3D/2D modelling suite for integral water solutions

Delft3D

Deltares systems

TIDE

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Enabling Delta Life

User Manual

Delft3D-TIDE

Analysis and prediction of tides

User Manual

Hydro-Morphodynamics

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Delft3D-TIDE, User Manual

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Deltares
Boussinesqweg 1
2629 HV Delft
P.O. 177
2600 MH Delft
The Netherlands

telephone: +31 88 335 82 73
fax: +31 88 335 85 82
e-mail: info@deltares.nl
www: https://www.deltares.nl

For sales contact:
telephone: +31 88 335 81 88
fax: +31 88 335 81 11
e-mail: software@deltares.nl
www: https://www.deltares.nl/software

For support contact:
telephone: +31 88 335 81 00
fax: +31 88 335 81 11
e-mail: software.support@deltares.nl
www: https://www.deltares.nl/software

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1 Guide to this manual

1.1 Introduction

This User Manual concerns the tidal analysis module, Delft3D-TIDE, of the Delft3D software suite.

The Delft3D-TIDE software package consists of the following sub-systems:

ANALYSIS	Harmonic analysis of tidal observation registrations.
PREDICT	Prediction of tidal water levels or tidal currents.
HILOW	Preparation of tide tables.
ASCON	Computation of tidal frequencies.
FOURIER	Fourier analysis of time-series.

To make this manual more accessible we will briefly describe the contents of each chapter and appendix.

If this is your first time to start working with Delft3D-TIDE we suggest you to read and practice the getting started of chapter 3 and the tutorial of chapter 7. These chapters explain the user interface options and guide you through the definition of your first calculation.

Chapter 2: Introduction to Delft3D-TIDE, provides specifications of Delft3D-TIDE.

Chapter 3: Getting started, explains the use of the overall menu program, which gives access to the Delft3D-TIDE module.

Chapter 4: Menu options, provides the description of the different menu options on the main menu of Delft3D-TIDE.

Chapter 5: General operation of the Delft3D-TIDE subsystems, describes the operation of the several subsystems of Delft3D-TIDE.

Chapter 6: Graphics, list the post-processing tools from the Delft3D suite which can be used in relation with Delft3D-TIDE.

Chapter 7: Tutorial, emphasis at giving you some first hands-on experience in using the several modules of Delft3D-TIDE.

Chapter 8: Conceptual description, describes the theory behind Delft3D-TIDE.

References, provides a list of publications and related material on the Delft3D-TIDE module.

Appendix A: Input file formats, gives a description of the input file formats of the subsystems ANALYSIS, PREDICT, HILOW and ASCON.

Appendix B: List of tidal components (internal component base), gives a description of all the tidal components use in Delft3D-TIDE (234); component name, frequency [°/h], amplitude in equilibrium tide and amplitude coupling relations.

Appendix C: Filename conventions, the required file name convention for each subsystem of Delft3D-TIDE is given.

Appendix D: Messages from Delft3D-TIDE, the error, warning and informative messages of Delft3D-TIDE are given in this appendix.

Appendix E: Content of the TIDE tutorial cases, the content of the tutorials for Delft3D-TIDE is given in this appendix.

1.2 Manual version

A manual applies to a certain release of the related numerical program. This manual applies to Delft3D-TIDE version 5.00.

1.3 Typographical conventions

Throughout this manual, the following conventions in text formats help you to distinguish between different types of text elements.

Example	Description
Module **Project**	Title of a window or a sub-window are in given in **bold**. Sub-windows are displayed in the **Module** window and cannot be moved. Windows can be moved independently from the **Module** window, such as the **Visualisation Area** window.
Save	Item from a menu, title of a push button or the name of a user interface input field. Upon selecting this item (click or in some cases double click with the left mouse button on it) a related action will be executed; in most cases it will result in displaying some other (sub-)window. In case of an input field you are supposed to enter input data of the required format and in the required domain.
<\tutorial\wave\swan-curvi> <siu.mdw>	Directory names, filenames, and path names are expressed between angle brackets, <>. For the Linux and UNIX environment a forward slash (/) is used instead of the backward slash (\) for PCs.
"27 08 1999"	Data to be typed by you into the input fields are displayed between double quotes. Selections of menu items, option boxes etc. are described as such: for instance 'select *Save* and go to the next window'.
`delft3d-menu`	Commands to be typed by you are given in the font Courier New, 10 points.
➢	In this User manual, user actions are indicated with this arrow.
$[\mathrm{m\,s^{-1}}]$ [–]	Units are given between square brackets when used next to the formulae. Leaving them out might result in misinterpretation.

