The MACSUR grassland model inter-comparison with the model CARAIB

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Framework

MACSUR task L2.4 Grassland model intercomparison :

- Phase 1 : Blind runs
- Phase 2 : Calibrated runs
- Phase 3 : Climate sensitivity analysis
- 9 models involved :

- Grassland-specific models: AnnuGrow, PaSim, SPACSYS

- Crop models: EPIC, STICS, ARMOSA

- Biome models: Biome-BGC, CARAIB, LPJmL

→ Ma et al. IEMSs conference, 2014 (Phase 1)

→ Next talk today of Renáta Sándor

The grassland model intercomparison of the MACSUR (Modelling European Agriculture with Climate Change for Food Security) European knowledge hub

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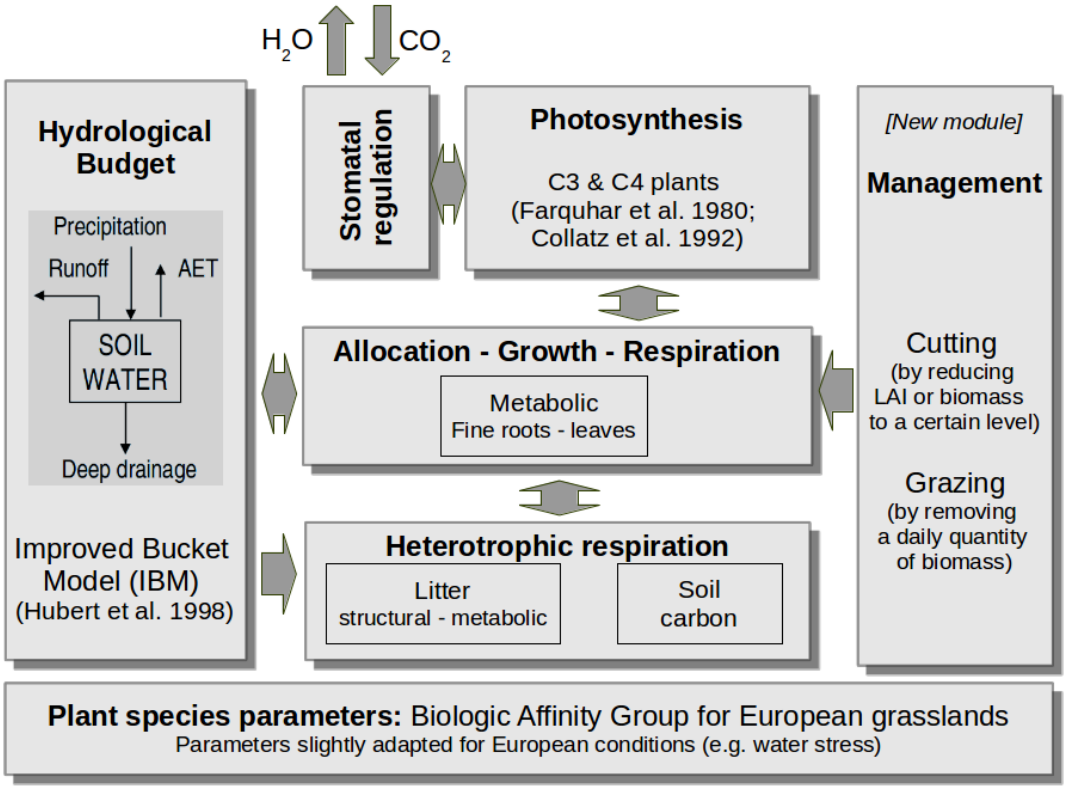
The grassland model : CARAIB

- A physically-based, mechanistic, dynamic vegetation model
- Focused on grassland
- New management functions for grassland: cut & grazing



