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Validation of extended range forecasts of rainfall and temperature in Cuttack district of Odisha

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Abstract
Validation of the qualitative and quantitative district level weather forecast under extended range forecast, one month leading to 15-30 days active or break period is required. Since 2011, the IITM's Extended Range Prediction group has been offering experimental real-time forecasts for up to 20 days, primarily concentrating on the weekly variations in the weather. The farming community benefits from medium and long-range weather forecasts because they reduce production losses brought on by unfavourable conditions. In this study, the accuracy of the long-range weather forecast for Cuttack, Odisha for the years 2017-18 is discussed in relation to temperature and rainfall, and it is contrasted with the medium-range forecast. Pre-monsoon, monsoon, post-monsoon, and winter season forecasts' accuracy was assessed individually using real-time data gathered from the station observatory. The investigation of the Cuttack district's weather forecasts revealed that, when compared to MRF, ERF provided the highest forecast accuracy for rainfall and minimum temperature. Rainfall prediction was tested using the ratio scores on a Yes/No basis, i.e. Heidke Skill Score (HSS), Hansen and Kuiper's (HK) ratings. The accuracy of rainfall predictions on a Yes/No basis for all seasons was 80.3%, while for the post-monsoon period in 2017-18, it was 95.3% and 90.2%. The Critical Values for Error Structure provided by NCMRWF was used to assess the weather forecast for additional parameters. For example, the useful forecast for rainfall is 85.9 for the post monsoon in 2017 and 77.1 for the monsoon in 2018. Lower prediction accuracy was shown by a higher Root Mean Square Error (RMSE) of rainfall during the monsoon season (19.2). Like that correct error structure for maximum temperature in monsoon and minimum temperatures for summer that indicated higher RMSE accuracy. Accurate weather forecasting with regard to a variety of meteorological criteria is crucial because it may be used to help farmers make strategic decisions about how to manage their crops.

Keywords: Forecasts, rainfall, temperature, observed, Odisha

1. Introduction
Verification of weather forecasts has been a controversial subject for more than sixty years and has affected nearly the entire field of meteorology. In our nation, the monsoon forecast is made with respectable precision. Since 1988, the India Meteorological Department's (IMD) forecasts have had a high success rate. IMD projections were qualitatively accurate in 19 of the last 35 years (1988-2022), or 90% of the time. However, the forecast error (difference between actual rainfall and expected rainfall) was greater than 10% in some years (1994, 1997, 1999, 2002, 2004, and 2007). It is not possible to have 100% success for forecasts based on statistical models. In broad portions of central and northwest India, the monsoon contributes 90% or more of the country's annual precipitation, accounting for around 75-80% of the total. Weather is a significant factor that affects both the likelihood of agricultural crops' success and their total failure. The precision and application at micro levels are two more aspects that affect how useful a weather forecast is. With longer forecast periods, forecast accuracy declines; Short-term, medium-term, extended-term, and seasonal weather forecasts are produced by IMD, and these forecasts are used in agriculture for tactical and strategic choices. There are various methods for predicting the weather: Synoptic approach can be used to predict short-term weather. Numerical weather prediction (NWP) can be used to predict the weather over the medium to long term, and statistical methods can be used to predict the weather over the long term. In a view of that, the application of seasonal and extended forecasts in agriculture with a low level of expertise has been originally tested. For a very long time, the user community has been asking for short- to medium-term district level quantitative weather forecasts. The forecasting system is the collection of methods or equipment needed for the study of historical data, choice of the best modelling structure, model validation, creation of forecasts, and monitoring and adjusting of them.

In order to assist farmers in making the most effective use of natural resources and to increase agricultural productivity, the Ministry of Earth Sciences' India Meteorological Department (IMD) now provides agro-meteorological advising services (MRWF). But in order to adjust the agricultural system to increased weather variability, it becomes more and more crucial to supply climatological information combined with extended range and seasonal weather forecast before the start as well as during the cropping season. One of the most difficult challenges in atmospheric sciences is producing extended range forecasts (ERF) for the tropics, which include the time scale from one week to nearly a month. It bridges the gap between seasonal forecasting and medium-range weather forecasting. So, for agricultural planning (sowing, harvesting, etc.), the forecasting of monsoon breaks in the extended range time scale, 2 to 4 weeks in advance, is crucial. This can enable tactical adjustments to the strategic decisions made based on the longer-lead seasonal forecasts and also help in timely review of the current monsoon conditions for providing outlooks to farmers. Present study is attempted to verify the Extended and medium range forecasts of rainfall and temperature.

