Our Smart Farm – crop monitoring and decision support for farmers

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British Crop Production Council Congress.

Shaping the Future of Crop Production

Harrogate 4th November 2025

The James Hutton Institute

Presentation overview

- Context setting – the rational for Our Smart Farm:
  - Multiple drivers: climate change impacts, **water availability (examples)** biodiversity, geopolitics, policies including climate mitigation, market…
  - Visualising the future climate – what does 2°C + look like?
  - Decision support in a complex world
- Crop modelling for decision support
  - Benefits for planning adaptation
  - Constrained by lack of basic data – Need for a culture shift in attitudes to sharing and collaboration
- Why field-scale based monitoring and modelling?
- **Tools for decision support: Our Smart Farm**

Research Context: Crop Production in the Big Picture

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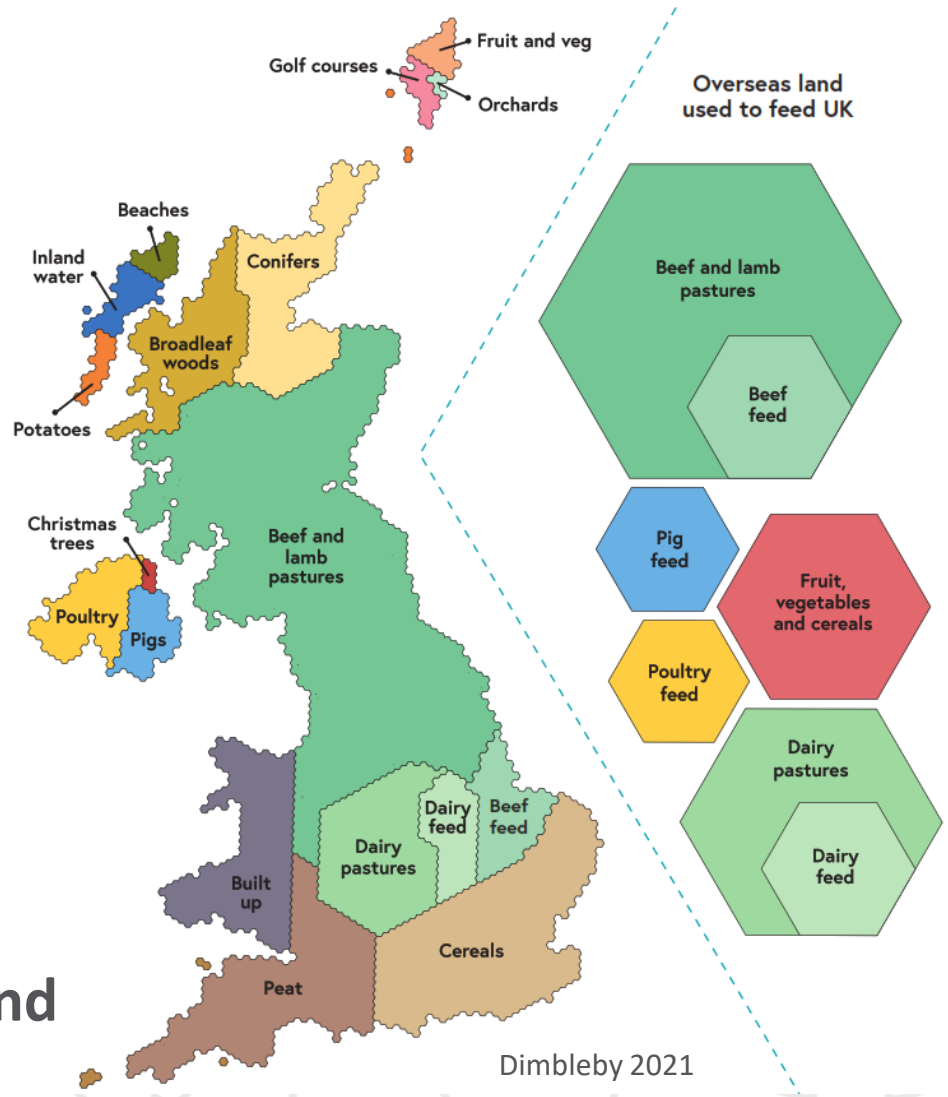
Importance of understanding climate change impacts

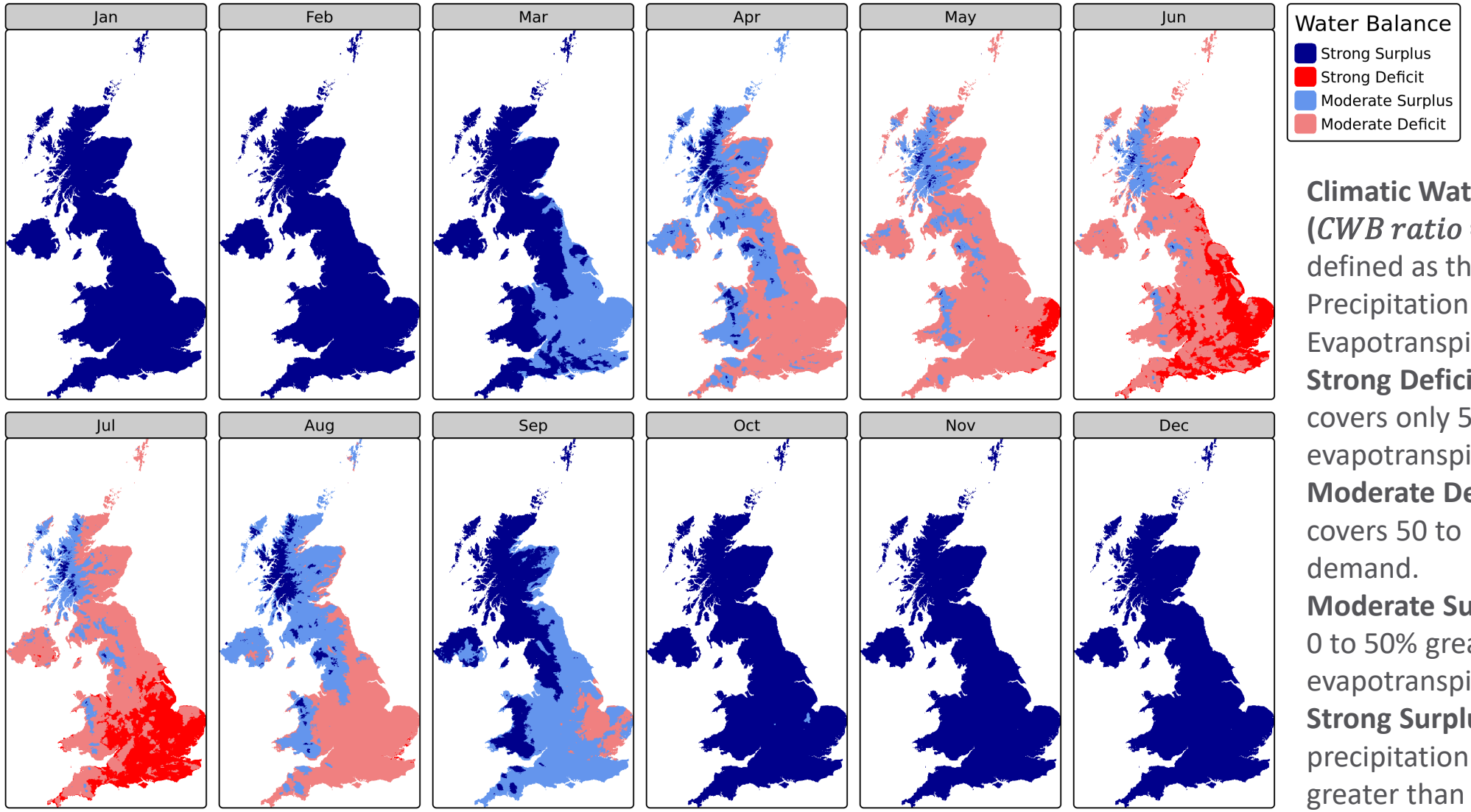
- How will crops respond to climate?
  - Growth and productivity
  - Climate trends and extremes
  - Resource use: fertilisers, chemicals
- How does this relate to wider issues of:
  - Climate and Biodiversity (poly)crises
  - Food and nutrition security, dietary change
  - Net Zero pathways
  - Viable and sustainable land-based sector
  - Land Use and Food System Transformations
- Understanding risks and opportunities
  - Risk perception deficit (global)
  - Spatial variation (soil-climate-management combinations)
  - Crop breeding for resilience
  - Crop suitability – new crops
- **Climate proofing farming, supply chains, policies and building resilience in socio-ecological systems**



Dimbleby 2021

What about water availability?

Climatic Water Balance for the Baseline Period 1960-1989



Climatic Water Balance Ratio ($CWB\ ratio$ = (P / $ET0$) defined as the ratio of Precipitation (P) to Reference Evapotranspiration (ET0).

Strong Deficits; precipitation covers only 50% or less of the evapotranspiration(ET0) demand.

Moderate Deficit; precipitation covers 50 to 100% of the ET0 demand.

Moderate Surplus; precipitation is 0 to 50% greater than the evapotranspiration demand.

Strong Surplus; where precipitation is 100% or more greater than the ET0 demand.

