

Resolving the C dynamics of fragmented, mixed-use landscapes using EO and process modelling – inferring management and the importance of scale

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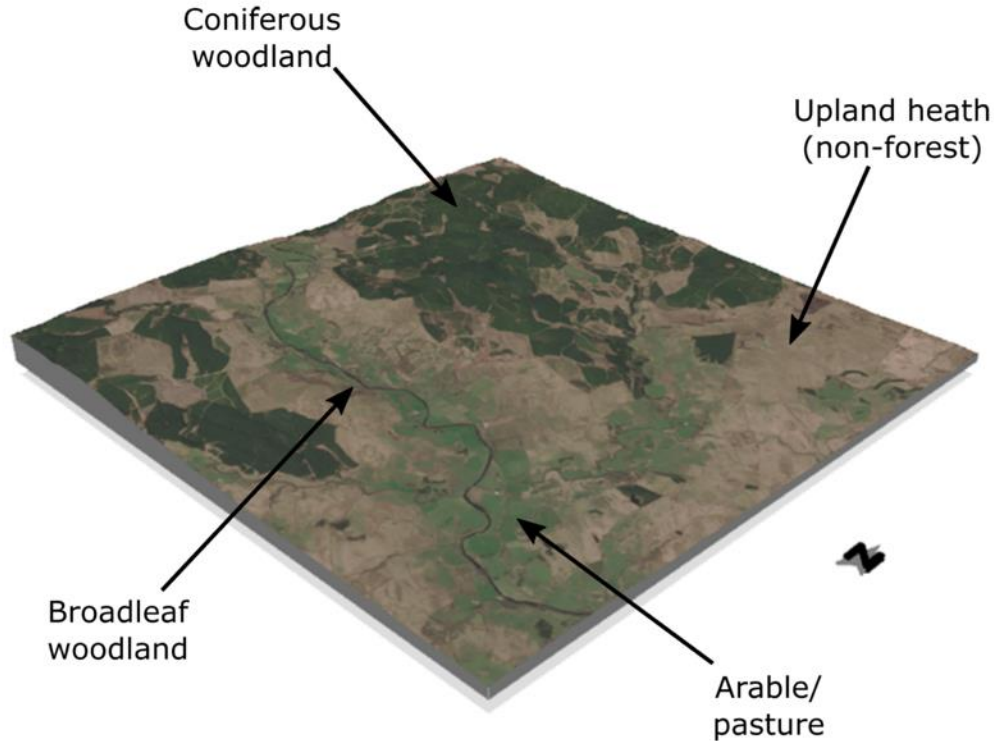
Land use change and agriculture impacts on the carbon cycle
ESA Carbon from Space Workshop



**National Centre for
Earth Observation**
NATURAL ENVIRONMENT RESEARCH COUNCIL

What is the C budget of this landscape?

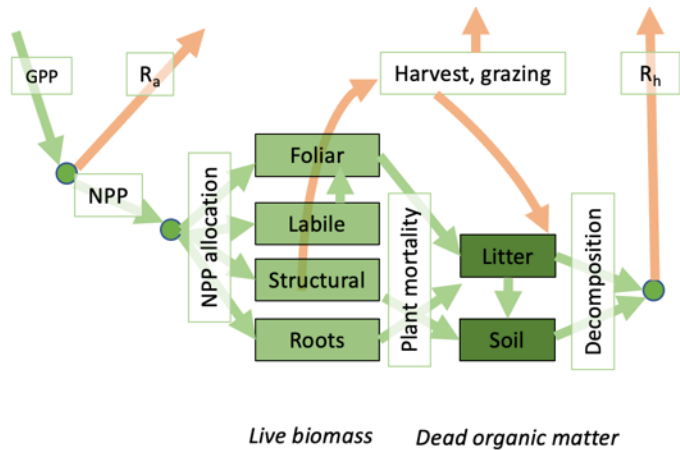
How sensitive is C to management?



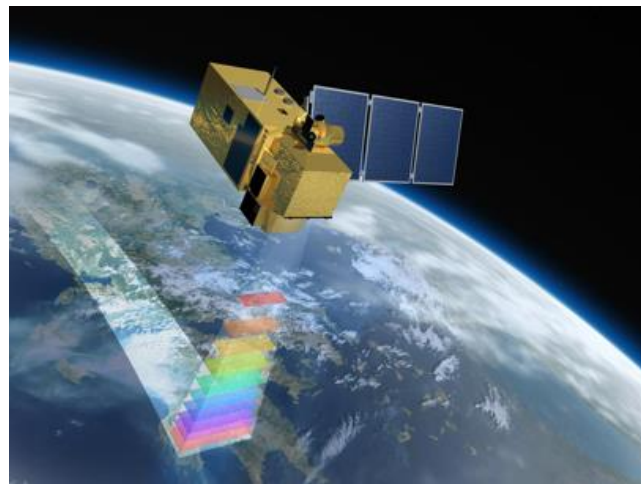
How resilient are these C stores?

How is C storage optimised alongside other goals such as yields?

