

iEMSs 2016  
July 10 - 14, 2016  
Toulouse, FRANCE



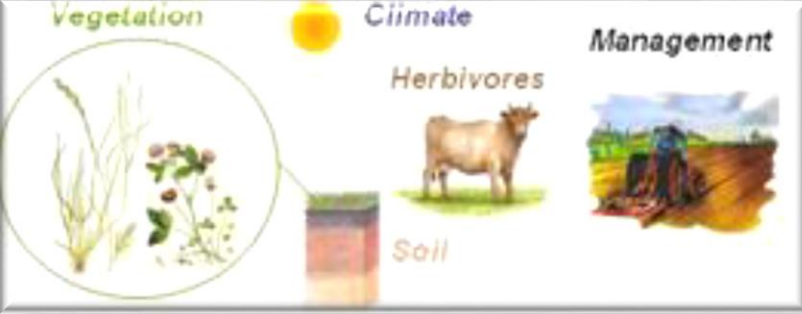
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# The Pasture Simulation model – evaluation of plant acclimatory effects on grassland systems in France

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# Grassland modelling

Inputs  
(climate, soil, management)

Initial values  
Parameters

**Pasture Simulation model  
(PaSim)**

**Production**

**Biophysics**

**Biogeochemistry**

Outputs

(forage yield, animal intake, milk production, soil water content, soil temperature, gross primary productivity, ecosystem respiration, net ecosystem exchange, N<sub>2</sub>O emissions, CH<sub>4</sub> emissions, etc.)

# The Pasture Simulation model

Mechanistic, biogeochemical model (Riedo et al., 1998) - Time resolution: ~30 minutes

Simulation of fluxes of water, energy, C and N at the soil-plant-animal atmosphere interface

Simulation of permanent (cut / grazed) grassland systems

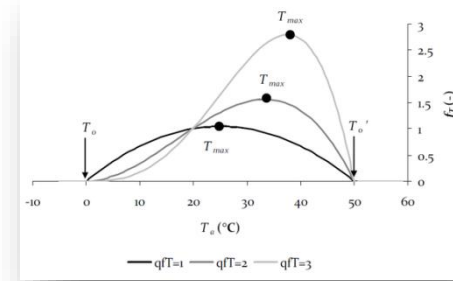


## Limitation of the models:

- Soil C pools averaged over the whole soil profile
- Homogeneous herds (type, age) of grazing animals
- No explicit representation of plant communities
- **Limited sensitivity to extreme events (e.g. regrowth after heat and water stress<sup>3</sup>)**

# Farquhar scheme (photosynthesis)

$$f_t = \left( \frac{T - T_0}{T_{opt} - T_0} \right)^q \cdot \left( \frac{T'_0 - T}{T'_0 - T_{opt}} \right)$$



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

$(f_T)$   
Temperature factor

$$P_{max} = P_{max,20} \cdot f_T \cdot P_{m,CO_2T} \cdot P_{mN} \cdot P_{mC}$$

$(P_{m,CO_2T})$   
CO<sub>2</sub>-temperature  
interaction

$(P_{mN}, P_{mC})$   
Functions of plant N  
and C concentrations

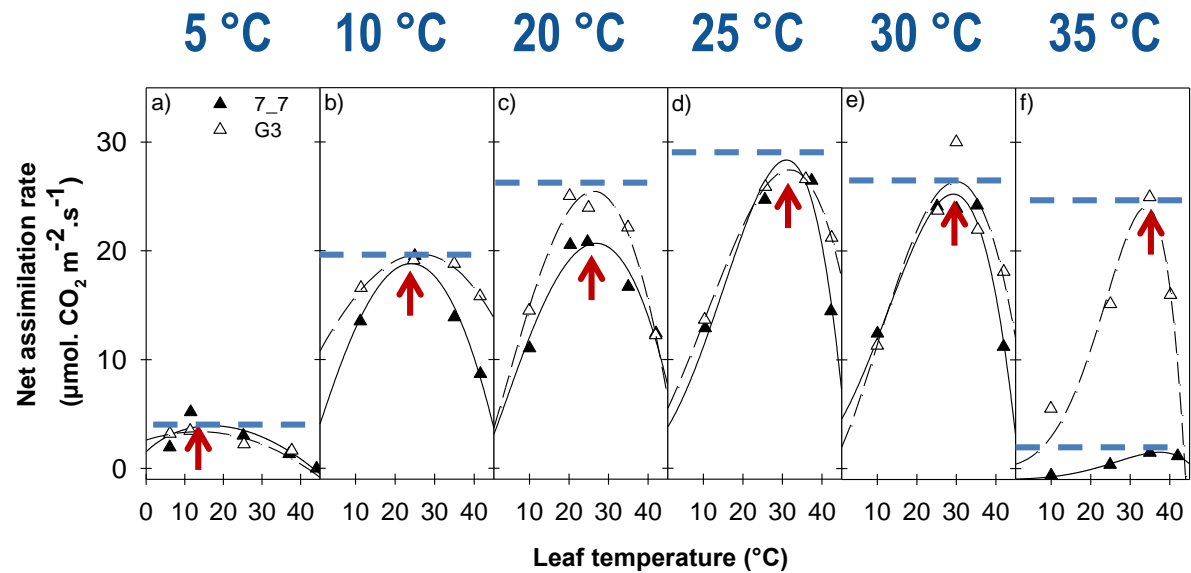
$$P_{m,CO_2T} = V_{cmax} \frac{A_{max}}{A_{max,350}}$$

