Climate Service Information System-Mechanism for Guiding Regional Climate Centres

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Objective, scope and functions of Climate Services Information System (CSIS) of WMO

- The Climate Services Information System (CSIS) component of the GFCS is the principal mechanism through which information about climate – past, present and future – is routinely archived, analysed, modelled, exchanged and processed.

- The CSIS is the 'operational core' of the GFCS; it is designed for producing and delivering authoritative climate information products through appropriate operational mechanisms, technical standards, communication and authentication. Its functions include climate analysis and monitoring, assessment and attribution, prediction (monthly, seasonal, decadal) and projection (50 years /centennial scale).

- Part of the CSIS is in place by different NHMS, but new infrastructure is needed to fulfil the GFCS vision.

The objectives of the CSIS are:

- Routinely to process and/or interpret data and products in order to generate and deliver user relevant climate information and knowledge. It will accomplish this by means of numerical, visual and text-based climate data, information and products that include, assessments, outlooks, warnings, bulletins, reports and statements useful for climate-related risk management and adaptation policies and decisions;

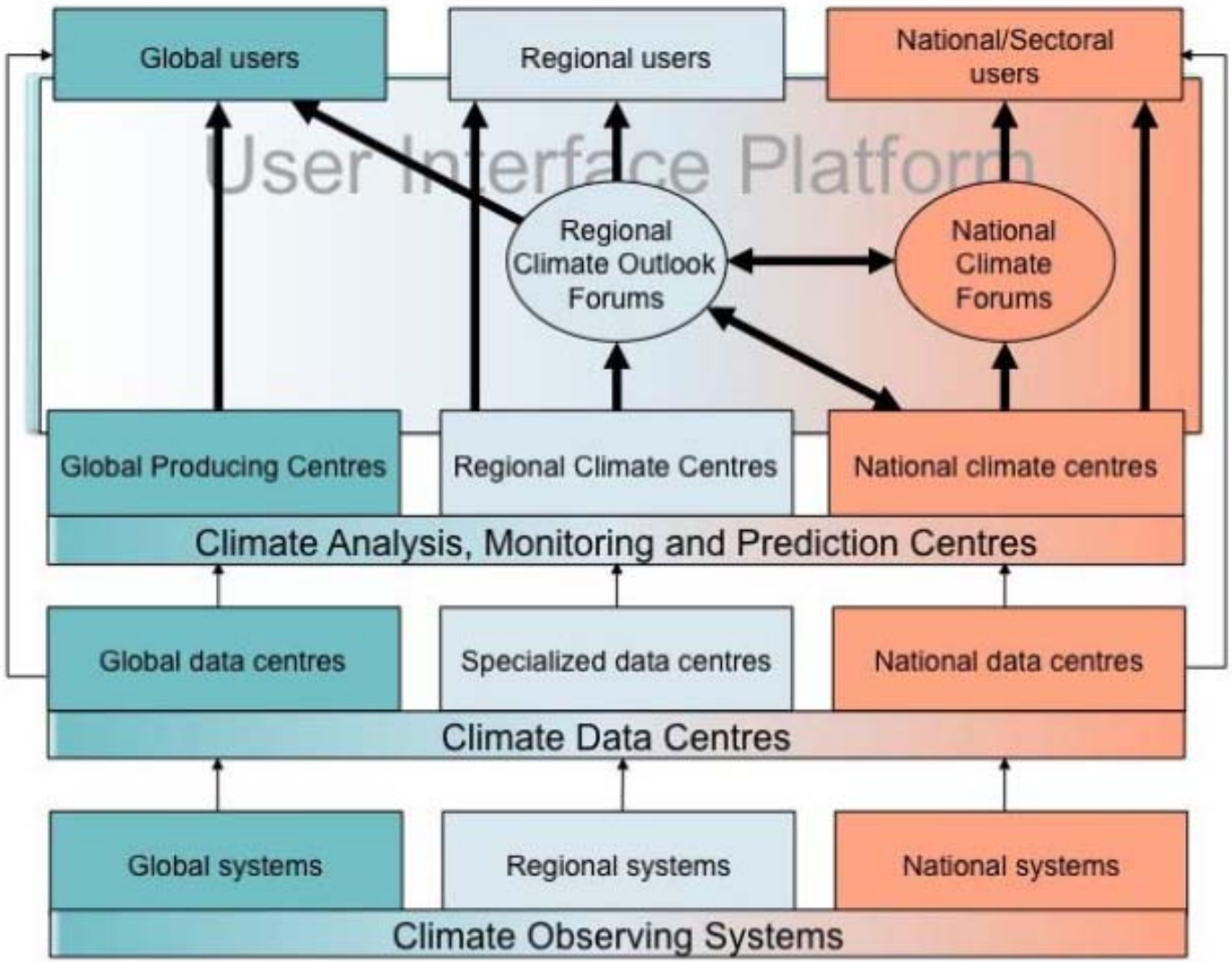
- To ensure that climate information and products (data, analysis, monitoring, prediction and projection) are generated, exchanged and disseminated in a timely manner through a three-tier network of collaborating institutions:

  - Globally through a range of advanced centres;
  - Regionally through a network of institutions with consensus-based regional mandates;
  - Nationally and locally by NMHSs and, through national institutional arrangements, their partners;

- To tailor global climate products to meet regional needs sustainably and operationally through strategically located regional climate centres, as well as according to mutual arrangements that support national requirements;

- To foster rapid development, operational production and dissemination of climate information at the national level by incorporating the relevant functions in national CSIS entities or other mechanisms that encompass the GFCS more broadly.

Major elements, structures and data/information flows of the CSIS



Data flows (thin lines) and value-added information flows (thick lines) into and through the entities and functions required for generating and delivering climate services. Implicit are the linkages and respective data and information exchanges between climate observing systems, the various climate data centres, and the climate analysis, monitoring and prediction centres. The central roles are played by the Regional Climate Outlook Forums and their national counterparts in synthesizing and clarifying information fed by the CSIS entities to the various elements of the User Interface Platform.

The range of CSIS functions

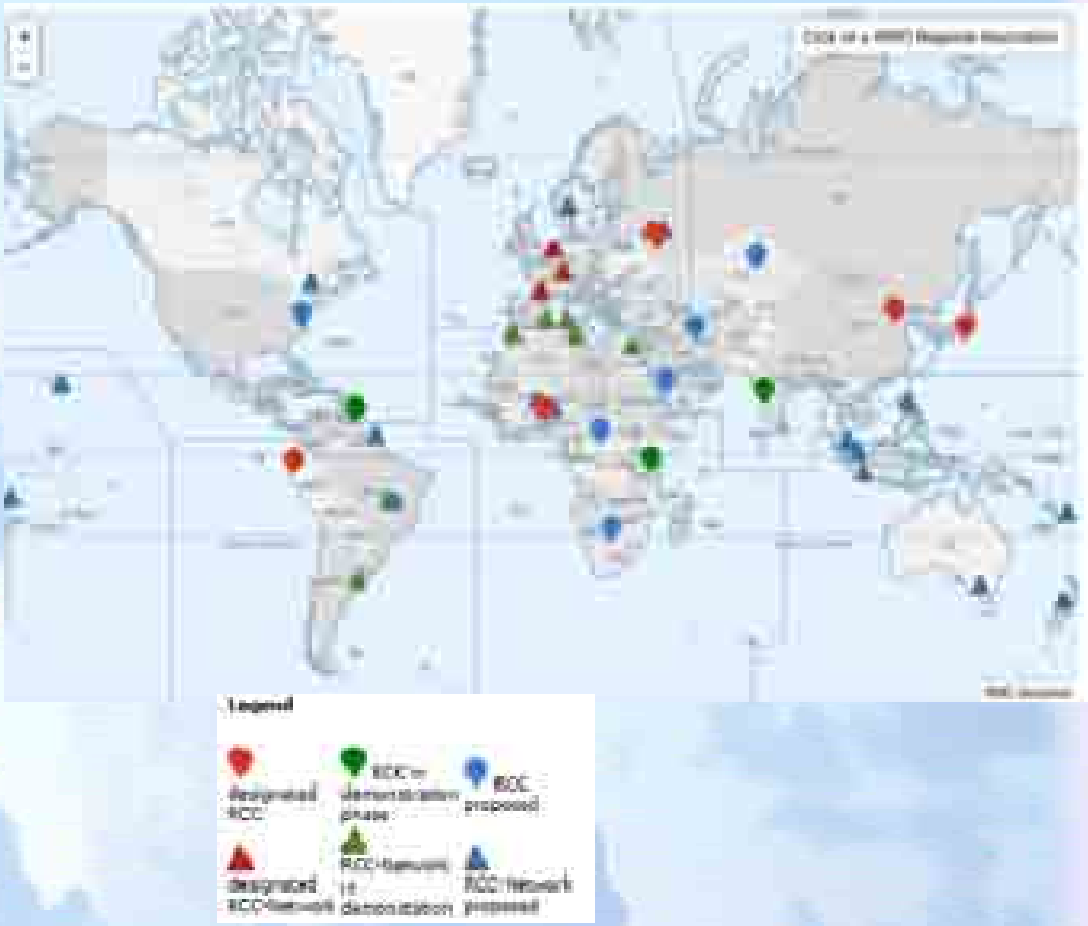
- Standardized management and exchange of climate and climate-related data as per WMO resolutions;
- Monitoring and analysing climate variability on different temporal scales, including extremes such as droughts and floods;
- Assessing and conducting attribution studies of observed climate anomalies;
- Predicting and projecting future climate states, including forecasting seasonal climatic anomalies and projecting long-term trends that could affect climate-sensitive sectors;
- Deriving products (datasets, text, maps, charts, statistics, etc.) that describe the past, present and future climate of a location, country, region and indeed the whole globe;
- Deriving tailored products and information within a range of social, economic and environmental contexts based on the tools and guidance developed by the User Interface Platform;
- Providing all such information and products to users in government, the general public, academia as well as to a diverse set of specialist users, along with advice on their interpretation and use;
- Undertaking capacity development activities to ensure effective incorporation of global and regional CSIS products in national level CSIS operations;
- Formulating recommendations for improvements in the observing and research inputs to CSIS operations provided by the Observations and Monitoring (O&M) and the RMP pillars.

CSIS Collaborating Institutions

- Globally: range of advanced centres such as the Global Producing Centres of Long Range Forecasts
- Regional: a network of entities with regional responsibilities such as the Regional Climate Centres
- Nationally and locally: National Meteorological and Hydrological Services, other national institutional arrangements

World Meteorological Organization (WMO) Regional Climate Centers

- RCCs are Centres of Excellence intended to perform regional-scale climate functions
- Established at the request of the Members of the Regional Associations
- Official accreditation given by WMO after a successful 2- 4 yr demonstration phase
- Primary users are the National Meteorological and Hydrological Services (NMHS)
- RCCs are complementary to and supportive of NMHSs, who will deliver all warnings and national-scale products in the appropriate language.
- Tries to adhere to WMO recommendations for open data sharing and metadata



Sources:

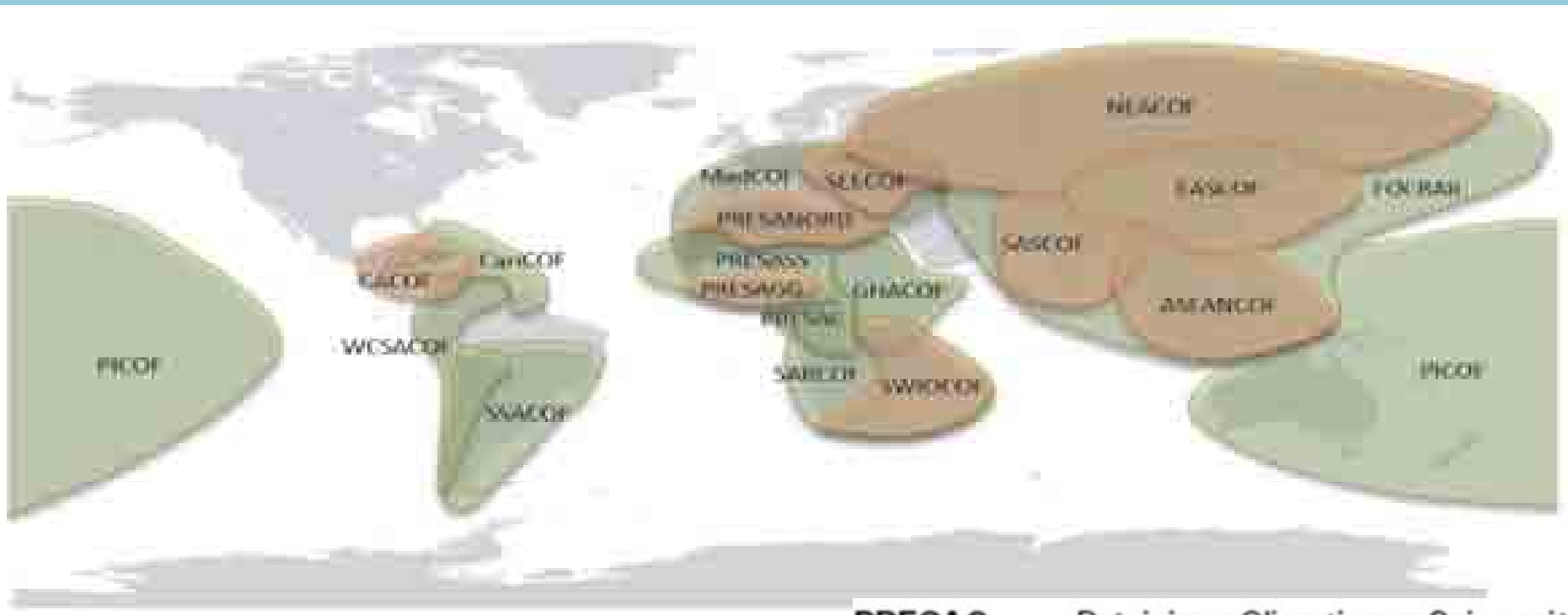
Hovsepyan;, A. 2016. "WMO Regional Climate Centers: CCl/CBS procedures for establishment and designation"; 2. How to establish and run a WMO RCC. http://www.wmo.int/pages/prog/wcp/wcasp/rcc/documents/WCASP80_ED4534.pdf

Regional Climate Outlook Forums

- A Regional Climate Outlook Forum is a platform that brings together climate experts and sector representatives from countries in a climatologically homogenous region to provide consensus based climate prediction and information, with input from global and regional producing centres and National Meteorological and Hydrological Services, with the aim of gaining substantial socio-economic benefits in climate sensitive sectors.

The RCOF process typically includes the following components:

- A training workshop on seasonal climate prediction to strengthen the capacity of national and regional climate scientists;
- Meetings of regional and international climate experts to develop a consensus for the regional climate outlook;
- Both climate scientists and representatives of user sectors interpret the available real-time seasonal prediction products from WMO GPCLRFs and RCCs, assess the skills of forecasting systems, develop the consensus seasonal climate outlook statement for the region, and discuss on the potential applications of RCOF products of the regional and international climate experts to develop a consensus for the regional climate outlook, typically in a probabilistic form;
- Special outreach sessions involving media experts to develop effective communication strategies.



In total there are 19 RCOFs

ASEANCOF	Association of Southeast Asian Nations Climate Outlook Forum
CACOF	Central American Climate Outlook Forum
CariCOF	Caribbean Climate Outlook Forum
EASCOF	East Asia winter Climate Outlook Forum
FOCRAII	Forum on Regional Climate Monitoring, Assessment and Prediction for Regional Association II (Asia)
GHACOF	Greater Horn of Africa Climate Outlook Forum
MedCOF	Mediterranean Climate Outlook Forum
NEACOF	North Eurasian Climate Outlook Forum
PICOF	Pacific Islands Climate Outlook Forum
PRESAC	Prévisions Climatiques Saisonnières en Afrique Centrale
PRESAGG	Prévisions Climatiques Saisonnières pour les pays du Golfe de Guinée
PRESANORD	Prévisions Climatiques Saisonnières en Afrique du Nord
PRESASS	Prévisions Climatiques Saisonnières en Afrique Soudano-Sahélienne
SARCOF	Southern African Regional Climate Outlook Forum
SASCOF	South Asian Climate Outlook Forum
SEECOF	South-East European Climate Outlook Forum
SSACOF	Southeast of South America Climate Outlook Forum
SWIOCOF	South West Indian Ocean Climate Outlook Forum
WCSACOF	Western Coast of South America Climate Outlook Forum

Historical climate data sets

- Developing and securing basic, historical climate data sets for characterizing past climate behaviour on all time and space scales remains one of the highest priorities for the CSIS.
- There are a number of other important data-related activities that would help establish a fully effective CSIS. Routinely collecting climate 'event' data, for example, would be one such contribution.
- Full event-scale data on climate anomalies like droughts, floods, cold and heat waves, Tropical Cyclones, would improve understanding of the distribution, frequency and intensity of serious hazards. This greater understanding is needed for better climate risk assessments.
- Other user groups may need products such as indices of climate extremes or other, more complex indices that combine several parameters with different thresholds (e.g., temperature with precipitation and humidity for the health sector).
- A review and update of user requirements for climate data, products and information should be undertaken through the GFCS as a collaborative endeavour between CSIS and UIP.
- Merging remotely-sensed data with traditional data to produce routine products at the national level offers a special challenge for the CSIS. Given the resources and technical proficiency required to handle and process satellite-based data, for example, such products should be routinely generated in RCCs, from where they can be distributed to client institutions that do not possess the required capabilities.

Climate Monitoring

- Monitoring of the climate provides information that can, for example, guide appropriate preparatory actions for mitigating the effects of extreme events. Close and meticulous monitoring also allows for detecting long-term climate change and determining its driving forces as well as its impacts around the world. Monitoring the climate at a global scale also helps to improve regional and national predictions.
- Local conditions do not occur in isolation from the rest of the world: regional and global scale climate drivers directly influence local weather and climate.
- Climate monitoring products are key CSIS contribution to the GFCS, with their scope evolving at global, regional and national levels in line with user requirements.
- In this regard it is important to stress the need for ongoing programmes of reanalysis to take advantage of recovered data and evolving analysis techniques.
- More frequent extreme events such as forest and grassland fires, floods, severe storms and drought are likely in a changed climate. Consequently, documenting their occurrence, including their meteorological settings and impacts, is critical for developing effective national early warning systems as well as appropriate mitigation and response actions.

Monthly/seasonal/decadal climate predictions

Climate projections and scenarios Information

Gap Areas

- Nationally, climate service providers in many developing countries need their human resource capacities enhanced through better access to basic and targeted training courses and facilities. They also need appropriate tools and guidance for customizing global and regional products to suit national and local priorities and purposes;

- On the national and regional levels there is a huge potential for retrieving vital past observations, extending the historical climatological record while simultaneously ensuring its quality and homogeneity as well as providing a solid foundation for the record into the future;

- Absence of long-term, authenticated meteorological records is a key gap that impedes providing a wide range of climate services in many lesser developed regions of the world.

Climate services by India Meteorological Department

India Meteorological Department the Custodian of Meteorological Records

India Meteorological Department (IMD) was established in 1875 subsequent to a disastrous tropical cyclone hit Calcutta in 1864, and the famines in 1866 and 1871 due to the failure of the monsoons.

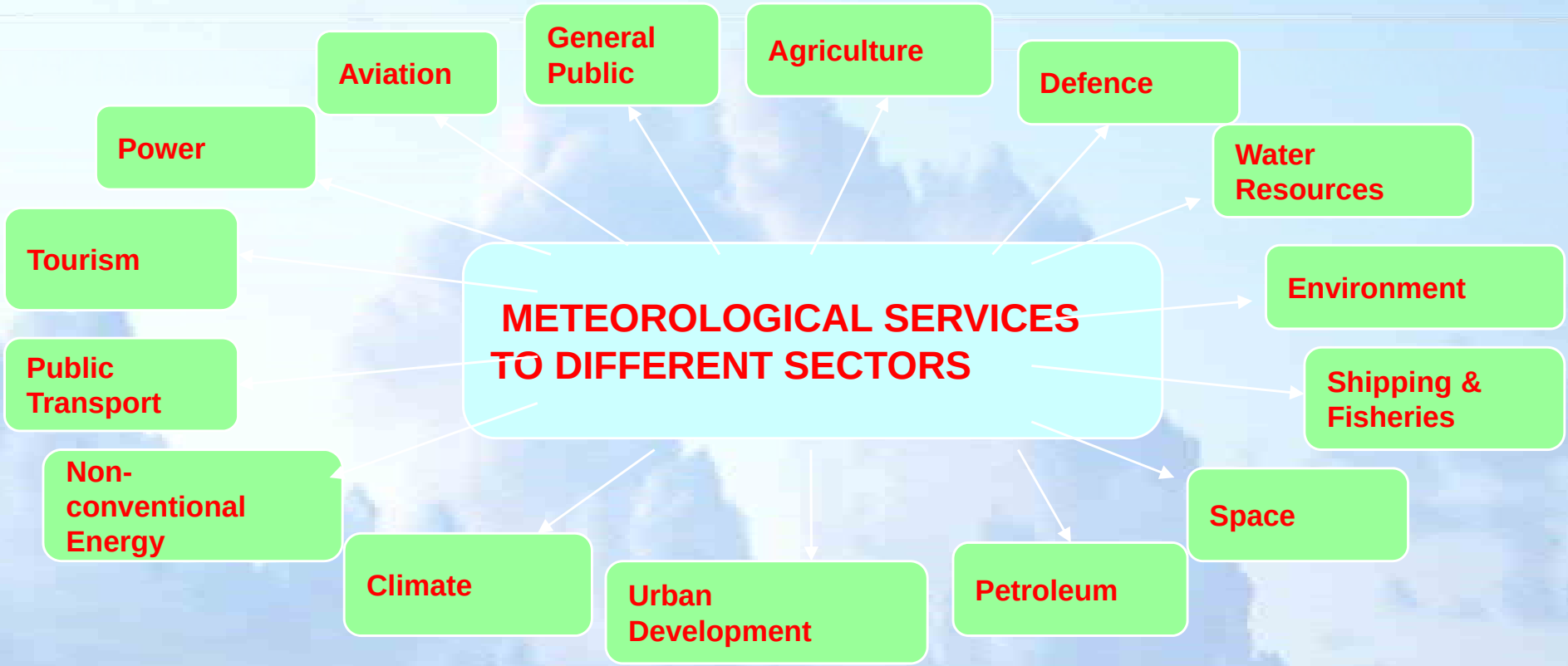
The rainfall data/observations were started well before. India is fortunate to have some of the oldest meteorological observatories of the world, that include Madras (now known as Chennai), established in 1793, Bombay (now known as Mumbai) in 1823 and Shimla in 1841.