Process models



Earth Observations



Model data fusion

- + Complete
- + Clear confidence limits
- + Capable of forecasts
- + Counter-factual

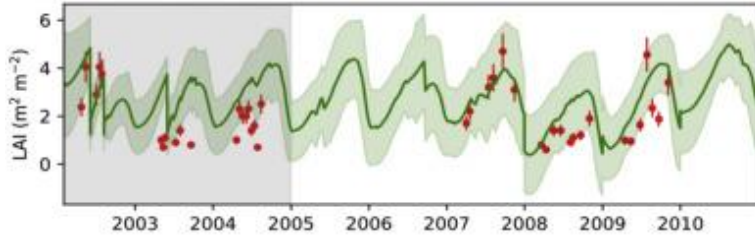
Two challenges

- i. Can EO data provide robust information on management factors?
- ii. What are appropriate scales for analysis and which are the scale-variant processes that must be managed?

(i) Identifying and diagnosing management effects



Calibration and validation at field scale

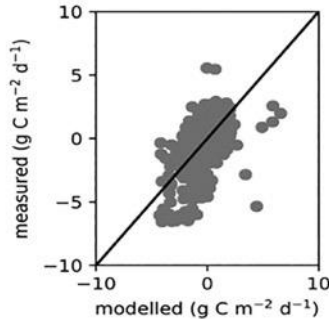
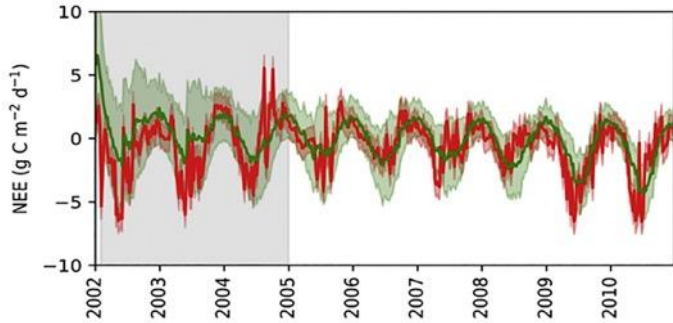


Sheep grazing in Midlothian
-Management data known



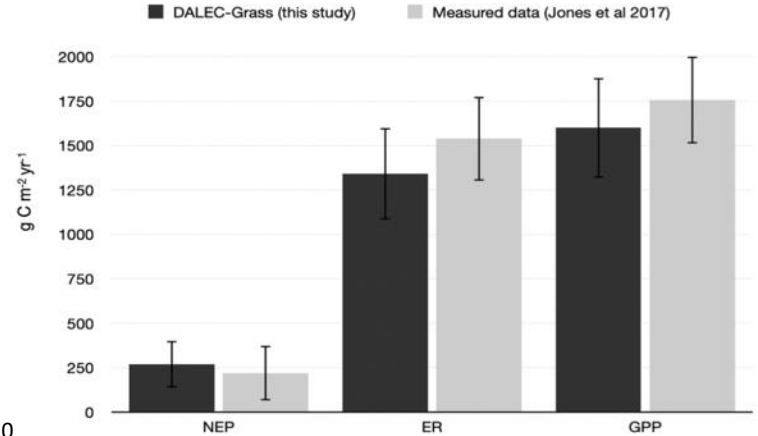
Calibration

S-2 LAI (red) and analysis (green)

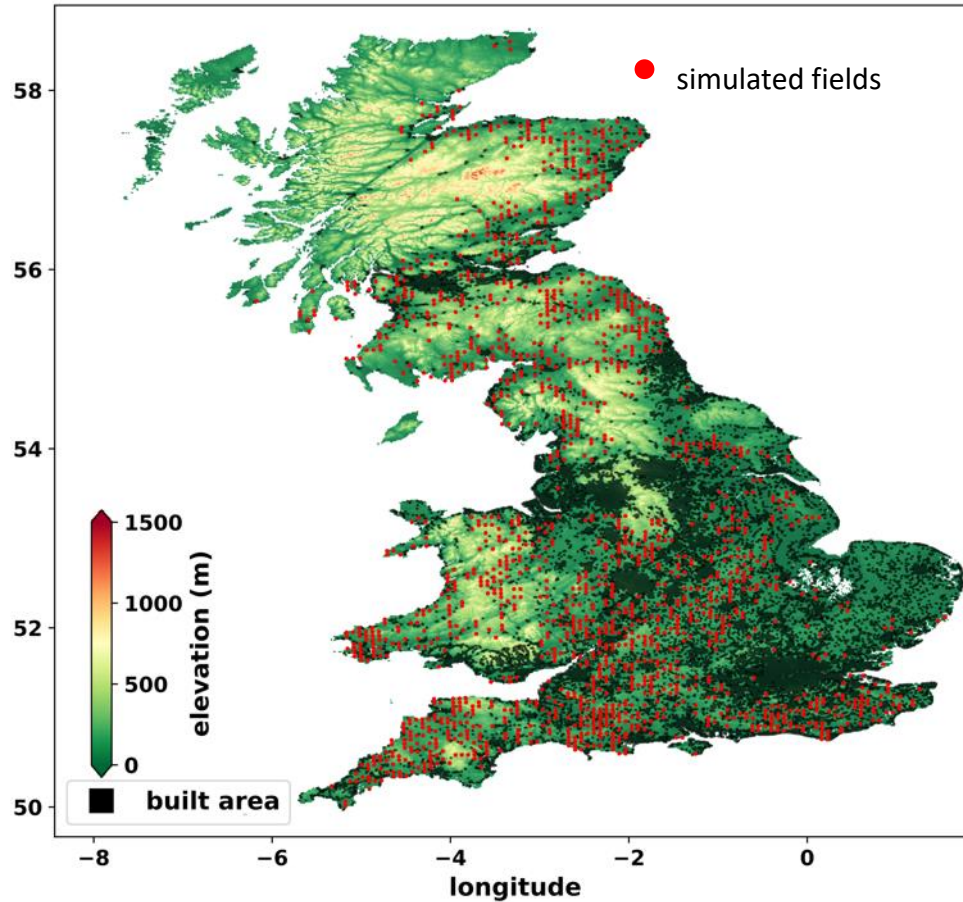


Eddy flux tower (red) and analysis (green)

