

Unconventional Resources Research

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**Shale Gas Innovation Workshop
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Some Key Questions/Objectives

- What is the state of the fluid in nano-sized pores and how does it flow?
- Can we accurately incorporate hydraulic and natural fractures in simulation of tight rocks so that better estimates of flow rates can be made?
- What is the accuracy of decline curve analysis for tight rocks?



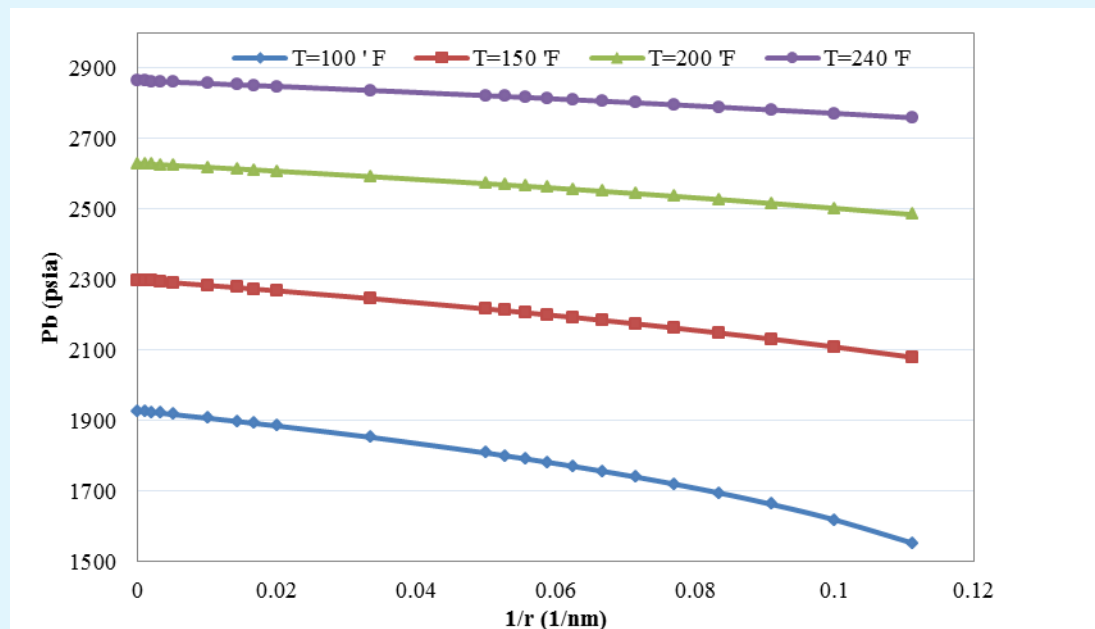
New Research Consortium

- We have initiated a new JIP on unconventional gas resources (Chevron and Hess are members)
- Focus is on gas and oil shales, and other tight rocks
- Dr. Luis Ayala and I are co-directors



Example: Effect of Nanopores on Phase Behavior

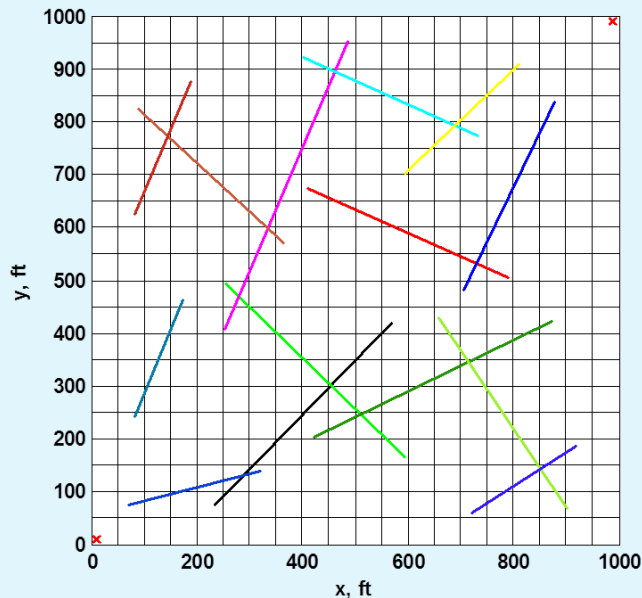
- Capillary pressure is large when pore sizes are small
- Interfacial tension changes the Gibbs free energy and therefore the phase behavior



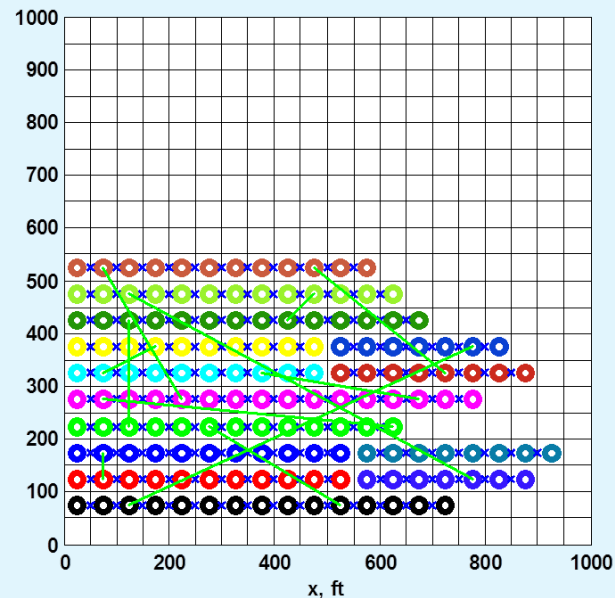
Example: Inclusion of Fractures in Simulation

- Fractures provide fast connections for production
- Fractures and matrix equations are decoupled, increasing accuracy and computational speed

