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Interactive comment on "Green's theorem in seismic imaging across the scales" *by* K. Wapenaar et al.

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Review of "Green's Theorem in Seismic Imaging Across the Scales"

By Kees Wapenaar, J. Brackenhoff and J. Thorbecke

This is an excellent overview paper on performing seismic imaging with up-to-date extensions to single-sided seismic redatuming and imaging. The manuscript provides a substantial contribution to scientific progress within the scope of Solid Earth (1). The scientific quality is good and the applied methods are valid (1). Except for the minor comments which are given below the scientific results and conclusions are presented in a clear and concise manner (1). My overall recommendation is for minor technical revisions.

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Discussion paper

The authors put a number of related concepts into a broader framework, including seismic interferometry, time reversal acoustics, back propagation, and source-receiver redatuming. In addition to the mathematics, the authors also provide very clear numerical examples to illustrate the concepts. I also like the contrasting of the data-driven with the more model-driven approaches. My comments are listed below.

As an initial general comment, I was a bit confused by the title, which includes “imaging across the scales”. It looks like the special issue does have this as part of the issue title, but for this particular paper, it looks like all the numerical examples are being done at similar scales. However, many of the applications described in the paper certainly can be applied for a range of scales.

The paper has an organization where several of the derivations are given in the supplement. The supplement then has its own appendix with more fundamental derivations. Although I like putting the more involved mathematics in a supplement, at a first reading it feels a bit too nested with initially the paper, then the supplement and then the appendix to the supplement. Maybe the supplement could just be an Appendix A and an Appendix B.

Another comment is the difference uses of the term homogeneous. In the introduction on Page 2, the term homogeneous Green’s function is initially given, but not defined until the following page. So, one could maybe just say that is will be defined below, or something to that effect. More broadly, "homogeneous" is often used in various contexts. For example on page 3, there is the homogeneous wave equation with no singularity on the right hand side, and the homogeneous Green’s function that obeys this. Homogeneous is also used for a constant speed and density model, say for example here outside the volume of interest. In addition, there is another common usage of it for homogeneous boundary conditions, which are utilized to obtain source-receiver reciprocity relation as in the top of Page 3. In any case, it’s always beneficial keeping these various usages clear to the reader.

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Discussion paper

The next general comment is related to the organization for some of the sub-sections. For example, in subsection 2.2 on time-reversal acoustics on page 4, the derivation is given with the full boundary S, but the figure 2 just shows S0 as an open boundary. Although this is explained later in this subsection, on the top of Page 6 for section 2.2, it would be useful to state this a bit earlier in each subsection since this is such an important part of the paper.

Another comment is related to the use of examples with multiple scattering with random scatterers and ones with layered media. For the single sided illumination cases, also a lower horizontal boundary is placed at the focusing depth xA. Would these horizontal boundaries limit the numbers of models that this can be applied to, for example, for vertical layering or some small scatterer cases? Also, are there pathological cases possibly related to not including the evanescent waves?

The following are more detailed editing comments given for page numbers and line numbers.

Page 2 Line 13. Maybe change "of the homogeneous Green's function" to "of the homogeneous Green's function, as defined below."

Page 2 Line 14. Maybe change "that do account" to "that account".

Page 3, line 2. After the reciprocity relation maybe add, "assuming homogenous boundary conditions". (But, then you would have define homogeneous BC).

Page 4, Line 14. Maybe note here that that S0 is only a partial open boundary approximation in Figure 2.

Page 4, Line 18. Maybe change "Figures 2d shows a cross-section" to "Figure 2d shows a horizontal cross-section".

Page 5 Figure 2 caption. Maybe change "Amplitude cross-sections" to "Amplitude cross-sections along a horizontal line through the subsurface point xA."

Page 5, Figure 2. Note for Figure 2d, for some of us that are colorblind, it is more clear to draw these curves with different line types or maybe symbols Figure 2d is an important subplot and it is worthwhile making it as clear as possible.

Page 6, Lines 5-9. Maybe contrast S and S0 a little earlier in the subsections.

Page 6, lines 24-25. Maybe clarify a bit more “because no widening of the aperture angle takes place”.

Page 7, Figure 4 caption. Maybe explain a little more in the figure caption the limitations of the example. Also refer the reader to Figure 9 for an improved image.

Page 8, Figure 4. Maybe in the caption explain the limitations of the example with the open boundary S0.

Page 9, Line 15. Is this limited to just the fundamental mode?

Page 9, Line 25. Change “Conform the theory” to what you want to say here.

Page 10, Figure 5a). What are the “e ed e e” on the lower part of figure 5a?

Page 15, Line 2. Could there be pathological cases in using horizontal focusing planes? Here the layering is also mostly horizontal.

Congratulations on a very nice paper.

- Robert Nowack

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