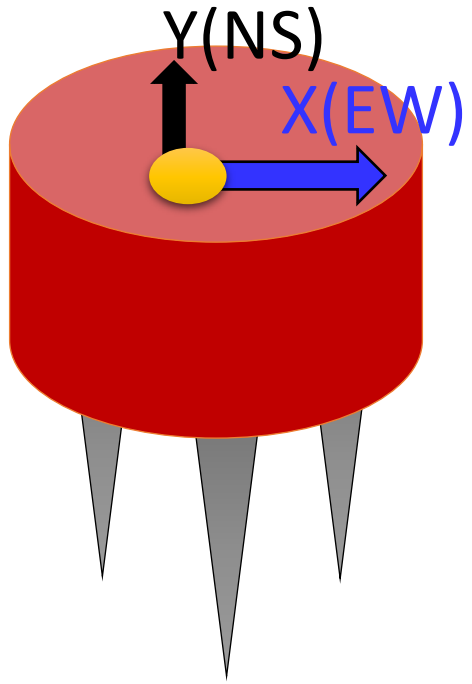
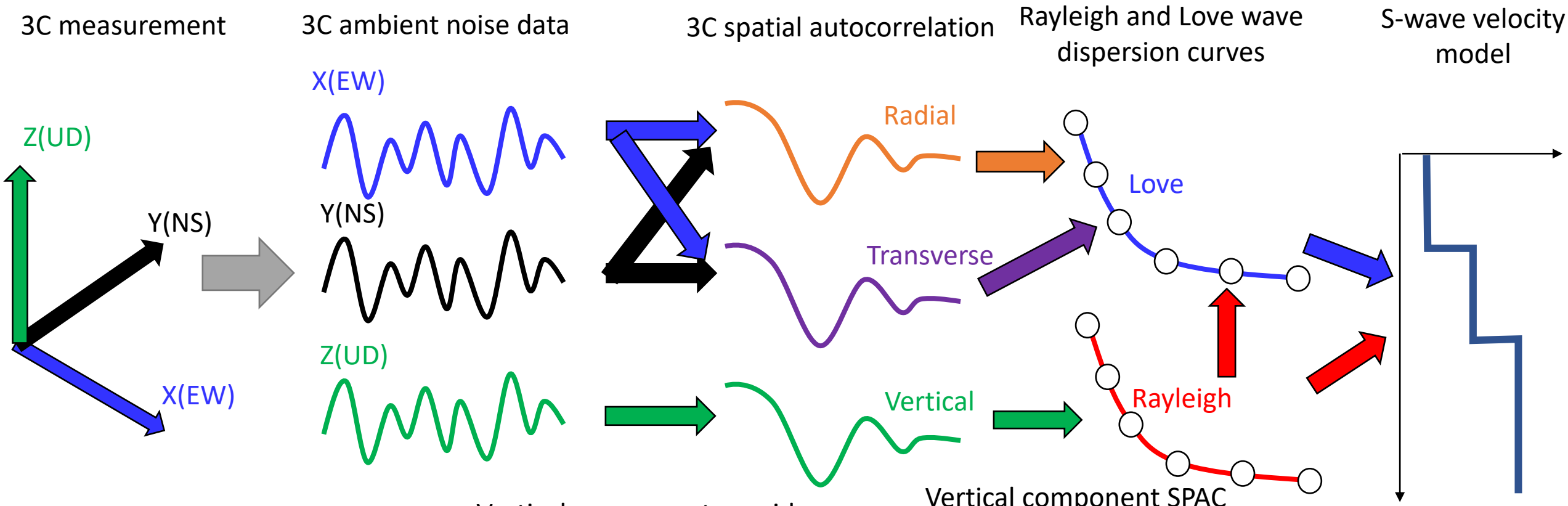
SeisImager/SW-3C

# Three-component spatial autocorrelation processing using SeisImager modules

- Processing ambient noise data obtained by Atom 3C and/or MT-Neo.
- SeisImager/SW3C license is required.
- Download the latest installer from :
  *http://seisimager.com/download/SeisImager.zip*

# Outline of three-component (3C) measurement and processing




3C measurement provides 3C ambient noise data.

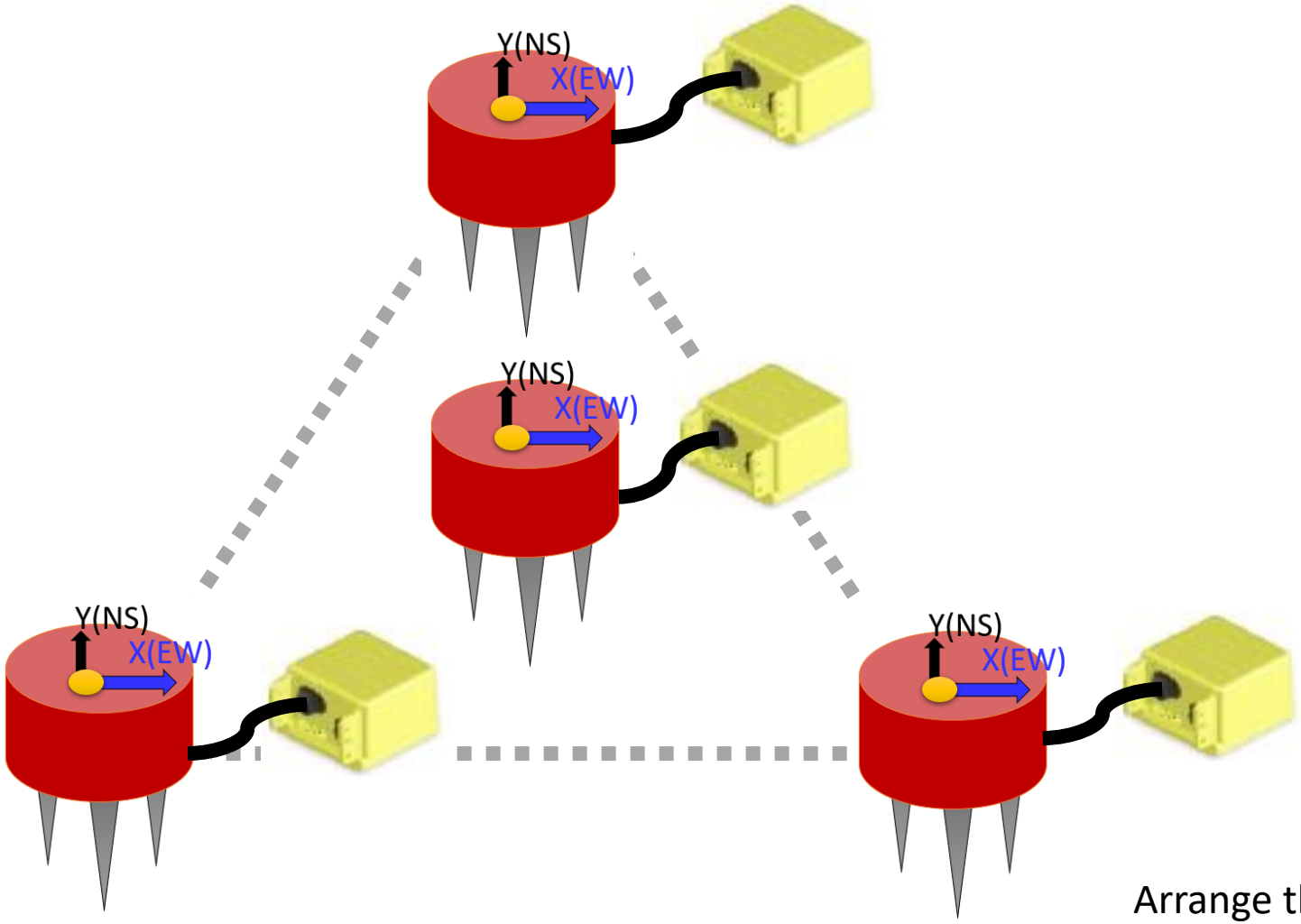
Vertical component provides vertical component SPAC. Horizontal components (X and Y) provide radial and transverse component SPACs.

Vertical component SPAC provides a Rayleigh dispersion curve. Horizontal components (radial and transverse) provide a Love dispersion curve using Rayleigh dispersion curve.

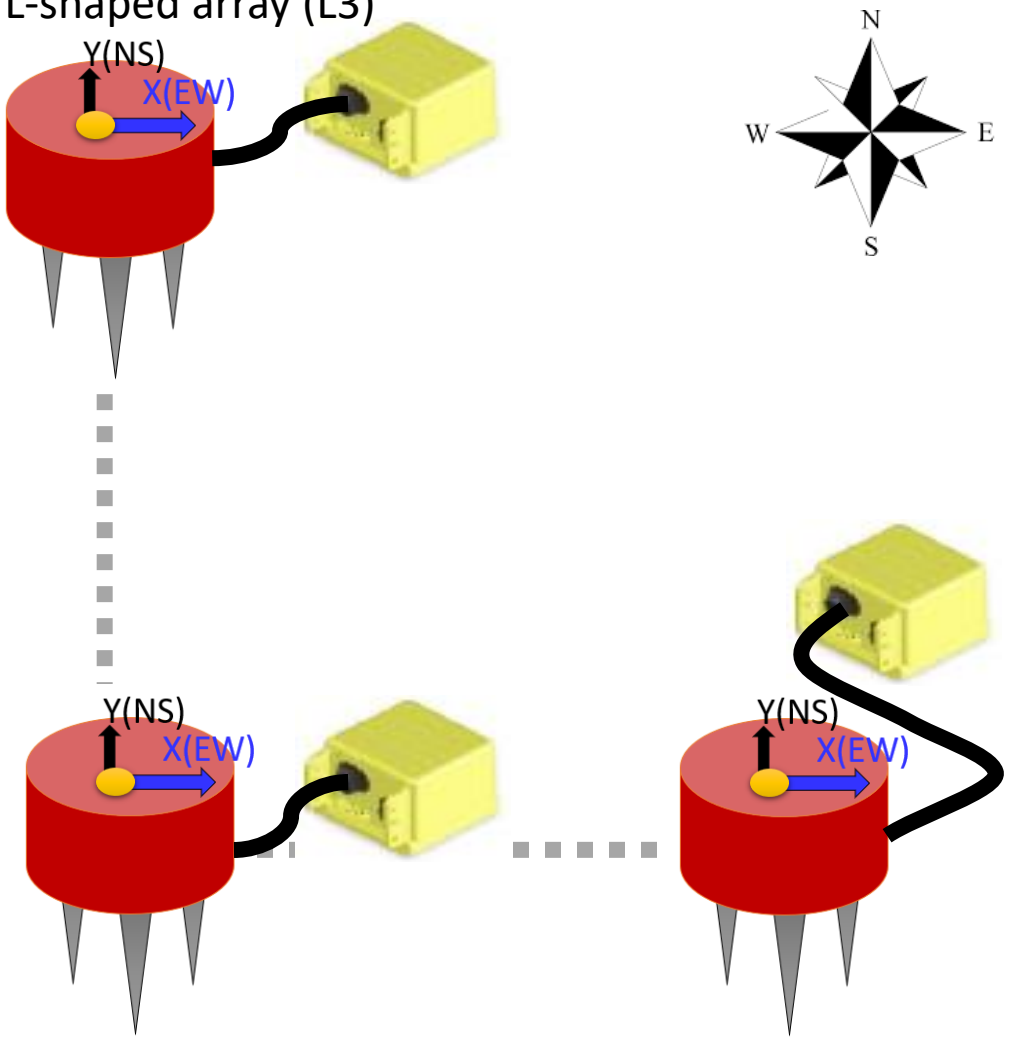
Joint inversion of Rayleigh and Love dispersion curves provide an S-wave velocity model.

# 3C ambient noise measurements for SPAC

Triangular array (T4)




L-shaped array (L3)

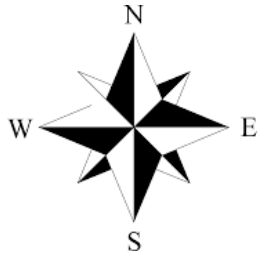


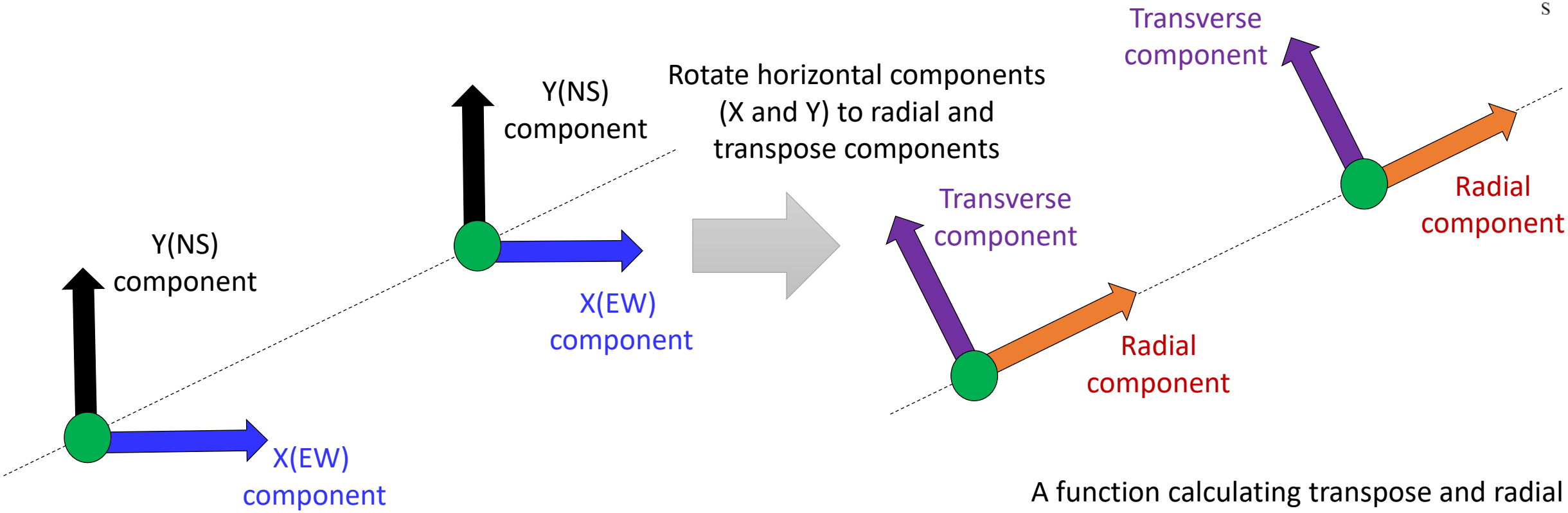

Arrange the orientation of all sensors to be the same direction

# Spatial autocorrelation for 3C ambient noise

Direction of horizontal components must be consistent throughout all sensors and kept track.

Radial and transverse components are defined for each receiver pair.

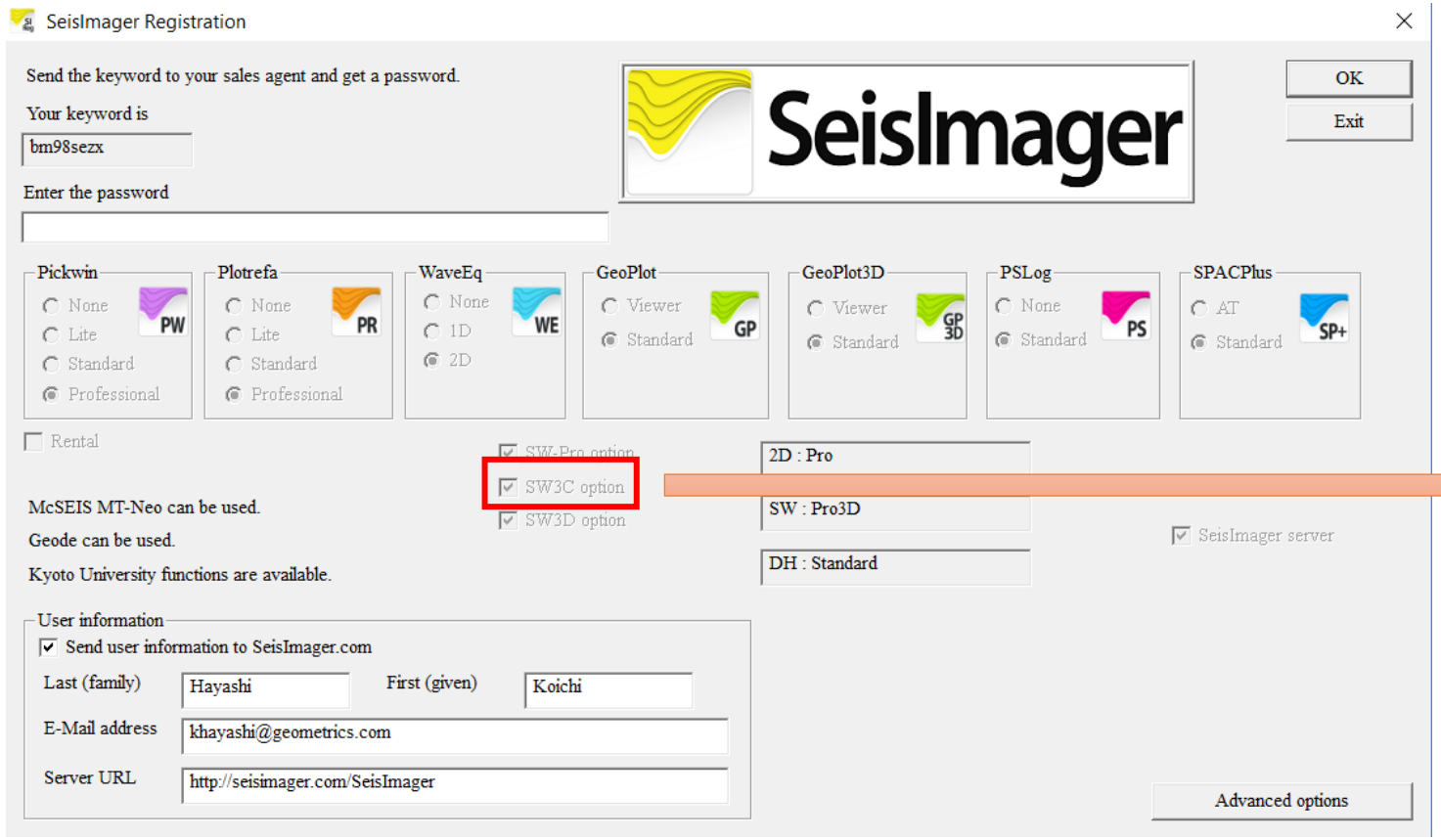



A function calculating transpose and radial components of SPAC from 3C ambient noise data was implemented in SPACPlus and dPickwin.

