Ecosystem Land-Use Modelling & Soil C GHG Flux Trial (ELUM)

Marta Dondini*, M. Richards, M. Pogson & P. Smith

marta.dondini@abdn.ac.uk

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL
UNIVERSITY OF ABERDEEN
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Forest Research
PRIFYSGOL ABERYSTWYTH UNIVERSITY
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THE UNIVERSITY of York

Who and what is ELUM?

The ELUM Project is a seven-member Consortium project commissioned and funded by the Energy Technologies Institute (ETI).

elum
BIOENERGY DIRECT LAND-USE CHANGE

Centre for Ecology & Hydrology	-	*Niall McNamara & Jon Finch*
University of Aberdeen	-	*Pete Smith*
University of Southampton	-	*Gail Taylor*
University of Edinburgh	-	*Saran Sohi*
Aberystwyth University	-	*Iain Donnison & Kerrie Farrar*
Forest Research	-	*Mike Perks & James Morison*
University of York	-	*Phil Ineson*
Project Manager	-	*Jonathan Oxley*

energy technologies institute

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ELUM Objectives

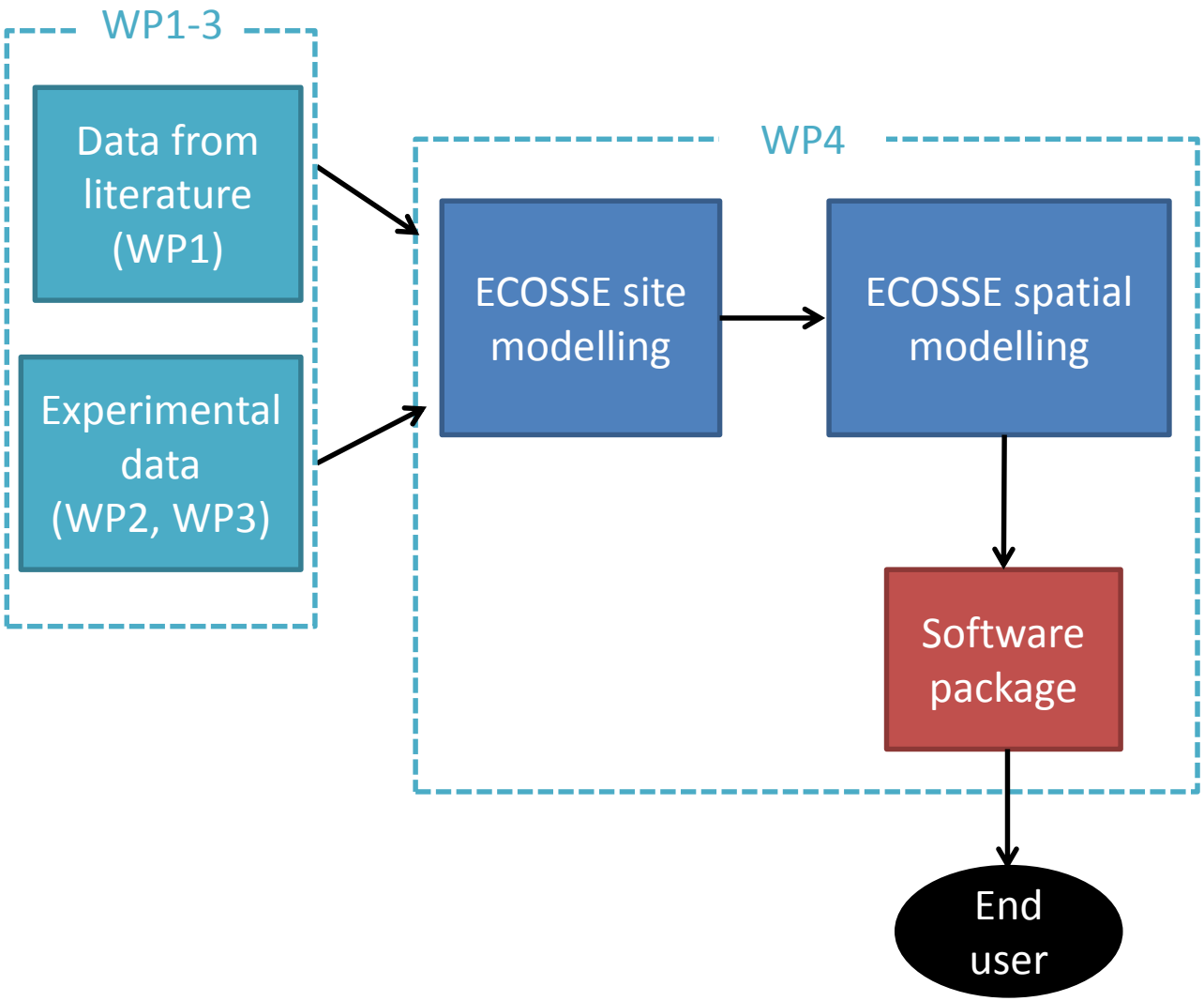
Understanding the impact of bioenergy land-use change on soil carbon and GHG fluxes

- Consider suitability of differing land use to energy crop changes
- Provide figures for soil carbon and GHG fluxes for major land-use changes in the UK

The creation of an *Ecosystem Modelling Tool* to be made available for all stakeholders

- Ecosystem modelling and planning framework for land-use change mapped spatially incorporating factors including GHG flux and hydrology
- Build model architecture to accommodate wider issues such as ecosystem services

Context within project



ECOSSE site modelling

WP2

74 UK paired soil sampling sites

- Soil C 0-30 cm
- Soil C 0-100 cm
- x 5 LU (Miscanthus, SRCW, SRF, Arable, Grassland)

Model evaluation to simulate soil C after LUC to bioenergy crops

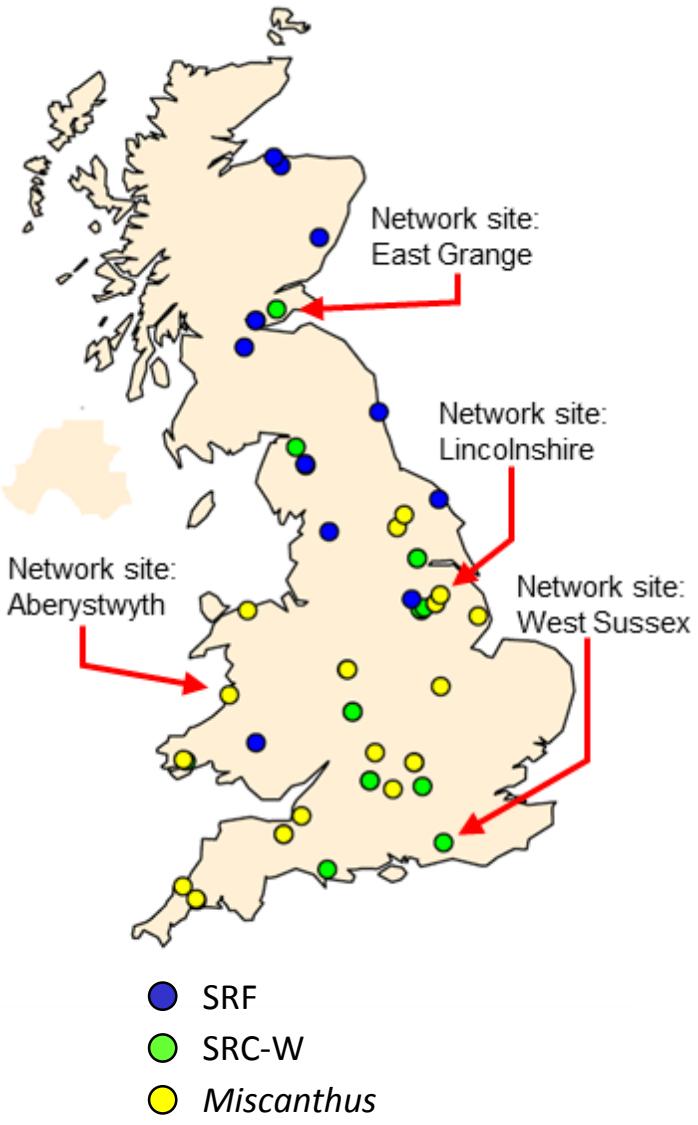
WP3

6 Network field sites

- 3 x GHG (CO_2, CH_4, N_2O), *by*:
- Static and IRGA chambers (CO_2, CH_4, N_2O)
- Eddy Covariance (CO_2)
- Automated chambers (CO_2)
- x 5 LU (Miscanthus, SRCW, SRF, Arable, Grassland)