Reference website: http://www.umccb.ulg.ac.be/Sci/m_car_e.html

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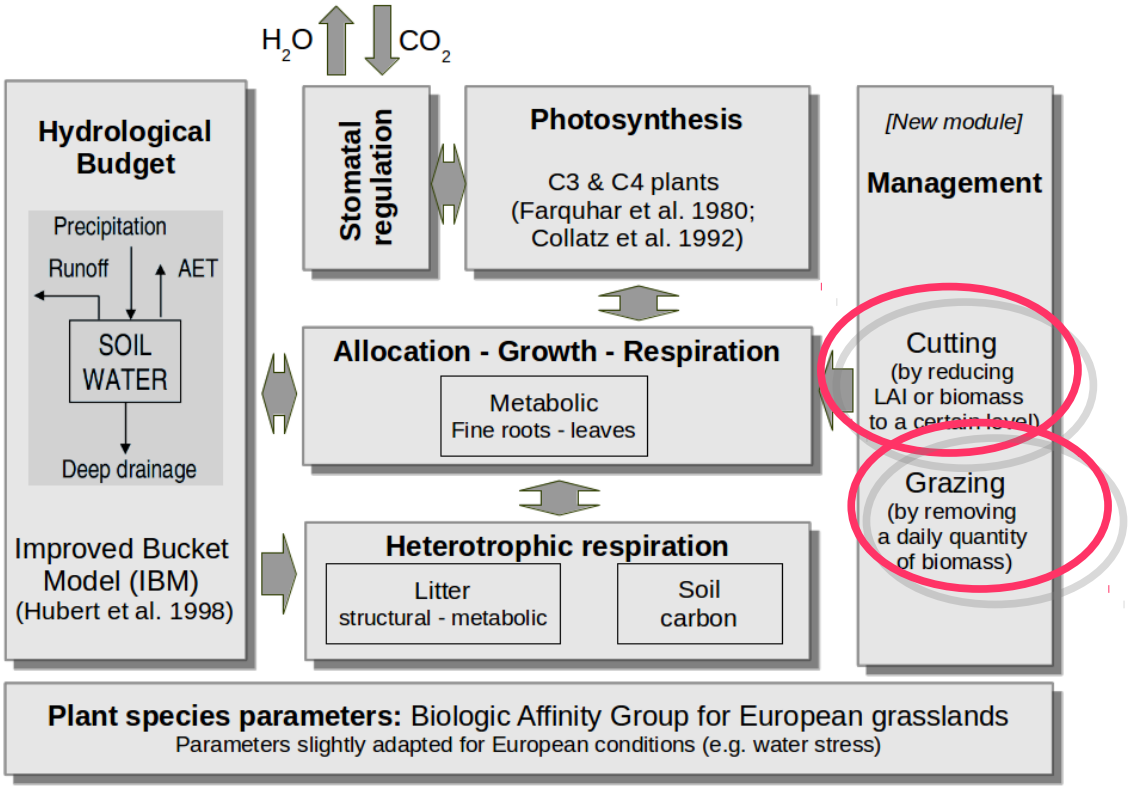

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The experimental sites – with eddy covariance data

