Inventory and mapping of *kharif* crops using machine learning with EOS-04 time-series SAR data

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Efficient discrimination of diverse *kharif* crops, remains crucial for crop monitoring and production forecasting, and plays a pivotal role in decision-making for food security in India. This study aims to harness temporal backscatter data from EOS-04 C-band synthetic aperture data (SAR) payload to achieve precise discrimination among six short-duration (cereal, oilseeds, fibre) and long-duration (fibre, pulses) *kharif* crops. The study integrates limited ground-truth polygons and a Random Forest machine learning approach for analysing EOS-04 time-series data. The classification accuracies were found to be higher than 75% across all *kharif* crops, with cereals exhibiting the highest accuracy, succeeded by fibre, oilseed and pulse crops. A key focus lies in identifying optimal polarization combinations for effective discrimination among diverse *kharif* crop types. The study reveals that the synergistic utilization of dual polarizations outperforms individual co- or cross-polarizations, notably benefiting discrimination of cotton, soybean and groundnut crops. Horizontal–vertical polarizations are found to be most effective for achieving peak accuracies in rice and red gram crops. Furthermore, the analysis indicates a promising potential for early crop assessment, presenting an opportunity to furnish precise crop estimates at least one and a half months before the harvest.

Keywords: C-band SAR, crop discrimination, EOS-04, *kharif* season, random forest.

of major food grains[1] and raw material availability for commercial crops. In addition, sowing progress and net sown area at district and taluka level are important inputs for agricultural drought assessment. Crop damage assessment within a crop growth period is required for claim settlement in crop insurance. In India, crop forecasting using remote sensing data started in late 80s under the Department of Agriculture and Cooperation (DAC) sponsored project CAPE (Crop Acreage and Production Estimation) was executed by the Space Applications Centre (SAC), Indian Space Research Organisation, Ahmedabad. This later developed into a national level programme, called FASAL (Forecasting Agriculture output using Space, Agro-meteorology and Land based observations)[2] which is in operation since August 2006, that finally led to the establishment of Mahalanobis National Crop Forecast Centre (MNCFC) in 2012. MNCFC aims at providing multiple pre-harvest acreage and production estimates of major *kharif* and *rabi* crops at national/state/district level using various remote sensing and ancillary data.

However, the presence of cloud cover in the *kharif* season limits the usage of optical remote sensing data. Therefore, space-borne synthetic aperture radar (SAR) remote sensing data needs to be used with assured and all-weather observations of earth surface. The data provided by SAR payloads are highly sensitive to the canopy structure and moisture content. The evolution of SAR technology has significantly improved crop mapping capabilities, transitioning from initial SARs in the 1990s (ERS-1 and -2, JERS-