Derivation of the full current density vector in the Earth's ionosphere low- and mid-latitude F region using ESA's Swarm satellites

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A new multi-spacecraft method to recover estimates of the average three-dimensional current density in the Earth's ionosphere is presented. It is demonstrated using the ESA's Swarm satellite constellation and by taking advantage of the favorable geometrical configurations during the early phase of the mission. The current density vector is calculated inside prisms whose vortices are defined by the satellite positions. The mathematical formalism differs from previous approaches such as the one known as the "curlometer". It makes use of the well-known curl-B technique and involves an inverse problem which allows for error propagation through the calculation. Data from the vector field magnetometers of the three satellites are used and special care is taken to characterize the errors on these data. The method is applied in the low- and mid-latitude F-region on 15 February 2014. It provides latitudinal profiles of the full current density vector together with the associated error bars in the morning and evening sectors. We observe several dynamical features such as clear signatures of field-aligned interhemispheric currents, potential signatures of the wind dynamo current system as well as mid-latitude east-west currents.