Seasonal monsoon simulation using GFS model with prescribed SST

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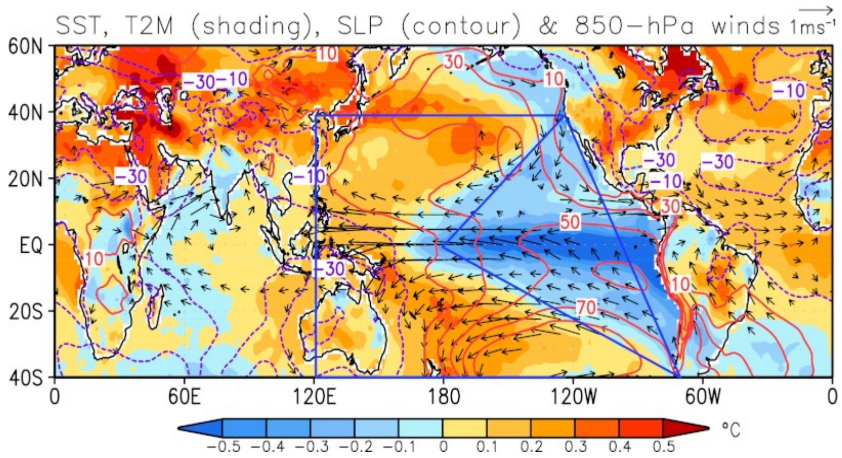
Objective

To examine the response of ENSO SST on the Asian monsoon using GFS model (Atmosphere only model)

Motivation



- To quantify the characteristic variations of the Pacific SST, which is western Pacific K-shape area and eastern Pacific triangle as a 'mega-ENSO'. This pattern is similar to ENSO but with a larger spatial scale and longer time scale. The mega-ENSO is a multi-timescale index.
- Influence of ENSO over the South Asian monsoon is changing (Krishna Kumar et al. 1999).
- GCMs fail to respond to ENSO SST in a realistic manner.
- Though the CFS system is extensively used for seasonal scale monsoon prediction, the atmospheric model (GFS) has not been tested on how this model responds to ENSO.

Model Configuration

➢The NGFS with spectral triangular truncation of 126 waves (T126) in the horizontal (equivalent to nearly a 100 Km Gaussian grid) and a finite differencing in the vertical with 64 sigma layers used for the study.

➢For a surface pressure of 1000 hPa, 15 levels are below 800 hPa, and 24 levels are above 100 hPa with the top level at 0.3 hPa. Vertical coordinate is hybrid sigma-pressure (64 levels). The hybrid coordinate system is terrain following in the lower levels and transforming to pure pressure levels in the upper levels.

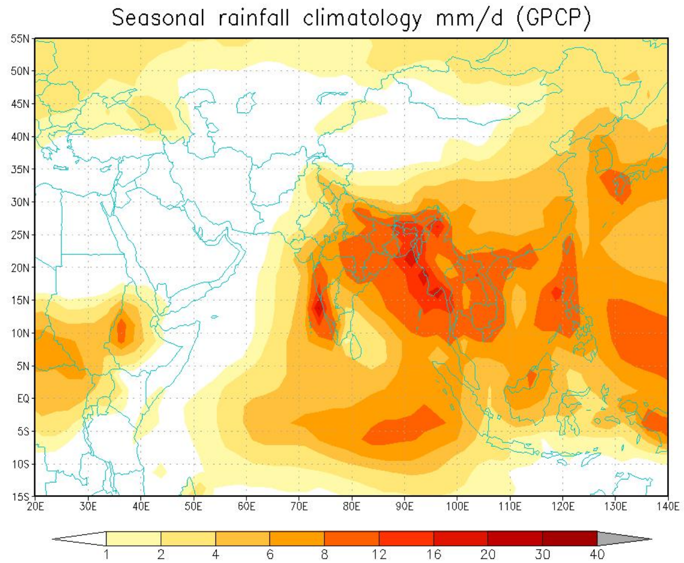
➢Orography data sets are based on a United States Geological Survey (USGS) global digital elevation model (DEM) with a horizontal grid spacing of 30 arc seconds (approximately 1 km). Orography statistics include average height, mountain variance, maximum orography, land-sea-lake masks are directly derived from a 30-arc second DEM for a given resolution.

