Atmospheric
Chemistry
and Physics
Discussions

Interactive comment on "Country-scale greenhouse gases budgets using shipborne measurements: a case study for the United Kingdom and Ireland" *by* Carole Helfter et al.

Anonymous Referee #2

Received and published: 10 December 2018

This paper reports the seasonal and annual budgets of CO2 and CH4 of the United Kingdom and Ireland over a period of three years from 2015 – 2017 using a mass balance approach and mixing ratio measurements on board a ferry that traversed the eastern side of the measurement site. I think that what is noteworthy about this contribution is the unique data set obtained from long-term measurements that enabled the seasonal and annual estimation of the fluxes, which is not possible from snapshot measurements using an aircraft –based platform. I also commend the authors for the rigor with which they estimated the fluxes using various approaches (considering seasonality, daytime/nighttime differences, etc.). The paper is also generally well-written with only a few typographical and grammatical mistakes.

I did notice, however, that the background concentration of CO2 and CH4 had so much variability, and that the authors used a mathematical fitting routine to obtain a smoothened background signal. Based on previous studies using the mass balance approach, the large variability in the background actually contributes a significant variability (i.e. uncertainty) in the estimated fluxes. Some of my thoughts on this are outlined below in the specific comments.

Specific comments:

(1) Not all your readers will be familiar with the geography of the measurement domain. Please provide a map of your measurement site together with the path of the ferry used in the study. Please label the map with the cities for reference. Direction of prevailing winds throughout the season will be also useful so that the reader can clearly see the transect of the ferry relative to the prevailing winds. This should be your figure 1. It helps if you set the stage for your readers.

(2) Figure 1 already shows the Hysplit backward trajectory frequencies but the reader will just assume that the ship is located where the highest frequency is found (color red). Also, the two rows apparently show two succeeding days in May 2015. That is not clearly described in the figure caption and the reader discovers this only after staring at the figure. I think that this figure should not be your first figure.

(3) Page 3: You state that background measurements were taken at the Mace Head site in Ireland – all the more reason why your figure 1 should include what's stated above in (1) but also the location of the background site. It's important to set the stage for the reader for greater appreciation of the measurements and the analysis.

(4) Page 3: Your figure 1 should be something like your Figure 2 but with more detail such as an arrow that shows the wind direction. It is likely not westerly winds throughout the year. It will be instructive if the authors are deliberate about stating/describing the meteorological conditions throughout the year. It would be good to show a windrose plot to support this.

(5) page 3 line 16: Rosynth – Zeebrugge are two important ferry end points that should be included in Figure 1.

(6) Page 3, line 30: Please state in the text where the calibration gases were obtained, how many was used, and their mixing ratios. Did they span the expected range of measured CO2 and CH4 mixing ratios from the measurement site? I note that the calibration gas was measured for 15 minutes? How often do you obtain a data point? Every 1 minute, every 15 seconds? Please state. How did you obtain the mean and uncertainty that was reported in Table 2, i.e. how many data points did you average every 15 minutes? What is the coverage factor k that was mentioned in Table 2. Please explain. And did you purge with the reference gas or with zero air?

(7) Page 4 and also page 5: Assumptions: What is tricky about the mass balance approach is the choice/estimation of the background. It can contribute one of the largest uncertainty in the estimation of the emission flux – because the air mass travels a couple of hours from the background site to the receptor site. Your measurements at the Mace Head site showed significant variability in the background. What's the effect of this variability on the estimated flux?

It is possible that the uncertainty is significantly larger than what equation (4) is estimating simply because there is so much variability in the background mixing ratio of CO2 and CH4. Based on the results of previous studies, the variability in the background significantly contributes to the uncertainty in the estimated fluxes. The authors are then advised to do a sensitivity analysis of the obtained fluxes using the standard deviations in the background obtained from Mace Head and comment on the results in the discussion (comparing against the uncertainty obtained in equation 4). Furthermore, on page 5 regarding the mass balance approach, what was the time - shift interval that was used to obtain the background? I ask this question because there is a significant travel time for the air mass to reach the receptor site. This is also the reason why in previous aircraft-based mass balance approaches, the mixing ratios at the "wings" of the transect (outside the plume) were actually used as the baseline or background

mixing ratio. (8) Page 4 on Data screening. Please state in this section that the histogram of data points showed in Figure 3 correspond to the data points that satisfy the data screening protocol, which emphasizes that only the data with westerly winds were used in the averaging and flux calculations.

Out of all the data points that you collected, how many points were used in the analysis? What's the percentage of useful data? Are there more points for certain months relative to others?

(9) Page 5: The authors used the wind speed and wind direction from the WRF model to calculate the fluxes. I am sure that there are multiple synoptic stations in UK and Ireland? How come the wind speed and wind direction data from those synoptic stations were not used in this study?

Were the back trajectories consistent with the synoptic station data? At what height above the ground were the back trajectories modeled for?

It will be good to show the time series of the PBL heights in the supplementary information for the domain and for the period of measurement. It would be also good to report if the modeled PBL depth has been validated with previous measurements (at least for those previous years when measurements of PBL depths were available), just to reassure yourselves that the modeled values are sufficient to be used in your calculations.

(10) Results. On seasonal and annual fluxes. Please check the units of your fluxes in Figure 6 and 7. I believe you meant g s-1 m-2 rather than g s-1 m-1.

Please also report the total number of data points per season.

(11) Figure 10 and 11. What does the gray shade represent in the figures? Please explain in the figure caption.

In Figure 11, you used the mean air temperature over the measurement domain. How many synoptic stations were used when you averaged the air temperature?

C5