With the gradual growth in the expansion of observational network varieties of data have been generated and accumulated in a span of many years.

Mandates

- To design optimal observational network for collection of reliable meteorological data as per WMO standard.
- To maintain long term authenticated meteorological records.
- To provide the data series for research and national building activities.
- To issue seasonal forecasts of southwest monsoon rainfall for economic growth of country.
- To advice farmers about cropping patterns, to face the vagaries of monsoon rainfall.
- To Install and upkeep of surface meteorological instruments.
- To issue day to day forecast of weather condition (actual and expected) over the country.
- To lay down norms for the aviation and cyclone warning services for the country to keep at par with the international standard.
- To impart training in the field of weather forecasting to Indian, South Asian and African meteorologists.

India Meteorological Department (Ministry of Earth Sciences) is catering to following sectors mainly through its weather forecasting and climate services



Pre requisites of effective climate services

Existence a Climate data Centre : availability of Climate data

Effective Climate Monitoring in different spatial and temporal scales

Reliable prediction systems on different time scales

Please visit the website : www.imdpune.gov.in for climate information

Components of Modern Climate Services

Climate Data Centre

Climate Monitoring

Climate Prediction

Generation of Climate data products

Climate Research & Training

Climate Application

(Primary aim of an effective climate service is to optimum use of climate information for societal benefits)

Data Processing System at National Data Centre (1977) of IMD

- DATA ARCHIVED AT NDC
  - SURFACE METEOROLOGICAL PARAMETERS
  - RAINFALL
  - SNOWFALL
  - UPPER AIR OBSERVATION
  - AUTOGRAPHIC
  - MARINE
  - AWS
- TOTAL HOLDINGS 290 MILLION RECORDS AS ON DATE
- EVERY YEAR ABOUT 2.5 MILLION RECORDS ARE ADDED TO ARCHIVES
- Data supply- On an average 10 Lakh records every month
  - » Revenue Rs 1.2 Crores/ year

ARCHIVES DETAILS AT NATIONAL DATA CENTRE, IMDPUNE

1 AWS		
o SYNOP	2007 - 2017	
2 SURFACE		
o Day's Summary (TB-II)	1969 - 2017	
o Synoptic Hours (TB-III)	1969 - 2017	
o Monthly Mean TB-II	1901 - 2017	
o Monthly Mean TB-III	1901 - 2017	
3 RAINFALL		
o Daily Rainfall	1875 - 2015	
o Monthly and Annual Rainfall	1901 - 2015	
o Sub-Divisional Rainfall	1875 - 2008	
o Secret	1901 - 2013	
o Weekly Rainfall	1901 - 2015	
o DRMS (Daily)	1990 - 2006	
o DRMS - Sub-Divisional Ramfall	1992 - 2006	
4 UPPER AIR		
o Pilot Balloon (PB)	1951 - 2012	
o Radiowind (RW)	1956 - 2004	
o Radiosonde (RS)	1951 - 2006	
o PB Monthly Means	1965 - 2012	
o RW Monthly Means	1971 - 2004	
o RS Monthly Means	1961 - 2004	
o Climat Temp	1971-2000	
o Radiosonde Normals	1971-1990	
5 AUTOGRAPHIC		
o Pressure	1969 - 2014	
o Temperature	1969 - 2014	
o Relative Humidity	1969 - 2008	
o Wind	1969 - 2000	
o Rainfall (SRRG)	1969 - 2014	
o Sunshine	1969 - 2012	
o Heavy Ramfall	1950 - 2009	
6 MARINE		
o Marine	1961 - 2016	
7 AGROMET		
o Crop Weather Scheme - 1 (CWS-1)	1944 - 2015	
o Evaporation	1972 - 2012	
o Evapotranspiration	1973 - 2012	
o Soilmoisture	1991 - 2012	
o Dew	1969 - 2013	
8 RADIATION		
o Global		1957 - 2015
o Diffused		1957 - 2015
o Bimetallic		1979 - 2003
o Terrestrial		1989 - 2009
o Direct Solar (BETA)		1997 - 2009
o Global - Incl.Plane		1984 - 2009
o Net		1965 - 2008
o Direct		1985 - 2008
o Reflected		1989 - 2007
o Monthly Means		1957 - 2013
9 TURBIDITY		
o Turbidity		1980 - 2003
o Ppt Chemistry		1981 - 2003
10 MONEX-79, MONSOON-77, ISMEX-73		
o MONEX-79 FGGE		1979 - 1979
o MONEX-79 Non-FGGE		1979 - 1979
o MONEX-79 Navaid		1979 - 1979
o MONSOON-77		1977 - 1977
o ISMEX-73		1973 - 1973
o IMAP		1982 - 1994
o Armex 2002		2002 - 2003
11 SPECIAL EXPEDITIONS		
o Sagar Kanya Ship		1982 - 2004
o Antarctica		1981 - 2007
12 ROCKETSONDE		
o Rocketsonde		1970 - 1993
13 OLR		
o OLR (Daily and Monthly Mean)		1987 - 2015
14 OZONE		
o Total Ozone		1957 - 2015
o Surface Ozone		1980 - 2015
o Ozonesonde		1980 - 2015
o Antarctica Ozone		1987 - 2011
15 MISCELLANEOUS		
o Current Weather		1997 - 2009
o WWR		1961 - 2000
o I.G.Y		1957 - 1958
o IMAP		1982 - 1994

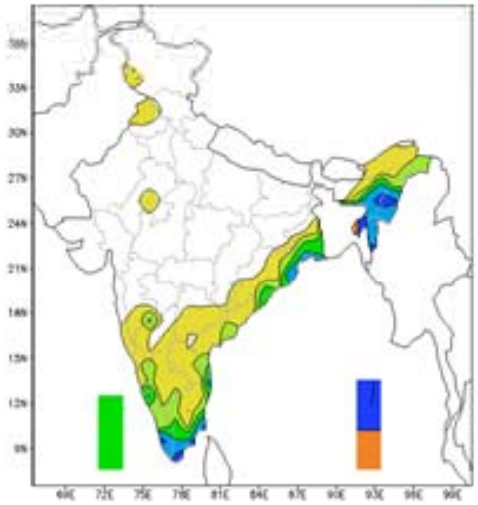
Climate Monitoring

- National Climate Centre started functioning at IMD Pune since 1995.
- India specific climate related activities like Climate Monitoring and Analysis.
- Subsequently Climate Monitoring over the south Asia

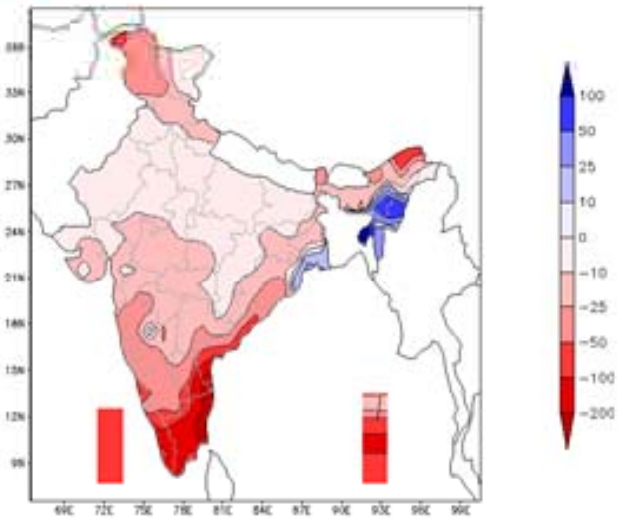
Surface

- Pressure
- Temperature
- Rainfall
- Time Series of a) rainfall and b) Temperature
- % Hot and cold days
- SPI maps

November 2016 diagrams

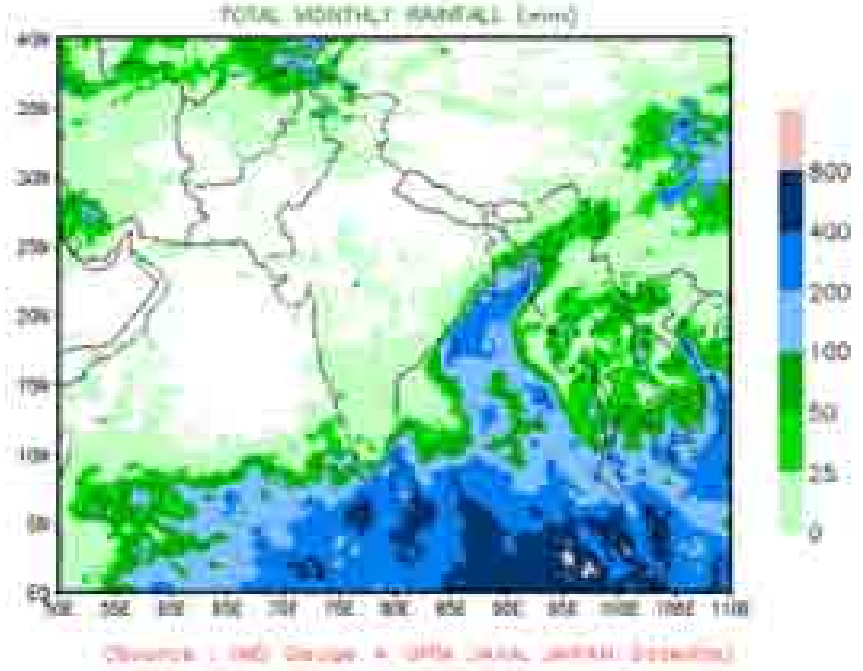


Rainfall (mm)



Rainfall Anomaly (mm)

– NOVEMBER 2016 –



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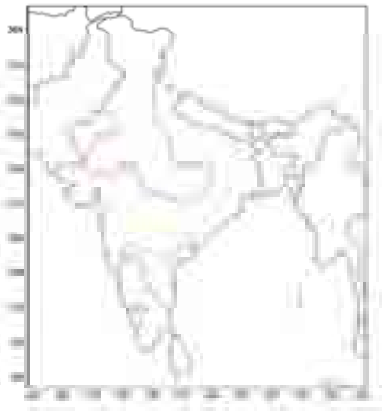
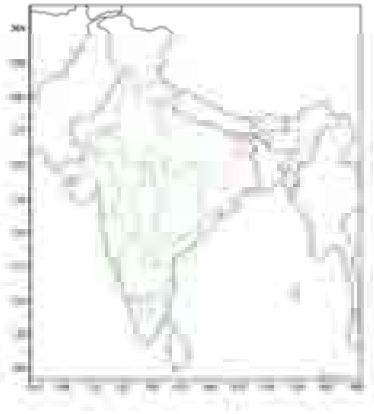
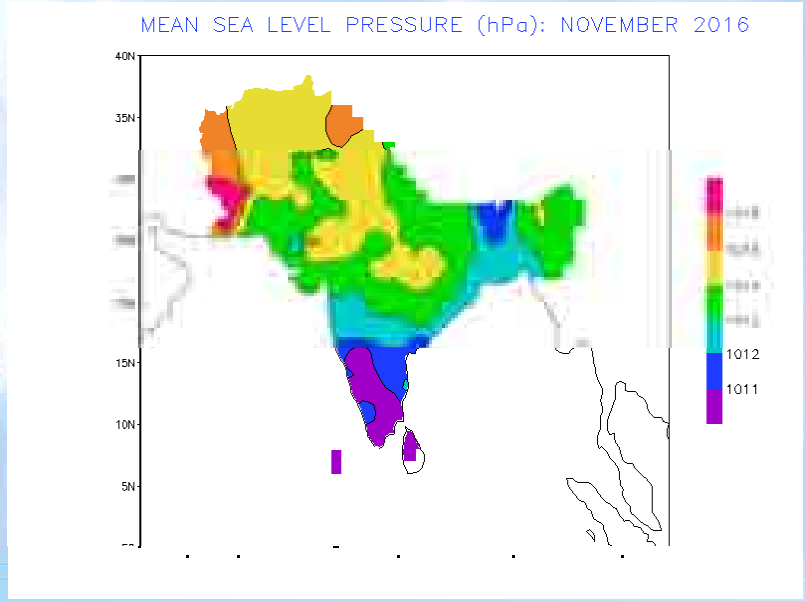


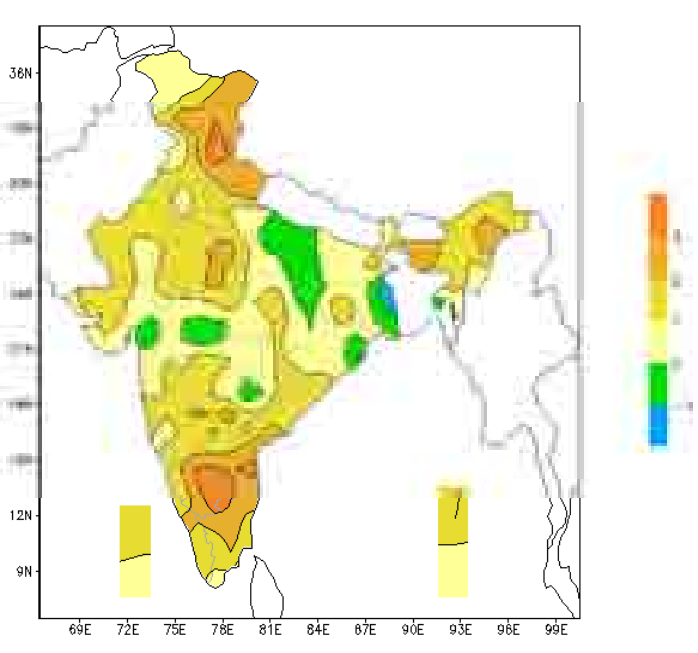
MSLP(hPa)



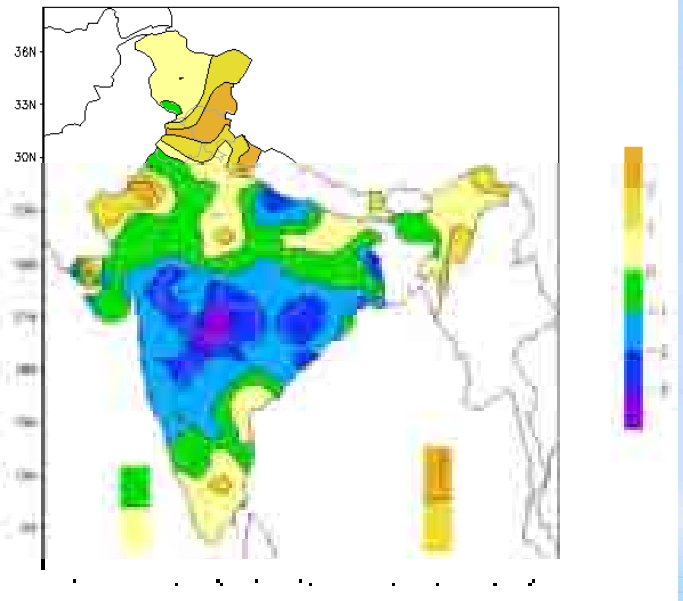
MSLP Anomaly (hPa)

