Joint ICTP-Trieste/ICTP-SAIFR Advanced School on
Regional Climate Modeling over South America
February 15-19, 2016 | São Paulo, Brazil

The Regional Earth System Model (RegESM) using RegCM4 coupled with the MITgcm ocean model

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ICTP The Abdus Salam International Centre for Theoretical Physics 50th Anniversary 1964 - 2014

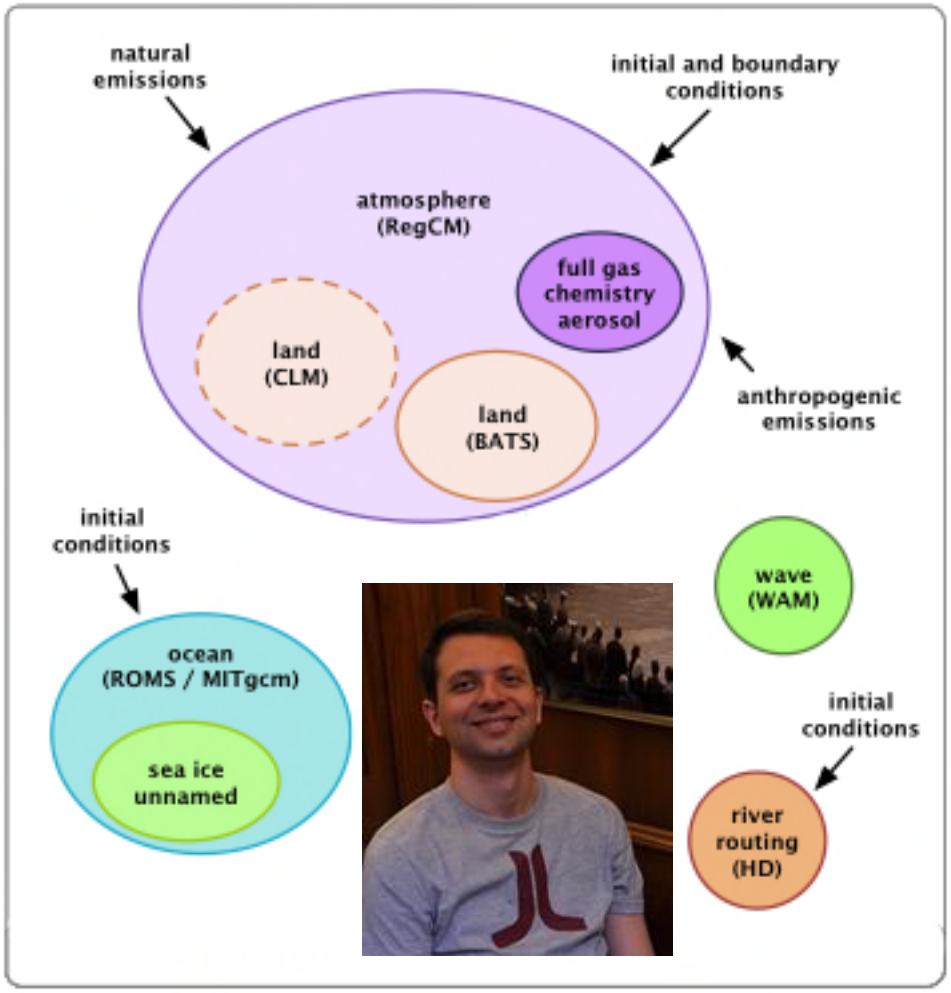
Earth System

USRA, Earth System Science Education strategy, 2008

before…

different earth system models

- Components:



ATM:
ICTP's RegCM (4.4.5.8)

OCN:
Rutgers Univ. ROMS (r737)
MIT, MITgcm (c63s)

RTM:
Max Planck's HD (mod. 1.0.2)

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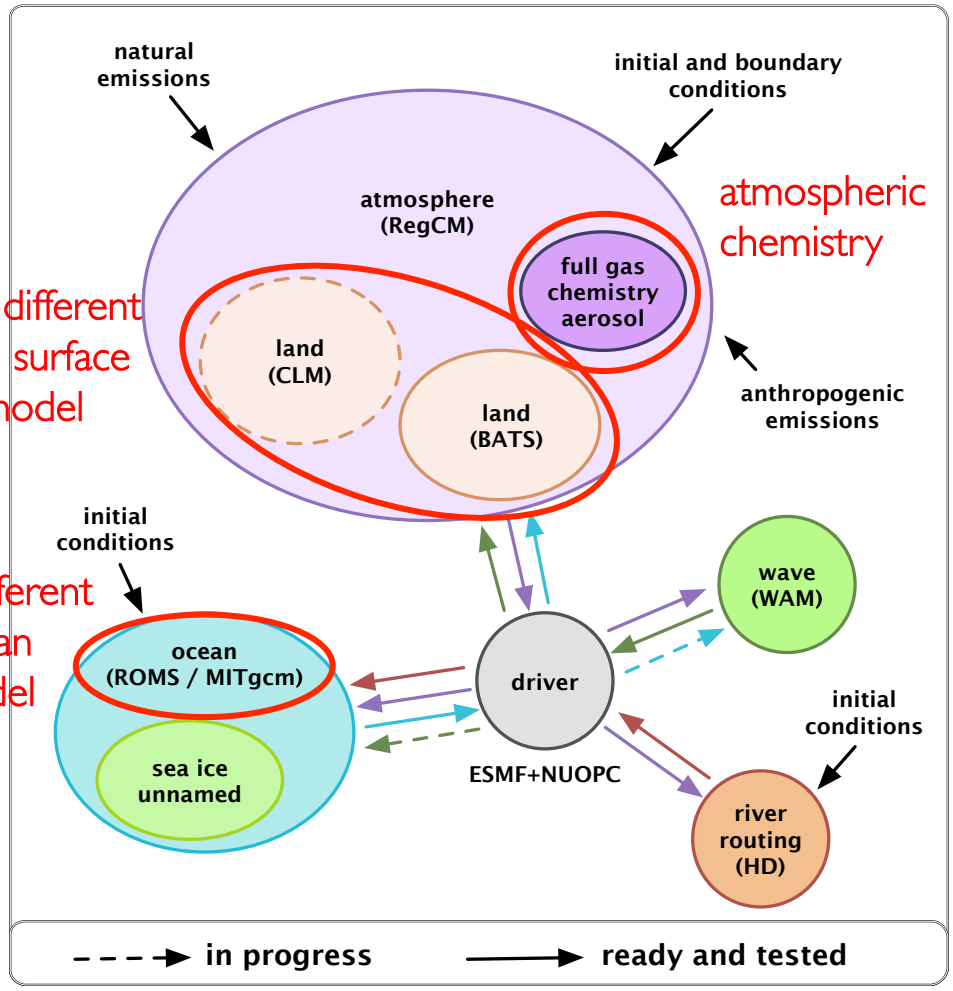
u.utku.turuncoglu@be.itu.edu.tr

now…

Regional Earth System Model is coupled modeling system that allows using variety of different earth system models (RegESM)

- Components:



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MIT, MITgcm (c63s)

RTM:
Max Planck's HD (mod. 1.0.2)

WAV:
ECMWF's WAM (4.5.3 MPI)

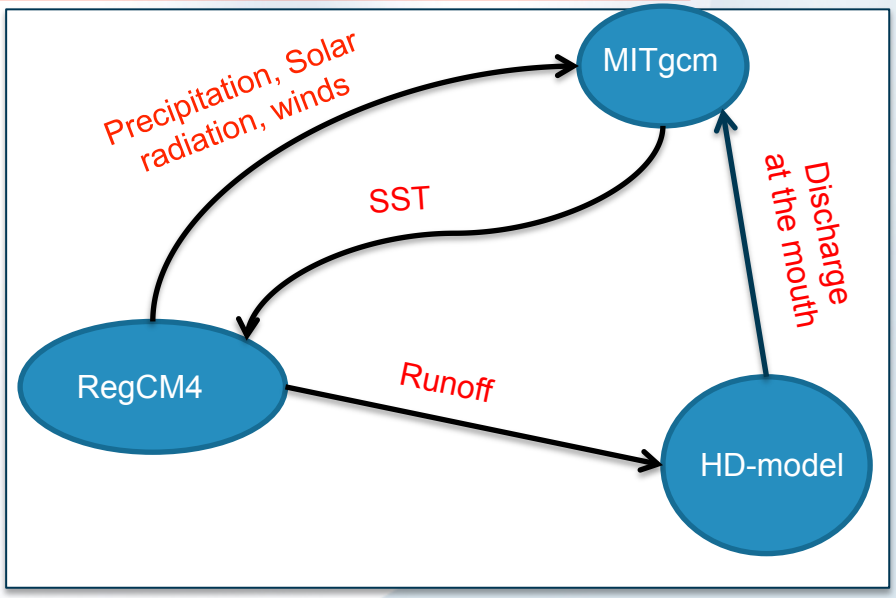
DRV:
RegESM (7.0.0b38)

