Dual porosity-dual permeability model in MRST

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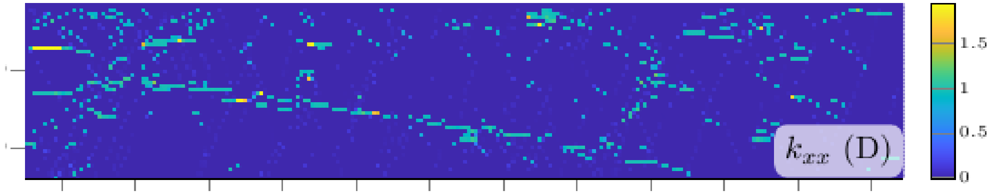
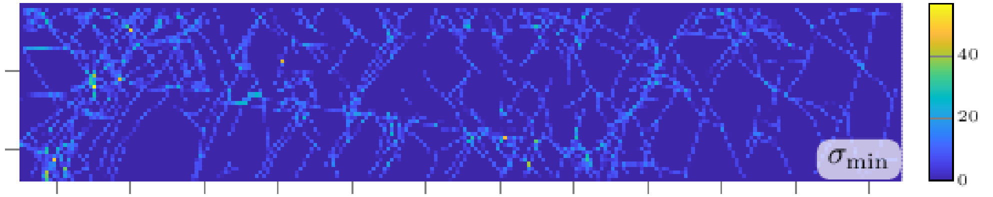
Fracture traces

Dual porosity/ dual permeability model

Upscaled fracture permeabilities



Shape factor



Discrete Fracture-Matrix (DFM) simulations are potentially most accurate, but

- Computationally demanding
- Difficult to create conforming meshes
- Uncertainties in fractures' properties

Upscaled simulations:

- Faster than DFM
- Challenging to obtain the accurate model closures

The dual porosity-dual permeability model (DPDP) model

Single-phase flow	Two-phase flow
$\frac{\lvert V\rvert\varphi_F}{\Delta t}\left(\rho_F^{n+1}-\rho_F^{n}\right)+\sum F_{F,k}=Q$	$\frac{\lvert V\rvert\phi_F}{\Delta t}\left[\left(b_{w,F}S_{w,F}\right)^{n+1}-\left(b_{w,F}S_{w,F}\right)^{n}\right]+\sum F_{w,F}=Q_w$
$\frac{\lvert V\rvert\varphi_M}{\Delta t}\left(\rho_M^{n+1}-\rho_M^{n}\right)+\sum F_{M,k}=-Q$	$\frac{\lvert V\rvert\phi_F}{\Delta t}\left[\left(b_{n,F}S_{n,F}\right)^{n+1}-\left(b_{n,F}S_{n,F}\right)^{n}\right]+\sum F_{n,F}=Q_n$
$Q=\rho_M\frac{K_m}{\mu}\sigma\left(p_M-p_F\right)$	$\frac{\lvert V\rvert\phi_M}{\Delta t}\left[\left(b_{w,M}S_{w,M}\right)^{n+1}-\left(b_{w,M}S_{w,M}\right)^{n}\right]+\sum F_{w,F}=-Q_w$
	$\frac{\lvert V\rvert\phi_M}{\Delta t}\left[\left(b_{n,M}S_{n,M}\right)^{n+1}-\left(b_{n,M}S_{n,M}\right)^{n}\right]+\sum F_{n,M}=-Q_n$
	$Q_\alpha=\sigma k_{\alpha,M}\frac{K_m k_{r,\alpha}}{\mu_\alpha}\left(p_{\alpha,M}-p_{\alpha,F}+g\Delta\rho\Delta h_\alpha\right)$

