AquaEdit
AquaCross
AquaView
AquaTool
Other
» AquaHarmony

User manual

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Contents

1 Introduction

AquaHarmony is an addon to the software package AquaSim. AquaSim is an analysis tool developed by Aquastructures AS, which utilizes the Finite Element Method (FEM) for calculation and simulation of structural response. It is suited for a range of structural configurations exposed to environmental loads such as:

- waves
- currents
- wind
- impulse loads
- operational conditions
- resonance

AquaHarmony is a data processing software for denoising and filtering current of measurements. **Note (1)**. This manual describes the theory and functionality of the software. The software provides a visual presentation of the processed data for further application in e.g., site reports.

Note (1)

As per AquaSim version 2.17, AquaHarmony is provided as a beta-version. Care should be taken when applied, and the validity of the results must be assessed.

1.1 Terminology

Through this manual, certain terms appear. Some of them are defined below.

Term	Definition
Denoising condition	The filtering criteria applied to the dataset when it is transformed from frequency domain to time domain.
Fourier Analysis	The study of how general functions can be presented as the sum of simpler harmonic functions.
Fourier Transform	Transformation of a function from time domain to frequency domain.
Fast Fourier Transform	Algorithm for transforming data form time domain to frequency domain.

2 Theoretical background

In this chapter, the theoretical basis of AquaHarmony is presented. AquaHarmony apply Fast Fourier Transform (FFT) for denoising of datasets. Fourier Transform (FT) is a linear representation of data. It transforms a function $f(t)$ to a new function $F(\omega)$ by means of integration. In the succeeding chapters, the basics of Fourier Analysis, Fourier Transform and Fast Fourier Transform is presented.

2.1 Fourier Transform

Fourier analysis is the study of how general functions can be presented as the sum of simpler harmonic functions. This is the basic concept of the software and is reflected by the name Aqua*Harmony* i.e., harmonic functions.

Consider a function $f(t)$, that may represent measurements of certain data as function of time t. Because of the time variable, the function f is represented in the time domain. By Fourier Transform, the function $f(t)$ is transformed from the time domain to a function in the frequency domain $F(\omega)$. Where ω represents the frequency. The advantage of transform from time domain to frequency domain is that it allows for analyzing the measurements from different mathematical perspectives. In denoising analysis, high frequency and steady state measurements is filtered out. For more information about Fourier Transform see e.g., (Wikipedia, 2021a).

2.1.1 Definition of Fourier Transform

A Fourier Transform consist of a real and a complex part. The real part of the transformation consists of sinus-waves and the complex part of cosine-waves. Let $f(t)$ represent a function of measurements. The Fourier Transform of t is defined by:

$$F(\omega) = F[f(t)] = \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt$$

Equation 1

where i is the complex unit $\sqrt{-1}$. Equation 1 tells us that a function is the infinite sum of harmonic components. This is illustrated in Figure 1.

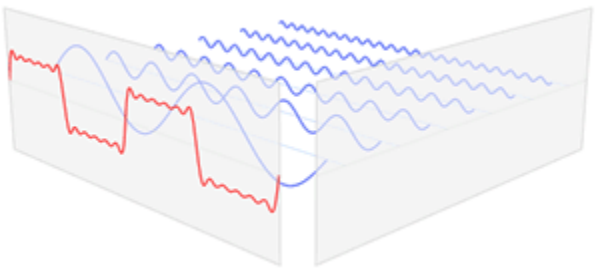


Figure 1 Fourier series with a linear combination og sine- and cosine-curves. From (Wikipedia, 2021a)

It is also possible to transform the Fourier Transform from frequency domain back to time domain, this is called Inverse Fourier Transform:

$$f(t) = F^{-1}[F(\omega)] = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) e^{-i\omega t} dt$$

Equation 2

In AquaHarmony, the denoising condition is defined in terms of periods. Then the data is transformed to frequency domain for filtering. After filtering, the data is transformed back into time domain by the Inverse Fourier Transform. The purpose of inverting the dataset back to time domain is because this format is required in further processing and analysis of the filtered data.

2.2 Fast Fourier Transform

Fourier analysis may be conducted in several ways. AquaHarmony is based on the algorithm Fast Fourier Transform. The Fast Fourier Transform (FFT) is an improvement of the Fourier analysis named Discrete Fourier Transform (DFT). The DFT converts a finite number of measurements, in time domain, into sequencies of equally spaced measurements in the frequency domain. Computing the transformation directly from the definition of DFT is a slow process due to the size of the generated matrixes. The FFT easily computes the transformation by factorization of the DFT matrix into smaller factors. Hence, FFT offers fast and efficient transformation of large datasets. An example of application is shown in Figure 2.

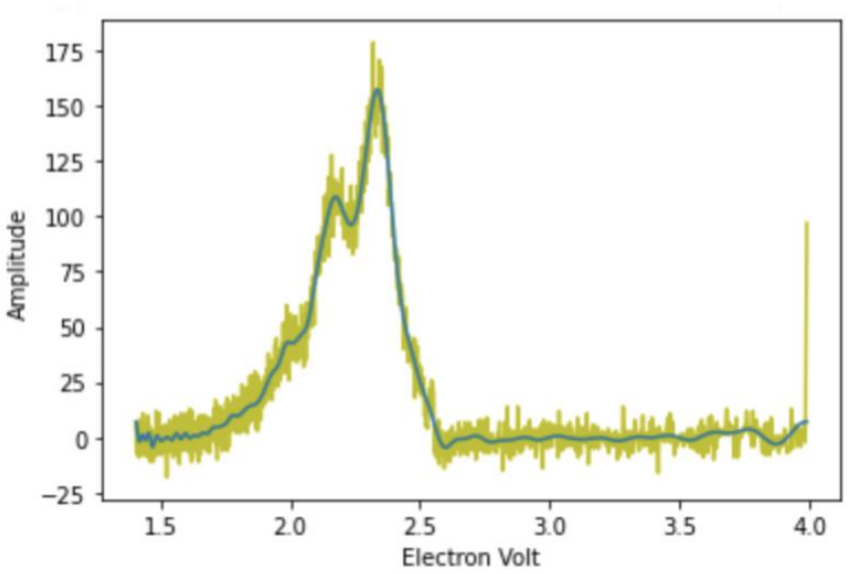


Figure 2 Measurements (green line) and FFT of the measurements (blue line). From (Chen, 2020a).

In short terms, the analysis by FFT is done in four main steps:

1. Original data with noise is imported to AquaHarmony.
2. The denoising condition is set by means of a low period cut-off- and harmonic periods.
3. The data is transformed from time domain to frequency domain through FFT and filtered according to the defined denoising condition.
4. The denoised data is inverted from frequency domain, back to time domain.

3 Interface

In this chapter, the interface of AquaHarmony is presented. First, some basics of the file format the software is customized for. Further, the interface and functionality are presented.

3.1 File formats and loading AquaHarmony

AquaHarmony loads .xlsx-files of a certain format. Meaning the Excel-files must be built up with a certain structure of rows and columns. This is to ensure the raw data is treated correctly when imported. An example of an input file is shown in Figure 3. A template for import of raw data can be generated from AquaHarmony. Data is saved with the format .hmodel.

