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Reverse time migration in VTI and TTI media

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Reverse time migration (RTM) using the two-way wave equation has an advantage that it can describe complicated models with high velocity-contrast model, although it requires heavy computational efforts. RTM images for subsurface structures are generally obtained by computing the zero-lag cross-correlation of the source and receiver wavefields. As it is known that the gradient at the first step of waveform inversion is equivalent to migration image, RTM shares the same algorithm as the full waveform inversion. In this case, RTM can be performed by computing virtual sources instead of forward modeling. We theoretically compare the aforementioned RTM techniques with each other for 2D transversely isotropic (TI) media in the time domain, and explain a limitation of the second method. We compose RTM algorithms based on the pseudo-acoustic wave equations for both the transversely isotropic media with vertical symmetry axis (VTI) and the tilted transversely isotropic media (TTI). Our RTM algorithms are based on the 10th order finite-difference method in space and the 2nd order finite-difference method in time. The pseudo-acoustic wave equations can be derived from the P-SV dispersion relation or the linear stress-strain relation together with the equations of motion. We performed VTI RTM using each equation for the HESS VTI data set. By comparing RTM images obtained by using each equation, we note that the two equations yield similar results. We also compare isotropic RTM with VTI RTM for the HESS VTI data set. While isotropic RTM was not able to describe some anisotropic structures well, the VTI RTM yielded clear images for the anisotropic structures. For TTI examples, we choose the 2007 BP TTI Velocity-Analysis Benchmark dataset. We apply the isotropic RTM, VTI RTM, and TTI RTM algorithms to the BP TTI dataset. By comparing the TTI RTM images with the isotropic or VTI RTM images, we could note that the TTI RTM yields the best results.