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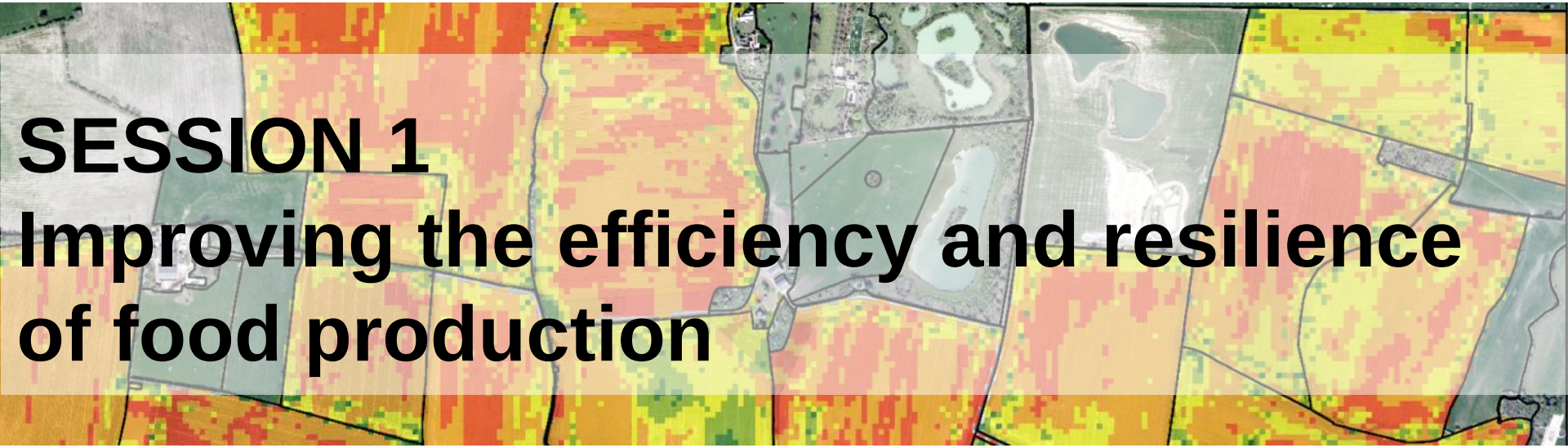

SESSION 1
Improving the efficiency and resilience of food production

UK Centre for Ecology & Hydrology

ROTHAMSTED RESEARCH

BGS British Geological Survey

Chair: Jonathan Storkey

funded by

UKRI Natural Environment Research Council

UKRI Biotechnology and Biological Sciences Research Council

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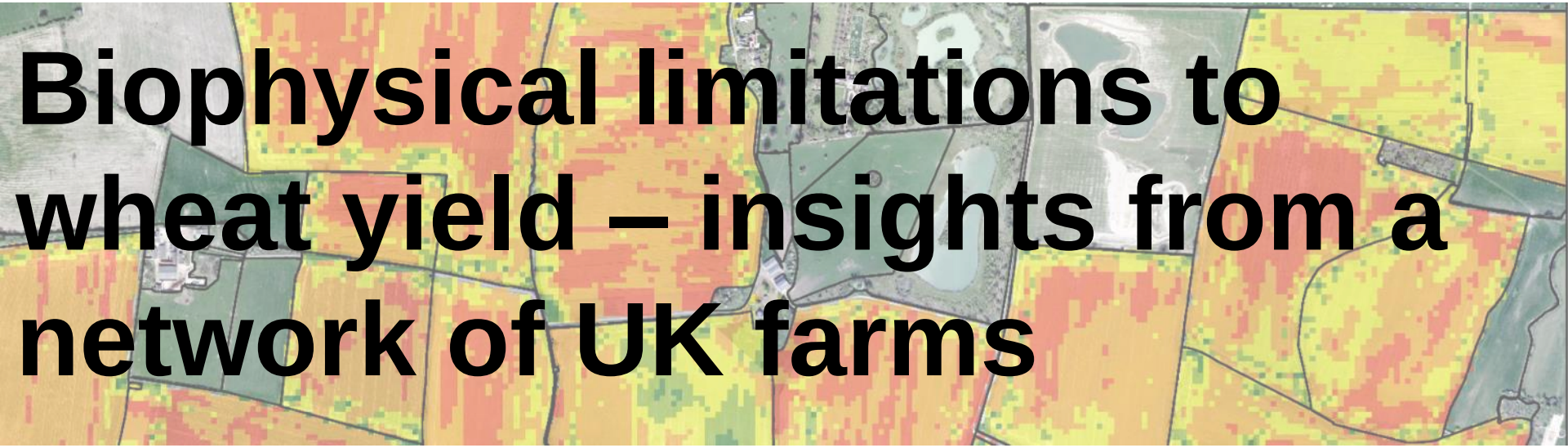


Biophysical limitations to wheat yield – insights from a network of UK farms

UK Centre for Ecology & Hydrology

ROTHAMSTED RESEARCH

BGS British Geological Survey

Ian Shield, Richard Whalley, Dan Morton

funded by

UKRI Natural Environment Research Council

UKRI Biotechnology and Biological Sciences Research Council

What explains variation in yield at different scales?

Farms chosen from 4 “regions” drawn on a map of the UK based upon different landscapes contained within.

