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STATISTICAL STUDY OF THE VARIABILITY OF IONOSPHERIC PARAMETERS MEASURED BY SWARM SATELLITES

Daria Kotova*, Yaqi Jin, and Wojciech Miloch
Department of Physics, University of Oslo, Norway;
* daria.kotova@fys.uio.no

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▸INTRODUCTION

The Swarm mission allows us to investigate the effects of changing solar activity on ionospheric variability. We use the Swarm in situ measurements of the electron density and derived parameters that have been combined into a unique dataset called the **I**onospheric **P**lasma **IR**regularities product (IPIR) **[1]**. IPIR provides characteristics of the plasma variability along the orbit and gives information on plasma density structures in the ionosphere in terms of their amplitudes, gradients and spatial scales.

Here we have continued the study of **Kotova et al. [2]** by including a larger data set and focusing on quiet geomagnetic conditions. We focused on distributions of electron density (Ne) and rate of change of density index (RODI) in 10 seconds in different regions in the Northern and Southern hemispheres for different solar activity levels.

> **Understanding the distribution of ionospheric parameters in the context of changing of solar activity level can have implications for the development of new satellite instruments and for the accuracy of GNSS precise positioning.**

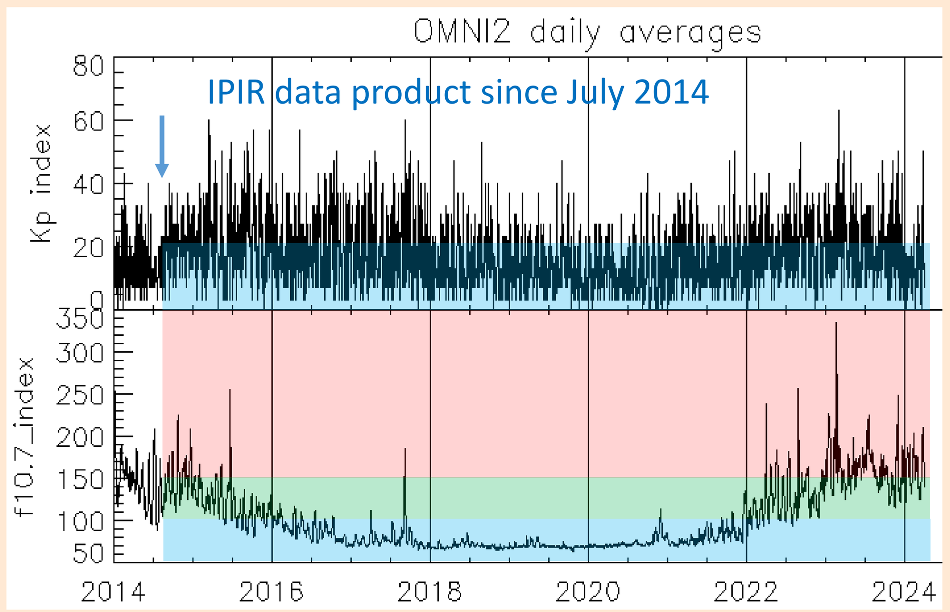

FIG.1: Geomagnetic (Kp) and solar (F10.7) activity indices, omniweb.gsfc.nasa.gov

