UPSCALING N_2O EMISSIONS FROM PLOT TO REGION

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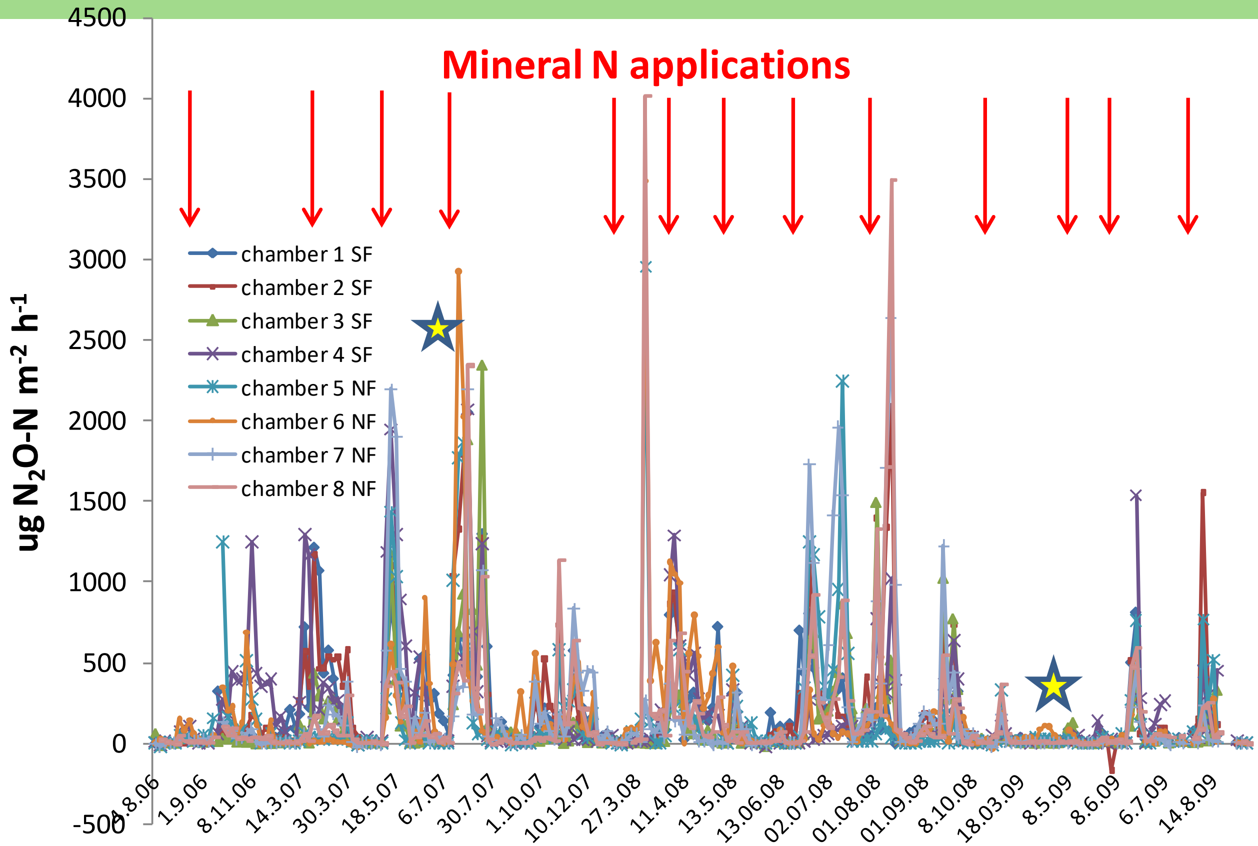
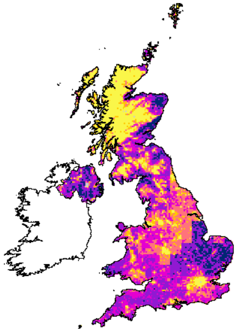
Soil N_2O fluxes are highly variable in space and time





Skiba et al, Biogeosciences, 10, 1231-1241, 2013

Jones et al, Biogeosciences, 14, 2069-2088, 2017

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Emission factor [% of N applied]	
2007	**6.5**
2008	**3.7**
2009	**1.6**

