

Crop-NET: Predicting the Effects of Climate Change on Crop Yields

Richard Pywell, UKCEH
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UK Research
and Innovation



UK Centre for
Ecology & Hydrology



ROTHAMSTED
RESEARCH





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Met Office, Defra, AHDB, NFU, AIC, NE, Syngenta, AGR11, Strutt & Parker, LEAF, farmers, agronomists, business advisors)

Hitting the headlines

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Harvest 2020: Grain yields show biggest fall for 20 years



© Tim Scrivener

Grain yields from 100 large arable farms across England were down the biggest drop in yields seen for 20 years.

This snapshot of harvest comes from the UK Centre for Ecology and high-tech sensors on the combines of this group of farmers.

The decline was compared with a five-year average yield, and within t yields faired the worst, with a 20% drop, while winter wheat yields we 14% and winter barley 10% less.

Richard Pywell, who led the work at the research institute, said this w assessment, as these are large-scale, well-mechanised farms, althou showed yields down by two-thirds.

"With a wet winter, many crops stood in wet soils, and were then hit b and a difficult time at harvest," he told *Farmers Weekly*.

See also: [Figures show massive changes in English cropping areas](#)

Great grapes do little to soothe farmers' wrath

Tom Knowles

It is news that will be of little consolation to British arable farmers after the worst harvest for at least 25 years.

The extreme weather that spoilt crops across the country has allowed vineyards to enjoy one of the best harvests for a generation.

Growers of wheat, rapeseed and barley have been devastated by torrential rain during the sowing season, a dry spring and then downpours last month. An analysis by the [UK Centre for Ecology and Hydrology](#) shows this has led to the worst harvest since comparable records began in 1995.

Satellite images of two million agricultural fields across Britain show a 40 per cent reduction in the areas planted with the higher-yielding and more profitable crops of wheat and oilseed rape compared with the previous five years. Torrential rain in February and early March affected the planting of spring-sown crops such as barley, reducing it by 37 per cent compared with the average over the past five years.

The same conditions have been perfect for vineyards. Frazer Thompson, chief executive of Chapel Wine in Tenterden, Kent, said: "In England, we always get the right weather for growing grapes, we just don't always get it in the right order. And this year, we've had it again in the right order."

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BUSINESS / FARMING

Harvest may be worst in 25

by Gemma Mackenzie

September 17, 2020, 10:23 am

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ANALYSIS

Worst harvest in years

British farmers have experienced the worst harvest for at least 25 years, according to the UK Centre for Ecology & Hydrology (UKCEH).

Analysis by the centre confirms reductions in both cropping area and yields following torrential rain at sowing time last autumn, an exceptionally dry spring, and heavy downpours last month.

On a Great Britain-wide basis, the area of autumn-sown crops was down 40% on the five-year average, and data

from combine harvesters suggests an average yield reduction of 15% for wheat, oilseed rape and barley. Scotland was the least affected area, with the wheat acreage down 11% and barley and oilseed rape down 4%.

"High investment by farmers in fertilisers, pesticides and machinery has generally ensured good yields in the past, but increasingly extreme weather makes it harder for them to make up the difference," said Dr William Fincham from UKCEH.

Data confirms record poor harvest after volatile weather

16 September 2020 | by FarmingUK Team | Arable, News, Renewables and

Environment



Weather blamed for UK's worst harvest in 25 years

By BRIAN HENDERSON

While some pockets of grain still remain to be combined in Scotland, scientific data has confirmed fears that, across the UK as a whole, farmers have had the worst harvest for at least 25 years, following four seasons of extreme weather.

Analyses by the UK Centre for Ecology & Hydrology (UKCEH) of satellite data from over two million fields revealed the extent of reductions in the amount of arable land sown with the major crops and also the yield at harvest. The fall comes after a triple whammy for farmers – torrential rain at crucial times hampered sowing of most types of crops, an exceptionally dry spring affected plant growth and heavy downpours in August created challenging harvesting conditions. Using data from satellites, the UKCEH found that there had been a dramatic reduction in the area planted with the traditional autumn sown crops of wheat and oilseed rape, largely due to the exceptionally wet autumn and winter resulting in saturated ground conditions.

Across Great Britain, the analysis showed there was a reduction of around 40 per cent in area of these crops, compared to the average for the previous five years, with some of the worst-hit areas of England seeing a drop of 70 per cent. Saturated ground caused by torrential rain in February and March also hampered the planting of the spring-sown crops such as barley.

Adding in real-time measurements from combine harvesters on over 500 fields showed that the actual yield at harvest for the wheat, oilseed rape and barley that was sown was down by an average of around 15 per cent, while some had fallen by two-thirds.

The extreme weather over several months has reduced both the quantity and quality of UK crops this harvest, hitting farmers' incomes – and UKCEH scientists and farming organisations have warned it could be increasingly difficult for producers to deal with the impacts of more frequent extreme weather events linked to climate change, with the past decade seeing more extreme wet and dry spells.

