Capacity building training on "Regional Severe weather and flash flood Hazard Early warning Mechanism"

SIDMC(IU),GIDM Campus, Gandhinagar, Gujarat, India

15th October 2019

South Asian Climate Outlook Forum (SASCOF)- A Mechanism for Preparing consensus climate forecast outlook for S. Asia

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भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Outline

- Regional Climate Center.
- Climate Outlook Forum
- South Asia Climate Outlook Forum (SASCOF)
- Basic of Seasonal Forecast
- Input for Preparation of Regional Climate Outlook
- The Process of Climate Outlook preparation
- New tool for Flash Flood Early Warning for S. Asia

WMO Regional Climate Center

WMO Regional Climate Centers (RCCs) are centres of excellence that create regional products that support regional and national climate activities, and thereby strengthen the capacity of WMO Members in a given region to deliver up-to-date climate information and prediction products for climate services.

RCC, Pune

http://rcc.imdpune.gov.in/Index.html

WMO Regional Climate Center

MANDATORY FUNCTIONS of RCC

- Operational Activities for Long Range Forecast (LRF)
- Operational Activities for Climate Monitoring
- Operational Data Services, to support operational LRF and climate monitoring
- Training in the use of operational RCC products and services

There are 3 WMO Designated RCC in RAII Region

Beijing Climate Center (BCC)
Tokyo Climate Center (TCC)
Regional Climate Center IMD, Pune

Regional Climate Outlook Forum

Regional Climate Outlook Forums (RCOFs) produce consensus-based, user-relevant climate outlook products in real time in order to reduce climate-related risks and support sustainable development for the coming season in sectors of critical socioeconomic significance for the region in question.

South Asian Climate Outlook Forum (SASCOF): Background

- In Asia, China has been coordinating a RCOF called 'Forum on Regional Climate Monitoring, Assessment and Prediction for Regional Association II (FOCRA II) since 2005, covering the entire Asian continent.
- Asia is a large continent with large differences in the climatological settings on a sub-regional scale. Therefore WMO's Regional Association II (Asia) recommended sub-regional RCOFs devoted to specific needs of groups of countries having similar climatic characteristics.
- Implementation of South Asian Climate Outlook Forum (SASCOF) in 2010 is a step in that direction with specific focus on the climate information needs of nations affected by the Asian summer monsoon climate.

South Asia Climate Outlook Forum (SASCOF)

Year	Host Country	Foreign Participants	Country
2018	India	6	Bangladesh, Bhutan, India, Maldives, Myanmar and Sri Lanka
2017	Bhutan	7	Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka.
2016	Sri Lanka	8	Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka
2015	Bangladesh	9	Afghanistan, Bhutan, Bangladesh, India, Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka.
2014	India	8	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, India and Sri Lanka
2013	Nepal	8	Afghanistan, Bangladesh, Bhutan, Maldives, Myanmar, Nepal, Pakistan and Sri Lanka
2012	India	7	Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, and Sri Lanka
2011	India	6	Bangladesh, Bhutan, India, Maldives, Nepal, and Sri Lanka
2010	India	6	Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka

South Asian Climate Outlook Forum (SASCOF10) : Thimphu, Bhutan

SASCOF Training workshops

Associated with SASCOFs forum meetings, Training workshops on seasonal prediction are also conducted. IMD designs and conducts the training workshops as per the regional requirement. Support of international experts is also used. The participating climate experts from the NMHS of the region are trained in using, interpreting and downscaling global seasonal prediction products and developing a consensus outlook.

SASCOF-6
Dhaka

SASCOF-5
India

SASCOF-4
Nepal

Basic of Seasonal Forecast

Scales of processes/models

Global

- Long waves
- El Nino
- Monsoons

Synoptic

- Jet streams
- High and low pressure centers
- Troughs and Ridges
- Fronts

Meso

- Thunderstorms
- Convective
- complexes
- Tropical storms
- Land/sea breezes
- Mountain/valley breezes
- Downslope wind storms
- Gap flows
- Cold air damming
- Nocturnal low-level jets
- Lake-effect snow bands

Urban

- Street-canyon flows
- Channeling around buildings, wakes
- Vertical transport on upwind and warm faces of buildings
- Flow in subway tunnels

Weather vs. Climate Forecasts

Weather Forecast

Run NWP model for a period up to two weeks (synoptic timescale)

***Objective*: Forecast relatively precise weather conditions at a specific time and place**

Example*: *NWP model suggests it will likely rain tomorrow afternoon because mid-latitude cyclone will occur over the U.S.

Climate Forecast

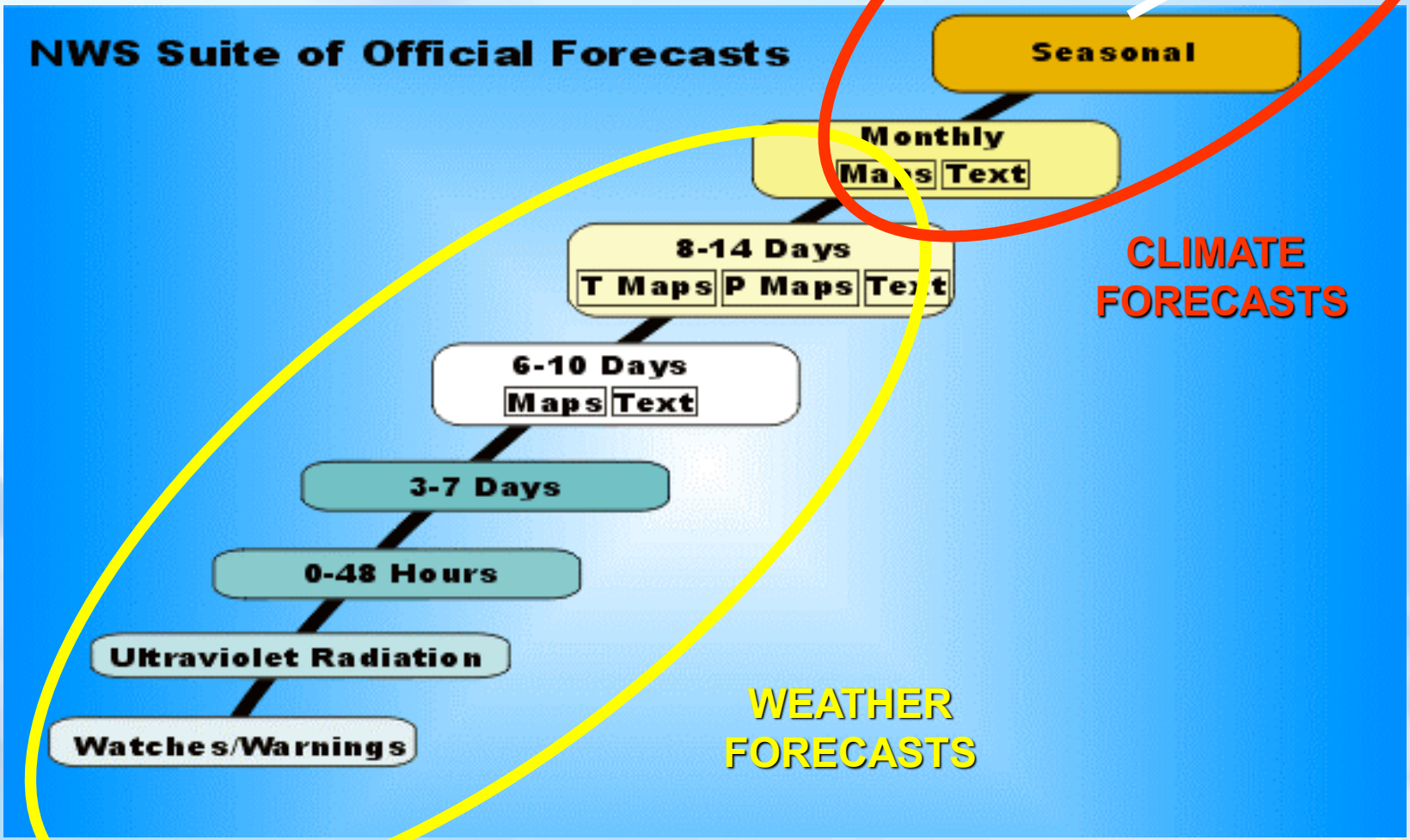
Run NWP model for a period longer than two weeks.

***Objective*: Forecast probability of deviation from average conditions, or climatology.**

Example*: *In the fall before an El Niño winter, a NWP model forced with warm sea surface temperatures in eastern tropical Pacific projects a circulation pattern favorable for above-average winter precipitation in Arizona.

NOT DESIGNED TO PREDICT EXACT WEATHER FOR SPECIFIC PLACES/TIMES MONTHS IN ADVANCE.

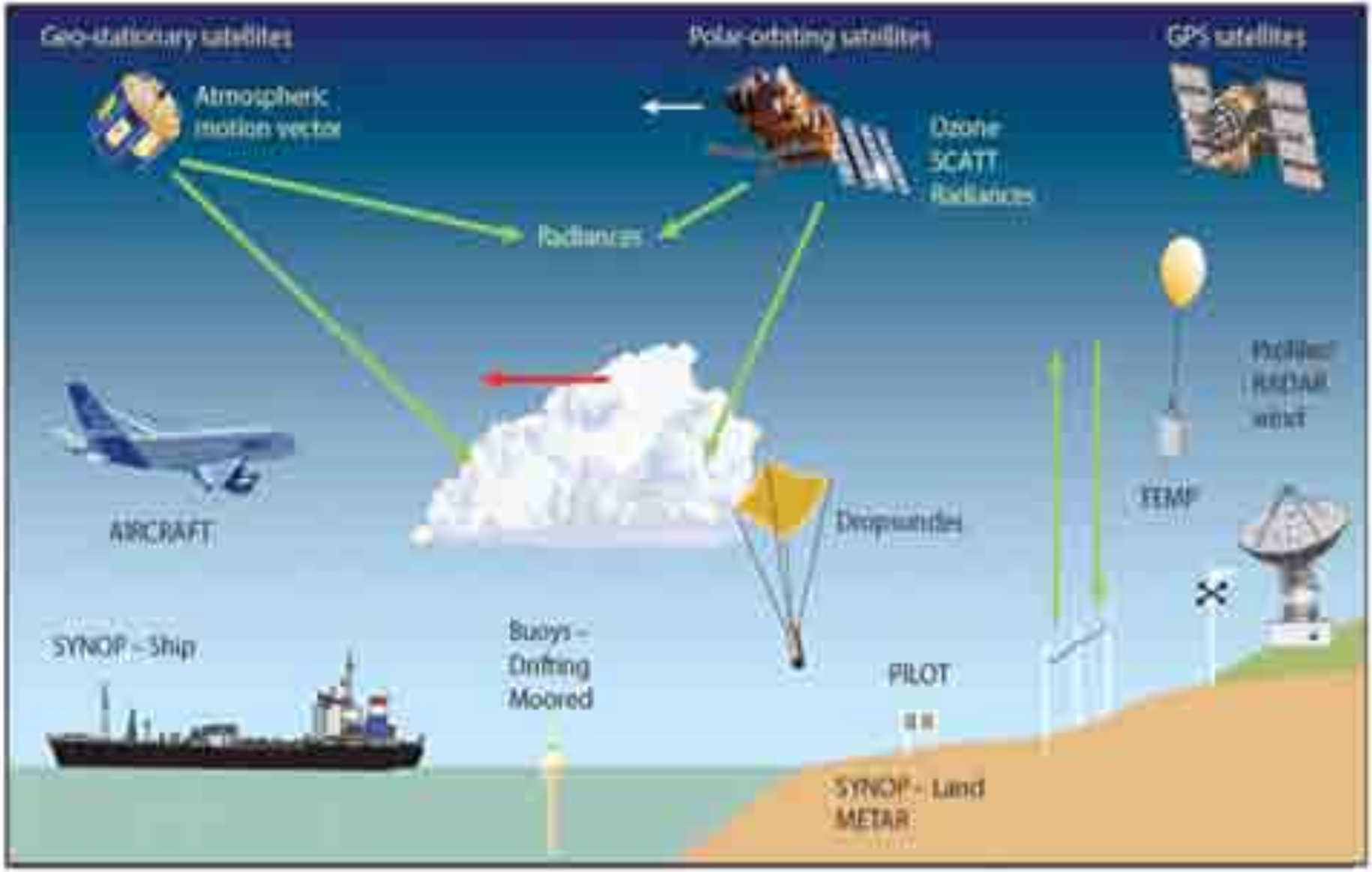
Various Weather & Climate Forecasts



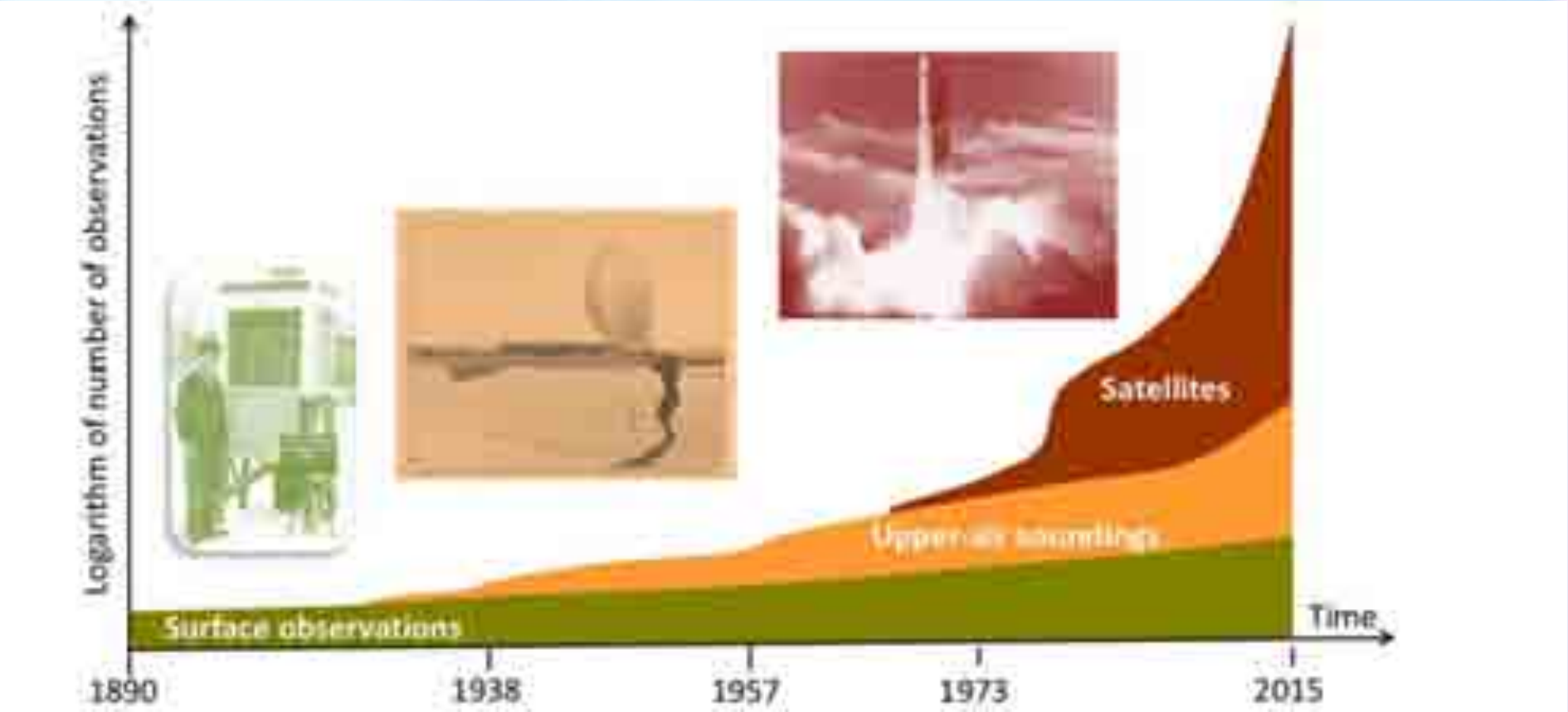
Extended & Seasonal Prediction

- Though the day to day changes in weather cannot be predicted for a period beyond 1-2 weeks, it has been suggested that climate variations (climate being defined as the space-time average of weather) can be predicted if averaged over certain space and time scales.
- How well we can predict it or if we can predict them at all depends upon our ability to understand and model the mechanisms causing the climate variations.

Weather Observation System



Weather Observation System

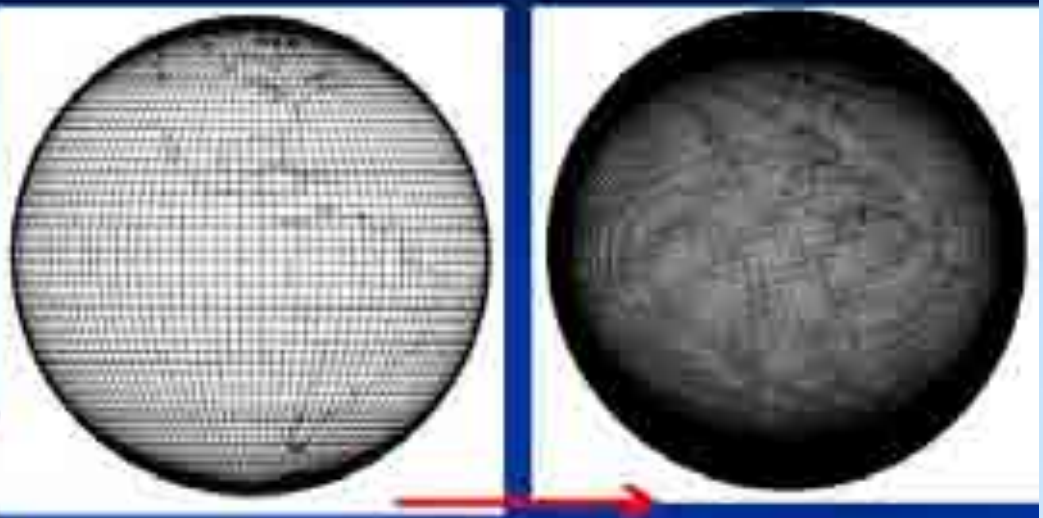


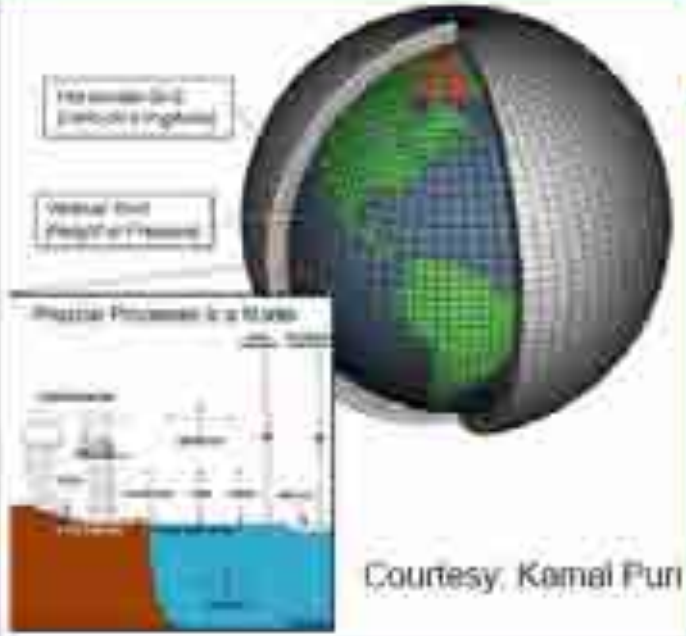
Basis of a weather / climate model

Representation of atmosphere temperature, wind, moisture, pressure on a grid

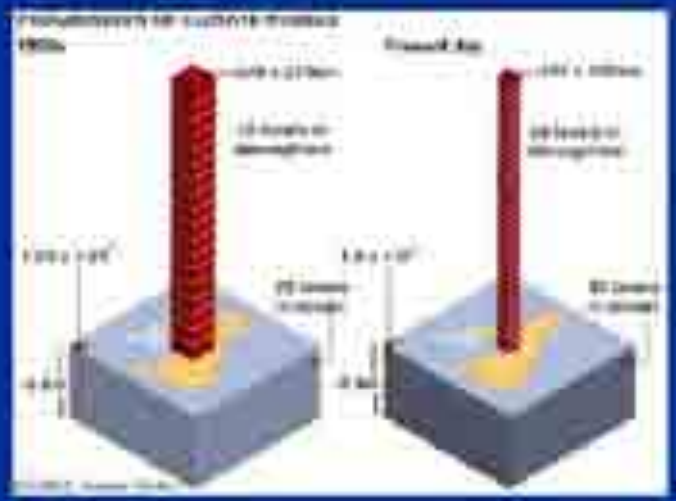
Equations of motions and laws of thermodynamics to predict rate of change of: T, P, V, q, etc.