Scotland

North Yorkshire

West Midlands

South East England

Harvest years 2018 – 21

Two fields per farm, a consistent strong and a less good performer

46 fields of autumn sown wheat

3 time points per crop, spring, post anthesis & harvest

10 – 12 sample points per field

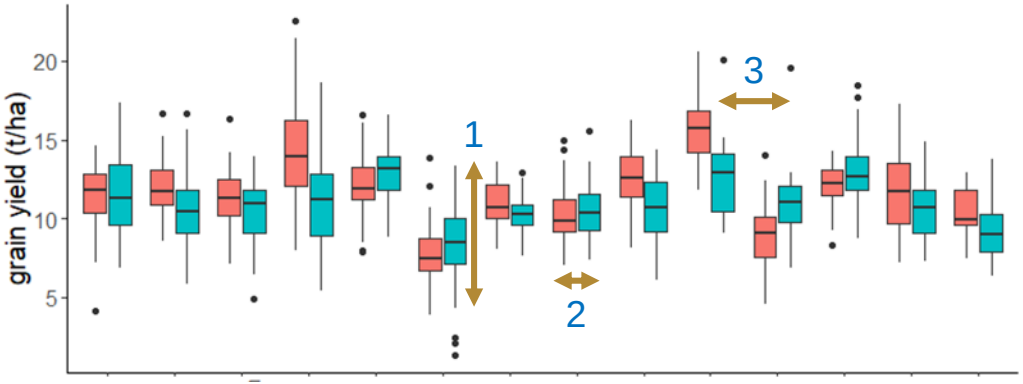
49 soil and crop factors

> 26,000 data points generated.

Expect the unexpected

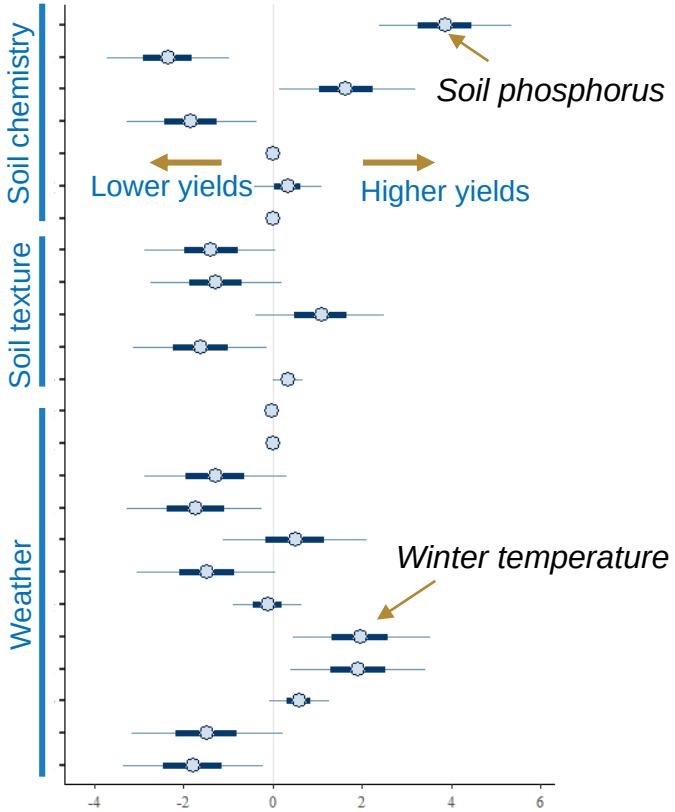
Field scale analysis

- Data can be analysed at different scales:

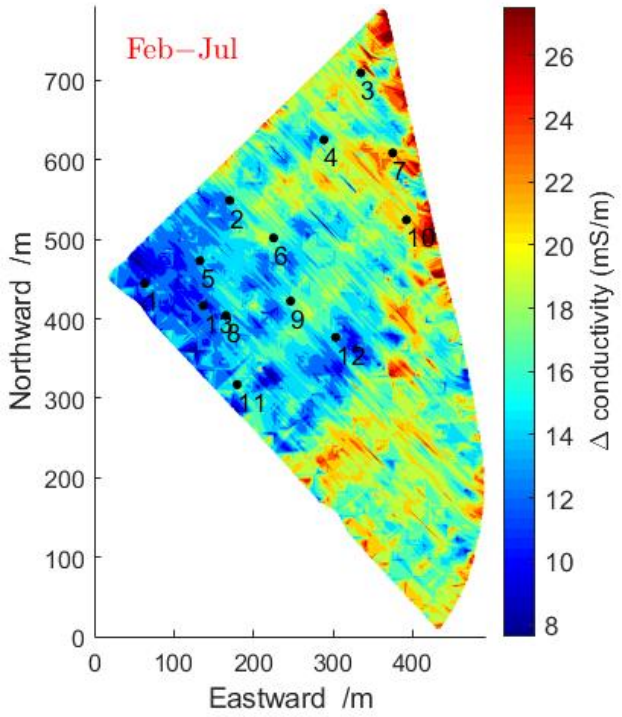


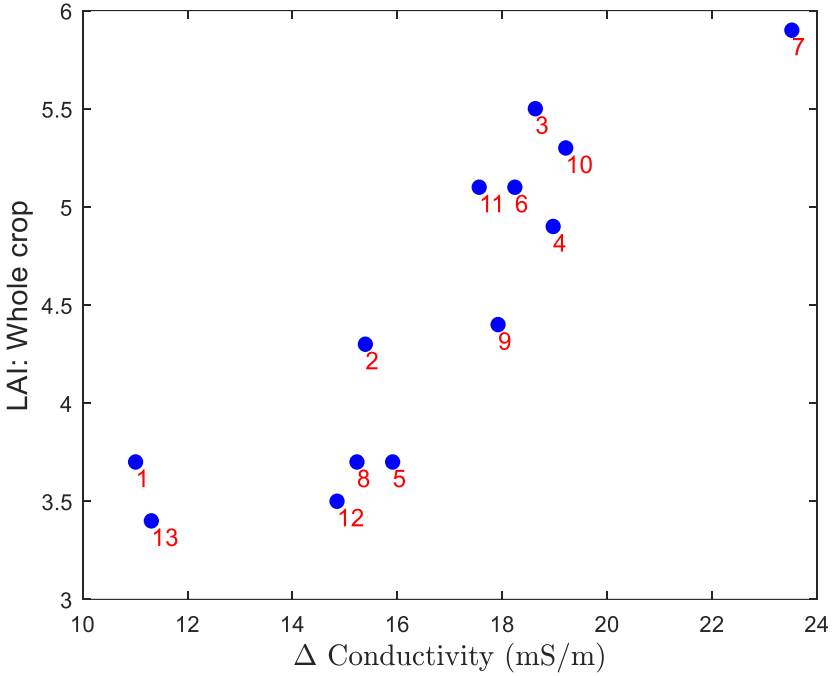
1. Within field
2. Between fields
3. Between farms

Example of *between field* analysis



Within field analysis using Electromagnetic induction (EMI)





Acknowledgements

18 different farms opened their gates and allowed us to roam all over their wheat fields.

Peter Fruen, Tim Barraclough & William Macalpine worked through some of the hottest (including spring) days of the last 4 years to collect these data.

Ho-Chul Shin processed multiple maps from electrical conductivity surveys.

Andrew Mead, Suzanne Clark & John Addy are frantically working their way through the statistical analysis of the data

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Soil moisture and groundwater dynamics and their impact on wheat yield

Photo: N. Archer

UK Centre for Ecology & Hydrology

ROTHAMSTED RESEARCH

BGS British Geological Survey

A. Tye, S. Collins, A. Moir, N. Archer, B. Marchant

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UKRI Natural Environment Research Council

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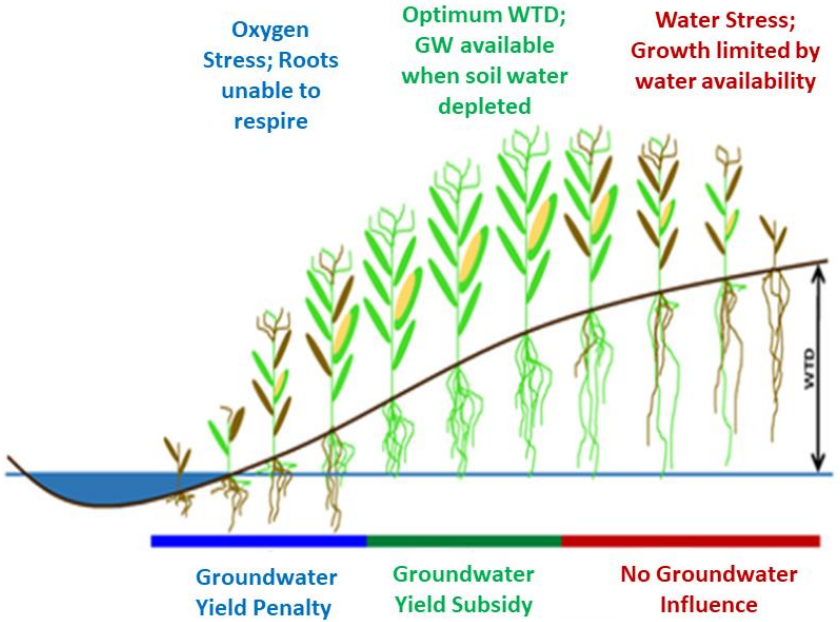
Addressing the wheat yield gap

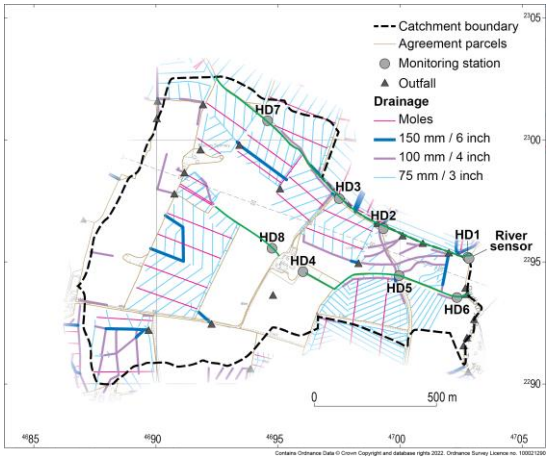
- With good agronomic practice main variable for yield variability is the growing season weather
- Changing climate – effects of ‘heat’ and ‘wetness’
- Understanding soil-crop systems key to consistently achieve ‘attainable yields’ and climate resilience
- On a clay, drained catchment, representative of the southern England wheat belt, we ask:

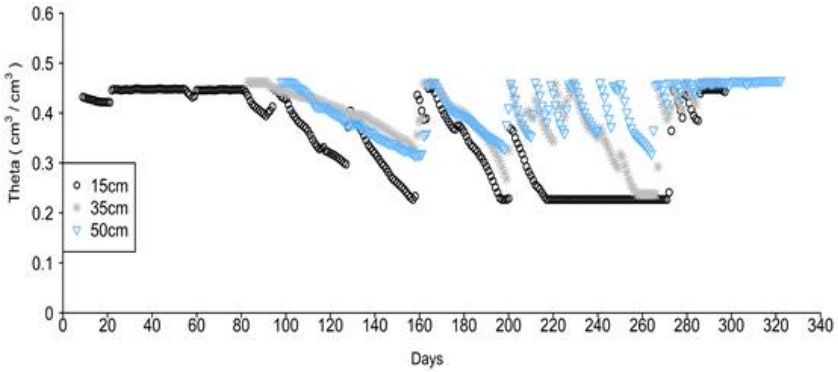
- **Where does resilience and weakness lie in such a soil-crop system?**
- **What are the controls on soil moisture?**
- **Is there a shallow groundwater influence on wheat yield?**
- **Hypothesis 1: Too much autumn rain limits yield (low areas)**
- **Hypothesis 2: That too little spring rain will limit yield (high areas).**



