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Application of structural oriented filtering for enhancing the output of coherence calculations

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Workflow for optimized coherence calculation

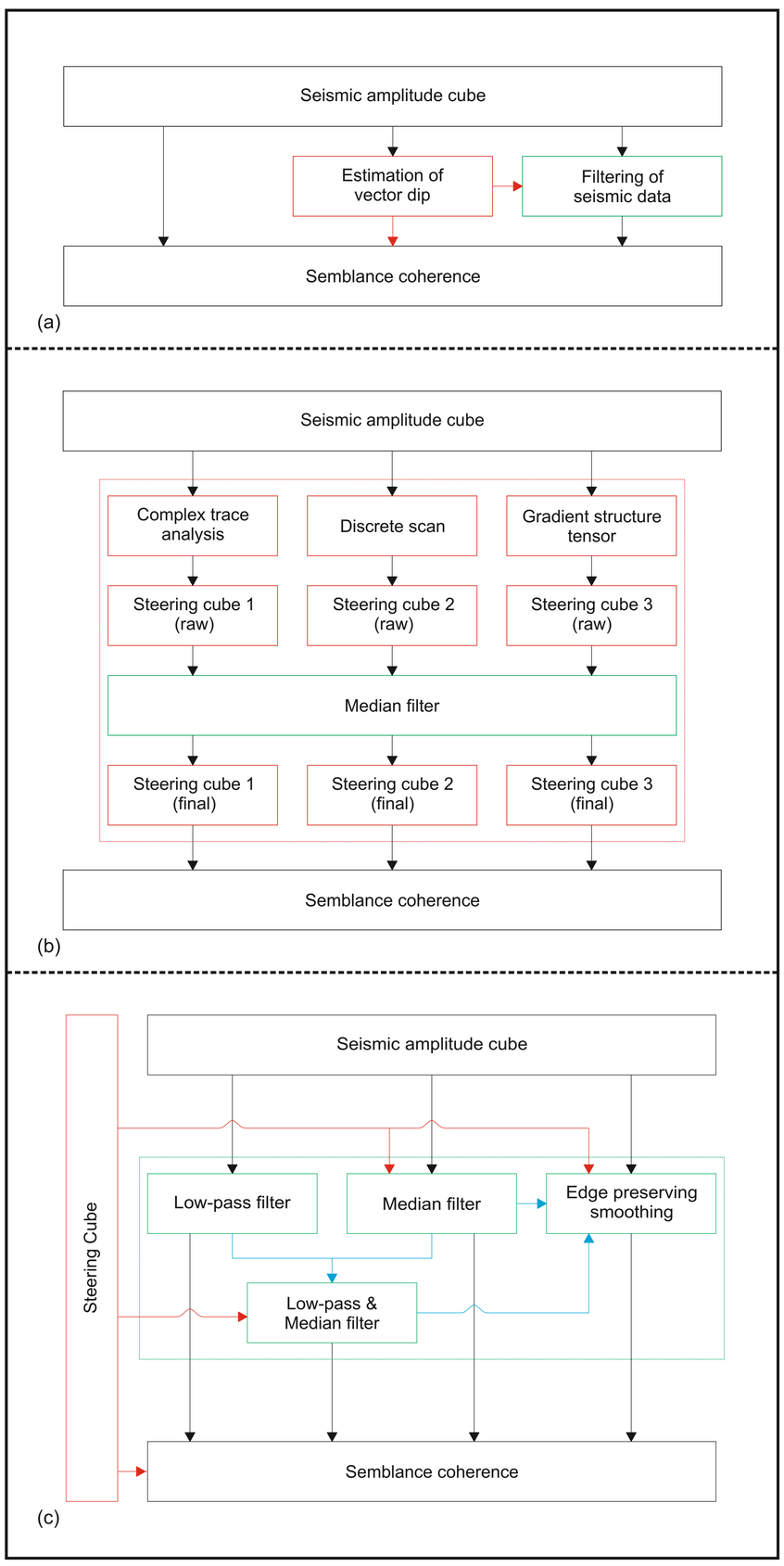

Figure 1: Flowchart showing the general workflow used for the calculation of semblance-based coherence (a). The process consists of three work steps, the estimation of vector dip (red box), the application of filters on the seismic amplitude cube (green box), and the calculation of semblance-based coherence.