Changes in water availability: baseline to 1990-2019

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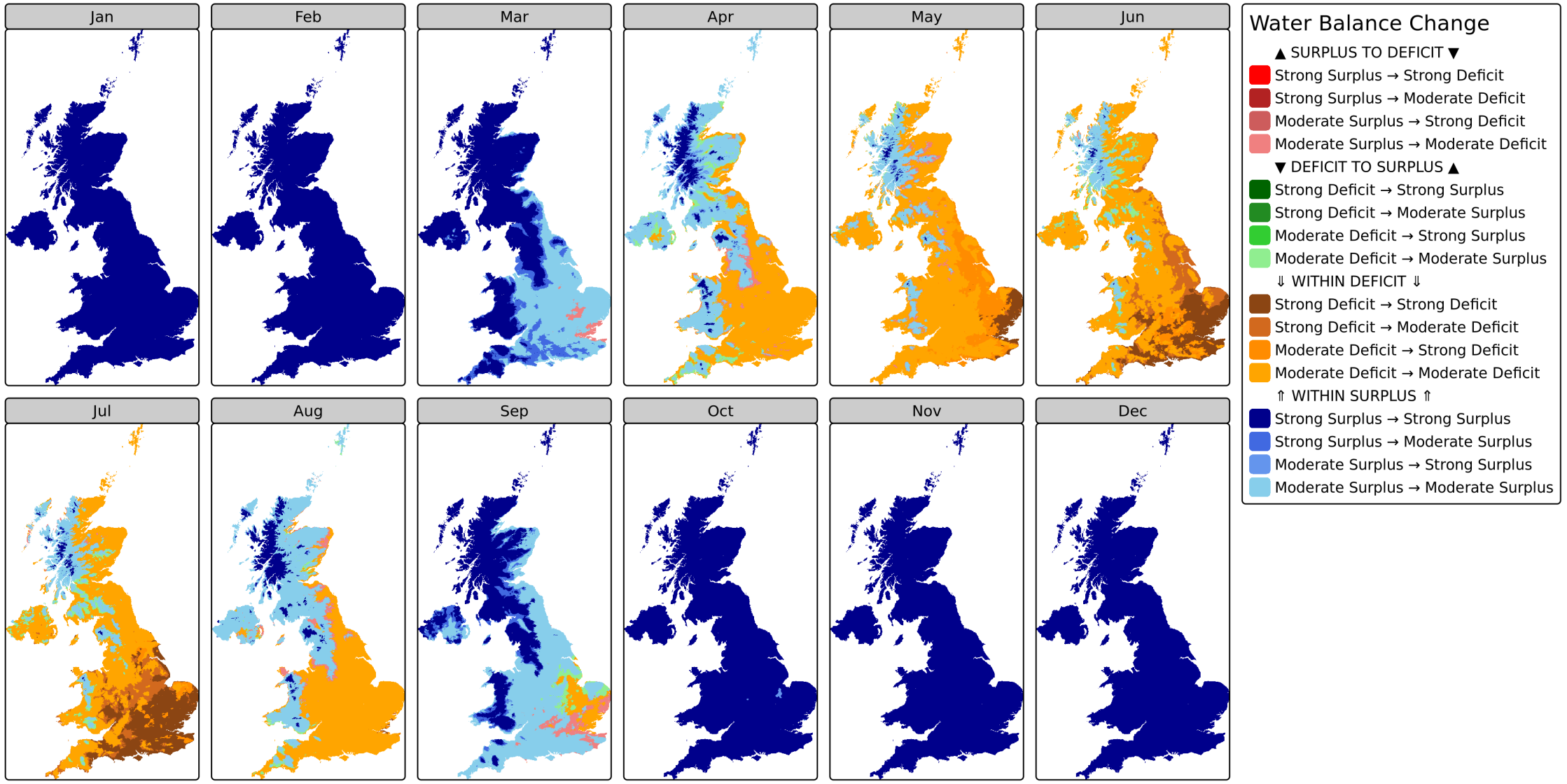
Climatic Water Balance Change for the Period 1990-2019 compared to 1960-1989 baseline



Changes in water availability: baseline to 2020-2049

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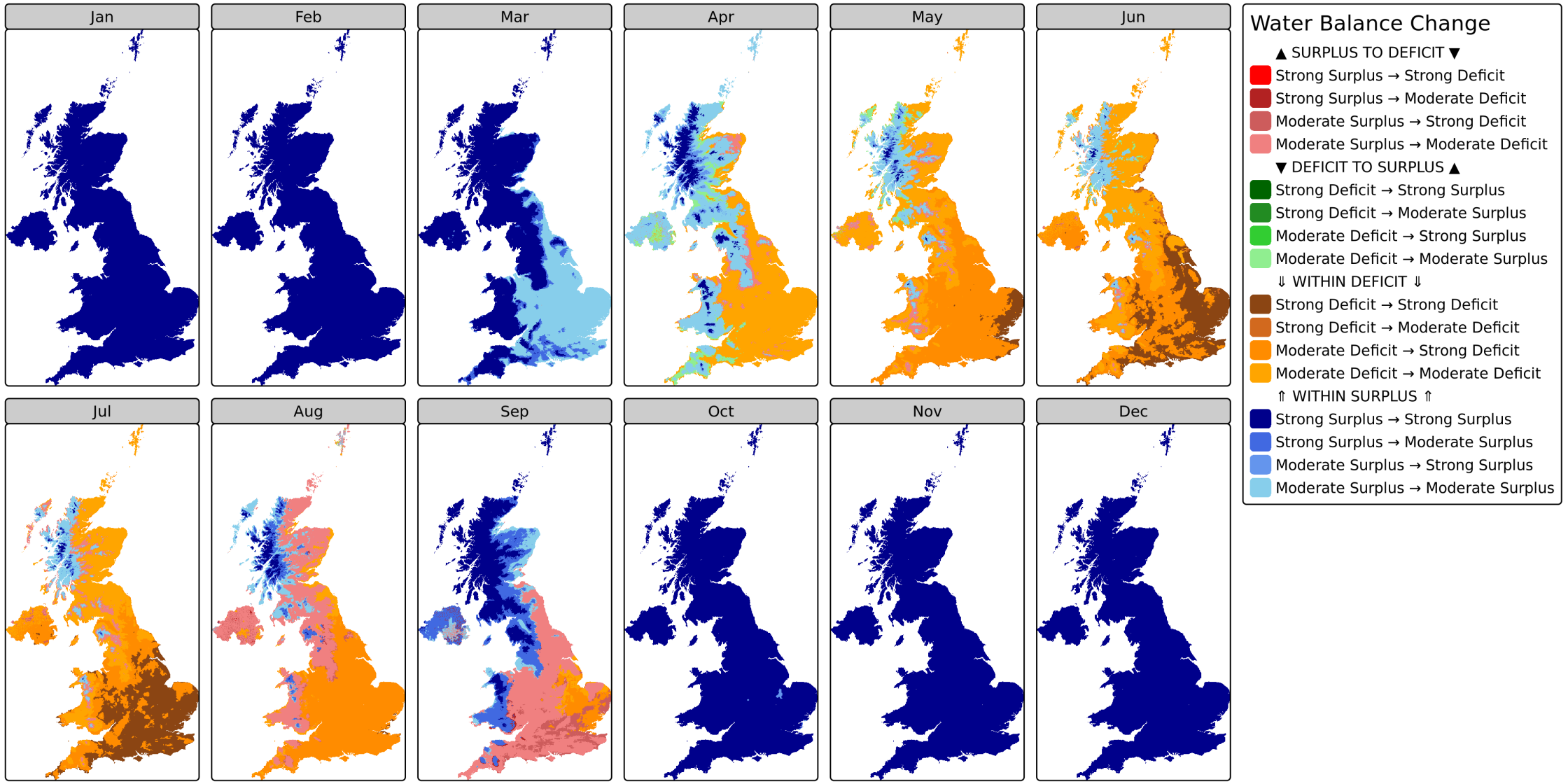
Climatic Water Balance Change for the Period 2020-2049 - Ensemble Member 06 (2°C warmer, 2% wetter)



Changes in water availability: baseline to 2050-2079

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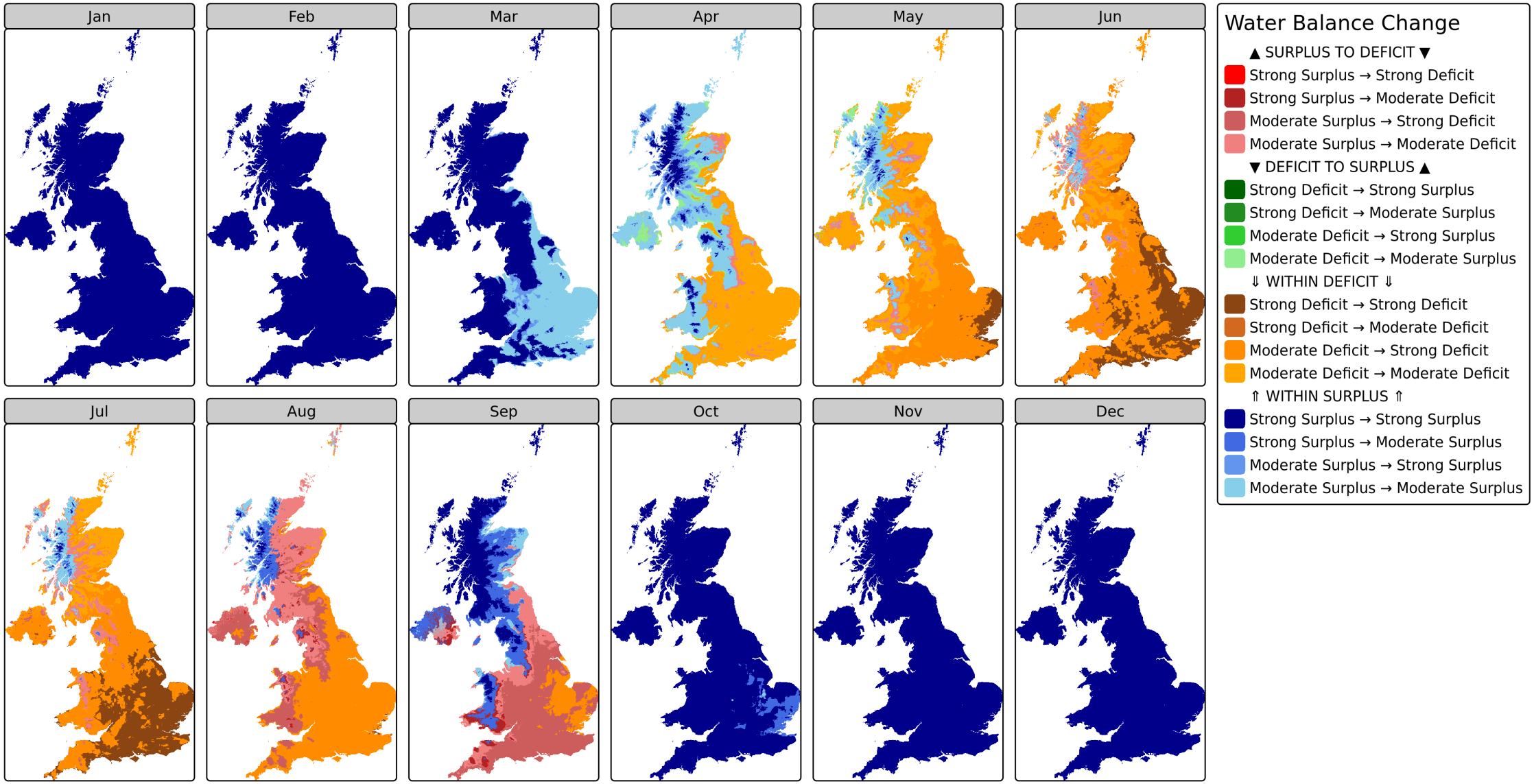
Climatic Water Balance Change for the Period 2050-2079 - Ensemble Member 06 (2°C warmer, 2% wetter)



Crop modelling to support decision making

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Benefits

- "Experimentation on the laptop, not the field": What if…?
- Field specific analysis based on simulations run with field data