$V_{cmax}$  = maximum catalytic rate of the enzyme Rubisco

$A_{max}$  = light-saturated photosynthetic rate

(functions of CO<sub>2</sub> compensation point and CO<sub>2</sub> concentration in the intercellular air spaces)

# Response to growth temperature



Shift of optimum temperature over a broad range of temperatures

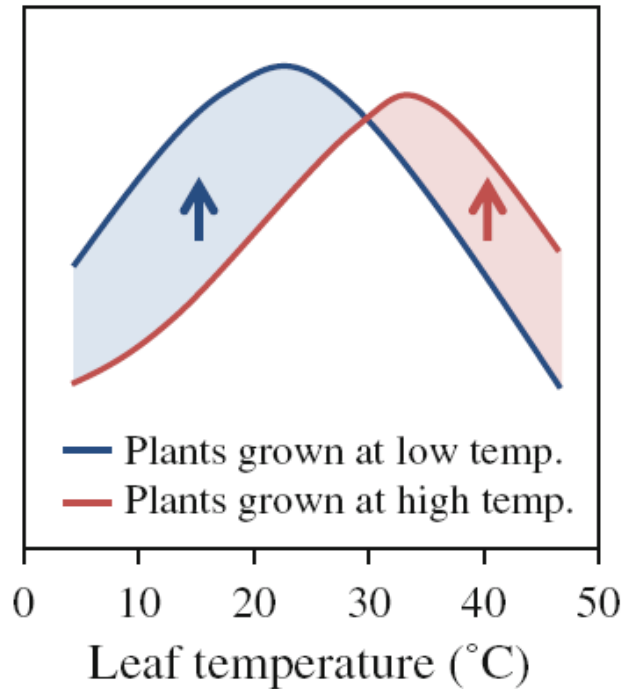
Homeostasis of maximum photosynthetic rate over a limited range of temperatures

Alfalfa (Mediterranean  vs temperate )

# Acclimation of photosynthetic response



Temperature response of photosynthetic rate



Increase of optimum temperature with increasing growth temperature



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

# PaSim - modified solution

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

~f (growth temperature)

$$P_{max} = P_{max,20} \cdot f_T \cdot P_{m,CO_2T} \cdot P_{mN} \cdot P_{mC}$$

$$f'_T = \left\{ \sin \left[ \pi \left( \frac{T - T_0}{T'_0 - T_0} \right)^\alpha \right] \right\}^\beta$$