Managing Exchange Fields

- Exchange fields between model components are defined by extra configuration file (exfield.tbl)

```
6 atm2ocn T
taux:eastward_10m_wind_stress:bilinear:cross:u:N/m2:m2/s2:cf3:0.0:F
tauy:northward_10m_wind_stress:bilinear:cross:v:N/m2:m2/s2:cf3:0.0:F
psfc:surface_air_pressure:bilinear:cross:cross:mb:mb:1.0:0.0:F
swrd:shortwave_radiation:bilinear:cross:cross:W/m^2:Cm/s:cf2:0.0:T
sflx:water_flux_into_sea_water:bilinear:cross:cross:kg/m^2s:m/s:0.001:0.0:T
nflx:surface_heat_flux:bilinear:cross:cross:W/m^2:Cm/s:cf2:0.0:T
1 ocn2atm T
sst:sea_surface_temperature:bilinear:cross:cross:C:K:1.0:293.16:F
2 atm2rtm F
rnof:surface_runoff:bilinear:cross:cross:mm/s:m/s:0.001:0.0:F
snof:subsurface_runoff:bilinear:cross:cross:mm/s:m/s:0.001:0.0:F
1 rtm2ocn F
rdis:river_discharge:nearstod:cross:cross:m^3/s:m^3/s:1.0:0.0:F
```

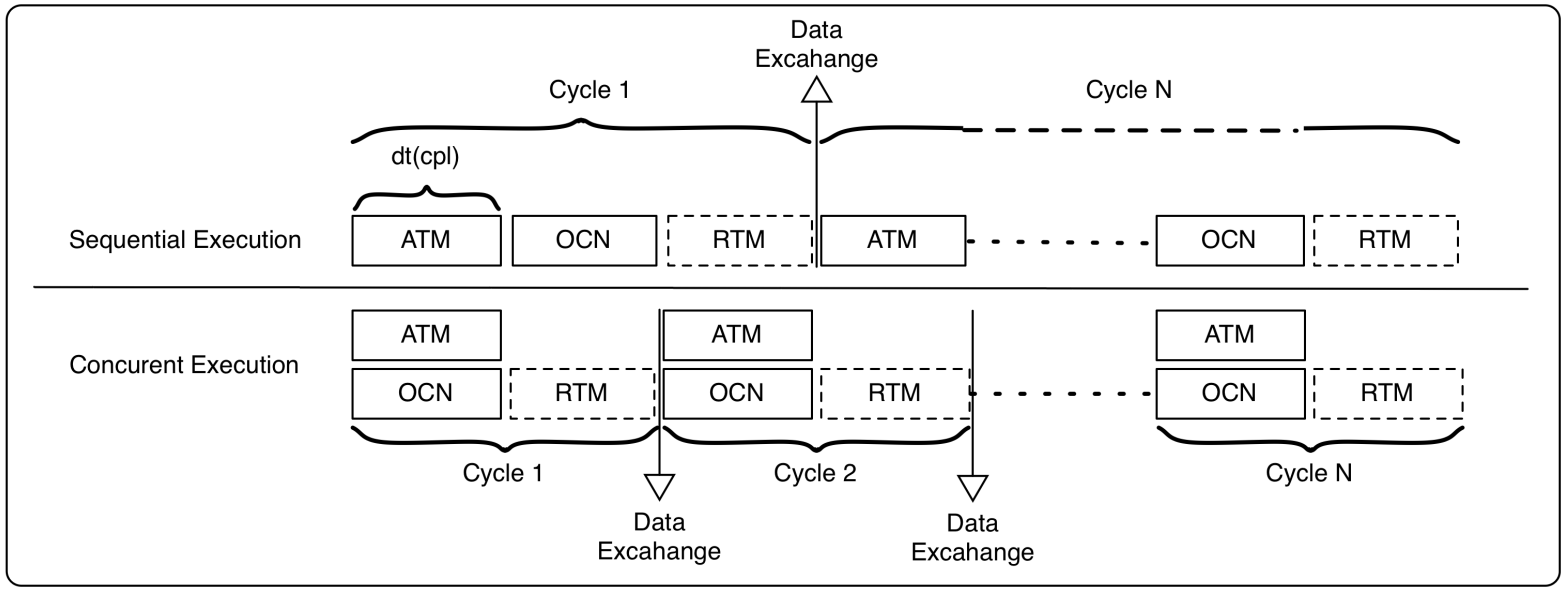
- The user can choose the exchange fields from the field pool



Sequential vs. Concurrent Execution

- RegESM also supports two different approach to run the model components.
  - Sequential: model components are run in order
  - Concurrent: all models are active at same time (it does not allow overlapping of the used cores / CPUs)

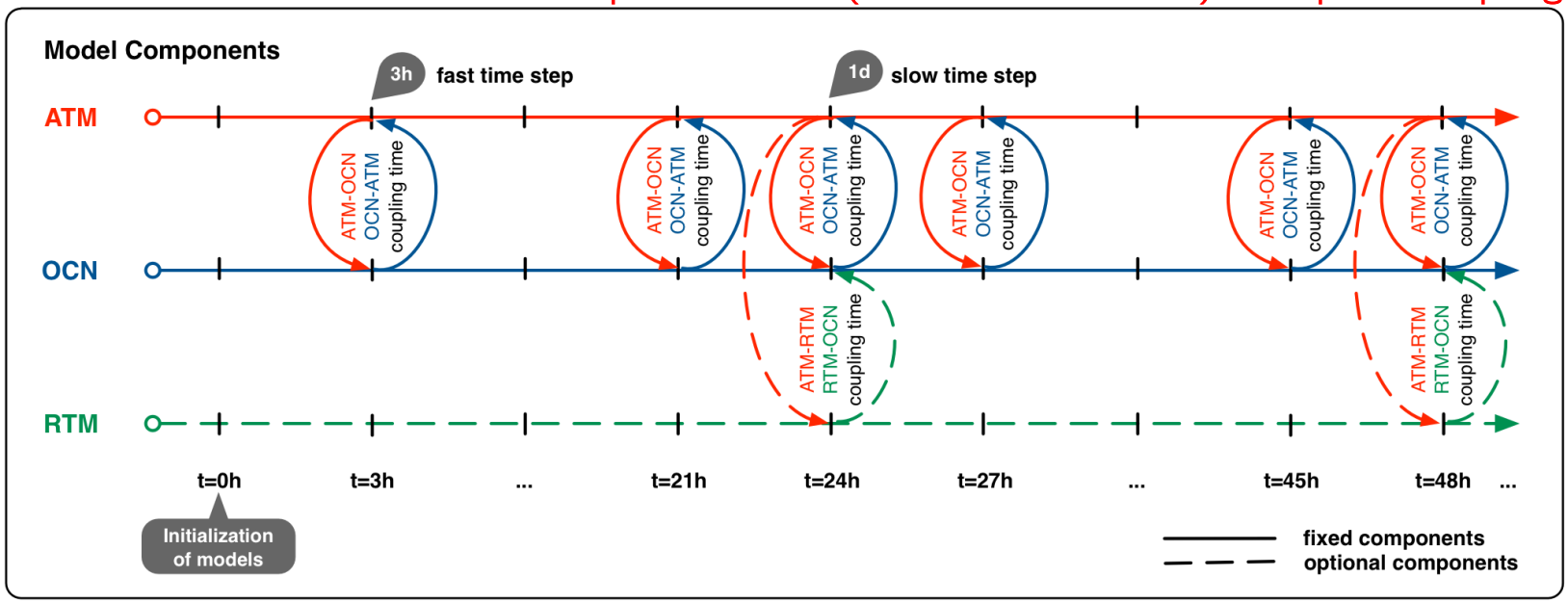
i.e. three component case (ATM+OCN+RTM)



Run Sequence in RegESM

- The RegESM uses explicit coupling schemes along with the support of fast and slow time steps.
  - Fast interaction among ATM and OCN (i.e. 1 or 3 hours)
  - Slow interaction between ATM and RTM, RTM-OCN (i.e. 1 day)

