Results section 2

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Injection through the left boundary

A: No capillary pressure.

As mentioned before, we simulate flow through a porous media with water injection through the left boundary in a homogeneous layered reservoir. We solve this problem with the ICCG and DICCG methods. The number of iterations necessary to achieve convergence is presented in Table 1 for various contrast between permeability layers. The first column contains the contrast between permeability layers ($\frac{\sigma_1}{\sigma_2}$). The number of iterations necessary to achieve convergence with the ICCG method is presented in the second column (Total ICCG Iterations). The thhbhird column presents the number of deflation vectors used (5 or 10 in this case). The number of iterations necessary to compute the snapshots with the ICCG method is presented in the 4th column (ICCG Iterations). In the 5th column, we present the total number of iterations, taking into account the snapshots computed with ICCG and the rest of the iterations computed with DICCG. In the last column, we present the total number of iterations of the DICCG methods with respect to ICCG.

We observe (see Table 1) that using deflation methods the number of linear iterations is reduced up to $\approx 7\%$ of the total number of iterations computed with ICCG. We also note that the number of iterations does not change dramatically varying the contrast between permeability layers or changing the number of deflation vectors. The largest increment in iterations occurs when we have a contrast of 10^6. Comparing this case with the homogeneous case, we note an increase of 10% in the number of iterations, which is a small increment. A contrast on the permeability layers of 10^1 or 10^6 results in five eigenvalues significantly larger than the rest (see Figure 3). Therefore, if we use five POD vectors instead of ten as deflation vectors the results are similar, which is shown in Table 1. For the case of higher contrast, the spectrum is more spread. This could explain the slight increase in the number of iterations when we increase the contrast.

The pressure field and the water saturation are presented in Figure 1 and Figure 2 for various times. We observe that the pressure is larger on the boundary where water is injected and it decreases towards the right boundary. We note that the water flows easily through the layers with higher permeability (see Figure 2).

$\frac{\sigma_2}{\sigma_1}$	Total ICCG Iterations	DICCG Method	ICCG Iterations (Snapshots)	DICCG Iterations	Total ICCG +DICCG	% of total ICCG Iterations
10^0	12210	$DICCG_{10}$	495	295	790	6
10^0	12210	$DICCG_5$	495	384	879	7
10^1	14783	$DICCG_{10}$	605	1270	1875	13
10^1	14783	$DICCG_5$	605	1573	2178	15
10^2	14513	$DICCG_{10}$	624	764	1388	10
10^2	14513	$DICCG_5$	624	919	1543	11
10^3	12714	$DICCG_{10}$	524	700	1224	10
10^3	12714	$DICCG_5$	524	923	1447	11
10^4	11151	$DICCG_{10}$	482	783	1265	11
10^4	11151	$DICCG_5$	482	960	1442	13
10^5	10958	$DICCG_{10}$	469	982	1451	13
10^5	10958	$DICCG_5$	469	1078	1547	14
10^6	9735	$DICCG_{10}$	442	1163	1605	16
10^6	9735	$DICCG_5$	442	1317	1759	18

Table 1: Number of linear iterations for various contrast between permeability layers. Injection through the left boundary, domain 32 x 32 cells.

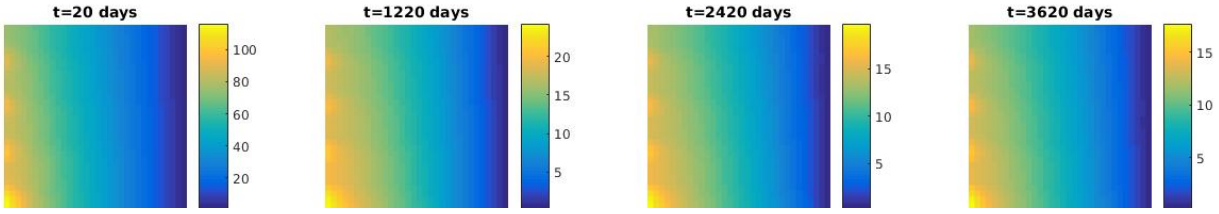

Figure 1: Pressure field [bars] for various times, for a contrast between permeability values of 10^1, 32 x 32 grid cells.

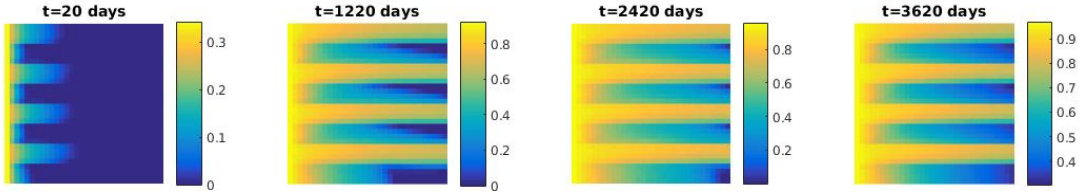

Figure 2: Water saturation for various times, for a contrast between permeability values of 10^1, 32 x 32 grid cells.

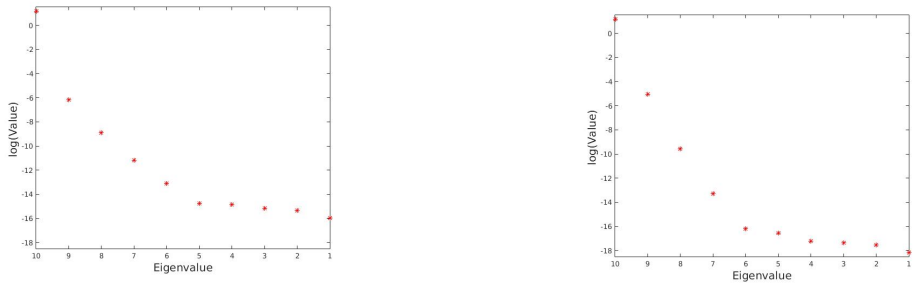

Figure 3: Eigenvalues of the correlation matrix $\mathbf{R} = \frac{1}{m}\mathbf{X}\mathbf{X}^T$ for a contrast between permeability values of 10^1 and 10^6.