GSpecDisp 1.4
Tutorial

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Contents

1 Introduction

GSpecDisp is an interactive package to measure phase-velocity dispersion of surface waves extracted by noise correlations. The purpose of this tutorial is to train users to measure phase velocity of a dataset. The input data are time-domain cross-correlations in SAC format. The data that we will use in this tutorial are from 55 cross-correlation files in northern Sweden (path of data: "./GSpecDisp1.4 /Projects/SNSN_north/data"). After this training, users can work with their own data. They need to set suitable parameters for their own dataset inside the Main Window of GSpecDisp. A description of different parameters of the Main Window can be found in the GSpecDisp manual.

In order to set the parameters that are used in this tutorial, you need to run a Matlab m-file called "tutorial_values.m" which is in the "./GSpecDisp1.4/defaults" folder by pressing F5 in the Matlab editor or typing in the Matlab command window.

2 Running GSpecDisp

To run GSpecDisp after unzipping the package into a desired directory, you should run the "GSpecDisp.m" by pressing F5 in the Matlab editor or typing in the Matlab command window (path is: "./GSpecDisp1.4 /GSpecDisp.m"). It automatically adds the required paths, and the Main Window appears (Fig. 1). No other installations are needed. All parameters can be set in the Main Window and all modules can be run by the Main Window.

Fig. 2 shows different parts of the Main Window. In the left panel, there are 5 menus and two buttons for opening the GSpecDisp manual (Help) and tutorial. By choosing a menu, the corresponding options of that menu appear on the right panel. You can use text boxes and buttons to set parameters for later use by GSpecDisp modules. 3 buttons (Default, Latest, Save) in each menu can be used for calling the default, latest used parameters, or save parameters, respectively. At the bottom of the Main Window, there are 5 modules (5 buttons) that are explained in the following sections.

You can call any module from the Main Window. All modules are independent from each other and from the Main Window. Therefore, you can open a module, do some measurements, close the module, change some parameters, reopen same module, and do some measurements without need to rerun GSpecDisp. You can open one module multiple times, and for example make measurements and compare them. They are all independent, but of course each of them uses the latest saved parameters.

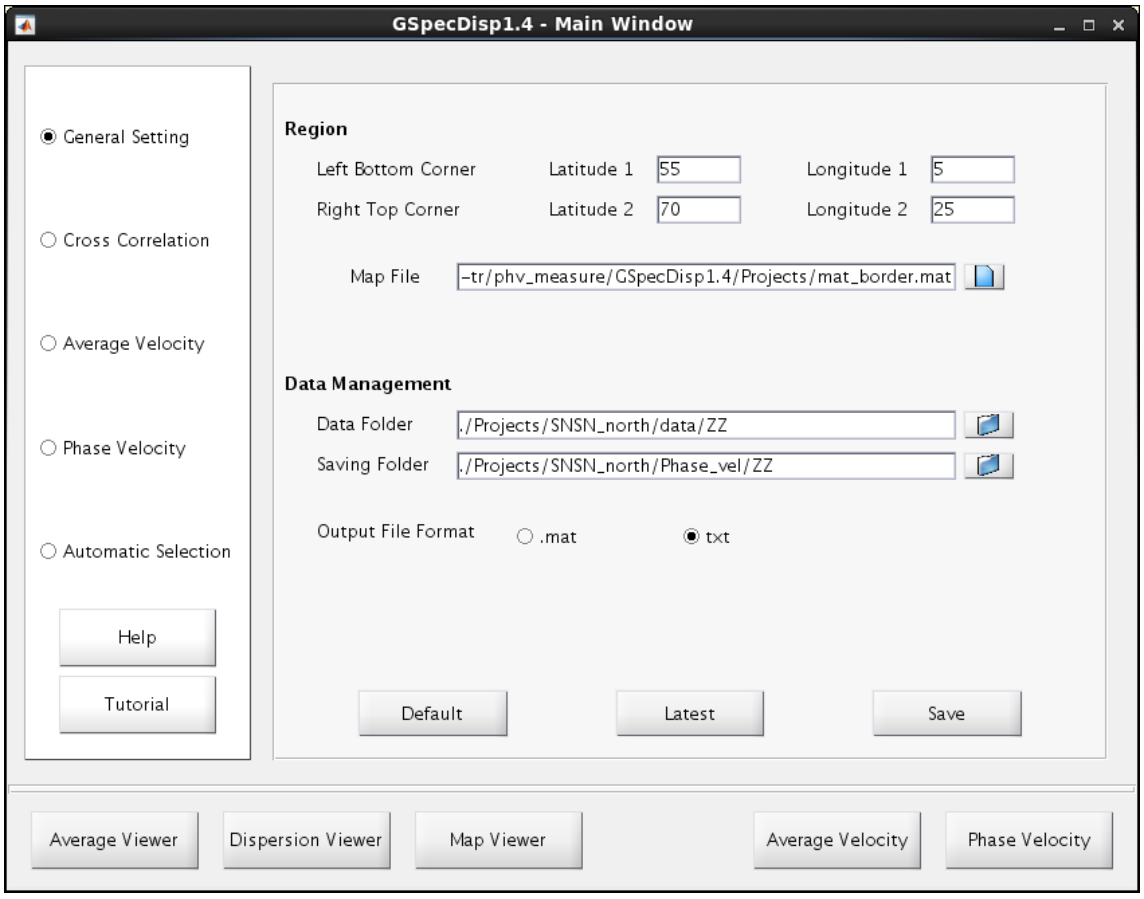

Figure 1: *Main Window - General Setting menu*

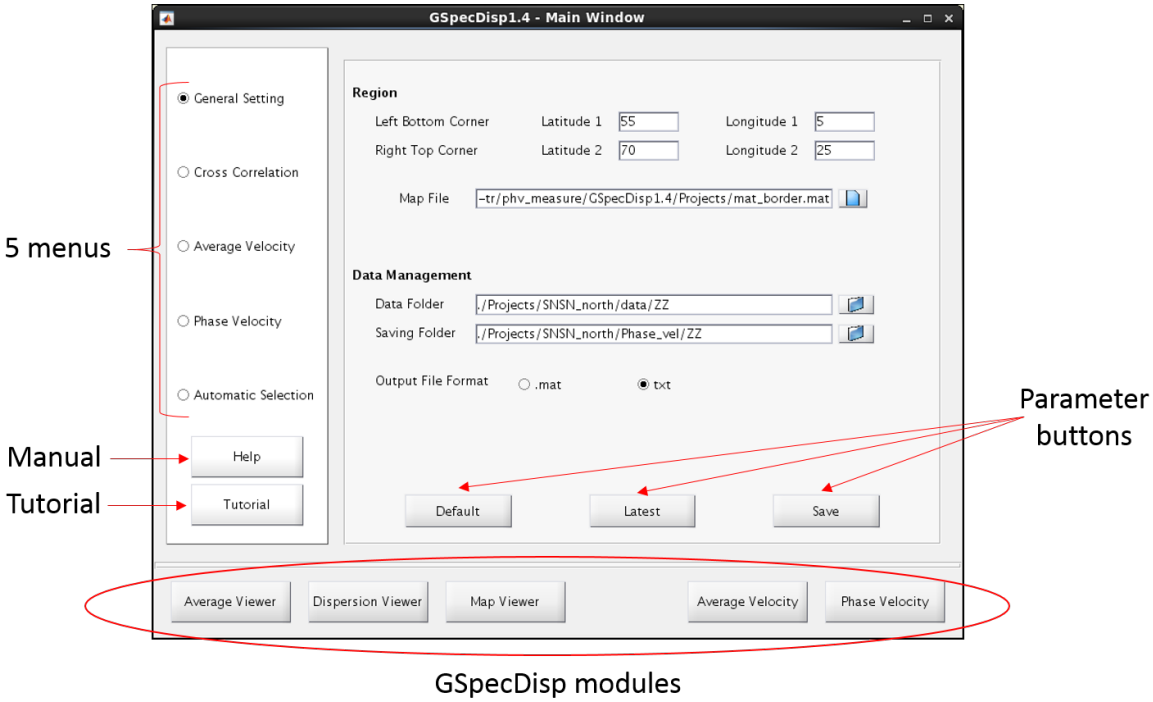

Figure 2: *Main Window elements*

3 Average Phase Velocity Estimation

To estimate an average phase-velocity dispersion curve for the entered data set, you can use Average Velocity module. First, you need to read data by using Open files or Open folder buttons. Use Open Folder to read all SAC files that are in the ZZ folder (Fig. 3). Then select the component to be ZZ and norm (1 means L_1, 2 means L_2, ...). 2 is already set. Then, press the Calculation button.

