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VERIFICATION OF DISTRICT-LEVEL WEATHER FORECAST OF KOLKATA AND ITS SUBURBS DURING MONSOON '2019 & 2020 FOR COMPARATIVE STUDY OF THE PERFORMANCE OF MODEL BETWEEN PRE COVID NON-LOCKDOWN AND COVID LOCKDOWN PERIOD

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Abstract

India Meteorological Department has started issuing district-level weather forecasts for up to 5 days on an operational basis from 1st June 2008. The weather parameters related to agro, namely rainfall, maximum and minimum temperature, wind speed, and direction, relative humidity, and cloudiness were chosen for outputs from the model. The rainfall forecast is generated based on multi-model ensemble techniques (MME) and ECMWF forecasts (presently IMDGFS) are used for forecasting other parameters. These forecast generated for the districts of West Bengal by the model is further moderated by State Agro Met. Centre, Kolkata, and forwarded to six Agro Met. Field Units (created by six agro-climatic zones in West Bengal) and seven District Agro Met. Unit (DAMU) for preparation of weather-based District as well as Block level Agromet advisory bulletin which benefits the farmers in their crop production. Thus forecast verification of the model as well as moderated value for the monsoon season of 2019 and 2020 has been done to make a comparative study of the model performance concerning Kolkata and its suburbs based on Probability of Detection, False alarm, Heidke Skill score, Missing rate, Critical Success Index, True Skill Score, Hanssen, and Kuipers Index, etc. The monsoon rainfall of 2019 and 2020 was chosen to study the performance of the model concerning the pre-covid non-lockdown and covid lockdown period so that the effect of pollutants on the performance of the model can be analyzed. The verification results show that the model forecast, as well as a moderated forecast of this region, has to be more refined by taking inputs of other parameters and index that has been computed by different recent research works on this region because this region is under the influence of tropical climate. Moreover, the comparative study between monsoon 2019 and monsoon 2020 reveals that there have been changes in the performance of the model.

Keywords: Pre Covid period, Covid period, Probability of Detection, False alarm, Heidke Skill score, Missing rate, Critical Success Index, True Skill Score, Hanssen and Kuipers Index.

I. Introduction

It was felt that the user community should be provided with district-level quantitative weather forecasts in short to the medium-range time scale for their use in their day to day life. This catering of weather service would have a good impact on the civilians as we know that the activities of humanity are controlled by the weather phenomena of that region and if it can be given accurately, five days well in advance, both quantitatively and qualitatively, then much planning can be made by the people including the farming community. Considering this need of the farming community, India Meteorological Department (IMD) has upgraded the Agro-Meteorological Advisory Service from agro-climatic zone to district level and now to block-level because of the high spatial variability of different weather parameters at the district level/block level which has a direct impact on crop growth and to generate crop and location-specific advisories. As a major step, IMD started issuing quantitative district level weather forecasts up to 5 days from 1st June 2008 based on the multi-model ensemble (MME) technique [IV, VI] for preparation of District Level Agromet Advisories. The products comprise quantitative forecasts for 7 weather parameters, viz., rainfall, maximum and minimum temperatures, wind speed and direction, relative humidity and cloudiness which mainly can impact crop production are being derived as model output. These forecast products are generated by National Weather Forecasting Centre, (IMD), New Delhi and further, it is being moderated (value-added) by State Agro Met. Centre (SAMC), Kolkata for the districts/blocks of West Bengal. These 5 days moderated values of districts and blocks are being sent to 6 Agro Met. Field Units (AMFU) namely AMFU Kalyani which represents the Gangetic Alluvial zone, AMFU Kharagpur which represents the Undulating Red and Laterite zone, AMFU Kakdwip which represents the Coastal Saline zone, AMFU Majhian which represents Vindhyan Alluvial zone, AMFU Pundibari which represents Terai Teesta Alluvial zone and AMFU Kalimpong which represents Northern Hill zone. In addition to it, the 5 days moderated values of districts and blocks forecast are also sent to 7 District Agro Met. Unit (DAMU) namely DAMU Purulia , DAMU Jalpaiguri , DAMU Mursidabad , DAMU North 24 Parganas , DAMU Birbhum , DAMU Malda and DAMU Bardhaman .The moderated value to the MME district forecast is done manually by considering the climatology of the region, products of other NWP models, prevailing synoptic condition of the region & neighborhood, satellite imageries of the day, Doppler Weather Radar products on the day of the forecast and the knowledge gathered by comparing MME forecast with the observed data in the previous years. The moderated value of the MME block forecast is being computed by the input of moderated value of districts of this state and nearby states by interpolation method. It is apparent that the quality of agromet advisories depends on the accurate weather forecast, hence there is a need to verify the forecast for different temporal scales and unique temporal scales to assess the performance of the model in an almost normal situation and close to the standardized situation, so that the robustness of the model can be checked and if necessary other inputs can be

incorporated in running the model for getting accurate forecasts. It is a time-evolving process and so all variations can be checked, when the situation arises, to make this model more robust. Forecast verification serves the role of identifying the accuracy of forecasts to improve future predictions and also stresses on accuracy and skill of prediction. The issue of district/block level weather forecast particularly in respect of rainfall and other parameters are extremely challenging, particularly in the monsoon period in tropical climate region. Fig 1 shows the flow diagrams of forecast preparation and subsequent dissemination to AMFUs and DAMUs. Fig 2 shows the sample of the five-day forecast of the Kolkata district, generated by the MME model. Fig 3 shows the 6 AMFUs and 7 DAMUs locations, where each AMFU represents each agro-climatic zones of West Bengal.

