Appendix

Efficiency at 2.1E9 Smoothing Operations				
MPI Processes	Nodes			
	1	**2**	**3**	**4**
1	0.9994	0.9989	0.9991	0.9986
2	0.9379	0.9383	0.9381	0.9369
3	0.9253	0.9251	0.9254	0.9248
4	0.9072	0.9070	0.9070	0.9077
5	0.9080	0.9079	0.9075	0.9083
6	0.9057	0.9061	0.9055	0.9064
7	0.8960	0.8965	0.8955	0.8962
8	0.8910	0.8909	0.8907	0.8911
9	0.8900	0.8901	0.8889	0.8899
10	0.8854	0.8848	0.8798	0.8667
11	0.8868	0.8821	0.8858	0.8850
12	0.8741	0.8339	0.8762	0.7638
13	0.8788	0.8671	0.8790	0.8776
14	0.8191	0.7613	0.8596	0.8390
15	0.8193	0.8654	0.8709	0.8414
16	0.8694	0.8562	0.8700	0.8426
17		0.8476	0.8336	0.8617
18		0.8359	0.8564	0.8608
19		0.8594	0.8324	0.8429
20		0.8426	0.8531	0.8471
21		0.8521	0.8545	0.8472
22		0.8187	0.8504	0.8173
23		0.8259	0.8400	0.8480
24		0.8114	0.8153	0.8094
25		0.8448	0.8407	0.8236
26		0.8055	0.8384	0.8383
27		0.8395	0.8277	0.8345
28		0.8346	0.8032	0.8332
29		0.8099	0.8267	0.8287
30		0.8242	0.8240	0.8105
31		0.8153	0.7986	0.8087
32		0.8159	0.8033	0.7101
33			0.8190	0.7937
34			0.7903	0.8101
35			0.7813	0.8026

36			0.7702	0.8106
37			0.8071	0.6861
38			0.7901	0.7811
39			0.7920	0.7956
40			0.7968	0.7745
41			0.7856	0.7964
42			0.7428	0.7442
43			0.7800	0.7208
44			0.6814	0.7755
45			0.7632	0.7656
46			0.7449	0.7415
47			0.7535	0.7621
48			0.6955	0.7736
49				0.7264
50				0.7353
51				0.7509
52				0.7528
53				0.7416
54				0.7240
55				0.7513
56				0.7411
57				0.6983
58				0.7159
59				0.7163
60				0.7189
61				0.7010
62				0.7071
63				0.6960
64				0.7177

Speedup at 2.1E9 Smoothing Operations				
MPI Processes	Nodes			
	1	**2**	**3**	**4**
1	0.9994	0.9989	0.9991	0.9986
2	1.8758	1.8765	1.8763	1.8739
3	2.7759	2.7752	2.7763	2.7745
4	3.6288	3.6280	3.6279	3.6307
5	4.5399	4.5393	4.5373	4.5416
6	5.4341	5.4365	5.4328	5.4387
7	6.2720	6.2755	6.2687	6.2732
8	7.1283	7.1275	7.1258	7.1286

9	8.0098	8.0113	8.0004	8.0092
10	8.8540	8.8482	8.7980	8.6675
11	9.7548	9.7032	9.7437	9.7350
12	10.4897	10.0066	10.5147	9.1655
13	11.4246	11.2723	11.4264	11.4086
14	11.4679	10.6576	12.0342	11.7466
15	12.2888	12.9806	13.0642	12.6211
16	13.9106	13.6984	13.9194	13.4812
17		14.4089	14.1720	14.6492
18		15.0461	15.4144	15.4949
19		16.3293	15.8148	16.0153
20		16.8515	17.0616	16.9418
21		17.8931	17.9444	17.7913
22		18.0119	18.7084	17.9807
23		18.9947	19.3192	19.5032
24		19.4743	19.5662	19.4249
25		21.1199	21.0181	20.5894
26		20.9424	21.7986	21.7961
27		22.6677	22.3491	22.5311
28		23.3695	22.4886	23.3285
29		23.4862	23.9730	24.0334
30		24.7246	24.7194	24.3158
31		25.2728	24.7556	25.0708
32		26.1073	25.7050	22.7222
33			27.0285	26.1936
34			26.8690	27.5427
35			27.3443	28.0895
36			27.7267	29.1808
37			29.8617	25.3856
38			30.0224	29.6808
39			30.8877	31.0288
40			31.8706	30.9780
41			32.2085	32.6538
42			31.1979	31.2572
43			33.5418	30.9945
44			29.9819	34.1234
45			34.3453	34.4513
46			34.2676	34.1103
47			35.4129	35.8194
48			33.3849	37.1310
49				35.5960
50				36.7674

