THE UNIVERSITY of EDINBURGH

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QUANTIFYING CARBON CYCLING IN MANAGED GRASSLANDS THROUGH MODEL–DATA FUSION

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OUTLINE

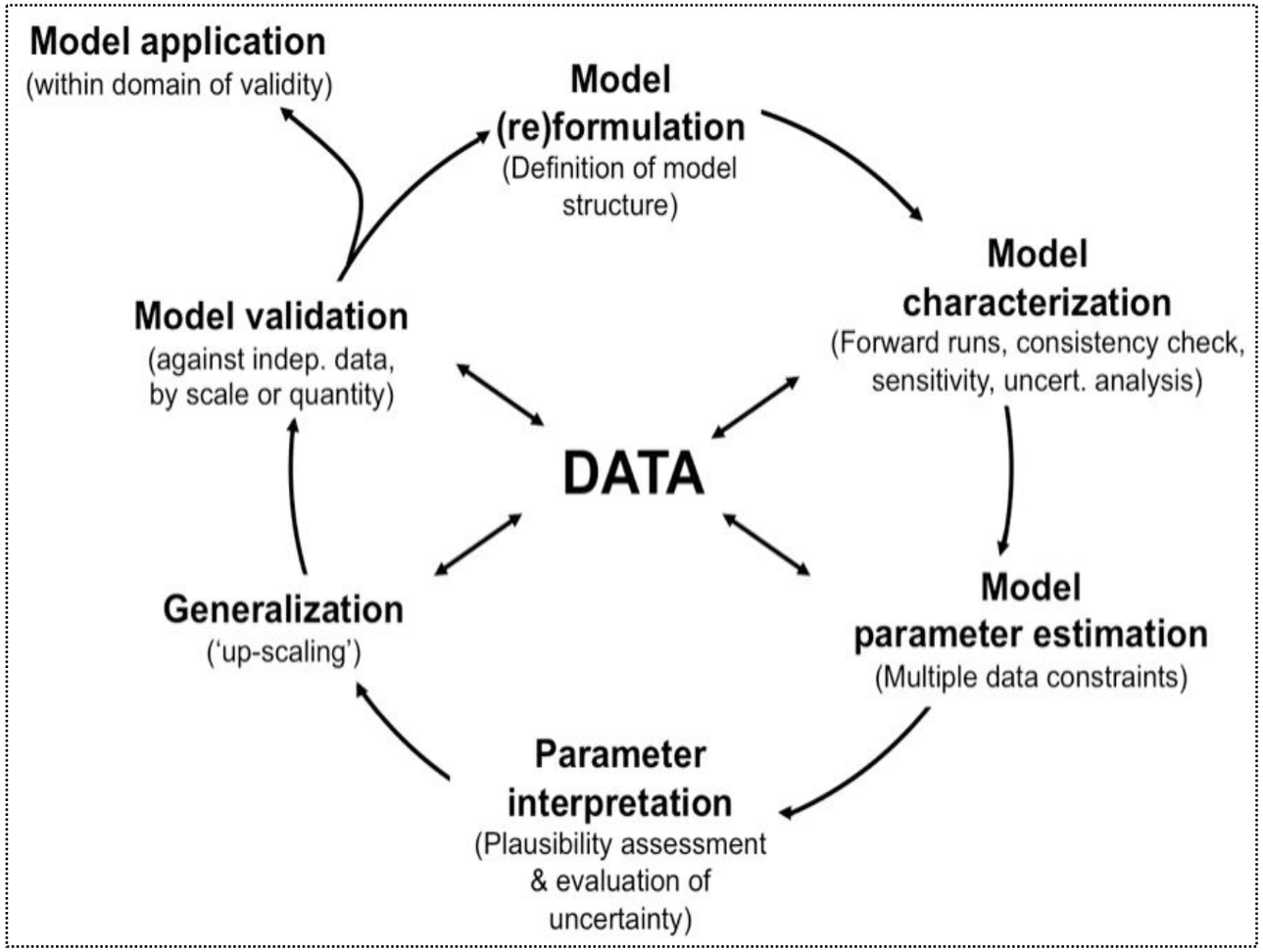
- Background, rationale and aim
- Methodology
- Results
- Conclusions
- Additional information and references

- Monitoring of grassland carbon (C) balance in space and time is needed
- C cycling in managed grasslands is dynamic and complex to assess
- Observations provide snapshots of a grassland's state
- Models provide grassland system/process representation

- Use observations and modelling to predict C cycling in managed grasslands
- Assimilate observations of leaf area index (LAI) which can be obtained in-situ and through earth observation (EO)
- Consider that spatial data on livestock density and harvest timing are very uncertain

