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agriculture facing extreme climatic events

PaSim simulations in the Massif Central of France

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The Pasture Simulation model (PaSim)

- Mechanistic, biogeochemical model (Riedo et al., 1998)
- Simulation of fluxes of water, energy, C and N at the soil-plant-animal atmosphere interface
- Simulation of permanent (cut / grazed) grassland systems
- Time resolution: ~30 minutes
- Reference grassland model in several projects:
  - Europe: EU FP7 AnimalChange, FACCE-JPI MACSUR
  - International: AgMIP, FACCE-JPI CN-MIP and Model4Pasture

PaSim - modified solution

~f (growth temperature)

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

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

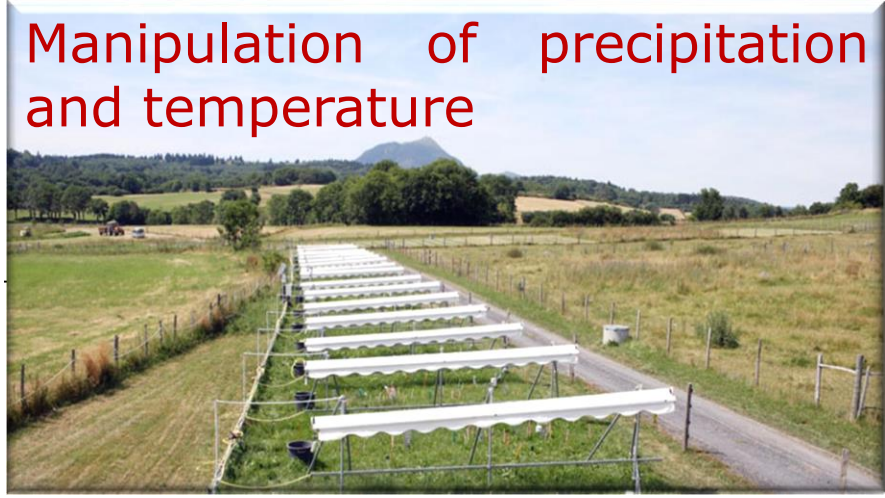
Zaka et al. (2015)

Permanent grassland sites (Massif Central of France)

Laqueuille

1040 m a.s.l.
Mean annual temperature: 8.0 °C
Annual total precipitation: 1000 mm

Manipulation of precipitation and temperature



Theix

880 m a.s.l.
Mean annual temperature: 8.7 °C
Annual total precipitation: 780 mm

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Theix - Manipulation of precipitation and temperature (2009-2012)

- Actual climate (**C**): 240.5 mm (summer rain), 768.8 mm (annual rain)
- Actual climate with summer extreme event (**CX**): heat wave (active warming system) and precipitation reduction (162 mm, 693.8 mm)
- Future climate (**WD**) corresponding to a projection of SRES A2 scenario for 2020-2049: night temperature increase (passive warming system) and precipitation reduction (146.0 mm, 564.8 mm)
- Future climate with summer extreme event (**WDX**): active warming system to mimic extreme temperature event under projected scenario (71 mm, 491.3 mm)

