DEFENSIE
LA DÉFENSE

Royal Higher Institute for Defence

Defence-related Research Action - DEFRA

ACRONYM: AIDefSpace

Title: Using Artificial Intelligence to defend telecommunications and satellite positioning systems from the interference of space weather events

Duration of the project: 01/12/2022 - 01/12/2026

Key words: solar activity, geomagnetic, ionosphere

Budget: 1.006.443 €

of which RHID contribution: 906.000€

PROJECT DESCRIPTION

Communication and positioning systems can be severely disrupted by space weather events. Solar flares and disturbances of the ionosphere can produce intense radio emission that disturb positioning and communication, can cause satellite anomalies, degraded over-the-horizon radar and loss of HF communications. The current state of the art in predicting these processes is severely limited by the availability of data. Predicting solar flares is especially challenging but also ionospheric disturbances and their impact require further improvement for reliable operational forecasting.

Our plan is to meet the immediate requirements of the national defence regarding the protection of ground and space assets using the latest advances in Artificial Intelligence. Our focus is the now- and fore-casting of the three elements that can directly influence the propagation of critical electromagnetic signals: the global geomagnetic, the global ionospheric, and solar energetic states. In this project we will exploit existing open databases of ground and space measurements of these three systems. This data will be used to perform corrections on existing standard models to consider non-standard variations due to solar activity.

We propose three major areas of investigation using machine learning (ML). First, Creation of a numerical model of the full global geomagnetic state that considers solar and heliospheric activity. Second, Creation of a global model of the current (and near-future) ionospheric plasma conditions, including critical parameters as the Total Electron Content (TEC), the altitude of the F-layer and the peak reflection frequency. Third, Development of an automatic report of the probability of flare activity for the next 24 hours.

The methodology of the AIDefSpace is articulated in six phases: 1) Data gathering, 2) Compilation of empirical models, 3) Analysis of the data using ML techniques, 4) Integration of empirical models, 5) Development and training of the ML models, 6) Full software integration. To achieve these goals, we select the best ML architectures for each one of the three models proposed (geomagnetic, ionospheric, solar activity).

AIDefSpace forms the required triple helix with all 3 entities needed with a public research institution coordinating (KULeuven) and a private company as partner (SpaceApps) in close collaboration with government entities in the defence sector and Belspo's space pole. A steering board will be established by our project with participation from all three entities. The partnership is well balanced because it puts together one of the most established public institutions (KU Leuven) active in space weather research with the leading company in Belgium focusing on space weather (SpaceApps).

AIDefSpace will reach three major research objectives:

1. Development of an automatic forecasting of the probability of flare activity for the next 24 hours. This activity will impact: Satellite orbit decay; Geolocation errors; Radio and Radar interference; High Frequency radio blackout and Satellite communication interference.
2. Creation of a numerical model of the full global geomagnetic state that takes into account solar and heliospheric activity. This activity will impact: Geolocation errors; Space track errors, Radar interference, Radio propagation anomalies, Spacecraft charging and drag; Power grid failures.
3. Creation of a global model of the current (and near-future) ionospheric plasma conditions, including critical parameters as the Total Electron Content (TEC), the altitude of the F-layer and the peak reflection frequency. This activity will impact: Degraded satellite communications and GPS Error relative to positioning, navigation, and timing.

These three tools will provide end users with accurate predictions on the suite of space weather processes that affect communications. The outcome of our work can become part of operational practices for planning and executing activities relying on positioning and communication. The proposal identifies examples of such need from past operational problems caused by space weather.

The expected outcome of our project will be ML-based models integrated into a software package and peer reviewed papers describing the methodology used.

CONTACT INFORMATION

Coordinator

Giovanni Lapenta
KULeuven, Departement Wiskunde
Giovanni.lapenta@kuleuven.be

Partners

Leslie Gale
Space Applications Services NV/SA
leslie.gale@spaceapplications.com

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