Table S1. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the cubed-sphere grid at the coarse resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/72 units)
		1 unit	6 units	36 units	72 units	
1	MPI only	0.3	0.9	1.0	2.0	0.16
	OpenMP only	0.3	0.2	0.1	0.2	2.07
	MPI==OpenMP	0.3	-	0.4	-	-
2	MPI only	0.044	0.137	0.390	0.810	0.05
	OpenMP only	0.044	0.060	0.048	0.052	0.85
	MPI==OpenMP	0.044	-	2.265	-	-
3-1	MPI only	0.7	1.3	2.2	2.9	0.23
	OpenMP only	0.7	1.1	2.6	5.1	0.13
	MPI==OpenMP	0.7	-	3.4	-	-
3-2	MPI only	12.4	4.3	1.5	1.9	6.45
	OpenMP only	12.4	4.3	3.9	7.8	1.58
	MPI==OpenMP	12.4	-	2.0	-	-
4	MPI only	198.6	67.2	12.1	9.8	20.26
	OpenMP only	198.6	69.9	29.1	42.6	4.66
	MPI==OpenMP	198.6	-	17.5	-	-
5	MPI only	0.2	0.1	0.5	1.0	0.18
	OpenMP only	0.2	0.1	0.5	1.2	0.14
	MPI==OpenMP	0.2	-	0.6	-	-
Total	MPI only	212.1	73.9	17.8	18.4	11.55
	OpenMP only	212.1	75.7	36.3	56.9	3.73
	MPI==OpenMP	212.1	-	26.0	-	-

Table S2. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the cubed-sphere grid at the medium resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/72 units)
		1 unit	6 units	36 units	72 units	
1	MPI only	4.4	6.6	11.0	22.6	0.20
	OpenMP only	4.4	2.0	1.6	1.8	2.49
	MPI==OpenMP	4.4	-	2.9	-	-
2	MPI only	0.049	0.119	0.412	0.824	0.06
	OpenMP only	0.049	0.054	0.055	0.059	0.83
	MPI==OpenMP	0.049	-	0.087	-	-
3-1	MPI only	3.9	14.7	32.9	69.5	0.06
	OpenMP only	3.9	8.2	16.1	19.6	0.20
	MPI==OpenMP	3.9	-	29.6	-	-
3-2	MPI only	71.3	29.2	9.5	15.9	4.49
	OpenMP only	71.3	30.9	10.5	17.5	4.08
	MPI==OpenMP	71.3	-	11.8	-	-
4	MPI only	2334.4	435.4	80.8	67.5	34.56
	OpenMP only	2334.4	461.0	124.5	131.7	17.73
	MPI==OpenMP	2334.4	-	111.0	-	-
5	MPI only	0.8	0.2	0.5	1.0	0.87
	OpenMP only	0.8	0.4	0.7	1.5	0.56
	MPI==OpenMP	0.8	-	0.7	-	-
Total	MPI only	2414.9	486.2	135.2	177.2	13.63
	OpenMP only	2414.9	502.6	153.4	172.1	14.03
	MPI==OpenMP	2414.9	-	155.9	-	-

Table S3. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the cubed-sphere grid at the fine resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/72 units)
		1 unit	6 units	36 units	72 units	
1	MPI only	24.7	37.7	100.4	215.4	0.11
	OpenMP only	24.7	10.1	6.0	6.9	3.58
	MPI==OpenMP	24.7	-	24.4	-	-
2	MPI only	0.070	0.109	0.302	0.751	0.09
	OpenMP only	0.070	0.118	0.074	0.076	0.92
	MPI==OpenMP	0.070	-	0.142	-	-
3-1	MPI only	37.6	62.8	305.8	621.4	0.06
	OpenMP only	37.6	64.8	149.5	161.5	0.23
	MPI==OpenMP	37.6	-	201.0	-	-
3-2	MPI only	586.7	137.0	92.8	142.8	4.11
	OpenMP only	586.7	172.5	57.1	56.2	10.45
	MPI==OpenMP	586.7	-	76.7	-	-
4	MPI only	25043.7	4522.2	757.6	591.3	42.35
	OpenMP only	25043.7	4751.8	845.7	728.1	34.40
	MPI==OpenMP	25043.7	-	802.8	-	-
5	MPI only	1.8	0.5	0.7	1.3	1.39
	OpenMP only	1.8	1.1	0.7	2.1	0.82
	MPI==OpenMP	1.8	-	1.2	-	-
Total	MPI only	25694.6	4760.4	1257.6	1573.0	16.33
	OpenMP only	25694.6	5000.5	1059.1	954.9	26.91
	MPI==OpenMP	25694.6	-	1106.2	-	-

