Response to reviewer #1

We first would like to sincerely thank the reviewer for his throughout review and his numerous useful comments that, we believe, contribute to significantly improve our manuscript. Each answer/comment of the reviewer below is followed by a "response" and when applicable by a more specific description of the "change(s)" we made to the manuscript.

General comment 1:

"Determining the deformation of a material element using a finite set of discreet points leads to a "boundary definition" error for the line integral that increases as the number of points decreases. The RGPS data set uses four-point cells to compute the deformation. The method proposed here starts with just three points, the minimum possible and the configuration with the maximum error. Thorndike 1986) discusses how the number of nodes determines the accuracy of the deformation estimates. Three nodes are worse than four by a factor of 2 or 3 (his Figure 23b)."

Thorndike, A. S. (1986), Kinematics of Sea Ice, in The Geophysics of Sea Ice, NATO ASI Series, edited by N. Untersteiner, Plenum Press, New York, pp 489-549.

Response:
This comment helped us to better characterize the accuracy of the unfiltered deformation obtained when using three or four nodes. We can now state that the error due to spurious opening/closing when using triangles is about 10% higher than the error obtained when using quadrangles. This new analysis is presented hereafter and in the paper.

We also discuss hereafter why the analysis of Thorndike (1986) and the statement: "Three nodes are worse than four by a factor of 2 or 3" do not apply to our problem.

Lindsay and Stern (2003) specifically studied the relationship between the number of points taken to compute deformation and the error due to spurious opening/closing. They found that the error drops by almost 50% when using 8 points instead of 4 points. When using 4 points (quadrangles), Lindsay and Stern (2003) found an error of 15% of the sliding distance. In the original manuscript, we presented the same kind of analysis with a simple test case considering one single crack. We found an error equal to 20% of the sliding distance when using 3 points (triangles).

We have now also analyzed the single crack test case when using quadrangles and we found that the opening/closing error is about 18% of the sliding distance. The opening/closing error when using triangles (3 points) is then only about 10% higher than the error obtained with quadrangles (4 points).

The factor of 10% found for the opening/closing errors is actually not in contradiction with the factor 2 or 3 derived from the analysis of Thorndike (1986) as the analyzed problems are actually not the same. The analysis of Thorndike (1986) estimates the "boundary definition" error over a circular region as a function of the number measurements on the circumference of this region. The error is then only estimated on the mean deformation over this region and does not take into account the spurious opening and closing that could occurs within this region. In our analysis, we also define a region (here a square domain) but we do not only consider the measurements at the circumference but all the measurements available at a given resolution within this region. In our case, the error is not estimated on the mean deformation over the region but as the accumulation of error for each cell.

For more details on the single crack test case with quadrangles, see our answer to the remark on Figure1.

We also add more justification on the choice of using triangles (See response to the remark of reviewer#2 related to Page 5113 lines 18-19).

<u>Changes</u>:
We add this paragraph:
“When repeating the same test case with quadrangles instead of triangles, we found a rms error of about 18% of the sliding distance u_p. For comparison, Lindsay (2003) found an error per unit crack of about 15 % of the sliding distance, for a similar test case on a mesh made of square cells. This analysis shows that using triangles only generates an increase of about 10 % of the opening (and closing) error compare to using quadrangles. This increase of the error is minor compared to the advantages of using triangles. Triangulation methods are more flexible. It roughly doubles the number of deformation estimates and it increases the resolution at which deformation is defined. For the rest of this paper, we then only present results on triangular meshes but the method could also be applied to other type of meshes.”

General comment 2:
"1) The spatial scale of the filtered data is ambiguous because the deformation is smoothed with between 1 to 10 or more triangles, so what is the spatial scale of each observation in the smoothed data? 2) How is the spatial scale determined for the scaling analysis? 3) The smoothing procedure has reduced the noise at the expense of spatial scale, as must always be the case with discreet points for the velocity. 4) Can the authors please more fully explore these ideas in the introduction?"

Response:
1) We agree that with a classical smoother the spatial scale of the smoothed deformation field does not have the same spatial scale as the unfiltered deformation field. For example, we found in the case of a unique crack that the value of the filtered shear along the crack is inversely proportional to n. This indicates that classical smoothers modify the spatial scale at which the deformation is defined. However, our method is different than classical smoothers. As explained in the manuscript, our method is " based on the fact that the deformation is by nature constant along a linear kinematic feature. Averaging motion derivatives along these features could then filter out the noise without spoiling the information on the real deformation." We verified this hypothesis with the single crack test case and we found that with our method the shear along the crack does not vary as a function of n, meaning that with our method the spatial scale of each observation in the smoothed data is the same as in the unfiltered data.

2) The spatial scale is the square root of the sum of the areas of the cells selected by the coarse graining procedure. See also our response to remark 5116-21.

