Annals of Arid Zone 51(1): 17-19, 2012

# Multiple Regression Model for Long Range Forecasting of South-West Monsoon Rainfall for Pune, Maharashtra

**S.S. Chinchorkar[1], V.B. Vaidya[2] and Vyas Pandey*[1]**

[1] *Anand Agricultural University, Anand 389 151, India*

[2] *Polytechnic in Agricultural Engineering, Anand Agricultural University, Dahod 388 110, India*

Received: July 2011

**Abstract:** The large spatial variability in monsoon rainfall over India demands for regional model to predict the seasonal rainfall. Hence, a local model was developed for predicting seasonal (June-September) rainfall of Pune using multiple regression technique. The monthly weather data of 36 years (1970-2005) was used for model development and data for next five years (2006-2010) were used for validation. The model explained 81% variability in seasonal rainfall with model error of 2.52%. During the validation period (2006-2010), the performance of model was quite satisfactory with model error of -1.94% only. This model was used to predict the rainfall for 2011 season. Results suggested that the rainfall during 2011 would be higher (51.2%) than the normal rainfall in Pune.

**Key words:** Multiple regression, rainfall forecasting, rainfall analysis, statistical model.

A major portion of annual rainfall over India is received during the south-west monsoon season (June-September). There are known vagaries of the monsoon as regards the onset as quantum of monsoon rains and its distribution in different parts of the country. Although the regional rainfall has large year to year fluctuations, the south-west monsoon rainfall over the country as a whole varies by about 10% of the mean rainfall (Rajeevan *et al*., 2004). However, this small fluctuation in the seasonal rainfall can have devastating impacts on India's economy. Therefore, prediction of south-west monsoon rainfall deserves high priority in India. The India Meteorological Department (IMD) has been issuing long range forecasts of the south-west monsoon rainfall since 1886. During the period 1988-2002, IMD's operational forecasts were based on the 16 parameter power regression and parametric models (Gowariker *et al*., 1989 and 1991). Two new models (8 and 10 parameter models) were introduced in 2003, with which the seasonal Indian summer monsoon rainfall for the country as whole are issued in mid-April and an update or second stage forecast is issued by the end of June for different homogenous regions of India.

Although at many a time the SW-monsoon rainfall of the country as a whole had been normal, but there have been quite large variation in regional rainfall distribution e.g., in 2006 country received 878.6 mm (normal rainfall), but Gujarat received 151% of the normal rainfall. Hence, regional or location-specific models are needed to be developed. Varshneya *et al*. (2010) developed models for different regions of Gujarat State using regression techniques in which the best models were selected based on higher $R^2$ and lower model error. These models explained 74 to 93% variability in seasonal rainfall with models error ranging between -2.5 to 5.1%. Sable *et al*. (2007) developed models for various locations of Maharashtra State, in which the group matching technique was used. From the matching group weighted mean was calculated to predict the seasonal rainfall of different locations of Maharashtra State.

Pune is situated on leeward side of Western Ghats located in a basin surrounded by uplands and hills and situated near the periphery of the Deccan Plateau. Local topography plays a major role in the rainfall receipt at Pune. There is no model available for predicting rainfall at Pune. Hence an attempt has been made to predict the south-west monsoon rainfall for Pune station.

## Materials and Methods

Weekly meteorological data of Pune (18° 31' N and 73° 52' E) for forty one years (1970-2010) were used in this study for developing and validating the model for predicting the seasonal rainfall. The weekly weather data viz., maximum temperature (Tmax), minimum

*E-mail: pandey04@yahoo.com

temperature (Tmin), relative humidity morning (RH-I), relative humidity afternoon (RH-II), wind speed (WS), bright sun shine (BSS), pan evaporation (Epan) were converted into monthly values as per the method defined by IMD. March to May period is very crucial for development of monsoon current.

