

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
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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 (Alxtreme), sponsored by Fondazione Compagnia di San Paolo and Fondazione Cassa Depositi e Prestiti CDP (call for proposal Artificial Intelligence).
Skills and	Attitudine alla ricerca e competenze base nel campo della matematica

**competencies
for the
development of
the activity**

applicata: metodi e modelli per fenomeni reali, algoritmi numerici per discretizzazione di modelli, approssimazione, machine learning. Buona conoscenza dei principali linguaggi di programmazione, come Python o Matlab.