DK-Proposal 32

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Mitigation of Polar Ionospheric Effects for GNSS Applications

Disciplines:
Geophysics, space physics, modelling

Motivation:
Global navigation satellite systems (GNSS), such as GPS and the European system Galileo currently under development, are used increasingly for numerous applications such as air and marine navigation, meteorology, land surveying, hydrography geophysics, geology, etc. The use of GNSS in polar regions can, however, be rather complicated. The satellite signals are affected by processes in the atmosphere on their way from the satellites to the receivers. In particular, ranging errors arise from the integrated electron density (total electron content - TEC) along the signal path. Ranging errors can be highly variable, both spatially and temporally, under conditions of enhanced auroral and polar cap activity which is often present in polar regions. In such cases the ranging errors are difficult to model and can lead to poor position accuracies. Additionally, small-scale high latitude irregularities in electron density can cause random rapid variations in phase and amplitude of the signal - termed scintillation – which may disrupt acquisition and tracking of the satellite signal, such that positioning and navigation with the receivers is made difficult or even impossible. Globally little attention has been paid to these problems, since the number of GNSS users in polar regions is relatively small. The need for reliable positioning is, however, very important in polar regions because of the remoteness, the rough topography, and the often rapidly changing weather conditions. The consequences of an accident with e.g. a marine vessel or an airplane can have serious environmental impact in the fragile polar regions. With the increasing development of the remote polar areas, including e.g. new traffic corridors, the need for a reliable infrastructure for navigation and positioning is becoming more and more important.

Research:
In order to mitigate the adverse effects of scintillation more information on processes in the ionosphere is necessary. This project will therefore include temporary installation of so-called scintillometers at various locations in Greenland. Data collected from the scintillometers will be combined with data from existing terrestrial and satellite based GNSS receivers, ground-based magnetometers, ionospheric radar observations, and auroral images to develop both TEC models and scintillation models for Greenland and adjacent parts of Canada. Outcome of the project will be a characterisation of auroal and polar ionospheric activities which can form the basis for developing real time scintillation monitoring services, and TEC models for polar navigation. The results of the project can also contribute significantly to the last phase of the development of Galileo. In order to communicate the results of the project to GNSS users, a concept for a warning system will be developed aiming at airborne users of GNSS, but useable also for many other user groups. The project is interdisciplinary in the sense that it combines geophysics and space physics with mathematical modelling and the technical GNSS research community. The project is a cooperation between organisations in Denmark, Canada and

Greenland, and there is potential for an even wider international cooperation involving other research groups. Financing for a Ph.D. student, who will study at both the Technical University of Denmark and the University of Calgary in Canada, will be included in the project and further strengthen the international cooperation. Partners in this proposal are the Technical University of Denmark, Kort & Matrikelstyrelsen, the Danish Meteorological Institute, the University of Calgary, and Greenland Airport Authority.