Recent Performance of Agro meteorological Services for Uttar Pradesh

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ABSTRACT

Deterministic quantitative district level weather forecast for 5 days is being issued on operational basis for the agriculture sector since 1st June, 2008. These forecast products comprise of quantitative forecasts for total eight weather parameters, viz., rainfall, maximum and minimum temperatures, wind speed and direction, maximum and minimum relative humidity and cloudiness. This quantitative forecast is primarily based on GFS-T1534 Global NWP Model which is disseminated to 7 AMFUs and the DAMUs under their jurisdiction through Agro-DSS after proper value addition based on Synoptic Guidance & Diagnostics supportedby objective guidance from other available NWP models appended with adverse weather warnings in textual format by SAMC Lucknow for preparation of weather based District Agromet Advisory Service bulletin under GraminKrishiMausamSewa. This study discusses the recent advances in performance skill of the operational district level weather forecasts over different parts of the state during different seasons of the year 2020. The verification results show that value added weather forecasts are reasonably accurate for operational sectoral application.

Keywords: *NWP, Multi-model ensemble, District level weather forecast, Skill scores, Verification, District Agromet Advisory Service bulletin and GraminKrishiMausamSewa.*

1. Introduction

Uttar Pradesh (UP) occupies an important place in the polity and economy of the country. The economy of UP is predominately agrarian. UP, India's most populous state, is the fourth largest state of India after Rajasthan, Maharashtra and Madhya Pradesh bound between the between 24˚ - 31˚N latitude and 77˚-84˚E longitude, occupies 7.33% area of the country comprises of two meteorological subdivisions viz. East UP & West UP and nine agro-climatic zones. About 60% population of the state is engaged in the agricultural sector and it stands first in terms of food grain production in the country as the state of UP alone contributes about 20% of the total food grains production of the country. The performance of agriculture and allied activities such as horticulture, animal husbandry, dairying & fisheries is critical in determining the growth rate of the State. The total area of the state is 240928 sq. km that has been divided into 18 Subdivisions, 75 districts, 315 tehsils and 826 community blocks (State Portal, Government of Uttar Pradesh). The total cultivated area of the state is 166.83 lakh hectares and the gross cropped area is 255.24 lakh hectares. The cropping intensity of the state is 153%. The agriculture contributes highest 66% to the Gross State Domestic Product (GSDP). Primarily based on the Rainfall and Soil, the state of Uttar Pradesh is further divided into 9 agro-climatic (Figure 1) zones/regions (Gulati et al. 2021).

Bhabar and Tarai Region includes the regions along the foothills of Himalayas comprising northern parts of Saharanpur, Muzaffarnagar, Bijnor, Moradabad, Rampur, Bareilly, Pilibhit, Lakhimpur Kheri, Bahraich and Shravasti districts. Central Western Plains includes regions of Rohilkhand i.e. Bareillyand Moradabad divisions. Western Plains includes Meerut division& surrounding areas of Saharanpur division. Semi-Arid Southern-Western Plains comprises Agra&Aligarh divisions. Central Plains includes Kanpur and Lucknow division along with Fatehpur district. Bundelkhand Region comprises Jhansi and Chitrakoot divisions. Northern-Eastern Plains includes Gorakhpur division and major parts of Devipatan division. Eastern Plains comprises Varanasi, Ayodhya and Azamgarh division and major parts of Prayagraj division. The last agro-climatic Vindhyan Region comprise regions of Mirzapur, Sonbhadra and Southern parts of Prayagraj district.

The varying Weather/climatic conditions in these agro-climatic zones and various geographical features play a dominant role in year-to-year