2. Material and Methods

2.1 Study Area

The study area is situated in the Cuttack district's north eastern region in the Indian state of Orissa. Geographically, it is located in the Mahanadi basin area at 20°37' N latitude and 86°9' E longitude. The region experiences monsoon weather, with yearly temperatures ranging from 13 °C to 37 °C and 120 cm of rainfall. Rainfall is at its highest during the monsoon season, which runs from June through October. Over 90% of the population in the study region works in agriculture, which makes up its entire economy.

2.2 Verification Methods

The validity of forecast values for weather parameters was evaluated using a variety of verification techniques. According to the guidelines of the National Center for Medium Range Weather Forecasting (NCMRWF), the forecast of rainfall and temperature have been verified by computing the error structure, which has been used to classify the forecast as correct, usable, or unusable based on the percent deviation in the forecast values as compared to observed values (Anonymous, 1999) [1]. The correct and usable cases were summed up and the combined values indicate the per cent usability of the forecasts of various parameters to the total events occurred in respective parameter. The verification of weather forecast given was done for four seasons *viz*., pre-monsoon (April to May), monsoon (June-September), Post-monsoon (October to December) and winter (January and March) as per the guidelines of NCMRWF (Anonymous, 1999) [1]. The methods adopted for verification are given as below:

2.3 Analysis of skill scores

The use of the contingency table approach to verify that the rainfall is a discrete or categorical variable (Murphy and Winkler, 1987; Murphy *et al*., 1989 and Schafer 1990) [9, 11, 12]. It provides details on the accuracy of forecasting as well as the many kinds of forecasting failures. For the purpose of verifying rainfall predictions, the ratio score (Y/N basis), Hansen and Kuipers Score (HKS), Probability of Detection Score, False Alarm Ratio Score (FAR), BIAS Score, and Percentage Correct (PC) are used.

2*2 Contingency table is used for calculation of the various skill scores and verification of the rainfall forecast (Murphy and Wrinkler 1987; Murphy *et al*., 1989) [9, 11] given in table 1.

2.4 Ratio score

The ratio score calculates the percentage of accurate forecasts. Values range from 0 to 100, with 100 denoting an accurate forecast. Rainfall seasonal and yearly ratio score (%) was calculated as follows:

Ratio score = (Correct forecast)/(Total forecast) = (YY+NN)/(YY+NN+YN+NY) Hanssen and Kuipers' Score (HKS): HKS is the ratio of the financial benefits of forecasting over climatology to the benefits of a set of flawless forecasts. HKS can range from -1 to +1 in value. If every forecast is accurate, it is +1; if every forecast is incorrect, it is -1. Rainfall-related annual HKS was computed as: HKS= ((NN*YY)-(NY*YN))/((NN+NY)(YN+NY))

Error structure and Root Mean Square Error (RMSE) are calculated for obtaining the skill of the rainfall and temperatures as:

$RMSE=[1/n \sum (f_i-o_i)^2]^{(1/2)}$

Whereas fi= Forecast value,f= Mean forecast value,oi=Observed value,o= Mean observed value,n= Total number of observations / forecast.

Critical value for error structure: Critical Value Error Structure was used to analyse the weather parameter forecasted by NCMREF, namely Rainfall, Tmax, and Tmin. The year (2017-18) was divided into four seasons i.e. pre-monsoon (March - May), monsoon (June – September), post monsoon (October - December) and winter (January - February) for verification analysis.

