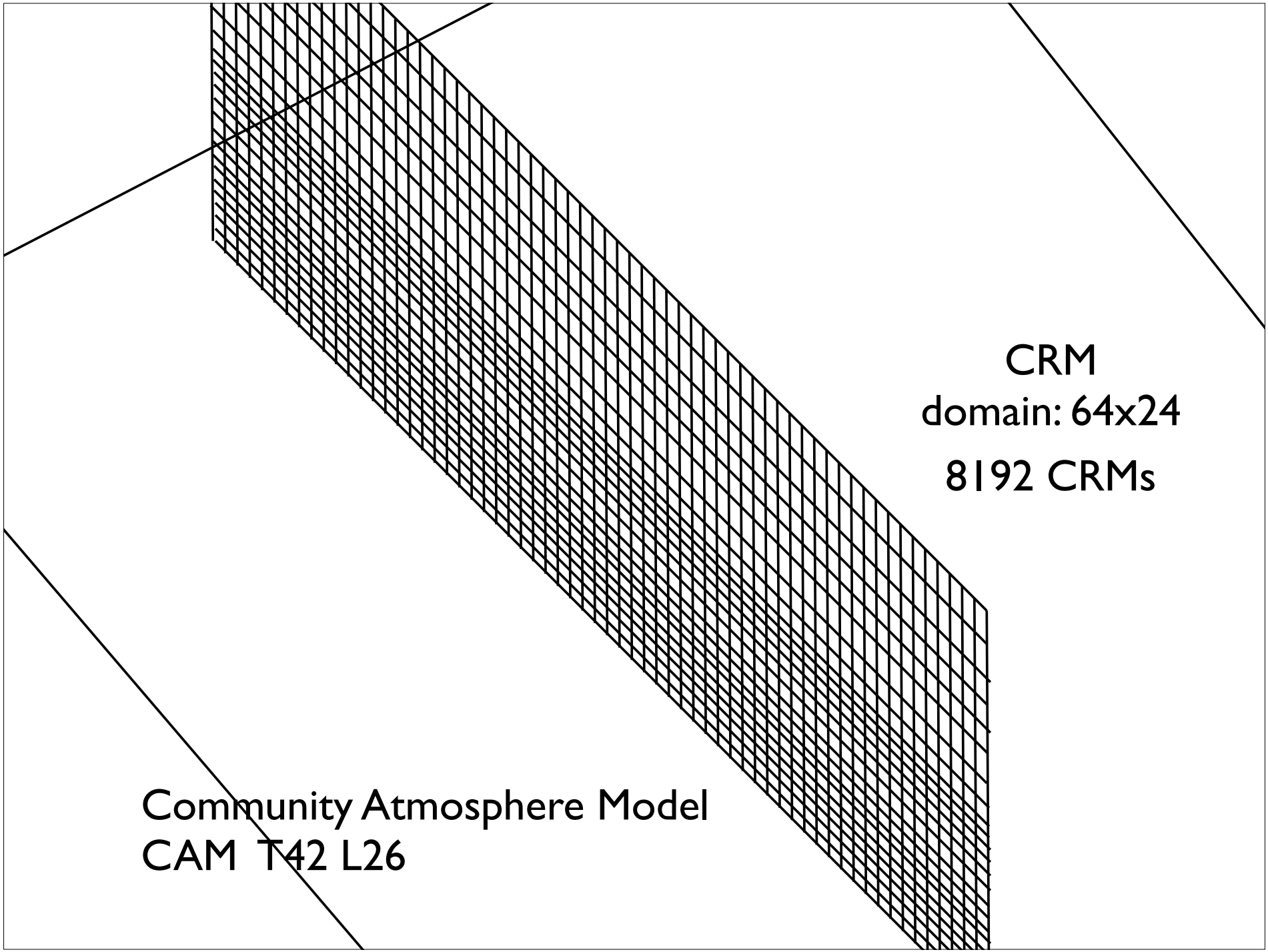
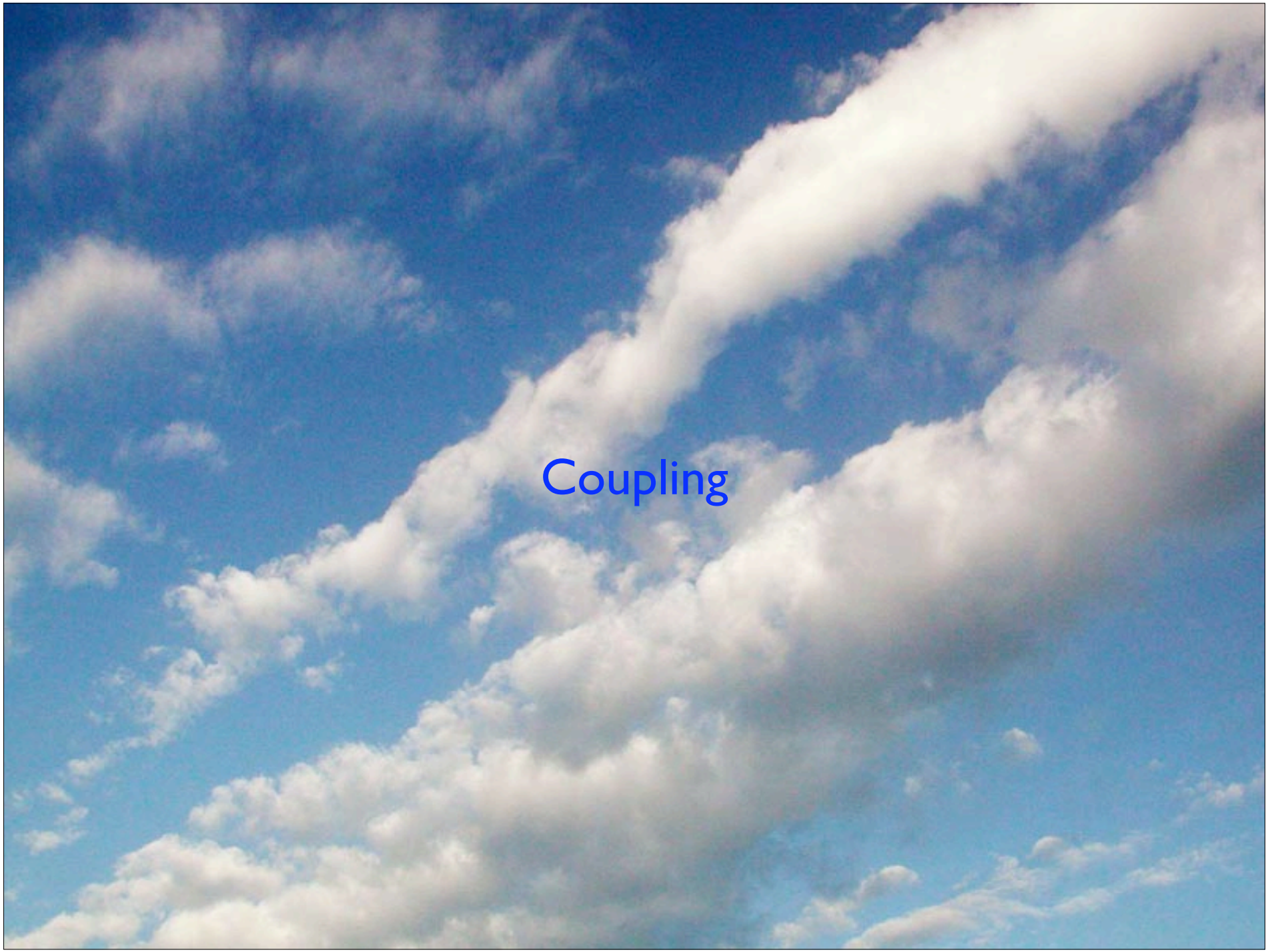
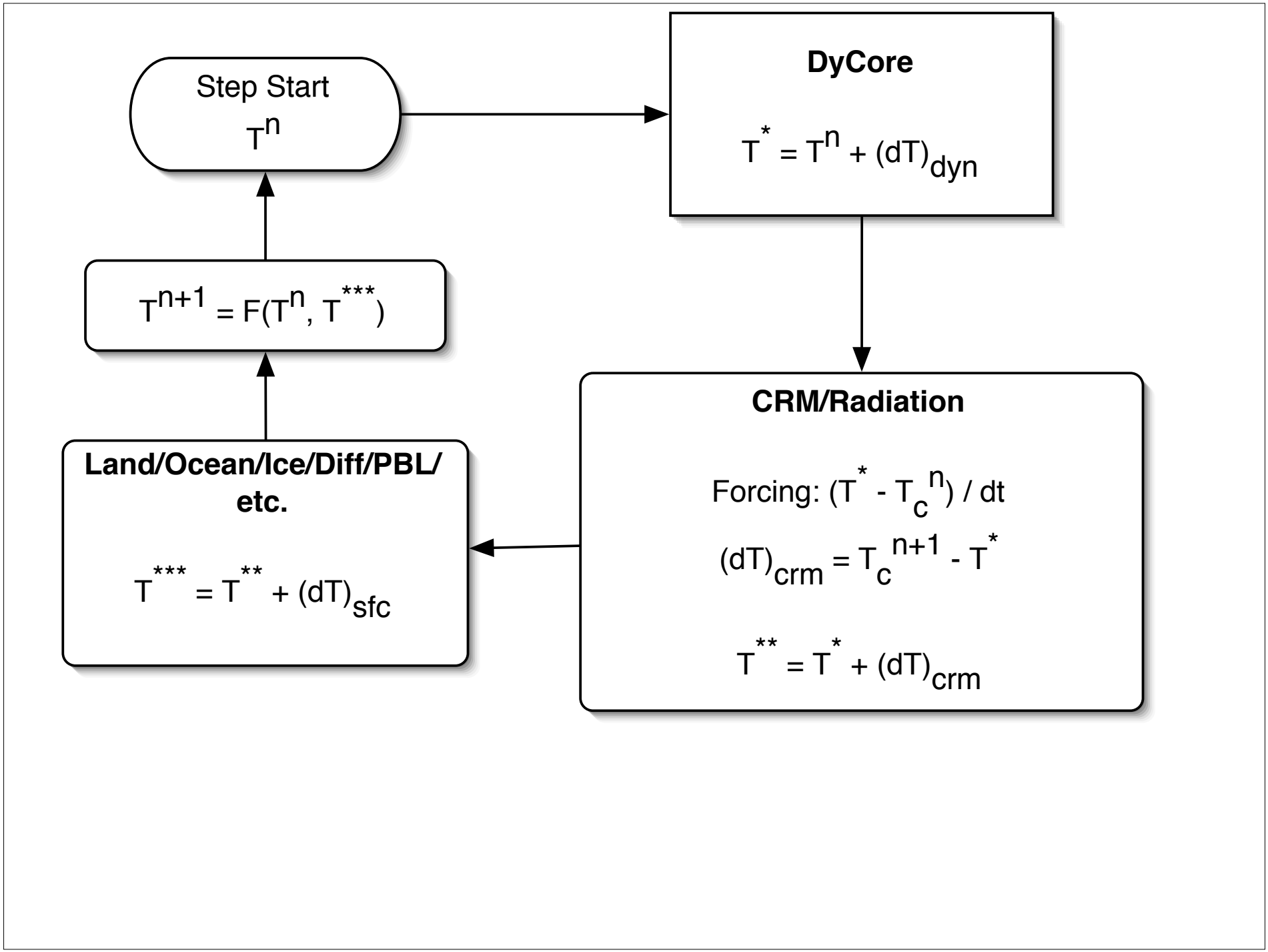
Marat Khairoutdinov

