ICTP-IITM-COLA Targeted Training Activity (TTA)

"Towards *Improved Monsoon Simulations*" at the ICTP from 13 June 2016 to 17 June 2016.

Title

SIMULATION OF INTRASEASONAL OSCILLATIONS OF THE INDIAN SUMMER MONSOON IN THE CMIP5 MODELS & RELATIONSHIP BETWEEN THE MONSOON DEPRESSIONS AND INTRASEASONAL VARIABILITY

By

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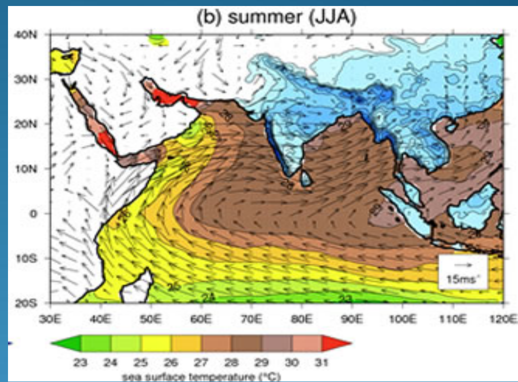
OUTLINE

- ✓Introduction
- ✓Objective
- ✓Data and Methodology
- ✓Results
- ✓conclusions

INTRODUCTION

Monsoon generally refers from the seasonal reversal in both precipitation and wind fields. As long as the wind is concerned, the monsoon circulation is characterized as a climate system with seasonal reversal in winds over and around the continents.

Summer monsoon



Source:

Precipitation is shown only for the land regions of Monsoon Asia from the APHRODITE dataset (Yatagai *et al.*, 2012); SSTs are from the HadISST dataset (Rayner *et al.*, 2003) from while 850hPa winds are taken from the ERA-40 Reanalysis (Uppala *et al.*, 2005).

Title of the work

SIMULATION OF INTRASEASONAL OSCILLATIONS OF THE INDIAN SUMMER MONSOON IN THE CMIP5 MODELS

Motivation of this study :

To examine whether observed features of the Intra seasonal oscillations (ISO's) of Indian summer monsoon are well represented in CMIP5 models or not?

Purpose of this study

A principal purpose of this study is to analyze the time series to find out the the periodicity of Intraseasonal Oscillations in Excess and Deficient years during 1986-2005 (time-period)

DATA AND METHODLOGY

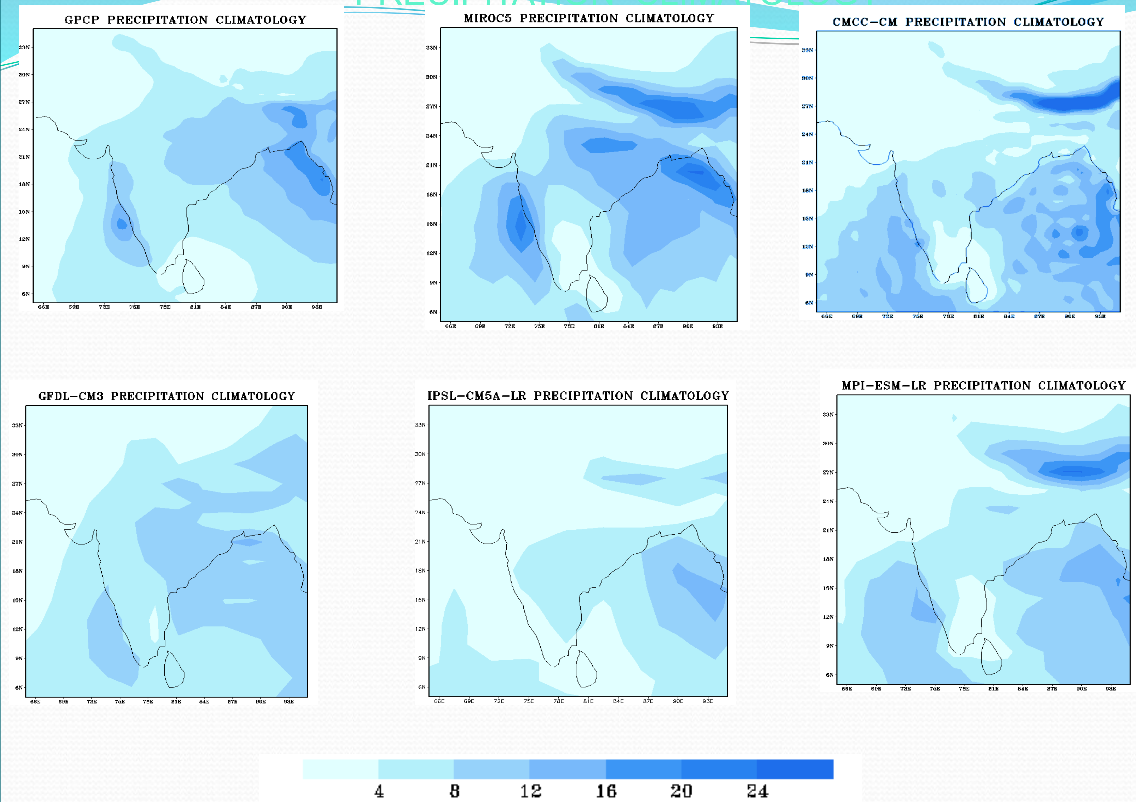
The daily precipitation field from the historical run of the out of 32 models I have chosen 5 models partici CMIP5 is used in this study . Sabeerali et al., 2013 suggested following models are fairly well represents monsoon ISO. So, we decided to choose these models for our study.

Details of the 5 Models That Participated in the CMIP5 Project

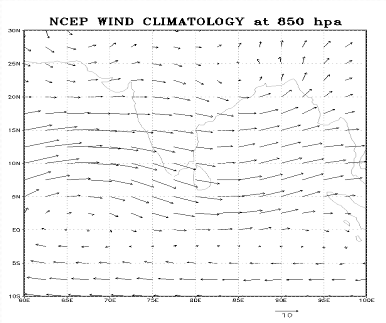
Model	Institution	Horizontal Resolution (lat × Lon)
CMCC-CM	Centro Euro-Mediterraneo per I Cambiamenti Climatici, Italy	T159L31
GFDL-CM3	Geophysical Fluid Dynamics Laboratory, USA	$2^\circ \times 2.5^\circ$ L48
IPSL-CM5A-LR	Institut Pierre-Simon Laplace, France	$1.875^\circ \times 3.75^\circ$ L39
MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology, Japan	T85 L40
MPI-ESM-LR	Max Planck Institute for Meteorology (MPI-M), Germany	T63 L47

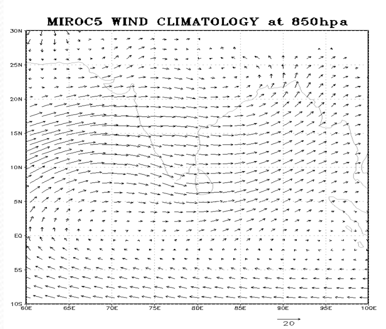
✓For validating the model outputs, for the period 1986–2005 and the daily Global Precipitation Climatology Project (GPCP) precipitation data for the period 1997–2008 [*Huffman et al.*, 2001] were also used. Since our focus is to assess the simulation of the BSISO of these 5 models, all the analyses are done for the season June to September (JJAS). Mean monthly or daily averaged NCEP/NCAR global wind data during 20 year period (1986-2005) have been used in the present study. these data sets have a spatial coverage of 2.5^0 lat× 2.5^0 long.