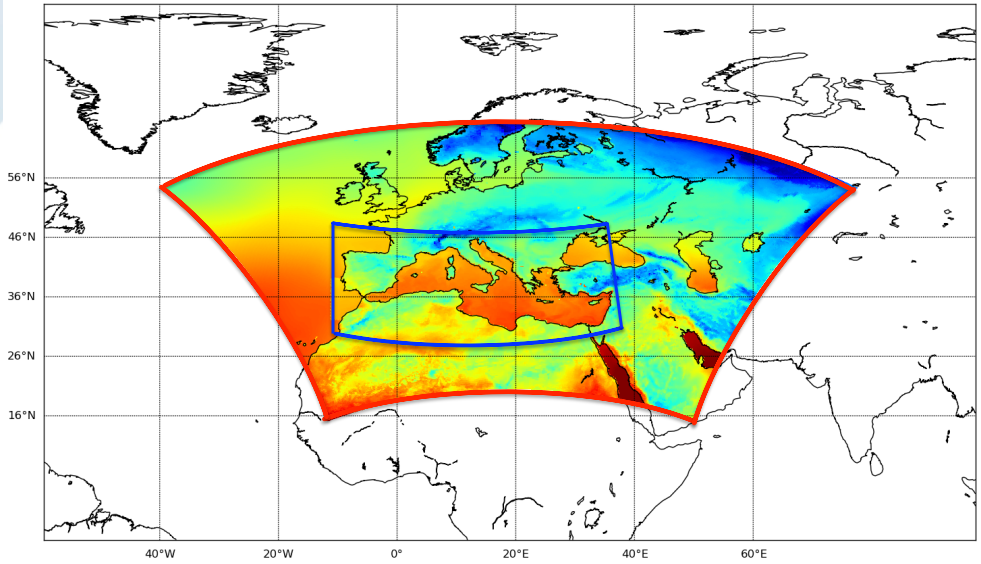
i.e. three component case (ATM+OCN+RTM) + explicit coupling



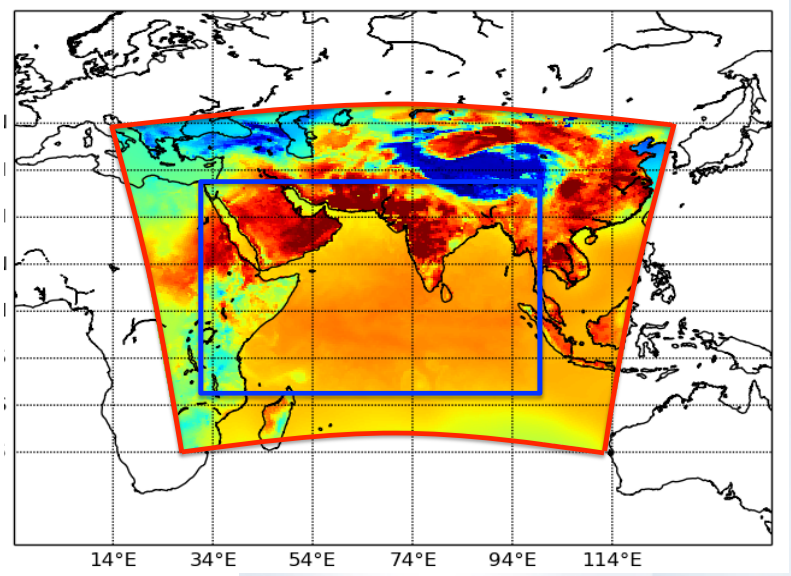
Special thanks to ESMF Group (especially to Gerhard Theurich) for their support and help

Tests with RegESM

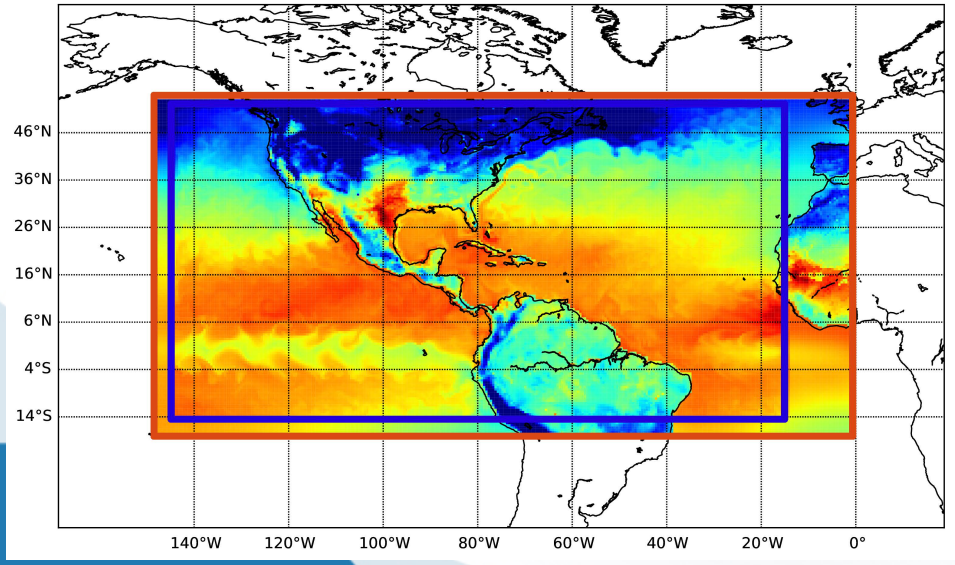
Mediterranean



South Asia



Central America



MED-CORDEX domain

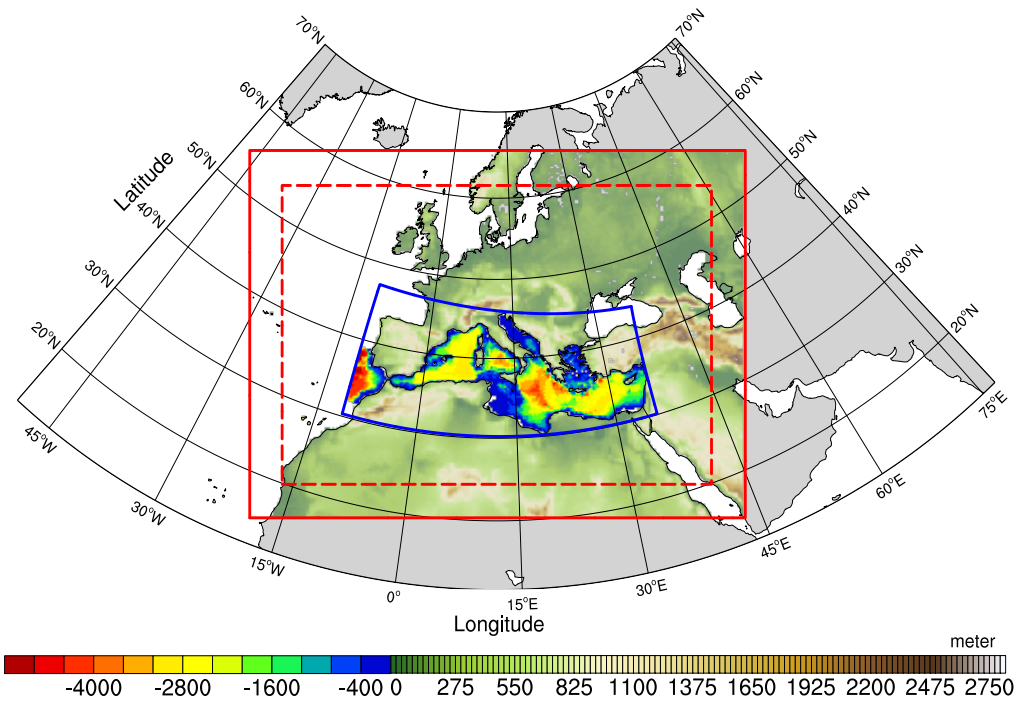


Figure 1. *The domain map for the RegESM simulation with topography of atmosphere model (RegCM4) and bathymetry of ocean component (MITgcm). The solid red box indicates full atmospheric model domain, relaxation zone is indicated between solid and dashed red box. The blue solid box shows ocean model domain.*

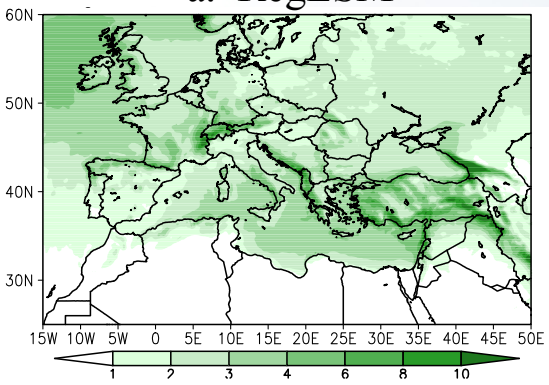
RegCM4 configuration:
MED-CORDEX experiment from 1979 up to 2013.
Model version: RegCM4.5
Horizontal Resolution: 20 km
Boundary conditions: ERA-Interim Reanalysis 0.75°
In our experiments we use the convection scheme of Grell over land and MIT-Emanuel scheme over ocean. The land-atmosphere interactions are parameterized using the biosphere-atmosphere transfer scheme (BATS) and the Zeng scheme is used to represent fluxes from water surfaces.

