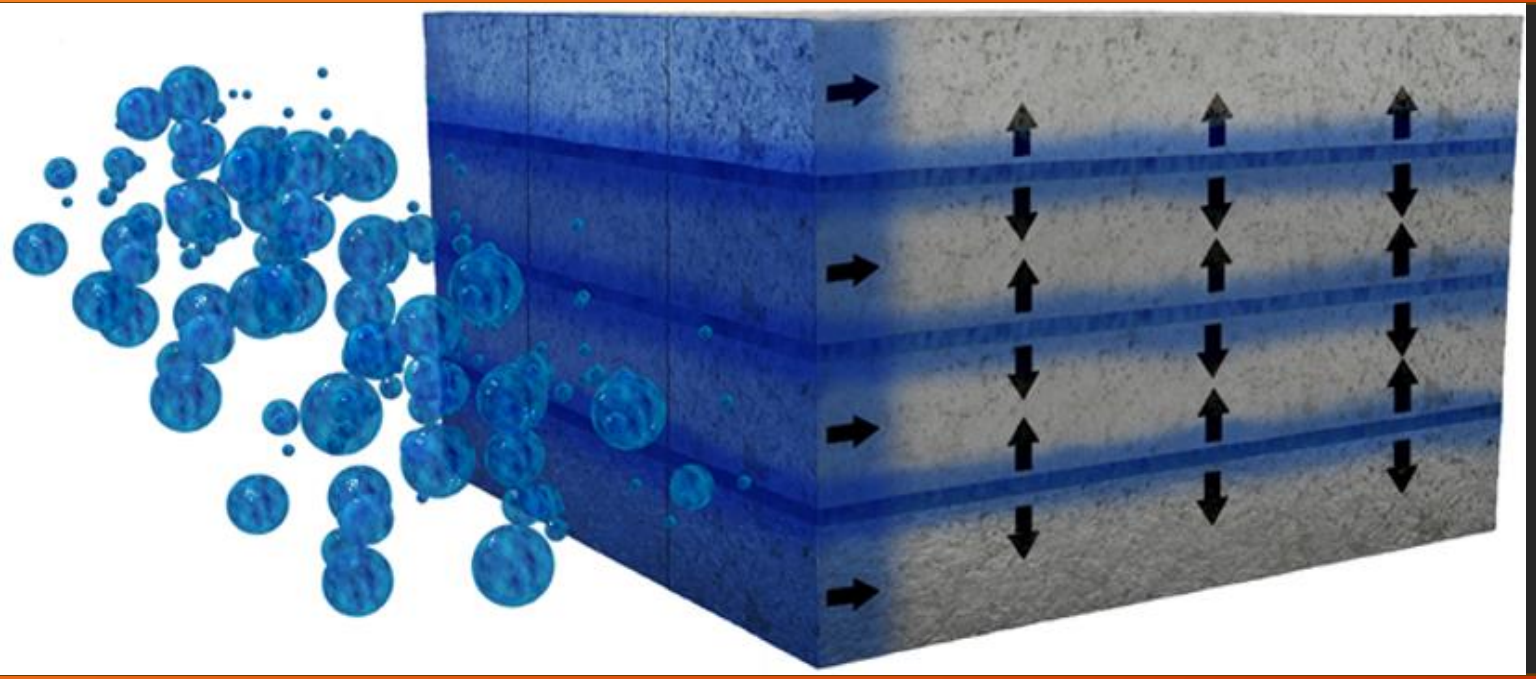
Oregon State University



Modeling Fluid Absorption in Anisotropic 3D-Printed Cement-Based Materials

Gupta et al., 2023

April 2nd, 2025

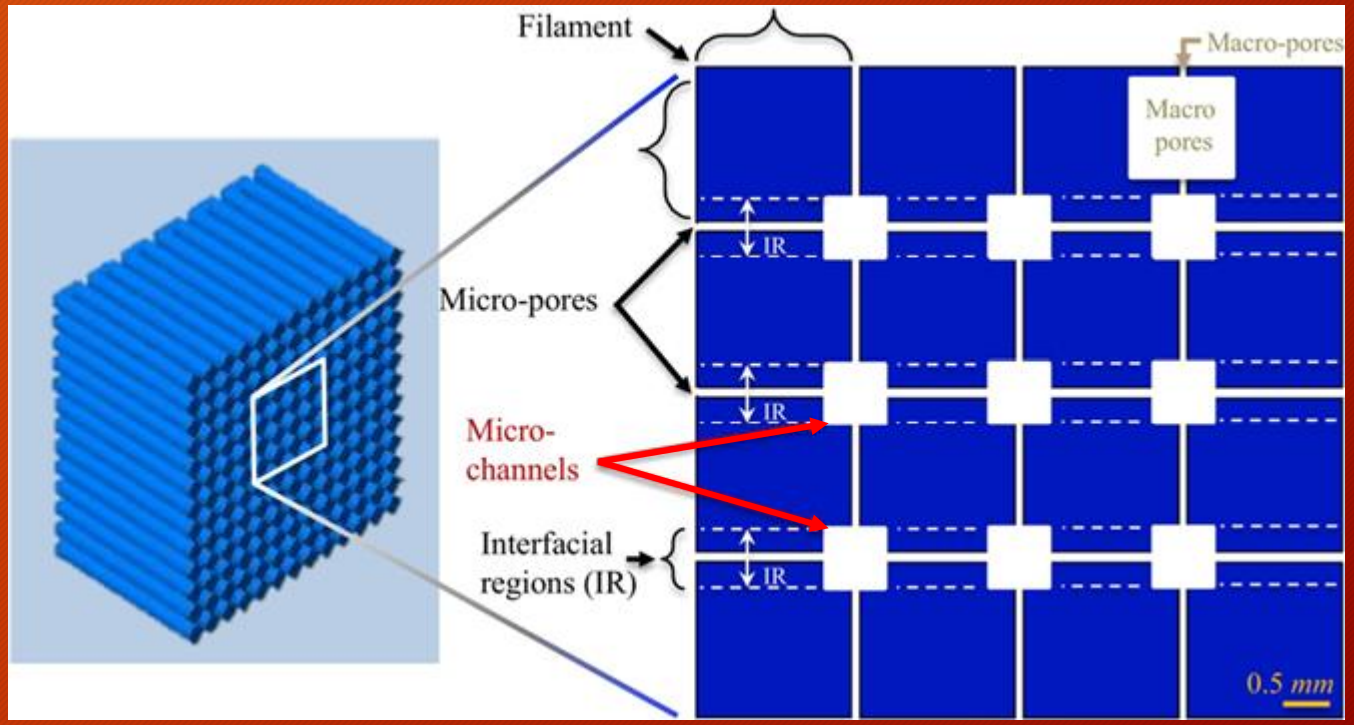
Tony de Siqueira Neto, O. Burkan Isgor, W. Jason Weiss

Collaborative Research Project

- Reza Moini, Ph.D., Assistant Professor of Civil and Environmental Engineering
- Shashank Gupta, Ph.D. Candidate

Layered Systems and Anisotropy

Modified from Moini et al., 2021



Layered Systems and Anisotropy

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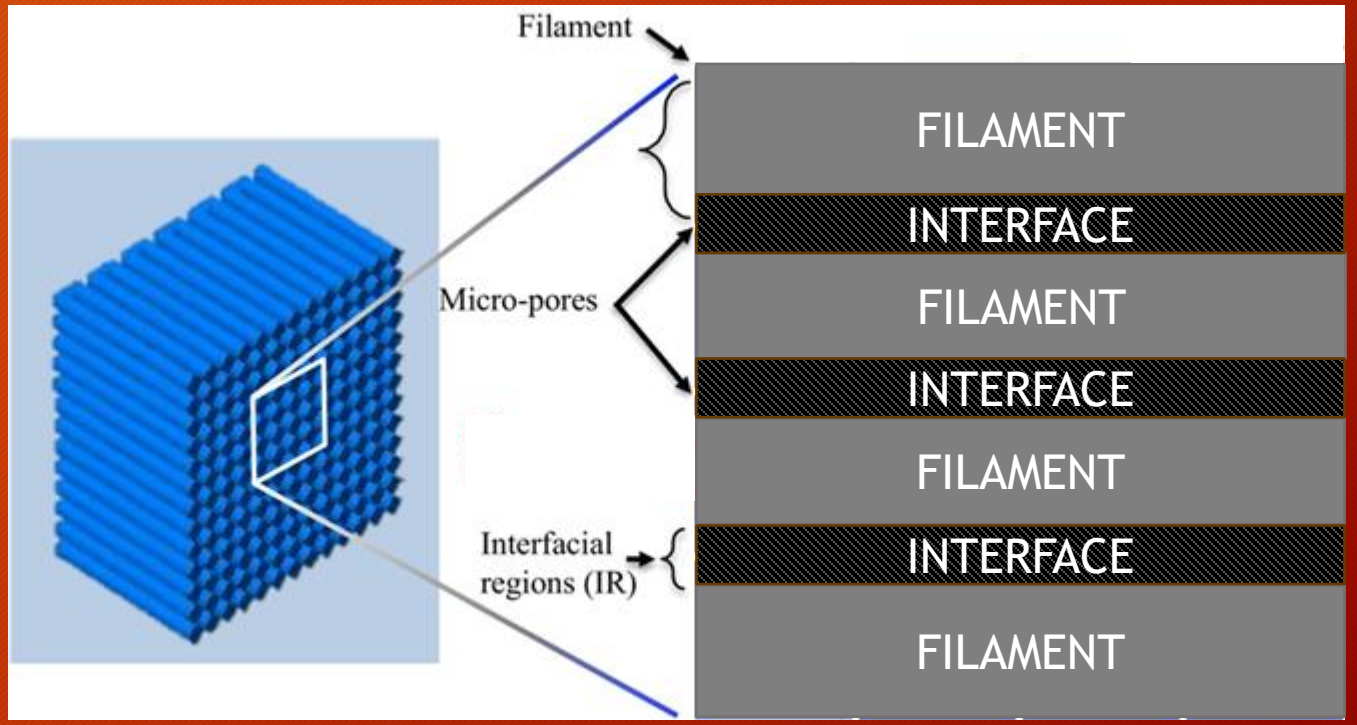
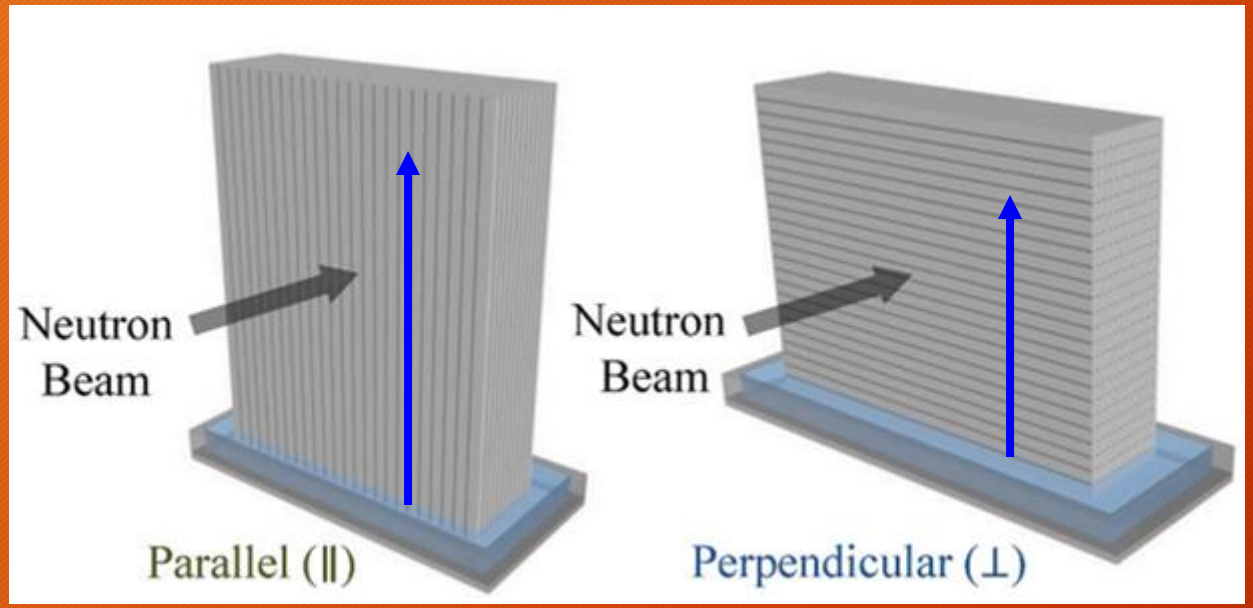
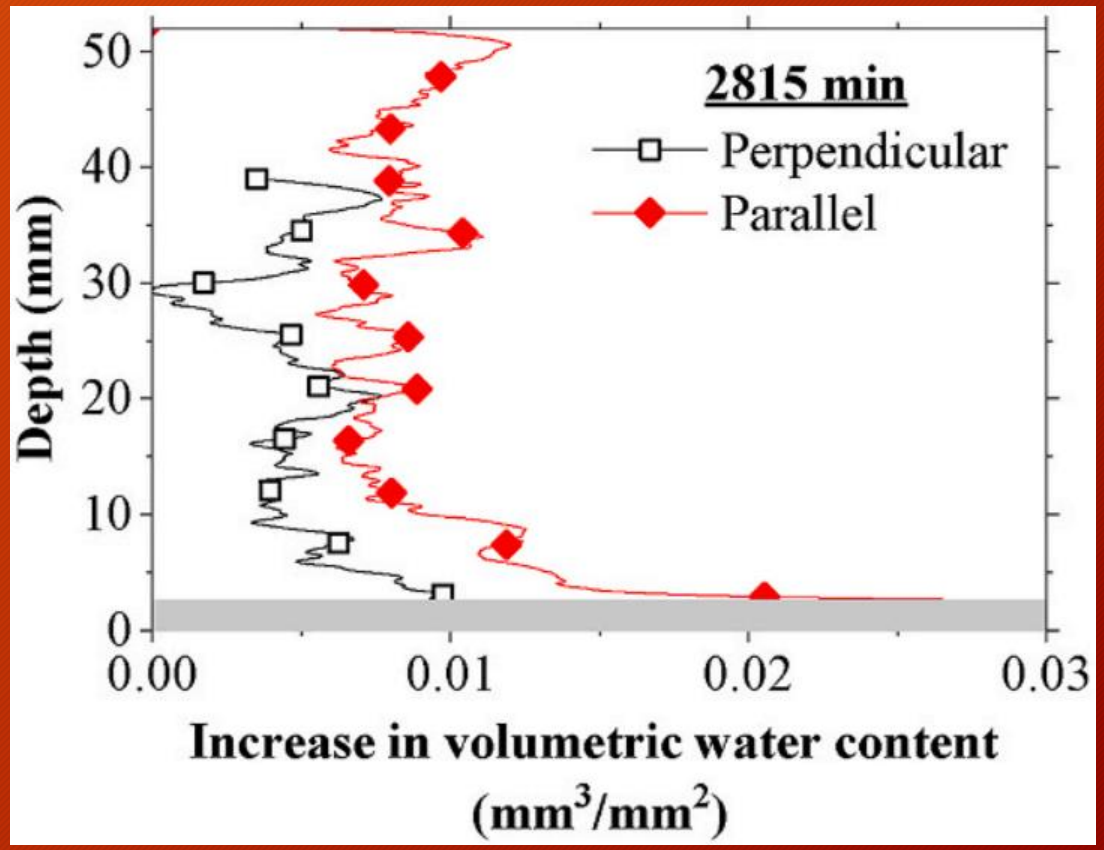


Fluid Absorption Experiments



Gupta et al., 2023



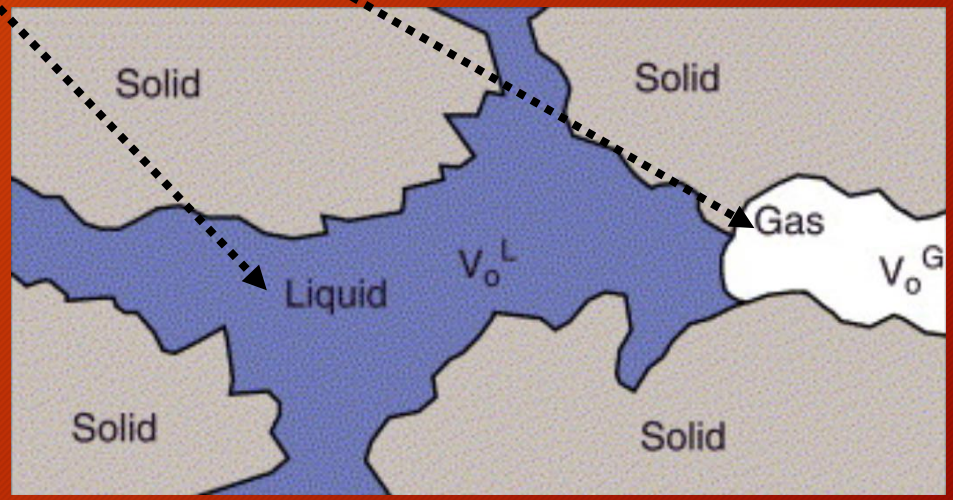
Fluid Absorption Modeling

$$\frac{\partial S}{\partial h}\frac{\partial h}{\partial t} = \frac{\partial}{\partial x}\left(\left(D_l(h) + D_v(h)\right)\frac{\partial S}{\partial h}\frac{\partial h}{\partial x}\right)$$

Degree of pore saturation (S) changing with time (t) and in space (x)

Fluid Absorption Modeling

$$\frac{\partial S}{\partial h}\frac{\partial h}{\partial t} = \frac{\partial}{\partial x}\left(\left(D_l(h) + D_v(h)\right)\frac{\partial S}{\partial h}\frac{\partial h}{\partial x}\right)$$



Samson et al., 2005

Fluid Absorption Modeling

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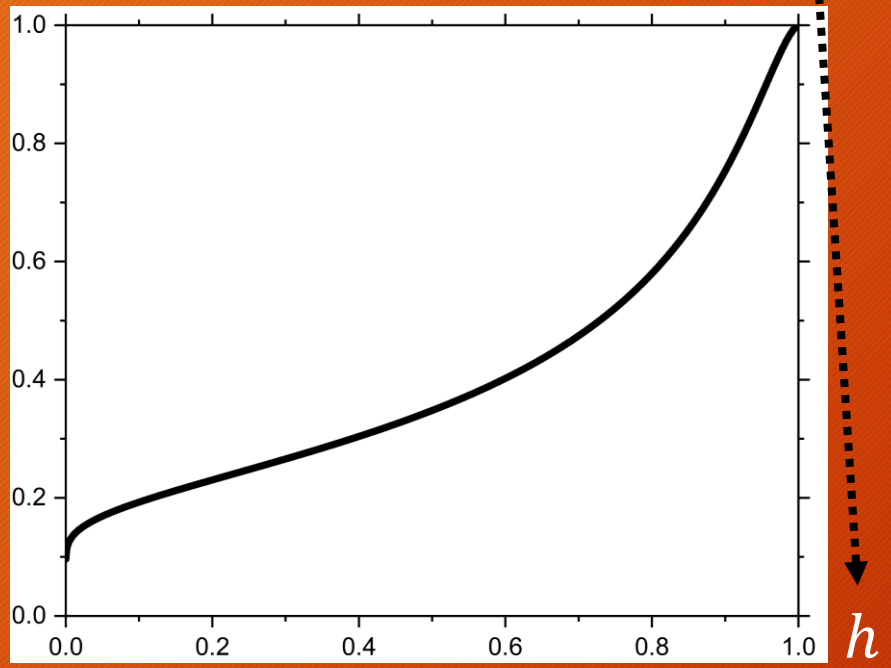
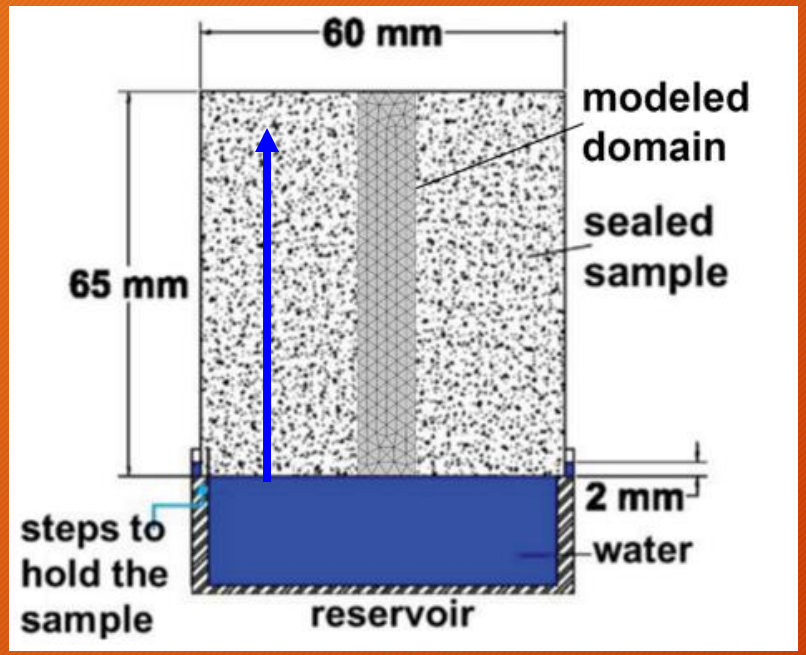