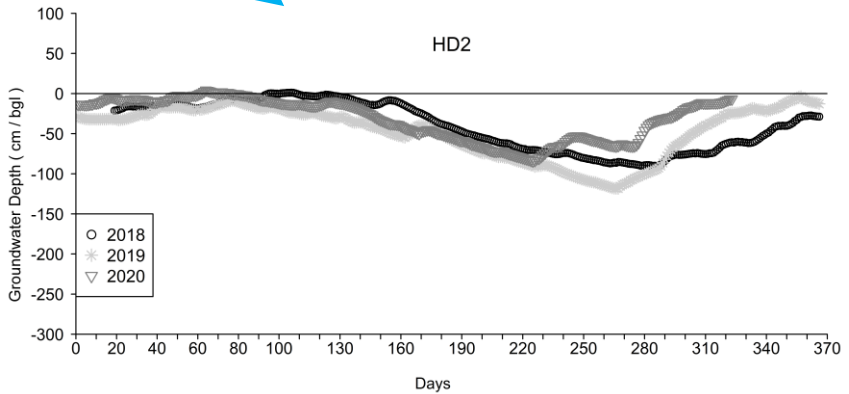
Our site

- 60ha arable catchment in Buckinghamshire
- 8 soil moisture and groundwater monitoring sites
- Digitised drainage network for inclusion in groundwater model
- Heavy cracking clays (Denchworth/Hanslope soils), drained



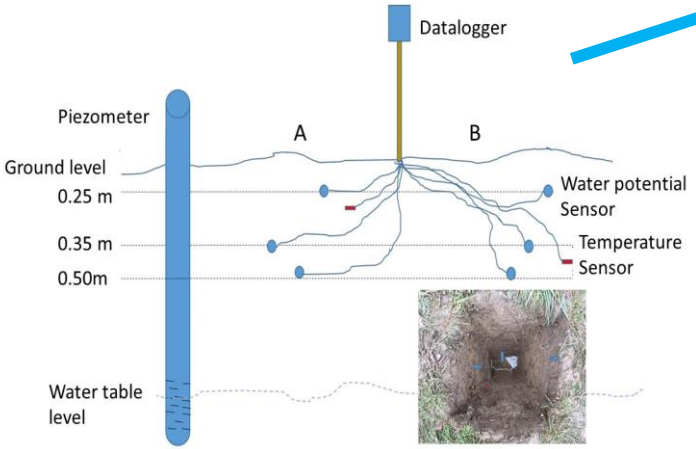


Soil Moisture HD2

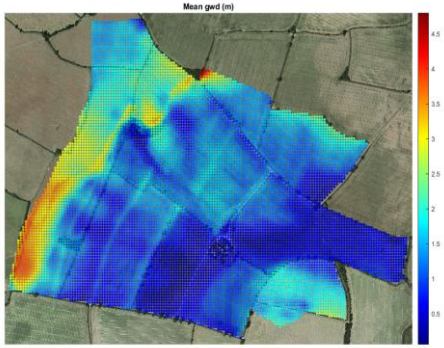


Groundwater HD2

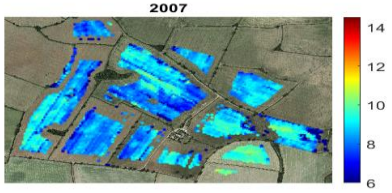
Yield Modelling



Groundwater Model Predictions (ModFlow)