3) We do not agree. In the case of the single crack, deformation should be constant along the crack but is polluted by the artificial noise. Averaging the deformation over the elements crossed by the crack should then not change the mean value of the deformation but only reduces the noise. In other words, whatever is the number of triangles used for the average, the spatial scale remains the same.

4) We now discuss these ideas and the difference between classical smoothers and our method in the presentation of the method.

Changes:
1) We add the following sentences in the paragraph presenting the classical smoother: "It also modifies the spatial scale at which the deformation is defined, resulting in a modification of the value of the shear along the crack. With the single crack case, the area-weighted average of the shear for the cells cut by the crack is found to be inversely proportional to n".

We add the following sentences when presenting our method: "Contrary to the smoother presented here above, the scale at which the deformation is defined remains constant with the second method. In other words, the mean value of the shear along the crack obtained with the second method does not vary as a function of n. We also verified that in the case of a regular mesh and a single crack aligned with the x-axis, the area-weighted average of the shear along the crack is strictly constant whatever the value of n."

2) More explanation on the scaling analysis has been added in the text. See our response to remark 5116-21.

3) No changes.

4) We now discuss the difference between classical smoothers and our method in the presentation of the method (see changes 1) here above).

Specific comments:

5106-2: Your method is far from nearly noise free.
Response: We agree that this statement is not very clear as we haven't quantified the remaining noise.
Changes: new sentence: "We propose a method to reduce the error generated when computing sea ice deformation fields from SAR-derived sea ice motion."

5106-17: Please give the original references for the cross-correlation techniques applied to SAR images.
Response: We added the references proposed by Referee #2: Fily and Rothrock (JGR-Oceans 1990) and Kwok et al (IEEE J. Ocean Engr 1990).
Changes: References added

5106-20: Also maybe reference GlobeICE here.
Response: This is a good suggestion but as far as we know, there is no peer-reviewed publication that we could use to make reference to the GlobICE dataset. Any suggestion would be welcome if we have missed a reference. For now, we therefore do not to add any reference to GlobICE in the introduction section.
Changes: No change

5107-27: What fraction of the RGPS deformation estimates is afflicted with this problem? Does it change the scaling analysis? How big a problem is this and can unrealistic values be easily filtered out? This seems to be one of your main motivations, but you have not really shown it to be a big problem.
Response: A very small fraction of the dataset is polluted by these unrealistic values, however it has a high impact on the scaling but also on the total opening and closing when integrated over the Arctic basin. The multifractal scaling analysis is very sensitive to extreme values, particularly when looking at the highest moment orders of the distributions. This is why in some studies based on RGPS deformation dataset the extreme values were simply eliminated with a threshold on the total deformation. However using such a threshold may also eliminate real extreme values. In other studies, the presence and impacts of these extreme values are simply not discussed. From the RGPS deformation dataset, it is not possible to know exactly what is the current shape of the quadrangles used to compute the deformation, it is then not possible to eliminate all the badly shaped element. Our approach based on the definition of a new mesh from the actual position of the RGPS data eliminates this problem.
Changes:
We modified the discussion on the presence of extremes values to answer these questions.

"For the period 2--10~February 2007, the composite picture made from RGPS has maximum opening, closing and shear rates equal to 1.73, -6.73 and 66.47 per day, respectively. These extreme values arise from highly distorted cells. A very small fraction of the dataset is polluted by these unrealistic values, however it has a high impact on the multifractal scaling analysis, particularly when looking at the highest moment orders of the distributions. In Marsan (2004) and Stern (2009), additional constraints on the initial and current size of the cells were applied and the cells with total deformation higher than 1 per day were not taken into account. In many other studies based on the RGPS deformation dataset, the presence and impacts of these unrealistic extreme values are simply not discussed.

The simple fact of redefining a new mesh from the actual position of the RGPS nodes allows us to avoid badly shaped cells and then to significantly reduce the number and magnitude of extreme values. For the same period, the composite picture obtained from the unfiltered version of our RGPS Image Pair dataset has maximum opening, closing and shear rates equal to 0.63, -1.17 and 1.97 per day, respectively. The smoother also logically decreases the extreme values. For this example, the filtered composite picture has maximum opening, closing and shear rates equal to 0.13, -0.20 and 0.73 per day, respectively."

5108-1: It would be useful here to elaborate on the difficulty in determining the line integral of the velocity for a material element (a cell) using a finite number of points. This might be a good place to have a complete discussion of the ideas presented by Thorndike (1986) about the error of deformation estimates due to the boundary definition and the number of points used.
Response: As explained in the answer to the general comment 1, the analysis made in Thorndike (1986) does not correspond to the problem we are trying to solve.
Changes: No change

5110-14: experience –> experiment
Response: Thank you for the correction.
Changes: This change has been applied at 3 different locations in the text.

