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A statistical investigation of the Cowling channel efficiency in the auroral zone

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The Cowling channel mechanism describes the creation of a secondary polarization electric field at sharp conductance boundaries in the ionosphere due to excess charges, in the case that the release of these charges to the magnetosphere is fully or partially impeded. The secondary currents generated by the polarization electric field effectively modify the ionospheric conductivity inside the Cowling channel. While the Cowling mechanism is generally accepted for the equatorial electrojet, there is a long-standing discussion about its the importance of this mechanism and its efficiency in the auroral electrojet.

We present a statistical investigation that enables us to identify the most probable Geospace conditions and MLT locations for a high Cowling efficiency. This investigation is based on more than 1300 meridional profiles of data from the MIRACLE network in Scandinavia, in particular ground magnetic field data from the IMAGE magnetometer network and electric field data from the STARE radar, supported with pointwise ionospheric conductance measurements from the EISCAT radar. We analyse the data in the framework of a 3D ionospheric model. The analysis results in a steep peak of high Cowling channel efficiency probability in the early morning sector (00-04 UT), with the largest probability around 02 UT and for medium and high geomagnetic activity. In agreement with an earlier single event study by Amm and Fujii (2008), we conclude that the most significant impact of the Cowling channel mechanism is not likely to occur close to the western edge of the substorm bulge (around the westward traveling surge) as has been suggested previously, but in the early morning part of the central substorm bulge.