Sensor Amount	3					
Sensor Name	S03		S06		S18	
Time	Magnitude	directions	Magnitude	directions	Magnitude	directions
01.01.2021 00:00		0.40655 63	0.40655 63	0.40655 63		
01.01.2021 00:10		0.44495 74	0.44495 74	0.44495 74		
01.01.2021 00:20		0.48177 84	0.48177 84	0.48177 84		
01.01.2021 00:30		0.51634 93	0.51634 93	0.51634 93		
01.01.2021 00:40		0.54662 101	0.54662 101	0.54662 101		
01.01.2021 00:50		0.56960 108	0.56960 108	0.56960 108		
01.01.2021 01:00		0.58208 114	0.58208 114	0.58208 114		
01.01.2021 01:10		0.58150 119	0.58150 119	0.58150 119		
01.01.2021 01:20		0.56664 122	0.56664 122	0.56664 122		
01.01.2021 01:30		0.53814 124	0.53814 124	0.53814 124		
01.01.2021 01:40		0.49876 124	0.49876 124	0.49876 124		
01.01.2021 01:50		0.45352 123	0.45352 123	0.45352 123		
01.01.2021 02:00		0.40947 119	0.40947 119	0.40947 119		
01.01.2021 02:10		0.37482 112	0.37482 112	0.37482 112		
01.01.2021 02:20		0.35661 104	0.35661 104	0.35661 104		

Figure 3 Example of input data, current measurements

3.2 Main View

Figure 4 presents the main view of AquaHarmony. It consists of:

1. Top Menu bar
2. Denoising Condition parameters for individual series of raw data
3. Raw data
4. and Filtered data

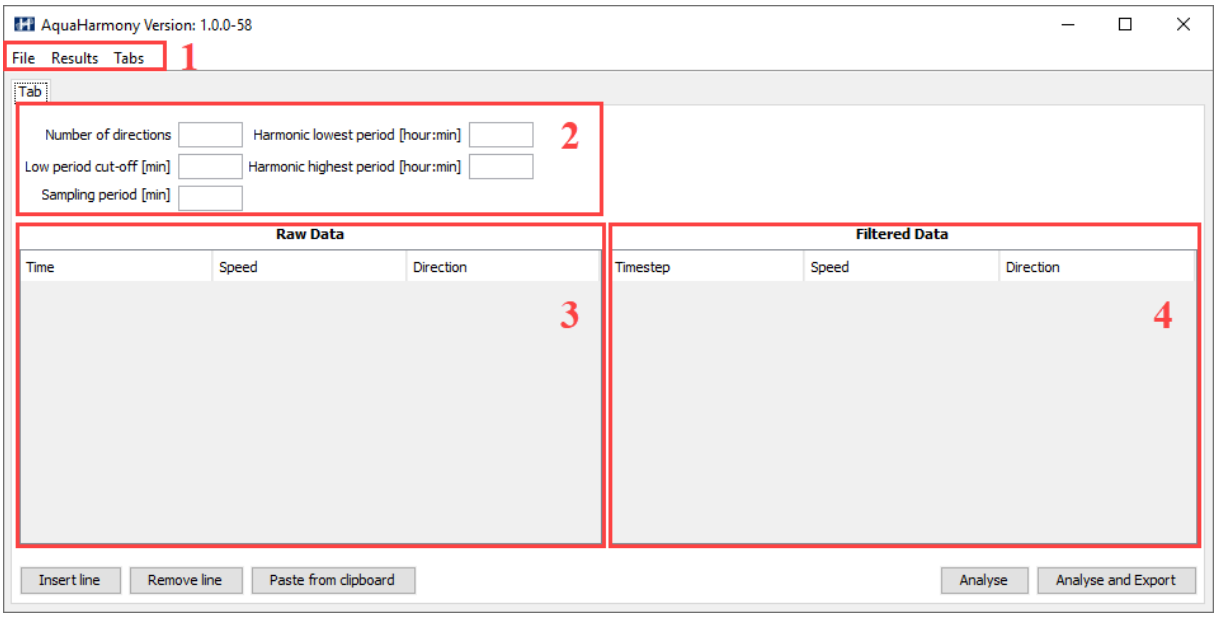


Figure 4 The main view of AquaHarmony

3.3 Top Menu bar

The Top Menu bar is found in the top left corner of the Main View. It provides access to import data, graphing results, and other setting. The different options are illustrated in Figure 5.

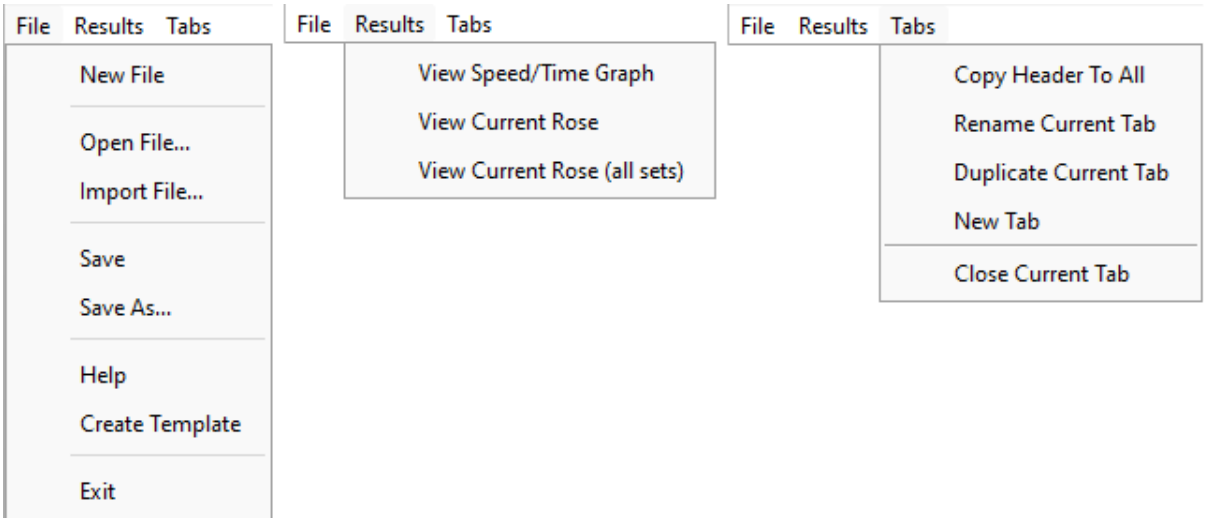


Figure 5 Options in the Top Menu bar

Detailed description of the option is found in Table 1.

Table 1 Options in the Top Menu bar

Option	Description
File	
New file	Resets the main view to a new AquaHarmony file. All current tabs are removed and a new tab is established.
Open file…	Opens file directory for selection of a AquaHarmony model (.hmodel).
Import file…	Opens file directory for selection of a .xlsx file.
Save	Saves the model. If the model has not been saved to file before, the user will get a dialog asking to choose a file name for the model.
Save As…	Allowing the user to save the model to a file name of the users choosing.
Help	Opens this user manual.
Create Template	Creates a working template (in .xlsx format) for import of raw data.
Exit	Exits and closes the software.
Graph	
View Speed/ Time Graph	Visualization of raw data and results in a scatter plot.
View Current Rose	Visualization of results as a function of orientation i.e., from 0 degrees to 360 degrees.
View Current Rose (all sets)	Visualization of results from all tabs in one graph.
Tabs	
Copy Header To All	Copy the parameters in the Denoising Condition-area from the current viewed tab to the other tabs.
Rename Current Tab	Enable the user to give the current viewed tab a new name.
Duplicate Current Tab	Duplicates (copies) the current viewed tab
New tab	Adds a new tab to AquaHarmony main view.
Close Current Tab	Closes the current viewed tab.

3.4 Denoising Condition

For each set of raw data, a denoising condition must be set. Normally, raw data of current velocities consists of measurements for several water depths. AquaHarmony recognize the different datasets for each water depth and presents them in different tabs. Each tab has the same options for defining the denoising condition and information parameters, as illustrated in Figure 6.