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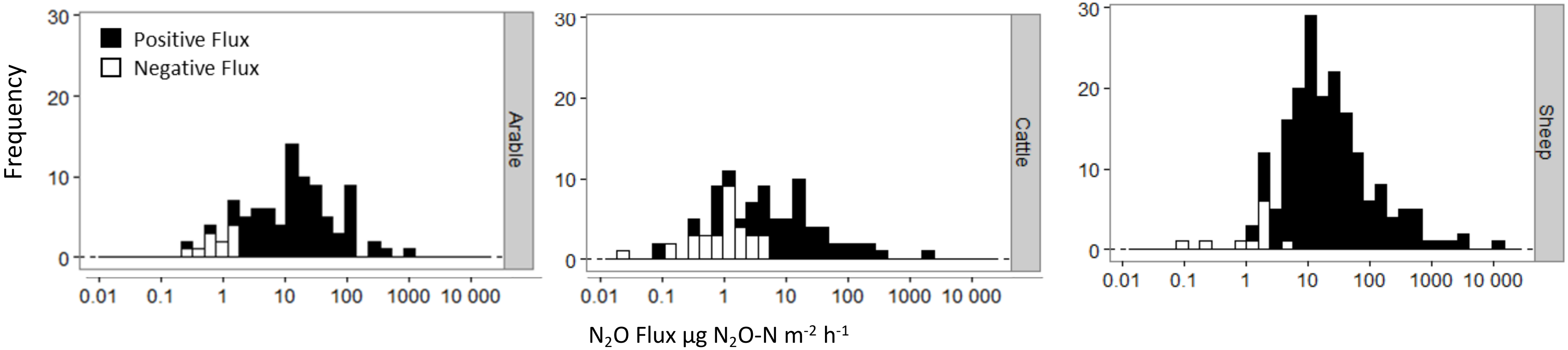
To reduce the uncertainty of N_2O flux measurements

- Gapfilling of static chambers
- Gapfilling of eddy covariance
- N_2O from urine patches
- Upscaling to the UK
  - Comparing bottom up Tier 1 model with atmospheric concentrations

Improve chamber flux calculations

Easter Bush Farm, 20 fields, 4 seasons, dynamic closed chamber + QCL



- N_2O flux is spatially heterogeneous and chamber measurements observe a log-normal spatial distribution in all conditions
- Bayesian statistics works with probabilities, combing prior knowledge with new data
  - (Created model based on best goodness of fit *Log NH4-N +NO3-N+ pH+ Soil C+ Soil N+Soil T + WFPS%*)
- Using Markov chain Monte Carlo simulations we can use log-normal data to estimate means and confidence intervals

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Nitrous oxide emission sources from a mixed livestock farm

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Cowan et al 2017 Agro. Ecosys. Environ. 243

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Arithmetic vs Bayesian flux calculation

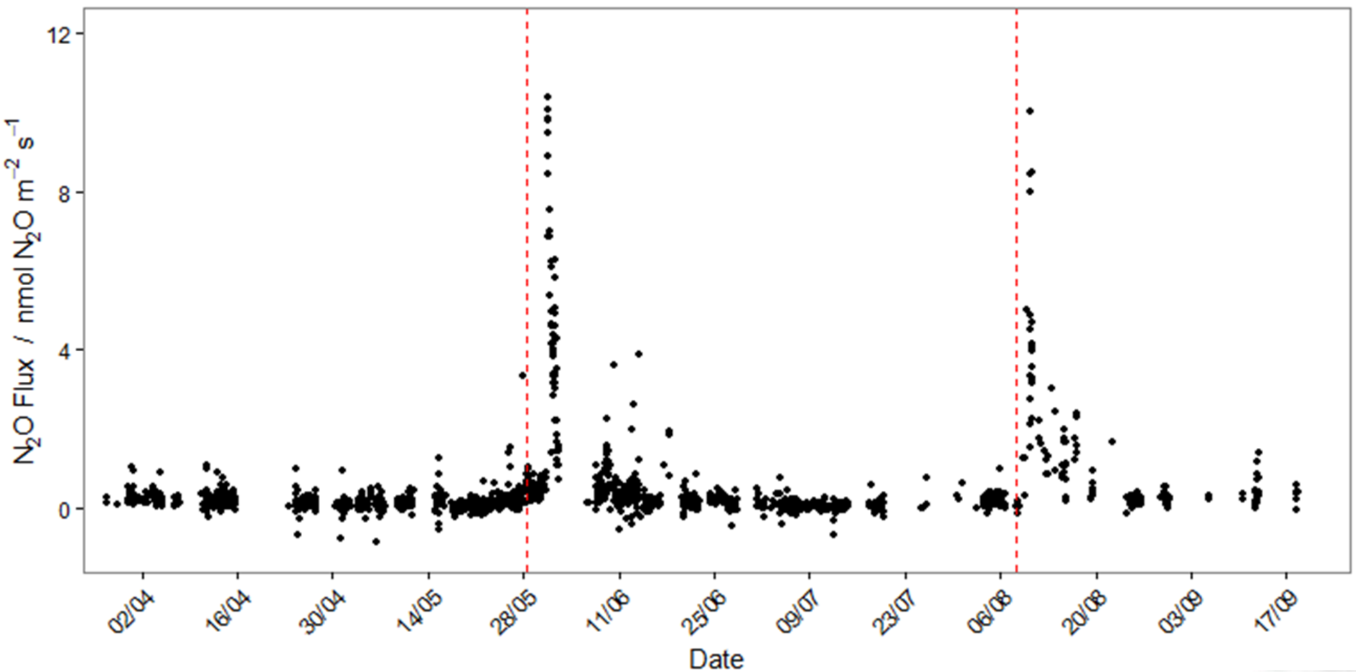
Mean N_2O flux values with 95% C.I.'s estimated for each source category per season using three different methods of calculation (units in μg N_2O-N m^{-2} h^{-1}).

