Sonicona
seismic software & services

Nanoseismic Suite Tutorial

SeisServ, SonoView and HypoLine

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This document provides a short introduction for the processing of seismic data in the Nanoseismic Suite. First, a dataset is chosen in SeisServ, then SonoView is used for visual screening and event detection. Finally, the events are located and Magnitudes are estimated interactively using HypoLine. This document follows a step-by-step approach. For each step, the action is described on the left, and the corresponding hotkeys or UI interaction is described on the right.

1 Data loading with SeisServ

1.1	SeisServ reads header files of various formats, and provides data and metadata to the other modules – SonoView and HypoLine. The demo only supports the included hardcoded datasets.	**File ➔ Load demo data ...**
1.3	SonoView starts automatically after laoding new data. You can also manually start SonoView and HypoLine here.	**Tools ➔ SonoView** **Tools ➔ HypoLine**
1.4	SeisServ automatically resamples all data to appropriate sampling rates for different tasks.	SeisServWindow: **Master Sampling Rate**
1.5	Switch between Light/Dark UI theme	**Theme ➔ Dark / Light**

2 Visual screening with SonoView

2.1	SonoView is controlled by using hotkeys. A full list is available in the **help menu**.	**Help ➔ Help** or **F1**
2.2	Sonoview shows a full page of Sonograms. Use the Arrow keys to **flip to the next page**.	Key *↓:* Next Page Key *↑:* Previous Page
2.3	On finding an event signature in the sonograms, mark it and **inspect the seismograms**.	Left click on the onset
2.4	On clicking the onset, TraceView will open in a separate window. Change the **event window length** to enclose the whole signature.	Key *Page↓:* Shrink event window Key *Page↑:* Enlarge event window
2.5	Adjust the seismogram **scaling**.	Key 'c': toggle common scaling Key 'g/G': decrease/increase gain
2.6	Adjust the seismogram **filtering**. You can adjust the preset filtering bands in the settings menu.	Keys '1' to '5': toggle a preset Filtering bands.
2.7	SonoView is designed to handle data from mini-arrays in the SNS configuration. You can hide and **show horizontal and array traces** in Traceview.	Key 'h': hide/show horizontal traces Key 'a': hide/show array traces
2.8	After confirming of the event, **write the event** to the detection list. Then you can assign a class to the event. Saved events are marked on the sonograms.	Key 'w': write event ➔ select event class
2.9	You can change a selected **events details** and add **comments**.	Key 'e': edit event
2.10	**Deleting events**	Key 'd': delete event.
2.11	You can jump to the **next or** the **previous event**.	Key '←': previous event Key '→': next event
2.12	All events are listet in the Event list, and can be **exported to csv** for further processing.	Key 'l': show event List

