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

Neutral winds and electric fields with EISCAT 3D

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Using incoherent scatter radar (ISR) to determine the neutral wind velocity in the ionosphere has been done for nearly 50 years. The method for finding the velocity of the neutral wind uses the ion velocity which is one of the parameters that the ISRs measure. The ion velocity is connected to the neutral wind velocity through collisions, and to electrical field through the Lorentz force where neither of these are directly known. However, at high altitudes, the ion motion is mostly dominated by the Lorentz force. When assuming that the electrical field is constant along the magnetic field lines, the neutral wind in the E region can be found. This procedure was first described by Brekke et al. [1], and has been used and improved since [see 2, and references therein].

Finding the three-dimensional ion velocity vector with monostatic radars require assumptions that the velocity does not change over a large volume in the ionosphere because the radar only finds one component of the vector and has to be pointed into another direction to find the next component [3]. With dish radars, the variation in time has to be neglected. One of the advancements of the upcoming ISR EISCAT 3D (E3D) is that it will be able to measure three components of the ion velocity simultaneously at all ranges [4]. This will make it possible to measure the ion velocity with relatively short time resolution and also its variation in space. Following the same procedure as described above, this will enable estimations of the neutral wind with short variations in time and space.

We estimate the ISR spectrum and its uncertainty to find the accuracy of ion velocity measurements of E3D. We find that it is strongly dependent on the electron density. Depending on the conditions and integration time, the uncertainty varies in the range 1-10 m/s. Traditionally, in the estimation of neutral wind, the influence of gravitation and ion pressure gradients have been neglected in the determination of neutral wind and electric field. The influence from gravitation is in the order of 0.1 - 1 m/s and may become significant, even though not necessarily important, for the ion velocity. Since E3D will have the capability to measure the pressure gradient, we investigate what order of magnitude it has to have in order to become significant to these measurements. In reality, also the electrical field might vary over height. If letting it do so, the underdetermined nature of the problem is revealed. By using other constraints, one can show that it is possible to obtain estimates of the electrical field in the upper E region as well.

References

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