Real time soil water measurement technology for improved irrigation management in arid environments

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www.biosaline.org
• Irrigation is by far the largest consumer of water in many arid regions, including the Gulf.

• Achieving high irrigation water productivity requires good on-farm irrigation management, which requires balancing water demand (ET) with water supply (soil water).

• Good measurements of both are important, but technology to measure soil water content (and salinity) has lagged behind that required to estimate ET.
Daily potential evapotranspiration estimated using ICBA weather data (mm/day)

<table>
<thead>
<tr>
<th>Date</th>
<th>ET₀ (mm/day)</th>
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</thead>
<tbody>
<tr>
<td>27-Sep</td>
<td>7.35</td>
</tr>
<tr>
<td>28-Sep</td>
<td>6.54</td>
</tr>
<tr>
<td>29-Sep</td>
<td>8.15</td>
</tr>
<tr>
<td>30-Sep</td>
<td>7.98</td>
</tr>
<tr>
<td>1-Oct</td>
<td>7.37</td>
</tr>
<tr>
<td>2-Oct</td>
<td>6.64</td>
</tr>
<tr>
<td>3-Oct</td>
<td>6.24</td>
</tr>
</tbody>
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http://www.biosaline.org/weather/DailyData.mht
Estimated Daily ET$_0$ at ICBA

Daily ET$_0$ (mm)

1-Oct-10 31-Dec-10 1-Apr-11 1-Jul-11 30-Sep-11
Soil water content

Has been measured for a long time using various techniques.

Electronic, computer, and communication technology is opening the door to new ways to measure and use soil water data.

However, it's important to understand what is being measured, what the data means, and what are its limitations.
Accuracy vs ease of use and continuous monitoring
Sensors based on the dielectric properties of soil (Frequency Domain, Time Domain) exploit the relatively large difference in permittivity between soil water and the other soil constituents (air, minerals)

Dielectric permittivity is affected by:

- Soil water content
- Soil water conductivity
- Soil temperature

\[
SWC = 0.0000043P^3 - 0.00055P^2 + 0.029P - 0.053
\]

Topp et al (1980)
Saturated
Dielectric permittivity is maximum
Bulk conductivity is maximum
Large pores drained. Small pores have water. Reduced dielectric permittivity. Bulk conductivity is lower.
Only very small pores have water. Permittivity and bulk conductivity are near minimum.
Soil water content

- 0 cm
- 10 cm
- 20 cm
- 30 cm
- 40 cm
- 50 cm
- 60 cm
Soil water content with depth and time

10 cm
30 cm
50 cm

5-Jun 10-Jun 25-Jun 5-Jul 15-Jul 25-Jul 4-Aug

SWC (% Volume)

27,000+ measurements
30 July

SWC (% Volume)

10 cm

30 cm

50 cm
Soil Water Content 0-60 cm

SWC (mm)

29-Jun 1-Jul 3-Jul 5-Jul 7-Jul 9-Jul 11-Jul 13-Jul
Change in soil water content during daytime (ET?)

Soil Water Content 0-60 cm

SWC (mm)

29-Jun 30-Jun 1-Jul 2-Jul 3-Jul 4-Jul 5-Jul

Change in soil water content during daytime (ET?)
Soil water content
Soil electrical conductivity
Soil temperature
Bulk electrical conductivity vs soil water content

0 dS/m
Bulk electrical conductivity vs soil water content

Electrical conductivity (dS/m) vs Actual SWC for 0 dS/m and 10 dS/m.
Soil water content and electrical conductivity at 30 cm Irrigated at 100% ET with water of EC 10 dS/m.
\[ EC_a = \left[ \left( \Theta_s + \Theta_{ws} \right)^2 \frac{EC_{ws}}{\Theta_s} + \frac{EC_s}{\Theta_{ws}} \right] + \left( \Theta_w - \Theta_{ws} \right) EC_{wc} \]

Pore water electrical conductivity and soil water content at 30 cm
Applications

• On-farm monitoring of irrigation performance and diagnostic analysis

• Irrigation research

• Development, calibration and verification of research and management models
Thank you