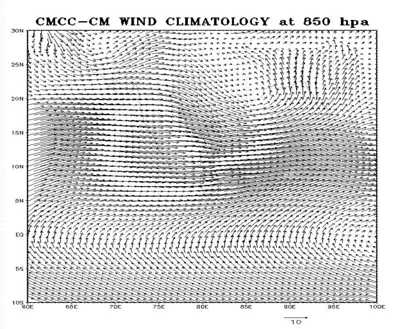
PRECIPITATION CLIMATOLOGY

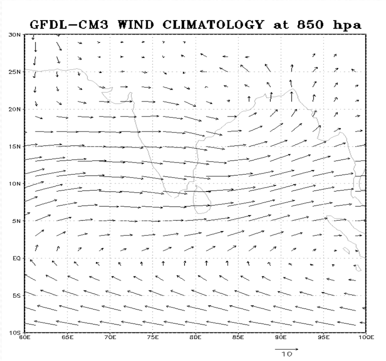


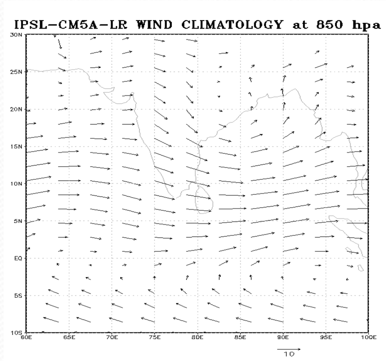
WIND CLIMATOLOGY at 850 hpa

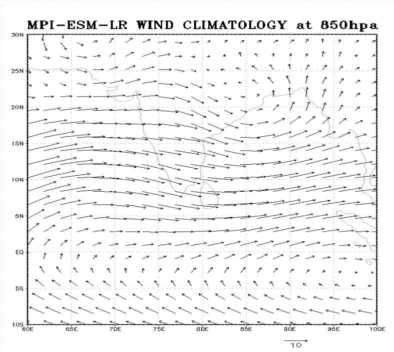




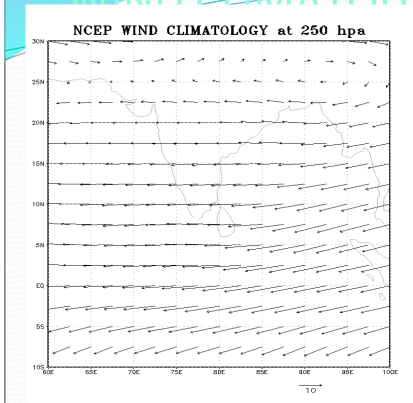


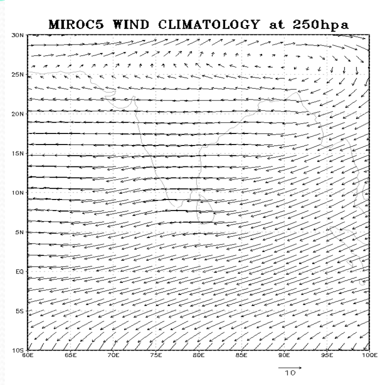


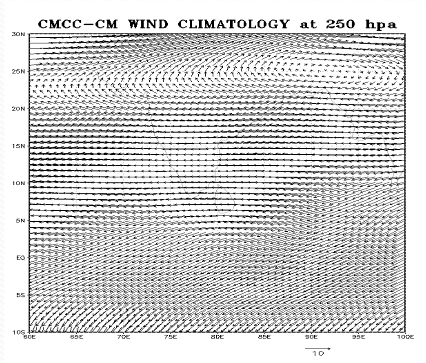


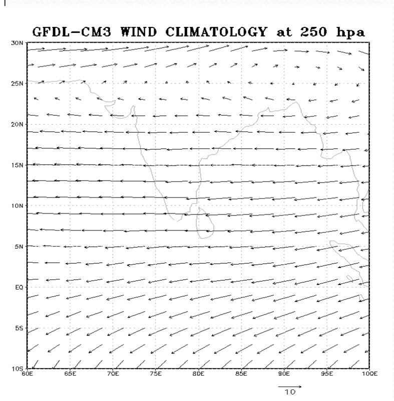


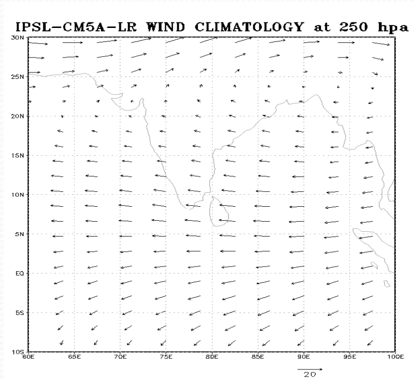
WIND CLIMATOLOGY at 250 hpa

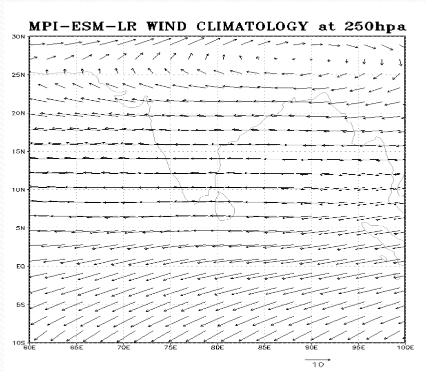






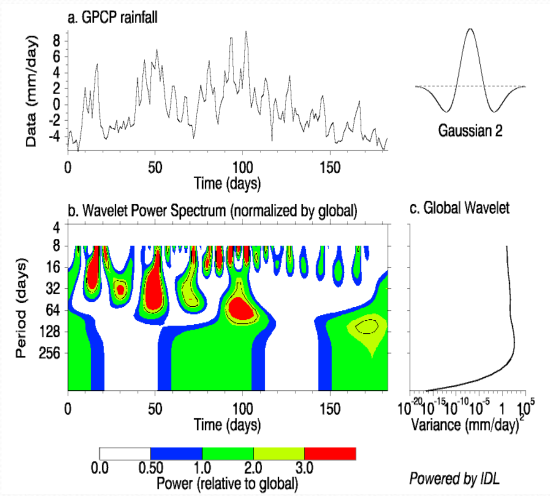




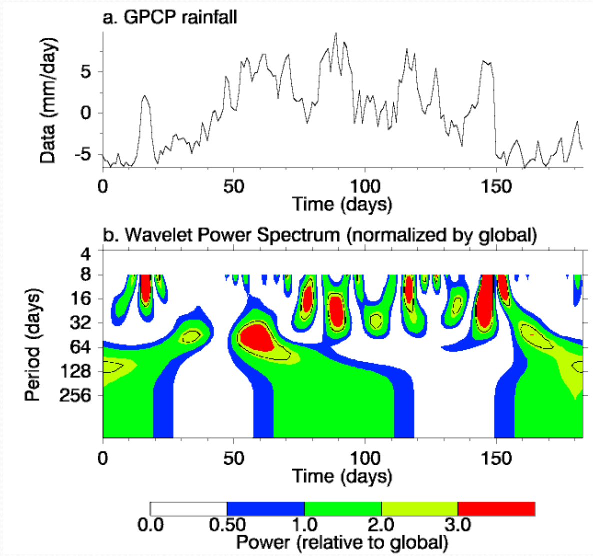


Time series of rainfall anomalies and wavelet spectrum of 184 days rainfall over the monsoon core region 10-30° N 70-100°E. The x axis denotes days from 1 June to 31October and y axis rainfall anomalies.

GPCP excess (Rf)-1997

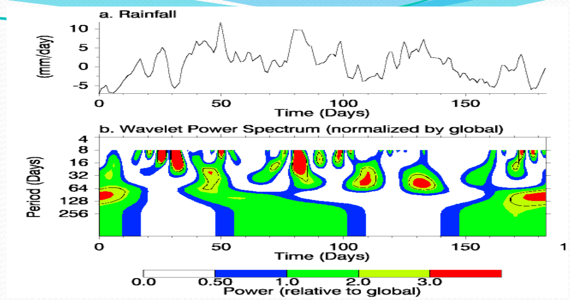


GPCP deficient (Rf)-2002

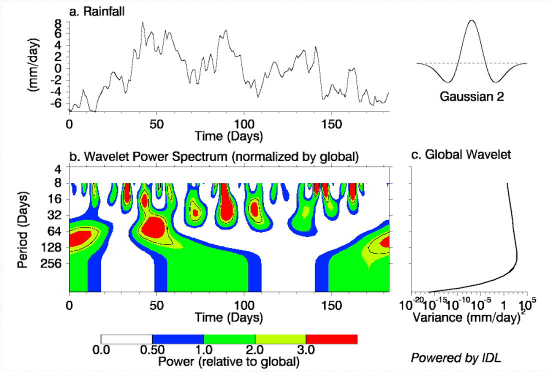


MIROC5-Excess (Rf)-1994

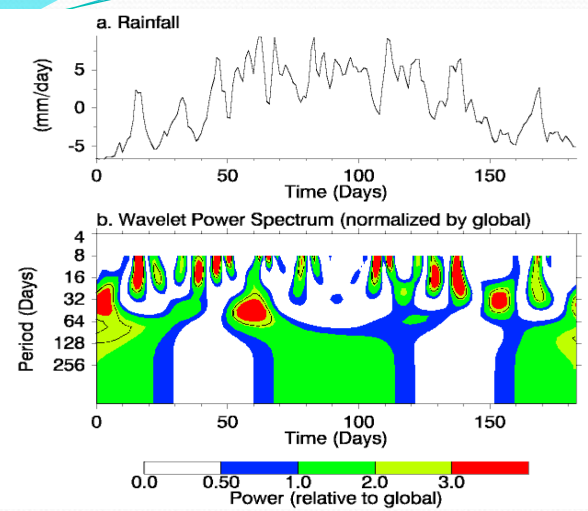
MIROC5 from excess year-(1994) shows the throughout the monsoon season June- October, 3-7 and 10-20 days ocillations are dominant. 30-60 days are very weak these peaks of anomalies 8-10 mm/day. Deficient year-(1991) shows the maximum rainfall 4-6 mm/day also 30-60 days are dominant at the start of the season there happen to be a dry period around 30 days at the onset phase which may contribute to overall decrease in seasonal quantum. Also an oscillation of around 20-30 days dominates the peak months of August which also affect the seasonal total rainfall.



