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Kinematic time migration and demigration of reflections in pre-stack seismic data

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SUMMARY

In kinematic time migration one maps the time, slope and curvature characteristics of seismic reflection events, referred to as reflection-time parameters, from the recording domain of the seismic data to the time-migration domain. The inverse process is kinematic time demigration. We generalize kinematic time migration and demigration in several respects: the reflection-time parameters may belong to arbitrary source–receiver offsets; local heterogeneity of the time-migration velocity model is accounted for; the mapping operations do not depend specifically on the type of diffraction-time function and the parametrization of the velocity model. Time-migration and time-demigration spreading matrices are obtained as byproducts of the mapping operations. These matrices yield a paraxial expression for the connection between midpoint and image-point gather locations of mapped reflection events. Also, we obtain the time-migration counterpart of the so-called second duality theorem in Kirchhoff depth migration. Diffractions and reflections are assumed to be without conversion, and sources and receivers are located along the same measurement surface. Our framework enables the identification of a full set of first- and second-order reflection-time parameters from time-migrated seismic data followed by a kinematic demigration to the recording domain. The idea of this route is to 'undo' eventual errors introduced by time migration and result in reliable estimation of recording-domain invariants, that is, parameters insensitive to the time-migration velocity model. The developed concepts associated with time migration are of interest in reflection seismic and global earth applications. Two numerical examples demonstrate the potential of kinematic time migration and demigration techniques in seismic time imaging and velocity-model building.

Key words: Image processing; Numerical approximations and analysis; Tomography; Body waves; Computational seismology; Wave scattering and diffraction.

1 INTRODUCTION

Time migration has been widely applied by the seismic processing industry for decades and still holds the position as the most frequently used imaging technique. Considering research and de- migration velocity model and a depth image of sufficient quality, it is often preferred to perform interpretation of geological structures on time-migrated images. In this way, the ill-posed part of the imaging process can be postponed until more information is available. This probably explains why time migration is still attractive, in spite of