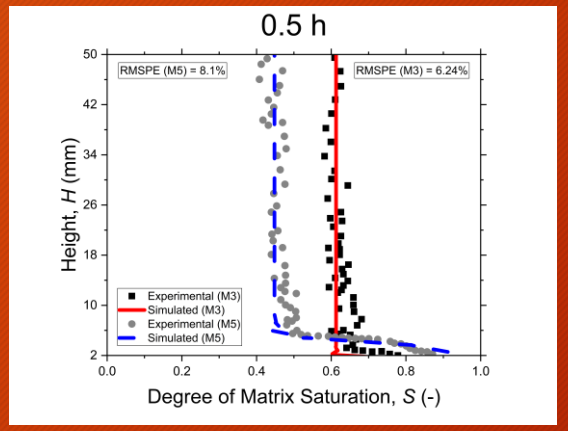
Samson et al., 2005

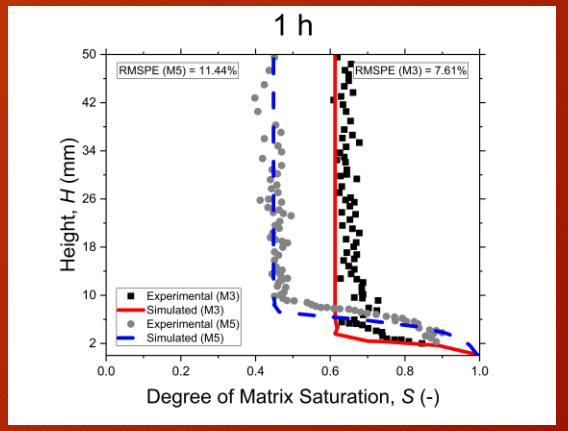
Model Validation

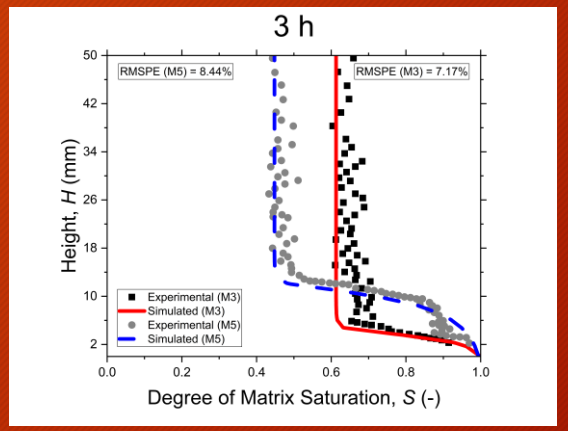
Moradllo et al., 2018

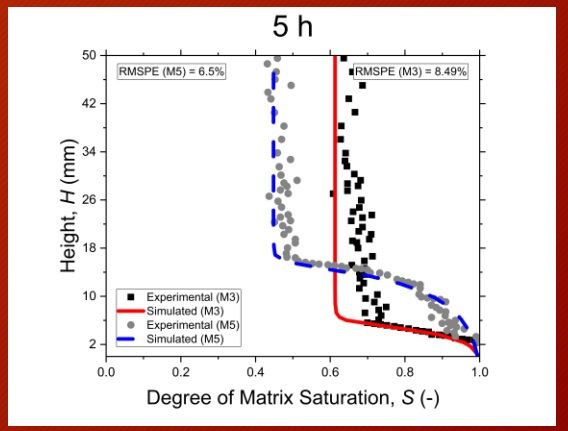


- 0.3 w/cm
- 0.5 w/cm



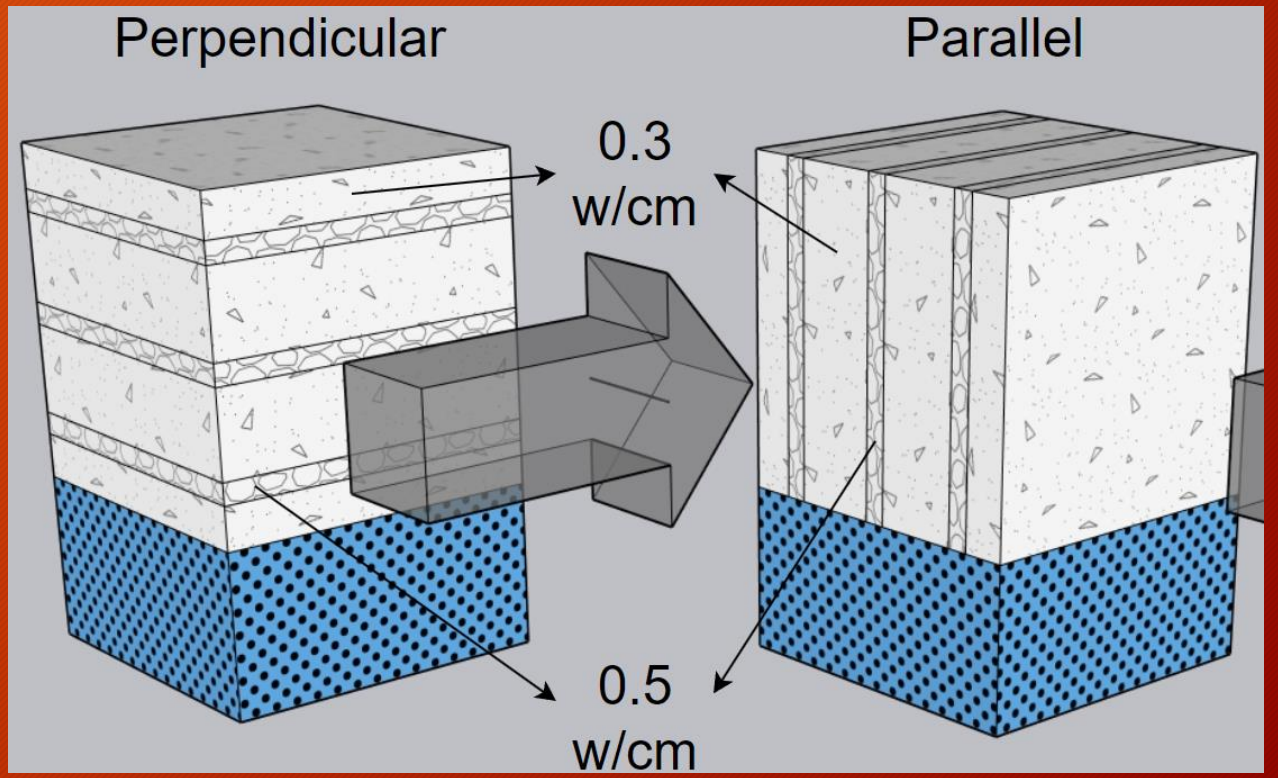






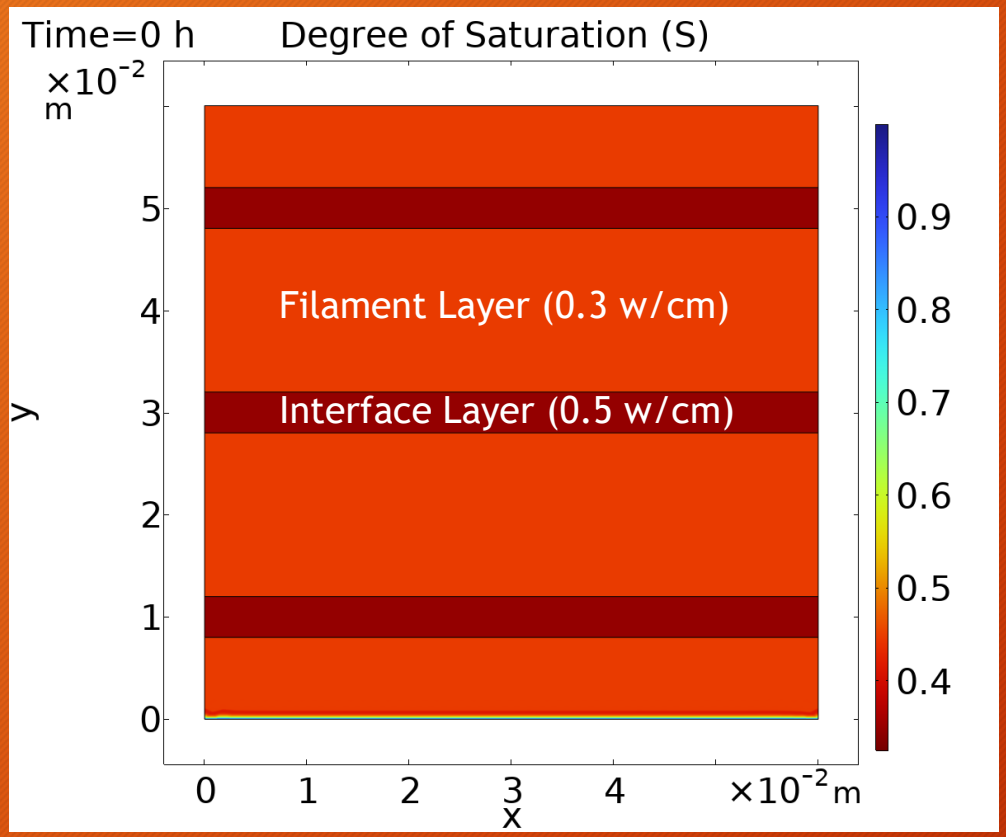
Simulated Layered Geometry

- Printed filaments (8 mm, 0.3 w/cm)
- Interfaces (2 mm, 0.5 w/cm)
- Degree of pore saturation (S) 2D contour plots



Absorption Simulations - Layered

- Perpendicular orientation



Absorption Simulations - Layered

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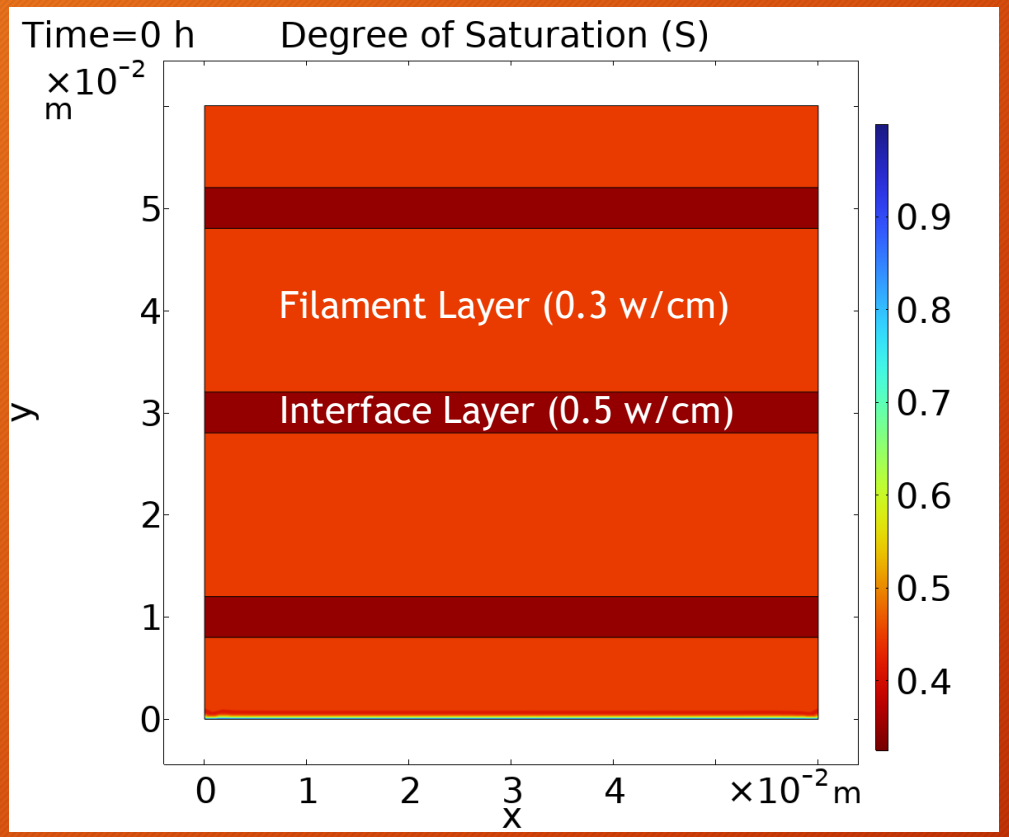
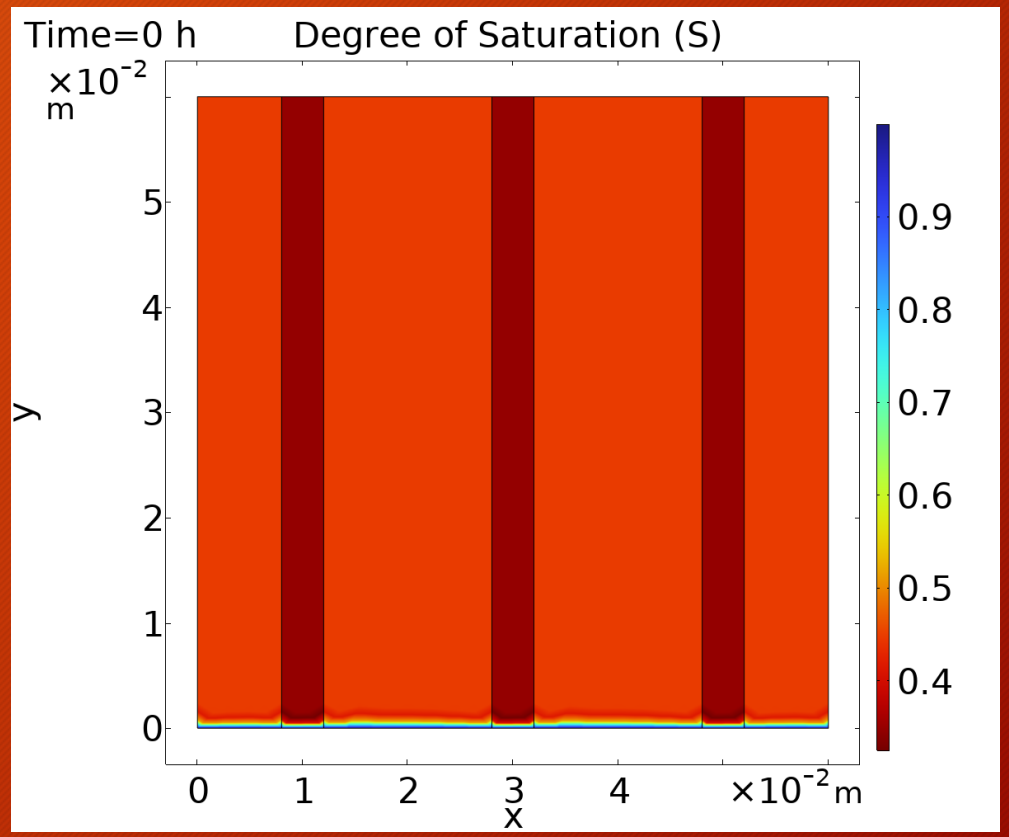


- Parallel orientation



Absorption Simulations - Layered

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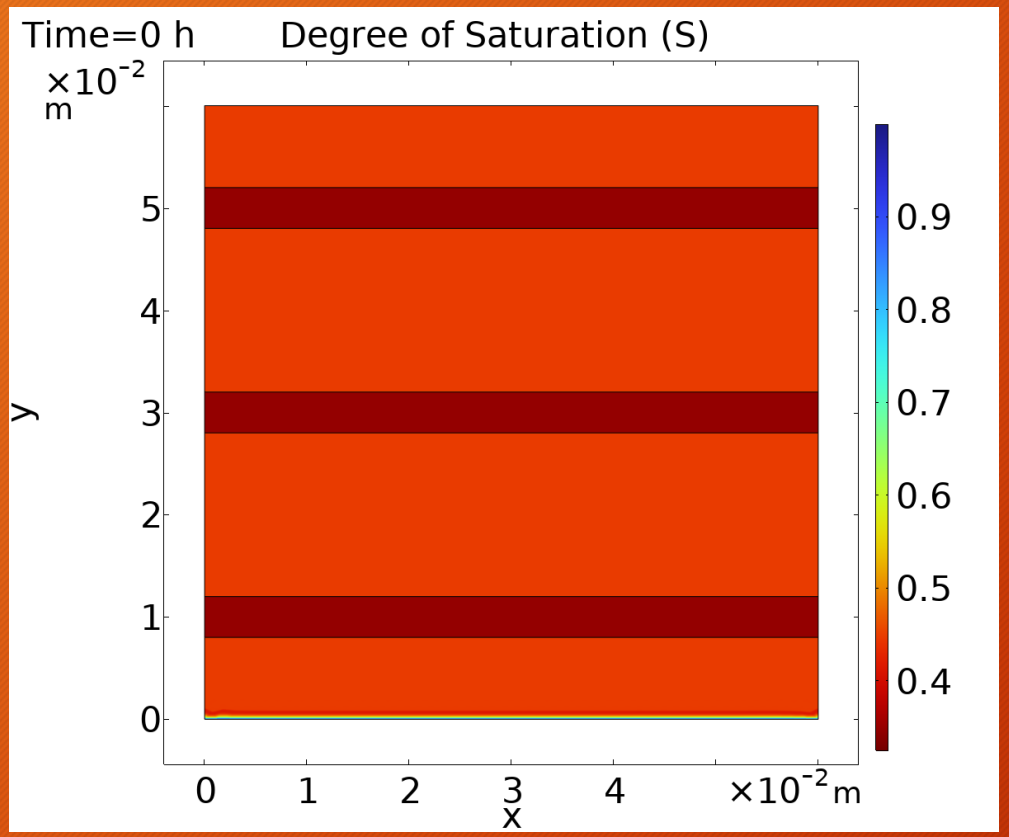

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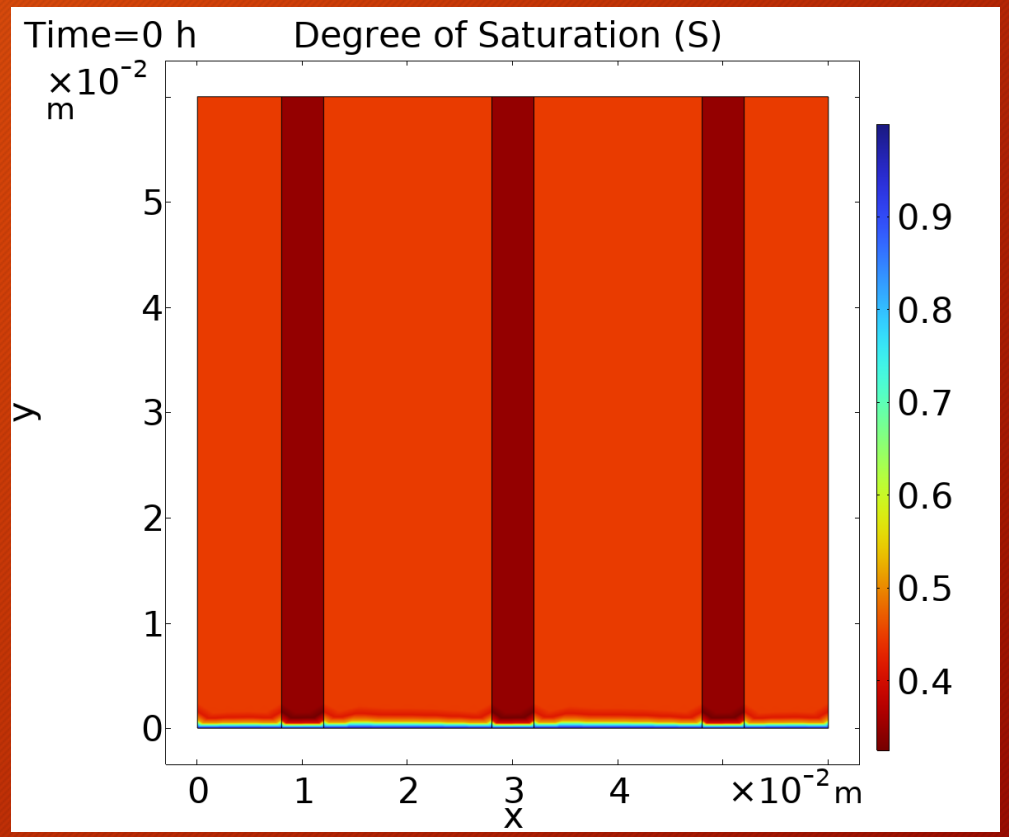

Absorption Simulations - Layered

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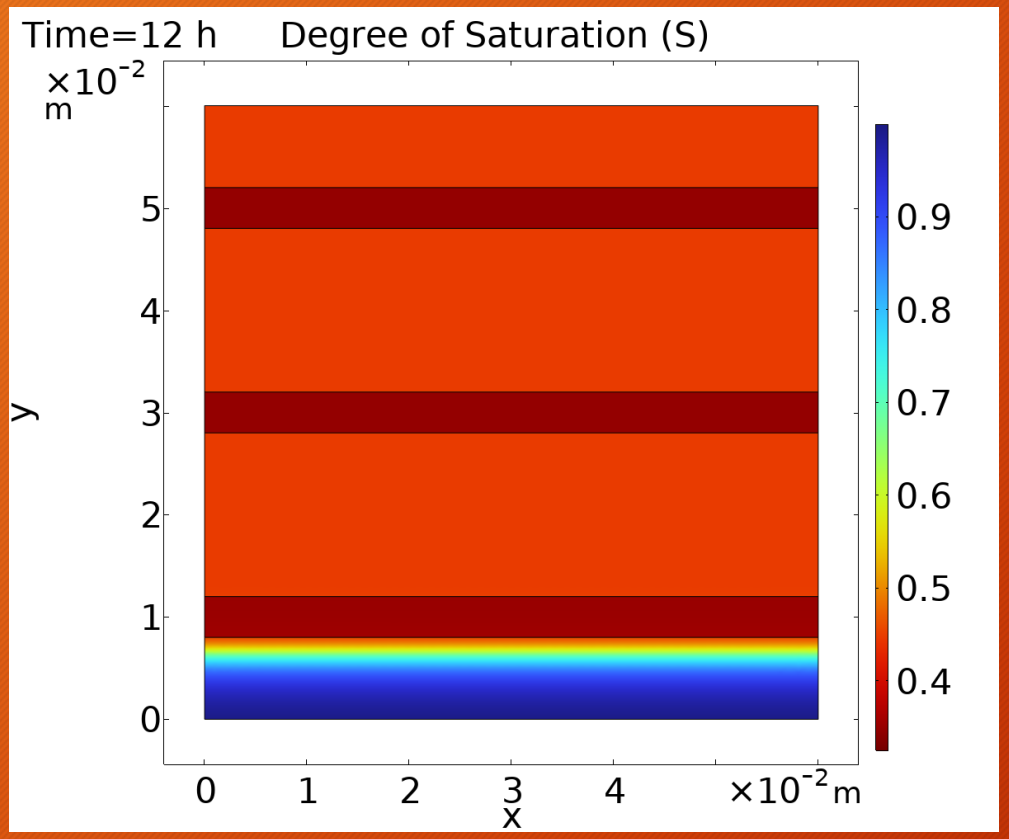
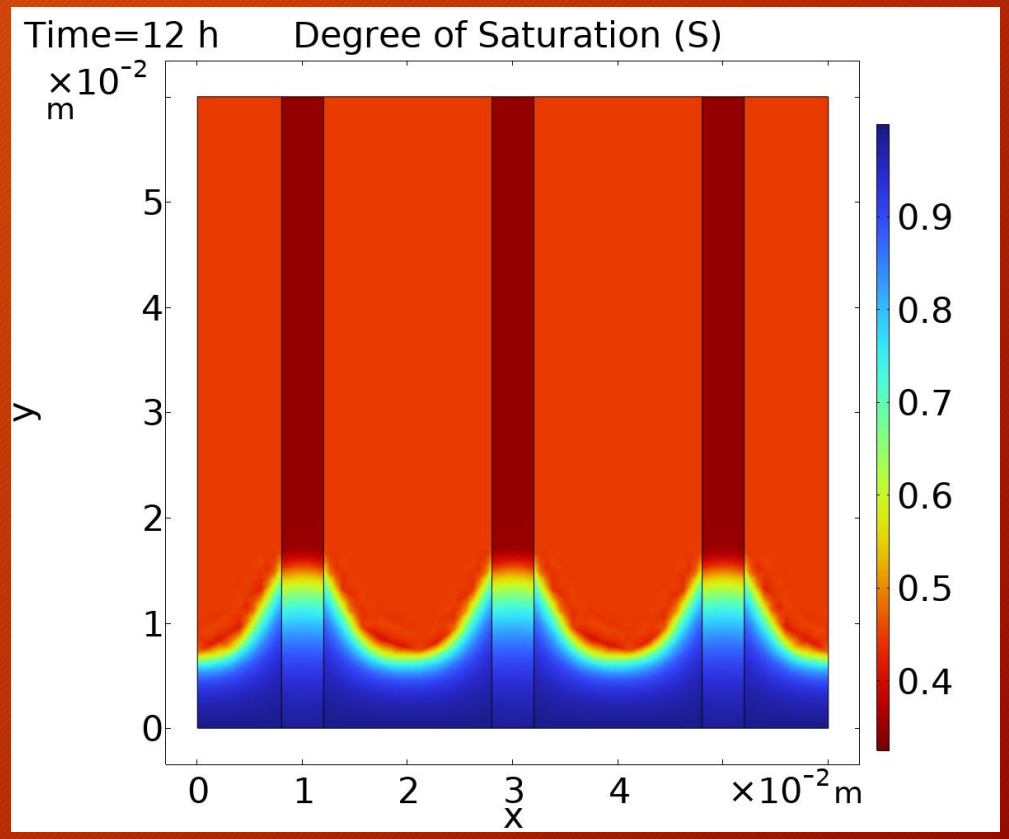


- Parallel orientation



Absorption Simulations - Layered

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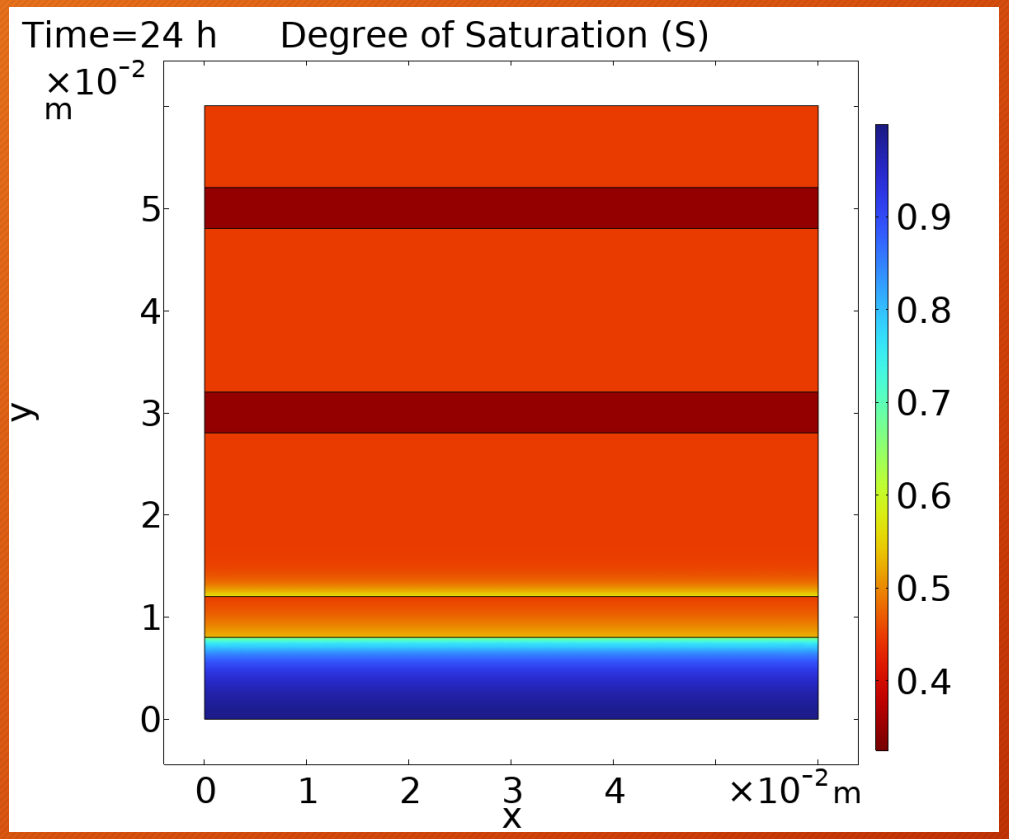

