CONFERENCE

IRRIGATION

QUELLES STRATÉGIES POUR ÉCONOMISER L'EAU ?
WHAT STRATEGIES FOR WATER SAVINGS ?

REGARDS CROISÉS EUROPÉENS

SHARING EUROPEAN VIEWS

13 - 14 nov. 2019

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irstea LA SCIENCE AU CŒUR DE L'ENVIRONNEMENT

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PROJET COFINANCÉ PAR LE FONDS EUROPÉEN AGRICOLE POUR LE DÉVELOPPEMENT RURAL
L'EUROPE INVESTIT DANS LES ZONES RURALES

Liberté • Égalité • Fraternité RÉPUBLIQUE FRANÇAISE

Réseau Rural Français 2014 - 2020

MUSE MONTPELLIER UNIVERSITY OF EXCELLENCE — KEY INITIATIVE WATERS

INVESTISSEMENTS D'AVENIR

G-eau Gestion de l'Eau, Acteurs, Usages

Montpellier SupAgro

AFEID Association Française pour l'Eau, l'Irrigation et le Drainage

AIRMF Association des Irrigants des Régions Méditerranéennes Françaises

agricultures & territoires CHAMBRE D'AGRICULTURE OCCITANIE

agricultures & territoires CHAMBRE D'AGRICULTURE PROVENCE-ALPES-CÔTE D'AZUR

AQUA VALLEY

UNIVERSIDADE DE LISBOA

INSTITUTO SUPERIOR DE AGRONOMIA
Universidade de Lisboa

FCT Fundação para a Ciência e a Tecnologia

LEAF
LINKING LANDSCAPE, ENVIRONMENT, AGRICULTURE AND FOOD

Combining soil water balance models and water stress indicators for irrigation scheduling - case study in Portuguese conditions and its context

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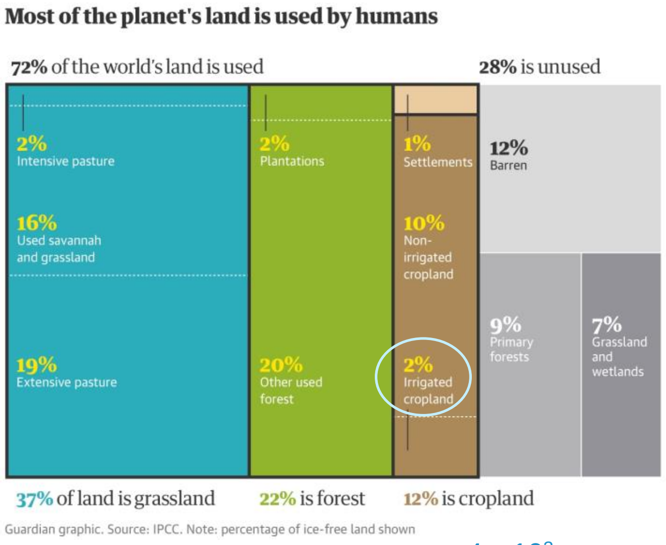
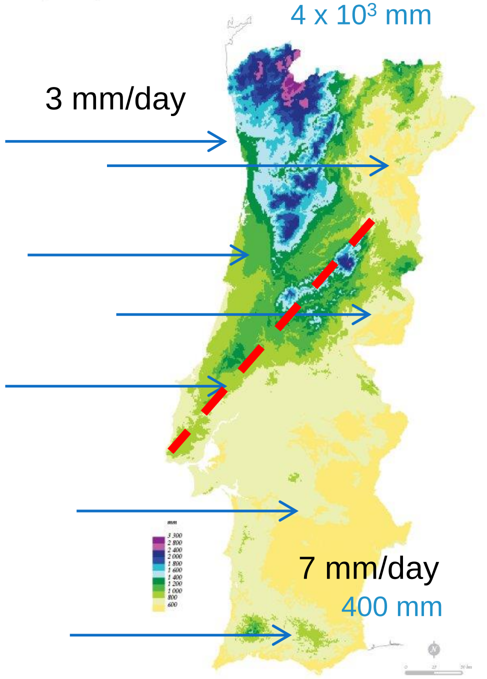
Context