3 HypoLine

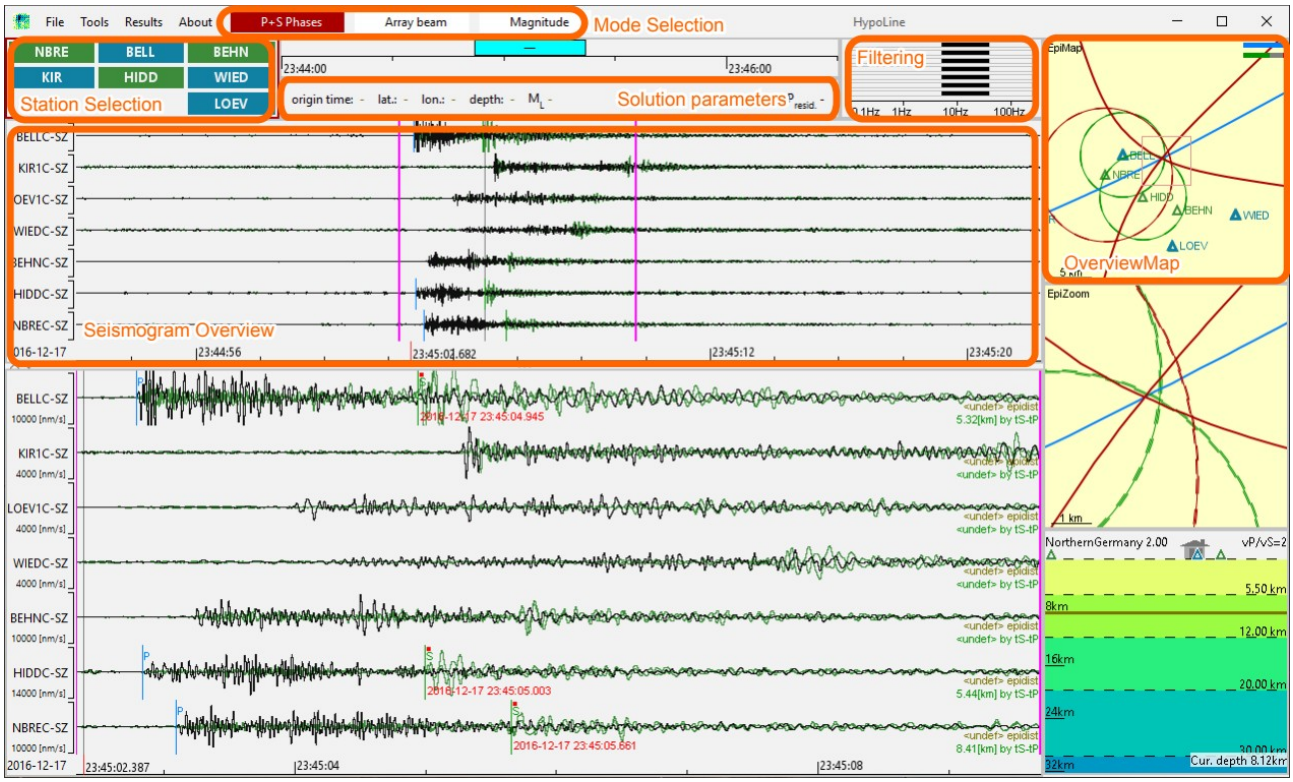

Figure 1: HypoLine in "P+S Phases" mode. If no station is selected, a network overview is displayed. The annotated elements are common to all HypoLine modes.

HypoLine is controlled by context based hotkeys. The position of the mouse pointer determines the active interface element (marked by a red border), which provides a number of options. To view the interactive **help**, hover the **mouse over** the UI element (for example the seismogram overview) and Key **F1**. This will provide a list of all possible actions and hotkeys.

HypoLine combines 3 modes to analyze earthquake data:

1. **P+S Phases Mode**: Phase picking and visualization of the resulting location constraints. Also visualizes P+S arrival simulation results for a set event.
2. **Array Beam Mode**: If small arrays are present, determine P+S beam azimuths and slowness.
3. **Magnitude Mode**: Determine local Magnitude M_L.

Some elements of the user interface are shared between the 3 modes, some are unique to each mode. HypoLine follows a color convention:

- **RED** marks the currently active objects/modes/windows.
- **BLUE** marks P picks, t_P hyperbolae. On maps, blue stations represent mini-arrays.
- **GREEN** marks S picks, t_S-t_P circles and horizontal components. On maps, green stations represent 3 component (3c) and 1 componen (1c) single stations.
- **YELLOW** marks user input and simulated onsets.

Below, we demonstrate a typical event location process using the DGMK dataset from Northern Germany.