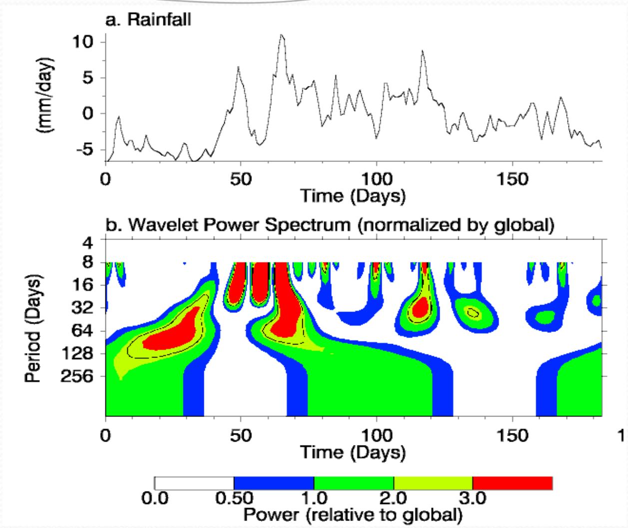
MIROC5-deficient(Rf)-1991



CMCC-CM-Excess(Rf)-1998

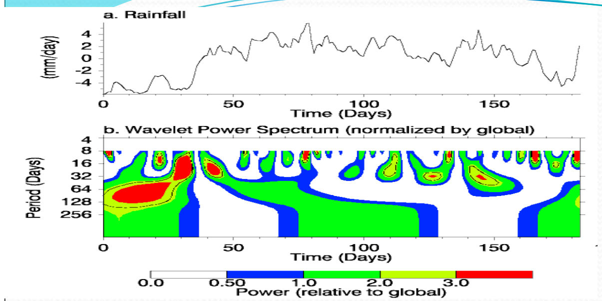


CMCC-CM-Deficient (Rf)-1987

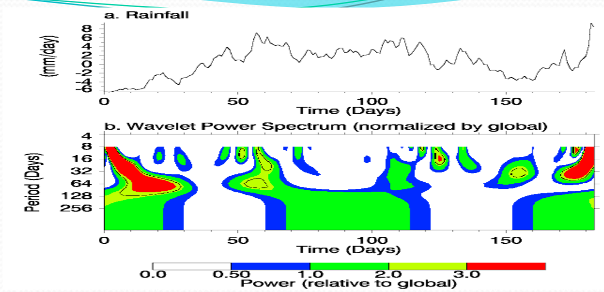


CMCC-CM from excess year - (1998) shows the low frequency oscillation of 30-60 days dominant at the start of the seasons and then throughout the season high frequency oscillations of 8-15 days are dominant during the excess-monsoon.

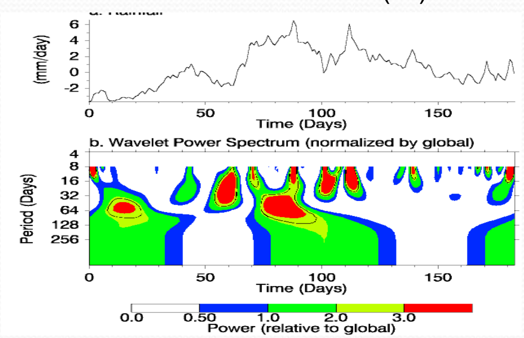
GFDL-CM3-Excess (Rf)-1991



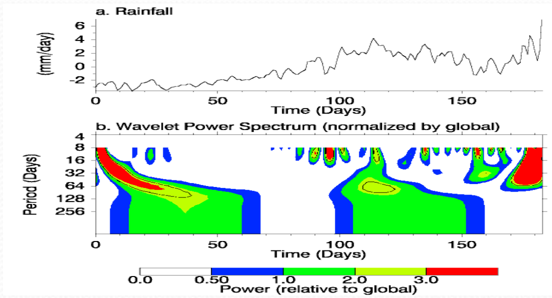
GFDL-CM3-deficient (Rf)-1997



IPSL-CM5A-LR-Excess(Rf)-1986

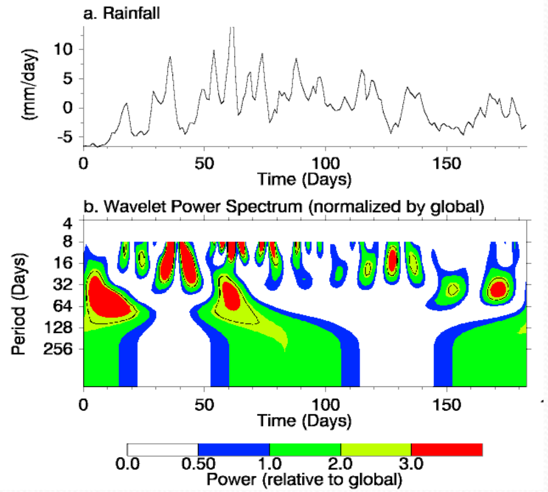


IPSL-CM5A-LR-deficient (Rf)-1987

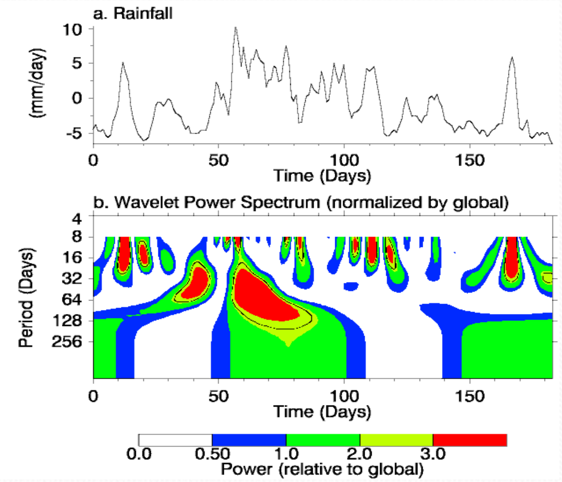


However GFDL-CM3 and IPSL-CM5A-LR does not Show conspicuous difference in the intraseasonal behavior of excess/deficient Monsoons.

MPI-ESM-LR-excess (Rf)-1998

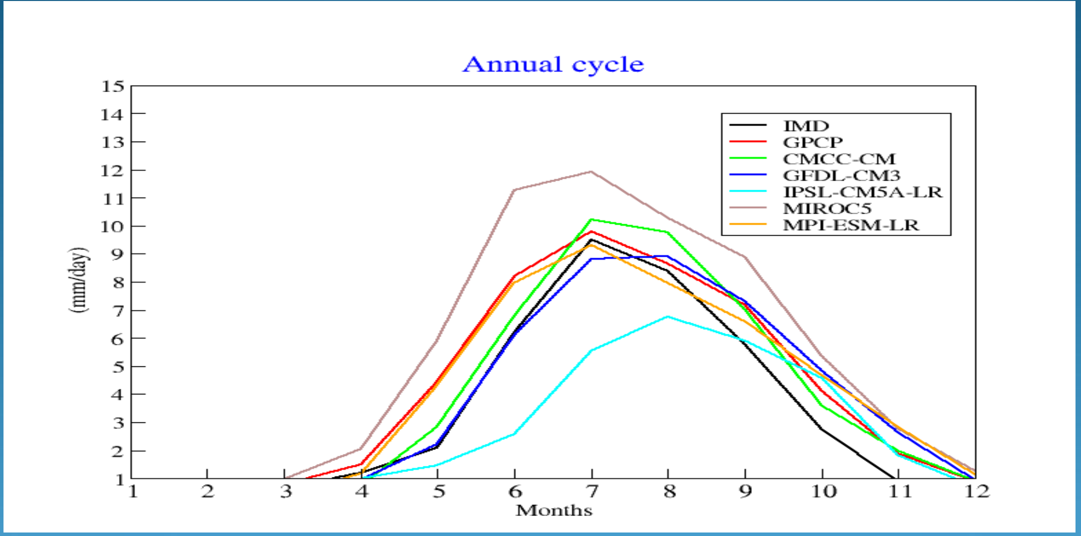


MPI-ESM-LR-deficient (Rf)-1989



MPI-ESM-LR model is characterized by dominance of 30-60 day mode in the month of June and July which may have significant impact on the seasonal quantum of rainfall.

Earlier studies (Ajayamohan and Goswami, 2007; Sperber and Annamalai, 2008) have suggested that the better representation of the BSISO associated with the ASM in a model depends on how well the model simulated the seasonal mean precipitation over the Indo-Pacific domain. Further, they also suggested that the spatial pattern of BSISO variance closely follows the spatial pattern of maximum seasonal mean precipitation regions. Therefore, here we examine the ability of the models in simulating the annual cycle, and climatological JJAS mean precipitation.



The annual cycle of the precipitation simulated in the 5 CMIP5 models over the monsoon core region (10°N–30°N, 70°E–100°E) together with observation (black & red line).

RESULTS

➢The observed climatology of seasonal rainfall from GPCP and IMD shows the centers of maximum rainfall one over the Western Ghats and the other one along the head Bay of Bengal. The rainfall over North West region and south east peninsula is minimum. The rainfall increases from North West to central India and decreases south eastward. Observed features are well simulated by MIROC5 and MPI-ESM-LR both simulates one more center of maximum rainfall over eastern Himalayan region.