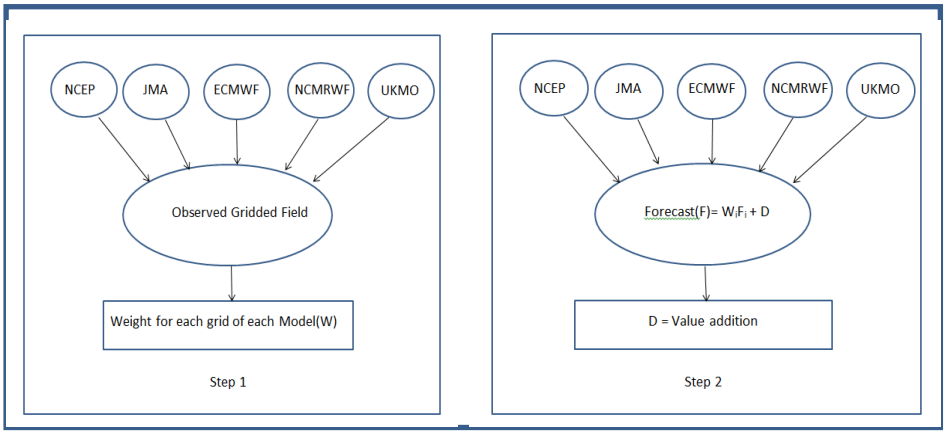

Fig 1. Generation of Forecast using MME model

INDIA METEOROLOGICAL DEPARTMENT
NWP MODELS BASED DISTRICT LEVEL WEATHER PREDICTION
ISSUED ON: 28-11-2021
VALID TILL 08:30 IST OF THE NEXT 5 DAYS
STATE : WEST-BENGAL

PARAMETERS	WEATHER FCST				
	DAY-1	DAY-2	DAY-3	DAY-4	DAY-5
	29112021	30112021	01122021	02122021	03122021
KOLKATA					
Rainfall (mm)	0	0	0	0	0
Max Temperature (deg C)	27	27	28	28	30
Min Temperature (deg C)	18	17	17	18	21
Total cloud cover (octa)	2	5	1	6	8
Max Relative Humidity (%)	55	55	61	52	49
Min Relative Humidity (%)	30	31	30	31	31
Wind speed (kmph)	007	009	009	011	009
Wind direction (deg)	342	353	16	16	52

Fig 2. Sample of five day forecast of Kolkata district, generated by MME model

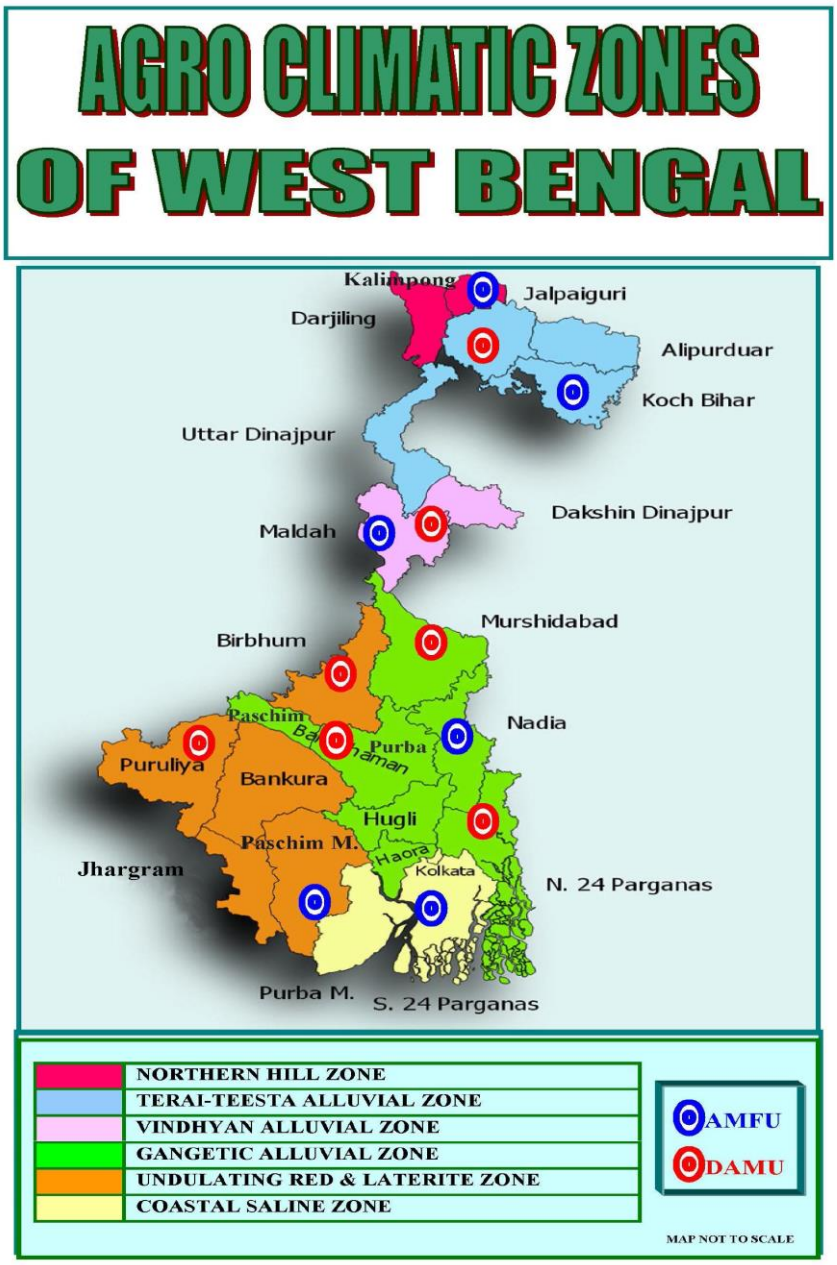

Fig 3. shows the 6 AMFUs and 7 DAMUs location

II. Multi-model ensemble technique

Multi-model ensemble samples the uncertainty in the model initial condition (via the different observational data, assimilation and initialization methods, lateral boundary conditions for the regional models) and model formulation (via the variety of model physical parameterization, numeric and resolution). It avoids the problem of systematic bias that occurs when a single model is used [II] Due to the differences in

model formulation, each model has its relative strength and weakness concerning prevailing synoptic, geographic and orographic conditions, with no model superior to others. Five NWP models were considered for this development work, which are as follows : (i) National Centre for Medium-Range Weather Forecasting (NCMRWF) (presently it uses IMD GFS T-1534), (ii) European Centre for Medium-Range Weather Forecasting (ECMWF T-799), (iii) Japan Meteorological Agency (JMA T - 959), (iv) United Kingdom Meteorological Office (UKMO) and (v) National Centre for Environmental Prediction Global Forecast System (NCEP GFS)

III. Data and Methodology

Verification has been carried out for the Kolkata district (which falls under the Coastal Saline agro-climatic zone) and its suburb North 24 Parganas district (which falls under the Gangetic Alluvial agro-climatic zone). The districts were chosen to study the performance of the model in light of the pollution effect that these highly dense populated districts were exposed to during pre covid non-lockdown period i.e monsoon rainfall of 2019 and covid lockdown period i.e monsoon rainfall of 2020. Area weighted average rainfall for all the districts (Both surface observatories and Daily rainfall monitoring stations) [III, V] was considered for verification. Forecast accuracy depends on how close the forecast was to the realized value. Here, the accuracy of a forecast is defined as how many days in the season the forecast was close to the actual weather (correct and usable) based on error structure.