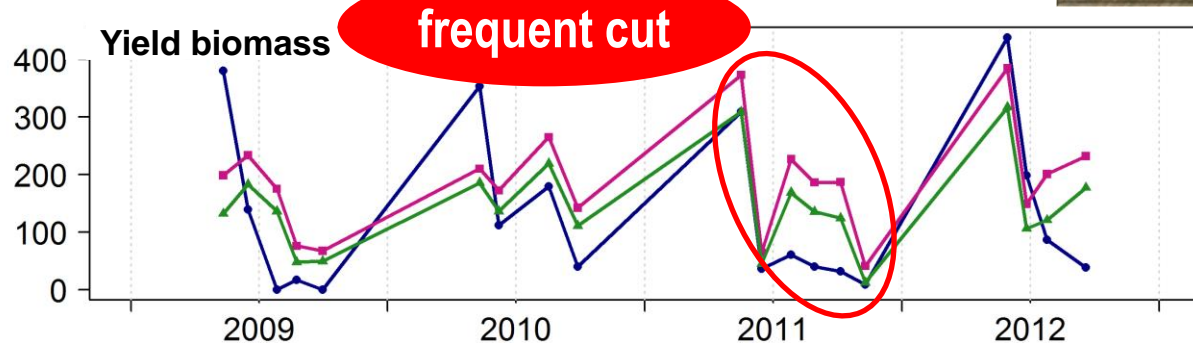
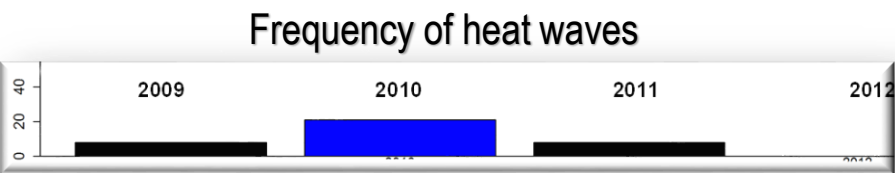
Modulation of maximum photosynthetic rate



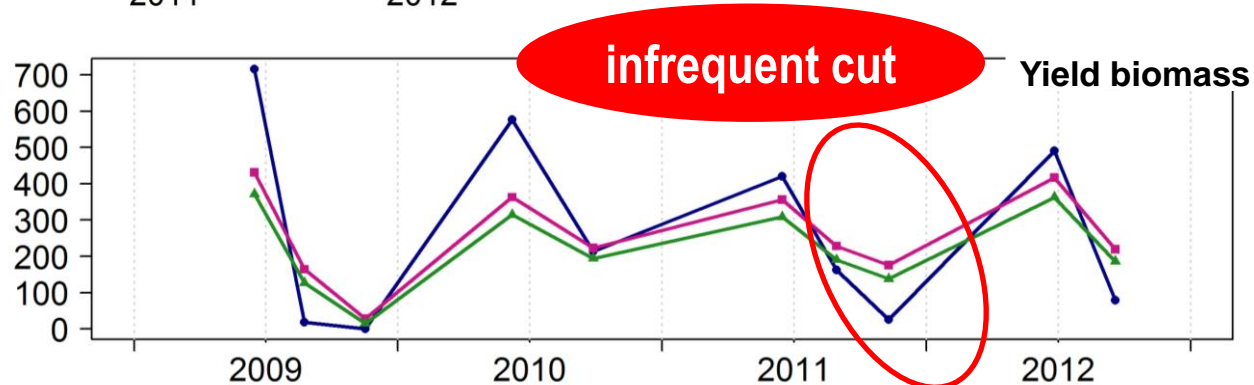
**Grassland simulations in  
the Massif Central of France**



