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Verification of medium range weather forecast for the *Kandi* region of Punjab

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सार - भारत मौसम विज्ञान विभाग (आईएमडी), चंडीगढ़ से प्राप्त हुए मौसम पूर्वानुमान और क्षेत्रीय अनुसंधान स्टेशन, बल्लोवाल सौंखड़ी के कृषि मौसम विज्ञान वेधशाला में दर्ज वास्तविक मौसम आंकड़ों की तुलना 2017-18 के मौसम पूर्वानुमान की वैधता और सटीकता की जांच करने के लिए की गई। मौसम प्राचलों के लिए प्रयोज्य विश्लेषण कौशल स्कोर और विभिन्न मौसमों में त्रुटि संरचना के लिए महत्वपूर्ण मूल्यों का उपयोग करके किया गया। मानसून और सर्दियों के मौसमों के दौरान पूर्वानुमानित और प्रेक्षित किए गए मानों के बीच व्युत्पन्न अनुपात स्कोर मानसून सत्रों की तुलना में अपेक्षाकृत अधिक पाया गया, जो पूर्वानुमान मॉडल के प्रदर्शन को मानसून के बाद और सर्दियों के मौसम में गर्मियों और मानसून के मौसम से बेहतर होने का संकेत देते हैं। मानसून ऋतु के दौरान अधिकतम तापमान और न्यूनतम तापमान की अपेक्षाकृत अधिक उपयोगिता देखी गई, जो किसानों के लिए रबी फसल की बुआई के पूर्व कार्यों के लिए महत्वपूर्ण हैं। हवा की गति का पूर्वानुमान फसल को विशेष रूप से रबी फसल को बचाने में महत्वपूर्ण भूमिका निभाता है और यह देखा गया कि इस मौसम (2017-18) में हवा की गति पूर्वानुमान 74 प्रतिशत तक सही था। मौसम प्राचलों का सटीक पूर्वानुमान अग्रिम में दिए जाने से किसानों को सही समय पर खेतों को तैयार करने और फसल प्रबंधन के लिए उपयोगी पाया गया है।

ABSTRACT. The weather forecasts received from India Meteorological Department (IMD), Chandigarh and actual weather data recorded at Agrometeorological observatory of Regional research Station, Ballowal Saunkhri were compared to check the validity and accuracy of weather forecast during 2017-18. The usability analysis for the weather parameters was done using skill scores and critical values for the error structure for the different seasons. The ratio scores derived between the forecasted and observed values during post-monsoon and winter seasons were observed to be relatively higher as compared to those for the monsoon seasons, indicating the performance of forecast models to be better in post-monsoon and winter seasons than in the summer and monsoon seasons. The relatively higher usability of maximum temperature and minimum temperature was observed during post-monsoon season, which are important to the farmers for the pre-sowing operations of the *rabi* crop. Forecasting of wind speed plays an important role in saving the crop from lodging especially in the *rabi* crop season and it was observed that in this season (2017-18) the wind speed prediction was 74 per cent correct. The accuracy of forecast of weather parameters in advance is found to be useful for farmers for doing appropriate field operations and crop management practices.

Key words – Medium range weather forecast, Ratio score, Skill score, RMSE (Root mean square error), Correlation.

1. Introduction

Weather forecast plays an important role in agriculture as agriculture production is highly dependent on variability in weather conditions. An accurate weather forecast not only helps in increasing agriculture production and quality of produce but helps in efficient use of limited resources. Forecast of onset of monsoon is therefore important for sowing and different crop management practices during *kharif* season and the prediction of winter season rainfall is important for the *rabi* crops in the northern and central parts of the country. The accurate forecasting of different weather parameters continues to be a major challenge for scientific community. Different types of forecasts can be made for few hours to one day (now casting), 1-3 days (short range), 3-10 days (medium) and month/season (long range) periods. The medium range weather forecasts are used for preparing agromet advisory bulletins which are very useful for scheduling of sowing, irrigation, agricultural operations and management of pest and diseases of field crops (Vashisht *et al*., 2008). Therefore, the capacity to provide timely, skillful weather forecasts offers the great potential to reduce vulnerability to the unpredictable weather conditions (Hansen, 2002). Khichar and Bishnoi (2003) have also assessed the accuracy of weather forecast for western agro-climatic zone of Haryana during *kharif* season. Different methods are available to test the accuracy of medium range weather forecast. Although the rainfall in *kandi* region is more as compared to the other areas of Punjab, the farmers in the *kandi* region of Punjab are highly dependent on the rainfall due to rainfed conditions. Therefore, the accuracy of weather forecast becomes more important. Keeping this in mind, the medium range forecast for the year 2017-18 has been tested using these methods to assess its accuracy for the *kandi* region of Punjab.

