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Utilizing remote sensing and GPS satellites combined with ground-based observations for producing real-time space weather predictions using machine learning techniques

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The scientific use of ground and space-based remote sensing technology is inherently vital for near-space environment studies and space weather research. Predicting where and when space weather events such as solar flares and X-rays bursts are likely to occur in a specific region of interest still remains a key challenge in near-earth environment research. While most of the governing forces and basic mechanics of space weather events can be cast into physical and numerical models, the lack of sufficiently detailed and real-time measurements prohibits accurate forecasting of such events. Here, we present preliminary result of an implementation of machine learning and deep learning methods, such as Support Vector Machines (SVMs), Auto-regressive Moving Average (ARMA) and Artificial Neural Network (ANN), applied with ionospheric Total Electron Content (TEC), extracted from Global Positioning System (GPS) path delays combined with solar flare activity data obtained by the solar x-ray imager on-board GOES-15 satellite. Our goal is to combine these results with cosmic-ray measurements, confined alpha particles and gamma-ray measurements, solar wind parameters, along with ground-based observations such as sunspot number (SSN) and the geomagnetic planetary A index (Ap), to construct real-time space weather events predictions for short time-scales. This study has two main objectives: (1) Continuous real-time space weather database, gathering all required data into localized data center. The continuous combined measurements of these parameters at different geographic locations, will be then used to distinguish between any enhanced signature associated with local or global event, both in the time and frequency domains. (2) Utilization of machine learning methods applied with the signatures associated with space weather event as a tool for producing short time-scales and real-time realistic predictions for such events. The above mentioned goals can be achieved by combining the existing freely available space weather measured data, along with the ionospheric GPS-TEC estimations using sophisticated high-level algorithms developed at the regional R&D center and Ariel University.