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Atmospheric Measurement Techniques Discussions

Interactive comment on "Nitrous oxide emissions from managed grassland: a comparison of eddy covariance and static chamber measurements" *by* S. K. Jones et al.

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General comments

This paper presents a careful comparative assessment of N2O fluxes measured by manual chambers and eddy covariance in grazed and fertilised grassland. Although not stated too clearly in the introduction, the objectives of the paper are (presumably) to assess the suitability of manual chambers and eddy covariance as methods for measuring N2O emissions at the field or plot scale, both in terms of instantaneous fluxes in response to trigger events, and in terms of time-integrated (cumulative) fluxes over several weeks with a view to deriving emission factors, thereby contributing to the

improvement of national inventories.

The paper focuses on detailed comparisons of methodologies, measurement/analytical techniques, gap-filling methods, on instantaneous and average fluxes, and on the many reasons that may explain discrepancies between EC and chambers. However, I feel that not enough weight has been given to the comparison of cumulative fluxes by both methods (Section 4.5 promises but does not deliver). The emphasis laid on chamber/EC discrepancies at a given time are clearly related to spatial features (both footprint and small-scale variability in emissions), but no clear conclusion is drawn on the comparative suitability of both methods for what is the most important objective of this type of study: to derive emission factors for different management choices and practices. Yes, the technical comparison of instantaneous fluxes can seem like comparing apples and oranges; and therefore a more meaningful comparison might focus on cumulative emissions, which are a product of both measurement technique and gap-filling. The methods are comparable in that they are both used by different scientists to answer the same question: how much N2O is emitted annually by agro-ecosystems?

The paper should try to answer the question of whether a handful of monthly/manually operated chambers are still adequate for estimating field-scale cumulative N2O emissions and EF, given that TDL- or QCL-based EC is becoming more widely available and integrates spatially as well as temporally. Chambers still have value for comparing treatments in small-scale plots, but may not be up to the challenge of improving our current real-world (field-scale) emission estimates (especially if they're not automatic chambers).

The paper is otherwise well written, logically structured and tables and figures are informative and clearly laid out.

Specific comments

p1081, l21 to p1082, l10: For static chambers, one could make the distinction between manually operated and automatic chambers. Manual chambers are limited in their temporal coverage (p1081, l27); not so for autochambers. The whole paragraph implies that static chambers (in general) suffer from limited temporal coverage.

p1083, l1: for the same reason as above, I would suggest adding "manually operated" just before "non-steady state chambers", so it is clear what kind of chambers we are dealing with.

p1082, l17: EC does not require a uniform source surface. Indeed, EC integrates a variable emission or flux signal over a certain area, and the measured flux is a proper integral value for that area regardless of whether the source is spatially constant or not. That is precisely the advantage of EC over chambers. What EC does require is spatial homogeneity in roughness and sufficient fetch so that a surface layer develops that has no vertical flux divergence. However, it is true that a strong horizontal gradient in concentration and horizontal advection lead to to biased flux if uncorrected.

p1082, l19-26: Relaxed eddy accumulation has also been widely used for N2O and could be cited here.

p1084, 18: presumably the ecd detection limit for N2O was 0.2 ppbV = 0.2 nl l-1 (not 0.2 μl/l = 0.2 ppm = 200 ppb) ?

p 1085, l26 to p1086, l8: more details of the calculation and correction procedures would be helpful: were there high frequency losses due to signal attenuation? a transfer function used? Planar fit? etc.

p1086, l9: I thoroughly agree with Referee A. Neftel that the EC flux detection limit is certaily above 11 ng N2O-N /m2/s, and also that the observed large negative fluxes (<-100 ng N2O-N/m2/s) cannot have any physical reality.

p1086, l13: why was the flux data capture much lower in 2008 (20% compared with 60-70% in the earlier years) ?

p1087, l4: "To compare fluxes measured by both methods...": it would be helpful to qualify that general objective by saying at the start that fluxes are compared in terms

of hourly fluxes, of daily fluxes and of cumulative (average or gap-filled) fluxes.

p1089, l27: the range 27.4 - 252 ng N2O-N /m2/s is not what I would call narrow. 27.4 is around the flux detection limit, while +252 is a factor ten higher and a very significant emission flux.

p1090, l4-7: A t-test is only applicable to data that are normally distributed, and yet the measured fluxes show that the distribution is not normal. The t-test should therefore not be used here; non parametric statistics could be used instead.

p1090, l23-24 and Figure 3: it would be nice to see confidence intervals for the regression slopes and intercepts

p1091, l7-8: the removal of the outlier increases the rˆ2 from 0.61 to 0.92, but the correlation is and remains actually negative, so the improvement of the regression is only very marginal despite the large increase in rˆ2.

