

Table 1: Speedup of UPCG solver GPGPU simulations relative to CPU simulations for the same UPCG preconditioner. Speedup values in **bold type** indicate simulations that did not converge within 50 outer iterations with up to 1,000 inner iterations.

Columns \times Rows \times Layers	Speedup		
	Jacobi	MILU0	GLSPOLY
200 \times 200 \times 1	1.513	0.990	2.972
500 \times 500 \times 1	9.536	1.699	16.315
1000 \times 1000 \times 1	18.871	1.404	26.786
2000 \times 2000 \times 1	24.453	1.938	33.615
4000 \times 4000 \times 1	26.918	1.936	35.154
200 \times 200 \times 2	3.234	1.517	6.146
500 \times 500 \times 2	13.420	1.742	18.665
1000 \times 1000 \times 2	19.877	1.322	25.420
2000 \times 2000 \times 2	23.871	1.861	29.516
200 \times 200 \times 3	5.234	1.517	9.231
500 \times 500 \times 3	15.848	1.769	20.843
1000 \times 1000 \times 3	22.444	1.265	27.658
2000 \times 2000 \times 3	25.171	1.870	30.760
200 \times 200 \times 10	11.552	1.715	17.564
500 \times 500 \times 10	20.806	1.833	25.826
1000 \times 1000 \times 10	24.981	1.889	29.888

Table 2: Speedup of UPCG solver GPGPU simulations relative to simulations performed using the PCG solver with the modified incomplete Cholesky (MIC) preconditioner. CPU times for the PCG solver with the MIC preconditioner are in seconds. Speedup values in **bold** type indicate simulations that did not converge within 50 outer iterations with up to 1,000 inner iterations.

Columns \times Rows \times Layers	CPU Time	Speedup		
	MIC	Jacobi	MILU0	GLSPOLY
$200 \times 200 \times 1$	0.6826875	0.487	1.101	0.841
$500 \times 500 \times 1$	10.27194	1.675	1.543	2.294
$1000 \times 1000 \times 1$	75.64222	3.241	1.239	2.957
$2000 \times 2000 \times 1$	536.2608	1.891	1.438	2.754
$4000 \times 4000 \times 1$	3891.683	1.357	1.696	2.839
$200 \times 200 \times 2$	1.683125	1.081	1.330	1.633
$500 \times 500 \times 2$	24.66269	3.156	1.534	3.497
$1000 \times 1000 \times 2$	175.7042	4.111	1.156	3.532
$2000 \times 2000 \times 2$	1058.137	1.967	1.590	2.837
$200 \times 200 \times 3$	3.040594	1.875	1.487	2.349
$500 \times 500 \times 3$	38.59184	3.908	1.530	4.075
$1000 \times 1000 \times 3$	315.6253	5.105	1.130	4.428
$2000 \times 2000 \times 3$	1962.365	2.560	1.634	3.562
$200 \times 200 \times 10$	18.50184	5.344	1.524	4.921
$500 \times 500 \times 10$	218.9169	8.683	1.598	7.643
$1000 \times 1000 \times 10$	1621.158	9.299	1.621	8.633

Table 3: Speedup of UPCG solver OpenMP simulations, with 4, 7, and 14 threads, relative to simulations performed using the PCG solver with the modified incomplete Cholesky (MIC) preconditioner. Speedup values in **bold** type indicate simulations that did not converge within 50 outer iterations with up to 1,000 inner iterations.

Columns \times Rows \times Layers	Speedup – 4 / 7 /14 Threads		
	Jacobi	MILU0	GLSPOLY
200 \times 200 \times 1	1.166/0.614/0.614	2.446/1.511/1.423	1.185/0.779/1.241
500 \times 500 \times 1	0.447/0.332/0.357	1.637/1.197/1.164	0.571/0.364/0.535
1000 \times 1000 \times 1	0.409/0.419/0.359	1.488/1.463/1.194	0.313/0.323/0.309
2000 \times 2000 \times 1	0.185/0.182/0.151	1.691/1.622/1.286	0.225/0.272/0.198
4000 \times 4000 \times 1	0.111/0.099/0.108	1.619/1.523/1.670	0.222/0.241/0.245
200 \times 200 \times 2	1.113/1.090/1.004	1.954/2.258/1.567	1.171/1.147/1.626
500 \times 500 \times 2	0.536/0.567/0.460	1.500/1.521/1.151	0.525/0.625/0.556
1000 \times 1000 \times 2	0.527/0.472/0.411	1.543/1.474/1.227	0.396/0.295/0.335
2000 \times 2000 \times 2	0.211/0.198/0.168	1.401/1.693/1.418	0.237/0.313/0.244
200 \times 200 \times 3	0.872/1.067/0.897	1.433/1.901/1.300	0.827/1.080/1.346
500 \times 500 \times 3	0.577/0.482/0.527	1.444/1.417/1.328	0.548/0.579/0.598
1000 \times 1000 \times 3	0.593/0.562/0.479	1.519/1.590/1.377	0.389/0.340/0.385
2000 \times 2000 \times 3	0.245/0.246/0.215	1.746/1.478/1.544	0.313/0.286/0.295
200 \times 200 \times 10	1.066/1.059/1.215	1.503/1.574/1.426	0.858/0.899/1.186
500 \times 500 \times 10	0.970/1.014/1.019	1.563/1.604/1.400	0.780/0.799/0.913
1000 \times 1000 \times 10	0.835/0.968/0.928	1.720/1.734/1.651	0.815/0.798/0.914