3.1 Event location in HypoLine: P+S phases

*Figure 2: "P+S Phases" mode with station **NBRE** selected. The annotated elements are unique to this mode.*

3.1	In this tutorial we locate a small earthquake in Northern Germany. **Load** the "DGMK_20161218" **dataset** in SeisServ to follow the tutorial. Ensure the master sampling rate is set to 500 Hz. **Select** the **event** window of interest in SonoView.	in SeisServ Window: **File → Load demo data → DGMK_20161218** Master Sampling Rate: **500Hz** In SonoView: **Click sonogram at event onset**
3.2	**Start HypoLine**. HypoLine will launch in "P+S Phases" mode with no station selected and display an overview of all stations in the seismogram windows (like Fig. 1).	Start Hypoline in SeisServ: **Tools → HypoLine**
3.3	HypoLine is controlled by using the mouse + hotkeys. Each interface element has it's own **help** menu listing all possible actions.	Mouse over interface element + **F1**
3.4	Adjust the **filtering** of the data if necessary.	Filter Panel: Set low / high filter corners: **left/right click on bars** Reset filters: **click empty space**
3.5	The data between the pink bars in the seismogram overview defines the Seismo**zoom plot**'s extend. Adjust the pink bars in the overview seismogram to include the onset at the nearest stations.	Seismogram Overview: **left/right click** to set extend of zoomed seismogram

3.6	Adjust seismogram **gain** or toggle **common scaling**.	Mouse over Seismozoom: Adjust gain: **left/right click on amplitude label below station name** Common scaling: **Key 'c' to toggle**
3.7	Switch to **sonogram display** to spot weak P/S onsets on seismogram panels. Sesimograms should be used for picking if possible.	Mouse over panel: **Key 's' to toggle**
3.8	You can hide the green **horizontal traces** overlaid on the black/white vertical components.	Mouse over Seismozoom: **Key 'h'**
3.9	View the network on the **overview map**. You can zoom in to inspect the layout of the blue mini arrays. Adjust the map to show all station before you continue.	Mouse over overview map: **drag to move** **left/right click on scalebar to zoom** **mousewheel to zoom**
3.10	**Select** the **station** with the first onset (BELL) using the station selection panel. Only this station'ss traces are displayed now (Vertical in black/white, horizontals in green). Adjust the Seismozoom panels extend by moving the pink bars in the seismogram overview to have a detailed view of the whole waveform (see Fig. 2).	Mouse over Station Selection: **Click on station to select**, **Click on empty space to return to overview**
3.11	You see **6 seismograms**. BELL is a **mini-array**. The first three traces in blue are vertical components of the outer sites (we will utilize these later on), black/white is the vertical component of the center site and green are its two horizontal components.	Mouse over Seismozoom: **Key 'e'** to hide outer sites.
3.12	**Pick the P and S** onsets on the center site (black/white, green) at station BELL. Ignore the outer sites (blue) for now.	Mouse over seismogram in Seismozoom: **left/right click to pick P/S onset**
3.13	You can also **remove** bad **picks**.	Mouse in empty space above station name: **left/right click to delete P/S**
3.14	You can also **change and modify** the **active pick.**	Mouse on station name: **left/right click to select P/S pick** Arrow keys: **shift active pick**
3.15	Repeat the process for the next three nearest stations (HIDD, NBRE and BEHN). For each pair of P picks one **hyperbola** will apper in the maps, for each station where P and S are picked, one **circle** will appear, constraining the possible location of the epicenter according to layer model and the picks.	Mouse over the maps: **Key 'h'** to toggle hyperbola display **Key 'c'** to toggle circle display

3.16	Switch back to the overview by clicking the empty space in the station selection. You can now see seismogams and picks for all stations. We now try to locate the epicenter. First let's **adjust** the **Epizoom map** to zoom into the convergence point of hyperbolae and circles.	Mouse over overview map: **Left/right click** to adjust Epizoom view
3.17	Now, adjust the **event depth** and try to bring circles and hyperbolae to converge in one point.	Mouse over the Epidepth panel: (lower left). **Key** the **Arrow keys** .
3.18	At the moment we are using a simple halfspace model. **Switch** to different **layer models** and observe how the circles and hyperbolae change.	Mouse over the Epidepth panel: **Key number keys 0-9**
3.19	You can alter layer models or create new ones and observe the influence on the constraints in real time using the **Layer Model Editor.** This version of HypoLine is limited to a fixed v_P to v_S ratio and velocities increasing with depth.	Mouse over the Epidepth panel: **Key 'l'** to open the Layer model editor
3.20	When you have found a combination of layer model and depth where the constraints converge – Model "Northern Germany 2.00" and a depth of ~6 km should work nicely – we can **place** the **epicenter** on the convergence point. Now, simulation results for each onset will be displayed in the Seismozoom plot.	Mouse over Epizoom map: **left click to place epicenter** **right click to remove epicenter**
3.21	**Origin time** is determined by the P wave traveltime to the currently active P pick's station.	To change active pick: **Left click station name in Seismozoom** or set **place new P pick**
3.22	You can now pick the other stations to verofy that their hyperbolae and circles are consistent with the previous findings.	