2. Materials and method

The value-added weather forecast received from India meteorological department, Chandigarh and actual weather data recorded at Agrometeorological observatory of Regional Research Station, Ballowal Saunkhri were compared to check the validity and accuracy of weather forecast during the year 2017-18. For the verification of the forecast, the year was divided into four groups on seasonal basis *viz*., Pre-monsoon, (April-May), monsoon (June-September), Post-monsoon (October-December) and winter (January-March). The usability analysis for the six weather parameters *viz*., cloud cover, rainfall, wind speed, wind direction, maximum temperature and minimum temperature were carried out using critical values for the error structure for the different seasons except relative humidity (Table 1). The correlation and RMSE analysis have also been done to establish relationship between eight observed and forecasted weather parameters (cloud cover, rainfall, wind speed, wind direction, maximum temperature, minimum temperature, morning and evening relative humidity) for the different seasons of the year.

The H K score (Kothiyal, 2017) and ratio score (Kothiyal, 2017) were calculated to test the weather forecast for rainfall during 2017-18. These scores are explained as below:

2.1. *Hanssen and Kuipers (True skill score)*

The H K Score is the ratio of economic saving over climatology due to the forecast to that of a set of perfect forecasts.

$$\text{H.K. Score} = \frac{\text{YYNN} - \text{YNNY}}{(\text{YY} + \text{YN})(\text{NY} + \text{NN})}$$

YY = No of days when rain was forecasted and also observed,

YN = No of days when rain was forecasted but not observed,

NY = No of days when rain was not forecasted but observed,

NN = No of days when rain was not forecasted and also not observed.

The value of H K score ranges between -1 to 1, 0 indicates no skill and 1 indicate perfect score. It explain how well did the forecast separate the yes event from the no event.

2.2. *Ratio score*

Ratio score is the ratio of correct forecast to total number of forecast for rainfall events. It was worked out on Yes/No basis for pre-monsoon, monsoon, post-monsoon and winter season. Ratio score was calculated as follows:

Ratio score = (hits + correct negative)/N

It range between 0 to 1, 0 indicates no skill and 1 indicate perfect score (Kothyal, 2017).

$$\text{Ratio Score} = \frac{\text{YY} + \text{NN}}{\text{N}} \times 100$$

2.3. *Root mean square error (RMSE)*

The root mean square error (RMSE) of weather parameters was worked out to find out absolute error between predicted and observed weather data of the station. The root mean square error (RMSE) is computed using the expression (Kothiyal 2017):

$$\text{RMSE} = \sqrt{\left\{\frac{1}{n}\sum(F_i - O_i)\right\}}$$

where, F_i = Forecasted values, O_i = Observed values and n = Number of observations.

3. Results and discussion

3.1. *Usability analysis and correctness of the forecasted weather parameters*

The usability analysis of the different forecasted weather parameters in relation to observed ones using critical values for error structure was carried out. The season-wise analysis is given as:

3.1.1. *Rainfall*

Out of 61, 115, 92 and 90 days observation period for Pre-monsoon 2017, *Monsoon* 2017, Post-monsoon

TABLE 1

Critical values for error structure for different weather parameters

Usability	Rainfall (mm)		Tmax and Tmin (°C)	Cloud cover (okta)	Wind speed (kmph)	Wind direction (degree)
	(≤10 mm)	(>10 mm)				
Correct	Diff ≤ 0.2 mm	Diff ≤ 2% of obs	Diff ≤ 1°C	Diff ≤ 1 okta	Diff ≤ 3 kmph	Diff ≤ 10°
Usable	0.2 mm < Diff ≤ 2.0 mm	2% of obs < Diff ≤ 20% of obs	1 °C < Diff ≤ 2°C	1 okta < Diff ≤ 2 okta	3 kmph < Diff ≤ 6 kmph	10° < Diff ≤ 30°
Unusable	Diff > 2.0 mm	Diff > 20% of obs	Diff > 2°C	Diff > 2 okta	Diff > 6 kmph	Diff > 30°

Diff = Absolute difference between observed and forecasted weather parameter; Obs = Observed