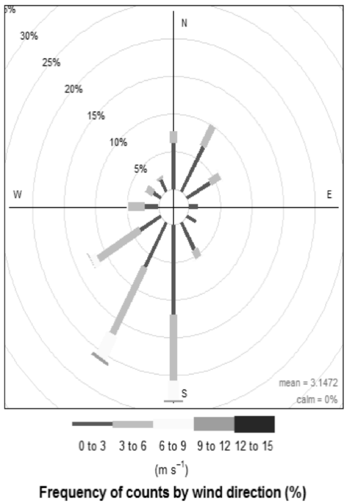
Source categories	Season	n	Naive Method Mean Flux	95% C.I.		Bayesian Method Mean Flux	95% C.I.	
				Lower	Upper		Lower	Upper
Arable	Autumn	19	6	−25	36	3	0	6
	Winter	18	6	−7	19	7	4	13
	Spring	24	64	−75	203	65	41	101
	Summer	36	102	−326	530	81	51	128
Cattle	Autumn	23	99	−757	954	11	4	21
	Winter	29	0	−4	4	0	−1	1
	Spring	29	57	−104	217	46	29	72
	Summer	11	14	0	28	14	10	19
Sheep	Autumn	26	46	−273	365	21	9	42
	Winter	0	NA	NA	NA	NA	NA	NA
	Spring	54	160	−770	1090	60	43	83
	Summer	112	111	−752	973	55	41	73

Bayesian method provides a robust approach to calculate uncertainty for low frequency flux measurements (i.e. chamber systems)

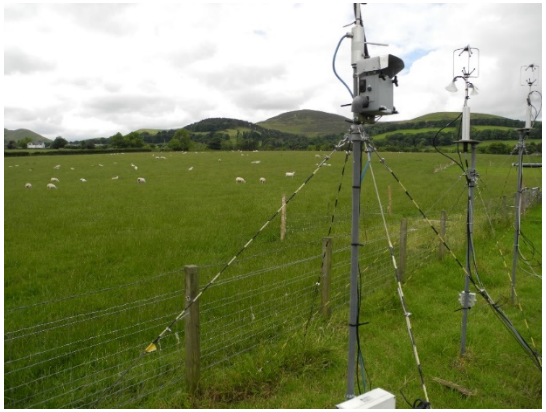
Cowan et al 2017 Agro. Ecosys. Environ. 243:929-102

Generalised additive mixed models for EC data





GAM is a smoothing technique, with little predictive power, GAM provides an appropriate tool for inputing the missing observations in the context of eddy covariance data.



Generalized Additive Mixed Model

Input data: Air T, Soil T, Rainfall, Wind speed, Wind direction (30 min), days since fertilisation