5110-20: What is "normalized resolution"?
Response: It is the mean distance between the points used for the "simple" test-cases. It is called normalized resolution as it is defined for a normalized area equal to 1 and should not be confounded with the resolution of the meshes generated to treat the actual observations.
Changes: We have now added this sentence to the first paragraph of section 2.1: "d is hereafter called the normalized resolution.".

5110-8: What becomes of the cells below the threshold? Is the filtering applied to these?
Response: The filtering does not apply to the cells whose deformation is below the threshold.
Changes: We add the following sentence for clarification: "No filtering is applied on the cells where deformation is below the threshold."

5111-4: 1) What is the equation for performing the smoothing? 2) Are the tensor components smoothed or just the invariants? 3) Exactly how are the kernel triangles selected? For example, are triangles included if there are no others above the threshold between a kernel triangle and the target triangle? (e.g. if there is a gap in the total deformation). 4) Are all target triangles smoothed, even if the are below the threshold? 5) For example if a triangle is near but not part of an LKF, is the smoother applied to it is well? 6) Or if it is part of the LKF, but below the threshold, is the smoother applied? 7) How would the two cases be distinguished?
Response:
1) The equation is now given in the text.
2) As explained in the original text (page 6, lines 25-26), the tensor components are smoothed. We agree with the reviewer that the equation makes it now clearer.
3) The kernel around a given reference cell is built as the subset of cells that fulfill the threshold criterion on the total deformation rate, and that can be reached from that reference cell by crossing a maximum of n successive edges.
4-5-6-7 The triangles below the threshold are not smoothed.
Changes:
We changed two paragraphs to answer these questions and to clarify the smoothing methods:
"We here denoted C the list of all the cells and for each cell c\in C, we define the kernel K_c\subset C as the subset of cells that can be reached by crossing a maximum of n edges. An example of kernel with n=7 is shown in Fig1c and d. The size of the kernel is noted IK_cl. For the example shown in Fig1c and d, IK_cl is equal to 87. The components of the filtered deformation are then defined by averaging over the cells of the kernel. For example, the filtered value for u_x on the cell c is defined as \tilde{u}^c_x=1/IK_cl\sum_{k\in K_c} u^k_x."

"We denoted S the list of all the selected cells. For each cell s in S, we define the kernel K_s \subset S as the subset of cells that can be reached by crossing only selected cells and a maximum of n edges. No filtering is applied on the cells where deformation is below the threshold.Our method preserves the localization of the deformation by avoiding mixing the deformation between LKFs (i.e., cells where the deformation is intense) and the surrounding rigid plates (i.e., cells where deformation is almost zero). Moreover, the way the smoothing kernels are built ensures that deformation between LKFs that are not connected will not be averaged together."

5111-11: Can you show that your smoother is unbiased? The mean divergence along the crack should be zero for both the unfiltered and the smoothed data and the mean shear should be the same for both. Does the thresholding method introduce a bias? You may need to use a much longer crack.

Response: On average the smoothing method does not introduce any bias. It was already shown in the conclusion of the paper when we said that the cumulative opening and closing are both reduced by the same value of about 60% when comparing the filtered data to the unfiltered one for the whole winter 2006-2007.

For one particular crack, the mean divergence and shear are not exactly the same in the unfiltered and smoothed data. For example, in the case of a single crack aligned with the x-axis, the mean divergence over the square domain in the unfiltered data is exactly zero when the mean divergence in the smoothed data only tends to zero for large n. However this error in the mean divergence of the smoothed data is always about one order of magnitude smaller than the error on the total opening/closing error of the unfiltered data. Moreover, when looking at a large number of single crack experiments, we verified that this error equally corresponds to negative or positive mean divergence, meaning that the mean divergence over a large number of cracks will not be influenced by this error. Concerning the threshold, it cannot introduce a bias as the threshold is on the total deformation, which is independent of the sign of the divergence.

Changes: No changes have been made to the text.

5111-19: The line with the disks in Fig.2 seems to go down to 5 or 6%, not 10%. What is the "residual error"?

Response: You are right. This was a mistake in the text, the residual error is about 5%, not 10%. The residual error is defined as the error remaining for large value of n.

Changes: We correct the value given in the text and we add this clarification for the residual error:

"For a resolution of 0.1, the residual error (i.e., the error remaining for n>d^-1) is about 5% as shown in Fig. 2."

5113-1: RGPS updates a cell only when all four points are simultaneously updated. There is no asynchronous error.

Response: We acknowledge our mistake due to a wrong interpretation regarding the synchronicity of the data in the RGPS deformation dataset.

Changes: We removed the statements related to asynchronous error.

5113-5: The cell update time is in fact the same as the update times for all the nodes. I can't find the exact reference that states this, but it is implied in the RGPS user documentation. If you actually find the node times from the Lagrangian product and compare them to the deformation update times you will find this to be true. This is a bit tricky because the nodes for each cell are not identified, but it can be done. As you indicate, it would make no sense for it to be otherwise.