➢The convection scheme employed in NGFS is the Simplified Arakawa-Schubert (SAS) convection, with cumulus momentum mixing and orographic gravity wave drag (Saha et al. 2010).

Data Used

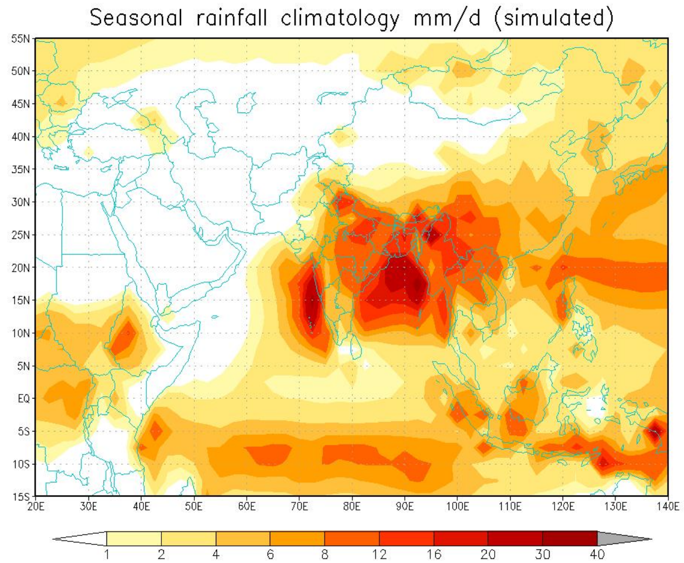
- Global Precipitation Climatology Project (GPCP) monthly precipitation data (2.5°×2.5°) from 1982 to 2010 (90N-90S, 0-360E)
- NOAA ERSSTv3b extended reconstructed monthly sea surface temperature data.
- The atmospheric initial conditions for the hindcasts have been taken from the NOAA/NCEP CFS Reanalysis (CFSR) initial conditions.
- Initial Condition : MAY 01 for every year and every experiment

Observed rainfall climatology



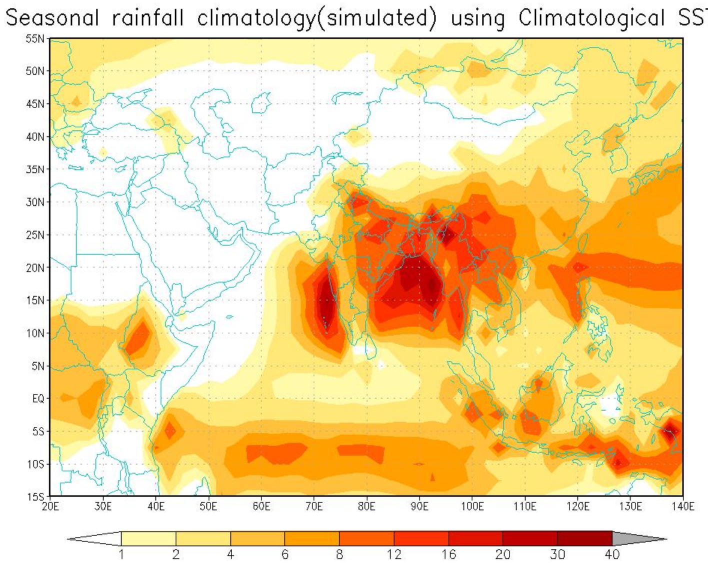
Observed rainfall pattern characterized by a maximum of rainfall over Western ghat, Eastern ghat, North-East region, Gangetic plan and Arakan coast

Simulated rainfall climatology using observed SST



The simulation of the climatological seasonal mean precipitation and circulations are an essential aspect for representation of the Indian summer monsoon (ISM) variability. Rainfall in Indian peninsular region is well captured by NGFS. Eastern ghat, western ghat and eastern part of India are showing over estimation in rainfall.