3. Results and Discussion

During the study period (2017-18), the data of actual and forecasted rainfall were analysed separately for all the seasons. All the scores with different verification structures for rainfall and temperature are described as Forecast accuracy (ACC) or ratio score: The ACC measures the proportion of correctly predicted rainfall occurrences to all expected events. For the pre-monsoon, monsoon, post-monsoon, and winter seasons, it is calculated on a Yes/No basis. It was highest (95.3%) for post monsoon season in 2018 and lowest (64.5%) for monsoon season in 2017, whereas it was 80.3 and 87.2 per cent for overall period in 2017-18 (Table 2).

Heidke skill score (HSS): It takes into account all correctly predicted outcomes, whether actual and hypothetical (i.e., non-events). It ranges from -1 to +1, with 0 denoting little skill in forecasting compared to chance. The HSS was 0.6, 0.3, 0.4, and 0.0 during the summer, monsoon, post-monsoon, and winter periods, respectively. It was 0.4 for whole year in 2017. Likewise for 2018 the HK score is (Table 1). Earlier Chauhan *et al*. (2008) [3] showed that the accuracy of rainfall forecast was outstanding in pre-monsoon and winter season above average for post- monsoon and year as a whole.

Error structure analysis: The weather forecast for rainfall was tested with Critical Values for Error Structure (Table 3) which has the highest correctness (85.9%) in post monsoon for 2017 and (77.1%) for monsoon in 2018 which is 28% and 35.6% higher than annual season respectively. Similarly, maximum temperature forecast has the highest correctness is for monsoon season i.e. 29.7 and 27.2 for the year 2017-18.

Meanwhile minimum temperature has the more correctness percentage in summer season 14.1% and 5.43% for both the year respectively (Table 4).

Root Mean Square Error: Higher Root Mean Square Error (RMSE) of rainfall is found in monsoon season (19.2) in 2017and (25.1) in 2018 indicated lower accuracy in prediction. But for maximum temperature RMSE value are 5.3 and 7.6 for summer in 2017 and for minimum temperature 6.5 and 13.5 for 2018 in post monsoon. Annual analysis: The predicted and observed weather parameters were analyzed for Correct (C), Usable (U) and Failure (F) events in terms of percentage. The highest percentages of correct events were 57.9 per cent for rainfall in 2017 which is more than 2018 (41.5). However, the highest percentages of 63.2 per cent and 67.4 percent failure events was observed for maximum temperature in 2017-18. Minimum temperature has the maximum failure event mostly for 2018 having 96.7% unusable percent with only 1.64% correctness. Kumar and Mukesh (2010) [13] also reported similar results for Bundelkhand region of Uttar Pradesh (27.5 to 40.6% of failure in different seasons) in wind direction prediction.

Table 1: Critical values for error structure suggested by NCMRWF

Parameter	Rainfall (mm)	Temperature (^{0}C)
Correct (C)	-10 to +10 mm variation	1 °C variation
Usable (U)	-20 to +20mm variation	2 °C variation

Table 2: Observed and predicted rainfall (%) by ERF of Cuttack districts of Odisha for the whole year during 2017-18

Season	RS		HK		RMSE	
	2017	2018	2017	2018	2017	2018
Summer	82.5	90.5	0.6	0.4	19.2	23
Monsoon	64.5	75.0	0.3	0.9	4.4	25.1
Post monsoon	90.2	95.3	0.4	0.3	4.7	0
Winter	87.2	94.2	0	0	15.2	19.1
Annual	80.3	87.2	0.4	0.7	16.1	9.9

Note: RS: HK: RMSE:

Table 3: Observed and predicted correct error structure (%) by ERF of Cuttack districts of Odisha for the whole year during 2017-18

Error structure (Correct %)		
Season	2017	2018
Summer	56.5	42.4
Monsoon	22.1	77.1
Post monsoon	85.9	14.1
Winter	90	10
Annual	57.9	41.5

Table 4: Day-wise observed and predicted Temperature by ERF of Cuttack districts of Odisha for the whole year (365 days) during 2017-18

