

Original Research Article

Forecast Validation and Usability of Medium Range Weather Forecast of Akola District

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ABSTRACT

The medium Range weather forecasts were observed and compared for their usability and reliability for the year 2014-15 for Akola district on seasonal and day wise scale. The forecast verification comprised of the anticipated weather information on Cloud Cover, Rainfall, Temperature, Relative Humidity I & II, Wind direction & Wind Speed. During the validation of forecast, the daily weather data was recorded at Agromet observatory, Dr. PDKV, Akola along with Forecast data received for medium Range weather forecasts from IMD Agrimet Pune, on every Tuesday and Friday. The methodology use for Forecast validation is by calculating the error structure as methods suggested by Rana *et al.*, 2005, Investigation Results revealed that on an entire year basis forecast regarding Rainfall was 93.15 per cent correct, 3.84 per cent usable and 3.01 per cent was fail, For Cloud cover was 90.41 per cent correct and usable in 6.85 percent, for Minimum temperature, it was 41.92 percent correct, while 13.97 per cent as usable and usability of Maximum temperature forecasts was 69.59 per cent correct, and 15.34 per cent as usable, for Wind Speed the correctness was 28.77 per cent while 33.15 per cent usable, for Wind Direction correctness was only 63.56 per cent with 4.84 per cent as a usable. For Relative Humidity I (%) the correctness was 76.71 per cent and 7.67 per cent as usable, both together accounting to 87.68 per cent and under Relative Humidity II (%) the correctness was only 34.25 per cent and 10.41 per cent as a usable. During monsoon season period (June -Sep 2014) the correctness was 85.25 per cent for Rainfall and 87.70 percent for Cloud Cover. Whereas during summer season period (April - May 2014) correctness was 50.42 per cent correct for Minimum temperature whereas; it was 83.61 per cent correct for Maximum Temperature. After calculating the validation of forecast values with observed values it was concluded that On the basis of simple and success probability, Rainfall and cloud cover forecasts for the season of summer, monsoon, post monsoon and winter were highly successful and reliability is to the tune of 93.98 to 97.99 per cent. Whereas On the basis of entire year good prediction was recorded and Reliability for Maximum temperature and minimum temperature had success to the tune of 84.24 to 68.48 per cent. in wind speed, i.e. 62.18 per cent and for wind direction it was 68.19 per cent. Relative Humidity (I) and Relative Humidity (II) had success to the tune of 89.68 to 60.17 per cent. Regarding skill score of rainfall, Hansen & Kuipers score (HK) and Heidke Skill Score (HSS) was positive which indicated the reliability of forecast to be satisfactory in all the seasons except post monsoon season. The Ratio score (RS %) and Critical Success Index (CSI) indicated the reliability of forecast to be satisfactory in all the seasons, but was not so good in post monsoon season and RMSE recorded annually was 8.34.

Keywords

Cloud cover,
Rainfall,
Reliability,
Temperature,
Weather
forecast, wind

Introduction

Weather is an important factor in agriculture sector and favorable weather is essential for sustainable agriculture which minimizes the weather hazards. Weather forecast related to agriculture is helpful in reducing the cost of cultivation of crops and increases the crop yield. Reliable and timely weather forecast also provides significant and useful inputs for precise impact assessment for agricultural activities. Weather conditions during cropping periods play a major role in success or failure of agricultural crop production. The degree of vulnerability of crops to climate variability depends mainly on the developmental stage of the crops at the time of weather aberration (Lansigan *et al.*, 2000). The rainfed agro-ecosystem of the state comprising of varied topographical, altitudinal and agroclimatic elements however faces several challenges such as temporal and spatial weather variability to realize optimum productivity. Therefore, favorable weather is desired for sustainable agriculture which minimizes the weather hazards. However, weather cannot be modified except on limited scale but agricultural operations can be reoriented to nearly accurate weather forecasts. Under the changed scenario where agriculture has become highly input and cost intensive, today the weather forecasts relating agriculture are indispensable to reduce the cost of cultivation for crops. Reliable and timely weather forecasts provide significant and useful inputs for precise impact assessment for agricultural activities and proper planning and management in agriculture which is full of uncertainty. Agromet advisory services based on medium range weather forecasts have been identified as a micro level management strategy for mitigating the impact of climatic variations on agricultural production and income (Devi and Rao 2008). A timely

medium range and seasonal forecast could provide tremendous benefits for appropriate management of aberrant weather. Farmers could there by adjust their cropping patterns and plan agricultural operations in order to obtain maximum production even during adverse weather conditions. In the present study efforts have been made to verify the suitability of the medium range weather forecasts for hot moist semi-arid agro climate of Akola region of Maharashtra state in relation to its applicability in agricultural management.