Response: Same answer as for the previous question.

Changes: We removed the statements related to asynchronous error.

5114-13: How are isolated deformation features treated? Is there a minimum kernel size?

Response: All the selected deformation features are treated the same way. The smoother is applied by averaging the deformation over the cells contained in the kernel only. In the extreme case where the kernel size is 1, the deformation remains then unchanged. There is no minimum kernel size.

Changes: We add this sentence to the paragraph:

"Indeed if a kernel only contains one cell, the smoother does not modify the value of the deformation over that cell."

5114-18: Why n=3?
Response: We acknowledge that this choice was not clearly explained in the first version of our paper. From the analysis of the simple test cases, n=3 is chosen as the reference value as it is the only value for which the initial error is at least divided by a factor 3.
Changes:
The choice of the reference value for n is now explained in the text at the end of section 2.1: "From this analysis, we identify n=3 as an optimal value as it is the only value for which the median error is reduced by at least a factor of 3 in any of the test-cases presented here.
In real cases, to define an optimal value for n is more difficult as it would depend on the number of intersecting cracks and on the local ratio between divergence and shear. For this study, we chose to use a constant parameter n and its reference value is fixed at n=3.
To validate the choice of the method's parameters (i.e., n and the threshold on the total deformation), we present in Sect. 3 another metric based on a multifractal scaling analysis of the deformation fields." We add in Section 2.2 a reference to Section 2.1: "with the parameter n equal to 3, which is the reference value defined in Sect 2.1"

5114-21: For the threshold of 0.02, what is the range of the quality index for different dates in 2006-2007?
Response: To quantify the range of the quality index, we look at the percentage of pairs of images for the entire winter 2006-2007 for which the quality index is lower than 50% and we found that only 14% of the pairs of images have a quality index lower than 50%.
Changes: We add this information in the text: "To quantify the range of the quality index, we look at the percentage of pairs of images for the entire winter 2006-2007 for which the quality index is lower than 50% and we found that only 14% of the pairs of images have a quality index lower than 50%. To further validate the choice of the model parameters, a consistency check based on a multifractal scaling analysis of the deformation fields is proposed in Sect. 3."

5115-25: A shear crack that is not straight may exhibit both opening and closing.
Response: We agree. A change of orientation of the crack will generate the same problems as the intersections between different cracks. See also our answer to the main comment of reviewer #2.
Changes: We change the word "which" by "where" in the following sentence: "Some features are so polluted by a succession of highly negative and positive values that it is very difficult to identify where cracks are opening, closing or sliding."

5116-21: Please give more information about how the scaling was computed. How are the scales determined given that the smoothing introduces a highly variable spatial scale for the individual triangles? Is the area associated with each smoothed triangle retained? How are the strain tensors computed?
Response: We added more information about the scaling. We do not agree that our smoothing method introduces highly variable spatial scale. The smoothing does not affect the scale at which deformation is defined. This point has been explained in the answer to the second main comment. The area associated with each triangle is the area of the triangle itself even when the deformation has been filtered. As explained in the answer to the remark on line 5111-4, each component of the strain tensor (i.e., the spatial derivatives of the displacement) is averaged.
Changes:
We add this description of the method used for the scaling. The rest of the changes are already described in our answer to the main comment 2 and to the question on line **5111-4**: "Sea ice shear and absolute divergence rates are computed at different spatial scales ranging from 7 to 700 km. For the lowest scale, which is also the scale of the triangular cells, all the cells are taken into account. For the other scales, the coarse graining procedure covers the domain with boxes of different sizes (14, 28, 56, 112, 224, 448 and 896 km). The boxes

actually overlap each other since a distance equal to half the box size separates their respective centers. For each box, we select the cells that have their center in the box. When the sum of the area of those cells is greater than half the box area, the deformation over the box is defined by averaging the spatial derivatives of the displacement weighted by the surface of each cell. The spatial scale for this new estimate of the deformation is the square root of sum of the cells area. The values of deformation obtained for each box size are then reported as a function of the spatial scale on a log-log plot (see Fig. 10 for the absolute divergence rate)."

5117-10: Please show the results for the RGPS deformation product as well. The unfiltered version of course has very large errors at small scales, as you indicate, so it is of less interest.

