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Improvements required in the weather forecast, its verification and its role in plant protection for further conveyance to the farmers

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Abstract

India Meteorological Department (IMD) provides medium range weather forecast for 3-10 days in advance. Verification of forecast has been a very important process in order to detect the changing weather conditions and adaptation of crop to the present weather conditions. There is a need for improvement in the weather forecast provided by IMD and the value addition at the regional level needs to be improved so that the verification process provides with more accurate information thus more accurate services to the farmers by the scientists or the advisory proposed at different SAUs. However, till now the services provided are working in an effective way and a large number of farmers have taken up the benefit of these services but still further improvement is possible. The advisory provides with the farming operations apt for the particular district and weather conditions. The conveyance of the plant protection measures that are to be taken up is done through agromet advisory bulletins (AAB) that are being used by various registered farmers on mkisan portal and those using Kisan Suvidha app launched by Ministry of Agriculture and Farmers Welfare.

Keywords: forecast verification, agromet advisory services, agromet advisory bulletins

Introduction

A recent assessment by the American Meteorological Society (1998) ^[1] attributed considerable skill to short-range forecasts, with skill decreasing in the medium range from good at 3 days to marginal at 7, with, in some cases, measurable skill persisting out to 10 days. Verification is the process of comparing forecasts to relevant observations and is one aspect of measuring the forecast's goodness. Verification measures the quality of forecasts. For many purposes, a more appropriate term is evaluation. Medium range forecast is given by IMD for rainfall, temperature, relative humidity, wind speed, wind direction and cloud cover and it is done using the models Global Numerical Weather Prediction Model (GNWPM) and Regional Climate Model (RCM). This is given for 3-10 days in advance thus providing the details what the weather would be in the coming days. Accuracy for nowcasting, short range, medium range and long range forecast is 90-98, 80-90, 70-75 and 60 percent respectively as estimated by IMD. Tamil Nadu Agricultural University (TNAU) also issues medium range forecast and seasonal climate forecast for rainfall, temperature, RH, wind speed, wind direction, cloud cover and seasonal rainfall using Regional Climate Model and Rainman software obtained from Australia (Statistical Model) respectively. Accuracy by TNAU for medium range and seasonal forecast is 70-75 and 60 percent respectively.

There are numerous reasons for verifying forecasts (Jolliffe and Stephenson, 2003) ^[2] that includes the preparation that should be looked up before any mishap. Now-casting and short range weather forecast is provided to civil aviation, VVIP functions and public including farmer and it is done over radio, television and daily newspaper, they are mostly not useful for Agromet advisory services, have a resolution of State level. Medium range forecast is provided to the farmers using SMS service, University and IMD websites, daily newspaper and television for district level and it is highly useful since a lead time of 3 to 5 days is provided to take farm decisions. Medium range weather forecast is provided through website to the farmers and it is highly useful at block level comprising of 50-60 villages in Tamil Nadu. Seasonal Climate is provided to the farmers using television, daily newspaper, radio, State Department Agriculture (SDA) and website of TNAU. This is highly reliable and useful at the district level.

Material and Methods

The medium range weather forecast for the tarai region of Uttarakhand (Udham Singh Nagar) is provided IMD, New Delhi.

This data is provided district wise and for various regions to the Regional Meteorological Centre (RMC) which value adds to the data according to the regional weather conditions and thus provide it on its website or on IMD website www.imdagrimet.gov.in. This regional data is verified against the daily data observed at the IMD approved agrometeorological observatory located at Norman E. Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. Various scores were used for verification and the verified medium range data was further used for preparation of agromet advisory bulletins which helps the farmer to prepare and take action as per required for that moment and time.

The following procedure was used for calculation of score in order to verify the available weather data:

The weather data as per IMD error structure classification is assigned correct, usable and unusable. Similarly for rainfall verification score the days are marked and their number is calculated as per no rainfall predicted as well as observed (YY), rainfall not predicted and observed (NN), rainfall predicted but not observed (NY) and rainfall observed but not predicted (YN). Various new skill scores including Heidke skill score (HKS), probability of detection (POD), probability of false detection (POFD), false alarm ratio (FAR), success ratio (SR), critical success index (CSI), bias score (BS), correlation coefficient, root mean square error (RMSE) and chi square test (for maximum and minimum temperature).