Colorado State University


CRM
domain: 64x24
8192 CRMs
Community Atmosphere Model
CAM T42 L26


Coupling

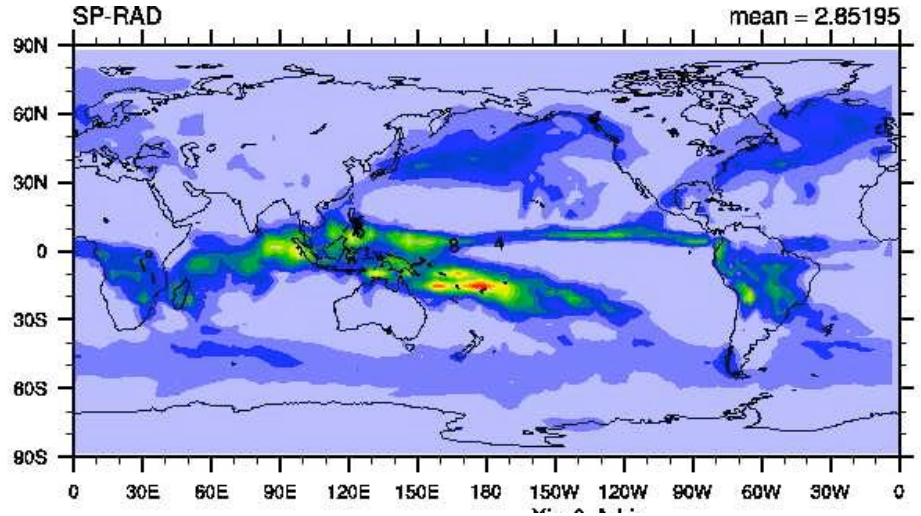

Step Start
T^n
DyCore
$T^* = T^n + (dT)_{dyn}$
$T^{n+1} = F(T^n, T^{***})$
CRM/Radiation
Forcing: $(T^* - T_c^n) / dt$
$(dT)_{crm} = T_c^{n+1} - T^*$
$T^{**} = T^* + (dT)_{crm}$
Land/Ocean/Ice/Diff/PBL/ etc.
$T^{***} = T^{**} + (dT)_{sfc}$

Cases (about 500-days each)

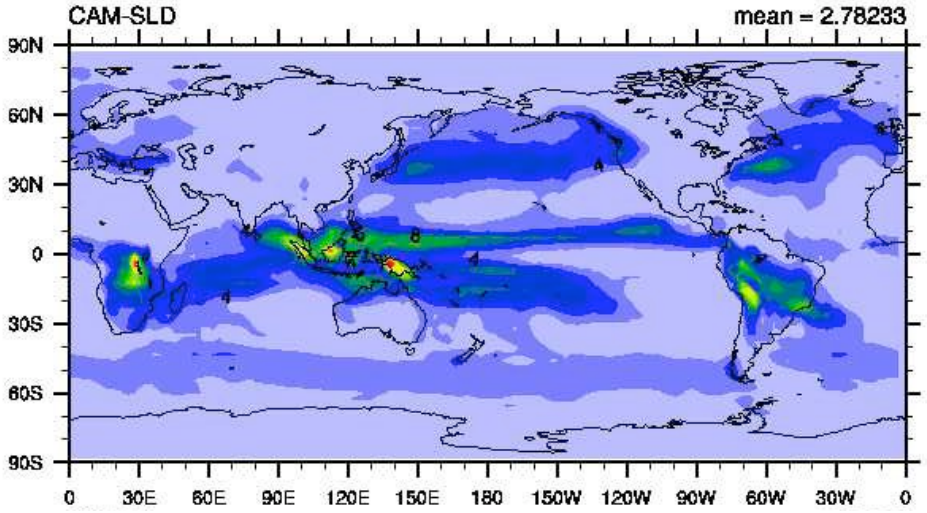
CAM-SLD	Standard physics
SP-NOR	SP with "original" coupling ("non-interactive radiation")
SP-RAD	SP with radiation transfer ("interactive radiation")
SP-SNW	Same as SP-RAD, but ice-to-snow aggregation rate is increased ten-fold ("microphysics")
SP-99	Same as SP-SNW, but for Sep. 1998-Jan. 2000 SSTs
SP-DRAG	Cloud-scale surface drag

