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3D Common Offset CRS for Data Pre-conditioning

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SUMMARY

Common Offset CRS allows to enhance S/N and to regularize pre-stack data, to be used for pre-stack migration algorithms, both in time and depth domain

Introduction

In recent years the need of a better accuracy in seismic imaging has become crucial and challenging, especially in the presence of a high geological complexity or low quality data. To fit this need, some preconditioning techniques have been developed to enhance the signal-to-noise ratio. The critical point in seismic data preconditioning is a good setup of parameters, but this implies an *a-priori* knowledge of the subsurface structures. To overcome this issue, a possible approach consists in both improving the mathematical-physical description of the problem and using a data-driven approach to directly extract the parameters from pre-stack data. CRS is widely known to be an optimal solution strategy to achieve such a goal, also allowing a reliability measure of the results' quality. In this work, we present an extension of the CRS technology to the Common Offset (CO) domain case. Although this approach may appear cumbersome from the computational point of view, we take advantage of our experience of simultaneous multi-parameter optimization strategy applied in the 3D ZO-CRS case. The Common Offset approach offers several advantages. At present, we just mention the possibility to obtain a regularized version of the input data, that can be used both in time or depth domain.

The Common-Offset CRS stack

The Common-Offset (CO) CRS has been introduced by Zhang et al. (2001) to simulate common-offset sections with improved signal-to-noise ratio. The same technique was applied by Höcht et al. (2009) for the interpolation in the CS and CMP domain. Müller et al. (2010) showed the potential of the CO-CRS method for regularization and S/N improvement of complete pre-stack datasets, as well as the superiority of the method with respect to the ZO-CRS-based data enhancement for data containing non-hyperbolic move-out. Both CRS-related techniques are data-driven approaches based on a multi-parameter traveltime formula in midpoint-offset coordinates, which defines a spatial stacking operator in the data domain. With respect to the conventional NMO/DMO/Stack sequences, CRS-oriented techniques provide a strong improvement of both the signal-to-noise ratio and event continuity, given the high number of traces contributing to the stacking process. While the ZO-CRS provides a global hyperbolic move-out correction over the whole offset range, the common-offset CRS can be applied locally in the offset domain to simulate a finite offset. If applied to the whole dataset, the method provides an enhanced version of the initial pre-stack dataset. As the CO-CRS calculates the stacking parameters for each bin/offset independently, it is actually a local approximation regularization, especially when small stacking apertures are used. The CO-CRS traveltime approximation, which refers to a point in the CO associated with a finite-offset *reference* ray, is parameterized in the most general 3D case in terms of 14 parameters (with respect to 8 in the ZO case). Moreover, the CO-CRS can correctly handle a wider range of events, namely apex shifted and converted events in addition to the unconverted normal events. Figure 1 shows a regularized before-stack dataset, which may be used for each kind of seismic processing, both in time and depth domain.

Figure 1 Comparison between a real, irregular cdp (left) and the reconstructed cdp (right) using CO-CRS. The missing offsets have been regularized using local hyperbolic approximation of the events.

Common Offset application in complex areas

Gentile et al. (2008) presented an integrated approach for depth velocity model building, using ZO CRS results to facilitate the interpretation in areas with high-noise level and no event continuity. Although CRS provides a substantial contribution to the solution of that and other cases, it was clear

that the CRS cannot completely exploit its potentiality since it is solely based on a global (stacked) data interpretation that cannot capture non-hyperbolic contributions on the whole traveltime. These drawbacks are due partially to the shape of the traveltime formulae and partially to the intrinsic complexity of reality. However, these effects can be substantially reduced when using a more accurate operator defined on a smaller region as in the case of the Common Offset domain using the CO-CRS operator. Moreover the CO-CRS improves both the S/N ratio and the reflection continuity in the CDP gathers. These directly impact on both the velocity analysis and the pre-stack migration with the twofold advantage of both maintaining the typical improvement of the CRS approach and avoiding the row approximation of a poststack processing. The limits of application of the technology are related to the validity of the CRS formulation that is accurate for mild lateral variations of the velocity field. Besides the improved interpretability, CO-CRS stacked CDP gathers provide better-defined semblance plots and clearer velocity trends with respect to the original data. Furthermore, prestack CO-CRS data yield improved seismic images, either migrated in time or in depth, with respect to post-stack migrated ZO-CRS sections, combining the benefits of the CRS noise reduction feature and the more accurate velocity analysis technologies and pre-stack migrations. Figure 2. shows a comparison between two stacks, before and after CO-CRS application.

Figure 2 Comparison between the stack of original data (left) and of CO-CRS output (right).

Conclusions

Pre-stack migrated CO-CRS data demonstrates far superior results for highly complex structure domain characterized by mild lateral velocity variations. Here, the combination of the noise-reducing capability of the CRS together with the more accurate pre-stack migration allows imaging seismic data that cannot be obtained using other approaches.

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