

OASIS: A useful coupler for SINTEX-F models on the Earth Simulator (ES)

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SINTEX-F1 Coupled GCM

(Luo et al. GRL 2003, J. Clim. 2005a; Masson et al. GRL 2005)

1. Model components:

AGCM (*MPI, Germany*): ECHAM4.6 (T106L19)

OGCM (*LODYC, France*): OPA8.2 ($2^\circ \times 0.5^\circ \sim 2^\circ$, L31)

Coupler (*CERFACS, France*): OASIS2.4

* *No flux correction, no sea ice model*

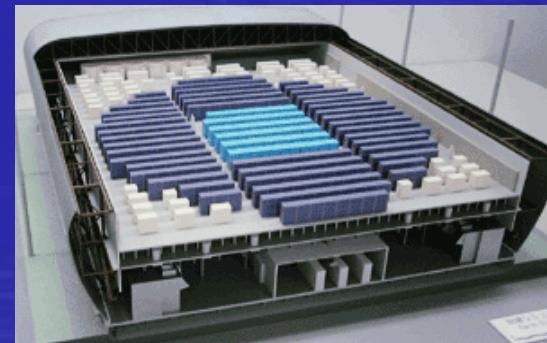
2. International collaborators:

LODYC: OPA model group

INGV (Italy): A. Navarra's group

MPI-Met: ECHAM model group

CERFACE: OASIS coupler group



Our history (from 2001)

- SINTEX at SX5 (2001-2002)
- SINTEX-F1 at ES (2002-2009.3)
- SINTEX-F2 at ES (2005-2009.3)
- SINTEX-F1,2 at ES2 (2009.4-)

SINTEX at SX5 (2001-2002)

- Original version (Italy-France):
ECHAM4.0 (f77, multi-tasking); OPA8.1;
OASIS2.4.0 (MPI2, *no MPI1*)
- New version (using 4 CPUs, 10-yr run):
ECHAM4.6 (f90, MPI)

SINTEX-F1 at ES (2002-2009.3)

- ➔ • 1st version (1-node, 220-yr run):
ECHAM4.6; OPA8.2; OASIS2.4.0
- 2nd version (3 nodes, not to be kicked out from ES):
ECHAM4.6; OPA8.2; OASIS2.4.1
Using MPI1: mpi_common_spawn does not work on ES
mpi_common_split is necessary
- 3rd version (for climate variation and prediction study):
OASIS was speeded up;
Model coupling physics was improved

The SINTEX-F1 Coupled GCM (*1st version*)

1. Coupling fields:

Tau, E-P, Qnsw, Qsw

ECHAM4 \leftrightarrow OASIS2 \leftrightarrow OPA8
SST

Technical points:

- a) Mozaic (area weighted) interpolation scheme:
SST, E-P, Qnsw, Qsw
- b) Bicubic spline interpolation: Tau (wind stress curl
is also conserved)
- c) Ocean & atmosphere grid/coastline mismatch
- d) Vector rotation to match with OPA coordinate

2. Coupling Frequency: Every 2 hours

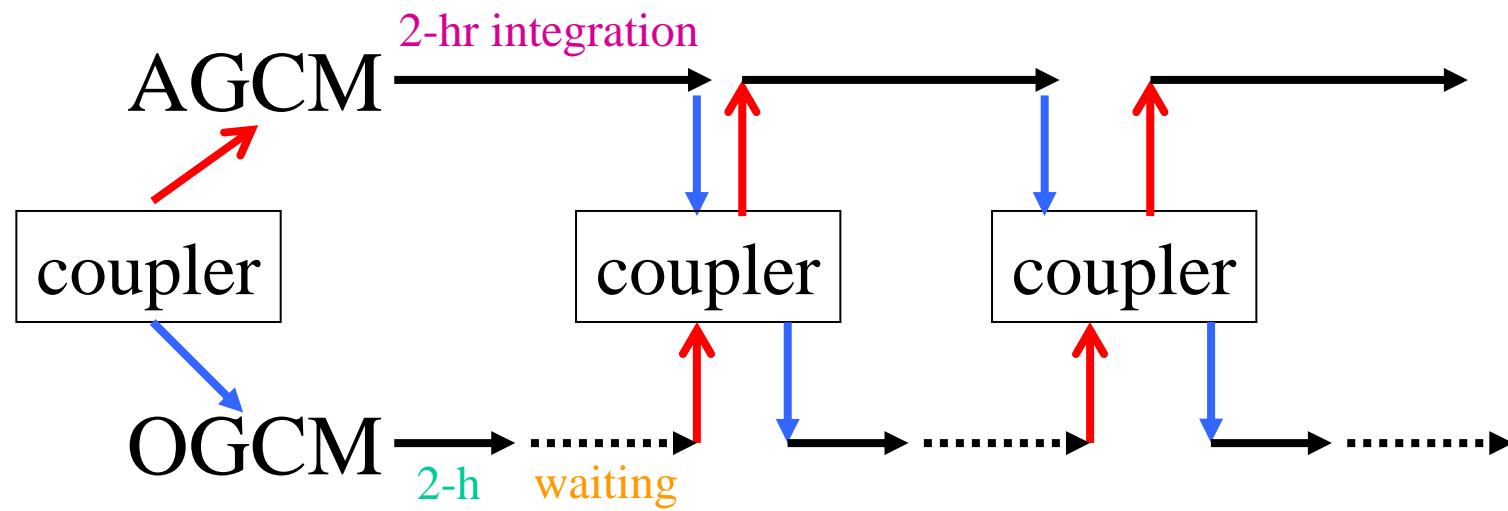
3. Initial condition:

ECHAM4: One year forced run by climatological SST

OPA8: Levitus annual climatology

4. Parallel computation

Parallel computation



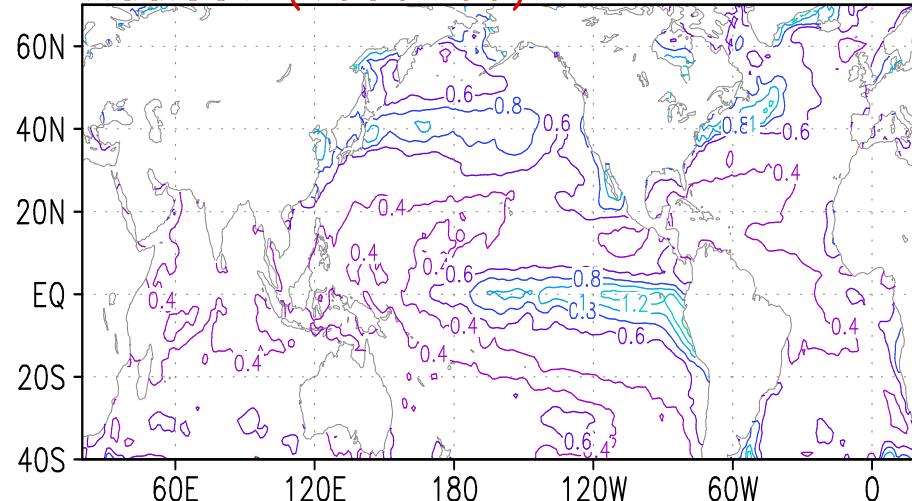
1-node (A8:O1:C1), 220-year integrations

ENSO simulation

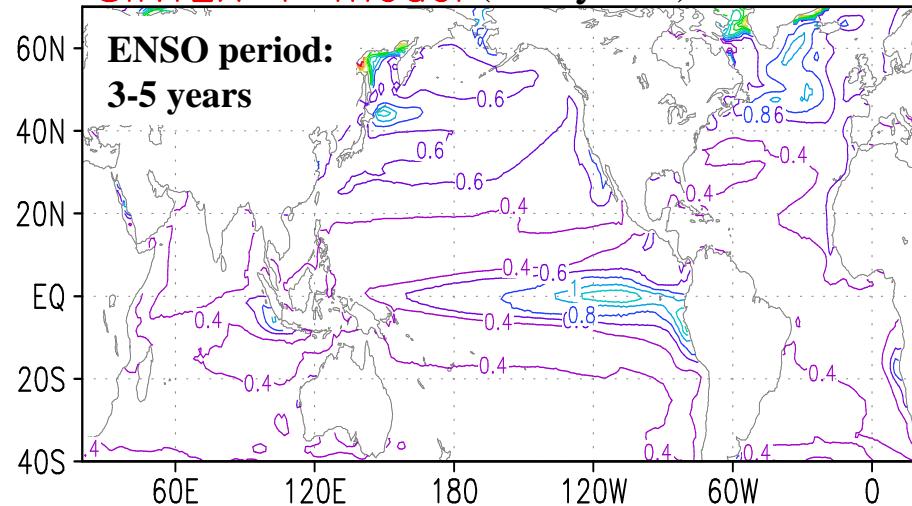
Luo et al. 2003

Standard deviation of SST

HadISST (1950–99)

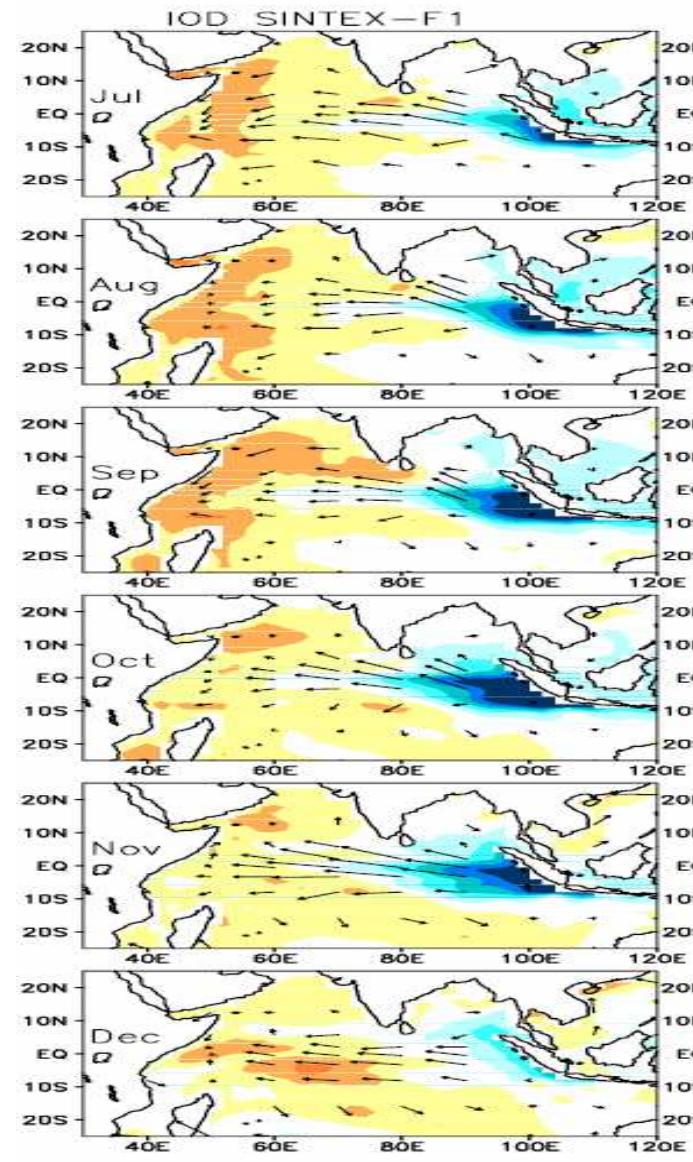


SINTEX-F model (200 years)



