Vol. 20, No. 1, pp. 125-131 (2020)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Decadal Variation in Weather Forecast Accuracy at Ludhiana, Punjab

BHAWNA SHARMA, K.K. GILL* AND KAVITA BHATT

Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana-141001, Punjab

ABSTRACT

India Meteorological Department (IMD), the only nodal agency in India issues biweekly forecast to the different centers to prepare agro-advisories for the benefit of farmers. Medium range weather forecasting of different weather parameters viz., rainfall, temperature and cloud cover during past four pentads (2000-05, 2005-10, 2010-15 and 2015-18) for Ludhiana station were verified on the annual and seasonal basis. Annual basis accuracy of rainfall was maximum 93 per cent during fourth pentad (2015-18) and lowest 89 per cent during first pentad (2000-05). Similarly, accuracy of cloud cover was maximum 77 per cent during the second pentad (2005-10). Maximum temperature accuracy was highest 79 per cent during the first pentad (2000-05) and least by 59 per cent during second (2005-10) and third pentad (2010-15) and 74 per cent accuracy of minimum temperature was highest during the first pentad (2000-05). On seasonal basis rainfall accuracy was maximum (99 per cent) during post monsoon season for third (2010-15) and fourth pentad (2015-18). Similarly, cloud cover accuracy was maximum (76 per cent) during post monsoon season for third pentad (2010-15). Maximum and minimum temperature accuracy was highest (74 and 60 per cent) for post monsoon season during second pentad (2005-10) and first pentad (2000-05), respectively. Similarly, wind speed accuracy was maximum (77 per cent) during summer season for second pentad (2005-10).Wind direction accuracy was 40 per cent which was highest recorded during post monsoon season for first pentad (2000-05).

Key words: Weather forecast, Pentads, Weather parameters, Usability analysis, Central Punjab

Introduction

Weather is dynamic in nature and controlled by numerous factors, a direct measurement of all these is made by a well spread network of ground level to mountain top observations along with upper air and ocean / sea observatories. It is an important phenomenon that determines the chances of success as well as complete failure of agricultural crops. The different parameters of weather have great impact on the crops during different stages of crop growth. The Climate Forecasting System (CFSV2.0) model (part of IITM-ESM2.0) has been extensively used for seasonal forecasting of ISM. Saha *et al.* (2014) has shown improvements in simulations of ISM as compared previous version of CFSV1. The finer technical details of ERPAS system and its usefulness in forecasting different weather systems such as heat waves, heavy rainfall events over Indian region (Abhilash *et al*., 2014; Sahai and Pattanaik, 2018). After rigorous benchmark testing, the ERPAS system has been handed over to IMD for operational activities and continuously being updated for better forecast skills (Sahai and Pattanaik, 2018).

*Corresponding author,
Email: kgill2002@gmail.com

Weather forecast system is developed to forecast the upcoming weather phenomenon in future that directly affects the crops production. The different weather parameters have great impact on the crops during different stages of crop growth (Gill and Babuta, 2013). These phenomenon's are not under human control but the microclimate of crop plants can be modified according to the need during their cultivation. Otherwise, it results in complete failure of crops, which ultimately lead to the food crisis. Optimum climatic conditions cause the success of crop and vice-versa. Medium range weather forecast having validity for three to ten days is beneficial for the agricultural crops. The utility of weather forecast further depends upon two factors i.e. accuracy and applicability at micro levels. According to estimate made by the agri-business indicated that 50 to 60 per cent correct and properly accurate forecast can be of economical use (Seeley, 1994). An agriculturally related forecast is not only useful for efficient management of farm inputs but also leads to precise impact assessment (Gadgil, 1989).

Indian economy is an agricultural economy, so unfavorable weather conditions like drought, thunderstorm, heat and cold waves have caused great loss to crop production. If the accurate weather based agro-advisories are prepared for the need base of agricultural procedures by dispersing timely to the farmers (at least seven days in advance) it can add extensively to the monitory advantages to the farmers through decreasing the production losses. Medium range weather forecasts have made important contribution in agriculture (Das and Sindhu, 2001).