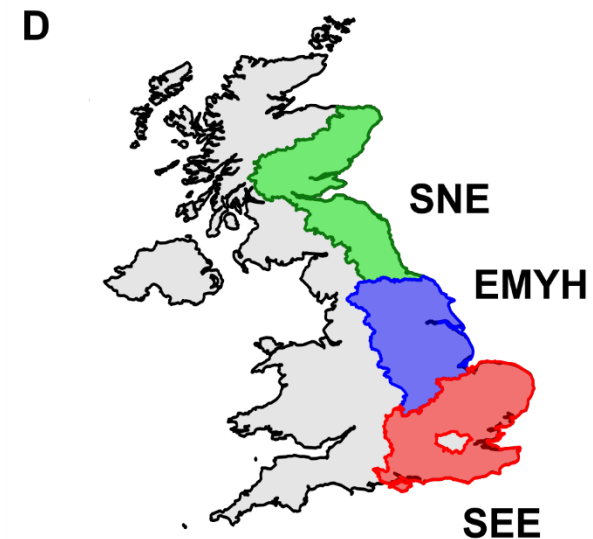
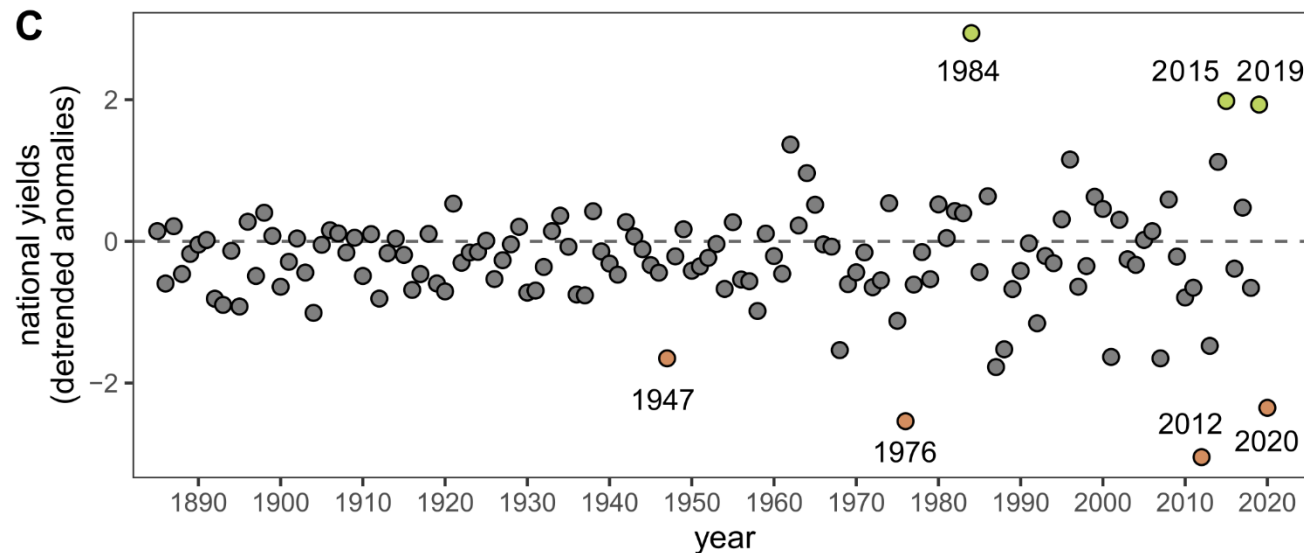
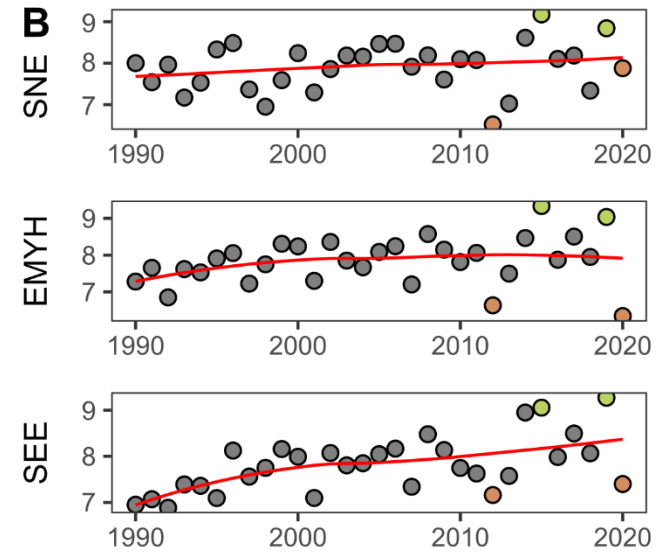
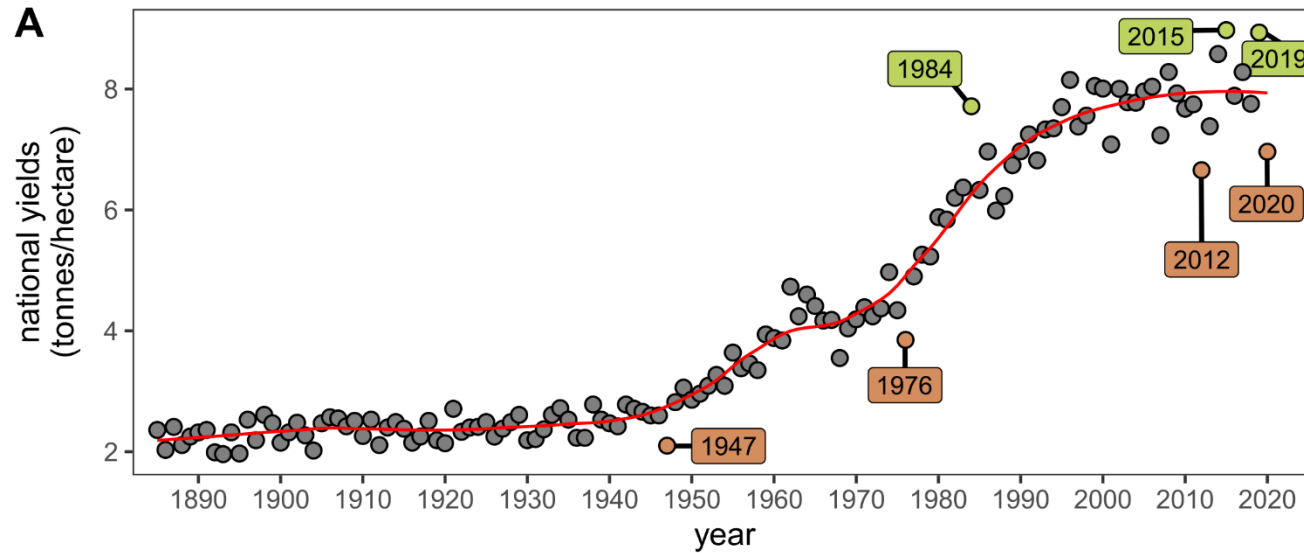
"It really has been a 'perfect storm' where British farmers have faced many challenges in the past few months due to the extreme weather, and the actual figures from this year's harvest confirm the widely predicted large falls in yields of most crop," said Dr William Fincham, who collated the crop yield data for UKCEH.

"High investment by farmers in fertilisers, pesticides and machinery has generally ensured good yields in the past, but increasingly extreme weather makes it harder for them to make up the difference. Farmers may need to widen the range of crops grown and change some agricultural practices in future to help spread the risk."

The centre's Professor Richard Pridmore said that modern sensor technology on satellites and combine harvesters helped provide an early warning of potential problems with the country's food supply, adding: "It also enables farmers to identify the areas of fields and farms where yields are less resilient to extreme weather and action should be taken."

bhenderson@farminguk.co.uk

Harvests becoming increasingly unpredictable



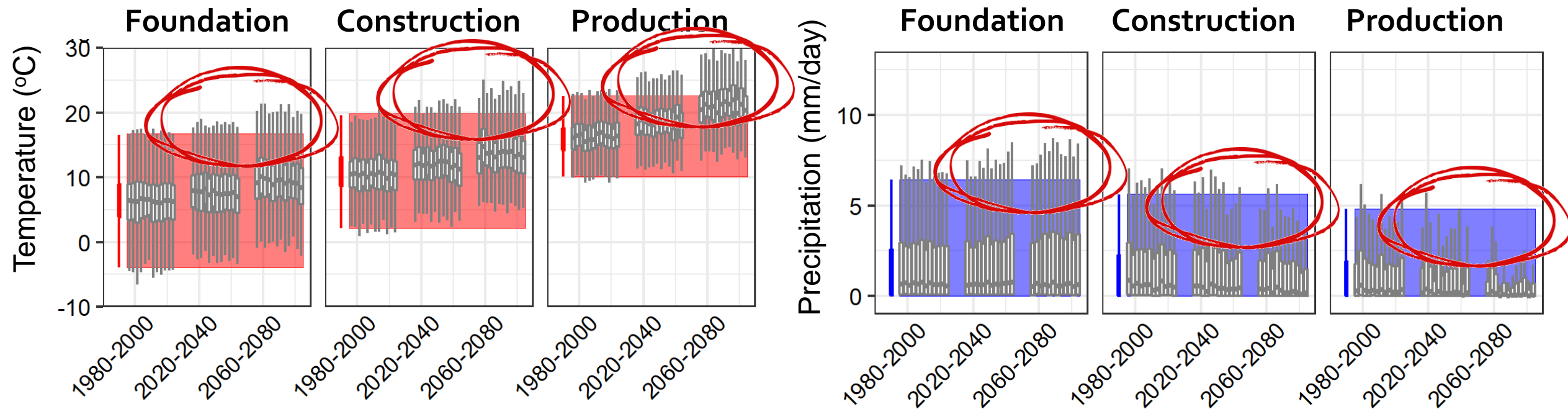
Projected climate for wheat growth phases South East

