Data in Brief

Derived datasets of daily weather, near surface soil status, flow rates and concentrations of nitrogen species from the North Wyke Farm Platform, England

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Abstract:	Weather conditions, hydrological responses and the dynamics of key nitrogen species in field runoff were continuously monitored at 15-minutes resolution on the intensively instrumented North Wyke Farm Platform (NWFP), a UK National Bioscience Research Infrastructure (NBRI), to support research on sustainable and resilient agriculture in the UK. Released data spanning 2013 to 2024 for 6 selected field catchments were aggregated to daily timestep, with reference to data quality flags, to produce continuous weather data, including maximum and minimum air temperature, daily total rainfall, wind speed and quality assured daily average soil moisture content, soil temperature at 10 cm depth, runoff rates, nitrate and nitrite concentrations, and ammonium concentrations. External data sources were sourced to infill some gaps for the weather data and summary statistics on data coverage were generated for the other data in an annual and seasonal basis where appropriate. Along with detailed field management data, the observed data provide a valuable resource for the parameterisation, calibration and validation of physically- based models on nitrogen losses at field scale to account for alternative management practices and land uses under changing climate conditions.
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30 October 2024

Dear Editors,

We herein enclose our draft paper entitled '**Derived datasets of daily weather, near surface soil status, flow rates and concentrations of nitrogen species from the North Wyke Farm Platform, England'** for consideration for publication in the Data in Brief.

Nitrogen cycling in soil on agricultural land is a complex process having significant impacts on the delivery of multiple ecosystem services (e.g. provisioning and regulatory services) and improvement of nutrient use efficiency. Process-based nitrogen models are increasingly being used for undertaking scenario comparison and development of alternative land management practices under changing climate conditions. Such models tend to require large amounts of data for their parameterisation, calibration and validation. Along with field management information, the North Wyke Farm Platform (NWFP) in Southwest England, as a UK National Bioscience Research Infrastructure (NBRI), has been collecting meteorological, soil water and nutrient loss in field runoff data at 15-minute intervals since 2011/12. However, there are acknowledged challenges for the wide use of such data for nitrogen modelling, including temporal resolution mismatch (15-minutes data vs the expected daily resolution inputs required for most models), gaps in meteorological data, and lack of detailed field management information. Efforts were therefore made to generate publicly available and ready for use datasets for agroecosystem modellers to facilitate the further development and refinement of nitrogen modelling. We have published the new datasets in the Zenodo repository and would like to introduce these data to the wider scientific community to fulfil their potential via your journal.

Yours

Yusheng Zhang

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ARTICLE INFORMATION

Article title

Derived datasets of daily weather, near surface soil status, flow rates and concentrations of nitrogen species from the North Wyke Farm Platform, England

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Abstract

Weather conditions, hydrological responses and the dynamics of key nitrogen species in field runoff were continuously monitored at 15-minutes resolution on the intensively instrumented North Wyke Farm Platform (NWFP), a UK National Bioscience Research Infrastructure (NBRI), to support research on sustainable and resilient agriculture in the UK. Released data spanning 2013 to 2024 for 6 selected field catchments were aggregated to daily timestep, with reference to data quality flags, to produce continuous weather data, including maximum and minimum air temperature, daily total rainfall, wind speed and quality assured daily average soil moisture content, soil temperature at 10 cm depth, runoff rates, nitrate and nitrite concentrations, and ammonium concentrations. External data sources were sourced to infill some gaps for the weather data and summary statistics on data coverage were generated for the other data in an annual and seasonal basis where appropriate. Along with detailed field management data, the observed data provide a valuable resource for the parameterisation, calibration and validation of physically- based models on nitrogen losses at field scale to account for alternative management practices and land uses under changing climate conditions.

