



Contribution ID : 41

Type : **Short communications**

A Robust Machine Learning Framework for Automated Detection of Solar Flare Effects in Distributed Magnetometer Networks

Space-weather disturbances can disrupt radio communications, navigation, defense, spacecraft operations and modern critical technological systems, making reliable characterization of the near-Earth response to solar activity important. Distributed magnetometer networks continuously monitor this environment, but heterogeneous data quality, local observing conditions, and station-by-station analyses limit their scientific potential. We address this challenge for solar flare effects (SFEs), rapid ground magnetic responses to flare-enhanced ionospheric conductivity associated here with X-class flares. We present a scalable and interpretable machine-learning framework that integrates measurements from six geomagnetic stations while preserving their physical context. The workflow combines missing-data characterization, short-gap imputation, robust anomaly detection, baseline removal, station-wise normalization, and temporal, statistical, spectral, and multiscale feature extraction. These representations are augmented with flare properties, cross-station relationships, and local solar-geometry descriptors. Four ensemble classifiers are optimized, probability-calibrated, and evaluated using class-balanced metrics, calibration diagnostics, station-level comparisons, and controlled noise perturbations. The leading calibrated LightGBM model achieves 0.957 balanced accuracy, an F1 score of 0.943, a recall of 0.957, and a ROC-AUC of 0.978. Interpretable analysis shows that local solar illumination governs SFE detectability, while magnetic-response features characterize its strength and evolution. The framework establishes distributed magnetometers as a unified intelligent observatory for scalable, confidence-aware space-weather research.

Primary author(s): QUISPE MENDIZÁBAL, Ricardo Angelo (Universidad Nacional Mayor de San Marcos); Mr MONTTOYA CALDERÓN, Erick (Núcleo Milenio YEMS, Universidad de Santiago de Chile)

Presenter(s): QUISPE MENDIZÁBAL, Ricardo Angelo (Universidad Nacional Mayor de San Marcos)