

**Government of India
Ministry of Earth Sciences
India Meteorological Department**

**Long Range Forecast Update for
2012 Southwest Monsoon Rainfall**

1. Background

As per the present operational long range forecasting system, India Meteorological Department (IMD) issues the operational long range forecast for nation-wide (country as a whole) southwest monsoon season (June-September) rainfall in two stages. The first stage forecast is issued in April based on data up to March and the second stage or update forecast is issued in June based on data up to May. In the second stage, along with update for the April forecast, forecasts for the monthly rainfall for July & August over the country as a whole and the season rainfall over four geographical regions of the country are also issued. Similarly forecast for the nation-wide rainfall during the second half of the season (August to September) is issued in July and that for the nation-wide rainfall for the month of September is issued in August.

This year (2012), the first stage forecast for the nation-wide season rainfall was issued on 26th April. The summary of the first stage forecast given below.

(a) Southwest monsoon seasonal rainfall for the country as a whole is most likely to be Normal (96-104% of Long Period Average (LPA)) with the probability of 47%. The probability (24%) of season rainfall to be below normal (90-96% of LPA) is also higher than its climatological value. However, the probability of season rainfall to be deficient (below 90% of LPA) or excess (above 110% of LPA) is relatively low (less than 10%).

(b) Quantitatively, monsoon season rainfall is likely to be 99% of the LPA with a model error of $\pm 5\%$. The LPA of the season rainfall over the country as a whole for the period 1951-2000 is 89 cm.

2. The Operational Forecasts Issued In June

IMD is now ready with the following forecasts:

- Updated quantitative and probabilistic forecasts for the Southwest Monsoon season rainfall for the country as a whole using a 6-parameter Ensemble Forecasting System.

- Quantitative and probabilistic forecasts for the monthly rainfall for July & August over the country as a whole using separate Principal Component Regression Models.
- Quantitative and probabilistic forecasts for the season rainfall for the 4 broad geographical regions of India (NW India, NE India, Central India and South Peninsula) using separate Principal Component Regression Models.

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 1951-2000 data are given below:

Region	LPA (mm)	Coefficient of Variation (%)
Season (June to September) Rainfall		
All India	887.5	10.7
Northwest India	615.0	18.9
Central India	975.5	15.0
Northeast India	1438.3	12.6
South Peninsula	715.5	15.3
Monthly Rainfall		
All India (July)	289.2	12.7
All India (August)	261.3	14.2

3. 6-Parameter 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).

The 6-parameter ensemble statistical forecasting system was also used to prepare probability forecasts for five pre-defined rainfall categories. The probability forecasts for the 2012 monsoon season rainfall for the 5 categories are given below.

Category	Rainfall Range (% of LPA)	Forecast Probability (%)	Climatological Probability (%)
Deficient	< 90	15	16
Below Normal	90 - 96	35	17
Normal	96 -104	42	33
Above Normal	104 -110	7	16
Excess	> 110	1	17

4. Forecasting System for the Monthly Rainfall over the Country as a Whole

For the quantitative forecasts of monthly rainfall (for the months of July & August) over the country as a whole, separate principal component regression models were used. The models for each month were based on separate set of predictors. The same models were also used for generating probability forecast for the pre-defined 3 (tercile) categories of monthly rainfall. The rainfall tercile categories have equal climatological probabilities (33.33% each). The probability forecasts for July and August rainfall over the country as a whole are given below.

Category	July Model		August Model	
	Rainfall Range (% of LPA)	Forecast Probability (%)	Rainfall Range (% of LPA)	Forecast Probability (%)
Below Normal	<94	36	<94	42
Normal	94 -106	41	94 -106	36
Above Normal	>106	23	>106	22

5. Forecasting System for the Seasonal Rainfall over the 4 broad geographical regions of the country

For the quantitative forecasts of rainfall during the southwest monsoon season (June to September) over the 4 geographical regions, new principal component regression models were used. The models for each region were based on separate set of predictors. The same models were also used for generating probability forecast for the pre-defined 3 (tercile) categories of monthly rainfall. The rainfall tercile categories have equal climatological probabilities (33.33% each). The probability forecasts for the seasonal rainfall over the 4 geographical regions are given below.

Rainfall Category	NW India		Central India		South Peninsula		Northeast India	
	Range (% of LPA)	Forecast Probability (%)	Range (% of LPA)	Forecast Probability (%)	Range (% of LPA)	Forecast Probability (%)	Range (% of LPA)	Forecast Probability (%)
Below Normal	<92	46	<94	42	<93	42	<95	34
Normal	92-108	47	94-106	43	93-107	41	95-105	40
Above Normal	>108	07	>106	15	>107	17	>105	26

6. IMD-IITM Coupled Dynamical Model Forecasting System

An experimental forecast for the 2012 southwest monsoon rainfall was generated using the research version of a high resolution coupled dynamical model being implemented at the Indian Institute of Tropical Meteorology (IITM), Pune. The model was developed by the National Centers for Environmental Prediction (NCEP), USA.

