Agric. Physics, Vol. 1, No. 1, pp. 43-47 (2001)

Medium Range Weather Forecasting and Agricultural Production

L.S. RATHORE, AKHILESH GUPTA AND K.K. SINGH
National Centre for Medium Range Weather Forecasting.
Department of Science & Technology, Mausam Bhavan Complex, Lodi Road,
New Delhi 100 003

ABSTRACT

The National Centre for Medium Range Weather Forecasting (NCMRWF) was established and dedicated to the nation with a major objective of developing medium range weather prediction models for weather systems in the Indian region and for agrometerological advisory services for farming community in India. Location specific agrometerological forecast of rainfall, cloud amount, wind, maximum and minimum temperatures valid for next 72 hours are disseminated to 73 Agrometeorological Advisory Service (AAS) Units Located at State Agricultural Universities (SAUs) and other field stations of these SAUs on every Tuesday through fast communication system (viz., Telefax, VSAT, Telephone). In addition 29 AAS units are sent these forecast twice a week (i.e. on Friday also). This information is utilised by the ASS units in formulating Agro-advisory bulletin for the concerned agro-climatic zone. These bulletins contain prevailing and predicted weather for next 72 hour and crop specific advisory for the week. These are disseminated through mass media and to selected progressive farmers through personal contact or telephone. NCMRWF receives regular feed-back from AAS units on the realised weather and farmers' response to the service. A majority of the advisory bulletins are prepared in regional languages viz., Marathi, Hindi, Punjabi, Malayalam, Gujarati, Telugu and Bengali in addition to English. Detailed methodology of preparation of forecast and coordination with different agencies along with verification of model forecasts are discussed in this paper.

Introduction

India is predominantly an agro-based country where agricultural production contributes nearly 29% of the growth of GDP. Much of the agricultural production in the country depends on the rainfall during south-west monsoon period of June to September. The most characteristic feature of the monsoon season is the occurrence of widespread and sufficiently large amount of rains spread over a period of nearly 100 days over most parts of the country. Forecasting of the onset of monsoonal rain and its subsequent phases of active and weak spells on a temporal scale of 3-10 days is of utmost importance for crop management. Prediction of rainfall spells during winter season also assumes considerable importance for sowing and growth of rabi crops in the northern and central parts of the country. Synoptic scale weather systems such as cyclones and depressions normally form over the data void ocean areas. They are the most deadliest natural disasters in the Indian context. Besides taking enormous toll of human lives they possess high potential for damaging properties especially the crops over the coastal areas where they make landfall. Prediction of their tracks and intensity assumes great significance.

Recent advances in the numerical weather prediction models and reliability of their forecast products have led to their extensive use in the day-today preparation of operational weather forecast. With the advent of supercomputing facility at the National Centre for Medium Range Weather Forecasting (NCMRWF), New Delhi it became possible to run a global spectral model for operational weather prediction for the period 3 days and beyond.

Provision of weather-based Agro Advisories to farmers in India is complex because of variety of climatic zones. Farming communities in these areas have their special needs in view of the variety of cropping patterns. Area specific agrometeorological services are, therefore, needed to suit the requirements of each agro-climatic zone. The Agrometeoro-logical Advisory Service (AAS) is a concept in this direction to help agriculturists to carry-out farm operations in tune with the rhythm of prevailing and prognosticated weather.

The paper discusses the weather forecasting scheme currently operational at NCMRWF for issuing location specific weather forecast 3 days in advance to the 73 Agromet Advisory Service Units located at different parts of the country. Verification results for these forecasts along with the prediction of certain specific weather events crucial for particular phenophases of different crops have been discussed. The role of different weather conditions on the growth of crops and agricultural production has also been discussed. The paper focuses the

relevance and need for better understanding of weather related information and forecast by the crop managers and farmers for increasing crop production.

NCMRWF, its mandate and organisational set-up of AAS

The National Centre for Medium Range Weather Forecasting (NCMRWF), a multidisciplinary project has been implemented by the Department of Science & Technology (DST) in collaboration with Indian Council of Agricultural research (ICAR), India Meteorological Department (IMD) and the State Agricultural Universities (SAUs). The NCMRWF is providing location specific medium range weather forecast for next 3 days to AAS units. Based on this forecast, the AAS units prepare an advisory bulletin, suggesting suitable cultural practices for farm management in view of prognosticated weather. The AAS set-up exhibits a multi-institutional multi-disciplinary synergy to render operational service for the use of farming community.