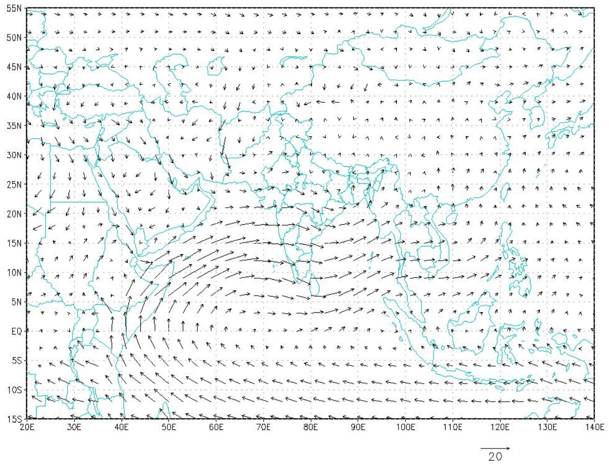
Simulated rainfall climatology using climatological SST



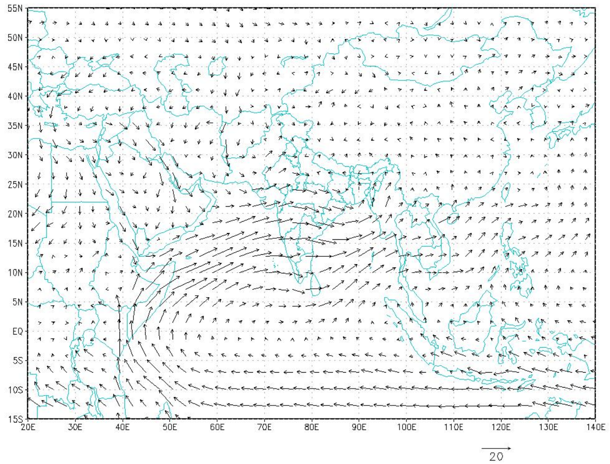
Rainfall climatology using climatological SST is almost same as climatology of rainfall using observed SST

Wind climatology (m/s) at 850 hPa

Observed



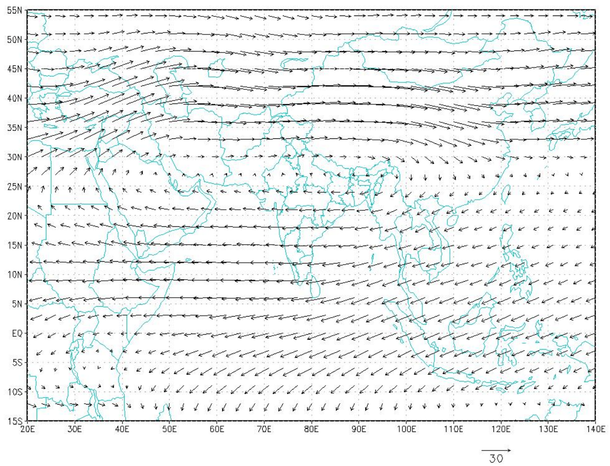
Simulated



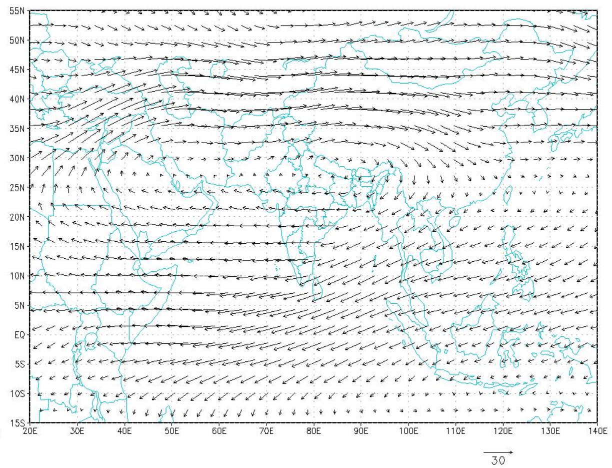
Cross equatorial flow, south westerly wind and monsoon trough are well simulated

