

XIV Séminaire STICS 2026 – Louvain-la-Neuve

Evaluating calibration strategies for a new winter wheat cultivar in STICS

Meije Gawinowski¹, Maël Aubry², Samuel Buis³, Cécile Garcia⁴, Jean-Charles Deswarte⁴, Marie-Odile Bancal¹, Marie Launay²

¹ Université Paris-Saclay, INRAE, AgroParisTech, UMR Ecosys, Palaiseau 91120, France

² INRAE, AgroClim, Avignon 84914, France

³ INRAE, UMR EMMAH, Avignon 1114, France

⁴ Arvalis – Institut du Végétal, Villiers-le-Bâcle, France

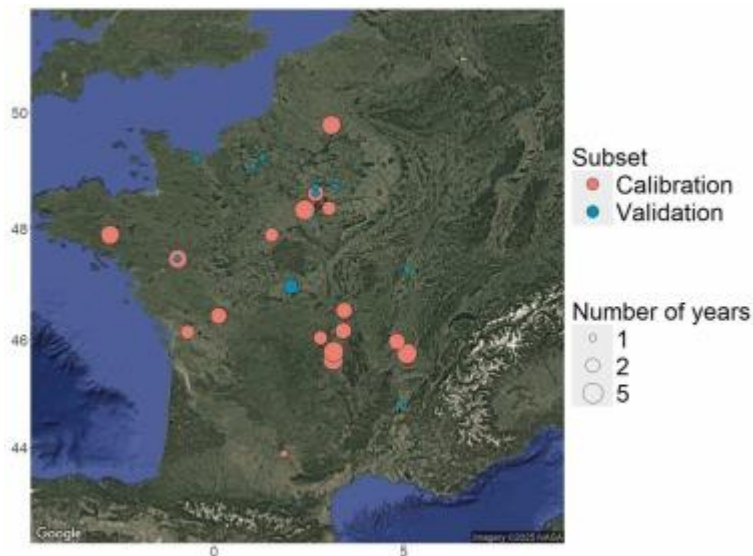
meije.gawinowski@agroparistech.fr



- Integrating new cultivars in a crop model → calibration of varietal parameters
- A case study for winter wheat in STICS to integrate more modern cultivars with a multi-trial data set provided by Arvalis (FSOV project REGARD; Gawinowski et al., 2025)
- The chaos in calibrating crop models (Wallach et al., 2021)
 - Availability of experimental data, target variables
 - Parameters to include, range of variation
 - Choice of algorithm and loss function
 - Sequential vs all-together protocol
 - Choice of calibration vs evaluation datasets
- AgMIP (Agricultural Model Intercomparison Project) initiative with multiple calibration exercises
- Intercomparison for phenology calibration in Wallach et al. (2023)
- New sequential protocol for global calibration proposed and tested on synthetic data in Wallach et al. (2024) with ongoing AgMIP intercomparison

Applying the protocol of Wallach et al. (2024) to estimate a new winter wheat cultivar in the STICS crop model

An extensive data base for winter wheat



Input data

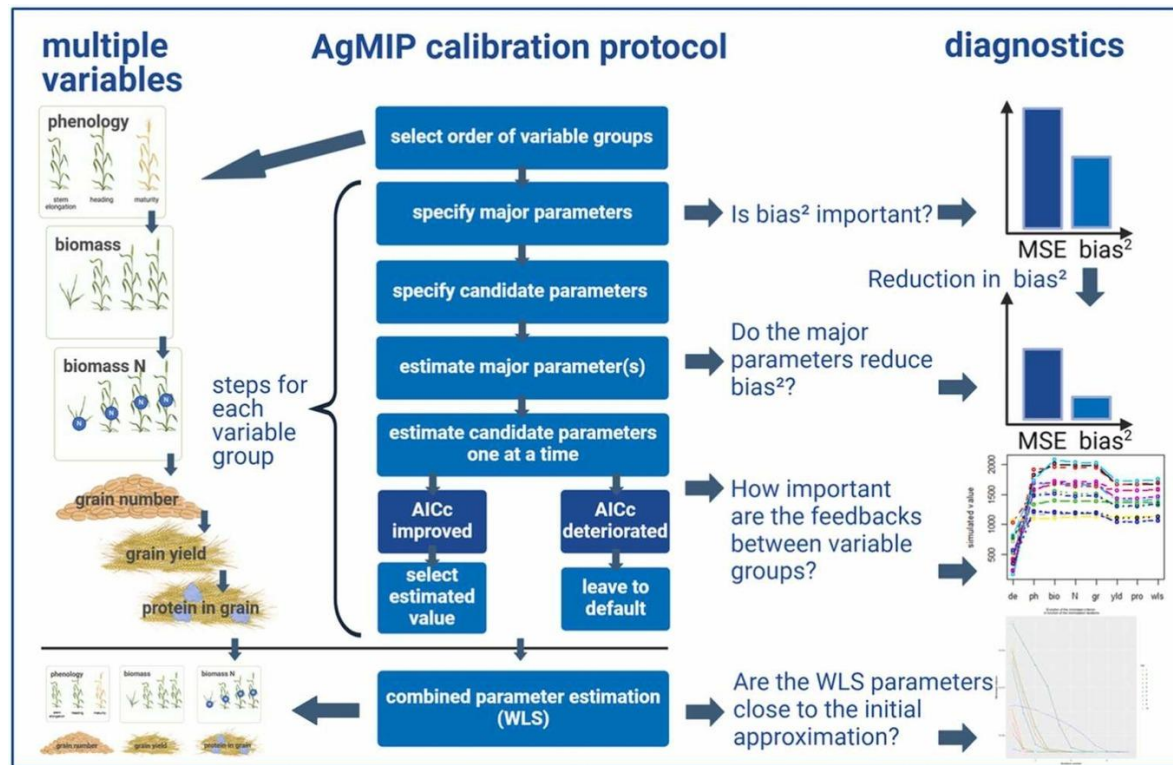
- Climatic data: weather stations + SAFRAN reanalysis
- Nearly independent environments for calibration and validation datasets per cultivar
- Soil general characteristics
- Water availability at field capacity
- Initial N availability determined based on the previous crop (Livre Blanc belge)