Response: It seems that we do not agree with the reviewer on that point. The error (evaluated as the opening/closing error) when using triangles is only about 10% higher than when using quadrangles as in the RGPS deformation dataset (see our answer to the main comment 1). Moreover the RGPS suffers from the distortion of the cells, as the grid is deformed progressively during the season. As explained in the answer to the comment on line 5107-27, these extreme values are difficult to filter and highly influence the multifractal scaling analysis. The presence of these unrealistic deformation values actually necessitates to add extra constraints on the data when performing a scaling analysis. Redefining a new mesh allows us to eliminate most of these erroneous values. Comparing the filtered version to the unfiltered version is then much more interesting because it allows us to clearly identify the impact of the noise on the scaling and the total opening and closing. Moreover, the unfiltered dataset covers exactly the same spatial and temporal domain, and is defined on the same mesh than the filtered dataset. This is not the case for the RGPS deformation dataset, which is even not defined at the same spatial scale (10 km for the RGPS deformation instead of 7 km for our filtered and unfiltered dataset). We then think that it was more interesting to compare the unfiltered and filtered dataset.

However, as asked by the reviewer, we give here the results of the scaling analysis performed on the RGPS deformation dataset. We apply the same constraints on the RGPS deformation data as in Stern (2009), meaning that we add constraints on the size of the cells and we reject the cell whose total deformation is higher than 1% per day. We perform the scaling analysis on the RGPS deformation dataset and we find the same problems as for the unfiltered version of our dataset (i.e., a strong deviation from the power law scaling, see figures 1,2 and 3).

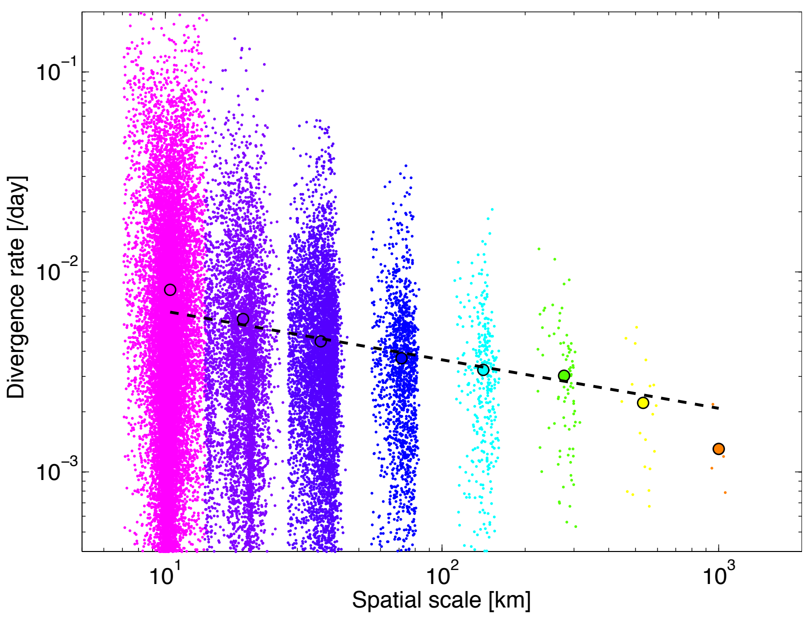


Figure 1: values of divergence (small dots) computed for spatial scales ranging from 10 to 1000 km. The mean values for each scale is shown by a black circle. The dashed line is the best power law fit of the

means. As in the unfiltered deformation obtained on the triangular mesh, a strong deviation from the power-law model is observed for the smallest spatial scales.

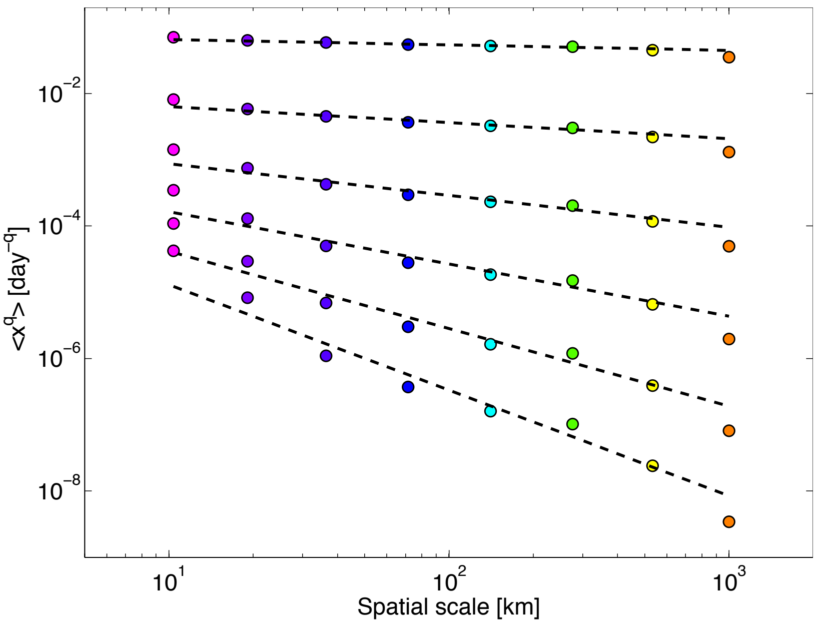


Figure 2: Results of the multifractal analysis applied to the RGPS deformation dataset for the same example as in the paper. As in the unfiltered deformation obtained on the triangular mesh, the strong deviation from the power-law scaling is stronger for the highest moment orders (see the bottom dashed lines).