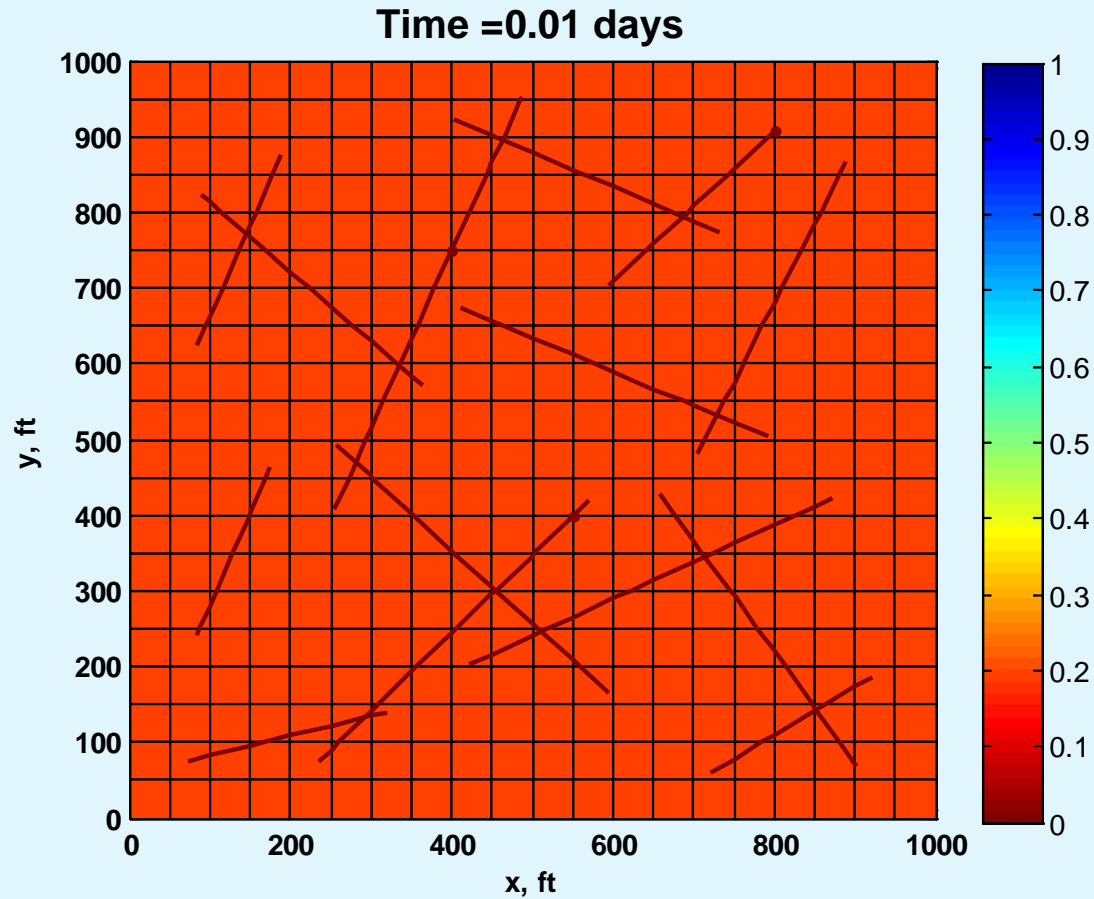
Synthetic Model



Fracture Layer



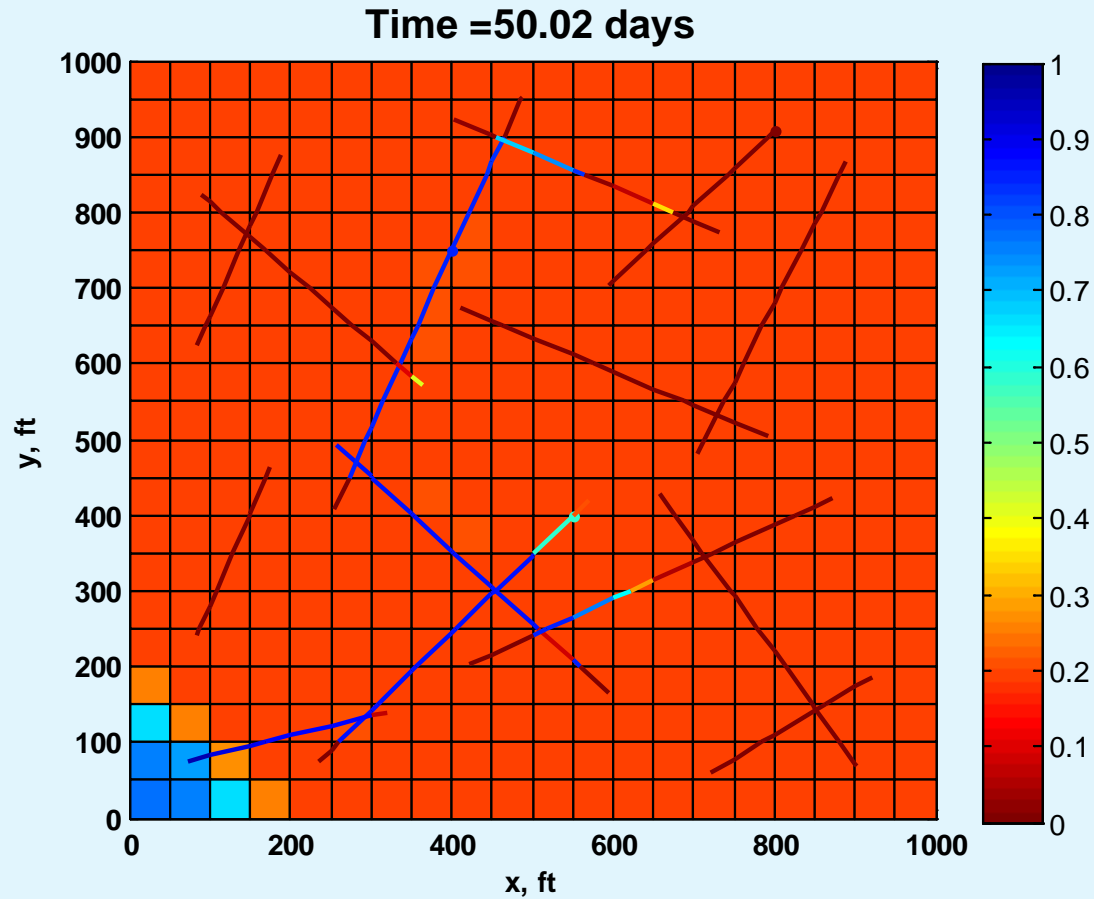
2D MODEL / WATER-FLOOD



**Water
saturation**



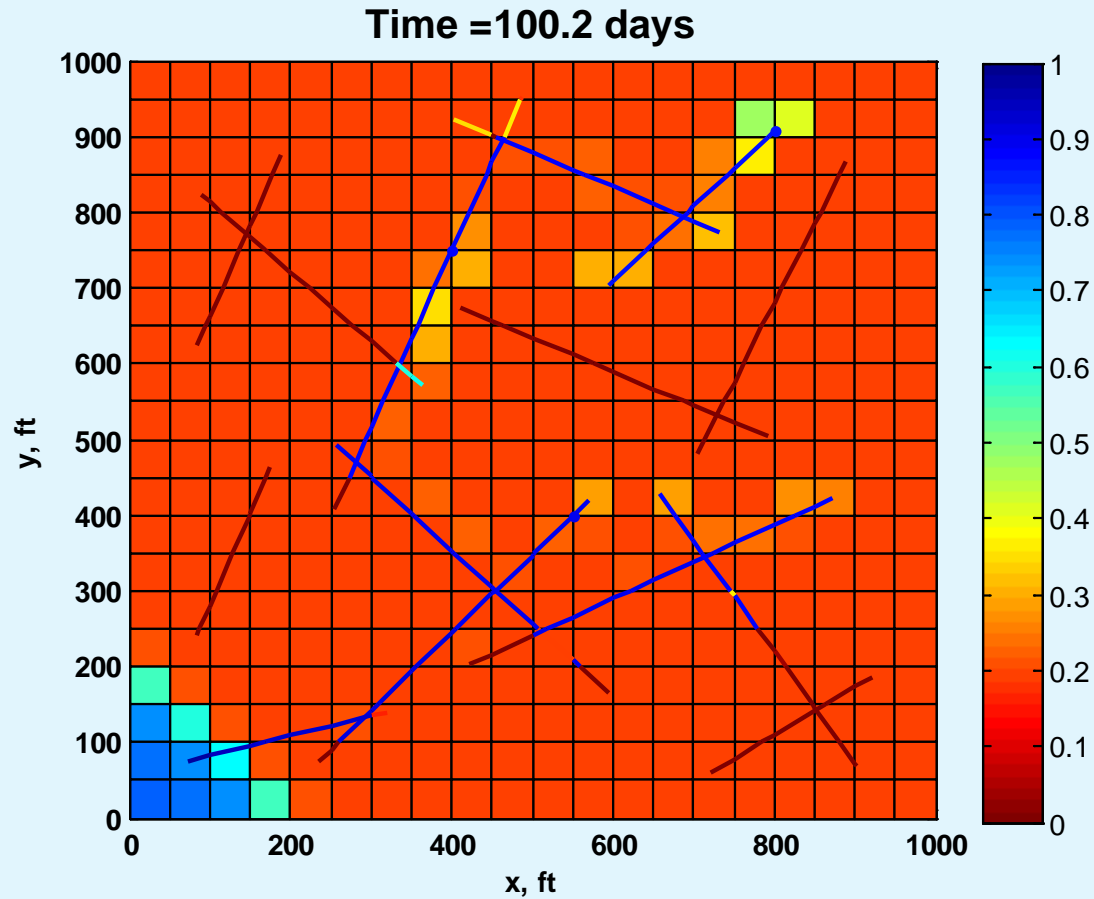