11 cultivars : Rubisko, Chevignon, Bermude, Oregrain, Premio, Cesario, Extase, Fructidor, Syllon, Tenor, Bergamo

1. Explore different calibration strategies for cultivar Rubisko to determine the most adequate (Gawinowski et al., 2025)
2. Apply the selected strategy to the other cultivars

Cultivar	Number of environments		Number of observations									
			Phenology		LAI		Plant biomass		Grain number		Grain yield	
	Calibr.	Valid.	Calibr.	Valid.	Calibr.	Valid.	Calibr.	Valid.	Calibr.	Valid.	Calibr.	Valid.
Syllon	8	2	8	2	0	0	0	0	8	2	8	2
Tenor	7	2	7	2	0	0	0	0	7	2	7	2
Bergamo	8	5	8	5	9	2	17	6	8	5	8	5
Fructidor	12	4	12	4	18	3	40	10	12	4	12	4
Extase	10	6	10	6	4	1	13	5	10	5	10	6
Oregrain	13	5	13	5	4	0	28	13	13	5	13	5
Cesario	22	5	22	5	24	12	82	17	20	4	22	5
Premio	27	7	27	7	1	0	92	27	27	7	27	7
Chevignon	29	8	29	8	7	9	52	20	28	6	29	8
Bermude	34	8	34	8	5	1	106	30	34	8	34	8
Rubisko	67	15	67	15	291	64	266	59	65	15	66	15

