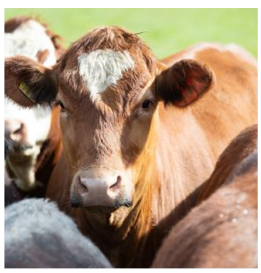
ROTHAMSTED RESEARCH

Biotechnology and Biological Sciences Research Council

North Wyke Farm Platform

Eddy Covariance Greenhouse Gas Data



User Guide

Version 1.0

The North Wyke Farm Platform: Eddy Covariance Greenhouse Gas Data

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Description: The North Wyke Farm Platform (NWFP) was established in 2010 to study and improve grassland livestock production at the farm-scale. The NWFP uses a combination of environmental sensors, routine field and lab-based measurements, and detailed management records to monitor livestock and crop production, emissions to water, emissions to air, soil health, and biodiversity. The rich NWFP datasets help researchers to evaluate the effectiveness of different grassland (and arable) farming systems, which in turn, contributes to the development of sustainable, resilient and net zero land management strategies. This document serves as a user guide to the greenhouse gas data captured using Eddy Covariance analysers and is associated with other dedicated user guides that detail the design, establishment and development of the NWFP, field events, and the quality control process of datasets.

Site: North Wyke, Okehampton, Devon, UK. Geographic location: 50.76944, -3.90138; 50°46’10” N, 3°54’05” W.

Funding: Rothamsted Research receives strategic funding from the UK Biotechnology and Biological Sciences Research Council (BBSRC). The NWFP has been supported by grants BB/J004308/1, BBS/E/C/000J0100 and is currently supported by grant BBS/E/RH/23NB0008 (2023-28).

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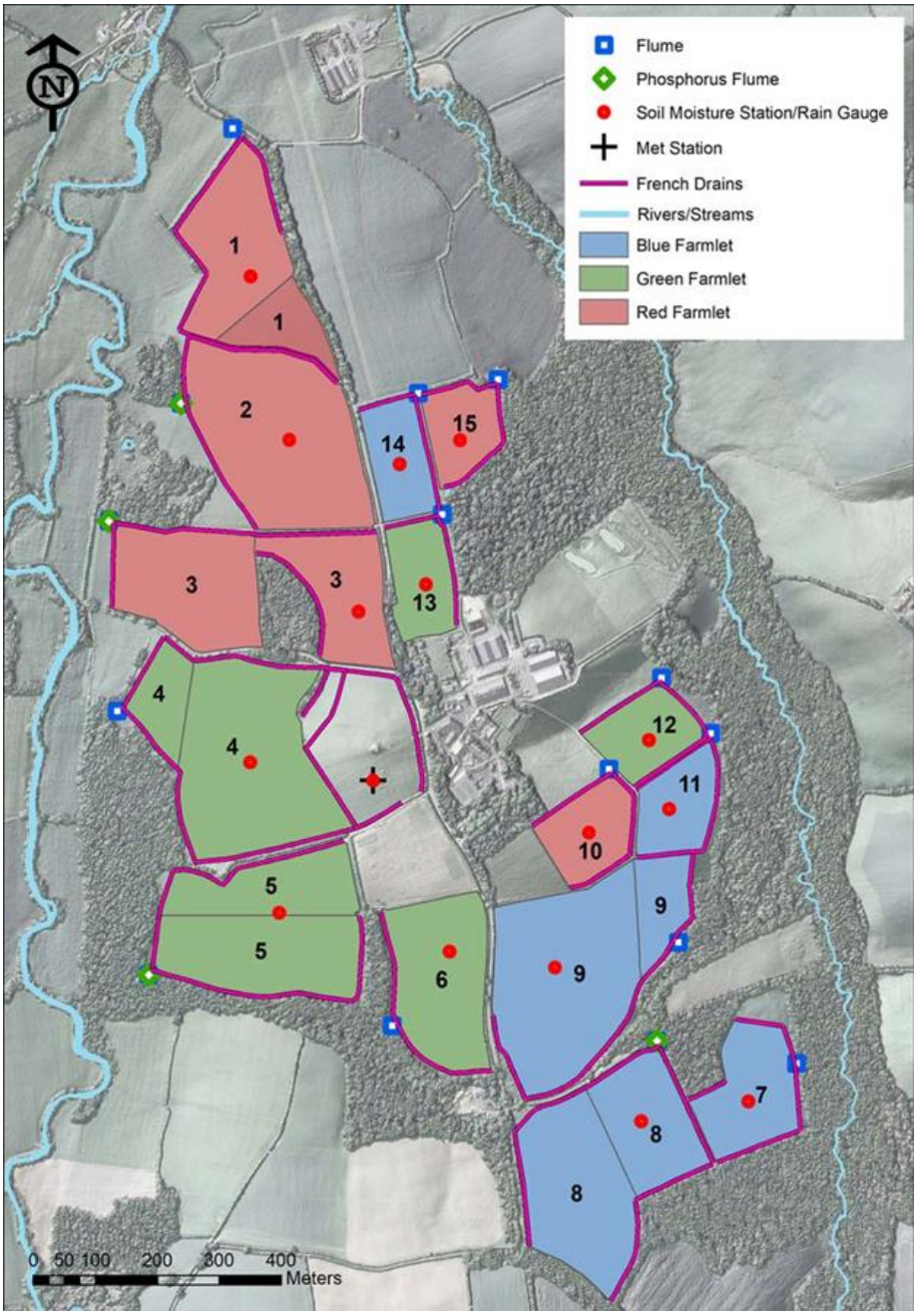
1 Introduction

