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The effect of high latitude distorted ion velocity distributions on radar and satellite observations

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It is now well-known that under the action of a strong electric field, ions in the high latitude F region acquire a toroidal (doughnut shape) velocity distribution as a result of collisions with neutral particles. As defined by the second moment of the velocity distribution, the resulting velocity distributions have different temperatures along and perpendicular to the magnetic field. An exact determination of the shape of the velocity distribution and associated anisotropy is, however, not a straightforward exercise because the ion-neutral collisional cross-section is not known with precision, and also because collisions between charged particles modify the velocity distribution and its velocity moments. Unfortunately, as just stated, it's not just the anisotropy that is affected by collisions, but also the velocity distribution itself, which means that spectral shapes obtained by Incoherent Scatter Radars (ISR) and satellite images of the velocity distribution must be handled with care. To that goal we have used a state-of-the-art Monte-Carlo simulation of the ion velocity distribution and its dependence on scattering cross sections between ions and neutrals to reconstruct spectra observed by ISR's. We have found that the interpretation of the radar spectra can be seriously affected by the shape of the velocity distribution during strong frictional heating events, not just in directions perpendicular to the magnetic field (as has been well-known for some time) but also along the magnetic field direction. This new result has been found to be due to the influence of a hot subpopulation in the tail of the velocity distribution along the magnetic field direction during heating events. We have reconstructed ISR spectra for a wide variety of cases, and have carried a systematic comparison with several observations, including some ran with special experiments on RISR-N and RISR-C. Among other things, we found that for small to moderate electric field strengths, a proper interpretation of the radar experiments requires the inclusion of ion-ion collisions, particularly if the line of sight is close the the magnetic field direction. We have also modeled the evolution of the velocity distribution above the collisional region, which introduces additional changes to the ion velocity distribution that depend on the time-history of a particular magnetic field tube. This, in turn, affects the values observed for the temperature anisotropy and for the vertical mean ion drift velocities, among other things. A comparison with Swarm observations is currently under way and progress on that subject will be reported on.

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