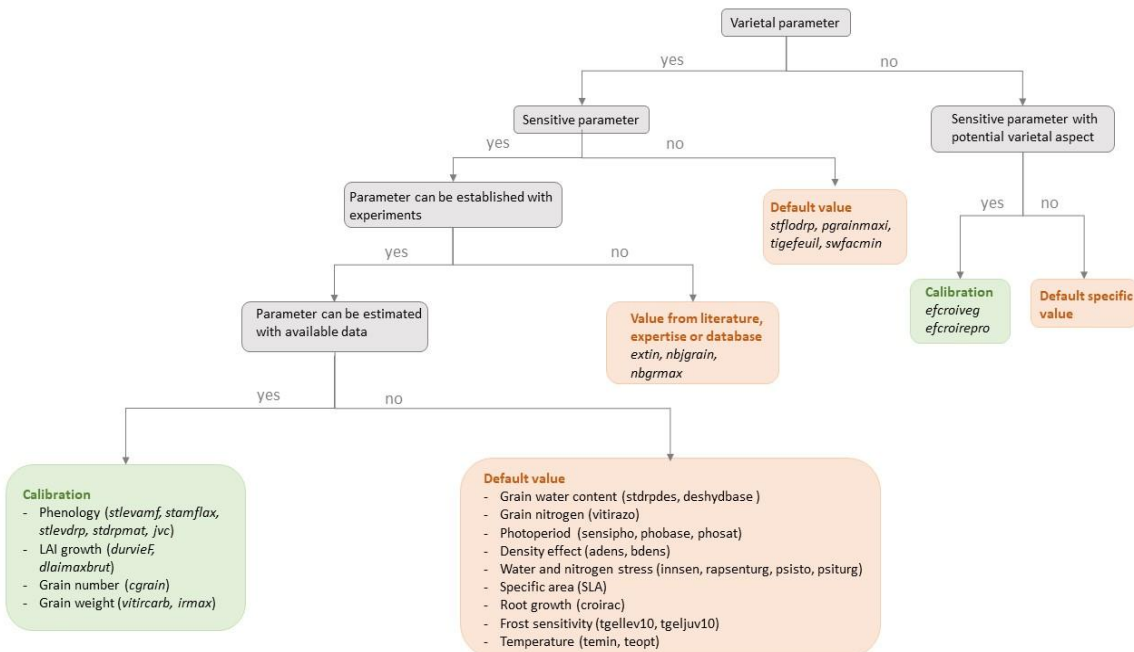
Calibration methodology



Calibration strategies

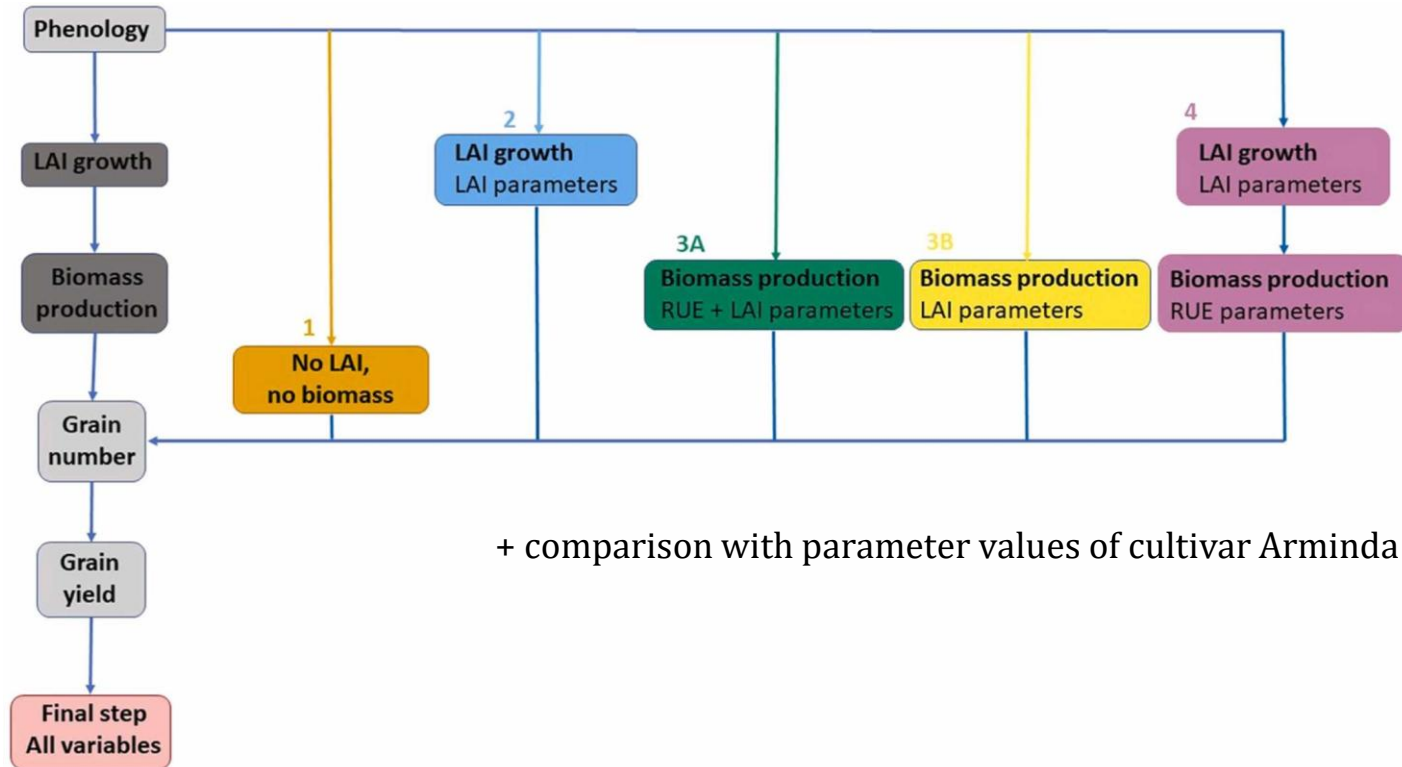
- Based on availability of experimental data (LAI, plant biomass)
- Different steps included in the methodology
- Which parameters for each step ?

Selection of parameters for calibration



Step	Parameter	Type	STICS name and unit	Range	Default value
1) Phenology	TT emergence - BBCH30	Major	<i>stlevamf</i> (°Cd)	[150,1000]	700
	TT BBCH30 - BBCH50	Major	<i>stamflax</i> (°Cd)	[100,500]	375
	TT BBCH50 - BBCH65	Major	<i>stlevdrp</i> (°Cd)	[500,2000]	837
	TT BBCH65 - BBCH90	Major	<i>stdrpmat</i> (°Cd)	[500,1000]	700
	Number vernalizing days	Candidate	<i>jvc</i> (days)	[40,60]	51
2) LAI growth	Maximum rate of gross daily increase of LAI	Major	<i>dlaimaxbrut</i> (m ² /plant/°Cd)	[0.000005, 0.001]	0.00047
	Maximum leaf lifespan	Major	<i>durvieF</i> (unitless)	[40,300]	200
3) Biomass production	Maximum RUE during vegetative phase	Major	<i>efcroiveg</i> (g/MJ)	[3,5]	4.25
	Maximum RUE during reproductive phase	Major	<i>efcrorepro</i> (g/MJ)	[2,5]	4.25
4) Set of grain number	Slope relationship between grain number and growth rate	Major	<i>cgrain</i> (grains/g/day)	[0.03, 0.04]	0.036
5) Grain filling	Rate of increase of C harvest index versus time	Major	<i>vitircarb</i> (g grains/g plant/day)	[0.00005, 0.002]	0.0007
	Maximum C harvest index	Candidate	<i>irmax</i> (unitless)	[0.45, 0.6]	0.55

Calibration strategies



Criteria to assess calibration performance

Criteria 1

Values of calibrated parameters

- Parameters should not be estimated at upper or lower bounds
- The biological relevance of parameters has to be examined

Criteria 2

Values of errors

$$MSE_v = \frac{1}{N_v} \times \sum_{i,t} (vobs(t) - vsim(t))^2$$

$$MSE_v = bias_v^2 + SDSD_v + LCS_v$$

$$bias_v^2 = (\bar{vobs} - \overline{vsim})^2$$

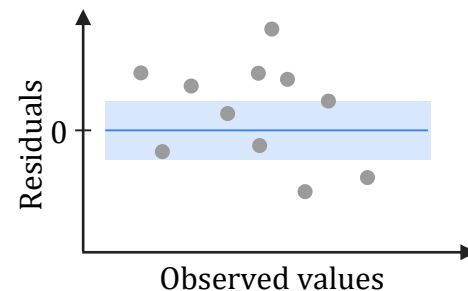
$$SDSD_v = (\sigma_{obs_v} - \sigma_{sim_v})^2$$