Observed range 1980-2000 = red/blue boxes

Grey box plots = UKCP18 projections 1980-2000; 2020-2040; 2060-2080

Hotter, drier summers

Milder, wetter winters



Project aims



1. Explore farmer and farm industry perceptions and responses to extreme weather and climate change
2. Co-design models and tools to support climate impact assessment and adaptation
3. Improve resilience of UK agriculture to climate change



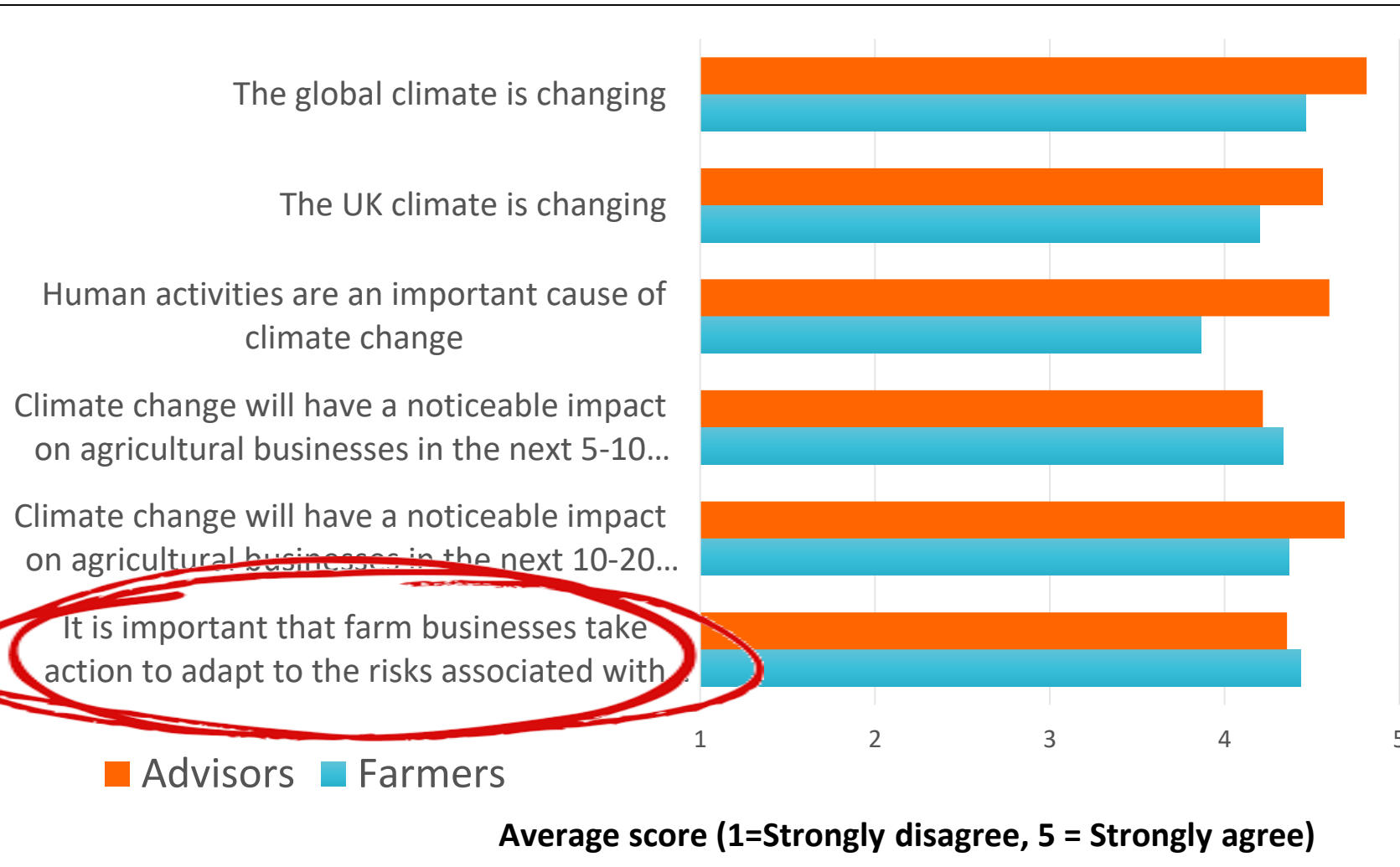
1. Farmer & stakeholder interviews



- **15 farmers**
- Type: Mix of arable and livestock
- Size: Predominantly large/very large farms
- Age: Younger than average farmers
- **16 farm advisors/other industry representatives**



Perception of climate risk to farming



- Consistent response btw farmers & stakeholders
- Strong agreement that climate change will impact businesses
- Adaptation is important

Adaptation strategies

Soil health

Farm
infrastructure

Crop & grass
varieties,
livestock breeds
etc.

Diversity in farm
business

Integrated pest
management

Forage
monitoring and
budgeting

Water capture &
storage

Agro-forestry,
intercropping &
shelter-belts

Future proofing
new machinery

Business
planning

Agroforestry



Image credit: Soil Association

Enabling adaptation

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- Holistic resilience
- Soil health, productivity
- Peer-to-peer learning
- Business planning
- Information, advice & support
- Decisions support tools



