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Assessment of Spatial Variably Saturated Flow by Irrigation Moisture Sensors in 2-Dimensions using COMSOL-Multiphysics 4.1

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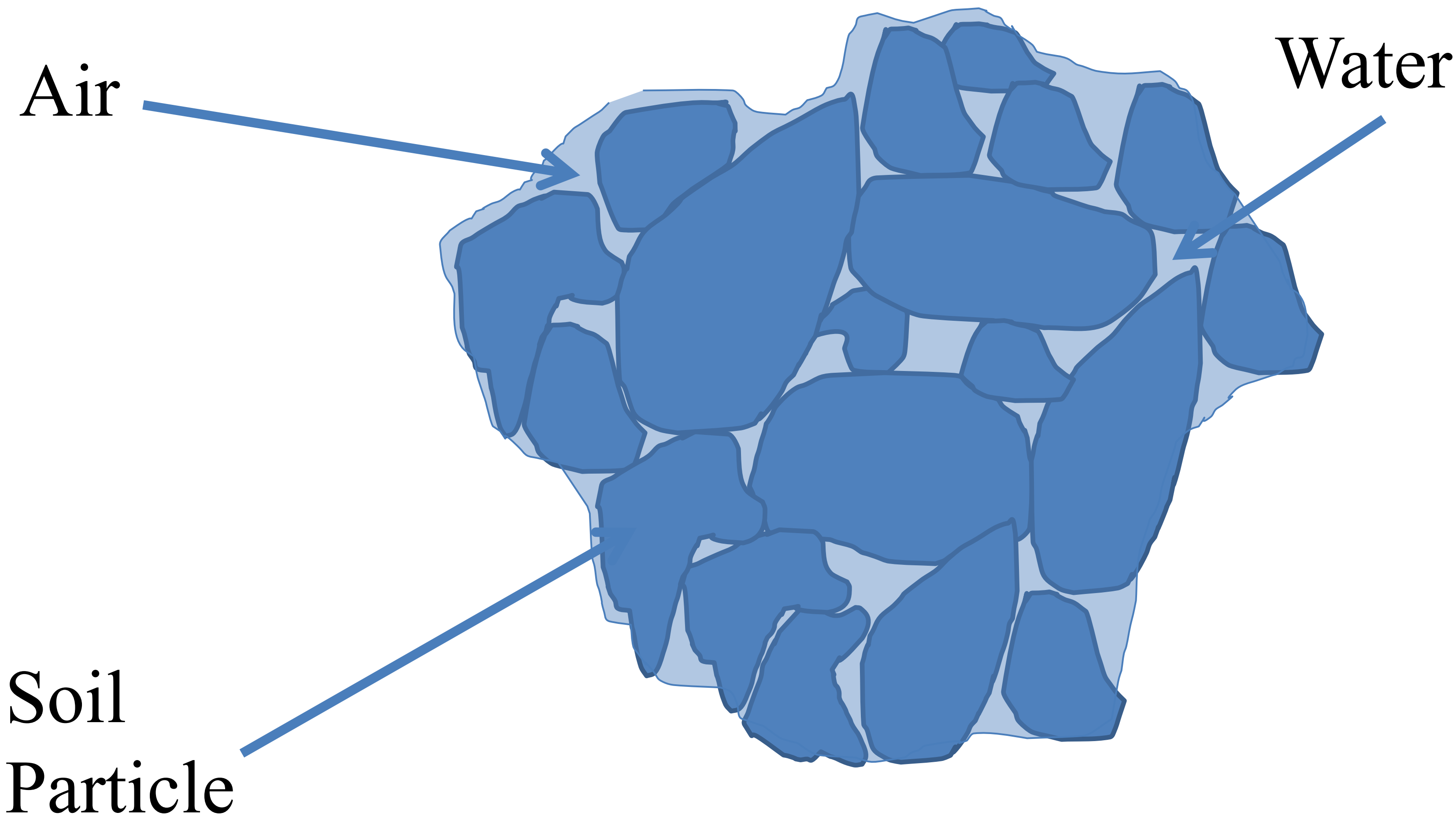
Problem Statement



Problem Statement

- Soil's capacity to transmit and store moisture as water enter and fill the pore spaces

- Major challenges using Richard's Equation is the complexity and non-linearity of its coefficients

