UNIVERSITY OF EXETER

Faculty of Environment, Science, and Economy

JULES
Joint UK Land Environment Simulator

EVALUATING THE CARBON SEQUESTRATION EFFICIENCY WITH VEGETATION DYNAMIC USING JULES-RED

Hsi-Kai Chou, Arthur Argles, Anna Harper, Peter Cox

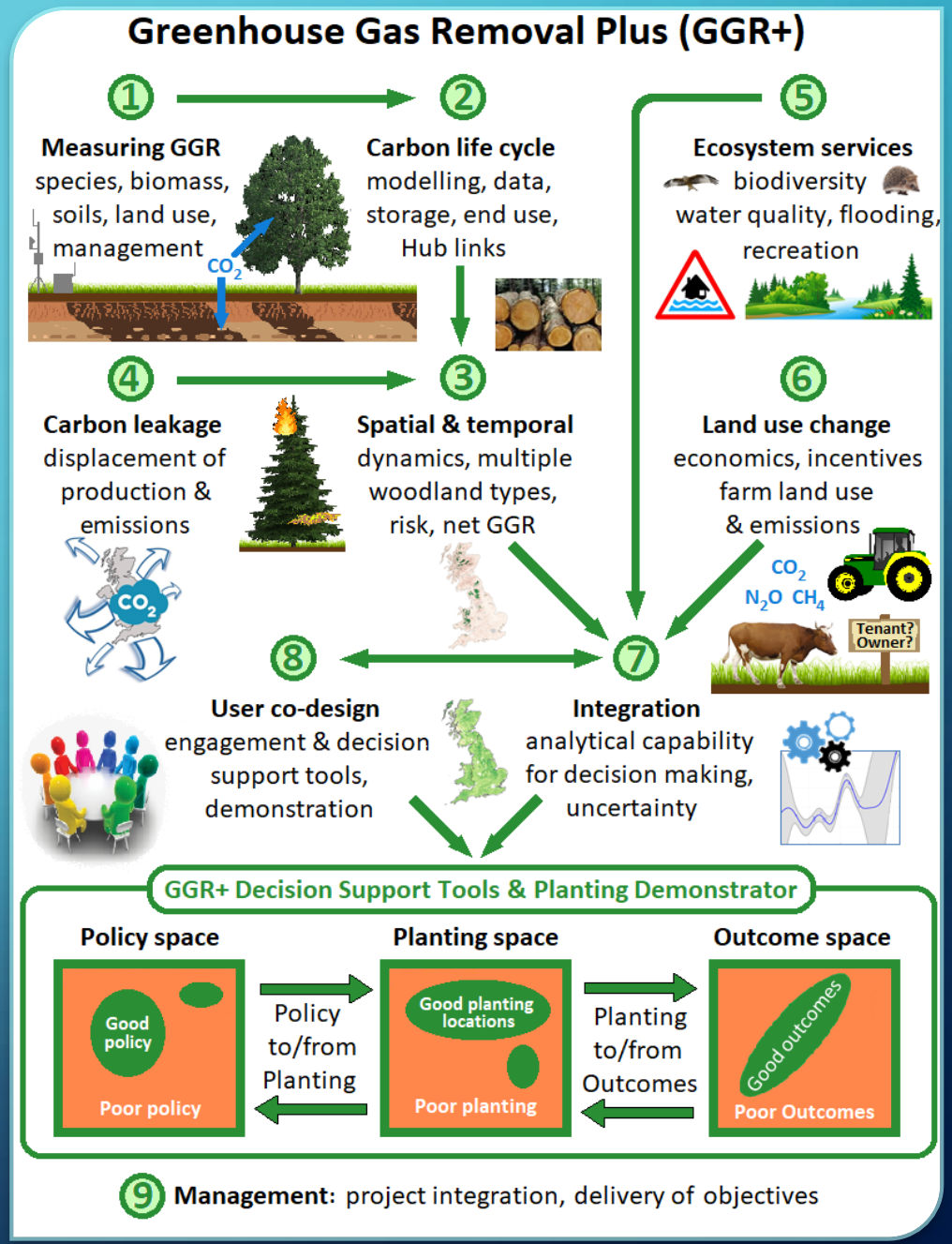
PRESENTER: DR HSI-KAI CHOU (H.CHOU@EXETER.AC.UK)

