

## **TomoScand - Ionospheric 3D multi-instrument tomography**

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TomoScand project consists of a general software for ionospheric 3D multi-instrument tomography, and a receiver network for Low Earth orbit (LEO) beacon satellite signals. The operational domain covers the ionosphere over Norway, Sweden and Finland, extending the field of view of EISCAT and EISCAT\_3D.

Ionospheric tomography is an ill-posed inverse problem. Even the use of various different ionospheric instruments cannot provide enough information for solving the electron densities directly. Hence, to obtain meaningful electron density reconstructions, some additional information is required. Here, the tomographic algorithm is based on Bayesian statistical inversion, where the prior information on ionosphere is given as a probability distribution. The prior distribution can be given in an interpretable manner with physically quantifiable parameters. As a result, the approach provides estimates for the most probable ionospheric electron densities, and the corresponding uncertainty estimates. To make the high-dimensional computations feasible, Gaussian Markov random fields are used to approximate the prior distribution with sparse matrices.

We demonstrate the performance of the algorithm with data from LEO beacon satellites, GNSS satellites, EISCAT Dynasonde and incoherent scatter radars, and Swarm satellite instruments. The ionospheric 3D tomography is then carried out for individual cases with all available instruments used at once, as well as consecutively with temporal resolution of minutes.