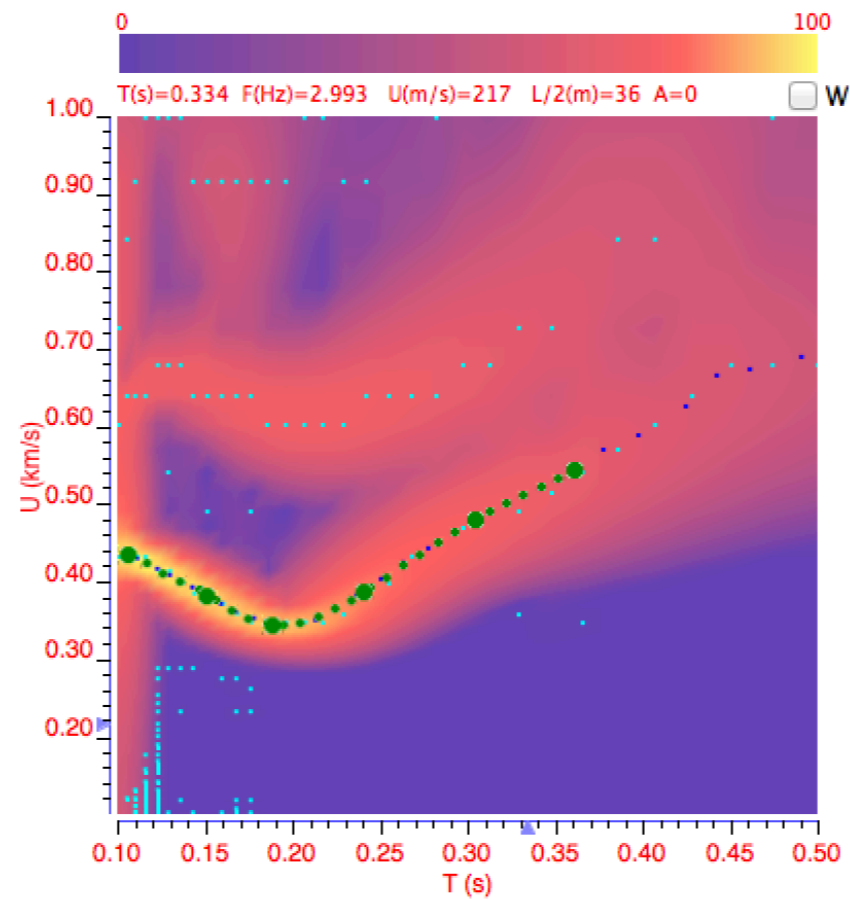




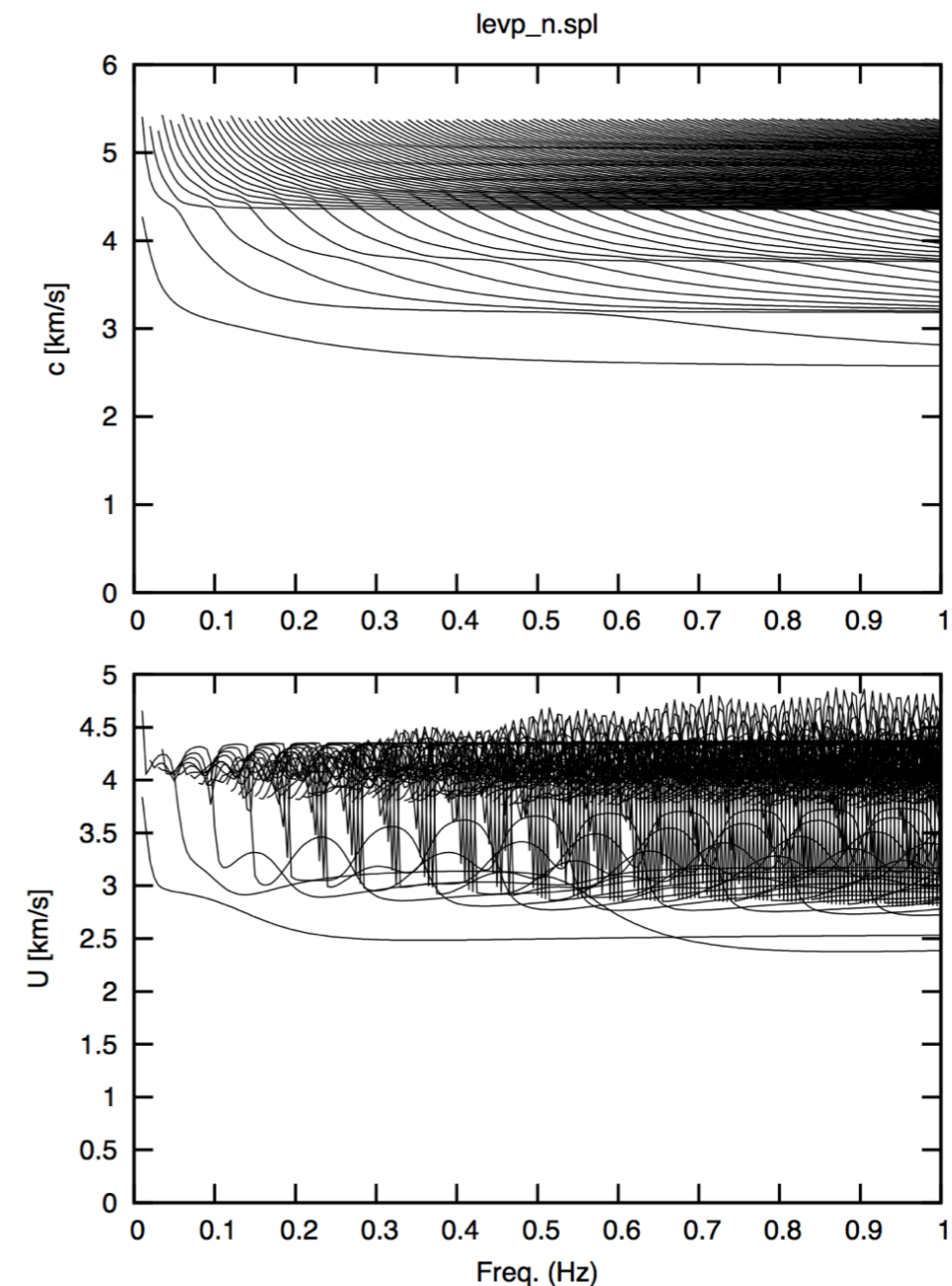
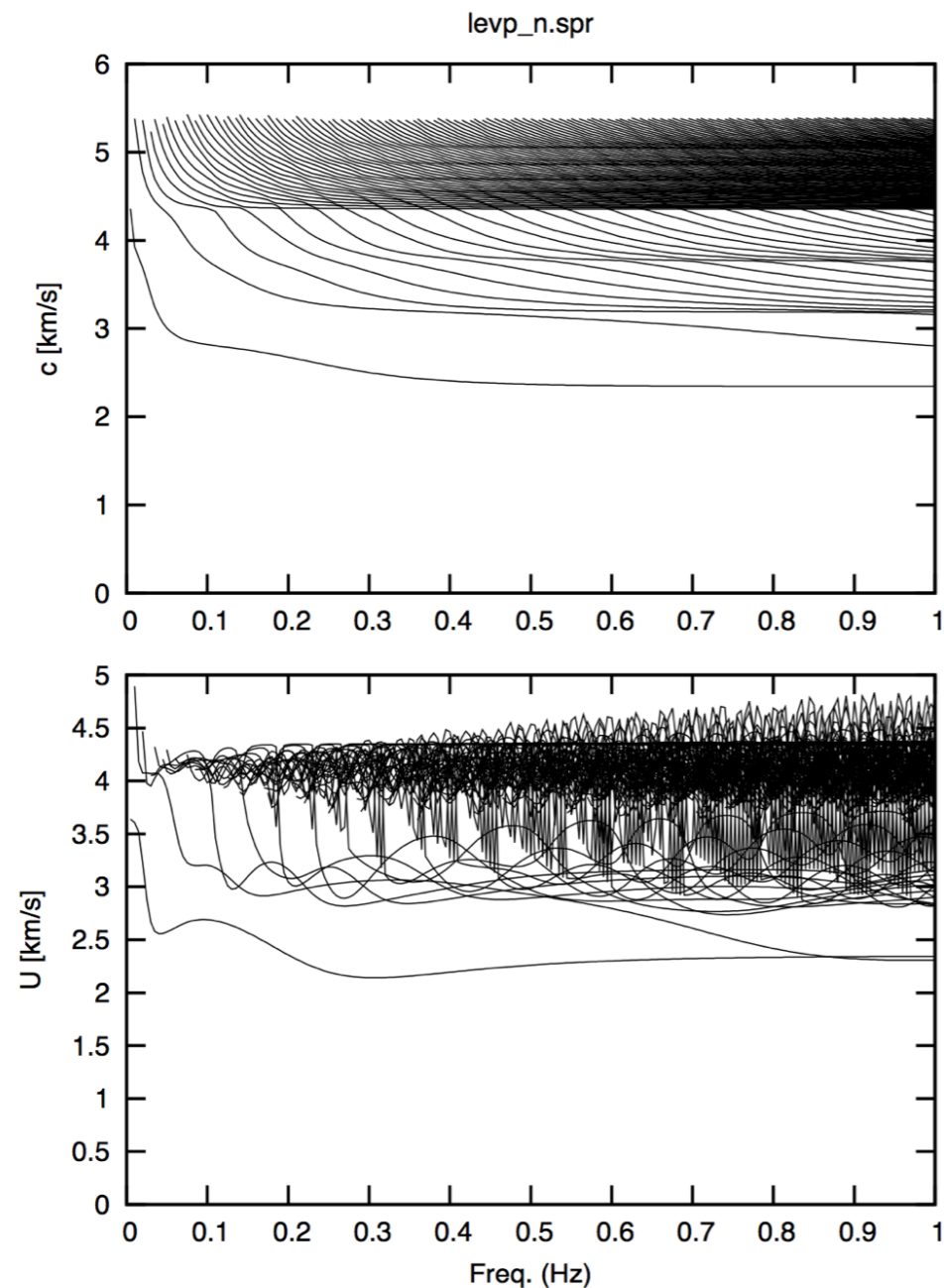
FTAN: Frequency Time ANalysis



Franco Vaccari
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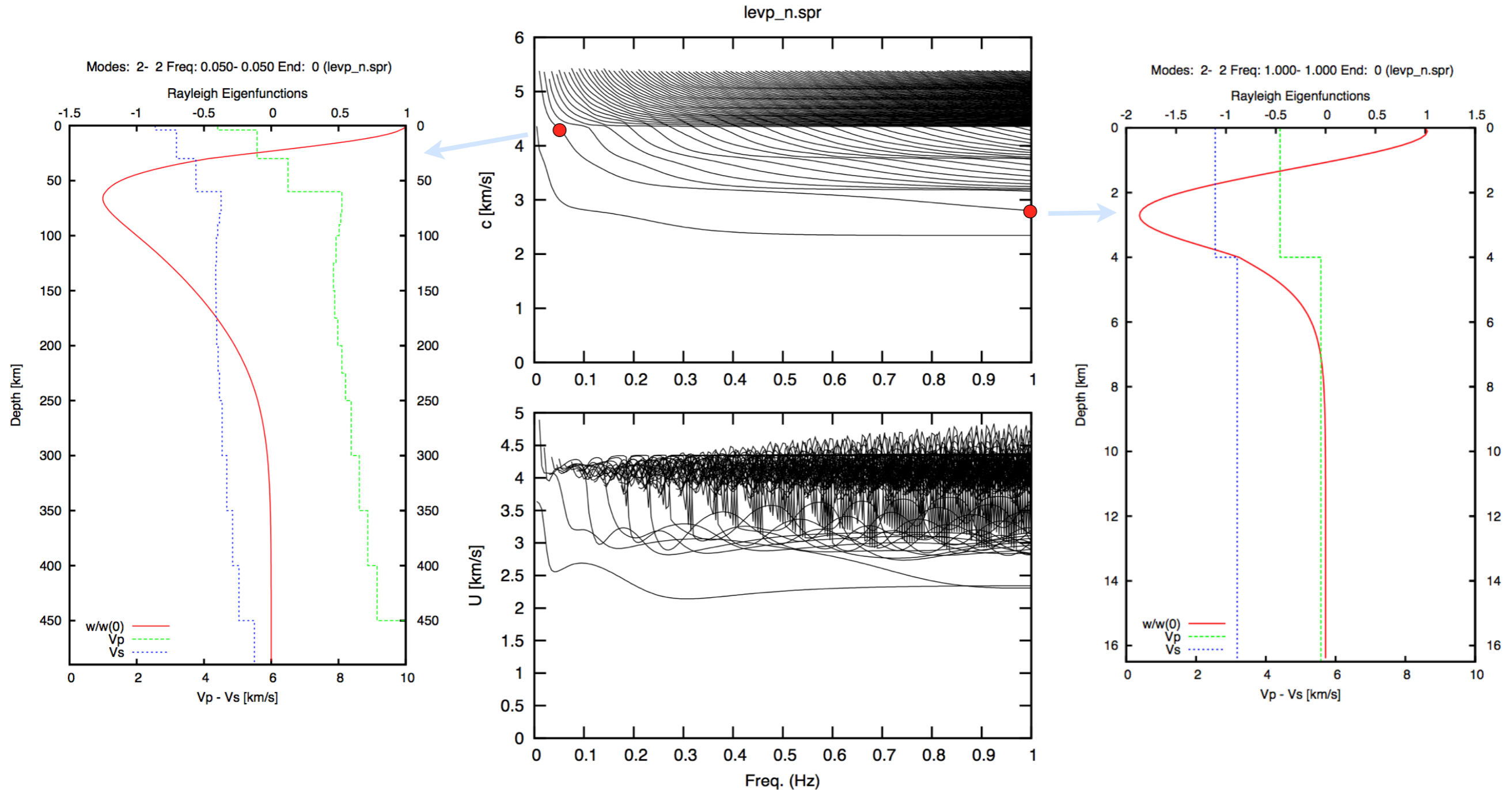
Surface wave dispersion

- Surface waves, showing not impulse nor quasi-harmonic behavior, are difficult to be studied in time or spectral domain, since their principal feature, dispersion, is described by a function rather than a single parameter.



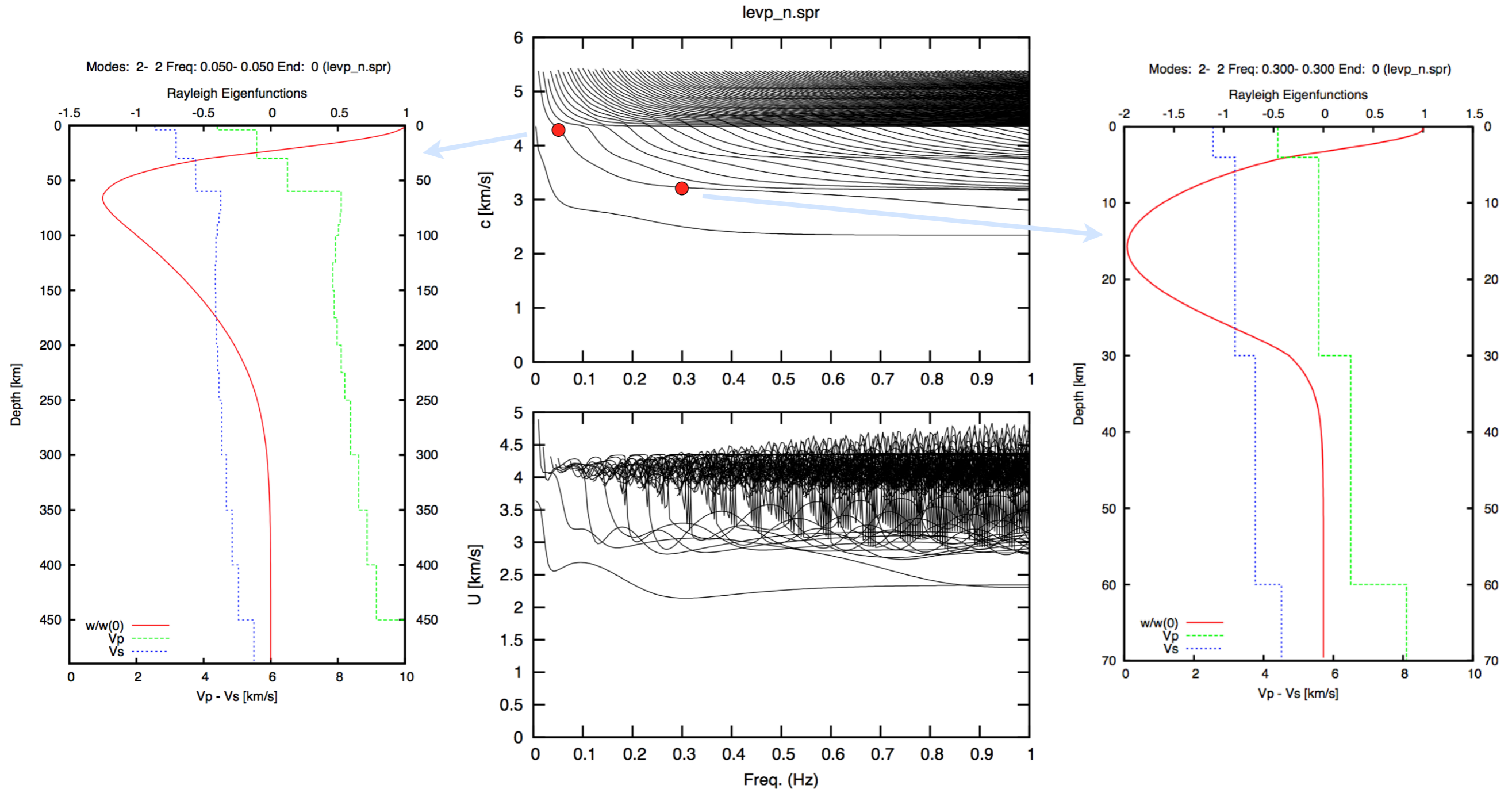
Surface wave dispersion

- For a given mode, shorter frequencies (longer periods) sample a larger portion of the structure, where faster layers are present: phase velocity c is therefore faster