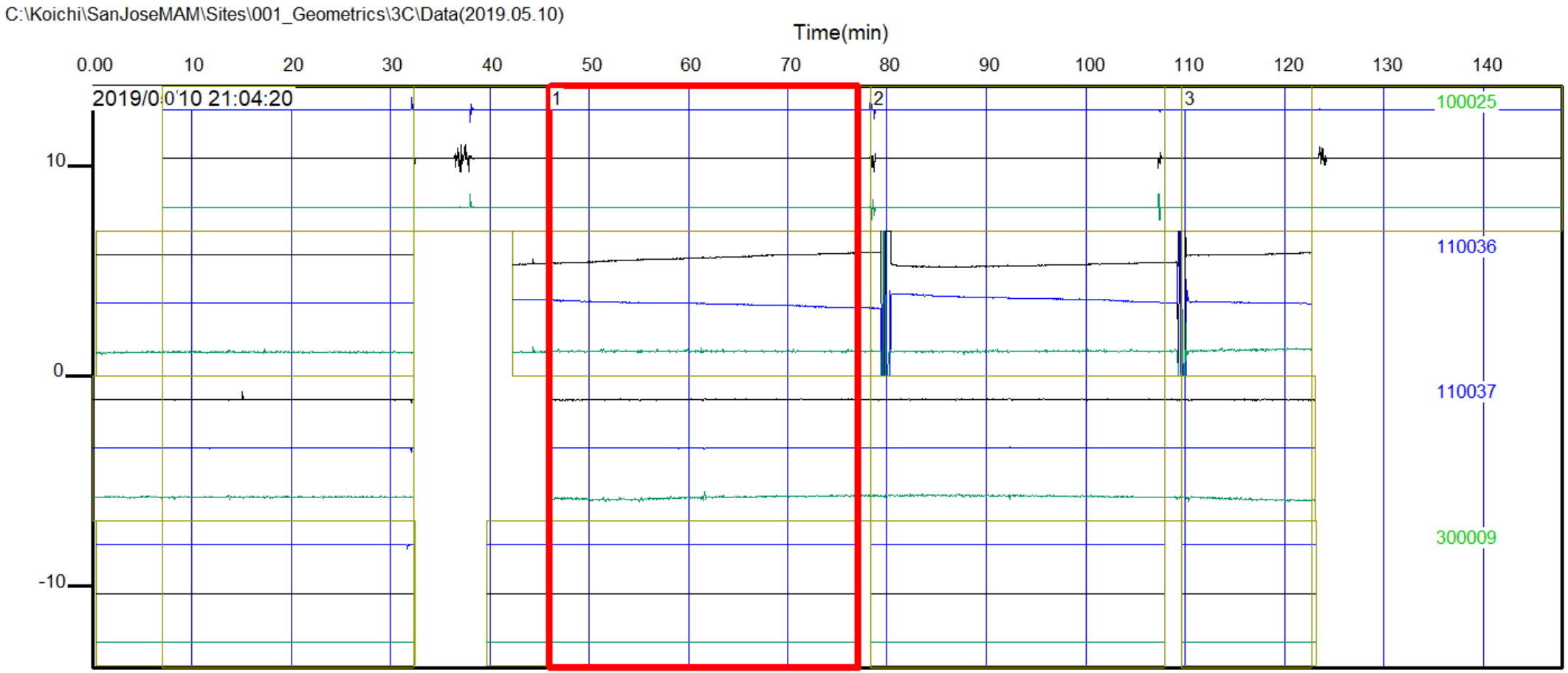
# SW3C option in SeisImager

"SW3C option" should be checked in SeisImagerRegistarioan to use 3C processing functions or joint inversion of Rayleigh and Love waves.

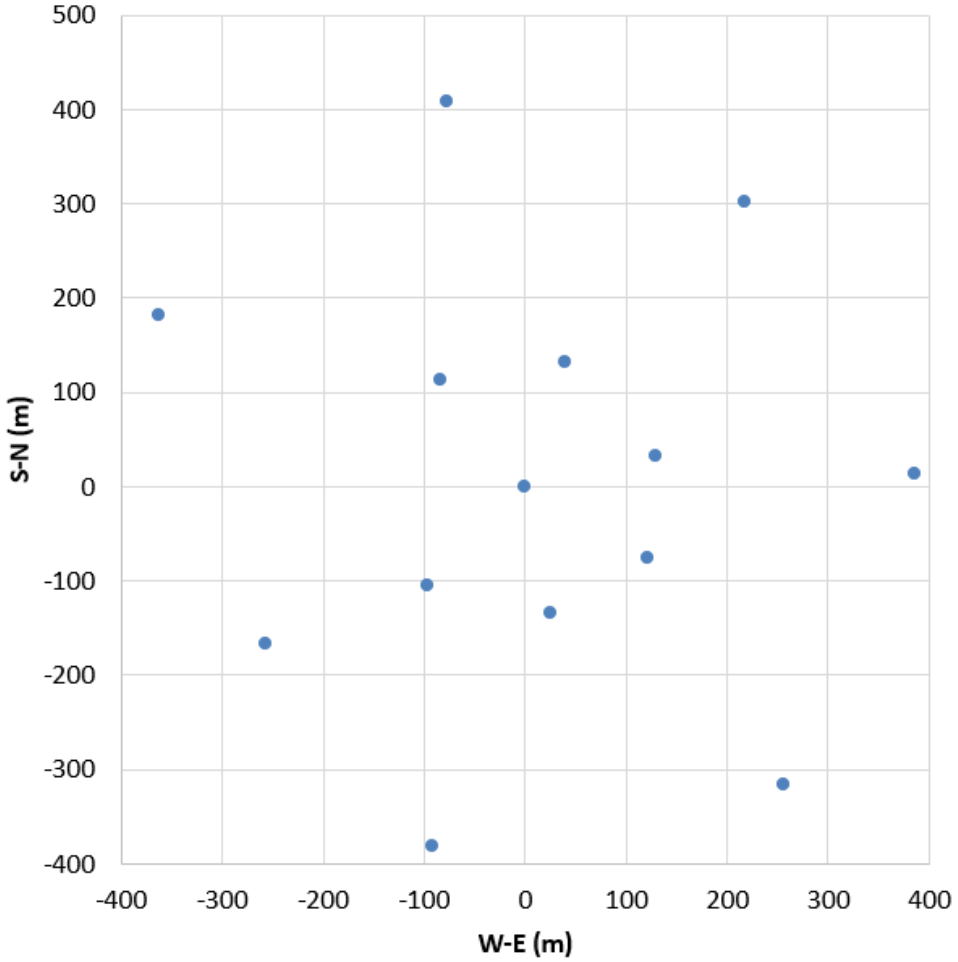



# Select a CTB including 3C ambient noise data

Example of three component data

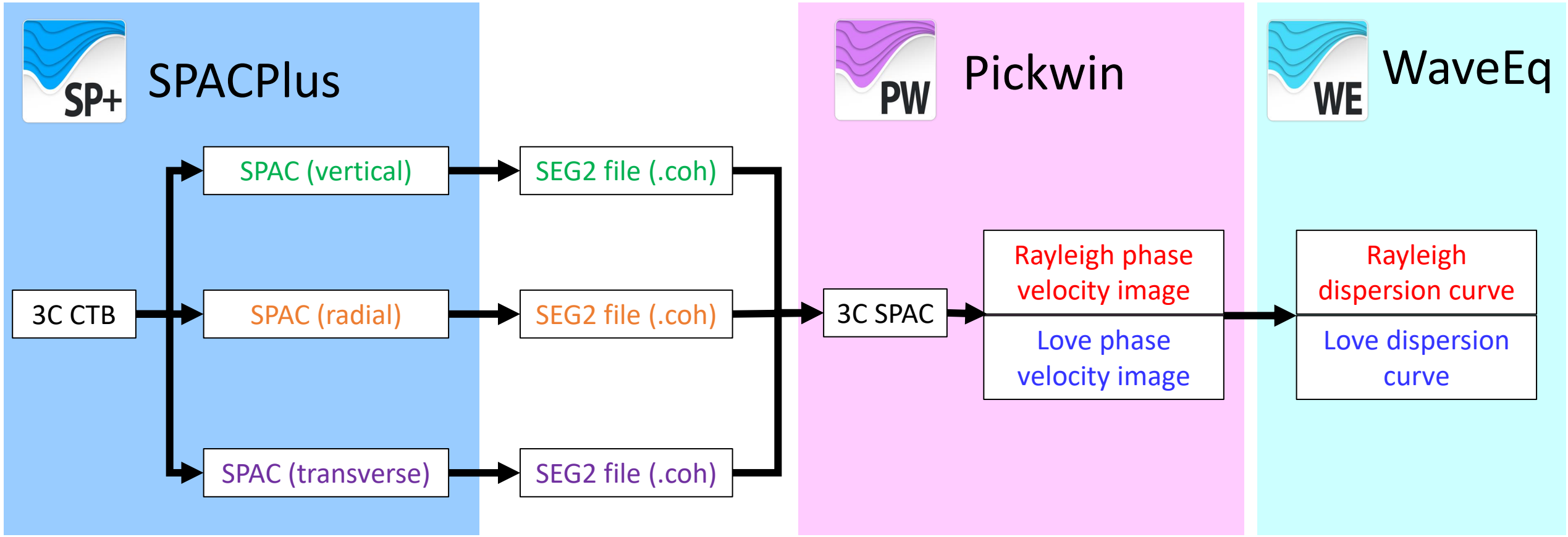


# Data example (3C measurements using 14 sensors)

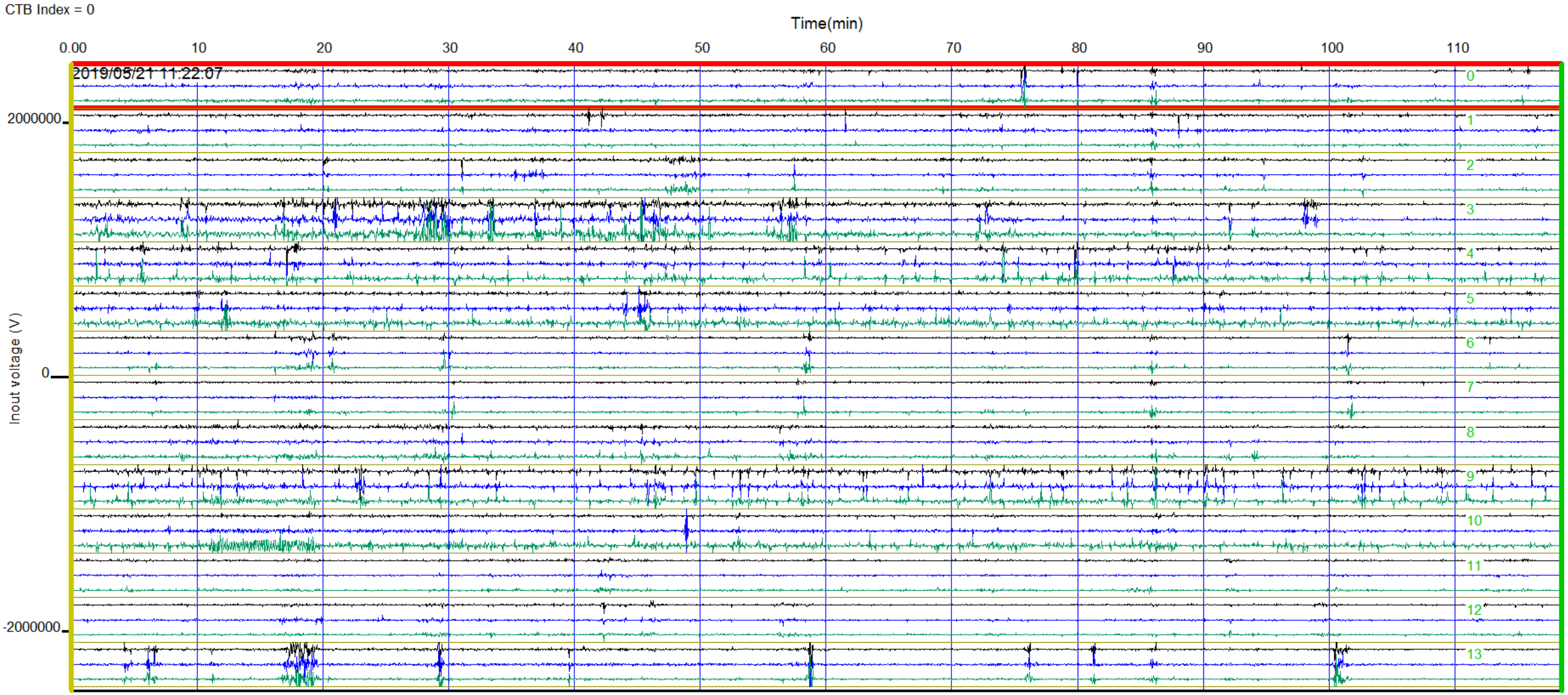



| Easting [m] | Northing [m] |
|---|---|
| 0 | 0 |
| 217.34 | 302.07 |
| 386.02 | 14.16 |
| -257.41 | -166.41 |
| -362.36 | 182.01 |
| -77.33 | 408.01 |
| 120.86 | -76.71 |
| 129.83 | 31.65 |
| -96.66 | -105.19 |
| 38.67 | 132.35 |
| -83.89 | 112.35 |
| 256.12 | -315.96 |
| -91.77 | -381.87 |
| 25.57 | -134.09 |

# 3C SPAC processing flow using SPACPlus, Pickwin and WaveEq



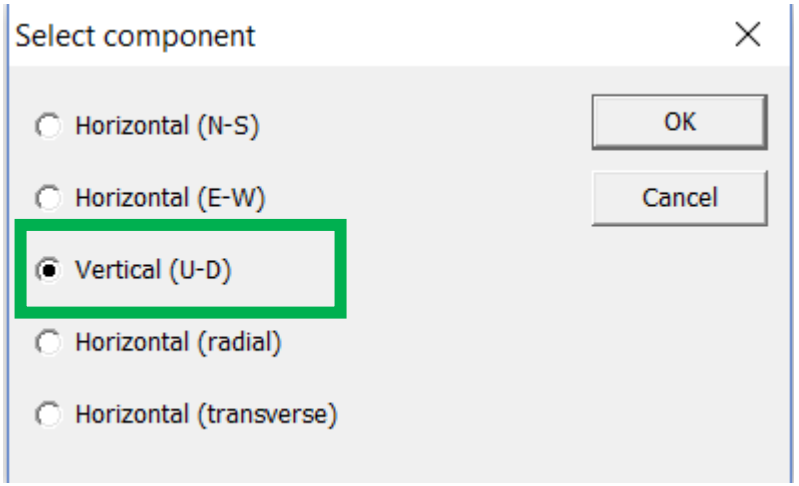
# CTB including 3C ambient noise data by 14 sensors



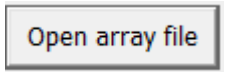
# Calculate SPAC for each component

Click  to calculate SPAC

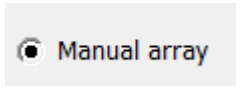
Select a component to be calculated (selecting vertical component)




Select array geometry. Click “Open array file” if manual array file will be used.

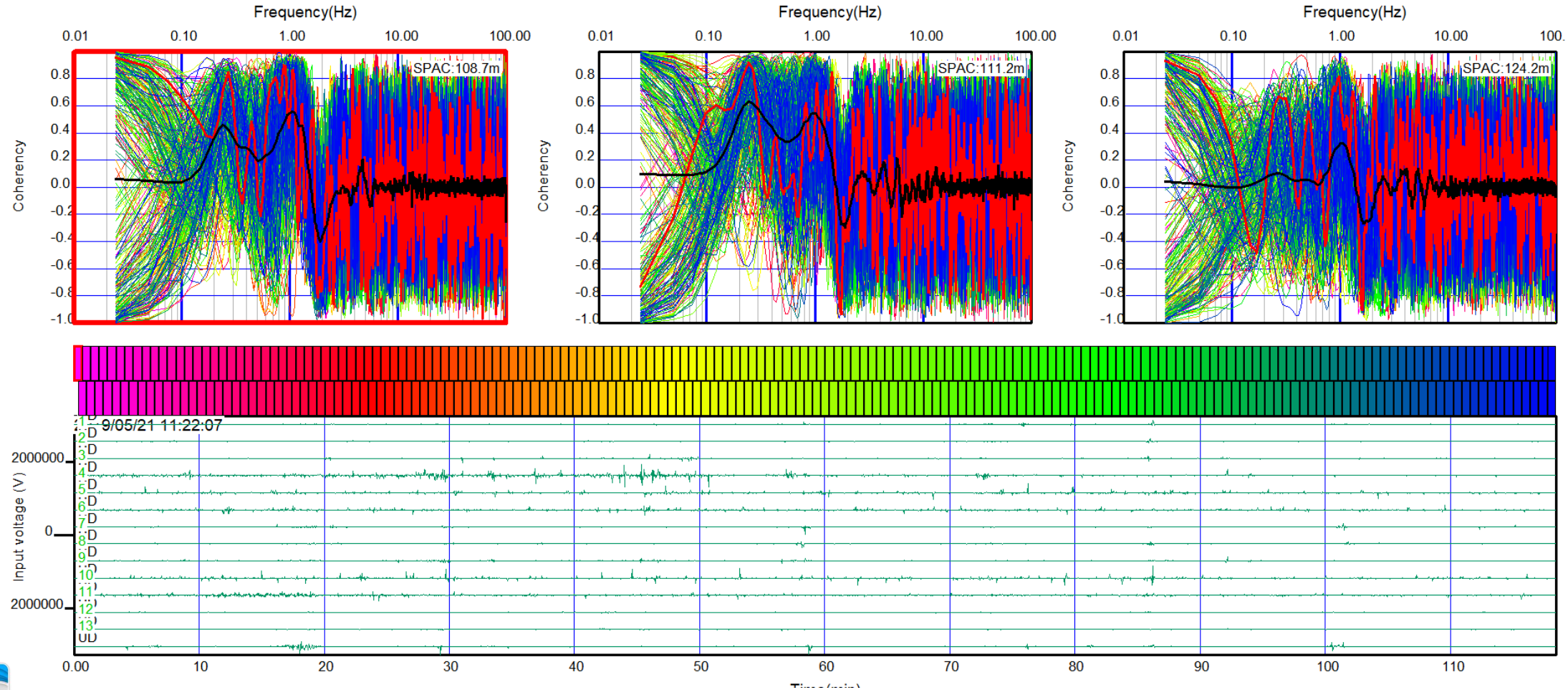



Select “Manual array” if manual array will be used.

