Optimization of triggered irrigation using a system dependent boundary condition in HYDRUS 2D/3D

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How to irrigate?

<table>
<thead>
<tr>
<th></th>
<th>Israel</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drip</td>
<td>70%</td>
<td>7%</td>
</tr>
<tr>
<td>Sprinkler</td>
<td>30%</td>
<td>48%</td>
</tr>
<tr>
<td>Surface</td>
<td>0%</td>
<td>45%</td>
</tr>
</tbody>
</table>

Special boundary conditions in HYDRUS 2D/3D

A subsurface drip boundary condition (with a drip characteristic function reducing irrigation flux based on the back pressure)

A surface drip boundary condition with dynamic wetting radius

When to irrigate?
How much to irrigate?

Current estimation: some 65% of water used for agriculture is not utilized by plants→ Evaporation, drainage, runoff, leakage in systems

Challenge - To produce as much food as possible using and effecting as little water as possible
Triggered irrigation boundary condition in HYDRUS 2D/3D

**Triggered Irrigation** - irrigation is triggered by HYDRUS when the pressure head at a particular observation node drops below a specified value.

Measured and simulated matric heads during 96 h of the experiments with potential transpiration rates of a 3 mm day^{-1} and b 5 mm day^{-1}. The irrigation threshold (a dotted line) was constant and equaled -40 cm.

Measured and simulated matric heads during 96 h of the experiments with potential transpiration rate of 3.5 mm day^{-1} and with irrigation amounts of a 4 mm and b 1 mm. The irrigation threshold is indicated with a dotted line.
Ratio of irrigation and potential transpiration [-] in sandy loam and loam soils for potential transpiration rates of 4 and 8 mm day⁻¹ as a function of the irrigation threshold. The irrigation amount was 4 mm per irrigation event.

Irrigation thresholds that yield \( I T_p \) [-] values of 1 as a function of potential transpiration for sandy loam and loamy soils with a water volume per irrigation pulse of 4 mm.

Sensor placement in heterogeneous soils:

Mean and coefficient of variation (CV) of simulated matric head at four distances: 0 cm (A), 10 cm (B), 20 cm (C), and 30 cm (D) from the dripper during 1 week simulation.
Effect size index (d) of irrigation events on matric head influenced by tensiometer distance from subsurface drippers in sandy loam and loam soils.

\[
d = \frac{\bar{x}_2 - \bar{x}_1}{s}
\]

- \( \bar{x}_1, \bar{x}_2 \) mean matric heads after and before irrigation, respectively
- S is the pooled standard deviation

Saline water irrigation scheduling

Conclusions:

The results show that HYDRUS 2D/3D predictions of irrigation events and matric heads are in good agreement with experimental data, and that the code can be used to optimize irrigation thresholds and water amounts applied in an irrigation episode to increase the efficiency of water use.

Irrigation threshold must change with increasing evapotranspiration.

Variability of matric head measurements increases substantially during changes in soil water status.

Algorithm which turns off the irrigation when the matric head rises above a preset value should be avoided because of the increase in variation of the tensiometer measurements during irrigation.

As the distance between the controlling tensiometer and the dripper grows, so does the variability of the total water irrigated, and more tensiometers are needed to correctly control the irrigation system.

When triggering saline water irrigation care should be taken for facilitating salt leaching.

<table>
<thead>
<tr>
<th>Distance from dripper (cm)</th>
<th>Average ( \bar{I_T}^{-1} )</th>
<th>Standard deviation</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.99</td>
<td>0.00</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>1.11</td>
<td>0.06</td>
<td>5.4</td>
</tr>
<tr>
<td>20</td>
<td>2.06</td>
<td>0.65</td>
<td>31.6</td>
</tr>
<tr>
<td>30</td>
<td>3.63</td>
<td>1.83</td>
<td>50.5</td>
</tr>
</tbody>
</table>

Average and standard deviation of irrigation-to-potential transpiration ratio (\( \bar{I_T}^{-1} \)) and drainage-to-total irrigation ratio (\( \bar{D} \bar{I}^{-1} \)) during 1 week simulation, as a function of tensiometer distance from the dripper.
Thank you!

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