➢MIROC5 simulate the wet (dry) bias over central India. CMCC-CM simulates maximum rainfall over north eastern parts slightly southward. GFDL-CM3 do simulate more rainfall over Western Ghats and North eastern parts, however with dry bias.

➢IPSL-CM5A-LR fails to capture the observed climatology. Thus there is large disagreement among models in simulating seasonal pattern of rainfall. However, these are important factors for better simulation of the BSISO. Almost MIROC5, MPI-ESM-LR, IPSL-CM5A-LR, GFDL-CM3, CMCC-CM models simulate the wind climatology well.

- Observed features of the intraseasonal variability by using wavelet analysis technique well captured by these CMCC-CM, MIROC5, MPI-ESM-LR. However GFDL-CM3 and IPSL-CM5A-LR does not Show conspicuous difference in the intraseasonal behavior of excess/deficient Monsoons. While two models are unable to reproduce the intraseasonal variability well, by using wavelet Analysis Technique. Even though fails to capture the observed features of intraseasonal variability by wavelet analysis technique with two models but wind climatology simulates properly with these five models.

- In this study CMCC-CM, MIROC5, MPI-ESM-LR are able to capture the observed features of the intraseasonal variability of the Indian summer monsoon.

- GFDL-CM3 and IPSL-CM5A-LR are fails to capture the observed features of the intraseasonal variability by using wave-let analysis technique.Five models out of 32 models give an opportunity to study the BSISO and its modulations under future warming scenarios.

Objective of this study

To understand the relationship between the monsoon depressions and intraseasonal variability over India.

Chen and wang (1999) studied the Intraseasonal variability in the South Asian summer monsoon strongly modulates the occurrence, frequency and tracks of monsoon depressions over the Indian monsoon region.

- ✓ **Monsoon depression is one of the most important synoptic scale disturbances on the quasi-stationary planetary scale** monsoon **trough over the Indian region during the summer** monsoon **season (June to September) in regard to its intensity and associated rainfall rates.**

- ✓ which mostly develops over North Bay of Bengal along the west or northwest track along the interior of India.

- ✓ **Its** presence or absence has important implications from the point of view of drought conditions over the monsoon domain.

- ✓ Climatology reveals that monsoon depressions generally from the Northern portion of the Bay of Bengal. The area covered by latitudes 17.5º N to 22.5º N and longitudes 87.5 º E to 90º E alone accounts
- ✓ 60 % of the total formations during July and August.

- ✓ In the month of September the zone of formation shifts somewhat southward.

- ✓ Thus climatologically the northern Bay of Bengal in July and August is a favorable region for cyclogenesis.

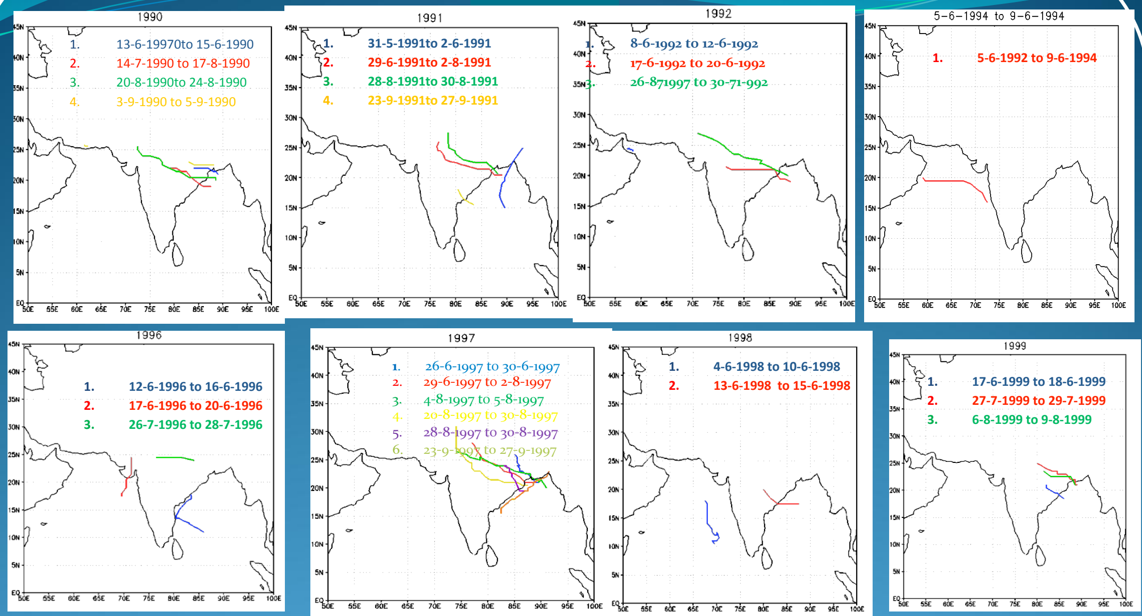
Data and Methodology

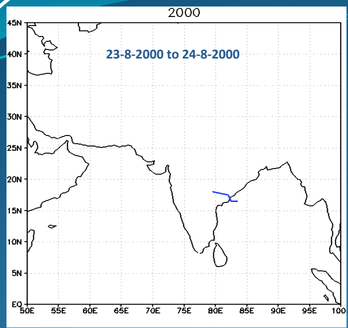
Data

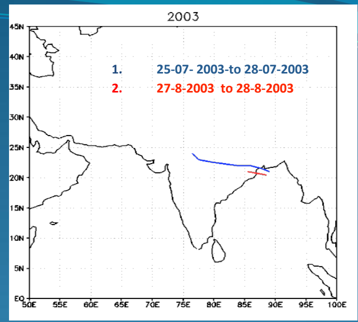
- ✓ Daily averaged NCEP/NCAR global wind data during 18 year period (1990-2007) have been used in the present study. These data sets have a spatial coverage of 2.5^{0} lat× 2.5^{0} long.
- ✓ The other ground-based rain data used here is from IMD. IMD prepared daily gridded rainfall datasets at 0.5 lat /long. Resolution (Rajeevan and Bhate2009). The higher res-solution IMD analysis at 0.5°lat./long.

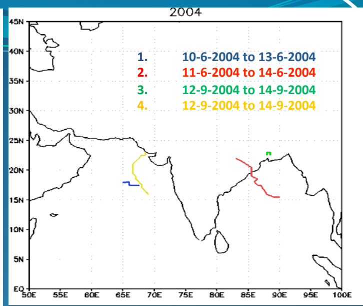
- ✓ **Methodology**
- ✓ Tracks of IMD to observe the tracking of Monsoon Depressions over Bay of Bengal.
- ✓ Wave-let Analysis to find out the periodicity and number of intraseasonal oscillations.
- ✓ Time-latitude cross section plots to observe the northward propagation of intraseasonal oscillations.
- ✓ Zonal Wind at 850 hPa by pentad analysis to detect the exact location of the low pressure area.
- ✓ Correlation method between rainfall and wind at 850 hPa.

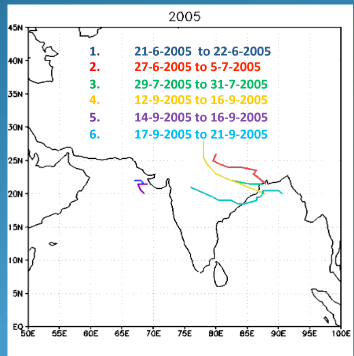
RESULTS

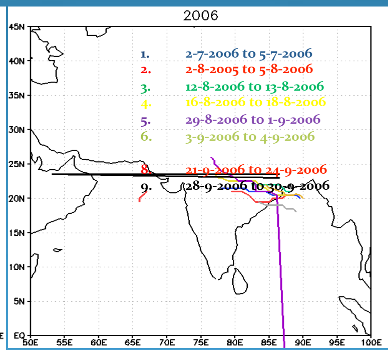

1990
1. 13-6-19970to 15-6-1990
2. 14-7-1990 to 17-8-1990
3. 20-8-1990to 24-8-1990
4. 3-9-1990 to 5-9-1990
1991
1. 31-5-1991to 2-6-1991
2. 29-6-1991to 2-8-1991
3. 28-8-1991to 30-8-1991
4. 23-9-1991to 27-9-1991
1992
1. 8-6-1992 to 12-6-1992
2. 17-6-1992 to 20-6-1992
3. 26-871997 to 30-71-992
5-6-1994 to 9-6-1994
1. 5-6-1992 to 9-6-1994
1996
1. 12-6-1996 to 16-6-1996
2. 17-6-1996 to 20-6-1996
3. 26-7-1996 to 28-7-1996
1997
1. 26-6-1997 to 30-6-1997
2. 29-6-1997 to 2-8-1997
3. 4-8-1997 to 5-8-1997
4. 20-8-1997 to 30-8-1997
5. 28-8-1997 to 30-8-1997
6. 23-9-1997 to 27-9-1997
1998
1. 4-6-1998 to 10-6-1998
2. 13-6-1998 to 15-6-1998
1999
1. 17-6-1999 to 18-6-1999
2. 27-7-1999 to 29-7-1999
3. 6-8-1999 to 9-8-1999