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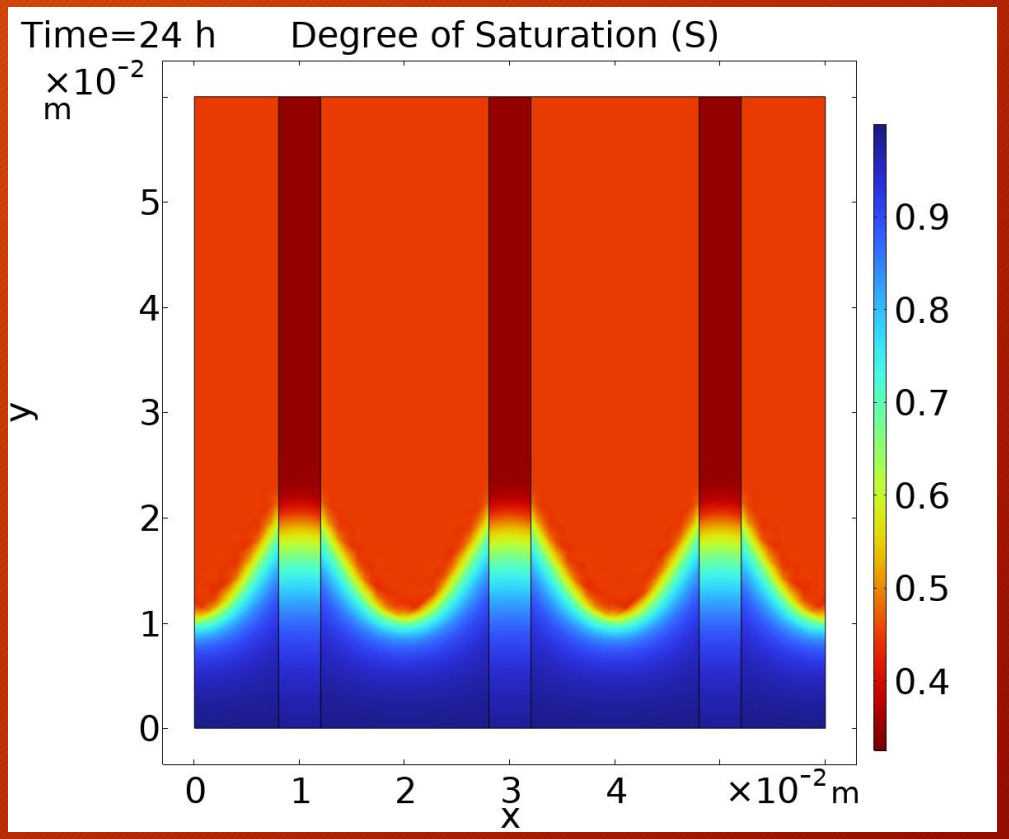
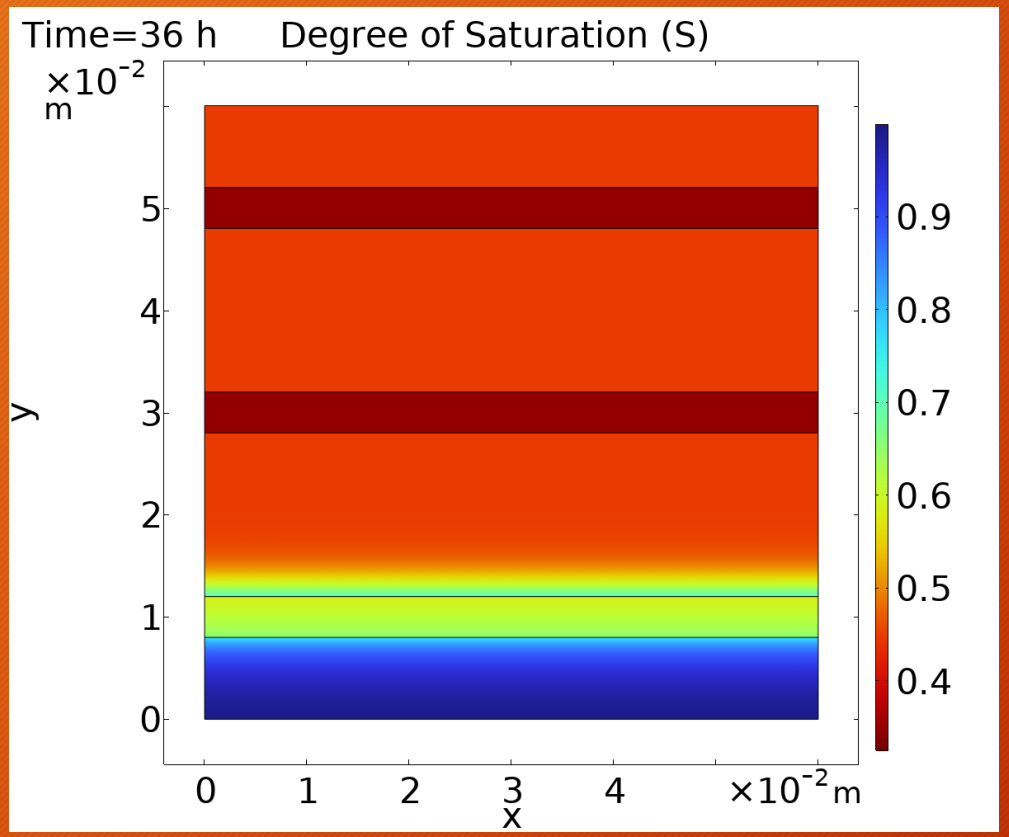
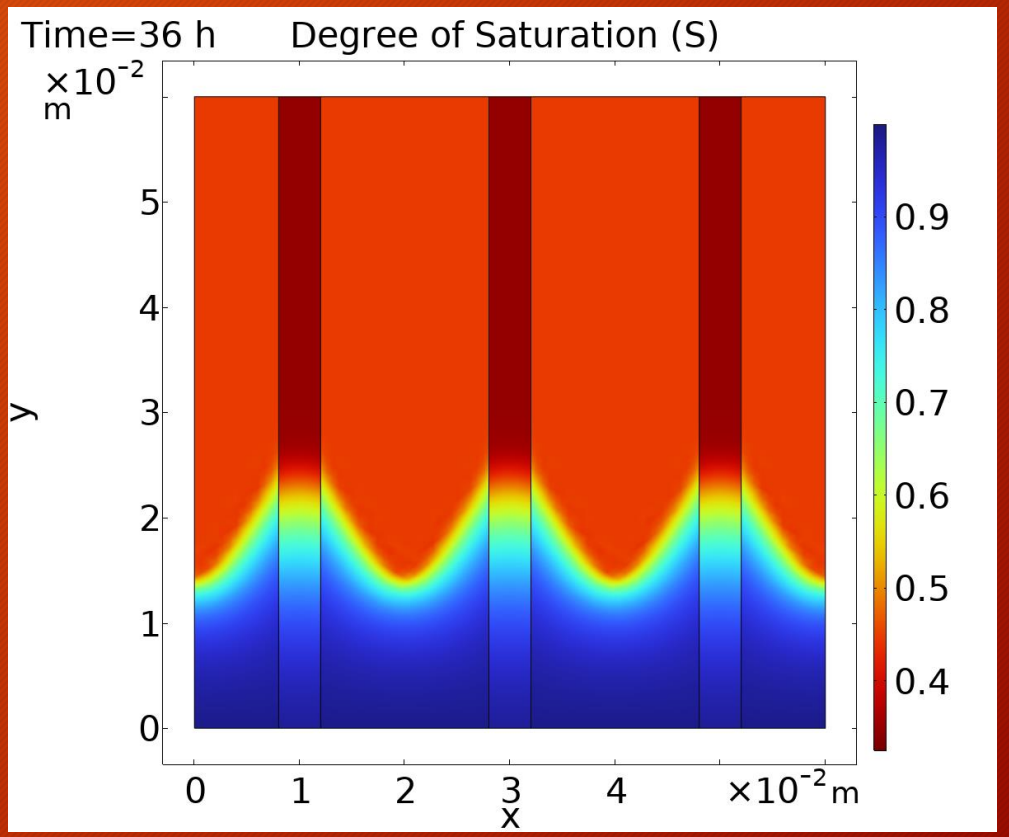


Absorption Simulations - Layered

- Perpendicular orientation



- Parallel orientation



Absorption Simulations - Layered

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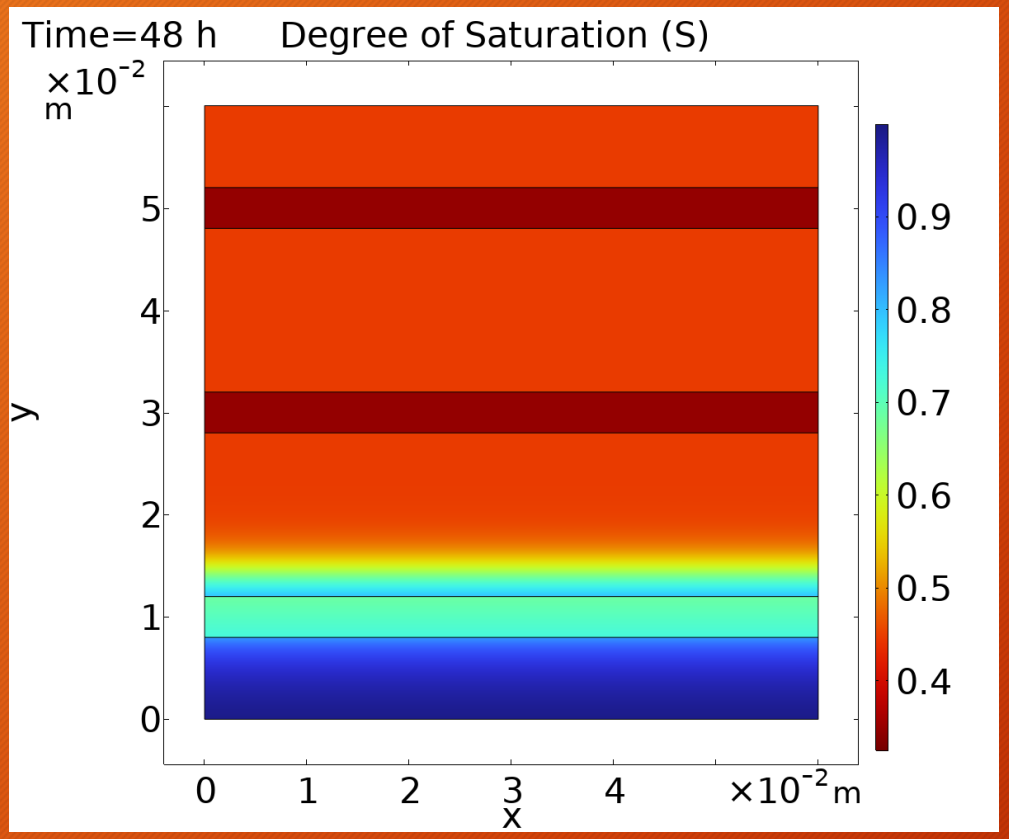

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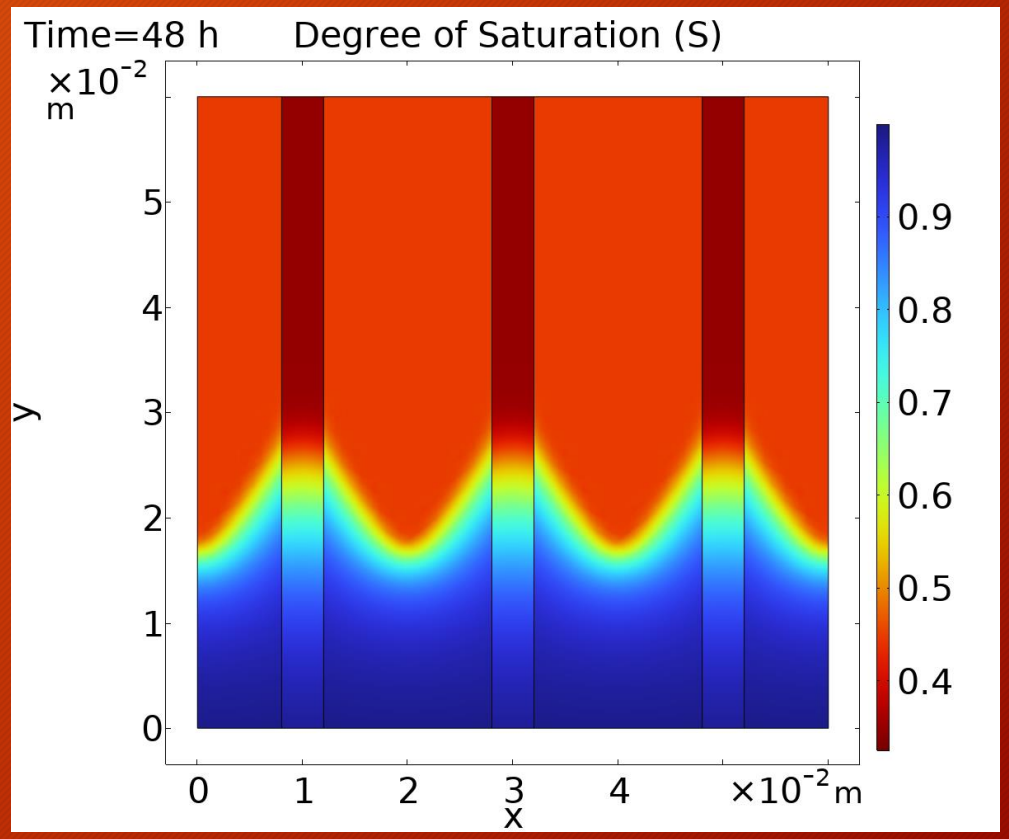

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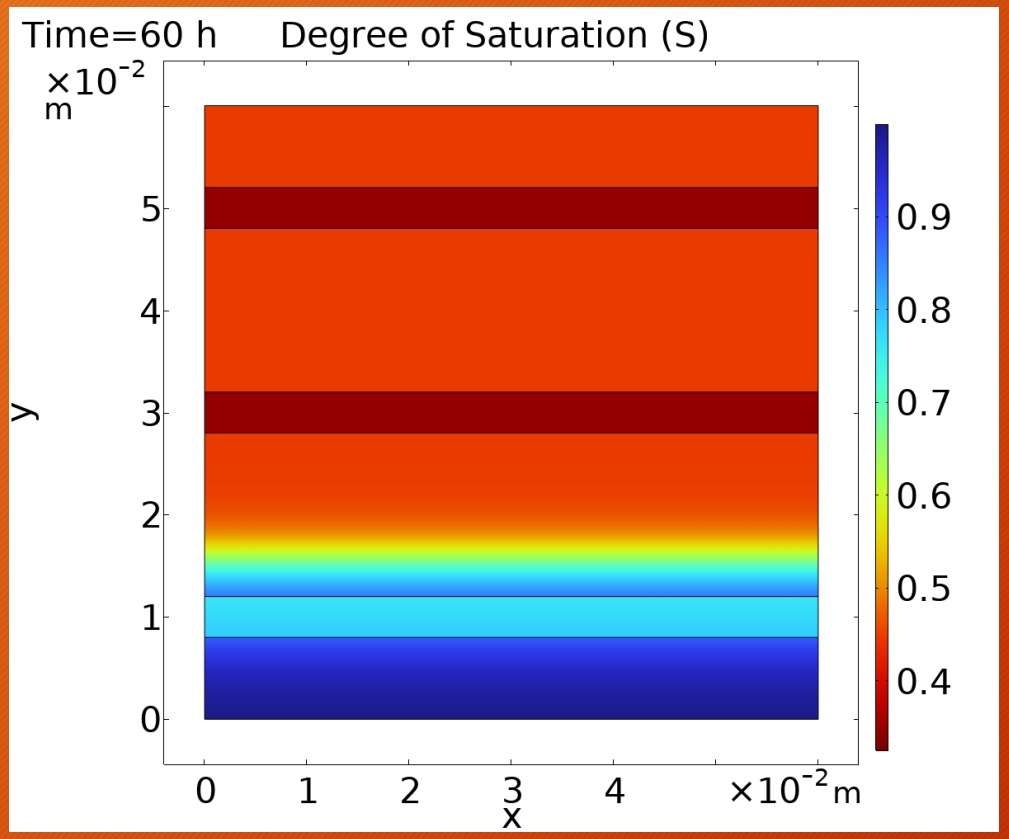

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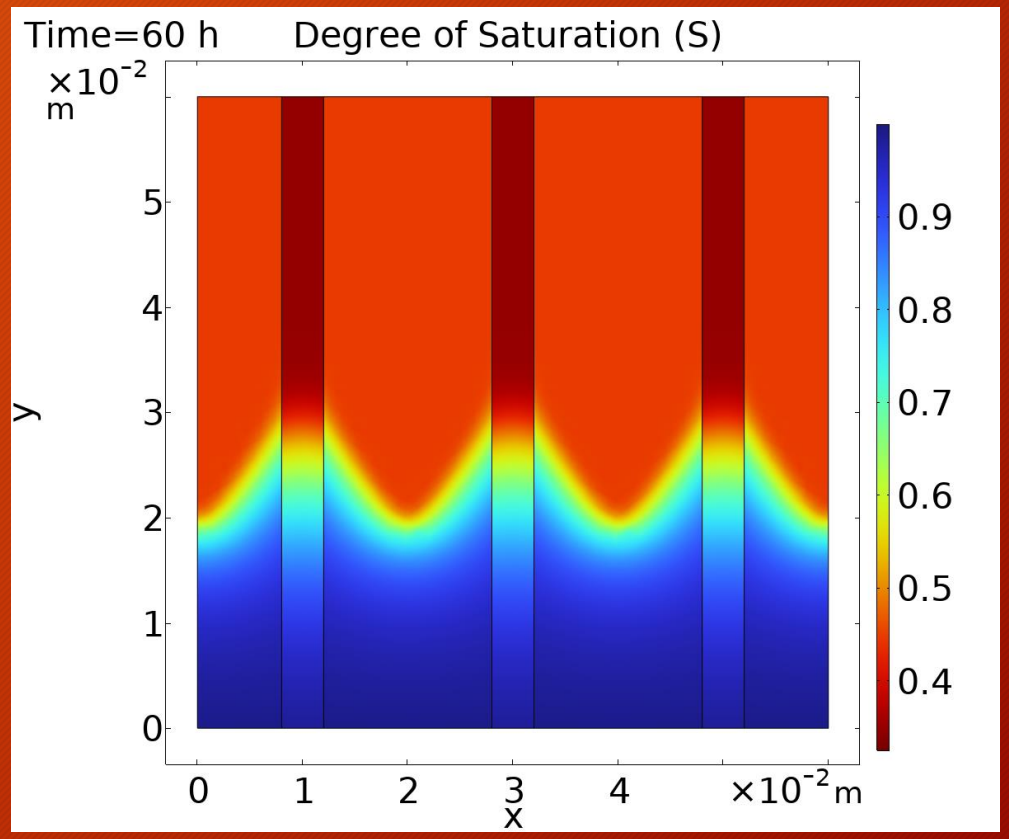

Absorption Simulations - Layered

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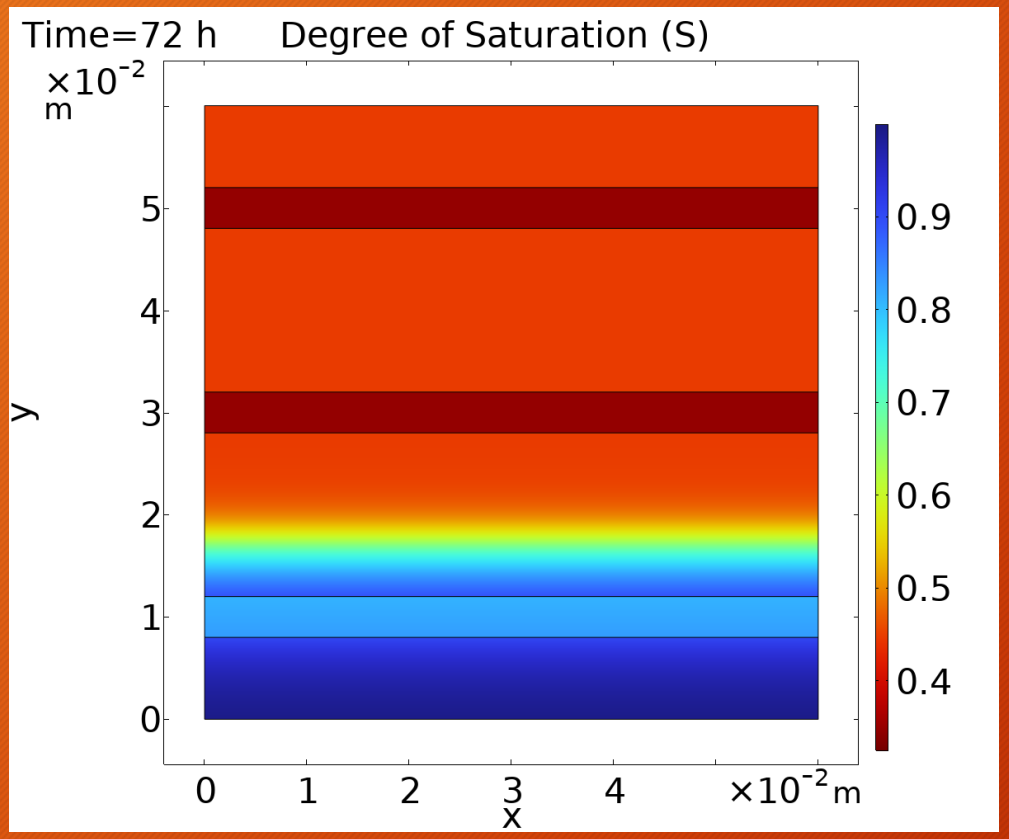

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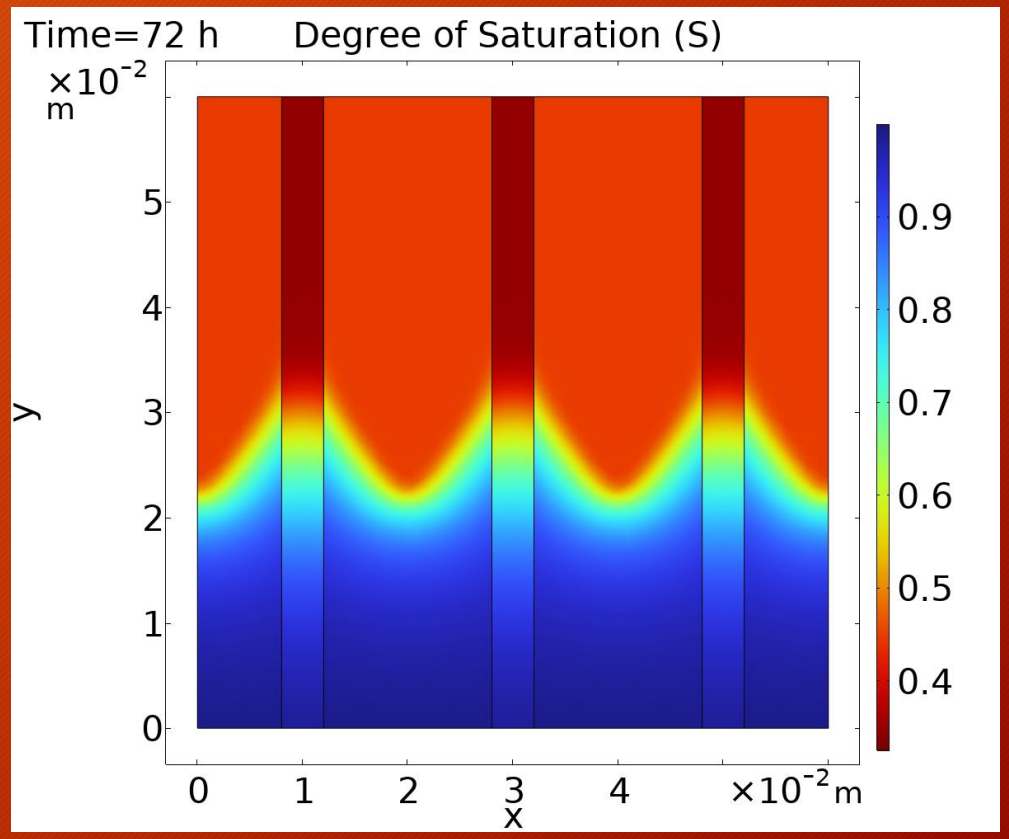