SPECIFICATIONS TABLE

Subject	Hydrology and water quality

Specific subject area	Daily timeseries of climate variables, soil moisture content, flow rates, nitrate, nitrite and ammonium concentrations.
Type of data	Table Filtered, Processed, Aggregated
Data collection	15-minute data along with quality flags from a selection of field scale catchments were downloaded from the NWFP data portal (https://nwfp.rothamsted.ac.uk/) between July and September 2024. The targeted catchments include Pecketsford (catchment 1), Great Field (catchment 2), Poor Field (catchment 3), Burrows (catchment 4), Orchard Dean (catchment 5) and Higher Wyke Moor (catchment 8). These catchments were selected for their representativeness of land use types, similar hydrological contributing areas (~6 ha), and relatively continuous data records. Data prior to 2013 were excluded to avoid the impacts of a catchment boundary change for catchment 4. Data quality flag-based filtering was undertaken to remove data records with potential issues. Data points with 'Good' and 'Acceptable' flags were accepted without change. Those with an 'Outlier' flag were checked individually. If multiple entries for the same timeslot were reported to have similar values, they were accepted. If an 'Outlier' value was reported for a single catchment then it was rejected. Data points with other quality flags were rejected out of caution. Daily totals, average values and sample counts from 09:00:00 were derived by creating pivot tables in Excel where adjusted date values were used as the row element. For weather data with <75% of the expected data points (n= 96, i.e. 72), the data from a nearby Met office station (North Wyke site) were used. For wind speed, large gaps (>3 days) were infilled with the monthly average for valid wind speed readings. For temperature data with smaller gaps (<3 days), linear interpolations were used. For longer gaps (>3 days), gridded daily data from the HADUK-Grid dataset [1] were used. For rainfall data, gaps were handled with reference to the monitored flow data. If there was no noticeable flow, then no rainfall was assumed. Otherwise, rainfall data from other sources were used; namely, observed data from the nearby Met station and daily data from HADUK-Grid.
Data source location	Institution: Rothamsted Research City/Town/Region: Devon County Country: England
Data accessibility	Repository name: Zenodo Data identification number: 10.5281/zenodo.14006971 Direct URL to data: https://zenodo.org/records/14006972

Related research article	None

VALUE OF THE DATA

- There is a demand for quality observed data for the development and further refinement of process-based models for a better understanding of nitrogen cycling processes in agricultural landscapes to support evidence-based improvement of nitrogen use efficiency and mitigation of the unintended consequence associated with intensive farming[2]. Combined with detailed site descriptions and field management information which is publicly available, high resolution monitored data from the NWFP collected over recent years could provide unique reference datasets for representing agricultural activities in a UK setting.
- Using transparent and standardized approaches, the aggregation of 15-minute data to daily time scale will avoid the uncertainty associated with the pre-processing of data before their use in a process based model. Access to data collectors, quality assessors and database administrators ensured appropriate interpretation of the quality flags. Local knowledge about alternative data sources ensured that the best available data were used for any necessary gap filling.
- Various data quality indicators, such as data coverage and valid data points for the daily estimates will give potential model developers and users' flexibility to select optimal years to use and to interpret any discrepancy between modelled outputs and observed values. These data series will be very useful for the testing of hydrological and water quality models in general with an emphasis on nitrate losses from different land uses (low intensity livestock grazing with beef and sheep and arable cropping).
- Data collection spanned a period where arable cropping was introduced into a typical livestock grazing area in multiple field catchments and coincided with recognized extreme weather conditions [3]. These unique combinations make the monitored data relevant to better process-based modelling of future climate change impacts under similar environmental settings.

BACKGROUND

Process-based modelling has been an invaluable approach to improve our understanding of hydrological and nitrogen processes on agricultural land, which are key to sustain various ecosystem services, including production of food and fibres, maintaining soil quality, and the filtering of harmful agri-chemicals to receiving aquatic environments. They are also the main tool for the assessment of potential impacts of alternative management practice under ever changing climate conditions. Most process-based models require large amounts of input data to operate and they also need to be calibrated and validated before their intended applications. The existing models are mostly run at daily time step and require continuous weather data. There is a scarcity of monitored data at comparable temporal resolution for the testing of such models. Along with detailed field management information, the NWFP has accumulated a relatively long time series dataset at 15-minute resolution for several field catchments [5][6][7][8] where some quality assurances have already been undertaken. Efforts were therefore made to further process the available data to make them suitable for the development and testing of physically based nitrogen models for UK settings.