DJF Precipitation Rate, mm/day

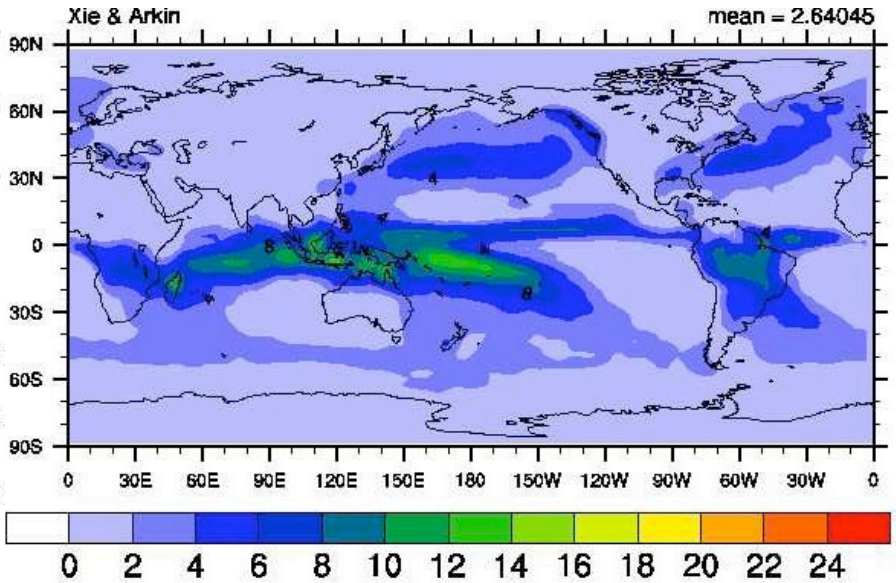
MMF



CAM

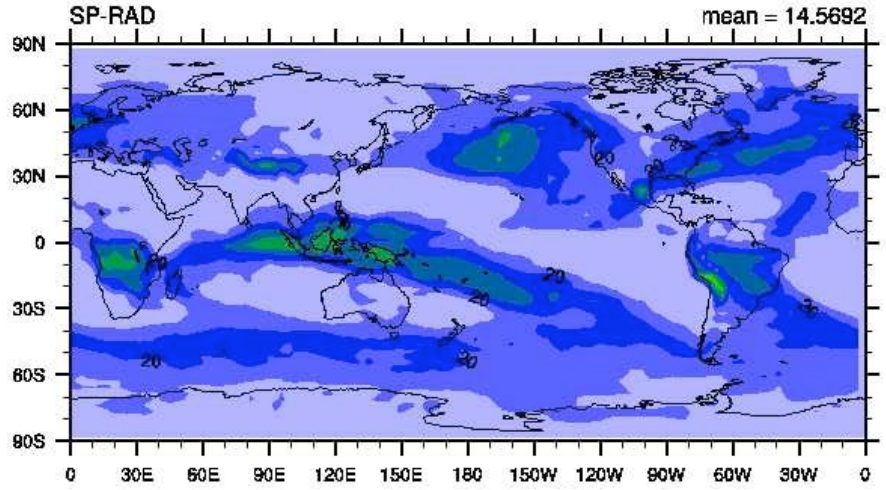


Obs

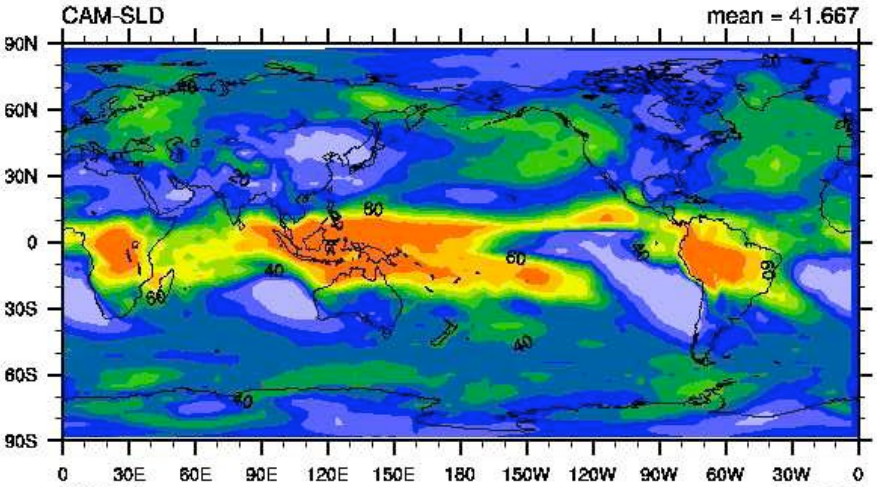


DJF High-Cloud Cover

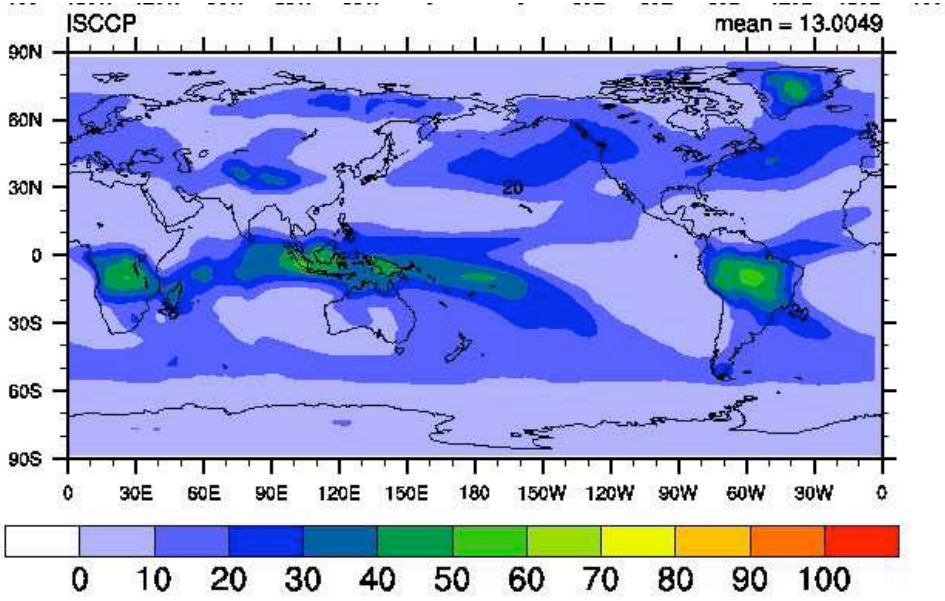
MMF



CAM

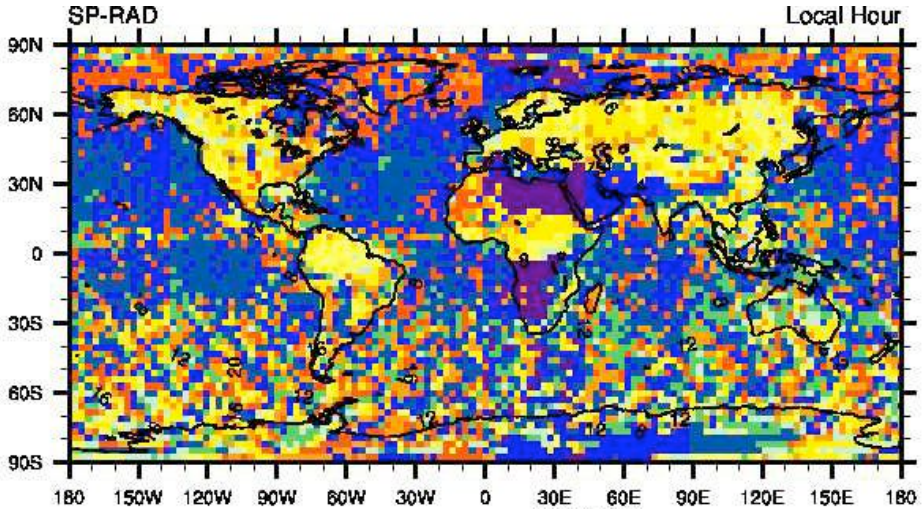


ISCCP

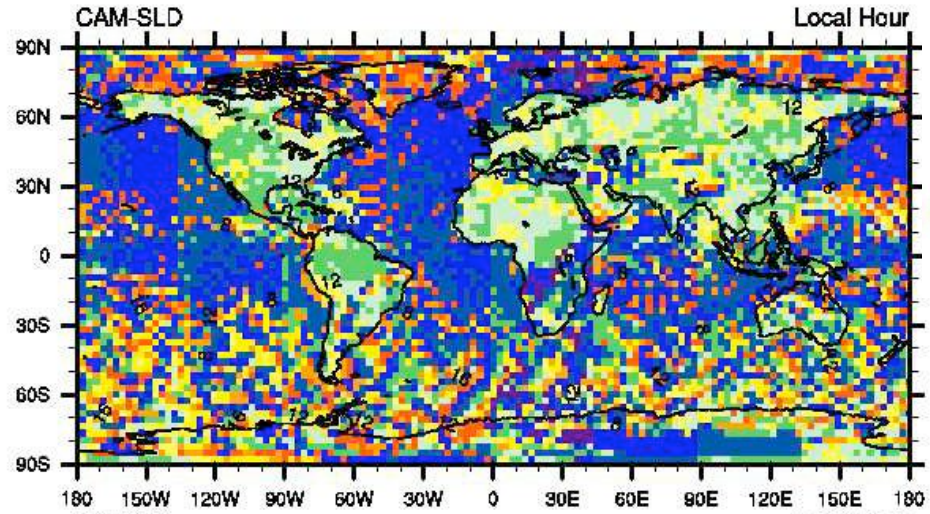


JJA Local Time of Non-Drizzle Precipitation Frequency Maximum

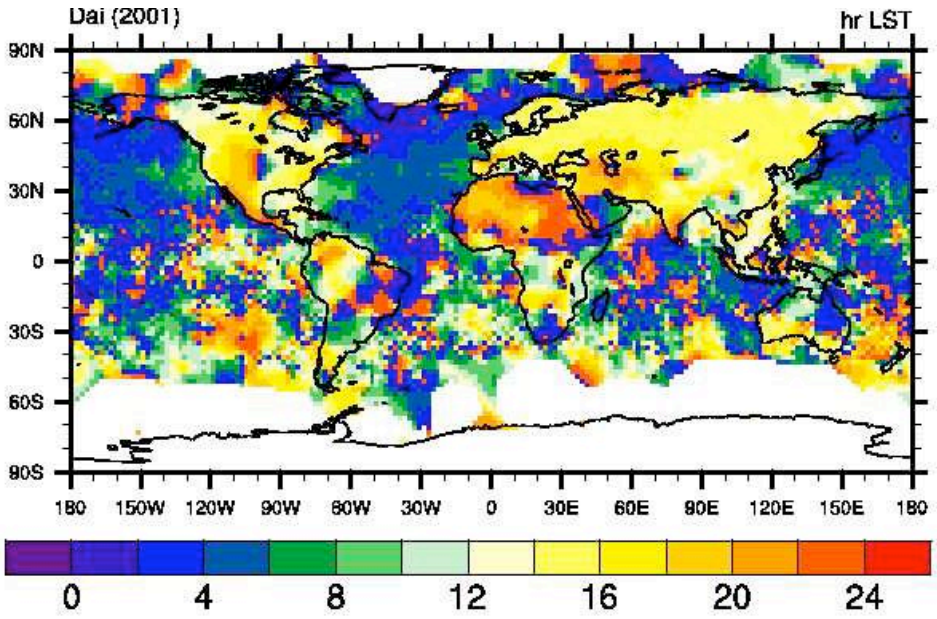
SP-CAM

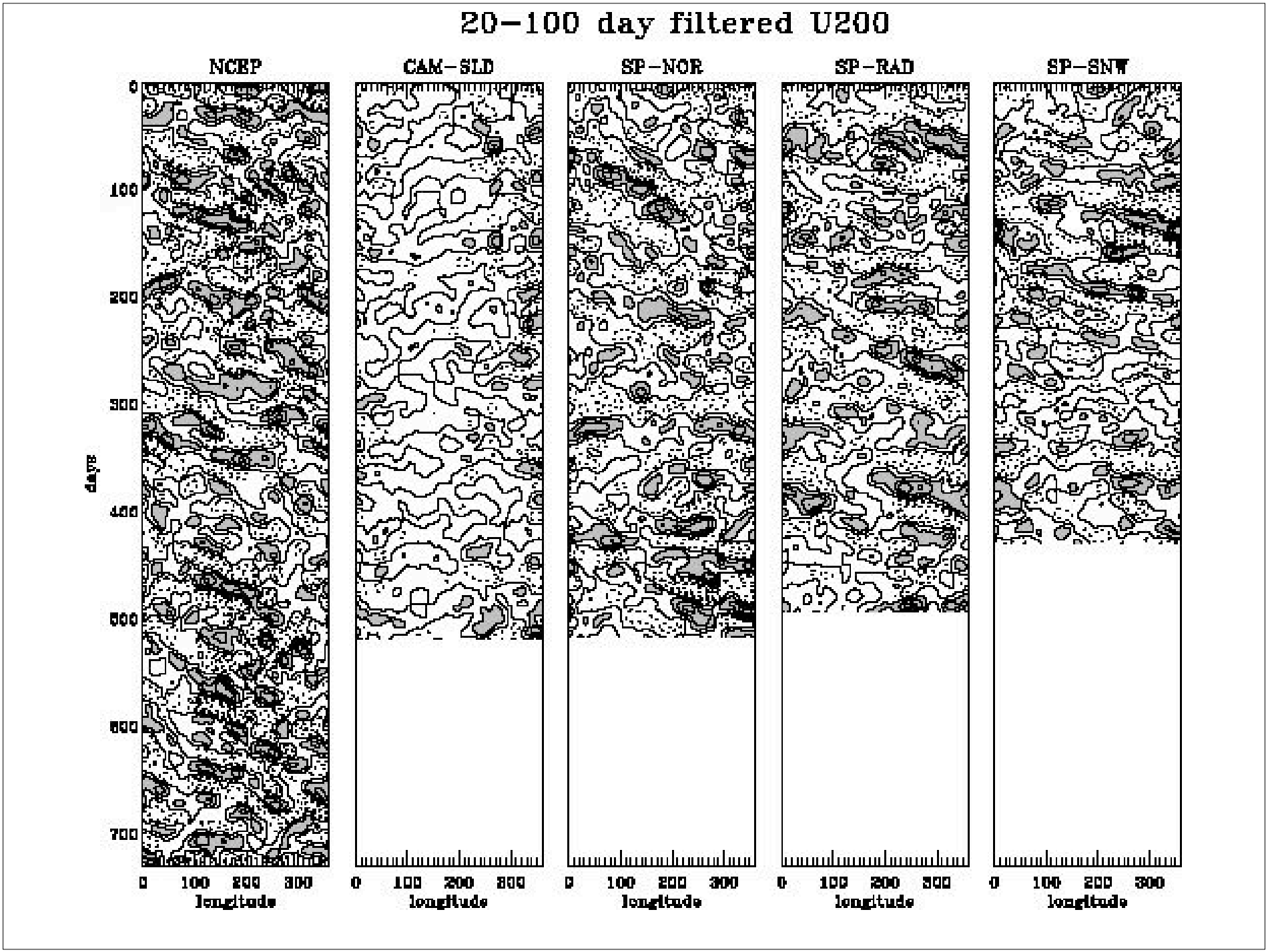


CAM

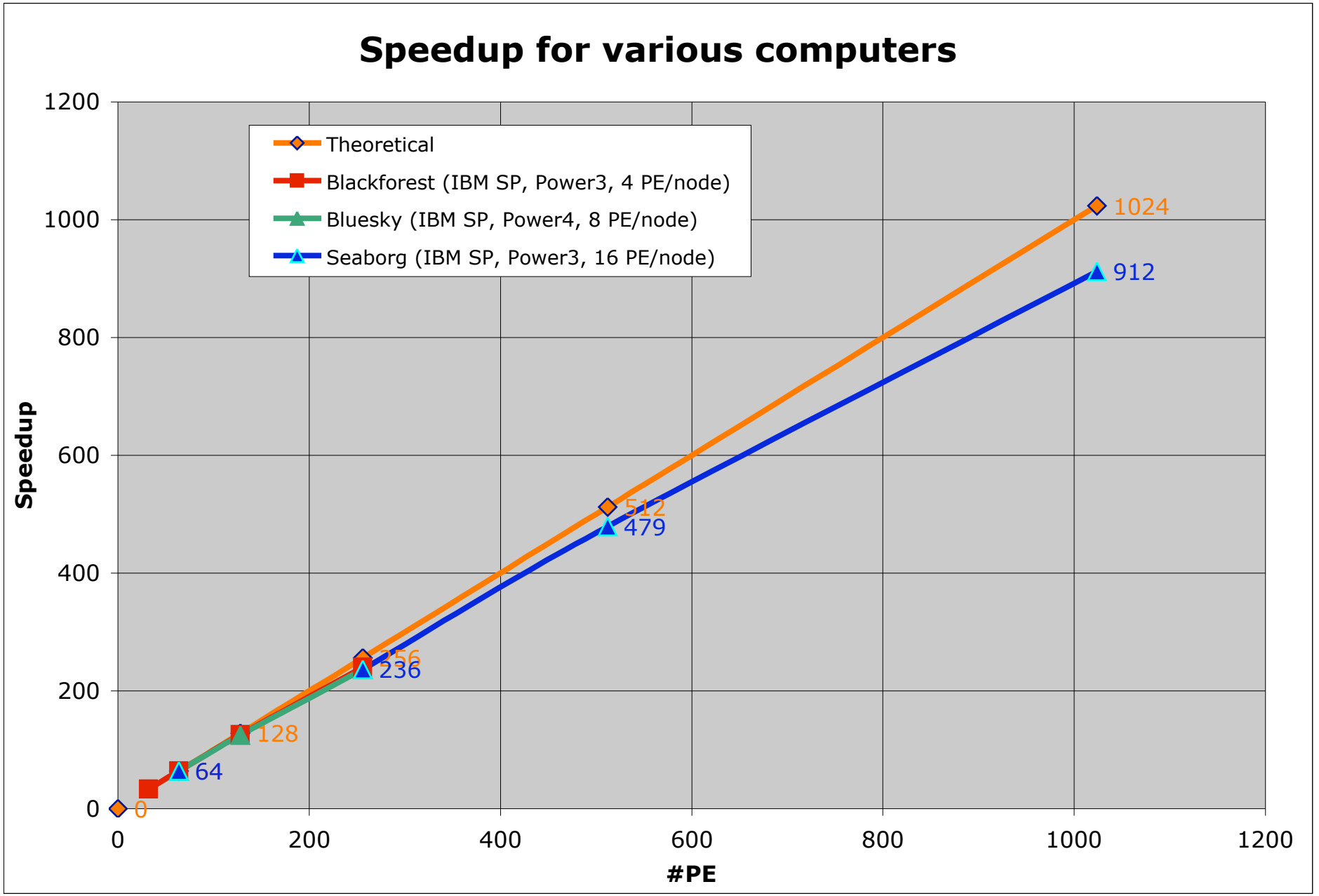


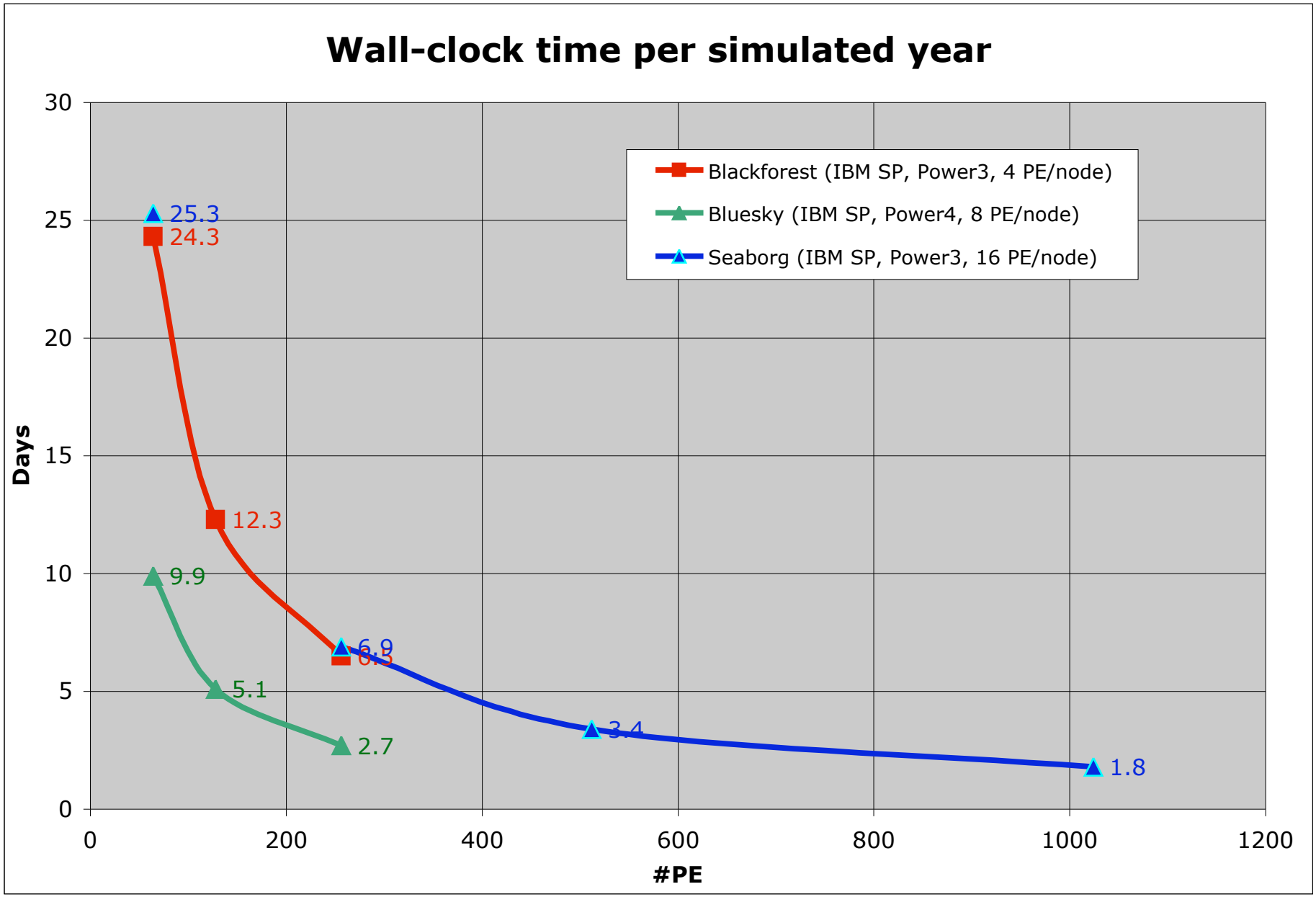
Dai (2001)




20–100 day filtered U200