Material and Methods

The Punjab state is located between 30 to 32° N latitude and 75 to 77° E longitudes. The elevation varies from 230 to 300 m above the mean sea level. Agroclimatically the state is delineated in five zones. The central plain was chosen for the study in which Ludhiana located in 75°48′ E longitude, 30° 54′ N latitude and 247 mm height above mean sea level. The maximum temperature of Ludhiana varies between 35.5-40.5 °C during the month of June being hottest month of the year whereas, January is the coldest month with minimum temperature ranges from 4.9-6.5 °C. The monsoon rainfall of Ludhiana is 604.5 mm and annual rainfall is 761.4 mm. The region is fallen under the semi-arid and sub-tropical climate. India Meteorological Department (IMD), generates location specific medium range weather forecast for rainfall, cloud cover, wind speed, wind direction, maximum and minimum temperature for 3 days during past four pentads (2000-05, 2005-10, 2010-15 and 2015-18) for central region of Punjab were verified. The forecasts were compared with daily-observed weather data from Agrometeorological observatory situated at Punjab Agricultural University, Ludhiana for the respective days. The reliability of forecasts of rainfall, temperature and cloud cover was verified by calculating the error structure. Historical data for observed and forecast weather for Ludhiana station has been collected from the project reports of Gramin Krishi Mausam Seva (GKMS) (2000-2018) for the different weather parameters i.e. maximum and minimum temperature, cloud cover, rainfall, wind speed, wind direction, ratio score, threat score, H.K. score and RMSE. Weather data of 18 years was divided into four pentads (2000-2005, 2005-2010, 2010-2015 and 2015-18) and was analyzed for all the parameters and then combined the 18 years data to show the change in trend seasonally and annually for the different weather parameters.

Results and Discussion

Annually analysis of weather forecast for the different weather parameters

Rainfall and Cloud cover

The usability of rainfall and cloud cover is presented in Fig. 1. The usability of rainfall varied from 89 per cent (2000-05) to 93 per cent (2015-18) However, in case of cloud cover highest usability was 86 per cent during first pentad (2000-05) and lowest 67 per cent during third (2010-15) and fourth pentad (2015-18).

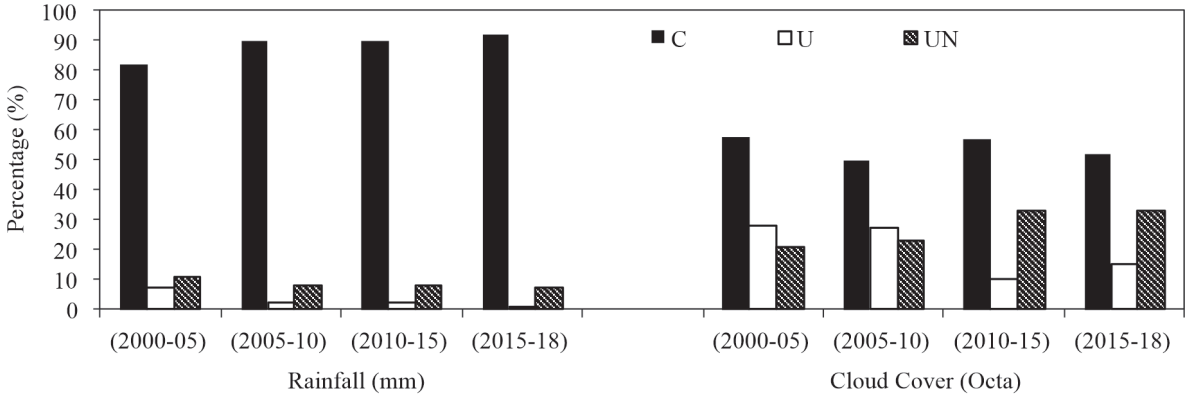

Fig. 1. Usability analysis of rainfall and cloud cover during past four pentads (2000-18)