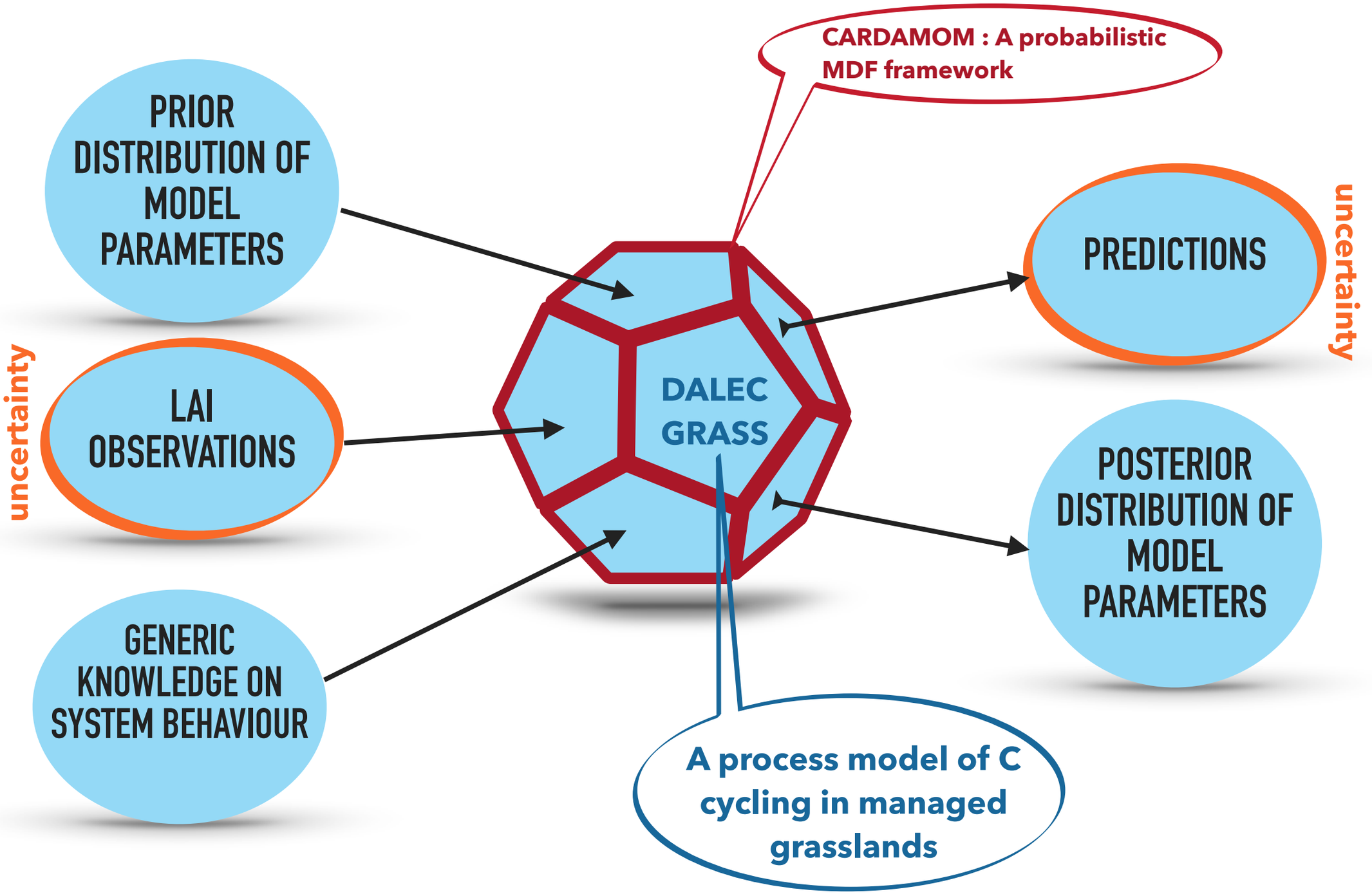
MODEL DATA FUSION (MDF)

- MDF is a framework that integrates observations and modelling in order to reduce the uncertainty around model parameters and structure and to quantify predictive uncertainty