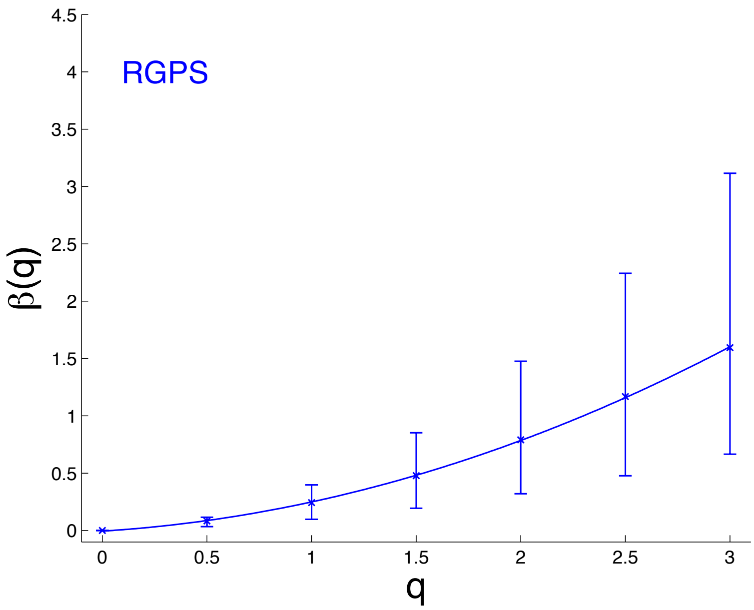


Figure 3: Structure function obtained with the RGPS deformation dataset. The min-max errors are of the same order as the ones of the unfiltered deformation fields presented in the paper.

We think that it is not necessary to include these plots in the paper and that it could bring some confusion among the readers. We think that the comparison of the unfiltered and filtered version of the deformation dataset is cleaner and more robust because we can control all the aspects of the calculation and clearly identify the effect of treating or not the artificial noise. If we restrict the analysis to the comparison with the RGPS deformation dataset, we think it is impossible to correctly assess the effect of the smoother for four main reasons: 1) the domains are not exactly the same, 2) the RGPS deformation suffers from distortion of the cells 3) the initial spatial scales are not the same 4) the RGPS dataset is made using quadrangles instead of triangles, which induces a different error in the unfiltered fields.

Changes: We have added the following statements to explain that we have applied the multifractal analysis to the RGPS deformation dataset and found the same problems as in the unfiltered deformation fields, meaning a strong deviation from the power-law scaling:
"We also performed the multifractal scaling analysis on the original RGPS deformation dataset with the same constraints on the data as in Stern (2009) and we found that the departure from the power-law is similar to the one observed for the unfiltered deformation data set."

5117-18: What are the min-max errors for some other (n, threshold) pairs? How specific is this optimal solution? And what is it for the RGPS 4-point cell data?
Response: Figure 4 shows the min-max errors for a threshold parameters ranging from 0 to 0.03 per day. Each curve corresponds to a different moment order (from 3 for the upper curve to 0.5 to the bottom curve). This analysis is done with n=3. For the threshold parameter, the minimum min-max error for scaling exponent of the third order moment is obtained with 0.02 per day. We acknowledge that the text was not correct, as we said "this combination gives the lowest min--max errors." but this is not the case for all the moment orders. This mistake is now corrected and we now more clearly indicate the limitations of this analysis and in particular the fact that it is based on a single example. The entire section has been recast as a consistency check rather than a full validation and the statement on the optimality of the value of the parameters have been toned down. See also our answer to main comment 2 of reviewer #2.