Coherence is a representation of the similarity between waveforms of neighboring traces. Thus, it gives us valuable information on discontinuities in our seismic data, which may be caused by faults, channels, or fractures. The aim of this study is finding an optimal workflow for generating coherence cubes. For the calculation we use the software package OpendTect (dGB Earth Sciences). The principal workflow (fig. 1) consists of establishing volumetric dip and azimuth cubes (steering cubes), apply filtering, and compute a coherence cube after each work step. These coherence cubes are then contrasted with each other (fig. 2).
For the estimation of the structural dip three methods exist. These are the complex trace analysis (Luo et al., 1996 and Barnes, 1996), the discrete scan method (Marfurt et al., 1998), and the gradient structure tensor method (Bakker, 2002) and Höcker & Fehmers, 2002).
The filters used were basically the mean (low-pass) filter, the median filter, and an edge preserving smoothing. After each filter applied we calculate the semblance-based coherence and compared the results. The first step is to apply only one filter onto the seismic data. The median filter and the edge preserving smoothing can also be dip guided by the steering cube (see red arrows) to improve the quality of the resulting coherence. The next step is to combine all three filter methods (see blue arrows). By using multiple filters the signal-to-noise ratio increases. Especially, suppression of acquisition footprints is much better. The optimal workflow using these methods is to use the median filtered discrete scan based vector dip estimation in combination with a low-pass filter, followed by a steered median filter, and finally followed by a steered edge preserving smoothing.
Coherence can be calculated using several methods. These include crosscorrelation-based coherence (Bahorich & Farmer, 1995), semblance-based coherence (Marfurt et al., 1998), eigenstructure-based coherence (Gersztenkorn & Marfurt, 1999), gradient structure tensor-based coherence (Bakker, 2002), least-squares-based coherence (Bednar, 1998), higher-order statistics-based coherence (Lu et al, 2005), and entropy measurement-based coherence (Cohen & Coifman, 2002). Another possibility for calculating coherence is variance-based methods, where the variance is in principal one minus the semblance. In this work we used semblance-based coherence estimations.

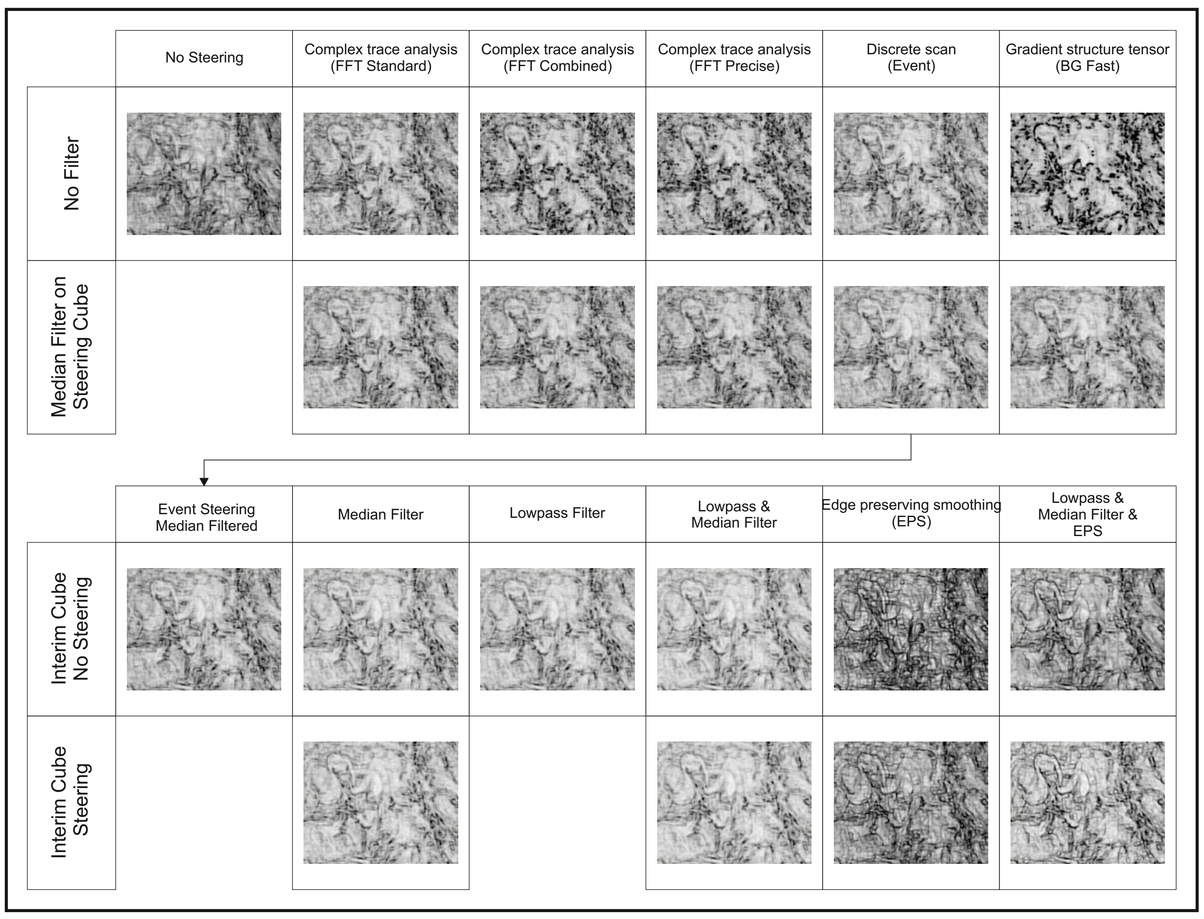

Figure 2: Summary of the applied workflow. The upper two rows show the testing of the different methods for vector dip estimation. In the first row no filter is applied on the steering cubes, whereas the second row shows the results if we apply a median filter on the steering cubes. The lower two rows show results for different filter algorithms. In the third row the filters are applied onto the data without dip guidance. For the results in row four also the filters are dip guided and thus improve the coherence calculation. The best results are achieved by combination of a low-pass filter, with a steered median filter, and a steered edge preserving smoothing.