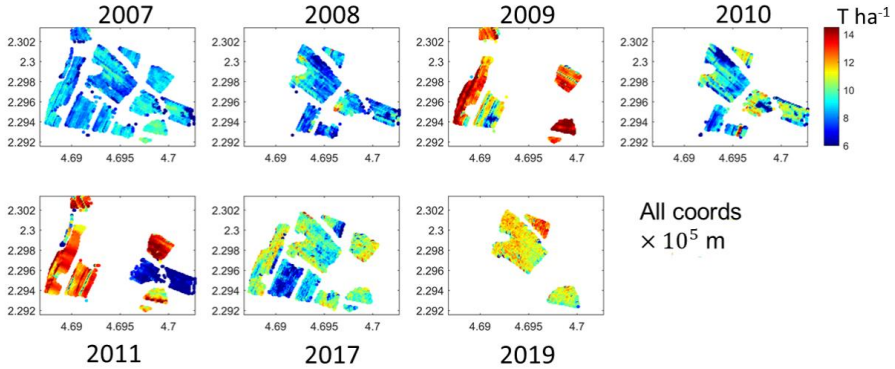


Combine Yield mapping

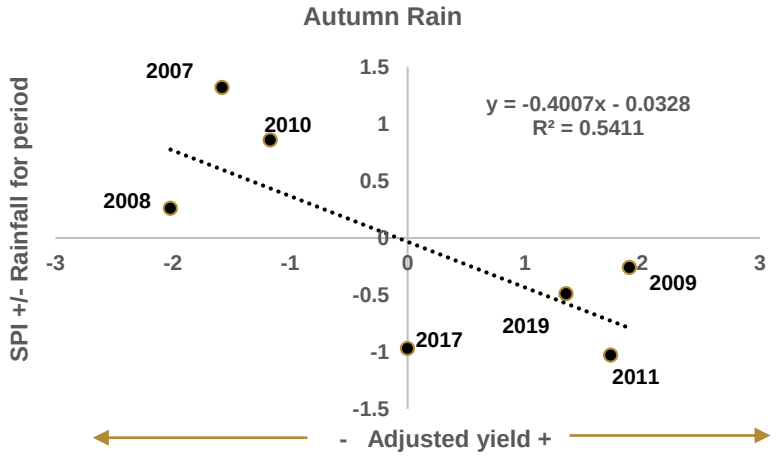


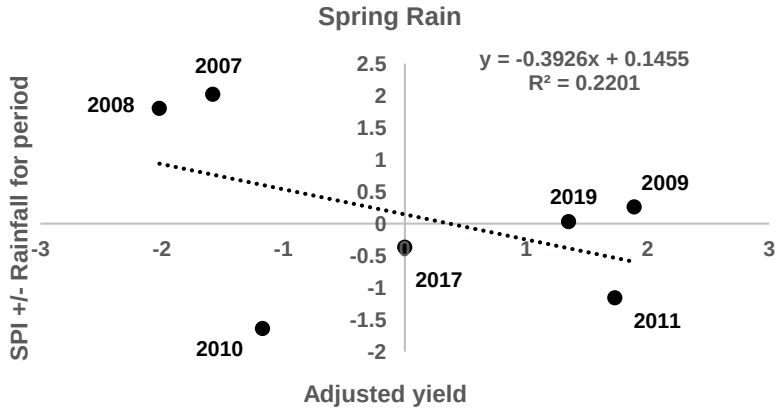
Statistical analysis of crop yield

Yield Influences



- **Autumn (Sep, Oct, Nov); Spring (Apr, May, Jun)**
- **Within a season some evidence that excess moisture in low areas of fields may limit yield**
- **Between season variation is larger**
- **Some evidence that larger autumnal rains may limit the establishment of seedlings and then yield (up to 20 % reduction). No evidence that small spring rainfall is limiting yield.**





Unpublished results

Resilience (R) & Weakness (W)

- Key finding is that temporal (yearly) variation in yield is found and some yield loss appears to be related to wet periods in autumn (W)
- In dry years there is no evidence of a yield benefit where wheat roots access shallow groundwater (W)
  – maybe due to root length of new cultivars
- Cracking clays allow adequate soil moisture recharge in a ‘regular’ summer - slightly dryer conditions improve yield (R)
- Drainage system ensures yearly patterns of soil moisture and groundwater are fairly similar (R)
- Impacts of drought unknown. No wheat grown 2018. However UK average ~10-20 % loss for 2018 which is comparable to wet autumn
- Relatively small unstructured yield dataset but of a real farming system
- Things to consider - cultivars, other soil types

Acknowledgements

We would like to thank Andy Butcher and Barry Townend for installation of the monitoring system, & the Hillesden Estate for accommodating us

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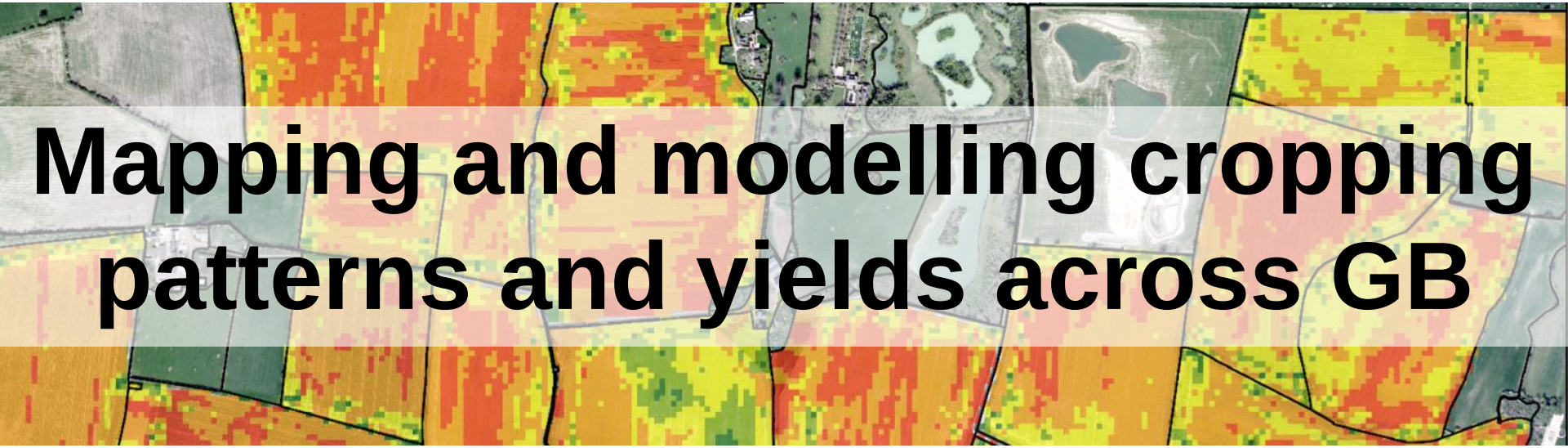


