भारत सरकार
GOVERNMENT OF INDIA
भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

LONG RANGE FORECAST
FOR
2010 SOUTHWEST MONSOON RAINFALL

1. Background

India Meteorological Department (IMD) issues operational long range forecasts for the southwest monsoon rainfall in two stages. First stage forecast is issued in April and the second stage forecast is issued in June. This year, the first stage forecast for the southwest monsoon rainfall over the country was issued on 23rd April, 2010. IMD has now prepared the second stage forecasts.

2. First Stage Forecast issued on 23rd April, 2010

IMD's long range forecast for the 2010 south-west monsoon season (June to September) is that the rainfall for the country as a whole is likely to be Normal. Quantitatively, monsoon season rainfall is likely to be 98% of the long period average (LPA) with a model error of ± 5%. The LPA of monsoon season rainfall over the country as a whole for the period 1941-1990 is 89 cm.

3. Second Stage Forecasts

The following forecasts are being released now:

a) Forecast update for the southwest monsoon season (June-September) rainfall over the country as a whole using a 6-parameter ensemble statistical model with a model error of ± 4%.

b) Forecast for the monthly rainfall over the country as a whole for the months of July & August using separate principle component regression models with a model error of ± 9%.

c) Forecasts for the southwest monsoon season (June-September) rainfall for the four broad geographical regions of India using separate multiple linear regression models with a model error of ± 8%. The list of states included in each of these four geographical regions is given below.

Northwest India – Jammu and Kashmir, Himachal Pradesh, Punjab, Rajasthan, Haryana, Chandigarh, Delhi, Uttaranchal and Uttar Pradesh.

Northeast India – Arunachal Pradesh, Meghalaya, Assam, Nagaland, Manipur, Mizoram, Tripura, Sikkim, West Bengal, Bihar and Jharkhand.

Central India – Gujarat State, Madhya Pradesh, Chattisgarh, Maharashtra, Goa and Orissa.

South Peninsula – Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Lakshadweep and Andaman and Nicobar Islands.

The long period average (LPA) and coefficient of variation of monthly and season rainfall over various regions based on the 1941-1990 data are given below:

Region	**LPA (mm)**	**Coefficient of Variation (%)**
Season (June to September) Rainfall		
All India	890	10
Northwest India	612	19
Central India	994	14
Northeast India	1429	8
South Peninsula	725	15
Monthly Rainfall		
All India (July)	293	13
All India (August)	262	14

4. Details of the Operational Statistical Models

4.1. Statistical Ensemble Forecasting System for the Seasonal Rainfall over the Country as a Whole

The 6 predictors used in the ensemble forecasting system for the update forecast for the southwest monsoon season (June-September) rainfall over the country as a whole are: North Atlantic Sea Surface Temperature (December + January), Equatorial SE Indian Ocean Sea Surface Temperature (February + March), East Asia Mean Sea Level Pressure (February + March), Central Pacific (Nino 3.4) Sea Surface Temperature Tendency (March to May - December to February), North Atlantic Mean Sea Level Pressure (May) and North Central Pacific Zonal Wind at 850hPa (May).

In the ensemble method, instead of relying on a single model, all possible models based on all the combination of predictors are considered. With 6 predictors, 63 different models can be developed. Out of these 63 models, few best models were selected based on its skill in predicting monsoon rainfall during a common period and ensemble mean was computed as the weighted average of the forecast from the selected models. The weights are proportional to the multiple correlation coefficients of the models during the training period. For developing the models, two different statistical techniques namely, Multiple Regression (MR) and Projection Pursuit Regression (PPR) were considered. Verification of the results with the past data showed that the ensemble method performed better than the individual models. The model error of 6 – parameter ensemble forecasting system is ±4%.

4.2. Principle Component Regression Models for Monthly (July & August) Rainfall over the Country as a whole

For the forecast of monthly (July and August) rainfall over the country as a whole, principal component regression (PCR) models with separate predictor sets containing 5 predictors each was used. The model error of each of these two PCR models is ± 9%. The 5 predictors used for July model are: east Asia mean sea level pressure (February + March), north Atlantic sea surface temperature (December of previous year), north America mean sea level pressure (January), north Atlantic mean sea level pressure gradient (March) and north central Pacific zonal wind at 850hPa (May).

The 5 predictors used for the August model are: south Atlantic mean sea level pressure (April), southeast Pacific sea surface temperature (May), NINO 3.4 sea surface temperature tendency (MAM-DJF)), south Pacific zonal wind at 850hPa (April), and outgoing long wave radiation over tropical north Atlantic (March).

4.3. Multiple Linear Regression Models for the Seasonal Rainfall over the four Broad Geographical Regions of India

For the forecasting of Southwest monsoon season rainfall over the four broad geographical regions of India (NW India, Central India, South Peninsula and NE India), multiple regression (MR) models were developed using 4, 4, 5 and 4 parameters respectively.

The 4 parameters used in the model for NW India are; North Atlantic surface mean sea level pressure gradient (May), South Atlantic surface mean sea level pressure (January), East Asia surface mean sea level pressure (February + March) and North Central Pacific Zonal Wind at 850hPa (May).

The 4 parameters used in the model for Central India are; Equatorial Indian Ocean surface mean sea level pressure (November of previous year), North Atlantic sea surface temperature (December +January), North Atlantic surface mean sea level pressure gradient (May) and North Atlantic surface mean sea level pressure (March).

