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Machine learning to estimate surface roughness from satellite images

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Soil surface attributes (mainly surface roughness and soil moisture) play a critical role in land-atmosphere interaction and have several applications in agriculture, hydrology, meteorology, and climate change studies. This study explores the potential of different machine learning algorithms (Support Vector Regression (SVR), Gaussian Process Regression (GPR), Generalised Regression Neural Network (GRNN), Binary Decision Tree (BDT), Bragging Ensemble Learning, and Boosting Ensemble Learning) to estimate the surface soil roughness from Synthetic Aperture Radar (SAR) and optical satellite images in an alluvial megafan of the Kosi River in northern India. In a field campaign during 10-21 December 2019, we measured the surface soil roughness at 78 different locations using a mechanical pin-meter. The average value of the in-situ surface roughness is 1.8 cm. Further, at these locations, we extract the multiple features (backscattering coefficients, incidence angle, Normalised Difference Vegetation Index, and surface elevation) from Sentinel-1 A/B, LANDSAT-8 and SRTM data. We then trained and evaluated (in 60:40 ratio) the performance of all the regression-based machine learning techniques.

We found that SVR method performs exceptionally well over other methods with (R= 0.74, RMSE=0.16 cm, and MSE=0.025 cm^2). To ensure a fair selection of machine learning techniques, we have calculated some additional criteria that include Akaike's Information Criterion (AIC), corrected AIC and Bayesian Information Criterion (BIC). On comparing, we observed that SVR exhibits the lowest values of AIC, corrected AIC and BIC amongst all other methods, indicating best goodness-of-fit.