Mapping and modelling cropping patterns and yields across GB

UK Centre for Ecology & Hydrology

ROTHAMSTED RESEARCH

BGS British Geological Survey

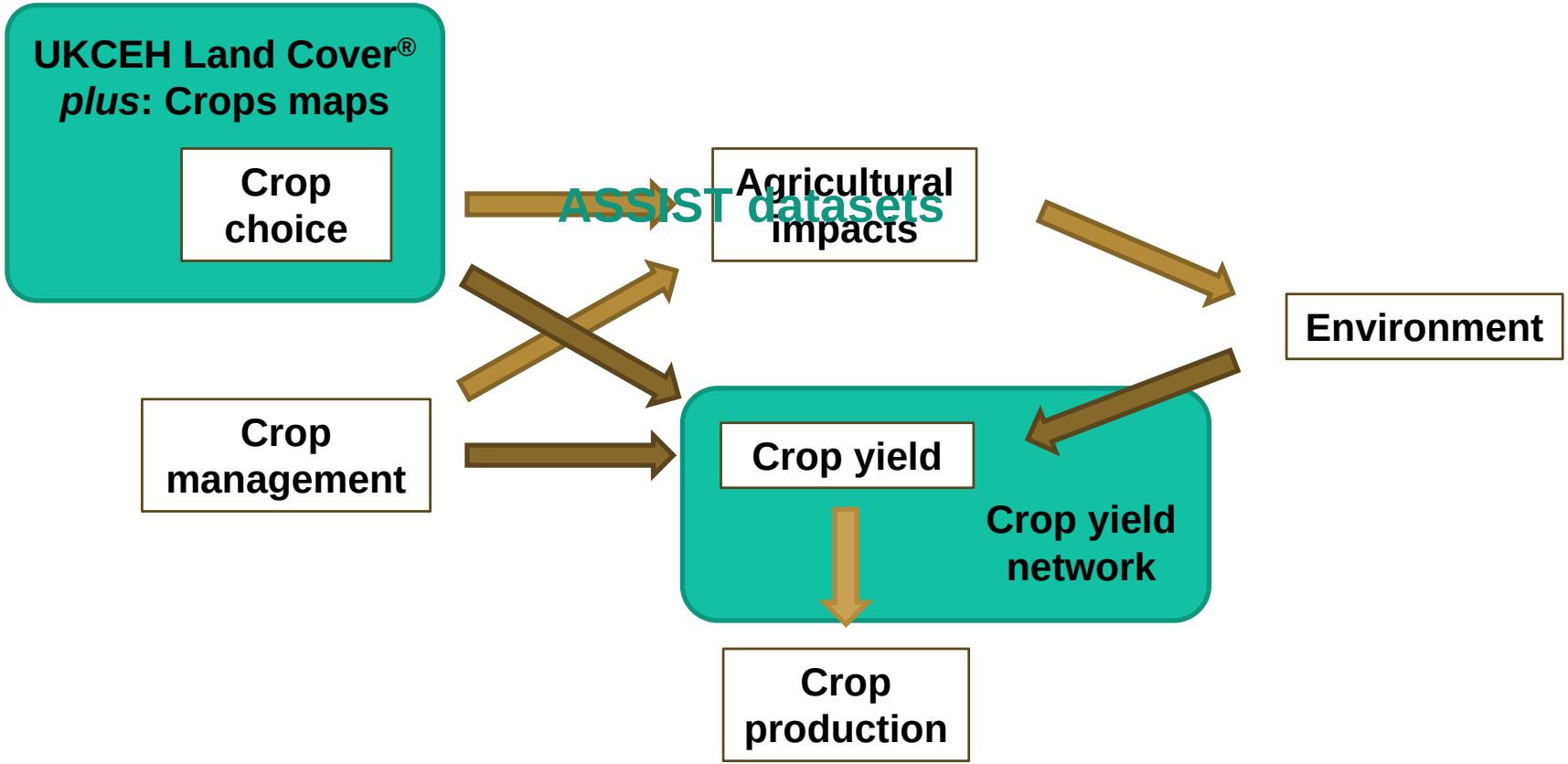
Emily Upcott, John Redhead, Will Fincham, Dan Morton, Richard Pywell

funded by

UKRI Natural Environment Research Council

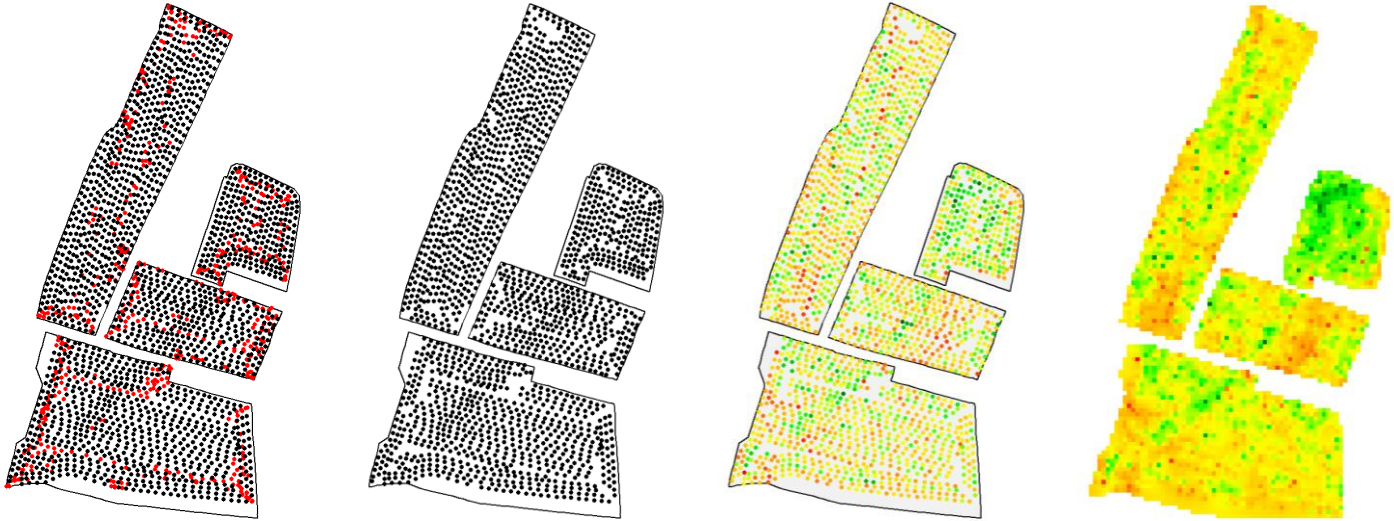
UKRI Biotechnology and Biological Sciences Research Council

Why crops?