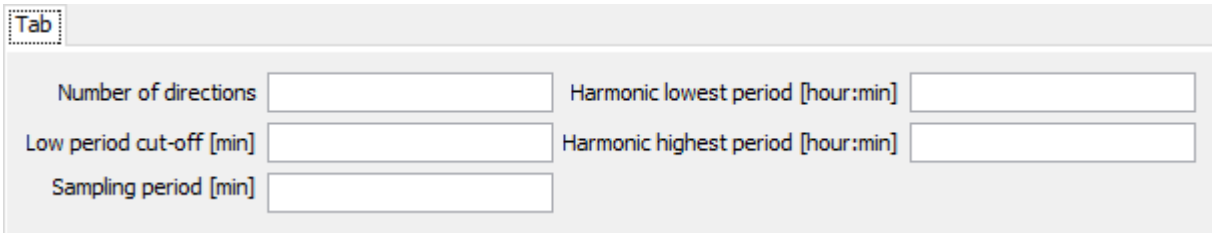


Figure 6 Denoising Condition and information parameters

Detailed description of the parameters is found in Table 2.

Table 2 Description of denoising condition and information parameters

Option	Description
Denoising condition	
Number of directions	Number of sectors the current rose will be divided into. For each sector, a maximum value of filtered data is presented. When the sectors are established, AquaHarmony set 0 degrees (north) as the starting mid-point. Then it is divided ± from 0 degrees into a total of $360^{\circ}/Number\ of\ directions$ number of sectors.
Low period cut-off	Parameter for filtering of low-period measurements from the raw data. All periods below this defined value are removed (in other words, filtered). E.g., if a dataset contains 10 measurements and the Low period cut-off removes 2 values, 8 measurements are returned. Removed data will result in a "smoother" dataset. Unit [minute].
Sampling period	Time interval between individual data-points. Current measurements are often logged with a time interval of 10 minutes. The user may identify this by considering the time between measurements in the input-data. Unit [minute].
Harmonic lowest period	Parameter for filtering of harmonic measurements, such as effect of tide. The lowest harmonic period is defined here. Removes all periods shorter than this defined value. Unit [minute].
Harmonic highest period	Parameter for filtering of harmonic measurements, such as effect of tide. The highest harmonic period is defined here. Removes all periods longer than this defined value. Unit [minute].

3.4.1 Low period cut-off

The Low period cut-off allows to cut the low periods (or high frequencies) of the measurements. In AquaHarmony, this value is interpreted as a period criterium. All periods below this defined value are removed from the dataset, resulting in fewer data points. The relation between the Low period cut-off and the frequency is described as:

$$T_{crit} = \frac{1}{f}$$

Equation 3

where T_{crit} is the Low period cut-off and f being the frequency of the data points. The filtering is based on the unfiltered raw data.

3.4.2 Harmonic lowest period and Harmonic highest period

These parameters are intendent for filtering of harmonic measurements, such as the effect of tidal currents. Typical period of tidal current is 6 hours. Periods within the range of the lowest and highest periods are filtered and removed from the dataset. The filtering is based on the unfiltered raw data. **Note (3)**.

Note (3)

Results from filtering applying Harmonic lowest/highest period and Low period cut-off is filtered and reported in separate files.

3.5 Raw Data

The Raw Data field is illustrated in Figure 7, where the raw data from the measurements are presented. It contains a table for presentation of measurement time, current speed and -direction. More detailed information is presented in Table 3.

Raw Data

Time	Speed	Direction
2021-01-01 01:00:00 CET	0.4066	63.4140
2021-01-01 01:10:00 CET	0.4450	73.8127
2021-01-01 01:20:00 CET	0.4818	83.7081
2021-01-01 01:30:00 CET	0.5163	92.8612
2021-01-01 01:40:00 CET	0.5466	101.0599
2021-01-01 01:50:00 CET	0.5696	108.1634
2021-01-01 02:00:00 CET	0.5821	114.0943
2021-01-01 02:10:00 CET	0.5815	118.8005
2021-01-01 02:20:00 CET	0.5666	122.2085
2021-01-01 02:30:00 CET	0.5381	124.1800
2021-01-01 02:40:00 CET	0.4988	124.4768
2021-01-01 02:50:00 CET	0.4535	122.7569
2021-01-01 03:00:00 CET	0.4095	118.6734
2021-01-01 03:10:00 CET	0.3748	112.2027

Insert line | Remove line | Paste from clipboard

Figure 7 Input dataset

Each column in the table is editable by double-clicking. **Note (4)**.

Note (4)

AquaHarmony assumes time zone GMT+00 (Central European Time). If your PC is located in another time zone, the time of the raw data will be adjusted upon import.

Table 3 Options in the Input dataset field

Option	Description
Time	Time when measurements were registered.
Speed	Magnitude of the measured speed/ velocity. The unit depends on what the sensor reports, but is usually measured in *m/s* or *cm/s*.
Direction	The direction of the measurements. The value should be interpreted as direction TOWARDS. Meaning that a value of e.g., 180 is interpreted as towards south. The unit is *degrees*.
Insert line	Generates a new empty row in the table. The user may type appropriate values for each column in the generated row.
Remove line	Deletes the selected row in the table. To select a row, simply right click on a row in the table.
Paste from clipboard	Pastes the latest data from your clipboard. AquaHarmony holds the following time formats: - Import from Excel: dd-MM-yyyy HH:mm:ss - Default time in table: dd-MM-yyyy HH:mm:ss - When copying: dd-MM-yyyy HH:mm:ss - When pasting: dd-MM-yyyy HH:mm:ss - When saving: yyyy-MM-dd HH:mm:ss Z
Analyse	Starts the analysis without saving results. Analysis includes filtering of the raw data based on the parameters in the defined denoising condition. Results are automatically viewed in the right section of the AquaHarmony window.
Analyse and Export	Starts the analysis and saves results in chosen folder. More information in Ch. 3.6.

3.6 Analyse and Export

Upon selecting **Analyse and Export**, a window for saving the analysis appear. The user should then assign the analysis a name. When selecting **Save**, the filtering analysis is conducted. 12 ASCII-formatted files are generated, an example is provided in Figure 8. In this example the analysis is named “run_”.

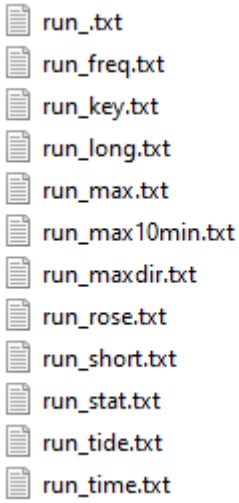


Figure 8 Example of result files.

Each result file contains information about the filtered dataset and analysis information. More detailed information about the content is provided in Table 4.