POSTDOCTORAL RESEARCHER, UNIVERSITY OF EXETER

JULES Annual Science Meeting 14 September 2023

GREENHOUSE GAS REMOVAL

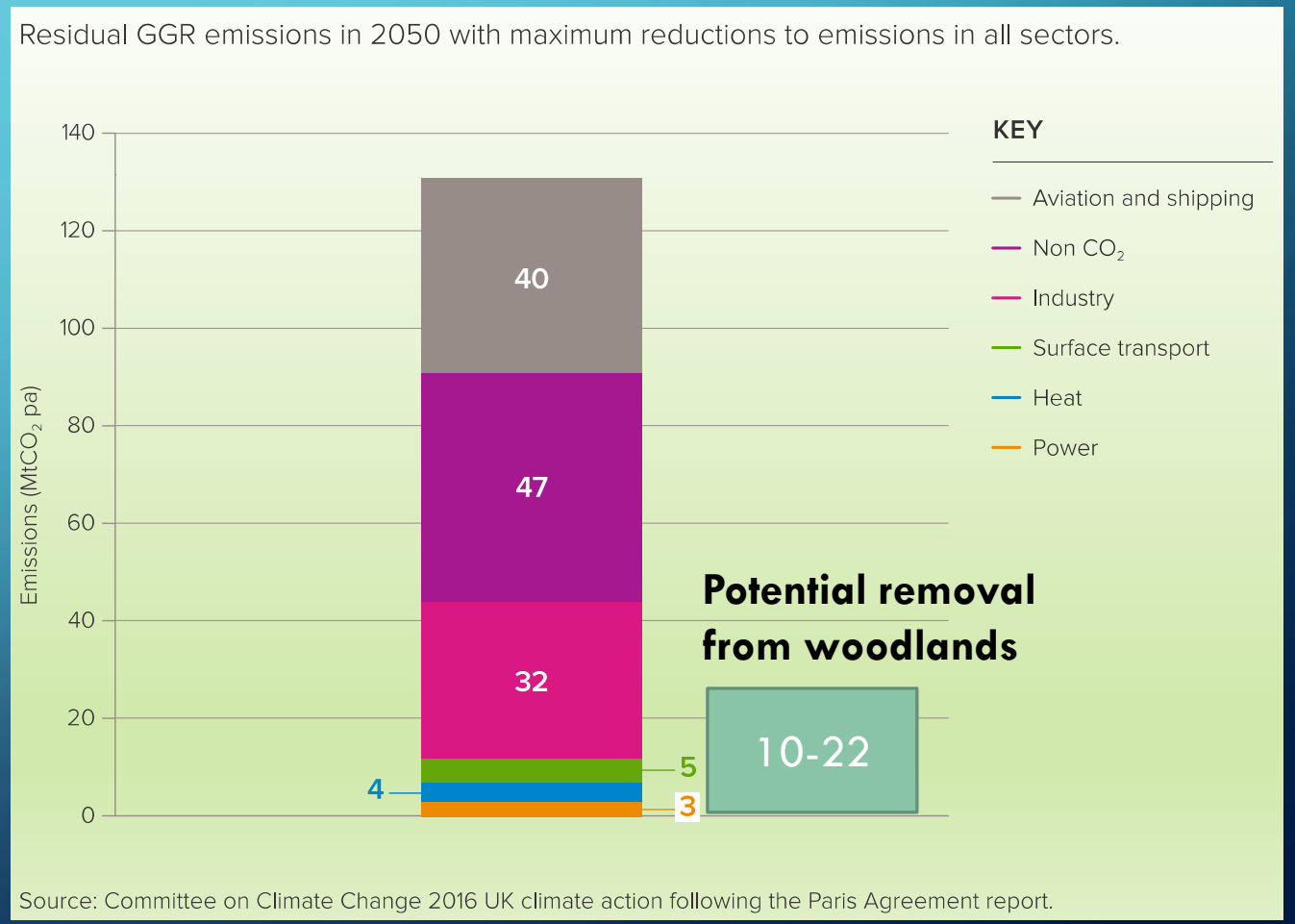
- The increasing trend of global warming is considerably attributed to greenhouse gas (GHG) emission, which has also threatened the ecosystem in many aspects.
- Limiting global warming to "well below 2 degrees Celsius" (Paris Agreement, 2015).
- Attaining net zero emissions of GHG by 2050 (HM Government in 2019).



