THE WEATHER PUNDIT

FE goes behind the scenes to know what happens at the met department before it announces the country's most awaited forecast—the monsoon—every year

Sandip Das

CONSIDERING THE mind-boggling information available on the India Meteorological Department (IMD) website, one would expect its technical centres to be chaotic places with scientists and technicians busy with machines and poring over complex data and satellite imagery as they predict weather across the country. However, what one sees instead are barely a dozen persons sitting in vastly empty spaces, working calmly at their computers, with supercomputers taking care of most of the work. But that does not dilute the fact that these people answer the most pertinent question for the country every summer—the monsoon forecast.

Not surprisingly, when science and technology minister Jaipal Reddy announced last week in Delhi, in a hall packed with journalists eager for the news, that the monsoon this year is likely to be normal, it sent a sigh of relief among policymakers.

Why a good monsoon is important for the country, and getting the forecast right even more important, can be easily explained by a few facts: more than half of India's 1.2-billion population is engaged in agriculture; about 55% arable land is dependent on monsoon rains, and agriculture contributes 15% to India's nearly $2-trillion economy. Which is why before announcing its forecast for the monsoon, the IMD consults the food, agriculture and other ministries, as its impact on the economy is considerable.

Accuracy is the name of the game here and the met department has had its share of hits and misses. The year 2002 was a game changer, when the met department could not predict deficiency in the monsoon rainfall, forcing scientists to go in for a review of the methods of forecast being used.

Shailesh Nayak, secretary, earth sciences ministry, admits that the statistical model, being followed by the met department since decades, has been successful in predicting 'mean or average rainfall' across the country, but has failed in providing regional variations in rainfall pattern.

For instance, he says, last year's deficiency in rainfall in parts of Gujarat, Maharashtra and Karnataka could not be captured because of deficiencies in this model. In April 2012, the IMD had predicted normal rainfall of 99% of LPA (Long Period Average, the average country-wide annual rainfall of 89 cm during 1951-2000) for the four monsoon months, while the actual rainfall was only 92% of LPA, with many parts of the country, such as Maharashtra, Gujarat and Karnataka, facing drought-like conditions because of deficient rainfall. "The forecast for July rainfall over the country as a whole was an overestimate and that for rainfall during the second half of the monsoon season was an underestimate," the IMD stated in its monsoon report of 2012.

The department has faced flak earlier too, for not accurately predicting deficient rainfall in 2003, 2004, 2007 and 2009. The IMD failed to foresee the worst drought in nearly four decades in 2009, predicting an average monsoon year, but the season ended with a rainfall deficit of 22%, making for the worst monsoon in nearly four decades. As a result, rice output fell and India had to import sugar, sending global prices to a 30-year high.

In 2007, in contrast to the forecast of below-average rainfall, the monsoon turned out to be above average.

Scientists argue that understanding variability in wind, pressure and temperature is not an easy process. "We need to constantly upgrade our computation capability to high-speed supercomputers for arriving at a more accurate weather forecast," says Swati Basu, director, National Centre for Medium Range Weather Forecast (NCMRDF), a Noida-based organisation under the ministry of earth sciences.

Nayak tells *FE* that the department is planning to fully shift to the dynamic model of forecasting monsoon, which will help the IMD make short-term predictions too. "We will be able to make short-term forecasts using the dynamic model. Followed in the US, Europe and Japan, the model is being used across the globe for more localised forecasts. Within the next five to six years, we will move to this model." The department has already started using this model since last year. The dynamic model depends more on the laws of physics and factors like formation of clouds, wind direction, etc, than purely math as used in the statistical method since the 1980s.

The IMD has also taken into account experimental forecasts. The model has been using data from premier national institutes like Space Applications Centre, Ahmedabad; Indian Institute of Science, Bangalore; Centre for Mathematical Modeling and Computer Simulation, Bangalore; and Centre for Development of Advanced Computing, Pune.

Besides, met scientists take into account experimental forecasts prepared by international institutes also, including 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 and Japan Agency for Marine, etc.

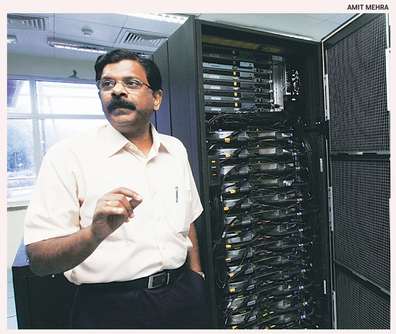
Recently, the met department joined hands with almost all the world's major weather forecasters in its effort to accurately forecast monsoon rains in the next four years, raising prospects for a rise of up to 15% in farm output, says LS Rathore, director general, IMD. "Significant improvement in accuracy of weather forecast has been achieved by using latest technology—satellite, doppler weather radars," says Rathore.