2. Stakeholder engagement / co-design

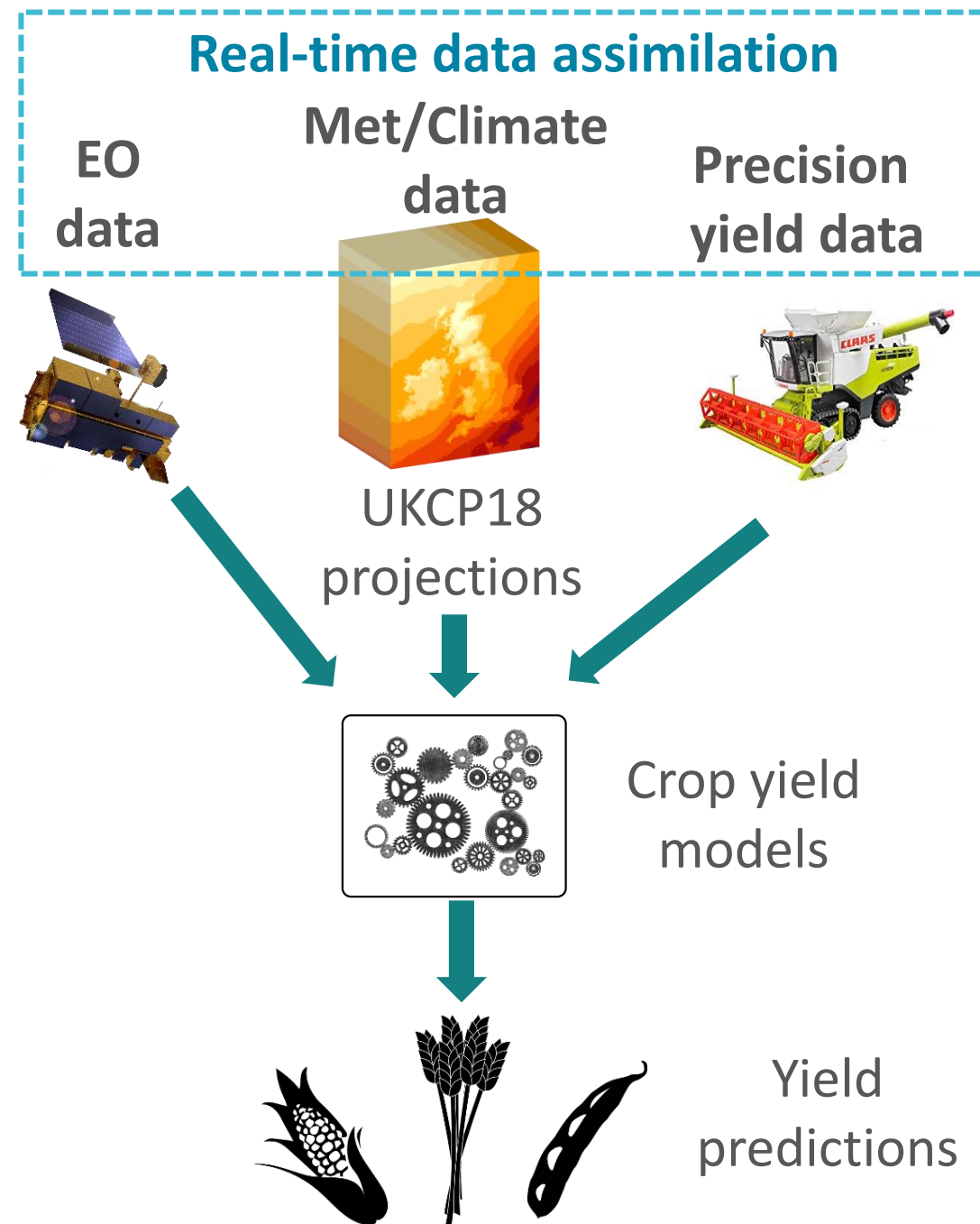


- Four stakeholder workshops to scope user requirements
- Farmers, advisors, industry, policy & NGOs
- Focused on arable & livestock
- Model/tool design:
 - *Simple to use*
 - *Specific to my fields/farm*
 - *Predict i) in year weather impacts; ii) longer-term climate impacts*
 - *Ability to self-learn*
 - *Benchmarking*
 - *Explore adaptation strategies*

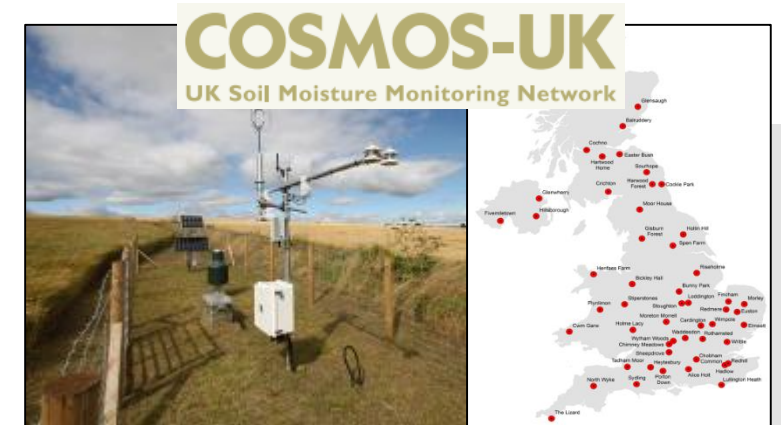
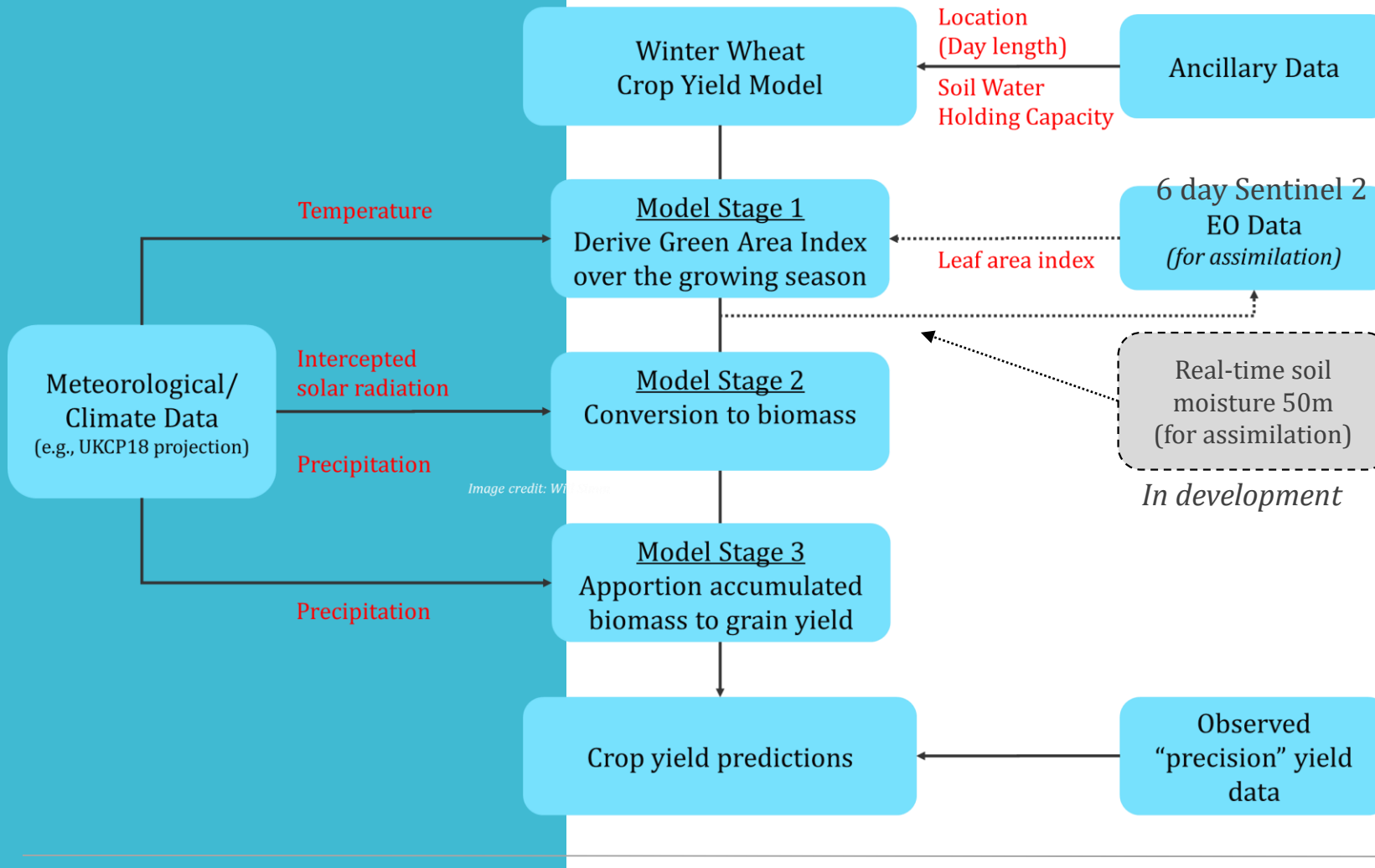