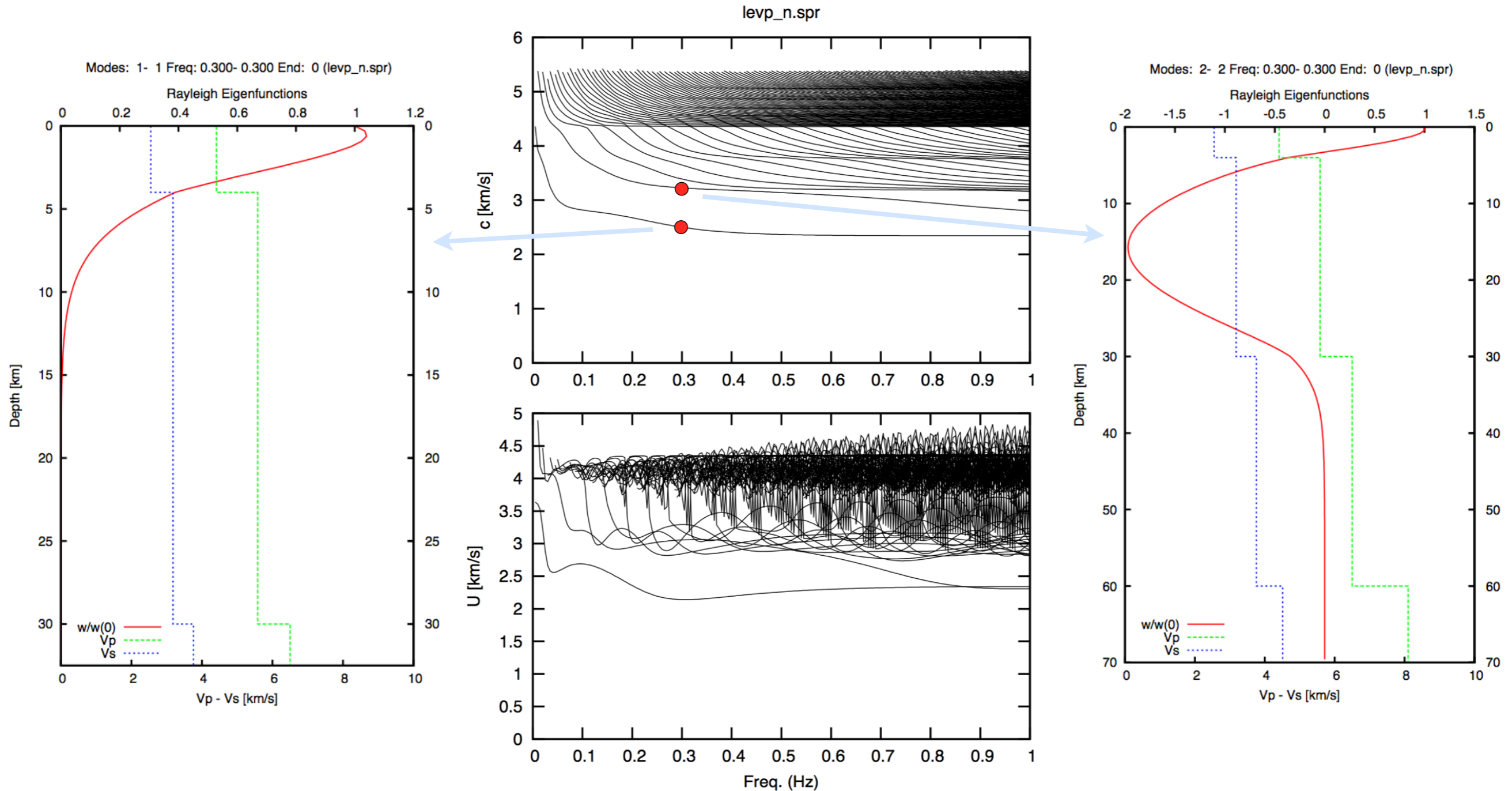
Surface wave dispersion

- For a given mode, shorter frequencies (longer periods) sample a larger portion of the structure, where faster layers are present: phase velocity c is therefore faster



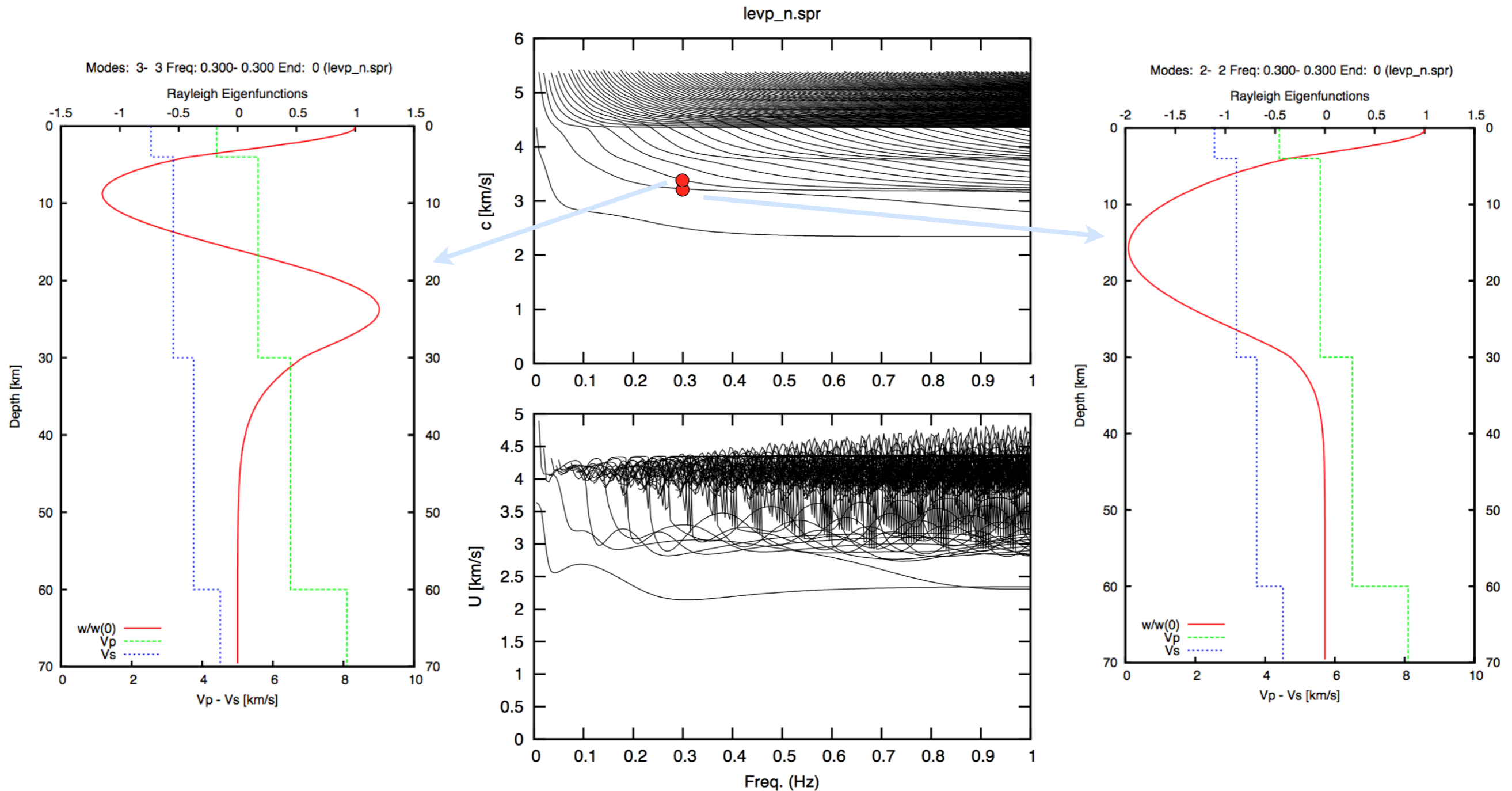
Surface wave dispersion

- For a given frequency, higher modes sample a larger portion of the structure, where faster layers are present: phase velocity c is therefore faster



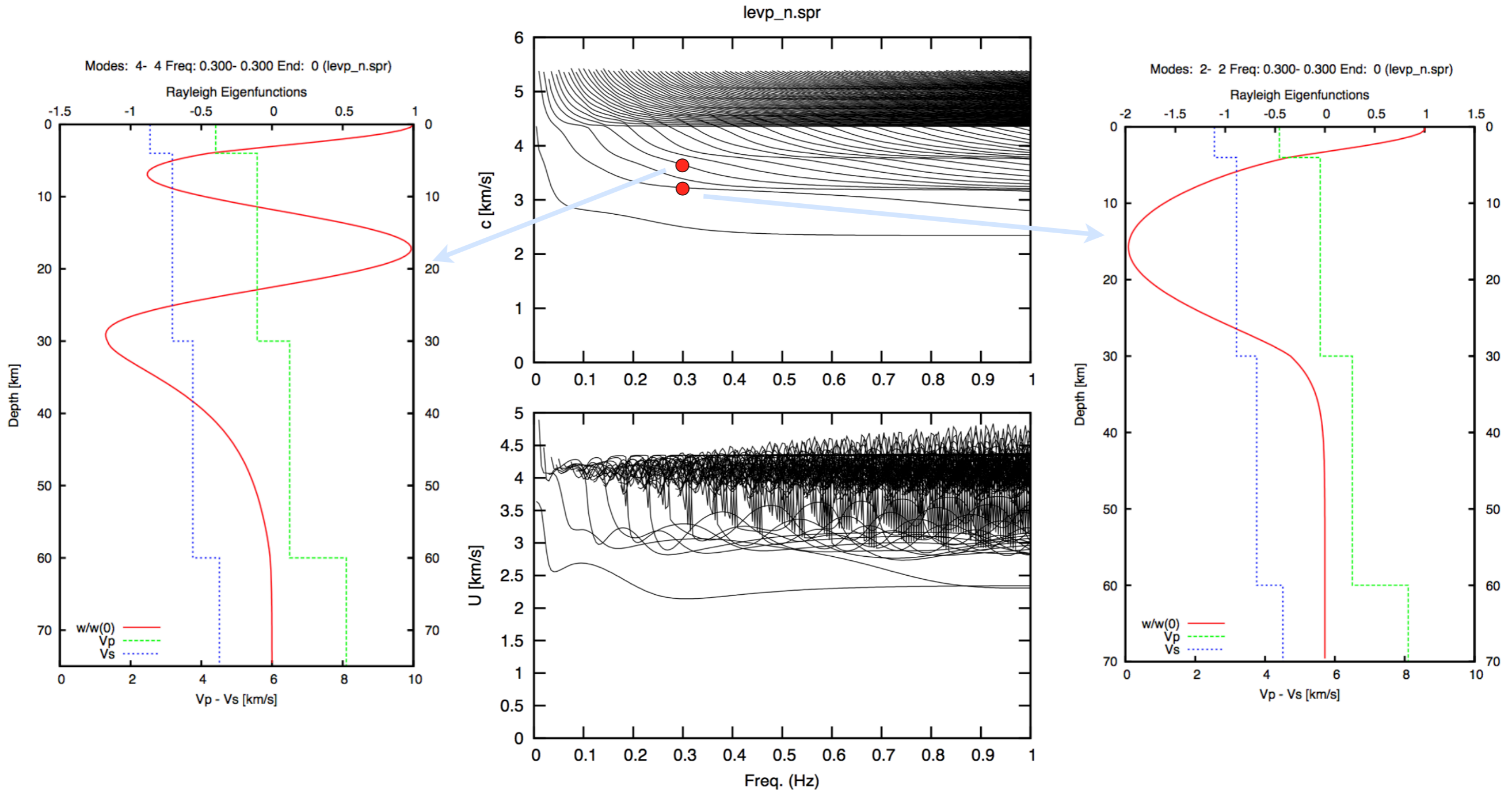
Surface wave dispersion

- For a given frequency, higher modes sample a larger portion of the structure, where faster layers are present: phase velocity c is therefore faster



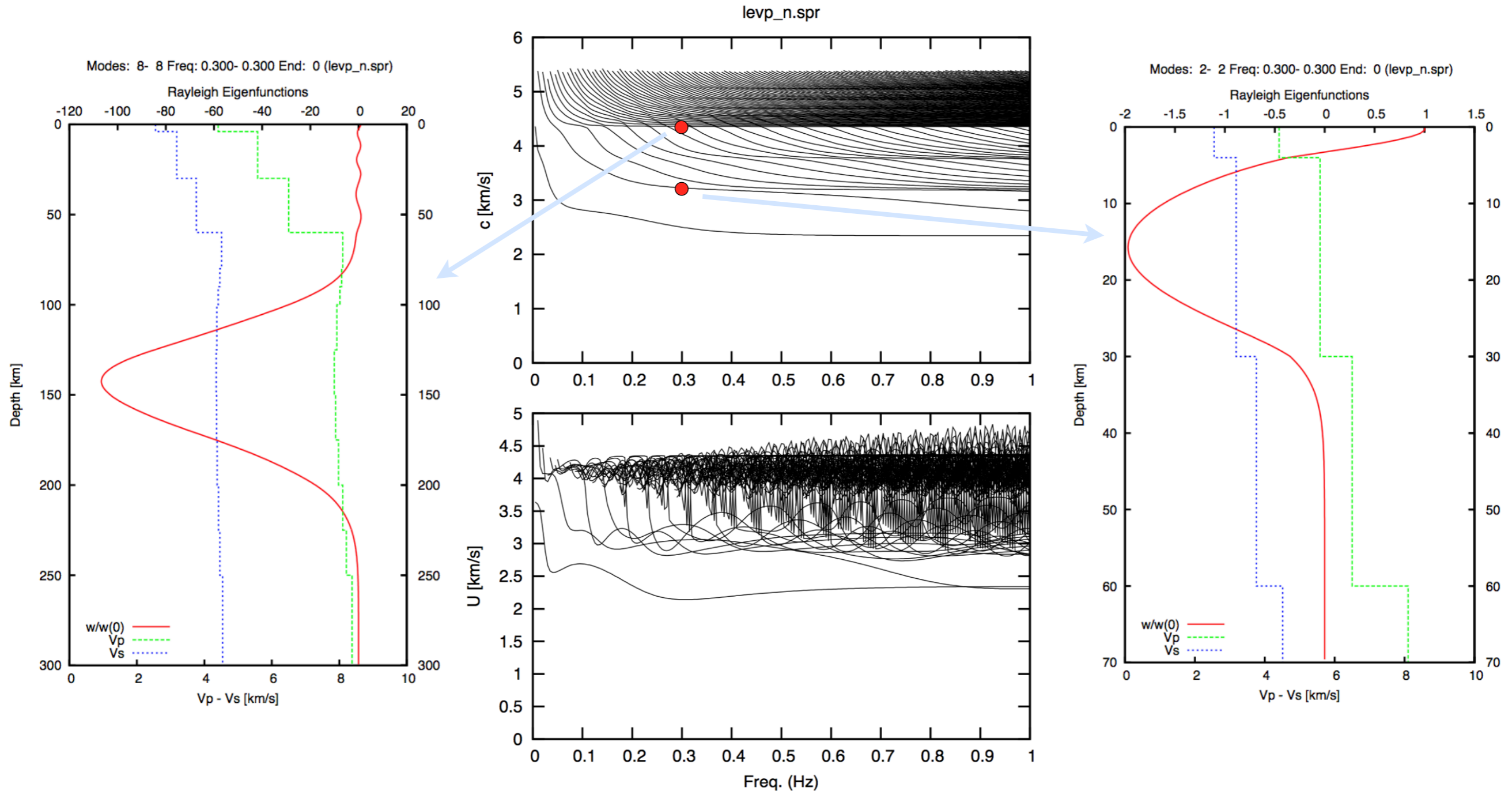
Surface wave dispersion

- For a given frequency, higher modes sample a larger portion of the structure, where faster layers are present: phase velocity c is therefore faster



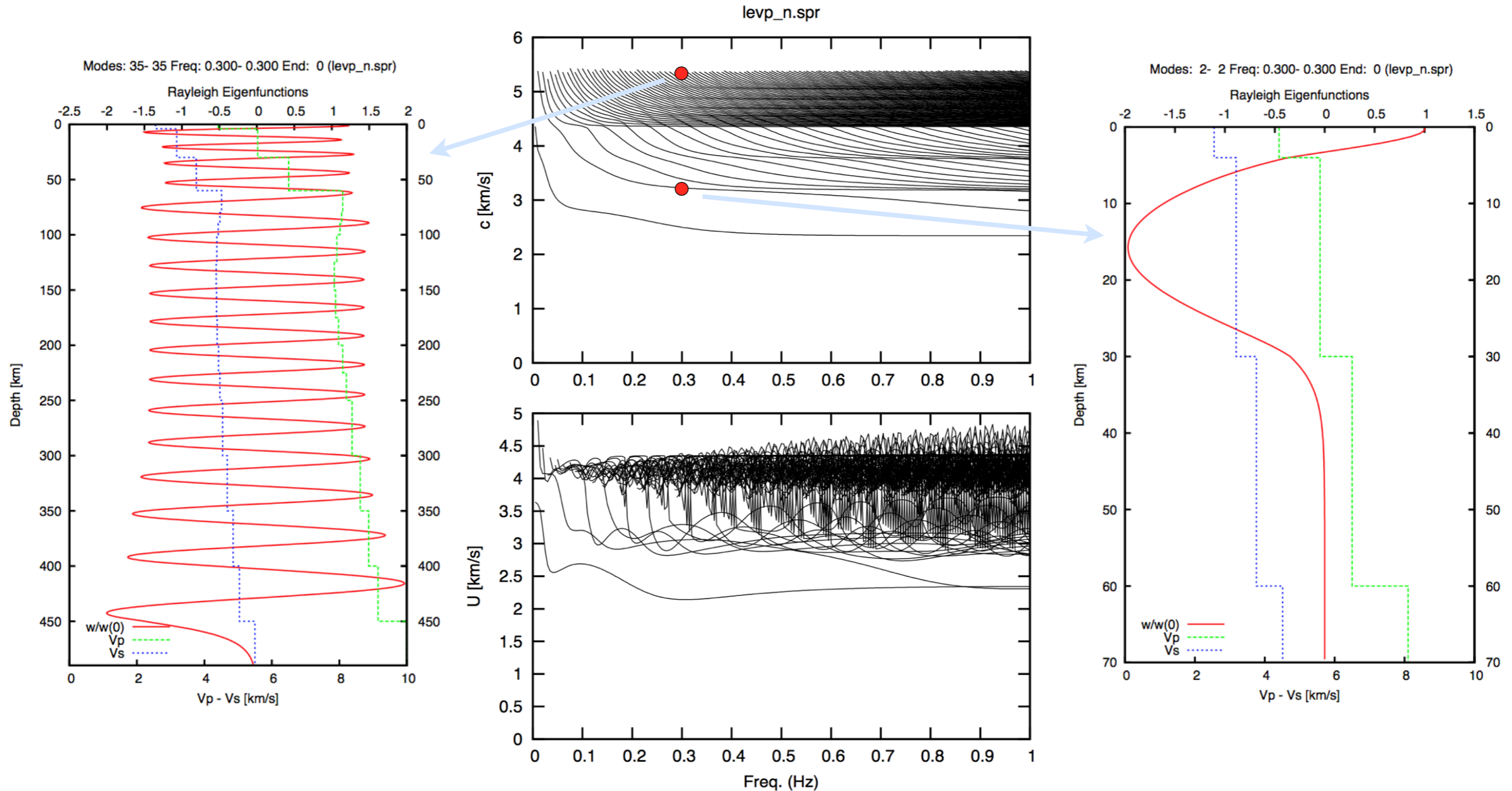
Surface wave dispersion

- For a given frequency, higher modes sample a larger portion of the structure, where faster layers are present: phase velocity c is therefore faster