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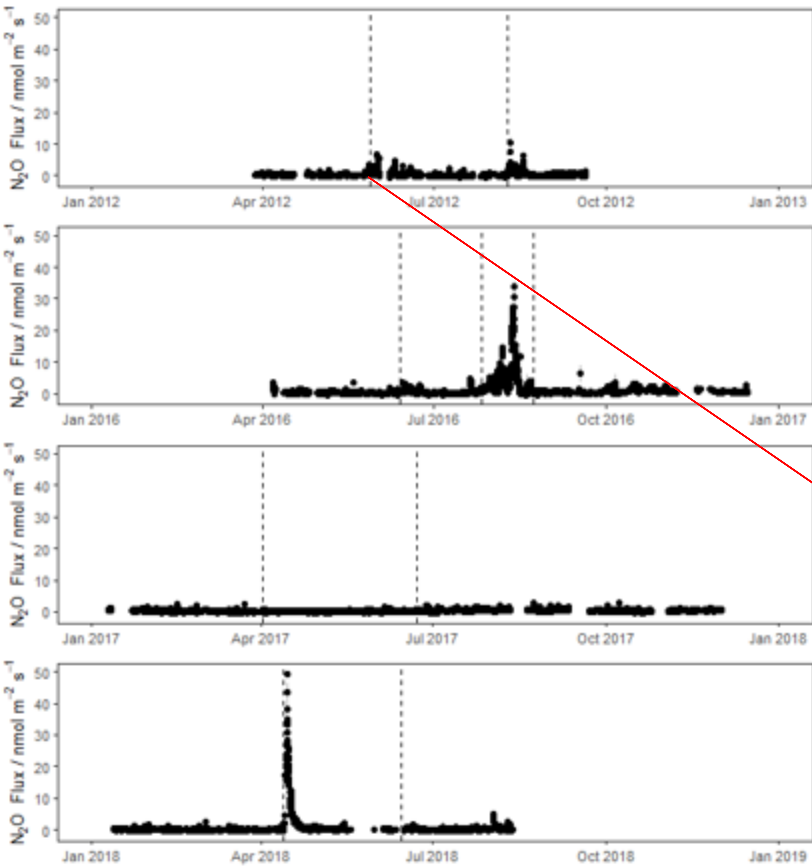
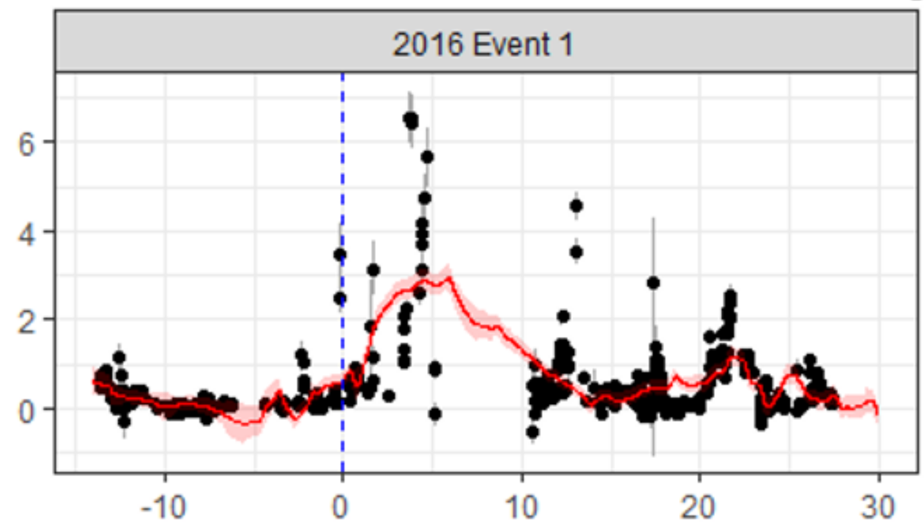
Cowan et al, submitted, 2019

Eddy covariance N_2O fluxes



Date	Field	Management	Fertiliser Application
01/05/12	South	Tilled & Resown	
28/05/12	North		AN 70 kg N ha^{-1}
09/08/12	Both		AN 70 kg N ha^{-1}
20/05/14	North	Tilled & Resown	
15/03/16	South	Sheep Removed	
13/06/16	Both		Urea 70 kg N ha^{-1}
16/07/16	South	Silage Harvest	
26/07/16	Both		Urea 50 kg N ha^{-1}
28/07/16	South	Sheep Returned	
23/08/16	Both		Urea 35 kg N ha^{-1}
21/05/17	Both		Urea 70 kg N ha^{-1}
22/06/17	Both		Urea 49 kg N ha^{-1}
12/04/18	Both		AN 70 kg N ha^{-1}
14/06/18	Both		AN 52 kg N ha^{-1}



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Cowan, Levy et al submitted, 2019