This document provides a guide to the greenhouse gas (GHG) data captured on the NWFP (Figure 1) using Eddy Covariance (EC) analysers. Information on the site characteristics, design and development of the NWFP, and the quality control (QC) system for the data can be found in the following User Guide documents available on the NWFP website:

- NWFP_UG_Design_Develop.pdf
- NWFP_UG_QC.pdf

Figure 1. Map of NWFP showing systems as of 2015-2019 (first system change period [1]).



[1] *Green farmlet = permanent pasture, Blue farmlet = high sugar grass/clover; Red farmlet = high sugar grass, and later converted to arable in autumn 2019 (start of second system change period). In November 2017, phosphorus was measured at catchment or flume 3 in addition to flumes 2,5, & 8. From autumn 2023 onwards phosphorus will be measured on all catchments. Numbers represent catchment number. Note some catchments consist of multiple fields.*

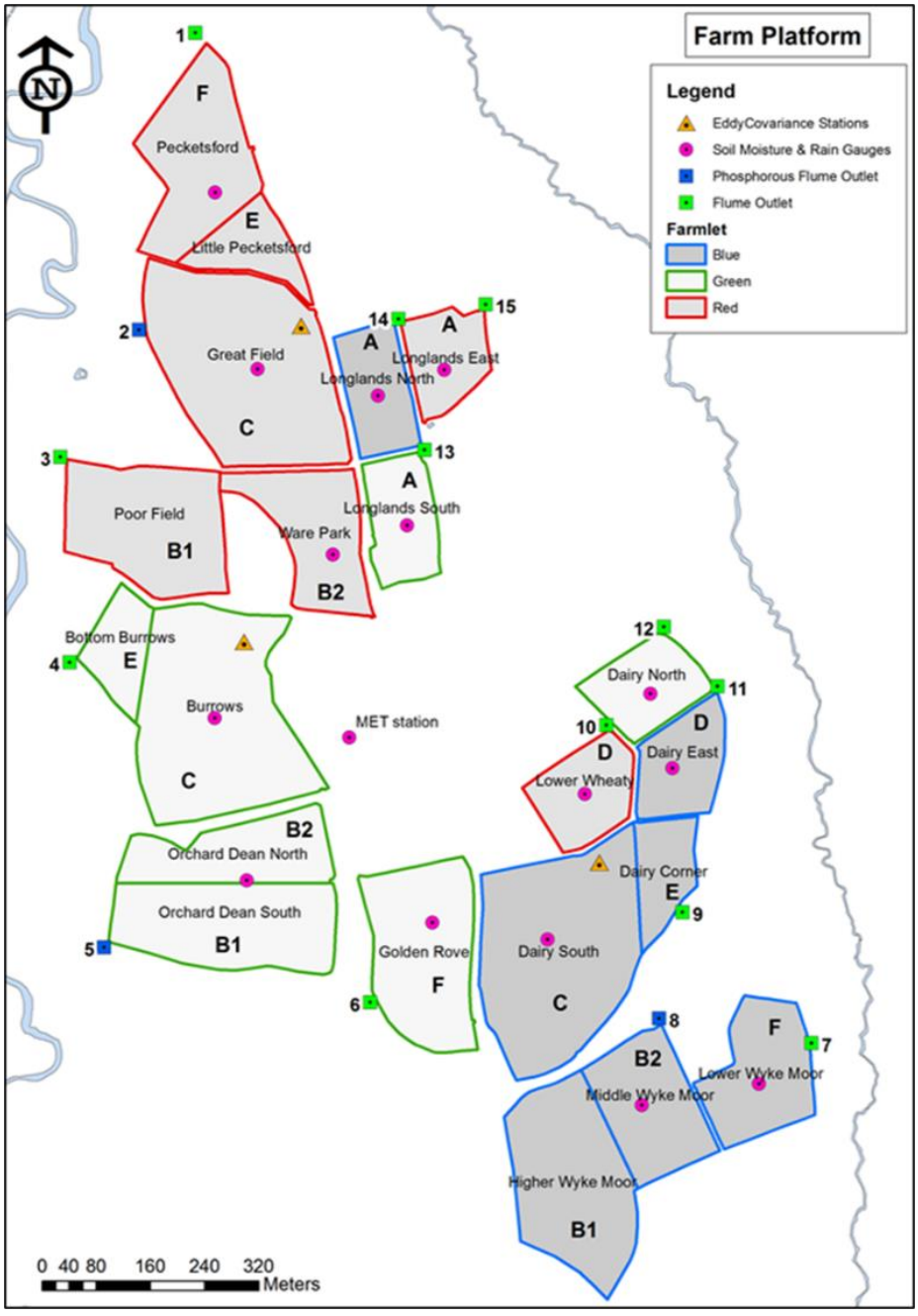
2 Instrumentation

2.1 Field Location

There are three automated Li-Cor Biosciences (Li-Cor, Nebraska, USA) EC systems installed on towers, all measuring carbon dioxide (CO_2) and two measuring methane (CH_4). The CO_2 measurements have been ongoing since January 2017; with the CH_4 measurements added in January 2018. The EC towers are sited on the larger fields of each NWFP farmlet (Figure 2):

- Green farmlet - 'Burrows' of Catchment 4
- Blue farmlet - 'Dairy South' of Catchment 9
- Red Farmlet – 'Great Field' of Catchment 2

Figure 2. Field location of Eddy Covariance towers on the NWFP (yellow triangles)



2.2 Position and Height

The Eddy Covariance technique measures a 'footprint' area, typically around 100 m long in our case. The exact area being measured depends on windspeed and direction, as well as the height of the tower.

As wind direction is predominantly West or Southwest all are positioned to the Northeast to maximise the time the towers are measuring from the field; their precise location is given in Appendix A. The EC towers and associated sensors are kept within fenced enclosures (approximately 8 m^2) within the fields, to protect them from being damaged by livestock (Figure 3). From January 2017 to June 2019, the analysers were approximately 1.6 m above the canopy (i.e., grass or crop) height. In July 2019, they were raised to approximately 2.6 m above canopy height. This was in order to increase the proportion of the field being measured.

Figure 3. Eddy Covariance tower and monitoring equipment.