Myrgiotis et al. 2020



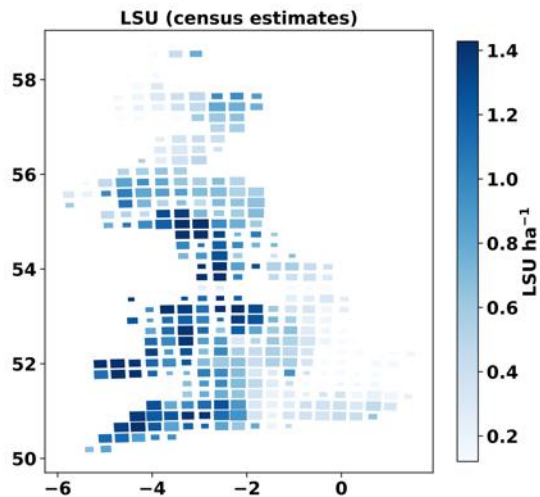
Copernicus LAI
Sentinel 2 LAI
ERA5 met data
SoilGrids



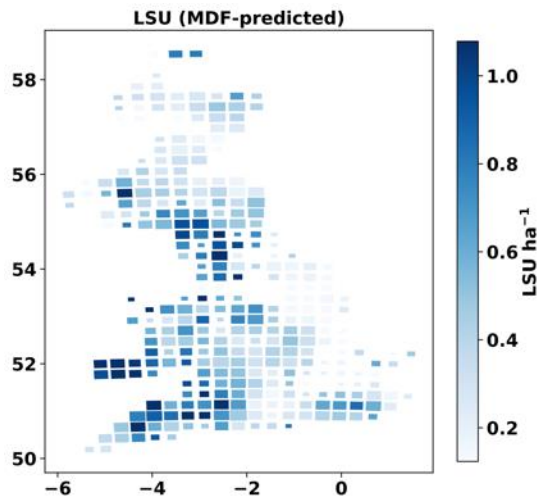
~2000 fields
➤ >9 ha
➤ Pasture

PREDICTED LIVESTOCK DENSITY - VALIDATION

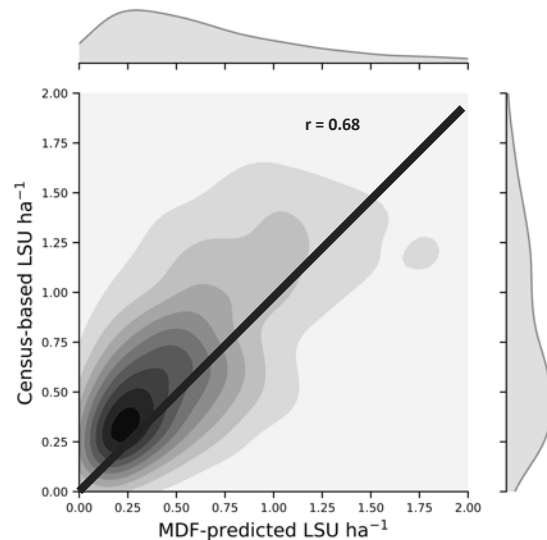
AgCensus data (5 km grid)



Model diagnostic

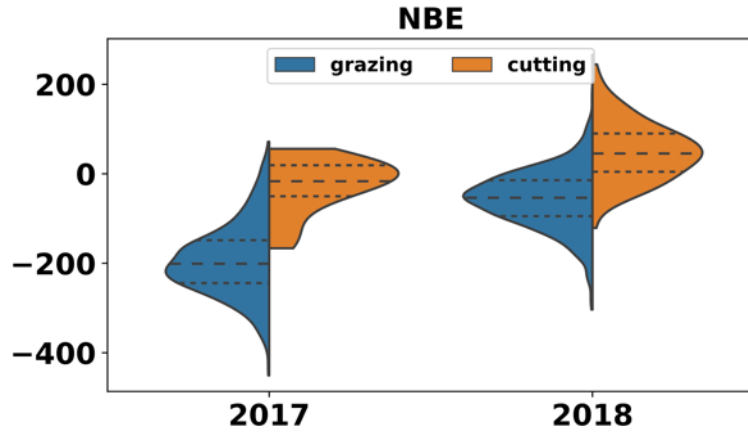


Independent validation
AgCensus data (5 km grid)