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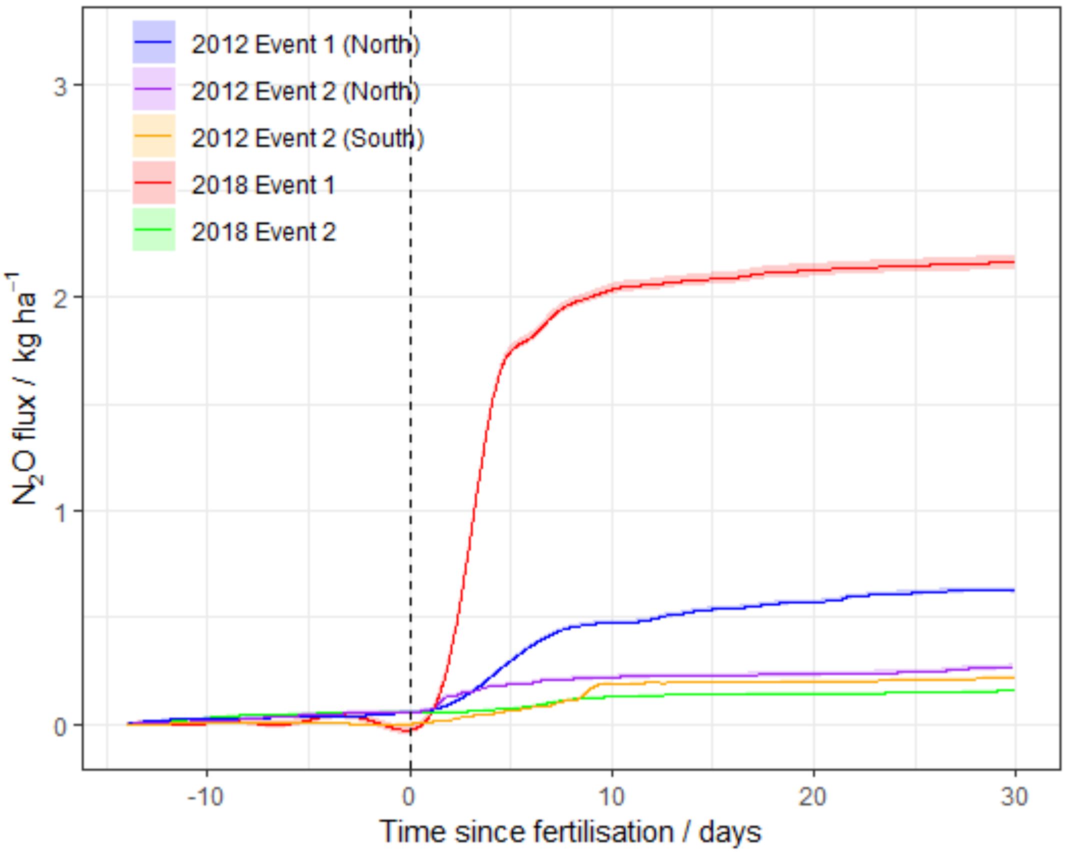
GAM method for eddy covariance fluxes



The GAM method is used to interpolate measurement data and estimate 95 % C.I.s in cumulative flux estimates (shaded).

Fertilizer = ammonium nitrate

Cowan, Levy et al, submitted, 2019

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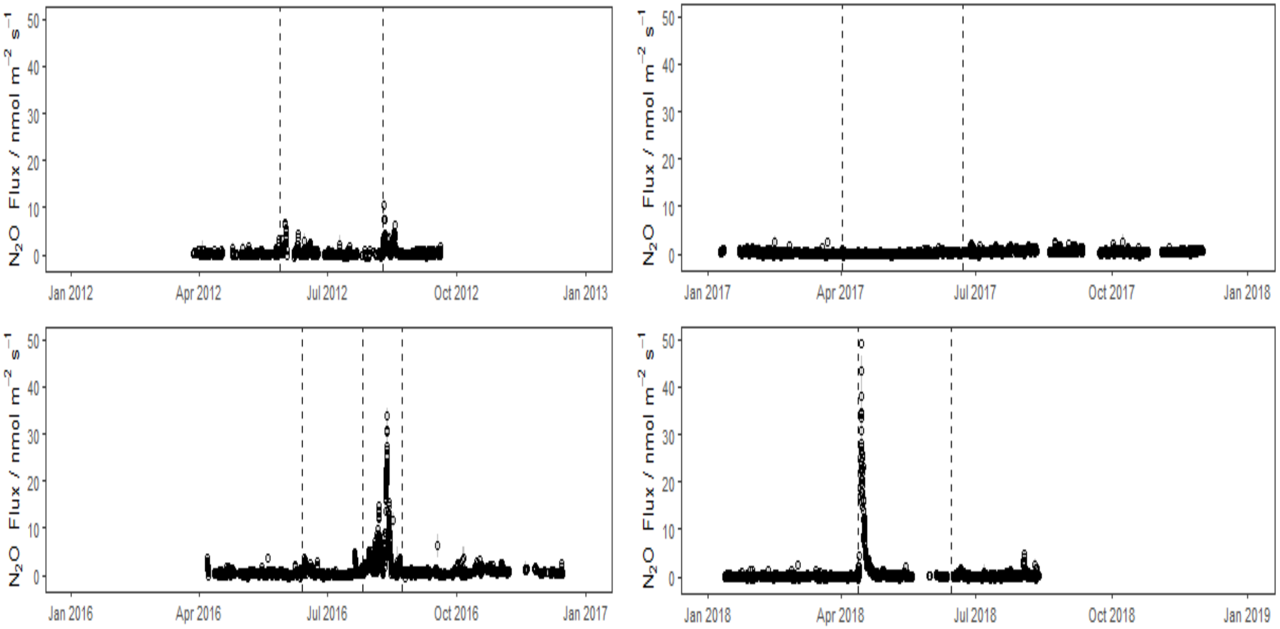
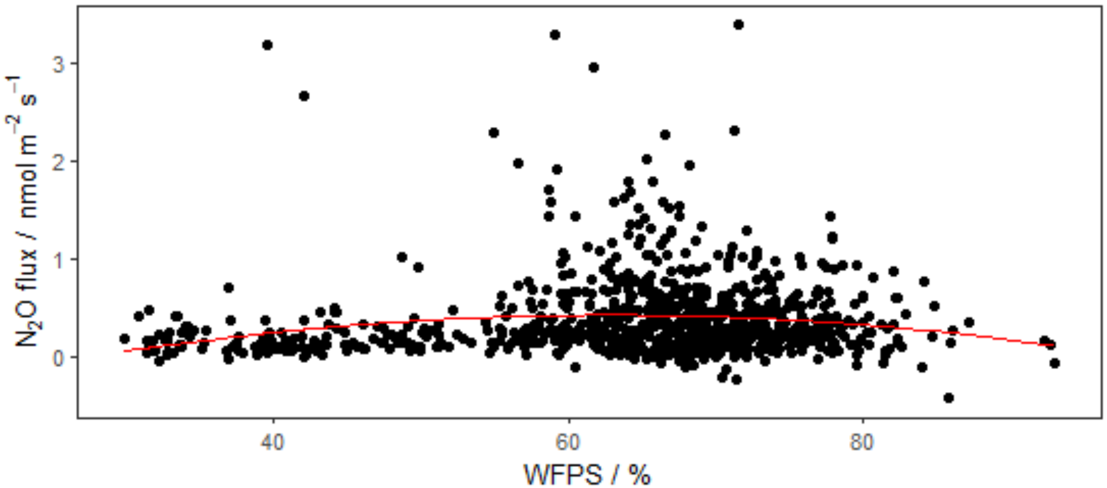
Generalised additive mixed models for EC data





