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Solid Earth
Discussions

Interactive comment on "Regional wave propagation using the discontinuous Galerkin method" *by* S. Wenk et al.

Anonymous Referee #2

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Stefan Wenk and coauthors show that an ADER-discontinuous Galerkin (DG) numerical scheme is an appropriate choice for continental scale simulations of seismic wave propagation in heterogeneous 3D Earth models, with reasonable computational cost. This includes a benchmarking exercise that compares ADER-DG and spectral element modelling (SEM) for a 1D model (PREM), showing a very good coincidence of the results. It also includes the successful modelling of real seismograms (long period > 33s, regional distances < 2300km) from a shallow earthquake in a structural heterogeneous environment, where waveform misfit (affecting mainly the phase of Rayleigh waves) is reasonable within our incomplete knowledge of crustal and upper mantle structure. An aspect I like about the manuscript is the balance between technical accuracy and understandable explanations, making the principals of ADER-DG and the motivation of the workflow accessible also to readers that may be not too familiar with such numerical schemes. Altogether, the relevance of the topic, the results, and the presentation make this manuscript clearly suitable for publication.

The main strength of ADER-DG is certainly the extreme flexibility in mesh design. Unstructured tetrahedra with highly variable size (thanks to local time stepping) are able to match geometrically complicate discontinuities. This makes ADER-DG a perfect choice for many local problems, but –as the authors recognize- on regional scale they are competing with SEM. I'd suggest clarifying two points: 1) differences in performance, and 2) differences of the results.

About 1): We know that the efficiency of a numerical scheme depends on the particular problem under consideration, and on how much effort has been spent on optimizing a particular coding. The authors should still keep this disclaimer in the text, but nevertheless I think they should give the numbers for the particular case they studied. There are some useful suggestions about how to do this in the comment by Vincent Etienne.

About 2): The authors compare ADER-DG and SEM using 1-D isotropic PREM. The main discontinuities are honoured in both meshes. In this way, proof of the high numerical accuracy of both methods can be achieved, but nothing can be said about the different meshing strategies. I'd suggest simulating the L'Aquila waveforms with SpecFEM, and comparing the results in fig. 6. Again, we know that a rigorous comparison is difficult, and no general conclusions can be drawn from one particular application. But it would give us a qualitative impression of the differences between a target solution (ADER-DG) and a simulation that does not honour the Moho explicitly (except for certain ranges in SpecFEM V5).

Independent of 1) and 2), the introduction of ADER-DG to regional problems is a valuable step forward, given that it has the desirable property of permitting a more precise implementation of a given Earth model. I enjoyed reading this manuscript, and hope that my suggestions might be useful for the authors.

Some minor comments to the authors (trying to avoid overlap with the very detailed comments by Vincent Etienne):

P. 1133, line 16: You say that ADER-DG is a Galerkin scheme, but to make clear the hierarchy of terminology (for the readers less familiar with such schemes), you might say explicitly that SEM is a Galerkin scheme, too. The conceptual difference is not due to the "G" (Galerkin vs. non-Galerkin), but due to the "D" (discontinuous vs. continuous, as you appropriately explain in the next paragraph)

p. 1134, line 15: "the size of the elements can vary tremendously..." How much is tremendously? Is there any limitation in practise? What range of element sizes is actually used in your regional model, for example within the crust?

p. 1136, line 13: produce -> produces

p. 1137, line 15: effort -> effort, (comma)

p. 1139, line 5, imprinting surfaces, conforming mesh: Please explain. You might introduce the concept of conforming meshes and its relation to ADER-DG before.

p. 1140, line 8, boundary conditions: Absorbing? More information required.

p. 1140, line 20, SpecFEM: it is not clear why you choose to benchmark the code against another numerical method, instead of to benchmark against a quasi-analytical solution directly. Especially since you interpret very subtle waveform differences later on.

p. 1142, line 10: peak frequency -> corner frequency

p. 1148, line 17: Explain/ interpret fig. 5: The shape of the STF does not matter, since you use a low pass (33s) clearly longer than the source duration, so seismograms are affected by a time shift, only.

p. 1148, line 23, P-wave fits: Good P-wave fits for periods >33s are not such a big deal, you would get them from any 1D code as well.

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p. 1149, line 5, boundary reflection: I'm not sure if I'm looking at the right wiggle, but what is it's origin, i.e. what type of wave, and from what boundary?

In fig. 6, three-component waveforms should be shown, definitely.

Interactive comment on Solid Earth Discuss., 4, 1129, 2012.