In order to provide numerical weather prediction (NWP) based agro-advisory service (AAS) to farmers, it has been decided to open an Agro-meteorological Field Unit (AMFU) one each in 127 agroclimatic zones of the country by NCMRWF. These AMFUs are co-located with the NARP Centres of ICAR and the SAUs so that research output could be effectively utilised in formulating the agro-advisories. At present, NCMRWF has established AAS units in 73 agroclimatic zones.

NCMRWF model outputs and the final forecast preparation

Routine Products

A typical set of prognostic charts produced at the NCMRWF contains:

a. Analysis chart based on data of a particular day for specified time (viz., 00 or 12 UTC) and levels (viz., 850, 700, 500 hPa etc.).

b. Forecast charts for different hours of forecast (viz., 24, 48, 72, hr etc.,) and levels (850, 700, 500 hPa etc.).

c. Precipitation forecast charts valid for 0300 UTC of day-1, day-2, day-3 etc.

Direct Model Outputs (DMO)

For the purpose of preparing location specific weather forecast for Agrometeoro-logical Advisory Units, the DMO forecast is prepared using the predicted values of the required surface weather elements at the Gaussian grids directly from the T-80 model output.

The values of the meteorological elements (analysis/forecast) at a particular location are obtained from the nearest grid point or from surrounding 4 grid points (through Bessel's formula of interpolation). For certain stations where orographic influence is large, these values are obtained from either of these methods depending on how best the station is represented by these grid point forecasts. The model output for each of the time step (15 min.) is accumulated to obtain forecast values for 24 hr ending at 0830 hrs IST. The forecast for following variables is obtained:

a. Total precipitation (mm)
b. Mean Sea Level pressure (hPa)
c. Average wind speed (Kmph)
d. Predominant wind direction (deg.)
e. Maximum Temp. (deg. C)
f. Minimum Temperature (deg. C)
g. Maximum Relative Humidity (%)
h. Minimum Relative Humidity (%)

Statistical Interpretation (SI) forecast

Some of the local weather elements such as temperature and rainfall are highly dependent on the local topographic and environmental conditions. In the NWP models it is difficult to include required modifications corresponding to these conditions at each and every grid point considered in the model. The problem becomes more complicated in the case of Global models. As the surface weather conditions arise due to the interaction of local topographic conditions with the prevailing synoptic situation on a particular day, a statistical technique which develops concurrent relationship between these two will have in built accounting capability for these local conditions. These techniques are referred to as the Statistical Interpretation (SI) techniques.

Synoptic interpretation and final forecast preparation

The final forecast for different stations is prepared after a careful analysis of DMO, SI and prevailing synoptic situation over different parts of the country. While due weightage is given to the model outputs, the synoptesian may at times, modify these outputs based on his knowledge of synoptic climatology of weather circulation features.

The philosophy of synoptic weather forecast lies in the careful analysis of the meteorological

observations and understanding of state of atmosphere in the first step and prognosticating the possible state of atmosphere during the next one or more days over the region of interest. However, such a technique using synoptic charts is purely subjective and requires the forecasters to undergo rigorous training spread over a long period to acquire sufficient amount of experience and understanding of day-to-day weather phenomena and their behaviour.

In the recent times, NWP model outputs have become important aid to the day-to-day weather forecast all over the world. The purpose of NWP prediction is not to dispense of with the traditional synoptic forecasting but to make its fullest use as a guide to operational synoptic forecast. Even to use the NWP products for operational purpose, a great deal of synoptic experience is required.

Preparation and dissemination of Agromet Advisory Bulletins

The agromet advisory bulletins contain location specific and crop specific farm level advisories prepared in local language and incorporate the available knowledge on crop - weather relationships. Weather based agro advisories take into account the prevailing weather, soil and crop condition, and based on the weather prediction suggest measures/practices to minimise the losses and also, optimise input in the form of irrigation, fertiliser or pesticides. Real time weather and climatic information are essential ingredients for development of agro-advisories. From NCMRWF, the weather forecast bulletin for the subsequent 3 days is disseminated biweekly to AAS Units. The nodal officer, basically an Agricultural Meteorologist, in co-operation with an inter disciplinary group of agricultural and extension specialists formulate agro-advisories. These AAS bulletins are disseminated to the progressive farmers of the area selected by SAUs' and other farmers through Mass Media. The bulletins include;