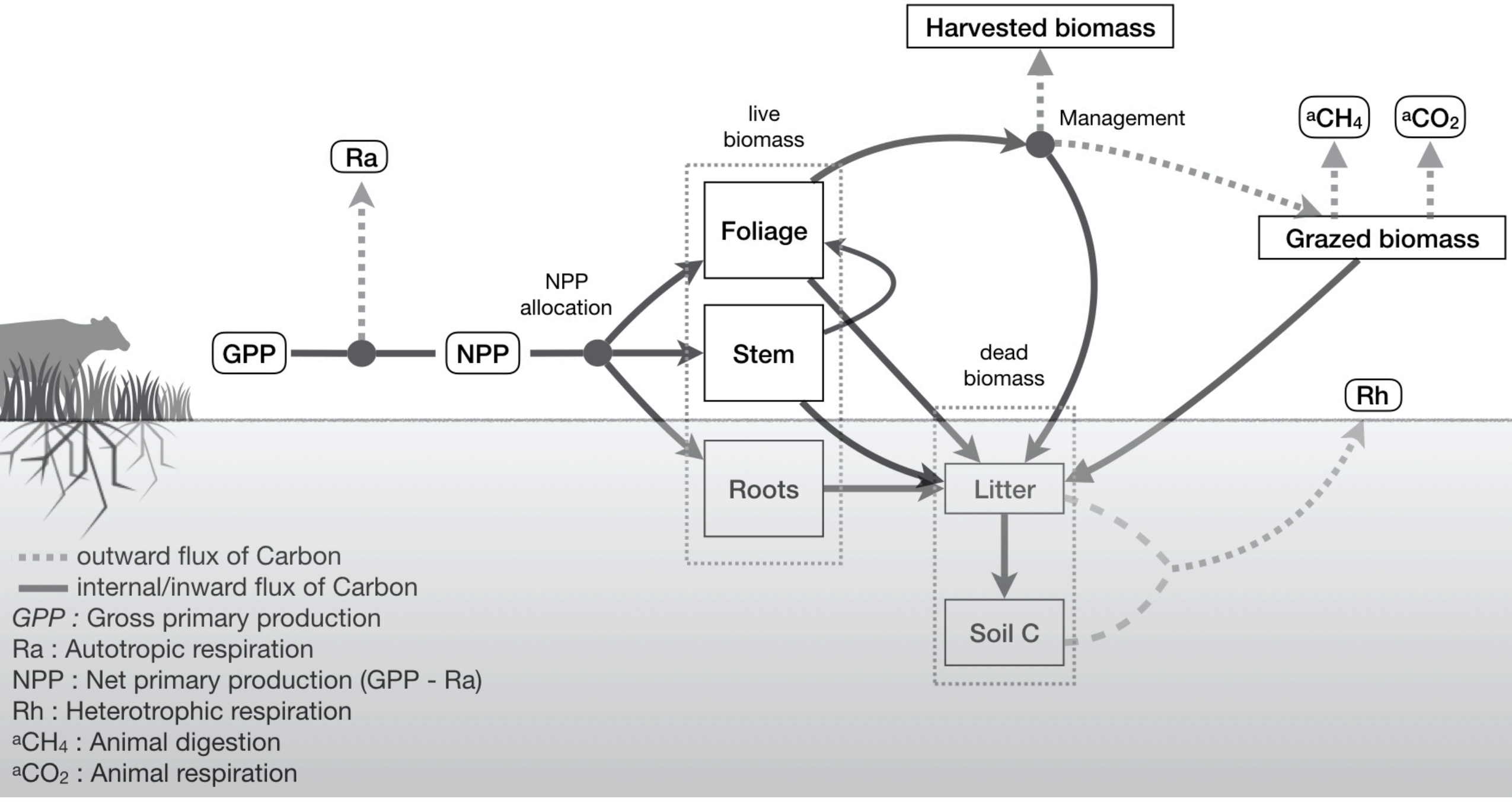
Generic description of the MDF concept

HOW WAS MDF USED ?



more info

THE DALEC-GRASS MODEL



DALEC-Grass models the dynamics of 5 pools and 19 fluxes on a daily basis using 33 parameters in total

DALEC-GRASS DRIVERS

- Shortwave radiation
- Atmospheric CO_2 concentration
- Air temperature (min/max)
- Vapour Pressure Deficit
- Management :
  - either livestock units per ha and harvest dates
  - or EO data on vegetation anomaly

more info

COMPUTATIONAL EXPERIMENTS

- MDF applied at two Scottish grasslands for which management (grazing/harvest) was **known**
  Field-measured LAI data were assimilated

- MDF applied at an English grassland using **EO-retrieved vegetation anomaly** data to infer management operations
  Sentinel-2 LAI data were assimilated

- MDF predictions compared to measured data on CO_2 fluxes, aboveground/root biomass, grazed biomass and harvest yields