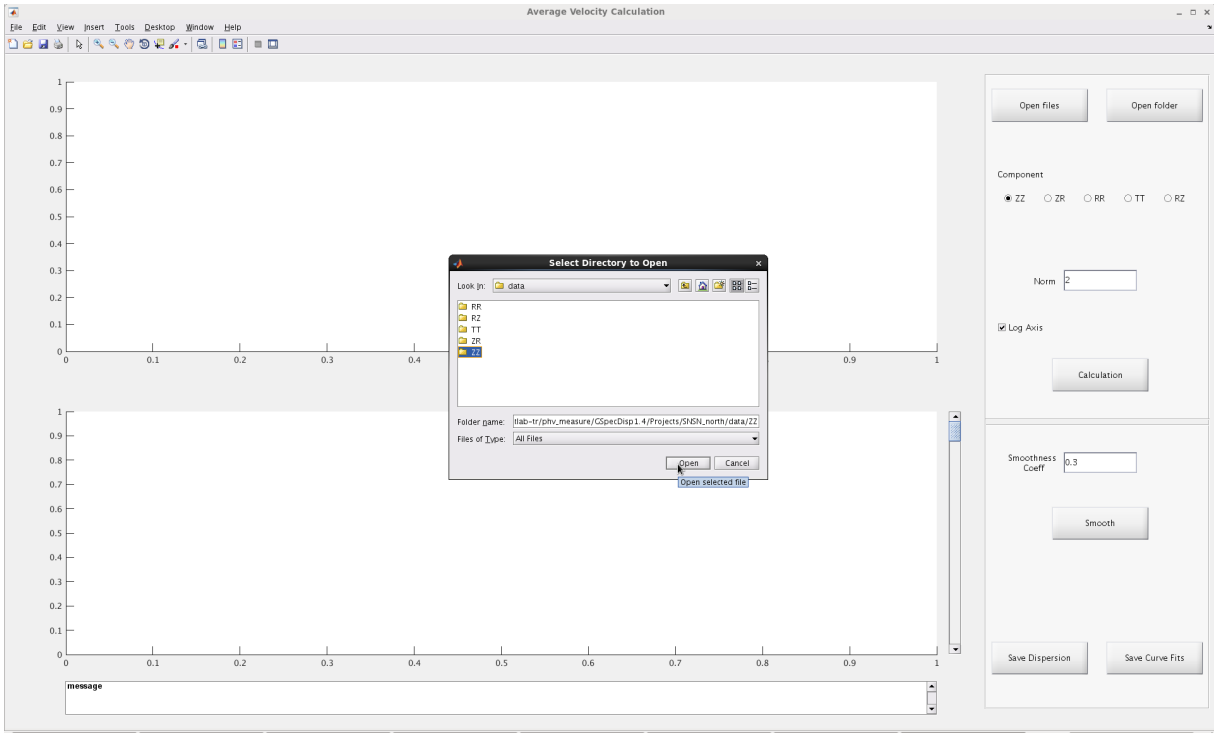

Figure 3: *Average Velocity module - open folder*

It takes a few seconds to calculate, and the results appear on the screen (Fig. 4). The upper plot is the estimated average phase velocity from the 55 station-pairs (notice title of upper plot). The lower plot shows the Bessel function curve fitting of all pairs at 33 s. You can use the mouse wheel or the scroll-bar to view the curve fittings at other periods (notice title of lower plot and a magenta diamond in the upper plot indicating the selected period).

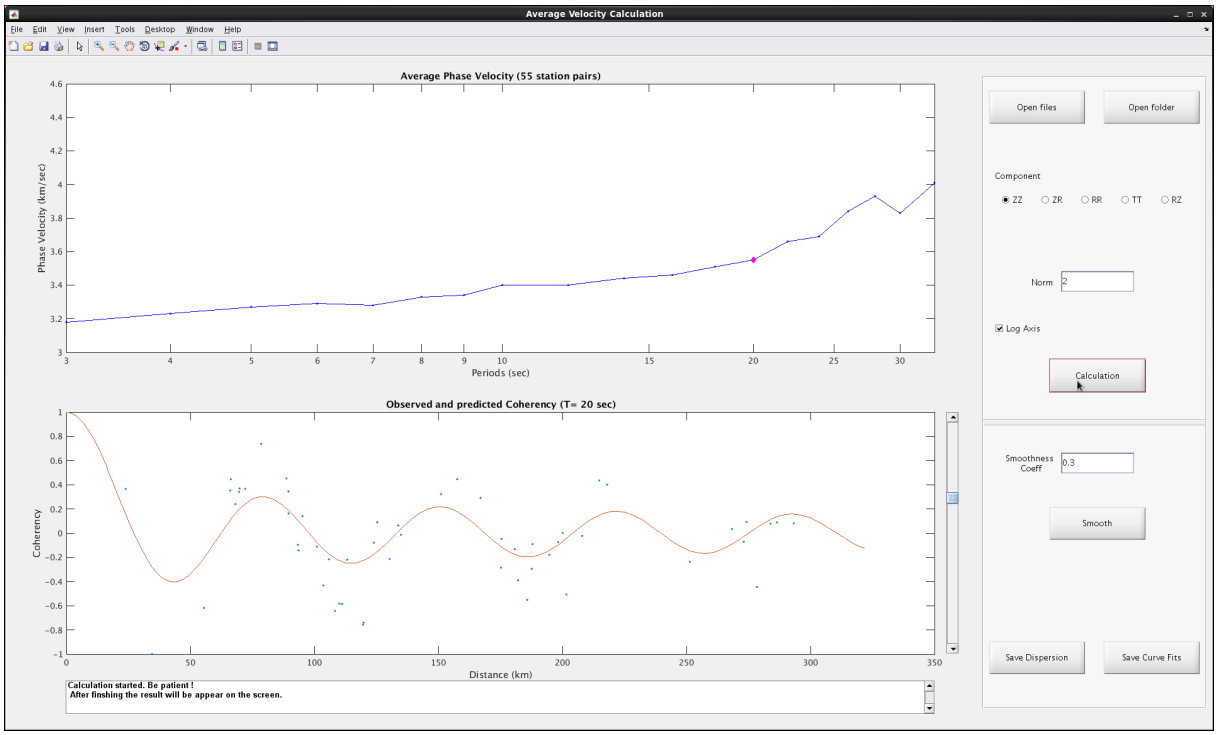

Figure 4: *Average Velocity module - results*

To smooth the estimated dispersion curve choose a smoothing coefficient and click the Smooth button (Fig. 5). The smoothed dispersion is shown as a red curve in the upper plot, and the curve fittings are modified based on the smoothed dispersion velocity. You can test different smoothness coefficients by changing their values and clicking the Smooth button without need of recalculation to get the best estimation. Then you can save the dispersion curves and the curve fittings.

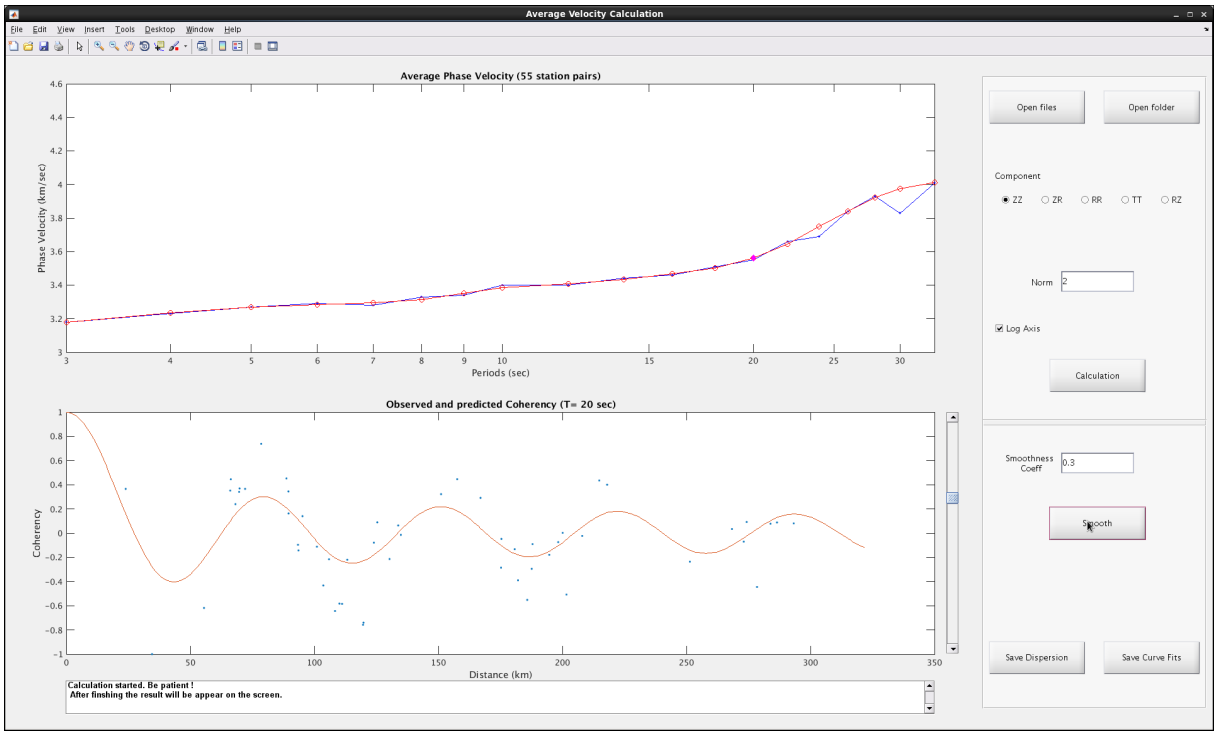

Figure 5: *Average Velocity module - smoothed dispersion*

4 Viewing Average Velocities

The Average Viewer module is to view, modify and create new average dispersion curves. With this module you can combine estimated average-velocity dispersion curves and create a new one. When you open average dispersion files, they will appear on the plot and the values are shown in the middle table (Fig. 6).

I have saved the measured average velocities from all possible components of the correlation tensor in the "./GSpecDisp1.4 /Projects/SNSN_north/Average_vel" folder. Use the open file button to open 4 of them with names ending with "_sm" (RR, RZ, ZR, and ZZ components). The dispersion curves of these components are for the Rayleigh wave (Fig. 6). Basically, all of these dispersion curves should be the same because they are for one wave type. Here, we want to combine them to estimate one dispersion curve for the Rayleigh wave.

