



modextreme
agriculture facing extreme climatic events

Workshop



The Team of Work Package 2



September 7-8,
2016, JRC



What does it do?

Performing the process of model optimization, that is, finding the minimum of an objective function value depending on a model output by varying the value of the model parameters





Key factors

- Identify an Objective Function (OF, a metric) that measures the agreement between observed and simulated data;
- Identify the strategy to use in order to optimize the OF (Solver);





Model calibration - considerations

- The use of modular models allows to isolate processes and calibrate them separately;
- Measurements have to be coherent with the simulation time step;
- Data have to be representative of the process under calibration;
- Calibrate just unknown and sensitive parameters;





Calibration criteria

- Calibrate as few parameters as possible;
- To be accepted, the calibrated value of a parameter has to be included in the physical domain of the parameter;
- Reduce parameter calibration range on the basis of *a priori* knowledge;
- Test calibrated parameters against new reference data;
- Test residuals to avoid systematic pattern;
- Distrust of calibrated values close to the bounds of the parameter range;
- Global vs Stepwise calibration;





Dreaming Crop Calibration

- Calibrate phenology;
- Calibrate potential biomass (calibrate maximum RUE, supposing that temperatures are not limiting factors, wide sampling, RUE constant over time?);
- Calibrate partitioning coefficients, again without stresses;
- Calibrate plant water use and soil water;
- Calibrate water stress conditions;
- Calibrate soil water content;
- N, C
- Repeat the procedure

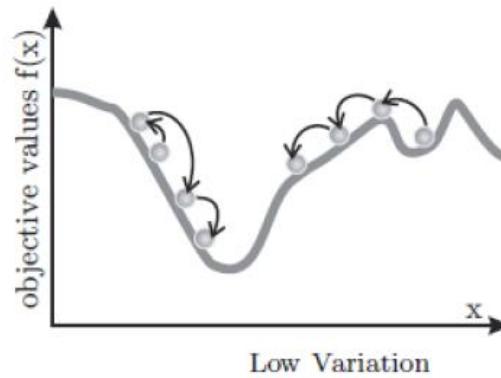




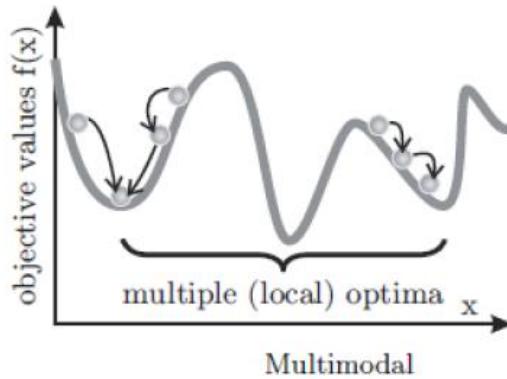
What could we face to?