DATA DESCRIPTION

The generated new data[4] are provided in an Excel workbook named 'Derived daily outputs from 15 minute NWFP data.xlsx' which contains 6 separate worksheets with self-explanatory sheet names, including 'Weather', 'Soil moisture', 'Soil temperature', 'Flow rate', 'Nitrate concentration', and 'Ammonium concentration', respectively. The first cell of each sheet gives a brief description of its content. Two blocks of data are presented on each sheet: daily time series for 6 catchments on the left and summary statistics data on data coverage on the right. For the 'Weather' sheet, a column with a header of 'Infilled variable list' lists individual data items that are not from NWFP monitoring for each data record. The majority of the data records were based entirely on NWFP monitoring and they were registered as 'Unchanged' in the appropriate column. For the other datasets, the number of accepted data points available following filtering and used for the calculation of daily values are tabulated. For summary data on the temporal coverage throughout the reported period, annual percentages are given for all data series. In addition, percentage coverages for the soil drainage period (October to March) are also shown for nitrate and ammonium concentrations. A sheet named 'Metadata' is provided to give a brief description of the data processing procedures involved. Information for relevant field management events, including ploughing, drilling and harvesting, fertilizer application timings and rates, manure spreading timing and rates are shown on a field basis in a separate workbook named 'Field management information for modelling.xlsx'. The membership of fields to the selected NWFP catchments is explained in a separate worksheet named 'Catchments and Fields'. A separate KMZ file ('catchment boundary.kmz') is included as part of the data package to show the geographic extent of the field catchments concerned.

EXPERIMENTAL DESIGN, MATERIALS AND METHODS

Catchments and land uses

The monitored 15-minute data are from 6 hydrologically-isolated catchments which formed part of purposely built farm platform for the comparison of 3 farming systems: permanent pasture as a control (Green farmlet), increased use of legumes and replacement of chemical fertiliser (Blue farmlet) and planned reseeding and regular renewal/arable (Red farmlet)[5]. Catchments 1, 2 and 3 are part of the NWFP Red Farmlet; Catchments 4 and 5 are part of the NWFP Green farmlet, and; Catchment 8 is part of the NWFP Blue catchment. Between 2013 and 2019, they were all used for low intensity sheep and cattle grazing. Catchments 1,2 and 3 were converted to arable cropping in the autumn of 2019 wherein different arable crops (winter wheat, winter oats) have since been cultivated under different land management practices (conventional ploughing, minimum tillage). Further details can be found in the assembled field management information provided.

Instrumentation & Sensors

Air temperature, wind speed, solar radiation and precipitation, were recorded at 15-minute intervals using dedicated meteorological equipment (Adcon, OTT HydroMet GmbH, Vienna, Austria) sited at an approximately central location on the farm platform. The instruments were co-located next to those of an official UK Meteorological Office site which has collected daily data (9am – 9am), since 1981.

Air temperature was measured using a thermistor with a range of -40 – 60 °C, wind speed was measured at a height of 3 m using an anemometer with a range of 1.44 – 270 km h^{-1}, and solar radiation was measured using a pyranometer (range 0 – 1600 W m^{-2}; resolution 0.1 W m^{-2}). From 2013 - 2015, precipitation was measured by a tipping bucket rain gauge (range = 0 – 100 mm hr^{-1}; resolution = 0.2 mm) but in April 2015, this was replaced with a more accurate Pluvio rain gauge (Adcon, OTT HydroMet GmbH, Vienna, Austria) with a range of 0.1 – 500 mm hr^{-1} and resolution of 0.01 mm. Although capable of monitoring precipitation data at 1-minute intervals, only 15-minute interval data were recorded. Given that the instruments were co-located with those of the UK Meteorological Office, periodic comparisons were conducted to check for consistency between the alternative measurements and differences of genuine concern were flagged during the quality control (QC) processing of the data described below.

Soil moisture, at depths of 10 cm and soil temperature at 15 cm, were monitored at 15-minute intervals from an approximately central location in each of the field scale catchments using a combined soil moisture and temperature probe (A51760; A51730, Adcon, OTT HydroMet GmbH, Vienna, Austria). The probe is connected via an SDI 12 interface to a remote terminal unit (RTU, A723 addIT Series 4, Adcon, OTT HydroMet GmbH, Vienna, Austria) for data transmission. The scaled frequency unit (SFU) data were converted to % soil moisture (%) using a formula shown below:

soil moisture = (SFU - 18.80) / 1.808

which is developed from calibrating the sensor output in 1m^3 blocks of North Wyke soil under a range of different soil moisture conditions. Between June - November 2015, the A51760 model Adcon sensors were replaced with the A51730 model, and the data converted using an updated calibration formula:

soil moisture = (SFU + 12.87) / 1.808

Hydrological flow from each catchment was collected by two French drains on the downslope boundaries of the catchments that merged in a confluence pit. From here, flow was channelled via a conduit to H Type flumes (TRACOM Inc., Georgia, USA), the size of which was determined by size of the catchment they are servicing. The level or stage height of water was recorded at 15-minute intervals using sensors sited in a stilling well near the flume outflow. Up until mid-2015, flow was monitored using bubble flow meters (4230, Teledyne ISCO, New England, USA). These were replaced with pressure level sensors (OTT Hydromet, Loveland, CO., USA).

The level height (H) data are converted to flow (L s^{-1}) using formulas specific to the size of the flume, and which are given in Table 1.

Table 1 Formulae for conversion of water height to discharge rate for different sized flumes

Catchment Number	Flume size (ft)	Formulae (H in metres) †
1	1.5	$L^{-s} = -0.00396436 - (0.07231968 * H^{0.5}) + (79.89379128 * H^{1.5}) + (900.3765227 * H^{2.5})$
2, 3, 5, 8	2.0	$L^{-s} = 0.022285358 - (0.55496382 * H^{0.5}) + (125.5275778 * H^{1.5}) + (939.5717311 * H^{2.5})$
4	2.5	$L^{-s} = 0.042446953 - (0.90725263 * H^{0.4}) + (108.676075 * H^{1.4}) + (937.5943603 * H^{2.5})$

A cabin sited at each flume contained telemetry devices for transmission of data via fibre optic cable, pumping equipment, and a bespoke stainless-steel by-pass flow cell (13 L capacity) that housed sensors to measure various water quality parameters at 15-minute intervals. Water from a sump in the conduit that supplies the flume was automatically pumped into and out of the underside of the flow cell by a bi-directional peristaltic pump (621VI\R, Watson-Marlow Inc., Massachusetts, USA). The V-shaped design of the flow cell ensured that there was no build-up of sediment or particulate matter either between samples or over time. The pumping cycle was controlled through a combination of the level sensor data, a netDL 1000 data logger (OTT Hydromet, Loveland, CO., USA), and a programmable logic controller (PLC LOGO, Siemens AG, Munich, Germany). The programmable logic controller (PLC) stored a programme that activated the peristaltic pump, as well as controlling its speed and direction. The sensor level data were captured by the netDL logger, and a signal sent to the PLC depending on the flow conditions. If a 15-minute flow point was >= 0.2 L s^{-1}, the PLC programme was activated and the pump operated, but if the flow point was <= 0.18 L s^{-1}, the PLC programme was de-activated, no pumping took place, and the volume of water in the flow cell was retained. This enabled sensors, such as ion elective electrodes (ISEs) that require permanent submersion in a liquid, from drying out.

Ammoniacal nitrogen (NH_4^+, NH_3) was measured by an ISE (range = 0 – 100 mg L^{-1}; resolution = 0.01 mg L^{-1}) as part of a suite of sensors attached to a multi-parameter sonde. Up until May 2016, YSI 6600V2 sondes (Xylem Inc Rye Brook, New York, U.S), that also held sensors measuring other water quality parameters including turbidity, dissolved oxygen, specific conductivity, pH and temperature, were used. During 2016, the YSI 6600V2 sondes were upgraded to YSI EXO 2 sondes fitted with smart sensors. The sondes communicated directly with the netDL logger via a Serial Data Interface.

Combined nitrate-N and nitrite-N were measured by a dedicated, self-cleaning, optical UV absorption sensor (NITRATAX Plus SC, Loveland, Colorado, USA) with a range of 0.1 – 100 mg L^{-1} and resolution of 0.1 mg L^{-1}.

Water Quality Sensor Calibration

Initially, two complete sets of the YSI 6600V2 sondes were used allowing one set to be calibrated in and stored in the laboratory while the other set was deployed in the field. After the upgrade to the

† *Taken from Field Manual for Research in Agricultural Hydrology, Agriculture Handbook No. 224, U.S. Department of Agriculture, February 1972*

YSI EXO 2 sondes in 2016, the design allowed for smart sensors to be plugged in and removed easily. Therefore, two complete sets of sensors were used; one set deployed in the field whilst the other was calibrated and stored in the laboratory, ready for deployment.