III.i. Error structure of quantitative district level weather forecast, if the forecasting parameter is out by one stage compared to observed, it is considered a correct forecast and if the same is out by two stages and more than that it is considered partially correct and wrong forecast respectively. The forecast has been verified with the help of observed data using the following error structure for rainfall for different districts in the state as has been done by [I] for the whole country.

The error structure considered for verification of rainfall forecast is as follows :

Correct Difference $\leq$ 25 % of observed

Usable 25 % of observed < Difference $\leq$ 50 % of observed

Unusable Difference $\geq$ 50 % of observed

(Difference is the absolute difference between observed and forecast rainfall)

Besides various skill scores like Probability of Detection (POD), False Alarm Rate (FAR), Missing Rate, Correct Non-Occurrence (C-Non), Critical Success Index (CSI), Bias for Occurrence (Bias), Percentage Correct (Pc), True skill score (TSS), Heidke skill score (Hss), Hanssen and Kuipers Index. (HK score) according to [VII] have also been used to verify the forecast using the following formulae based on the matrices (2X2) given below:

Forecast /observation	Rain	No Rain
Rain	A(YY)	B(YN)
No Rain	C(NY)	D(NN)

A = No. of Hits (predicted and observed)

B = No. of False Alarms (predicted but not observed)

C = No. of misses (observed but not predicted)

D = No. of correct predictions of no rain (neither predicted nor observed)

(i) Forecast Accuracy (ACC) or the Ratio Score or Hit Score: It is the ratio of correct forecasts to the total number of forecasts.

$$ACC = \frac{\text{Correct Forecast}}{\text{Total Forecast}} = \frac{A+D}{N} = \frac{YY + NN}{(YY + NN + YN + NY)}$$

(ii) Hanssen and Kuipers Scores or True Skill Score (HK score) : It is the ratio of economic saving over climatology due to the forecast to that of a set of perfect forecasts.

$$HK = \frac{\text{Correct Forecast} - (\text{Correct Forecast})_{\text{random}}}{N - (\text{Correct Forecast})_{\text{random unbiased}}}$$

$$HK = (Acc)_{\text{events}} + (Acc)_{\text{non-events}} - 1 = \frac{AD-BC}{(A+C)(B+D)}$$

Range : -1 to +1

Perfect : 1

Advantage: Equal emphasis on yes/no events.

(iii) Probability of detection (POD)

$$POD = \frac{\text{Correct rain forecast}}{\text{Rain observation}} = \frac{A}{A + C}$$

Range : 0 to 1 ; Perfect Score = 1

(iv) False alarm ratio $= \frac{\text{False alarms}}{\text{Hits + False alarms}}$

$$FAR = \frac{B}{A + B}$$

$$\text{(v) BAIS score} = \frac{\text{Rain forecast}}{\text{Rain observed}}$$

$$BAIS = \frac{A + B}{A + C}$$

III.ii. Verification procedure

Verification of forecast has been done daily, i.e first day, second day, third day, fourth day and fifth day from the date of issue of the forecast.

Rainfall is the area-weighted average of the district.

IV. Results and discussion

It is observed that the rainfall shows a good accuracy with the moderated value forecast during monsoon than a model for both the years of study i.e monsoon 2019 and monsoon 2020, both qualitatively and quantitatively in most of the day-wise forecast of district South 24 Pargana and North 24 Pargana, as demonstrated both by Table 1 to 8.

TABLE : 1

SOUTH 24 PARGANAS (MONSOON 2019) MODEL VERSUS REALISED RAINFALL		DAY1	DAY2	DAY3	DAY4	DAY5
Skill Score or Ratio Score of rainfall	RS=	76.47	79.41	55.88	79.41	76.47
Hanssen & Kuipers Index	HK score	0.3	0.23	-0.18	0.79	0.28
Probability of detection (POD)=	POD=	0.8	0.89	0.69	0.79	0.85
False alarm ratio (FAR) =	FAR=	0.08	0.14	0.28	0	0.15
Critical Success index (CSI)=	CSI=	0.75	0.78	0.55	0.79	0.74
Heidke Skill Score (HSS)=	HSS=	0.21	0.24	-0.18	0.18	0.28
Missing Rate	MR=	0.25	0.57	0.47	0	0.5
Correct non Occurrence	C Non=	0.08	0.07	0.05	0.04	0.12
Bais	BAIS=	1	1.07	1.32	0.96	1.04
Percentage Correct	PC=	76.47	79.41	55.88	79.41	76.47
	RMSE =	16.47	16.73	13.91	12.86	21.27
	Correct=	26.47	23.53	11.76	14.71	17.65
	Usable=	0	2.94	8.82	5.88	11.76

TABLE : 2

SOUTH 24 PARGANAS (MONSOON 2019) MODERATED VALUE VERSUS REALISED RAINFALL		DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Skill Score or Ratio Score of rainfall	RS=	94.12	88.24	88.24	100	85.29
Hanssen & Kuipers Index	HK score	0.5	0.22	0.33	1	0.39
Probability of detection (POD)=	POD=	1	0.97	1	1	0.96
False alarm ratio (FAR) =	FAR=	0.06	0.09	0.13	0	0.13
Critical Success index (CSI)=	CSI=	0.94	0.88	0.88	1	0.84
Heidke Skill Score (HSS)=	HSS=	0.64	0.28	0.45	1	0.47
Missing Rate	MR=	1	0.75	1	1	0.8
Correct non Occurrence	C Non=	0.06	0.03	0.07	0.03	0.1
Bais	BAIS=	1	1.07	1.07	0.97	1.03
Percentage Correct	PC=	94.12	88.24	88.24	100	85.29
	RMSE =	10.69	13.45	9.59	8.45	12.71
	Correct=	23.53	41.18	26.47	32.35	41.18
	Usable=	38.24	23.53	29.41	26.47	11.76

