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Plasmasphere Contribution to Total Electron Content at High and Middle Latitudes

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Introduction and motivation

- GNSS measurements enable to obtain total electron content (TEC) values along the entire "receiver-satellite" line-of-sight (up to ~ 20000 km altitude) with high temporal resolution and spatial coverage.
- However, the measured TEC is the sum of the ionosphere (IEC) and plasmasphere (PEC) electron contents. Therefore TEC data, in a certain sense, "mix" the ionosphere and plasmasphere contents.
- It is impossible to separate the ionosphere and plasmasphere contributions to TEC from GNSS measurements only, additional data are required.

Data and methods

- To calculate ***TEC*** data, we use data from GNSS receivers located at middle (IRKJ, 52°N, 104°E) and high (NRIL, 69°N, 88°E) latitudes. Absolute vertical ***TEC*** values are calculated by the method developed in [Yasyukevich et al., *Res. In Phys.*, 5, 2015. 32-33; free software: www.gnss-lab.org].

- To estimate ionosphere electron content (***IEC***), we use measurements from ionosondes located in Irkutsk and Norilsk. ***IEC*** is calculated by the procedure described in [Huang & Reinisch, *Radio Sci*. 36(2), 2001. 335-342].

$$\boldsymbol{IEC} = \int_{0}^{h_mF2} N_e(h)dh + \int_{h_mF2}^{\infty} N_T(h)dh$$

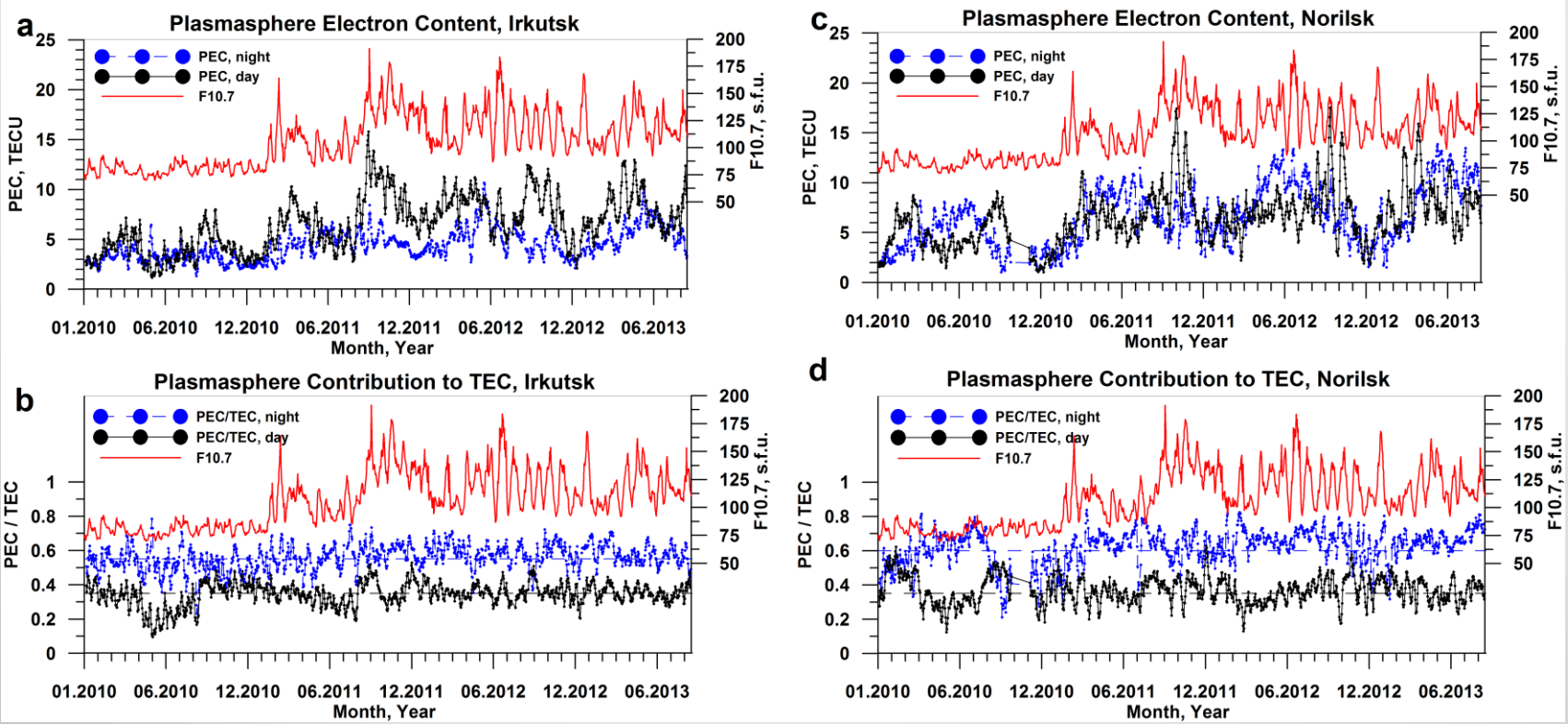
- To separate the ionosphere and plasmasphere contributions we define plasmasphere electron content (***PEC***) as :