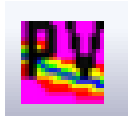



Click “OK” to calculate SPAC.

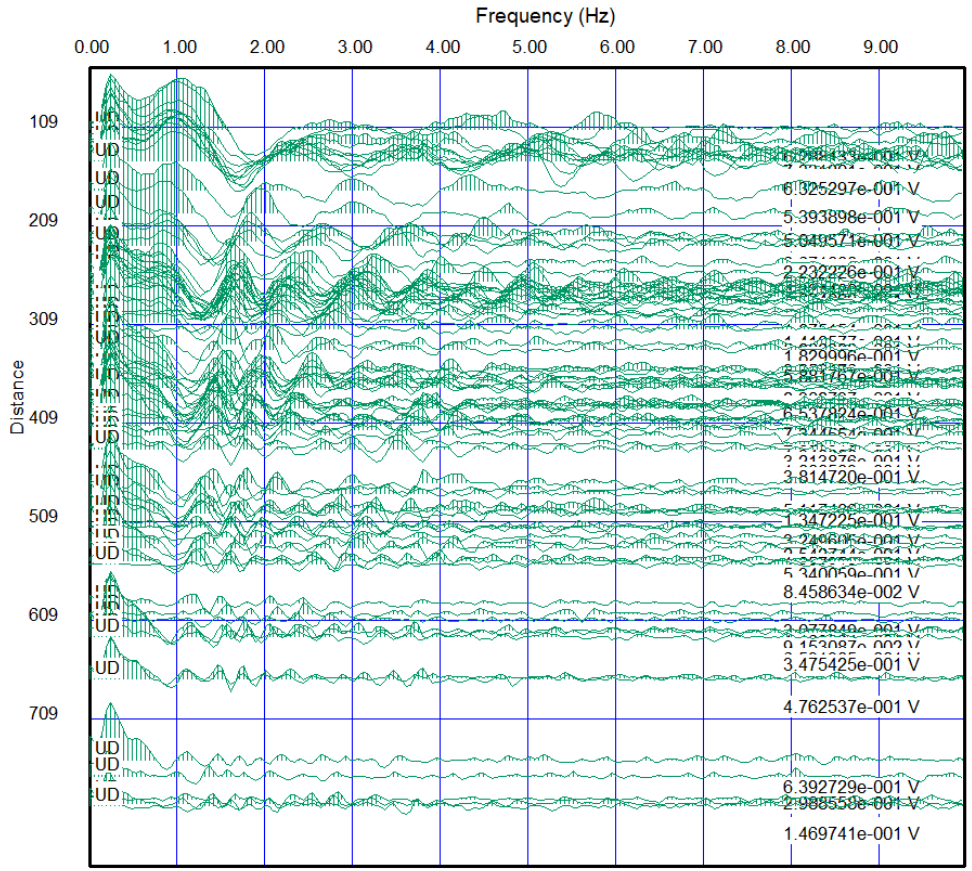
# Individual SPAC for each receiver spacing

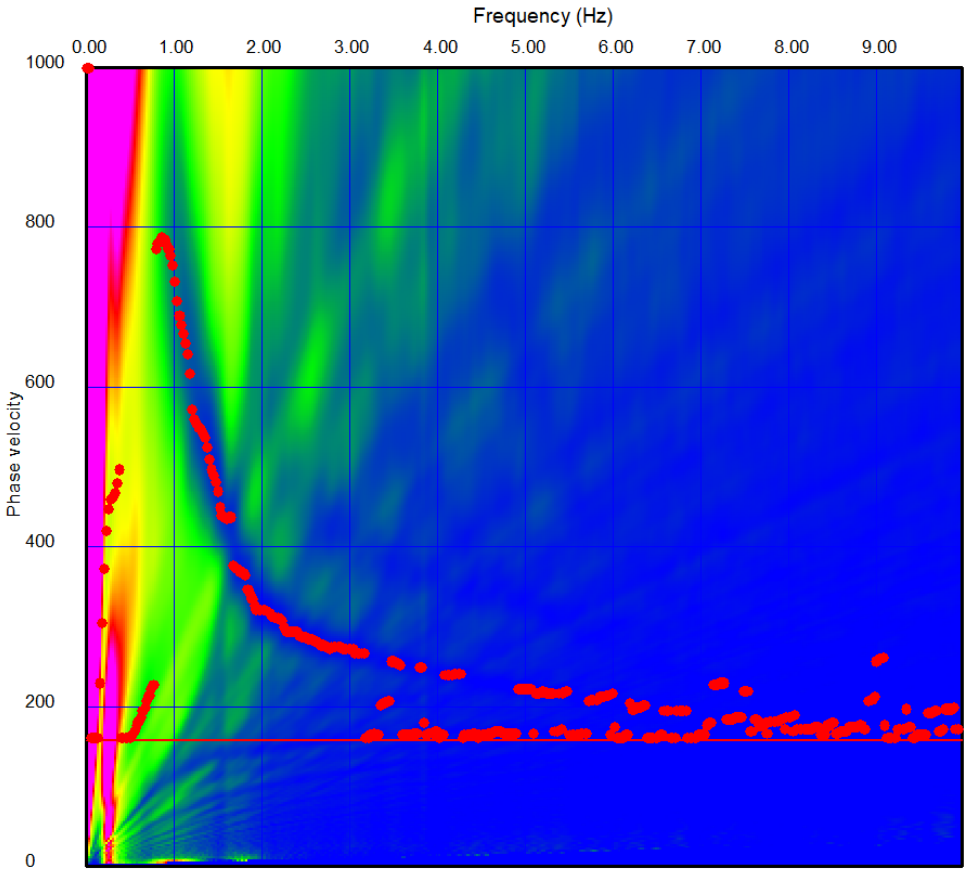


# Calculate dispersion curve for each component

Click  to calculate dispersion curve

*Vertical component*

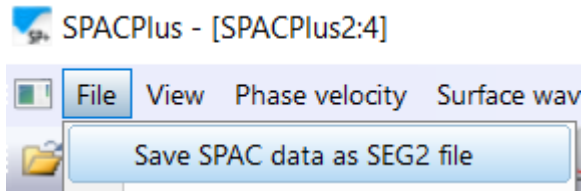


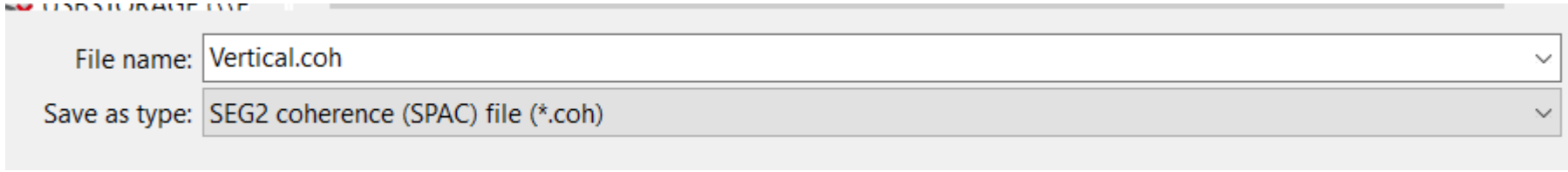

Dispersion curve from vertical component corresponds to Rayleigh wave dispersion curve.

# Save coherencies of each component to a SEG2 file

Select “File”, “Save SPAC data as SEG2 file” to coherencies to a SEG2 file.

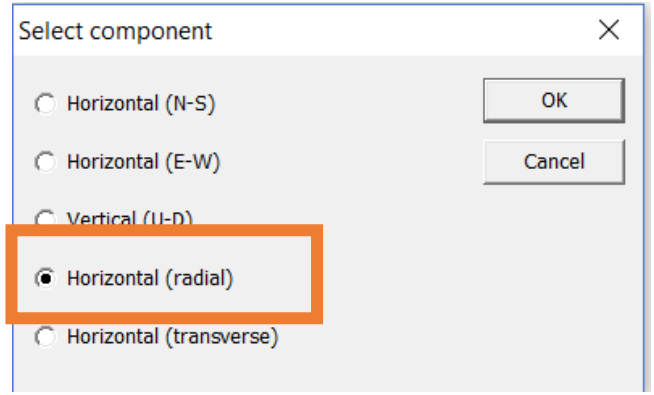


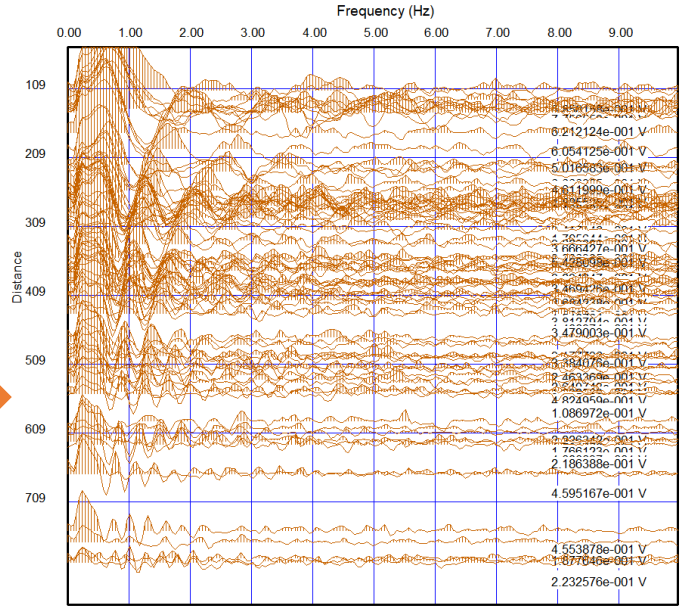

Use extension “.coh” to save coherencies.

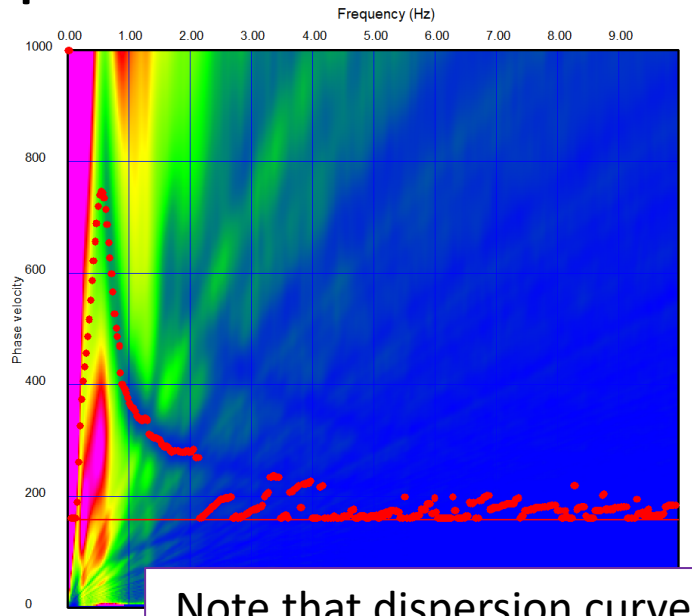


# Repeat SPAC calculation for all components

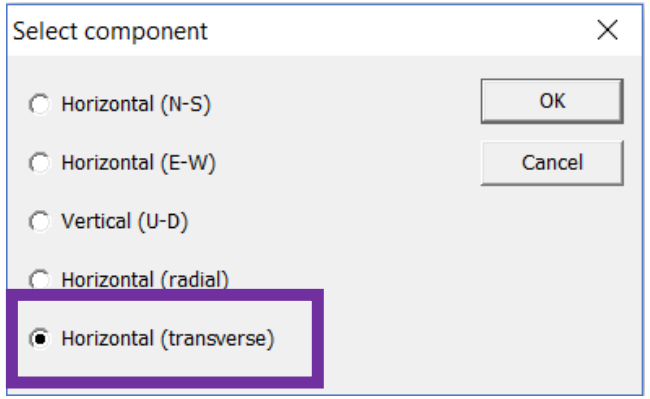
## *Radial component*

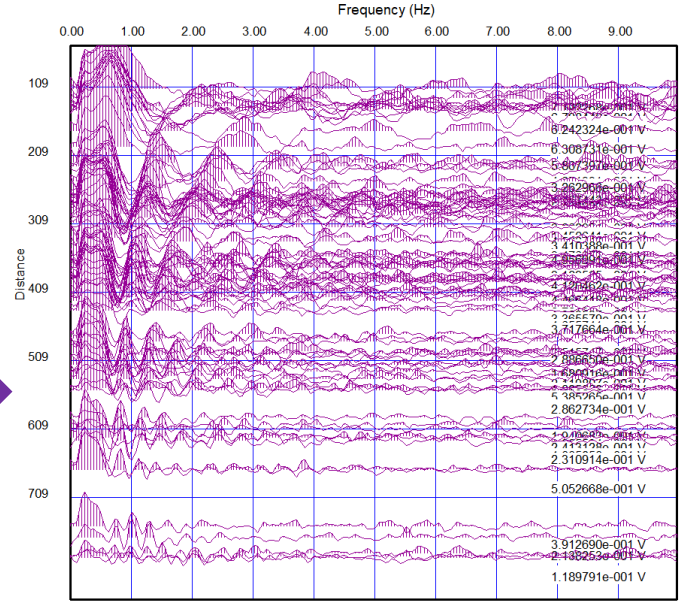


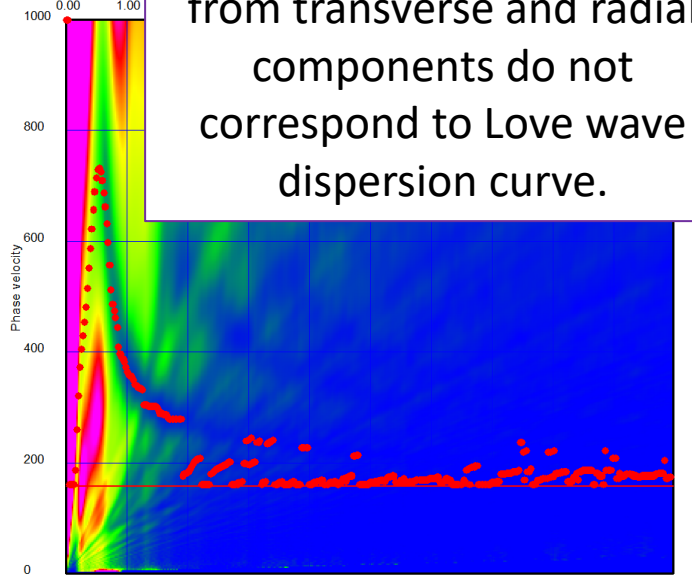




## *Transpose component*



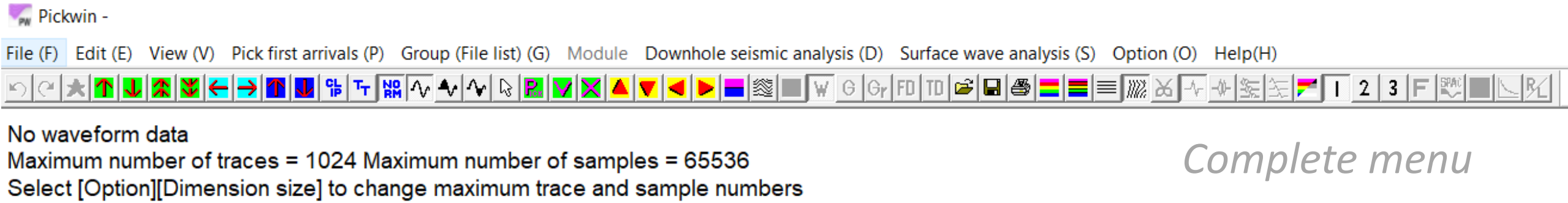




Note that dispersion curves from transverse and radial components do not correspond to Love wave dispersion curve.

