Ray-tracing simulation of auroral radar backscatter

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It is well known that the auroral radar backscatter is specific anisotropic radiowave scattering by the E- and F-layer metre-to-decametre scale field-aligned irregularities in the auroral and equatorial ionosphere. Such auroral radar backscatter can be used as tracers for monitoring of plasma convection and other geophysical phenomena in the polar ionosphere. Currently, the Super Dual Auroral Radar Network (SuperDARN) of HF radars and the VHF STARE radars are widely used for geophysical applications.
A physical problem of the HF-VHF auroral radar backscatter is coupling between the integral echo power, Doppler velocity and elevation angle envelopes and the ionospheric parameters in the backscatter volume including a volume configuration and structure. Due to the ionospheric refraction also the random irregular and tilted ionosphere one can search for a realistic coupling solution(s) only by means of step-by-step ray-trajectory tracing.
The presentation describes the FMI-MSTU ray-tracing model. The model can use any ionospheric N(h)-parameters, the spatial power spectra of irregularities and the radar specification as the frequency, radar site and the antenna orientation. The model uses the IGRF and IRI models. The outputs are a family of the range-altitude distributions including the radar volume cross-sections, the echo velocities and spectral widths (based e.g. on the linear fluid plasma theory) and the two-way radiowave absorptions and retardation times. The 3D range-altitude distributions of the output parameters are converged to the 2D height-integrated radar-vision format (radar range profiles), which is suitable for a direct comparison with natural instrumental measurements. Examples how the model describes backscatter configuration and structure as well as the ionospheric images of some geophysical situation are presented and discussed.