

Interactive comment on “Improved Atmospheric Characterization through Fused Mobile Airborne Surface *In Situ* Surveys: Methane Emissions Quantification from a Producing Oil Field” by Ira Leifer et al.

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General comments: This is an interesting and innovative paper, describing how both mobile surface measurement across strong local topography and parallel aircraft measurements have been used to derive methane emission fluxes. This is an important problem, and has wide applications. By using aircraft and vehicle to validate each other, both methodologies are improved. In the US, instrumented aircraft are available. In many less wealthy nations that is not the case and measurement will have to depend on vehicles supplemented by light drones. The topographic problem is also

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widely applicable, in the many locations where the boundary layer is poorly mixed. Thus although aspects of the experiment can be criticized and the introductory section is very inadequate, the paper is an interesting and useful contribution, that should be published after revision.

Specific details: The Introductory section is incoherent, and depends in part on outdated papers. It needs to be revised substantially.

Line 35 should probably cite up to date NOAA results, perhaps from Dlugokencky's papers. For lifetime (also line 43-44), be careful not to mix up the various definitions of lifetime and again best to use a recent Dlugokencky paper or use IPCC.

>Yes, Ed's work now cited.

Line 38 – Nisbet et al 2015 is an error. No such paper. It's 2014. Maybe better cite the major Nisbet et al 2016 Glob. Biogeo. Cycles paper, and also Schwietzke et al. (in Nature recently) on fossil fuel emission. Either here or in L50 cite Saunio, M. et al (2016) The global methane budget 2000–2012, Earth System Science Data, 8, 697-751, doi:10.5194/essd-8-697-2016.

>We have cited Saunio et al 2016 and Nisbet et al 2016. There was an error in the endnote database for Nisbet 2014 that has been corrected.

Line 43 Claim of a 40% drop in lifetime - There is a major discussion on whether or not OH is changing and maybe that's far beyond the scope of this paper. Also may be confusing lifetime definitions (perturbation/replacement) in general comment.

>We agree that lifetime, although worthy of mentioning in general, is well beyond the scope of the paper and thus the lifetime aspects are now greatly reduced.

Line 49. See for example Rigby, M. and 18 others (2017) Role of atmospheric oxidation in recent methane growth. Proc. Natl. Acad. Sci. USA. 114, 5373-5377.

>Now cited in the OH loss paragraph with a summary sentence.

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Line 50. Maybe cite Saunio, M. et al (2016) again.

>Done

Line 51 on – several more recent papers to cite on US fossil fuel emissions. Bruhwiler et al (2017) in JGR very effectively questioned Turner et al. , so I think this could be rewritten as the Turner et al conclusions should be discounted.

>Deleted.

Line 58-59 – The inventory discussion could be picked up around line 55 and should lead into Kirschke et al, and Saunio et al (2 papers, 2016, 2017) and maybe mention Nisbet and Weiss's earlier top down/bottom up comment in Science, 2010.

Line 62 – many more recent papers than White 1976!

>True, but they really do not make this point as specifically or as well. Also, much of the science of my father's generation seems to be in the process of disappearing down the memory well – and so I would like to keep White highlighted. That said, the works of Peischl et al. (2015; 2016) is added. I note that both Peischl et al., (2015;2016), also cite White et al. (1976).

This paragraph L61-70 needs updating. Also it could mention some of the European work – for example in several papers by Bergamaschi et al.

>Have added Saunio et al. (2017), who is working these days with Bergamaschi on inversion modeling.

Line 92-3 could be written by a PR firm selling dodgy goods. Most people live on the plains, not in the high Himalayas.

>Point taken. Deleted. Although most people lived on the plains, wherever feasible, the wealthy have always lived on more defensible hills above the plains where the poor lived (and were flooded, marauded, etc.

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Line 120 – reference for air flow to 1km only?

>Zhong et al., (2004) again. Added.

Figure 1a looks like a photo of some poster on the floor: :terrible, key is unreadable. Why the angled projection???

>Redone

Line 168 'stranded CH4 clouds' – we see these too, but don't call them stranded. They are not washed up on the beach (strand) – they are making their own independent progress as yet unmixed. They are important as they come from single event sources, which can be keys to the emissions from a gas field – e.g., water processing.

>Agreed, they are not stranded on a beach. Rephrased as “upwind CH4 plumes”

Line 196 - precision and accuracy please, calibration etc etc. (though I accept the point in L252)

>Added.