Objective of Study

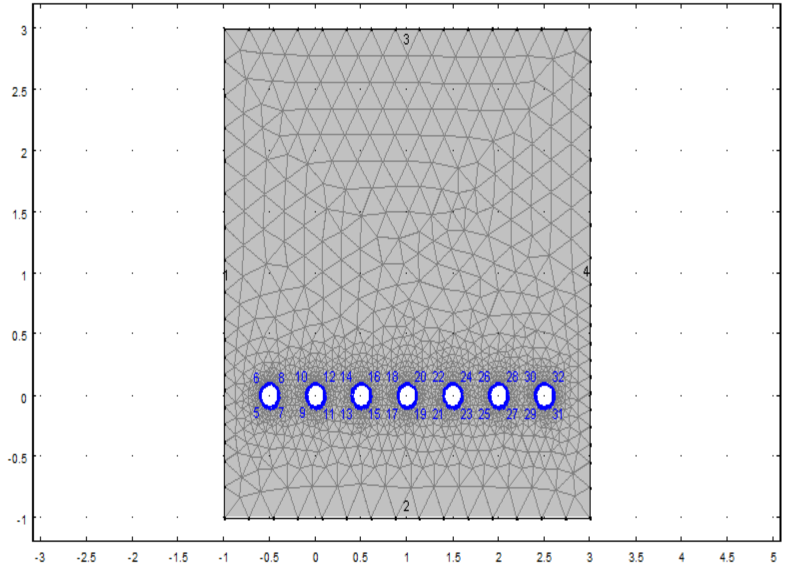
Determination and visualization of the localized effective saturation distribution around irrigation sensors after various time steps.

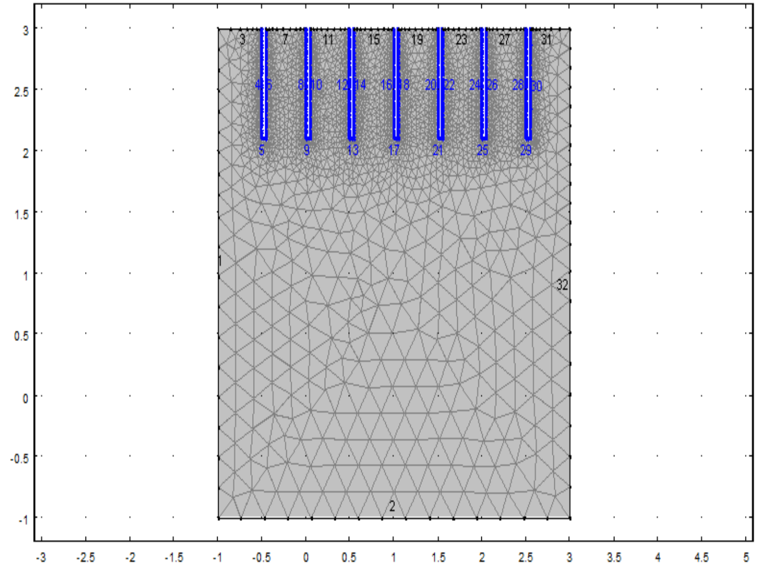
Modeling Procedure

- A hypothetical soil column 4 m by 4 m, 7 irrigation sensors inserted and spaced at 0.5 m

- Homogeneous soil properties with characteristics taking from “Solved with COMSOL Multipysics 4.1. Variable Saturated Flow”
- Richards Equation interface in Comsol was applied