Grillenburg, DE, 375 m

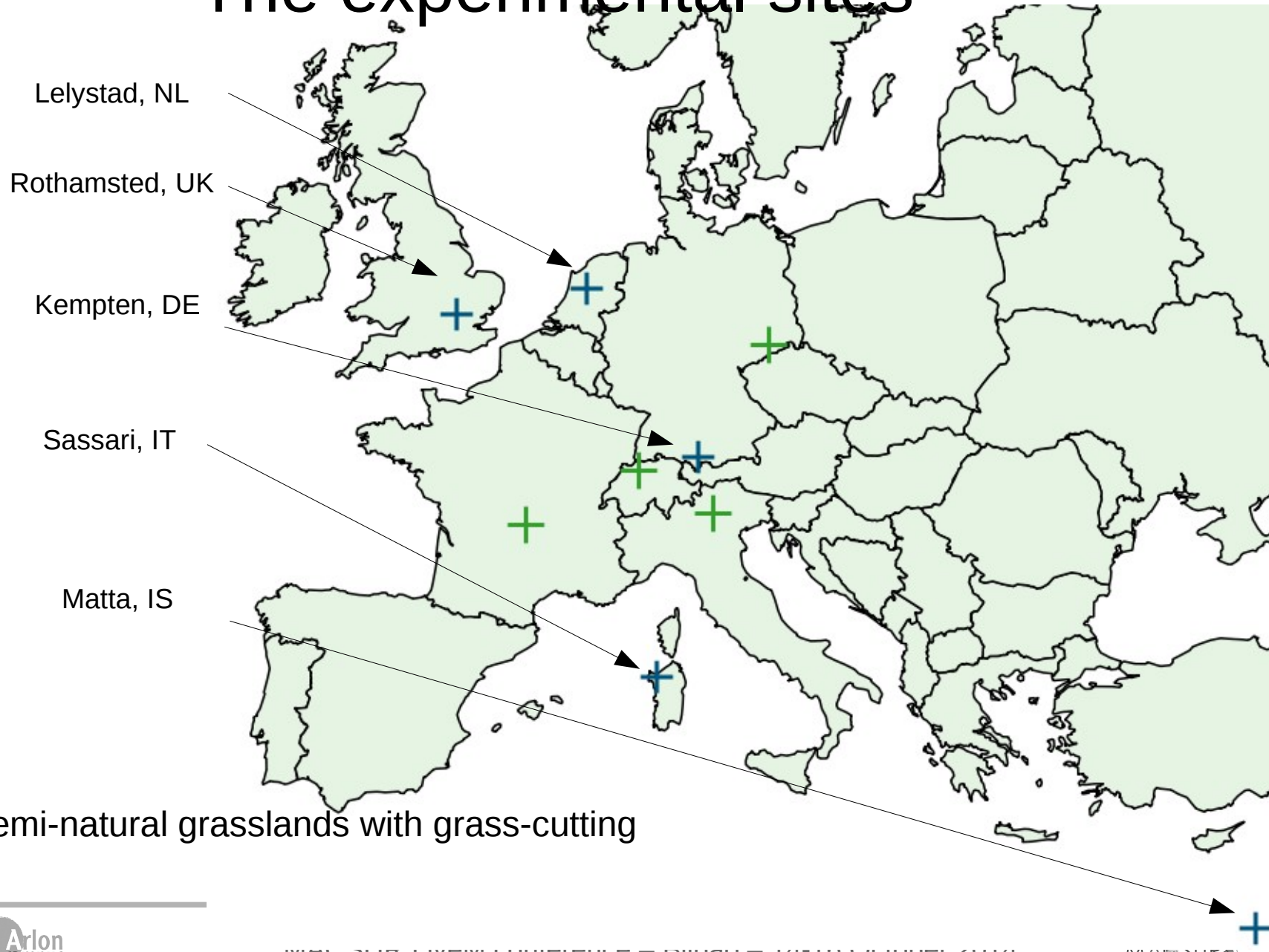
Oensingen, CH, 450 m

Monte-Bondone, IT, 1550 m

Laqueuille, FR, 1040 m

- Semi-natural grasslands : grazed (Laqueuille) or cut (other 3)
- 4 Eddy-covariance sites : flux measurements available : GPP, RECO, ET, ...

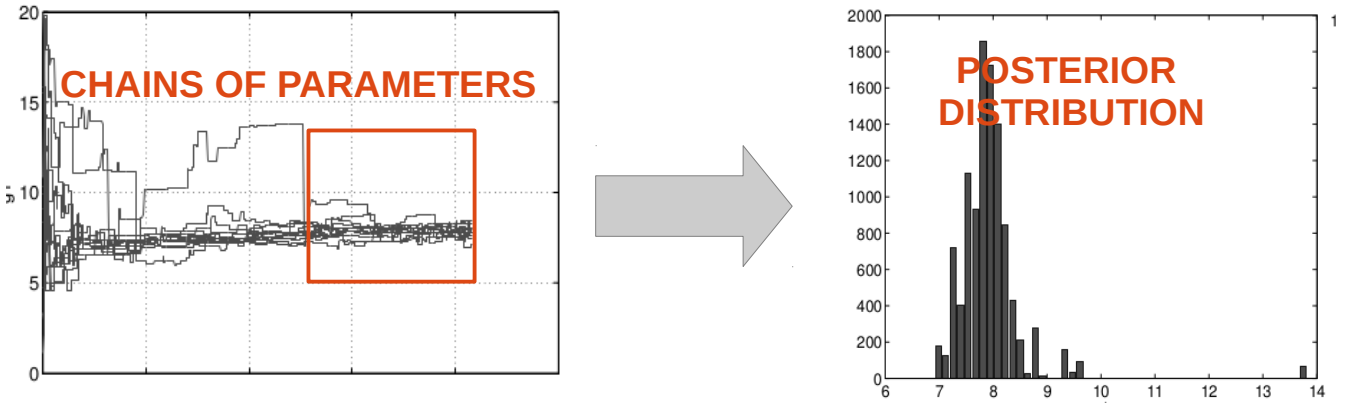
The experimental sites



- Semi-natural grasslands with grass-cutting

2nd phase : Model calibration

- Inverse problem: $Optimal\ parameters = argmin\left(Observations - Modeled\left(parameters\right)\right)$
- DREAM_ZS: a Markov-Chain Monte-Carlo sampler (Bayesian method)
- 10 parameters were sampled using 3 measurements variables from Eddy covariance: GPP, RECO, ET + their uncertainties (U_{GPP}, U_{RECO}, U_{ET})
- A multi-objective cost function (CF) was used : CF = f(GPP, U_{GPP}, RECO, U_{RECO}, ET, U_{ET})

