Coupled Climate Modeling with a Fine Resolution CCSM

(an oceanography perspective)

Why, What, When, Where, How, Who?

Why?

- The real ocean is full of eddies. We strive to make our models represent the real world.
- More accurate science:
  - A coarse resolution ocean model with an accurate parameterization of transient eddy processes will never produce the correct climate for the correct reasons because the fine scales of the time-mean flow will still be inaccurate.
- More precise science:
  - Many applications in climate change require information scales finer than we currently resolve (e.g. coastal upwelling systems)
- New science:
  - Recent studies suggest the emergence of completely new modes of coupled low-frequency variability when both the ocean and atmosphere are capable of generating turbulence through flow instabilities. (Kravstov, Berloff, …)

What?

- We want to put together a fully-coupled version of CCSM with an eddy resolving ocean component
- Experience in ocean-alone basin- to global-scale models indicates that a horizontal resolution of at least 0.1º and 40-50 levels is necessary (≥ 1000x cost of current CCSM for ocean component)

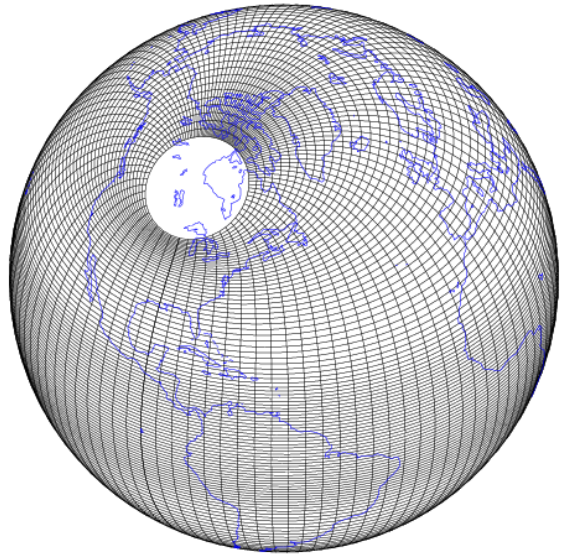
When? Where?

- Fully coupled integrations of CCSM3 with eddy-resolving ocean component are underway **today** at *CRIEPI*.
- Resources have been secured through DOE to undertake several new efforts (*ORNL* End Station, LLNL Grand Challenge) 2007-?
- Proposal has been submitted requesting additional computing resources sufficient for several centuries of integration (*ANL* INCITE) 2008-2010.

CRIEPI High-Resolution Integration

- Begun under Kyosei project at Earth Simulator Center
- Continuing on internal resources at CRIEPI
- Currently have 7 year integration of T85 x0.1 fully coupled CCSM3 system completed, initialized with spun-up ocean state

Model description and Optimization



Base: CCSM3 (vector6 version)

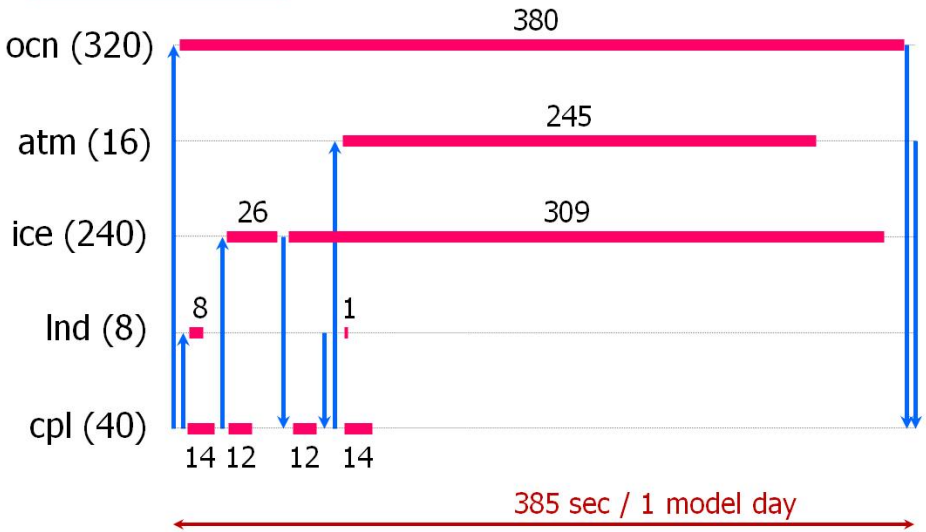
Ocean Model : **POP1**
0.1deg dipole grid (L40)

