Climate Modeling Applications on PARAM Padma
HPC User Group Meet - 2009

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Outline

- Introduction to climate modeling applications
- Coupled climate system model on PARAM Padma
- Seasonal forecasting applications
- ECPC Seasonal Forcesat Model
- UK Metoffice PUM vn6.0
- NCEP's Climate Forecast System

Introduction

Weather denotes daily fluctuations in the state of atmosphere and ocean, whereas climate denotes the state of the mean conditions of the system in a month, season or decade in advance.

Introduction

Though the underlying mathematical model of the system is same for Weather and Climate, the numerical approximations involved are quite different.

These approximations depend on the spatial and time scale of the phenomenon studied.

Introduction

Seasonal forecasting applications attempt to predict the mean atmospheric state in advance of a season.

The ocean and land state form the boundary conditions for the atmospheric model.

The effect of prescribing the boundary conditions are quite important to get a correct seasonal prediction.

Seasonal forecast models

Two classes of applications are used:

- Atmosphere only models with prescribed ocean boundary conditions
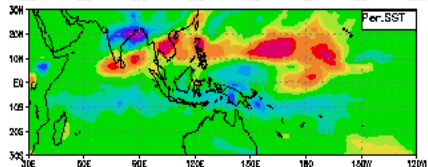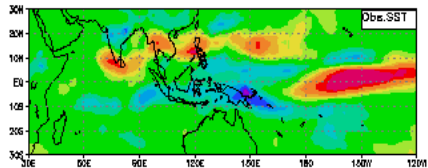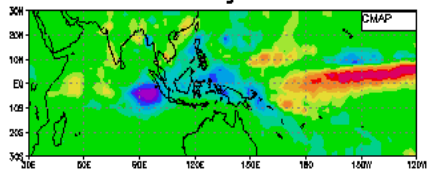- Coupled ocean-atmosphere models

Atmospheric GCMs

- Initial conditions start from the given atmospheric state (Ocean boundaries are prescribed).
- Climatological SSTs - based on the history of climatic conditions.
- Persisted SST - assuming that the ocean condition do not change drastically from the start of the forecast.
- Only the mean conditions of the state is prescribed (not dynamic).

SFM

- Atmosphere general circulation model for Seasonal Forecasting.
- Developed at Environmental and Climate prediction Center, UCSD.
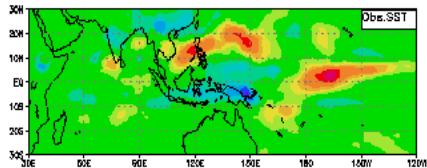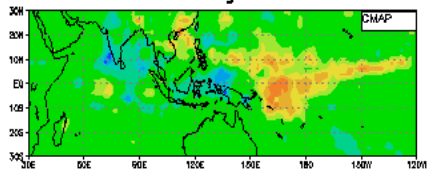- Now used for seasonal forecasting of Indian Monsoon by IMD.

SFM

- Global spectral model.
- T62 resolution in the horizontal domain.
- 28 levels in the vertical domain.
- 30 min time-step.

SFM Anomaly for 1997

SFM Anomaly for 2002
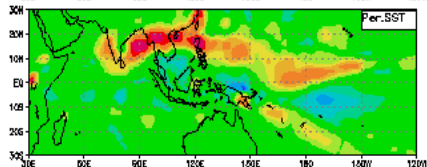
Computational Performance of SFM

No. of PEs	Wall clock time for execution (1 day run)
1 X 2	2 min 15 sec
1 X 4	1 min 8 sec
1 X 8	38 sec
2 X 8	25 sec