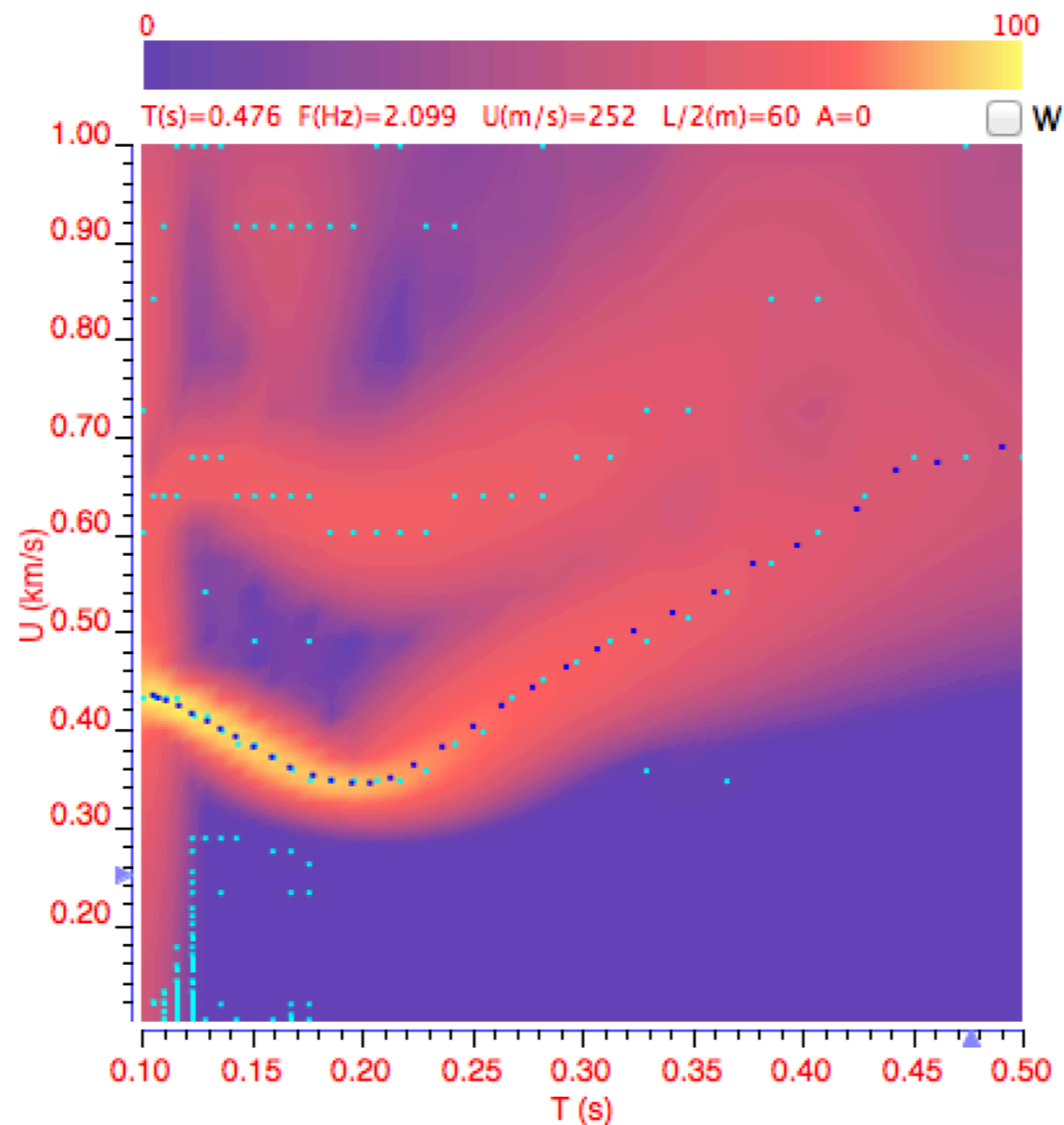
Surface wave dispersion

- For a given frequency, higher modes sample a larger portion of the structure, where faster layers are present: phase velocity c is therefore faster



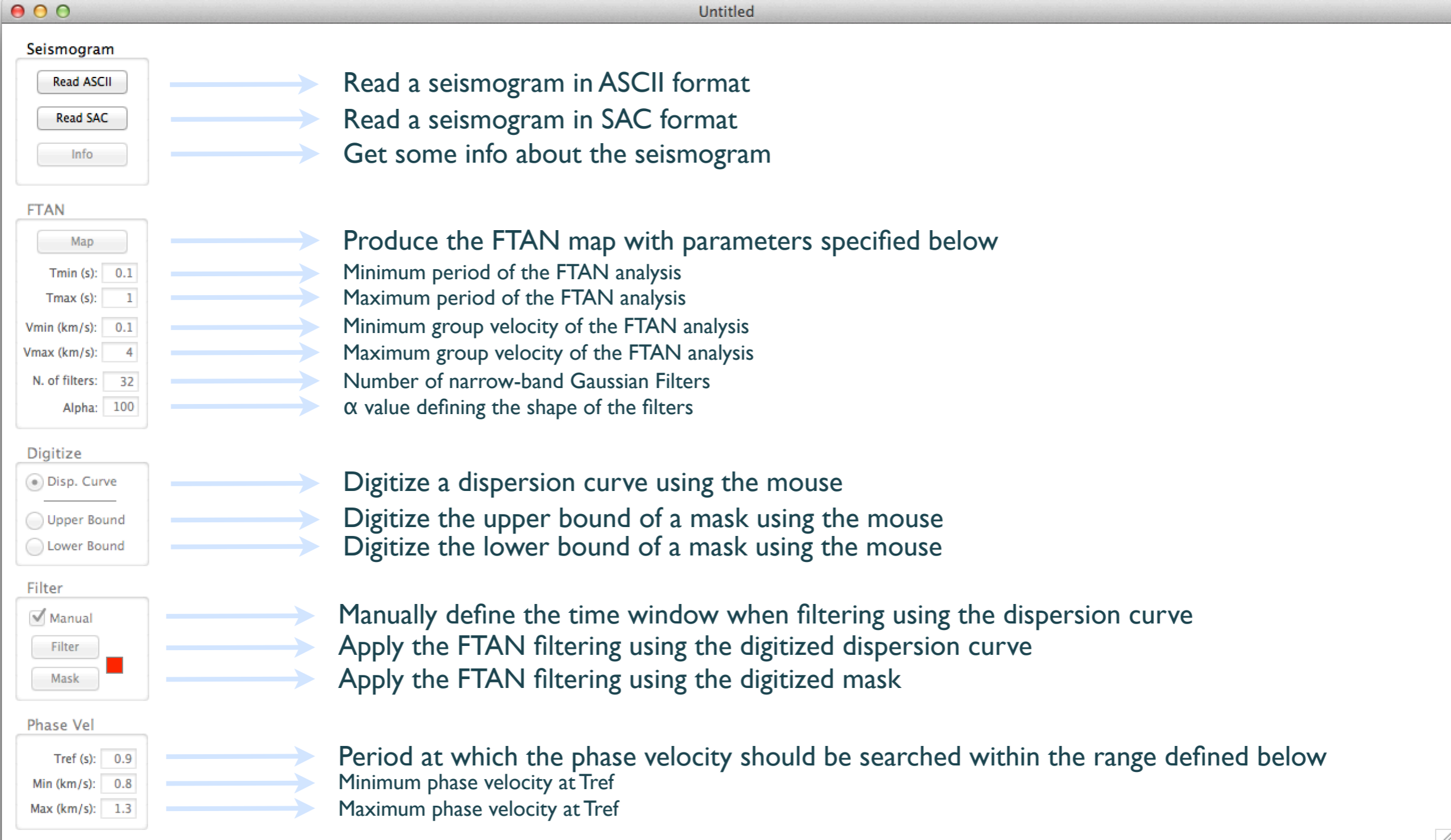
FTAN - Graphical representation

- Converting:
 - the frequency to period T
 - arrival times t of energy packets to group velocity U
- one has the typical FTAN map of a signal:



FTAN - XFTAN20123 graphic user interface

New empty window

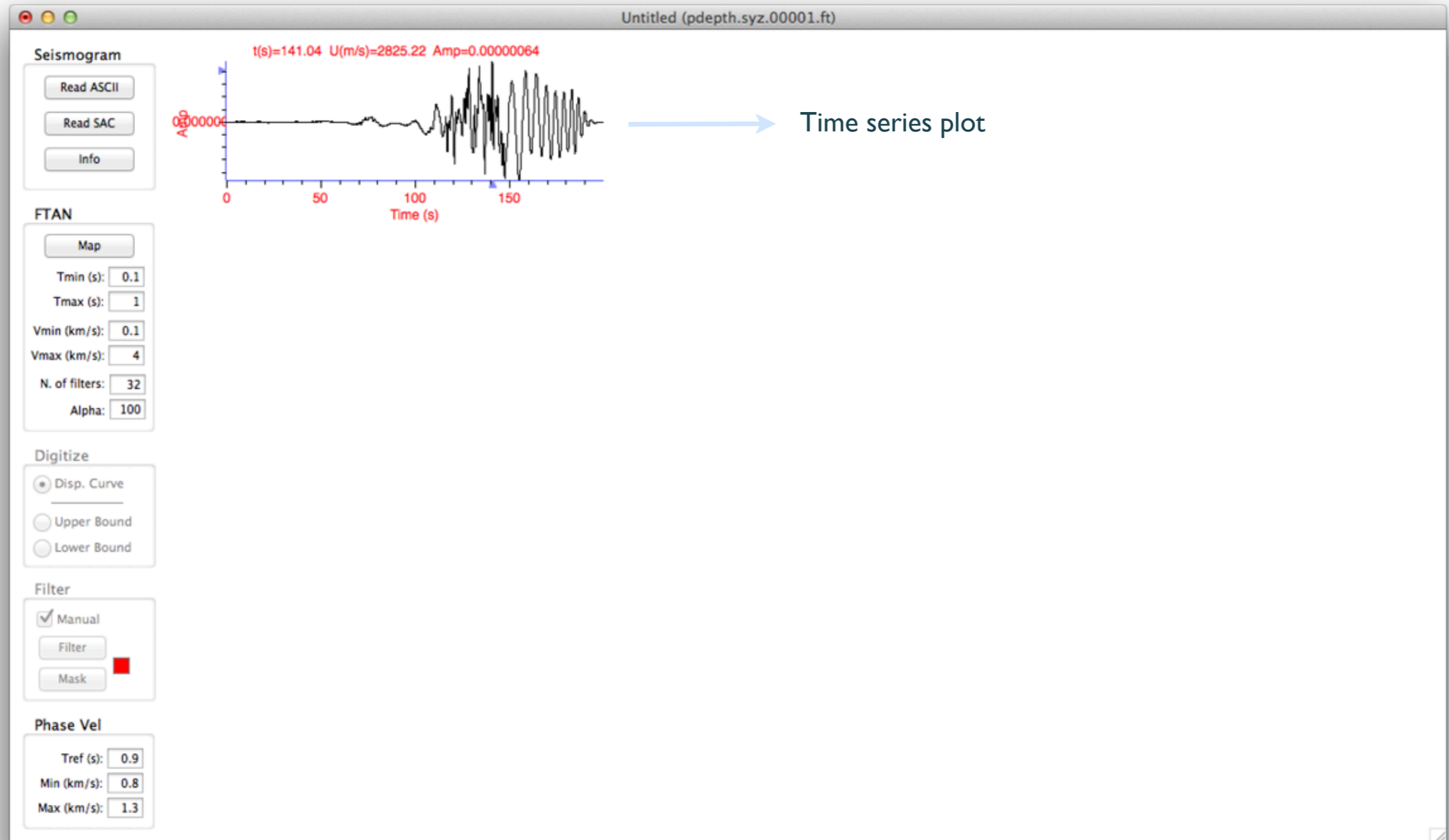


The screenshot shows a window titled "Untitled" with several control panels on the left and their corresponding functions on the right, connected by blue arrows.

- Seismogram**
 - Read ASCII → Read a seismogram in ASCII format
 - Read SAC → Read a seismogram in SAC format
 - Info → Get some info about the seismogram
- FTAN**
 - Map → Produce the FTAN map with parameters specified below
 - Tmin (s): 0.1 → Minimum period of the FTAN analysis
 - Tmax (s): 1 → Maximum period of the FTAN analysis
 - Vmin (km/s): 0.1 → Minimum group velocity of the FTAN analysis
 - Vmax (km/s): 4 → Maximum group velocity of the FTAN analysis
 - N. of filters: 32 → Number of narrow-band Gaussian Filters
 - Alpha: 100 → α value defining the shape of the filters
- Digitize**
 - Disp. Curve → Digitize a dispersion curve using the mouse
 - Upper Bound → Digitize the upper bound of a mask using the mouse
 - Lower Bound → Digitize the lower bound of a mask using the mouse
- Filter**
 - Manual → Manually define the time window when filtering using the dispersion curve
 - Filter → Apply the FTAN filtering using the digitized dispersion curve
 - Mask → Apply the FTAN filtering using the digitized mask
- Phase Vel**
 - Tref (s): 0.9 → Period at which the phase velocity should be searched within the range defined below
 - Min (km/s): 0.8 → Minimum phase velocity at Tref
 - Max (km/s): 1.3 → Maximum phase velocity at Tref

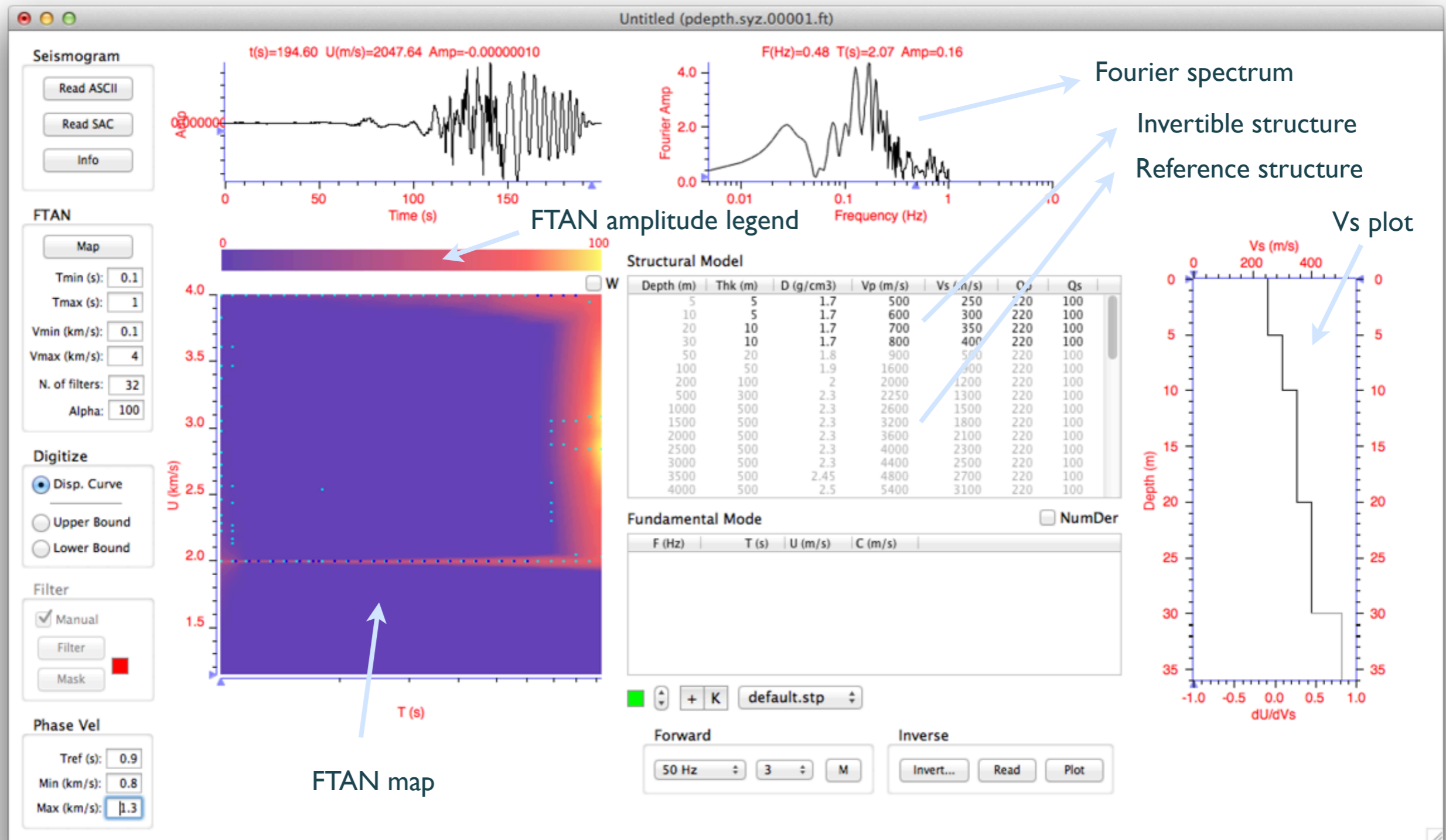
FTAN - XFTAN20123 graphic user interface

