GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
RAJYA SABHA
UNSTARRED QUESTION NO. 2914
ANSWERED ON 13/08/2026

STRENGTHENING LONG RANGE FORECASTING CAPABILITIES

2914. SHRI ASHOKRAO SHANKARRAO CHAVAN:
DR. DINESH SHARMA:
SHRI NARESH BANSAL:
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SHRI AMAR PAL MAURYA:
SMT. SADHNA SINGH:
SHRI KESRIDEVSINH JHALA:
SHRI JAGGESH:

Will the Minister of **EARTH SCIENCES** be pleased to state:

(a) whether the Multi-Model Ensemble forecasting system adopted by the India Meteorological Department has improved the accuracy and reliability of long-range monsoon forecasts;
(b) if so, the details thereof;
(c) the steps being taken to address challenges such as the spring predictability barrier in long-range monsoon prediction;
(d) whether any new modelling and observational systems are being introduced to improve prediction of extreme rainfall events in hilly and coastal regions; and
(e) if so, the details thereof, and the roadmap for further strengthening India's long-range forecasting capabilities in the coming years?

ANSWER
THE MINISTER OF STATE (INDEPENDENT CHARGE) FOR
MINISTRY OF SCIENCE AND TECHNOLOGY
AND EARTH SCIENCES
(DR. JITENDRA SINGH)

(a)-(b) The India Meteorological Department (IMD), under the Ministry of Earth Sciences (MoES), has progressively upgraded its Long Range Forecast (LRF) system by adopting an advanced Multi-Model Ensemble (MME) forecasting approach based on coupled dynamical climate models. The MME system combines forecasts from multiple climate models, thereby reducing uncertainties associated with individual models and improving the reliability and skill of seasonal forecasts. The adoption of the MME forecasting system has led to a significant improvement in the reliability of seasonal monsoon forecasts. During the period 2021–2025, the average absolute error of the first-stage forecast was 3.1% of the Long Period Average (LPA), while the average absolute error of the second-stage forecast further reduced to 2.2% of the LPA. In comparison, the average absolute error during 2016–2020 was 7.8% of the LPA.

Thus, the average absolute error has reduced from 7.8% to 2.2% of the LPA, indicating a substantial enhancement in the reliability and skill of the seasonal prediction system following the adoption and operational refinement of the MME forecasting system. The MME system has also enhanced the consistency of forecasts by improving the representation of large-scale climate drivers such as the El Nino–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), leading to more reliable seasonal monsoon predictions.

(c) The Spring Predictability Barrier (SPB) is a well-recognized scientific challenge in seasonal climate prediction, particularly in forecasting the evolution of the ENSO, which significantly influences the Indian summer monsoon. IMD addresses this challenge through continuous monitoring of oceanic and atmospheric parameters and by utilizing forecasts from the Monsoon Mission Coupled Forecasting System (MMCFS) and other leading international climate centers. These inputs are considered to improve the accuracy and reliability of long-range monsoon forecasts.

To effectively address forecast uncertainties associated with the SPB, IMD follows a two-stage forecasting strategy for the Southwest Monsoon Season (June–September). The first stage forecast is issued in April, followed by an updated second stage forecast in May. Thereafter, monthly forecasts are issued for June, July, August, and September, along with updates of the seasonal rainfall forecast. In addition, an updated forecast for the second half of the monsoon season (August–September) is issued in late July, incorporating the latest observed oceanic and atmospheric conditions and model guidance. This sequential forecast strategy enables IMD to progressively improve forecast accuracy as the monsoon season approaches and evolves.

(d)-(e) Yes. The Government has taken several measures to further improve long-range monsoon forecasting and prediction of extreme weather events in the country, including hilly and coastal regions. These include:

- Adoption of advanced Multi-Model Ensemble and coupled dynamical climate models for operational long-range forecasting.

- Continuous upgradation of numerical weather prediction models through improved model physics, higher spatial resolution, advanced data assimilation techniques supported by enhanced computational capabilities, i.e., augmentation of new high-performance computing systems within MoES, and artificial intelligence/machine learning-based forecasting tools.

- Strengthening of the national meteorological observation network through the installation of additional Doppler Weather Radars, Automatic Weather Stations, Automatic Rain Gauges, upper-air observing systems, wind profilers, and other observing platforms.

- Expansion of satellite-based observations through indigenous meteorological satellites and the data assimilation of satellite, weather radar, and in situ observations into numerical models to improve weather forecast accuracy.

- Development of impact-based forecasting and multi-hazard early warning systems for extreme weather events, including heavy rainfall, thunderstorms, lightning, heatwaves, coldwaves, cyclones, and dense fog.
- Dissemination of weather forecasts and warnings through multiple communication platforms, including mobile applications, APIs, web portals, SMS, television, radio, and social media, in coordination with Central and State Government agencies.
- Capacity enhancement under the Mission Mausam Program through modernization of observation systems and advanced Earth system modeling.

The above measures are being implemented across the country and benefit all States and Union Territories.

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