EU H2020 - MOSES Innovation Action

MOSES TUTORIAL – CROP PARAMETERS DATABASE

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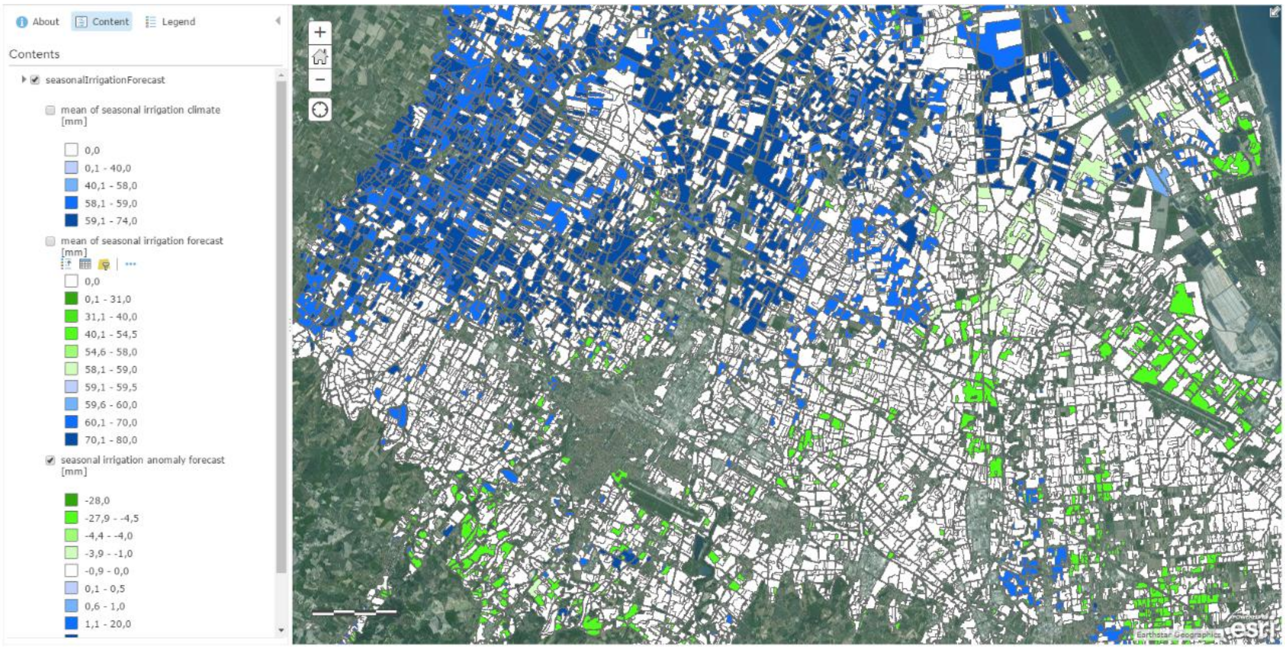

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SUMMARY

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AIM OF THE TUTORIAL

The MOSES platform includes soil water balance module that simulates crop development algorithms aimed at computing the development of crops and, as a consequence, water needs depending on their phenological stages, defined by parameters stored in the 'modelParameters' database. All the MOSES partners involved in the setup of DAs are invited to check and update the crop parameters described in this tutorial in order to carry out a first calibration of specific parameters for the main crops of each MOSES DA.

The aim of this tutorial is to explain where the crop parameter database is stored and which are the main parameters to edit.

MOSES FTP SERVER

Crop parameters can be updated on the MOSES platform by the MOSES FTP server, reachable by means of the following account:

IP: 84.253.153.145
port: 21
user: provider
pwd: mosesProvider

In the main FTP folder you will find 4 subfolders, one for each Demonstration Area, named DA_IT (Italy), DA_MO (Morocco), DA_RO (Romania) and DA_ES (Spain).

CROP PARAMETER DATABASE

A copy of the crop parameters database for each DA is stored in the FTP folder (static\SWB):

DA_XX\STATIC\SWB\modelParameters_XX.db

where XX is the code of the DA.