IOD simulation

Yamagata et al. 2004

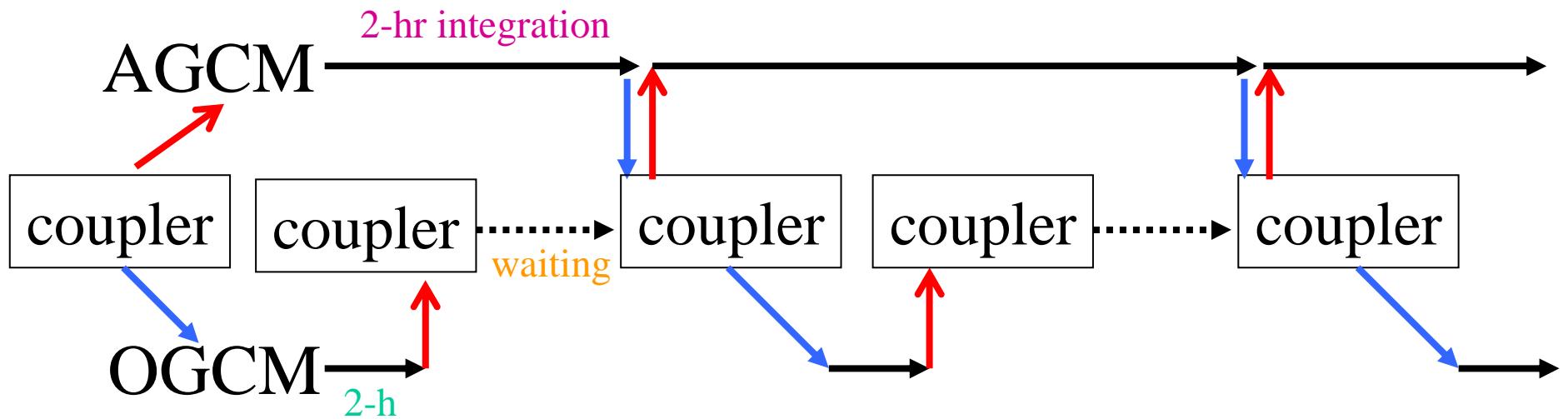


SINTEX-F1 at ES (2002-2009.3)

- 1st version (1-node, 220-yr run):
ECHAM4.6; OPA8.2; OASIS2.4.0
- 2nd version (3 nodes, not to be kicked out from ES):
ECHAM4.6; OPA8.2; OASIS2.4.1
 - MPI2: mpi_common_spawn does not work on ES.
 - MPI1: mpi_common_split is necessary
- ➔ • 3rd version (for climate variation and prediction study):
OASIS was speeded up;
Model coupling physics was improved

The SINTEX-F1 Coupled GCM (*3rd version*)

Parallel computation (~23% faster) :



New Coupling fields:

Tau, E-P, Qnsw, Qsw

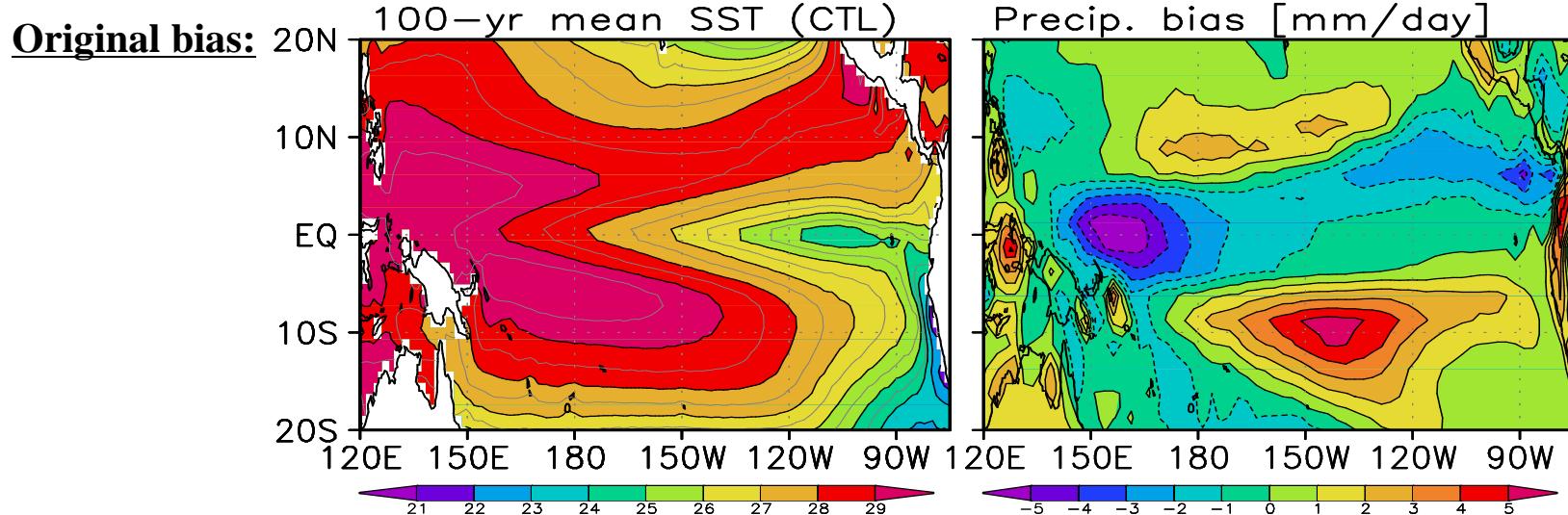
ECHAM4 \longleftrightarrow OASIS \longleftrightarrow OPA8

SST, Uo

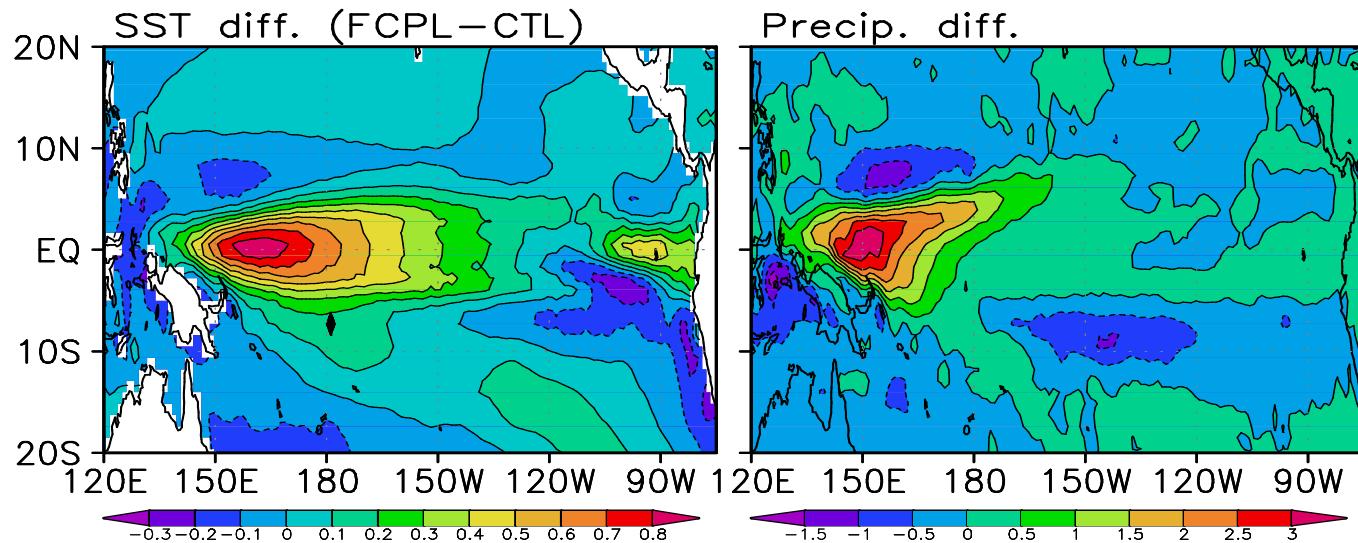
Technical points: Vector rotation to match the coordinate of A-OGCM

Reducing the model climatology bias

Luo et al. J. Climate 2005a

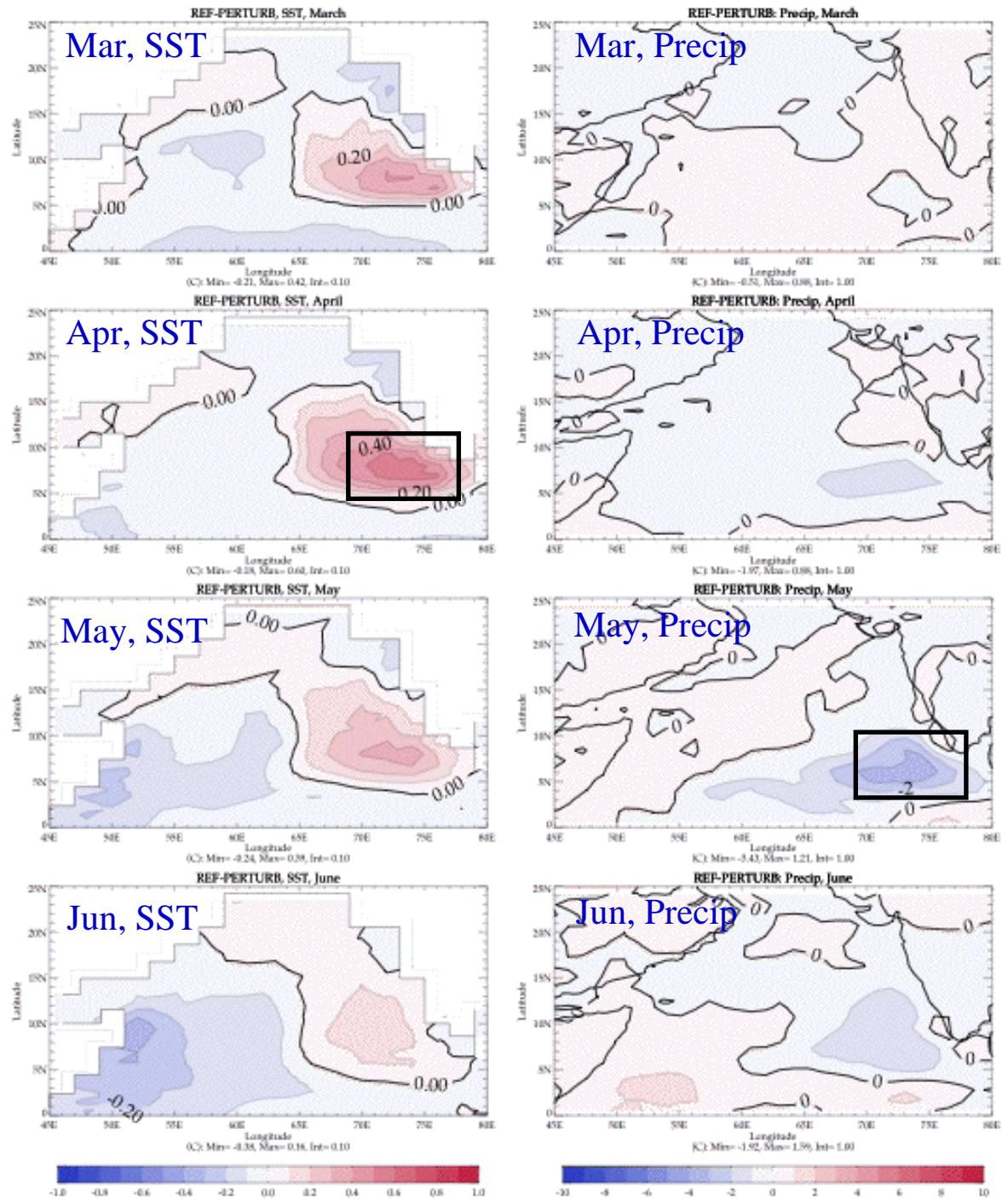


After improving the coupling physics (velocity is now continuous across the air-sea interface):



