The project is devoted to solve important problem of the Earth's atmosphere physics related to generation and dynamics of ionospheric plasma disturbances, in particular irregularities and structures with different scales. The ionosphere is part of Earth's upper atmosphere, between 80 and about 1000 km. The ionosphere is important because it reflects and modifies radio waves used for communication and navigation. During geomagnetic storms, the ionosphere becomes very instable and highly structured. The goal of project is to track in time and space the major features of ionospheric disturbances that impact satellite communication and navigation. Primary scientific objective of the project is to improve knowledge about physics of ionospheric plasma disturbances, in particular its spatial size, location, life-time, etc. Ionospheric disturbances at different latitudinal regions of the Earth have totally different mechanisms of their generation and development. At quiet time, the mid-latitude ionosphere is typically free from ionospheric irregularities. It is still not well understood how dangerous for radio-signals propagation can be ionospheric irregularities developed at midlatitudes during geomagnetic storms.

This project bases on multi-instrumental study of ionospheric disturbances phenomenon using Swarm satellite observations and data from more than 6000 ground-based GNSS receivers. Three Swarm satellites are flying at ~450-550 km altitude inside the ionosphere and measure multiple ionospheric characteristics along its trajectory, as well as around the satellite. The multi-instrumental observations onboard three satellites flying from pole to pole in different sectors and at different altitudes combining with ground-based observations will be used for comprehensive study of ionospheric disturbances phenomena.

Figure below illustrates modeled formation of strong ionospheric disturbances within between altitudes of 500 and 900 km that look like multiple bubbles deformed normal layered plasma distribution. Such structures affect and distort propagation of GPS signals towards the recipients on the ground such as ground-based GPS receiver or users of GPS navigators. The Swarm satellite can encounter these structures along its orbit trajectory and register the ionospheric disturbances at this orbit altitude (as in situ measurements). The GPS receiver onboard Swarm satellite can track multiple GPS signals passing the ionospheric disturbances just above the Swarm orbit. GPS observations from the ground level by huge number of 6000 stations (view from one station shown as a yellow cone) can supplement the satellite information from the orbit to understand how these ionospheric disturbances look like from different observational points and how exactly they affect GPS receiver performance for ground-based and space-based GPS receivers. The project will produce new knowledge about morphology of ionospheric disturbances that occur at various latitudes and longitudes around the globe during geomagnetic storms.