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January 11th, 2007

To the Associate Editor, Geophysics:

Re: Paper GEO-2006-0303
This letter is in response to the review received December 7^{th}, 2006 of paper GEO-2006-0303 entitled *Riemannian wavefield extrapolation: Non-orthogonal coordinate systems*. I thank the Associate Editor and three reviewers for their comments, and for catching a number of mathematical and language typos in the manuscript. I respond to the reviewer's comments in two sections below. In 'General Comments', I address issues that were common to most or all reviewers. This is followed by point-by-point responses of more specific concerns.

General Comments

1) Efficiency and Computational Costs - Most of the reviewers stated that the manuscript should include a commentary on the efficiency of the RWE algorithm relative to Cartesian-based extrapolation. I have added an additional section after the extrapolation examples entitled "Implementation Costs". The accompanying table presents the results of a benchmark test that conveys the additional overhead costs of the RWE approach. I also discuss the extra memory requirements required to hold the additional coefficients in memory.

2) Additional Migration example - I agree with the reviewers that another RWE migration example would be informative. (A migration example was included in the Expanded Abstract volumes of the 2005 and 2006 SEG Annual conventions.) However, I am not entirely sure that a conventional migration example best demonstrates the approach. RWE is most effective when it is used to model wavefields that have a particular directionality (e.g., Green's functions or overturning waves). Recently, I submitted a 'Letter to Geophysics' that uses one-way RWE operators as the forward modeling and migration component of waveform inversion. In particular, I show that RWE on a coordinate system oriented in the direction of the overturning wavefield accurately models the early arrivals important for waveform inversion. I would argue that this 'migration' example better demonstrates the utility of the RWE approach. (The document is attached in support.)

If the AE feels that a conventional migration results is a requirement for publication, though, then I am willing to generate a Sigsbee migration image as suggested. Because this task is not just a 'minor revision', I would ask that AE for an additional 3 weeks to complete what I feel is a 'moderate revision'.

Response to the Associate Editor

1) The a_i in equation 12 is supposed to represent the elements of the vector **a** directly below equation 12. I agree that this is a confusing notation. This is modified to read "where **a** is a vector of non-stationary coefficients".

2) The editorial comments have been addressed accordingly.

Reviewer 1

1) I have included a third panel in figure 6 that compares the RWE- and Cartesian-based extrapolation result to a two-way finite-difference propagation result.

2) The extra 't' has been added to 'he'.

Reviewer 2

1) The reviewer is correct that the step from equation 6 to 7 is strictly valid only for a medium of constant slowness. In practice, this problem is addressed using approximation techniques that develop the standard extrapolation operators (e.g. PSPI, SSF, etc). I have added the following sentence to reflect this:

> Note that the use of these dual operators is strictly accurate only for constant slowness functions. Situations where s spatially varies leads to a non-physical and simultaneous space-wavenumber dependence. However, this is routinely handled through various approximations that are discussed below."

2) I agree with the reviewer that the word "extended split-step Fourier" is confusing. What I am trying to convey is that one can use extend the single split-step Fourier approach to 'multi-coefficient split-step Fourier". This is required because we are now dealing with up to 10 mixed-domain coefficients. I have changed the word "extended" throughout the manuscript such that it reads "multi-coefficient".

3) Equations C-3 and C-9 have been changed to be in accordance with the correct expression in equation 11.

Reviewer 3

1) I have added the following sentence at the bottom of page 8 stating explicitly which extrapolation operator is used to generate the examples: "All that results in the following sections were generated with the combined PSPI plus SSF correction extrapolation operator."

2) This point is covered in the last sentence of the paragraph two on page 11:

> “Note that the propagation creates explainable boundary artifacts: reflections on the left are due to a truncated coordinate system and hyperbolic diffractions on the right are caused truncated plane-waves.”

3) I have included a third panel in figure 6 that compares the RWE- and Cartesian-based extrapolation result to a two-way finite-difference propagation result. This panel demonstrates that the RWE-generated Green’s function is quite close (at least kinematically) to the expected result.

4) The figure captions for both figures 6 and 8 have been expanded in detail.

I look forward to hearing the response from Geophysics regarding the manuscript corrections.
Sincerely,

Jeff Shragge
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