’

2.1 Study area and site location: This section is long and quite hard to follow, in particular there are many details given about various parts of the city and it does not convey a clear message to the reader. It may be easier to follow if the section was restructured, so that after the description of the city (P5 L30 – P6 L8) comes the description of the measurement location (P6 L28 – P7 L9) starting with ‘The measurements of methane... persons per km<sup>2</sup>’ (P7 L8-10) and then the land cover description (P6 L10 – L27). This should make it easier to identify exactly which areas are being discussed in relation to the city as a whole, as opposed to the measurement location and source

area. Please also reduce repetition and unnecessary text.

P6 L4: Delete 'definitely'

P6 L8: Start a new paragraph at 'The measurements...'

P6 L10-11: It is not clear what is being 'averaged' here. May be best to omit 'average' and change 'reaches' to 'is' or provide further details (e.g. mention wind sectors used).

P6 L18-20: May be best to switch these two sentences describing the general study area with the previous one which talks about differences between sectors.

P6 L14, L20, L22: There are several different heights given here, presumably for different areas of the city. However, it is not clear to the reader which are the relevant heights, i.e. those that are considered to be within the measurement footprint and used to estimate the roughness and displacement height. Are the '10-12 storey buildings' within the footprint? Have they been included in the calculation of  $z_0$ , but not  $z_d$ ? The values given here seem to match those given in Pawlak et al. (2011), so it may be worth directing the reader to that reference in particular. However, different values are given in Offerle et al. (2006a). Please explain. It would also be useful to give the site name so that readers can relate this work easily to previous work carried out at the same location.

P6 L31-33: To avoid repetition delete this part ('when ... air') as it effectively says the same as the first half of the sentence and this point has already been made earlier in the paper as well.

P7 L3-7: Suggest rephrasing as, 'The source area of turbulent fluxes was estimated (Fig. 1) for data collected during unstable stratification ( $(z-z_d)/L < -0.05$ ) around midday (10.00 – 14.00) following the method of Schmid (1994).'

P7 L7-9: Could rephrase as, 'The source area ranged from 250 to 750 m away from the measurement station.'

P7 L9-17: This part does not really belong in the site description – it would fit better in the results. Suggest simply saying ‘The gas distribution network and sewerage system around the flux tower are shown in Fig. 1’ here, and saving the methane discussion for the results. (Note Fig. 2 in L17 should be Fig. 1.)

2.2 Instrumentation and data processing: This section is generally clear but splitting into smaller paragraphs would help improve readability. One or two sentences may need to be moved around so that each paragraph deals with a particular topic before moving on to the next. P7 L20-30: Suggest rewriting more concisely.

P8 L21: Delete ‘during the measurements’

P8 L23, L26: Better to use ‘RSSI’ throughout this sentence, as opposed to switching between RSSI and signal strength of the instrument/signal strength value.

P8 L21-26 and Fig. 2: Mention that Fig. 2 indicates the cleaned dataset (RSSI > 20%), e.g. in the figure caption. This should also be made clearer for the percentages discussed in the text, e.g. ‘...RSSI > 20% were chosen. Of these, RSSI exceeded 70% in only about 8% of cases...’

P9 L10: Delete ‘In the calculations’

P10 L2: Delete ‘earlier’

3. Results: Suggest new paragraphs at P10 L28 (stability), P11 L8 (fluxes).

P11 L32: New paragraph before ‘It seems...’

P11 L31-32, P12 L25: Could the authors suggest an explanation for the exception in July and August 2013? A little more discussion would be helpful (e.g. compare bottom two panels in Fig 3 and the statistics in Table 2 – the variability seems to be possibly more of an exception than the average values). In Fig 4 months in different years have been grouped together to create the daily cycles. Are the patterns significantly different if the years are considered separately (in general and particularly for summer 2013)?

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P12 L4: Is there any evidence for increased discharge from motor vehicles in winter? Is this related to combustion conditions or the traffic load?