Conclusion

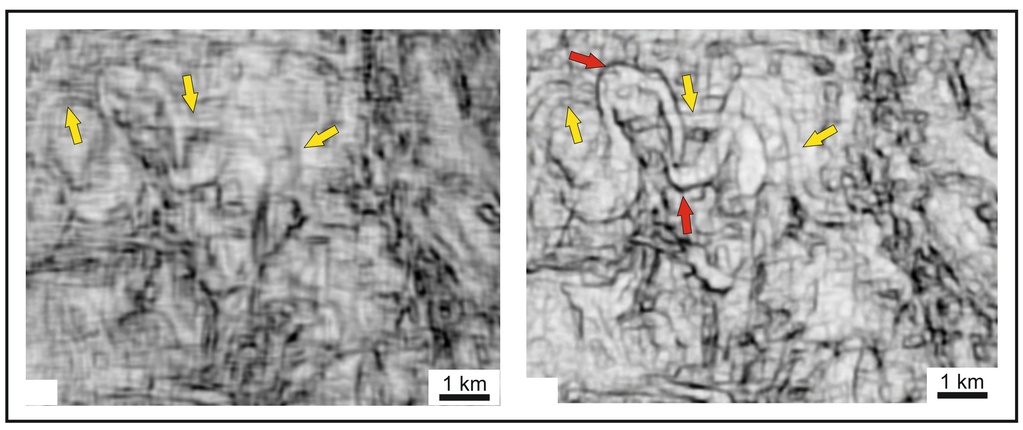

Figure 3: Depth-slice for the first case study, showing the semblance coherence for touch of a button (a) and the combination of low-pass filter, steered median filter and steered edge preserving smoothing (b). The channel system becomes sharper (red arrows) and clearer to identify from (a) to (b). Some of the features cannot or can only hardly be seen on the touch of a button picture (see yellow arrows).

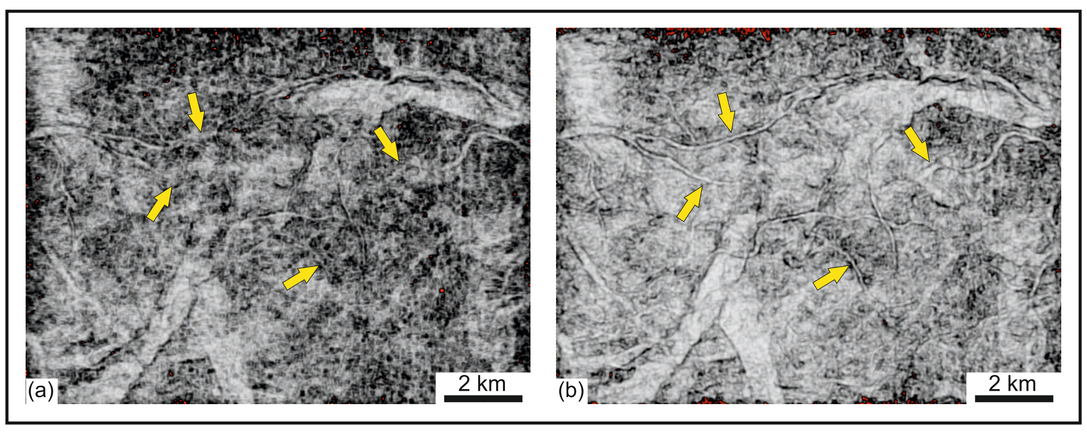

Figure 4: Time-slice for the second case study (a) showing the semblance coherence calculated without any filtering and steering of data. The right picture (b) shows the same time-slice, but in this case the data is filtered and steering is used according to the workflow described before. The yellow arrows indicate some channels where a clear improvement of the semblance coherence can be observed. Some of these channels – especially at the two arrows at the top left – cannot be seen if we interpret a simple touch of a button coherence .

We show in this work an optimized workflow for enhanced coherence calculation. The developed workflow for coherence calculation increased the quality of our coherence cubes. With the help of this workflow we greatly suppressed acquisition footprints without smearing the geological features of interest. This is especially true, for channel systems and faults (fig. 3 and fig. 4).
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