

## Memo

**To**  
Users of the Input Reduction tool

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**Subject**  
Input Reduction Tool - Description and User Manual

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## 1 Introduction

Numerical process-based models that compute coastal morphodynamics are typically forced by environmental conditions such as wind, tide and/or waves. Furthermore, these models typically feature a large computational demand. In order to speed up such models, the model forcing conditions could be represented by a statistical representation. In case of the tide, this could be a 'representative tide' that results in spring-neap averaged sediment transport patterns. In the case of waves, this could be a statistical representation of the entire wave climate, which in turn results in representative sediment transport patterns for a limited number of wave conditions. The process of obtaining such statistical representative forcing conditions is called input reduction.

Often, one of the most profitable input reductions is related to the wave climate. A wave climate typically features a large range of different conditions, as it is obtained from measured time series (buoys) or long-term hindcast models. Representing such a wave climate by roughly 10 to 100 representative waves often pays off. Because of this, various input reduction methods focussing on waves have been developed. Many are described and applied in literature (e.g. Walstra et. al., 2013), but a broad overview is provided by Olij (2015) and Queiroz (2017).

The Input Reduction tool (IR-tool) is a Matlab based tool and associated user interface (UI) which is part of the freely available Open Earth Tools (OET). It is designed to reduce wave climates into a statistical representation (a reduced wave climate) using different wave input reduction techniques, while it also includes options to take into account the relevance of each wave condition within a sediment transport model using a transport proxy.

## 2 Input Reduction Tool – User Manual

### 2.1 Installation

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

- [https://svn.oss.deltares.nl/repos/openearthtools/trunk/matlab/applications/tools/input\\_reduction\\_tool](https://svn.oss.deltares.nl/repos/openearthtools/trunk/matlab/applications/tools/input_reduction_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 (version 2016a or later), simply run the following code:

- `input_reduction_tool();`

This will open the user interface as shown in Figure 2.1. The upper half of the interface (focussing on user input) consists of 'Step 1 – Loading data', 'Step 2 – Input reduction method' and 'Step 3 – Exporting data', while the lower half of the interface is dedicated to visualization and feedback.

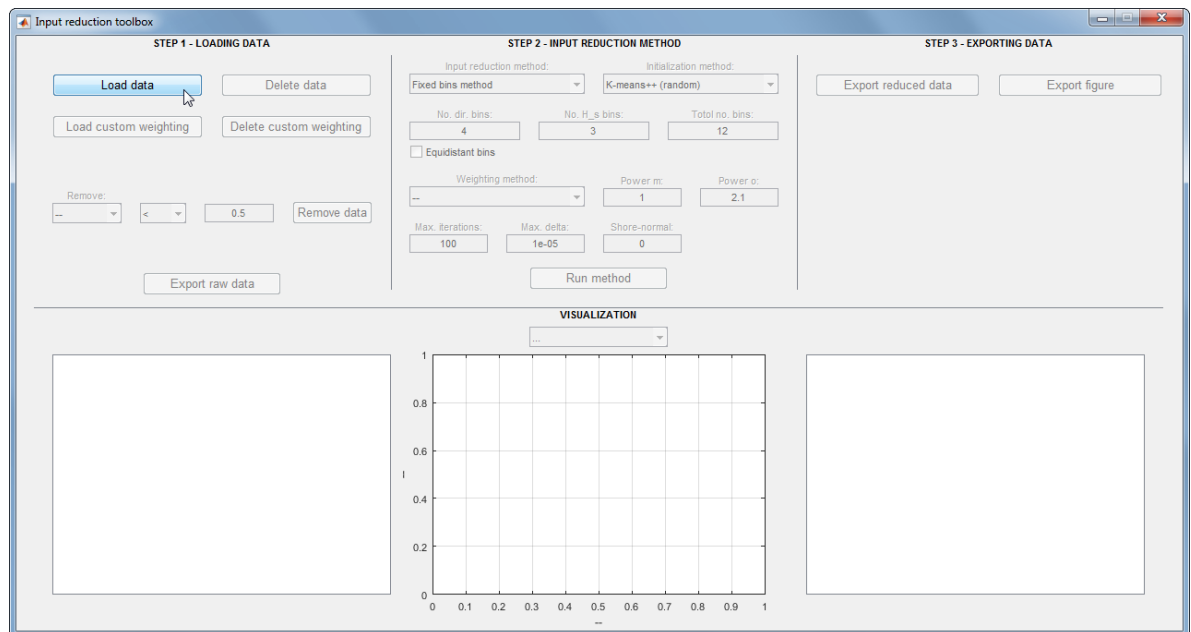


Figure 2.1 Overview of the user interface of the input reduction tool upon start-up

## 2.3 Using the tool

Below, a description of the 3 steps the user should follow is provided.

