

The authors' response to Referee #1

Comments on Reply on RC2', of Fridrich Valach, 30 May 2023

I am generally satisfied with the authors' responses to my comments.

There is one exception. I cannot agree with their statement that an appreciable part of the eastward By component deflections are caused by field-aligned currents. It is true that the Fukushima theorem is strictly valid only at polar regions. It has to be noted, however, at European latitudes the field inclination is about 70°, which is much closer to the polar than to the equatorial conditions. If the authors insist on their claimed FAC to By relation, they have to demonstrate how much FAC density and which geometrical configuration is required for generating such large By deflections. Also, the influence of conductivity gradients is often overestimated in the context of FAC ground effects. Such hand waving arguments are not sufficient.

Much more convincing and easier to explain is a certain amount of Hall current in north-south direction for causing the By deflections. Such north-south Hall currents appear between pairs of FACs separated in east-west direction. This FAC issue definitely has to be fixed before publication.

Response:

After we have rethought the issue of FACs vs declination variation, we agree with the referee.

Indeed, from a simple model in which we imagine the FAC as part of a very long straight wire, which must be above the dynamo layer, and assuming an inclination of 70°, it follows that:

A. The magnetic field due to the FAC can be recorded only by ground-based observatories that are not less than 300 km away or even farther away.

B. For the 2003 event, Wang et al. (2006) found FACs with current densities of no more than 10 $\mu\text{A}/\text{m}^2$. Assuming a cross-section of the wire of about 10,000 square kilometres (just our guess), it would give a current of 10^5 A. Such a current could cause a variation of 70 nT at a distance of 300 km. For the horizontal intensity of 20,000 nT, those 70 nT mean a declination change of 12'. This value is approximately one order of magnitude less than the observed change in declination (hourly means).

Based mainly on item A, we realize that our interpretation needs to be corrected. We are grateful to the reviewer for his/her advice on Hall current in the north-south direction between pairs of FACs separated in the east-west direction.

*The changes we have made in the manuscript are as follows:
(We refer to the line numbers in the manuscript with indicated changes.)*

Lines 260-261 have been removed.

Line 306: "or FACs" have been erased.

Lines 324-336 have been replaced with a new paragraph (Lines 337-343).

Line 354: A part of the text in this line has been erased.

Lines 386-387: The text in these lines has been changed.

Lines 467-468: One item in References was removed.

We thank the editor Dr Christos Katsavrias and the anonymous referee for their time devoted to our manuscript.