While NCMRDF provides information to the IMD on short-term weather forecast (five days in advance) on the temperature and weather conditions for 117 towns across the country, Pune-based Indian Institute of Tropical Meteorology (IITM) is the key organisation responsible for long-term weather forecasts for the country.

Meanwhile, all eyes are on the skies, as the country hopes for the met department to have got the 'normal' forecast right this year.

A scientist analysing satellite images

AMIT MEHRA



A scientist explains the role of supercomputers in weather forecasting at the National Centre for Medium Range Weather Forecast, Noida

ARUL HORIZON

Pune-based Indian Institute of Tropical Meteorology (IITM) is the key organisation responsible for long-term weather forecasts for the country

GOING COMMERCIAL

WHILE THE IMD has been providing most of its weather forecast services free, the civil aviation ministry pays the IMD for getting weather reports for all airports across the country. The met department has also provided special weather services during the Kumbh Mela, Amarnath Yatra, Commonwealth Games and the ICC Cricket World Cup, to name a few.

As for going commercial, IMD officials admit they do not have capacities to provide customised weather forecasting that would help agriculture and other sectors. "We need to develop our capacities for downscaling the existing data for special weather forecast services. We see a significant demand from sectors such as wind energy generation and transportation sector," says Shailesh Nayak, secretary, ministry of earth sciences. Specialised weather forecast for cash crops, such as cotton, corn, sugar and others, is also being worked upon. But it would take a couple of years to develop technical capacities to generate such customised forecasts.

At present, the IMD provides short-term weather forecasts for 117 cities and towns in the country. These services have been used by sectors such as sports, event management, among others.

HITS & MISSES

- In 2012, normal rainfall of 99% of LPA was predicted, while actual rainfall was only 92% of LPA, with Maharashtra, Gujarat and Karnataka facing drought-like conditions.
- In 2009, the IMD failed to foresee the worst drought in nearly four decades, predicting an average monsoon year. But the season ended with a rainfall deficit of 22%.
- In 2007, in contrast to the forecast of below-average rainfall, the monsoon turned out to be above average.

History of forecasting: From thermometer to supercomputer

Sandip Das

WHILE TRACING the origin of forecasting rains, it could be concluded that the beginnings of meteorology or predicting rains in India could be traced to ancient times. Early philosophical writings of 3000 BC era, such as the *Upanishads*, contain references about the processes of cloud formation, rain and the seasonal cycles caused by the movement of earth around the sun. Varahamihira's classical work, the *Brihatsamhita*, written around 500 AD, provides clear evidence that a deep knowledge of atmospheric processes existed even in those times. It was believed that rain came from the sun and that good rainfall in the rainy season was key to bountiful agriculture and food for the people.

Kautilya's *Arthashastra* contains records of scientific measurements of rainfall and its application to the country's revenue and relief work. Kalidasa in his epic *Meghdoot* mentioned the date of the onset of monsoon over central India and traced the path of monsoon clouds.

However, IMD officials say modern meteorology had its firm scientific foundation in the 17th century after the invention of the thermometer and barometer, and the formulation of laws governing the behaviour of atmospheric gases.

Wind directions, observatories

Research by the weather department had stated that in 1636, Halley, a British scientist, published his treatise on the Indian summer monsoon, which he attributed to a seasonal reversal of winds due to differential heating of the Asian land mass and Indian Ocean.

Incidentally, some of the oldest meteorological observatories of the world are located in India. The East India Company established several such stations, such as the one in Kolkata in 1785 and Chennai in 1796, for studying India's weather and climate. The Asiatic Society of Bengal, founded in 1784 at Kolkata and in 1804 at Mumbai, promoted scientific studies in meteorology in India.

Beginning of IMD

A disastrous tropical cyclone struck Kolkata in 1864 and this was followed by monsoon failures in 1866 and 1871. In 1875, the government established the India Meteorological Department (IMD), bringing all meteorological work in the country under a central authority. The headquarters of the IMD were later shifted to Shimla from Kolkata then to Pune, and finally to New Delhi.

From a modest beginning in 1875, the met department has expanded its infrastructure for meteorological observations, communications, forecasting and weather services and has achieved parallel scientific growth.

Computers, satellites

One of the first few electronic computers introduced in the country in 1980s by then prime minister Rajiv Gandhi was provided to the IMD for scientific applications in meteorology. India was the first developing country in the world to have its own geostationary satellite, INSAT, for continuous weather monitoring of this part of the globe and particularly for cyclone warning.