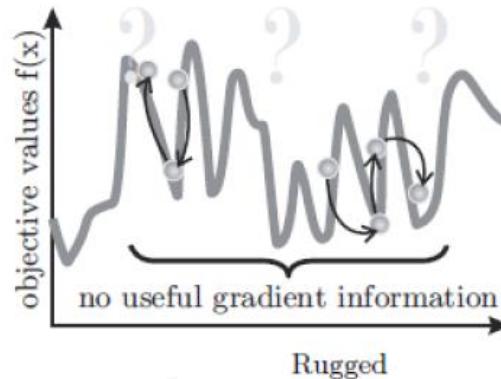
Best Case



Low Variation



Multimodal



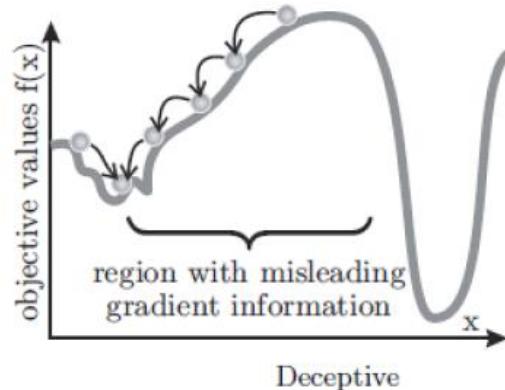
Rugged



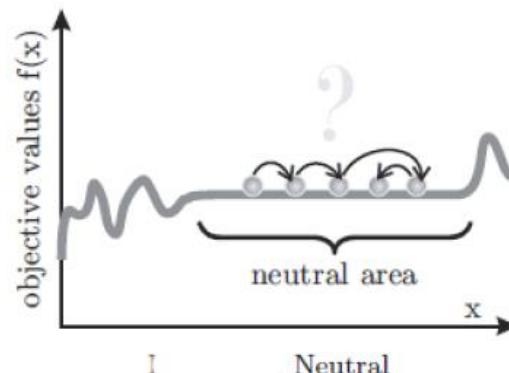
Image: Tony Campbell/Shutterstock



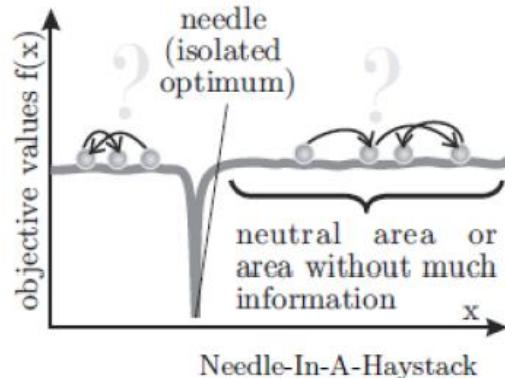
What could we face to?