Wind climatology (m/s) at 200 hPa

Observed

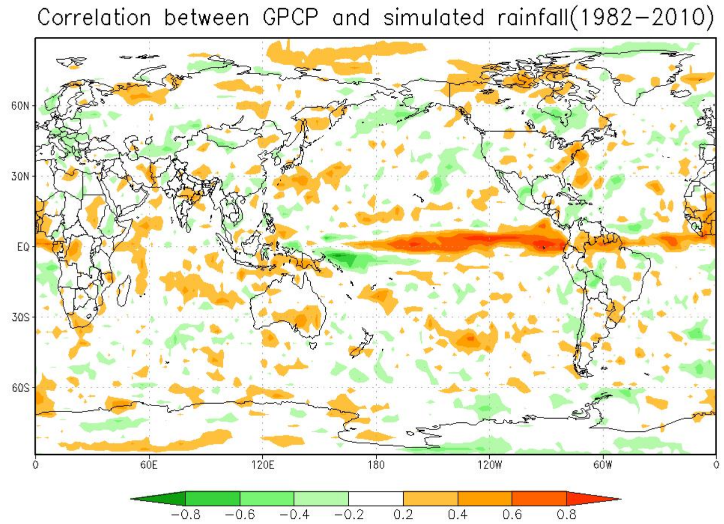


Simulated



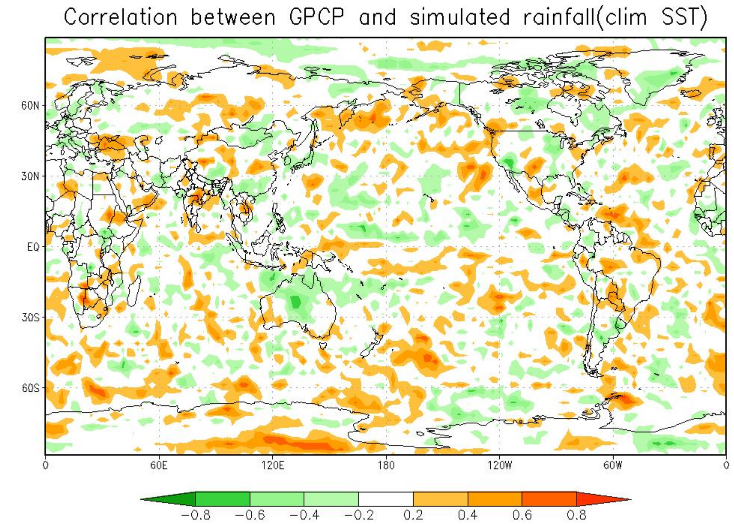
Tibetan anti-anticyclone and tropical easterly jets are well simulated

Correlation between observed and simulated rainfall



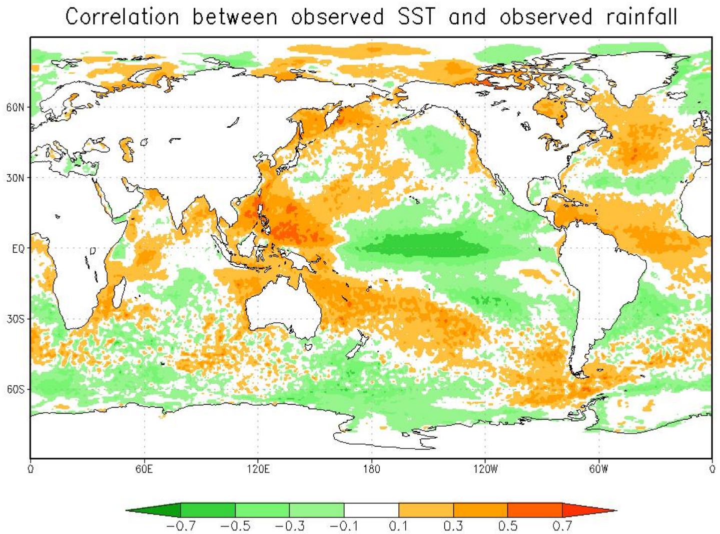
There is strong correlation over Pacific Ocean. Rainfall over Madhya Pradesh, Odisha and some part of West Bengal is also correlated.

Correlation between observed and simulated rainfall



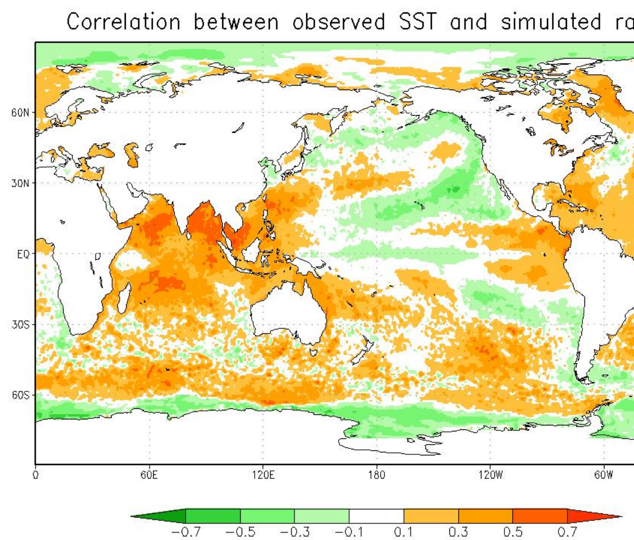
The SST impact is not seen because there is no inter-annual variability in this simulation. All the skill in this plot is due to internal dynamics.