Objectives

To receive the daily weather data recorded at Agromet observatory, Dr. PDKV, Akola.

To receive five days medium Range weather forecasts from IMD on every Tuesday and Friday.

To observed and compared the medium Range weather forecasts for their usability and reliability for the year 2014-15 for Akola district on seasonal and day wise scale.

Forecast Validation of anticipated weather information on Cloud Cover, Rainfall, Temperature, Relative Humidity I & II, Wind direction & Wind Speed with daily weather data recorded to received five days medium Range weather forecasts.

Materials and Methods

The Akola, selected region for study is located in district Akola of Maharashtra state, which is located in Eastern Maharashtra Plateau at 20⁰42' N Latitude, 77⁰02' E Longitude and elevation of 305 m msl (elevation at Agro met observatory). The region is classified as hot moist semi-arid climate with medium and deep clayey

black soils (shallow loamy to clayey black soils as inclusion), medium to high AWC and LGP of 120-150 days. Akola centre receives an average (1971-2000) annual rainfall of 811 mm in 43 rainy days. Medium Range Weather Forecasts (MRWF) on rainfall, cloud cover, wind speed, wind direction, maximum and minimum temperature received from IMD for 5 days of 2014-2015 for Akola region of Maharashtra were analyzed for forecast validation. The forecasts obtained for Medium range weather forecast were compared with daily observed weather data for the seasonal and annual basis from the actual data recorded recorded at agro meteorological Observatory at Dr, Panjabrao Deshmukh Krushi Vidhayapeeth, Akola.(Anonymous 2014).To assess the reliability, validation of forecast was carried out for different weather parameter like Cloud Cover, Rainfall, Temperature, Relative Humidity I, Relative Humidity II, Wind direction & Wind Speed by calculating the error structure.

The correct and usable cases were summed up and combined values indicated the percent usability of the forecasts. Root Mean Square Error (RMSE) was calculated for all the parameters. The rainfall forecast was validated with Ratio score indicating the success rate of correct forecast and Hanssen and Kuiper score indicating the skill (H K score). Critical Success Index (CSI) and Heidke Skill Score (HSS) were also calculated to get reliability of forecast. The validation of weather forecasts was done for four seasons, viz. pre monsoon (March to May), South West monsoon (June to September), post monsoon (October to December) and winter season (January to February) as defined by India Meteorological Department. The validation methods as suggested by Rana *et al.*, 2005. were used.

Error structure

Rainfall: Correct ± 10 mm. Usable ± 20 mm, Unusable $> \pm 20$ mm

Temperature: Correct 1°C , Usable $\pm 2^{\circ}\text{C}$, Unusable $> \pm 2^{\circ}\text{C}$

Wind Speed: Correct ± 3 kmph, Usable ± 6 kmph, Unusable $> \pm 6$ kmph

Skill Score: For the qualitative analysis of rainfall forecast, H.K. score and Ratio Score tests have been used which are based on 2 x 2 contingency Table.

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

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

Where,

- H = Predicted and Observed
- M = Observed but not Predicted
- F = Predicted but not Observed
- Z = Neither Predicted nor Observed
- N = Total Number of Observation
- f1 = Predicted values
- oi = Observed values

Skill Score

$$\text{Ratio Score (RS)} = \frac{\text{H}}{\text{H} + \text{M} + \text{F} + \text{Z}}$$

$$\text{Critical Success Index (CSI)} = \frac{\text{H}}{\text{H} + \text{M} + \text{F}}$$

$$\text{Heidke Skill Score (HSS)} = \frac{\text{ZH} - \text{FM}}{[(\text{Z} + \text{M})(\text{M} + \text{H}) + (\text{Z} + \text{F})(\text{F} + \text{H})]}$$

$$\text{Hanssen and Kuipers score 9 (HK)} = \frac{\text{HZ} - \text{Mf}}{[(\text{Z} + \text{F})(\text{H} + \text{M})]}$$

Root mean Square Error (RMSE) = $[1/N \sum (f_i - o_i)^2]^{1/2}$

Results and Discussion

Results revealed that the Ratio Score for the entire year, was to the tune of 82.47 per cent, While for the for the summer season (April – May 2014) was to the tune of 14.52 per cent and for kharif season (June – September 2014) it was observed to be 22.74 per cent.