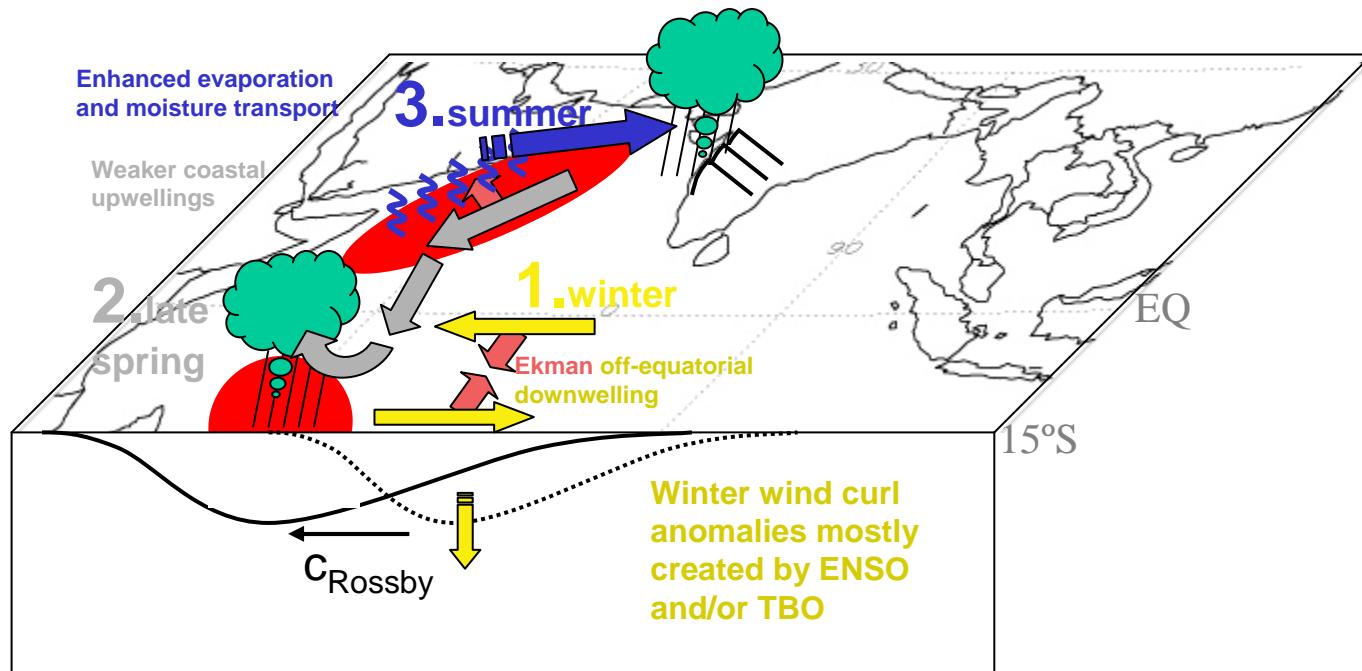
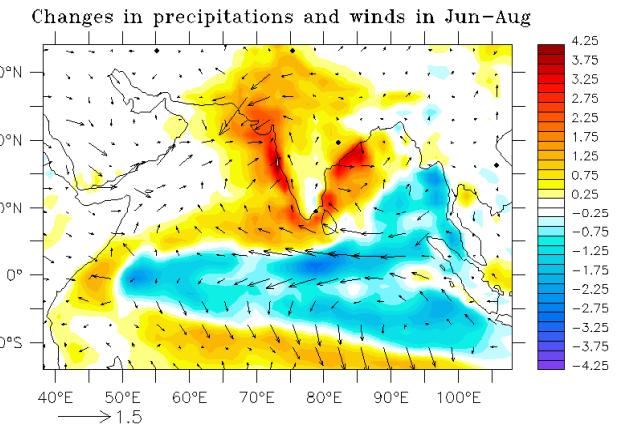
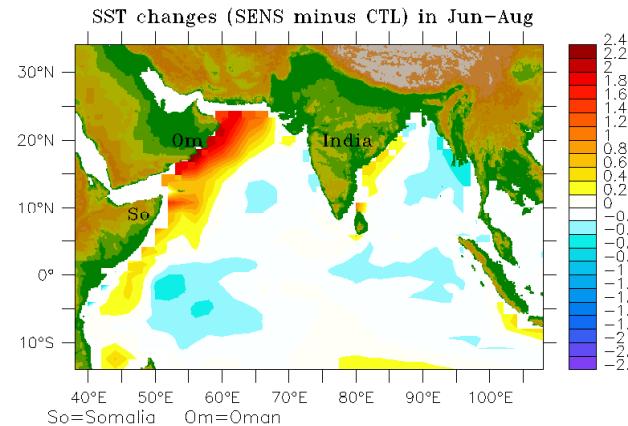
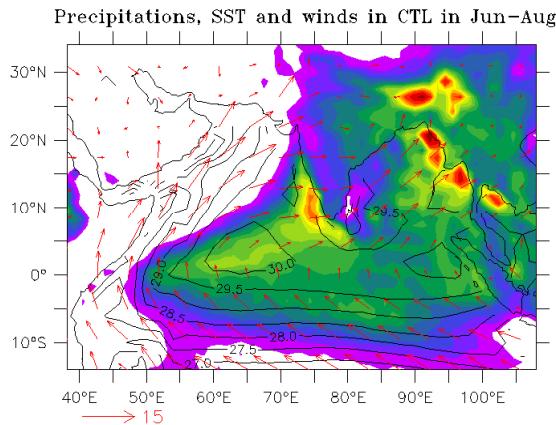
Impact of the barrier layer in the Southeast Arabian Sea to the monsoon onset