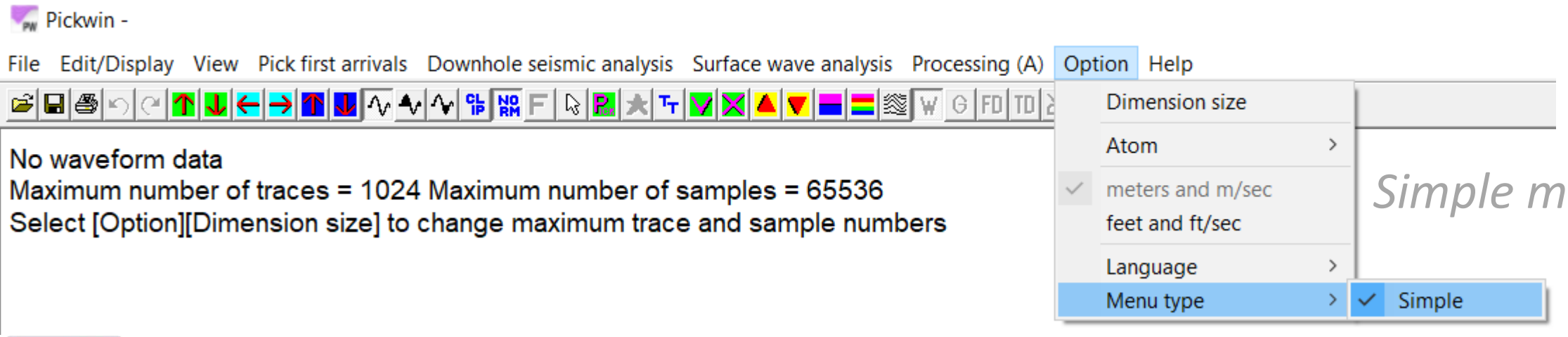
# Switch Pickwin to the complete menu

Use the “Complete menu” to process 3C SPAC data.




*Complete menu*

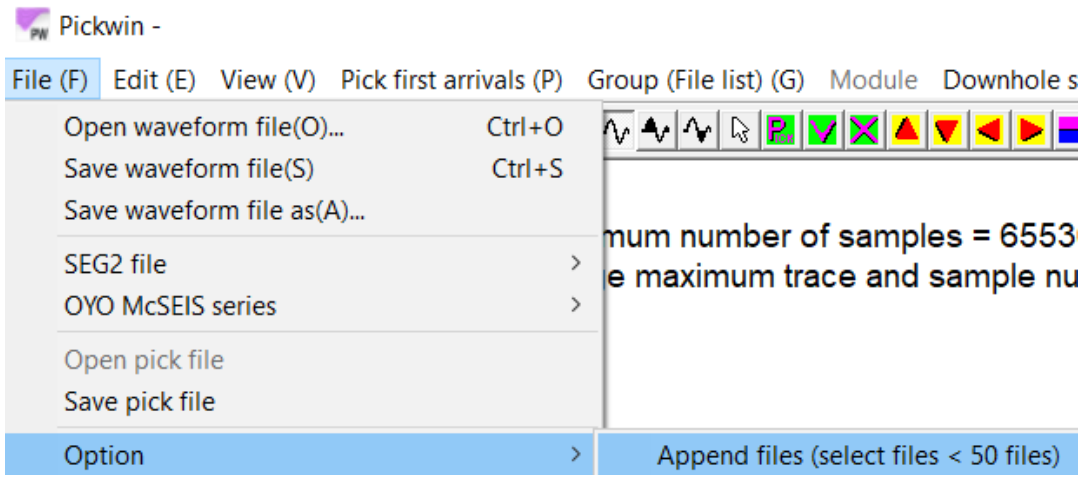
Select “Option”, “Menu type”, “Simple” to the menu type from “Simple” to “Complete”.



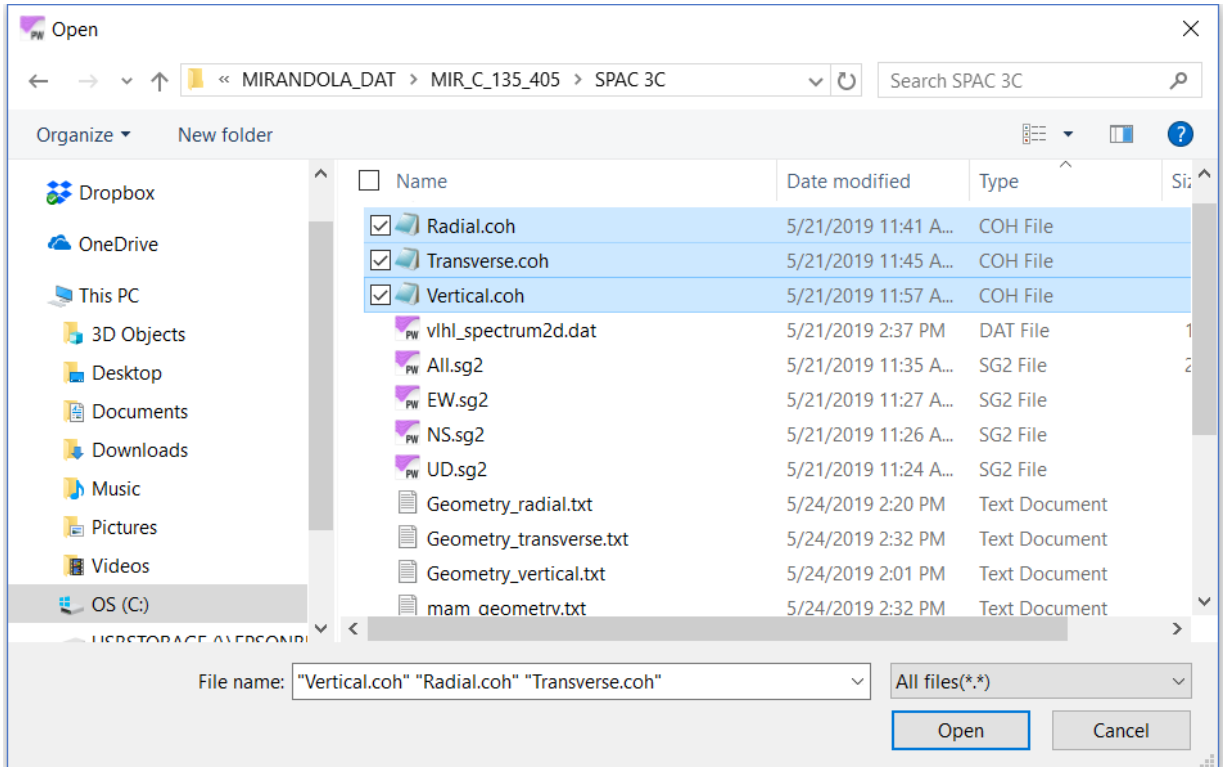

*Simple menu*

# Import three SPAC files to Pickwin

Select “File”, “Option”, “Append files” to import multi files at once.

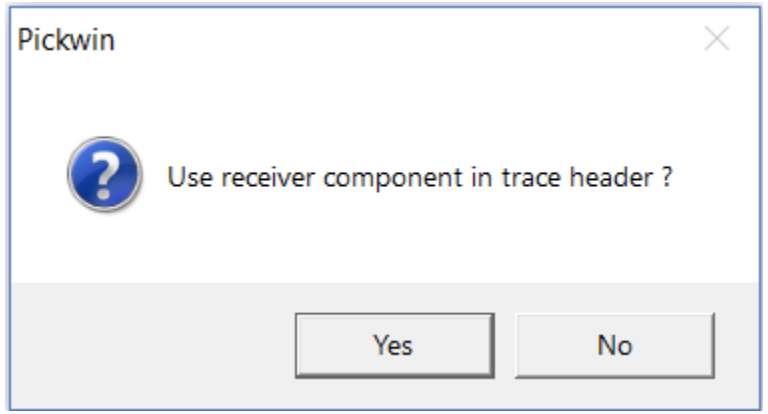



Select three coherency files (vertical, radial and transverse) and click “Open”.

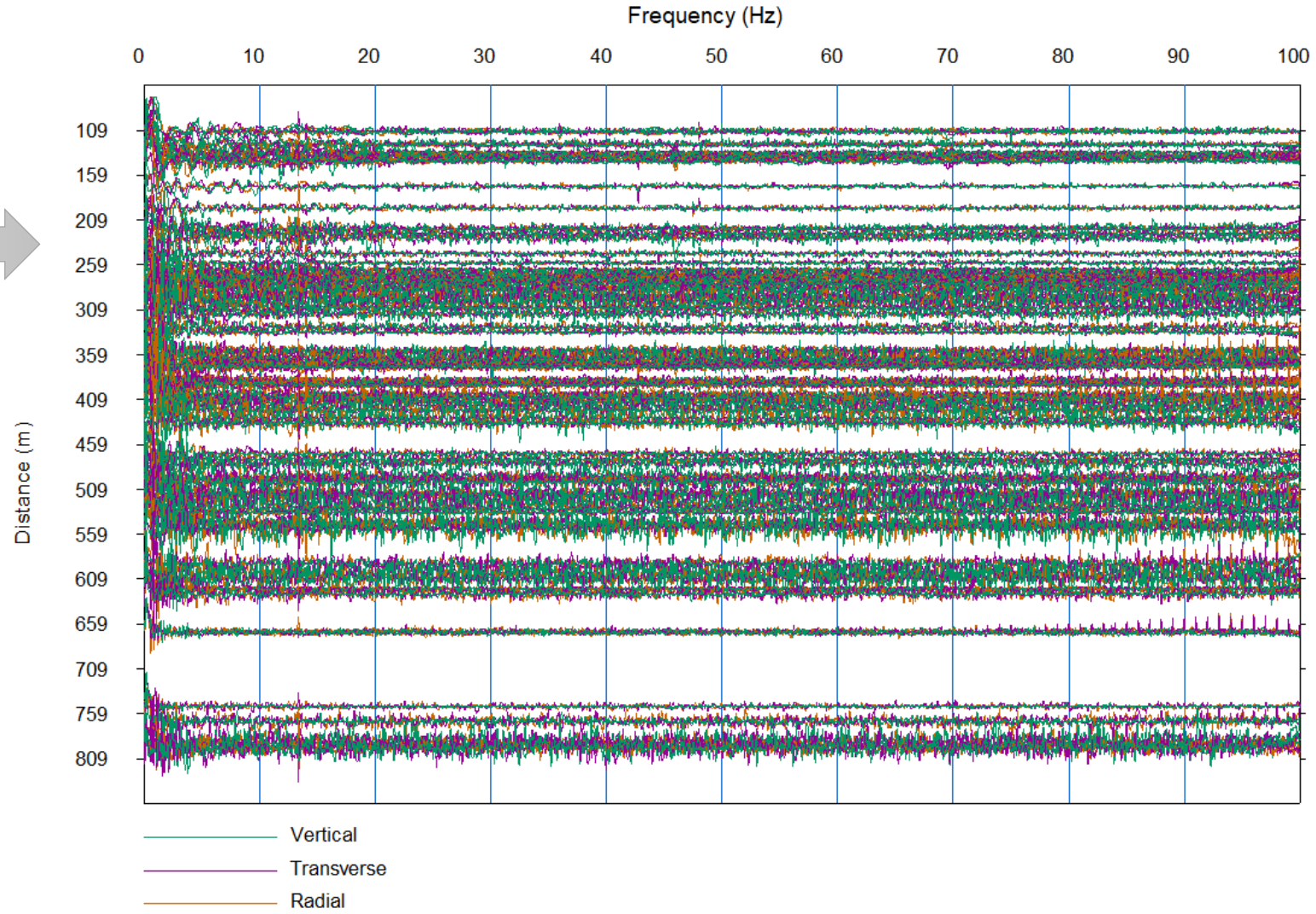


# Import three SPAC files to Pickwin

Click “Yes” to continue.



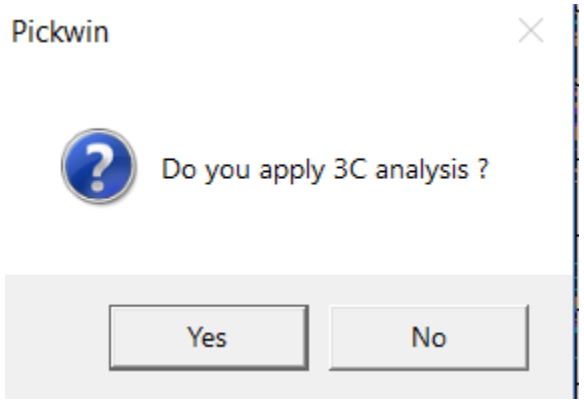

Three component (vertical, radial and transverse) SPACs appear.



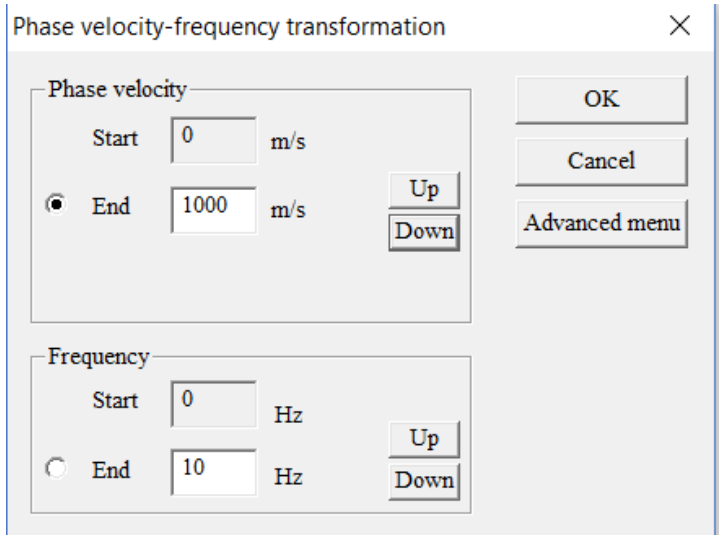
# Calculate Rayleigh and Love phase velocity images

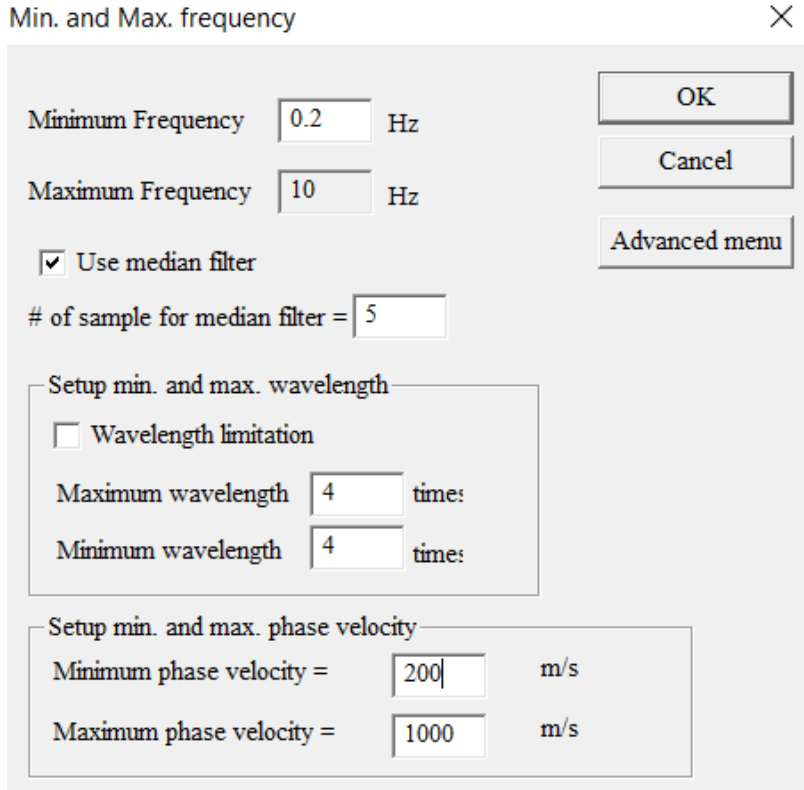
Click  or press “Ctrl+D”
to calculate phase velocity images.

Click “Yes” to apply 3C SPAC analysis.




Set up transformation parameters as usual.



# Calculate Rayleigh and Love phase velocity images

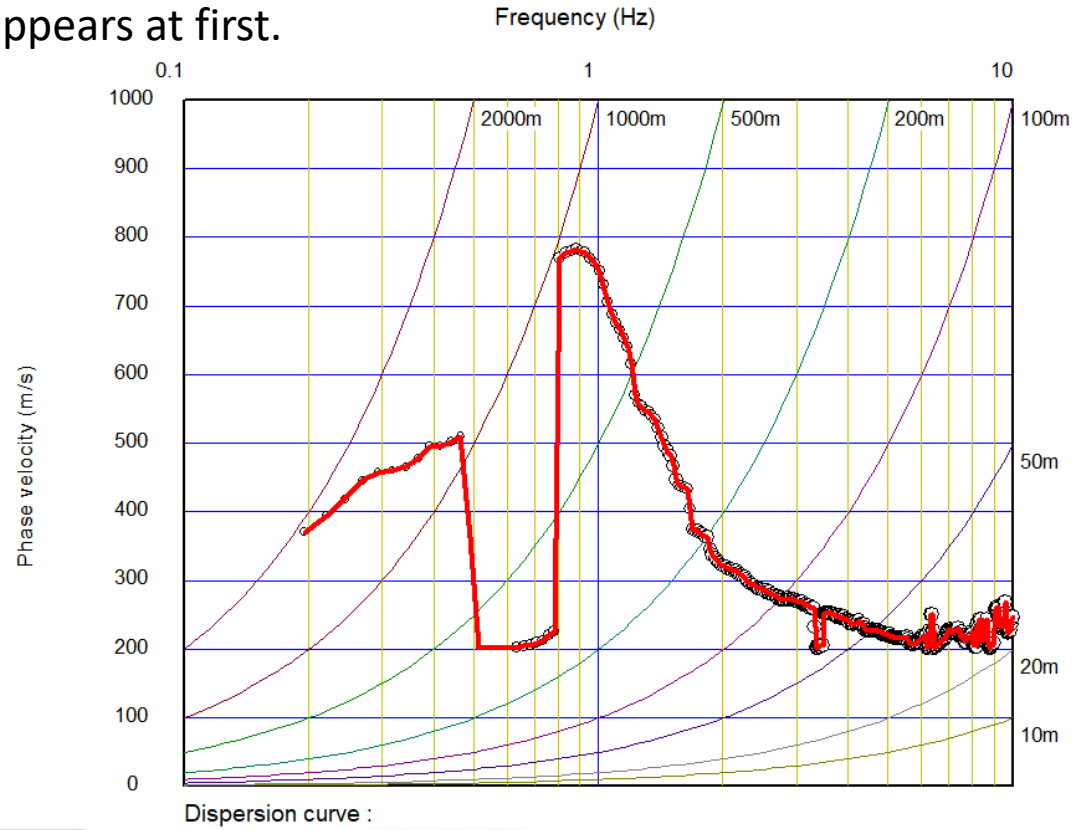
Ryleigh wave phase velocity image appears at first.