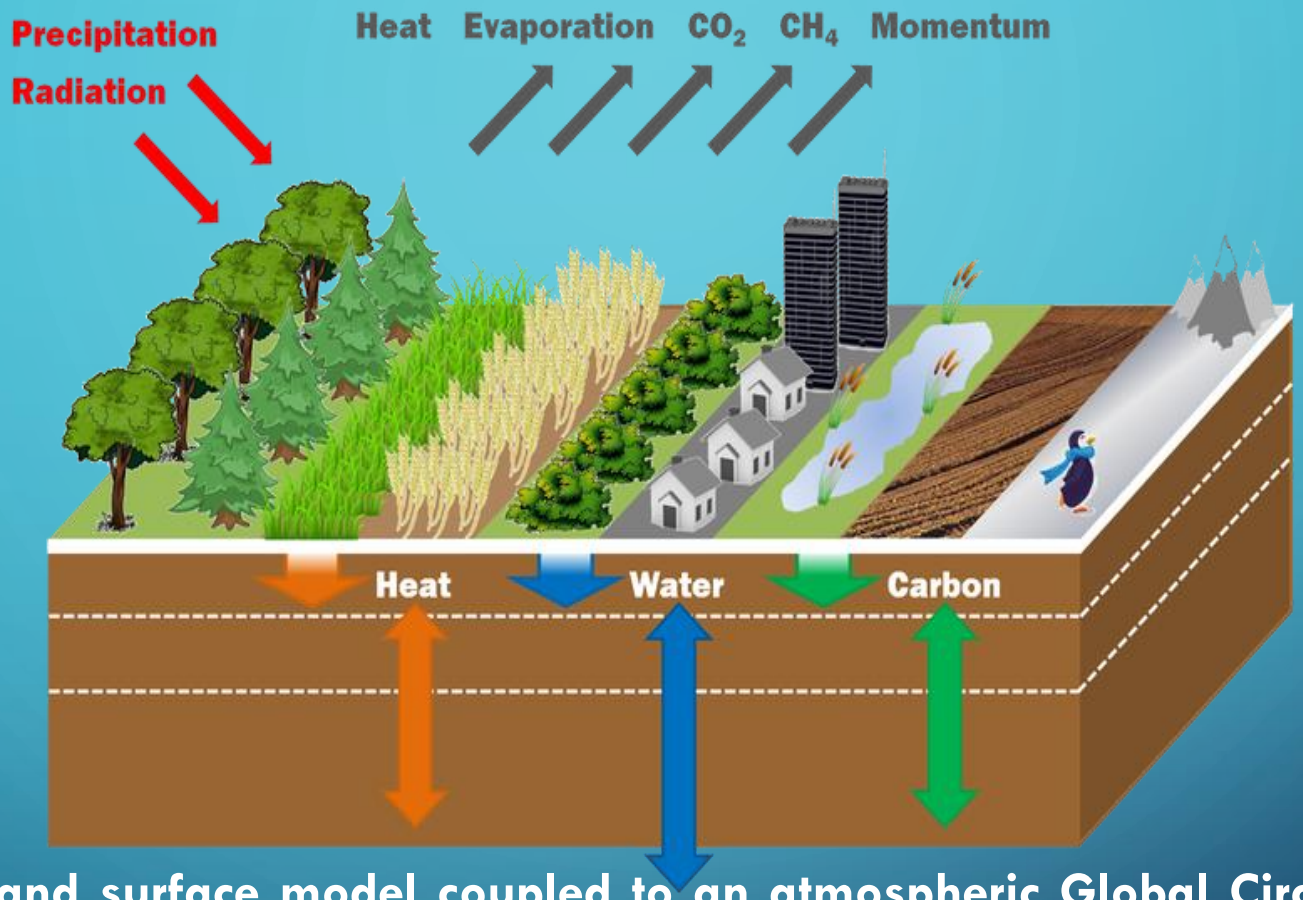
NetZero PLUS

TREE PLANTING GOAL

- Planting 30,000 hectares of new woodlands every year by 2025 (Department for Food, Environment, and Rural Affairs)
- The potential for carbon removal varies depending on
- Where you plant ?
- What you plant ?
- What is displaced ?



The Joint UK Land Environment Simulator (JULES)

