Integrated workflow for surface-wave dispersion inversion and profiling

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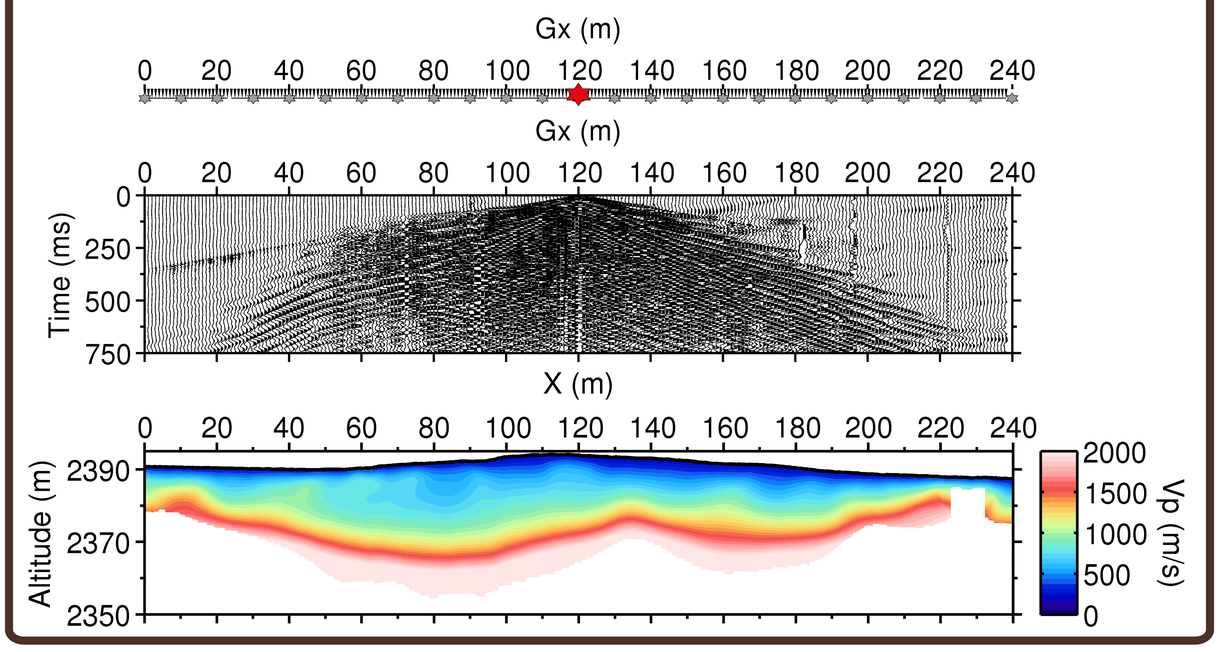
While surface-wave prospecting methods are classically applied for the one-dimensional (1D) estimation of shear (S-) wave velocities (Vs), two-dimensional (2D) profiling still requires implementing specific processing and inversion tools that are not yet widely available in the community. We present here a MATLAB-based, free and open-source tool performing surface-wave inversion and profiling (SWIP) to retrieve 2D lateral variations of Vs from typical seismic shot records. The workflow is presented using real field data collected in a shallow hydrothermal system in Yellowstone National Park.

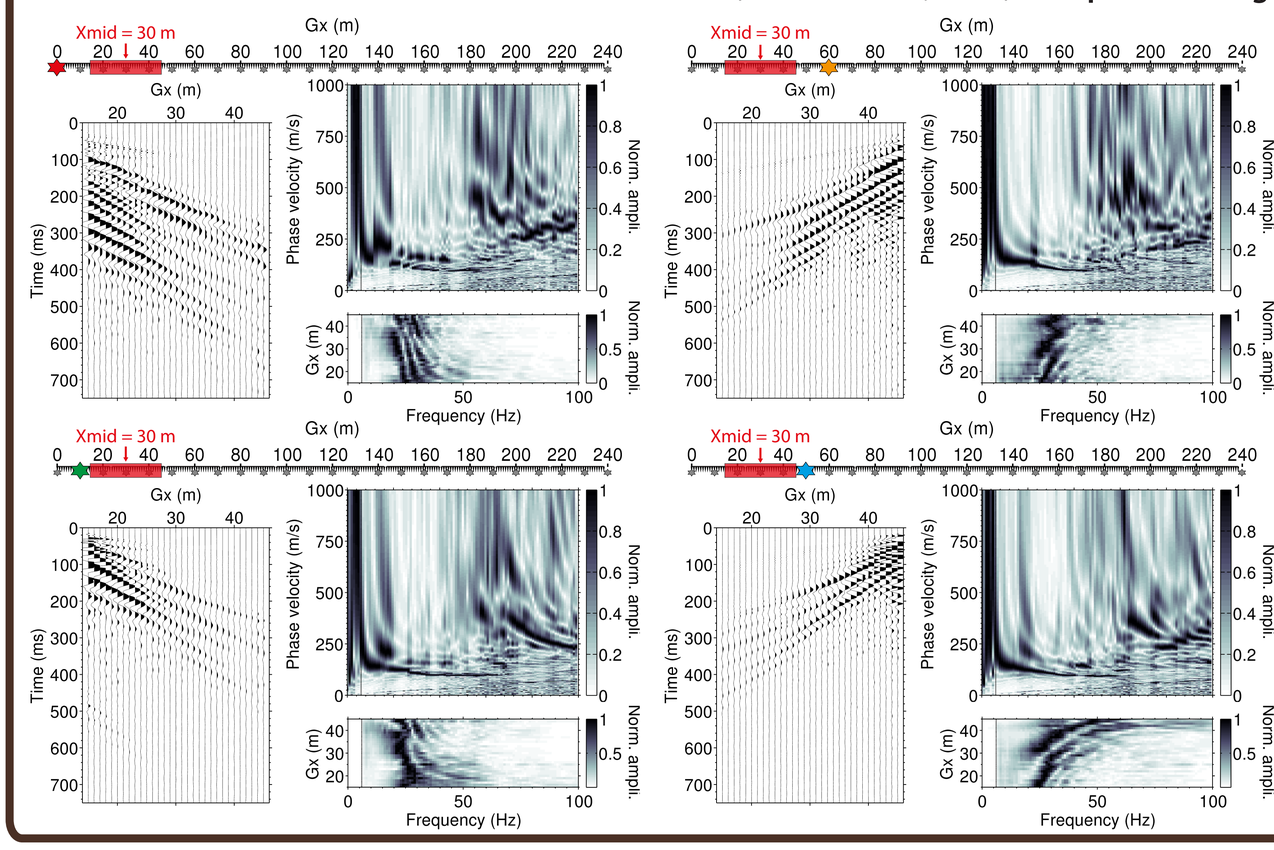
1 Acquisition setup and data format

Classical **refrac./reflec. setup** => hammer/plate + vertical component geophones
Able to manage **multi-deployment** and **multi-shot acquisition** setups
Handles data with open software **Seismic Unix** => SEG2 to SU converter included



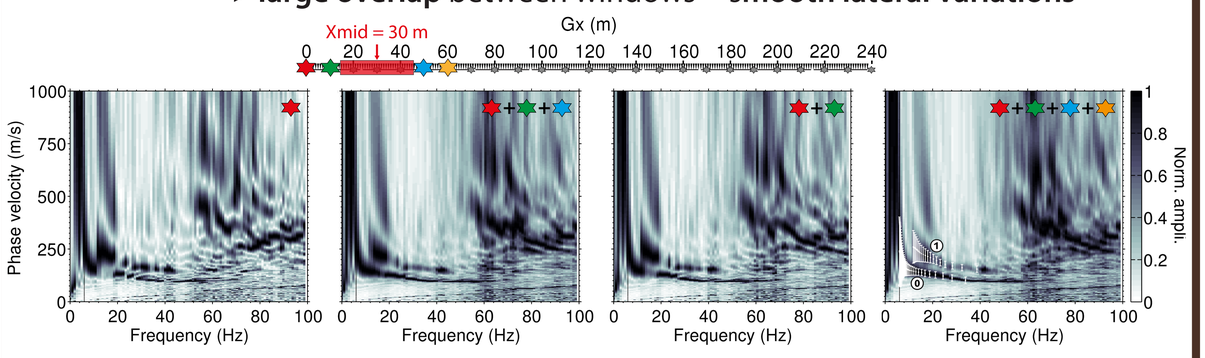
2 Data windowing and dispersion extraction

Data windowing to consider a 1D medium (O'Neill *et al.*, 2003, Neducza, 2007)
=> selection of seismic data subsets centered on a specific position (**Xmid**)
=> extraction of seismic data for each shot illuminating the selected subset
=> wavefield transform to *f-c* domain (Mokhtar *et al.*, 1988) = **dispersion image**

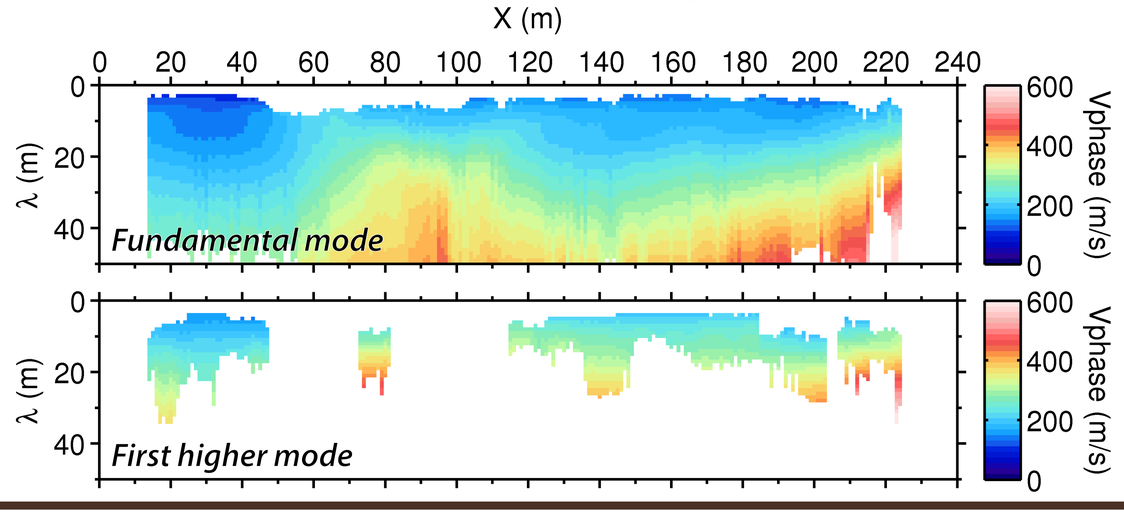


3 Dispersion stacking and picking

Stacking of dispersion images computed at each Xmid position
=> increase **signal-to-noise** ratio and help **mode identification**
Shift window along the line to obtain a set of stacked dispersion images
=> **large overlap** between windows = s**mooth lateral variations**

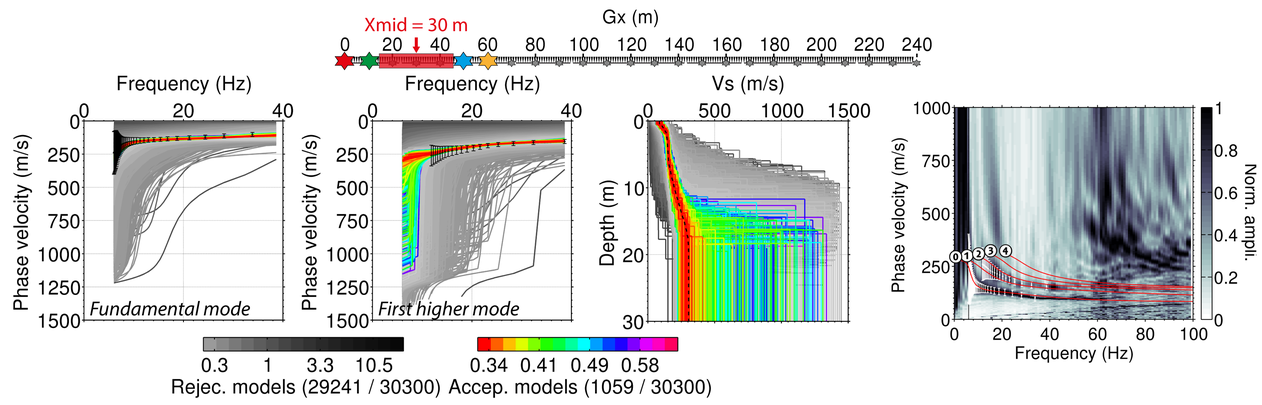


Picking of dispersion images at each Xmid position = **dispersion curve**
=> **error** in phase velocity depending on the **image resolution** (O'Neill *et al.*, 2003)

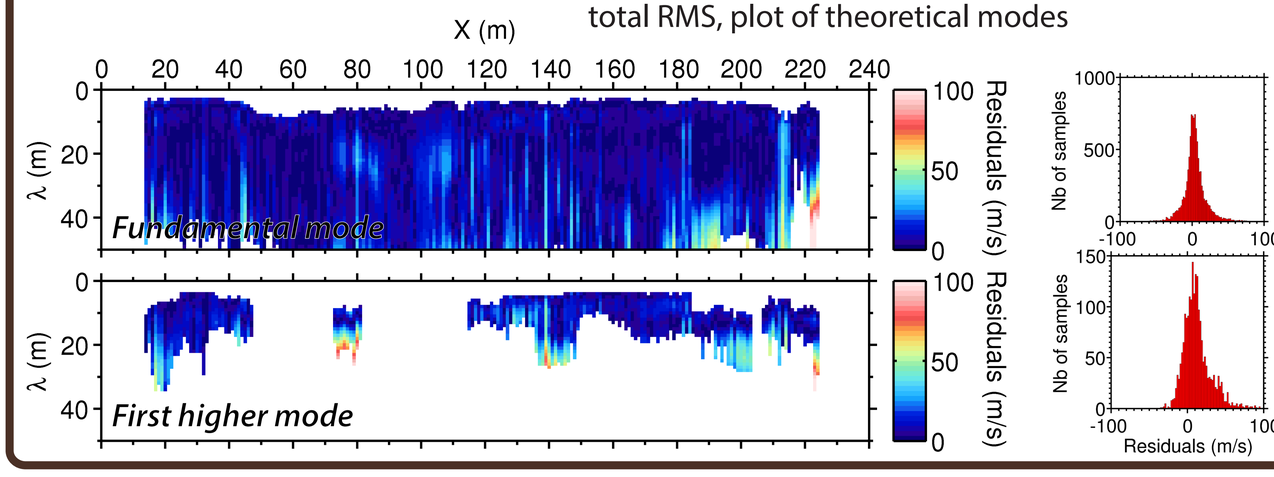


4 Dispersion inversion

Separate inversion of dispersion curves for each Xmid with the **Neighborhood Algorithm** implemented in the open software **Geopsy** (Wathelet *et al.*, 2004)
=> **blind parameterization** or **semi-automatic** from P-wave refraction results
=> extraction of ***n* best models** or **within error bars** to build average model

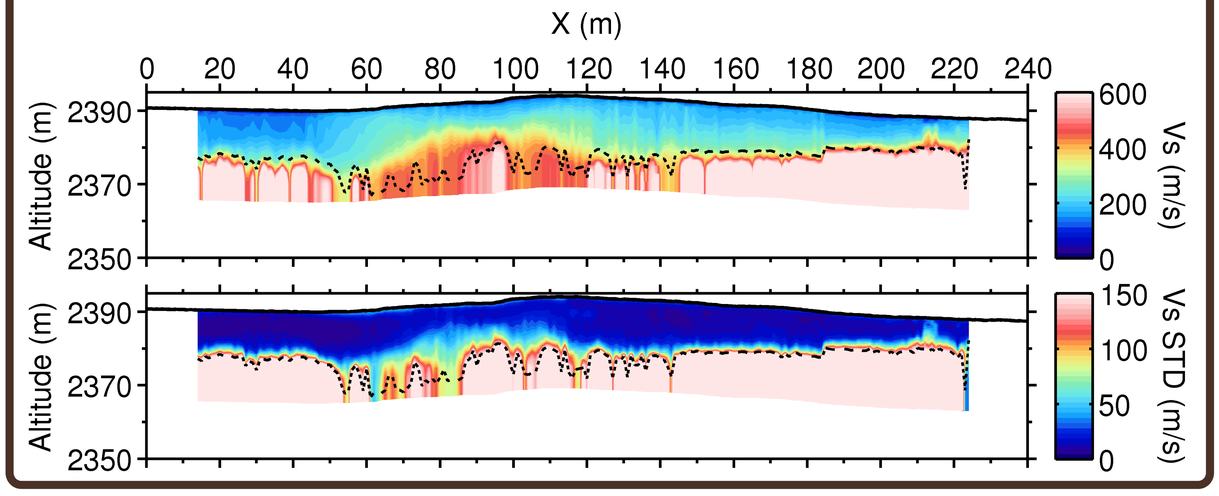


Quality control of inversion results => residual pseudo-section, single inversion misfit total RMS, plot of theoretical modes



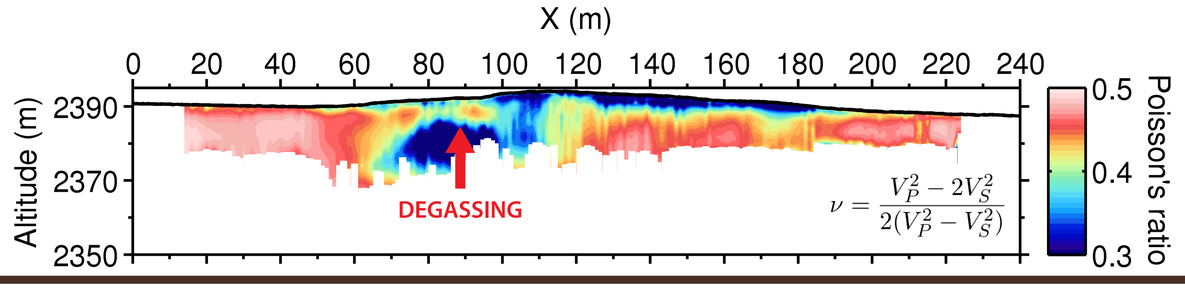
5 Pseudo-section and investigation depth

Creation of a **2D pseudo-section of Vs** with each final 1D Vs model
=> **depth of investigation** estimated at each Xmid from **standard deviation** of all selected models



6 Poisson's ratio calculation

When Vp is available along the line (e.g. from tomographic inversion), **Vp/Vs** and **Poisson's ratio** (ν) are calculated using Vs obtained from SWIP
=> **supplementary information** to discriminate **lithology/saturation**



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References
Mokhtar *et al.* (1988), *Geophys.*, **53**
O'Neill *et al.* (2003), *Explor. Geophys.*, **34**
Neducza (2007), *Geophys.*, **72**
Wathelet *et al.* (2004), *Near Surf. Geophys.*, **2**