"The IMD has always used contemporary technology. In the telegraph age, it made extensive use of weather telegrams for collecting observational data and sending warnings. Later, the IMD became the first organisation in India to have a message switching computer for supporting its global data exchange," says Shailesh Nayak, secretary, ministry of earth sciences.

Supercomputers

The IMD, at present, has a High Power Computing System (HPCS) with a capacity of around 120 Tera Flops located at several institutes across the country. And following the government's recent move to hike computing capability further, things can only improve.

The national Monsoon Mission, launched last year with a budgetary support of ₹400 crore for five years to support research work related to the mission, will help implement a dynamic prediction system for the prediction of monsoon in all time scales, short range to seasonal, at appropriate spatial scales with improved prediction skill.

OPPOSING WINDS

When Skymet, a private weather services company, came out with its own monsoon forecast even before the IMD this year, it brought a whiff of competition for the met department, as well as a possible opening for privatisation of weather forecasting

Geeta Nair

WHEN SKYMET, a private weather services company, pre-empted the India Meteorological Department (IMD) this year in coming out with a monsoon forecast even before the IMD, it set a precedent. No other organisation, private or government, has ever competed with the IMD in monsoon forecasting. By doing this, Skymet Weather Services has come as a dose of competition for the IMD as well as a possible opening for the privatisation of weather forecasting in India. "(Forecasting by private organisations) is a bit like selling medicines without clinical trials," says DS Pai, head of Long Range Forecasting, IMD, adding, "Our predictions are as good as anywhere in the world. This cannot be done without government support and private companies will not spend that much money without getting returns." He adds that the IMD's predictions have been correct and are based on access to a lot of data globally as well as in-house expertise, which no private agency could have. Private weather agencies can work in smaller countries but for a vast country like India, the infrastructure needed is bigger, he feels. "A lot of resources go into forecasting so there is a need for a dedicated telecom network for met observatories, global sharing of data and collaborative research, huge computing powers and expertise. The IMD has a 100-year-old history of doing this work," he says.

ARUL HORIZON

Forecasting by private organisations is a bit like selling medicines without clinical trials, says DS Pai, head of Long Range Forecasting, India Meteorological Department (IMD)

Skymet this year made public its monsoon 2013 forecast and predicted normal rainfall days before the official IMD forecast was made on April 26. Interestingly, a day before the IMD's forecast, Maharashtra agriculture minister Radhakrishna Vikhe-Patil said the IMD's monsoon forecast isn't reliable. The Maharashtra state government is establishing a network of 2,061 weather stations to provide information to various departments and the minister said once these stations are operational, they would use Skymet for analysis and providing advisory services to farmers. He has appointed Skymet as a consulting partner and wants to use its services for forecast as well as other data services.

Skymet, founded by Jatin Singh, is just 10 years old and offers weather-based business solutions for media, power, shipping and telecom sectors. It also provides risk management services to power, renewable energy, aviation, construction, food and beverage industries in India. Skymet started by providing weather infographics to newspapers and now provides seasonal, as well as short-range forecasts. The venture is backed by Omnivore Partners, an early-stage agricultural technology-focused VC. It is also a Villgro incubatee. Villgro is a social enterprise incubator that focuses on incubating innovative products and services that use market-based models to positively impact rural India. However, it is early days for Skymet.

Pai believes seasonal predictions have their limitations but the IMD is doing its best using globally accepted models to make skilfull forecasts. As of now, forecasting is done using a low-cost statistical model which is useful but has its limitation as it cannot make forecasts for smaller regions. For this, a dynamic model is needed and the government and its agencies have been working to develop this model for close to a decade. The research is going on at the Indian Institute of Tropical Meteorology (IITM). "We will compare the model for a few years more and then start using it," says Pai. This is part of the Monsoon Mission launched by the Earth System Sciences Organisation (ESSO) to improve forecasting in the short-range to the long-range time scales. The ESSO and IITM are coordinating with climate research in India, the US, UK, Japan, Korea and the World Meteorological Organization (WMO). The Space Applications Centre, Ahmedabad; Indian Institute of Science, Bangalore; Centre for Mathematical Modeling and Computer Simulation, Bangalore; Centre for Development of Advanced Computing, Pune, and the IITs are also involved in the research.

This scale of work, research and resources that the government is doing is not impossible to replicate for a private company and Skymet has provided an option. But whether it can last and make consistent predictions remains to be seen.

INTERVIEW: AJIT TYAGI

FORMER DIRECTOR GENERAL, IMD

'IMD's performance has been satisfactory'

WEATHER PREDICTION has been a tricky affair for most weather forecasting agencies across the globe. **Ajit Tyagi**, *former director general (2006-12), India Meteorological Department (IMD), spoke to* **Sandip Das** *on various aspects of the complex weather forecasting system. Excerpts:*

How has the IMD's monsoon forecast evolved over the past decade or so?