$$LCS_v = 2 \times \sigma_{obs_v} \times \sigma_{sim_v} \times (1 - r)$$

Errors should be minimized across all the considered variables

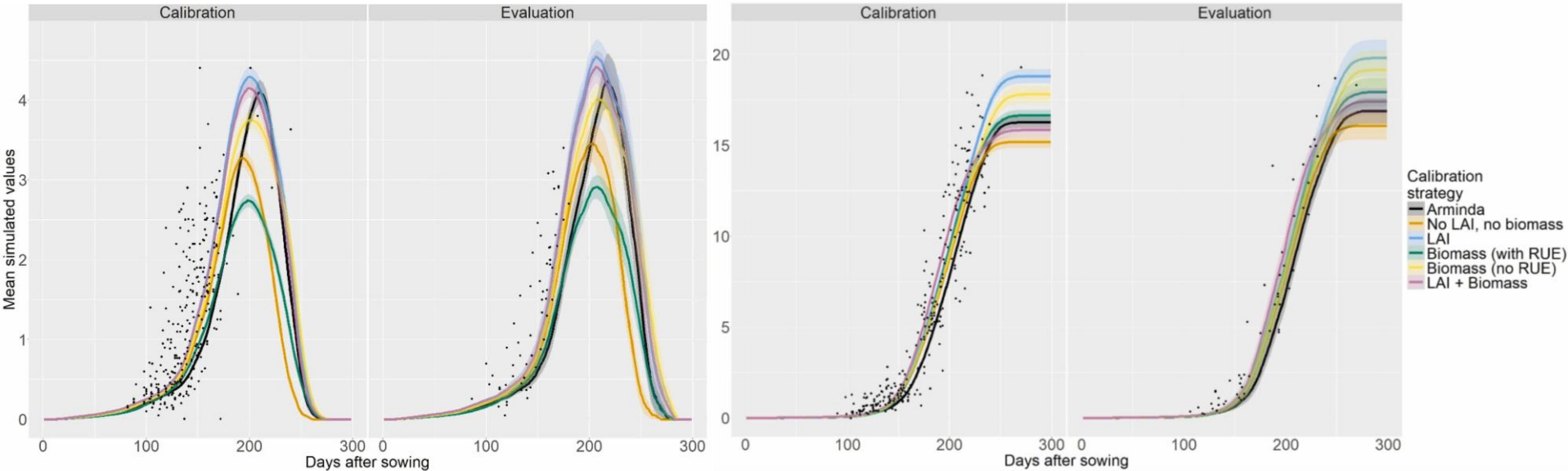
Criteria 3

Analysis of residuals