Table S4. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the latitude–longitude grid at the coarse resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/72 units)
		1 unit	6 units	36 units	72 units	
1	MPI only	0.2	1.1	1.2	2.6	0.09
	OpenMP only	0.2	0.2	0.1	0.1	1.93
	MPI==OpenMP	0.2	-	0.4	-	-
2	MPI only	0.051	0.121	0.312	0.832	0.06
	OpenMP only	0.051	0.041	0.045	0.052	0.98
	MPI==OpenMP	0.051	-	2.021	-	-
3-1	MPI only	0.4	0.8	0.7	1.1	0.38
	OpenMP only	0.4	0.7	1.6	3.4	0.12
	MPI==OpenMP	0.4	-	1.2	-	-
3-2	MPI only	12.4	5.0	1.6	2.0	6.26
	OpenMP only	12.4	5.2	4.4	8.9	1.40
	MPI==OpenMP	12.4	-	2.0	-	-
4	MPI only	261.7	81.2	16.2	11.7	22.44
	OpenMP only	261.7	89.7	45.1	54.4	4.81
	MPI==OpenMP	261.7	-	23.9	-	-
5	MPI only	0.2	0.1	0.5	0.8	0.21
	OpenMP only	0.2	0.1	0.6	1.1	0.15
	MPI==OpenMP	0.2	-	0.6	-	-
Total	MPI only	274.9	88.4	20.5	19.0	14.50
	OpenMP only	274.9	95.8	51.8	68.0	4.04
	MPI==OpenMP	274.9	-	30.2	-	-

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Table S5. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the latitude–longitude grid at the medium resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/72 units)
		1 unit	6 units	36 units	72 units	
1	MPI only	2.7	9.1	14.4	30.0	0.09
	OpenMP only	2.7	1.3	0.8	0.8	3.27
	MPI==OpenMP	2.7	-	4.3	-	-
2	MPI only	0.063	0.109	0.361	0.773	0.08
	OpenMP only	0.063	0.064	0.067	0.075	0.84
	MPI==OpenMP	0.063	-	0.113	-	-
3-1	MPI only	2.7	7.3	9.5	18.5	0.15
	OpenMP only	2.7	4.2	7.7	9.5	0.28
	MPI==OpenMP	2.7	-	9.8	-	-
3-2	MPI only	80.7	34.7	11.8	16.0	5.03
	OpenMP only	80.7	38.5	12.1	22.5	3.59
	MPI==OpenMP	80.7	-	13.1	-	-
4	MPI only	3370.0	625.4	141.3	98.2	34.31
	OpenMP only	3370.0	642.8	154.1	161.5	20.86
	MPI==OpenMP	3370.0	-	137.2	-	-
5	MPI only	0.7	0.2	0.6	1.1	0.65
	OpenMP only	0.7	0.4	0.5	2.0	0.36
	MPI==OpenMP	0.7	-	0.8	-	-
Total	MPI only	3456.9	676.9	178.1	164.7	20.99
	OpenMP only	3456.9	687.3	175.3	196.5	17.59
	MPI==OpenMP	3456.9	-	165.2	-	-

Table S6. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the latitude–longitude grid at the fine resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/72 units)
		1 unit	6 units	36 units	72 units	
1	MPI only	18.5	71.2	125.7	276.4	0.07
	OpenMP only	18.5	14.9	12.7	11.0	1.68
	MPI==OpenMP	18.5	-	26.7	-	-
2	MPI only	0.073	0.171	0.446	0.883	0.08
	OpenMP only	0.073	0.070	0.124	0.081	0.90
	MPI==OpenMP	0.073	-	0.118	-	-
3-1	MPI only	24.5	35.2	82.8	159.3	0.15
	OpenMP only	24.5	37.7	46.6	50.2	0.49
	MPI==OpenMP	24.5	-	57.3	-	-
3-2	MPI only	704.4	163.1	99.6	137.0	5.14
	OpenMP only	704.4	194.4	68.0	69.3	10.17
	MPI==OpenMP	704.4	-	90.2	-	-
4	MPI only	49137.6	7272.5	1208.5	1004.5	48.92
	OpenMP only	49137.6	7275.6	1355.3	1058.6	46.42
	MPI==OpenMP	49137.6	-	1265.4	-	-
5	MPI only	1.7	0.9	1.1	1.8	0.94
	OpenMP only	1.7	1.3	1.3	3.8	0.46
	MPI==OpenMP	1.7	-	1.6	-	-
Total	MPI only	49886.9	7543.0	1518.2	1580.0	31.57
	OpenMP only	49886.9	7524.0	1484.1	1193.0	41.82
	MPI==OpenMP	49886.9	-	1441.3	-	-