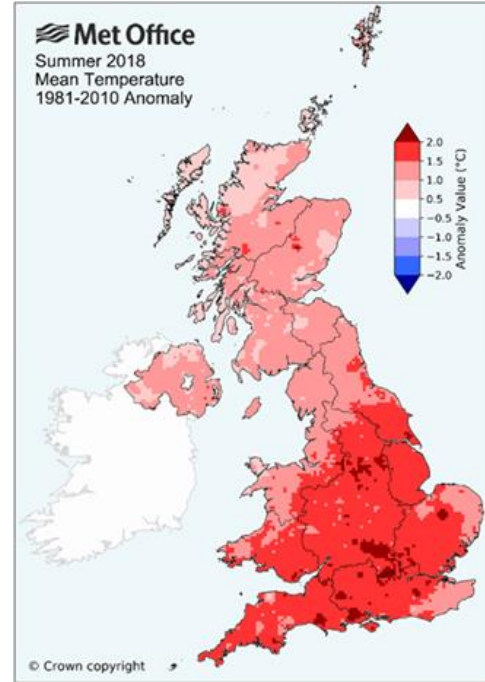


LSU (livestock units) : 1 dairy cattle =1 LSU , 1 sheep = 0.11 LSU

C BALANCE AND FLUXES

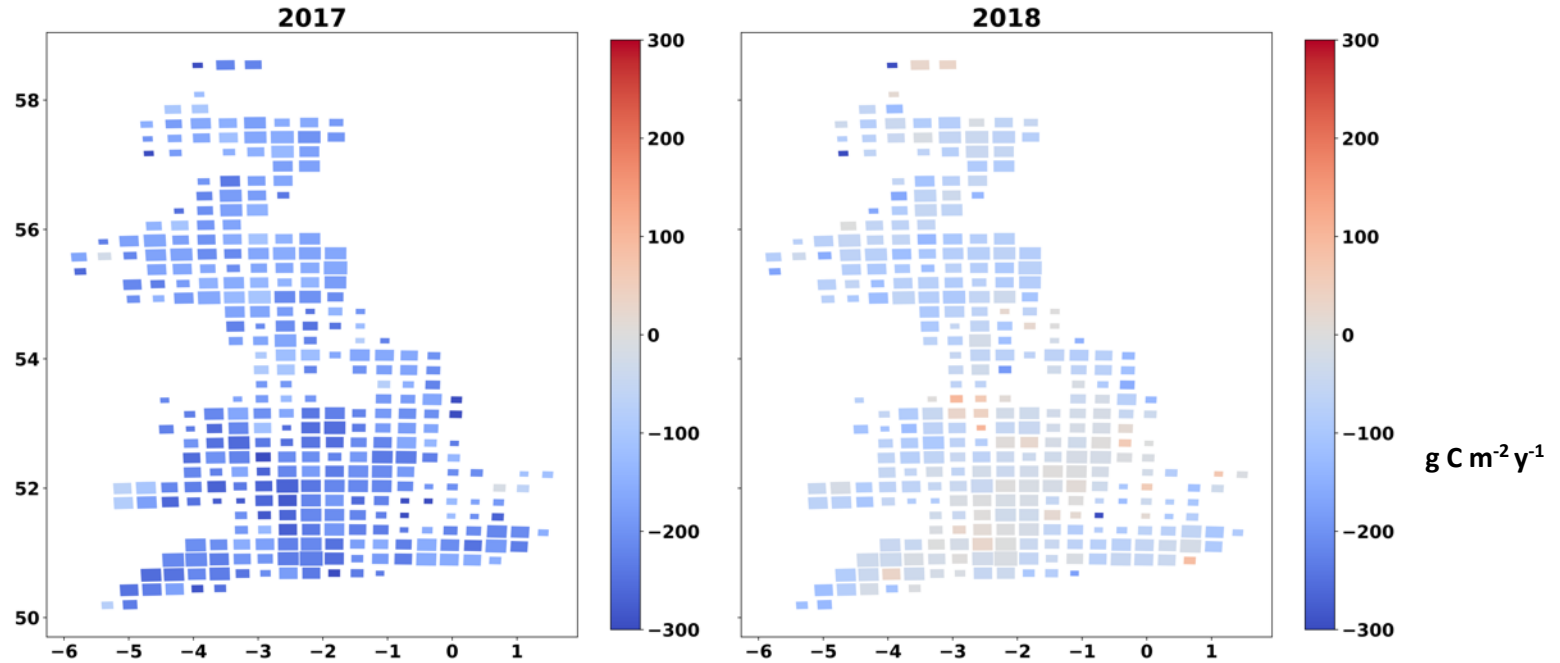


Net biome exchange



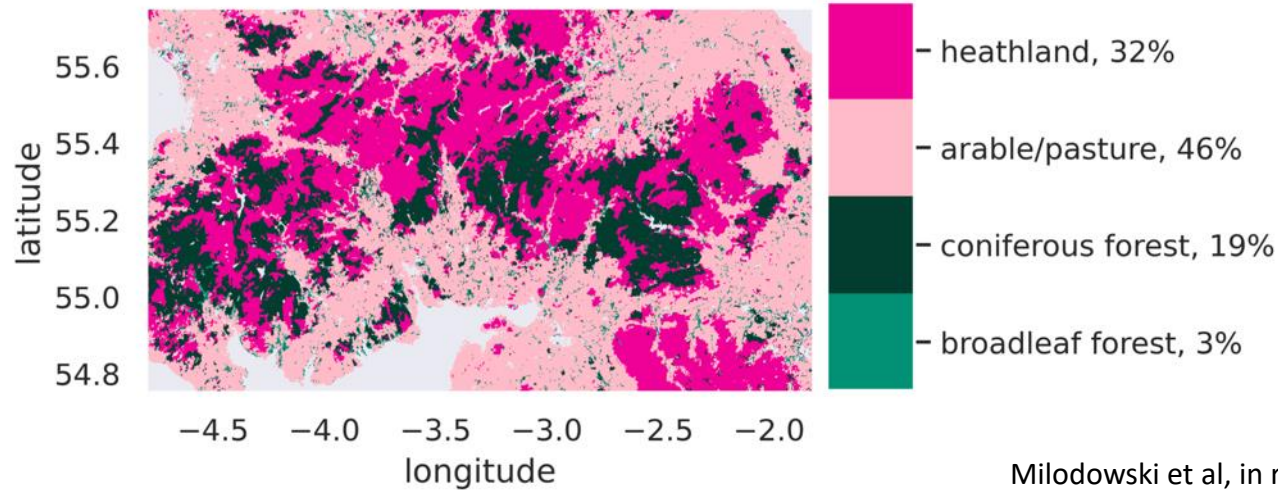
2018 heatwave

INTER-ANNUAL CHANGE IN NET BIOME C EXCHANGE (NBE)



A 9-fold increase in the number of simulated fields for which $\text{NBE} > 0$
Management and climate interact to determine net C emissions