UKCEH Land Cover®
plus: Crops maps
Crop choice
ASSIST datasets
Agricultural impacts
Environment
Crop management
Crop yield
Crop yield network
Crop production

ASSIST data: crop yields

18 crop types



Precision yield monitors collect fine-scale data

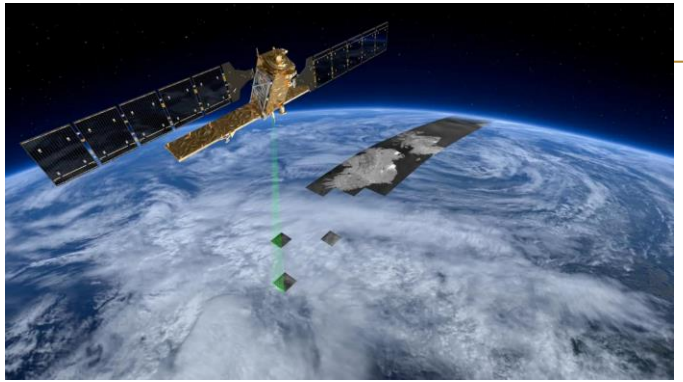
Data cleaned to remove anomalies & artefacts

Extract yield values

Values smoothed across field

Network of 1950 fields

ASSIST data: crop maps



- UKCEH Land Cover® *plus*: Crops is the first GB-wide field-level crop map
- Produced by UKCEH and RSAC, every year since 2015
- Sentinel 1 & 2 backscatter/optical data
- < 2 million fields in Great Britain
- 10-15 crop types classified and verified

Unravelling nationwide issues…

2020: unfavourable weather at critical times

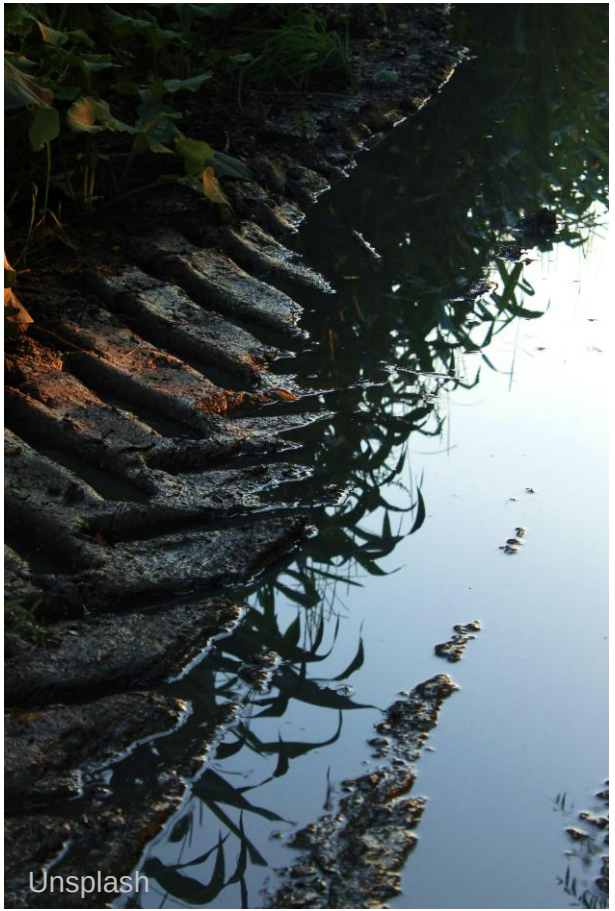
Agronomist & Arable Farmer | High-tech data confirm record poor harvest after year of extreme weather: UK Centre for Ecology & Hydrology

FARMERS WEEKLY Harvest 2020: Grain yields show biggest fall for 20 years

Farminguk **Data confirms record poor harvest after volatile weather**

THE TIMES Great grapes do little to soothe farmers' wrath

- Crop yields down 10-20% from crops in same fields in previous years
- Areas sown with winter crops down by ~40%