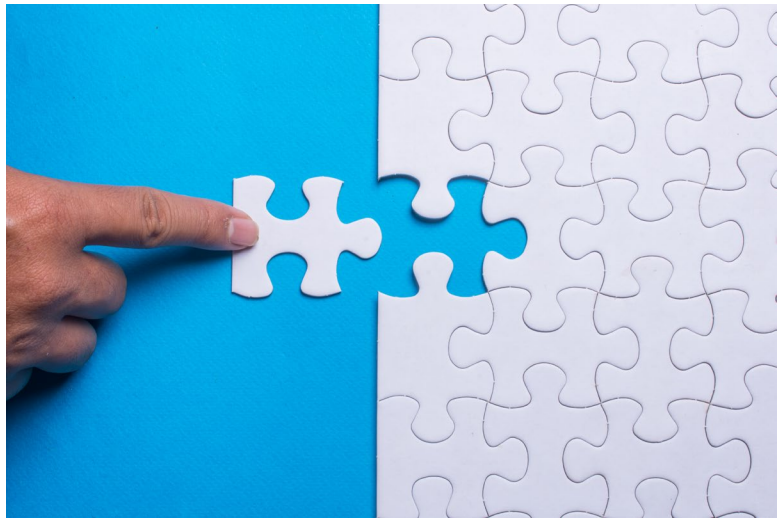
Challenges:

- **Lack of basic data for model calibration and validation**
- Calibrating models for future climatic conditions
- Spatial variability: climate, soils, management
- **Model use beyond research: credibility and how to get farmer participation?**
- Data ownership

Solutions:

- **Use farmer-supplied data**
- Multiple model ensembles and protocols
- Real-time input and monitoring data: soils, climate, sensors and Earth observations
- Networked data collection (LoraWan, 5G)
- High Performance Computing, API's
- Machine Learning / AI

Basic observed data – the missing piece of the puzzle



"In Scotland, with a 1km climate grid resolution, there are c. 57,000 unique soil-climate combinations in the arable areas alone, but we have a small handful of experimental farms and therefore observed data points for model calibration"

Fundamental needs for crop model calibration and validation, with combinations of:

- Tillage
- Sowing date
- Fertiliser type, rate, dates
- Irrigation, if any
- Growth stages (phenology) and dates
- Yield (biomass and grain / tuber etc.)
- Rotations / land use history

Challenges:

- Culture of data sharing
  - Issues of data ownership
  - Monetising data vs public good (subsidy payments)
- **Fostering data exchange: proving benefit to farmers**
- **Providing the mechanisms for farmer-researcher collaboration = Our Smart Farm**

How to build better farmer-science collaboration?

- Need a culture change to foster observed data exchange and collaboration between farmers and scientists
- Virtuous cycle: need platforms to enable data sharing and in return provide model results to data providers
- Foster “Win-Wins”: More observed good quality data means better calibrated models = improved utility
- Better calibrated models means *credibility* for use in decision support
- Spatially applicable crop models means improved *salience* and *relevance* to meet farmer’s needs

Why field-scale based monitoring and modelling?

- Scale at which management decisions are applied
- Crop management data is or can be made available

Rationale for Our Smart Farm

- **Provide a platform** for better farmer-science collaboration: data sharing
- Science needs farmer supplied data to calibrate models
- Need for decision support tools to enable ‘experimentation on the laptop, not the field’ to allow financial viability and plan for adaptation to multiple drivers, including climate change

Our Smart Farm: Providing a platform to enable farmer-science collaboration on observation and simulation sharing

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A new two-way data exchange and crop simulation modelling research platform.

Farmers use **Our Smart Farm** to monitor their crop growth and development using Earth Observations, and their own input data to run crop models. Then they use the outputs to understand and identify the limiting factors affecting yield and production consequences to make informed decisions to adjust crop management and increase income while reducing environmental impact.

- Can be applied anywhere in the world
- Currently arable focus, grass growth module exists

Funding provided by Scottish Government

Our Smart Farm Platform

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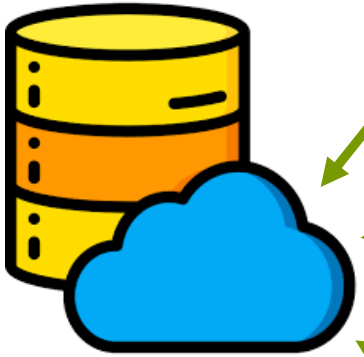
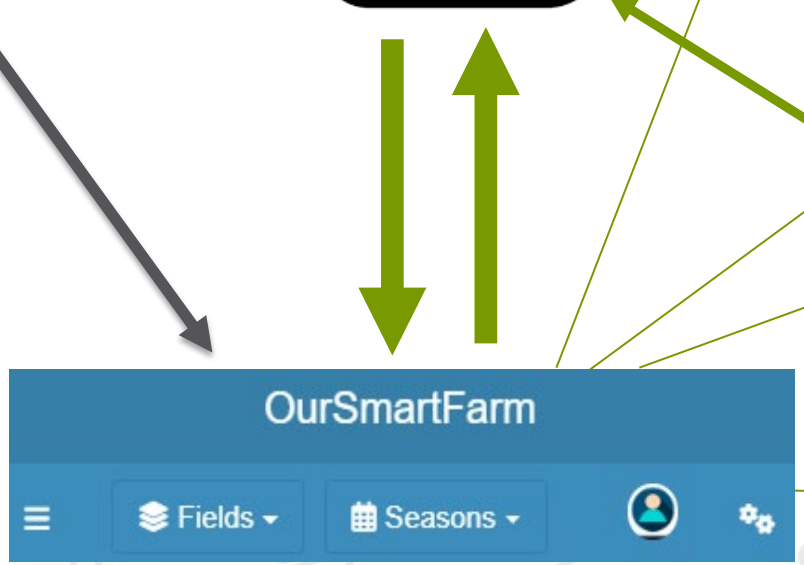
Farmer supplied field activities/Observations