MITgcm configuration:
1/12° horizontal resolution, 75 vertical levels.
Sea Surface Salinity with time relaxation constants of 2 days and 1.8 days respectively.
The benchmark simulation is a stand-alone run forced by the air-sea fluxes from ALADIN dynamical downscaling of ERA-interim (12 km horizontal resolution), and with relaxation terms on Sea Surface Temperature

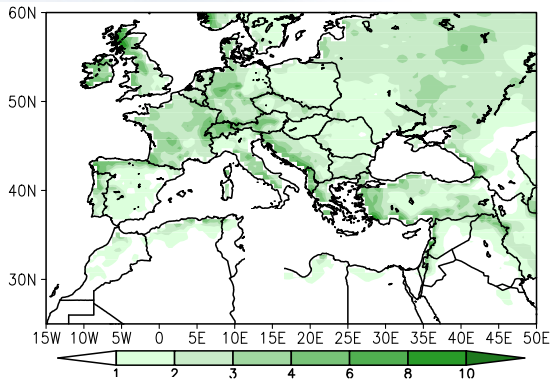
MED-CORDEX domain

Precipitation maps for the season DJF from 1979 up to 2013 (mm/day)

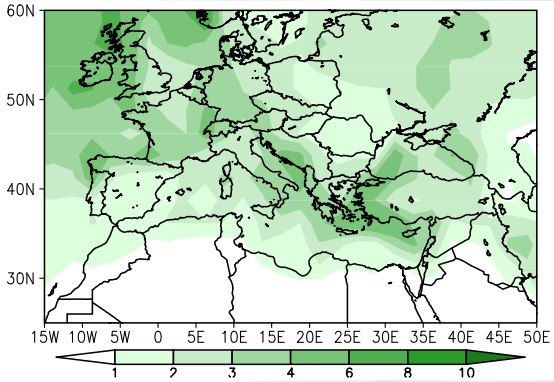
a. RegESM



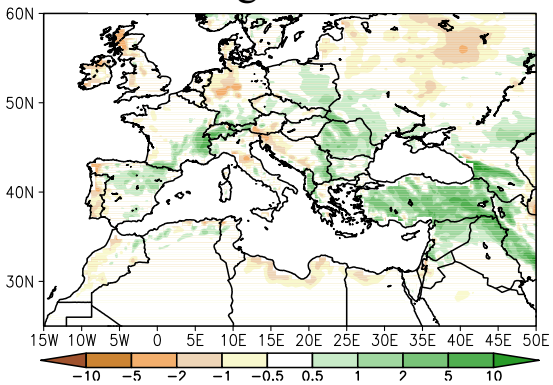
b. UDEL



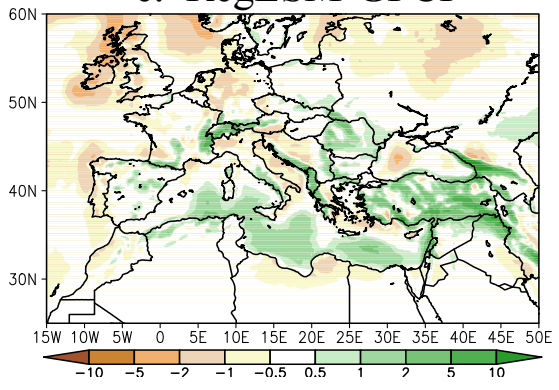
c. GPCP