Temporal correlation between observed SST and observed rainfall



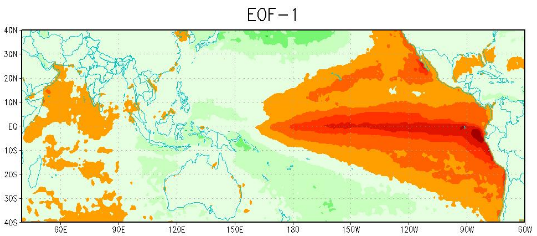
Rainfall over Indian region is negatively correlated with SST of Pacific Ocean. Some short of K-pattern is shown in this plot. Basically it is negatively correlated and is mega-ENSO.

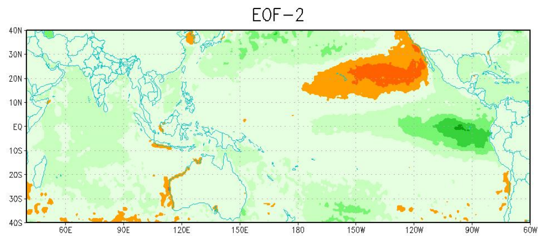
Temporal correlation between observed SST and simulated rainfall

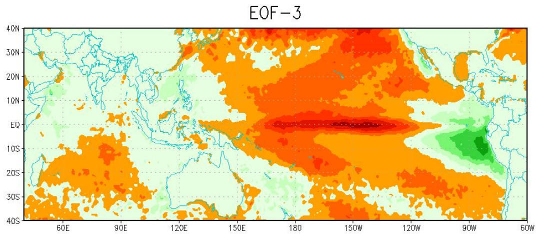


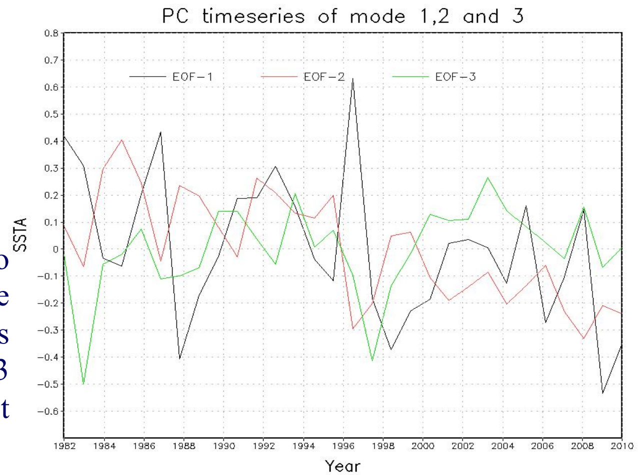
Model is unable to capture this feature. Rainfall is strongly correlated with SST over Indian Ocean which may not be correct.