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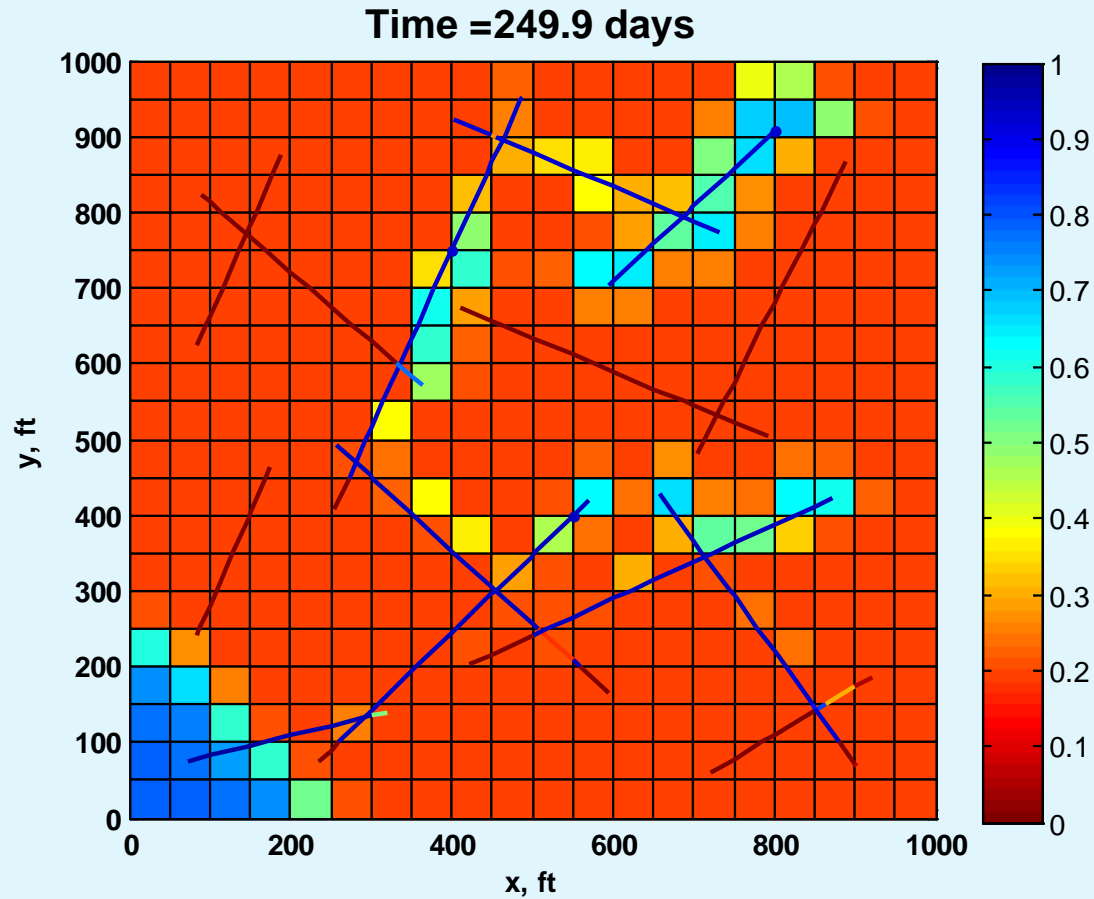
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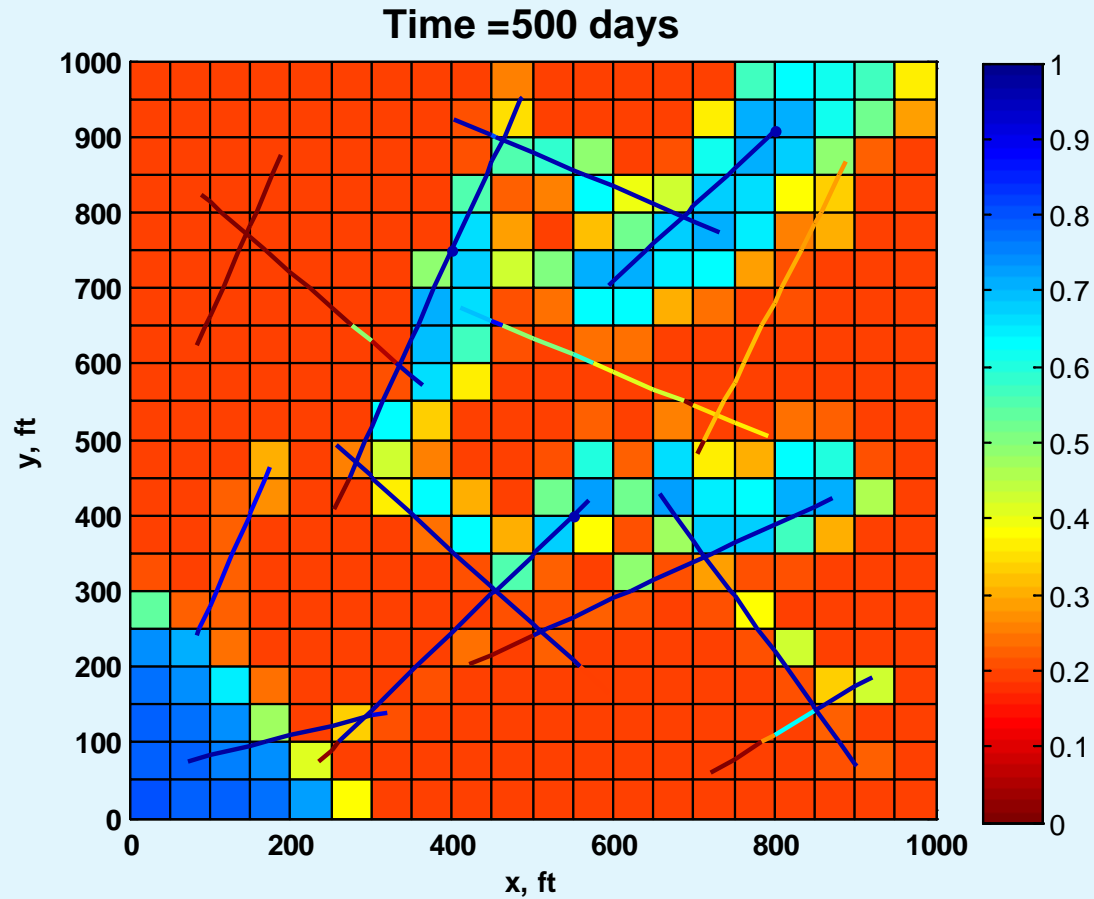