10 Million equations:
100,000 Points × 100 Levels × 10 variables
Time step – 10 minutes

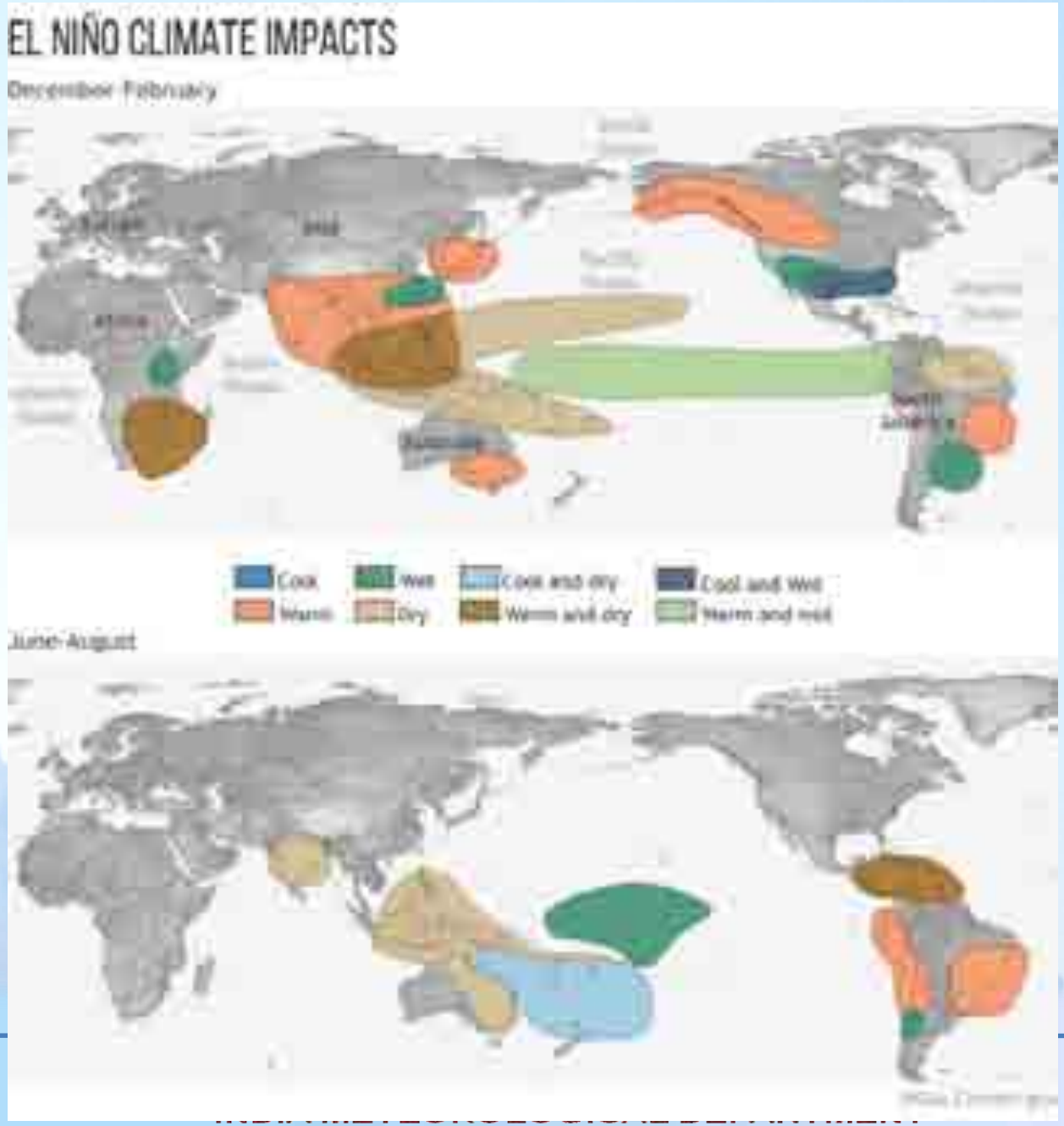




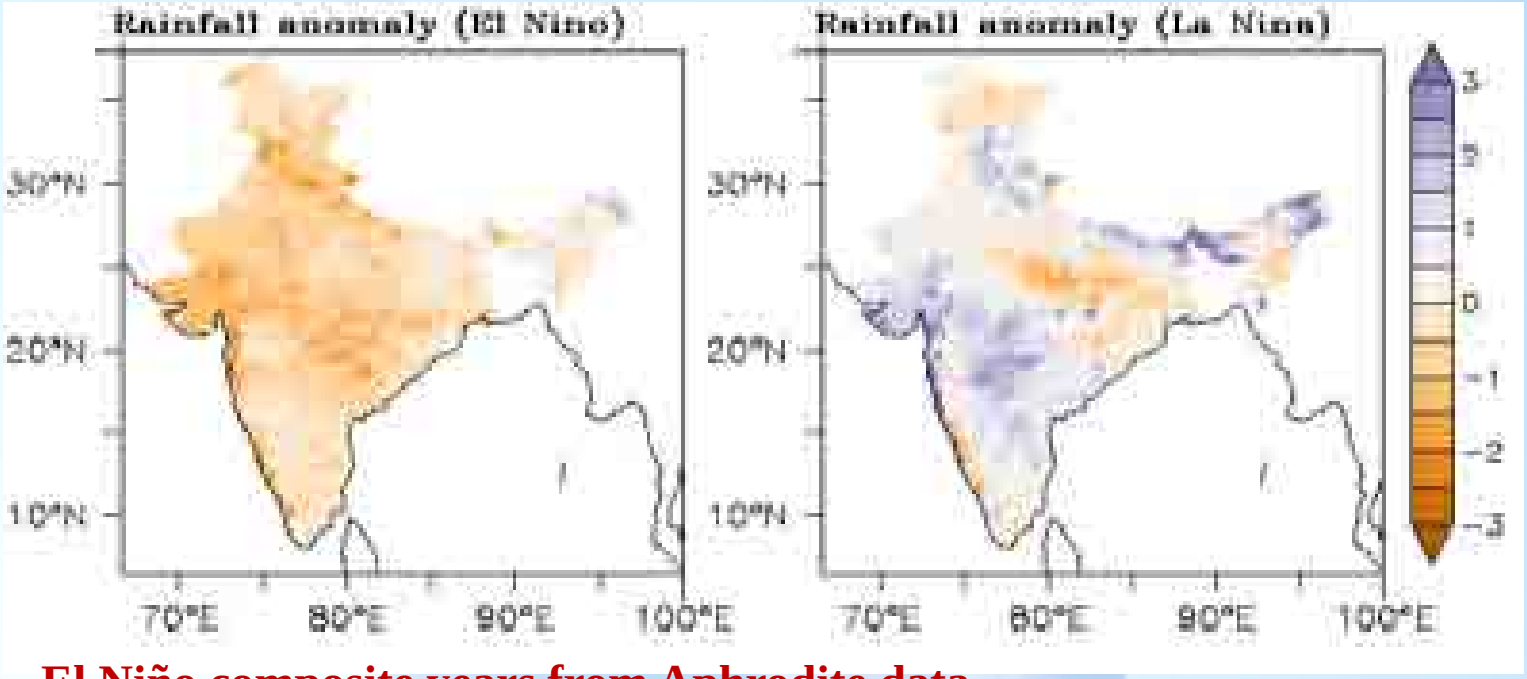
Courtesy: Kamal Puri



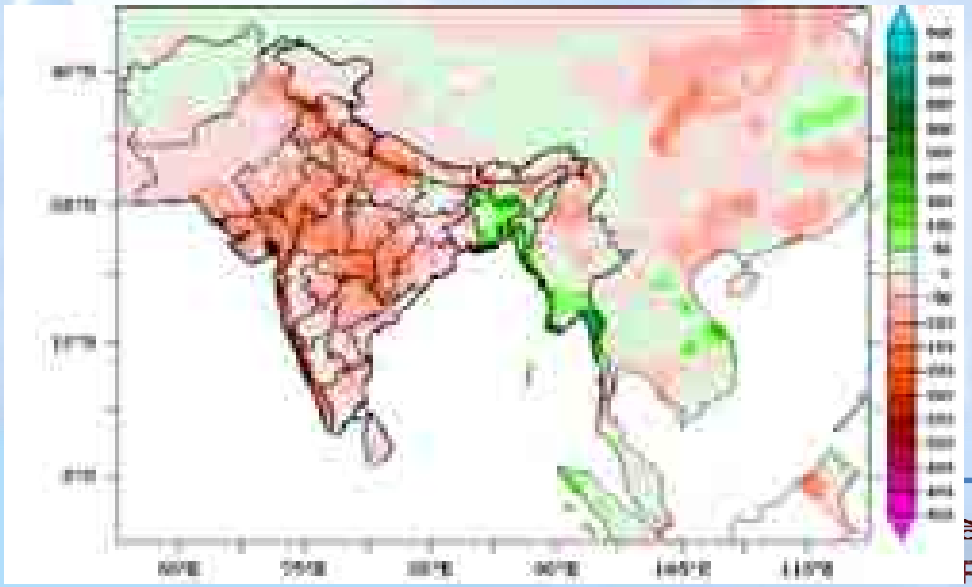
El Niño impact



Composite of Precipitation Anomaly for El Niño and La Niña Years



El Niño composite years from Aphrodite data



El Niño Years :
1951, 1953, 1957, 1963, 1965, 1969, 1972, 1982, 1987, 1991, 1997, 2002, 2004, 2009

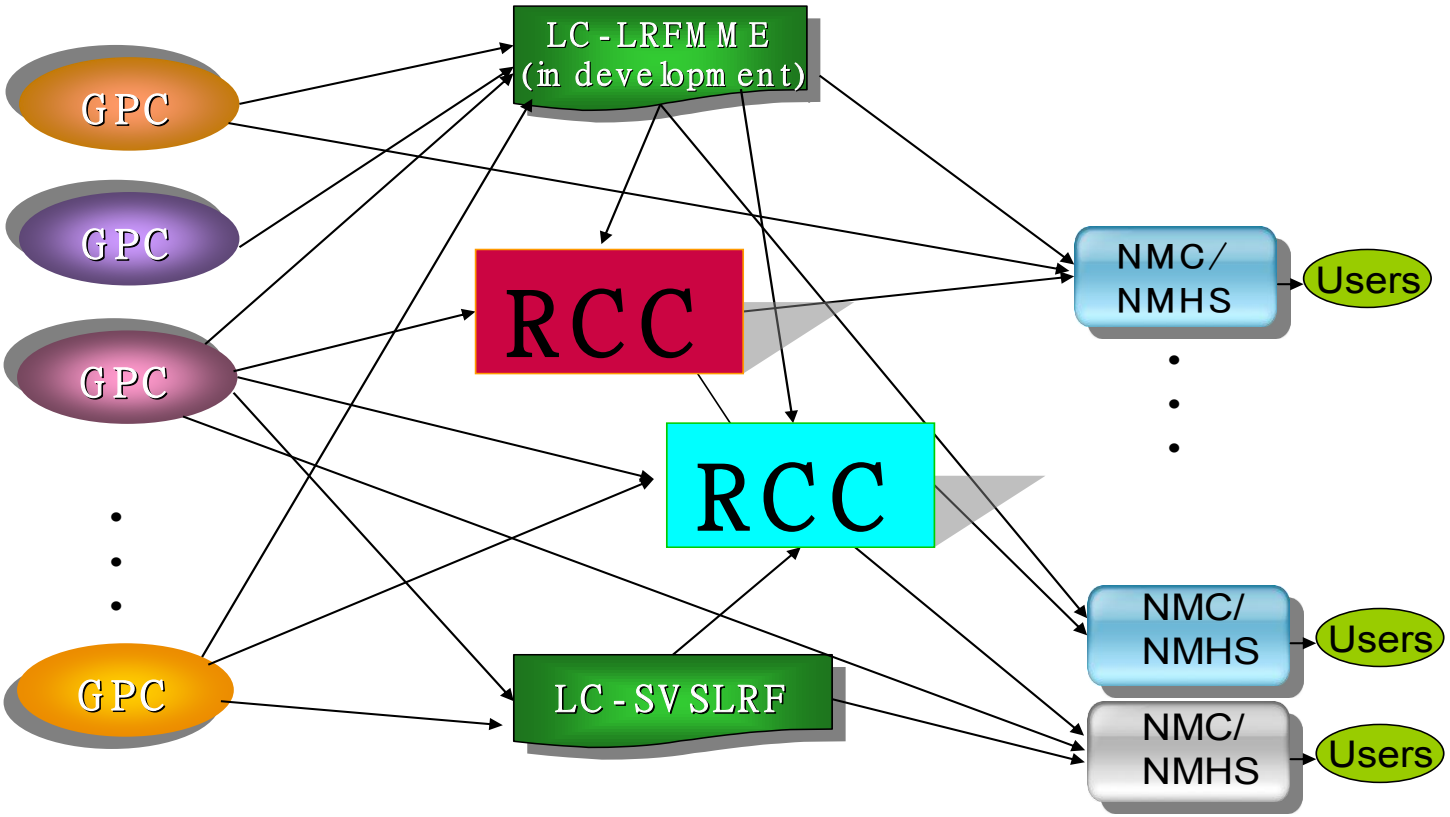
La Niña Years:
1955, 1970, 1973, 1988, 1998, 2007, 2010

WMO LC-LRFMME

- **WMO Lead Center for Long-Range Forecast Multi-Model Ensemble**
  - Collect seasonal forecast data for all GPCs for long-range forecast
  - Develop products based on multi-model methods
  - Disseminate products to NMHSs, RCCs, ROFs,…

WMO Arrangement for Providing Long Range Forecasting Services Under Frame Work For RCC Activities

(A network of Centres)

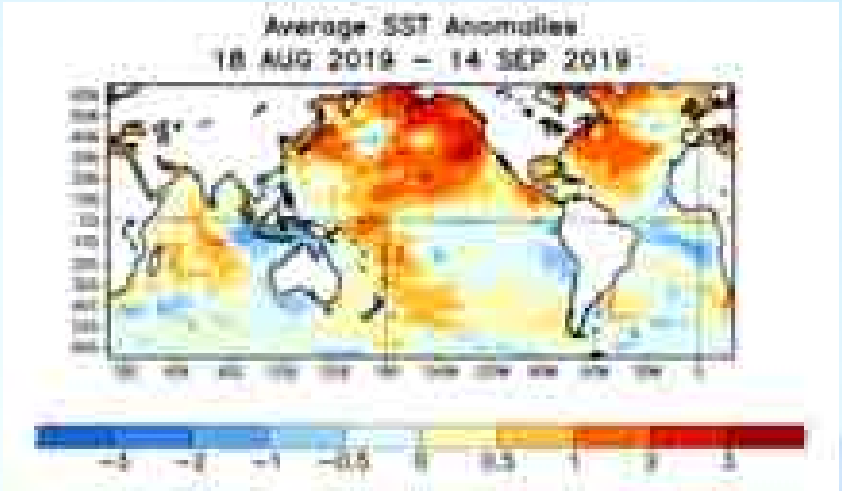


WMO Global Producing Centers

- Melbourne: Bureau of Meteorology (BoM), Australia
- Beijing: China Meteorological Administration (CMA)/ Bejing Climate Center (BCC)
- Washington: Climate Prediction Center (CPC), NOAA, United States of America
- ECMWF: European Centre for Medium-Range Weather Forecasts
- Tokyo: Japan Meteorological Agency (JMA)/ Tokyo Climate Centre (TCC)
- Seoul: Korea Meteorological Administration (KMA)
- Toulouse: Meteo-France
- Exeter: Met Office, United Kingdom
- Montreal: Meteorological Service of Canada (MSC)
- Pretoria: South African Weather Services (SAWS)
- Moscow: Hydrometeorological Centre of Russia
- CPTEC: Center for weather forecasts and climate studies/ National institute for space research (INPE)

ENSO & IOD:
Status and Forecast

Latest Global SST Departures (°C) and ENSO Conditions over Pacific

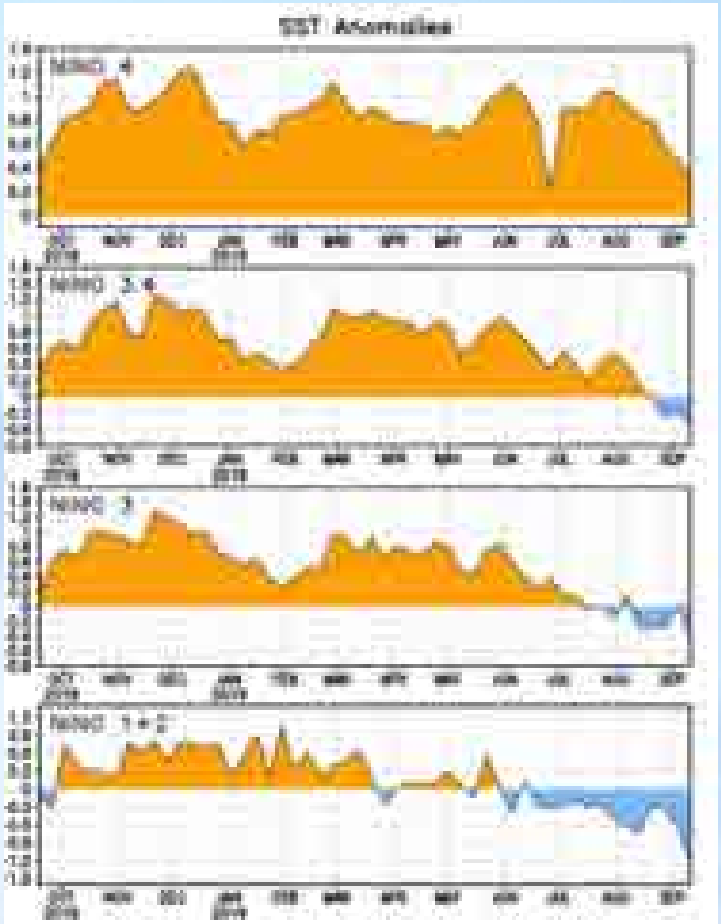


Data source
CPC, USA

The latest weekly SST departures are:

Niño 4	0.3°C
Niño 3.4	-0.3°C
Niño 3	-0.5°C
Niño 1+2	-1.3°C

Recent evolution of NINO SSTs

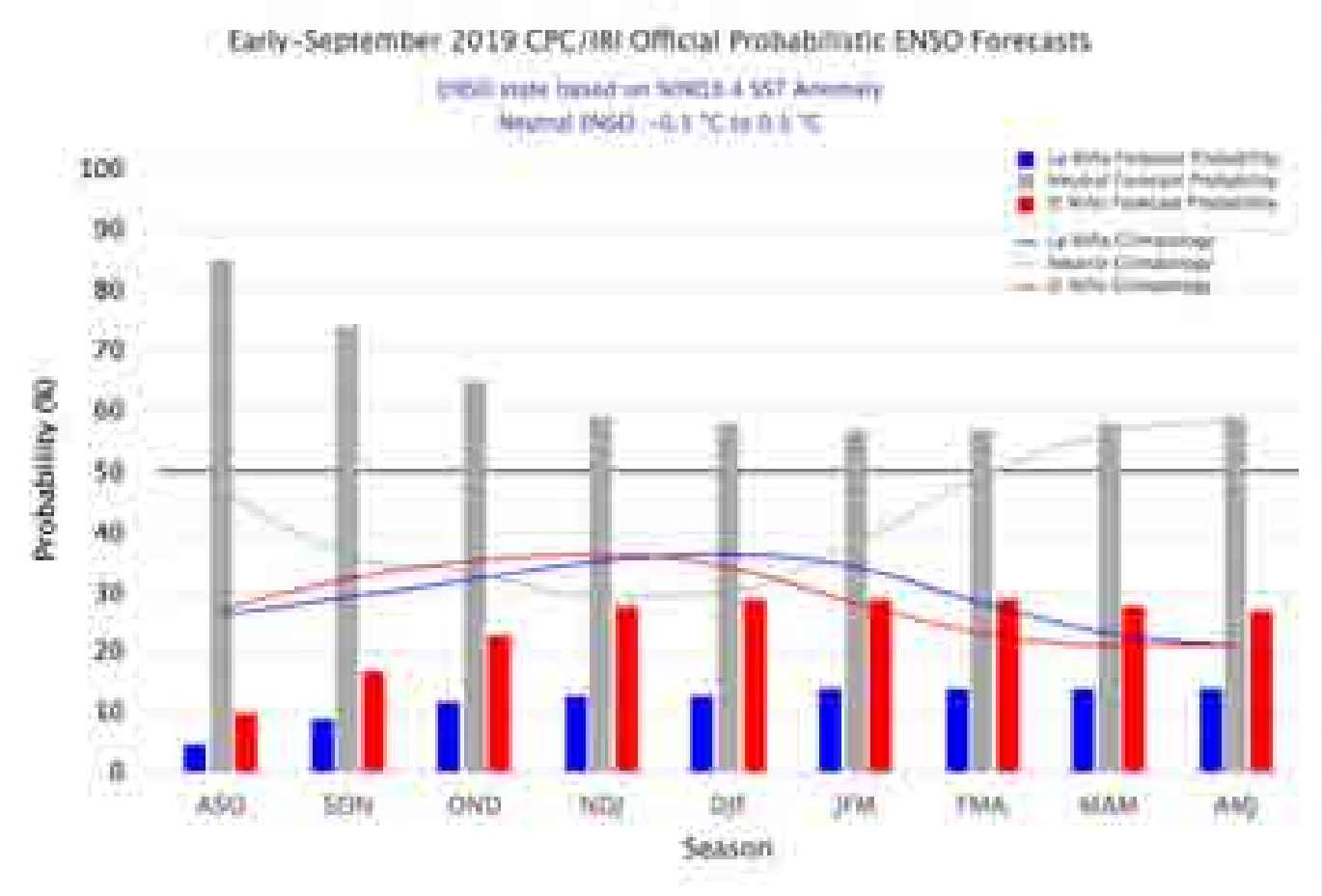


Data source
CPC, USA

During the last four weeks, equatorial SSTs were above average across the western Pacific Ocean and also the central Indian Ocean. SSTs were below average near Indonesia and in the east-central and eastern Pacific and central Atlantic

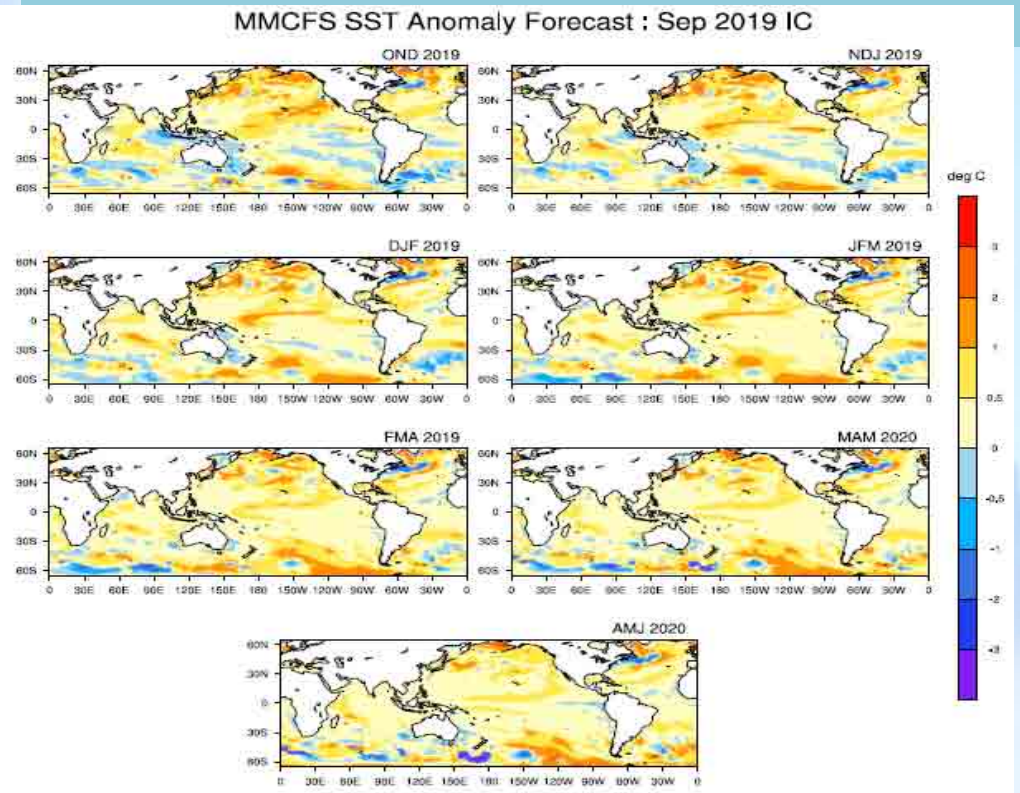
Latest ENSO Forecast (September 2019)

IRI, USA

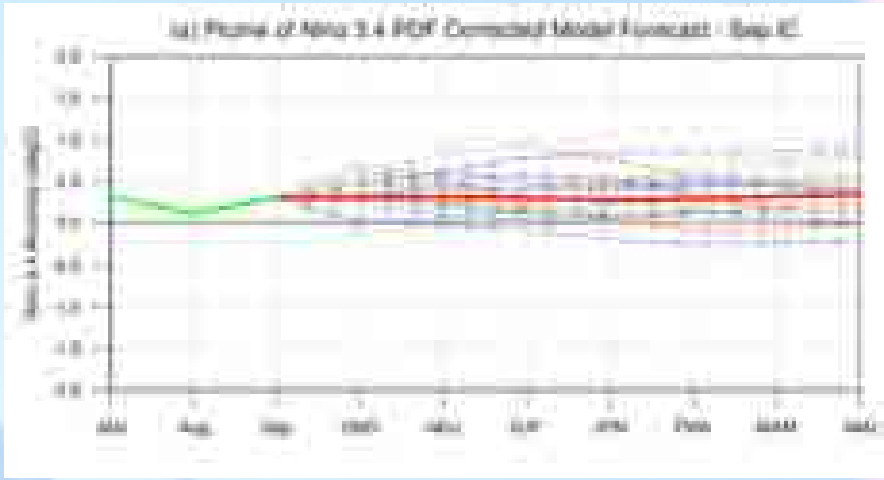


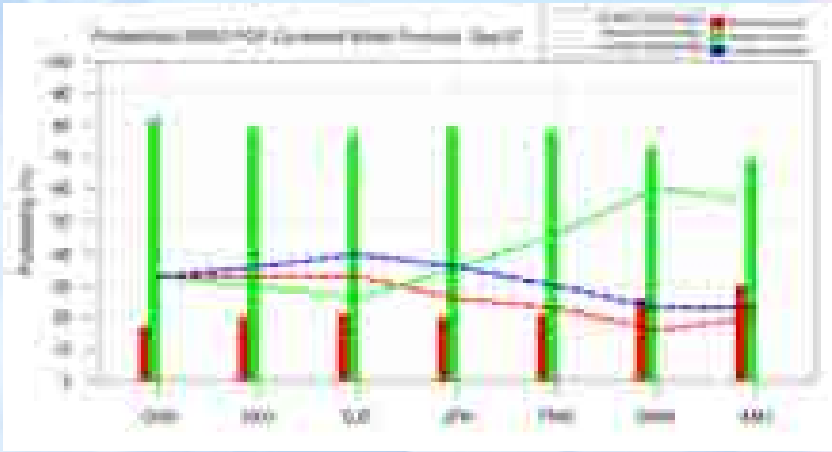
ENSO-neutral is most likely to continue through the Northern Hemisphere spring 2020.

ENSO Forecast - MMCFS: September IC



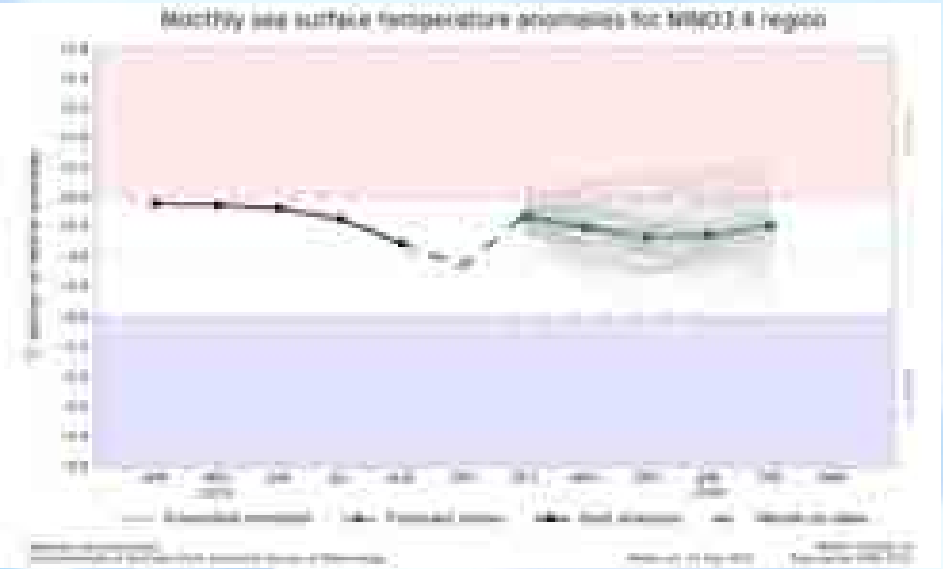
Plume of Nino 3.4 PDF Corrected Model Forecast – Sep IC

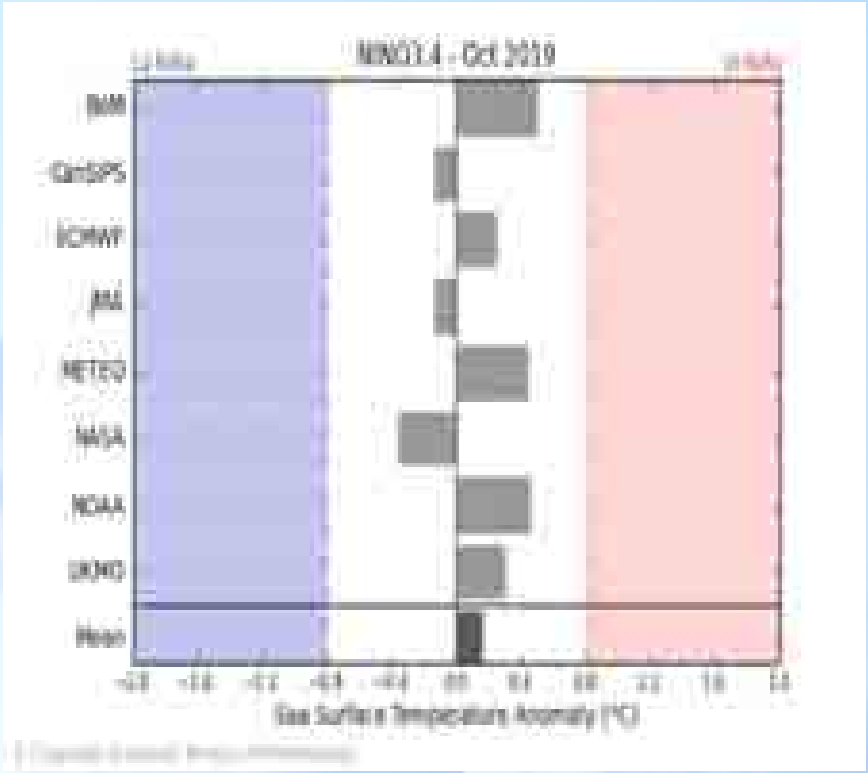




In September, Negative anomaly observed over the NINO3.4 region. Latest MMCFS forecast indicate continuation of the ENSO neutral conditions during NE monsoon season.

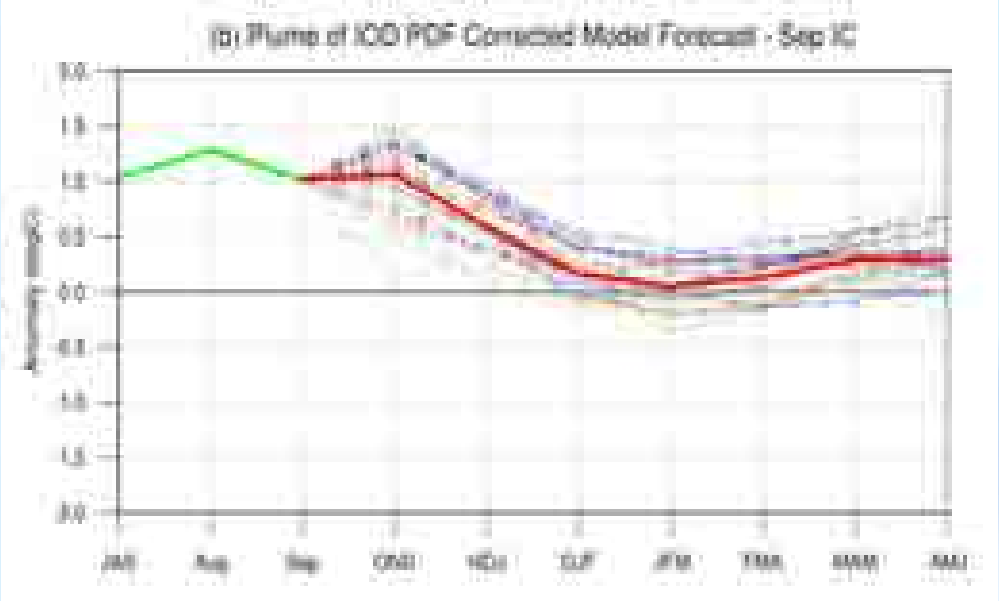
BoM, Australia: ENSO Forecast

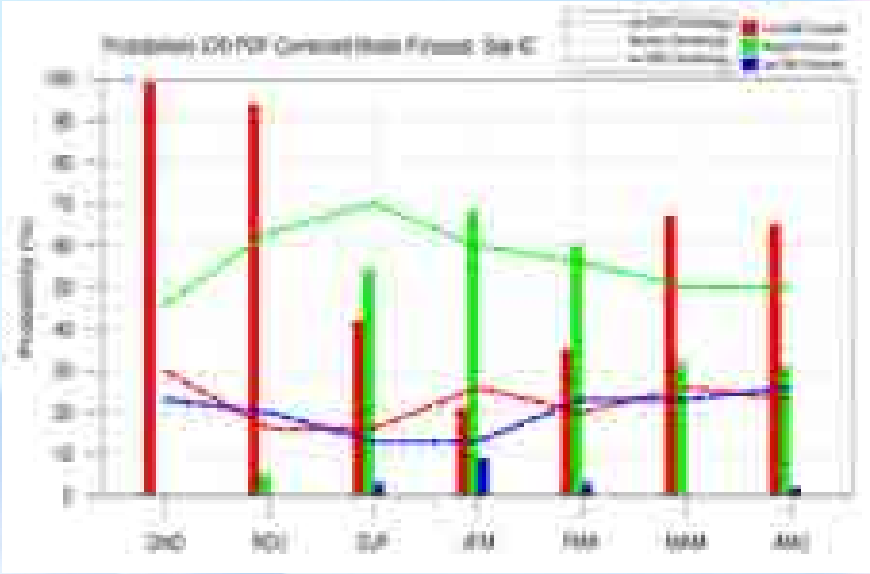




Pacific Ocean will continue to be in ENSO Neutral conditions in the coming months.