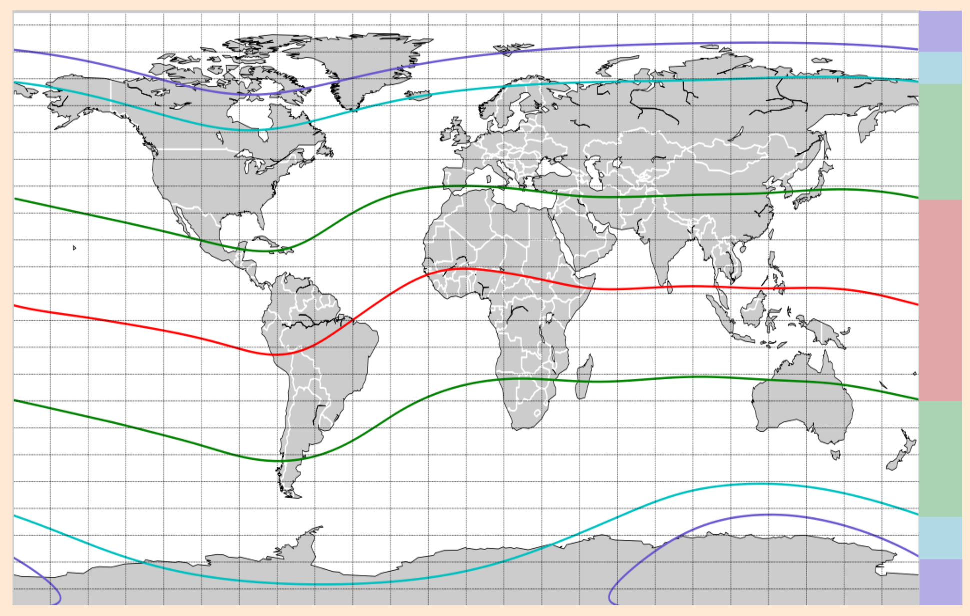

FIG.2: Selected regions in the Northern and Southern Hemispheres

We used Swarm data selected only for quiet geomagnetic conditions (Kp≤2). For these data, we consider different levels of solar activity based on solar radio flux at 10.7 cm : high solar activity (HSA) at F10.7>150, moderate solar activity (MSA) at 100<F10.7<150 and low solar activity (LSA) for F10.7<100. Regions were defined based on the *Ionosphere_region_flag* in the IPIR data product **[1]**, selecting equatorial and polar regions, mid- and high-latitudes in both hemispheres.

