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

Tissa H. Illangasekare[1], Andrew C. Trautz[1] and Rainer Helmig[3]

[1]*Center for Experimental Study of Subsurface Environmental Processes, Colorado School of Mines*

[2]*Department of Civil and Environmental Engineering, Princeton University*

[3]*Department of Hydromechanics and Modeling of Hydrosystems, University of Stuttgart, Germany*

CESEP
Center for Experimental Study of Subsurface Environmental Processes

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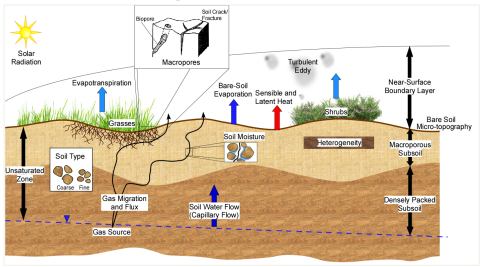
Conditions Effecting Soil Moisture Dynamics in the Land-Atmosphere-Vegetation Continuum



(Trautz and Illangaskare,2015)

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

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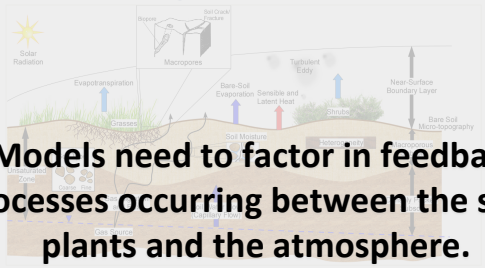


Models need to factor in feedback processes occurring between the soils, plants and the atmosphere.

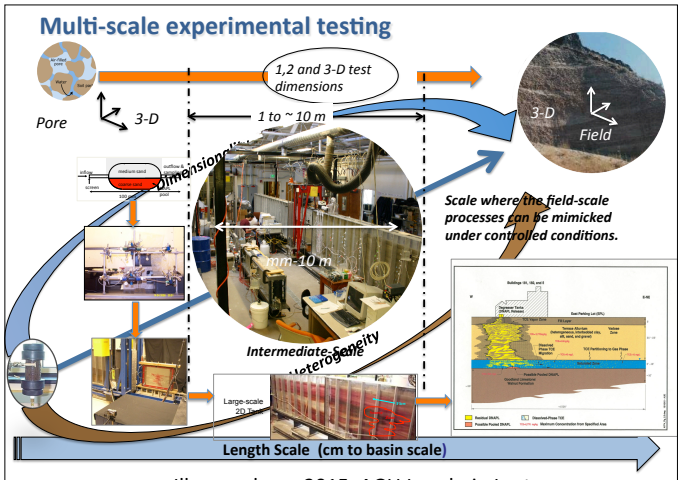
(Trautz and Illangaskare,2015)

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

Purpose of ongoing research….

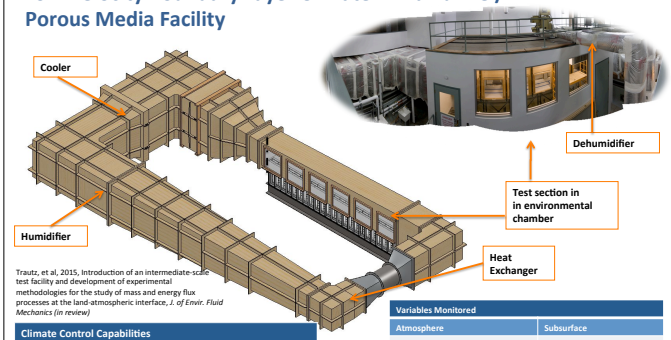
- The fundamental study of soil moisture processes at land/atmospheric interface at all relevant scales is not possible in the field.
- Vegetation further complicates the problem as plants have irregular geometries in the root zone and atmosphere which constantly change.
- To test an alternative experimental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

Multi-scale experimental testing



Illangasekare, 2015. AGU Langbein Lecture

Low Velocity Boundary Layer Climate Wind Tunnel/ Porous Media Facility

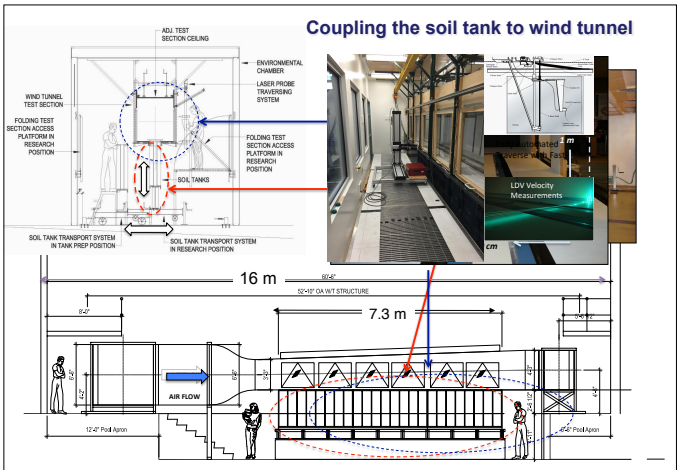


Trautz, et al, 2015, Introduction of an intermediate-scale test facility and development of experimental methodologies for the study of mass and energy flux processes at the land-atmospheric interface, *J. of Envir. Fluid Mechanics (in review)*

