Contribution ID: **73** Type: **Oral**

Observations of particle precipitation with EISCAT radars

Monday 16 September 2024 15:30 (30 minutes)

The EISCAT incoherent scatter radars in Tromsø, northern Norway, and in Longyearbyen, Svalbard measure key parameters of the ionospheric plasma (electron density, electron and ion temperatures, and plasma bulk velocity) at multiple altitudes along the radar beam. The radars are thus ideal instruments for observing electron density enhancements produced by particle impact ionization.

Electron density profiles measured along a geomagnetic field-line at D and E region altitudes can be inverted into electron precipitation energy spectra. We have inverted energy spectra of 1-100 keV electron precipitation with about 1 minute time resolution from all available EISCAT data measured with field-aligned radar beam at 80-150 km altitudes since 1998. The dataset enables statistical studies of electron precipitation characteristics at two magnetic latitudes, one in the auroral oval (66.73° MLAT) and one in polar cap (75.43° MLAT). Ionization produced by > 100 keV electrons below 80 km altitude is observed with some radar operation modes, but the complex D region chemistry makes the energy spectra inversion more demanding than below 100 keV. Also ionization by proton precipitation is observed, but it is less common than electron precipitation and its energy spectra have not been inverted.

The radars in Tromsø will be soon replaced with the next-generation EISCAT3D radar with a core site in Skibotn, Norway, and remote receivers in Finland and Sweden at about 130 km distance from the core site. EISCAT3D will use aperture array antennas and digital beamforming, enabling multiple simultaneous beams and virtually instantaneous beam steering. The radar can thus paint the sky with a rapidly moving transmission beam and produce 3D maps of the ionosphere. Novel analysis techniques are expected to enable electron energy spectra fits along multiple field-lines from EISCAT3D data.

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Session Classification: Stratosphere / mesosphere / thermosphere response and coupling of atmospheric layers

Track Classification: Stratosphere / mesosphere / thermosphere response and coupling of atmospheric layers