TABLE : 3

SOUTH 24 PARGANAS (MONSOON 2020) MODEL VERSUS REALISED RAINFALL		DAY1	DAY2	DAY3	DAY4	DAY5
Skill Score or Ratio Score of rainfall	RS=	82.35	79.41	76.47	88.24	91.18
Hanssen & Kuipers Index	HK score	0.31	-0.18	-0.16	0.81	0.42
Probability of detection (POD)=	POD=	0.82	0.82	0.84	0.88	0.91
False alarm ratio (FAR) =	FAR=	0	0.04	0.1	0	0
Critical Success index (CSI)=	CSI=	0.82	0.79	0.76	0.88	0.91
Heidke Skill Score (HSS)=	HSS=	0	-0.05	-0.12	0	0
Missing Rate	MR=	0	0.14	0.38	0	0
Correct non Occurrence	C Non=	0	0	0	0	0
Bais	BAIS=	1	1.04	1.12	1	1
Percentage Correct	PC=	82.35	79.41	76.47	88.24	91.18
	RMSE =	25.78	24.41	19.55	16.22	29.7
	Correct=	14.71	5.88	2.94	8.82	5.88
	Usable=	8.82	14.71	11.76	5.88	11.76

TABLE : 4

SOUTH 24 PARGANAS (MONSOON 2020) MODERATED VALUE VERSUS REALISED RAINFALL		DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Skill Score or Ratio Score of rainfall	RS=	97.06	97.06	91.18	94.12	97.06
Hanssen & Kuipers Index	HK score	0.6	0	0.3	0.5	0
Probability of detection (POD)=	POD=	0.97	1	0.97	0.94	0.97
False alarm ratio (FAR) =	FAR=	0	0.03	0.06	0	0
Critical Success index (CSI)=	CSI=	0.97	0.97	0.91	0.94	0.97
Heidke Skill Score (HSS)=	HSS=	0	0	0.35	0	0
Missing Rate	MR=	0	1	0.67	0	0
Correct non Occurrence	C Non=	0	0	0.03	0	0
Bais	BAIS=	1	1.03	1.03	1	1
Percentage Correct	PC=	97.06	97.06	91.18	94.12	97.06
	RMSE =	16.5	13.63	10.69	11.93	17.22
	Correct=	38.24	50	38.24	35.29	41.18
	Usable=	30.59	25.71	28.82	27.65	20.59

TABLE : 5

NORTH 24 PARGANAS (MONSOON 2019) MODEL VERSUS REALISED RAINFALL		DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Skill Score or Ratio Score of rainfall	RS=	88.24	85.29	82.35	82.35	82.35
Hanssen & Kuipers Index	HK score	0.22	0.24	-0.13	0.2	0.2
Probability of detection (POD)=	POD=	0.97	0.9	0.88	0.87	0.87
False alarm ratio (FAR) =	FAR=	0.09	0.07	0.07	0.07	0.07
Critical Success index (CSI)=	CSI=	0.88	0.85	0.82	0.82	0.82
Heidke Skill Score (HSS)=	HSS=	0.28	0.21	-0.09	0.16	0.16
Missing Rate	MR=	0.75	0.4	0.33	0.33	0.33
Correct non Occurrence	C Non=	0.03	0.03	0	0.04	0.04
Bais	BAIS=	1.07	1.03	1.07	1.04	1.04
Percentage Correct	PC=	88.24	85.29	82.35	82.35	82.35
	RMSE =	16.14	18.55	16.92	13.28	27.69
	Correct=	29.41	8.82	20.59	17.65	17.65
	Usable=	17.65	17.65	8.82	8.82	2.94

TABLE : 6

NORTH 24 PARGANAS (MONSOON 2019) MODERATED VALUE VERSUS REALISED RAINFALL		DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Skill Score or Ratio Score of rainfall	RS=	94.12	91.18	91.18	94.12	91.18
Hanssen & Kuipers Index	HK score	0.5	0.3	-0.03	0.33	0.6
Probability of detection (POD)=	POD=	1	0.97	0.97	1	0.94
False alarm ratio (FAR) =	FAR=	0.06	0.06	0.06	0.06	0.03
Critical Success index (CSI)=	CSI=	0.94	0.91	0.91	0.94	0.91
Heidke Skill Score (HSS)=	HSS=	0.64	0.35	-0.04	0.48	0.52
Missing Rate	MR=	1	0.67	0.67	1	0.33
Correct non Occurrence	C Non=	0.06	0.03	0	0.03	0.06
Bais	BAIS=	1	1.03	1.06	1.03	0.97
Percentage Correct	PC=	94.12	91.18	91.18	94.12	91.18
	RMSE =	11.46	9.13	12.31	10.38	9.17
	Correct=	41.18	41.18	44.12	47.06	29.41
	Usable=	17.65	14.71	11.76	11.76	17.65

TABLE : 7

NORTH 24 PARGANAS (MONSOON 2020) MODEL VERSUS REALISED RAINFALL		DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Skill Score or Ratio Score of rainfall	RS=	82.35	79.41	76.47	88.24	91.18
Hanssen & Kuipers Index	HK score	0.21	0.17	-0.16	0.23	0.24
Probability of detection (POD)=	POD=	0.82	0.84	0.84	0.88	0.91
False alarm ratio (FAR) =	FAR=	0	0.07	0.1	0	0
Critical Success index (CSI)=	CSI=	0.82	0.79	0.76	0.88	0.91
Heidke Skill Score (HSS)=	HSS=	0	0.12	-0.12	0	0
Missing Rate	MR=	0	0.29	0.38	0	0
Correct non Occurrence	C Non=	0	0.04	0	0	0
Bais	BAIS=	1	1.04	1.12	1	1
Percentage Correct	PC=	82.35	79.41	76.47	88.24	91.18
	RMSE =	23.87	24.03	21.5	16.37	27.92
	Correct=	8.82	8.82	11.76	8.82	17.65
	Usable=	11.76	8.82	5.88	8.82	8.82

TABLE : 8

NORTH 24 PARGANAS (MONSOON 2020) MODERATED VALUE VERSUS REALISED RAINFALL		DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Skill Score or Ratio Score of rainfall	RS=	97.06	94.12	88.24	94.12	97.06
Hanssen & Kuipers Index	HK score	0.54	0.33	-0.03	0.33	0.7
Probability of detection (POD)=	POD=	0.97	1	0.97	0.94	0.97
False alarm ratio (FAR) =	FAR=	0	0.06	0.09	0	0
Critical Success index (CSI)=	CSI=	0.97	0.94	0.88	0.94	0.97
Heidke Skill Score (HSS)=	HSS=	0	0.48	-0.05	0	0
Missing Rate	MR=	0	1	0.75	0	0
Correct non Occurrence	C Non=	0	0.03	0	0	0
Bais	BAIS=	1	1.03	1.1	1	1
Percentage Correct	PC=	97.06	94.12	88.24	94.12	97.06
	RMSE =	15.09	13.71	16.95	11.55	17.52
	Correct=	38.24	47.06	32.35	32.35	17.65
	Usable=	29.41	14.71	23.53	23.53	44.12

It is mentioned that sum of Correct & usable forecast together represents the total accuracy of forecast, quantitatively , The results has also been demonstrated by graphical representation in Figs.4 to 11 .