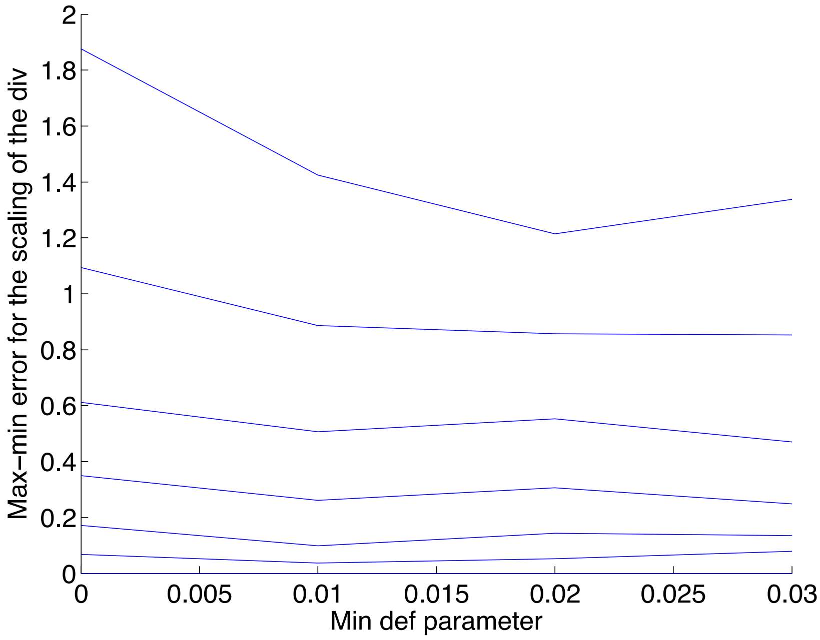


Figure 4

Figure 5 shows the min-max errors for a n parameters ranging from 0 to 6. Each curve corresponds to a different moment order (from 3 for the upper curve to 0.5 to the bottom curve). This analysis is done with a threshold=0.02 per day. When varying n, the lowest min-max error for the highest order is obtained with n=2. The min-max error for order 2.5 is minimum for n=3. As for the threshold parameter, the value chosen as reference value does not give the minimum min-max errors for all the moment orders. This is now clearly stated in the text.

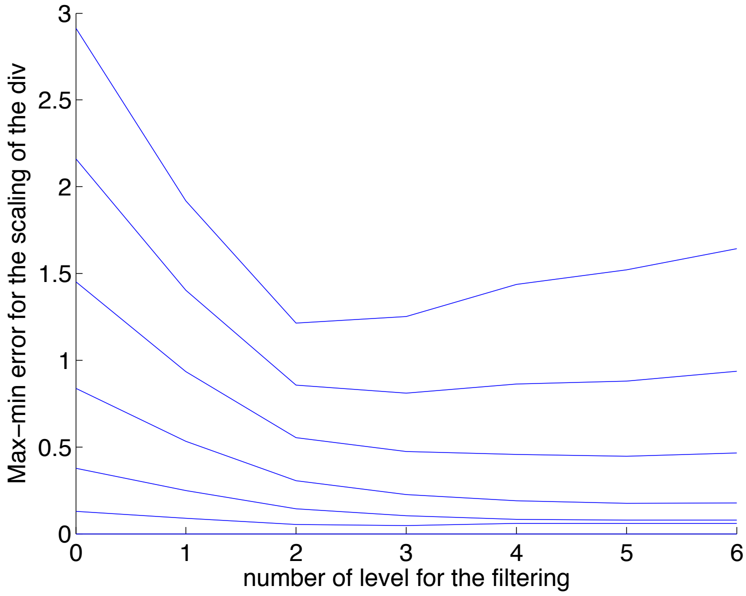


Figure 5

For the RGPS 4-point cell data, the min-max errors are given here above. For the highest order moments (2, 2.5 and 3), the min-max errors with the RGPS deformation dataset are closer to the error obtained with the unfiltered case (i.e., with n=0 on the plot here above) than with the case filtered with the reference parameters n=3 and threshold=0.02 per day.

Order moment:	0.5	1	1.5	2	2.5	3
Min-max errors:	0.08	0.30	0.66	1.16	1.77	2.45

Changes:
We adapted accordingly the paragraph on the metric:
"Applied to the composite fields used as example here, we find that using a threshold for the total deformation of 0.02 per day gives the lowest min-max error for the highest order. For the parameter n, the lowest min-max error for the highest moment order is obtained with n=2, but n=3 is better for the other moment orders. The application of our metric to this single example tends to indicate that the reference values are well chosen. However, this metric should be applied to a larger number of examples to really identify the best values for the parameters."

We also add this sentence in the discussion:
"We also performed the multifractal scaling analysis on the original RGPS deformation dataset with the same constraints on the data as in Stern (2009) and we found that the departure from the power-law is similar to the one observed for the unfiltered deformation data set."

5118-14: Again, the unfiltered data are of less interest because the 3-point deformations rates are very poorly determined. What are the values for the RGPS data? The whole point of your paper is to improve on the RGPS deformation values, not the unfiltered data set.
Response: As in the main comment 1 and the comments on 5117-10 and 5107-27, the reviewer argues that the unfiltered deformation field is much worse than the RGPS deformation fields but this is not the case, as explained in our answer to main comment 1 and to the comments on 5117-10 and 5107-27.

The whole point of the paper is to propose a method to reduce the opening/closing error generated by the derivation of the deformation from any motion dataset. The impact of using triangles or quadrangles on the opening/closing error is quite small (10%) compared to the effect of our filtering method, which reduces this error by a factor 8. Moreover the problem of cell distortion present in RGPS data generates ill-defined deformation with unrealistic values that are much higher than in our unfiltered deformation fields. For all these reasons and for those explained in our answer to 5117-10**,** we decided to not include the scaling analysis of the RGPS deformation dataset in the paper.