Masson et al. GRL2005

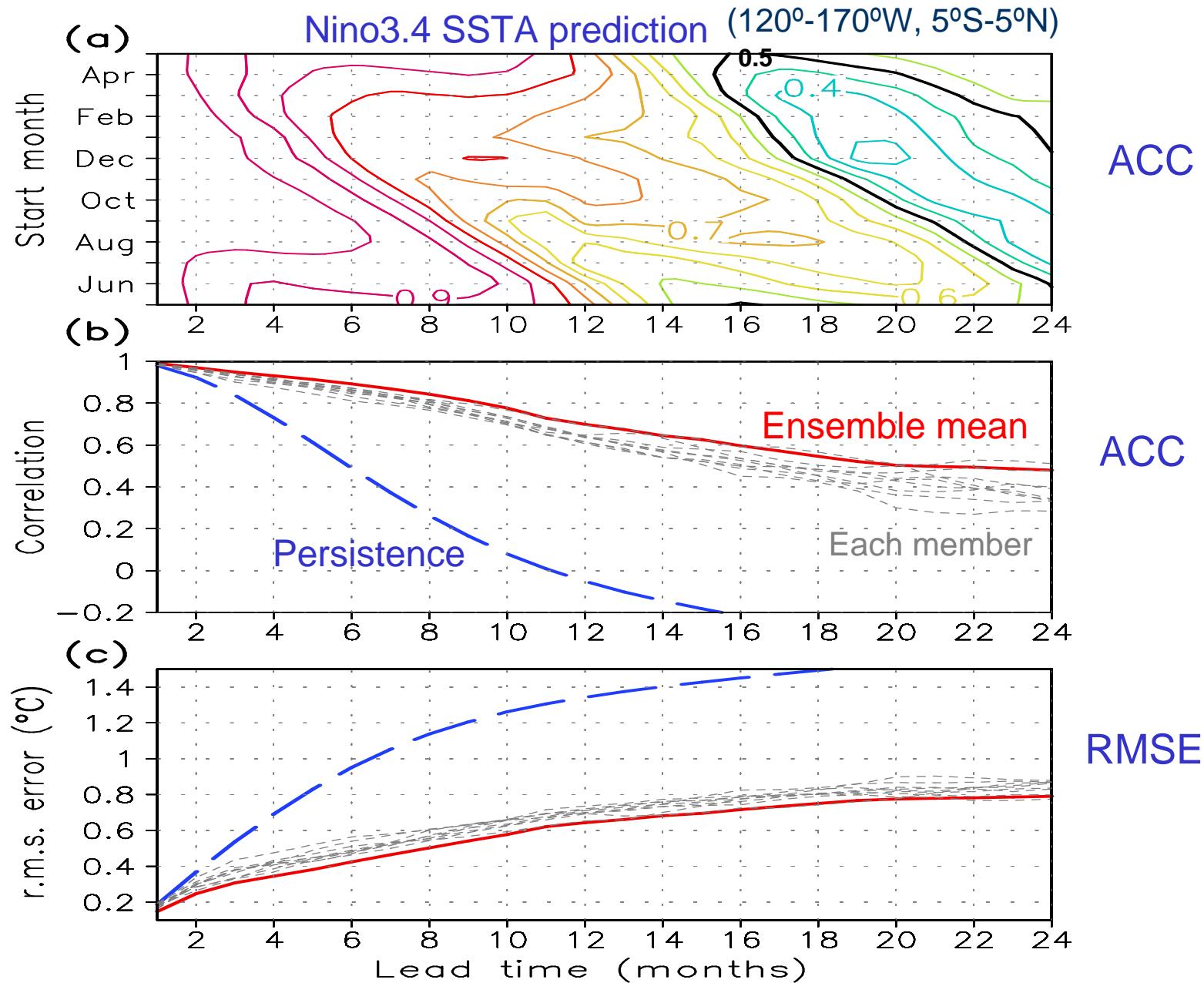


Impact of western Arabian Sea upwelling to the West Indian monsoon

Izumo et al. 2008, J. Climate

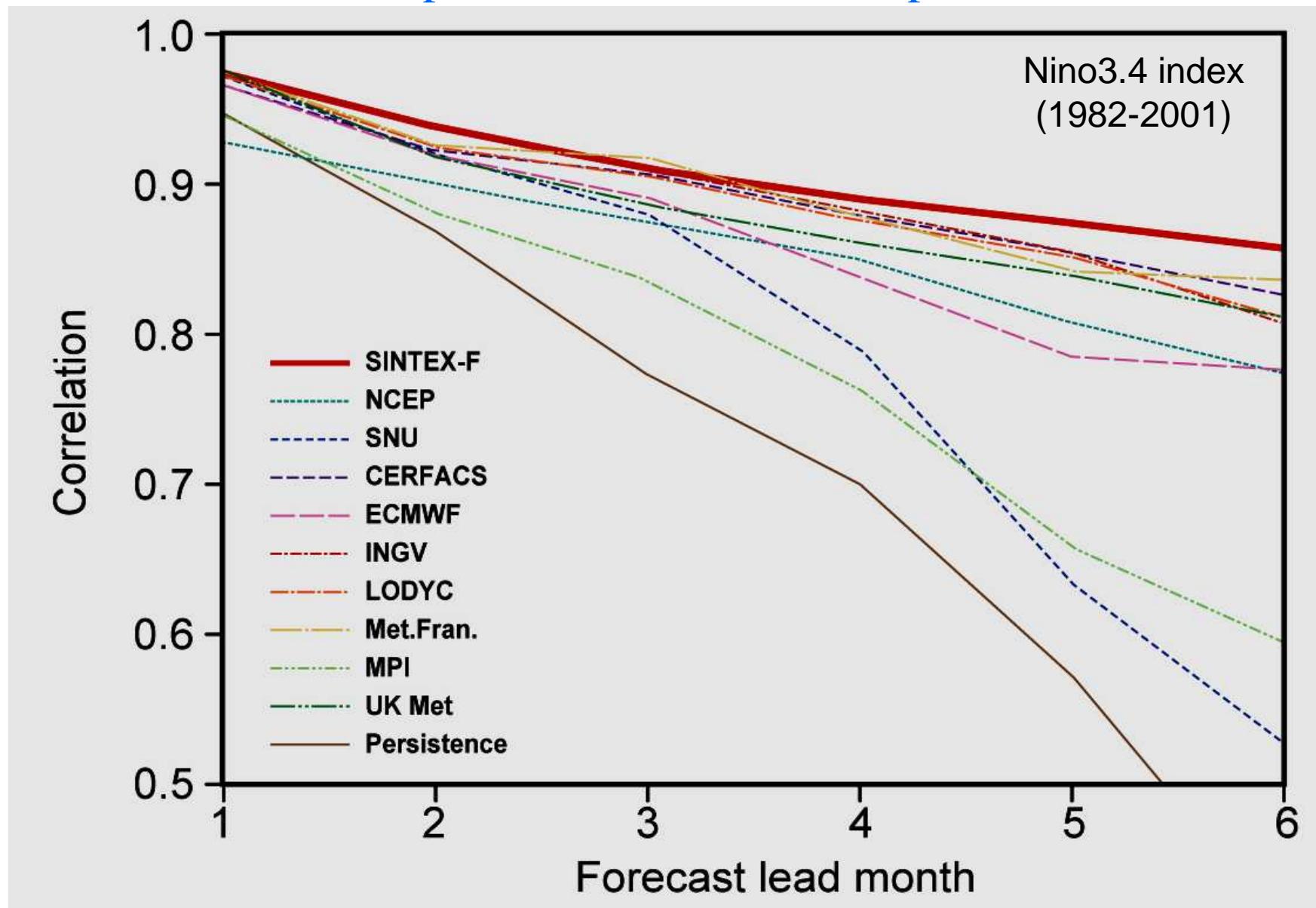


ENSO prediction up to 2-year ahead:



Luo et al., J. Climate, 2008, 84-93.

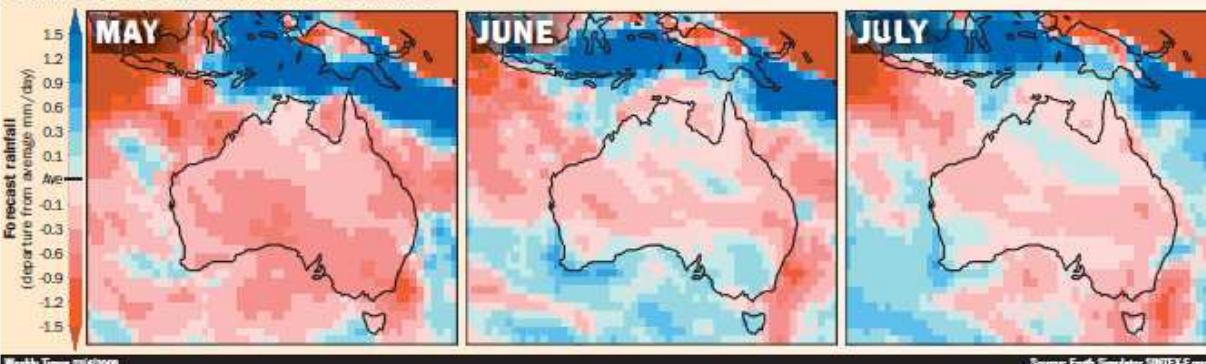
ENSO prediction skill of 10 coupled GCMs



Adapted from Jin et al. 2008, APCC CliPAS

DRY RUN AHEAD

Japanese predictions for the next three months



Forecasts from
1 April 2008

Rain hopes fading

Drought
tip from
box trees

By SIMONE DALTON

AS ANZAC Day draws near, and concerns about the autumn break intensify, weather watchers are looking to nature, patterns and history to work out what is in store.

Wind several weeks ago prompted hopeful memories of 1982 when a dust storm was followed weeks later by an early break which heralded a wet year.

Others are reporting rabbit breeding and mice on the run as a sign of approaching rain.

But retired farmer Mervyn Obst, from Jepant, hopes he is wrong with his tip of a dry season ahead in northwest Victoria.

Mr Obst has been watching the box tree for weather signs after being taught by his uncle nearly half a century ago.

He watches when and how prolifically the trees flower from late spring to late summer, with a prolific flowering meaning a better season.

"The earlier the flowering the earlier the break, the later the flowering the later the break," he said.

This year the trees produced no flowers at all, similar to the situation before the 1982 drought. He said others near Swan Hill and Birchip had also no flowers on box trees.

Mr Obst said he was optimistic about some good falls next year.



Praying for rain: agents sold 8200 weaner calves at Cooma and Bombala in southern NSW last week.

Cattle hold the line

By JENNY KELLY

FARMERS are talking about the lack of autumn rain at salesyards—but not acting on it just yet.

Store cattle prices held their value at major markets last week as northern orders and lingering hopes of a season-changing rain kept people bidding.

Agents sold 8200 Angus and Hereford weaner calves at Cooma and Bombala in southern NSW last week for an average of \$511 for steers and \$400 for heifers.

Victorian Hereford breeder John McKeown, who received a top of \$630 for 300 steers at Bombala, said the market was showing amazing resilience.

"When we booked them in several weeks ago we were just hoping for rain, but the fact it hasn't seemed to make much difference to the prices," he said.

In a trend that completely defied the odds, agents at Wodonga and Wangaratta last week quoted store cattle at dearer.

At Wodonga, Angus heifers with one-month-old calves sold to \$1240, while Hereford weaner steers sold to \$650 at 205kg per liveweight.

Brian Unthunk Rodwell auctioneer Michael Unthunk said it was a surprise result in a week when most market watchers had expected prices to crumble.

"Yet there was a good field of buyers with higher than expected results for all grades of cattle," he said.

Selling on the AuctionsPlus computer network was also buoyant last week, with lightweight steers on northern NSW properties selling at 205c-217c/kg.

AuctionsPlus market commentator Dean Lamminich said he just hoped the season and export markets played out well for buyers.

The confidence being shown at present is admirable and one hopes well-founded," he said.

- Northern buyers set a cracking pace, Pages 34-35

By PETER HUNT

FARMERS across southeast Australia may have to wait until spring for drought-breaking rain, according to Japanese long-range forecaster Toshio Yamagata.

"It is very unfortunate but our SINTEX-F model run by the Earth Simulator predicts rather dry conditions for at least the next three months," Prof Yamagata said.

"This is because the model, as an ensemble mean, predicts a weak positive IOD (Indian Ocean Dipole) again in this year."

A positive IOD is associated with a slump in the development of crucial northwest cloud bands that develop over the Indian Ocean and carry moisture across the continent to southeast Australia.

When the dipole is positive the sea surface temperatures around Indonesia and northern Western Australia are cooler than average.

The cooler conditions reduce sea-surface evaporation and consequently the amount of moisture in the atmosphere.

Reduced atmospheric moisture levels lead to a slump in the formation of crucial northwest cloud bands that sweep across the continent to deliver rain to southeast Australia.

In May last year, Prof Yamagata, who is a lead scientist with the Japan Agency for Marine-Earth Science and Technology,

23 Apr 2008, The Weekly Times

<http://www.jamstec.go.jp/frcgc/research/d1/iod/index.html>



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SINTEX-F1 CGCM forecast (27-member ensemble)



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Japanese[日本語]

Notes

May 15, 2009

ENSO forecast: The probability to have an El Niño late this year is increasing.

IOD forecast: Negative IOD would occur during boreal summer and fall.

Related with the negative IOD during summer-fall, Australia would have good rain.

Eastern China-western Japan and Europe might be cooler than normal. India would have poor summer monsoon (less rainfall).

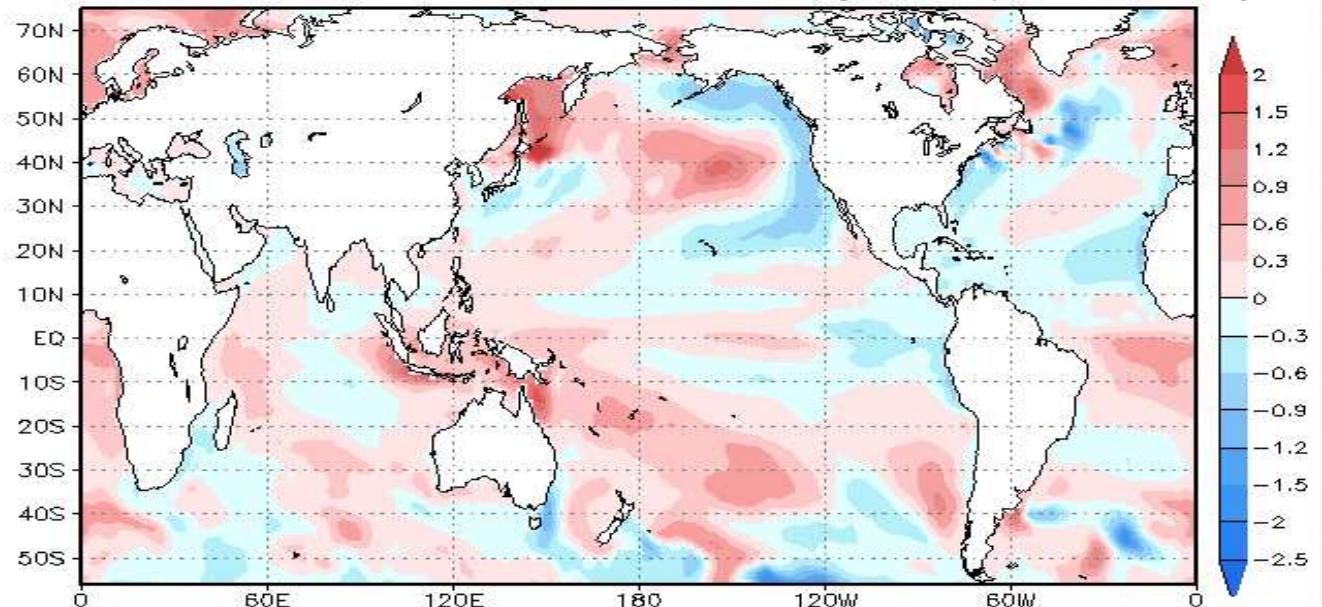
Note: Certain biases may arise from the renewing of Earth Simulator. In particular, El Niño signal appears to be underestimated according to our preliminary check.



