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Interactive comment on "Photospheric vortex flows close to the polarity inversion line of a fully emerged active region" *by* Jean C. Santos and Cristiano M. Wrasse

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Dear referee,

thank you very much for your comments and questions, they certainly helped to improve the quality of the article. Below I have tried to answer most of your comments and questions.

Section 2 Data and Methodology In this section, the choice of the active region NOAA 9289, located at the southern solar hemisphere, and the companions between December 31, 2000 and January 3, 2001, is cited. As the magnetogram (MDI) taken on

January 2, 2001 and shown in figure 1, this region is located very close to the center of the Sun. Questions: Does the methodology used necessarily require that the analyzed region to be close to the center of the solar disk, to avoid projection effects?

Answer: For active regions far from the disk center (closer to limb) the validity of the assumption that B_LOS is equal to the perpendicular component of the magnetic field is not true. The derivation of the velocity usually assumes that we are following the temporal evolution of the normal component of the magnetic field. So, in this case the B_LOS should be corrected for projection effects in order that we may assume the equality of the normal component and B_LOS.

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Does the positional variation of the active region during the 3.6 days whose evolution accompanied carry some implication of the determinations of the evolution of the magnetic field along the line of sight (BLOS)?

Answer: The effects of the variation in position of the active region during the 3.6 days are considered small enough that they could be disregarded in this case.

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In addition, it is mentioned that a range of 192 min. was considered for the BLOS data, in this time interval, the variations in flows and speeds may be significant for the establishment of the obtained vorticity patterns?

Answer: We have used the full disk 96 min cadence data from MDI. We calculated the velocity field for the intervals 96min, 192min, 288 min, ... the best results were obtained for the 192 min. For the 96 min the LCT/FLCT method was not able to capture the vortex patterns with the apodizing window selected.

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What considerations, implications, approximations (if any) should be made in the case

of an active region close to the solar slime, for example?

Answer: As far as I know, for regions very close to the solar limb the method has problems to be implemented and is not useful.

In the beginning (first sentence) of page 4, the authors describe that at time t = 1920 min. begins to form a negative polarity region (N1), connected to the active region main negative polarity, and two small positive polarity regions, one northern of the negative polarity (P1) and other southern (P2). However, in the previous frame shown in figure 2 for t = 1728 min. (or even for t = 1532 min.) these same N1, P1 and P2 regions are already identifiable. My question: what criterion (visual only?) was used to identify these instants and stages (coalescence of polarity fragmentation and establishment structuring of regions with well defined polarities) from the magnetogram images?

Answer: The description of the evolution of the magnetic field around the polarity inversion line was qualitative and based in visual criterion. The text of the corrected version of the manuscript was modified to make this point clear. Page 7 Figure 3: Colors and symbols (asterisks) used, especially yellow, to show the location of the critical points (asterisks) (blue: Saddle Point, red: Attracting Node / Focus, yellow: Repelling Node / Focus) are small and difficult to see without magnification.

Answer: The figure was modified in the corrected version of the manuscript in order to improve the quality.

I suggest using the same notation to denote the components x and y (x, y). In the equations and matrices they are typed in italics and in the text they are not.

Answer: The notation was modified in the corrected version of the manuscript.

In the last sentence of page 5, the authors state that "Critical points are the salient features of a flow pattern". This statement seems somewhat vague, must be better clarified (based on what consideration or criterion) or referenced.

Answer: What we wanted to say here is that critical points have more significance than just points where the velocity vanishes. We have modified the corrected version of the manuscript and interpreted the critical points as fixed points of a map in a dynamical system, where if we know their location and their type we can predict the orbit of a particle around the position of the critical points.

Suggestion: Presented sequentially the figures 4 and 5 (top and bottom panels), according to the results they want to present. In the first paragraph of the section results, the authors cite that they first investigated the fractal dimension of flowing 2D structures, the results of which appear only in the bottom panel of Figure 5. However, the authors cite the Figure 5 (velocity) before the Figure 4.

In my opinion, it might be more coherent to present the results sequentially. First the velocity values (figure 5 top), then the evolution of the regions which present velocity above that calculated from the velocities of figure 5 (figure 4). Finally, the fractal dimensions (Figure 5 bottom). For readers, it may not be clear which parameters were determined from which others. Maybe it separates them in 3 figures (4, 5 and 6).

Answer: We have modified the order of presentation of the results in the revised version of the manuscript.

They were select only the critical points classified as Attracting Focus, which represent vortices that converge to this particular point. Were identified any points scored as Repelling Focus? They represent vortices as well, but diverging. Can do these critical points also contribute to the nature of plasma turbulence?

Answer: There are both, attracting and repelling focus, present in the 2D flow field around the PIL. We focus on attracting focus since this kind of vortex flow can bring together opposite polarities or increase the amplitude of the unipolar field at the same time that it twists the field lines. Landau-Hopf theory of turbulence requires that the flow increases the modes present in the Fourier decomposition, but nothing is told about the direction of the vortexes.

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And on the saddle points, in the conclusion the authors mention that they are the types of critical points more common. However, in the present work, they do not mention how many saddle points were detected and what they represent in this analysis of the dynamics of the plasma and the flux of the photospheric magnetic field. However, in the present work they do not mention how many saddle points was detected and what they represent in this analysis of the dynamics of the plasma and the flux of the photospheric magnetic field.

Answer: We included the total number of detected saddle points in the revised version of the manuscript.

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Figure 7 (page 11). Abbreviations of the critical points presented in the caption of figure 7 are not in the text. I suggest including it in the caption.

Answer: We have included the description of the abbreviations in the caption of the figure in the revised version of the manuscript.

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The values of the fractal dimension also have variations shown in Figure 5 (bottom). How to interpret these fluctuations in the fractal dimension during the evolution of the region around the PIL?

Answer: Changes in the value of the fractal dimension imply changes in the self similarity of the analyzed structures. This could be related with a change in the physical process occurring in the flow. But it is difficult to make this affirmation for the flow we have analyzed.

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2019-33/angeo-2019-33-AC2-supplement.pdf

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