This file is a SQLite database and can be easily managed by the *sqlitebrowser* open source software, that you can download at:

https://github.com/sqlitebrowser/sqlitebrowser

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STRUCTURE OF THE PARAMETER DATABASE

The *modelParameters* database is organized in four tables, the only tables that have to be checked and calibrated are: **moses_crop** and **crop**.

The table **moses_crop** (see Fig. 1) is a table where each crop is defined by a model identifier (*id_crop*) linked to the corresponding MOSES crop class identifier (*id_moses),* used in the Early Crop Map and In Season Crop Maps.

Table: moses_crop

	id_moses	type	id_crop	irri_ratio
	Filter	Filter	Filter	Filter
1	HHcn	summer herbaceous cotton	NULL	1.0
2	HHhh	summer herbaceous generic	CORN	1.0
3	HHmz	summer herbaceous maize	CORN	1.0
4	HHpo	summer herbaceous potato	POTATO	1.0
5	HHsb	summer herbaceous springbeet	SPRINGBEET	1.0
6	HHsf	summer herbaceous sunflower	SUNFLOWER	1.0
7	HHso	summer herbaceous sorghum	SORGHUM	1.0
8	HHsy	summer herbaceous soybean	SOYBEAN	1.0
9	HHto	summer herbaceous tomato	TOMATO	1.0
10	HPad	perennial herbaceous alfalfa	ALFALFA	1.0
11	HPax	perennial herbaceous alfalfa 1st year	ALFALFA1Y	1.0
12	HPma	perennial herbaceous generic	ALFALFA	1.0
13	HPme	perennial herbaceous meadow	GRASS	1.0
14	HWba	winter herbaceous barley	IRRIWHEAT	1.0
15	HWhw	winter herbaceous generic	IRRIWHEAT	1.0

*Fig. 1 - **moses_crop** table for the Spain DA*

The field *type* is a description of the MOSES crop class and the field *irri_ratio* [-] defines how much is actually irrigated this crop class.

For instance, if in a study area, the alfalafa is not irrigated (as in Italy), the *irri_ratio* has to be set to 0, whereas if it is fully irrigated (as in Spain) *irri_ratio* has to be set to 1.

If in a DA the class of 'summer herbaceous generic' includes both irrigated and not irrigated crops, *irri_ratio* has to be set to the ratio between the two categories. For example *irri_ratio* = 0.6 means that the irrigated area is the 60% of the total area covered by 'summer herbaceous generic'.

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WARNING: in some cases the *id_crop* is not defined. This means that this crop is not set at all in the model (e.g. the **cotton**, see Fig. 1). There are two solutions about this:

1) the user can choose a crop that can be considered similar for development and water needs; for example: **pear** is used to simulate the **apple tree** that is missing in the model;

2) a new crop can be added in the crop table, following the instructions explained in the following paragraphs.

The **crop** table stores all the model parameters for each crop simulated by soil water balance model. The list of parameters is shown in Fig. 2 and it will be explained in details in the following paragraph.

Name	Type
Tables (4)	
crop	
id_crop	TEXT
crop_name	TEXT
type	TEXT
sowing_doy	INTEGER
plant_cycle_max_duration	INTEGER
lai_min	REAL
lai_max	REAL
lai_grass	REAL
thermal_threshold	REAL
upper_thermal_threshold	REAL
degree_days_emergence	INTEGER
degree_days_lai_increase	INTEGER
degree_days_lai_decrease	INTEGER
lai_curve_factor_a	REAL
lai_curve_factor_b	REAL
root_depth_zero	REAL
root_depth_max	REAL
root_shape	INTEGER
root_shape_deformation	REAL
degree_days_root_increase	INTEGER
kc_max	REAL
irrigation_shift	INTEGER
irrigation_volume	REAL
degree_days_start_irrigation	INTEGER
degree_days_end_irrigation	INTEGER
psi_leaf	NUMERIC
stress_tolerance	REAL
frac_read_avail_water_min	REAL
frac_read_avail_water_max	REAL
degree_days_max_sensibility	INTEGER
max_height_surface_puddle	REAL
moses_crop	
id_moses	TEXT
type	TEXT
id_crop	TEXT
soil_driessen	
soil_vangenuchten	

*Fig. 2 – **crop** table structure*

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CROP TABLE

Each crop is typically characterized by several parameters, described in the **crop** table, where each record describes the crop in terms of phenological characteristics, water needs and typical irrigation parameters.