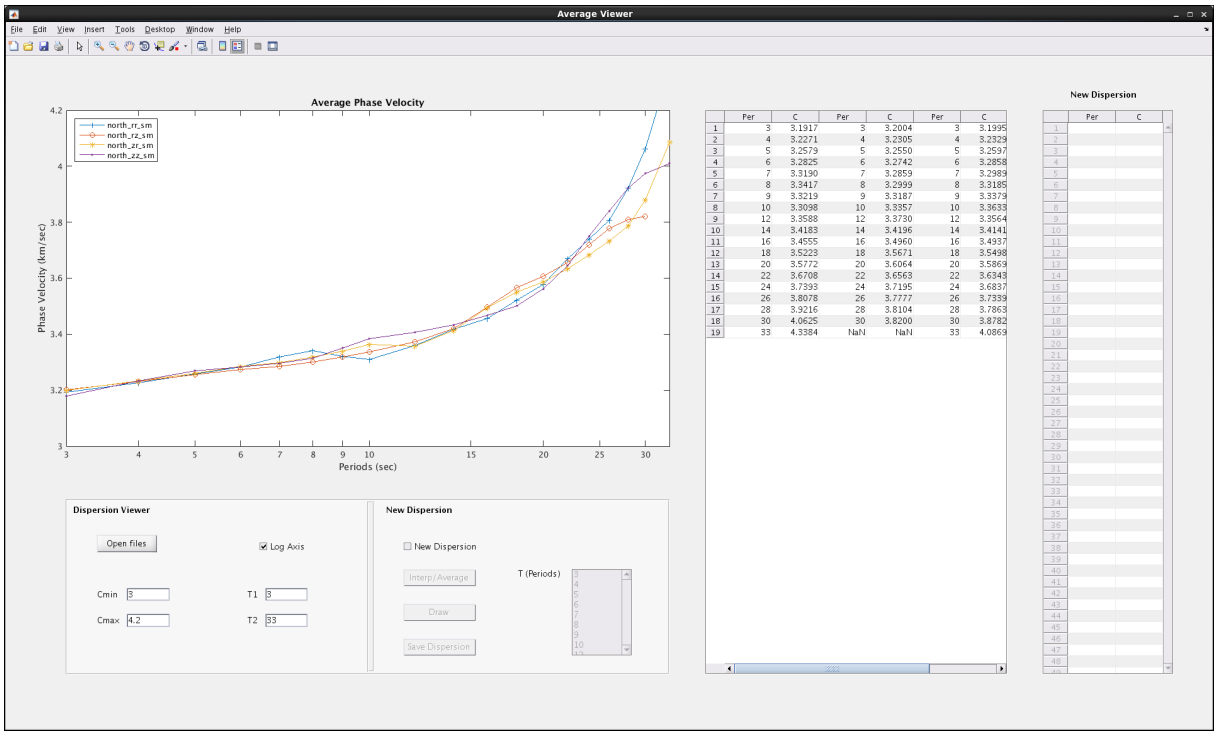

Figure 6: *Average Viewer module - open estimated average velocities of Rayleigh wave from 4 different components*

Click on the New Dispersion check-box, then click on Interp/Average button to see new values in the table to the right (Fig. 7). This button finds the average value of phase velocities from the 4 components. Now, you can click the Draw button to plot the new dispersion curve with magenta color (Fig. 7). You can click on the New Dispersion table and change the values manually. You can also add new rows to the dispersion table by pressing "n" or "N" on the keyboard (Fig. 8). Then you can save the New Dispersion by clicking Save Dispersion button and name it as, e.g., "Rayleigh_wave_north". Later, the average dispersion curve can be specified in the Main Window (see Fig. 10) to be used for automatic selection of dispersion curves for individual station pairs.

The same procedure can be done for the Love wave. However, we only have one measurement for the Love wave from TT component. If you click Interp/Average button, the New Dispersion values will be the same as TT component. Then you can change it manually or save it.

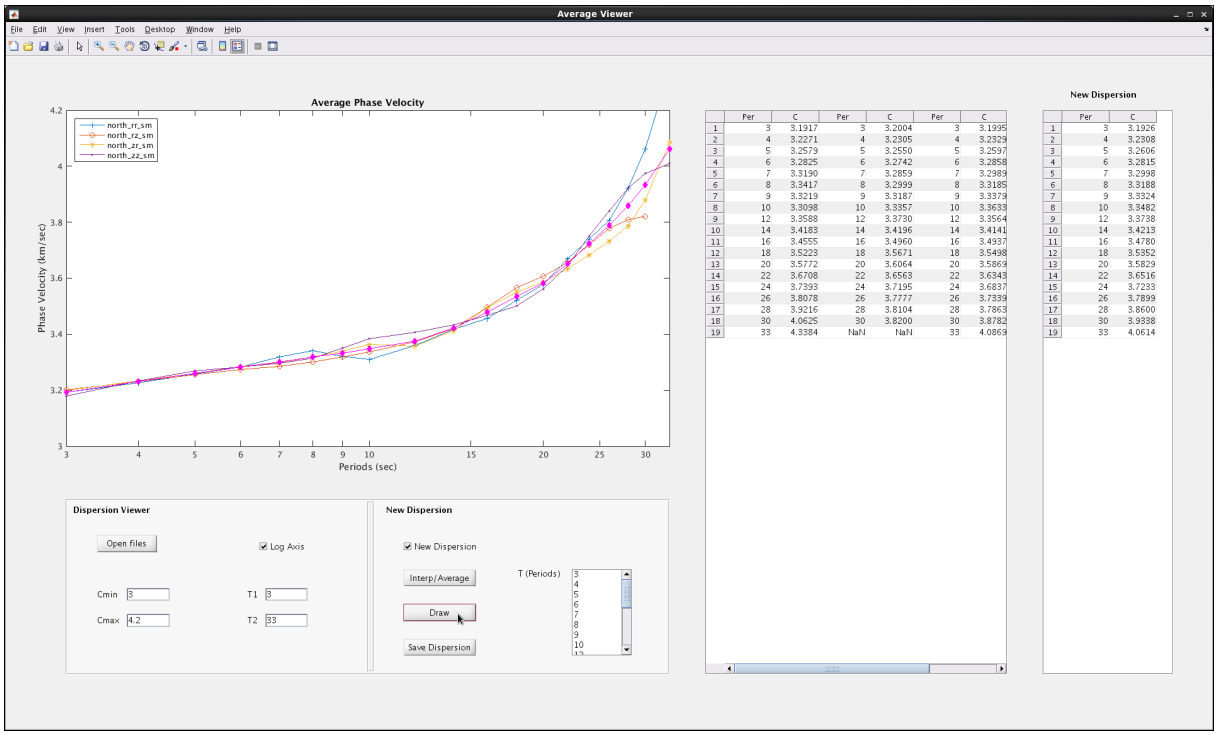

Figure 7: *Average Viewer module - making the New Dispersion and plot it as a magenta curve*

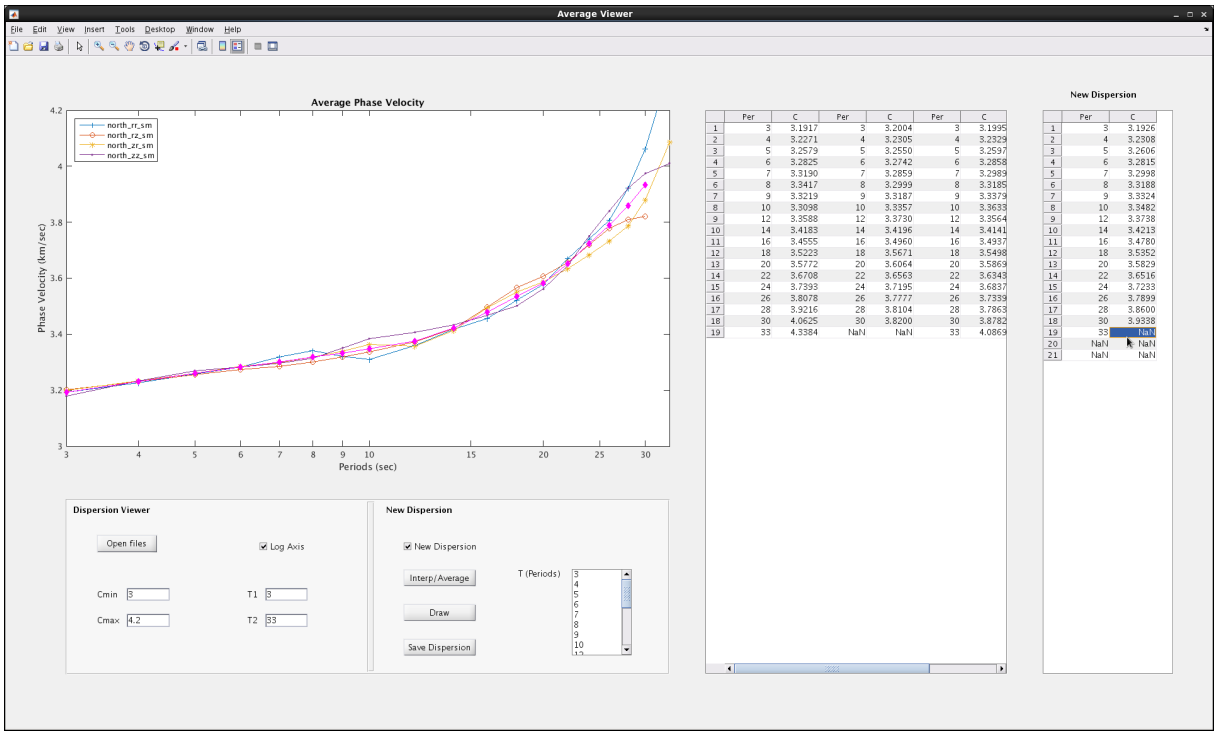

Figure 8: *Average Viewer module - changing the New Dispersion manually and add 2 new rows to it. NAN (not a number) can be filled by numbers.*

5 Measuring Phase Velocity of each Pair

The Phase Velocity module is used to measure the phase-velocity dispersion curve of each cross-correlation. The measurement can be done on 5 correlation components using suitable Bessel functions. Therefore, selecting the correct component is very important. To make the phase-velocity measurement, you first need to read data (SAC files), and second be sure that you have selected the correct component. Press the Open File button and use crtl+A to select all files in the ZZ component folder (Fig. 9).

The Phase Velocity module measures the phase-velocity dispersion curve of the first file ("dun _ert_zz"), and shows the possible dispersion curves as dots (Fig. 11). The red dashed curve is the reference-dispersion curve. The title of the top plot is the name of the current SAC file and the inter-station distance. The location of the two stations is shown on the regional map in the top right corner. The bottom plot is the real part of the spectrum of this pair as a function of period.

