Estimating the confidence of coherence anomalies

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1. Introduction:

Semblance and other coherence measures are routinely used in seismic processing such as velocity spectra analysis, seismic edge detection and volumetric dip estimation, and edge-preserving structure-oriented filtering.

In the study, we reexamine the analysis by Douze and Laster (1979) on the significance of velocity-based semblance analysis in order to evaluate the significance of coherence anomalies within a noisy background, and the choice of parameters for structure-oriented filtering. These same concepts are readily generalized to eigen-structure type coherence estimates. After that, we applied the significance of coherence to the Footprint Suppression Workflow using edge preserved Structure-Oriented Filtering.

2. Theoretical Analysis:

Taner and Koehler (1969) define the semblance, s, of a collection of J seismic traces u_j within a 2K+1 sample vertical analysis window to be the ratio of the energy of the average trace to the average energy of the individual traces:

$$s(t)=\frac{\sum_{k=-K}^{+K}\alpha_k\left\{\left[\sum_{j=1}^{J}\beta_j u_j(t+k\Delta t)\right]^2+\left[\sum_{j=1}^{J}\beta_j u_j^H(t+k\Delta t)\right]^2\right\}}{\sum_{k=-K}^{+K}\alpha_k\left\{\sum_{j=1}^{J}\beta_j\left[u_j^{\,2}(t+k\Delta t)+u_j^{H^2}(t+k\Delta t)\right]\right\}}$$

where, denotes the measured amplitude of the *j*th trace at sample *t*, are the weights applied to the kth sample and β_j the weights applied to the *j*th trace.

Following Douze and Laster's (1979), we approximate the F-statistic with d1 and d2 degrees of freedom and non-centrally parameter (Blandford, 1974) as:

$$F_s(d_1,d_2,\varepsilon)=\frac{(J-1)\sum_{k=-K}^{+K}\alpha_k\left\{\left[\sum_{j=1}^{J}\beta_j u_j(t+k\Delta t)\right]^2+\left[\sum_{j=1}^{J}\beta_j u_j^H(t+k\Delta t)\right]^2\right\}}{\sum_{k=-K}^{+K}\alpha_k\left\{\sum_{j=1}^{J}\beta_j\left[u_j^{\,2}(t+k\Delta t)+u_j^{H^2}(t+k\Delta t)\right]-\left[\sum_{j=1}^{J}\beta_j u_j(t+k\Delta t)\right]^2+\left[\sum_{j=1}^{J}\beta_j u_j^H(t+k\Delta t)\right]^2\right\}}$$

$$d_1=f_B\sum_{k=-K}^{+K}\alpha_k\Delta t$$

$$d_2=d_1\sum_{j=1}^{J}\beta_j$$

$$\varepsilon=Jd_1\left(\frac{S}{N}\right)^2$$

- **Bandwidth** — Spectral Analysis
- **S/N** — Disorder
- **Temporal analysis window** — Dominant frequency: spectral analysis
- **Spatial analysis window** — Similar to the temporal analysis window: to generate a cubic sub volume