Sea Ice Model : **CSIM4**
0.1deg dipole grid, Runs on OCN grid

Atmospheric Model : **CAM3**
T85 (L26)

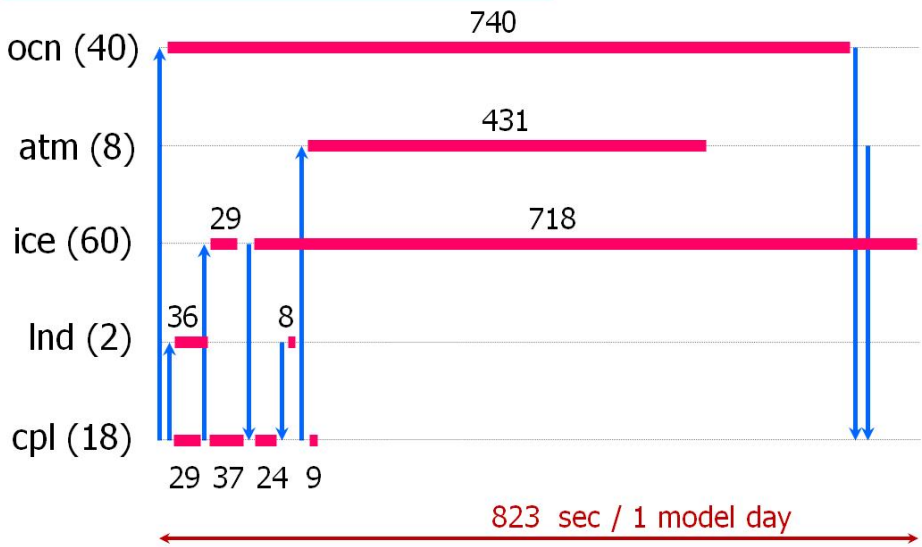
Land Surface model : **CLM2**
T85 (L26) ,Runs on ATM grid

Earth Simulator



POP:
440 fullsteps/day
CSIM:
thermodynamics timestep = 360 sec,
dynamics timestep = 120 sec.

CRIEPI SX-8 (max. limit 16 node)



POP:
220 fullsteps/day
CSIM:
thermodynamics timestep = 200 sec,
dynamics timestep = 100 sec.

