Nonlin. Processes Geophys. Discuss., 1, C166–C171, 2014
www.nonlin-processes-geophys-discuss.net/1/C166/2014/

Nonlinear Processes in Geophysics
Discussions
Open Access

Interactive comment on "Conjugate fluctuation analysis for a set of 41 magnetic clouds measured by the ACE spacecraft" *by* Ojeda González et al.

Ojeda González et al.

ojeda.gonzalez.a@gmail.com

Received and published: 23 May 2014

General Comments:

We partially agree with the main points raised by the reviewer. It is fact that the rotation is smoother in the innermost regions of the magnetic cloud. However, even considering this process, we understand that there is some significance in our results involving the unprecedented persistence fluctuation analysis of the IMF time series. The results should be interpreted from a point of view more empirical than theoretical. We understand that the main feature of our results is to separate, using a new analytical approach, the regions of cloud those belonging to other ranges of the solar

wind (neighboring regions in time series of IMF).

Importantly, this article does not intend to discuss new physical considerations on the magnetic clouds. The persistence exponents were used to provide a new auxiliary tool to help in the magnetic cloud identification process. Although the technique alone can not identify MCs, it can be useful to improve the quality of the identification. As discussed in the paper, within the range of the clouds, is likely to increase the persistence exponents. Moreover, a fine analysis of this feature may be important in the automatic monitoring of this phenomenon. It is noteworthy that, at least according to the literature we know, the correspondence between persistence and magnetic cloud location in IMF time series had not yet been published.

Few comments, point by point:

1. We agree with the comment, before Dasso et al (2005) other authors studied ICMEs and were cited in that paper. The previous comment will be added in the final version of the manuscript. The sentence "A cloud ejected from the Sun ... numerical simulations (Vandas et al., 2002)" will be deleted on the manuscript, because this topic is not treated.
2. We disagree with the comment: The first half of the second paragraph in introduction address the issue of the Hurst exponents to study time series on Space Physics. However, the first paragraph explain some characteristics of the clouds.
3. A detailed explanation about the criterion of selecting 41 of 80 events was explained by Ojeda et al (2014), p 104 - 105, (Geofisica internacional 53-2: 101-115): " A total of 17 events listed in Table 2 are not treated in this work. The reason is that the ACE data before about the end of 1997 were not qualified

for research use. Huttunen et al. (2005) used the measurements recorded by the WIND spacecraft for this initial period."... " We avoid in this analysis mixing dataset from different types of spacecraft. Another problem is that the WIND data available in averages present 3 s, 1 min, and 1 h time resolution, a different resolution than the one used by ACE.
The MC events that are not associated with shock waves are not tested here. They are presented in Table 3 (22 events). The purpose of this selection, in this exploratory study, is to deal with the cases presenting the three periods (clear Pre-MC, MC and Post-MC). Thus, with the well-defined MC cases, the assumption is to objectively unravel the magnetically quiescent interval related to the MC period..."
In summary, 80-(17+22)=41 events were studied in this work.

In Table 1 (in the end of this comment), we chech if the 41 events are all in Lepping's list. The first eleven columns are the same as were published in Lepping's list. Seven events are not published in Lepping's list. These events are shown with symbol "−". It are the events 5, 10, 16, 17, 20, 27 and 28 as shown in column number 12. In Lepping's list a quality factor is published. This quality factor inform about how well is its model to identify each MC. The quality factor is published in a range of 1 to 3, i.e. Q=1 ≡ Excellent, Q=2 ≡ Good and Q=3 ≡ Poor. We used the previous idea to create a quality factor that can help to evaluate the quality of the identification, i.e. Q=1 ≡ Excellent (three exponents are larger than threshold values), Q=2 ≡ Good (two exponents are larger than threshold values), Q=3 ≡ Poor (only one exponent is larger than the threshold value) and Q=0 ≡ Ill-defined (three exponents are lower than the threshold values, the IMF shows little evidence of MCs). The numbers that are larger than the threshold ($\langle\alpha\rangle > 1.392$; $\langle H_a\rangle > 0.327$; $\langle H_u\rangle > 0.875$) are shown in bold font. We found 83% $(34/41 \times 100\%)$ of MCs with quality fator Q=1 or Q=2. The previous result is better than 70.6% $(24/34 \times 100\%)$ reported in the Lepping's list.

