URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

Aurora and ionosphere research with a nanosatellite's camera and radio wave spectrometer

Esa Kallio* (1), Ari-Matti Harri (2), Anita Aikio (3), Mathias Fontell (1), Riku Jarvinen (1,2), Kirsti Kauristie (2), Antti Kero (3), Antti Kestilä (2), Petri Koskimaa (2), Juha-Matti Lukkari (1), Olli Knuuttila (1,2), Jauaries Loyala (1), Joonas Niittyniemi (1), Johannes Norberg (2), Jouni Rynö (2), Esa Turunen (3), Heikki Vanhamäki (3), Noora Partamies (4), and Mikko Syrjäsuo (4)

(1) Aalto University, School of Electrical Engineering, Department of Electronics and Nanoengineering, Espoo, Finland, e-mail: esa.kallio@aalto.fi; (2) Finnish Meteorological Institute, Helsinki, Finland; (3) University of Oulu, Finland; (4) The University Centre in Svalbard, Norway

The Suomi100 nanosatellite was launched on Dec. 3, 2018 [1]. The 1 Unit (10 cm x 10 cm x 10 cm) polar orbit cubesat will perform geospace, ionosphere and arctic region research at 500 km altitude with a color camera and a radio wave spectrometer instrument which can operates in the 1 -10 MHz frequency range.

Suomi 100 satellite type of nanosatellite, so called cubesat, provides a cost-effective possibility to facilitate in-situ measurements in the ionosphere. Moreover, combined cubesat observations with ground-based observations give a new view on auroras and associated electromagnetic phenomena. Especially, joint cubesat – ground-based observation campaigns enable the possibility of studying the 3D structure of the ionosphere.

Moreover, increasing computation capacity has made it possible to perform simulations where properties of the ionosphere, such as propagation of the electromagnetic waves in the medium frequency (MF: 0.3-3 MHz) and high frequency (HF: 3-30 MHz) ranges is based on a 3D ionosphere model and on first-principles modelling. Electromagnetic waves at those frequencies are strongly affected by ionospheric electrons and, consequently, those frequencies can be used for studying the plasma. On the other hand, even if the ionosphere originally enables long-range telecommunication at MF and HF frequencies, the frequent occurrence of spatio-temporal variations due to space weather events disturb communication channels, especially at high latitudes.

We present computational simulation and measuring principles and techniques to investigate the arctic ionosphere by a polar orbiting cubesat at HF and MF frequencies. We introduce 3D simulations, which have been developed to study the propagation of the radio waves, both ground generated man-made radio waves and space formed space weather related waves, through the 3D arctic ionosphere with a 3D ray tracing simulation. We also introduce the Suomi100 cubesat mission and its camera and radio spectrometer observations.

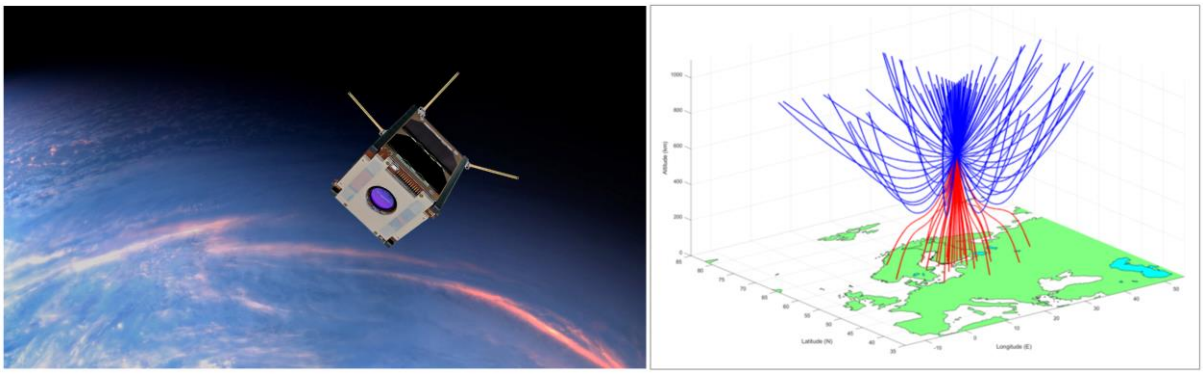

Figure 1. (left) A composite figure of the Suomi 100 satellite photographed before the launch and a dayside photograph of the Earth by the satellite from the orbit. (right) An example of the analysis where the origin of the radio waves observed by the Suomi 100 satellites' radio spectrometer above Finland is investigated by the developed 3D ray tracing model. Blue (red) rays show the source regions from the space (ground)

References

[1] http://www.suomi100satelliitti.fi/eng.