In the table below, key parameters for crop development and irrigation are listed.

DB parameter	Parameter description	Unit	Validity range
id_crop	ID crop	[-]	
crop_name	Extended name of the crop	[-]	
type	Type (herbaceous, fallow, fruit tree, grass, horticultural)	[-]	
Development			
sowing_doy	Sowing day	Day of the year	1 - 365
plant_cycle_max_duration	Crop cycle max lenght (for fruit tree: 365 days)	days	1 - 365
lai_min	Minimum value of LAI	$m^2\ m^{-2}$	0 - 3
lai_max	Maximum value of LAI	$m^2\ m^{-2}$	1 - 7
lai_grass	Value of LAI for grassed crops	$m^2\ m^{-2}$	0 - 3
thermal_threshold	Temperature threshold to compute degree day sum	°C	0 - 20
upper_thermal_threshold	Upper temperature threshold	°C	
degree_days_emergence	Degree days sum for emergence	°C	0 - 300
degree_days_lai_increase	Degree days sum for LAI increase	°C	200 - 3000
degree_days_lai_decrease	Degree days sum for LAI decrease	°C	200 - 3000
lai_curve_factor_a	Factor *a* of exponential curve of LAI increase	[-]	0 - 10
lai_curve_factor_b	Factor *b* of exponential curve of LAI increase	[-]	-0.1 - 0
Root			
root_depth_zero	Start of rooting system depth	m	0 - 0.15

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root_depth_max	Max rooting depth	m	0.3 - 2
root_shape	Root shape (cylinder: 1, ellipsoid: 2, gamma function: 3, cardioid: 4)	[-]	
root_shape_deformation	Coefficient of deformation of the rooting system	[%]	1 - 2
degree_days_root_increase	Degree days sum for the development of the rooting system	°C	200 - 2000
Irrigation			
irrigation_shift	Minimum number of days from the last irrigation	days	1 - 30
irrigation_volume	Maximum irrigation volume	mm/day	0 - 100
degree_days_start_irrigation	Degree days sum for the start of the irrigation period	°C	0 - 6000
degree_days_end_irrigation	Degree days sum for the end of the irrigation period	°C	0 - 6000
Water needs			
kc_max	Maximum crop coefficient	[-]	0.5 - 2
psi_leaf	Leaf resistance	hPa	1000 - 20000
stress_tolerance	Tolerated threshold on the ratio Tr/Tmax (actual vs maximum transpiration) 1 = no controlled stress	[-]	0-1
frac_read_avail_water_min	Fraction of readily available water during the minimum sensibility phase to water stress	[-]	0-1
frac_read_avail_water_max	Fraction of readily available water during the maximum sensibility phase to water stress	[-]	0-1
degree_days_max _sensibility	Degree days sum corresponding to the phenological stage of maximum sensitivity to water stress	°C	200 - 3000
max_height_surface_puddle	the depth of the water puddle	mm	0 - 500

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PARAMETERS CALIBRATION

The MOSES user has to describe crops identified in Early Crop Map and In Season Crop Maps by means of parameters referring to the vegetative cycle and irrigation methods.

To define the crop cycle, key parameters to set are *sowing_doy* (the day of the year in which usually the crop is seeded) and *plant_cycle_max_duration* (the maximum length of the crop cycle in days). The computation of the phenological stages is carried out on the basis of the thermal threshold, that the user has to define in *thermal_threshold* field.

From this data, the degree days needed by the crop for the emergence (*degree_days_emergence*), for the maximum leaf area index development (*degree_days_lai_increase*) and for the leaf area index senescence (*degree_days_lai_decrease*) have to be set.