3.2 Optional: Array beams

As an optional step, we can analyze array beams if the network contains mini-arrays. We try to find array beams defined by back azimuth and slowness. Their intersection provides another independent estimate of the epicenter, and the slowness helps to identify seismic and acoustic phases.

Array beams are also independent of the layer model. This is especially useful when working on short campaigns, where a conclusive layer model is not yet established.

3.22	Now switch to "**Array Beam**" mode to utilize the mini-arrays in the network. Then select one of the 4 mini-arrays (see Fig. 3).	**Click "Array Beam"** in the top menu bar. Then select one of the mini arrays: **Click a station name** in the station selection panel. Mini-arrays are colored **blue**

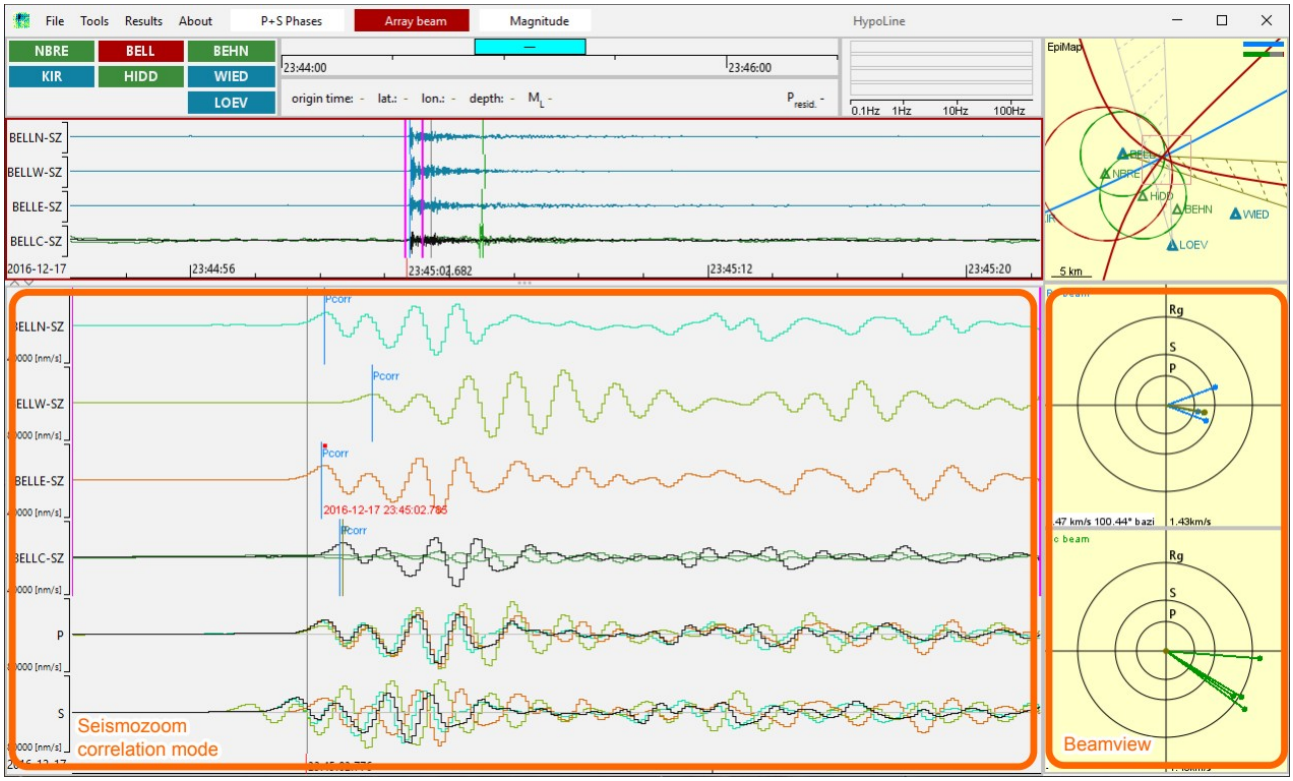

Figure 3: "Array beam" mode with mini-array BELL selected. The annotated elements are unique to this mode.

3.23	The Seismozoom panel now operates in **correlation** mode. You see 4 traces – the 3 vertical traces of the outer sites on top, then the vertical trace of the central station overlayed by it's horizontals. Place the **correlated P pick** (P_{Corr}) on the first significant feature of the first onset of the waveform. Repeat this for all 4 traces. You may also try to place S_{Corr}, if it is recognisable in the vertical traces.	On Seismozoom (correlation mode): **left / right click seismograms** to place P_{Corr} and S_{Corr} picks.
3.24	Whil placing P_{Corr} and S_{Corr} picks 2 additional traces appear, combining all vertical traces shifted according to the picks. You can **adjust** the P_{Corr} and S_{Corr} **picks** to find the best overlap of the traces.	Mouse on station name: **left/right click to select P_{Corr}/S_{Corr} pick** **Arrow keys** to adjust pick
3.25	On the left, you find 2 polar plots (Beamview) – the upper one for the P beam, the lower for the S. Each combination of 3 picks provides 1 array beam estimate. Pick the **array beam** according to the plausibility of the 4 estimates shown. The beam will now be displayed on the maps.	Mouse on Beamview: **Left click** on beam estimates to set beam. **Right click** to remove beam.
3.26	You can switch to **different polar grids** for the Beamview. This is useful to identify seimic and acoustic phases, and provide an angle of incidence for teleseismic events.	Mouse on Beamview: **Key F1** for a full list of supported polar grids.