51				38.2943
52				39.1464
53				39.3059
54				39.0985
55				41.3236
56				41.5016
57				39.8012
58				41.5228
59				42.2631
60				43.1365
61				42.7598
62				43.8375
63				43.8492
64				45.9314

Time (Seconds) at 2.1E9 Smoothing Operations				
MPI Processes	Nodes			
	1	**2**	**3**	**4**
1	32.398676	32.414565	32.40934	32.426887
2	17.262379	17.255604	17.257678	17.279871
3	11.664676	11.667732	11.663006	11.670628
4	8.92318	8.925084	8.925371	8.918607
5	7.132353	7.133348	7.136499	7.129688
6	5.958767	5.956089	5.960176	5.953761
7	5.162744	5.159835	5.16546	5.161694
8	4.542535	4.543019	4.544104	4.542315
9	4.042593	4.041837	4.047366	4.042891
10	3.657178	3.659572	3.680444	3.735857
11	3.319452	3.337103	3.323229	3.32621
12	3.086888	3.23591	3.079533	3.532868
13	2.834289	2.872573	2.83383	2.838249
14	2.823588	3.038267	2.690695	2.756596
15	2.634952	2.494536	2.47856	2.565587
16	2.32775	2.36381	2.326281	2.401901
17		2.247254	2.284824	2.2104
18		2.152091	2.100664	2.089752
19		1.982969	2.047476	2.021849
20		1.921519	1.897857	1.911273
21		1.80966	1.804488	1.820017
22		1.797731	1.730796	1.800851
23		1.704712	1.676075	1.660262

24		1.662732	1.65492	1.666962
25		1.533178	1.5406	1.572678
26		1.546167	1.485439	1.485609
27		1.428486	1.448847	1.437148
28		1.385589	1.43986	1.388025
29		1.378704	1.350706	1.347312
30		1.309648	1.309922	1.331663
31		1.28124	1.308006	1.29156
32		1.240287	1.259695	1.425057
33			1.198014	1.236201
34			1.205123	1.175649
35			1.184179	1.152763
36			1.167845	1.109649
37			1.084349	1.275548
38			1.078545	1.090956
39			1.04833	1.043561
40			1.015998	1.045273
41			1.005341	0.99163
42			1.037907	1.035936
43			0.965378	1.044717
44			1.080001	0.948924
45			0.942793	0.939893
46			0.94493	0.949289
47			0.914369	0.903994
48			0.969913	0.872062
49				0.909666
50				0.880684
51				0.845569
52				0.827163
53				0.823807
54				0.828177
55				0.783584
56				0.780223
57				0.813555
58				0.779825
59				0.766164
60				0.750651
61				0.757264
62				0.738648
63				0.738451
64				0.704975

Efficiency with 4 Nodes			
MPI Processes	Size		
	1024	**2048**	**4096**

1	0.9986	0.9991	1.0000
2	0.9369	0.9299	0.9267
3	0.9248	0.9244	0.9178
4	0.9077	0.9150	0.9167
5	0.9083	0.9092	0.9136
6	0.9064	0.9053	0.9093
7	0.8962	0.8974	0.9074
8	0.8911	0.8920	0.9070
9	0.8899	0.8858	0.9029
10	0.8667	0.8842	0.9027
11	0.8850	0.8879	0.9011
12	0.7638	0.8852	0.8990
13	0.8776	0.8714	0.8964
14	0.8390	0.8747	0.8968
15	0.8414	0.8708	0.8954
16	0.8426	0.8524	0.8844
17	0.8617	0.8621	0.8880
18	0.8608	0.8536	0.8856
19	0.8429	0.8485	0.8808
20	0.8471	0.8438	0.8834
21	0.8472	0.8416	0.8822
22	0.8173	0.8354	0.8818
23	0.8480	0.8585	0.8711
24	0.8094	0.8506	0.8794
25	0.8236	0.8420	0.8792
26	0.8383	0.8393	0.8778
27	0.8345	0.8333	0.8780
28	0.8332	0.8504	0.8751
29	0.8287	0.8574	0.8621
30	0.8105	0.8633	0.8665
31	0.8087	0.8200	0.8688
32	0.7101	0.7872	0.8414
33	0.7937	0.8518	0.8539
34	0.8101	0.7916	0.8606
35	0.8026	0.8190	0.8308
36	0.8106	0.8615	0.8543
37	0.6861	0.7933	0.8566
38	0.7811	0.8253	0.8462
39	0.7956	0.7818	0.8513
40	0.7745	0.8188	0.8433
41	0.7964	0.8527	0.8559
42	0.7442	0.7836	0.8430