TABLE 2

Usability analysis of the rainfall forecast

Season	Total	Correct	Usable	Unusable	Success	%age
April-May 2017	61	58 (96)	0 (0)	3 (4)	58	95
June-September 2017	115	58 (50)	4 (3)	54 (47)	62	54
October-December 2017	92	92(100	0 (0)	0 (0)	92	100
January-March 2018	90	89 (99)	0 (0)	1 (1)	89	99
Total (2017-18)	358	297(83	4 (1)	58 (16)	301	84

*Figures in parentheses indicate percentage

TABLE 3

Skill score - Rainfall forecast

Season	NN	YY	NY	YN	Ratio Score	H. K. Score
April-May, 2017	45	2	6	8	77.05	0.08
June-September, 2017	31	31	51	6	53.91	0.22
October-December, 2017	83	0	8	1	90.22	-0.09
January-March, 2018	77	1	5	7	86.67	0.06
Total	236	34	70	2	76.96	0.07

2017 and Winter 2018, the accuracy of rainfall forecast was 95%, 54%, 100% and 99%, respectively (Table 2). The rainfall prediction was found to be highly erratic during *monsoon* season. The rainfall during the *monsoon* season of 2017 was 887 mm which was almost 6.8 per cent higher than the normal. Dry spells during *monsoon* affect *kharif* season crops particularly in rainfed areas. Therefore, the rainfall prediction should be more accurate during the monsoon season as compared to other seasons because *kharif* season is most important for crops from farmer point of view particularly in rainfed agriculture. The percent unusable forecast was more during the *monsoon* season, thus it needs to be improved. During the *post monsoon 2017* there was 34.4 mm rainfall whereas forecast during that period was 41.0 mm. The rainfall recorded during pre-monsoon 2017 and winter 2018 was 74.0 mm and 66.8 mm, whereas forecasted rainfall during this period was 62.0 mm and 15.0 mm, respectively. The comparative forecast for the entire year 2017-18 was 83% correct, 1% usable and 16% unusable (Table 2). Ray (2016) observed similar pattern of the usability of annual rainfall.

3.1.1.1. *Skill scores for rainfall*

For verification of rainfall forecast 2 × 2 contingency table between daily forecasted and observed rainfall events was made and based upon this table, different scores for evaluating the skill rainfall forecast were worked out and presented in Table 3. The ratio scores

TABLE 4

Usability analysis of cloud cover forecast

Season	Total	Correct	Usable	Unusable	Success	%age
April-May, 2017	61	31 (51)	16 (26)	14 (23)	47	77
June-September, 2017	115	40 (35)	27 (23)	48 (42)	67	58
October-December, 2017	92	77 (84)	5 (5)	10 (11)	82	89
January-March, 2018	90	53 (59)	17 (19)	20 (22)	70	78
Total (2017-18)	358	201(56)	65 (18)	92 (26)	266	74

*Figures in parentheses indicate percentage

TABLE 5

Usability analysis of the maximum temperature forecast

Season	Total	Correct	Usable	Unusable	Success	%age
April-May, 2017	61	22 (36)	17(28)	22 (36)	39	64
June-September, 2017	115	49 (43)	22(19)	44 (38)	71	62
October-December, 2017	92	47 (51)	26(28)	19 (21)	73	79
January-March, 2018	90	25 (28)	32(36)	33 (37)	57	63
Total (2017-18)	358	143 (40)	97(27)	118 (33)	240	67

*Figures in parentheses indicate percentage

during post-monsoon and winter seasons were relatively higher as compared to *monsoon* seasons indicating the performance of forecasting models to be better in post-monsoon and winter seasons under rainfed area. It was highest (90.2 %) for post-monsoon season and lowest (53.9%) for *monsoon* season, whereas it was 76.9 per cent for overall period. The ratio score for the rainfall forecast for pre-monsoon and winter was 77.05% and 86.67%, respectively (Table 3). Similar results were reported by Vashisht *et al.* (2008).

The H K scores for pre-monsoon, *monsoon*, post-monsoon and winter period were 0.08, 0.22, 0.09 and 0.06, respectively. It was 0.07 for whole year (Table 3). The highest value for the *monsoon* season indicates that a good forecast during *monsoon* is more economical as compared to the other seasons.

3.1.2. *Cloud cover*

From the usability analysis of cloud cover, it has been observed that the overall forecast (April 2017-March 2018) was 56% correct, 18% usable and 26% unusable. Among different seasons, the highest accuracy was during October-December 2017 (89%) followed by January-March 2018 (78%), April-May 2017 (77%) and June-September 2017 (58%) (Table 4). The prediction of cloud cover forecast was correct almost in all the seasons. Vashisht *et al.* (2008) also observed similar results in cloud cover forecast.