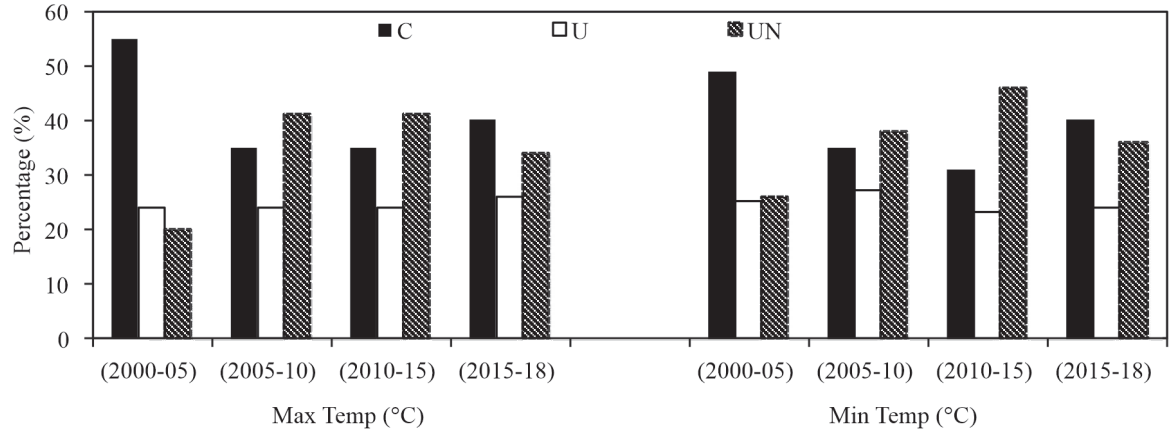

Fig. 2. Usability analysis of maximum and minimum temperature during past four pentads (2000-18)

Maximum and Minimum temperature

The usability of maximum and minimum temperature is represented in Fig. 2. The highest usability of maximum temperature was 79 per cent during first pentad (2000-05) and lowest of 59 per cent during second (2005-10) and third pentad (2010-15). For the minimum temperature, highest usability was 74 per cent during first pentad (2000-05) and lowest by 54 per cent during third pentad (2010-15).

Statistical analysis of different weather parameters

Ratio score

The comparative study of ratio score is represented as Table 1, which revealed, ratio score for rainfall was highest (83.5%) during third pentad (2010-15) and lowest (78.9%) during fourth pentad (2015-18). For cloud cover highest ratio score was ranged between 71.9 per cent (2000-05) to 91.2 per cent recorded during third pentad (2010-15), whereas, highest ratio score for maximum and minimum temperature were 76.2 and 77.2 per cent, respectively during second pentad (2005-10) and third pentad (2010-15). However, for wind speed, ratio score values ranged between 59.8 to 77.0 per cent. Ratio score for wind direction was 87.1 highest during second pentad (2005-10) followed by decrease.

Threat score

The comparative study of threat score is represented as Table 2, which depicts, threat score for rainfall was highest by 0.28 during first pentad (2000-05) and lowest (0.19) during fourth pentad (2015-18). For cloud cover, lowest threat score was 0.29 during first pentad (2000-05) and

Table 1. Ratio score of different weather parameters during past four pentads (2000-18)

Years	Rainfall	Cloud cover	Max. Temp	Min.Temp	Wind speed	Wind direction
			(%)			
2000-05	80.21	71.92	75.66	75.06	77.03	85.76
2005-10	79.08	75.64	76.23	71.78	69.07	87.13
2010-15	83.51	91.18	76.17	77.20	60.84	83.72
2015-18	78.86	85.13	73.41	75.17	59.82	85.42

Table 2. Threat Score of different weather parameters during past four pentad (2000-18)