### 2.3.1 Step 1 – Loading data

In order to use the input reduction tool, wave input data is required. Wave data should contain significant wave height ( $H_s$ ), peak wave period ( $T_p$ ) and direction ( $dir$ ). Optionally, the associated weight can be added to the data, which describes the associated weighting to each of the provided wave conditions. Often, this would be (a proxy) of sediment transport used in the applied model. The wave data can be loaded by clicking the button 'Load data'. The user is prompted to provide a file in which wave data is available, in one of the following formats:

- An ASCII/text file (\*.txt, \*.csv, \*.dat)
  - This text file should contain columns of at least  $H_s$ ,  $T_p$  and dir (optionally weight), and separated by a certain delimiter. The user will be asked to locate the file, followed by identifying and labelling the columns accordingly.
- A Matlab file (\*.mat)
  - This \*.mat file should contain a [Mx3] matrix including  $H_s$ ,  $T_p$  and dir (optionally weight). Optionally, a 'cellstring' including variable names is included. This file-format is also used when data is exported by the input reduction tool, for later re-use.

Example files are provided within the OET repository, and can be found in the folder:

- [../matlab/applications/tools/input\\_reduction\\_tool/example\\_wave\\_input\\_data/](http://.../matlab/applications/tools/input_reduction_tool/example_wave_input_data/)

Note that this step can also be automated or avoided when providing the input reduction tool with wave data already during start-up:

- `input_reduction_tool([Hs_data, Tp_data, dir_data]);`
- `input_reduction_tool([Tp_data, Hs_data, dir_data], {'T_p', 'H_s', 'dir'});`
- `input_reduction_tool([Tp_data, Hs_data, dir_data, weight_data]);`

In this case, the provided wave data is immediately loaded.

Following either of the above options, the UI now appears as in Figure 2.2. The loaded raw wave data is shown in both table and scatterplot format (of which the latter can be manipulated in terms of axis dimensions).

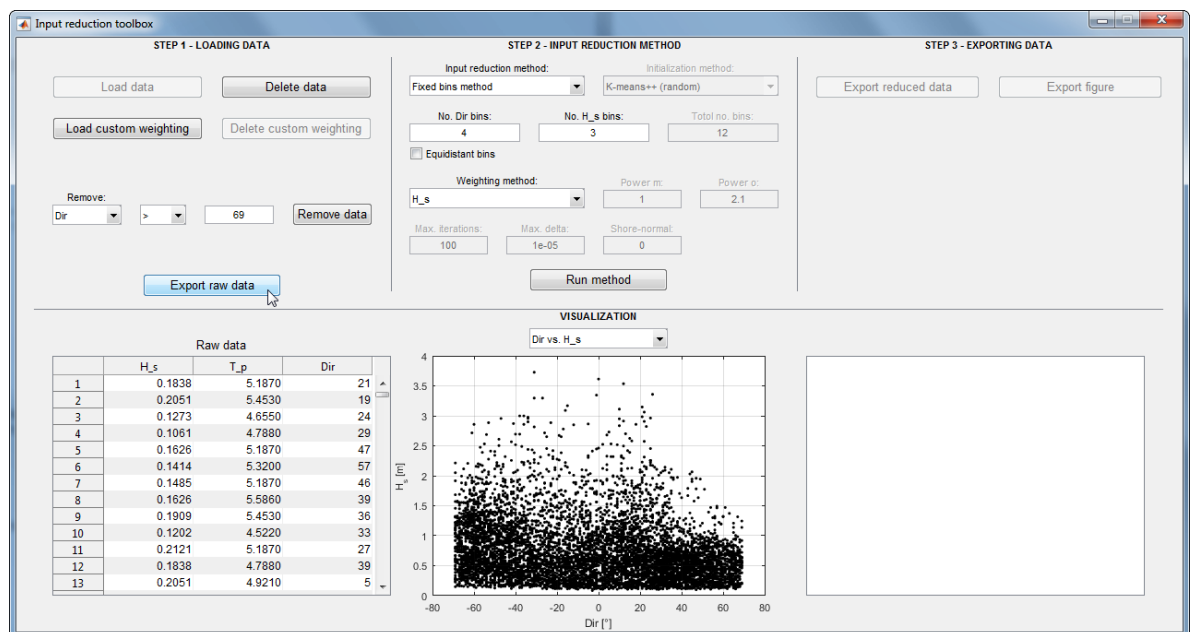


Figure 2.2 Overview of the user interface of the input reduction tool after loading of data