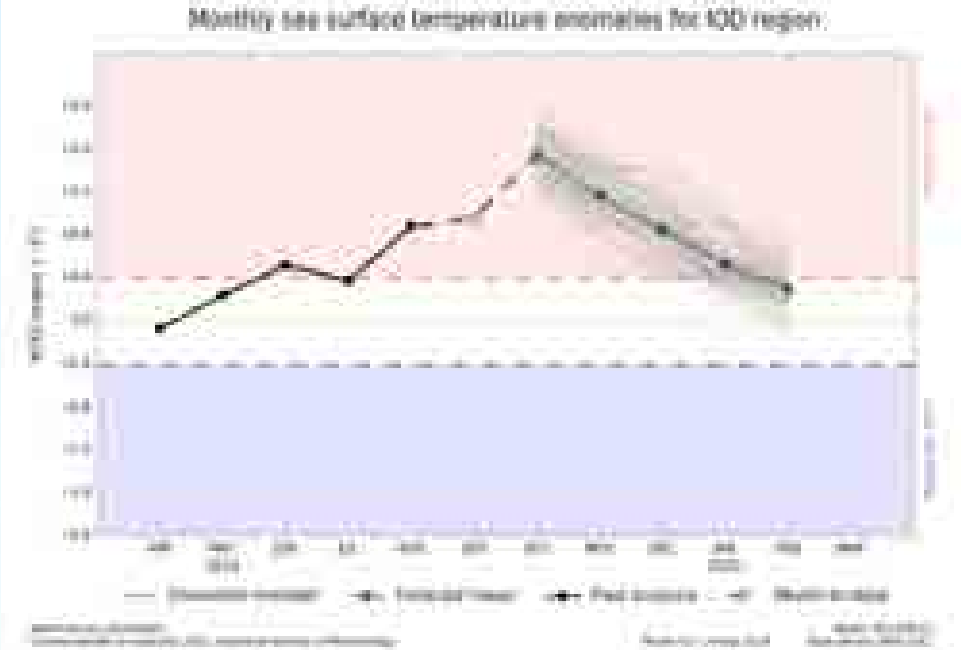
IOD Forecast - MMCFS: September IC

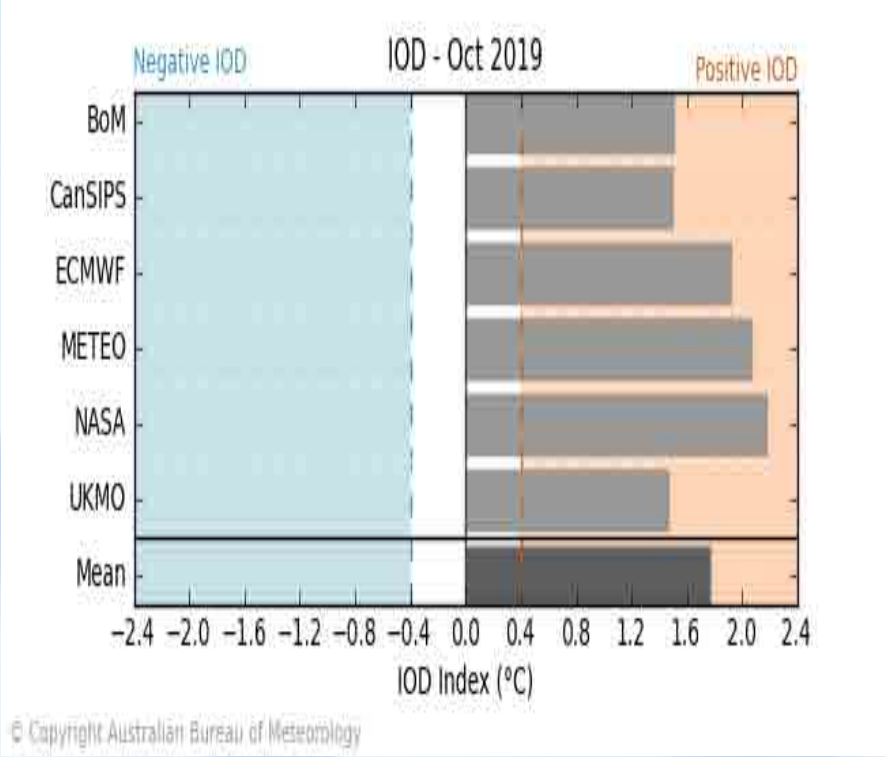




The positive IOD conditions are likely to continue

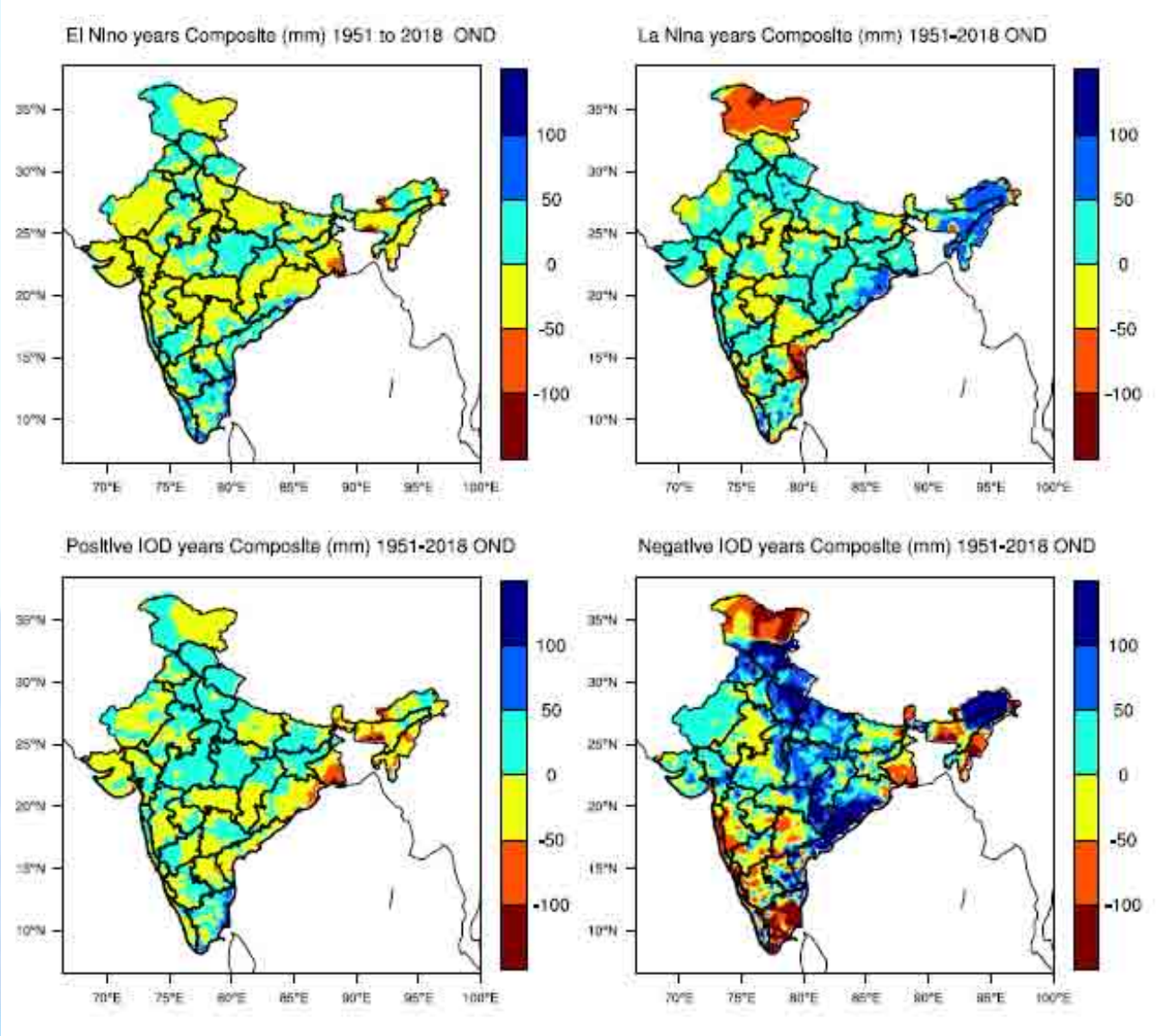
BoM, Australia: IOD Forecast



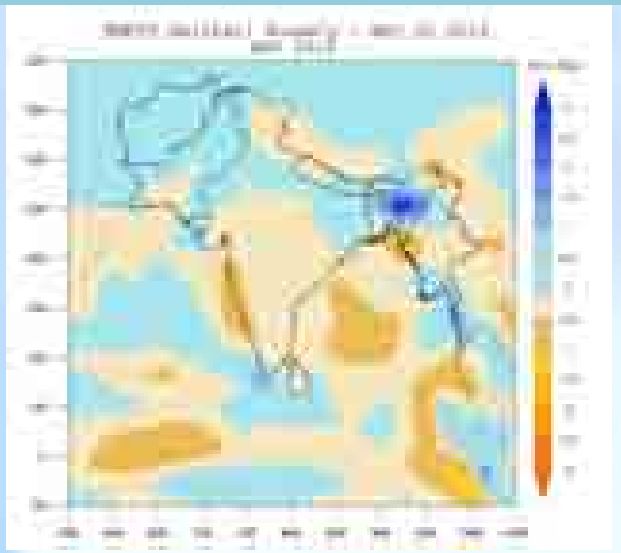


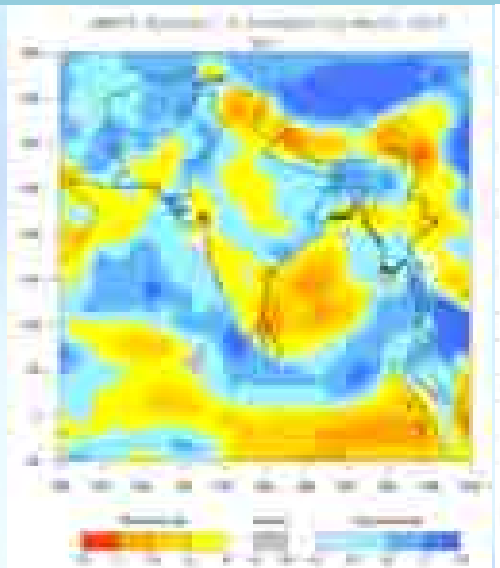
IOD forecast: **Positive IOD conditions to continue for the southern hemisphere spring**

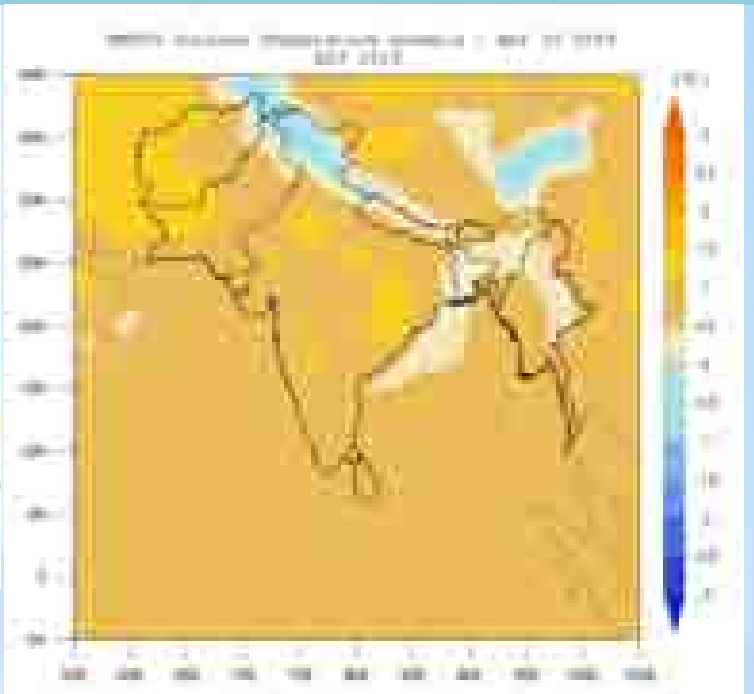
Rainfall Composite ENSO & IOD

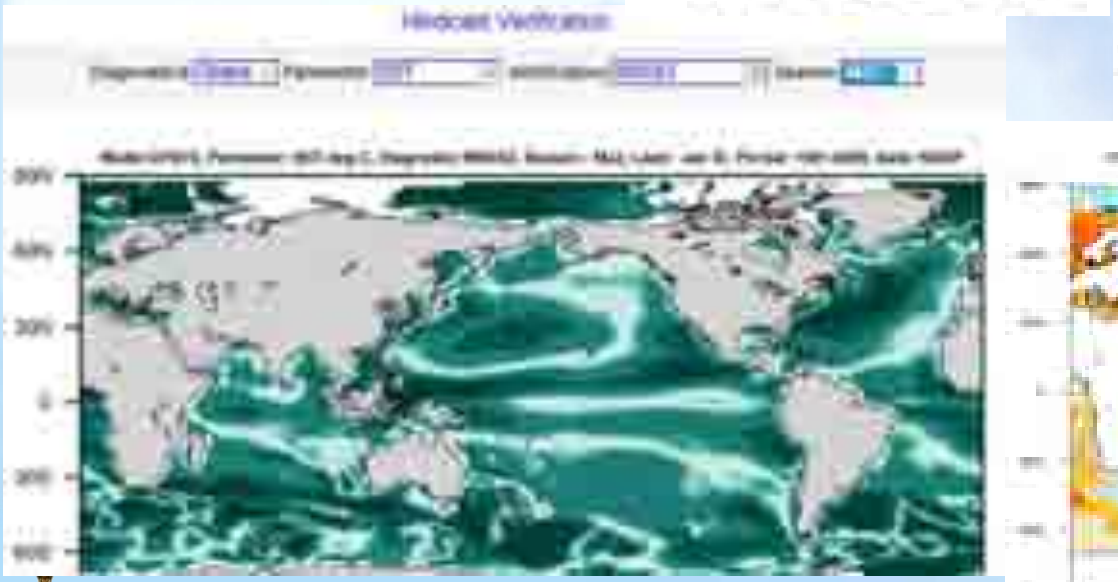


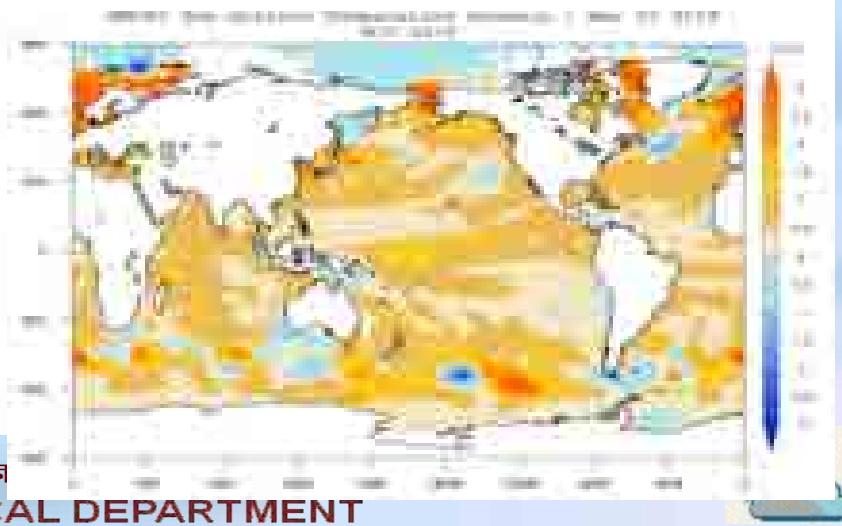
MMCFS Seasonal Forecast



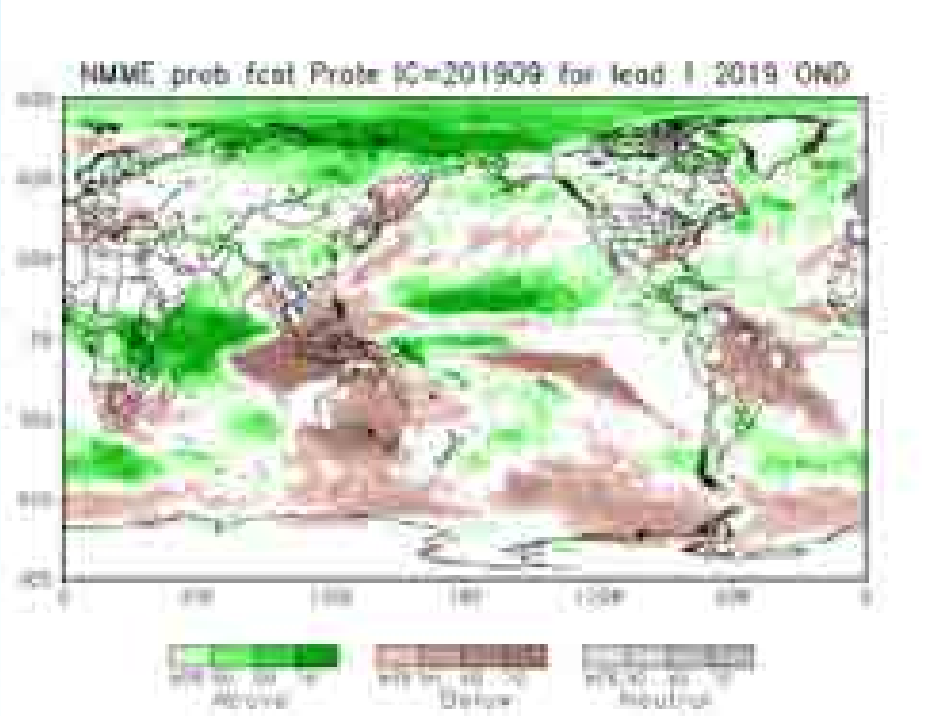


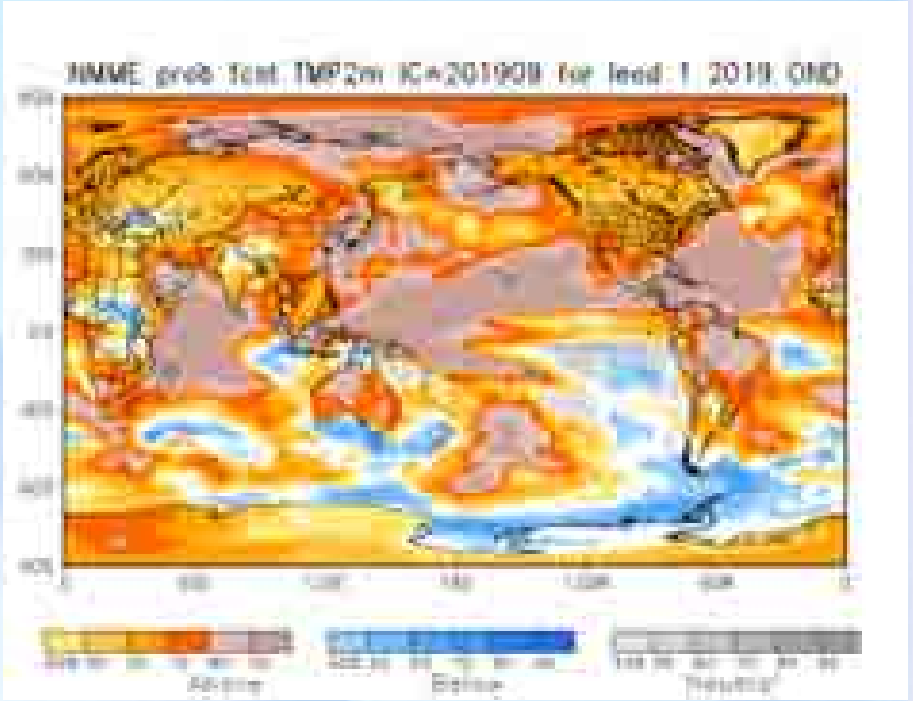






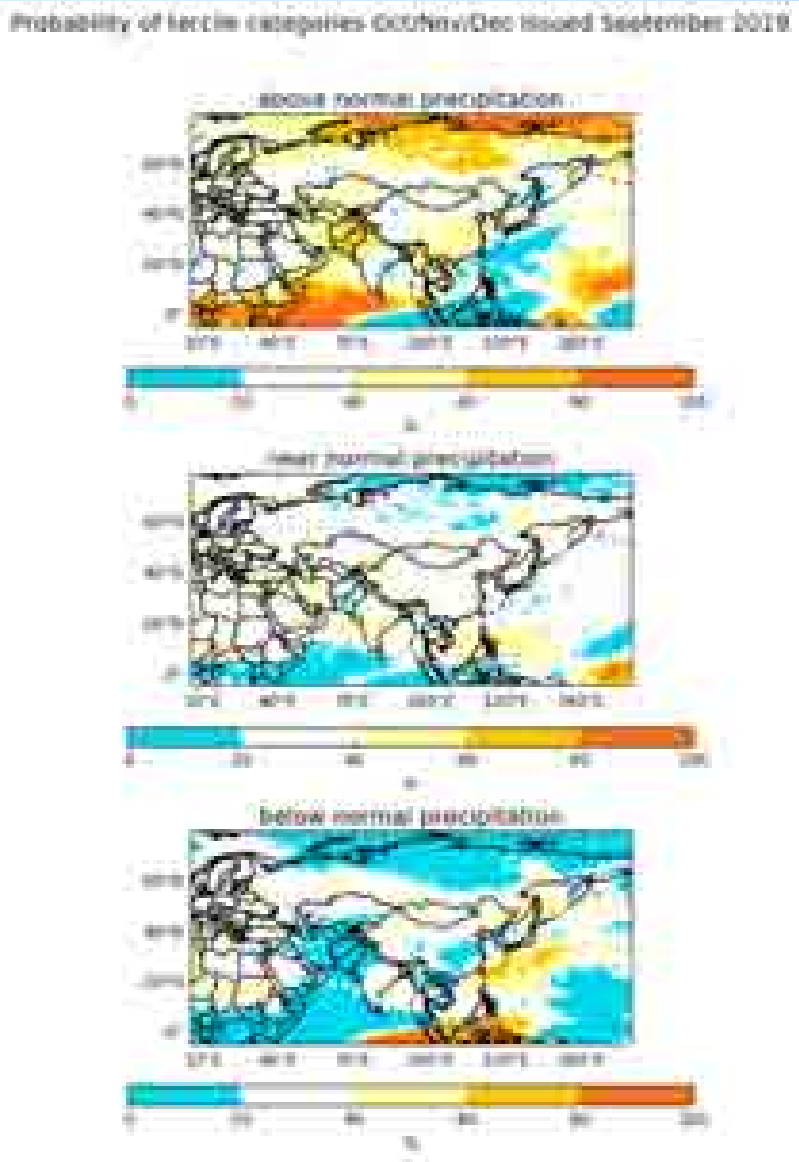
NMME Probabilistic Forecast





Glosea5 PRECIPITATION probability forecasts (OND)

Met Office, UK



OND: Slightly above normal over north western part of the region.
- elsewhere in SASCOF region, signals are weak.

