Research in Astrophysics from Space (E)
Application of Machine Learning Techniques in Solar and Heliospheric Physics (E2.4)

FROM SUN TO EARTH: MACHINE LEARNING FOR SPACE WEATHER FORECASTING

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Space weather involves many processes from the solar interior, through the active Sun, to planetary and Earth systems, and it may also impact the Earth's surface and interior. The most energetic explosive events on the solar surface are solar flares, which are characterized by intense electromagnetic emission and often followed by coronal mass ejections (CME) during which solar material, such as electrons and solar plasma, is ejected throughout the solar corona into interplanetary space. It has been established that flares, CMEs and related solar events, can generate geomagnetic storms which, when particularly intense, pose significant risks to terrestrial and space-based infrastructure, with potential economic and safety implications. Current space weather forecasting adopts two courses of action: on the one hand, physics-based models utilize mathematically-founded descriptions of the processes underpinning solar and space physics; on the other hand, machine learning tools exploit statistical inference from the past to perform predictions and identify the data descriptors that mostly impact them. In this talk we focuse on the use of machine learning techniques in space weather forecasting: we discuss which are the main key points concerning feature-based machine learning and deep learning techniques and we show how to include physical information in the training process. We show the results in three significant applications of space weather: flare forecasting starting from magnetograms of active regions, prediction of the transit time of CMEs from Sun to Earth starting from remote-sensing and in situ data, and prediction of severe geomagnetic events starting from in situ measurements of solar wind and magnetic field acquired at the Lagrangian point L1.