d. RegESM-UDEL



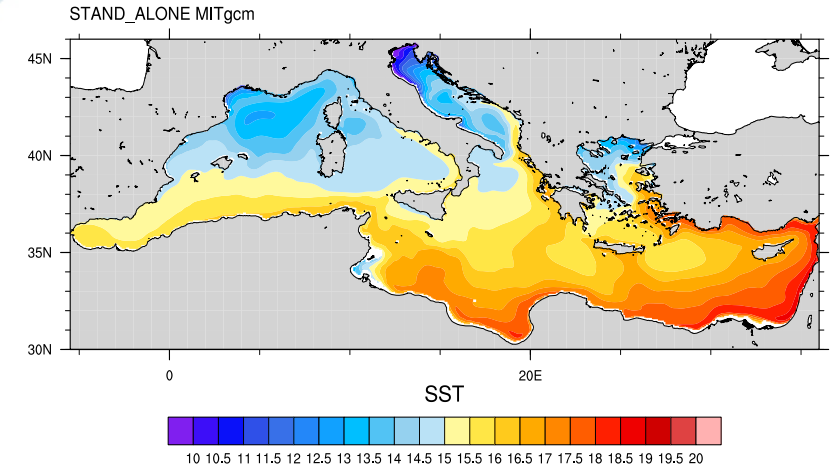
e. RegESM-GPCP



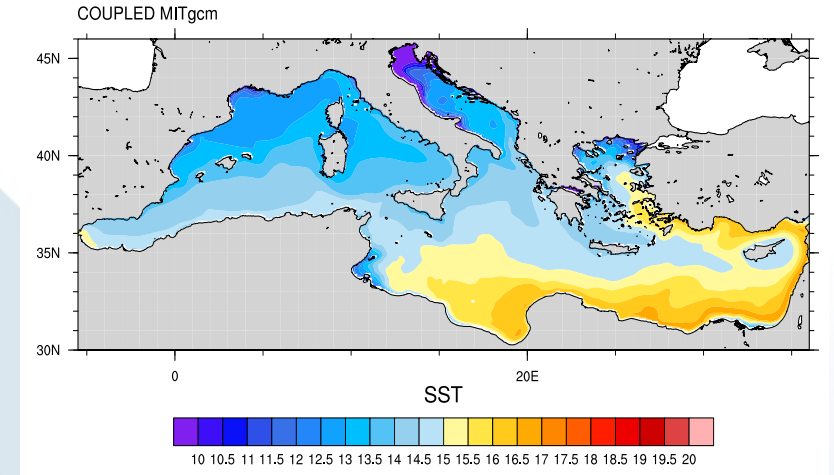
MED-CORDEX domain

SST

MITgCM

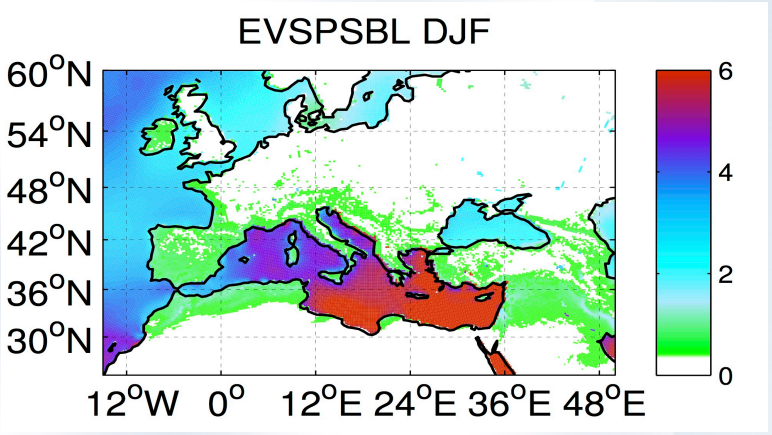


RegESM

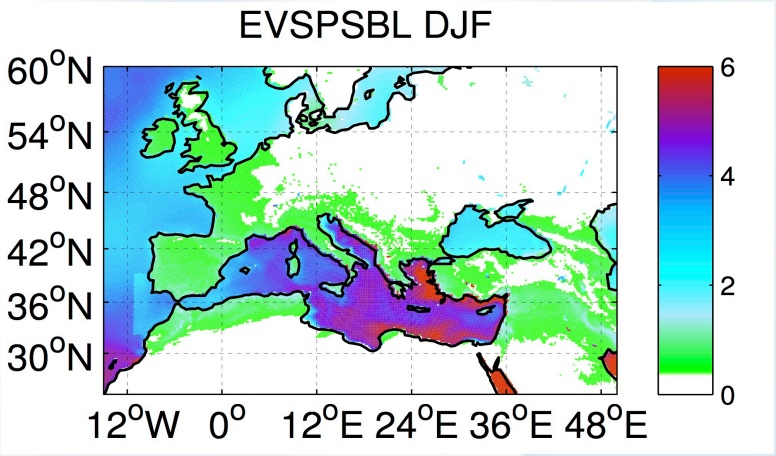


EVAPOTRANSPIRATION

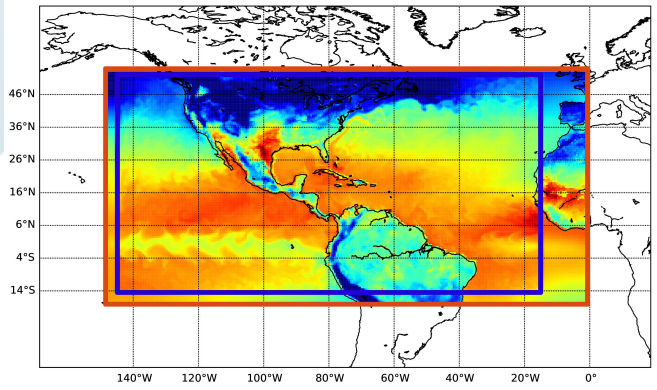
RegCM



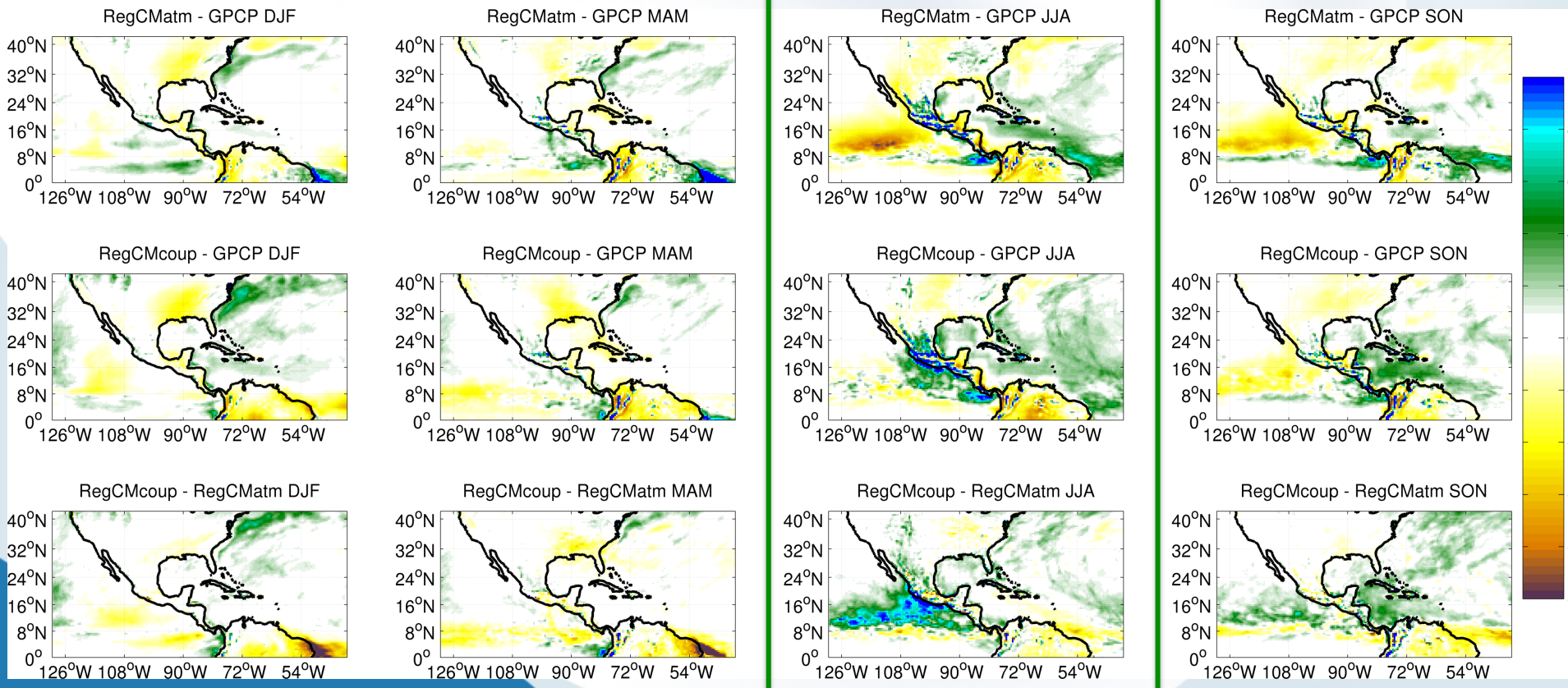
RegESM



Central America domain



by Ramon Fuentes Franco
Test from 1989 up to 1992
RegCM4 driven by EIN 0.75 at 50km
Mitgcm at 25km



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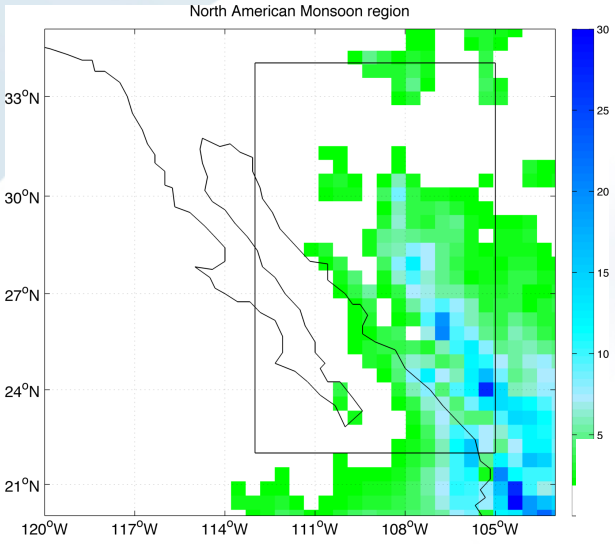
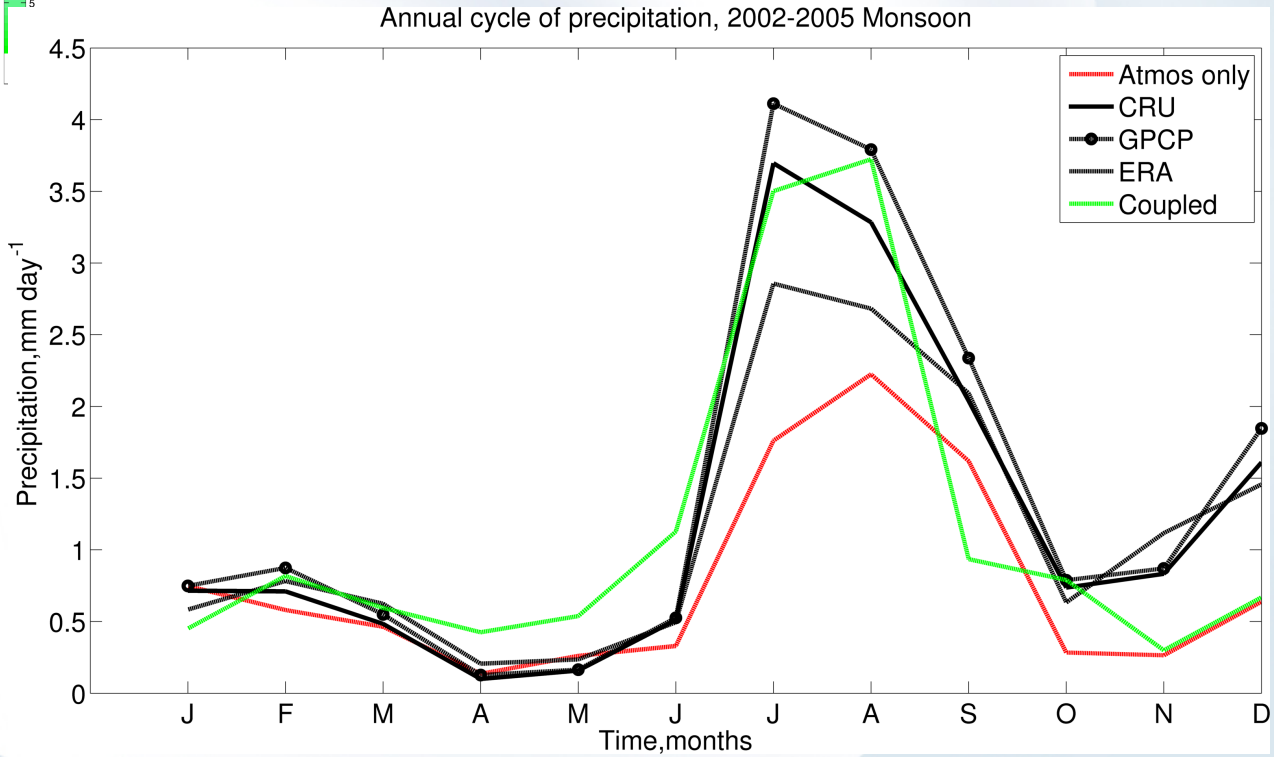
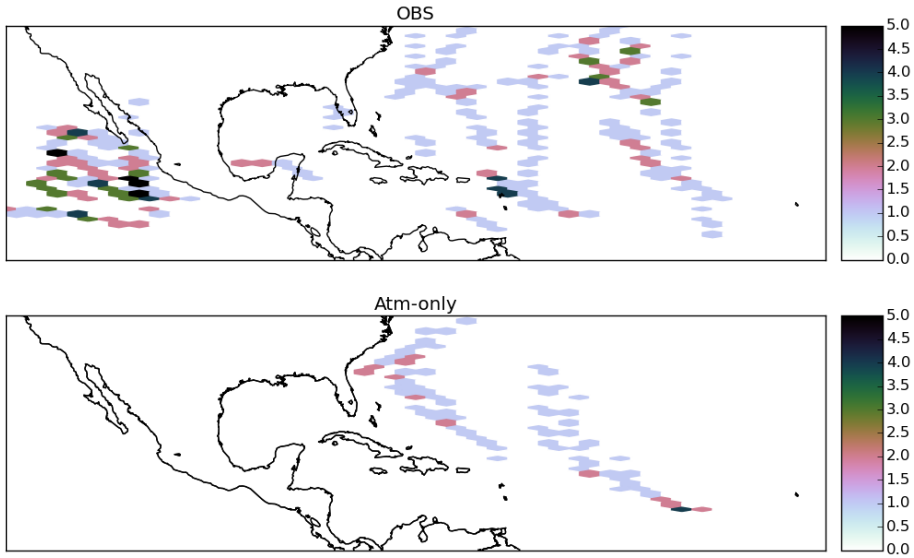