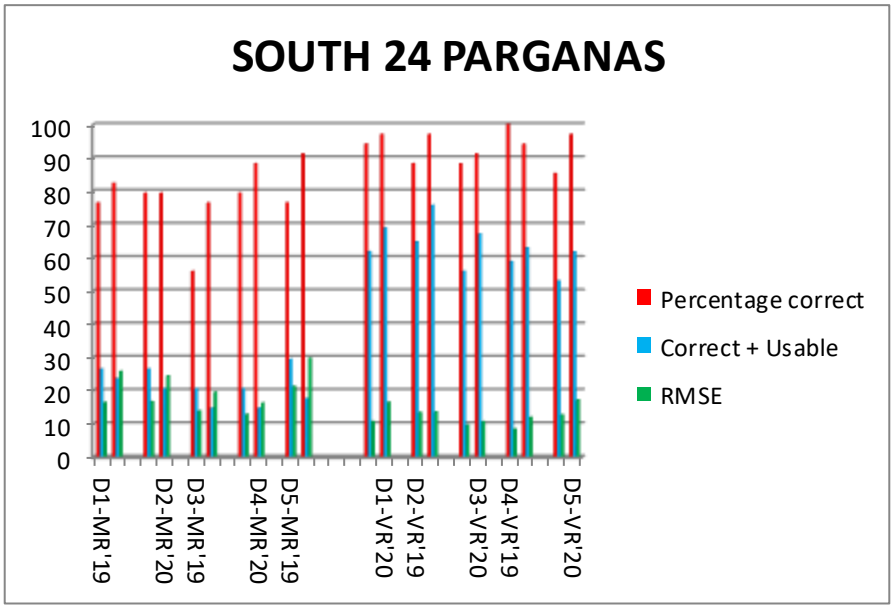

Fig.4. Correct+Usable, RMSE & PC of Day1 to Day5 of Model versus Realised (MR) of 2019 & 2020 and Value add versus Realised (VR) of 2019 & 2020 of South 24 PGNS

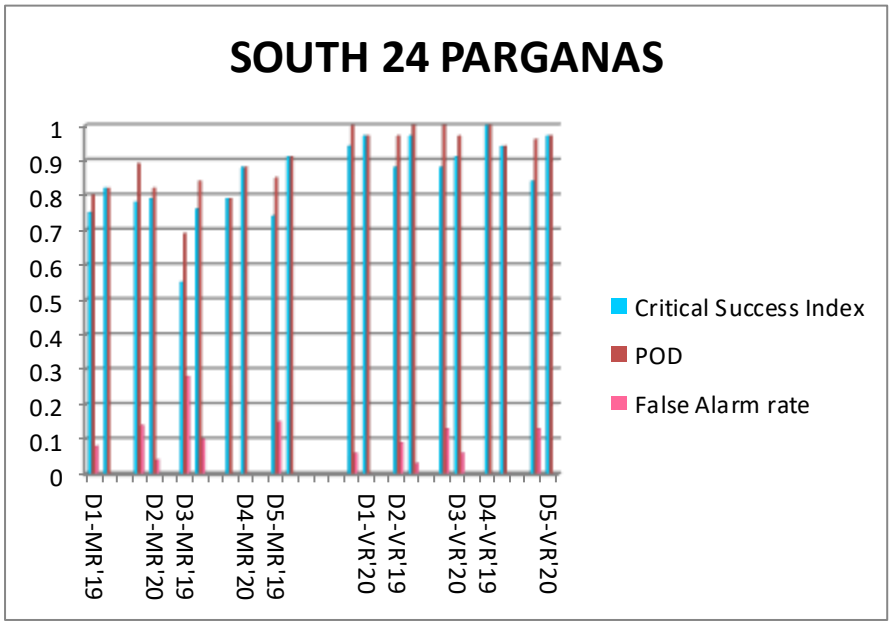

Fig 5. POD, FAR & CSI of Day1 to Day5 of Model versus Realised (MR)of 2019 & 2020 and Value add versus Realised (VR) of 2019 & 2020 of South 24 PGNS

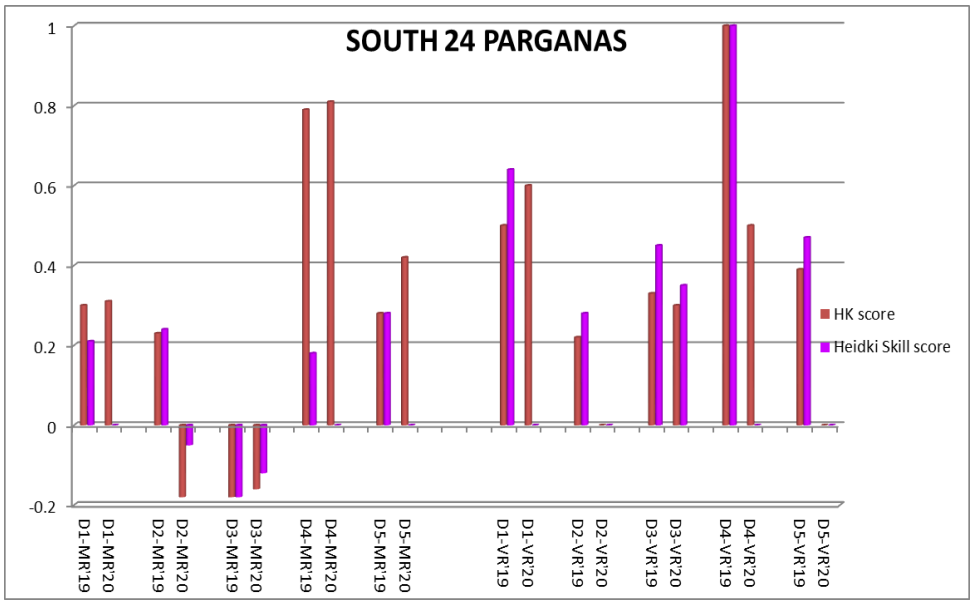

Fig-6 HK score & Hss of Day1 to Day5 of Model versus Realised (MR)of 2019 & 2020 and Value add versus Realised (VR) of 2019 & 2020 of South 24 PGNS