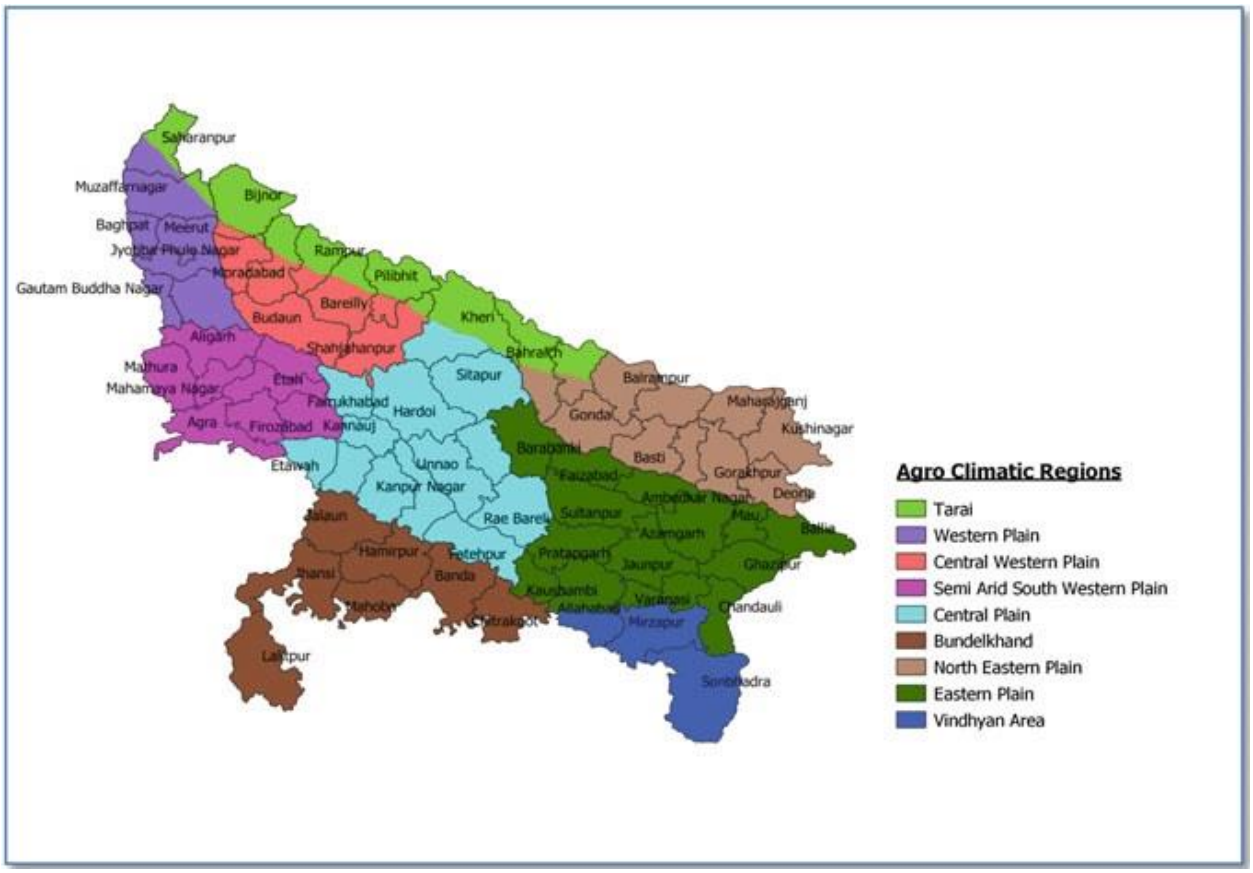

Figure 1: Agro-climatic zones of Uttar Pradesh.

fluctuation in crop production; both in rain fed or irrigated agriculture. Though complete avoidance of farm losses due to weather is not possible, however losses can be minimized to a considerable extent by making adjustments, through timely agricultural operation and accurate weather forecasts. General Weather Forecasts based on the temporal validity are of four types, viz., nowcasting (3 hrs), short range forecast (valid upto 72 hours), medium range (valid for 5-10 days), extended range (up to 2-4 weeks) and long-range or seasonal forecast (valid for month to season).

Generalized forecasts have, however, limited use in farming. Weather information for agricultural operations shall be a tailored product that can be effectively used in crop planning and its management. A comprehensive weather based farm advisory is an interpretation of how the weather parameters, in future and present will affect crops, livestock, farm operations and suggests actions to be taken. The Agro-Met Advisory Services (AAS) is supposed to be more effective if they are given in simple and local language that farmers can understand it. In order to make the AAS more successful and continuous process, it is to be supported with: (a) agro meteorological database, (b) crop conditions, (c) real time weather, research results on crop-weather relationships, and (d) skilled manpower in multidisciplinary resources and users interface. Keeping all these aspects in view, this project is proposed to take the AAS to the doorsteps of farmers, by using the latest emerging IT and web technologies.

Realizing the importance of weather information in agriculture, the Indian Meteorological Department (IMD) of the Ministry of Earth Sciences in active collaboration with Indian Council of Agricultural research (ICAR), State Agriculture Universities (SAUs) and other allied organizations started rendering weather forecast based District level Agrometeorological Advisory Services (AAS) for benefits of farmers in the country under the scheme “GraminKrishiMausamSewa (GKMS). AAS provides advance weather information along with crop specific agro-met advisories to the farming community by using state of the art technology

through efficient delivering mechanism of the information which ultimately enables farmers to take appropriate actions at farm level.