Moreover the *upper_thermal_threshold* field defines the threshold above which the crop stops to grow.

The leaf area index development is calculated on the basis of these parameters: the minimum leaf area index at the beginning of the crop cycle (*lai_min*), the maximum lai reached during the season (*lai_max*) and, especially for fruit trees, if the orchards have a grass cover, the user has to define the leaf area index of the grass (*lai_grass*).

The maximum crop coefficient (*kc_max*) has to be defined in order to compute actual evapotranspiration.

In order to describe the rooting system of the crop, the user has to set how much is the depth of the beginning of roots with respect to the ground (*root_depth_zero*), in other words, the height of the root collar, and the maximum reachable depth (*root_depth_max*) of the roots.
The previous data with the degree days sum for the development of the rooting system (*degree_days_root_increase*) definition allow to compute the curve of root development.

It is crucial also the definition of the shape of the roots (*root_shape*), selecting the following codes:

1 → cylinder

2 → ellipsoid

3 → gamma function

4 → cardioids

In addition, the coefficient of deformation (*root_shape_deformation*), expressed as percentage ranging from 1 to 2, can be used to adapt the selected shape to the actual shape of the crop.

In order to assess the crop water demand, the irrigation process is controlled by the parameters listed in the table such as *irrigation_shift* (the number of days between two irrigations) and *irrigation_volume* (the maximum volume of water distributed for each irrigation during the crop cycle in mm).

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These parameters allows the user to define the irrigation methods (i.e. micro irrigation, sprinkler irrigation) depending on time shifts and maximum volumes for each irrigation.

The irrigation season length is controlled by *degree_days_start_irrigation* and *degree_days_end_irrigation* parameters: the actual irrigation period starts and stops according to a degree days sum, taking into account the weather conditions of every specific year, anticipating it in warm years and delaying it in cold ones.

Another parameter useful to calibrate the crop is *stress_tolerance*: it expresses the tolerance of the crop to water stress as the ratio between actual transpiration and maximum transpiration, where 1 means no stress tolerance for the crop.

A further description of the crops in terms of water stress sensitivity can be provided by these parameters: *frac_read_avail_water_min*, i.e. the fraction of readily available water during the minimum sensitivity phase to water stress and *frac_read_avail_water_max*, i.e. the fraction of readily available water during the maximum sensitivity phase to water stress. The moment of maximum sensitivity is defined by the corresponding number of degree days sum *degree_days_max_sensibility*, usually linked to the flowering phenological stage.

HOW THE IRRIGATION ALGORITHM WORKS

Irrigation dates are computed according to the soil water content, taking into account water stress sensitivity values specific for crops and phenological phases. The value of crop sensitivity to the water stress is the readily available water percentage between the wilting point and the field capacity; below this threshold, the water stress would start and the model, if allowed by the user, simulates an irrigation.

By means of the controlled stress percentage, it is possible to extend the stress period up to a value physiologically tolerable by the plant. Stress percentage value is computed by means of the ratio between actual and potential transpiration.

The irrigation algorithm of MOSES SWB can be summarized in this way:

1) the model checks if the current day of simulation is included in the irrigation season (using *degree_days_start_irrigation* and *degree_days_end_irrigation*)

2) the model checks if a number of days equal or greater than *irrigation_shift* is progressed from the last irrigation

3) the model checks if the readily available water in the rooted zone (weighted on the basis of the root density in the different layers of soil) is minor than the crop sensitivity value to the water stress (computed by *frac_read_avail_water_min*, *frac_read_avail_water_max* and *degree_days_max_sensibility*).

4) the model check if the current ratio between actual transpiration and maximum transpiration is minor than the tolerated value (*stress_tolerance*).

If all the previous conditions are true, an irrigation volume is distributed. This is computed as the minimum between the predefined maximum *irrigation_volume* and the water volume needed to

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restore the rooted zone to the field capacity. This computational choice is applied in order to avoid excessive irrigations that would be converted in run-off losses.

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