OBS CLOCK SYNCHRONIZATION
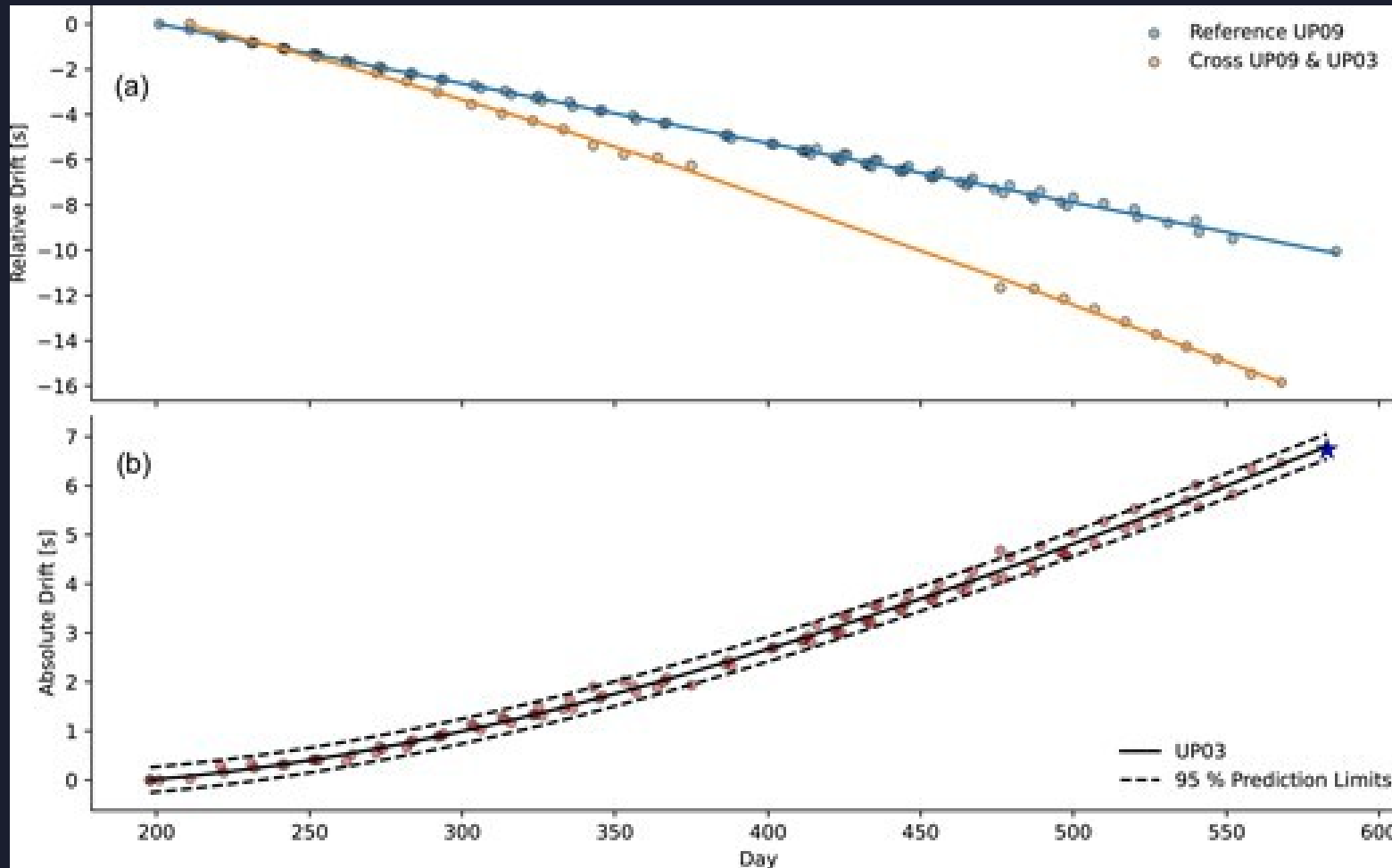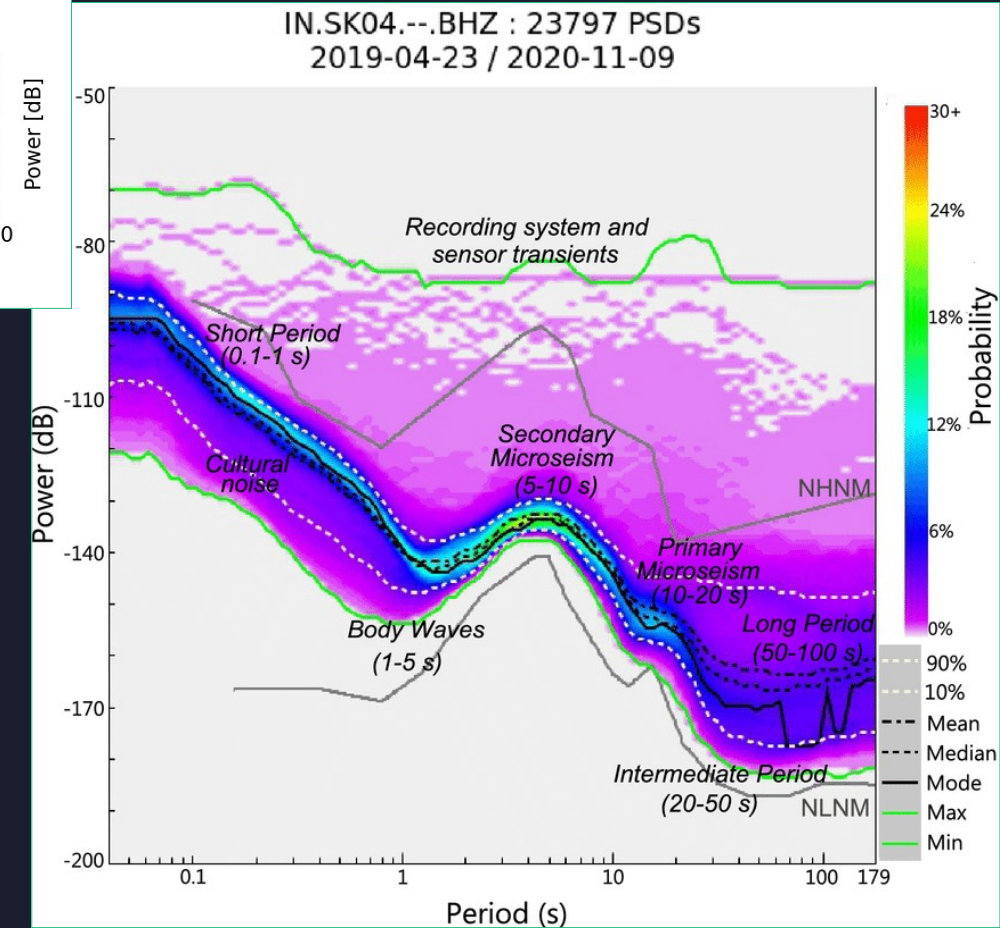
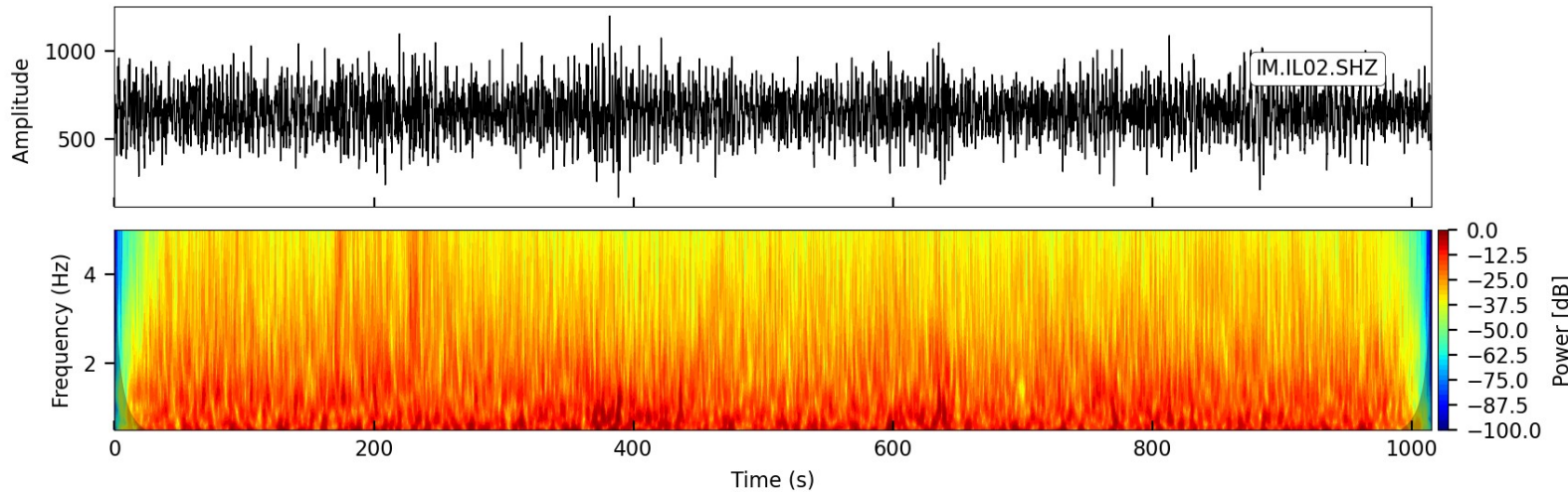*Dr. Roberto Cabieces Díaz*