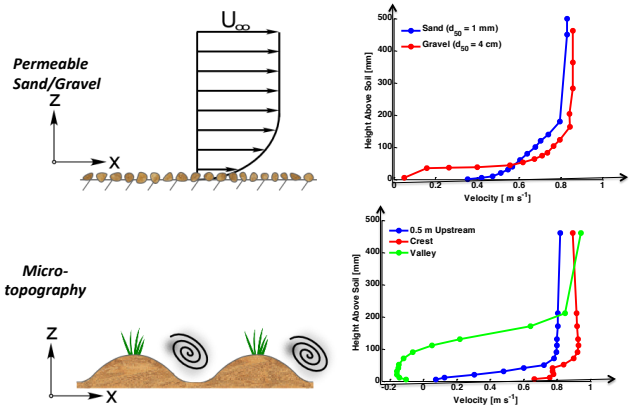
Climate Control Capabilities	
Wind Speed	0.8 – 9.6 ± 0.01 m s^{-1}
Temperature	-4.4 – 45 ± 1 ˚C
Relative Humidity	5 – 95 ± 3 %

Variables Monitored	
Atmosphere	Subsurface
Air Temperature	Soil Temperature
Relative Humidity	Soil Moisture
Atmospheric Pressure	Soil Air Pressure
Wind Speed	Evaporation Rate
Gas Concentration	Gas Concentration

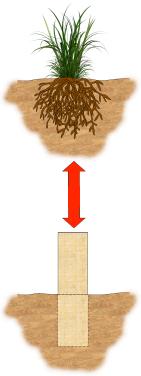
Coupling the soil tank to wind tunnel



Effects of Surface Conditions



Analog for a Plant



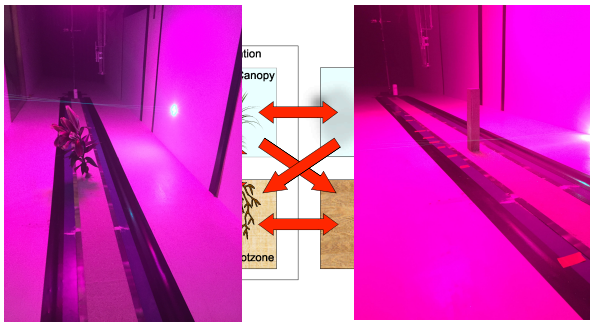
Similarity

- 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

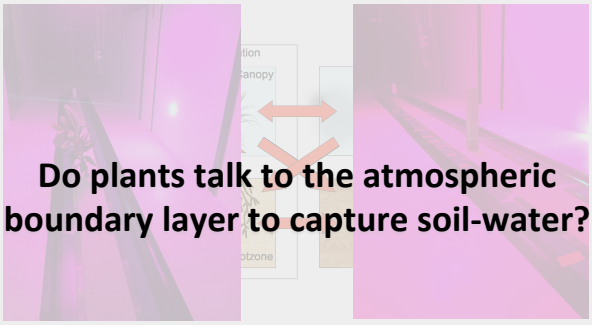
Experimental Design



Oriental Lily
(*Lilium orientalis*)

Limestone Block
(*Indiana Limestone*)

Experimental Design

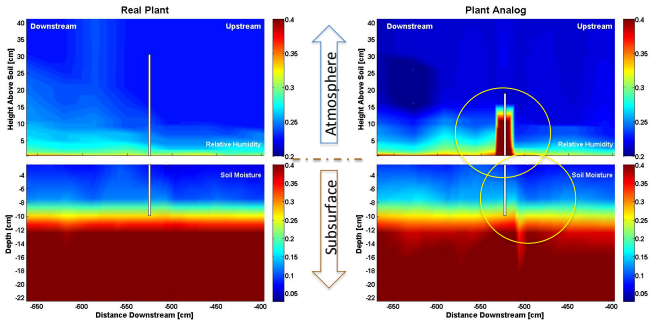


Do plants talk to the atmospheric boundary layer to capture soil-water?