PUM

- Global atmosphere model of UK Meteorological office.
- Finite-differencing based grid-point model.
- Unified modeling framework for weather and climate prediction purposes.
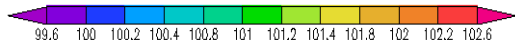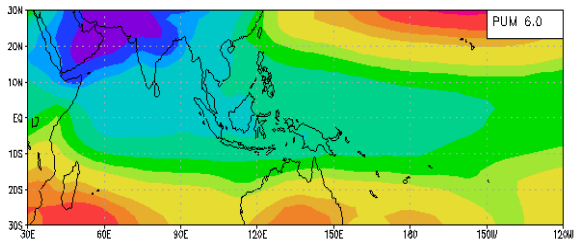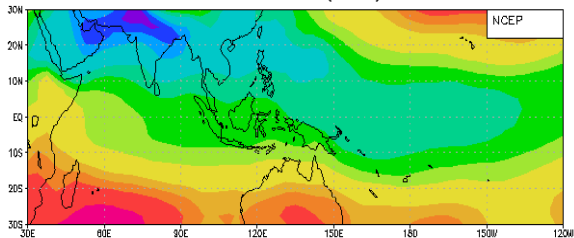- Soon to be used by NCMRWF for operational purposes.

PUM

- Resolution: 96 X 73 X 38 grid points.
- 96 time-steps per model day.
- Among the better models used for Indian Monsoon prediction.
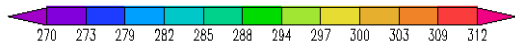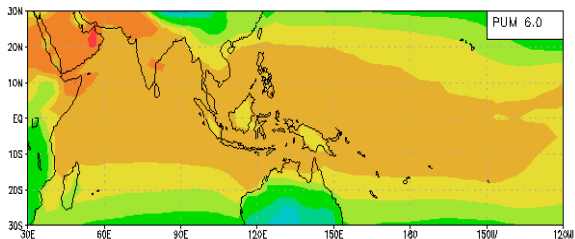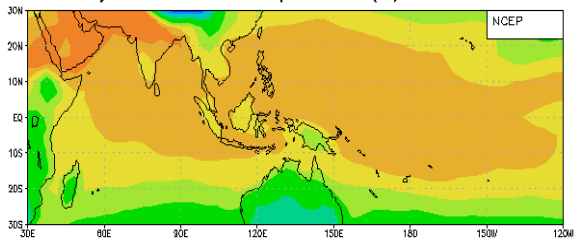
Monthly Mean Precipitation(mm) — June 2004
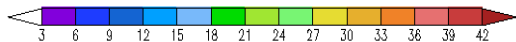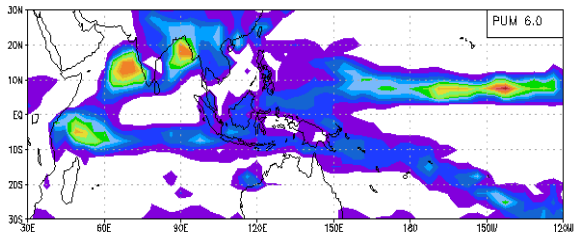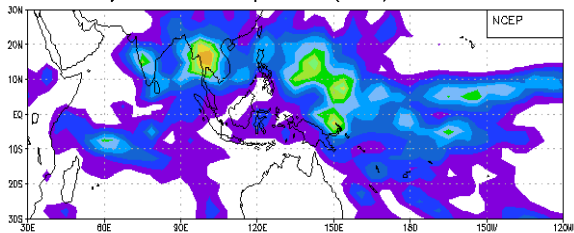
Mean Sea Level Pressure(KPa) – June 2004

Monthly Mean 2m Temparature(K) − June 2004

Coupled Ocean-atmosphere GCMs

- Comprehensive modeling of ocean.
- Ocean models provide the boundary conditions for the atmosphere model and vice-versa.
- There is a dynamic evolution of the boundary condtions.
- Software complexity is high.

CFS

- Developed at Environmental Modeling Center at NCEP.
- Fully coupled model: ocean-land-atmosphere: with no flux correction.

- Global Forecast System.

- T62 in horizontal, 64 layers in vertical.

- The "land" portion of the CFS is the land surface model found in the GFS.

- Feels the ocean via fluxes of momentum and heat from the water surface, as determined in part by the sea surface temperatures (SSTs) forecast by MOM3.