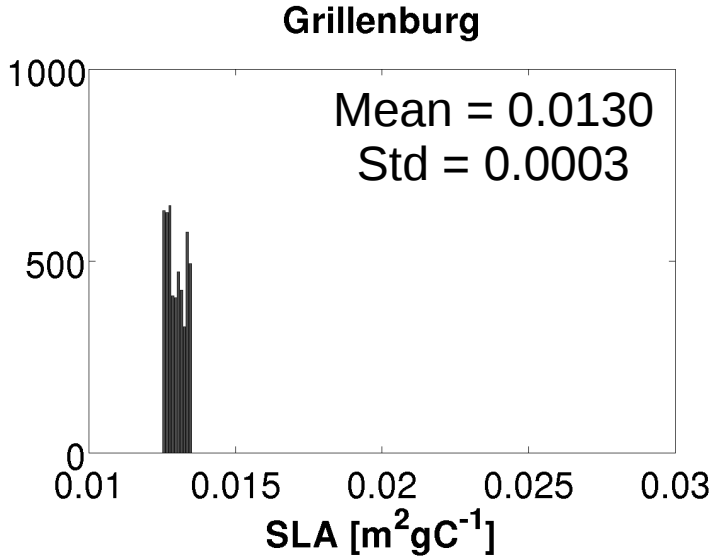


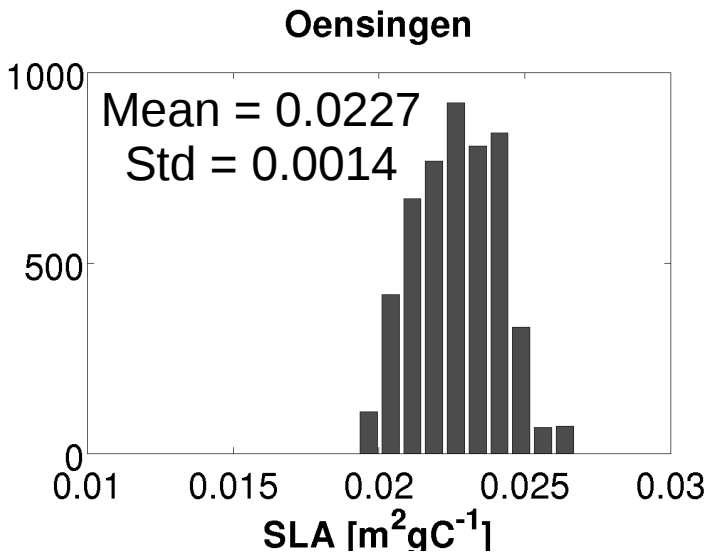
Laloy, E., and J.A. Vrugt, High-dimensional posterior exploration of hydrologic models using multiple-try DREAM_(ZS) and high-performance computing, Water Resources Research, 48, W01526, 2012

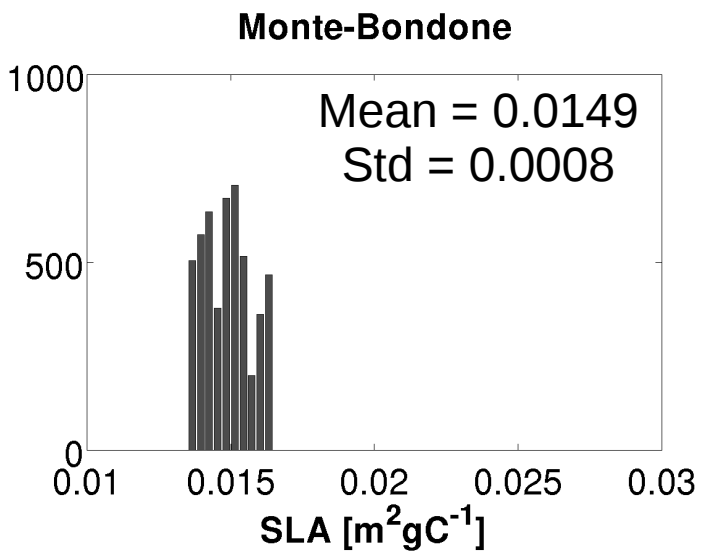
Vrugt, J.A., C.J.F. ter Braak, C.G.H. Diks, D. Higdon, B.A. Robinson, and J.M. Hyman, Accelerating Markov chain Monte Carlo simulation by differential evolution with self-adaptive randomized subspace sampling, International Journal of Nonlinear Sciences and Numerical Simulation, 10(3), 273-290, 2009.

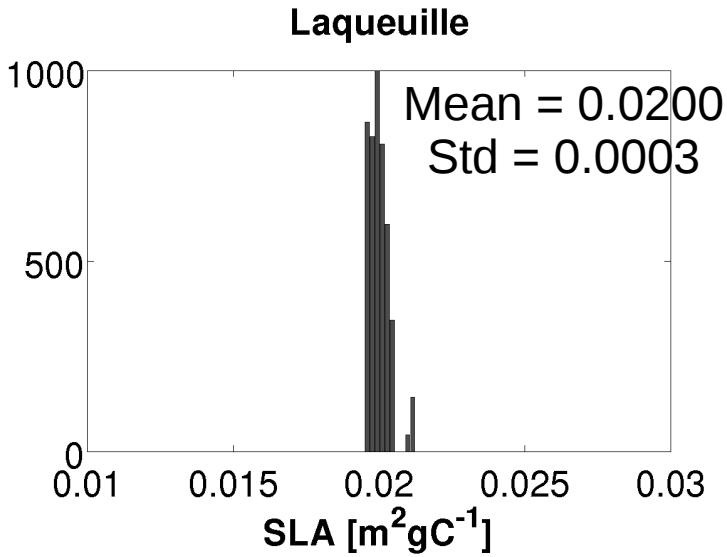
Results 2nd phase: parameter samplings

Specific leaf area (SLA) [m²/gC]