Energy Budget of Atmosphere

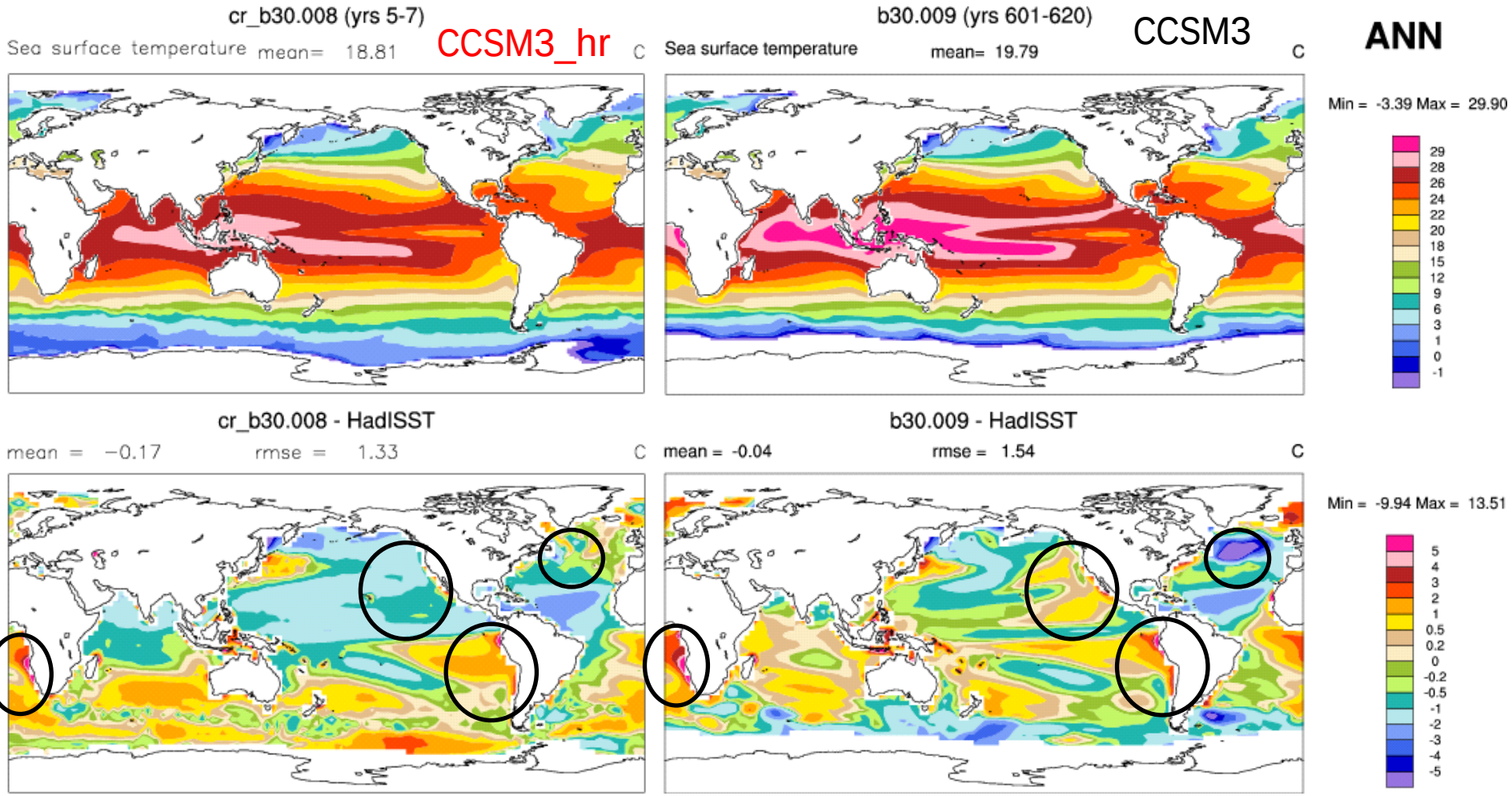
- Very similar with CCSM3 control (b30.009 601-620)

CCSM3_hr CCSM3

	cr_b30.008	b30.009 (yrs 601-620)	OBS data	
top of atmosphere fluxes (W/m2)				
outgoing longwave (all sky)	233.19	235.39	238.963	CERES
(clear sky)	264.1	265.689	266.878	CERES
absorbed solar (all sky)	234.7	237.219	244.691	CERES
(clear sky)	290.02	291.201	294.702	CERES
longwave cloud forcing	30.91	30.299	27.194	CERES
shortwave cloud forcing	-55.31	-53.981	-48.586	CERES
energy budget	1.51	1.829	5.728	
surface fluxes (W/m2)				
absorbed solar (all sky)	160.34	159.549	165.893	ISCPP
(clear sky)	220.6			ISCPP
net longwave (all sky)	59.4	58.473	49.425	ISCPP
(clear sky)	87.36			ISCPP
latent heat	81.79	82.69	84.948	ISCPP
sensible heat	17.11	18.525	15.795	ISCPP
energy budget	2.04	-0.139	15.725	
cloud fraction (%)				
total	54.68	55.797	66.715	ISCPP
low	38.99			
middle	17.52			
high	28.78			
precipitation (mm/d)				
total	2.82	2.83	2.608	GCGP
large-scale	1.06			
convective	1.77			
precipitable water (mm)	22.97	23.843	24.597	NVAP
Surface temperature (K)	287.99	287.958	287.683	NCEP

