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Challenges and Opportunities in Agrometeorology

Springer

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FOREWORD

In the era of increased climate variability, the challenges and expectations from Agro-meteorological services have increased tremendously. It is well known that intense rainfall, floods, drought etc. have caused damage to the tune of approximately 100 billion dollars in Asia and Pacific regions. The extreme weather events are cause of concern owing to physical destruction potential to crop, at times leading to large scale devastation. The crops need certain threshold values of different meteorological parameters. Hence, large scale variations beyond their tolerance may hamper growth, development and reproduction processes. These ranges of congenial meteorological conditions are specific to crop, varieties and also phenological stages. There is a need to understand crop-weather relationship and accordingly develop crop management strategy. The farming community is interested to get timely information on weather conditions and management advisories to minimize the losses caused by extreme weather conditions. While generating such advisories, the alternate management options should be spelt out unambiguously to enable user to choose the viable and cost effective practice.

There are increasing demands for timely and effective agrometeorological information for non-farm applications. The growing interest in the possible impact of natural and human induced climate variability and climate change on agriculture and forestry have opened up new dimensions and have created new demands for information. The need of the hour is to effectively integrate the skills we have developed in operational, experimental and theoretical aspects of agricultural meteorology and deploy them for agricultural production system to make it more weather and climate resilient.

Risk proofing through weather based crop insurance is aiming to minimize farmers vulnerability. Agrometeorologists should evaluate for the various regions, seasons and crops, the inter annual variability in crop outturns so as to assist in fixing up of premium in a more realistic and rational manner. Also the system must rise to the need for providing fault free reference meteorological observation to determine the payback based on unfavorable weather conditions. There is need for combined use of expertise in meteorological and agricultural sciences in assisting the farmers to cope with and/or counteract the direct and indirect effects of weather anomalies. The book focuses on the important issues dealing with improving, identifying, assessing and managing the agrometeorological risks for enhancing sustainable food production, particularly in marginal and rain-fed areas. I strongly feel that some of the methods discussed in the book will render assistance to operational agrometeorologists to generate more meaningful advisories in an objective form. I hope that the papers presented will serve as a significant source of information to the scientific community, farming community and other stakeholders involved in providing agrometeorological services to farmers.

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Preface

The global food security and sustainable agriculture are the key challenges before the scientific community in the present era of enhanced climate variability, rapidly rising population and dwindling resources. Agriculture is intimately tied to weather and climate influencing every aspect from long term planning to tactical decisions in day-to-day management operations. Agrometeorology has a vital role to play in increasing agricultural production in a sustainable manner using state-of-art technology and resources efficiently. It is the responsibility of the meteorologists to advise the farming community well in advance to take full advantage of benevolent weather and precautions against malevolent weather to minimize losses. Uncertainties of weather and climate pose a major threat to food security of the world in general and developing countries, in particular. Asia in recent years has made considerable progress in the field of agriculture. However, in order to keep pace with the increasing population, the growth in agricultural production should be sustainable. The problem, therefore, has to be addressed collectively by scientists, planners and the society as a whole.

In view of need for increasing agricultural productivity to meet the demand of rapidly growing population and coping with enhanced uncertainties and risks in agriculture, Agrometeorology is facing lot of challenges as well as opportunities for achieving the path of sustainability. Indian Meteorological Society in association with World Meteorological Organization, India Meteorological Department, Ministry of Earth Sciences, Department of Science and Technology and Department of Space, Government of India organized and International Conference (INTROMET 2009) on “Challenges and Opportunities in Agrometeorology” during 23–25 February 2009 in New Delhi, India. The conference was participated by about 300 experts from India and 20 from abroad (USA, Korea, Egypt, Ukraine, Italy, Philippines, South Africa, China and Switzerland) including International organization like WMO.