After reading a seismogram



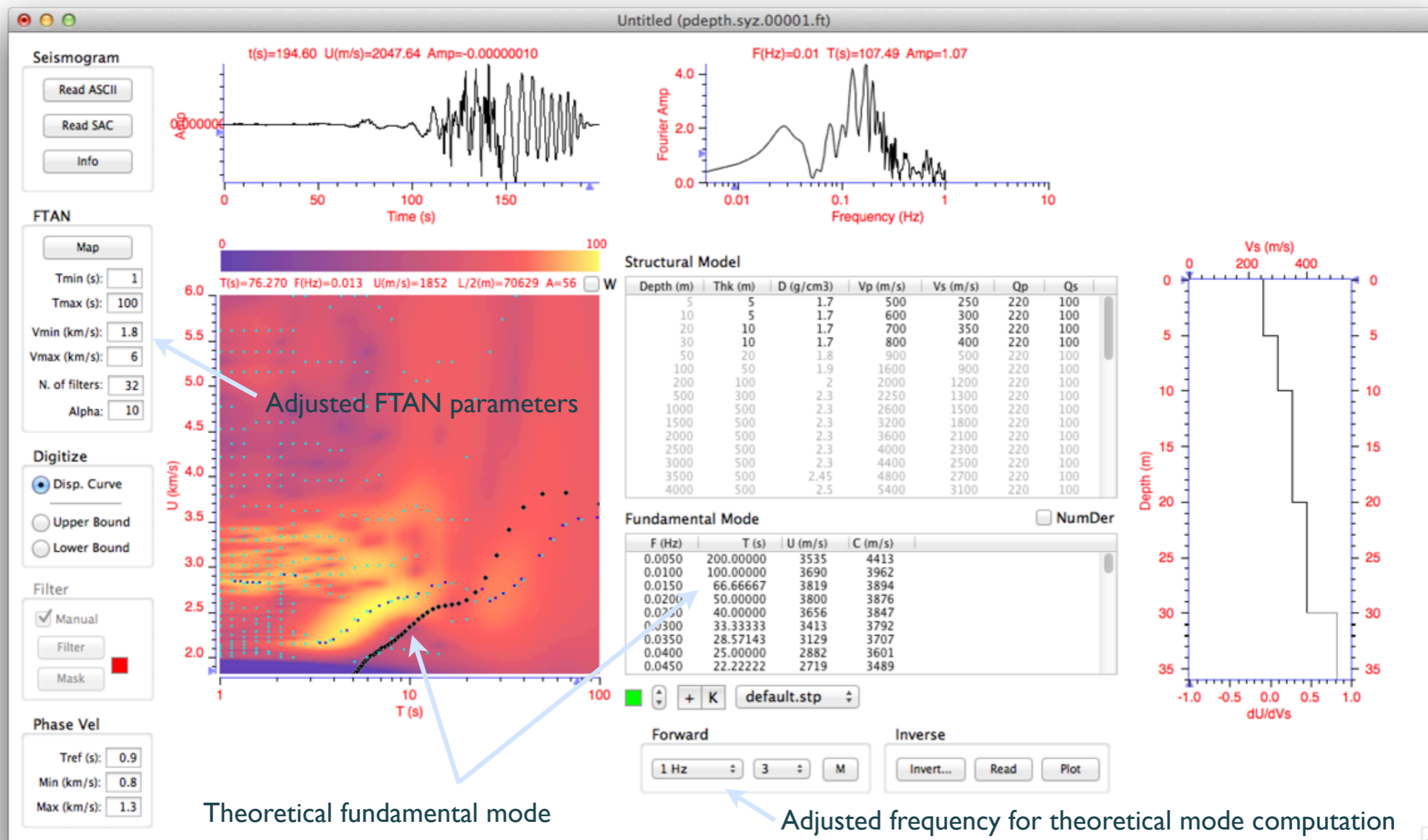
FTAN - XFTAN20123 graphic user interface

- FTAN map has been produced with default parameters



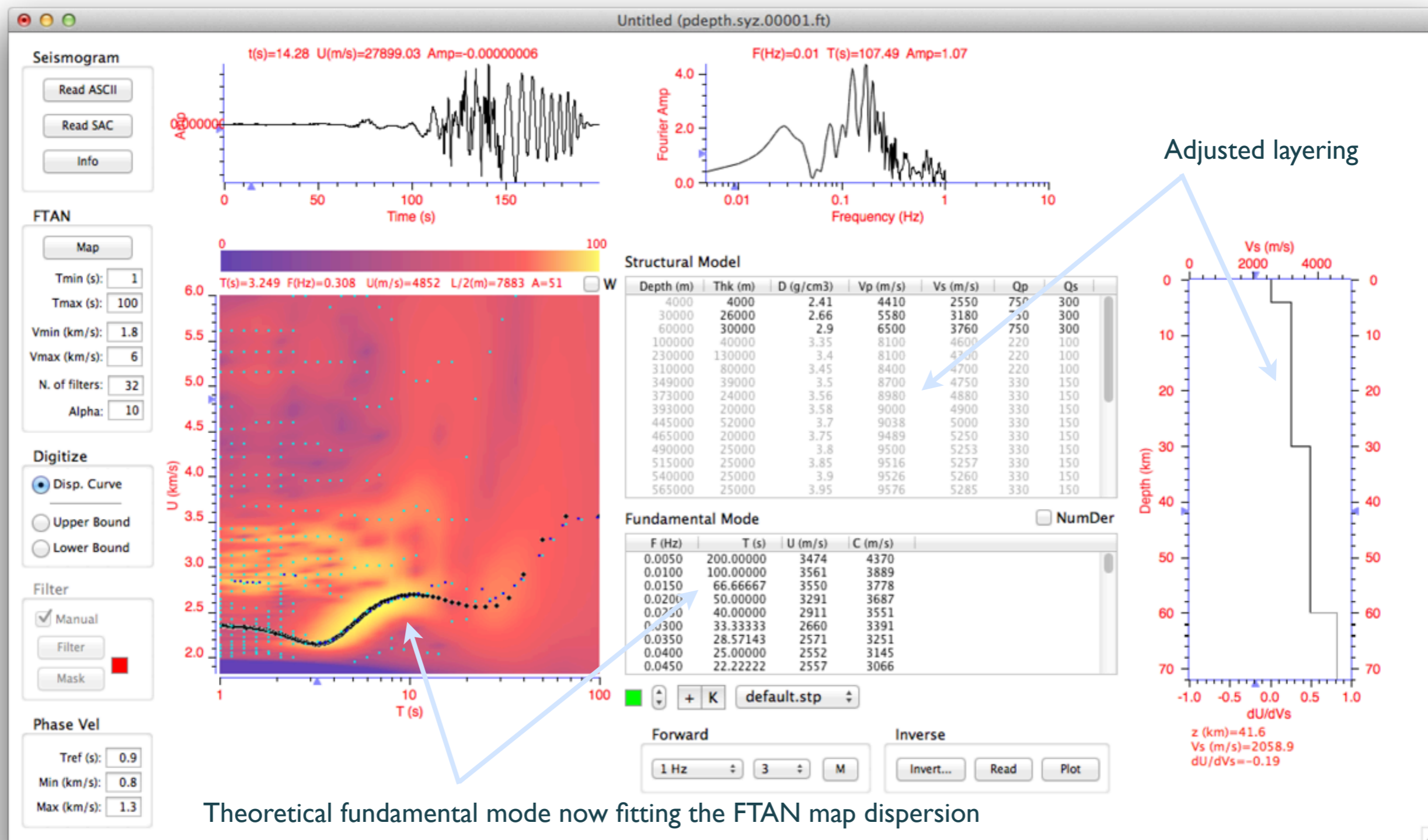
FTAN - XFTAN20123 graphic user interface

FTAN map after adjusting parameters



FTAN - XFTAN20123 graphic user interface

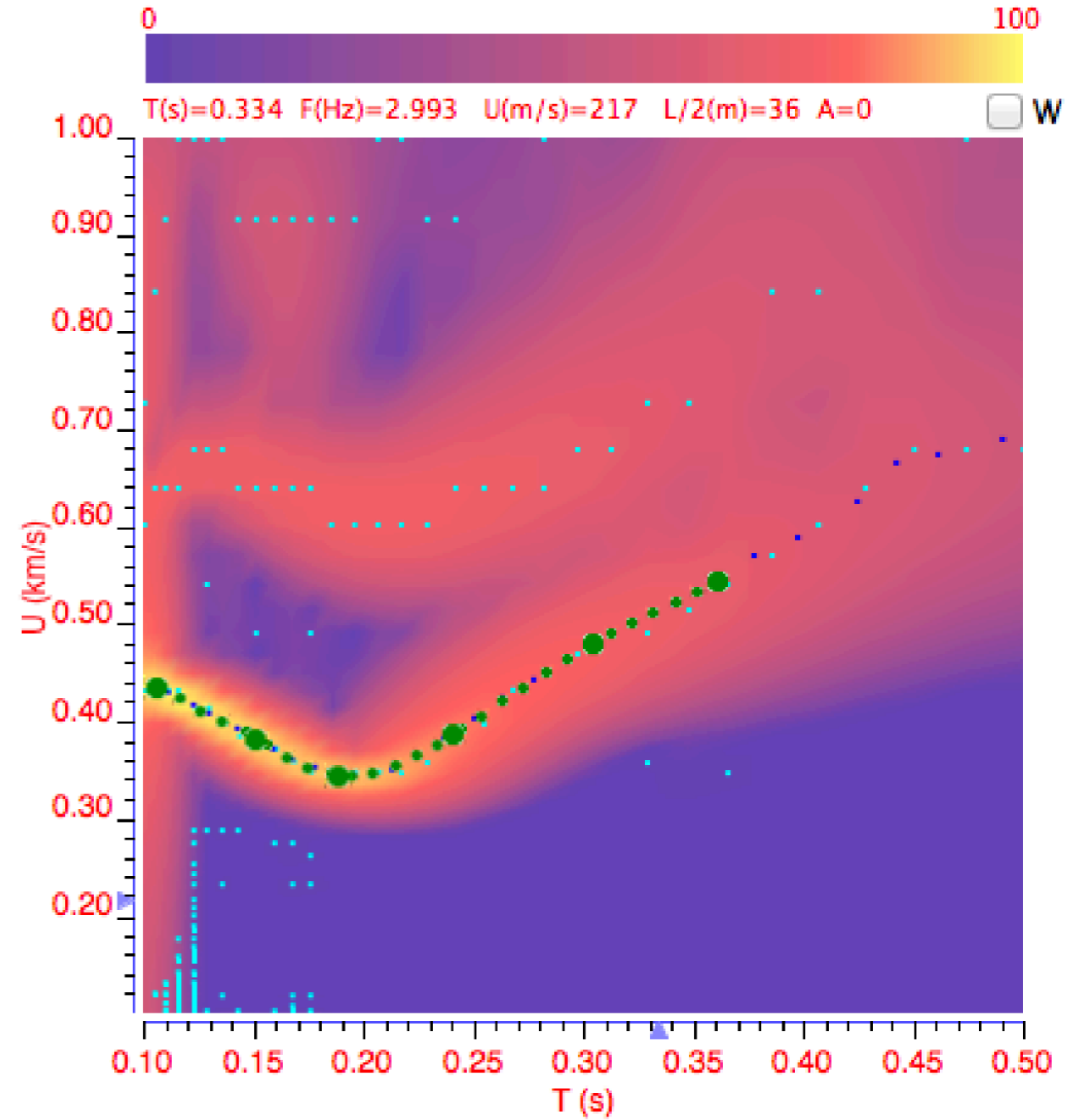
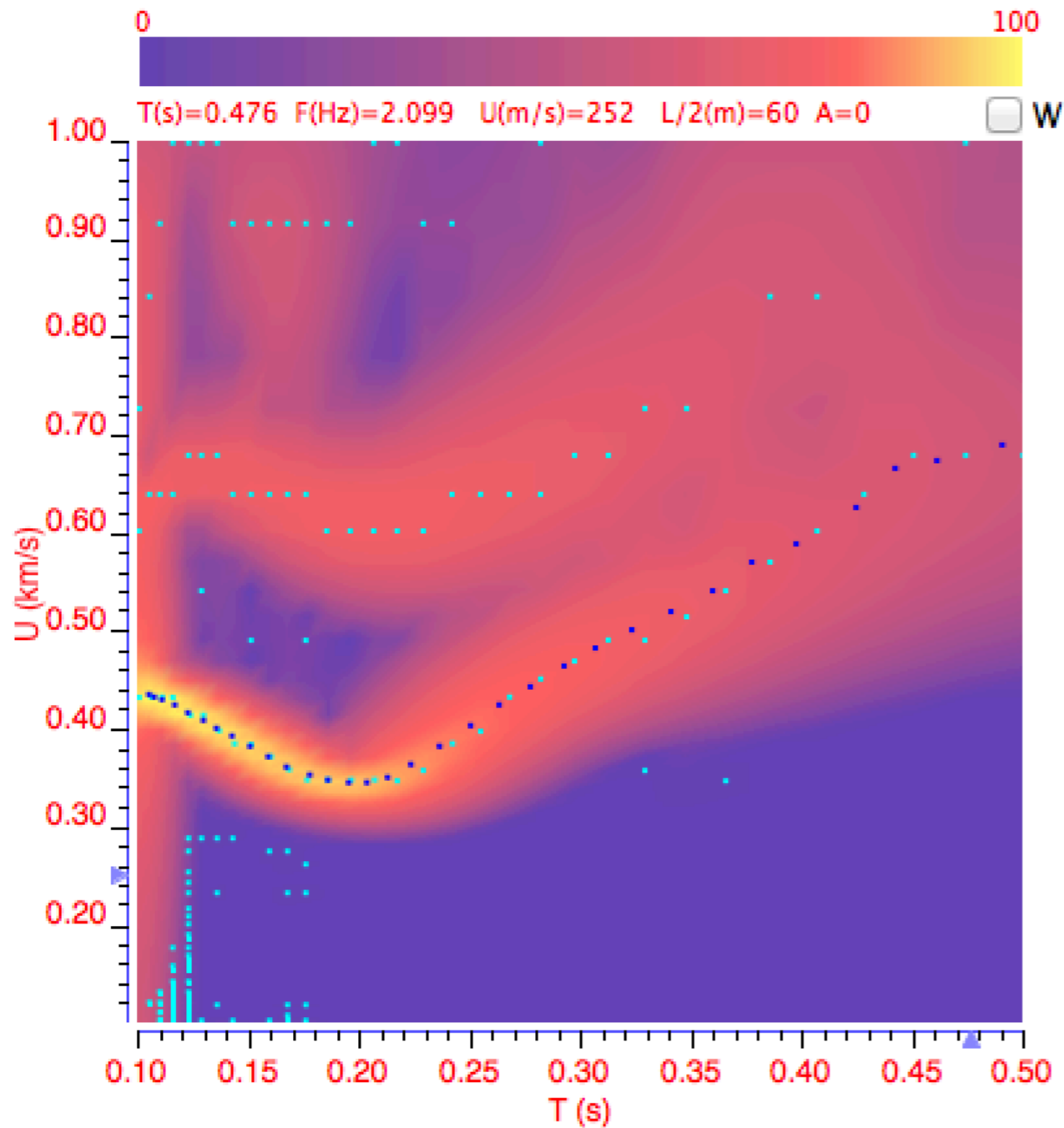
FTAN map after adjusting structure layering



Theoretical fundamental mode now fitting the FTAN map dispersion

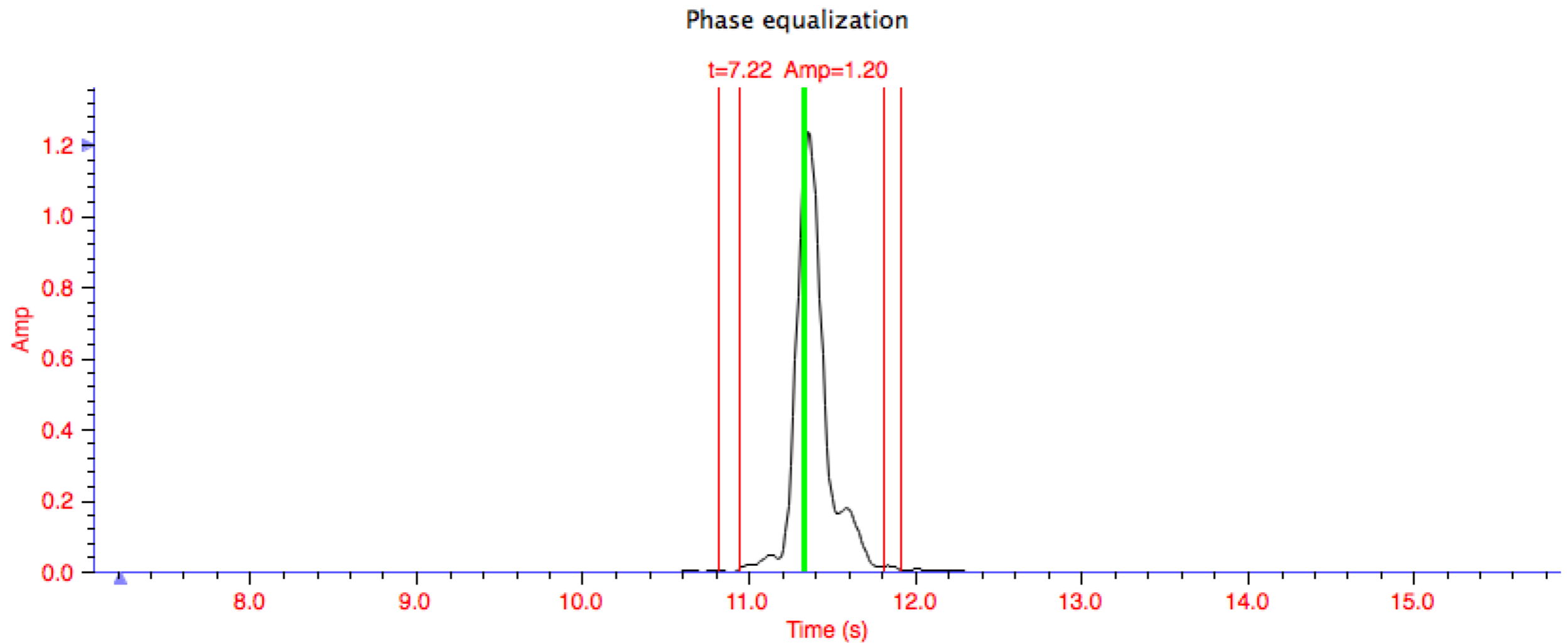
FTAN - Dispersion

- Dispersion curve of Rayleigh fundamental mode digitized manually by the user on the FTAN map (from synthetic seismogram)