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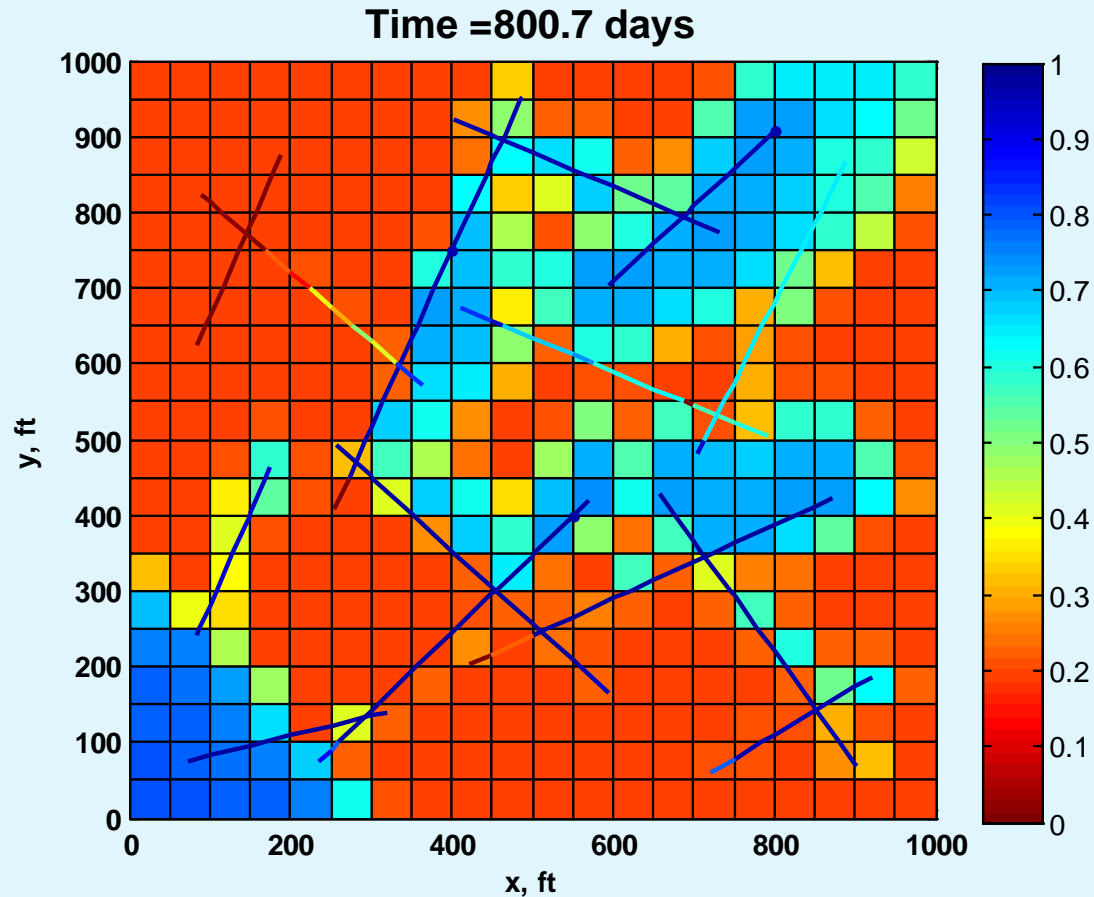
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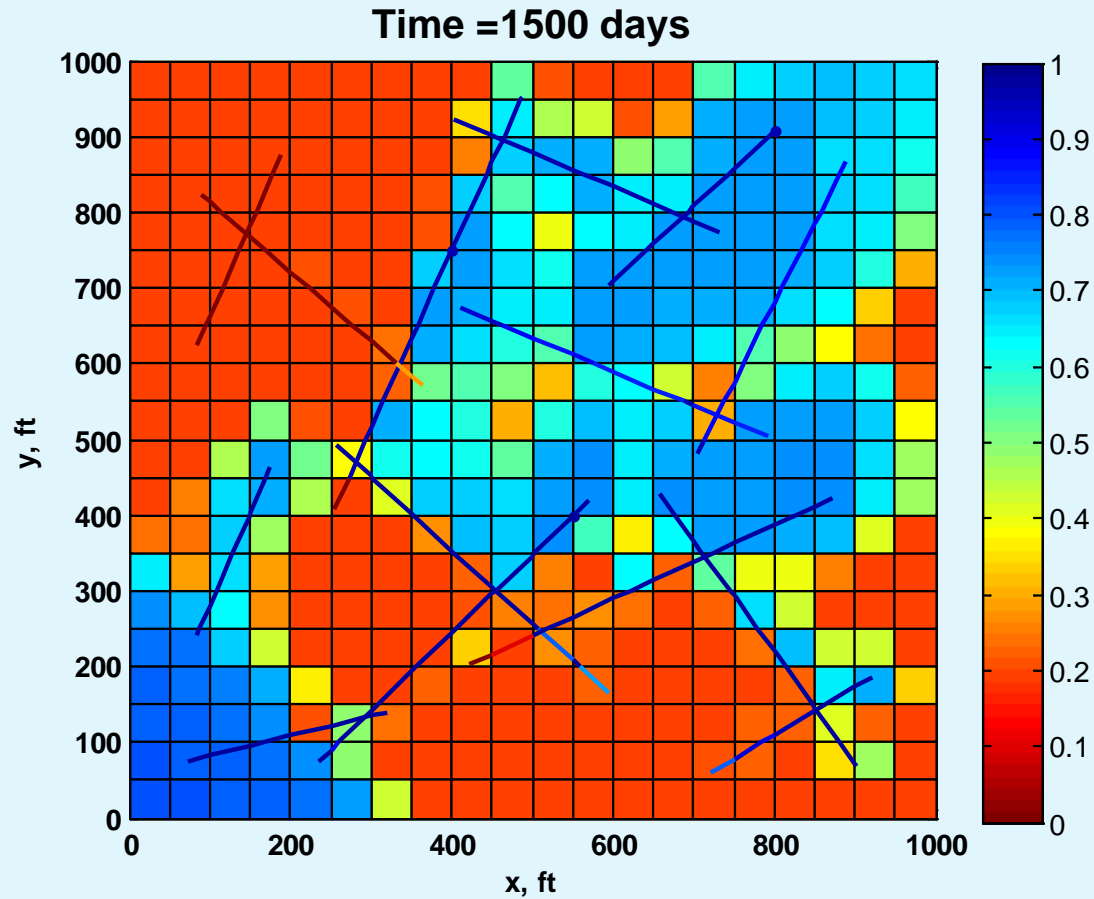
