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Curvelet-based seismoelectric data processing

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The study of seismoelectric and electroseismic wave conversions has lead to the development of promising imaging techniques expected to detect thin layers (Pride & Garambois, 2002; Haines & Pride, 2006) or to help characterize fluid changes in a reservoir (Thompson *et al.*, 2007).

Information on porous material properties provided by the type-I coseismic electric field accompanying surface and body waves is limited to the vicinity of the electrical receivers, as opposed to the type-II electromagnetic interface response (IR) which can help detect porous contrasts and/or fluid changes within the subsurface *at depth*. Hence, one of the key issues seismoelectric data processing currently needs to address is the separation between both types of waves. This is a challenging problem, as the amplitudes of the IR are usually several orders of magnitude weaker than those of the surrounding coseismic wavefield.

As the nearly flat zero-slowness IR exhibits a strong velocity contrast with respect to the much slower coseismic waves, it can be extracted by using dip-based filters, such as f-k filters and filters in the radon domain (Haines, 2007). Although these techniques are often successful at enhancing the IR, their impact on the recovered signal amplitudes has not been thoroughly studied yet. Synthetic electrograms generated with a full-waveform seismoelectric forward modeling code written by Garambois & Dietrich (2002) enabled us to study the behaviour of the IR's characteristic dipolar amplitude pattern recovered through filtering.

In order to better preserve the IR amplitudes, we have developed a new filtering strategy based on the Fast Discrete Curvelet Transform, or FDCT (Candès *et al.*, 2006). Curvelets are a recent addition to the ever-expanding family of multiresolution tools (Ma & Plonka, 2010) that can be described as localized plane waves, which oscillate in one direction and are smooth in the transverse direction (Herrmann *et al.*, 2008). Seismic or seismoelectric wavefronts can be optimally described using these multiscale, multidirectional anisotropic needle-shape structures. We have built a mask in the curvelet domain zeroing out seismoelectric samples corresponding to non-zero samples from the accelerogram, thus taking advantage of the relationship between seismic and seismoelectric wavefields. This mask consists in a threshold function combined with a Gaussian distribution promoting horizontal (*i.e.* zero-slowness) directions. When applied to synthetic data, this filter enabled to successfully extract the IR while less altering its dipolar radiation pattern than the conventional dip-based techniques. This strategy was successfully applied to a seismoelectric dataset acquired in sedimentary deposits, and permitted to isolate an IR generated at the water table.

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