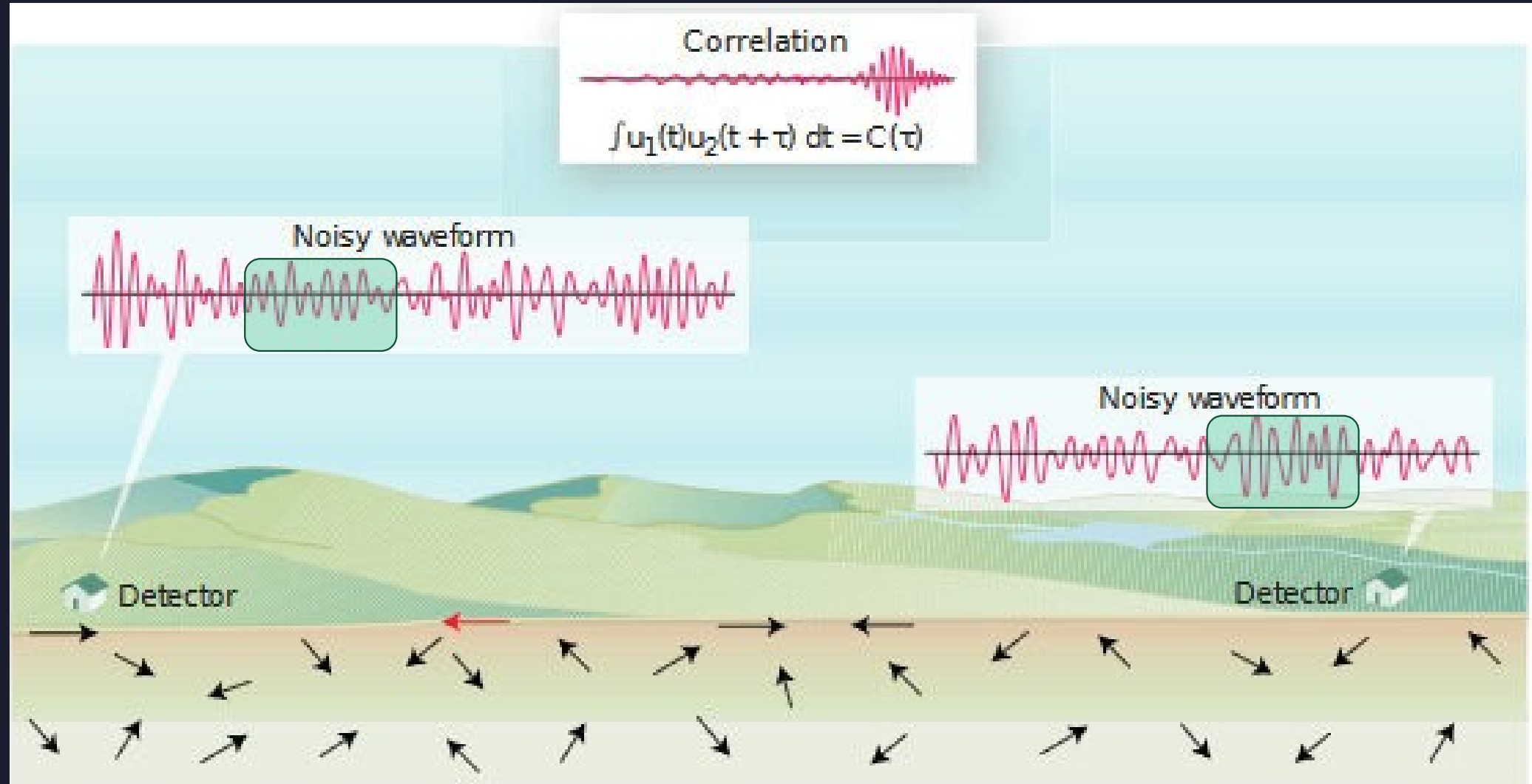Lisbon, 26-Aug-2025

INTRODUCTION: CLOCK DRIFT

No clock
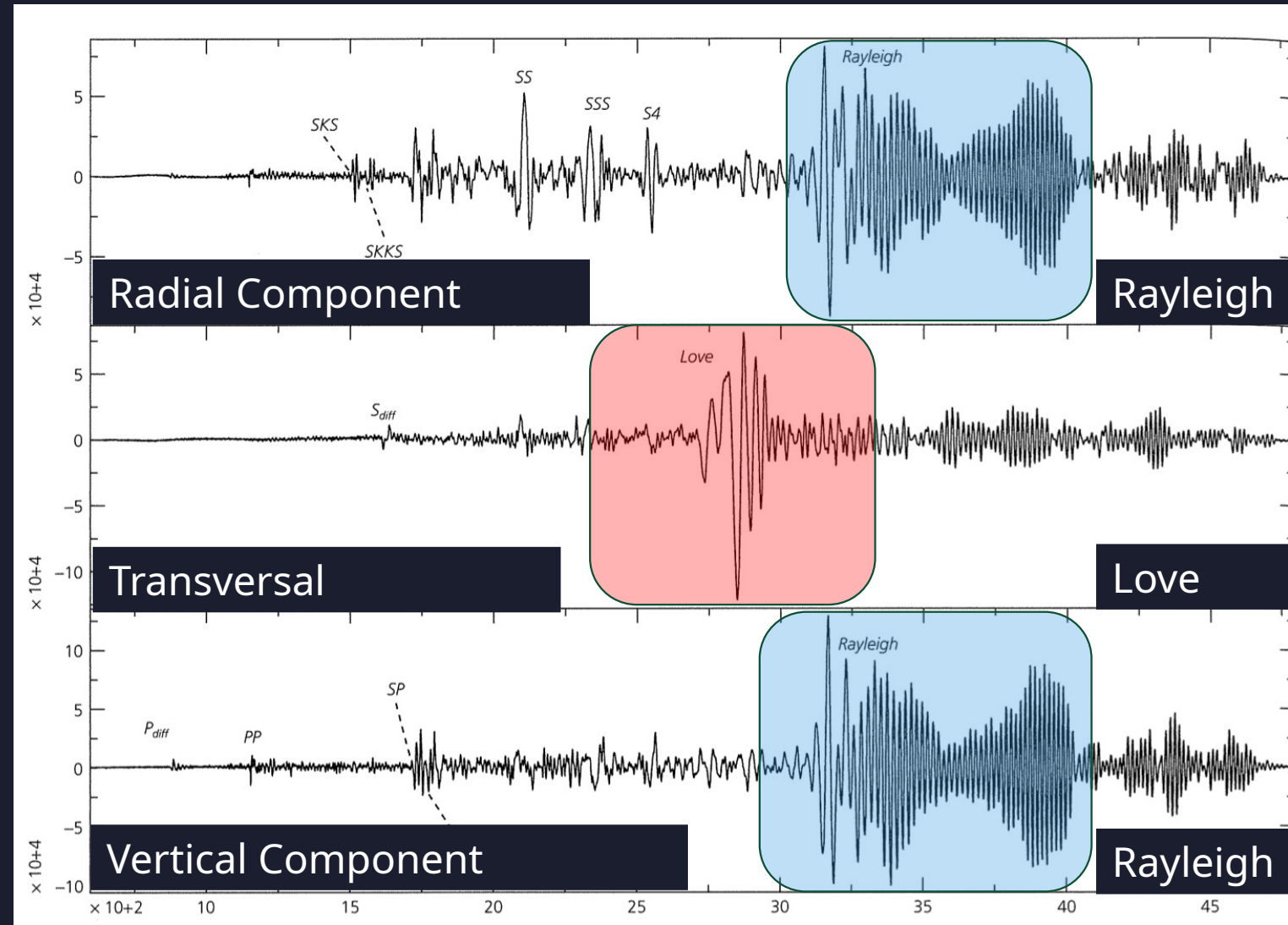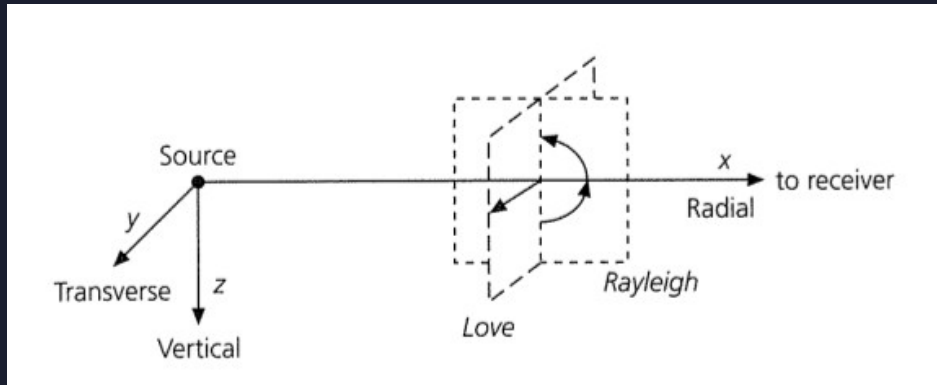No Network
applications

Seismic Wave speed VS
clock Accuracy

HOW TO SOLVE THE PROBLEM: NOISE SOURCE & MECHANISM

BACKGROUND KNOWLEDGE

SURFACE WAVES

BACKGROUND KNOWLEDGE

$$c = \frac{\omega}{k} \qquad U = \frac{d\omega}{dk} = c + k\frac{dc}{dk} = c\left(1 - k\frac{dc}{d\omega}\right)^{-1}$$

Event from Japan (Mw = 5.6), 2004/07/17 06:10:18
Recorded by the station in eastern Tibet
Epicenter Distance: 3770.9 km

vertical
unfiltered

100 s
90 s
80 s
70 s
60 s
50 s
40 s
30 s
20 s

5.0 4.5 4.0 3.5 3.0
Group velocity (km/sec)