Model evaluation to simulate soil GHG fluxes after LUC to bioenergy crops

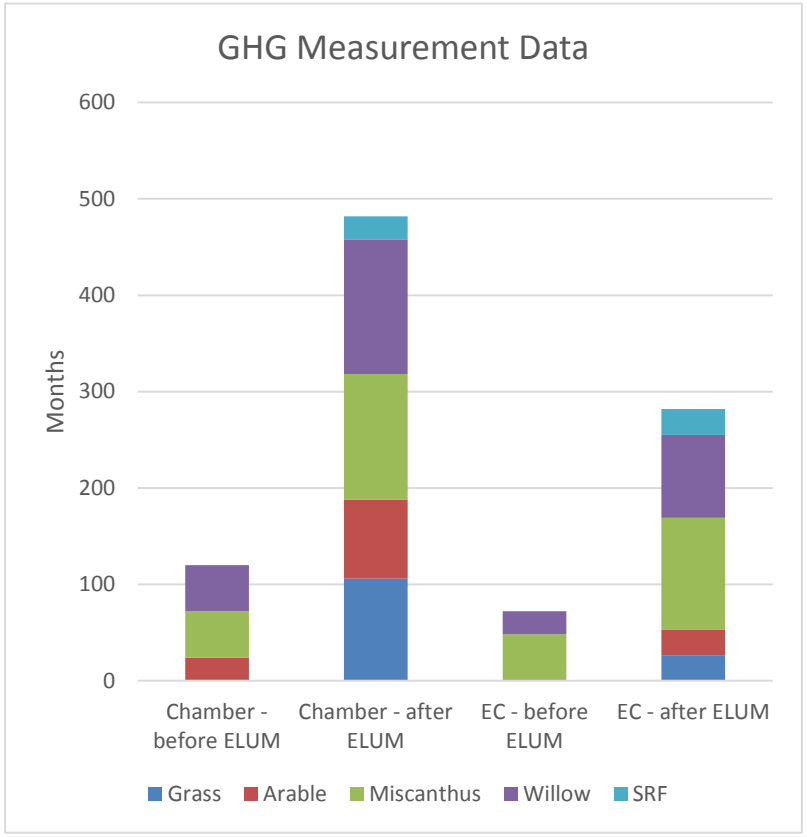
ELUM Sites



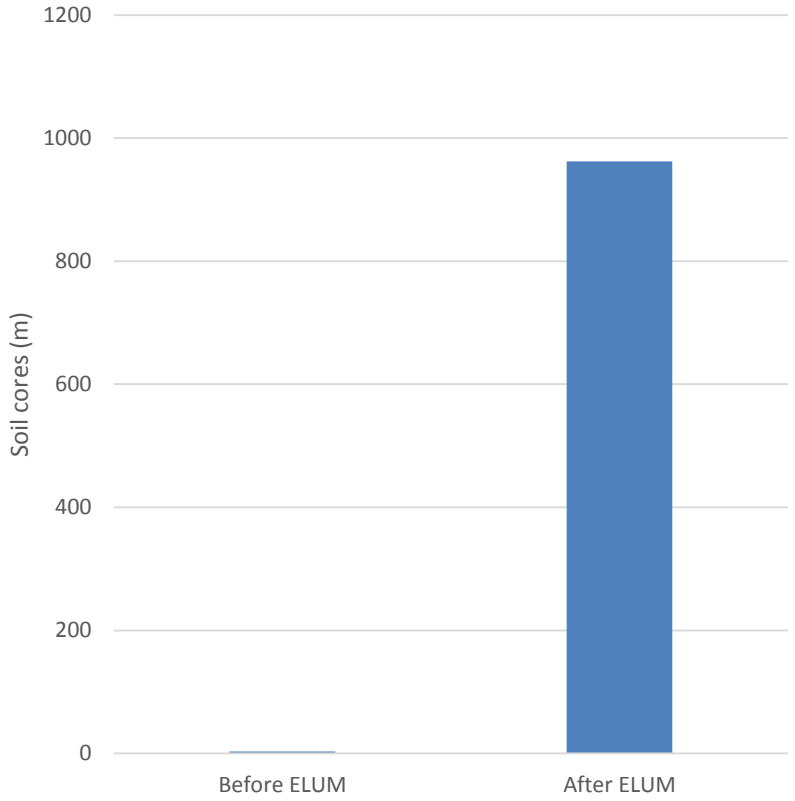
East Grange	SRF *x* Grassland SRC *x* Arable
Lincolnshire	Miscanthus *x* Arable SRC *x* Arable
Aberystwyth	*Miscanthus x* Grassland
West Sussex	SRC *x* Grassland

Wealth of Accumulated UK Bioenergy GHG & soil C Data

GHG Measurement Data



Soil Core Sampling



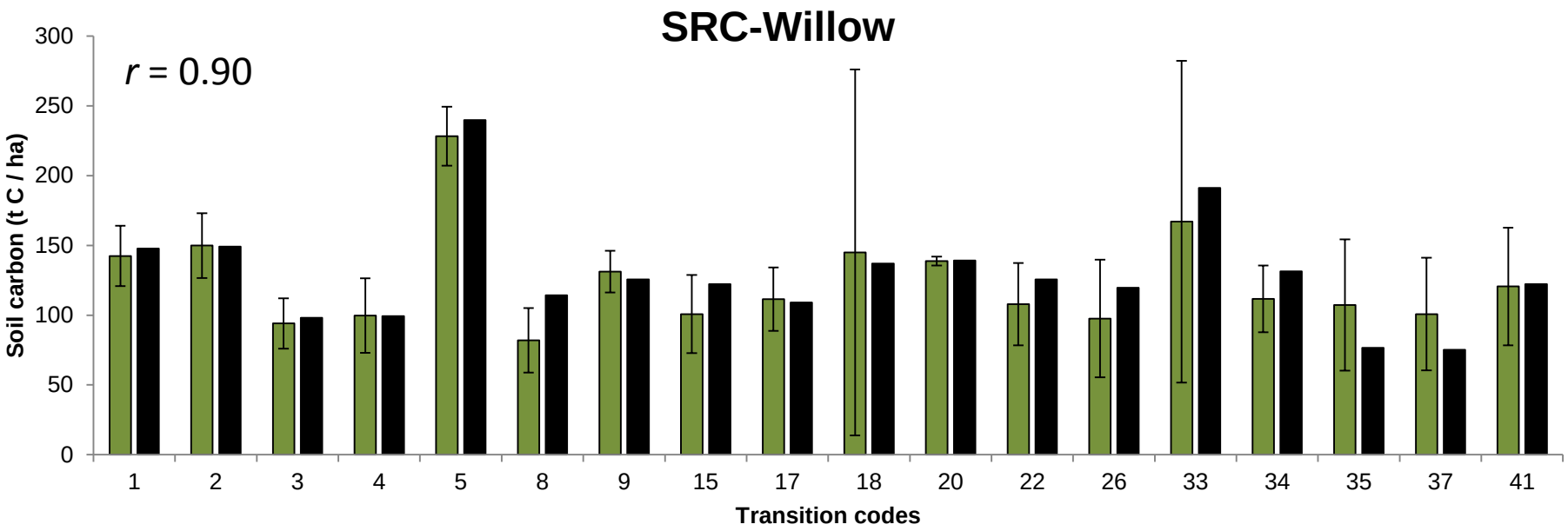
Collected 2,191 soil cores = 2.8 tonnes of soil