Table 4 Files generated from AquaHarmony

Filename	Description
<filename>.txt	Rearranged unfiltered raw data. The first row summarizes the parameters defined in the denoising condition. Then unfiltered data and corresponding direction in [degrees].
<filename>freq.txt	Raw- and filtered data transformed to frequency domain. The relation between the frequency f $[1/min]$ and period T $[min]$ is given as: $T(min) = (1/f) \cdot Sampling\ period \quad [min]$ The second column contains unfiltered raw data converted to frequency domain. The third column is the filtered frequencies. If 0.0E+00, then this means that frequencies are removed and filtered form the dataset.
<filename>key.txt	Key data about software version and license information.
<filename>long.txt	Filtered data. Reports all data with periods longer than “Harmonic highest period”.
<filename>max.txt	First column numbers the directions/ sectors. Second column is the directions/ sectors, unit [degrees]. Third column is maximum unfiltered raw data within the corresponding direction/ sector. Fourth column is maximum filtered data within the corresponding direction/ sector. Fifth column is the difference between unfiltered and filtered data, absolute value.
<filename>maxdir.txt	Filtered data. First column numbers the directions/ sectors. Number of the last row should correspond to the

	value defined in “Number of directions”. Second column is the directions/ sectors, unit [degrees]. Third column is maximum unfiltered input-data within the corresponding direction/ sector. Fourth column is maximum filtered data within the corresponding direction/ sector. Fifth column is the difference between unfiltered raw data and filtered data, absolute value.
<filename>rose.txt	Data basis for the Current Rose graph. First dataset, in this file, is filtered data (maximum value within a direction/ sector) based on “Low period cut-off”, polar coordinates. Second dataset is unfiltered data, polar coordinates. Third dataset is the same as the first dataset, only presented in cartesian coordinates. Fourth dataset is the same as the second dataset, only presented in cartesian coordinates.
<filename>short.txt	Filtered data. Reports all data with periods shorter than “Harmonic lower period”.
<filename>stat.txt	All data presented (not only maximum within a direction/ sector). First column is numbering of each row. Second column is unfiltered data. Third column is filtered data. Fourth column is the difference between unfiltered and filtered data, absolute value.
<filename>tide.txt	Filtered data based on the denoising condition in “Harmonic lowest period” and “Harmonic highest period”. “Lowest period cut-off” is not included. Cartesian coordinates.
<filename>time.txt	Same as <filename>.txt, only this is filtered data.

3.7 Filtered Data

When analysis is completed, the filtered dataset will appear in the Filtered Data section of the main view, as illustrated in Figure 9. The time is converted from the format *Year-month-day Hour:Minute:Seconds* to timesteps. The timestep start at 1.0 and ends at the last filtered measurement.

Filtered Data

Timestep	Speed	Direction
1	0.4066	63.4140
2	0.4450	73.8127
3	0.4818	83.7081
4	0.5163	92.8612
5	0.5466	101.0598
6	0.5696	108.1634
7	0.5821	114.0943
8	0.5815	118.8005
9	0.5666	122.2085
10	0.5381	124.1800
11	0.4988	124.4768
12	0.4535	122.7569
13	0.4095	118.6734
14	0.3748	112.2027
15	0.3566	104.1748

Figure 9 Filtered Data section of the main view

3.8 Graphs

Both the unfiltered raw data and the filtered data may be presented is graphs; as a function og time or as a function of direction. The latter is referred to as Current Rose.

3.8.1 View Speed/Time Graph

The graph is found in Graph > View Speed/Time Graph. The measurements are presented as a function of time. It is possible to view both the unfiltered- and the filtered dataset separately or together, as exemplified in Figure 10.

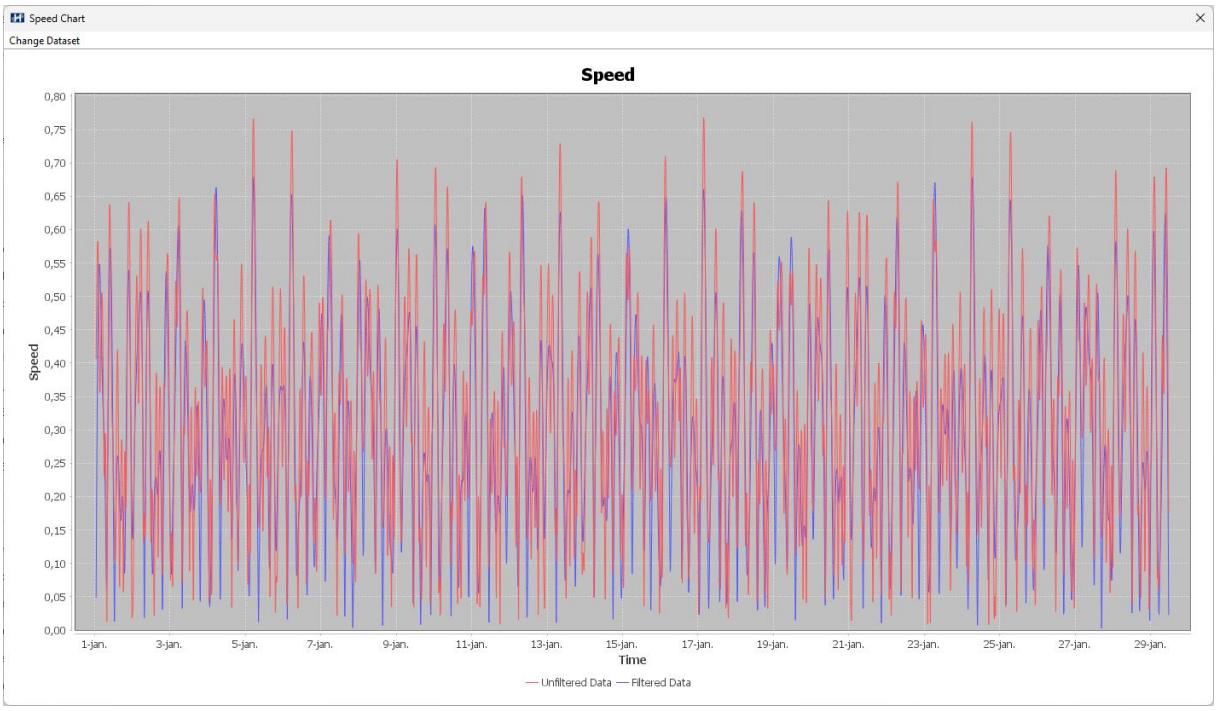
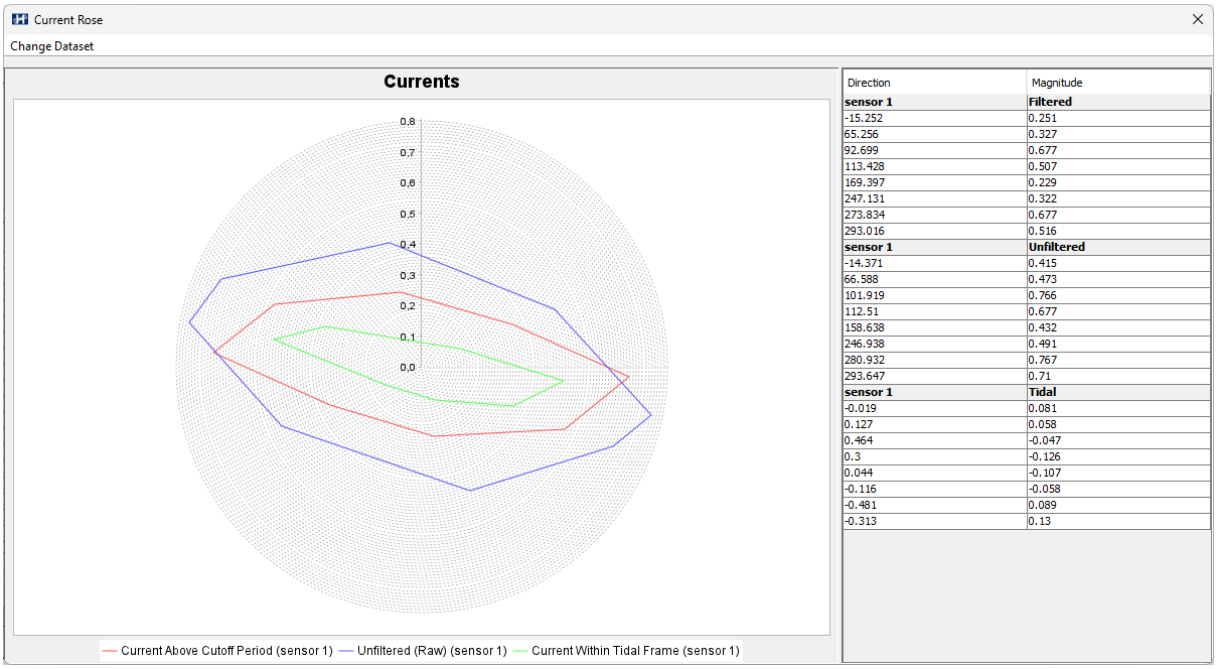


Figure 10 Unfiltered raw data (blue line), filtered data (red line)

3.8.2 View Current Rose

The Current Rose is found in Graph > View Current Rose. The Current Rose presents the dataset as a function of direction. As for the Graph, both the unfiltered raw data and filtered data may be displayed. An example is seen in Figure 11.



