1. ABOUT THE DATASET

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Title: Pear phenology and climate data from 1960-2020, Kent, UK.

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Rights-holder(s): Laura Reeves

Publication Year: 2022

Description: This dataset contains flowering times (in Julian days) of 12 different pear cultivars from 1960-2020 collated from the National Institute of Agricultural Botany East Malling Research (NIAB EMR) in East Malling, Kent and the National Fruit Collection in Brogdale. There are four different phenological stages included:

- First flowering; when the first flower is open on the pear tree (First\_and\_ten\_flowering.csv)

- Ten percent flowering, when 10% of flowers are open on the pear tree (First\_and\_ten\_flowering.csv)

- Full flowering, when over 50% of flowers have opened on the tree(Full\_flowering.csv);

- Last flowering, when 90% of petals have fallen (Last\_flowering.csv)

Alongside this weather variables including maximum, minimum and mean temperatures for each month, total monthly rainfall, total monthly frost days, January-April average mean temperature and January-April total frost days, used within the principal components analysis (PCA) and linear mixed models (LMM). Weather variables were calculated using Met Office data from Brogdale and East Malling weather stations. The data set also contains frost days Jan-Apr and mean Jan-Apr temperature predicted for 2080, for 4 different Representative Concentration Pathway (RCP) scenarios, calculated using data from the UK Climate Projections User Interface (UKCP, 2021).

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Related publication:

Reeves, L., Fountain, M., Garratt, M. and Senapathi, D. (2022) Climate induced phenological shifts in pears – a crop of economic importance in the UK. Agriculture, Ecosystems and Environment. Accepted 18/07/2022

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2. TERMS OF USE

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3. PROJECT AND FUNDING INFORMATION

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Title: Pears, pests and natural enemies: modelling tri-trophic interactions in a changing climate

Dates: 21/09/2020 - 21/09/2024

Funding organisation: BBSRC

Funding type: BBSRC training grant funded PhD project.