3. Crop-NET model & tools

- Assimilates real-time climate, EO & soil moisture
- Validated against measured yield data
- Bias-corrected UKCP18 data to predict climate risks/opportunities
- Predict future potential yields in any location in GB (2M+ fields)
- Models for Wheat, Oilseed Rape and Grass
- Utilises data labs on JASMIN HPC
- Opportunities for continuous model improvement (digital twins)

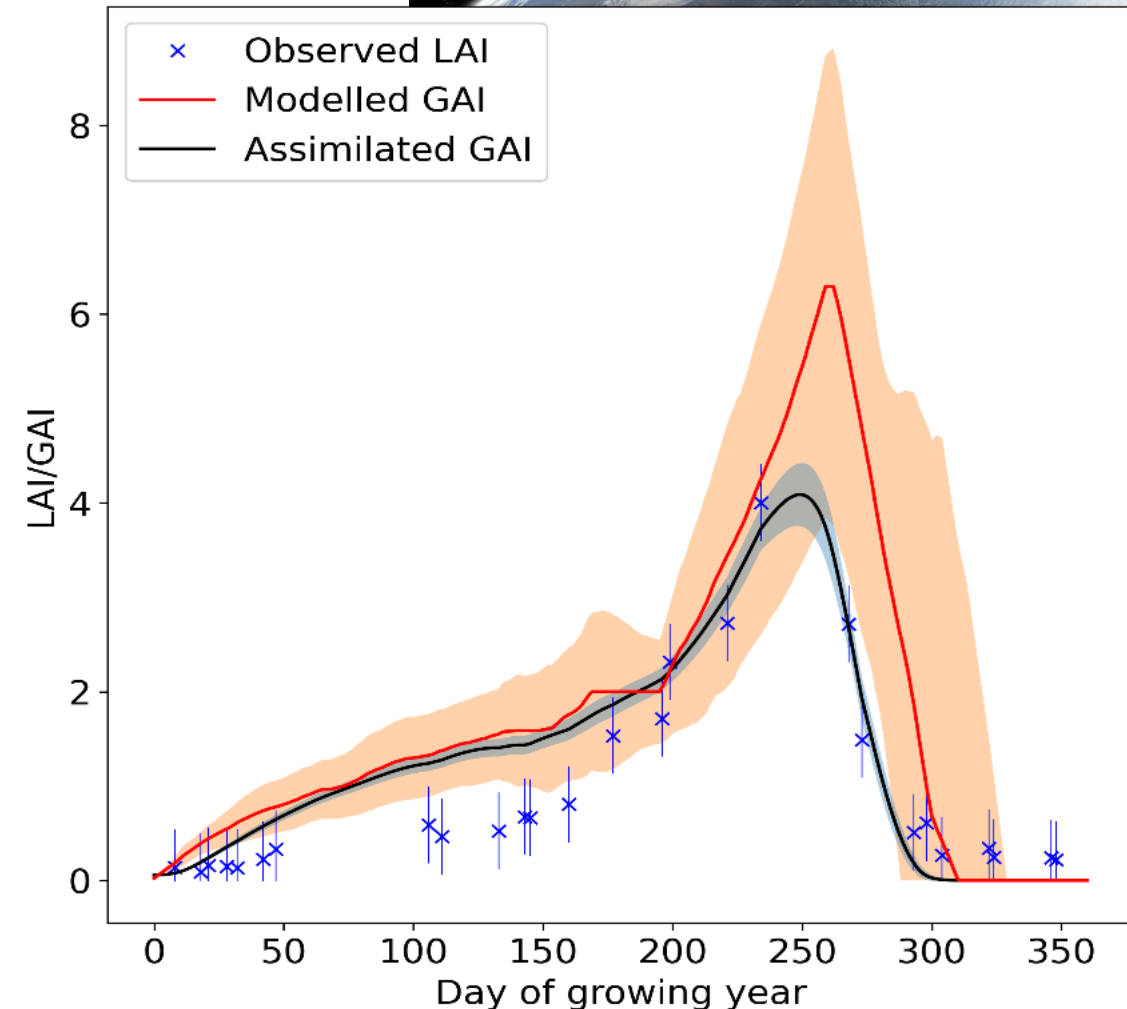
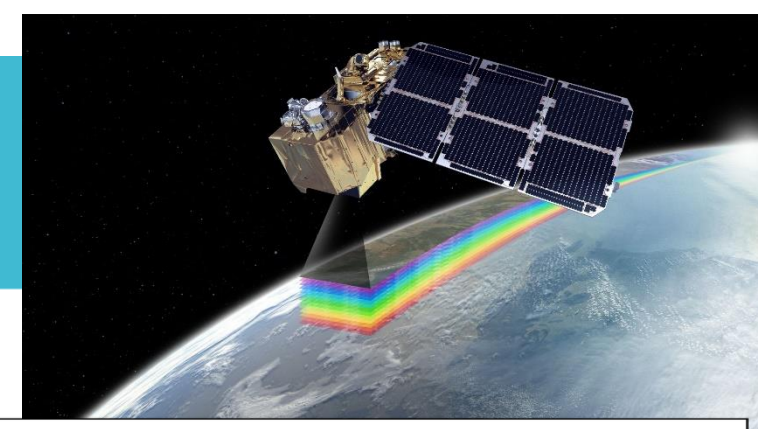


Model and Data Flows



EO data assimilation

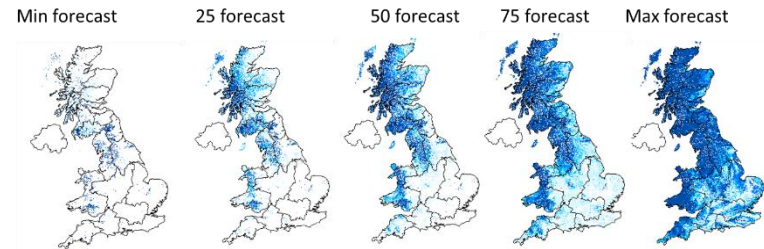
- EO can provide direct measurements of fPAR, GAI, soil moisture etc
- Crop-NET wheat model directly assimilates GAI
- Corrects potential yield to actual yield for individual 10×10m grid cell and fields



