

## **FIRST-PRINCIPLES MODEL PREDICTION OF SOME NEW IONOSPHERIC PHENOMENA AND DISTURBANCES THAT SHOULD BE VALIDATED**

**MAXIM KLIMENKO<sup>\*</sup>, VLADIMIR KLIMENKO<sup>\*</sup>, KONSTANTIN RATOVSKY<sup>\*\*</sup>,  
FEDOR BESSARAB<sup>\*</sup>, EUGEN ROZANOV<sup>\*</sup>, TIMOFEI SUKHODOLOV<sup>\*</sup>, IRINA  
ZAKHARENKOVA<sup>\*</sup>, YURY YASYUKEVICH<sup>\*\*</sup>, ANNA YASYUKEVICH<sup>\*\*</sup>, DAVID  
THEMENS<sup>\*\*\*</sup>, ALEXANDER KARPACHEV<sup>\*\*\*\*</sup>, YURIJ KORENKOV<sup>\*</sup>**

<sup>\*</sup> West Department of Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation  
RAS Kaliningrad, Russia  
e-mail: maksim.klimenko@mail.ru

<sup>\*\*</sup> Institute of Solar-Terrestrial Physics SB RAS Irkutsk, Russia  
e-mail: ratovsky@iszf.irk.ru

<sup>\*\*\*</sup> University of New Brunswick, New Brunswick, Canada  
e-mail: david.themens@gmail.com

<sup>\*\*\*\*</sup> Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation RAS Moscow, Russia  
e-mail: karp@izmiran.ru

Advances in first-principles models have predicted anomalies and phenomena in the ionosphere previously non-highlighted using observation data. In this report we present a brief review of some novel aspects in ionospheric physics and morphology that was revealed by Global Self-consistent Model of Thermosphere, Ionosphere and Protonosphere (GSM TIP) and by the new Entire Atmosphere GLocal model (EAGLE) that combines the upper atmosphere model (GSM TIP) and the neutral atmosphere model (HAMMONIA). For instance, recent GSM TIP or EAGLE simulations have revealed: 1) after-storm positive ionospheric response in mid-latitude F region ionospheric density that is associated with neutral composition redistribution; 2) nighttime F3-layer formation due to non-uniform in height vertical ExB plasma transport; 3) vertical structure in delay of ionospheric electron density variability relative to 27-day variability in solar activity index; 4) the post sunset enhancement and pre-sunrise reduction of total electron content as response to 2009 sudden stratospheric warming that are formed via disturbances of meridional and zonal electric field; 5) the stratification of the storm-enhanced tongue of ionization during 2015 St. Patrick geomagnetic storm that is explained by combine effect of neutral tongue structure and storm-time thermospheric wind disturbances. The existence of some from these ionospheric features was proofed by other model results and validated using different ground-based and satellite measurements. For our validation effort we used the analysis of vertical TEC values from raw GPS/GLONASS measurements, incoherent scatter radars data, ionosonde manually scaled data, topside sounding data. It is important to note that the validations of highlighted ionospheric phenomena should be continued in order to reveal their statistical significance. Additionally to validation problem we investigated the global electron content variations for all presented modeled event in order to understand its possibility as ionospheric index. This study was financially support-

ed by the Russian Science Foundation (Grant No. 17-17-01060), and by the Russian Foundation for Basic Research (Grant No. 18-05-00594).