Priorities for modelling European grasslands under climate change

Gianni BELLOCCHI  Richard P. KIPLING  Perttu VIRKAJÄRVI  Laura BREITSAMETER
70 institutes in 18 countries

- Capacity building
- Integrated modelling
- Applying approaches
Setting the research agenda

Livestock health and disease modelling workshop
Reading (UK) 24-25th June 2015

Grassland vulnerability and quality modelling workshop
Wageningen (NL) 17-19th June 2015
Two main outcomes

**Agricultural Systems**

Review

*Modeling European ruminant production systems: Facing the challenges of climate change*

**Science of The Total Environment**

Review

*Key challenges and priorities for modelling European grasslands under climate change*
Modelling the impact of extreme events

Modelling different regions and production systems

Modelling soil variables / processes

Modelling multi-species swards

Modelling livestock and pasture interactions

Modelling plant responses to environmental change

Modelling overwintering

Modelling the impact of extreme events

Modelling livestock and pasture interactions

Modelling plant responses to environmental change

Modelling overwintering

Challenges for grassland modelling under climate change

Modelling the provision of ecosystem services

Incorporating plant pests and pathogens into models

Model & data scales

Data for models

Fit-for-purpose models

Modelling adaptation strategies

Modelling different regions and production systems

Modelling nutritional variables required to predict animal performance

Modelling nutrient cycles and greenhouse gas balances

Mediating factors

15 challenges

Mediation of climate change impacts by site, system and management

Direct and indirect effects on the sward

System outputs
Modelling different regions and production systems
Modelling soil variables / processes
Modelling livestock and pasture interactions
Modelling nutritional variables required to predict animal performance
Modelling multi-species swards
Modelling soil variables / processes
Modelling adaptation strategies
Modelling plant responses to environmental change
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Mediation of climate change impacts by site, system and management
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Direct and indirect effects on the world
Fit-for-purpose models
Data for models
Model & data scales
Modelling the impact of extreme events

Modelling nutrient cycles and GHG balances
Plant acclimation

\[ f_T = \left( \frac{T - T_0}{T_{opt} - T_0} \right)^q \left( \frac{T_0' - T}{T_{opt}' - T_{opt}} \right) \]

\( (P_{\text{max,20}}) \)
Max photosynthesis at 20 °C

\[ P_{\text{max}} = P_{\text{max,20}} \cdot f_T \cdot P_{m,CO_2T} \cdot P_{mN} \cdot P_{mc} \]

\( (f_T) \)
Temperature factor

\( (P_{m,CO_2T}) \)
CO₂-temperature interaction

\[ P_{m,CO_2T} = V_{cmax} \frac{A_{\text{max}}}{A_{\text{max,350}}} \]

\( (P_{mN}, P_{mc}) \)
Functions of plant N and C concentrations

Farquhar scheme (photosynthesis)

\( V_{cmax} = \) maximum catalytic rate of the enzyme Rubisco

\( A_{\text{max}} = \) light-saturated photosynthetic rate

(functions of CO₂ compensation point and CO₂ concentration in the intercellular air spaces)
Response to growth temperature

Shift of optimum temperature over a broad range of temperatures

Homeostasis of maximum photosynthetic rate over a limited range of temperatures

Alfalfa (Mediterranean ▲ vs temperate ▲ ▲)
Acclimation of photosynthetic response

Yamori et al. (2014)

Increase of optimum temperature with increasing growth temperature

Growth temperature acts as a modifier of the response curve of assimilation

Temperature response of photosynthetic rate

Plants grown at low temp.
Plants grown at high temp.

Leaf temperature (°C)
Farquhar scheme - modified solution

Zaka et al. (2016)

\[ T_{opt} = a \cdot T_{m,d} + b \]

\[ \sim f \text{ (growth temperature)} \]

\[ P_{max} = P_{max,20} \cdot f_T \cdot P_{m,CO_2} \cdot P_{mN} \cdot P_{mC} \]
Grassland simulations (model PaSim) in the Massif Central of France
Manipulation of precipitation and temperature

Frequency of heat waves

The hottest year in the series, with 9.4 °C on average and three days with maximum air temperature >35 °C

Yield biomass

Frequency of heat waves

Saint Genès-Champanelle
880 m a.s.l.
8.7 °C
780 mm

frequent cut

infrequent cut
Observational flux site

Frequency of heat waves

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011

Ecosystem respiration

extensive grazing

Laqueuille

1040 m a.s.l.
8.0 °C
1000 mm
Research applications in grassland modelling will continue, but for such applications to sustain long-term interest farm-scale and policy applications need to be developed and applied...

Long-term networks to build capacity and support joined-up approaches

FAO HEADQUARTER
November 3, 2015
Rome, ITALY

DG AGRI
September 20, 2016
Brussels, BELGIUM

ROUND TABLE
May 23, 2016
Florence, ITALY

DG AGRI
April 9, 2014
Brussels, BELGIUM
THÜNEN

INRA METAPROGRAMMES
ADAPTATION OF AGRICULTURE AND FORESTS TO CLIMATE CHANGE