FTAN - Phase equalization

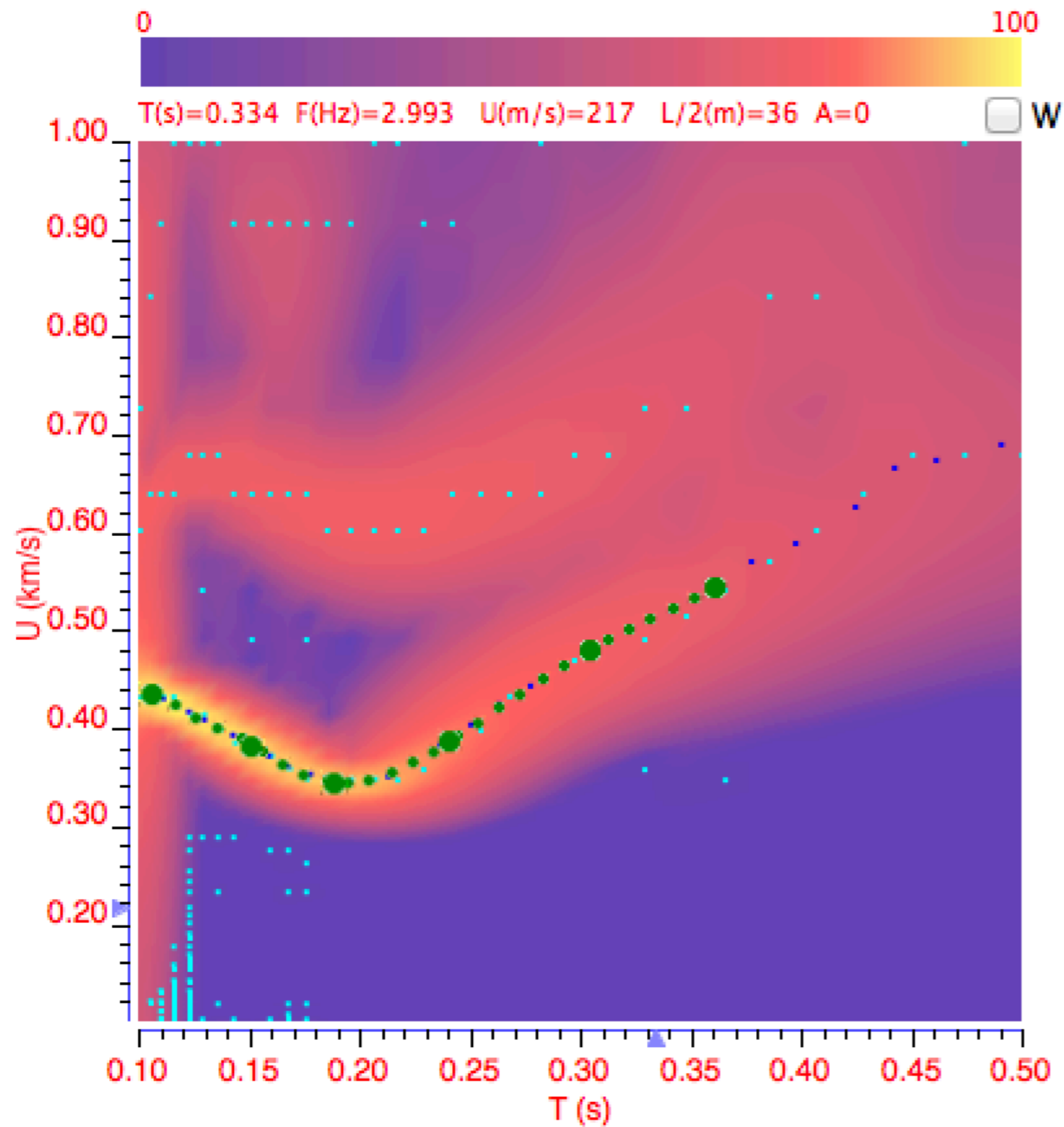
- Performed according to the user-identified dispersion relation for Rayleigh fundamental mode



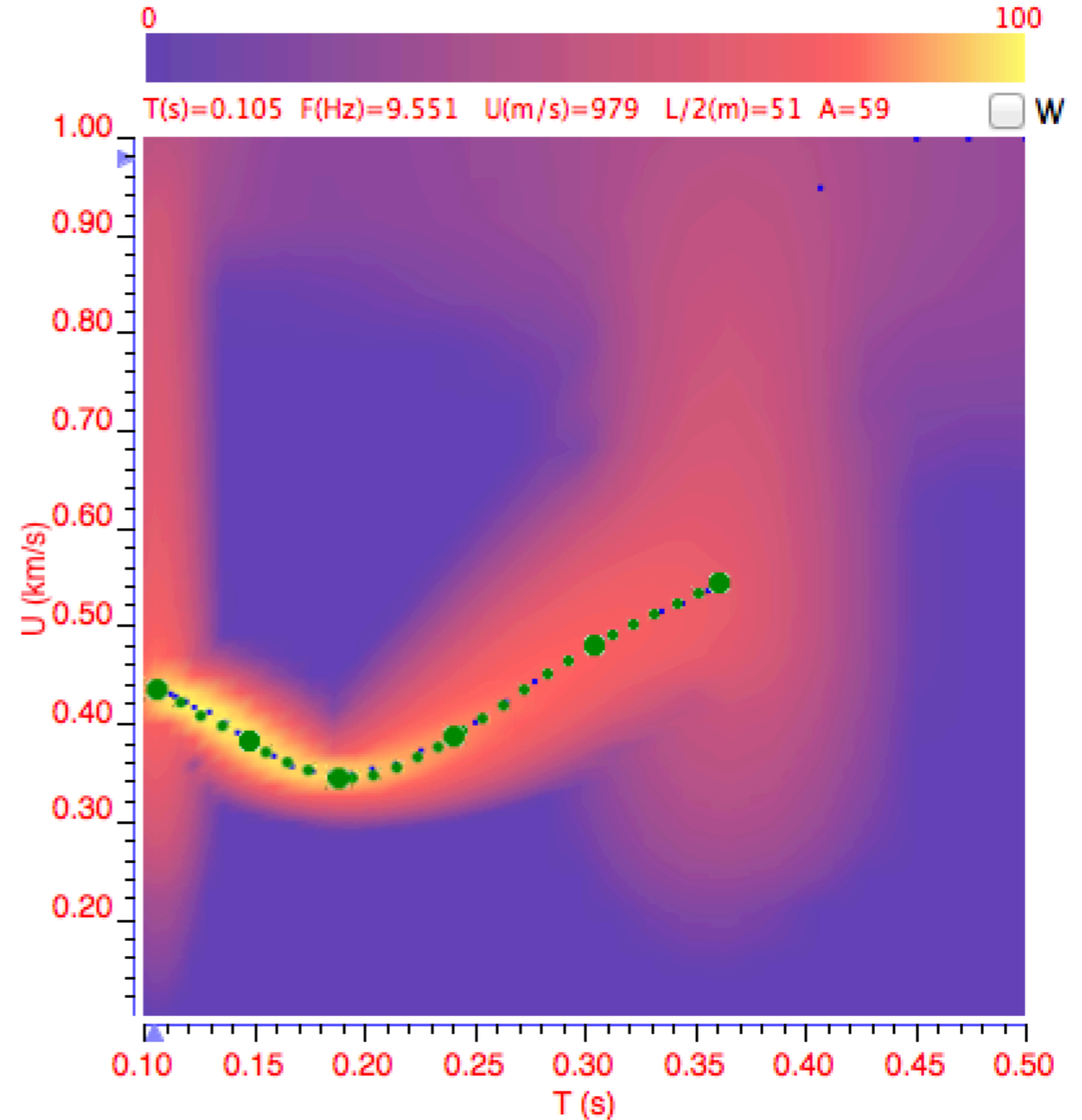
FTAN - Filtered map

- Filtered according to the user-identified dispersion relation for Rayleigh fundamental mode

Original

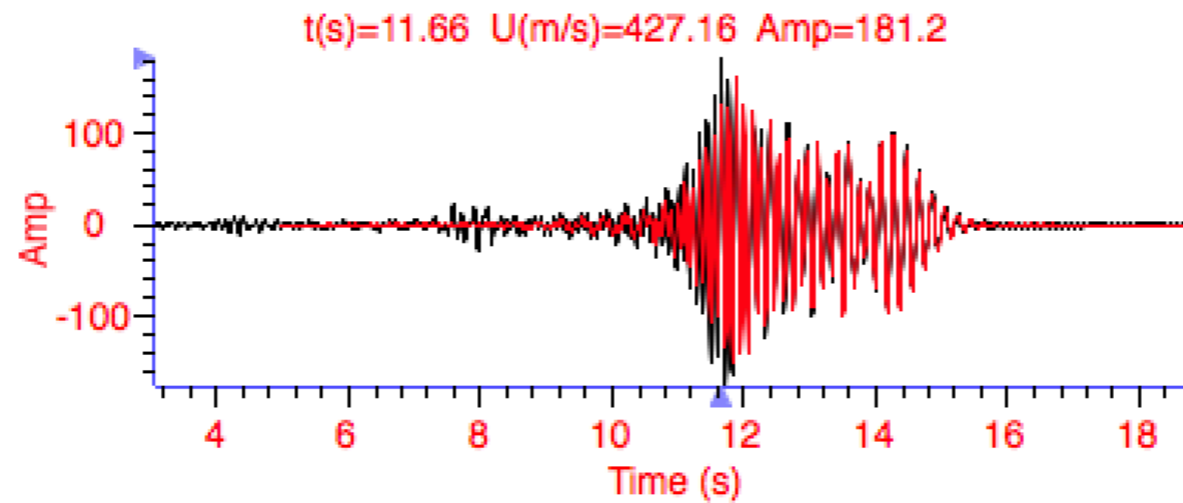


Filtered



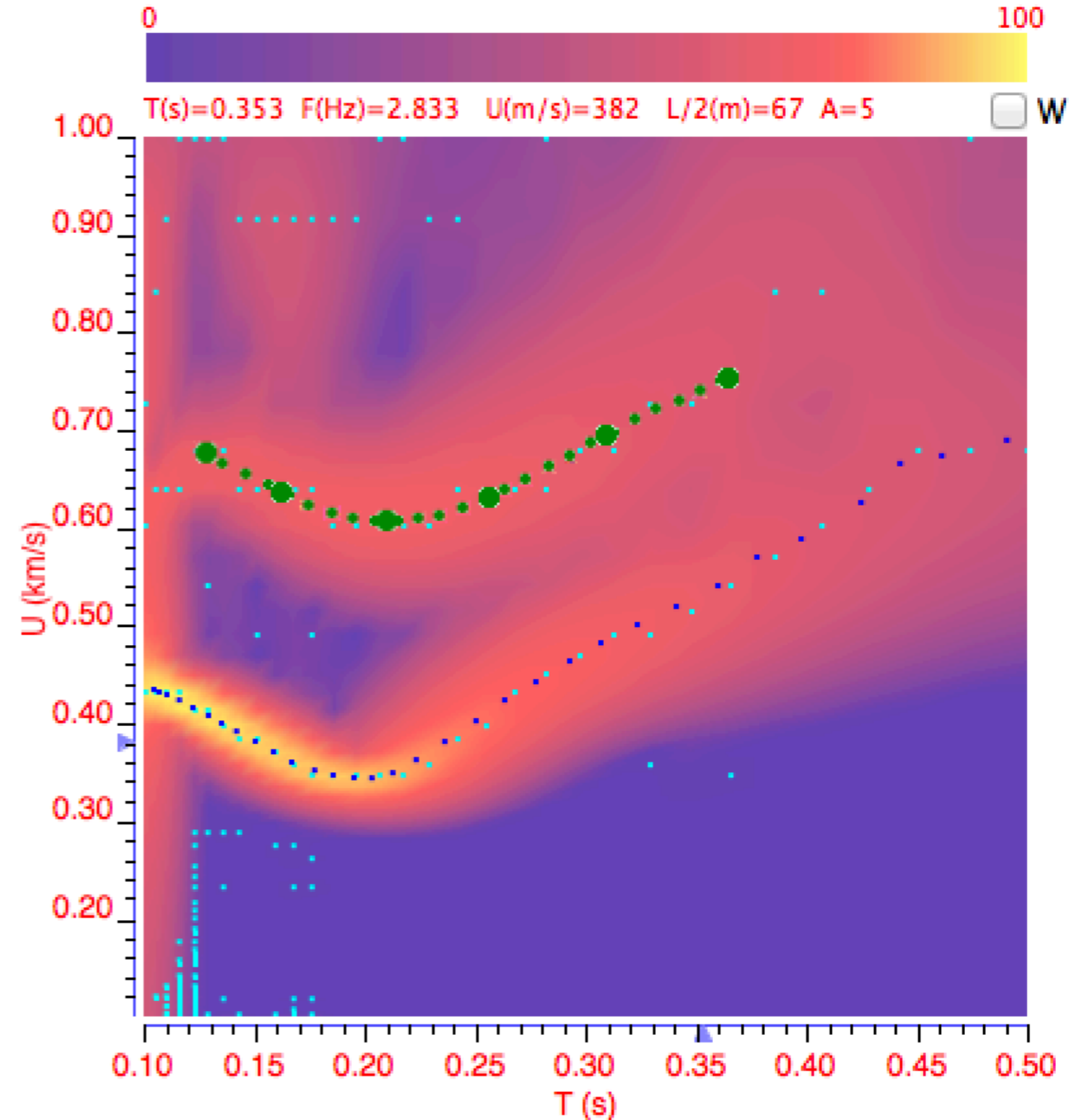
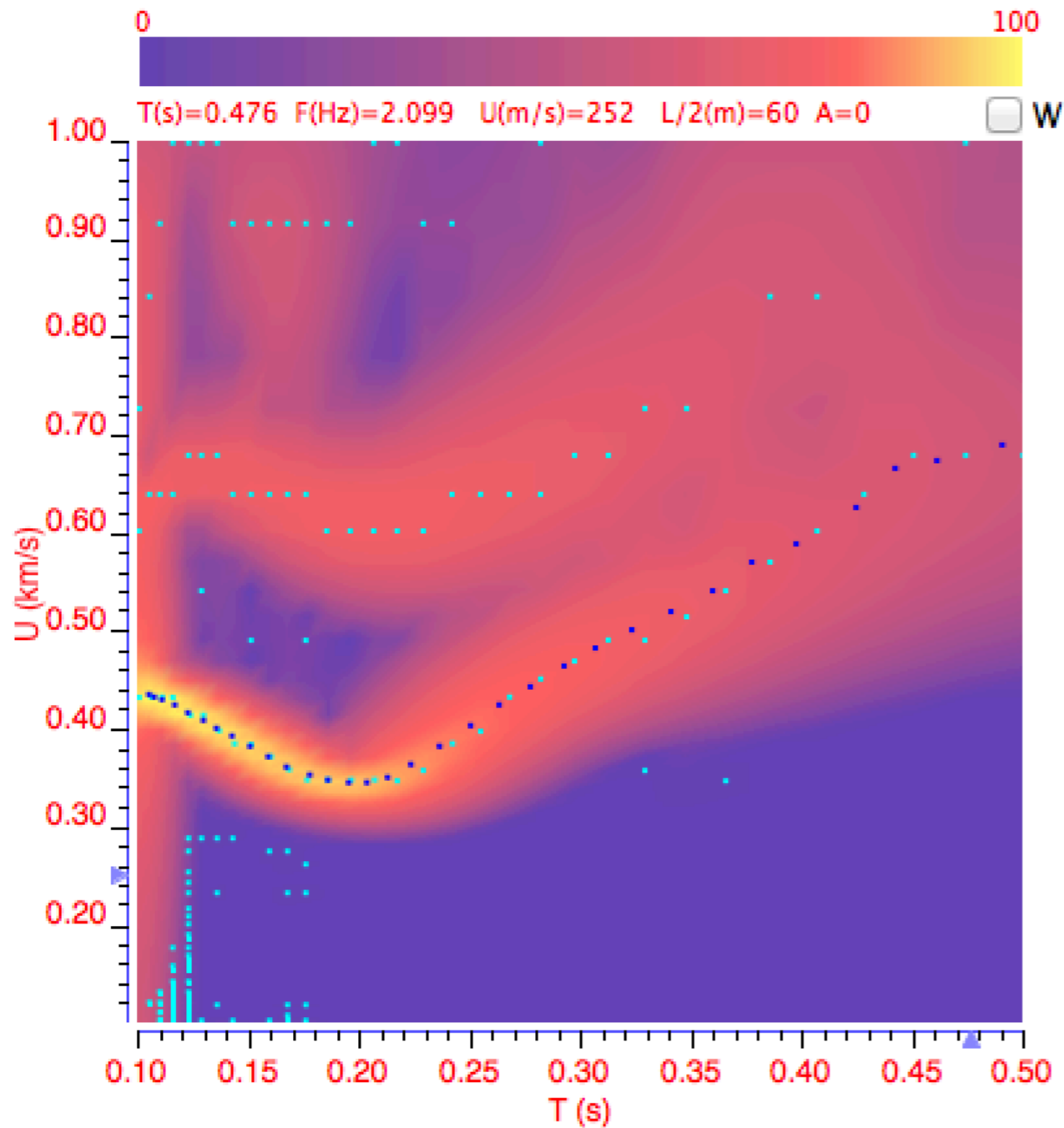
FTAN - Filtered seismogram

- Performed according to the user-identified dispersion relation for Rayleigh fundamental mode



