

## Supplementary Material

### Management matters: Testing a mitigation strategy for nitrous oxide emissions on intensively managed grassland

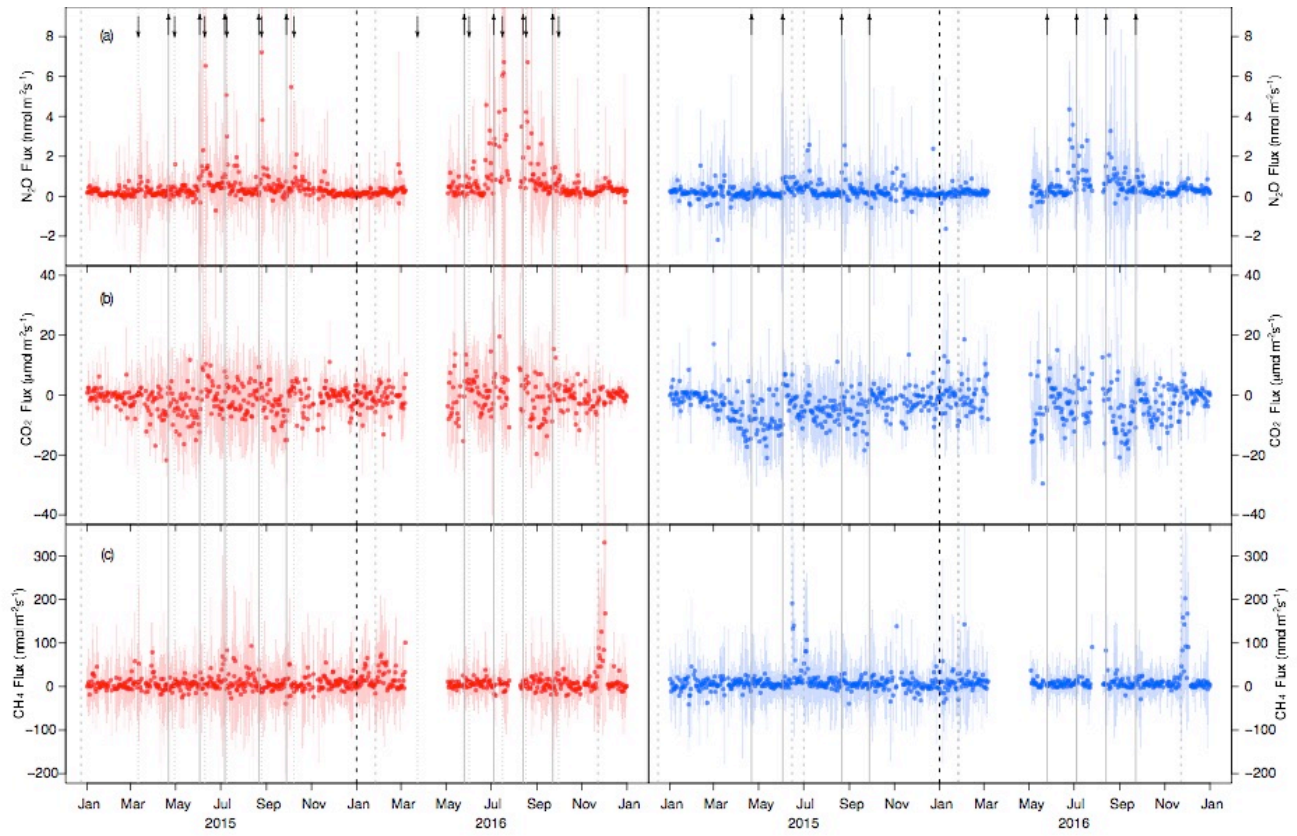
Kathrin Fuchs<sup>1</sup>, Lukas Hörtnagl<sup>1</sup>, Nina Buchmann<sup>1</sup>, Werner Eugster<sup>1</sup>, Valerie Snow<sup>2</sup>, Lutz Merbold<sup>1,3</sup>

