

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2022-720

Anonymous Referee #1

Referee comment on "Disentangling methane and carbon dioxide sources and transport across the Russian Arctic from aircraft measurements" by Clément Narbaud et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-720-RC1>, 2022

Acp-2022-720 Reviewer Comments

General

This manuscript represents the latest in a series of interesting studies based on research flights above Russian source regions. It presents a complex dataset consisting of many parameters, but rightly focusses on the vertical profiling at key localities with expected variation due to local sources or long-range transport. It is an appropriate contribution to the special issue.

Some sections lack precision and contain statements that are too vague and need constraining. Often too much conjecture without supporting evidence. The surveys were in September. It is not clear why early September was chosen so some clarification is needed, but as a period of minimum sea ice and maximum thaw it makes sense to target this period, although not as a period of maximum emissions. Have the authors considered increased shipping emissions at this time, or make a statement that the inventory may now need to include such sources.

It is not clear why Mace head is chosen as a comparative site for this study. What is it supposed to show? Using the monthly average puts the value in the middle of the observed flight ranges. If the MHD background sector only had been averaged then the averages would have been closer to those at Mauna Loa and closer to the baseline for observations (higher CO₂ and lower CH₄). MHD can be a good background for air masses crossing Europe at 50-70°N, but only for air from the westerly sectors.

The manuscript is well-written and clear for the most part, but there are many small

scientific points requiring clarification outlined below, and some additional typographic errors highlighted directly on the attached manuscript. There are a few very minor corrections needed to the English that can be easily sorted out, with adjacent words ending in s. Either the first will end in s or the second in s depending if the phrase is referring to singular or plural observations. One such phrase has been highlighted.

Detailed Points

Line 31-32 – ‘rise of 1.09 °C in the last decade (2011-2020) compared to the last decades of the 19th century (1850-1900)’. This is confusing - do you mean that the average temperature for 2011-2020 was 1.09°C higher than the average for 1850-1900?

Line 44 – ‘(178 to 206 Tg CH₄ yr⁻¹)’. Exactly same range as agriculture - one is incorrect

Line 89 – ‘specific signatures’. What is meant by this?

Table 1 – The UTC dates are a little confusing. Seeing the maps first it seems like there are 2 flights on 2 separate dates, rather than one flight in the middle of the day local time.

Figure 2 – The Picarro instrument rack appears to be installed below flight deck level, below which there is a label S, that is not explained in the caption. Anything specific about the positioning as this is the key instrument for this manuscript and is too new to be explained in the 2011 paper on plane layout.

Line 139 – ‘a ridge coming from’. Maybe should emphasize for the non-meteorologists that this is high pressure.

Line 144 – ‘60% of the measurements were taken above the Arctic Circle (> 66° N)’. Move this sentence elsewhere. It is splitting discussion of vertical measurements.

2.2 Instrumentation – For the Picarro there is no mention of the pumping speed or the delay time between the air entering the 3m tube and the measurement. The offset could be important during vertical profiling through stratified air masses, if origins are different.

Line 160-161 – ‘temperature (up to 15 °C hr⁻¹)’. Seems to be a strange value. The aircraft can ascend to 10000m in 10 minutes during which time T will change by much

more than 15°.

Line 208-209 - 'minimal mole fraction for each flight'. Not clear what this is. Is this a single value? Does the minimum not change with time of day and the extent of mixing at lower altitudes? What happens if the flight passes through a stratospheric wave at high altitude and records a lower mole fraction. Needs some more explanation.

2.4 Methane flux inventories – Why is each flux category sentence a separate paragraph? Would be clearer as a list.

Line 238 – 'analysed separately'. Does this include a different selection of background mole fraction?

Line 244 – 'Mace Head (1979 ppb).' Is this a monthly average? Mace head has a well-defined background sector. If there is high pressure bringing continental European emissions to the site the monthly average will be significantly above the Atlantic background.

Figure 4 - Very low mole fractions of CH₄ on 2 flights - see earlier comment about stratospheric air. Lower CO₂ at Mace Head than flights or Mauna Loa. Is biospheric uptake due to continental outflow also the reason.

Lines 266-269 - Need to explain the two flights with large CH₄ variability in the CH₄ section 3.1.1

Lines 298-299 – 'Eastern flights present an enhancement of +10 ppb to +20 ppb compared to Mauna Loa and Barrow mixing ratios respectively at 35 ppb and 30 ppb for the same altitude range'. Not clear. Can probably rephrase as 'compared to respective Mauna Loa and barrow mixing ratios of 35 and 30 ppb.

Lines 308-309 - You are using the CO data that has very big errors, without showing the errors. Is 4 ppb significant if the instrument was not working well?

Section 3.3 – Is it possible to defined the boundary layer height for these flights and on

Figure 6. The CO₂ and CH₄ profiles give a strong indication of where they are likely to be,

but were sondes released from the aircraft to give this information and confirm the height. Currently the BL information is quite general. Fig 6a could have the same CO₂ scale labels as b and d given that the range is the same.

Figure 7 caption – Need to specify if local or UTC times and be consistent in usage throughout.

Line 352 – ‘coming from the BL’. What evidence is there for this coming from the BL when figure 7 shows total column footprints?

Figure 8 - Both a and c have the vertical axes labelled as CH₄ when it should be CO.

Lines 383-384 – ‘and the closest one being Kenai Alaska liquid natural gas terminal’. Are the trajectories / particle dispersion for this flight time appropriate for a contribution from this source?

Line 390 – ‘depending on the geographical by source type and location’. Something missing.

Figure 9 – It would be useful to have the 1:1 line on the graph to highlight the underestimations of the model.

Figures 10 and 11 - The altitude is shown by the grey line but there is no scale from it. We can make presumptions from previous figures, but it needs some indication in the caption, e.g. bottom of graph = 0m, top = 10,000m, or similar.

Line 535 and associated earlier results discussion - Need to clarify latitudes for ground CO₂ sinks in September. Most studies of the boreal and Arctic zone CO₂ suggest that for latitudes >50°N the vegetation is a net source of CO₂ by September, not a sink (e.g. Welp et al., ACP, 2016)

Overall – check for consistency of use of mixing ratio. I think I saw at least one mention of mole fraction.

Reference List – Structure and ordering looks good, but I did not check for consistency with text citations.

Supplementary Information – This is useful. Is Figure B1 discussed in the text? This comes back to my earlier comment and the increased utilisation of this route by shipping at this time of year and the associated emissions.

Please also note the supplement to this comment:

<https://acp.copernicus.org/preprints/acp-2022-720/acp-2022-720-RC1-supplement.pdf>