State Agro-Meteorological Centre of Uttar Pradesh started in 1987 with inception of Meteorological Centre Lucknow to extend meteorological services to the farming community in the state. Agro-meteorological Advisory Unit is regularly issuing State Composite Agro-met Advisory Bulletins Bi-weekly (in Bi-Lingual) on every Tuesday and Friday in co-ordination with the State Agricultural University and State Agricultural Department for the benefit of the farming community in the state. Seven Agro-met Field (Figure 2) Units (AMFU) at Modipuram (Meerut), Kanpur, Bahraich, Faizabad (Now Ayodhya), Allahabad (Now Prayagraj), Varanasi (BHU) and Bharari (Jhansi) of Uttar Pradesh are also issuing district-wise Agro-met Advisory Bulletins Bi-weekly (in bi-lingual) on every Tuesday and Friday. In each district, agro-met advisory (Figure 3) is being issued by District Agro Meteorological Units (DAMUs) and 7 AMFUs at block level for their respective districts.

Quantitatively, deterministic Numerical Weather Forecast (NWP) for 8 different meteorological parameters based on GFS-T1534 NWP Model output running operationally at 12.5 Km spatial resolution has been utilized as primary guidance for generation of the district level dataset after proper value addition based on various Synoptic Inputs & Diagnostics supported by objective guidance from other available NWP models, which are considered useful from the agriculture perspective, valid for next five days is being issued on bi-weekly basis at District level covering all 75 Districts of the state and a thorough verification mechanism is followed for evaluation of the performance. Sridevi et al. (2019) evaluated the deterministic rainfall forecasts from two different versions of IMD's operational Global Forecast System (GFS) Model viz. GFS T-574 & GFS T-1534 over Indian regions for hydro-meteorological applications and found that GFS T-1534 shows a relatively high skill compared to GFS T-574 over North India for day-1 to day-5 forecasts particularly on Day-4 & Day-5 which signifies that newer version of the GFS simulates Indian monsoon rainfall more realistically than the previous versions, with much reduced biases in the core monsoon trough region. This is the reason why GFS T-1534 model products have been utilized in this study.In this study the forecast performance in different Agro-Climatic Zones of Uttar Pradesh has been presented during different seasons for the state of U.P.

Nowcast information on extreme weather events like cyclone, thunderstorm and hailstorm etc are provided to the farmers in advance through SMS/Various social media platforms in order to take necessary action. Extended range forecast are also translated in advisory for outlook for next 15 days with weekly update on every Thursday to help the farmers, planners and other stakeholders. In the wake of changing climate leading to more uneven distribution of rainfall and other weather elements spatially and temporally, block level weather based services to farmers is being implemented by IMD and ICAR by establishing District Agro-Meteorological Units (DAMUs) at Krishi Vigyan Kendra (KVK) in each district. 17 such DAMUs are already functional in 17 districts across the state, which are issuing Block Level Advisories in consultation with respective AMFUs & MC Lucknow, however process for establishment of further 37 DAMUs is in the final stage. The various components of GKMS service viz. observing weather, its monitoring and forecast; crop specific advisory bulletin generation; outreach and feedback have been digitized on an integrated platform, called automated Agromet Decision Support System. This includes a dynamic framework to link the existing knowledge base on crop weather calendar, contingency action plan etc. to translate weather forecast into actionable farm advisories for efficient farm level decision making.

These bulletins are transmitted to media viz. AIR, Doordarshan, Community Radio etc. in local language for the use of farmers and other user agencies. Weather Forecast and Agro Advisories are also being sent through SMS to more than 1.35 Cr registered farmers of the state on their registered mobile numbers through m-Kisan Portal, which was fully functional operational till Pre-COVID Era of 2020. Along withmass media& social media platforms, other modes of communication such as