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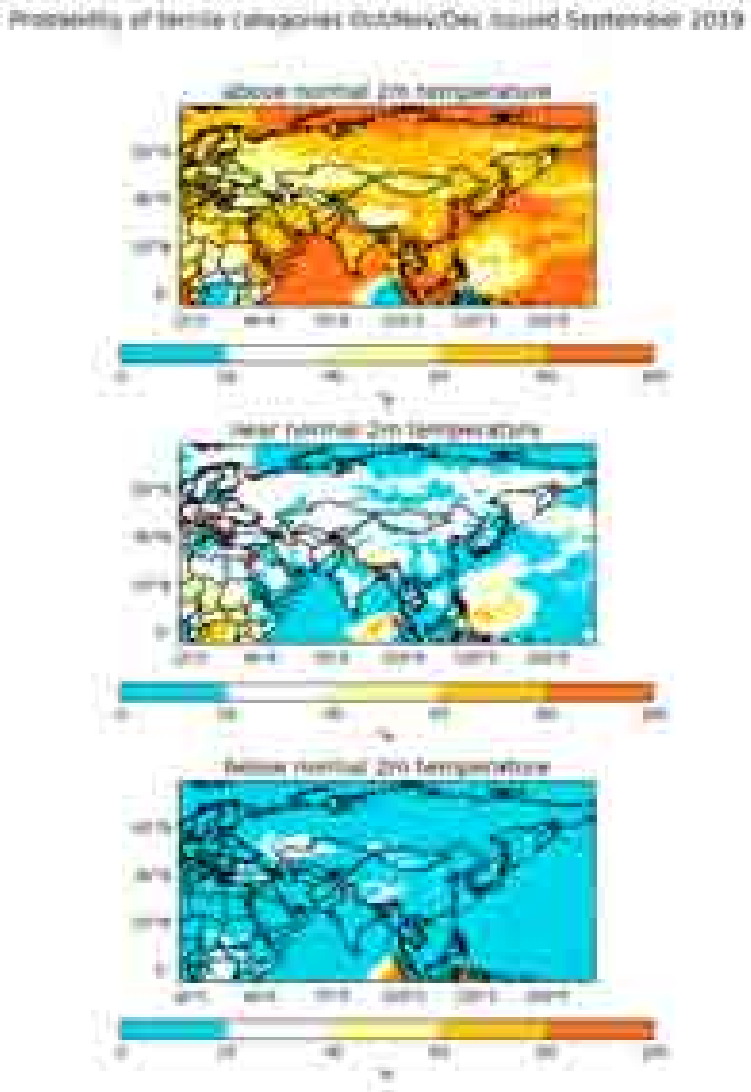
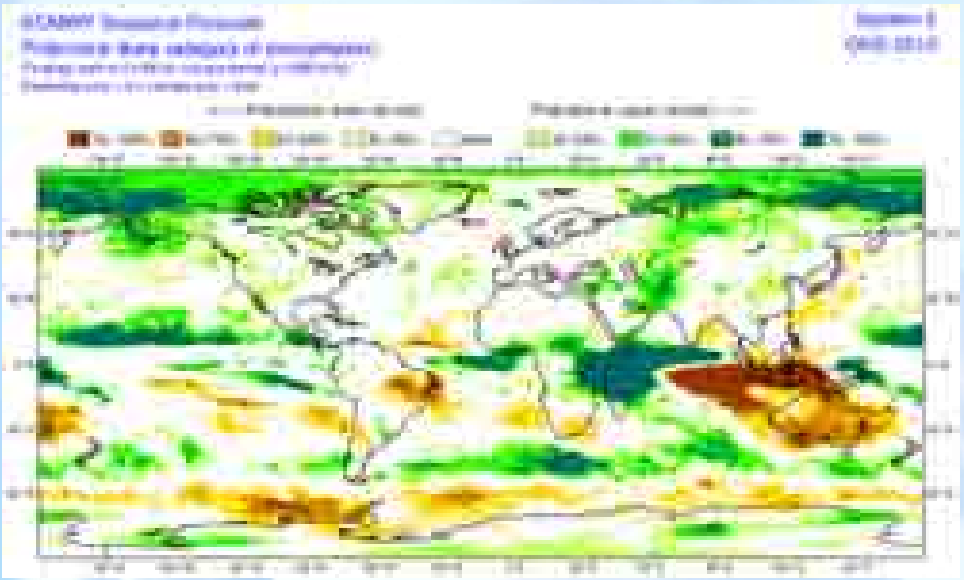
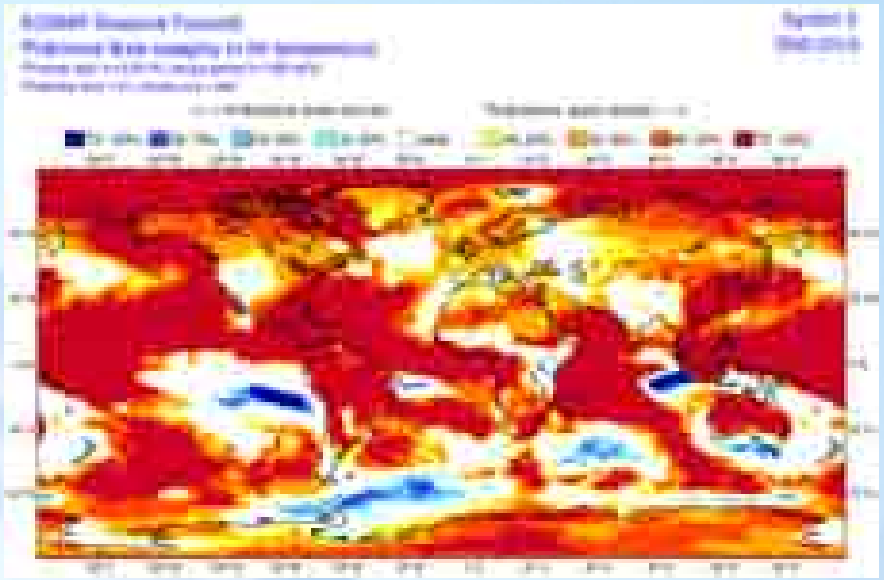
Glosea5 TEMPERATURE probability forecasts(OND)

OND : Above Normal temp. are likely over most parts of the region.



ECMWF Precipitation & T2M Anomaly Forecast

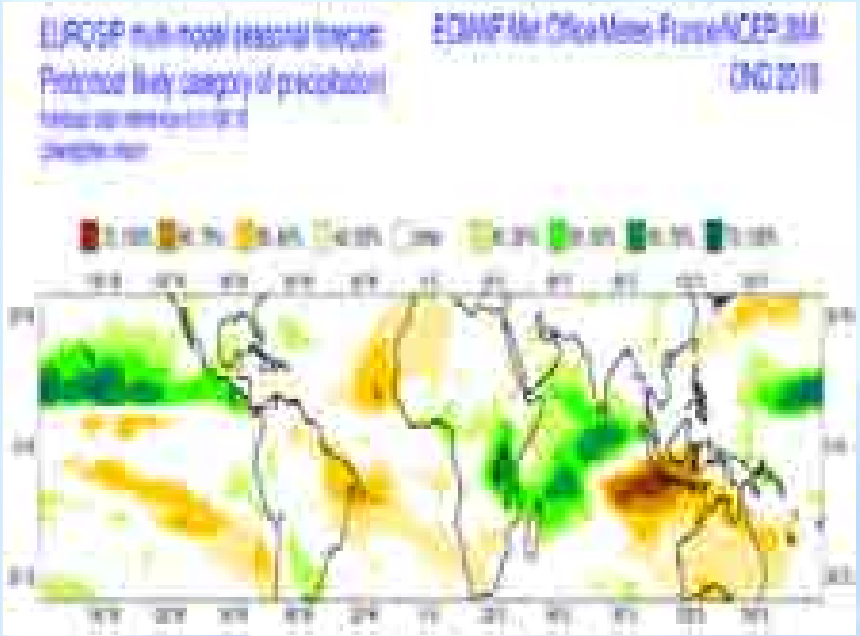


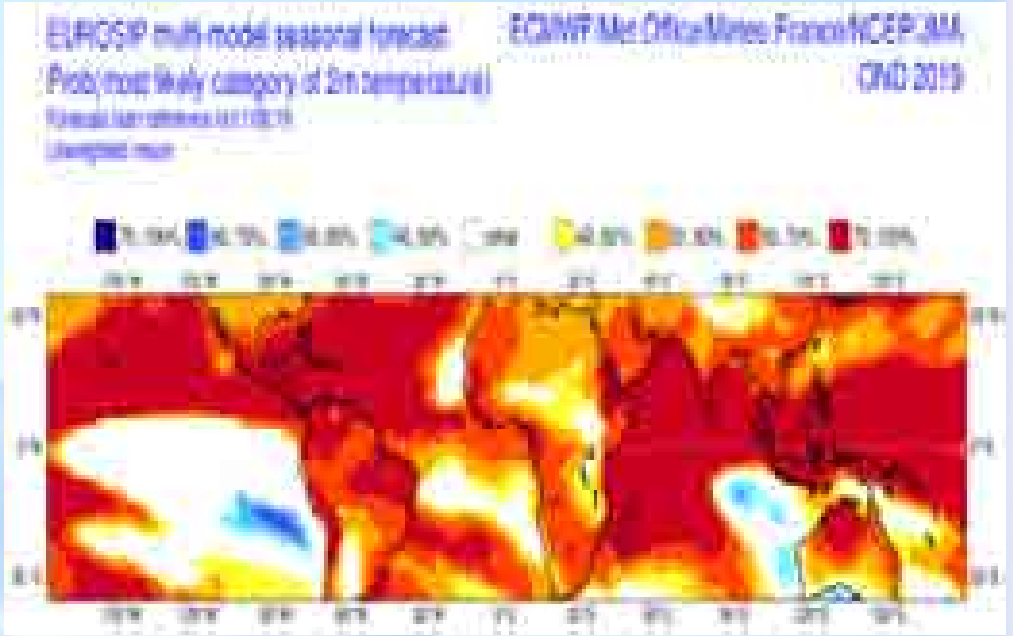


OND: Above normal over southern parts of the region. Normal precipitation over remaining areas.

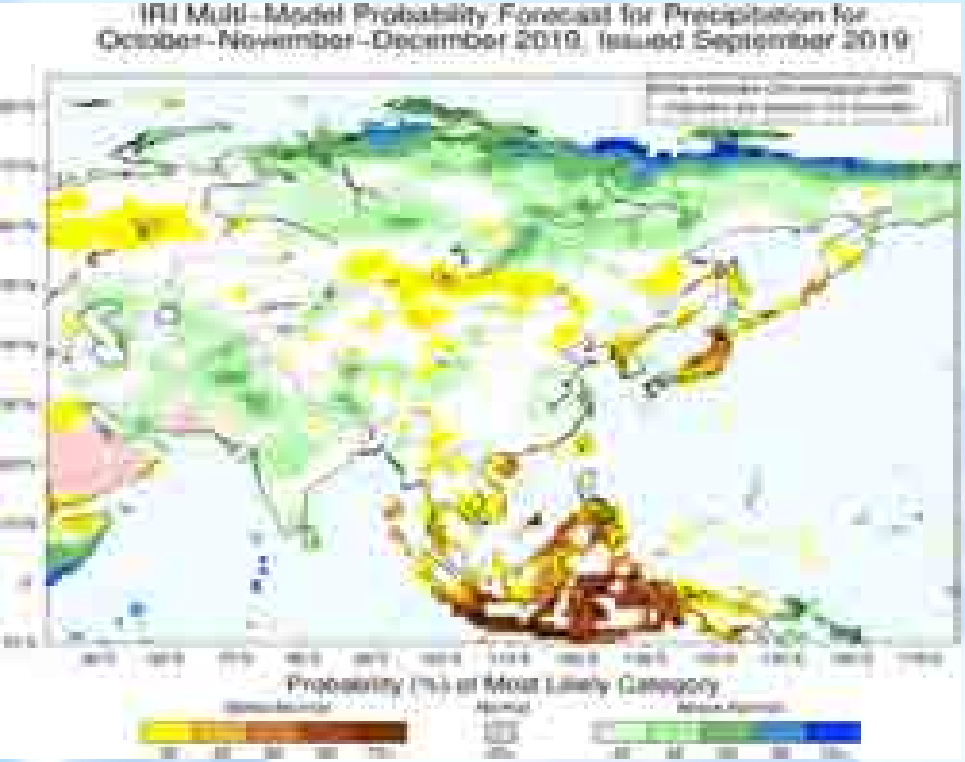
OND: Normal to above normal temp are likely over southern parts of the region.

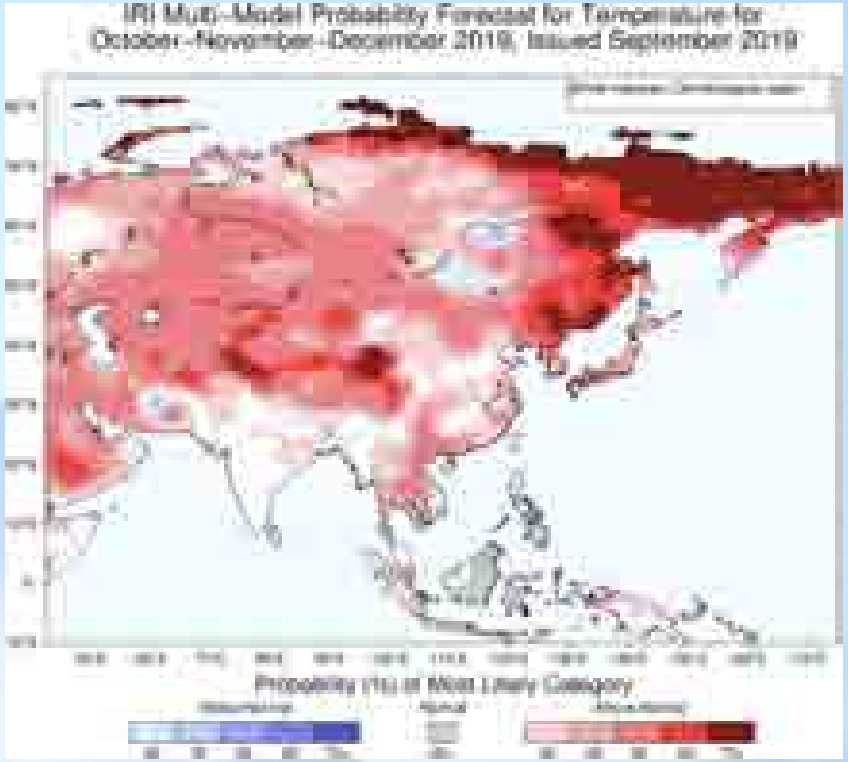
EUROSIP Precipitation & T2m Anomaly Forecast





IRI Precipitation & T2M Anomaly Forecast

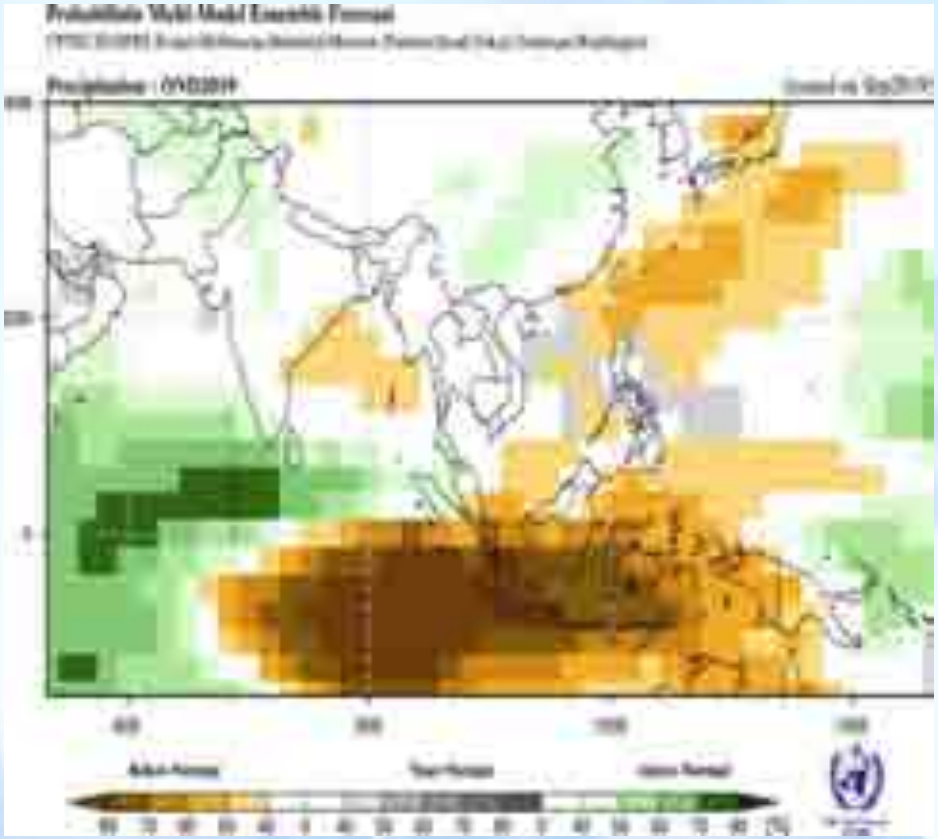


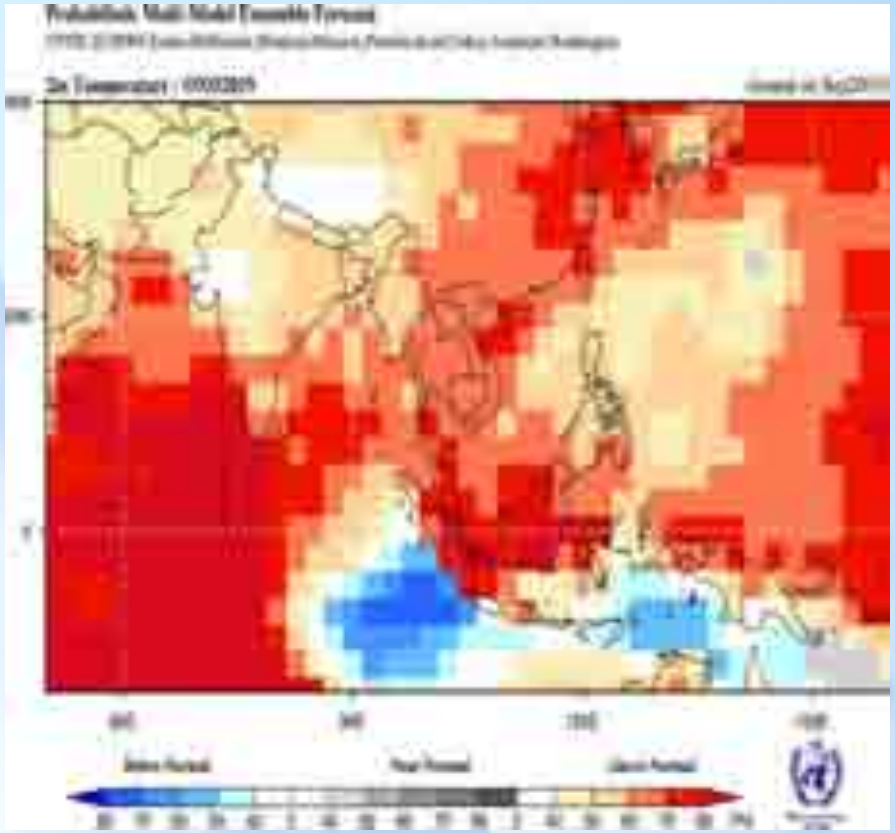


DJF: Above normal precipitation over north western and southern parts of the region. Climatological probabilities over remaining regions.