Deceptive



I Neutral



Needle-In-A-Haystack



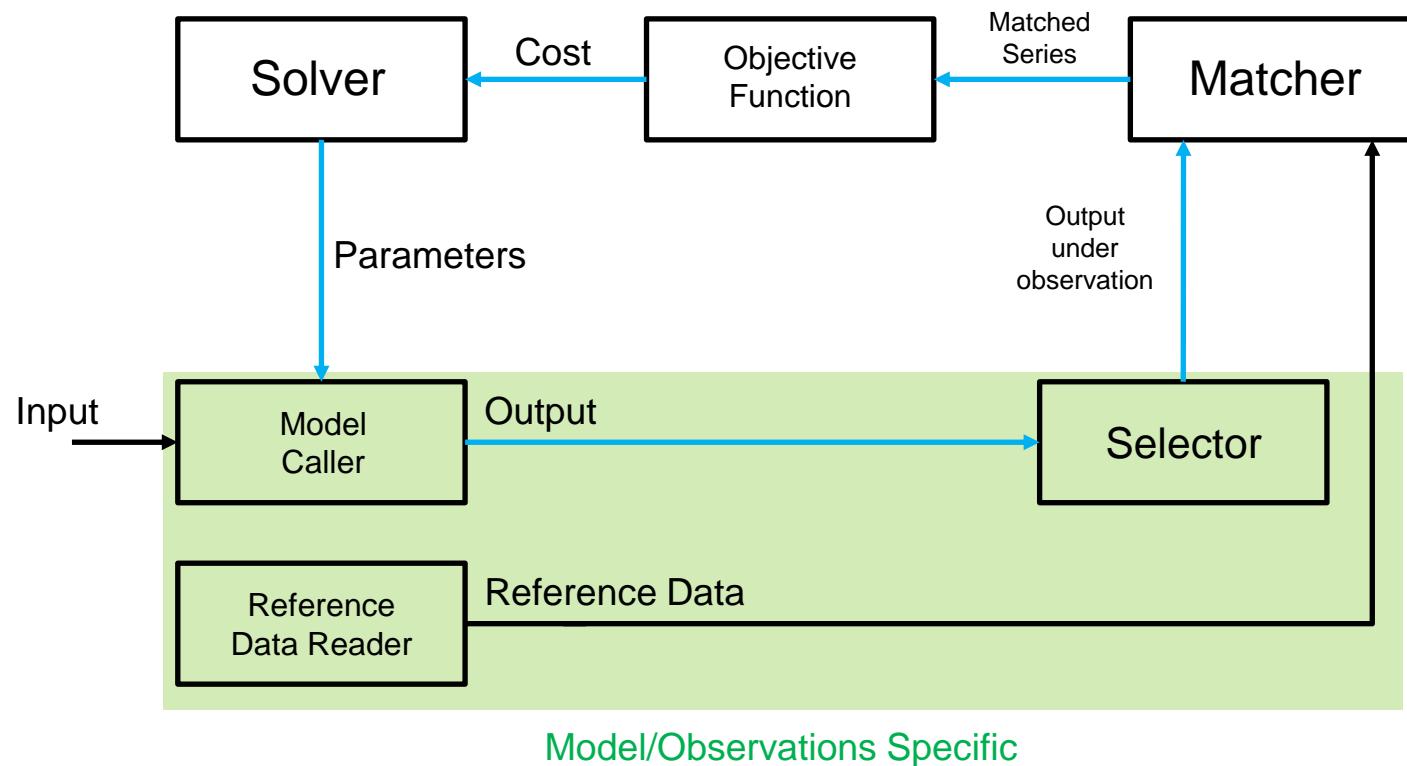
Nightmare



Image: Tony Campbell/Shutterstock



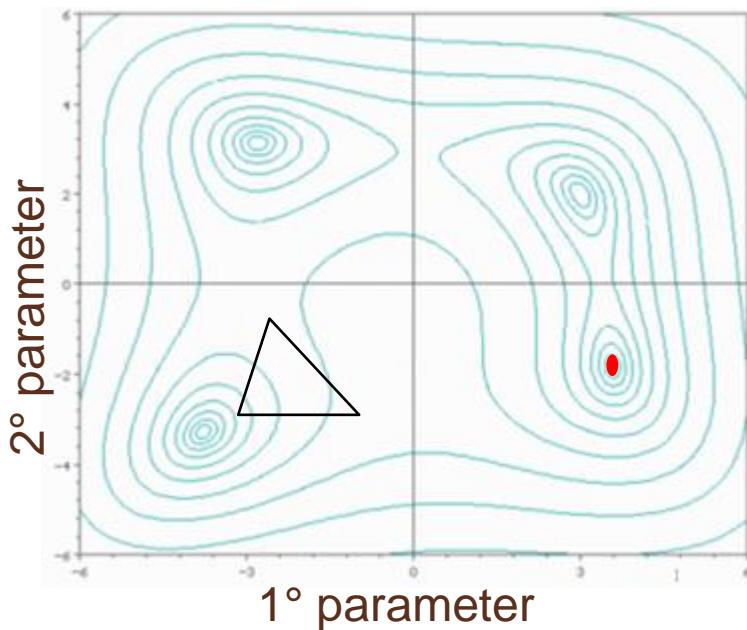
Calibration process workflow





Solver details

OBJECTIVE FUNCTION (f.i., RRMSE)



LOCAL
MINIMUM

- Nelder and Mead, 1965
- Figure of $N + 1$ test points (where N is the number of parameter) to investigate the hyperspace of parameter value combinations, called **Simplex**
- Simplex moves like an ameba to optimize the objective function





Optimizer – GUI

Optimizer

Optimization Configuration Settings Help

MPE | Optimization Solver Modeling Solution Reference Data

Optimization Elements

Configuration Item	Value	Value Hints and
Solver	Simplex Random Start	
Objective Function	UNIMI_CRA.Optimizer.ObjectiveFunctions.IRENE.IRENEObjectiveFunction	
Modeling Solution	CropSystModelingSolution.CropSystModelCaller	
Selector	WFOSTReferenceReaderAndSelector.CropSystSelector	
Reference Data Reader	WFOSTReferenceReaderAndSelector.CropSystReferenceDataReader	
Matcher	Equality Matcher	
Variables	Objective Function Variables	
variable	Output and Covariate	
name	LimitedAboveGroundBiomass	
covariate	DevelopmentStage LimitedGreenLeafAreaIndex LimitedAboveGroundBiomass	
IRENIndexSelector		

Configure Parameters under Optimization

Behaviour	Parameter key	Component	Current Value	Strategy	Name	Description

Configure Fixed Parameters

Behaviour	Parameter key	Component	Current Value	Strategy	Name	Description





Optimizer – GUI – MS tab

Optimizer

Optimization Configuration Settings Help

MPE | Optimization Solver Modeling Solution Reference Data

Configuration

Iterate	Configuration Item	Value	Value Hints and Definitions
<input type="checkbox"/>	Simulation Configur...	Daily step with dat...	
<input checked="" type="checkbox"/>	Weather Configura...	CRA.WDFWeather...	
<input type="checkbox"/>	Weather Switch C...	True, using FAO5...	
<input type="checkbox"/>	Weather Switch C...	True	
<input type="checkbox"/>	Weather Switch C...	True	
<input checked="" type="checkbox"/>	Agromanagement ...	Load rules from ag...	
<input checked="" type="checkbox"/>	Soil data Configura...	Read soil data fro...	
<input type="checkbox"/>	CropSystPot Switc...	false	
<input type="checkbox"/>	CropSystPot Switc...	false	
<input type="checkbox"/>	CropSystPot Switc...	false	
<input type="checkbox"/>	CropSystPot Switc...	true	
<input type="checkbox"/>	SoilM_Switches_Eoti...	false	