5 <sup>1</sup> Department of Environmental Systems Science, Institute of Agricultural Sciences, ETH Zurich, Universitätstrasse 2, CH-8092 Zurich, Switzerland

<sup>2</sup> AgResearch, Grasslands Research Centre, PB 11008, Palmerston North 4442, New Zealand

<sup>3</sup> Mazingira Centre, International Livestock Research Institute (ILRI), P.O. Box 30709, KE-00100 Nairobi, Kenya

*Correspondence to:* Kathrin Fuchs ([kafuchs@ethz.ch](mailto:kafuchs@ethz.ch))



**Figure S1.** (a) Daily averaged N<sub>2</sub>O fluxes, (b) daily averaged CO<sub>2</sub> fluxes, and (c) daily averaged CH<sub>4</sub> fluxes at the control (left, red) and the experiment parcels (right, blue) in 2015 and 2016. Shaded areas indicate within-day variability (standard deviations of 10 min fluxes). Black downward arrows and dotted lines indicate fertilization events, upward arrows and solid lines indicate mowing, and dashed lines indicate the beginning of grazing events.

Variable	Sensor	Type	Manufacturer	Measurement height	Frequency	#	Parcel	Location
(a) EC Fluxes								
N <sub>2</sub> O, CH <sub>4</sub> concentration	QCLAS	miniQCL	Aerodyne, Billerica (Massachusetts), USA	2.40 m	10 Hz concentration measurements, processed to 30 min average fluxes	1	T	Tower
CO <sub>2</sub> , H <sub>2</sub> O concentration	Open Path IRGA	LICOR 7500	Licor, Lincoln (Nebraska), USA	2.40 m	20 Hz concentration measurements, processed to 10 and 30 min average fluxes	1	T	Tower
Wind vectors, sonic temperature	Sonic Anemometer	Gill R3-50	Gill Instruments Ltd, Lymington (Hampshire), United Kingdom	2.40 m	20 Hz measurements, processed to 10 and 30 min average fluxes	1	T	Tower
(b) Environmental variables								
Temperature, Humidity	Temp/Humidity	HydroClip S3	Rotronic AG, Basserdorf, Switzerland	2 m	sampled every 10 s, 30 min sums	1	T	Tower
Precipitation	Rain Gauge	Type 10116	Toss GmbH, Potsdam, Germany	1 m	sampled every 10 s, 30 min sums	1	T	Tower
Precipitation	New rain gauge	Lamrecht 15188 H	LAMBRECHT meteo GmbH, Goettingen, Germany	1 m	sampled every 10 s, 30 min averages	1	T	Tower
Photosynthetically active radiation	Par Sensor	PARlite	Kipp & Zonen B.V., Delft, The Netherlands	2 m	sampled every 10 s, 30 min averages	1	T	Tower
Refectcd photosynthetically active radiation	Reflected Par	PARlite	Kipp & Zonen B.V., Delft, The Netherlands	2 m	sampled every 10 s, 30 min averages	1	T	Tower
Radiation components	Net-Radiometer	CNR1	Kipp & Zonen B.V., Delft, The Netherlands	2 m	sampled every 10 s, 30 min averages	1	T	Tower between parcels
Soil heat flux	Soil Heat Flux Plate	HFP01	Hukseflux B.V., Delft, The Netherlands	-0.02 m	sampled every 10 s, 30 min averages	3	A, B, T	Both parcels
Vegetation height	Webcam	IN-5907HD	INSTAR Deutschland GmbH, Huenstetten, Germany	1 m	6 h	2	A, B	Both soil measurement plots
Soil temperature	Soil Temperature Sensors	T109	Campbell Scientific Inc., Logan (Utah), USA	-0.05, -0.10, -0.20, -0.50, -1 m (standard WMO-depths)	sampled every 10 s, 10 min averages	2*5	A, B	Both soil measurement plots
Volumetric soil water content*	Soil Moisture Sensors	EC-5	Decagon, Pullman (Washington), USA	-0.05, -0.10, -0.20, -0.50, -1 m (standard WMO-depths)	sampled every 10 s, 10 min averages	2*5	A, B	Both soil measurement plots
Soil temperature and moisture*	Soil Temperature and Moisture Sensors	5TM	Decagon, Pullman (Washington), USA	-0.05, -0.10, -0.20 m (standard WMO-depths)	sampled every 10 s, 10 min averages	2*3	A, B	Both soil measurement plots
Matrix potential	Tensiometer	T8	UMS, Munich, Germany	-0.10, -0.20 m	sampled every 10 s, 10 min averages	2*2	A, B	Both soil measurement plots
Oxygen concentration	Oxygen sensors	in-house manufactured based on EC410	SGX Sensortech, Chelmsford, UK	-0.10 m	sampled every 10 s, 10 min averages	2*1	A, B	Both soil measurement plots
	Logger	CR1000	Sentron, Roden, Netherlands and EC410 Oxygen sensors, SGX Sensortech, Chelmsford, UK	cabinet	sampled every 10 s, 30 min averages	1	Box	
	Logger	CR10X-2M	Campbell Scientific Inc., Logan (Utah), USA	cabinet	sampled every 10 s, 10 min averages	1	Box	
	Logger Multiplexer	AM16/32	Campbell Scientific Inc., Logan (Utah), USA	cabinet		1	Box	

Variable	Method	Measurement Height	Frequency	#	Parcel	Location
(c) Vegetation						
Leaf area index	LAI2000	1 m	at harvest events	2*10	A, B	Random sampling along a transect within the EC footprint
Dry biomass or yields	0.1 m <sup>2</sup> , seperated legumes/non-legumes, dried at 70°C	> 0.04 m	at harvest events	2*5 to 10	A, B	Random sampling along a transect within the EC footprint
Clover proportion	From samples of 0.1 m <sup>2</sup> , legumes/non-legumes, dried at 70°C			> 0.04 m	at harvest events	2*5 to 10
C content of biomass	Mass spectronomy, of legume/non-legume samples			> 0.04 m	at harvest events	2*5 to 10
N content of biomass	Mass spectronomy, of legume/non-legume samples			> 0.04 m	at harvest events	2*5 to 10
(d) Soil chemistry						
Dissolved organic carbon	Soil samples, extracted in 0.5M K <sub>2</sub> SO <sub>4</sub> solution and analyzed with a JenaAnalytics Total non-purgeable organic C	0 - 0.2 m depth	daily one day before and until one week after fertilization events	2*5	A, B	Random sampling along a transect within the EC footprint
Total N	Soil samples, extracted in 0.5M K <sub>2</sub> SO <sub>4</sub> solution and analyzed with a JenaAnalytics		daily one day before and until one week after fertilization events	0 - 0.2 m depth		2*5
Soil NO <sub>3</sub> -N concentration	Soil samples, extracted in 0.5M K <sub>2</sub> SO <sub>4</sub> solution and analyzed with a VWR v-1200 Spectrometer		daily one day before and until one week after fertilization events	0 - 0.2 m depth		2*5
Soil NH <sub>4</sub> -N concentration	Soil samples, extracted in 0.5M K <sub>2</sub> SO <sub>4</sub> solution and analyzed with a VWR v-1200 Spectrometer		daily one day before and until one week after fertilization events	0 - 0.2 m depth		2*5

**Table S1.** Details on the measurement setup including variables measured, sensor specifications, sensor locations, and measurement frequencies for continuous measurements such as (a) eddy covariance and (b) soil and meteorological sensors, as well as method, sampling frequency and locations for sampled data such as (c) vegetation and (d) soil samples.

Year	Biomass export (DM kg ha <sup>-1</sup> )	
	Control parcel	Later clover parcel
2007	10743	7427
2008	12597	6906
2009	12479	8362
2010	8435	4937
2011	6286	4774
2012 <sup>a</sup>	4121	3622
2013	10746	10210
2014	>8626 <sup>b</sup>	16320

<sup>a</sup>Year of grassland restoration

<sup>b</sup>Incomplete records during 2014

5

**Table S2.** Annual yields 2007-2014 based on the field book entries of the farmer.