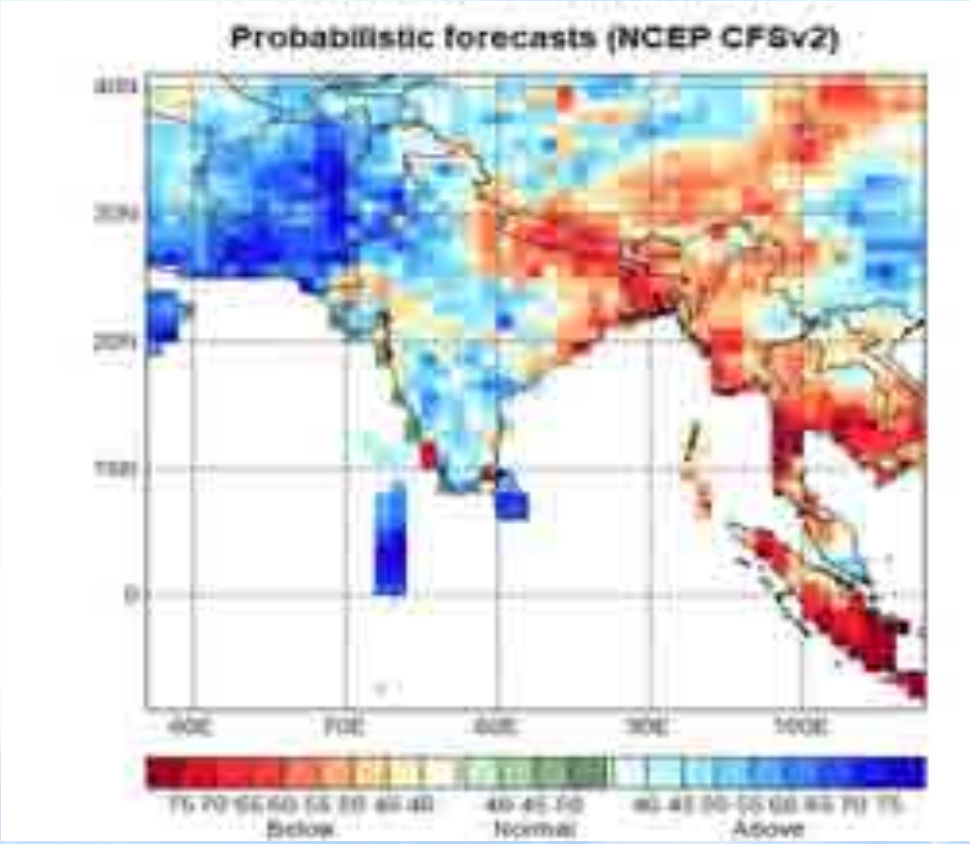
DJF :Above Normal temp. likely over North western and some North Eastern parts of the region during the OND seasons

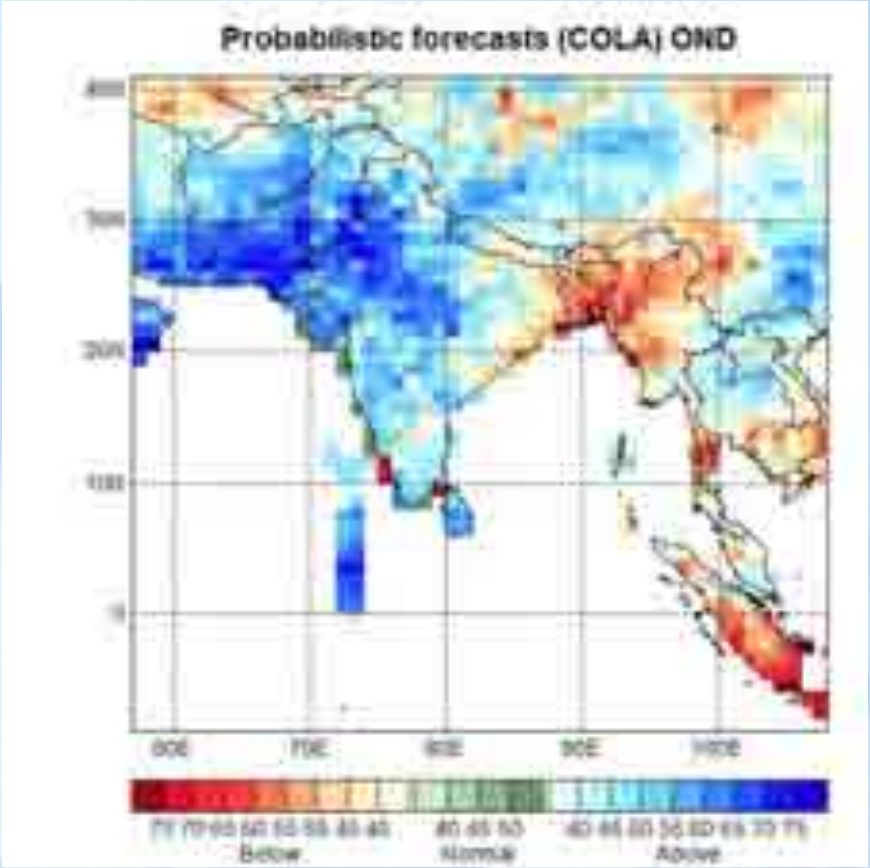
WMO_LC_LRFMME Forecast for the 2019 OND Season