Direction	Magnitude
sensor 1	**Filtered**
-15.252	0.251
65.256	0.327
92.699	0.677
113.428	0.507
169.397	0.229
247.131	0.322
273.834	0.677
293.016	0.516
sensor 1	**Unfiltered**
-14.371	0.415
66.588	0.473
101.919	0.766
112.51	0.677
158.638	0.432
246.938	0.491
280.932	0.767
293.647	0.71
sensor 1	**Tidal**
-0.019	0.081
0.127	0.058
0.464	-0.047
0.3	-0.126
0.044	-0.107
-0.116	-0.058
-0.481	0.089
-0.313	0.13

Figure 11 Unfiltered data (red line), filtered data (blue line)

Current within Tidal Frame visualize results from Harmonic highest- and Harmonic lowest period.

4 Warnings and messages

This chapter provides information about selected warnings and messages that AquaHarmony may display.

4.1 Save file Corrupted

This message implies that there is something wrong with your .hmodel. The cause is most likely that there is something wrong with the .hmodel-file. The .hmodel-file is a human readable XML file so you can view it in many text editors (e.g. Notepad++). Corrupted data will be omitted upon loading data in AquaHarmony.

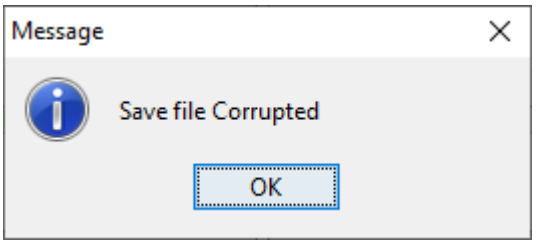


Figure 12 Message: Save file Corrupted

5 Example of application AquaHarmony

In this chapter a simple how-to-use-example for application of AquaHarmony is presented. The example is divided into three main sections: preprocessing, analysis and postprocessing.

5.1 Learning objectives

Upon completion of this example, you will be able to:

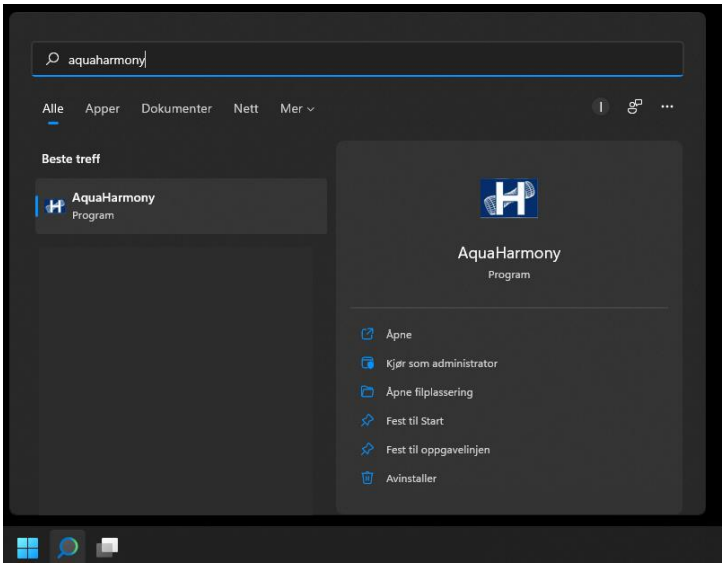
- Create template-file for import of raw data
- Import of raw data
- Set denoising condition (filtering criteria)
- Run and save analysis
- View results as current rose and as a function of time

5.2 Preprocessing

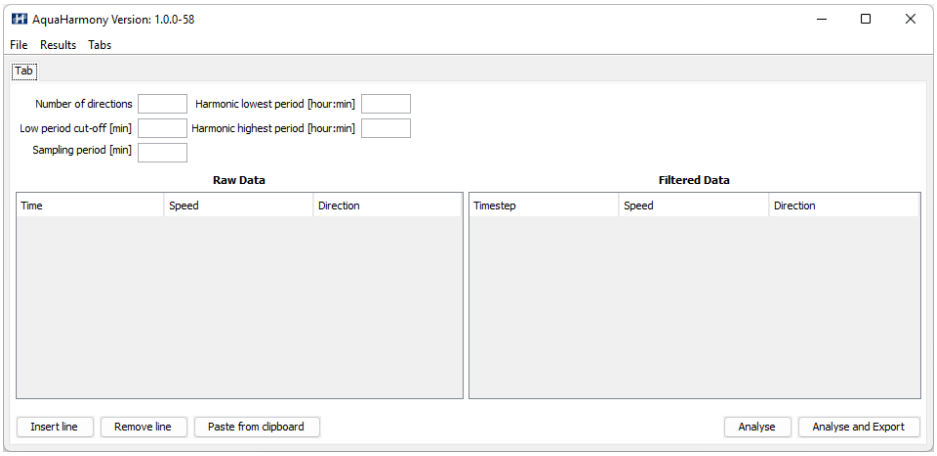
In this example you will need raw data for the analysis.

1 Load AquaHarmony

From the start menu on your computer search AquaHarmony.

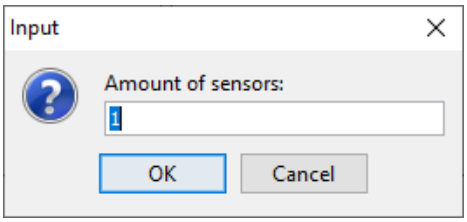


Load the program. The main view is presented in the figure below.



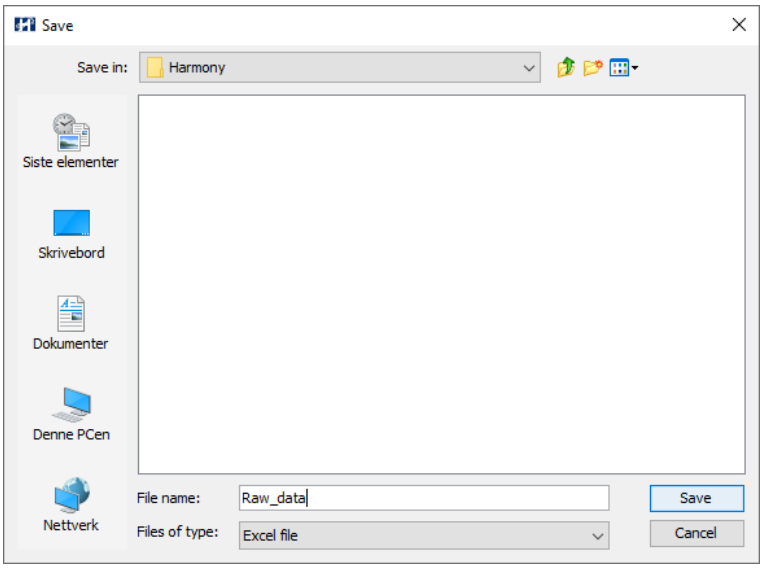
2 Create Template

AquaHarmony reads raw data with a specific format. To ensure that your data is read correctly, you should first create a template for the raw data. Select **File** > **Create Template**. This example is based on data found in Ch. 5.5. In the **Input** window for **Amount of sensors**, type 1.