Years	Rainfall	Cloud cover	Max. Temp	Min. Temp	Wind speed	Wind direction
2000-05	0.28	0.29	0.31	0.28	0.33	0.22
2005-10	0.25	0.30	0.23	0.22	0.30	0.14
2010-15	0.24	0.35	0.23	0.20	0.25	0.09
2015-18	0.19	0.42	0.24	0.24	0.15	0.06

highest of 0.42 during fourth pentad (2015-18). The maximum temperature threat score was ranged between 0.23 (2005-10 and 2010-15) to 0.31 (2000-05). For minimum temperature it was highest (0.28) during first pentad (2000-05) and lowest (0.15) during third pentad (2015-18). For wind speed highest threat score was 0.33 during first pentad (2000-05) and lowest (0.15) during third pentad (2015-18), whereas, for wind direction threat score was calculated highest (0.22) during first pentad (2000-05) and lowest by 0.06 during fourth pentad (2015-18).

Hanseen and Kuipers (H.K.) score

The comparative study of H.K. score is presented as Table 3, which revealed, H.K. score for rainfall was highest (0.41) during second pentad (2005-10) and lowest by 0.14 during fourth pentad (2015-18). Study of H.K. score for cloud cover revealed that it was maximum (0.66) during third pentad (2010-15) and lowest (0.06) during first pentad (2000-05), whereas, highest H.K. score for maximum and minimum temperature was 0.23 (2005-10 and 2010-15) and 0.21(2010-15), respectively. However, for wind speed, H.K. score values ranged between -0.19 (2010-15) to 0.12 (2000-05). Study of H.K. score for wind direction was highest (0.45) during first pentad and lowest (0.14) per cent fourth pentad (2015-18).

Root mean square error (RMSE)

The comparative study of root mean square errors for past four pentads represented as Table 4, which depicts RMSE for rainfall was highest 7.52 during third pentad (2010-15) and lowest (5.25) during first pentad (2000-05). For cloud cover, lowest RMSE of 2.24 was calculated during second pentad (2005-10) and highest (2.92) during third pentad (2010-15). The RMSE of maximum and minimum temperature was recorded highest during second pentad (2005-10). For wind speed, highest RMSE of 6.09 was recorded during fourth pentad (2015-18) and lowest of 3.41 during second pentad (2005-10), whereas, for wind direction, highest RMSE was

Table 3. HK Score of different weather parameters during past four pentads (2000-18)

Years	Rainfall	Cloud cover	Max. Temp	Min. Temp	Wind speed	Wind direction
2000-05	0.26	0.06	0.15	0.15	0.12	0.45
2005-10	0.41	0.15	0.23	0.13	-0.11	0.41
2010-15	0.19	0.66	0.23	0.21	-0.19	0.24
2015-18	0.14	0.47	0.15	0.20	-0.16	0.14

Table 4. Root mean square errors (RMSE) of different weather parameters during past four pentads (2000-18)

Year	Root mean square errors (RMSE)					
	Rainfall	Cloud cover	Max. Temp.	Min. Temp.	Wind speed	Wind direction
2000-05	5.25	2.68	3.05	3.74	4.12	75.81
2005-10	6.16	2.24	4.55	3.94	3.41	94.05
2010-15	7.52	2.92	3.41	2.68	4.40	91.89
2015-18	5.88	2.48	3.15	2.37	6.09	100.00

calculated (100.00) during fourth pentad (2015-18) and lowest of 75.81 during first pentad (2000-05).

Seasonal variation of usability percentage of weather forecast (2000-18)

Rainfall

Analysis of rainfall during the past four pentads (2000-18), post monsoon was the most dominating season for rainfall (Fig. 3) which constituted 99 per cent correct forecast for the third (2010-15) and fourth pentads (2015-18). On the contrary, most significant proportion of unusable forecast was 24 per cent witnessed during monsoon season during the first pentad (2000-05).

Cloud cover

During the past four pentads (2000-18), post-monsoon was the most dominating season for cloud cover (Fig. 4) depicting correct forecast of 76 per cent during the third pentad (2010-15). On the contrary, most significant proportion of unusable forecast was 49 per cent witnessed during monsoon season for the fourth pentad (2015-18).