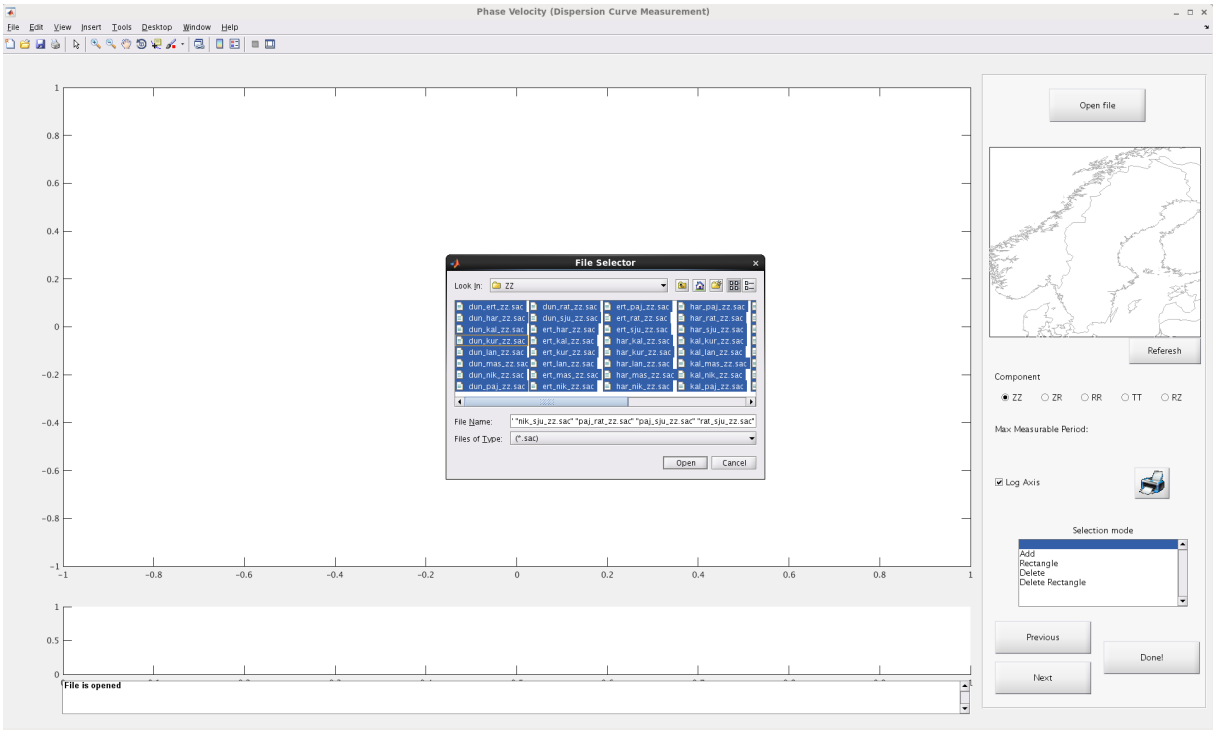

Figure 9: *Phase Velocity module - open files*

Because the automatic selection option has been chosen in the Main window and given the file name which contains the average velocity of the Rayleigh wave (Fig. 10), the selected dispersion points by the automatic selection appear as red circles (Fig. 11). Then you should select the correct dispersion curve. You can use the Selection Mode options to refine the automatically selected points. Now, from the Selection Mode box click on the Rectangle tool. Look at Max Measurable Period to see up to what period you can select dispersion points. For the "dun_ert_zz" pair this is 23 seconds. Then, left click on the plot and hold and drag it to select not-selected points which you think are

the correct dispersion curve for this pair (Figs 12, and 13). The real part of the spectrum and the average velocity of the region are important to select the correct dispersion curve.

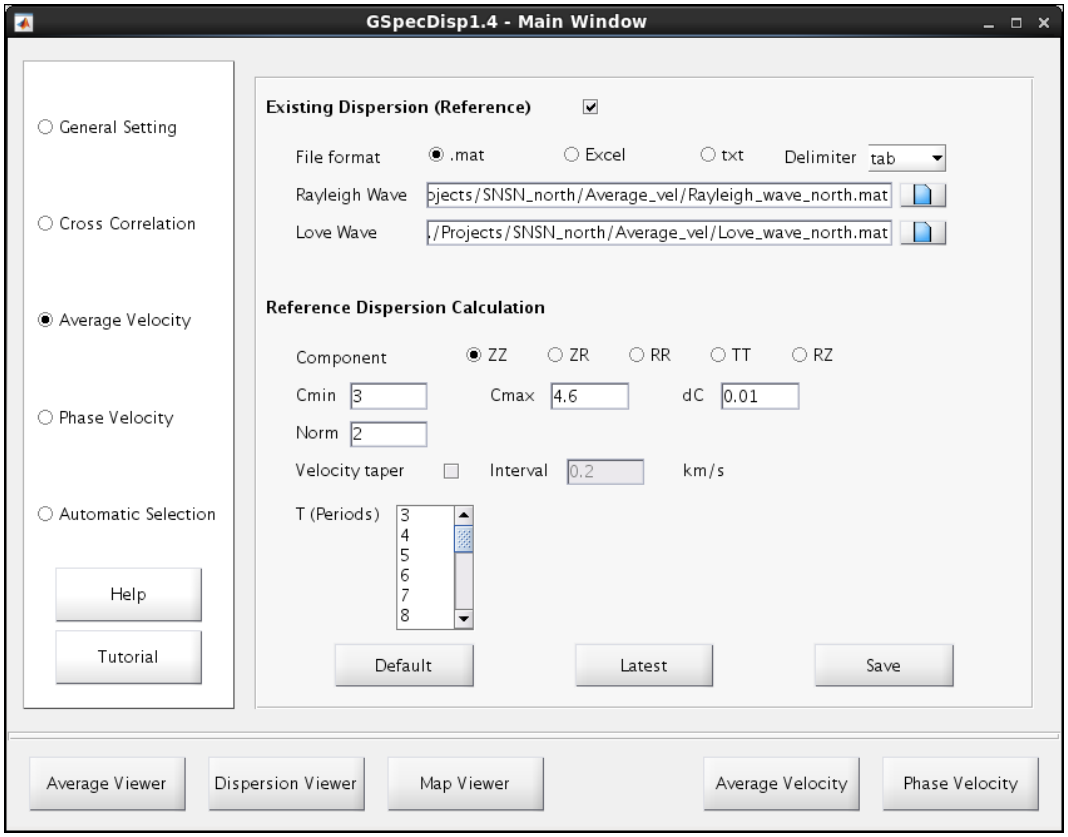

Figure 10: *Main Window (Average Velocity menu) - average dispersion curve of Rayleigh wave is read in Existing Dispersion part*

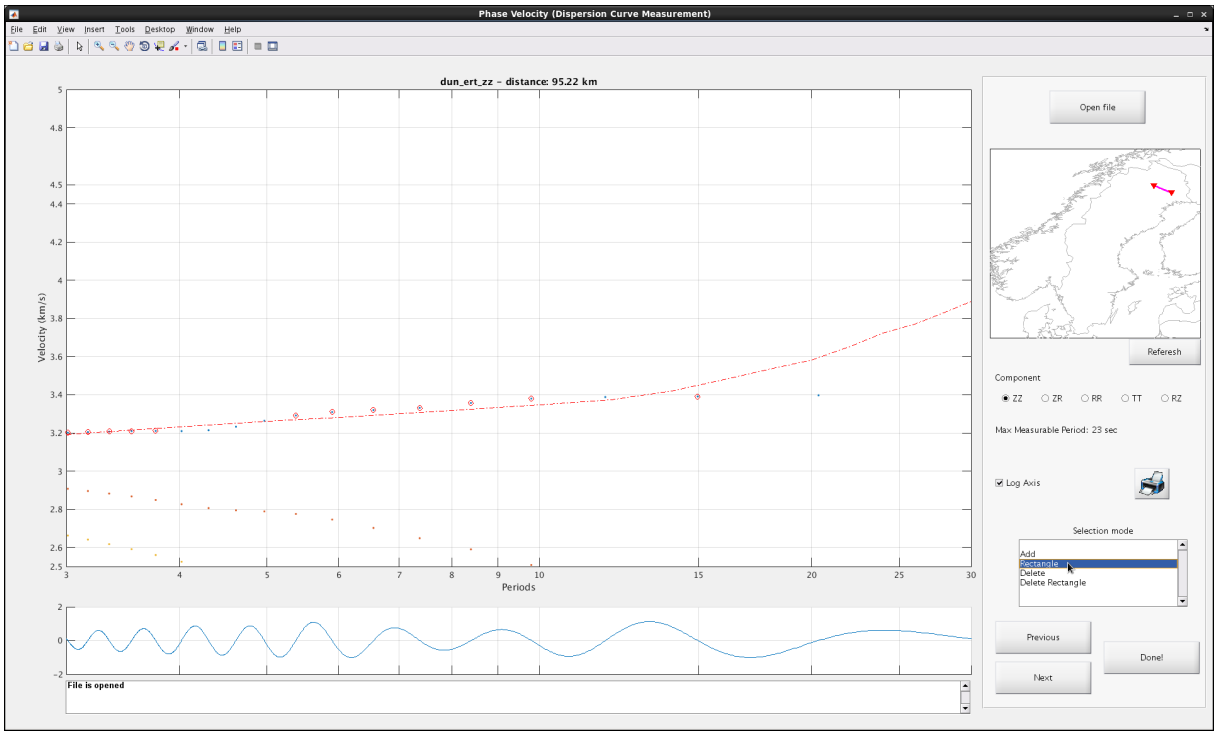

Figure 11: *Phase Velocity module - measured dispersion curves and the real part of spectrum*