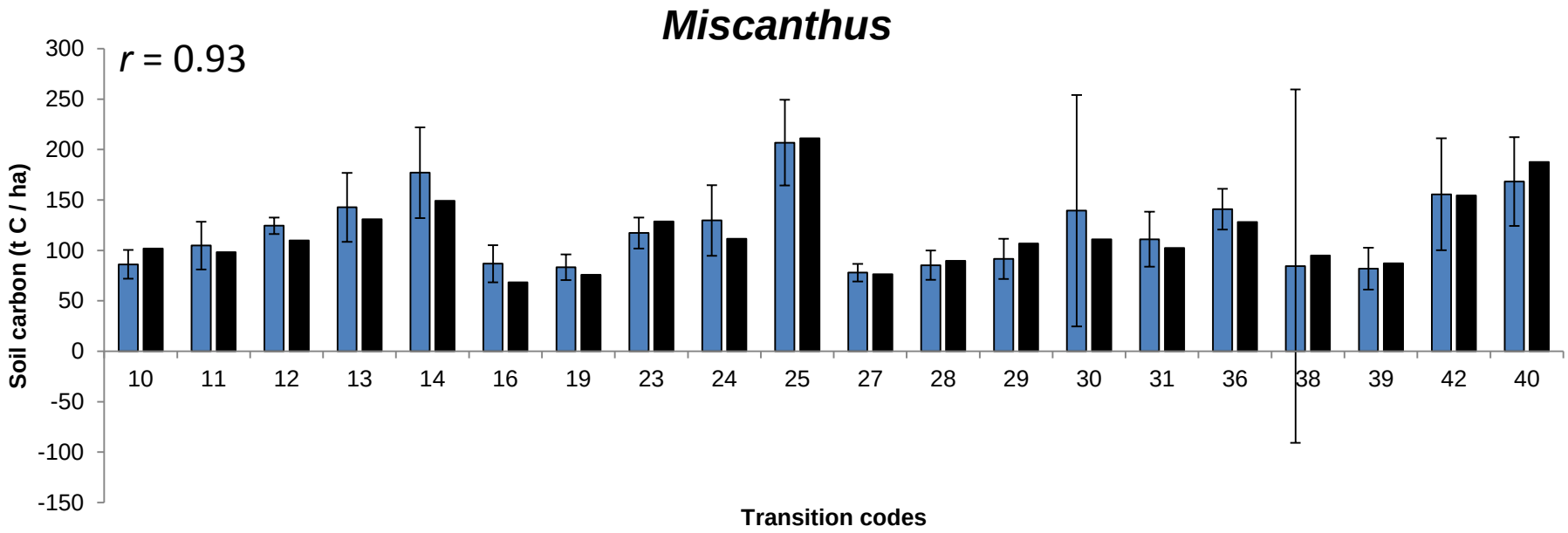
Model requirement

- Soil depth
- C content (kg C/ha)
- Bulk density (g/cm^3)
- pH
- % clay by weight
- % silt by weight
- % sand by weight
- Latitude
- Number of growing seasons
- Land uses
- Precipitation (mm/month)
- Temperature (degC/month)
- Long term Temperature & Precipitation

Soil C – 1m

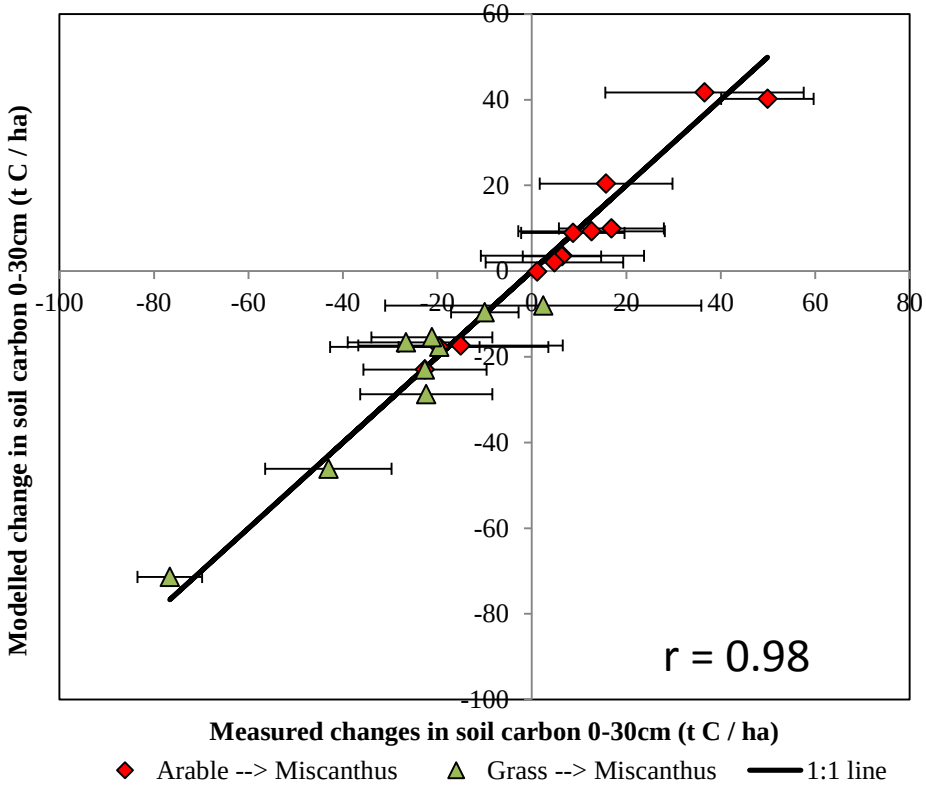
Dondini et al., 2015. GCB-B (in press)