The experimental forecast for the 2012 monsoon season using the IMD – IITM dynamical prediction system using April initial conditions indicates that the rainfall during the 2012 monsoon season (June to September) averaged over the country as a whole is likely to be 104% ± 4% of long period model average (LPMA).

7. Forecasts by Other National and International Institutions

In addition, IMD has taken into account the experimental forecasts prepared by the national institutes like Space Applications Centre, Ahmedabad, Centre for Mathematical Modeling and Computer Simulation, Bangalore, Center for Development of Advanced Computing, Pune and Indian Institute of Tropical Meteorology, Pune. Operational/experimental forecasts prepared by international institutes like the National Centers for Environmental Prediction, USA, International Research Institute for Climate and Society, USA, Meteorological Office, UK, Meteo France, the European Center for Medium Range Weather Forecasts, UK, Japan Meteorological Agency, Japan Agency for Marine-Earth Science and Technology, Asian-Pacific Economic Cooperation (APEC) Climate Centre, Korea and World Meteorological Organization's Lead Centre for Long Range Forecasting - Multi-Model Ensemble have also been taken into account.

The experimental forecasts for the seasonal rainfall over the country as a whole show large divergence (from deficient to excess rainfall).

8. Onset and Advance of Monsoon 2012

This year, setting in of southwest monsoon over Andaman Sea was delayed by about 3 days. It set in over Kerala on 5th June as against the IMD forecast date of 1st June ± 4 days. On 6th June, it rapidly advanced mainly along the west coast and over northeastern States and covered entire Kerala, coastal Karnataka, Goa, southern parts of Konkan, Madhya Maharashtra, entire Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and parts of sub-Himalayan West Bengal & Sikkim. After a hiatus in the advance of monsoon for a period of about one week, on 13th June, the monsoon further advanced into some more parts of Madhya Maharashtra, interior Karnataka, most parts of Tamil Nadu, remaining parts of south Bay of Bengal and some more parts of central & north Bay of Bengal. By 21st June, monsoon covered most parts of Arabian Sea, extreme south Gujarat, most parts of Maharashtra, entire Andhra Pradesh, Orissa, West Bengal & Sikkim, Chhattisgarh, Bihar, Jharkhand, Bay of Bengal and some parts of east Madhya Pradesh and east Uttar Pradesh.

As on 21st June, the Northern Limit of Monsoon (NLM) passed through Lat 21.0°N/ Long. 60.0° E, Lat 21.0°N/ Long. 65.0°E, Veraval, Navsari, Malegaon, Betul, Jabalpur, Siddhi, Varanasi, Gorakhpur and Lat 28.0°N/ Long. 83.0°E.

The cumulated seasonal rainfall over the country as a whole during the period 1-21st June is 76% of LPA.

9. Sea Surface Temperature (SST) Conditions in the Equatorial Pacific & Indian Oceans

After the disappearance of moderate to strong La Nina conditions in May 2011, weak La Nina conditions reemerged in early August, 2011 and became weak to moderate during later part of 2011. The weak/moderate La Nina conditions continued till first half of February 2012, after which it started weakening and dissipated in the early April 2012. As of now, ENSO neutral conditions are prevailing. The latest forecasts from a majority of the dynamical and statistical models indicate ENSO neutral conditions are most likely (with a probability of about 60%) to prevail during the monsoon season. There is also substantial probability (about 36%) for emergence of weak El Nino conditions during later part of the monsoon season. However, the probability of reemergence of La Nina conditions during the monsoon season is very less.

In addition to ENSO events, other factors such as the Indian Ocean Sea surface temperatures (SSTs) have also some influence on Indian monsoon. Recent forecasts from some coupled models suggest possibility of the development of a weak negative Indian Ocean Dipole event during the second half of the year, which may not have much impact on the Indian monsoon. As the extreme sea surface temperature conditions over Pacific and Indian Oceans particularly ENSO conditions over Pacific (El Nino or La Nina) are known to have strong influence on the Indian summer monsoon, IMD is carefully monitoring the sea surface conditions over Pacific and Indian oceans.

10. Summary of the Update Forecasts for 2012 Southwest Monsoon Rainfall

i) Southwest Monsoon Season Rainfall over the country as a whole

Rainfall over the country as a whole for the 2012 southwest monsoon season (June to September) is most likely to be normal (96-104% of LPA).

Quantitatively, monsoon season rainfall for the country as a whole is likely to be 96% of the long period average with a model error of $\pm 4\%$. The Long period average rainfall over the country as a whole for the period 1951-2000 is 89 cm.

ii) Monthly (July & August) Rainfall over the country as a whole

Rainfall over the country as a whole for the month of July 2012 is likely to be 98% of its LPA and that for the month of August is likely to be 96% of LPA both with a model error of $\pm 9\%$.

iii) Season Rainfall over Broad Geographical Regions

Over the four broad geographical regions of the country, rainfall for the 2012 Southwest Monsoon Season is likely to be 93% of its LPA over North-West India, 96% of its LPA over Central India, 95% of its LPA over South Peninsula, and 99% of its LPA over North-East India all with a model error of $\pm 8\%$.