Table S7. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the cubed-sphere grid at the fine resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/800 units)
		1 unit	20 units	200 units	800 units	
1	MPI only	33.8	62.5	72.0	85.8	0.39
	5 OpenMP threads	33.8	15.3	15.0	16.0	2.11
	10 OpenMP threads	33.8	7.8	10.1	10.1	3.36
2	MPI only	2.0	1.3	3.5	6.6	0.30
	5 OpenMP threads	2.0	2.3	0.2	2.1	0.94
	10 OpenMP threads	2.0	0.1	0.2	2.0	0.97
3-1	MPI only	24.7	180.5	204.0	210.6	0.12
	5 OpenMP threads	24.7	96.5	104.1	105.0	0.24
	10 OpenMP threads	24.7	92.3	97.9	98.4	0.25
3-2	MPI only	701.8	167.8	111.9	148.1	4.74
	5 OpenMP threads	701.8	104.4	76.0	89.5	7.84
	10 OpenMP threads	701.8	76.8	72.5	90.5	7.75
4	MPI only	26395.2	1580.3	137.1	45.0	586.52
	5 OpenMP threads	26395.2	1615.0	140.9	46.4	569.19
	10 OpenMP threads	26395.2	1682.8	155.6	50.3	525.18
5	MPI only	2.4	27.2	61.1	81.7	0.03
	5 OpenMP threads	2.4	15.7	38.5	51.0	0.05
	10 OpenMP threads	2.4	1.0	34.9	41.7	0.06
Total	MPI only	27159.8	2019.5	589.7	577.8	47.01
	5 OpenMP threads	27159.8	1849.1	374.7	310.0	87.62
	10 OpenMP threads	27159.8	1860.8	371.2	292.9	92.73

Table S8. Run time and parallel speedup of each main step of PatCC1 under different parallel settings, when using the latitude–longitude grid at the fine resolution level. "3-1" and "3-2" indicate the first stage (decompose the whole grid into kernel sub-grid domains) and second stage (expand each kernel sub-grid domain) of the third step, respectively.

Main step ID	Settings of MPI+OpenMP	Run time (ms) under different numbers of computing resource units				Parallel speedup (1 unit/800 units)
		1 unit	20 units	200 units	800 units	
1	MPI only	50.5	87.3	98.0	97.7	0.52
	5 OpenMP threads	50.5	21.8	21.5	26.5	1.90
	10 OpenMP threads	50.5	15.2	14.7	15.6	3.24
2	MPI only	10.4	2.2	4.0	20.0	0.52
	5 OpenMP threads	10.4	2.2	1.9	0.4	26.97
	10 OpenMP threads	10.4	1.6	0.1	0.3	30.27
3-1	MPI only	45.3	86.1	78.6	86.2	0.53
	5 OpenMP threads	45.3	41.8	49.0	76.6	0.59
	10 OpenMP threads	45.3	40.8	65.2	71.9	0.63
3-2	MPI only	867.3	160.6	103.9	126.6	6.85
	5 OpenMP threads	867.3	112.6	84.8	50.2	17.29
	10 OpenMP threads	867.3	85.9	47.1	51.2	16.95
4	MPI only	50721.1	2382.9	312.5	139.0	364.95
	5 OpenMP threads	50721.1	2434.8	309.5	124.9	406.05
	10 OpenMP threads	50721.1	2563.1	322.4	129.4	392.06
5	MPI only	2.4	32.5	91.2	131.8	0.02
	5 OpenMP threads	2.4	15.8	36.5	77.0	0.03
	10 OpenMP threads	2.4	1.1	30.0	52.6	0.05
Total	MPI only	51696.9	2751.7	688.1	601.3	85.97
	5 OpenMP threads	51696.9	2628.9	503.3	355.6	145.40
	10 OpenMP threads	51696.9	2707.6	479.5	320.9	161.09