# Manipulation of precipitation and temperature



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



● Obs

■ Existing PaSim

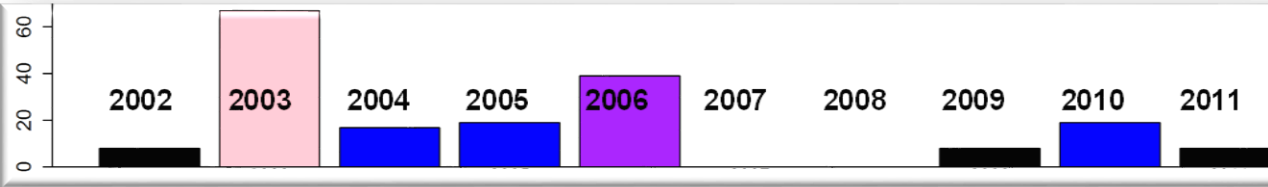
▲ Advanced PaSim

# Observational flux site

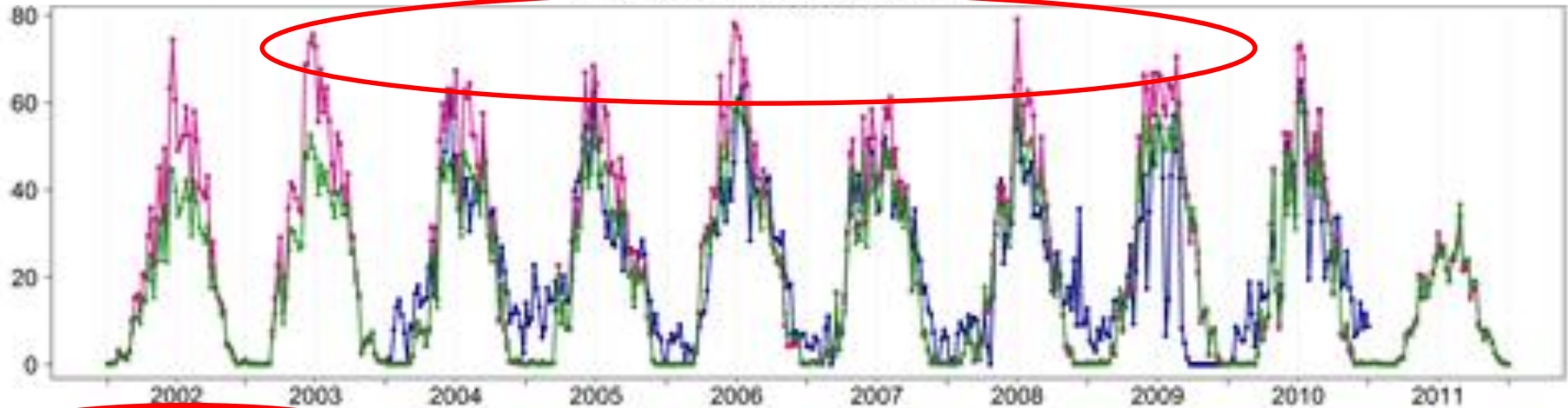
Laqueuille



Frequency of heat waves



Ecosystem respiration



extensive grazing

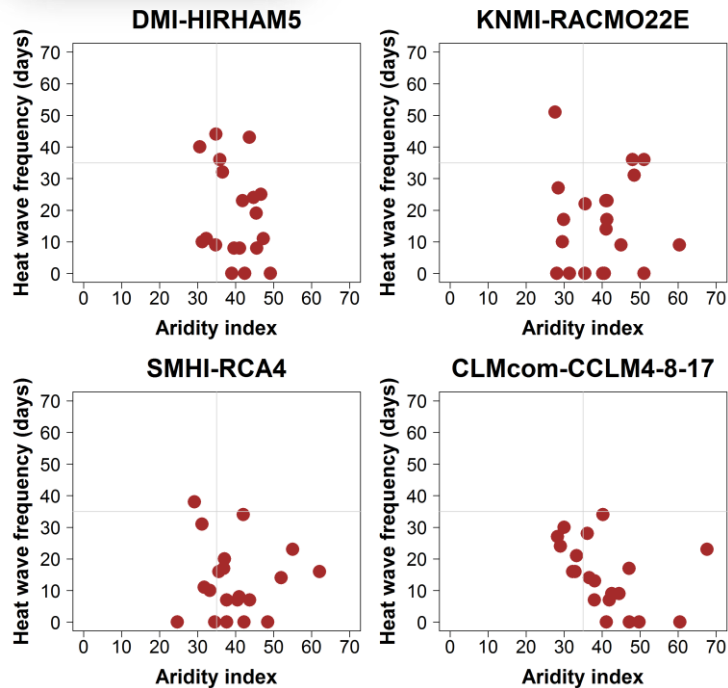
Observation Existing PaSim Modified PaSim



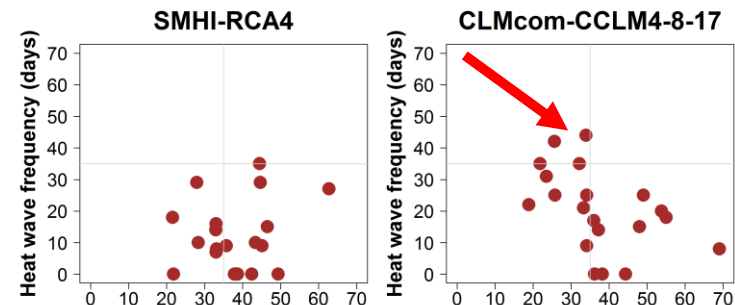
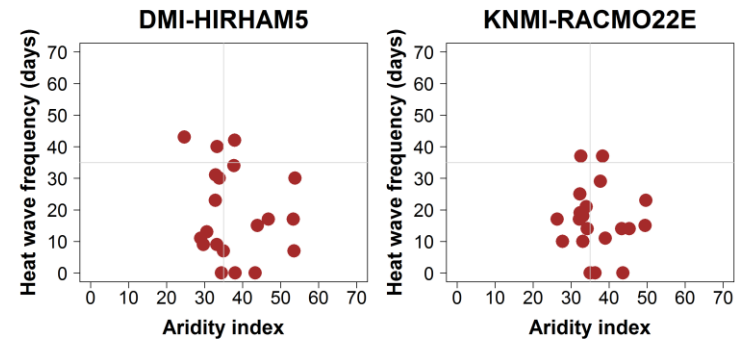
# Climate scenarios