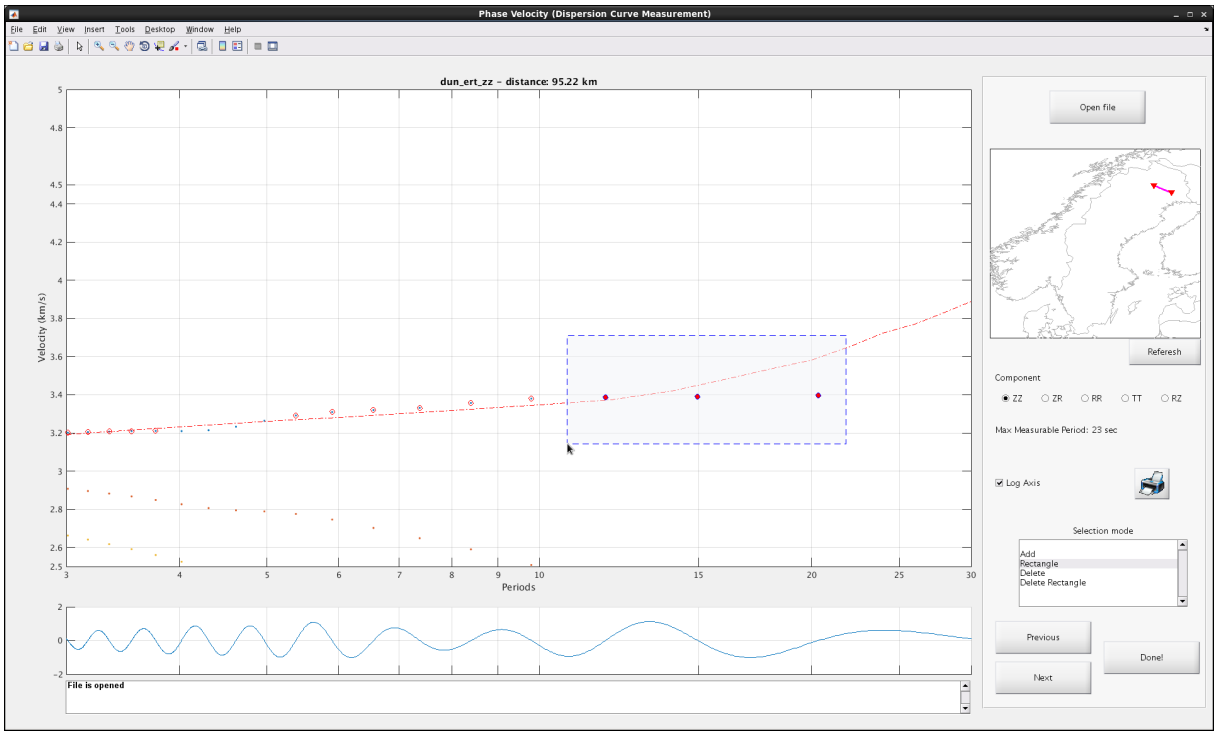

Figure 12: *Phase Velocity module - selection of the correct dispersion curve using Rectangle tool*

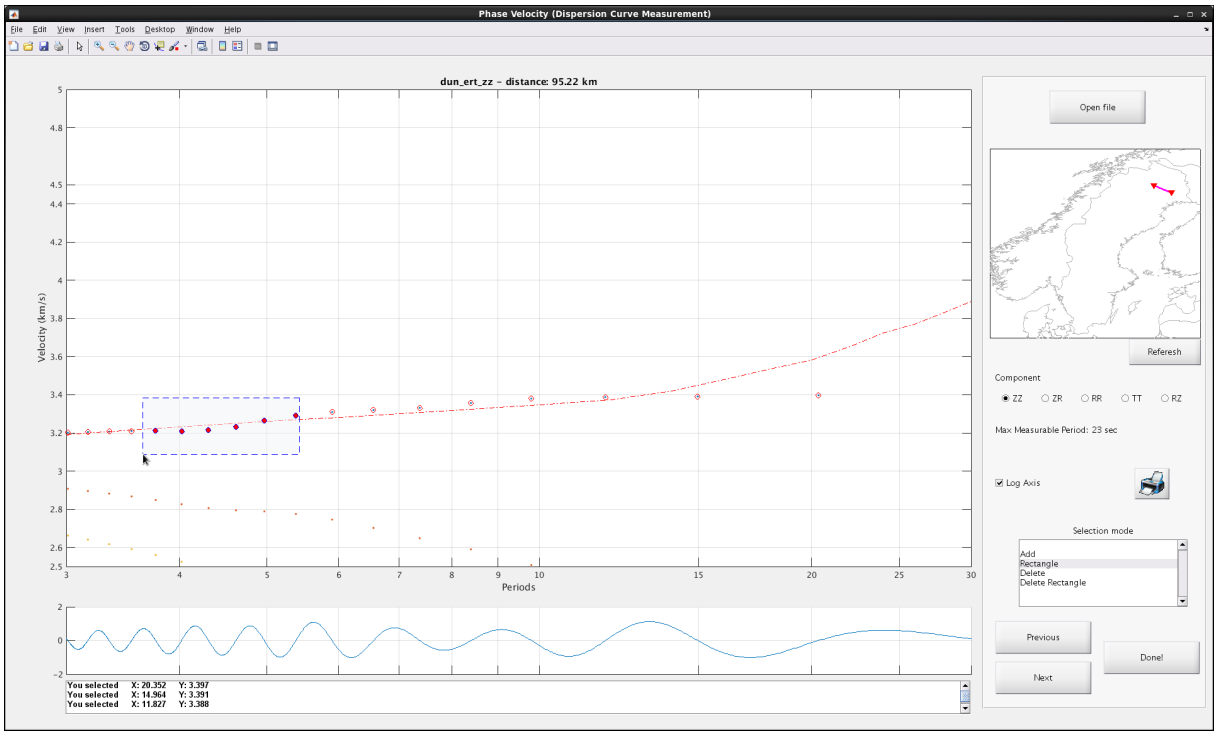

Figure 13: *Phase Velocity module - selection of the correct dispersion curve using Rectangle tool*

By pressing the Done button, the selected dispersion is saved in the saving folder (defined in the Main Window) and the module starts to measure the phase-velocity dispersion curve for the next pair. Another example of the velocity measurement is presented in Figs 14 and 15, where I first delete the two points which have been selected by the automatic dispersion as I do not think they are correct. Then, I add some points at shorter periods. Notice that the Delete and Delete Rectangle only work on the selected point(s) (points that are indicated as red circles - see Fig 14).

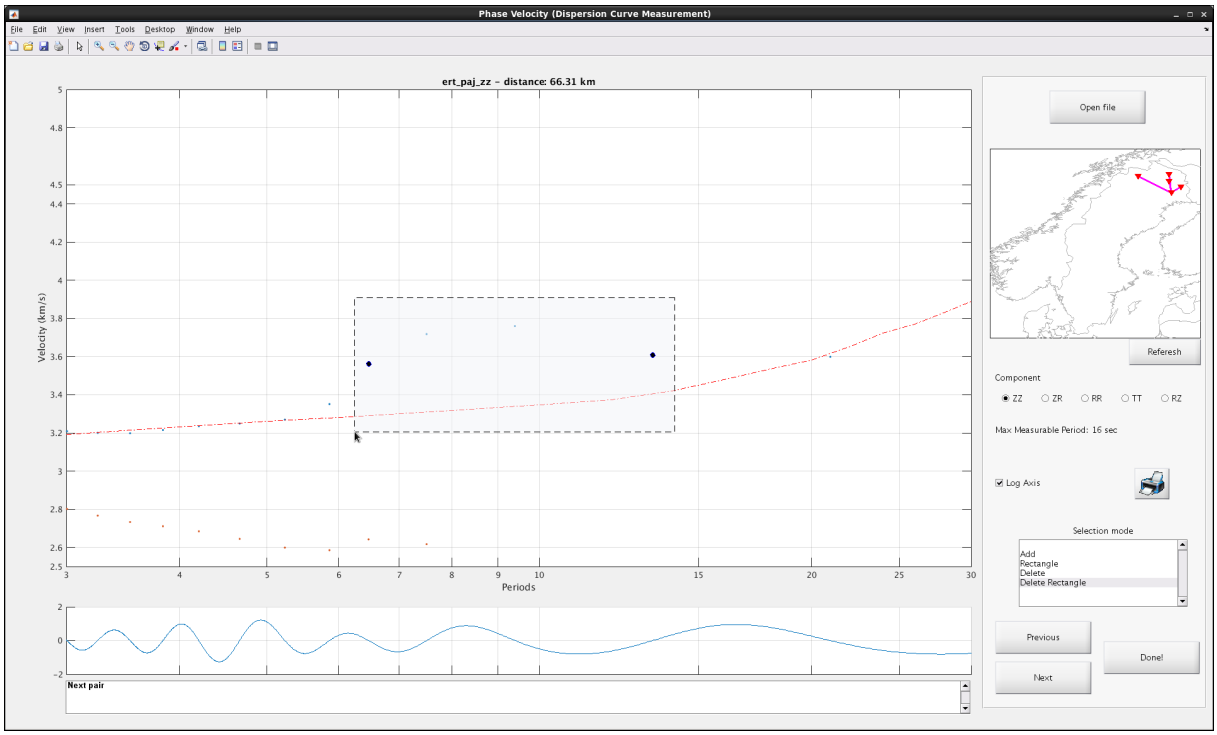

Figure 14: *Phase Velocity module - delete two incorrect dispersion points using Delete Rectangle tool*