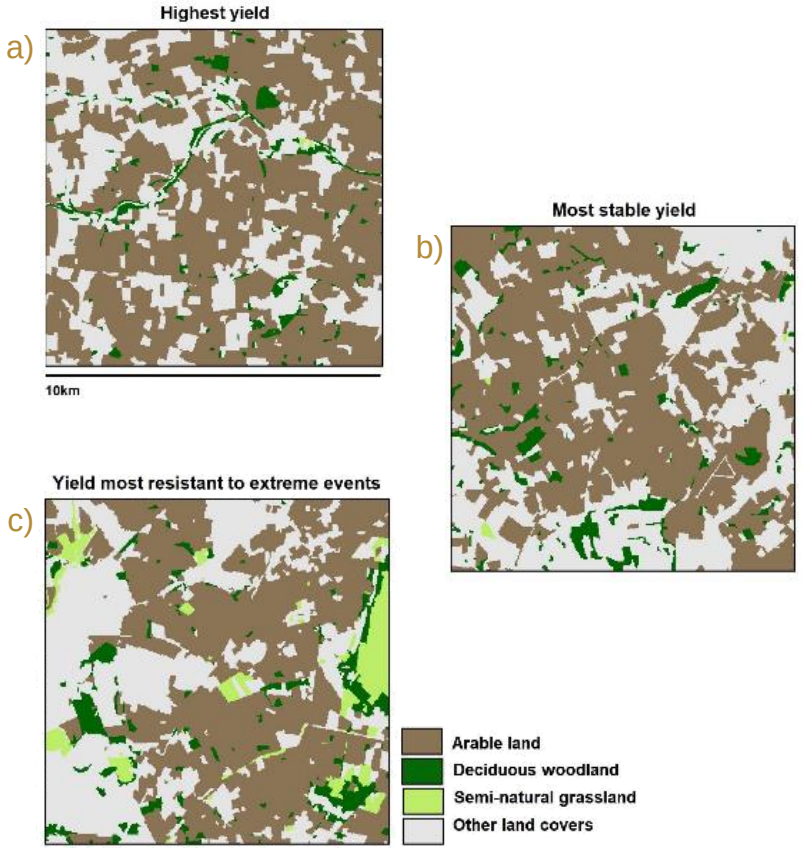
…and suggesting sustainable solutions

Yield resilience & wider landscape

a) **Relative yield** is highest in landscapes with most agricultural land

b) But **yield stability** is higher when agricultural land is combined with semi-natural habitats

c) And **yield resistance to extreme years** is highest in landscapes with high % cover of and proximity to semi-natural habitats

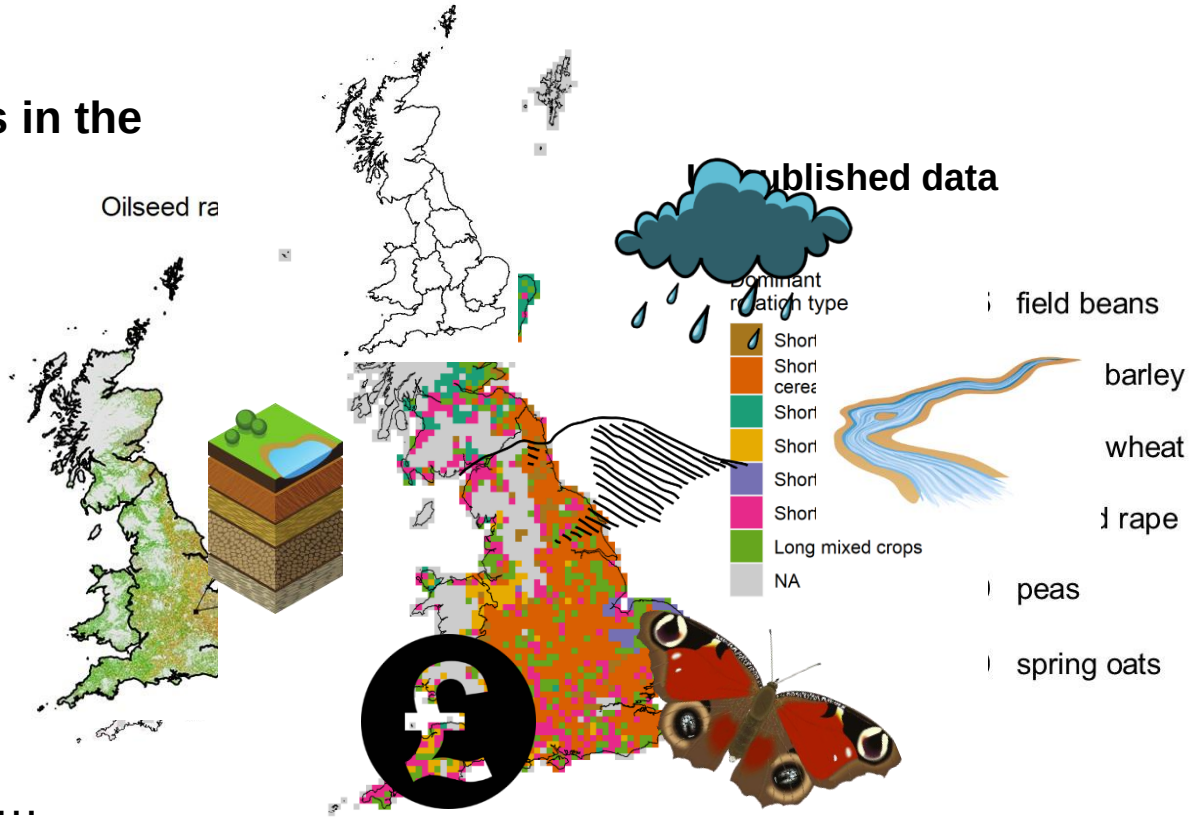


Redhead, J.W., Oliver, T.H., Woodcock, B. A. & Pywell, RF. (2020) The influence of landscape composition and configuration on crop yield resilience. Journal of Applied Ecology, doi.org/10.1111/1365-2664.13722

Cropping patterns

Crop maps: cropping patterns in the landscape

- Cropping stability
- Crop sequences → rotations
- Rotation types, predictions
- Combine with other datasets…



www.ceh.ac.uk/news-and-media/blogs/what-we-can-learn-several-years-uk-crop-map-data

Acknowledgements

Thanks go to:

- *All the farmers who permitted us to use their yield data*
- *Ian Knapper (Defra) for arranging access to yield data*
- *Pete Henrys and Susan Jarvis (UKCEH) for their involvement in our crop rotations work*

funded by Biotechnology and Biological Sciences Research Council, Natural Environment Research Council