Further step after verification include the preparation of AABs in accordance with agromet advisory services that are prepared by different SAUs and consists of scientist that are expert in various agricultural fields. The following procedure is followed:

Part I: Weather information

It Includes

- A. Weather summary of the preceding week which includes salient features like dry spells, heavy rain, depressions and cyclones, squalls, desiccating winds, temperature extremes, etc.
- B. Medium Range Weather Forecasts for next five days in terms of descriptive terminology easy to comprehend by the farmers. A table depicting the weather forecasts is given by IMD.

Part II: Crop information

It Includes

Crop data that consists description of state and stage of the crops, information intensity and area affected by various pests and diseases, and information on crop stress is provided.

Part III: Advisory

It includes

Advisory on major crops that include cereal crops, pulses, oil crops, vegetables, orchards and livestock is provided in accordance with the regional conditions. Suitable advisories for various phenophases that include seed bed preparation, sowing/planting, stand establishment, vegetative stage, flowering-reproduction stage, maturation and harvest are incorporated. These are addressed to specific agricultural practices e.g. irrigation, fertilizer application, warning on environmental vulnerability of plants and animals with suggestions to mitigate the effect of adverse weather, intercultural operations, control measures of pests and diseases with timings for application of insecticides or pesticides. Advice on post-harvest processes is also included.

Suggestions on problems related to livestock management, dairy cattle, poultry, etc. can also be mentioned on the bulletins.

Part IV: Some other incorporation in AAABs for their better usage by farmers

A. Sowing

Recommendations on the sowing of crop type, its variety, sowing dates based on prevailing conditions in the respective area such as soil-type, weather, available natural resources can be included for further farmer assistance. Seed treatments can also be specified. In case of unusual conditions like delayed monsoon, dry sowing and cropping pattern are also suggested.

B. Pesticide/insecticide application

Emphasis on undesirable application of pesticides and fertilizers is also done in the AAS bulletins. It can be used for prevention of pesticide application by advising the farmers on spraying the required dose if the weather conditions are not congenial for pest infestation. Future wind direction and rainfall conditions are considered while application of insecticides. In case of heavy rain the insecticide spray must be done after the spell is over.

C. Livestock

Guidelines regarding food, shelter, hygiene and health of the animals can be given.

Dissemination of agromet advisory bulletins

This is a very important step as it is the only way of maximum utilization of service provided through agromet advisory bulletin

- Short Message Service or Interactive Voice Responses is a very popular method to reach out to the farmers registered on mKisan Portal.
- Uploading the Agromet Advisory Bulletin on Govind Ballabh Pant University of Agriculture and Technology and IMD for better reach out.
- Multi linkages among the Agri Experts, Knowledge Institutions, Service Providers, etc.
- An Interactive Information Dissemination System (IIDS) and Information and Communication Technologies (ICT) based agricultural information dissemination models.
- Agrimet Domain being linked to websites of other ministries which are Rural, Panchayati Raj, etc.

Results and Discussion

Verification

During the post monsoon season, the predicted rainfall was correct up to 100% while it was lowest during the monsoon season (68%). The unusable predictions were highest during the monsoon season i.e. 32% while it was negligible during post monsoon and summer season (2%). The scores for the entire monsoon season clearly depicts the good rains, missed events, false alarms and no rains as the rainfall amount is maximum during this season. This is due to the maximum rainfall that occurred in the monsoon months from June-September in which the south-west monsoon dominates along with variation in quantity between predicted and observed values is very high while the other seasons having few forecasts of rainfall. Though, the rainfall prediction should be more accurate during the monsoon season when compared to other seasons since kharif season is most important for crops from farmer point of view. Results obtained by Vashisth *et al.*

(2009) [3] have the similarity with our results. The HSS, POD, FAR, POFD, SR, CSI and BS are the new scores that can individually define the skill of the forecast. POD and FAR if worked out together give reliable forecast verification. The various skill scores are diagrammatically presented in graphical form in fig. 1. Major part of the forecast defines the correct forecast for cloud cover for the following season. Vashisth *et al.* (2009) [3] presented results as similar to our findings for statistical parameters.