ii) scale-variance in the carbon dynamics of fragmented, mixed-use landscapes

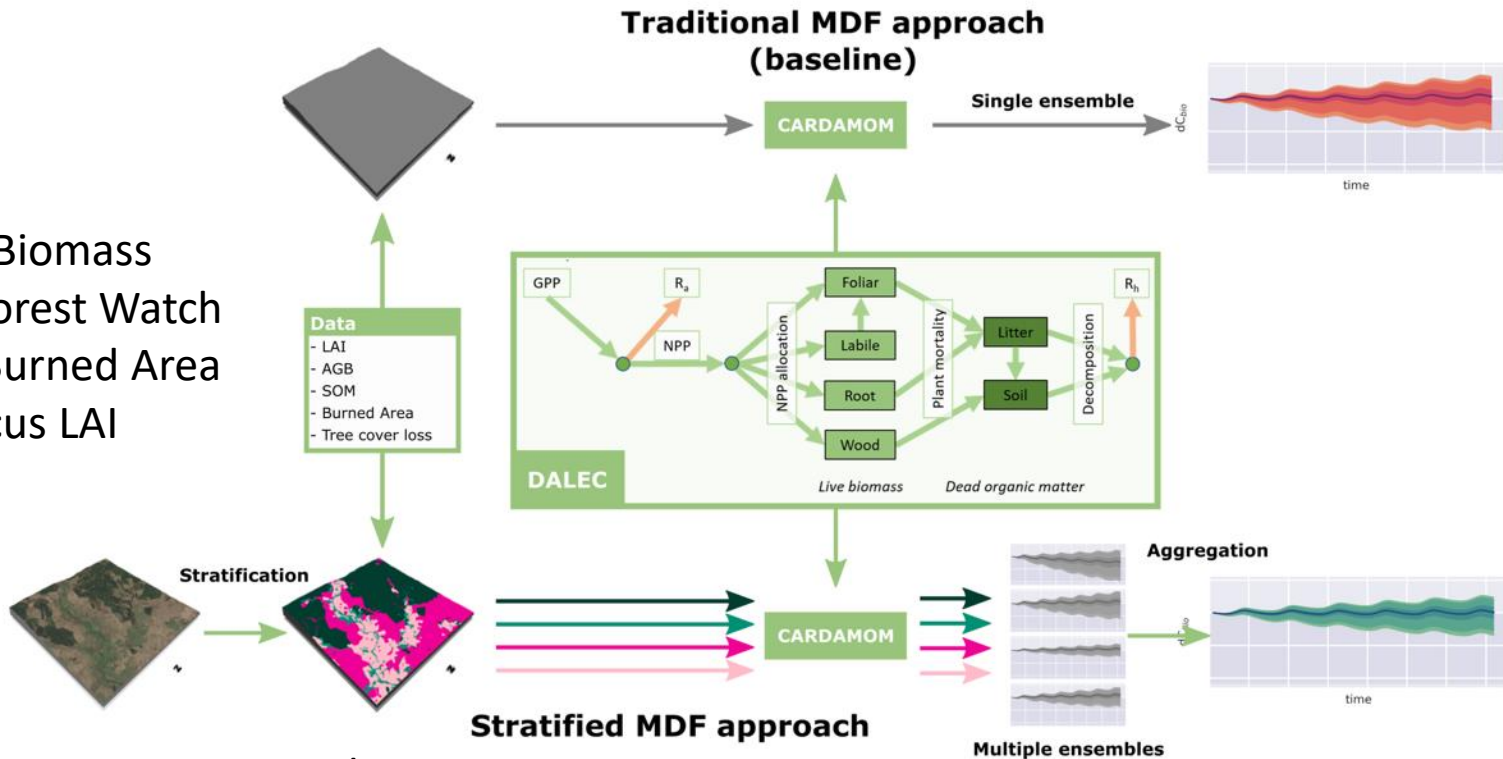


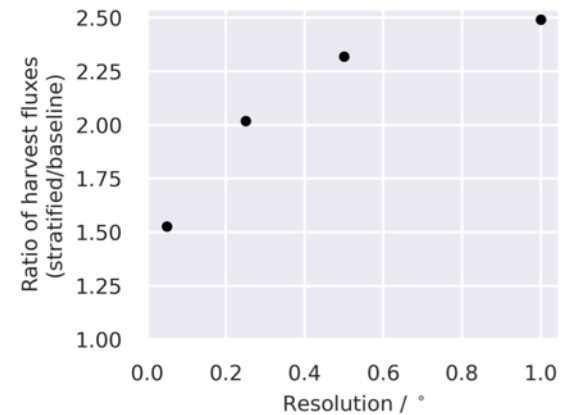
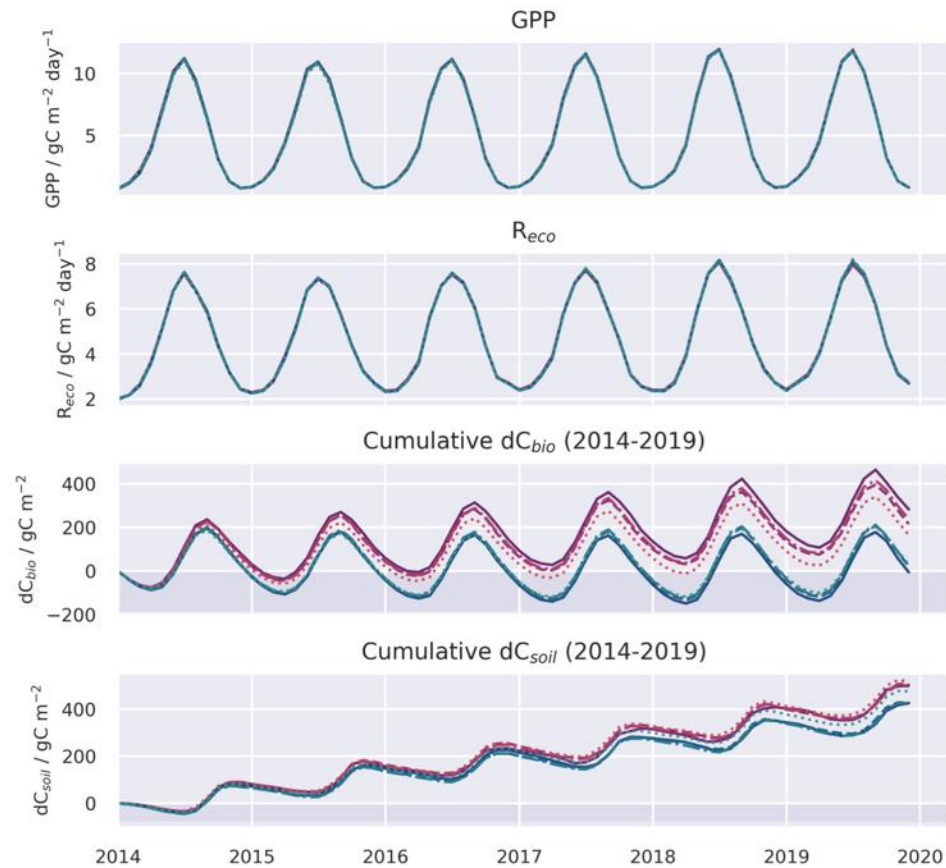
Milodowski et al, in review