Group velocity

Phase velocity

Group V:
Energy
propagation
speed

Time

Distance
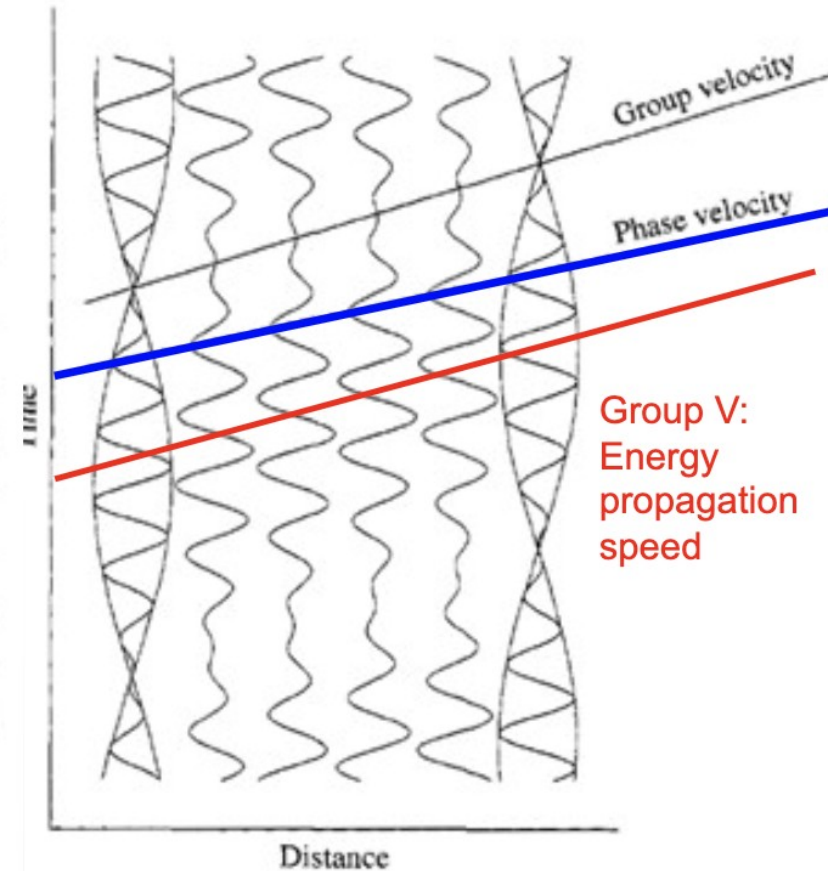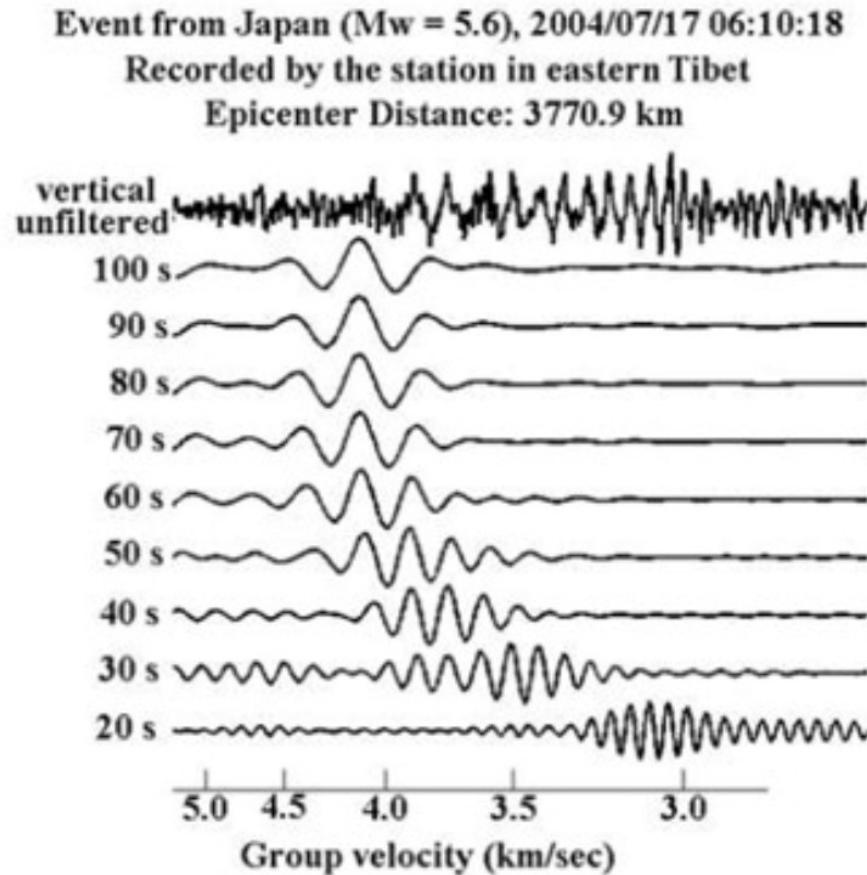
EMPIRICAL GREEN FUNCTIONS (EGF)

Phase 1:

```
┌──────────┐      ┌──────────────────────────────────────────────────┐
│          │      │ Remove instrument response, remove mean, remove  │
│ Raw data │ ───► │ trend, band-pass filter, and cut to length of 1-day│
│          │      │                                                  │
└──────────┘      └──────────────────────────────────────────────────┘
```