4. Applications:

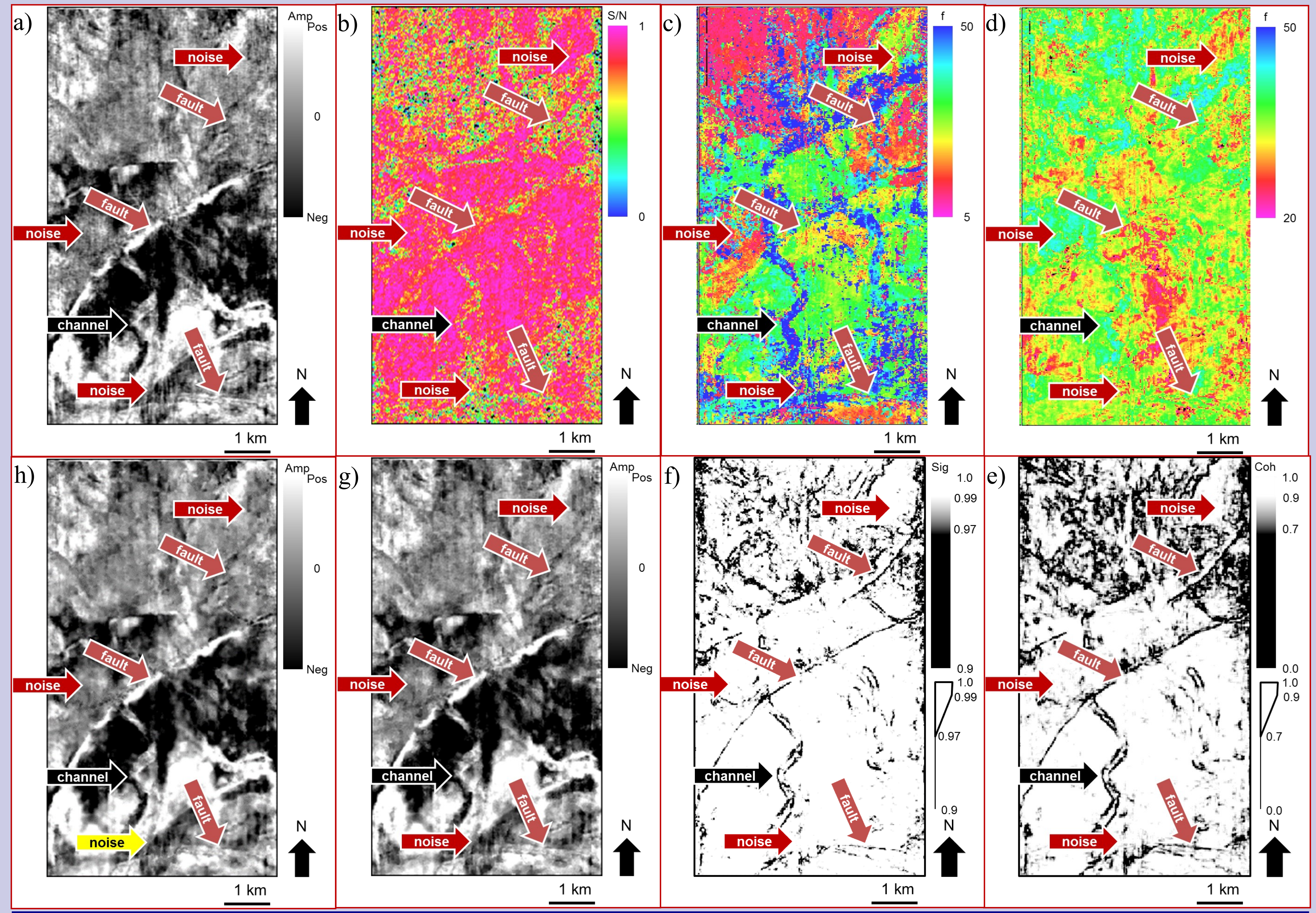
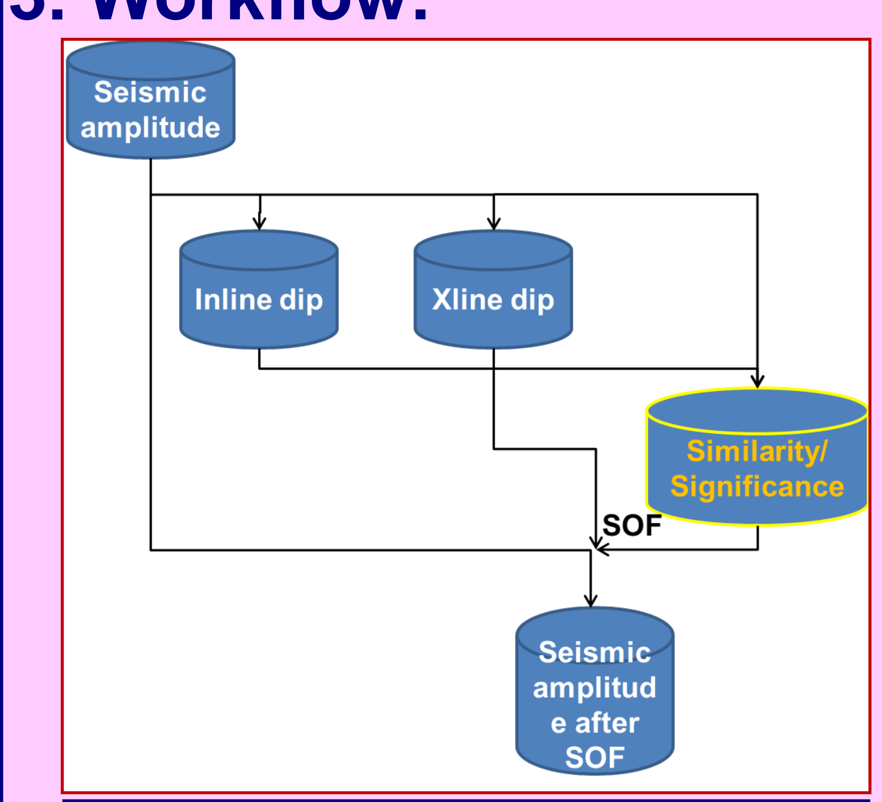


Figure: Time slice at 0.6 s along a) seismic amplitude; b) Signal to Noise Ratio; c) peak frequency; d) bandwidth; e) energy-ratio similarity; f) significance of (e) coherence; g) Structure-Oriented Filtered data based on (e) similarity; h) Structure-Oriented Filtered data based on (f) significance of coherence anomalies.

3. Workflow:



The Structure-Oriented Filtering Workflow

5.Conclusions:

- We provide a means of qualifying the significance of coherence anomalies based on the F-statistic. There are four factors for significance calculation: vertical window size, bandwidth, the number of seismic traces as well as the S/N.
- Structure-oriented filtering is a useful tool to remove the acquisition footprint artifacts. The weights, w, in structure-oriented filtering are highly important for the filtered results, which is used to preserve the geological features as well as removing the footprint artifacts.

6.Acknowledgements:

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7. Reference

- Douze, E. J., and S. J. Laster, 1979, Statistics of semblance: Geophysics, 44, 1999-2003.

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