Maximum temperature

During the past four pentads (2000-18), post monsoon was the most dominating season (Fig. 5) for maximum temperature which constituted 74 per cent correct forecast during second pentad (2005-10). On the contrary most significant proportion of unusable forecast was 48 per cent witnessed during monsoon season during third pentad (2010-15).

Minimum temperature

During the past four pentads (2000-18), post-monsoon was the most dominating season for minimum temperature (Fig. 6) which constituted

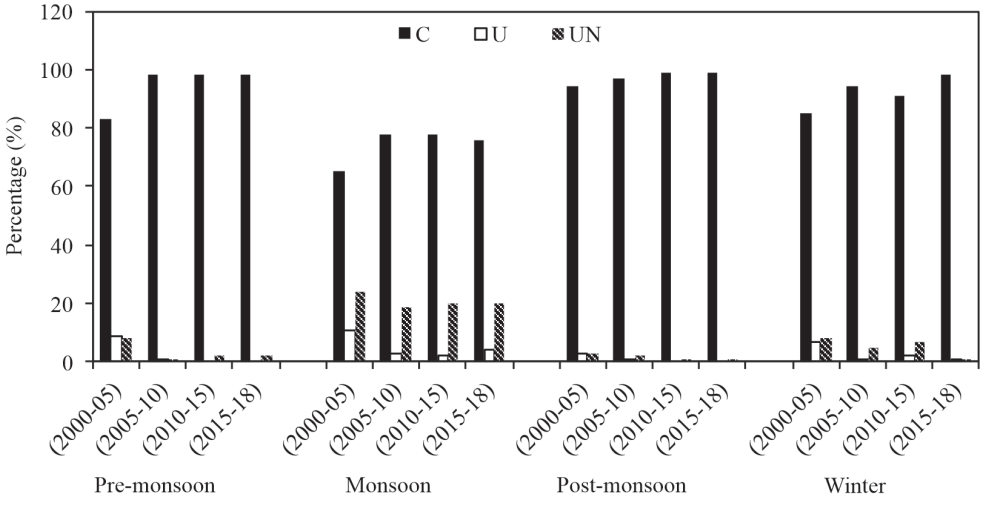

