3D unique capabilities of AMISR for studying high latitude phenomena.

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Earth's polar region encompasses an exceptional plasma environment, where fundamentally important physical processes in the geospace system occur. The full extent of these processes can only be measured using four-dimensional observations (3D + time). This includes, but is not limited to, M-I interactions at major plasma boundaries, auroral precipitation, and most importantly, magnetic reconnection. The geographical location of the phased arrays from the Advanced Modular Incoherent Scatter Radar (AMISR) systems at Poker Flat (PFISR) and Resolute Bay (RISR) and their electronically steerable beams offer the only instance for a full 4D scan of the plasma over the polar region. We exemplify the power of this capability by utilizing their unique sampling schemes.

This research focuses on RISR as a 4D sensor of magnetosphere-ionosphere interactions at the polar cap boundary and its collaborative measurements with the co-located Optical Mesosphere Thermosphere Imagers (OMTI) and space-based measurements by the Defense Meteorological Satellite Program (DMSP) constellation. The observations show how a high-latitude reconnection pulse leads to a mixing of soft-particle precipitation with pre-existing plasma structures, thus producing local islands of elevated Ne and Te in the ionosphere (i.e., "hot patches").

Figure 1 shows how the RISR data can be interpolated as a solid 3D volume (c) from the raw samples obtained from the radar (b) following what the beam pattern is (a) for the experiment used as a source. Since this is a 42 beam experiment, it allows for an even and larger scan of the plasma above the radar. The trade-off between integration time and the number of beams becomes apparent as a longer integration time is necessary to obtain sufficient statistics given a large number of beams. Other key elements that affect the interpolation exist, such as beam distribution, amount of pulse patterns, etc.

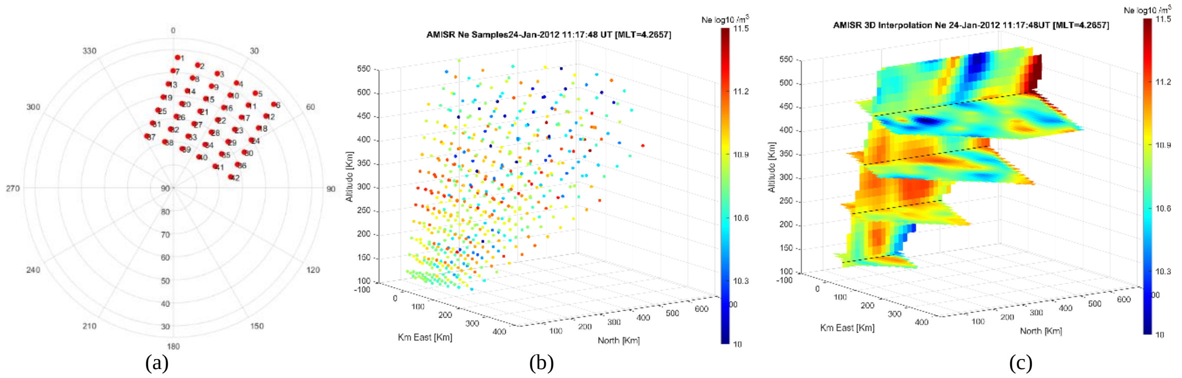

Figure 1. a) RISR beam pattern for long-pulse in horizon coordinates for 24 January 2012. b) Example of three-dimensional sampling acquired from this mode c) Example of 3D density interpolated data from samples.

This 4D data product allows for a virtual single beam radar to be created that looks directly vertically. This virtual beam can move in the Lagrange frame of reference as the plasma flows through the 3D volume. These "spaghetti" plots offer the chance to study the plasma as it moves along with its field line, where phenomena like recombination, plasma generation, and diffusion can be learned. Bulk Doppler velocities obtained from the radar can be used in two main ways: 1) direct line-of-site velocities allows to identify plasma transport across an auroral boundary; 2) full 3D resolved velocity vectors reveal 3D transport and diffusion effects at coarse spatial resolution. Both have their issues when applied. The first assumes a purely horizontal plasma movement and measurements close to the point of interest. The latter is an ill-conditioned inverse problem that is highly dependent on beam distribution.

AMISR is, so far, the only facility that can currently achieve all the above with its 3D capabilities and range of data processing.