(RCP8.5, 0.25°, 40 pixels, bias-corrected, four models, three 20-year time horizons)

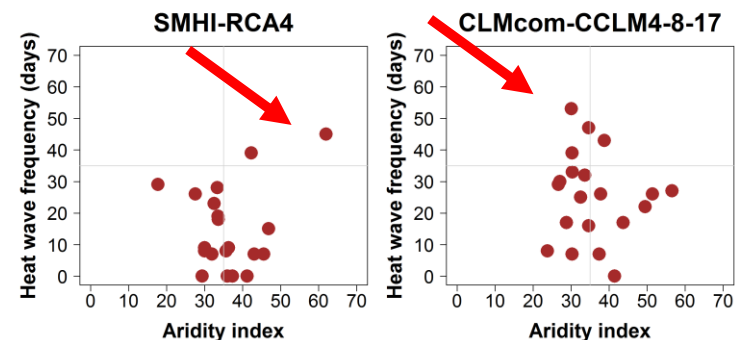
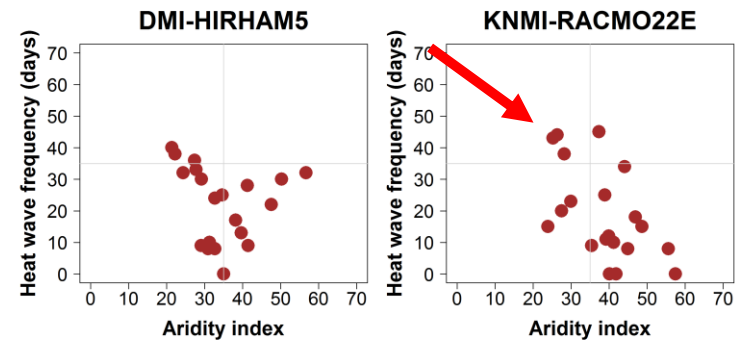
2000



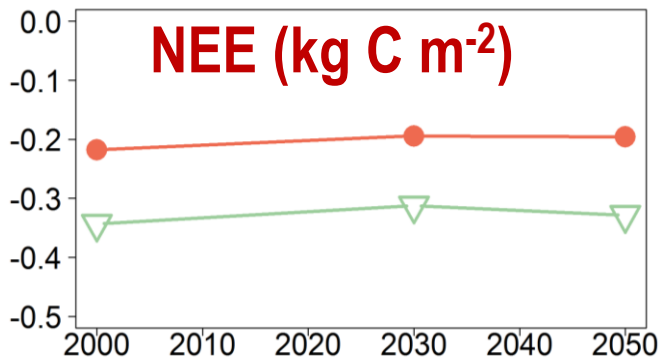
2030



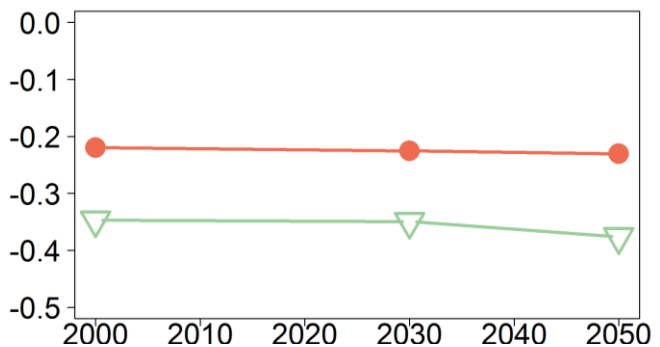
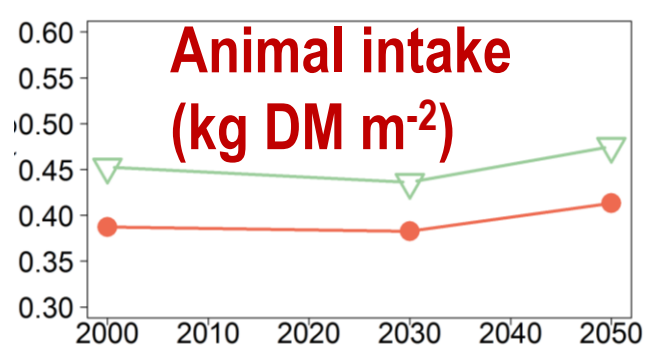
2050