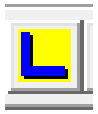
Click  to switch Rayleigh/Love phase velocity images.

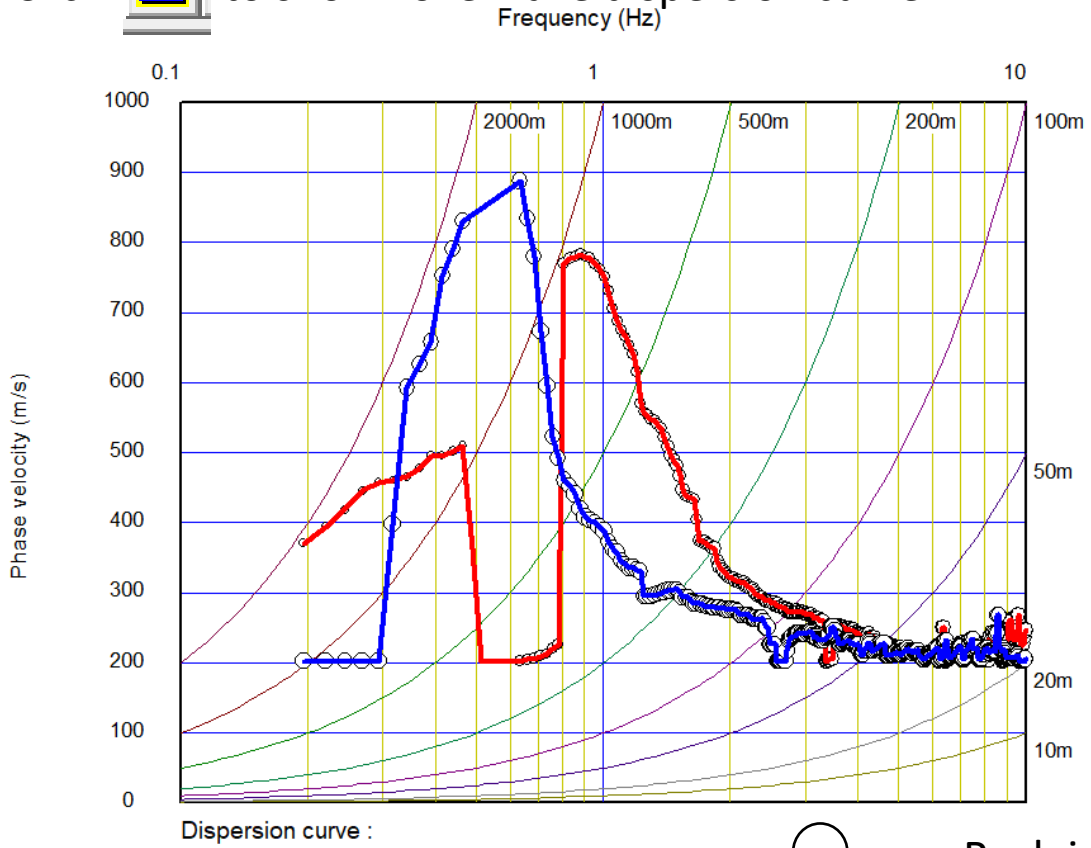
# Show Rayleigh and Love dispersion curves by WaveEq

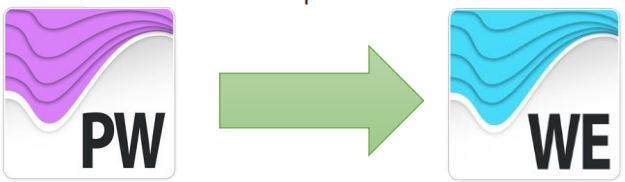
Click  or select “Surface wave analysis”, “Show phase velocity curve (1D)” to show dispersion curves by WaveEq.

WaveEq launched and Rayleigh wave dispersion curve appears at first.



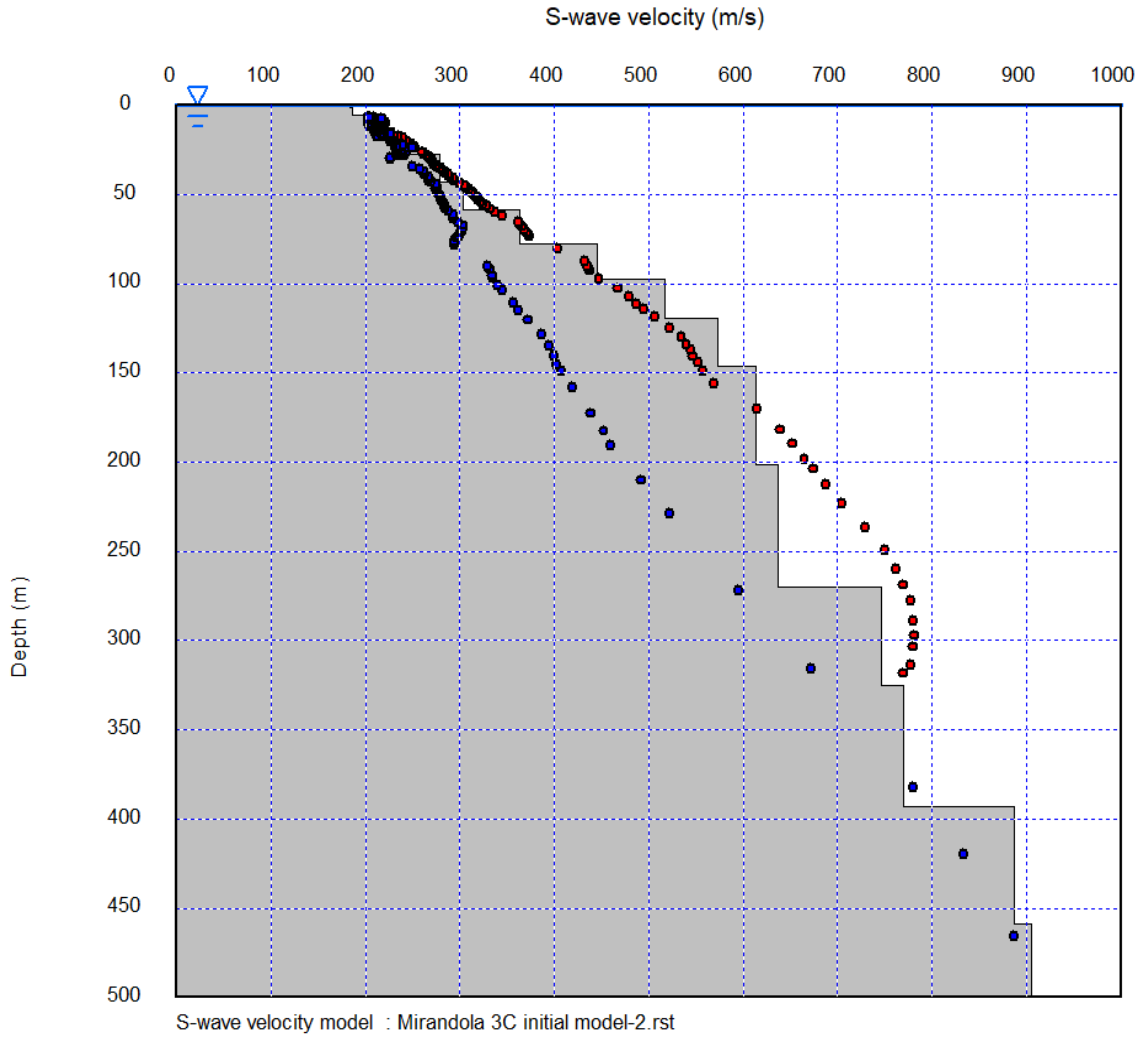

Click  to show Love wave dispersion curve.



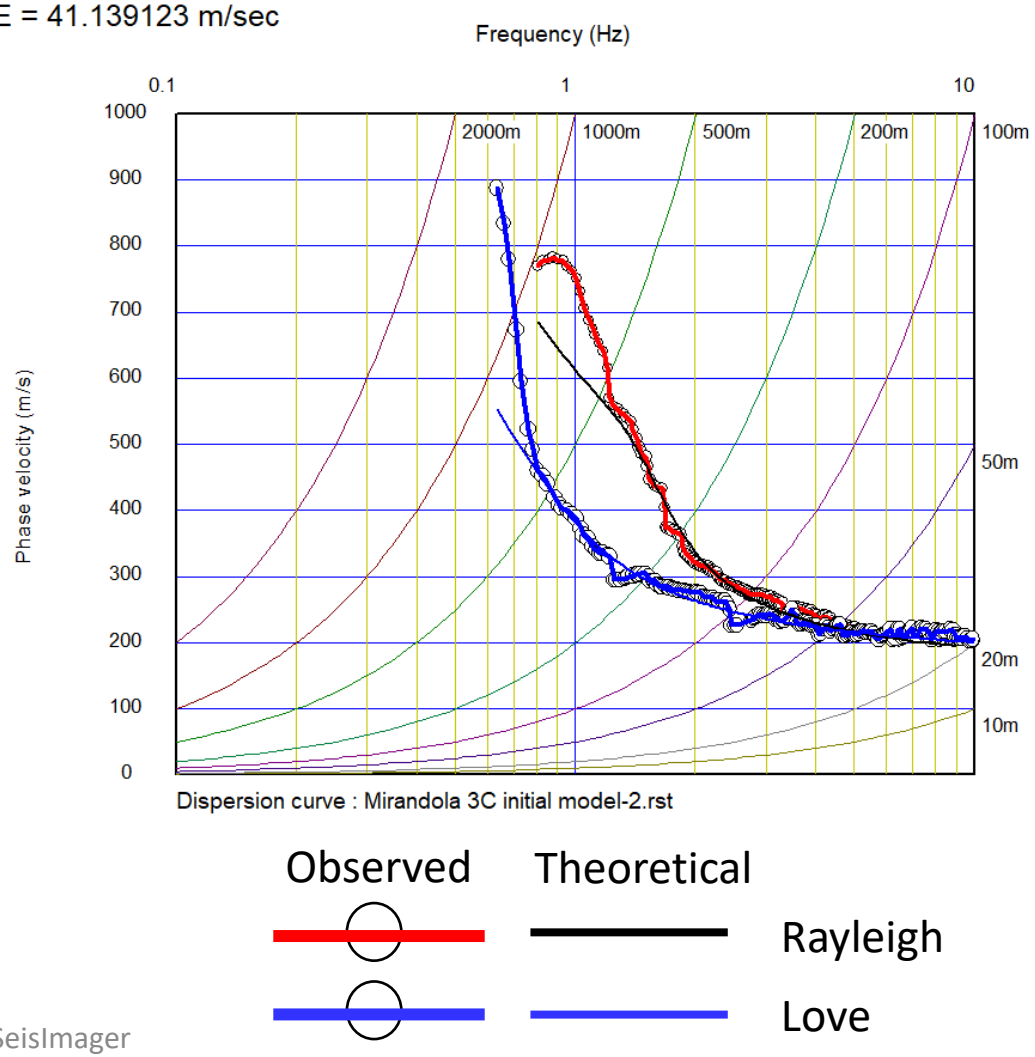



# Edit dispersion curve and prepare an initial model

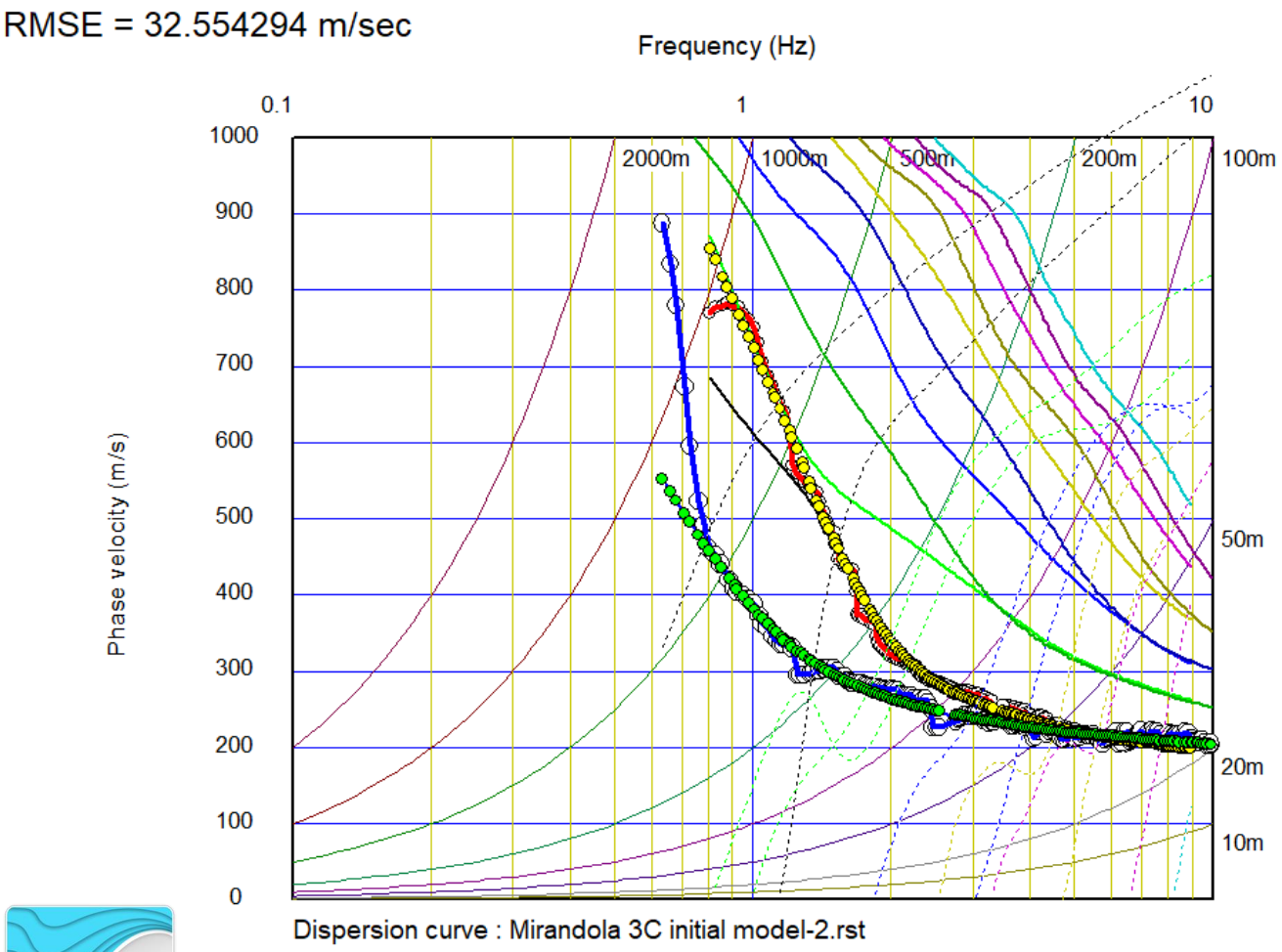
Edit dispersion curves and prepare an initial model as usual.

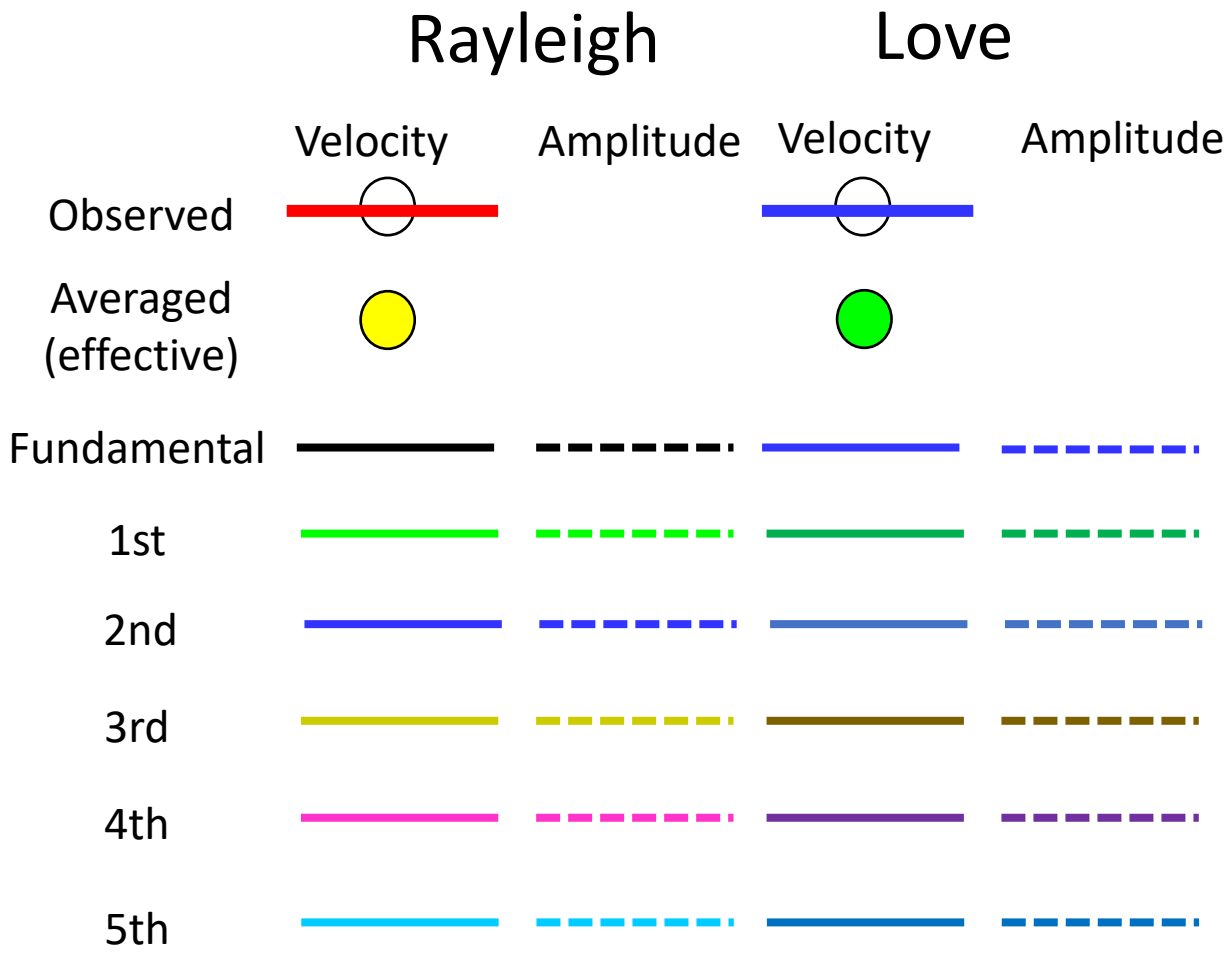



Comparison of observed and theoretical dispersion curves (fundamental mode).