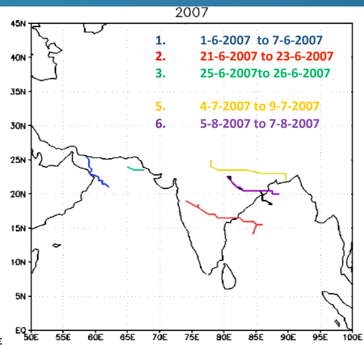

2000
23-8-2000 to 24-8-2000


2003
1. 25-07- 2003-to 28-07-2003
2. 27-8-2003 to 28-8-2003

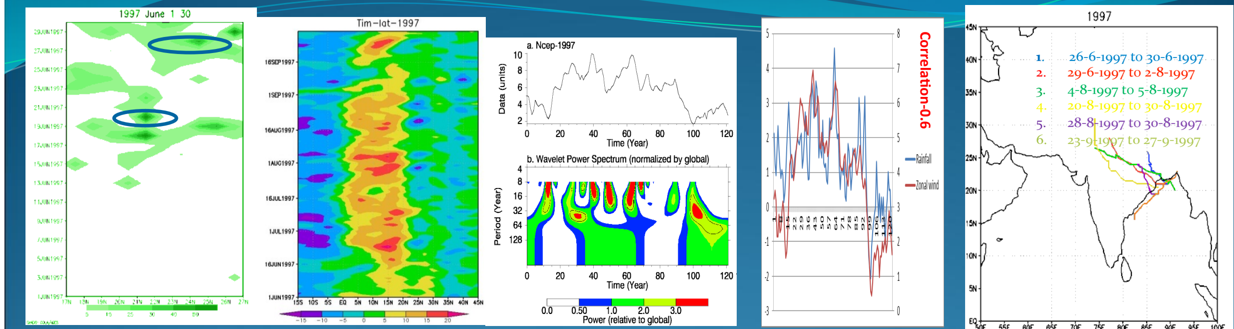

2004
1. 10-6-2004 to 13-6-2004
2. 11-6-2004 to 14-6-2004
3. 12-9-2004 to 14-9-2004
4. 12-9-2004 to 14-9-2004


2005
1. 21-6-2005 to 22-6-2005
2. 27-6-2005 to 5-7-2005
3. 29-7-2005 to 31-7-2005
4. 12-9-2005 to 16-9-2005
5. 14-9-2005 to 16-9-2005
6. 17-9-2005 to 21-9-2005

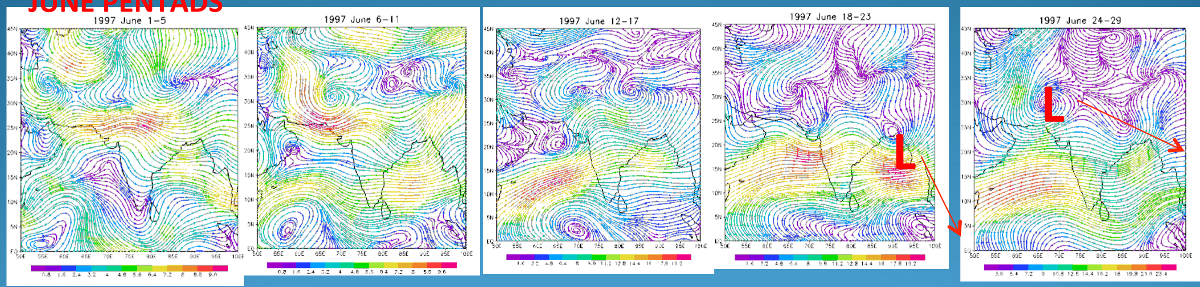

2006
1. 2-7-2006 to 5-7-2006
2. 2-8-2005 to 5-8-2006
3. 12-8-2006 to 13-8-2006
4. 16-8-2006 to 18-8-2006
5. 29-8-2006 to 1-9-2006
6. 3-9-2006 to 4-9-2006
8. 21-9-2006 to 24-9-2006
9. 28-9-2006 to 30-9-2006


2007
1. 1-6-2007 to 7-6-2007
2. 21-6-2007 to 23-6-2007
3. 25-6-2007to 26-6-2007
5. 4-7-2007 to 9-7-2007
6. 5-8-2007 to 7-8-2007

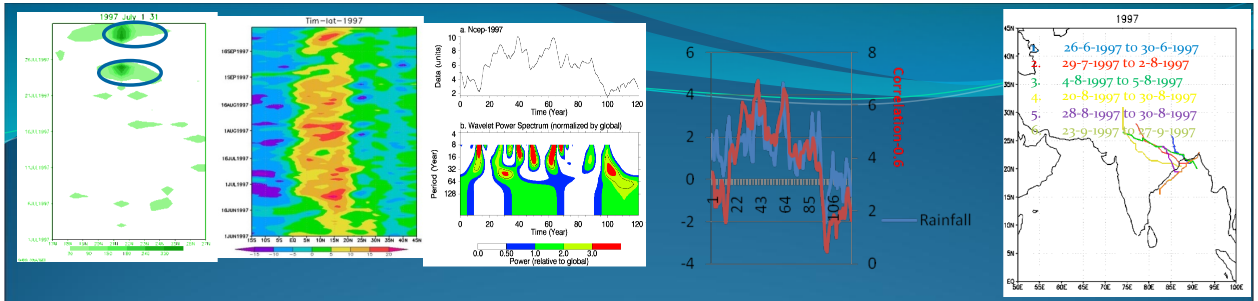
Normal Rainfall year-1997



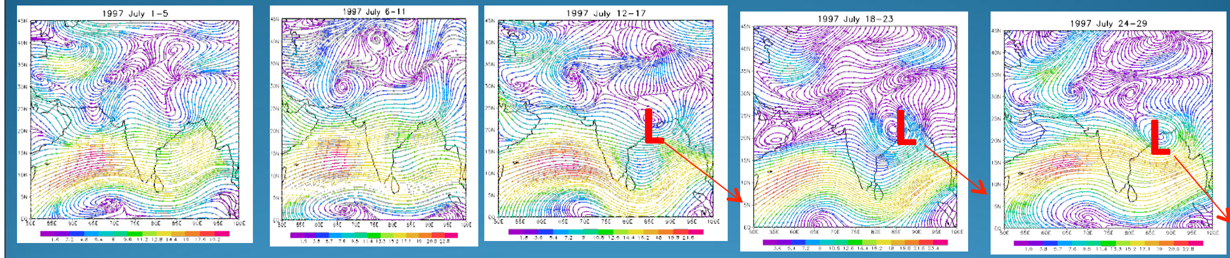
JUNE PENTADS



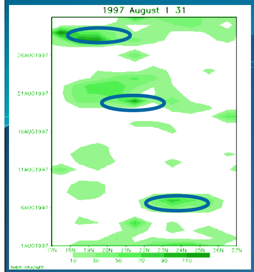
In this year six depressions are observed in the normal year . The bands starting from equator ward and moving northward it indicated that convection Zone is moving towards northward intensity of depressions is very less.

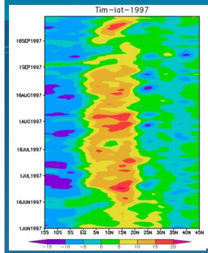


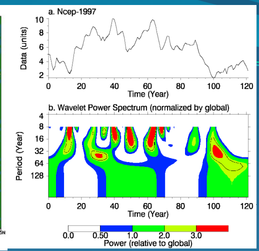
JULY

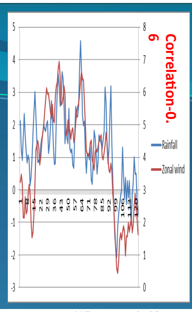


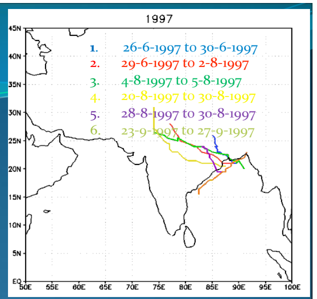
wind speed intensified with the increasing precipitation. Then in July 29th one more depression observed at between 15˚-20˚N with the wind speed more than 15 m/sec.