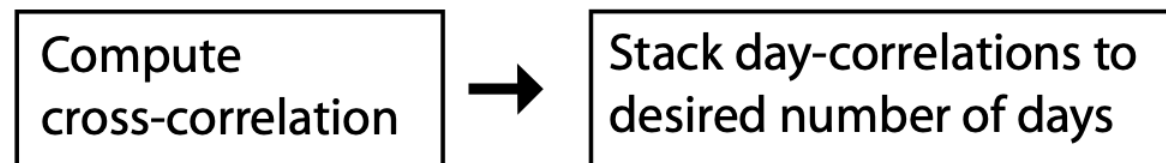
```
┌──────────────────┐      ┌──────────────────────────┐
│ Apply time domain│ ───► │ Apply spectral whitening │
│ normalization    │      │                          │
└──────────────────┘      └──────────────────────────┘
```

Phase 2:

```
┌──────────────┐      ┌──────────────────────────┐
│ Compute      │ ───► │ Stack day-correlations to│
│ cross-correlation│  │ desired number of days   │
└──────────────┘      └──────────────────────────┘
```

METHODOLOGY, EGF

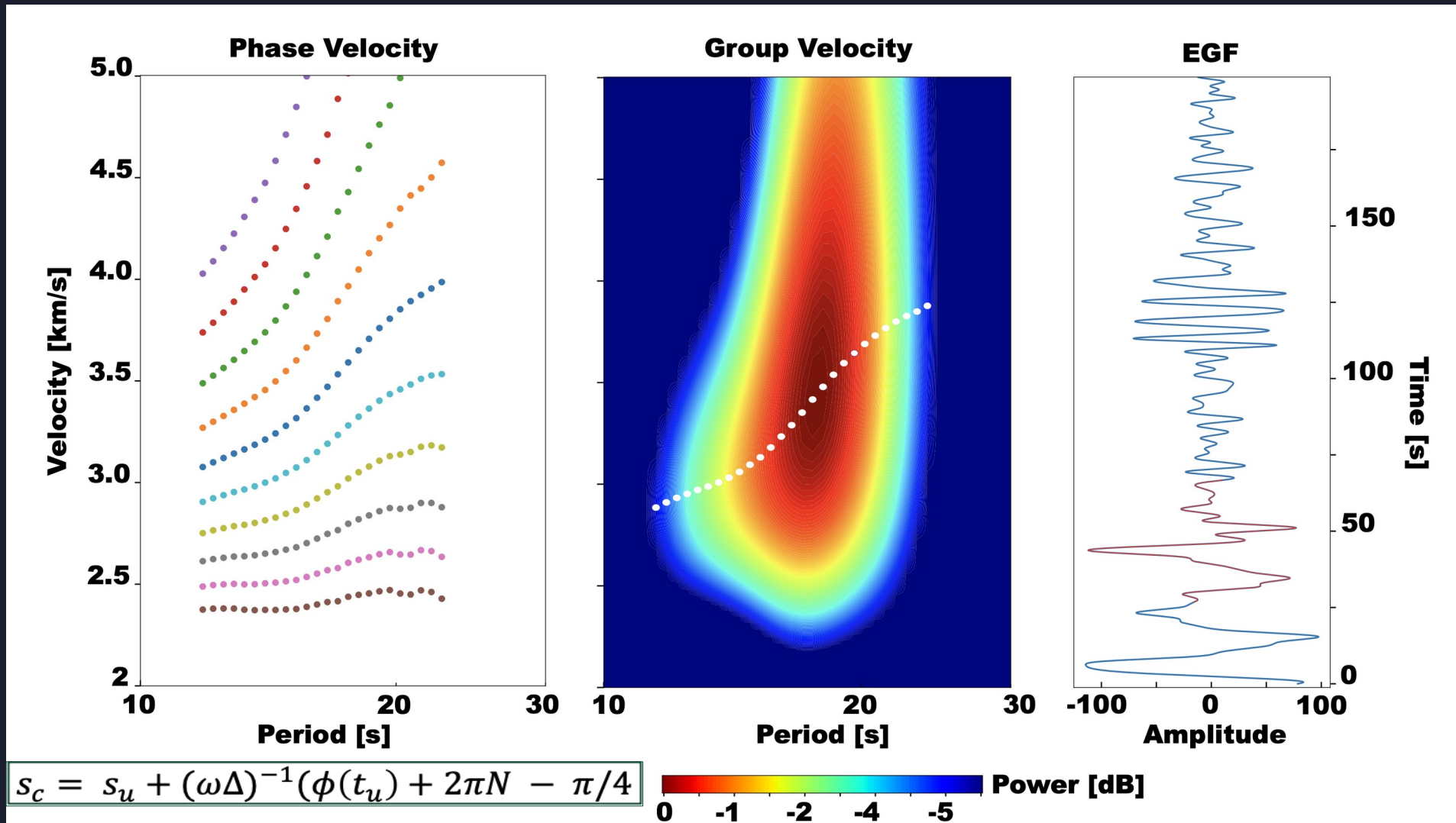a) Land-Land   (ARPC - MAPC)