The correct percentage is highest for the post monsoon season while for the other season it is nearly same for all, thus depicting the forecasts are found to be very good if usable forecasts are also taken into account. The overall results revealed that correct and usable forecast values for cloud cover ranges between 70 to 85% while unusable between 15 and 30% across the season and percentage of correct and usable forecast is highest (85%) during winter season followed by post monsoon (80%), monsoon (71%) and summer (69%) respectively. Predicted values are higher than the observed one for the monsoon, winter and summer season. The forecast is good for the whole year with the best forecast for the post monsoon season.

The forecasted wind speed in all the seasons were treated as failed since unusability of forecasted value is very high. Only summer season depicted a slight correct forecast. The correct and unusable values are more or less same in all the seasons except winter where unusable is twice of the correct values. Almost similar results were obtained for the parameter by Khichar *et al.* (2010) [4]. The data clearly explains the high unusability approximately equaled by correct along with an extremely low usable values. Thus, the error structure explains the poor forecast of wind direction. Post monsoon and winter season show the predicted values to be higher than the observed. The overall forecast for the year resembles to be poor for the wind direction. The correlation coefficient and RMSE values represent a weak and highly erroneous relationship. Lunagaria *et al.* (2009) [5] obtained almost same results for wind speed and direction. The overall forecast for maximum temperature is good with good correlation coefficient for the year with the best for the post monsoon season. This represents a good forecast for the minimum temperature over the year. The observed values were always higher for all the seasons as depicted. The maximum and minimum temperature gives almost similar results for the entire year. The forecast is found to be very good for the entire year with the best for the monsoon season. Almost similar results were obtained by Gill and Babuta (2013) [6]. The chi square values clearly depict their significance by their higher total value for the winter season where large variation is seen in the predicted and observed values for both maximum and minimum temperature. This is followed by summer season which shows a little significant difference followed by the monsoon and post monsoon with the latter having lowest significant overall chi square. Highest overall chi square during the winter season for the minimum temperature clearly depicts the large variation in the observed and predicted data values. The results have been depicted in table 1 and 2.

Agromet advisory bulletins

Future Prospects

Media communication is a good promoter of AAS for those farmers who have attained adaption of recent technological advancements in farm management. This implies less profit to less advanced categories by development communication.

The absorption of information by these people can only increase, if bought to take off stage on the socio-economic front. For this the Nodal Officers in association with extension agencies have to concentrate their attention on these sections of society.

Credibility, practicability and timeliness of AAS are important criteria so that one can act upon them. The messages should be clearly worded, adequately descriptive and trustworthy. The loss suffered by faithful media acceptors is to be genuinely compensated for induction of innovativeness and experimentation. Imaginative thinking is required for devising suitable setup for implementation of this in practice. This will gradually augment the credibility of the media among the general public. AAS is required to save the time loss at different steps as well as forecast should be done at least at block level since at micro level it will be more correct and easily communicable.

The correlation between mass media exposure and development is highest for the agriculturists. This is the indication for the mass media being suitable agencies for bringing about agricultural development and rural transformation. The rural people are more exposed to radio as the communication media. This reveals that there is no relation between education and exposure to this medium, thus this medium is used to spread information among rural people who are less educated. The quality and coverage of broadcast meant for the rural people is to be improved. The broadcasts need to include local and simple language devoid of sophisticated and technical terms. Rural forums need to be formed for conducting discussions regarding development broadcast, it may help to alleviate the difficulties created by lack of personal contacts between the communicator and the receiver.

