Abstract

Rainfall over the Indian subcontinent, especially Madhya Pradesh in central India and Myanmar has large Intra-seasonal and interannual variability causing droughts and floods in many years. The main objectives of the present research are to (i) examine the intra-seasonal ad interannual variability of the summer monsoon over central India and Myanmar and look for any predictive signal for drought; (ii) examine the potential of extended-range and seasonal predictions from dynamic models for drought prediction and (iii) examine the suitability of crop yield models to provide indication of droughts through modeling. Additional objectives include prediction of several drought indices to identify and predict droughts.

In this study, rainfall variability in daily and monthly scale over central India as Madhya Pradesh (MP) and Myanmar has been examined using observed rainfall (GPCP and IMD gridded) data. Skill of an extended range forecast system has been evaluated for identifying droughts over central India and Myanmar up to 20-days in advance. Moreover, skill of seasonal forecast using 11 different handcast model data is also studied. Performance of the crop simulation model DSSATv4.5 is also evaluated over four district of Madhya Pradesh. In addition, the soil moisture and evapotranspiration relationship with rainfall is also studied so that drought can be monitored. Consistencies among various datasets such as rainfall, surface temperature, soil moisture and evapotranspiration have been examined. These parameters are from various different sources and critical for drought monitoring and prediction.

It is found that during weak phases of monsoon, central India receives deficit rainfall with weaker monsoon circulation and this phase is characterized by an anticyclonic circulation anomaly at 850hPa centred on MP. The EOF analysis of daily rainfall suggests that the two leading modes explain about 23.7 % of rainfall variability in intraseasonal timescale. These two modes represent drought/flood conditions over MP. Relationships of weak phases of rainfall over central India with real time multivariate (RMM) indices of MJO have been examined. It is found that RMM-6, RMM-7, RMM-1 and RMM-2 describe the drought conditions over central India. However, frequency of drought occurrence over MP is more during RMM-7 phase. Surface temperature increases by about 0.5 to 1 degree during weak phases of rainfall over this region.

For Myanmar, It is found that monthly rainfall in June, July and August months do not have any relation among each other indicating that monthly rainfall received in Myanmar in these three months vary due to different mechanisms. Using composite wind analysis for excess and deficit rainfall years, it is found that deficiency of rainfall occurs when south-westerly winds at 850hPa are weaker over the region in June.

During excess rainfall years, south westerly wind anomalies seen in June turn to stronger and milder westerly winds in July and August respectively. However, a cyclonic anomaly is seen over North Bay of Bengal adjoining western coast of Myanmar in all the three months. It is found that the Myanmar rainfall is correlated positively with the SST over central Pacific Ocean. Therefore, lead-lag relationship between Myanmar rainfall and Nino indices has been carried out. Lead-lag relationship between Niño indices and Myanmar rainfall suggest that this relationship changes from month to month during the monsoon season. The cooler SST leads (for all Niño indices) but warmer SST lags rainfall in Myanmar in June. During deficit years, a sinking motion is seen in the central Pacific and ascending motion is over the western Pacific. This pattern continues more or less from March to July. Moreover, August rainfall has consistently positive correlation with Nino 1+2 SSTs starting from April, though the correlation is not significant. An empirical orthogonal function (EOF) analysis of monthly and seasonal mean rainfall over the region has been carried out. The leading mode (EOF-1) shows coherent spatial patterns between the Indian monsoon rainfall over east and central parts of the India and rainfall over the western Pacific. The second leading mode of seasonal rainfall shows a trend in rainfall during the study period.

Further, skill of an extended range forecast system has been evaluated for identifying droughts over central India and Myanmar 20-days in advance. Rainfall forecasts from 44 ensemble members of the forecast system developed Indian Institute of Tropical Meteorology (IITM), Pune have been used to prepare probabilistic rainfall forecasts. It is seen that the uncertainties in the forecasts (in terms of ensemble spread) increases from day-5 to day 20. The present study represents the drought predictions using extended range forecast so the bins 0-5mm/5day and 5-25mm/5day (no rain or less rain) were studied in detail. It is found that the modeling system has a tendency to over-forecast rainfall probabilities. With bias correction, the forecasts become more reliable. The relative operating characteristics (ROC) scores indicate that the hit rate for a particular rain category is more than false alarm rate making the forecast suitable for application.

Soil moisture and evapotranspiration relationship with rainfall is also studied. Soil moisture and evapotranspiration anomalies have positive pattern during good rainfall events over central India and gradually reduce and become negative anomalies during weak phases. Variations of soil moisture during active and weak phases of summer monsoon are very important for sustenance of the crop and subsequent crop yield. This study documents the inter-comparison of soil moisture data from European Space Agency (ESA), ECMWF reanalysis-interim (ERA-I) and climate forecast system reanalysis (CFSR) during dry spells of monsoon seasons from 2002 to 2011. The ESA soil moisture correlates well with observed gridded rainfall. ERA-I over-estimates the soil moisture, while CFSR soil moisture agrees with observation.

Over Myanmar, soil moisture values from reanalysis are very high and ERA-I soil moisture does not show much variability from year to year. Day to day variations of soil moisture in central parts of India and central parts of Myanmar during weak monsoon conditions indicate that, because of the rainfall deficiency, soil moisture values also decreases up to 0.1 m^3/m^3 compared to climatological values of more than 0.35 m^3/m^3. The soil moisture in CFSR and ERA-I vary differently.

Performance of the crop simulation model Decision Support System for Agrometeorology Transfer (DSSAT) v4.6 is also evaluated. Different sowing dates for four stations in Madhya Pradesh for each year were used to assess the performance of the DSSATv4.5 model for rice crop yield from 1990–2011 during drought years. Drought years were identified using observed rainfall datasets from India Meteorological Department (IMD) from June to September (JJAS) for the selected stations viz., Balaghat, Jabalpur, Narsinghpur and Seoni. Two popular varieties of rice (IR 36 and Swarna) were taken in this study. It is found that the DSSAT CERES-rice model predicted yield was higher than the observed yield requiring a bias correction and detrend analysis. Moreover, various drought indices such as standardized precipitation index (SPI), standardized precipitation-evapotranspiration index (SPEI) and palmer drought severity index (PDSI) were computed using the mean of the forecast distribution up to 20-days in advance. It was found that these are in reasonable agreement with those from observations. Therefore, the drought indices from the extended range prediction system are quite useful to identify droughts over central India and Myanmar up to 20-days in advance.