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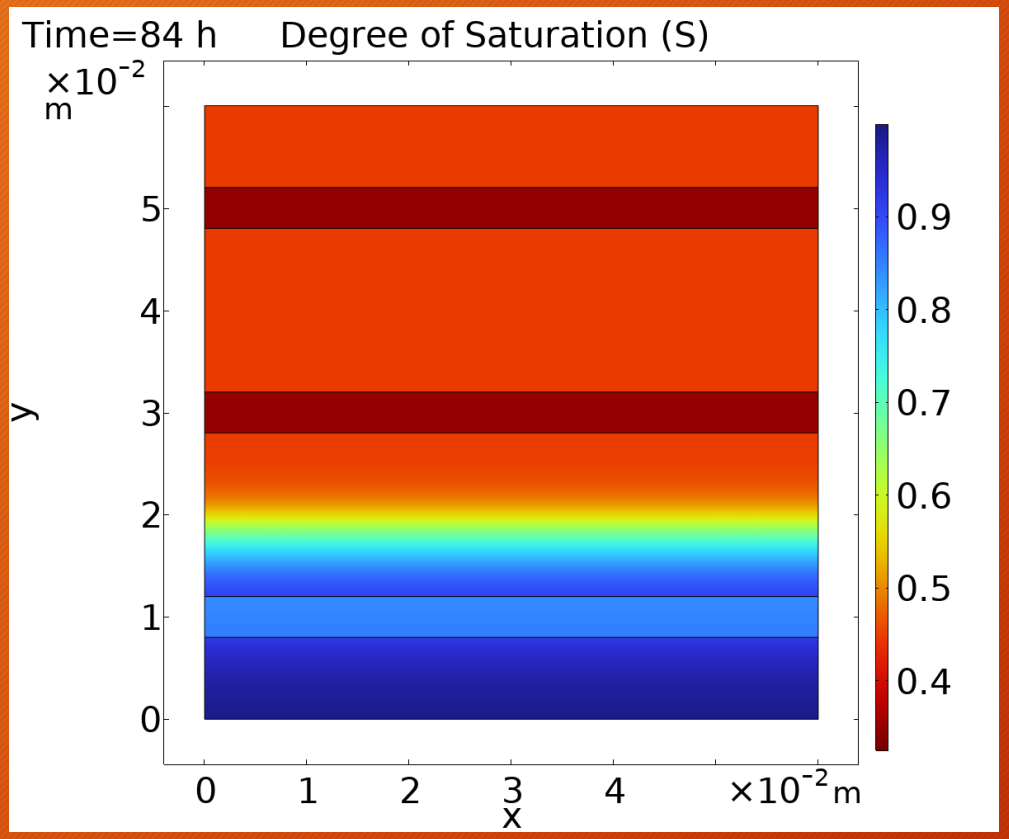

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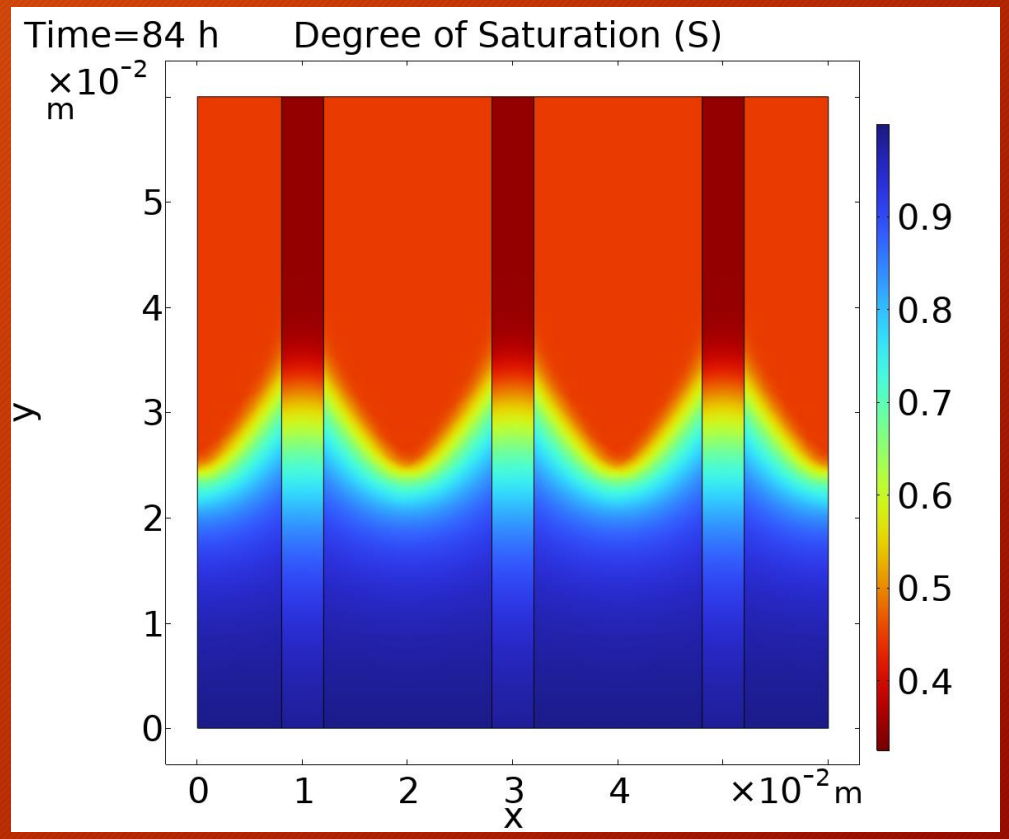

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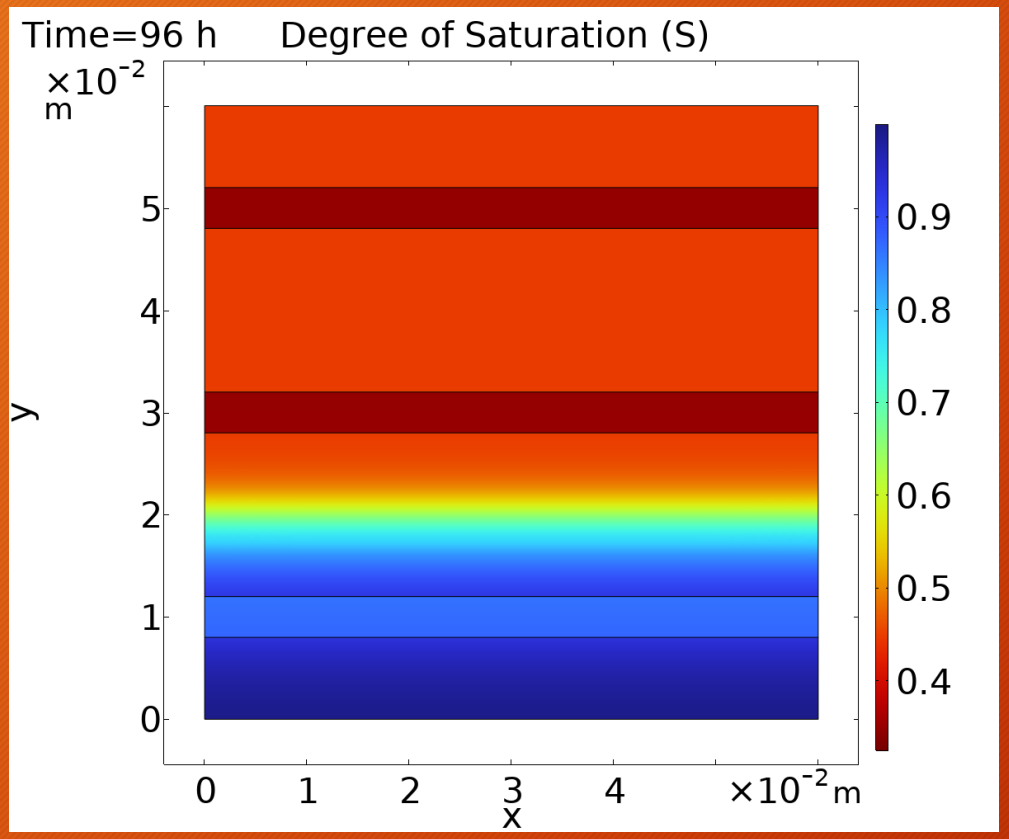

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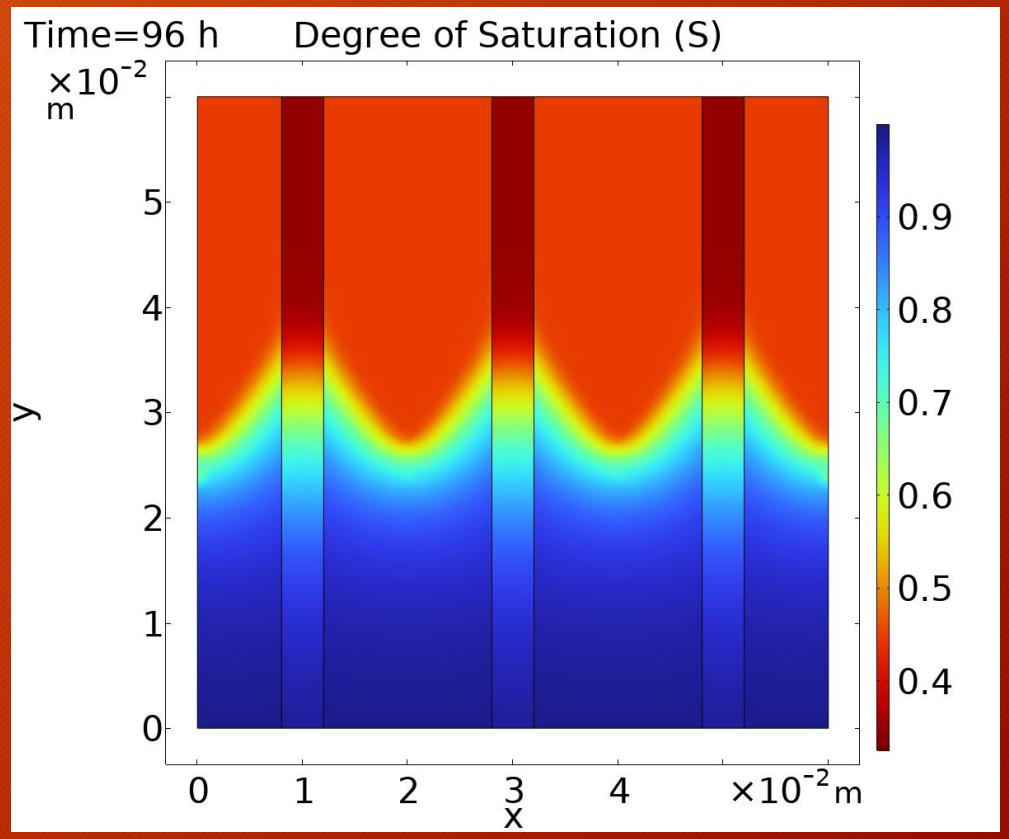
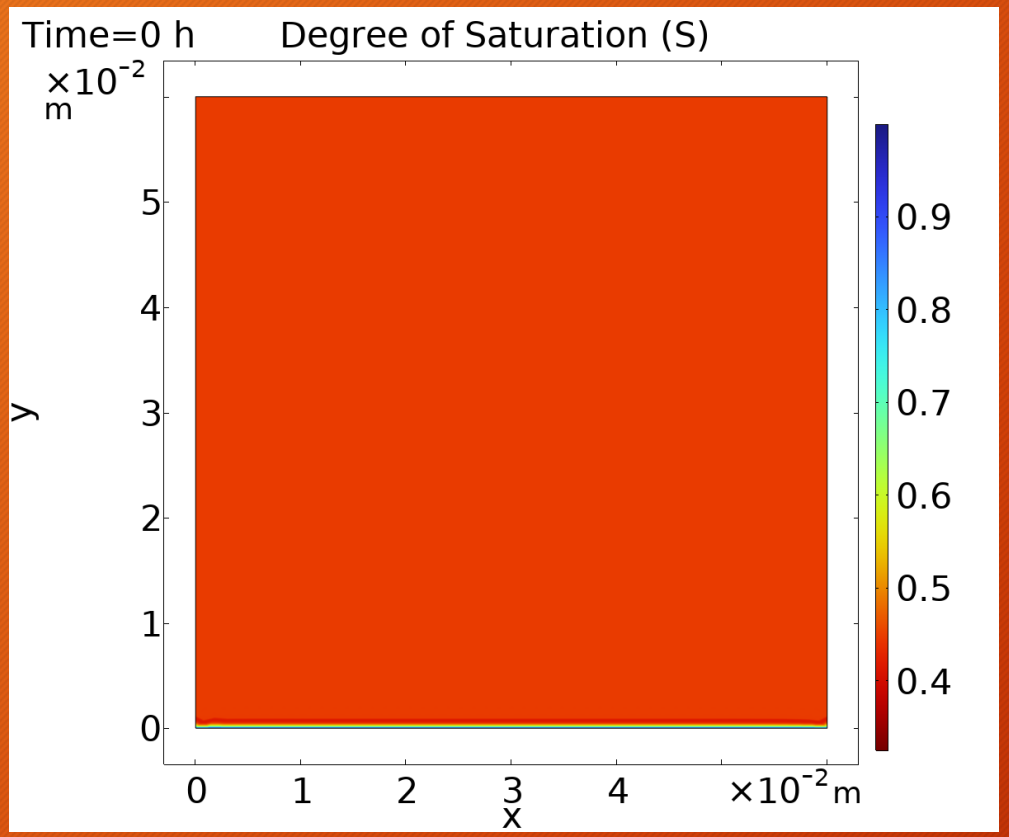
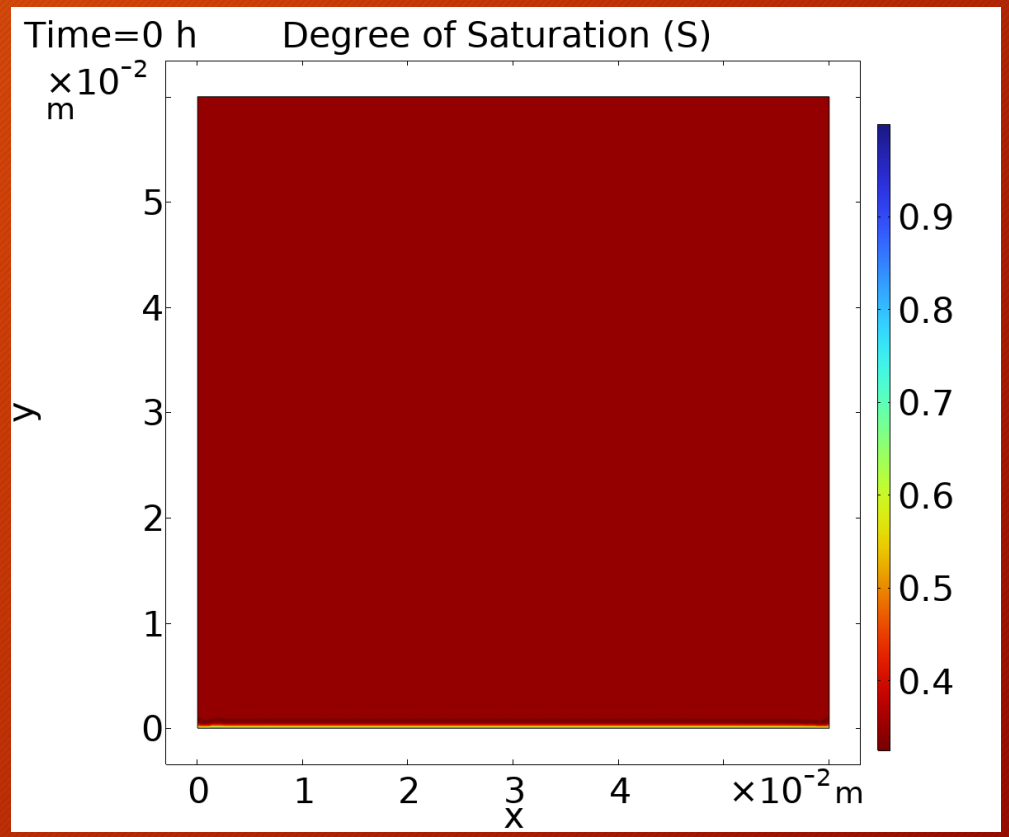


Absorption Simulations - Isotropic

- 0.3 w/cm (Filament material)



- 0.5 w/cm (Interface material)



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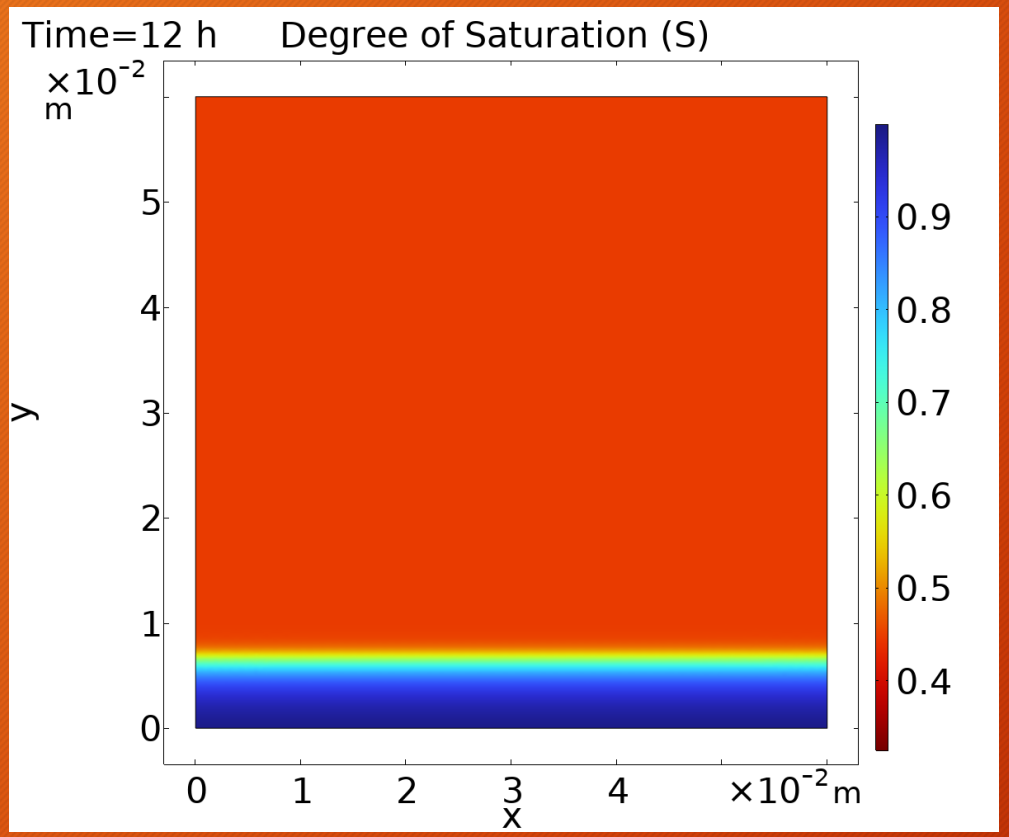

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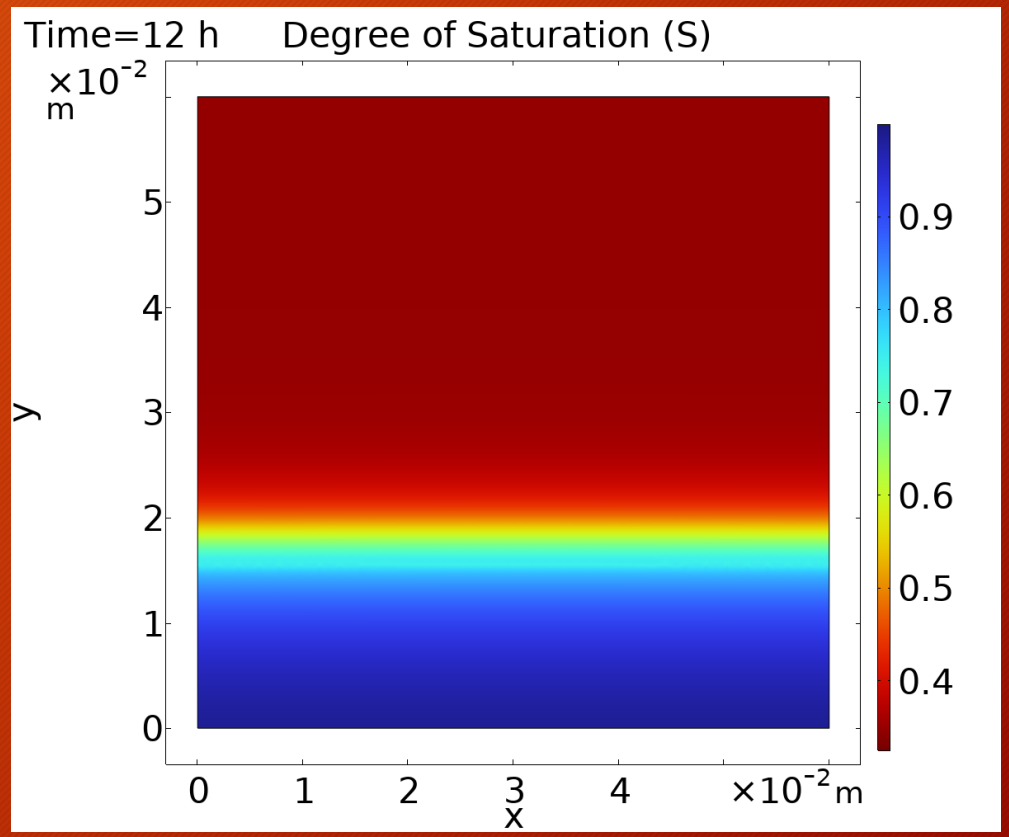

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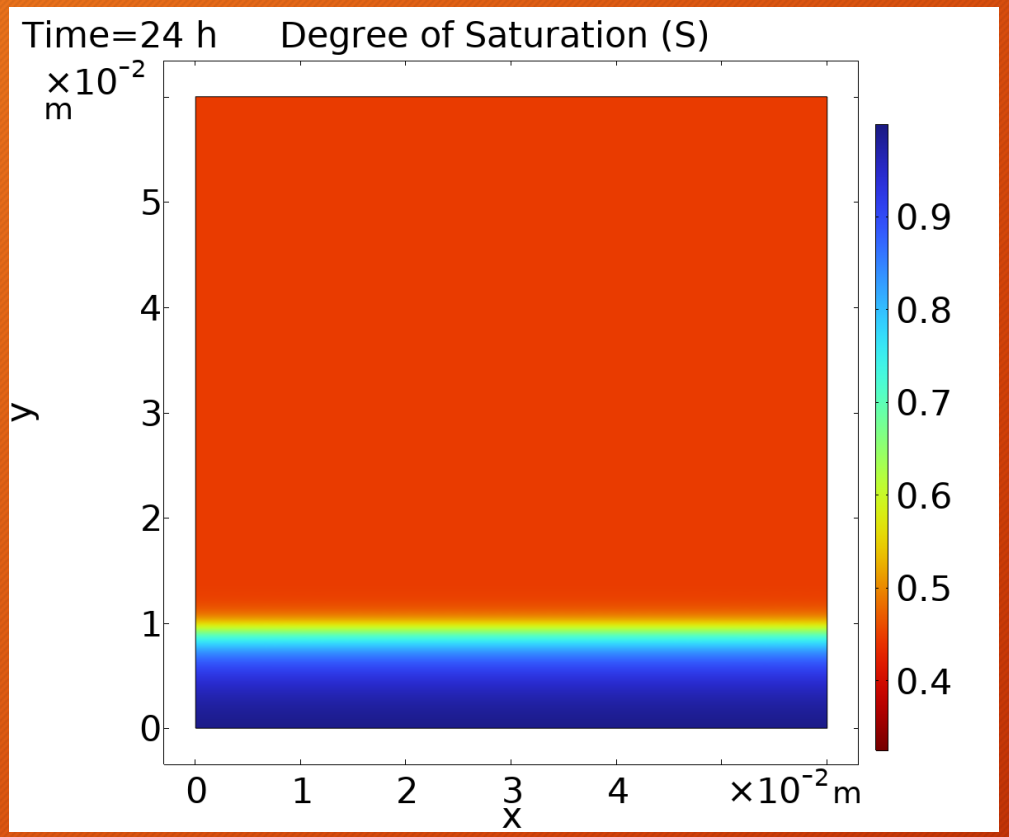