Grant no.: BB/V509747/1

4. CONTENTS

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File listing

1. Climate\_scenarios.csv:
* 5 variables, 7 rows.
* Variables include: Scenario (the type of RCP, current or historical scenario used), Average Jan- Apr mean temp (°C), SE mean Jan- Apr temp (°C)(the standard error for the mean Jan-Apr temperature),
* Missing data codes: NA
* Description: This is the average mean temperature and frost days from Jan-Apr, as well as the SE, predicted for each of the climate scenarios, used within the linear mixed model for future flowering times for 2080. The RCP scenarios include RCP 2.6 (low emissions scenario), RCP 4.5 (medium emissions scenario), RCP 6.0 (medium-high emissions scenario) and RCP 8.5 (high emissions scenario). These were compared to current (1990-2020) and historical (1960-1989) scenarios. To calculate future temperature scenarios for 2080, data was extracted using the UK Climate Projections User Interface (UKCP, 2021). The predicted increase in mean air temperature at 1.5m for 2080 was then calculated for January to April (baseline scenario 1981-2000) for a 25 km-by-25 km region in Kent, surrounding East Malling, these temperatures were calculated for each of the four RCP scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5.) and added to the average 1981-2000 January-April temperature (6.30˚C). Frost days were calculated by totalling the number of days where the daily minimum temperature was below 0 ˚C. Future frost day scenarios were calculated for 2080 for RCP2.6 (low emissions) and RCP8.5 (high emissions) scenarios. Daily minimum temperature data for 2080 was extracted using the UK Climate Projections User Interface for a 60 km-by-60 km region in Kent. Frost days were calculated by summing the number of days where the minimum temperature was below 0 ˚C.
1. Frost\_days\_EMR\_BR.csv
* 6 variables 1452 rows.
* Variables include: Date (1960-2020), Site (EM- East Malling or BR- Brogdale), Frost (total number of frost days where the minimum temperature is below 0 ˚C for that month, Year (1960-2020), Month (1-12) and m (Jan-Dec).
* Missing data codes: NA
* Description: This is the total number of frost days for each month from 1960-2020 for 2 sites (East Malling and Brogdale) in Kent. They have been calculated from the minimum temperatures of Met Office records, where a frost day is a day where the minimum temperature goes below 0 ˚C. These data have been used in the PCA to infer which months have most impact on pear flowering time and the LMM to predict flowering times in 2080 under future RCP scenarios.
1. First\_and\_ten\_flowering.csv
* 78 variables, 918 rows.
* Cultivar.name (the pear cultivar), Date, Year (1960-2020), Month, Day, Period (first or ten percent flowering stage), Site (Brogdale or East Malling), JDay (flowering time in Julian days), Cultivar.no (cultivar number 1-12, based on name), Jun\_Max (average maximum temperature for that month ˚C), Jul\_Max, Aug\_Max, Sep\_Max, Oct\_Max, Nov\_Max, Dec\_Max, Jan\_Max, Feb\_Max, Mar\_Max, Apr\_Max, May\_Max, Jun\_Min (average minimum temperature for that month ˚C), Jul\_Min, Aug\_Min, Sep\_Min, Oct\_Min, Nov\_Min, Dec\_Min, Jan\_Min, Feb\_Min, Mar\_Min, Apr\_Min, May\_Min, Jun\_Mean (average mean temperature for that month), Jul\_Mean, Aug\_Mean, Sep\_Mean, Oct\_Mean, Nov\_Mean, Dec\_Mean, Jan\_Mean, Feb\_Mean, Mar\_Mean, Apr\_Mean, May\_Mean, Oct-Apr\_Max (average Oct-Apr maximum temperature), Oct-Apr\_Min (average Oct-Apr minimum temperature), October\_to\_April\_Mean (average Oct-Apr mean temperature), An\_Max (average annual maximum temperature), An\_Min (average annual minimum temperature), Annual\_Mean (average annual mean temperature), Jan\_rain (Total rainfall for that month mm), Feb\_rain, Mar\_rain, Apr\_rain, May\_rain, Jun\_rain, Jul\_rain , Aug\_rain, Sep\_rain, Oct\_rain, Nov\_rain , Dec\_rain, An\_rain (total annual rain), Jan\_F (total frost days for that month), Feb\_F, Mar\_F, Apr\_F, May\_F, Jun\_F, Jul\_F, Aug\_F, Sep\_F, Oct\_F, Nov\_F, Dec\_F, January\_to\_April\_temp (average mean Jan-Apr temperature ˚C), January\_to\_April\_frost (Total number of frost days Jan-Apr).
* Missing data codes: NA
* Description: The flowering times (in Julian days) of 12 different pear cultivars from 2 different sites (East Malling and Brogdale in Kent) from 1960-2020. This includes data for first (when the first flower is open on the pear tree) and ten percent (when 10% of the flowers are open on the pear tree) phenological stages, used for the GAMM, LMM and PCA models within the paper. Weather data has also been collated from Met Office records from Faversham and East Malling weather stations. Weather variables calculated include mean, maximum and minimum (˚C) temperatures for each month (with May-Dec months from the previous year), average annual temperatures and Jan-Apr temperatures, total rainfall for each month (mm) and total frost days for each month.