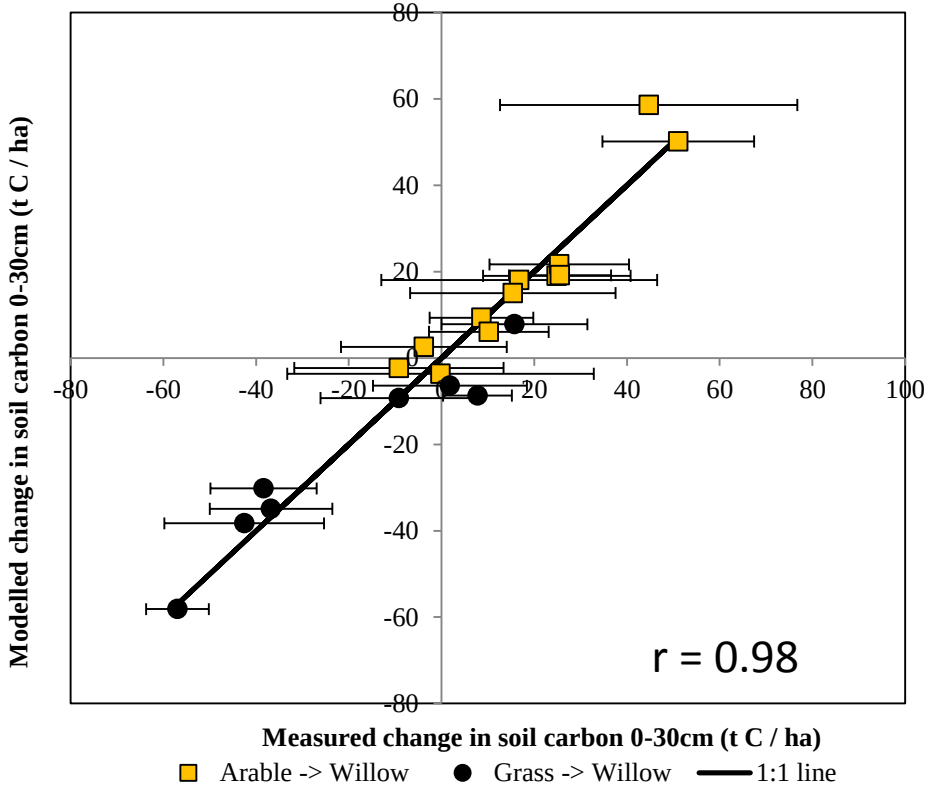




Soil C change 0-30 cm

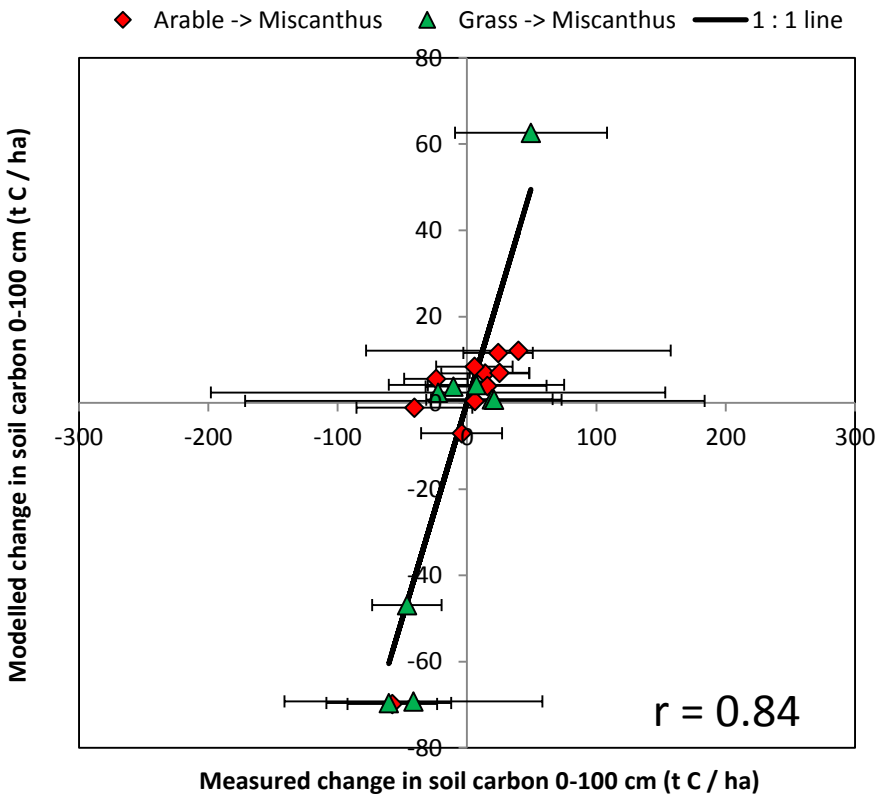
Dondini et al., 2015. GCB-B (in press)

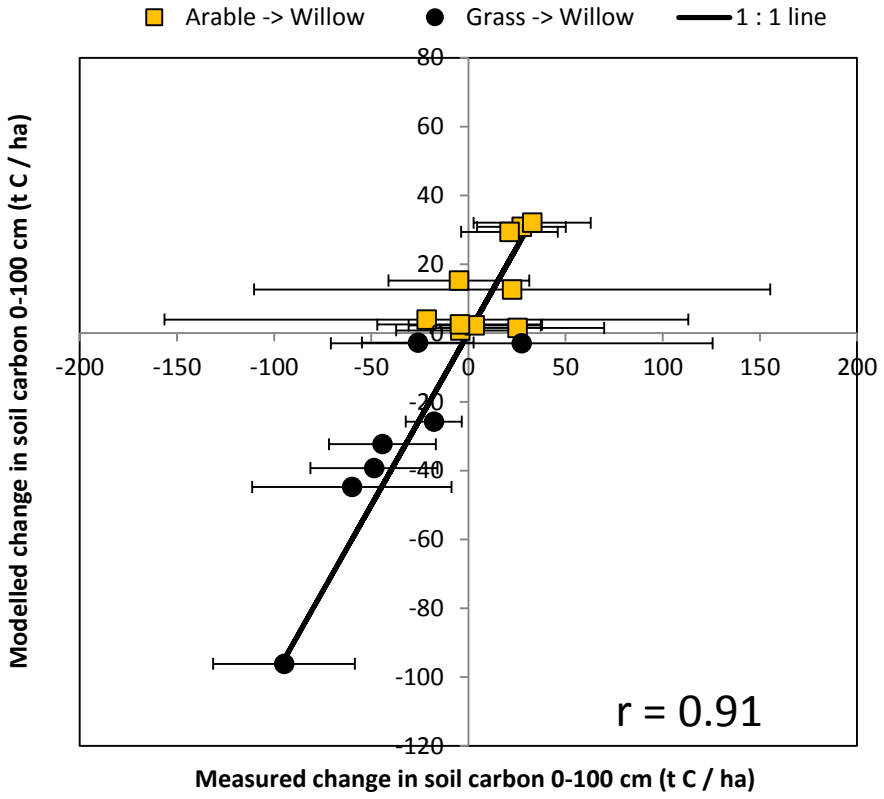




Soil C change 0-100 cm

Dondini et al., 2015. GCB-B (under review)





CO_2 Fluxes

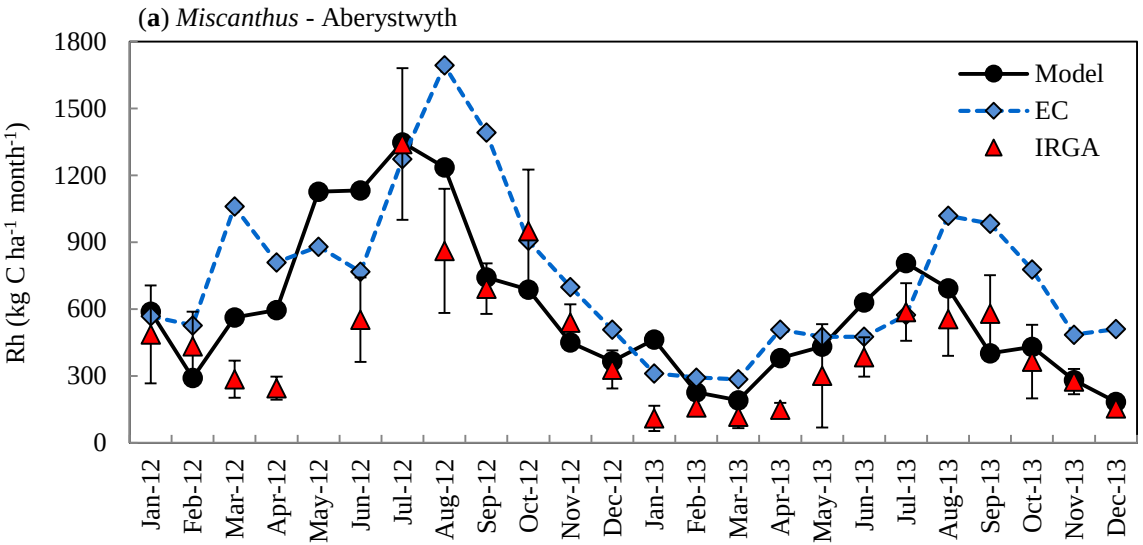
Plant +
Root +
Soil

Root +
Soil

```
**********************************************************

  E_____C___O_____S_____S_____E
  Estimator of C in Organic Soils: Sequestrn & Emissions

                ECOSSE VERSION 6.1.a1

                Modular SUNDIAL-MAGEC
                      + 5cm layers for all soil states
**********************************************************
Choose mode of model run
 1 = Site specific
 2 = Spatial simulation of cells
 3 = Limited data site simulation
 4 = Test run of USD
```