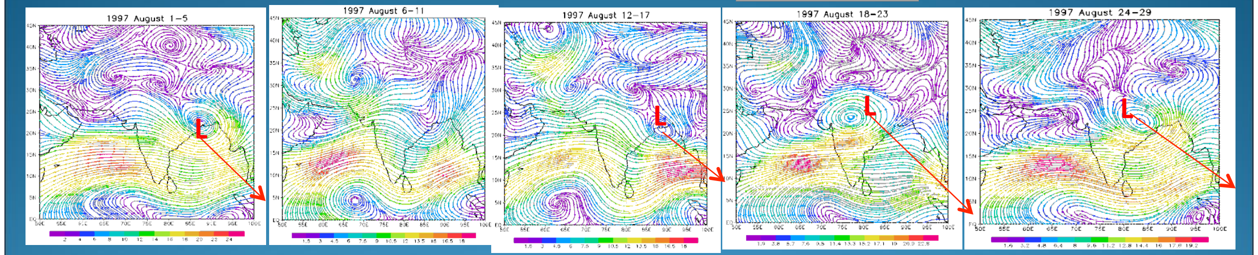




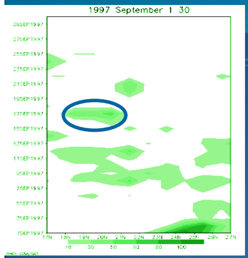


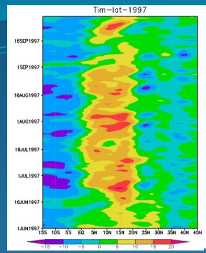


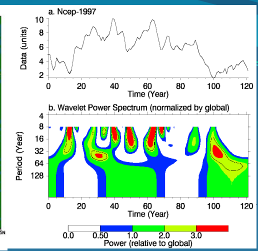


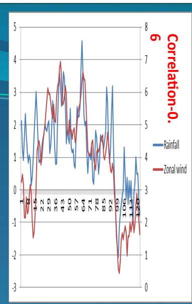


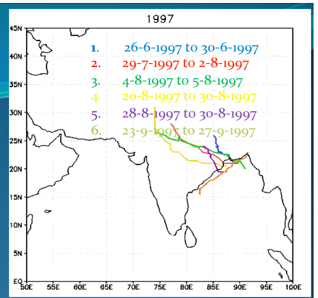
Then again in August (16, 20, 28) three depressions are observed with the windspeed 15-20m/sec at 15˚ N.



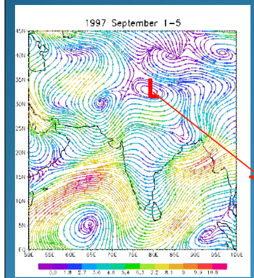


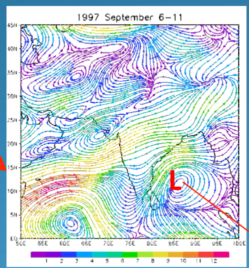


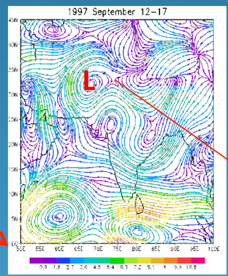


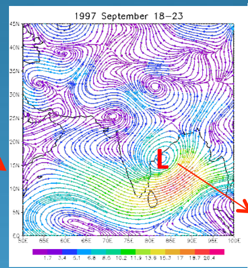


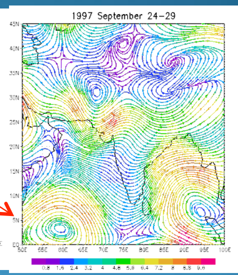
SEPTEMBER





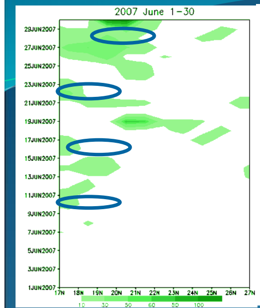


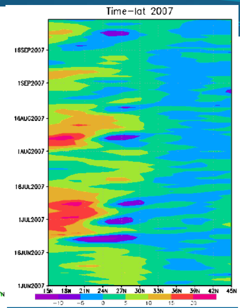


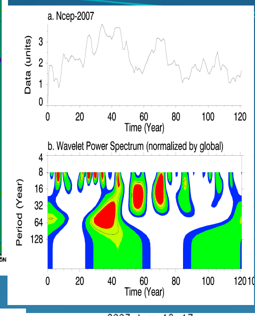


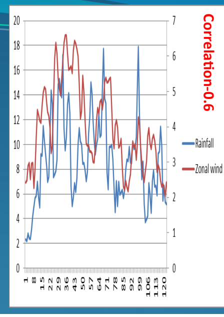
in September 23rd one depression has observed with the windspeed 15-20m/sec at 15° N.

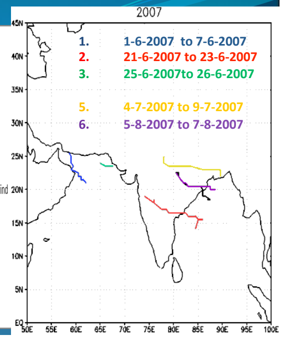
Excess rainfall year - 2007



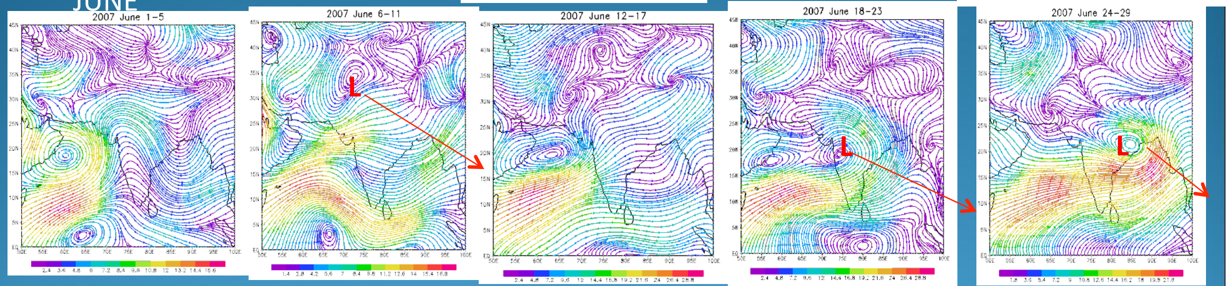




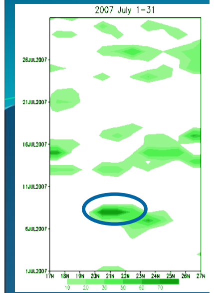


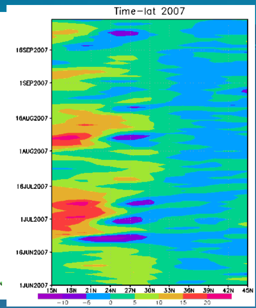


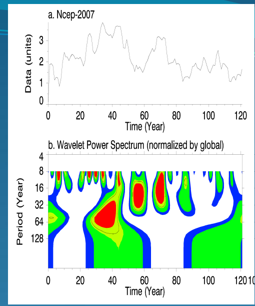
JUNE

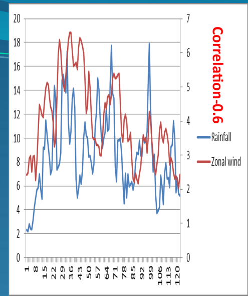


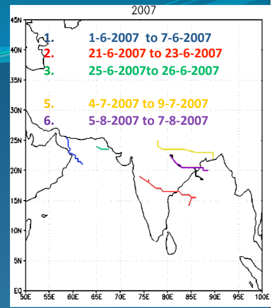
Monsoon was active in many days in June inspite of early onset over kerala on 28th may.
Further advancement due to super cyclonic storm (GONU) over the Arabian sea revived as a weak current on 9th June and subdued monsoon conditions prevailed till the third week of june with the formation of deep depression over central bay of bengal on 21 june.



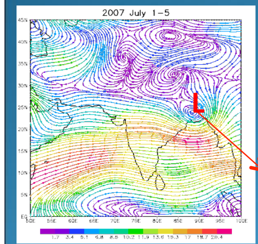


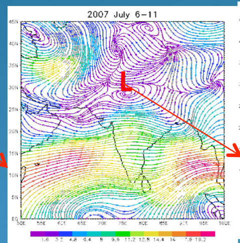


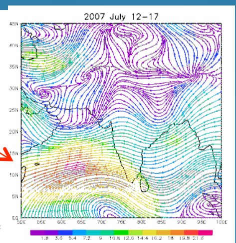


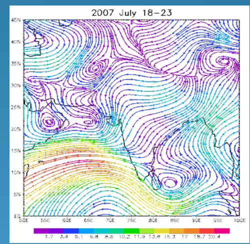


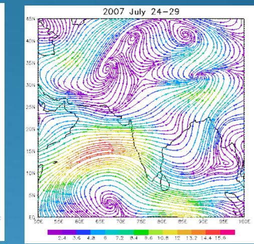
JULY



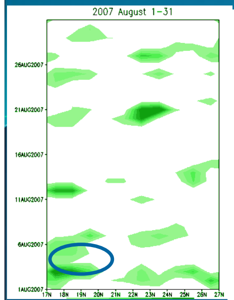


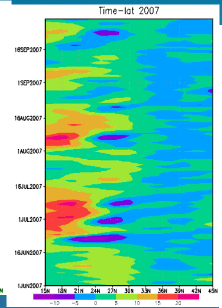


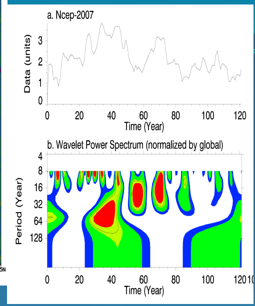


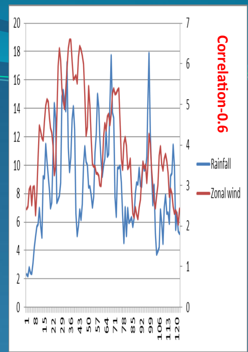


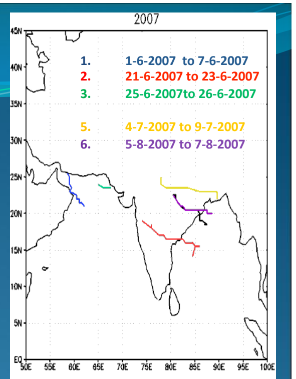
Due to formation of deep depression over Bay of Bengal on 21st June monsoon conditions revived and monsoon conditions remained active till 10th July during the 2nd half of the July Break like situations prevailed over the country.

