



AI Driven Weather Forecasting

For Prelims: [Artificial Intelligence](#), [Machine Learning](#), [World Meteorological Organization](#), [El Nino](#), [Indian Ocean Dipole](#)

For Mains: Role of AI/ML in climate and weather forecasting in India, Importance of Mission Mausam for climate resilience

[Source: TH](#)

Why in News?

The growing incidence of [extreme events](#), such as heatwaves and flash floods, is pushing India to increasingly rely on [Artificial Intelligence \(AI\)](#) and [Machine Learning \(ML\)](#) to enhance its weather forecasting capabilities, a move further bolstered by the launch of '[Mission Mausam](#)'

How is India Adopting AI-Based Weather Forecasting?

- **AI-Based Weather Forecasting:** It refers to the use of AI and Machine Learning to analyze **data from various sources** to predict weather patterns and extreme events with high accuracy, helping in better decision-making and disaster management.
- **India's Key Initiatives Related to AI Based Forecasting:**
 - **Weather Information Network and Data System (WINDS):** The **Ministry of Agriculture and Farmers Welfare** has initiated the **WINDS** to generate hyper-local, long-term weather data.
 - WINDS will install over **200,000 ground stations**, significantly enhancing weather data collection, which will improve weather predictions, especially for agricultural and disaster management needs.
 - **AI and Machine Learning Centre:** The MoES has established an AI and Machine Learning Centre in Pune to enhance weather forecasts, focusing on short-range rainfall predictions, high-resolution urban datasets, and **nowcasting** rainfall and snow using Doppler radar data.
 - **AI-based Monsoon Prediction Models:** DST Centre of Excellence in Climate Modelling (CECM) at IIT-Delhi in collaboration with other researchers have developed **AI/ML-based models for monsoon prediction**, using historical data and climate drivers like [El Nino](#) and the [Indian Ocean Dipole \(IOD\)](#).
 - These models have demonstrated better performance than traditional physical models, with a **forecast success rate of 61.9%** for the 2002-2022 period.
 - The models can also predict rainfall months in advance and can be updated based on evolving climate data.

What is Mission Mausam?

- **About:** Mission Mausam, launched in 2024 under the **Ministry of Earth Sciences (MoES)**, to

modernize India's weather and climate forecasting systems.

- It aims to make the country **“Weather Ready” and “Climate Smart”** by enhancing scientific research, disaster preparedness, and sector-specific advisories.
- **Need:** India's dependence on **agriculture**, increasing climate variability, and frequent extreme weather events make accurate forecasting vital.
 - Mission Mausam addresses these challenges by enhancing monsoon prediction for better **crop planning** and supporting rural development through improved resource management and infrastructure planning.
- **Implementation Strategy:** It will be implemented mainly by the [India Meteorological Department \(IMD\)](#), [Indian Institute of Tropical Meteorology\(IITM\)](#), and the [National Centre for Medium-Range Weather Forecasting \(NCMRWF\)](#).
 - It focuses on enhancing weather forecasting through infrastructure development (**Doppler radars, weather stations**).
 - The mission also leverages **supercomputing power**, utilizing advanced systems like [Pratyush and Mihir](#) for precise climate modeling.
- **Current Status:** Over 37 [Doppler Weather Radars](#) are installed across India, enhancing real-time monitoring.
 - The Mausam app offers weather forecasts for 450 cities, and seasonal prediction models have improved under the National Monsoon Mission.





CABINET DECISION 11-09-2024

MISSION MAUSAM

Cabinet approves 'Mission Mausam' to create a more weather-ready and climate-smart Bharat with an outlay of Rs.2,000 crore over 2 years

BENEFITS

- ❖ A multi-faceted and transformative initiative to tremendously boost India's weather and climate-related science, research and services
- ❖ Will help better equip stakeholders, including citizens and last-mile users, in tackling extreme weather events and the impacts of climate change
- ❖ Mission focus to include improving observations and understanding for providing highly accurate and timely weather and climate information across temporal and spatial scales
- ❖ Mission to be implemented by 3 institutes of the Ministry of Earth Sciences:
 - India Meteorological Department
 - Indian Institute of Tropical Meteorology
 - National Centre for Medium-Range Weather Forecasting

How is AI Forecasting Different from Traditional Forecasting Methods?