43	0.7208	0.8508	0.8483
44	0.7755	0.8475	0.8514
45	0.7656	0.7478	0.8476
46	0.7415	0.8486	0.8469
47	0.7621	0.7924	0.8192
48	0.7736	0.7248	0.7938
49	0.7264	0.7666	0.8333
50	0.7353	0.7325	0.8287
51	0.7509	0.8004	0.8236
52	0.7528	0.7582	0.8069
53	0.7416	0.7446	0.8108
54	0.7240	0.8364	0.8217
55	0.7513	0.7323	0.8315
56	0.7411	0.7981	0.8308
57	0.6983	0.7227	0.8174
58	0.7159	0.7950	0.8252
59	0.7163	0.6938	0.8107
60	0.7189	0.8240	0.8171
61	0.7010	0.8196	0.8105
62	0.7071	0.8087	0.8081
63	0.6960	0.7933	0.8289
64	0.7177	0.6451	0.7151

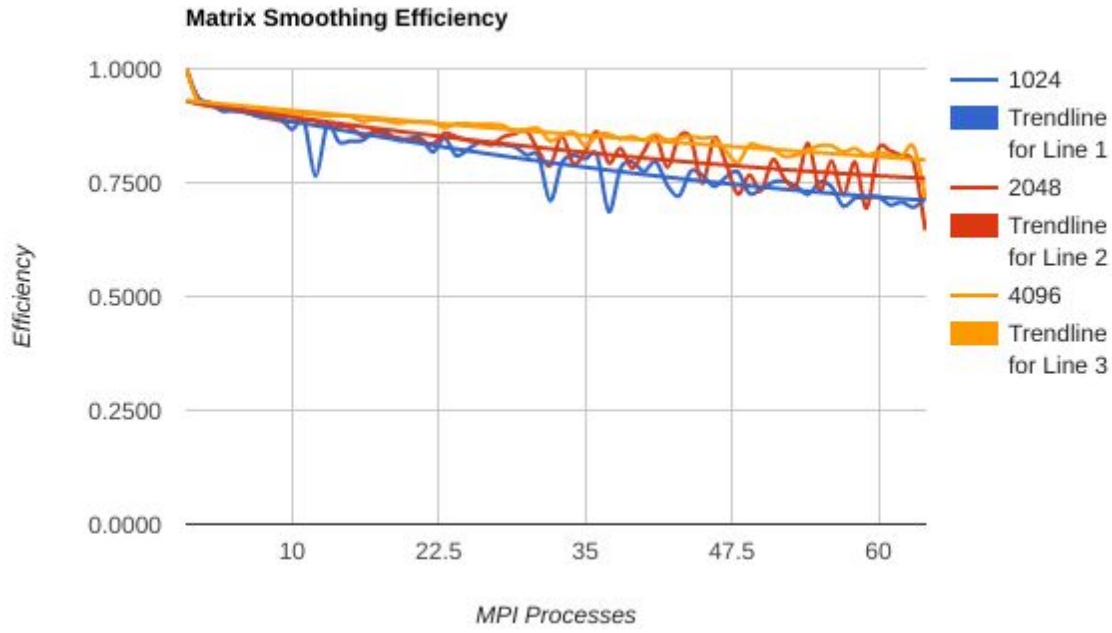
Speedup at Different Matrix Sizes			
MPI Processes	Size		
	1024	**2048**	**4096**
1	0.9986	0.9991	1.0000
2	1.8739	1.8598	1.8534
3	2.7745	2.7731	2.7534
4	3.6307	3.6602	3.6669
5	4.5416	4.5461	4.5682
6	5.4387	5.4317	5.4558
7	6.2732	6.2817	6.3521
8	7.1286	7.1363	7.2558
9	8.0092	7.9718	8.1262
10	8.6675	8.8421	9.0268
11	9.7350	9.7664	9.9118
12	9.1655	10.6229	10.7876
13	11.4086	11.3279	11.6535
14	11.7466	12.2459	12.5549
15	12.6211	13.0627	13.4316