Field boundary





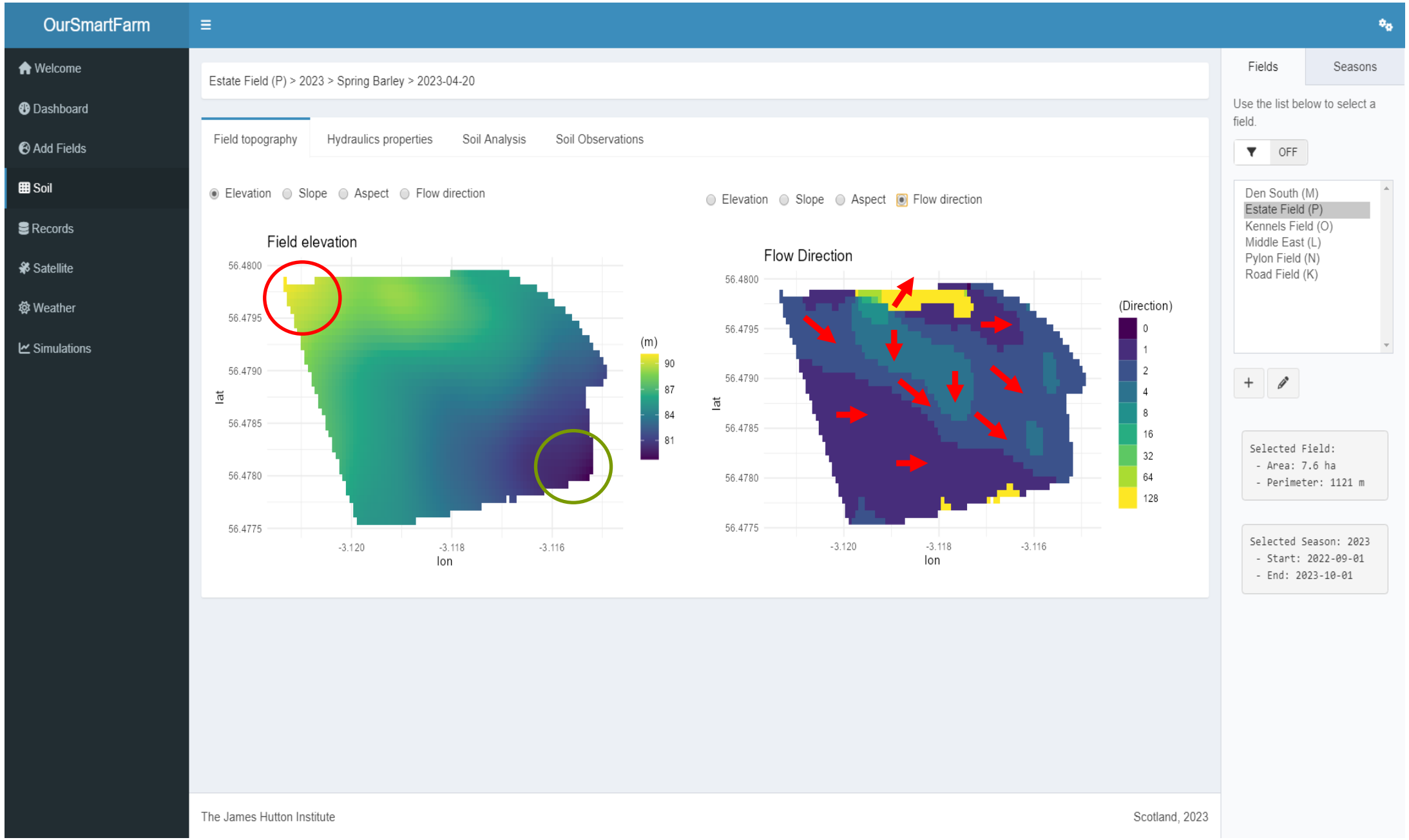
Weather / Climate API

Soil API

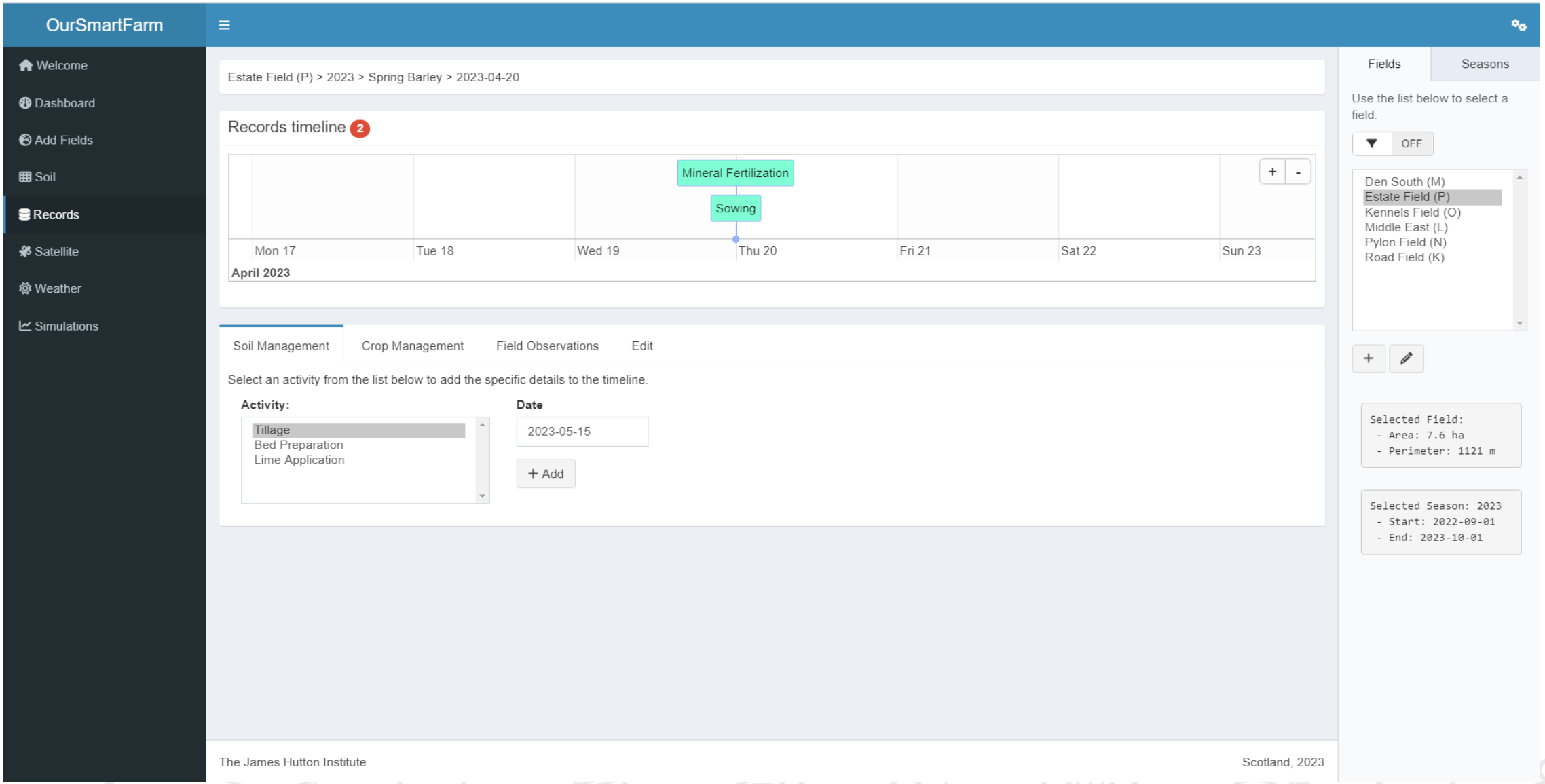
Earth Observation API

Crop Model API

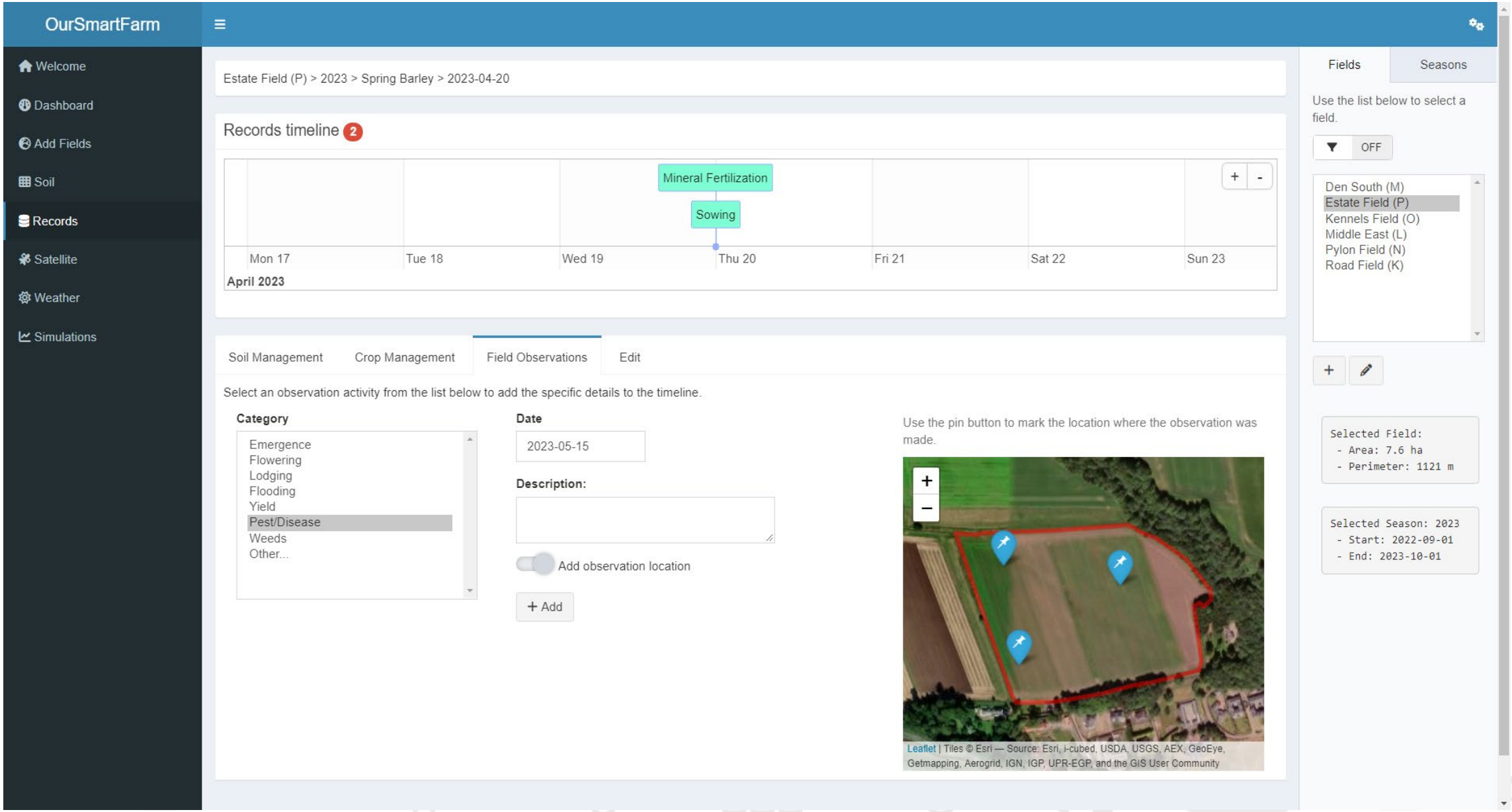
Field Topography & Water Flow Direction



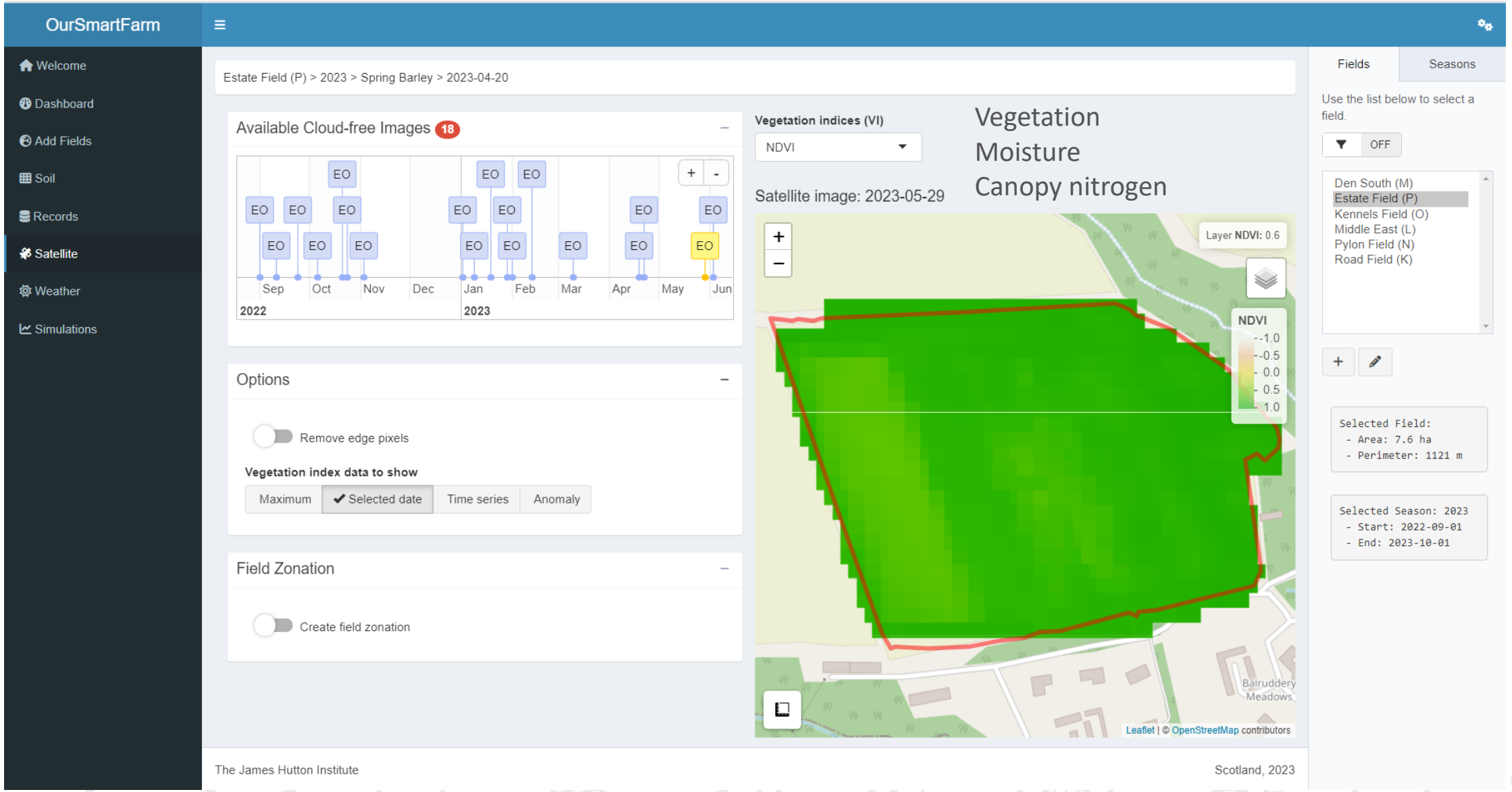
Field Activities, Management, Soils Analysis +



Field Observations



Spatial Analysis – Satellite Imagery



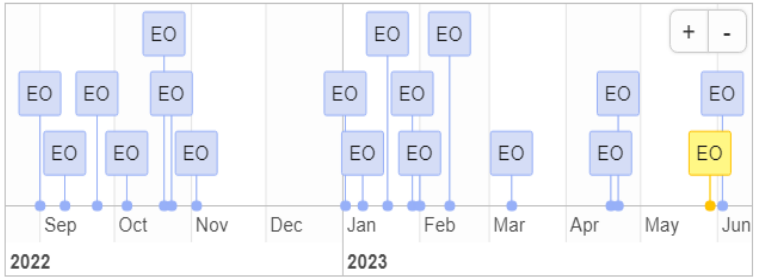
Field Zonation

OurSmartFarm

- Welcome
- Dashboard
- Add Fields
- Soil
- Records
- Satellite
- Weather
- Simulations