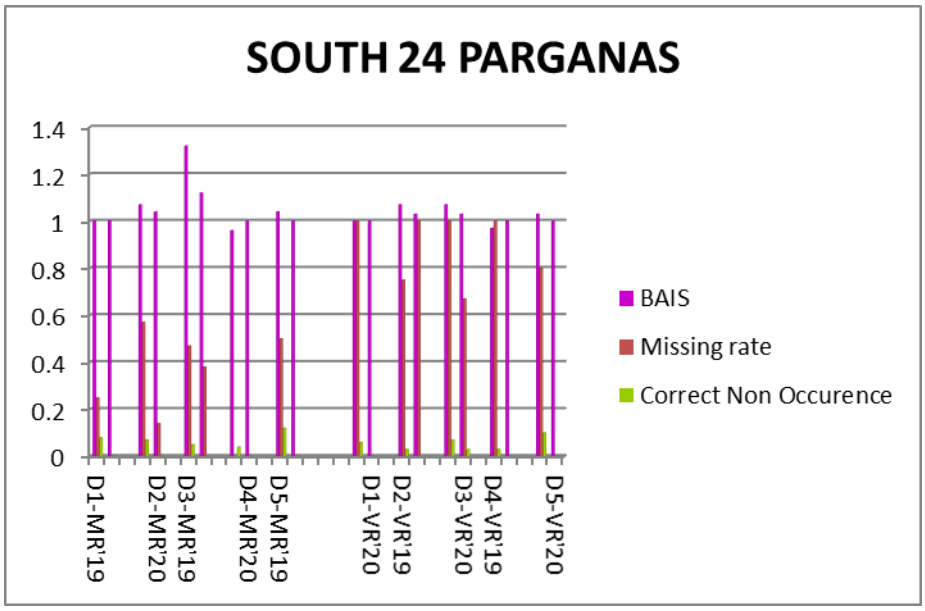

Fig 7. MR, Correct Non, Bais of Day1 to Day5 of Model versus Realised (MR)of 2019 & 2020 and Value add versus Realised (VR) of 2019 & 2020 of South 24 PGNS

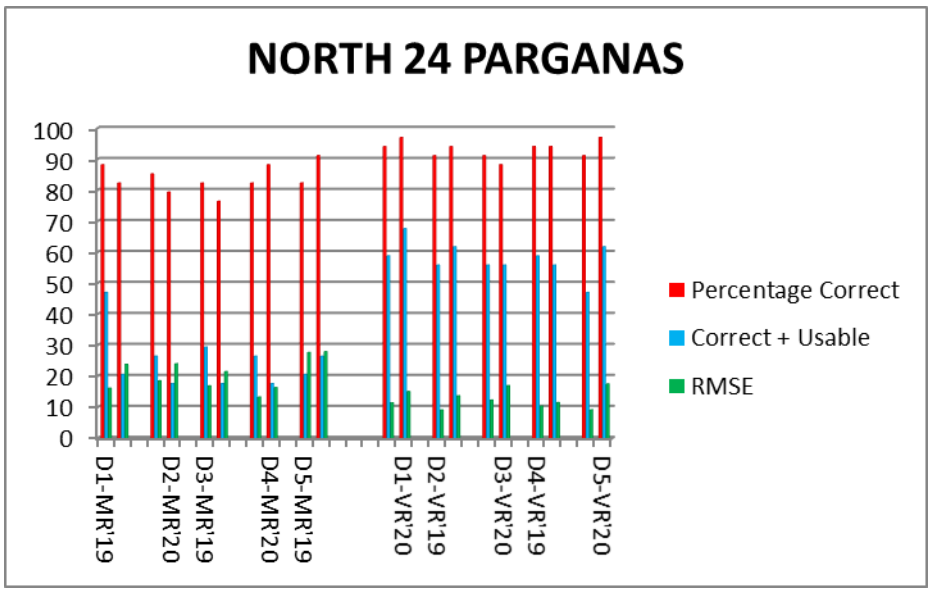

Fig 8. Correct+Usable, RMSE & PC of Day1 to Day5 of Model versus Realised (MR)of 2019 & 2020 and Value add versus Realised(VR) of 2019 & 2020 of North 24 PGNS

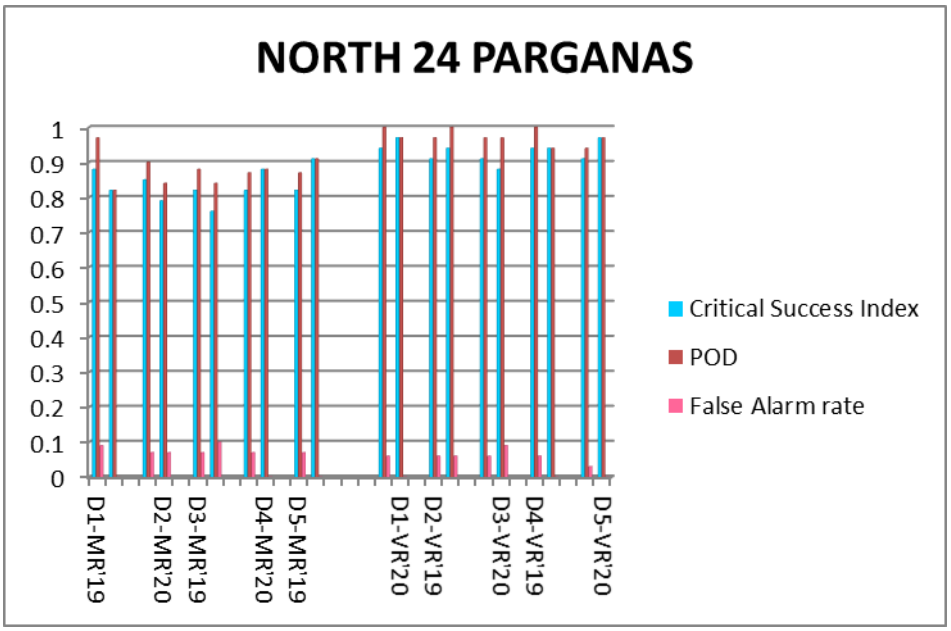

Fig 9. POD, FAR & CSI of Day1 to Day5 of Model versus Realised (MR)of 2019 & 2020 and Value add versus Realised (VR) of 2019 & 2020 of North 24 PGNS