Seasonal Forecast

Parameter: May 2009 : Start Date
 Summer : Target Season

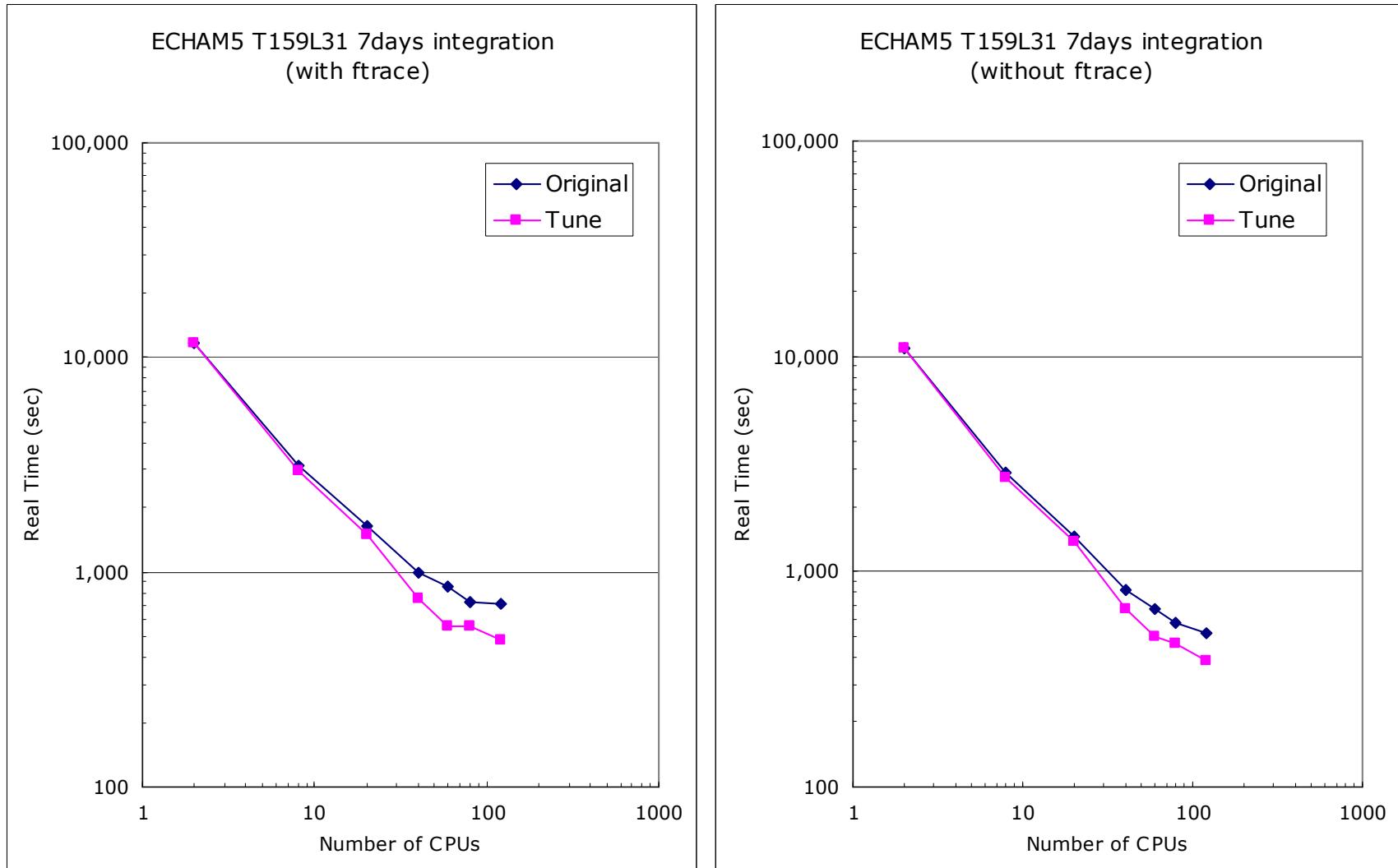
Predicted JJA2009 SST anom. from 1may2009 (27-member)



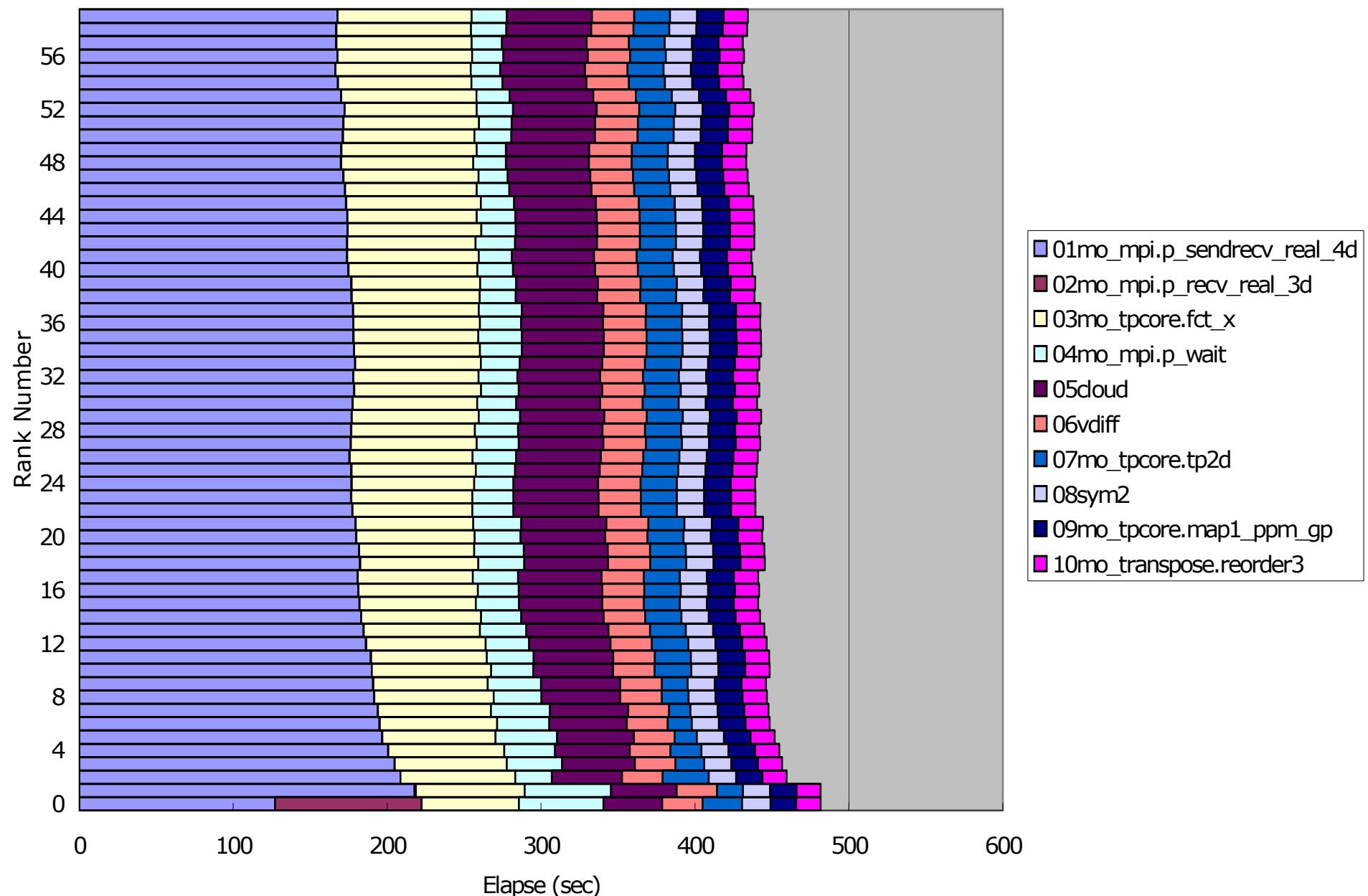
SINTEX-F2 at ES (2005-2009.3)

- • Tuning ECHAM5 (and developing OPA9 by LODYC group) at ES
- 1st version:
ECHAM5.3.0 T106L31; OPA8.5 0.5°x0.5°; OASIS3_2-3
- 2nd version:
ECHAM5.3.2; OPA9+LIM2; OASIS3_2-5_para
- 3rd version: Many tunings for the CGCM performance (still ongoing)

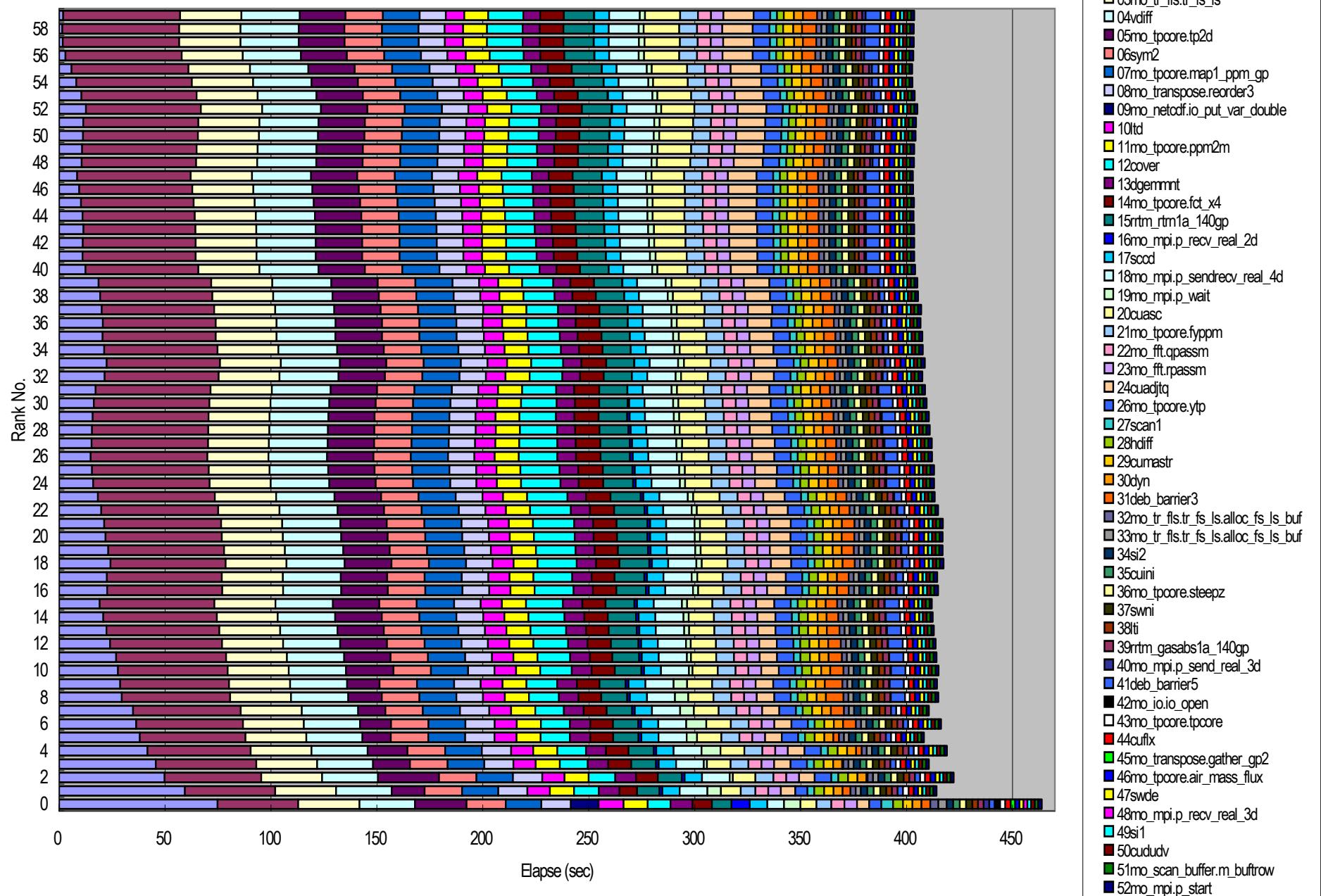
Scalability



Elapse for top 10 routine (ECHAM5 T159L31 60CPU NPROCA=60 NPROCB=1 Original Version)