Estate Field (P) > 2023 > Spring Barley > 2023-04-20

Available Cloud-free Images 18



Options

Field Zonation

Create field zonation

Number of zones

✔2 | 3 | 4 | 5 | 6

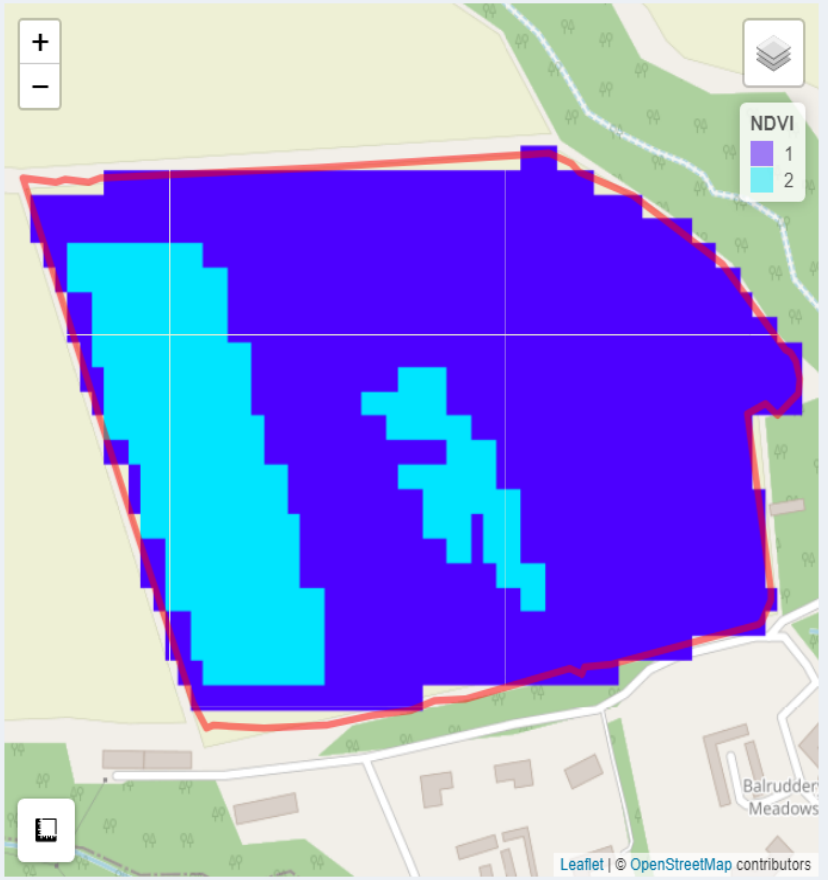
Zones Statistics

Zone	Mean	Area (%)
1	0.82	76
2	0.65	24

Vegetation indices (VI)

NDVI

Satellite image: 2023-05-29



Fields | Seasons

Use the list below to select a field.

OFF

- Den South (M)
- Estate Field (P)
- Kennels Field (O)
- Middle East (L)
- Pylon Field (N)
- Road Field (K)

```
Selected Field:
 - Area: 7.6 ha
 - Perimeter: 1121 m
```

```
Selected Season: 2023
 - Start: 2022-09-01
 - End: 2023-10-01
```

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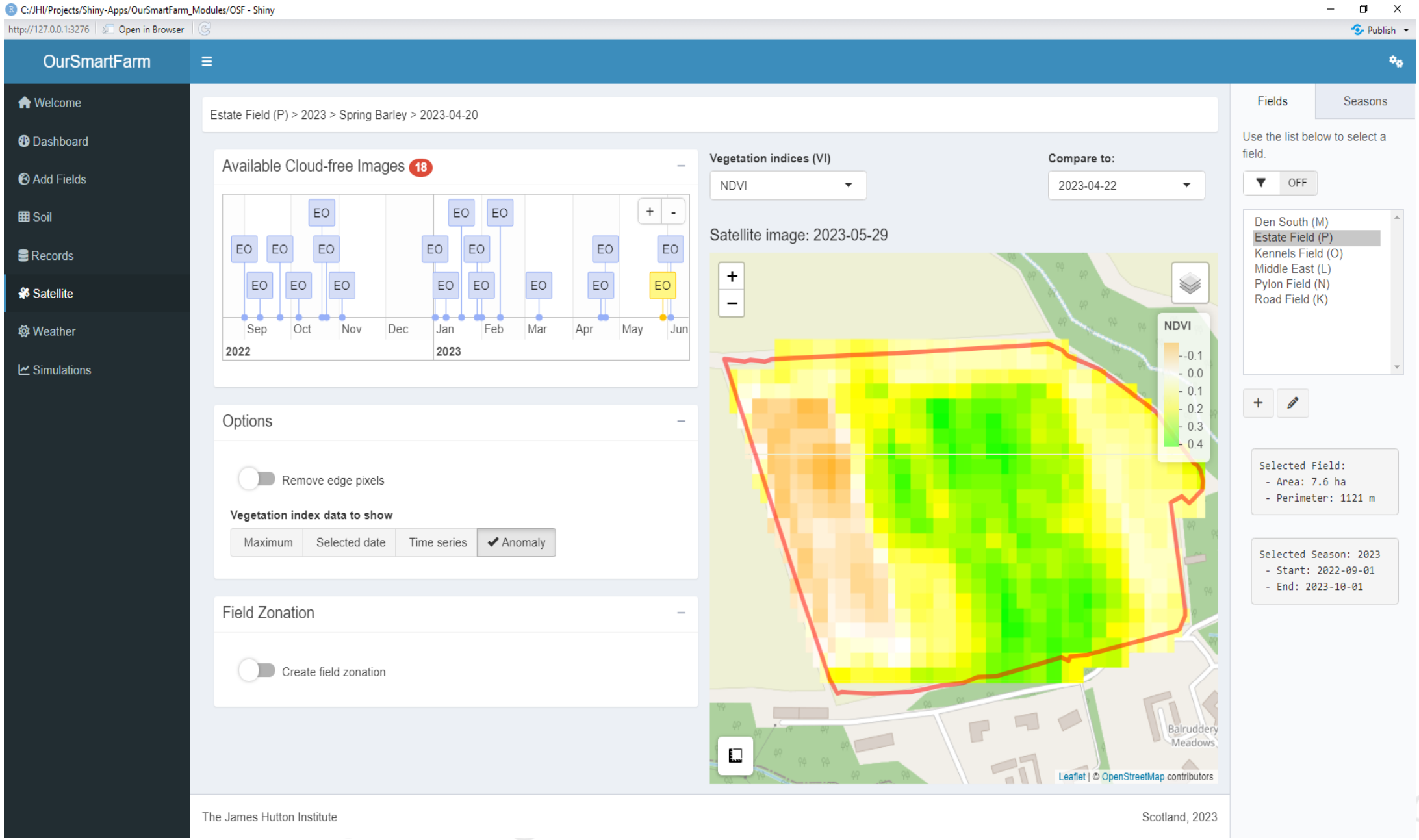
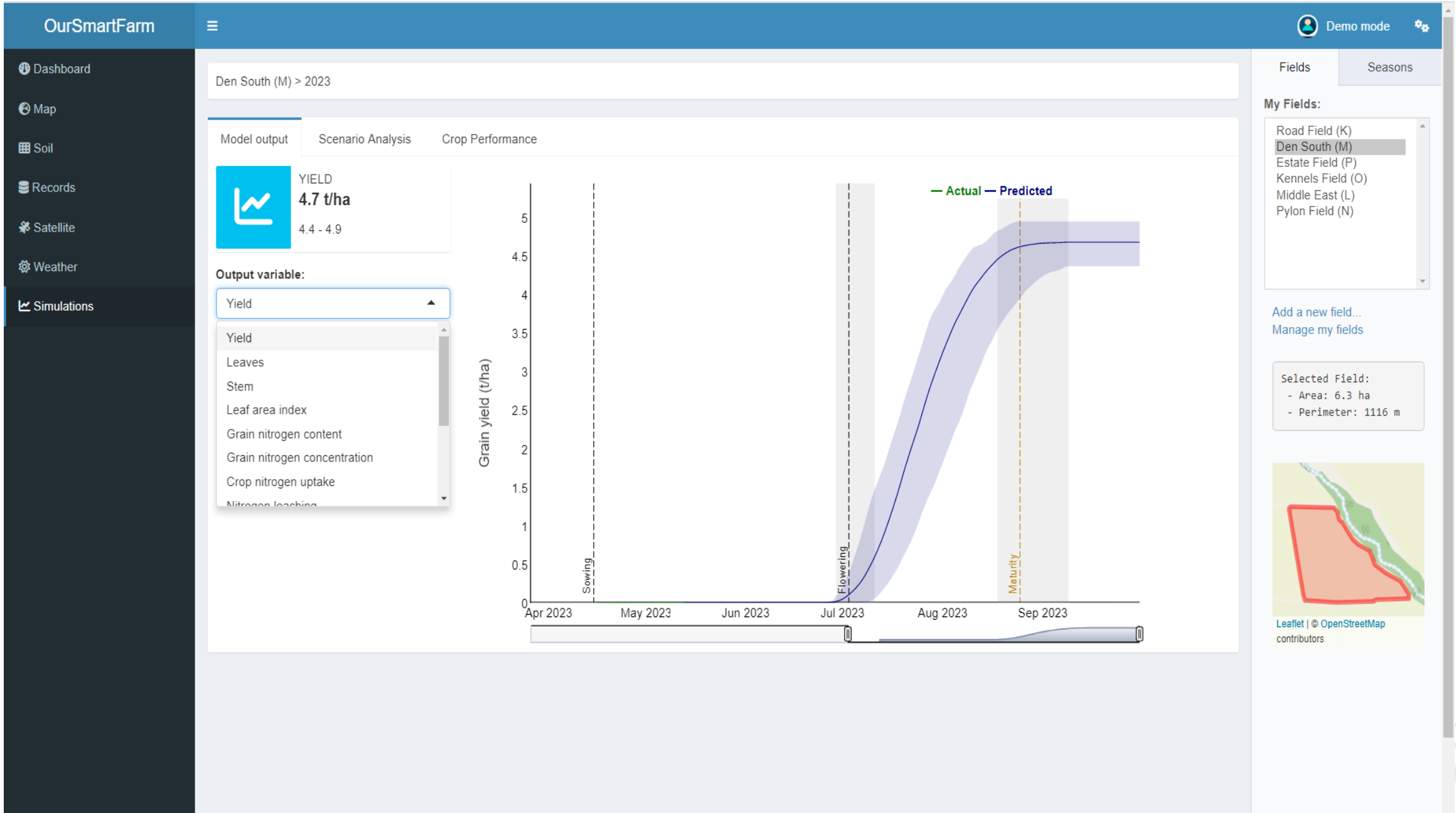
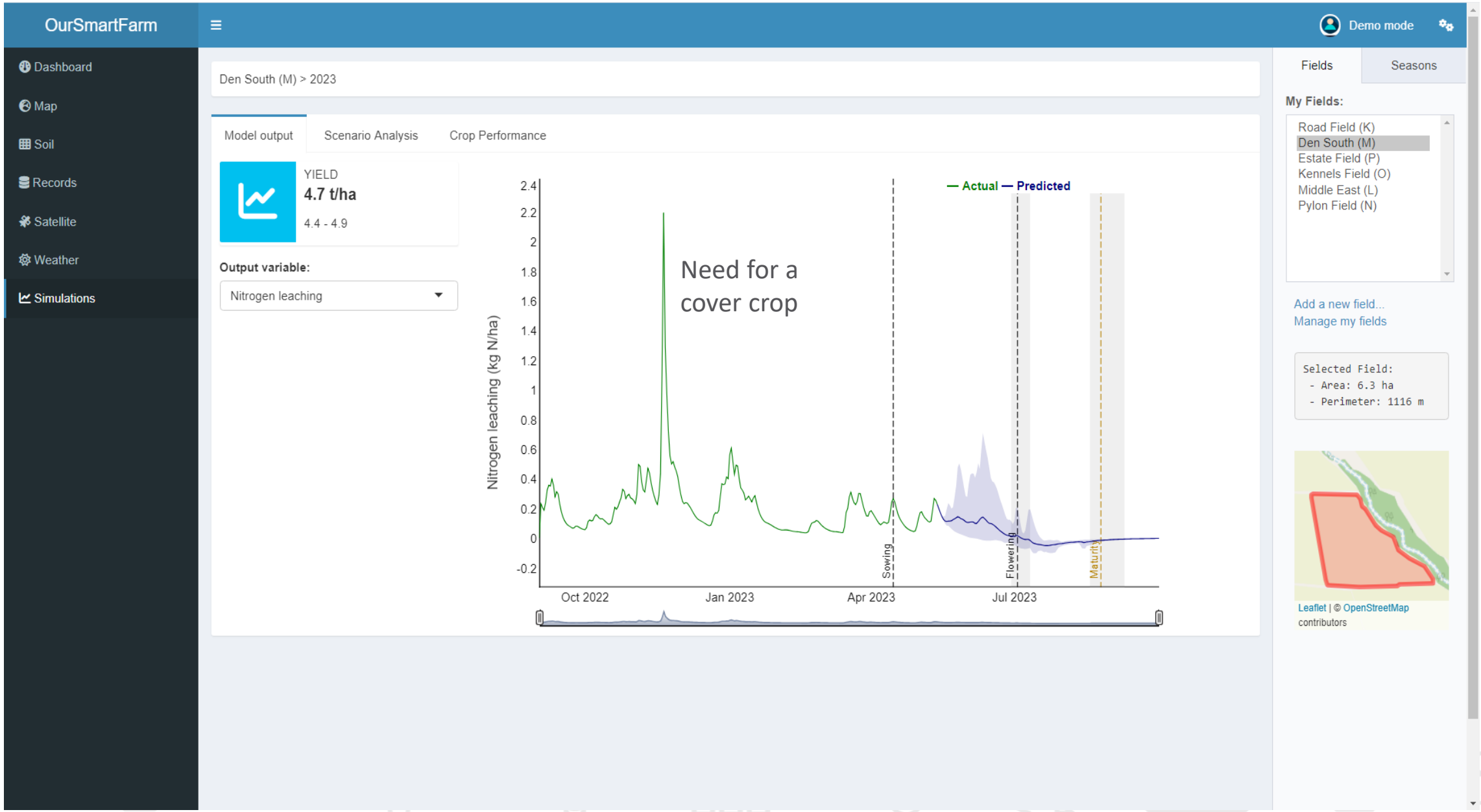
Crop Growth Anomaly: variation between years