The 5 parameters used in the model for South Peninsula are; Southeast Indian Ocean mean sea level pressure (May), Southeast equatorial Indian Ocean sea surface temperature (October of previous year), northwest Europe land surface air temperature (January), Southeast Pacific surface mean sea level pressure (May), Northwest Pacific zonal wind at 850hpa (February).

The 4 Parameters used in the model for the North-East India are: South Atlantic mean sea level pressure (January), North Atlantic mean sea level pressure (April), Southwest Pacific sea surface temperature (March) and Central Pacific sea surface temperature (May).

All the four multiple linear regression models have model errors of ± 8% of LPA.

5. Experimental Dynamical Model Forecast

During the last five years (2005-2009), IMD has been preparing experimental dynamical forecasts of seasonal monsoon rainfall using the seasonal forecast model (SFM) adopted from the Experimental Climate Prediction Center (ECPC), USA. For the preparation of experimental dynamical model forecast for 2010 monsoon season, persisting May sea surface temperatures were used as the boundary conditions. Ten ensembles were obtained using the initial conditions corresponding to 00Z from 21st May to 30th May 2010. The model climatology was prepared using the observed SSTs during the period 1985-2004.

The experimental SFM forecast for the 2010 Southwest monsoon season rainfall suggests positive rainfall anomalies over entire country, with strongest anomalies over most parts of northeast India and south. For the country as a whole the experimental forecast suggests normal rainfall.

6. Forecast from Other Institutes

IMD has also taken into account the experimental forecasts prepared by the national institutes like Indian Institute of Tropical Meteorology (IITM), Pune, Indian Institute of Science (IISc), Bangalore, Space Applications Centre (SAC), Ahmedabad, National Aerospace Laboratories (NAL), Bangalore, Centre for Mathematical Modelling and Computer Simulation (CMMACS), Bangalore and

National Centre for Medium Range Weather Forecasting (NCMRWF), Noida and operational/experimental forecasts prepared by international institutes like World Meteorological Organization (WMO)'s Lead Centre for Long Range Forecasting - Multi-Model Ensemble (LRFMME), the National Centers for Environmental Prediction (NCEP), USA, International Research Institute for Climate and Society (IRI), USA, Meteorological Office, UK, the European Center for Medium Range Weather Forecasts (ECMWF), UK, the Experimental Climate Prediction Center (ECPC), USA, and Asian-Pacific Economic Cooperation (APEC) Climate Centre, Korea.

The experimental forecasts from majority of the statistical and dynamical models suggest normal to above normal monsoon season rainfall over the country as a whole.

7. Onset and Advance of Monsoon 2010

Associated with the formation of cyclone "LAILA" over Bay of Bengal, southwest monsoon set in over Andaman Sea on around 17th May, 3 days before its normal date. Subsequently monsoon reached Kerala on 31st May, just one day before its normal date and advanced over northeastern states by 2nd June. In the press release issued on 14th May 2010, IMD had forecasted that the monsoon will set over Kerala on 30th May with a model error of ±4 days. Subsequent to onset of monsoon over Kerala, another cyclonic storm ("PHET") formed over the Arabian Sea and this delayed further advancement of the monsoon across west coast by about one week. Around 6th June, the monsoon got activated and by middle of June, it covered nearly half of the country. As on 24th June, the northern limit of monsoon (NLM) continues to pass through Lat. 22.0°N/ Long. 60.0°E, Lat. 22.0°N/ Long. 69.0°E, Rajkot, Ahmedabad, Indore, Seoni, Pendra, Ambikapur, Daltonganj, Gaya, Muzaffarpur and Raxaul.

The cumulated seasonal rainfall over the country as a whole during the period 1-24th June is 89% of LPA.

8. Conditions over the equatorial Pacific and Indian Oceans

The El Nino conditions over equatorial Pacific that started in the mid June 2009 peaked in December and dissipated during early May, 2010. Since then, ENSO-neutral conditions are prevailing with negative SST anomalies observed over the equatorial Pacific from the middle of May. The latest forecasts from a majority of the dynamical and statistical models indicate continued and rapid cooling of the equatorial Pacific to below La Nina thresholds. There is very high probability (about 60%) for the La Nina conditions to develop during the monsoon season, which favours stronger than normal monsoon.

It is important to note that in addition to El Niño and La Niña events, other factors such as the Indian Ocean Sea surface temperatures (SSTs) have also significant influence on India monsoon. Recent forecasts from some coupled models suggest possibility of the development of a weak positive Indian Ocean Dipole event during the 2010 monsoon season, which may not have much impact on the Indian monsoon. However, IMD is carefully monitoring the possible evolution of La Nina conditions over Pacific and the Indian Ocean Dipole.

9. Summary of the Update Forecasts for 2010 Southwest Monsoon Rainfall

i) Southwest Monsoon Season Rainfall

Rainfall over the country as a whole for the 2010 southwest monsoon season (June to September) is likely to be normal. Quantitatively, monsoon season rainfall for the country as a whole is likely to be 102% of long period average (LPA) with a model error of ±4%.

ii) Monthly (July & August) Rainfall

Rainfall over the country as a whole in the month of July 2010 is likely to be 98% of LPA and that in the month of August is likely to be 101% of LPA both with a model error of ± 9 %.

iii) Rainfall over Broad Geographical Regions

Over the four broad geographical regions of the country, rainfall for the 2010 Southwest Monsoon Season is likely to be 102% of LPA over North-West India, 103% of LPA over North-East India, 99% of LPA over Central India and 102% of LPA over South Peninsula, all with a model error of ± 8 %.

New Delhi
The 25th June 2010
4th Asadha 1932 (SE)

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