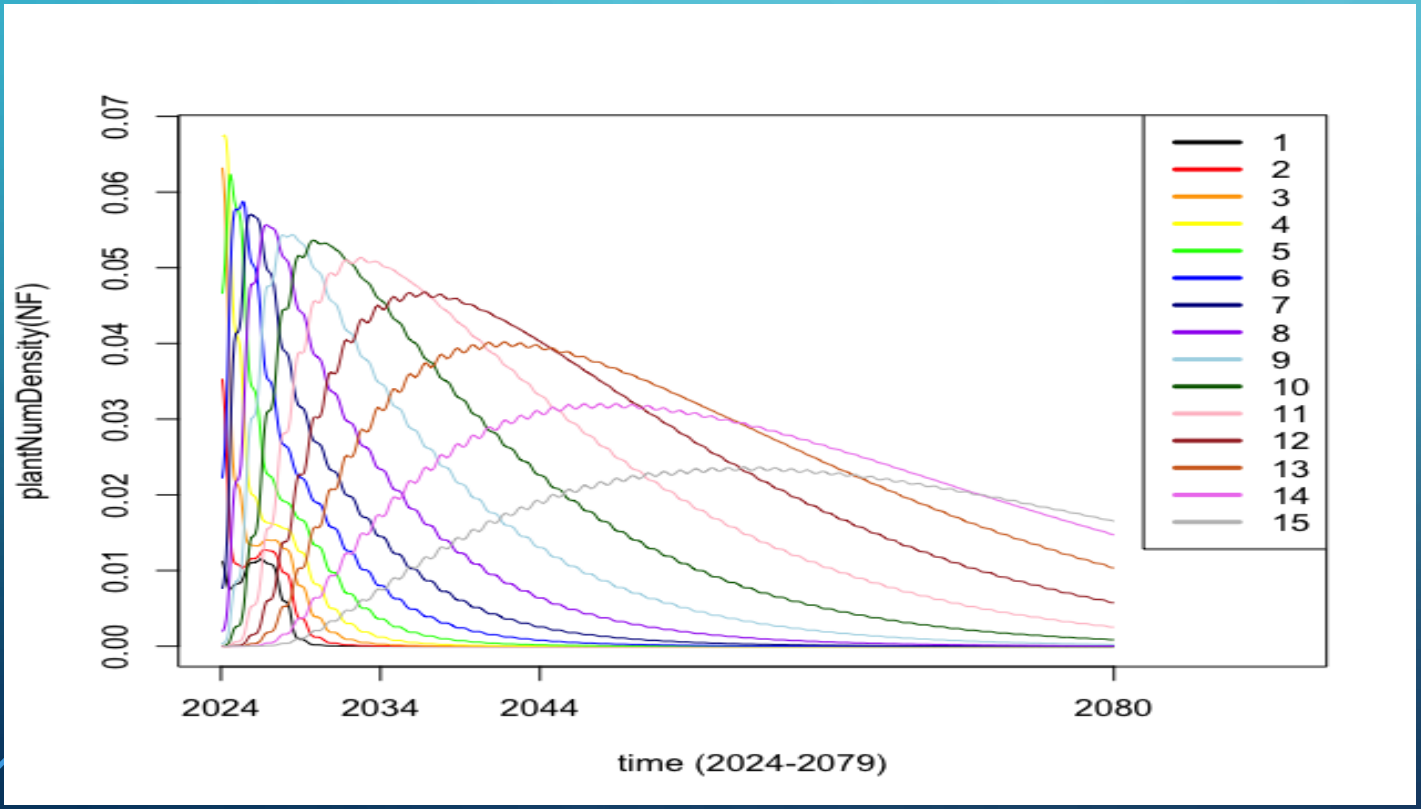


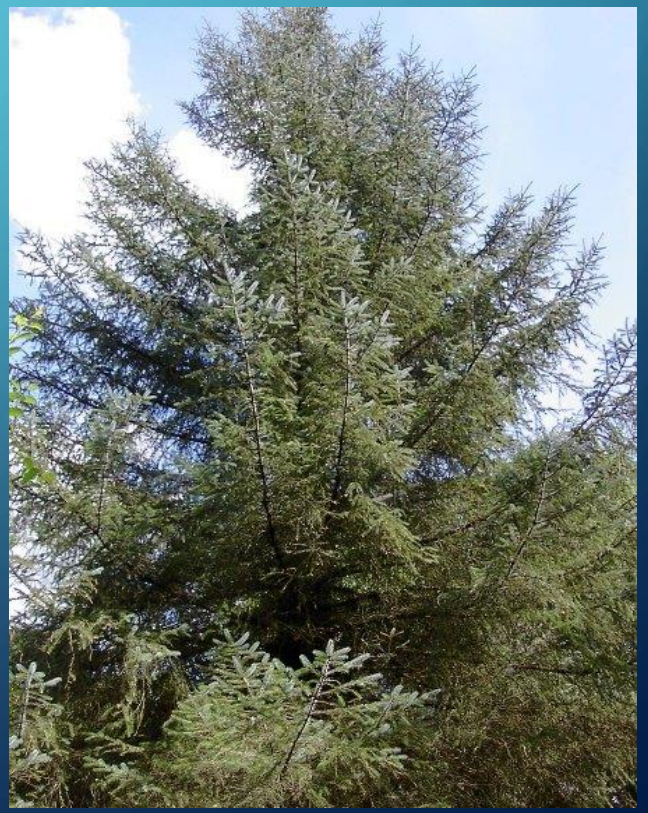
- A community land surface model coupled to an atmospheric Global Circulation model, which can simulate the fluxes between the land surface and the atmosphere.
- Simulates the processes that control carbon uptake and storage on land.
- Predicts hydrology and energy exchange with the atmosphere.
- Predicts what kind of vegetation grows where.

- JULES-RED (Robust Ecosystem Demography)

- An alternative model which captures important changes in forest demography.

- Growth curve and demography of Sitka spruce were calibrated in a plantation site in Harwood Forest (Argles et al., 2023).