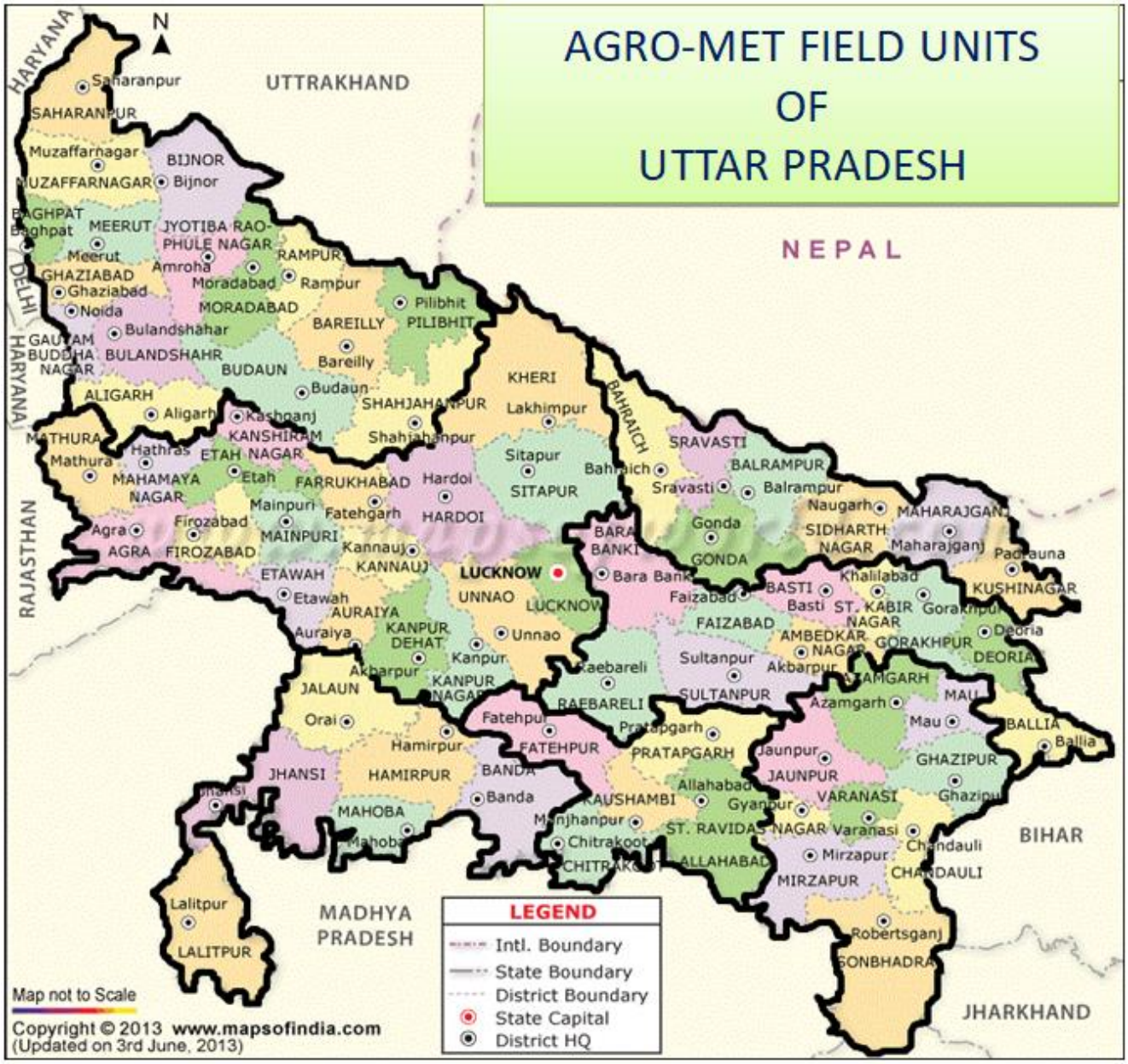

Figure 2: Agro-met Field Units in Uttar Pradesh.

'Kisan Call Center' and 'Text To Speechare' being aggressively used to maximize our outreach. Also, these bulletins are being transmitted through Web Servers & Smartphone/I-phone Apps (Meghdoot) to the registered users for their area of concern besides being uploaded in the website.

Verification of the forecasts is an important activity as it not only helps to monitor the forecast quality, but also helps greatly to improve the skill of forecasting systems. Therefore, an attempt has been made to conduct systematic verification of forecast of deterministic agricultural forecast as per to Murfy (1993). There are three goodness of forecast verification:

(i) Consistency - Forecasts agree with forecaster's true belief about the future weather.

(ii) Quality - Correspondence between observations & forecasts.

(iii) Value - Incremental benefits of forecasts to users.

In this study, forecast verification of 5 day deterministic quantitative forecast for agriculture sector issued by State Agro-Meteorological Centre (SAMC) Lucknow for different districts of Uttar Pradesh has been carried out by using a 2×2 contingency table (Wilks, 1995) during the year 2020.