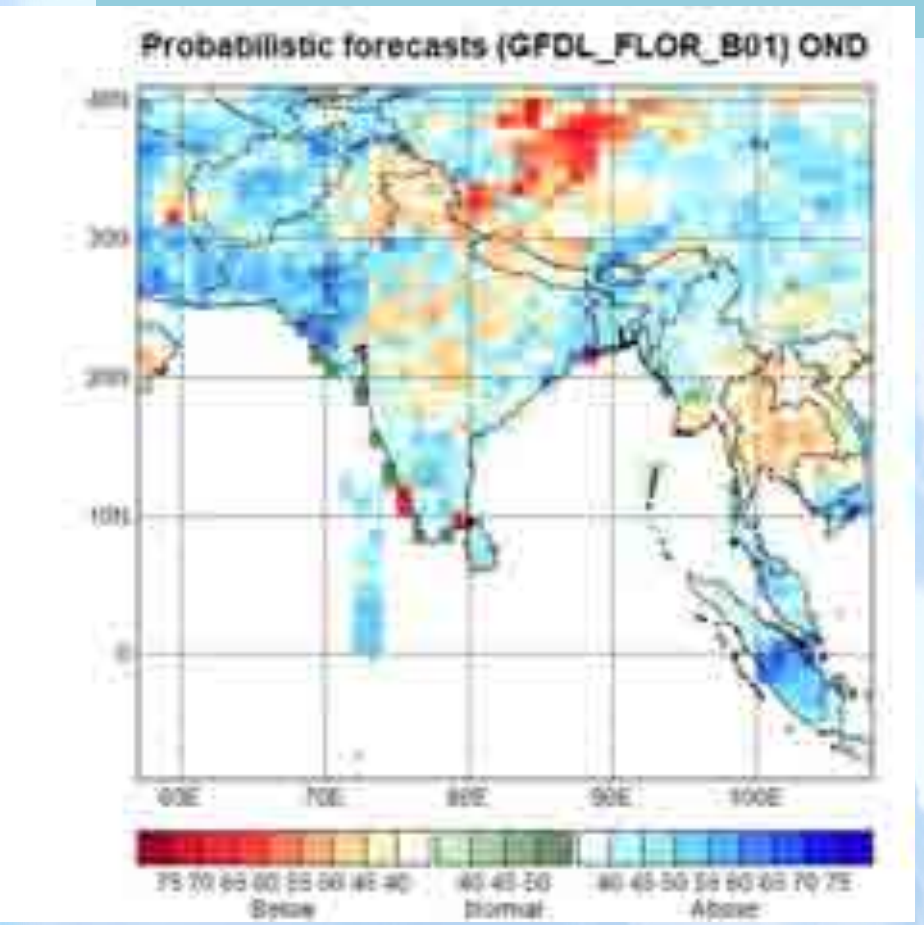


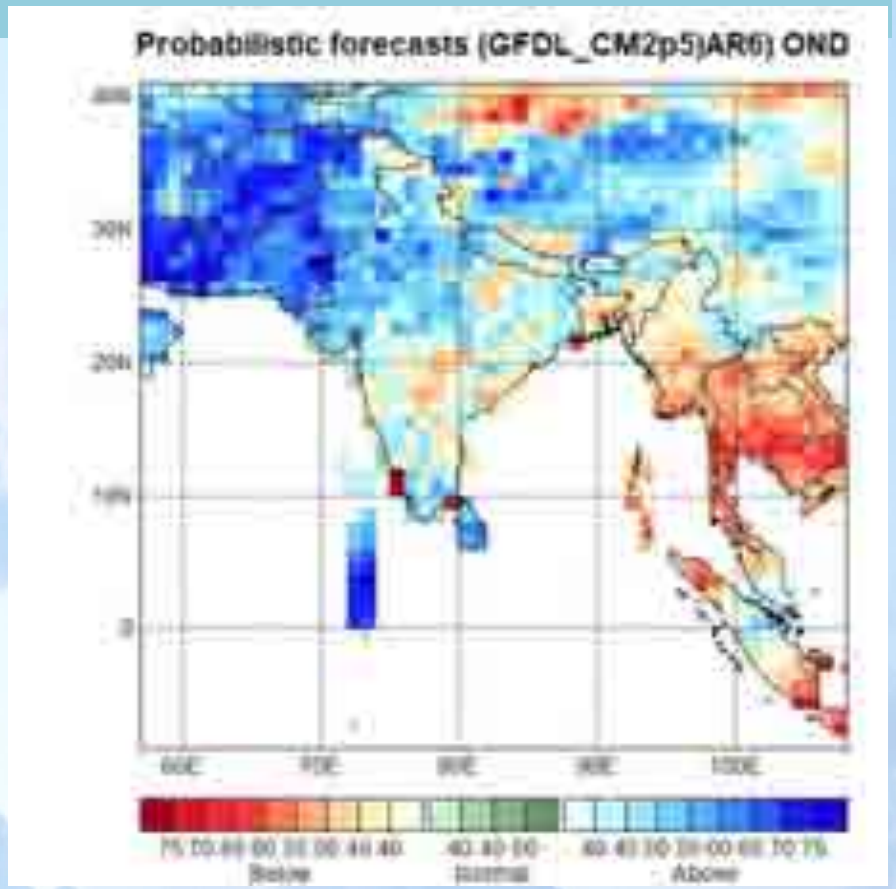
Calibrated CPT Forecast :NMME Model



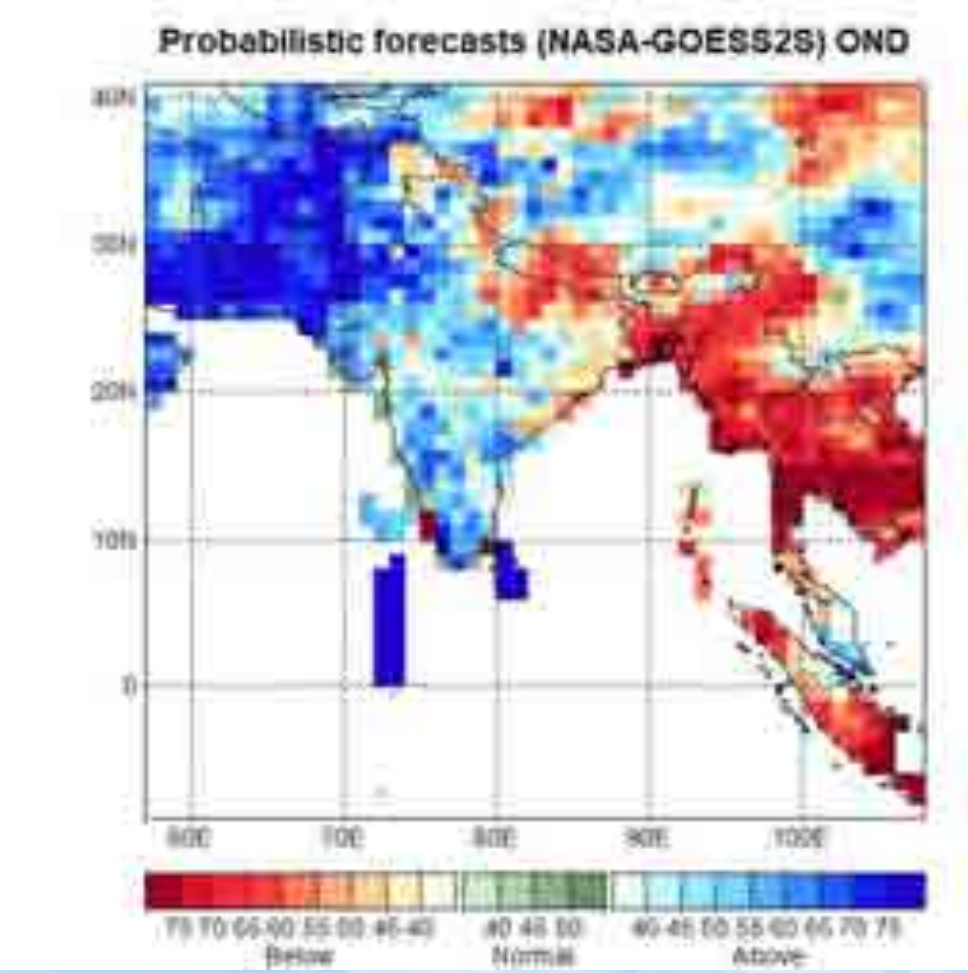


Calibrated CPT Forecast :NMME Model

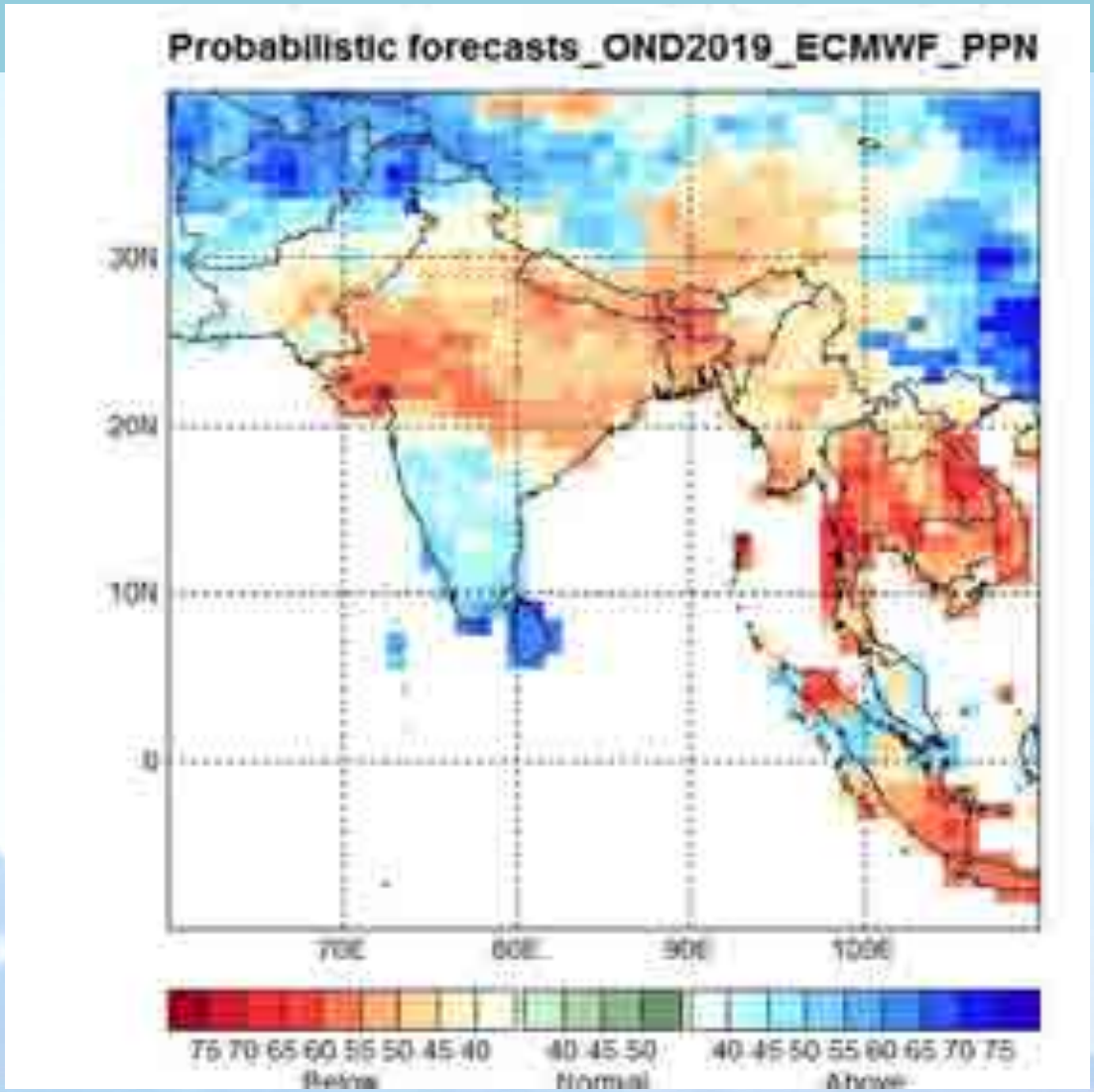




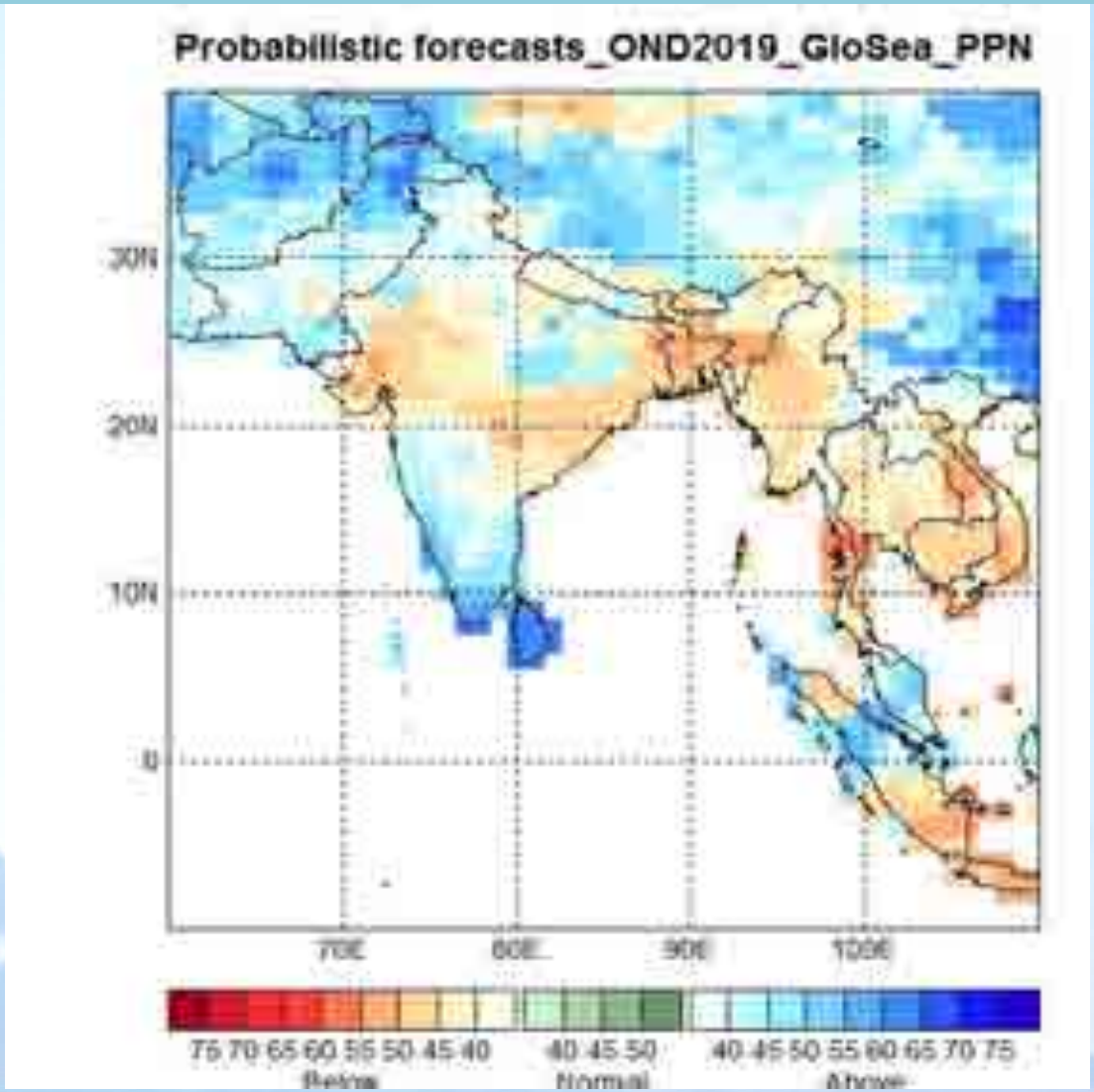
Calibrated CPT Forecast :NMME Model



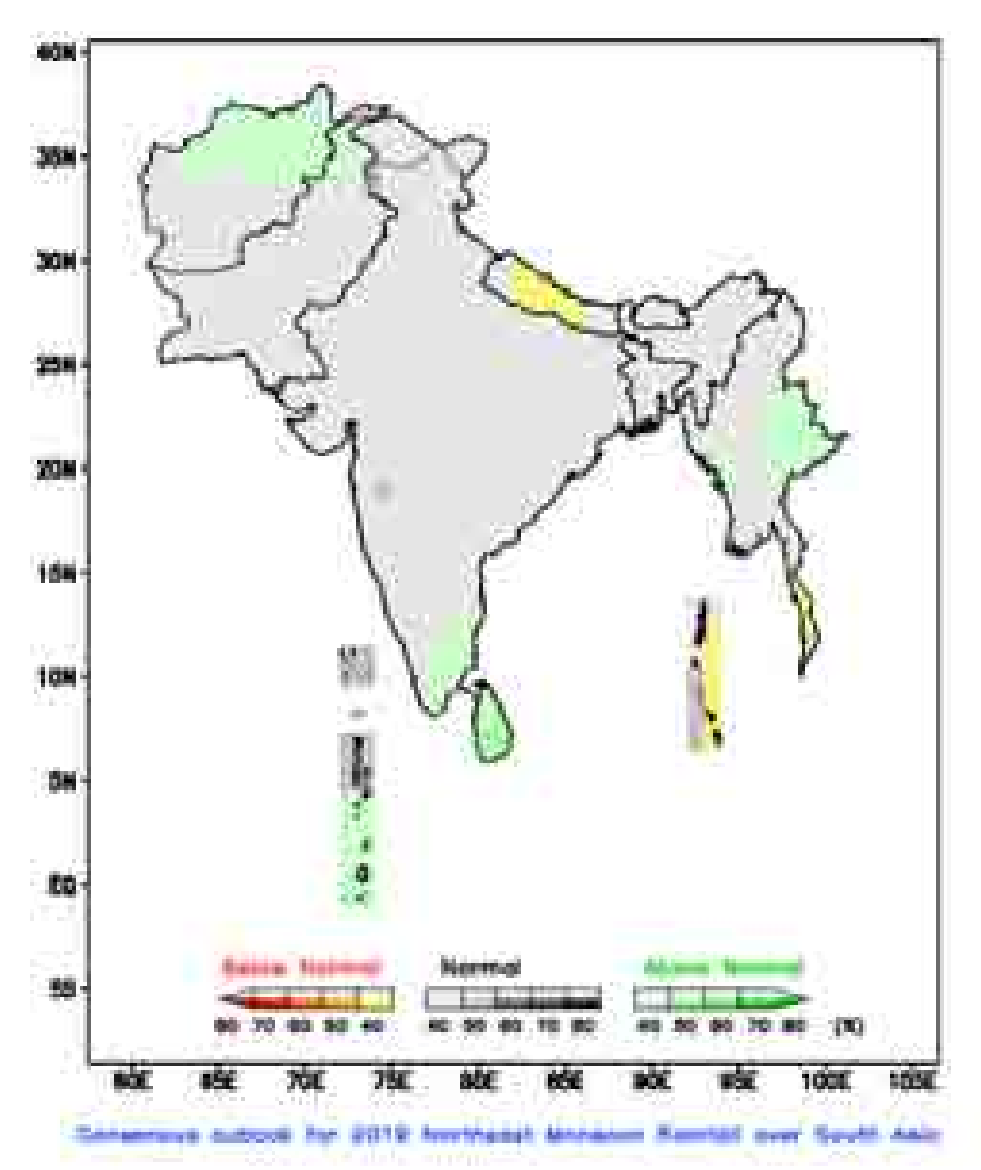
Calibrated CPT Forecast :ECMWF Model



Calibrated CPT Forecast :UKMet office



SASCOF-15 Consensus forecast map (Draft)



ENSO IOD Bulletin

Regional Climate Centre (RA II Region)
India Meteorological Department, Pune

WMO

Seasonal Climate Outlook for South Asia

ENSO Bulletin

Climate Diagnostic Bulletin

Annual Climate Summary

Consensus Statement

Earth System Science Organization (ESSO)
Ministry of Earth Sciences (MoES)
India Meteorological Department

El Niño Southern Oscillation (ENSO) and
Indian Ocean Dipole (IOD) Bulletin

April 2019

Highlights:
Currently weak El Niño conditions are prevailing over the equatorial Pacific Ocean and

Information about current ENSO and IOD conditions and forecast

SASCOF Consensus statements

South Asian Climate Outlook Forum (SASCOF-2)

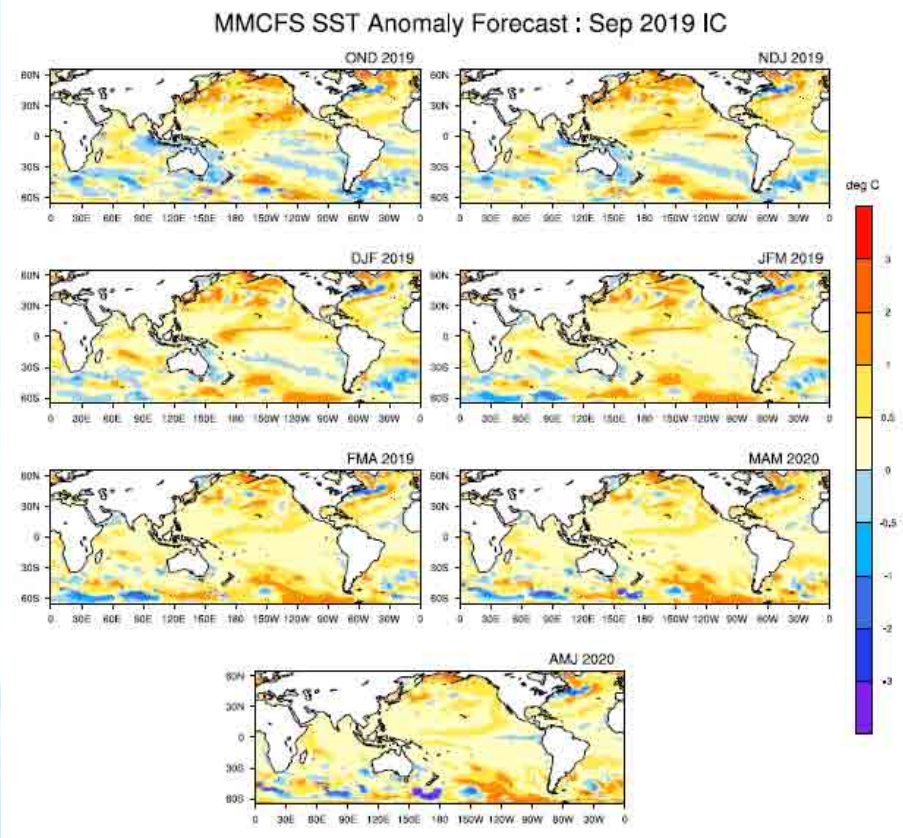
Pune, India, 13-15 April 2011

Consensus Statement

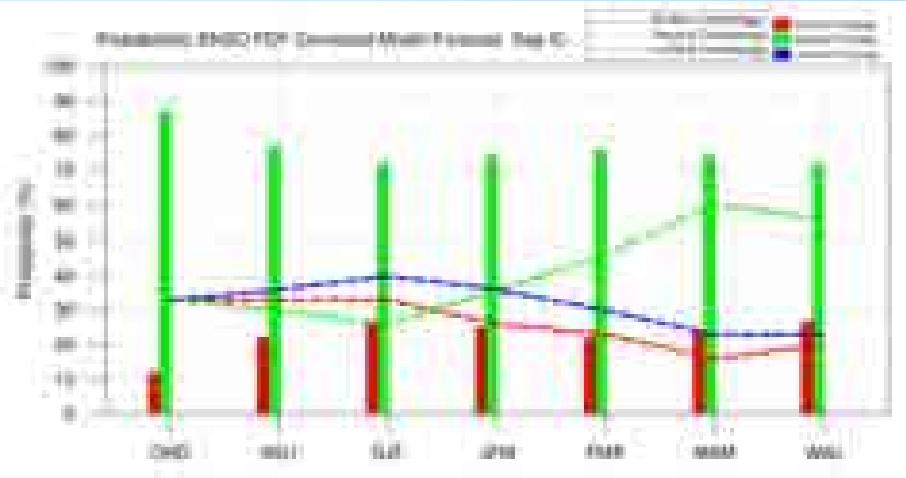
Summary

A consensus outlook for the 2011 southwest monsoon rainfall over South Asia was developed, through an expert assessment of the available indications. The outlook, based on the various prevailing global climate conditions and forecasts from different empirical and dynamical climate models, indicates large

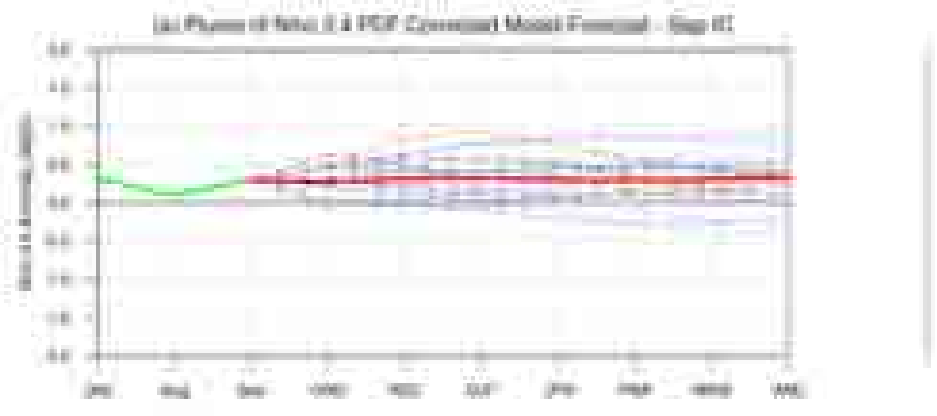
ENSO Forecast - MMCFS: Sep IC (24 ens)



Probability of Nino 3.4 PDF Corrected Model Forecast – Sep IC

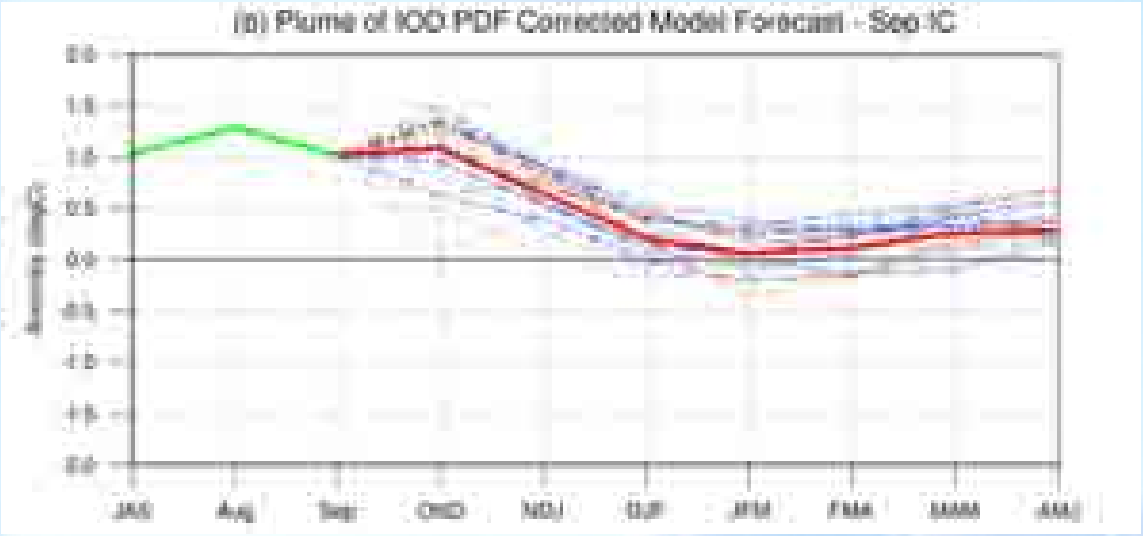


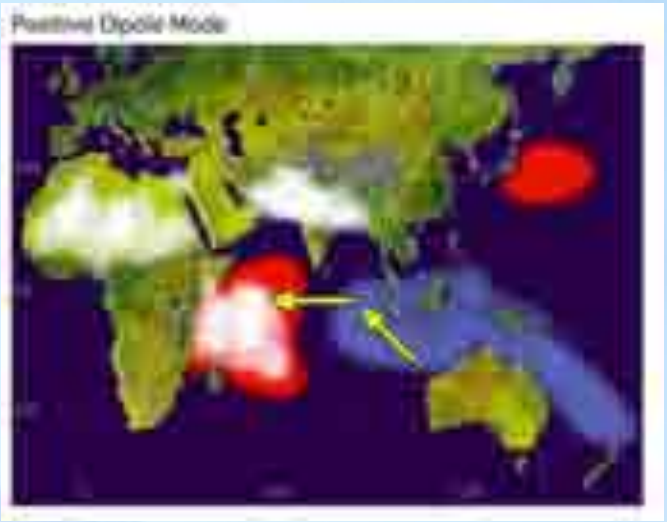
Plume of Nino 3.4 PDF Corrected Model Forecast – Sep IC

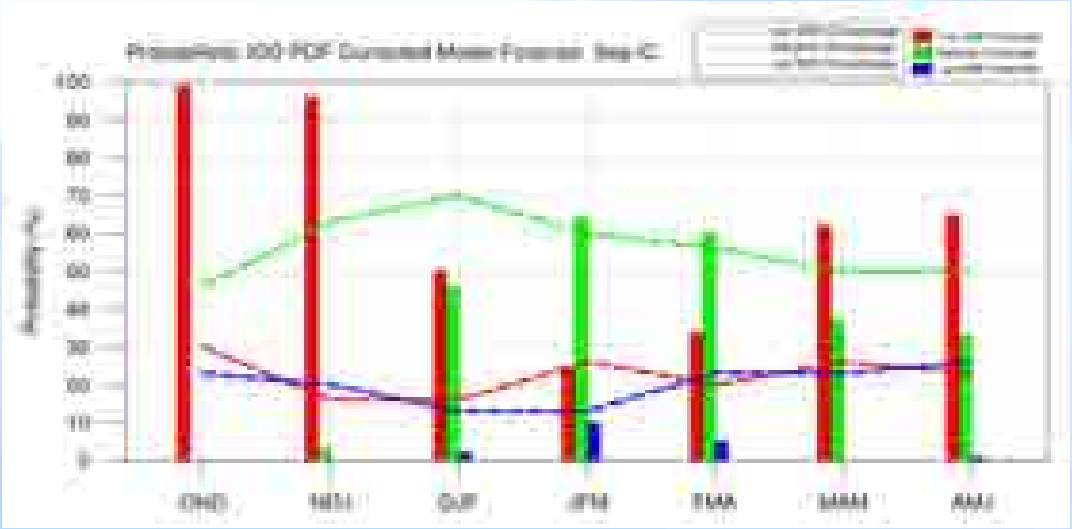


Prevailing ENSO neutral condition will continue up to the end of monsoon season.