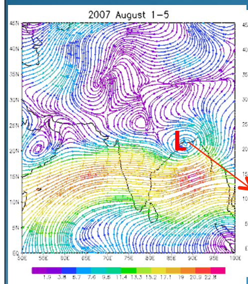


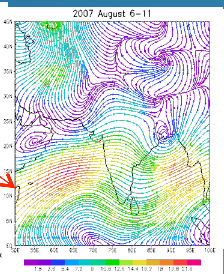


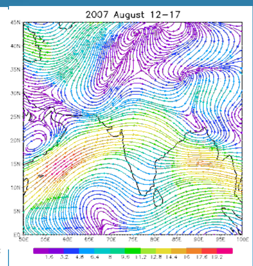


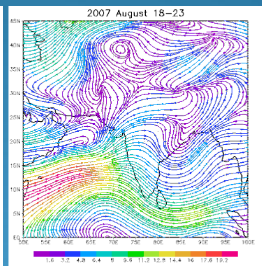


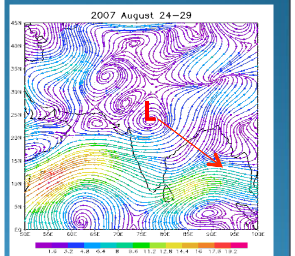






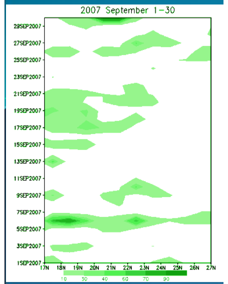


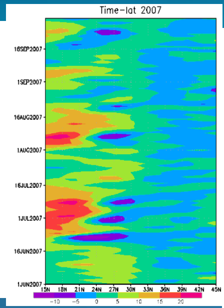


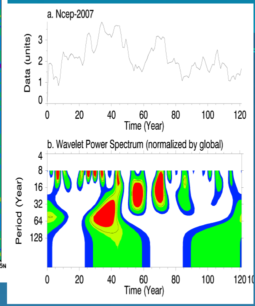


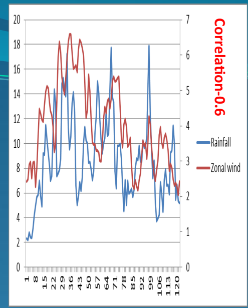
AUGUST

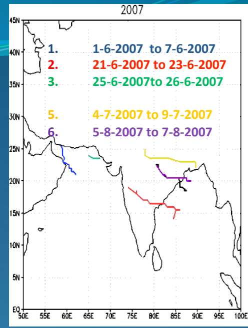
Monsoon again became active in the beginning of August and remained due to formation of Depression.



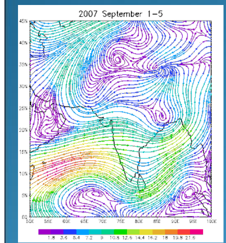


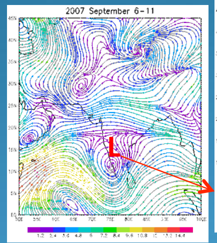


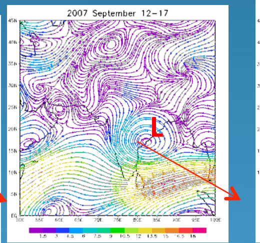


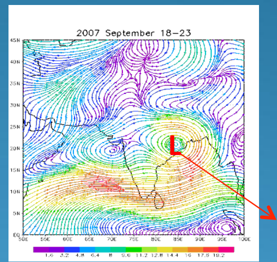


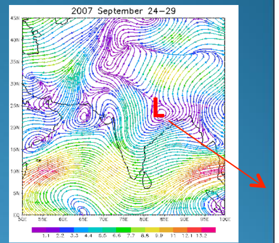
September





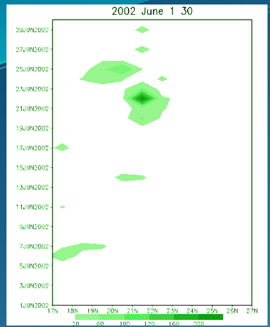


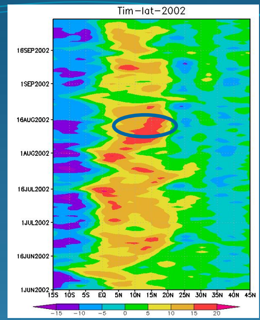


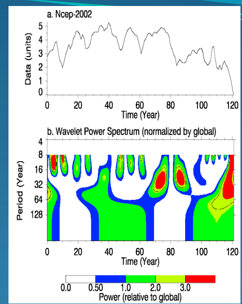


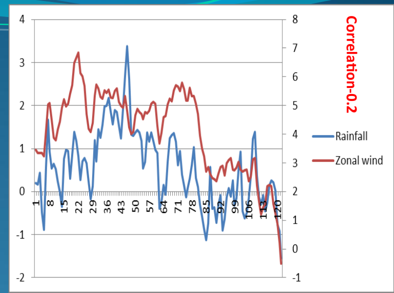
Monsoon recovered during the second week of September which caused heavy rains.
over many parts of the country the active conditions through east-west trough prevailed till the end of the season.

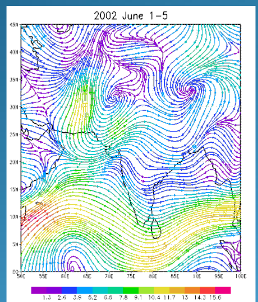
DEFICIENT RAINFALL YEAR - 2002

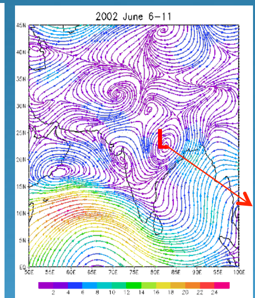


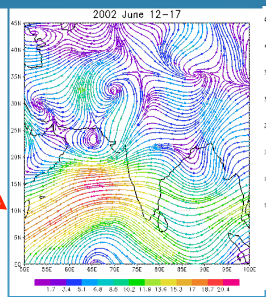


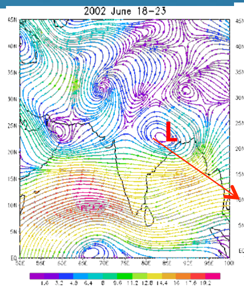


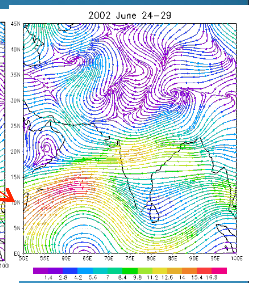




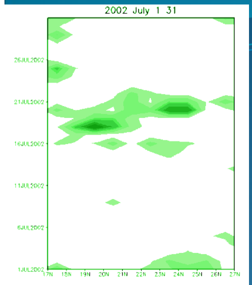


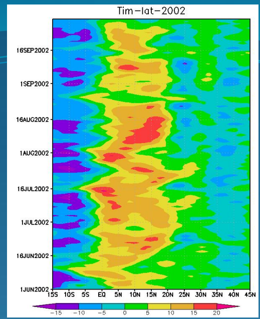


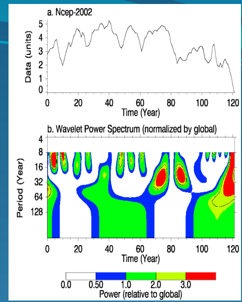


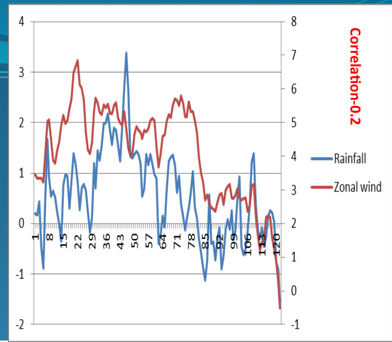


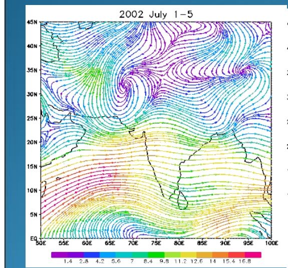
In this year there is no depression observed from above figure during the summer monsoon. The bands starting from equator ward and moving northward in this figure clearly we observed in the establishment phase of the monsoon there is no depression but wind speed is more than 20 m/sec at 5-20˚N.