3.1.3. *Maximum and minimum temperature*

Relatively higher usability of maximum and minimum temperature was observed during post-monsoon which was of some importance to the farmers as far as the pre-sowing operations of the *rabi* crop are concerned (Table 5). The analysis for the maximum temperature reveals that the highest accuracy of forecast was during post-monsoon 2017 (79%) followed by pre-monsoon 2017 and winter 2018 (64%). During *monsoon* 2017 accuracy was 62%.

The analysis for the minimum temperature reveals that the forecast was 35% correct, 23% usable and 42% unusable for the entire year. During *monsoon* 2017, it was 34% correct. The overall highest success rate of the forecast was 66% for winter 2018 followed by post-monsoon 2017 (64%). The highest unusable forecast was 56% for pre-monsoon, 2017 (Table 6). Vashisht *et al.* (2008) also reported similar results of the maximum and minimum temperature.

3.1.4. *Wind speed and wind direction*

Forecasting of wind speed has a vital role in saving the crop from lodging especially in the *Rabi* (winter) crop

TABLE 6

Usability analysis of the minimum temperature forecast

Season	Total	Correct	Usable	Unusable	Success	%age
April-May, 2017	61	18 (30)	09 (15)	34 (56)	27	44
June-September, 2017	115	39 (34)	23 (20)	53 (46)	62	54
October-December, 2017	92	34 (37)	25 (27)	33 (36)	59	64
January-March, 2018	90	33 (37)	26 (29)	31 (34)	59	66
Total (2017-18)	358	124 (35)	83 (23)	151 (42)	207	58

*Figures in parentheses indicate percentage

TABLE 7

Usability analysis of the wind speed forecast

Season	Total	Correct	Usable	Unusable	Success	%age
April-May, 2017	61	20 (33)	24 (39)	17 (28)	44	72.1
June-September, 2017	115	19 (17)	44 (38)	52 (45)	63	54.8
October-December, 2017	92	18 (20)	41 (45)	33 (36)	59	64.1
January-March, 2018	90	34 (38)	33 (37)	23 (26)	67	74.4
Total (2017-18)	358	91 (25)	142 (40)	125 (35)	233	65.1

*Figures in parenthesis indicate percentage

TABLE 8

Usability analysis of the wind direction forecast

Season	Total	Correct	Usable	Unusable	Success	%age
April-May, 2017	61	03 (05)	07 (11)	51 (84)	10	16.4
June-September, 2017	115	13 (11)	20 (17)	82 (71)	33	28.7
October-December, 2017	92	01 (01)	03 (03)	88 (96)	4	4.3
January-March, 2018	90	05 (06)	18 (20)	67 (74)	23	25.6
Total (2017-18)	358	22 (06)	48 (13)	288 (80)	70	19.6

*Figures in parenthesis indicate percentage

season and it was observed that the forecast of wind speed was maximum (33%) and minimum (17%) correct during April-May, 2017 and June-September, 2017, respectively. For the entire year the forecast was 25% correct (Table 7). About 40 per cent of wind speed prediction was found to be useful to the farmer during the year. Similarly, during summer when there is scarcity of irrigation water for growing vegetables and other crops, the wind speed also becomes very important as it sweeps the moisture away from the surface. The usable prediction of wind speed was 17 per cent during June-September, 2017. As far as wind direction is concerned, the predictions were found to be highly variable when comparison was made between the predicted wind direction and mean wind direction recorded in the morning and afternoon only. The table on the usability analysis of wind direction reveals that forecast was 6% correct for almost whole of the year being highest (11%) for June-September, 2017 and lowest (1%) for October-December, 2018 (Table 8).

3.2. *Root mean square error and correlation between observed and forecasted weather parameters*

Among seasons of the year, the RMSE was found in the range from 3.18-21.2 mm, 1.38-3.22 Okta, 1.95-2.91 °C, 2.07-3.54 °C, 4.69-6.74 kmph, 74.26-107.56 degree, 9.77-17.18% and 15.59-20.36% for rainfall, cloud cover, maximum & minimum temperature, wind speed, wind direction, morning relative humidity and evening relative humidity, respectively (Table 9). The