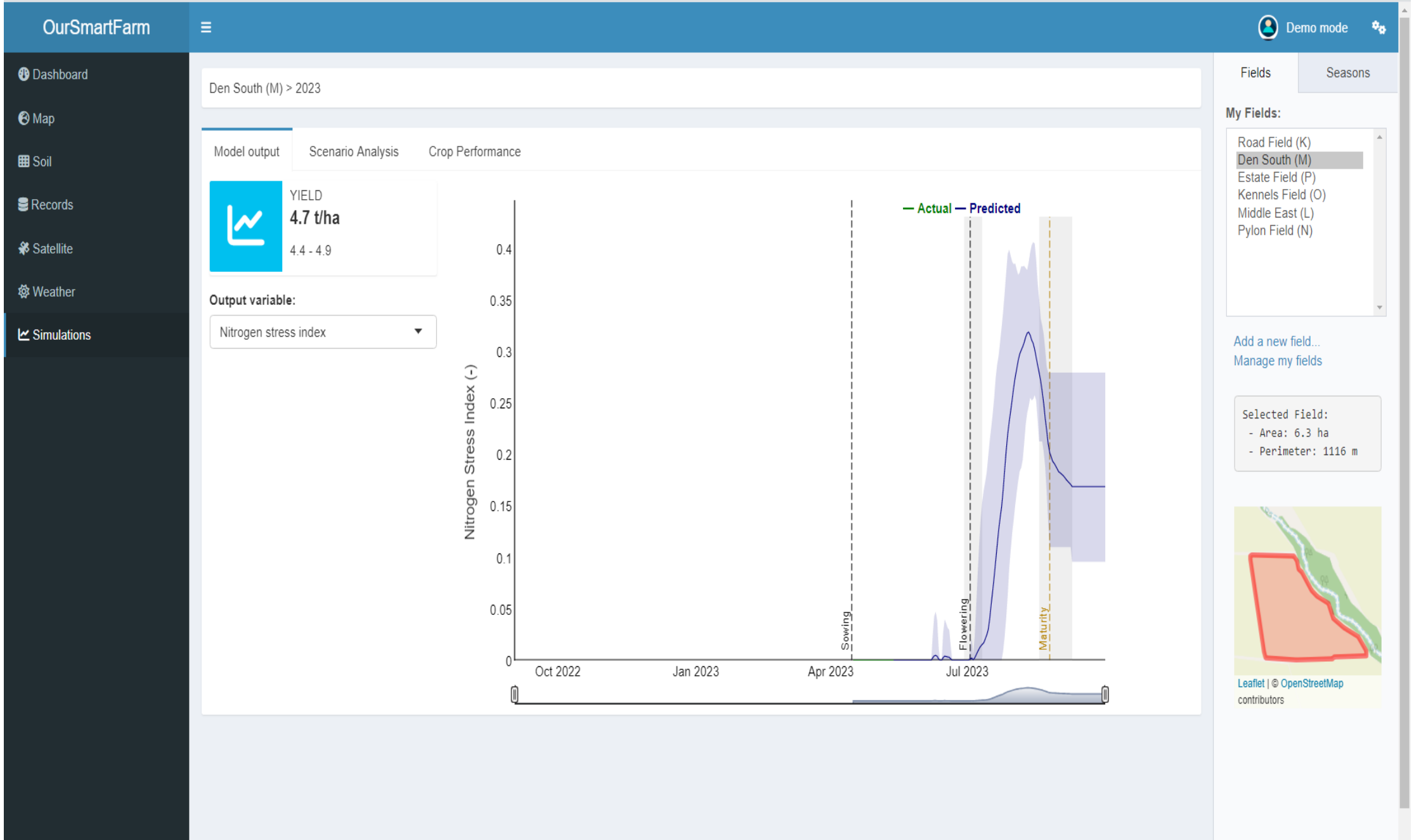
Model Simulations (Crop Yield Forecasting)



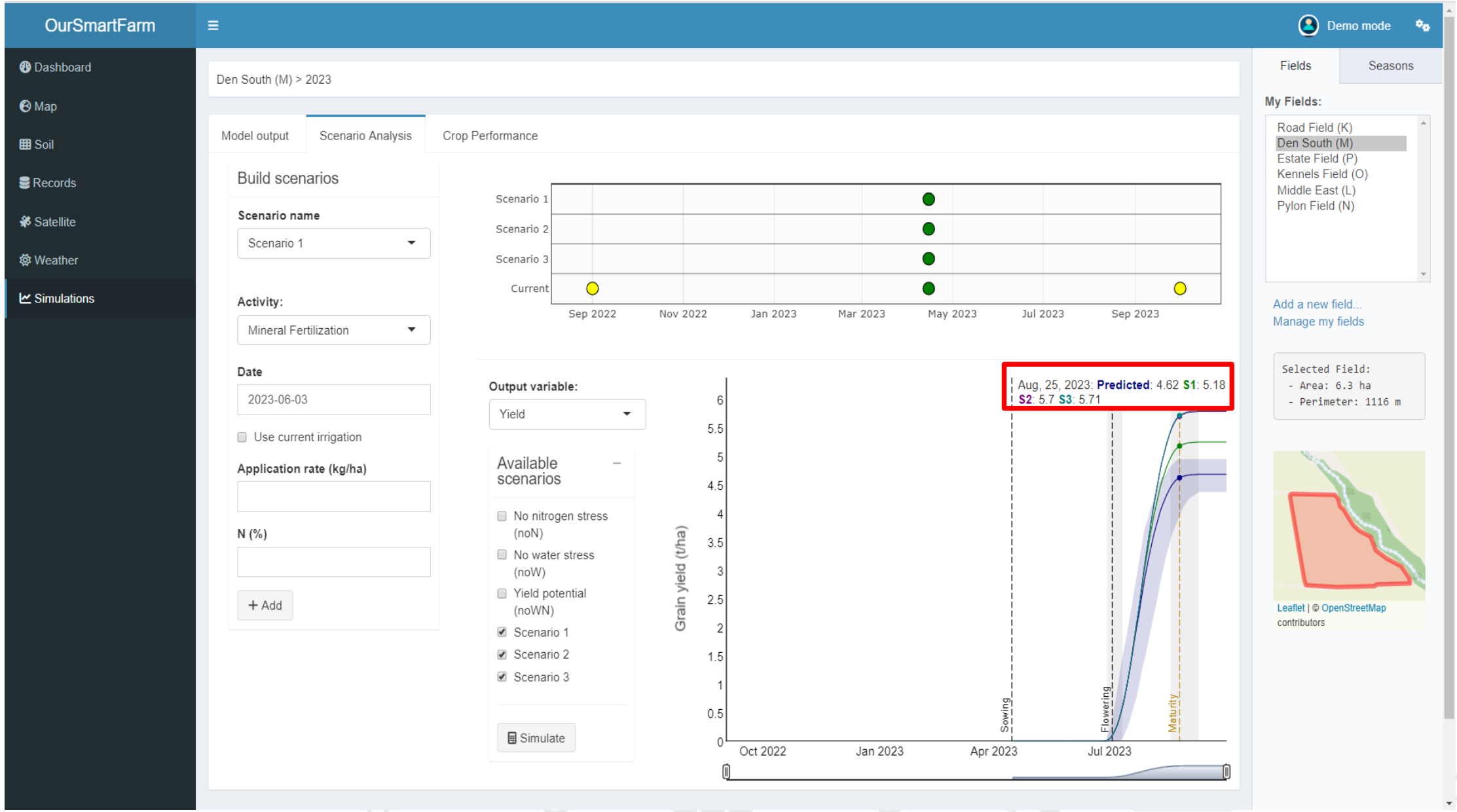
Model Simulations (Nitrogen Leaching)



