Memo

To
Users of the ACDC tool

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Subject
Aggregation of Coastline Dynamics & Changes (ACDC) - Description and User Manual

1 Introduction

Different timescales are often relevant when conducting studies that focus on the dynamics and changes of coastlines (e.g. in coastal erosion or impact studies). An overview of different timescales and relevant processes/dynamics on coastline changes include (amongst others):

- Long term:
  - Gradients in alongshore sediment transport
  - Changes in large-scale sediment supply (e.g. fluvial or aeolian sediment supply)
  - Sea level rise, subsidence
- Intermediate term:
  - Seasonal differences (e.g. cross-shore profile changes)
  - Impact of interventions (e.g. structures, nourishments)
  - Natural (cyclic) variability (e.g. beach states, bar patterns, evolving features)
- Short term:
  - Impact of storms or other short term extreme events
    (Note that short term extreme events can cause irreversible effects in a system due to breaching, over-wash, loss of sediment in a canyon, reshuffling or relocation of large sedimentary features, etc. In turn, this can have significant impact on intermediate and long term processes)

In order to assess the total dynamics and changes of coastlines, the above processes need to be combined. Typically, this is a difficult task, since processes:

1. Interact, and can therefore be affected by other processes
2. Are modelled using different numerical models (focusing on a specific process or spatial/ time scale), which in turn often have different numerical representations of 'the' coastline

In order to support coastal engineers in combining the total dynamics and changes of coastlines, the Aggregation of Coastline Dynamics & Changes tool (ACDC tool) is developed. The ACDC tool is aimed at overcoming the difficulties associated with item 2 above. This means that it can be used to combine results from different models (and therefore different processes and timescales), which are mapped to 1 consistent definition of the coastline. The ACDC tool does not overcome the issues associated with point 1, as the interaction between processes and scales is very case specific, non-linear, and not generically known.

2 ACDC Tool – User Manual

2.1 Installation

The ACDC tool can be found within the Open Earth repository at the following location:

- https://svn.oss.deltares.nl/repos/openearthtools/trunk/matlab/applications/tools/coastline_aggregation_tool/

No installation is required, but the entire Matlab trunk of the Open Earth Tools needs to be checked-out on your computer and included within the Matlab path using `oetsettings`. A tutorial on how to achieve this can be found on the following web page:

- https://publicwiki.deltares.nl/display/OET/MATLAB

2.2 Getting started

After opening Matlab (advised to use version 2016a or later), simply run the following code:

- `help aggregation_of_coastline_changes_and_dynamics;`

This will generate an up-to-date overview of how to interact with the tool through code. In order to use the tool, it can be called as follows:

- `aggregation_of_coastline_changes_and_dynamics(coastline,data,settings);`

Note that three input fields are required:

- **coastline**
  - This is a Matlab structure in which the definition of the reference coastline is supplied to the ACDC tool. All data and model results are mapped to this coastline.
- **data**
  - This is a Matlab structure in which data and model results are supplied to the ACDC tool. All data and model results will be handled and mapped to the coastline.
- **settings**
  - This is a Matlab structure in which some general settings are supplied to the ACDC tool. The settings focus primarily on plotting behaviour and tool output.

Example input structures can be obtained by calling the function without input fields:

- `aggregation_of_coastline_changes_and_dynamics`
- `[coastline_x,data_x,settings_x] = aggregation_of_coastline_changes_and_dynamics`

2.3 Using the tool

In order to use the tool, the three input structures ‘coastline’, ‘data’ and ‘settings’ need to be provided (see Section 2.2 above):

- `aggregation_of_coastline_changes_and_dynamics(coastline,data,settings);`

The following sections describe the input fields in more detail, reference will be made to Figure 2.1, in which some definitions (incl. the reference coastline) is provided.

