Sensitivity and uncertainty analysis of grassland models in Europe and Israel

Renáta Sándor, S Ma, M Acutis, Z Barcza, L Doro, D Hidy, M Köchy, J Minet, E Lellei-Kovács, A Perego, S Rolinski, F Ruget, G Seddaiu, L Wu, G Bellocchi

MACSUR Conference 2015 Integrated Climate Risk Assessment in Agriculture & Food
University of Reading, UK
Wednesday 8th – Friday 10th April 2015
Grassland model inter-comparison in MACSUR

**Construction:**
- Model inter-comparison at selected sites in Europe (plot-scale simulations)
- Guidelines and minimum dataset requirement for model evaluation
- Common protocol for the modelling teams
- Data segregation
- Evaluation and uncertainty analysis of model outputs

**Aims:**
- To quantify uncertainties on yield and carbon-flux outputs
- To explore the sensitivity of grassland models to climate change factors
- To analyze the correlation between the ensemble and the individual model results
- To establish highlights for getting better estimations
Grassland modelling

Parameters
- PaSim
- SPACSYS
- AnnuGrow

Input variables
- STICS
- EPIC
- ARMOSA

Initial values
- Biome-BGC
- MuSo
- LPJmL
- CARAIB

Grassland-specific

Crop models (adapted to grasslands)

Vegetation models

Outputs: GPP, NEE, RECO, ET, ST, SWC, yield

Simulations: uncalibrated, calibrated, validated, sensitivity (CO₂, Temp, Prec.)
Study sites

- **Flux-tower observational sites**
  - (GPP, NEE, RECO, ET, ST, SWC, yield)
  - Data: hourly resolution

- **Grassland experimental sites**
  - (yield)
  - Data: cutting events

- **Kemp-1**: intensive (4 cuts/year)
- **Kemp-2**: extensive (2 cuts/year)

- **Roth-1**: NH4 – fertilization
- **Roth-2**: NO3 – fertilization

- **LAQ1**: intensive  (N fertilized)
- **LAQ2**: extensive (non fertilized)

**Locations:**
- Rothamsted
- Lelystad
- Grillenburg
- Kempten
- Oensingen
- Laqueuille
- Monte Bondone
- Sassari
- Matta
Study sites

- Matta
- Sassari
- Laqueuille
- Rothamsted
- Lelystad
- Oensingen
- Kempten
- Grillenburg
- Monte Bondone

Aridity index (b)

- humid sites
- sub-humid sites
- arid sites
GPP sensitivity to CO$_2$ scenarios: ensemble model

**Baseline:** 380 ppm

**GRI**

- $y = 19,039e^{0.4789x}$
- $R^2 = 0.9895$

**LAQ1**

- $y = 7,1381e^{0.6964x}$
- $R^2 = 0.949$
Sensitivity of outputs to CO$_2$ scenarios at GRI

Baseline: 380 ppm
Sensitivity of outputs to CO$_2$ scenarios at LAQ1
GPP sensitivity to T scenarios: ensemble model

**GRI**

\[ y = 33,286x - 122,33 \]

\[ R^2 = 0,9569 \]

**LAQ1**

\[ y = 59,114x - 231,4 \]

\[ R^2 = 0,9909 \]
Sensitivity of outputs to T scenarios at GRI

Temperature scenarios at GRI

GPP

NEE

RECO

ET

SWC

ST
Sensitivity of outputs to T scenarios at LAQ1

Temperature scenarios at LAQ1

GPP

Relative changes of GPP (%)

-20 -10 0 10 20 30 40 50
-25% -10% 0% 10% 25%

NEE

Relative changes of NEE (%)

-400 -200 0 200 400
-25% -10% 0% 10% 25%

RECO

Relative changes of RECO (%)

-20 -10 0 10 20 30 40
-25% -10% 0% 10% 25%

ET

Relative changes of ET (%)

-20 -10 0 10 20 30 40
-25% -10% 0% 10% 25%

SWC

Relative changes of SWC (%)

-20 -10 0 10 20 30
-25% -10% 0% 10% 25%

ST

Relative changes of ST (%)

-40 -20 0 20 40
-25% -10% 0% 10% 25%
GPP sensitivity to P scenarios: ensemble model

**GRI**

\[ y = 11,743x - 49,6 \]
\[ R^2 = 0,8469 \]

**LAQ1**

\[ y = 21,429x - 63,333 \]
\[ R^2 = 0,8927 \]
Sensitivity of outputs to P scenarios at GRI

Graphs showing the relative changes of GPP, NEE, RECO, ET, SWC, and ST with varying precipitation scenarios at GRI.
Sensitivity of outputs to P scenarios at LAQ1

- **GPP**
- **NEE**
- **RECO**
- **ET**
- **SWC**
- **ST**
Sensitivity of yield biomass to CO₂

- +5% CO₂
- +10% CO₂
- +15% CO₂
- +25% CO₂
- +50% CO₂
- +100% CO₂

Yield biomass (g C m⁻²)
Conclusions

◆ The responsiveness of different models to climate change factors shows a wide spread of the outputs that is difficult to interpret based only on visual basis
  ◆ Some models are not sensitive at all while some models do not show a down-regulation of photosynthesis at elevated CO$_2$ concentrations (so that simulated GPP could indefinitely increase with increasing atmospheric CO$_2$ concentrations)

◆ The ensemble average tends to be a better representation of the observed outputs than single model realizations, which is a similar conclusion to the one obtained with crop models in other studies

Modelling European Agriculture with Climate Change for Food Security — a FACCE JPI knowledge hub —

Thank you for your attention!