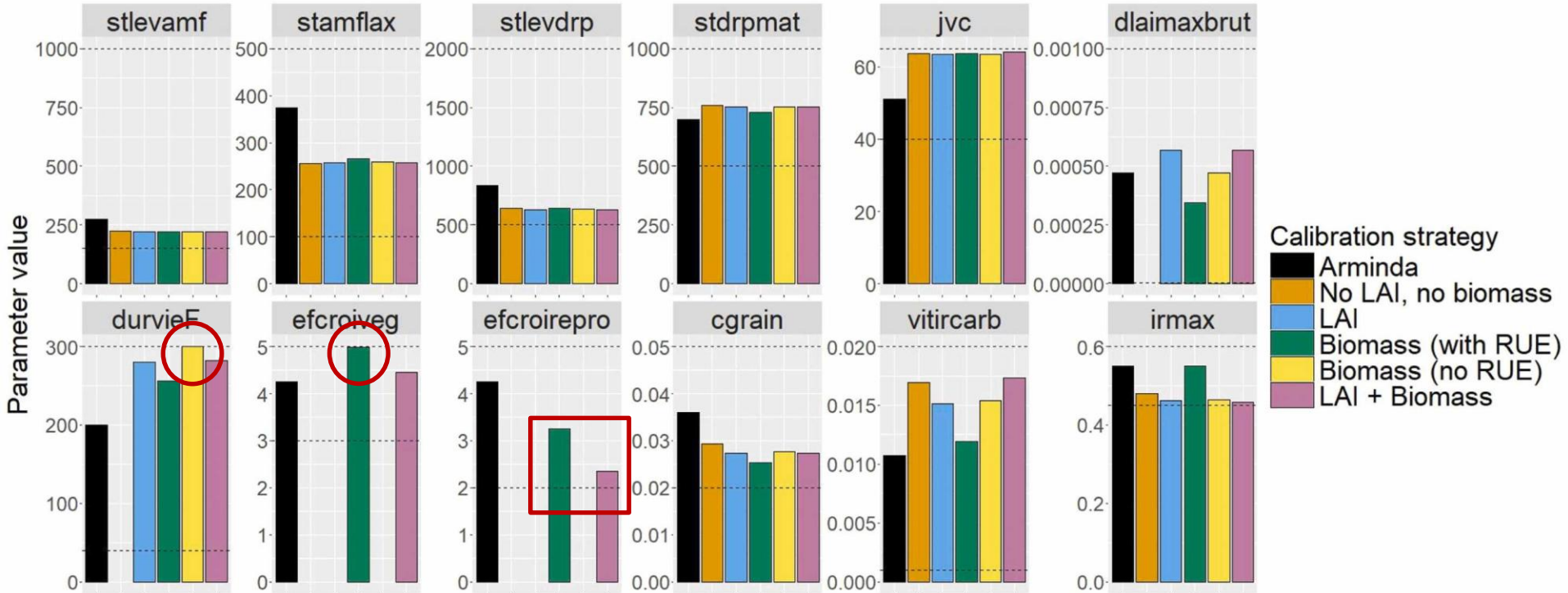


Residual (observations - simulations) curves should be flat

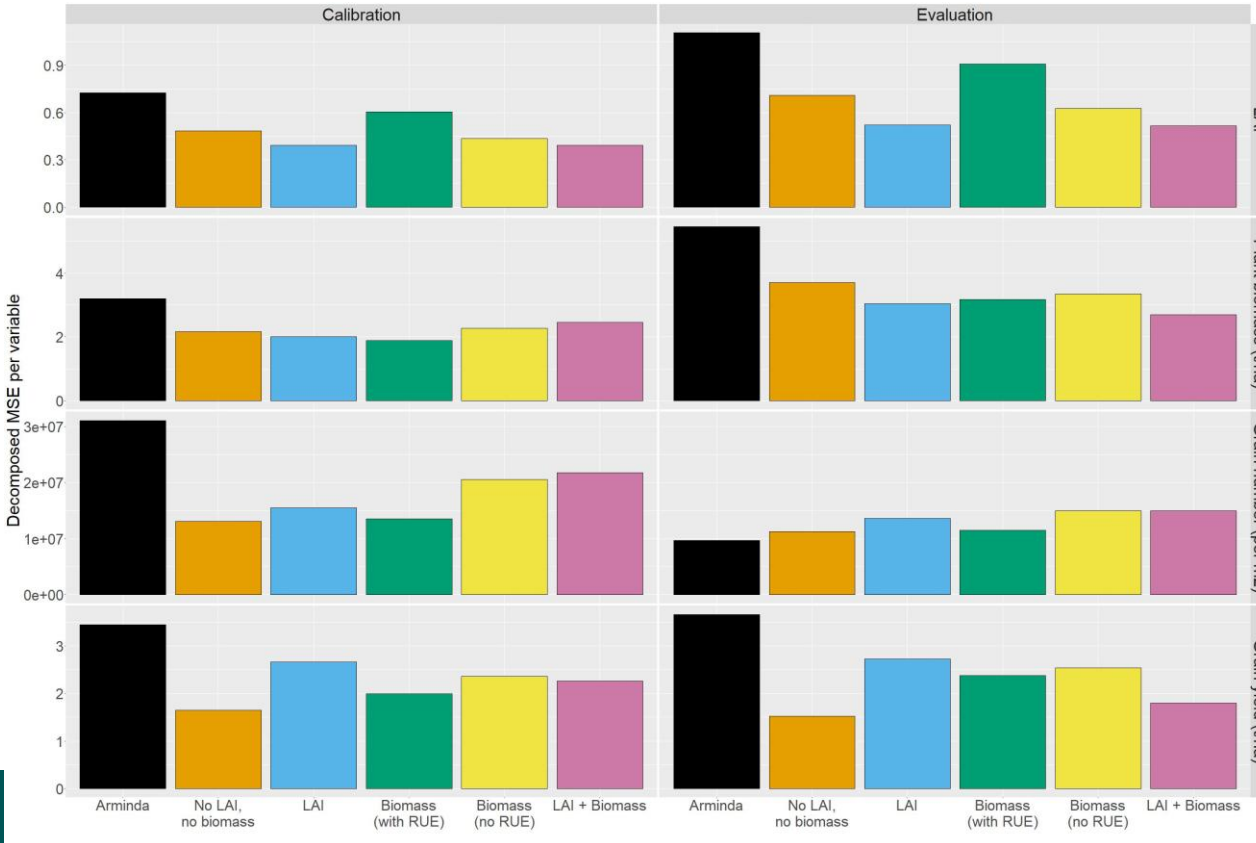
Simulations with calibrated parameters for LAI and biomass



