Predicting equatorial plasma bubbles with SWARM

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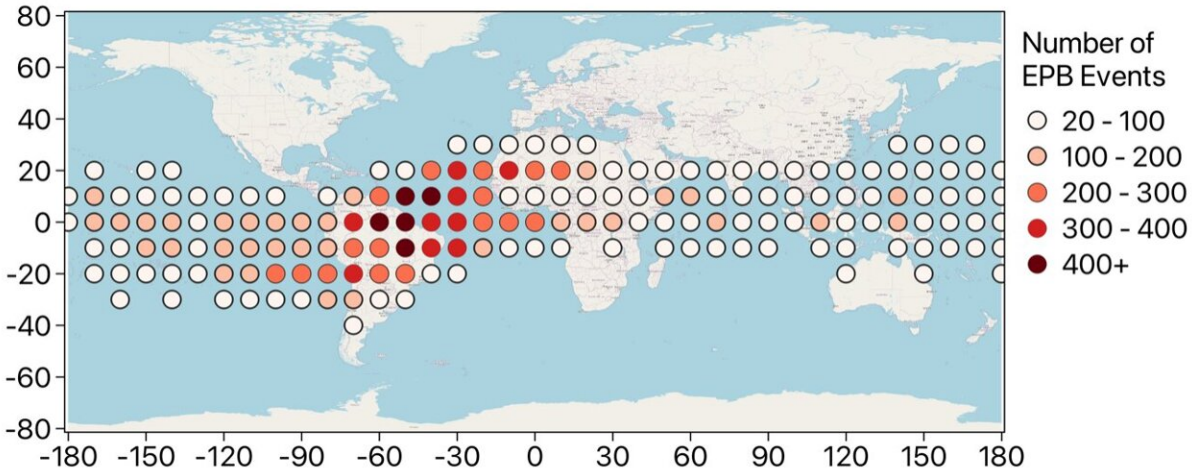

Map of Equatorial Plasma Bubble (EPB) events across the Earth. Most bubbles occur over the Atlantic in a region called the 'South Atlantic Anomaly'. Here high energy particles and gamma rays penetrate deep into our atmosphere and influence the creation of bubbles. Credit: Sachin Reddy/University College London/Mullard Space Science Laboratory

Changes in atmospheric density after sunset can cause hot pockets of gas called "plasma bubbles" to form over the Earth's equator, resulting in communication disruptions between satellites and the Earth. New AI models are now helping scientists to predict plasma bubble events and create a forecast. The work was presented this week at the National Astronomy Meeting (NAM 2022) by Sachin Reddy, a Ph.D. student at

University College London.

Shortly after sunset, pockets of super-heated gas called "plasma bubbles" form in the upper atmosphere and stretch into space (up to 900 km above the Earth's surface). These bubbles start small and grow rapidly—from the size of a football pitch to that of a small country in just a couple of hours. As the bubbles grow bigger, they can prevent satellites from communicating with the Earth by blocking and warping their radio signals.

To predict plasma bubbles, a team of researchers has collated 8 years of data from the SWARM satellite mission. The spacecraft has an automatic bubble detector on-board called the Ionospheric Bubble Index. This compares changes in the density of electrons and the magnetic field strength to check if bubbles are present: a strong correlation between the two indicates the presence of a plasma bubble.

The satellite flies at an altitude of 460 km (about 30x higher than a commercial plane) through the middle of most plasma bubbles. The model combines the data collection from SWARM with a machine learning approach to make predictions on the likelihood of a plasma bubble event occurring at any time.

Crescent moon rising above the cusp of the Earth's atmosphere. Credit: NASA

The results show that the number of plasma bubble events varies from season to season, just like the weather, and that the number of events increases with solar activity. Despite this, the model finds location to be a far more crucial element in predicting plasma bubbles than the time of year, with most events occurring over a region in the Atlantic called the South Atlantic Anomaly. The AI model predicts events with an accuracy of 91% across different tests.

Reddy says that "just like the weather forecast on Earth, we need to be able to forecast bubbles to prevent major disruptions to satellite services. Our aim is to be able to say something like: 'At 8pm tomorrow there is a

30% chance of a bubble appearing over the Horn of Africa.' This kind of information is extremely useful for spacecraft operators and for people who depend on satellite data every day, just like you and me."

More information: Conference: nam2022.org/

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