

Interactive comment on “Verification of an ADER-DG method for complex dynamic rupture problems” by C. Pelties et al.

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General comments

The paper “Verification of an ADER-DG method for complex dynamic rupture problems” by *Pelties et al.* attempts to verify an arbitrary high-order derivative Discontinuous Galerkin (ADER-DG) method by comparing dynamic rupture simulation results to results of Finite Element simulations. As the authors have published papers using ADER-DG in the past, benchmarking their implementation against other models used in the community is desirable and worth publishing.

The paper is structured by different areas of interest in the realm of dynamic rupture simulations. The authors try to reproduce a large number of test cases (bi-material

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interfaces, branching, supershear rupture) which is impressive. By covering a large variety of topics the authors show good insight into the field of dynamic rupture simulations. They’ve also dealt sufficiently with the literature of each of their subtopics. The authors use the SCEC test cases for comparison of their simulation results which allows for comparison with other existing and future approaches to dynamic rupture simulations. Their choice to compare against a FaultMod instance for their verification exercises is a reasonable one, as FaultMod has been used by various researchers to model dynamic rupture. The authors themselves use SeisSol, a software that I was not aware of yet.

In general their results for SeisSol (ADER-DG) and FaultMod (FEM) are in good agreement. This indicates, that both codes can be used to model a similar subset of earthquake physics. A nice side effect of this benchmarking study is that the reader can learn about the capabilities of FaultMod.

Specific comments

The paper shows an impressive number of SCEC test cases where the ADER-DG and the FEM results are in good agreement. However it would be nice to see where agreement is not as great – if you came across any such cases. Current limitations of ADER-DG and SeisSol in terms of applicability for dynamic rupture simulations would be valuable information for a reader who is about to choose their method and software to conduct dynamic rupture studies. This could be part of a small “open questions” paragraph near the end of the paper. Adding such a paragraph is at the authors’ discretion, however the authors should address their code’s limitations and I think a paragraph dedicated to this would substantially add value to the paper.

I’d be interested to see if the simulation results have a similar effect in a spatially larger geological context: The interseismic and final slip of an earthquake are important for studying static stress triggering, rupture jumps at step-overs and post-seismic stress transfer. Could you show to what extent potency and final slip profiles are in agree-

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ment?

P5987, L20ff: As the meshes have different edge lengths, you have apparently not used the same mesh in both methods. Have you used the same mesh generation software or algorithms for the ADER-DG and FEM simulations?

P5987, L21ff: Did you only coarsen the mesh for ADER-DG or for both methods?

P5987, L23: Does Figure 1a (P6018) show the mesh for ADER-DG or for FEM? Please extend the caption.

P5987, L20: Could you briefly elucidate why ADER-DG, $\mathcal{O}(5,200m)$ and FEM, $\mathcal{O}(2,100m)$ are comparable, as they have a different order of accuracy and mesh element size?

P5986: As both methods remove high-frequency oscillations in different ways, yet provide similar simulation results: Do the dissipation in ADER-DG and the viscous layer/Newmark damping in FEM need time-consuming adjustment (e.g. parameter sweeps) to obtain comparable simulation results, is there an analytical way to do it or did it work out of the box?

Technical corrections

P5983, L14ff and other long sentences throughout the text: try to make shorter sentences with less inserted auxiliary sentences to increase readability. Instead of:

“The physical solution is not necessarily insensitive to the precise parametrization of the added damping, which interferes with the actual physics of interest, for example by slowing down the rupture propagation (Andrews, 2005) and smoothing out small scale features, and may also reduce the time step length and thus increase the computational effort considerably.”

you could make 3 sentences out of the one above:

“The physical solution is not necessarily insensitive to the precise parametrization of

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an added damping. The damping may interfere with the actual physics of interest, for example by slowing down the rupture propagation (Andrews, 2005) and smoothing out small scale features. The artificial damping may also reduce the time step length and thus increase the computational effort considerably.”

There are some issues with the consistency of style:

P5984, L24 vs. P6005, L7 and others: use either “bi-material” or “bimaterial”, but not both

P5988, L8 vs. P5983, L13: sometimes you separate authors by “;”, sometimes by “,”. Be consistent.

P5990, L4 vs. P5985, L20: “distance from the fault” vs “distance to the fault”.

P5997: “velocity-weakening” (L22) vs. “velocity weakening” (L24)

P5997, L17: “Figures” instead of “Figure”, but generally decide for one way throughout the document and don't mix: either “Figure/Figures” or “Fig./Figs.”

P6003, L14: Throughout the paper you've used present tense to talk about your current work. Here and in some following sentences (e.g. P6004, L11) you are using past tense.

P5984, L10-11: So far you've used a lot of commas for auxiliary sentences. Here you don't. Then you go back to using a lot of commas, but sometimes (P5991L15) not. Either way is fine, but try to stay consistent.

P5987, L17: Although this sentence is correct, you break your previous style by omitting the comma before “we”.

I am not a native English speaker, so take my advice on grammar with a grain of salt:

P5983, L4: “... approximated accurately ...”, I know what you mean but it sounds contradicting. Please change this to your own discretion.

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P5984, L19: "... spontaneous rupture dynamic simulations ..." should be "... spontaneous rupture dynamics simulations ..."

P5986, L17: Is it really an algorithm? What about "time stepping scheme"?

P5986, L26ff: Can you break this sentence up? Especially the last bit (page 5987, line 1) does not seem to fit grammatically.

P5987, L6: free-surface should be "free surface"

P5987, L17: Wouldn't "each" be better than "every"?

P5988, L6: missing "." after "transition"

P5989, L26: maybe use "each", not "every"?

P5991, L7: Could you remove "sometimes"? It is at an incorrect position in the sentence and does not provide additional information.

P5992, L2: should be "... or by allowing the full branch to rupture"

P5992, L21: "continues a further". The "a" should go.

P5992, L22: "distance the main fault", missing "along"

P5992, L25: "starts a little bit later like" – Could you write this less colloquial?

P5992, L27: I am confused by the "as well as at the end". Either the second "as" has to go or something is missing

P5993, L5: "we consider this differences" should be "we consider these differences"

P5993, L13: "are more similar" – Could you rephrase and be more specific?

P5993, L15: "in the direct vicinity show" would be easier to read if it was "in the direct vicinity of the branching point show"

P5993, L16: "At this point, we mention that" could be "We'd like to point out that"

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P5993, L26: Change word order to "Under certain circumstances such stress perturbation could generate additional propagation modes of rupture ..."

P5993, L19: Change word order to "These differences can also be noted ..."

page 5997, line 9: "... is a smoothly version ..." should be "... is a smooth version ..."

P5997, L11: please add comma after "self-consistency", as you have one before "for"

P5997, L15: use "smoothly" instead of "smooth"

P5998, L20: I think, the code is not called SBIE, could this be rephrased to something like "and the three-dimensional spectral boundary integral element method implementation by Lapusta and Liu (2009)" ?

P5999, L22: Try to make the last sentence a statement that works without references to the sentences before, like: "We conclude that the advanced geometric flexibility of ADER-DG/SeisSol combined with its(?) enhanced accuracy ... in complicated setups." Additionally, depending on your intention you might want to use "complex" instead of "complicated".

P6003, L13: "experimental based law" could be "experiment-based law" or "experimentally based law"

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