

## ***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***

**Jean C. Santos and Cristiano M. Wrasse**

jeansantos@utfpr.edu.br

Received and published: 4 June 2019

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.

Page 2, line 7: In Bonet et al., 2008, it is said that “how that the vortexes are indeed associated to the occurrence of bright points”. It is actually the other way round, the bright points are indeed used as vortex tracers.

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Answer: this sentence was modified in the revised version of the manuscript.

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Page 2, line 7: However, strong flares (M- or X-class) are usually associated to rapid (abnormal) sunspot rotation. I think it is more precise “However, strong flares (M- or X-class) are sometimes associated to rapid (abnormal) sunspot rotation”, since the focus is on rotation but the main mechanism may be shear motions. Vorticity is very important, not only in the context for flares, but in different solar scenarios (e.g., the authors can check the relationship of vorticity and internal waves in Vigeesh et al., 2017).

Answer: thank you very much for the reference. The sentence was modified in the revised version of the manuscript.

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Fig 2. In this figure, the polarity N1 looks more like deforming, while the polarity P1 looks like protruding into N1. For some description on polarity protrusion and their role in flares, please refer to Kusano et al. (2012); Toriumi et al. (2013).

Answer: thank you very much for the references and for this comment. It is very difficult to notice all the details of the evolution visually. I have inserted a sentence describing what you have mentioned.

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In page 5, line 1, please mention why FLCT is preferred over LCT, and over other more appropriate methods for magnetograms like LCT with induction equation (i.e., DAVE-4VM, Schuck, 2008).

Answer: the LCT/FLCT method was used due its simplicity to implement and since it requires only the LOS component of the magnetic field. We included a discussion of more appropriated methods in the revised version of the manuscript and will try to

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implement the DAVE method for using in the next works.

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The chosen cadence (192 min) probably will lead to very small values on the surface velocity field (which it seems the case), which makes the vortices detection more complicated (meaning “vortices” on typical granulation times, as minutes, and then allowing the long-lasting vortices to be detected). The cadence for LCT usually is adjusted to the structures one desires to track. How is this considered in this work?

Answer: we have used full disk 96min cadence MDI data to study this particular active region. We have applied the LCT/FLCT method to different cadences 96, 192, 288, ... and the best result in terms of velocity flow and vortex detection was the presented cadence. The vortex detection method seems to work reasonably well independent of the velocity amplitude, but this should be checked. For future analysis we will use HMI data, which has better spatial and temporal resolution.

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Importantly, the method described in Section 2.1 is similar to that developed in Kato & Wedemeyer (2017) (see references therein for their basis, as Chong et al. 1990). Please cite also this work, and it can be used for comparison. Also another very recent method is explained in Giagkiozis et al. (2018) and some references therein.

Answer: thank you very much for the references. I have included them into this work and also the one from rempel (2017).

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Page 6, line 20: some percentages on false positives and missing events would improve the quality of the work.

Answer: I have included a percentage which represents the accuracy of the method (about 70%) in finding and classifying the critical points correctly.

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Since LCT is very dependent on cadence and spatial sampling, one wonders how the result on fractal dimension would be with HMI data (0.6" pixel  $-1$ ), different cadence (shorter than 192 min), and around PIL/around a one-polarity region. This work would really improve by adding these extra analyses and re-computing the D dimension.

Answer: thank you very much for your suggestion. We are starting the analysis of fractal dimension of magnetic structures in the solar atmosphere and, different of other works that analyze the fractal dimension of the whole active region, we would like to investigate in more detail the PIL of different active regions related to flares. However, we are still understanding the meaning of the fractal dimension in the case of the Sun. I would think that the increase in spatial resolution of the data would not change this value since it is related to the self similarity of the geometrical structure.

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Page 9, line 2. Are these vortices percentage dependent on the solar hemisphere? May they be dependent on the PIL? The extra analyses (as inside/outside the PIL) can contribute also to this particular point and moreover, to the whole work relevance.

Answer: for vortexes detected outside active regions the percentage depends on the solar hemisphere. However, I did not read any work on these percentages for vortexes detected on the PIL or around an active region. That is a good topic for investigation in a future work.

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In the abstract (page 1, line 4), it is said “eigenvalues of the Jacobian matrix of the linear transformation”. Of which magnitude? One guesses that it is the surface velocity field.

Answer: the eigenvalues obtained were not far from unit when they were not zero.

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Page 1, line 22: "In the quiet Sun convective flows concentrate magnetic fields in the downdraft region". Please change to plural, regions.

Answer: this error was corrected in the revised version of the manuscript.

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Please mention the cadence and spatial sampling of MDI in the data description paragraph (starting in page 2, line 29). The spatial sampling and cadence only appears when explaining Fig.1. Please mention also that they are full disk MDI data, since potential readers may be not fully familiar with solar imaging datasets.

Answer: the information was included in the revised version of the manuscript.

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Please add units in Figure 1. Are these arcsecs?

Answer: the units are in pixels. I have included in the caption of the figure.

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Equations: A hyphen over the letter is a bit misleading, since it reminds to a vector. Probably other symbol would be a better choice.

Answer: the symbols were modified in the revised version of the manuscript.

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Page 6, line 18: "The solid (dashed) contour line indicate the regions where BLOS assumes the value of +100 G (-100 G). Probably is better explained as "The solid (dashed) contour line indicate the regions where BLOS equals the value of +100 G (-100 G)"

Answer: the sentence was modified in the revised version of the manuscript.

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Page 6, line 22: "The the identification of the critical points (LIC)" probably can be rephrased as: hereafter, LICs. What "LIC" does stand for in this work? Is it 'line integral convolution', as in Kato & Wedemeyer (2017)?

Answer: yes, LIC stands for line integral convolution. The sentence was modified in the revised version of the manuscript.

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Please add maximum and minimum values for the units in Figure 3.

Answer: The minimum values are always zero.

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Page 7, line 9, section Results: please detail how the fractal dimension is computed in this case.

Answer: a section was included in the revised version of the manuscript describing the fractal dimension computation method.

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Page 7, line 16: Please explain how is resampled (what was the original size of the image which is resampled to 128x128?

Answer: the original velocity field had 45x65 and was resampled using nearest-neighbor interpolation.

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Please detail in the text the content of Figure 7. Are these counts noncumulative? Are they computed every time step?

Answer: the counts are noncumulative and are computed every time step. We included

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this information in the revised version of the manuscript.

Please also note the supplement to this comment:

<https://www.ann-geophys-discuss.net/angeo-2019-33/angeo-2019-33-AC3-supplement.pdf>

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Interactive comment on Ann. Geophys. Discuss., <https://doi.org/10.5194/angeo-2019-33>, 2019.