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On the importance of the Cowling channel mechanism in the vicinity of the substorm breakup spiral

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Together with an auroral substorm breakup, the substorm current wedge is developing. The westernmost edge of this current wedge is often co-located with a westward traveling surge (WTS) which develops out of the breakup spiral. In the vicinity of this auroral form, currents are diverted into the magnetosphere via strong and concentrated upward flowing field-aligned currents (FAC). There has been a long-standing discussion on whether these currents are fed remotely, through a Cowling channel that carries horizontal currents westwards and may extend up to several hours in local time east of the WTS, or locally via downward FAC in the closer environment of the breakup spiral/ surge.

In this study, we re-analyse a pseudobreakup event on February 3, 1999, around 22 UT, which was published by Amm et al. (2001). For this event, the authors have established spatial maps of the electric field, ionospheric conductances, true currents, and FAC in the vicinity of the breakup spiral, using data from the MIRACLE network of ground-based instruments in northern Fennoscandia, analysed with the method of characteristics. In this study, by applying analytical predictions of the ratio of Hall and Pedersen currents and their associated FAC for a Cowling channel, the previously published data is used to show that local current closure must play a significant role for the total current closure of the FAC flowing up in the breakup spiral, and that the Cowling mechanism alone cannot explain the results of the previous study. We also divide up the total current system into a Cowling-related and a non-Cowling-related part, in order to show spatially the relative importance of the Cowling current part.