$$\boldsymbol{PEC} = \boldsymbol{TEC} - \boldsymbol{IEC}$$

- Temporal resolution of the calculated ***TEC*** and ***PEC*** is 15 min (corresponds to the ionosondes' data).

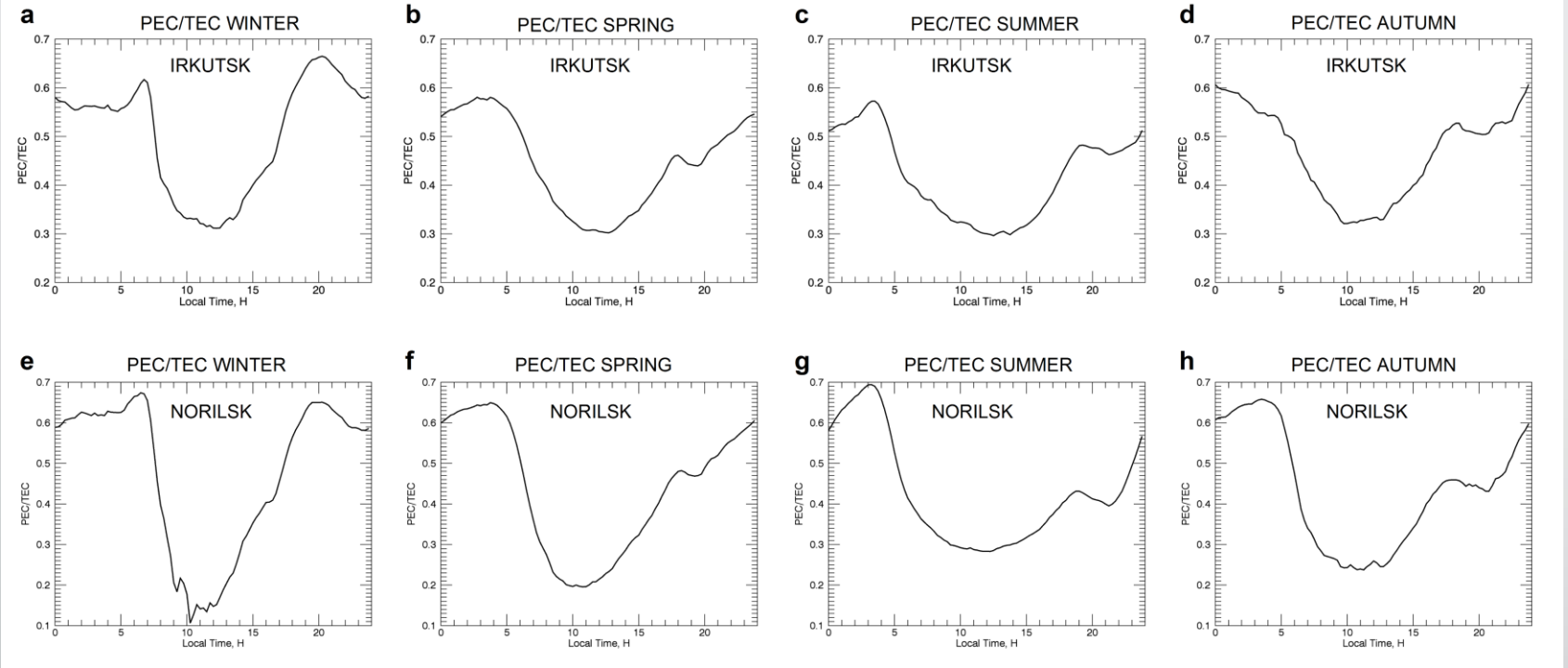
- We also compare obtained experimental data with simulations from IRI-plas model [Gulyaeva, *Astronom. & Astrophys. Trans.*, 22, 2008, 639-643]