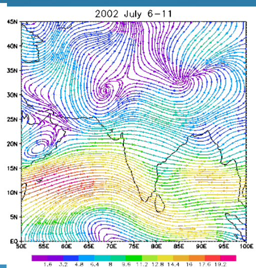


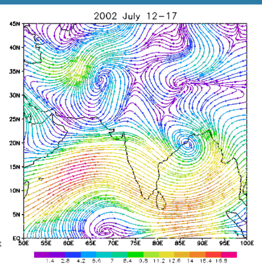


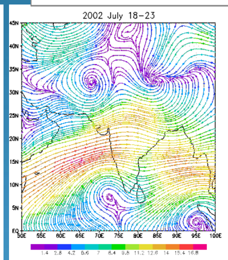


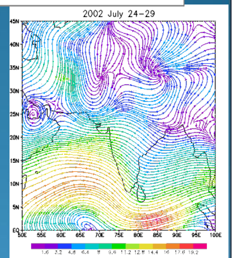




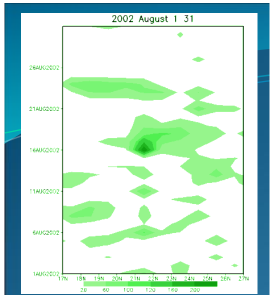


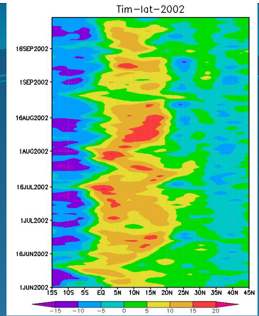


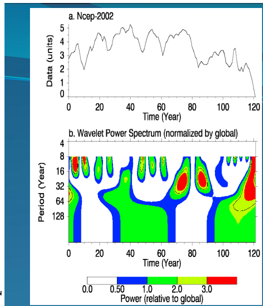


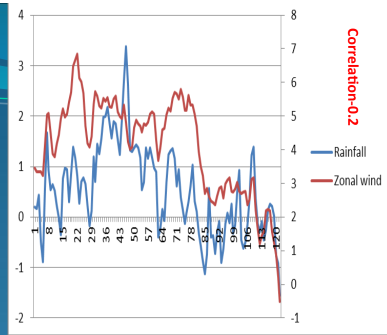


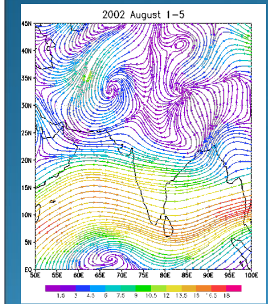
in July during principal rainy month there is no depressions but wind speed with 15 m/sec at 15-20˚N.

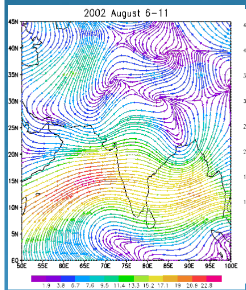


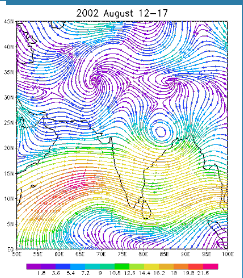


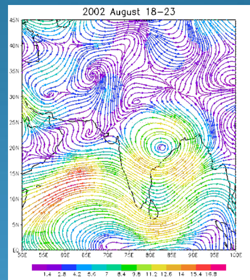


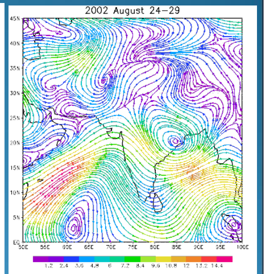




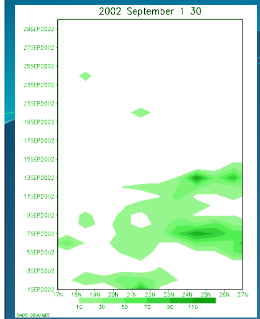


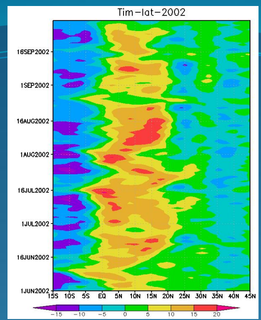


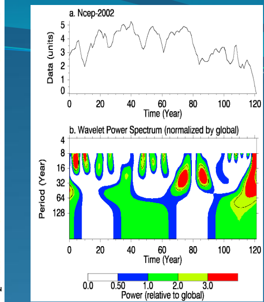


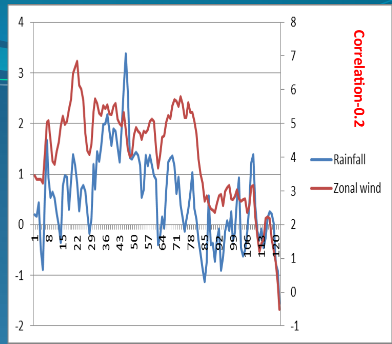


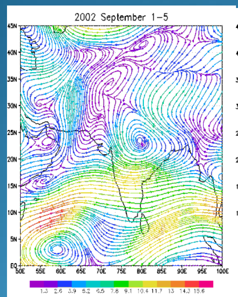
In August during break period there is no depression but wind speed more than 15 m/sec at 5-20˚N.

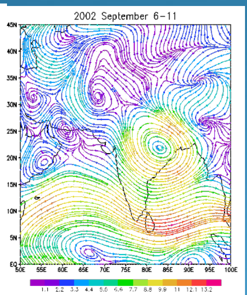


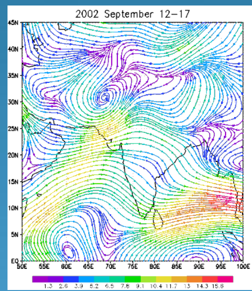


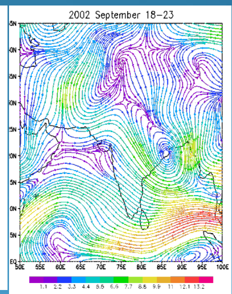


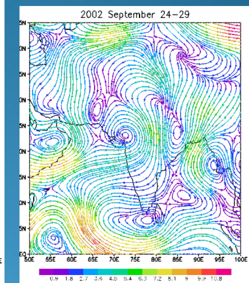












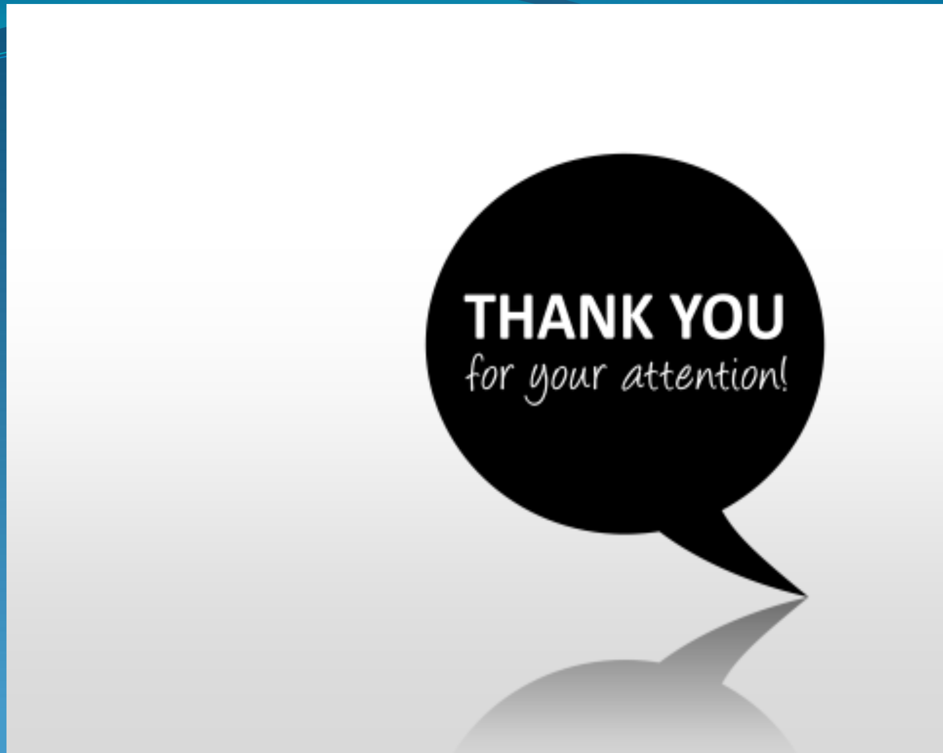
in September during withdrawal phase al so there no depressions but wind speed all so negligible.

Future work

❖Identification of genesis points for low pressure systems over the Bay of Bengal for the available period using regional model/ NCEP-NCAR reanalysis data.

❖To understand the dynamical /environmental parameters like windshear, Sea surface temperature, vorticity and potential vorticity maxima which controls genesis of monsoon deprssions; that leads to intraseasonal oscillation convective activity in northward direction over Indian domain.

❖Assess the monsoon depression relation on monsoon intraseasonal oscillation activity through statistical theories and regional and climate models.


THANK YOU
for your attention!