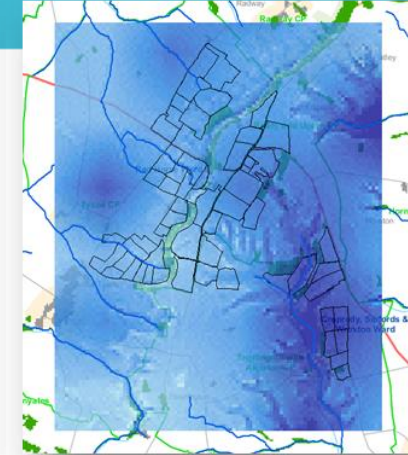
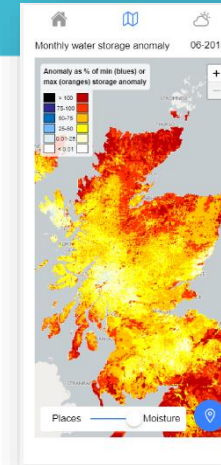
Soil moisture data assimilation

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Ongoing work to provide **wetness forecasts** on a smartphone **app** for **agricultural sector**

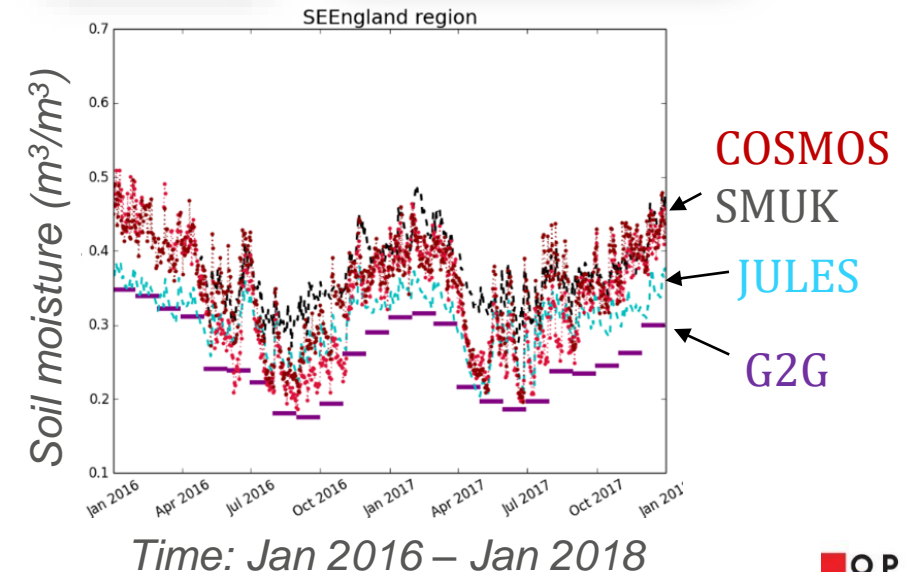


Forecasts of wetness over the next month

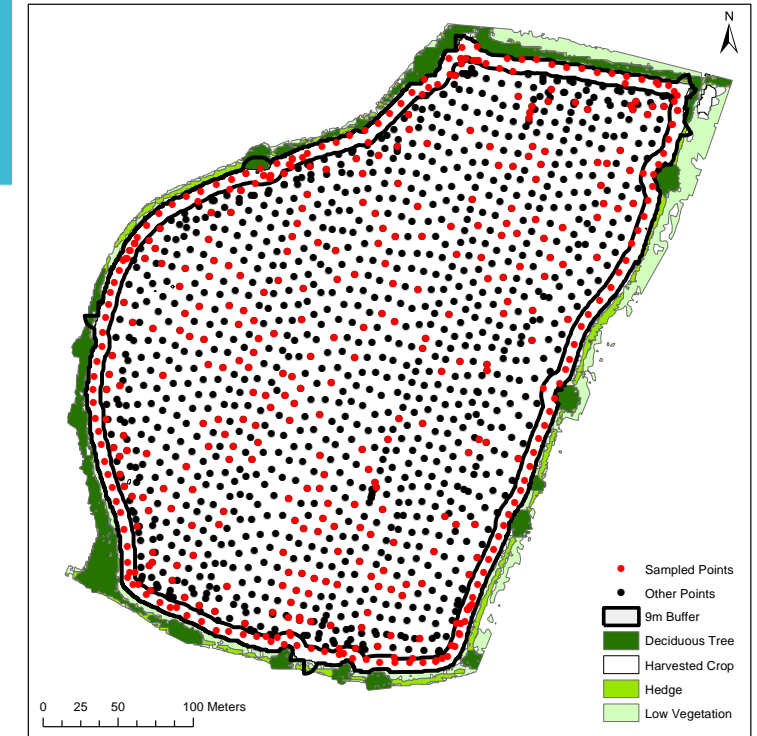
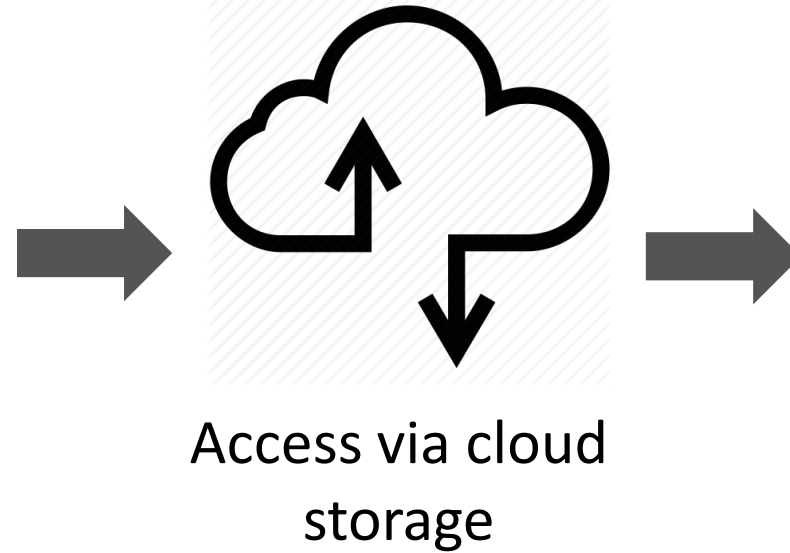
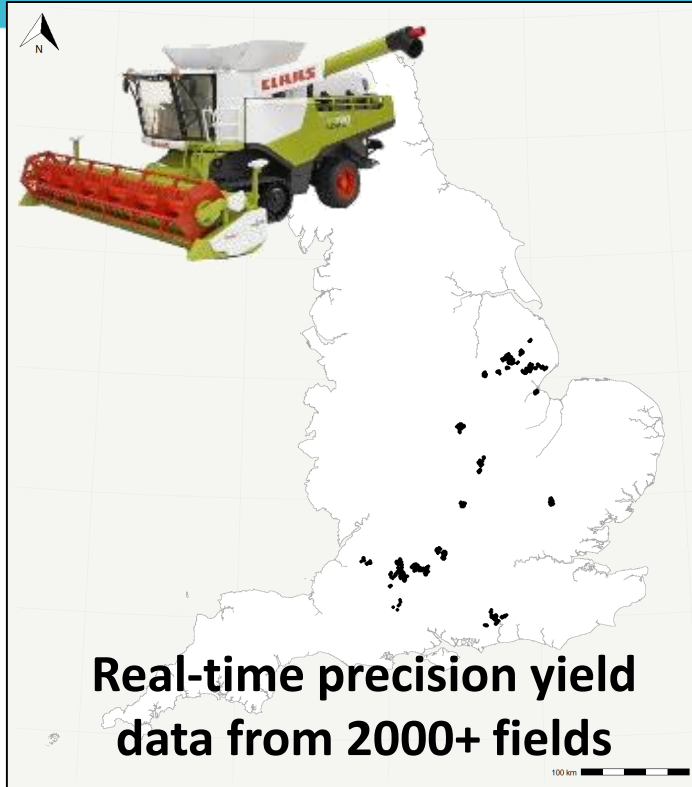