PEC and plasmasphere contribution to TEC



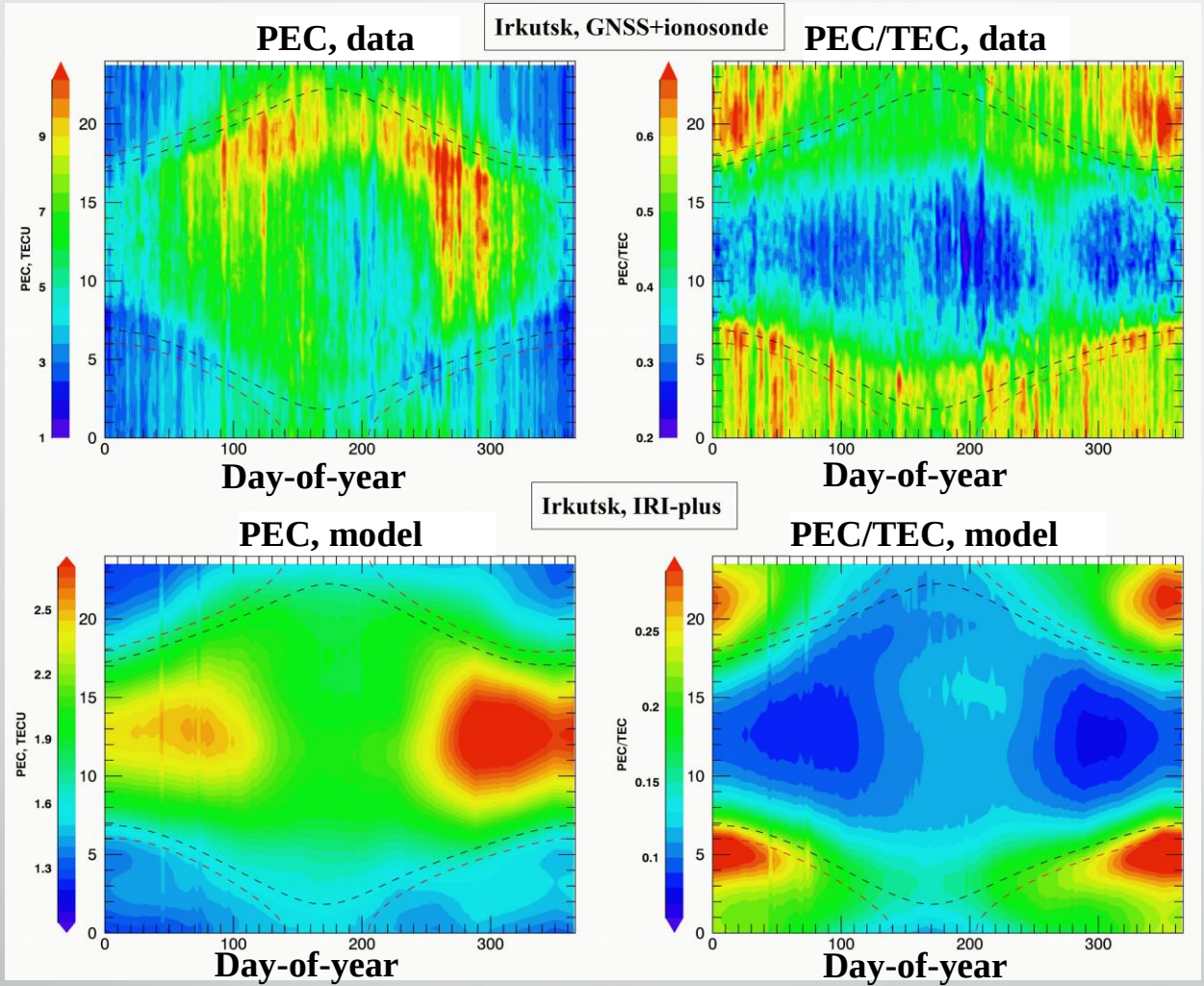
- PEC values follow the changes in the level of solar activity.
- On daytime, PEC is 25-30% of TEC. At nighttime, the plasmasphere contribution increases substantially. It averages about half of TEC (up to 70%).
- At high-latitudes nighttime PEC is higher than at mid-latitudes.
- Plasmasphere contribution to TEC (PEC/TEC ratio) practically does not change with solar activity: it fluctuates around 0.35 at midday and ~0.55-0.6 at night.