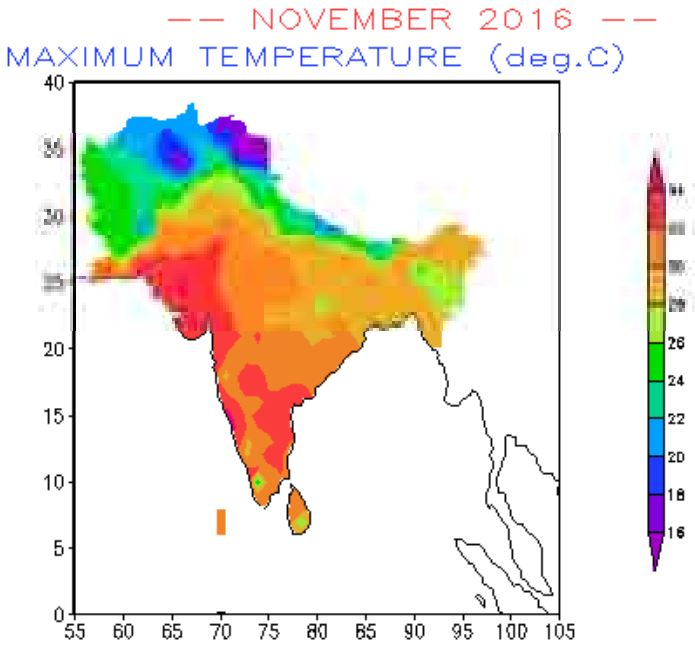


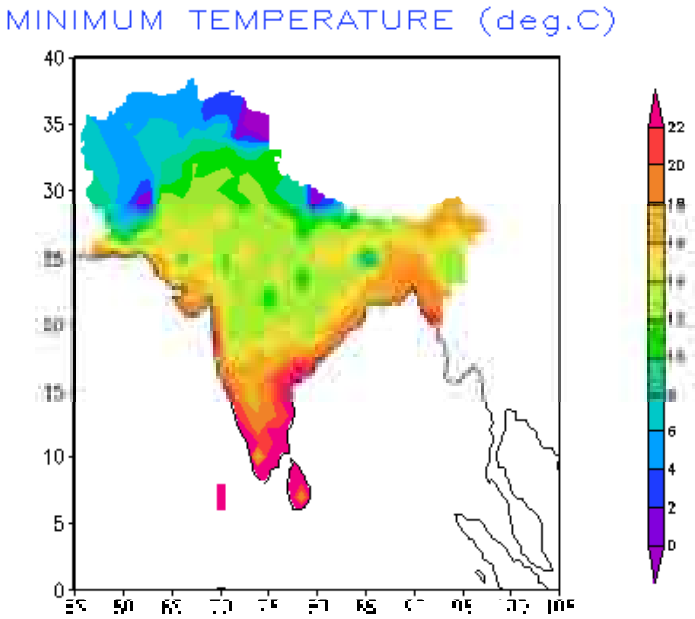
Tx anomaly



Tn anomaly







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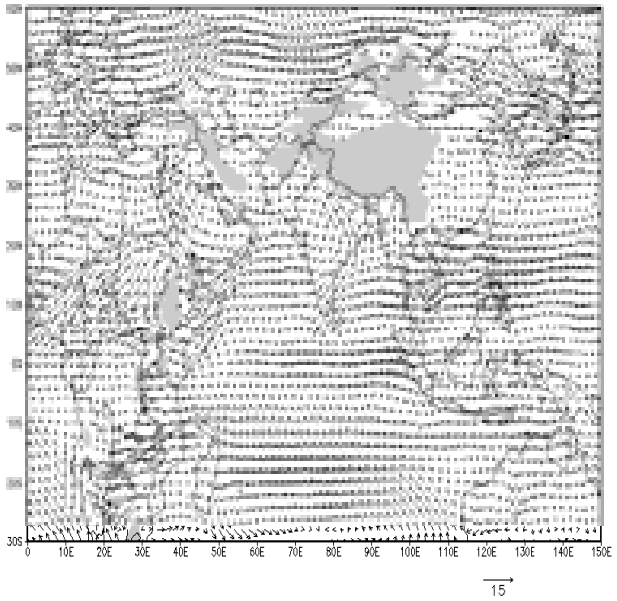
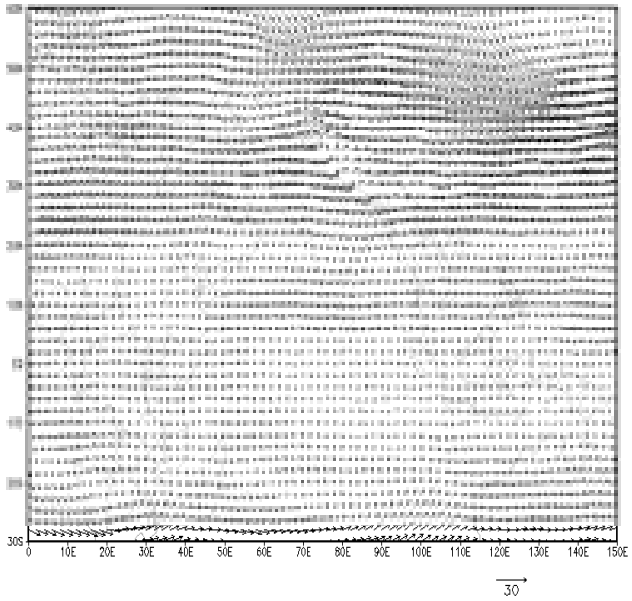
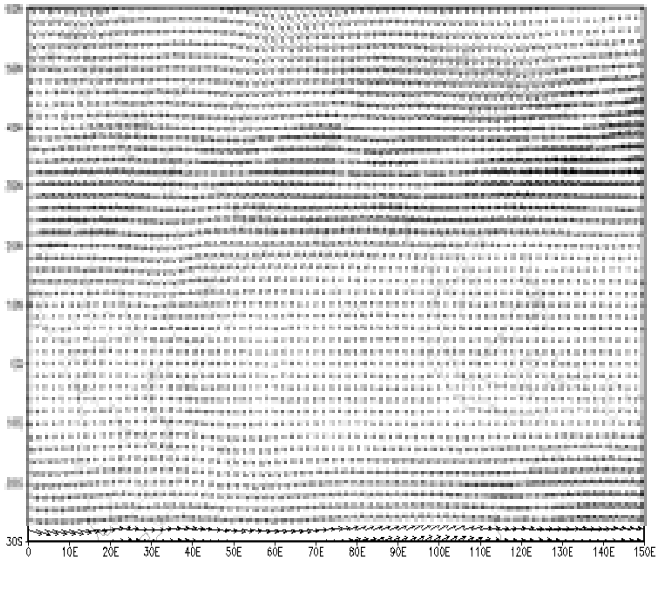
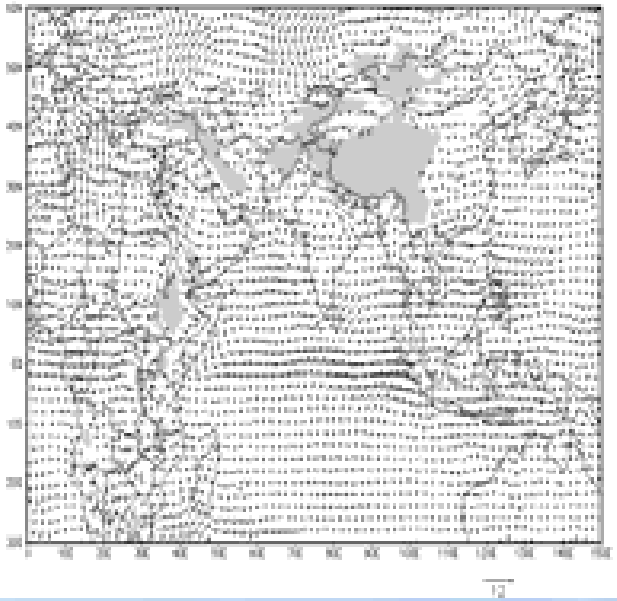
Upper Air

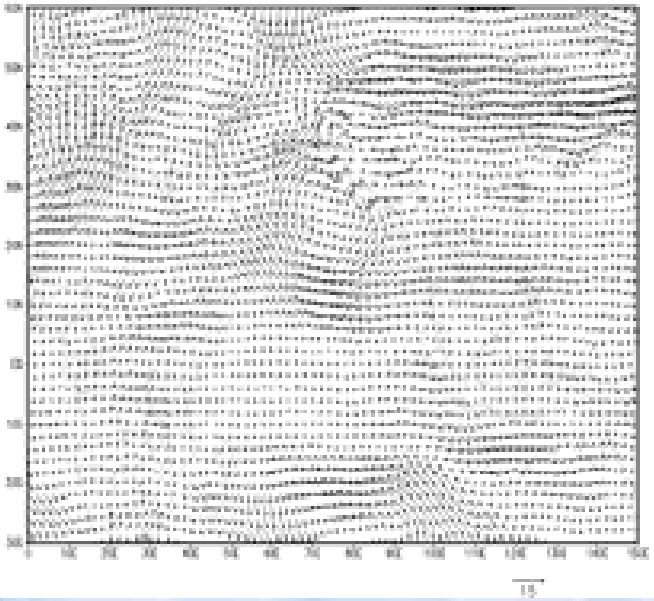
- Circulation Anomalies
- OLR
- Rotational and divergence field

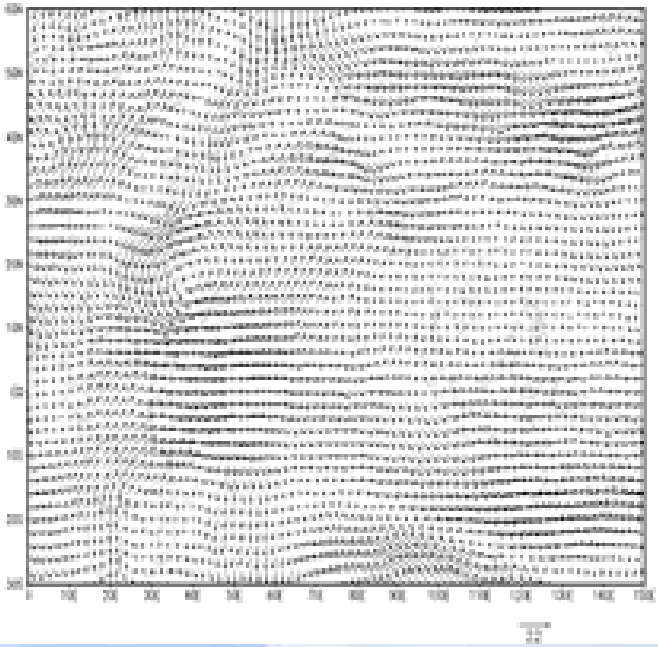












Monthly mean wind and its anomaly at 850, 500 & 250 hPa respectively

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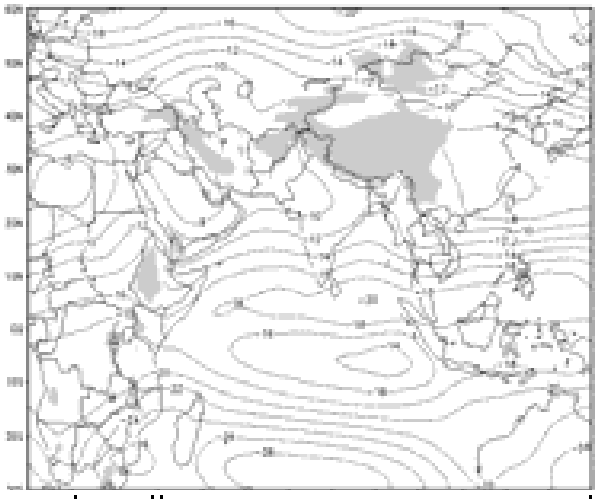
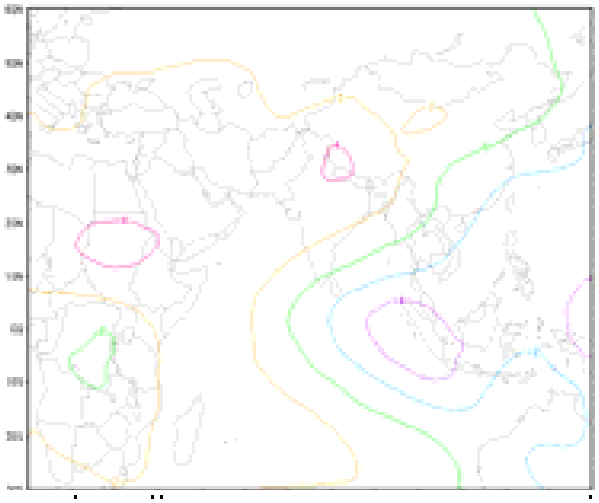
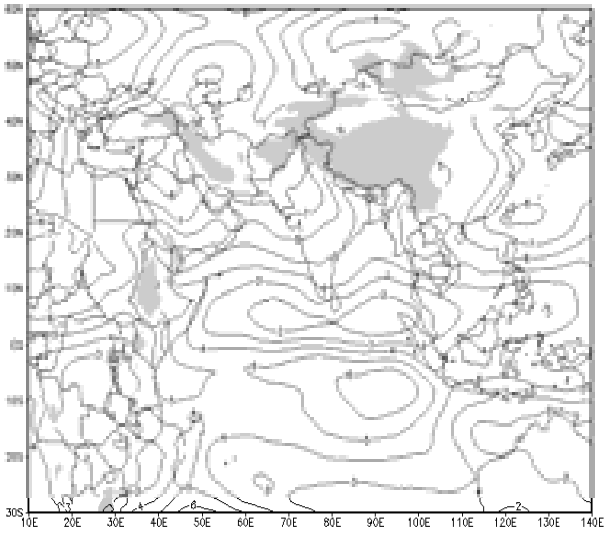
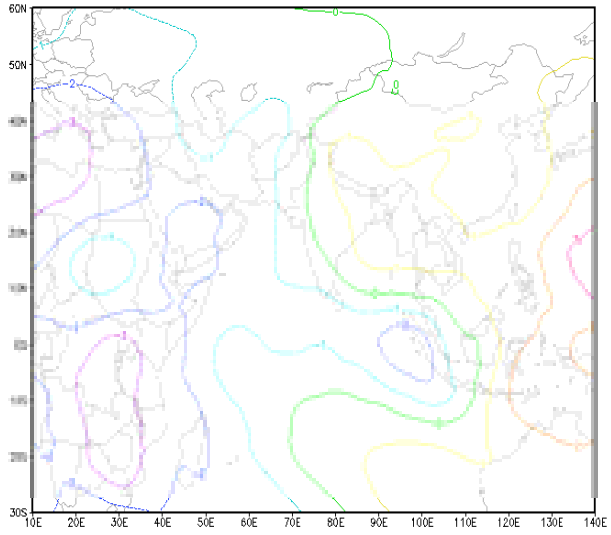


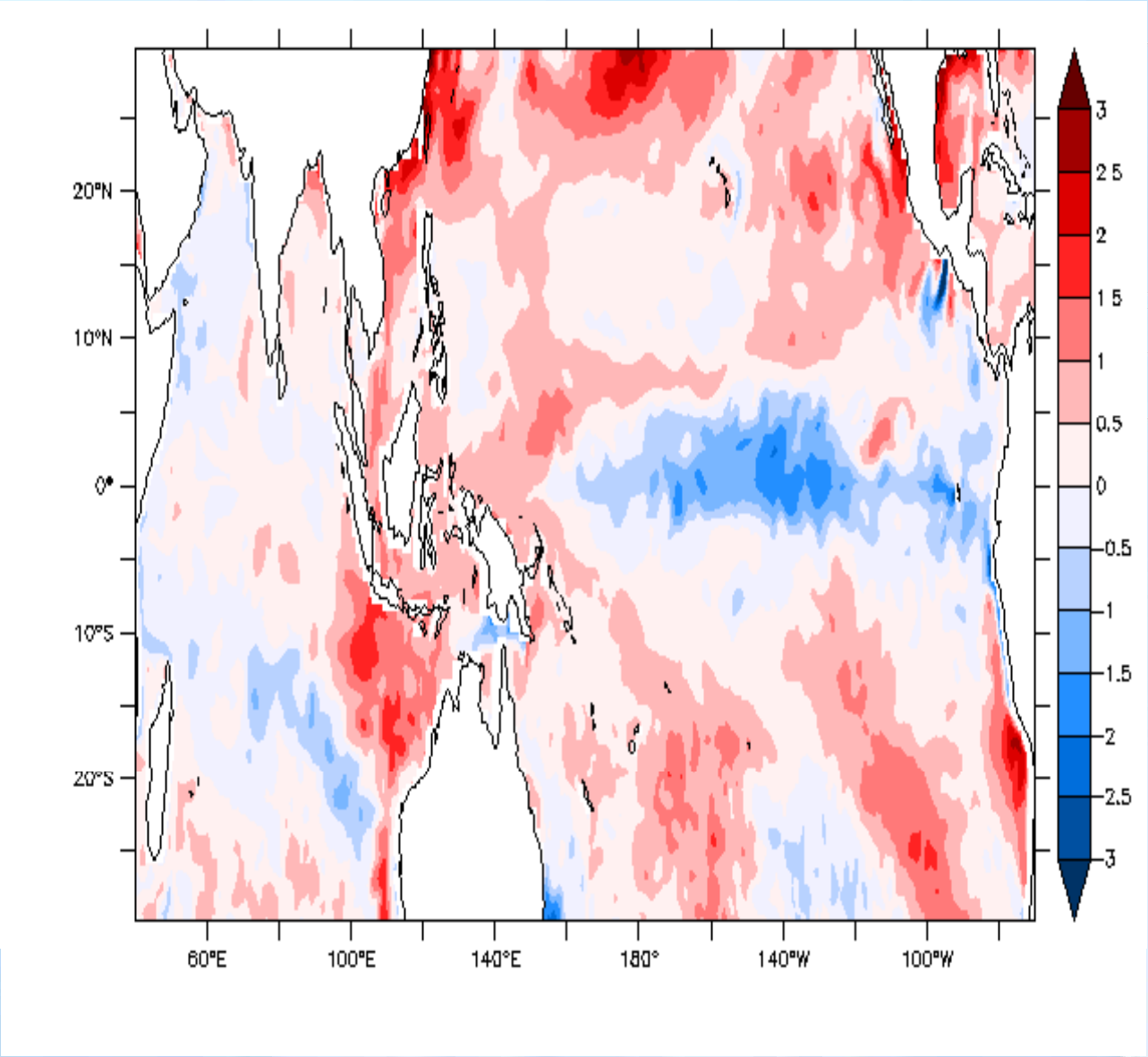




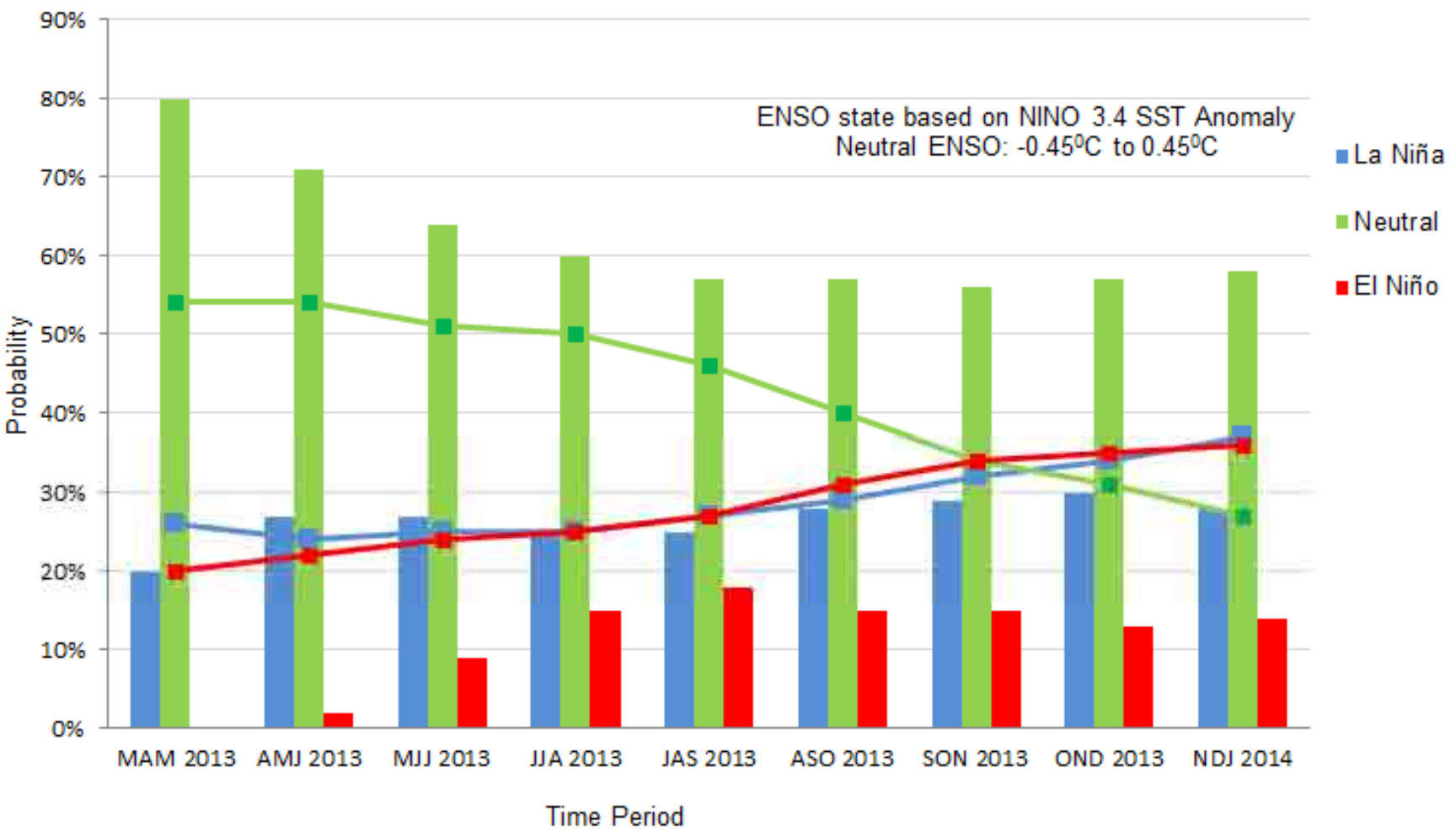


Monthly mean Stream function and its anomaly at 850 hPa

Monthly mean Velocity Potential and its anomaly at 250 hPa



SST Anomaly (^{0}C)



CPC/IRI CONSENSUS ENSO FORECAST

(portal.iri.colombia.edu)

Climate Monitoring and Analysis

Brings out monthly, seasonal and annual climate diagnostic bulletins for Indian region regularly.

Climate Prediction

Climate prediction was initially limited to issue of long range forecast (using statistical) for monsoon season rainfall over India as a whole. Subsequently forecast for four homogeneous regions was also issued .

Under ambitious project of the MoES (development of reliable dynamical prediction systems for all the time scales) global coupled forecasting system (CFS) under monsoon mission (MM) and Coupled dynamical system for four weeks (extended range) were developed.

The same have now been implemented at IMD.