Fig. 3. Seasonal usability of rainfall forecast

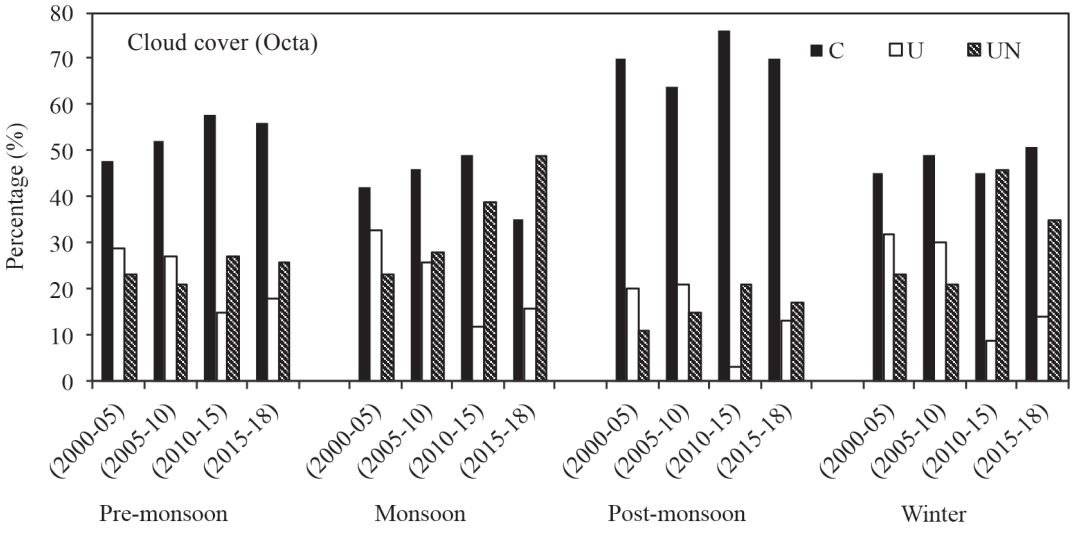

Fig. 4. Seasonal usability of cloud cover forecast

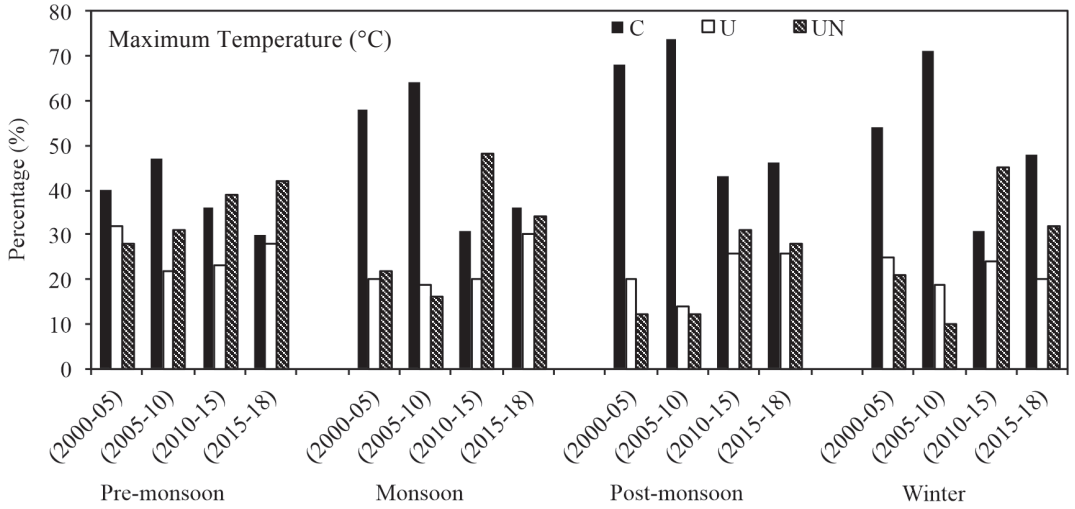

Fig. 5. Seasonal usability of maximum temperature forecast

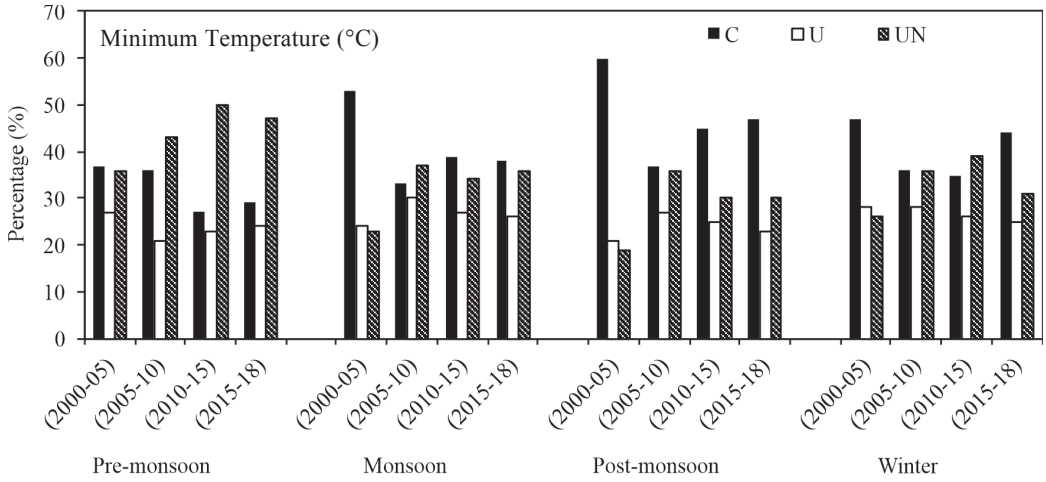

Fig. 6. Seasonal usability of minimum temperature forecast

60 per cent correct forecast for the first pentad (2000-05). On the contrary, most significant proportion of unusable forecast was witnessed during pre-monsoon season (50%) for the third pentad (2010-15).

