Solid Earth Discuss.,
https://doi.org/10.5194/se-2019-67-RC2, 2019


Solid Earth
Discussions



# *Interactive comment on* "2-D finite displacements and finite strain from PIV analysis of plane-strain tectonic analogue models" *by* David Boutelier et al.

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Received and published: 21 May 2019

The paper presents a new tool that provides critical information on finite strain field evoution within scaled analog experiments of tectonic processes. The tool provides information about Lagrangian strain fields that is not easily available with other open-access tools. The authors validate the approach within several simple but illustrative examples that demonstrate the power of the approach. This is a tool that I look forward to using with my experimental data!

I recommend that you use the name of the software, tecPIV, throughout the paper to help the reader associate the innovative technique with the specific code that you've developed.

Digital Image Correlation with Lagrangian reference frame have been used with analog models in the past and it may be helpful to include some of these references. For example, Tonenboehn et al., (2018) used Particle Tracking Velocimetry (PTV) to track advection through restraining bends. The PTV results are not as useful as the finite strain presented because they only produce displacement paths, rather than full strain field. We also found that the PTV works best with a different type and spacing of markers than the PIV; thus, requiring two different experiments to get both sets of data. Pointing out this deficiency of PTV could provide an opportunity to highlight further advantages of tecPIV.

Would there be a CPU benefit to adaptive refinement, where third and fourth pass finer resolution interrogations were applied to areas with changing displacement and higher while areas of rigid translation just had 1 or 2? This would be similar to the adaptive remeshing that is employed in some finite element method models. The resulting data would not be on a regular grid so the CPU benefit might have to be weighed with the awkwardness of the non-gridded result. The discussion of the paper could outline the utility of this.

Presentation of the standard equations is helpful though much of the text as it allows the reader to follow the principles of the analysis. One exception is that the equations for calculating principal strain become a bit pedantic. Because these can be found in any mechanics or structural geology textbook, equations 12-15 could be removed for brevity and standard textbook can be cited. Citations to standard textbooks would be helpful throughout. For example, section 3.5 is new to me and I had a hard time appreciating the reason to set up the strain tensors in either left or right stretch. Citations of a textbook or two would give me resources to better appreciate this approach.

Section 2.7 should be called the incremental principal strain. The maximum shear orientation here is noted to be 45ËŽ degrees from the principal strain orientations but

I believe this is only true for incremental strain where vorticity is near zero.

I greatly enjoyed reading about the Eularian sum approach. I tried to code this up myself at one point and the accumulated errors in the summation were horrible. One reason for this was that my strain field was not static and so I should have used Lagrangian, which I eventual did using PTVLab (Toeneboehn et al, 2018). This paper could be more up front in its recommendations to readers on when to use Eularian and when to use Lagrangian. For example, Figure 10 is helpful for delineating the incremental and cumulative displacements. I wonder if adding a grid of points (vector grid) to this figure would help demonstrate why an Eularian summation is not the best approach for this problem.

The benchmarks for testing the Eularian analysis and Lagrangian summation are very well done. Because the tests are synthetic, they report a minimum error for the analysis. This is mentioned on page 18 line 5 and got me thinking about imaging issues. It would be interesting to see how the same tests perform with random noise added to the velocities. This could simulate the potential impact various experimental effects such as slightly out of focus cameras, unclear resolution of individual particles etc. For example, it would be good to know if the technique amplifies errors inherent aleatoric uncertainties or if these errors are just passed through the analysis without amplification.

Specific comments: Page 1 line 21 ‘pass through an evolution’ ← awkward Page 6 line 36 “..less unique distribution of ??? values than a large one.” Are this displacement values, image correlation values or something else? Page 7 line 7: narrow shear zones. (plural) Page 7 line 10: . . . distribution of image values . . .. Page 7 line 14:.. where models produce deformation (or rigid body rotation) is to calculate. . . Page 8 line 2: The change of coordinate system doesn’t have to be associated wit rotation. One could arbitrarily assign a different coordinate system. Page 12 line 1: .. were ← should be where Page 16 line 4: .. were ← should be where Page 18 line 11:. Sentence is confusing and could be refined for clarity. Above? Section 3.4 The invariants are the same for Eularian and Lagrangian so don't need to repeat these equations. This section can be removed. Page 19 line 6: comma after strain Figure 11 could use more guidance for readers unfamiliar with the approach. Numbering of the deformation can show which is first and which is second. Maybe set up as XXX + YYY = ZZZ For the two cases and then the reader can see that the result is the same for the two cases. Page 20 line 14: Deformation zones (deformation bands are a particular structure and the technique here can be applied more broadly than just to deformation bands.)

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