Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-282-RC2, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Estimating CH_4, CO_2, and CO emissions from coal mining and industrial activities in the Upper Silesian Coal Basin using an aircraft-based mass balance approach" *by* Alina Fiehn et al.

Anna Karion (Referee)

anna.karion@nist.gov

Received and published: 20 June 2020

This is a well-written, well-researched manuscript and should be published in ACP after 2 major corrections noted below. Overall, the authors have done a lot of work on this flight data (although only 2 flights). But especially given that there are only two flights, there are two additional revisions that should be considered.

1) Characterization of the wind conditions prior to the flights. This is done qualitatively ("relatively steady"), but not quantitatively, and can be used in the sensitivity analy-

sis and uncertainty calculation. The mass balance requires the wind to be constant (Eulerian equation). If it is not constant over the transit time, there is uncertainty.

2) Use of biosphere model in sensitivity analysis. This is less important to the final result, but in the sensitivity analysis using the upwind transect as the background condition, the method of use of the biosphere model is confusing. The authors only subtract the biospheric influence one hour prior to measurement, because the upwind measurement was made one hour prior. This needs more explanation to me at least. However, since this method is only used to look at the sensitivity of background choice, it is a more minor issue than the above.

More discussion on both these points is below, with other detailed/minor comments.

L23: "estimates... which are well within the range"...

L60: e.g. reads awkwardly, I would write " which are used in climate projections, for example.".

L87 should say "using an airborne eddy covariance" (or maybe "the airborne eddy covariance...").

Figure 1. Could there be an inset to show the larger map where this is located? The google earth image does not actually show any location boundaries etc, or lat/lon indicators.

L102: make and model or reference for "well-established" CRDS? Were all 3 gases measured by both instruments? [I see now this is further described in Section 2, so perhaps just refer here to that section].

L108 - this is a very nice aspect of this study that is usually not done!

L112: Perhaps Chapters should be "Sections"? (this is up to the editors). Later the text does refer to "Sections", so consistency would be good.

L124: Earlier several remote sensing instruments were mentioned, but this work only

focuses on the in-situ measurements. Is there a reason for this?

L138 I don't think there should be a comma after both.

L165-166: The wind speed (and direction) also must remain constant over the transport time. This is a key assumption that the flux measured out of the downwind plane (or "wall") is equal to the emissions flux from the surface. Variability from this assumption is likely to happen, so that should be accounted for in the uncertainty analysis. Using wind speeds measured by the aircraft in the afternoon may not be the correct approach if they are not representative of the wind field over the whole domain over the transit time. If downwind wind is used, it should be shown that the wind speed was constant (or what the variability was) through the time it took for the air to transit the domain. Fig 6(a) in Karion et al., ACP, 2019 (https://doi.org/10.5194/acp-19-2561-2019) shows (granted, in an extreme case with long residence time) the difference between true emissions and measured emissions in a downwind plane using a forward model. Given the relatively small domain here, it's likely fine to assume steady winds over transport time, but this should be stated (and the variability of the wind included in uncertainty/sensitivity analysis).

L211, using the upwind as a "check" has been done before, citing some literature here would strengthen the justification of this choice.

L229 "form" should be "from"

Section 2.2.2. It is not clear to me why only the last hour of the footprint is used to estimate influence of biogenic fluxes on the downwind transect. For the final mass balance, the edges of the plume are used as the background, so it don't understand why the time between the upwind and downwind sampling matters. For the case of using the upwind transect, I am still not clear on the use of the 1 hour time frame. More on this in the next section.

L264: Very nice detailed error analysis: This is where I believe that uv should include

the variability of the wind over the transport time, not just measurement error. Perhaps added in quadrature to the 0.3 m/s, and constant over the whole grid. Or, now reading 2.3.2, perhaps it should be considered in the sensitivity portion, as it would be a systematic error.

L283: Table 1 repeated

L328: no comma after 'cases'

L388 - Agree! This addresses my issue above about steady winds over the transit time - so the section 2.2 above should mention this as well. In table 3, I would recommend also showing the mean wind and standard deviation for the Lidar over the 3-4 hours transit time, not only the flight time (to address my earlier comment). Several times this section says "relatively steady" - using the lidar data, this can be quantified and stated here.

L429-435. This is one issue with Kriging in space samples that were conducted at different times! It seems that hopefully the correction did the job, but in general, one might think this is a reason to do separate mass balance calculations for each transect (with each its own PBL depth), and then average. But either way changing conditions are difficult to deal with, and the authors have made a decent attempt at accounting for this, so no need to do this.

Figure 5 these are nice useful figures. What is the averaging time prior to Kriging? Or is it the native 0.5-Hz data that is Krigged?

L490. To clarify the method for using VPRM above, is it not accounted for at all in the version where the edges are used as background, and only when the upwind background is used? This makes sense if the assumption is that the uptake is the same at the edges and in the center, which in this case is a reasonable assumption (maybe not in an urban area). Does the enhancement from VPRM not change across the transect? That would then justify not including it when using the edges as background.

Regarding the upwind backround use of VPRM: I am still confused by the use of one hour only, and given how variable the uptake is in time due to the diurnal cycle of fluxes, it's not clear how to deal with this. If biogenic fluxes were constant in time and space, then the full trajectories (footprints) should be used until the location of the upwind leg. Otherwise, I think this is too complex to handle in the method it has been handled here. If the upwind leg were flown one hour *after* the downwind legs then how would this work? I am wondering if the upwind transect just cannot be used other than to show the lack of significant upwind fossil sources. Please explain/justify the use of the one hour time frame, and how this would work if the upwind leg were flown simultaneously or after the downwind leg - would you not subtract VPRM at all in that case? Seems wrong.

L515: Definitely agree with this statement on biosphere-atmosphere fluxes being complex!

L520 (sensitivity using average wind speed during downwind legs): This is close to what I suggested earlier. However, this is the average over the flight time, not transport time. One could use the transit time instead (from lidar perhaps, or from the model), as was done by Karion 2013 & 2015, to see the effect. What matters more is what the wind was at the location and time of emission - if it was high, then less CH4 was picked up in that air mass, if low, vice-versa.

SI: Table 1 can the caption also explain the offset of local time from UTC so the reader can quickly translate the UTC hours to local?

How frequent is "frequently calibrated" (approximately - daily? hourly?). Text S1 gives the mole fractions of the cylinders in ppm for both gases, but the text says ppm/ppb. Should be ppm/ppm.

The drift with time uncertainty is estimated using the flight time, so presumably the calibrations did not occur during flight, so frequently is > 2.5 hours?

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-282, 2020.