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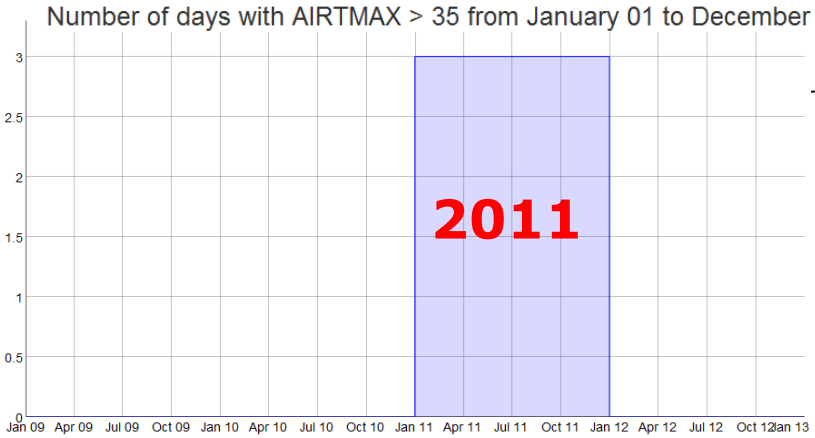
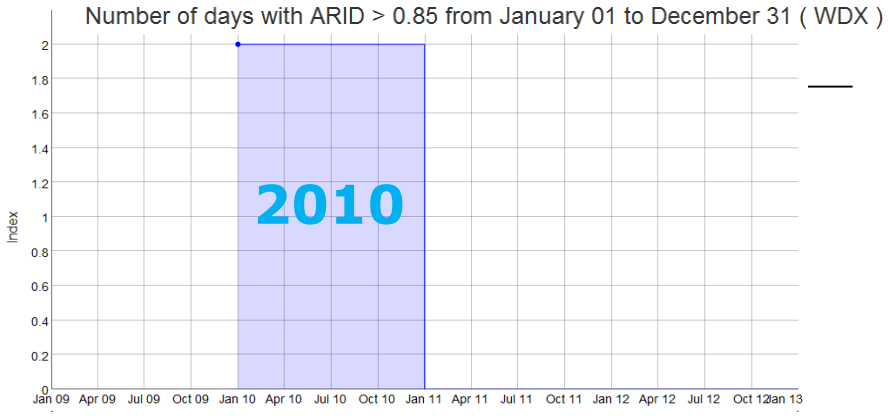
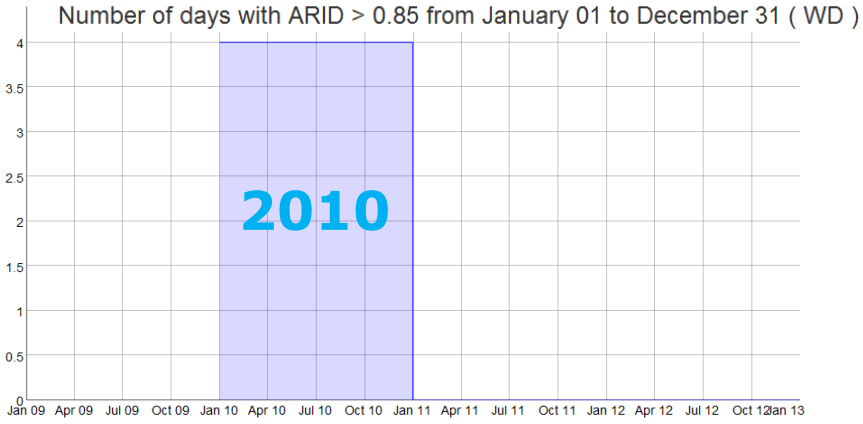
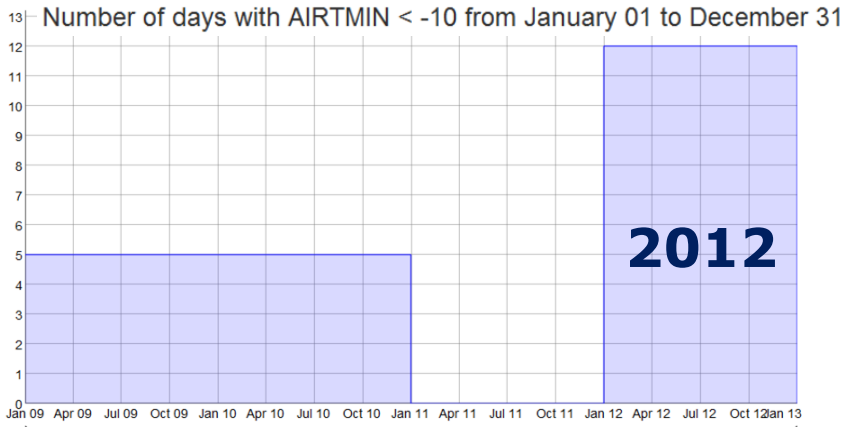
Zwicke et al. (2013)