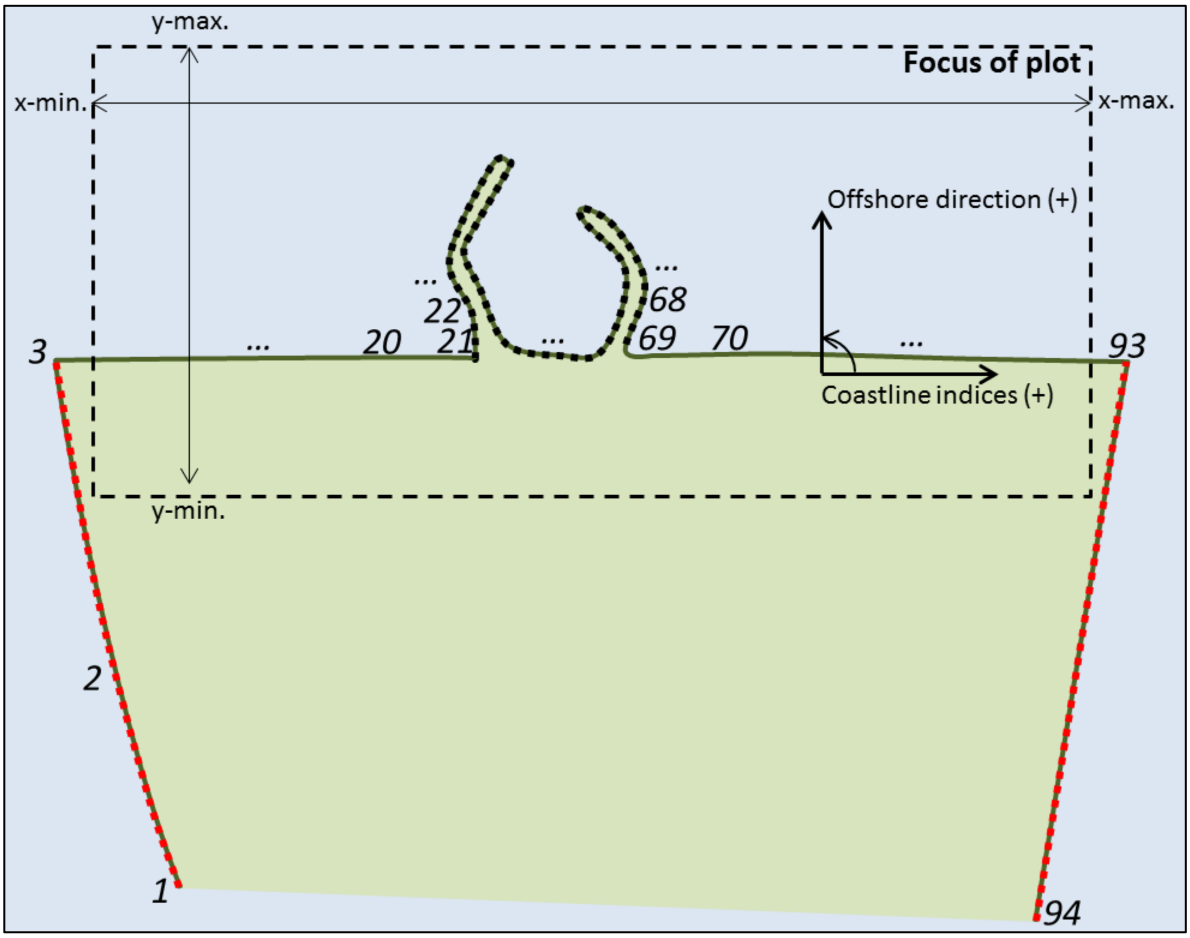

Figure 2.1 *Definitions of the uniform (reference) coastline in the ACDC tool*

2.3.1 Input fields - Coastline

The uniform (reference) coastline is defined through the following keywords in the coastline Matlab structure:

- coastline.**ldb_file***　(coastline in *.ldb format, a single line)
- coastline.**structure_inds**　(ldb-indices of structures, ignored)
- coastline.**ignore_inds**　(ldb-indices of coastline parts to ignore)
- coastline.**EPSG***　(Coordinate system code (EPSG) of the ldb)

These keywords (***** is mandatory) are used as follows:

- coastline.**ldb_file***
  – The uniform (reference) coastline is defined through a landboundary (*.ldb) file containing X and Y values in a certain projected coordinate system (EPGS) or a [Mx2] matrix containing the X and Y values. The coastline is used as a reference

line, on which the different model output (coastline dynamics and changes) will be mapped. This is a critical step, since different models (might) have slightly different definitions for the coastline (due to different grid-size, resolution, model definitions or 1D-2D-3D representations), but also to be able to easily manually add data. The coastline may only contain a single coastline section (no NaN's or no-value data in between). Be aware that we assume the sea-side to be on the left size of the landboundary when following the x,y indices upwards (see Figure 2.1).