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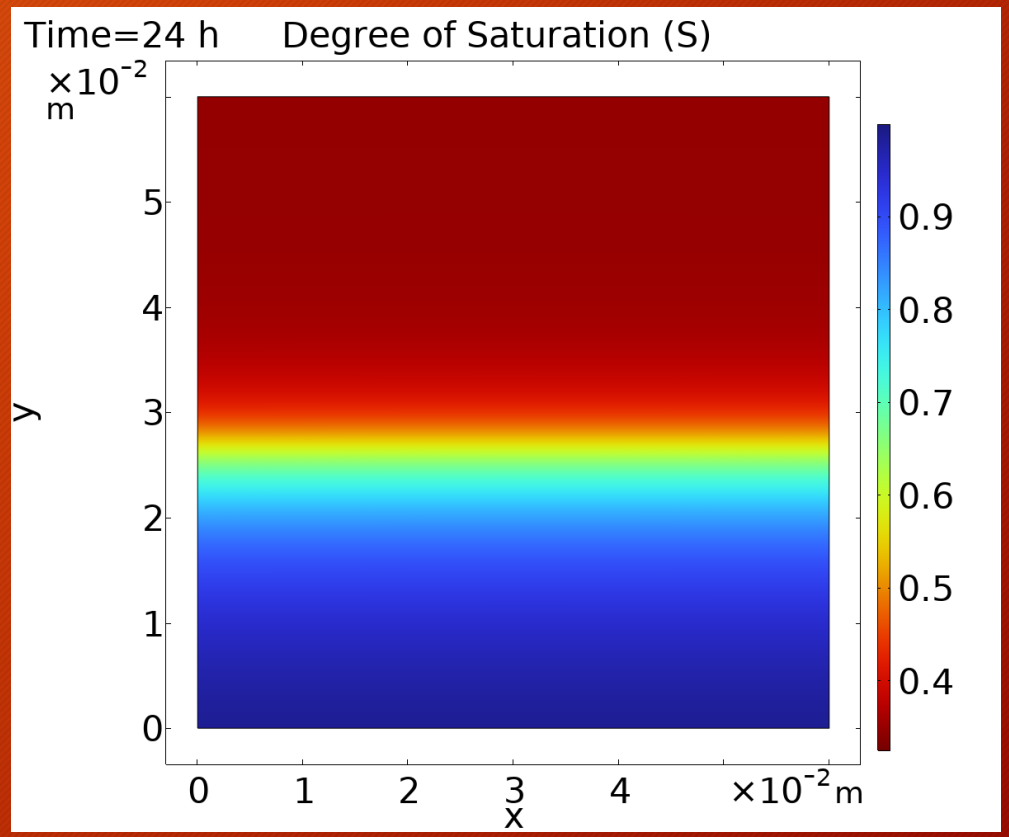

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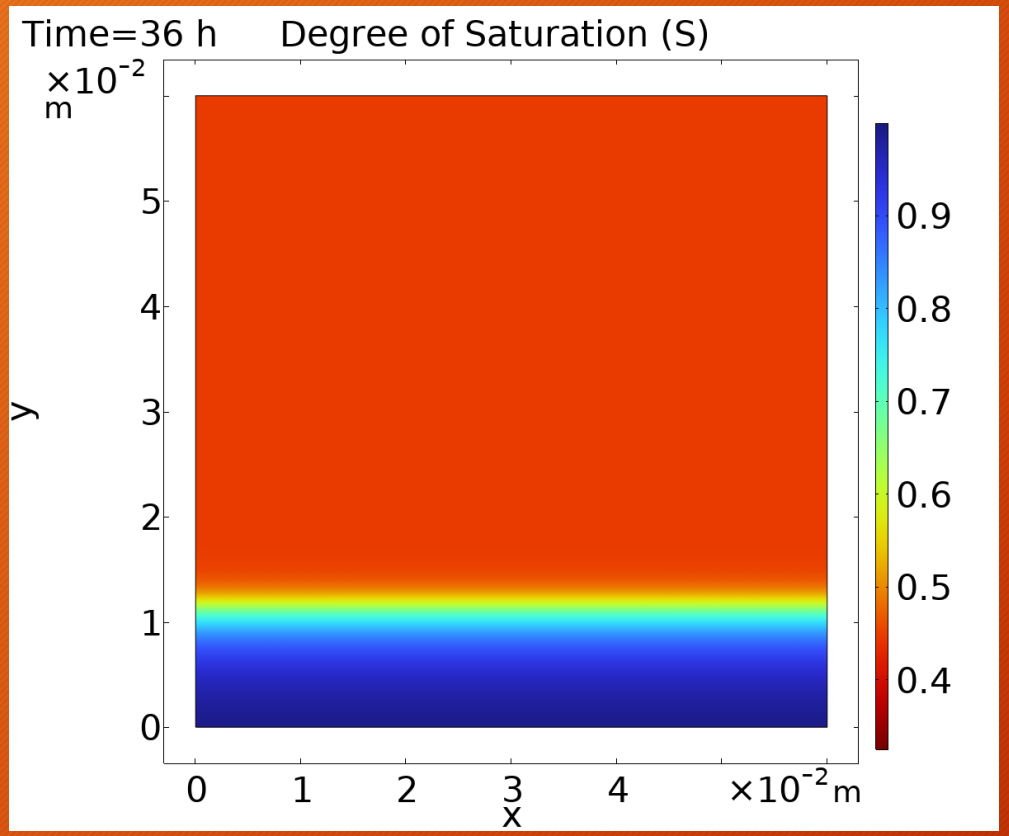

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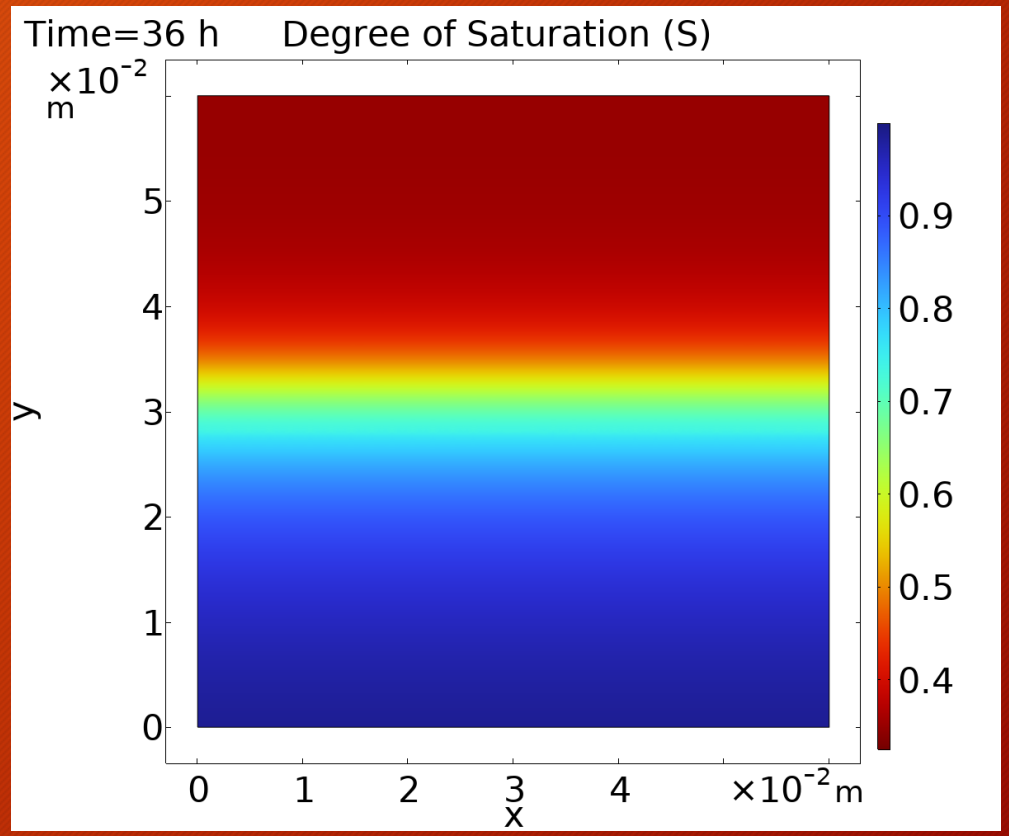

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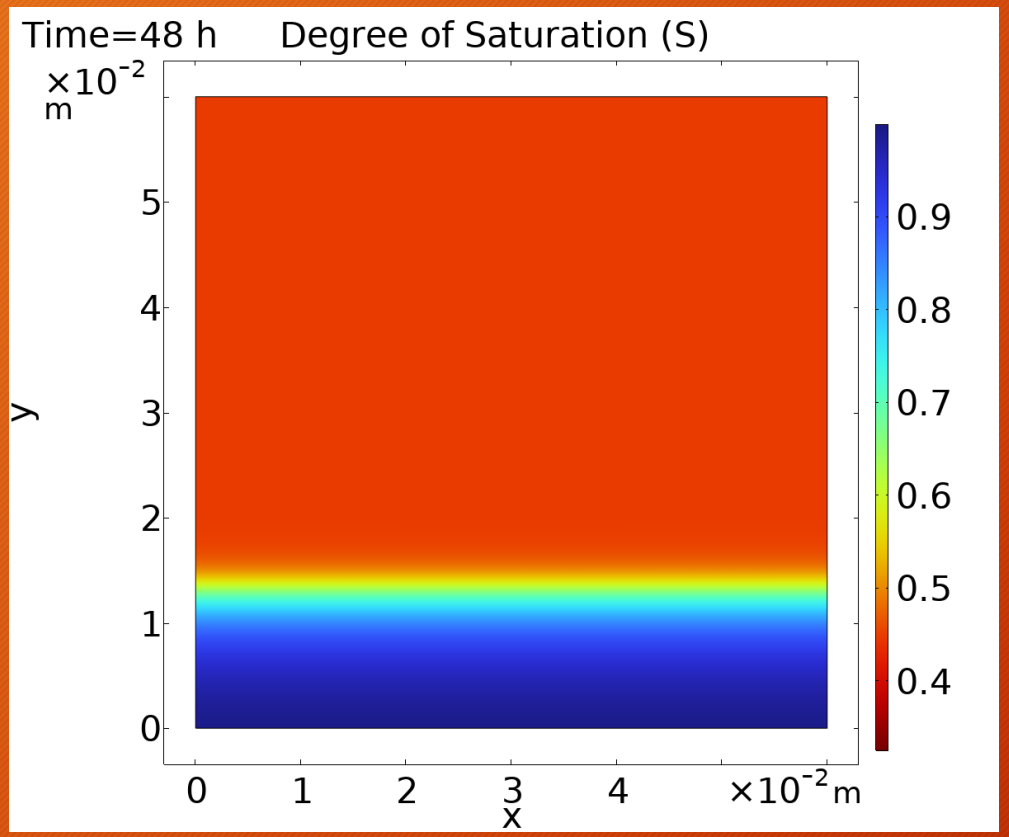

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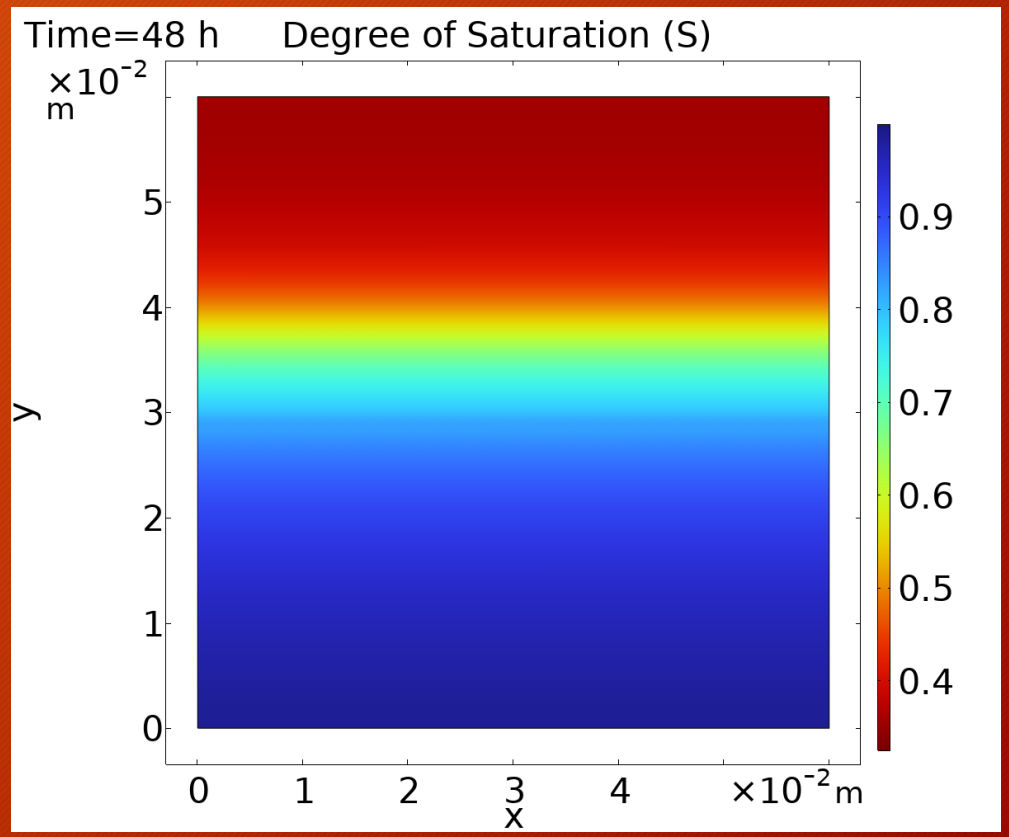

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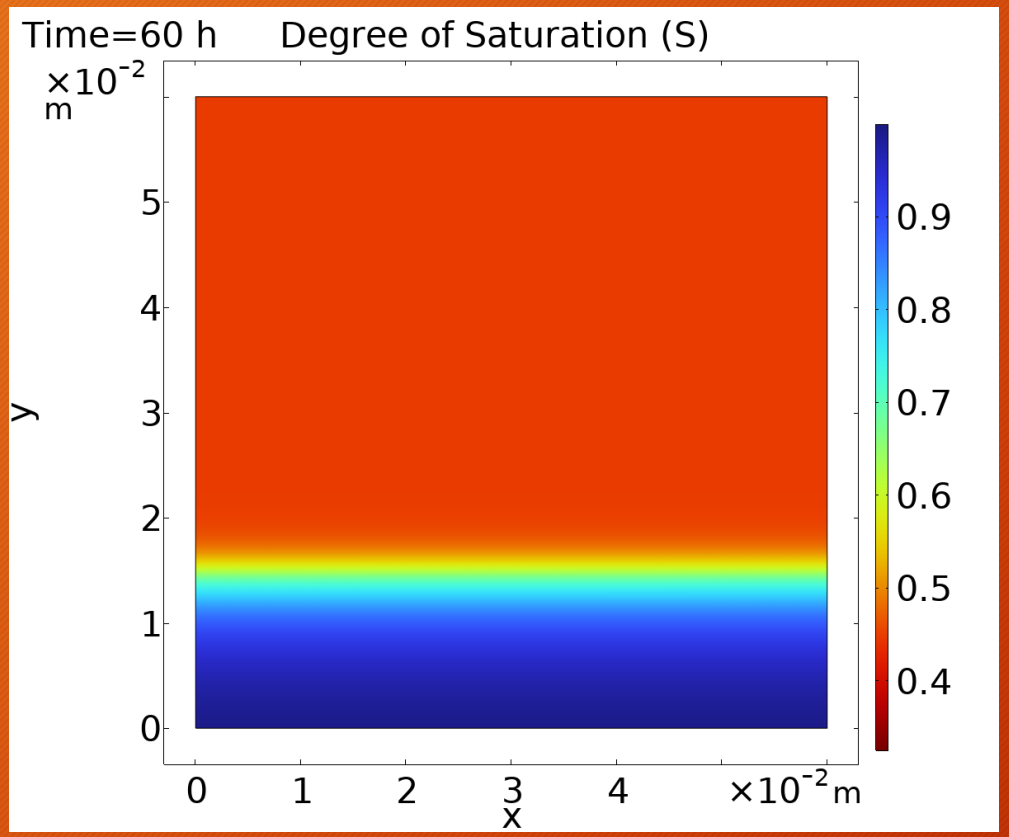

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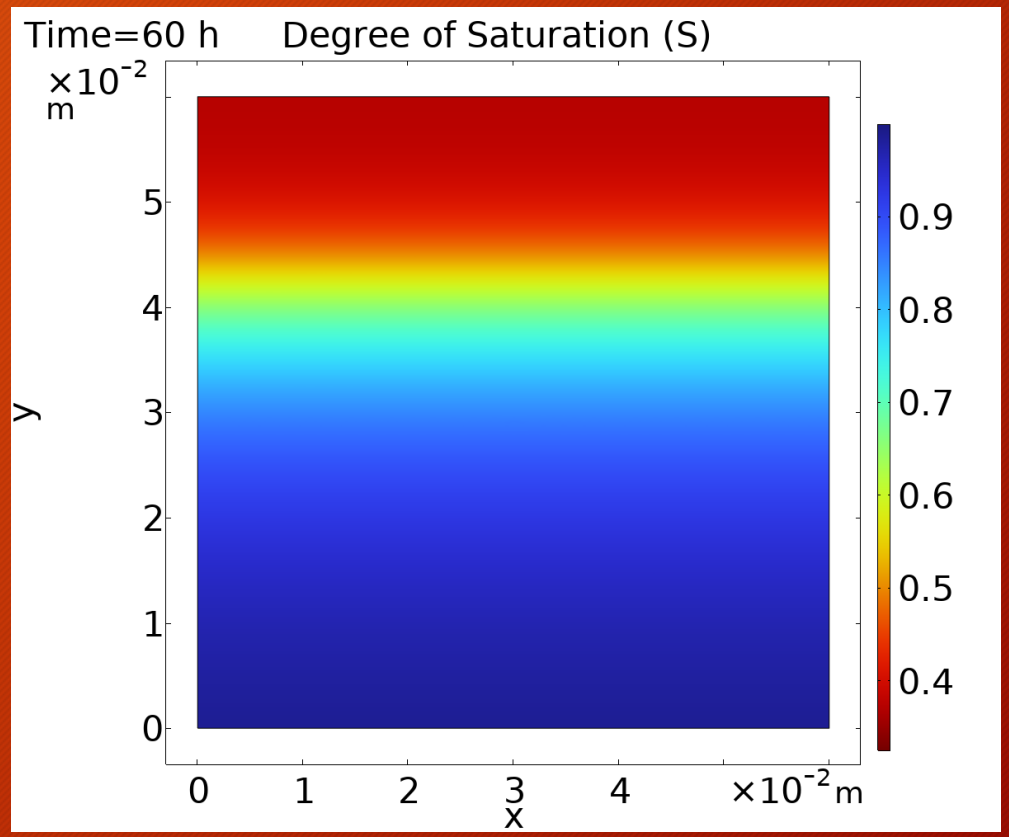

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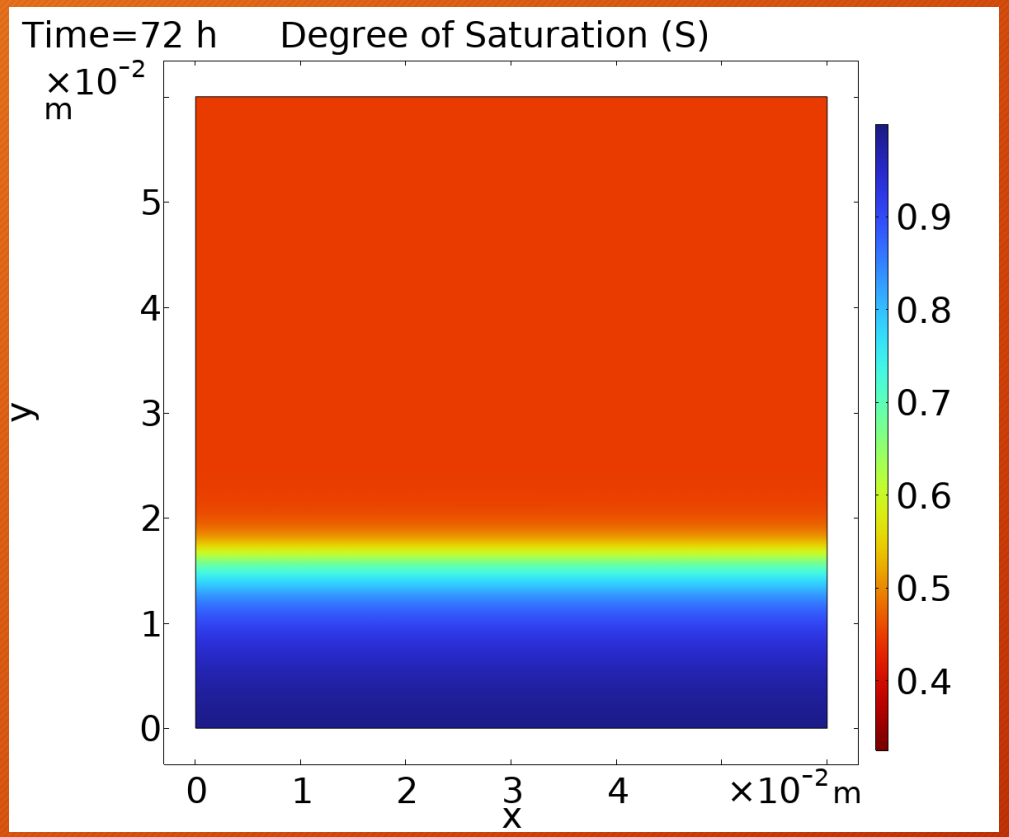

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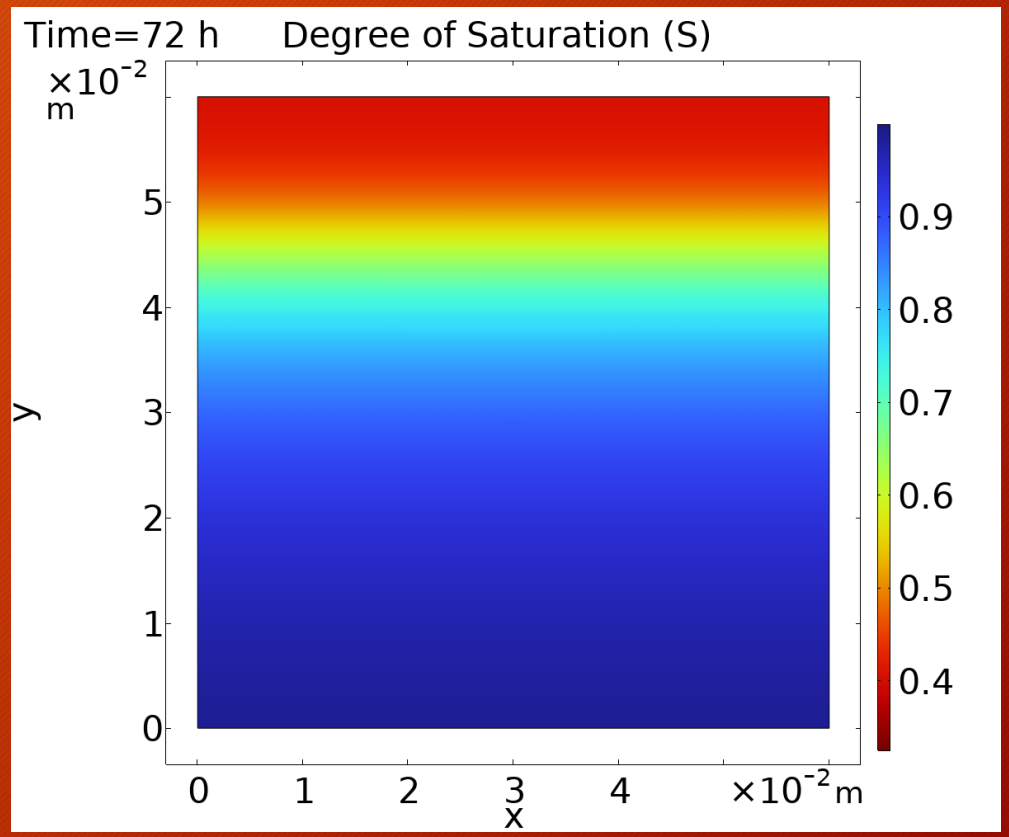