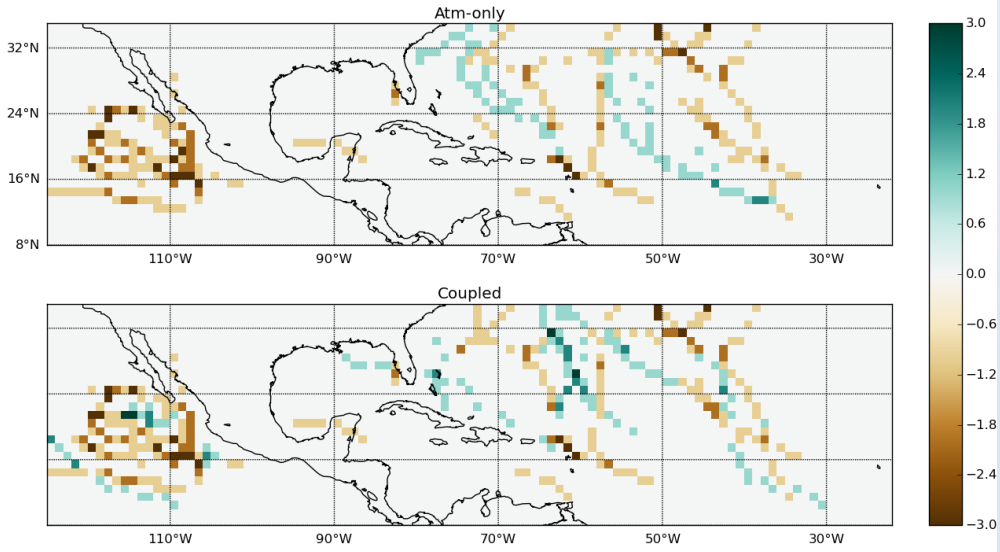
Central America domain

maps detected cyclones



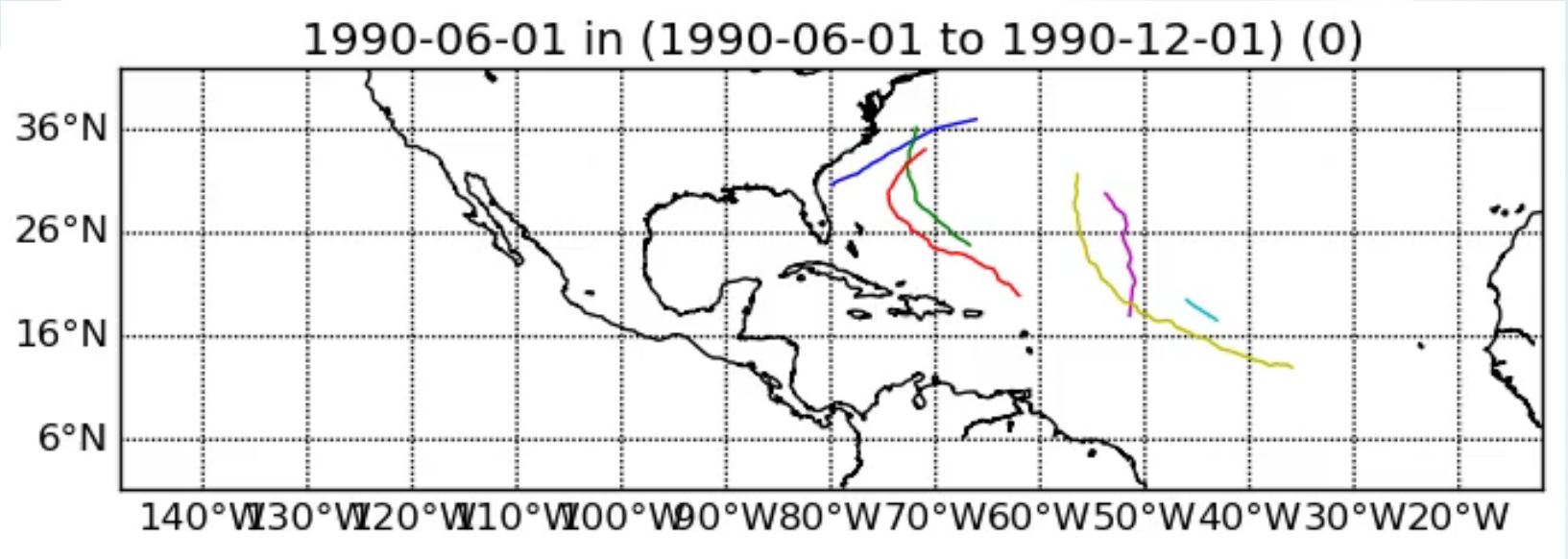
Cyclones during 1990

Biases

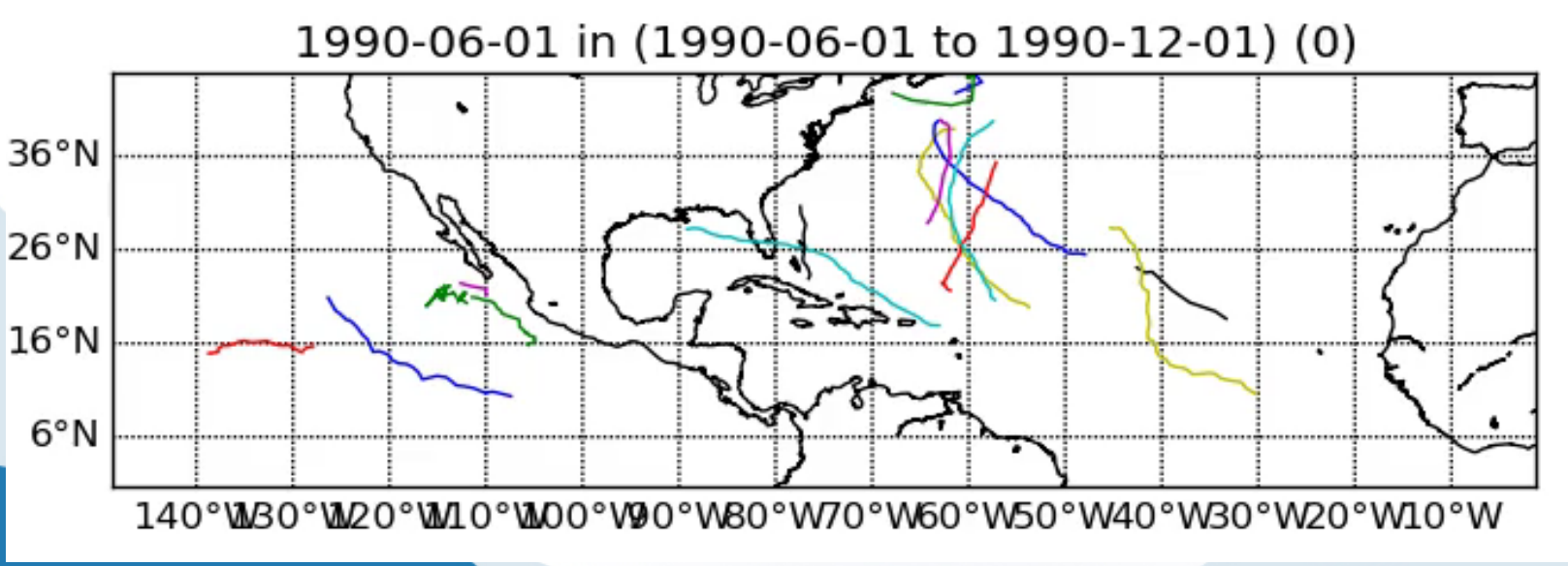


Central America domain

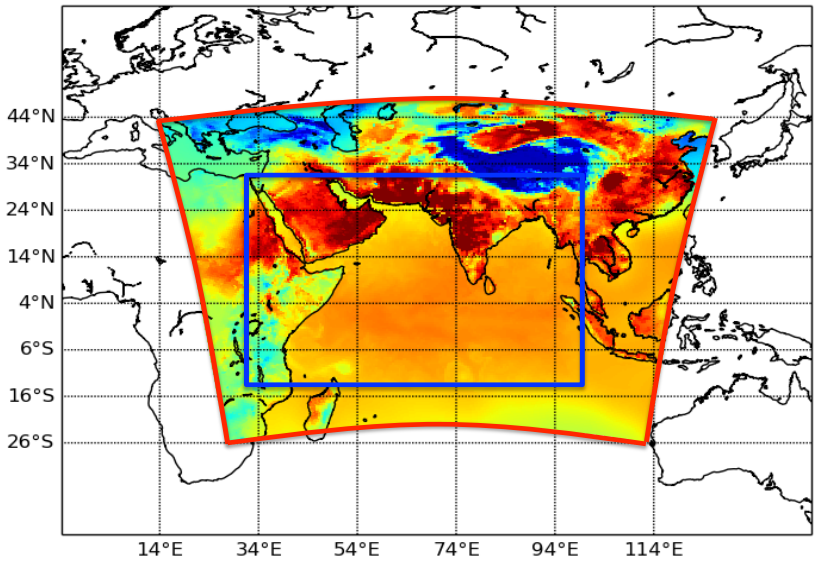
Regcm



coupled



South Asia domain



by Fabio Di Sante

Experiments

- 5 Years simulated (1988 – 1993)
- Last 3 years used for validation purpose
- Coupled and Uncoupled runs