- `coastline.structure_inds`
  - The indices of the *.ldb file that you want to draw as structures (will also be ignored as dynamic coastline), in {[x1:x2],[x1:x2]} format (use {} to leave it empty). For the example in Figure 2.1, this would be {[21:69]}.
- `coastline.ignore_inds`
  - The indices of the *.ldb file that you want to ignore as dynamic coastline, in {[x1:x2],[x1:x2]} format (use {} to leave it empty). For the example in Figure 2.1, this would be {[1:3],[93:94]}.
- `coastline.EPSG*`
  - The coordinate system (in EPSG code) of the coastline (and project). Run the following call to look for an EPSG code (or on the website www.epsg-registry.org):
    `load('EPSG.mat','coordinate_reference_system')`
    Make sure you select a projected coordinate system (there is no lon. & lat. support).

2.3.2 Input fields - Data

The data and model results that need to be mapped to the uniform (reference) coastline are defined through the following keywords in the data Matlab structure:

- `data.name` (name/identifier of provided model/data)
- `data.plot_type` (type of plot, e.g. 'lines' or 'shades')
- `data.color` (plotting color of the model/data)
- `data.from_model` (true/false, load the data from a model?)
- `data.model_name` (model name, if from_model is true)
- `data.model_files` (model files, if from_model is true)
- `data.model_EPSG` (model EPSG, if from_model is true)
- `data.most_likely_run` (model indice, if from_model is true)
- `data.use_min_max_range` (true/false, use a custom min/max range)
- `data.most_likely_diff` (most-likely diff, if from_model is false)
- `data.min_diff` (min. diff, if use_min_max_range is true)
- `data.max_diff` (max. diff, if use_min_max_range is true)
- `data.set_model_time` (manually set model time, instead of [1 end])
- `data.set_model_vert_level` (manually set vert. level of coastline)

Multiple dimensions can be added to the data structure in order to include multiple sources of data. These keywords are used as follows:

- `data.name`
  - An identifier/name for the results (will be placed in e.g. legends, titles)
- `data.plot_type`
  - Identifier for the plotting results, can be 'shades' or 'lines'.
- `data.color`

  - Matlab formatted RGB color [0-1 0-1 0-1]
- data.from_model
  - Obtain data from a model (true or false)

    Is the data coming from a model that needs to be analysed within this script? Then set this keyword to true. Are you manually providing the data? Then set this keyword to false.

    If the keyword from_model is true, provide the data keywords if model_name, model_files, model_EPSG, use_min_max_range (if this is set to true, also supply min_diff & max_diff, which will include the min and max values on top of the most-likely/median model result) and most_likely_run (indice of the run from model-files that needs to be used as the most-likely result).

    If the keyword from_model is false, provide the data keywords most_likely_diff, min_diff and max_diff
- data.model_name
  - In case from_model is true, data needs to be loaded from model output files or other data files. This can be of the type 'Unibest CL+', 'Delft3D 4', 'Data' and 'Landboundaries'.
- data.model_files
  - A list (Matlab cellstring) of files to load per data source. Use multiple files to refer to multiple model output files that include output ranges. Note that the type should be trim-*.dat for Delft3D 4, *.PRN for Unibest CL+, *.mat for Data (max. 1 file) and *.ldb for Landboundaries. Note that for the model_name ‘Landboundaries’ the first landboundary is used as a reference line for the others! The correct format of a Matlab cellstring is {'file_1','file_2','file_3','file_4'}.
- data.model_EPSG
  - The coordinate system of the model, it will automatically convert the output to the uniform (reference) coastline system if needed
- data.most_likely_run
  - The indice of the run (in model_files) that needs to be considered as the most-likely (default) computation. Leave this empty ([]) to use the median model result
- data.use_min_max_range
  - In case the use_min_max_range is true the most-likely model result will be used, and the uncertainties added as min and max differences
- data.most_likely_diff
  - Most-likely differences w.r.t. the reference coastline (negative is erosion). Can also be specified in [XYZ] data, such that it will be interpolated to the reference coastline. Note that this keyword is only used in case from_model is false.
- data.min_diff
  - Min. differences w.r.t. the most-likely result, so must be negative. Can also be specified in [XYZ] data, such that it will be interpolated to the reference coastline
- data.max_diff
  - Min. differences w.r.t. the most-likely result, so must be positive. Can also be specified in [XYZ] data, such that it will be interpolated to the reference coastline
- data.set_model_time
  - By default, the coastline difference from model results is determined by the difference between the initial (1) and last (end) indice of the model results. Setting

this switch to true will allow the user to select a time indice from a list of time-points in the model results. This option only works for model_name 'Delft3D 4' and 'Unibest' and will be ignored for others. Alternatively, one can simply set the indices in this keyword, e.g. data(3).set_model_time = [1 165]. The indices will be checked according to the size of the model dataset.