SCOTTISH GRASSLAND #1

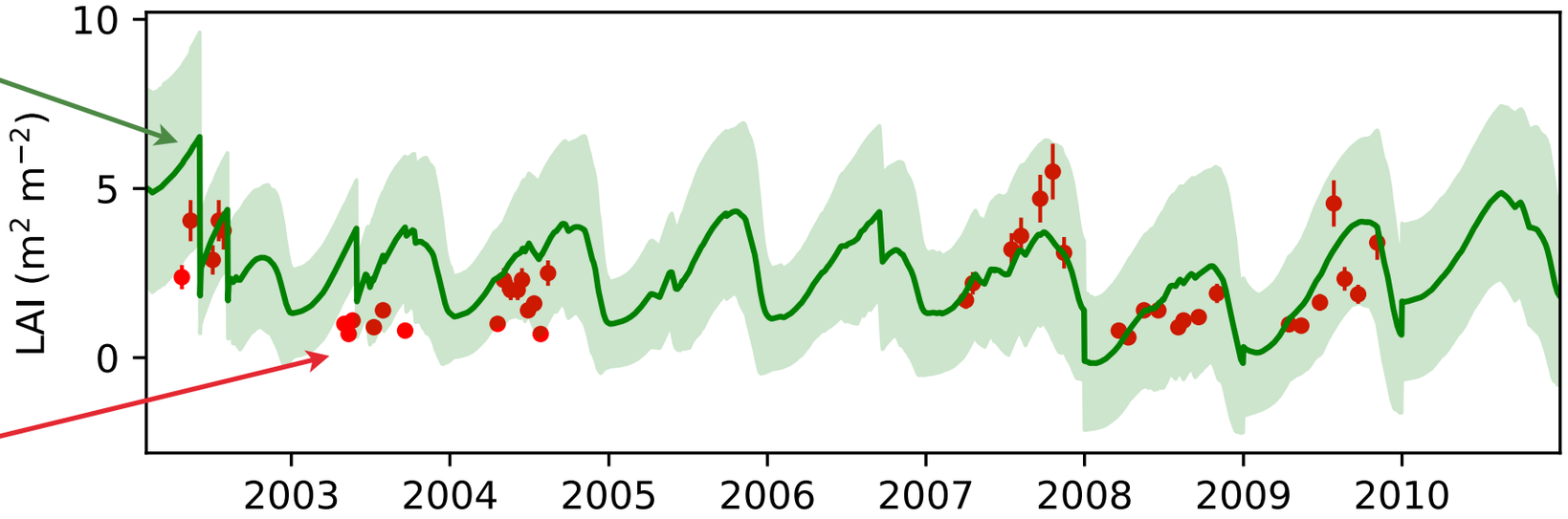
- Grazed and harvested grassland
- 9 years of data
- LAI, NEE, ecosystem respiration

more info

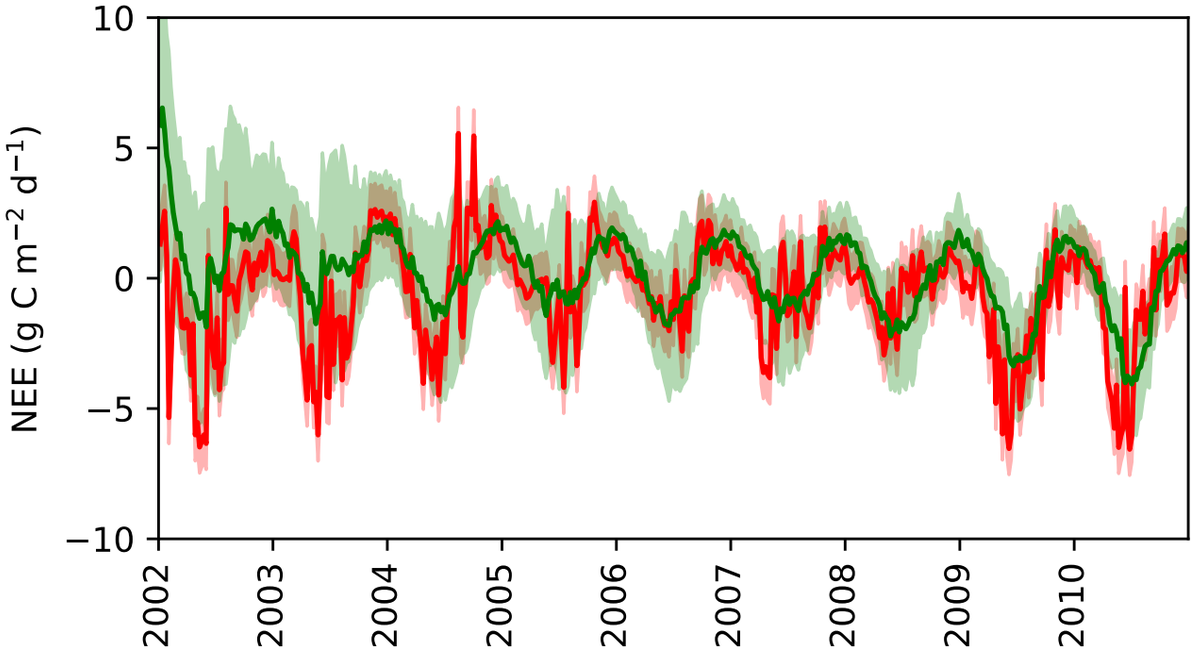
SCOTTISH GRASSLAND #1

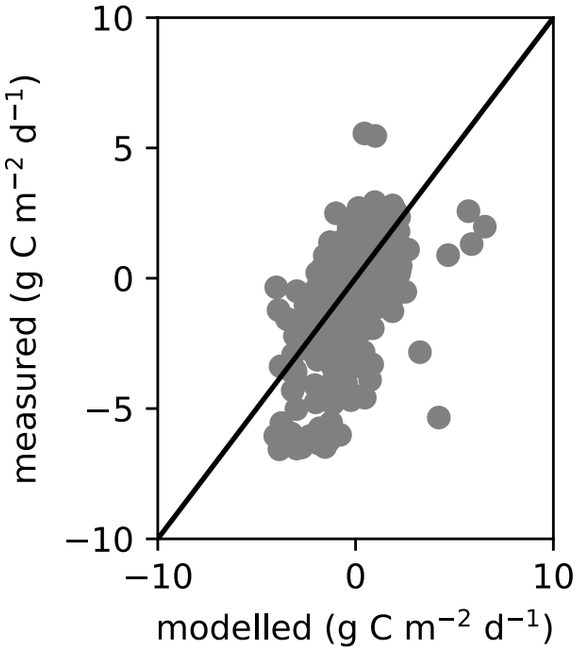
MDF-predicted mean and 95% confidence intervals