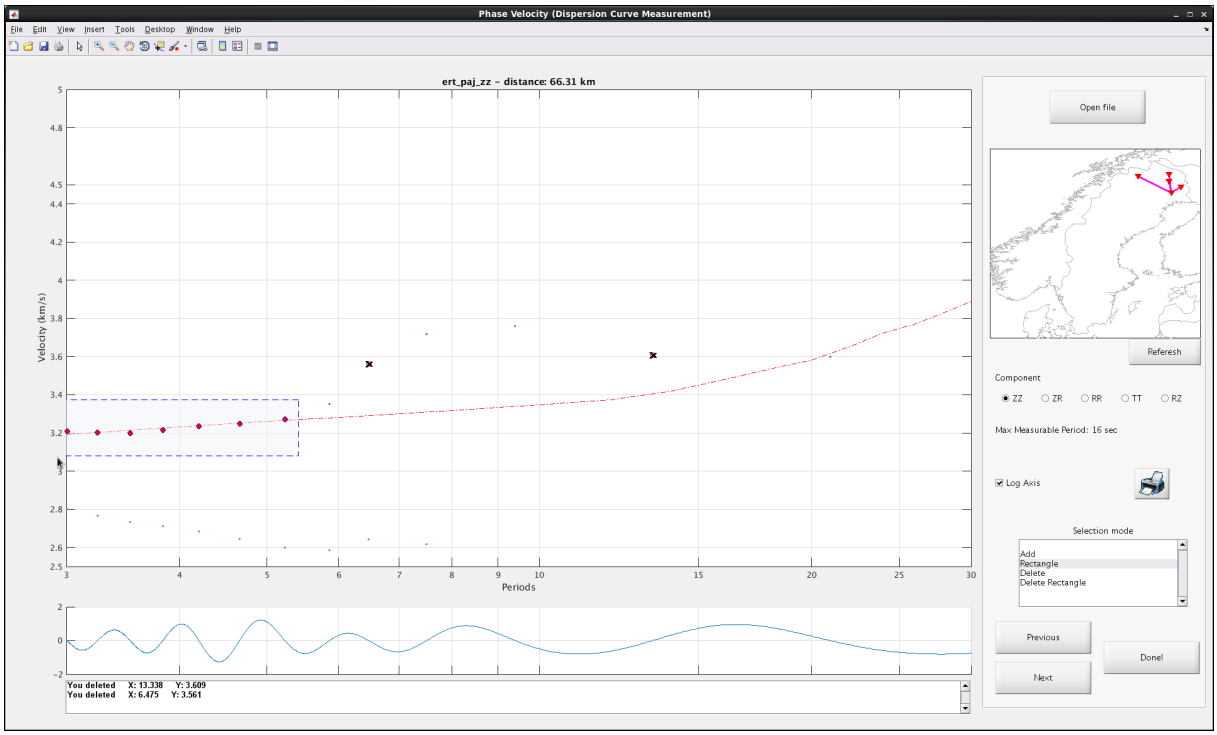

Figure 15: *Phase Velocity module - select other points using Rectangle tool*

You can take a snapshot of the current measurement simply by clicking on the print button on the right panel (Fig. 16). A small window is opened, and then you can change

the title of the plot, select the format and resolution, include the real part of spectrum or not, and define a file name. Finally, if you press the print icon, the figure will be saved (Fig. 17).

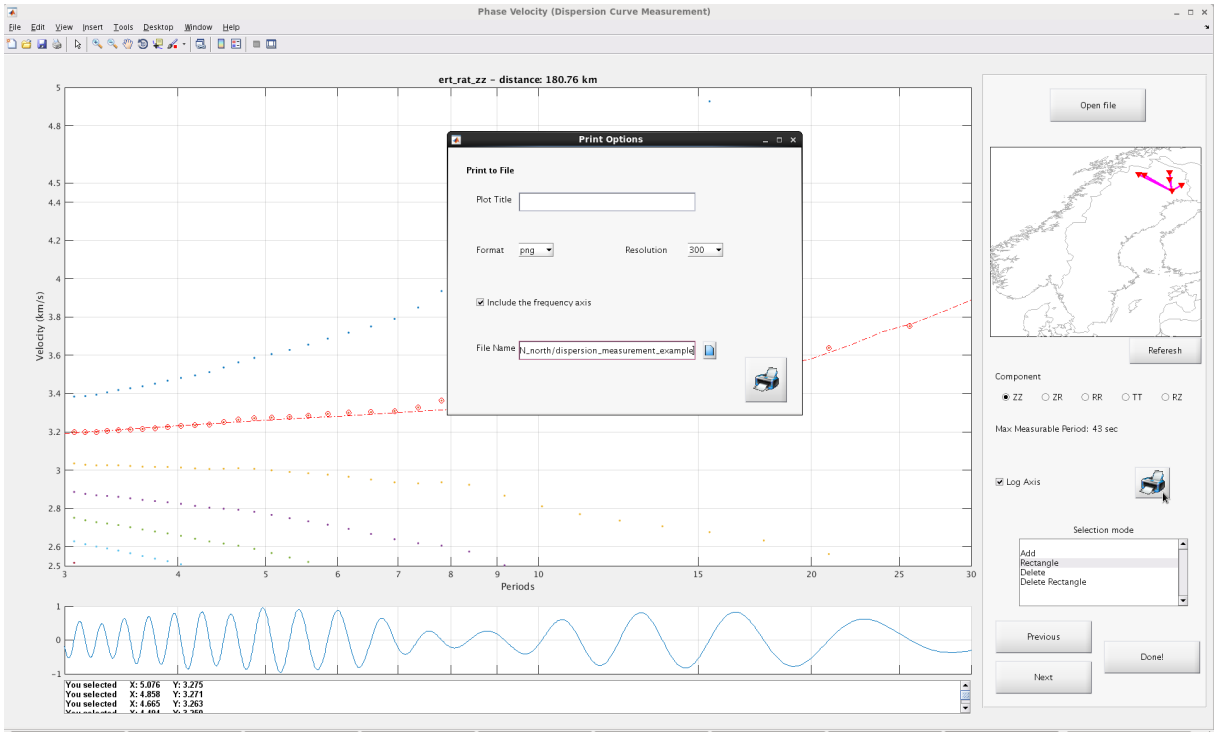

Figure 16: *Phase Velocity module - print out the velocity measurement*

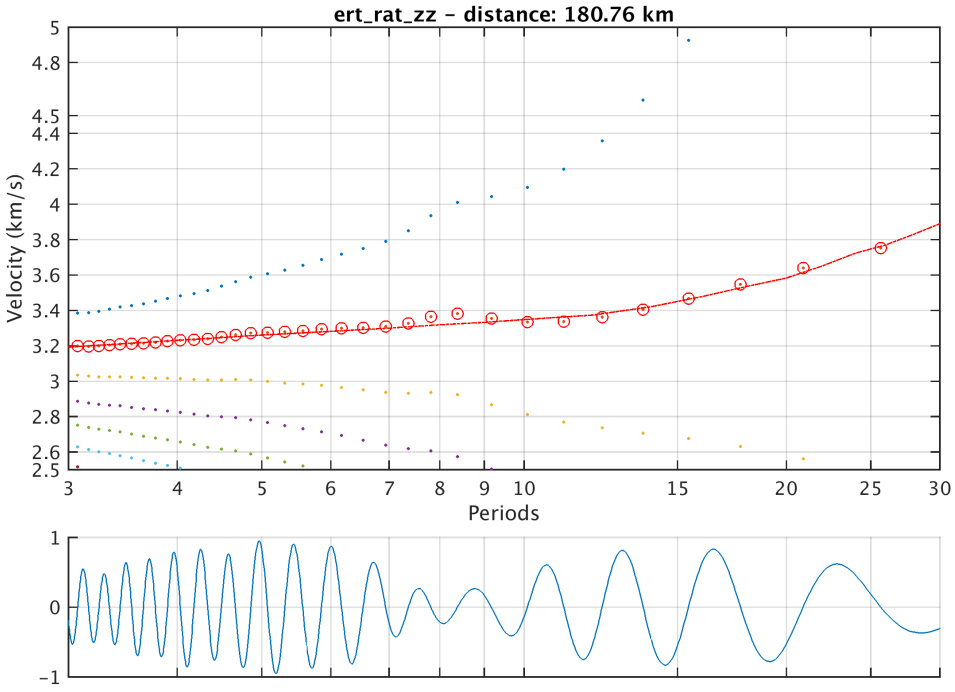

Figure 17: *Phase Velocity module - saved dispersion curve*

6 Viewing Measured Phase Velocities

The Dispersion Viewer is included to compare and print/save the measured and interpolated dispersion curves (Fig. 18). You can open the first column of the previously measured dispersion curves. This is a good way to see and compare dispersion curves for different pairs.