- `data.set_model_vert_level`
  - By default, the coastline is defined at the 0-line, in case you want to change this, set the vertical z-level in this keyword. This option only works for the model_name 'Delft3D 4' and will be ignored for others.

2.3.3 Input fields - Settings

The settings related to plotting behaviour and tool outputs are defined through the following keywords in the settings Matlab structure:

- `settings.combined_fig` (true/false, combine into 1 fig)
- `settings.cumulative_results` (true/false, sum model results)
- `settings.filled_LDB` (true/false, filled coastline)
- `settings.x_lims` (optional, X-limits [x1 x2])
- `settings.y_lims` (optional, Y-limits [y1 y2])
- `settings.plot_factor` (difference exaggeration factor)
- `settings.background_image` (optional, background image file)
- `settings.background_world_file` (optional, background world file)
- `settings.output_folder` (script output storage location)
- `settings.save_figures_to_file` (true/false, save figs to file)
- `settings.save_mat_files` (true/false, save model data to mat-files)
- `settings.save_kml_files` (true/false, save results to KML-files)
- `settings.diff_indices` (creates difference plots, data, etc.)
- `settings.show_splash` (optional, turn on the EPIC splash screen)
- `settings.file_suffix` (optional, add suffix to saved files)

These keywords are used as follows:

- `settings.combined_fig`
  - Set this to true to include all different models/data in a single figure
- `settings.cumulative_results`
  - Turns model results relative to earlier model results, note that the model order (in data) is now relevant. Uncertainties are now effectively shown cumulatively.
- `settings.filled_LDB`
  - Plot the provided landboundary as filled or not (*.ldb should fit this functionality, see Figure 2.1). Note that if you also provide a background image (in settings.background_image) this keyword will be ignored for spatial aggregation plots. It is advised (for the sake of visibility) to have this keyword set to true at all times (again given that your *.ldb fits this functionality, you can make sure this is the case by using the function ldbTool).
- `settings.x_lims`
  - Custom x-limits of the plot, keep empty ([]) to determine automatically (result-based), also see Figure 2.1.
- `settings.y_lims`

  – Custom y-limits of the plot, keep empty ([]) to determine automatically (result-based), also see Figure 2.1.
- `settings.plot_factor`
  – Multiplies coastline changes with a factor (for visualisation purposes in spatial plots)
- `settings.background_image`
  – Provide a background image (jpg, epg, bmp, tif, png or gif). Must be in the same coordinate system as the coastline. Can be converted with help of e.g. QGIS.
- `settings.background_world_file`
  – World-file associated with the background image. Must be in the same coordinate system as the coastline. Can be converted with help of e.g. QGIS
- `settings.output_folder`
  – Output folder, a location where output figures are stored (if save_figures_to_file = true) as well as other output data (*.mat and/or *.kml files)
- `settings.save_figures_to_file`
  – Switch to turn on exporting of figures to (*.png) files
- `settings.save_mat_files`
  – Switch to turn on exporting of data (*.mat) files
- `settings.save_kml_files`
  – Switch to turn on exporting of results to Google Earth (*.kml) files. Results are combined in a single (*.kml) file
- `settings.diff_indices`
  – Allows users to turn on the creation of both difference data files & difference plots. The data/plots to be created are based on the provided indices within the keyword 'settings.diff_indices' and must obey the following format:

    ```
    settings.diff_indices =     [1 2;
                                  1 3;
                                  5 4];
    ```

    In this case, data/model #1 is compared to #2, #2 with #3 & #4 with #5. If the 2nd models feature more erosion, the resulting most-likely result is negative. So if the most-likely result is positive, more accretion has occurred within the 2nd model, w.r.t. the 1st model.

    The changes in differences between min and max w.r.t. the most-likely results are also provided. This means that if the min or max result is positive, the uncertainty band has widened (w.r.t. the most-likely result). So if the uncertainty band decreased in size (on either side), the min and max values are negative.

    This keyword is coupled to: settings.save_figures_to_file, which saves difference figures if true and settings.save_mat_files, which saves diff data to *.mat file(s) if true.