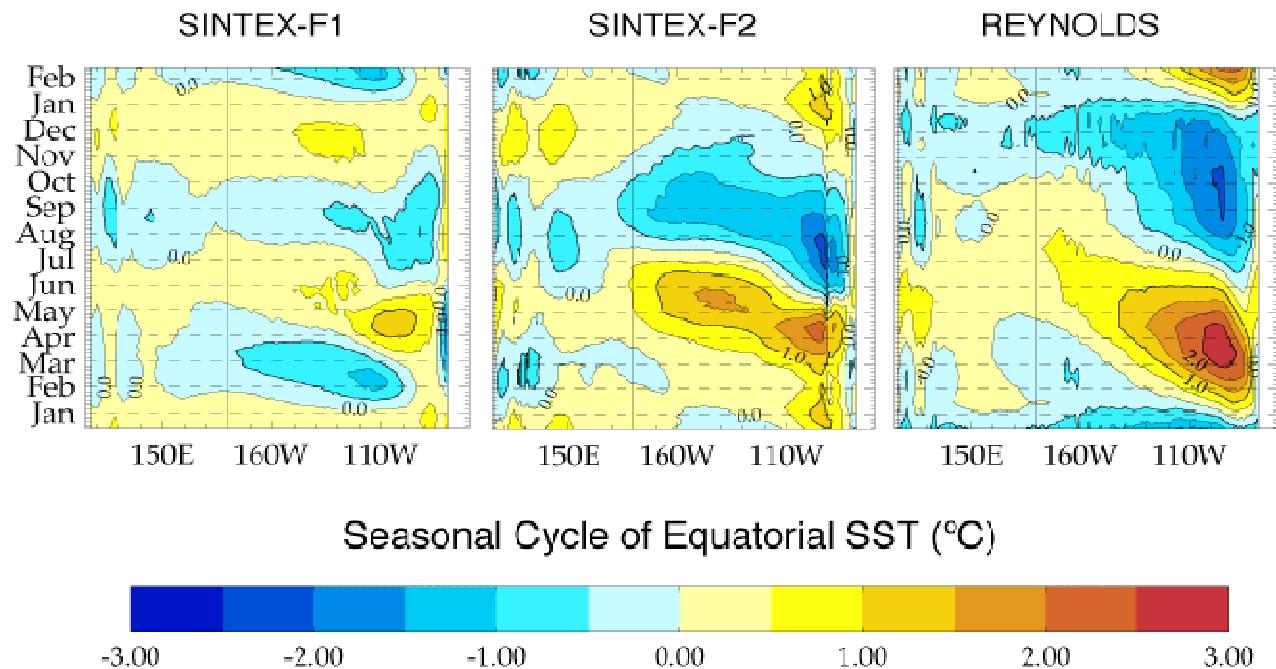
Elapse distribution by FTRACE (echam5 T159L31 60CPUs t34)



SINTEX-F2 (1st version)

ECHAM5 T106L31; OPA8.5 0.5°x0.5°; OASIS3_2-3 (80-yr run)

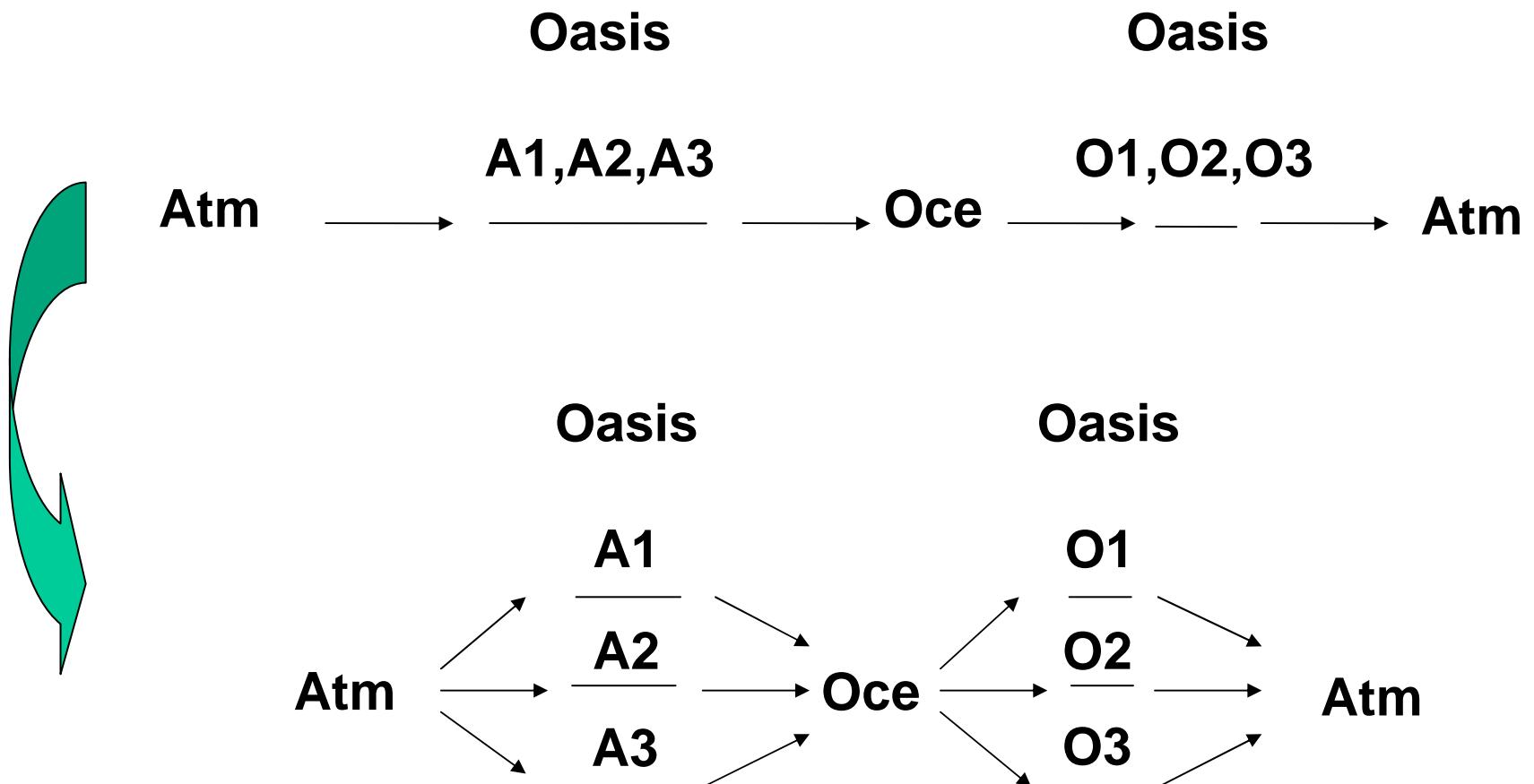
Improved
simulation of the
Pacific SST
seasonal cycle



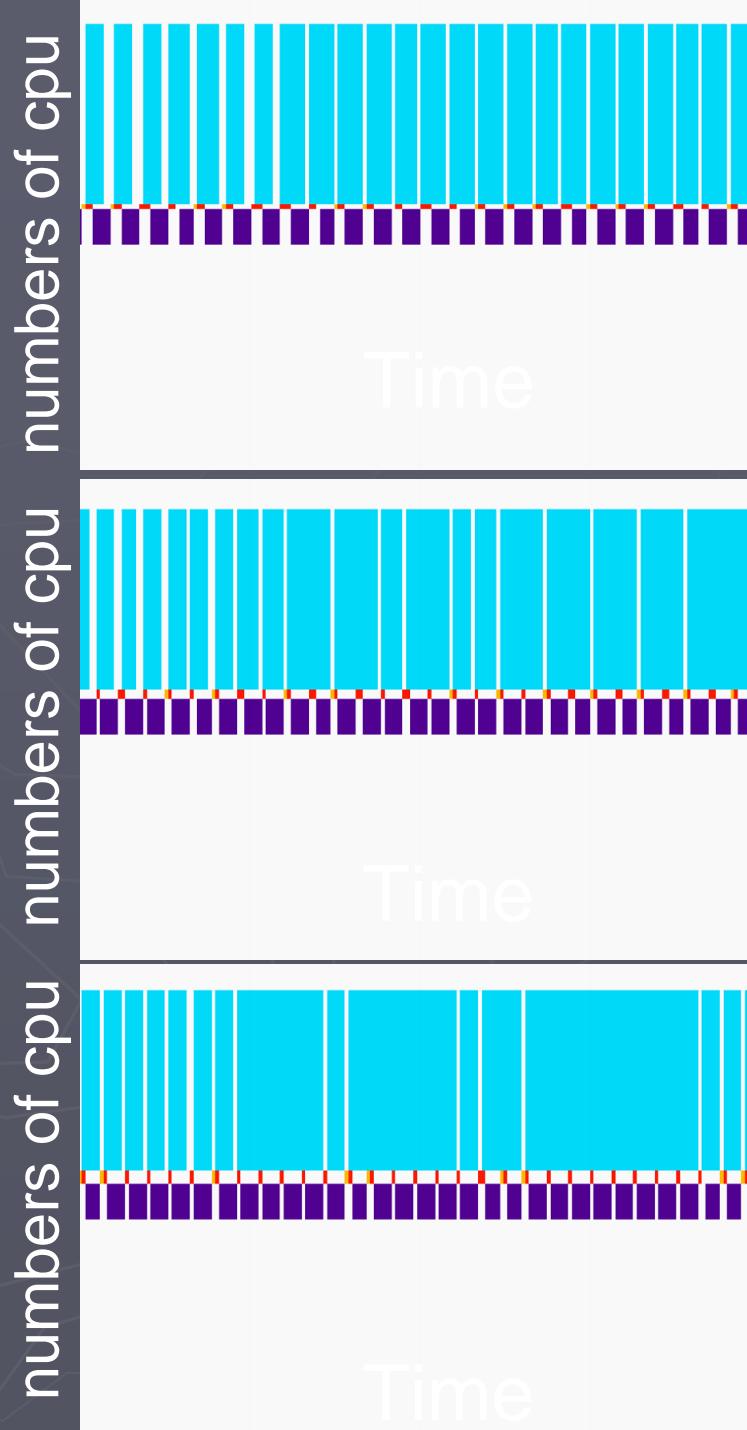
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- 3rd version: Many tunings for the CGCM performance (still on-going)