Similarly, during post monsoon season (October– November 2014) and winter season (December 2014 – March 2015) it was observed to be 15.62 and 29.59 per cent, respectively.

Cloud cover (Okta)

Overall usability analysis for Cloud cover (Okta) was revealed in Table 1 (Fig. 1) that Cloud cover (Okta) forecast for entire year was highly successful i.e. 90.41 per cent correct, 6.85 per cent Usable and 2.74 per cent Failure during the entire year April 2014 – March 2015.

During the period April – May 2014 the percentage of correct forecast occurrence was 98.36 per cent, followed by October– November 2014 (88.52 per cent) and June – September 2014 (87.70 per cent). While that of Usable percentage was 10.66 per cent during period June – September 2014, failure percentage was highest during the period of December 2014 – March 2015 i.e. 75.21 per cent.

Rainfall (mm)

Overall usability analysis for rainfall was revealed in Table 1 (Fig. 1) that Rainfall (mm) forecast for entire year was highly successful (93.15 per cent) correct, 3.84 per

cent Usable and 3.01 per cent Failure during the entire year April 2014 – March 2015. During the period April – May 2014 the percentage of correct forecast occurrence was 100.00 per cent, followed by October– November 2014 (96.72 per cent). While failure percentage of 7.38 was observed during the period of June – September 2014.

Wind Speed (kmph)

Overall usability analysis for wind speed was revealed in Table 2 (Fig. 2) that Wind speed (kmph) forecast for entire year was only 28.77 per cent correct, 33.15 per cent Usable and 38.08 per cent Failure during the entire year April 2014 – March 2015.

During the period June – September 2014, the percentage of correct forecast occurrence was 54.92 per cent. While that of Usable percentage was 57.38 per cent during October– November 2014. Failure percentage was highest during the period of December 2014 – March 2015 (60.66 per cent).

Wind direction (degree)

Overall usability analysis for Wind direction (degree) was revealed in Table 2 (Fig. 2) that Wind direction (degree) forecast for entire year was 63.56 per cent correct, 3.84 per cent Usable and 32.60 per cent Failure during the entire year April 2014 – March 2015.

During the period June – September 2014, the percentage of correct forecast occurrence was i.e. 75.41 per cent, followed by the period December 2014 – March 2015 (66.94 per cent). While that of Usable percentage was 6.56 per cent during period October– November 2014, while Failure percentage was highest during the period of April – May 2014 (47.54 per cent).

Error structure

Predicted Parameter	Observed Parameter	
	Rain	No Rain
Rain	H (YY)	M (NY)
No Rain	F (YN)	Z (NN)

Table.1 Overall usability analysis Cloud Cover (Okta) & Rainfall (mm)

Sr. No.	Period	Forecast occurrence						Total
		Cloud cover (Okta)			Rainfall (mm)			
		Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	
1	April 2014 – March 2015	330 (90.41)	25 (6.85)	10 (2.74)	340 (93.15)	14 (3.84)	11 (3.01)	365
2	April – May 2014	60 (98.36)	1 (1.64)	0 (0.00)	61 (100.00)	0 (0.00)	0 (0.00)	61
3	June – September 2014	107 (87.70)	13 (10.66)	2 (1.64)	104 (85.25)	9 (7.38)	9 (7.38)	122
4	October– November 2014	54 (88.52)	4 (6.56)	3 (4.92)	59 (96.72)	1 (1.64)	1 (1.64)	61
5	December 2014 – March 2015	19 (15.70)	11 (9.09)	91 (75.21)	116 (95.87)	4 (3.31)	1 (0.83)	121

Table.2 Overall usability analysis of Wind Speed (kmph) & Wind direction (degree)

Sr. No.	Period	Forecast occurrence						Total
		Wind Speed			Wind direction			
		Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	
1	April 2014 – March 2015	105 (28.77)	121 (33.15)	139 (38.08)	232 (63.56)	14 (3.84)	119 (32.60)	365
2	April – May 2014	9 (14.75)	15 (24.59)	37 (60.66)	30 (49.18)	2 (3.28)	29 (47.54)	61
3	June – September 2014	67 (54.92)	31 (25.41)	24 (19.67)	92 (75.41)	5 (4.10)	25 (20.49)	122
4	October– November 2014	10 (16.39)	35 (57.38)	16 (26.23)	29 (47.54)	4 (6.56)	28 (45.90)	61
5	December 2014 – March 2015	19 (15.70)	40 (33.06)	62 (51.24)	81 (66.94)	3 (2.48)	37 (30.58)	121