TABLE 9

Root mean square error and correlation analysis

Parameter	Months	RMSE	r
Rainfall	Pre-monsoon 2017	3.66	0.72
	Monsoon 2017	21.2	0.09
	Post-monsoon 2017	4.19	-0.02
	Winter 2018	3.18	-0.06
Cloud Cover	Annual 2017-18	1.91	0.64
	Pre-monsoon 2017	3.22	0.43
	Monsoon 2017	1.38	0.60
	Post-monsoon 2017	1.94	0.67
Max. Temp.	Winter 2018	2.57	0.71
	Annual 2017-18	2.81	0.54
	Pre-monsoon 2017	1.95	0.93
	Monsoon 2017	2.91	0.86
Min. Temp.	Post-monsoon 2017	3.54	0.75
	Winter 2018	2.63	0.33
	Annual 2017-18	2.07	0.96
	Pre-monsoon 2017	2.30	0.90
Morning RH	Monsoon 2017	18.17	0.20
	Post-monsoon 2017	11.89	0.60
	Winter 2018	9.77	0.11
	Annual 2017-18	10.82	0.39
Evening RH	Pre-monsoon 2017	17.73	-0.04
	Monsoon 2017	20.36	0.62
	Post-monsoon 2017	15.59	0.26
	Winter 2018	16.82	0.31
Wind Direction	Annual 2017-18	79.29	0.19
	Pre-monsoon 2017	74.26	0.18
	Monsoon 2017	107.56	0.09
	Post-monsoon 2017	91.44	-0.16
Wind Speed	Winter 2018	5.98	0.13
	Annual 2017-18	6.74	0.15
	Pre-monsoon 2017	5.75	0.14
	Monsoon 2017	4.69	0.20

RMSE value of 4.69 km/h and correlation 0.20 for wind speed of winter months depicts low error with less difference between the forecasted and observed values. Similar results of wind speed and wind direction with high RMSE and low correlation were observed by Kothiyal *et al.* (2017).

Correlation coefficients were derived between the forecasted and observed values during 2017-18 for different seasons (Table 9). It was observed that the forecast values were better for cloud cover and wind speed during winter, temperature during post-monsoon, relative humidity during *monsoon* and rainfall in pre-monsoon.

TABLE 10

Linear regression relationship between observed and predicted weather parameters

Parameter	Months	Linear regression relationship	Coefficient of determination (R^2)
Maximum Temperature	Pre-monsoon 2017	Y = 0.5846X + 16.539	0.50*
	Monsoon 2017	Y = 0.6544X + 11.17	0.29*
	Post-monsoon 2017	Y = 0.9316X + 2.1508	0.87*
	Winter 2018	Y = 0.7747X + 6.1565	0.74*
	Annual 2017-18	Y = 0.8984X + 3.3394	0.85*
Minimum Temperature	Pre-monsoon 2017	Y = 0.5846X + 16.539	0.57*
	Monsoon 2017	Y = 0.3631X + 16.334	0.11*
	Post-monsoon 2017	Y = 1.0281X + 1.1966	0.92*
	Winter 2018	Y = 0.7761X + 3.2811	0.81*
	Annual 2017-18	Y = 0.9474X + 2.2924	0.92*
Rainfall	Pre-monsoon 2017	Y = 0.4776X + 0.4378	0.52*
	Monsoon 2017	Y = 0.0534X + 7.8854	0.01
	Post-monsoon 2017	Y = 0.0134X - 0.1761	0.03*
	Winter 2018	Y = 0.0061X - 0.1124	0.05*
	Annual 2017-18	Y = -0.0178X + 6.438	0.07*
Cloud Cover	Pre-monsoon 2017	Y = 0.5252X + 1.332	0.40*
	Monsoon 2017	Y = 0.3877X + 3.2237	0.18*
	Post-monsoon 2017	Y = 0.6552X + 0.4376	0.36*
	Winter 2018	Y = 0.4628X + 1.0894	0.22*
	Annual 2017-18	Y = 0.6181X + 1.4033	0.35*
Morning RH	Pre-monsoon 2017	Y = 0.1579X + 35.194	0.04*
	Monsoon 2017	Y = 0.7687X + 13.654	0.36*
	Post-monsoon 2017	Y = 0.1542X + 68.767	0.01
	Winter 2018	Y = 0.4215X + 42.942	0.15*
	Annual 2017-18	Y = 0.9546X- 3.2666	0.61*
Evening RH	Pre-monsoon 2017	Y = -0.0212X + 22.896	0.0016
	Monsoon 2017	Y = 0.6197X + 10.21	0.38*
	Post-monsoon 2017	Y = 0.2878X + 40.95	0.09*
	Winter 2018	Y = 0.3381X + 30.505	0.16*
	Annual 2017-18	Y = 0.6223X + 12.215	0.42*
Wind Direction	Pre-monsoon 2017	Y = 0.1857X + 75.652	0.03*
	Monsoon 2017	Y = 0.103X + 109.73	0.03*
	Post-monsoon 2017	Y = 0.1172X + 185.41	0.007
	Winter 2018	Y = -0.275X + 180.21	0.02*
	Annual 2017-18	Y = -0.1156X + 156.58	0.02*
Wind Speed	Pre-monsoon 2017	Y = 0.1822X + 9.219	0.02*
	Monsoon 2017	Y = 0.3413X + 7.5574	0.02*
	Post-monsoon 2017	Y = 0.2317X + 6.7108	0.02*
	Winter 2018	Y = 0.2808X + 7.1616	0.04*
	Annual 2017-18	Y = 0.3815X + 7.093	0.08*