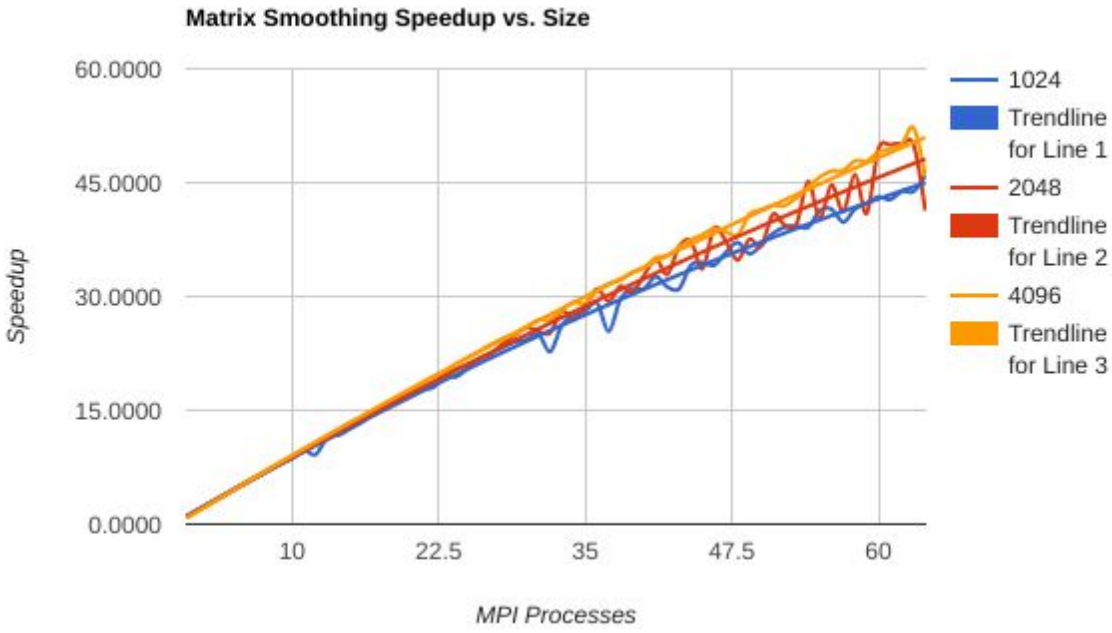
16	13.4812	13.6387	14.1502
17	14.6492	14.6565	15.0954
18	15.4949	15.3652	15.9414
19	16.0153	16.1221	16.7343
20	16.9418	16.8762	17.6680
21	17.7913	17.6728	18.5252
22	17.9807	18.3790	19.3992
23	19.5032	19.7454	20.0352
24	19.4249	20.4153	21.1058
25	20.5894	21.0512	21.9799
26	21.7961	21.8225	22.8227
27	22.5311	22.5002	23.7067
28	23.3285	23.8104	24.5035
29	24.0334	24.8643	24.9998
30	24.3158	25.9000	25.9948
31	25.0708	25.4191	26.9327
32	22.7222	25.1912	26.9242
33	26.1936	28.1106	28.1782
34	27.5427	26.9153	29.2593
35	28.0895	28.6663	29.0764
36	29.1808	31.0127	30.7541
37	25.3856	29.3513	31.6940
38	29.6808	31.3629	32.1539
39	31.0288	30.4909	33.2013
40	30.9780	32.7514	33.7328
41	32.6538	34.9616	35.0899
42	31.2572	32.9117	35.4061
43	30.9945	36.5824	36.4774
44	34.1234	37.2883	37.4615
45	34.4513	33.6488	38.1437
46	34.1103	39.0350	38.9552
47	35.8194	37.2425	38.5036
48	37.1310	34.7901	38.1048
49	35.5960	37.5643	40.8338
50	36.7674	36.6237	41.4350
51	38.2943	40.8202	42.0054
52	39.1464	39.4244	41.9586
53	39.3059	39.4663	42.9714
54	39.0985	45.1658	44.3721
55	41.3236	40.2760	45.7301
56	41.5016	44.6921	46.5266
57	39.8012	41.1923	46.5930