Lines 228-247 calculation and also 248-253. Maybe cite some of the Aliso canyon work here?

>Done. Thanks!

L271 – pre/post-surveys. Good. When was this? How comparable in meteorology?

>Added. “Primary changes were development of near surface winds, and a slight increase in the PBL”

L300-25 This section is very interesting. I'm surprised the PBL is located to a 20-m precision in the complex topography. Seems very precise.

>Its very sharp – and something that we often see in California. The Marine layer PBL is often visualized by clouds and is equally sharp (almost every day on my morning commute), sometimes to a few meters!

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L312 – tall pine trees? How tall - Not being Californian, are these 5m (tall in N.East Norway hills) or 150m redwoods?

>They are tall in a California sense. Added that they are 30m+

L342 – really a town called Bodfish? are they inland codfish? or an obscure mermaid-body genus? Is this paper really about Bodfish bubbleology? The mind boggles.

>It was a gold rush town named after a gentleman last name bodfish. The history of California is weird!

L365 – there is a lot of agriculture in the area – cows, wet fields, drains. This needs to be discussed. Are there any large cattle feed lots in and around Bakersfield? Landfills?

>The one nearby dairy in the upwind direction is now pointed out on fig. 7A, and discussed. Potential plumes from the only nearby upwind dairy (Fig. 7a, white arrow) were directed by winds to pass to the west of the oil fields. The only Landfill is to the south (and not along the flow path. There are no wet fields in this part of the San Joaquin Valley – that is only in the Sacramento area. Water is a little too precious here, and it gets too hot!

Fig 8 – really interesting figure could have a bit more discussion.

L396 – how rapid is the rise? Any guesses?

>I think the answer is pretty darn fast, methane has half the density of air, but mixing is not going to be similar to that for a 600K plume. In the Aliso Canyon leak (see <https://www.youtube.com/watch?v=exfJ8VPQDTY>) it looks like many meters per second. That said, it seems a bit overly speculative to put a number in print. . . .

L402 – nice to get some d13C(CH4) isotopes to pin down the methane. See comment above about cattle and landfills in the area. Also Bakersfield is a big city – sewage.

>Agreed, however, no isotope instruments were available.

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L435 – intermittent activity – what the paper calls ‘stranded plumes’ – any idea how common this is?

>For CO₂, this would be more from cycling of the co-generation power plant being on and off, the language is now clarified to “the co-generation plant only being active some of the time, confirmed by data from the GOSAT-COMEX campaign.”

L440,442 – collected Lagrangian – English language disjunction. ?in Lagrangian mode??

>Changed to “in a Lagrangian sense”

L441 – poor English again –a platform? Or platforms?

>Changed to “measurement platforms”

L471 – faux precision. 1.6km

>Changed. Thank you, that is something I usually catch in reviews I do!

L473-480 – good.

L503 – mountain peak – hitherto hidden in the discussion, now pops out. I hope you told the pilot: : : could be mentioned earlier as a problem.

>The pilot flies more or less where we ask, but of course they can change their route as they see fit. Also, they are military pilots flying a converted military jets, and tend to do things their way a bit, For example, in one of the flight segments (not here), the pilot realized he needed to drop a thousand feet, so he did a barrel roll and dove. Now discussed in section 2.1

L532 – maybe cite some of the NOAA work in other gasfields – intermittent sources.

>Apologies, but the intermittency for CO₂ was from cycling the power plant on and off. Actually, and this is the subject of another paper that we are writing, on the field level, CH₄ emissions are not intermittent, but stochastic – law of large numbers of leaks. In

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that paper, though, we do show that at the well level, they are intermittent. The text has been adjusted slightly.

L533 – CO₂ – maybe, or just a lot of trucks and all sorts of other sources?

>Thanks, this needed extra clarification. Added “Additionally there are no upwind (non-oil field) roads, only the foothills of the Sierra Nevada Mountains.”

L540 and 551 – would be nice to see some isotopes on this.

>Agreed, however, no isotope instruments were available.

L556 – repeat comment – no, we do NOT all live on the tops of Everest and Aconcagua. We live in the swamps of Calcutta and Shanghai. Schiphol runway, the center of Holland, is 11 ft under the ocean.

Agreed, this comment is very useful for Tehran and La Paz (both with major local gasfields) but it’s irritating to hammer it twice.

>Having lived a year in Den Haag, I understand your point. Deleted.

Overall – interesting paper. Accept with revision.

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