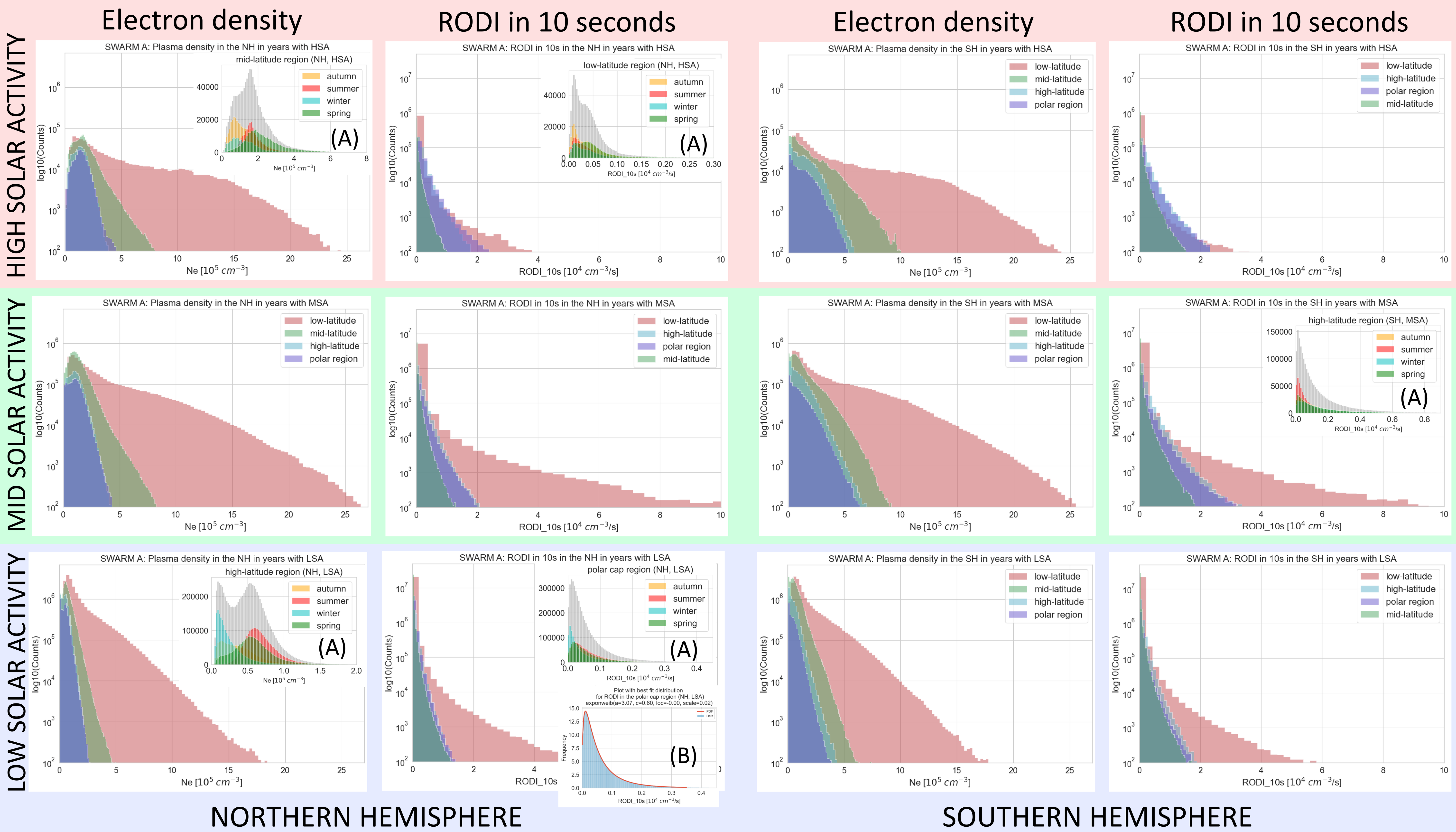

FIG.3: Distributions (histogram) of the electron density and RODI in 10s measured by Swarm A in Northern and Southern hemispheres during the days with high (top row), middle (central row) and low (bottom row) solar activity levels. The colours present the distribution in different regions: red in the low latitude region, green in the mid-latitude, blue in the high latitude, and purple in the polar cap regions. Y-axes presented in logarithmic scale. Small plots (A) present some cases for one region with a more in-depth analysis of seasonal variability. The gray histogram represents the overall distribution, and the colors represent the contributions of the seasons. (B) Example of the best probability density functions (red line) determined to fit the histogram of the data (blue).