Season	Correct Structure % (Tmax)						Correct Structure % (Tmin)					
	2017			2018			2017			2018		
	Correct	Usable	Unusable	Correct	Usable	Unusable	Correct	Usable	Unusable	Correct	Usable	Unusable
Summer	13.0	11.9	75	8.7	15.2	76.0	14.1	20.6	65.2	5.43	0	94.5
Monsoon	29.7	20.6	49.5	27.2	22.3	50.4	9.8	23.7	66.3	0	0	100
Post monsoon	21.7	26.0	52.1	6.5	7.6	85.8	6.5	16.3	77.1	0	0	100
Winter	6.6	3.3	90	13.3	25	61.6	1.6	5	93.3	0	0	100
Annual	19.9	16.9	63.1	15.0	17.4	67.4	8.7	18.0	73.2	1.64	1.6	96.7

3.1 Comparison of ERF & MRF

The medium range weather forecast verified on different weather parameters *viz*., rainfall, maximum and minimum temperature during past years (2017-18) has been verified annual and seasonal for Cuttack district. Ability of rainfall, maximum temperature, and minimum temperature of Medium range weather forecasting was compared with extended range forecasting. Among the seasons, post-monsoon season gave the highest accuracy for rainfall. Highest ratio score observed during (2017-18) was in post monsoon (98%), that showing accuracy much correct for ERF as compare to MRF for 2017. Likewise, MRF is also having greater impact to minimize crop losses which is studied by Badawe *et al*., (2001) [14] about the utilities of agro-advisory services in the middle Konkan region of Maharashtra. The verification of forecasts revealed that the correctness of forecasts in respect of rainfall occurrence was fairly accurate; however, the prediction for the amount of precipitation needed improvement. Similarly, ratio score of ERF were high in winter (94.8%) during 2018, showing more correct than MRF. Whereas, for MRF lowest ratio score was 72.02 percent during 2018.Analyzed correct structure for rainfall forecast under ERF was given more correctness in post monsoon than MRF. But in monsoon correct % of MRF (80%) is higher than ERF (60%) that gave a moderate correctness for summer. Meanwhile usable forecast is maximum in pre monsoon under ERF (Fig.1). MRF correctness is much lower throughout all seasons during 2017-18. So usable forecast is much worthy for ERF of rainfall. Similarly, 2018 usable forecast is higher in pre monsoon for MRF and lower in post monsoon as compare to ERF. Ashok kumar *et al*. explained similarly a forecasting system for objective medium range location specific forecasts of surface weather elements was evolved at the National Centre for Medium Range Weather Forecasting (NCMRWF). For maximum temperature highest correct percentage in summer (33%) which is comparatively higher than MRF (12%). Agro advisory Services: Presently, IMD generates location specific extended range weather forecast for rainfall, maximum and minimum temperature trends. On the basis of Extended range and medium range weather forecasts received from and using surface weather data of past and current weeks, the agro-advisories are prepared for a real time crop management in Odisha. The verification of forecasts revealed that the correctness of forecasts in respect of rainfall occurrence was fairly accurate; however, the prediction for the amount of precipitation needed improvement. The mission of the Agro meteorological Advisory Services (AAS) of NCMRWF and ERF is to help farmers maximize profits by decreasing weather related losses and increasing the timeliness of operations. According to total monsoon rainfall of Cuttack district for 2017-18, agro advisories (Table 6).

