Increasing agricultural water efficiency in Mediterranean drylands through accurate assessment of actual ETR of irrigated crops

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Overview of ‘water augmentation’ related results from two Euromed* projects

*(funded by the European Commission)*

- **Project IRRIMED**
  - (2003-2007)
    - IRD-cesbio, coord, UofW (NL), UofJ, NCARTT, MWI (JO), UCA & ORMVAH (MA), ACSAD (SY), INRGREF (TN)

- **Project PLEIADeS**
  - (2006-2009) (coord Spain)
    - IRD-cesbio, UCA & ORMVAH (MA)

  - Numerous experiments and models performed by a large number of fellow scientists, researchers, PhD students and field engineers => see literature published and list of colleagues:

  [www.irrimed.org](http://www.irrimed.org)
Moroccan test site

High Atlas Mountains
up to 4200 m above sea level

Tensift Basin / Arid Plain
Rainfall ~ 240 mm/y
PET ~ 1400 mm/y
Agriculture Uses 85%
of Available Water

ASADWA Valparaiso 2010 * 3
Pilot area of Marakesh (Morocco)
Drastic increase in irrigated areas

93000 ha in 1975
=> 181000 ha in 2002
Monitoring the irrigation water budget

Water consumption of irrigation is a key variable of the water balance of the watershed

Information required:
- Land Cover type
- Vegetation development
- Climate
- Irrigation practices
- Soil properties
- etc.
FAO-56 approach of ETR

Improvements seeked: \( ET_0 \) & local KCs
Met Stations

- Rg
- Vv
- Dv
- Ta, HR
- Rain

Reference Evapotranspiration $ET_0$
FAO-56 approach of ETR

$ET_0$

Reference

$ET_c = K_c * ET_0$

Potential Evapot.

$ETR = K_c * K_s * ET_0$

Real

Improvement seeked : local KCs
Eddy covariance
(turbulence analysis)

3 D wind speed

Instantaneous vapor content

Actual Evapotranspiration at plot level
Crops measured in Morocco

- **wheat**
  - R3 - 2002/03
  - R3 - 2003/04

- **Olives**
  - Agdal
  - R3

- **Orange**
  - Saada 1 et 2
  - Agafay
Measuring fluxes in the soil

- TDR (water content)
- thermistance (temperature)
- Plaquette de flux (thermal flux)
Sprinkler Irrigation System Layout For Alfalfa Crop
University of Jordan Agriculture Research Station
Jordan Valley

Measurements on the Jordanian test site

Eddy-Correlation location
N=32 05' 21.4"
E= 035 35' 46.7"

Sprinkler Irrigation System Layout For Alfalfa Crop
University of Jordan Agriculture Research Station
Jordan Valley
Scintillometry

Large scale ETR

Transmitter $L_{LAS}$

Receiver $\sigma_{in}^2$

$C_n^2$

$Z_{LAS}$

$\text{LAS T}$

$\text{LAS R}$

$\text{EC}$

$\text{OLivres}$

Experimental Site

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Actual ETc versus predicted

Example of cauliflower in the Jordan Valley

![Graph showing Kc for Cauliflower in the Jordan Valley]
Actual ETc versus predicted

Example 2 alfa alfa in the Jordan Valley

Many other results, in brief large differences observed (in the order of 30%) usually lower than FAO data, if you irrigate « by the book », you waste water
On farm Application: Saada exp. Farm / wheat

Application of localised irrigation, with corrected Kcs from ETC measurements

Results:

- done by ORMVAH Centre des techniques d’irrigation Saâda
- period (3 campaigns): 2004-2006

<table>
<thead>
<tr>
<th>Results enhanced method</th>
<th>Reference (mean)</th>
<th>Increase in Yield</th>
<th>Water saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (Mg/ha)</td>
<td>Irrigation (m3/ha)</td>
<td>Yield (Mg/ha)</td>
<td>Irrigation (m3/ha)</td>
</tr>
<tr>
<td>7.5</td>
<td>3370</td>
<td>2.7 ± 10</td>
<td>4800</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>+170%</td>
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<td></td>
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<td></td>
<td>30%</td>
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</tbody>
</table>
Monitoring at farm level with satellite example of series of FORMOSAT-2 images acquired over the moroccan test site

Spatial resolution (multispectral mode): 8 m

Revisit time: 4 day (potentially 1 day)

4 spectral bands:
blue, green, red, near-infrared

Same viewing angle

Images from Nov. 10 2005 to 10 January 2006

7,4 x 4,3 km² (total size ~ 24x24 km²)
18 novembre 2005
28 novembre 2005

Labours

Installation de serres
8 décembre 2005

Labours

Installation de serres
décembre 2005

Labours

Installation de serres
16 décembre 2005

Labours
29 décembre 2005

Récolte
(Orge fourrager)

Installation de serres
10 janvier 2006

Irrigation en cours ?

Récolte (Orge fourrager)
Satellite monitoring of crop development
Vegetation index to estimate Kc in real time

FAO single crop coefficient method

$$ETR = ET0 \times Kc$$

Climate = ET0

=> Given by a meteo station

Crop coefficient (Kc)

=> Estimated in the field or by satellite
Closer to Actual Evapotranspiration

Illustration of the Satellite interest

Potential Needs (ETM) = 13 133 000 m³
Estimated Consumption (ET) = 8 213 000 m³

Cumulated Evapotranspiration from 17/12/2002 to 31/05/2003
**Application to Pumpings estimates**

\[ \Delta \text{Soil} = (\text{Rain} + \text{G. Irrigation} + \text{Pumpings}) - (\text{ET} + \text{Percolation} + \text{Runoff}) \]

Net pumpings = Bulk pumpings - percolation

- 2 simplifying hypothesis in semi-arid plain over one year:
  - No Runoff (R=0)
  - Over a year \( \Delta S = 0 \)

**Net Pumpings** = ET – (Rain + G. Irrigation)
Pumping estimates inside irrigation units

Consumption estimates

Accounted superficial Irrigation

Difference = PUMPINGS

Difference = A rough approximation of raw pumping
Comité Scientifique Français de la Désertification

www.csf-desertification.org
Abou Networking ...

Desert Net International

A Global Network of Scientists for Desertification Research

c/o www.european-desertnet.eu
(temporary address)