Diurnal variations in plasmasphere contribution



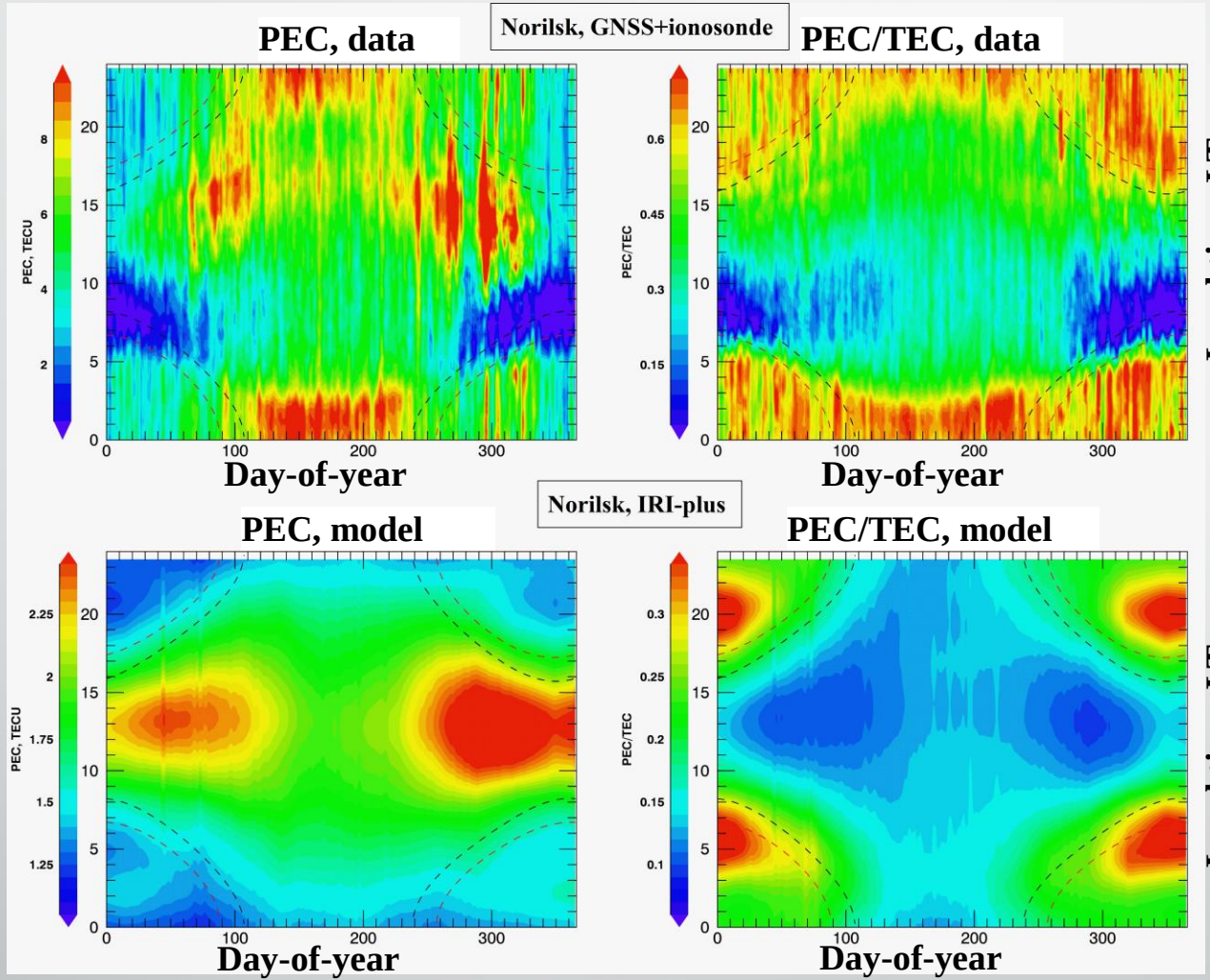
- PEC/TEC ratio varies significantly within local time.
- PEC/TEC ratio reaches up to 0.6-0.7 at the nighttime.
- Maximum in plasmasphere contribution to TEC is registered before sunrise.
- At the daytime the PEC/TEC ratio drops to minimum value (0.2-0.3) around midday. This minimum is the narrowest in winter and the widest in summer.

Experimental data and IRI-plas model (Irkutsk)



The local time versus day-of-year distributions of PEC (left) and PEC/TEC ratio (right) from experimental data (top) and the IRI-Plas model simulations (bottom). PEC and PEC/TEC ratio distributions feature significant diurnal and seasonal variations.

Experimental data and IRI-plas model (Norilsk)



The same distributions for Norilsk. The model underestimates the level of the plasmasphere contribution. But general dynamics from experimental data and IRI-Plas model are close.

Summary

- PEC/TEC ratio features strong diurnal and seasonal variations.
- On daytime, PEC is 25-30% of the total electron content and has it minimum value in summer midday.
- At nighttime, the plasmasphere contribution increases substantially: it averages about half of TEC value, and reaches in some periods 70%.
- The maximum contribution of the plasmasphere to TEC is registered before sunrise.
- PEC/TEC ratio practically does not change with solar activity.
- General dynamics in PEC and PEC/TEC ratio from experimental data and IRI-Plas model are close. The model underestimates the level of the plasmasphere contribution.

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Thank you for attention!

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