After loading data, it can be deleted using the 'Delete data' button. Custom weighting can optionally be added using the 'Load custom weighting' button, which in turn again prompts to either an ASCII or \*.mat file. These files are assumed to have the same format as raw wave data, except now only contain a single column with weighting values.

Parts of the data can also be removed. Simply change the indicated logic and click the 'Remove data' button. This allows users to remove (for instance) insignificant waves (smaller than a certain  $H_s$  or  $T_p$ ), or waves coming from unrealistic directions (measurement errors or irrelevant waves).

### 2.3.2 Step 2 – Input reduction method

Within this step, an input reduction method is applied to the provided raw data. A total of 7 input reduction methods can be selected:

1	Fixed bins	(binning method)
2	Maximum dissimilarity	(binning method)
3	Energy flux	(binning method)
4	Crisp K-means	(clustering method)
5	Fuzzy K-means	(clustering method)
6	Harmonic K-means	(clustering method)
7	Sediment transport bins	(binning method)

Binning methods rely on user defined bins to compute representative waves, whereas the clustering methods iteratively grow clusters around centroids, which in the end define representative waves.

When selecting any input reduction method, its relevant input variables are automatically activated within the UI. Below, a list of variables including description is provided:

- Initialization method
  - Clustering methods require initial centroids, generated using different methods
- No. Dir bins
  - The number of pre-defined bins along the directional axis, it is good practice to keep this an even number when waves are normalized w.r.t. the offshore direction
- No.  $H_s$  bins
  - The number of pre-defined bins along the significant wave height ( $H_s$ ) axis
- Total number of clusters
  - Total no. of clusters to be created by the clustering method
- Equidistant bins
  - Fixes the bins in accordance to maximum bin heights
- Weighting method
  - Assigns weight to the wave data (a proxy of sediment transport), this can be  $H_s$ ,  $H_s^m$  or a proxy of wave energy ( $E = 1/8 * c_g * H_s^2 * g * \rho$ ). In case custom weighting has been loaded, this can be used as well
- Power m
  - The power m in the function  $H_s^m$ , used for weighting of wave conditions.
- Power o

- Used in the fuzzy and harmonic K-means methods, the power  $\alpha$  is used in the membership function, which assigns certain wave conditions to certain clusters (see Olij, 2015).
- Max. iterations
  - The maximum amount of iterations that clustering methods will perform in case the internal error is larger than the maximum allowed internal error (see Olij, 2015).
- Max. delta
  - The internal error of clustering methods, in case the internal error is smaller than this max. delta, the clustering method is completed (see Olij, 2015).
- Shore normal
  - The shore normal direction within the wave data, as used in the sediment transport bins method. Note that (for now) this can only be 0 (and the wave climate thus needs to be normalized w.r.t. the shoreline when considering this method).

A selected (and further specified) method can be executed by clicking the ‘Run method’ button, after which the results are provided in the visualization area in both the scatterplot and reduced data table (Figure 2.3). Within the scatterplot, the bins or clusters are coloured and the centroids and/or representative waves highlighted by a red cross. Bin extents are also shown in case the weighting is a direct proxy of  $H_s$  (e.g.  $H_s$  or  $H_s^m$ ).