Geometry and Meshing



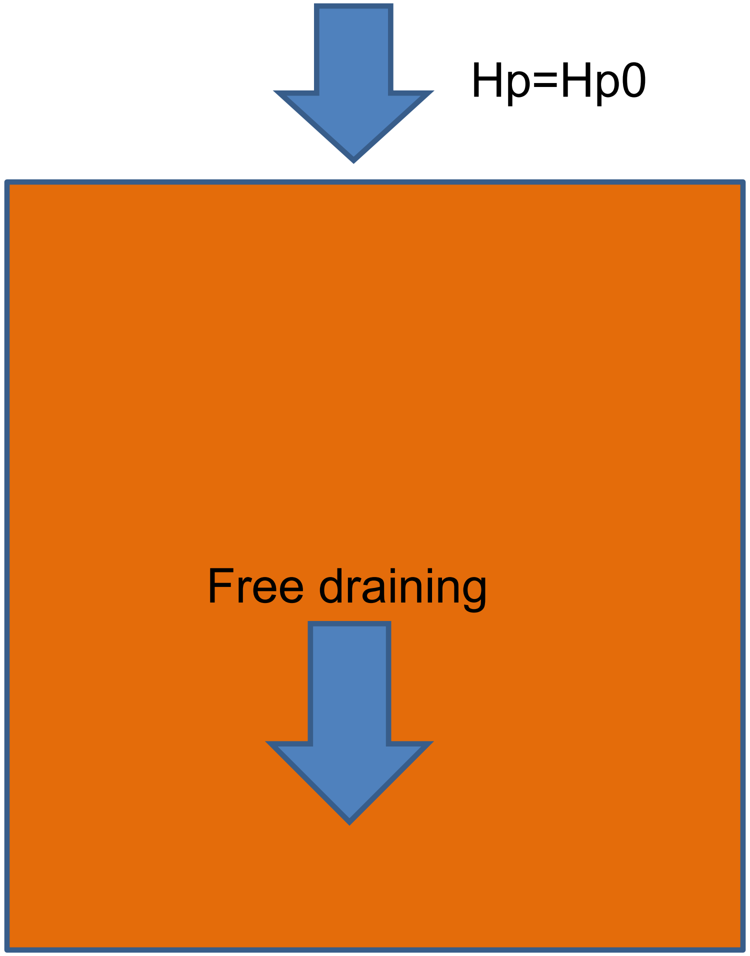


Governing Equations

$$[C + \mathrm{Se}S]\frac{\partial H_p}{\partial t} + \nabla \cdot [-K\nabla(H_p + D)] = 0$$

- H_p = Pressure head [m]
- C = Specific Capacity [m^{-1}]
- S_e = Effective Saturation
- S = Storage Coefficient [m^{-1}]
- t = time [s]
- K = Hydraulic Conductivity [ms^{-1}]
- D = Coordinate (x,y,z) for the vertical elevation [m]

Boundary Conditions



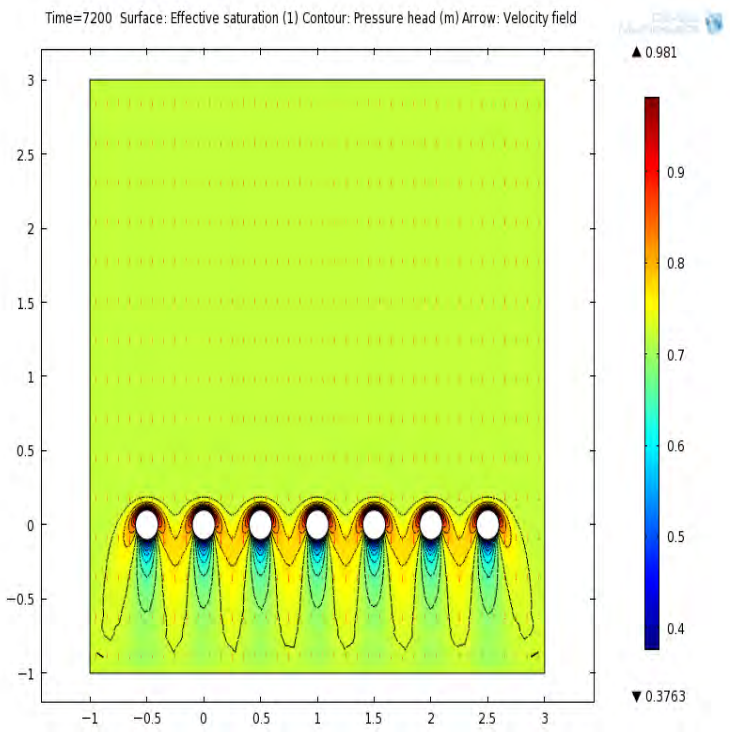
Hp0 = initial pressure head which is constant through the column