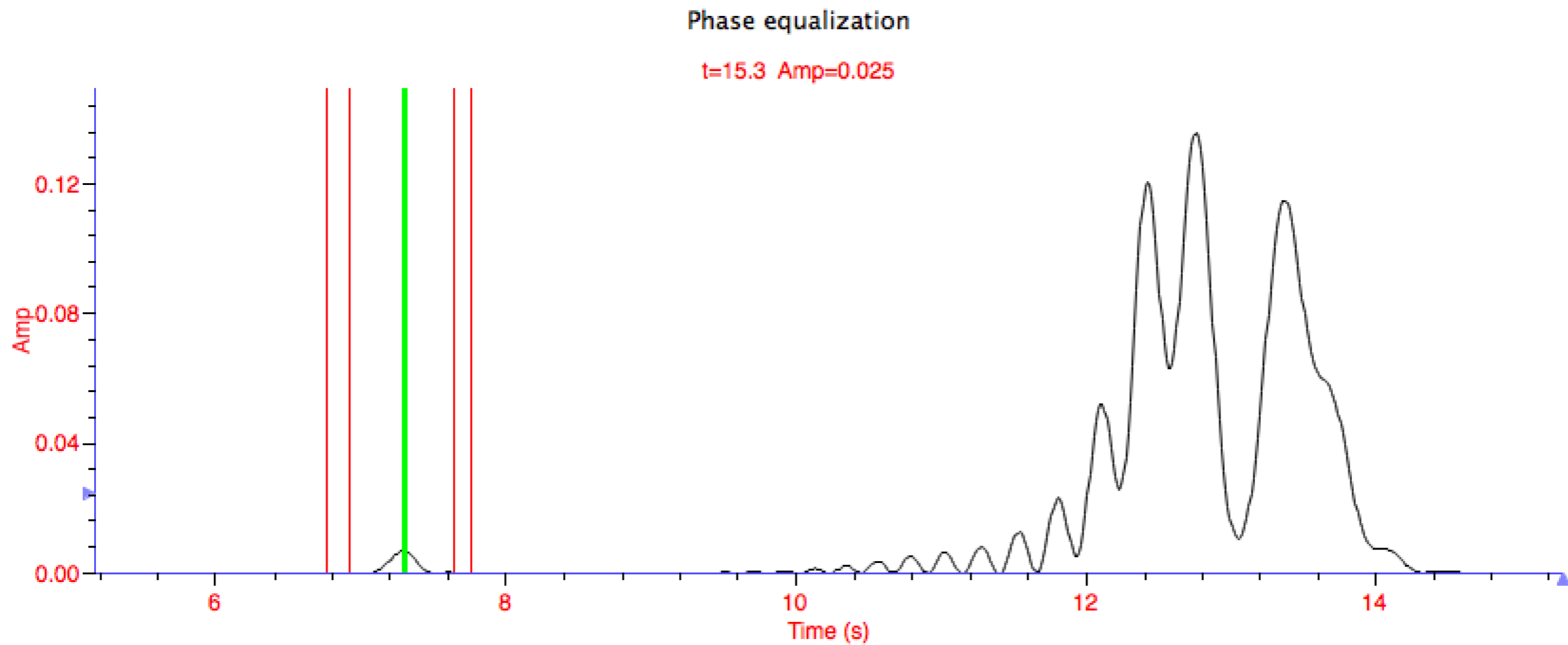
FTAN - Filtered map, higher mode

- Dispersion curve of Rayleigh higher mode(s) digitized manually by the user on the FTAN map



FTAN - Phase equalization

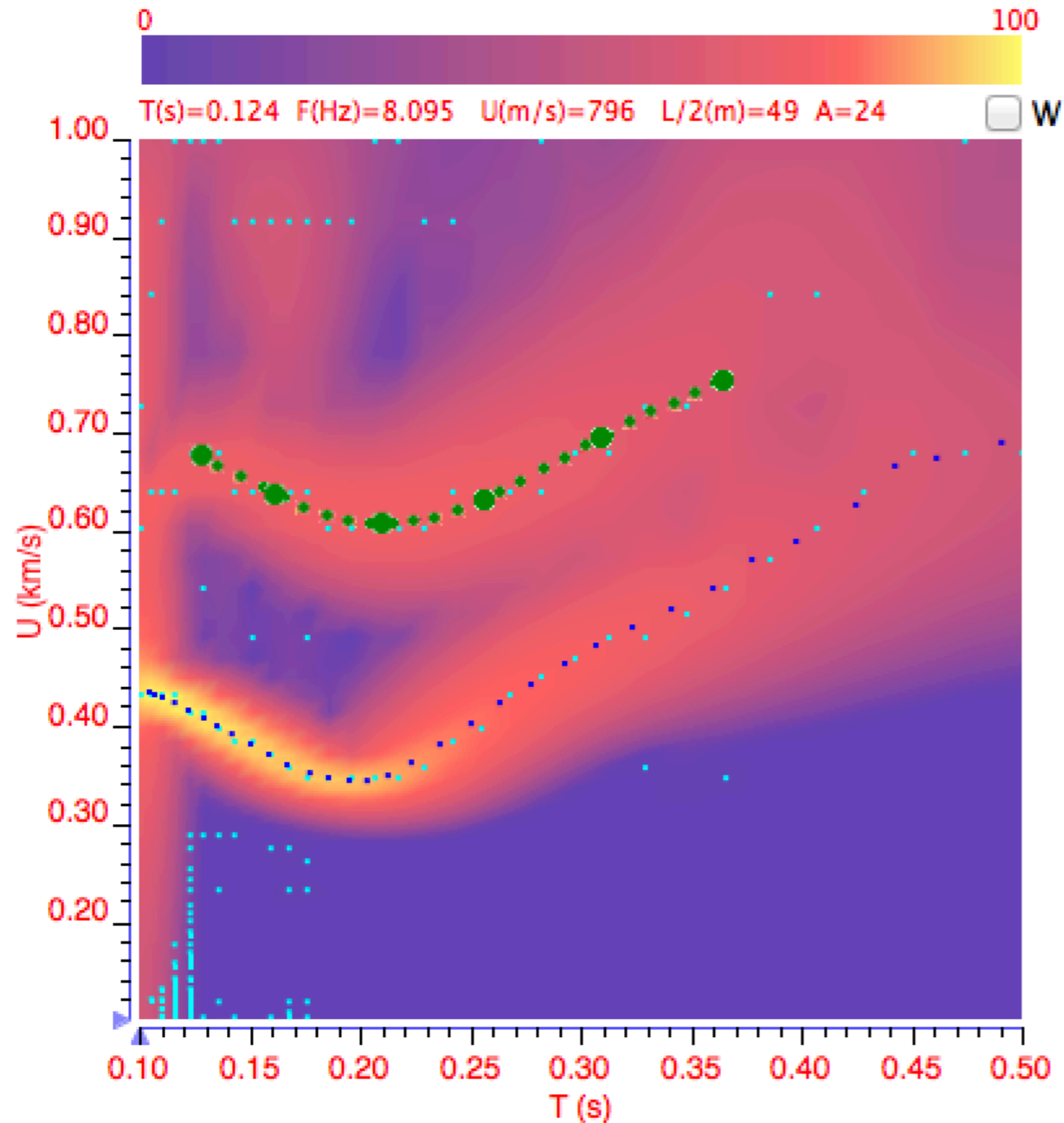
- Performed according to the user-identified dispersion relation for Rayleigh higher mode(s)



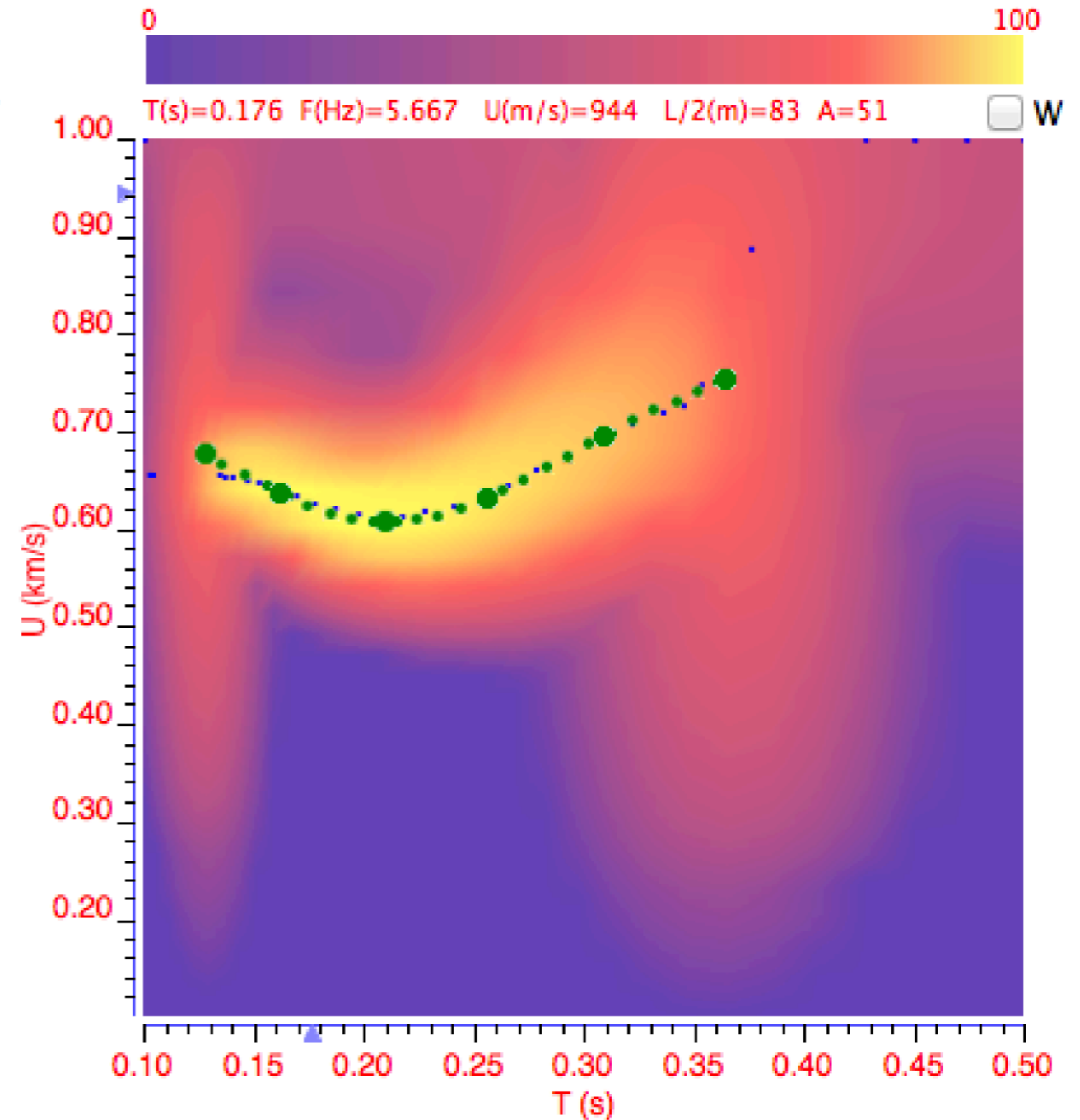
FTAN - Filtered map, higher mode

- Performed according to the user-identified dispersion relation for Rayleigh higher mode(s)

Original

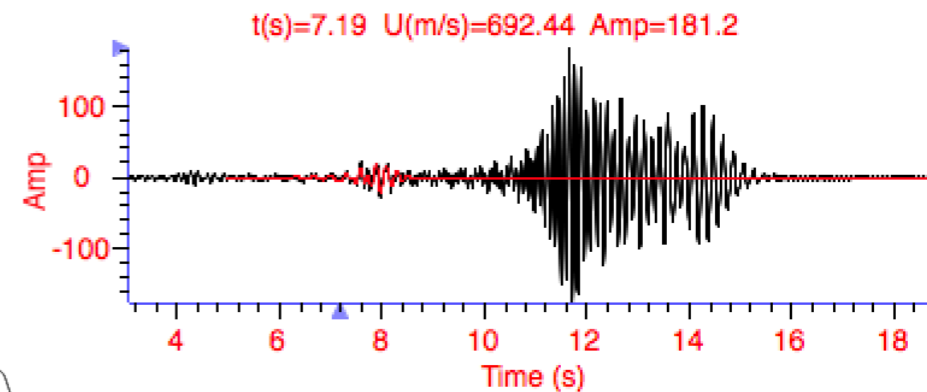
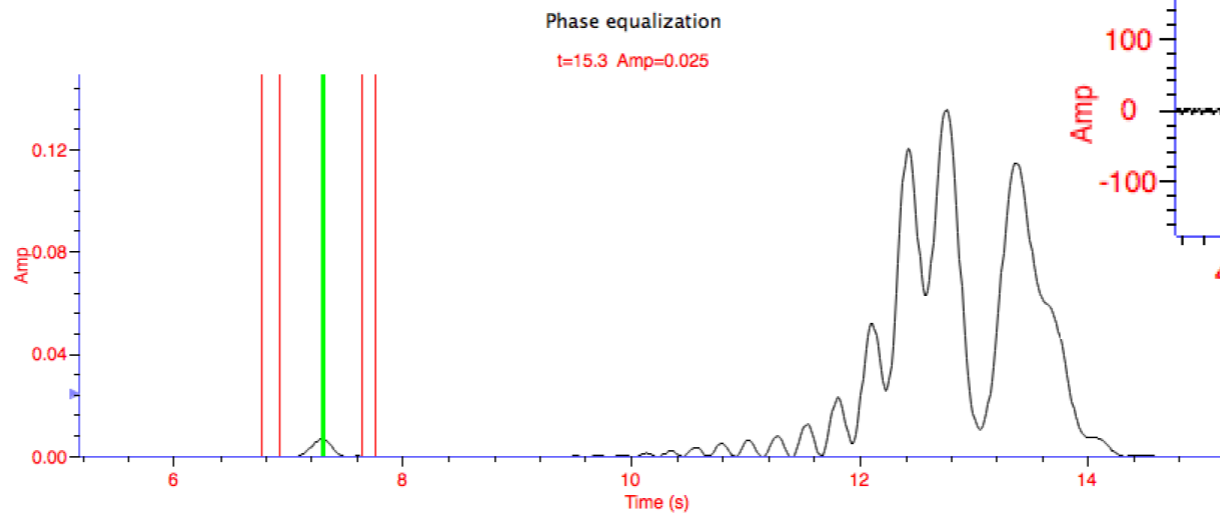
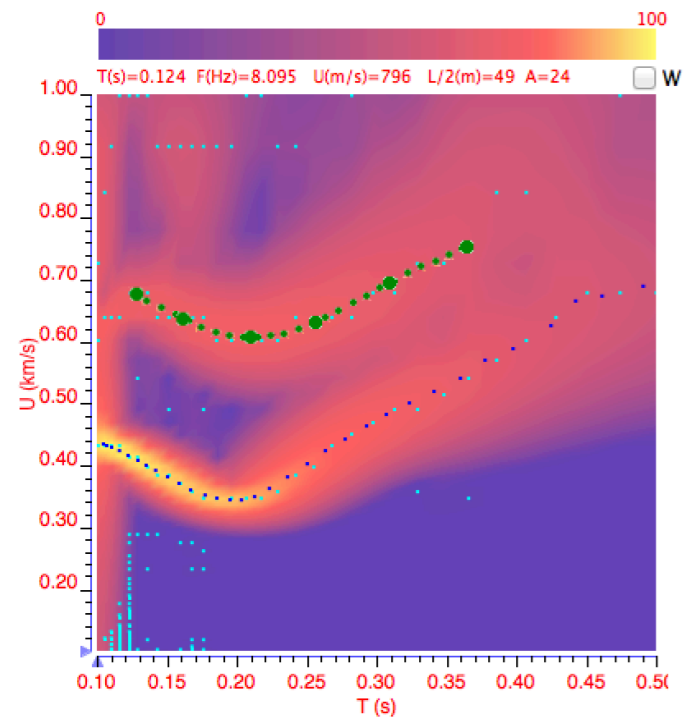
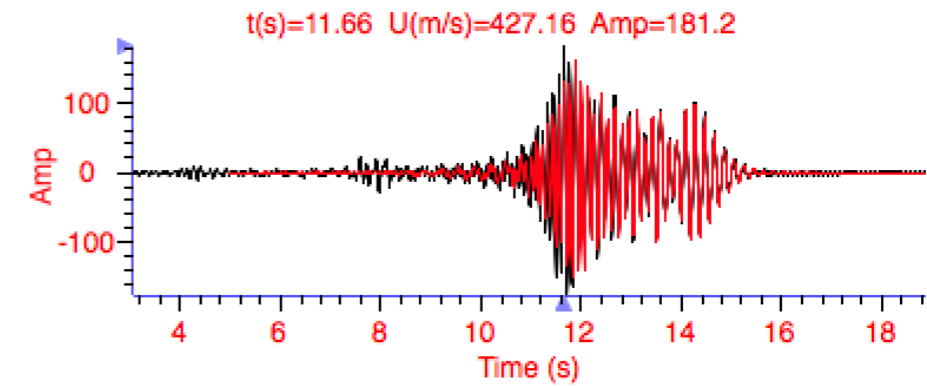
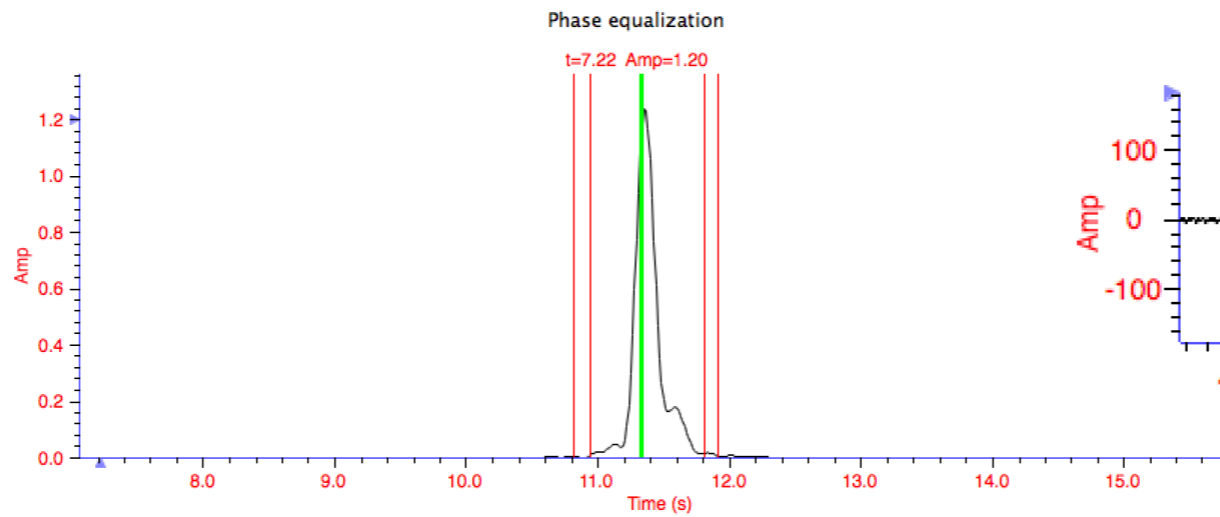
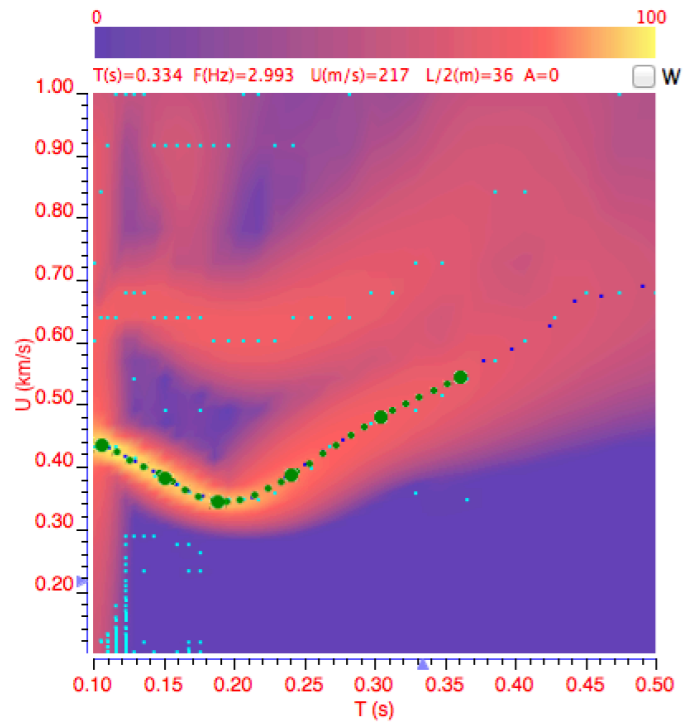