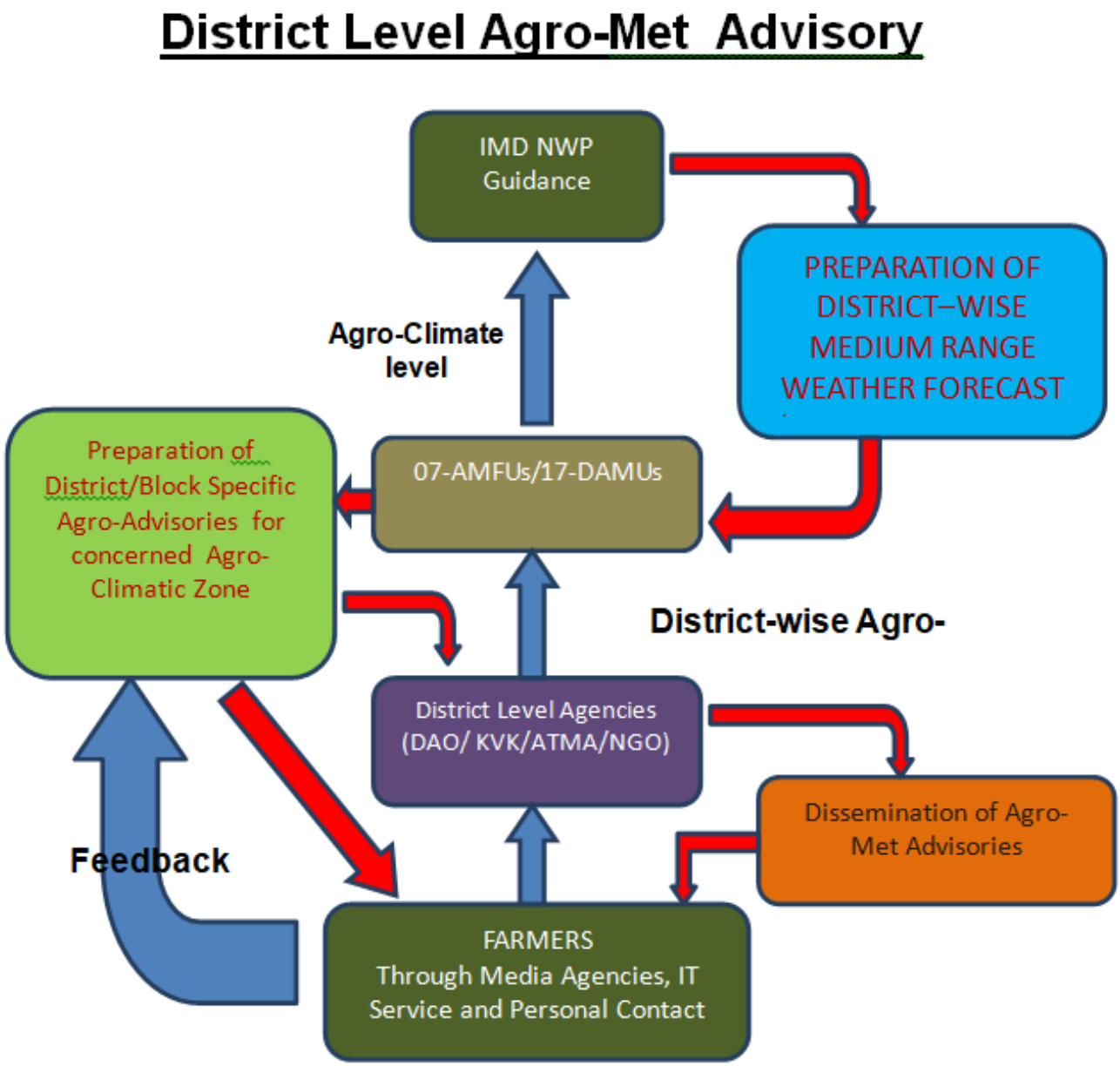

Figure 3: District level agro-met advisory in Uttar Pradesh.

2. Data and Methodology

The station observation data for different seasons of the year 2020 of various representative stations across the state has been obtained from the IMD archive and utilised for the statistical verification of the deterministic NWP Elements for next five days available on Agro DSS Portal.

SAMC is issuing weather forecast valid up to next 120 hours for the 9 Agro Climatic Zones containing 75 districts (Figure 1). In present study we have adopted categorical dichotomous forecast verification scheme (Mariani and Casaioli, 2008), i.e., yes/no statement. To calculate seasonal performance over a year, forecast-observation pairs are pooled in space and time for the year 2020. This technique will lead to only small uncertainty in the values of the daily-monthly-seasonal scores. In this Forecast Verification Process Different Statistical Skill Scores viz. Probability of Detection (POD), False Alarm Ratio (FAR), Missing Rate (MR), Correct Non Occurrence (C-NON), Percentage Correct (PC), Critical Success Index (CSI), BIAS, True Skill Statistics (TSS) & Heidke Skill Scores (HSS) have been computed on seasonal scale to assess the utility usability of the forecast within permissible limits.

The various forecast verification methods are described in Stanski et al. (1989) and Wilks (1995). Heavy rainfall occurrence is a dichotomous and deterministic variable. Accordingly, the suitable verification methods have been used in the study using a 2×2 contingency table (Wilks, 1995) as given in Table 1.

Table 1. Wilks 2x2 contingency table.

		FORECAST	
		YES	NO
OBSERVED	YES	A (Hit)	B (False Alarm)
	NO	C (Miss)	D (Correct Rejection)

Using this contingency table, the following indices have been calculated.

