MATHEMATICAL SCIENCES

DISMA - Physics-based models and data-driven AI methods for space weather

Funded By	COMPAGNIA DI SAN PAOLO [P.iva/CF:00772450011] Dipartimento DISMA
Supervisor	PERRACCHIONE EMMA - emma.perracchione@polito.it
Contact	PERRACCHIONE EMMA - emma.perracchione@polito.it SCIALO' STEFANO - stefano.scialo@polito.it
Context of the research activity	This project intends to integrate the most innovative numerical and deep learning techniques with physical models to simulate highly complex dynamics, as the ones of solar flares and coronal mass ejections (CMEs). On one hand, there are the deterministic models simulating the propagation of CMEs, and on the other hand, advanced machine learning techniques have been exploited for building space weather predictions, only considering data. Both approaches are characterized by strengths and weaknesses, and for this reason neither of them currently provides optimal predictions. Hence the project's aim consists in exploring a third way that combines the strengths of the two previous approaches.
Objectives	This project intends to build a pipeline of artificial intelligence (AI) techniques able to calibrate numerical models based on the physics of space weather, with the aim of protecting satellite infrastructures. Indeed, geomagnetic storms are difficult to predict, and this is confirmed by the fact that neither deterministic models nor data-driven AI approaches are able to provide forecasting scores acceptable to timely guarantee protection of the technological space assets from the impacts related to the corresponding solar storms. Essentially all flare forecasting algorithms are currently trained against historical archives containing full-disk images of the magnetic topography characterizing the solar active regions. These archives systematically provide a huge amount of descriptors and it is currently well-established that this redundancy of information significantly hampers the prediction performances of the AI-based forecasters. Hence, tools belonging to the approximation theory framework, as greedy schemes will be applied in this context, in order to identify among this set of features, the actual precursors of the flaring occurrence. It is part of the project Physics-based AI for predicting extreme weather and space weather events (AIxtreme), sponsored by Fondazione Compagnia di San Paolo and Fondazione Cassa Depositi e Prestiti CDP (call for proposal Artificial Intelligence).
Skills and	

Skills and competencies for the development of the activity	Aptitude for research and foundational skills in applied mathematics: methods and models for real-world phenomena, numerical algorithms for model discretization, approximation, and machine learning. Good knowledge of major programming languages, such as Python or MATLAB.