Research and development have been an integral part of long-range forecasting work at the IMD. Research work is done to 1) understand monsoon variability; 2) identify useful predictors; 3) develop more accurate statistical models and 4) assess the skills of various atmospheric and coupled models. These studies have identified new tele-connection patterns and mechanisms of monsoon variability, and new predictors for long-range forecasting. Many new statistical techniques like Ensemble Multiple Regression, Artificial Neural Network, Canonical Correlation Analysis, Discriminant Analysis and Pursuit Projection Regression have been used to develop statistical models. The IMD has started, in addition to the deterministic rainfall forecast based on the Multiple Regression Technique, probabilistic forecast based on the Ensemble Multiple Regression Technique. It also takes into consideration inputs provided by dynamical models.

How do you assess the IMD's performance in giving forecast (in terms of accuracy)?

While the IMD has not been able to predict drought (in fact, no forecasting centre in the world has been able to), its performance for other years has been satisfactory within the model errors. The right interpretation of probabilistic forecast does provide some indication of likely drought.

What are the technologies used by the IMD in its forecast?

As of now, the operational IMD system is primarily based on statistical techniques. It runs experimental dynamical models and also takes into consideration the forecast of dynamical models of leading centres of the world.

Will dynamic models help the IMD in improving its forecasting system?

The future lies with the dynamical model. The ministry of earth sciences, under the Monsoon Mission, is working to improve the coupled atmospheric and oceanic model for monsoon predictions. Once the forecast skills of the dynamical models become better than the statistical ones, the IMD is expected to use dynamical models for operational monsoon forecasts.

What are the key areas where monsoon forecast is used?

There are many areas where monsoon forecast is used more efficiently and effectively. One such example is the weekly crop weather watch meetings organised by the ministry of agriculture. These help in continuously evaluating and updating forecasts for operational application in agriculture. Coping with the drought of 2009 and the difficult months of June and July 2012 are some success stories of such interactions. Similar close coordination and cooperation will be useful with other ministries such as water, power and state governments.

Another area where our focus should be is to provide forecast for extended range (two-three weeks) at the state level. The IMD should start providing experimental forecasts and inputs on extended range to state governments.

MONSOON AND ITS IMPACT

ON AGRICULTURE

Only about 40% of the cultivable area in India has irrigation cover. So the southwestern monsoon plays a critical role in determining the performance of many kharif crops, which contribute more than half of the country's food production and include agricultural commodities that play a critical role in determining the food inflation graph. Due to deficient rainfall in many parts of the country last year, India's foodgrain output is expected to be around 250-255 million tonnes in 2012-13, down from previous year's record output of 259 million tonnes.

ON ECONOMY

According to a December 2010 report of the National Council of Applied Economic Research on the 'economic benefits of weather and marine services', an estimated 30 sectors, such as aviation, agriculture, tourism, fishery, forestry, insurance, port and harbour management, commerce and retail trade, depend directly on weather conditions.

PROGRESS PATH AND DURATION

The southwest summer monsoon enters the country because of a low-pressure area that's caused by the extreme heat of the Thar Desert and adjoining areas during summer. Usually, southwestern monsoon hits the Kerala coast around June 1, then takes about a week to cover south Indian states such as Kerala, Karnataka and Andhra Pradesh. The rains progress to paddy-growing areas of eastern India during the first fortnight of June, entering the oilseed-producing areas of central India in the third week of June. Cotton areas in the western region get rains by the first week of July. June-September is the period during which monsoon rains occur. More than 60% of the total annual rain received in India occurs during these four months.

LONG PERIOD AVERAGE (LPA)

The LPA is calculated on the basis of the average annual rainfall received during 1951-2000 at 89 cm. The IMD declares a 'normal' monsoon year if rainfall during a year is between 95% and 105% of the LPA. If rainfall during June-September falls below 85% of the LPA, the IMD declares it a deficient monsoon year.

THE LA NIÑA AND EL NIÑO PHENOMENA

El Niño means 'little boy' in Spanish and refers to an abnormal warming of the eastern Pacific ocean, which wreaks havoc on weather patterns across Asia-Pacific. A strong El Niño can lead to monsoon failure in Asia and droughts in Australia, as well as wetter-than-normal weather in parts of South America. The name La Niña also originates from Spanish, meaning 'the girl'. La Niña usually enhances the Asian monsoon, and it can be a factor in shaping the Indian monsoon. The presence of El Niño weakens the monsoon rains, while the latter strengthens it. The South Asian Climate Outlook Forum has noted that this year there is 'uncertainty' partly because of the spring time predictability limit and partly due to the likely absence of El Niño and La Niña conditions in the Pacific during the monsoon.