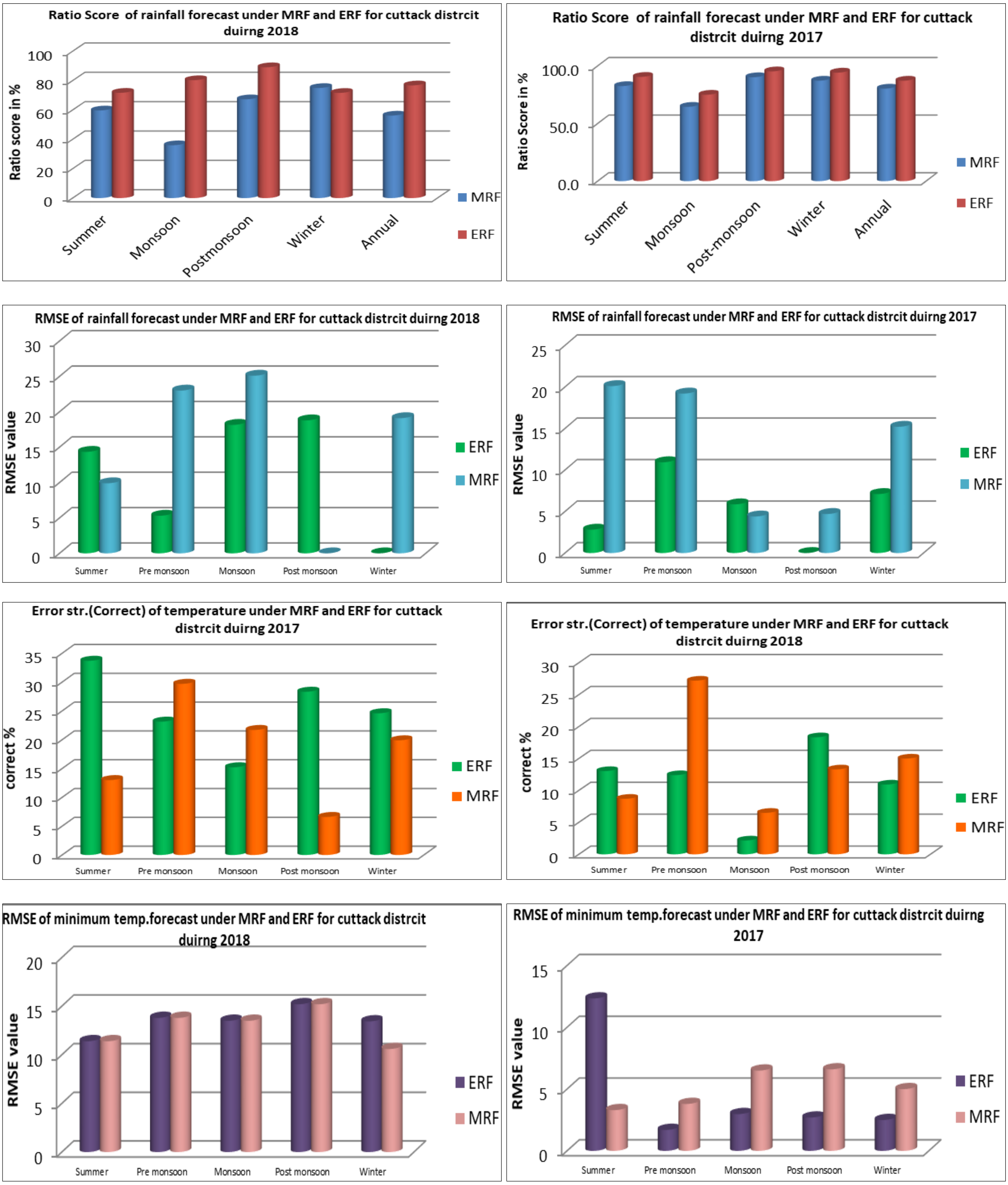

Fig 1: Comparison of ERF and MRF during the year 2017 and 2018

Table 5: Root Mean Square Error (%) of Maximum and minimum temperature

Season	Tmax		Tmin	
	2017	2018	2017	2018
Summer	5.3	7.6	3.3	11.4
Monsoon	2.9	3.1	3.8	13.8
Post monsoon	2.8	3.9	6.5	13.5
Winter	4.1	4.7	3.1	10.2
Annual	4.2	5.0	5.0	10.6

Table 6: Total forecasted and observed monsoon rainfall (mm) of Cuttack district in 2017-18

Year	June		July		August		September	
	Forecasted	Observed	Forecasted	Observed	Forecasted	Observed	Forecasted	Observed
2017	224.0	192.7	232.5	216.5	257.0	510.5	292.5	276.1
2018	195	175.1	412.5	460.7	292.5	351.8	157	374.9

Source: Extracted from monthly extended range forecast map of IMD (2017-18)

3.2 Advisories for rice crop
As the rainfall amount is 224.0mm for 2017 in Cuttack district, it is sufficient to go for land preparation and sowing of non-paddy crops and raising of rice nursery. In 2018, as the rainfall amount is 195.0 so it is sufficient to go for dry bed nursery can be done in the month of June. For both the years the amount of received rainfall is more than 200mm, hence farmers can go for puddling and rice transplanting mainly in up- medium land on priority basis, sowing of non-paddy crops can be done in the month of July. As the years of 2017-18 likely to receive around 300-500mm rainfall, hence farmers can go for puddling and rice transplanting in low land in the month of august. Similiarly in the month of September, rainfall amount more than 200 mm so intercultural operations and top dressing can be done.