NCEP
CAM–SLD
SP–NOR
SP–RAD
SP–SNW
days
0
100
200
300
400
500
600
700
0
100
200
300
longitude


Computational Performance


Speedup for various computers
Theoretical
Blackforest (IBM SP, Power3, 4 PE/node)
Bluesky (IBM SP, Power4, 8 PE/node)
Seaborg (IBM SP, Power3, 16 PE/node)
Speedup
#PE
0
200
400
600
800
1000
1200
0
64
128
256
236
512
479
1024
912

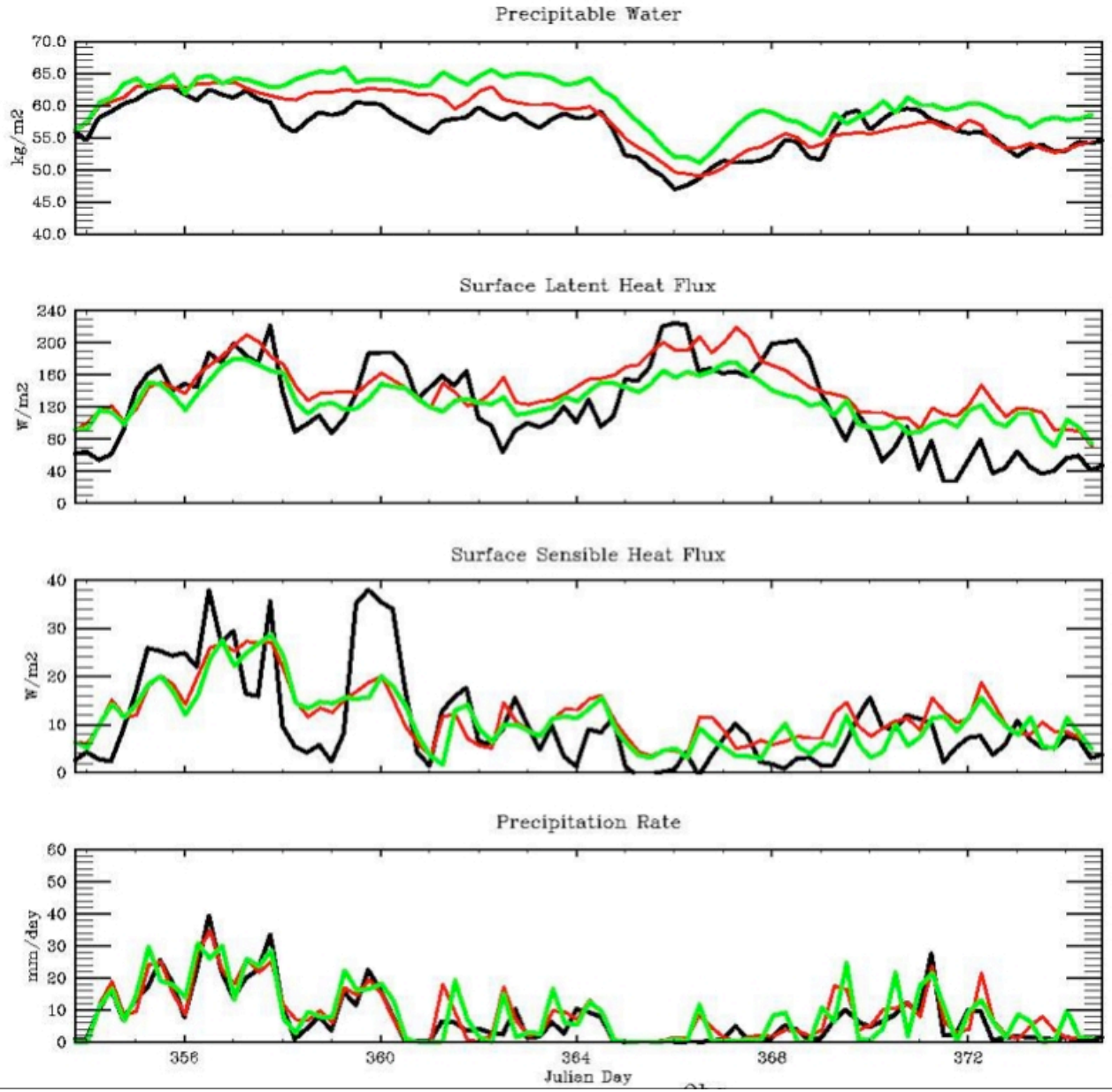

Wall-clock time per simulated year
Days
#PE
0
5
10
15
20
25
30
0
200
400
600
800
1000
1200
Blackforest (IBM SP, Power3, 4 PE/node)
Bluesky (IBM SP, Power4, 8 PE/node)
Seaborg (IBM SP, Power3, 16 PE/node)
25.3
24.3
12.3
9.9
5.1
2.7
6.9
3.4
1.8


CRM Resolution and Domain Size:
Sufficient ?

CRM in MMF	Grid Levels	Standard CRM
63.54712		50.00000000
253.2022		160.5263062
615.9903		292.1051941
1195.853		444.7367249
1984.489		618.4208984
2969.779		813.1577148
4131.035		1028.947266
5352.024		1265.789429
6529.58		1523.684082
7663.525		1802.631470
8755.213		2102.631592
9809.521		2423.684326
10832.01		2765.789551
11835.68		3128.947510
12832.92		3513.157959
13827.02		3918.421143
14819.79		4344.736816
15810.46		4792.104980
16797.76		5260.525879
18044.73		5750.000000
19804.43		6250.000000
22073.80		6750.000000
24940.45		
28489.32		
32729.16		

