# Simulation of electron environment in space at 36,000 km

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A spacecraft at near-Earth orbit is continuously bombarded by charged particles. Finnish Meteorological Institute has developed a unique model that simulates electron environment in the near-Earth space.

Finnish Meteorological Institute's new model specifies the electron environment at any orbit where important satellites are moving. FMI' s new IMPTAM (Inner Magnetosphere Particle Transport and Acceleration Model) model is a unique tool and the only one in Europe. "Specifying the electron flux at any satellite orbit, we will be able to provide satellite operators the critical information for surface charging of satellite materials", says the main developer of the IMPTAM model, FMI's researcher Dr. Natalia Ganushkina.

At present, there are about 1000 operational satellites at different orbits in the near-Earth space and all of them pass through the regions where the radiation environment can vary significantly with location. All the variability is imposed by the activity of the Sun.

Electrons with these energies constitute one of the most important parts of the radiation environment in the near-Earth space. First, they are responsible for discharges on the surface of the outer spacecraft layers that can cause significant damage and spacecraft anomalies. Second, they are accelerated to much higher energies of megaelectronvolts and populate the Earth's radiation belts which are from the radiation hazard viewpoint the two most critical regions around the Earth.

Main drivers of transport and acceleration of electrons with energies of 50 to 150 kiloelectronvolts (keV) to geostationary orbit (36000 km above the Earth) in space. Electrons come to geostationary orbit from the areas in space located at about 10 Earth Radii (1 Earth Radius is equal to 6400 km) from the Earth in the direction away from the Sun. They move towards the Earth not in empty space but in magnetic and electric fields whose presence was established from observations. These magnetic and electric fields guide electrons, and if they change, electrons move differently. Since we do not have satellites in every point in space to tell us what are the magnitudes of the fields, we need to use models for these fields.

A very good agreement is achieved between the observed electrons in form of electron fluxes measured by several satellites at geostationary orbit and our model electron fluxes at the same locations as satellites. The main factor was found to be the inclusion of small-scale electric fields related to reconfiguration of electric and magnetic fields during substorms, phenomena which occurs in our space very often, almost every day and last 1-3 hours. Substorms are responsible for spectacular aurora displays which we can see at high latitudes. The good agreement indicates that our model contains the necessary physical processes correctly, and can be used for other orbits, not only for geostationary.

The IMPTAM model development and improvement is underway the SPACECAST project (fp7-spacecast.eu) funded by the European Union Seventh Framework Programme. The present study which is mostly scientific is the base for the adaptation of scientific models to operational ones in near future.

**More information:** Ganushkina, N. Y., O. A. Amariutei, Y. Y. Shprits, and M. W. Liemohn (2013), Transport of the plasma sheet electrons to the geostationary distances, *Journal of Geophysical Research*, Space Physics, 118, DOI: 10.1029/2012JA017923

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