- GFDL MOM3.
- 1/3° x 1° in tropics; 1° x 1° in extratropics; 40 layers
- Quasi Global domain (74° S - 64° N).
- Predicts ocean currents, surface and sub-surface temperature and salinity.
- Feels the atmosphere via fluxes of momentum (from 10-meter winds), heat (through solar and longwave radiation and sensible and latent heat fluxes at the sea surface), and fresh water (through precipatation and evaporation).
- Average values for each of these inputs are calculated once daily and then used to force the MOM3 for the next 24 forecast hours.
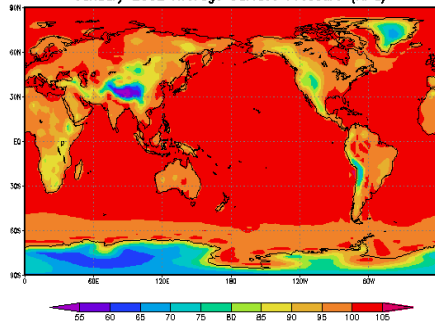
Coupled Atmosphere-Land-Ocean Model
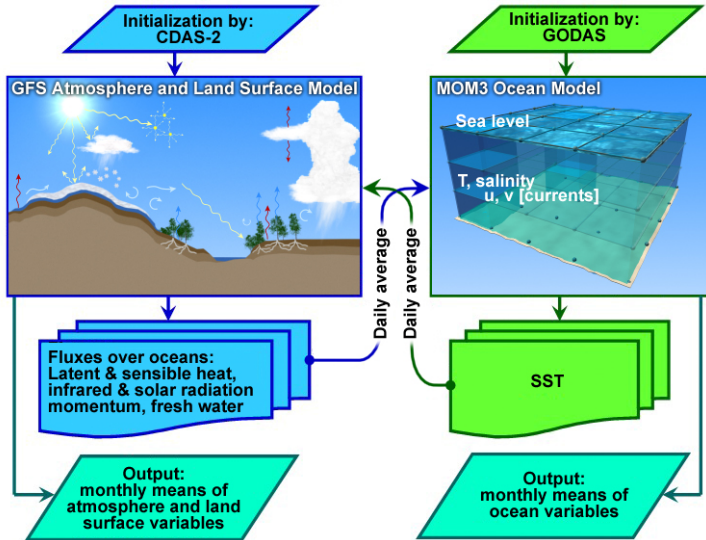
CFS Output (Atmosphere)
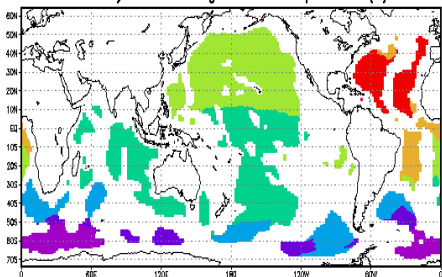

January 2002 Average 2m Temperature (K)
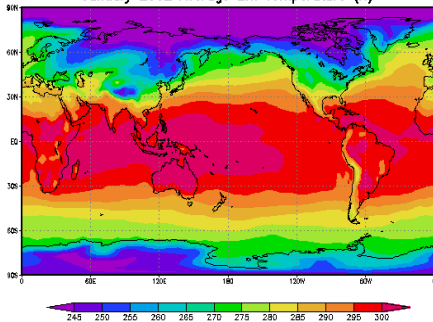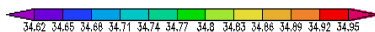
January 2002 Average Surface Pressure (KPa)

CFS Output (Ocean)
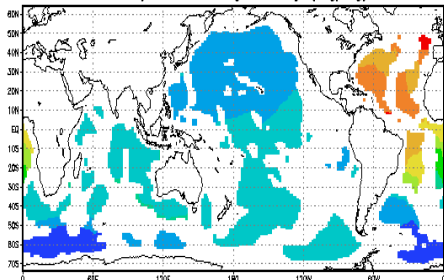
Computational Performance of CFS

No. of PEs	Wall Clock time for execution	Nodes used
1 x 2	17 min 27 sec	tf88
1 x 4	9 min 11 sec	tf91
1 x 8	5 min 55 sec	tf91
2 x 4	6 min 41 sec	tf91, tf88
2 x 8	4 min 57sec	tf91, tf88
2 x 8	10 min 28sec	tf88, tf91
2 x 8	5 min 52 sec	tf89, tf90
4 x 8	31 min 50sec	tf76, tf86, tf88, tf91
1 x 16	3 min 27 sec	tf92

Thank You