Downscaling
1km **soil-moisture** and
wetness maps
to a higher
(50m)
resolution.

Research groups across UKCEH are comparing **soil-moisture** estimates derived using various sources of information including COSMOS and statistical data to understand the differences



Precision yield data pipeline



Yield
mapping

Pattern
analysis

Early
warning

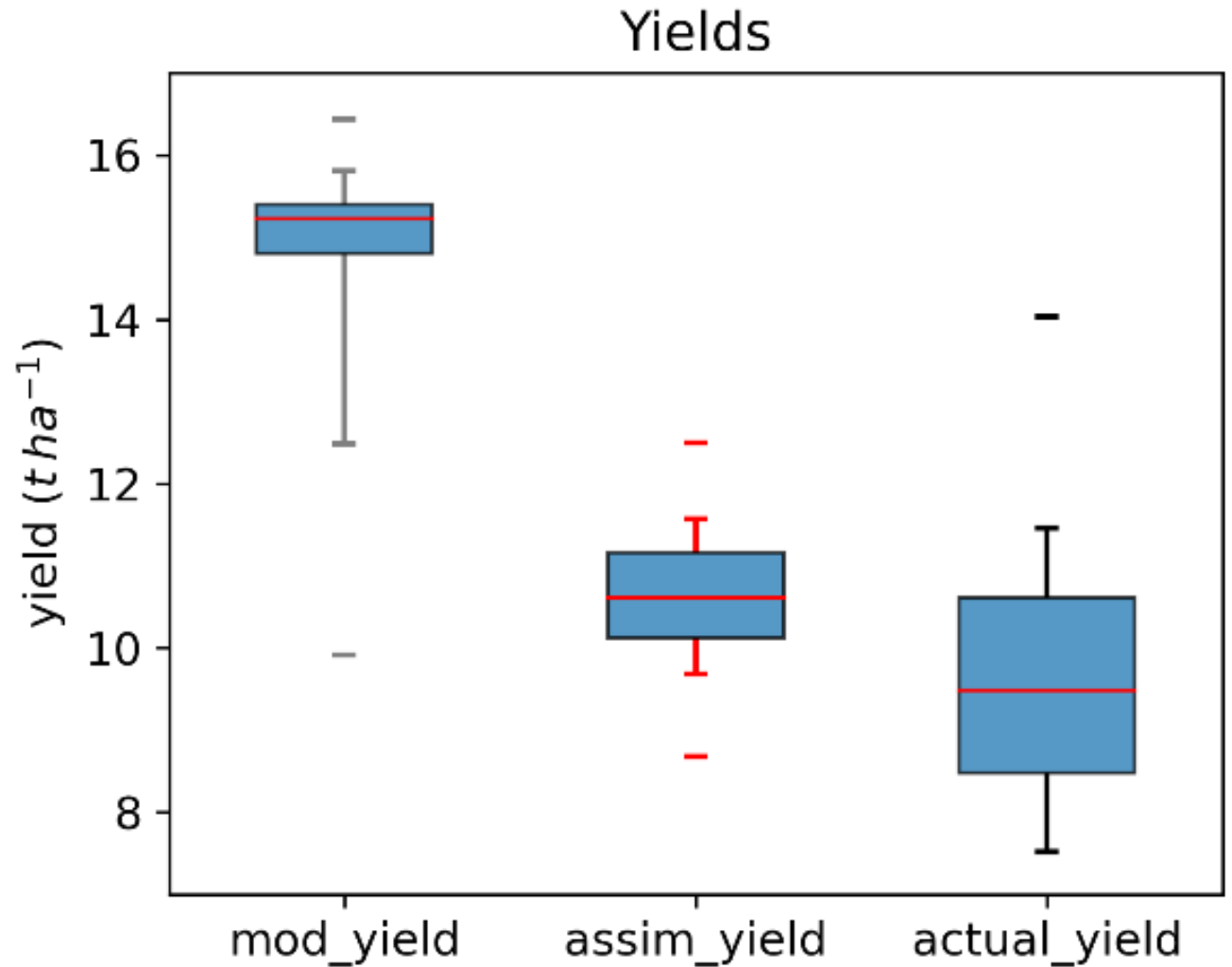
Digital
twinning

Yield model
validation

Model validation



- Compare against precision yield observations
- Averaged over whole field
- Significant improvement in model accuracy
- Reduction in yield to be more in line with actual yields
- Explore in-field variation in yield @ 10×10m



Change in potential wheat yields for GB (2010-2080)

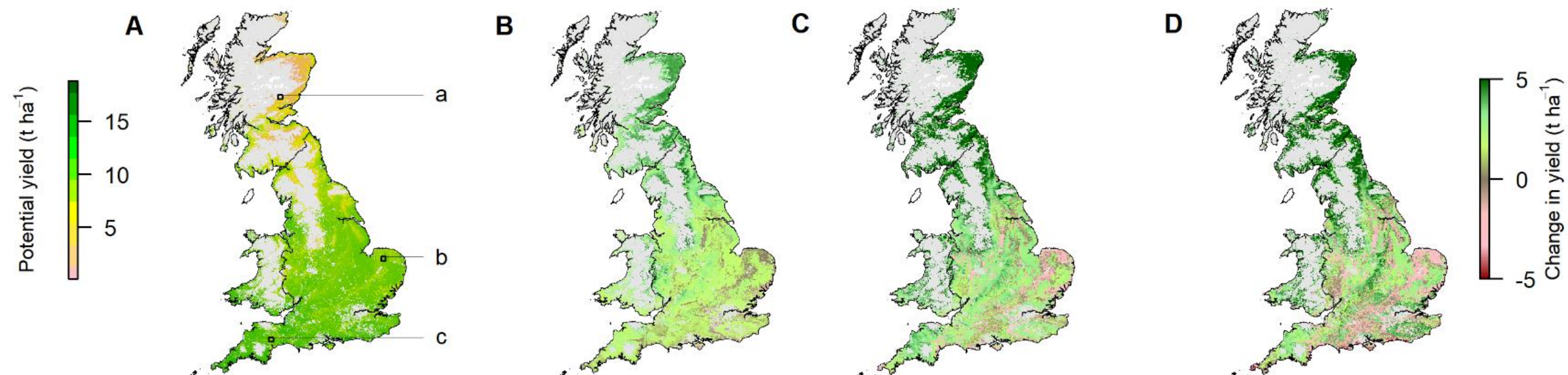


2010-20

2030-40

2050-60

2070-80



Crop-NET Yield demonstrator

CropNet Demonstrator

Enter BNG reference (Easting,Northing)