Model closures

- Rock and fluid properties for the matrix and fractures continua

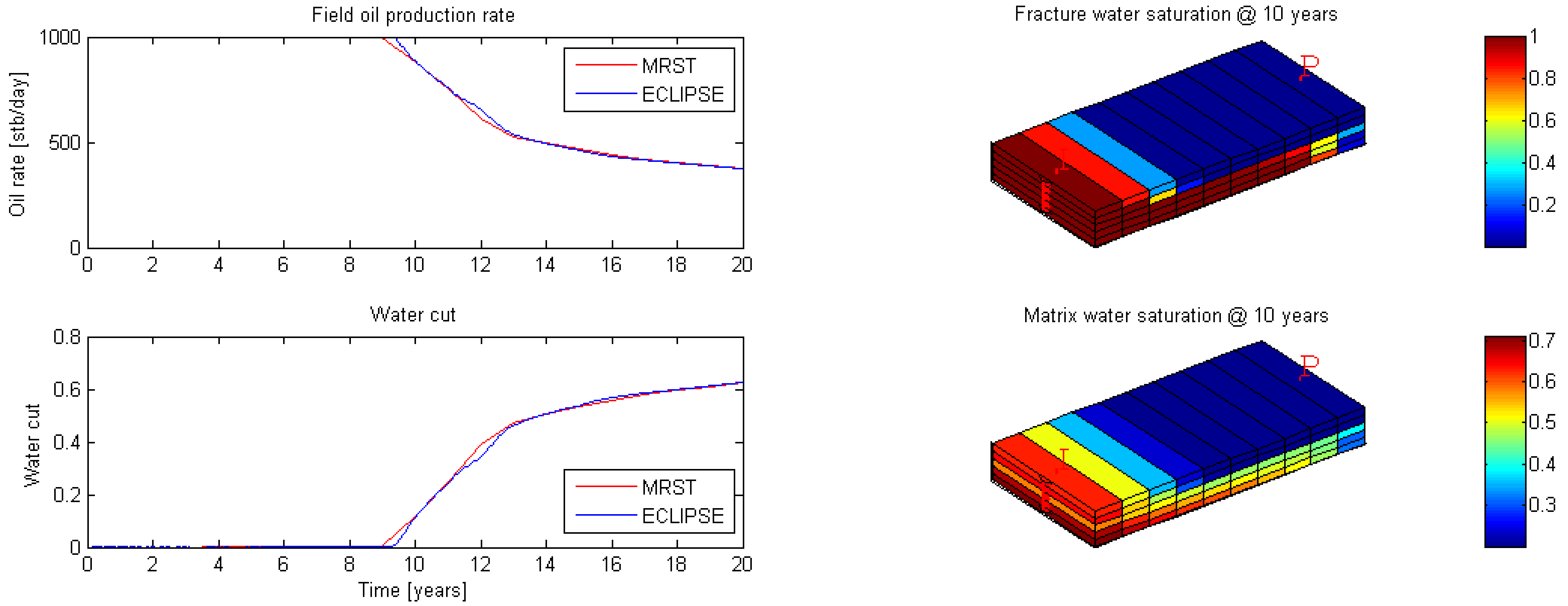
Implementation

- Modification of the dual porosity (DP) module of MRST
- Main changes:
  - A new `TwoPhaseOilWaterModelDPDP` class inherited from `TwoPhaseOilWaterModelDP` with the definition of the matrix flow equations and the corresponding boundary conditions
  - A new `VariableShapeFactor` class inherited from `ShapeFactor` with the definition of the shape factor, varying from one grid block to another
  - Fixed several bugs in the existing DP module
- Tested with mrst-2020a
- Current limitations:
  - Single phase or two immiscible phases
  - Wells connections to the fracture continuum only

- Repository: https://github.com/nikolai-andrianov/DPDP-MRST

Example 1: SPE 6th comparative study – water injection with the DPDP model

- Modifications with regards to the original problem formulation of SPE-18741:
  - Consider only oil and water
  - Represent oil as dead oil with a typical compressibility
  - Matrix permeability is increased by the factor of 10 to achieve more pronounced differences as compared to the dual porosity model
- Good match with the reference solution (ECLIPSE)



Example 2: Waterflooding in the Geiger et al. (2011) fracture geometry

- The fine-scale matrix and fracture properties are upscaled using fine-scale simulations
- Incompressible two-phase flow model with Corey-type relative permeabilities and a tabulated cap. pressure
- Constant rate injection in the horizontal direction
- Good match between the DPDP results and the fine-scale reference solution