Daily mean WFPS% & N_2O Flux at Easter Bush, Cowan et al, in preparation

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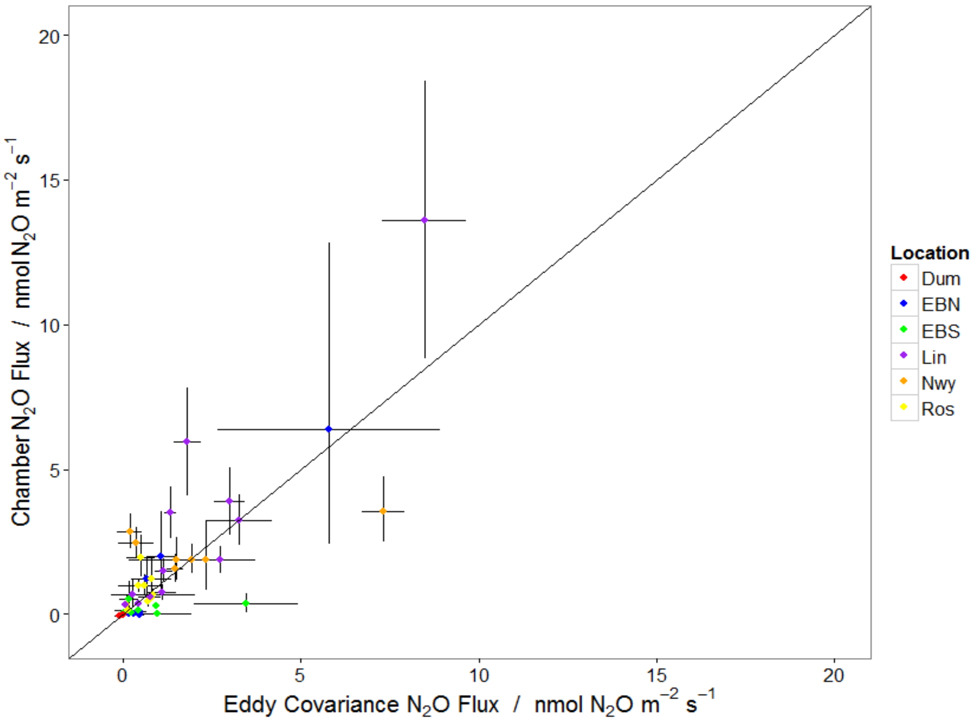
COMPARING PLOT AND FIELD SCALE N_2O FLUXES

Static chamber
~0.1 m^2
1 h
Daily-weekly
Lots of gaps
High uncertainty

Eddy covariance
~100 m^2
>10Hz
'Continuous'
Less gaps
Lower uncertainty



Levy et al, European J. Soil Sci. 68, 2017

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InveN2Ory

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NOVEL USE OF UAV TO IMPROVE FIELD SCALE ESTIMATES OF N_2O FLUXES FROM GRAZED GRASSLANDS

12% of field is covered in urine patches
Contribution to N_2O emissions
Urine 47%, N fertiliser 53%

frontiers in Sustainable Food Systems

ORIGINAL RESEARCH
published: 25 April 2018
doi: 10.3389/fsufs.2018.00010

Identifying Urine Patches on Intensively Managed Grassland Using Aerial Imagery Captured From Remotely Piloted Aircraft Systems