Select **OK**.

Navigate to a folder where you want to save the template. In this example we have chosen Documents\AquaSim\AquaHarmony and named it “Raw_data”. The template will be saved in Excel-format.



Select **Save**.

The Excel-template will automatically be loaded with some preset information. This is information about the number of- and name of sensor(s), followed by headers for where the raw data is to be pasted.

	A	B	C	D
1	Sensor Amount	1		
2	Sensor Name	sensor 1		
3	Time (dd.mm.yyyy hh:mm:ss)	Magnitude	directions	
4				
5				
6				
7				

The raw data must, at time being, be in a specific format. This is **day.day.month.month.year.year.year.year hour:hour:minute:minute:second:second**.

3 Paste raw data to the template

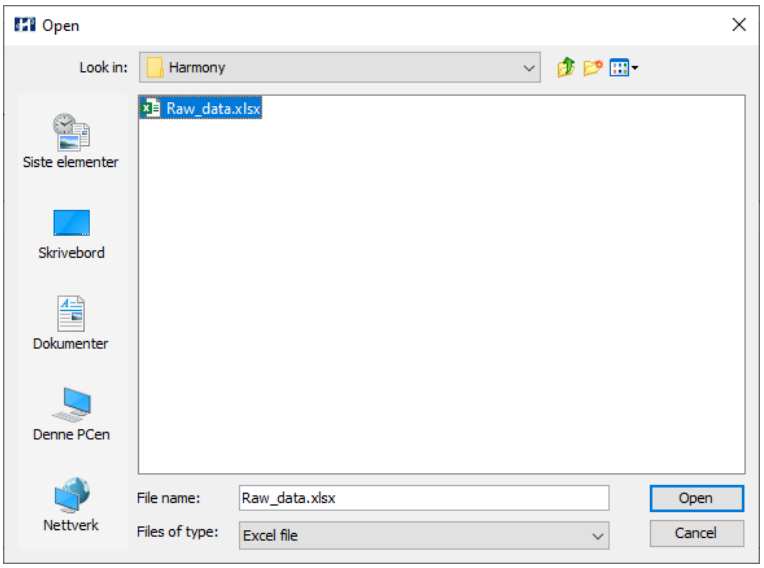
Copy the data from Table 5 (see Ch. 5.5) and paste it in the template-file.

	A	B	C
1	Sensor Amount	1	
2	Sensor Name	sensor 1	
3	Time (dd.mm.yyyy hh:mm:ss)	Magnitude	directions
4	01.01.2021 00:00:00	0.406552421	63.414018
5	01.01.2021 00:10:00	0.444950278	73.812697
6	01.01.2021 00:20:00	0.481772524	83.708068
7	01.01.2021 00:30:00	0.516341715	92.861176
8	01.01.2021 00:40:00	0.546617822	101.05985
9	01.01.2021 00:50:00	0.569598384	108.16339
10	01.01.2021 01:00:00	0.582081705	114.09434
11	01.01.2021 01:10:00	0.581502964	118.80047
12	01.01.2021 01:20:00	0.566644277	122.20848
13	01.01.2021 01:30:00	0.538137824	124.18
14	01.01.2021 01:40:00	0.498758619	124.47676
15	01.01.2021 01:50:00	0.453518498	122.75689
16	01.01.2021 02:00:00	0.409472121	118.67342
17	01.01.2021 02:10:00	0.374823629	112.20269

Save the template.

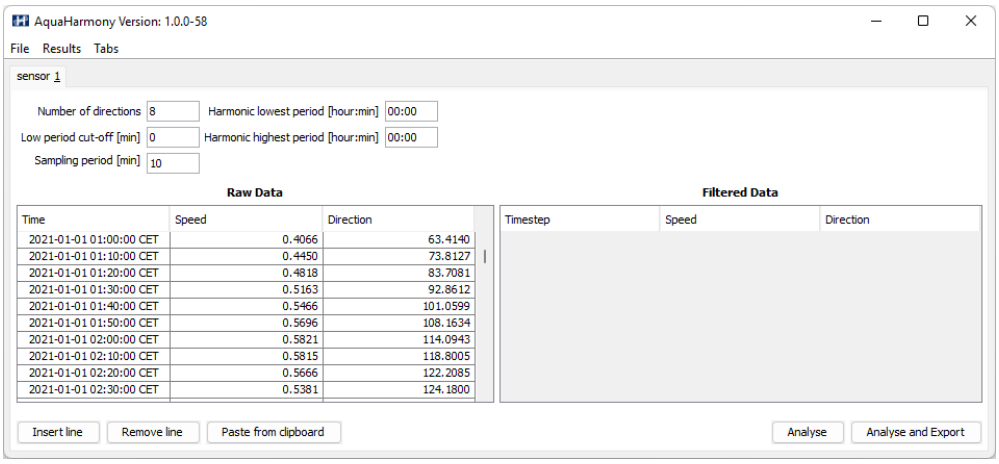
4 Load raw data to AquaHarmony

From the main view in AquaHarmony, select **File** > **Import File…** Navigate to where you saved the template-file.



Select the file and press **Open**.

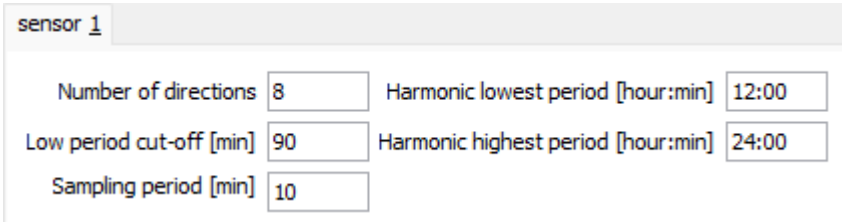
The raw data is imported and your AquaHarmony window should resemble the figure below.



AquaHarmony apply Central European Time format. Depending on the location of your computer, the time in AquaHarmony may deviate from the time in the raw data file.

5 Set denoising condition

For more information on the parameters for the denoising condition reference is made to Ch. 3.4. In this example, the **Low period cut-off** is 90 minutes, **Harmonic lowest period** is 12 hours and the **Harmonic highest period** is 24 hours.

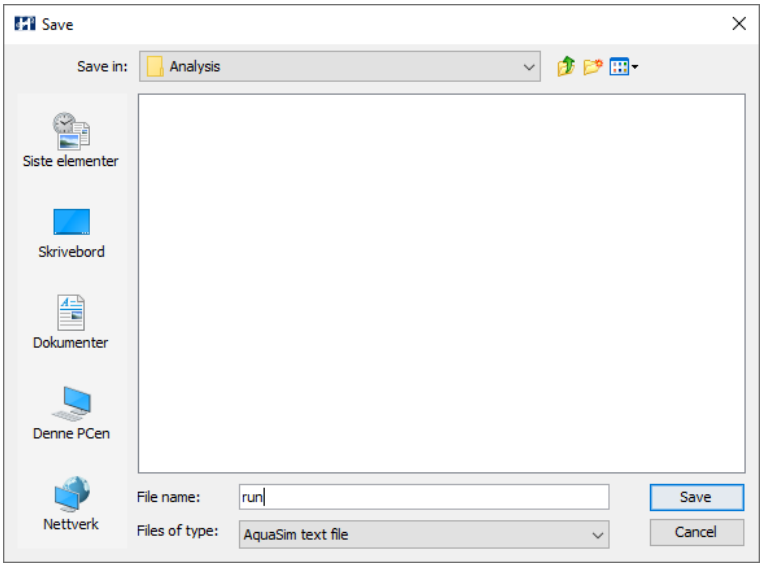


The preprocessing is finished.