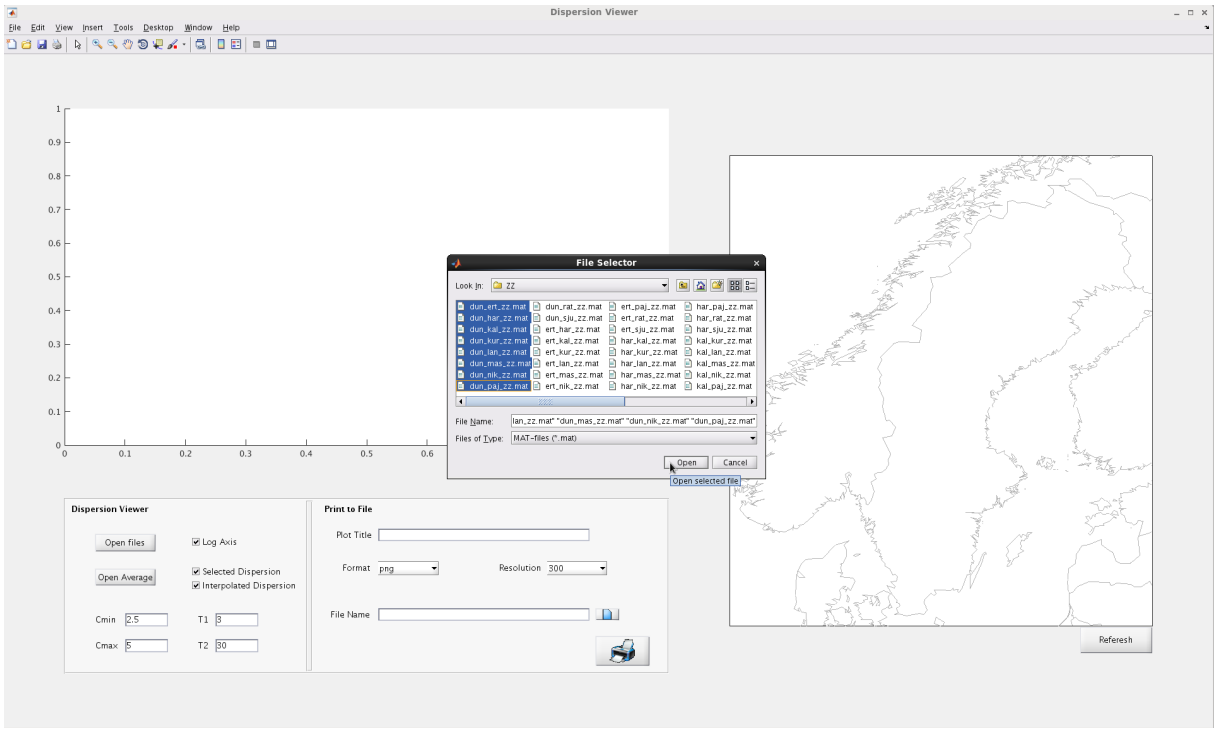

Figure 18: *Dispersion Viewer module - open measured dispersions*

There are two options (check boxes) to display the selected dispersion values at the zero crossings (the points that were selected from Phase Velocity module) or interpolated dispersion values at predefined periods or both (Figs 19 and 20). You can check and un-check to see dispersion values (the two check-boxes). When both options are checked the interpolated values are displayed as diamonds. Finally, you can save the plot to a file.

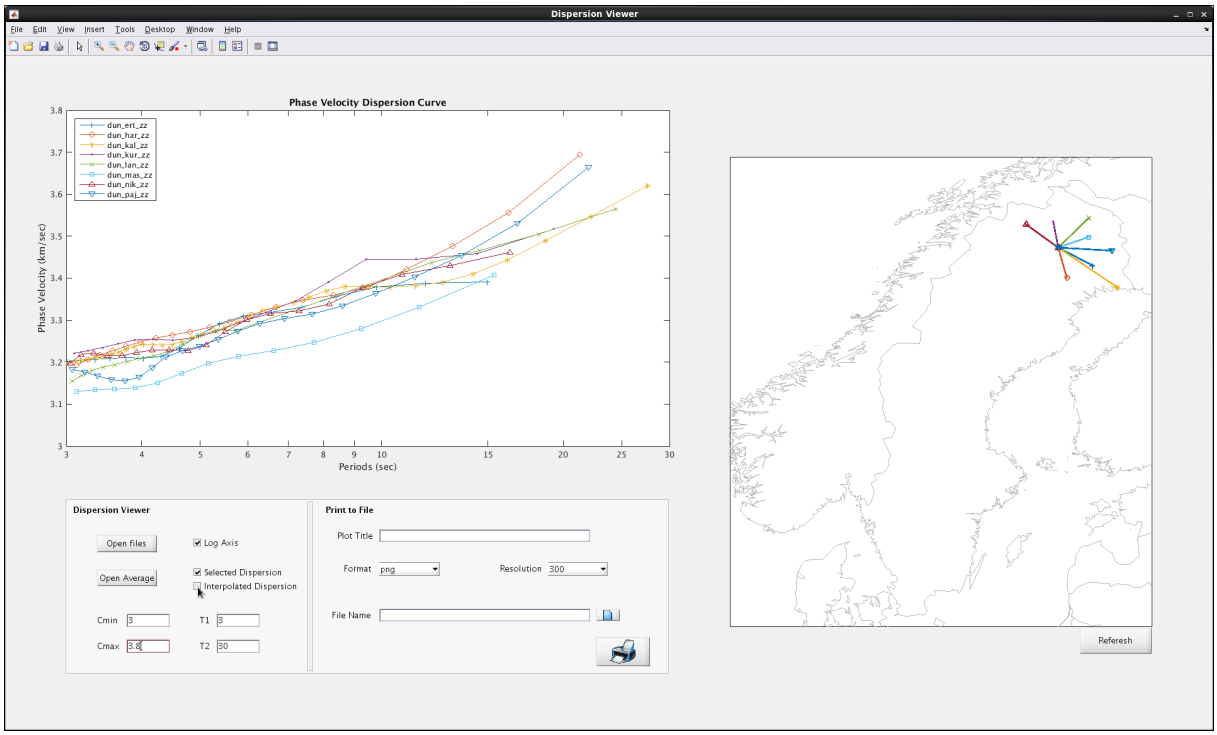

Figure 19: *Dispersion Viewer module - selected dispersions from Phase Velocity module*

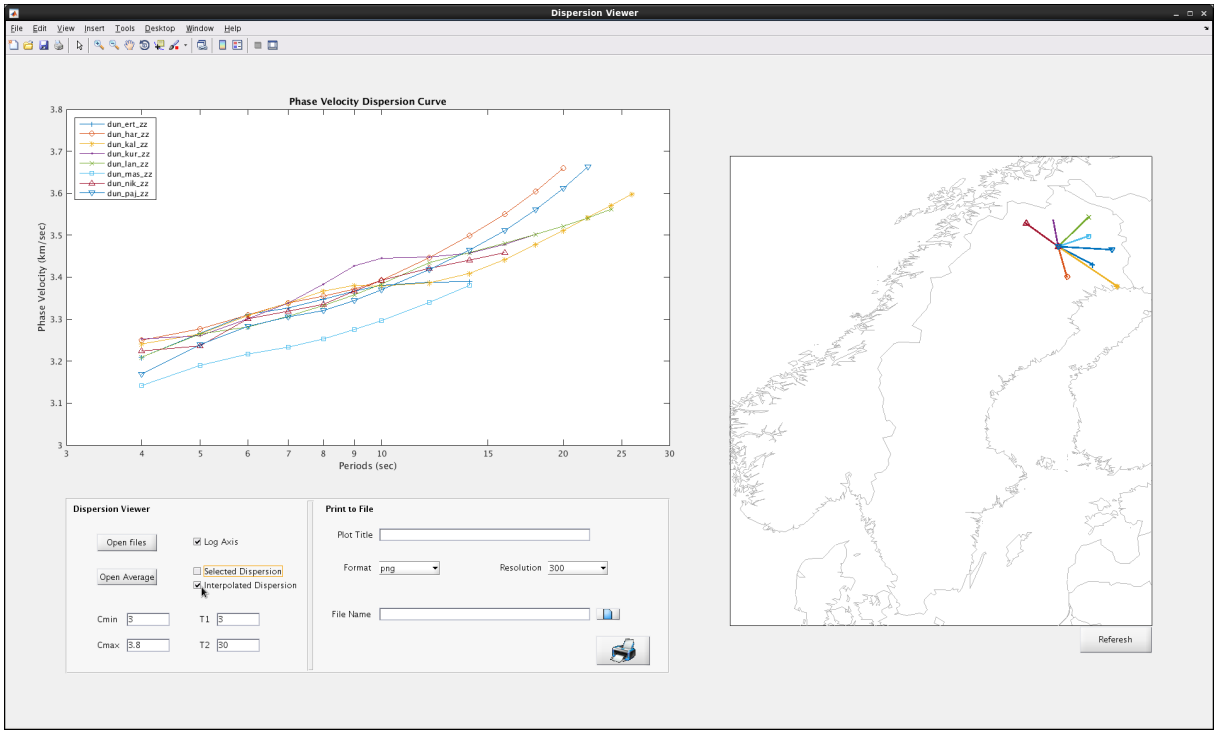

Figure 20: *Dispersion Viewer module - interpolated dispersions*

7 Mapping Measured Phase Velocities

The Map Viewer is used to map and print/save the interpolated phase-velocity dispersion curves. You can read the measured dispersions (.mat files) of various pairs and the module maps the interpolated phase velocities at the predefined periods. To do so, click on the Open Folder button and select the ZZ folder which contains all measured dispersion curves (Fig. 21). Then, interpolated velocities at each period are mapped starting from the longest period. The mouse wheel or the scroll-bar can be used to map phase velocities at other periods (Fig. 22). There are many options to reach the desired Map (see the manual). Finally, you can print out (save) the map to a file (Figs 23 and 24).