Nowadays, department of information technology is planning to develop ICT facilities for the rural and remote people. Some activities have already been started as to provide AAS link to Village Knowledge Centers at Taluka level and Short Message Service (SMS) is also being provided to the farmers. IMD is still exploring to tie with the different public and private organizations to use Interactive Voice Responses (IVRs). At village level a man or a woman can be assigned as a monsoon manager or climate manager who can be trained in science and art of weather forecast thus disseminating AAS at village level to promote community development program.

For good AAS to the farmers, a strong weather observation is required along with strong/correct forecast at the block level, thus to support block level advisory, AAS expansion is needed to district agromet units (DAMUs). Automation of agromet advisories will provide for easy and fast dissemination of important information to the required users. IMD has decided to provide 530 DAMUs for easy and fast dissemination of information to the farmers in future.

Through forecast verification and economic impact studies can be done in order to derive maximum benefits through proper marketing. Till record 10,500 farmers in U.S. Nagar and Nainital region have registered on mKisan portal to avail the SMS facility and this clearly defines the profit of farmers. Farmers have shown a positive response towards the agricultural practices and plant protection measures provided in the bulletins which are frequently followed by the farmers through mKisan portal and Kisan Suvidha app of Ministry of Agriculture. Based on the weather forecast provided by IMD as well as agrometeorological observatory saves the farmer from application and then wastage of their farming inputs due to rain and other weather parameters.

Integration of medium range forecast with the extended forecast will help in planning different agricultural practices for good yield. AAS service based dissemination system help in forewarning the farmers, thus covering the crop losses. Medium range forecast can also be used in Nitrogen fertilizer

management and the scientific forecasts need a blend with the traditional methods for ready adoption and benefits for the farmers. The success of the above project is ensured if the AAB is demand and user driven.

Table 1: The error structure for the various weather parameters during the four seasons (2016-17)

Parameters		Ppn.	CC	WS	WD	Max.T.	Min.T.
Monsoon (%)	C	45	48	14	48	55	52
	U	23	23	34	12	15	22
	UN	32	29	52	40	30	26
Post monsoon (%)	C	93	72	7	43	57	44
	U	7	8	31	11	28	30
	UN	0	20	62	46	15	26
Winter (%)	C	96	48	7	28	32	40
	U	2	37	22	12	27	23
	UN	2	15	71	60	41	37
Summer (%)	C	95	46	22	42	38	34
	U	3	23	37	9	20	17
	UN	2	31	41	49	42	49

Table 2: Statistical parameters depicting variation in predicted and observed weather data for the four seasons (2016-17)

Parameters		Monsoon	Post Monsoon	Winter	Summer
Ppn.	Corr. Coeff.	0.254	0	0.517	-0.05
	RMSE(mm)	21.019	2.667	3.37	4.279
CC	Corr. Coeff.	0.31	0.49	0.21	0.28
	RMSE(Octa)	2.35	1.97	3.24	2.43
WS	Corr. Coeff.	0.14	-0.02	0.04	0.33
	RMSE(km/h)	4.4	4.67	5.29	3.34
WD	Corr. Coeff.	0.34	0.23	0.07	0.47
	RMSE(degree)	94.49	132.72	124.54	97.79
Max. T.	Corr. Coeff.	0.393	0.843	0.546	0.86
	RMSE(OC)	2.114	1.356	2.748	2.436
	Chi square	16.77	4.43	31.5	16.97
Min. T.	Corr. Coeff.	0.185	0.943	0.565	0.89
	RMSE(OC)	1.715	1.91	2.165	2.93
	Chi square	19.69	19.38	128.6	59.08

