Coastal Morphology Analysis

MorphAn

Interreg North Sea Region Building with Nature
European Regional Development Fund
EUROPEAN UNION

Deltares
Enabling Delta Life

Manual

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Analytical tool for sandy coasts

User manual

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Quick start plan for MorphAn

This chapter provides a simplified step-by-step plan to get you quickly started with MorphAn. It describes the basic steps you need to take to work with MorphAn [Figure 1]. The subsequent chapters of this user manual go into these steps in much more detail.

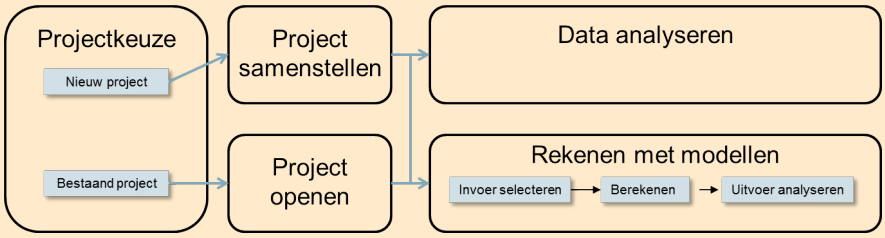


Figure 1: *Summary of main steps for working with MorphAn*

In general, the necessary steps are:

- ◇ Step 1: Select project
- ◇ Step 2: Setup project
- ◇ Step 3: Open project
- ◇ Step 4: Analyze data
- ◇ Step 5: Run models

Step 1: Select project

Once MorphAn is started, an empty (new) project is displayed. At this point you can choose to build a new project. You can also reopen a previously saved project. The opening of an existing project and setup of a new project are discussed below in sections Step 2: Setup project and Step 3: Open project.

Step 2: Setup project

A MorphAn project always contains a MorphAn workspace. A workspace contains data plus one or more models, and can be added to a project in two ways:

- ◇ In the **Home** ribbon, click on icon **New WorkSpace** [Figure 3.2]
- ◇ In the **Project Explorer** window, right-click on the project; then in the context menu, click "Add → New Item...". In the dialog box that then appears, select "*MorphAn Workspace*"' [section 3.2.1, Figure 3.3].

A setup wizard will then start, enabling you to add models to the workspace, and to select files containing data to be included in the workspace Data folder. For more information on the use of this setup wizard, see chapter 3.

Step 3: Open project

To open a previously saved project, click the **File** tab, then select **Open**. Projects are saved in files with the extension ".dsproj". From the Open file dialog box, search for the saved project you wish to open. When you have selected the saved project, click **Open** to load the selected project. Any projects saved using MorphAn version 1.2 or higher can be loaded into this version of MorphAn. Note that this only applies to projects developed for the Dutch coast. Unfortunately, projects developed for other areas cannot be loaded. Projects saved with versions of MorphAn older than 1.2 cannot be opened in this version. In that case it is

advised to export the relevant project data from the project in the older version, then to open it in the desired new version.

Step 4: Analyze data

MorphAn provides several tabs for analysis of the imported data. The imported data can be found in the **Project Explorer** window. Below the newly-imported workspace is a folder with the name **Data**. This folder contains all imported data (including cross-shore profile measurements and boundary conditions). To view the imported cross-shore profile measurements, open the **cross-shore profile measurements** sub-folder. When you double-click on one of the items in the sub-folder, a selection screen opens [Figure 2]. This screen allows you select the locations and years for which analysis figures can be opened. When a selection is active, the buttons in the corresponding **Data** tab in the ribbon at the top of the screen become colored. [Figure 3]. Any of the colored buttons can then be clicked for a specific view of the selected data. For a detailed description of the available visualizations, see chapter 4.

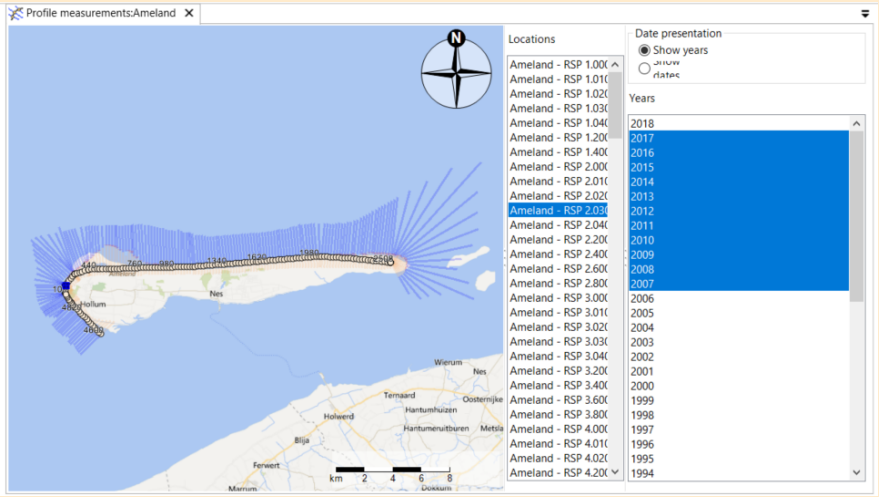


Figure 2: *Example of the selection screen for the analysis of measurement data*

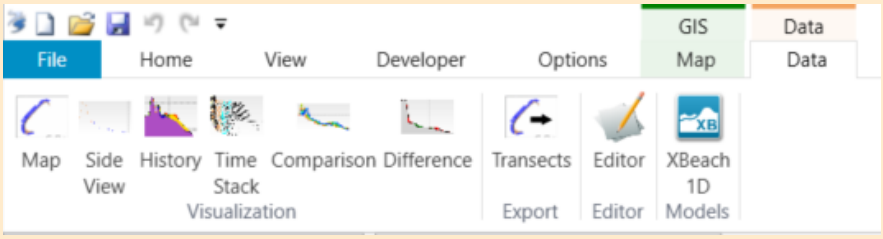


Figure 3: *Example of an activated Data tab for the analysis of measurement data*

Step 5: Run models

Step 5a: Select input

Before you can run a model, you must first make a selection of the locations and years to be modeled. To see all the input for a model, first expand the model folder (click on the "+" beside the folder), then likewise expand the **Input** folder. The top-level models in the Project Explorer window all have three entries in the input list:

- ◇ Selection (the locations and transects to be modeled)

- ◇ Profiles (the cross-shore profile measurement dataset to be used). This item inherits the name of the selected cross-shore profile measurement dataset.
- ◇ Boundary conditions (the boundary conditions to be used). This item inherits the name of the selected boundary conditions dataset.

The sub-models (for example, to calculate erosion points, normative results, momentary or expected coastline) work with the same input as the top-level models. This information therefore does not need to be re-specified. The **Input** folders of these sub-models also contain model-specific input.

To make a selection, double-click on the **Selection** item in the **Input** folder. A screen will then appear with a map and four lists [Figure 4]. The two lists on the right show the measurements included (Selected) in a modeling run. The two lists on the left show the measurements (locations or years) that are still available for selection. You can use the buttons between the two location lists (**Unselected** and **Selected**) to add or remove items. The list of years (**Unselected**) then shows the available measurements for the selected locations. For a model to run successfully, the required years must also be added to the selection. The previously imported input files from the **Data** folder will then be displayed under the **Input** folder of each model, based on the selection made and the boundary conditions required for the specific model. The specification of model input is explained further in section 2.4.1.

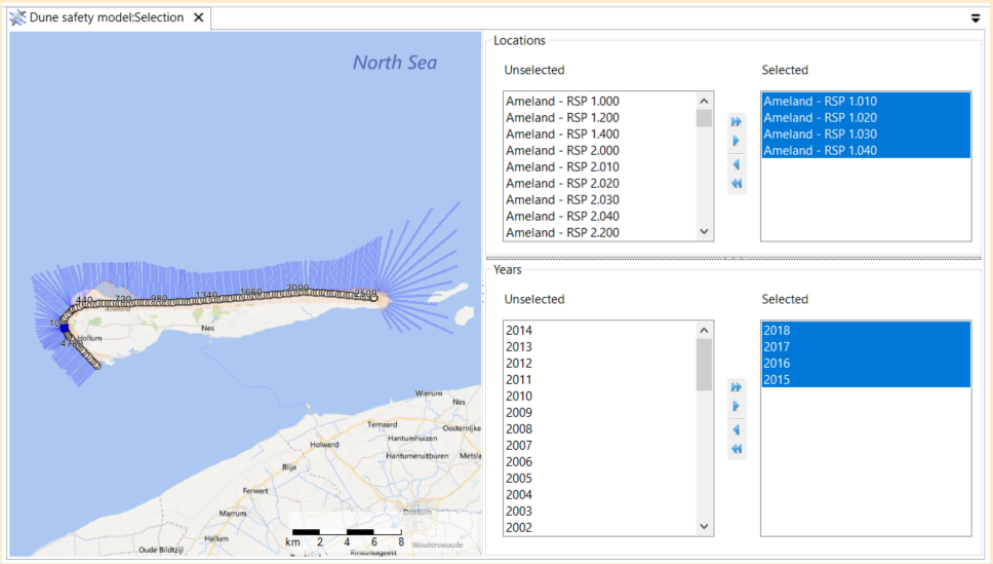


Figure 4: *Example of the selection of locations and years for the modeling run*

Many of the models and sub-models have a settings screen that will appear when you double-click on the item in the **Project Explorer** window. This screen enables you to change the settings of the model for the next run. These settings generally apply to the entire model, rather than to an individual location or profile. section 2.4.1 provides more information on how to specify input to models.

Step 5b: Run model

To start running a model, right-click on a model in the **Project Explorer**, then click **Run Model**. You can also start running a model from the **Home** ribbon. To run the highlighted (selected) model, click on the Run Current button (F9); to run all models in the project, click on the Run All button (Ctrl-F9). Information on the progress of the running model(s) is continuously

refreshed in the **Messages** window. This information can also be reviewed in the **Output** folder of the relevant model (double-click **Run Report**].

Step 5c: Analyze output

To view the calculation results, double-click an item in the **Output** folder of the relevant model in the **Project Explorer** window [section 2.4.3]. To export the output data, right-click on the output item in the **Output** folder of the relevant model in the Project Explorer, then click **Export...**. In certain cases a selection screen will appear, in which you can choose the type of data to be exported (e.g. as shown in Figure 5: here you can select either calculation results in the form of images, or a text file in csv format with the results of a TCL calculation). You will then be prompted to give a name and location for the exported file. Data exported in csv (comma-separated values) format can be opened in Excel. Excel then automatically converts it to xls format, which you can further process and save in the usual way.

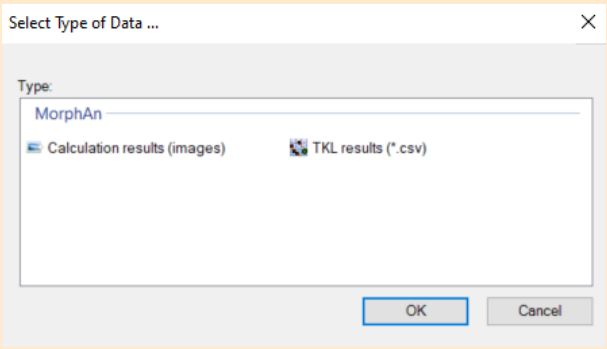


Figure 5: *Example of an export data selection screen*

1 Introduction to MorphAn user manual

1.1 Description of MorphAn

MorphAn is a software tool for the analysis and assessment of sandy coasts. The **graphical user interface** supports various actions:

- ◇ **Analysis and visualization** of the transect data loaded into the software
- ◇ **Management and editing** of imported data
- ◇ Modeling of **dune safety** with the aid of the Duros+ (or D++) model linked to a normative model per location
- ◇ Determination of an **expected coastline (TCL)** based on the calculated momentary coastline (MCL) of selected profiles
- ◇ Calculation of **volume development** based on the imported measurement data

Functionality can optionally be added to MorphAn to support the following actions:

- ◇ **Analysis of bed development** aimed at preventing scour holes in front of water barriers
- ◇ Running dune safety calculations using **XBeach**
- ◇ Automation of actions or extension of MorphAn functionality by means of **Scripting**

MorphAn is available in either an English or a Dutch language version. This manual applies to the English language version of MorphAn.

1.2 MorphAn System requirements

For MorphAn to run without problems, it is preferable to install the program on a computer that meets the following minimum requirements:

- ◇ Microsoft Windows 7 or higher
- ◇ Microsoft .NET Framework version 4.5 or later
- ◇ Intel Core i5 processor (or equivalent)
- ◇ 8 GB RAM
- ◇ Display resolution of 1920x1080 pixels

1.3 MorphAn data

Before you can run any analyses or calculations in MorphAn, you first have to provide data. In MorphAn versions older than 1.6.1, Dutch coastline data was automatically included with the installation. From version 1.6.1 and later, the user must now manually load the necessary data into MorphAn. The latest Dutch coastal data is freely available from the MorphAn website (go to `https://oss.deltares.nl/web/morphan/data`).

The following Dutch coastal data is available from the MorphAn website:

- ◇ Folder “locations” contains files of locations for the Dutch coast [section 3.3]. There is also a subfolder with the hydra-locations of other non-coastal Dutch water bodies .
- ◇ Folder “profiles” contains the profile files for the Dutch coast up to and including the year 2017 [section 3.4].
- ◇ Folder “safety” contains boundary conditions for modeling with the dune safety model [section 3.5]. These boundary conditions relate to the probability of breach on the dyke sections as per WBI2017 (Statutory Assessment Instruments 2017).
- ◇ Folder “Coastal development” contains boundary conditions for modeling with the coastal development model [section 3.5].

- ◇ Folder “Volume development” contains boundary conditions for modeling with the volume development model [section 3.5].
- ◇ Folder “nourishments” contains the nourishment data for the Dutch coast up to and including 2017 [section 3.6].
- ◇ Folder “layers” contains landward boundaries for the Dutch coast for use when modeling with the dune safety model [section 6.4]. These files are derived from layer data held by the flood defense authorities. **NB**: the current layer data may deviate from the data supplied in these files. In the event of a Statutory Assessment, we recommended that you verify the current layer information against the supplied landward boundary of the flood defense.

This data is intended to help you quickly get started with MorphAn. The user should take note of the limitations that apply to this data. We will go into this in more detail in the subsequent sections of this manual.

The user settings for the input file folders can be modified by setting options [section 2.3]. This enables you to make the data available by default within a MorphAn workspace.

1.4 The Delta Shell Framework

Technically, MorphAn is a plug-in for the “Delta Shell framework” developed by Deltares. Delta Shell is an integrated modeling environment that provides a platform for the integration of various models, data and tools. It comprises a framework plus a user interface that supports those various models. The program is easy to configure and can be quickly learned. Delta Shell offers a user-friendly and open framework for morphological, hydraulic and hydrological applications. It includes tools for the setup or import of different types of data or models, performing simulations of individual models or combinations of models, and the analysis of data or model results. It has an open architecture that enables the user to integrate external software (referred to as plug-ins). The user can download information in a variety of standard data formats and from various GIS systems. A more detailed description of the Delta Shell Framework has been written by Donchyts and Jagers (2010). Other plug-ins written for this Framework (and therefore suitable for use with MorphAn) include: D-Flow FM, Sobek, WFD Explorer (KRW verkenner) and Habitat. MorphAn 1.6.1 runs on the DeltaShell 1.3 platform.

1.5 Reading guide

This user manual is intended to support the user in working with MorphAn. This chapter is preceded by a Quick start plan for MorphAn. The remaining chapters provide the following information:

- ◇ Chapter 2 describes the various components of the MorphAn software.
- ◇ Chapter 3 describes the MorphAn workspace.
- ◇ Chapter 4 describes how to analyze data in MorphAn
- ◇ Chapter 5 describes how to manage and edit data in MorphAn.
- ◇ Chapter 6 describes the dune safety model.
- ◇ Chapter 7 describes the coastal development model.
- ◇ Chapter 8 describes the volume development model.
- ◇ Chapter 9 describes the bank analysis model.
- ◇ Chapter 10 describes the additional installation options.
- ◇ Chapter 11 states the modifications incorporated in this and previous MorphAn software releases.

2 Working with MorphAn

2.1 Introduction to working with MorphAn

This chapter provides a general overview of the main features of MorphAn:

- Section 2.2 describes the MorphAn project structure and how to add objects to it. These objects may be items, models or folders.
- Section 2.4 describes how to add the various MorphAn models, select the input data and run a model, and how to display and export the results.
- Section 2.5 describes the MorphAn user interface and how to customize it.
- Section 2.6 describes the possibilities for working with maps.
- Section 2.7 describes how to import and export data.

2.2 Working with projects

2.2.1 MorphAn project structure

The structure of a MorphAn project is displayed in the **Project Explorer** tool window. Below the item **Projects** you can add a wide variety of MorphAn objects [Figure 2.1].

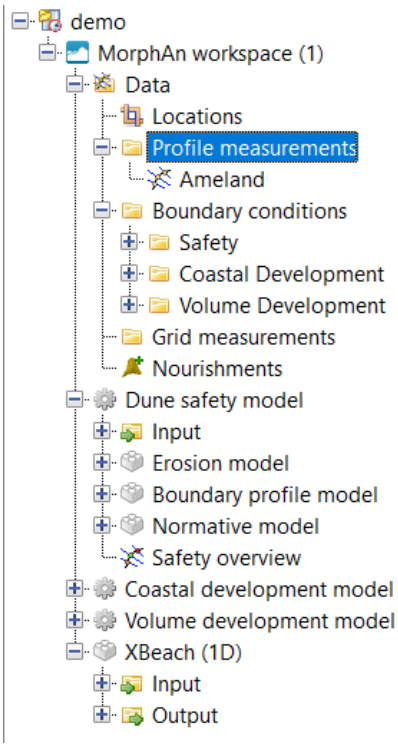


Figure 2.1: *A typical MorphAn project structure*

There are two ways to add objects into the structure:

1 In the **Home** tab of the ribbon, click **New Folder**, **New Item**, **New model** or **New Workspace** [Figure 2.2].

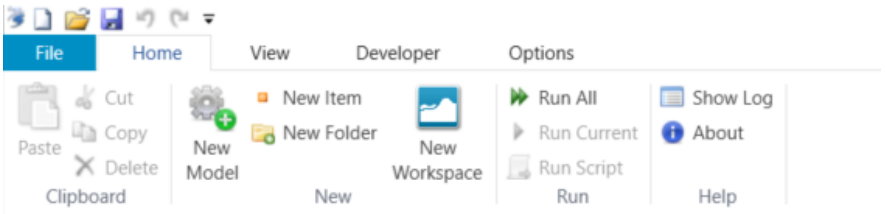


Figure 2.2: *Adding an object via ribbon tab* ***Home***

2 In the **Project Explorer** tool window, right-click on an existing item, then click Add, followed by **New Item...**, New Model... or **New Folder** [Figure 2.3].

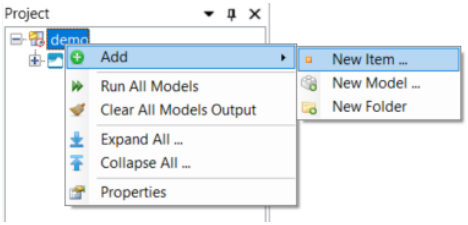


Figure 2.3: *Adding an object via the Project Explorer*

The objects that make up a MorphAn project are usually one of the following three types (explained further below):

- **Item** - Shows data of any type
- **Model** - Shows a model
- **Folder** - Shows a folder similar to a Windows file folder

2.2.2 Items

MorphAn recognizes the following item types [Figure 2.4]:

- Map - Adds an empty map to the project
- Map (world) - Adds a world map to the project. This world map comprises the Open Street Map and the Bing Maps - Aerial
- Text Document - Adds an empty text document to the project
- Web Link - Adds a web link to the project
- MorphAn workspace - Adds a MorphAn workspace. The MorphAn workspace is a special item that is described in detail in chapter 3.

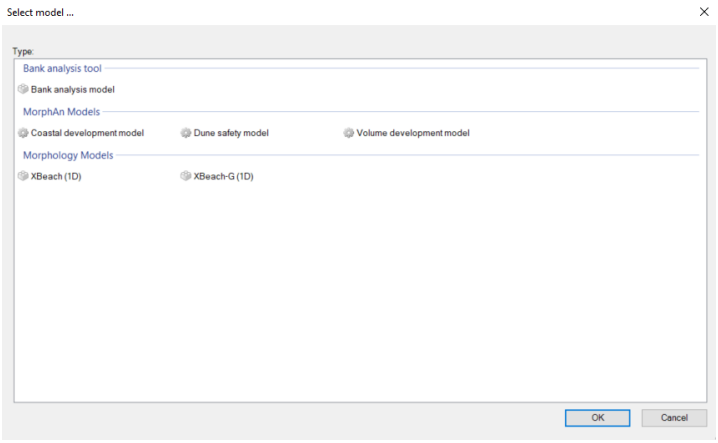


Figure 2.4: *Selection screen showing items that can be imported into the Project Explorer*

Every item generally has a corresponding (document) window in which you can view and (if applicable) edit the item contents. To open the window, in the **Project Explorer** tool window, either double-click on the item, or right-click on the item and select *Open*.

2.2.3 Models

A model is a calculation engine with associated input and output. In MorphAn you can work with the following models:

- Dune safety model
- Coastal development model
- Volume development model
- Bank analysis model
- XBeach 1B

The first four models can only be added within the MorphAn workspace. The XBeach1D model can be added either inside or outside of a MorphAn workspace [Figure 2.5].

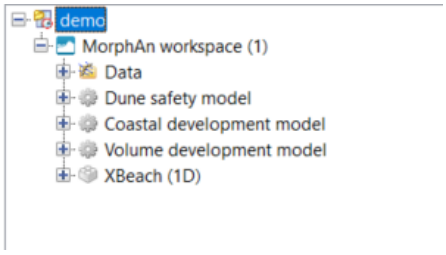


Figure 2.5: *Models in MorphAn*

You can add a model in the following ways:

- Add a new model via the **Home** tab of the ribbon [Figure 2.2].
- When you run the MorphAn workspace wizard, you can select the dune safety model, the coastal development model and the volume development model [Figure 2.6].

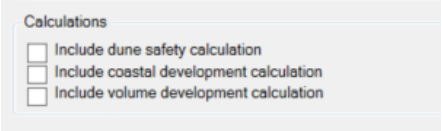


Figure 2.6: *Adding models with MorphAn workspace wizard*

◇ Finally, you can always manually import a model. In the Project Explorer, right-click on the workspace, then select “Add New Model”.

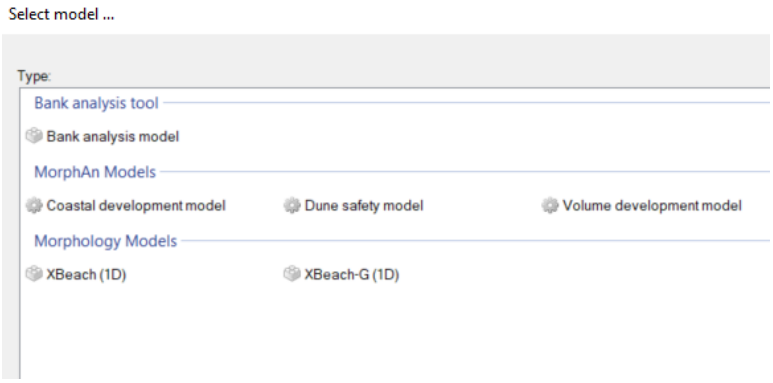


Figure 2.7: *Selection window for adding a new model to a workspace*

The Dune safety model, Coastal development model and Volume development model each consist of underlying sub-models [Figure 2.8].

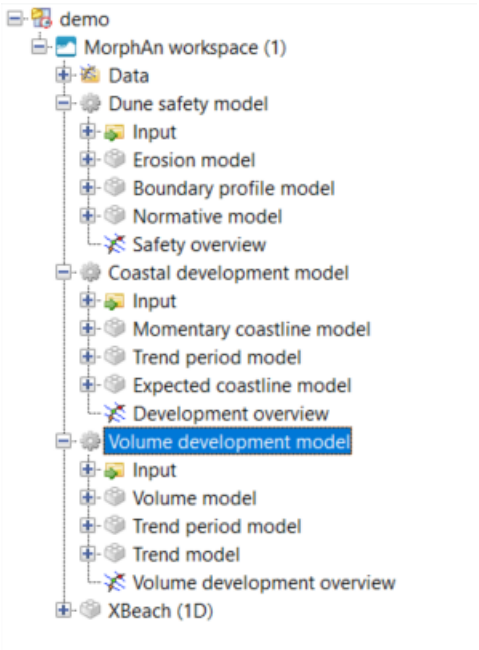


Figure 2.8: *Sub-models in MorphAn*

Section 2.4 describes in detail how the user can work with models in MorphAn.

2.2.4 Folders

A Folder in a MorphAn project is comparable to a folder or directory in the windows file system. A folder can be used to organize and group data (items and models). Folders are also used in Models to group input and output items.

2.3 Working with options

MorphAn provides certain options that you can adjust to customize your software environment. Click “Bestand” in the ribbon to open the File menu, then select Options. This opens the Options window [Figure 2.9].

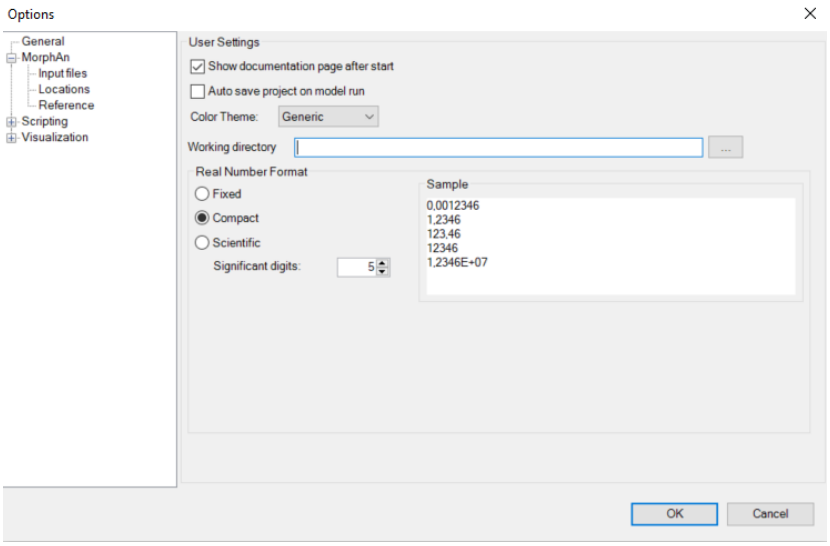


Figure 2.9: *Options window showing general user settings and number format*

The following settings can be adjusted:

- “Algemeen” - use to change user settings and number format [Figure 2.9].
- “MorphAn - Invoerbestanden” - use to change the default folders for input files [Figure 2.10]. By default, the MorphAn wizard retrieves input data from these folders.

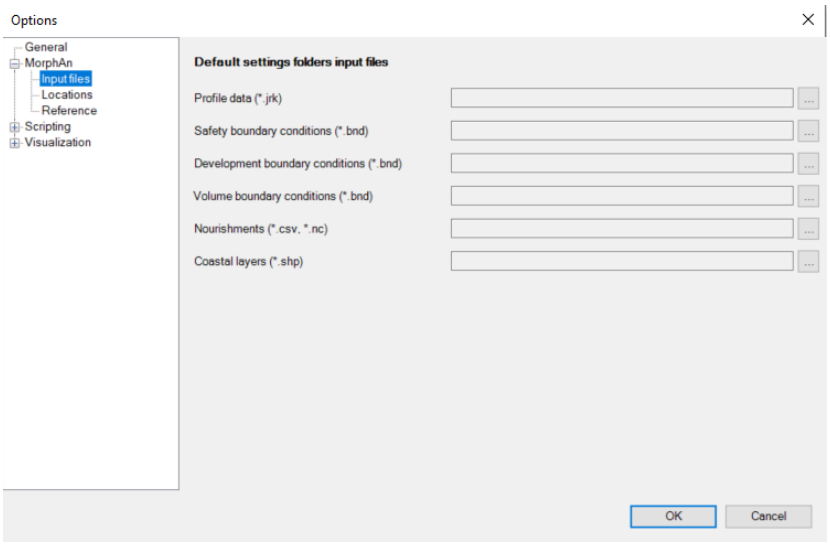


Figure 2.10: *Options window showing default folders for input files*

◇ “MorphAn - Kustlocaties” - use to set the default locations (grid) file and Coordinate system. The defaults at installation are “NLkustlocaties)nl.grd” and “Amersfoort / RD New” [Figure 2.11].

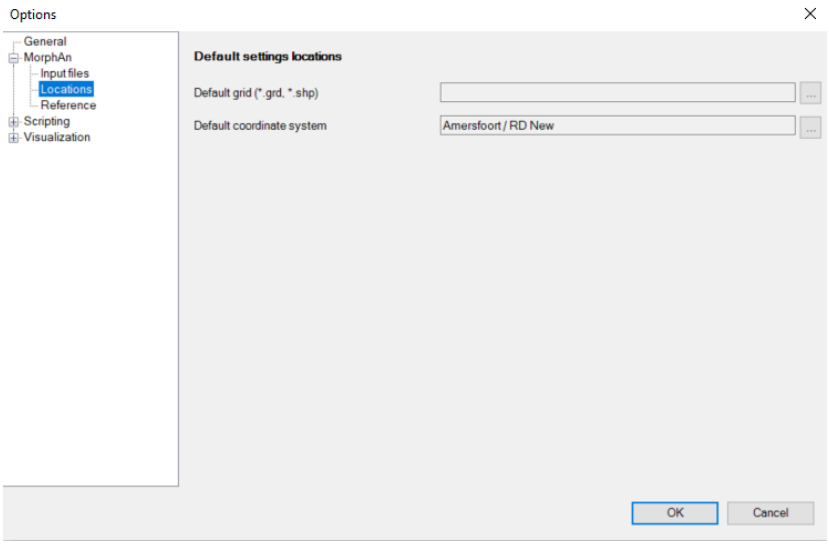


Figure 2.11: *Options window showing default locations file and coordinate system*

◇ “MorphAn - Referenties” - use to edit the vertical/horizontal axis labels shown in figures [Figure 2.12]. Modify the labels here if the model data is not relative to the standard RSP or NAP reference.

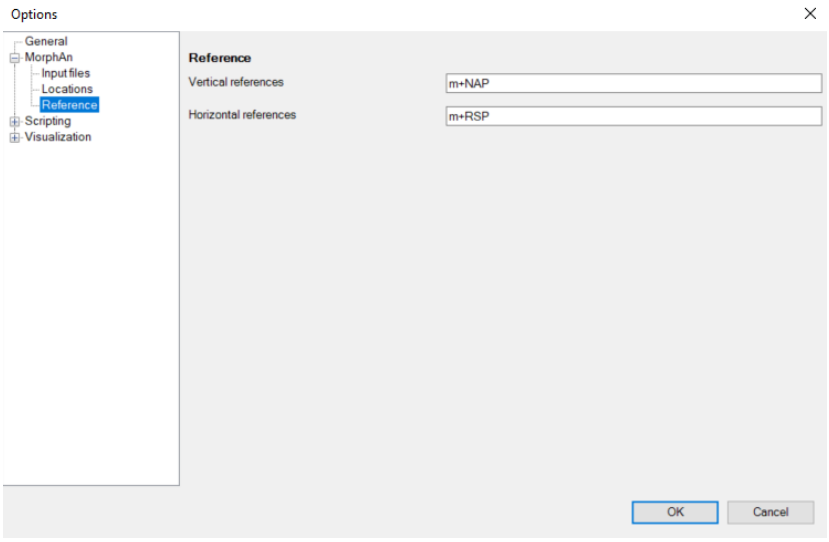


Figure 2.12: *Options window showing vertical/horizontal references for figures*

◇ The last two options enable you to change the way MorphAn displays scripts and graphical figures.

2.4 Working with models

2.4.1 Select model input

Each of the models Dune safety, Coastal development, Volume development and Bank analysis contain an **Input** folder in which you can edit the input for the calculations based on the

data imported into the MorphAn workspace. (This works differently for the XBeach1D model.) The **Input** to each of the four models named above consist of the following items [Figure 2.13]:

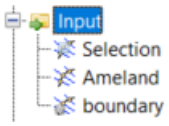


Figure 2.13: *Options for model input*

- ◇ **Selection** - This item specifies the locations and years included when you run this model (and its sub-models).
- ◇ **Cross-shore profile measurements** - This item identifies the cross-shore profile measurement set that will supply transect data to this model (and sub-models) when you run the model. The name of the item corresponds to the selected profile measurement set [section 3.4].
- ◇ **Boundary conditions** - This item identifies the boundary condition set referred to by this model (and its sub-models) when you run the model. The name of the item corresponds to the selected boundary conditions set [section 3.5]. The bank analysis model forms an exception. No boundary conditions can be imported for this model.

Select locations

Double-click on the **Selection** item to open an editor for selection of location and year [Figure 2.14]. Within this window you can define a subset of locations to be used when the model is run. You can select locations both by dragging a rectangle over the map [section 2.6] or by clicking in the left locations list (“Unselected”). To copy the highlighted locations to the “Selected” panel, use the buttons between the two lists. Once you have a list of selected locations, the “Unselected” years list will give you an overview of all years for which cross-shore profile measurements are available for the selected locations. To finalize the selection, select one or more years for the model to run with, and copy these to the “Selected” years list using the buttons between the lists.

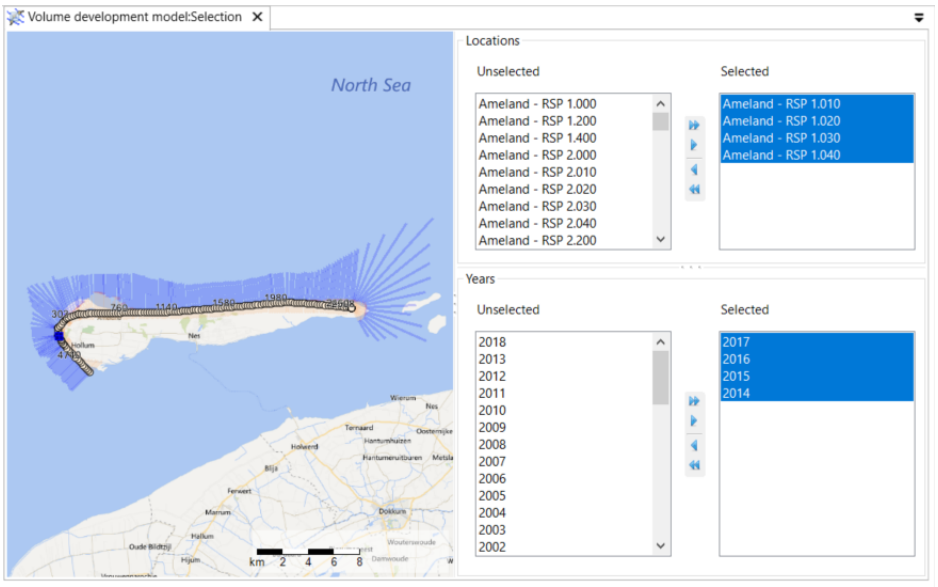


Figure 2.14: *Selecting locations and years for a model*

Select boundary conditions

Double-click on a model's **Boundary conditions** (which have the same name as the selected boundary condition set) to open a window for viewing and editing the relevant boundary conditions used in that model (and its sub-models). Figure 2.15 shows a typical boundary conditions window for the Coastal Development model. The window consists of a table of all available boundary conditions in the selected set for the selected locations. A drop-down list at the top of the window makes it possible (if necessary) to quickly switch to one of the other boundary condition sets available in the workspace.

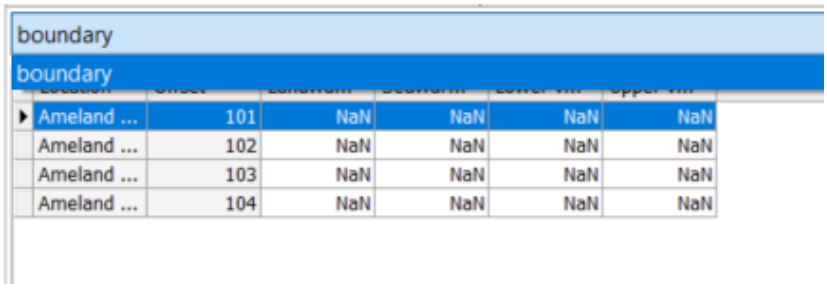


Figure 2.15: *Selecting boundary conditions*

Select profile measurements

Double-click on a model's **Cross-shore profile measurements** (which have the same name as the selected profile measurement set) to open a window for viewing the profile measurement set used. Figure 2.16 shows an example of such a window. The window consists of a list of selected locations and a profile view of the transect at that location for a certain time (year). You can check the moment in time shown in the figure in the Time Navigator [section 2.5.8]. When you highlight a different transect in the list on the left, the view changes. This window likewise has a drop-down list at the top of the screen for selecting a different set of cross-shore profile measurements from the sets loaded into the workspace.

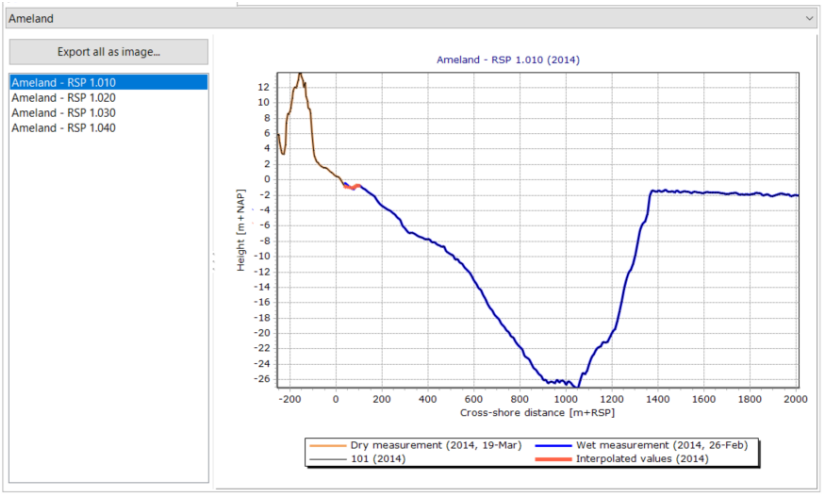


Figure 2.16: *Selecting profiles*

2.4.2 Run the models

There are several ways to run a model:

- ◇ Right-click on the model in the **Project Explorer** tool window, then click **Run Model**
- ◇ Click on (Run Current) in the ribbon tab **Home**

◇ Select a model and press F9, or press Ctrl+F9 to run all models in the project

MorphAn refers to the project explorer to determine which calculations to perform:

◇ When the project is selected, calculations are performed for all models.
◇ When the MorphAn Workspace is selected, calculations are performed for all models within this workspace.
◇ When a model is selected, a calculation is performed for the selected model plus any sub-models.
◇ When a sub-model is selected, only this sub-model is calculated.

If any data is modified after running a model, certain results may no longer be current. These are marked in the project explorer [Figure 2.17].

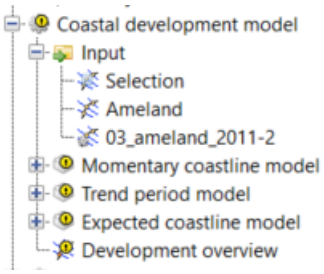


Figure 2.17: *Calculated results that may have been superseded*

2.4.3 View results

After the successful completion of a modeling run, two new items are added to the **Output** folder of each model (or sub-model). The first item is the quantitative output data. The second item is the Run Report, which is produced for each sub-model. This Run Report contains all messages that appeared in the Message window while the model was running. For the **Dune safety model** and the **Coastal development model** the run results can also be displayed in an overview map.

To visualize any output item, simply double-click on the relevant item. The output items of sub-models are often presented as a table of calculated values and a chart to visualize the results. An overview map is presented as a map that shows all results from the sub-models. If the window of the results of one of the sub-models is open at the same time, then when you click on a result in the map, the selected result then appears in the sub-model window, and vice versa [Figure 2.18].

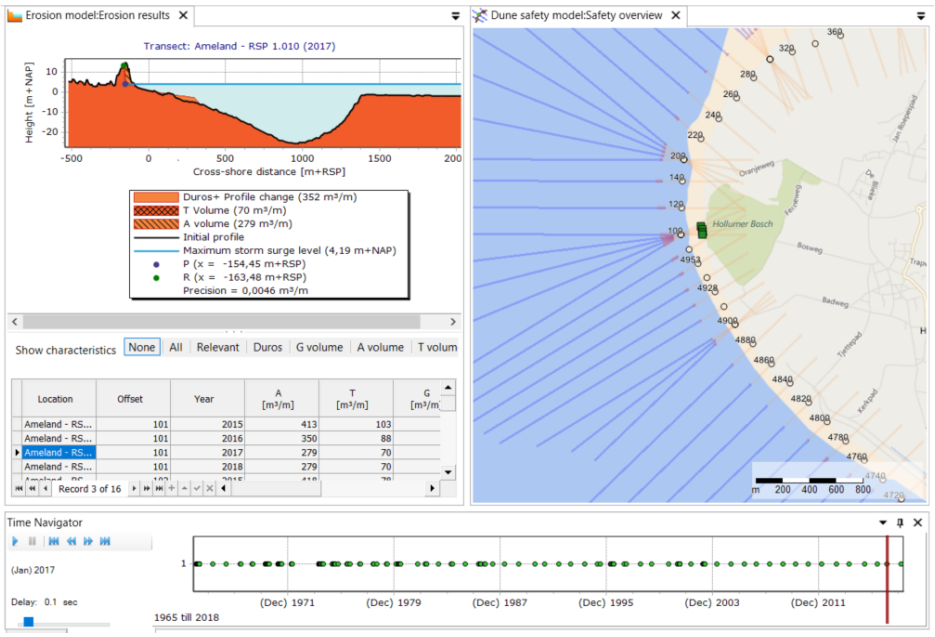


Figure 2.18: *Viewing model results*

The overview map shows only one year at a time. You can use the time navigator [section 2.5.8] to shift through time, so that other moments in time are also shown on the map. You can modify the appearance of the overview map according to your visualization needs, by adding information or changing the styling of different layers. You can also export the results in shapefile format. For more information, see section 2.6.

2.4.4 Export results

In addition to visualization, you can also export the output from all sub-models. To do so, right-click on any output item and select *Export...*. Most items can be exported in a variety of formats. For example, all individual results can be saved in image format, while the modeling results can also be exported as tables (*.csv). The Dune safety model also provides the option of exporting final profiles calculated by the model.

2.5 Working with screens

2.5.1 General screen structure in MorphAn

Figure 2.19 shows the general structure of the screen interface in MorphAn, with as many screens visible as possible.

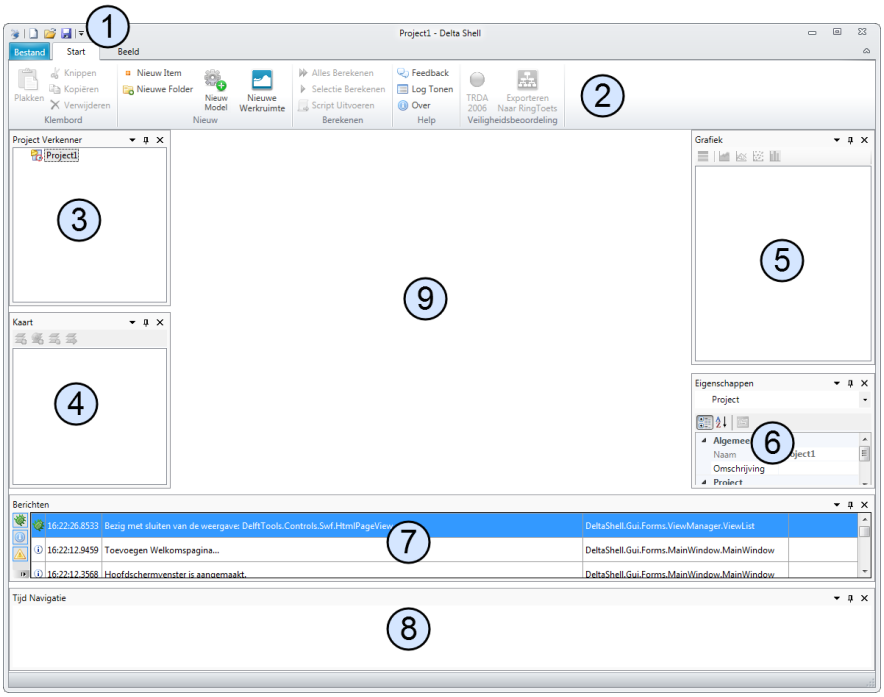


Figure 2.19: *The MorphAn interface*

The screen structure has the following components:

- Quick Access Toolbar (1)
- Section 2.5.2: Ribbon (2)
- Section 2.5.3: Project Explorer (3)
- Section 2.5.4: Map tool window (4)
- Section 2.5.5: Chart tool window (5)
- Section 2.5.6: Properties tool window (6)
- Section 2.5.7: Messages tool window (7)
- Section 2.5.8: Time Navigator tool window (8)
- Section 2.5.9: Central panel (9)

You can reposition and dock all windows almost any way you like to make your work easier [section 2.5.10].

2.5.2 Ribbon

The top section of the screen is referred to as the ribbon [item 2 in Figure 2.19]. The ribbon contains action buttons, for example to show a map (when a document window is selected), or to edit project items (shortcuts). The ribbon is organized as a set of tabs:

- **Home**: This is a general tab with many handy shortcuts for working with projects [Figure 2.20].

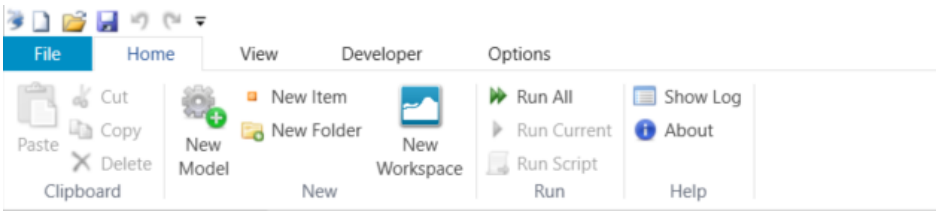


Figure 2.20: *Features available in ribbon tab* ***Home***

◇ **View**: This tab enables you to show and hide windows. You need it to restore a window that you have hidden by clicking the cross in the title bar of the window [Figure 2.21]. In addition, the “Offset column” button enables you to include an additional column for “Offset” in any table with a “Location” column. This makes it easier to sort and filter the tables.

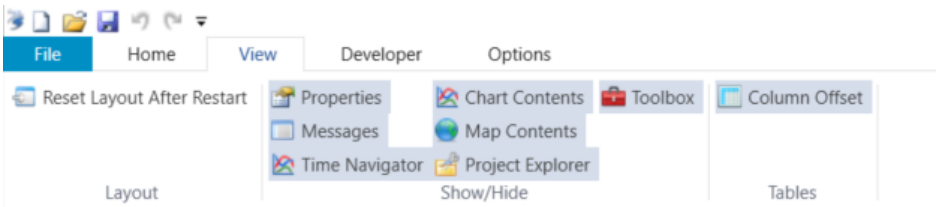


Figure 2.21: *Features available in ribbon tab* ***View***

◇ **Chart**: When a chart is shown in one of the document windows, the Chart tab provides actions to adjust the display of the chart (e.g. font size, color palette), or export the chart [Figure 2.22].

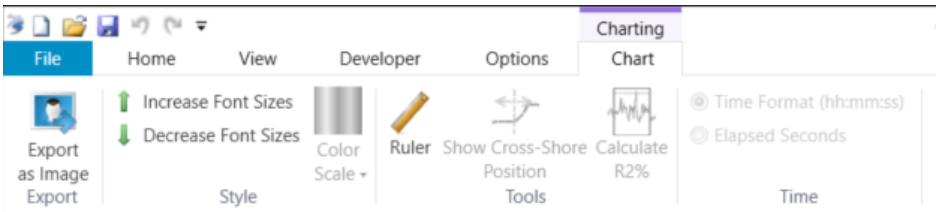


Figure 2.22: *Features available in ribbon tab* ***Chart***

◇ **Map**: When a map is shown in one of the document windows, the Map tab provides actions to customize the map display according to your preferences, or to export the map (see [Figure 2.23].

Figure 2.23: *Features available in ribbon tab* ***Map***

◇ **Data**: This tab has been added by the MorphAn plug-in to provide optional screens for the analysis and editing of data [Figure 2.24].

Figure 2.24: *Features available in ribbon tab* ***Data***

◇ **Boundary Data**: This tab has been added to provide functions for analysis and editing of boundary conditions [Figure 2.25].

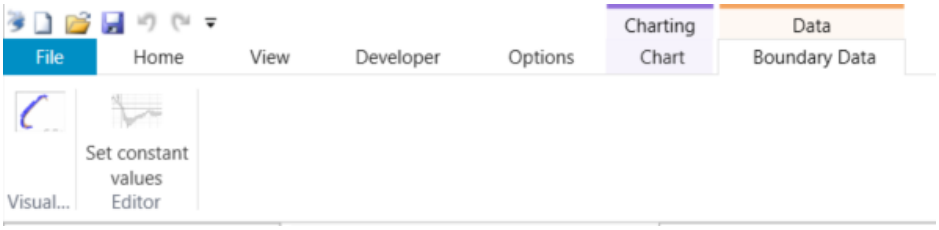


Figure 2.25: *Features available in ribbon tab* ***Boundary Data***

◇ **Profile generation**: This tab has been added to support profile generation based on grid measurements [Figure 2.26].

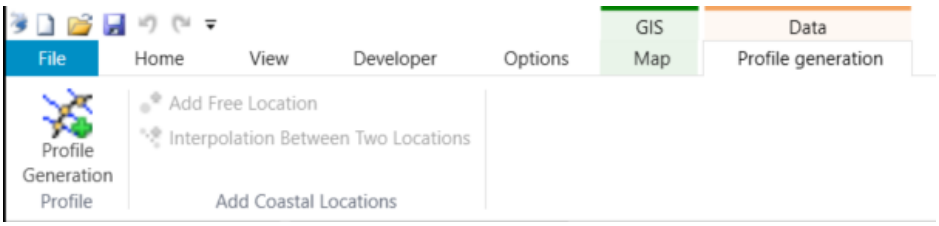


Figure 2.26: *Features available in ribbon tab* ***Profile Generation***

2.5.3 Project Explorer tool window

The **Project Explorer** tool window is the primary window for navigation through projects and their data. This tool window presents all components of a project in a tree structure [Figure 2.27]. Within this window, you can organize the project into Folders [section 2.2.4], drag and drop items between folders, or use Cut (Ctrl+X) and Paste (Ctrl+V). You can hide or remove the project explorer tool window using the pin or cross icons in the top right corner [section 2.5.10]. You can restore the window by clicking the **Project Explorer** button in the **View** tab of the ribbon [Figure 2.21]. To find out exactly where in the project tree the active item belongs that is shown in the central panel, simply click the icon in the top left of the Project Explorer tool window.

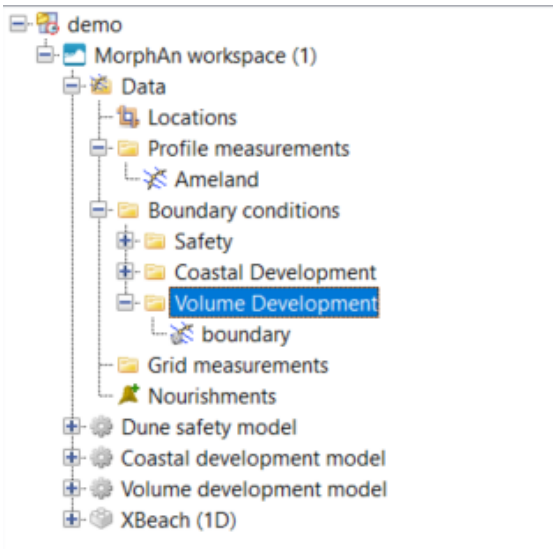


Figure 2.27: *Example of tool window* ***Project Explorer***

There are various ways to view or edit the project structure:

- ◇ left-click to select
- ◇ right-click for a context menu of available actions
- ◇ double-click to show the document window, depending on the item or model that was clicked

2.5.4 Map tool window

When the document window shows an active map [Figure 2.34], you can manage the map layers in the **Map** tool window [Figure 2.35]. This functionality is described in section 2.6.3.

2.5.5 Chart tool window

When the document window shows a chart (graphical) object, the **Chart** tool window [Figure 2.28] shows the individual lines and points with their properties. If you click on an item in the Chart tool window, the **Properties** tool window will show the full properties. You can then edit the properties, for example to change the range of the chart axes, or to modify the chart colors and labels. This makes it possible to export the figures with uniform axes. You can also temporarily switch certain lines or points on or off. Please note that this function is not yet available for the transect editor in the current version of MorphAn.

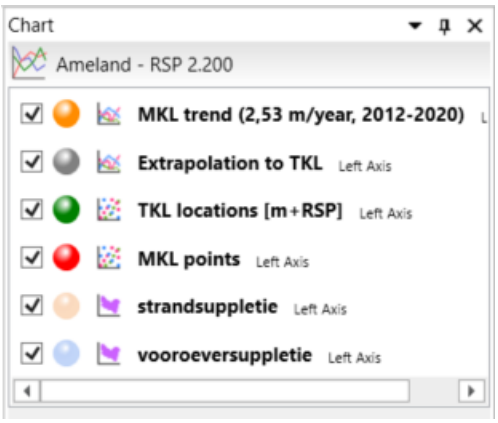


Figure 2.28: *Example of tool window* ***Chart***

2.5.6 Properties tool window

Whenever an element in the interface is selected (e.g. in the Project Explorer, on a map, in a results chart, or in the Chart tool window), the Properties of that element will be displayed in the tool window **Properties.** You can also edit the displayed properties in this tool window [Figure 2.29].

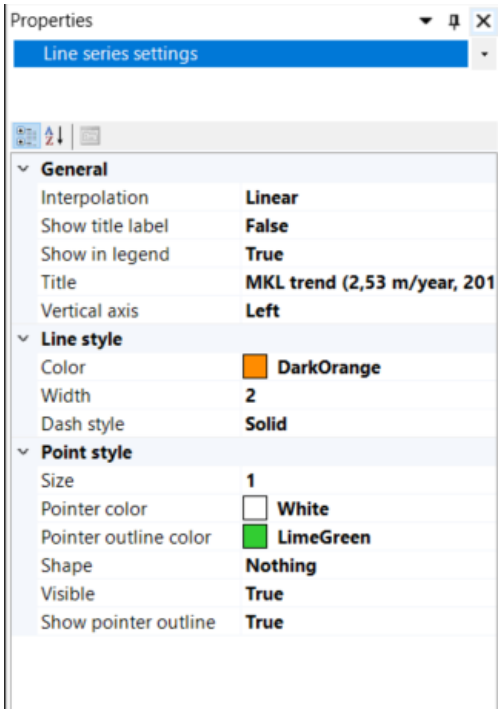


Figure 2.29: *Example of tool window* ***Properties***

2.5.7 Messages tool window

The **Messages** tool window is a logging window. Messages produced by the models and various other parts of the system are displayed here in chronological order. Depending on the message contents, each message is preceded by an icon [the icons are explained in Table 2.1]. If the Messages window is closed then reopened [section 2.5.10], only new messages will be displayed. Older messages are stored in two places:

1 In the Project Explorer, a Run Report is added to the output folder of each model when it

is run. This report contains all messages issued by the model during its run.

2 In addition, an application log is maintained for every MorphAn session (from program start to exit). This log file stores all messages generated during the session. You can view the application log at any time by clicking the **Show Log** button in the **Home** tab of the ribbon.

Table 2.1: *Message types*

Icon	Message Type
	Information
	Warning
	Error

2.5.8 Time Navigator tool window

The **Time Navigator** tool window is used to navigate through the time (steps) of a time-dependent variable. Any screen that displays time-dependent information has its own time navigator. This enables you to navigate through time. This time navigation can take two forms:

◇ Single time indication. In this case, the time navigator bar has a vertical line indicating position in time. Only a single moment in time is displayed, as stated on the left [Figure 2.30].

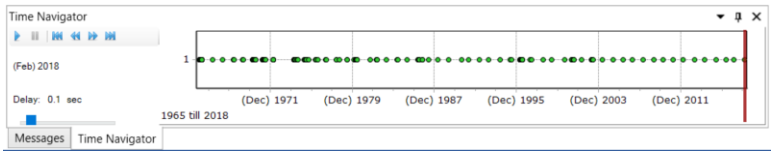


Figure 2.30: *Time Navigation with single time indication*

◇ Time range [Figure 2.31]. In this case, the navigator bar has a rectangle indicating start and end time. All data points are displayed that lie between the start and end times.

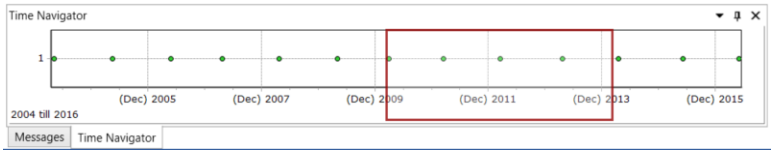


Figure 2.31: *Time Navigation with time range display*

2.5.9 Central panel

The central panel is where tabbed “document windows” are displayed for you to view and edit the information shown. Examples of document windows are:

◇ Map (one or more)
◇ Editors
◇ Visualization screens

There are normally multiple document windows open in the central panel. These are displayed

as overlapping tabs. You can navigate through the open tabs using the selection icon in the upper right corner.

2.5.10 Docking and modifying windows

The graphical user interface can easily be adapted to personal preference by docking the windows. When you drag the title bar of a window while keeping the left mouse button pressed, a docking guide will appear [Figure 2.32]. Then, when you “drop” the window under one of the indicators in the docking guide, the window will be docked in the corresponding panel. This can be done with all open tabs, but also with tool windows. You can also undock any window from its current position and display it anywhere you want on the desktop (Floating). Two icons are present in the title bar of every open window [Figure 2.33]. Their purpose is to:

- ◇ fix the window’s position or auto-hide the window by moving it to a tab (the pin);
- ◇ hide the window from the interface until you show it again using the Show/Hide button in the View tab of the ribbon (the X).

You can also adjust the size of the display panels according to your preferences: simply drag and drop the border between two panels using the left mouse button.

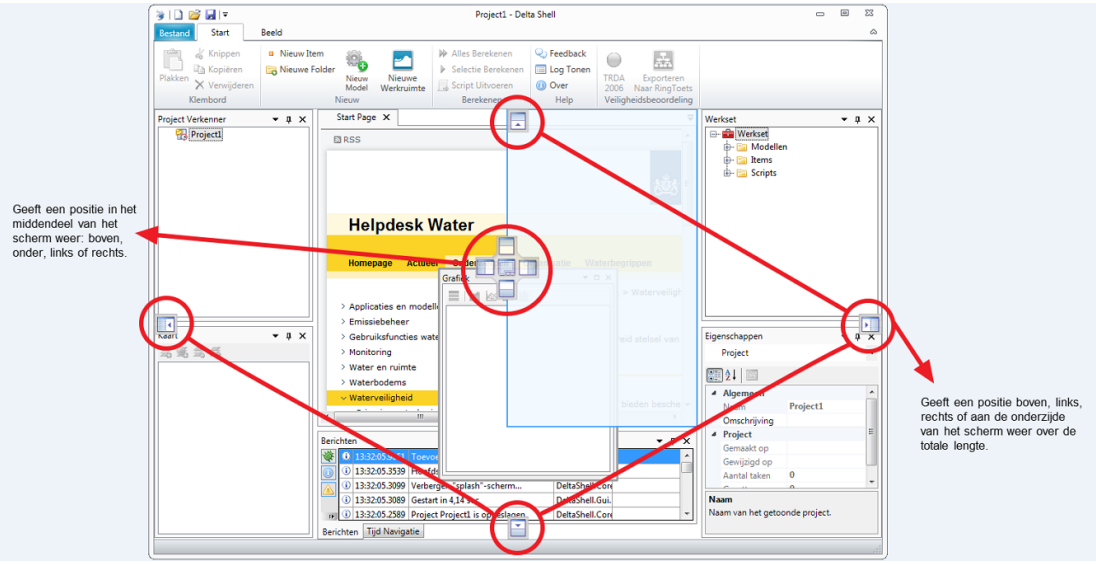


Figure 2.32: *Docking guide that appears when dragging a tool window across the screen*

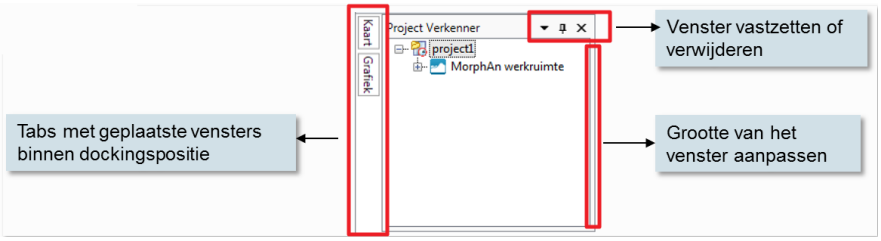


Figure 2.33: *Adjusting window display*

2.6 Working with maps

2.6.1 Description of working with maps

You can add and edit GIS maps in MorphAn [Figure 2.34]. A map consists of one or more layers on which information can be displayed, such as features (points, lines, or planes, often supplied as an .shp file) or a photo with a georeference (e.g. a .tiff file) like those from ArcGIS. When you open a map, the **Map** tab [section 2.5.2, Figure 2.23] with useful shortcuts and action buttons will appear in the ribbon. At the same time, the map layers will be displayed in the **Map** tool window, and if the map is time-dependent, then it will also be linked to the **Time Navigator** [section 2.5.8]. You can use the Map tab shortcuts to show or hide decorations such as the north arrow, scale bar and legend, or to adjust the zoom or position of the displayed map area. A map is one of the standard items in MorphAn [section 2.2.2]. This map is used for many purposes, for example as an aid to selecting model input, or to present calculation results [section 2.4.3].

2.6.2 Opening background map

It is possible to assign a default background map for use wherever a map layer is shown. To achieve this, add a new map to the project (or search for an existing map in the **Project Explorer**), then right-click on the map item for the context menu, and select “Use as default background layer”. The map name then becomes bold, and the map is added as a background layer in any screen that shows a map. It is also possible to create a default background map via the setup wizard for a MorphAn workspace [section 3.2.1].

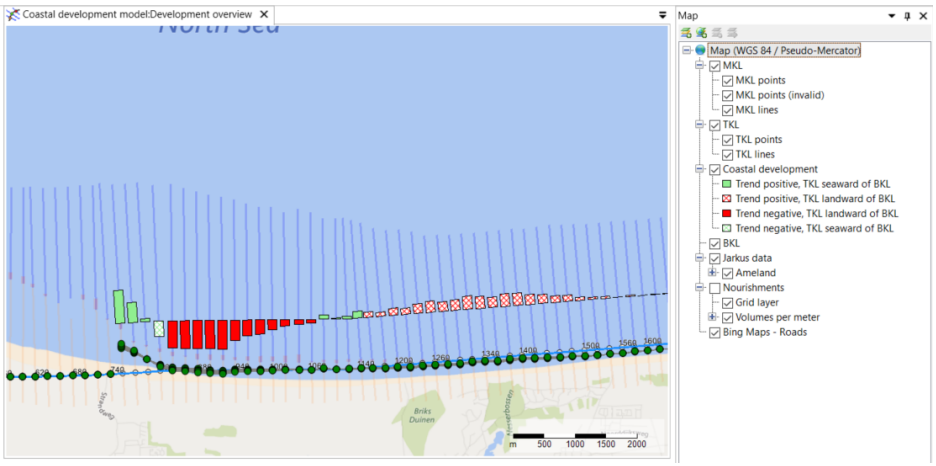


Figure 2.34: *Example of a map with results from the Coastal Development Model*

2.6.3 Editing map layers

You can manage and edit map layers in the tool window **Map** [Figure 2.35], using the four icons at the top left of the tool window:

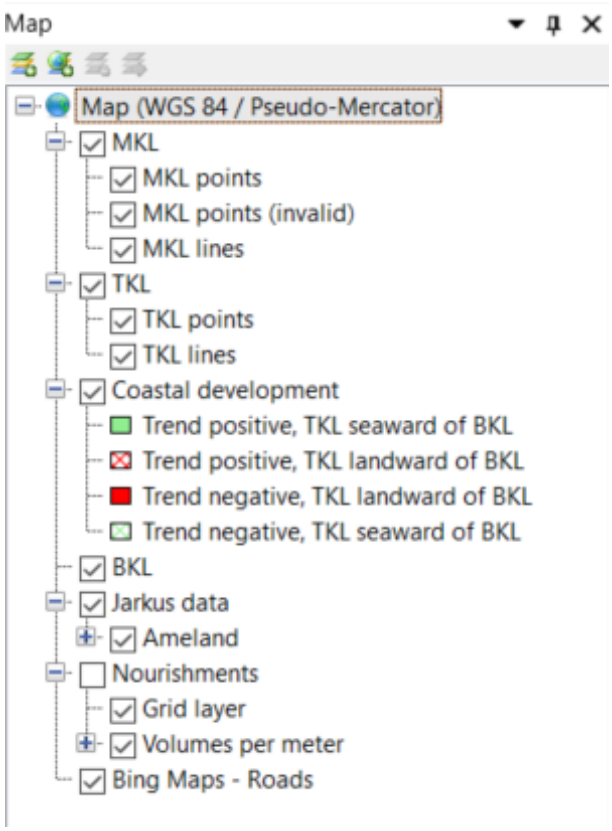


Figure 2.35: *Example of tool window* ***Map***

- ◇ Use to import a map layer from a file (e.g. a <.shp> or <.tif> file).
- ◇ Use to import a map layer from a geoserver (e.g. WMS).
- ◇ Use to remove a layer from the map.
- ◇ Use to export a map layer.

Each layer can be shown or hidden by checking/unchecking the box beside the item. You can do this for an entire layer, or just for specific sub-layers within a layer (if present). When you double-click on a layer, the layer properties editor will open showing line styles, line weights, colors, etc. You can modify these properties according to your preferences.

When you right-click on a layer, a menu appears with options for that layer [Figure 2.36]. Among these options are the following:

- ◇ **Properties** - edit the drawing style of the layer. This allows you to modify the color (scale) and appearance of the features on this layer. This is also where you can turn labels on or off.
- ◇ **Zoom to extent** - set the zoom level of the map such that all information in this layer fits exactly into the display panel.
- ◇ **Show in legend** - show this layer in the map legend.
- ◇ **Hide all layers but this one** - show only this layer on the map and hide all the others.

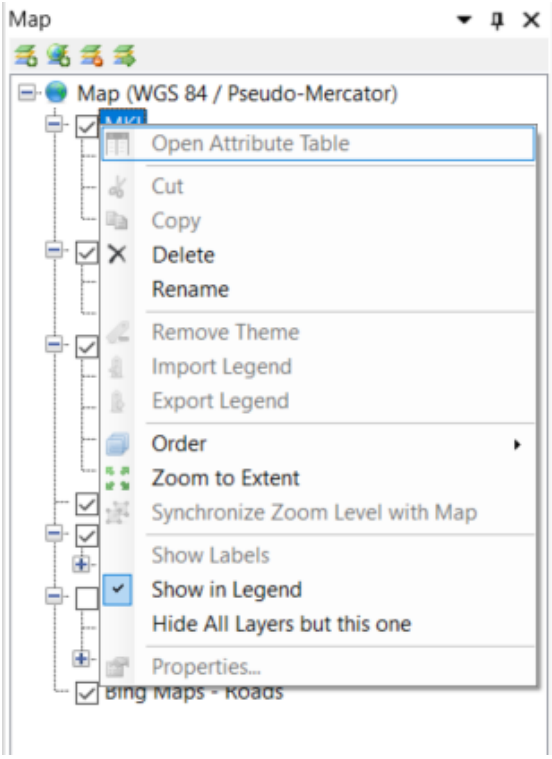


Figure 2.36: *Options menu that appears when you right-click on a map layer*

2.6.4 Map projection

In principle, a map is shown as a projection onto the coordinate system that was selected when the workspace was created. However, when an online map layer is added from a geoserver (such as open street map), then the coordinate system is changed to that of the online map layer. All existing map layers in the workspace are then transformed to the new system. This can cause the following issues with map layers imported by the user:

- ◇ An imported raster layer is not transformed to the new system. The layer will appear somewhere near the equator. The same occurs with <.shp> files imported without a good <.prj> file [Figure 2.37].

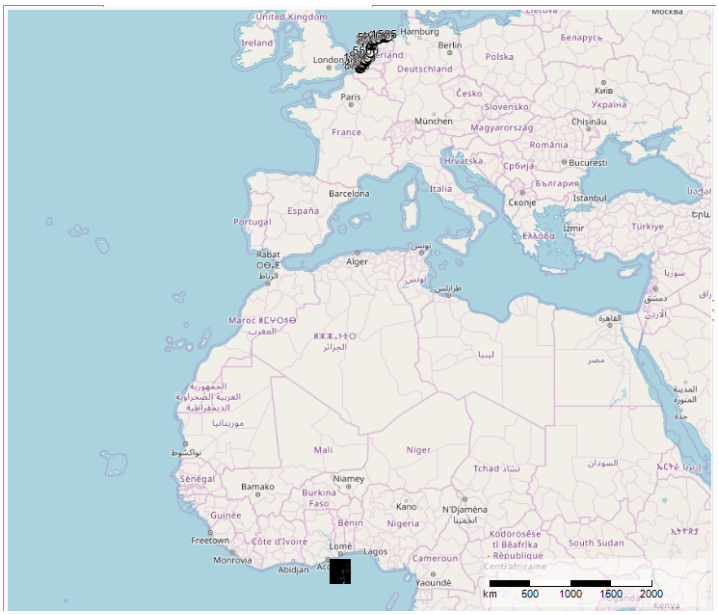


Figure 2.37: *Result of an incorrect transformation*

◇ MorphAn uses the proj.4 standard when transforming map layers. This standard must also be present in the <.prj> files of the imported <.shp> files. If not, there may be minor shifts between the imported map layers and the map layers generated by MorphAn. The solution in this case is to replace the <.prj> files. The <.prj> files included in the public documents can serve as an example [section 1.3].

Note that this can cause a shift between the map layers created in MorphAn and the map layers imported from the files.

2.7 Import and export

If an importer or exporter is already defined for an item in the **Project Explorer** window, then you can export or import data in MorphAn using the right-click context menu, and select either **Export...** or **Import...**. You can use a special plug-in, or a standard importer or exporter provided in the Framework itself for the clicked item. Certain items can be exported in more ways than one (e.g. calculation results can be exported either as a figure, or in csv format for processing in Excel).

MorphAn has a predefined csv file exporter for all calculation results. This format is compatible with Microsoft Excel. Note that the standard column separator is ";" (semicolon), and the standard decimal format of numeric values is "." (period) [section 2.4.4].

3 MorphAn workspace and data

3.1 Introduction to MorphAn workspace and data

Every MorphAn project is assembled within a *MorphAn work space*. This workspace includes a **Data** folder that contains all required data. You can also add any number of models to the workspace. These models access and use the data in the workspace Data folder. Figure 3.1 shows a typical project with a MorphAn workspace containing a set of data and three models.

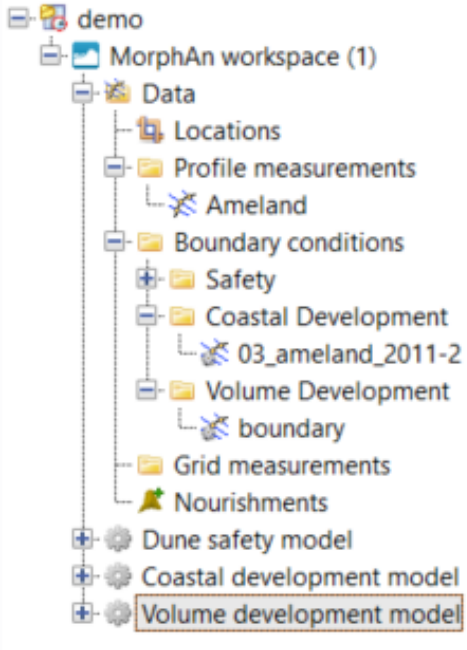


Figure 3.1: *MorphAn workspace with the Data folder and three models*

This chapter discusses the various parts of the MorphAn workspace and the data that can be imported into it:

- Section 3.2 explains how to add a MorphAn workspace to a project.
- Section 3.3 describes location data.
- Section 3.4 describes profile measurement data.
- Section 3.5 describes boundary condition data.
- Section 3.7 describes grid measurement data.
- Section 3.6 describes nourishment data.

3.2 Adding a MorphAn workspace

3.2.1 Create new workspace

A MorphAn workspace can be added to a project in two ways:

◇ In the **Home** tab, click **New Workspace** [Figure 3.2].

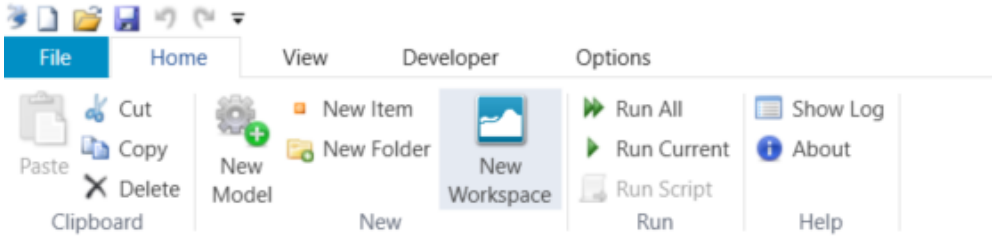


Figure 3.2: *Creating new MorphAn workspace from ribbon tab* ***Home***

◇ In the **Project Explorer** window, right-click on the project; then in the context menu, click "Add → New Item...". In the dialog box that then appears [Figure 3.3], select "*MorphAn workspace*".

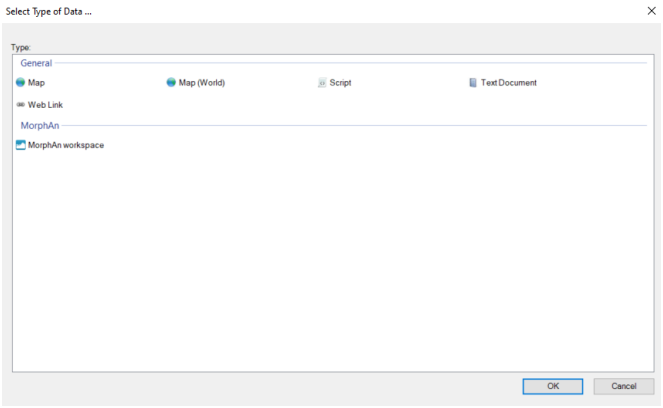


Figure 3.3: *Creating new MorphAn workspace via Project Explorer*

This then launches the MorphAn workspace setup wizard, in which you can select data to be imported into the workspace [section 3.2.2]. Even after you have finished running the wizard, you can still import additional data and add models to the workspace [section 3.2.3].

3.2.2 MorphAn workspace setup wizard

Welcome page

The first thing you see after you click on or select New Workspace is the welcome page [Figure 3.4]. Click *Next* to continue.

Figure 3.4: *Workspace setup wizard welcome page*

Workspace settings

The next page is “MorphAn werkruimte instellen”, in which you can specify the following workspace settings [Figure 3.5]:

- “MorphAn werkruimte naam:” leave as-is or change the workspace name.
- “Berekeningen”: select one or more of the following three models [section 2.4]:
  - Dune safety model
  - Coastal development model
  - Volume development model

The models you select have an influence on the data items to be imported later in the MorphAn workspace setup wizard.

- “Coördinatenstelsel”: here you can select the coordinate system onto which the imported data is to be projected. The default value is the coordinate system selected in the MorphAn settings [section 2.3]. Click [...] to see a list you can choose from.
- Lastly on this page, under “Gegevens” you can select whether you want the wizard to import data to the workspace, or to create an empty MorphAn workspace.

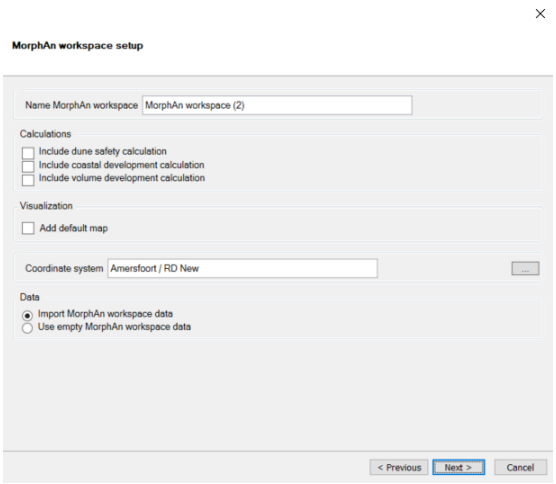


Figure 3.5: *Workspace setup Settings page*

When you are satisfied with the settings, click *Next* to continue with the next page of the wizard. If you have chosen to create an empty workspace, then the finish wizard page of the wizard will appear. Otherwise, the wizard will continue with the page for import of locations (option 2) or the import of locations and profiles from the combined locations and profiles file (option 1).

Option 1: Import locations and profiles from the combined location and profile file

When the selects option 1, the locations and profiles can be imported from the location and profile file.

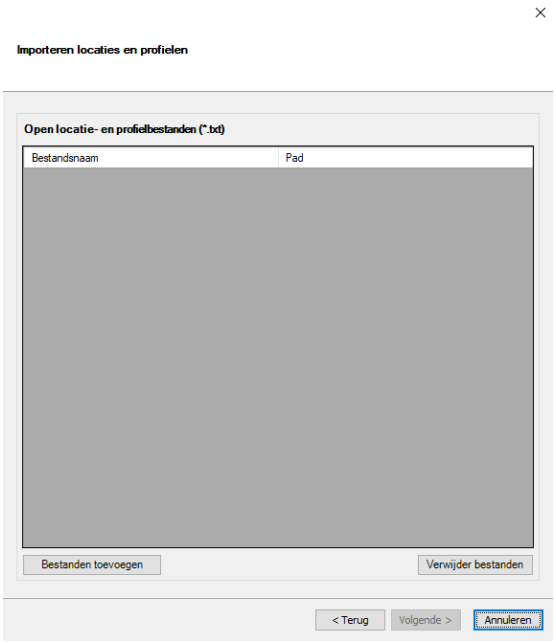


Figure 3.6: *Import profiles and locations*

Option 2: Import locations

By default, locations will be imported from the location file selected in the MorphAn settings [section 2.3]. In this page you can choose to delete this file and/or add other location files [Figure 3.7]. These location files are further explained in section 3.3.

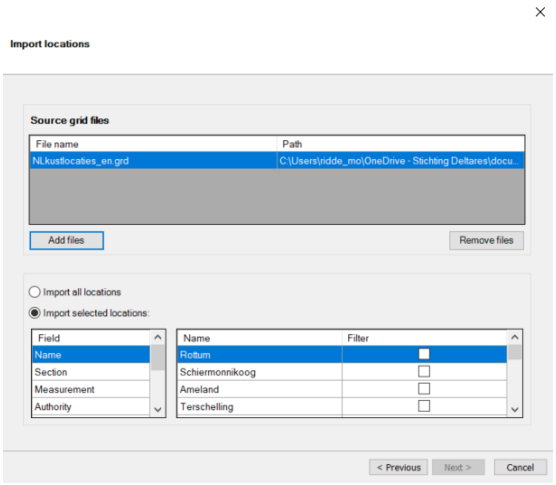


Figure 3.7: *Importing locations*

In the lower part of the page, you can choose to import all locations included in the location file. However, you can also manually select specific locations to be imported by filtering: highlight a filter field in the locations file, then check the filter box beside the location(s) you wish to include. When you have made your selection (all or a filtered subset), click “Volgende” to continue with then next page of the wizard.

Import cross-shore profiles

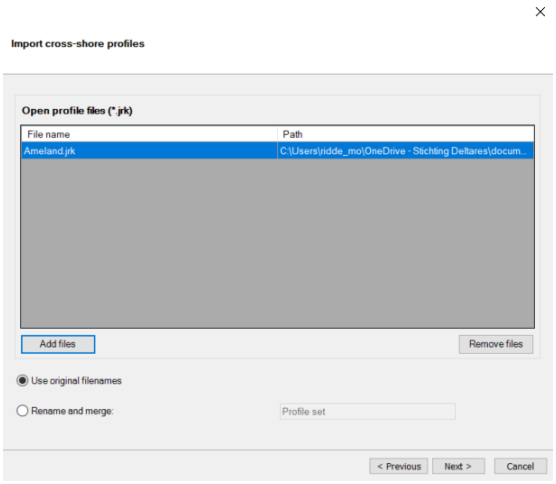


Figure 3.8: *Importing cross-shore profiles*

After importing the locations, the MorphAn setup wizard shows a list of files containing related cross-shore profiles that can be imported [Figure 3.8]. The wizard defaults to the folder selected in the MorphAn settings [section 2.3]. You can add and/or remove files using the buttons provided. Once you have made your selection, you can choose to use the original profile names to identify the profile series, or enter a name under which all of the profiles are merged. Click on “Volgende” to continue with the next page. Section 3.4 describes profile files in more detail.

Import boundary conditions

As with the cross-shore profile files, the MorphAn wizard shows only the files that are related to an imported location [Figure 3.9]. The data in a file is only imported when the box is actually checked. A distinction is made between the import of boundary conditions for safety (dune safety model), coastal development (coastal development model) and volume development (volume development model). MorphAn will check certain boxes by default if a model has already been selected. Section 3.5 describes boundary condition files in more detail.

As with cross-shore profiles, it is also possible to merge imported boundary conditions into one set. When you click “Volgende”, a page appears showing the progress of the import process.

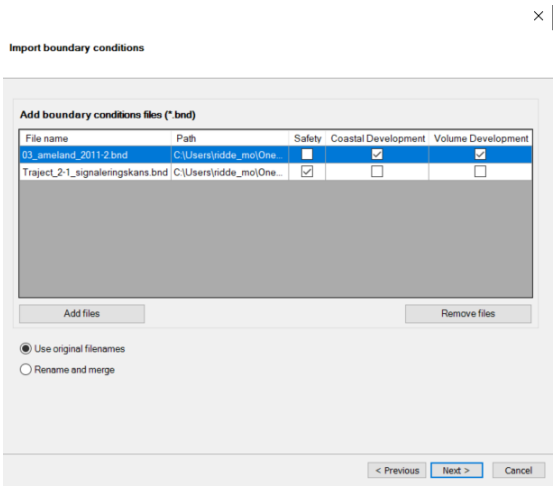


Figure 3.9: *Importing boundary conditions*

Import nourishments After the boundary import of the boundary condition, the nourishments can be imported. Since MorphAn requires one nourishments file, the user has the option to select one file.

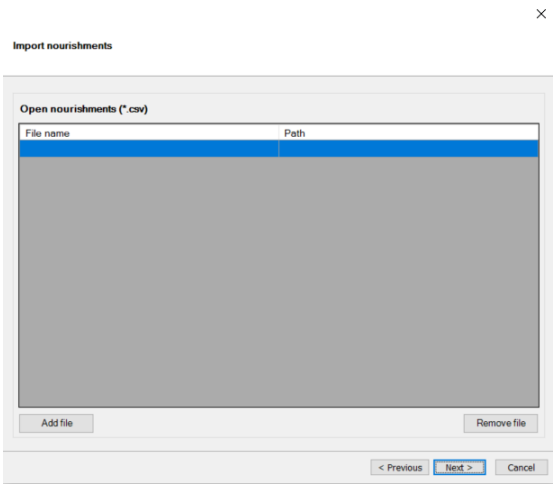


Figure 3.10: *Importing nourishments*

Progress of data import process

The next page of the wizard shows the progress of the import process [Figure 3.11]. When all data has been imported, click “Volgende” to continue with the next page.

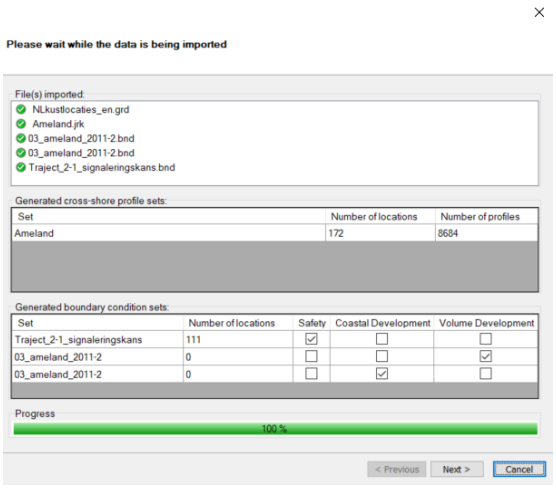


Figure 3.11: *Progress of data import process*

Filter coastal locations

When the data import is finished, a “Filter kustlocaties” page appears, that enables you to filter the imported coastal locations. This is an outdated functionality that may disappear in future [section A.6]. When you click “Volgende”, the finish wizard page appears.

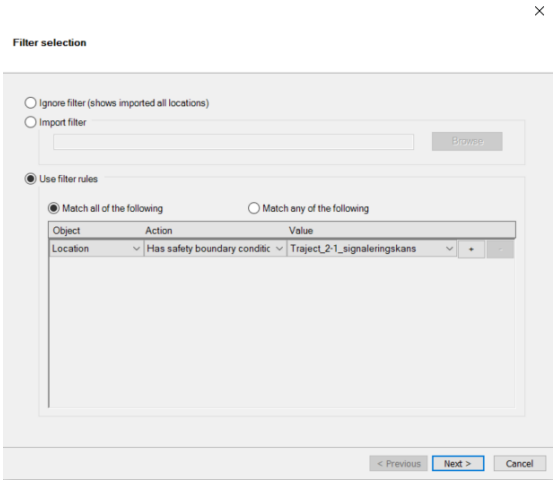


Figure 3.12: *Filter selection*

Finish wizard page

When the finish wizard page appears, click “Voltooien” to end the import process.

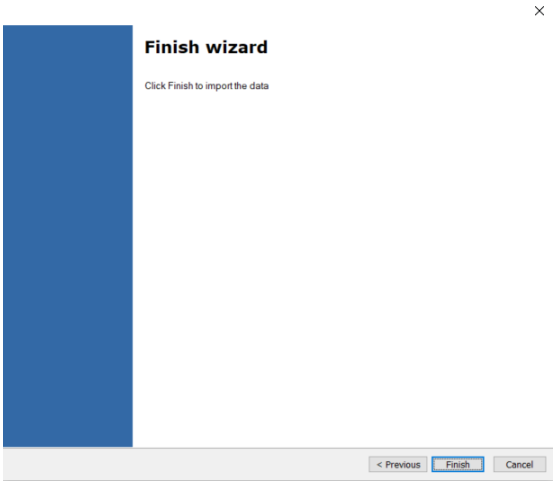


Figure 3.13: *Finish wizard page*

3.2.3 Add data and models to workspace

Once you have created a workspace, you can still always add data and models to that workspace. To do this in an existing MorphAn workspace, right-click on the workspace **Data** folder and select **Import...**. A selection page then appears [Figure 3.14].

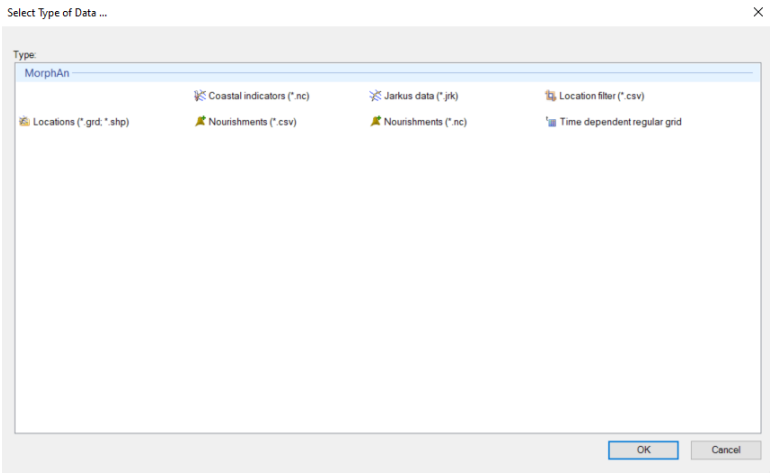


Figure 3.14: *Importing data into an existing MorphAn workspace*

You can also add models to the workspace. This is described in section 2.4.1.

3.3 Locations

Every cross-shore profile measurement and boundary condition is linked to a location on the coast (or bank). This is a line described by a base point and angle (bearing). Height and depth measurements are projected from points along that line. The boundary conditions are also linked to these locations. Section A.1 describes the required format for location files.

You can import locations either using the Workspace setup wizard, or manually from a location file. You can also edit and export locations [section 5.2].

3.4 Cross-shore profile measurements

A MorphAn workspace **Data** folder can be used to store cross-shore profile measurements. These are placed in the subfolder **Profile measurements**. This folder can contain multiple sets of cross-shore profile measurements. Each set contains one or more profile measurements and is therefore comparable to the contents of a .jrk file. You can select which set of cross-shore profile measurements is to be used as input to the models. This enables you to specify different variants of a dataset side by side in the same workspace, and to compare the analyses or calculations of those different sets with one another. At various points you can use an import tool to fill or augment a dataset with measurements. The source data must always be supplied in a cross-shore profile measurement file (*.jrk). Section A.2 provides a detailed description of this format.

There are two menus in MorphAn for management of cross-shore profile measurement sets, and both are activated with a right-click of the mouse. The first of these appears when you right-click on the **Profile measurements** folder (see Figure 3.15). The options in this context menu are as follows:

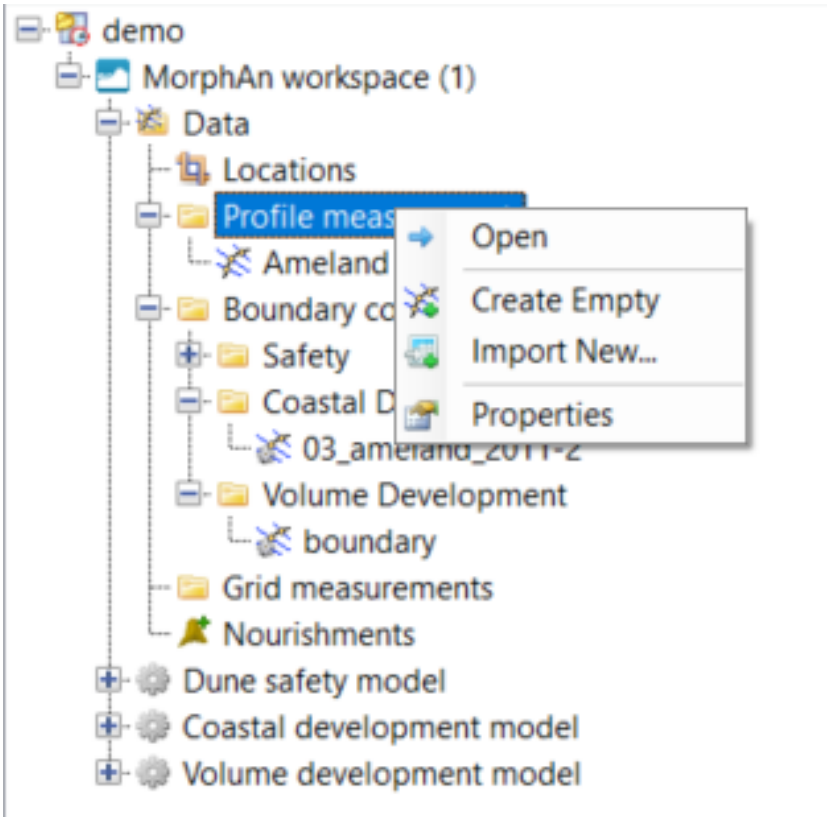


Figure 3.15: *Menu for managing profile measurements within a workspace*

- ◇ **Open** - opens the document window for management of the various cross-shore profile measurement sets [section 5.4].
- ◇ **Create Empty** - creates a new set without adding measurements.
- ◇ **Import New...** - enables you to add a new set and immediately import the contents of a file (*.jrk. This option opens a file import dialog allowing you to choose the (*.jrk) file containing the data to be loaded.
- ◇ **Properties** - displays the properties of the selected set in the “Properties” tool window.

The second type of context menu (see Figure 3.16) appears when you right-click on one of

the sets in the **Profile measurements** folder. You can then choose from the following options:

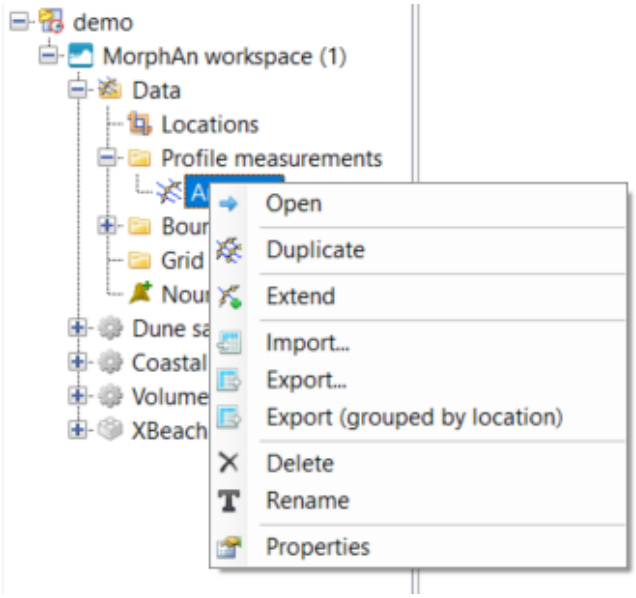


Figure 3.16: *Menu for managing individual Profile measurements*

- ◇ **Open** - Opens the document window for the selected set of measurements. This is an output screen that enables you to perform an analysis or modify the data [chapter 4 and chapter 5].
- ◇ **Duplicate** - Creates a copy of the current set. Use this option to modify an existing set and compare it with the original.
- ◇ **Extend** - Launches a wizard with which you can add empty measurements for locations and years that do not yet have measurements included in the set. These empty measurements can be input using the “Editor” [section 5.5].
- ◇ **Import...** - Imports additional cross-shore profile measurements into the selected set. A dialog box will appear, allowing you to select the file containing data to be imported.
- ◇ **Export...** - Exports the measurements in the selected cross-shore profile measurements set to a file in .jrk or .xyz format. A dialog box will appear, allowing you to specify the file name and folder for saving the data.
- ◇ **Export (grouped by location)** - Exports the measurements in the selected cross-shore profile measurements set to a xyz fromat where the data is grouped by the location.
- ◇ **Delete** -Deletes the selected set from the “Profile measurements” folder (option shown only if there is more than 1 set in the folder).
- ◇ **Rename** - To change the name of the selected cross-shore profile measurement set (you can also press F2 when the set is selected).
- ◇ **Properties** - Displays the properties of the selected set in the “Properties” tool window.

3.5 Boundary conditions

A workspace also contains input data for use when running models. As with profile measurements [section 3.4], you can also manage multiple sets of these **Boundary conditions**. Compared to profile measurements, the main difference is that the boundary conditions are divided into three different subfolders, one per model (dune safety, coastal development and volume development). When you right-click on the **Boundary conditions** folder or one of its sub-items in the **Project explorer**, the menus and options that appear are comparable to those of profile measurements [Figure 3.15 and Figure 3.16]. However, when importing new boundary conditions, a selection page will appear allowing you to choose the type of model for which the boundary conditions are intended [see also section 5.3]. The required format of

a boundary conditions import file is described in section A.4.

The three model types each use different boundary conditions. This is apparent in the three subfolders. Each subfolder contains only the boundary conditions applicable to the corresponding model. Also, when importing the models, only the applicable boundary conditions for that type of model are available.

When you double-click on one of the boundary condition sets (or select **Open** in the right-click context menu), the boundary conditions view opens for the selected set of boundary conditions in the document window [Figure 3.17]. This view shows a table with all boundary conditions that are present in that set. The figure above the table shows (if possible) a visualization of the boundary conditions for the coastal location selected in the table. To learn more about boundary conditions and their visualization, see section 5.3.

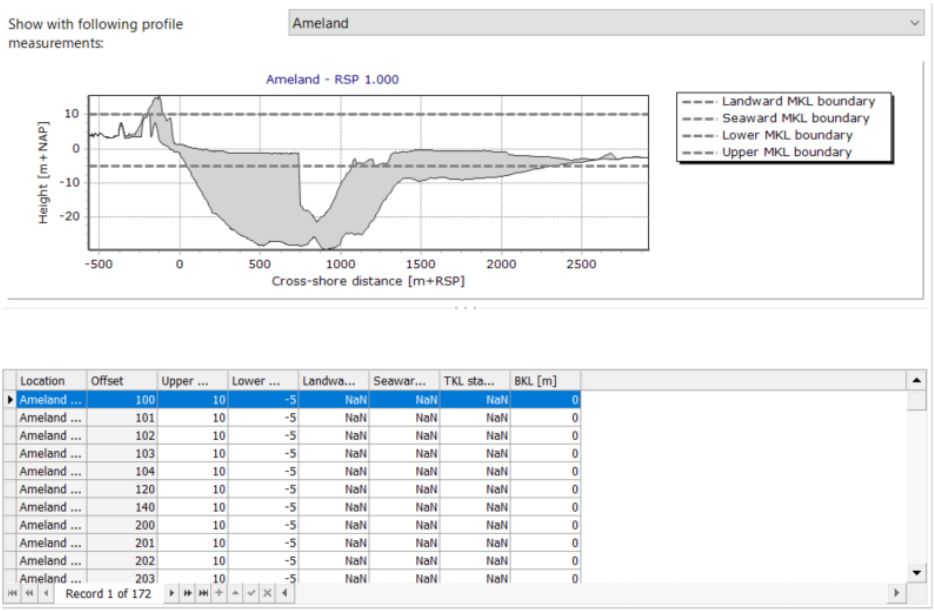
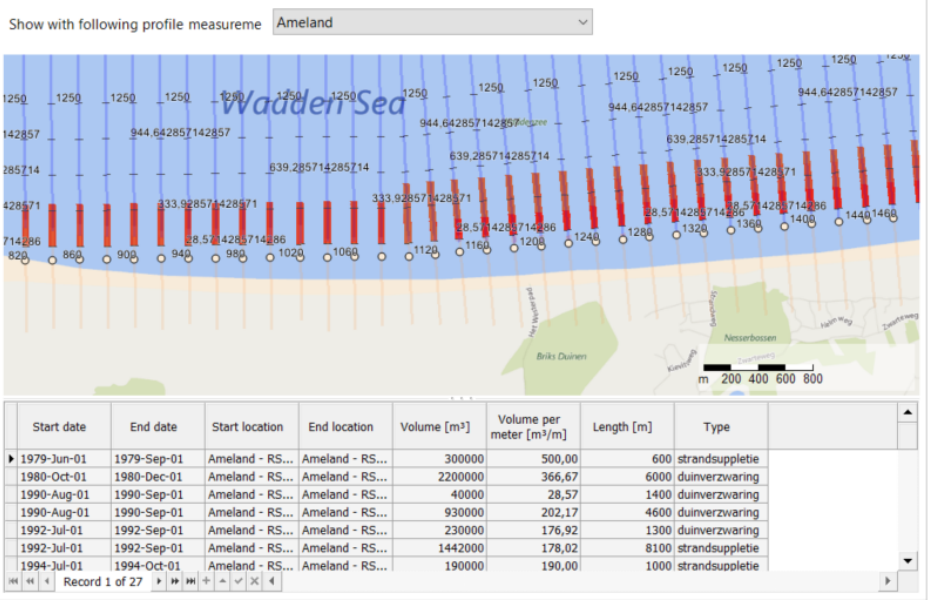


Figure 3.17: *Document window for visualization or editing of boundary conditions*

3.6 Nourishments

Information can also be added to a workspace describing the time period and volume of any applicable nourishments that have been performed. To add nourishment data, right-click on the **Data** folder (or the **Nourishments** subfolder), then choose *Import...* in the context menu, and in the ensuing dialog select one of the *Nourishments* importers (.csv or .nc). The importer will then list the data under the **Nourishments** item. The “Nourishments” data will be shown in its own document window view, but also in the relevant charts and maps (this can be switched on and off in the **Map** or **Chart** tool window). The information is displayed where relevant, such as in the input and output screens of model calculations. See section A.5 for a description of the format of a nourishments import file.



Start date	End date	Start location	End location	Volume [m³]	Volume per meter [m³/m]	Length [m]	Type
1979-Jun-01	1979-Sep-01	Ameland - RS...	Ameland - RS...	300000	500,00	600	strandsuppletie
1980-Oct-01	1980-Dec-01	Ameland - RS...	Ameland - RS...	2200000	366,67	6000	duinverzwaring
1990-Aug-01	1990-Sep-01	Ameland - RS...	Ameland - RS...	40000	28,57	1400	duinverzwaring
1990-Aug-01	1990-Sep-01	Ameland - RS...	Ameland - RS...	930000	202,17	4600	duinverzwaring
1992-Jul-01	1992-Sep-01	Ameland - RS...	Ameland - RS...	230000	176,92	1300	duinverzwaring
1992-Jul-01	1992-Sep-01	Ameland - RS...	Ameland - RS...	1442000	178,02	8100	strandsuppletie
1994-Jul-01	1994-Oct-01	Ameland - RS...	Ameland - RS...	190000	190,00	1000	strandsuppletie

Record 1 of 27

Figure 3.18: *Document window for visualization of nourishments*

3.7 Grid measurements

In MorphAn 1.4 and later, you can import and add time-dependent grid measurements to the MorphAn workspace. MorphAn enables you convert the grid measurements into profile measurements, for subsequent analysis in a bank analysis model.

An import wizard is available for grid measurements. To start this wizard, in the **Project Explorer** right-click **Data** [Figure 3.19 left], then click **Import...** in the context menu. In the dialog box that appears, select data type **Time-dependent regular grid** or **WCS (Internet) grid**, and confirm by clicking **OK** [Figure 3.19 right]. You can also start the wizard as follows: right-click **Grid measurements** in the **Project Explorer**, then click **Import New...** in the context menu.

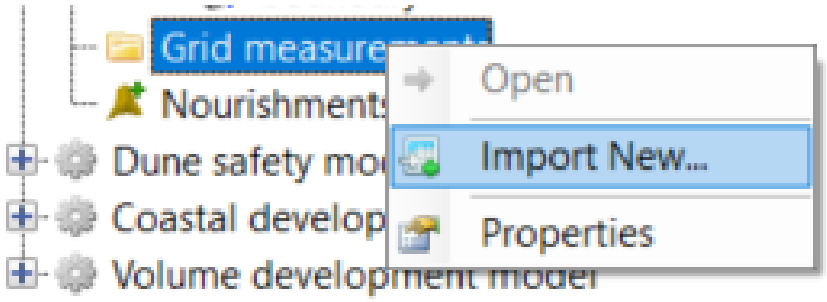


Figure 3.19: *Importing grid measurements*

When the wizard welcome page opens, click **Next** to open the time dependent regular grid import page [Figure 3.20]. In this page, select the files you wish to add, and the grid time per file:

- **1**] Click **Add files** to open a file selection dialog. The selected files appear in a table in the central panel.
- **2**] If you do not wish to select all files in the table (default is select all), then you should

now select the files you wish.

◇ **3**] Set the Next time, time step and time units, then click **Set grid time(s)**.

◇ **4**] Click **Next** to continue.

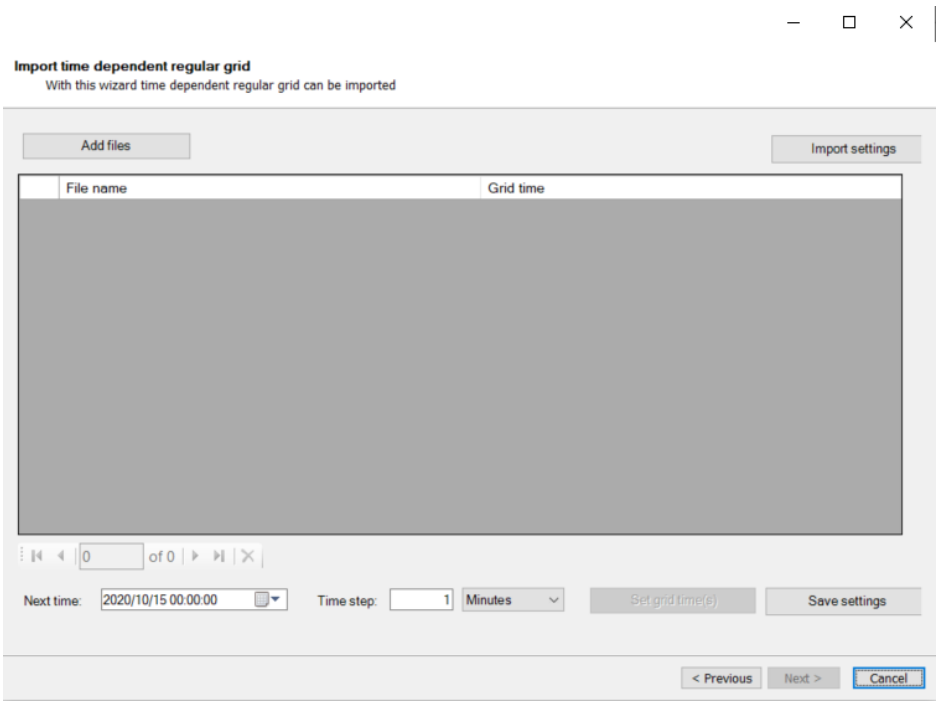


Figure 3.20: *Wizard page for selection and time settings of files to be imported as a grid measurements set*

The finish wizard page will now appear. Click **Finish** to close the wizard. The files are imported and added to a grid measurement set. This set is now visible in the **Grid measurements** subfolder of the **Project explorer** window. See section 4.3 for the selection and visualization of the grid measurements.

4 Data analysis in MorphAn

4.1 Introduction to data analysis

This chapter explains the use MorphAn to analyze (sea)bed data:

- ◇ Section 4.2 describes the analysis of (sea)bed data in *profile* form.
- ◇ Section 4.3 describes the analysis of (sea)bed data in *grid* form.

4.2 Analysis of profile measurements

4.2.1 Overview of visualizations for profile measurements

Data can be analyzed in various visualization windows. To access the various visualizations, open the document window of a set of profile measurements (double-click one of the sets or right-click → Open) section 3.4). The resulting window [Figure 4.1] shows a map and two lists. You can select the locations you wish to visualize from the Locations list and/or the map. For each selected location, the Years list shows the available measurements. When you have selected the years you wish, six buttons are enabled in the Visualization group of the **Data** tab of the ribbon [Figure 4.2]. Each of these buttons can be used to open a new document window for a different analysis of the selected data.

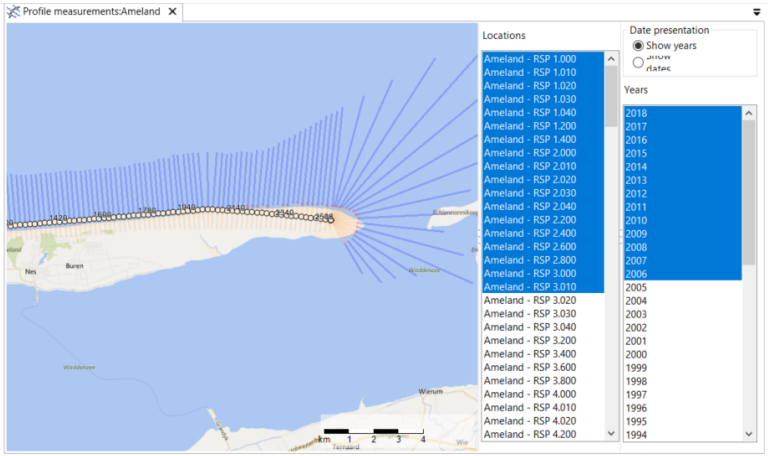


Figure 4.1: *Selection of locations and years*

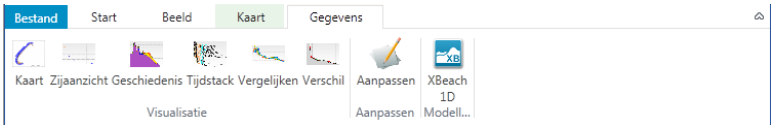


Figure 4.2: *Data tab with Visualization options*

MorphAn offers the following visualizations for the analysis of the selected profile measurements and years:

- ◇ Section 4.2.2 describes the visualization “map overview”.
- ◇ Section 4.2.3 describes the visualization “transect side view”.
- ◇ Section 4.2.4 describes the visualization “time history”.
- ◇ Section 4.2.5 describes the visualization “time stack”.
- ◇ Section 4.2.6 describes the visualization “time difference”
- ◇ Section 4.2.7 describes the visualization “transect comparison”.

4.2.2 Map overview visualization

The **Map** shows a geographical view of the data of all available transects. The map only shows measurements with a specific date. You can use the time navigator to step in time through the data [section 2.5.8]. The map can be modified or extended with other information (e.g. from shape files, or by using WMS layers) [section 2.6].

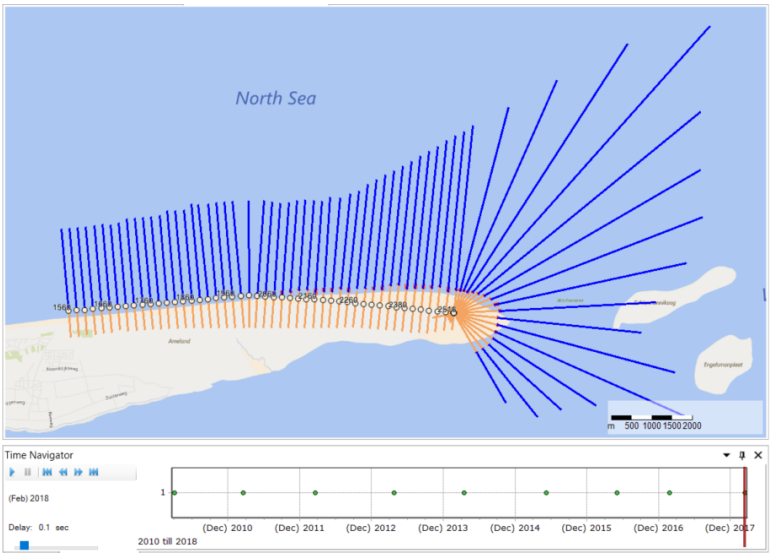


Figure 4.3: *Example of a map in combination with the Time Navigator*

4.2.3 Transect side view visualization

The **Side View** shows the profile at the selected locations based on all individual measurements that together make up the profile measurement [Figure 4.4]. The colors indicate the type of measurement (wet or dry) or a section that is interpolated. Move the slider in the Time Navigator to go forwards or backwards in time through the data. The list to the left of the chart enables you to view transect data at a different location.

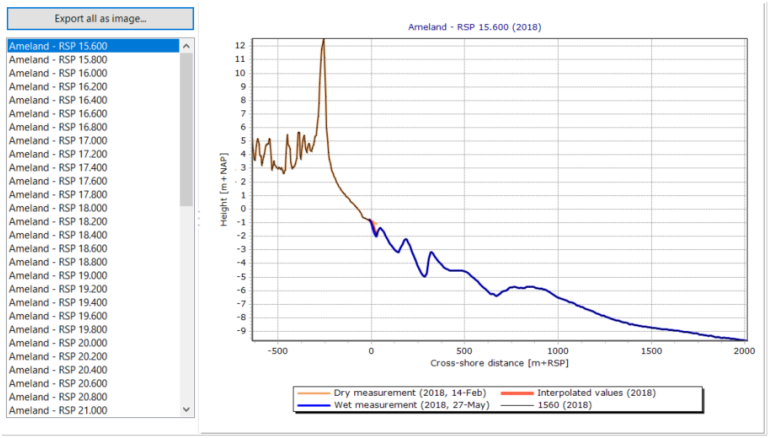


Figure 4.4: *Transect side view with Time Navigator*

4.2.4 Time history visualization

The **History** visualization [Figure 4.5] shows a chart of measurements for a single location as overlaid solid areas, enabling you to analyze the development over time. You can omit certain years by checking the boxes beside each year in the Chart tool window (not shown in Figure).

The charted location can be selected in the list on the left side of the history window. The chart then shows all measurements in the selected years for that location. The most recent measurement of the selection is displayed as a thick line to indicate the maximum. You can choose a Color Scale in the Style group of the **Chart** tab of the ribbon, and adjust the chosen scale via the **Chart** tool window and Properties tool window. This way you can optimize the chart for your analysis.

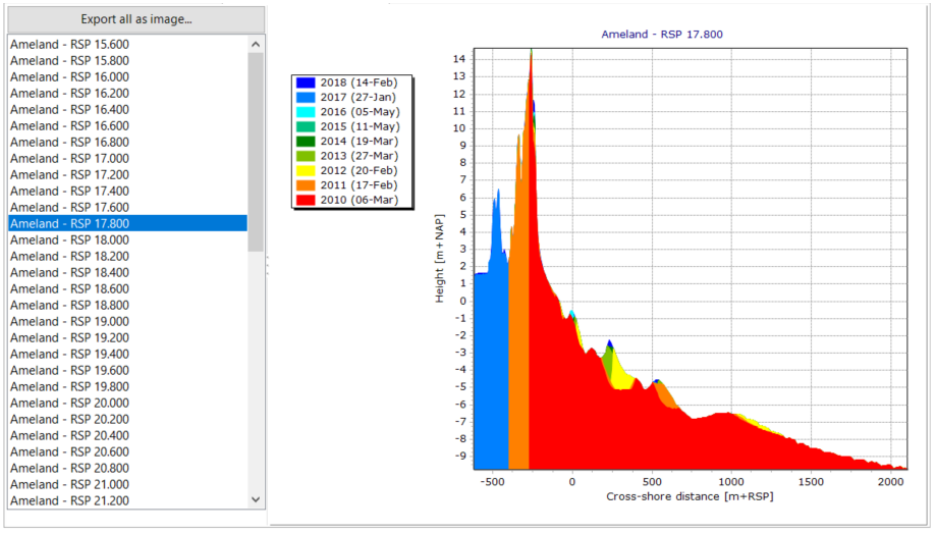


Figure 4.5: *Typical Time History visualization*

4.2.5 Time Stack visualization

The **Time Stack** visualization [Figure 4.6] shows the profiles of the selected locations for successive years. As with the Time History window, only a single location can displayed in the Time Stack window. This allows you to view the development of a particular part of the coast over time. To make the analysis easier, you can specify the limits and colors to highlight specific height zones in the profile.

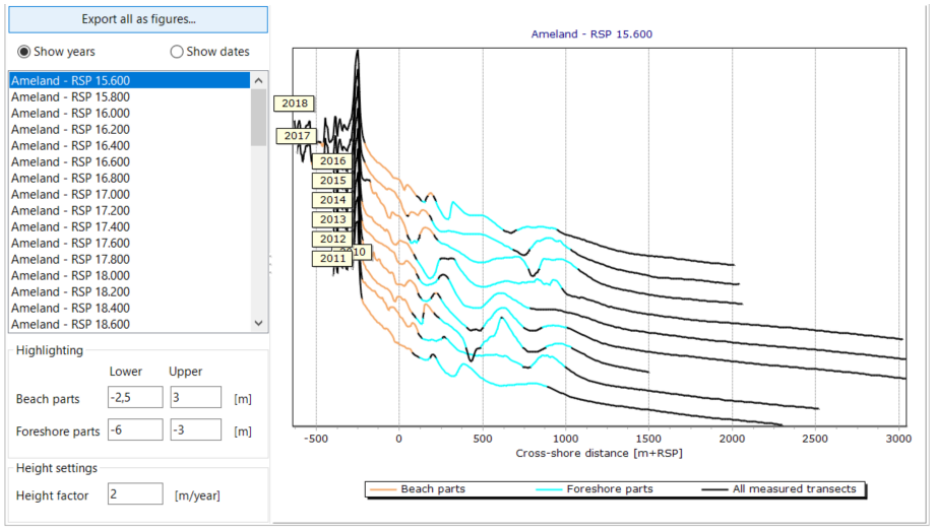


Figure 4.6: *Typical Time Stack visualization*

4.2.6 Time difference visualization

The **Difference** visualization [Figure 4.7] charts the difference between two profiles measured at different dates at a selected location. You can adjust the interval between the two profiles using the Time Navigator [section 2.5.8]. To change the dates of the first and last profile measurement, simply drag the left and right edges of the slider in the Time Navigator. The colors indicate the height difference between the two selected dates in the navigator. Accretion (height of last measurement increased relative to first measurement) is shown as a green area; erosion (last measured height decreased relative to first) is shown in red.

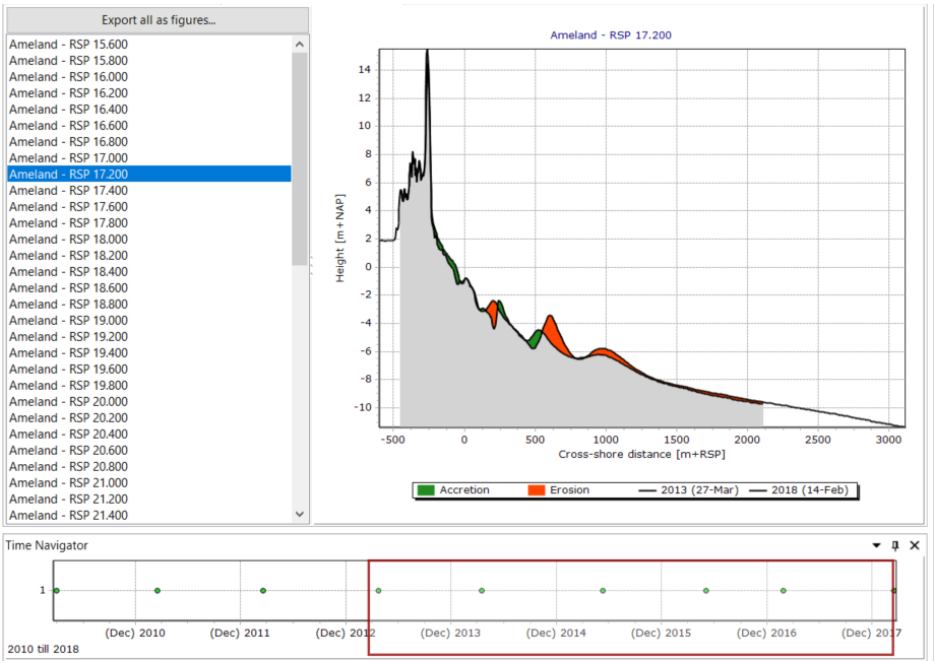


Figure 4.7: *Typical Time difference visualization showing also the Time Navigator setting of the analysis period.*

4.2.7 Transect comparison visualization

The **Comparison** visualization [Figure 4.8] enables you to compare the profiles, either of multiple years for a single location (Show single), or multiple locations for a single year (Show single year). As with other visualizations, you can optimize the legibility of the chart by choosing an alternative color scale in the **Chart** tab of the ribbon.

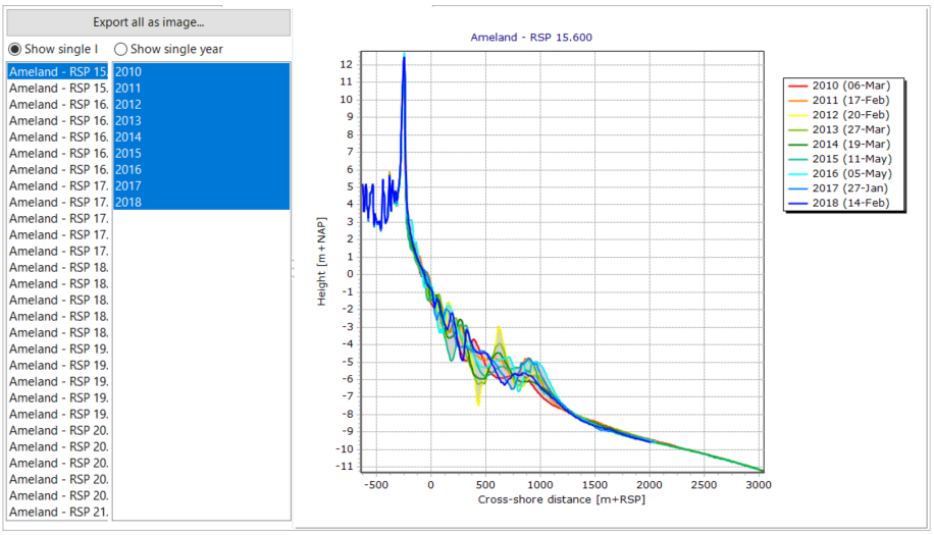


Figure 4.8: *Typical Transect Comparison visualization*

4.3 Analysis of grid measurements

4.3.1 Visualization of grid measurements

To visualize grid measurements, double-click on a grid measurement set, or right-click a grid measurement set to open the context menu, then select **Open** [Figure 4.9]. The height visualization will initially be displayed. To hide the Height visualization, uncheck the box beside **Height** in the Map toolbox window. To display the visualization of height, (sea)bed slope, or difference in height between two dates, simply check the box [Figure 4.9] beside **Height**, **Slope** or **Difference**. These options are further explained below.

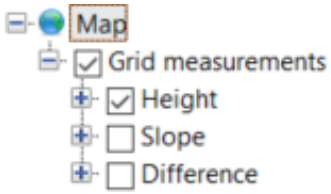


Figure 4.9: *Visualization of grid measurements*

4.3.2 Visualization of height

To visualize the heights of grid measurements, open the grid measurements, then check the **Height** box in the **Map** tool window. Use the Time Navigator [section 2.5.8] to visualize the height for different periodic measurements. Figure 4.10 shows a map window in which different heights are visualized. The different heights displayed in the figure are taken directly from the grid measurements. No further calculations have been performed.

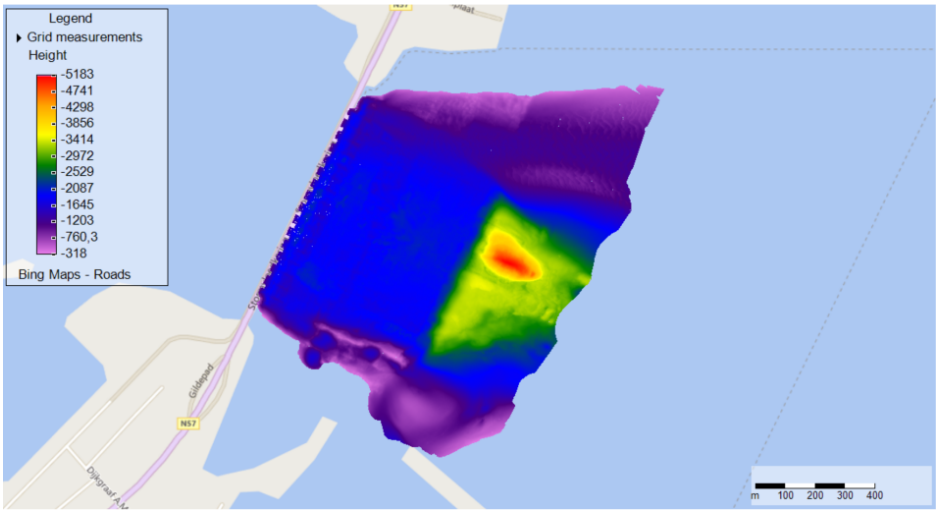


Figure 4.10: *Typical map display with height visualization.*

4.3.3 Visualization of (sea)bed slope

To visualize the slope of the beach or seabed, open the grid measurements (if not already open), then in the **Map** tool window, check the **Slope** box and uncheck the other visualizations (e.g. **Height**). Use the Time Navigator [section 2.5.8] to visualize the seabed slope for different periodic measurements. Figure 4.11 shows a map window in which the bed slope is visualized.

There are various methods for calculating the slope. To modify the calculation method, click on map layer “Slope” in the Map tool window. MorphAn will then display the properties of the selected map layer [also Figure 4.12]. The field “Distance for slope calculation” allows you to enter a value for MorphAn to apply when calculating a slope on the (sea)bed. Starting from a cell, MorphAn will look at the depth at the specified distance in surrounding cells, and divide the depth difference by the specified distance. You can choose an alternative “Method” to set the directions for inspecting surrounding cells. Methods such as “Right” or “Left” look exclusively in one direction and are therefore quick. The “Circle” method looks at all relevant cells, and is therefore more accurate, but it can be slow. To avoid a long wait, you can also opt for the method “Circle with maximum number of directions”. This tells MorphAn to calculate and display the maximum (sea)bed slope in no more than the specified number of directions. If the circle with specified radius circumscribes more cells than the maximum number of directions, MorphAn will divide the directions proportionally up to the maximum over the circle.

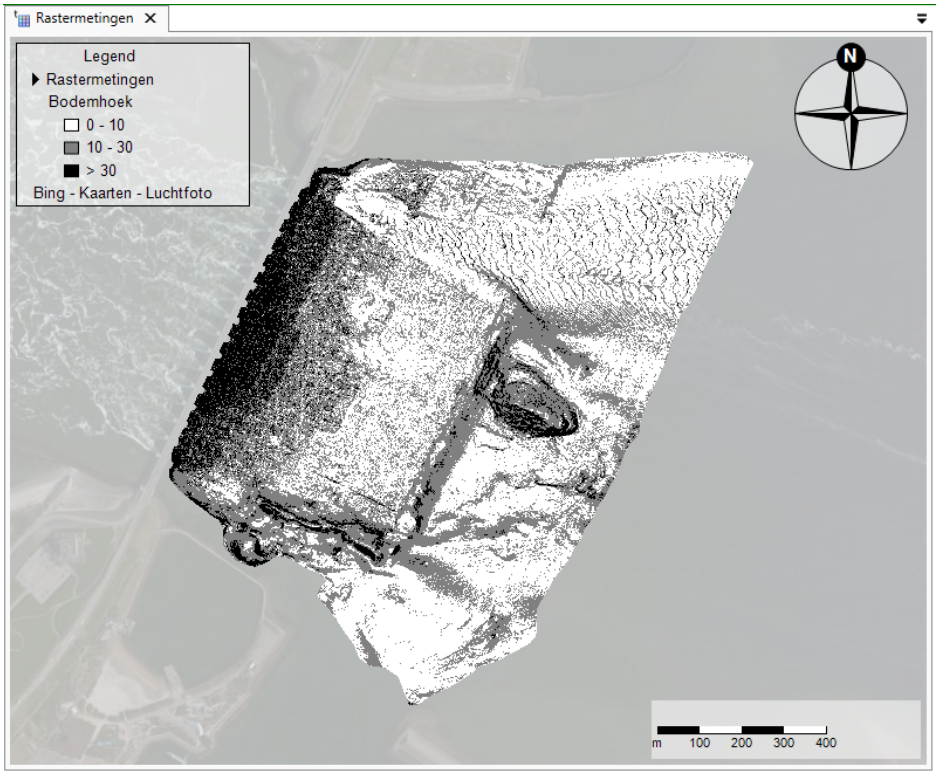


Figure 4.11: *Typical map display of the calculated slopes.*

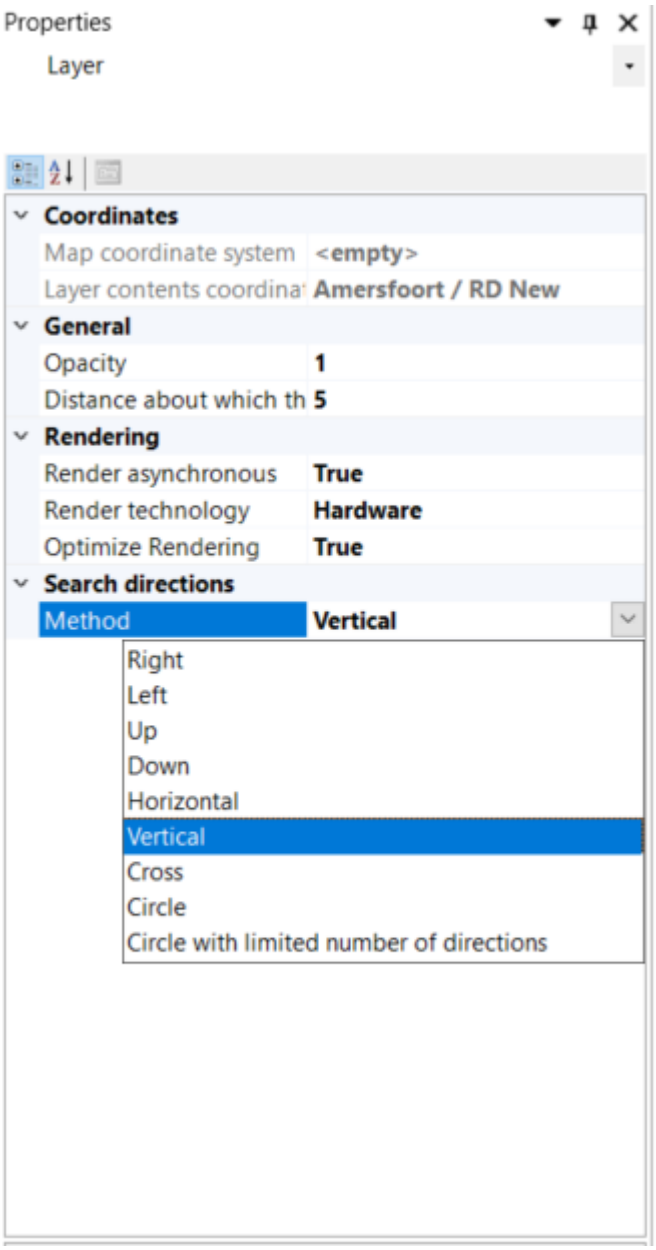


Figure 4.12: *Typical properties of a "Slope" map layer.*

4.3.4 Visualization of difference between two grids

You may wish to see what has happened to the bed height over time [Figure 4.13], or perhaps check whether, how and where nourishments or bed protection have been performed [Figure 4.14]. MorphAn can make a visualization of the difference in bed height over time to help you with this type of analysis.
To visualize the height difference between two periodic measurements, open the grid measurements (if not already open), then in the **Map** tool window, check the **Difference** box and uncheck the other visualizations (e.g. **Height** and **Slope**).

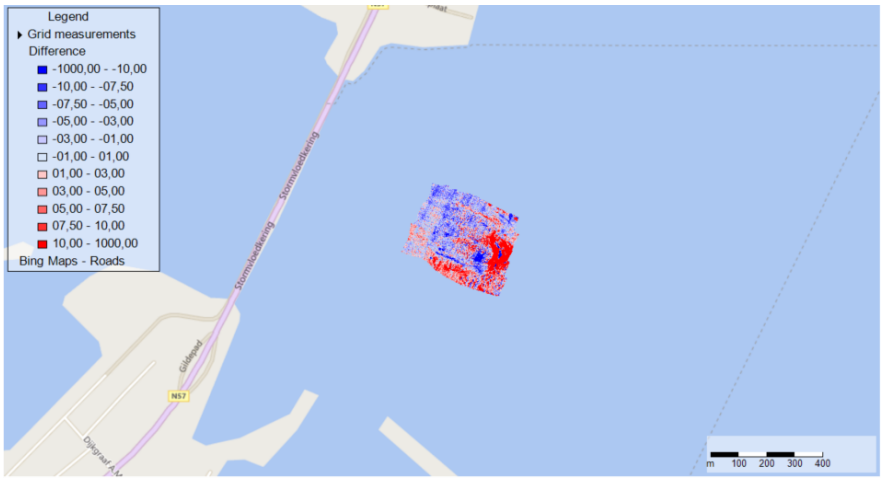


Figure 4.13: *Change in height between two dates.*

The difference in height between dates t1 and t2 is calculated by subtracting the height of date t1 from that of date t2.
Use the Time Navigator [section 2.5.8] to specify a time interval. The difference is calculated between the first and last measurement in the selected time interval.

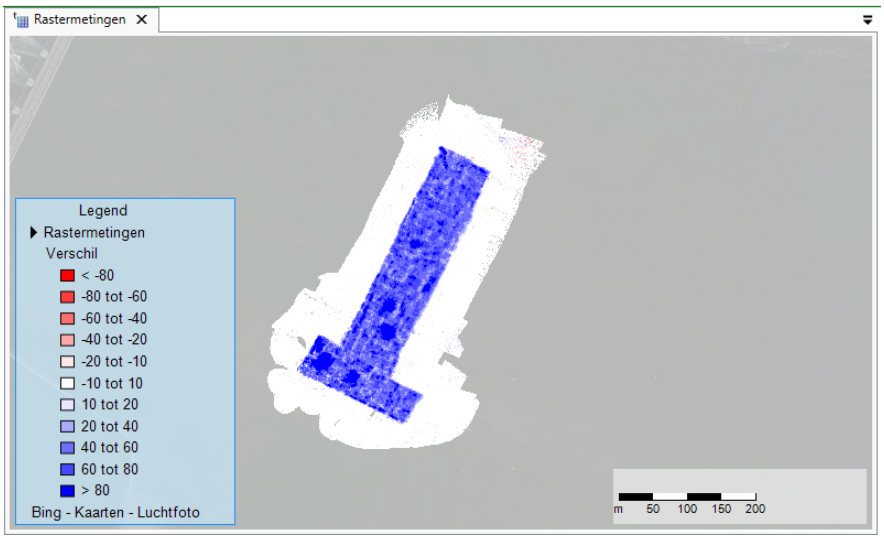


Figure 4.14: *Visualization of the difference in bed height due to a nourishment*

4.3.5 Show all grid measurements

It is also possible to display all height data from the various grid measurements on a single map. In the “Data” folder of a MorphAn workspace, right-click on the “Grid measurements” folder, then select “Open” in the context menu. A map will open showing all grid measurements.

5 Managing and editing Data in MorphAn

5.1 Introduction to managing and editing data

Chapter 4 described various ways to analyze the data added to a MorphAn workspace. In our experience it is often also necessary to be able to edit data and assemble custom sets of transect measurements. This chapter addresses the relevant features available in MorphAn:

- ◇ Section 5.2 describes how to manage imported location data.
- ◇ Section 5.3 describes how to manage imported boundary conditions.
- ◇ Section 5.4 describes how to organize imported profile data.
- ◇ Section 5.5 describes how to edit the imported profile data.
- ◇ Section 5.6 describes how to generate profiles from one grid measurement set.
- ◇ Section 5.7.1 describes how to generate intermediate transects.
- ◇ Section 5.8 describes how to export profiles.

5.2 Manage locations

When you double-click on the **Locations** Item in the **Data** folder of the MorphAn workspace, a selection dialog will appear [Figure 5.1]. This dialog asks whether you wish to open the **Locations (filter)** view or the **Locations (manager)** view. The Locations (manager) view [Figure 5.2] enables you to manage coastal locations. In this window you can add new locations, edit existing locations, or even remove locations. This section discusses this window in detail.

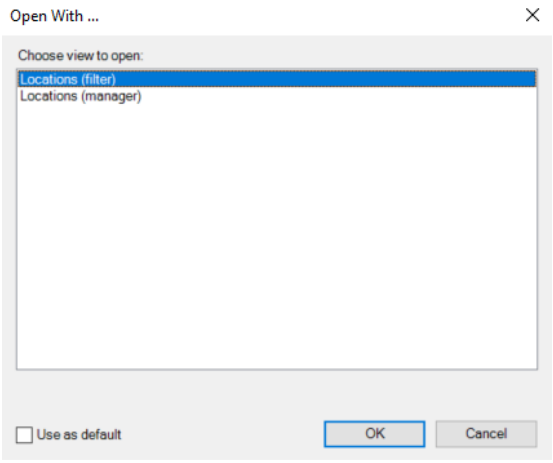


Figure 5.1: *Selection dialog for locations (filter) or locations (manager)*

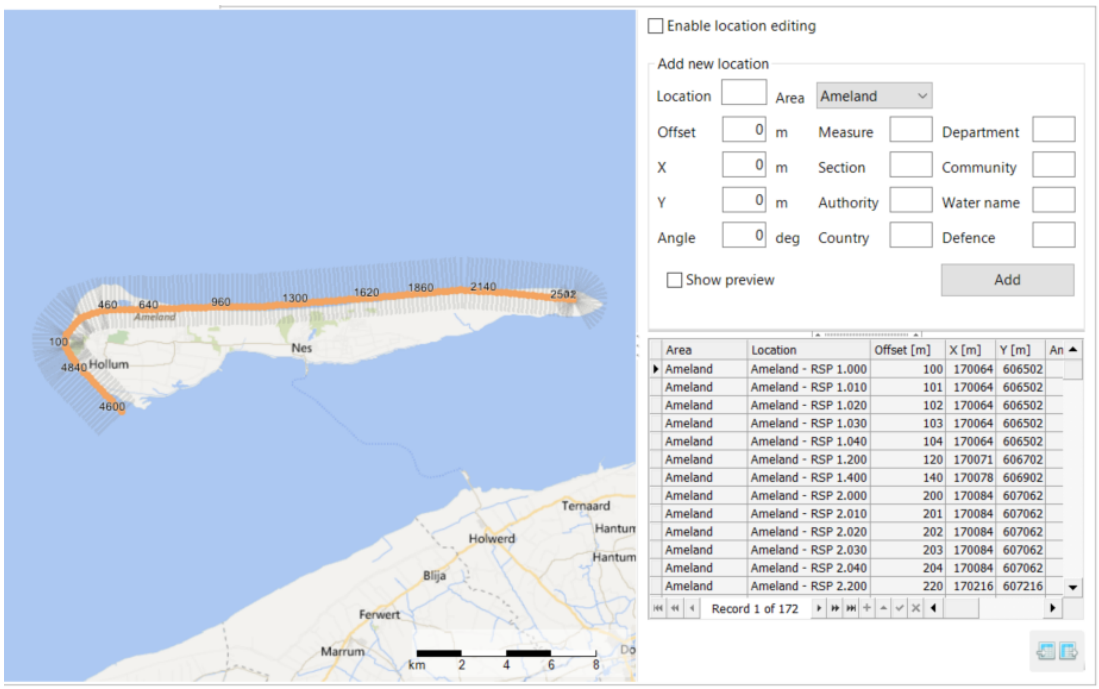


Figure 5.2: *Typical Locations (manager) window.*

When the screen first opens, you can only *add* locations. There are three ways to add locations:

◇ **Use the form in the window** - enter data directly in the “Add new location” form on the right side of the Locations (manager) view [Figure 5.3] :

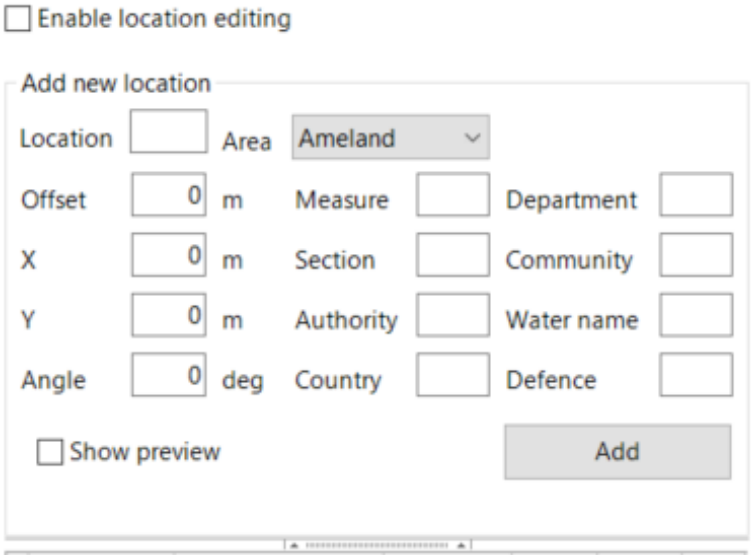


Figure 5.3: *“Add new location” form in upper right part of the Locations (manager) window.*

- **Location** - The Id of the location; this is the name shown in tables in MorphAn. This Id must be unique.
- **Area** - coastal area to which the new location belongs
- **Offset** - offset of the new location from the zero point of the coastal area.
- **X** - The X coordinate (in RD) of the new location

- **Y** - The Y coordinate (in RD) of the new location
- **Angle** - The angle of the transect through the new location
- **Measure** - type of location
- **Section** - For example a dyke section
- **Authority** - Governing body at the location
- **Country** - Country of the location
- **Department** - Region, province, county, etc. of the location
- **Community** - Municipality of the location
- **Water name** - Geographical name of the water body at the location
- **Defence** - Type of water defence, shore or coast.

Click **Add** to add the new location to the coastal area.

◇ **Add free location** - Another method is to click on the option "Add Coastal Locations → Add Free Location" in the **Map** tab of the ribbon. You can then click anywhere on the map. An input dialog (similar to [Figure 5.4]) will then open, showing the X and Y coordinates of the point clicked, with an estimate of the coastal area, offset and angle of the transect. Edit this information as necessary, then click **OK** to add the new location.

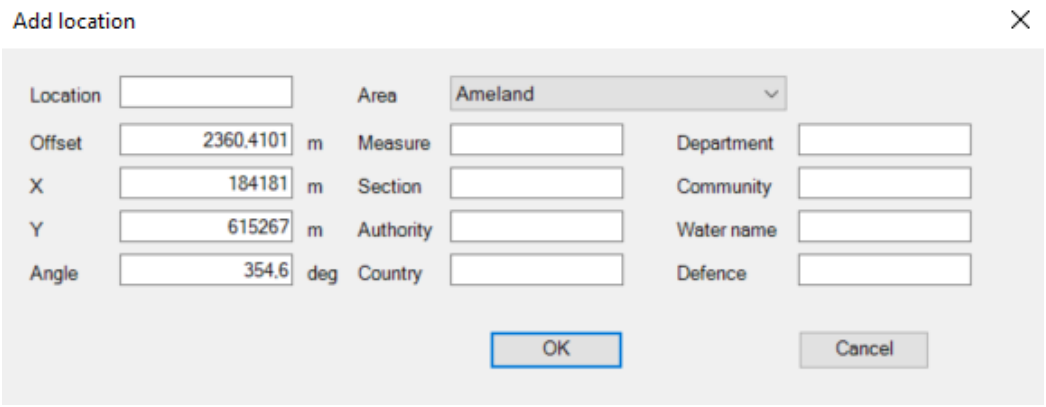


Figure 5.4: *"Add free location" dialog*

◇ **Interpolation between two locations** - One other method is to automatically generate intermediate transects. Click on the second option in the "Add Coastal Locations" group of the **Map** tab of the ribbon. You will then be prompted to select two locations on the map. After you have done this, a dialog similar to that in Figure 5.5 will appear. At this point you can edit the selected locations if necessary. You can also enter either the number of locations to generate or the distance between locations, as well as how to handle duplicate locations (those whose coastal area and offset are identical to existing locations in the project). When you click **OK**, the locations are added to the workspace.

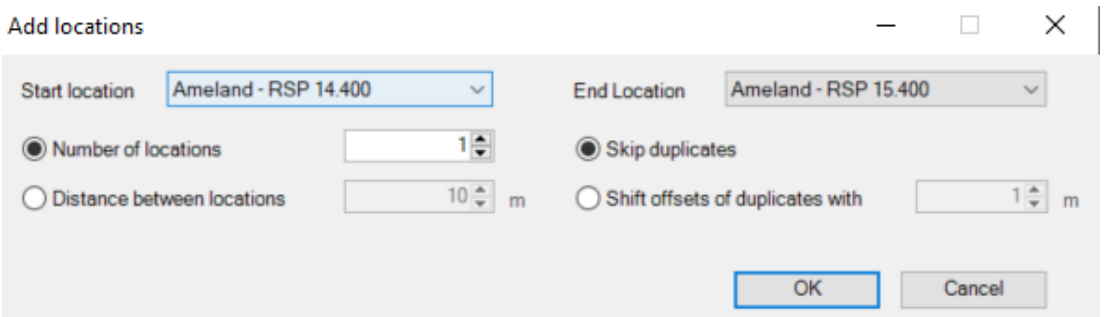


Figure 5.5: *"Interpolation between two locations" dialog*

At the top of the window [Figure 5.2] you can choose whether locations may be modified or deleted. When you check this “Enable location editing” option, a pop-up similar to that in [Figure 5.6] will appear. This pop-up warns you of the potential risks of editing or removing locations. For example, it can cause the location filter to be modified, and related profile measurements or nourishments could be removed. Moreover, the editing of locations can cause the results from modeling runs to be lost.

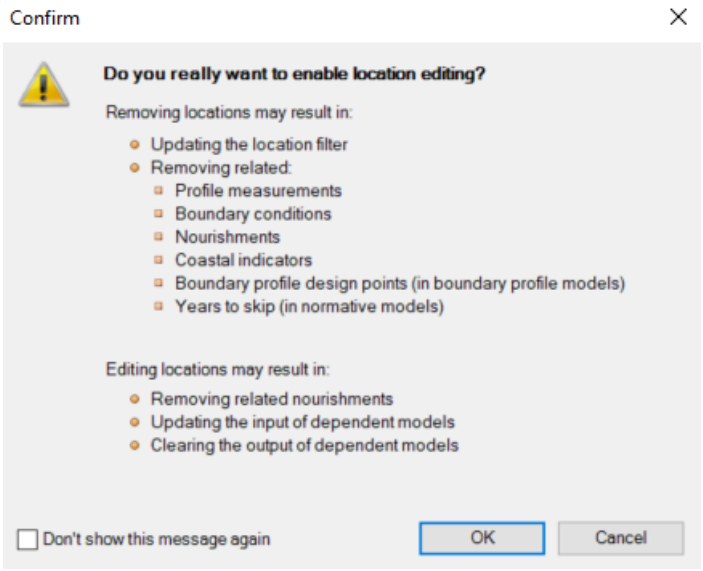


Figure 5.6: *Pop-up that appears after checking the “Enable location editing” option. This pop-up warns of the potential risks of editing or removing locations.*

5.3 Manage boundary conditions

The **Boundary conditions**folder in the **Project Explorer** includes three subfolders for the three types of model (dune safety, coastal development and volume development). Each subfolder can contain one or more sets of boundary conditions. Within the models present in the workspace, you can only select boundary conditions of the same type as the model. For example, within the dune safety model you can only select boundary conditions that are present in the dune safety subfolder.

MorphAn provides features for organizing existing sets. For example, you can create a new (empty) set, duplicate an existing set, rename a set, or add new boundary conditions to an existing set. These features work in the same way as those for organizing profile measurement sets, as described in section 3.4. When you import a new set of boundary conditions (right-click on the boundary conditions folder, click Import and select the required boundary conditions), you will see a screen in which you can select the type of model to which the boundary conditions belong [Figure 5.7]. You can also import the boundary conditions for all models, if you select all three types of model.

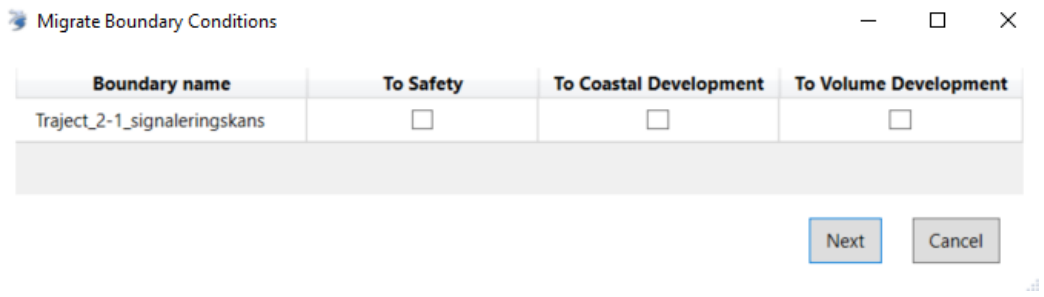


Figure 5.7: *Selection screen after importing the boundary conditions.*

When you open a boundary conditions file, the boundary conditions for all available locations are displayed in a table. If there is no value available for a certain location in the location file then this is represented as “NaN” [Figure 5.8]. The figure above the table shows graphically the minimum and maximum values of the profile measurements for the available years at each location selected in the table. The figure also displays the vertical boundaries from the boundary conditions. In the case of dune safety boundary conditions, the figure also shows the maximum storm surge level (Rp). The figure for coastal development and volume development boundary conditions shows the seaward boundaries. You can change the selected profile measurements set via the drop-down menu above the figure.

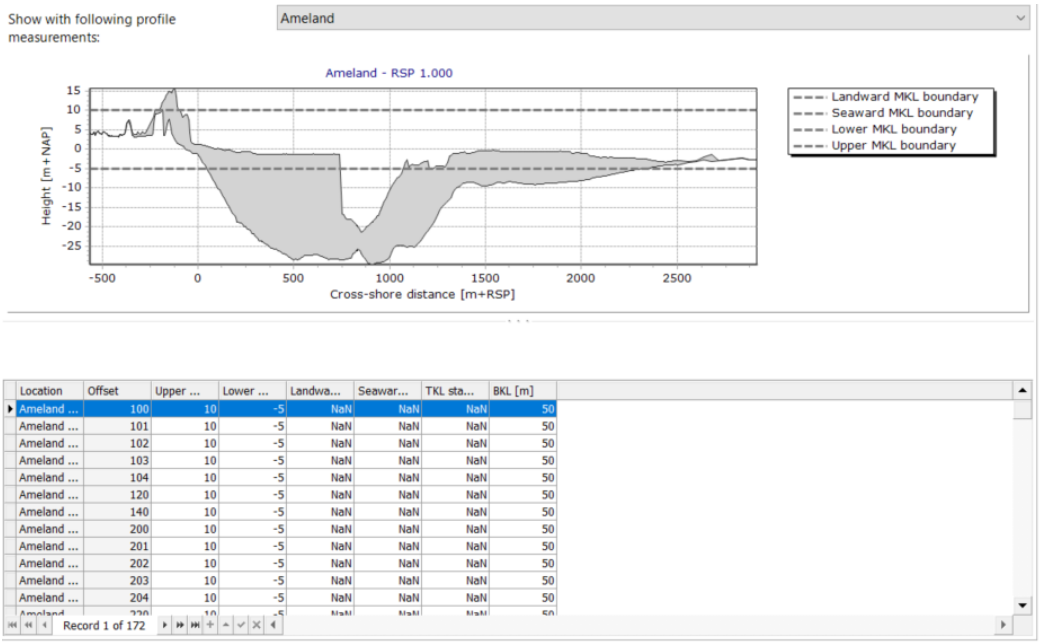


Figure 5.8: *Document window showing (lower section) boundary conditions table and (upper section) corresponding figure of profile measurements and vertical boundaries from the boundary conditions.*

In addition to the figure, you can also view the boundary conditions on a map. You can activate this with the Visualization button in the Boundary Data tab of the ribbon [Figure 5.9].

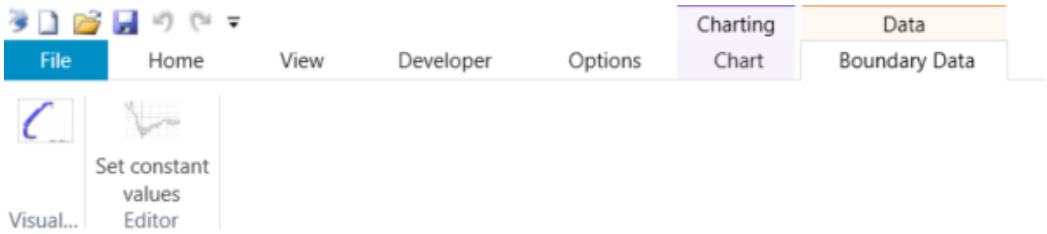


Figure 5.9: *Boundary data ribbon tab with the button for map visualization*

This map shows all locations, with a red symbol indicating locations with boundary conditions. In addition, the horizontal boundaries are shown on the map as lines. For dune safety boundary conditions, these lines represent the Xgp values and dune row. For development boundary conditions, the lines represent the landward and seaward boundaries. For dune safety boundary conditions the H_s, T_p, $D50$, Rp and $T_{m-1.0}$ values are represented as bar charts [Figure 5.10].

You can adjust the length, width, and cross-shore distance of the bar charts in the **Properties** tool window. You can also adjust the maximum and minimum values of the bars.

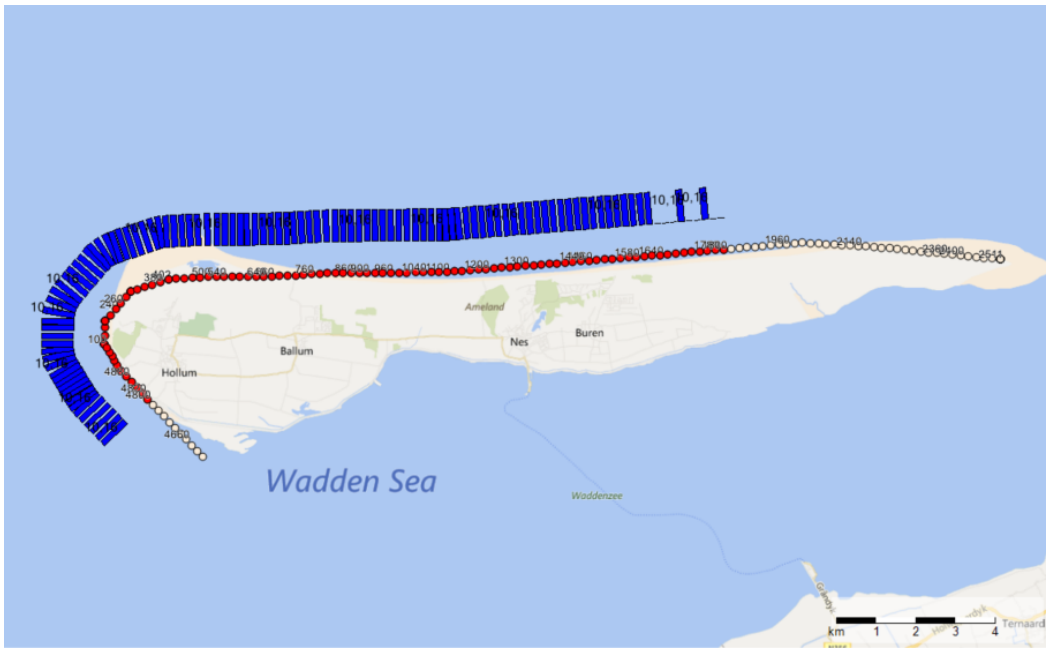


Figure 5.10: *Dune safety boundary conditions shown on a map.*

5.4 Organize profile measurements

5.4.1 Options for organizing profile measurements

The **Profile measurements** data folder in the **Project Explorer** window contains one or more sets of profile measurements for use in models added to the workspace. Section 3.4 has already described the features available in the **Project Explorer** window to manage these sets. When you double-click on the Profile measurements folder, the corresponding document window [Figure 5.11] will open, with more options for managing sets of profile measurements.

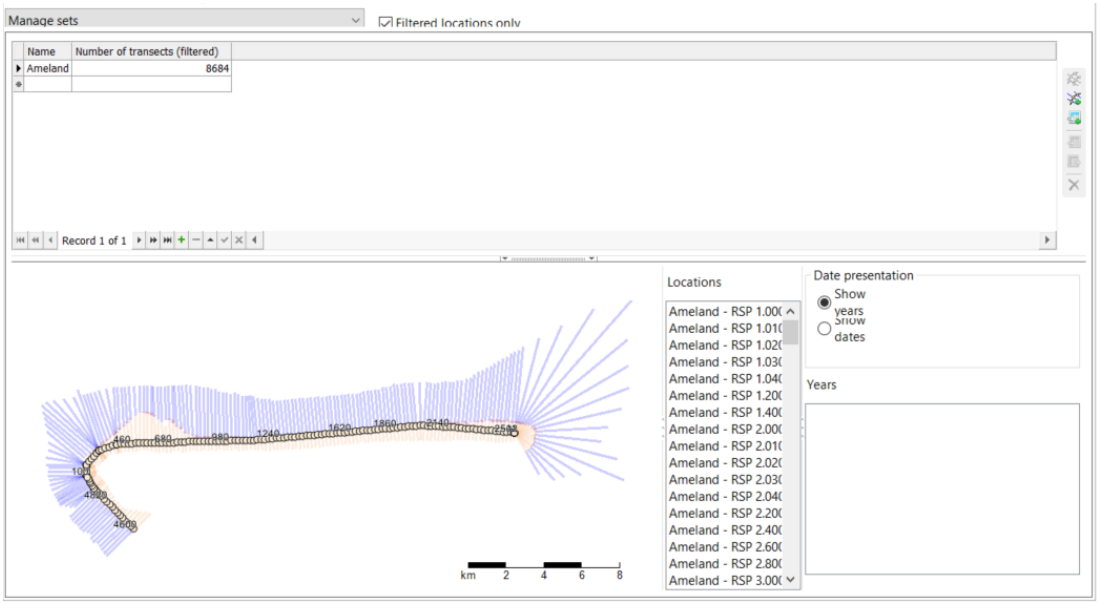


Figure 5.11: *Profile measurements document window. In the upper left corner of the window is a drop-down menu from which you can choose the working mode of the window.*

In the upper left of this window is a drop-down menu that allows you to choose one of three working modes for the window:

- ◇ **Manage sets** - use to add, delete, duplicate or rename sets [section 5.4.2].
- ◇ **Manage measurements in set** - use to remove measurements from a set, extend a set with empty measurements, and import and/or export the coordinates of measurements [section 5.4.3].
- ◇ **Exchange measurements between sets** - use to copy individual measurements from one set to another [section 5.4.4].

These working modes are discussed further in the following sections.

5.4.2 Manage sets of profile measurements

By default, the window opens in “Manage sets” mode [Figure 5.12]. In this mode you see a table showing the available profile measurement sets, also stating the number of measurements present in each set. If the box “Filtered locations only” is checked, only those measurements compliant with the location filter [section 3.3] are counted; otherwise, all measurements are shown. On the right margin of the window you can see several action buttons (in certain cases they are active only when a set is selected). In addition, you can also rename a measurement set directly in the table. The buttons offer the following actions:

- ◇ **Create set after import** → Imports measurements from a .jrk file [section A.2] and

adds a new set with these measurements to the workspace.

◇ **Import measurements of selected set** → Imports measurements from a .jrk file [section A.2] and adds these measurements to the selected (existing) set.

The lower part of the window shows a map for the selected set, together with the available profile measurements. This screen works in a similar way to the analysis window of an individual measurement set [section 4.2.1]. It is therefore also linked to the **Time Navigator** [section 2.5.8], and after selecting one or more locations and years, you can open an analysis window from the **Data** tab in the ribbon.

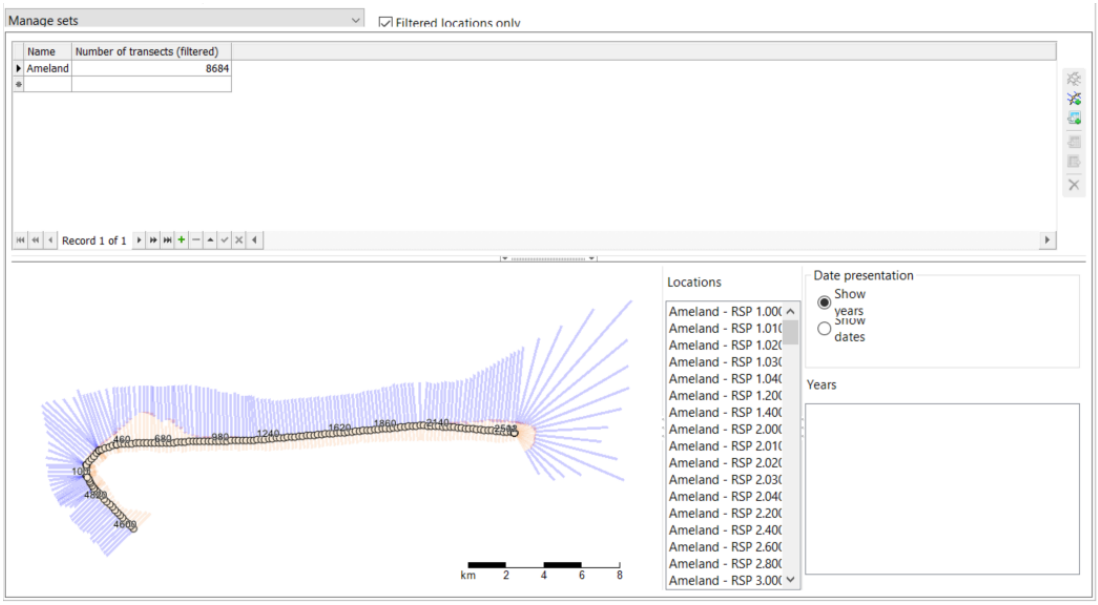


Figure 5.12: *Typical document window for the profile measurements folder when "Manage sets" mode is set*

5.4.3 Manage profile measurements in a set

With the document window set to this mode, you can add, remove or replace one or more measurements in a set. The window then appears as shown in Figure 5.13. The window is now split horizontally, with a table of transect measurements below, and a preview of the selected measurement above. Above the preview you can select a cross-shore profile measurement set from a drop-down list. The measurements from the selected set are listed in the table below. Depending on the selection in the table, buttons to the right of this table offer the following actions:

◇ **Duplicate** → Adds a copy of the selected set of measurements.

◇ **Add** → Adds measurements to the set as defined in the *.jrk file [section A.2]. This action starts a wizard.

◇ **Import** → Imports additional profile measurements from a *.jrk file.

◇ **Export** → Exports the profile measurements as a *.jrk file.

◇ **Remove** → Removes the selected set of profile measurements.

A set of cross-shore profile measurements might contain one or more duplicates. This means that two or more measurements are defined in the same location and for the same year. When

MorphAn runs a model, it is assumed that there is only one profile measurement per year at the same location. Duplicate measurements can cause unexpected results. This window enables you to remove duplicates. You first need to filter the measurements table to show only duplicate measurements. To do this, click the filter icon that appears when the mouse hovers over the heading of the “Duplicate” column. You now have the option to show only the rows in which this column is “Checked”. If this option is not available, then there are no duplicate measurements in the set. Next, sort the duplicate measurements by location (click on the heading above the “Location” column) or year. This simplifies the process of selecting the measurements that need to be removed. Lastly, click **Remove selected measurement(s)** to discard the unwanted duplicates.

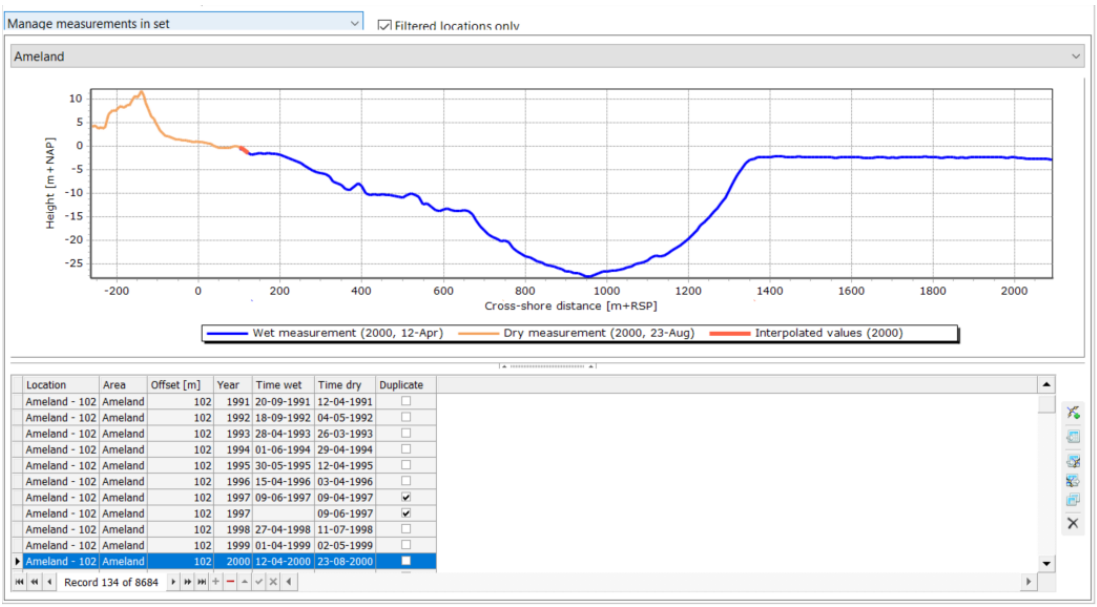


Figure 5.13: *Managing measurements in a set*

5.4.4 Exchange measurements between sets

The third mode of this document window enables you to copy measurements from one set to another. When this mode is chosen, the window appears as shown in Figure 5.14. The window contains two tables of measurements (two sets), each headed by a drop-down menu for selection of the displayed set. You can copy selected measurements from one set to the other (use the single arrow to copy left to right, or right to left); or you can copy *all* measurements from one set to the other (use double arrows).

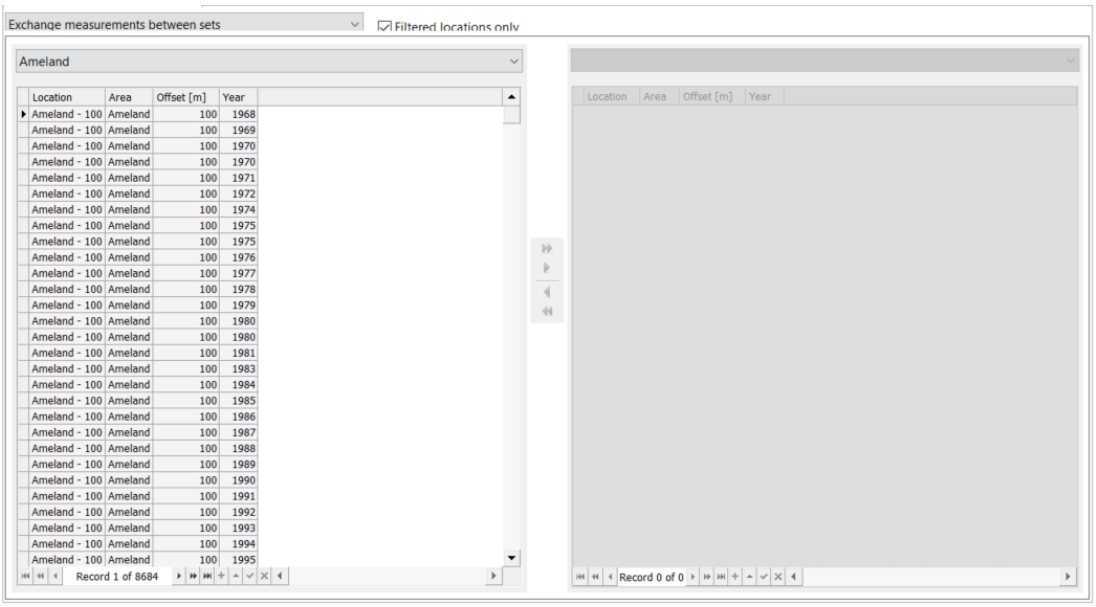


Figure 5.14: *Exchanging measurements between sets*

5.5 Edit profile measurements

5.5.1 Options for editing profile measurements

When you have an analysis window open for a profile measurement set [Figure 4.1, section 4.2.1], you can open an additional window in which you can edit the coordinates of individual measurements in the set. To open this “Transect editor” window, click the *Editor* button in the **Data** tab of the ribbon. Figure 5.15 shows an example of this window. The transect editor enables you to edit the data in several different ways. The editor can also be started when the “Profile measurements” document window is opened in “Manage sets” mode [section 5.4.2] and you have already made a selection of locations and years.

Figure 5.15 shows a drop-down list in the top left corner, from which you can select one of the actions described below. Each action represents a specific editing method. Two tables are displayed on the left below the drop-down list. The upper table shows the locations you can choose for editing. The lower table shows the years that you can edit at the selected locations. To the right of these two tables, the upper part of the window contains an entry form (for most editing actions), while the lower part shows a list of selected measurements and a preview of the editing action. If you have made a selection of locations and years, this list will automatically be filled with the corresponding measurements that you can edit. When you click on one of these measurements, the preview shows the result of the editing action for this measurement. When you are satisfied with the new settings, click on the **Apply** button at the lower right of the window. The editing action will then be applied to all selected measurements. The drop-down list at the top left of the window offers the following methods for editing the coordinates in a measurement:

- **Add / remove shape** - Add (nourish) or remove (erode) different shapes to/from the measurement [section 5.5.2].
- **Add / remove layer** - Raise or lower the entire profile by a uniform “sediment layer” (e.g. to adjust for sea level changes, account for dynamic dune management, etc.) [section 5.5.3].
- **Remove above level** - Completely remove one or more dune rows above a specified reference level [section 5.5.4].
- **Extend** - Augment measurement data with data from past years at the same location [section 5.5.5].

- ◇ **Change individual points** - Edit coordinates of individual measurement points on the profile [section 5.5.6].
- ◇ **Revert edit action** - Undo one or more edits [section 5.5.7].

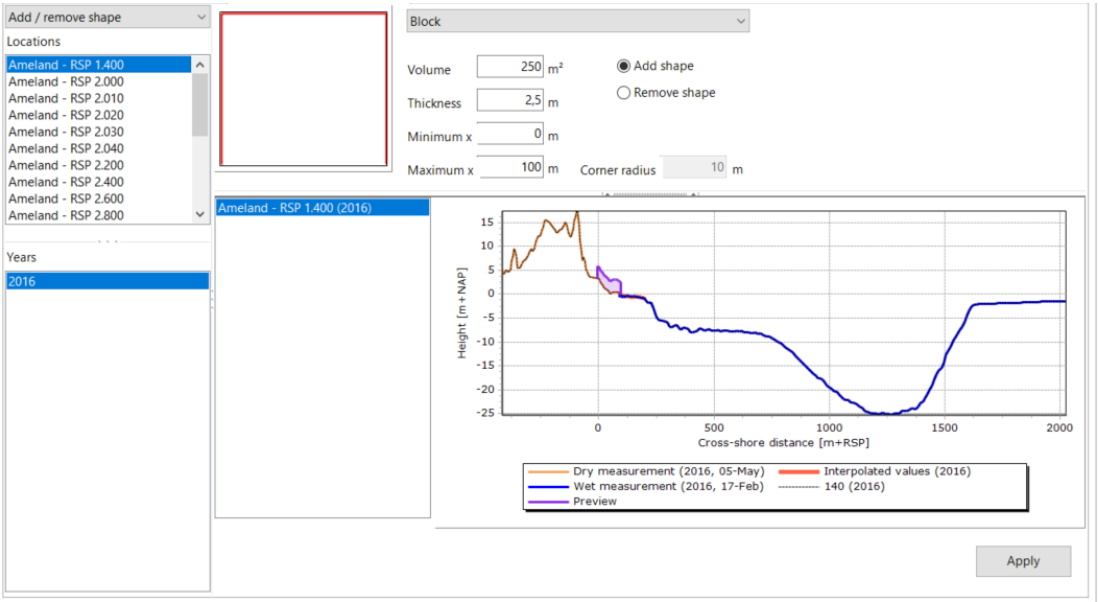


Figure 5.15: *Typical transect editor window.*

5.5.2 Add / remove shape

If you wish to add/remove a volume of sand to/from the profile, use the “Add/remove shape” editing action. Figure 5.16 shows an example of the editing window when this editing action is selected. Use the editor to enter the settings to be used (top of the screen) and the locations and years that you wish to adjust (tables on the left). A preview of the effect of the adjustment is shown in the middle of the screen for each selected measurement. The settings you choose determine the shape, volume and extents of the adjustment. The settings you can enter are:

- ◇ **Shape** - Choose this from the drop-down list at the top of the window. There are three options:
  - □ **Block** - This is the simplest shape, which adds or removes an approximately rectangular block of sand.
  - □ **Sine** - This option specifies a semi-sinusoidal profile for the volume to be added or removed.
  - □ **Long** - This is a combination of the above two shapes. The central zone corresponds to a rectangular shape between the rising and falling sides of a semi-sinusoidal profile (of the same height).
- ◇ **Volume** - This specifies the size of the sand adjustment. The units are m^3/m
- ◇ **Thickness** - You can also specify the thickness of the volume to be added or removed. If you change the type of shape, the volume will remain the same and the thickness of the shape will then be adjusted.
- ◇ **Minimum x** - This is the cross-shore distance to the start of the shape. xMin must always be a numerically lower value than xMax. Moreover, the difference between these two must also be greater than 2x the “Corner radius”.
- ◇ **Maximum x** - This is the cross-shore distance to the end of the shape. xMax must always be a numerically higher value than xMin. Likewise, the difference between these two must be greater than 2x the “Corner radius”.

- ◇ **Add shape** - The specified shape is added to the height values in the transect.
- ◇ **Remove shape** - The specified shape is subtracted from the height values in the transect.
- ◇ **Corner radius** - When you select the “Long” shape, you can also specify here the radius (in meters) of the rounded corners of this shape.

If you have selected locations and years in the left side of the window, then you can see the effect of the adjustment on each measurement by clicking on individual transects in the list beside the preview. The selected measurement is then visualized in the preview. When you click **Apply**, the adjustment will be automatically applied to all selected measurements.

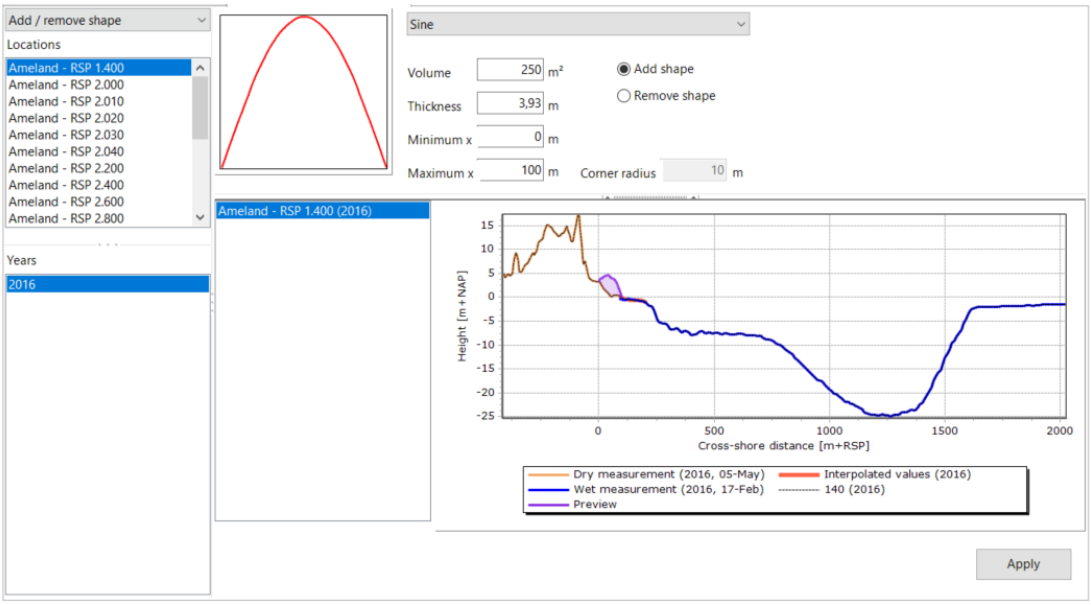


Figure 5.16: *Typical transect editor window with the “Add/remove shape” action selected.*

5.5.3 Add /remove sediment layer

The “Add/remove layer” editing action allows you to raise or lower the profile above or below a predefined level with a specific thickness of sediment. Figure 5.17 shows an example of the editing window when this editing action is selected. You can edit several settings in the upper part of this screen:

- ◇ **Add sediment layer** - Raise the profile with the specified thickness.
- ◇ **Remove sediment layer** - Lower the profile with the specified thickness.
- ◇ **Thickness** - Thickness of sediment layer to be added or removed (i.e. how much is the profile to be raised/lowered).
- ◇ **Reference Level** - Height of reference for the add/remove action. This can be specified in two ways:
  - □ **Above** - Adjust the profile only above the specified reference level.
  - □ **Below** - Adjust the profile only below the specified reference level.
  - □ **Relative to NAP** - Reference level is absolute height relative to NAP.
  - □ **Relative to Rp** - Reference level is specified relative to the Rp parameter (maximum storm surge level) stated in one of the available boundary condition sets. When this option is selected, the drop-down list to the right is activated. You can then select the required boundary condition set. When calculating the adjustment, the value entered in the “Reference Level” field is added to the Rp value for this location in the specified boundary conditions file.

If you have selected locations and years in the left side of the window, then you can see the effect of the adjustment on each measurement by clicking on individual measurements in the list beside the preview. The selected measurement is then visualized in the preview. When you click **Apply**, the adjustment will be automatically applied to all selected measurements.

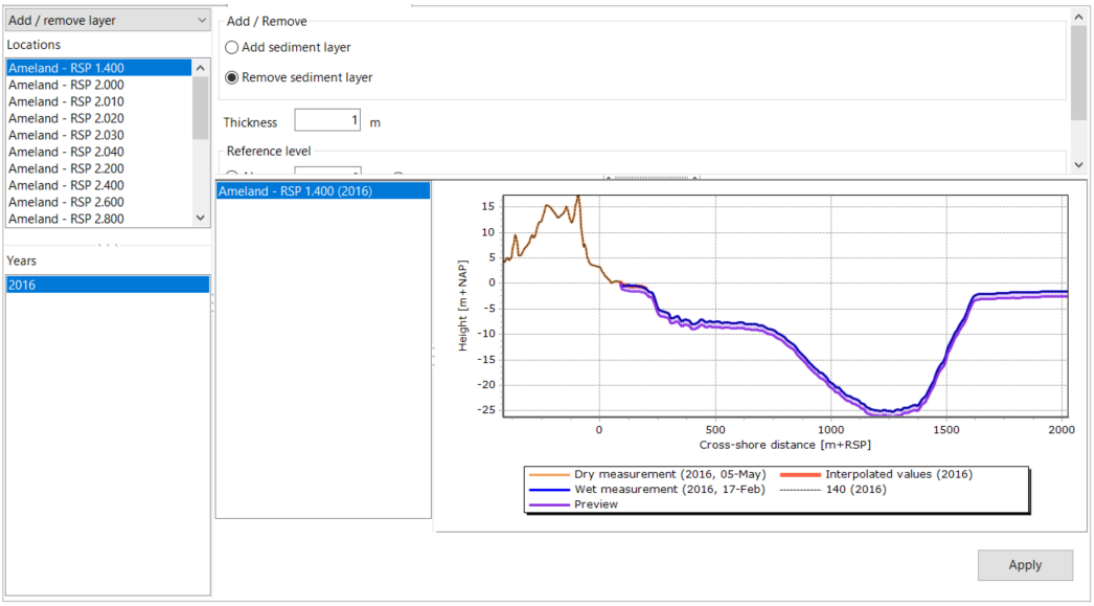


Figure 5.17: *Typical transect editor window with the "Add/remove layer" action selected.*

5.5.4 Remove above level

Use the "Remove above level" editing action when you need to remove one or more dune rows from the measured profile. Figure 5.18 shows an example of the editing window when this editing action is selected. In the upper section of the screen you can enter various settings for this action:

- **Maximum number of dune rows** - This sets the number of dune rows to be removed.
- **Maximum landward distance** - Here you can specify the maximum distance landwards for removal of dunes. Any time a setting is changed, MorphAn recalculates the effect at the given reference level (height). First, MorphAn determines the most seaward point where the dune face intersects the reference level. This will be the starting point for dune removal. Working landwards from this point, MorphAn then determines which "maximum" is met first: dune rows, or landward distance. The distance at which this happens is the effective distance over which sand is removed from the dune(s).
- **Reference Level** - Height of reference for the "Remove above level" action. This level can be specified in two ways:
  - **Relative to NAP** - Reference level is absolute height relative to NAP.
  - **Relative to Rp** - Reference level is specified relative to the Rp parameter (maximum storm surge level) stated in one of the available boundary condition sets. When this option is selected, the drop-down list to the right is activated. You can then select the required boundary condition set. When calculating the adjustment, the value entered in the "Reference Level" box is added to the Rp value for this location in the specified boundary conditions file.
- **Slope of dune face** - If the maximum landward distance is to be applied, a dune face is made from the reference level to surface level. The value entered here specifies the slope of this dune face.

If you have selected locations and years in the left side of the window, then you can see the effect of the adjustment on each measurement by clicking on individual measurements in the list beside the preview. The selected measurement is then visualized in the preview. When you click **Apply**, the adjustment will be automatically applied to all selected measurements.

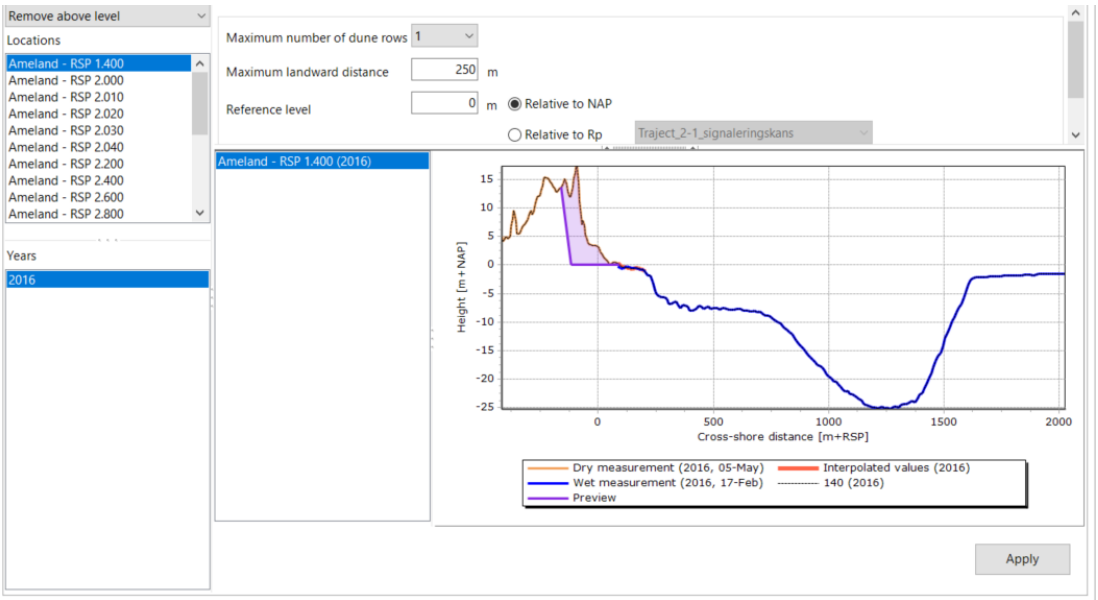


Figure 5.18: *Typical transect editor window with the "Remove above level" action selected.*

5.5.5 Extend profile data

Use this transect editing action to augment a transect with additional landward or seaward measurements, by interpolation from other data. After selecting the required locations and years, the settings you enter in the **Extend** editing action specify the extent (in m from the local transect origin) within which measurements should be added. A value lower than that of the most landward measurement point will extend the transect landward. A value higher than the most seaward measurement point will extend the transect seaward. You have two options for adding data:

- **From map** - This makes use of the existing data on the map shown in the upper part of the window. You can use the "Map" tool window to add extra layers of grid data (e.g. .asc or .bil files) to the map [section 2.6.3]. For a better view of the map, click on the icon in the top left of the map, and the map will occupy a greater area in the window. The map can be reduced in size the same way. Two parameters allow you to control the interpolation from map data:
  - **Dx** - This field indicates the distance interval in meters between interpolated points. For example, a Dx value of 10 means an interpolated value will be added to the existing transect every 10 meters until the entered extent is reached.
  - **Height factor** - A multiplier for the values derived from the map. This makes it easier to process and convert map height data recorded in e.g. centimeters to profile data in meters.
- **From other measurements** - The alternative method for adding data is to interpolate from profile measurements previously performed at this location. In the **Go back** field you can specify how many of the immediately preceding years to use for interpolation. Note that this interpolation method considers *all* measurements in the cross-shore profile measurement set, and not just the measurements selected for editing. However, the interpolation

source transects are not modified. They are used only to extend the selected profiles. You can also enter how many years ahead (**Go forward**) to interpolate.

As with the other editing actions, you can click on the list of measurements to view the effect of the edits at different locations. The edits will be applied and saved only when you click the **Apply** button at the lower right of the window.

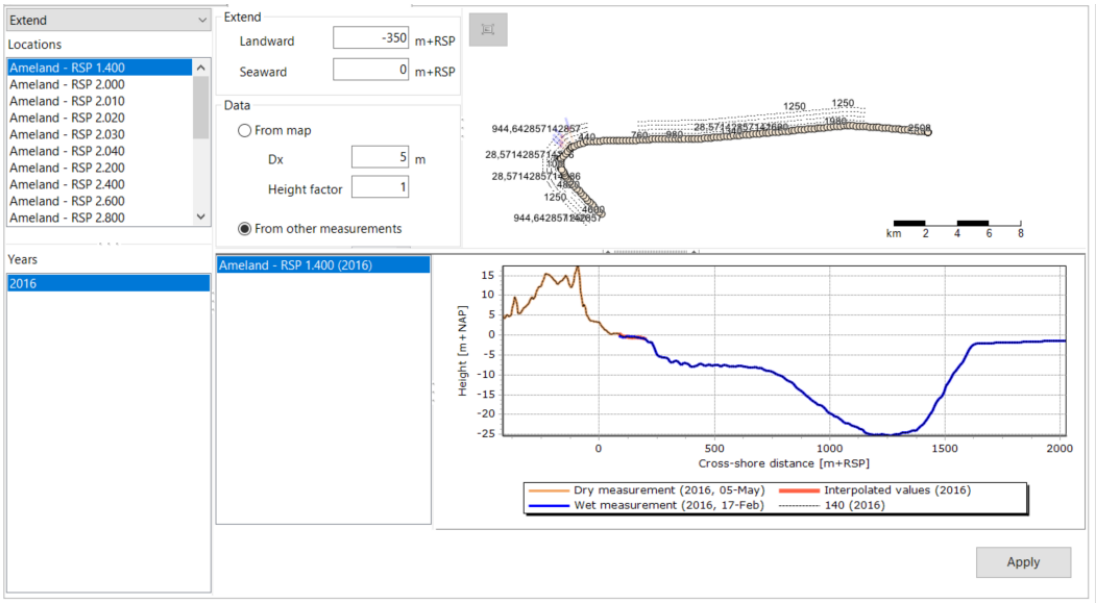


Figure 5.19: *Typical transect editor window with the "Extend" action selected.*

5.5.6 Change individual points

The "Change individual points" transect editing action differs somewhat from the other actions. When you choose this option, the window displays only a table of measurement points and a preview. Although you still see the two tables with locations and years [left in the window, see also Figure 5.20], you cannot select multiple locations and/or years. Obviously, only one measurement can be edited at a time. If one location and one year are selected, the measured profile will be displayed. You can then directly edit the Z values in the table of measurements, and the modifications will be previewed on the right. To save the edits, click the **Apply** button in the lower right of the window.

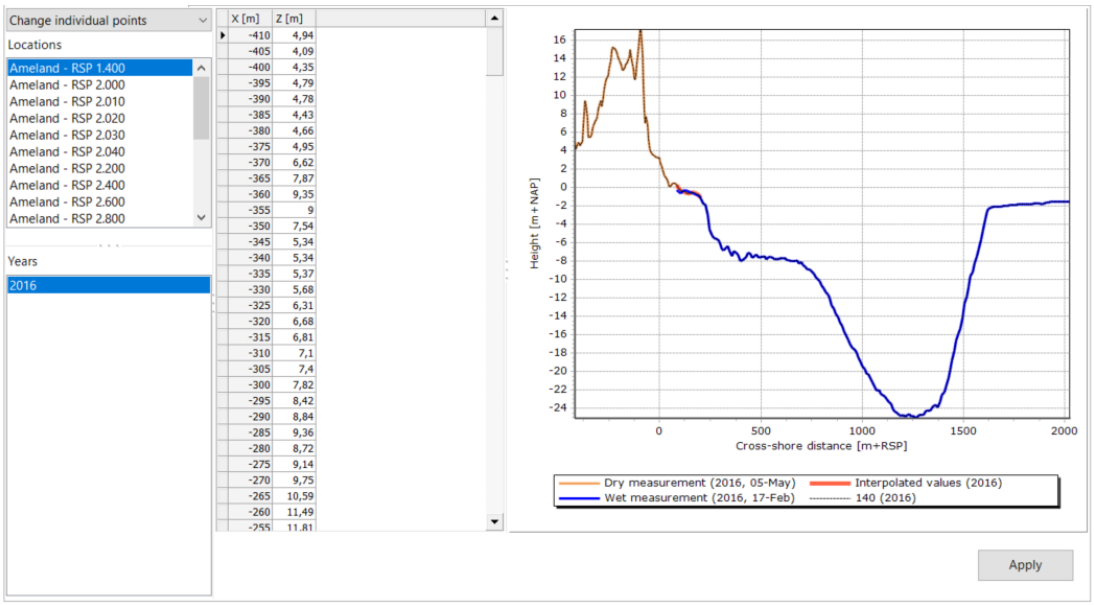


Figure 5.20: *Typical transect editor window with the "Change individual points" action selected.*

5.5.7 Revert edit action

The "Revert edit action" allows you to undo edits you have previously applied. Figure 5.21 shows an example of a location where 3 edits have been applied. In the settings panel at the top, you can select how many edits to revert using the counter, or select individual edits to revert. You can only revert edits in chronological order. When you click the **Apply** button, the selected edits will be reverted for the selected locations and years.

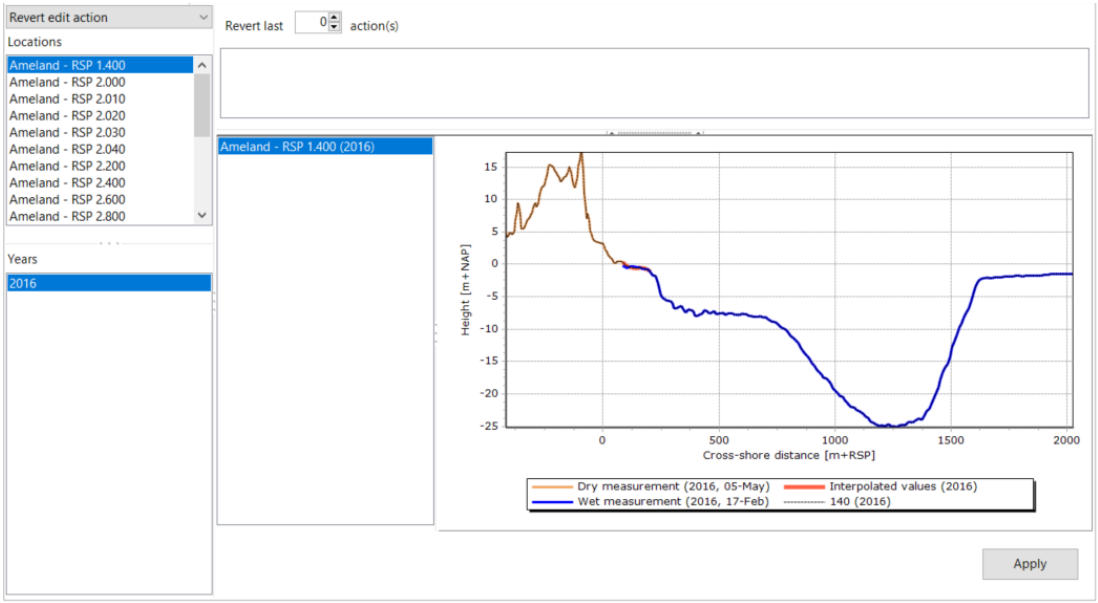


Figure 5.21: *Typical transect editor window with the "Revert edit action" selected.*

5.6 Automatically create profile measurements from one grid measurement set

Profiles with measurements can be generated from grid measurements. In the **Project Explorer**, right-click on a **Grid measurement** set, and select **Create profiles from grid...** from the context menu. This starts a wizard which will prompt you to select transect definition files. After selecting the files, click **Next** to go to the **Location details** screen where you can enter settings for the generation of profiles [Figure 5.22]. The following details can be entered:

- **Coastal area** - Name of the coastal area
- **Name of new profile measurements set** - Name you wish to use for the new set of profile measurements
- **Remove other locations from filter** - If checked, then the current locations will be removed from the filter
- **Multiplication factor** - Factor to convert input heights to meters. For example, if the input Z values are in centimeters then you should enter 0.01 to convert these values to meters
- **Dx** - The desired transverse grid point interval in meters.

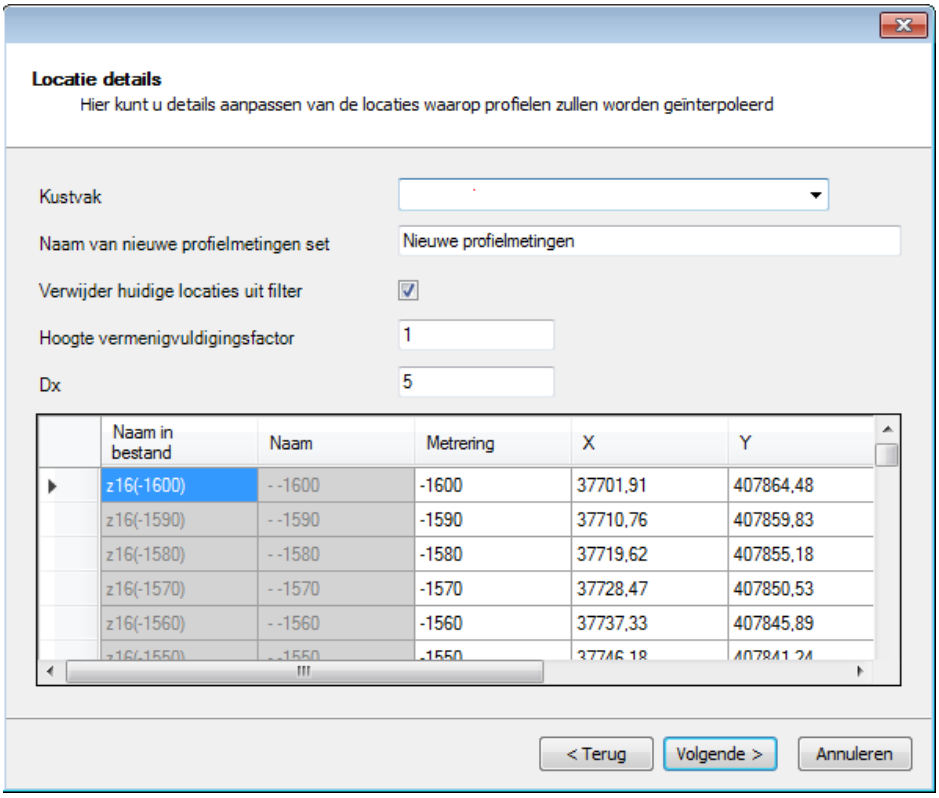


***Figure 5.22: Location details** page of the **Create profiles** wizard*

Once you have set the location details, click “Next” and MorphAn will start to generate profile measurements. Progress is displayed in a list [Figure 5.23]. In this progress list, a green tick indicates successful interpolation of a profile measurement at a particular location, while a red cross indicates that the interpolation was unsuccessful. When the process has ended, click **Next** followed by **Finish** to close the wizard. Successfully created profiles can now be found in the **Profile measurements** folder of the **Project Explorer**.

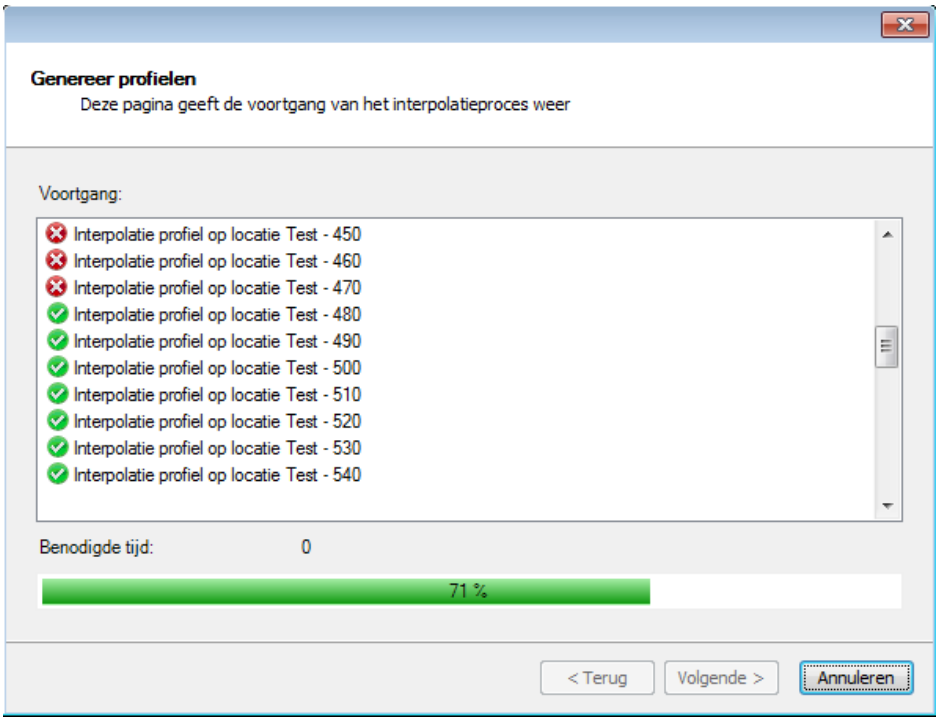


***Figure 5.23: Create profiles** interpolation progress page of the **Create profiles** wizard*

5.7 Generate intermediate transects

5.7.1 Options for generating intermediate transects

When determining coastal safety, it is sometimes desirable to define additional locations and profile measurements between two existing coastal locations. This enables you to make a more detailed assessment of the safety in the vicinity of a potentially weaker point in the dune massif. MorphAn supports the generation of these transects from grid measurements. This section describes the possibilities offered by MorphAn for generating profile measurements at existing locations or newly defined intermediate locations.

To create intermediate transects, first open the document window for the “Grid measurements” subfolder in the “Data” folder of a MorphAn workspace: either double-click on this folder, or right-click on the folder and select “Open”. The document window will open with a map showing all grid measurements. In addition, an extra “Profile” group appears in the “Data” tab of the ribbon, as shown in Figure 5.24. When you click the button **Profile Generation**, the grid measurements document window is augmented with additional capabilities for generating transects based on the imported grid measurements [Figure 5.25]. At the same time, the buttons in the “Add Coastal Locations” group in the “Data” tab are also activated, enabling you to add single or multiple extra locations when generating transects.

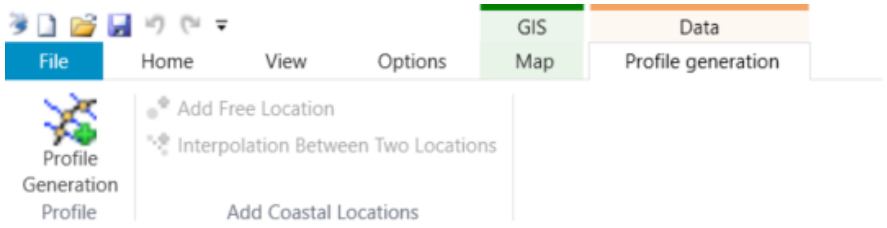


***Figure 5.24:** Data tab in the ribbon when document window is open for all grid measurements.*

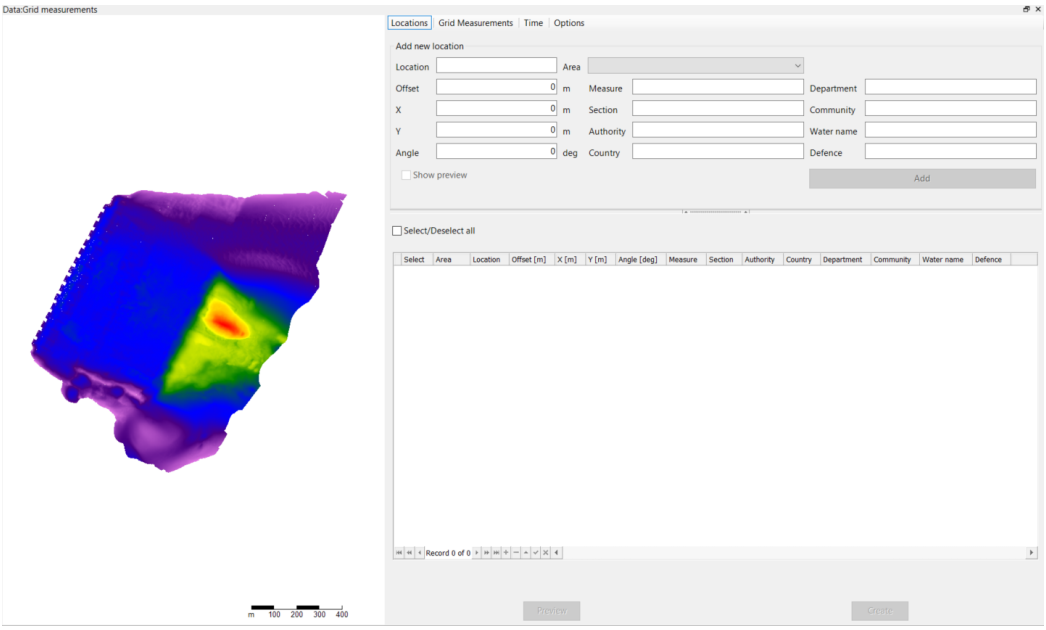


Figure 5.25: *Typical MorphAn application window when profile generation is active*

You can enter settings for profile generation in the upper right panel of the document window. The tabs in this panel allow you to enter settings related to selected locations, selected grid measurements, the times for generated profile measurements, plus output options. The following sections discuss these settings in more detail.

After locations and grid measurements are selected, the **Create** button at the lower right of the document window will be activated, and you can generate transects. MorphAn shows the transect generation progress in a separate dialog. When profile generation has finished, the locations of newly-created profile measurements are automatically added to the workspace and the location filter [section 3.3]. Although you cannot edit the added locations in *this* screen, you can still do so as described in section 5.2. Until the new locations are added to the workspace, they can still be edited in this panel.

5.7.2 Add and select locations

When you open the **Locations** tab at the top of the settings panel, you will see the settings shown in Figure 5.26. The table shows all locations in the MorphAn workspace (or only the filtered locations, if this is indicated at the bottom of the panel). There are three ways you can define locations for transect generation:

- ◇ **Manually enter new locations.** The “Add new location” form at the top of the panel enables you to enter a new location manually. The items you must enter are the location, offset, X, Y, and transect angle. If the *Show preview* box is checked, then the specified location will appear on the map. If you are satisfied with the new location, click *Add* and the location will then be added to the table.
- ◇ **Indicate locations on the map.** In the “Add Coastal Location” group of the *Profile generation* Data tab, you will see a button to *Add Free Location*. After you click this button, you can indicate a location directly on the map by positioning the cursor, and confirming with left-click. You can then edit the data before the new location is added to the table. Use the “Esc” key to cancel this action if necessary. This action is otherwise identical to adding a free location as described in section 5.2.
- ◇ **Automatically insert locations between two existing locations.** In the “Add Coastal

Locations" group of the *Profile generation* Data tab, you will see a button for *Interpolation Between Two Locations*. After you click this button, you can indicate two locations directly on the map. You can then edit the start and end location and other settings before the new locations are added to the table. After you click "OK", the locations are added. Use the "Esc" key to cancel this action if necessary. This action is otherwise identical to Interpolation between two locations as described in section 5.2.

Until you actually create (generate) the new transects from the data in the table, you can still always edit the data describing the new locations. After transect generation, the locations are included in the workspace, and they can no longer be edited using this table. The first column of the table contains a check box for location selection. Transects can only be generated when one or more locations have been selected (provided also that times and grid measurements have been selected). MorphAn will then attempt to generate transects for the specified locations.

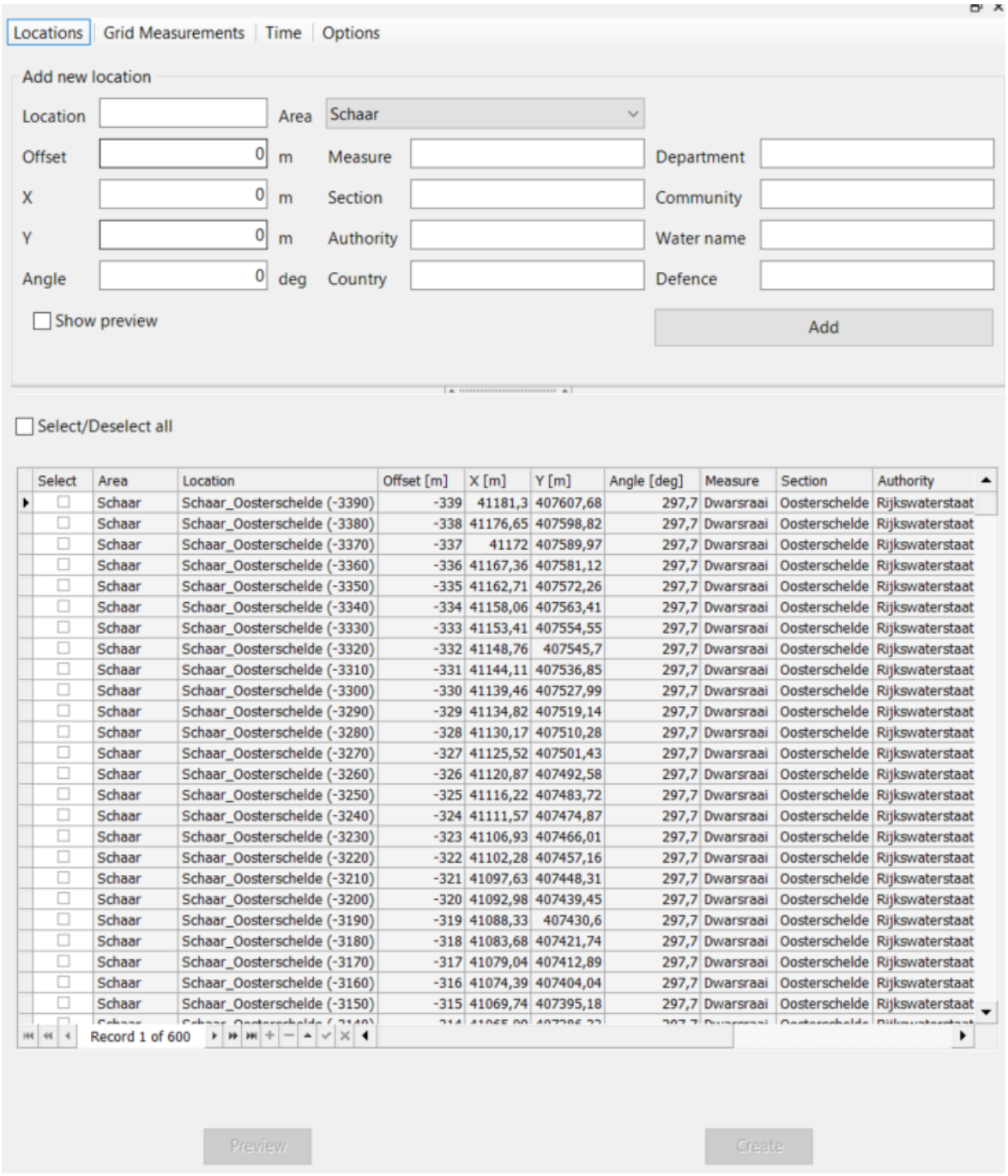


Figure 5.26: *Location selection table for intermediate transect generation*

5.7.3 Select grid measurements

To select grid measurements for transect generation, click on the **Grid Measurements** tab at the top of the settings panel, and you will see a table as in Figure 5.27. This table shows all grid measurements from the MorphAn workspace corresponding to the document window. The following items can be specified per grid measurement:

- ◇ **Select** - Check this box to include this grid measurement set in transect generation.
- ◇ **Landward boundary [m]** - The landward boundary indicates the minimum cross-shore distance (from the generated local profile origin) for transect generation from this set of grid measurements. This enables you to control the influence on transect generation from grid measurement sets with differing levels of uncertainty.
- ◇ **Seaward boundary [m]** - The seaward boundary indicates the maximum cross-shore distance (from the generated local profile origin) for transect generation from this set of grid measurements. This enables you to control the influence on transect generation from grid measurement sets with differing levels of uncertainty.
- ◇ **Height factor** - A multiplier for the values derived from the grid measurement set to convert to the height units of the generated transects.
- ◇ **Type of measurement** - Indicates whether the transects generated from this grid measurement set should be of type Dry, Wet or Interpolated. All transects generated from the various grids together form the final set of transects (profile measurements) that will be added to the workspace. When assembling the generated transect geometry, MorphAn always first examines the interpolated data, then augments the geometry with wet or dry measurements. This column enables you to specify the type of measurement to generate based on the selected grid measurement.

A separate transect is generated for each grid measurement. Each generated transect is designated with the *Type of measurement* selected here. All “sub-transects” generated from the various grids together form the complete generated transect that gets added to the workspace. When assembling the generated transect geometry, MorphAn always first examines the Interpolated data, Dry and wet measurements are then added, prioritized by the order of the grid measurement sets in the table. If necessary, use the buttons below the table to change the order.

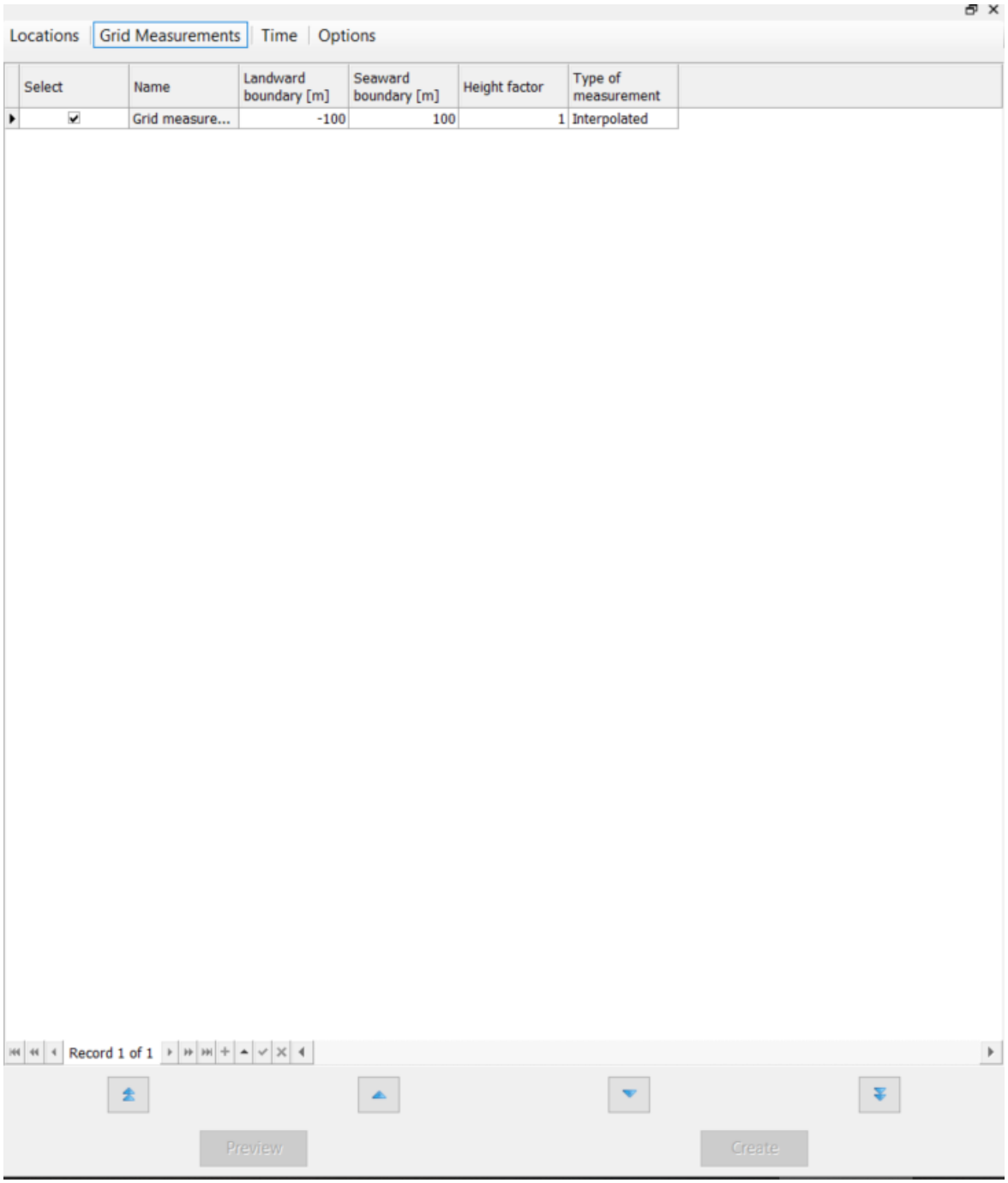


Figure 5.27: *Grid measurement selection panel for generation of intermediate transects*

5.7.4 Select times

MorphAn attempts to generate transects based on the selected locations and grid measurements. If the grid measurements are time-dependent (multiple grid measurements over time), you can assemble multiple transects for different times for a specific location and combination of grid measurements. To generate transects for specific times, click on the **Time** tab at the top of the settings panel as shown in Figure 5.28. This settings tab enables you to specify the times (i.e. dates) for transect generation. For each time-based grid measurement, MorphAn will then select the time closest to the time specified here. If the time stamp of a grid measurement is further from the specified time than the *Grid time margin* (entered in the lower part of the window), then that grid measurement will be ignored during transect generation for the specified time. To add times for generated profiles, select the time in the drop-down calendar, and click **Add Time**. To delete times from the list, select a time in the table and press the "Delete" key.

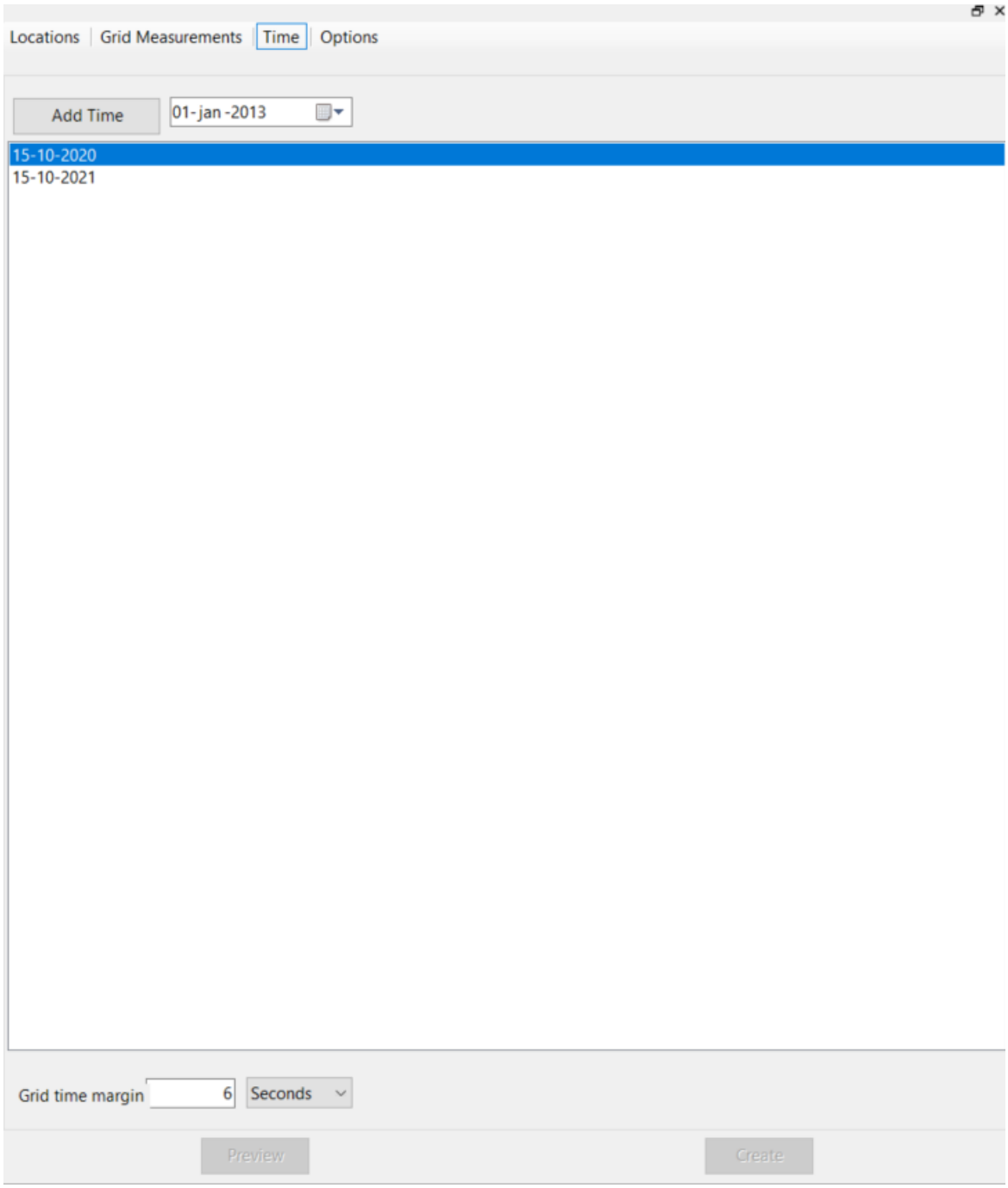


Figure 5.28: *Time selection tab for intermediate transect generation*

5.7.5 Options

Finally, there are a few other options you can specify for transect generation. Click on the **Options** tab at the top of the settings panel to open the screen as shown in Figure 5.29. You can now set the following options:

- ◇ **Name of new created set of transects**. Here you can choose an existing set of profile measurements to which the generated transects should be added. If you instead specify a new name, then a new set of profile measurements will be created.
- ◇ **Remove current locations from filter**. If you check this option, MorphAn will remove all current locations from the filter after generating the new intermediate transects. Locations of all generated transects are always added to the filter, and are therefore immediately visible in other parts of the workspace.
- ◇ **Save new locations to file (*.grd)**. You can choose to save all newly added locations (with generated transects) to a * .grd file. Check the box beside “Save new locations to file (*.grd)”, then select a windows folder and file name for the new locations.
- ◇ **Save created transects (*.jrk)**. Generated transects can also be automatically saved in a *.jrk file. Check the box beside “Save created transects (*.jrk)”, then select a windows folder and file name for the newly generated transects.
- ◇ **Discretization resolution (dx)**. Lastly, you can specify the resolution (coordinate interval) for the transects interpolated from grid measurements. The resolution is often matched to the resolution of the grid measurements. Note that a finer resolution will increase the time required for interpolation.
- ◇ **Interpolation type** The interpolation method. The user can select between the Nearest Neighbor and the Biliear method.

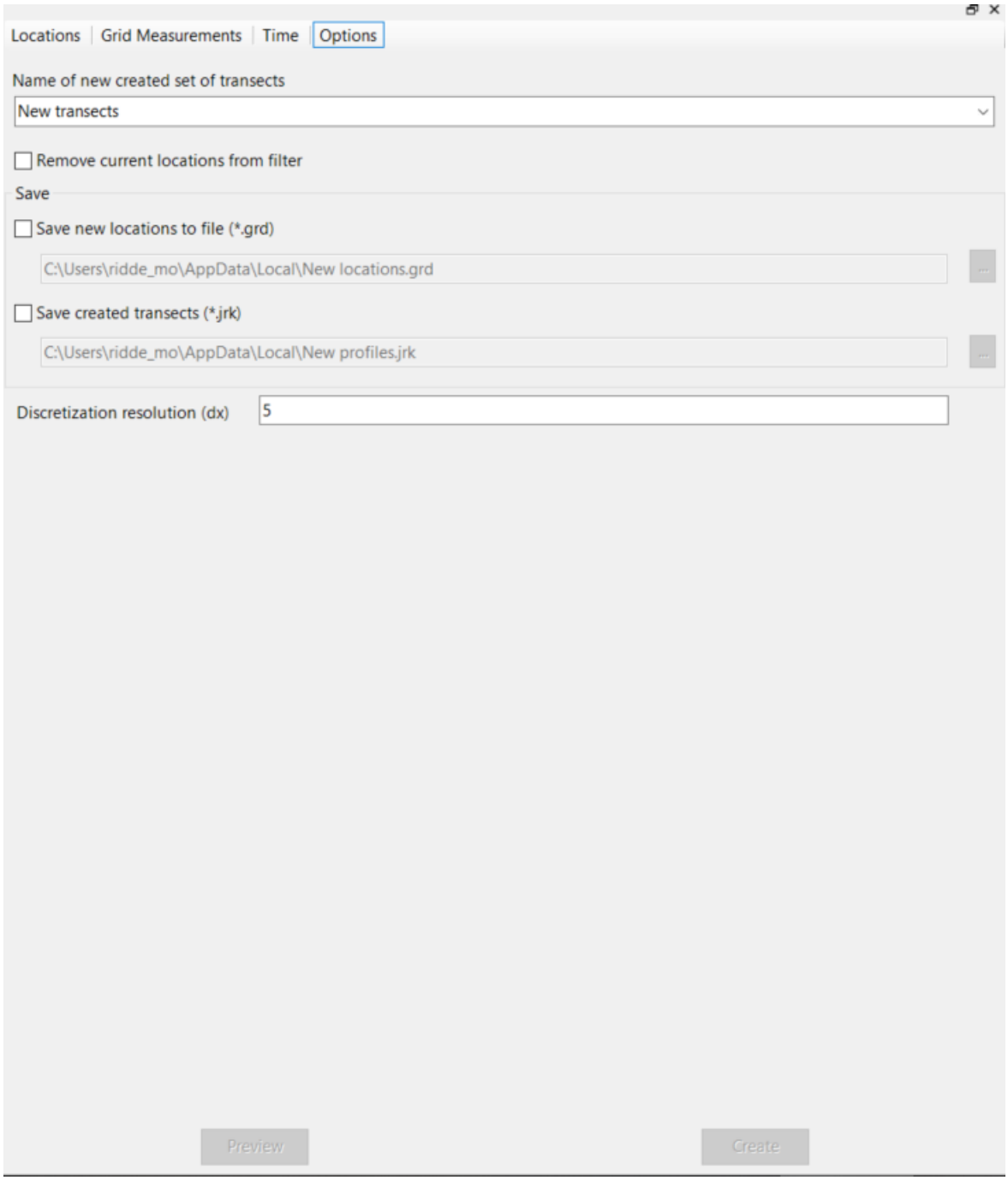


Figure 5.29: *General options for intermediate transect generation*

5.8 Export of profiles

You can export edited or existing profiles to jarkus files or xyz files. There are two ways to export the profiles:

- ◇ Right-click on one of the sets in the **Profile measurements** folder, and a context menu will appear [Figure 3.16]. Click **Export...** to open a file selection dialog for export to a jarkus or xyz file. You can choose which file type after you click **Export...**.
- ◇ If you wish to export only part of the profile measurement set, you can do so via the Export button in the data tab when that set is selected. First open the desired profile measurement set, then select the locations and years you wish to export [Figure 5.30]. You can then export that selection by clicking on the Export button in the data tab [Figure 5.31].

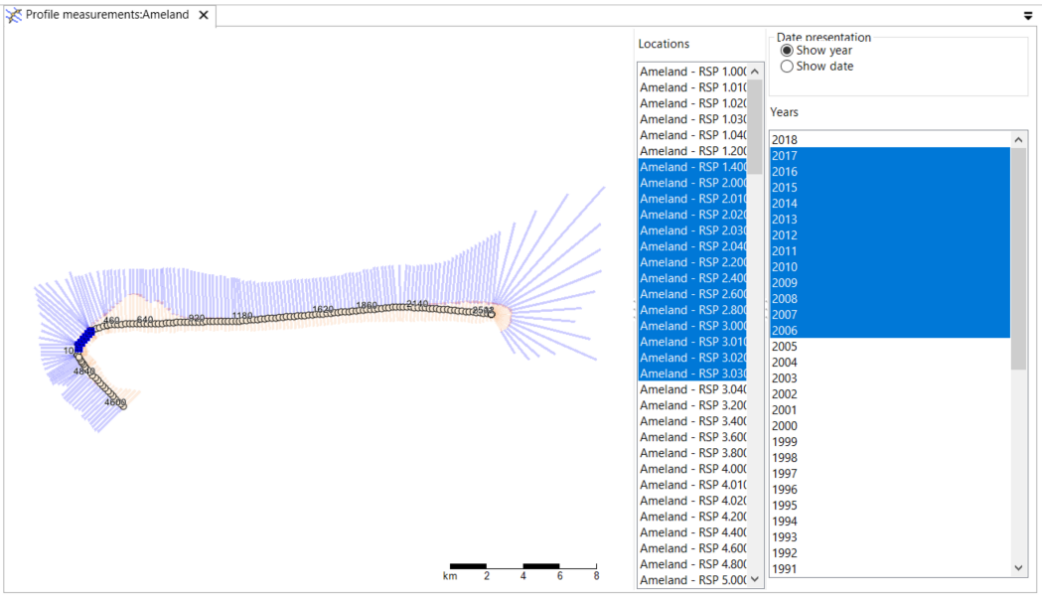


Figure 5.30: *Section of profile measurements for export.*

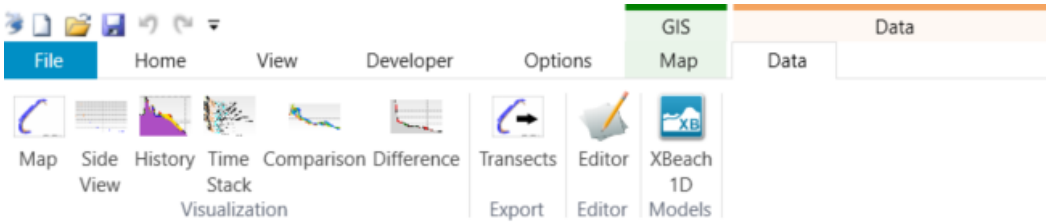


Figure 5.31: *Export button in the Data tab*

In the case of an xyz file, the points along the profile measurement are transformed into spatial x,y values (given a coordinate system). This means that the original profiles are no longer identified in the xyz file. Each line in the file is a new data point with the x,y values (column X and Y), the (sea) bed height (column Z) and the date (column T). This xyz file offers a convenient way to import jarkus data into a GIS program. when the user selects the combined location and profile file, then the export also includes the data about the locations.

6 The Dune Safety model

6.1 Introduction to Dune Safety model

The Dune Safety model is used to model the safety of the coast of the Netherlands for the purpose of Statutory Assessment, according to the principles in the 2006 Technical Report on Dune Erosion ("TRDA2006", (ENW, 2007)) or the 2011 Report on Dune Water Defenses ("RD2011", (Deltares, 2012)). The calculations required are performed using sub-models. These are described in the following sections:

1 Section 6.3 - First, the erosion calculation must be performed using the Duros+ (or D++) model. This is done by running the **Erosion model**.
2 Section 6.4 - Next, it is advisable to calculate the position of the boundary profile, based on the calculated erosion results or input parameters. The **Boundary profile model** provides for this.
3 Section 6.5 - Lastly, a diagram of the normative results must be made, showing the calculated erosion results over time compared to the landward boundary of the flood defenses. The **Normative model** supports this analysis and produces the necessary result charts.

The selection of transects and years, and the choice of the profile measurements and boundary conditions of the Dune Safety model are both carried out based on the items in the **Input** folder of the Dune Safety model. For more details, please refer to section 2.4.1. In this chapter we discuss the settings and screens that are specific to the Dune safety model. We will start by looking at how to set the model to calculate according to TRDA2006 [section 6.2], and the possibilities for deviating from that standard. We will then discuss the input and output per sub-model [section 6.3 through section 6.5].

6.2 Dune safety model settings

A range of settings can be modified when running the Dune Safety model. Some of these settings are prescribed in TRDA2006 (ENW, 2007). You can configure these settings automatically at any time by clicking on the TRDA2006 button in the **Options** tab of the Ribbon [Figure 6.1]. To edit the settings of the main model (or one of the sub-models), double-click on the model or sub-model. Figure 6.2 shows the settings window that appears when you double-click on a dune safety model. At the top left of this window are two "Calculation settings" buttons. Click on one of these to replace all calculation settings of the model with the standard settings for either TRDA2006 or RD2011. The other settings in this window are discussed in the following sections.

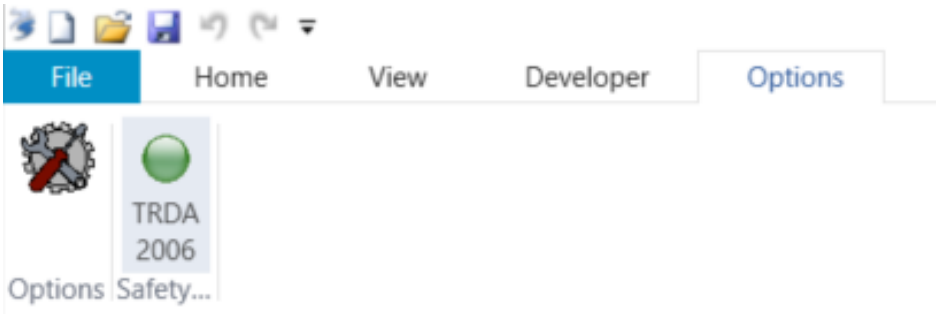


Figure 6.1: *Options tab of the ribbon when the TRDA2006 dune safety model settings button is active*

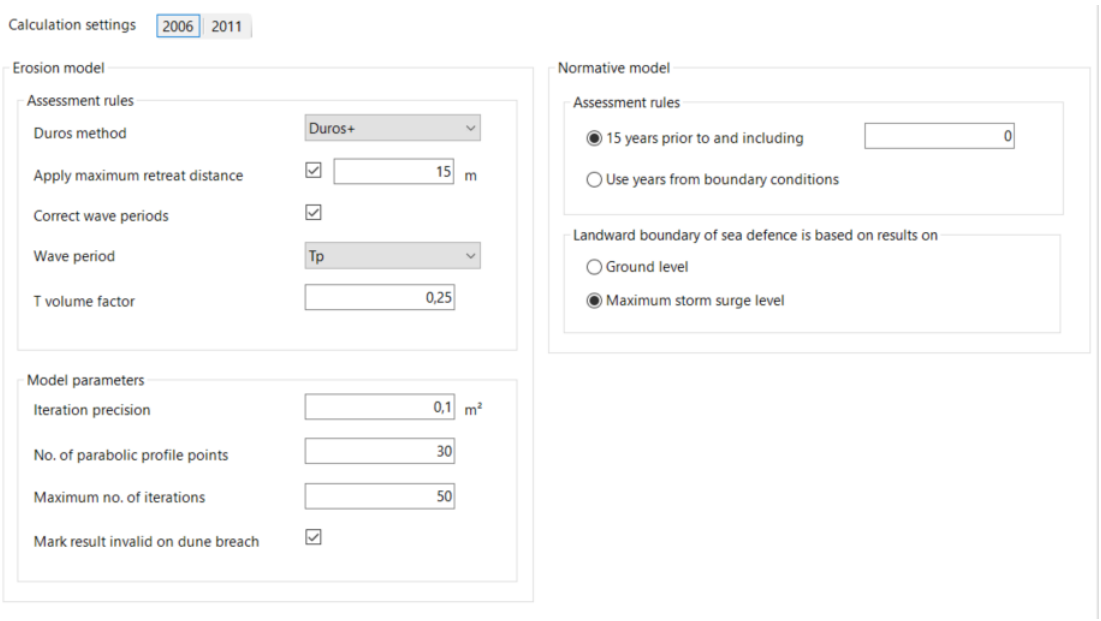


Figure 6.2: *Settings screen for configuration of a dune safety model (and its sub-models)*

6.3 Erosion model

6.3.1 Erosion model settings

To open the erosion model settings [Figure 6.3], double-click on the Erosion model (the same settings can also be edited in the Dune Safety model settings window). This screen enables you to adjust various settings for the dune erosion calculations. The erosion model settings are displayed as two groups:

- **Assessment rules** - Settings related to the rules in TRDA2006 (ENW, 2007)
- **Model parameters** - Settings of a more numerical nature. These settings influence the speed and precision of calculation, or how results are presented.

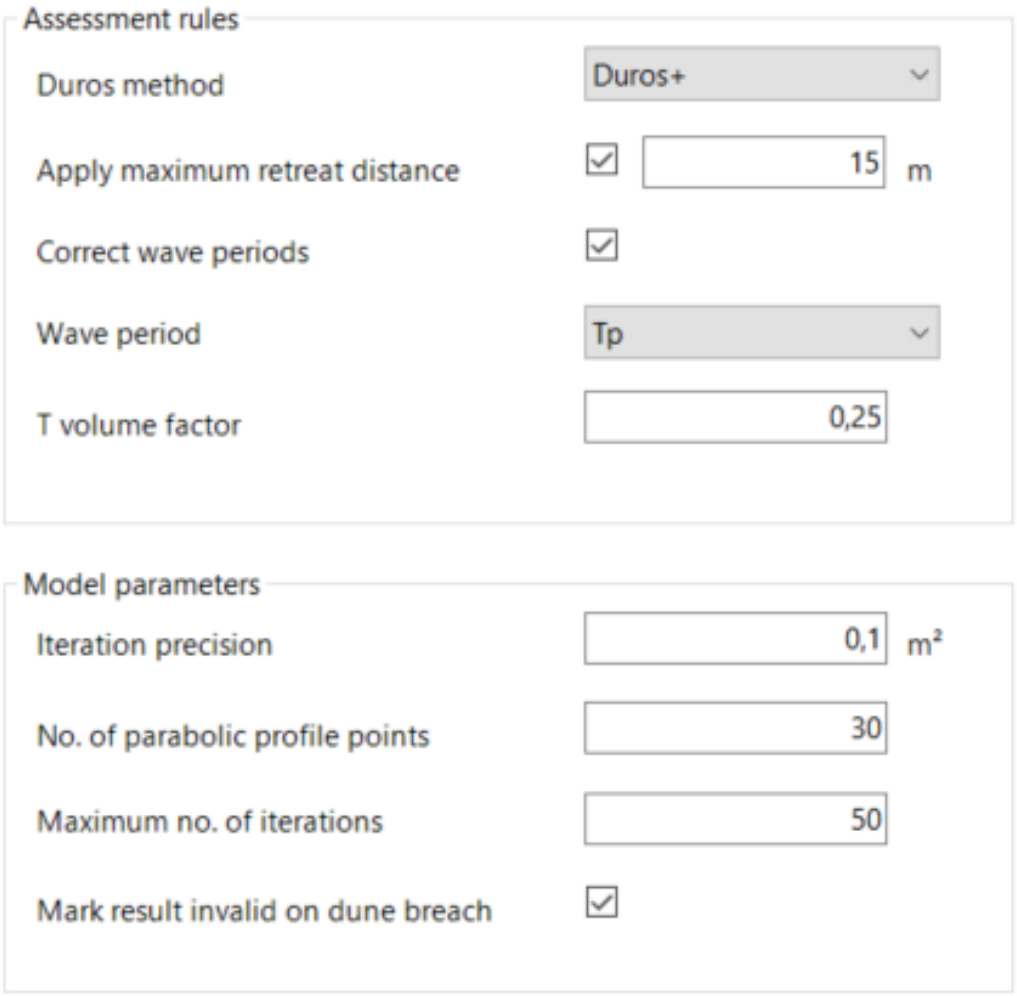


Figure 6.3: *Settings screen for configuration of an erosion model*

The Assessment rules are specified with the following settings:

- ◇ **Duros+ method** - Here you can choose from three calculation options: always use the Duros+ model (as specified in TRDA2006); always use D++; or use D++ for the Wadden Islands and Duros+ for the rest of the Dutch coast (as per RD2011).
- ◇ **Apply maximum retreat distance** - The TRDA2006 specifies that the additional retreat of the erosion line caused by the erosion volume may not exceed 15m. This option enables you to set this limit on or off. In the adjacent field you can optionally enter a retreat distance other than the standard 15 meters (this is not mentioned in any technical report). If this limit is the prevailing factor for the model results, then this will be indicated by an icon in the top right corner of the visualization screen for the model output.
- ◇ **Correct wave periods** - The technical reports specify that the wave period used in modeling must lie within predetermined limits. When you check this box, wave periods outside this margin will be automatically corrected: to 12 or 20 seconds (in the case of T_p); or to 10.8 or 18 seconds (if modeling using $T_{m-1.0}$).
- ◇ **Wave period** - Select a wave period for the model from the drop-down list: model all locations using the T_p from the boundary conditions (as specified in the TRDA2006) or the $T_{m-1.0}$; or (as specified in the RD2011) using $T_{m-1.0}$ for the Wadden Sea, and T_p for the rest of the Netherlands.
- ◇ **T volume factor** - a multiplier to calculate the erosion volume from the A volume. The

TRDA2006 (ENW, 2007) specifies this value as 0.25. If the chosen Duros method is D++, then this factor must be 0.18.

The “Model Parameters” group contains the following settings:

- ◇ **Iteration precision** - This is the maximum difference between accretion and erosion that is considered to represent sufficient equilibrium between erosion and accretion when the Duros model parabola is aligned with the initial profile. A low value will yield a very precise result, but this requires an extremely long run time. A high value will yield a fast, but less accurate result.
- ◇ **No. of parabolic profile points** - This is the number of profile points that the model uses to describe the parabolic profile.
- ◇ **Maximum no. of iterations** - The Duros modeling process iteratively seeks to achieve an equilibrium between erosion and accretion. If no optimum is achieved after the specified maximum number of iterations, the calculation is considered unsuccessful, and the model is halted. This is done to keep the model from endlessly looping in a effort to optimize the result.
- ◇ **Mark result invalid on dune breach** - This last setting specifies how the model indicates situations in which the regular or additional erosion volume exceeds the available volume in the first dune row: checked box means “Invalid” (no result, no visualization); unchecked box means “Questionable” (but there *is* both a result and visualization). The technical reports state that in the event of a dune breach, “further investigation is required”.

6.3.2 Erosion model input

The erosion Model calculates the erosion results based on the parameters in the selected boundary conditions file. The transect selection is determined by the selection entered at the level of the Dune Safety model [section 2.4.1]. The single item in the **Input** folder of this model contains the boundary conditions that apply to this model for the selected transects. To edit the boundary conditions, double-click on this item. Any modifications will also take effect in the Data folder of the workspace. If these boundary conditions are used in any other model, then they will also be automatically modified in *that* model.

The table displays the following boundary conditions:

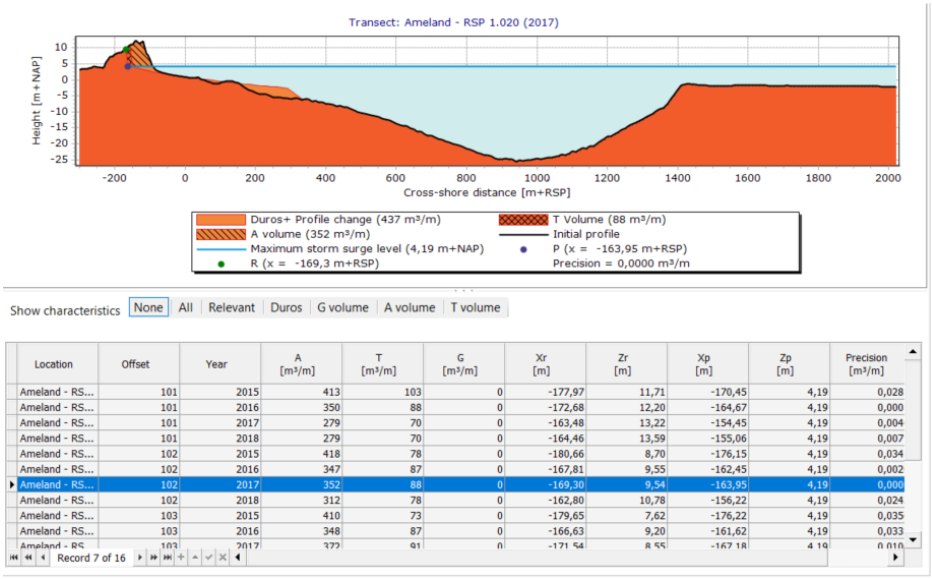
- ◇ **Hs [m]** - Significant wave height at the peak of the storm.
- ◇ **Tp [s]** - Peak wave period at the peak of the storm.
- ◇ **Tm-1.0 [s]** - Spectral wave period at the peak of the storm. In the TRDA2006 (ENW, 2007) this value is recommended at those points where no single-peaked JONSWAP spectrum is found. The model’s **Wave period** setting indicates whether to use this value or the Tp for modeling.
- ◇ **Rp [m NAP]** - Maximum storm surge level (for modeling).
- ◇ **D50 [μm]** - Median grain size at this location.
- ◇ **G0 [m^3/m]** - Basic sand volume for taking coast curvature into account during modeling [(ENW, 2007)]
- ◇ **Depth [m]** - Depth at the point where the wave boundary conditions are derived (only used when the selected “Duros method” setting is D++)
- ◇ **Dune row [m+RSP]** - Dune valleys (profile points below storm surge level) seaward of this position are disregarded when the model determines whether there is a dune breach. For example, you can use this input variable to prevent the model from detecting a dune breach in a small foredune just in front of the target dune row.

6.3.3 Erosion model output

After running the Erosion model, there will be two new items in the model's **Output** folder in the **Project Explorer** tool window:

- ◇ Erosion results
- ◇ Run report

When you double-click on the item **Erosion results**, a window similar to Figure 6.4 will appear. This window contains a table and a chart. The table shows all calculated transects and years as well as the most important properties and outcomes. The chart shows the result for the transect selected in the table. The row of buttons above the table can be used to change the information displayed in the table. While the model is running, MorphAn logs any exceptional situations (characteristics). If applicable, these will appear in the chart. You can use the buttons above the table to choose which of these characteristics are displayed as extra columns in the table.



Location	Offset	Year	A [m³/m]	T [m³/m]	G [m³/m]	Xr [m]	Zr [m]	Xp [m]	Zp [m]	Precision [m³/m]
Ameland - RS...	101	2015	413	103	0	-177,97	11,71	-170,45	4,19	0,028
Ameland - RS...	101	2016	350	88	0	-172,68	12,20	-164,67	4,19	0,000
Ameland - RS...	101	2017	279	70	0	-163,48	13,22	-154,45	4,19	0,004
Ameland - RS...	101	2018	279	70	0	-164,46	13,59	-155,06	4,19	0,007
Ameland - RS...	102	2015	418	78	0	-180,66	8,70	-176,15	4,19	0,034
Ameland - RS...	102	2016	347	87	0	-167,81	9,55	-162,45	4,19	0,002
Ameland - RS...	102	2017	352	88	0	-169,30	9,54	-163,95	4,19	0,000
Ameland - RS...	102	2018	312	78	0	-162,80	10,78	-156,22	4,19	0,024
Ameland - RS...	103	2015	410	73	0	-179,65	7,62	-176,22	4,19	0,035
Ameland - RS...	103	2016	348	87	0	-166,63	9,20	-161,62	4,19	0,033

Figure 6.4: *Results of erosion model*

Use the mouse to zoom in or out on the chart. Drag a selection rectangle down-right to zoom in; drag up-left to zoom out. You can also use ctrl+scroll wheel to zoom in or out. You can view all input and output details of any selected result in the Properties tool window. Furthermore, you can adjust the styling of the figure using the **Chart** tool window [section 2.5.5], and you can navigate through the results as described in section 2.4.3.

6.4 Boundary profile model

6.4.1 Boundary profile model input

Based on a boundary profile design, the Boundary Profile Model will iteratively fit profiles perpendicular to the coastline (in the profile measurements). The outcome of the model is treated as the landward boundary of the flood defense in the normative results, as produced by the normative model [section 6.5]. The model has four input items:

- ◇ **Erosion results** - This is a link to the results from the Erosion model. This data can serve as input for modeling the boundary profile.
- ◇ **Boundary conditions** - This item has the same name as the selected boundary conditions, and enables you to adjust the period and years considered by the model when determining overruns of the seaward boundary of the flood defense.
- ◇ **Plan view geometry** - This item is used to specify the boundary profile on a map. By default, the boundary profile is always taken behind the most landward erosion point. However, in the document window of this item you can also choose to either take the values from the boundary conditions file, position the boundary profile automatically at the back of the foredune, or manually draw or import a boundary profile [explained later in this section].
- ◇ **Cross-shore geometry** - With this item you can check the boundary profile in a side view. You can set limits for the geometric fit, but you can also specify which point in the side view is specified by the line on the map in the plan view.

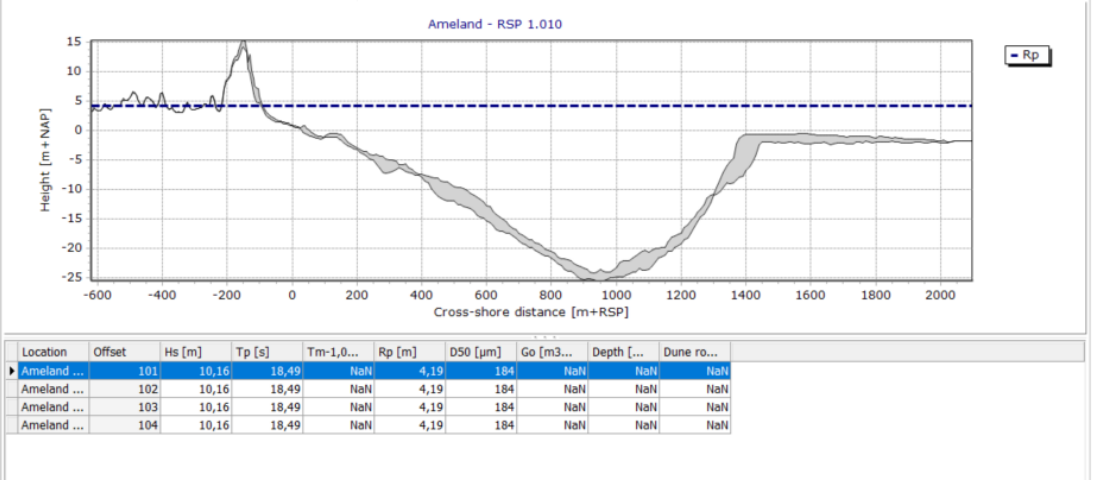
Erosion results

This item is a direct link to the results of the “Erosion model” [section 6.3.3]. In this case, the most landward erosion result calculated for the corresponding location is used. When three or more invalid erosion results are found, and / or when no questionable or valid results are available, then no boundary profile will be calculated for this location.

Boundary conditions

The relevant boundary conditions can be edited in the same way as in the Erosion model. Double-click on the boundary conditions item in the “Input” folder of the “Boundary profile model”. The corresponding document window will open [Figure 6.5], including a table in which the following boundary conditions can be edited:

- ◇ **Hs [m]** - Significant wave height at the peak of the storm.
- ◇ **Tp [s]** - Peak wave period at the peak of the storm.
- ◇ **Tm-1.0 [s]** - Spectral wave period at the peak of the storm. In the TRDA2006 (ENW, 2007) this value is recommended at those points where no single-peaked JONSWAP spectrum is found. The model’s **Wave period** setting indicates whether to use this value or the Tp for modeling.
- ◇ **Rp [m+NAP]** - Maximum water level during the storm (calculated value).
- ◇ **Xgp [m+RSP]** - The location of the boundary profile if supplied by the boundary conditions file. The “Plan view geometry” document window also enables you to specify the location of the boundary profile in a different way (see further in this section).



Location	Offset	Hs [m]	Tp [s]	Tm-1,0...	Rp [m]	D50 [µm]	Go [m3...	Depth [...	Dune ro...
Ameland ...	101	10,16	18,49	NaN	4,19	184	NaN	NaN	NaN
Ameland ...	102	10,16	18,49	NaN	4,19	184	NaN	NaN	NaN
Ameland ...	103	10,16	18,49	NaN	4,19	184	NaN	NaN	NaN
Ameland ...	104	10,16	18,49	NaN	4,19	184	NaN	NaN	NaN

Figure 6.5: *Typical document window in which boundary conditions of the boundary profile model can be edited*

Plan view geometry

The item “Plan view geometry” contains a design of the boundary profile on the map. In the **Project Explorer** window, double-click on the item to open a document window similar to Figure 6.6. The screen contains three panels:

- The panel “Specification position boundary profile” on the left side is where you specify how the boundary profile geometry is to be drawn.
- The upper right panel contains a map showing the boundary profile
- The lower right panel contains a chart that shows the following for each location in the selection for the model:
  - Height of the ground surface at that point on the boundary profile
  - Height of the maximum storm surge level at that location

This screen allows you choose from several methods to create a boundary profile. There are three buttons at the top of the panel “Specification position boundary profile”:

- **Landward boundary** - This option is used to position the boundary profile with respect to the landward boundary of the flood defense. When this option is selected, the left panel of the screen will change [Figure 6.7]. You can specify a fixed position of the boundary profile in two ways:
  - **From boundary conditions** - In this case, the values specified in the boundary condition set (Xgp) are used as the location of the boundary profile.
  - **From map** (default option) - With this option you can specify the position of the boundary profile on the map (or in the table). Three tools are provided in the “Map specification” box for this purpose:
    - *Import .shp...* - You can select a shapefile that contains the specification of a boundary profile using a LineString or MultiLineString.
    - *Draw on map* - Enables you to draw a boundary profile directly on the map using the mouse. Click the mouse where you wish to add a point. Double-click on the final point of the boundary profile. The boundary profile and its position will then be calculated at all locations. You can also choose this tool in the **Map** tab of the ribbon.
    - *Draw on map (auto)* - This works similarly to the previous tool, but in this case you move the mouse with the left button pressed (freehand, rather than straight lines).

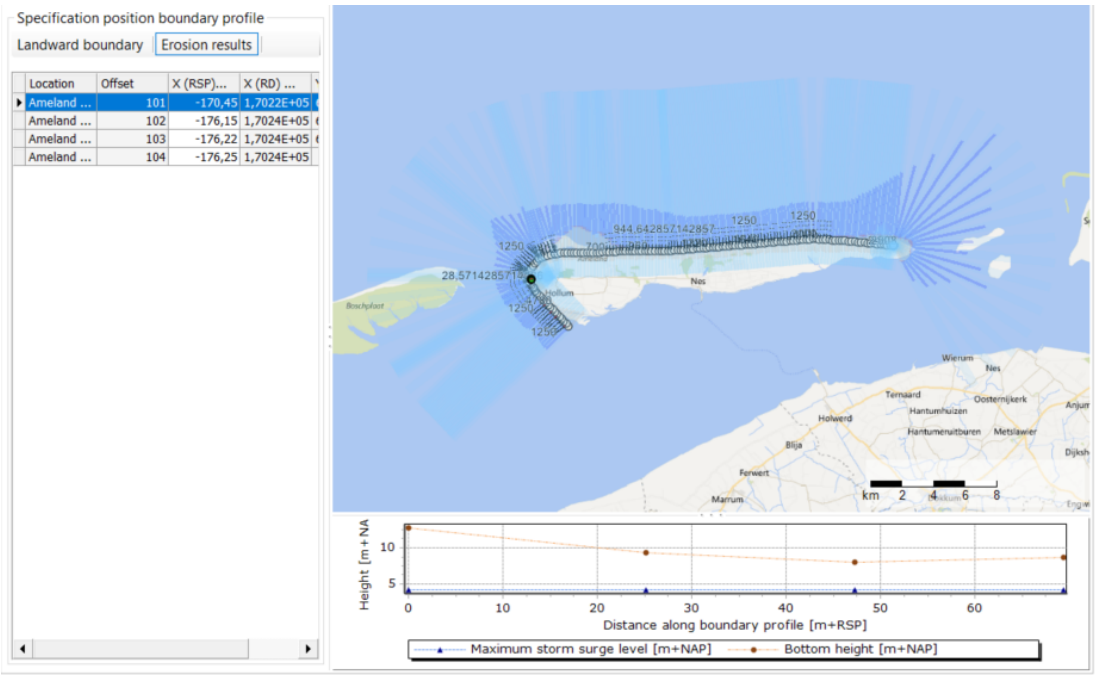


Figure 6.6: *Typical document window showing plan view geometry for boundary profile design*

On release of the mouse button, the boundary profile is calculated. Likewise, this tool is also in the **Map** tab of the ribbon.

If you define the boundary profile by drawing on a map, then MorphAn will need to calculate where this line intersects with the transects to arrive at the boundary profile position per transect. On the right of the "Map specification" box, you can specify an "Intersection range" to limit the distance from the transect origin for calculation of intersection points. If the model detects multiple intersections on a single transect, then the most seaward point always takes precedence.

- **Erosion results** - Click on this button to make the boundary profile automatically pass through the most landward calculated erosion point at a given location.
- **Back of first dune** - This option likewise automatically calculates the position of the boundary profile, but in this case, at the back of the first dune row (foredune). This is determined as the point where, viewed from the sea, the profile first crosses below the maximum storm surge level after it has risen above that level for the first time. If no such point exists, although a dune is present, then the most landward measurement point is used.

The table in the lower part of the left panel shows the specified or calculated point of the boundary profile per transect (both as a cross-shore distance and as geographical coordinates). When the option "Back of first dune" is selected, only the calculated position will be displayed for the most recent profile. You can edit a calculated point on boundary profiles in the table at any time. The "Specification position boundary profile" mode will then automatically switch to "Landward boundary → From map". These are the positions that will be used as "anchors" when calculating the boundary profile.

You will then be prompted to indicate whether the specified position is at "Ground Level" or the position entered in the table is at "Maximum storm surge level". If a position is specified at maximum storm surge level, the front side of the boundary profile calculated by the model at that position will have a slope of 1:1 landward relative to ground level. However, if positions

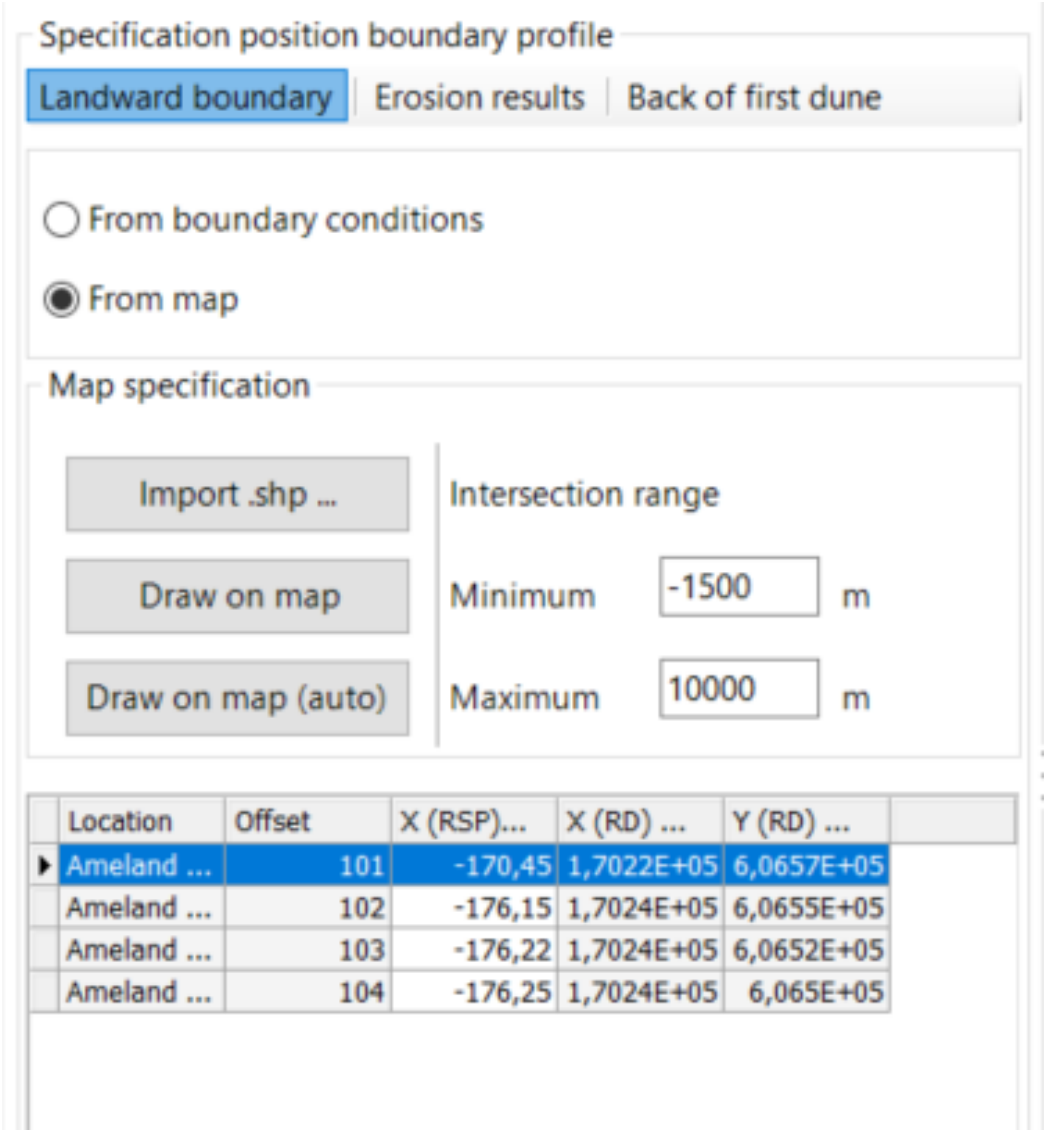


Figure 6.7: *View of the left panel of the document window for the Plan view geometry for Landward Boundary specification of the boundary profile via option "From map"*

are specified as being at ground level, then the front side of the profile will be calculated as the line with a slope of 1:1 seaward from the specified point at ground level to a point at maximum storm surge level.

During manual editing of the boundary profile design, you can use several tools in the **Map** tab of the ribbon [as shown in Figure 6.8]. The tools fall into various categories. When editing or designing a continuous boundary profile, three of these are important. In the figure, these are circled in red:

- **Selection (Tools)** - The Tools group includes tools for selecting objects on the map. This can be done in two ways:
  - **Pointer select** - Select using the pointer. You can either select individual points on the map, or draw a rectangle within which everything is selected.
  - **Lasso select** - Click and drag the mouse to draw a shape that encloses the objects you want to select.

- **Edit** - The tools in this group are used to modify the boundary profile. The following editing actions are available:
  - **Move geometry points** - Move all points of the drawn boundary profile.
  - **Move a single geometry point** - Move one of the points on the drawn boundary profile (if a point is first clicked), or the entire boundary profile (if the line is first clicked).
  - **Add point to geometry** - Insert an additional point on the drawn boundary profile.
  - **Remove point from geometry** - Delete a single intermediate point from the drawn boundary profile.
- **Draw (Boundary Profile)** - This group contains two tools for drawing a new boundary profile. After using either of these two tools, the "Specification position boundary profile" will automatically be set to "Landward boundary". The same drawing tools are also available in the "Plan view geometry" document window:
  - **Draw Boundary Profile** - Use this tool to draw a new boundary profile as one or more straight line segments. Each mouse click adds a new point and line segment to the drawn profile. A double-click of the mouse inserts the final point and line segment.
  - **Draw Boundary Profile (Auto)** - Use this tool to draw an entire boundary profile as a freehand line. Simply hold the left mouse button pressed while you drag the mouse, and the drawn boundary profile will exactly follow the mouse movement.

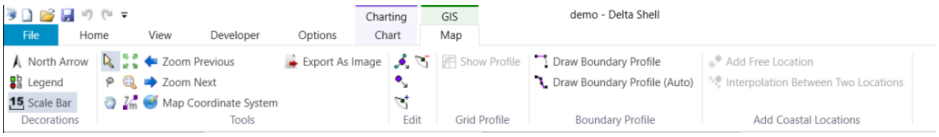


Figure 6.8: *The Map Ribbon tab, showing the tools that are useful for boundary profile design circled in red*

Cross-shore geometry

The "Cross-shore geometry" item gives you more control over the cross-sectional shape of the calculated boundary profile. Moreover, this screen shows which position in the cross-sectional view corresponds to the specified location of the boundary profile in the "Plan view geometry". Double-click on the item to open a document window similar to that in Figure 6.9. This screen allows you to specify or edit the following settings:

- **TRDA2006 geometric profile** - By default, TRDA2006 requires that a boundary profile should be modeled with a fixed shape. This requirement is met when the large button above the "Geometry specification" is pressed.
- **Geometry specification** - When the "TRDA2006 geometric profile" button is not pressed, further options are enabled for specifying the geometric shape of the boundary profile. If a non-standard specification is in effect, the required volume is calculated based on the "default" geometric profile, and a shape with the same volume is then calculated based on the edited specifications. You can specify a non-standard geometric shape for the boundary profile by selecting one of the following:
  - **Fixed crest width** - The specified crest width is maintained during calculations. MorphAn only accepts crest widths from 0 to 50 meters.
  - **Fixed crest height** - The height of the crest of the boundary profile is held constant, and the width is adjusted to the required volume. MorphAn accepts heights from 0 to 10 meters. Keep in mind that in the case of a fixed crest height lower than 1 meter, all calculated boundary profiles that fall below the required 1 meter will be kept above the maximum storm surge level.
  - **Back slope** - Here you can adjust the back slope by editing the horizontal component.

◇ **Specification position boundary profile** - These options are active only if “Landward boundary” geometry specification is selected in the plan view geometry item [Figure 6.4.1]. In that case you can specify the level at which the boundary profile lies on the cross-section geometry at the given locations:

- **Ground level** - The entered position lies at ground level on a 1:1 seaward slope of the boundary profile down to the maximum storm surge level.
- **Maximum storm surge level** - The entered position lies at maximum storm surge level. This therefore indicates the most seaward point of the boundary profile.
- **Iterate landward** - When unchecked, this box indicates that the entered base position is on the back slope (most landward point) of the boundary profile; checked indicates a seaward boundary, in which case the user can choose between the preceding two options for the level. If the box is unchecked (base position on back slope), the point is automatically assigned a height at maximum storm surge level.

◇ **General** - Several general settings can also be entered:

- **Wave period** - You can select this setting for the model from the drop-down list: T_p, $T_{m-1.0}$ or a combination of both. The combined option means using $T_{m-1.0}$ from the boundary conditions for locations in the Wadden Sea, and T_p for all other locations.
- **Allow volumetric boundary profile** - When checked, this option means that if a geometric fit with the specified geometry cannot be achieved, the boundary profile must achieve a volumetric fit.
- **Use minimum volume of 16.875** m^3/m - The TRDA2006 states that the boundary profile must be modeled with a minimum crest height of 2.5 m. Given the prescribed slopes and crest width, it follows that the minimum volume present is 16.875 m^3/m. This option enables you to disable the minimum height constraint (and therefore also the minimum volume), so that boundary profiles with a lower volume can also be modeled.

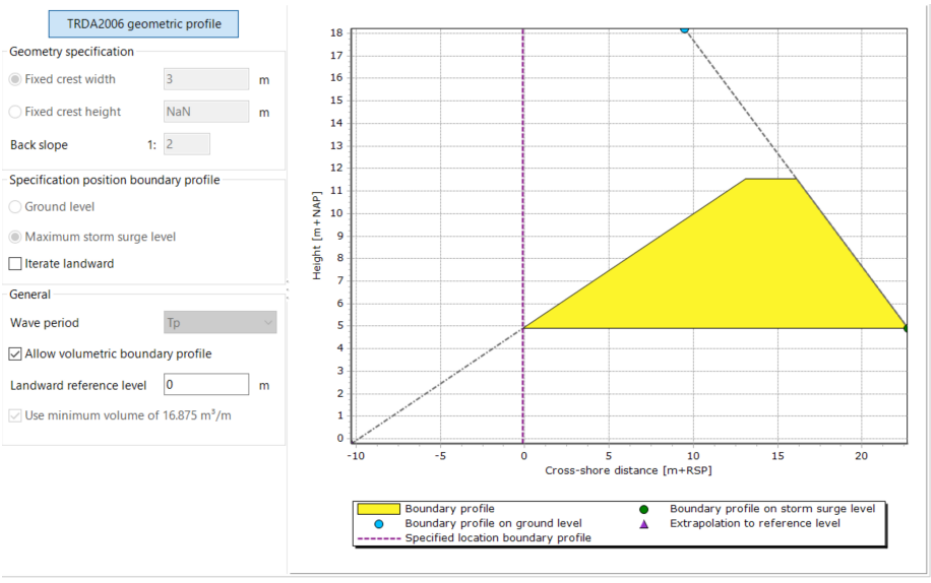


Figure 6.9: *Typical cross-shore geometry window in the boundary profile model*

6.4.2 Boundary profile model output

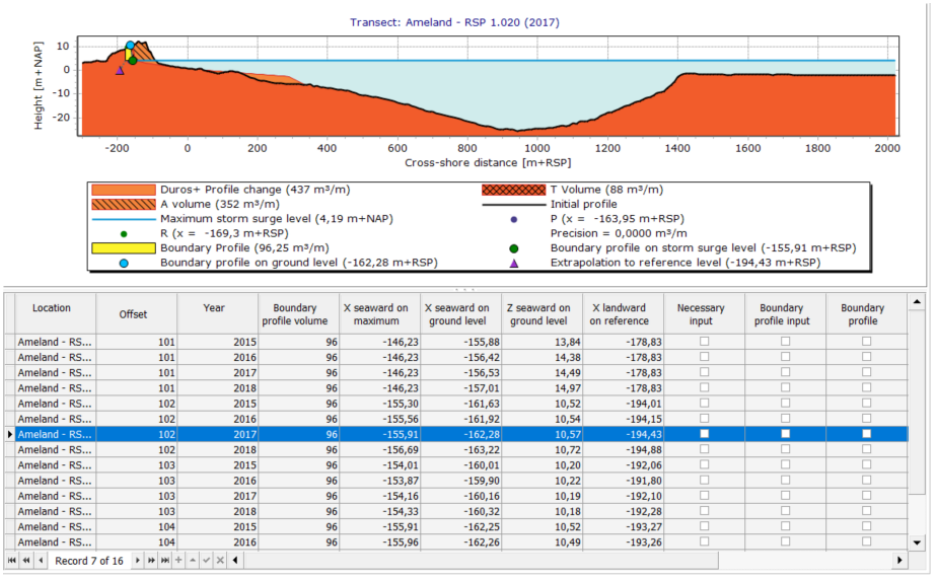
After running the Boundary profile model, two new items are added to the **Output** folder of the model in the **Project Explorer**:

◇ Boundary profiles

◇ Run report

When you double-click on the item *Boundary profiles*, a window similar to Figure 6.10 will open. This window contains a table and a chart. The table shows all calculated transects and years as well as the most important properties and outcomes. The chart shows the result of the transect selected in the table. The chart also shows the calculated erosion result.

Use the mouse to zoom in or out on the chart. Drag a selection rectangle down-right to zoom in; drag up-left to zoom out. You can also use ctrl+scroll wheel to zoom in or out. All input and output details of any selected result can be viewed in the comprehensive **Properties** tool window.



Location	Offset	Year	Boundary profile volume	X seaward on maximum	X seaward on ground level	Z seaward on ground level	X landward on reference	Necessary input	Boundary profile input	Boundary profile
Ameland - RS...	101	2015	96	-146,23	-155,88	13,84	-178,83	☐	☐	☐
Ameland - RS...	101	2016	96	-146,23	-156,42	14,38	-178,83	☐	☐	☐
Ameland - RS...	101	2017	96	-146,23	-156,53	14,49	-178,83	☐	☐	☐
Ameland - RS...	101	2018	96	-146,23	-157,01	14,97	-178,83	☐	☐	☐
Ameland - RS...	102	2015	96	-155,30	-161,63	10,52	-194,01	☐	☐	☐
Ameland - RS...	102	2016	96	-155,56	-161,92	10,54	-194,15	☐	☐	☐
Ameland - RS...	102	2017	96	-155,91	-162,28	10,57	-194,43	☐	☐	☐
Ameland - RS...	102	2018	96	-156,69	-163,22	10,72	-194,88	☐	☐	☐
Ameland - RS...	103	2015	96	-154,01	-160,01	10,20	-192,06	☐	☐	☐
Ameland - RS...	103	2016	96	-153,87	-159,90	10,22	-191,80	☐	☐	☐
Ameland - RS...	103	2017	96	-154,16	-160,16	10,19	-192,10	☐	☐	☐
Ameland - RS...	103	2018	96	-154,33	-160,32	10,18	-192,28	☐	☐	☐
Ameland - RS...	104	2015	96	-155,91	-162,25	10,52	-193,27	☐	☐	☐
Ameland - RS...	104	2016	96	-155,96	-162,26	10,49	-193,26	☐	☐	☐

Record 7 of 16

Figure 6.10: *Typical boundary profile screen showing results of a modeling run*

The following parts of the boundary profile are shown in the figure:

- ◇ **Erosion result** - This is a copy of the result displayed in the output of the “Erosion model”.
- ◇ **Boundary profile** - The yellow shaded area shows the calculated boundary profile.
- ◇ **Boundary profile base position** - The green circle indicates the position of the boundary profile at the maximum storm surge level.
- ◇ **Landward boundary of sea defense** - The blue circle indicates the position of the boundary profile at ground level.
- ◇ **Extrapolation to reference level** - The purple triangle indicates the back slope of the boundary profile extrapolated to the reference level specified in the settings of the model.

6.5 Normative model

6.5.1 Normative model settings

When you double-click on the “Normative model”, a document window opens in which you can specify the Assessment rules by which a normative point can be designated “Invalid” [Figure 6.11]. If you choose the rule “15 years prior...” and specify a year in the adjacent field, then the model will look back over the preceding 15 years. (A value of 0 means the model will take the most recent measurement point in the profile measurements). If there are more than 2 calculated erosion points (R points) landward of the specified seaward boundary of the flood

defense, a normative point (the third-worst point) will be designated Invalid. Alternatively, if you choose the rule “Use years from boundary conditions”, then the model will search the boundary conditions of each location for a start and end year. This is further explained later in this section.

In this window you can also influence how the model determines the “Landward boundary of the flood defense”. The model bases this on the results of the “Boundary profile model”. There are two options: “Ground level” or “Maximum storm surge level”. The model will then determine the most seaward position of the selected locations from all calculations within the specified period (excluding the years it must disregard; see section 6.5.2).

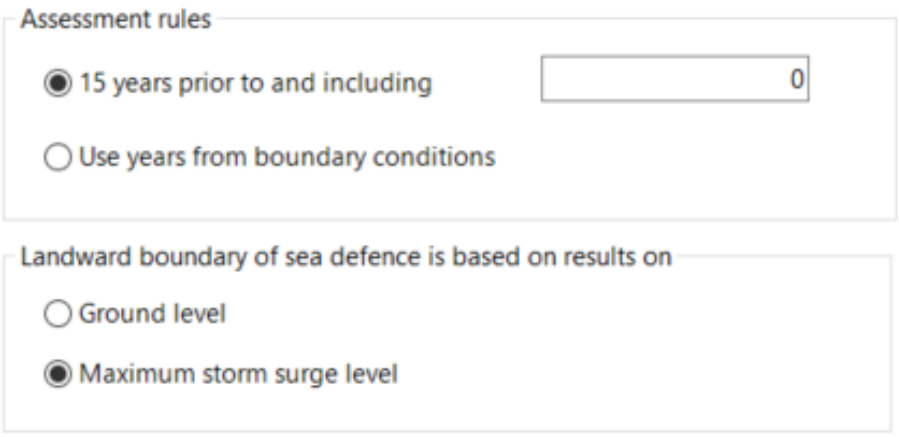


Figure 6.11: *Normative model settings window*

6.5.2 Normative model input

The normative model calculates a normative result for each transect location based on the previously calculated erosion results and the boundary profile results. The assessment rules in the settings specify whether to determine R point overruns of the flood defense seaward boundary within a fixed period (15 years prior to...) for all locations, or a specific period per location. In the case of “per location”, a start and end year must be provided for each location. This information is obtained from the boundary conditions section A.4]. The **Input** folder of this model therefore contains three items:

- **Erosion results** - A reference to the outcomes of the Erosion model
- **Boundary profiles** - A reference to the outcomes of the boundary profile model
- **Boundary conditions** - This item has the same name as the selected boundary condition set, and enables you to adjust the period and years considered by the model when calculating the frequency of overruns of the seaward boundary of the flood defense.

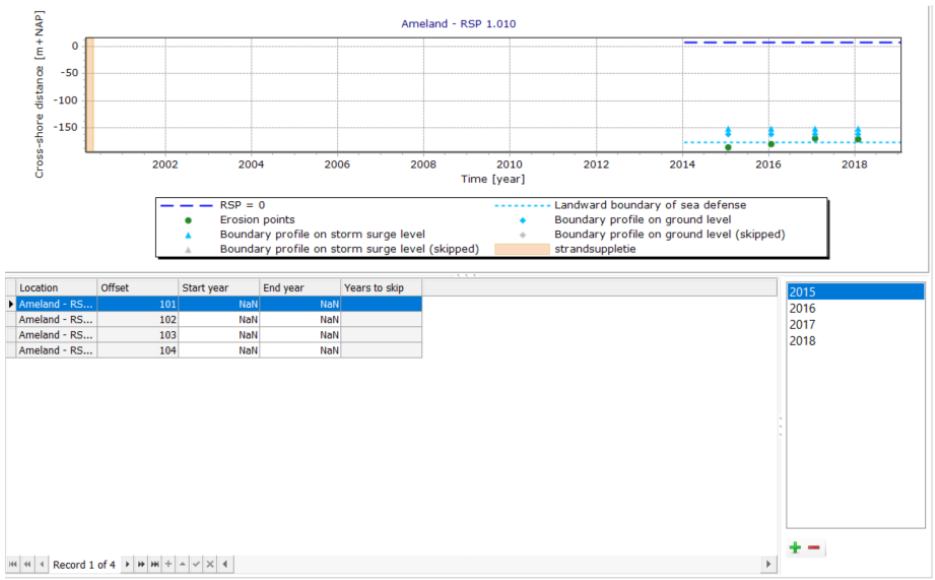


Figure 6.12: *Typical window with results of the normative model*

Double-click on the boundary conditions item to open a window similar to Figure 6.12. In the lower part of the window you can specify a start and end year for individual transect locations, as well as the years that should be skipped when the model runs. These years are only included in calculations if the second assessment rule is selected in the settings screen [Figure 6.11]. To specify a start and end year for an individual location, enter a year directly in the table. There are three ways to specify or edit the “Years to skip”:

- ◇ **Click on the chart** - First select a location in the table, then click on one of the green R (erosion point) dots. This will be added to the “Years to skip” for this location. To remove a skipped year from the list for a location, select the location, then click on the gray dot corresponding to the skipped year.
- ◇ **Using the + and - buttons** - To add or remove one or more years to skip to or from multiple locations, first select multiple locations in the table, then click on the desired years in the list on the right. Finally, click on the **+** button to *add* the years to the “Years to skip” lists. Otherwise, click on the **-** button to *remove* the specified years from the lists.
- ◇ **Import** / **Export** - When you right-click on the boundary conditions in the project explorer, the context menu gives you the option to *Import...* or *Export...*. This enables you to import or export the “Years to skip” as a csv file. The format of this csv file is described further in section A.7.

6.5.3 Output

After the Normative model has run, the **Output** folder of the model in the **Project explorer** will contain the item **Normative results**. When you double-click on this item, a window similar to Figure 6.13 will open. This window contains a table and a chart. The table shows the most important properties and outcomes for each location in the model. The chart shows the normative results for the location selected in the table below the chart.

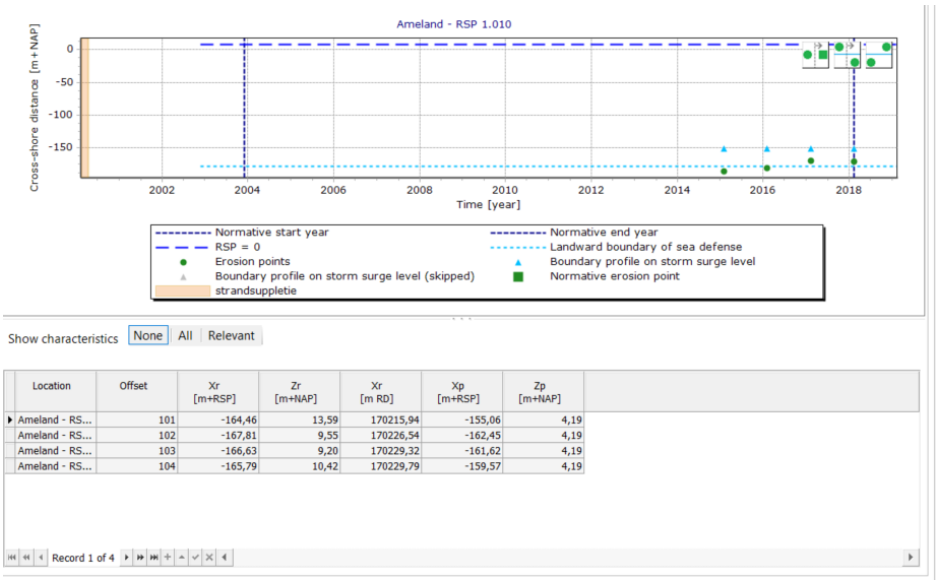


Figure 6.13: *Normative model results*

6.6 Dune safety overview

When you double-click on the **Safety overview** item below the sub-models in the Project explorer, an overview map will open in the document window [Figure 6.14]. All calculated erosion results are visualized in this *Safety overview*. The map also shows the bandwidth of the calculated R points over the modeled period, plus all normative points. The map can only show data for a single moment in time. To view the results of another moment or to animate the entire modeled period, you can also work with the Time Series Navigator [section 2.5.8]. If you wish, you can show additional information on the map, e.g. from shapefiles. Section 2.6 explains more about how to work with maps.

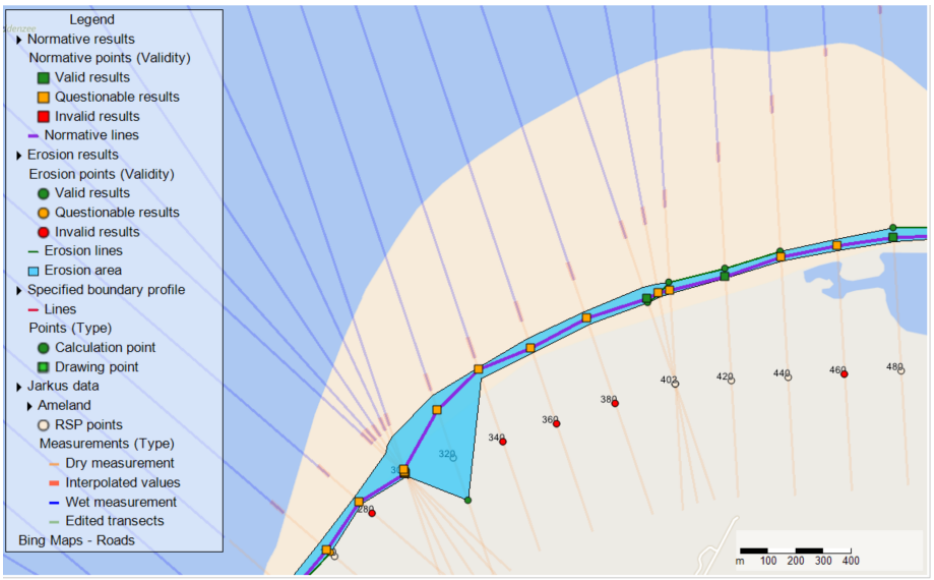


Figure 6.14: *Typical Dune safety overview window showing results of a modeling run for Vlieland*

7 The Coastal Development model

7.1 Introduction to coastal development model

This model is used to support coastline assessment within the coastline monitoring program. In the Netherlands, results are published in the atlas of coastal charts (Rijkstwaterstaat, 2012). The coastal development model comprises three sub-models. These sub-models are based on coastal management policies agreed in 1990. A predefined Base Coastline (BKL) has been in effect since then. The BKL specifies the minimum position of the coastline relative to the zero point of a coastal location. In 2001, the BKL position at certain locations was adjusted. The selection of transects and years, plus the choice of profile measurements and boundary conditions for the coastal development model, are both made using the items in the **Input** folder of the model. For more details, please refer to section 2.4.1. This input applies automatically to the three sub-models:

- ◇ Section 7.2 describes the MKL model used to calculate the Momentary Coastline.
- ◇ Section 7.3 describes the Trend Period model used to determine the trend period for assessing the development of a Momentary Coastline.
- ◇ Section 7.4 describes the TKL model which calculates the Expected Coastline.

7.2 MKL model

7.2.1 MKL model description

The MKL model calculates the momentary coastline points (MKL) based on measurement data and boundary conditions for every coastal location and year in the selection. This section explains the inputs and outputs of this model.

7.2.2 MKL model input

The MKL model calculates the momentary coastline based on the parameters in the selected boundary condition file. The transect selection is determined by the selection entered at the level of the coastal development model [section 2.4.1]. The single item in the **Input** folder of this model specifies the boundary conditions that apply to this model for the selected transects. To edit the boundary conditions, double-click on this item. Any modifications will also take effect in the **Data** folder of the workspace. If these boundary conditions are used in any other model, then they will also be automatically modified in *that* model.

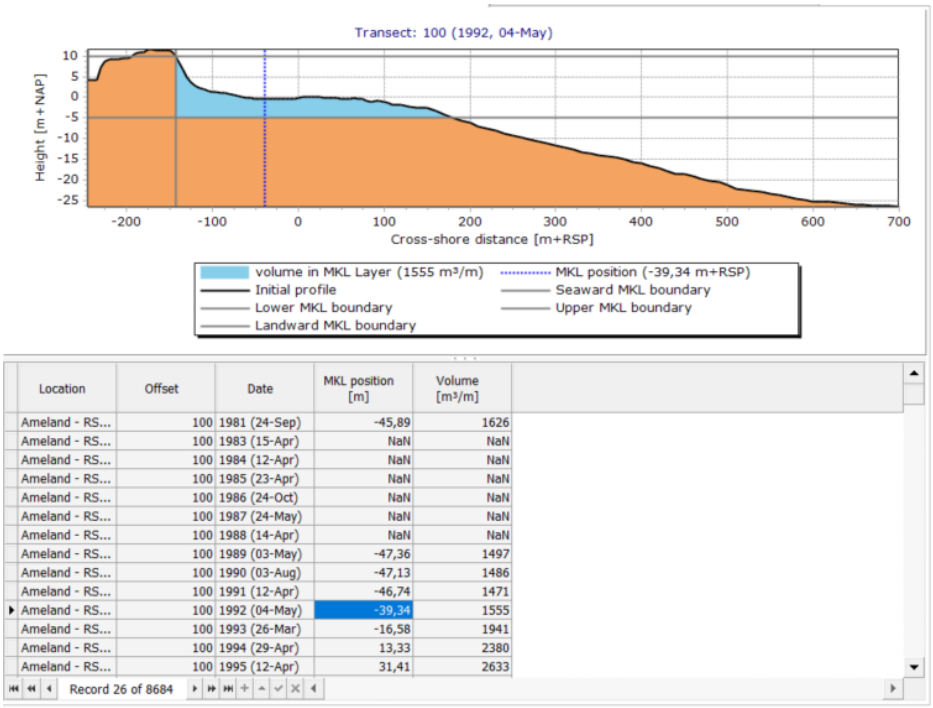
7.2.3 MKL model output

After running the MKL model, the **Output** folder of the model in the **Project Explorer** will contain two new items:

- ◇ MKL points
- ◇ Run report

When you double-click on the item *Momentary coastline locations (MKL)*, a window similar to Figure 7.1 will open. This window contains a table and a chart. The table shows all calculated transects and years as well as the most important properties. The chart shows the calculated momentary coastline position of the transect selected in the table. The MKL is indicated by a vertical dark blue dotted line. The light blue shaded area indicates the calculated volume between the specified MKL boundaries (represented by light gray lines). Use the mouse to zoom in or out on the chart. Drag a selection rectangle down-right to zoom in; drag up-left to zoom out. You can also use ctrl+scroll wheel to zoom in or out. You can view all input and

output details of any selected result in the Properties tool window.



Location	Offset	Date	MKL position [m]	Volume [m³/m]
Ameland - RS...	100	1981 (24-Sep)	-45,89	1626
Ameland - RS...	100	1983 (15-Apr)	NaN	NaN
Ameland - RS...	100	1984 (12-Apr)	NaN	NaN
Ameland - RS...	100	1985 (23-Apr)	NaN	NaN
Ameland - RS...	100	1986 (24-Oct)	NaN	NaN
Ameland - RS...	100	1987 (24-May)	NaN	NaN
Ameland - RS...	100	1988 (14-Apr)	NaN	NaN
Ameland - RS...	100	1989 (03-May)	-47,36	1497
Ameland - RS...	100	1990 (03-Aug)	-47,13	1486
Ameland - RS...	100	1991 (12-Apr)	-46,74	1471
Ameland - RS...	100	1992 (04-May)	-39,34	1555
Ameland - RS...	100	1993 (26-Mar)	-16,58	1941
Ameland - RS...	100	1994 (29-Apr)	13,33	2380
Ameland - RS...	100	1995 (12-Apr)	31,41	2633

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Figure 7.1: *Typical screen showing calculated MKL points*

7.3 Coastline trend period model

7.3.1 Coastline trend period model description

Based on nourishment data, the trend period model will make an initial estimate of a valid period for calculating a trend in the development of the MKL values. The TKL model will later use this trend to model the “Expected Coastline” (TKL).

7.3.2 Coastline trend period model settings

Double-click on the Trend period model in the project explorer, and a window similar to Figure 7.2 will open. This window allows you to adjust the following settings of the model:

- **Period of interest** - The first setting specifies a period between a start year and end year. Calculated MKL points outside this period will be disregarded when the model is run.
  - **Start year** - The first year of the period of interest. The analysis ignores MKL points outside this period.
  - **End year** - The final year of the period of interest. The analysis ignores MKL points outside this period.
- **Trend period length** - The model will search through the period of interest for a set of successive years in which no nourishment has occurred. The model always searches for the most recent period in which that was the case. It also takes into account the following:
  - **Minimum length** - The minimum number of years in a period. Periods shorter than this minimum are disregarded.
  - **Maximum length** - The maximum number of years in a period. In any period longer than this maximum, only the last years of the period are included in the trend calculation.

- **Nourishment types** - Lastly, you can also specify the types of nourishment to include in the analysis. This can be done in two ways:
  - **Minimum volume per meter** - A minimum volume can be specified. Nourishments with a lower volume will be disregarded in the calculation of the trend period.
  - **Nourishment type** - The table in the lower part of the settings window shows all types of nourishments present in the Data folder. In this table you can select the nourishment types to be included in the calculation (the unselected types will be disregarded). If the box in the second column is checked, then all nourishments of that type will be included in the calculations. You can optionally use the two buttons above the table (**Select all types** and **Unselect all types**) to save mouse clicks when selecting all or none.

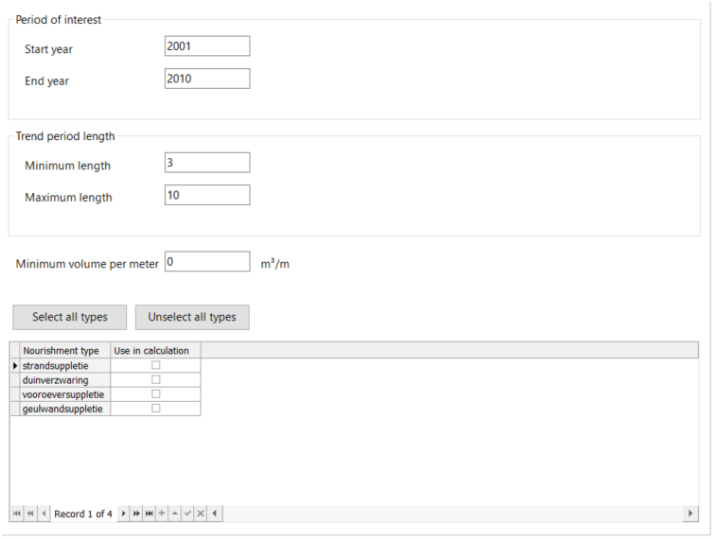


Figure 7.2: *Settings window for the Trend period model*

7.3.3 Coastline trend period model input

Because this model uses only the nourishment data, the **Input** folder of this model contains a single item that links directly to the nourishment data in the workspace Data folder [section 3.6].

7.3.4 Coastline trend period model output

After the model has run, there will be two output items:

- Trend periods
- Run report

When you double-click on the *Trend periods* item, a window will open showing a table with the calculated start and end year for every location. If you right-click on the *Trend periods* item, you will have the option to export the calculated trend periods to a *.csv file.

7.4 TKL model

7.4.1 TKL model description

Based on the MKL points from the MKL model [section 7.2] and a predefined trend period, the TKL model calculates the trend in the development of the MKL points. This trend is then used to calculate the expected position of the coastline at predefined times (plus the moment when the expected coastline intersects with the BKL, if applicable).

7.4.2 TKL model input

The model takes its input from the calculated MKL values. The model also depends on a specification of the trend data (trend period and BKL). The model has two input items:

- ◇ **MKL points** (MKL calculation results, linking directly to the MKL model output).
- ◇ **TKL calculation definitions**

When you double-click on the second item, a screen similar to that in Figure 7.3 will open. The upper part of this screen contains a chart showing the specified years and nourishments; the lower part has three tabs. The screen will open to the **Trend data** tab, which contains a table with the following columns:

- ◇ **Location and Offset** - Transects for which the input is defined in the adjacent columns.
- ◇ **Trend start year** - The first year of the period for which a trend of the MKL points is to be calculated.
- ◇ **Trend end year** - The last year of the period for which a trend of the MKL points is to be calculated.
- ◇ **TKL start year** - This is the first year for extrapolation of the trend. If no successful MKL calculation can be found for that year, the model will search back in time to the first successful MKL calculation. If this falls within the trend period range specified by the *Trend start year* and *Trend end year* , then the trend will be continued. Otherwise, the trend will be extrapolated from the found MKL point (found by searching back in time). This parameter is not mandatory. If you leave it unspecified in the table (NaN = Not a Number), the above extrapolation rule will automatically be applied from the most recent calculated MKL point. The initial entry in this column is derived from the selected boundary conditions.
- ◇ **BKL** - This is the predetermined base coastline at the specific location. This value is likewise derived from the selected boundary conditions.

This table is used to specify the start and end years for calculating the trend (first two columns). These values are not derived from the boundary condition set; they are directly linked to the model. There are two methods you can use to copy to another model (such as another TKL model, or a Trend model in a volume development model):

- ◇ **Export** / **Import** - To export the years to a csv file, in the Project Explorer right-click on *Input -> TKL calculation definitions*, choose *Export...* and select “Trend periods (*.csv)”. Likewise, to import the file into another model, use the same method (but then choose *Import...* rather than *Export...*.).
- ◇ **Cut** / **Paste** - You can copy data directly from one table into another table using Copy (ctrl+C) in the first table, and Paste (ctrl+V) in the second table. Alternatively, you can click Copy or Paste in the context menu that appears when you right-click in a table with one or more cells selected.

You can use the button above the table to directly fill the table with all results (trend data) calculated by the Trend model.

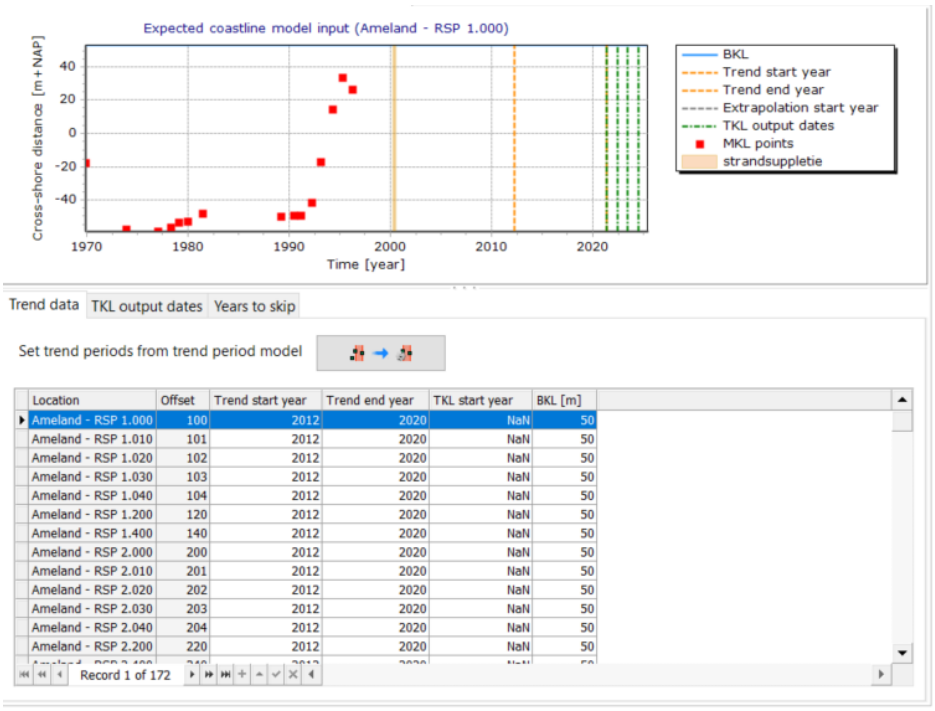


Figure 7.3: *Typical window for entry of trend data and BKL.*

Apart from the trend data (trend period, TKL start year and BKL) in the first tab, you also need to specify the dates for which a TKL has to be calculated: click on the **TKL output dates** tab in the lower part of the screen. The window then appears as in Figure 7.4. To add dates, select a date in the calendar, then click the button “Add time”. To remove a date, first select it, then press the Delete key.

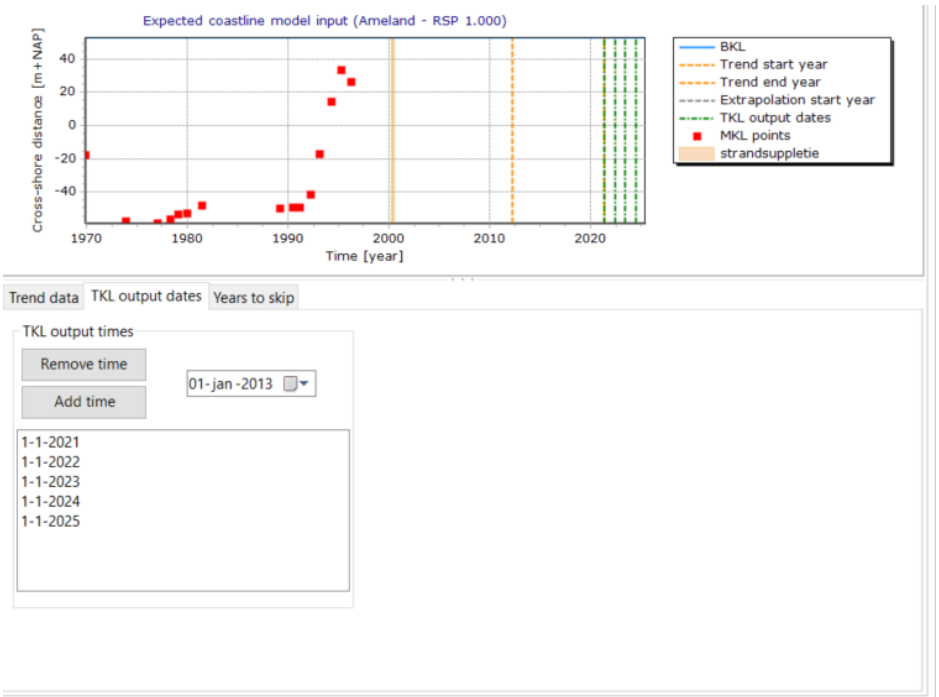


Figure 7.4: *Typical window for defining output dates for calculating TKL values.*

Lastly, for each location you can optionally specify any **Years to skip** in the trend calculation. When you click on this tab, the window appears as in Figure 7.5. As with the Normative model in the Dune Safety model [section 6.5.2], you have three ways to specify which years should be skipped for a location:

- **Click on the chart** - First select a location in the table, then click on one of the red MKL points. This will be added to the "Years to skip" for this location. To remove a skipped year from the list for a location, select the location, then click on the gray dot corresponding to the skipped year.
- **Using the + and - buttons** - To add or remove one or more years to skip to/from multiple locations, first select multiple locations in the table, then click on the desired years in the list on the right. Finally, click on the **+** button to *add* the years to the "Years to skip" lists. Otherwise, click on the **-** button to *remove* the specified years from the lists.
- **Import** / **Export** - When you right-click on the boundary conditions in the **Project Explorer** tool window, the context menu gives you the option to *Import...* or *Export...*. This enables you to import or export the "Years to skip" as a csv file. The format of this csv file is described further in section A.7.

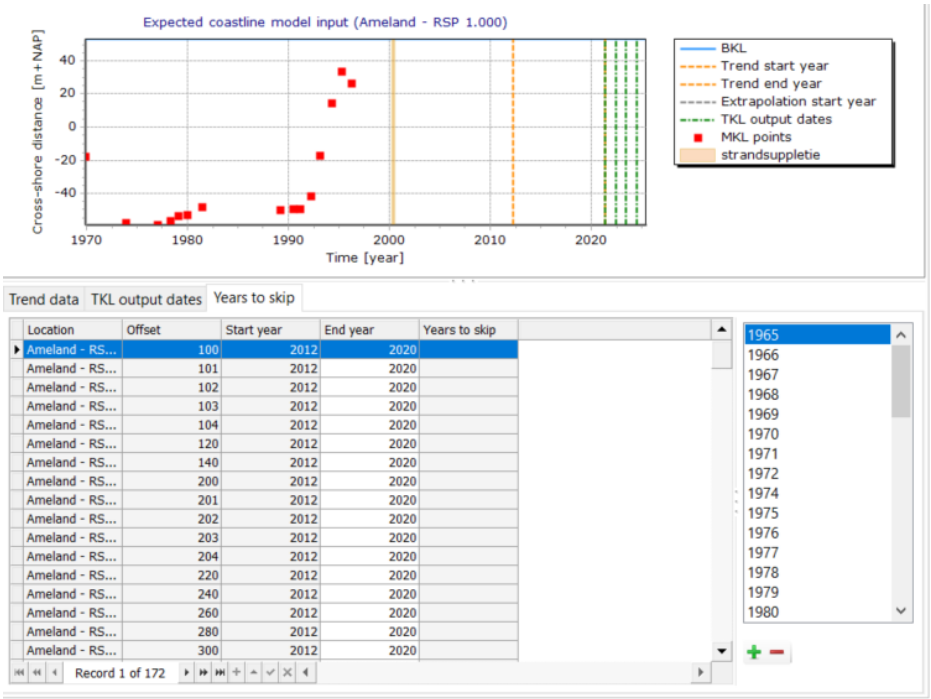


Figure 7.5: *Typical window for specifying years to skip during calculation*

7.4.3 TKL model output

After running the TKL model, two new items are added to the **Output** folder of the model in the **Project Explorer**:

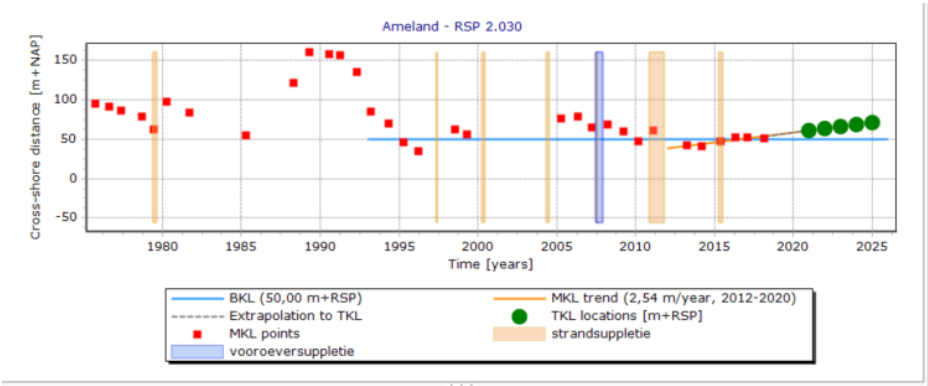
- Expected coastline locations (TKL)
- Run report

When you double-click on the Expected coastline locations (TKL) item, a window will open similar to that in Figure 7.6. The calculated trend and TKL values are shown both as a chart and in a table. The following values are displayed for each location:

- **BKL** - The BKL position used to determine the moment that the calculated trend line

intersects with the BKL.

- ◇ **Trend** - The calculated trend for MKL development.
- ◇ **R2** - A measure of the precision with which the trend line describes the MKL development. A value of 1 represents perfect precision; the closer to 1, the better.
- ◇ **BKL intersection** - Date at which the calculated trend line intersects the BKL position. The value in this column of the table can take the following forms:
  - □ **Heden** - ("Now") Indicates that the trend line intersects the BKL *before* the TKL start year.
  - □ **NaN** - ("Not a Number") Indicates that the trend line intersects the BKL *after* the TKL start year and the trend is *positive*.
  - □ **MMM-yyyy** - If the trend line intersects the BKL *after* the TKL start year and the trend is *negative*, this column shows the month and year of BKL intersection.
- ◇ **TKL yyyy** - Calculated TKL positions (one column per TKL output date).
- ◇ **TKL - BKL yyyy** - The difference between each calculated TKL position and the BKL position (one column per TKL output date).



Location	Offset	BKL [m]	Trend [m/year]	R2	BKL intersection	MKL at start year TKL	TKL 2021 (01-Jan)	TKL 2022 (01-Jan)
Ameland - RS...	100	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	101	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	102	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	103	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	104	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	120	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	140	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	200	50,00	NaN	NaN	NaN	NaN	NaN	NaN
Ameland - RS...	201	50,00	1,82	0,6415	Heden	45,05	53,55	55,37
Ameland - RS...	202	50,00	-4,41	0,2398	Heden	46,18	27,12	22,71
Ameland - RS...	203	50,00	2,54	0,7811	NaN	50,81	60,69	63,23
Ameland - RS...	204	50,00	4,50	0,8955	NaN	65,95	78,01	82,51

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Figure 7.6: *Typical Expected coastline locations (TKL) screen showing calculated trend and TKL values*

If you wish to adjust the styling of the lines and markings on this chart, select an item in the Chart tool window, then edit the properties of that item in the Properties window [section 2.6.3]. To omit certain details from the chart, uncheck the box for those details in the Chart tool window.

7.5 Overview of coastal development model results

When you double-click on the **Development overview** item below the sub-models in the Project explorer, an overview map will open in the document window [Figure 7.7]. This map shows the calculated development over time of both the MKL and TKL points (use the Time Navigator to move through the time series [section 2.5.8]). The map also shows the BKL and the coastal development trend, comparable to a coastline chart. Lastly, the map can

also show the profile measurements for each transect (in this figure, the “Jarkus data” map layer). A detailed description of the options for visualization of results on the map is included in section 2.4.3.

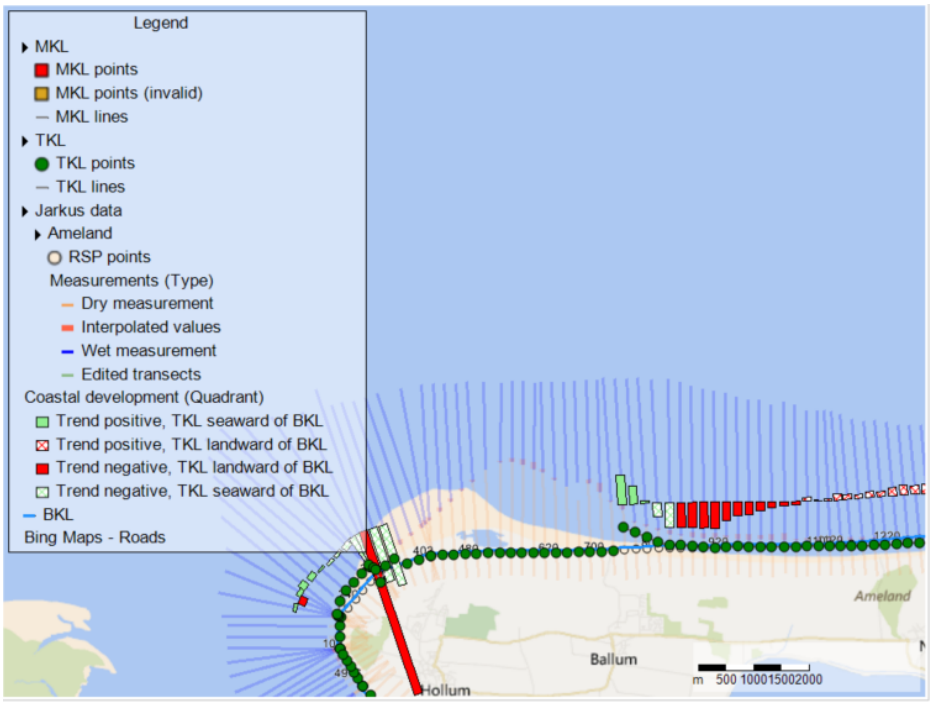


Figure 7.7: *Typical development overview screen showing results from the coastal development model. The Time Navigator window can be seen below the map.*

8 The volume development model

8.1 Introduction to volume development model

The volume development model calculates the volume development in the cross-shore profile at the specified location, within predefined vertical and horizontal boundaries on the transect. The model has much in common with the Coastal Development model. This chapter will therefore mainly focus on those aspects that differ from that model. As with the coastal development model, the input items and their use are described in section 2.4.1. Unlike the coastal development model, the volume development model does not generate an overview map. However, it likewise comprises three sub-models:

- ◇ Section 8.2 describes the volume model.
- ◇ Section 8.3 describes the trend period model for determination of the trend period.
- ◇ Section 8.4 describes the calculation of the volume development trend.

8.2 Volume model

8.2.1 Volume model description

This model essentially makes identical calculations to the MKL model [section 7.2]. The difference is that this model offers more flexibility in specifying and working with the boundaries of the slice of coastline for which a volume is calculated. For example, in the volume model you do not need to specify an upper boundary (or you can specify a boundary above the dune crest), and instead of using the boundary conditions in the boundary conditions file, you can replace one or more of the default values with a manually entered value. On the other hand, the calculated volume does not result in a geographical position such as the MKL point on a transect.

8.2.2 Volume model input

The **Input** folder of the volume model in the **Project explorer** contains only one item: the boundary conditions. You can use this file to provide the seaward, landward, upper and lower boundaries of individual transects for the volume model. To open a window in which you can view and manually edit these values, double-click on the *Boundary conditions* item.

8.2.3 Volume model output

After running the Volume model, two new items are added to the **Output** folder of the model in the **Project Explorer**:

- ◇ **Volumes** - This item contains information about the calculated volumes.
- ◇ **Run report** - the Run Report contains all messages that appeared in the Message window while the model was running.

When you double-click on the *Volumes* item, a window will open showing the results for each transect in both chart and table form. The calculated volume is shown as a blue area on the cross-shore profile per transect and year. For each selected transect, the *Properties* window shows the boundary values actually used by the model [Figure 8.1].

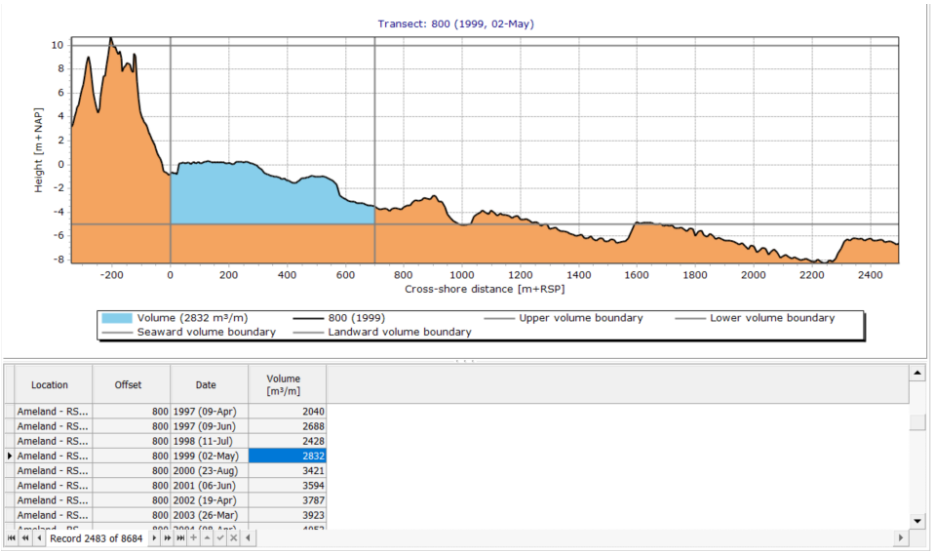


Figure 8.1: *Typical results visualization screen for the Volume model*

8.3 Volume trend period model

The trend period model included in the volume development model is identical to that in the coastal development model. For more information on this model and its use, see section 7.3.

8.4 Volume trend model

As with the TKL model [section 7.4], the trend model calculates a trend in the development of the calculated volumes per location. However, unlike the TKL model, no intersection is calculated between this trend and a reference value. In general therefore, the Trend calculation definitions input screen is similar to that of the TKL model. The main difference is that there is no equivalent input tab for “TKL output dates”. For more information on the principles and use of this type of model, see section 7.4.

9 The bank analysis model

9.1 Bank analysis model description

MorphAn offers a bank analysis model for the analysis of depth data. The tool uses soundings, grid measurements, real and generated profile measurements [section 5.6], plus a predefined critical slope value, to create a chart and a map that show where the seabed slope exceeds the critical value. This model also enables you to import and visualize “landfills” (seabed fill areas) and “bottom protections” (seabed protection material).

You can add a bank analysis model to your MorphAn workspace at any time. In the **Project explorer**, right-click on the **MorphAn work space**. A context menu appears. Click the option **Add new model**, and the “Select model” screen will appear. Select **Bank analysis model**, then click **OK**, and a bank analysis model will be added below the last model in the workspace [Figure 9.1]. We will now review the model’s settings, input and output.

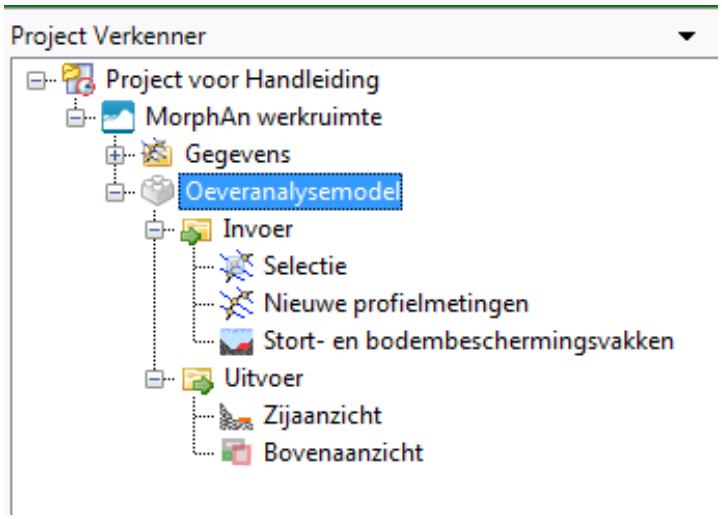


Figure 9.1: *A bank analysis model in the project explorer*

9.2 Bank analysis model settings

Each bank analysis model has its own settings. To edit these settings, select a bank analysis model in the project explorer. In the **Properties** window (Figure 9.2), you can now view and if necessary modify the **Critical slope** and selected profile measurement set used by the model. Seabed slopes that exceed this critical slope will be highlighted in the output of the bank analysis model [Figure 9.6]. The **Critical slope** is a positive (absolute) value. This makes it plain whether a slope is excessive, regardless of whether the slope is upward or downward.

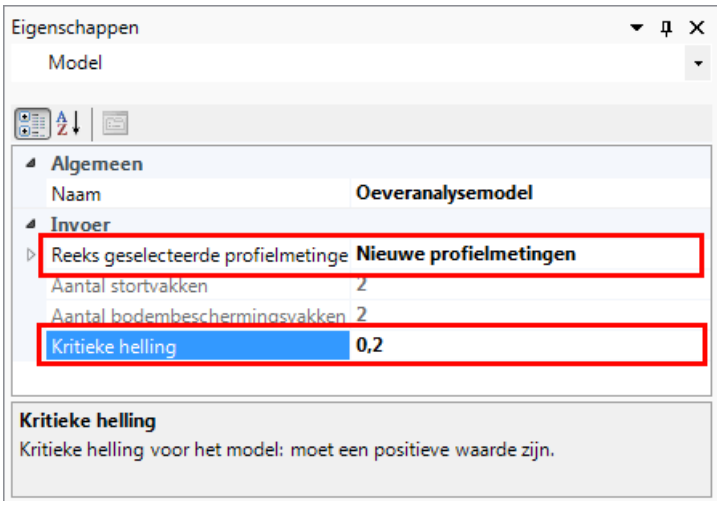


Figure 9.2: *Properties of a bank analysis model*

9.3 Bank analysis model input

The input to a bank analysis model is the set of profile measurements that are to be analyzed. These profile measurements and the selection for the analysis are specified as described earlier in section 2.4.1.

In a bank analysis model, the landfill and bottom protection areas can be displayed on an interactive map and in a cross-sectional view. To import landfill and bottom protection areas into the model, in the **Project Explorer** right-click on **Landfill and bottom protection** in the Input folder of the model. Then select **Import...** in the context menu [left side of Figure 9.3].

You will then be prompted to select the type of data: **Bottom protection area (*.txt)** or **Landfill area (*.txt)** [right side of Figure 9.3]. Select the data type, click **OK**, and after you have selected the necessary files, they will be imported. Section A.10 describes the required file format for this landfill and bottom protection data.

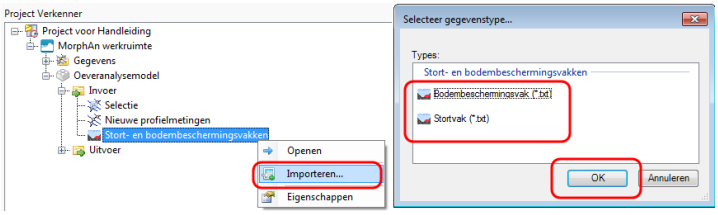


Figure 9.3: *Left: selecting* ***Import...*** *in the* ***Project Explorer****.*
Right: ***Selecting data type...***

For a plan view of the landfill and bottom protection areas imported into the model, double-click on the **Landfill and bottom protection** item in the **Project explorer** [Figure 9.4]. These areas are also displayed in the output [section 9.5].

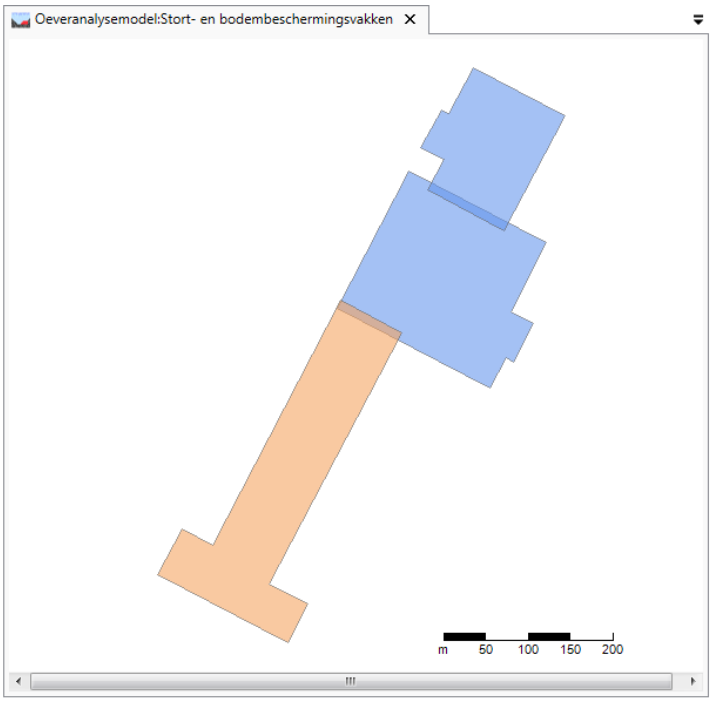


Figure 9.4: *Plan view of landfill (orange) and two bottom protection areas (blue).*

9.4 Running the bank analysis model

Once the input is in order [section 9.3], the model can be run. To run the model, right-click on the bank analysis model in the **Project explorer** and select **Run Model** [Figure 9.5].

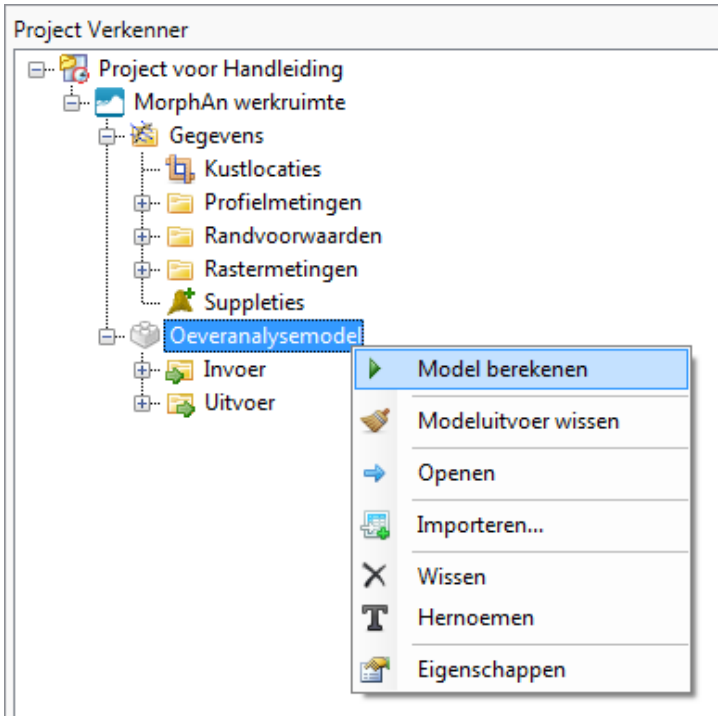
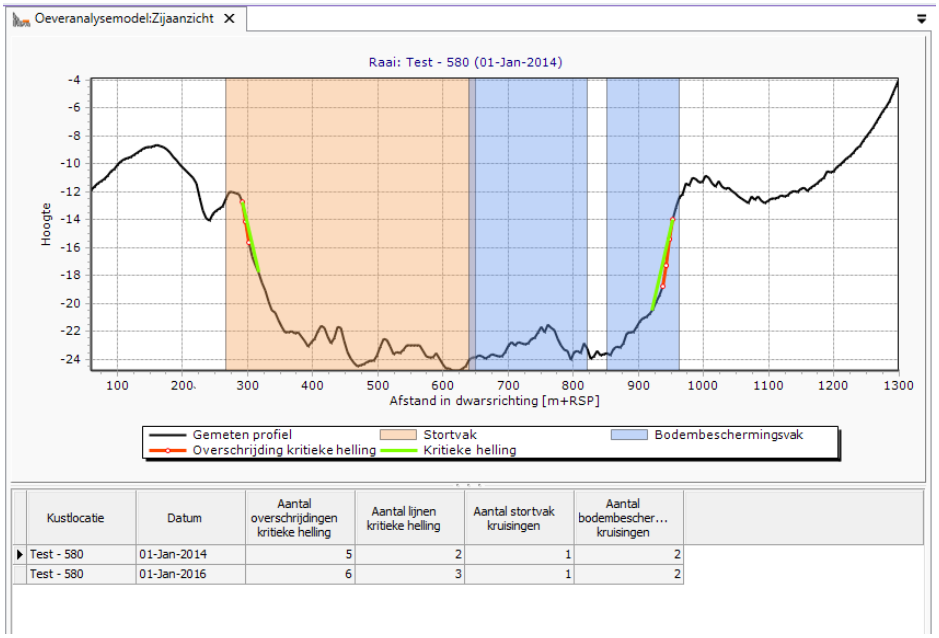


Figure 9.5: *Selecting **Run Model** option from right-click context menu of **Bank analysis model**.*

9.5 Bank analysis model output

9.5.1 Bank analysis result side view

When the bank analysis model has run, you can display the side view: double-click **Side view** in the **Project explorer**.
Figure 9.6 shows the side view of a successfully run model. The colored areas represent the landfill and bottom protection areas. In this example it is clear that the critical slope is exceeded in two places. With the information in this chart showing where the critical slope (here in green) is exceeded, you can now determine whether the problem is serious.
The table below the side view gives for each location (transect) the date, plus a count of: segments exceeding critical slope; critical slope lines; landfill crossings; and bottom protection crossings.



Kustlocatie	Datum	Aantal overschrijdingen kritieke helling	Aantal lijnen kritieke helling	Aantal stortvak kruisingen	Aantal bodembescher... kruisingen
Test - 580	01-Jan-2014	5	2	1	2
Test - 580	01-Jan-2016	6	3	1	2

Figure 9.6: *Side view of a profile measurement in the bank analysis model.*

9.5.2 Bank analysis result plan view

When the bank analysis model has run, you can display the plan view: double-click **Plan view** in the **Project explorer**.
Figure 9.7 shows (left) the output plan view of a successfully run model. The colored areas represent the landfill and bottom protection areas. You can also clearly see which profile measurements have excessive slopes.
The right side of the figure shows the corresponding side view that appears after selecting a profile in the plan view (in this case 700; the selection is visible as a blue square at the bottom of the profile).

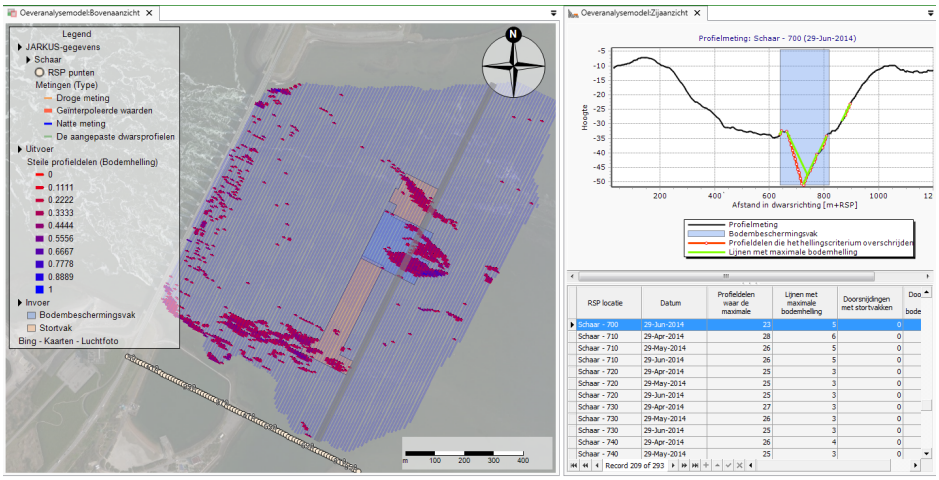


Figure 9.7: *Typical visualization of results of a bank analysis model, showing both plan and side view.*

10 Additional installation options

Your MorphAn installation offers three optional features that are not automatically present in the default installation. Two of these optional features are available in prototype form. The optional features are:

- ◇ Section 10.1 describes the Scripting feature of MorphAn.
- ◇ Section 10.2 describes the XBeach 1D modelling option in MorphAn.

Because XBeach 1D and Scripting are still in a prototype phase, this user manual does not include a comprehensive description of these features. However, a brief explanation of these features is provided below. The added functionality provided by the Bank Analysis tool is described in section 5.6 (automatically create profile measurements from one grid measurement set) and chapter 9 (bank analysis model).

10.1 Scripting

The scripting plug-in enables you to write MorphAn scripts in the programming language Python. In theory you can call any function that is already programmed in the software but has no command (icon or shortcut) in the user interface. For example, it is possible to add measurement data to graphical output, compare results between different models, or export data in a format not yet defined in MorphAn.

If the scripting plug-in has been added to MorphAn, then the corresponding items will be visible in the **Toolbox** tool window. This window is where you manage your scripts. You will also see a **Scripts** tab in the MorphAn ribbon. This tab contains many tools to ease the process of writing, editing and running scripts. Under the Scripts item in the toolbox you will also find several example scripts that can help you get started with writing your own scripts.

10.2 XBeach 1D

The XBeach plug-in installs the XBeach (Kingsday) model with cross-shore 1D functionality. This functionality makes use of the corresponding WTI settings. When activated, this plug-in adds a new model to the project. The **Input** folder of this model contains the following items:

- ◇ **Profile** - Specifies the input profile (and optionally the structure). In this item you can also edit the definition of the calculation grid.
- ◇ **Waves** - Contains a time series of wave conditions (specified in the form of a spectrum).
- ◇ **Tide** - Specifies the periodicity in the water level. The document window of this item also enables you to generate or import a tide.
- ◇ **Parameters** - Specifies the duration of the modeling cycle, plus material characteristics, such as the grain diameter of the sand.
- ◇ **Output specification** - Specifies the required output variables, as well as the time intervals and locations where they must be output.

The **Output** folder contains the following items:

- ◇ **Cross-shore** - Shows in cross-section the results of the model (for a specific moment in time).
- ◇ **Time series** - Charts the development of the results of the model at a single location against time.
- ◇ **Point(s)** - Charts the development of the modeled point against time.
- ◇ **Runup** - Charts the movement of the waterline over the duration of the modeling cycle.

Apart from the individually-specified model, you can also generate a model from within an existing MorphAn WorkSpace. There are several places where this is possible:

- **From the analysis selection screen** - If the XBeach 1D plug-in is installed, there will be a button in the **Data** tab of the ribbon that you can use to create XBeach 1D models. First, select the required locations and years, just as you do when opening an analysis window [section 4.2.1], then click on this button. MorphAn will then create an XBeach 1D model for each selected measurement.
- **Transect selected on the map** - When you have opened a map from the analysis window [section 2.6], you can select individual transects directly on the map. With a selection activated, the context menu enables you to generate an XBeach 1D model for each selected profile. The context menu appears when you right-click with the cursor on the map.
- **Erosion points** - After running the erosion model, open the “Erosion results” in the document window [section 6.3.3]. In the results table, select one or more transects and right-click above the selection. The context menu then offers the option to create XBeach 1D models based on the calculation result. In this case, in addition to the input profile, the water level, D_{50}, wave height H_s and wave period are automatically filled.
- **Erosion result on the map** - With the Safety overview open in the document window [section 6.6], you can select one or more results on the map. Right-click above the selection to open the context menu, and select the option to create XBeach 1D models for the selected results. Just as with the erosion points method, the created models contain all required parameters.

11 Release notes

11.1 MorphAn 1.10.1

- ◇ The long wave height is added to the output of the XBeach model.
- ◇ A Bug related to the layers in the dune safety model is solved. As a consequence, the line in the plan view of the dune safety model is not saved. Only the individual points are saved.
- ◇ A bug related to generating profiles from a raster is solved. When generating a raster the profile measurement set is given the specified name.
- ◇ In the wizard the user has the option to import profiles and location from a new file format. This new file contains information about the profiles and the locations.
- ◇ A bug related to the input of the models and boundary conditions is solved. It is possible to open a model, which does not contain any boundary conditions.
- ◇ A new export is added. The functionality is added to export profiles and locations to one file.
- ◇ A new interpolation method is added to the generating profile functionality.
- ◇ When generating profiles from rasters, the user can select locations based on a the map view.
- ◇ The default website is adjusted on the homepage.

11.2 MorphAn 1.9.0

- ◇ Update of the english user manual.
- ◇ Import of nourishments is added to the wizard.
- ◇ A Bug related to the legend in the nourishments map is solved.
- ◇ A bug related to the empty screen at the boundary conditions is solved.
- ◇ A export of profile measurements is added, where the user can export profile measurements from multiple years to one file.
- ◇ The function to apply constant values in the volume model is removed. This functionality is present in the folder boundary conditions of the data model.
- ◇ A bug related to the input of the models and boundary conditions is solved. It is possible to open a model, which does not contain any boundary conditions.
- ◇ Functionality added to select all the profiles in the profile generator.
- ◇ The offset is added to the xyz export.
- ◇ The date of the dry and wet measurements is visible in the properties screen of the coastal development model.
- ◇ In the functionality of the boundary conditions to apply constant values, it is visible whether the columns already contain a constant value and which values this is.

11.3 MorphAn 1.8.3

11.3.1 Changes

- ◇ An export feature has been added to the profile measurements. This enables profile measurements to be exported to .xyz files. A selection of profile measurements can also be exported to .xyz or .jrk.
- ◇ The label in figures can be modified in the options. This allows the user to modify the default axis label ‘M+NAP’ or ‘M+RSP’ to indicate a different reference.
- ◇ The labels ‘M+NAP’ and ‘M+RSP’ in tables and screens are replaced by simply ‘m’.
- ◇ A ‘delete’ button has been added to the selection of the TKL output points.
- ◇ The boundary conditions are divided into a separate sub-folder per type of model. This selection also applies to the input to the models, so that only compatible boundary conditions for that model can be selected.
- ◇ The options and wizard for MorphAn workspace setup have been modified to support the

distinction between the three types of boundary condition. The options now enable three different folders to be specified for the wizard to search for Boundary conditions (for each type of model).

- ◇ A map has been added for visualization of Boundary conditions. The horizontal boundaries can be shown as lines on the map (horizontal boundaries, Xgp and Dune row). Locations with corresponding boundary conditions are now indicated on the map with an additional symbol.
- ◇ In the Dune safety model, the values in the boundary conditions (Rp, Hs, Tp, Tm-1.0, D50) can also be represented on the map view as bar charts. The user can modify the bar chart properties.

11.3.2 Compatibility aspects

- ◇ **Opening old projects** - This version of MorphAn can also open projects saved with earlier versions of MorphAn (MorphAn 1.2 or later). A selection screen will open in which the user must specify which boundary conditions belong to which model.

11.4 MorphAn 1.6.1

11.4.1 Changes

- ◇ The MorphAn workspace has been reprogrammed to make it easier to select locations and quickly load the corresponding boundary conditions. The formats of the location files have also been modified, so that there are no limitations on the use of MorphAn for coastal areas other than the original 17 Dutch coastal areas.
- ◇ Another change concerns the storage location for data included with MorphAn. This is now stored in the folder $<$..\Users\Public\Documents\MorphAn\Data $>$. New data is also added in the form of nourishment data, location files and landward boundaries of flood defenses, and HR (hydraulic boundary conditions) for dune erosion calculations based on the breach probability as per the assessment norm.
- ◇ The location manager, with which locations can be added or edited, has been extended to support the new functionality.
- ◇ Multiple instances of the same message are now bundled to improve readabilty and increase the speed of MorphAn.
- ◇ Improvements have been made to the qualitative information related to the results of the boundary profile model and the Normative model. This concerns output in the form of a table and the use of icons in the chart.
- ◇ XBeach calculations now use the XBeach Kingsday version, with WTI settings assumed.
- ◇ Various bugs have been resolved.

11.4.2 Compatibility aspects

- ◇ **Opening old projects** - This version of MorphAn can also open projects saved with earlier versions of MorphAn (MorphAn 1.2 or later).

11.5 MorphAn 1.6

11.5.1 Changes

MorphAn 1.6 includes a number of improvements, which are summarized below:

General

- ◇ Improvement in Location files and their import (*.grd)

11.5.2 Compatibility aspects

- **Opening old projects** - This version of MorphAn can also open projects saved with earlier versions of MorphAn (MorphAn 1.1 or later).

11.6 MorphAn 1.5

11.6.1 Changes

MorphAn 1.5 makes it easier to generate intermediate transects for the purpose of safety assessment. The new version also includes many improvements and optimizations. These are summarized below.

General

- Improved rendering of grid data on maps.
- Improved refreshment rate for several tables to improve speed.
- Offset column (optional) added to tables with coastal locations, to make it easier to sort and filter.
- Bug fix for critical error that sometimes occurred when importing grid data.
- Ability to split boundary condition files
- Inclusion of new HR (WTI2017) draft figures and HR for coastline care.

Generation of profile measurements

- Map view added for all imported grid measurements.
- Simplified generation of profile measurements based on grid data [section 5.7]. This tool can use various grid measurements to create sets of profile measurements. The tool also supports the process of defining intermediate transects and using these to generate profile measurements. The user can specify the moments in time for which the new profile measurements are to be generated. Any resulting new locations or profile measurements can be stored directly in a file.
- The tabs in the Ribbon have been modified to replace references to “JARKUS” with “Data”. A new “Profile generation” tab has been added to the ribbon to further simplify the generation of profile measurements.

Safety assessment

- Take the first dune row into account when calculating a boundary profile.
- Bug fix to improve synchronization between results.
- “Export to Ringtoets” button has been removed. This no longer worked after modifications to Ringtoets.

Coastline care

- Expected coastline (TKL) model now runs for default period of 5 years instead of 1 year.
- Initially hide erroneous results in time-dependent charts (e.g. change in calculated MKL over time).
- Bug fix to prevent error message when editing the start or end year for determining the trend in a volume development model.
- Modified default colors for nourishments.
- The calculated trend in volume development has been removed from the export results of the TKL model due to the many issues it raised.

11.6.2 Compatibility aspects

- **Opening old projects** - This version of MorphAn can also open projects saved with earlier versions of MorphAn (MorphAn 1.1 or later).

11.7 MorphAn 1.4

11.7.1 Changes

MorphAn 1.4 contains a **bank analysis tool**. The major difference in this version is the ability to analyze seabed slopes in MorphAn. Several new features have been added for this purpose:

- The first is the ability to import **Grid measurements** into the Data folder of a MorphAn workspace. These measurements can be analyzed on the basis of the measured height, the difference between the measured heights at two moments in time, and the seabed slope between two adjacent grid cells.
- Another new feature is the **automatic generation of profile measurements** based on the imported grid measurements. These profile measurements can then be evaluated and analyzed using the regular tools.
- A new model has also been added to identify points in a set of profile measurements where a slope angle is exceeded, based on a pre-specified maximum seabed slope criterion, plus (if applicable) the position of existing seabed protection and/or seabed fill areas. The results are visualized in both cross-section and plan view.

MorphAn 1.4 has also been extended with the ability to read data directly from PDOK services (government mapping data services). Three types of web services are available via the PDOK website. These are comparable to the services that will be available after the Landelijke Opslag Lodingen (national hydrographic database) is made accessible to the public. A link is provided to two types of services:

- **WMS** (Web Map Service). The user invokes the WMS by specifying a geographical area. The WMS then provides an image that visualizes the requested information. MorphAn 1.4 incorporates a link to the following WMS representations on PDOK (although entering a different WMS link will also give a result). These complement the existing links with OpenStreetMap, Bing layers and the Rijkswaterstaat geoserver:
  - National topographical map (AHN1)
  - National topographical map (AHN2)
  - National topographical map (AHN3)
  - BAG (*national basic register of addresses and buildings*)
  - Protected nature conservation areas
  - Administrative boundaries
  - CBS Bestand Bodemgebruik 2008 (*land use data*)
  - CBS Bestand Bodemgebruik 2010 (*land use data*)
  - CBS Bevolkingskernen 2008 (*population centers*)
  - CBS Bevolkingskernen 2011 (*population centers*)
  - CBS Gebiedsindelingen (*administrative boundaries to municipality level*)
  - CBS Provincies (*provinces*)
  - CBS Wijken en Buurten 2009 (*districts and neighborhoods*)
  - CBS Wijken en Buurten 2010 (*districts and neighborhoods*)
  - CBS Wijken en Buurten 2011 (*districts and neighborhoods*)
  - CBS Wijken en Buurten 2012 (*districts and neighborhoods*)
  - CBS Wijken en Buurten 2013 (*districts and neighborhoods*)
  - CBS Wijken en Buurten 2014 (*districts and neighborhoods*)
  - Rural cycling routes

- Long-distance hiking routes
- Mussel and oyster habitats
- Mussel spawn
- Natuurmeting Op Kaart 2010 (*map of natural landscape*)
- Natuurmeting Op Kaart 2011 (*map of natural landscape*)
- Natuurmeting Op Kaart 2012 (*map of natural landscape*)
- Natuurmeting Op Kaart 2013 (*map of natural landscape*)
- Natuurmeting Op Kaart 2014 (*map of natural landscape*)
- NWB - Spoorwegen (*national railway map*)
- NWB - Vaarwegen (*national waterway map*)
- Surface water bodies
- Town and country planning
- Dredging disposal sites
- Vaarweg Informatie Nederland (*waterway information*)
- Road data
- Wetlands

◇ **WCS** (Web Coverage Service). A WCS service is similar to a WMS, but it provides numerical data, rather than images. MorphAn 1.4 includes an initial implementation of the link between MorphAn and the PDOK WCS. This method enables grid measurements to be added to the project directly from the service. The user must indicate which service is to provide the data to be downloaded, and then specify the required area. The grid data is then downloaded. After the grid data has been added to the workspace, the user can start using the grid measurement as if it were imported from a file.

11.7.2 Compatibility aspects

◇ **Opening old projects** - This version of MorphAn can also open projects saved with earlier versions of MorphAn (MorphAn 1.1 or later).

11.8 MorphAn 1.3

11.8.1 Changes

◇ **Dutch-language interface** - The principal change in MorphAn 1.3 is the translation of the interface into Dutch. This is reflected in all visible parts of the interface, but also in e.g the message log.

◇ **Modification of the boundary profile model** - in addition to the plan view, MorphAn 1.3 also contains a side view for designing a boundary profile. This extends and improves the functionality in two ways [section 6.4]:

- **More control over the profile shape** - First of all, the user now has more control over the shape of the geometric boundary profile. In addition to the default shape, there is now a choice of a fixed crest height, a fixed crest width, or a specific back slope. The geometric boundary profile will then be made to fit while maintaining this custom definition, but with the same volume. If this proves impossible, then there is also the option to fit the boundary volumetrically.
- **Clearer definition** - The side view now also includes a visualization of the cross-shore profile of the specified boundary profile. Among other things, this visualization indicates the location of the transect in the plan view. This makes it easier to interpret the significance of this anchor point (does it lie on the back side of the boundary profile, or in fact on the front side at ground or storm surge level?).

11.8.2 Compatibility aspects

The following considerations apply to compatibility between versions:

- **Opening old projects** - This version of MorphAn can also open projects saved with earlier versions of MorphAn (MorphAn 1.1 or later).
- **Opening old projects in Dutch** - If MorphAn is launched in Dutch, then it is still possible to load old projects. These will have been saved with an older, English version of MorphAn. Some parts of the project tree (e.g. model names) will probably still be in English. However, model settings will be preserved, and the results of calculations will be unchanged.
- **Opening projects with a boundary profile model** - Projects saved with an older version of MorphAn can also contain boundary profile models. In the new version, the specification of the boundary profile is divided into a side view and a plan view specification. Old settings will be transferred to the correct place, and settings that were not previously present will be set such that the calculation results are unchanged (the default geometric profile as described in TRDA2006 will be assumed).

11.9 MorphAn 1.2.3

- **Various bug fixes**
  - Error messages no longer appear when MorphAn is installed on a computer with other software that uses the same version of GeoAPI.
  - Units are displayed in a consistent way in the various screens.
  - “BKL intersection date” in properties tool window is now displayed correctly.
  - The normative results now show the correct points on the boundary profile.
- **Improved loading of old projects** - When loading an old project, MorphAn now prompts for whether that project needs to be converted into a newer version. If the user confirms this, the project will immediately be saved. This prevents the project from getting stuck in some intermediate state.
- **Improved location selection** - All screens where locations can be selected now have two columns showing selected and unselected locations (instead of all locations).
- **Improved synchronization of output screens** - When selecting an MKL or Erosion result, the corresponding TKL point or normative result is also displayed.
- **Automatic nourishment type selection removed** - The option to “automatically” select nourishment types has been removed from the settings screen for the “Trend Period Model”. New buttons have been added to “Select all types” or “Unselect all types”. See also section 7.3.2
- **Modified trend period definition screen for the Expected Coastline Model** - The “Trend period definition” screen has been modified to show only one table. Trend period start and Trend period end are no longer part of the boundary conditions. The trend period is now part of the model, and it can be exported or imported into other models (e.g. other “Expected Coastline” models or “Volume trend” models). See also section 7.4.2
- **Ruler tool in charts** - Virtually all charts now have a “Ruler” as a distance guide when viewing the charts.

11.10 MorphAn 1.2

- ◇ **Profile measurements manager**
- ◇ **RSP location manager**
- ◇ **Boundary profile model**
- ◇ **Export results to Ringtoets**
- ◇ **Coastal development model** - years to skip, exporter
- ◇ **Scripting - prototype**
- ◇ **XBeach 1D prototype**

11.11 MorphAn 1.1

- ◇ **Transect editor**
- ◇ **TRDH2011 / TRDA2006 settings**
- ◇ **Nourishments database**
- ◇ **Trend period model**

11.12 MorphAn 1.0

First official release

References

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Donchyts, G. and B. Jagers, 2010. "DeltaShell-an open modelling environment." In *Internafional Environmental Modelling and Software Society (iEMSs) 2010 Internafional Congress on Environmental Modelling and Software*.

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A Imported file formats

A.1 Format of coastal location files

Each record in a location file contains fields that specify coastal areas and locations. An explanation of these fields is given in Table A.1. The location file can be provided either as a comma-separated value file with the extension <.grd>, or as a shapefile. Examples of both types of files are installed in the public documents [section 1.3].

Field name	Unit	Required	Description
ID	[-]	yes	Location ID
AreaId	[-]	yes	Area ID
Area (Gebied)	[-]	yes	Area name (see remark below)
Offset (Metrering)	[m]	yes	Location position within area
x	[m]	yes	x coordinate
y	[m]	ja	y coordinate
Angle (Hoek)	[deg]	yes	Transect angle
Section (Transect)	[-]	no	Section of flood defense
Measure (Meting)	[-]	no	Type of profile measurement
Authority (Overheid)	[-]	no	Flood defense authority
Country (Land)	[-]	no	Country name
Department (Provincie)	[-]	no	Department name
Community (Gemeente)	[-]	no	Community or Municipality name
Watername (Waternaam)	[-]	no	Name of water system

Table A.1: *Properties of location files, applicable from MorphAn 1.6.1*

The following conditions apply to a location file:

- ◇ Several fields can use either an English or Dutch field name. The Dutch names are shown in brackets () in the field name column of Table A.1.
- ◇ Only the required field names need to be present
- ◇ The field names are not case sensitive.
- ◇ The decimal separator must be a period (.) - and *not* a comma (,).
- ◇ Each “AreaId” must have a unique name in the field “Gebied”.
- ◇ If the location file contains other field names, then it will not be imported.

Location files in <.grd> format must also comply with the following additional conditions:

- ◇ The first record in the file (header row) contains the field names in separate columns
- ◇ The subsequent records contain a new row for each location in which the columns correspond to the field names in the header.
- ◇ Columns are separated by a *semi-colon* or *tab*

The format specification above for location files is applicable from MorphAn version 1.6.1. Location files created for earlier versions of MorphAn can still be imported. Because earlier location files did not contain the field “Gebied”, for records with AreaId from 1 - 17 this field is automatically filled with the names of the 17 Dutch coastal areas as per Table A.2.

AreaId	Area
1	Rottum
2	Schiermonnikoog
3	Ameland
4	Terschelling
5	Vlieland
6	Texel
7	Noord - Holland
8	Rijnland
9	Delfland
10	Maasvlakte
11	Voorne
12	Goeree
13	Schouwen
14	Neeltje-Jans
15	Noord-Beveland
16	Walcheren
17	Zeeuws-Vlaanderen

Table A.2: *Area names inserted when field "Gebied" is not supplied*

A.2 Format of profile measurement files

Annual coastal measurements can be imported in a <.jrk> file. An annual coastal measurement can consist of three sub-measurements (a depth sounding, a height measurement and possibly an interpolated segment to link these two to each other). MorphAn adds a fourth type of measurement: a modified profile segment. This makes it possible to save modified profiles in <.jrk> format, and re-import them at some point in the future, without losing the original data. Below is an extract from the contents of a profile measurements file.

```
5 1995 4808 0 1204 108 285
-750        3561        -745        3701        -740        3851        -735        3631        -730        3431
-725        3391        -720        3421        -715        3541        -710        3801        -705        3651
-700        3411        -695        3691        -690        3711        -685        3431        -680        3141
-675        3081        -670        3071        -665        2971        -660        2981        -655        2941
-650        2901        -645        2831        -640        2781        -635        2751        -630        2741
-625        2741        -620        2731        -615        2721        -610        2731        -605        2701
-600        2651        -595        2621        -590        2641        -585        2661        -580        2691
-575        2711        -570        2701        -565        2811        -560        2851        -555        2801
-550        2781        -545        2751        -540        2711        -535        2781        -530        3201
-525        3111        -520        2791        -515        2581        -510        2571        -505        2641
-500        2731        -495        2721        -490        2691        -485        2601        -480        2581
-475        2651        -470        2701        -465        2641        -460        2671        -455        2641
-450        2781        -445        2931        -440        3111        -435        3161        -430        3111
-425        3321        -420        3521        -415        3111        -410        3211        -405        3451
-400        3631        -395        3721        -390        3791        -385        3911        -380        3431
-375        3681        -370        4121        -365        4111        -360        3921        -355        3771
-350        3751        -345        3561        -340        3361        -335        4471        -330        5601
-325        5661        -320        5041        -315        4441        -310        4791        -305        5621
-300        5961        -295        6291        -290        5681        -285        5521        -280        5311
...
```

A profile file contains multiple sets of records, with each set comprising a profile attribute record containing seven values, followed a block of records with profile data. Below is an example of a profile attribute record:

```
6 2008 900 0 1904 205 219
```

The profile attribute record contains the following values:

AreaId	In this example: 6.
Year	Year the profile was measured. In this example: 2008.
Transect number	Offset of the location in decameters. In this example: 900 decameters.
Profile code number	Code indicating the measurement type. The possible codes are: ◇ an annual cross-shore measurement profile ◇ a groyne transect (aligned with the groyne) ◇ an auxiliary groyne transect (immediately beside the groyne)
Date of height meas.	Date of height measurements of beach and dune in format ddmm. In this example: 1904, which means April 19.
Date of soundings	Date soundings were taken in format ddmm. In this example: 205, which means May 2.
Number of Points	The number of XY measurements for this profile. In this example: 219.

The profile attributes record is followed by a block of profile data, i.e. XY measurements. The XY measurements are provided in the sequence: X[1], Y[1], X[2], Y[2], etc. X is in meters with respect to the offset point (zero point of a coastal location), with a positive value indicating seaward, and negative being landward direction (any decimals must be entered with a period as decimal point). Y is in centimeters with respect to NAP. A code number is appended to the Y value. 7001 means Y = NAP 700 cm with code number 1. This code number indicates one of the following:

1 Height measurements (by optical leveling).
2 Height measurements, for which sounding data from the same area are present in the file.
3 Manually-added interpolated values in the zones where leveling and sounding data overlap.
4 Soundings, for which height measurements from the same area are also present in the file.
5 Soundings.
6 Modified coordinate.

For the file to be correctly imported, it is important to take account of the following points:

◇ There is no fixed number of XY values per record. The number of XY pairs can also vary from record to record. However, it is important that both the X and Y value of any pair are in the same record.
◇ XY-values with code numbers 1 and 2 are imported as individual measurements. The same applies to XY-values with code numbers 4 and 5. When creating the composite profile, XY values with code 2 or 4 are ignored.
◇ Empty records are allowed.
◇ X values may be decimals with a period (.) as decimal separator.

A.3 Formaat samengevoegd locatie- profiel bestand

The Combined locations- and profile file contains the data of both the locations and the profiles in one file. The format of this file is:

```
# profile measurements
# x: distance w.r.t. RSP
# z: elevation
# Measurement_type: Dry=0,Wet=1,Interpolated=2,JarkusMeasurement=3,ExtendedGroin=4,HelpGroin=5,Edited=6
Nprofiles=3
Area Id=7;7;7;
year=2016;2016;2016;
Offset=20;30;50;
```

```
Xrsp=110133;110100;110035;
Yrsp=551820;551725;551535;
Anglersp=288.9;288.9;288.9;

x;z;Measurement_type;date;x;z;Measurement_type;date;x;z;Measurement_type;
-100;1;0;2016-01-01;-100;20;0;2016-05-01;-100;5;1;2016-02-01;
-50;0.5;0;2016-01-01;-100;19;0;2016-01-05;-100;5;1;2016-02-01;
...
```

The meta data is given in the four first lines. The number of profiles is indicated by the Nprofiles keyword followed by the location data. A location is defined by a x and y coordinate of the RSP point and an angle. In addition the offset, year and area id is given for each location.

The data of the profiles is given by a matrix, where each profile is represented by four columns. The first columns contains the distance with respect to the RSP point. The second column contains the corresponding depth. The third and fourth columns show the date and measurement type.

A.4 Format of boundary condition files

A boundary conditions file contains a table with boundary conditions per transect. An example of a typical boundary conditions file is shown on the next page. When creating a boundary conditions file, take account of the following points:

- ◇ All records that begin with an asterisk (*) will not be imported (and are therefore treated as comments).
- ◇ MorphAn will attempt to interpret the first record that does not begin with * as a list of keywords. This list defines the column order for the boundary conditions provided in the table.
- ◇ There is no predefined column order.
- ◇ The table must contain at least the columns **Kv** and **Nr**. Without these columns, boundary conditions cannot be linked to a location.
- ◇ An asterisk (*) is treated as “undefined”. In that case, the existing value in a boundary conditions set will not be modified.
- ◇ Decimal values must use a period (.) as decimal separator.
- ◇ Columns must be separated by a tab.
- ◇ A value for the D50 can be supplied in [m], but also in [μm]. Any value less than 1 is assumed to indicate a grain size value specified in [m].

If no keyword record is supplied in the file (or this record begins with *), then the default column order is assumed:

Kv Nr Hs Tp Rp D50 Go Dvt Xgp Xgp200 Xkz Xbzz S1 S2 L Ho La Jr1 Jr2 BKL Xafkap Xzeemkl X1 Xz Yo Yb Xp d

Table A.3 provides a summary of the possible keywords in a MorphAn boundary conditions file. Beside each keyword, the table gives the name of the boundary condition as used in the interface, plus a brief explanation.

Kv	Nr	Hs	Tp	Rp	D50	d	Go	Xgp	Ho	La	Jr1	Jr2	JrEx1	BKL	Xlandmkl	Xzeemkl	X1	Xz	Yo	Yb
5	4000	10.7	17.1	4.2	197	*	*	*	3	-5.16	2001	2010	*	60	* *	-420	1200	*	*	
5	4020	10.7	17.1	4.2	197	*	*	*	3	-5.16	2001	2010	*	60	* *	-480	1200	*	*	
5	4040	10.7	17.1	4.2	197	*	*	*	3	-5.16	2001	2010	*	70	* *	-460	1200	*	*	
5	4060	10.7	17.1	4.2	197	*	*	*	3	-5.16	2001	2010	*	100	* *	-220	1200	*	*	
5	4082	10.7	17.1	4.2	197	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4084	10.7	17.1	4.2	197	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4086	10.7	17.1	4.2	197	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4098	10.7	17.1	4.2	197	*	*	*	3	-5.16	2001	2010	*	105	* *	-190	1200	*	*	
5	4111	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4113	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4115	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4128	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	108	* *	-165	1000	*	*	
5	4140	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4142	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4144	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4158	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	76	* *	-160	1000	*	*	
5	4170	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4172	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4174	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4187	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	64	* *	-170	900	*	*	
5	4200	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4202	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4204	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4217	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	51	* *	-170	900	*	*	
5	4227	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4229	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4231	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4239	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	37	* *	-170	900	*	*	
5	4242	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4244	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4246	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4253	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	29	* *	-180	800	*	*	
5	4256	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4258	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4260	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4266	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	4	* *	-180	800	*	*	
5	4268	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4270	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4272	10.7	17.1	4.2	193	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4279	10.7	17.1	4.2	193	*	*	*	3	-5.16	2001	2010	*	18	* *	-160	800	*	*	
5	4283	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4285	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4287	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4293	10.7	17.1	4.2	192	*	*	*	3	-5.16	2001	2010	*	66	* *	-160	800	*	*	
5	4297	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4299	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4301	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4307	10.7	17.1	4.2	192	*	*	*	3	-5.16	2001	2010	*	81	* *	-150	800	*	*	
5	4312	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
5	4314	10.7	17.1	4.2	192	*	*	*	*	*	*	*	*	*	* *	*	*	*		
...																				

Table A.3: *Explanation of keywords in the <.bnd> file*

	Keyword	**Name in interface**	**Explanation**
	Kv	Coastal area number	Number of the coastal area to which the transect belongs
	Nr	Transect Location	Transect number (in decameters)
Dune erosion	Rp	Rp	Storm surge level [*m + NAP*]
	Hs	Hs	Significant wave height [*m*]
	Tp	Tp	Peak wave period [*s*]
	Tm	Tm-1.0	Spectral wave period [*s*]
	D	Depth	Water depth at position of Hs and Tp [*m*]
	D50	D50	Sand grain diameter at which 50% of the weight of a sample is fine [μm or *m*]
	XDnRij	Dune row	Position of first dune row. Dune breach seaward of this position will not cause the calculation to fail. [*m*]
	Go / G0	G0	Reference value for the transport difference of different classes of coast curvature [*m3/m*]
	Xgp	Xgp	Position of calculated fit of boundary profile [*m*]
	NrmJr1	Start year	Start year of Rt period of normative model
	NrmJr2	End year	End year of Rt period of normative model
MKL/TKL	Ho	Upper MKL boundary	Upper boundary of MKL slice in [*m + NAP*]
	La	Lower MKL boundary	Lower boundary of MKL slice in [*m + NAP*]
	Xlandmkl	Landward MKL boundary	Landmark boundary of MKL slice in [*m*]
	Xzeemkl	Seaward MKL boundary	Seaward boundary of MKL slice in [*m*]
	JrEx1	TKL start year	Start year from which the trend line is extended.
	BKL	BKL	Base coastline [*m*]
Volume	Yb	Upper volume boundary	Upper boundary of volume calculation in [*m + NAP*]
	Yo	Lower volume boundary	Lower boundary of volume calculation in [*m + NAP*]
	Xl	Landward volume boundary	Landward boundary of volume calculation in [*m*]
	Xz	Seaward volume boundary	Seaward boundary of volume calculation in [*m*]

A.5 Format of nourishment files

Nourishment data can be added by importing the data from a <.csv> file. This section describes the format required for this file. The <.csv> file contains a table in which each record in the file represents a new row, and the columns are separated by a comma (,). All decimal values must use a period (.) as decimal separator. MorphAn will not import any record starting with a hash (#). When importing a file, MorphAn assumes that the first record that starts without a hash contains keywords, indicating what value the corresponding column represents. The keywords in this record (separated by commas) must be the same as shown in Table A.4. MorphAn assumes that all keywords are present, and will refer to the keyword record for the sequence of the data columns in the file (so there may be other columns in the file). The file is then imported one record at a time. Any record containing an empty column will result in the value “Undefined” being assigned to the nourishment.

Table A.4: *Explanation of the keywords in the <.csv> file for import of nourishment data*

Keyword	Name in interface	Explanation
JaarBeginUitvoering	Start date	Year nourishment started
MaandBeginUitvoering	Start date	Month (number from 1 to 12) nourishment started
JaarEindUitvoering	End Date	Year nourishment ended
MaandEindUitvoering	End date	Month (number from 1 to 12) nourishment ended
Volume	Volume [m3]	Total volume of nourishment
KustVakNummer	-	Nourished coastal area number
BeginRaai	Start location	Transect number (in decameters) of the first transect of the nourishment
EindRaai	End location	Transect number (in decameters) of the last transect of the nourishment
Lengte	Length [m]	Actual length of nourishment in longshore direction
Type	Type	Description of type of nourishment
Opmerkingen	-	Free text field for comments regarding the nourishment

An example of a typical nourishment <.csv> file is shown on the next page.

```
#This is a sample file with several nourishments
#These first two records will not be imported by MorphAn
n_code,MaandBeginUitvoering,JaarBeginUitvoering,MaandEindUitvoering,JaarEindUitvoering,BeginRaai,EindRaai,Lengte,Type,Volume,Opmerkingen,KustVakNummer
612,4,1952,10,1952,34.00,34.40,400,underwater nourishment,50000,foreshore nourishment,16
611,1,1952,12,1952,32.60,33.40,800,beach nourishment,775000,,16
532,1,1953,12,1953,100.50,101.50,1000,beach nourishment,70000,,9
498,1,1962,12,1967,57.00,57.00,,beach nourishment,1500000,during extension of harbor groyne,7
581,1,1966,12,1966,15.00,17.00,2000,dune reinforcement,150000,"laying sand dyke with crest at NAP +6.0 m; temporary measure",12
613,1,1966,3,1966,34.00,34.40,400,underwater nourishment,32000,foreshore nourishment,16
582,1,1968,12,1968,13.00,15.00,2000,landward dune reinforcement,800000,,12
533,9,1969,10,1969,100.00,101.50,1500,beach nourishment,45000,,9
583,11,1969,3,1970,15.01,16.01,1000,beach nourishment,401000,1st nourishment: (R20),12
584,1,1970,12,1970,4.00,6.00,2000,dune reinforcement,200000,,12
534,1,1971,12,1971,115.70,118.75,3050,beach nourishment,18940000,,9
586,5,1971,9,1971,15.01,16.01,1000,beach nourishment,610000,2nd nourishment: for preservation of sand dyke 1965,12
654,5,1971,11,1971,0.40,0.85,450,beach nourishment,206000,,17
587,1,1972,12,1972,16.50,17.25,750,dune reinforcement,100000,,12
588,1,1972,12,1972,18.75,19.00,250,dune reinforcement,100000,,12
589,10,1973,2,1974,14.50,17.50,3000,beach nourishment,2300000,"see dune reinforcement 14.50-17.50;3rd nourishment; beach nourishment and dune reinforcement; loss (0.3)",12
687,10,1973,2,1974,14.50,17.50,3000,dune reinforcement,1000000,"see beach nourishment 14.50-17.50;3rd nourishment; strand and dune reinforcement; loss (0.3)",12
608,1,1973,12,1973,1.80,2.20,400,beach nourishment,210000,,15
568,1,1973,12,1973,10.50,12.50,2000,beach nourishment,250000,temporary measure,11
572,4,1974,4,1974,12.60,13.60,1000,beach nourishment,110000,temporary measure (1973-1975),11
571,9,1974,12,1974,12.60,13.60,1000,dune reinforcement and beach nourishment,110000,temporary measure (1973-1975),11
573,1,1974,12,1974,12.60,15.20,2600,beach nourishment,150000,,11
535,4,1975,8,1975,98.50,101.50,3000,beach nourishment,700000,with erosion buffer to NAP+3.3m,9
599,4,1975,4,1975,17.00,17.41,410,beach nourishment,112000,,13
615,1,1975,12,1975,34.00,34.40,400,beach nourishment,45000,,16
536,1,1976,12,1976,115.70,119.00,3300,beach nourishment,1500000,,9
590,1,1976,12,1976,18.50,19.00,500,dune reinforcement,50000,,12
499,9,1976,9,1976,12.98,13.75,775,dune reinforcement,342000,,7
537,1,1977,12,1977,115.70,118.75,3050,beach nourishment,870000,,9
591,11,1977,10,1979,5.75,9.75,4000,landward dune reinforcement,1600000,relief applied in 1979-1980,12
592,4,1977,7,1977,14.50,17.50,3000,beach nourishment,1267000,4th nourishment,12
575,10,1977,12,1977,8.80,12.50,3700,beach nourishment,1045000,"see depot 8.80-12.50",11
684,10,1977,12,1977,8.80,12.50,3700,depot,55000,"see beach nourishment 8.80-12.50",11
594,4,1978,6,1979,9.75,11.25,1500,landward dune reinforcement,2000000,relief applied in 1979-1980,12
471,6,1979,9,1979,1.60,2.20,600,beach nourishment,300000,,9
560,1,1979,12,1979,11.50,13.40,1900,beach nourishment,150000,,10
500,1,1979,12,1979,11.15,12.80,1650,dune reinforcement,470000,reinforcement of sea barrier - Callantsoog,7
485,9,1979,11,1979,25.60,31.20,5600,beach nourishment,3089668,with erosion buffer to NAP+4.5m,6
472,10,1980,12,1980,10.00,16.00,6000,seaward dune reinforcement,2200000,,3
538,1,1981,12,1981,99.00,101.00,2000,beach nourishment,10000,,9
539,1,1982,12,1982,99.00,101.00,2000,beach nourishment,15400,,9
576,10,1983,12,1983,11.60,14.40,2800,beach nourishment,440000,,11
595,8,1984,12,1984,14.50,17.50,3000,beach nourishment,330000,"5th nourishment; work halted",12
486,7,1984,12,1984,18.13,24.00,5870,beach nourishment,3021115,with erosion buffer to NAP+4.5m,6
577,1,1984,12,1984,8.00,14.00,6000,seaward dune reinforcement,3400000,"depot for seaward dune reinforcement; relief applied prior to June 1986",11
616,4,1984,4,1984,9.50,10.45,950,landward dune reinforcement,150000,,16
617,5,1984,6,1984,22.75,23.56,810,seaward dune reinforcement,90000,,16
540,3,1985,4,1985,98.75,101.25,2500,beach nourishment,250000,"see erosion buffer 98.75-101.25",9
681,3,1985,4,1985,98.75,101.25,2500,erosion buffer,80000,"see beach nourishment 98.75-101.25",9
...
```

Besides the <.csv> format, it is also possible to open a nourishment database saved in NetCDF format. This functionality has been added to facilitate the exchange of databases. Much data is available within the OpenEarthTools database (only in NetCDF format). It is not yet possible to use all this information generically in MorphAn. However, the nourishment database can be loaded. For a description of that format, please refer to http://www.openearth.eu. The NetCDF file with nourishments is produced using matlab code which is stored in a repository:

https://svn.oss.deltares.nl/repos/openearthrawdata/trunk/rijkswaterstaat/suppleties/convertSuppleties2nc.m

Access to this code requires a password that can be obtained via http://www.oss.deltares.nl

A.6 Format of filter files

MorphAn 1.6.1 still offers the option of applying a filter to locations. This feature is expected to be replaced in future versions. We therefore do not recommend the use of this feature. For users still wishing to work with the filter feature, this section provides necessary information describing the format of filter files.

A filter file is a <.csv> file that specifies a table with two columns, with values separated by a colon (*;*). The first record in the file is the header:

- ◇ The first column gives the coastal area of the location, indicated by “Kv”. This field is identical to field “AreaId” in the locations file.
- ◇ The second column specifies the offset of the location, indicated by “Nr”. This field is identical to field “Metrering” or “Offset” in the locations file.

The subsequent lines contain the values for the locations included in the filter. An example of a filter file is shown below:

```
Kv;Nr
5;4808
5;4825
5;4844
5;4862
5;4880
5;4898
5;4915
5;4933
5;4952
5;4970
5;4988
5;5005
5;5023
```

A.7 Format of years to skip <.csv> file

In the Normative Erosion model (part of the Dune Safety model, see also section 6.5) it is possible to specify per location which calculated erosion results (i.e. years) should be omitted from the visualization of the normative results. This data can also be exported and/or imported. The file format for saving these specifications is described below. The file is of type <.csv> with 3 columns separated by a semicolon (;):

- ◇ **Kv** - Coastal area number (= AreaId)
- ◇ **Nr** - Transect number (in decameters)
- ◇ **Kv** - Specification of years separated by commas (,)

The first record of the file must contain only the following string: “Kv;Nr;Years to skip”. There may be no empty lines between. The records that follow must all contain at least two semi-colons.

```
Kv;Nr;Years to skip
5;4988;
5;4808;2001,2004,2005,2006
5;4825;2001,2005,2006,1995
5;4844;2001,2004,2005,2006
5;4862;2001,2005,2006
5;4880;2001,2004,2005,2006
5;4898;2005.2006
5;4915;2001,2004,2006
5;4933;2001,2004,2005,2006
5;4952;2005.2006
5;4970;
5;5005;
```

A.8 Format of grid measurement files

Grid measurements can be added by importing the data from an <.asc> file. This section describes the format required for this file. The first records of the <.asc> file specify the grid properties, and the subsequent records provide all the height values of the grid. All decimal values must use a period (.) as decimal separator.

The following grid properties are specified:

- ◇ **ncols** - Number of columns with height values (only integers)
- ◇ **nrows** - Number of rows with height values (only integers)
- ◇ **xllcorner** - x-position of the first height values in the rows
- ◇ **yllcorner** - y-position of the height values in the last row
- ◇ **cellsize** - Distance between two adjacent grid points (same in both in x and y direction)
- ◇ **nodata_value** - This value means “treat this height measurement as non-existent”

The height values immediately follow the grid property records. Each record contains 4 columns separated by spaces. The height value of the grid point with x-position (xllcorner) and y-position (yllcorner) is the first value of the last record. The x-position of the grid point of the second to last record is (xllcorner + cellsize). The y-position of the grid point of the second value on a record is (yllcorner + cellsize).

Below is an example of the contents of an <.asc> file with grid measurements.

```
ncols        4
nrows        3
xllcorner     39890.00
yllcorner     407280.00
cellsize      0.50
nodata\_value  -9999
-9999 2 3 4.0
5 6 7 -9999
1 2 -9999 -9999
```

A.9 Format of location files for grid measurements

Profile measurements can be generated from grid measurements. In the **Project Explorer**, right-click on a **Grid measurement** set, and select **Create profiles...** from the context menu.

This starts a wizard which will prompt you to select transect definition files. The format of these files is shown below. This is a plain text <.txt> file of 7 columns separated by spaces, and with a period as decimal point. Records that start with " # ", " $ " or " > " are ignored.

- ◇ **raai** - Name of transect. MorphAn will try to use this name to determine the offset, by using the value in brackets, or in the absence of brackets, max. 6 digits from this value. Periods and commas are ignored.
- ◇ **Xb** - x-position of the starting point of the transect
- ◇ **Yb** - y-position of the starting point of the transect
- ◇ **offset1** - Distance between the starting point of the transect and the origin of the location
- ◇ **Xe** - x-position of the end point of the transect
- ◇ **Ye** - y-position of the end point of the transect
- ◇ **offset2** - Distance between the end point of the transect and the origin of the location

An example of a profile measurement definition import file is shown below:

```
#-------------------------------------------------------------------------------
#Export at 7-9-2012 13:37:35
#Linedatabase D:\USERDATA\...\OSK\General data\LineData\2002p_2102p_TOW.pro
#-------------------------------------------------------------------------------
#
#SINGLE LINES:
# column 1    2        3         4   5        6         7
#       Name Easting1 Northing1 KP1 Easting2 Northing2 KP2
#
# Axis Schaar (south-north)   :  z16 39118.54 407120.73 0.000 39769.32 408360.28 1.400
#
# e.g. longshore transect z16(-1600) = longshore transect 1600 in south-north direction, west of SKO
# e.g. longshore transect z16(1600)  = longshore transect 1600 in south-north direction, east of SKO
#
#Cross-shore transects Schaar
\$ -9999 [3223223]
>raai
>Xb
>Yb
>offset1
>Xe
>Ye
>offset2
z16(-1600) 37701.91 407864.48 0.000 38352.69 409104.03 1.400
z16(-1590) 37710.76 407859.83 0.000 38361.54 409099.38 1.400
z16(-1580) 37719.62 407855.18 0.000 38370.40 409094.73 1.400
z16(-1570) 37728.47 407850.53 0.000 38379.25 409090.08 1.400
z16(-1560) 37737.33 407845.89 0.000 38388.11 409085.44 1.400
z16(-1550) 37746.18 407841.24 0.000 38396.96 409080.79 1.400
```

A.10 Format of landfill and bottom protection area files

The Bank Analysis model allows the import of Landfill and bottom protection areas. The format of these files is shown below. This is a plain text <.txt> file of 3 columns separated by spaces and/or semicolons (;), and with a comma as decimal point.

- ◇ **X** - x-position of a polygon vertex (all decimal values must use a comma (, ') as decimal separator)
- ◇ **Y** - y-position of a polygon vertex
- ◇ **ID** - An integer that identifies the polygon

The polygons are composed of lines between the successive vertices with the same ID number. For the polygon to be closed, it is required that the first and last vertex of the same polygon have identical x and y positions. The first vertex is the record after the header record, or the first record with a different polygon ID number. The last vertex is determined when a different polygon ID number is encountered, or if end of file is reached.

Below is an example of a landfill or bottom protection area file:

```
X; Y; ID;
39704,49; 407118,12; 21;
39855,02; 407039,12; 21;
39878,24; 407083,37; 21;
39833,97; 407106,61; 21;
39987,35; 407398,74; 21;
39916,52; 407435,93; 21;
39767,79; 407152,65; 21;
39732,37; 407171,24; 21;
39704,49; 407118,12; 21;
```