Parameters Keys

- Foggia_WH_CS
- Maize_Europe
- maize_europe_-1
- Maize_Europe_1
- Maize_Europe_1+10
- Maize_Europe_1+20
- Maize_Europe_2
- Maize_Europe_2+10
- Maize_Europe_2+20
- Maize_Europe_3
- Maize_Europe_3+10
- Maize_Europe_3+20
- Maize_Europe_4
- Maize_Europe_4+10
- Maize_Europe_4+20
- Maize_Europe_5
- Maize_Europe_5+10
- Maize_Europe_5+20
- Maize_Europe_6
- Maize_Europe_6+10

Sel Canc

Modeling Solution Parameters - Select a value to move parameters to the Optimization tab

Behaviour	Parameter key	Component	Strategy	Name	Description
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	ThermalTimeToE...	Thermal
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	ThermalTimeToF...	Thermal
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	ThermalTimeToB...	Thermal
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	ThermalTimeTo...	Thermal
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	BaseTemperatur...	Base
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	CutoffTemperatu...	Cutoff
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	PhotoInhibition	Dayle
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	PhotoInsensitivity	Dayle
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	HighTemperature	High t
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	LowTemperature	Low t
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	A	Verna
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	DaysToStartVern...	Days
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	DaysToComplete...	Days
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	MinimumFactor	Minim
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	InitialLeafAreaIn...	Initial
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	MinimumInitialGr...	Maxim
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	LeafAreaIndexIni...	Leaf a
<input checked="" type="checkbox"/>	Foggia_WH_CS	CropSystPot	CropSyst param...	DevelopmentSta...	Devel





Optimizer – GUI – Optimization tab

Optimizer

Optimization Configuration Settings Help

MPE |

Optimization Solver Modeling Solution Reference Data

Optimization Elements

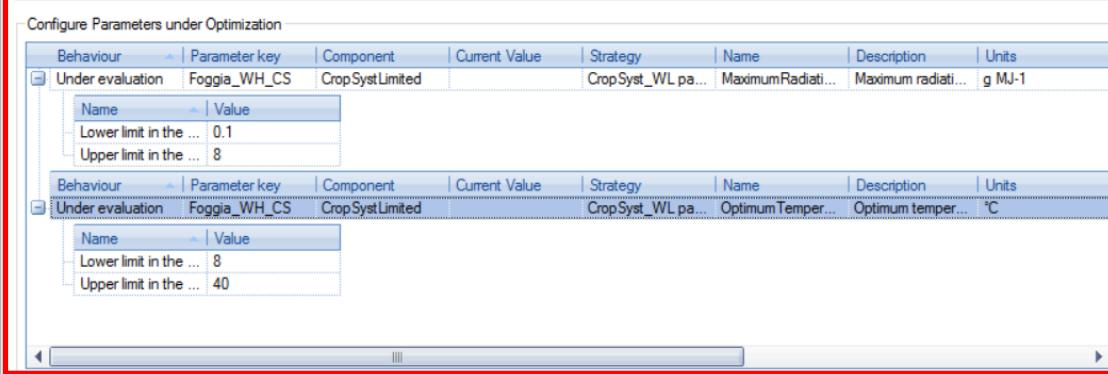
Configuration Item	Value	Value Hints and Definitions
Solver	Simplex Random Start	
Objective Function	UNIMI_CRA.Optimizer.ObjectiveFunctions.IRENE.IRENEObjectiveFunction	
Modeling Solution	CropSyst Modeling Solution.CropSyst ModelCaller	
Selector	WOFOSTReferenceReaderAndSelector.CropSyst Selector	
Reference Data Reader	WOFOSTReferenceReaderAndSelector.CropSystReferenceDataReader	
Matcher	Equality Matcher	
Variables	Objective Function Variables	
variable	Output and Covariate	
name	LimitedAboveGroundBiomass	
covariate	LimitedAboveGroundBiomass	
IRENEIndexSelector	UNIMI_CRA.Optimizer.ObjectiveFunctions.IRENE.IRENEIndexSelector	