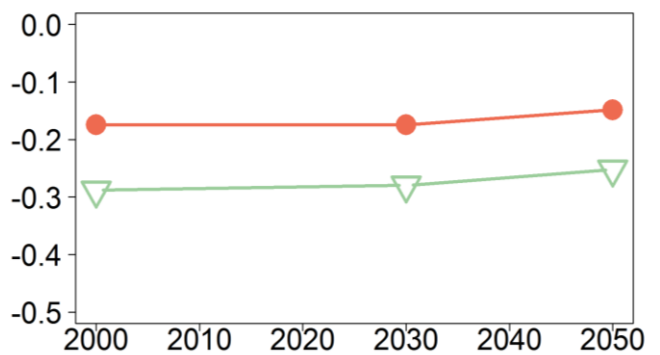
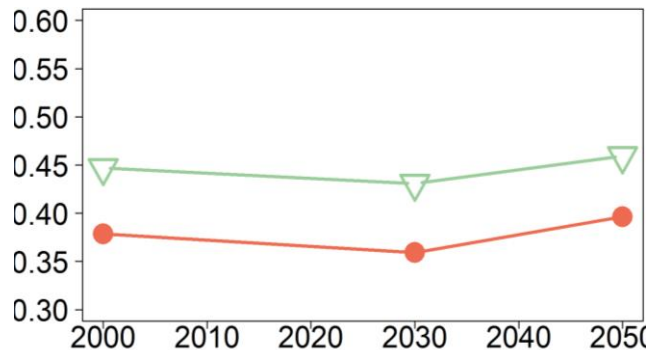
Net ecosystem exchange  
Animal intake of dry matter



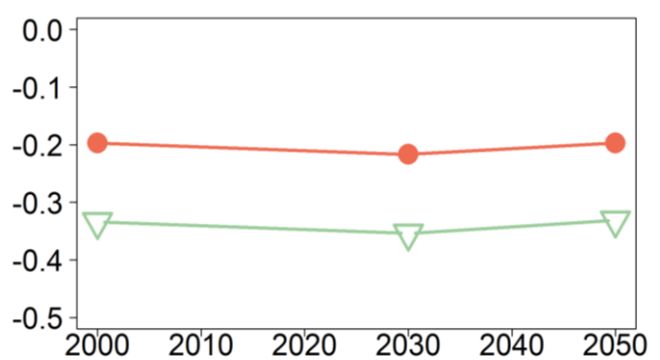
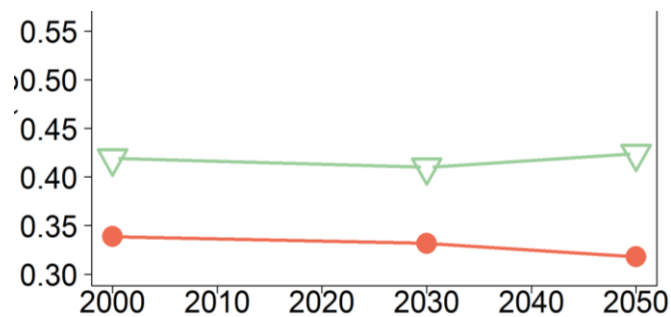
DMI-HIRHAM5



