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

David Boutelier et al.

david.boutelier@newcastle.edu.au

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We thank the reviewer for the constructive comments on the manuscript. We havetaken these comments into account to produce a significantly clearer manuscript. Below are the specific comments and how they have been addressed in the revision.

COMMENT: 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.

RESPONSE: The name now appears multiple times throughout the paper.

COMMENT: 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.

RESPONSE: The introduction now mentions the alternative use of the PTV and its limitation. In addition, the discussion section also brings back the idea of PTV, in an ultimate step after PIV in future developments.

COMMENT: 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.

RESPONSE: This proposition has been added to a new discussion section about future development. It is a challenging but interesting idea.

COMMENT: 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.

RESPONSE: We have followed the recommendation and removed Eqs. 12 to 14. Eq.

15 is required to explain how the orientation of the principal strain is calculated as well as the magnitude.

COMMENT: 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.

RESPOENSE: We added a reference to a textbook as suggested.

COMMENT: 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.

RESPONSE: Yes this section is about incremental strain. This is now clearly indicated in the section title.

COMMENT: 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 La- grangian, 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.

RESPONSE: A section has been developed about the advantages and disadvantages of both methods and when they are more appropriate. Whether the strain field is static or not is a key factor to take into account.

COMMENT: For example, Figure 10 is helpful for delineating the in- cremental 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.

RESPONSE: Figure 10 is designed to show that the finite displacements do not account for the length of the path. We believe tracking a single material point conveys this specific message best.

COMMENT: 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 anal- ysis. 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 amplifica- tion.

RESPONSE: We focused on the ability of the methods to produce an accurate sum without adding errors. It has been demonstrated that random noise or error in the incremental data vanishes in the cumulative data because only the signal is constant. Schrank et al. 2008 used this property with analogue shear zone where the incremental signal was very small but the changes in trends where noticeable in the stronger cumulative signal.

Specific comments: COMMENT: Page 1 line 21 ‘pass through an evolution’ ← awkward

RESPONSE: Sentence has been modified

COMMENT: Page 6 line 36 “..less unique distribution of ??? values than a large one.” Are this displacement values, image correlation values or something else?

RESPONSE: Intensity values are correlated. This is now clarified.

COMMENT: Page 7 line 7: narrow shear zones. (plural)

RESPONSE: This has been corrected

COMMENT: Page 7 line 10: . . . distribution of image values . . ..

RESPONSE: This has been corrected

COMMENT: Page 7 line 14:..where models produce deformation (or rigid body rotation) is to calculate. . .

RESPONSE: This has been corrected

COMMENT: 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.

RESPONSE: A translation does not change the deformation tensor, but a rotation will.

COMMENT: Page 12 line 1: .. were ← should be where

RESPONSE: This has been corrected

COMMENT: Page 16 line 4: .. were ← should be where

RESPONSE: This has been corrected

COMMENT: Page 18 line 11:. Sentence is confusing and could be refined for clarity. Above?

RESPONSE: The sentence has been clarified.

COMMENT: 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.

RESPONSE: This has been corrected

COMMENT: Page 19 line 6: comma after strain

RESPONSE: This has been corrected

COMMENT: 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.

RESPONSE: This has been corrected

COMMENT: 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.)

RESPONSE: This has been corrected

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