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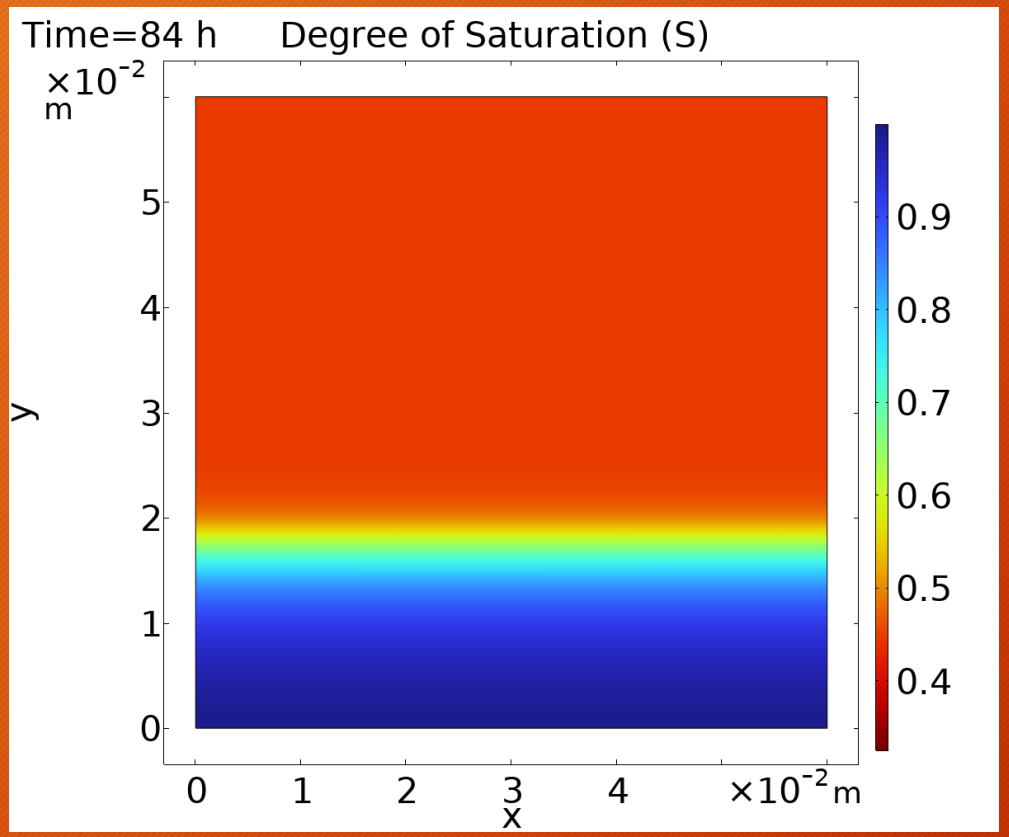

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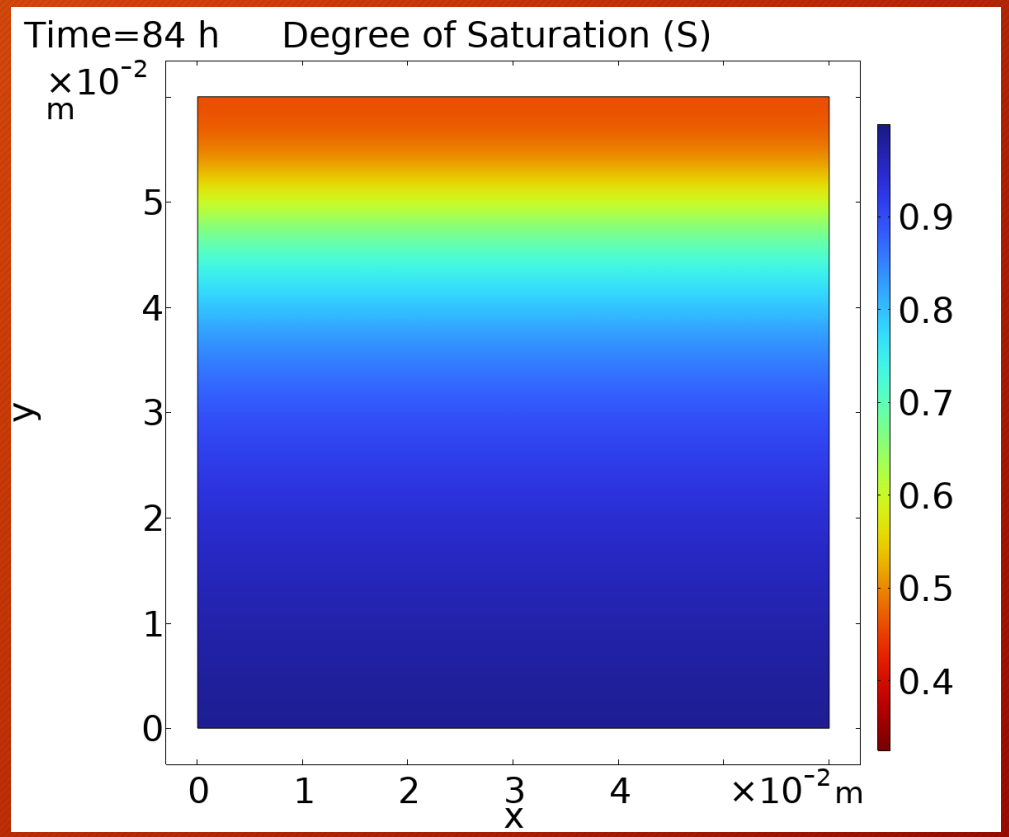

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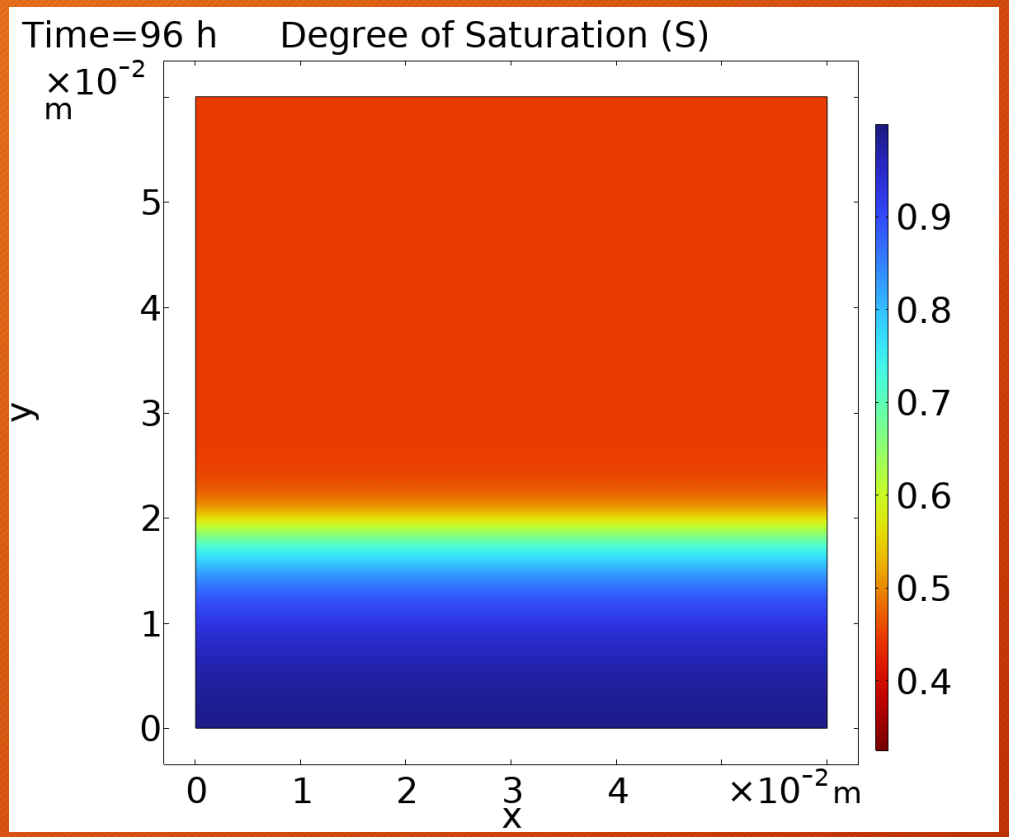

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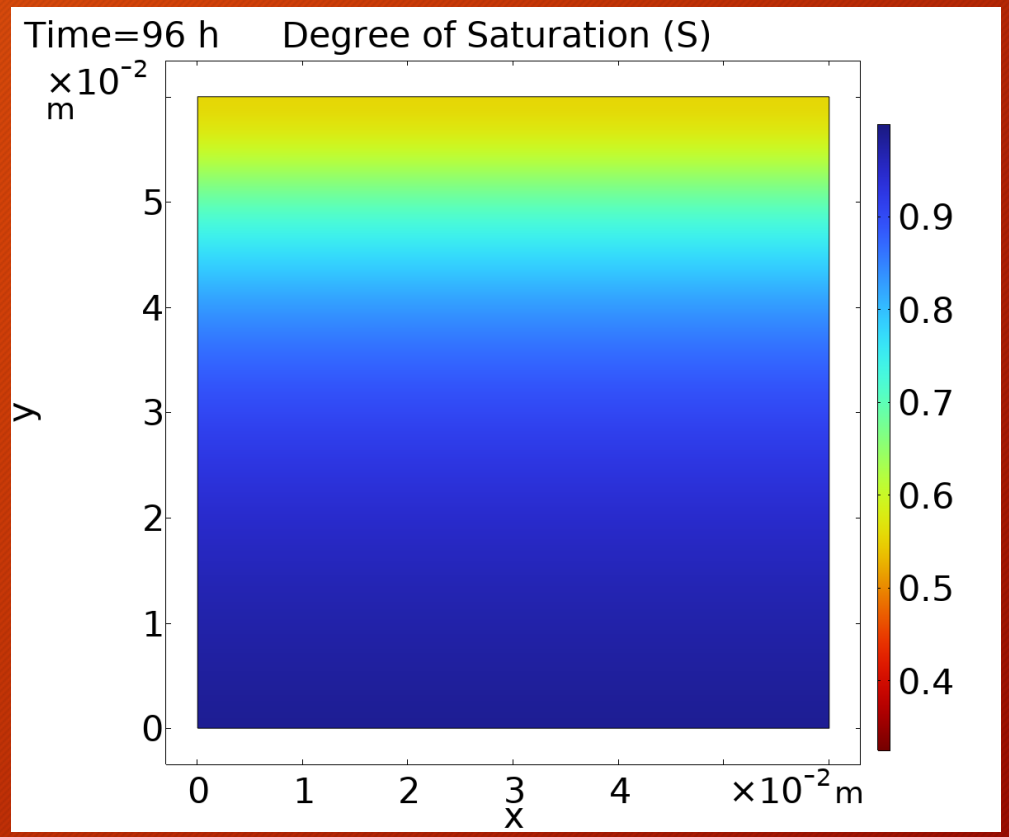
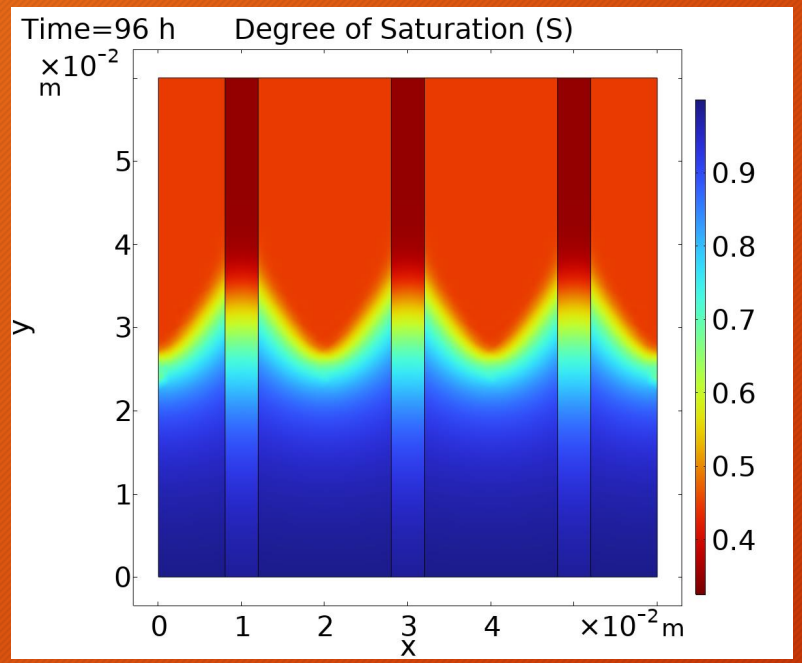


Moisture Profile Analysis

- What is the role of the interfaces in fluid absorption?
- How does this role change with the orientation of the layered system?



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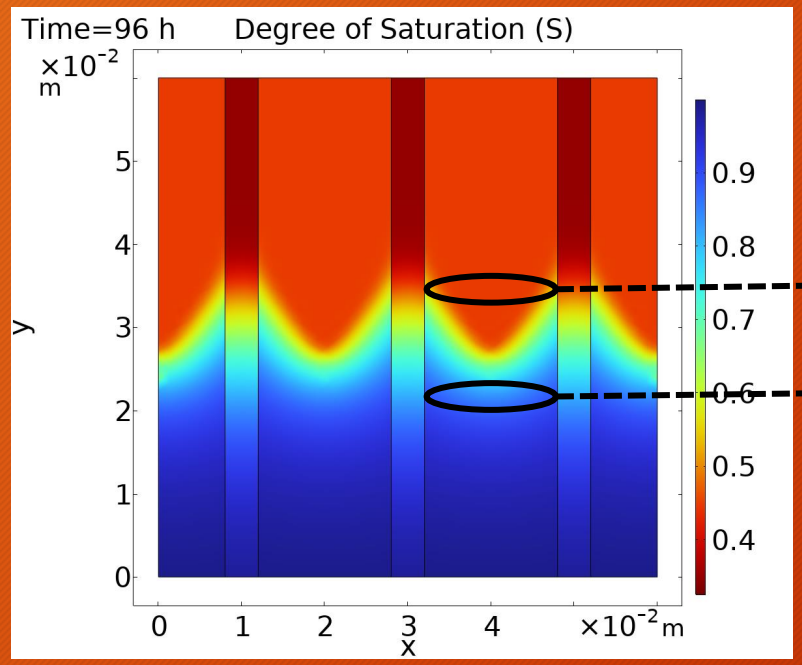
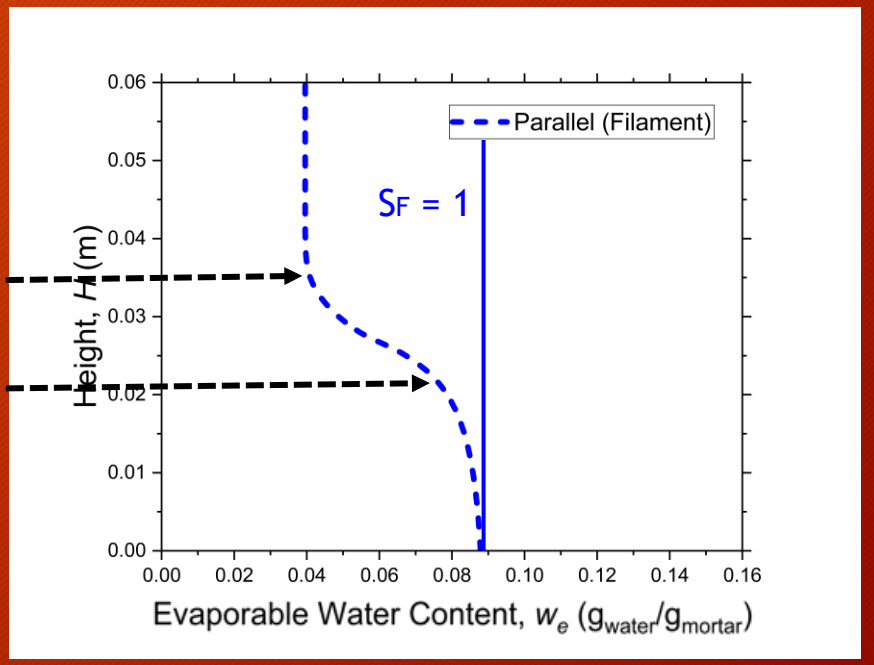
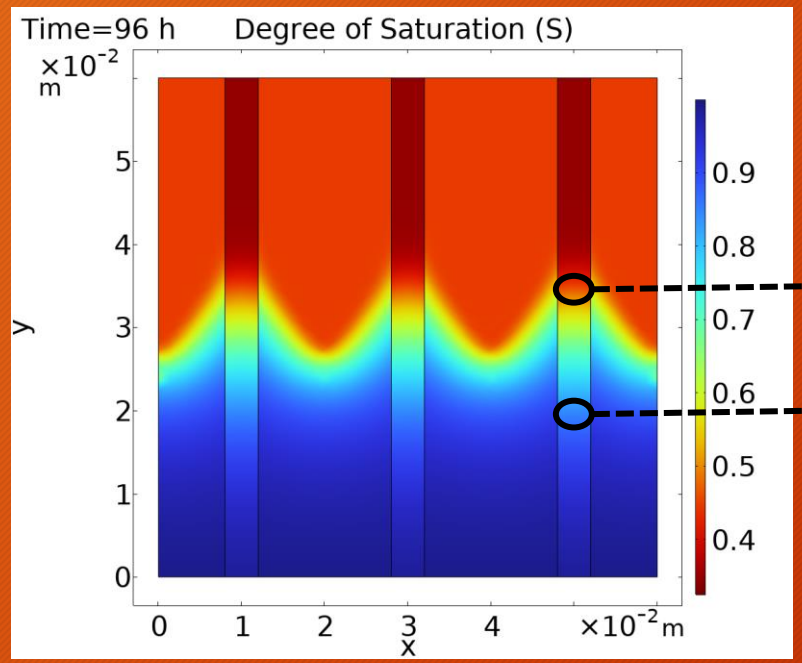
- How does this role change with the orientation of the layered system?

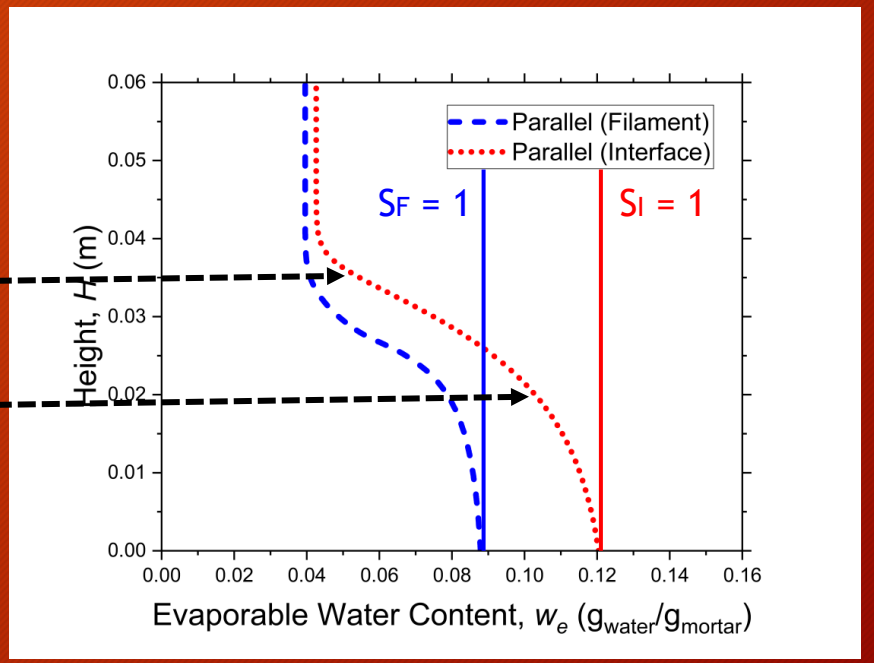




Moisture Profile Analysis

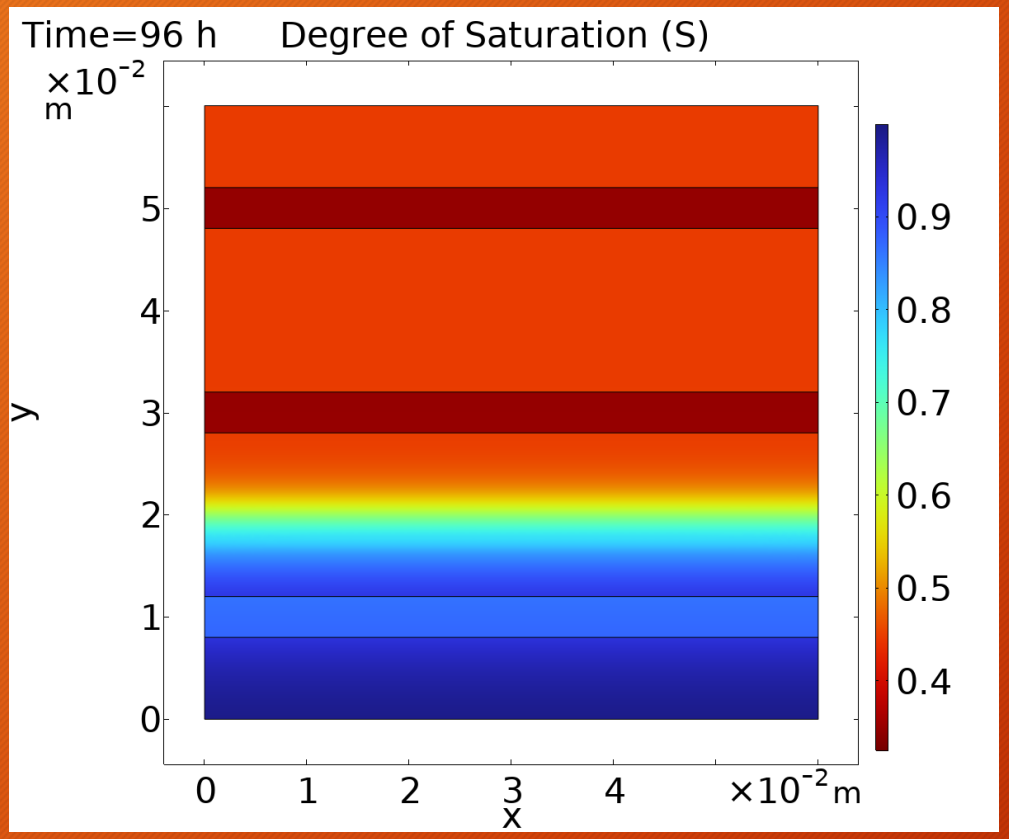
- What is the role of the interfaces in fluid absorption?
- How does this role change with the orientation of the layered system?