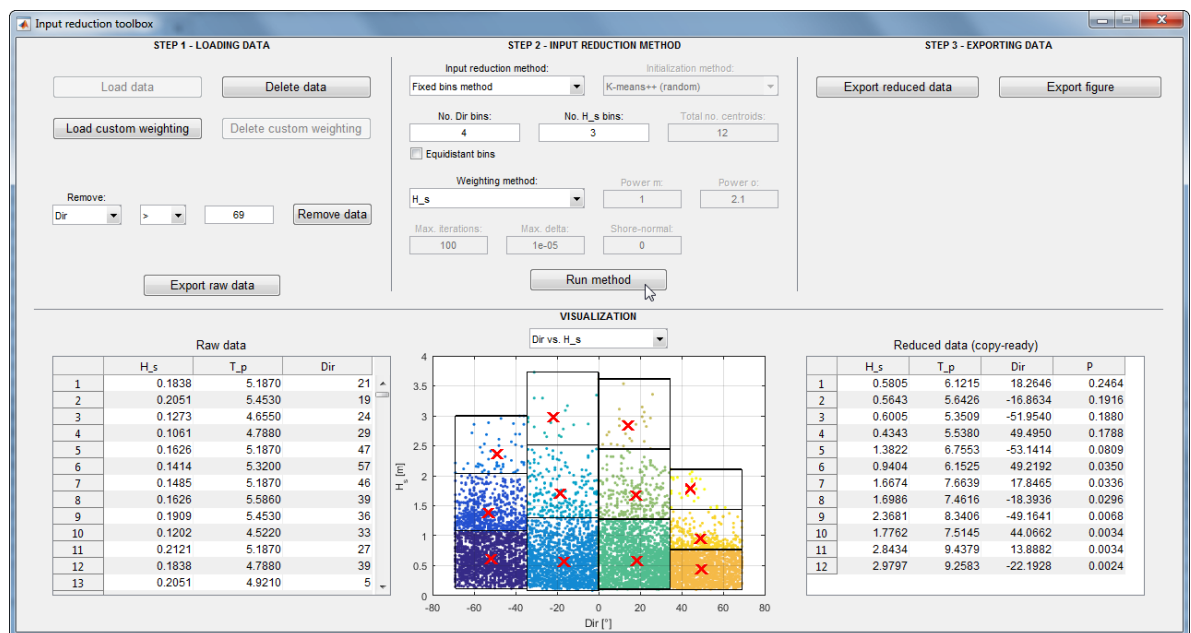


Figure 2.3 Overview of the user interface of the input reduction tool after running the input reduction method ‘fixed bins’ (binning method)

### 2.3.3 Step 3 – Exporting data

After a method is applied, its results can be saved to either a \*.mat file (including the reduced wave climate) by clicking the ‘Export reduced data’ button. The scatterplot including input reduction method results can also be saved to a figure in high resolution (\*.png) in any of the available dimensional combinations (or 3D) by clicking the button ‘Export figure’. This way, results of different methods can be saved for later use, or compared (e.g. Figure 2.5). The table with reduced data can also be copied by selecting it and hitting CTRL+C.