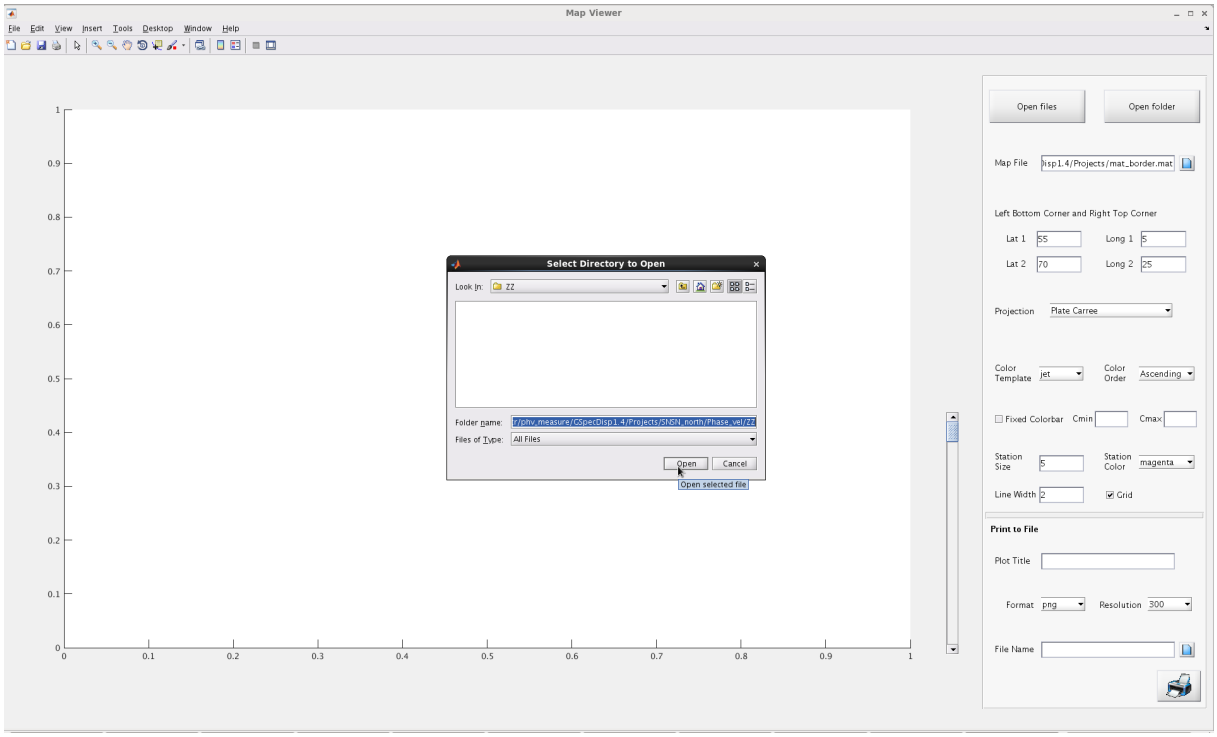

Figure 21: *Map Viewer module - open folder*

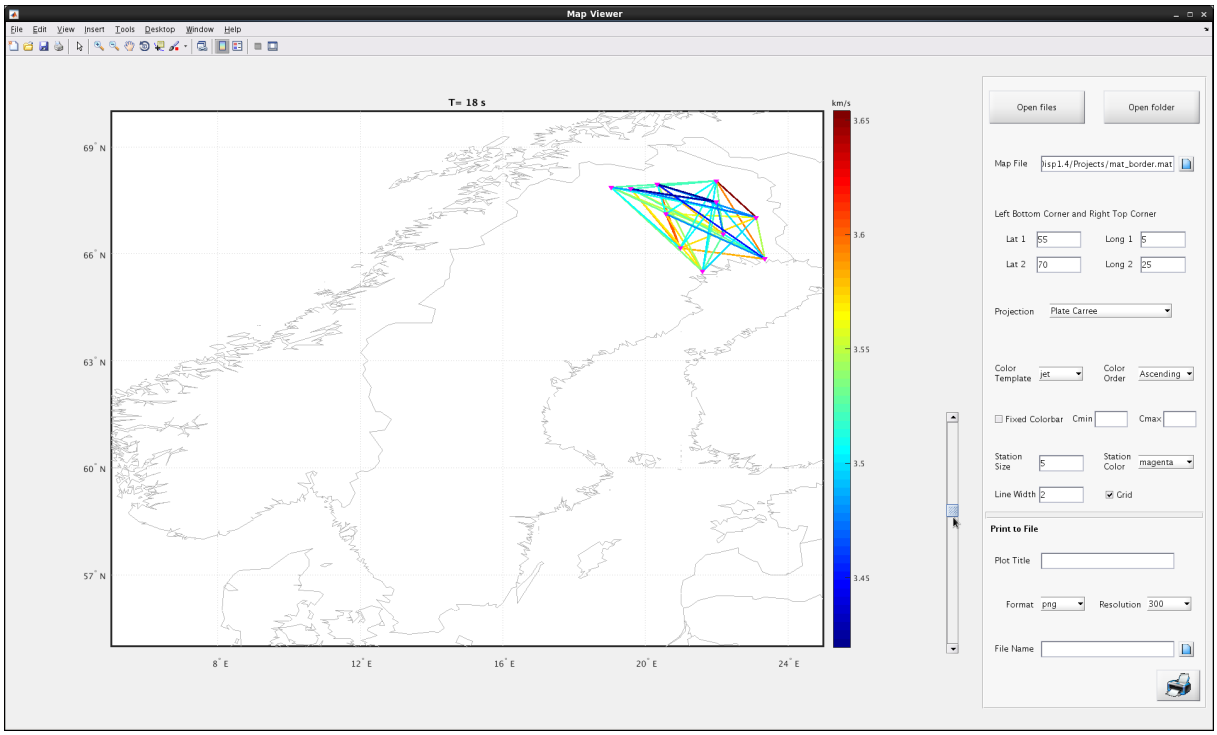

Figure 22: *Map Viewer module - interpolated dispersion at period of 18 sec*

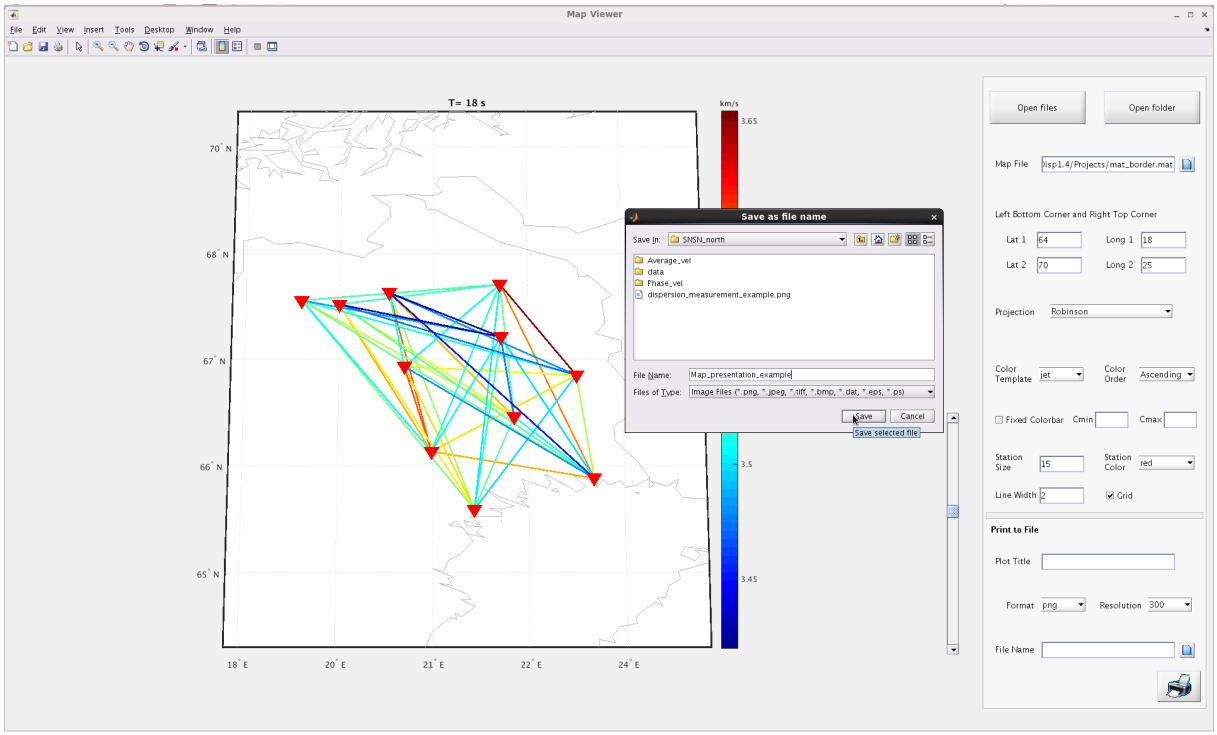

Figure 23: *Map Viewer module - print out the velocity measurement at period of 18 sec*

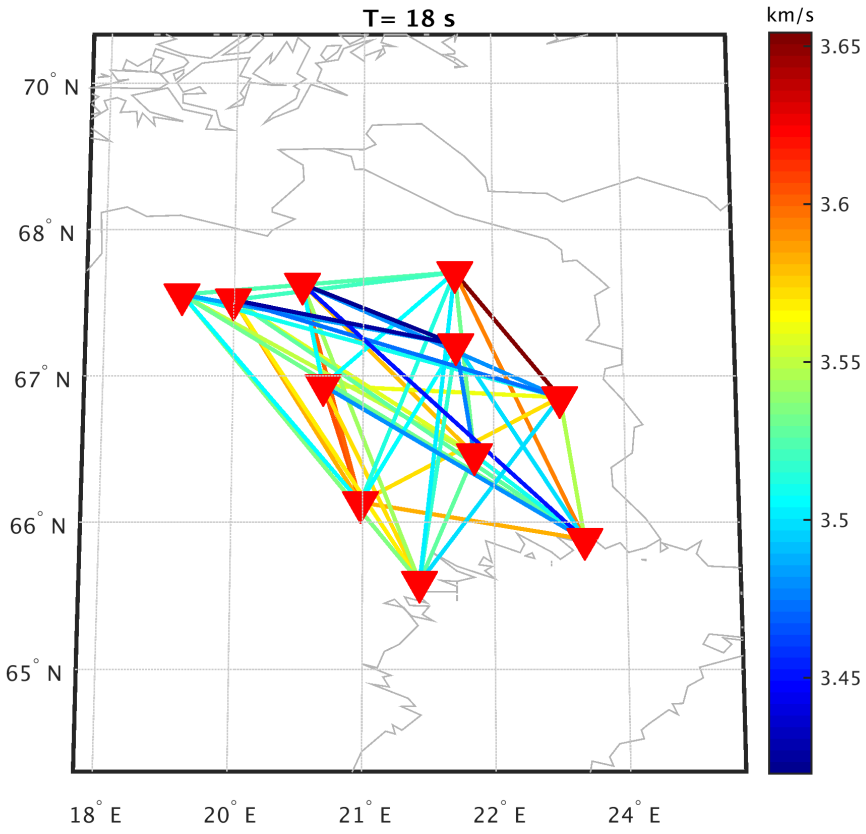

Figure 24: *Map Viewer module - saved map*