Table.3 Overall usability analysis : Maximum Temperature (°C) & Minimum Temperature (°C)

Sr. No.	Period	Forecast occurrence						Total
		Maximum Temperature			Minimum Temperature			
		Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	
1	April 2014 – March 2015	254 (69.59)	56 (15.34)	55 (15.07)	153 (41.92)	51 (13.97)	161 (44.11)	365
2	April – May 2014	51 (83.61)	5 (8.20)	5 (8.20)	31 (50.82)	12 (19.67)	18 (29.51)	61
3	June – September 2014	82 (67.21)	17 (13.93)	23 (18.85)	82 (67.21)	20 (16.39)	20 (16.39)	122
4	October– November 2014	43 (70.49)	11 (18.03)	7 (11.48)	21 (34.43)	8 (13.11)	32 (52.46)	61
5	December 2014 – March 2015	78 (64.46)	23 (19.01)	20 (16.53)	19 (15.70)	11 (9.09)	91 (75.21)	121

Table.4 Overall usability analysis: Relative Humidity (I) Morning (%) & Relative Humidity (ii) Evening (%)

Sr. No.	Period	Forecast occurrence						Total
		Relative Humidity (I) Morning			Relative Humidity (ii) Evening			
		Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	Correct (Correct %)	Usable (Usable %)	Fail (Fail %)	
1	April 2014 – March 2015	280 (76.71)	28 (7.67)	57 (15.62)	125 (34.25)	38 (10.41)	202 (55.34)	365
2	April – May 2014	24 (39.34)	7 (11.48)	30 (49.18)	24 (32.88)	8 (10.96)	41 (56.16)	61
3	June – September 2014	52 (83.87)	7 (11.29)	3 (4.84)	54 (44.26)	16 (13.11)	52 (42.62)	122
4	October– November 2014	52 (83.87)	7 (11.29)	3 (4.84)	12 (19.67)	5 (8.20)	44 (72.13)	61
5	December 2014 – March 2015	115 (95.04)	1 (0.83)	5 (4.13)	47 (38.84)	9 (7.44)	65 (53.72)	121

Table.5 Skill Score: Abstract					
Period	Ratio Score (RS %)	Critical Success Index (CSI)	Hansen & Kuipers Score (HK)	Heidke Skill Score (HSS)	Root Mean Square Error (RMSE)
April 2014 – March 2015	82.47	0.37	0.43	0.43	8.34
April – May 2014	14.52	0.2	0.23	0.26	--
June – September 2014	22.74	0.42	0.33	0.33	--
October– November 2014	15.62	0.0	-0.03	0.0	--
December 2014 – March 2015	29.59	0.35	0.61	0.46	

Fig.1 Overall usability analysis for Cloud cover (Okta) & Rainfall (mm)

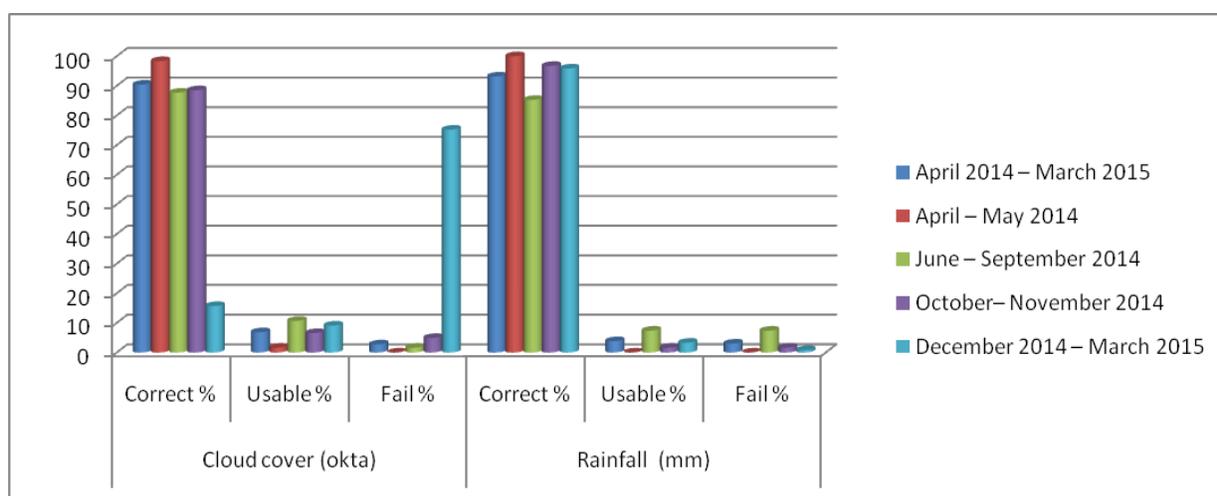


Fig.2 Overall usability analysis for Wind speed (kmph) & Wind direction (degree)