58	41.5228	46.1103	47.8605
59	42.2631	40.9315	47.8291
60	43.1365	49.4399	49.0247
61	42.7598	49.9966	49.4383
62	43.8375	50.1393	50.1022
63	43.8492	49.9758	52.2188
64	45.9314	41.2840	45.7681

Compute Time (Seconds) at Different Matrix Sizes			
MPI Processes	Size		
	1024	**2048**	**4096**
1	32.426887	131.133651	507.560805
2	17.279871	70.445989	273.862217
3	11.670628	47.244942	184.345888
4	8.918607	35.79468	138.421297
5	7.129688	28.819146	111.112008
6	5.953761	24.120419	93.035779
7	5.161694	20.856601	79.907484
8	4.542315	18.358918	69.955994
9	4.042891	16.43481	62.462537
10	3.735857	14.817068	56.23074
11	3.32621	13.414886	51.20977
12	3.532868	12.333231	47.052581
13	2.838249	11.565653	43.556303
14	2.756596	10.698635	40.429147
15	2.565587	10.0297	37.790299
16	2.401901	9.606104	35.871052
17	2.2104	8.939037	33.625053
18	2.089752	8.526702	31.84052
19	2.021849	8.126427	30.331884
20	1.911273	7.763276	28.728891
21	1.820017	7.413361	27.399656
22	1.800851	7.12849	26.165197
23	1.660262	6.635189	25.334614
24	1.666962	6.417484	24.049443
25	1.572678	6.223625	23.093075
26	1.485609	6.003664	22.240287
27	1.437148	5.822828	21.410942
28	1.388025	5.502413	20.714766
29	1.347312	5.269182	20.303529
30	1.331663	5.058486	19.526336

31	1.29156	5.154183	18.846387
32	1.425057	5.200811	18.852341
33	1.236201	4.660689	18.013323
34	1.175649	4.86766	17.347742
35	1.152763	4.570344	17.456896
36	1.109649	4.224547	16.504556
37	1.275548	4.463669	16.015124
38	1.090956	4.177381	15.786086
39	1.043561	4.296844	15.288048
40	1.045273	4.000282	15.047193
41	0.99163	3.747385	14.465244
42	1.035936	3.980789	14.33606
43	1.044717	3.581355	13.915028
44	0.948924	3.513562	13.549456
45	0.939893	3.893591	13.30714
46	0.949289	3.35634	13.029928
47	0.903994	3.517881	13.182749
48	0.872062	3.76586	13.320739
49	0.909666	3.487747	12.430468
50	0.880684	3.577316	12.250105
51	0.845569	3.209553	12.083767
52	0.827163	3.323191	12.097245
53	0.823807	3.31966	11.812112
54	0.828177	2.900749	11.439257
55	0.783584	3.252922	11.099536
56	0.780223	2.931492	10.909532
57	0.813555	3.180566	10.893996
58	0.779825	2.841334	10.605484
59	0.766164	3.200828	10.612435
60	0.750651	2.649977	10.353627
61	0.757264	2.620473	10.267016
62	0.738648	2.613013	10.130958
63	0.738451	2.621564	9.720318
64	0.704975	3.173495	11.090332


Matrix Smoothing Efficiency
1.0000
0.7500
0.5000
0.2500
0.0000
Efficiency
10
22.5
35
47.5
60
MPI Processes
1024
Trendline for Line 1
2048
Trendline for Line 2
4096
Trendline for Line 3