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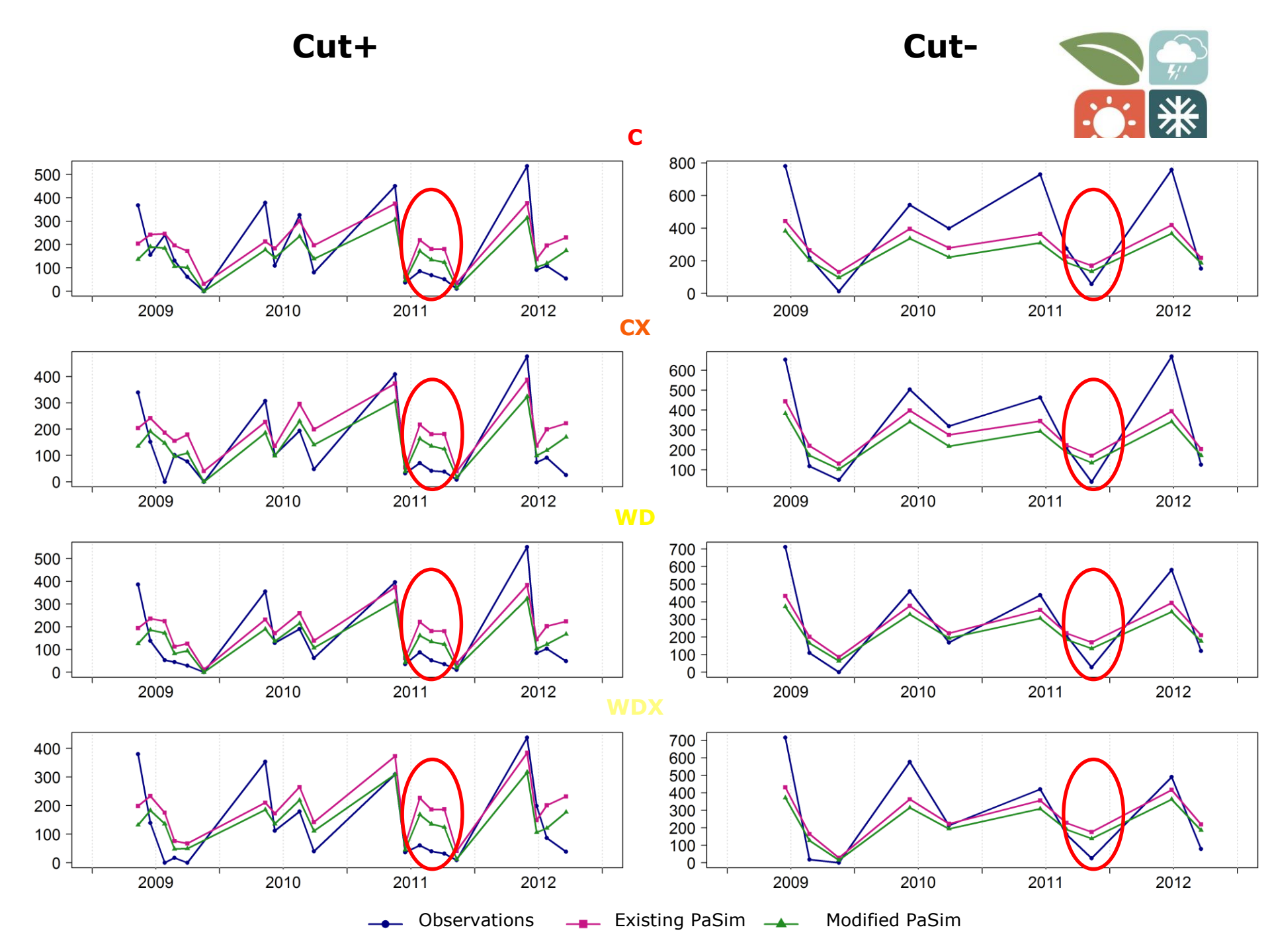
http://modextreme.org/webxtreme


Cut+
Cut-
C
CX
WD
WDX
2009
2010
2011
2012
Observations
Existing PaSim
Modified PaSim

Performance indicators (Cut-)