P12 L30: Suggest deleting 'Most importantly' – unless the annual variability presented in Section 3.2 is in doubt.

The description of time needs to be more precise so that the reader understands exactly what is meant. Examples include P13 L4: 19.00-20.00 is probably too late to call 'afternoon', 'evening' is better. P13 L6: Change 'during the noon hours' to 'around noon', 'around midday' or 'during the middle of the day'. P13 L9: Does 'before noon' refer to the morning maximum (7.00-8.00)? Might be better to say 'in the morning'. P13 L11: Talks about the increased distribution 'during the day' but FCH4 is lowest during the day and peaks in the morning and evening.

Fig. 5 and Fig. 6 are excellent. The discussion accompanying Fig. 6 is very clear.

P15 L24-26: As the partitioning of the sources of the observed methane flux is unknown, it is not possible to say that it is the anthropogenic sources that are less active at weekends. Rather, the weekday/weekend comparison suggests that the sources are likely to be anthropogenic because the observations show weekday/weekend differences.

P15 L26-P16 L4: These differences are small and the inconsistency between summer/winter and spring/autumn makes it hard to draw clear conclusions (as indicated by the authors). Further analysis and discussion may be informative. If the data are examined by month do the same seasonal differences emerge, or is this behaviour due to particular months skewing the results? Are the findings any clearer if holidays are taken into account as well as Monday-Friday and Saturday-Sunday differences? Are there significantly different fluxes on Saturday compared to Sunday, reflective of people's behaviour? Are there temperature differences between weekdays and weekends which may explain some of the trends seen?

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The wind direction analysis is interesting but would benefit from deeper examination and discussion. The large vegetated area to the west of the flux tower should be mentioned. Observed FCH<sub>4</sub> also appears to be lower for southerly wind directions, potentially coinciding with the undeveloped area and scarcity of gas and sewerage pipes (Fig. 1). Is the large intersection to the south-west likely to have heavier traffic loads compared to other roads in the area? The discussion needs to explore further than building density – i.e. the results should be related to the networks shown in Fig. 1. More could be made of the temporal differences in the spatial patterns (i.e. the similarity in the magnitude of FCH<sub>4</sub> observed during both warm and cold seasons to the west, versus major changes in other wind sectors). If sufficient data are available, the authors may want to consider generating seasonal diurnal cycles for different wind sectors (or groups of wind sectors) to explore whether temporal signatures typical of anthropogenic behaviour (rush hours, weekday/weekend differences, seasonal heating demand) offer additional insight into the various CH<sub>4</sub> sources.

P16 L18: Could the LPG station be responsible for the increased FCH<sub>4</sub> observed over the broad range of south-westerly wind directions? Does it coincide with the 230-240° wind sector during the warm period? It may be helpful to mark the LPG station (and any other identifiable point sources) on Fig. 1. What about the high fluxes seen between 70-80° in the cold period?

Findings from the earlier analysis should be used to develop work towards the end of Section 3. Anthropogenic controls, spatial differences and relation to CO<sub>2</sub> are considered almost independently in Sections 3.5, 3.6 and 3.7. But the spatial differences suggest different processes or source strengths are important in different wind sectors, so these findings should be considered in weekday/weekend differences and the relation to CO<sub>2</sub>. Building heating and traffic are important in winter, but less so in summer when photosynthesis also occurs, and less so for the vegetated sectors. The relation between FCO<sub>2</sub> and FCH<sub>4</sub> should include a deeper discussion of the underlying processes – and when and where one might expect FCO<sub>2</sub> and FCH<sub>4</sub> to be correlated or

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not.

Either at the end of Section 3 or near the start of the Conclusion it would be helpful to have a brief summary of what has been deduced from the analysis in terms of the various CH<sub>4</sub> sources and sinks for this site, i.e. which processes are important when and where.