The INTROMET-2009 was organized with the specific objectives to focus on the above issues and draw attention of global agrometeorological community, administrators and policy makers to debate and devise improved methods and techniques for better prediction, preparedness and mitigation of the adverse weather impacts and aware of the possible impact, consequences and mitigation measures to sustain food security. The scientific programme was deliberated through following eight sub-themes in addition to opening and closing session wherein 45 oral presentations were made:

- Weather Forecasting
- Monsoon Variability and Crop Production
- Operational Agrometeorology
- Agromet. Information System
- Adaptation to Climate Change
- Risk Evaluation and Management
- Crop Weather Relationship
- Extreme Weather Events

Further, 63 short oral presentations were also made on above themes along with poster display. A special session was organized to share the wisdom of Veteran Scientists on “Role of IMS in addressing Challenges in Weather and Climate Service”.

All the participants in the conference took part actively in discussion on these papers and to develop several useful recommendations for all organizations involved in providing agrometeorological services to farmers to cope up with agrometeorological risk management, particularly the National Meteorological and Hydrological Services. The main recommendations emerged from the Conference are summarized as under:

- Set up a comprehensive meteorological observation system ranging surface including Agromet., upper air, radar, satellite etc. for weather forecast up to district/taluka level and possibly at village level.
- Development user oriented meteorological information system keeping in view region-specific requirements of varied users including farming community.
- Establishment of mechanism for greater collaboration/feedback between the providers of information and users and also between meteorologists and agriculture scientists.
- Develop action plan at district level for climate change, identity hot spots and promote inter-disciplinary collaboration to enable effective mitigation of impacts in all sectors of economy.
- Greater role in International arena through the establishment of Regional Climate Centre with association of WMO and other International Organization.
- Review of Agromet curriculum in Agricultural Universities with emphasis on Agromet services, Outreach and Human Resource Development.

Selected papers have been edited and compiled in form of this book. As Editors of this volume, we are highly thankful to all the authors for their efforts and cooperation in bringing out this publication. We are also grateful to the World Meteorological Organization and various Ministries/Departments of the Government of India like Ministry of Earth Sciences, Ministry of Science and Technology, India Meteorological Department, and Department of Space for providing financial support and encouragement. Our special thanks are to the Springer for this publication and Mr Subhash Khurana and Mr Dinesh Khanna for the assistance.

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Indian Meteorological Society

The Indian Meteorological Society (IMS) established in 1956 has more than 2,000 members at present. The society has been able to reach not only to meteorological community but also amongst a wide spectrum of scientists of allied fields from more than 50 national and international organizations. It carries out its activities from HQ office in Delhi as well as through its 17 Chapters located at different places in India viz. Ahmedabad, Pune, Mumbai, Kolkata, Chennai, Nagpur, Visakhapatnam, Bhopal, Bhubaneswar, Bangalore, Hyderabad, Cochin, Thiruvananthapuram, Guwahati, Noida, Varanasi and Other Places.

The IMS activities are related to encouragement and expansion of R&D in atmospheric, oceanic and allied sciences, sponsored research in meteorology, publication of its biennial Journal – Vayu Mandal (since 1970), IMS News, News letters, scientific books etc. It also organizes annual series of national conference named "TROPMET" since 1992 supplemented with international conference called "INTROMET" every 4 year. Awareness programmes about meteorology and allied sciences are regularly organized in the country. It is co-founder of International Forum of Meteorological Societies. It also felicitates the outstanding scientists by conferring on them the Fellowships and has constituted five national and one international awards in the field of meteorology and atmospheric sciences.

The details of the Society are available on http://www.indianmetsoc.com.

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Chapter 1
Modernization of Observation and Forecasting System in IMD in Support of Agromet Services

Ajit Tyagi

Abstract India Meteorological department has added many data and research networks during the 135 years for climate-dependent sectors, such as agriculture, forestry, and hydrology, rendering a modern scientific background to atmospheric science in India. The inclusion of the latest data from satellites and other modern observation platforms, such as Automated Weather Stations (AWS), and ground-based remote-sensing techniques in recent years has strengthened India's long-term strategy of building up a self-reliant climate data bank for specific requirements, and also to fulfill international commitments of data exchange for weather forecasting and allied research activities. It has augmented forecasting capabilities to meet the operational requirements of day to day seamless weather forecasts in various ranges.