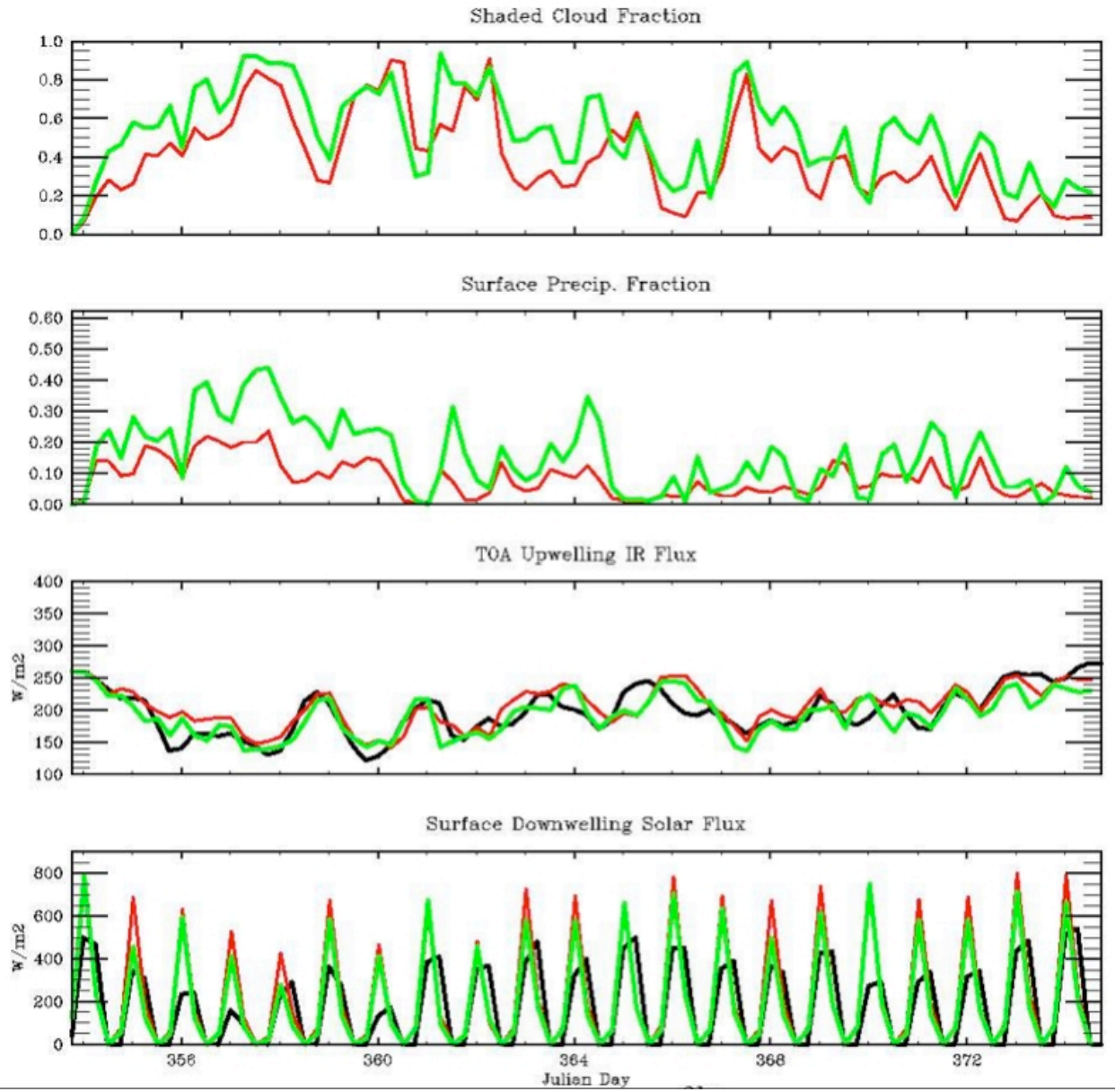
TOGA-COARE

Obs — 128x128x64 2km — 64x24 2km



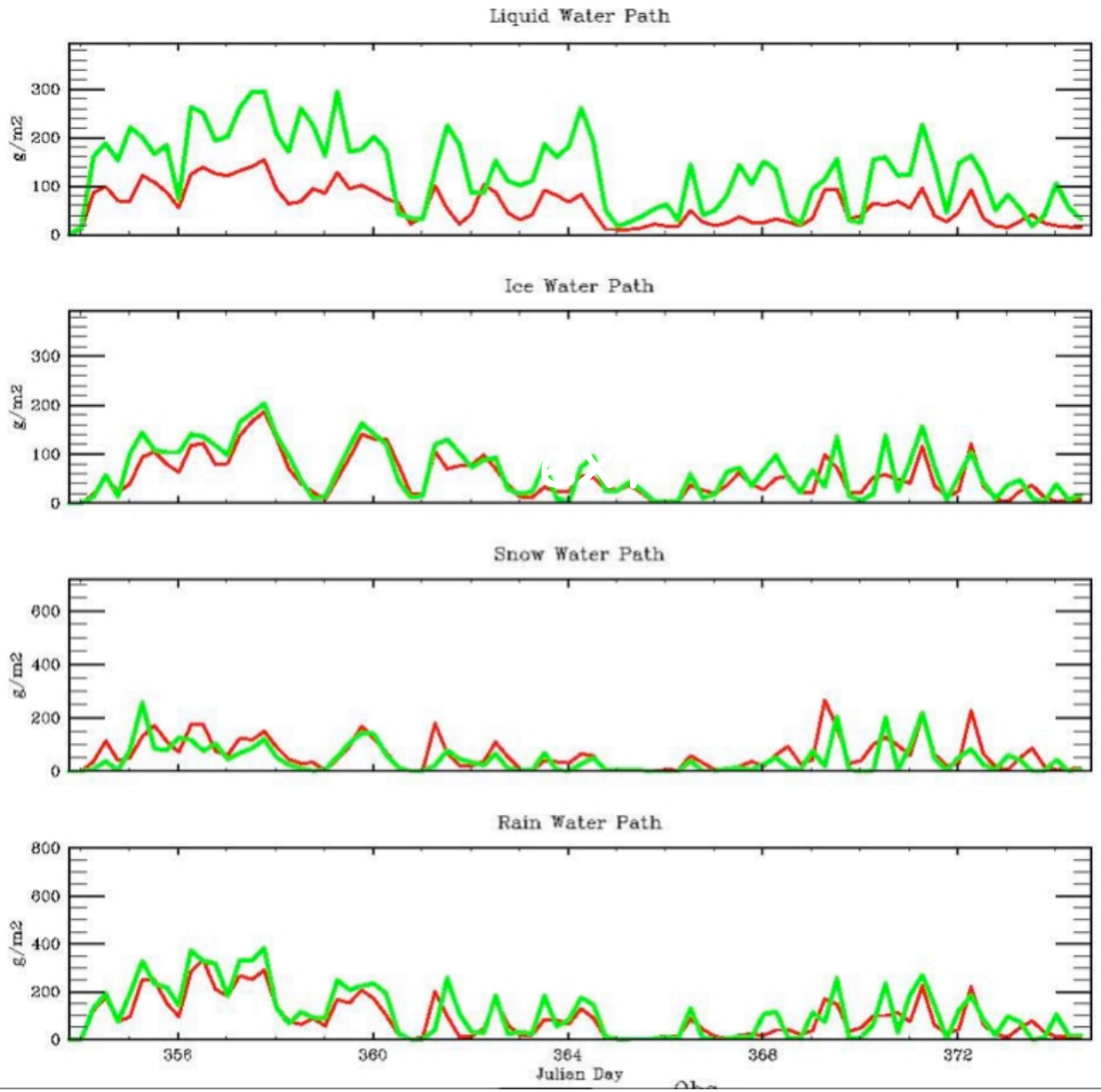
TOGA-COARE

Obs 128x128x64 2km 64x24 2km



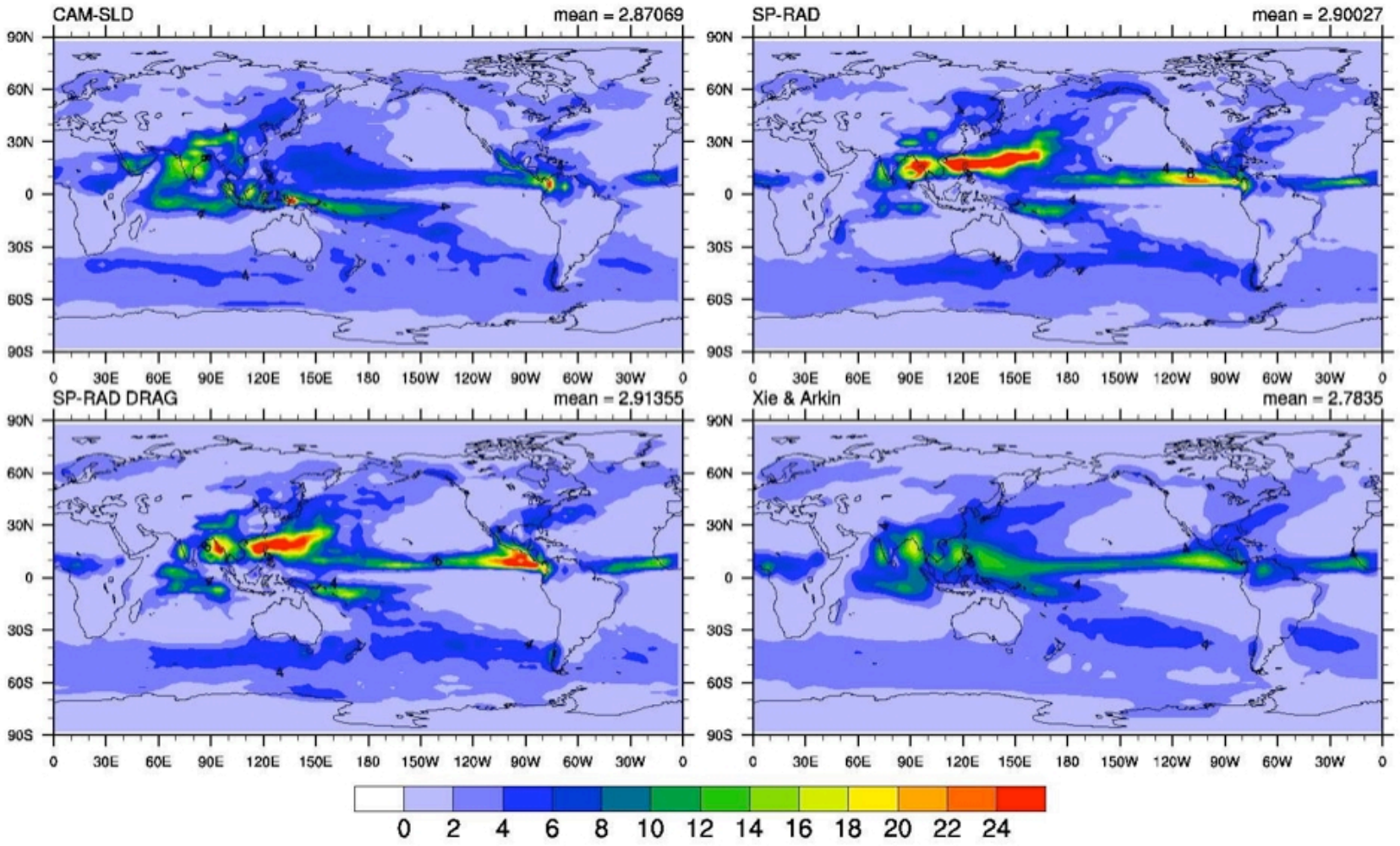
TOGA-COARE

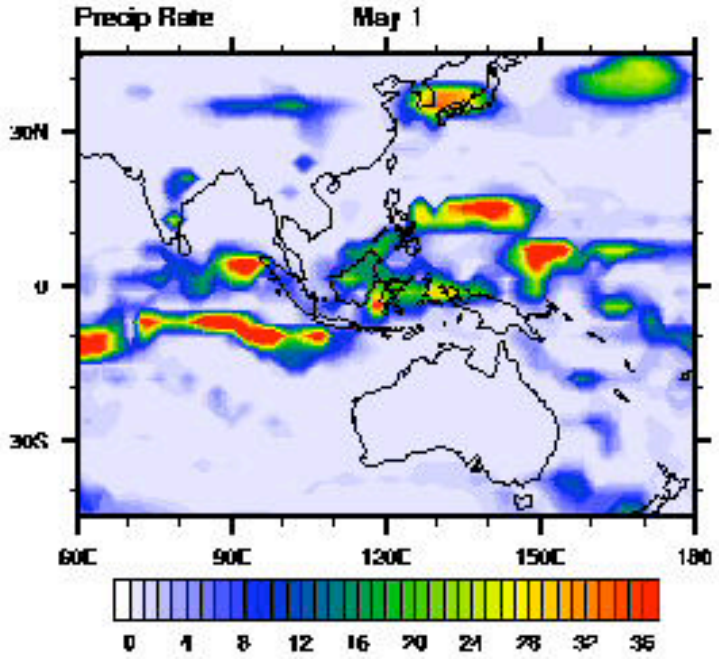
Obs 128x128x64 2km 64x24 2km

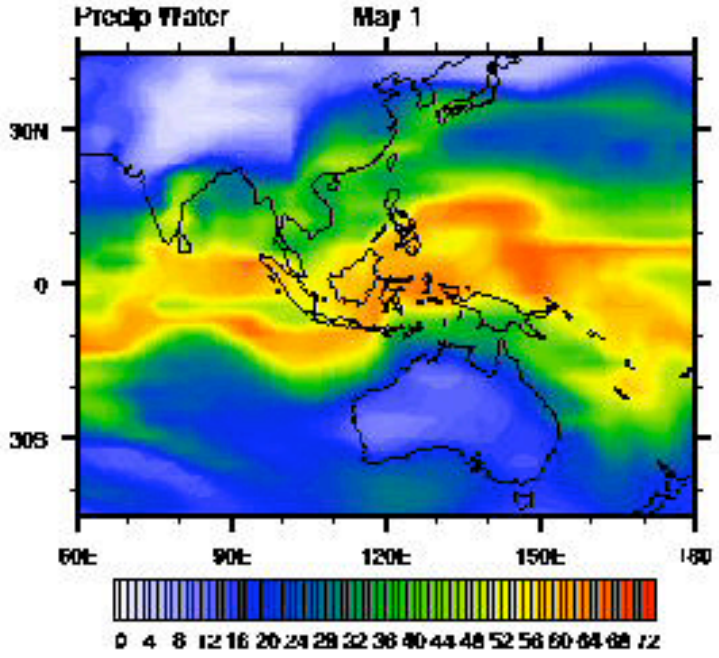


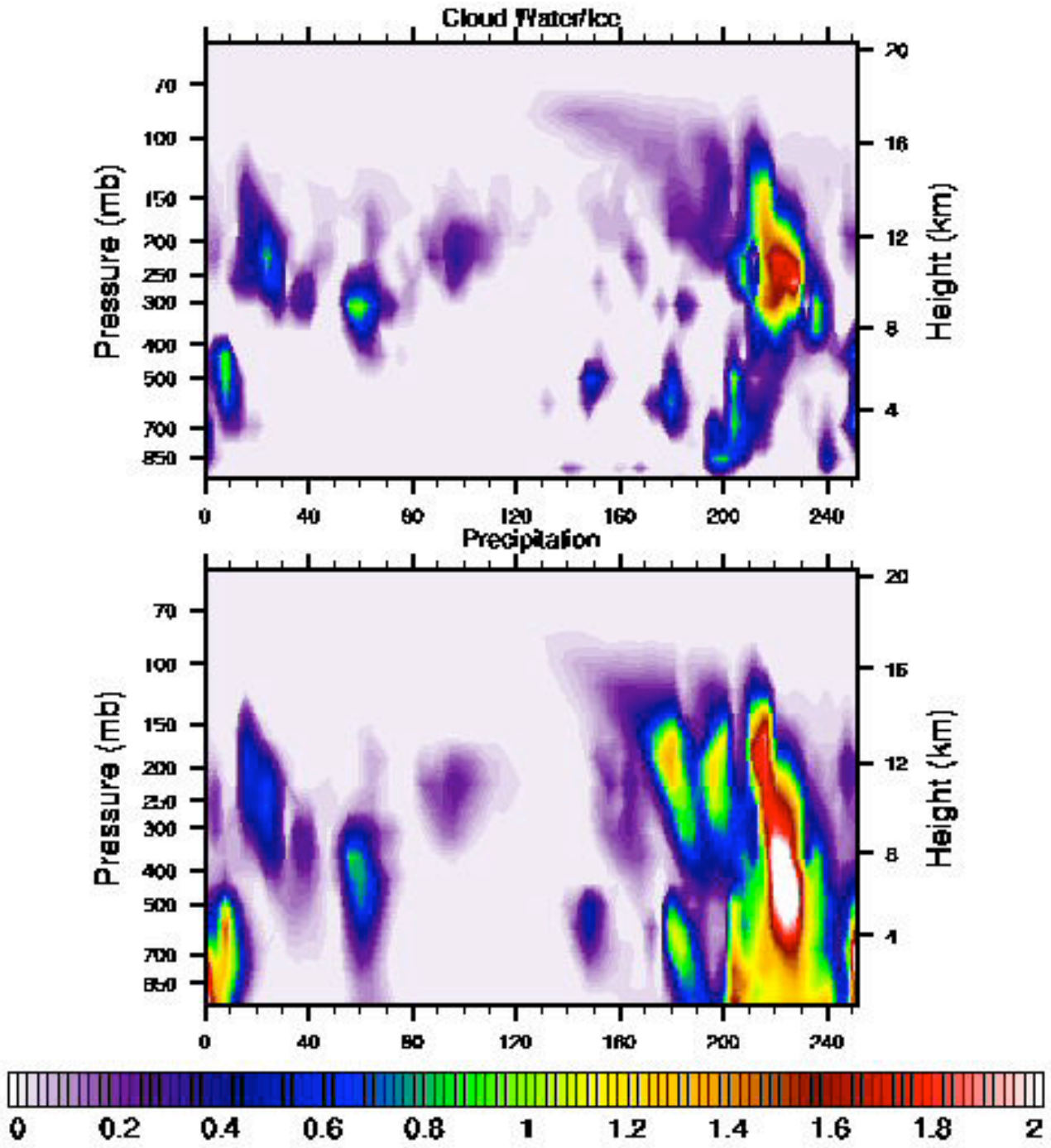

Great Red Spot

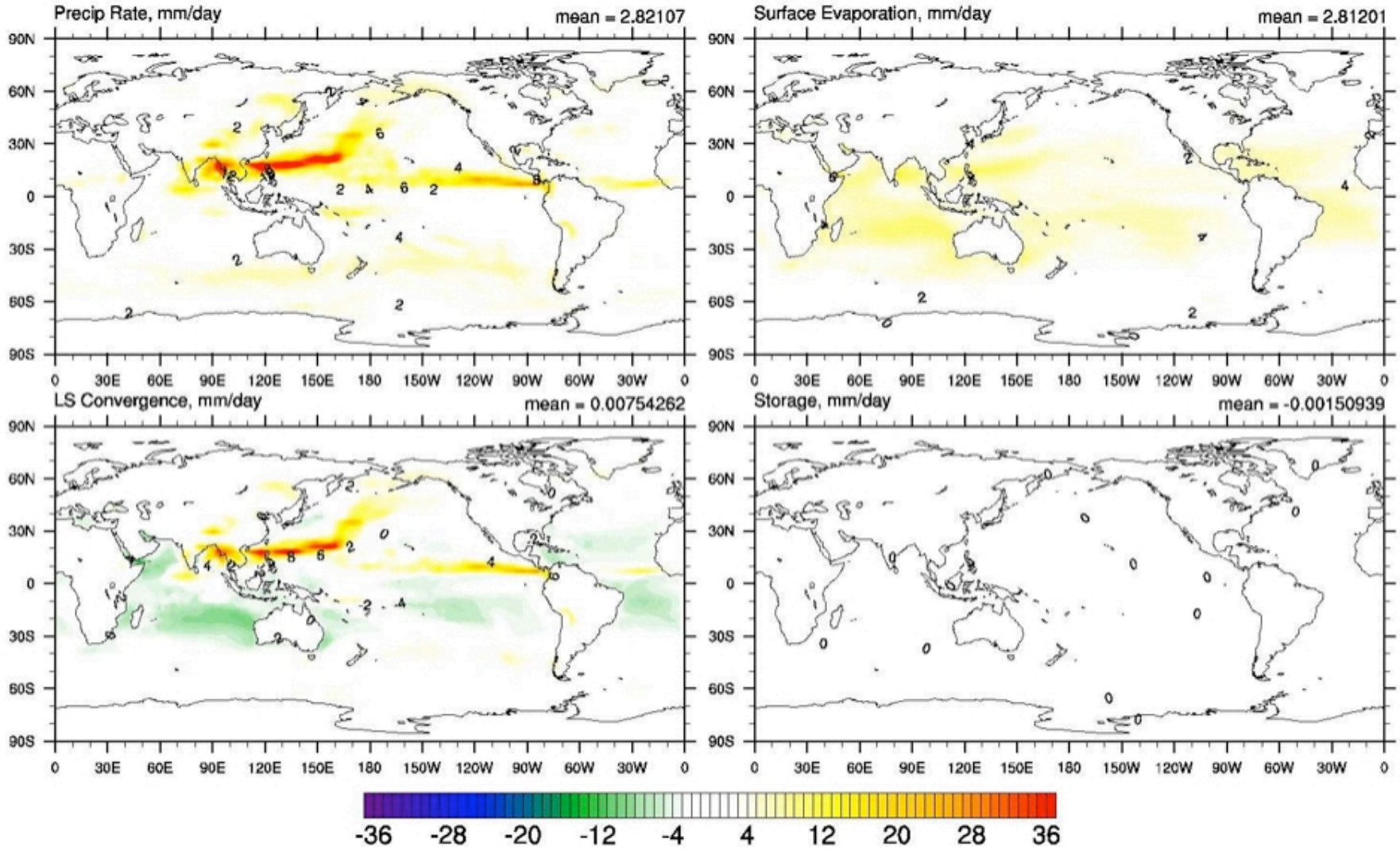
JJA Precipitation Rate, mm/day




Precip Rate
May 1
30N
0
30S
60E
90E
120E
150E
180
0 4 8 12 16 20 24 28 32 36


Precip Water
May 1
30N
0
30S
60E
90E
120E
150E
180
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72