Configure Parameters under Optimization

Behaviour	Parameter key	Component	Current Value	Strategy	Name	Description	Units
Under evaluation	Foggia_WH_CS	CropSystLimited		CropSyst_WL pa...	MaximumRadiati...	Maximum radiati...	g MJ-1
	Name	Value					
	Lower limit in the ...	0.1					
	Upper limit in the ...	8					

Behaviour	Parameter key	Component	Current Value	Strategy	Name	Description	Units
Under evaluation	Foggia_WH_CS	CropSystLimited		CropSyst_WL pa...	OptimumTemper...	Optimum temper...	°C
	Name	Value					
	Lower limit in the ...	8					
	Upper limit in the ...	40					

Configure Fixed Parameters



Parameter under optimization





Optimizer – Objective Functions

Optimization Solver Modeling Solution Reference Data

Optimization Elements

Configuration Item	Value	Value Hints and Definitions
Solver	Simplex Random Start	
Objective Function	UNIMI_CRA.Optimizer.ObjectiveFun...	
Modeling Sol...	CropSystModelingSolution.CropSyst...	
Selector	WOFOSTReferenceReaderAndSele...	
Reference D...	WOFOSTReferenceReaderAndSele...	
Matcher	Equality Matcher	
Variables	Objective Function Variables	
variable	Output and Covariate	
name	LimitedAboveGroundBiomass	
covari...	LimitedAboveGroundBiomass	
IRENEIndex...	UNIMI_CRA.Optimizer.ObjectiveFun...	

OptimizerPopupForm

Simple ▾ RRMSE

OneWayAnovaStrategy
Probabilities
REF
RMdAE
MdAE
PatternIndices
rPearson
rSpearmans
SignificanceForLeastModelFitting
ReducedMajorAxis
EF
TStudent
CRM
IOA
MAE
MBE
RRMSE
RMSE

Take negative value if optimum is maximum

Available Simple metric and Composite indeces to optimize





Composite indices

Composite indices can be composed by:

- Two different metrics calculated against one calibration variable (available);
- The same metric calculated against more than one calibration variable (not available);
- Different metrics against different variables;
- Weight to the metric or to the variable?





Optimizer – Results

Optimizer

Optimization Solver Configuration Settings Help

Optimization Solver Modeling Solution Reference Data

Optimization Elements

Configuration Item	Value
Solver	Simplex Random Start
Objective Function	UNIMI_CRA.Optimizer.ObjectiveFunctions.IRENE.IRENEObjective...
Modeling Sol...	CropSyst Modeling Solution.CropSyst ModelCaller
Selector	WOFOSTReferenceReaderAndSelector.CropSyst Selector
Reference D...	WOFOSTReferenceReaderAndSelector.CropSyst ReferenceDataR...
Matcher	Equality Matcher
Variables	Objective Function Variables
variable	Output and Covariate
name	LimitedAboveGroundBiomass
covari...	LimitedAboveGroundBiomass

Optimization Results

Field	Value
Converged	Yes
Function Minimum	7.696510013366...
Iterations	15
variable Matches...	133/133

Configure Parameters under Optimization

Behaviour	Parameter key	Component	Current Value	Strategy	Name	Description	Units
Under evaluation	Foggia_WH_CS	CropSystLimited	18.34759489400...	CropSyst_WL pa...	OptimumTemper...	Optimum temper...	°C
	Name	Value					
	Lower limit in the ...	17					
	Upper limit in the ...	23					

Behaviour	Parameter key	Component	Current Value	Strategy	Name	Description	Units
Under evaluation	Foggia_WH_CS	CropSystLimited	3.0423630968399	CropSyst_WL pa...	MaximumRadiati...	Maximum radiati...	g MJ-1
	Name	Value					
	Lower limit in the ...	2					
	Upper limit in the ...	4					

Configure Fixed Parameters

Behaviour	Parameter key	Component	Current Value	Strategy	Name	Description	Units
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Parameter range