Pseudo-parallélisation



40 echam
1 oasis
8 opa



2916s

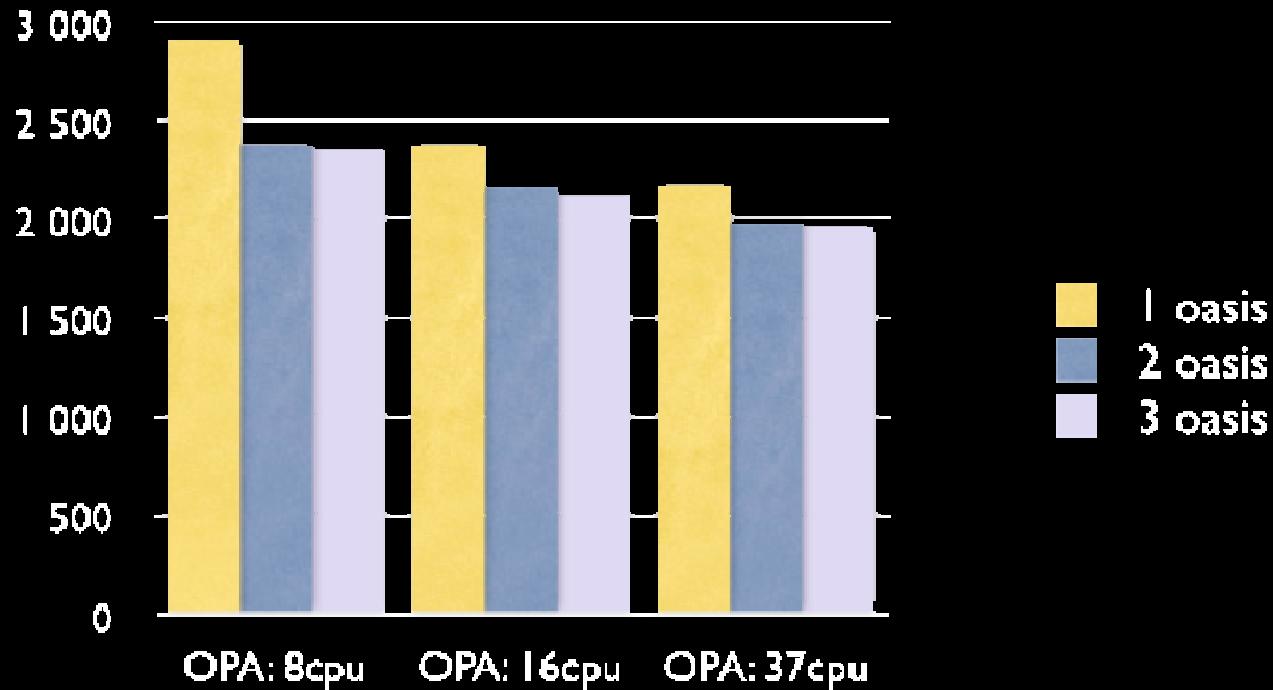
Reduce
Oasis
CPU time

2480s

Waiting
time of
ECHAM
and OPA
decreased

2360s

Results summary



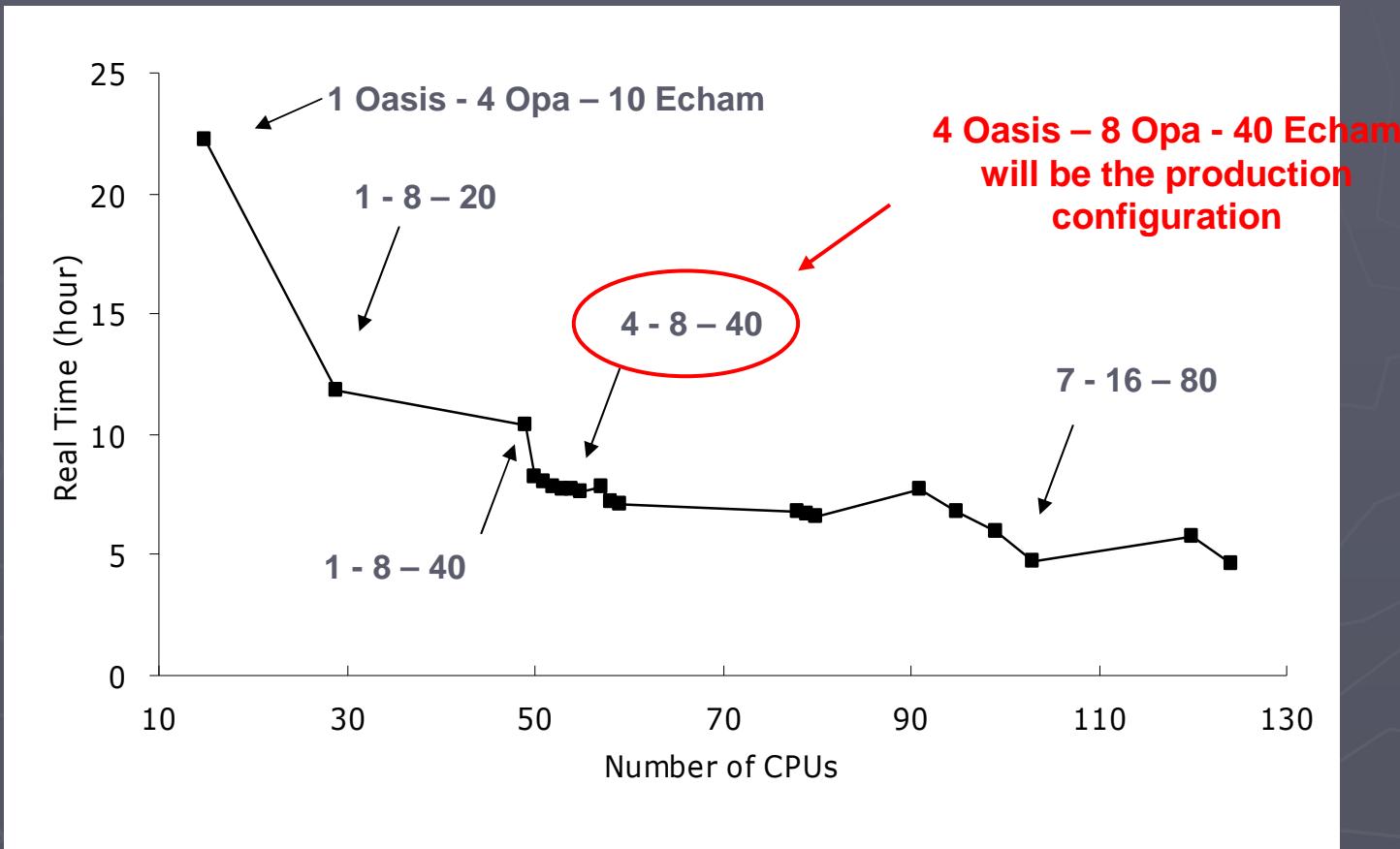
2 OASIS and 8 OPA (10 cpus)



1 OASIS and 16 OPA (17 cpus)



Results summary



1 year simulation

The SINTEX-F2 Coupled GCM (2nd version)

1. Coupling fields:

Tau, E-P, Qnsw, and Qsw over water, Tau, E-P, snow fall, Qsw, Qnsw over ice, 10m wind speed, non-solar heat flux derivative



SST, Uo, sea ice cover, (ice temp., thickness, and albedo)*ice fraction

We are using 6 CPUs for OASIS3

2. Coupling Frequency: Every 2 hours

3. Initial condition:

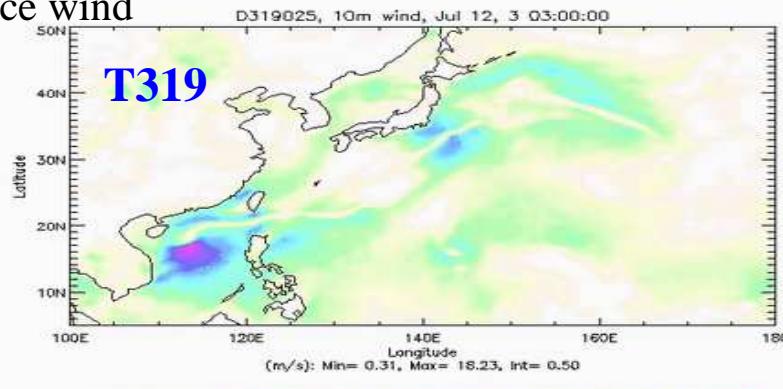
ECHAM5: One year forced run by climatological SST

OPA9: Levitus annual climatology

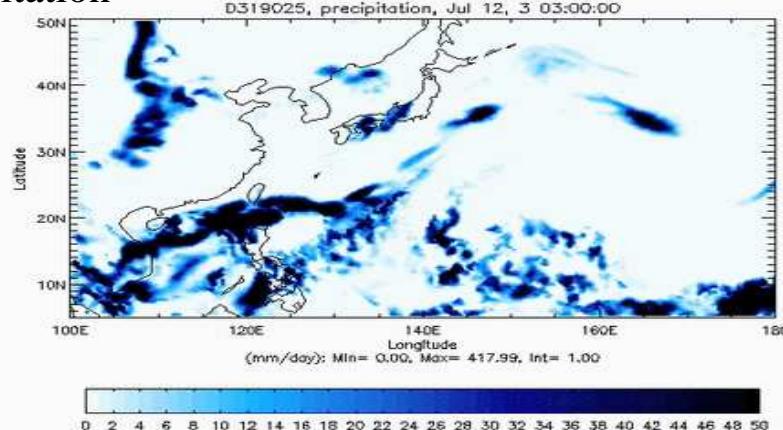
SINTEX-F2 (2nd version)

ECHAM5 T319; OPA9+LIM2 0.25°x0.25°; OASIS3_2-5_para (7-yr run)

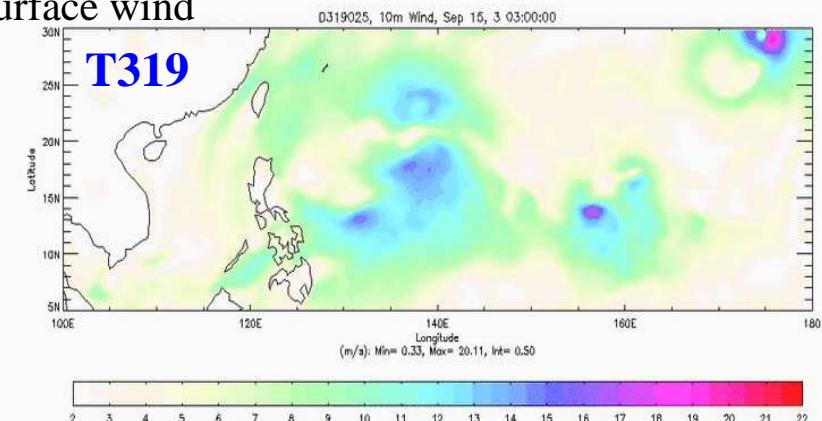
Surface wind



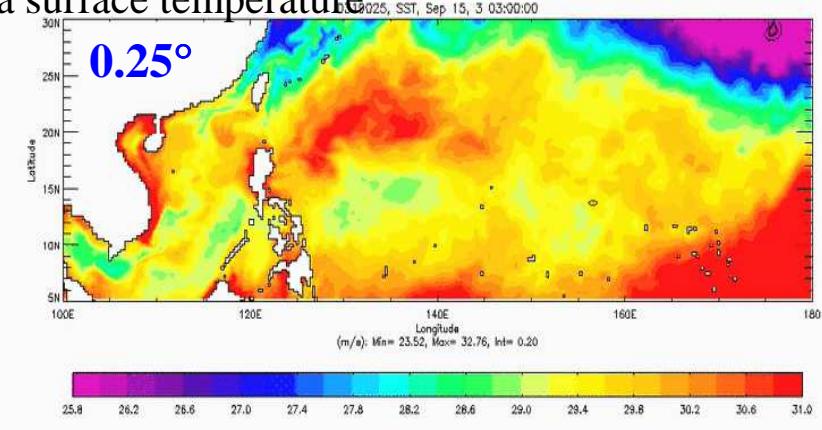
Precipitation



Surface wind



Sea surface temperature



Differences between ES2 and ES

● ハードウェア(諸元表)

		地球シミュレータ (ES)	地球シミュレータ (ES2)	Ratio: ES2/ES
CPU	Clock	1GHz	3.2GHz	3.2x
	Vect. perf.	8GF	102.4GF	12.8x
Node	CPU num.	8	8	1x
	Vect. perf.	64GF	819.2GF	12.8x
	Memory	16GB	128GB	8x
	Comm. speed betw. nodes	12.3GB/s x2	8GB/s x8 x2	5.2x
System	Total nodes	640	160	1/4x
	FLOPS	40TF	131TF	3.2x
	Memory	10TB	20TB	2x
	Network Topology	Single-Stage Crossbar Network	Fat-tree Network	—

SINTEX-F1,2 at ES2 (2009.4-)

Performance in ES2 (compared to ES)

- SINTEX-F1:

1-node: ~1.5 times slower

3-node: ~3 times slower

Main problem: large idl time; slow communication; short vector length

- SINTEX-F2:

4-node: ~3.5 times slower

Main problem: Slow MPI communication (within individual model and between models); NEMO has large netcdf I/O time; short vector length.