The conclusion is strong and provides a good synthesis, setting this work in context. The comparisons with other sites and other cities is well-written and useful.

P18 L25-7: Can the authors suggest a reason for this?

– Minor comments –

Title: ‘results of a 2-year campaign’ reads better.

P1 L17-23: In my view this is too much detail for the abstract and ‘the measurement station . . . approximately 1 kilometre’ should be omitted.

P1 L30: CH<sub>4</sub> and FCH<sub>4</sub> are introduced here; to improve readability it may be more helpful to introduce them earlier (or not at all in the abstract), as currently several different ways of referring to the methane flux are used.

P2 L1-2: To improve readability, delete ‘The studied area of the centre of Łódź is also characterised by a cycle of methane exchange – the’

P2 L4: Change ‘was characteristic of’ to ‘occurred in’

P5 L8: Change ‘at the same time hinder’ to ‘do not allow’

P10 L13: Either ‘The climate of central Poland is’ or ‘The climate of Łódź is’ (the reader already knows that Łódź is in central Poland from P5 L31).

P10 L28: Delete ‘Generally, it can be noted that’. (You could say ‘generally’ before ‘prevailed’ if it is important.)

P10 L29: Change ‘could rarely be’ to ‘was rarely’

P13 L9: Is 'or' the best word here?

P13 L13: New paragraph after 'hypothetical'

P13 L13: The meaning of this sentence is unclear, suggest deleting.

P14 L4: Suggest deleting 'when they were up to 2.0 g m<sup>-2</sup> month<sup>-1</sup>' as this sounds as though it contradicts the Jan/Feb values. Alternatively change 'up to' to 'around'.

P14 L26: Intended meaning of 'supplementing' is unclear; 'observing' may be more suitable.

P14 L30: Although additional data may be useful for more advanced gap-filling algorithms, simplifications are often used, as is the case in this study. Therefore suggest changing 'are required' to 'may be useful', or similar.

P15 L28: Delete 'mg m<sup>-2</sup> day<sup>-1</sup>'?

P16 L7: Suggest starting this section with 'As mentioned in Section 2.1, building density is...'

P16 L23: Missing value.

P17 L2-7: Delete as this point has been made already in the Introduction.

P17 L9: Change 'should be asked' to 'can be addressed'

P17 L18-20: This sentence is not very precise. Suggest rephrasing to say something like, 'We therefore conclude that FCO<sub>2</sub> data cannot be used to facilitate gap-filling of FCH<sub>4</sub> data in the centre of Łódź.'

P17 L32: Change 'in the case' to 'for'

P18 L25: Meaning of 'at the same time' is unclear. Suggest deleting or changing to 'for the same period' if that is the intended meaning.

P18 L25: 'before and after noon' is not very precise and potentially misleading: 'morn-

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ing and evening' or giving the times would be better.

P19 L1-3: Hinting at the discrepancy between CH<sub>4</sub> observations and inventory estimates at this stage leaves the reader suddenly doubting the measurements they have just read about! Therefore this sentence might be more appropriate earlier on (either where the Florence results are discussed or when inventory data are mentioned).

P28 Add percentage units to the table or caption.

P31 L2: Delete 'set' Figure captions: 'in the Łódź centre' can be deleted from most figure captions as it seems unnecessary.

P35 L3: Suggest 'light blue' and 'dark blue' lines.

– Technical corrections –

P2 L26: Delete 'the'

P4 L11: Change 'hang' to 'mount'

P4 L13: Change 'poorly' to 'not' or 'poorly widespread' to 'rare'

P5 L16: Change 'a turbulent' to 'the turbulent'

P6 L1: Delete 'a'

P12 L25, Pg14 L5: Change 'twice' to 'two times'

P28 L2, P29 L2: Change to 'July 2013'

P30 L3 Change to '10.00 to 14.00'

P32 Fig 3: Change y-axis label to 'air' (not 'ait')

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Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2015-979, 2016.