The multiple regression analysis was performed by trial and error method to obtain the best combination of predictor parameters as decided by highest $R^2$ and lowest error. The model was developed with data of 36 years (1970-2005) and validated with independent data set of 5 years (2006 to 2010) and forecast was made for 2011.

The performance of the model was studied in terms of error analysis like mean absolute error (MAE), mean bias (MBE), root mean square (RMSE), per cent error (PE) and average error (%) following standard statistical techniques (Walker, 1924).

## Results and Discussion

The average annual rainfall (1970-2009) of Pune is 746.1 mm, of which 570.2 mm is recorded during June to September. July receives highest rainfall (166.3 mm) followed by June (148.5 mm). The mean monthly maximum temperature varies between 27.6°C in August to 37.8°C in April, while minimum temperature varies between 11.2°C (January) to 23.0°C (May). The mean monthly RH-I ranges between 62 to 90%, while RH-II ranges between 18 to 75%.

Correlation coefficients worked out between monthly weather parameters during March to May with seasonal rainfall (June to September) are given in (Table 1). This shows that seven parameters viz. RH-I, WS in the month of March and April and RH-II, WS and BSS hour in the month of May had significant correlations (at 5% level). However, the multiple regression model developed with trial and error method, had seven more variables. Thus total of 14 predictors were included in the model giving highest $R^2$ of 0.81* and model error of 2.52%. The model equation is as given below.

Y= -1165.57+17.13*Tmax (Mar.)-99.11*Tmin (Mar.)+23.04*RH-II (Mar.)-139.53*WS (Mar.)+33.81*BSS (Mar.)+5.83*Epan (Mar.)-13.93*Tmin (Apr.)+33.01*WS (Apr.)-75.12*BSS (Apr.)+59.71*Tmax (May)+10.59*RH-I (May)+2.37*WS (May)+69.83*BSS (May)-20.80*Epan (May)

The model thus developed was used to predict the rainfall in different years. The observed and predicted rainfall is much closer to each other (Fig. 1). It has depicted rainfall fluctuations very well during the testing period except few years like 1983, 1990 and 1994 during which the deviations were quite large. The deviation ranged between 1.3 mm in the year 1980 and 227.3 mm in the year 1992.

*Table 1. Error analysis of forecasting model for Pune*

| Error analysis | All data set (1970-2005) | Independent data set (2006-2010) |
|---|---|---|
| MAE (mm) | 16.5 | -1.9 |
| MBE (mm) | -0.4 | -1.1 |
| RMSE (mm) | 30.0 | 35.7 |
| PE (%) | 5.2 | 6.2 |
| Average error (%) | 2.52 | -1.94 |

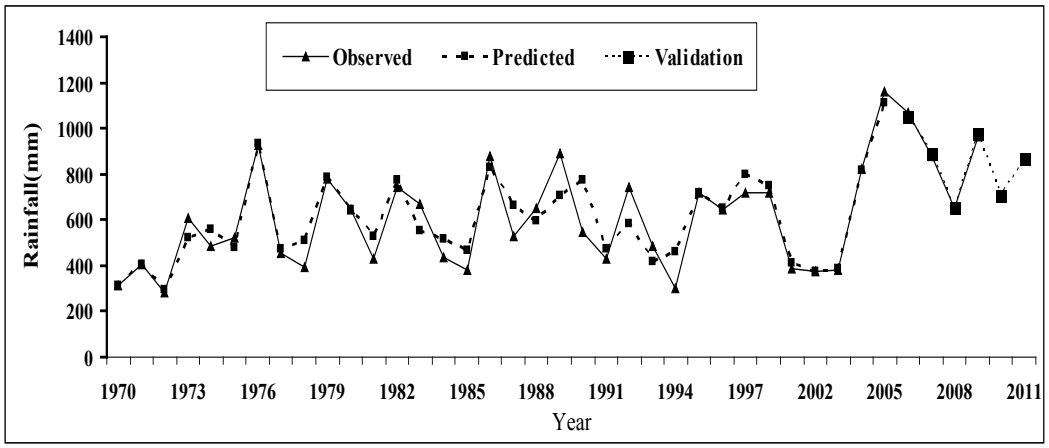


*Fig. 1. Observed and predicted seasonal rainfall at Pune.*

*Table 2. Correlation of average monthly meteorological parameters with seasonal rainfall (June to September)*