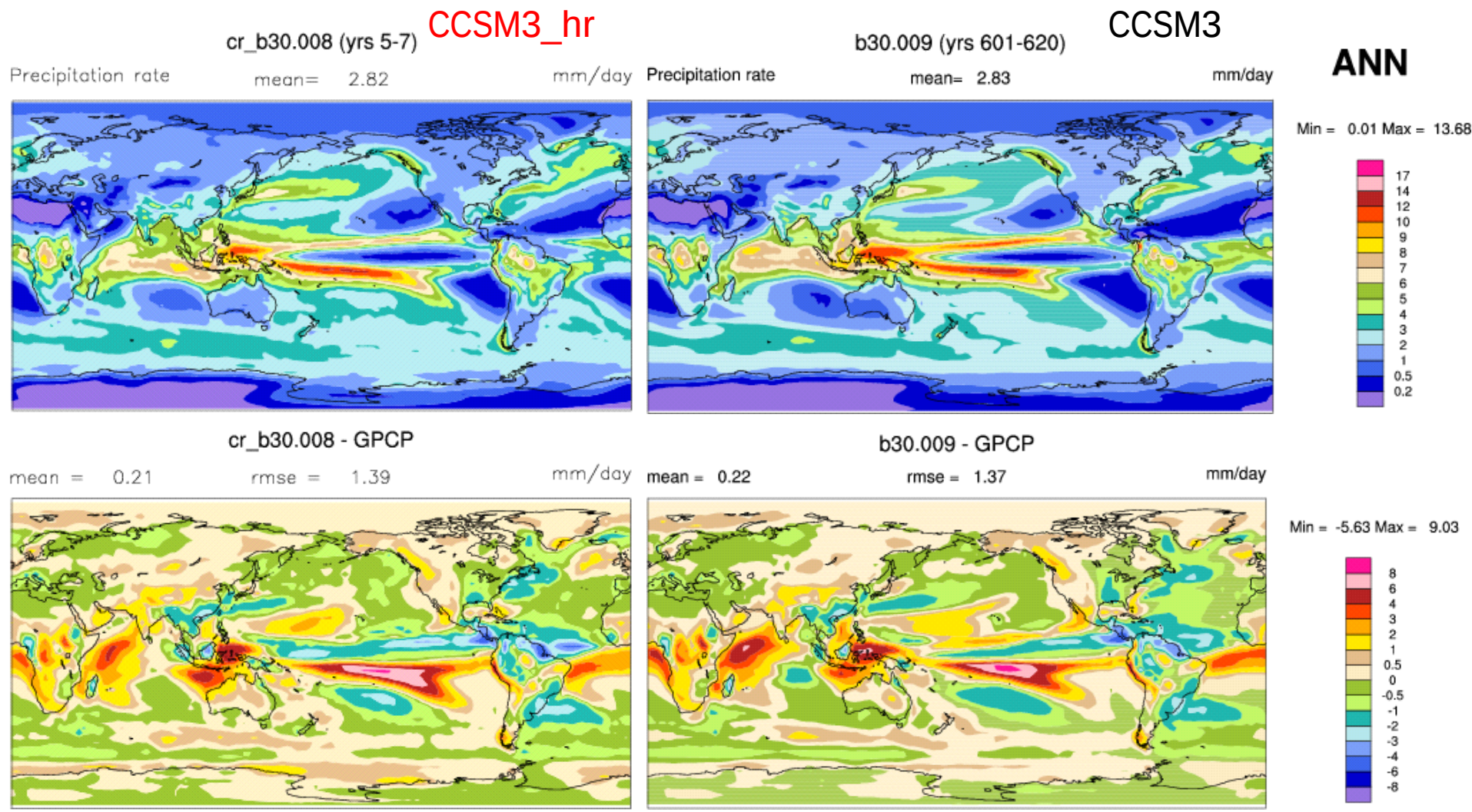
Sea Surface Temperature

- Bias at east boundary of basin is improved, but remain slightly



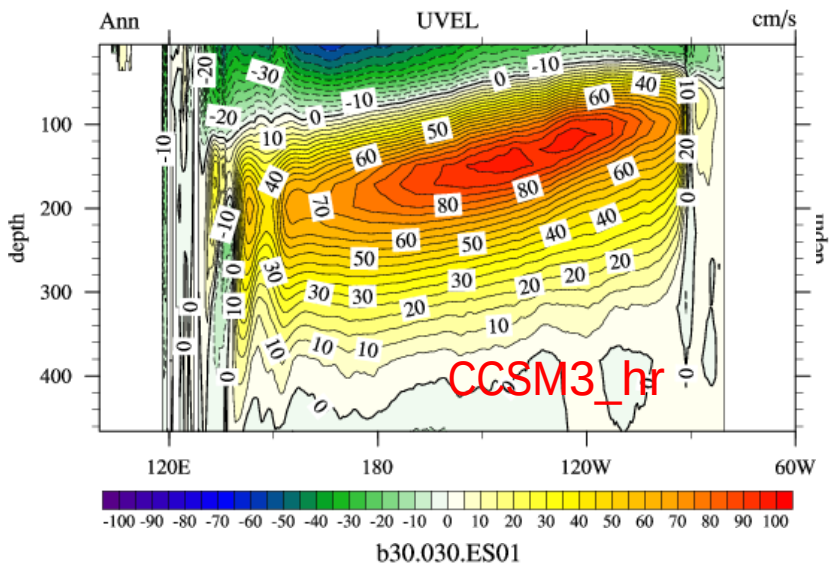
Precipitation Rate

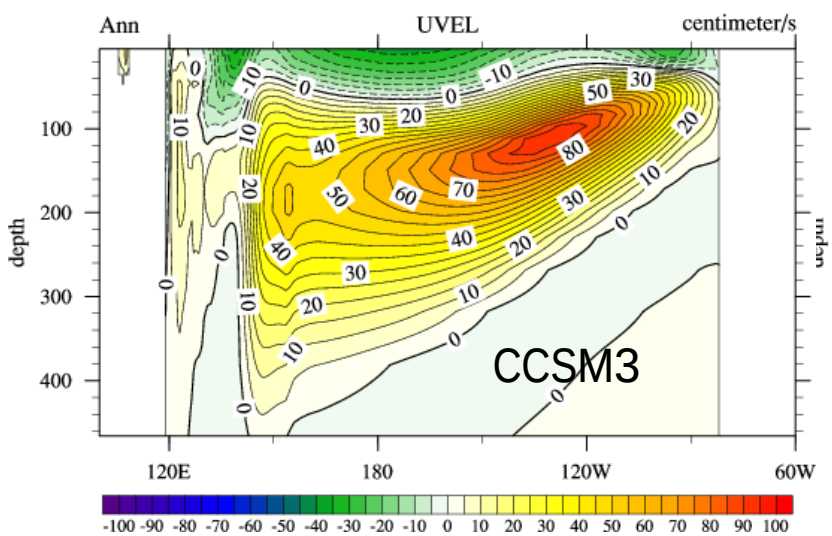
- Very similar. ITCZ is not improved



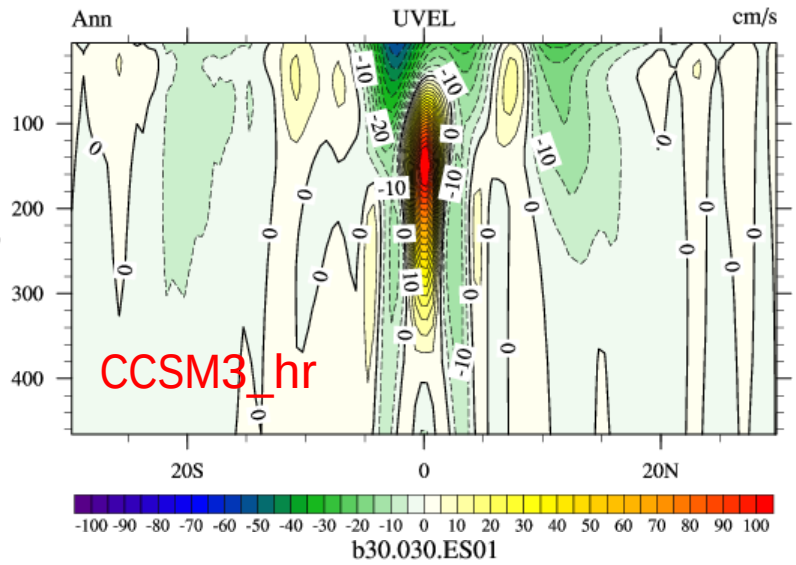
Equatorial Under Current