4. Conclusion
Based on the aforementioned findings, it was determined that the extended range forecast in Cuttack, Odisha for the years 2017–18 provided a good degree of accuracy between observed and predicted rainfall and temperature. An improved monsoon forecast on an extended time scale is now becoming more and more necessary. It is not only the Agriculture sector which is benefited from the proper outlook of extended range forecast, a skilful extended range forecast can also be very useful for reservoir operation in reducing floods. The goal of verification is to examine a prediction's consistency, quality, and value. This forecast has high quality, satisfies accurate verification, and produces positive results when compared to MRF.

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6. Reference
1. Anonymous. Medium-range weather forecast confirmation. Agrometeorological advice service guide (Eds.S.V.Singh, L.S.Rathore and H.K,N,Trivedi). New Delhi, NCMRWF, and DST; c1999. p. 73-93.
2. Borah N, Sahai AK, Abhilash S, Chattopadhyay R, Joseph S, Sharmila S, *et al*. An assessment of real-time extended range forecast of 2013 Indian summer monsoon. Int. J Climatol. 2015;35(10):2860-2876. Doi:10.1002/joc.4178.
3. Chauhan VS, Chaudhari GB, Pandey V. Medium-range weather forecast verification for the middle Gujarat region, in Agromet. 2008;10:90-93.
4. Dukhore KK, Patel HR, Pandey V, Shekh AM. Economic effect assessment employing agro-advisory services in middle Gujrat agro-climatic zone, Agriculture. 2008;2:541-544.
5. Dobryshman EM. WMO Tech Note No. 120: Review of Forecast Verification Techniques; c1972. p. 17-20.
6. Himangsu Das, Rai Anuj. Forecast verification analysis of rainfall and temperature for Malkangiri districts of Odisha. 2018;6(5):1731-1734. https://www.researchgate.net/publication/328118493
7. Niwas R, Khichar ML, Singh, Diwan. Verification of the Haryana region's western weather forecast for the medium term. Agricultural Meteorological Services; c2010. p. 193-200.
8. Pattanaik DR, Das Ashok Kumar. Prospect of implementation of extended range prediction in water resource management: A case study over the Mahanadi River basin. Natural Hazards. 2015;77:575-595.
9. Murphy AH, Winkler R. A general framework for forecast verification was published in 1987 in Mon. Wea. Rev. 1987;115(7):1330-1338.
10. Monica Ray. Validation of medium range weather forecast for Keonjhar district of Odisha. Int. J For. Crop Improv. 2016;7(2):161-166.
11. Murphy KM, Shleifer A, Vishny RW. Industrialization and the big push. Journal of political economy. 1989 Oct 1;97(5):1003-26.
12. Schulz B, Banuett F, Dahl M, Schlesinger R, Schäfer W, Martin T, *et al*. The b alleles of U. maydis, whose combinations program pathogenic development, code for polypeptides containing a homeodomain-related motif. Cell. 1990 Jan 26;60(2):295-306.
13. Kumar M, Mohanty S, Nayak SK, Parvaiz MR. Effect of glycidyl methacrylate (GMA) on the thermal, mechanical and morphological property of biodegradable PLA/PBAT blend and its nanocomposites. Bioresource technology. 2010 Nov 1;101(21):8406-15.
14. Thomas ML, Badwe RA, Deshpande RK, Samant UC, Chiplunkar SV. Role of adhesion molecules in recruitment of Vδ1 T cells from the peripheral blood to the tumor tissue of esophageal cancer patients. Cancer Immunology, Immunotherapy. 2001 Jun;50(4):218-25.