1. Full\_flowering.csv
* 78 variables, 916 rows.
* Cultivar.name (the pear cultivar), Date, Year (1960-2020), Month, Day, Period (full flowering stage), Site (Brogdale or East Malling), JDay (flowering time in Julian days), Cultivar.no (cultivar number 1-12, based on name), Jun\_Max (average maximum temperature for that month ˚C), Jul\_Max, Aug\_Max, Sep\_Max, Oct\_Max, Nov\_Max, Dec\_Max, Jan\_Max, Feb\_Max, Mar\_Max, Apr\_Max, May\_Max, Jun\_Min (average minimum temperature for that month ˚C), Jul\_Min, Aug\_Min, Sep\_Min, Oct\_Min, Nov\_Min, Dec\_Min, Jan\_Min, Feb\_Min, Mar\_Min, Apr\_Min, May\_Min, Jun\_Mean (average mean temperature for that month), Jul\_Mean, Aug\_Mean, Sep\_Mean, Oct\_Mean, Nov\_Mean, Dec\_Mean, Jan\_Mean, Feb\_Mean, Mar\_Mean, Apr\_Mean, May\_Mean, Oct-Apr\_Max (average Oct-Apr maximum temperature), Oct-Apr\_Min (average Oct-Apr minimum temperature), October\_to\_April\_Mean (average Oct-Apr mean temperature), An\_Max (average annual maximum temperature), An\_Min (average annual minimum temperature), Annual\_Mean (average annual mean temperature), Jan\_rain (Total rainfall for that month mm), Feb\_rain, Mar\_rain, Apr\_rain, May\_rain, Jun\_rain, Jul\_rain, Aug\_rain, Sep\_rain, Oct\_rain, Nov\_rain, Dec\_rain, An\_rain (total annual rain), Jan\_F (total frost days for that month), Feb\_F, Mar\_F, Apr\_F, May\_F, Jun\_F, Jul\_F, Aug\_F, Sep\_F, Oct\_F, Nov\_F, Dec\_F, January\_to\_April\_temp (average mean Jan-Apr temperature ˚C), January\_to\_April\_frost (Total number of frost days Jan-Apr).
* Missing data codes: NA
* Description: The flowering times (in Julian days) of 12 different pear cultivars from 2 different sites (East Malling and Brogdale in Kent) from 1960-2020. This includes data for full (when 50% of flowers are open on the pear tree) phenological stage, used for the GAMM, LMM and PCA models within the paper. Weather data has also been collated from Met Office records from Faversham and East Malling weather stations. Weather variables calculated include mean, maximum and minimum (˚C) temperatures for each month (with May-Dec months from the previous year), average annual temperatures and Jan-Apr temperatures, total rainfall for each month (mm) and total frost days for each month.
1. Last\_flowering.csv
* 78 variables, 918 rows.
* Cultivar.name (the pear cultivar), Date, Year (1960-2020), Month, Day, Period (last flowering stage), Site (Brogdale or East Malling), JDay (flowering time in Julian days), Cultivar.no (cultivar number 1-12, based on name), Jun\_Max (average maximum temperature for that month ˚C), Jul\_Max, Aug\_Max, Sep\_Max, Oct\_Max, Nov\_Max, Dec\_Max, Jan\_Max, Feb\_Max, Mar\_Max, Apr\_Max, May\_Max, Jun\_Min (average minimum temperature for that month ˚C), Jul\_Min, Aug\_Min, Sep\_Min, Oct\_Min, Nov\_Min, Dec\_Min, Jan\_Min, Feb\_Min, Mar\_Min, Apr\_Min, May\_Min, Jun\_Mean (average mean temperature for that month), Jul\_Mean, Aug\_Mean, Sep\_Mean, Oct\_Mean, Nov\_Mean, Dec\_Mean, Jan\_Mean, Feb\_Mean, Mar\_Mean, Apr\_Mean, May\_Mean, Oct-Apr\_Max (average Oct-Apr maximum temperature), Oct-Apr\_Min (average Oct-Apr minimum temperature), October\_to\_April\_Mean (average Oct-Apr mean temperature), An\_Max (average annual maximum temperature), An\_Min (average annual minimum temperature), Annual\_Mean (average annual mean temperature), Jan\_rain (Total rainfall for that month mm), Feb\_rain, Mar\_rain, Apr\_rain, May\_rain, Jun\_rain, Jul\_rain , Aug\_rain, Sep\_rain, Oct\_rain, Nov\_rain, Dec\_rain, An\_rain (total annual rain), Jan\_F (total frost days for that month), Feb\_F, Mar\_F, Apr\_F, May\_F, Jun\_F, Jul\_F, Aug\_F, Sep\_F, Oct\_F, Nov\_F, Dec\_F, January\_to\_April\_temp (average mean Jan-Apr temperature ˚C), January\_to\_April\_frost (Total number of frost days Jan-Apr).
* Missing data codes: NA
* Description: The flowering times (in Julian days) of 12 different pear cultivars from 2 different sites (East Malling and Brogdale in Kent) from 1960-2020. This includes data for last (when 90% of petals have fallen) phenological stage, used for the GAMM, LMM and PCA models within the paper. Weather data has also been collated from Met Office records from Faversham and East Malling weather stations. Weather variables calculated include mean, maximum and minimum (˚C) temperatures for each month (with May-Dec months from the previous year), average annual temperatures and Jan-Apr temperatures, total rainfall for each month (mm) and total frost days for each month.