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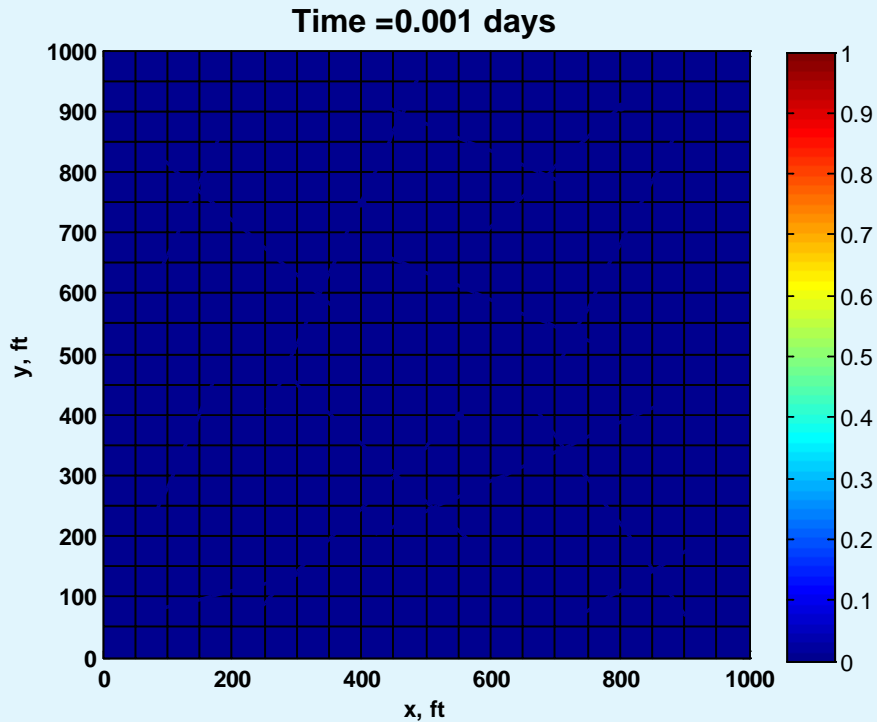
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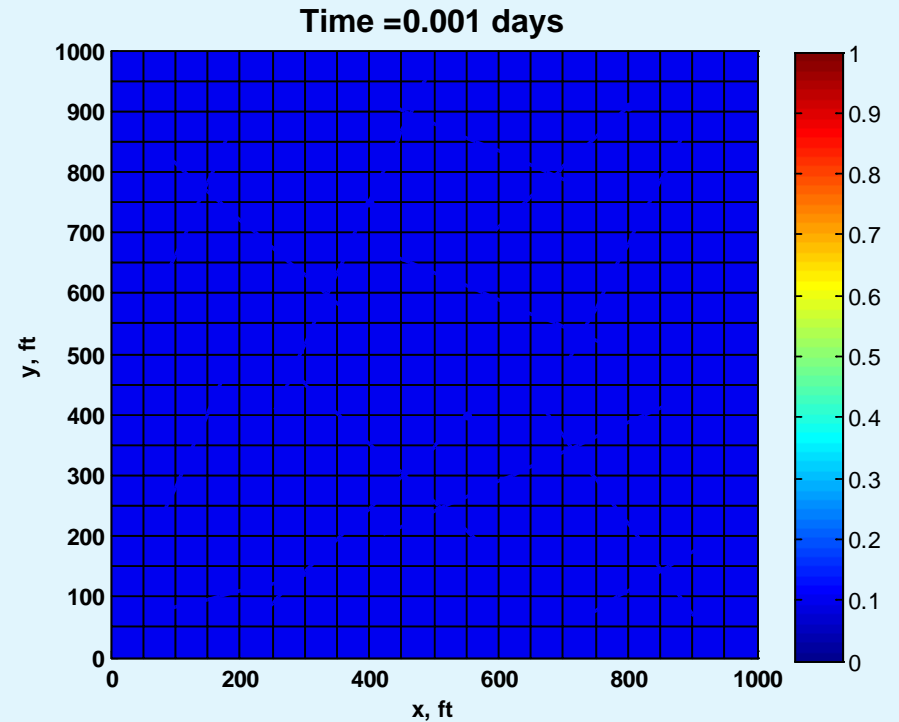
2D MODEL / WATER-FLOOD