(i) Weather summary of the preceding week,
(ii) weather forecast in the medium range,
(iii) crop data including state and stage of crops, information on pest and disease, and
(iv) specific advisories/recommendations on agricultural operations

Feedback mechanism and economic impact assessment of agro-advisories

Periodic feedback on worthiness of forecast and usefulness of advisories is also obtained by NCMRWF. Feedback from selected farmers and Research and Development under different SAUs' are being documented on whether they have adjusted their day to day farming operations in response to the advice laid in AAS and also on their additional requirements.

Agricultural universities also conduct certain extension programmes and educate farmers about agro-advisory techniques through mass media such as TV, Radio, Press and also through Kisan Mela, in which Nodal Officers of AAS units participate and make farmers aware with its usage in their farming operations. Annual review meetings are conducted for the evaluation of the use of AAS and weather information. All nodal officers from the AMFUs, and scientists from NCMRWF, IMD, ICAR participate in this meeting for the assessmet of the performance of AAS units. Also further possible ways for improvement in the existing system are discussed. A need is felt to continuously monitor, evaluate and refine the projections made in the project in terms of benefit from economic view points. In order to achieve this goal, an impact assessment criteria has to be developed in such a manner that one can very easily evaluate that how far a farmer can be benefitted to save available natural resources, cost and time by utilising agro-advisories in making tactical decisions during his management practices. Therefore, worthiness of AAS can be judged by implementing this impact criteria. An attempt has been made to make some qualitative assessment of the economic value of agro-advisories based on the forecast issued by the NCMRWF. Annexure-I gives some of the specific cases of economic gain attained by the farmers from these advisories. It may, however, be mentioned that these figures might have been arrived at using some subjective judgement and should not be taken in absolute terms. Much more comprehensive and objective techniques are required to be developed for such assessments.

Operational use of model products

The model outputs of NCMRWF are available throughout the year covering all the four seasons viz., Winter (January-February), Pre-monsoon (March-May), Monsoon (June-September) and Post-monsoon (October-December). The performance of the model varies from year to year and season to season and also within the same season system to system depending upon how best the system and the environment have been

captured in the analysis and forecast fields of the model. Moreover, there could be some weather systems which behave in a quite unusual manner in terms of their tracks or precipitation characteristics. In such cases, the forecast errors are expected to be large compared to those for other well behaved systems.

Prediction of synoptic scale weather systems

Since large scale rainfall occurs during monsoon and winter seasons over different parts of the country, model performance is evaluated more critically for these seasons. The centre is providing 3-day prediction of onset and progress of southwest monsoon over different parts of the country to IMD on an operational basis (real time). The southwest monsoon is characterised by the formation and movement of low pressure systems across the country giving rise to much needed widespread rainfall for the paddy and other crops. These systems although not of very high intensity have enormous potential to fetch large amounts of rainfall. The prediction of their genesis and subsequent movement assume considerable importance in the planning of farm operation and water management. Most of the monsoon systems travel upto the central parts of the country and thus the northwest India remains deficient of rainfall. Tropical-extratropical interactions during monsoon season play very important role in filling up this gap. However, the rainfall due this interaction is often so heavy and intense that it becomes hazardous to life and property.

Verification of location specific weather forecast

NCMRWF is responsible for providing location specific forecast to different AAS units for preparation of agroadvisories. These products are disseminated to these units twice-a-week. The ratio scores of forecasts for some selected stations during five winter and six monsoon seasons indicate that these scores vary from 70-99% during winter; the figures for monsoon vary from 55-80%. This shows that winter rain is much better predicted as compared to monsoon rain. Pre-monsoon and post-monsoon seasons are characterized by the formation and movement of cyclonic disturbances over the sea area.