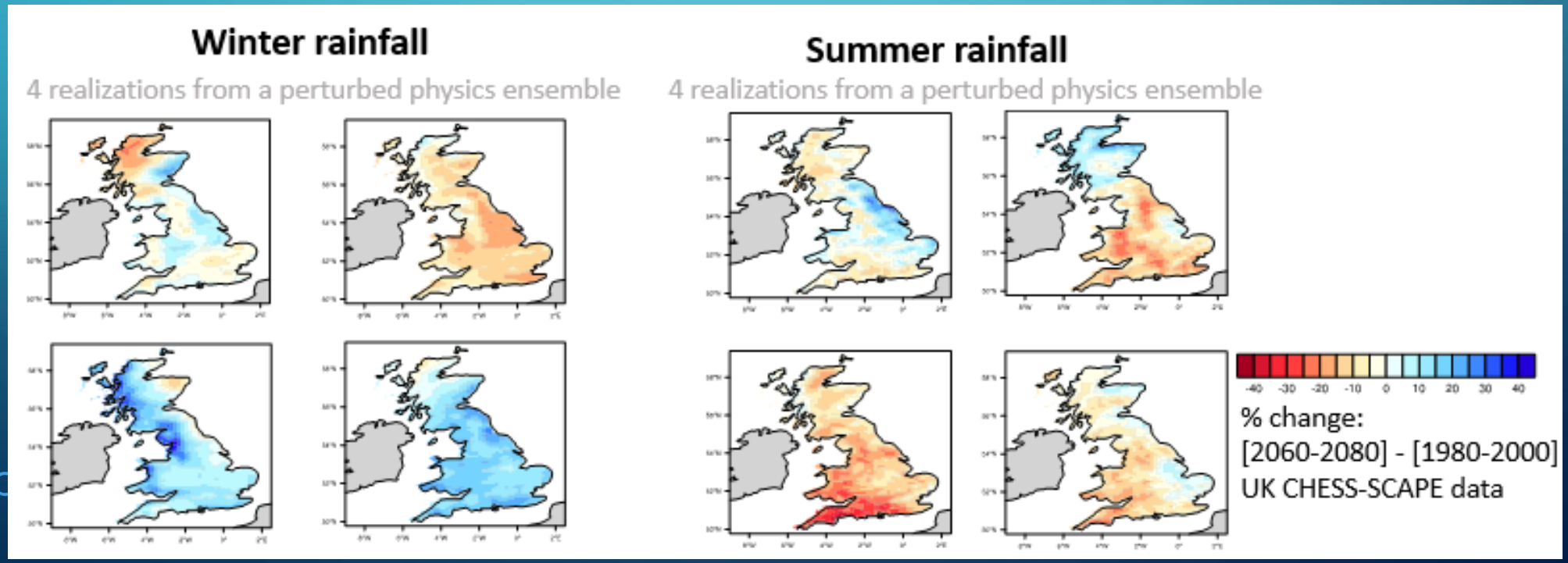


- Climate change patterns in RCP2.6

- The climate scenario follows RCP2.6 (very stringent pathway, CO2 emissions start declining by 2020 and go to zero by 2100, 1.0°C temperature increase in 2010) using the CHESS-SCAPE forecasting data.

- Summer temperature 1.0-2.3˚C warmer

- Winter temperature 0.9-2.1˚C warmer



- Mapping the spatial-temporal dynamic of Greenhouse Gas Removal using JULES-RED

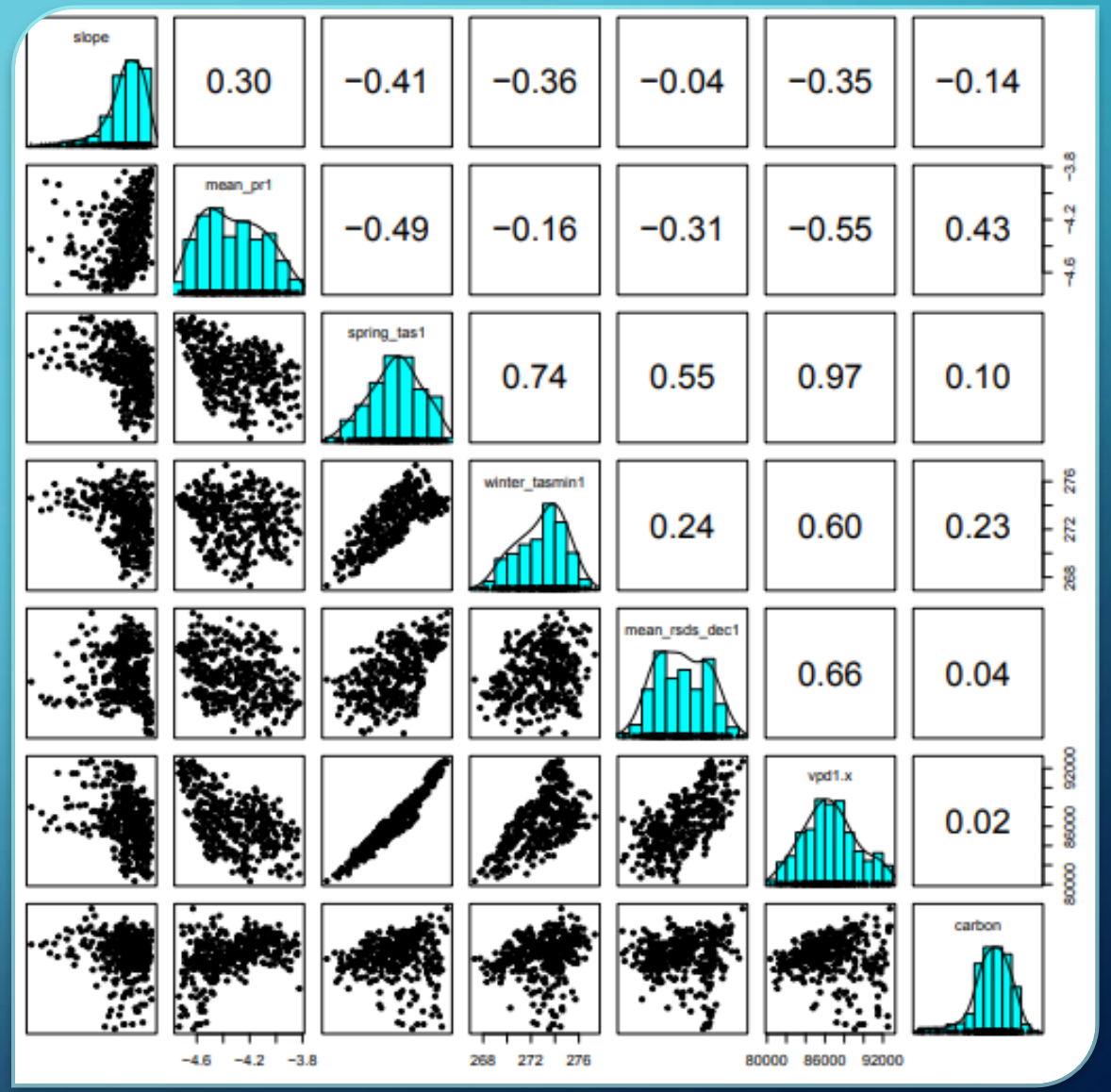
- We aim to map the carbon accumulation in 2040/2060/2080 within the UK.