Conclusion

The present study concluded that medium range weather forecasts are quite usable for agro-advisories except wind direction which needs further improvement in the model. Rainfall, cloud cover, and temperatures gives good accuracy during past four pentads. On seasonal basis, post-monsoon season gave the highest accuracy than the other seasons, whereas, monsoon season is having the least accuracy than other seasons. Based on the weather prediction, the AAS bulletins are prepared and delivered by AMFUs twice in a week around the year. The AAS bulletins contain the possible risk mitigation steps for all the weather sensitive agricultural operations for the crops grown in the area/region of AMFU. The IMD is making research efforts to improve the accuracy of weather forecast for quality agromet bulletins. The proposed content development framework allows the improvement of monsoon season forecast for the development of content related location-specific weather sensitive crop operations to improve the quality of agromet bulletins.

References

Abhilash, S., Sahai, A.K., Borah, N., Chattopadhyay, R., Joseph, S., Sharmila, S., De, S., Goswami, B.N. and Kumar, Arun. 2014. Prediction and Monitoring of Monsoon Intra-seasonal Oscillations over Indian monsoon region in an Ensemble Prediction System using CFSv2, Climate Dynamics, **42**: 9-10, 2801-2815, doi:10.1007/ s00382-013-2045-9.

Das, D.K. and Sindhu, J. 2001. Importance of weather forecasting in agriculture. *Fertilizer News* **46** (12): 89-102.

Gadgil, S. 1989. Monsoon variability and its relationship with agricultural strategies. Inter. Symposium on climate variability and food security in developing countries New Delhi, India: 249-67.

Gill, K.K. and Babuta, R. 2013. Reliability analysis of medium range forecasts in central plain region of Punjab. *J. Krishi Vigyan* **1**(2): 70-73.

Pai, D.S., Sridhar, L., Rajeevan, M., Sreejith, O.P., Satbhai, N.S. and Mukhopadhyay, B. 2014. Analysis of daily rainfall events over India using a new long period (1901-2010) high resolution (0.25° × 0.25°) gridded rainfall data set, *Mausam* **65**: 1, 1-18.

Pattnayak, K.C., Panda, S.K., Saraswat, Vaishali and Dash, S.K. 2018. Assessment of two versions of regional climate model in simulating the Indian Summer Monsoon over South Asia CORDEX domain. *Climate Dynamics* **50**: 3049-3061.

Rajagopal, E.N., Iyengar, G.R., Mitra, A.K., Prasad, V.S., Gupta, M. Das, George, John P., Kumar, Preveen D., Saji, Mohandas, Ashrit, R. and Dube, A. 2014. "Recent Advances in Numerical Weather Prediction", Vayu Mandal, 19-31, imetsociety.org/wpcontent/pdf/vayumandal/ 2014/2014_2.pdf.

Saha, S.K., Pokhrel, S., Chaudhari, H.S., Dhakate, A., Shewale, S., Sabeerali, C.T., Salunke, K., Hazra, A., Mahapatra, S. and Rao, S.A. 2014. Improved simulation of Indian summer monsoon in latest version of NCEP Climate Forecast System free run. *International Journal of Climatology* **34**: 1628-1641, doi:10.1002/joc.3791.

Sahai, A.K. and Pattanaik, D.R. 2018. "Evaluation of Real-Time Extended Range Forecast (ERF) of southwest monsoon, heat wave, cold wave, cyclogenesis and northeast monsoon during 2017", No. ESSO/IMD/NWP- Extended Range Forecast (ERF) Report No. 01 (2018)/05.

Seeley, M.W. 1994. The future of serving agriculture with weather/climate information and forecasting some indications and observations. *Agric Forest Meterol* **69**: 47-59.

Received: March 5, 2020; Accepted: June 7, 2020