b) OBS-OBS   (CUBA - MHTO)

c) Land-OBS   (LAPC - PINA)
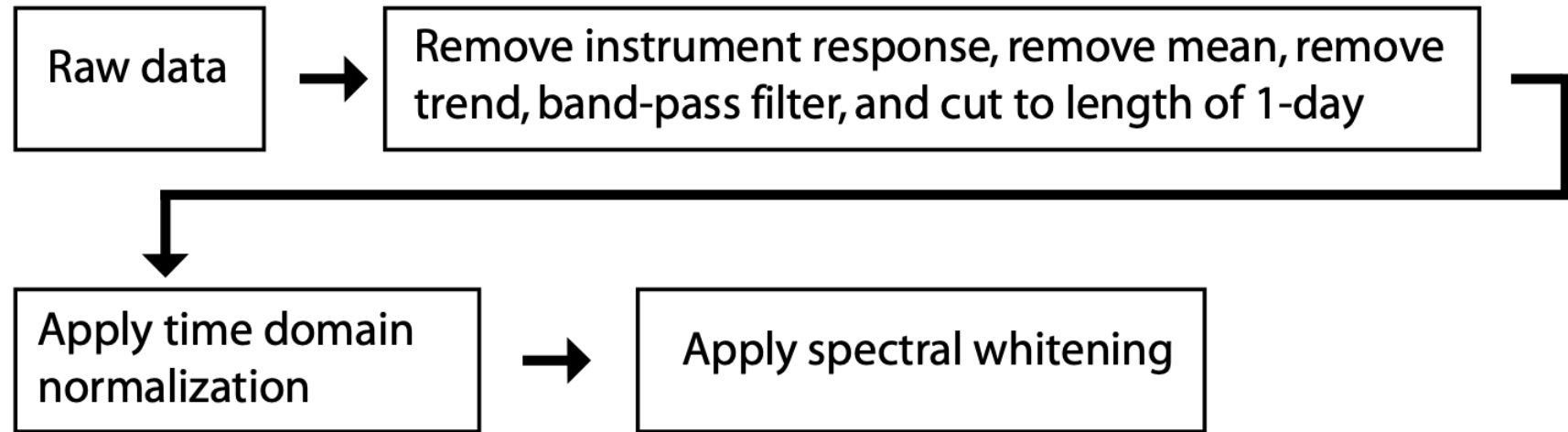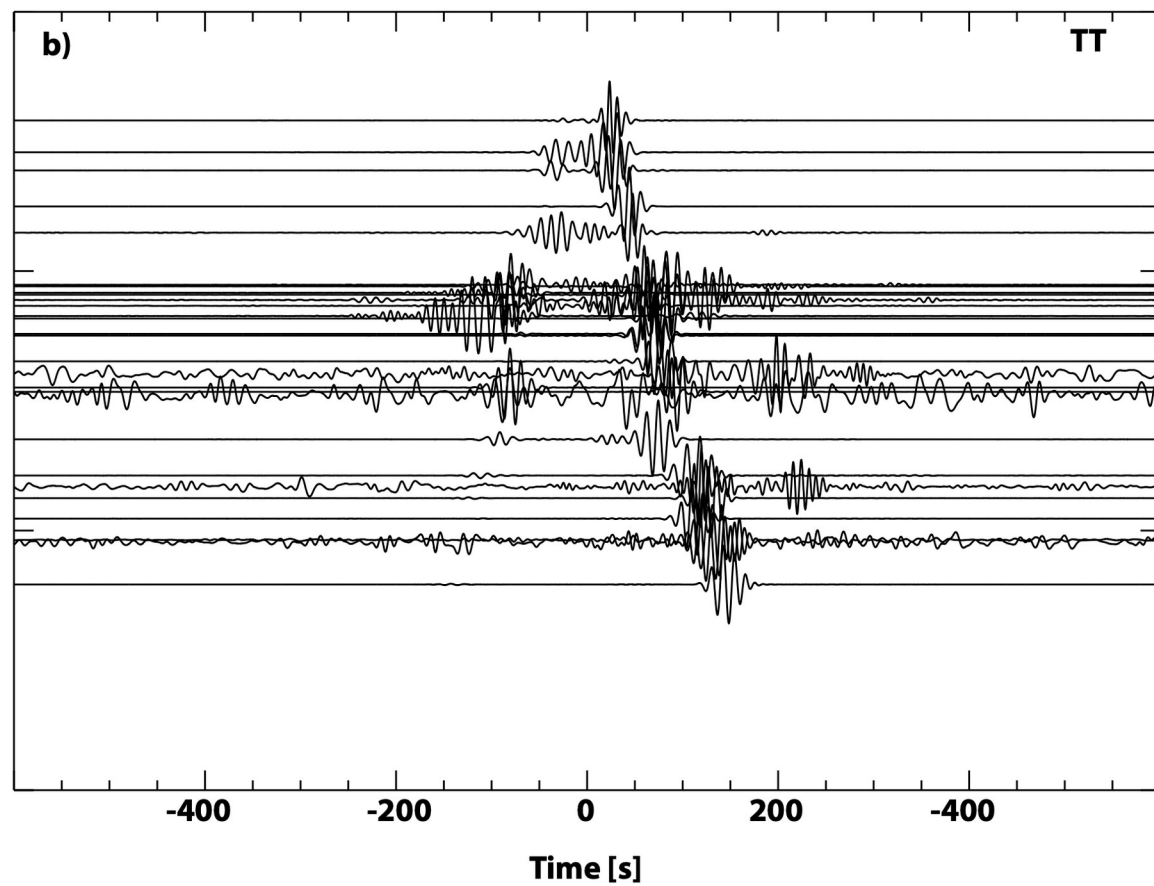