Model Simulations (Nitrogen Stress Index)



Scenario Analysis “experimentation on the laptop”



OSF helps upscale to regional and national level crop modelling

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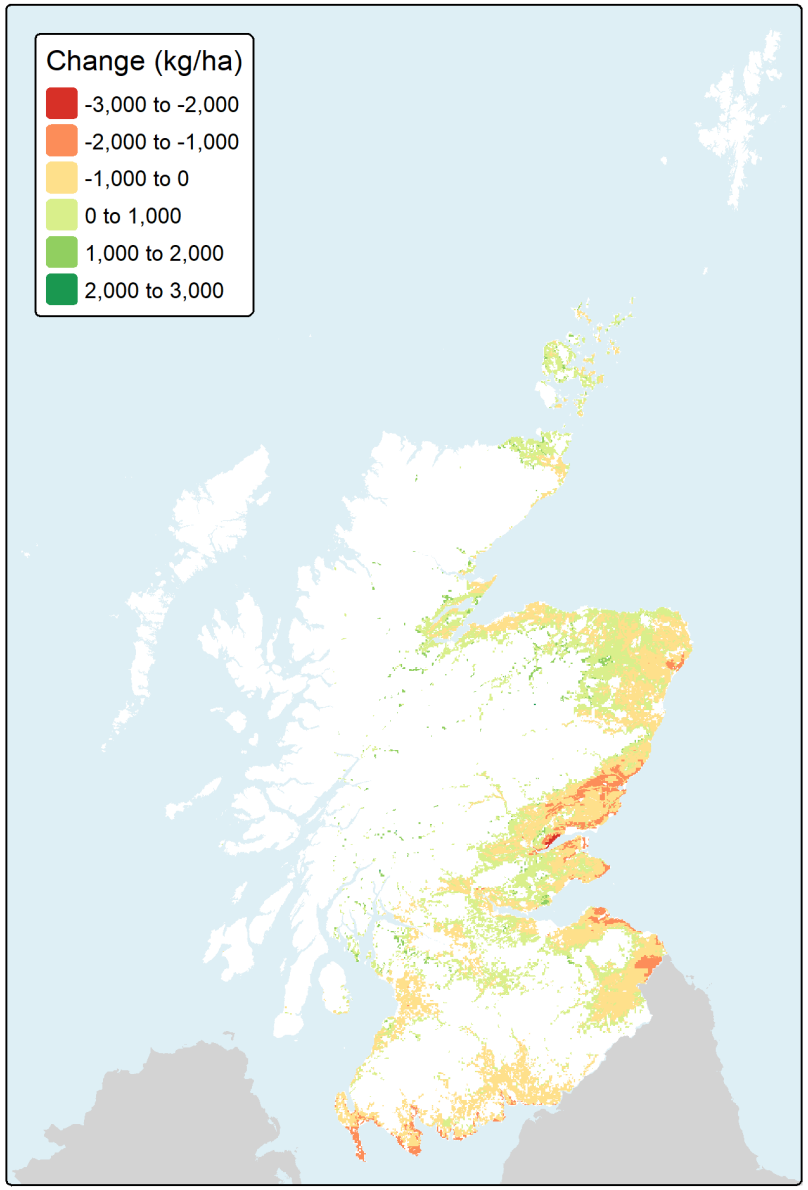
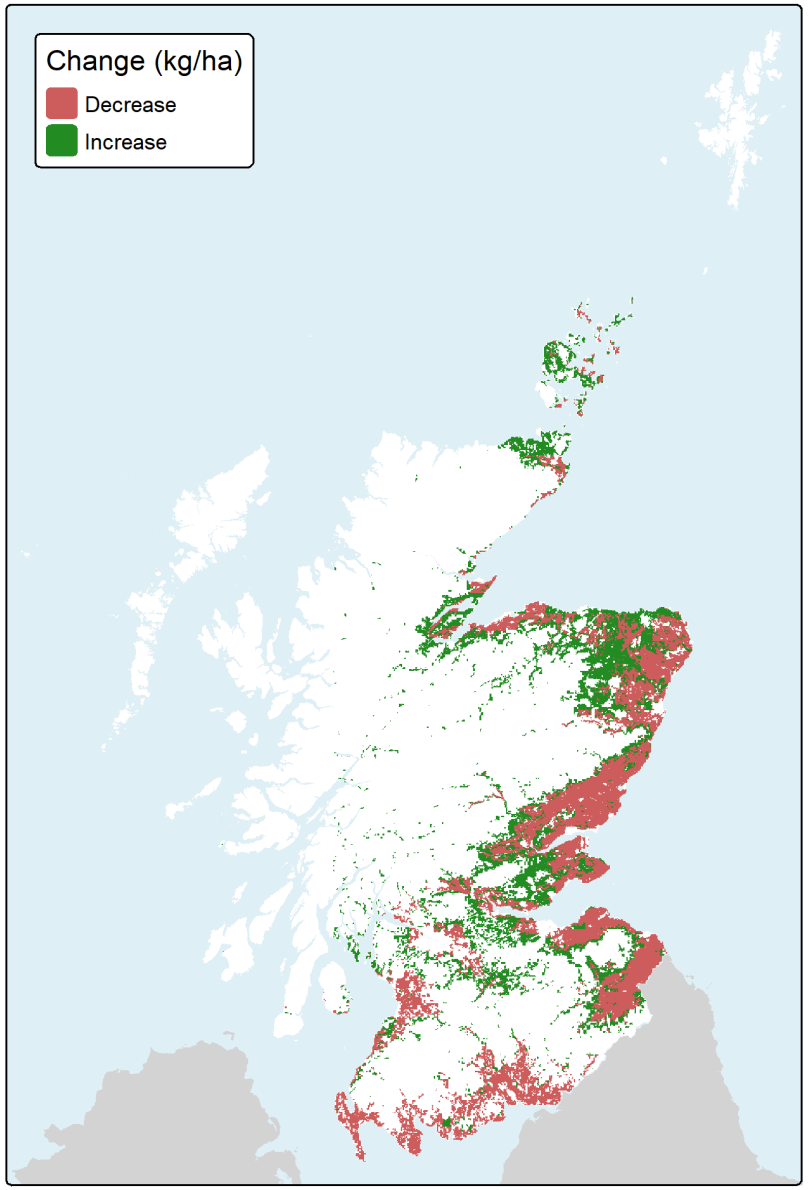
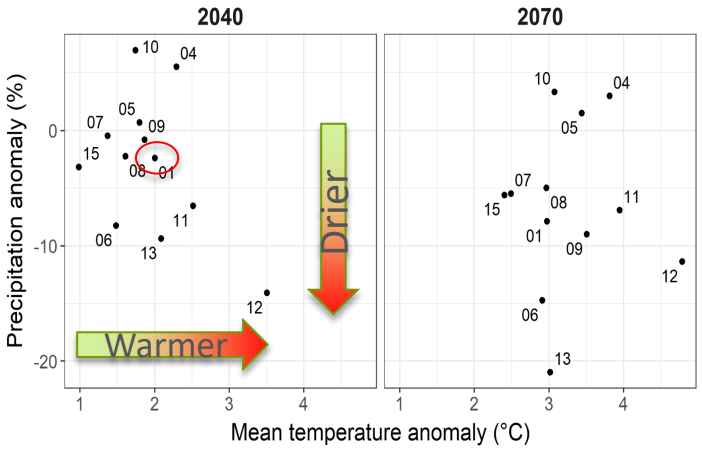
Grain Yield Change for Ensemble Member 01



Grain Yield Change for Ensemble Member 01



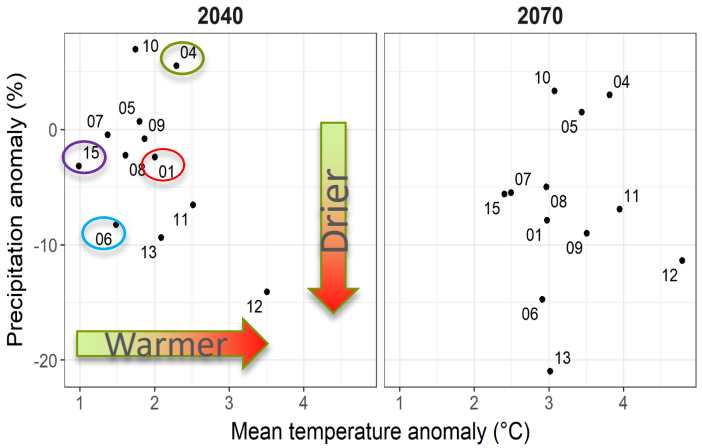
Spring Barley simulated yield changes for 2045-2054 compared to 2010-2019 baseline using 1 Regional Climate Model (UKCP18) projection (EM01, 2°C warmer, 3% drier)



Estimated climate change anomaly compered to 1960-1989 baseline period

Calibration based on OSF helps upscale to regional and national level crop modelling

Spring Barley simulated yield changes for 2045-2054 compared to 2010-2019 baseline using 1 Regional Climate Model (UKCP18) projection (EM01, 2°C warmer, 3% drier)

