Innovation in Hydrometry – from ideas to operation
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Assessing opportunities of water and energy saving and monitoring of a Large-Scale Pressurized Irrigation System using actual evapotranspiration retrieved by surface energy balance

H. **Awada**[a], G. Ciraolo, A. Maltese[a], M.A. Moreno Hidalgo[b], G. Provenzano[c], J.I. Còrcoles[b]

Hassan Awada

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Research objectives

- Setting up methodologies to **optimize** irrigation systems accounting for **water consumption**.
- Assess the trade-offs between **irrigation water saving** and **energy consumption**.
- Estimating of the **actual evapotranspiration** of crops in an irrigation scheme using **satellite-based image-processing models.**

Methods

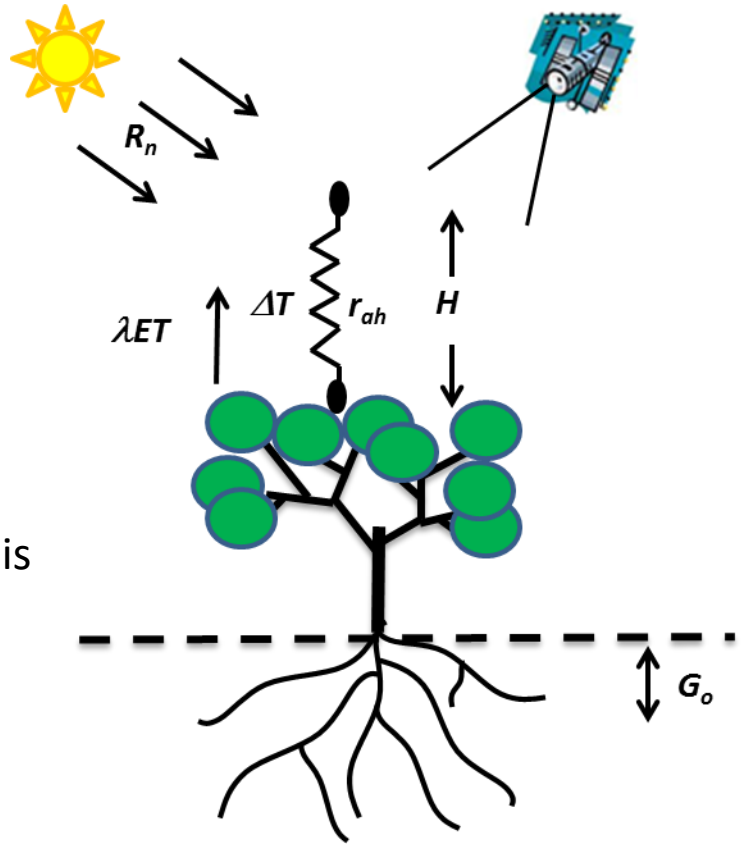
Surface Energy Balance Approaches (single source)

$$\lambda ET = R_n - G_0 - H$$

Evaporative fraction and daily actual evapotranspiration

$$\frac{\lambda ET_{ist}}{R_{n,ist} - G_{0,ist}} = \Lambda_{ist} \approx \Lambda_D = \frac{\lambda ET_D}{R_{n,D} - G_{0,D}}$$

with: $G_{0,D} \cong 0 \Longrightarrow ET_D = 1.1 \frac{\Lambda_{ist} \times (R_{n,D} - G_{0,D})}{\lambda}$



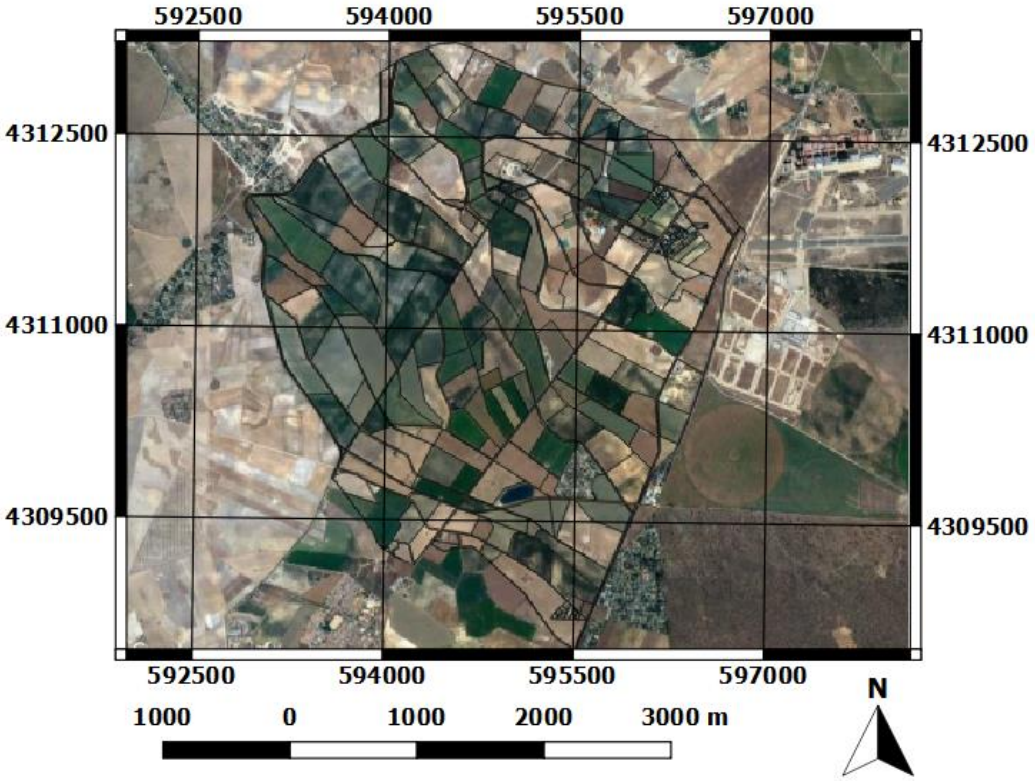
Seasonal "actual" evapotranspiration

$$ET_M = ET_D \frac{\sum_{D=1}^{n} ET_{0,D}}{ET_{0,D}}$$

The ET_0, a non-water limited *ET* from a reference surface, is determined from meteo. data (FAO-56 Penman-Monteith parameterization).

Study area and data

The irrigation society SAT Llano Verde, located in the province of Albacete (Spain), in Castilla-La Mancha region (municipality of Aguas Nuevas).



Water Consumed Hydrant (10^3 m^3)					
Period	MAY	JUN	JUL	AUG	SEPT
2006	640	540	1090	888	505
2007	491	800	1280	992	668
2008	239	504	1125	1169	658

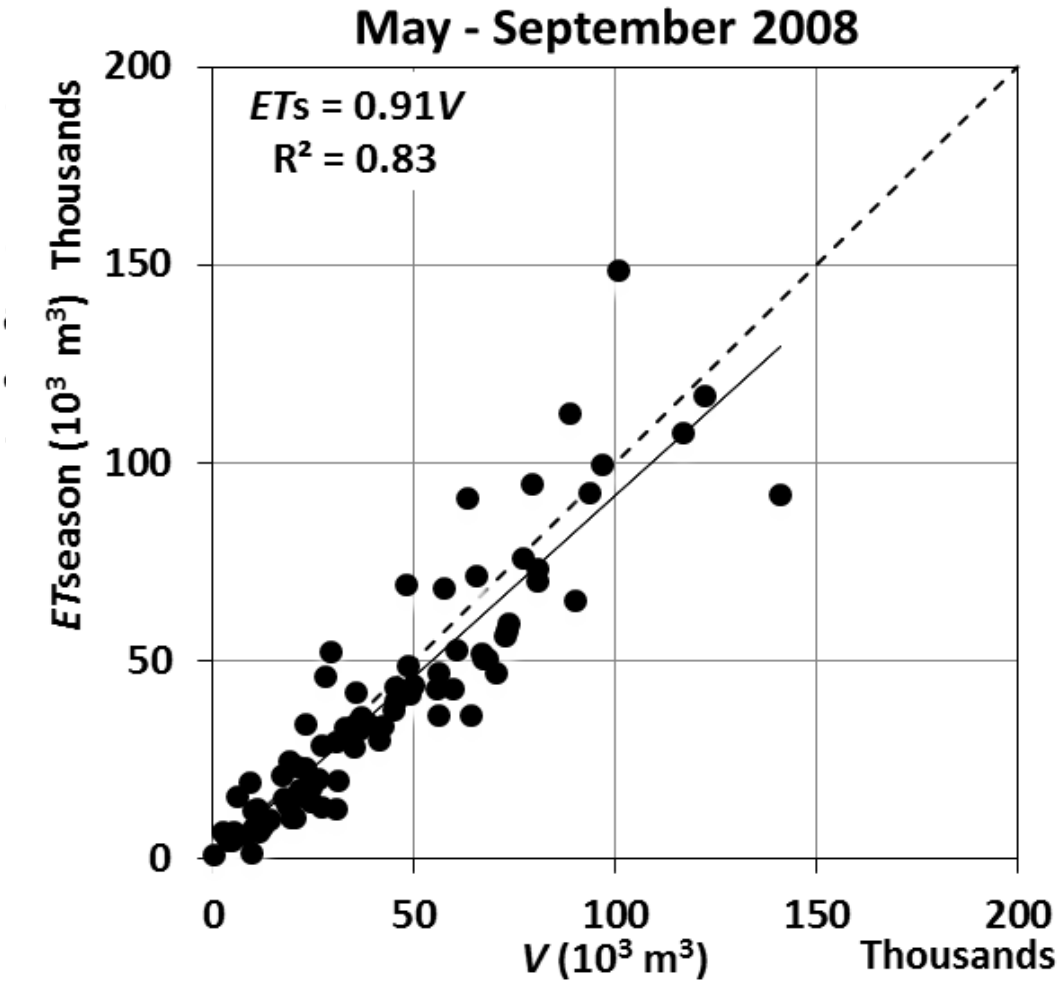
Energy Consumed Invoice (10^3 kw.hr)					
Period	MAY	JUN	JUL	AUG	SEPT
2006	191	158	314	252	144
2007	148	235	373	289	186
2008	70	154	362	381	176

Remote sensing data

- A selection of **Landsat-5 TM** nearly **cloud-free scene**. TM overpasses (Path 199 and 200, Row 33) were evaluated during the irrigation season (May to September) of the years 2006, 2007 and 2008, **with 26 satellite images** representing different irrigation requirement.

RESULTS

Water requirement (m^3) estimated *vs*. the downstream hydrant measured water consumption (m^3).

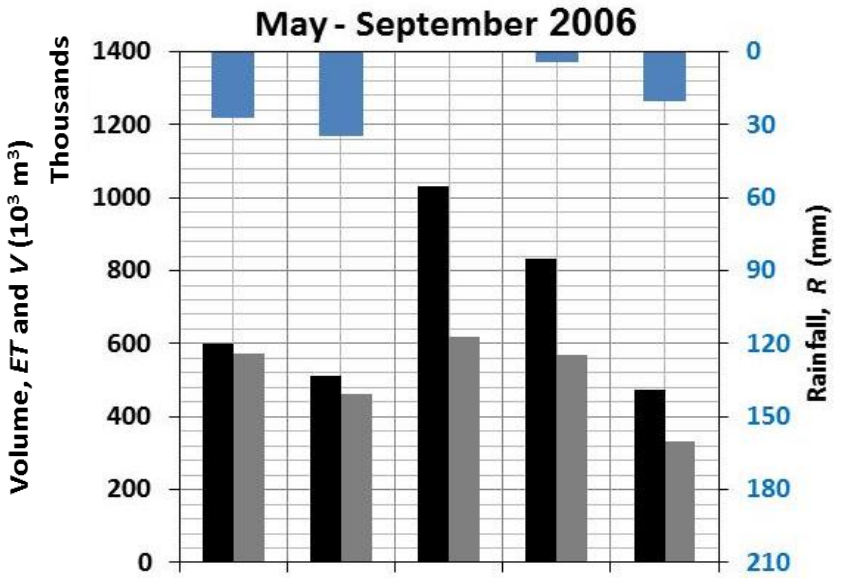


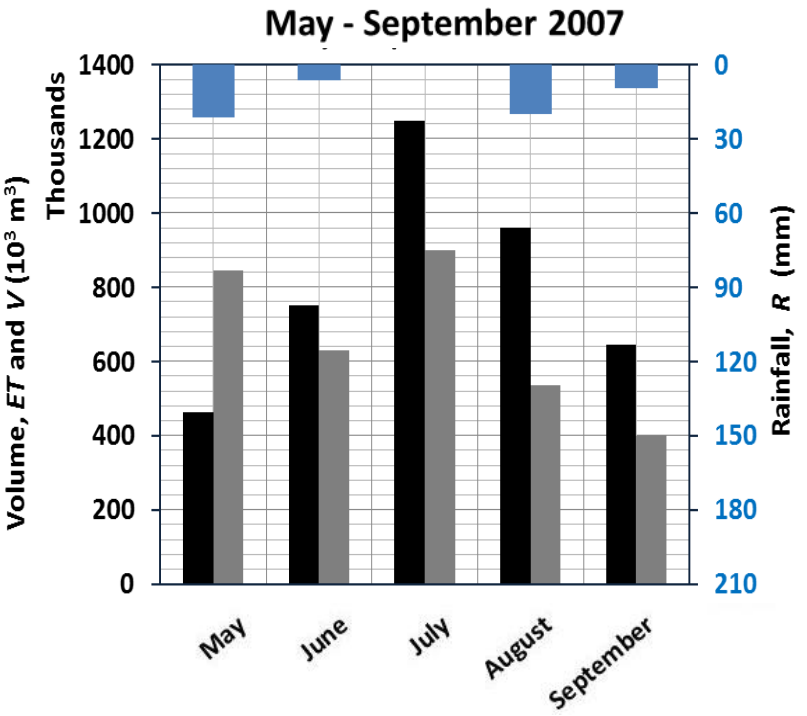
Year	Fuction	R^2
2006	ETs=0.68V	0.86
2007	ETs=0.75V	0.83
2008	Ets=0.91V	0.83

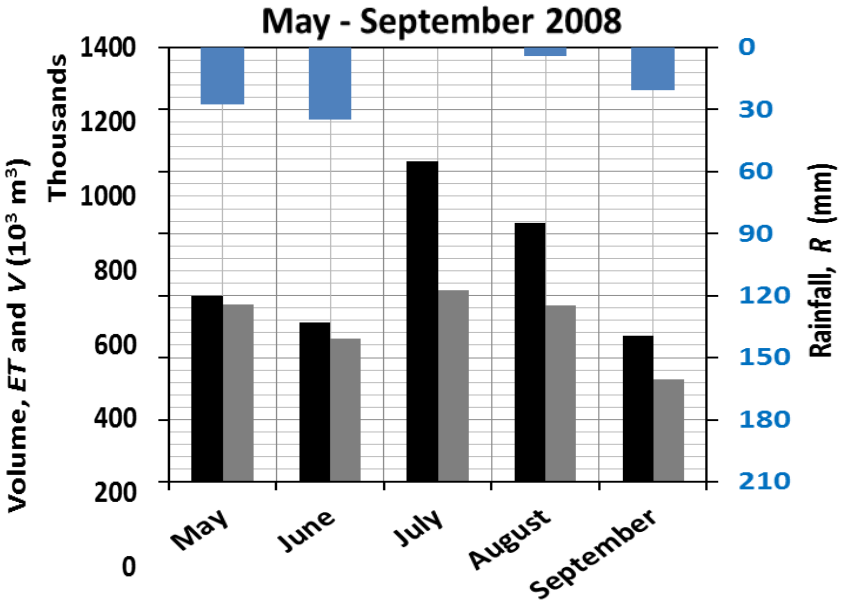
Quantifying *ET* at field level among a population of cultivated fields allowed the estimation of water demand downstream hydrants that irrigate those fields. Results on a seasonal basis (years 2006 to 2008) are shown.

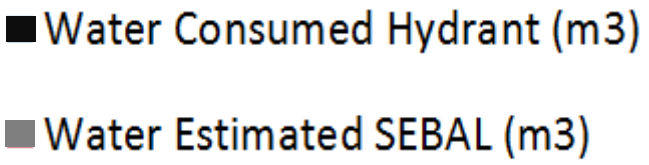
RESULTS

Monthly water consumes estimated by single source SEB model *vs*. measured monthly water supplied at hydrants and monthly rainfall









RESULTS

Considering SEB estimations as a reference, it is evident that farmers apply an excess amount of water. An exception was the month of May 2007 and 2008.

	Water Saving ($m^3 ha^{-1}$)			ENERGY Saving (Kw hr ha^{-1})		
	2006	2007	2008	2006	2007	2008
May	46.6	0.0	0.0	13.9	0.0	0.0
June	86.7	189.4	86.1	25.3	57.2	26.3
July	680.7	537.2	386.2	196.0	156.7	124.2
August	436.7	655.6	356.1	123.9	191.2	115.9
September	231.7	381.5	108.6	66.1	106.5	29.0

On the left side: The monthly electricity fee for pumping water, by considering the total volume of water consumed downstream hydrant, the monthly energy consumed per m^3 of water ($Kw.hr.m^{-3}$) is calculated and the amount of energy (Kw.hr) that would be saved following SEB recommendation.

Preliminary conclusion and further developments

- ✓ The estimation of actual ET allows monitoring the performance of irrigation systems, necessary for irrigation water management
- ✓ Water use efficiency can be estimated over various crop types, soil conditions and management practices.
- ✓ A SEB model applied over a on-turn pressurized irrigation system in the irrigation district “SAT Llano Verde” of Albacete (Spain) evidenced that a considerable amount of water could be saved corresponding to 26.2, 28 and 16.4% of seasonal water consumption from the years 2006 to 2008 respectively.
- ✓ A single source model should be less appropriate than two source model over sparse vegetation. Thus, we are carrying out an analogous analysis over an irrigation district in Castelvetrano (Sicily, South of Italy) characterized by row crop cultivations (orange and olive orchards, vineyards) using the TSEB-IC model.


THANK YOU