- The Forest (Sitka spruce) are scheduled to be planted in the start of 2024 at 2500 trees/ha density.

- Points are initially selected based on soil properties, geography and climate classifications.

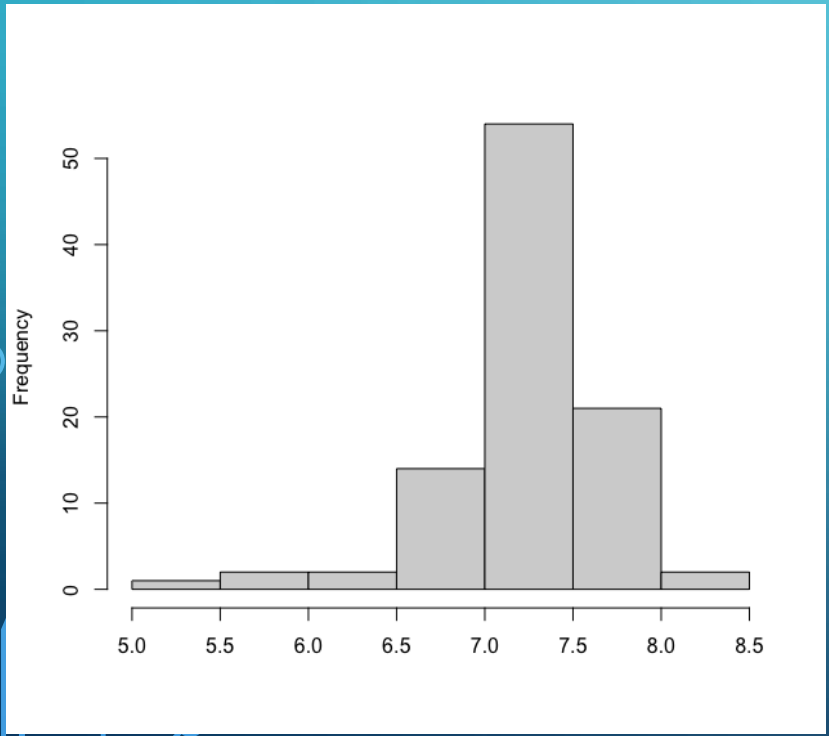
- Mapping the spatial-temporal dynamic of Greenhouse Gas Removal using JULES-RED

- **Correlation analysis on the input data and vegetation carbon.**
- **Rainfall, minimum winter temperature has higher impact on the vegetation carbon.**