Probability of detection (POD) = A/ (A+B)

False alarm rate (FAR) = C/(C+A)

Missing rate (MR) = B/ (B+A)

Correct nonoccurrence (C-NON)=D/(C+D)

Critical success index (CSI) = Threat score = A/(A+B+C)

Bias for occurrence (BIAS) = (A+C)/(A+B)

Percentage correct (PC) = (A+D)/(A+B+C+D)*100 = Hit rate*100

Heidke skill score (HSS) = 2(AD-BC)/ [(B^2 +C^2 +2AD+(B+C)(A+D)]

For a perfect forecast, POD = 1, FAR = 0, MR = 0, CSI = 1, BIAS = 1, PC = 100% and HSS = 1.

3. Results and Discussion

The results of verification of Quantitative Agro-met Forecast for the year 2020 for different seasons have been presented and discussed for different representative stations. The verification results of agro-meteorological NWP are presented in Table 2 (a-i).

3.1 Winter season

The results of Winter season forecast shows that POD has been found to be between 0.7-1.0 for most of the days in 5 day forecast period except some minor variations from station to station which indicates a very good predictability skill of Winter Season Rainfall induced mostly due to movement of extra-tropical disturbances which comes as a very handy utilizable parameter from agro-meteorological perspective of UP state. Similarly the MR has been quite low & many times zero which is another complementary indicative of good forecast skill towards detection. On contrary, the FAR has also been quite small ranging between 0-0.3 except occasional chances which shows that the skill of forecast towards over prediction was also within admissible ranges and similarly the Correct Non Occurrence value close to 1 almost during entire 5 day forecast period again indicates that no events have also been predicted with great accuracy. Now, when we discuss about the HSS parameters we observe that the value of critical success index that determines the threat score has considerably good value above 0.7 most of the occasions except few exceptions which indicates towards the good predictability skills of rare events. Similarly the values of HSS have most of the time been above 0.8 which shows that the fractional improvement over random chances has been quite good. Despite all these parameters for assessment of skill, the direct measure of the skill PC also shows the values great than 94% most of the times which itself is a very good indicative of the improved forecast skill in recent years.

3.2 Pre-Monsoon season

The results of Pre-Monsoon season forecast shows that POD has been above 0.8 most of the times almost for all five days except some minor variations from station to station which indicates a very good skill towards capturing the Agrometeorological parameters over the state of UP. Similarly, the MR has been quite low (below 0.2) on most of the occasions which is another complementary indicative of good forecast skill towards detection. On the contrary, the FAR has also been quite small ranging between 0.1-0.3 except occasional chances which shows that the skill of forecast towards over prediction was also within admissible ranges and similarly the C-NON value close to 1 (always above 0.9) almost during entire 5 day forecast period again indicates that no

Table 2. (a-i) The verification results of agro-meteorological NWP.

(a) BHABHAR & TARAI REGION Representative Station: BAHRAICH					
Skill Scores	**WINTER SEASON (JF-2020)**				
	Day1	Day2	Day3	Day4	Day5
POD	**1.0**	**1.0**	**0.5**	**1.0**	**1.0**
FAR	**0.3**	**0.0**	**0.7**	**0.0**	**0.3**
MR	**0.0**	**0.0**	**0.5**	**0.0**	**0.0**
C-NON	**0.9**	**1.0**	**0.9**	**1.0**	**0.9**
CSI	**0.8**	**1.0**	**0.3**	**1.0**	**0.7**
BIAS	**1.3**	**1.0**	**1.5**	**1.0**	**1.5**
PC	**94.1**	**100.0**	**82.4**	**100.0**	**94.1**
TSS	**0.9**	**1.0**	**0.4**	**1.0**	**0.9**
HSS	**0.8**	**1.0**	**0.4**	**1.0**	**0.8**

(b) WESTERN PLAIN ZONE Representative Station: MEERUT					
Skill Scores	**WINTER SEASON (JF-2020)**				
	Day1	Day2	Day3	Day4	Day5
POD	**0.8**	**1.0**	**0.7**	**0.7**	**1.0**
FAR	**0.0**	**0.3**	**0.0**	**0.0**	**0.3**
MR	**0.2**	**0.0**	**0.3**	**0.3**	**0.0**
C-NON	**1.0**	**0.9**	**1.0**	**1.0**	**0.9**
CSI	**0.8**	**0.7**	**0.7**	**0.7**	**0.8**
BIAS	**0.8**	**1.5**	**0.7**	**0.7**	**1.3**
PC	**94.1**	**94.4**	**94.1**	**94.1**	**94.1**
TSS	**0.8**	**0.9**	**0.7**	**0.7**	**0.9**
HSS	**0.9**	**0.8**	**0.8**	**0.8**	**0.8**