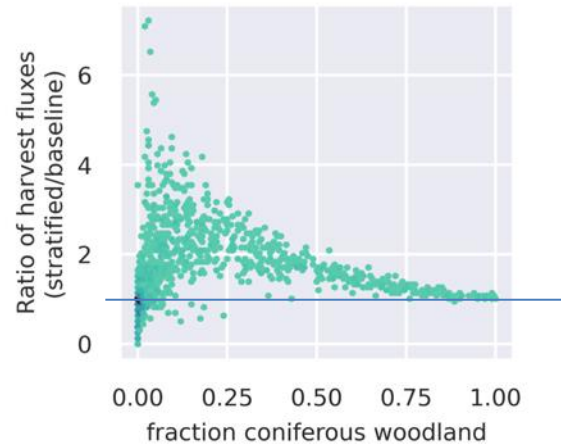
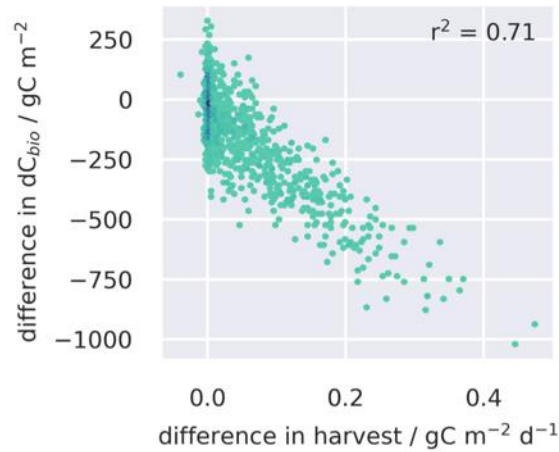
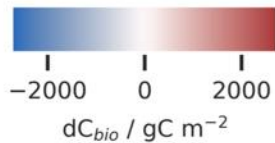
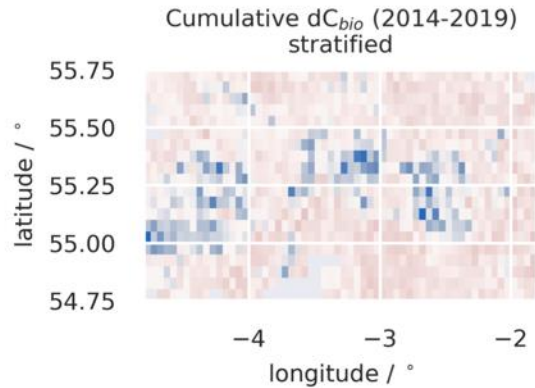
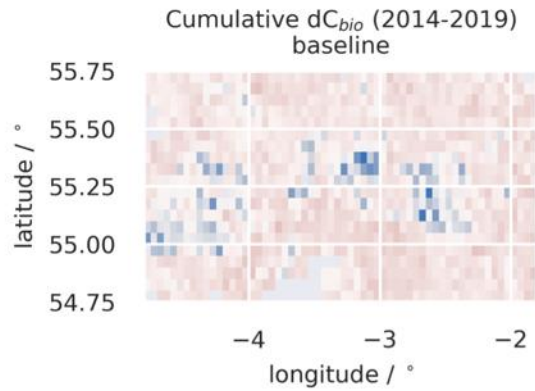