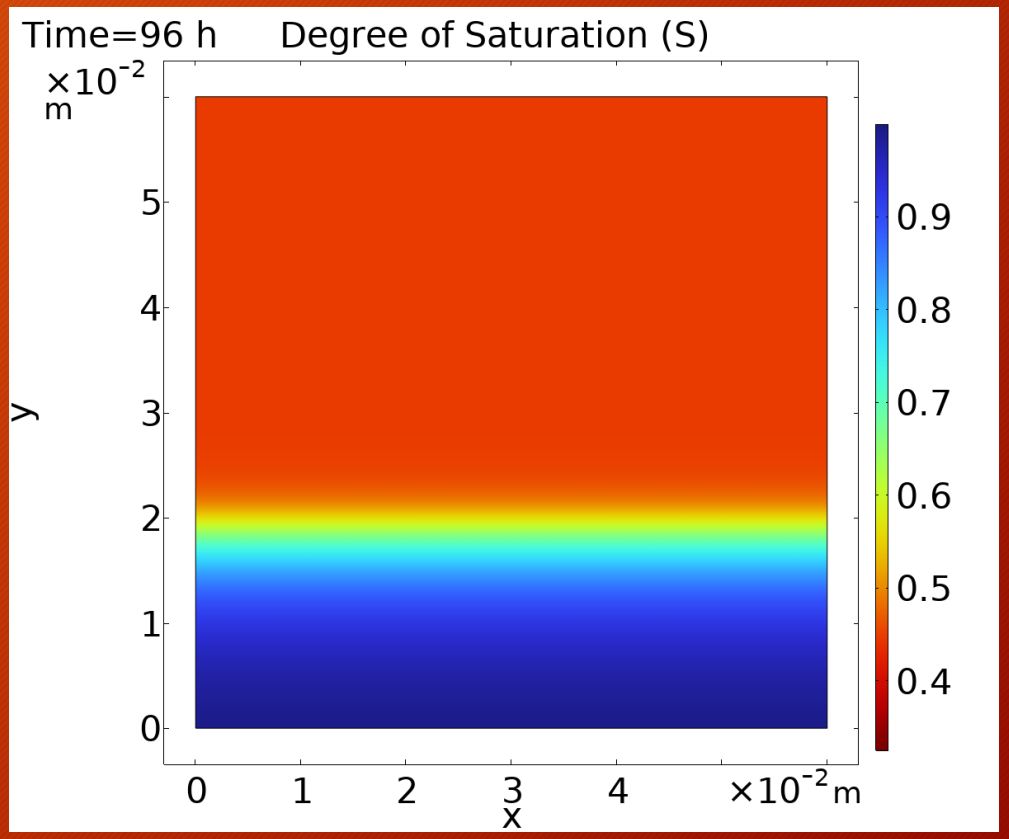


Perpendicular vs. Isotropic (0.3 w/cm)

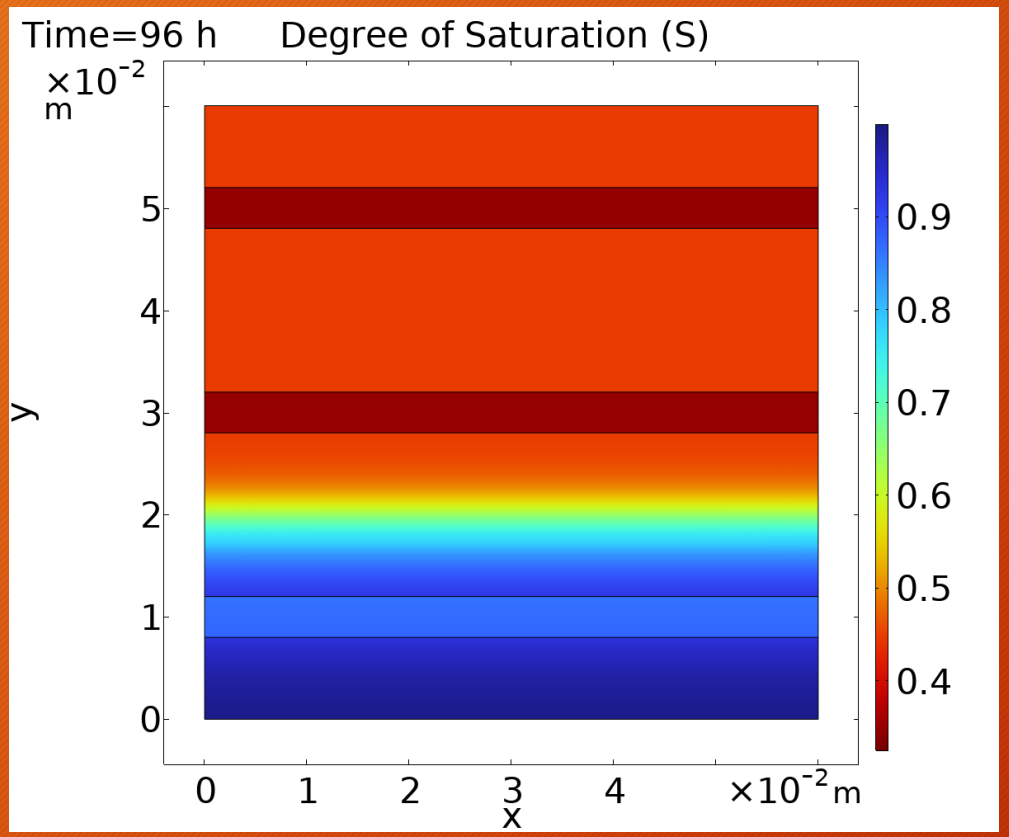
- Perpendicular

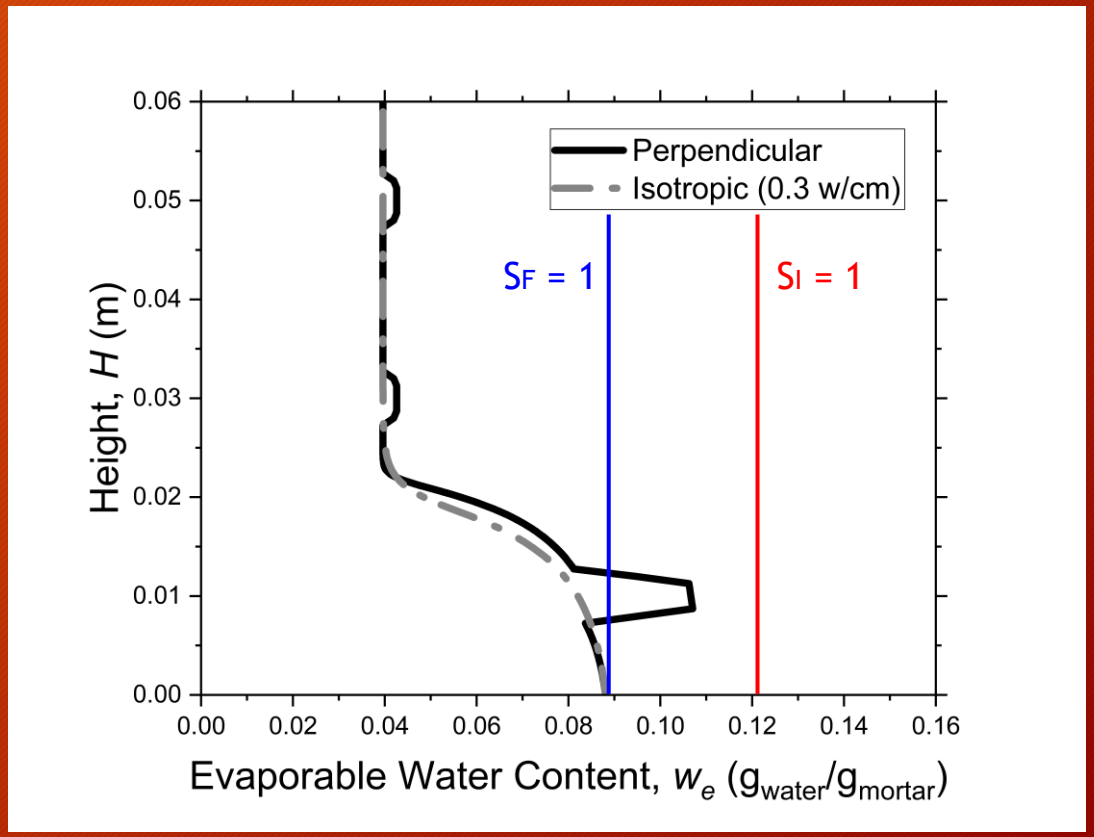


- Isotropic, 0.3 w/cm



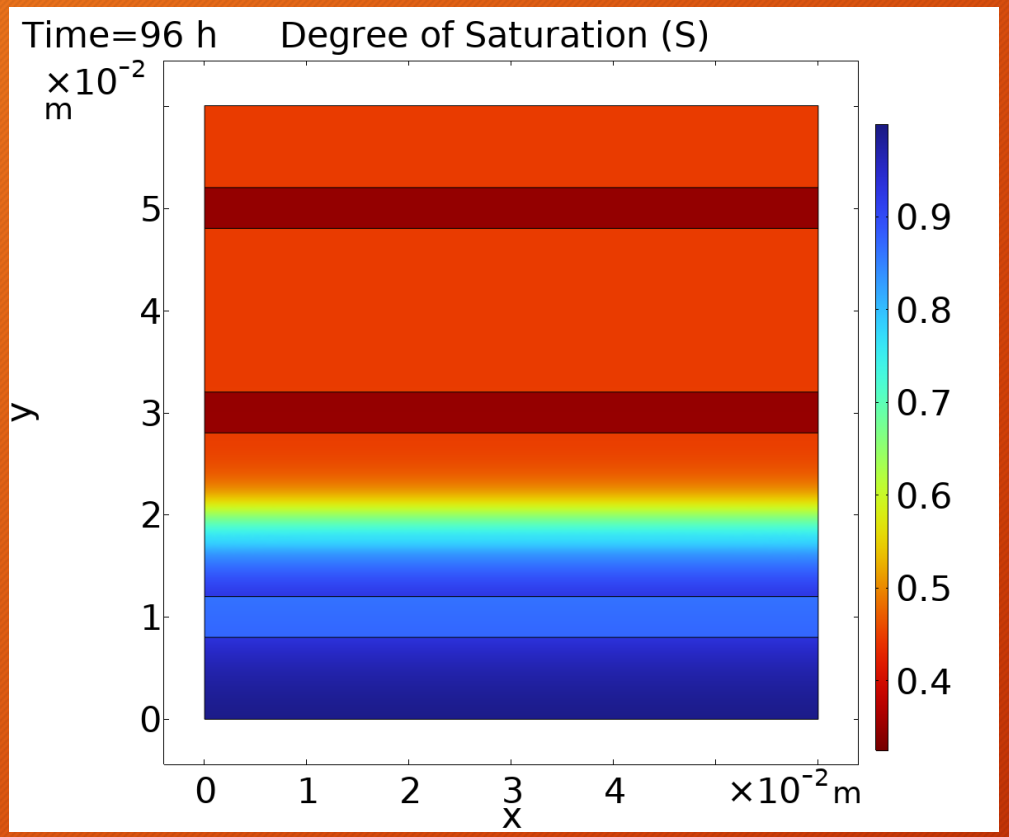
Perpendicular vs. Isotropic (0.3 w/cm)

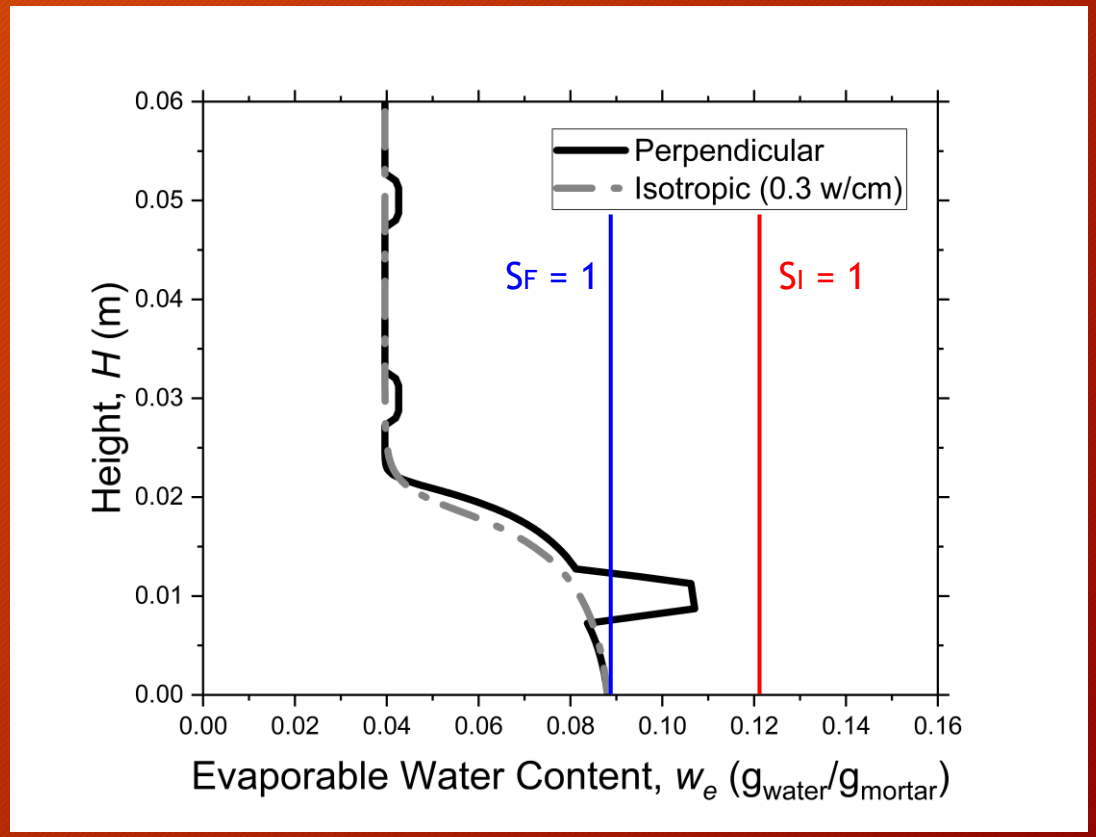




Perpendicular vs. Isotropic (0.3 w/cm)

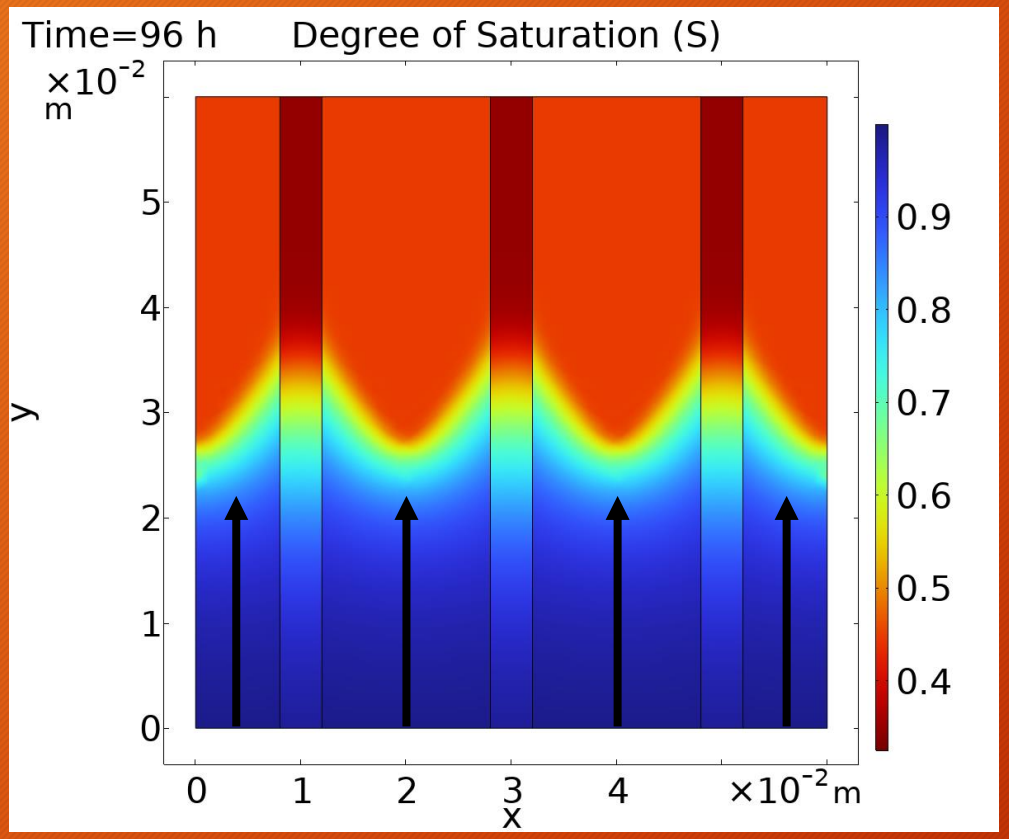
- Interfaces act as “sponges”



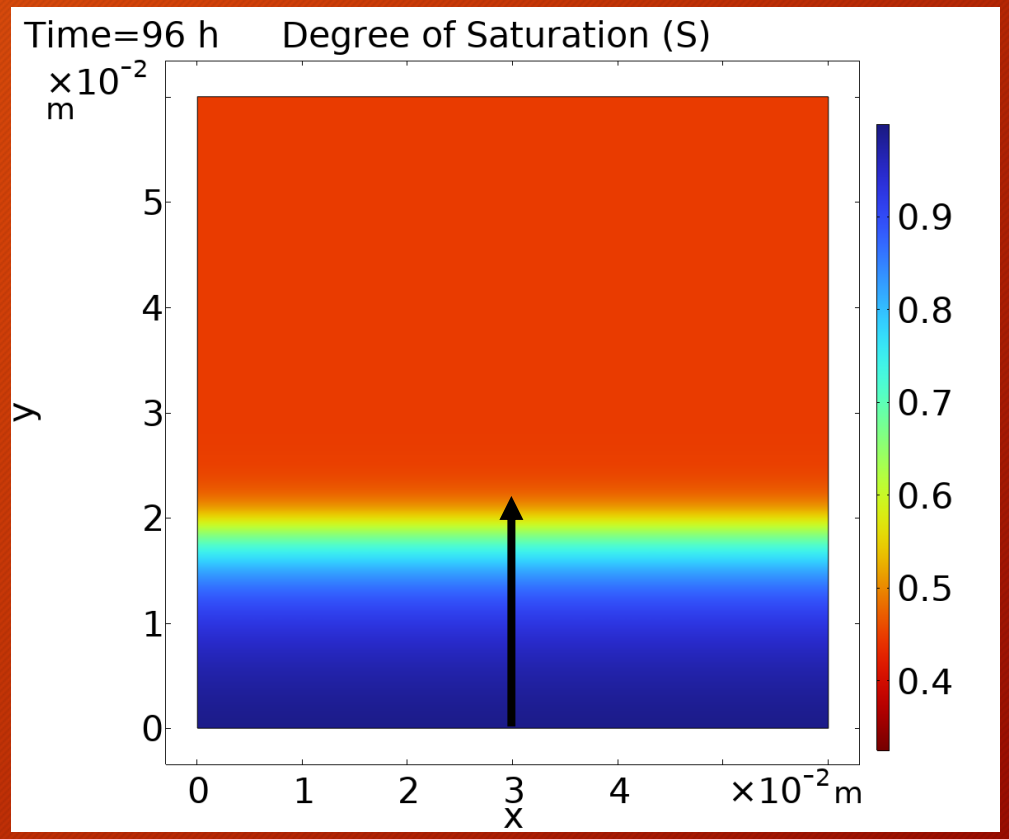


Parallel vs. Isotropic (0.3 w/cm)

- Parallel

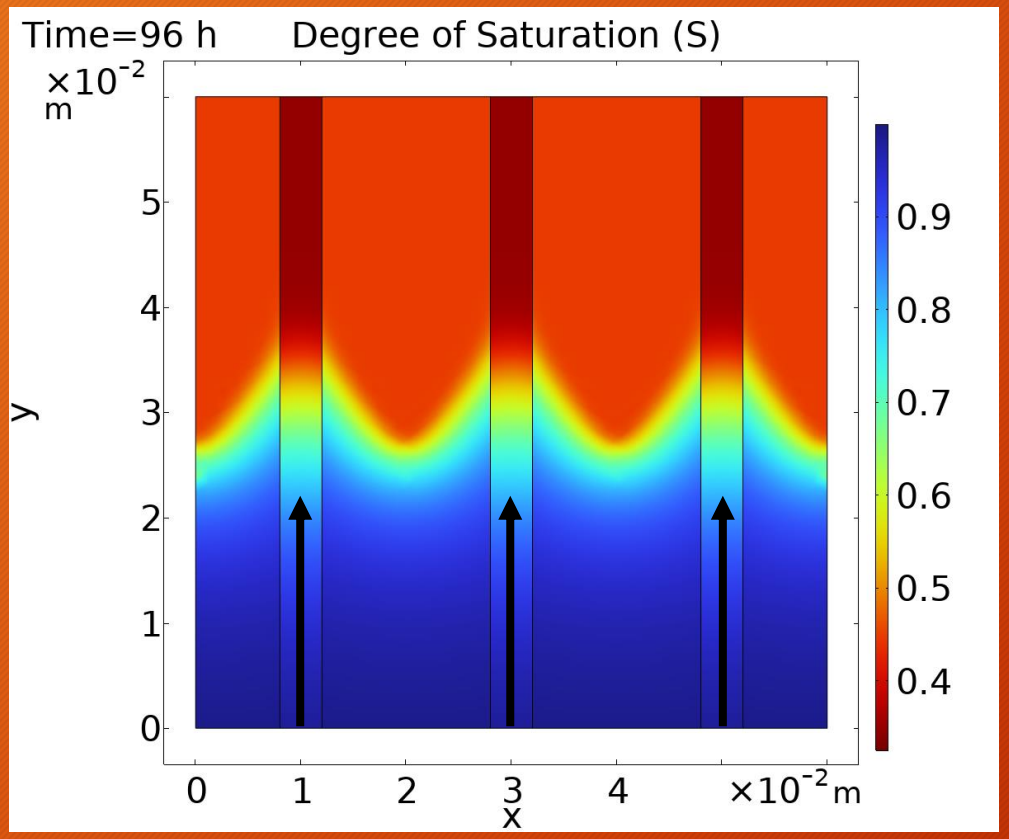


- Isotropic, 0.3 w/cm

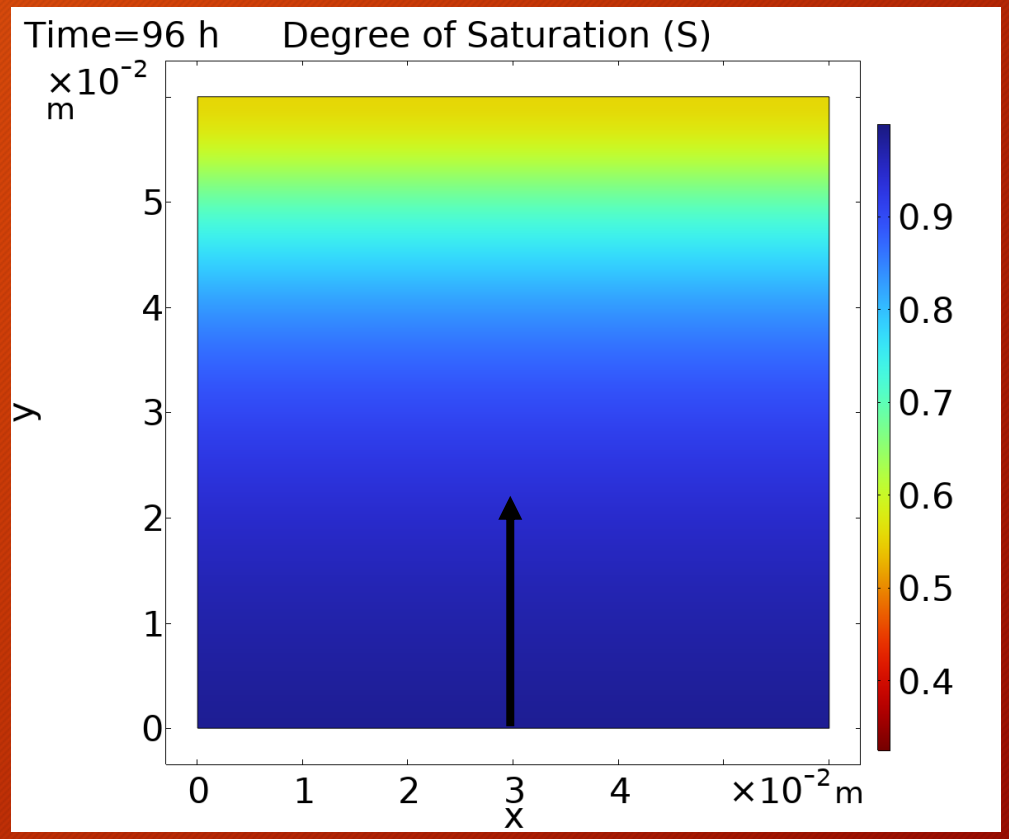


Parallel vs. Isotropic (0.5 w/cm)