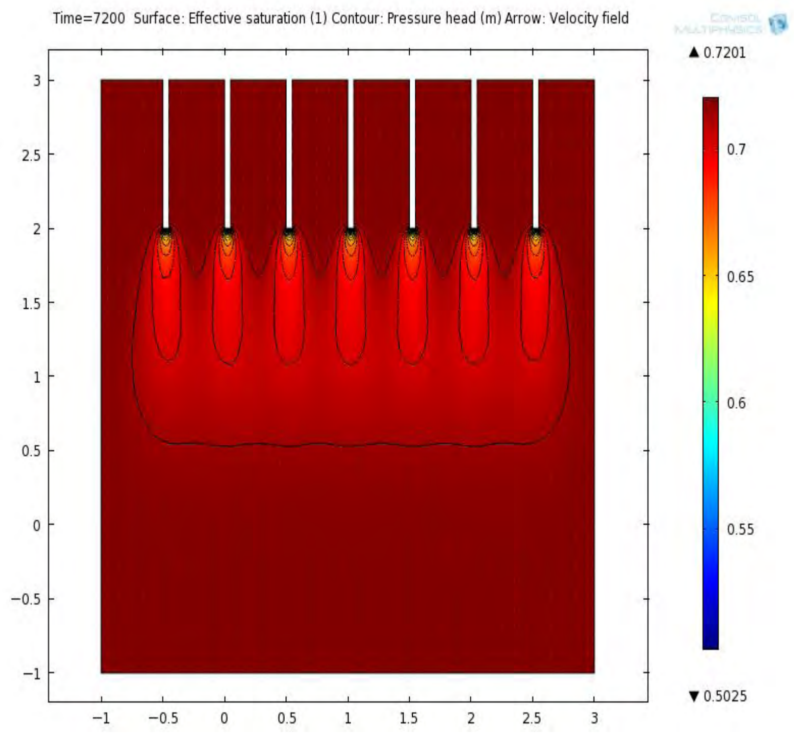
Numerical Simulations

- The Richard’s Equation interface which automated van Genutchen formulae in Comsol Multiphysics was used

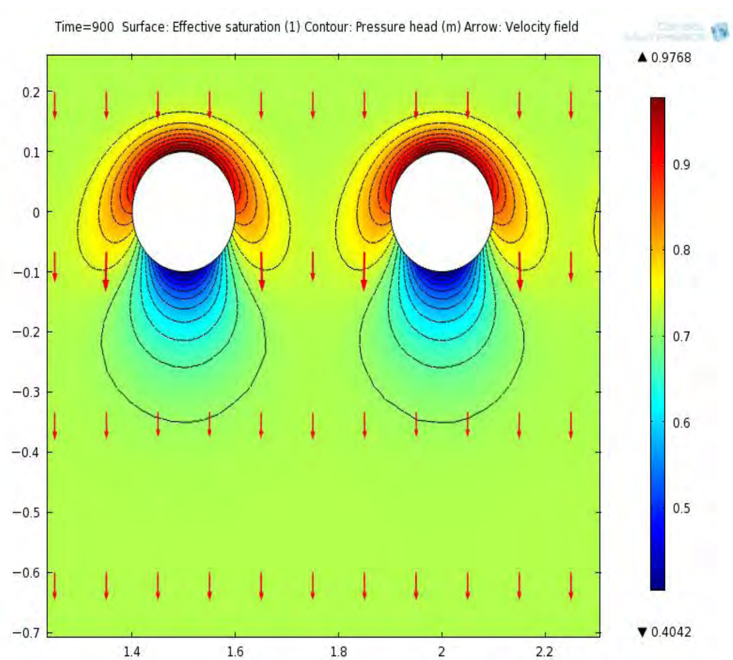
- Time dependent for 60, 300, 900, 1200, 7200 seconds

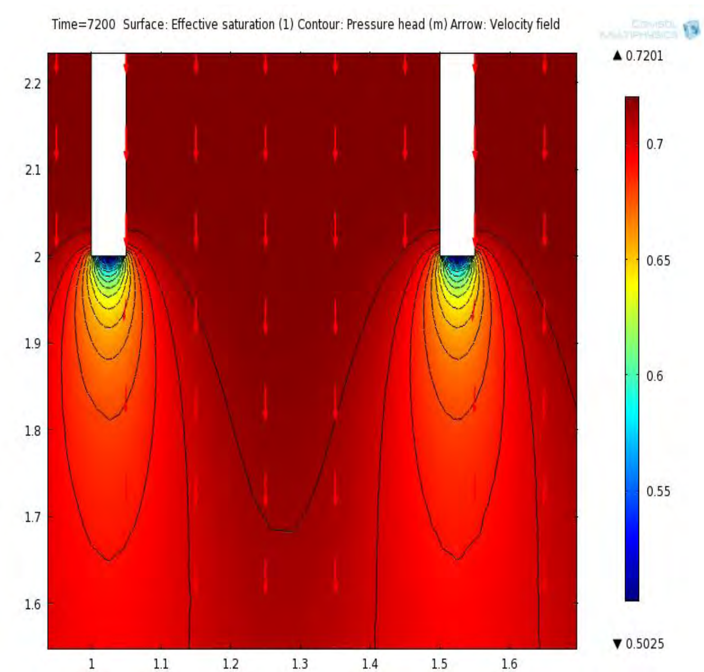
Results


Time=7200 Surface: Effective saturation (1) Contour: Pressure head (m) Arrow: Velocity field
▲ 0.981
▼ 0.3763