| Name of parameters | March | April | May |
|---|---|---|---|
| Maximum temperature (Tmax) | 0.01 | -0.03 | 0.24 |
| Minimum temperature (Tmin) | -0.26 | -0.10 | -0.10 |
| Relative humidity morning (RH-I) | 0.37* | 0.37* | -0.16 |
| Relative humidity afternoon (RH-II) | -0.09 | 0.11 | -0.41* |
| Wind speed (WS) | 0.36* | 0.38* | 0.36* |
| Bright sun shine hour (BSS) | -0.03 | 0.28 | 0.35* |
| Pan evaporation (Epan) | -0.27 | -0.27 | 0.04 |

The observed and predicted rainfall for validation period (2006-2010) (Fig. 1) show very close matching. The rainfall predicted by the model deviated from the observed rainfall by -1.4 to -6.8%. During validation period the observed rainfall varied from 676.0 to 1086.3 mm and the model was able to predict the rainfall with reasonably good accuracy.

The performance of model was also evaluated in terms of error analysis which revealed that the MAE, MBE and RMSE of model were 16.5 mm, -0.4 mm and ±30.0 mm, respectively (Table 2). Even with independent data, the RMSE is ±35.7 mm. The model error of 2.52% for all data (1970-2005) and –1.1% for independent data sets (2006-2010) revealed the well acceptability of the model. Thus, this model can be used to predict the seasonal rainfall for Pune using predictors up to May.

The validated model was used to forecast the seasonal rainfall (June-September) for the year 2011. The model has predicted 863.1 mm of seasonal rainfall which is 51.2% higher than the normal rainfall, whereas, this year Pune recorded 827.3 mm rainfall (95.8% accuracy), which further strengthens model's accuracy.

## Acknowledgments

We thank Agromet Division, IMD, Shivajinagar, Pune, for providing meteorological data of Pune to develop model. We are also thankful to Mr. Vijay Bhat, Pune, for valuable guidance from time to time.

## References

Gowariker, V., Thapliyal, V., Kulshrestha, S.M., Mandal, G.S., Sen Roy, N. and Sikka, D.R. 1991. A power regression model for long range forecast of south-west monsoon rainfall over India. *Mausam* 42: 125-130.

Gowariker, V., Thapliyal, V., Sarker, R.P., Mandal G.S. and Sikka, D.R. 1989. Parametric and power regression models: New approach to long range forecasting of monsoon rainfall in India. *Mausam* 40: 115-122.

Rajeevan, M., Pai, D.S., Dikshit, S.K. and Kelkar, R.R. 2004. IMD's new operational models for long-range forecast of south-west monsoon rainfall over India and their verification for 2003. *Current Science* 86(3): 422-431.

Sable R.N., Salunke, S.S., Hazari, A.K., Bagade, S.V., Chinchorkar, S.S., Gunjal, K.R. and Dalvi, T.D. 2007. Prediction of pre-monsoon and second stage rainfall prediction of Maharashtra. In *Proceeding of One Day National Seminar on Monsoon* 2007. Department of Agril. Meteorolgy, MPKV, Pune.

Varshneya, M.C., Chinchorkar, S.S., Vaidya, V.B. and Pandey, Vyas 2010. Forecasting models for seasonal rainfall for different regions of Gujarat. *Journal of Agrometeorology* 12(2): 202-207.

Walker, G.T. 1924. Correlation in seasonal variations of weather, IV, A further study of world weather. *Memories of India Meteorological Department*, 24: 275-332.

Printed in April 2013