The sonde/sensor sets were rotated approximately every month, minimising downtime, and ensuring continuous high data quality. All sensors were checked in standards of known concentration and drift values recorded. Once drift checked, the sonde sensors were cleaned and stored appropriately until they were calibrated prior to deployment. In the case of NH_4^+/NH_3 ISEs, a 2-point calibration (1mg L^{-1} - 100 mg L^{-1}) was used, and sensor modules were replaced every 12 months. Following storage, ISEs were re-hydrated by soaking for 24 hours in a 100 mg L^{-1} NH_4^+ standard prior to calibration and deployment.

The Nitratax UV absorption sensors remained in situ and were calibrated monthly in the field using a 2-point calibration (0 mg NO_{2+3} L^{-1} (Reverse Osmosis water) - 11.3 mg NO_{2+3} L^{-1}). Sensor drift that might be due to lens contamination was checked prior to cleaning the lens and wiper blade. In addition, the sensors underwent an annual service including a 3-point factory calibration.

For more detailed information on the design and set-up of the North Wyke Farm Platform (NWFP) and the instrumentation described above, please refers to relevant guide documents [5,6,7,8].

Quality Control of Data

A detailed description of the QC processing of the data can be found in Hawkins et al. [9]. Briefly, the QC process used bespoke R (http://www.r-project.org) scripts on four weeks' worth of data at a time. Each data point was given an appropriate flag to give an indication of reliability.

A Sensor Downtime Log (SDL) of all sensor issues was maintained including details on the sensor, its location, the start and end times the sensor was functioning incorrectly, information about the issue and the required QC action (i.e. set recorded data as missing (NA) or add an 'unreliable' flag to each data point). Exports from the SDL were automatically used as part of the QC process and based on the records, data were flagged unreliable for certain periods which could be from a few hours up to months. The QC process applied limits to identify extreme distributional (lower limit and upper limit) outliers, whilst other limits were used to identify simple distributional (lower limit and upper limit) outliers. The limits were not statistically set but were based on expert judgement of the data to identify unusual or interesting low- and high-valued measurements. Values exceeding extreme upper or lower limits, or deemed impossible, were set to NA. Thus, the assignment of flags was rather subjective and based on various events that have taken place (recorded in the downtime log), that might potentially have affected the data, without knowing the full extent of it. Data quality flags that might be assigned to a data point and their explanations are given in Table 2.

Table 2 Data quality flags – description and details

Flag	Details
Not set	No information on quality available
Good	Data were checked and deemed good
Acceptable	Data were checked and no issues were found
Suspicious	Data were checked and might have been affected by an event
Highly Suspicious	Data were checked and have definitely been affected by an event

Reject	Data were rejected
High Sensor Drift	Calibration values indicate that the readings were high over the time period. As calibration takes place monthly, it is impossible to know if or how much the instrument drifted at the measurement timestamp as this is not a linear relationship
Missing Sensor Drift	Missing instrument calibration information, this level of instrument drift during the period is unknown
Outlier	The value falls outside 'regular' limits but within the extreme limits, therefore could still be fine
Level Reset	Level pressure sensors were reset, indicating this could result in a step change in flow
Calibration	Calibration Datetime of the instrument

LIMITATIONS

Due to the impacts of Covid shutdown, the data coverage for some years is low. Generally speaking, there is also low coverage for crop growth periods (May to August) because of low/discontinuous flow conditions at field scale and the threshold flow-based sampling regime. No comparable data on nitrogen related emissions to air, such as nitrous oxide, were available at similar temporal resolution or coverage.

ETHICS STATEMENT

Hereby, we (Yusheng Zhang, Jane Hawkins, Hadewij Sint, Adrian L. Collins) have declared that we have read and follow the ethical requirements for publication in Data in Brief and confirm that the current work does not involve human subjects, animal experiments, or any data collected from social media platforms.

CRediT AUTHOR STATEMENT

Yusheng Zhang: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing –original draft, Writing –review & editing; Jane Hawkins, Investigation. Validation, Writing –original draft; Hadewij Sint, Investigation, Validation; Adrian L. Collins: Conceptualization, Validation, Funding acquisition, Project administration, Resources, Supervision, Writing –original draft, Writing –review & editing.

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DECLARATION OF COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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