Assimilated in-situ LAI



- **Measured**
- **Simulated**



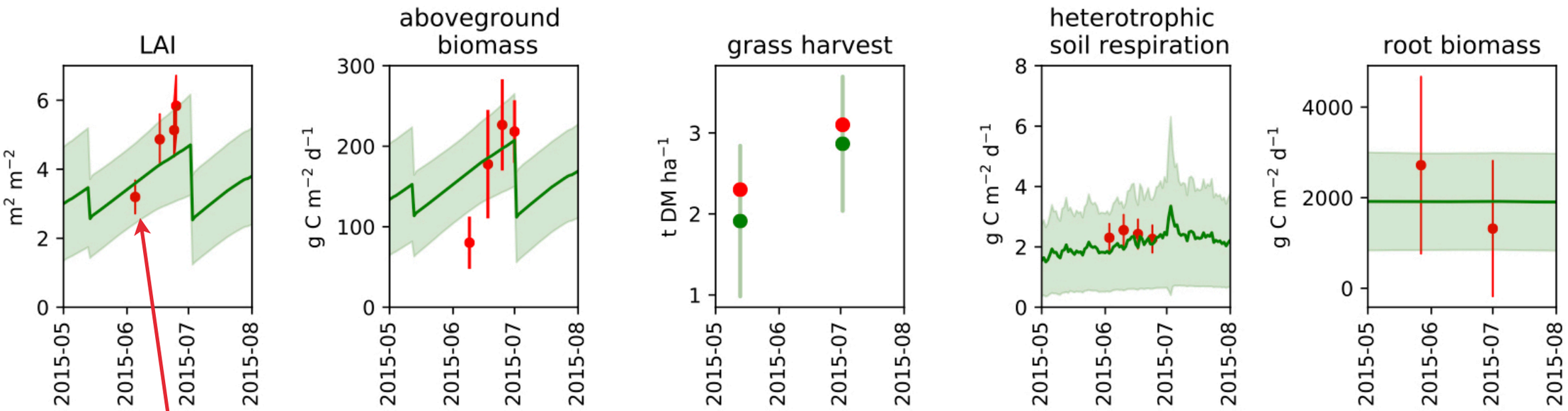


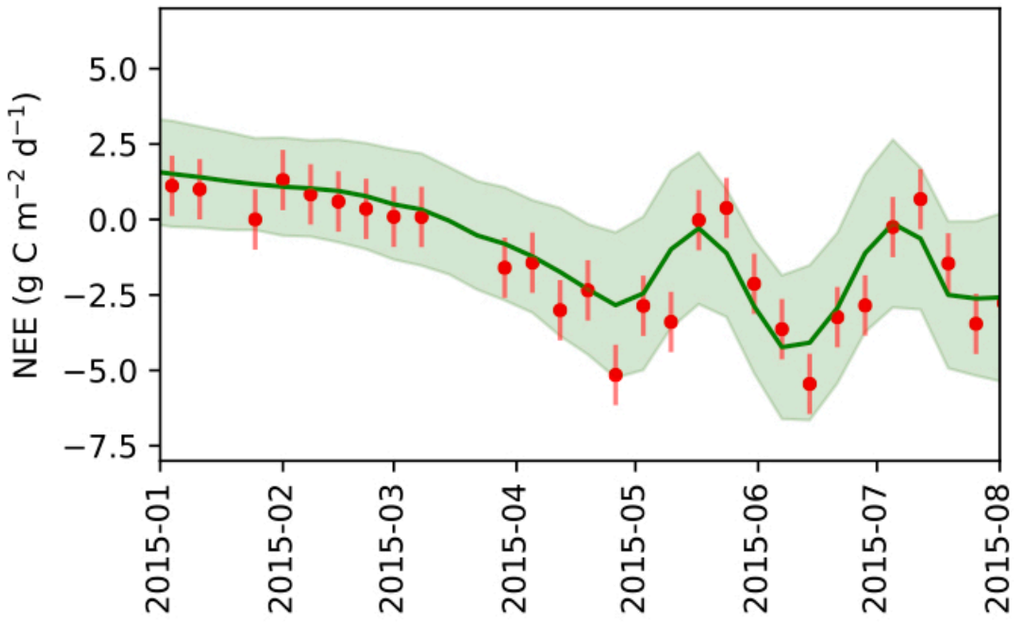
SCOTTISH GRASSLAND #2

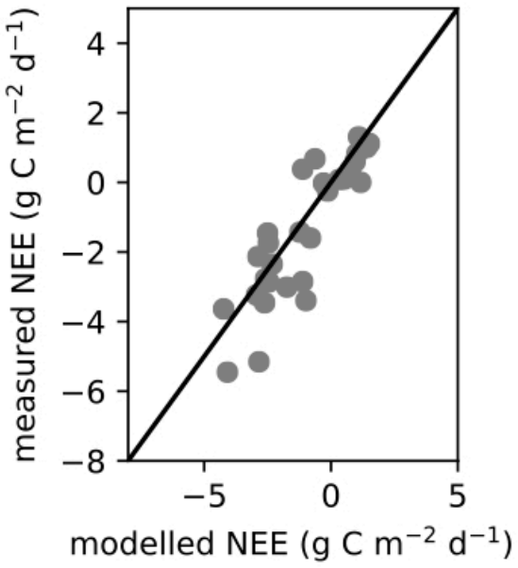
- Harvested grassland
- 1 year of data
- LAI, NEE, aboveground/root biomass, soil respiration

more info

SCOTTISH GRASSLAND #2