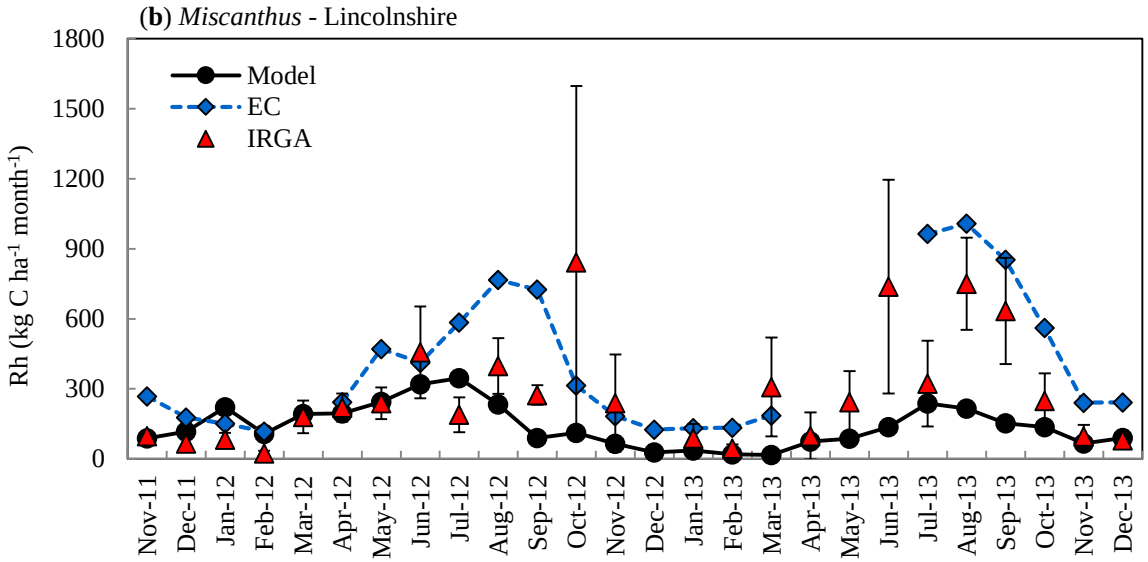
Miscanthus

Dondini et al., 2015. GCB-B (under review)



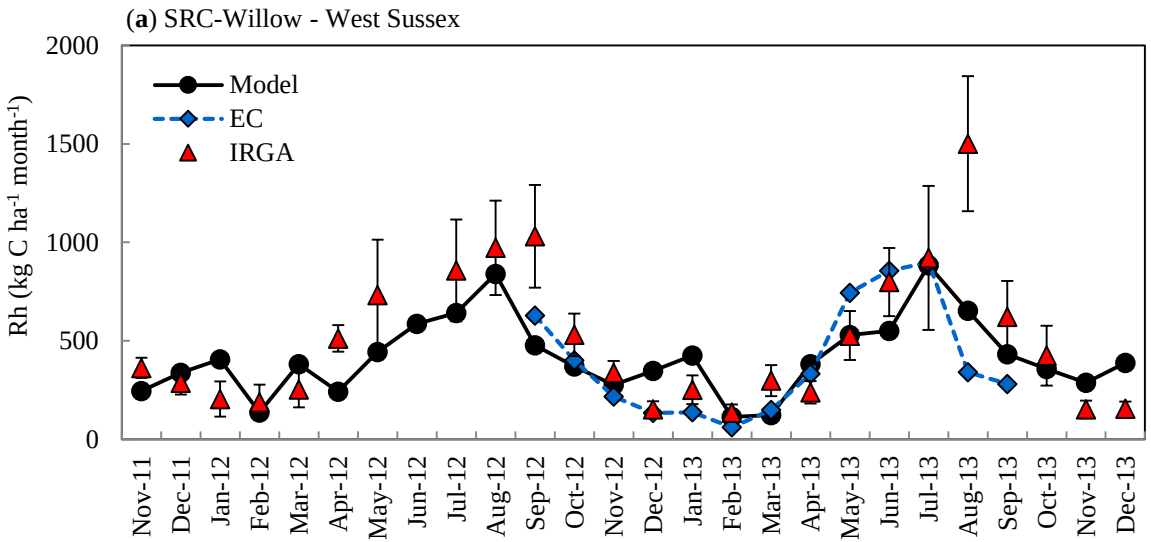
	IRGA	EC
r = Correlation Coeff.	0.80	0.70

	IRGA	EC
r = Correlation Coeff.	0.26	0.54



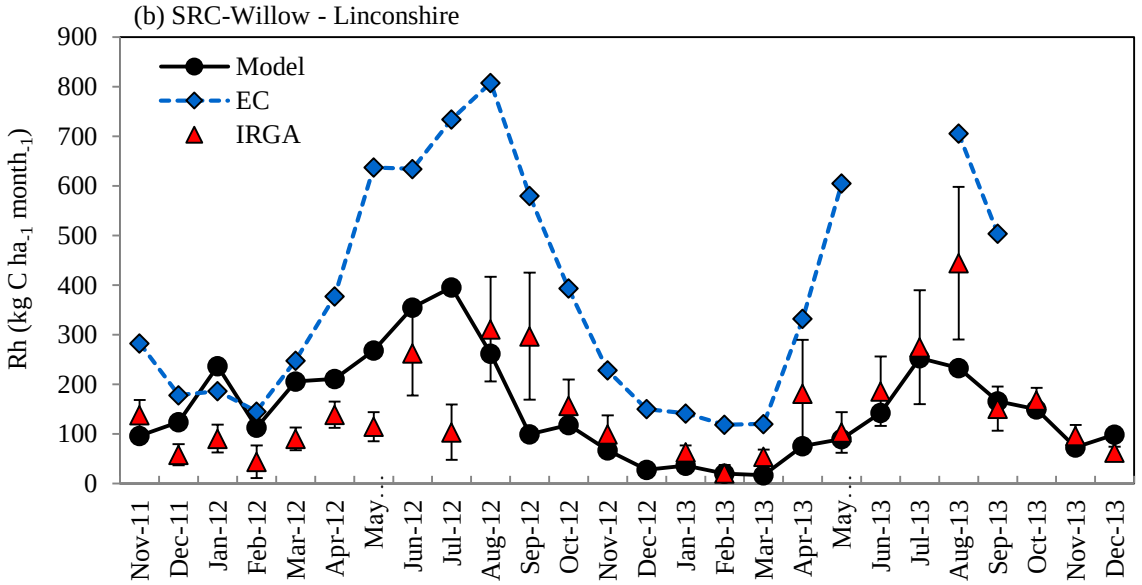
SRC-Willow

Dondini et al., 2015. GCB-B (under review)



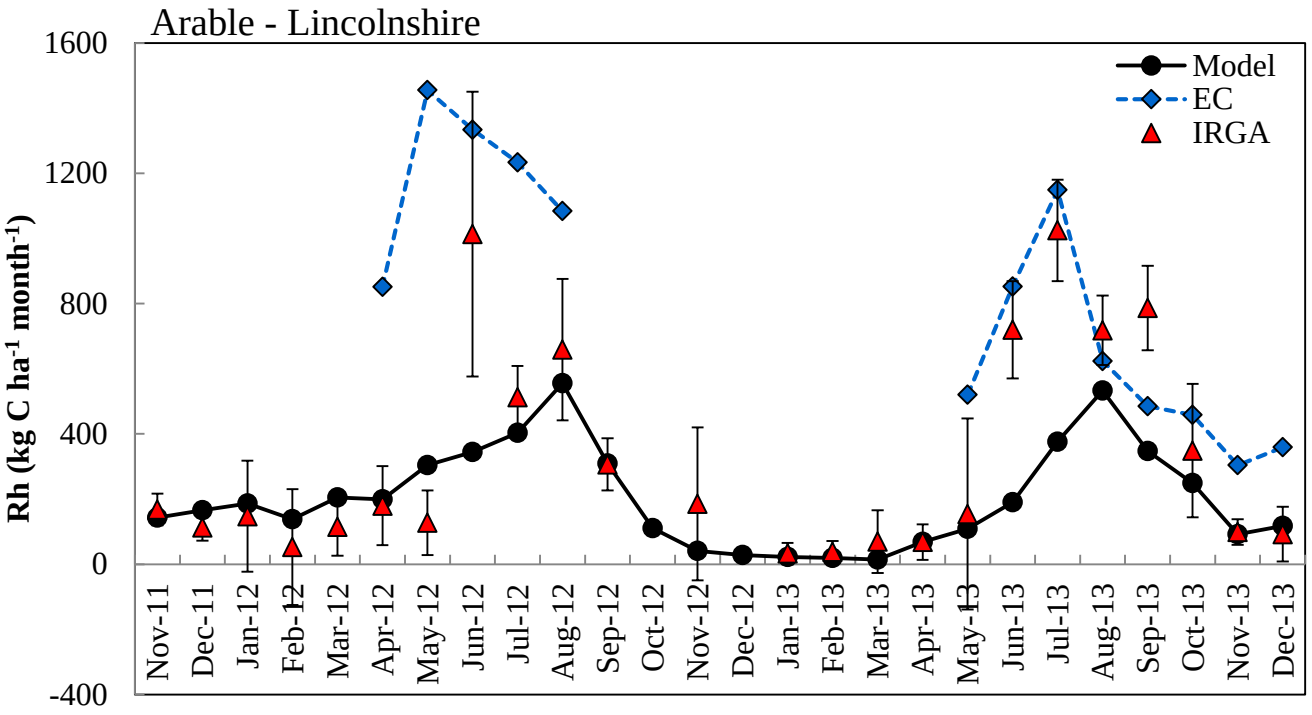
	IRGA	EC
r = Correlation Coeff.	0.74	0.77