Irrigable Land (Equipped) and Irrigated Land					
Land Use	Used Agricultural Land	Irrigable Land (equipped)		Irrigated Land	
Agricultural Region	(ha)	(ha)	(%)	(ha)	(%)
Entre Douro e Minho	211 154	94 829	45%	81 858	39%
Trás-os-Montes	432 873	46 666	11%	39 852	9%
Beira Litoral	125 436	61 116	49%	51 314	41%
Beira Interior	337 031	49 580	15%	35 649	11%
Ribatejo e Oeste	391 006	112 539	29%	101 208	26%
Alentejo	1 956 508	155 123	8%	138 231	7%
Algarve	88 297	16 274	18%	16 170	18%
Mainland Portugal	3 542 305	536 127	15%	464 283	13%

38% of total area

5 % of total area





Irrigated Land by Major Crop Group and Irrigation System

Irrigation System / Major crop groups	Gravity		Sprinkler & Drip		Total
	ha	%	ha	%	ha
Permanent Crops	12 245	9	123 254	91	135 499
Temporary Crops	99 993	36	177 131	64	277 124
Grazing Land	34 443	66	17 561	34	52 004
Total	146 681	32	317 946	68	464 627

Water Delivery

Water Users Associations & Public Irrigation Companies		Private Schemes		Total
ha	%	ha	%	
135 300	25	400 827	75	536 127

Irrigation Land by Agricultural Region and Irrigation System

Irrigation System / Agricultural Region	Surface		Sprinkler & Drip		Total
	ha	%	ha	%	ha
Entre Douro e Minho	46 809	57	35 268	43	82 078
Trás-os-Montes	27 942	70	11 930	30	39 871
Beira Litoral	25 454	50	25 908	50	51 361
Beira Interior	11 084	31	24 575	69	35 660
Ribatejo e Oeste	19 120	19	82 120	81	101 240
Alentejo	14 653	11	123 595	89	138 247
Algarve	1 618	10	14 552	90	16 171
Mainland Portugal	146 681	32	317 946	68	464 627

Irrigated crops

Crop Types	Area (ha)	%
Wheat	5 770	1,2%
Corn	81 190	17,5%
Rice (Paddy)	29 250	6,3%
Fodder crops	87 807	18,9%
Grazing land	51 661	11,1%
Potato	11 834	2,5%
Sunflower	4 093	0,9%
Tomato for industry	17 943	3,9%
Other extensive vegetables	10 025	2,2%
Vegetables (intensive)	14 654	3,2%
Citrus	15 048	3,2%
Other Fresh Fruits (Orchards)	23 683	5,1%
Olive Tree	65 887	14,2%
Vineyard	25 181	5,4%
Other Crops	20 706	4,5%
Total	**464 731**	**100,0%**

Irrigation Indicators

Indicators	Avg Irrigated land	Unit Consumption
Agricultural Region	(ha/farm)	(m^3/ha)
Entre Douro e Minho	1,9	6 662
Trás-os-Montes	1,8	6 331
Beira Litoral	1,4	8 253
Beira Interior	2,3	7 929
Lisboa e Vale do Tejo	7,3	7 787
Alentejo	18,5	6 937
Algarve	2,6	9 973
Mainland Portugal	3,2	7 349

Management at plot scale (irrigation scheduling: how much water and when)

A. **Water balance** where **crop water requirements** (ETa) is estimated by simple models

B. **Water stress indicators** (short term stress)
used for irrigation scheduling (by direct measurements):

- Soil water content
- Soil water potential
- Leaf water potential
- Stem water potential
- Stem diameter derived variables
- Relative transpiration (Ks, e.g. with sap flow tech.)
- Leaf temperature (e.g. IR by remote sensing, portable cameras)

If used separated:

The **water balance (A)** informs first how much to irrigate (irrigation depths) and, secondly, when to irrigate, mainly based on parameters of the system (mainly FC, PWP, allowable depletion p).

List of uncertainties, Ferreira 2017 (Horticulturae)

The **water stress indicators (B)** inform when to irrigate, if thresholds are known,
and possibly also how much to irrigate based on trial and error, and is not usable for planning.

None of these possibilities (A or B) is fully satisfactory by itself.
Instead of being seen as "alternatives" a combination of these two approaches is a relatively common solution, namely in services provided to farms:

A. modelling of ETa = input in the water balance equation, in order to get the change in soil water (=output), thus soil water status (water content in m^3/m^3 or soil water depletion, in mm).
B. water stress indicators for plant/crop or soil water status (e.g. soil water content, m^3/m^3).