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पृथ्वी विज्ञान मंत्रालय

India Meteorological Department
Ministry of Earth Sciences
Climate Monitoring and Prediction Group

Climate Diagnostics

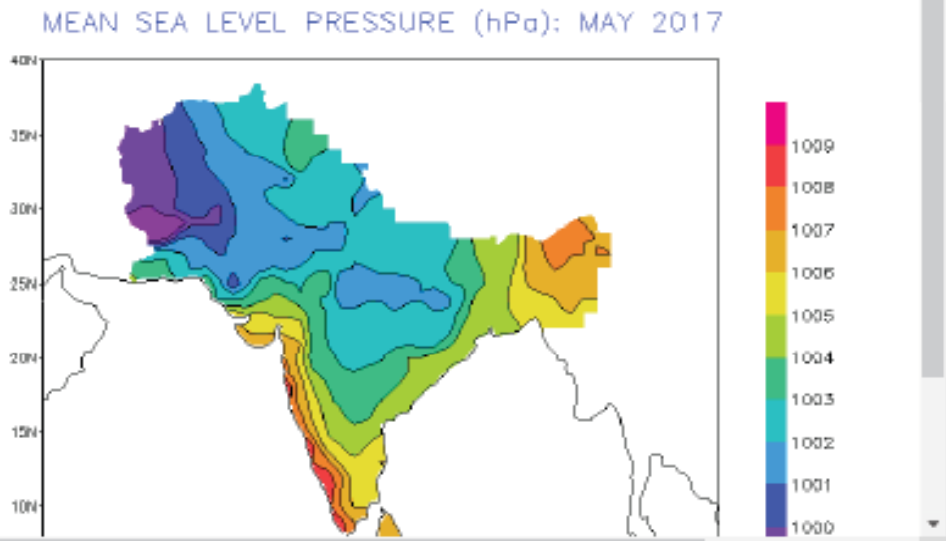
- Pressure (Diagnostics/Pressure.html)
- Temperature (Diagnostics/Temperature.html)
- Daily Rainfall (Diagnostics/Daily_Rainfall.html)
- Cummulative Rainfall (Diagnostics/Cummulative_Rainfall.htm
- Rainfall (GPM) (Diagnostics/Rainfall_GPM.html)
- Wind (Diagnostics/Wind.html)
- Stream Function (Diagnostics/Stream_Function.html)
- Velocity Potential (Diagnostics/Velocity_Potential.html)
- OLR (Diagnostics/OLR.html)
- OLR Anomaly (Diagnostics/aolr.html)
- Climate Indices (Diagnostics/Climate_Indices.html)
- Sea Surface Temperature (Diagnostics/SST.html)

Month

Select

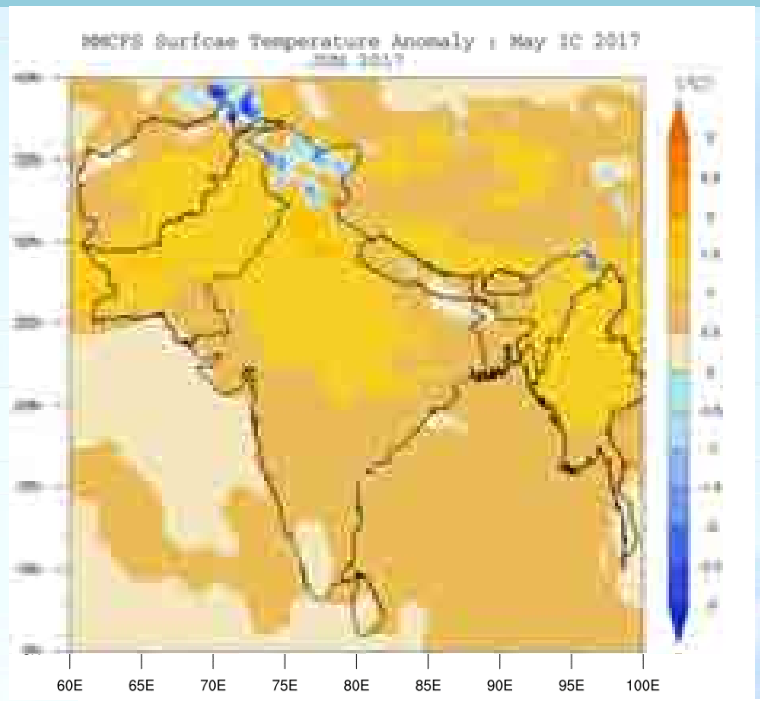
Year

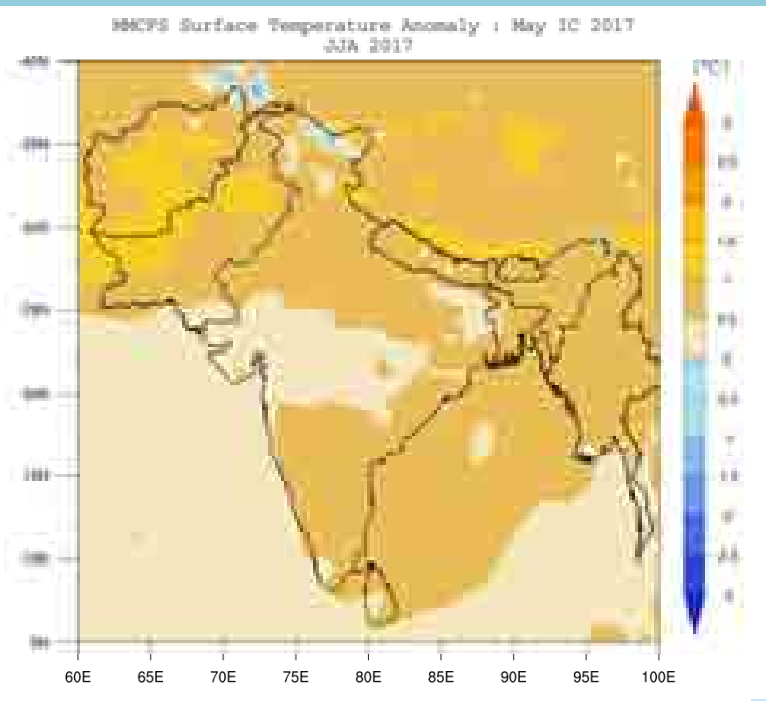
2017

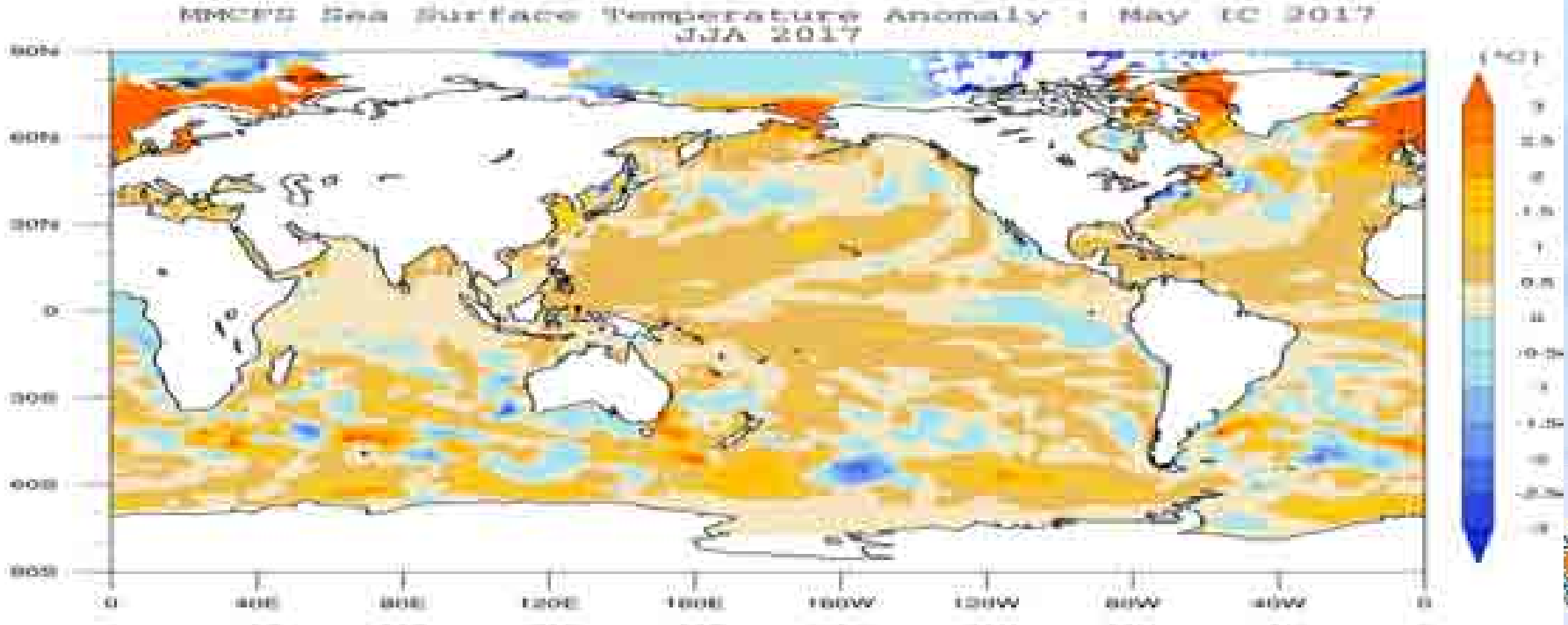


Important Links : IMD New Delhi (http://www.imd.gov.in) | MoES (http://moes.gov.in) | NCMRWF (http://www.ncmrwf.gov.in/index.php) | NIOT (https://www.niot.res.in) | CLMRE (http://www.cmlre.gov.in) | NOAA (http://www.noaa.gov) | IITM (http://www.tropmet.res.in) | Incois (http://www.incois.gov.in/portal/index.jsp) | WMO (https://www.wmo.int/pages/index_en.html)