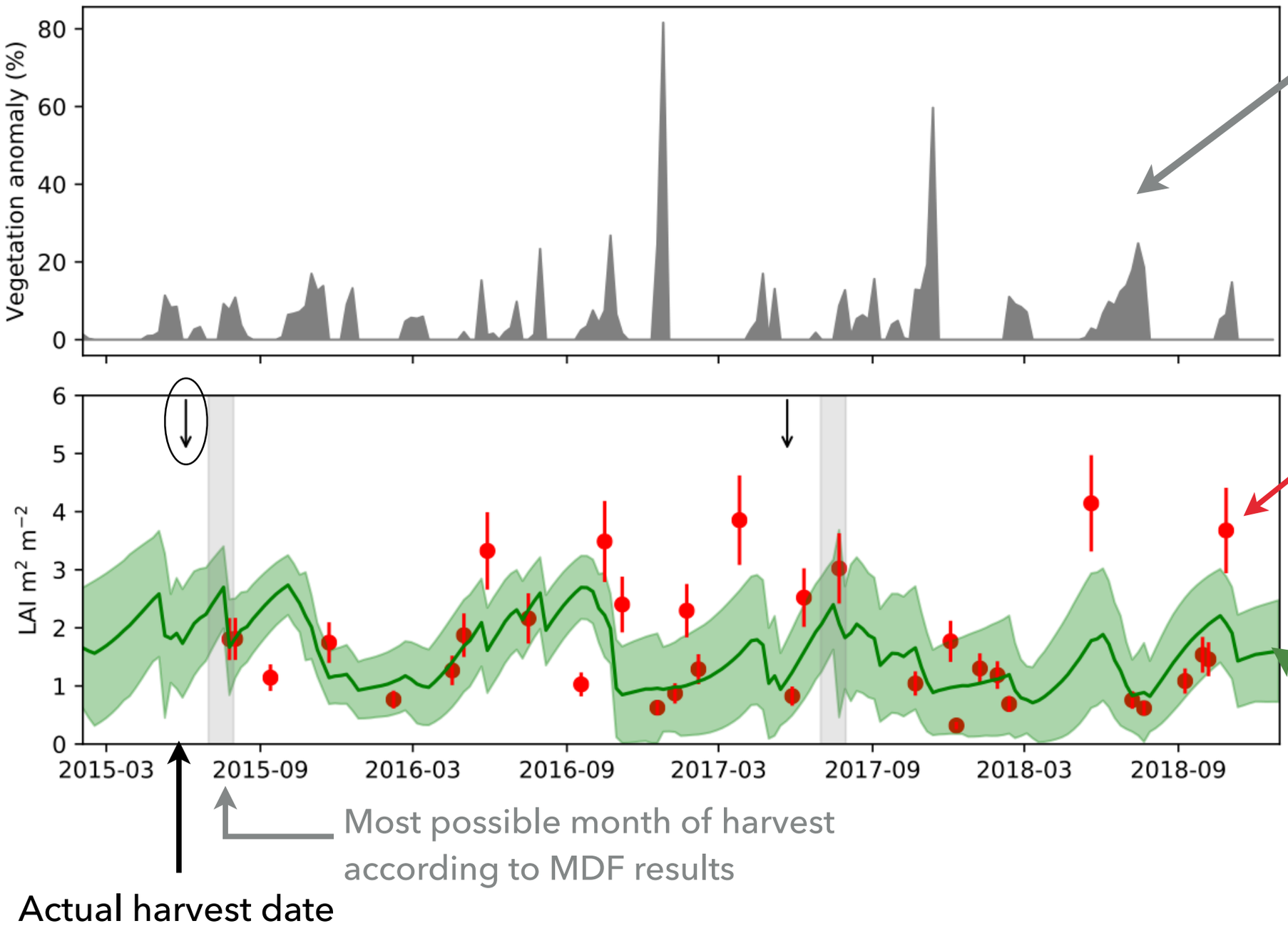
- **Measured**
- **Simulated**

ENGLISH GRASSLAND

- Grazed and harvested grassland
- 4 years of data
- Livestock type/no per ha, harvest yields

more info

ENGLISH GRASSLAND – LAI



Model driver: time-series describing the timing and relative intensity of vegetation reduction