Optimization result

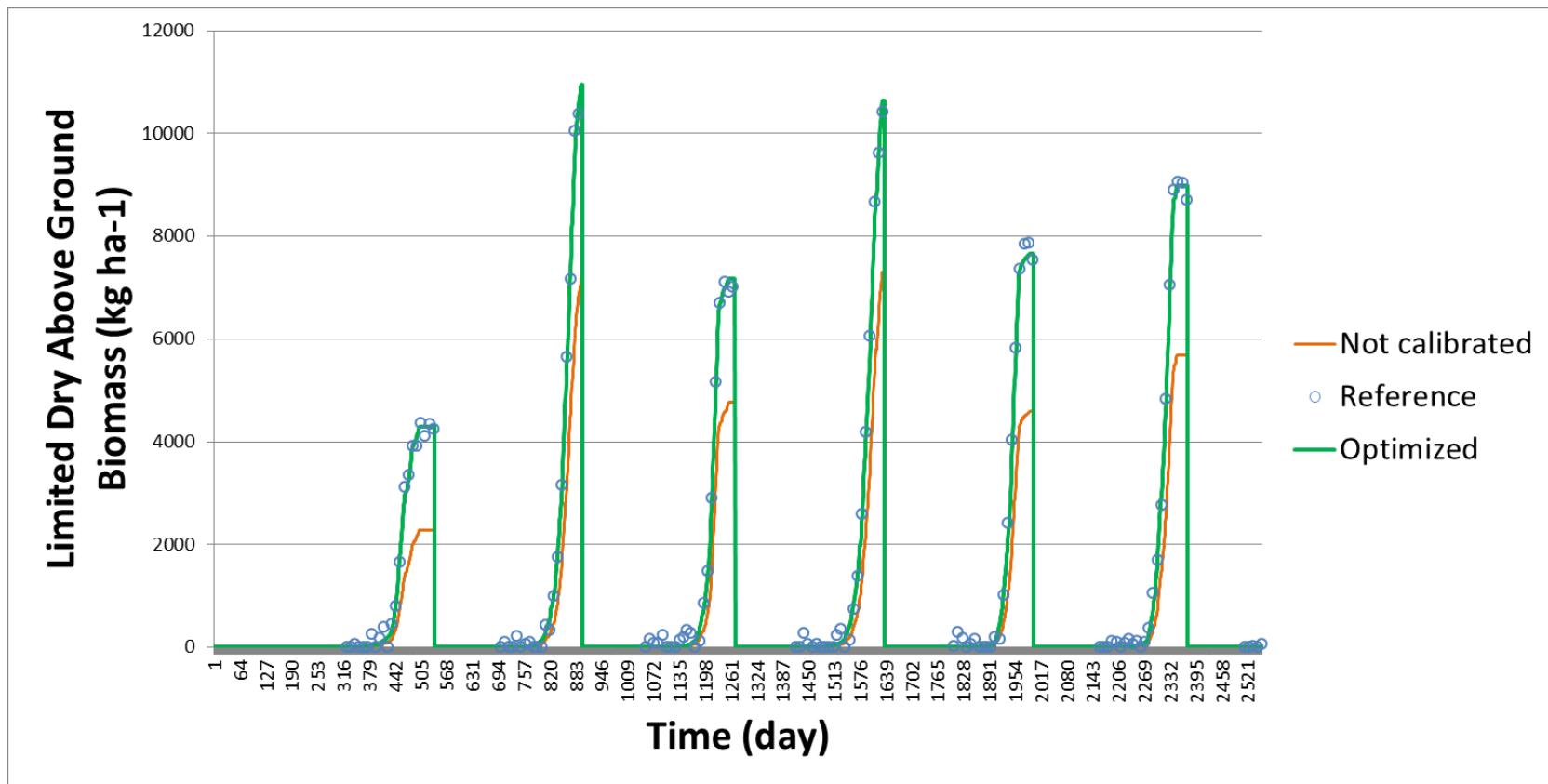
Parameter calibrated value





Optimizer – case study results

- RUE 2 -> 3.04; OptimumTemperature: 15 ->18.34





Composite index - example

Loaded combinations and weights

	Index	Index ID	Weight	
▶	RRMSE	9	0.2777777...	
	EF	10	0.7222222...	

Loaded Indexes

RRMSE
EF

Loaded thresholds and calculated index values

	Index	Index ID	Composite	Favourable threshold	Unfavourabl threshold	Value	
▶	RRMSE	9	false	10	25	0	
	EF	10	false	0.9	0.4	0	

Calculated fuzzy-values of the loaded thresholds

	Index	Favourable/l Value	
▶	RRMSE	Favourable 1	
	RRMSE	Unfavourable 0	
	EF	Favourable 1	
	EF	Unfavourable 0	

Composed Index value

1