Juliette Maire[1,2,3,4]*, Simon Gibson-Poole[2,3], Nicholas Cowan[4], Dave S. Reay[3], Karl G. Richards[1], Ute Skiba[4], Robert M. Rees[2] and Gary J. Lanigan[1]

[1] Soils and Land Use Department, Teagasc, Wexford, Ireland, [2] Future Farming Systems, Scotland's Rural College, Edinburgh, United Kingdom, [3] School of Geosciences, University of Edinburgh, Edinburgh, United Kingdom, [4] Atmospheric Chemistry and Effects, Centre for Ecology and Hydrology, Penicuik, United Kingdom

Juliette Maire (Walsh Fellowship PhD student with CEH, SRUC, Edin. Uni., Teagasc),
Frontiers in Sustainable Food systems Vol 2 article 10

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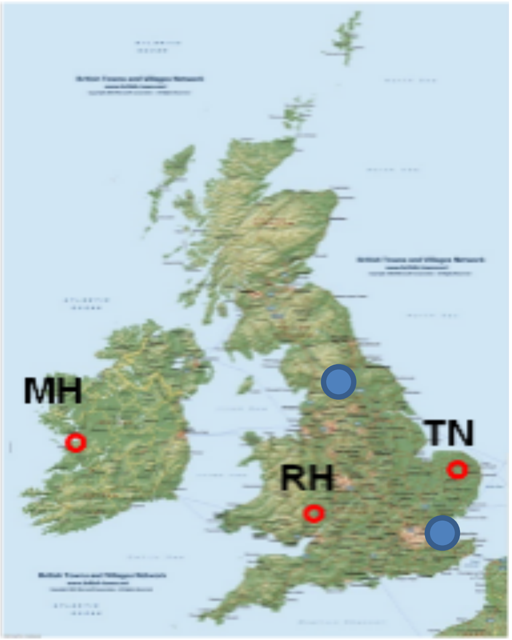
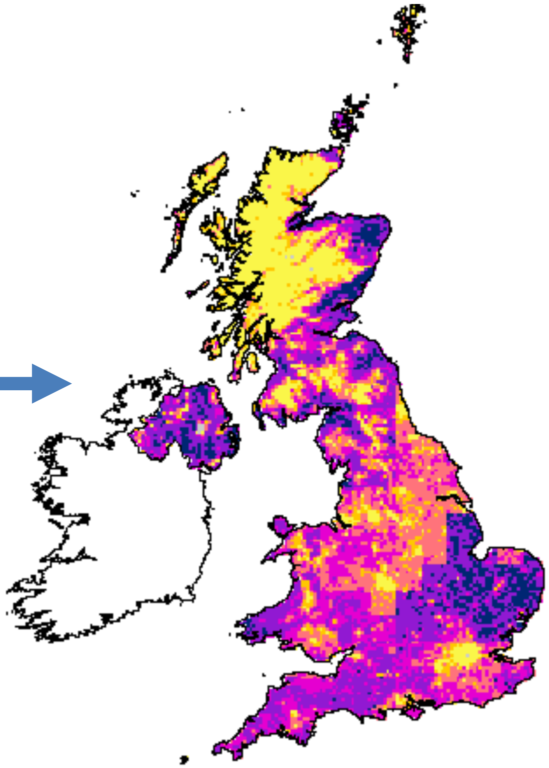
Comparing N_2O emissions inventories with atmospheric concentration measurements

- Global Atmospheric Watch stations
- Tall Towers
- National disaggregated N_2O emission inventory (5 km^2)





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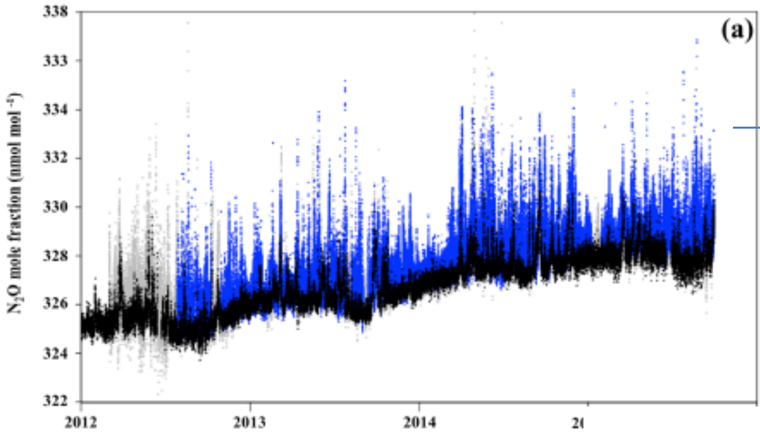
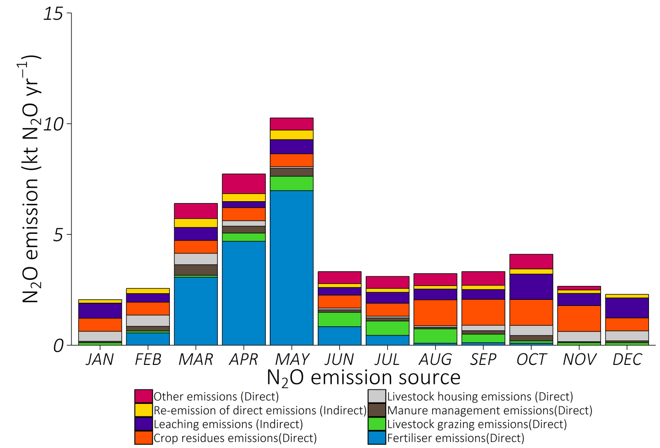
Comparing national scale N_2O emission inventories using bottom-up and top down methods