Assimilated Sentinel2-based LAI

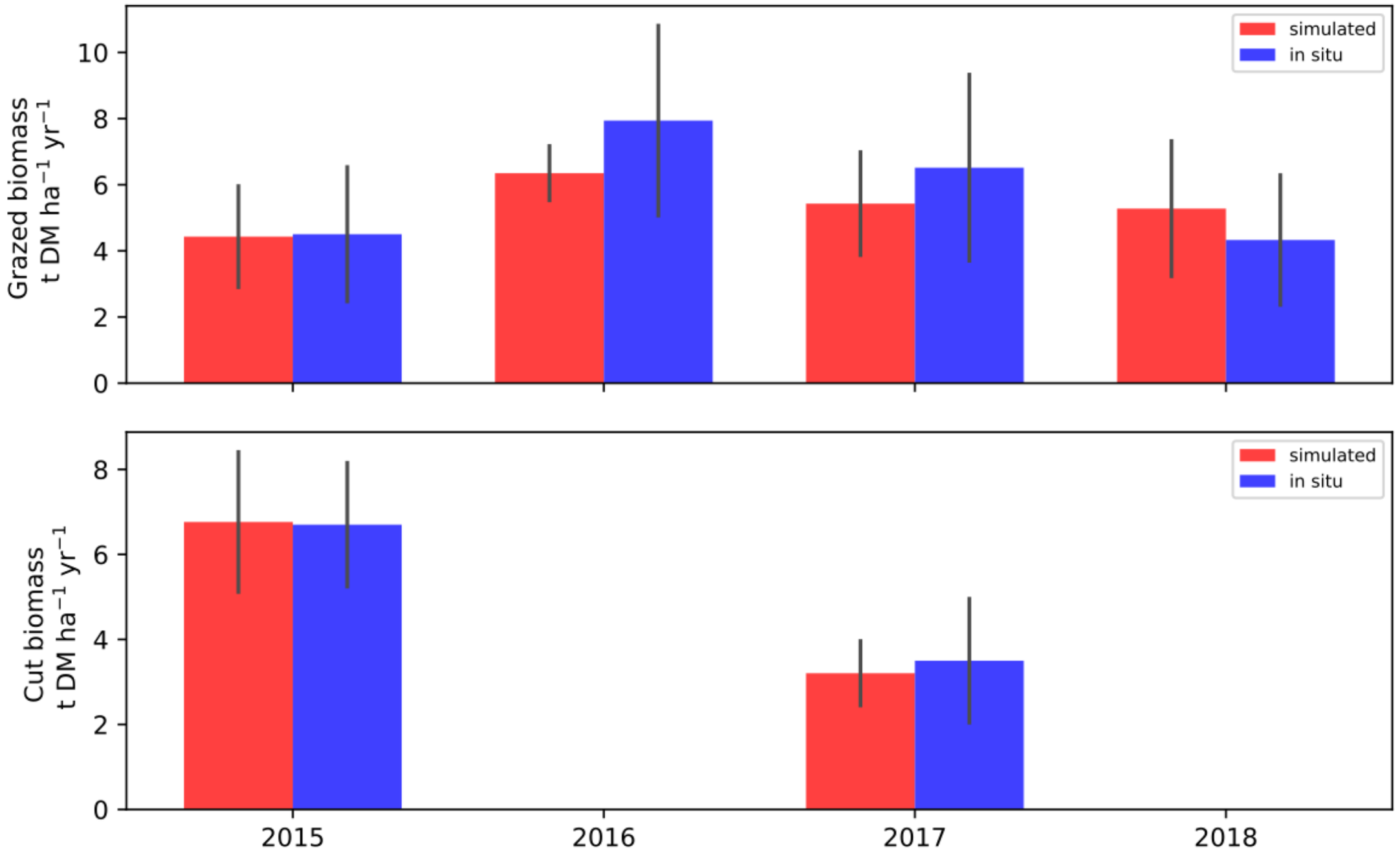
MDF-predicted mean and 95% confidence intervals