	IRGA	EC
r = Correlation Coeff.	0.44	0.70



Arable

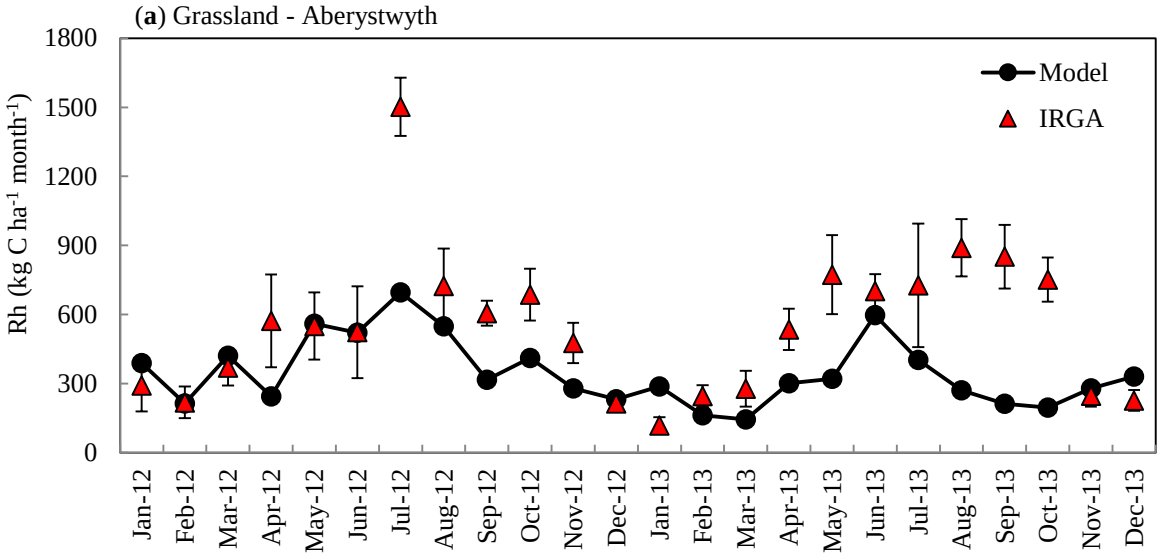
Dondini et al., 2015. GCB-B (under review)



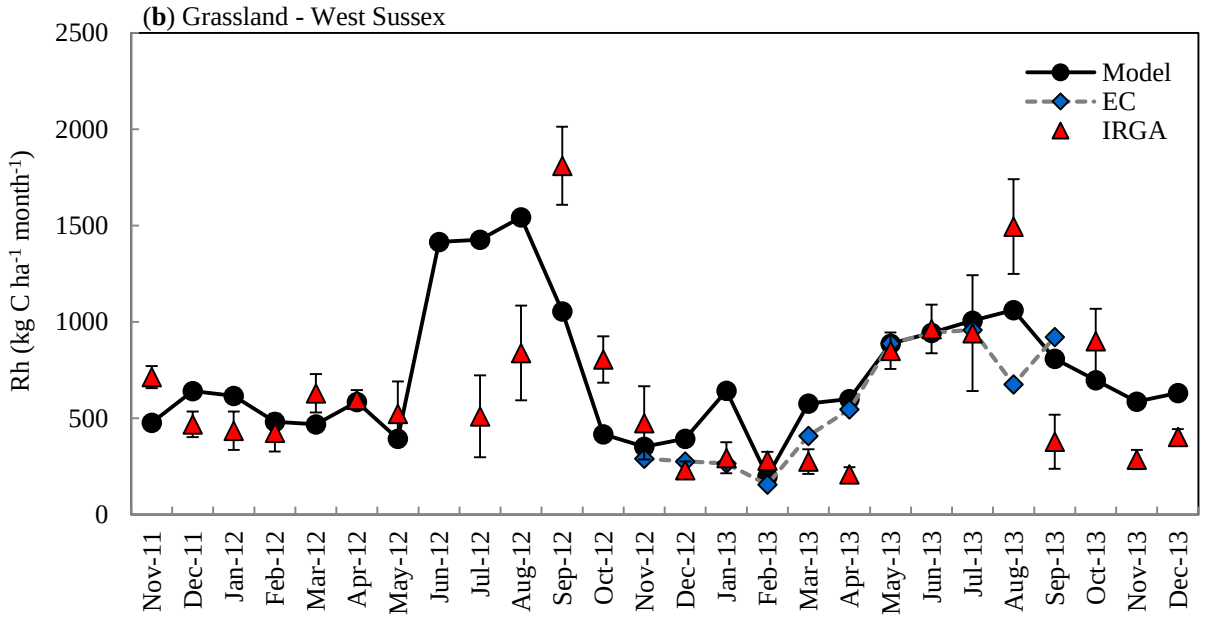
	IRGA	EC
r = Correlation Coeff.	0.75	0.50

Grassland

Dondini et al., 2015. GCB-B (under review)