Matrix Smoothing Speedup vs. Size
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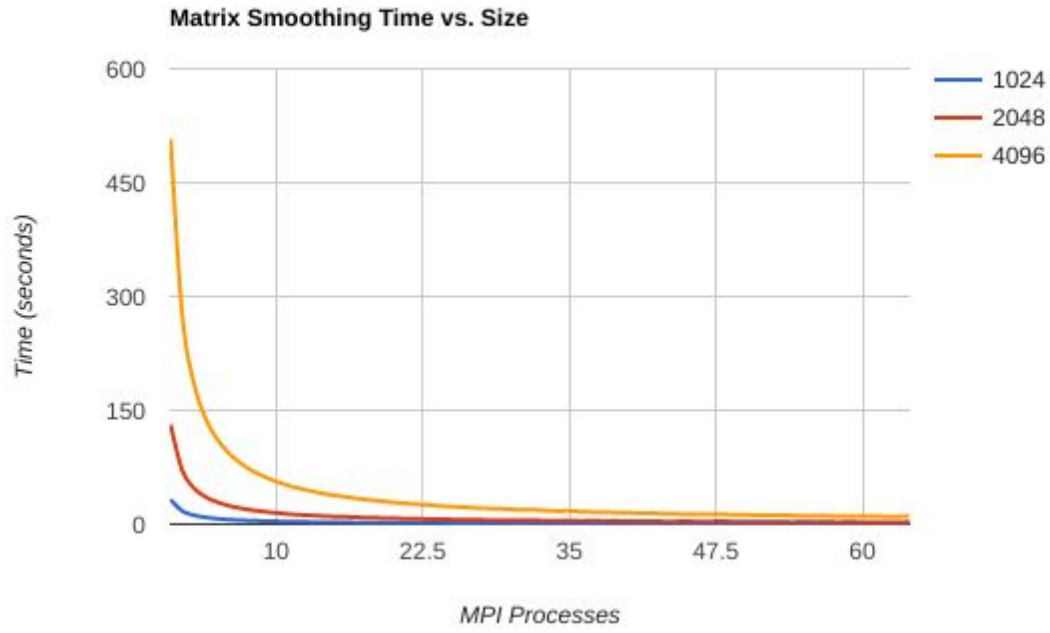
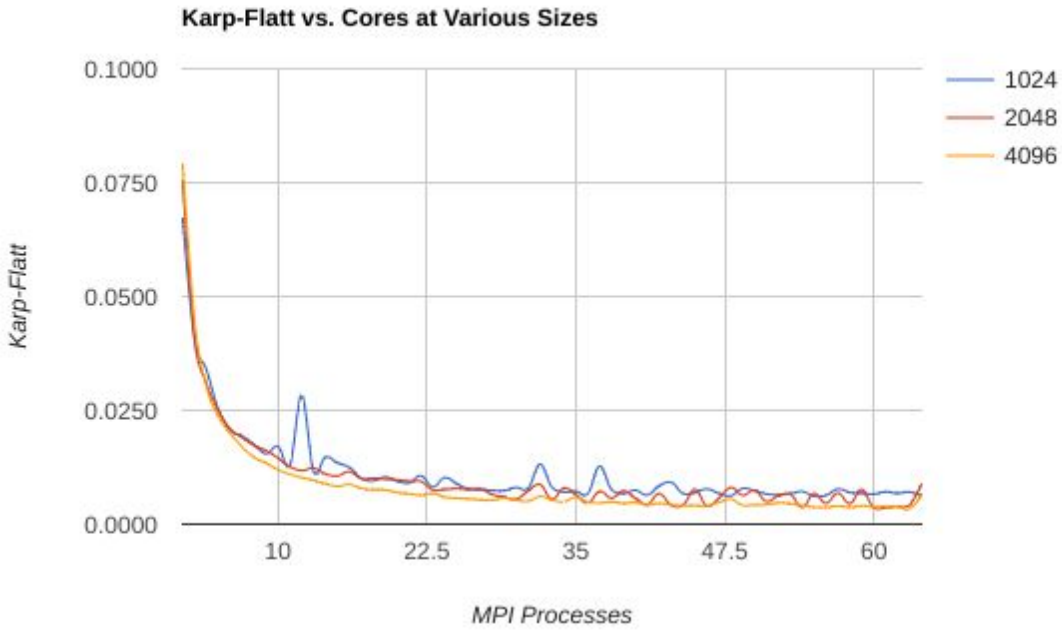