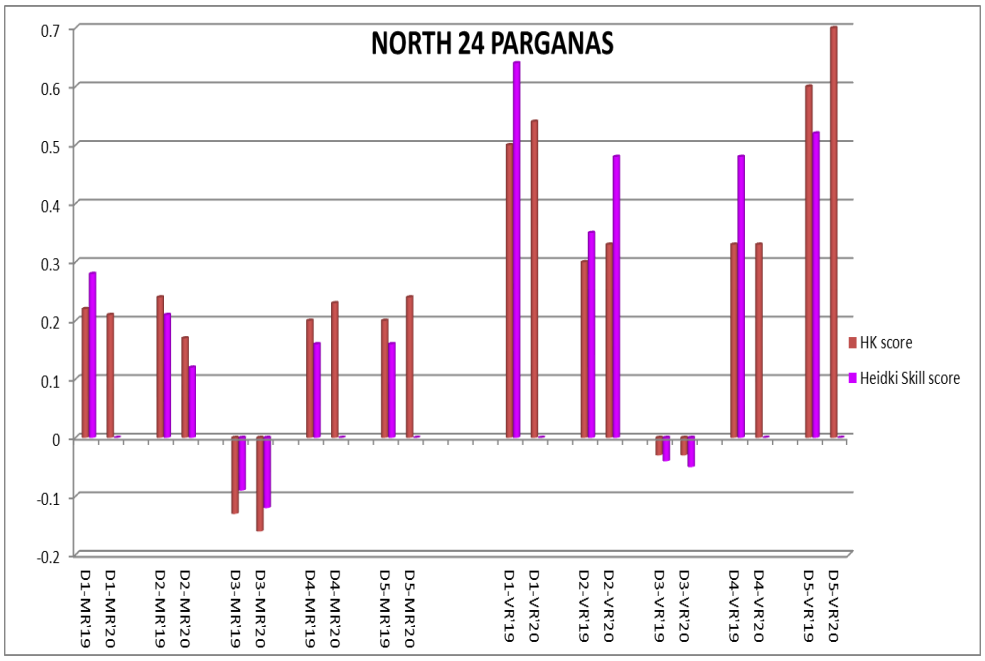

Fig 10. HK score & Hss of Day1 to Day5 of Model versus Realised (MR)of 2019 & 2020 and Value add versus Realised (VR) of 2019 & 2020 of North 24 PGNS

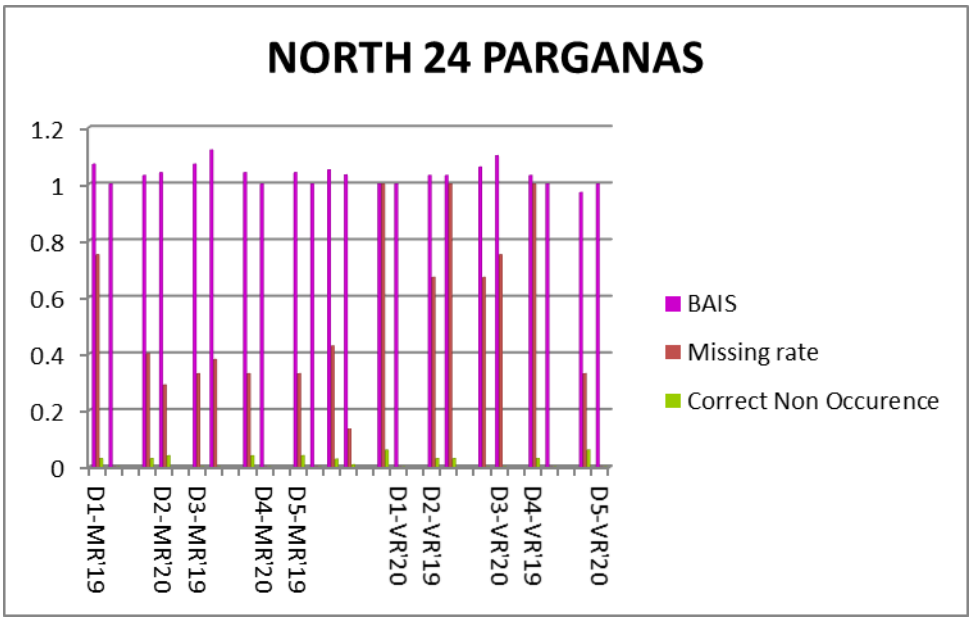

Fig 11. MR, Correct Non, Bais of Day1 to Day5 of Model versus Realised (MR)of 2019 & 2020 and Value add versus Realised (VR) of 2019 & 2020 of North 24 PGNS.

(A) Rainfall verification

Based on the criteria mentioned, the forecast verification has been performed of model versus realized monsoon rainfall '2019 and 2020 of South 24 Pargana district and its suburb North 24 Pargana district which is exposed to more pollution due to city status and where IMD observatories are located and data is authentic (one met. the observatory is in Alipore, Kolkata which is representative of South 24 Parganas district and another met. the observatory is in the Dumdum Airport area which is representative of the North 24 Parganas district). The same has been done for moderated value versus realized monsoon rainfall in '2019 and 2020. It may be noted that in IMD, the monsoon season is considered as months - June, July, August and September.