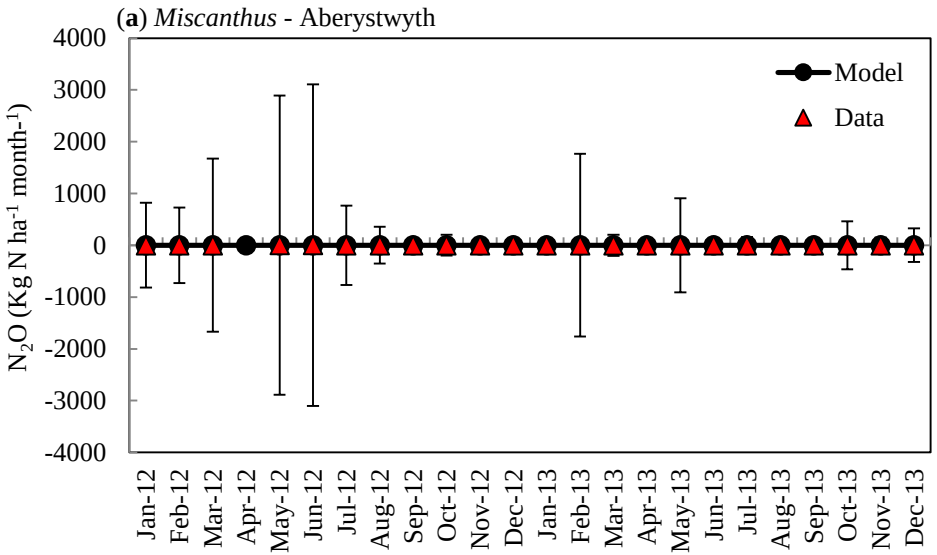
	IRGA
r = Correlation Coeff.	0.53

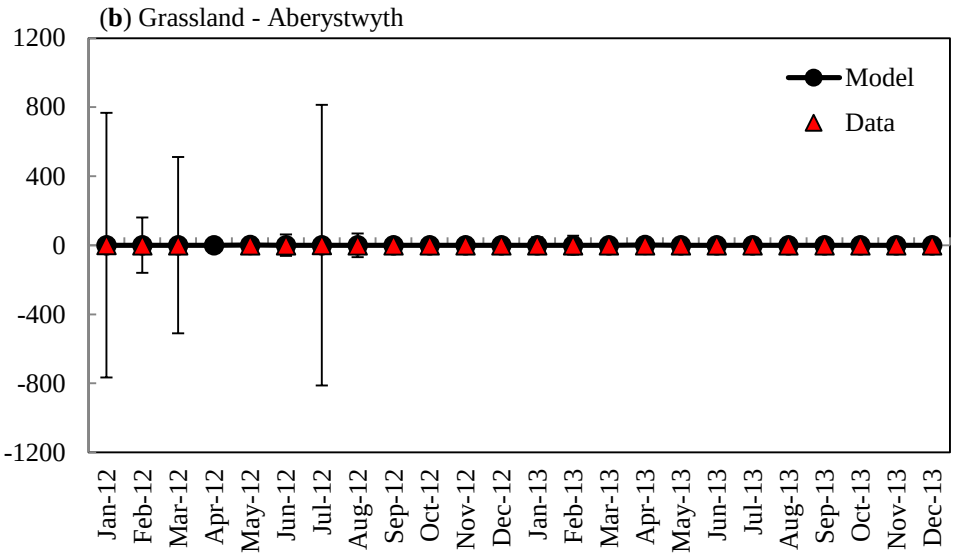


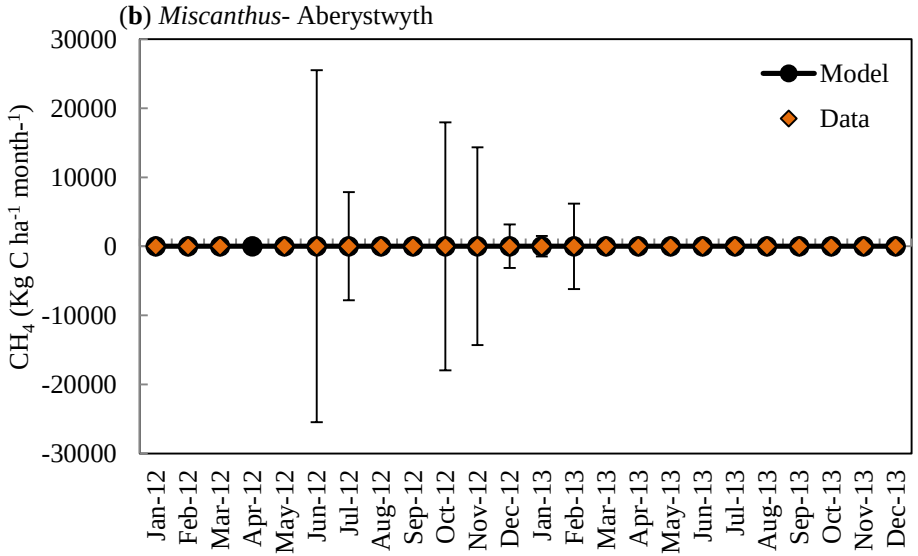
	IRGA	EC
r = Correlation Coeff.	0.51	0.98

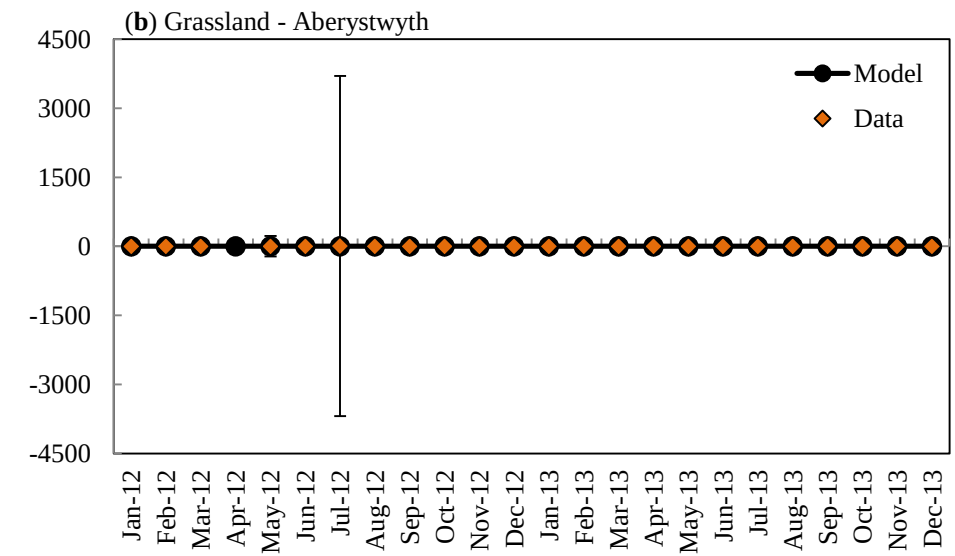
N_2O and CH_4 fluxes

Dondini et al., 2015. GCB-B (under review)



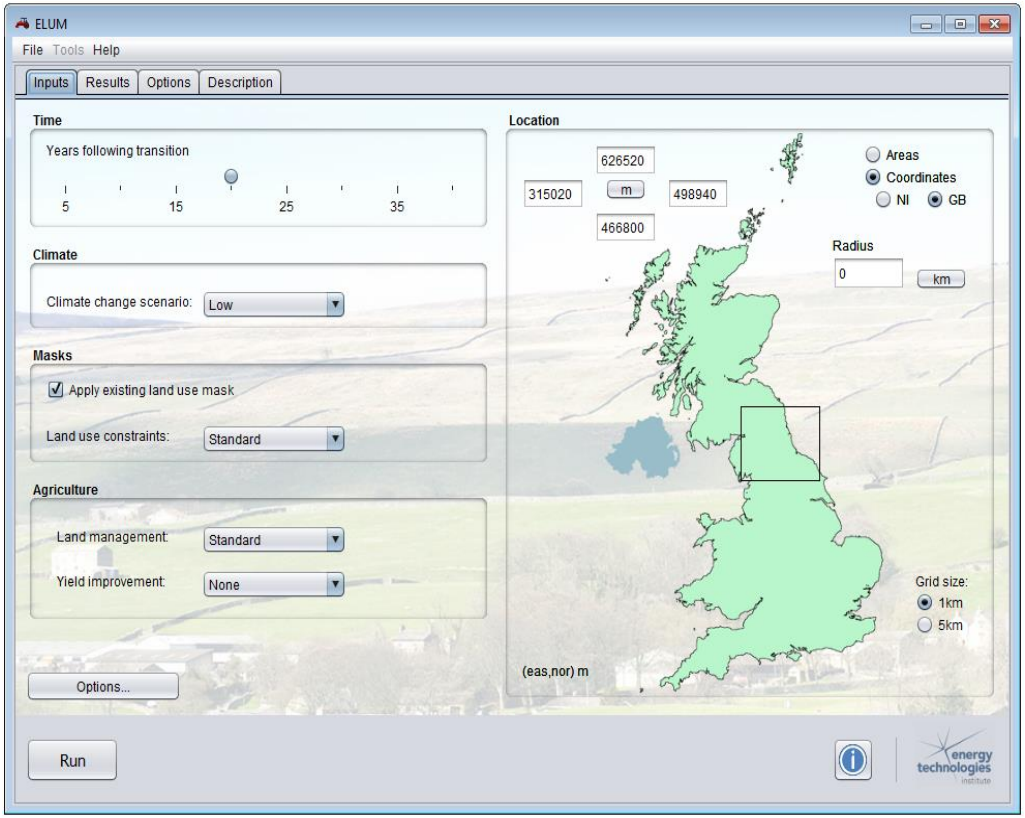






ELUM Modelling Tool

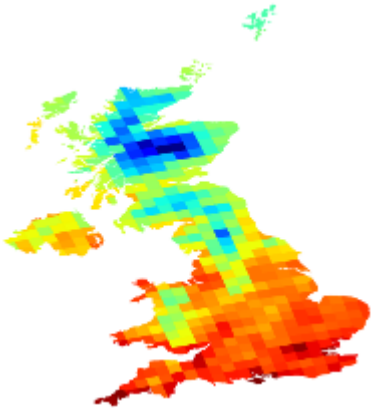
- **Graphical user interface (GUI)** is the only part of the package that users interact with
- **Look-up table** stores core results from process-based model (ECOSSE)
- **Meta-model** selects results and processes them as necessary (e.g. applies masks, regression equations)
- **Data processing tools** compare results, obtain totals and plot maps and graphs
- **Package** is applied to UK at 1 km, but modular design means it could easily be applied to any world region and resolution