# Comparison of observed and theoretical dispersion curves (Higher modes)

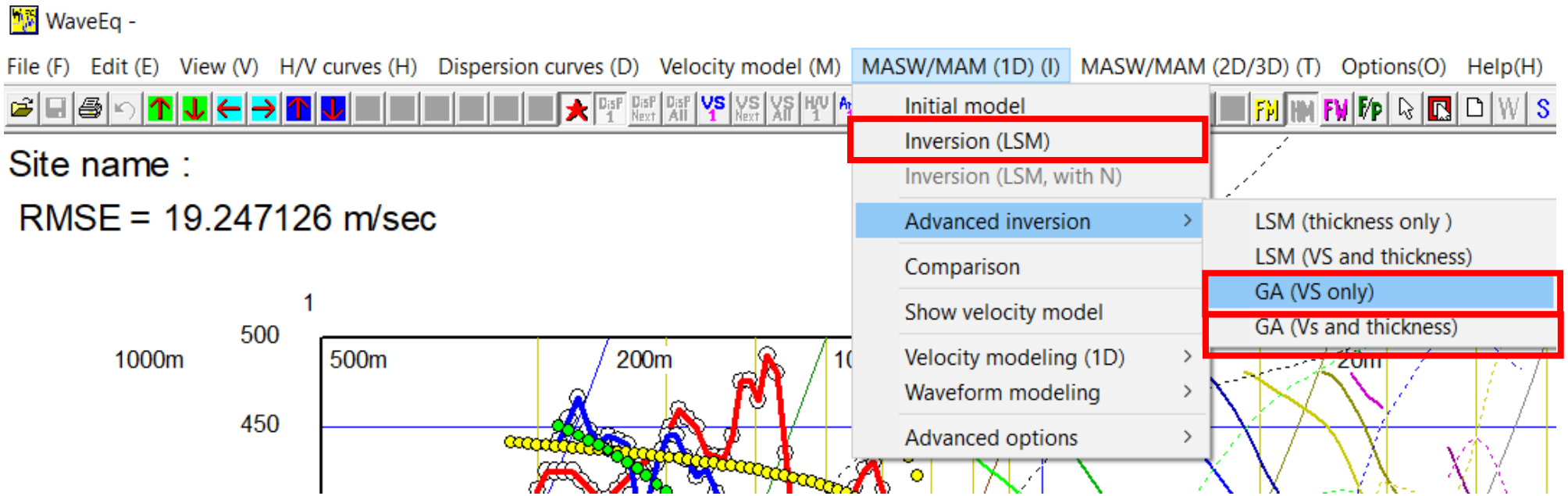


# Joint inversion of Rayleigh and Love waves

Joint inversion of Rayleigh and Love waves using non-linear least squares method or Genetic Algorithm (GA) were implemented in WaveEq.

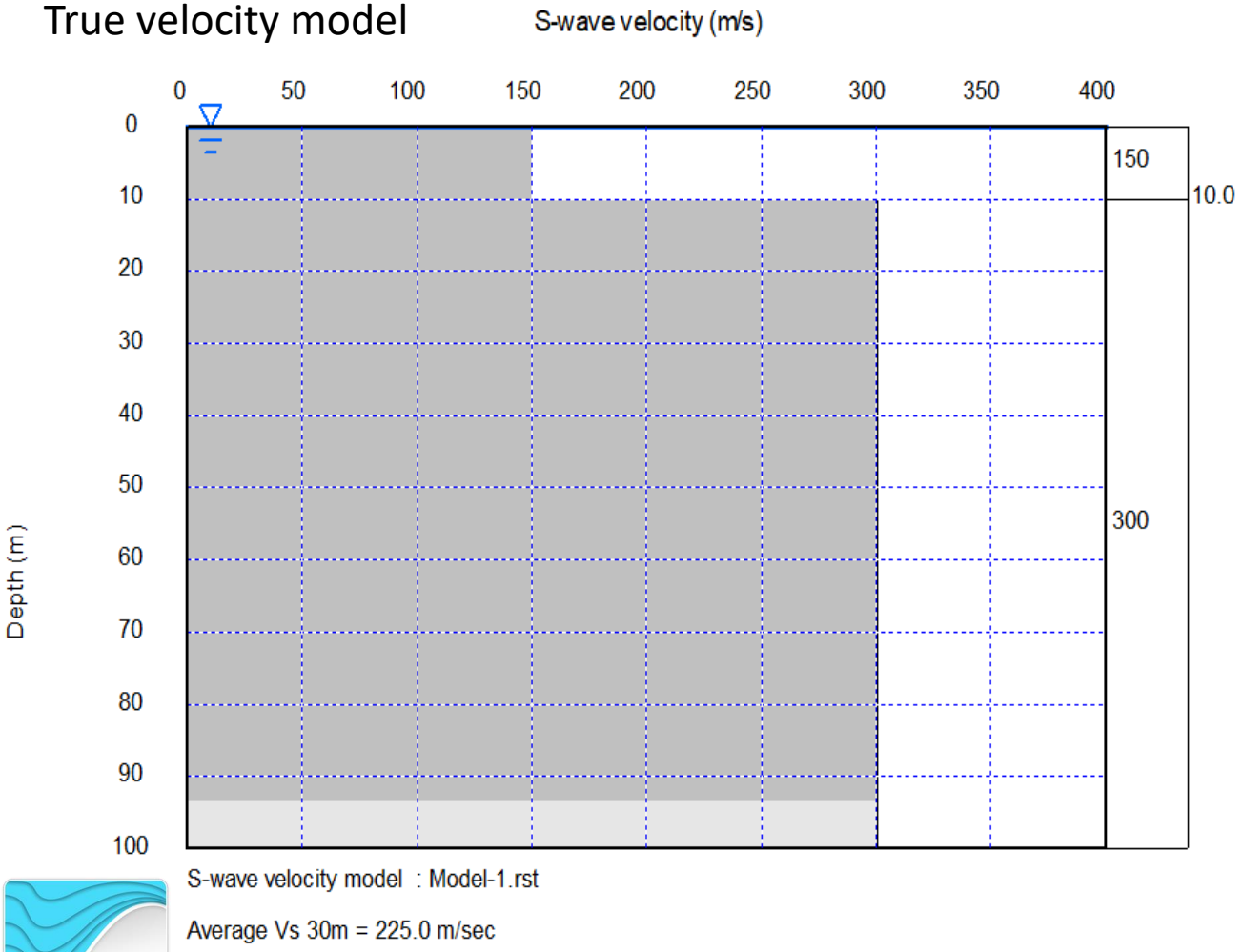
Inversions are available in “Inversion (LSM)”, “GA (Vs only)” and “GA (Vs and thickness)” in “MASW/MAM (1D)” of WaveEq.



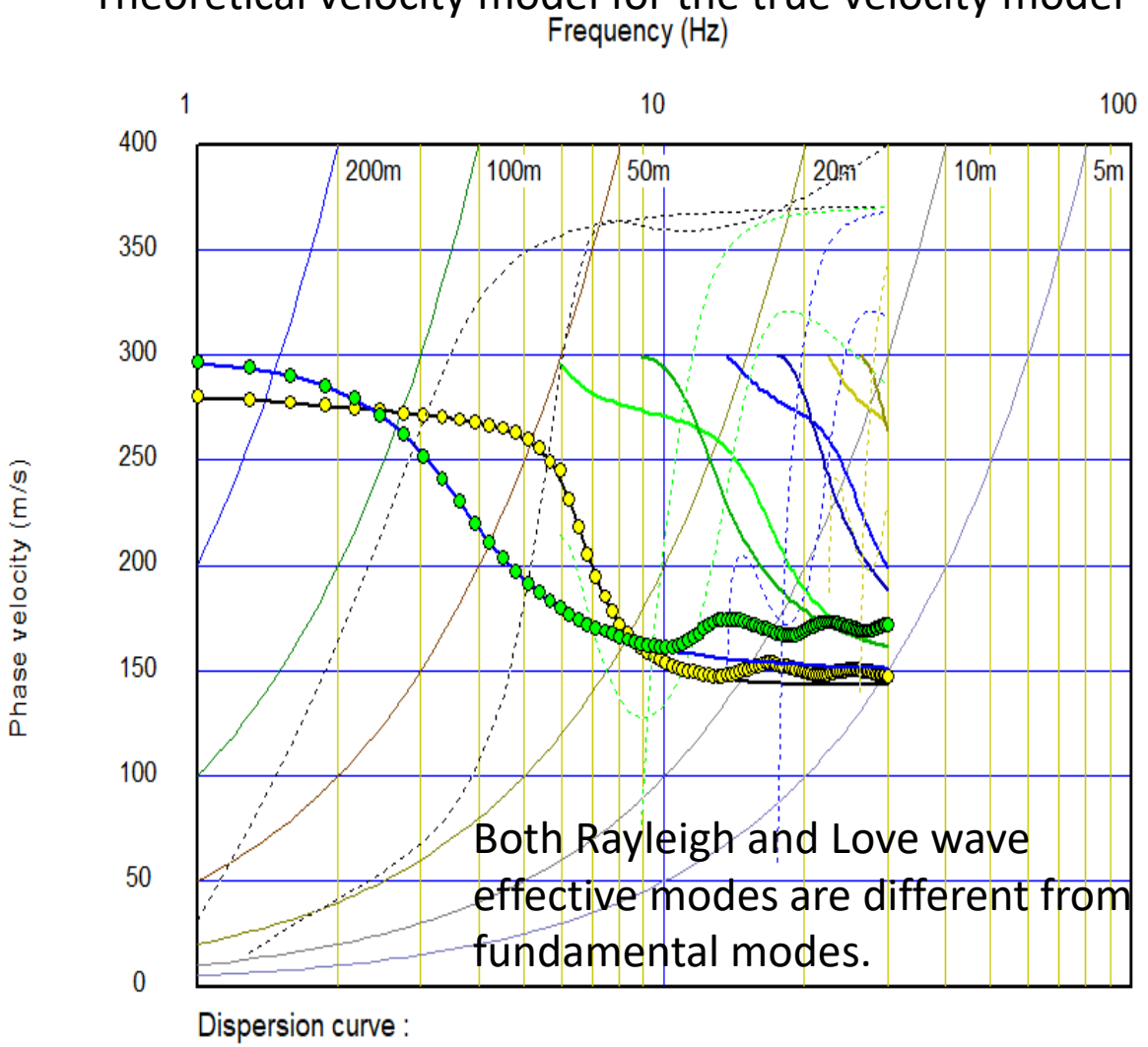
# Joint inversion of Rayleigh and Love waves

## *Numerical example using two layer model*

True velocity model

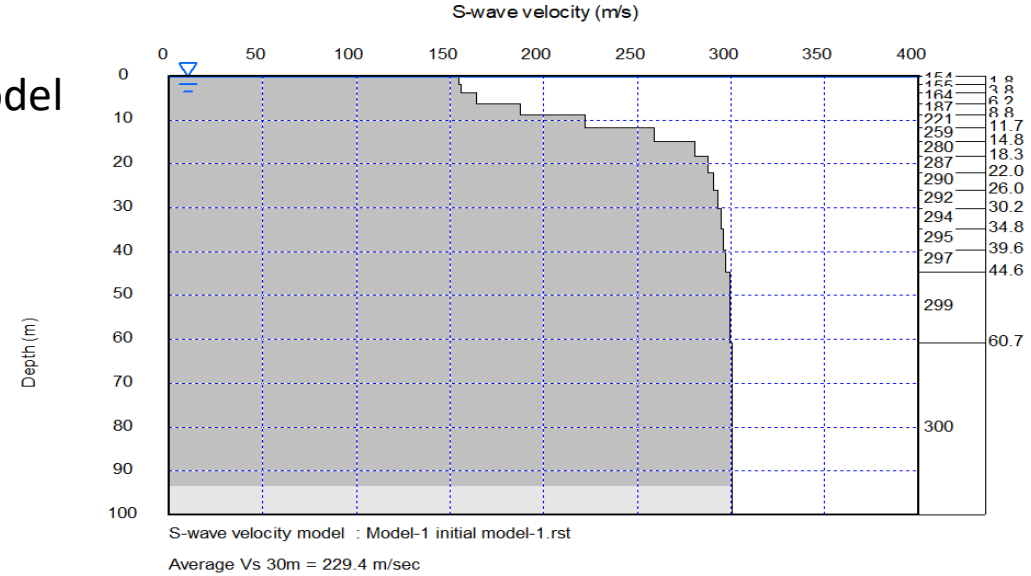



Theoretical velocity model for the true velocity model



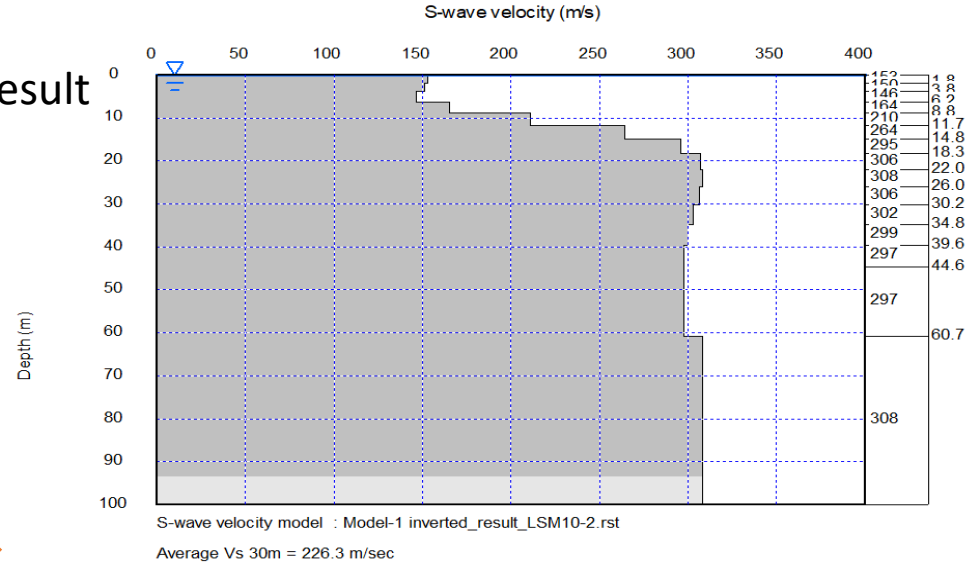
# Joint inversion of Rayleigh and Love waves (only fundamental mode)

