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A new method to estimate ionospheric electric fields and currents using ground magnetic data from a local magnetometer network

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Determination of ionospheric electric parameters from direct or indirect measurements is a fundamental task in ionospheric physics. In this study we present a new method to estimate ionospheric electric fields and currents using ground magnetic recordings and measured or modelled ionospheric electric conductivity as the input data. This problem has been studied extensively in the past, and the standard analysis technique for such a set of input parameters is known as the KRM method (developed by Kamide et al. in 1981).

The new method presented in this study makes use of the same input data as the traditional KRM method, but differs significantly from it in the mathematical approach that is used. In the KRM method one tries to find such a potential electric field, that the resulting current system has the same curl as the ionospheric equivalent currents. In the new method we take a different approach, so that we determine such a divergence-free current system that, together with the equivalent currents, it is consistent with a potential electric field. This approach results in a slightly different equation, that makes better use of the information contained in the equivalent currents.

In regional studies the (unknown) boundary conditions at the borders of the analysis area play a significant role in the KRM solution. In order to overcome this complication, we formulate a novel numerical algorithm to be used with our new calculation method. This algorithm is based on the cartesian elementary current systems (CECS). With CECS the boundary conditions are implemented in a natural way, making regional studies less prone to errors. We compare the traditional KRM method and our new CECS-based formulation using realistic models of typical meso-scale phenomena in the auroral ionosphere, including the Ω-bands and the Harang discontinuity.