These two outputs can be used for control and adjustments, or to get new information (as in example 1):

Example 1:

Knowing the water stored in soil for day i (WS_i, mm) and:

- Precipitation *P*, measured
- Irrigation depth *I*, measured
- Actual ET ET_a, estimated
- Drainage estimaded, when applicable

It is possible to get the water stored the next day WS_{i+1} using:

$$WS_{i+1} = WS_i + P + I - D - ET_a$$

The volumetric soil water content (θ) for the next day i+1, is:

$$\theta_{mod,i+1} = WS_{i+1}/z_{average}$$

Comparing these estimated values $\theta_{mod,i+1}$
with those measured $\theta_{mes,i+1}$
the parameters of ET_a estimation can be adjusted.

Which are these parameters?

K_s, *p*
K_c
…

Variables and parameters to obtain:

$$ET_0 = \frac{0{,}408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0{,}34u_2)}$$

$$ET_a = ET_0 \times K_c \times K_s$$

$$K_s = \frac{TAW - SWD}{TAW \times (1-p)}$$

K_c simple, not dual

Assuming irrigation till FC and sum since last irrigation:

$$SWD = \theta_{V,FC} \times z - \sum ET_a$$

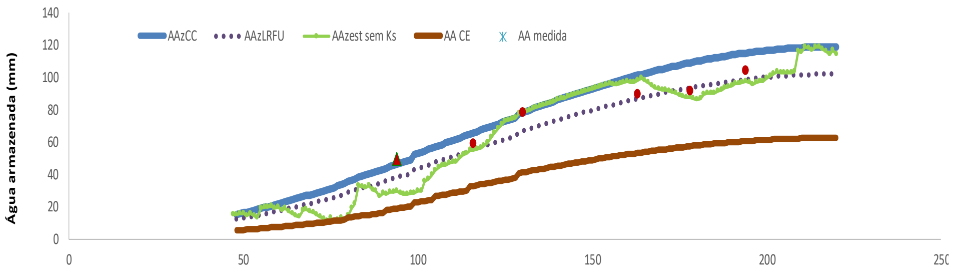
$$TAW = (\theta_{V,FC} - \theta_{V,WP}) \times z$$

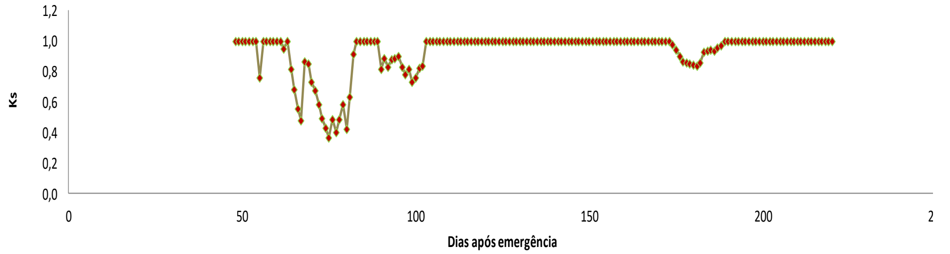
$$\theta_{V,WP} = Da \times \theta_{m,WP} \qquad \theta_{V,FC} = Da \times \theta_{m,FC}$$

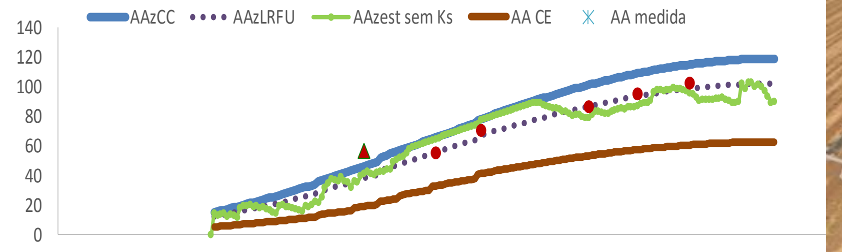
Assume *p* = 0,3
e.g. from table 22 FAO 56 (lack of specific studies):

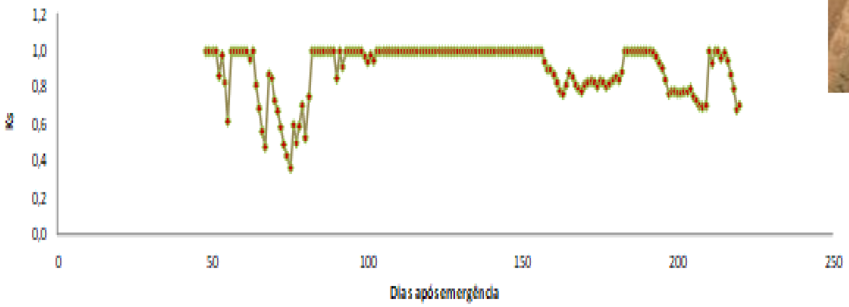
Parameters obtained experimentally
Da, $\theta_{m,WP}$, $\theta_{m,FC}$

Parameter obtained by comparison between modelled and measured values of θ:
$$K_c = f\,(LAI)$$

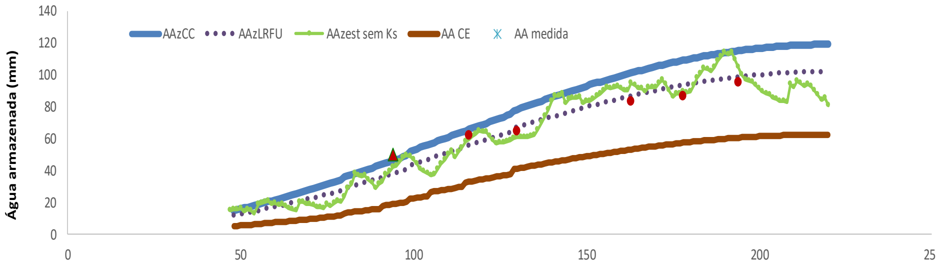

AAzCC
AAzLRFU
AAzest sem Ks
AA CE
AA medida
Água armazenada (mm)

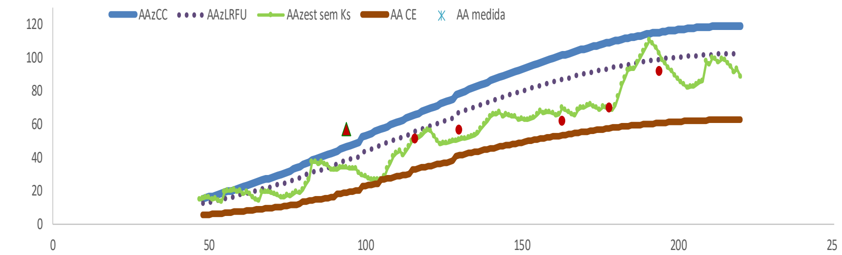

Ks
Dias após emergência

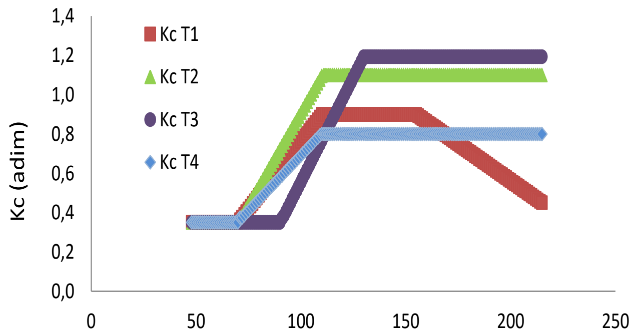

AAzCC
AAzLRFU
AAzest sem Ks
AA CE
AA medida

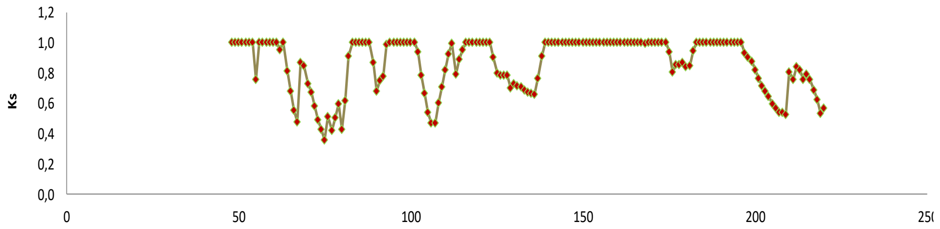

Ks
Dias após emergência

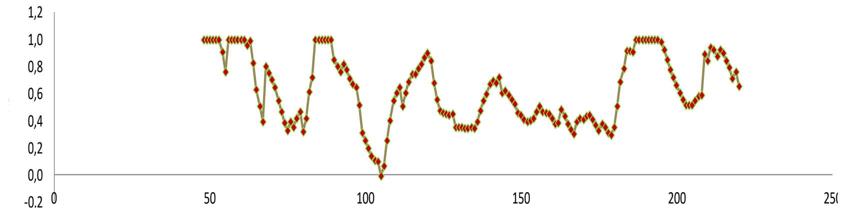

4 plots:
simple (T1, T3)
and double line,
2 under stress
(T3, T4)
N
Local 1
Local 2

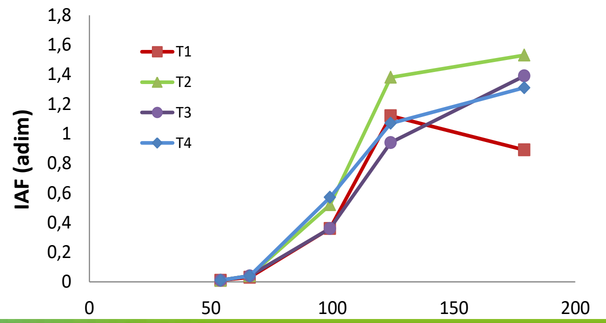

AAzCC
AAzLRFU
AAzest sem Ks
AA CE
AA medida
Água armazenada (mm)


AAzCC
AAzLRFU
AAzest sem Ks
AA CE
AA medida


Kc T1
Kc T2
Kc T3
Kc T4
Kc (adim)


Ks




T1
T2
T3
T4
IAF (adim)

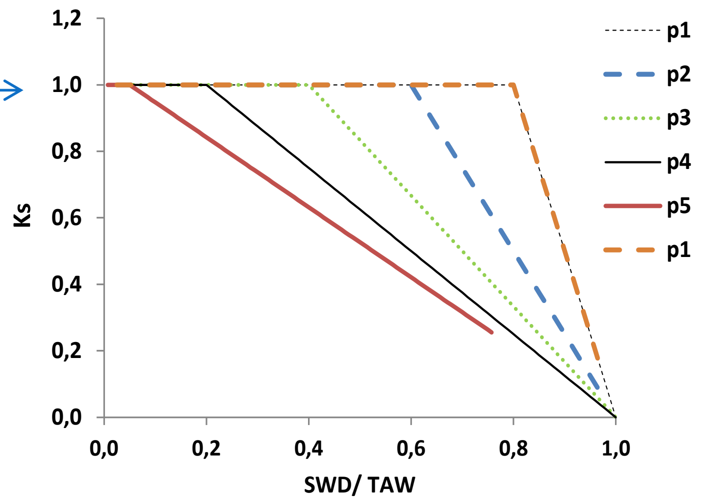
Another example would concern a deep rooted woody crop, considered very resilient to water stress: *Olea europea*.
Results published (3 years of fluxes measurements) show that:

1. drip irrigated olive trees under DI can use more water than the total irrigation volume, even being young
   Conceição et al., 2017 http://dx.doi.org/10.1016/j.agwat.2017.05.011

2. there is important exploitation of deep soil layers (irrigated and rainfed), suggesting that measurements in upper soil layers are only indicative (limitations of soil measurements used alone);
   Conceição et al. 2018 https://doi.org/10.17660/ActaHortic.2018.1199.9
   Ferreira et al. 2018 https://doi.org/10.1007/s11104-018-3585-x

3. usual modelling approaches alone can severely fail, in case of the generally applied deficit irrigation (evapotranspiration reduced by stress).
   Ferreira 2017 https://doi.org/10.3390/horticulturae3020038
   Lourenço et al. (submitted Acta Hort)

With these olive trees, both ETa modelled (Ks) and soil measurements would fail for irrigation scheduling purposes in DI.
Predawn leaf water potential and
selected stem diameter derived variable were useful.
More difficult to extract model parameters without ET measurements.
Possible?



p1 to p5: 0.8; 0.6; 0.4; 0.2; 0.05

TAW1 to 5: 50, 100, 200, 250, 350 mm