PITHIA-NRF TNA Success story: **CPD&EGA** (**C**haracterization of **P**lasma **D**epletions and **E**ffects on **G**eodetic **A**pplications)

The ionosphere is a region in the upper atmosphere extending from approximately 50 km to 2,000 km above the Earth's surface with free charged particles, called plasma, that is formed mainly through photoionization by solar radiation. Irregular variations in the ionosphere can significantly impact radio communications, satellite operation, navigation, and numerous other applications that rely on the propagation of radio waves. Equatorial Plasma Bubbles (EPBs) are regions of depleted ionization which are mostly confined within ±25° latitude and of transitory duration. The dynamics of EPBs are not yet fully understood and are the main form of ionospheric irregularities in the equatorial F-region.

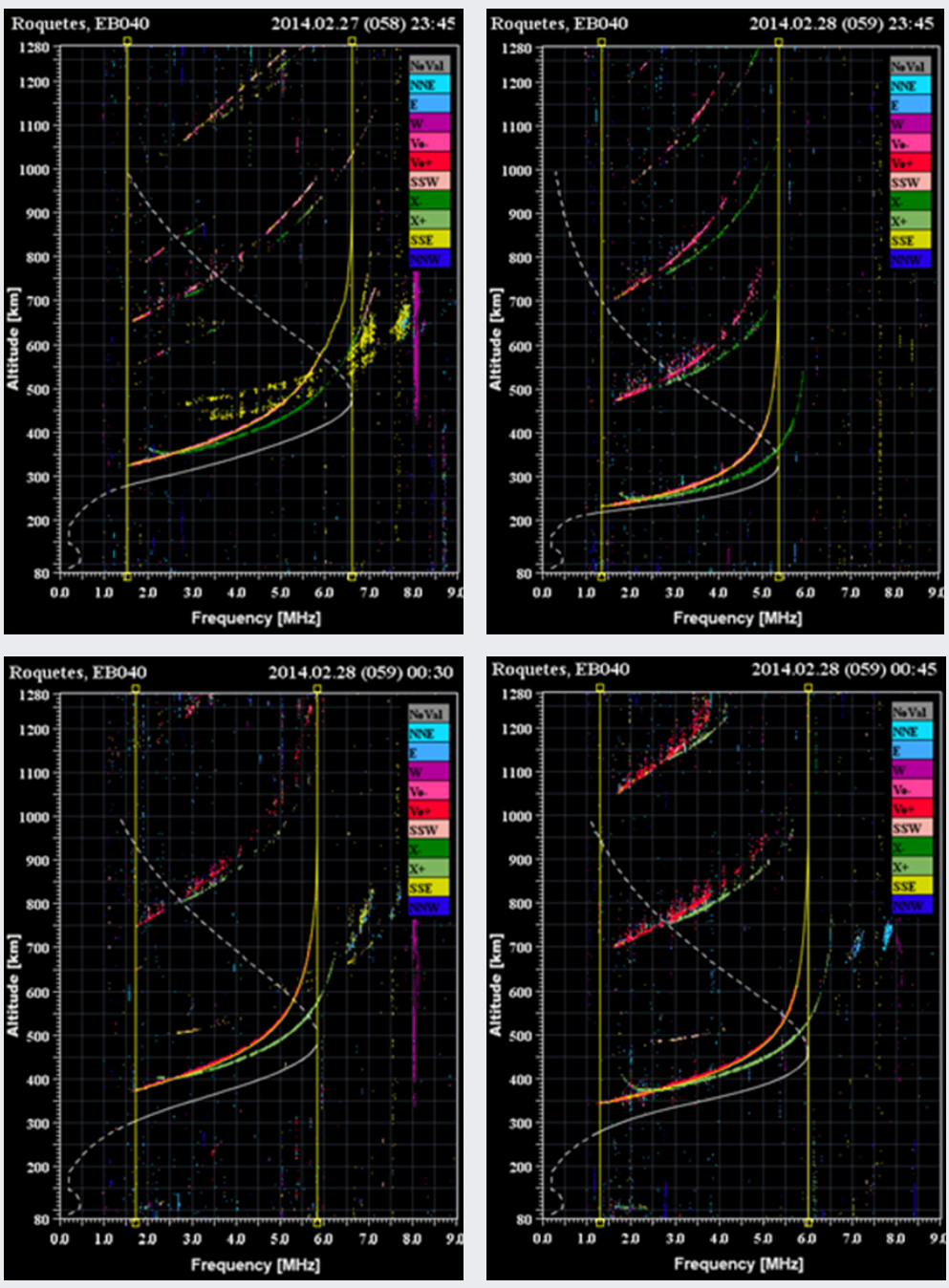
Thanks to PITHIA-NRF TNA, researchers from the Nanjing University Information Science Technology (Nanjing, China) joined the Ebro Observatory (Roquetes, Spain) PITHIA-NRF node, to study the ionospheric plasma depletions. Using a multi-instrumental data combination consisting of airglow remote sensing, ionosonde, magnetometers, and in-situ satellite data, the geomagnetic storm of the 27 February 2014 was investigated. This storm caused GNSS positioning errors exceeding undisturbed levels by at least 2 times, and ionospheric corrections reached amplitudes of up to ±20 m.

The results of the project made possible to describe the potential of ionosonde data to characterize localized plasma depletions. Moreover, the combination of these data with other techniques, allowed to identify 3 large plasma depletions (EPBs) and characterize their origin and dynamics. The research confirmed that the EPBs irregularities reached unusual latitudes as high as 40 north, the movement of the irregularity from equatorial latitudes to the northeast direction and that the ionosphere was lifted by 100 km from undisturbed levels.

Based on the project results, a paper was published and presented at the IUGG 2023 conference:

- Calabia, A., Imtiaz, N., Altadill, D., Yasyukevich, Y., Segarra, A., Prol, F. S., et al. (2024). Uncovering the drivers of responsive ionospheric dynamics to severe space weather conditions: A coordinated multi-instrumental approach. Journal of Geophysical Research: Space Physics, 129, e2023JA031862. https://doi.org/10.1029/2023JA031862.
- A. Calabia Aibar. Ionospheric Plasma Depletions and coupled Space Weather Processes during the Geomagnetic Storm of 27 February 2014. 28th General Assembly of the International Union of Geodesy and Geophysics (IUGG), Berlin 2023 https://doi.org/10.57757/IUGG23-4265.

The two ionograms of the upper row show that the ionosphere was lifted by more than 100 km from undisturbed levels; i.e. from 320 (right) to 470 km (left). The three ionograms recorded from 27 February at 23:30 UTC observe oblique echoes with a SSE (South–Southeast) direction turning to have a NNE (North–Northeast) direction on 28 February at 00:45 UTC, which subsequently turn into undisturbed ionograms (i.e., vertical echoes only). The latter observations indicate a gradient in the electron density, which can be attributed to the movement of an irregularity in the NE direction.



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