

## **Interactive comment on “Spatial analysis of oil reservoirs using DFA of geophysical data” by R. A. Ribeiro et al.**

**R. A. Ribeiro et al.**

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Received and published: 21 July 2014

article

We thank the referee for the thoughtful reading of the manuscript. To make the manuscript more convincing we follow the suggestion of the second reviewer and added a new couple of figures showing the spatial distribution of **DFA** exponents. We attached the contour plots of the five studied variables. A visual inspection of these figures shows that sonic and density variables reveal a better spatial structure than others variables, this result is in agreement with our statistic tests.

We review the explanation of the Monte Carlo test presented in the Methodol-

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ogy subsection 2.3.2, second paragraph. We hope this change in the text will make the presentation of our randomization test more clear. The new paragraph is the following:

*We use a Monte Carlo test, or a randomization test, to check if  $k$ -clusters method create groups that are closer, in a metric sense, than groups generated by an aleatory way. We define an index  $\Omega$  of neighbourhood in the following way. Consider the map of the field with all wells. Over each well we attach a geometric ball (or a disk) of radius  $b$ . The wells that are spattially closer share overlapping balls in opposition to distant wells. This schema of overlapping balls is used to measure if two wells that are in the same  $k$ -group are closer or not. For all pairs of well logs we perform the computation: if the balls of two well logs overlap and belong to the same group we count  $\Omega \rightarrow \Omega + 1$  otherwise we do nothing. The index  $\Omega$  is normalized by the number of groups and the maximal number of elements in each  $k$ -group. After that we shuffle the well logs over the  $k$ -groups and compute  $\Omega_{shuffled}$  over the shuffled data. The idea of this method is to compare if the  $k$ -groups are more distant of each other than groups chosen at random. We estimate a  $p$ -value as the probability of  $\Omega$  being larger than the  $\Omega_{shuffled}$  distribution.*

We comment the other critics pointed out by the reviewer using topics.

- *section 1, line 18: We changed the sentence of this line by the following: The **DFA** parameter summarizes fluctuation information of a time series, this parameter is related with the autocorrelation properties and the spectrum of frequency of the data. The **DFA** exponent in this sense is an overall measure of its complexity.*

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- *section 1:* We use the concept of spatial pattern in a broad sense. The Monte Carlo algorithm used to test spacial patterns in our manuscript check for differences of **DFA** exponent among neighbour wells. If **DFA** exponent between closer wells are similar it is an indicative of presence of spatial patterns. Similar in the previous sentence means more comparable than it would be by chance. In this broad sense a spatial pattern is anything that deviate from a random pattern.
- *subsection 2.2:* The original algorithm to evaluate **DFA** exponent was developed by Peng et al, and it is available in C-language and Matlab. We introduced a citation in the text of the work of Peng.
- *subsection 2.2:* We will change in the text for linear correlation coefficient  $R$  and add the citation: David A. Freedman *Statistical Models, Theory and Practice* (Cambridge University Press, 2009, Cambridge). This is indeed the usual linear correlation coefficient between to data sets.
- *subsection 3.1:* We computed  $C(\tau)$  for

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age();i.src="http://contentmanager.copernicus.org/webservices/webbug.php?h="+es
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by convenience. The correlation function decreases with τ until it reaches a
point in which it starts oscillating around zero, a state characterize by absence
of correlation. If we take very long τ we will include useless noise in the
statistics.

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1. We change in section 2.3.1, pag 17: "ordered according to the distances  $\tau$ .  $Corr(\tau)$  is estimated as follows [Equation (4)] where the sum in equation is performed over all possible pairs  $Num$ ."
2. About the units in the legend of figure 1. We have not plotted units for sonic, gamma ray, density, resistivity and porosity because these are indirect measurements. The sonic is a measure of the time for a sonic wave propagates across the rocks. The gamma ray measures the total emission of radioactivity of the rocks, it is important in lithology. The density, despite it is done in  $g/cm^3$ , it obtained by an indirect measurement of backscattering radiation. The resistivity is measured in  $\Omega m$ , but in geophysics it is employed a quantity adequately normalized by the resistivity of water. The porosity (neutronic porosity) is an indirect measure of the interaction of neutrons with the electron cloud of the atoms of the rocks.

3. Horizontal and vertical axes refer to  $x$  and  $y$  distances. We use arbitrary unities of length. For completeness it was introduced a  $y$  in the graphic and we clarified that we use arbitrary unities in figure legend.
4. The text was revised to improve grammar and style.

Thanks for your comment.

PS: Following the policy of the journal, the update of the manuscript will be done after the end of the discussion process.