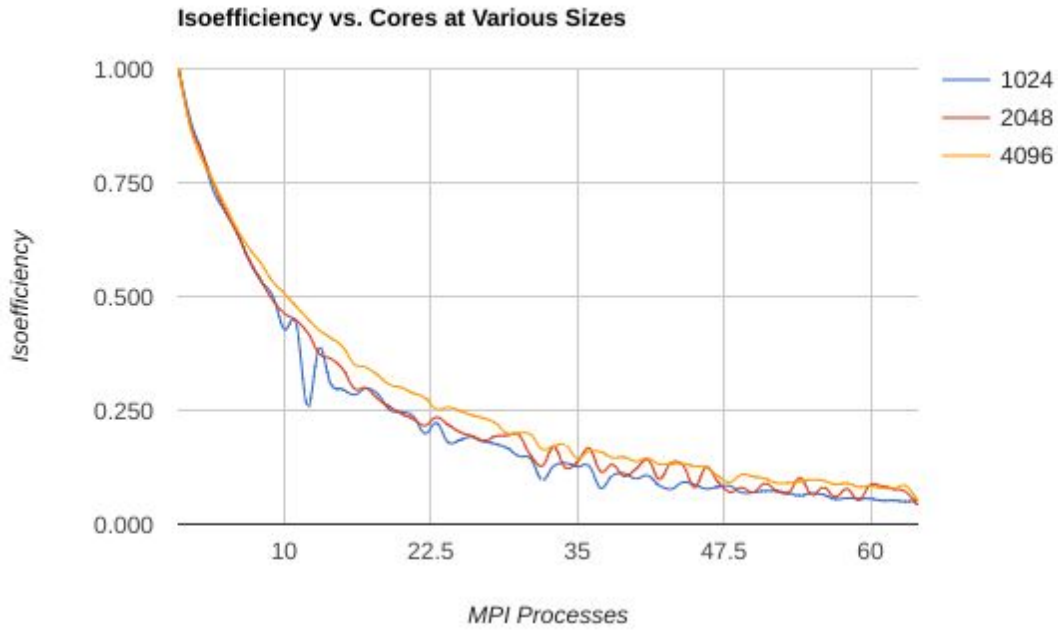
45.0000
30.0000
15.0000
0.0000
Speedup
10
22.5
35
47.5
60
MPI Processes
1024
Trendline for Line 1
2048
Trendline for Line 2
4096
Trendline for Line 3