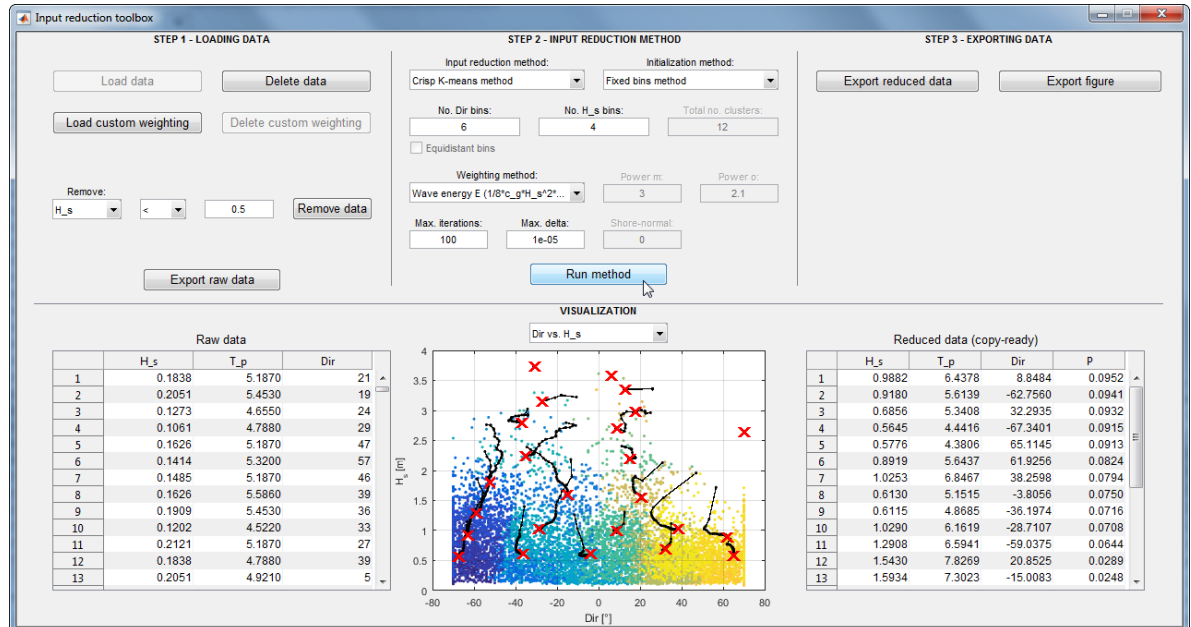


Figure 2.4 Overview of the user interface of the input reduction tool after running the input reduction method 'crisp K-means' (iterative clustering method)

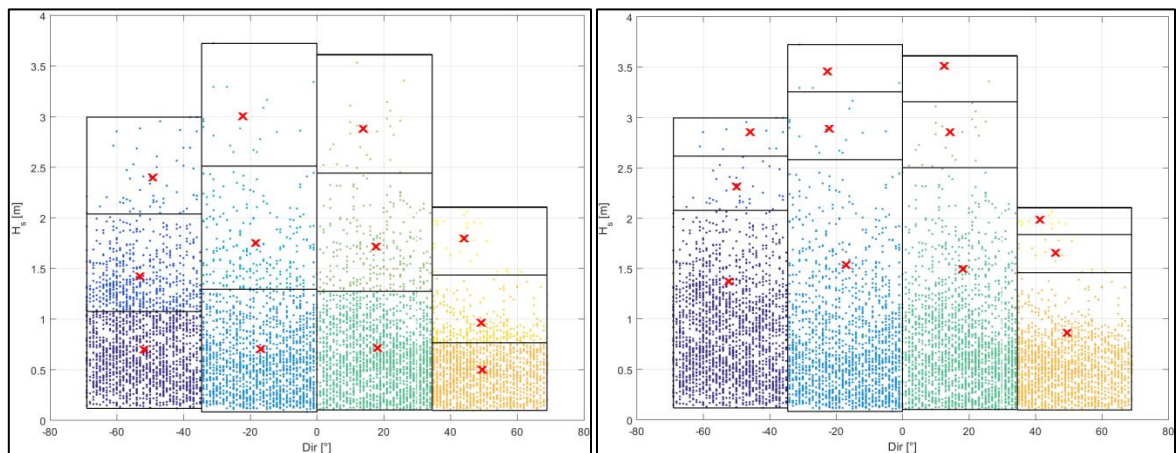


Figure 2.5 A result of fixed bins results on identical wave data, in the left panel applied with a default weighting ( $H_s$ ) and on the right power  $m = 3$  (assuming that the equivalent of sediment transport is  $H_s^3$ ).

### 3 Concluding remarks

Wave climate reduction is often required to keep computational demands of process-based numerical models focussing on coastal morphodynamics in check. Various methods to perform input reduction on a wave climate are described in literature.

The input reduction tool is a user friendly interface that combines 7 complex wave input reduction methods, including their intra variations and necessary variable specification. It supports loading of raw-data through multi-formatted files or syntax, manipulating and exporting of raw data, as well as exporting of reduced wave climates and figures. During the process of input reduction, the user is interactively updated about progress made within the

visualization area (lower panel of the tool). The input reduction tool is freely available through the Open Earth Tools repository.

## 4 Acknowledgement

The Input Reduction tool is developed as part of the research cooperation between Deltares and the Korean Institute of Science and Technology (KIOST). The development is funded by the research project titled "Development of Coastal Erosion Control Technology (or CoMIDAS)", which is funded by the Korean Ministry of Oceans and Fisheries and the Deltares strategic research program Coastal and Offshore Engineering. This financial support is highly appreciated.

## 5 References

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- Walstra, D. J. R., Hoekstra, R., Tonnon, P. K. & Ruessink, B. G. (2013), *Input reduction for long-term morpho-dynamic simulations in wave-dominated coastal settings*, Coastal Engineering 77, 57–70. URL: <http://dx.doi.org/10.1016/j.coastaleng.2013.02.001>