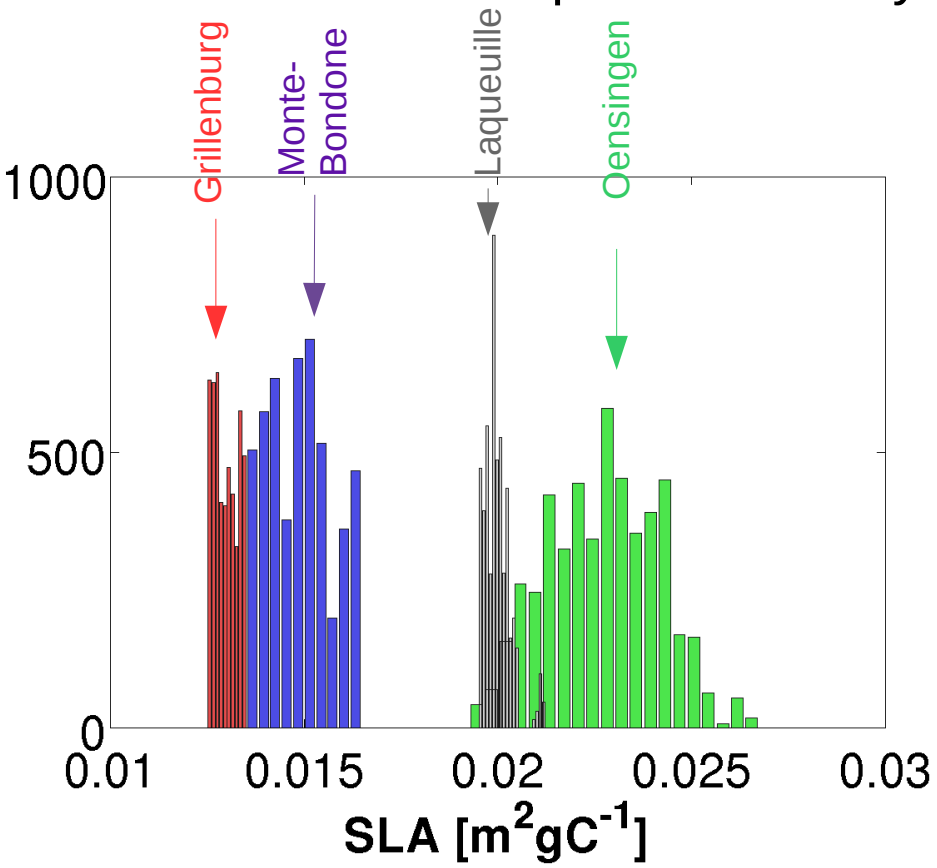


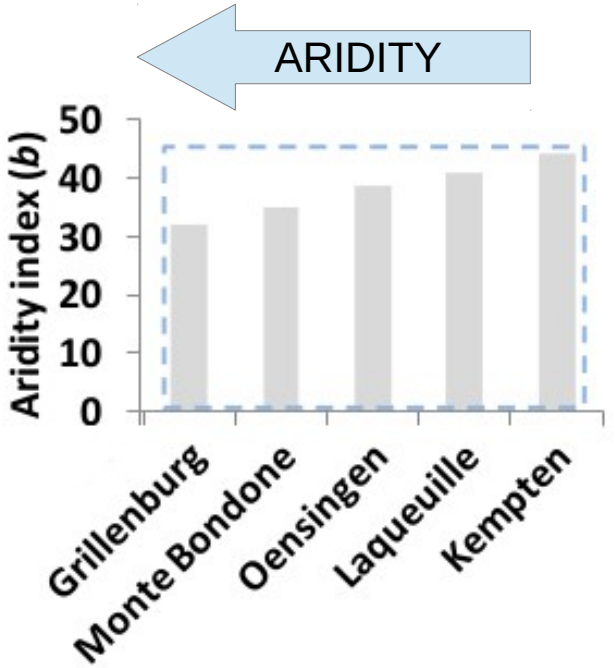


Results 2nd phase: parameter samplings

Specific leaf area (SLA) [m²/gC]

- SLA in CARAIB : *effective* SLA for a plant functional type !
- Actually, SLA is variable between leaves and along the season
- SLA is known to depend on aridity (-) and intensification (+)