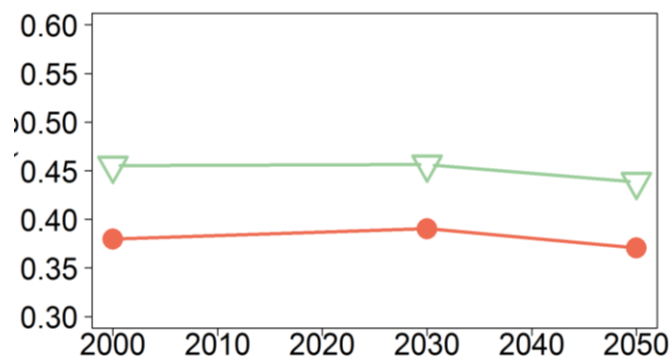
KNMI-RACMO22E



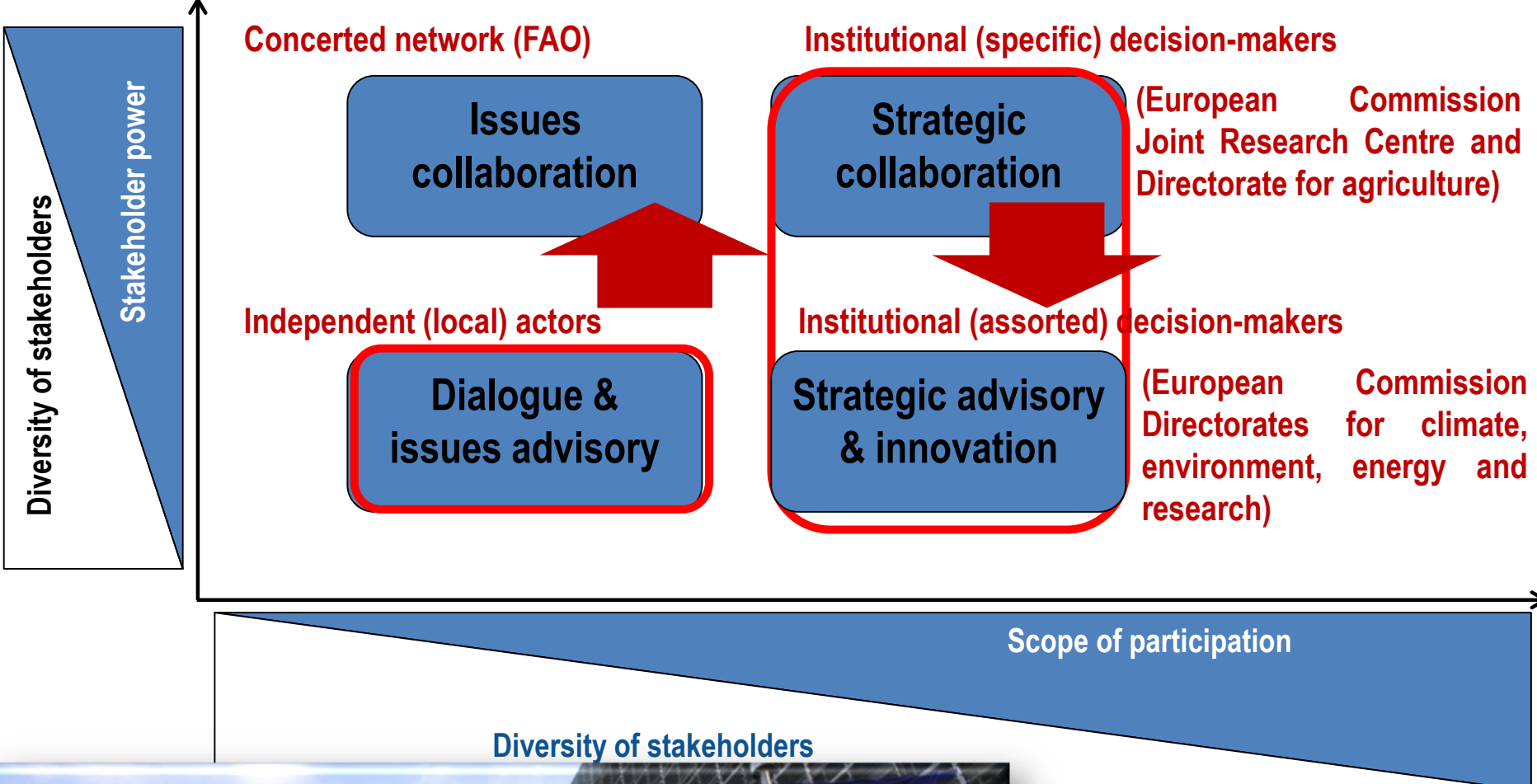
SMHI-RCA4



CLMcom-CCLM4-8-17



Existing PaSim  
Modified PaSim



**DG AGRI - LUNCHTIME SESSION**  
 September 20, 2016  
 Brussels, BELGIUM

**Deliberation  
 with  
 stakeholders**



This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 613817.2013-2016