Initial model

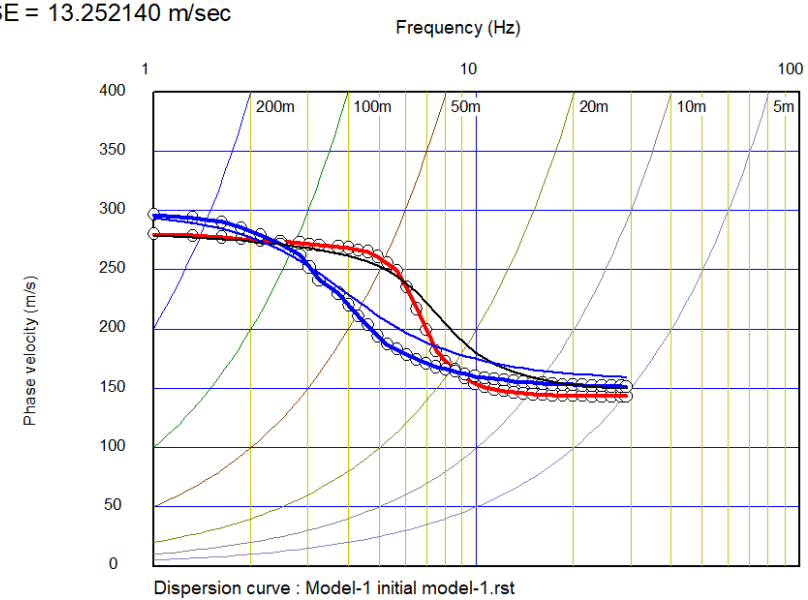



RMSE = 13.252140 m/sec

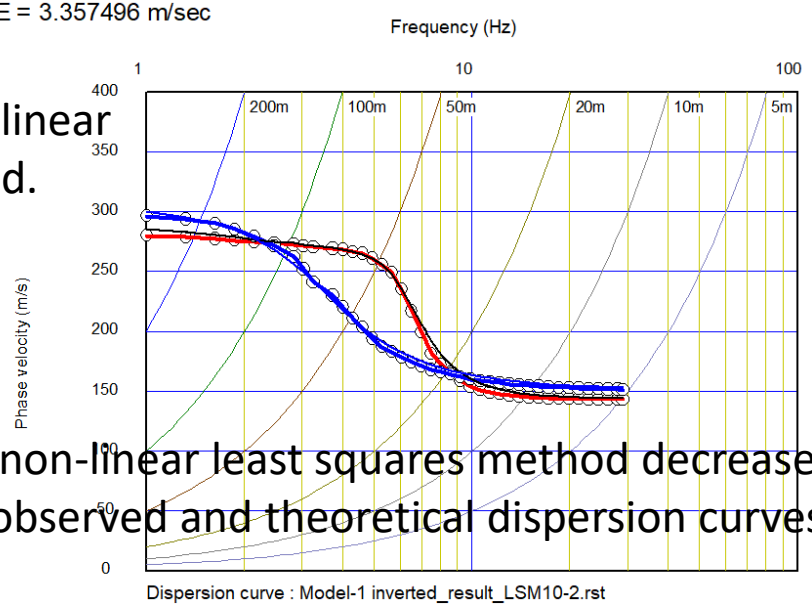
Inverted result




RMSE = 3.357496 m/sec



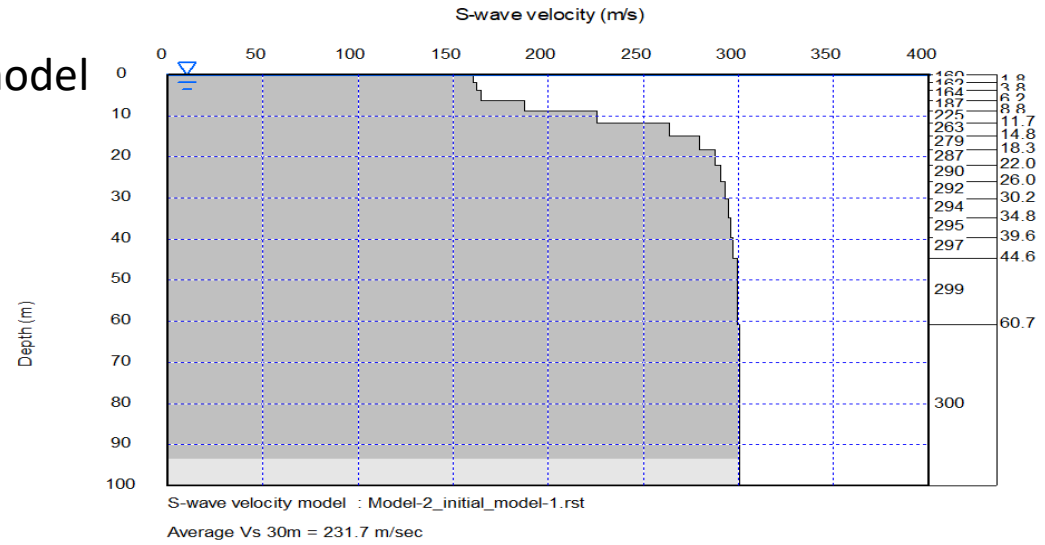

Inversion using non-linear least squares method.



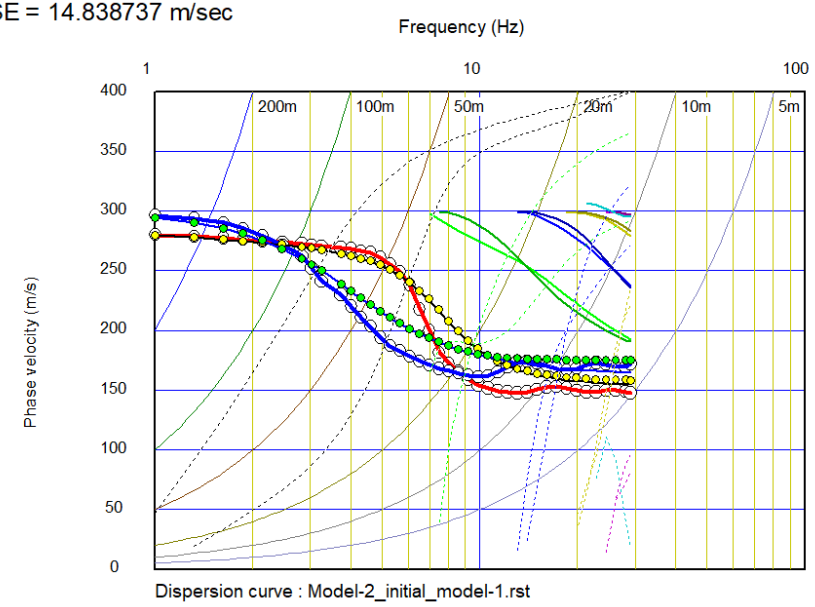

Inversion using non-linear least squares method decreased the error between observed and theoretical dispersion curves.

# Joint inversion of Rayleigh and Love waves (including higher modes)

Initial model

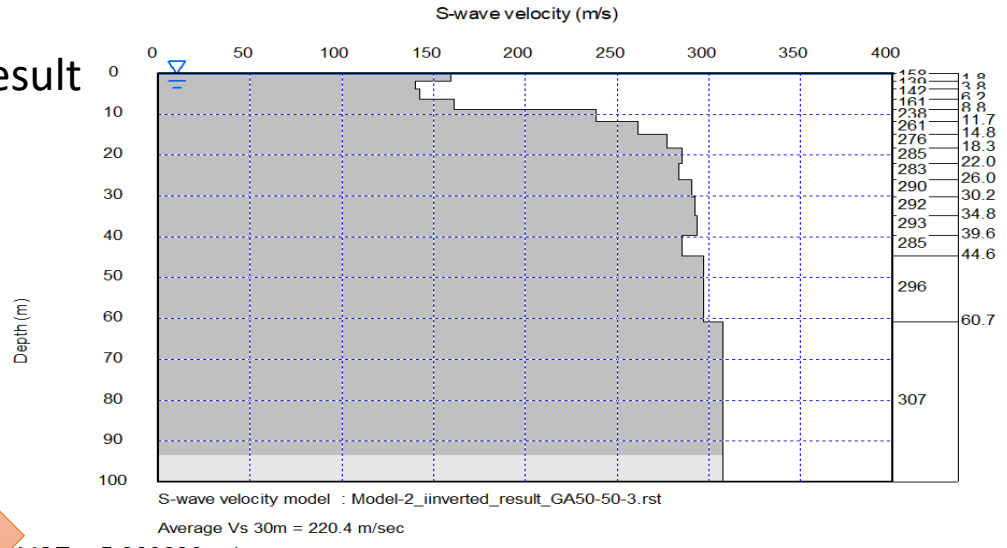



RMSE = 14.838737 m/sec

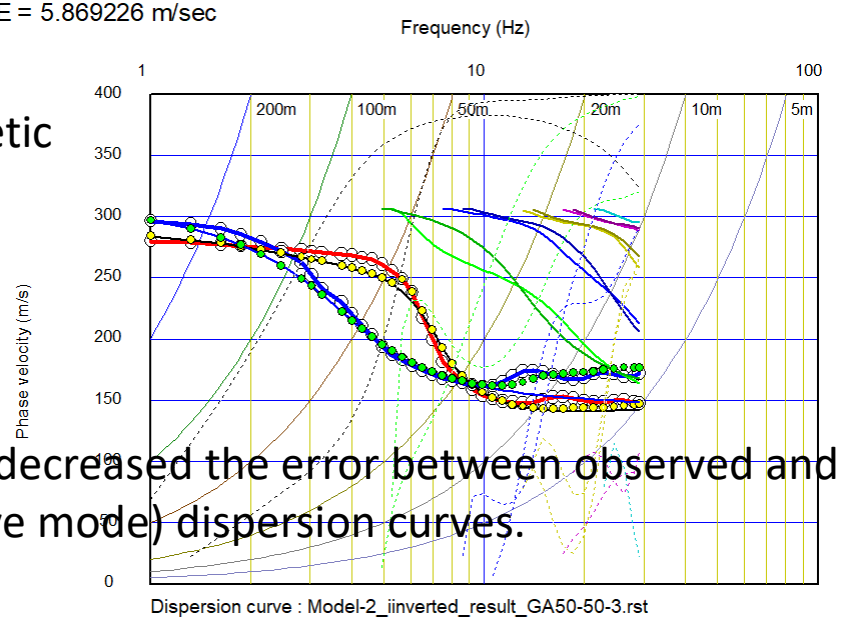



Inversion using Genetic Algorithm (GA).

Inverted result




RMSE = 5.869226 m/sec

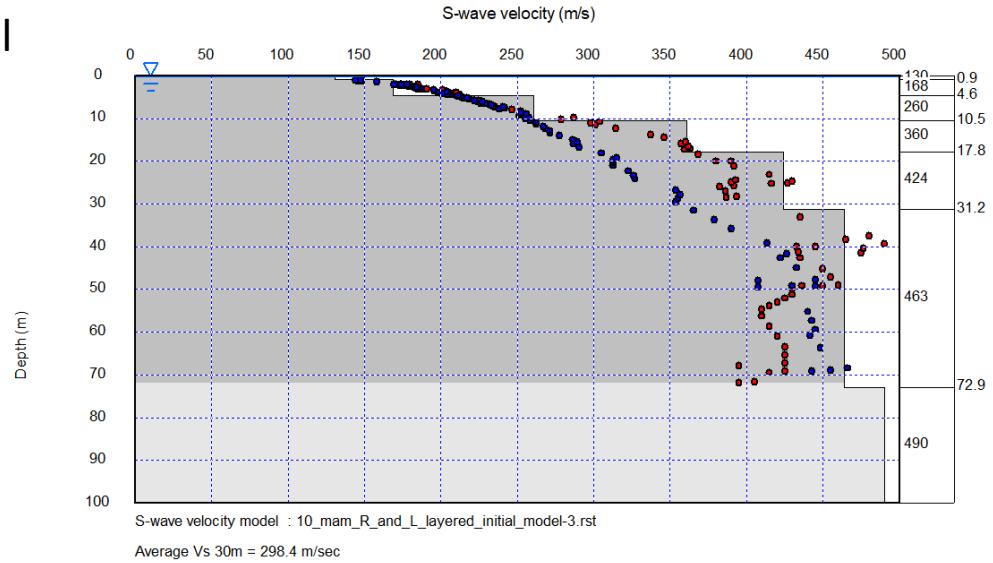



Inversion using GA decreased the error between observed and theoretical (effective mode) dispersion curves.

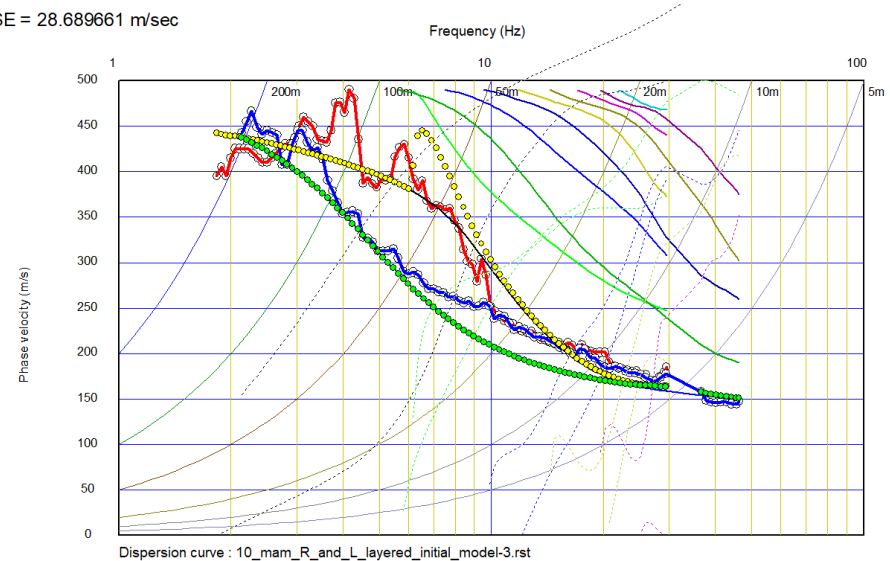
# Joint inversion of Rayleigh and Love waves (including higher modes)

*Field data example*

Initial model

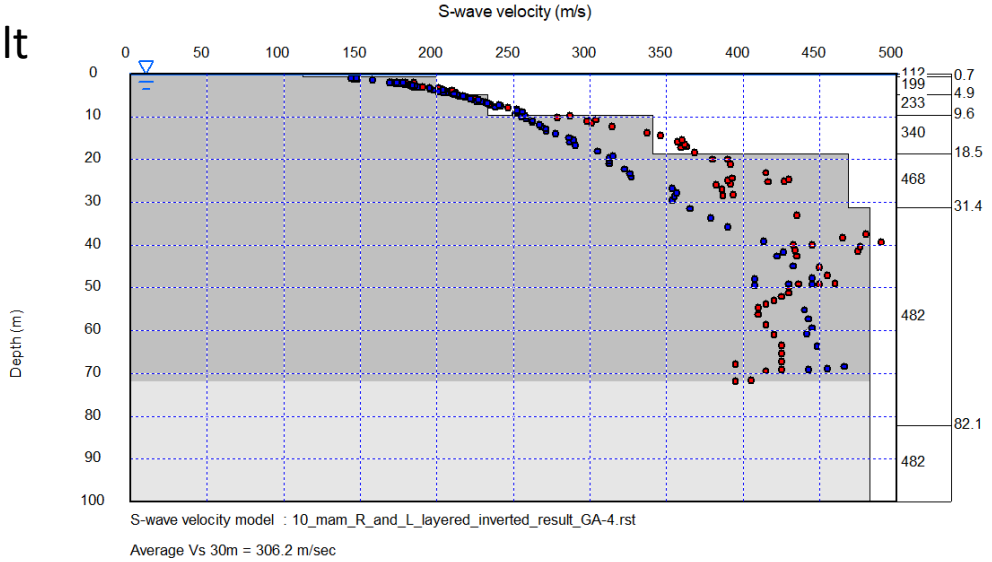



RMSE = 28.689661 m/sec

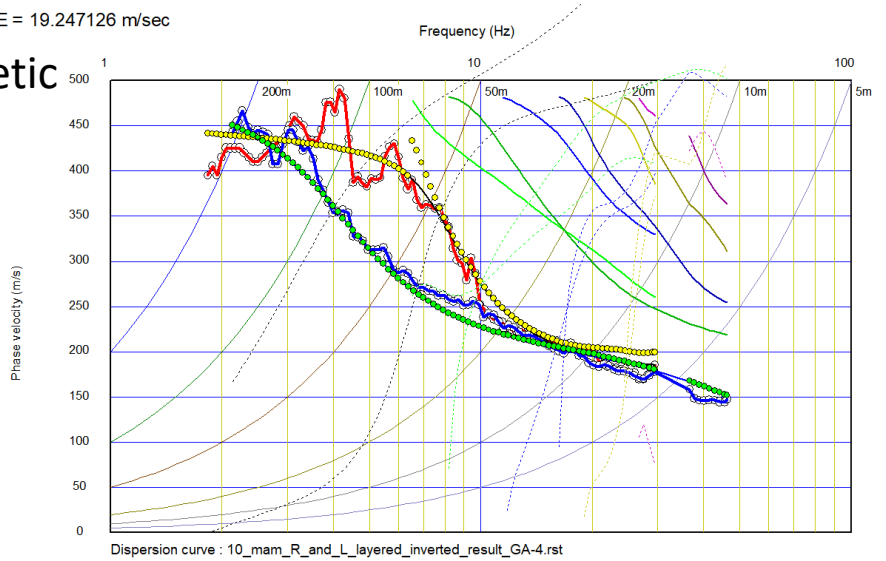



Inversion using Genetic Algorithm (GA).