Experimental design

ESA-CCI Biomass
 Global Forest Watch
 MODIS Burned Area
 Copernicus LAI
 SoilGrids







Stratification links management to land use

Summary

- Management is a key determinant of the C balance of managed grasslands
- Extreme weather can convert grassland C sinks to sources.
- **EO can detect field-scale variability in these outcomes.**
- Land-use controls the spatial distribution of C stocks and ecological processes related to their management and disturbance
- Accounting for fine-scale structure in heterogeneous landscapes is vital for ensuring the ecological fidelity of MDF
- **Disturbance processes are scale variant**

Thanks to GCEL:

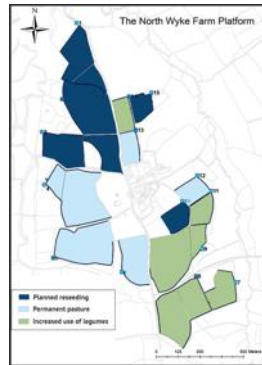
Luke Smallman, Anthony Bloom, Andrew Revill

Also:

Data from Copernicus, SoilGrids, ESA CCI-Biomass, Global Forest Watch

Funding: NERC, BBSRC, ESA, NCEO, Newton Fund, UKSA

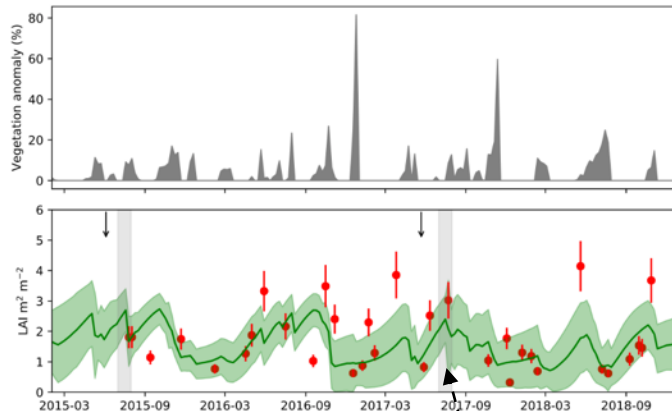




Field-scale application via remote sensing

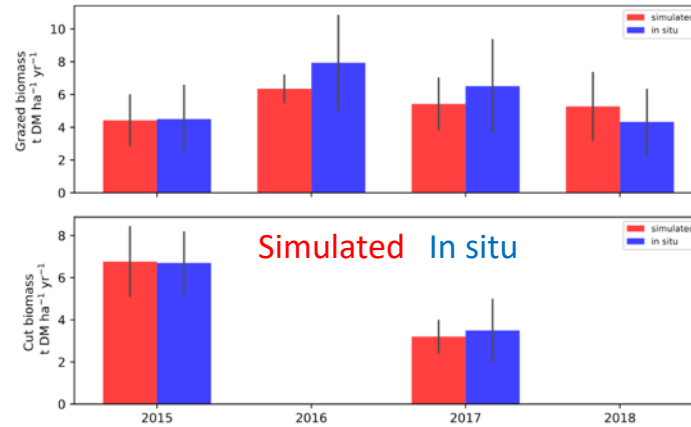
UK grassland
Nr Exeter

Assimilating PROBA-V vegetation anomaly and Sentinel-2 LAI



↓ Actual harvest Predicted harvest

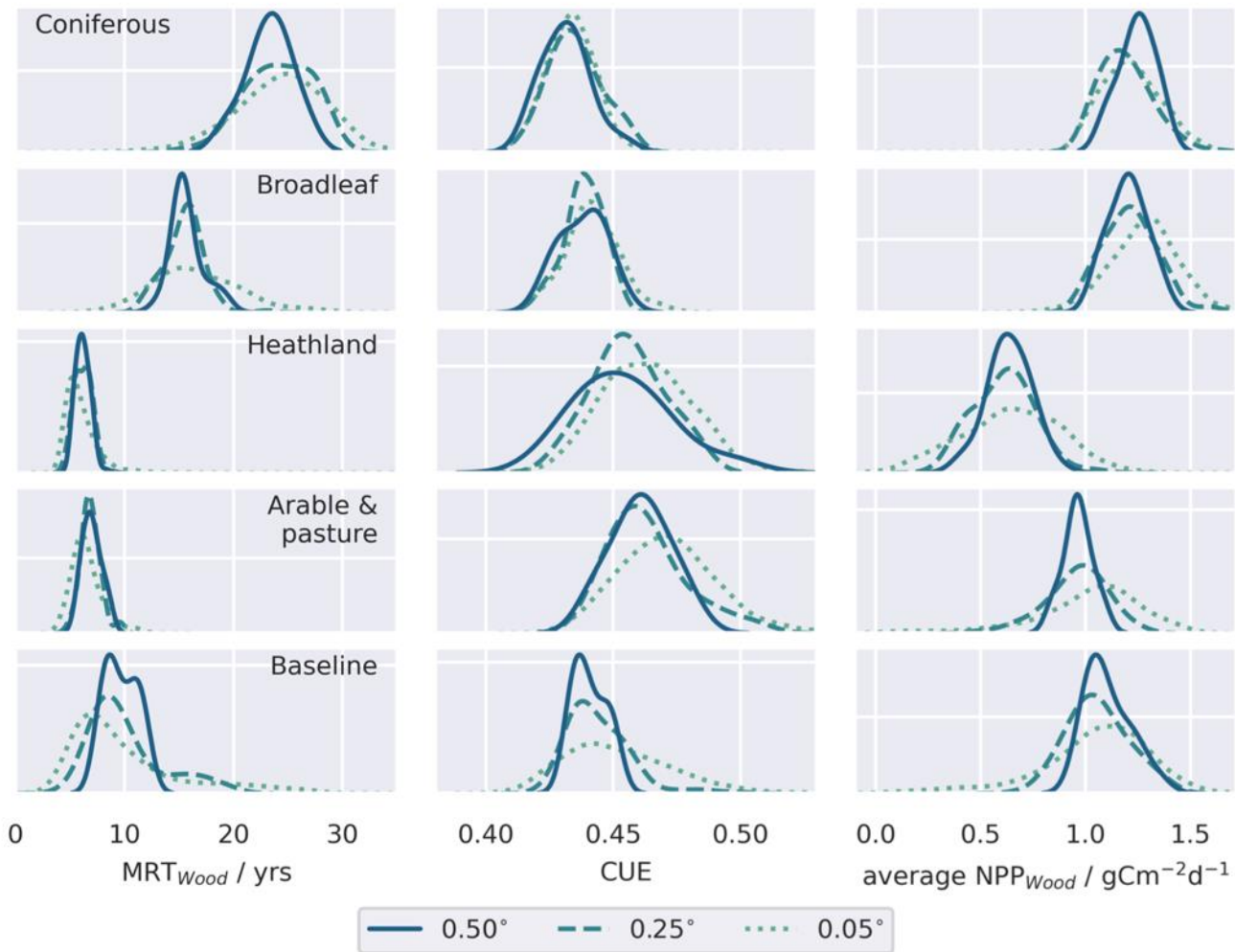
Independent tests against in situ grazing and cuts



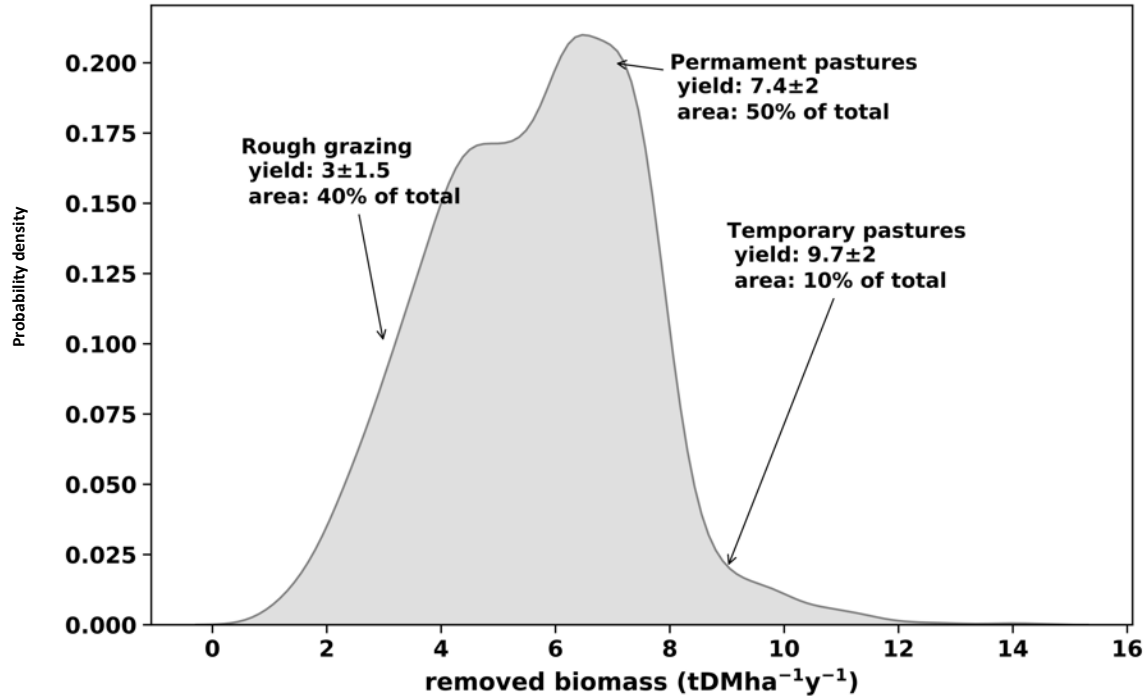
Myrgiotis et al. 2021

Forced with climate, no management data





PREDICTED ANNUAL YIELD (GRAZED+CUT BIOMASS)



SEASONAL NET ECOSYSTEM C EXCHANGE (NEE)