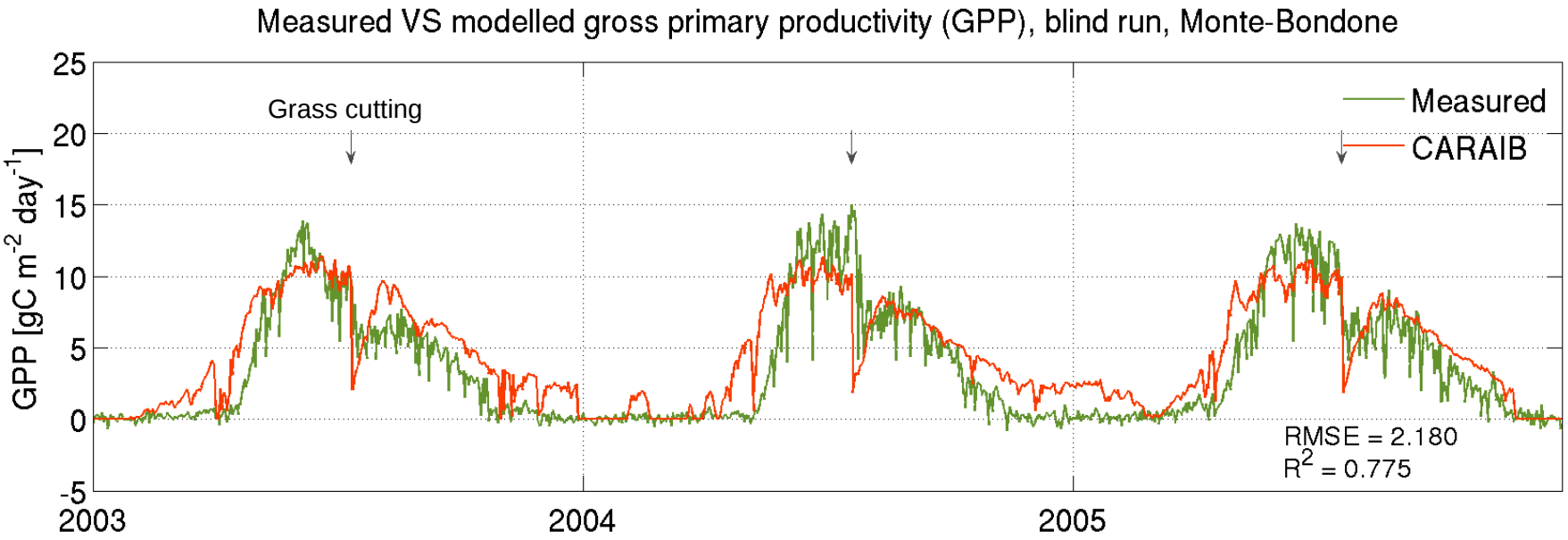




De Martonne-Gottmann aridity index
from Ma et al. iEMSs, 2014

Results 1st phase – blind runs

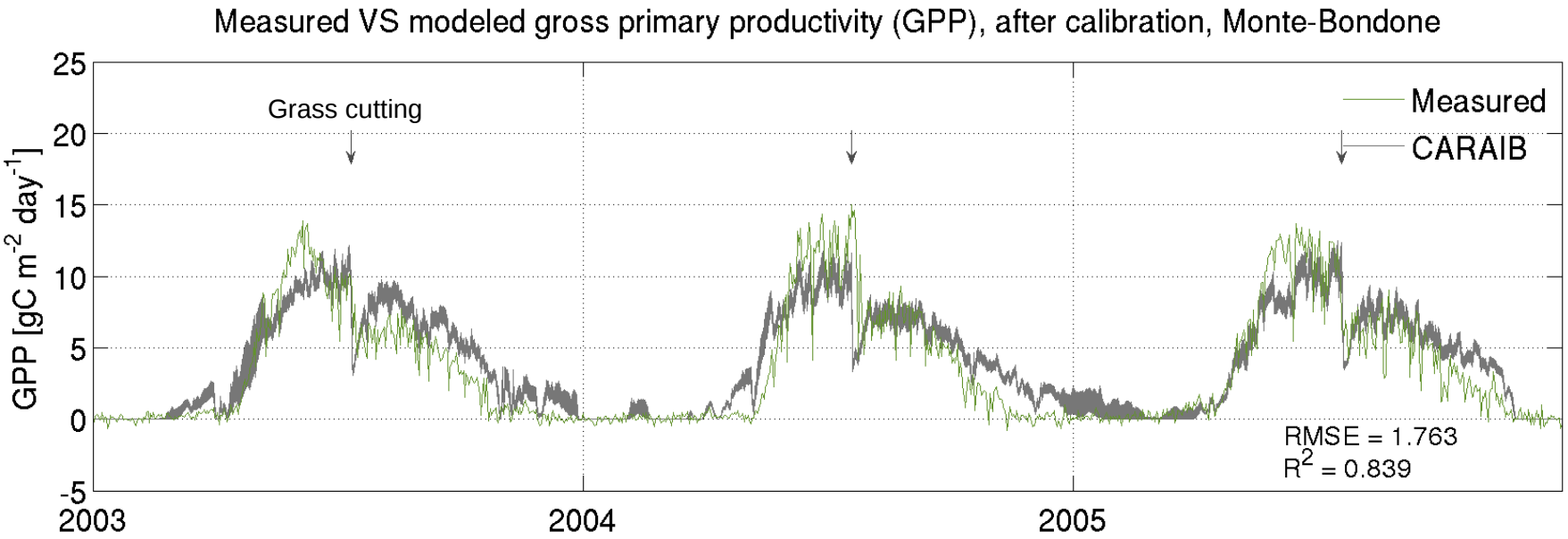
Measured vs modelled Gross Primary Productivity (GPP)



- Blind run without site-specific model calibration.
- Monte-Bondone : 1 grass cutting /year.

Results 2nd phase – calibrated runs

Measured vs modelled GPP



- Model runs after calibration using a Bayesian algorithm : 1000's of modelled signals → model sensitivity.
- Better agreement...

3rd phase - Climate sensitivity

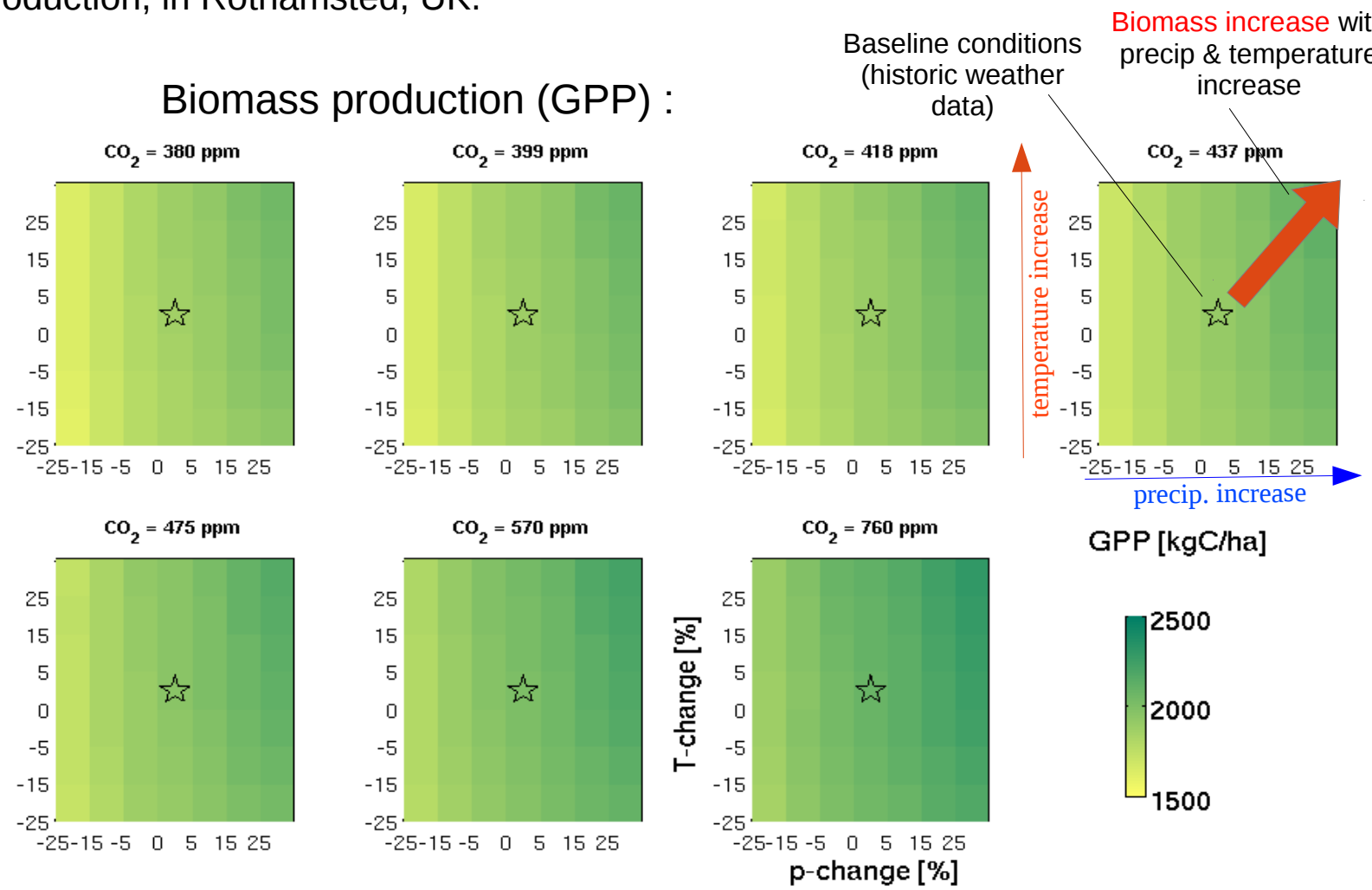
Methodology

- Analyse sensitivity of model to temperature, precipitation and [CO_2] change
- For precipitation and temperature, altered values are y = y ± x%*SD where percent changes are -25%, -15%, -5%, +5%, +15% & +25% and SD the standard deviation of temperature and precipitation.
- For [CO_2], altered values are the baseline (380 ppm) + 5%, 10%, 15%, 25%, 50% & 100%.
- 9 sites, 4 to 30 years, 6 x 6 x 6 = 216 scenarios

Results 3rd phase : Climate sensitivity

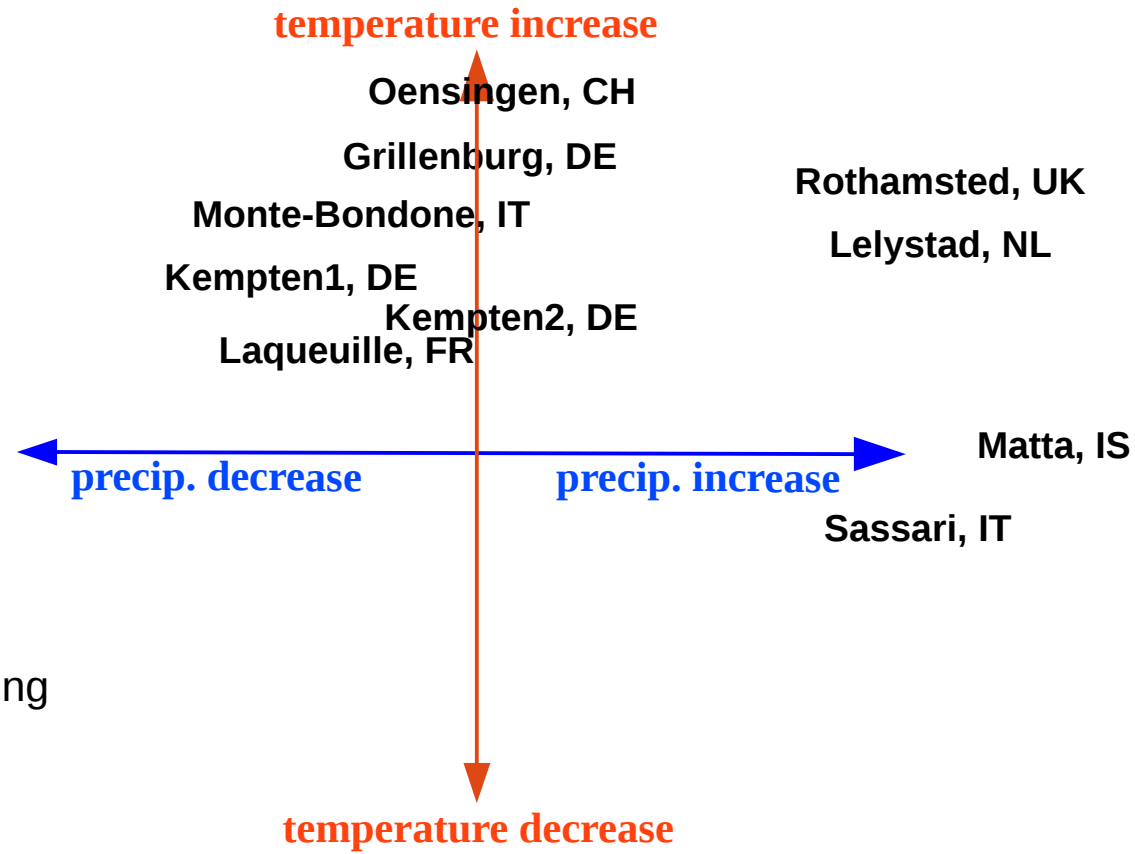
Mean (over years) impact of temperature, precipitation and [CO2] change on grassland production, in Rothamsted, UK.

Biomass production (GPP) :



Results 3rd phase : Climate sensitivity

Sites can be classified according to their climatic sensitivity for biomass increase (after Pirttioja et al. 2014, MACSUR CropM WP4) :



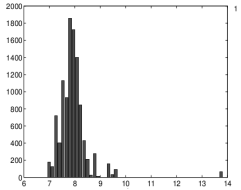
Note : All sites show an increase in biomass production with increasing CO2.

Not only sites but also grasslands models can be classified...

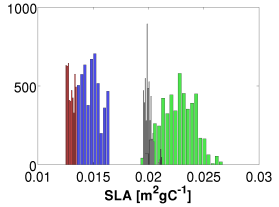
Conclusion

2nd phase : Bayesian sampling with DREAM_ZS :

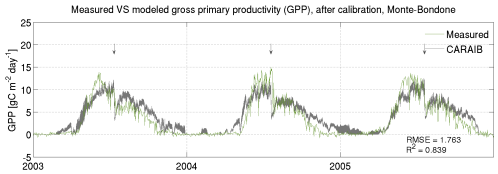
- Obtain a uncertainty assessment on model parameters



- Compare distributions of parameters between the sites



- Obtain an interval on model output due to parameters uncertainties



3rd phase : Climate sensitivity

- Huge amount of results
- Grasslands sites can be compared and classified
- Still on-going work...

Thanks for your attention