Concluding remarks

Providing agromet advisory bulletins based on location specific medium range forecast is a new experiment which has been well received and appreciated by the farmers of the country. Feed-back collected by the NCMRWF from different units shows great enthusiasm among the farmers because of quantitative and deterministic nature of the forecast disseminated to them. However, such forecasts are still required to achieve desired level of accuracy in terms of quantity of weather elements. Farmers of different regions are constantly demanding for longer than 3 days prediction (more precisely weekly forecast) currently provided by the centre. The centre is endeavouring to increase its tempora! limits of forecast to five days and expand its existing network to 127 units in near future so as to cover all the 127 agro-climate zones in the country. This is a formidable proposition. Plans are also afoot to connect these units with a more reliable and hi-tech communication link for more effective operations. As a direct consequence of agro-advisory service the impact on agricultural production is proposed to be evaluated through more effective and objective methodology.

Examples of Economic Benefits incurred by the farmers from NCMRWFs forecast based Agroadvisories on specific weather events crucial for farming operation (based on the feedback provided by the ASS units)

A. Coimbatore

(I) NCMRWF's forecast on 4.7.95 for next 3 days

* Partly cloudy weather with no rainfall expected.
* Increase in wind speed.
* No change in temperature.

Agroadvisory

* Due to increase in wind speed support may be given for crops like banana.
* Crops may be irrigated depending upon the soil moisture condition because dry weather is forecasted.
* Leaf tip drying in onion might be due to high wind speed.
* If sucking pest is noticed, the crops may be sprayed with Metasystox @ 2 ml/lit.

Economic gain

* Prediction realised
* Farmers saved banana crops. The loss was reduced to the tune of Rs. 10,000/- per acre
* In onion, one spraying was reduced because the leaf tip drying was mainly due to high wind

speed and not due to sucking pest. Saving on spray in onion saved Rs 500/- per acre.

(II) NCMRWF's forecast on 29. 8.95 for next 3 days

* Sky overcast upto 31.8.95.
* 5 mm rain on 29th and 30th.
* SW wind of 10 kmph
* No change in temperature.

Agroadvisory

* Light rains are expected. Prepare the dry lands and seeds for pre-monsoon sowing.
* Since cloudiness is expected protect the grapes crop by spraying 4 ml of Karathane in 10 lit of water for powdery mildew and spray Ridomil for downey mildew.

Economic gain

* Prediction realised.
* Pre-monsoon sowing proved to be very useful. Increased income by Rs. 1200/- per acre compared to monsoon sown crop.
* Protective spray given to grapes reduced three sprays in controlling the powdery mildew diseases and saved Rs 1300/- per acre.

(B) Kovilpatti (Tamil Nadu)

(I) NCMRWF's Forecast on 19.09.95

* Rains likely within a week.

Agroadvisory

* Farmers are advised to take up early sowing of Sorghum, Cotton and Pulses

Economic gain

* Good rainfall activity realised.
* Early sown crop of Sorghum escaped attack of Midge and Earhead buck.
* 40 to 50% increase in yield/hectare with the result additional income of Rs 6750/ha.
* Early sowing of Cotton and Pulses also escaped attack of Jassid and Boll worm.
* 40 to 50% higher yield for Cotton and Pulses resulting in additional income of Rs 4000/ha.
* Saving of Rs 1500 to 2000/ha towards the cost of plant protection due to early sowing of crops.

(II) NCMRWF's forecast on 03.10.96

* Onset of NE monsoon rains to commence within a week.

Agroadvisory

* Farmers are advised to take dry seeding in anticipation of rains.

Economic gain

* NE monsoon rains commenced on 10th October and continued for more than 10 days.
* Timely sowing of crops has increased the yield by 50%.

(C) Ludhiana.

(i) NCMRWF's forecast on 20.8.96 for next 3 days

* Rains likely next 3 days.

Agroadvisory

* Farmers are advised to drain out excess water from cotton, maize, arhar, moong, mash, groundnut and soyabean crops.
* Undertake earthing up and propping up of sugarcane crops to prevent from lodging.

Economic gain

* Good rainfall activity upto 6 cm on 21st August, 1996.
* Considerable savings by the farmers. Estimate not known.

(II) NCMRWF's forecast 06.12.96

* Minimum temperature to fall considerably during next 3 days.

Agroadvisory

* Farmers are advised to give frequent but light irrrigation to minimise frost damage to sensitive crops.
* Burn semiarid rice straw at 3-4 places located in north west spot of field in evening to generate smoke to prevent frost damage.

Economic gain

* Minimum temperature had fallen by 6-8 deg. below normal. Frost realised.
* 6 thousand hectares of area under potato crop was affected by frost.
* Savings upto 30% of the total production could be estimated.