Criteria 1: values of calibrated parameters

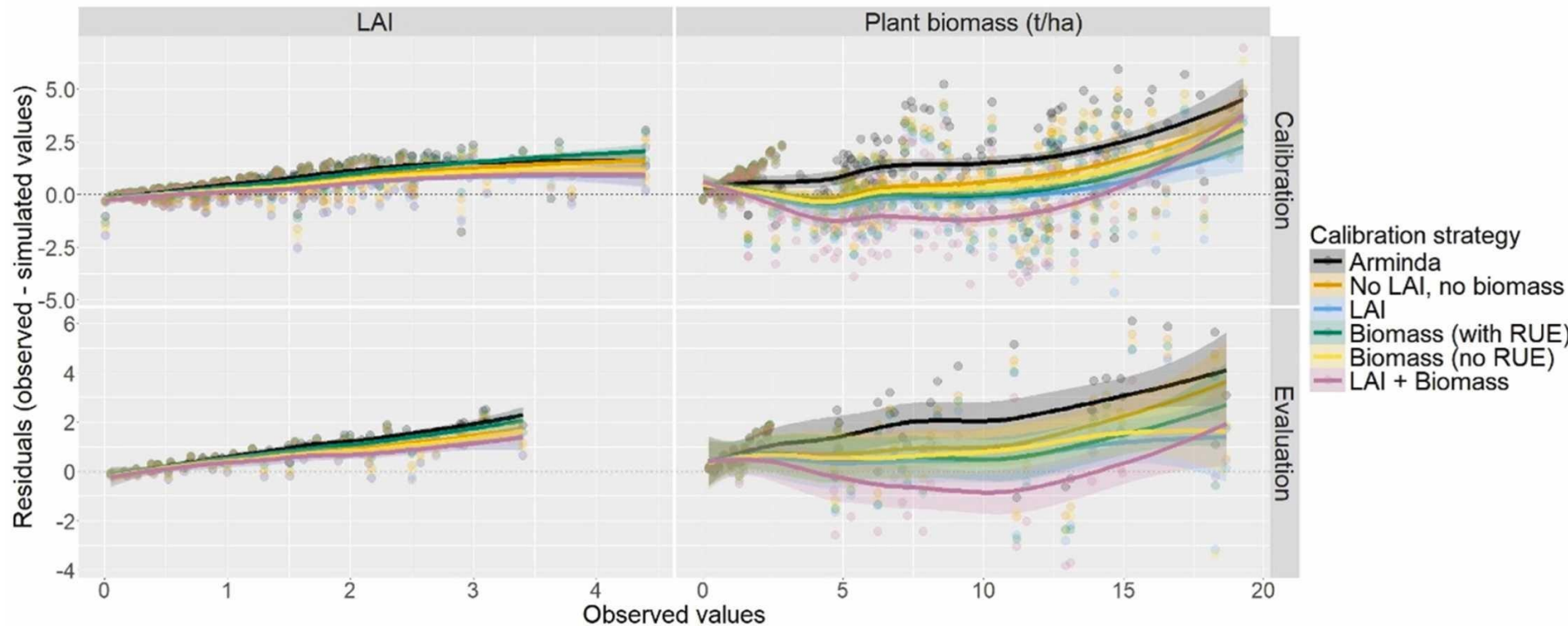


Criteria 2: Mean Square Error (MSE)



- Low MSE for phenology across all strategies
 - Decrease of MSE compared to Arminda simulations
 - LAI MSE is lower when LAI data is included
 - But not the case for biomass
 - High LAI MSE for « Biomass (with RUE) »
 - Lower MSE for grain number and grain yield when LAI and biomass data are not included
- Lowest MSE for « LAI + Biomass »

Criteria 3: analysis of residuals



Selection of the best calibration strategy

- Criteria 1 – parameter values: some bound issues for *efcroiveg* and *durvieF* with « Biomass (without RUE) » and « Biomass (with RUE) » methods, low values for *efcroirepro*
- Criteria 2 – MSE values: lowest error on grain yield when LAI and data excluded, lowest global error with « LAI + Biomass »
- Criteria 3 – residuals : simulated maximum LAI and biomass at maturity are underestimated, the flattest residuals curve is obtained for the « LAI » strategy

The « LAI » strategy is the winner ! But results clearly impacted by the temporal availability of LAI and biomass data...

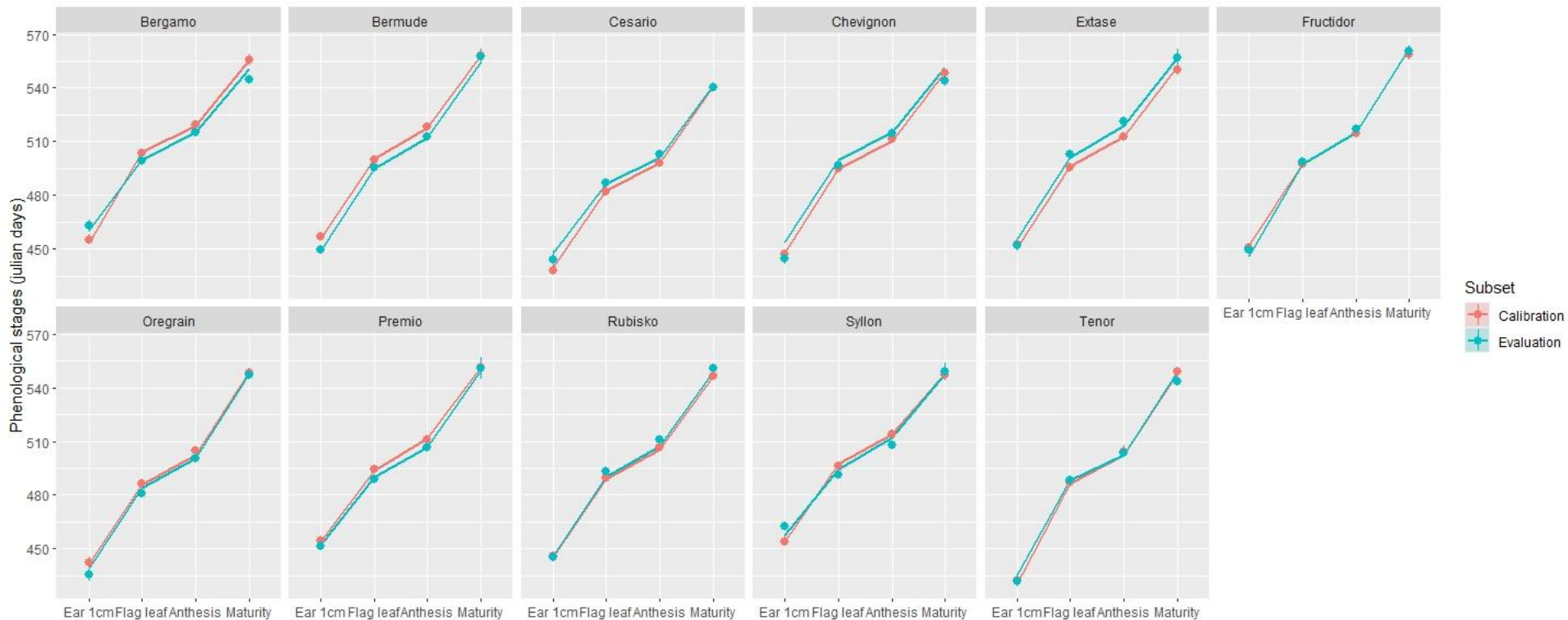
Attempt to explore temporal data availability on synthetic data (not published)