Matrix Smoothing Time vs. Size
600
450
300
150
0
Time (seconds)
10
22.5
35
47.5
60
MPI Processes
1024
2048
4096


Karp-Flatt vs. Cores at Various Sizes
0.1000
0.0750
0.0500
0.0250
0.0000
Karp-Flatt
10
22.5
35
47.5
60
MPI Processes
1024
2048
4096


Isoefficiency vs. Cores at Various Sizes
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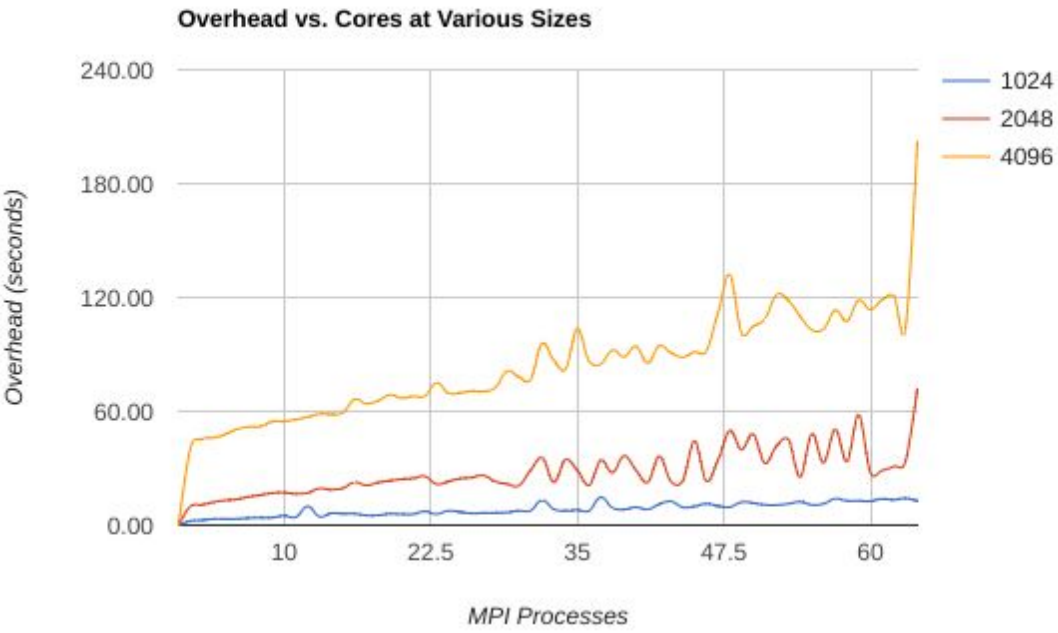
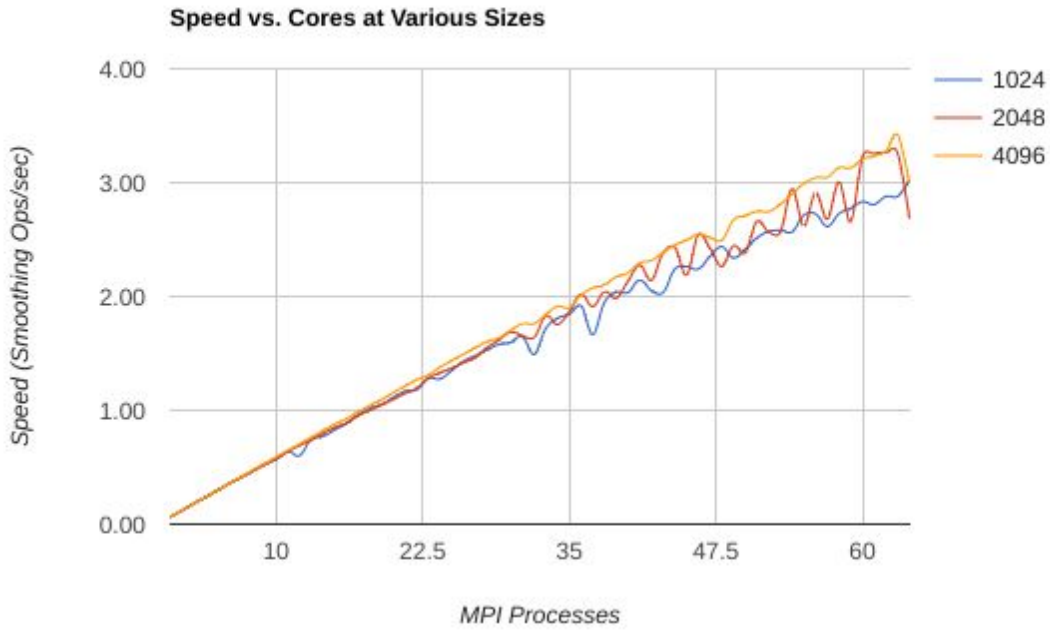
0.750
0.500
0.250
0.000
Isoefficiency
10
22.5
35
47.5
60
MPI Processes
1024
2048
4096


Overhead vs. Cores at Various Sizes
240.00
180.00
120.00
60.00
0.00
Overhead (seconds)
10
22.5
35
47.5
60
MPI Processes
1024
2048
4096



Correctness testing

Basic Smooth Result (matrixComputeTest())

2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000
2.000000, 1.999998, 1.999997, 1.999996, 1.999995, 1.999995, 1.999996, 1.999997, 1.999998, 2.000000
2.000000, 1.999997, 1.999994, 1.999992, 1.999990, 1.999990, 1.999992, 1.999994, 1.999997, 2.000000
2.000000, 1.999996, 1.999992, 1.999989, 1.999987, 1.999987, 1.999989, 1.999992, 1.999996, 2.000000
2.000000, 1.999995, 1.999990, 1.999987, 1.999985, 1.999985, 1.999987, 1.999990, 1.999995, 2.000000
2.000000, 1.999995, 1.999990, 1.999987, 1.999985, 1.999985, 1.999987, 1.999990, 1.999995, 2.000000
2.000000, 1.999996, 1.999992, 1.999989, 1.999987, 1.999987, 1.999989, 1.999992, 1.999996, 2.000000
2.000000, 1.999997, 1.999994, 1.999992, 1.999990, 1.999990, 1.999992, 1.999994, 1.999997, 2.000000
2.000000, 1.999998, 1.999997, 1.999996, 1.999995, 1.999995, 1.999996, 1.999997, 1.999998, 2.000000
2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000, 2.000000

Parity 1: 0000000000000000