Inverted result

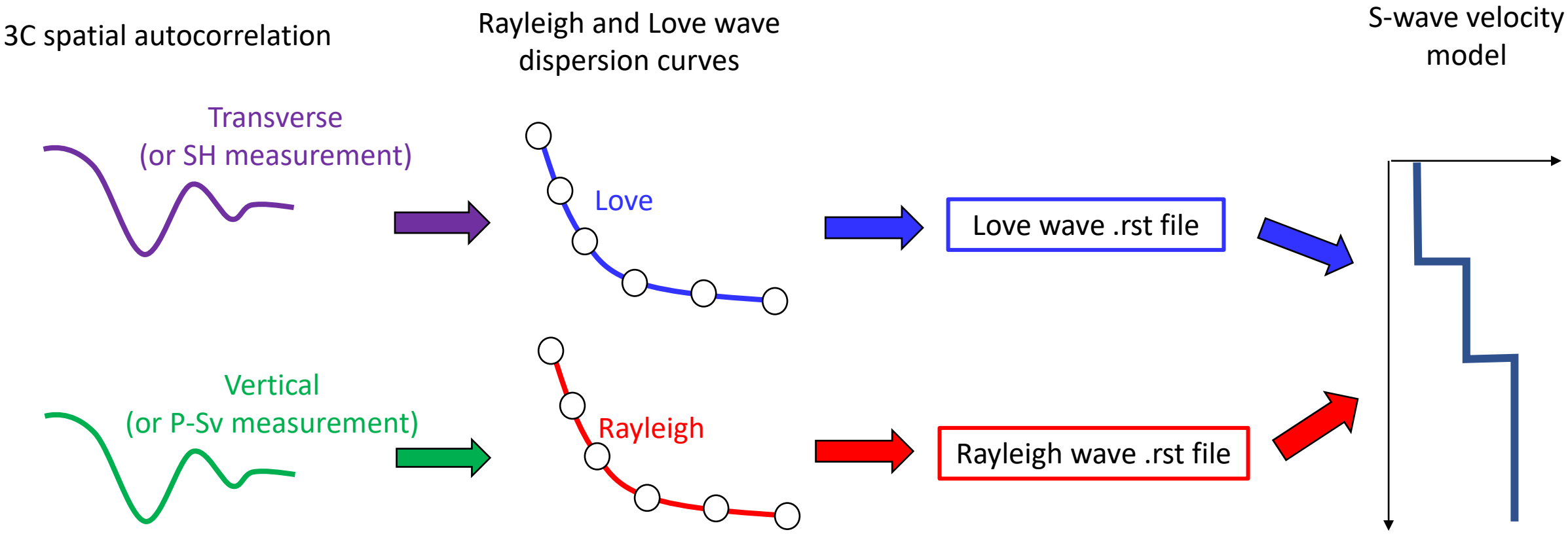



RMSE = 19.247126 m/sec



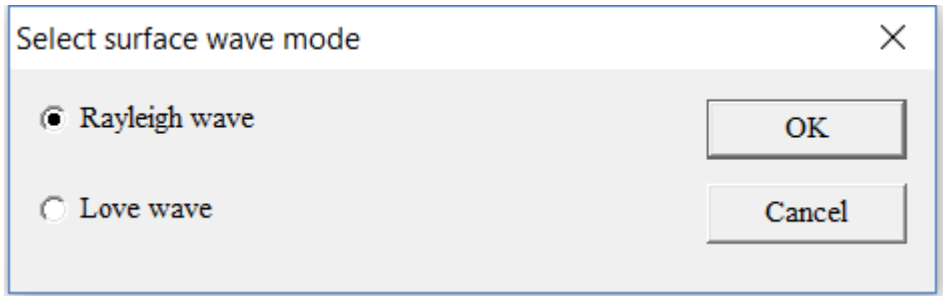
# Option : Use dispersion curve from transverse component as Love wave

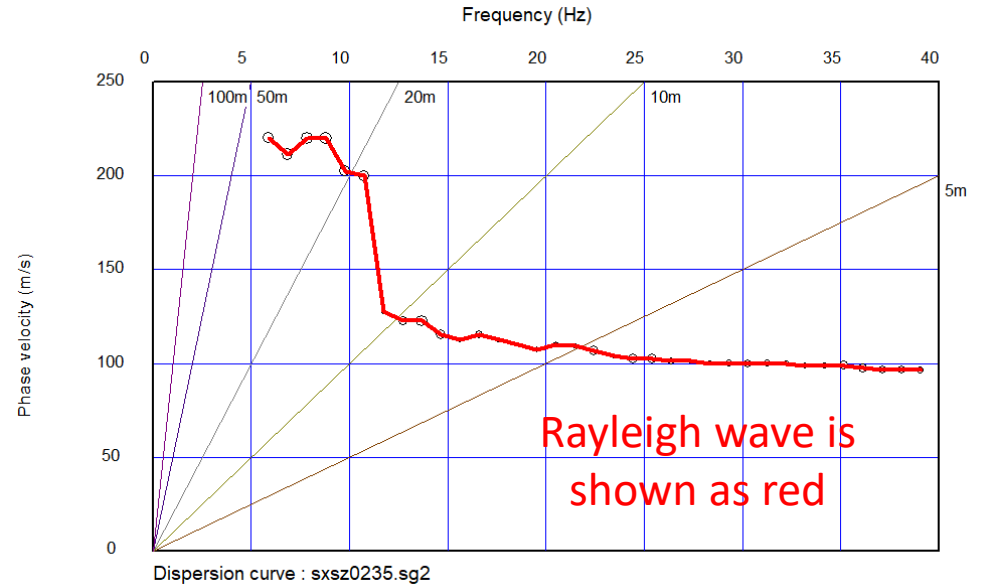
Theoretically, phase velocities of transverse component is close to that of Love waves. You may consider dispersion curve of transverse component as that of Love waves. In active methods, dispersion curves obtained from SH measurements can be considered as the dispersion curves of Love waves.

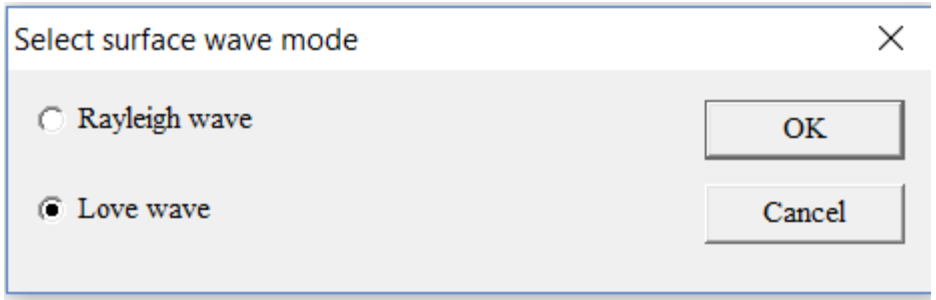


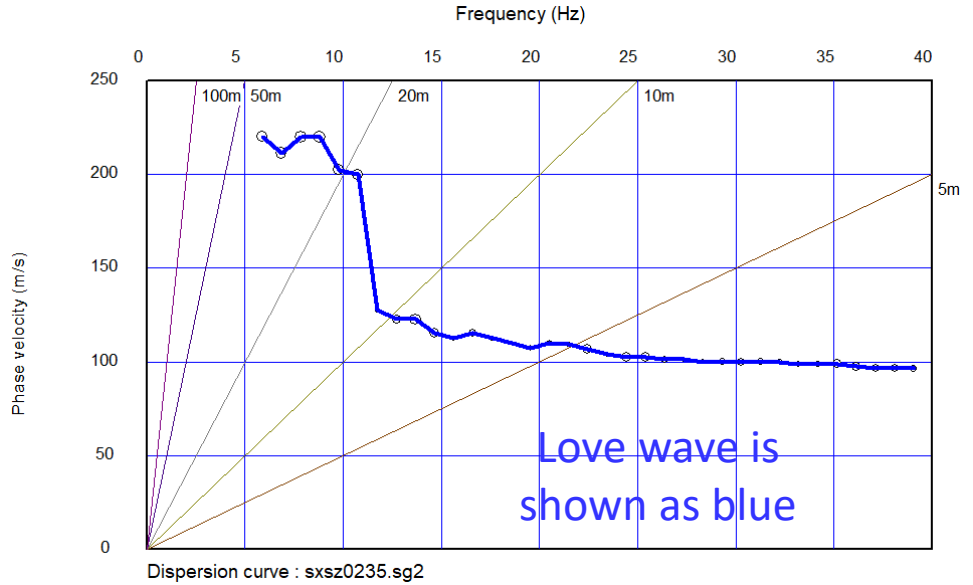
# Option : Select Rayleigh or Love dispersion curve

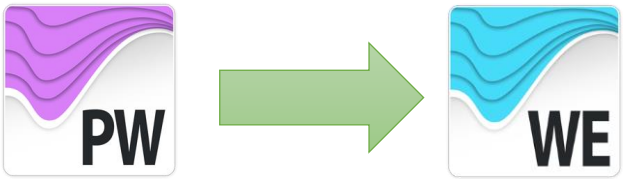
You have a chance to select Rayleigh or Love dispersion curve when launching WaveEq from Pickwin.



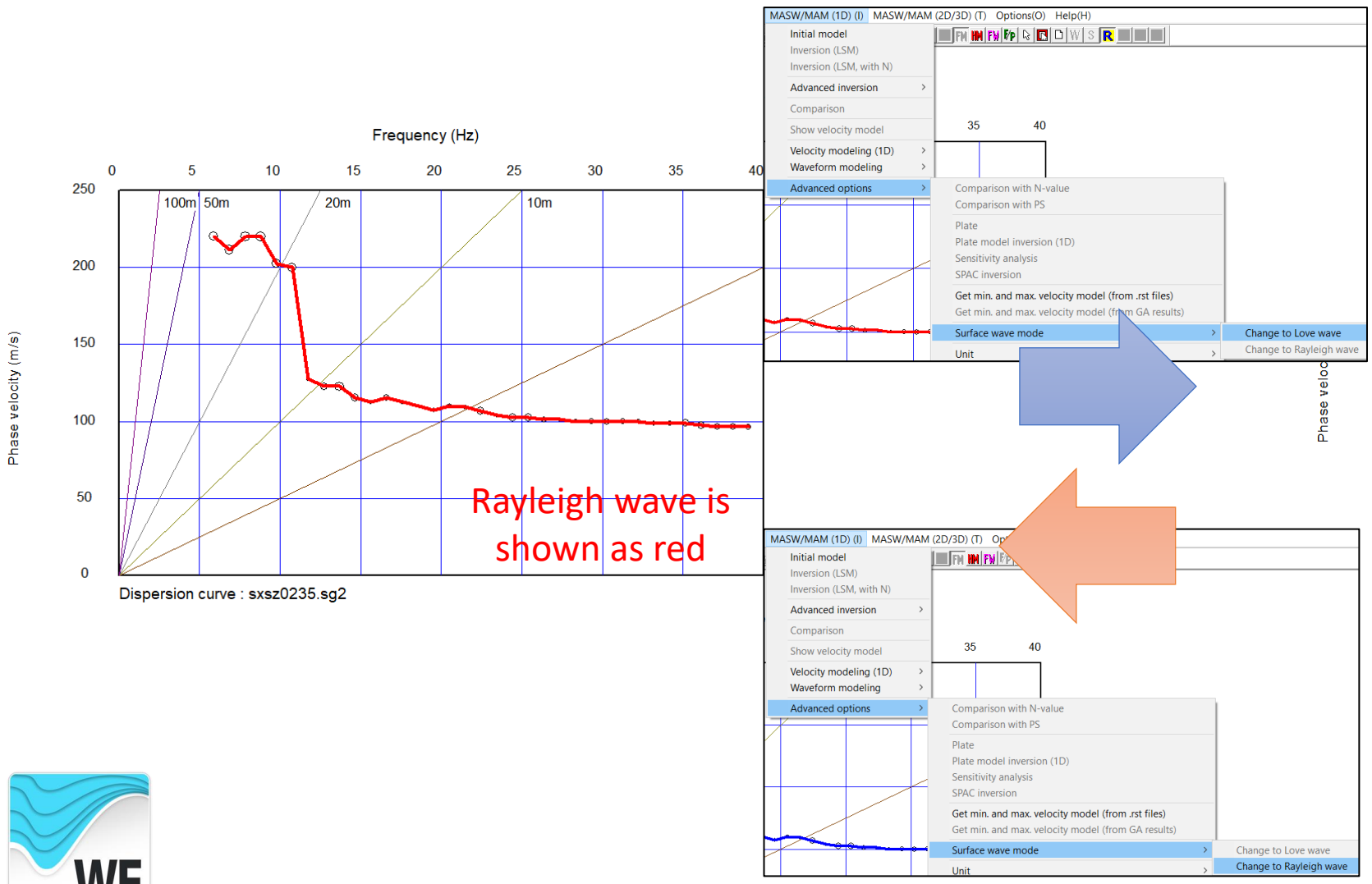



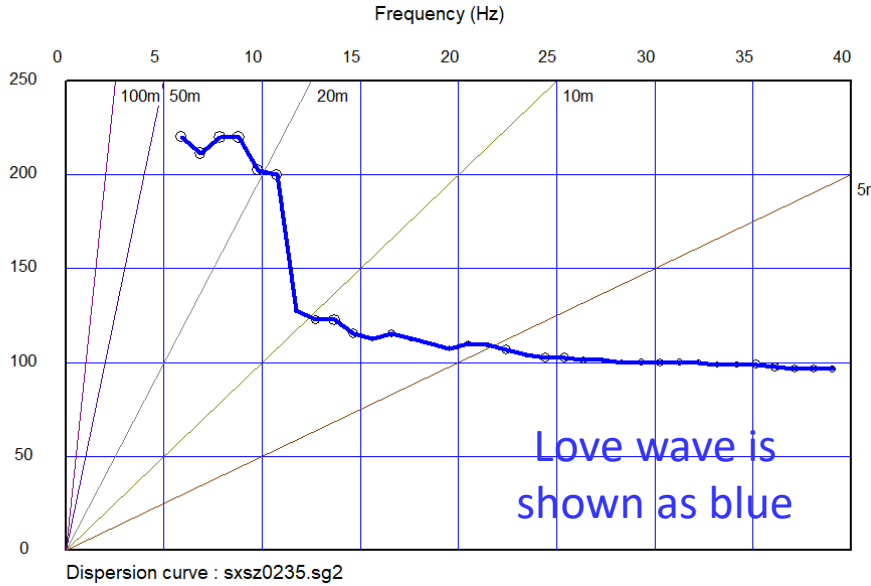



# Option : Switch Rayleigh or Love dispersion curve

It is possible to switch (or select) Rayleigh or Love dispersion curve.
Use “MASW/MAM (1D)”, “Advanced option”, “Surface wave mode”.

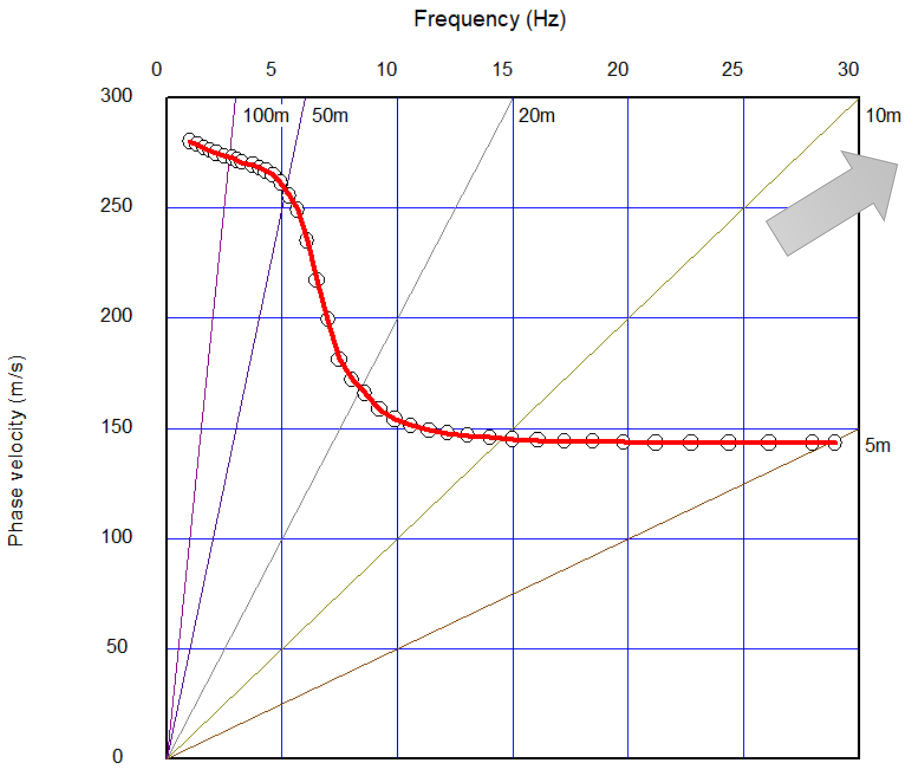


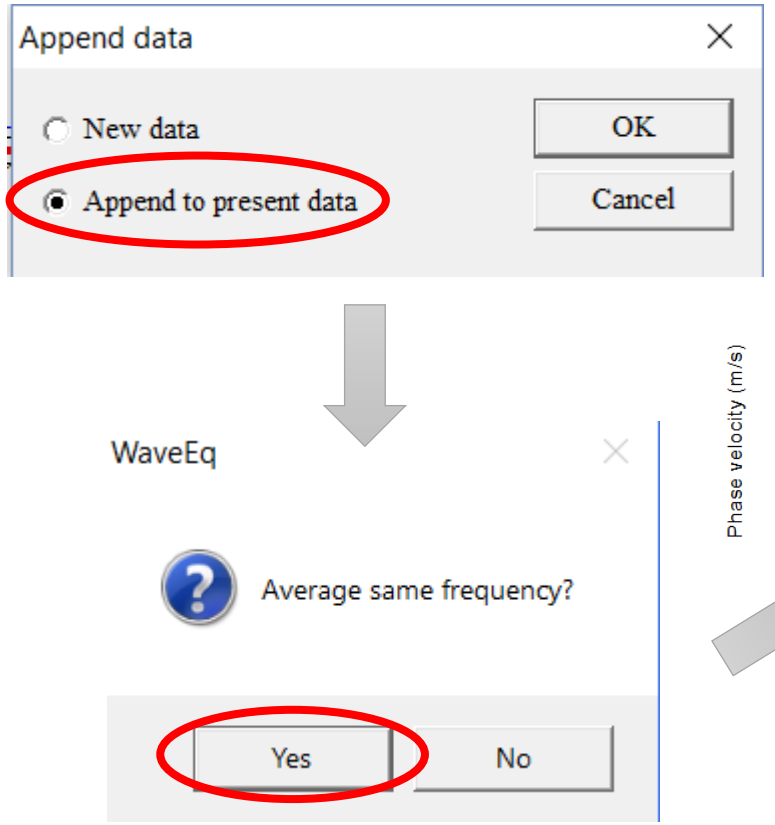
# Option : Combine Rayleigh and Love dispersion curves

1) Save Rayleigh and Love wave dispersion curves to individual files.

2) Open one (Rayleigh/Love) file.




3) Open another (Love/ Rayleigh) file and append it.




4) Select “Yes”.

5) Rayleigh and Love dispersion curves are shown together.