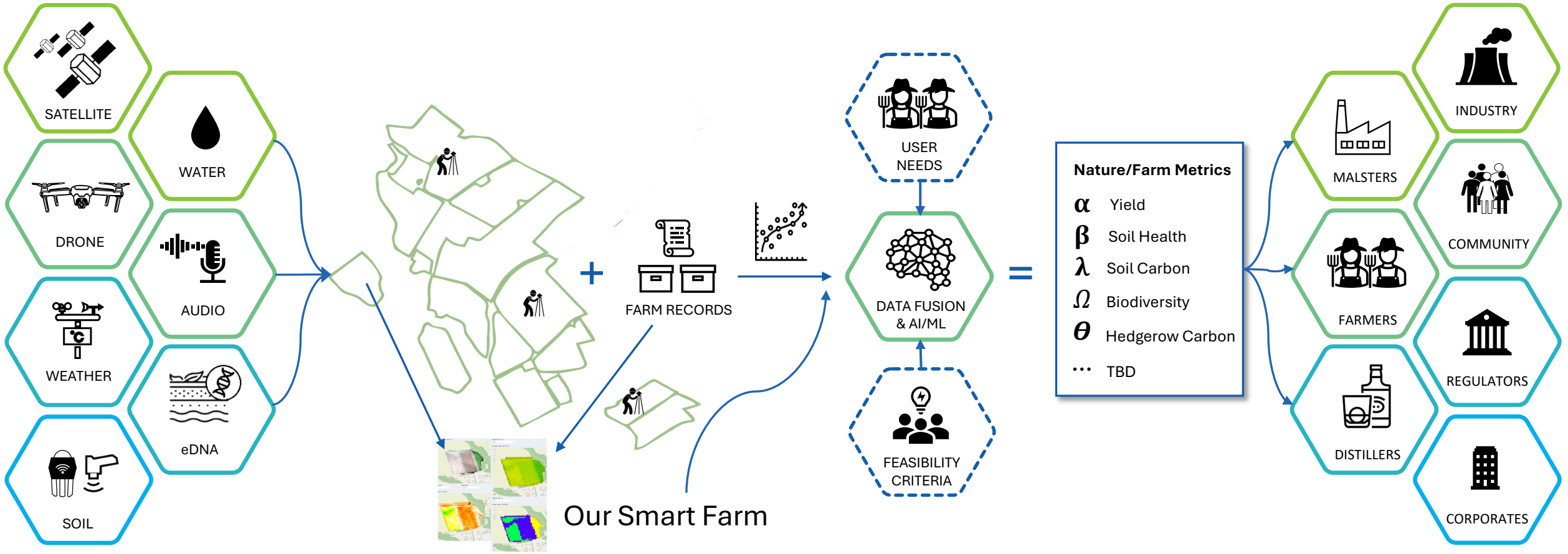


Estimated climate change anomaly compered to 1960-1989 baseline period

Related projects

- FarmBalance: Intelligence as a Service
  - Detailed farm monitoring to enable monetisation of Natural Capital within the supply chain
  - De-risking transformations to sustainable practices in land use and management
- Retina Project: GHG Monitoring, Report and Verification
  - Dynamic monitoring, reporting and verification for implementing negative emission strategies in managed ecosystems
  - Integrating a ‘gold standard’ GHG Monitoring, Reporting and Verification platform with Our Smart Farm
- In development – integration with James Hutton Institute disease forecasting modelling

FARMBALANCE TECH AND SCIENCE TO MEET USER NEEDS



Data Collection
Mix of near-continuous & periodic data collection techniques

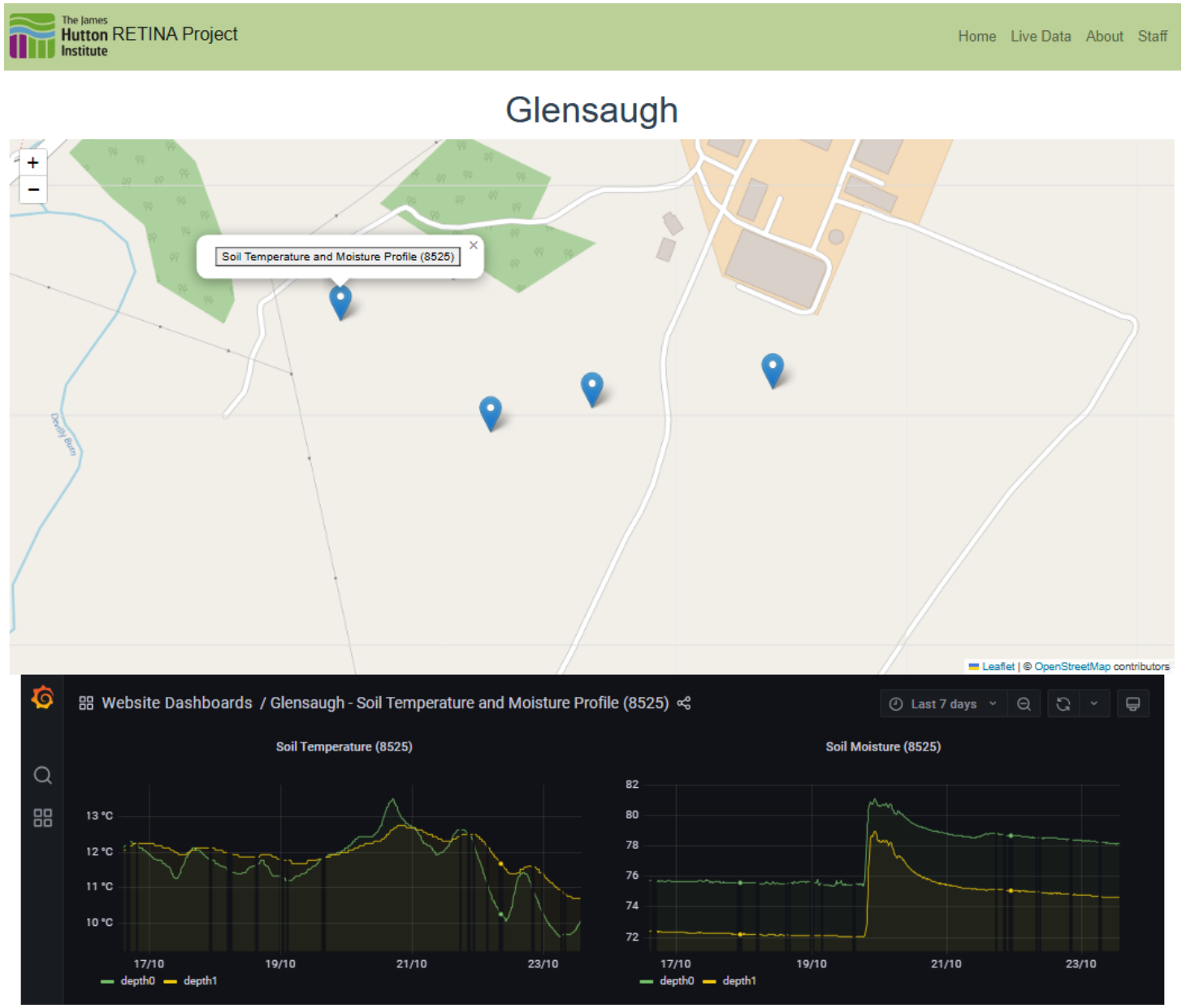
Data Calibration & Validation
All techniques calibrated & tested at Cairnfield Farm using field survey data and historical farm records

Model Development & Metric Derivation
Development of key natural capital metrics using a novel blend of validated data collection methods with incorporated feedback from user engagement & feasibility studies

Reliable Insights Delivered
Natural capital insights and opportunities created across the supply chain

Department for Environment Food & Rural Affairs
UKRI Innovate UK
FarmBalance

Retina Project for Monitoring, Reporting & Verification



- Soil carbon sequestration focus
- Cloud-based platform
- Combines new field-base, landscape sensor technology with satellite data and modelling
- Mobile App for providing management changes
- Near real time modelling of carbon changes and GHG emissions
- Setting standards for MRV

RETINA Project

Summary – key messages

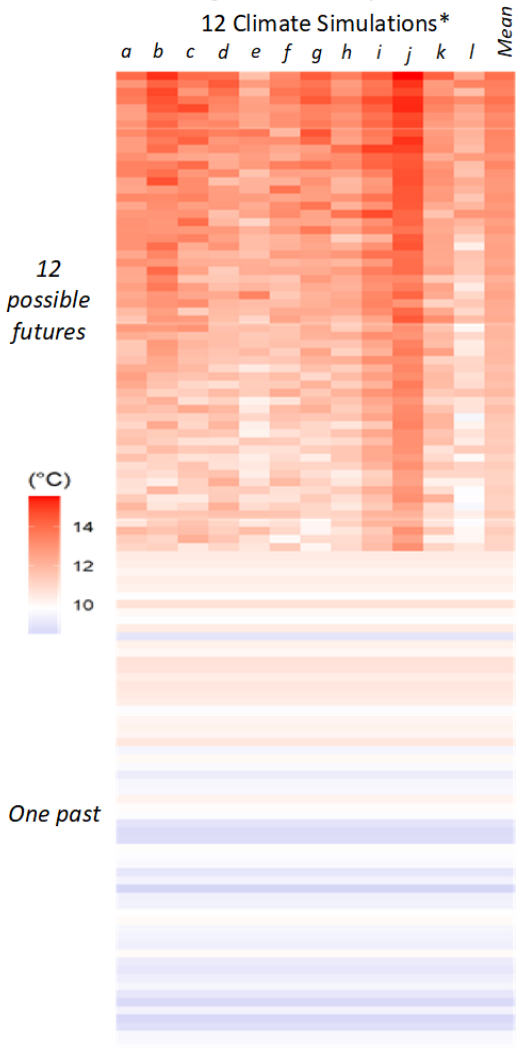
- Multiple threats necessitate resilience building
- Need a cultural shift in approaches to data sharing
- Potential from new data collection and processing technologies
- Capabilities for modelling at the field scale for decision support including climate change impacts, mitigation and adaptation
- Science needs a better working relationship with farmers for a 2-way data exchange
- Our Smart Farm provides a platform to help facilitate this.
- Need to take a global perspective of risks….

Putting projected UK changes in a global perspective

- UK may be ‘relatively’ less impacted directly by climate change and ecosystem degradation (initially) than other countries.
- BUT – we need to take a global perspective to understand local and UK-scale impacts and adaptation needs.

CoP26: Putting Glasgow’s changing climate in a global context

Glasgow’s temperature



* UKCP18 Climate Projections, RCP8.5
Mid-point for scale: average temperature 1980-2010

Plausible Global Impacts

2080 4.4°C (3.3 – 5.7°C)† Unprecedented droughts, heatwaves, floods. Severely reduced agricultural production.

2070 Loss of climate regulation ecosystem services: only 38% of emissions captured by Nature. Ocean acidification increases. Mass species extinction.

2060 Amazon rainforest collapse. Sea level rise of 0.5m means many Island States disappear.

2050 2.4°C (1.9 – 3.0°C)† Paris Agreement 2°C limit exceeded. 300m people displaced by sea level rise. Arctic Sea practically ice-free (September).

2040 1.6°C (1.3 – 1.9°C)† global average temperature rise exceeds 1.5°C. More frequent droughts, intense storms and flooding, increased rate of species extinction, loss of coral reefs. Arctic releasing more carbon. Food Security threats.

2030 50 million climate refugees.

2021 Atmospheric CO_2 is 412 ppm. Emissions from energy increasing by 4.8%. Nature increasingly a source of carbon, not a sink. 25 million climate refugees.

2003 European heatwave with 20,000 heat related deaths.

1960 Atmospheric CO_2 is 318 parts per million.

† Increase above pre-industrial levels, IPCC AR6 WG1 2021

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OurSmartFarm
https://oursmartfarm.hutton.ac.uk/

FarmBalance - Satarla
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