Observed data for phenology and yield components + simulated LAI and/or biomass with noise sampled at 5 points

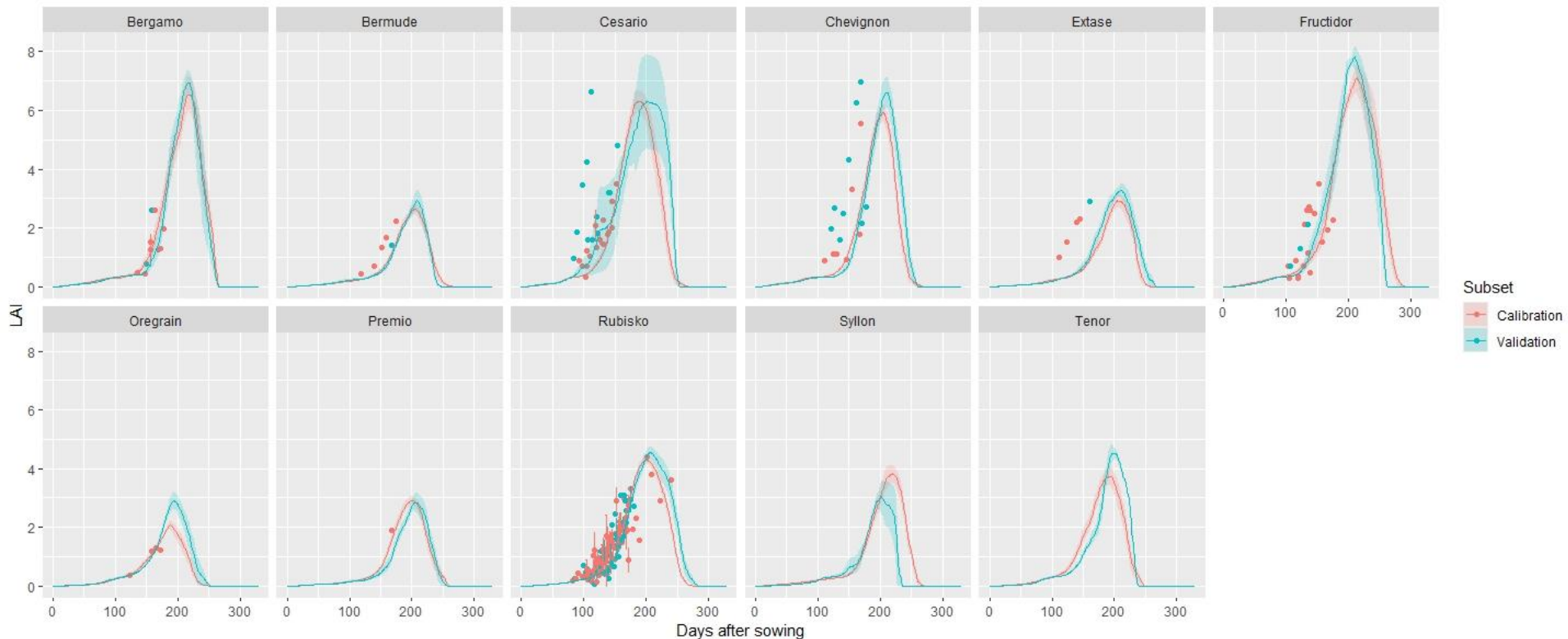
- Before maximum LAI
- Around maximum LAI
- After maximum LAI

→ No significant difference between these options of temporal data availability

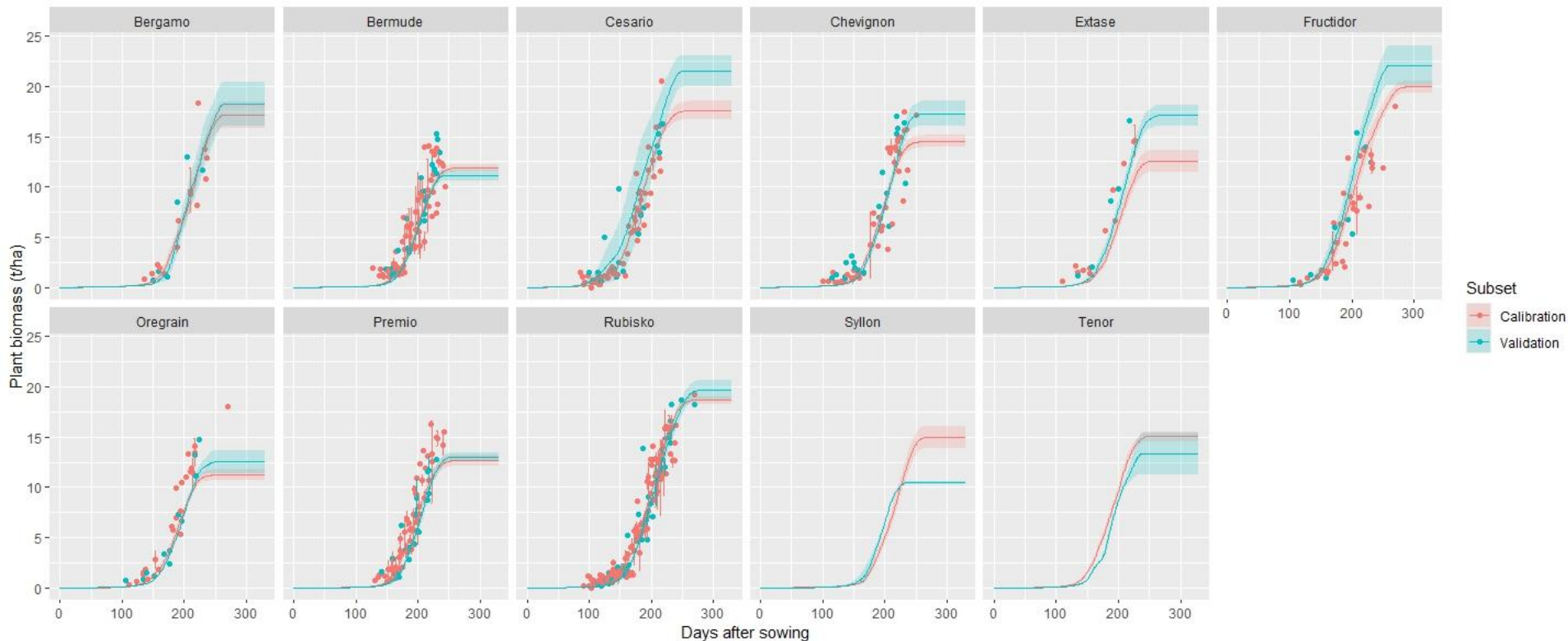
Application of « LAI » strategy on all the cultivars



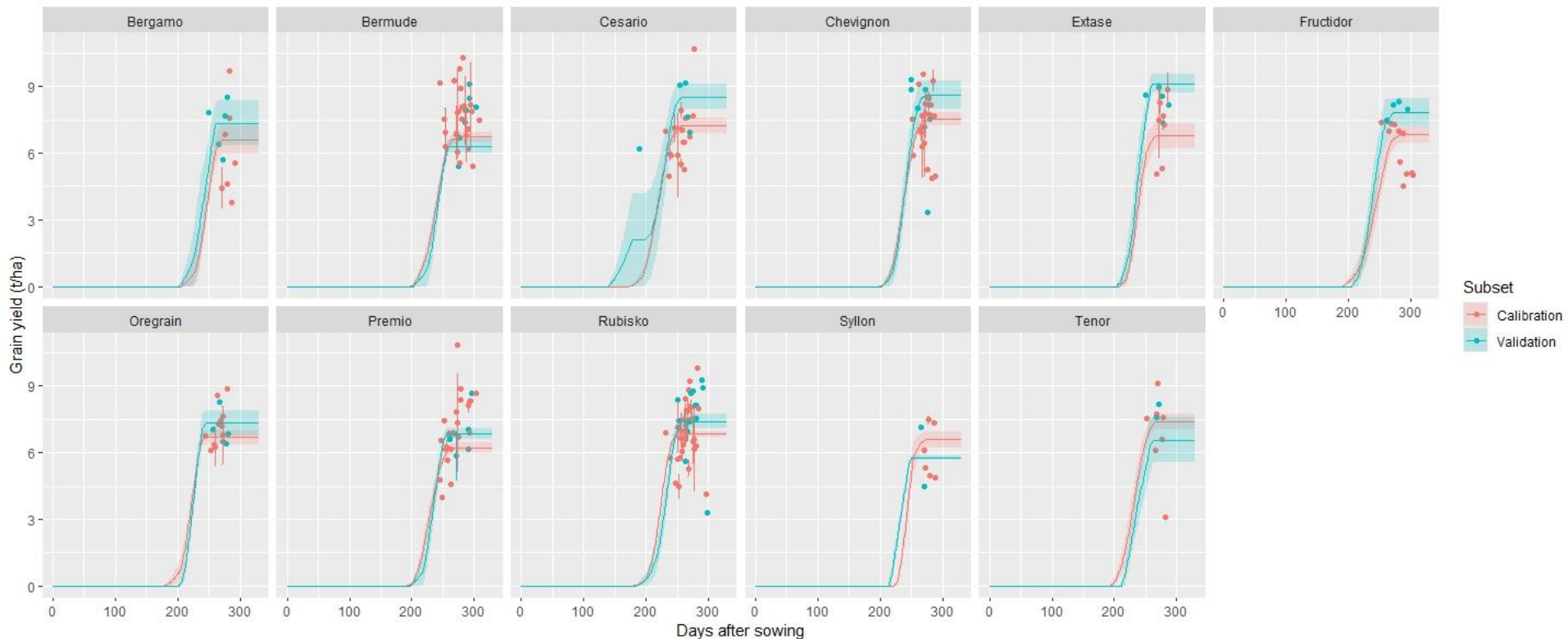
Application of « LAI » strategy on all the cultivars



Application of « LAI » strategy on all the cultivars




Application of « LAI » strategy on all the cultivars



Varietal parameters available on DataGouv

<https://doi.org/10.57745/FDPIXY>

 Some parameters are not (yet) considered varietal in STICS (cgrain, irmax) so a new plant file should be made for each cultivar

Conclusion

- Calibration difficulties linked to the temporal availability of LAI and biomass data
- 3 criteria enabled to check the biological behaviour of model calibration; RUE parameters should be adjusted with caution due to compensations between different parameters
- Difficulties to consider varietal parameters linked to plant response to abiotic factors (water stress, N, CO₂) due to these compensations
- 11 new modern cultivars available for STICS simulations!

Perspectives

- Integration of these cultivars in STICS
- Further exploration is considered
 - Discussion on varietal specificity of different STICS parameters
 - Increase the number of candidate parameters for each step
- Recommendations for the acquisition of experimental data
 - At maximum for LAI
 - Near maturity for plant biomass
- Applying this comparison of calibration strategies to other data sets ?

Thank you for your attention !

meije.gawinowski@agroparistech.fr