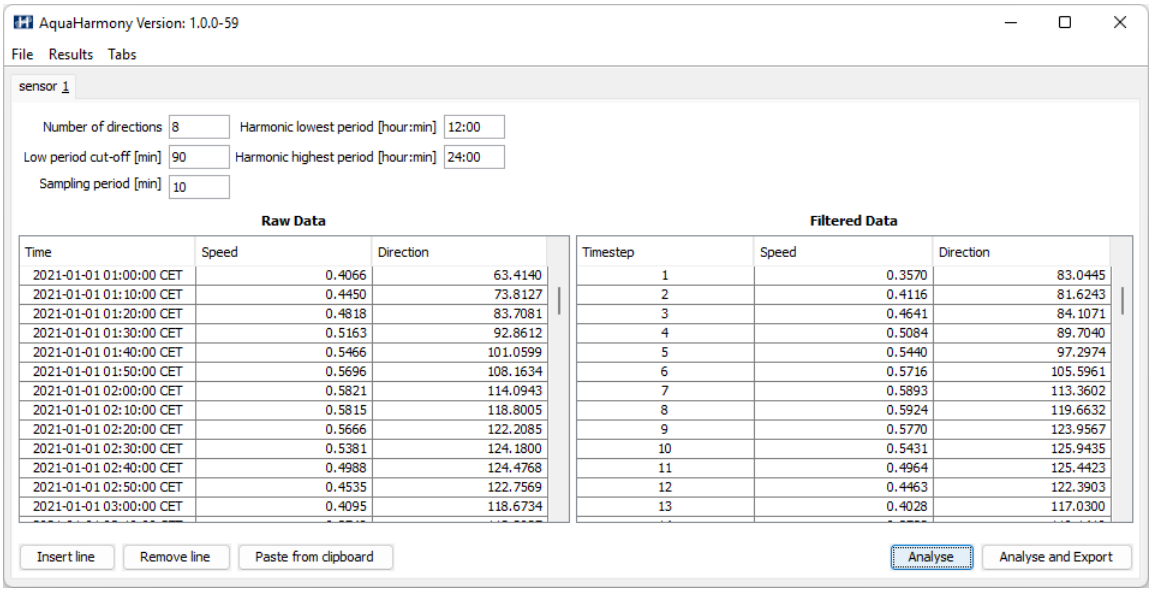
5.3 Analysis

6 Analyse and Export

To run and generate result files, select **Analyse and Export**. Navigate to an appropriate place to save the analysis. We have chosen Documents\AquaSim\AquaHarmony, and created the folder Analysis. In the section **File name**, type a name of the analysis. We have chosen *run*.

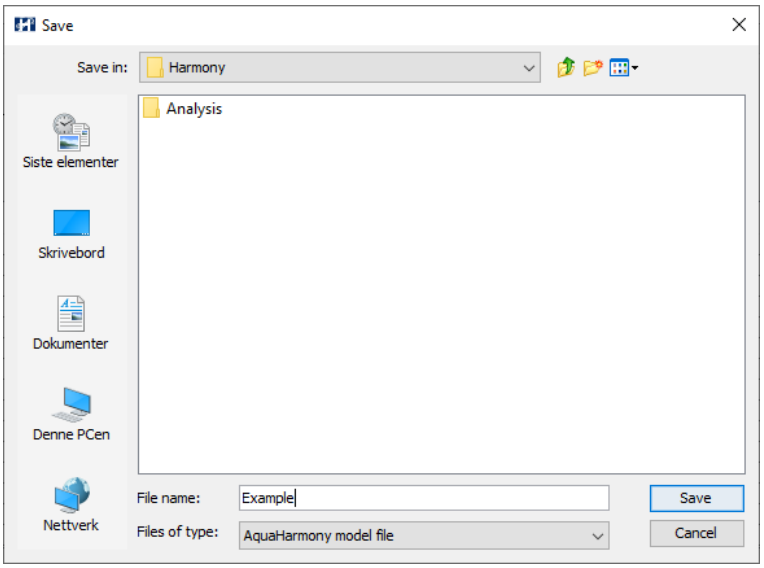


Select **Save**. The analysis (or filtering) starts. When the filtering is finished, the results (filtered data) will appear to the left in the main view of AquaHarmony.



7 Save

Good saving routines are important to ensure data is not lost. Select **File** > **Save** and navigate to an appropriate place where you want to save the data. We have chosen Documents\AquaSim\AquaHarmony, and named the file *Example*.

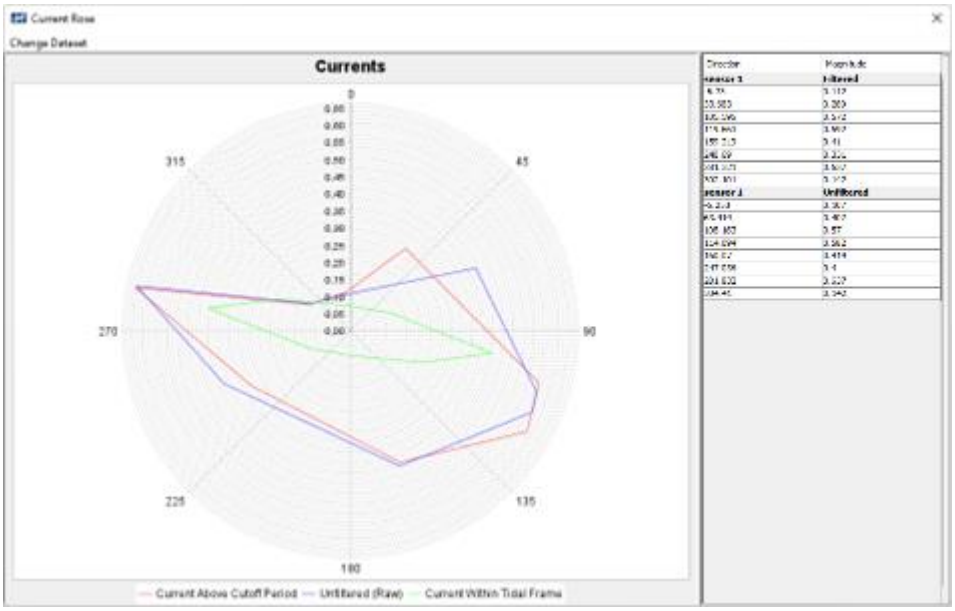


Select **Save**. The file will be saved with the format .hmodel (Harmony model).

5.4 Postprocessing

8 View Current Rose

The filtered data can be viewed in terms of a current rose. Select **Results** > **View Current Rose**.

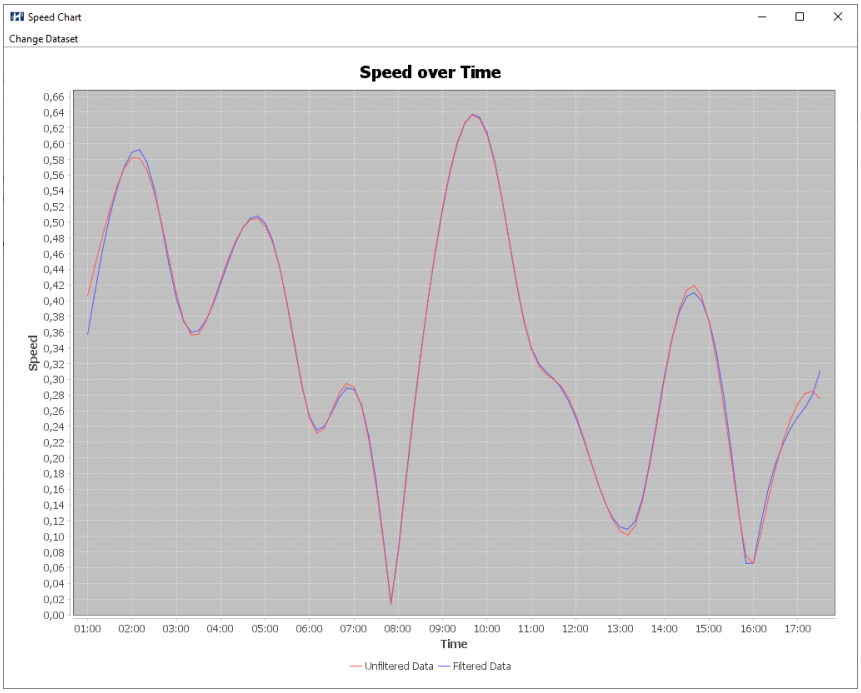


From the **Change dataset** menu, you can choose to view both filtered and raw data. In addition, the harmonic components can be toggled on or off. To the left in the Current Rose window the datapoints from the rose is shown. These can be copied to clipboard.