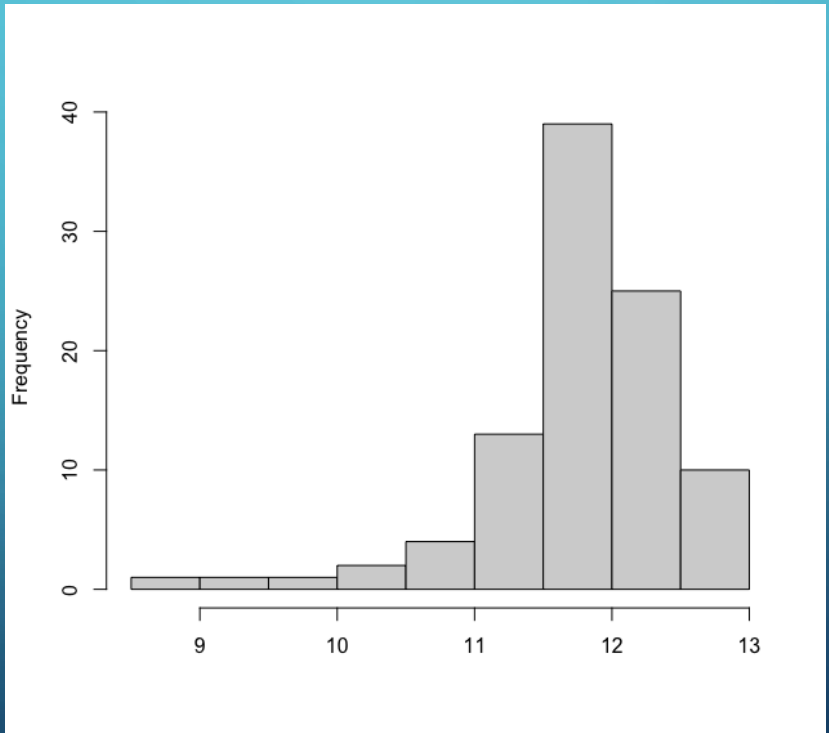


- Mapping the spatial-temporal dynamic of Greenhouse Gas Removal using JULES-RED

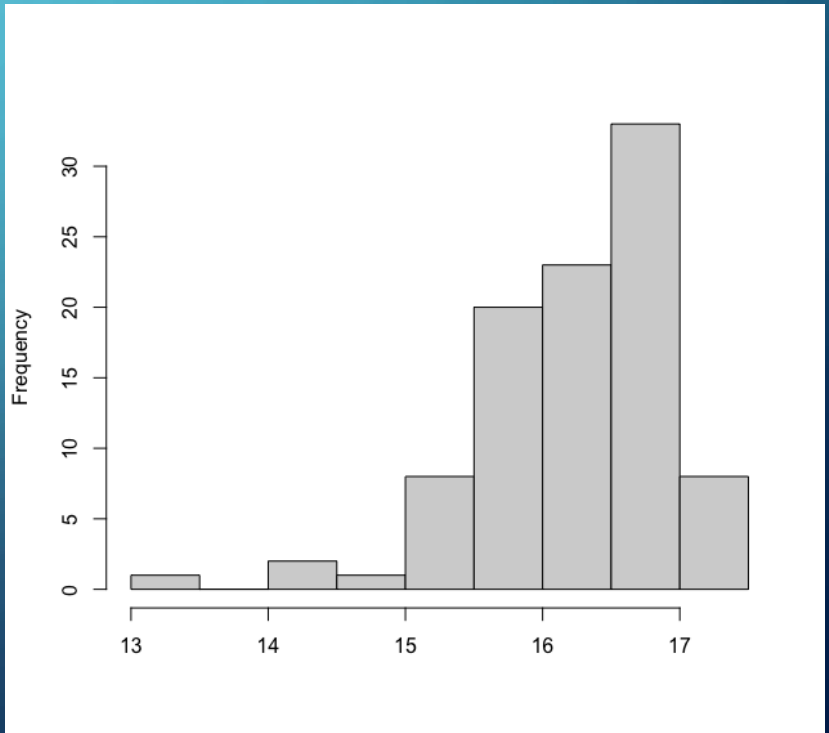
  - **The distribution of accumulated carbon in 2040, 2060, 2080.**
  - **Ranging from 13.45 to 17.35 kg/m^2 in 2080 (+29%).**