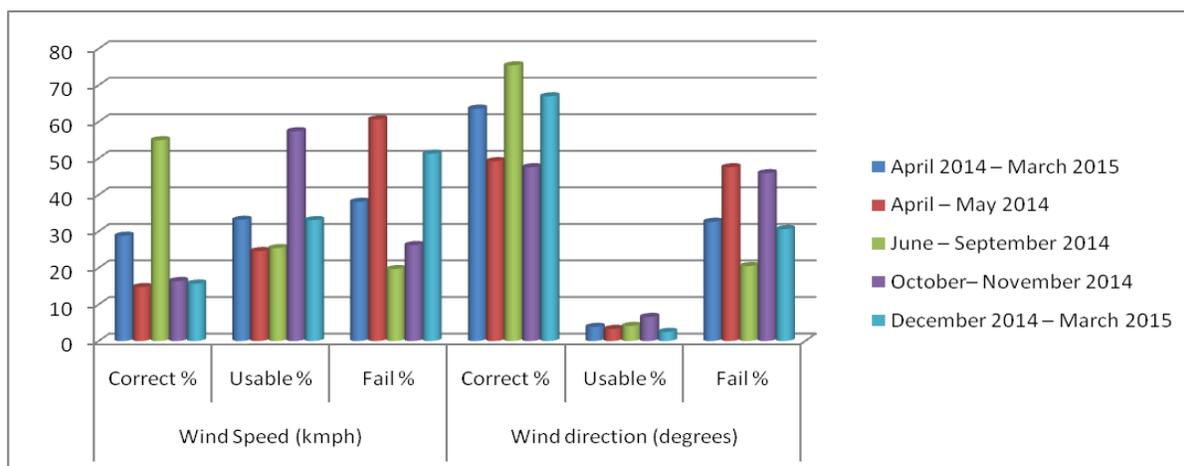


Fig.3 Overall usability analysis for Maximum Temperature (°C) & Minimum Temperature (°C)

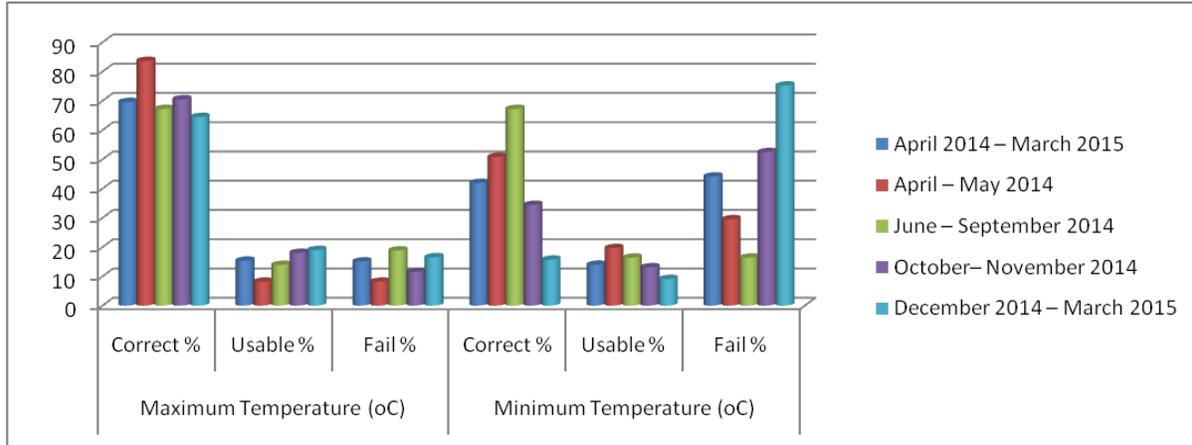
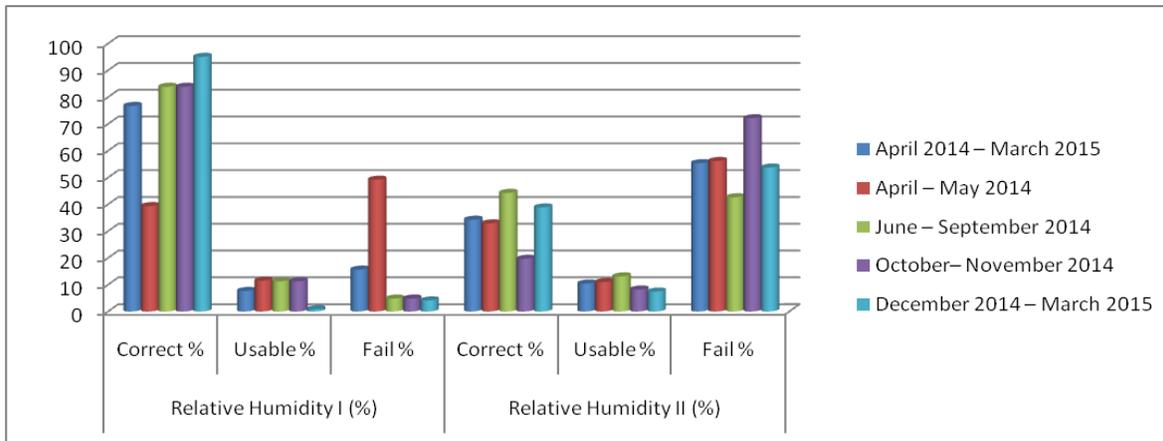