Normally, measurements consist of thousands of datapoints. This example is based on 100 datapoints, which is few, and the results will therefore become somewhat inadequate.

9 View Speed over Time

The filtered and raw data can also be viewed as a function of time. Select results > View Speed/Time Graph.



The visibility of the filtered- and raw data (e.i, unfiltered data) can be toggled on and off from the **Change dataset** menu.

--- End of example ---

5.5 Example raw data

Example data for import to AquaHarmony.

Table 5 Raw data

Time	Current magnitude	Current direction
01.01.2021 00:00:00	0.406552	63.41402
01.01.2021 00:10:00	0.44495	73.8127
01.01.2021 00:20:00	0.481773	83.70807
01.01.2021 00:30:00	0.516342	92.86118
01.01.2021 00:40:00	0.546618	101.0599
01.01.2021 00:50:00	0.569598	108.1634
01.01.2021 01:00:00	0.582082	114.0943
01.01.2021 01:10:00	0.581503	118.8005
01.01.2021 01:20:00	0.566644	122.2085
01.01.2021 01:30:00	0.538138	124.18
01.01.2021 01:40:00	0.498759	124.4768
01.01.2021 01:50:00	0.453518	122.7569
01.01.2021 02:00:00	0.409472	118.6734
01.01.2021 02:10:00	0.374824	112.2027
01.01.2021 02:20:00	0.356605	104.1748
01.01.2021 02:30:00	0.357298	96.36492
01.01.2021 02:40:00	0.373506	90.54301
01.01.2021 02:50:00	0.39866	87.49402
01.01.2021 03:00:00	0.426626	87.06942
01.01.2021 03:10:00	0.453229	88.70788
01.01.2021 03:20:00	0.475977	91.77196
01.01.2021 03:30:00	0.493215	95.6667
01.01.2021 03:40:00	0.503392	99.86835
01.01.2021 03:50:00	0.504758	103.927
01.01.2021 04:00:00	0.495494	107.4532
01.01.2021 04:10:00	0.474191	110.0824
01.01.2021 04:20:00	0.440493	111.4097
01.01.2021 04:30:00	0.395776	110.8873
01.01.2021 04:40:00	0.343865	107.6817
01.01.2021 04:50:00	0.291824	100.5723
01.01.2021 05:00:00	0.250398	88.38079
01.01.2021 05:10:00	0.231275	71.96151
01.01.2021 05:20:00	0.237778	55.80364
01.01.2021 05:30:00	0.259676	44.00351
01.01.2021 05:40:00	0.282242	36.97296
01.01.2021 05:50:00	0.294449	33.47086
01.01.2021 06:00:00	0.29001	32.36706
01.01.2021 06:10:00	0.266318	32.96424
01.01.2021 06:20:00	0.223511	34.92942
01.01.2021 06:30:00	0.163791	38.31782

01.01.2021 06:40:00	0.090871	44.41186
01.01.2021 06:50:00	0.01321	93.99664
01.01.2021 07:00:00	0.07933	218.4185
01.01.2021 07:10:00	0.166011	227.3476
01.01.2021 07:20:00	0.249941	234.0309
01.01.2021 07:30:00	0.328551	240.5007
01.01.2021 07:40:00	0.400341	247.0357
01.01.2021 07:50:00	0.464456	253.611
01.01.2021 08:00:00	0.520241	260.0986
01.01.2021 08:10:00	0.566828	266.3312
01.01.2021 08:20:00	0.602921	272.1353
01.01.2021 08:30:00	0.62685	277.3502
01.01.2021 08:40:00	0.636893	281.8322
01.01.2021 08:50:00	0.631774	285.4453
01.01.2021 09:00:00	0.611184	288.042
01.01.2021 09:10:00	0.576239	289.4377
01.01.2021 09:20:00	0.529769	289.3854
01.01.2021 09:30:00	0.476398	287.5677
01.01.2021 09:40:00	0.422303	283.6513
01.01.2021 09:50:00	0.374403	277.494
01.01.2021 10:00:00	0.338544	269.5439
01.01.2021 10:10:00	0.316832	261.1172
01.01.2021 10:20:00	0.306114	253.9537
01.01.2021 10:30:00	0.299747	249.3132
01.01.2021 10:40:00	0.291206	247.6606
01.01.2021 10:50:00	0.276467	249.016
01.01.2021 11:00:00	0.254529	253.3519
01.01.2021 11:10:00	0.226901	260.7831
01.01.2021 11:20:00	0.196679	271.5814
01.01.2021 11:30:00	0.167406	286.0603
01.01.2021 11:40:00	0.141843	304.4103
01.01.2021 11:50:00	0.121285	326.7737
01.01.2021 12:00:00	0.106632	353.7467
01.01.2021 12:10:00	0.101544	25.85357
01.01.2021 12:20:00	0.113153	59.56432
01.01.2021 12:30:00	0.144634	87.73304
01.01.2021 12:40:00	0.191327	108.1171
01.01.2021 12:50:00	0.24591	122.6835
01.01.2021 13:00:00	0.301356	133.5413
01.01.2021 13:10:00	0.351311	142.0475
01.01.2021 13:20:00	0.390266	149.011
01.01.2021 13:30:00	0.413889	154.9195
01.01.2021 13:40:00	0.419362	160.07
01.01.2021 13:50:00	0.40562	164.6333
01.01.2021 14:00:00	0.373415	168.6719

01.01.2021 14:10:00	0.325218	172.1139
01.01.2021 14:20:00	0.26496	174.6363
01.01.2021 14:30:00	0.197782	175.2842
01.01.2021 14:40:00	0.130332	171.0295
01.01.2021 14:50:00	0.074923	150.5796
01.01.2021 15:00:00	0.065401	100.9898
01.01.2021 15:10:00	0.102983	75.79602
01.01.2021 15:20:00	0.147317	72.02661
01.01.2021 15:30:00	0.187187	75.22836
01.01.2021 15:40:00	0.220911	81.1923
01.01.2021 15:50:00	0.248372	88.29502
01.01.2021 16:00:00	0.269156	95.65328
01.01.2021 16:10:00	0.281996	102.7011
01.01.2021 16:20:00	0.284912	109.0663
01.01.2021 16:30:00	0.275765	114.4903

6 References

Chen, N. (2020a, 12 01). *Ning Chen*. Retrieved from Deniosing Data with Fast Fourier Transform: https://kinder-chen.medium.com/denoising-data-with-fast-fourier-transform-a81d9f38cc4c

Wikipedia. (2020, 05 20). *Morison equation*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Morison_equation

Wikipedia. (2021a, 05 04). *Fourier Transform*. Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Fourier_transform