2020 EAGE ANNUAL
82ND CONFERENCE + EXHIBITION
AMSTERDAM | THE NETHERLANDS

Marchenko Multiple Elimination: from point-source to plane-wave datasets applications

Giovanni Angelo Meles, Lele Zhang, Jan Thorbecke, Kees Wapenaar and Evert Slob

Summary. Seismic images provided by reverse time migration can be contaminated by artefacts associated with the migration of multiples. Multiples can corrupt seismic images, producing both false positives, i.e. by focusing energy at unphysical interfaces, and false negatives, i.e. by destructively interfering with primaries. Multiple-related artefacts can be dealt with via Marchenko methods, either via Green's functions redatuming or data domain schemes (i.e., multiple prediction / primary synthesis algorithms). Data domain Marchenko methods were originally designed to operate on point source gathers, and can therefore be computationally demanding when large problems are considered. However, computationally attractive schemes operating on plane-wave datasets were also derived, by adapting Marchenko point source gathers methods to include plane-wave concepts. As a result, current Marchenko algorithms allow fully data-driven synthesis of primary reflections associated with point and plane-wave source responses. Numerical tests show that while the best images are obtained when well sampled point source gathers are processed, using few multiple-free plane-wave gathers can be used as an unexpensive and effective processing step.

Introduction. Most standard processing steps are based on linear approximations, for which multiply scattered waves represent a source of coherent noise. When linearized methods are used, multiples should be suppressed to avoid concomitant artefacts. Multiple-related artefacts can be dealt with via Marchenko redatuming (Broggini et al. (2012)). Recent advances in Marchenko methods led to revised derivations which resulted in fully data driven demultiple / primary synthesis algorithms (van der Neut and Wapenaar (2016); Zhang and Staring (2018). We refer to the class of applications introduced by van der Neut and Wapenaar (2016) as 'data domain Marchenko methods'. Data domain Marchenko schemes were adapted to include plane-wave concepts (Meles et al. (2019)), thus combining the computational benefit of using plane-wave data for imaging with a data-driven demultiple scheme. Here, we compare application of Marchenko Multiple Elimination (MME) methods to point source and plane-wave datasets.

Marchenko Multiple Elimination: from point-source to plane-wave. We present imaging results of MME of data computed with the model shown in Fig. 1. We first employ MME to synthesize primaries associated with point source and plane-wave gathers. Note that the computational cost of the application of MME to one point source gather is the same as involved in the processing of one plane-wave gather. We then apply reverse time migration (RTM) to the processed datasets. Note also that migrating one point source processed gather has the same computational cost of migrating one plane-wave processed gather. Theoretically, the best imaging results are achieved by processing and migrating densely sampled point source datasets (Fig. 2(a)). However, artefacts contaminate the image when few point source gathers are migrated ((Fig. 2(b)). On the other hand, a scheme that operates on plane-wave datasets can produce multiple-free images from only a small number of plane-wave datasets (see Figs. 2(c) and (d)). To better illustrate the demultipling performances of MME, the migration of unprocessed data is shown in Fig. 2(e).

Conclusions. Data domain Marchenko methods can incorporate point source and plane-wave concepts. Point source applications produce the best results, provided that densely sampled gathers are processed, but tend to be rather expensive for large datasets, while plane-wave methods can be used as an initial and unexpensive processing step.

Acknowledgment. This research was partly funded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No: 742703).

References

Broggini, F., Snieder, R. and Wapenaar, K. [2012] Focusing the wavefield inside an unknown 1D medium: Beyond seismic interferometry. *Geophysics*, **77**(5), A25–A28.

Meles, G.A., Zhang, L., Thorbecke, J., Wapenaar, K. and Slob, E. [2019] Data-driven retrieval of primary plane-wave responses. *arXiv preprint arXiv:1908.09554*.

van der Neut, J. and Wapenaar, K. [2016] Adaptive overburden elimination with the multidimensional Marchenko equation. *Geophysics*, **81**(5), T265–T284.

Zhang, L. and Staring, M. [2018] Marchenko scheme based internal multiple reflection elimination in acoustic wavefield. *Journal of Applied Geophysics*, **159**, 429–433.