Oriental Lily
(*Lilium orientalis*)

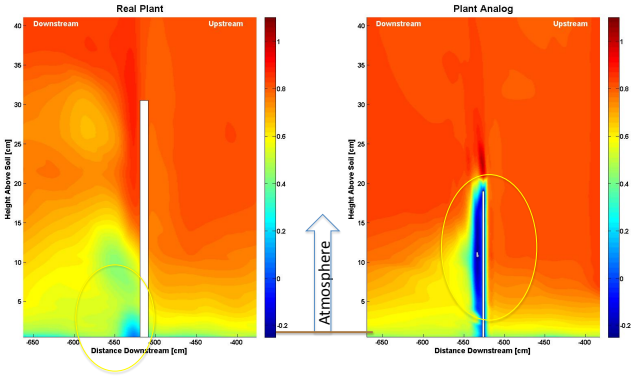
Limestone Block
(*Indiana Limestone*)

Coupled Soil Moisture and Relative Humidity



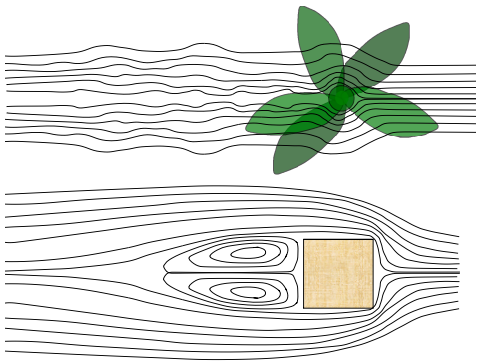
Soil Moisture Accuracy: ±3%
Relative Humidity Accuracy: ±2%

Atmospheric X-Velocity Measurements

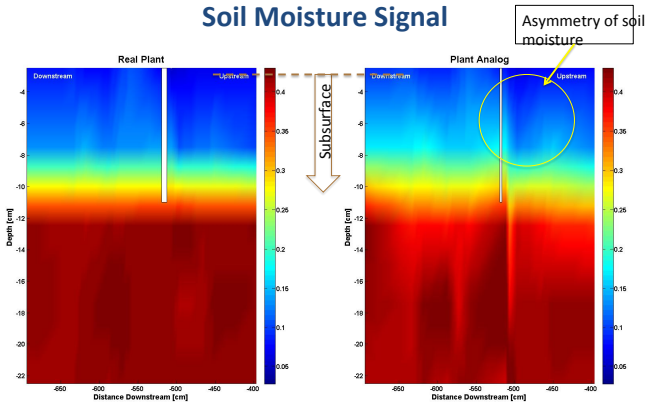


Velocity Accuracy: ± 0.01 $m\,s\hat{}-1$

Expected Flow Interception



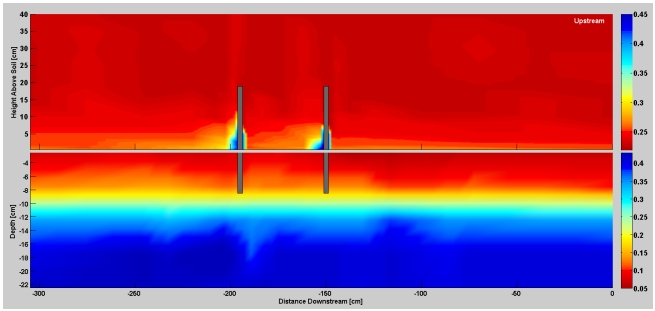
Soil Moisture Signal



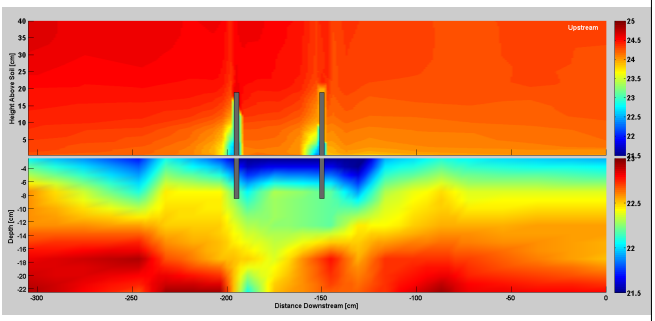
Plant

Analog

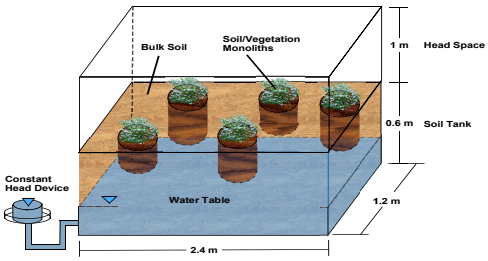
Relative Humidity – Soil Moisture (affected by spacing)



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.