V. Conclusion

Given the importance of the District Level Weather Forecast (DLWF) for the preparation of good quality Agromet advisories, the initiative has been taken by the SAMC and MC of IMD to verify the quality of DLWF for further improvement of the accuracy of the forecast. Rainfall for the monsoon season has been considered for in-depth verification because rainfall affects the more in agriculture productivity. This verification report has been prepared based on two years of data especially to study the aberration of the forecast during monsoon that is given by the model and the forecaster (who uses his knowledge) during the unique situation of the weather being non exposed to various pollution effects(which happened during lockdown due to covid i.e monsoon 2020) against weather being exposed to various pollution effects (which normally happens during non-lock down due to non-covid i.e monsoon 2019). Extensive efforts have to be made in this region by the researchers in collaboration

with the National Weather Forecasting Centre (NWFC) and Agricultural Meteorological Division, IMD, Pune, to incorporate various indexes and parameters in running the model, for the improvement of the quality of the forecast. The observations from the verification results of rainfall are summarized below :

(i) Qualitatively the model forecast and the forecaster who performs value addition of model forecast, for rainfall, can predict correctly and capture the event in this region.

Statistics for the model forecast are as follows:

* The average Percentage accuracy for five days for South 24 Parganas of the model was approx. 73.5% in 2019 and 83.5 % in 2020 and for North 24 Parganas of the model was approx. 84.1% in 2019 and 83.5% in 2020.
* The average H.K score for five days for South 24 Parganas of the model was approx. 0.28 in 2019 and 0.24 in 2020 and for North 24 Parganas of the model was approx. 0.15 in 2019 and 0.14 in 2020.
* The average POD for five days for South 24 Parganas of the model was approx. 0.80 in 2019 and 0.85 in 2020 and for North 24 Parganas of the model was approx. 0.90 in 2019 and 0.86 in 2020.
* The average FAR for five days for South 24 Parganas of the model was approx. 0.13 in 2019 and 0.03 in 2020 and for North 24 Parganas of the model was approx. 0.07 in 2019 and 0.03 in 2020.
* The average CSI for five days for South 24 Parganas of the model was approx. 0.72 in 2019 and 0.83 in 2020 and for North 24 Parganas of the model was approx. 0.84 in 2019 and 0.83 in 2020.
* The average HSS for five days for South 24 Parganas of the model was approx. 0.15 in 2019 and -0.03 in 2020 and for North 24 Parganas of the model was approx. 0.14 in 2019 and 0.0 in 2020.
* The average MR for five days for South 24 Parganas of the model was approx. 0.36 in 2019 and 0.10 in 2020 and for North 24 Parganas of the model was approx. 0.43 in 2019 and 0.13 in 2020.
* The average C.Non for five days for South 24 Parganas of the model was approx. 0.07 in 2019 and 0.0 in 2020 and for North 24 Parganas of the model was approx. 0.03 in 2019 and 0.01 in 2020.
* The average Bais for five days for South 24 Parganas of the model was approx. 1.08 in 2019 and 1.03 in 2020 and for North 24 Parganas of the model was approx. 1.05 in 2019 and 1.03 in 2020.
* The average RMSE for five days for South 24 Parganas of the model was approx. 16.25 in 2019 and 23.13 in 2020 and for North 24 Parganas of the model was approx. 18.52 in 2019 and 22.74 in 2020.

Statistics for Value addition are as follows:

* The average Percentage accuracy for five days for South 24 Parganas of value addition was approx. 91.2% in 2019 and 95.3 % in 2020 and for North 24 Parganas of value addition was approx. 92.4 % in 2019 and 94.1 % in 2020.
* The average H.K score for five days for South 24 Parganas of value addition was approx. 0.49 in 2019 and 0.28 in 2020 and for North 24 Parganas of value addition was approx. 0.34 in 2019 and 0.37 in 2020.

* The average POD for five days for South 24 Parganas of value addition was approx. 0.99 in 2019 and 0.97 in 2020 and for North 24 Parganas of value addition was approx. 0.98 in 2019 and 0.97 in 2020.
* The average FAR for five days for South 24 Parganas of value addition was approx. 0.08 in 2019 and 0.02 in 2020 and for North 24 Parganas of value addition was approx. 0.05 in 2019 and 0.03 in 2020.
* The average CSI for five days for South 24 Parganas of value addition was approx. 0.91 in 2019 and 0.95 in 2020 and for North 24 Parganas of value addition was approx. 0.92 in 2019 and 0.94 in 2020.
* The average HSS for five days for South 24 Parganas of value addition was approx. 0.57 in 2019 and 0.07 in 2020 and for North 24 Parganas of value addition was approx. 0.39 in 2019 and 0.09 in 2020.
* The average MR for five days for South 24 Parganas of value addition was approx. 0.91 in 2019 and 0.33 in 2020 and for North 24 Parganas of value addition was approx. 0.73 in 2019 and 0.35 in 2020.
* The average C.Non for five days for South 24 Parganas of value addition was approx. 0.06 in 2019 and 0.01 in 2020 and for North 24 Parganas of value addition was approx. 0.04 in 2019 and 0.01 in 2020.
* The average Bais for five days for South 24 Parganas of value addition was approx. 1.03 in 2019 and 1.01 in 2020 and for North 24 Parganas of value addition was approx. 1.02 in 2019 and 1.03 in 2020.
* The average RMSE for five days for South 24 Parganas of value addition was approx. 10.98 in 2019 and 13.99 in 2020 and for North 24 Parganas of value addition was approx. 10.49 in 2019 and 14.96 in 2020.

(ii) Quantitatively the accuracy level still needs to be improved for this region.

Statistics for the model forecast are as follows:

* The average Correct + Usable for five days for South 24 Parganas of the model was approx. 24.70 % in 2019 and 18.23 % in 2020 and for North 24 Parganas of the model was approx. 30.0 % in 2019 and 19.99 % in 2020.

Statistics for Value addition is as follows:

* The average Correct + Usable for five days for South 24 Parganas of the model was approx. 58.82 % in 2019 and 67.26 % in 2020 and for North 24 Parganas of the model was approx. 55.30 % in 2019 and 60.59 % in 2020.

(iii) Thus it is observed from the quantitative forecast analysis of value addition against realized rainfall, that the percentage of correct and usable has increased markedly in monsoon 2020 i.e lockdown period than that of monsoon 2019 i.e non-lockdown period which subsequently gives a hint that pollution does affect the occurrence of rainfall. The poor percentage of correct and usable models against realized rainfall implies that the model has to be more refined by incorporating other parameters for making it fully automatic. Though more studies have to be done in this area for drawing solid inferences, what is regretful is that this unique situation will not arise frequently and so the authors tried to capture the aberrations in the weather events during this period.

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Conflicts of Interest:

There is no conflict of interest regarding this article

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