Filtered



FTAN - Filtered seismograms

Performed according to the user-identified dispersion relation



FTAN - Parametric tests from synthetics

● Effect of motion type:

- Same distribution of ridges in the FTAN map
- Change in the period range more evident in the FTAN map

● Effect of epicentral distance

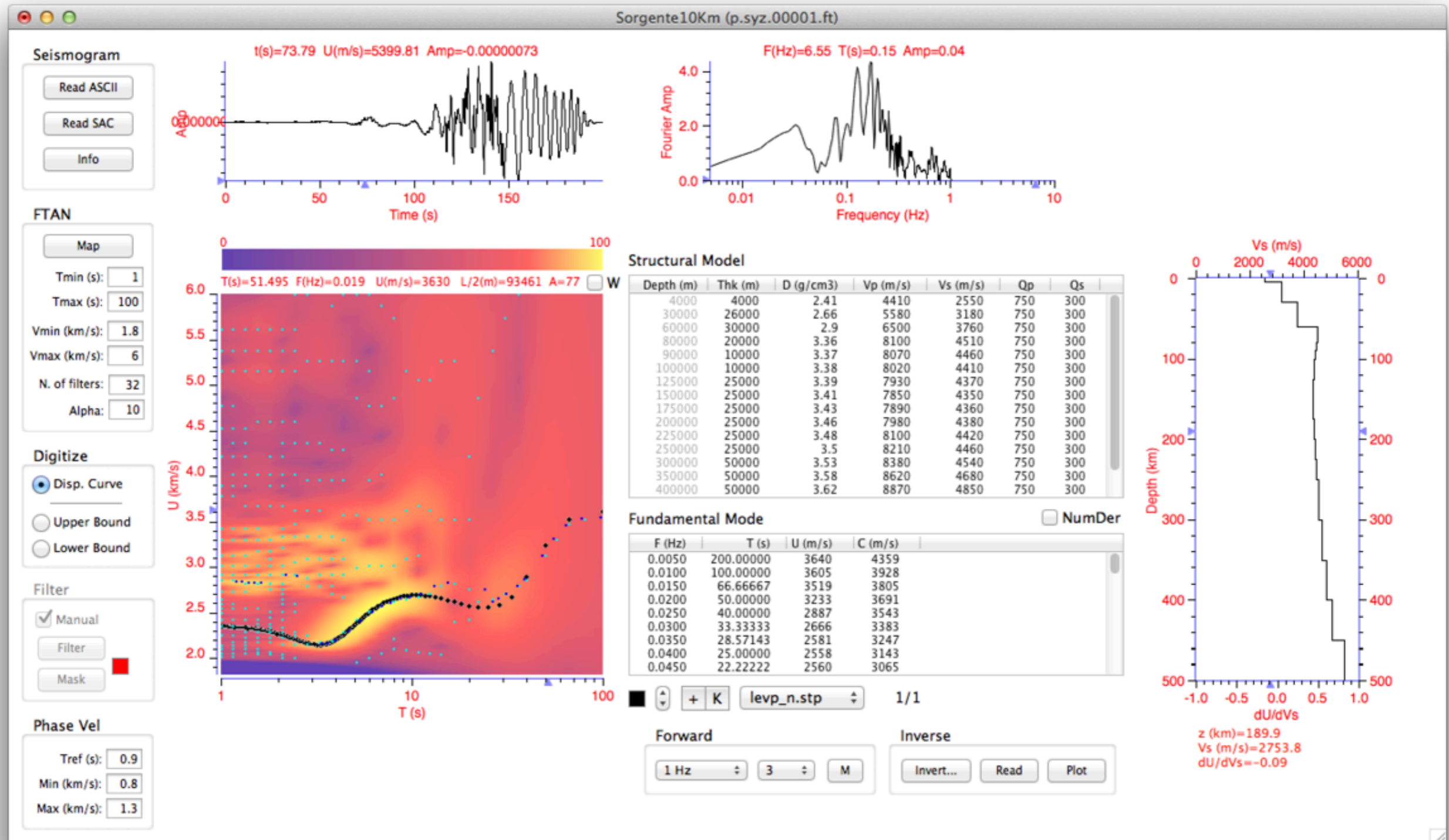
- Stable fundamental mode dispersion identification
- Better signal/noise ratio with increasing distance

● Effect of source depth

- Longer periods better excited by deeper sources for the same mode
- Different excitation of modes: higher modes better excited by deep sources

