GPS technologies as means for natural hazards monitoring

Sergey Pulinets, Dmitry Davidenko, Maria Titova

Space Research Institute (IKI), Russian Academy of Sciences, 84/32, Profsoyuznaya str., 117997, Moscow, Russia

The majority of natural hazards (except floods) create dynamic impact on the Earth's atmosphere and through different mechanisms of atmosphere-ionosphere coupling imprint their dynamics in the variations of electron concentration. We investigate both: effect themselves and physical mechanisms of their generation. For some effects such as earthquakes and volcano eruptions the ionospheric effects have predictive capabilities because reveal themselves before the disaster. Two main coupling mechanisms are considered: acoustic gravity waves generated by the large-scale atmospheric events such as hurricanes or atmospheric pressure modulation by tsunamis, and electromagnetic coupling mainly through the Global Electric Circuit local disturbances.

1. Hurricanes. Usually we observe the positive TEC anomaly over the hurricane location. We can consider possibility of the strong electric field from the top of hurricane penetration into the ionosphere or modulation of the ionospheric potential by decrease of troposphere conductivity by the hurricane body. AGW effects could be expected as well.
2. Dust/sand storms. Extensive positive TEC anomaly is generated over the large-scale dust cloud due to decrease of troposphere conductivity and corresponded increase of ionosphere potential. The similar but weaker positive TEC anomalies are observed as post-volcano eruption ash cloud effect.
3. Tsunamies. The wave-like disturbances are observed over the tsunami wave due to AGW propagation to the ionospheric altitudes.
4. Radioactive pollution. All types of radioactive pollution (natural – Oklo), nuclear waste storage leakage, nuclear power plant disasters, nuclear weapon tests create formation of positive and negative large-scale irregularities in the ionosphere mainly due to electromagnetic coupling through the modulation of air conductivity.
5. Pre-earthquake and volcano eruption effects have the nature similar to nuclear pollution but in this case natural radon emanation serve as the source of air ionization. Because the earthquake preparation is the long-lasting effect, the splashes of radon emanation due to tectonic movements may appear before the seismic event, we have possibility to observe the ionospheric anomalies before the disaster.
6. Post-earthquake earthquake and volcano eruption effects due to large-scale movements of air excite the acoustic gravity waves propagating to the ionosphere altitudes could be registered by GPS TEC measurements. Sometimes the AGW effects are also registered before earthquake.

Different GPS technologies are used to reveal the ionospheric effects of natural disasters: GPS TEC measurements, occultation technology, high orbit ionospheric tomography, differential GIM maps and others. We demonstrate technologies of automatic detection of ionospheric anomalies excited by disasters.

According the comparison of the different types of atmosphere-ionosphere coupling we can state that electromagnetic coupling approximately two orders of magnitude more effective than AGW coupling mechanism. The role of the Global Electric Circuit (GEC) has universal character in atmosphere-ionosphere coupling regardless of the type of disaster.

This work was supported by the Russian Science Foundation under grant 18-12-00441.