Validation

Ocean

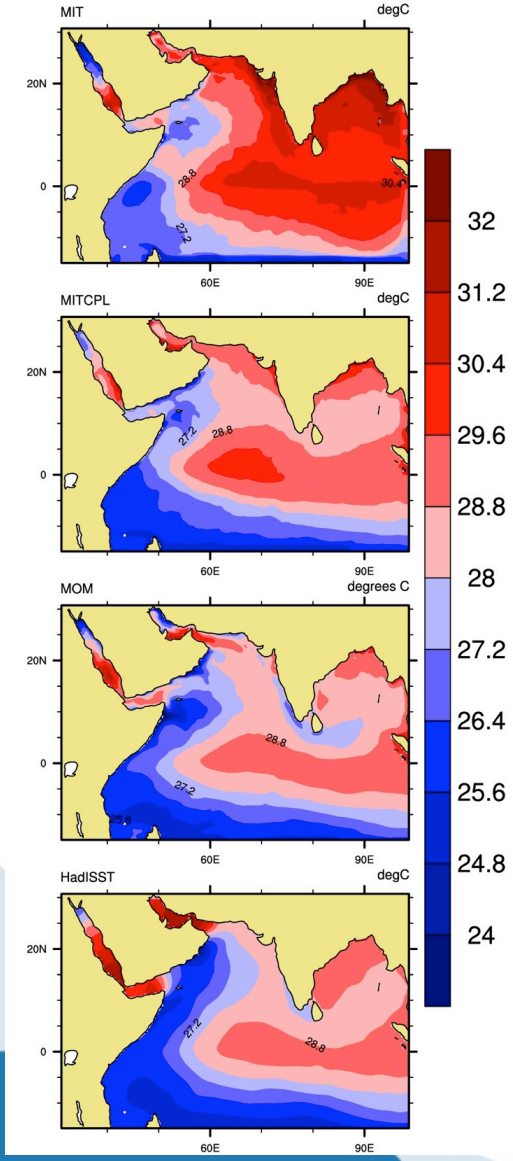
- SST on JJAS season

Atmosphere

- Precipitation bias on JJAS season
- Annual cycle for precipitation

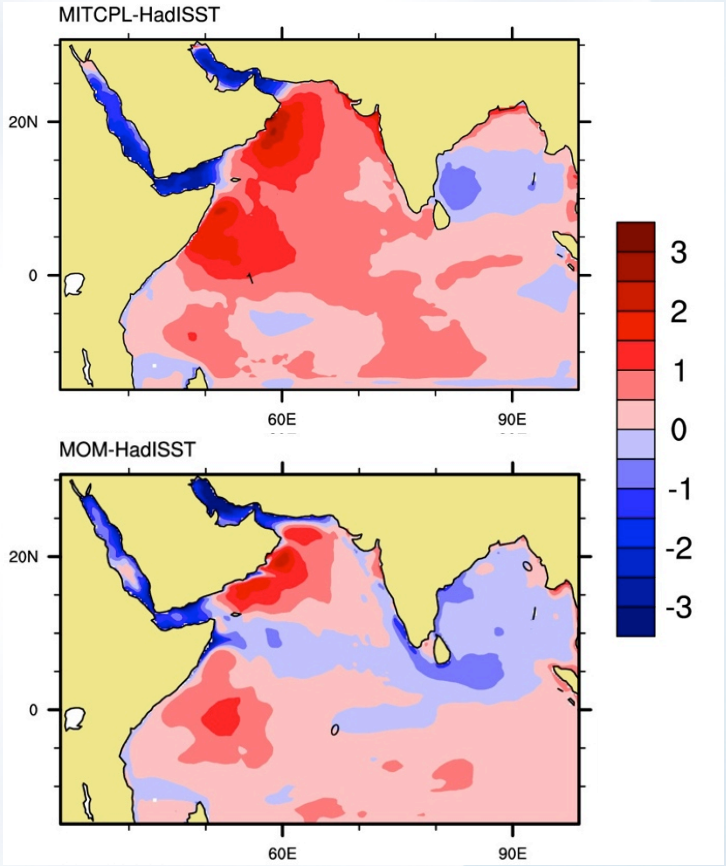
South Asia – Ocean Validation

SST JJAS

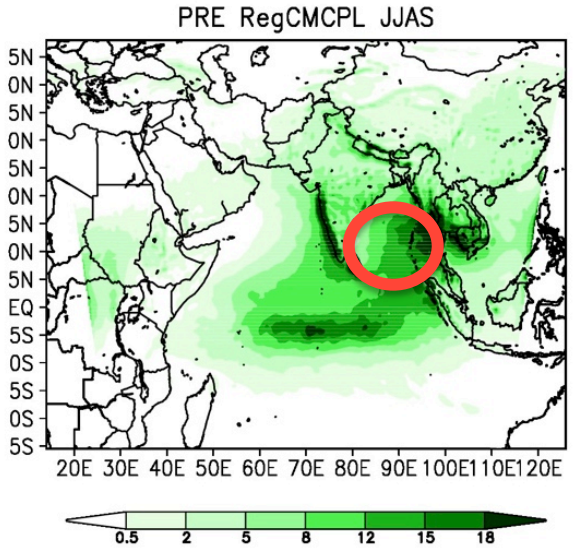


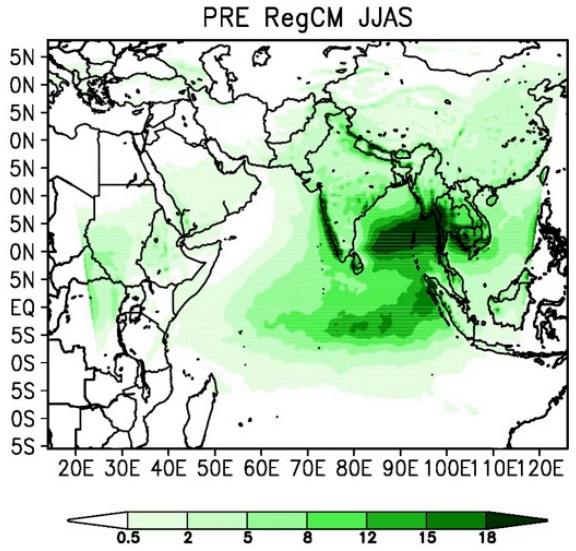
OBS

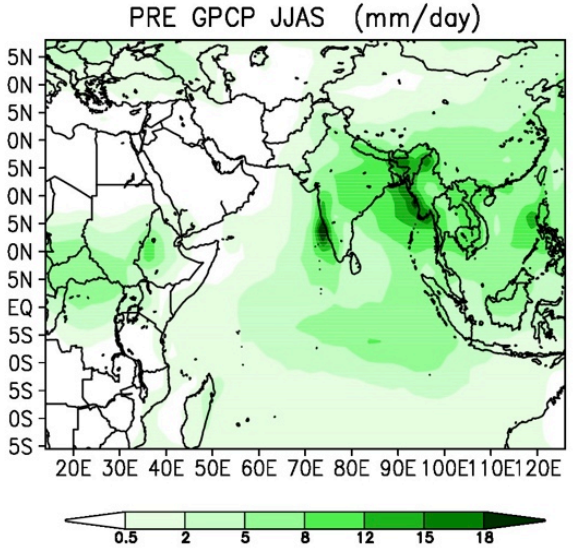
Bias SST JJAS



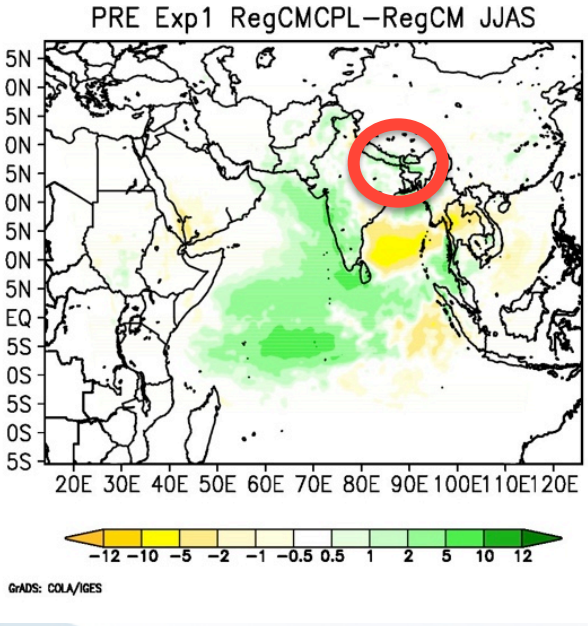
South Asia – Atmosphere Validation







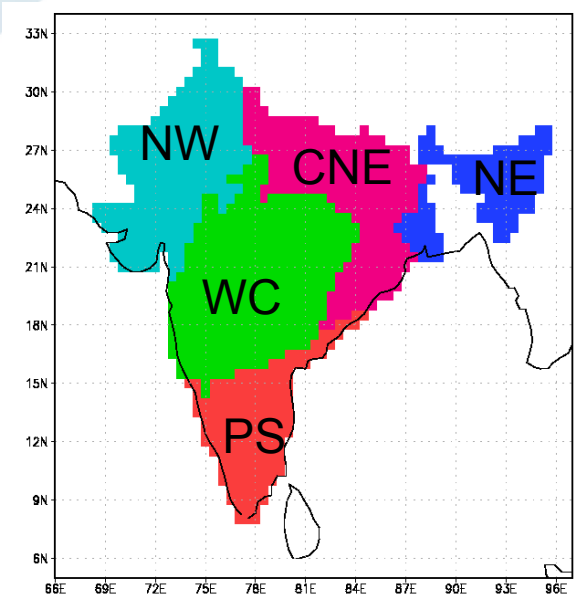
Drier over Bay of Bengal respect to the standalone



Wetter over Bangladesh and Central Northeast Indian region respect to the standalone

