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Local determination of ionospheric electric fields from coherent scatter radar data using the SECS technique

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Due to the variable spatio-temporal availability of backscatter from ionospheric coherent scatter radars like SuperDARN or STARE, merging the line-of-sight data of ionospheric plasma velocities that are measured by the radars to spatial maps of such velocities or of electric fields is a non-trivial task. Often this task is solved in a way that statistical a priori information about the global ionospheric electric potential is used in addition to the actual measured data, in order to compensate for lack of measurements in certain regions. However, the disadvantage of such a solution is that the influence of the a priori model may get strong or even dominating the results, in which cases it is hard to determine how well the resulting electric field represents the actual situation for a given point of time and space.

Spherical elementary currents systems (SECS) are basis functions that can describe any continuously differentiable vector field on a sphere. Originally, they have successfully been applied to model ionospheric currents based on ground and spacecraft magnetic field data, which explains the historical notion of "current systems" in the name.

We present a new technique based on SECS that allows to model distributions of ionospheric plasma flows or electric fields based on coherent scatter radar data of line-of-sight plasma flows without any additional statistical a priori assumptions, on a local region within which the backscatter availability was moderate to good. This region can have any shape and does not need to have boundaries along constant latitude or longitude. Using a synthetic electric field model and variable backscatter availability levels to create input data sets, we test how well the technique is able to reconstruct the original electric field, as a function of available backscatter. Finally, the application of the technique is demonstrated for real data cases, measured by the CUTLASS radars over northern Europe.