Anomalies in space: A silent risk to critical infrastructure

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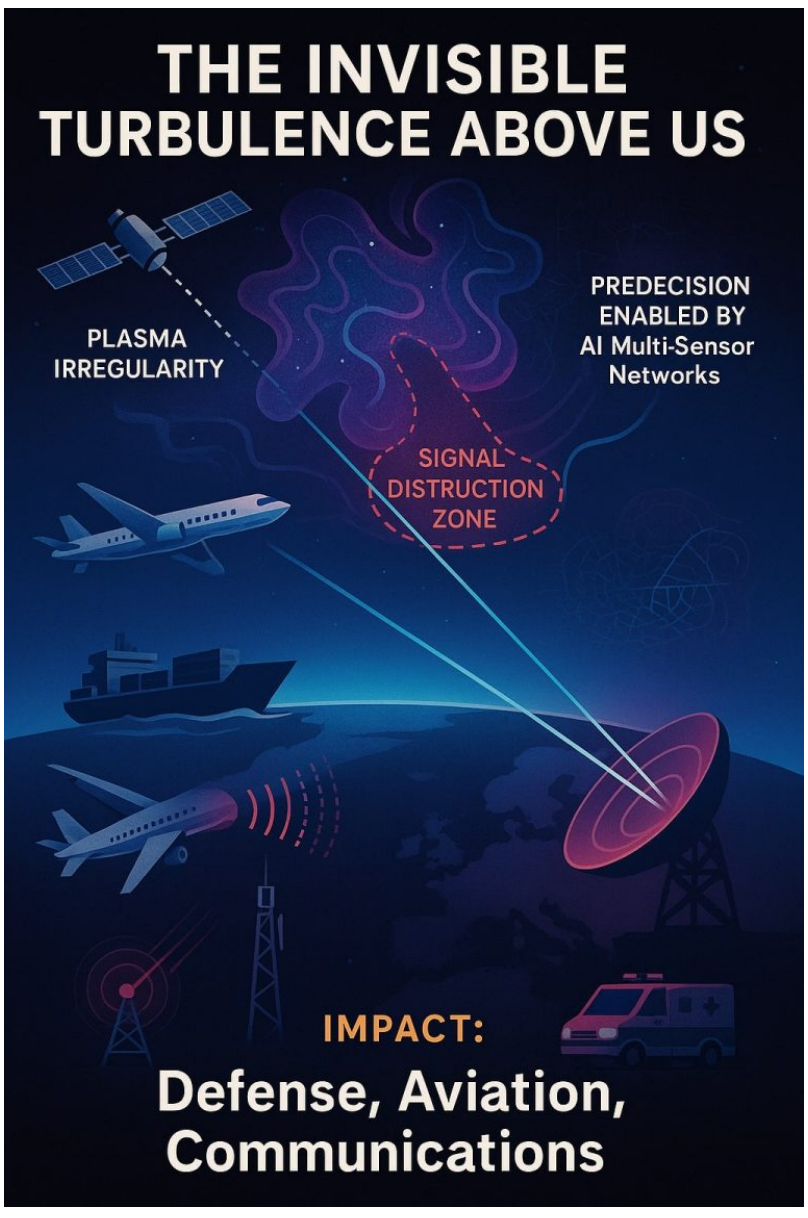
The Earth's ionosphere, an electrified layer of the upper atmosphere, is a vital part of our space environment. It enables or interferes with many of the technologies we rely on daily, such as satellite navigation (GNSS), radio communications, surveillance systems, and satellite operations.

However, this region is not smooth or stable. It is constantly affected by mysterious space anomalies, including invisible structures such as plasma bubbles, wave-like disturbances, and sudden changes in density, which disrupt signals travelling through it.

These anomalies are triggered by a combination of natural processes, such as solar radiation, geomagnetic and lower atmospheric activity that lead to instabilities in space plasma, and increasingly, by human activity in space.



Disturbances caused by anomalies in space

When these anomalies occur, they can distort or block signals used for navigation and communication, causing errors in aircraft positioning, disruptions in high-frequency radio links, and even delays in emergency response operations.

For defence and security applications, including radar and over-the-horizon surveillance, such disturbances can mask targets or degrade performance.

Observing the ionosphere in more detail than ever before

Despite their importance, these anomalies are currently underrepresented in most space weather prediction models. Existing models either smooth out small-scale disruptions or fail to detect them entirely.

This is largely because, until recently, we lacked enough data to track how these irregularities form and evolve, especially at different altitudes and across different regions of the world. However, even when data exists, their confidence is often low, which degrades the performance of prediction models.

Now, for the first time, we have the tools to tackle this challenge. Thanks to a growing network of ground-based sensors and space-based satellites, we can observe the ionosphere in more detail than ever before. At the same time, advances in artificial intelligence allow us to analyse and curate these massive datasets, detect irregularities, and model their behaviour.

The **DISPEC project** addresses these challenges by developing software tools capable of curating data from various observational platforms in space and on the ground, and by demonstrating the efficiency of the resulting high-level data products in enhancing the performance of ionospheric prediction models. This will enable the prediction of when and where anomalies in space may occur —and how they may impact communication, navigation, and surveillance systems.

In a world that increasingly depends on secure, uninterrupted space-based services—and where space is becoming more crowded, especially in low-Earth orbit —monitoring and predicting irregularities in space plasma is no longer a scientific luxury. It's an operational necessity.

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