▸BOX-PLOT

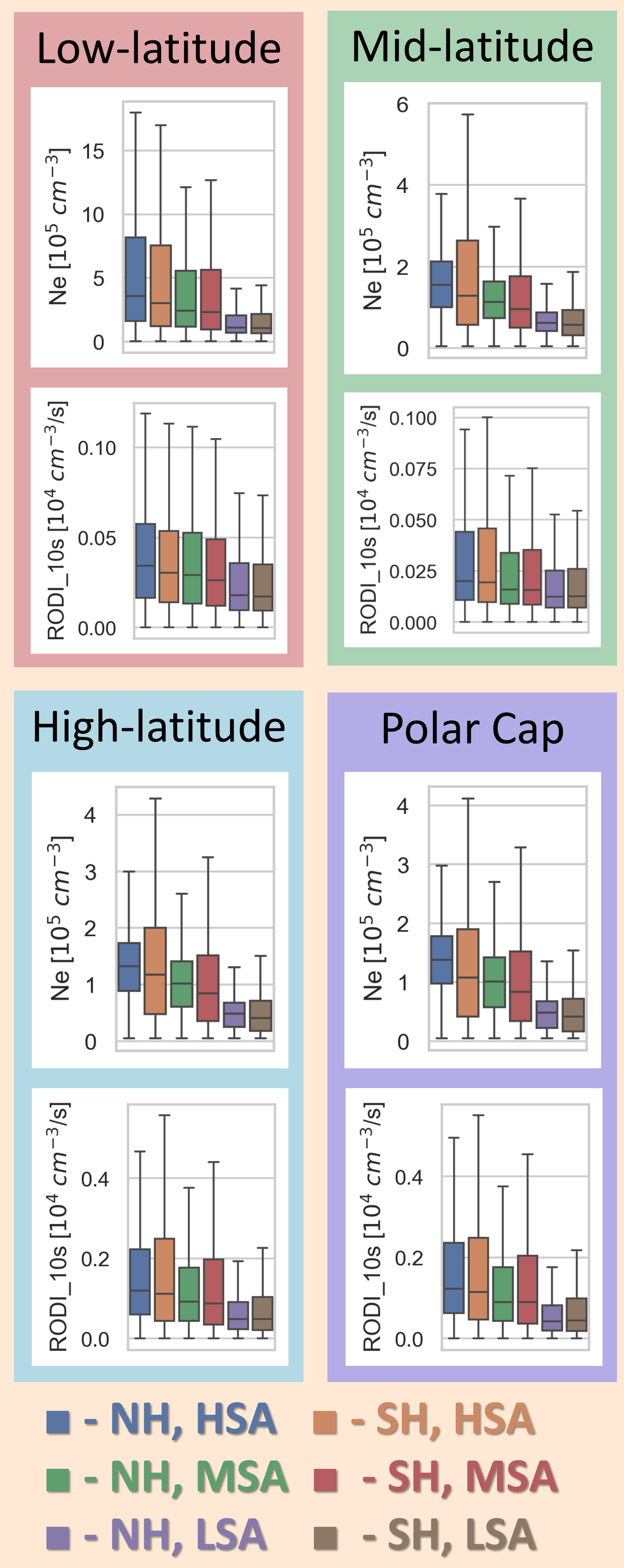

FIG.4: Box-plot with whiskers of Ne and RODI in 10s measured by Swarm A in Northern and Southern hemispheres. The box is drawn from lower (25%) to upper (75%) quartile percentiles with a horizontal line to denote the median value.

▸WORK WITH BIMODAL DISTRIBUTION of Ne

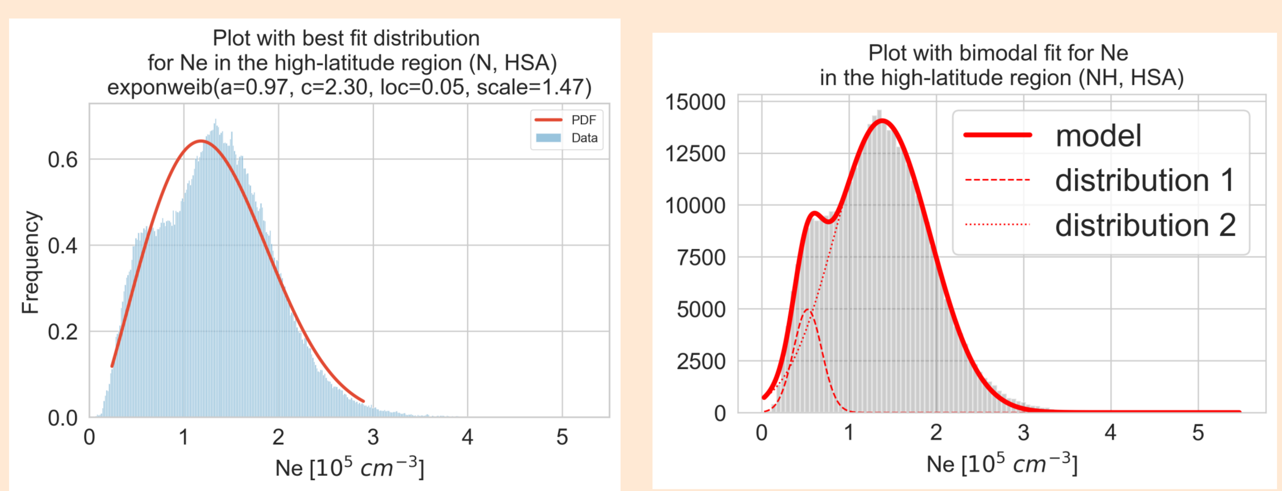

FIG.5: An example of approximation of the bimodal Ne distribution using the model a sum of Gaussian curves.

▸CONCLUSIONS

- **The main source** of a two-peaked distribution of electron density is primarily **solar illumination of the region**.
- Comparing both hemispheres **during different solar activity levels**, we obtained **higher values** of RODI in 10s and electron density **in the Southern hemisphere**.
- **Our results** provide information on the shape of the distribution and probability density functions of Ne and derived ionospheric parameters (as RODI in 10 seconds) that **can be used as a baseline important for other modeling studies**.

▸REFERENCES

[1] Jin et al., 2022

[2] Kotova et al., 2022

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