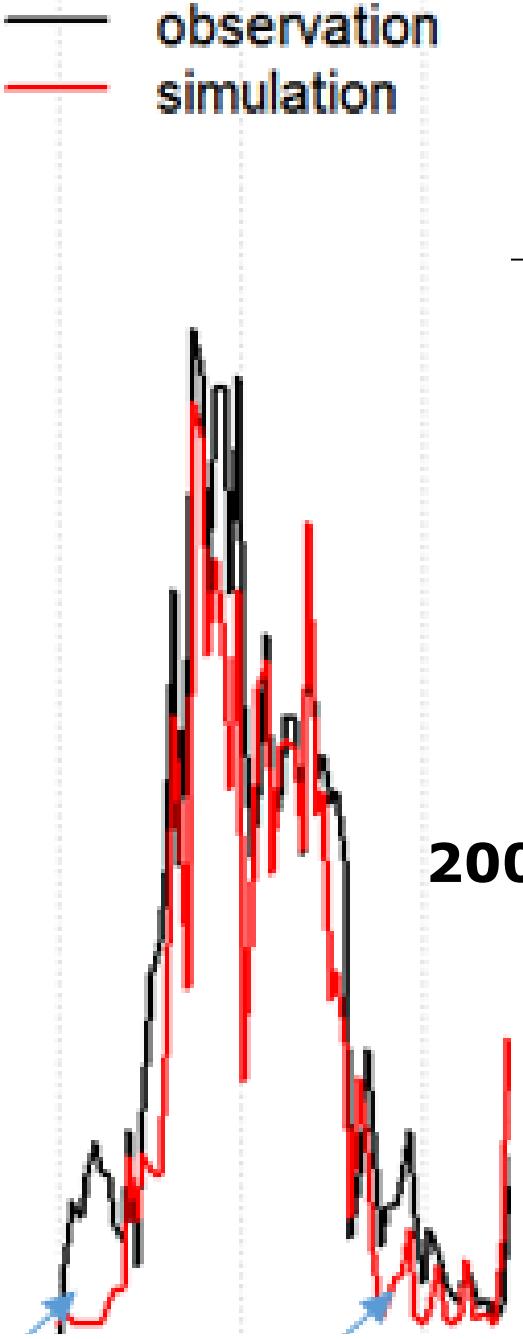
	C	CX	WD	WXD
Observed mean	2.69	2.16	1.94	1.85
Existing solution				
Simulated mean	2.00	1.92	1.83	1.79
Mean squared error (best, 0 – +infinity, worst)	296.30	128.25	118.41	140.00
Index of agreement (worst, 0 – 1, best)	0.84	0.81	0.80	0.80
Modelling efficiency (worst, -infinity – 1, best)	0.59	0.41	0.39	0.38
Correlation coefficient (worst, -1 – 1, best)	0.95	0.96	0.95	0.93
t test probability of equal means (worst, 0 – 1, best)	0.12	0.43	0.70	0.83
Modified solution				
Simulated mean	1.67	1.61	1.56	1.51
Mean squared error (best, 0 – +infinity, worst)	399.03	179.87	156.51	173.25
Index of agreement (worst, 0 – 1, best)	0.87	0.84	0.83	0.83
Modelling efficiency (worst, -infinity – 1, best)	0.71	0.58	0.55	0.55
Correlation coefficient (worst, -1 – 1, best)	0.96	0.96	0.95	0.94
t test probability of equal means (worst, 0 – 1, best)	0.05	0.12	0.25	0.33