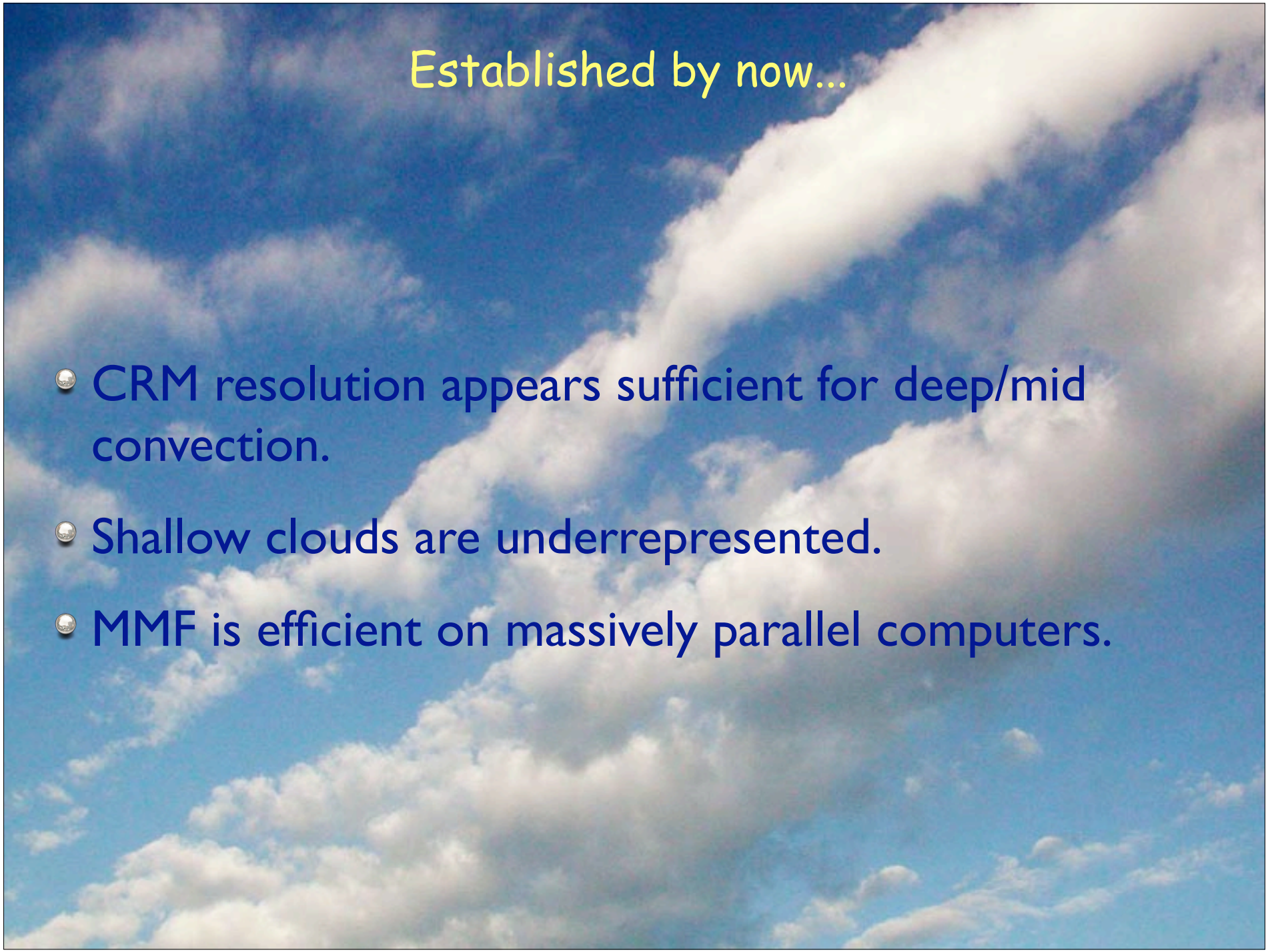

Cloud Water/Ice
Pressure (mb)
70
100
150
200
250
300
400
500
700
850
Height (km)
20
16
12
8
4
0
40
80
120
160
200
240
Precipitation
Pressure (mb)
70
100
150
200
250
300
400
500
700
850
Height (km)
20
16
12
8
4
0
40
80
120
160
200
240
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Precip Rate, mm/day
mean = 2.82107
Surface Evaporation, mm/day
mean = 2.81201
LS Convergence, mm/day
mean = 0.00754262
Storage, mm/day
mean = -0.00150939
90N
60N
30N
0
30S
60S
90S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
-36 -28 -20 -12 -4 4 12 20 28 36


It is suspected that …
Prototype-MMF implementation (periodic-domain CRM in each grid column of GCM) itself may be responsible for the "Great Red Spot".

Strategy for Understanding GRS

- Test the current approach using "Big-Brother" model, that is CRM as a super-parameterization within a CRM.
- Advantage: a "true" solution can be produced by a high-resolution CRM, and used for direct comparison.


Established by now...
CRM resolution appears sufficient for deep/mid convection.
Shallow clouds are underrepresented.
MMF is efficient on massively parallel computers.

Model development

- "Big Brother" Model: 100% coded, needs DBT
- Global MMF with CRM continuous along the longitudinal circles: CRM part coded, needs a coupler to the GCM
- Quasi-3D CRM


The End