2040

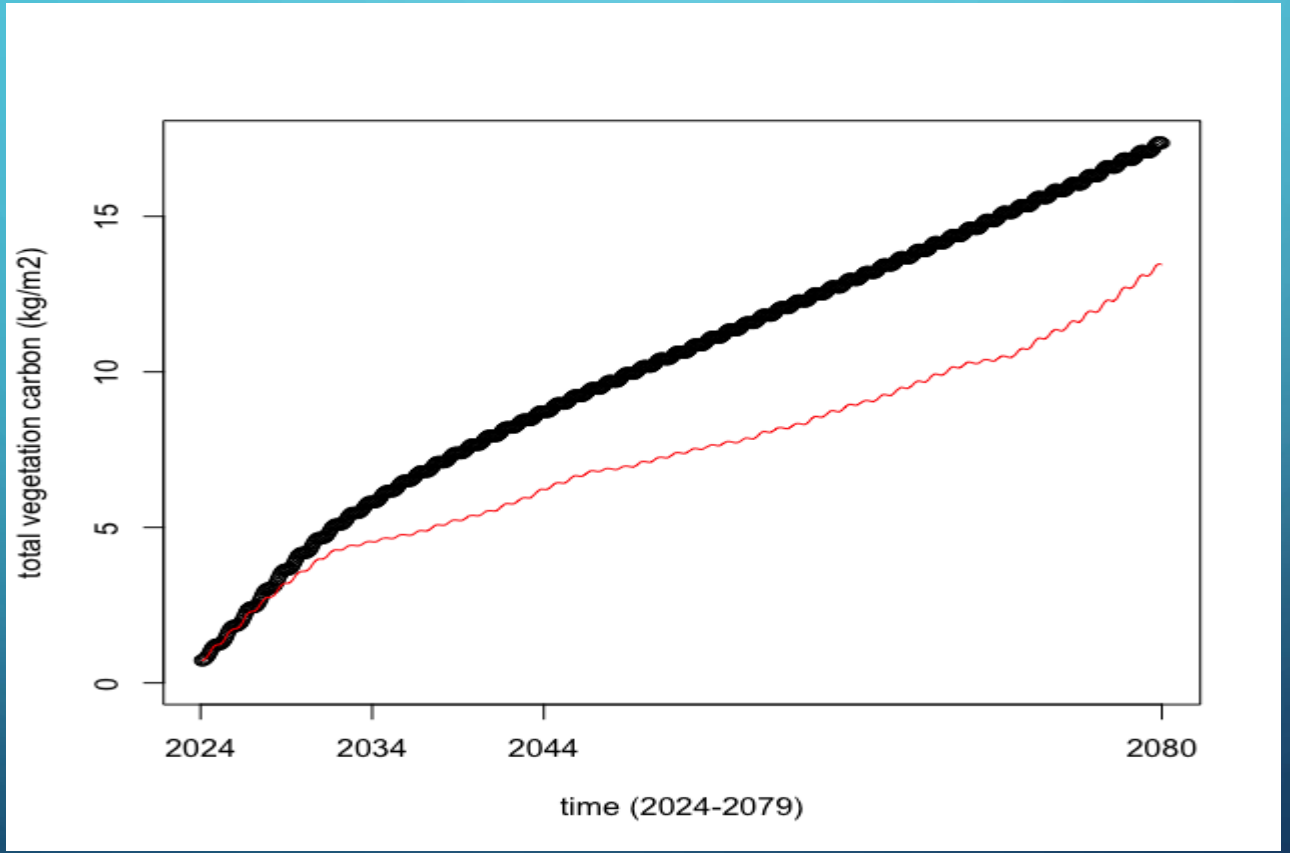


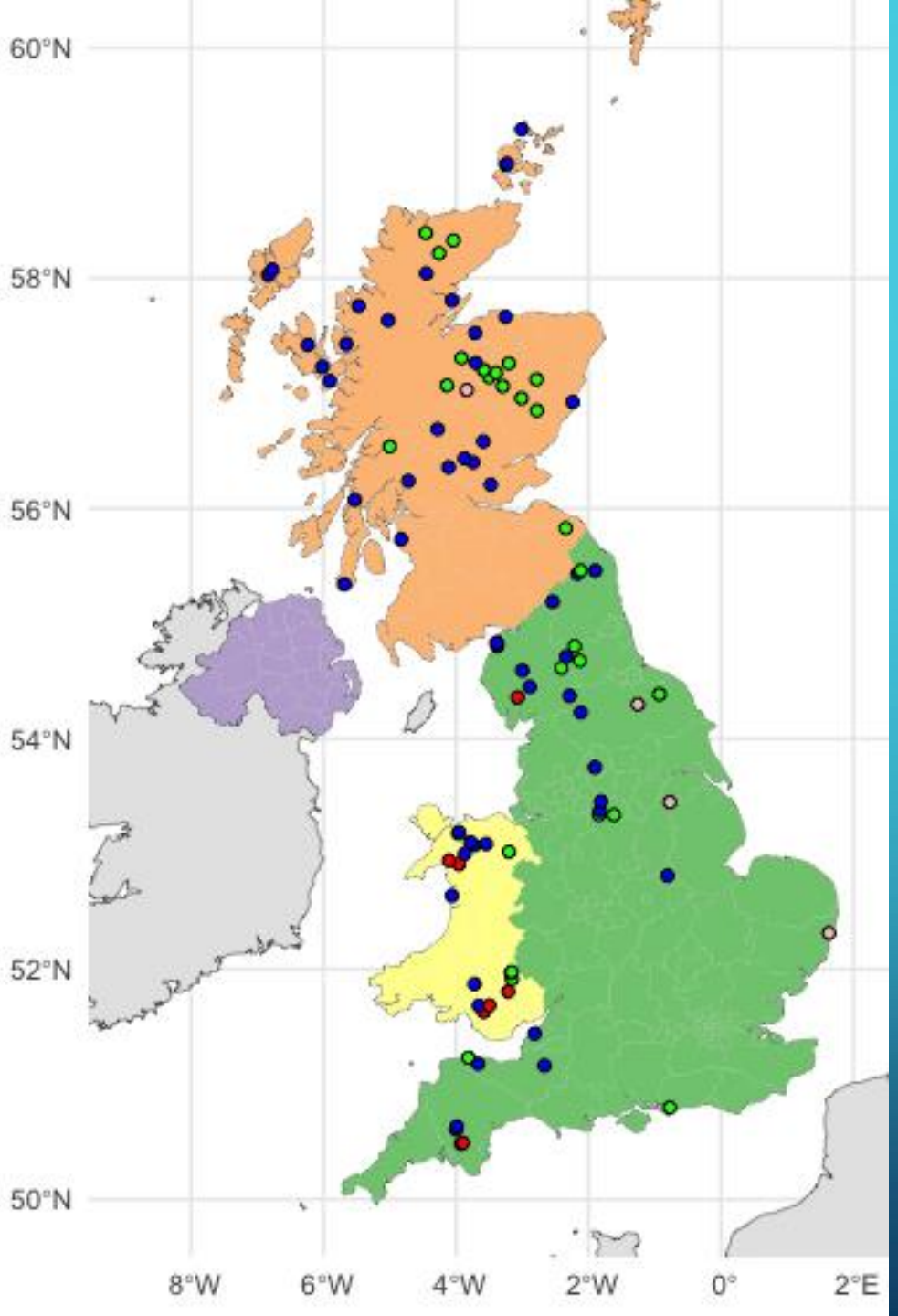
2060



2080

- Mapping the spatial-temporal dynamic of Greenhouse Gas Removal using JULES-RED
  - **Carbon accumulation in single site (maximum site and minimal site as example).**





Mapping the spatial-temporal dynamic of Greenhouse Gas Removal

- In 2080, vegetation carbon ranges from 13.45 to 17.35 kg/m^2
- Red point: vegetation carbon greater than 17kg/m^2
- Blue point: vegetation carbon between 16-17kg/m^2
- Green point: vegetation carbon between 15-16kg/m^2
- Pink point: vegetation carbon less than 15kg/m^2

Summary

- Interesting case study where government is considering:
  1) How to incentivize tree planting, and
  2) Optimal land use for multiple purposes.
- We identify rainfall and temperature to be the most effective factors determining carbon accumulation.
- We demonstrate the capability and effectiveness of GGR, which serves as a reliable reference for land use management strategy
- We currently model the plantation of **Sitka spruce**, and we will extend the model for other common plantation types.
- The model could further be used to evaluate the potential carbon accumulation under other climate scenarios (RCP 4.5, RCP8.5, etc.)