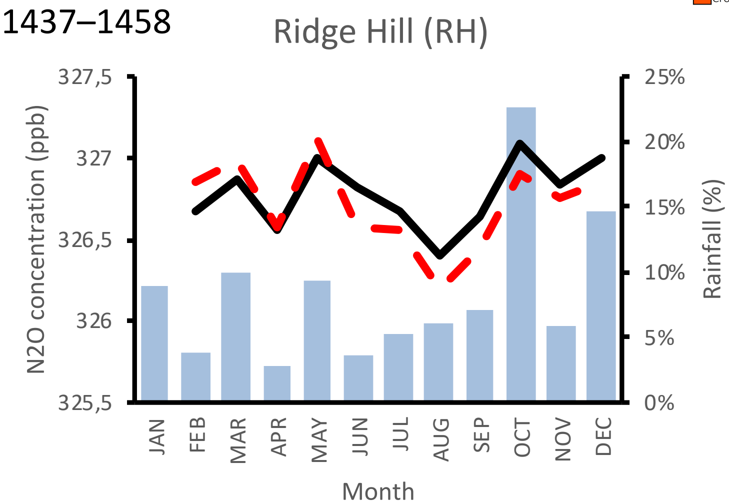
Stanley et al, 2018 Atmos. Meas. Tech., 11, 1437–1458

Atmospheric transport model NAME

Alistair Maning, MetOffice



Ed Carnell, Ulli Dragosits



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Agricultural UK GHG PLATFORM

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Carnell, Dragosits, Manning et al, paper in preparation

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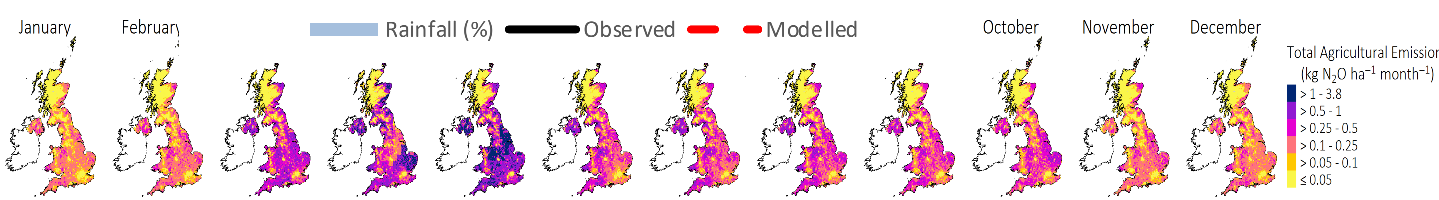
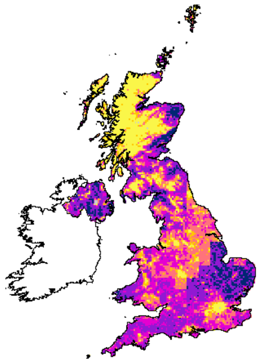


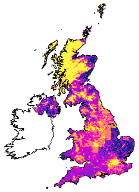
A NEW CONCEPT FOR NATIONAL CH_4 & N_2O REPORTING

Status quo
Tier 1,2,3
bottom up
inventories



Change to
Develop inventory using spatially resolved atmospheric concentrations plus atmospheric transport model and constrain with bottom up Tier 1

+



Benefits of greater emphasis on Top Down

- Inverse model can monitor actual changes in emissions
  i.e. detect mitigation
- Emissions can be constrained in countries lacking in activity data
- Cheaper than verification with labour intensive chamber systems
- Use chambers only for emission hotspot areas, or developing mitigation

A. Leip, U. Skiba, A. Vermeulen, R.L. Thompson Atmos. Environ. 174 (2018) 237–240

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