From 24 cases reported by Lepping with Q=1 or Q=2, only one disagree with our results. However, some conflicting results could be expected, because Lepping used a different dataset to identify MCs, besides the quality factor refers to his model. Seven cases were not reported by Lepping and was found Q=0 in two of them. Table 1 (in the end of this comment), last four columns, is a summary of the results derived from Figure 4 shown in the manuscript.

4. We agree with the comment, this was a digitization error. The results shown in all graphics into the manuscript used 9 Jan, instead of 10 Jan. We did not find another errors.

5. We have rewriting the entire phrase as: It is noteworthy that there are some exceptions as events 5, 20 and 25 in Table 1. However, in the context of present analysis, we do not investigate each of these cases in detail, since they are just a few for the sample with 41 time series. Anyway, this is a study to be carried out further, because they are important to redefine the boundaries of the clouds.

6. Ok.

7. This is a very important question in the context of this work. The alpha value characterizes a multiscale phenomenon that can be observed from the fluctuations of the amplitude of the IMF. The coherent structures associated with magnetic clouds are related to scales of hours. However, there are several components of fine structures which we call noise component (on the order of seconds). These disturbances may be caused by different processes (e.g., Alfvén waves interacting with the cloud). Another possible component of nonlinearity at small scales is the fact that there are disturbances outside the coherence Bx and Bz plane (see e.g. Figure 3 , V. Bothmer and Schwenn, Ann Geophysicae 16:1-24, 1998). Here, the calculation of the exponent alpha is taken as the average of the alpha values of each component (Bx, By and Bz). Therefore, the threshold values represent the average complexity signature of the maximum fluctuation of the

system. Certainly, the fluctuation is not self-similar. But, as pointed out by the reviewer, it is a self-affine phenomenon. It means that, there are similar patterns of fluctuation but only in some scales, not all. An analysis of multi-resolution (for example, by using wavelets) may be important for future work to investigate this process. In the classification of persistence processes, the value of alpha, in the range 1.39 to 1.54, only indicates that in the transition region the variability pattern is typically a nonstationary process very close to a Brownian-like fluctuation (≈ 1.5). However, more important than characterizing the process in this context, the detection of the transition should be addressed as the most important issue.

8. This has been corrected.

9. From our point of view, the persistence analysis is not able to distinguish physical differences between both cases (regions), but the same average values are suggesting that both regions may be being influenced by the noise component (non-linear processes at finer scales involved in the dynamics of the IMF).

10. English has been improved as a whole.

Kind regards,

Ojeda, G. A.; Gonzalez, W. D.; Mendes, O.; Domingues, M. O.; Rosa, R. R.

Table 1. The first eleven columns are the same as were published in Lepping's list. MCs that were not identified in Lepping's list are shown with "–". The 41 events in the manuscript (see Table 1 in the manuscript) are shown in column number twelve. The last four columns from the left to the right give: the Hurst exponent, the Hausdorff exponent, the alpha exponent and the quality of the MCs respectively.