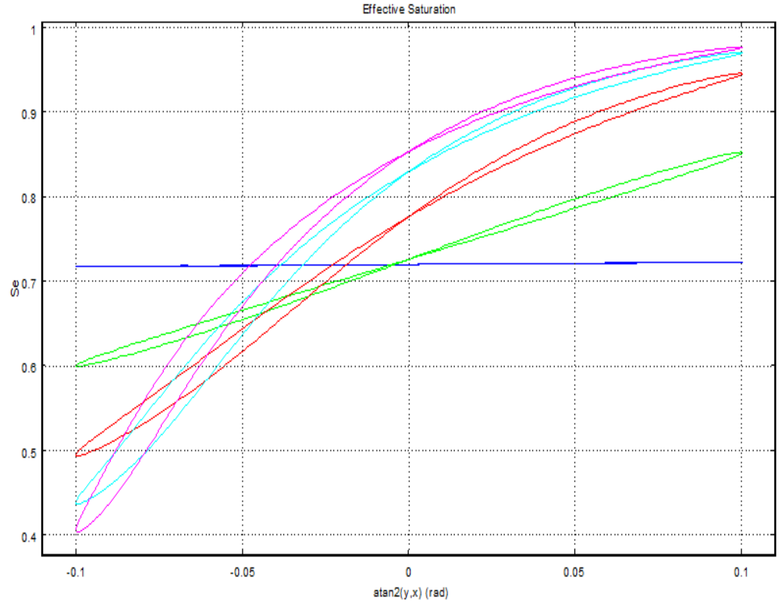

Time=7200 Surface: Effective saturation (1) Contour: Pressure head (m) Arrow: Velocity field
▲ 0.7201
▼ 0.5025

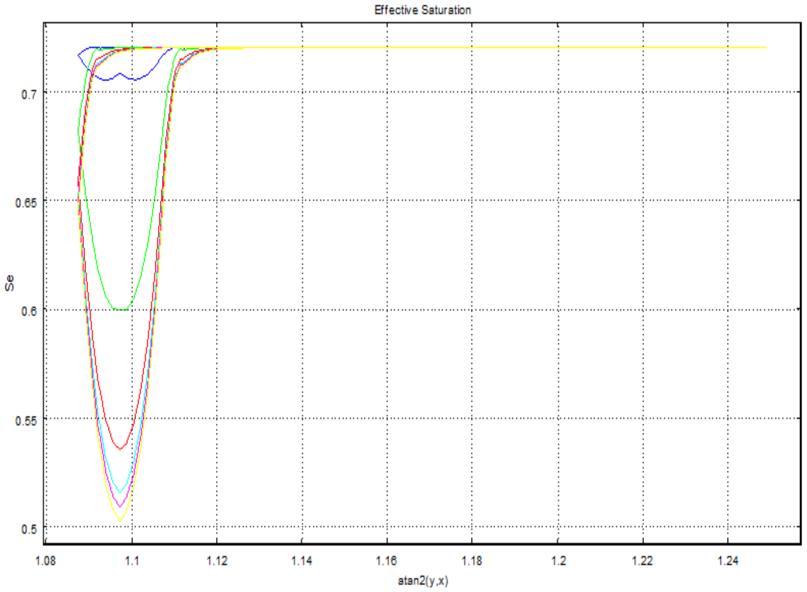
Results


Time=900 Surface: Effective saturation (1) Contour: Pressure head (m) Arrow: Velocity field
▲ 0.9768
▼ 0.4042
0.9
0.8
0.7
0.6
0.5
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
−0.6
−0.7
1.4
1.6
1.8
2
2.2


Time=7200 Surface: Effective saturation (1) Contour: Pressure head (m) Arrow: Velocity field
▲ 0.7201
▼ 0.5025
0.7
0.65
0.6
0.55
2.2
2.1
2
1.9
1.8
1.7
1.6
1
1.1
1.2
1.3
1.4
1.5
1.6

Results


Effective Saturation
Se
1
0.9
0.8
0.7
0.6
0.5
0.4
-0.1
-0.05
0
0.05
0.1
atan2(y,x) (rad)


Effective Saturation
Se
0.7
0.65
0.6
0.55
0.5
1.08
1.1
1.12
1.14
1.16
1.18
1.2
1.22
1.24
atan2(y,x)

Relevance of Results

http://www.landscapeirrigation.com/

http://www.greenhousegrower.com

Conclusion

- COMSOL Multiphysics have been demonstrated as a capable tool to solve this problem

- Location of sensors and what orientation to use in irrigation water management experiments are very important for sustainable agriculture.

Acknowledgement

Drs. Andrew Hinnel, Alex Furman and Ty Ferre (Department of Hydrology and Water Resources, University of Arizona) who originally worked the problem in PDE interfaces

References

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Questions