p1092, l11 and thereafter: shouldn't it be stated that, despite known artefacts affecting EC fluxes (mostly flux losses from signal attenuation, sensor response and sensor separation, which can, and must, to some extent be corrected for), EC should be considered a reference method for N2O fluxes and cumulative emissions at the field scale, against which chamber results should be assessed? The point is, chamber setups in field-scale experiments will always be subject to large uncertainties, and a matter for endless discussion on spatial (and temporal) variability, where it is impossible to tell if the integrated flux is 50% or 75% over- or under-estimated. At least, with EC, chances are that the uncertainty in the time-integrated emission flux is of the order of 20%, and most probably on the under-estimation side. Of course, for other applications, such as the investigation of background fluxes and their response to environmental conditions, chambers are very valuable tools.

p1093, l14-18: rainfall (and differences therein between Scotland and the rest of Europe) are only part of the equation; it is SWC and specifically WFPS or the lack of oxygen that drives denitrification. Therefore soil type and water retention curves must be considered as well as precipitation.

p1094, l12: is the coefficient of variation for temperature calculated from temperature in °C or in °K?

p1095, l13-20: this seems to belong to Methods

p1096, l2-3: I don't agree that the CVs for EC represent temporal variability only, because wind direction and the upwind extent of the footprint are temporally variable, so that the flux footprint is also spatially variable.

p1096, l9-11: Spatial variability is probably also a function of spatial variations in microbial communities (diversity, count).

p1098, l6: this study is the LONGest intercomparison to date, but since there were generally fewer chambers (only 4-14, vs 16, 30, 32 in other studies) on the field, it may not be the most meaningful.

p1098, l27: emission hotspots ARE seen by the EC but they are averaged out in the flux for the whole footprint if low emission dominates spatially; they are nonetheless accounted for in true proportion in that flux.

p1099, l3: I would change "around midday" to "during daytime", more generally.

p1099, section 4.5: the part on cumulative fluxes does not say much about which method gives larger cumulative emissions overall. The numbers are mentioned in Section 3.3, but it is difficult to derive a general picture. I have plotted numbers from Table 3, showing cumulative, gap-filled EC fluxes by the three methods (ECa, ECb, ECc) vs cumulative emissions by the chamber method (see attached supplement). This kind of comparison, showing only 6 data points (one per event) encapsulates both the measurement technique itself as well as the gap-filling / data interpretation method, which is needed to come up with a cumulative estimate. The latter part is more of an expert knowledge-based part of the method, than the actual standardised measurement

technique itself, but nonetheless an essential part of the analysis that is translated into EFs and used for inventories. Overall, then, EC can be seen to provide cumulative estimates that are lower at the high end of the emission range, but higher at the low end (ie slope of 0.6-0.7, positive intercept of 0.1 kgN2O-N/ha).

p1107, Table 1: WFPS% could be shown alongside SWC

Technical Corrections

p 1083, l13: "fieldS"

p1083, l23: "livestock" in one word

p1089, l13: suggest add "daily" to read "The variation between daily maximum and minimum fluxes...", and also on l15, "...average daily variation..."

p1091, 23: change "Overall..." to "Over all..."

p1095, l20-21: "The magitude of fluxes ... WAS frequently..."

p1095, l28: "coefficientS of variation (CVs) were..."

p1096, l19: suggest replace "big" with "large"

p1097, l3: "larger than IN EC (30-min)flux measurements"

p1098, l1: Pihlatie et al. is 2005, not 1999

p1099, l18: suggest change "missed" to "missing"

p1100, l2: change "back ground" to "background"

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 1079, 2011.

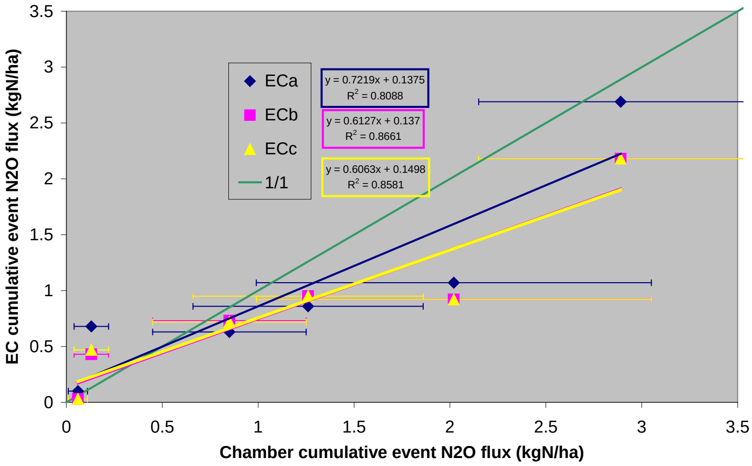

Fig. 1. Comparison of cumulative fluxes by both methods