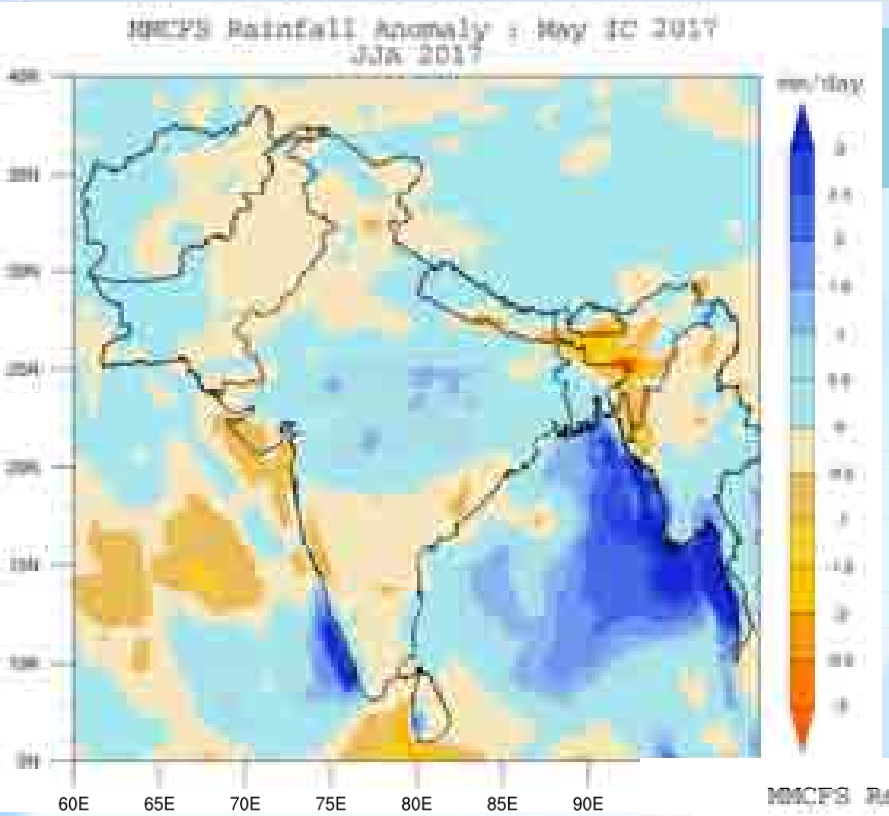
Temperature

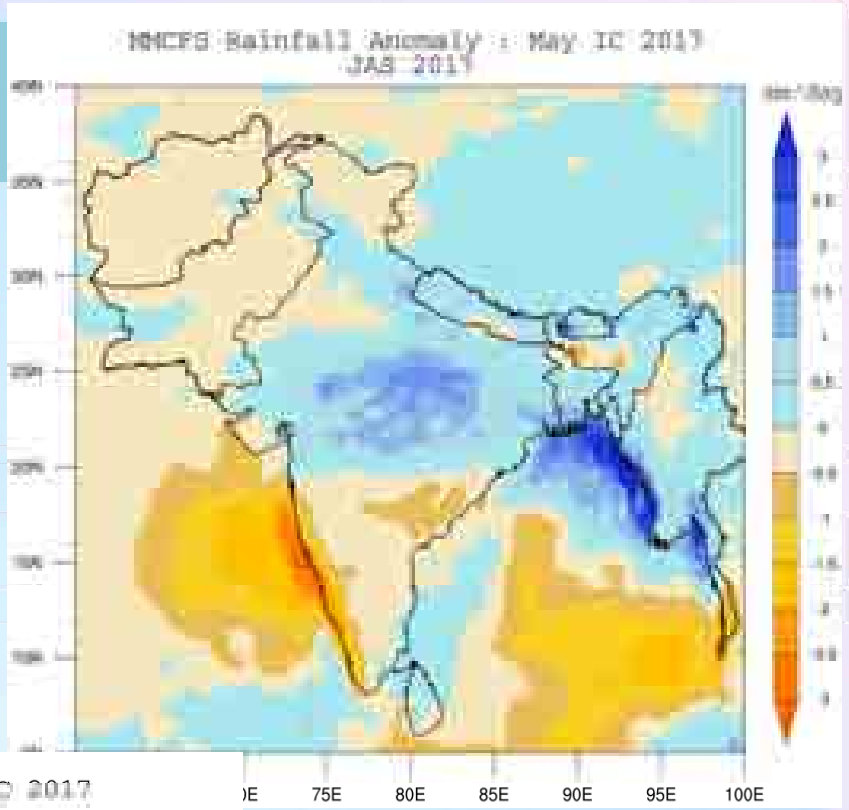


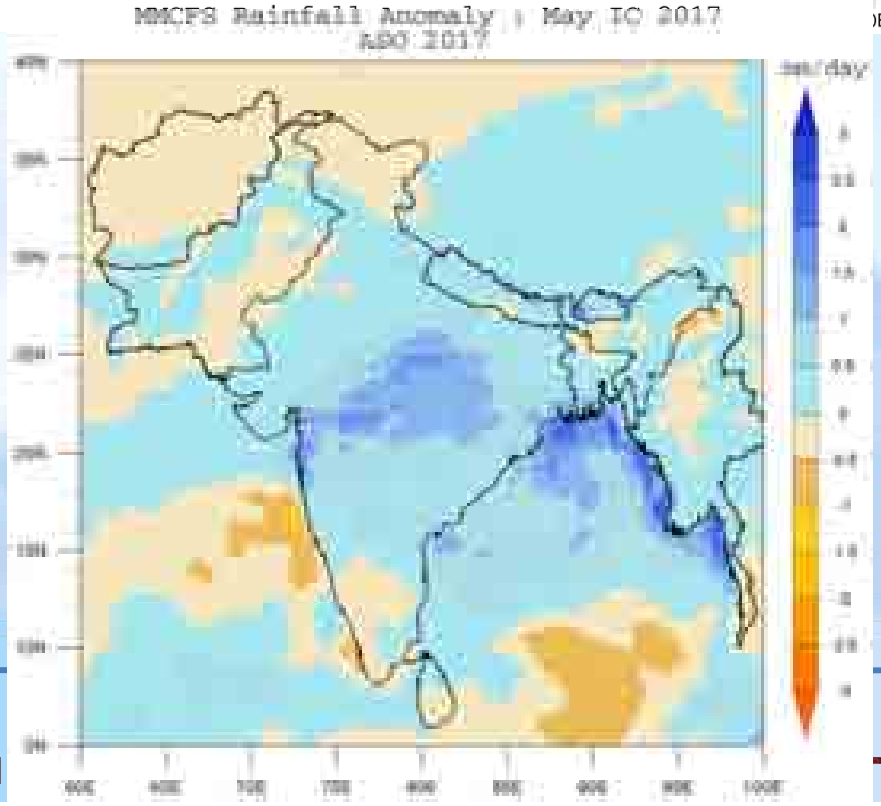




Rainfall

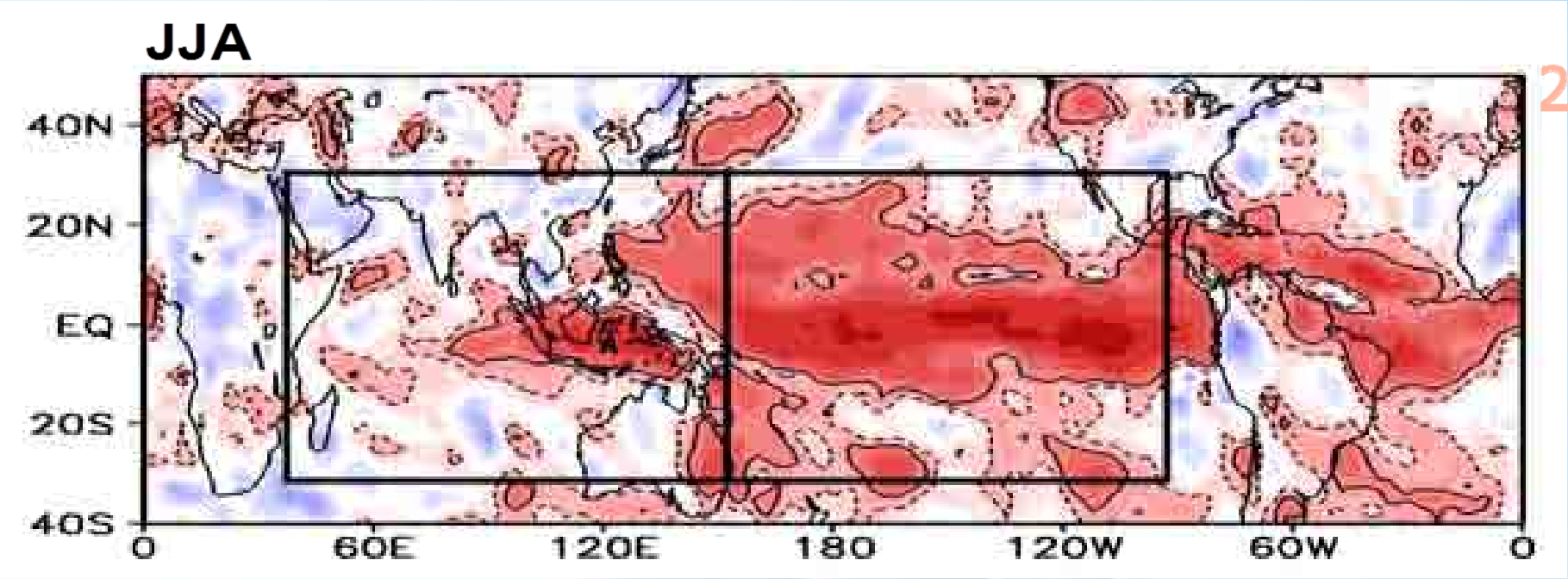

MMCFS Rainfall Anomaly : May IC 2017
JJA 2017
mm/day
60E
65E
70E
75E
80E
85E
90E


MMCFS Rainfall Anomaly : May IC 2017
JAS 2017
75E
80E
85E
90E
95E
100E


MMCFS Rainfall Anomaly : May IC 2017
ASO 2017
mm/day

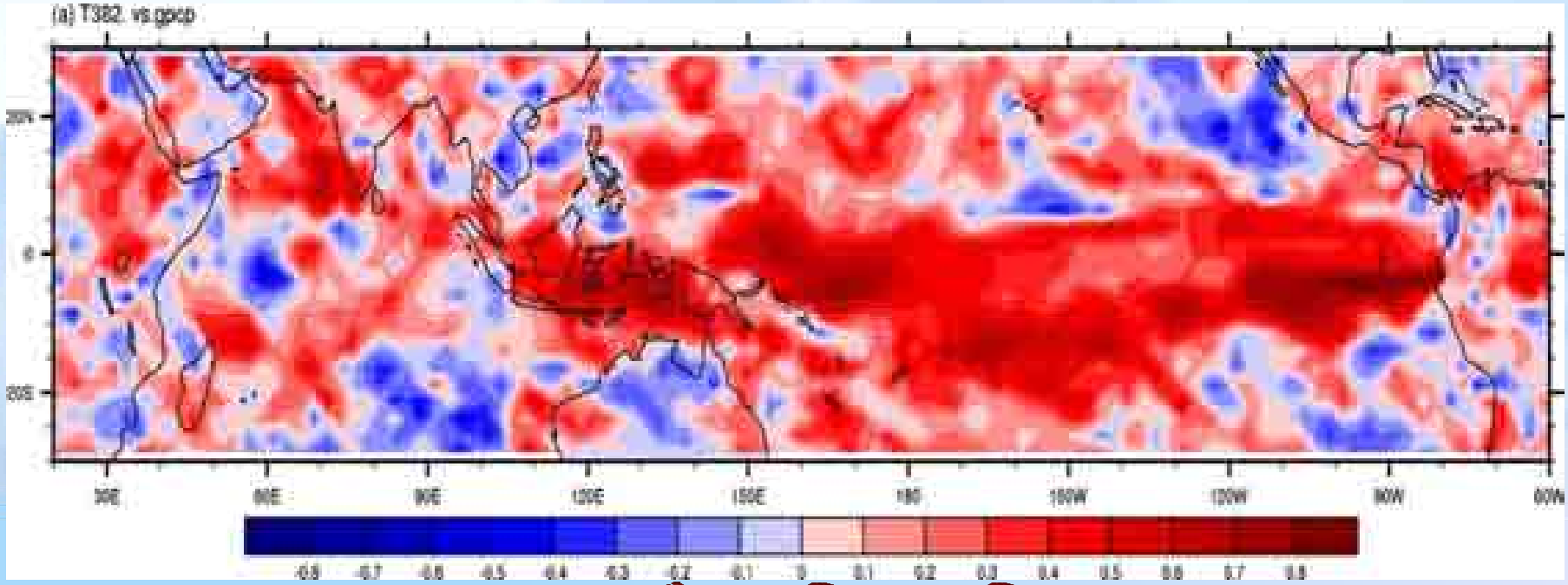
IN

Skill scores for precipitation



2005

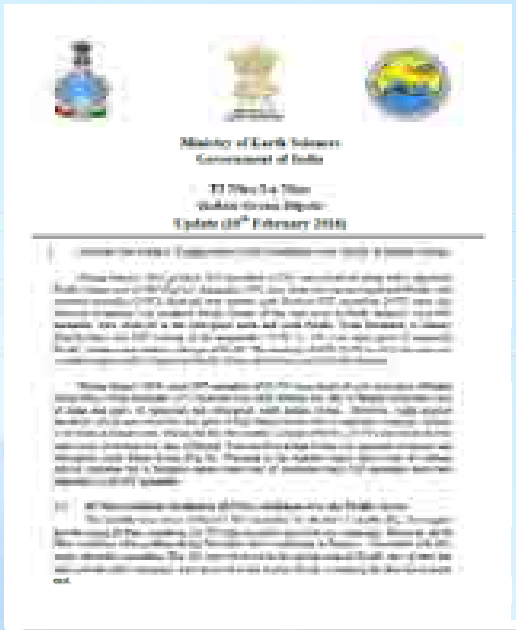
Past to Present



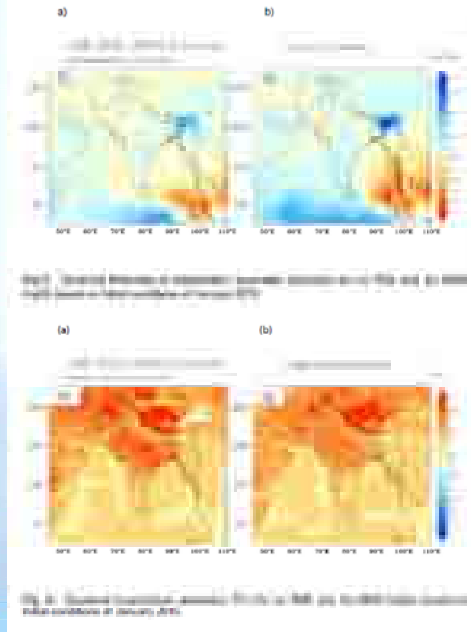
2016

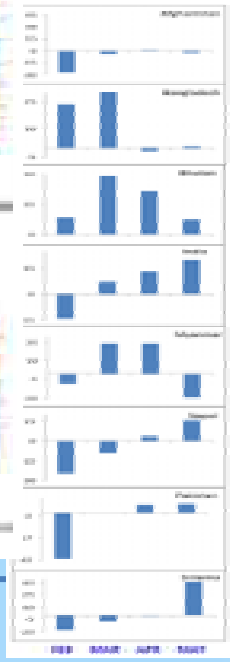
Use of CFS2 forecasting systems

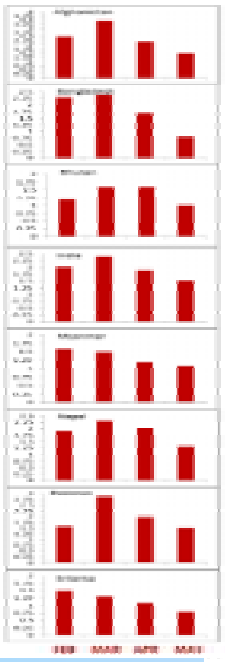
Seasonal Climate Outlook for South Asia

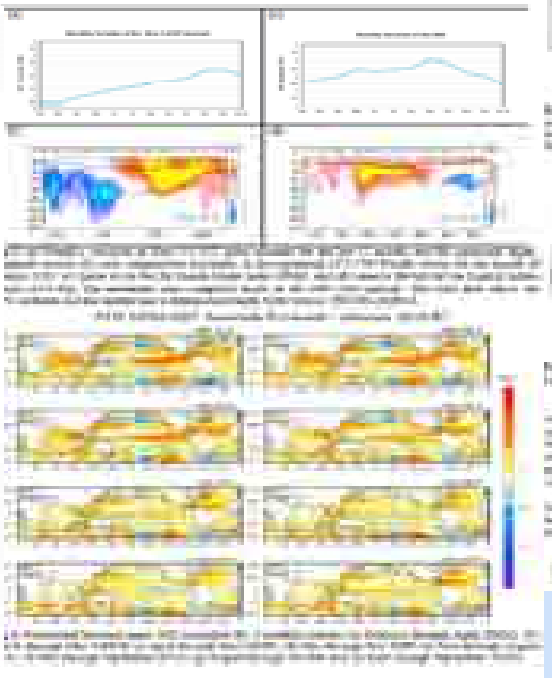


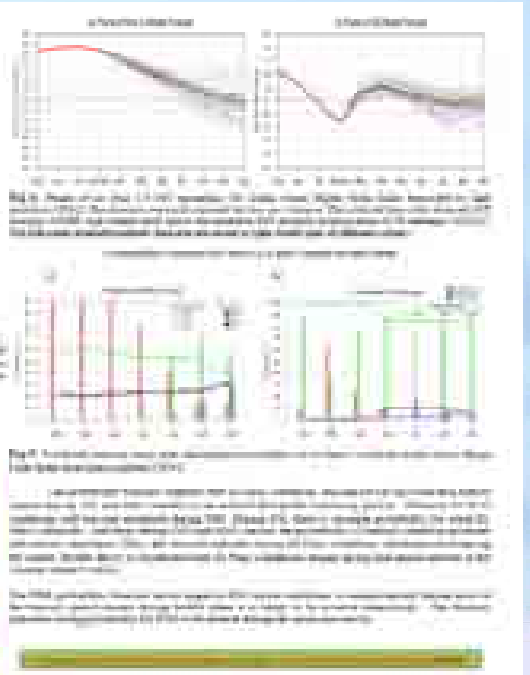
ENSO & IOD Forecast Bulletin (Every month)



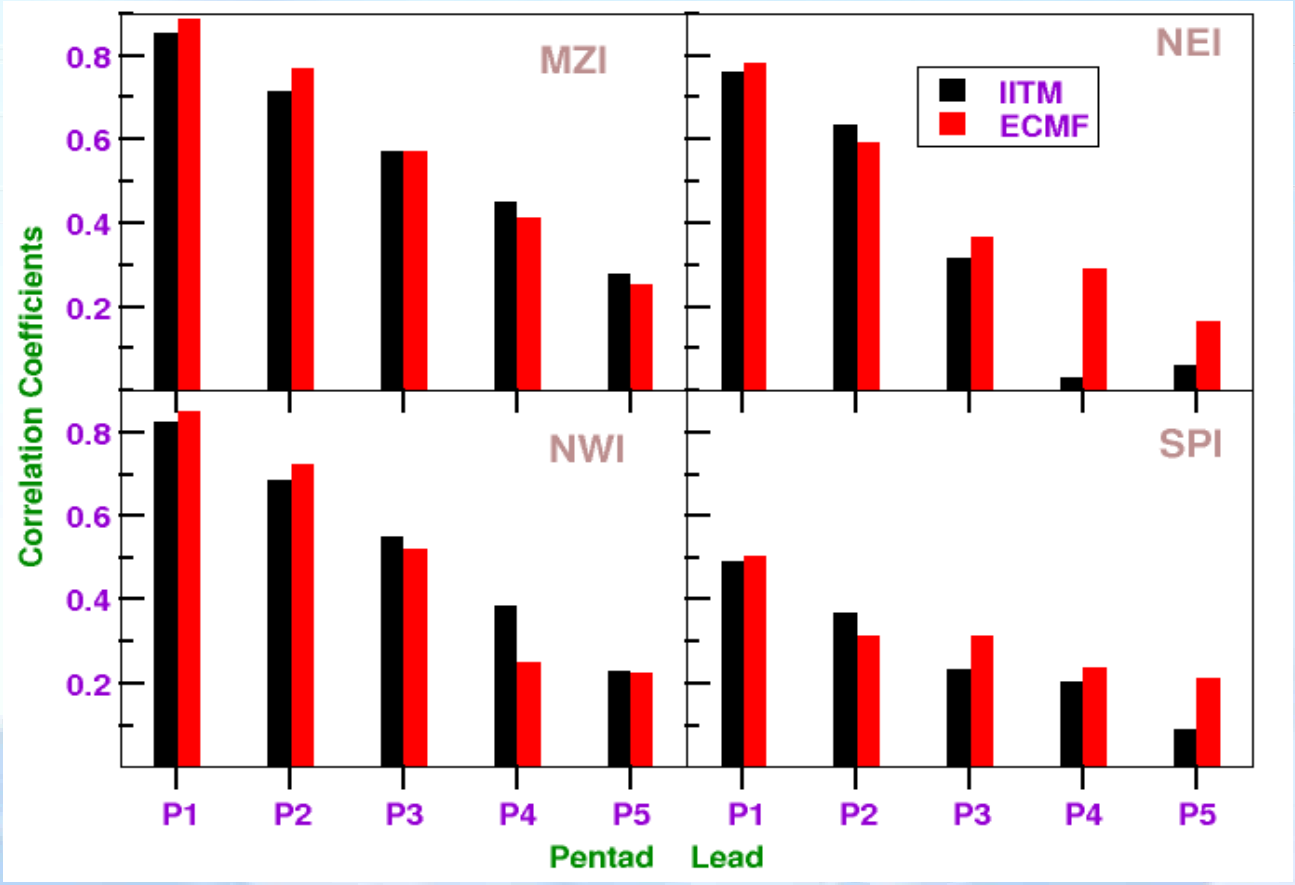






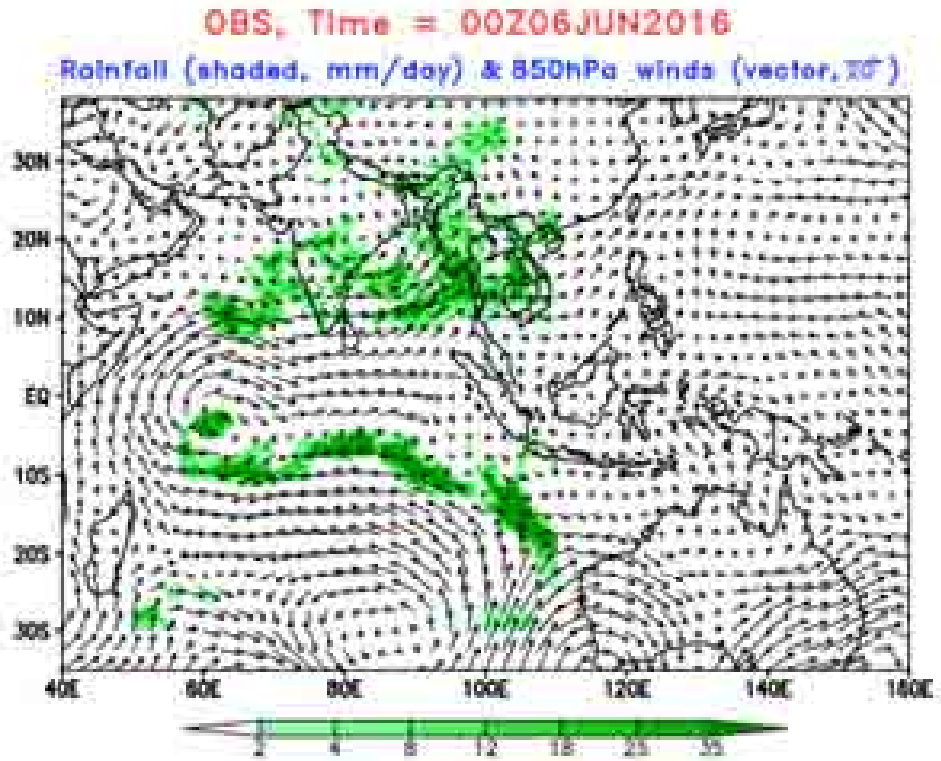


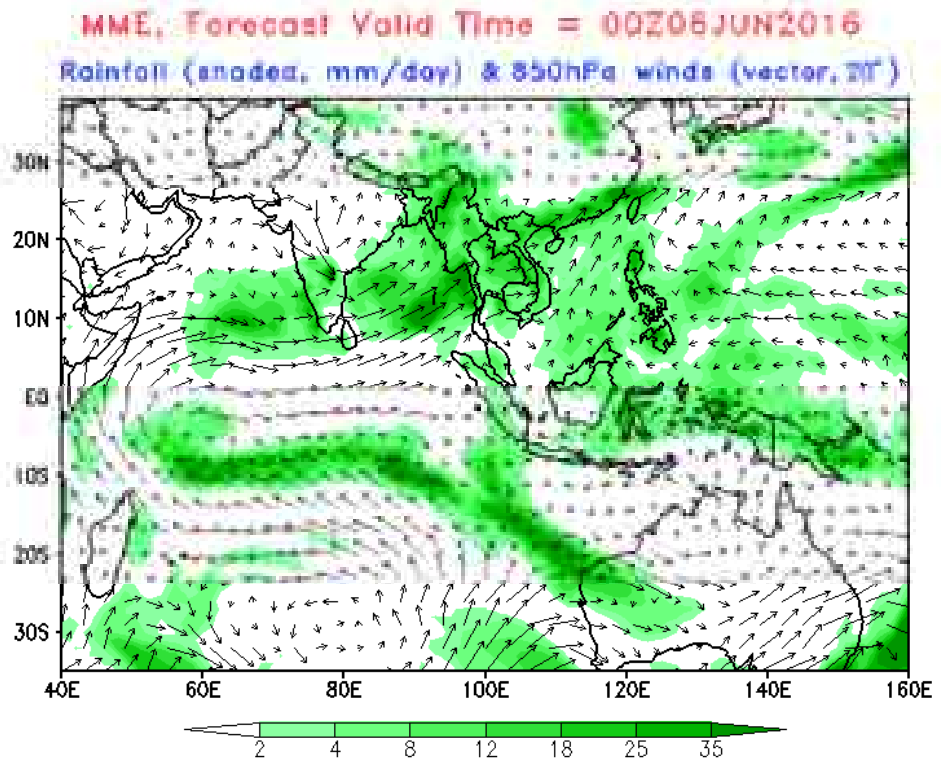
Skill of Extended Range



ERP: Some Important Events

Progression of ISM 2016





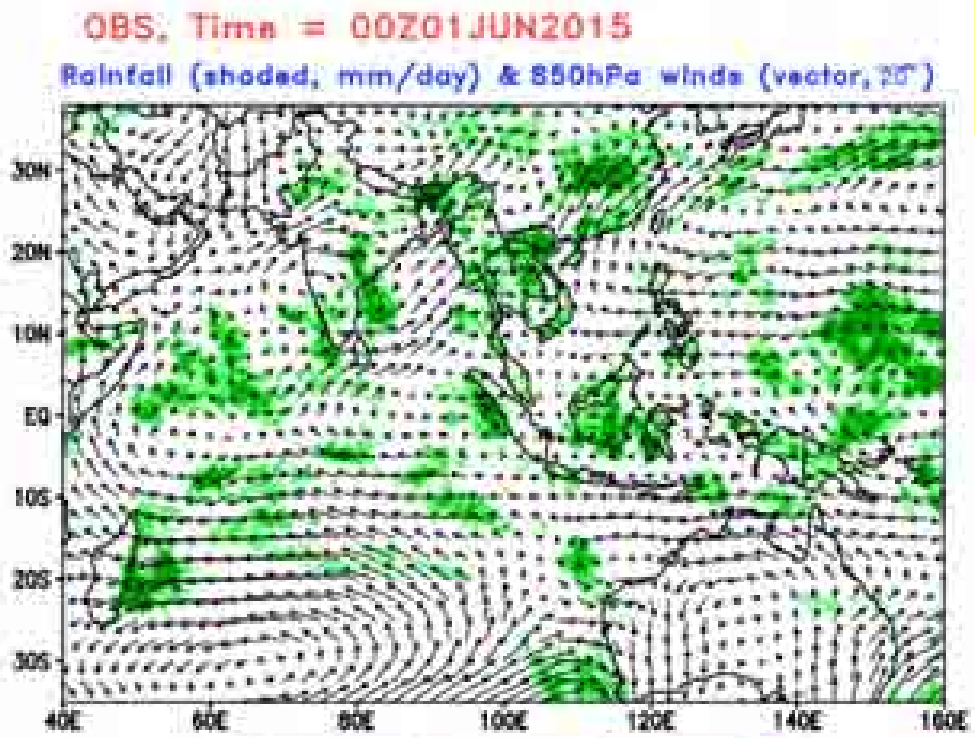
IC: 0605

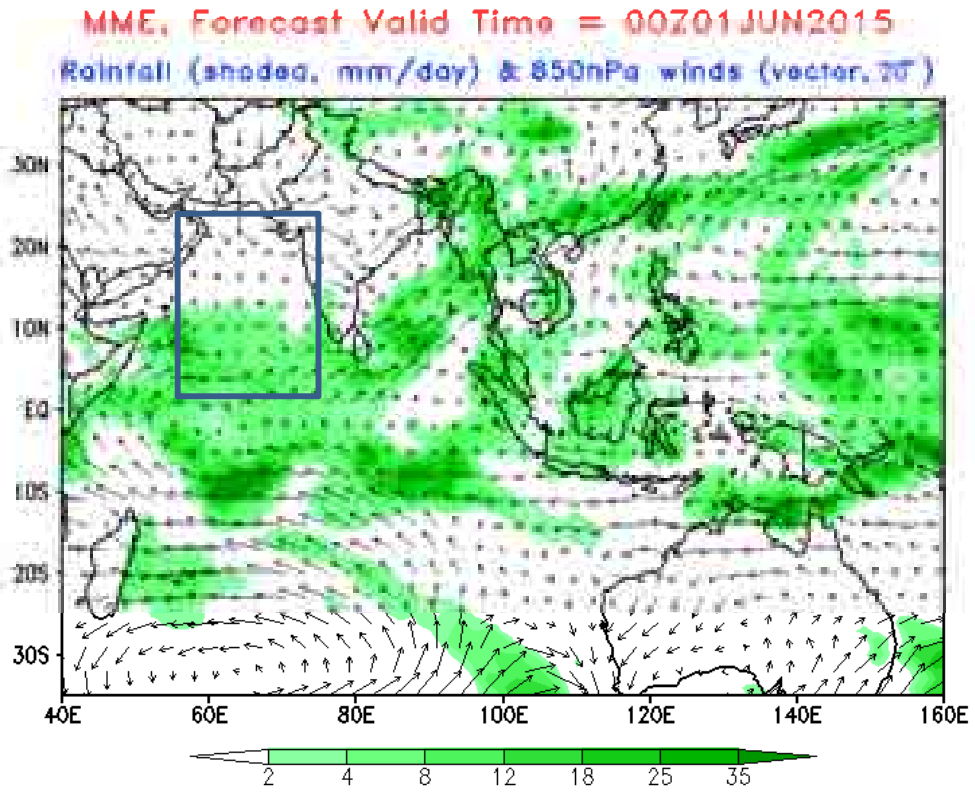
एम.एम.ई के द्वारा पूर्वी दिशा से (बंगाल की खाड़ी होते हुए) मॉनसून की विशेष प्रगति का अनुमान 17 जून के आस-पास का किया गया था।