* Significant at 1% level of significance

There was a high value of root mean square values for *monsoon* rainfall as compared to others seasons (Table 9). Correlation coefficients were derived between the forecasted and observed values during (2018-19) for different seasons (Table 9) and it was observed that the correlation between forecasted and observed values were better for maximum and minimum temperature during all the seasons. The overall results obtained represent a good forecast for winter and poor forecast for *monsoon* season. There is need for improvement in *monsoon* season forecast. The skill scores worked efficiently for the post-monsoon season and the correct percentage for cloud cover is highest for the post-monsoon season.

3.3. *Regression analysis*

Regression analysis of weather forecast parameters for the year 2017-18 was done and linear regression equations were developed between observed and predicted values of different weather parameters and the values of coefficient of determination were worked out for regression analysis between observed and predicted weather parameters (Table 10). The regression analysis of weather forecast for the year 2017-18 shows that the co-efficient of determination (R^2) value between observed and predicted data were 0.85 and 0.92 each for T_{max} & T_{min}, 0.35 for cloud cover, 0.07 for rainfall, 0.61 for morning RH, 0.42 for evening RH, 0.08 for wind speed and 0.02 for wind direction, indicating that stable parameters *viz*., maximum & minimum temperature had the highest R^2 value whereas, lowest R^2 value were for rainfall, wind speed and wind direction. Since, the agricultural production is highly dependent upon weather conditions; weather prediction models need refinement to be modified to predict rainfall and wind speed correctly.

4. Conclusions

The ratio scores during post-monsoon and winter seasons were relatively higher as compared to summer and *monsoon* seasons indicating the performance of forecast models for the *kandi* region to be better in post-monsoon and winter seasons than in the other two seasons. Relatively higher usability of maximum temperature and minimum temperature was observed during post-monsoon which was of some importance to the farmers as far as the pre-sowing operations of the *rabi* crop are concerned. The medium range weather forecasts were used for preparing agromet advisory bulletins for the farmers of study area which were very useful for scheduling of sowing, irrigation, agricultural operations and management of pest and diseases of field crops. The farmers feel it to be useful since they receive advices on appropriate field operations and management practices depending on suitability of weather conditions. The forecast provided by IMD is good enough but precision is needed because as accuracy level for the most important parameter like rainfall, wind speed and direction is poor though they are very important for various farming operations to be taken up by the farmers. There is also need for more accurate prediction of temperature parameters also. So, there is need for further improvement in medium range weather forecasting for its better applicability in farmers' fields.

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References

Hansen, J. W., 2002, "Realizing the potential benefits of climate prediction to agriculture: issues, approaches & challenges", *Agricultural Systems,* **74**, 309-330

Khichar, M. L. and Bishnoi, O. P., 2003, "Accuracy of weather forecast for western agroclimatic zone of Haryana during *Kharif* season", *Haryana Agricultural University Journal Research*, **33**, 2, 97- 101.

Kothiyal, S., Singh, R. K., Nain, A. S., Padalia, Himani and Chaturvedi, Gaurav, 2017, "Verification of medium range weather forecast for Udam Singh Nagar region in order to improve Methodology followed", *International Journal Current Microbiology Applied Science*, **6**, 12, 1995-2005.

Ray, M., 2016, "Validation of medium range weather forecast for Keonjhar district of Odisha", *International Journal of Forestry and Crop Improvement*, **7**, 2, 161-166.

Vashisth, A., Das, D. K., Bhagawati, Goutom and Sharma, P. K., 2008, "Accuracy of weather forecast for semi-arid climate of Delhi for Agricultural Management Practice", *Journal Agricultural Physics*, **8**, 51-58.