3 Data Collection and Processing

3.1 Collection

All three EC towers have an enclosed carbon dioxide/water (CO_2 / H_2O) analyser (LI-7200RS, Li-Cor, Nebraska, USA) and a sonic anemometer (Gill Windmaster Pro, Gill Instruments Ltd, Lymington, Hampshire, UK). Data for CO_2 / H_2O fluxes have been measured from January 2017 to present. Open path CH_4 analysers (LI-7700, Li-Cor, Nebraska, USA) were originally installed on the towers in Red and Green farmlets from January 2018 to June 2019. In July 2019, one of the CH_4 analysers was relocated from the Red farmlet to the Blue farmlet due to the arable conversion of the Red farmlet. Data for CH_4 fluxes have been measured from January 2018 to present.

Additionally, all three towers have Li-Cor biomet systems to measure meteorological variables from the soil and atmosphere that can be used for gap-filling and interpretation of GHG flux data. A summary of the availability of data collected since 2017 is given in

Appendix B. It should be noted that there are gaps in these data, ranging from hours to weeks, due to the requirement for maintenance or servicing of the analysers.

A single nitrous oxide (N_2O) analyser was installed on the Blue farmlet tower in 2023. These data will be added to the data portal in due course.

3.2 Processing

The raw flux data are processed using EddyPro® software from Li-Cor Biosciences. This computes fluxes from the raw data and outputs 30-minute averages, recorded at 0 and 30 minutes past the hour. All data are in Universal Standard Time, kept correct by GPS units on the analysers. The data available for download from the NWFP Data Portal are presented in the European Fluxes Database format (http://www.europe-fluxdata.eu/home/guidelines/how-to-submit-data/variables-codes). A description of the columns for this format is included in Appendix C.

This format has useful information for QC of the data, including quality flags, friction velocity (u-star) and footprint location information. We have not removed or replaced any data from these files, so occurrence of low-quality data should be expected and filtered by the user.

Depending on the wind speed and direction, the footprint being measured at any individual timestamp may not be fully within the field. This will be evident from the footprint variables. However, the position of the towers was chosen to maximise the amount of time the footprint was within the field, given known windspeed and direction typical for the area.

3.3 Associated Data

Until 2019 (i.e., prior to the red farmlet transition to arable), all three EC fields would have been grazed by livestock (cows, sheep, and lambs) and may have also been used for silage production. Since ploughing, reseeding and fertilizer applications can affect GHG measurements, these field events must be considered alongside the GHG data, as do the number of grazing livestock. Data for field events and animal counts are available on the Data Portal. To an extent, GHG measurements will capture (or reflect) these field events, but in some cases data gaps exist where it has been necessary to remove the equipment (e.g., for ploughing to take place).

4 Data Portal

The NWFP Data Portal (https://nwfp.rothamsted.ac.uk/) allows accessibility to the core NWFP datasets to not only Rothamsted Research but also the wider research community. The data are open access and free to download but users are required to register their interest.

For information on the latest version of the 15-minute datasets and the changes since the last version, please refer to the User Guide entitled 'NWFP_UG_QC.pdf' available on the NWFP website:

http://resources.rothamsted.ac.uk/farm-platform-national-capability/data-portal-guides-and-information.

In addition, the website offers a wealth of online, and regularly updated information to complement the data.

5 Citing the Data

If you choose to use any of datasets provided by the NWFP in a publication, please cite:

- *Orr, R. J., Murray, P. J., Eyles, C. J., Blackwell, M. S. A., Cardenas, L. M., Collins, A. L., Dungait, J. A. J., Goulding, K. W. T., Griffith, B. A., Gurr, S. J., Harris, P., Hawkins, J. M. B., Misselbrook, T. H., Rawlings, C., Shepherd, A., Sint, H., Takahashi, T., Tozer, K. N., Whitmore, A. P., Wu, L. and Lee, M. R. F. (2016). The North Wyke Farm Platform: effect of temperate grassland farming systems on soil moisture contents, runoff and associated water quality dynamics. European Journal of Soil Science, 67, 4, 374-385. (doi:10.1111/ejss.12350).*

In addition, if using data from the baseline period please cite:

- *Takahashi, T., Harris, P., Blackwell, M. S. A., Cardenas, L. M., Collins, A. L., Dungait, J. A. J., Hawkins, J. M. B., Misselbrook, T. H., McAuliffe, G. A., McFadzean, J. N., Murray, P. J., Orr, R. J., Rivero, M. J., Wu, L. and Lee, M. R. F. (2018). Roles of instrumented farm-scale trials in trade-off assessments of pasture-based ruminant production systems. Animal, 12, 8, 1766-1776. (doi:10.1017/S1751731118000502).*

- *Orr, R. J., Griffith, B. A., Rivero, M. J. and Lee, M. R. F. (2019). Livestock Performance for Sheep and Cattle Grazing Lowland Permanent Pasture: Benchmarking Potential of Forage-Based Systems. 9, 2, 101-118. (doi:10.3390/agronomy9020101).*

For the datasets used, please cite the latest version of the relevant User Guide PDF document(s), listed in the table below, that describe the establishment and development of the NWFP, and the various datasets produced in detail. The link to these can be downloaded from the NWFP website. Note that the User Guide entitled 'NWFP_UG_Design_Develop.pdf' should be cited irrespective of the dataset used.

Data used	Main title of User Guide PDF document
All datasets	NWFP_UG_Design_Develop.pdf
15-minute time-series datasets (water, soil moisture, meteorology)	NWFP_UG_Hydrology&WaterQuality_Data.pdf NWFP_UG_SMS_Data.pdf NWFP_UG_MET_Data.pdf
Greenhouse gases	NWFP_UG_EC_GHG_Data.pdf NWFP_UG_GreenFeed_Data.pdf
Field surveys	NWFP_UG_FieldSurvey_Data.pdf
Livestock	NWFP_UG_Livestock_Data.pdf
Field events	NWFP_UG_FieldEvents_Data.pdf

Also, please include the following sentences in the acknowledgments section:

"The North Wyke Farm Platform is a UK National Capability supported by the Biotechnology and Biological Sciences Research Council (BBS/E/RH/23NB0008)."

"We acknowledge the interests of the Ecological Continuity Trust (ECT), whose national network of LTEs includes the experiment on which this research was conducted."

6 Appendices

Appendix A. Precise location of the EC towers.

Treatment	Catchment name	Field name	Field size (ha)	Longitude	Latitude	Elevation (m)
Green	Catchment 4	Burrows	6.39	-3.90613	50.7698	154.4
Blue	Catchment 9	Dairy South	6.49	-3.89857	50.7669	167.0
Red	Catchment 2	Great Field	6.65	-3.90513	50.7739	149.9

Appendix B. Summary of data availability.

	2017			2018			2019			2020		
	Red	Blue	Green	Red	Blue	Green	Red	Blue	Green	Red	Blue	Green
CO_2/H_2O	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Biomet	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CH_4				✓		✓	✓		✓		✓	✓
N_2O												

Appendix C. Detailed description of columns in downloaded EC GHG data.

Variable Name	Unit	Group on Portal	Description (European Fluxes Database)
CH4_1_1_1	[nmol CH_4 mol^{-1}]	CH_4	CH_4 concentration
CO2_1_1_1	[mmol CO_2 mol^{-1}]	CO_2	CO_2 concentration
Datetime	[dd/mm/YYYY HH:MM:SS]		
FC_1_1_1	[umol CO_2 m^{-2} s^{-1}]	CO_2	CO_2 flux
FC_SSITC_TEST_1_1_1	[#]	CO_2	Quality check – CO_2 flux (0=high, 1=medium, 2=low quality)
FCH4_1_1_1	[nmol CH_4 m^{-2} s^{-1}]	CH_4	CH_4 flux
FCH4_SSITC_TEST_1_1_1	[#]	CH_4	Quality check – CH_4 flux (0=high, 1=medium, 2=low quality)
FETCH_70_0_0_1	[m]	Footprint	Fetch at which footprint cumulated probability is 70%
FETCH_80_0_0_1	[m]	Footprint	Fetch at which footprint cumulated probability is 80%
FETCH_90_0_0_1	[m]	Footprint	Fetch at which footprint cumulated probability is 90%
FETCH_MAX_0_0_1	[m]	Footprint	Fetch at which footprint cumulated probability is maximum
FN2O	[nmol N_2O m^{-2} s^{-1}]	N_2O	N_2O flux
H_1_1_1	[W m^{-2}]	Air	Sensible heat flux
H_SSITC_TEST_1_1_1	[#]	Air	Quality check - sensible heat flux (0=high, 1=medium, 2=low quality)
H2O_1_1_1	[mmol H_2O mol^{-1}]	Air	H_2O vapor mole fraction
LE_1_1_1	[W m^{-2}]	Air	Latent heat flux
LE_SSITC_TEST_1_1_1	[#]	Air	Quality check - latent heat flux (0=high, 1=medium, 2=low quality)
LWIN_1_1_1	[W m^2]	Meteorological sensors	Longwave Radiation Incoming
LWOUT_1_1_1	[W m^2]	Meteorological sensors	Longwave Radiation Outgoing
MO_LENGTH_0_0_1	[m]	Air	Monin-Obhukov length
PA_0_0_1	[kPa]	Air	Atmospheric pressure
PPFD_1_1_1	[µmol Photon m^2 s]	Meteorological sensors	Photosynthetic Photon Flux Density Incoming
RH_0_0_1	[%]	Air	Relative humidity
RH_1_1_1	[%]	Meteorological sensors	Relative Humidity
RN_1_1_1	[W m^2]	Meteorological sensors	Net Radiation
SHF_1_1_1	[W m^2]	Meteorological sensors	Soil Heat Flux Sensor 1
SHF_2_1_1	[W m^2]	Meteorological sensors	Soil Heat Flux Sensor 2

SHF_3_1_1	[W m^2]	Meteorological sensors	Soil Heat Flux Sensor 3
SWC_1_1_1	[m^3 m^3]	Meteorological sensors	Soil Water Content Sensor 1
SWC_2_1_1	[m^3 m^3]	Meteorological sensors	Soil Water Content Sensor 2
SWC_3_1_1	[m^3 m^3]	Meteorological sensors	Soil Water Content Sensor 3
SWIN_1_1_1	[W m^2]	Meteorological sensors	Shortwave Radiation Incoming
SWOUT_1_1_1	[W m^2]	Meteorological sensors	Shortwave Radiation Outgoing
T_SONIC_0_0_1	[°C]	Air	Sonic temperature
T_SONIC_SIGMA_0_0_1	[°C]	Air	
TA_0_0_1	[°C]	Air	Air temperature
TA_1_1_1	[K]	Meteorological sensors	Air Temperature
TAU_1_1_1	[kg m^{-1} s^{-2}]	Air	Momentum flux
TAU_SSITC_TEST_1_1_1	[#]	Air	Quality check - momentum flux (0=high, 1=medium, 2=low quality)
TS_1_1_1	[K]	Meteorological sensors	Soil Temperature Sensor 1
TS_2_1_1	[K]	Meteorological sensors	Soil Temperature Sensor 2
TS_3_1_1	[K]	Meteorological sensors	Soil Temperature Sensor 3
U_SIGMA_0_0_1	[m s^{-1}]	Wind	Standard deviation of velocity fluctuations (towards main-wind direction after coordinates rotation)
USTAR_0_0_1	[m s^{-1}]	Wind	Friction velocity
V_SIGMA_0_0_1	[m s^{-1}]	Wind	Standard deviation of lateral velocity fluctuations (cross main-wind direction after coordinates rotation)
VPD_0_0_1	[hPa]	Air	
W_SIGMA_0_0_1	[m s^{-1}]	Wind	Standard deviation of vertical velocity fluctuations
WD_0_0_1	[Decimal degrees]	Wind	Wind direction
WS_0_0_1	[m s^{-1}]	Wind	Wind speed
WS_MAX_0_0_1	[m s^{-1}]	Wind	Maximum wind speed
ZL_0_0_1	[#]	Wind	Stability parameter