SINTEX-F1: 1-node (A8:O1:C1)

- Real Time (sec) : 2774.242390
- User Time (sec) : 1095.205480
- Sys Time (sec) : 15.014430

ECHAM4 (8 CPUS): CPU time

	Frequency						Vect. Len.			Bank conflict network	
• lwtt	56678400	1220.311(17.5)	0.022	12894.2	5439.7	99.11	184.9	1102.586	0.229	0.277	0.026 553.802
• mo_mpi.p_sendrecv_real_4d	403200	687.967(9.8)	1.706	325.8	0.0	95.10	53.6	614.906	4.100	4.481	1.323 525.744

ECHAM4 (8 CPUS): Elapse time

	Elapsed time	Comm. Time									
• mo_mpi.p_stop	653.656	653.656	0.178	0.0	0	0.0					
• mo_mpi.p_bcast_int_i8	630.779	630.764	12.634	8.0	49760	388.8K					
• mo_mpi.p_sendrecv_real_4d	233.601	233.287	231.711	543.4K	806400	417.9G					
• mo_ncdf.io_put_var_double	205.631	0.000	0.000	0.0	0	0.0					
• lwtt	164.481	0.000	0.000	0.0	0	0.0					

Oasis2.4.1 (1 CPU): CPU time (231.350 sec.)

• mozaic	3240	101.002(43.7)	31.173	1669.6	403.9	96.76	97.2	95.352	0.002	0.004	0.169 74.251
• extrap	1440	56.646(24.5)	39.337	729.0	77.9	50.11	30.1	18.997	0.007	21.468	0.037 15.052
• clim_import	4667	17.569(7.6)	3.764	270.6	0.0	93.51	46.7	15.283	0.306	0.265	0.030 13.089

Oasis2.4.1 (1 CPU): Elapse time

• clim_import	1177.983	1145.089	0.972	1144.745	0.972	313.2K	4667	1.4G			
• clim_quit	1027.089	1027.079	1.000	0.038	0.000	0.0	0	0.0			
• mozaic	110.482	0.000	0.000	0.000	0.000	0.0	0	0.0			
• clim_start_mpi	93.211	93.197	1.000	93.197	1.000	17.0K	4	68.0K			
• clim_export	72.969	44.944	0.616	44.092	0.604	298.7K	4680	1.3G			

OPA8.2 (1 CPU): CPU time (162.483 sec.)

• clim_import	2520	25.866(15.9)	10.264	243.1	0.0	93.81	42.1	23.142	0.157	0.151	0.045 19.862
• diabld	720	19.461(12.0)	27.029	1135.3	219.6	92.26	255.8	0.299	0.003	2.840	0.036 0.076

OPA8.2 (1 CPU): Elapse time

• clim_import	956.994	939.403	0.982	939.308	0.982	211.9K	2520	521.4M			
• restcom.restdefv	776.015	0.000	0.000	0.000	0.000	0.0	0	0.0			
• histcom.histwrite_real	208.089	0.000	0.000	0.000	0.000	0.0	0	0.0			

SINTEX-F1: 3-node (A20:O1:C1)

- Real Time (sec) : 1938.914877
- User Time (sec) : 468.200321
- Sys Time (sec) : 276.778289

ECHAM4 (20 CPUS): CPU time

	Frequency			Vect. Len.			Bank conflict network		
• lwt	56678400	1216.601	(15.4)	0.021	12933.5	5456.3	99.11	184.9	1099.216
• mo_mpi.p_sendrecv_real_4d	2736000	892.849	(11.3)	0.326	799.8	0.0	97.23	98.9	752.402

ECHAM4 (20 CPUS): Elapse time

	Elapsed time	Comm. Time							
• mo_mpi.p_bcast_int_i8	721.610	721.592	717.365	8.0	124400	971.9K			
• mo_mpi.p_stop	616.027	616.027	615.901	0.0	0	0.0			
• mo_ncdf.io_put_var_double	203.230	0.000	0.000	0.0	0	0.0			
• clim_import	162.474	152.267	152.217	400.0K	2160	843.8M			
• mo_ncdf.io_enddef	157.957	0.000	0.000	0.0	0	0.0			

Oasis2.4.1 (1 CPU): CPU time (218.457sec.)

• mozaic	3240	101.102	(46.3)	31.204	1667.9	403.5	96.76	97.2	95.460	0.001	0.002	0.169	74.356
• extrap	1440	56.848	(26.0)	39.478	726.4	77.6	50.11	30.1	19.097	0.006	21.562	0.037	15.150
• rmaxim	28080	16.963	(7.8)	0.604	742.7	64.6	20.58	255.9	0.046	0.006	7.544	0.000	0.006

Oasis2.4.1 (1 CPU): Elapse time

• clim_quit	983.840	983.830	1.000	0.064	0.000	0.0	0	0.0					
• clim_import	491.892	465.864	0.947	465.733	0.947	313.2K	4667	1.4G					
• mozaic	101.132	0.000	0.000	0.000	0.000	0.0	0	0.0					
• clim_start_mpi	87.786	87.771	1.000	87.771	1.000	17.0K	4	68.0K					
• extrap	56.886	0.000	0.000	0.000	0.000	0.0	0	0.0					

OPA8.2 (1 CPU): CPU time (147.139sec.)

• diabld	720	19.419	(13.2)	26.970	1137.8	220.1	92.26	255.8	0.303	0.004	2.872	0.024	0.081
• isrchfge	12060720	12.868	(8.7)	0.001	383.3	24.0	82.51	68.5	4.509	0.001	0.096	0.000	3.683

OPA8.2 (1 CPU): Elapse time

• restcom.restdefv	768.606	0.000	0.000	0.000	0.000	0.0	0	0.0					
• clim_import	261.297	248.282	0.950	248.197	0.950	211.9K	2520	521.4M					
• histcom.histwrite_real	191.712	0.000	0.000	0.000	0.000	0.0	0	0.0					

SINTEX-F1,2 at ES2 (2009.4-)

Performance in ES2 (compared to ES)

- SINTEX-F1:
 - 1-node: ~1.5 times slower
 - 3-node: ~3 times slower

Main problem: large idl time; slow communication; short vector length
- SINTEX-F2:
 - 4-node: ~3.5 times slower

Main problem: Slow MPI communication (within individual model and between models); NEMO has large netcdf I/O time; short vector length.

SINTEX-F2: 4-node (A16:O8:C6)

- Real Time (sec) : 1402.496494
 - User Time (sec) : 1387.978568
 - Sys Time (sec) : 5.874619

ECHAM5(rank 0); CPU time(1286.988)

ECHAM5(rank 0): CPU time(1286.988)		Frequency			Vect. Len.			Bank conflict network						
•	mo_mpi.p_stop	1	901.526	(70.0)	901525.521	305.1	0.0	53.87	96.2	195.689	0.008	0.010	0.877	167.382
•	mo_couple.couple_init	1	164.169	(12.8)	164168.679	974.3	0.0	98.62	120.0	149.560	0.004	0.006	0.822	123.405
•	mo_mpi.p_wait	13201	33.673	(2.6)	2.551	949.9	0.0	97.48	123.0	29.365	0.142	0.390	0.156	24.418
•	cloud	8400	18.322	(1.4)	2.181	17171.4	6562.7	99.55	177.6	16.741	0.116	0.264	0.217	8.886

ECHAM5 (rank 0): Elapse time

<u>ECHAM5 (rank 0): Elapse time</u>	Elapsed time	Comm. Time							
• mo_mpi.p_stop	903.092	903.086	1.000	213.246	0.236	0.0	0	0	0.0
• mo_couple.couple_init	164.602	164.361	0.999	164.348	0.998	55.6K	28	1.5M	
• mo_grib.out_stream.write_grib	56.61	0.000	0.000	0.000	0.000	0.0	0	0.0	
• mo_mpi.p_wait	33.730	33.611	0.996	31.657	0.939	174.1K	60000	10.0G	
• mo_couple.couple_get_o2a	30.303	11.220	0.370	11.210	0.370	400.0K	360	140.6M	

Oasis3 (rank 0): CPU time (1387.873sec.)

<u>Oasis3 (rank 0): CPU time (1387.873sec.)</u>													
•	waitpc	1	910.864(65.6)	910863.845	956.3	0.0	98.48	119.9	823.759	0.010	0.015	4.467	681.510
•	getfld	120	252.274(18.2)	2102.285	923.1	0.0	98.61	120.0	230.806	0.055	0.066	1.196	192.752
•	inimcm	1	167.418(12.1)	167417.991	971.1	0.0	98.60	119.7	152.409	0.036	0.054	0.835	125.730
•	mozaic	240	51.061(3.7)	212.756	1627.1	390.5	95.99	95.6	48.239	0.001	0.001	0.085	37.609

Oasis3 (raqnk 0): Elapse time

<u>Oasis3 (raqnk 0): Elapse time</u>									
• waitpc	912.820	912.816	1.000	905.250	0.992	0.0	0	0.0	
• getfld	258.515	252.473	0.977	252.378	0.976	371.1K	649	235.2M	
• inimc	169.150	168.643	0.997	167.570	0.991	4.9K	163	791.3K	
• mozaic	51.135	0.000	0.000	0.000	0.000	0.0	0	0.0	

NEMO (rank 0): CPU time (942.714sec)

NEMO (rank 0): CPU time (942.714sec)													
• lib_mpp.mppsync	1	478.335(50.7)	478335.435	517.9	0.0	57.62	120.0	117.949	0.005	0.008	0.778	100.825	
• lib_mpp.mpprecv	90182	219.795(23.3)	2.437	959.7	0.0	98.58	120.2	199.968	0.193	0.185	1.087	165.548	
• Cpl_oasis3_cpl_prism_recv	3240	191.558(20.3)	59.123	947.2	0.0	98.62	120.3	174.833	0.086	0.099	0.928	145.307	

NEMO (rank 0): Elapse time

<u>NEMO (rank 0): Elapse time</u>	• lib_mpp.mppsync	478.532	478.532	1.000	213.060	0.445	0.0	0	0.0
	• nf90_tools.nf90_write_data	366.823	0.000	0.000	0.000	0.000	0.0	0	0.0
	• lib_mpp.mpprecy	219.866	219.659	0.999	219.017	0.996	25.5K	90182	2.2G

Problems and Things to do

SINTEX-F1 at ES2 (30-day integration):

	AGCM	CGCM	idle time?	CPUs (A:O:C)
1-node:	20	47	27	8:1:1
3-node:	13	32	21	20:1:1

SINTEX-F2 (5-day integration):

4-node:	8	23(=OASIS3)	<1	16:8:6
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- OASIS2&3 (and AOGMs) need to be speeded up (in particular, MPI communication)
- solve NEMO netcdf I/O problem

Please give us your advice and helps!

THANK YOU!