Model Inputs

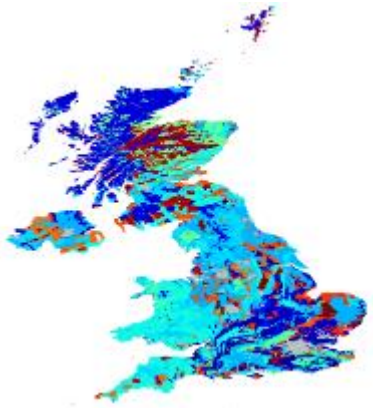
- Input data:

Climate

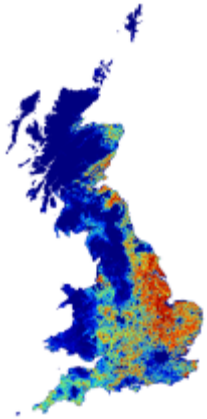


Crop yield

Soil



Land cover



Constraints

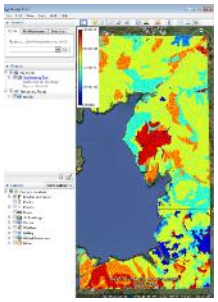
N.B. Data are pre-processed to account for issues of different coordinate systems, grid alignment and separate/missing NI data

Output Formats

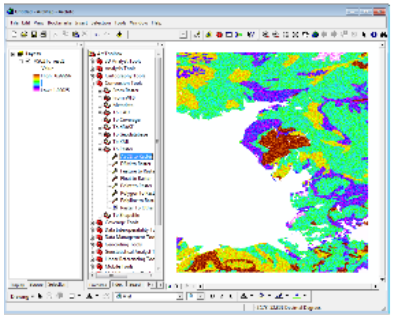
- Results are shown in the GUI as a map, time-series and histogram
- Users can choose to export results in csv, kml or GIS format

csv

Google Earth



ArcGIS



Results are given for net change in:

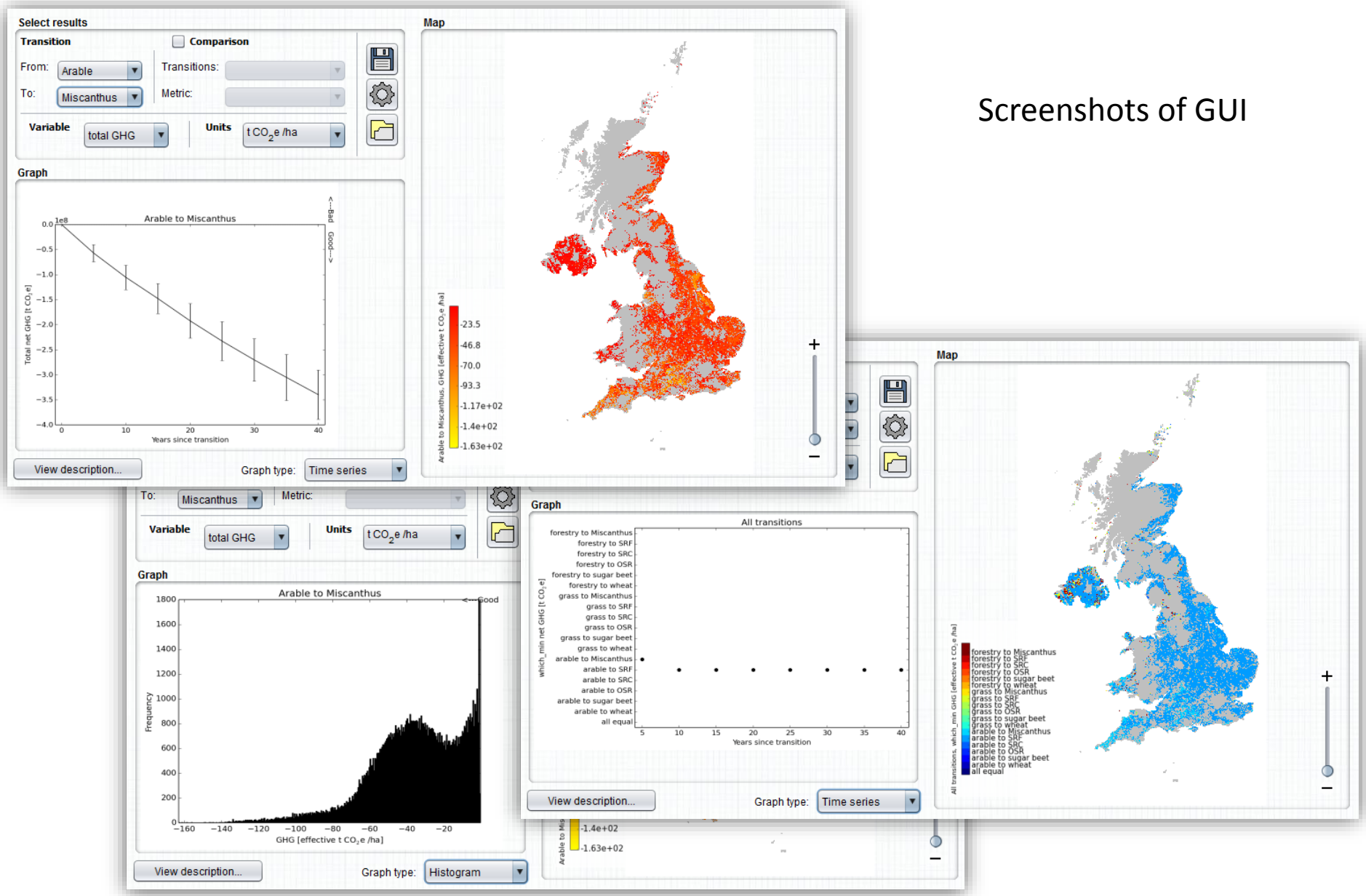
- GHG
- CO_2
- CH_4
- N_2O
- Soil C

Units are:

- Cumulative t CO_2e /ha
- Cumulative t CO_2e /odt

All results are relative to the emissions had no transition taken place

Output Example



Screenshots of GUI

Key Messages

- The ECOSSE model is extremely accurate to predict soil C after land-use change (LUC) from arable/grassland to Willow, *Miscanthus* and short-rotation forest, to a soil depth of 1 metre.
- Soil CO_2 emissions from bioenergy and conventional crops have been measured using two different techniques, all showing a good correlation with the modelled values.
- The ECOSSE model is also capable of simulating small GHG fluxes such as N_2O and CH_4 fluxes under conventional and bioenergy crops. Changes in soil C provides the largest contribution to the impact of LUC on GWP.
- ELUM Modelling Tool allows users to evaluate the impacts of a variety of land-use transitions between crop types.
- Longer-term monitoring and further work will be required to reduce residual uncertainty.

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Photo of the Day (April 15, 2010): Nature and Environment. National Geographic