    It is strongly advised to set the keyword settings.cumulative_results to false when using this keyword (unless you really know what you’re doing).
- `settings.show_splash`
  – When set to true (false by default) an epic ACDC splash screen is shown while this this function is running
- `settings.file_suffix`

– When saving figures, kml's or data to a file, a default file-name is used (based on the aggregation). A suffix can be added to these filenames by using the keyword settings.file_suffix. By default, this is empty: '' (example: file_suffix = '_run2_test').

3 Example call and subsequent figures

As an indicative example for Anmok beach, South Korea, when considering the following 4 different sources of data relevant to coastline dynamics and changes (both from model results and data analysis):

- Long-term coastline trends (Unibest CL+ model results)
- Impact of a human intervention (Delft3D model results)
- Natural variability of bar dynamics (Data analysis results)
- Short-term morphological storm impact (XBeach model results)

Figures can be created through the following example call:

################################ Matlab code ################################

```
%% coastline structure:

coastline.ldb_file          = 'some_ldb_file.ldb';
coastline.structure_inds = {[130:149];[269:304]};
coastline.ignore_inds     = {[1:130],[304:354]};
coastline.EPSG            = 32652;


%% data (incl. model output) structure:

% Source #1:
data(1).name               = 'Long-term trends (Unibest CL+)';
data(1).plot_type          = 'shades';
data(1).color              = [0 0 1];
data(1).from_model         = true;
data(1).model_name         = 'Unibest CL+';
data(1).model_files        = {'d:\default\com4m.PRN',...
                              'd:\sensD50_high\com4m.PRN',...
                              'd:\sensD50_low\com4m.PRN',...
                              'd:\sensDIR_neg\com4m.PRN',...
                              'd:\sensDIR_pos\com4m.PRN',...
                              'd:\sensHS_high\com4m.PRN',...
                              'd:\sensHS_low\com4m.PRN'};
data(1).model_EPSG         = 32652; % optional
data(1).use_min_max_range = false;
data(1).most_likely_run    = 1; % first run is used as most-likely

% Source #2:
data(2).name         = 'Impact of a human intervention (Delft3D)';
data(2).plot_type    = 'shades';
data(2).color        = [0.9 0.9 0];
data(2).from_model   = true;
data(2).model_name   = 'Data';
data(2).model_files = {'output\mat_files\Delft3D_data.mat'}; % pre-made
```

```
% Source #3:
data(3).name        = 'Natural variability due to bar dynamics';
data(3).plot_type   = 'shades';
data(3).color       = [1 0 0];
data(3).from_model = false;
data(3).model_name  = 'Data'; % optional
data(3).model_files = {''}; % optional
data(3).model_EPSG  = []; % optional
data(3).use_min_max_range = true;
data(3).most_likely_run = []; % optional
data(3).most_likely_diff = 0; % Identical to data(2) result
data(3).min_diff     = -17.5309; % min. range
data(3).max_diff     = 19.8684; % max. range

% Source #4:
data(4).name        = 'Short-term morphological storm impact (XBeach)';
data(4).plot_type   = 'shades';
data(4).color       = [0 0.5 0];
data(4).from_model = false;
data(4).model_name  = 'Data';
data(4).model_files = {''};
data(4).model_EPSG  = [];
data(4).use_min_max_range = true;
data(4).most_likely_run = [];
load('XBeach_retreat_data.mat'); % Load & use manually created xyz data:
data(4).most_likely_diff = [retreat_data.ref_line retreat_data.median];
data(4).min_diff         = [retreat_data.ref_line retreat_data.min];
data(4).max_diff         = [retreat_data.ref_line -retreat_data.median];


%% Settings structure:

settings.combined_fig            = true;
settings.cumulative_results      = true;
settings.filled_LDB              = true;
settings.x_lims                  = [494200 496300];
settings.y_lims                  = [4180100 4181700];
settings.plot_factor             = 1;
settings.background_image        = 'image.jpg';
settings.background_world_file = 'image_UTM52N.jgw';
settings.output_folder           = 'output\aggregation'; % can be relative
settings.save_figures_to_file    = true; % save to file
settings.save_mat_files          = true; % save to file
settings.save_kml_files          = true; % save to file
settings.diff_indices            = [1 2]; % create difference between 1 & 2
settings.show_splash             = true; % optional
settings.file_suffix             = '_example';

aggregation_of_coastline_changes_and_dynamics(coastline,data,settings);
% The above starts the tool with using coastline, data and settings.
```

############################## End Matlab code ##############################

The following figures are subsequently created:

1 Alongshore variability of the coastline for the different models/data (see Figure 3.1)
2 Spatial variability of the coastline for the different models/data (see Figure 3.2)
3 Difference plots between scenarios (e.g. impact of a human intervention, see Figure 3.3)

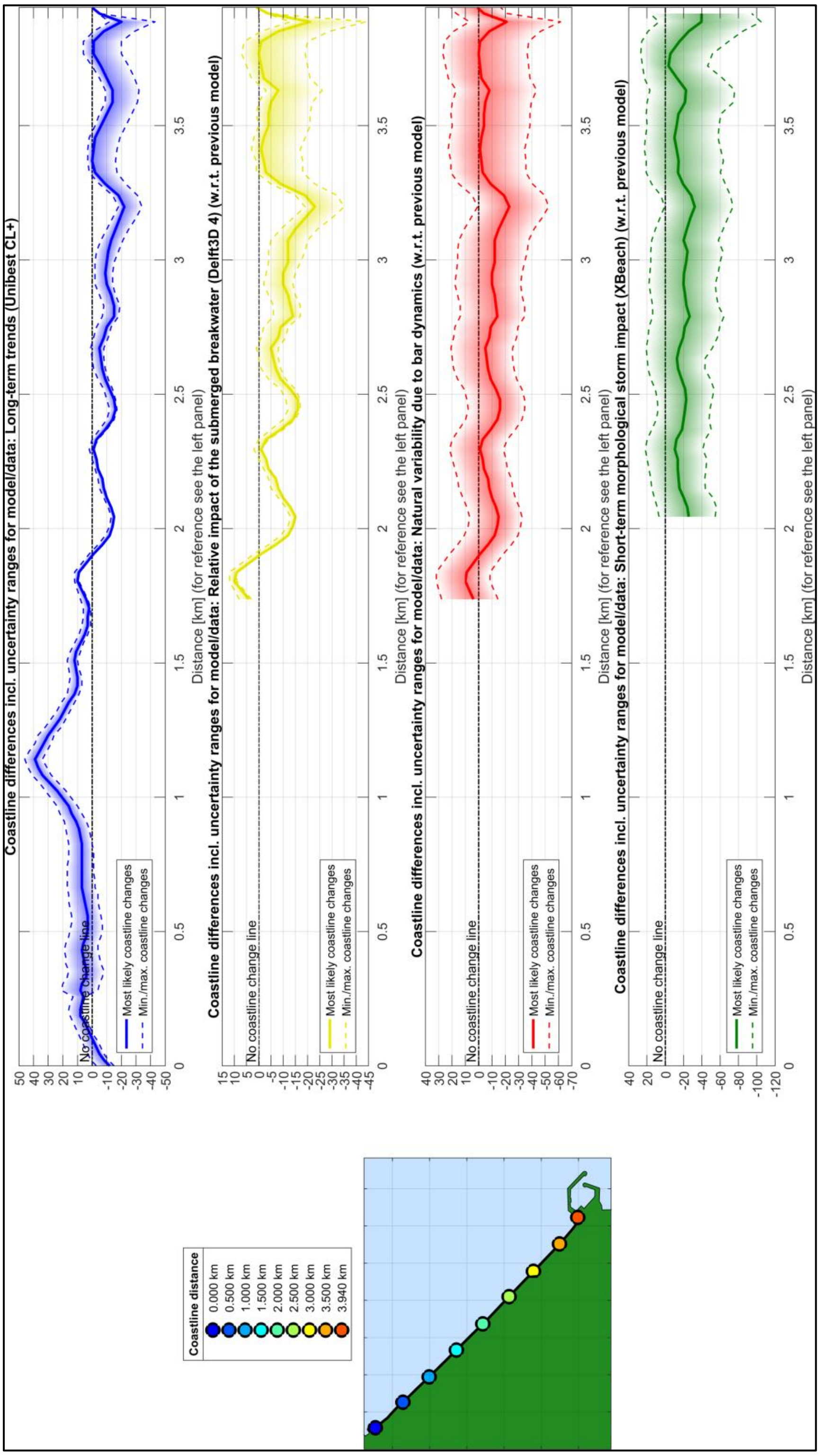

Figure 3.1 Example: coastline changes due to 4 different sources, incl. cumulative uncertainty bands

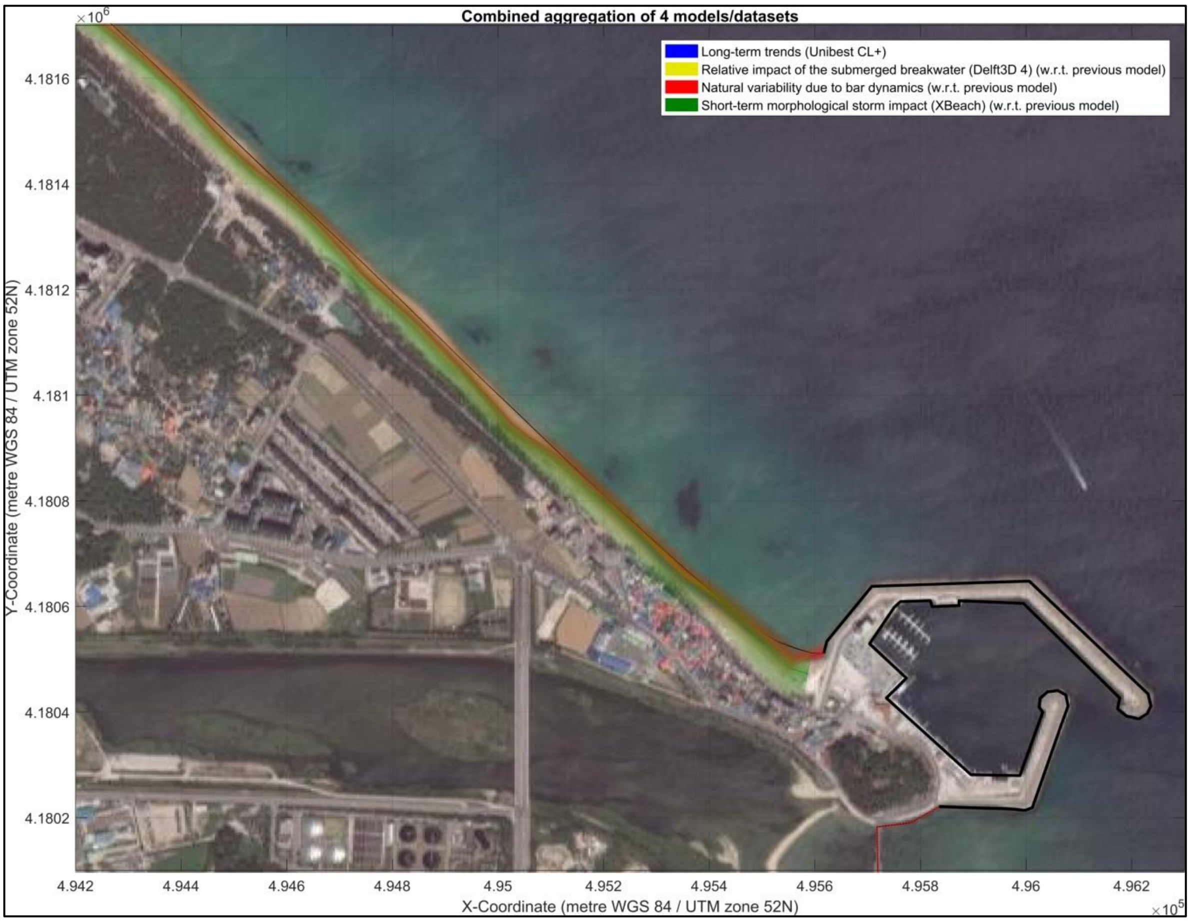

Figure 3.2 Example: coastline changes due to 4 different sources, incl. cumulative uncertainty bands

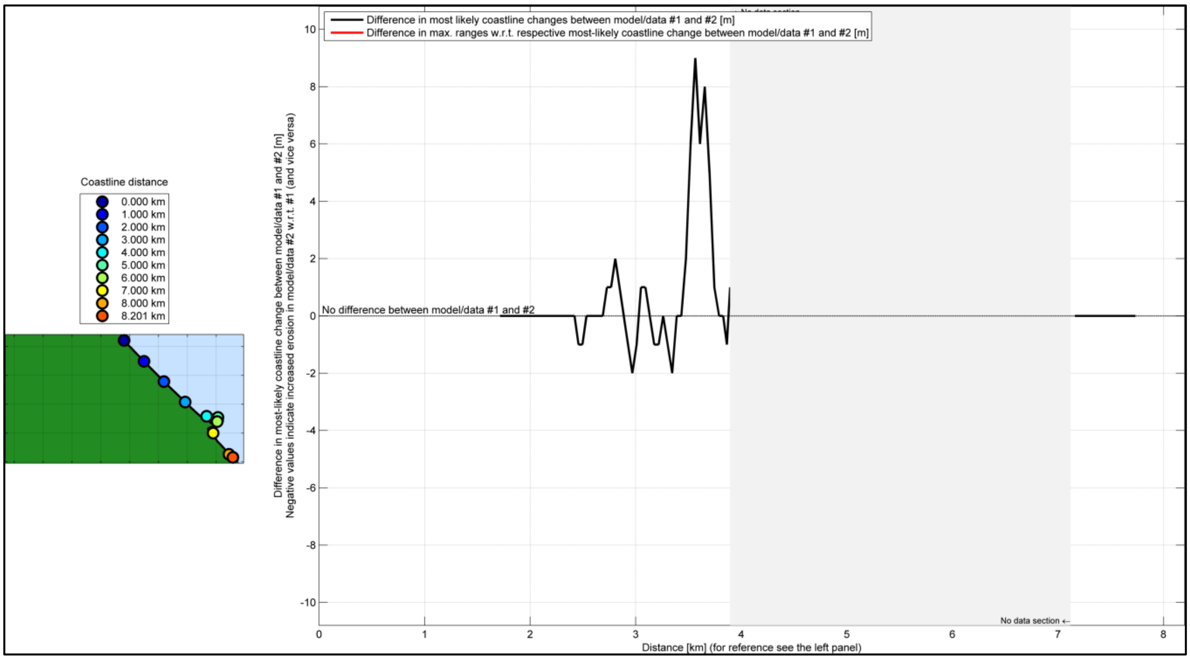

Figure 3.3 Example: Relative coastline changes between a situation with and without a human intervention

4 Concluding remarks

Considering coastline dynamics and changes often related to various processes, time scales and spatial scales. In order to combine these, different sources of data (e.g. data analysis and different numerical models each focussing on different physical processes) need to be combined (aggregated).

The aggregation of coastline dynamics and changes tool (ACDC tool, Figure 4.1) aims to help coastal engineers when combining results from data analyses and different models (and therefore different processes and timescales) that have an impact on total coastline dynamics and changes. It aggregates all results by mapping to a uniform (reference) coastline.

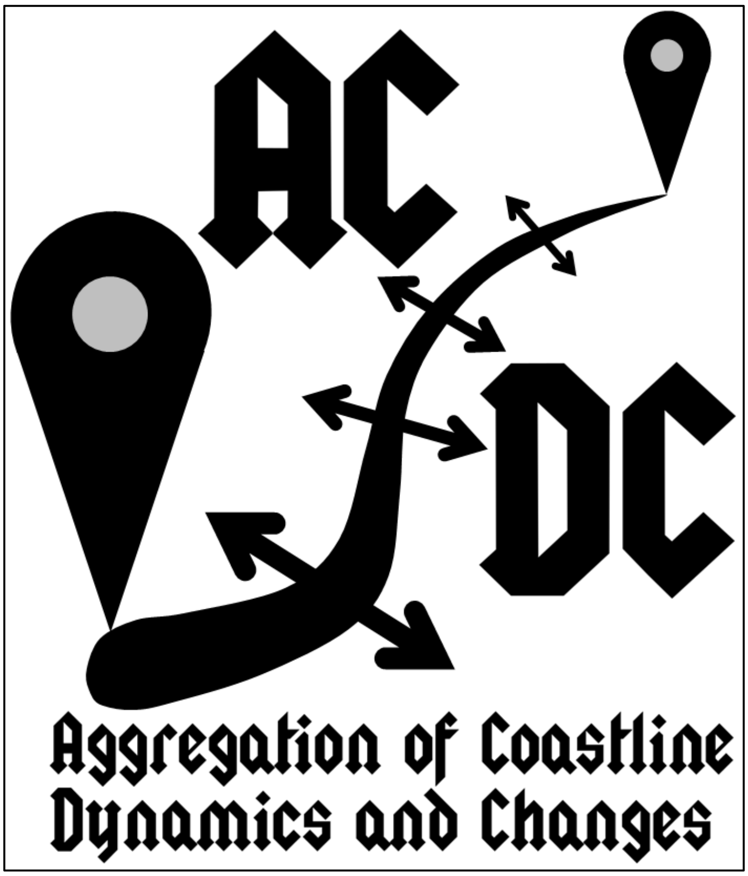

Figure 4.1 Epic splash screen of the ACDC tool

5 Acknowledgement

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