2D MODEL / GAS-FLOOD



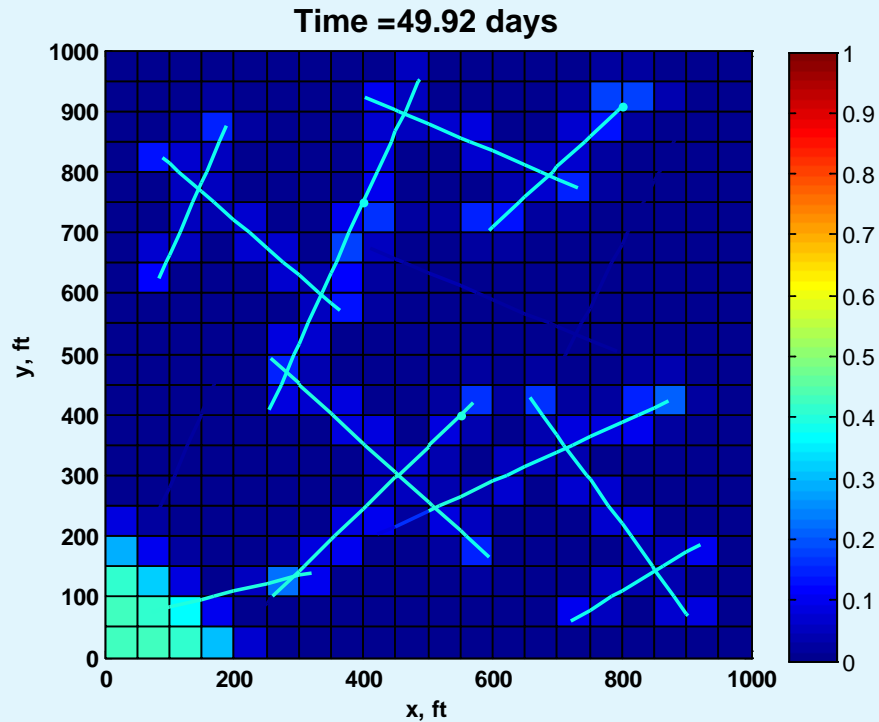
**CO2 mole fraction in
oil**



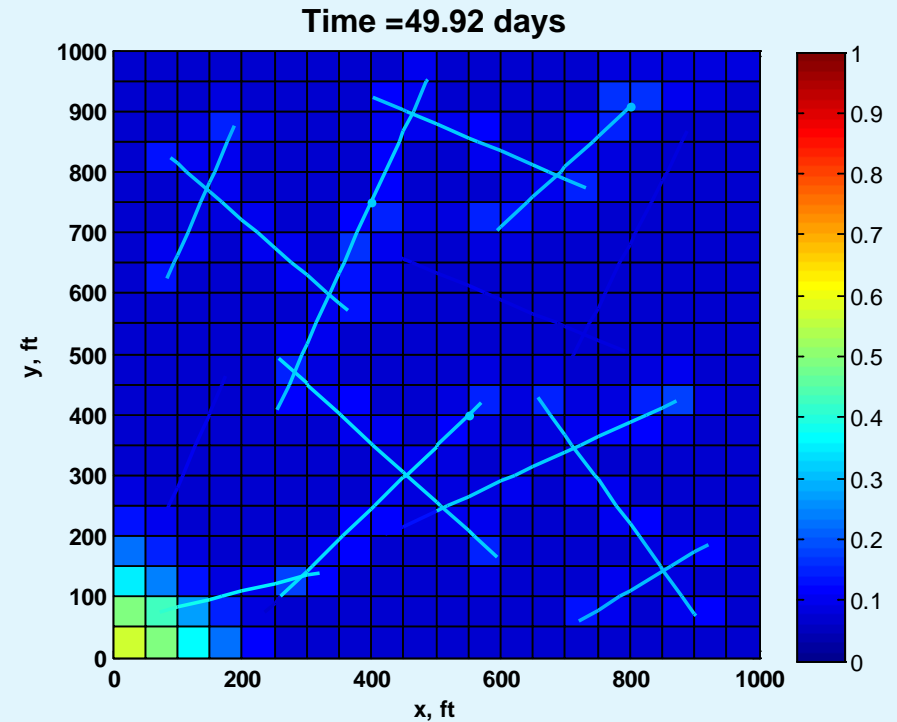
**Gas
saturation**



2D MODEL / GAS-FLOOD



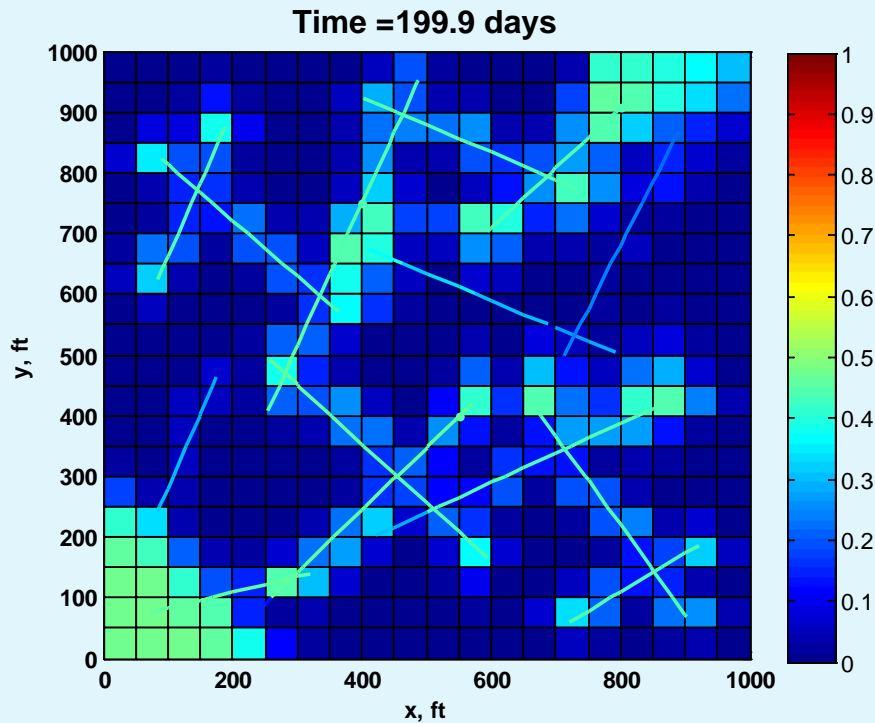
CO2 mole fraction in oil



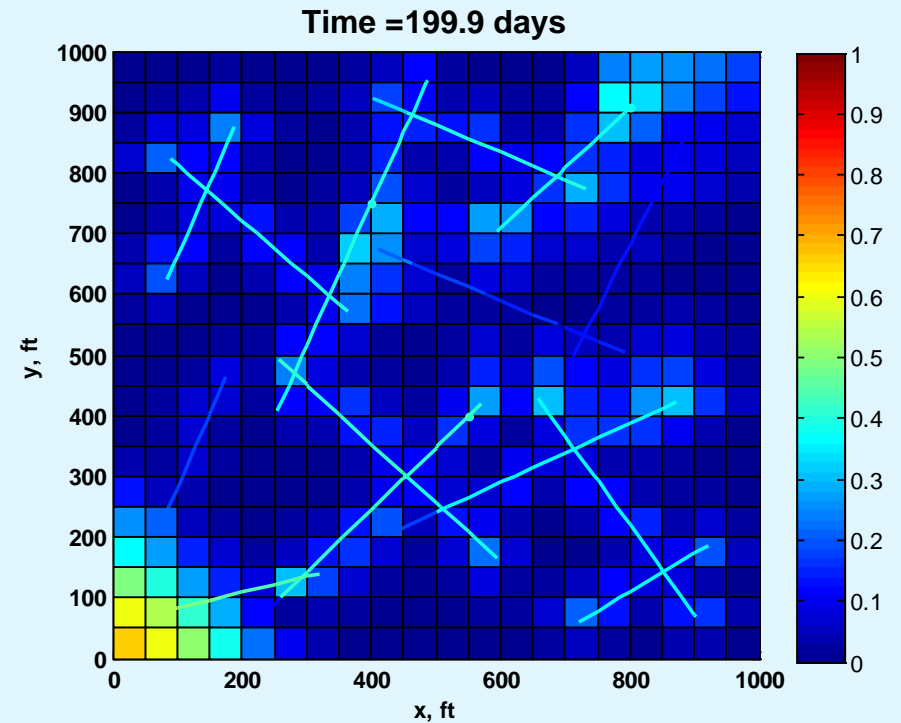
Gas saturation



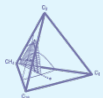
2D MODEL / GAS-FLOOD



CO2 mole fraction in oil

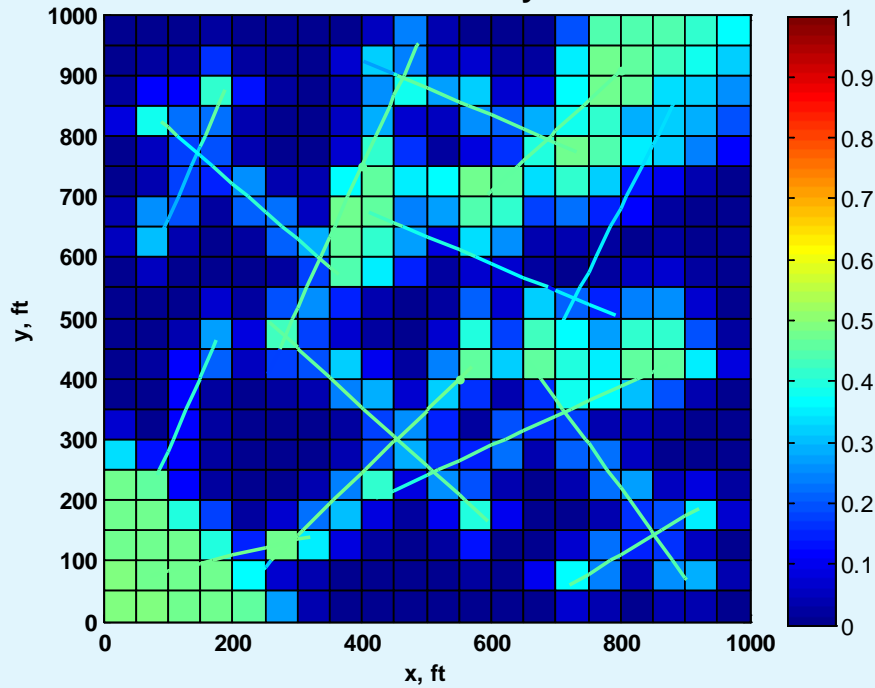


Gas saturation



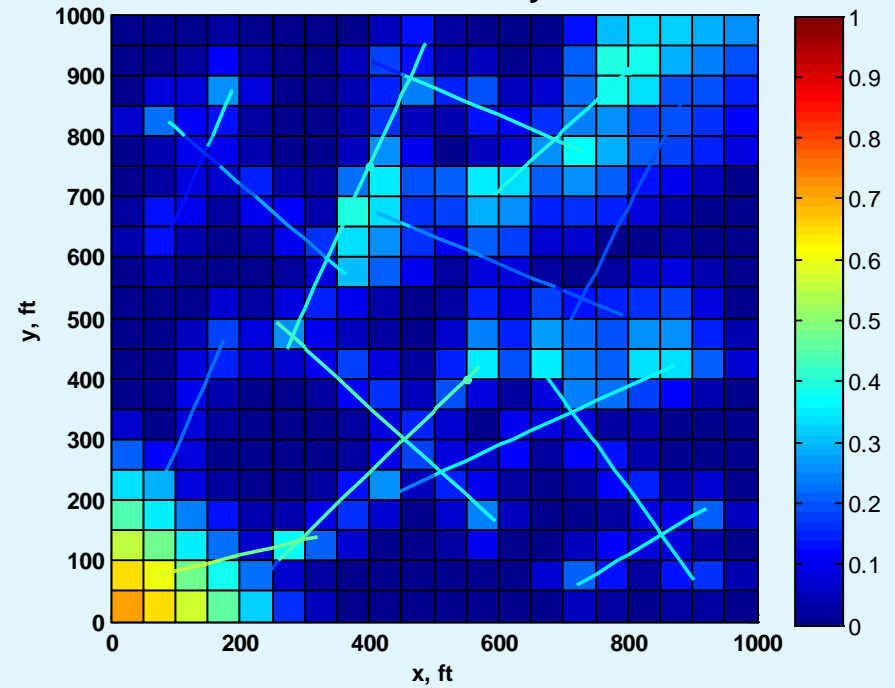
2D MODEL / GAS-FLOOD

Time = 399.9 days



CO2 mole fraction in oil

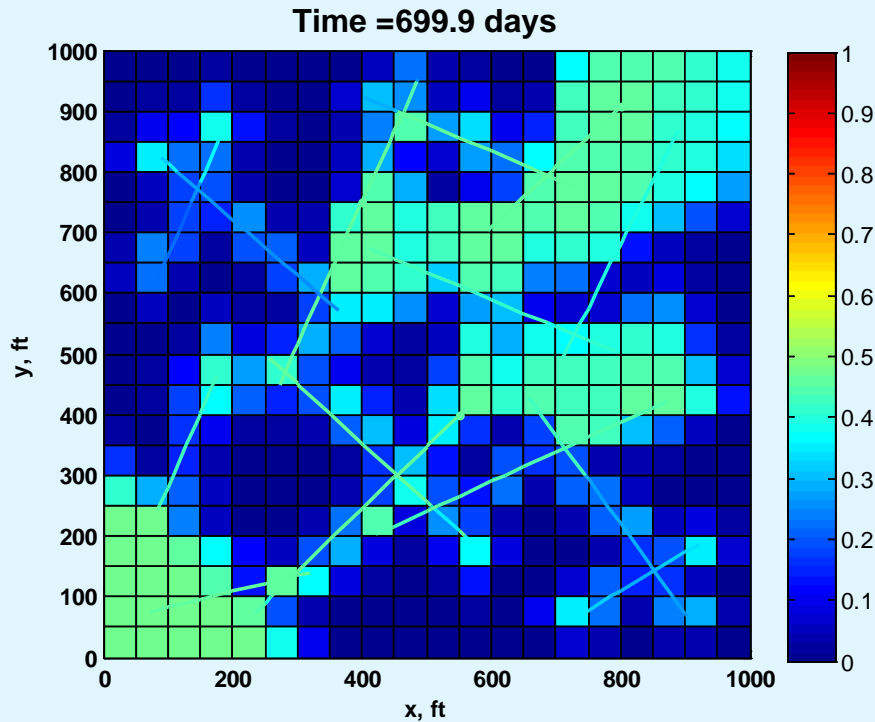
Time = 399.9 days



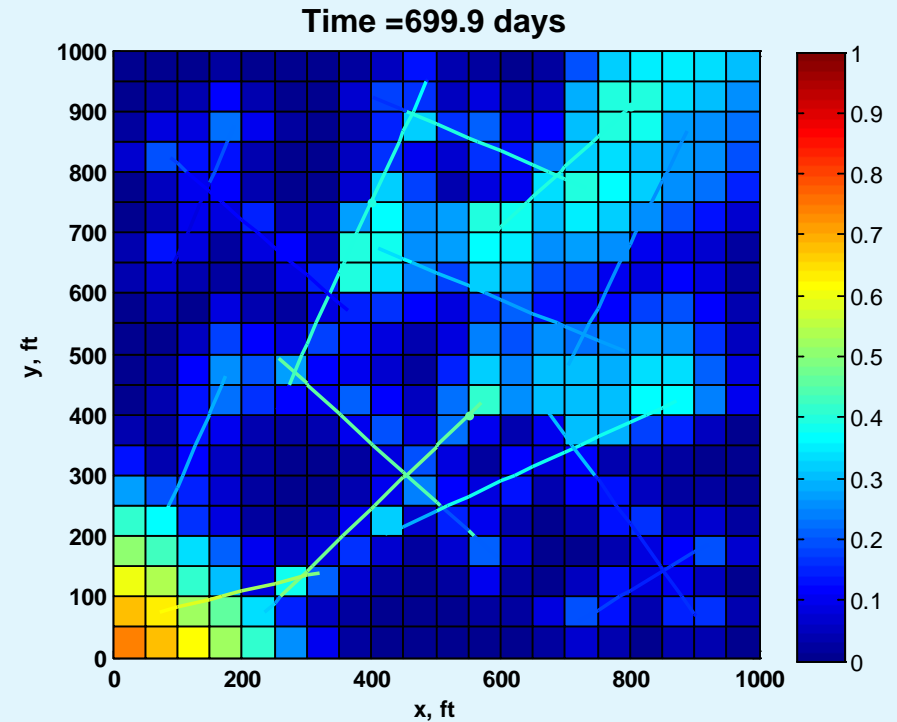
Gas saturation



2D MODEL / GAS-FLOOD



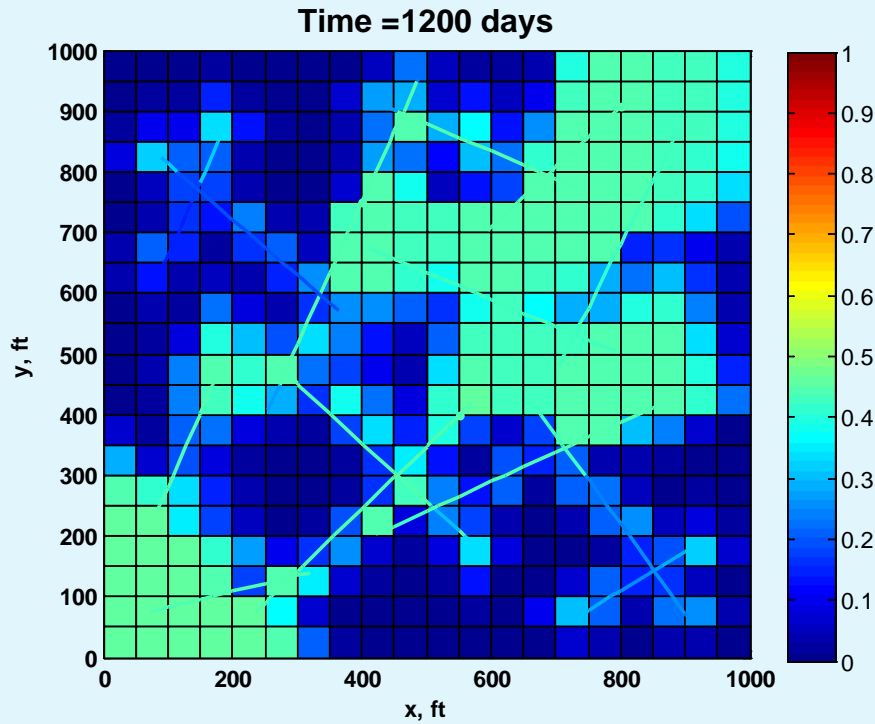
CO₂ mole fraction in oil



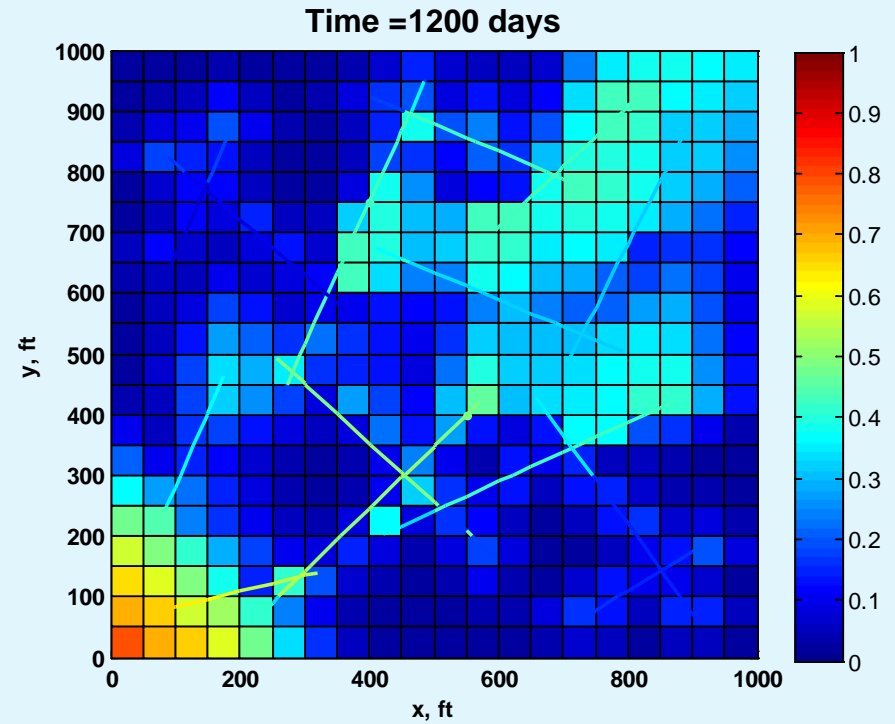
Gas saturation



2D MODEL / GAS-FLOOD



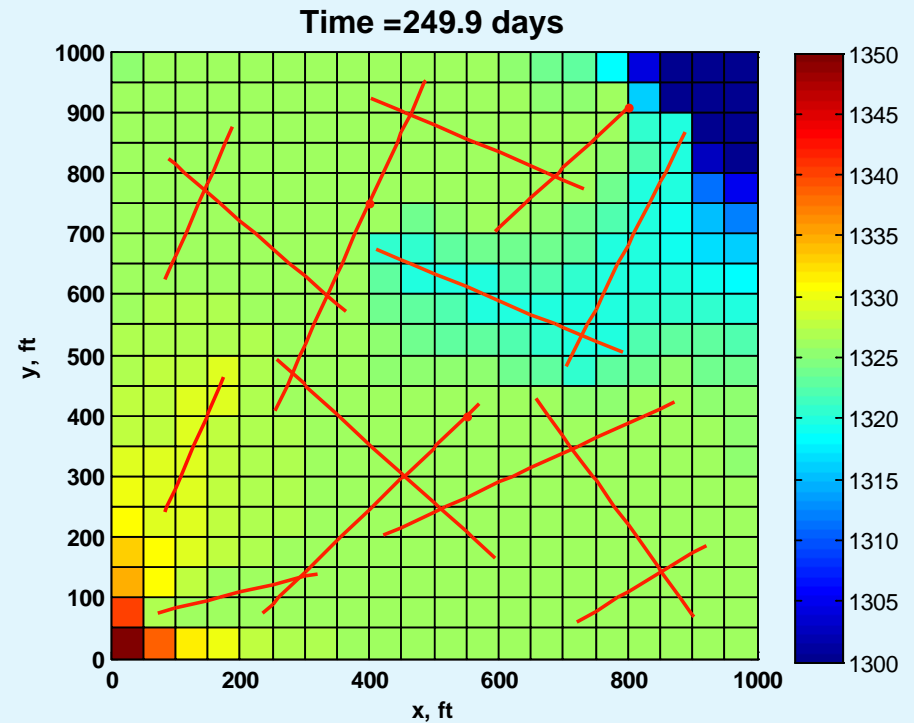
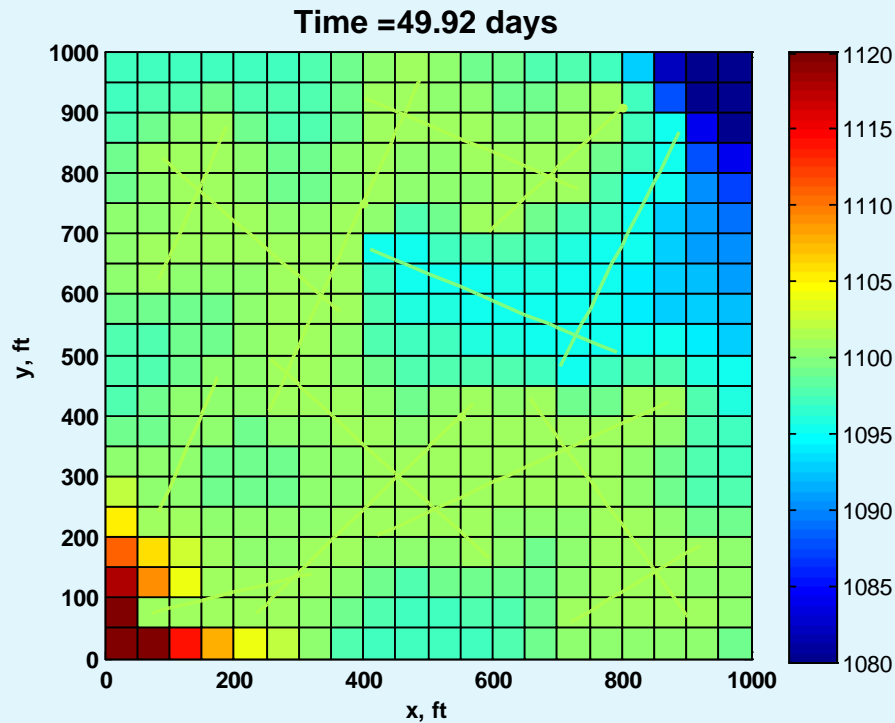