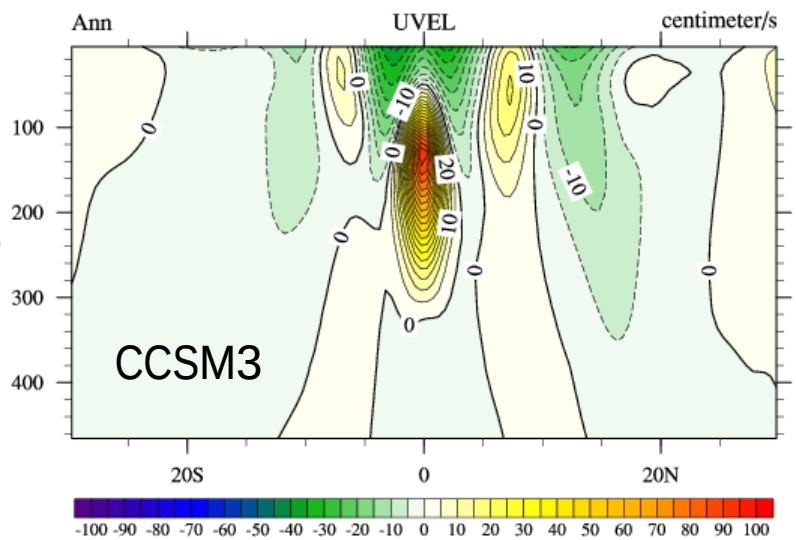
Zonal section





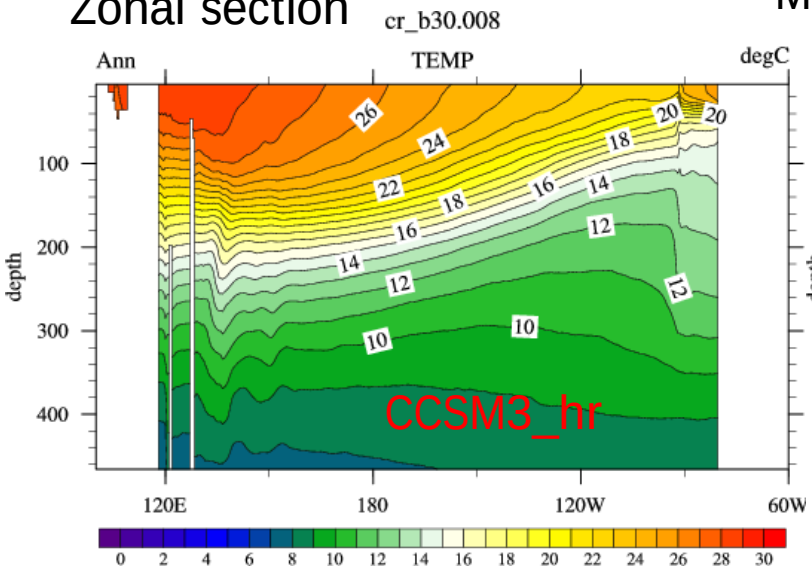
Meridional section at 155W



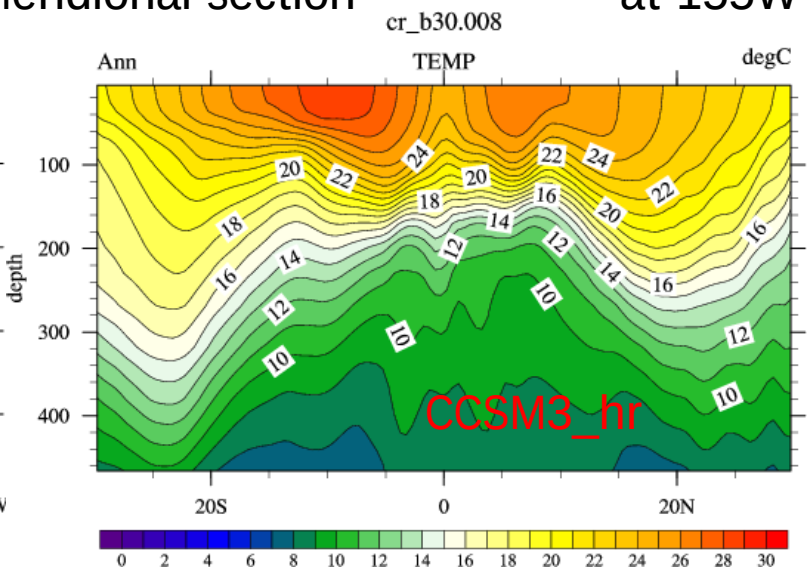


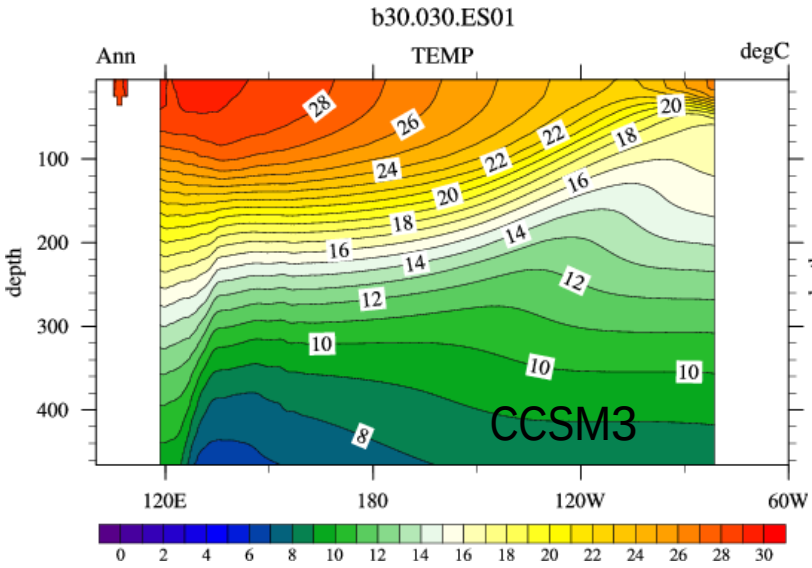
Temperature at Equatorial area

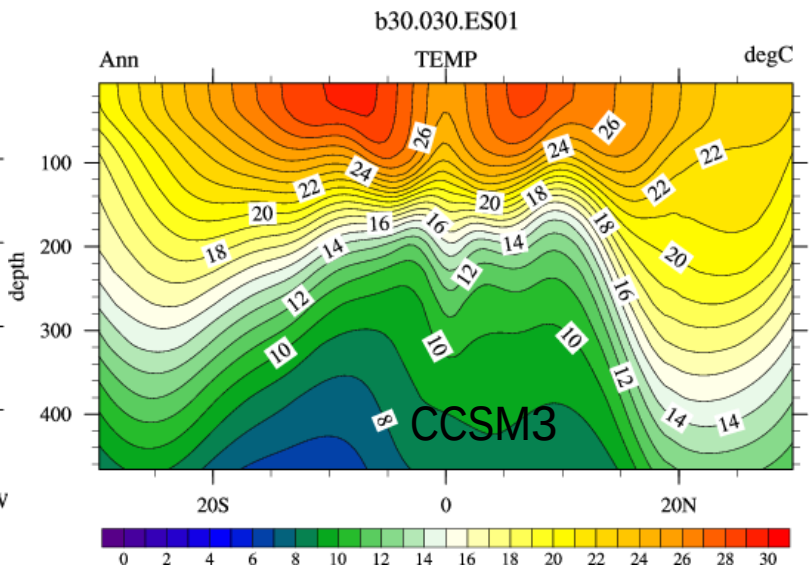
Zonal section



Meridional section at 155W







How, Who?

- Computing resources are precious, but we have been relatively successful in getting them.
- Human resources are sub-critical in each of the individual efforts. It is hard to envision a significant expansion of resources in this area in the near term.
- We must better coordinate our efforts to eliminate duplication of effort, coordinate development, and leverage resources

Vision for this Session

- Topics for discussion:
  - What are our common scientific goals?
  - How can these efforts contribute to CCSM overall?
  - What SE requirements do we have in common across these projects and with the rest of CCSM?
  - What resources (human or computational) can we share?
  - What resources (human or computational) should we pursue together?