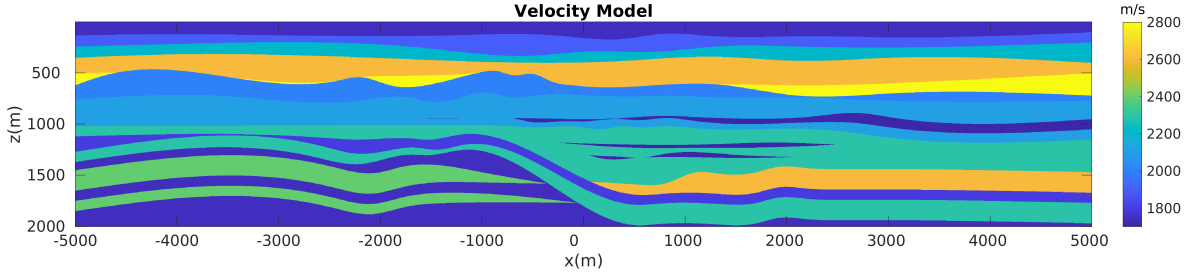

Figure 1 *Velocity model used in the discussed numerical experiment.*

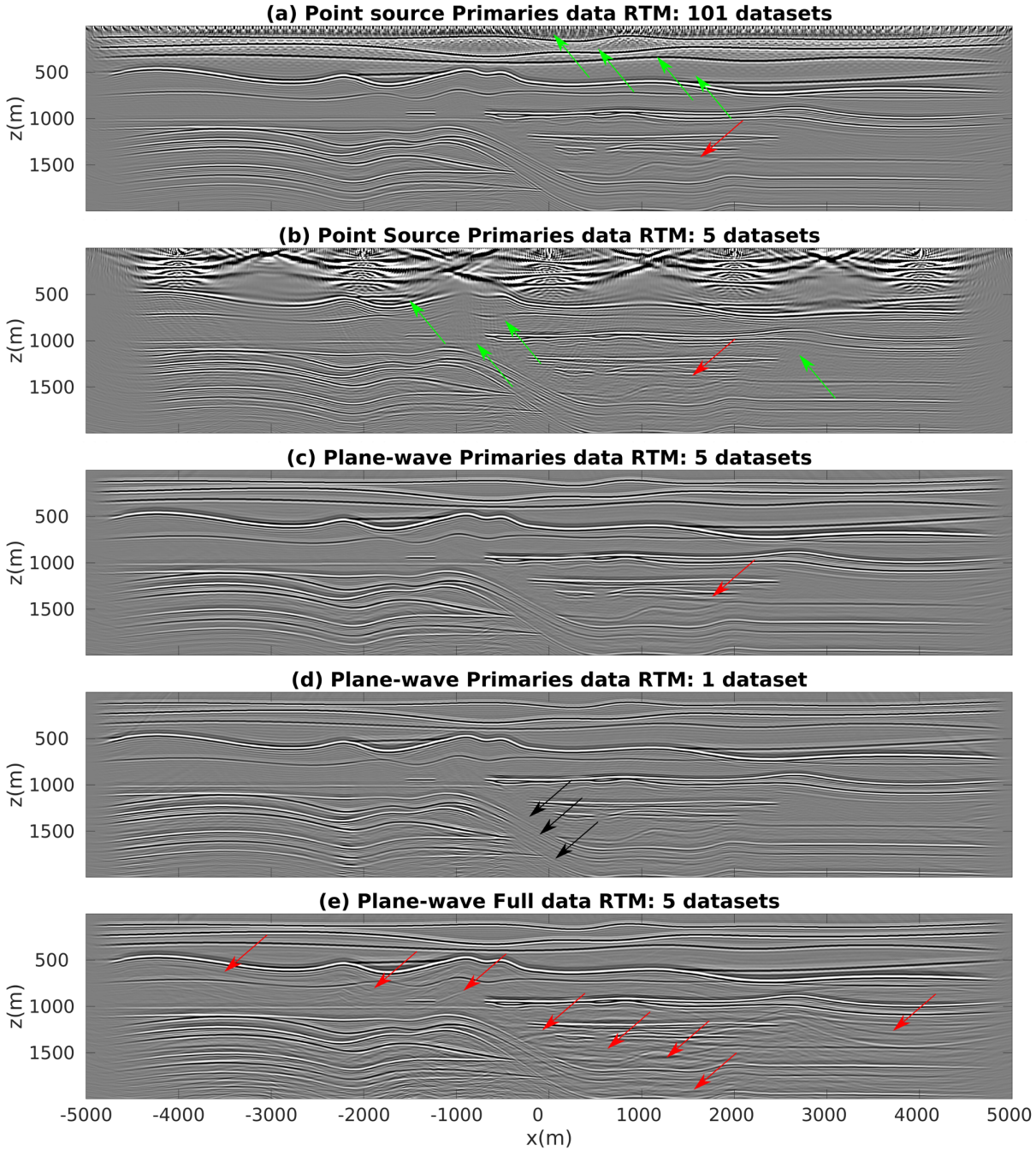

Figure 2 *Imaging results associated with the synthesis and migration of 101 (a) and 5 (b) point source primaries datasets, respectively. Red and green arrows indicate multiple- and sampling-related artefacts, respectively. Imaging results associated with the synthesis and migration of 5 (c) and 1 (d) plane-wave primaries datasets, respectively. Black arrows in (d) point at dipping interfaces poorly recovered due to limited illumination in single plane-wave imaging. Note that these interfaces are well reconstructed when 5 plane-wave datasets are employed (c). (e) Imaging result associated with the migration of 5 unprocessed plane-wave datasets. Multiples, indicated by red arrows, corrupt large portions of the image, producing both false positives and false negatives. The computational cost associated with results in (b), (c) and (d) is 5%, 5% and 1% of that involved in (a).*