1.1 Introduction

Agriculture in India is the means of livelihood of almost two thirds of the work force in the country and needs accurate weather forecasts to plan when to sow seeds, irrigate and fertilise their fields, and harvest their crops. Since most of the area used for agricultural activity is rain fed, agricultural output is influenced by overall seasonal rainfall as well as by intra-seasonal rainfall variations. The dependence of agriculture on weather information and forecasts is going to increase in future on two counts. First is due to increase in extreme weather events and climate variability caused by global warming and second is from increase in demand of food products from growing population having higher quality of life. In addition to

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general forecast being provided by IMD to agriculture sector at macro scale, there is increasing demand from horticulture, floriculture, and crop specific sectors for location specific forecasts on different time scales.

In view of growing operational requirements from various user agencies, there is a need for a seamless forecasting system covering short range to extended range and long range forecasts, particularly for the agricultural requirements. Such forecasting system is to be based on hierarchy of Numerical Weather Prediction (NWP) models. For a tropical country like India where high impact mesoscale convective events are very common weather phenomena, it is necessary to have good quality high density observations both in spatial and temporal scale to ingest into assimilation cycle of a very high resolution non-hydrostatic mesoscale model. A major problem related to skill of NWP models in the tropics is due to sparse data over many parts of the country and near absence of data from oceanic region.

1.2 Augmentation of Observational System

In view of the importance of data in the tropical numerical weather prediction, IMD has been in the process of implementing a massive modernization programme for upgrading and enhancing its observation system. In the first phase of modernisation 550 additional AWS out of which about 125 will have extra agricultural sensors like solar radiation, soil moisture and soil temperature and 1,350 Automatic Rain Gauge (ARG) stations will be installed in the current year. In addition to this, a network of 55 Doppler Weather Radar has been planned of which 12 are to be commissioned in the first phase. DWR with the help of algorithms can detect and diagnose weather phenomena, which can be hazardous for agriculture, such as hail, downbursts and squall. Normalized Difference Vegetation Index (NVDI) derived from the CCD payload of presently available INSAT-3A satellite is useful for agriculture for monitoring the vegetation on a broad scale. NOAA/MODIS/Metop polar orbiting satellite data receiving and processing system will be installed at New Delhi, Chennai and Guwahati. This will enable availability of real time products from these satellites for use in forecasting by conventional means and by assimilating in NWP models in turn improving the Agro meteorological forecasts also. A new satellite INSAT-3D is scheduled to be launched during third quarter of the year. INSAT-3D will usher a quantum improvement in satellite derived data from multi spectral high resolution imagers and vertical sounder. In addition to above, IMD is also planning to install wind profilers and radiometer to get upper wind and temperature data. Data from AWSs, ARGs, DWRs, INSAT-3D, NOAA/MODIS/ Metop and wind profilers will available in real time for assimilation in NWP models. A High Power Computing (HPC) system with 300 terabyte storage is being installed at NWP Centre at Mausam Bhawan. It will greatly enhance our capability to run global and regional models and produce indigenous forecast products in different time scales.

1.3 Forecasting System

Currently, IMD runs a number of regional NWP models in the operational mode. IMD also makes use of NWP global model forecast products of other operational centres, like NCMRWF T-254, ECMWF, JMA, NCEP and UKMO to meet the operational requirements of day to day weather forecasts.