5. METHODS

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*Flowering data*

Phenological data on pear flowering were collected for the following metrics:

* first (first flower opens on a tree or flower’s anthers are visible),
* ten percent (when 10% of flowers are open on the tree),
* full (when 50% of flowers have opened on the tree), and
* last (90% of petals have fallen)

These data were collected at two sites; from 1960-2020 at NIAB EMR (formerly East Malling Research, 51.2885° N, 0.4383° E) and 1960-2019 at the Brogdale Collection (51.3007° N, 0.8762° E). Full and last flowering was recorded at both sites in the South-East of England, first flowering was only recorded in East Malling for 2 cultivars, whilst ten percent flowering was recorded at Brogdale for all cultivars. Phenological data was collated for twelve standard pear cultivars (cv.) including: Beurre Hardy LA (BH), Beurre Superfin (BS), Clapp's Favourite (CF), Conference (Con), Doyenne du Comice (DC), Durondeau LA (Du), Glou Morceau LA (GM), Louise Bonne of Jersey (LB), Nouveau Poiteau LA (NP), Packham's Triumph (PT), Precoce de Trevoux (PdT) and Williams' Bon-Chretien (WB). Dates of when each of the four phenological stages were converted into Julian days before being analysed.

*Weather data*

To analyse flowering phenology weather data (1959-2020) from the East Malling weather station (51.288° N, 0.448° E) in Kent were used for pear data from NIAM EMR. For Brogdale flowering phenology, Faversham (51.297° N, 0.878° E) weather data were used. The following weather data were collated from Met Office MIDAS database (MetOffice, 2021): daily maximum and minimum temperature data and daily rainfall from East Malling. Daily maximum and minimum temperature data and daily rainfall from Faversham. Mean temperatures were calculated from an average of maximum and minimum temperatures. Frost days were calculated by summing the number of days where the daily minimum temperature was below zero. Monthly mean, maximum and minimum temperatures, Frost days for each month (Oct-Dec and Jan-May) were calculated and total rainfall for each month were calculated, for use within the PCA analysis.

*Future emissions scenarios*

For historical and current temperature data, mean January to April temperatures were calculated from 1960-2020, using data from East Malling (51.288° N, 0.448° E) and Faversham (51.297° N, 0.878° E). To calculate future temperature scenarios for 2080, data was extracted using the UK Climate Projections User Interface (UKCP, 2021). The predicted increase in mean air temperature at 1.5m for 2080 was calculated for January to April (baseline scenario 1981-2000) for a 25 km-by-25 km region in Kent, surrounding East Malling (562500.00, 162500.00), these temperatures were calculated for each of the four RCP scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5.) and added to the average 1981-2000 January-April temperature (6.30˚C).

For historical frost day data, total frost days from January to April were calculated from 1960-2020, using data from East Malling (51.288° N, 0.448° E) and Faversham (51.297° N, 0.878° E). Frost days were calculated by totalling the number of days where the daily minimum temperature was below 0 ˚C. Future frost day scenarios were calculated for 2080 for RCP2.6 (low emissions) and RCP8.5 (high emissions) scenarios. Daily minimum temperature data for 2080 was extracted using the UK Climate Projections User Interface for a 60 km-by-60 km region in Kent. Frost days were calculated by summing the number of days where the minimum temperature was below 0 ˚C. RCP4.5 and RCP6.0 future frost day scenarios could not be calculated as minimum daily temperatures for these two scenarios were not available from the UK Climate Projections User Interface.

References:

MetOffice. (2021). Met Office MIDAS Open: UK Land Surface Stations Data (1853-current). Retrieved from <https://data.ceda.ac.uk/badc/ukmo-midas-open/data>

UKCP. (2021). UK Climate Projections User Interface Data: Anomalies for probabilistic projections (25km) over UK, 1961-2100. Retrieved from <https://ukclimateprojections-ui.metoffice.gov.uk/products/form/LS1_Sample_01>