Most possible month of harvest according to MDF results

Actual harvest date

more info

ENGLISH GRASSLAND – GRAZING AND CUTTING



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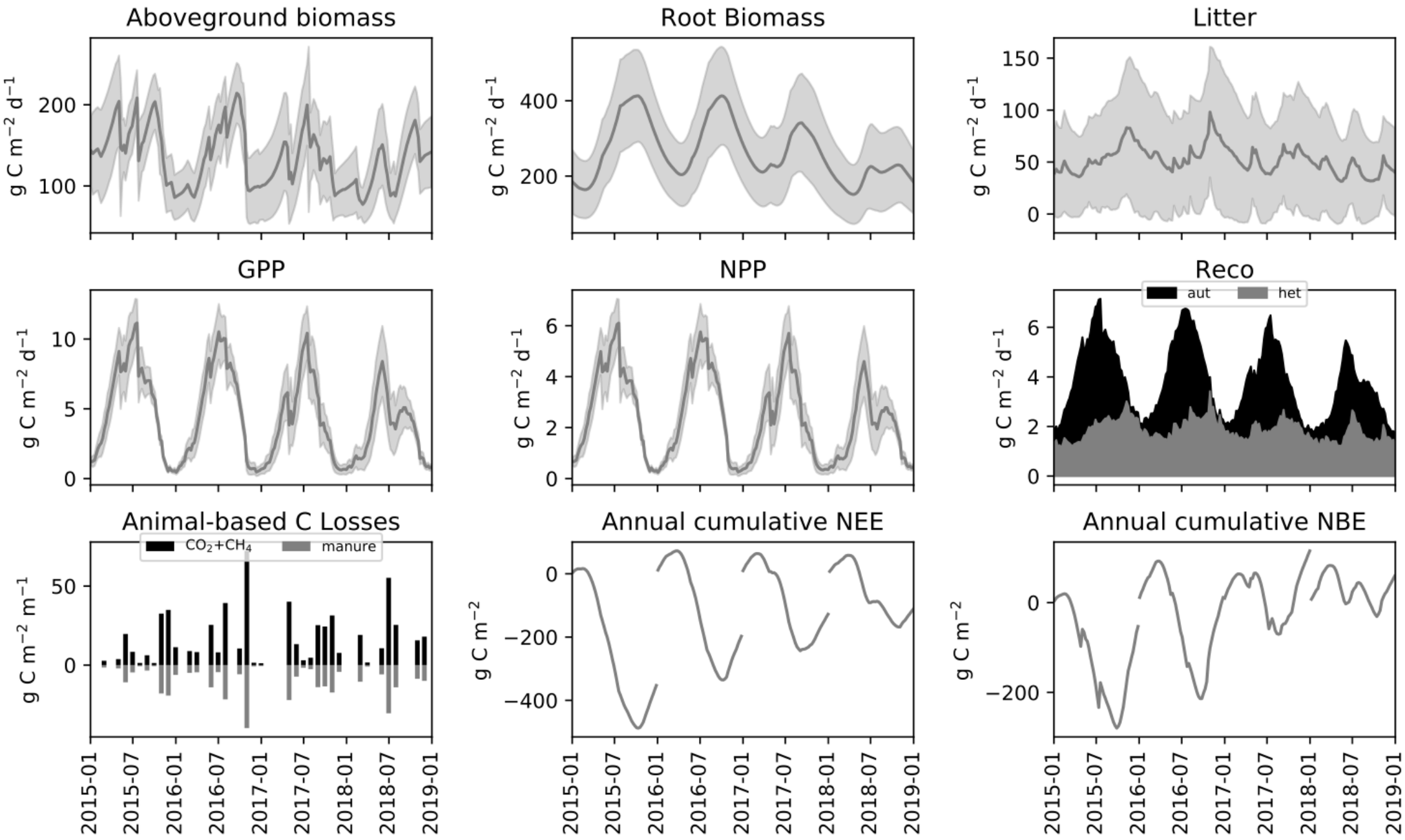
ENGLISH GRASSLAND – C CYCLING



Shaded area shows 95% confidence intervals. Where not present only the modelled mean is presented.

- Fusing observations and modelling produced realistic representation of C cycling in managed grasslands
- Monitoring C balance in space and time is possible considering the volume and resolution of EO data
- Grassland management information is necessary for spatial application of MDF
- Inferring management from EO data is complex but feasible with MDF
- MDF can handle the uncertainty in observations, parameters and drivers

- DALEC-Grass is a development of the Data Assimilation Linked Ecosystem Carbon (DALEC) model (https://doi.org/10.1111/j.1365-2486.2004.00891.x)
- The CARDAMOM MDF framework is described in https://doi.org/10.5194/bg-12-1299-2015
- For information on the sites used in the study visit https://cosmos.ceh.ac.uk/network and search for 'Easter Bush', 'Crichton' and 'North Wyke'
- For code availability see vmyrgiotis.github.io
- Slide 6: CARDAMOM uses the Metropolis-Hastings MCMC method to sample from the prior parameter distributions
- Slide 6: Generic knowledge on system behaviour is based on relevant research findings
- Slide 8: Met data obtained from ECMWF (ERA-Interim)
- Slide 15: Vegetation anomaly data obtained from https://land.copernicus.eu/global/products/
- Slide 15: Sentinel-2 images obtained from the Copernicus Open Access Hub and processed into LAI data using the Sentinel Application Platform (SNAP)
- Slide 16: Recorded data on livestock type, density and weight were used to produce the grazed biomass estimates assuming *dry matter demand = 1.5-3.5% of livestock weight*

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GREENHOUSE GAS REMOVAL RESEARCH PROGRAMME