462453,189845

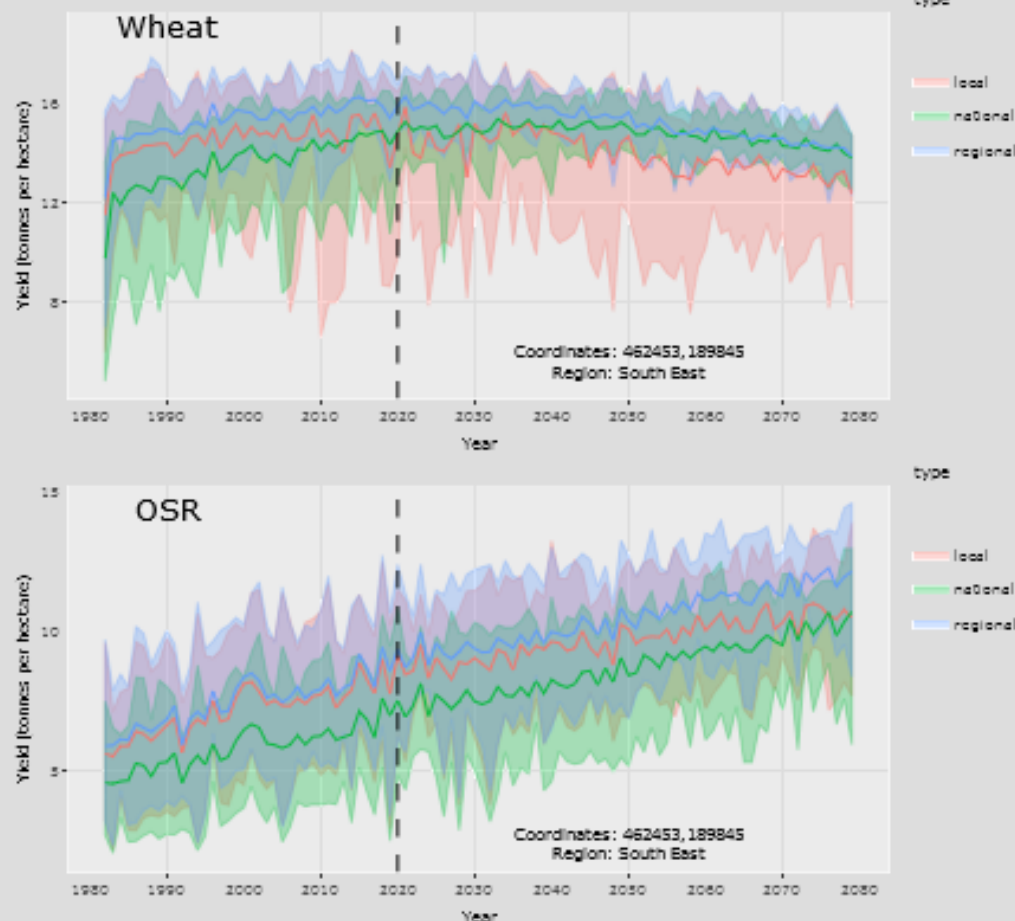
Select location from map

☐ adjusting the local yield curve based on actual yield (optional)

Choose elements to overlay:

☒ regional ☒ national ☒ current year

Future Potential Yield Plots

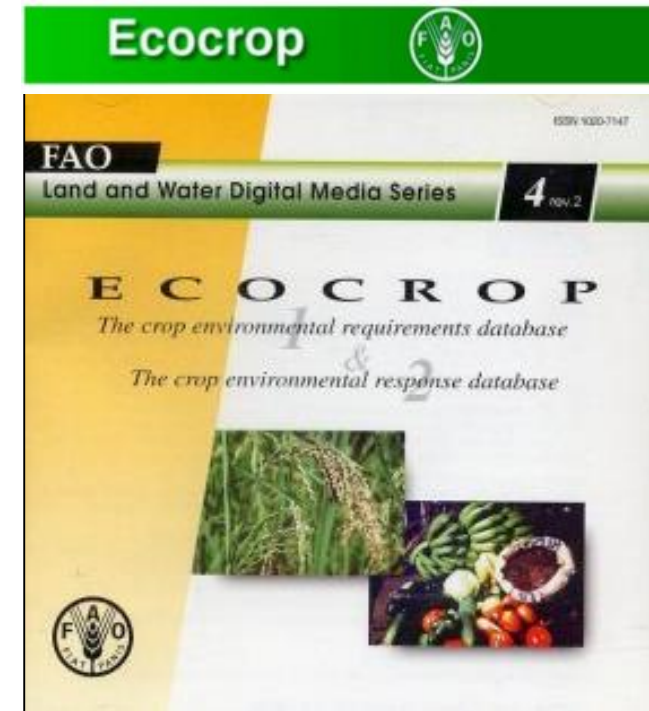


- Demonstrator built on JASMIN data labs
- Prediction for field via map/grid ref/post code
- Optional CO₂ fertilisation
- Adjusting for actual yield
- Crops: WW, OSR, grass
- Benchmarking: national, region, local

Climate suitability of UK cropping systems



- Database with climate parameters for >2000 crops
- Mechanistic model calculates climate suitability
- Coded to incorporate bias-corrected 1km UKCP18 climate driving data
- Run for UK in forecast mode
- Suitability of existing UK crops into future
- **Identifies potential new crops**
- **Adaptation: identifies resilient, 'climate smart' crop rotations**



<http://ecocrop.fao.org>



Summary



- Farmers increasingly aware of extreme weather & climate change impacts on their businesses
- Progressive farmers are interested in adaptation / resilience, especially ‘win-wins’
- Climate risks need to be viewed with wider challenges the industry faces
- Crop-NET / ECOCROP tools provide useful ways of assessing the risks and exploring potential adaptation strategies
- Co-design with stakeholders is essential



Introducing Julian Gold, Manager of the Hendred Estate, Oxon



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Thank you

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Website: www.ukclimateresilience.org

Twitter: @UKCRP_SPF

YouTube: UK Climate Resilience programme



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