EOF analysis of Sea Surface Temperature Anomaly

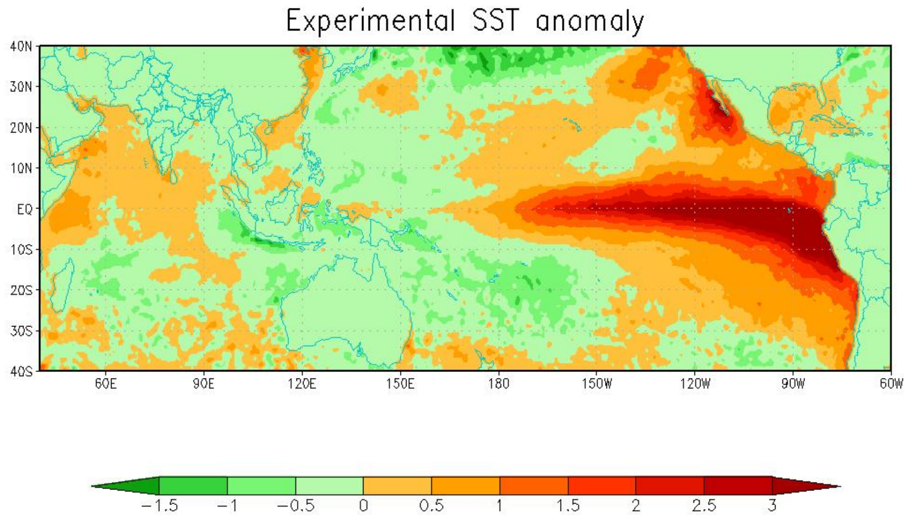






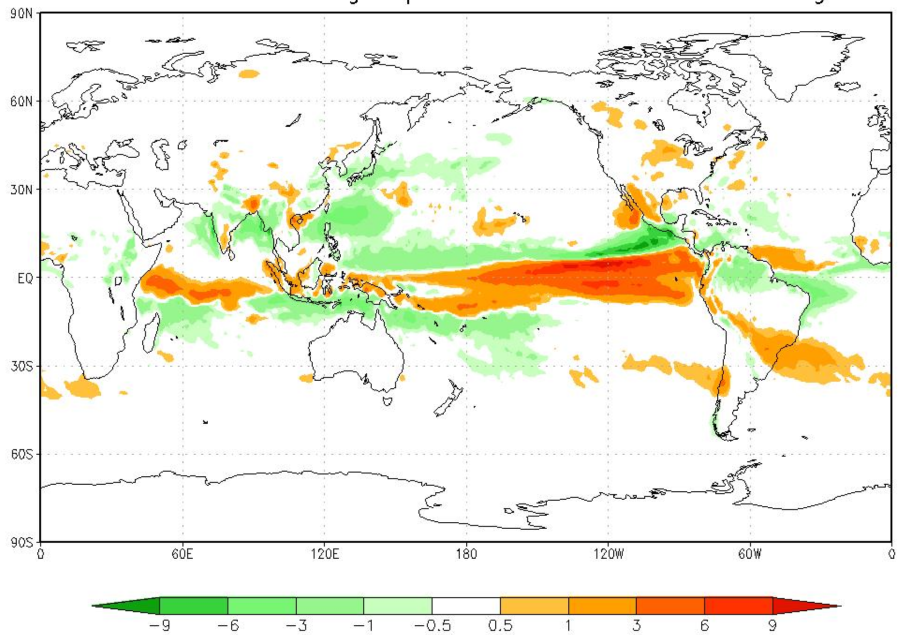


The EOF-1captures the well-known El Niño pattern. This mode explains about 27% of the Pacific SST variability. EOF-2 mode explains about 14% variance in Pacific SST. EOF-3 explains 9% variance. First EOF is the most dominant pattern of variability.

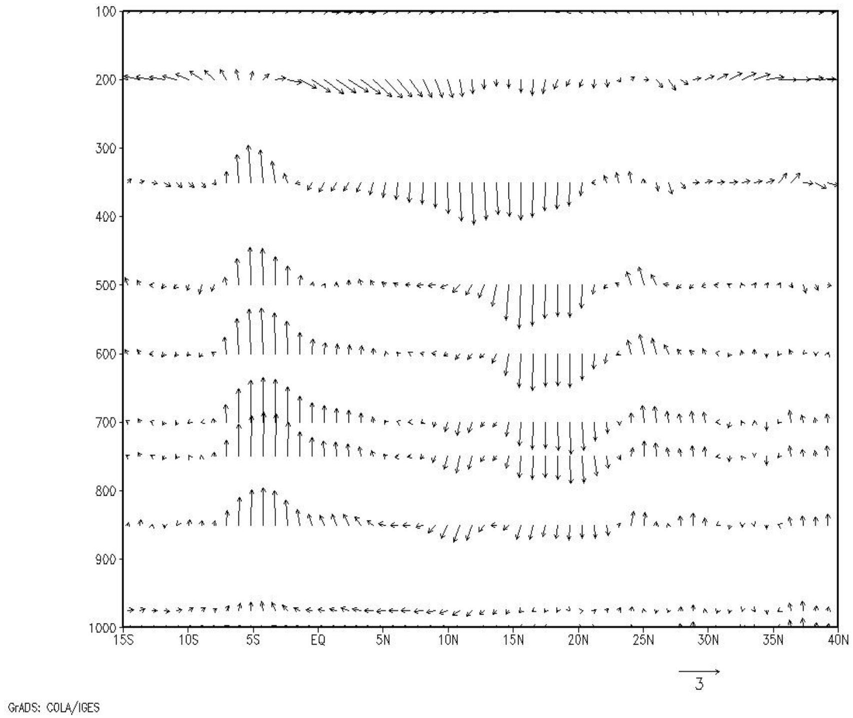


Experimental SST is the addition of climatological SST and contribution of first mode of SST anomaly. This new SST is the boundary forcing for the experimental run of 16 season.