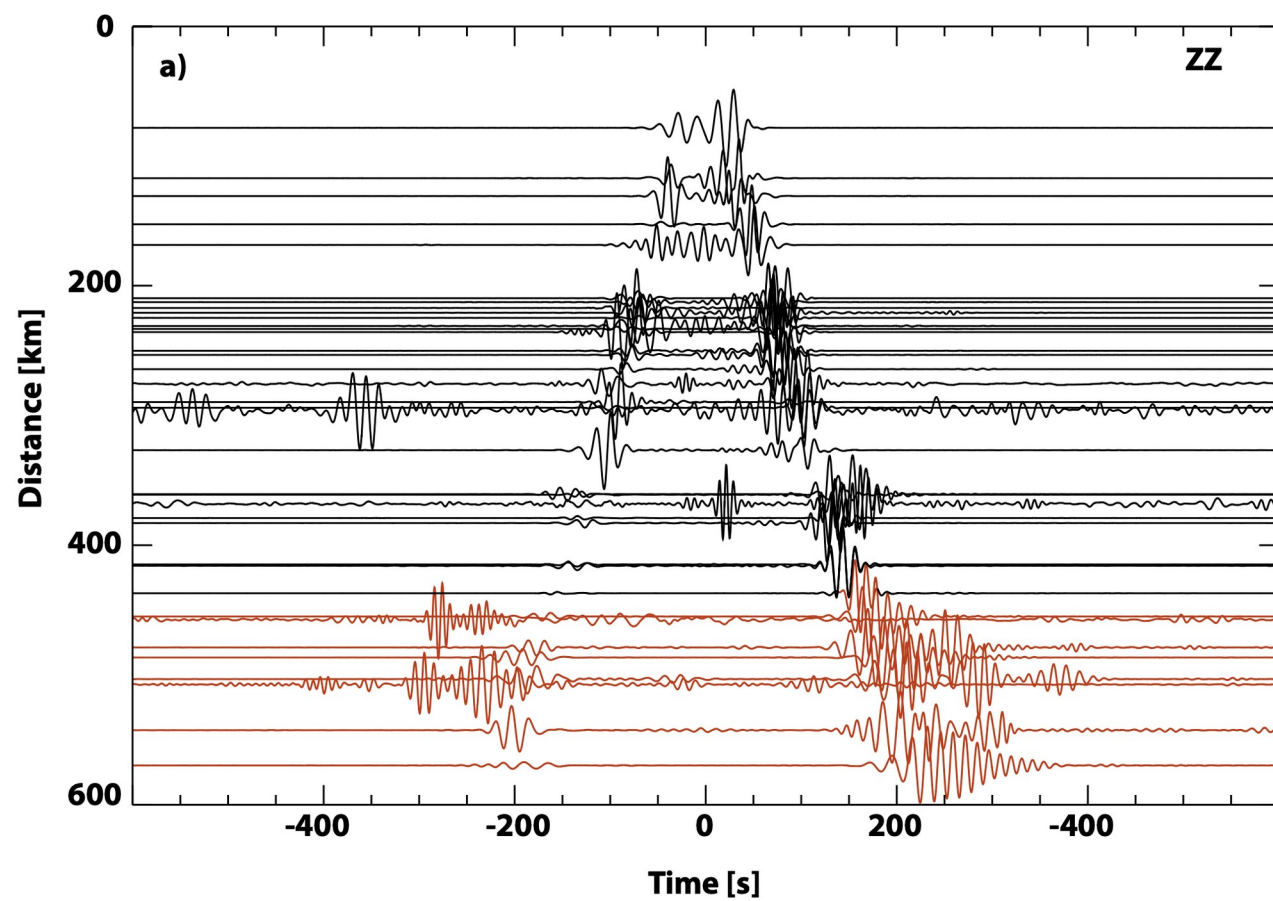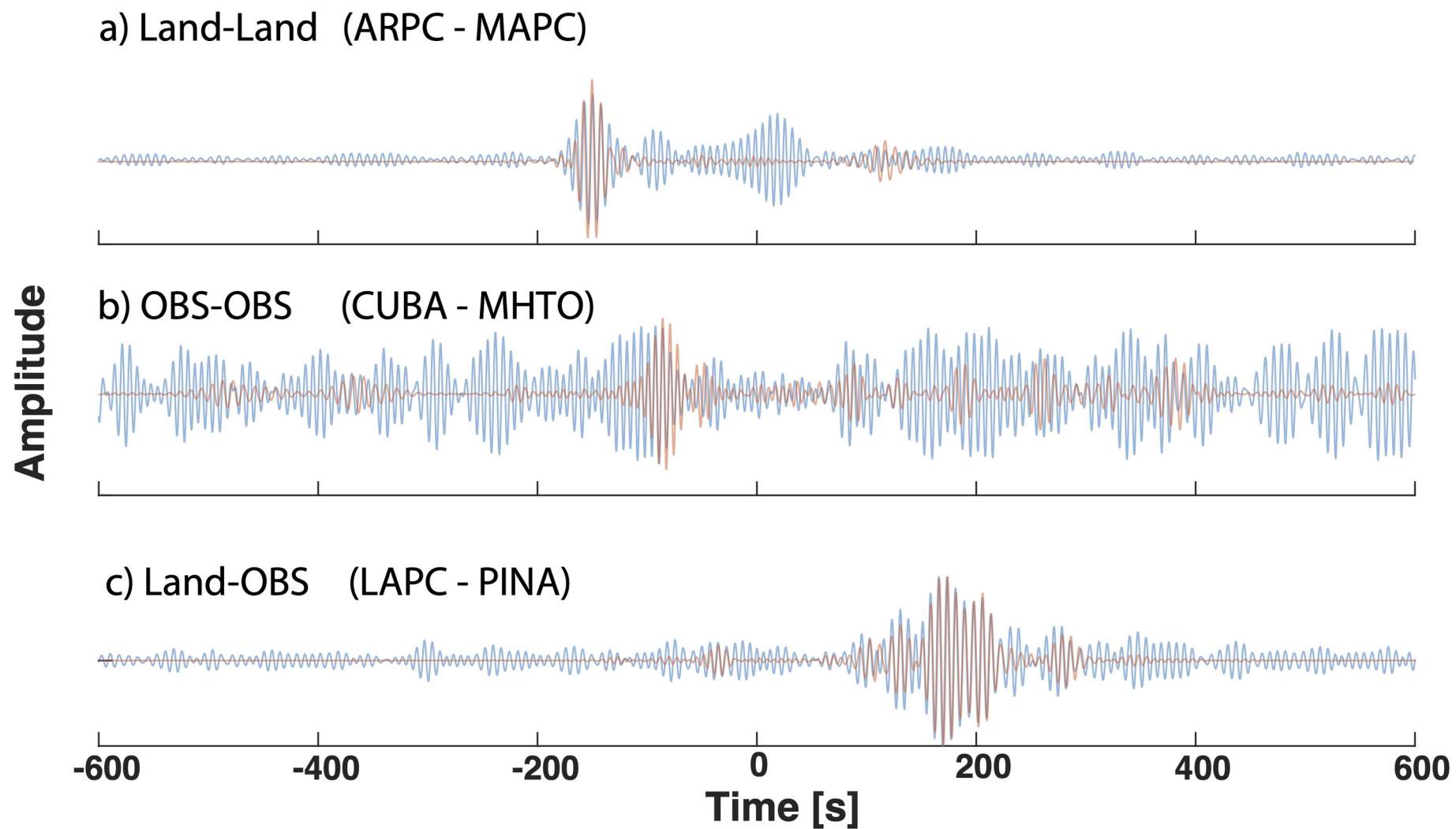
DISPERSION CURVE MEASUREMENT