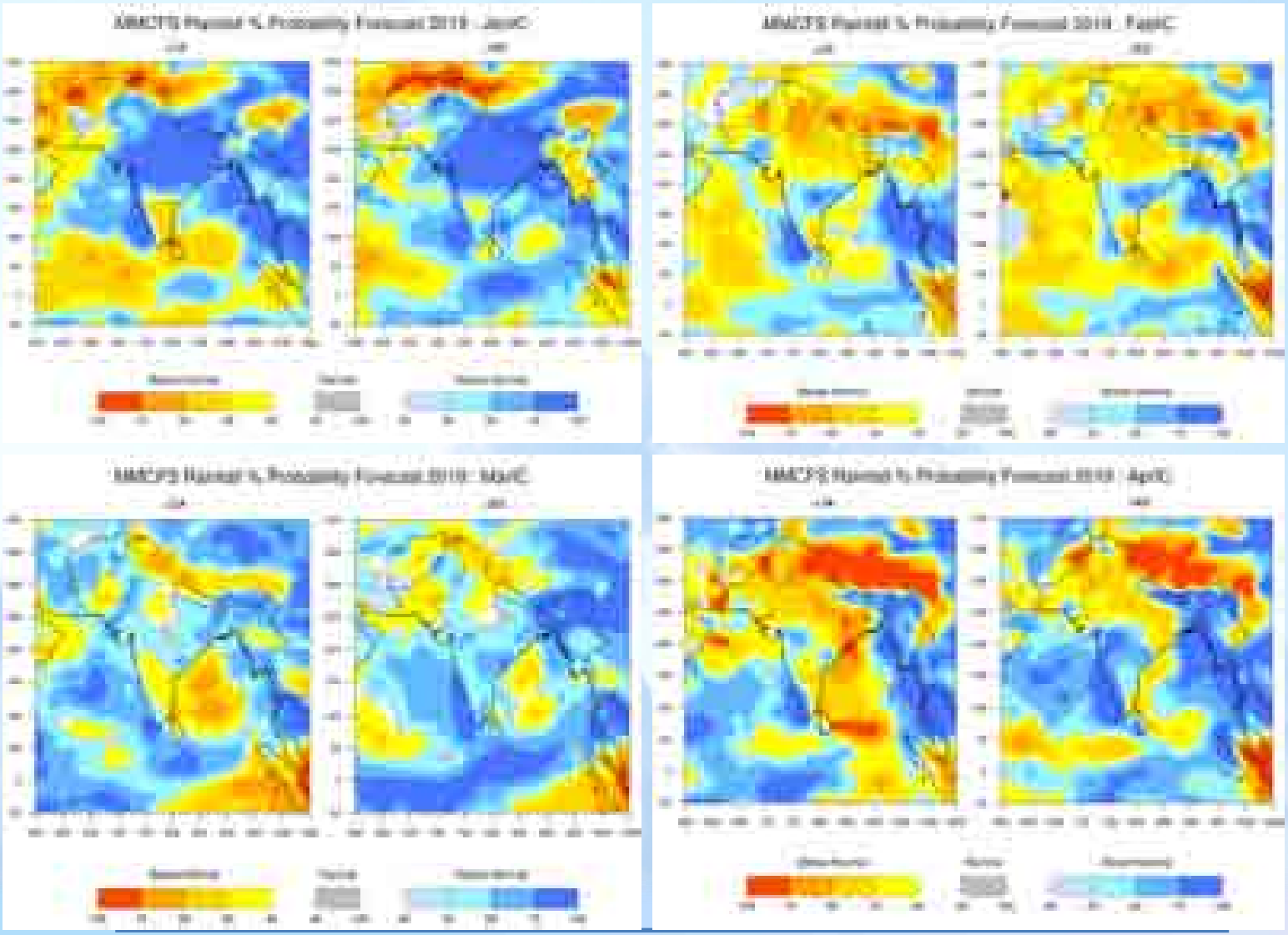
Indian Ocean Dipole: MMCFS Sep IC (24 ens)







South Asia MMCFS Probability Forecast Rainfall%



Flash Flood Guidance System

- Flash Flood Guidance System for South Asia
- Soil & Water Assessment Tool (SWAT) model indigenously customised in collaboration with IIT Delhi
- Variable Infiltration Capacity Model developed by IIT Gandhinagar
- Real-time Interactive MeTEYE : Indigenously developed GIS Visualisation of all model products into one platform for effective interpretation on dynamic time scales.

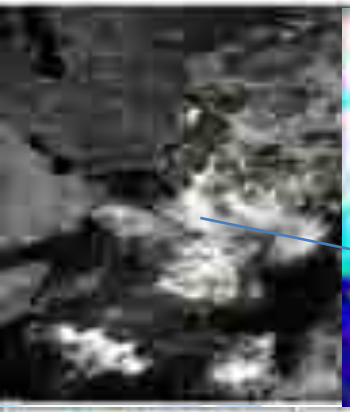
Flash Flood Guidance System

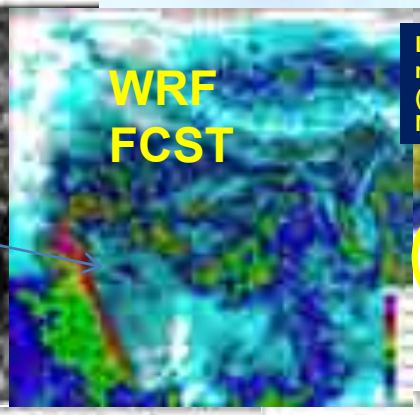
- Globally accepted model and at operational over 64 countries.
- Unlike a predictive system, It is a diagnostic system to provide real-time informational guidance pertaining to potential small scale flash flooding throughout the region of application.
- It uses Sacromental Soil Moisture LS model to produce Average Soil Moisture (mm) which estimates upper zone water tension upto 30 cms.
- The model runs every 6 hours with continuous satellite inputs every hour.
- Use of Radar Data to be incorporated to provide guidance at selected urban cities.
- Few Case studies over our region being validated for submission to research publishing soon.
- Presently the system is live and active at IMD Server, likely to be operationalized this May 2019 with a press release.

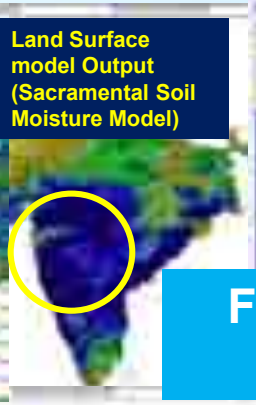
A Flash Flood Guidance System caters flash flood guidance at sub catchment scale over the entire South Asian region

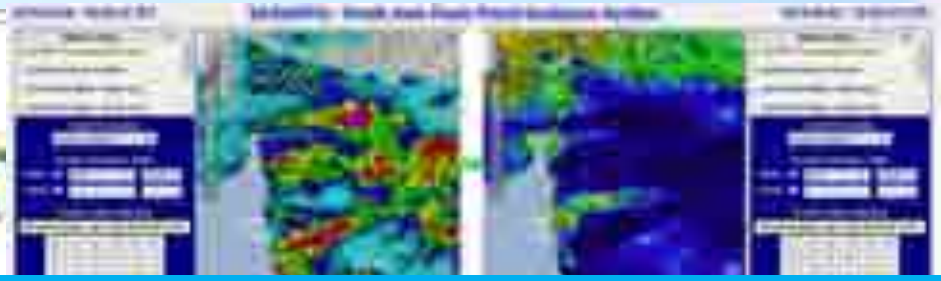
WMO recognised IMD as a Regional Leader in catering services to Nepal, Bhutan, Bangladesh, Sri Lanka

Visualises multiple outputs/ forecasts of the micro level catchment areas at the same time which identifies flash flood prone zones to be operational this Monsoon 2019

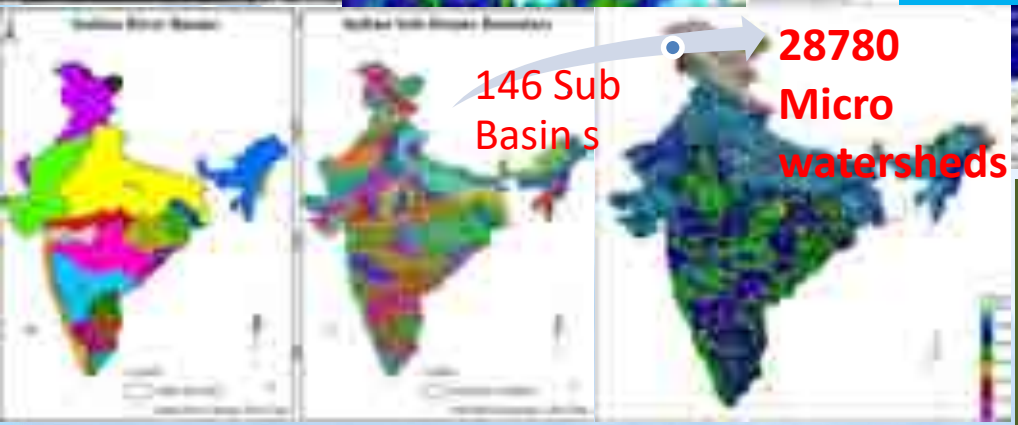


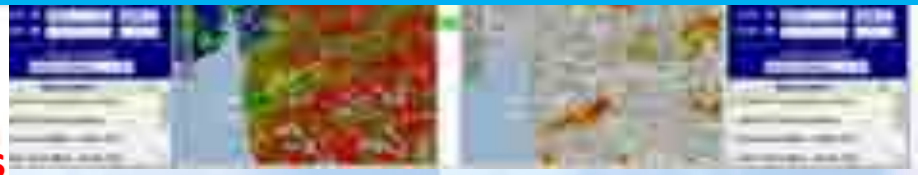






Focuses mainly on Hilly regions, Steep terrains, Urban cities





Advanced Functionalities of this system are providing guidance on Impact based flood warning, Landslide occurrence prediction, Urban Flash Flood Warning, Riverine / Channel routing, Seasonal to sub seasonal run off, Flow forecasting.

Single access to be provided to each RMC's.

Hands on Training to be imparted for selected participants for

Alerts, Warnings, Guidance

International access already executed and IMD keeps a watch to provide necessary guidance to member countries timely via email, CAP (if

FLASH FLOOD GUIDANCE SYSTEM USERGUIDE & OPERATIONAL SOP IS READY

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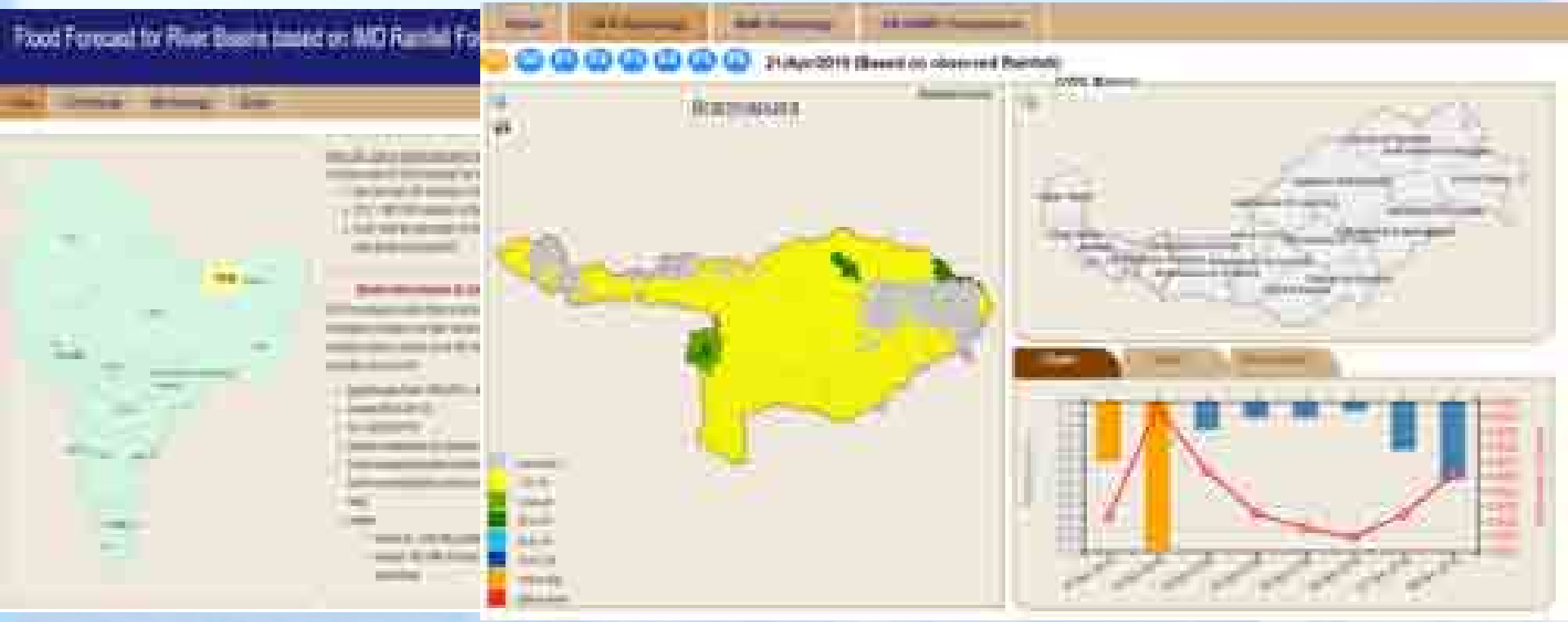
SWAT is an evaluating tool of soil & water developed by USDA Agricultural Research Service (Neitsch et al., 2002)

A river basin scale model SWAT (Soil & Water Assessment Tool) customized to predict the impact of land management practices in large, complex watersheds.

It is a distributed model operates in continuous daily time step at basin scale : modified as per Indian Conditions.



In Collaboration with IIT Delhi

An interactive GIS customised map server available to public domain for dynamic visualisation

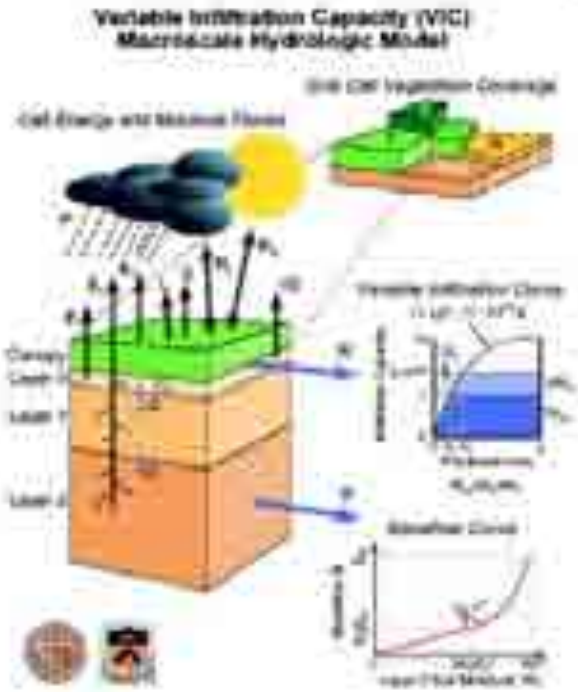
Courtesy: Prof. Dr. Gosain et al., Dr. Sandhya Rao et al., Dr.

Source: India Meteorological Department, India WRIS , Central Water Commission & USDA.

Variable Infiltration Capacity (VIC) Model Products for Land Surface Hydrology

VIC model

Methodology



- Developed by Liang et al. (1994).
- Macro scale semi distributed hyd. model.
- Solve water and energy within grid.

(Source: Liang et al. 1994)

Input parameters

1. Soil
2. Vegetation library
3. Vegetation parameter
4. Elevation band

Forcing data

1. Precipitation
2. Minimum and maximum temperature
3. Wind

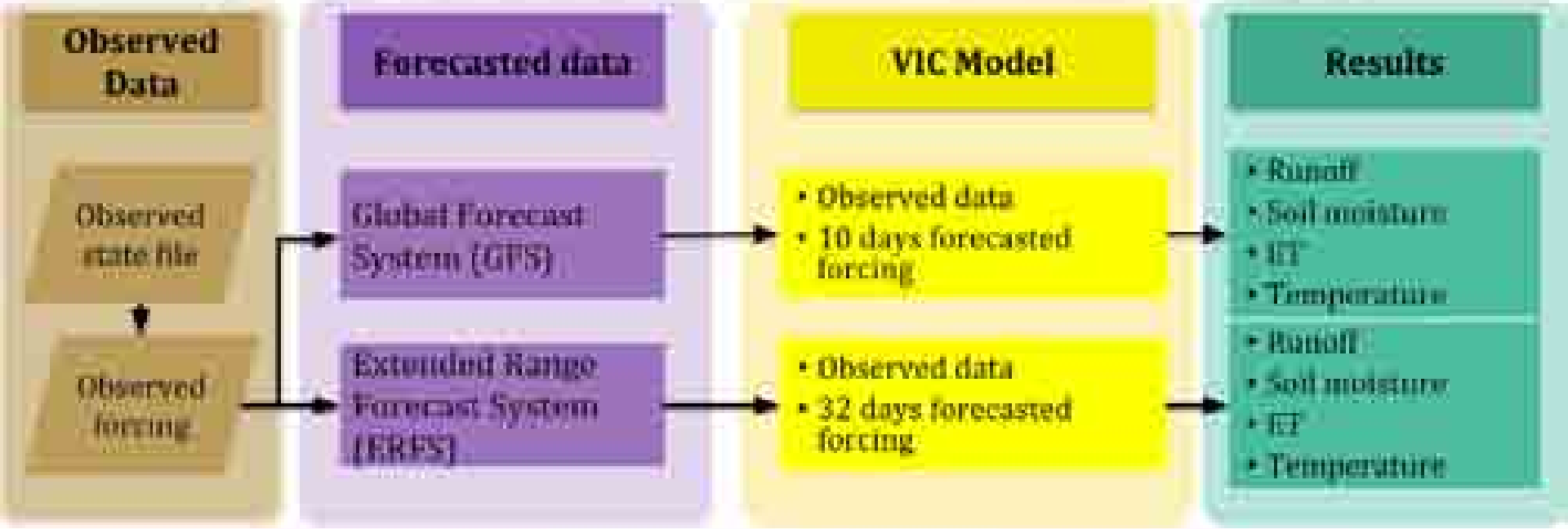
Major water budget components

1. Evapotranspiration
2. Soil moisture
3. Total runoff

In collaboration with IIT Gandhinagar

General Flowchart

Methodology



Comparison (GFS)

Temporal: Daily

Spatial: ~12 km

Comparison (ERFS)

Temporal: Weekly

Spatial: 1 Degree

Courtesy: Dr. Vimal Mishra et al, Dr. D.R. Patnaik et al, Dr. V.R. Durai et al team

VIC Model – Inputs & Forcing Data

Provides sub grid variability of elevation, soil, and vegetation (Gao et al. 2010).

Vegetation parameters extracted from the Advanced Very High-Resolution Radiometer (AVHRR) global 1km spatial resolution land cover information.(Sheffield and Wood 2007; Hansen et al. 2000).

Utilizes Harmonized World Soil Database version 1.2 (HWSD) soil data to develop **soil parameters** run in VIC model at sub-continental river basins. Sources of Vegetation library and elevation bands taken from Gao et al. (2010).

Observed data precipitation (0.25 degree) while temperature (0.5 degree), further regridded into 0.25 degree Tmax & Tmin using high-resolution digital elevation model (30 m) (for lapse rate) and the SYMAP algorithm as described in Maurer, et al. (2002).

Observed Wind data from NCEP/NCAR.

Forecasted precipitation, temperature, and wind data from IMD GFS at **0.125 degrees** for 10 forecast days at 3-hour temporal resolution, further regridded to 0.25 degree.

Forecasted precipitation, temperature, and wind data from ERFS at **1 degree** for 32 forecast days at 1-day temporal resolution, further regridded to 0.25 degree to make it consistent with the observed data.

Forecasted data

Global Forecast System (GFS)

- 3 hourly, ~12 km, 10 days forecast
- Regridded to 0.25°
- Runs once in a day

- High temporal resolution
- High spatial coverage

Extended Range Forecast System (ERFS)

- Daily, 1 degree, 32 days forecast
- Regridded to 0.25°
- Runs once in a week

- Accuracy
- Extended range forecast data

Forecast products

- Precipitation (mm)
- Max. temperature (°C)
- Min. temperature(°C)
- Wind (m/s)

Courtesy: Dr. D.R. Patnaik et al, Dr. V.R. Durai et al & NWP team

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Thank you