CO₂ mole fraction in oil



Gas saturation



2D MODEL / GAS-FLOOD



THANK YOU

$$c_D = \frac{1}{2} \operatorname{erfc} \left(\frac{x_D - t_D}{2 \sqrt{\frac{t_D}{N_{Pe}}}} \right) + \frac{1}{2} e^{-x_D N_{Pe}} \operatorname{erfc} \left(\frac{x_D + t_D}{2 \sqrt{\frac{t_D}{N_{Pe}}}} \right)$$

$$c_D = c_D(t_D - t_{D1})$$

$$c_D = \frac{1}{2} \operatorname{erfc} \left(\frac{x_D - t_D}{2 \sqrt{\frac{t_D}{N_{Pe}}}} \right)$$

The computational cost of conventional flash calculations increases significantly with the number of components making it impractical for use in many finely-gridded composition spaces and other applications. Previous research to increase flash calculation speed has been limited to those with zero binary interaction parameters (BIPs) or approximations based on an eigenvalue analysis of the binary interaction matrix. Practical flash calculations, however, nearly always have some nonzero BIPs. Further, the speed of eigenvalue methods varies depending on the choice and number of the dominant eigenvalues. This paper presents a new and simple method for significantly increasing the speed of flash calculations for any number of nonzero BIPs. The approach requires the solution of up to two reduced parameters regardless of fluid complexity or the number of components and is based on decomposing the BIPs into two parameters using a simple quadratic expression. The new approach is exact in that the equilibrium phase compositions for the same BIPs are identical to those with the conventional flash calculation. Eigenvalue analysis is required. Further, the new approach eliminates the Rachford-Rice procedure and is more robust than the conventional flash calculation procedure. We demonstrate the new approach for several example fluids, and show that speed up by a factor of about 3 – 20 is obtained over conventional