Fig.4 Overall usability analysis for Relative Humidity (%) & Relative Humidity (%)



Maximum Temperature (°C)

Overall usability analysis for Maximum Temperature (oC) was revealed in Table 3 (Fig. 3) that Maximum Temperature (oC) forecast for entire year was 69.59 per cent correct, 15.34 per cent usable and 15.07 per cent failure during the entire year (April 2014 – March 2015). During the period April – May 2014 the percentage of correct forecast was highest i.e 83.61 per cent, while that of usable percentage was highest during the period of December 2014 – March 2015 (19.01 per cent) and failure percentage was noted highest during the period of June – September 2014 (18.85 per cent).

Minimum Temperature (°C)

Overall usability analysis for Minimum Temperature (oC) was revealed in Table 3 (Fig. 3) that forecast for entire year was 41.92 per cent correct, 13.97 per cent Usable and 44.11 per cent Failure during the entire year April 2014 – March 2015. During the period June – September 2014, the percentage of correct forecast occurrence was 67.21 per cent, while that of Usable percentage during the period April – May 2014 was 19.67 per cent. Failure percentage was highest (75.21) during the period of December 2014 – March 2015.

Relative Humidity I (%)

Overall usability analysis for Relative Humidity I (%) was revealed in Table 4 (Fig. 4) that Relative Humidity I (%) forecast for entire year was 76.71 per cent correct, 7.67 per cent Usable and 15.62 per cent Failure during the entire year April 2014 – March 2015. During the period December 2014 – March 2015, the percentage of correct forecast occurrence was 95.04 per cent, followed by the period October– November 2014 and June – September 2014 i.e (83.87 per cent). While that of Usable percentage was 11.48 per cent during period April – May 2014. Failure percentage was (49.18) highest during the period of April – May 2014.

Relative Humidity II (%)

Overall usability analysis for Relative Humidity II (%) was revealed in Table 4 (Fig. 4) that Relative Humidity II (%) forecast for entire year was 34.25 per cent correct, 10.41 per cent Usable and 55.34 per cent Failure during the entire year April 2014 – March 2015. During the period June – September 2014, the percentage of correct forecast occurrence was 44.26 per cent, while that of Usable percentage was 13.11 per cent during period June – September 2014. The failure percentage was (72.13) highest during the period of October– November 2014.

Skill Score

The overall skill score abstract was revealed in Table 5. As regards the HK Scores was 0.43 for the entire year. During kharif season it was 0.23 and 0.33. June – September 2014. While that of post monsoon season period (October– November 2014) was observed negative i.e (-0.03). Highest HK score of 0.61 was observed during winter season period (December 2014 – March 2015). The positive values in most of the season indicates the reliability of forecast is good and satisfactory. For Rainfall, highest RMSE of was recorded as 8.34 for the entire year. The ratio score (RS %) Were 82.47 for

the entire year which ranges from 14.52 % to 29.59 % for all the season Critical success index (CSI) was observed from range 0.0 to 0.35. While that of Heidke Skill score (HSS) observed to be in range from 0.0 to 0.46 for the entire year RMSE calculated the entire year is 8.34. which indicates good and satisfactory rainfall forecast for the year 2014-2015.

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