South Asia – Atmosphere Validation

Annual Cycle



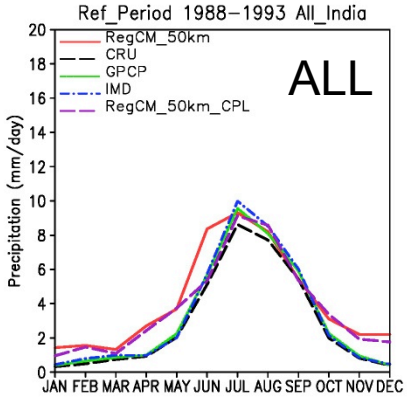
Northwest (NW)

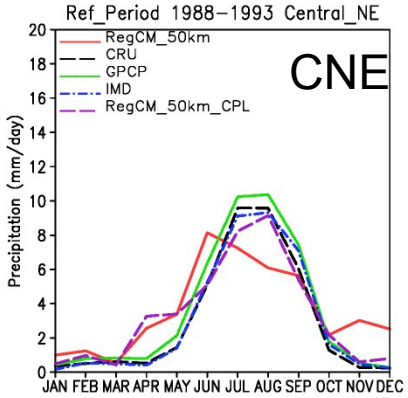
Central Northeast (CNE)

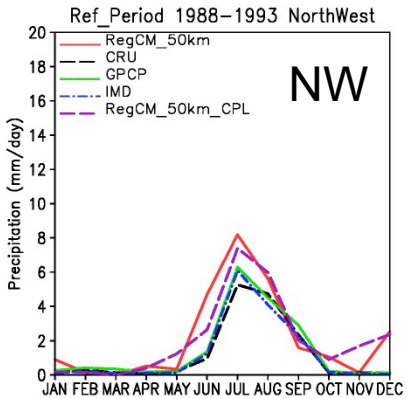
Northeast (NE)

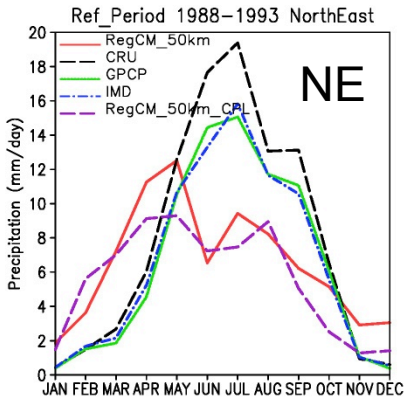
West Central (WC)

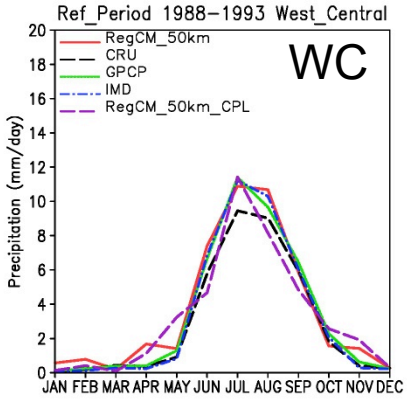
Peninsular (PS)

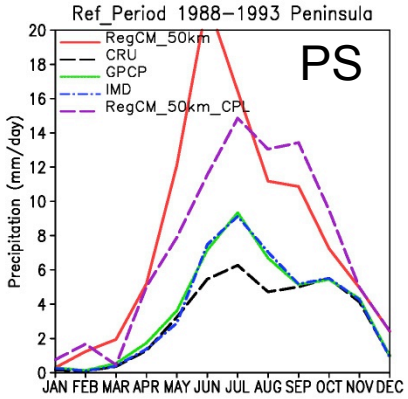








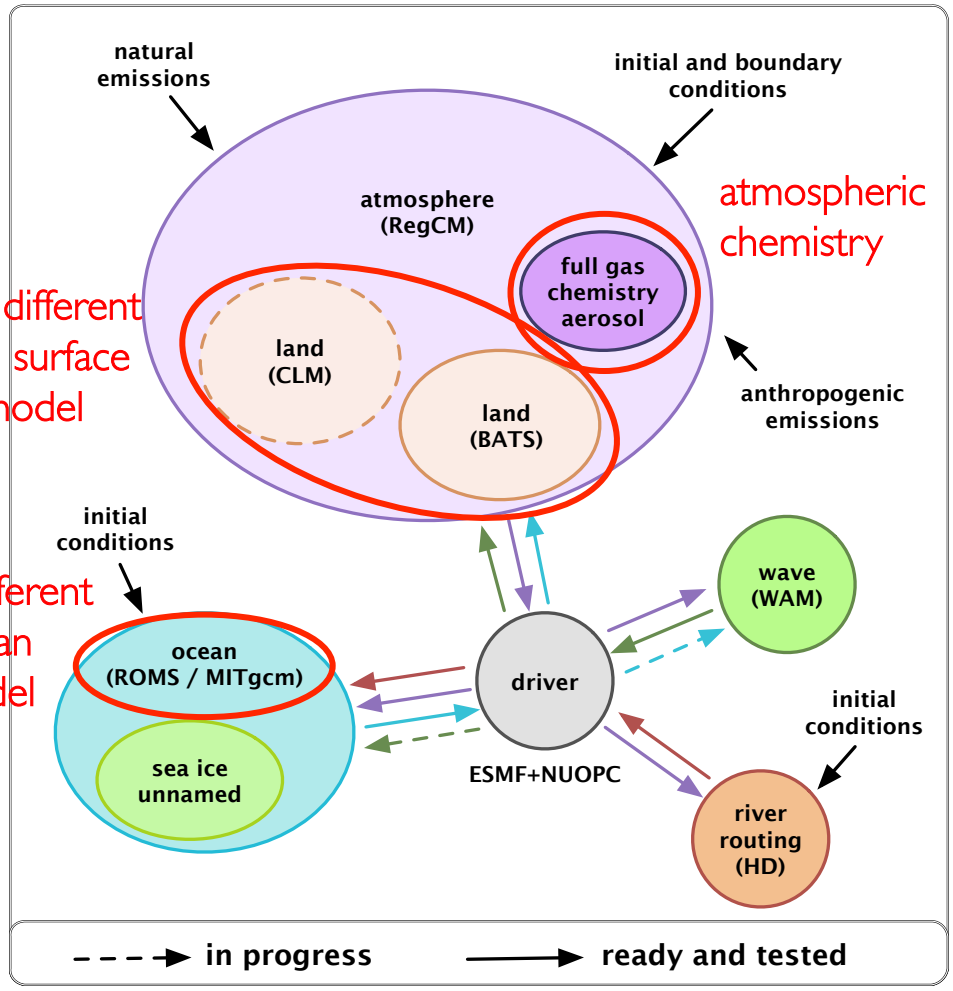




Conclusions

Regional Earth System Model is coupled modeling system that allows using variety of different earth system models (RegESM)

- Components:



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50th Anniversary 1964 - 2014

Obrigada