We here give the values requested by the reviewer, but we do not include this value in the paper for the reason explained here above. For the snapshot from the RGPS deformation dataset analyzed here, the slope (power law exponent) for q=1 is -0.16 for shear and -0.24 for divergence. The curvature of the structure function is 0.11 for shear and 0.14 for divergence.

Changes: No changes in the text.

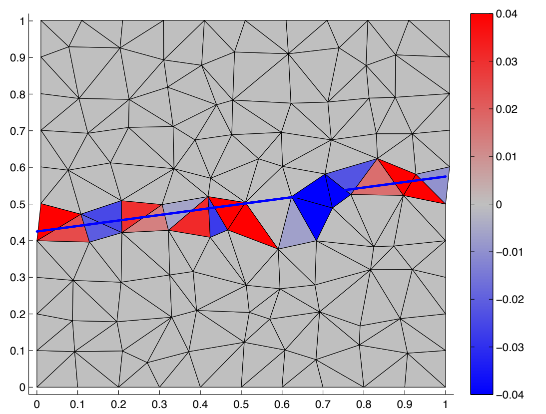
5120-6: You have not shown how the scaling from the RGPS deformation product differs from that of the new smoothed data set.
Response: No, we did not because these values may differ for different reasons: the spatial and temporal domain is not exactly the same, the spatial scales are not the same, the criterion to select the data for the scaling analysis are not the same (additional criterion needed for the RGPS deformation to avoid extreme values). See also answer to the comments on 5117-10 and 5118-14.

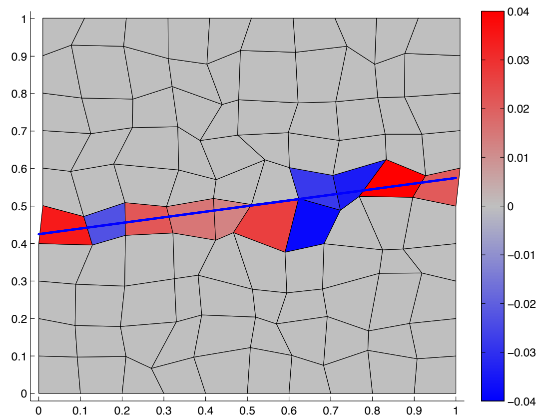
Changes: We now explain in the text that the RGPS deformation fields present a departure to the power-law scaling similar to our unfiltered fields (see remark on 5117-10).

Fig. 1: Clearly the classical smoother you use has a much larger spatial scale than the new method. More interesting would be to show what the results would look like for a square grid of nodes, similar to the RGPS cells. Maybe replace the classical smoother, which doesn't make much sense anyway, with a 4-node version. Just define a square grid of nodes and show the deformation for the 4-point cells, for the unfiltered triangles from the same grid, and for the new smoothed version.

Response: We think showing results with the classical smoother makes sense, as it illustrates the classical approach of just taking more points to compute the deformation. The example in Figure 1 has 29 points on the circumference of the region and then corresponds to compute the deformation with a large cell defined by these 29 points. Computing the deformation with 4-points is just another application of the same idea and it has the same drawback: it changes the spatial scale at which the deformation is defined and does not significantly reduce the noise.

We prefer to keep our example with the classical smoother as it clearly shows that our approach is different than the classical approach of just defining larger cells. It also allows us to introduce the smoothing method. We do not think that comparing the results on triangular and quadrangular meshes, as in the following figures, would be useful. As we already explained, the total opening/closing error obtained with the triangles is just 10% higher than with quadrangles.





Changes:

We now specifically explain how our filtering method does not induce a change in the spatial scale at which deformation is defined. See also our answer to main comment 2

Fig 3: What is normalized resolution?
Response: It is the mean distance between the points used for the simple test cases. It is called normalized resolution as it is defined for a normalized area equal to 1 and should not be confounded with the resolution of the meshes build for real cases.
Changes: We have now added this sentence to the first paragraph of section 2.1: "d is hereafter called the normalized resolution." We do not change the caption of this figure.

Fig.6: Please add the black triangles here too so we can see which are smoothed.
Response: To keep the same visual aspect as the for unfiltered divergence fields we prefer not to add black triangles on figure 6.
Changes: We add in the caption of figure 6:
"The triangles that have been treated by the smoother are those in black in Fig. 5. For the other triangles, the value of the deformation remains the same as in Fig. 4".

Figs 10-12: What are the scaling relationships for the RGPS deformation data? The unfiltered data is not very interesting, since you have added a lot of noise by using just three points at the smallest scale. The more interesting question is how the RGPS data compares.
Response: Same answer as for the question 5117-10.
Changes: No change has been made for these figures.