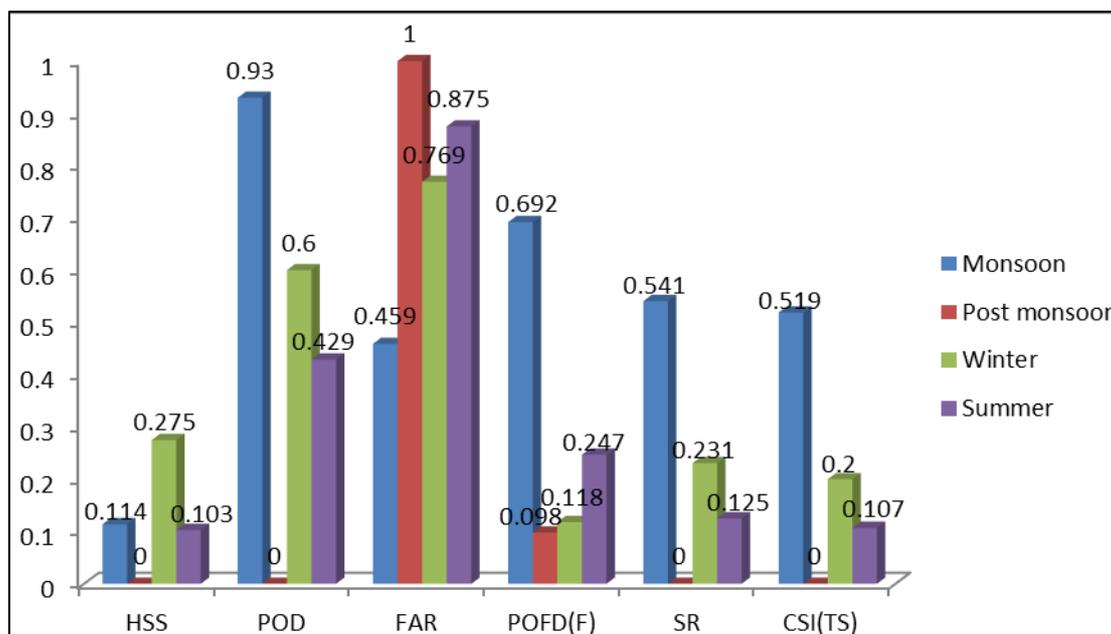


Fig 1: Graphical representation of the skill scores used for verification

Conclusion

The rainfall forecast was good for the winter and post monsoon season on viewing the entire skill scores for the year. The correct percent depicts a good forecast but with high RMSE. The cloud forecast for the entire year is good

with an extremely good forecast for the post monsoon season. The forecast is good with high correct percent, moderately high correlation and low RMSE. The wind speed and wind direction forecast for the year was very poor with high unusability, low correlation and high RMSE. Over the year

the forecast for maximum and minimum temperature is good with high usability, high correlation and low RMSE.

Agromet Advisory Service provides service to the farmers through Agromet Advisory Bulletin prepared on the basis of medium range weather forecast received from IMD which consists of the entire recommended farming practices and crops that are to be followed in accordance with the forecast in future. AAS provides various dissemination facilities which consist of SMS, IVRs, A IR and bulletins. Further improvement is required for providence of good forecast along with agromet recommendations within the time frame that should be with high speed and time bound. The AABs are prepared with the help of panel of experts who deal in different fields of agriculture and veterinary science and they provide the suggestions about the various farming practices along with plant protection measures based on medium range weather forecast that would be suitable for the following period. Now it is high time that it should also include biometeorological advices regarding human health especially about different seasonal disease incidence due to high/low temperature, high humidity and rainfall if continued for longer period.

The Agromet Advisory Service is working in an efficient way to provide maximum services to the farmers but the forecast system does not work efficiently considering the communication facility and timely no availability of forecast to Agromet Field Units due to which the farmers do not get aware of circumstances/advisory in time. Thus, the main improvement needed in the forecast of weather is clearly depicted in the above study where the rainfall in monsoon season, max temperature in summer, min temperature in winter, wind speed and wind direction forecast during the year are poor though being the main factor affecting the farmer and their farming practices. The forecast of these parameters are required to be improved drastically in future so that timely measures could be initiated to save the crops by farmers.

Finally, the study concludes the importance of the forecast for the farmers and their farming activities. Thus, improvement is necessary in the forecast and their systems so that it can work efficiently and provide the best agromet advisory services based on medium range weather forecast to the farmers of Udham Singh Nagar.

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