Incorporating land-atmospheric-vegetation feedbacks into subsurface models used for agriculture water management.

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Conditions Effecting Soil Moisture Dynamics in the Land-Atmosphere-Vegetation Continuum

- Soil type and heterogeneity
- Soil disturbance and macroporosity
- Vegetation type and distribution
- Micro-topographic features
- Atmosphere conditions (e.g. turbulence, temperature, humidity)

Models need to factor in feedback processes occurring between the soils, plants and the atmosphere.

- Soil type and heterogeneity
- Soil disturbance and macroporosity
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- Micro-topographic features
- Atmosphere conditions (e.g. turbulence, temperature, humidity)

Purpose of ongoing research....

- The fundamental study of soil moisture processes at land/atmospheric interface at all relevant scales is not possible in the field.
- Vegetation further complicates the problem as plants have irregular geometries in the root zone and atmosphere which constantly change.
- To test an alternative experimental approach that allowing soil moisture dynamics in the presence of plants to be fundamentally studied.

Multi-scale experimental testing

<table>
<thead>
<tr>
<th>Source Zone</th>
<th>Flow Field</th>
<th>1,2 and 3-D test dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D Tank</td>
<td>1 to ~10 m</td>
<td>L.2 and 3-D test dimensions</td>
</tr>
</tbody>
</table>

Illangasekare, 2015. AGU Langbein Lecture

Low Velocity Boundary Layer Climate Wind Tunnel/Porous Media Facility

<table>
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<tr>
<th>Test section in environmental chamber</th>
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<table>
<thead>
<tr>
<th>Climate Control Capabilities</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed</td>
<td>0.0 – 0.001 m/s</td>
</tr>
<tr>
<td>Temperature</td>
<td>-4.4 – 45 ± 1 °C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>5 – 95 ± 3 %</td>
</tr>
</tbody>
</table>

Illangasekare, 2015. AGU Langbein Lecture
Coupling the soil tank to wind tunnel

Effects of Surface Conditions

Analog for a Plant

- **Similarity**
  - Presents obstruction to airflow
  - Provides “root” water suction
  - Offers surfaces for “transpiration”
  - Soil moisture dependent transpiration rates

- **Reduced Complexity**
  - No growth during experiments
  - No nutrient input requirements
  - Easily definable geometry
  - Bluff body flow aerodynamics applicable

Experimental Design

Do plants talk to the atmospheric boundary layer to capture soil-water?

Coupled Soil Moisture and Relative Humidity

- **Soil Moisture Accuracy:** ±3%
- **Relative Humidity Accuracy:** ±2%
Atmospheric X-Velocity Measurements

Velocity Accuracy: ±0.01 m s⁻¹

Expected Flow Interception

Soil Moisture Signal

Asymmetry of soil moisture

Relative Humidity – Soil Moisture (affected by spacing)

Temperature – Temperature

The case for multidimensional modeling of coupled land-atmospheric-vegetation processes: use of multidimensional and multiscale experiments
Conclusions

• Intermediate (intermediary) scale is a useful tool.
• Use of the blocks is a first step in reduced complexity.
• Approach allows for the study of interaction plants (atmosphere, subsurface & feed backs)
• Preliminary data shows the plant interacting with the boundary layer to capture soil-water.
• Need for a new types of models for agriculture water management.
• Need to develop up-scaling and down-scaling methods.