Code	Year	Month	Day	(DOY)	Hour	Month	Day	(DOY)	Hour	$Q.^a$	Table1	$\langle Hu_{(j)} \rangle$	$\langle Ha_{(j)} \rangle$	$\langle \alpha_{(j)} \rangle$	$Q.^b$
28	98	Jan	07	007	3.3	Jan	08	008	8.3	1	01	**0.901**	**0.365**	**1.460**	1
30	98	Feb	04	035	4.5	Feb	05	036	22.5	2	02	**0.907**	**0.463**	**1.587**	1
31	98	Mar	04	063	14.3	Mar	06	065	6.3	1	03	**0.897**	**0.329**	**1.457**	1
32	98	May	02	122	12.3	May	03	123	17.3	3	04	**0.891**	**0.363**	**1.496**	1
–	–	–	–	–	–	–	–	–	–	–	05	**0.891**	**0.341**	1.330	2
35	98	Aug	20	232	10.3	Aug	21	233	19.3	1	06	**0.912**	**0.457**	**1.593**	1
36	98	Sep	25	268	10.3	Sep	26	269	13.3	2	07	**0.903**	**0.404**	**1.503**	1
37	98	Oct	19	292	5.1	Oct	19	292	14.6	3	08	**0.907**	**0.400**	**1.493**	1
38	98	Nov	08	312	23.8	Nov	10	314	1.3	1	09	**0.894**	**0.369**	**1.437**	1
–	–	–	–	–	–	–	–	–	–	–	10	0.874	0.307	1.388	0
39	99	Feb	18	049	14.3	Feb	19	050	12.3	3	11	0.866	**0.358**	1.310	3
40	99	Apr	16	106	20.3	Apr	17	107	21.3	3	12	**0.898**	**0.439**	**1.440**	1
41	99	Aug	09	221	10.8	Aug	10	222	15.8	1	13	**0.892**	**0.362**	**1.470**	1
43	00	Feb	12	043	17.1	Feb	13	044	0.6	3	14	**0.886**	**0.347**	1.293	2
44.1	00	Feb	21	052	9.8	Feb	22	053	13.3	3	15	**0.893**	**0.414**	**1.413**	1
–	–	–	–	–	–	–	–	–	–	–	16	**0.890**	0.316	**1.435**	2
–	–	–	–	–	–	–	–	–	–	–	17	0.860	0.280	**1.474**	3
46	00	Jul	15	197	21.1	Jul	16	198	9.9	2	18	**0.895**	**0.398**	**1.542**	1
47	00	Jul	28	210	21.1	Jul	29	211	10.1	2	19	**0.879**	**0.412**	**1.521**	1
–	–	–	–	–	–	–	–	–	–	–	20	0.866	0.326	1.234	0
49	00	Aug	12	225	6.1	Aug	13	226	5.1	2	21	**0.889**	**0.375**	1.349	2
50	00	Sep	18	262	1.9	Sep	18	262	15.1	3	22	0.860	0.326	**1.408**	3
51	00	Oct	03	277	17.1	Oct	04	278	14.1	1	23	**0.898**	**0.432**	**1.437**	1
52	00	Oct	13	287	18.4	Oct	14	288	16.9	2	24	**0.884**	**0.355**	1.337	2
53	00	Oct	28	302	23.3	Oct	30	304	0.3	3	25	**0.888**	**0.380**	1.340	2
54	00	Nov	06	311	23.1	Nov	07	312	18.1	2	26	**0.894**	**0.332**	**1.514**	1
–	–	–	–	–	–	–	–	–	–	–	27	**0.909**	**0.427**	**1.423**	1
–	–	–	–	–	–	–	–	–	–	–	28	0.857	0.299	**1.502**	3
57	01	Apr	12	102	7.9	Apr	12	102	17.9	2	29	**0.882**	0.296	1.235	3
58	01	Apr	22	112	0.9	Apr	23	113	1.4	2	30	**0.884**	**0.380**	1.348	2
59	01	Apr	29	119	1.9	Apr	29	119	12.9	2	31	**0.889**	**0.402**	**1.516**	1
60	01	May	28	148	11.9	May	29	149	10.4	1	32	**0.895**	**0.381**	1.360	2
62	01	Oct	31	304	21.3	Nov	02	306	10.3	3	33	**0.883**	**0.382**	**1.477**	1
65	02	Mar	24	083	3.8	Mar	25	084	22.8	2	34	**0.892**	0.321	**1.419**	2
66	02	Apr	18	108	4.3	Apr	19	109	2.3	1	35	**0.893**	**0.384**	1.366	2
68	02	May	19	139	3.9	May	19	139	23.4	1	36	**0.885**	**0.368**	**1.542**	1
71	02	Aug	02	214	7.4	Aug	02	214	21.1	2	37	**0.878**	**0.350**	**1.498**	1
72.2	02	Sep	30	273	22.6	Oct	01	274	11.9	3	38	**0.887**	0.299	**1.428**	2
73	03	Mar	20	079	11.9	Mar	20	079	22.4	1	39	0.867	**0.341**	**1.545**	2
76	03	Aug	18	230	11.6	Aug	19	231	4.4	2	40	**0.895**	**0.411**	**1.517**	1
77	03	Nov	20	324	10.8	Nov	21	325	2.3	2	41	**0.887**	**0.407**	**1.483**	1

[a] From Lepping's list: QUALITY: 1 = EXCELLENT, 2 = GOOD, 3 = POOR

[b] Our results: QUALITY: 1 = EXCELLENT (three exponents are larger than threshold values), 2 = GOOD (two exponents are larger than threshold values), 3 = POOR (only one exponent is larger than the threshold value), 0 = ILL-DEFINED, the field shows little evidence of MCs (three exponents are lower than the threshold values)