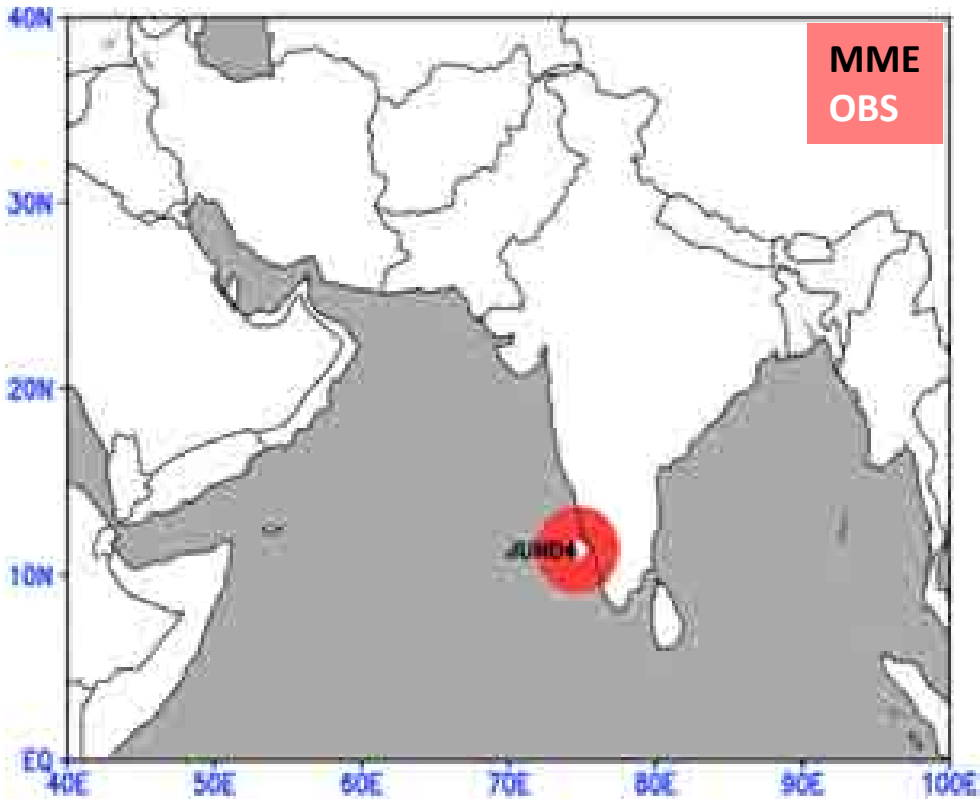
Prediction of Cyclogenesis

Cyclone "Ashobaa" during Onset phase of 2015 monsoon

IC: 0531



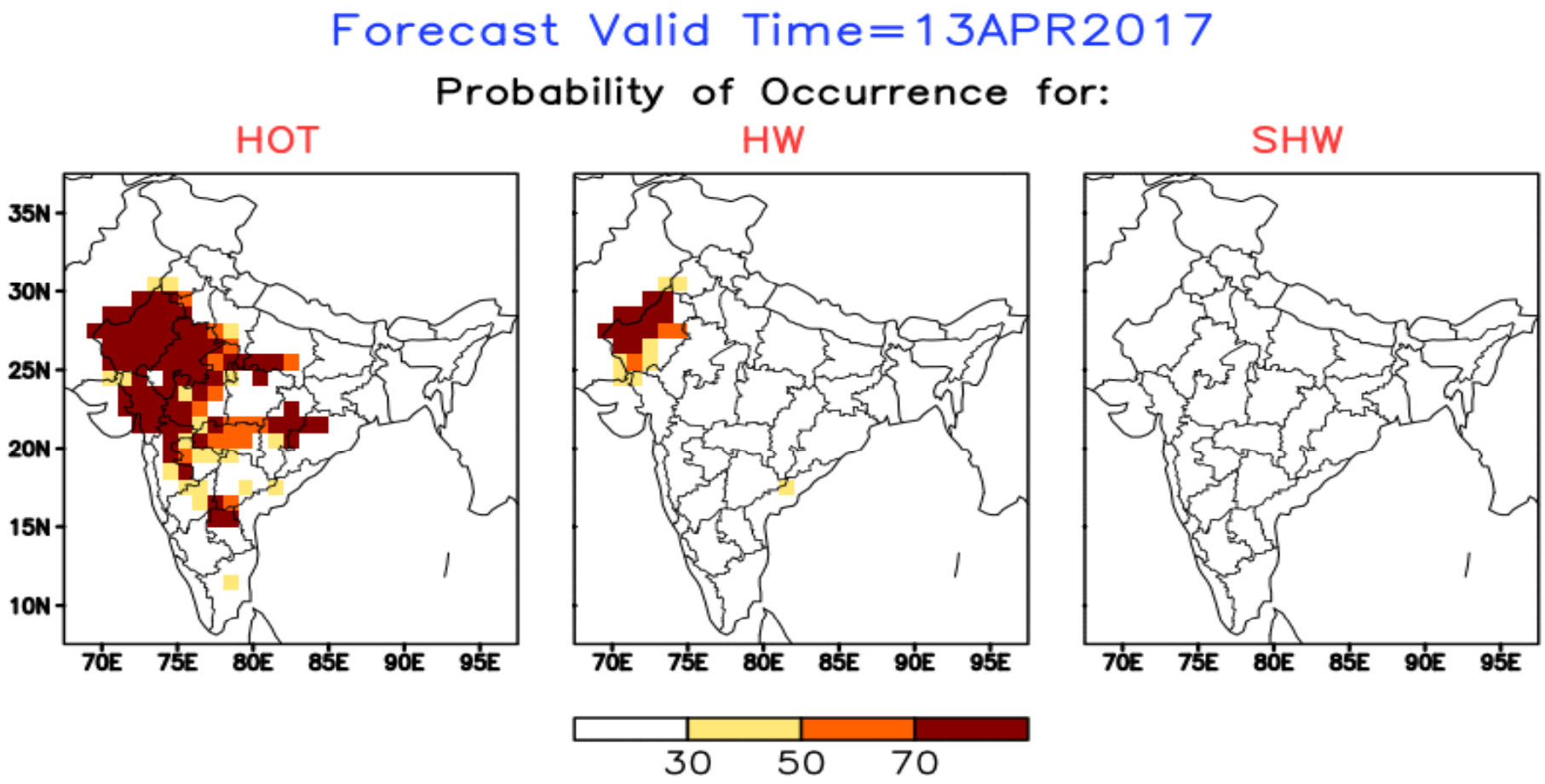




Low Pressure System (LPS) over southern tip of peninsula is likely to intensify and move towards Oman coast. This system may dissipate around 11th June and till then the monsoon activity will be weaker than normal over India.

Heat Wave in April 2017

IC: 0412

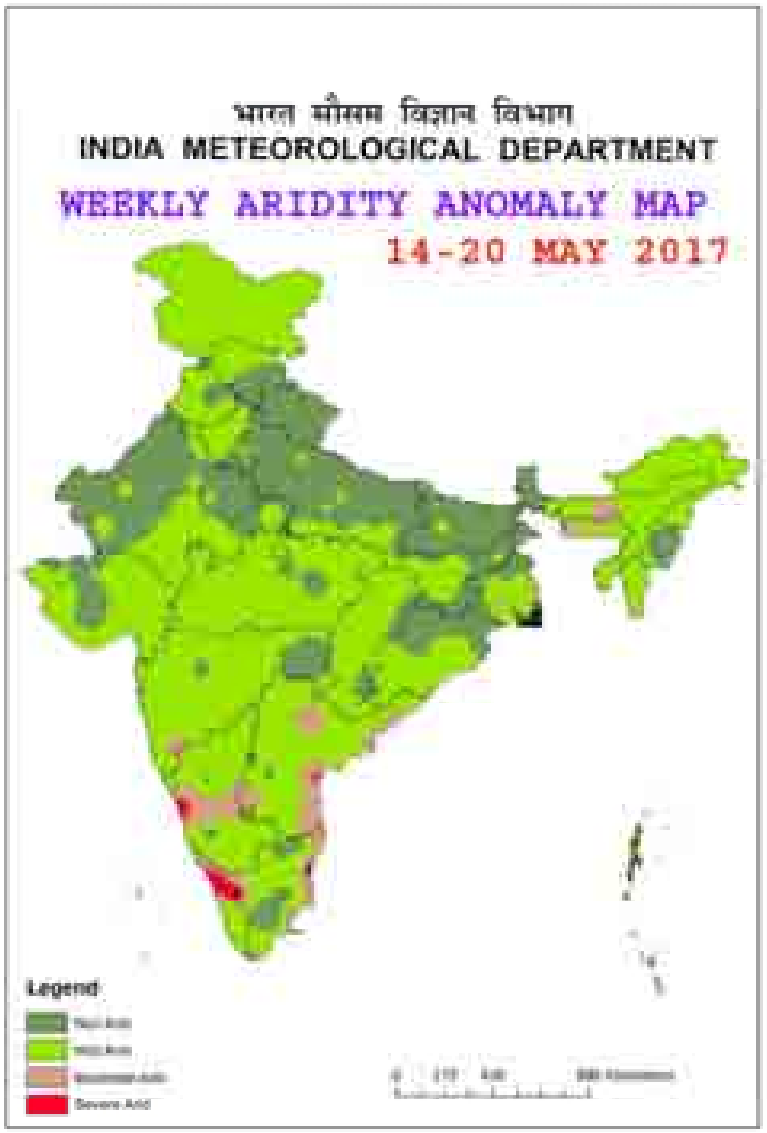


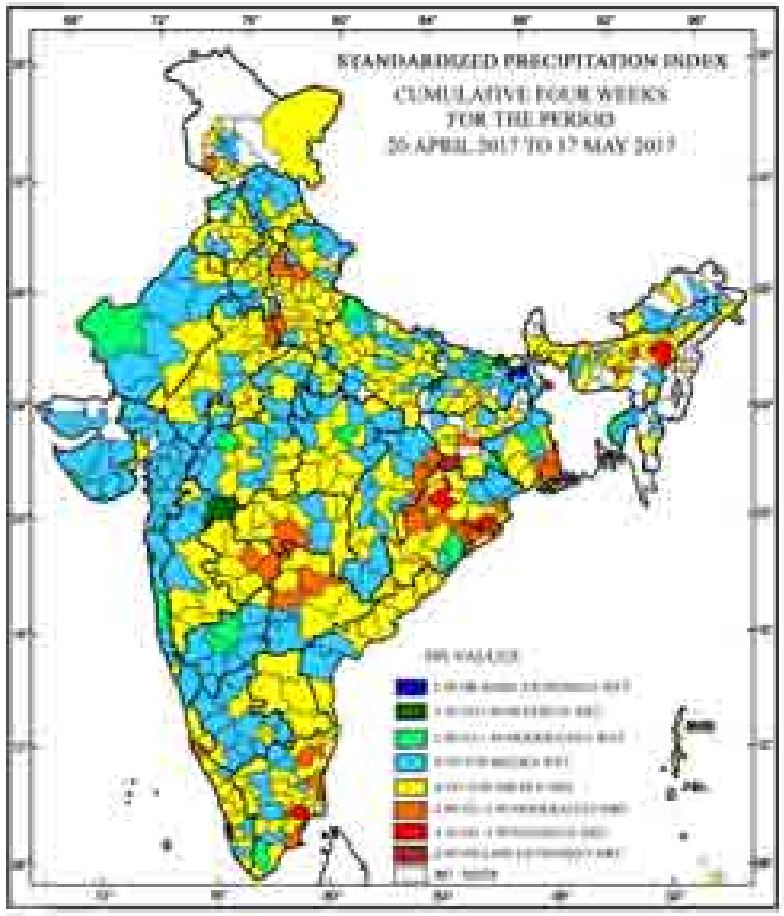
Climate Applications

Agriculture Sector: Monitoring drought conditions and preparation of outlook for the next week using Aridity anomaly and SPI maps

Water Sector: Rainfall monitoring, Basin wise rainfall monitoring and forecast

Health sector: Heat action plan , heat index maps and identifying meteorological windows for diseases

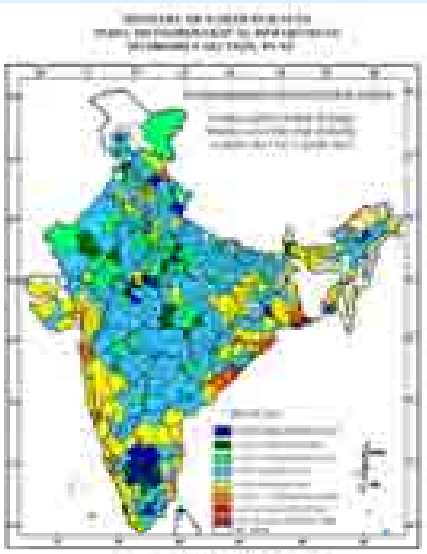


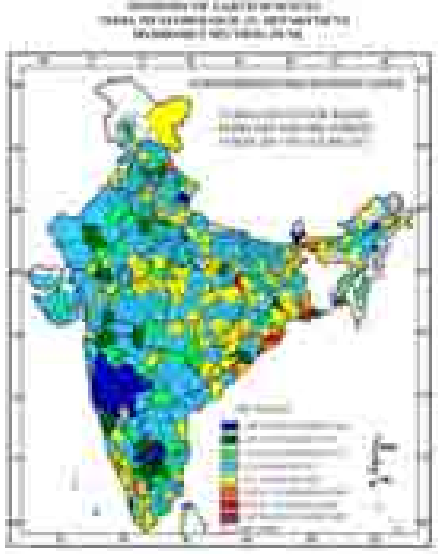


Forecasts for these maps are also generated during the monsoon season and are available at IMD Pune web site

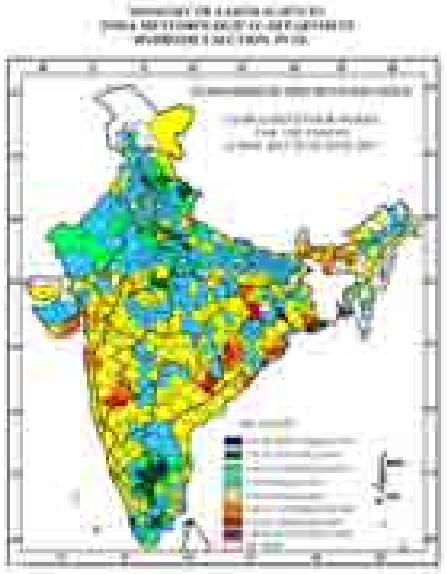
SPI Weekly Forecast

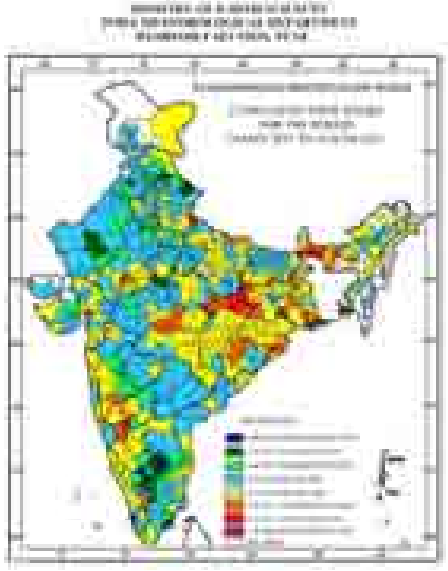
Forecast



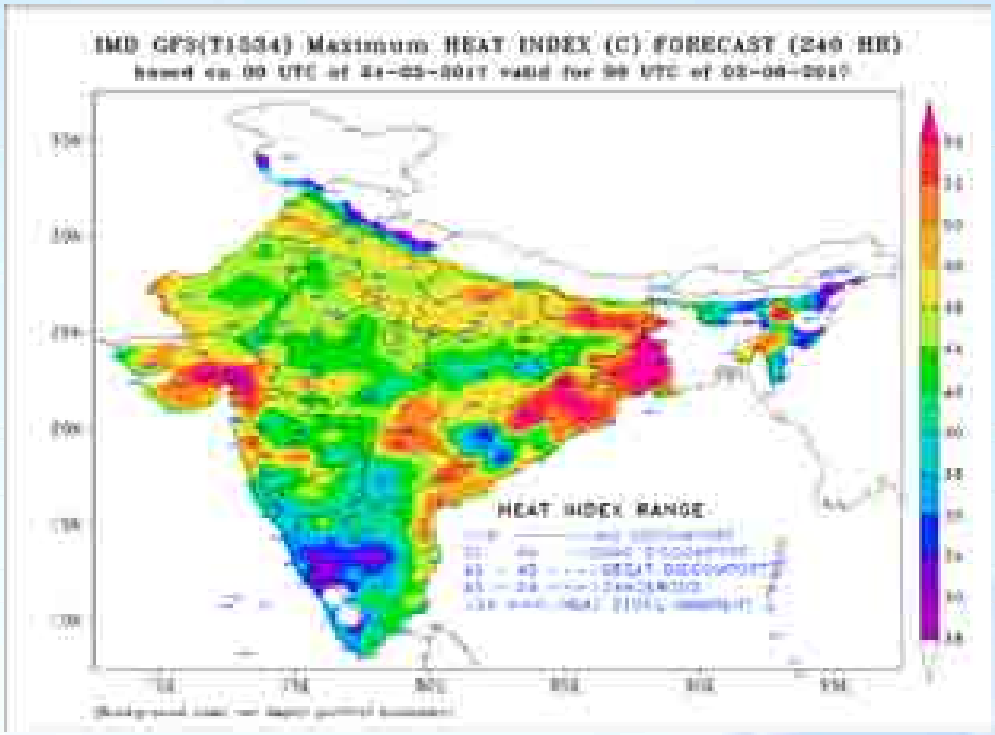


Realized

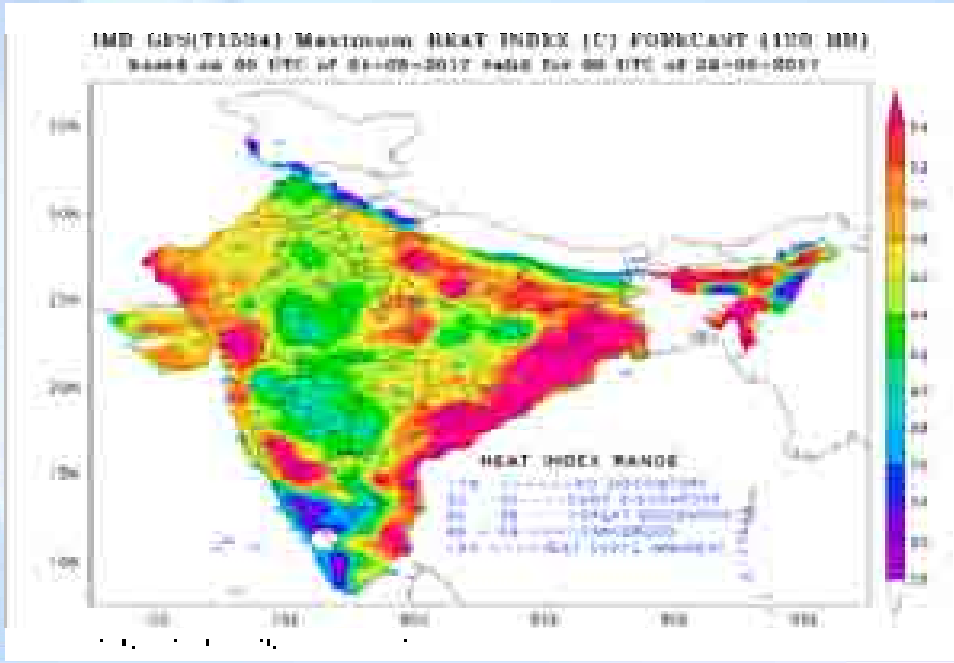




Forecast Performances									
WEEK 2017		Correct F/C	In ±1 cat	In ± 2 cat	In ± 3 cat	In ± 4 cat	In ± 5 cat	In ± 6 cat	In ± 7 cat
23	Freq	283	229	32	15	2	0	0	0
23	%	50.4	40.8	5.7	2.7	0.4	0.0	0.0	0.0
24	Freq	301	209	37	9	8	3	0	0
24	%	53.1	36.9	6.5	1.6	1.4	0.5	0.0	0.0



Heat Action plan for 9 cities including Nagpur are already in place



Favorable conditions Malaria

weeks	VBD	Threshold minimum temp (Th-Tmin)	Region(s) with Predicted Tmin within range of Th-Tmin	Threshold maximum temp (Th-Tmax)	Region(s) with Predicted Tmax within range of Th-Tmax
19th May to 25th May	Malaria Plasmodium Falciparum	16–19 ^{0}C	Himachal Pradesh and some part of Uttarakhand	33-39^{0}C	Himachal Praedsh, Uttarakhand, Punjab, Haryana, Major part of Uttar Pradesh, whole Bihar, West Bengal, Tamilnadu, Kerala, Karnataka, Konkan, Madhya Maharashtra, Sourashtra & Kutch, Major part of Gujarat region, Northeastern states, Major part of Jharkhand.
	Malaria Plasmodium vivax	14–15 ^{0}C	Jammu and Kashmir.		
26th May to 01st June	Malaria Plasmodium falciparum	16–19 ^{0}C	Some part of Himachal Pradesh.	33-39^{0}C	Uttarakhand, Himachal Pradesh, Bihar, West Bengal, Tamilnadu, Kerala, Karnataka, Madhya Maharashtra, Konkan, Sourashtra & Kutch, Major part of Jharkhand, Some part of Orissa, Andhra Pradesh, All Northeastern states.
	Malaria Plasmodium vivax	14–15 ^{0}C	Jammu and Kashmir.		

Use of Climate Data

To prepare reference meteorological conditions (Climatology).

To Understand Climate Patterns / Systems.

To Monitor Climate / Prepare Climate Diagnostics.

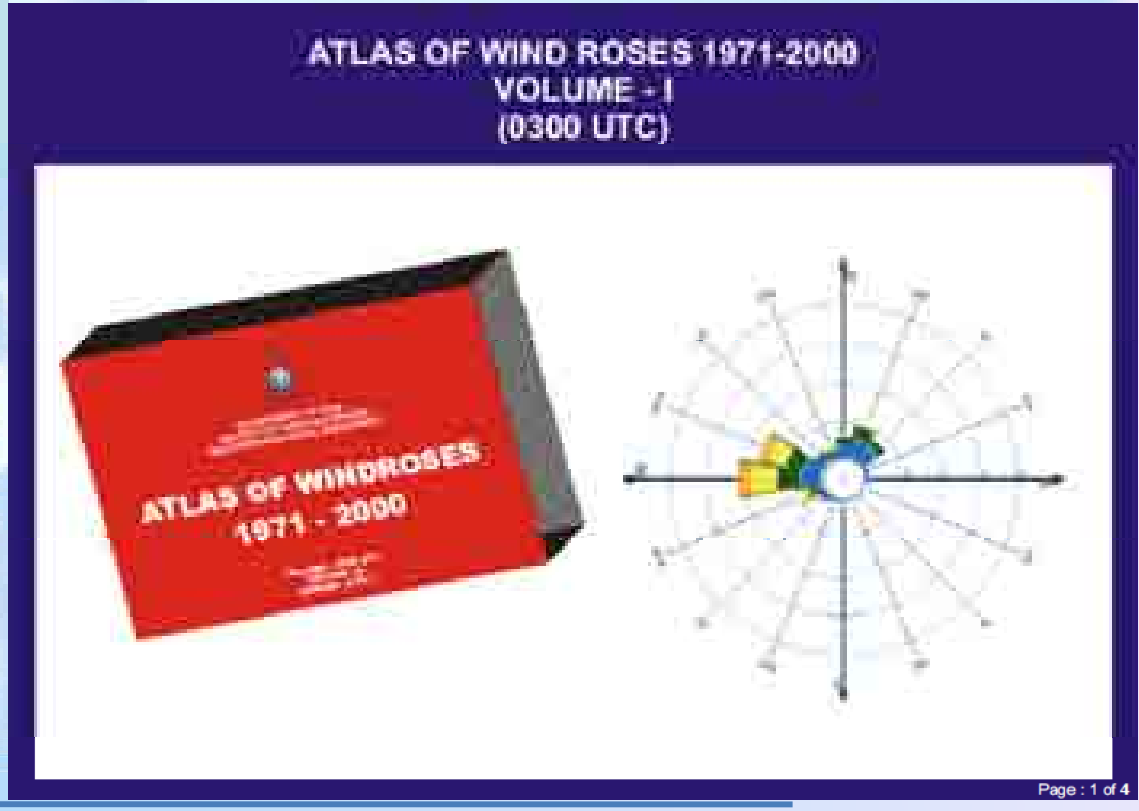
To Understand Tele connections of different Climate Systems.