DISPERSION CURVE MESUREMENT

$$s_c = s_u + (\omega\Delta)^{-1}(\phi(t_u) + 2\pi N - \pi/4)$$
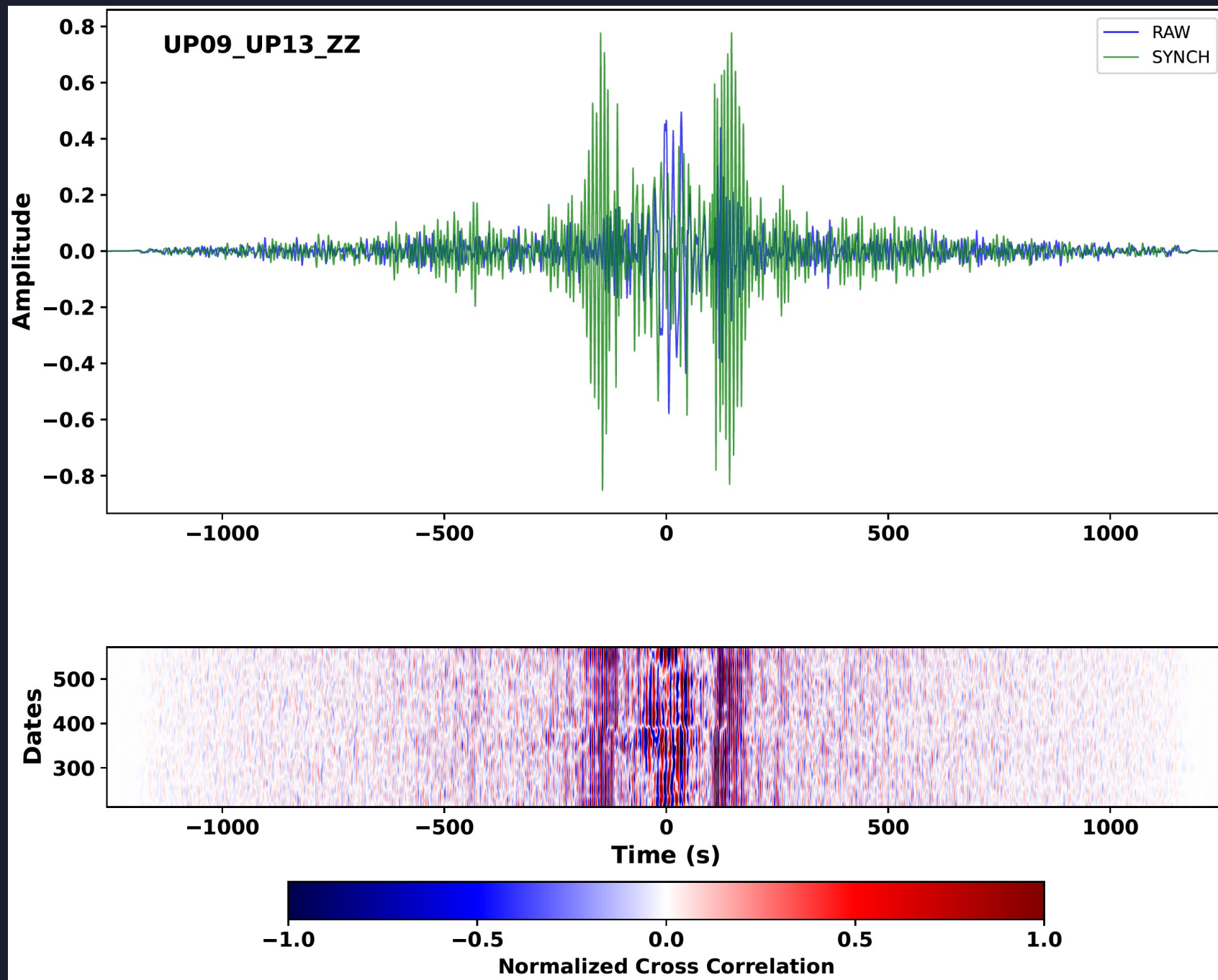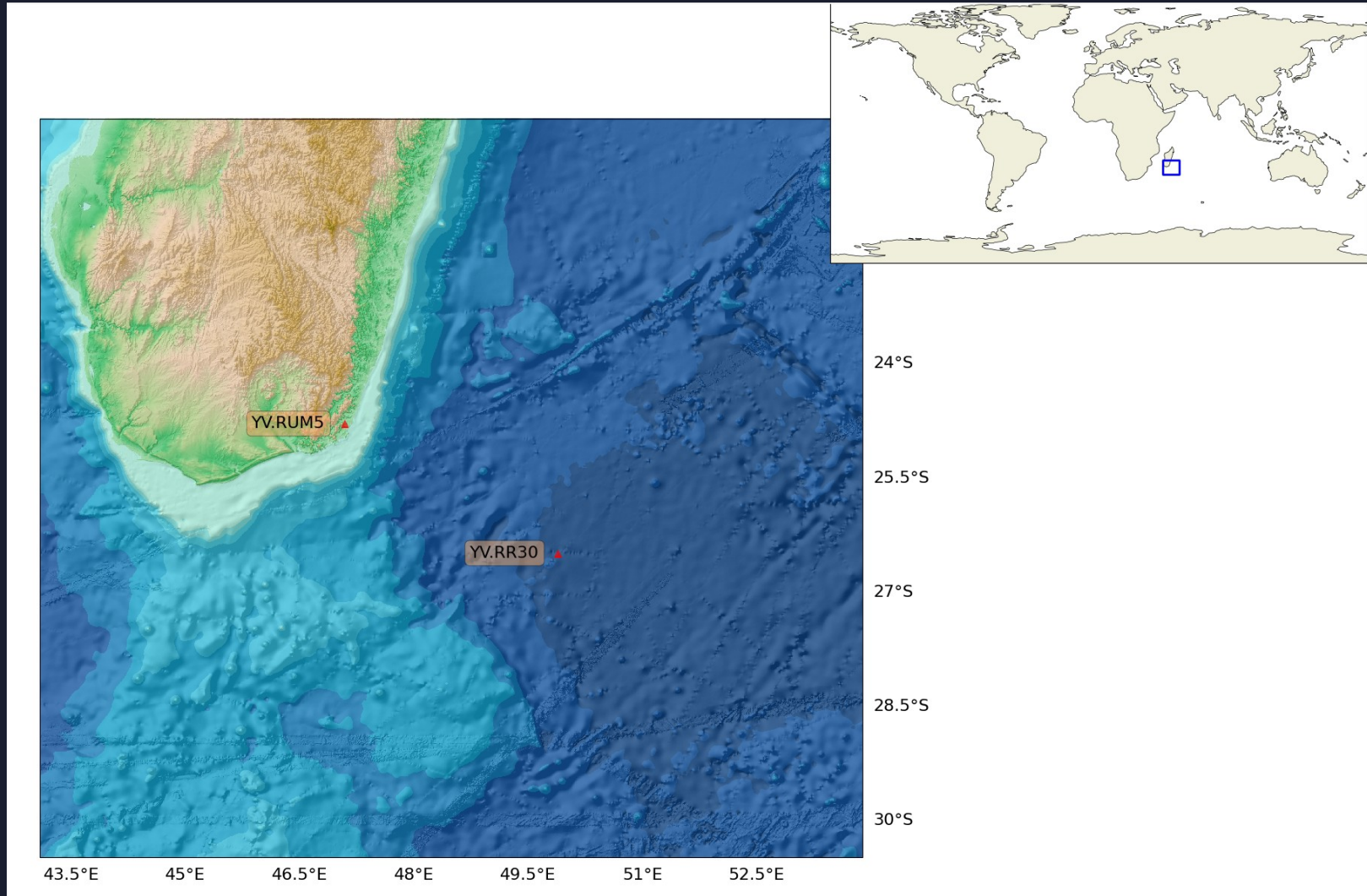
EGF'S SUNCHRONIZATION
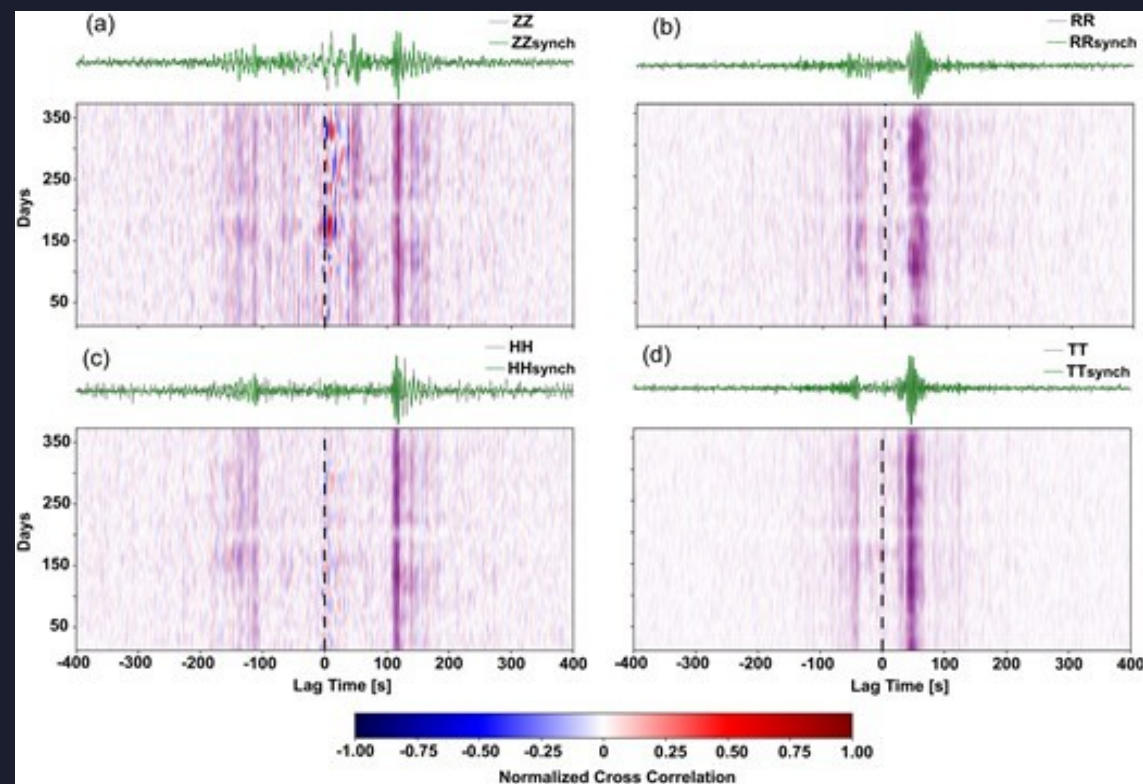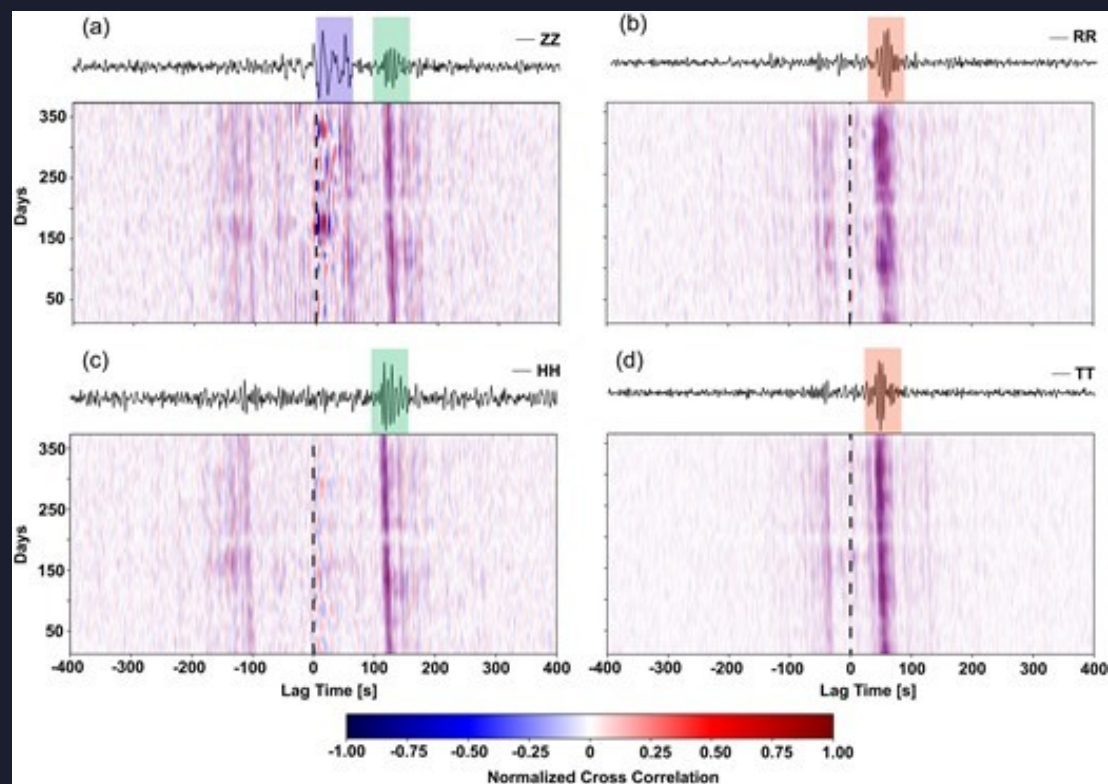
IN DETAIL,

DO IT YOURSELF USING: ISP

Configuration

Seismic Ambient Noise

Preprocessing Box

Processing Time Window `900`

	Nets	Stations	Channels
Filter Files			`HHZ,BHZ`

☐ Remove Instrument

f1 `0.0025`   f2 `0.0050`   f3 `2.0000`   f4 `5.0000`

water level `40`   Units `VEL`

☑ Decimation

New Sampling Rate `10`

☑ Pre-Filter   f1 `0.020`   f2 `0.200`   corners `4`

☑ Time Normalization

method `running avarage`   time window `25.0`

☑ Spectral Whithening

Freq.bandwidth `0.02`

Stack Box

Stations `_____`   Components `BHZ,HHZ`

Method `Linear`   `2`

Maximum Interdistance `1000 km`

Daily Overlap `50 %`

☑ Compute daily Stacks   ☐ Autocorr and Horizontals

OK