(c) CENTRAL WESTERN PLAIN ZONE Representative Station: BAREILLY					
Skill Scores	**PRE-MONSOON SEASON (MAM-2020)**				
	Day1	**Day2**	**Day3**	**Day4**	**Day5**
POD	**0.8**	**0.8**	**0.5**	**0.9**	**0.9**
FAR	**0.2**	**0.3**	**0.4**	**0.1**	**0.1**
MR	**0.2**	**0.2**	**0.5**	**0.1**	**0.1**
C-NON	**1.0**	**0.9**	**0.9**	**0.9**	**0.9**
CSI	**0.7**	**0.6**	**0.4**	**0.8**	**0.8**
BIAS	**1.0**	**1.2**	**0.8**	**1.0**	**1.0**
PC	**92.3**	**88.5**	**81.5**	**92.3**	**92.3**
TSS	**0.8**	**0.7**	**0.4**	**0.8**	**0.8**
HSS	**0.8**	**0.7**	**0.5**	**0.8**	**0.8**

(d) NORTH-EASTERN PLAIN ZONE Representative Station: GORAKHPUR					
Skill Scores	**PRE-MONSOON SEASON (MAM-2020)**				
	Day1	**Day2**	**Day3**	**Day4**	**Day5**
POD	**0.5**	**0.6**	**0.4**	**0.6**	**0.4**
FAR	**0.3**	**0.2**	**0.5**	**0.4**	**0.2**
MR	**0.5**	**0.4**	**0.6**	**0.4**	**0.6**
C-NON	**0.9**	**0.9**	**0.9**	**0.8**	**0.9**
CSI	**0.4**	**0.6**	**0.3**	**0.4**	**0.4**
BIAS	**0.8**	**0.8**	**0.8**	**1.0**	**0.6**
PC	**76.9**	**84.6**	**81.5**	**76.9**	**76.9**
TSS	**0.4**	**0.6**	**0.3**	**0.4**	**0.4**
HSS	**0.5**	**0.6**	**0.4**	**0.5**	**0.5**

(e) CENTRAL PLAIN ZONE Representative Station: FURSATGANJ-RAIBAREILLY					
Skill Scores	**MONSOON SEASON (JJAS-2020)**				
	Day1	**Day2**	**Day3**	**Day4**	**Day5**
POD	**0.6**	**0.8**	**0.6**	**0.5**	**0.7**
FAR	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**
MR	**0.4**	**0.2**	**0.4**	**0.5**	**0.3**
C-NON	**1.0**	**0.9**	**1.0**	**1.0**	**1.0**
CSI	**0.6**	**0.7**	**0.6**	**0.5**	**0.7**
BIAS	**0.6**	**0.9**	**0.6**	**0.5**	**0.7**
PC	**62.9**	**82.9**	**70.6**	**57.1**	**77.1**
TSS	**0.6**	**0.7**	**0.6**	**0.5**	**0.7**
HSS	**0.4**	**0.7**	**0.5**	**0.3**	**0.6**

(f) BUNDELKHAND ZONE Representative Station: JHANSI					
Skill Scores	**MONSOON SEASON (JJAS-2020)**				
	Day1	Day2	Day3	Day4	Day5
POD	**0.6**	**0.4**	**0.7**	**0.5**	**0.5**
FAR	**0.2**	**0.4**	**0.2**	**0.2**	**0.3**
MR	**0.4**	**0.6**	**0.3**	**0.5**	**0.5**
C-NON	**0.8**	**0.7**	**0.6**	**0.8**	**0.7**
CSI	**0.5**	**0.3**	**0.6**	**0.5**	**0.4**
BIAS	**0.7**	**0.7**	**0.8**	**0.7**	**0.7**
PC	**65.7**	**57.1**	**64.7**	**62.9**	**57.1**
TSS	**0.4**	**0.2**	**0.3**	**0.3**	**0.2**
HSS	**0.5**	**0.4**	**0.4**	**0.4**	**0.4**

(g) SEMI ARID SOUTH-WESTERN PLAIN ZONE Representative Station: ALIGARH					
Skill Scores	**POST MONSOON SEASON (OND-2020)**				
	Day1	Day2	Day3	Day4	Day5
POD	**-**	**-**	**-**	**1.0**	**-**
FAR	**-**	**-**	**-**	**0.0**	**-**
MR	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
C-NON	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
CSI	**-**	**-**	**-**	**1.0**	**-**
BIAS	**-**	**-**	**-**	**1.0**	**-**
PC	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
TSS	**-**	**-**	**-**	**1.0**	**-**
HSS	**-**	**-**	**-**	**1.0**	**-**