3.3 Magnitude estimation

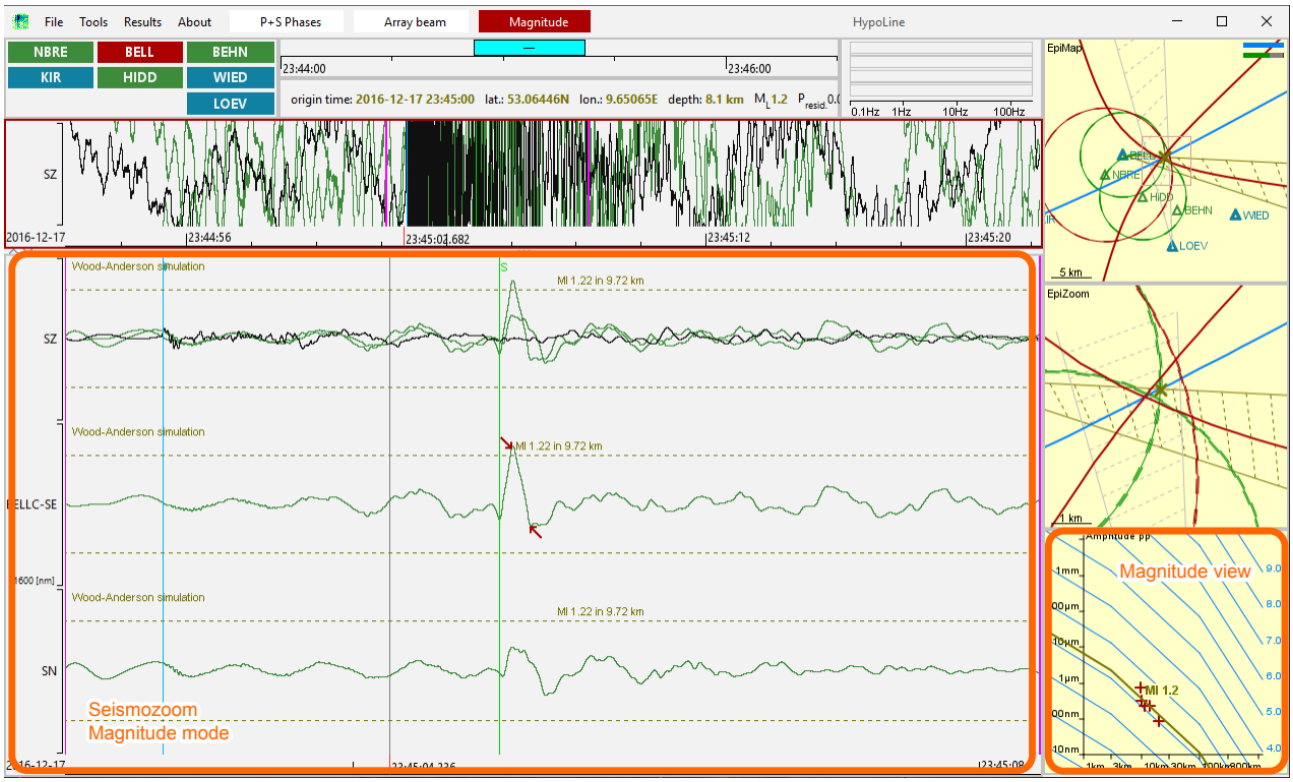

Figure 4: "Magnitude" mode with station BELL selected. The annotated elements are unique to this mode.

3.27	HypoLine is optimized for local and regional scales. Therefore we use local Magnitudes determined from horizontal S wave amplitudes on a Wood Anderson Seismometer and an amplitude/distance correction curve. Open **Magnitude mode** (see Fig. 4).	**Click "Magnitude"** in the top menu bar. Then select one of the stations
3.28	**Select** a **station**. The Seismozoom panel now operates in Magnitude mode. As we rely on horizontal components, only 3c stations are displayed. The seismogram is filtered and integrated to display displacement amplitudes on a Wood-Anderson seismometer. Global filter settings are ignored her.	**Click the station name** in the station selection panel
3.29	Zoom to the S wave, **pick** the **highest peak and lowest valley** within a single half-wave on the horizontal components. Repeat this for each station, where a visible S wave exists in the Wood-Anderson seismogram.	On Seismozoom (magnitude mode): **left / right click on horizontal trace** to mark highest peak and lowest valley
3.30	For each station, Peak-to-Peak amplitude is marked over epicentral distance in the plot on the lower right. **Set** a final **Magnitude**. It is displayed as a yellow curve, which should approximate the Peakt-to-Peak marks of the stations.	Mouse over Magnitude View: **Left click** to set Magnitude result **Right click** to delete Magnitude Use **Arrow keys** to shift Magnitude

3.4 HypoLine: Result handling

3.31	**Save** your work to a xml file. This contains all picks, filter settings, the epicenter etc. This file can be **restore**d to continue your analysis later on.	Top menu bar: **Results ➜ Save to protocol** **Results ➜ Load from protocol**
3.32	Copy the location result to the **clipboard** for **pasting** into a Spreadsheet.	Mouse over Solution Parameter panel (Above seismogram overview) **Key 'c'** to copy to clipboard
3.33	Inspect **bulletin** of former event solutions	**Results ➜ Show protocol bulletin**
3.34	**Reset** HypoLine to analyze the next event. This discards all unsaved data.	**Results ➜ Reset Results**

Thank you for using the Nanoseismic Suite!

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