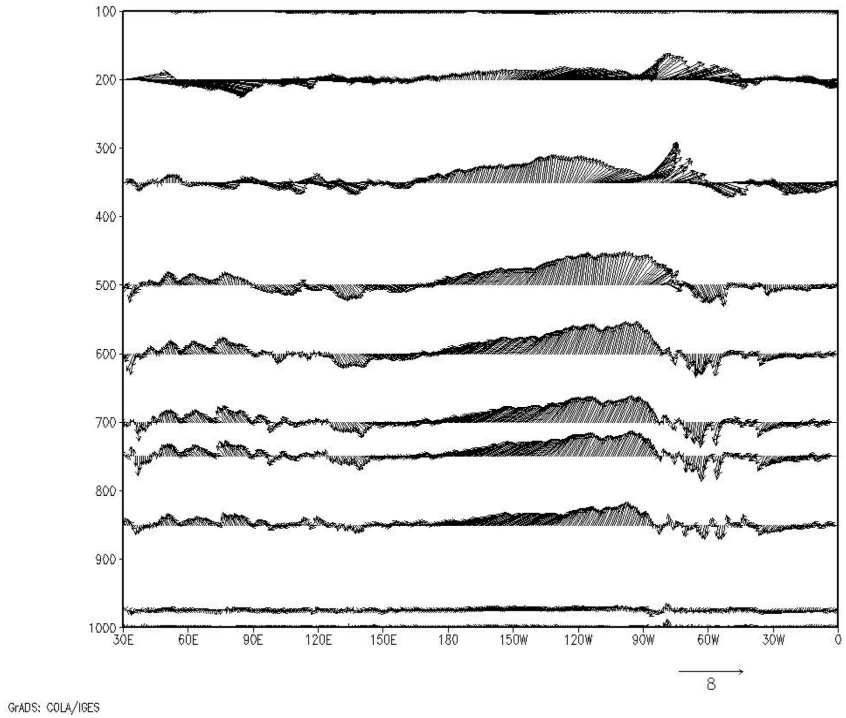
Difference in rainfall using experimental SST and Climatological SST



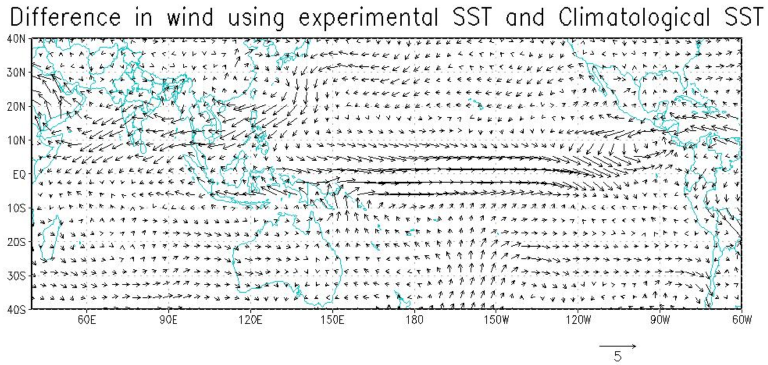
When SST increases in Pacific region, rainfall decreases in most part of the BIMSTEC region



JJAS Hadley circulation, representing the latitude-height section (longitude averaged from 70 to 95^{o}E) of meridonial and pressure vertical velocities (scaled by -100) for el-Nino case (Difference of EXP and CLIM)



JJAS Walker circulation, representing the longitude-height section (latitude averaged from 10S to 10N) of zonal and pressure vertical velocities (scaled by -100) for el-Nino case (Difference of EXP and CLIM)



Wind pattern is consistent with circulation during ENSO. Model simulates westerly anomalies at 850-hPa over the equatorial pacific. Northeasterly and easterly wind anomalies covers the BIMSTEC region. This weakens southwest monsoon

Thanks