To use information of climate data analysis for societal benefits.

Climate Services : beginning (using simply the climate data)

Publication of normal Viz: Climatological tables upper air wind analysis / Radiation maps(climatology),Rainfall maps and its probabilistic distribution maps, Wind rose diagrams etc. and its periodical updating:

110 years districts monthly rainfall data series in CD



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Climate data products

- NCC generates, many climate data products for smaller spatial and temporal scales for the user community. These data products include followings:

- Daily gridded (1^o X 1^o) rainfall and temperature data
- Daily gridded(0.5^o X 0.5^o and 0.25^0x 0.25^0 [long series]) rainfall data
- Monthly , daily and weekly rainfall data for the districts , states and all India for 1901-2015

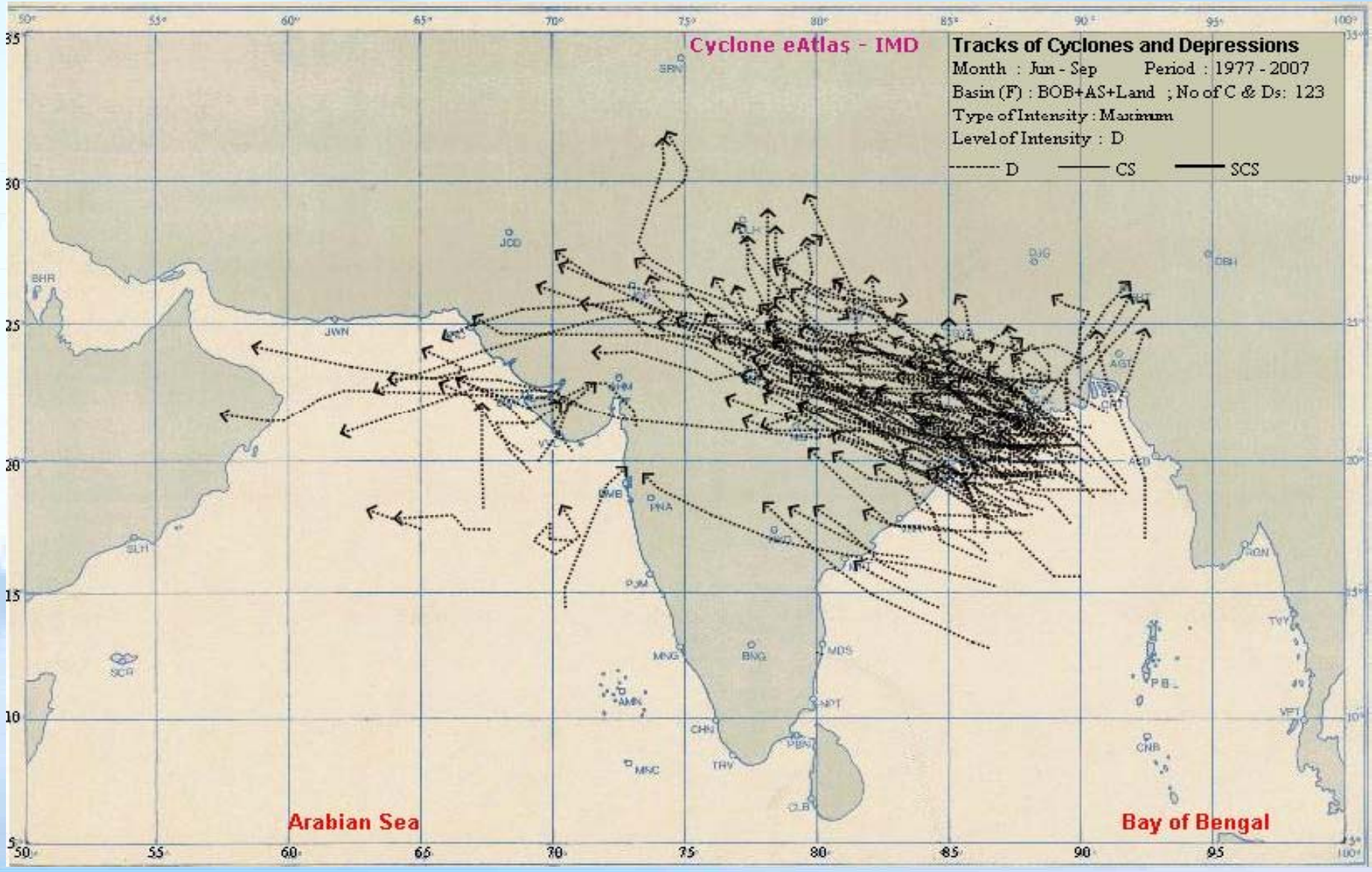
These data have been supplied many international research institutes and universities

So far more than 600 research paper have been published in peer reviewed journals using these data sets

Utility of Climate data / publications brought out as indicated earlier

- To identify deviation of the current weather / climate value
- Observing behaviour of any extreme events
- Generation of Climate Information for user sectors
- For Detection of Climate Change: Temporal and Spatial

MONSOON DEPRESSIONS

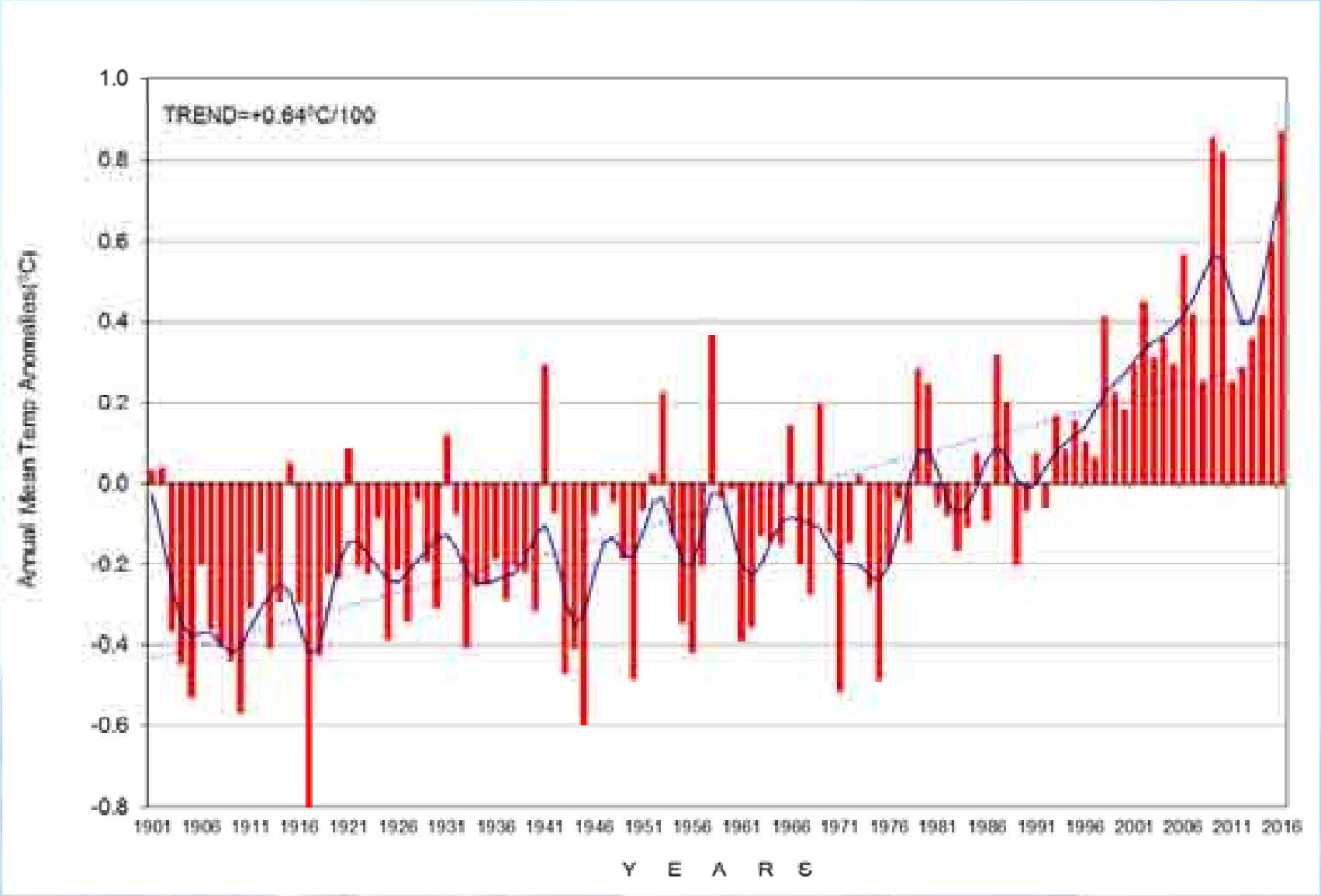


Rainfall harvesting potential for Maharashtra

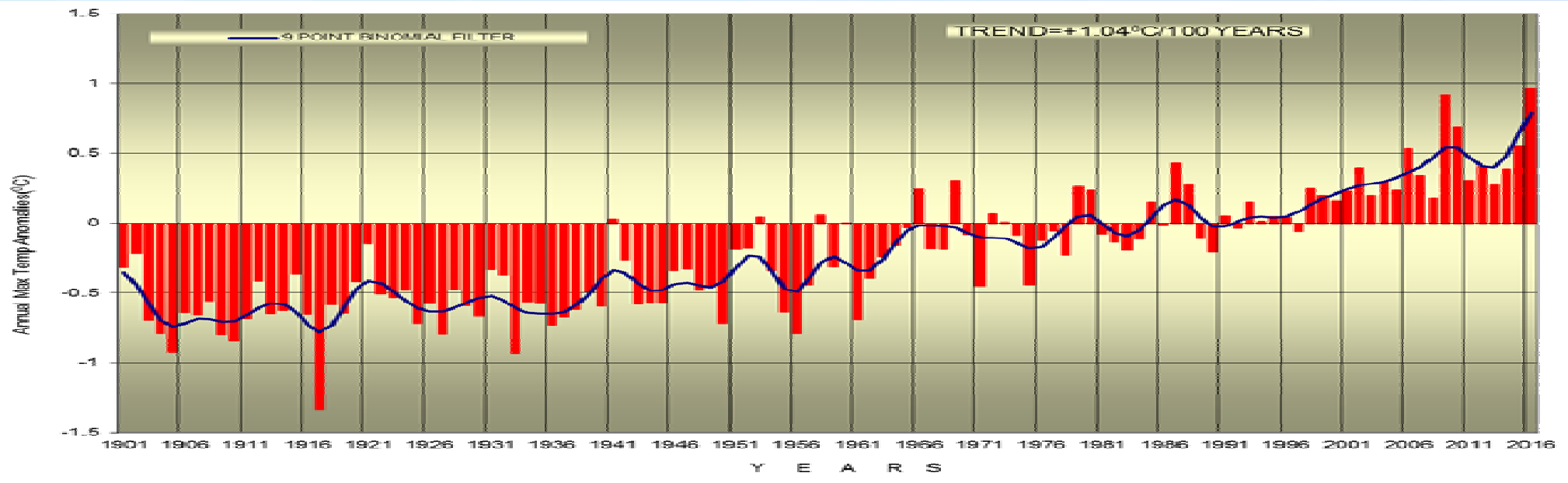
g. 3 Rain water potential in litre/sqft map for the southwest monsoon season

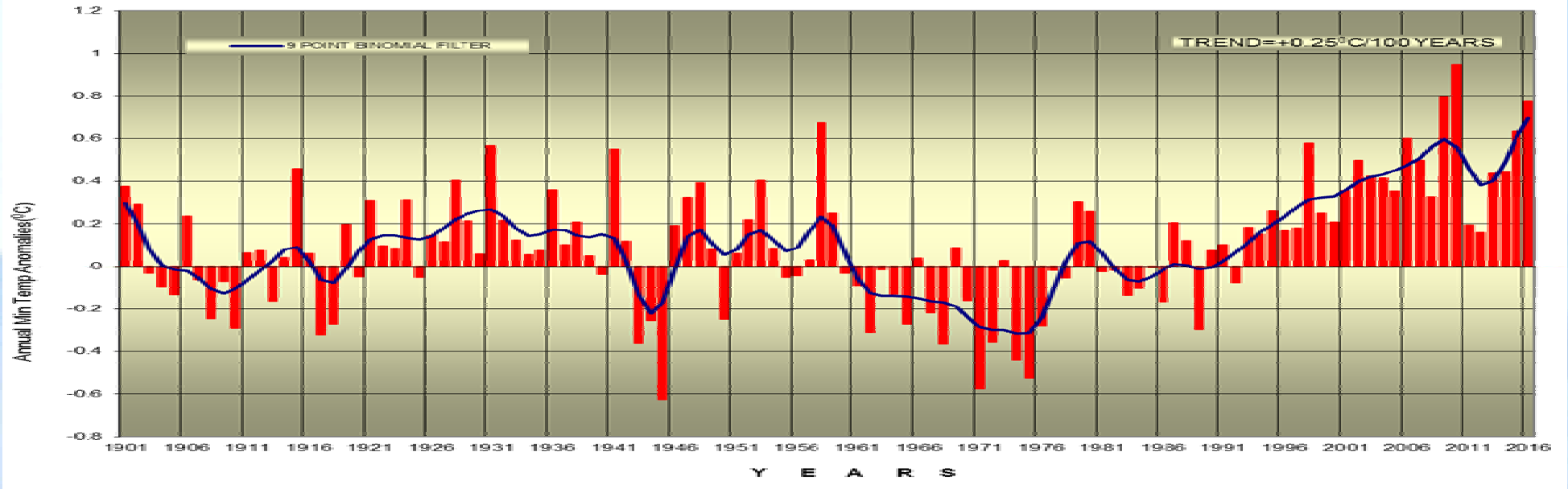
Climate trends

Temperature



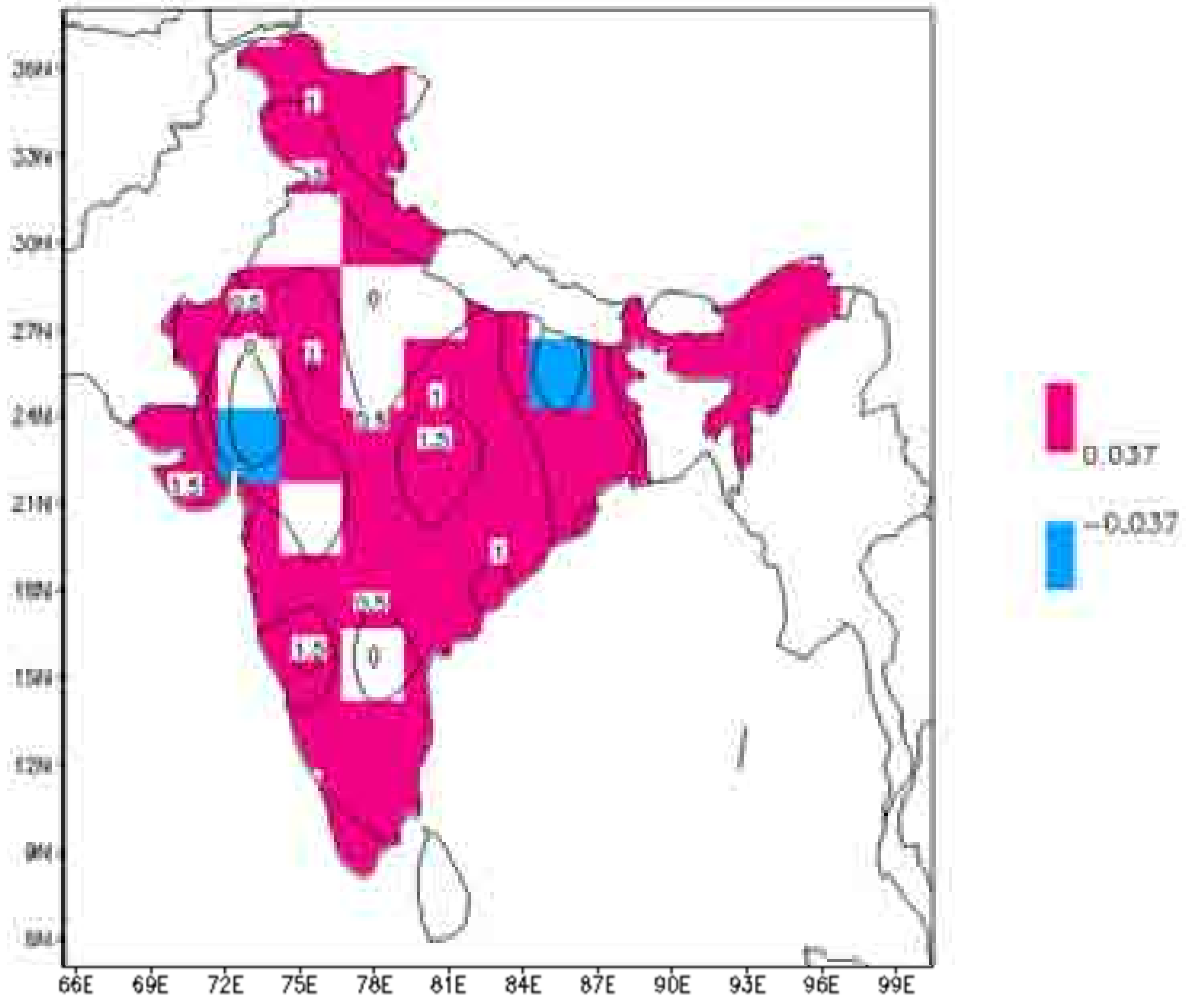
All India annual mean temperature anomaly (1901-2016)



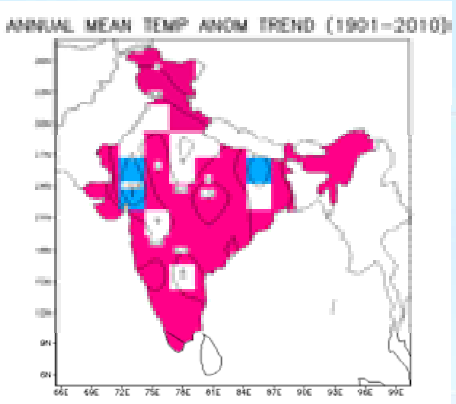


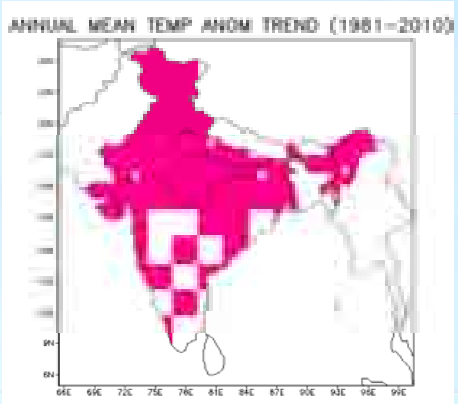
All India annual maximum / minimum temperature anomaly (1901-2016)

ANNUAL MEAN TEMP ANOM TREND (1901–2016)