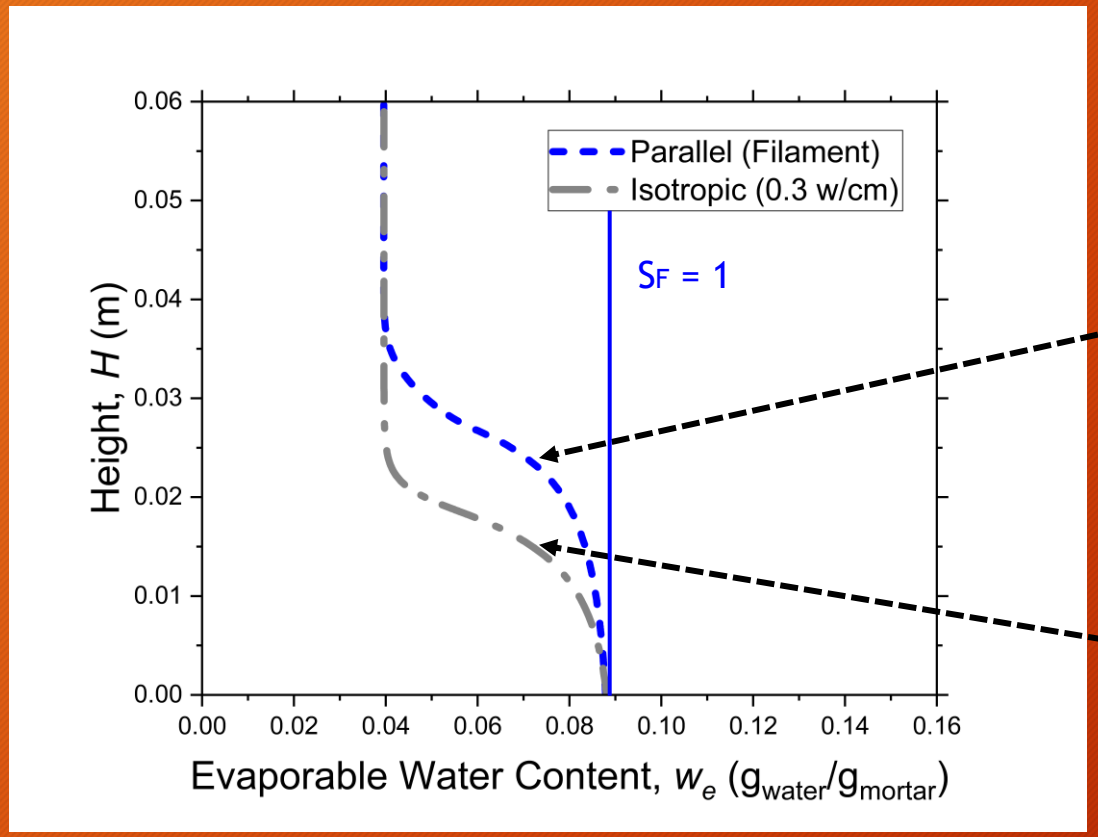
- Parallel

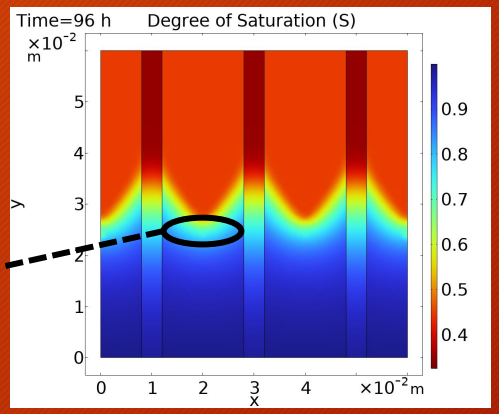


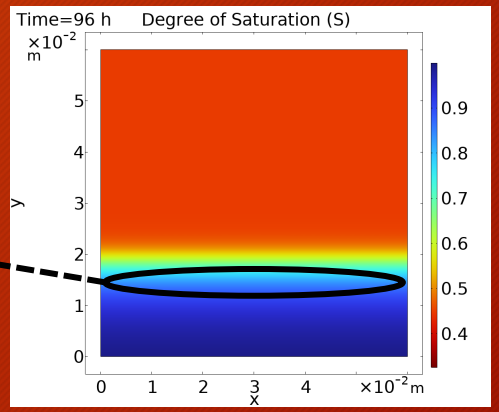
- Isotropic, 0.5 w/cm



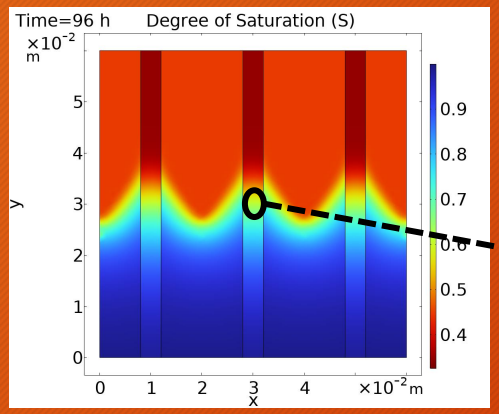
Parallel vs. Isotropic (0.3 w/cm)

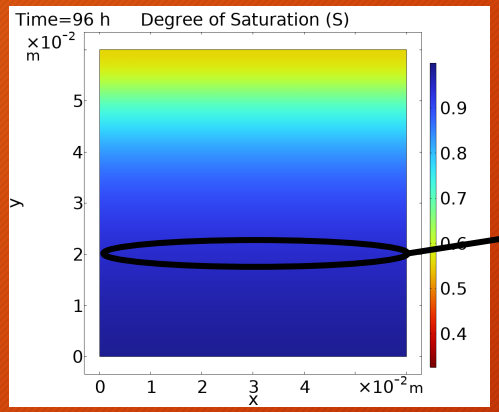


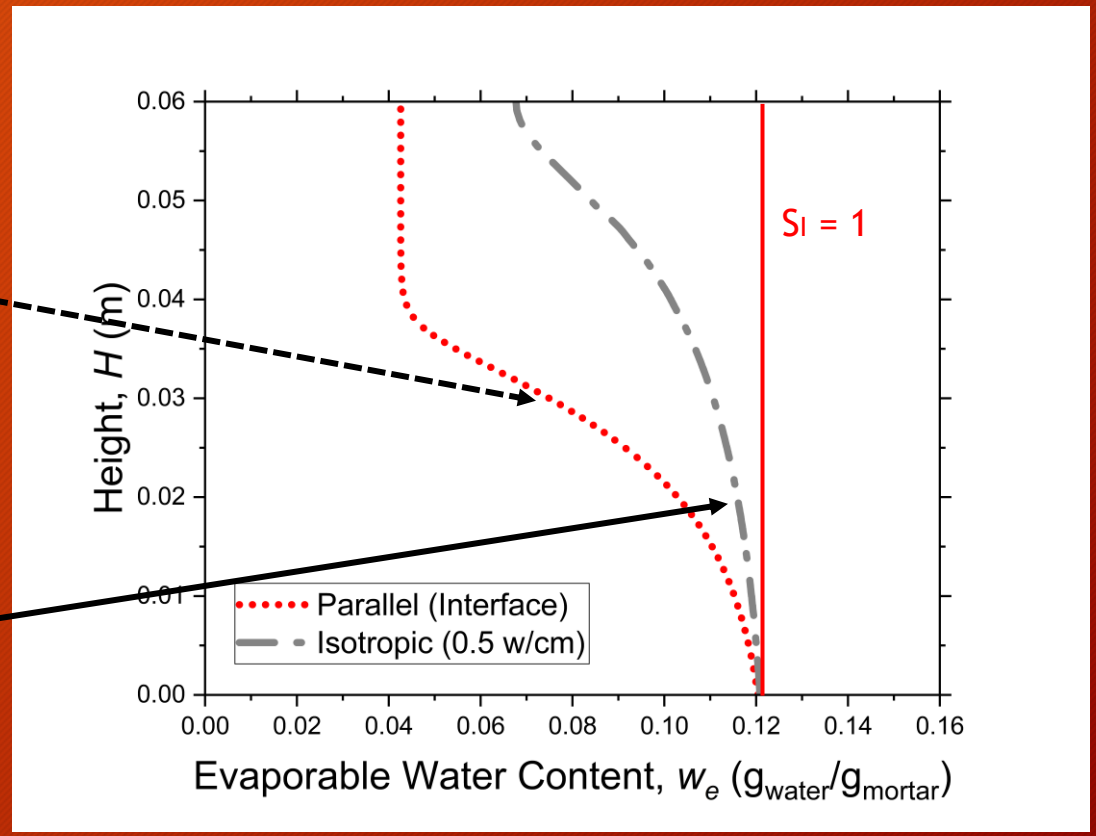




Parallel vs. Isotropic (0.5 w/cm)

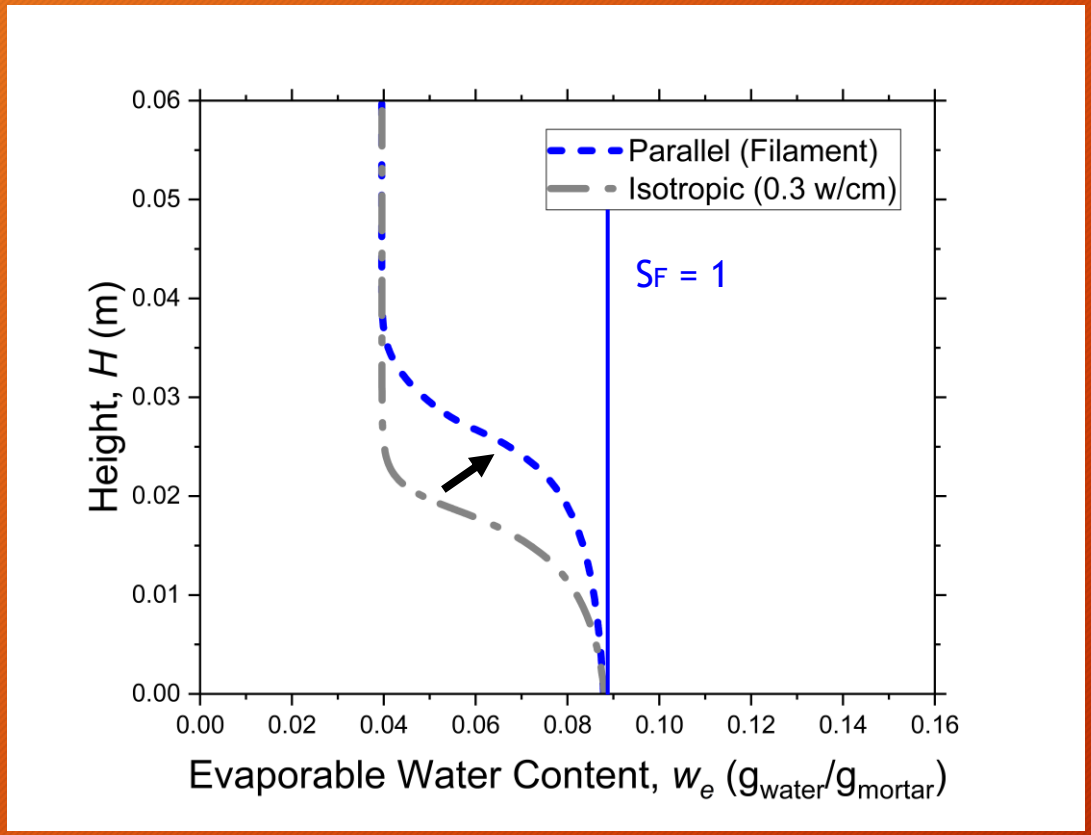


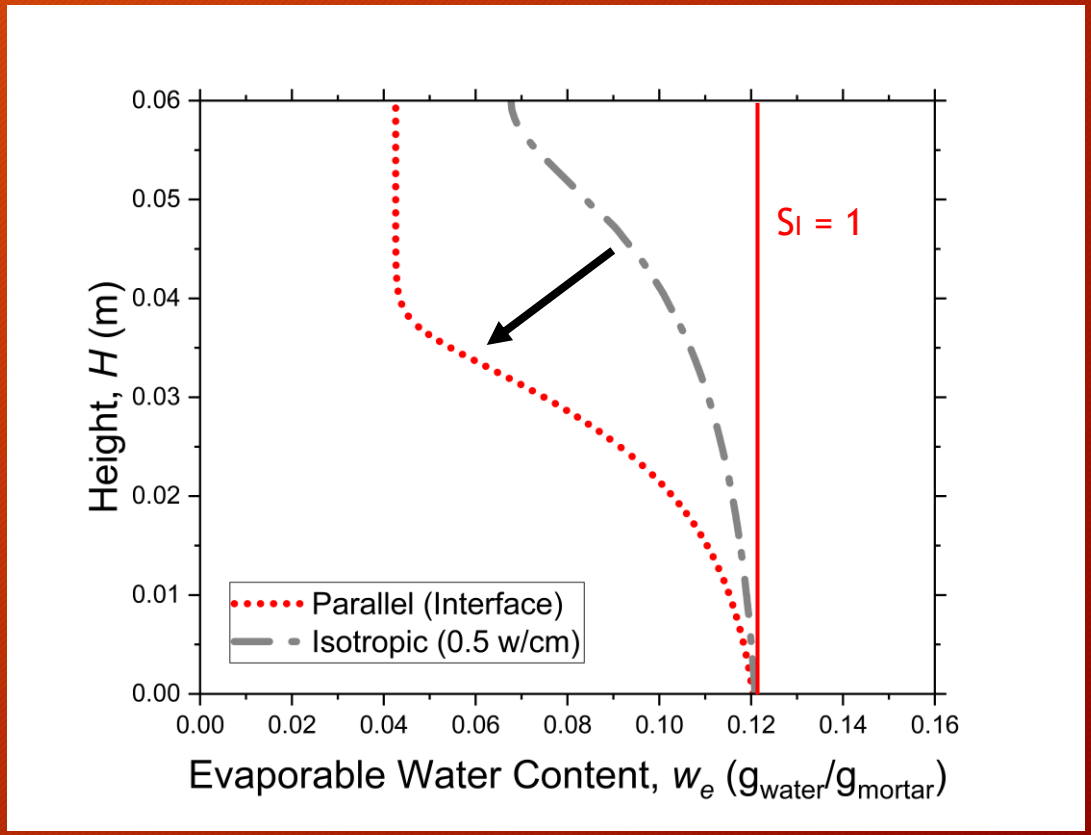




Parallel vs. Isotropic

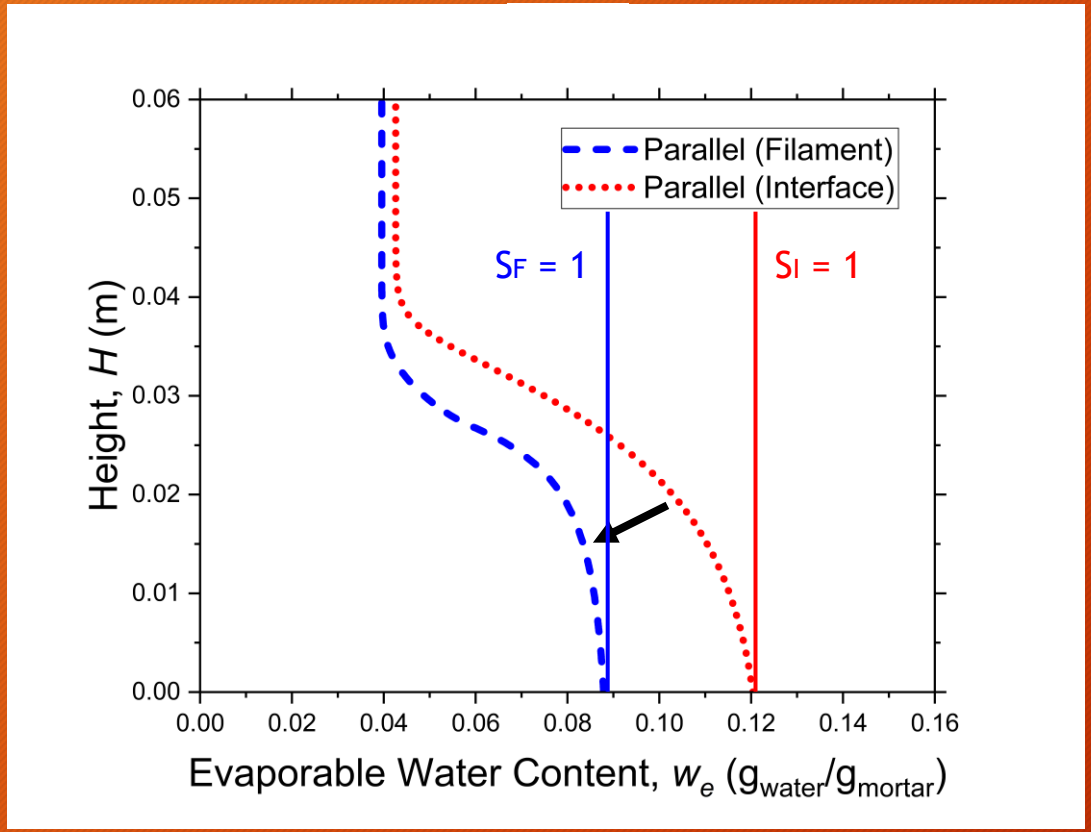
- Lateral transport, interfaces act as “channels”

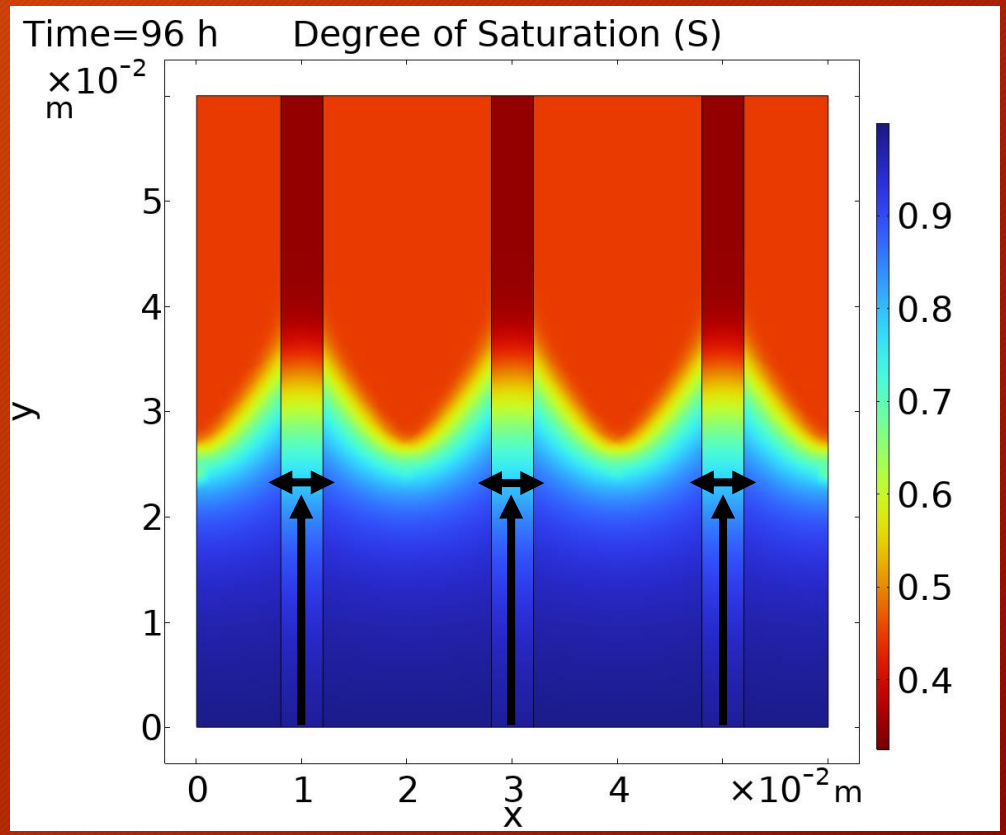




Parallel vs. Isotropic

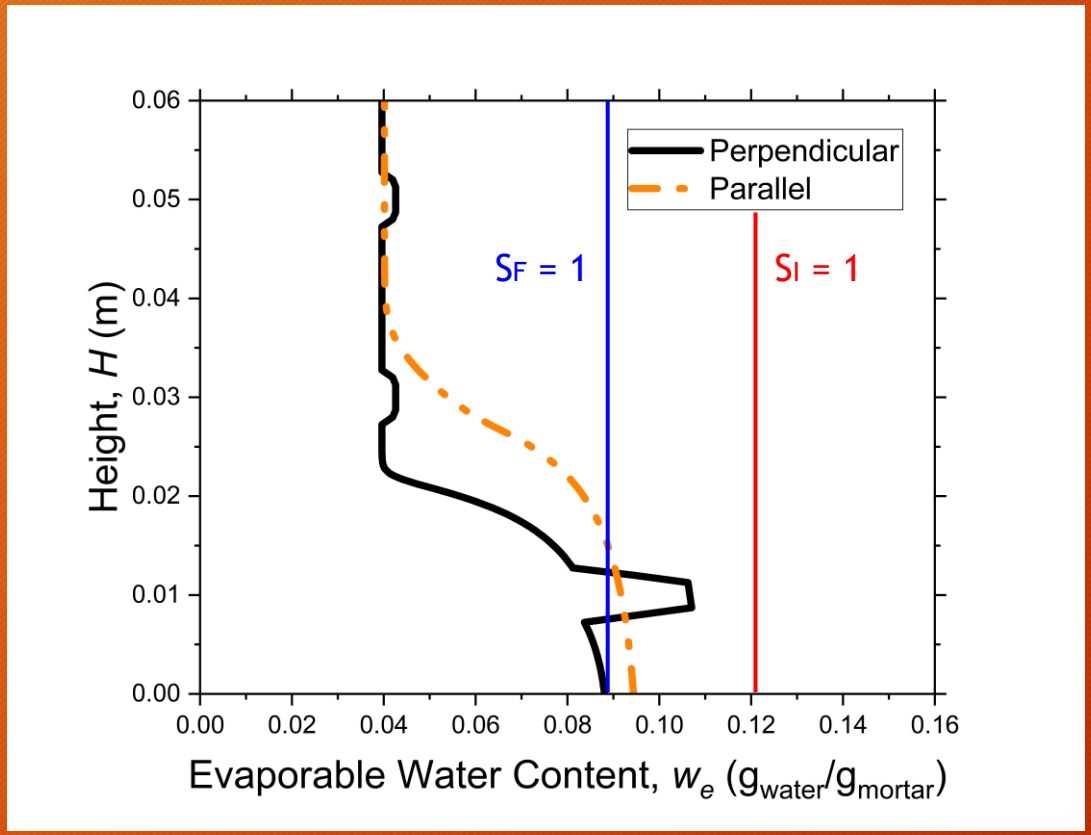
- Lateral transport, interfaces act as “channels”

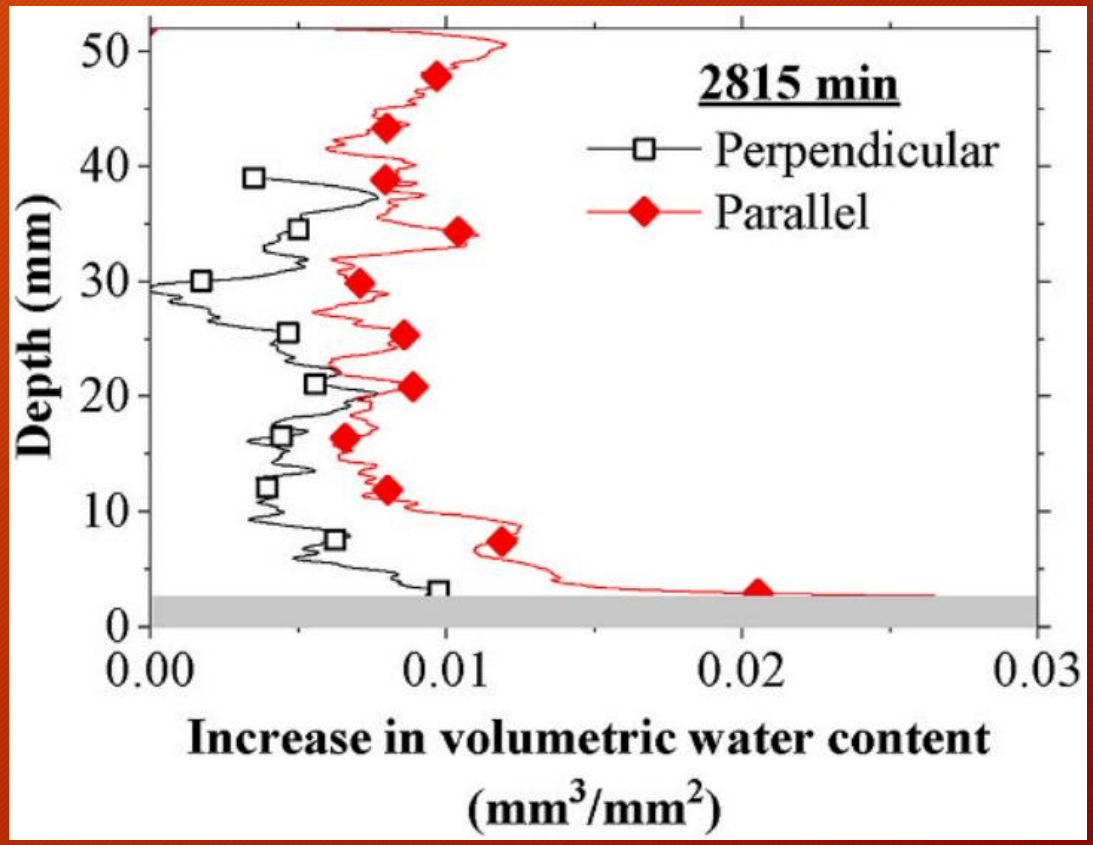




Parallel vs. Perpendicular

- Higher fluid absorption when layers are parallel





Summary

- A finite element model was used to simulate fluid absorption in an anisotropic 3D-printed mortar system, in parallel and perpendicular orientations
- Fluid transport in anisotropic systems is directional
- Perpendicular interfaces act as “sponges”, little influence on absorption
- Parallel interfaces act as “channels”, bring fluid to filaments, increase absorption

Acknowledgements

- National Science Foundation (Award No. 2129606)
- Tier 1 University Transportation Center for Durable and Resilient Transportation Infrastructure (Recipient Identifying No. 69A3552348339)

- More questions/comments? Email me: **desiquel@oregonstate.edu**