Aspect	AI Models	Traditional Methods (Numerical Weather Prediction (NWP))
Data-Driven vs. Physics-Based	AI models use large datasets to detect patterns and correlations without understanding physical processes, such as atmospheric interactions, uncovering hidden	Traditional models use physical equations on fluid dynamics and thermodynamics to simulate the atmosphere.

	connections.	
Computational Approach	AI enhances real-time forecasting by evolving algorithms and detecting subtle patterns.	NWP models need supercomputers for complex, time-consuming calculations, especially in long-term forecasts.
Flexibility and Adaptability	AI adapts to new data, handles diverse inputs (e.g., ocean salinity), and adjusts to different geographical conditions.	NWP models rely on fixed rules, making them less flexible and requiring updates for extreme events.
Prediction of Extreme Events	AI predicts extreme events like heatwaves and floods more accurately and earlier by analyzing large datasets.	NWP is good for general weather but struggles with localized extreme events.

What are the Challenges with AI-based Forecasting?

- **Data Quality and Availability:** AI models **need large, high-quality datasets**, but weather data is **often inconsistent, sparse, or inaccurate**, especially in remote areas.
- **Complex Weather Systems:** Weather systems are **chaotic and nonlinear**, making it difficult for AI to predict them accurately. Regional variability adds further complexity.
- **Interpretability:** AI models often act as "black boxes," meaning their predictions are hard to explain, leading to trust issues among non-experts.
- **Lack of Expertise:** AI-based forecasting requires **cross-disciplinary expertise** in both **climate science and machine learning**, which is scarce in India.
- **Limited Computational Infrastructure:** AI models require significant computing power, especially for high-resolution forecasts.
 - Many Indian institutions still lack the necessary infrastructure, such as high-performance GPUs, to support AI-based weather prediction.
- **Bias and Trust Issues:** AI models are often criticized for their "black-box" nature, making it difficult to interpret how predictions are made.
 - AI models may inherit biases from the data they're trained on, leading to unreliable predictions, and public trust in AI-based forecasts is a concern.

What Measures Can Improve the Effectiveness of AI-Based Weather Forecasting in India?

- **Hybrid Approach:** Combining AI/ML with traditional physics-based models creates hybrid systems that leverage the strengths of both.
 - This approach enhances forecast accuracy, especially for complex weather patterns, by fusing data-driven insights with physical atmospheric principles.
- **Crowdsourcing for Localized Data Collection:** Leveraging platforms like **Google Maps**, and **Google DeepMind's GenCast AI model**, citizens can contribute localized weather data, aiding real-time feedback for AI models to refine predictions.
 - Integrating this data into **apps like Mausam** enhances community-driven forecasting, improving accuracy for extreme weather events.
- **Expanding Ground Station Networks:** Expanding **Automatic Weather Stations (AWS)** and **Automatic Rain Gauges (ARG)** networks through initiatives like **WINDS** (which aims to create 200,000+ new stations) will strengthen data for AI models.
 - Tapping into private sector networks and ensuring seamless integration can further boost forecasting accuracy.
- **Global Collaboration:** India can accelerate AI-based weather forecasting by collaborating with global leaders like Google, and **National Aeronautics and Space Administration (NASA)** on joint projects and shared datasets.
 - Establishing AI/ML and Climate Science Institutes will foster interdisciplinary expertise, supported by the DST and MoES.
 - Hosting annual AI in Weather Forecasting Conferences and offering training programs will ensure a continuous supply of skilled professionals.

Drishti Mains Question:

What are the major challenges faced in implementing Artificial Intelligence based weather forecasting in India? Suggest measures to overcome them.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims

Q. With reference to 'Indian Ocean Dipole (IOD)' sometimes mentioned in the news while forecasting Indian monsoon, which of the following statements is/are correct? (2017)

1. IOD phenomenon is characterised by a difference in sea surface temperature between tropical Western Indian Ocean and tropical Eastern Pacific Ocean.
2. An IOD phenomenon can influence an El Nino's impact on the monsoon.

Select the correct answer using the code given below:

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Ans: (b)

Mains:

Q. What do you understand by the phenomenon of temperature inversion in meteorology? How does it affect weather and the inhabitants of the place? (2013)

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