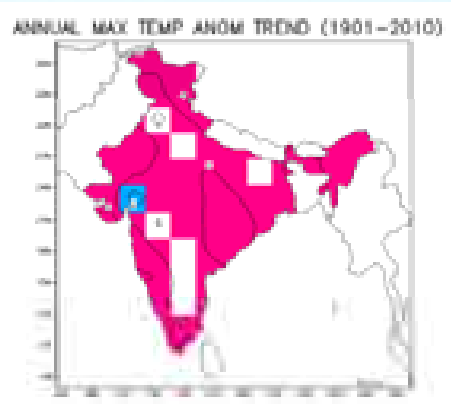


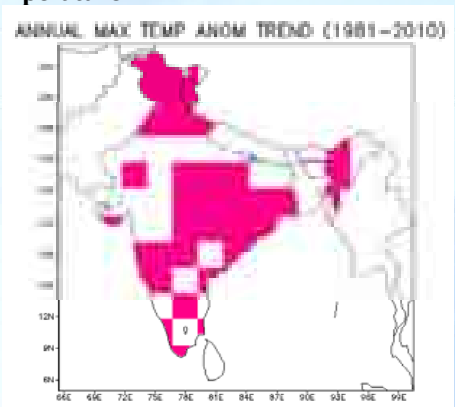
Mean Temperature



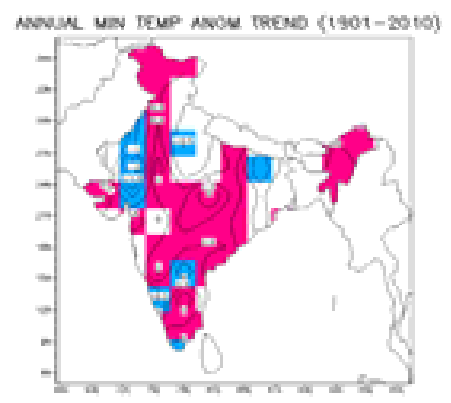


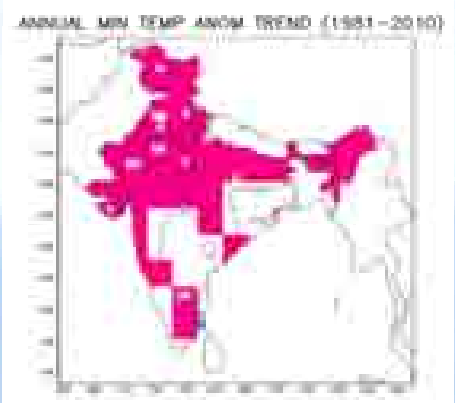
Maximum Temperature





Minimum Temperature

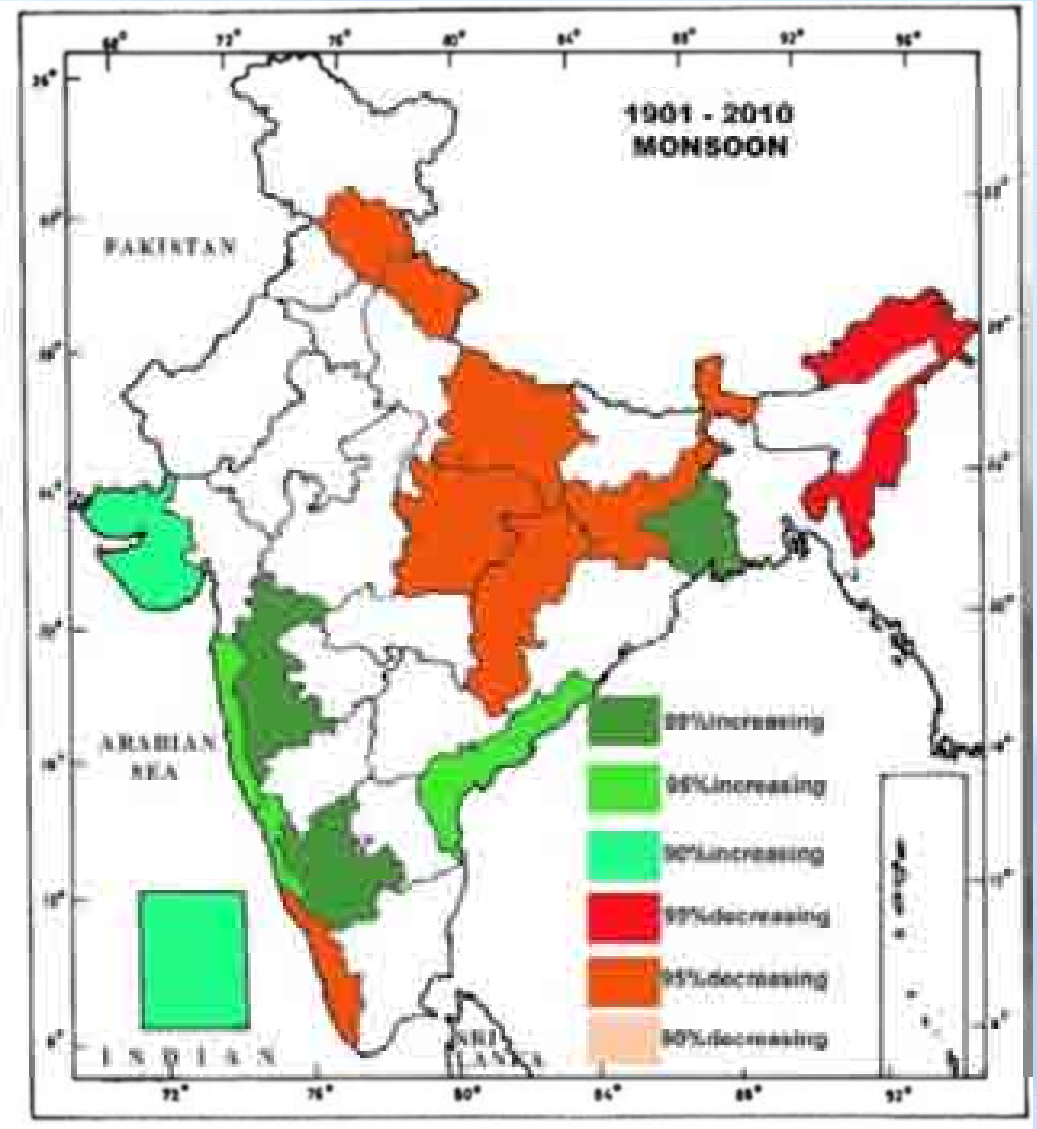




Spatial pattern of the trend in annual mean, maximum and minimum temperature for the 1901-2010 and 1981-2010 periods. Regions where the trends are statistically significant (at the 95% confidence level) are shaded (red and blue show significant increase and decrease, respectively) and magnitude of trend during the periods is depicted by contour lines.

RAINFALL

Trends in the monsoon season rainfall for the 36 meteorological sub-divisions of India for the period 1901-2010



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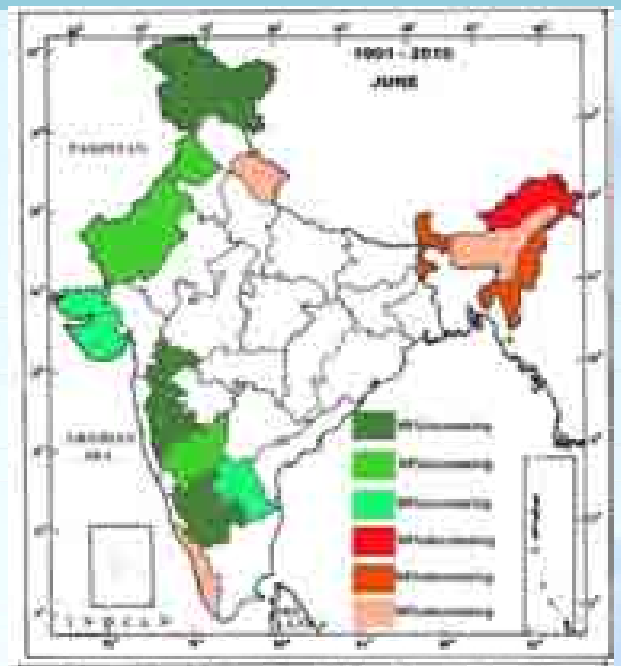
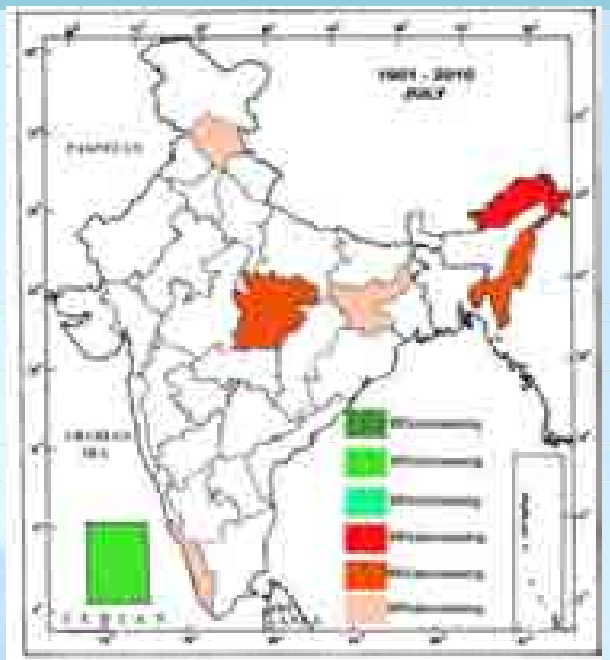
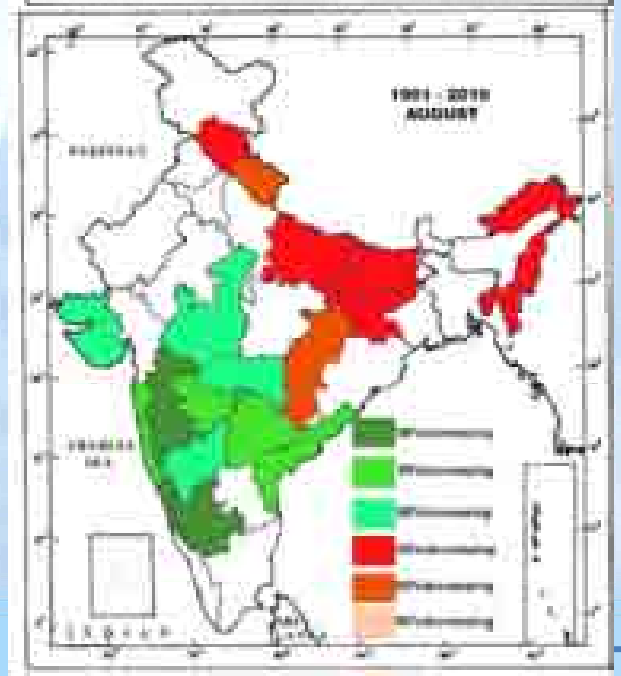
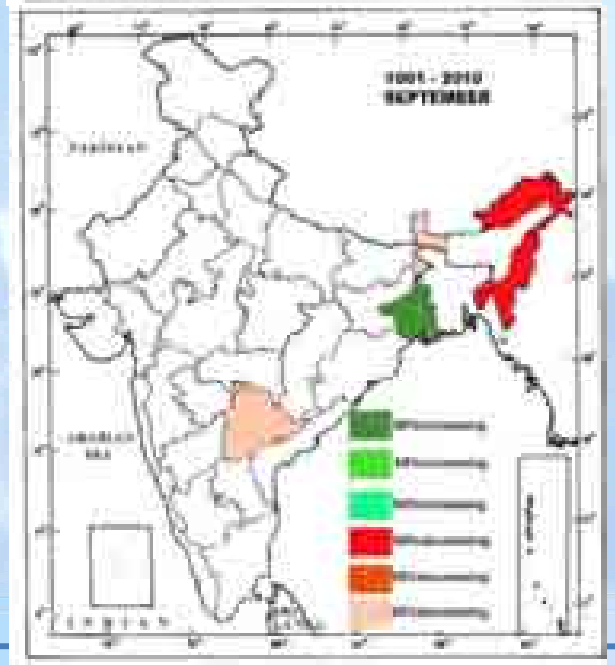
Trends in the monthly rainfall for the 36 meteorological sub-divisions of India for the period 1901-2010.









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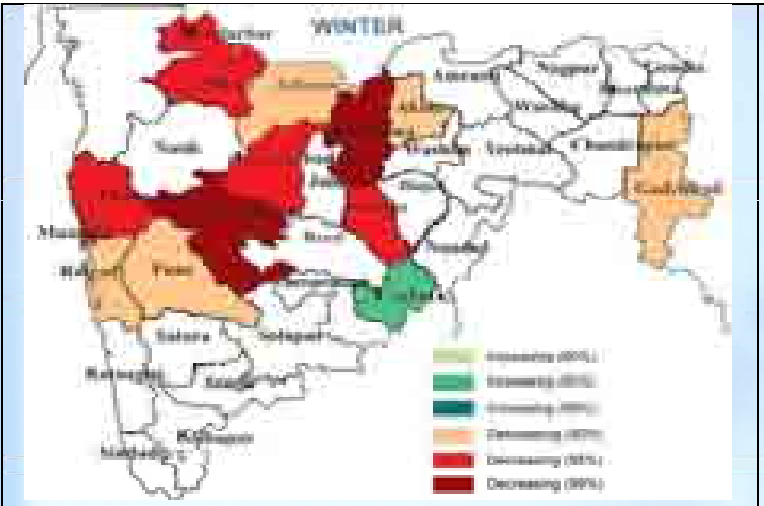
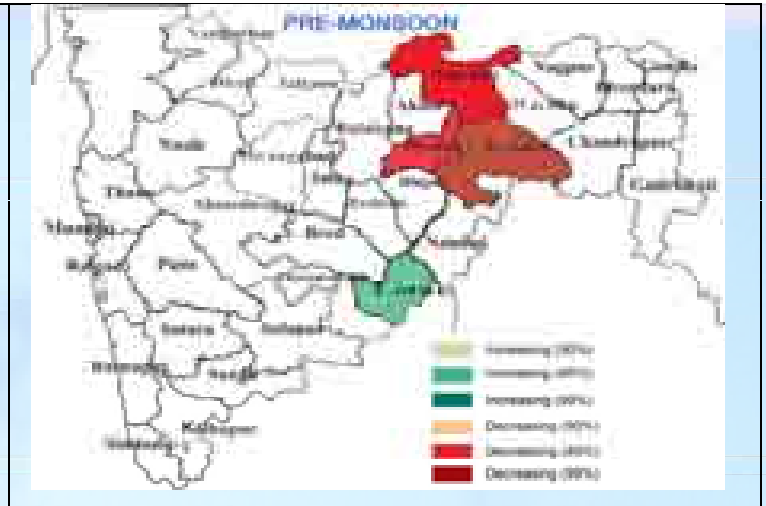
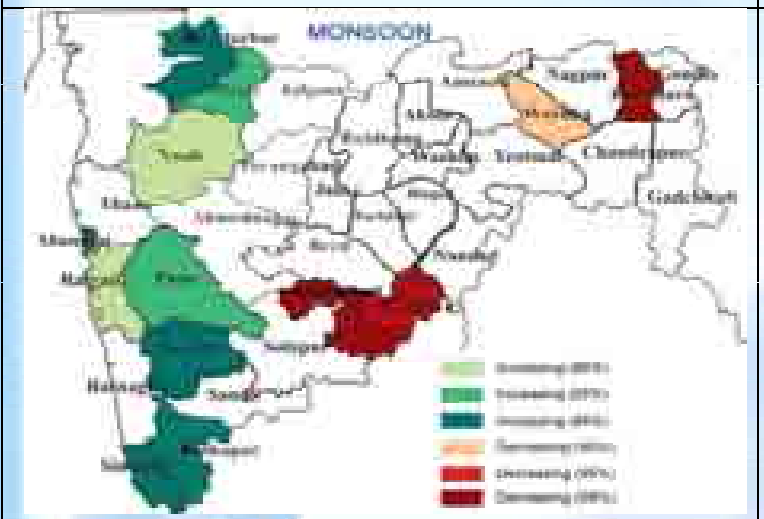
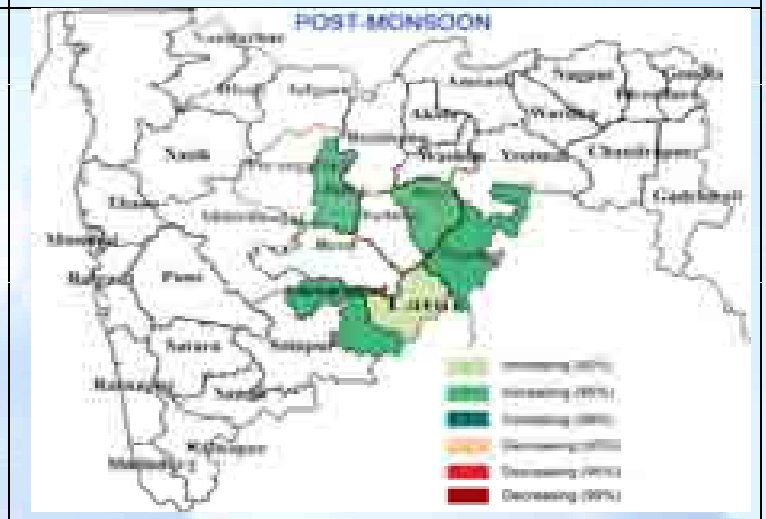
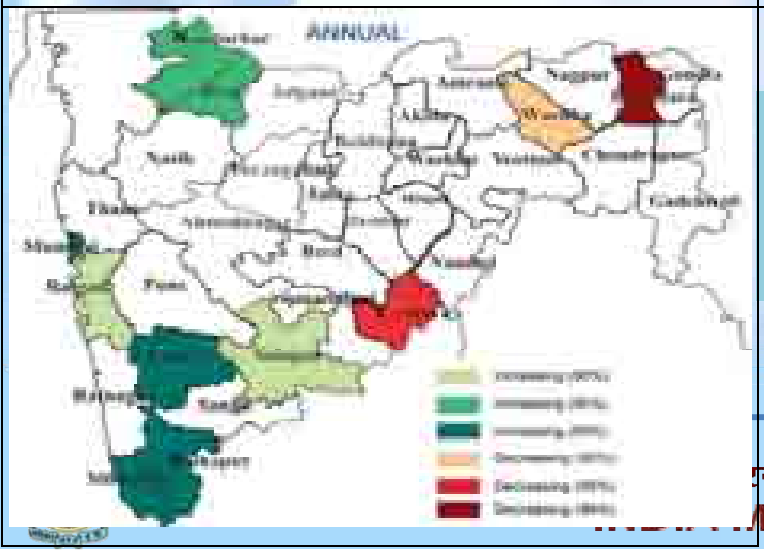




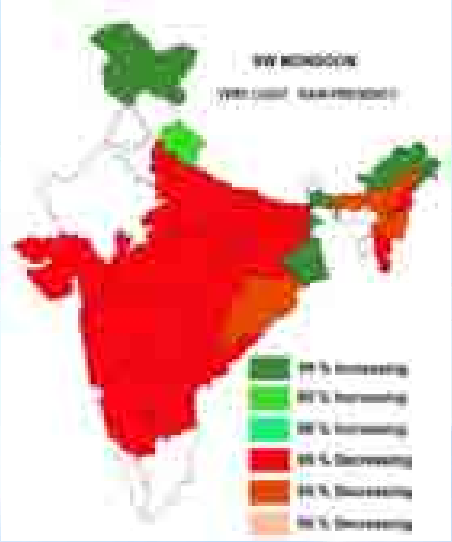


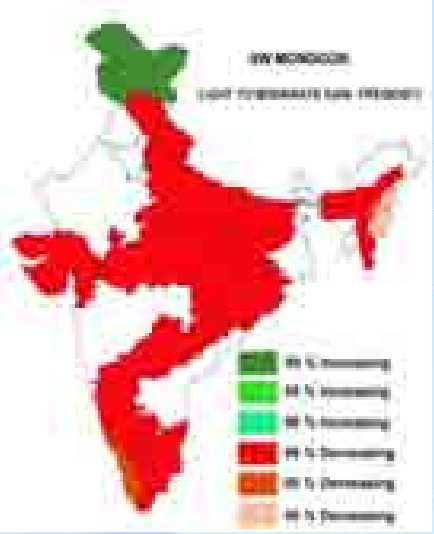


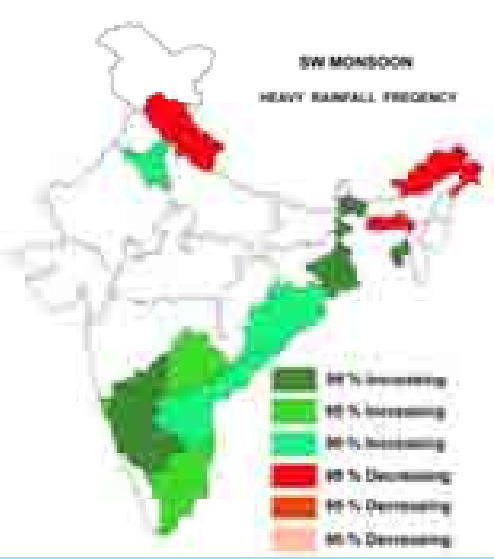


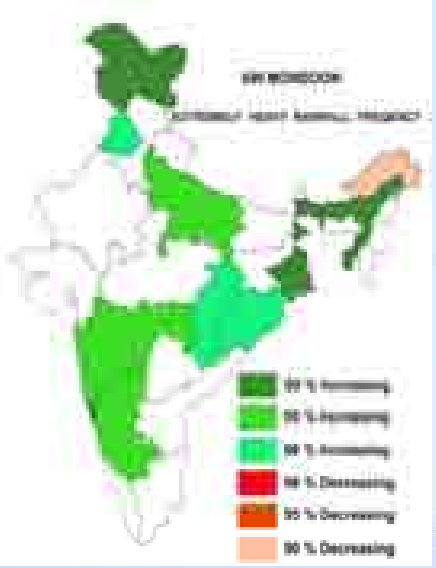
Trends in the seasonal and annual rainfall over the districts of Maharashtra

Trends in the frequencies of different rainfall events over the states during the southwest monsoon season (June- September) (1901-2010)









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THANK YOU