(h) VINDHYAN ZONE Representative Station: CHURK-SONBHADRA					
Skill Scores	**POST MONSOON SEASON (OND-2020)**				
	Day1	Day2	Day3	Day4	Day5
POD	**0.3**	**0.3**	**0.7**	**0.0**	**0.3**
FAR	**0.7**	**0.5**	**0.3**	**1.0**	**0.5**
MR	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**
C-NON	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**
CSI	**0.2**	**0.3**	**0.5**	**0.0**	**0.3**
BIAS	**1.0**	**0.7**	**1.0**	**0.3**	**0.7**
PC	**84.6**	**88.5**	**92.3**	**84.6**	**88.5**
TSS	**0.2**	**0.3**	**0.6**	**0.0**	**0.3**
HSS	**0.3**	**0.4**	**0.6**	**0.0**	**0.4**

(i) EASTERN PLAIN ZONE Representative Station: VARANASI					
Skill Scores	**POST MONSOON SEASON (OND-2020)**				
	Day1	Day2	Day3	Day4	Day5
POD	**1.0**	**0.3**	**0.5**	**0.4**	**0.2**
FAR	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**
MR	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
C-NON	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
CSI	**1.0**	**0.3**	**0.4**	**0.4**	**0.2**
BIAS	**1.0**	**0.3**	**0.8**	**0.4**	**0.2**
PC	**100.0**	**92.6**	**88.5**	**88.5**	**84.6**
TSS	**1.0**	**0.3**	**0.5**	**0.4**	**0.2**
HSS	**1.0**	**0.5**	**0.5**	**0.5**	**0.3**

events have also been predicted with great accuracy. Now, when we discuss about the HSS we observe that the value of critical success index that determines the threat score has considerably good value ranging between 0.6 – 0.8 most of the occasions except few exceptions which indicates

towards the good predictability skills of rare events. Similarly the values of HSS have most of the time been above 0.7 which shows that the fractional improvement over random chances has been quite good. Despite all these parameters for assessment of skill, the direct measure of the skill PC also shows the values close to 90% most of the times which itself is a very good indicative of the improved forecast skill in recent years.

3.3 Monsoon season

The results of Monsoon season forecast shows that the skill is not as good as in case of Winter & Pre-Monsoon Season, but still accounting the vagaries of Monsoon it may be considered as good. The POD has been in the range 0.6-0.8 most of the times almost for all five days except some minor variations from station to station which indicates a very good skill towards capturing the Agrometeorological parameters over the state of UP. Similarly the MR has been below 0.5 most of the occasions which may be considered as satisfactory from Intra-seasonal variation point of view. On contrary, the FAR has also been quite small below 0.2 which shows that the skill of forecast towards over prediction was also within admissible ranges and similarly the C-NON value has always been above 0.9 almost during entire 5 day forecast period again indicates that no events have also been predicted with great accuracy. Now, when we discuss about the HSS we observe that the value of critical success index that determines the threat score has considerably good value ranging between 0.5 – 0.7 most of the occasions except few exceptions which indicates towards the good predictability skills of rare events. Similarly the values of HSS have most of the time been above 0.6 which shows that the fractional improvement over random chances has been quite good. Despite all these parameters for assessment of skill, the direct measure of the skill PC also shows the values most of the time reamin 70% or more which itself is a very good indicative of the improved forecast skill in recent years.

3.4 Post-Monsoon season

Mainly, Post-Monsoon season being generally dry season except occasional rains induced mostly due to movement of extra-tropical disturbances, many of the Skill Scores are not that illustrative and explanatory in nature but still the high values of PC & C-Non Scores indicate the goodness of the seasonal forecast for effective utilization from agro-meteorological perspective in the state of UP in recent years.

4. Conclusions

The following broad conclusions can be drawn from this study:

(i) There is positive improvement in the accuracy & skill of deterministic agro-meteorological Forecast specially in Day-4 & Day-5 forecast in the recent past with noticeable improvement in the various skill scores which can mainly be attributed to the improvement in NWP models, observational networks, application of modern forecasting tools and techniques and finally due to the trained manpower.

(ii) The Percentage Correct values are close to 90% or above most of the time except Monsoon season where it is close 70%. Probability of detection values are generally above 0.8 except Monsoon season where these are in the range of 0.6-0.8. Missing Rate has also been quite low below 0.2 most of the times except Monsoon season where it was slightly high close to 0.4 on average. Despite few exceptions False Alarm Ratios have also been below 0.2 most of the time on average. Correct Non-occurrence score has also been above 0.9 most of the times except monsoon season when at times it has been 0.8. Based on these basic statistical skill scores values of various derived/hybrid skill scores have also been reasonably good.

Acknowledgements

The authors are thankful to Director General of Meteorology, IMD for providing the facilities to carry out this work. The authors are also thankful to Mr. R. P. Kuril, Mr. Abhilash Shukla, and Ms. Anjulata Sharma, IMD Lucknow for their help in data collection/analysis used in the manuscript.

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