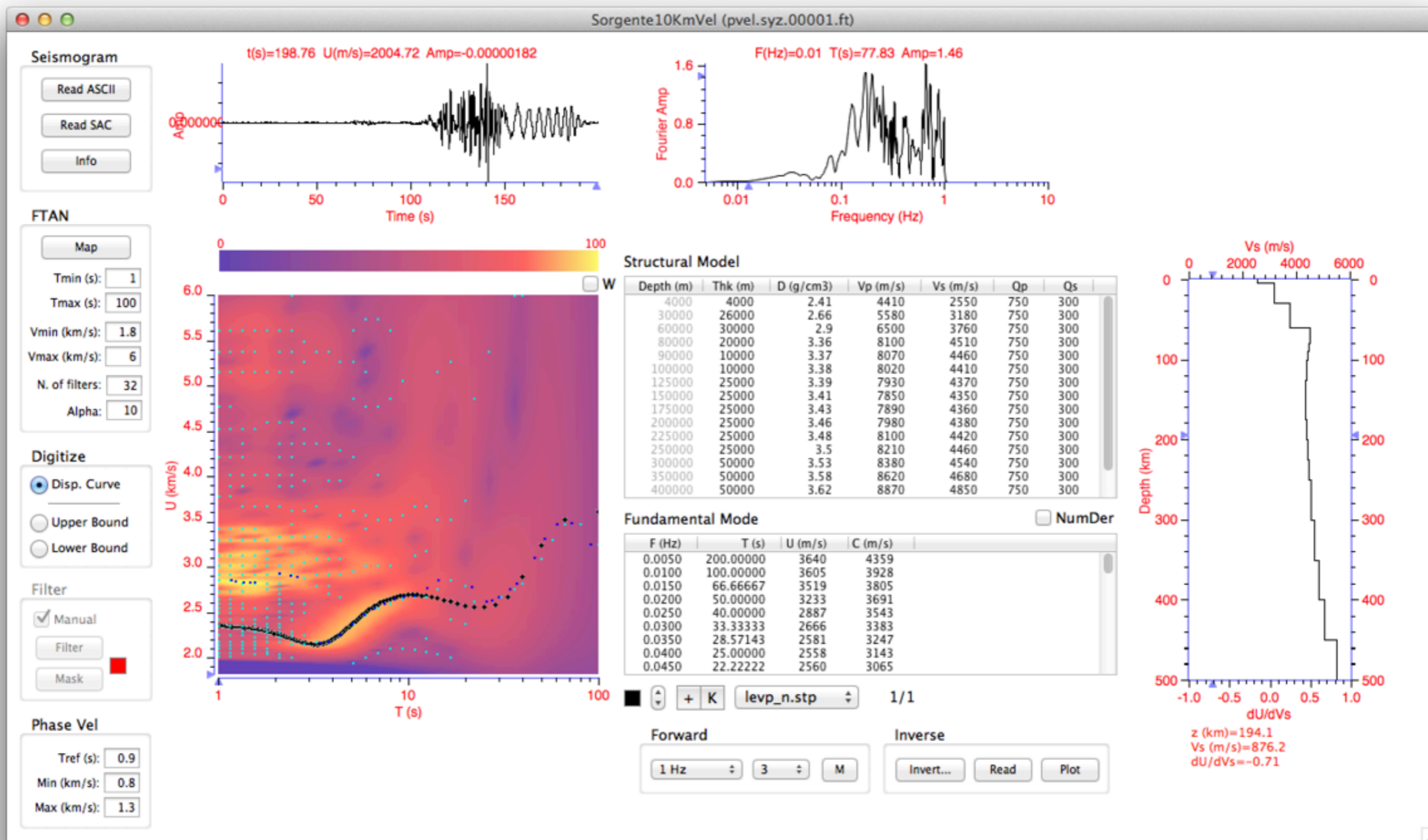
FTAN - Effect of motion type

Displacement time series



FTAN - Effect of motion type

Velocity time series



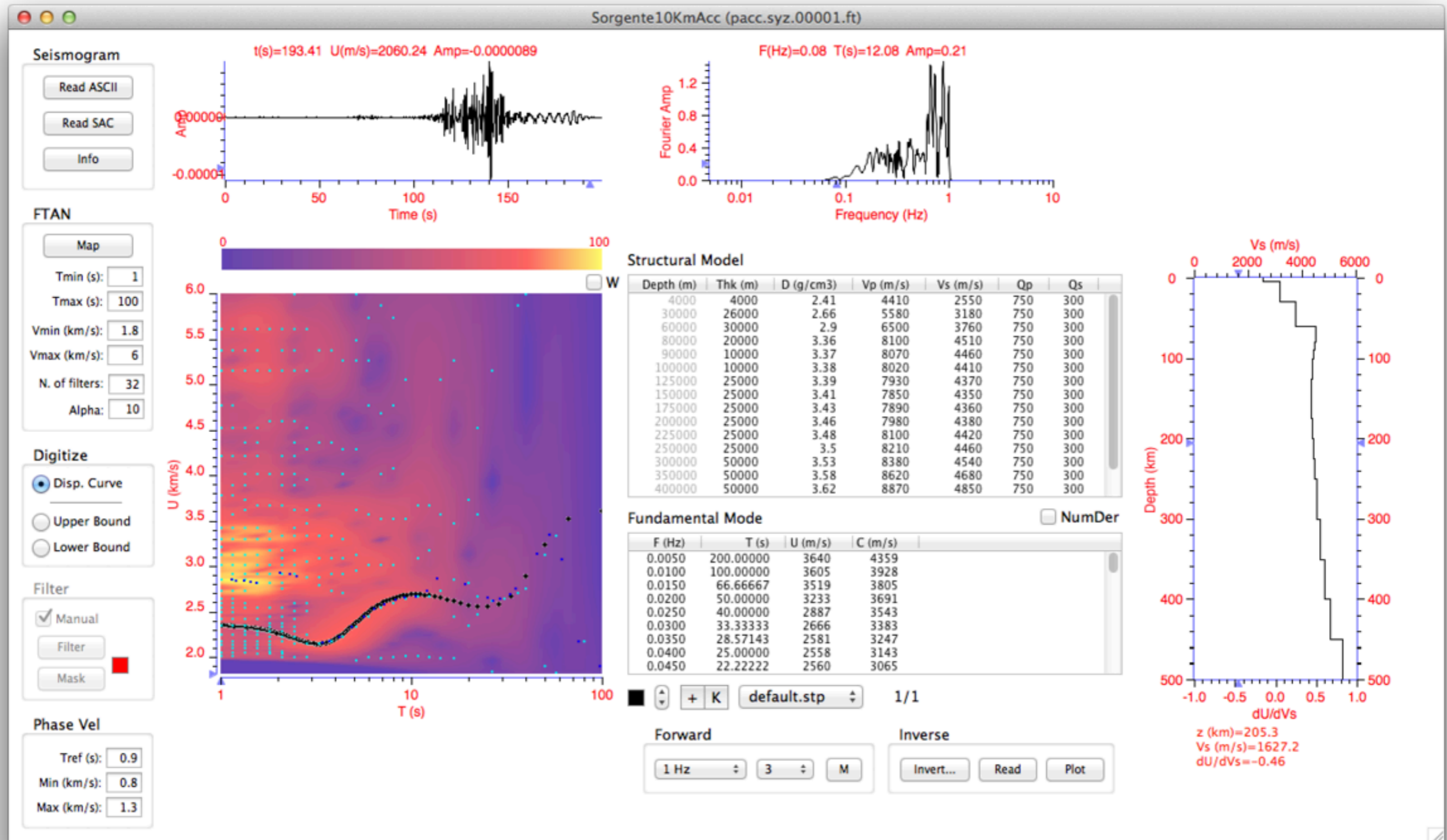
levp_n.stp 1/1

Forward: 1 Hz 3 M

Inverse: Invert... Read Plot

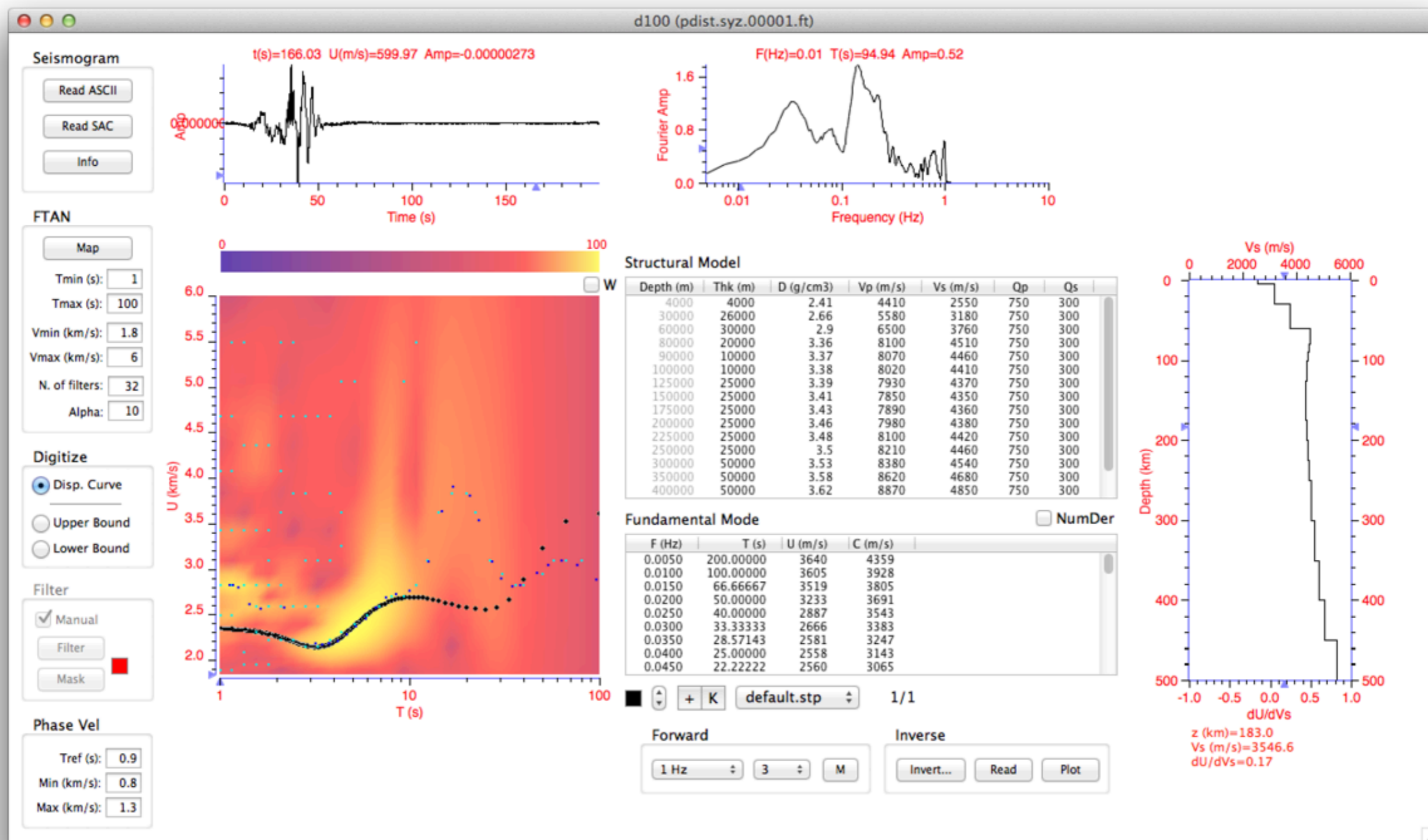
FTAN - Effect of motion type

Acceleration time series



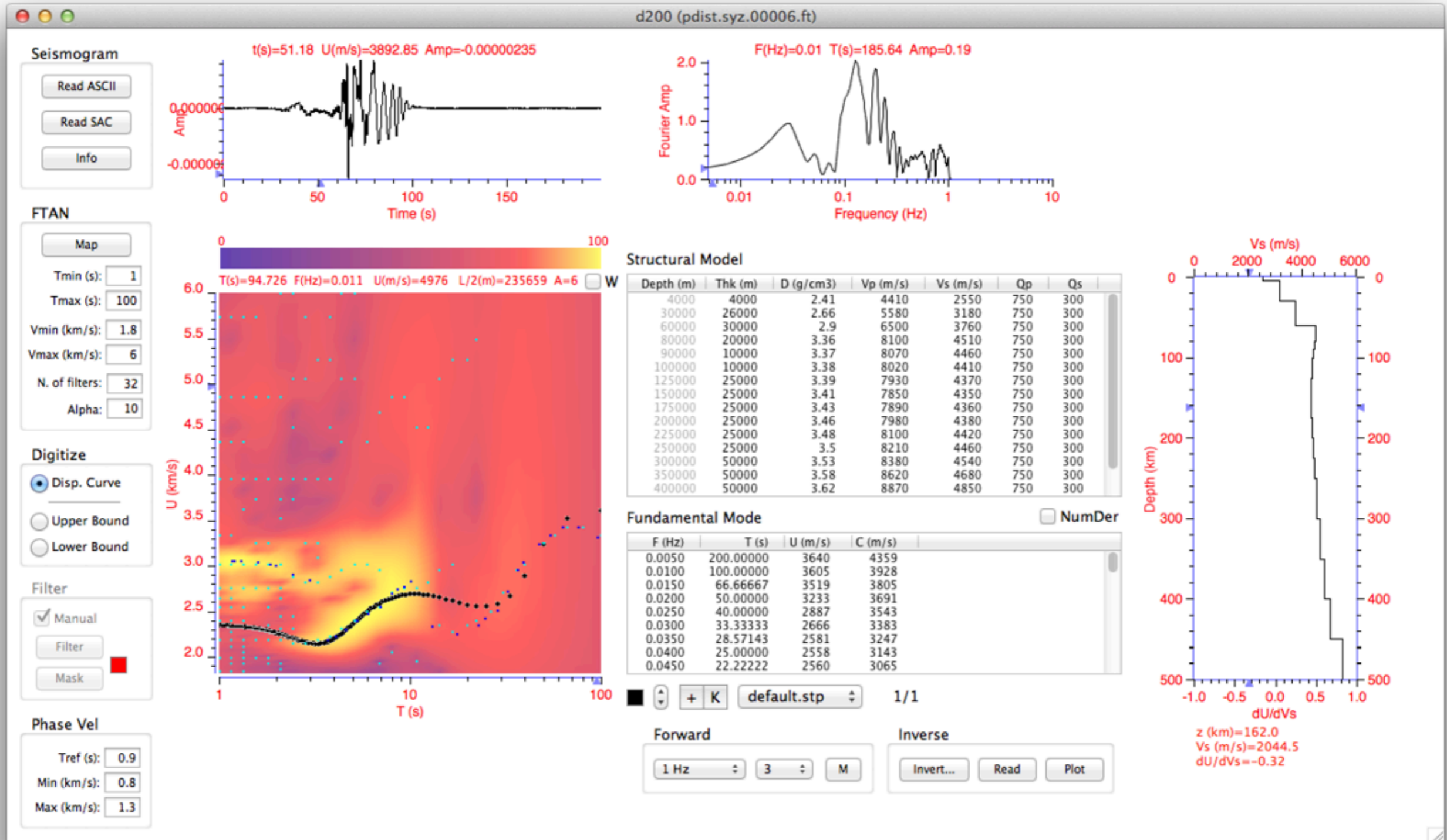
FTAN - Effect of epicentral distance

100 km



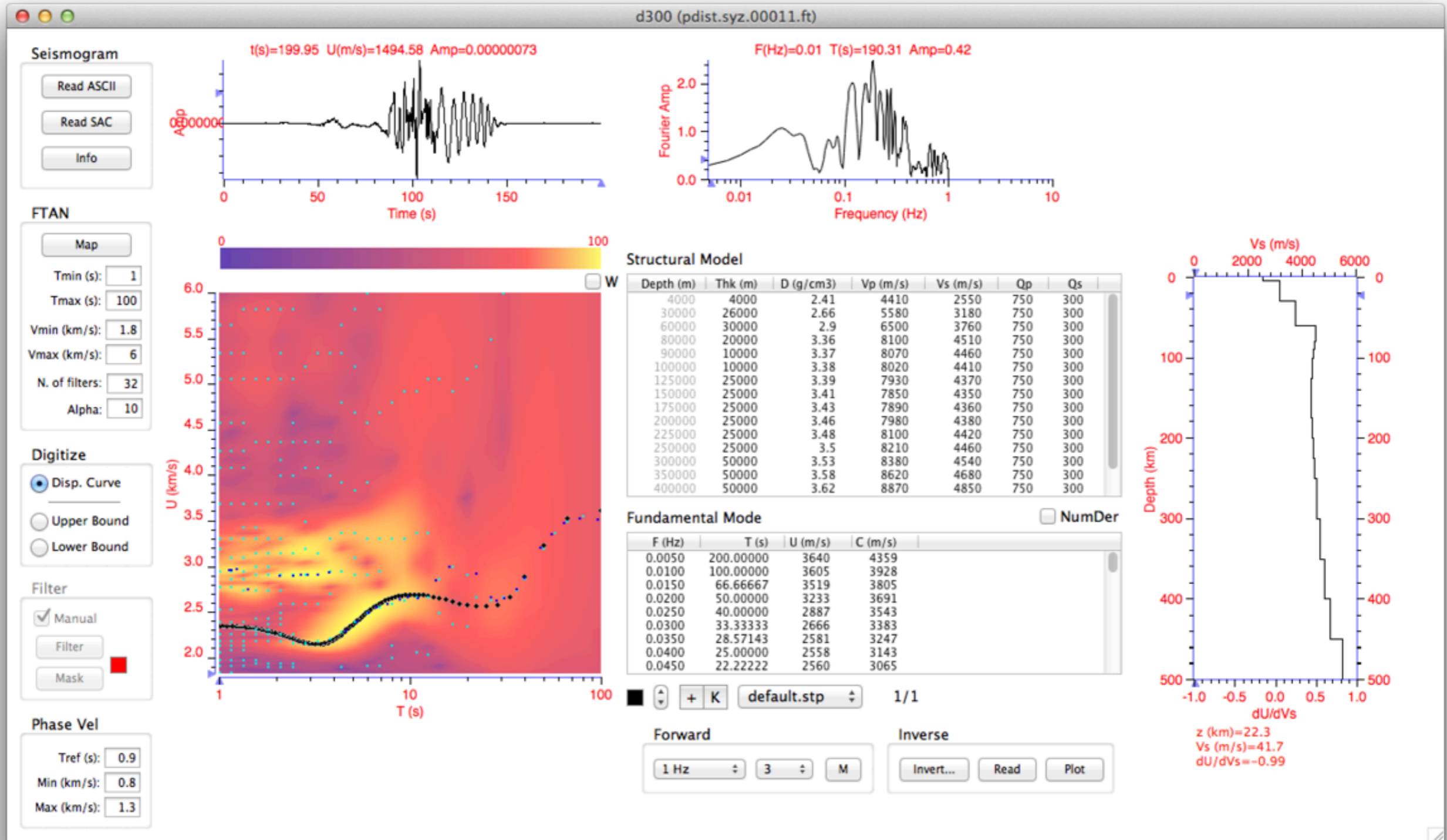
FTAN - Effect of epicentral distance

200 km



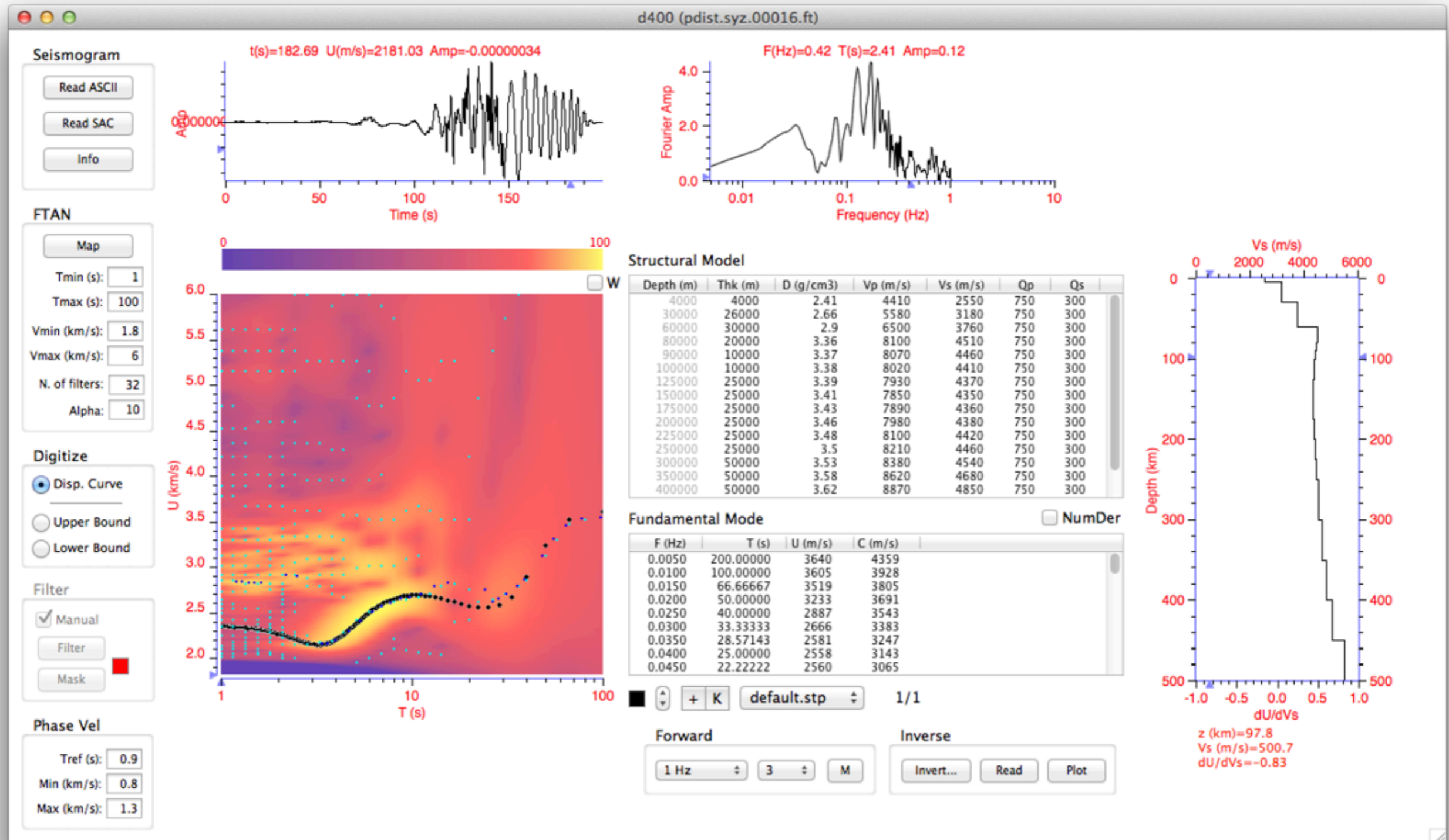
FTAN - Effect of epicentral distance

300 km



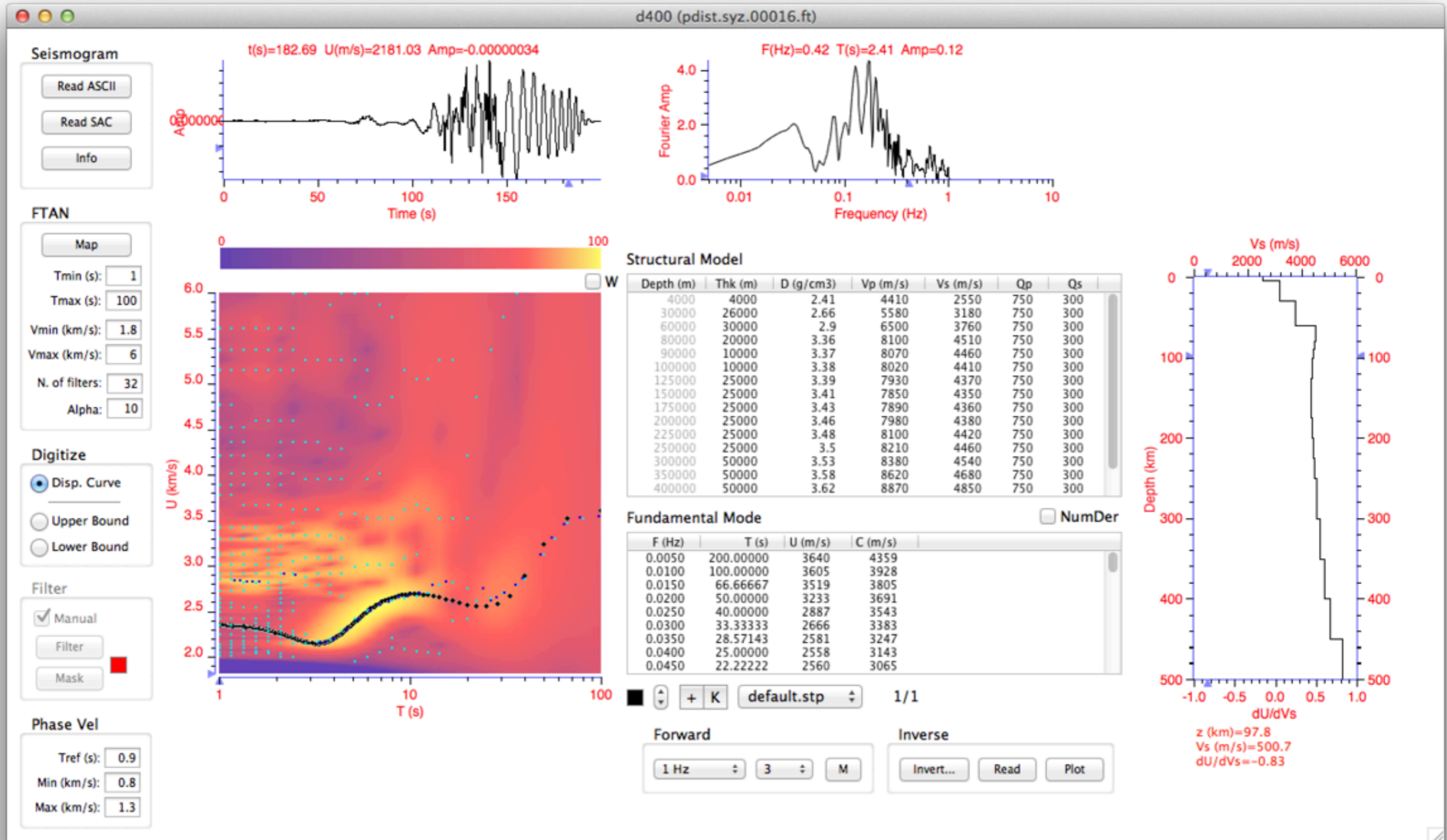
FTAN - Effect of epicentral distance

400 km



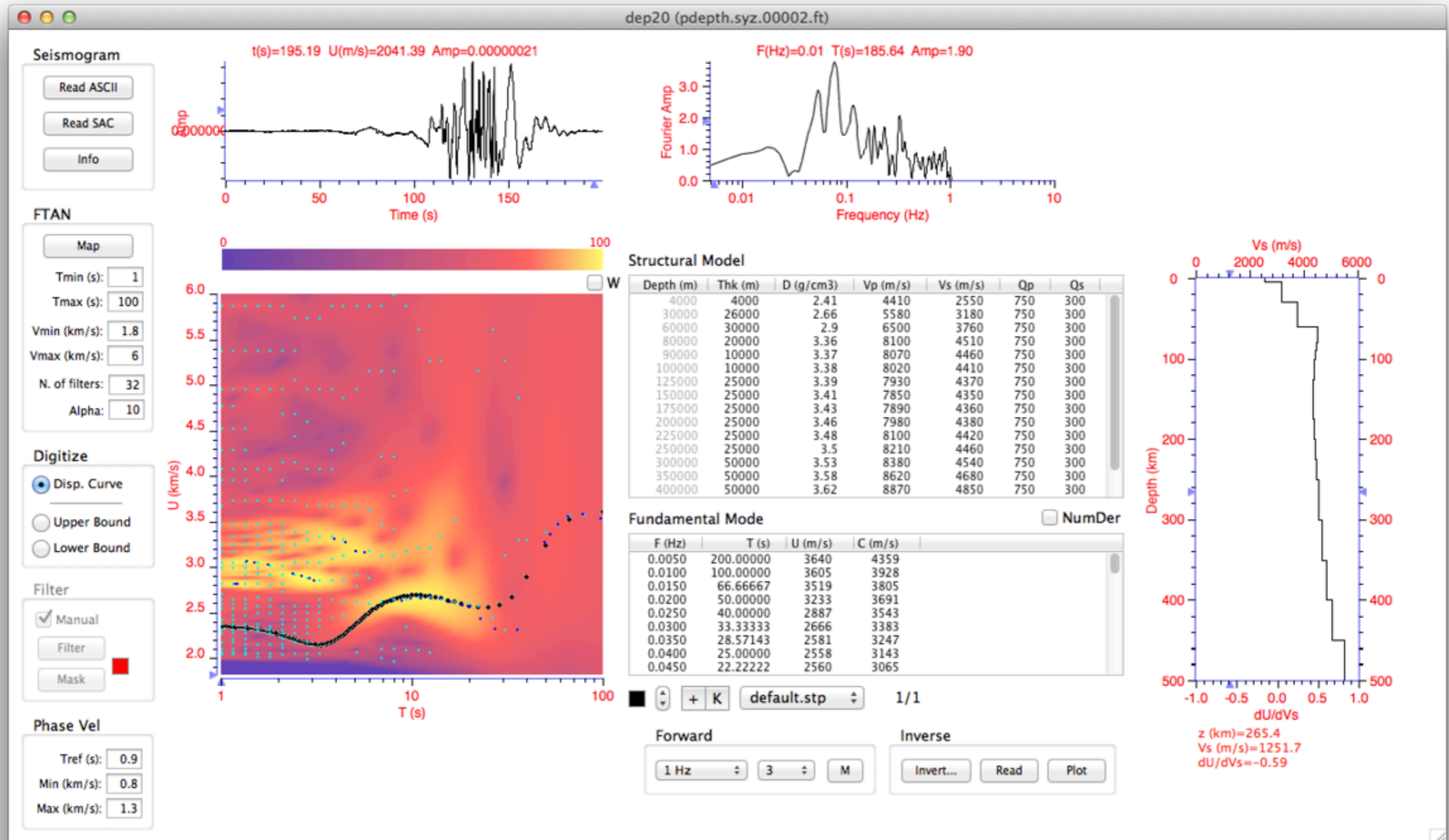
FTAN - Effect of source depth

10 km



FTAN - Effect of source depth

20 km



FTAN - Effect of source depth

30 km

