A modification of the PINE model for real-time plasmasphere forecasts

Stefano Bianco[1], Irina Zhelavskaya[1,2], Yuri Shprits[1,2,3]
bianco@gfz-potsdam.de
[1]GFZ German Research Centre For Geosciences, Germany, [2]University of Potsdam, Germany, [3]University of California, Los Angeles, CA, USA

1. Motivation

- Size and shape of the plasmasphere are driven by the level of solar wind and geomagnetic activity (2-7 Earth radii).
- Plasma density in the plasmasphere is important for quantifying the role of plasma waves in the formation and decay of the Earth's radiation belts.
- Radiation belts electrons are harmful to satellites since they are the source of surface and deep dielectric charging.
- The PAGER project ref.[1] aims to provide a two-days-ahead forecast of the risks through a pipeline of algorithms connecting the solar activity with the satellite charging.
- A component of the PAGER project ia a model of plasma density in the plasmasphere having solar wind and Kp as inputs forecasted by other components of the project.

4. Method

- Nowcast model using a feedforward neural-network following the PINE model ref. [2, 3].
- Restricting input features to the Kp index, the proton density, $vsw * B_{south}$, where v_{sw} is the solar wind speed and B_{south} the southward component of B_z.

3. Data

- Solar wind data at L1 ref. [4].
- Kp index ref. [5].
- Electron density along the Van Allen Probes (VAP) orbits ref. [6]

Sparse electron density data in the equatorial plane along the VAP orbits and varying in time due to solar activity.

5. Validation results

Validation on plasmapause locations extracted from IMAGE EUV images ref. [7] during several geomagnetic conditions

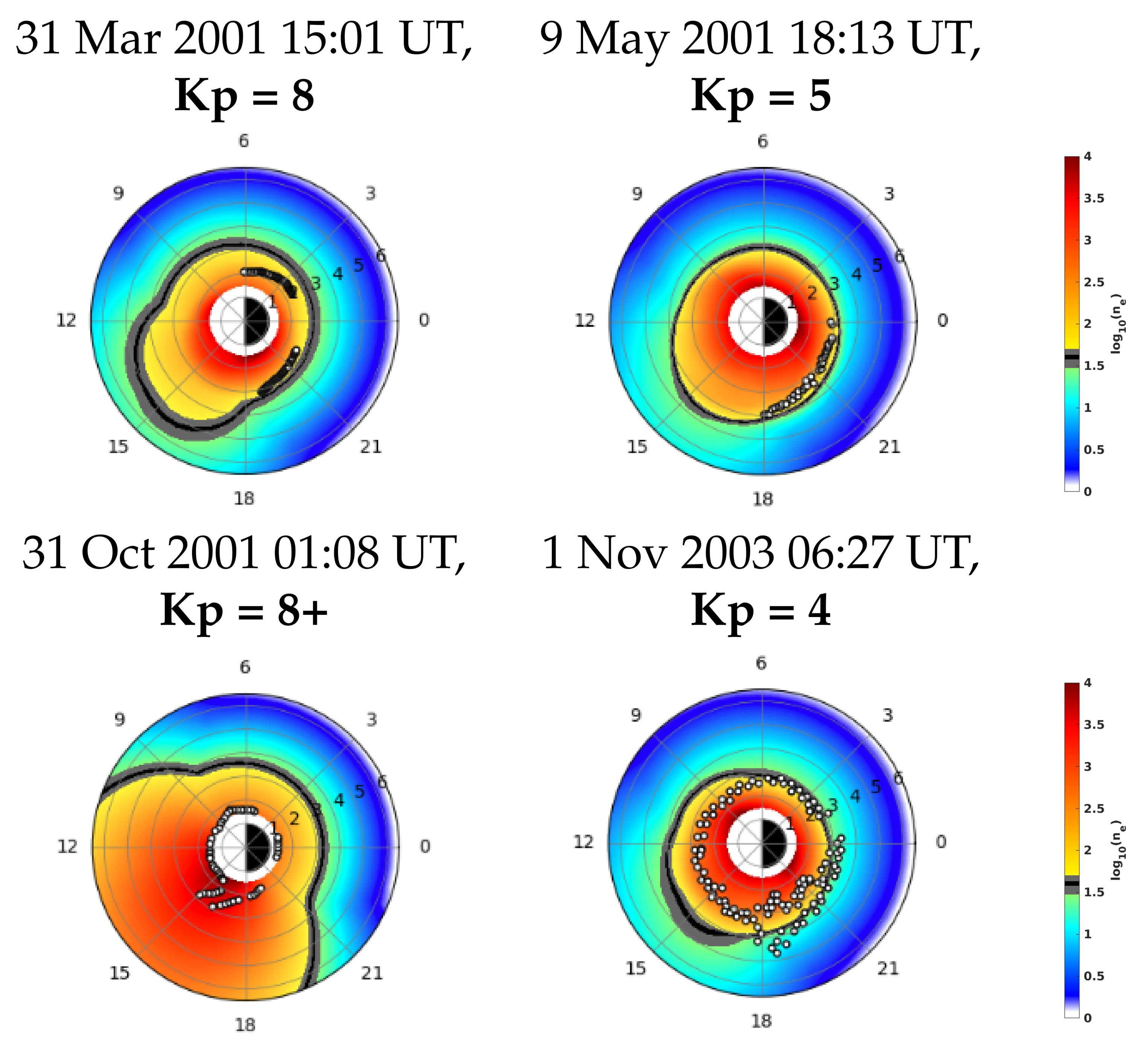

Figure: Grey dots are plasmapause locations extracted from IMAGE EUV images ref.[5]. Black line represents the predicted plasmapause location, while the grey area around it represents the uncertainty.

- Good approximation of the plasmapause location during quiet times (not shown in the picture), moderate storms and also some strong storms.
- The model captures generally the erosion associated to a storm, but not the plume structure, which is the elongated structure that can be seen for example in the event of 31 Oct 2003.
- The model struggles during the main phase of the 2003 Halloween storm, but good performance during its recovery phase.

7. Points to improve/ideas

- data augmentation for extreme storms and plumes
- deeper neural networks to capture the plumes.
- suggestions?????

Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 870452 (PAGER).

References

1. PAGER project, https://www.spacepager.eu/
2. Zhelavskaya et al, (2017), J. of Geophys. Res. Space Physics, 122, 11,227-11,244.
3. Zhelavskaya et al, (2021), J. of Geophys. Res. Space Physics, 126, e2020JA028077.
4. OMNIWeb (http://omniweb.gsfc.nasa.gov/form/dx1.html)
5. Zhelavskaya et al, (2017), J. of Geophys. Res., 122, 11,227-11,244, doi:10.1002/2017JA024406.
6. Zhelavskaya et al, (2016), J. of Geophys. Res., 121, 4611–4625, doi.org/10.1002/2015JA022132.
7. http://enarc.space.swri.edu/EUV/