Towards operational quantification of GHG exchange in heterogeneous agricultural landscapes and experimental plots

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Why are we interested in this?

- Climate mitigation efforts and carbon market projects in the LULUCF sector rely on measuring, reporting and verifying (MRV).
- This requires emission registration techniques matching landscape patchiness.
- For mitigation measures applied in small pilots (sub-hectare to a few hectares) mobile automatic chambers and mobile EC-devices can contribute to low-cost emission registration.
- There is a large demand for techniques with an annual costs of 5,000-10,000 to monitor GHG emissions from a single pilot.
How to efficiently quantify GHG budgets at small scale?

- Eddy covariance needs minimum size & is expensive
- Chambers may not capture heterogeneity & is laborious

E.g.: Small peat meadow submerged drains plot to limit CO2 emitted from oxidising peat
Questions addressed here (preliminarily):

1. Can we get reliable Eddy Covariance (EC) flux with small footprints?
   
   *Tested low measurement height at adjacent fields*

2. How does EC compare with chamber measurements?
   
   *Compared a few automatic chamber data sets with EC*

3. Can we replace EC by measuring only standard deviation of [CO₂], [CH₄] or [H₂O] (& use cheaper instruments!)?
   
   *Analysed 1-year data on peat meadow, mimicking slow sensors*

4. Can we get away with short EC campaigns with one roving system visiting several locations?
   
   *Analysed subsets of 1-year data on peat meadow*
Pair of eddy covariance sets at 1 m height on peat meadows with and without submerged drains

(Comparison phase. Later separated to one field each.)
1: Footprints almost always within field size of 100 m, but this forces to position mast in one corner of field; *Quality criteria are acceptable (not shown here)*

EC masts at NE side of 150 x 70 m fields, require SW winds
2: Eddy covariance and chambers compare well

- Chambers show heterogeneity
- Automatic chambers show very consistent data
- EC covers the whole footprint and is continuous
- EC gives more gaps (rain, poor turbulence, rejected wind direction)
3: Eddy covariance correlates reasonably well with standard deviation of CO\textsubscript{2} or H\textsubscript{2}O

Suggests we could use slow sensors (also for CH\textsubscript{4} and N\textsubscript{2}O) to estimate MEAN fluxes but need extra information on e.g. sign of flux.
4: we need a few short campaigns per season to represent all data (for this grassland). Between seasons, other controls change.

Light response of NEE for all data (blue X-es) versus three 10-day campaigns (other symbols) in Peat meadow grassland.
Conclusions

1: With low measurement height we can get acceptable and valid fluxes in small footprints.

2: Eddy covariance and chambers compare well here.

3: We may be able to rely on standard deviations of concentrations only, using slower sensors, to estimate fluxes of several inert scalars.

4: We only need a few short campaigns per season to represent all data, at least for simple vegetation cover.

For operational GHG flux monitoring, a combination of roving EC, fixed variance and meteo observations may be economical and sufficiently accurate.
Still some work to do!
(additional material)
We find no difference in emissions between the peat soil treatments. But they do depend on ground water depth.

Both fluxes drop if Groundwater rises above -40 cm