Recently, IMD implemented a multimodel ensemble (MME) based district level 5 days quantitative forecast system as required for the Integrated Agro-advisory Service of India. The technique makes use of model outputs of state of the art global models from the five leading global NWP centres (Krishnamurti et al. 1999). The Pre-assigned grid point weights on the basis of anomaly correlation coefficients (CC) between the observed values and forecast values are determined for each constituent model at the resolution of $0.25^\circ \times 0.25^\circ$ and the multimodel ensemble forecasts (day 1 to day 5 forecasts) are generated at the same resolution on a real-time basis. The ensemble forecast fields are then used to prepare forecasts for each district taking the average value of all grid points falling in a particular district. An inter-comparison of spatial co-relation co-efficient (CC) between observed and forecasts rainfall on the basis of the MME technique and the member models is

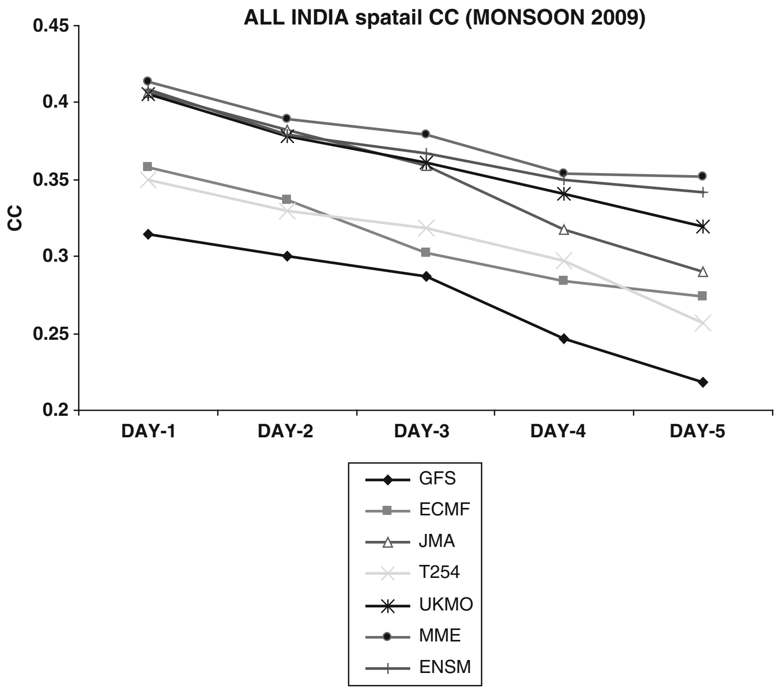

Fig. 1.1 An inter-comparison of country mean spatial CC of day 1 to day 5 forecasts of rainfall by NCEP, *ECMWF*, *JMA*, NCMRWF, *UKMO*, mean ensemble and *MME* for summer monsoon 2009

illustrated in Fig. 1.1. The results show that MME is superior to each member model at all the forecasts (day 1 to day 5).

In order to evaluate the performance of district level forecasts, skill score – Probability of Detection (POD) is considered. POD is defined as:

$$POD = \frac{H}{H + M}$$

Where H indicates hits and M for missing events for the following rainfall categories:

1. Rain or no rain
2. Light Rain: 0–10 mm
3. Moderate Rain: >10 mm and <65 mm
4. Heavy Rain: >65 mm

State-wise performance of district level rainfall forecasts for day 1 and day 5 forecasts for some selected states like Orissa, Rajasthan, Maharashtra, Gujarat and Kerala, which represent east central India – the domain of monsoon low; northwest India – region of less monsoon rainfall; west India; region of mid-troposphere circulation and extreme south east Peninsula are illustrated in Figs. 1.2 and 1.3. For the day 5 forecasts, results of Madhya Pradesh (central India) is also included