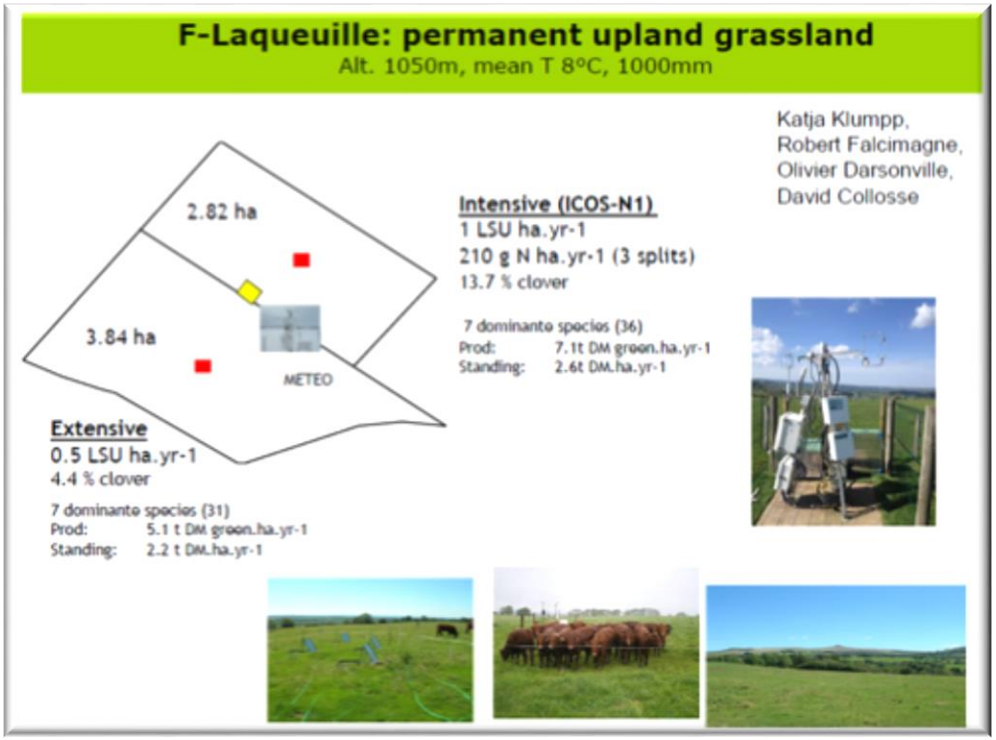
Performance indicators (Cut+)

	C	CX	WD	WXD
Observed mean	2.29	1.77	1.91	1.69
Existing solution				
Simulated mean	2.72	2.64	2.55	2.46
Mean squared error (best, 0 – +infinity, worst)	149.67	166.61	169.08	176.18
Index of agreement (worst, 0 – 1, best)	0.75	0.70	0.73	0.70
Modelling efficiency (worst, -infinity – 1, best)	0.09	-0.26	-0.01	-0.22
Correlation coefficient (worst, -1 – 1, best)	0.89	0.85	0.85	0.83
t test probability of equal means (worst, 0 – 1, best)	0.18	0.01	0.06	0.03
Modified solution				
Simulated mean	2.00	1.94	1.93	1.86
Mean squared error (best, 0 – +infinity, worst)	147.08	117.66	145.67	132.84
Index of agreement (worst, 0 – 1, best)	0.81	0.77	0.79	0.77
Modelling efficiency (worst, -infinity – 1, best)	0.47	0.27	0.38	0.26
Correlation coefficient (worst, -1 – 1, best)	0.91	0.87	0.87	0.84
t test probability of equal means (worst, 0 – 1, best)	0.36	0.56	0.96	0.57

Gross primary production

Laqueuille (France)





Underestimations in winter time (with constant T_{opt})

Ma et al. (2015)

Literature sources

- Ma, S., Lardy, R., Graux, A.-I., Ben Touhami, H., Klumpp, K., Martin, R., Bellocchi, G., 2015. Regional-scale analysis of carbon and water cycles on managed grassland systems. Environmental Modelling & Software 72, 356-371.
- Riedo, M., Grub, A., Rosset, M., Fuhrer, J., 1998. A pasture simulation model for dry matter production, and fluxes of carbon, nitrogen, water and energy. Ecological Modelling 105, 141–183.
- Zaka, S., Frak, E., Julier, B., Gastal, F., Louarn, G., 2015. The thermal acclimation of photosynthesis only differs at high temperature between Mediterranean and temperate cultivars of alfalfa (*Medicago sativa* L.). AoB Plants, submitted.
- Zwicke, M., Alessio, G.A., Thiery, L., Falcimagne, R., Baumont, R., Rossignol, N., Soussana, J.-F., Picon-Cochard, C., 2013. Lasting effects of climate disturbance on perennial grassland above-ground biomass production under two cutting frequencies. Global Change Biology 19, 3435–3448.

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