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Verification of Rainfall forecast for Visakhapatnam district of Andhra Pradesh

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Abstract
The present investigation was done to verify the medium range weather forecasting issued by NCMRWF for Agrometeorological Field Unit, Anakapalle of Visakhapatnam district of Andhra Pradesh with the actual rainfall recorded during the last four years (2016-17 to 2019-2020). The reliability of rainfall forecast was evaluated by using error structure using 2x2, ratio score, HK score and RMSE values for monsoon season. The results showed considerable increment in terms of HK score, ratio score and RMSE values in forecast accuracy of rainfall. The mean seasonal Ratio Score (RS) ranged between 67.4 to 91.2 percent, Hanssen & Kuipers skill scores ranged from 0.1 to 0.6.

Keywords: Verification, Rainfall, Visakhapatnam, reliability, rainfall

Introduction
The technological and scientific developments in agriculture will not be helpful and useful unless weather is favourable during the crop growth period (Sevak Das and Desai A I, 2018) [5]. Weather is one of the most important factors that influence the crop growth, development and finally agricultural production. Among the weather factors rainfall distribution plays a vital role for reaping higher yields. The vagaries of monsoon encountered during crop season often create crisis in food production. (Mohan Singh and Bharadwaj, 2012) [3]. An accurate weather forecast not only helps in increasing agriculture production and quality of produce but also helps in efficient use of limited resources (Navaneet Kaur and Singh, 2019) [4]. Knowing the weather in advance helps in planning of agricultural operations *viz*., sowing, scheduling irrigation, fertilizer application, spraying, harvesting etc. Therefore, providing accurate forecast to the farmer will helps in minimising the risk due to weather factors and to realise the sustained yield. In the present study efforts have been made to verify the rainfall forecast issued by NCMRWF using different test criteria.

Materials and Methods
The medium range weather forecast on rainfall received from National Centre for Medium Range Weather Forecasting (NCMRWF) for five days from 2016 to 2020 was verified with daily observed weather data for respective days collected from CPO, Visakhapatnam district to study the accuracy of rainfall. The verification of rainfall forecasts was done by using different criteria *viz*., Ratio Score, HK Score and RMSE for Southwest monsoon season (June to September), Northeast monsoon season (October-December), winter season (January to February) and summer season (April to May).

Ratio score
It is the ratio of correct forecast to total number of forecast for rainfall events. It was worked out on Yes/No basis. Ratio score was calculated as follows:

Ratio score = (hits + correct negative)/N

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

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

Where
YY = No of days when rain was forecasted and also observed,
YN = No of days when rain was forecasted but not observed,

Hanssen & Kuipers skill score

$$\text{Hanssen \& Kuipers skill Score} = \frac{\text{YY. NN} - \text{YN.NY}}{(\text{YY+YN})\ (\text{NY+NN})}$$

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

Hanssen & Kuipers skill score indicates the ratio of economic saving over climatology due to the forecast to that of a set of perfect forecasts. It ranges between -1 and +1 through 0, the zero indicating no skill.

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) [2]:

$$\text{RMSE} = \sqrt{[1/n \sum (Fi - Oi)]}$$

Where, Fi = Forecasted values, Oi = Observed values and *n* = Number of observations.

Results and Discussions
The forecast accuracy of rainfall for different seasons is presented in Table-1. The results of last 4 years (2016-17 to 2019-20) indicated that highest ratio score was observed in winter season (91.2%) followed by South west monsoon season (89.6%), North east monsoon season (78.3%) and summer season (67.4%). Similar results were also observed by Himangshu Das *et al*, 2018 [1].
HK score ranged between 0.1 to 0.6 among different seasons. Highest HK score was recorded with North east monsoon period (0.6) followed by Sumer season (0.3), whereas lowest HK scores of 0.1 and 0.2 were recorded with South West monsoon period and Winter period respectively.
The lowest RMSE value was observed in the winter and summer seasons signifying least error between observed and forecasted data. Similar results were also reported by Himangshu Das *et al*, 2018 [1].

Table 1: Quantitative analysis of rainfall forecast and realization.

Season	2016-17	2017-18	2018-19	2019-20	Mean (2016-20)
	Ratio score (%)				
Southwest Monsoon	86.1	95.1	86.9	90.2	89.6
Northeast Monsoon	85.9	82.6	68.5	76.1	78.3
Winter	98.3	100	84.7	81.7	91.2
Summer	66.3	72.8	58.7	71.7	67.4
	H.K Score				
Southwest Monsoon	0.2	0.0	-0.1	0.3	0.1
Northeast Monsoon	0.6	0.6	0.5	0.6	0.6
Winter	0.0	0.0	0.3	0.5	0.2
Summer	0.3	0.5	0.1	0.4	0.3
	RMSE				
Southwest Monsoon	16.8	16.5	21.5	19.0	18.5
Northeast Monsoon	17.4	12.6	2.5	15.3	12.0
Winter	0.1	0	3.5	3.2	1.7
Summer	3.6	9.4	7.5	10.3	7.7

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