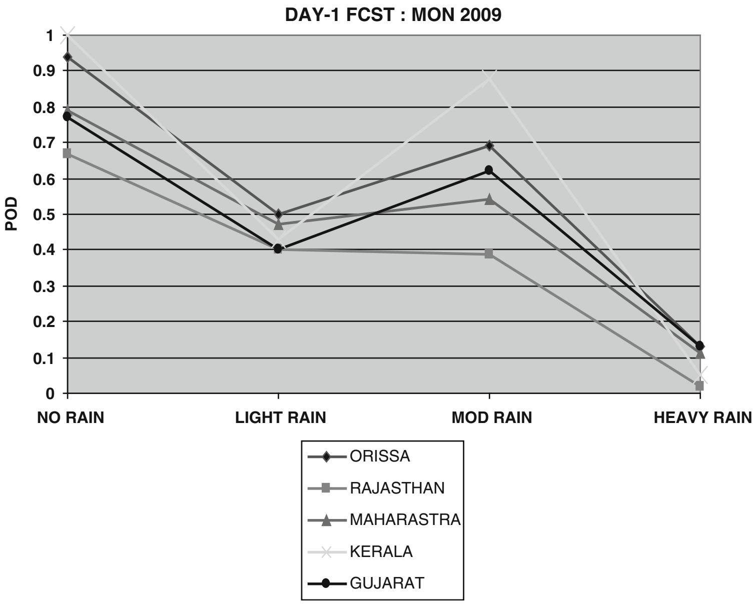

Fig. 1.2 State-wise performance of district level day 1 forecasts for some selective states

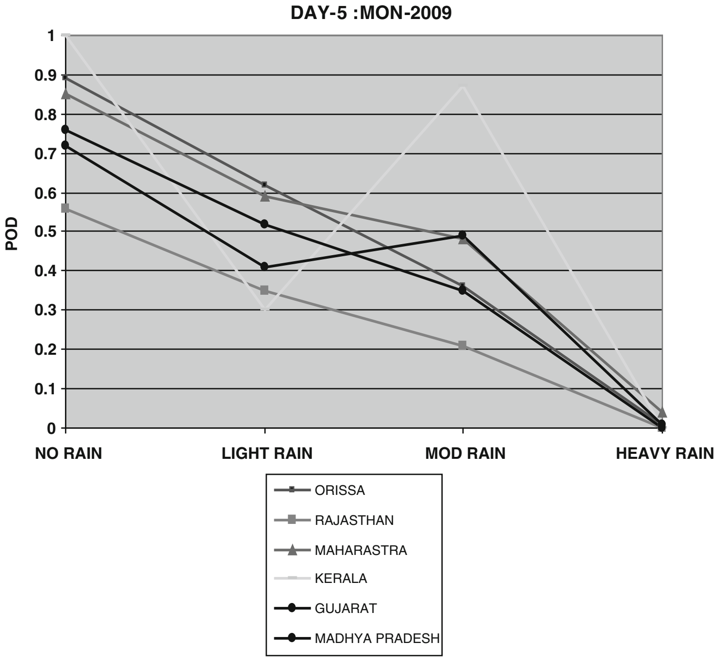

Fig. 1.3 State-wise performance of district level day 5 forecasts for some selective states

(Roy Bhowmik et al. 2009; Roy Bhowmik and Durai 2010). The results show that performance skill of forecast of the district level rainfall for the rainfall amount of moderate range is reasonably good for all these states, where POD is more than 0.4. District-wise performance of day 1 to day 5 rainfall forecasts for the districts of Orissa is shown in Fig. 1.4. For Orissa, POD for rain/no rain case has been above 0.8 at all the districts, for light rain it is around 0.6, for moderate rainfall it is between 0.3 and 0.4 and for heavy rainfall it is close to 0.

A dynamical statistical technique is developed and implemented for the real-time cyclone genesis and intensity prediction. Numbers of experiments are carried out for the processing of DWR observations to use in nowcasting and mesoscale applications. The procedure is expected to be available in operational mode soon. Impact of INSAT CMV in the NWP models has been reported in various studies. Various multi-institutional collaborative forecast demonstration projects such as, Dedicated Weather Channel, Weather Forecast for Commonwealth Games 2010, Land falling Cyclone, Fog Prediction etc. are initiated to strengthen the forecasting capabilities of IMD.

With the availability of new observations and infrastructure from the modernization programme of IMD, future Weather Forecasting System of IMD would be as briefly given below: