Grenoble passive seismic

Diego Domenzain

Boise State University

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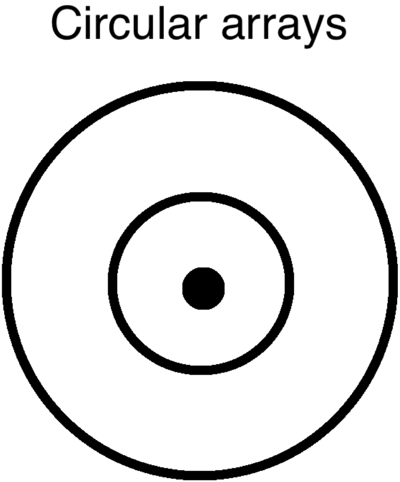
Outline

- Data
- Methods
- Implementation
- Observations

Data

Data



three of these, center in all, 3 component data

Methods

Main idea

seismic event $\rightarrow$ group dispersion $\rightarrow$ integral $\rightarrow$ phase dispersion

Main idea

interferometry $\rightarrow$ group dispersion $\rightarrow$ integral $\rightarrow$ phase dispersion

Inspiration

Campillo et al, 1996

Shapiro et al, 1997

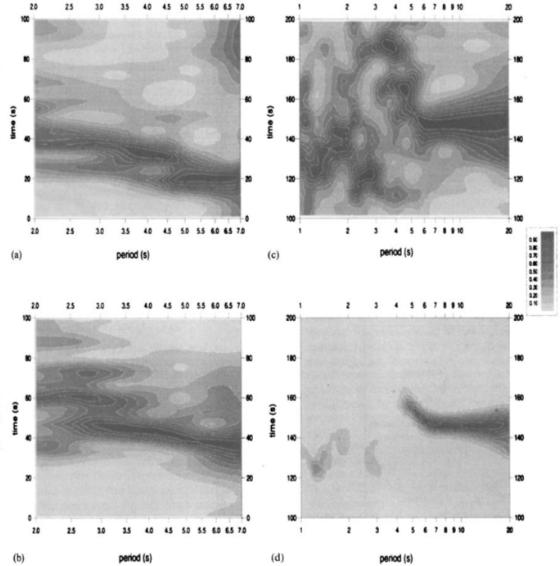
Brenguier et al, 2007

Surface-wave tomography on valleys and volcanoes from noise records and group velocities

(MX volcanic belt & Piton de la Fournaise)

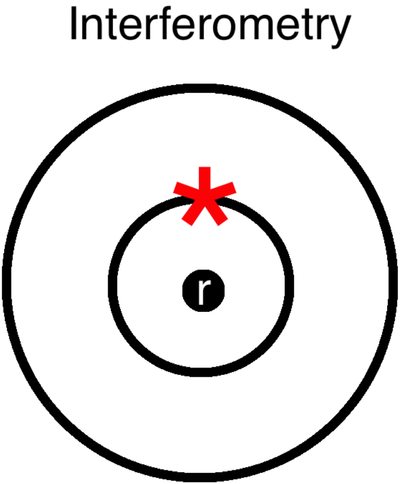
* they use all 3 component data

Inspiration



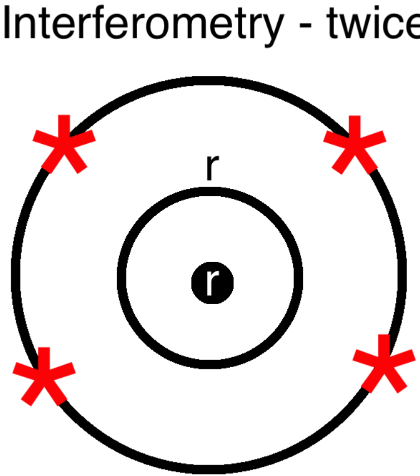
idea is so old, it's in black and white (Shapiro et. al, 1997)

Idea 1



do many source-receiver pairs

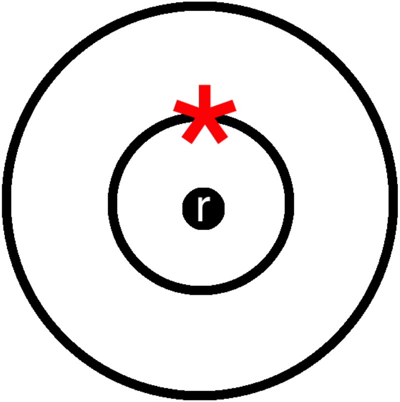
Idea 2 - part 1



many outer virtual sources

Idea 2 - part 2

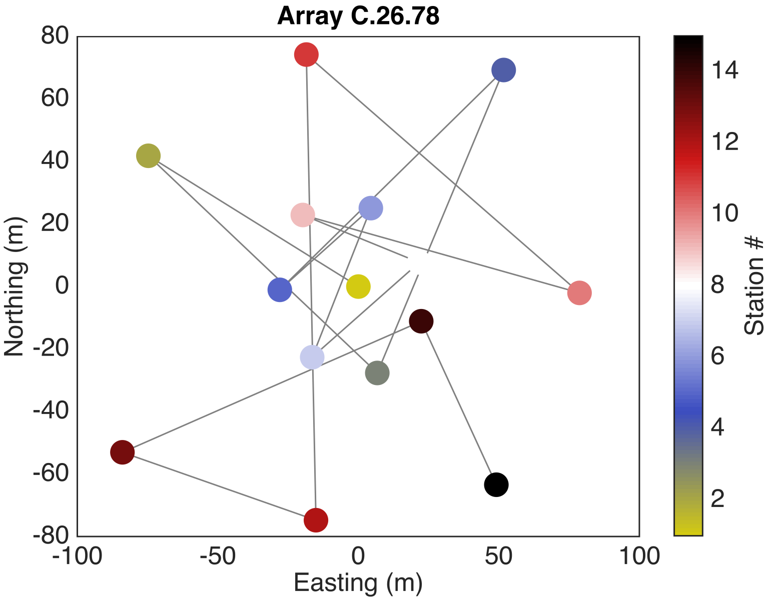
Interferometry - twice



focus on one source-receiver, then do Idea 1

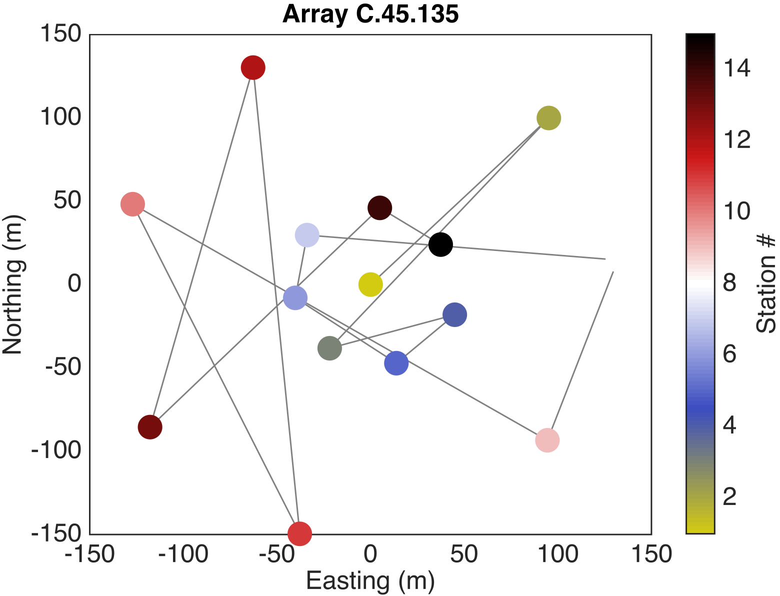
Implementation

Array “small”

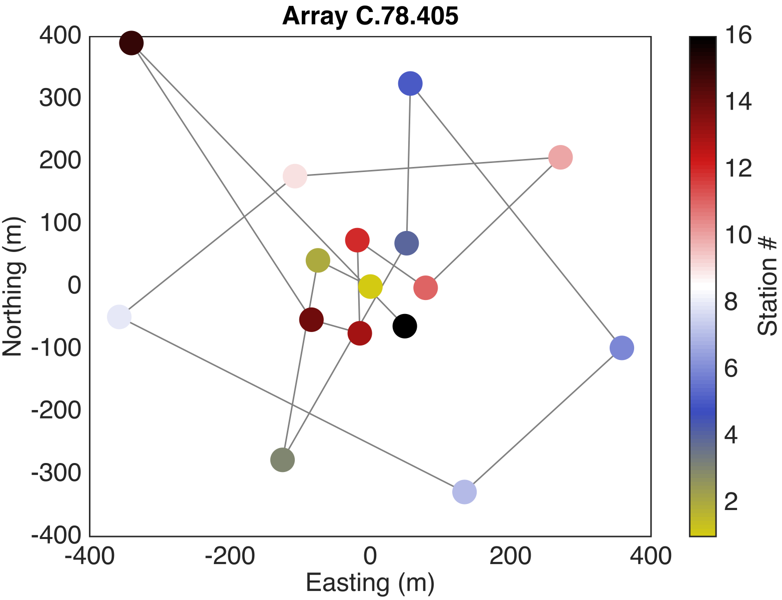


Array C.26.78
80
60
40
20
0
-20
-40
-60
-80
Northing (m)
-100
-50
0
50
100
Easting (m)
14
12
10
8
6
4
2
Station #

Array "medium"

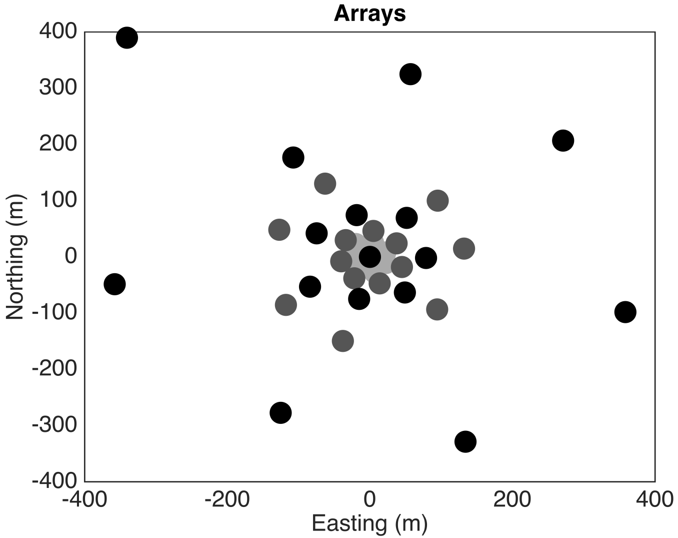


Array "large"



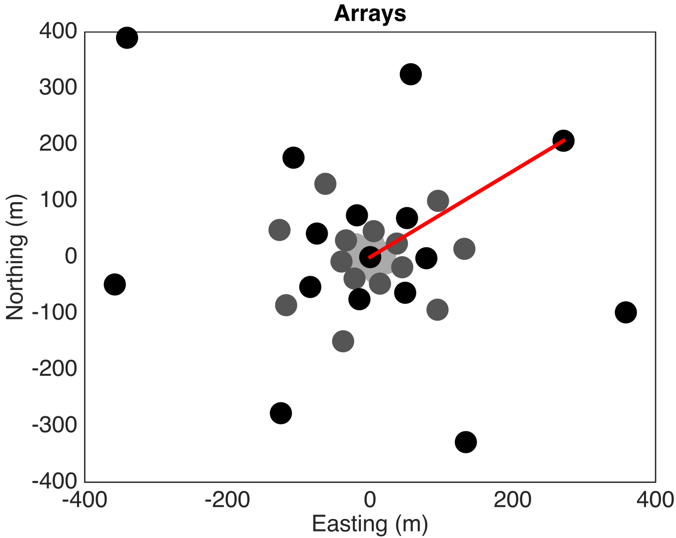
Array C.78.405
400
300
200
100
0
-100
-200
-300
-400
Northing (m)
-400
-200
0
200
400
Easting (m)
16
14
12
10
8
6
4
2
Station #

All arrays



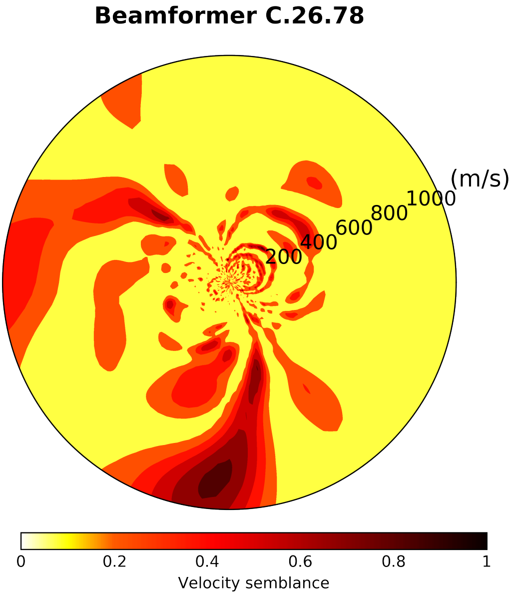
it's a white walker signal (spiral)

Arrays line

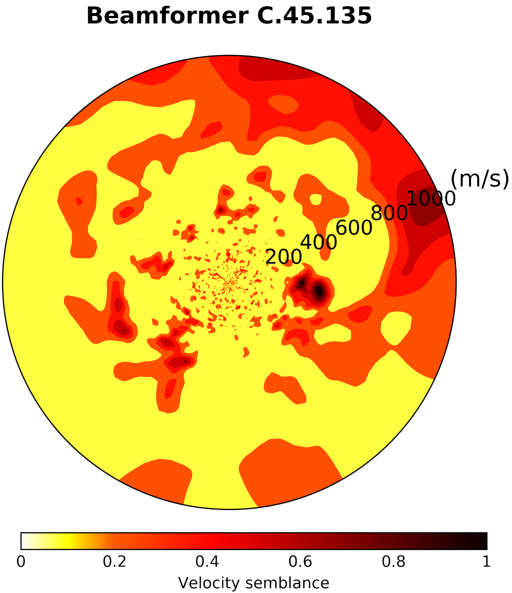


stations 8, 15 and 10 of arrays small, medium and large respectively

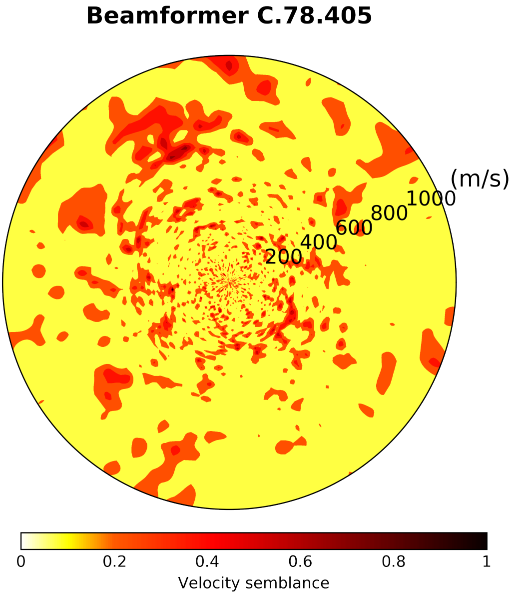
Noise sources



Noise sources

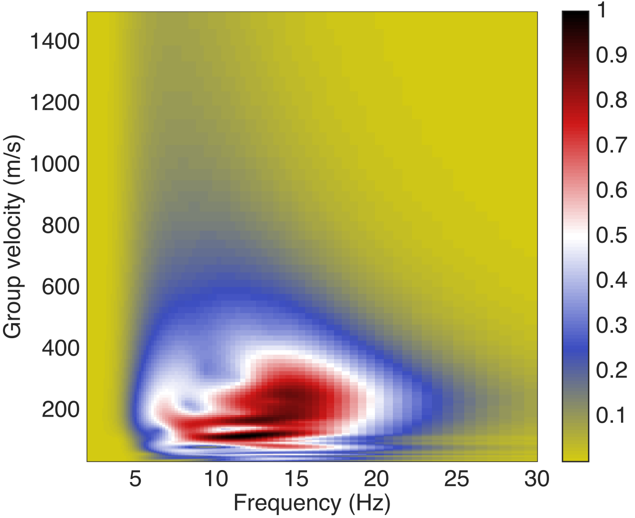


Noise sources

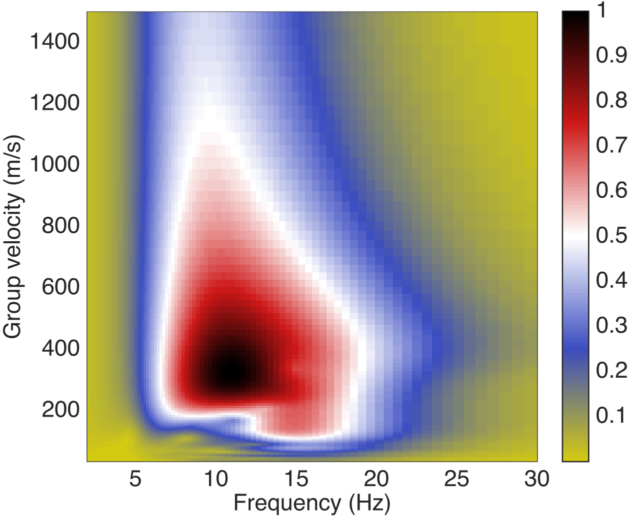


On y vamos!

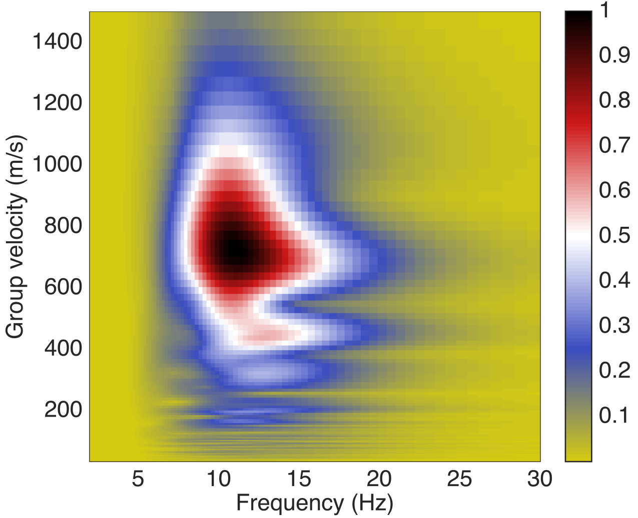
Group velocity “small”



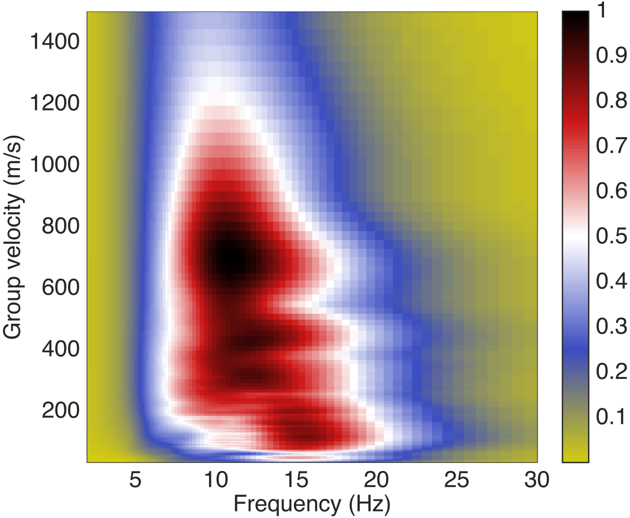
Group velocity “medium”



Group velocity “large”



Group velocity - all together



Group to phase velocity

Let v_g, v_p, ω and k denote group velocity, phase velocity, angular frequency and wavenumber respectively. We have,

$$v_g = \partial_k \, \omega,$$
$$v_p = \frac{\omega}{k}.$$

Let s denote slowness,

$$v_g = \partial_k (k \, v_p) \qquad \text{or} \qquad s_g = \partial_\omega (\omega \, s_p)$$

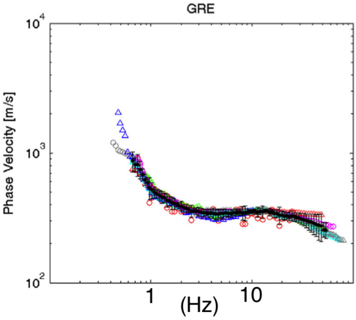
and so

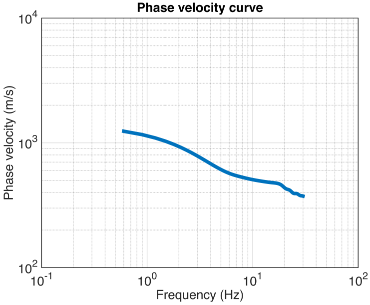
$$v_g = k \partial_k \, v_p + v_p \qquad \text{or} \qquad s_g = \omega \partial_\omega \, s_p + s_p.$$

Solving these differential equations we have,

$$v_p(\omega) = \frac{1}{k} \left(k_o \, v_p^o + \int_{k_o}^{k} v_g(k) \, \mathrm{d}k \right) \qquad \text{or}$$
$$s_p(\omega) = \frac{1}{\omega} \left(\omega_o \, s_p^o + \int_{\omega_o}^{\omega} s_g(\omega) \, \mathrm{d}\omega \right).$$

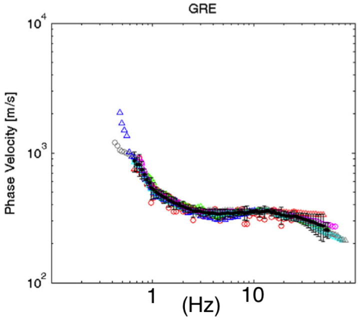
Phase velocity - Idea 1

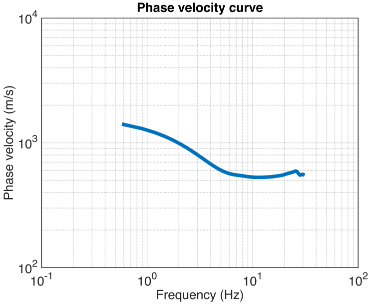




Garofalo et al, 2016

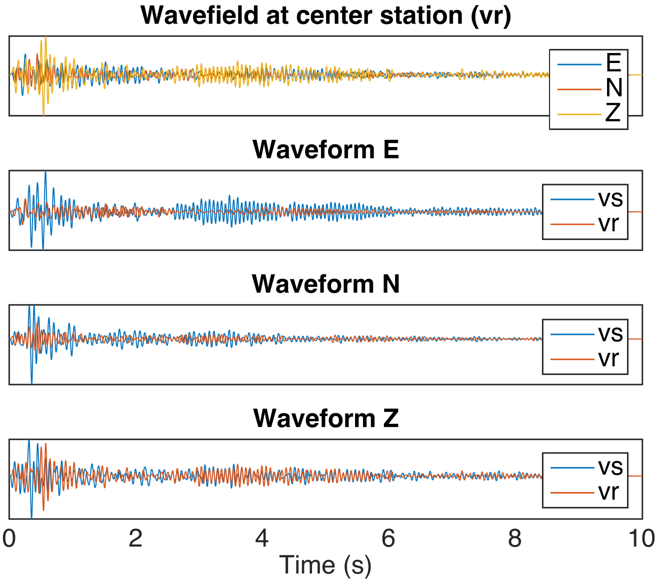
Phase velocity - Idea 2



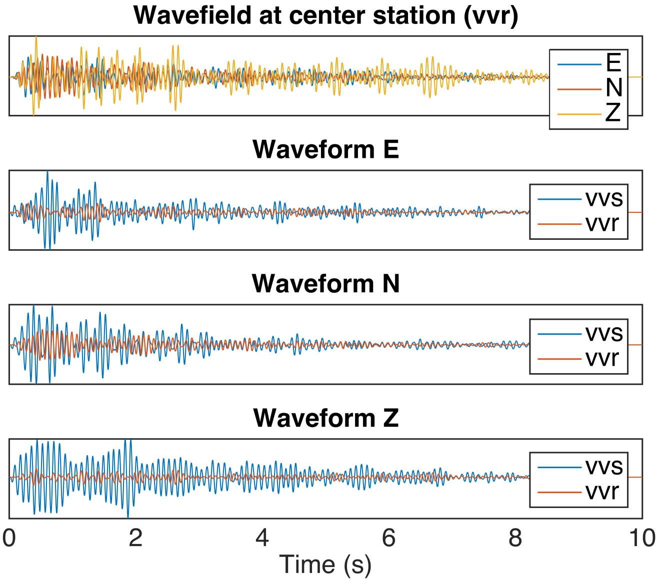


Garofalo et al, 2016

Shot gather - Idea 1



Shot gather - Idea 2



Observations

Interesting

- This method overshoots (or undershoots) values for v_p
- Concavities of v_p are switched
- Interferometry-inception enhances contrasts in v_p
- Sensitive knobs to turn:

  - Frequencies for bandpass:

    data can get aliased and turn into wiggly cones

  - Time windows for xcorrelations:

    group dispersion semblance can become skewed and useless

  - Choosing s_p^o:

    phase velocities can result increasing in frequency