1.4 Changes with respect to previous versions

Version	Description
1.0	5 header lines were expected in all input files, without any restriction to the first character of each header line.
2.01	a '+' is inserted as first character in each header line.
5.00	New overall GUI to support spaces in directories and filenames. Memory of PREDICT increased to 550 000, a prediction of one year with a time interval of one minue is now possible ($550\,000 > 531\,360 = 369 \times 24 \times 60$). Maximum memory allocation for dynamic storage increased to 550 000. Number of time-series for Standard Fourier Transform and Fast Fourier transform is increased to 550 000 to support the synodic period of 369.0 days.

2 Introduction to Delft3D-TIDE

In most continental shelf seas, coastal seas and estuarine areas the astronomical tide is the main driving force of the water motion. At times equally important is the motion induced by meteorological phenomena like wind and storms. Consequently, for almost all activities along the coast and offshore, a sound knowledge and understanding of the behaviour of water level and current is required. Tidal analysis and tidal prediction are of great help in this.

Local water level or current registrations of at least one month can be analysed to separate the astronomical part from the meteorologically induced part of the observation. The so obtained tidal constants fully determine the local tide, and can be used to predict the astronomical water level or current, respectively, for any period in the past or future.

Deltares program system Delft3D-TIDE has been especially designed to perform tidal analysis and tidal prediction for various complicated situations. It has been used extensively in numerous studies at more than 400 locations world-wide.

The following sections give an extensive description of the various sub-systems.

Section 5.1,	ANALYSIS	Tidal analysis of observed series.
Section 5.2,	PREDICT	Tidal prediction.
Section 5.3,	HILOW	Preparation of tide tables.
Section 5.4,	ASCON	Calculation of astronomical factors.
Section 5.5,	FOURIER	Fourier analysis of time-series (standard and fast Fourier transform).
Chapter 6,	Graphics	Graphical presentation of time-series or spectral series using Delft3D-QUICKPLOT and GPP.

It includes a general introduction on how to run the system, a step by step description of the input file(s), how to interpret the output files and remedies, a list of error messages and warnings including explanations is given in Appendix D.

2.1 Global description of the sub-systems

Analysis	Harmonic analysis of tidal observation registrations. Options: astronomical coupling, multiple instruments, sub-series to account for data gaps, linear trend, accuracy analysis.
Predict	Prediction of tidal water levels or tidal currents for given periods on the basis of a set of tidal constants.
Hilow	Preparation of tide tables (tables with times and heights of high and low water) for the period of the supplied time-series. The latter may be an observation, a hindcast or a prediction.
Ascon	Computation of tidal frequencies, astronomical arguments and nodal factors for any tidal component and any date time group.
Fourier	Fourier analysis of time-series.

For plotting relevant output files (time-series as well as spectral series) we refer to the graphical programs GPP (GPP UM, 2013) and Delft3D-QUICKPLOT (QUICKPLOT UM, 2013).

2.2 How to install the software

See Delft3D Installation Manual (Delft3D IM, 2013).

3 Getting started

3.1 Delft3D-TIDE as Delft3D module

To start Delft3D:

◇ On an MS Windows platform:

  ➢ Select Delft3D in the Applications menu or click on the Delft3D icon on the desktop.

◇ On Linux:

  ➢ Type `delft3d-menu` on the command line.

Next the title window of Delft3D is displayed, Figure 3.1.

***Figure 3.1:** Splash window of Delft3D*

After a short while the main window of the Delft3D-MENU appears, Figure 3.2.

◇ Whether or not you may have support on Delft3D modules, depends on the support contract you have.

For now, only concentrate on exiting Delft3D-MENU, hence:

➢ Press the *Exit* button.

The window will be closed and you are back in the Windows Desk Top screen for PCs or on the command line for Linux.

Remark:

◇ In this and the following chapters several windows are shown to illustrate the presentation of Delft3D-MENU and Delft3D-TIDE. These windows are grabbed from the PC-platform. For Linux workstations the content of the windows is the same, but the colours may be different.

3.2 Getting into Delft3D-FLOW and Delft3D-TIDE

To continue restart the Delft3D-MENU program as indicated above.

➢ Click on button *Flow*.

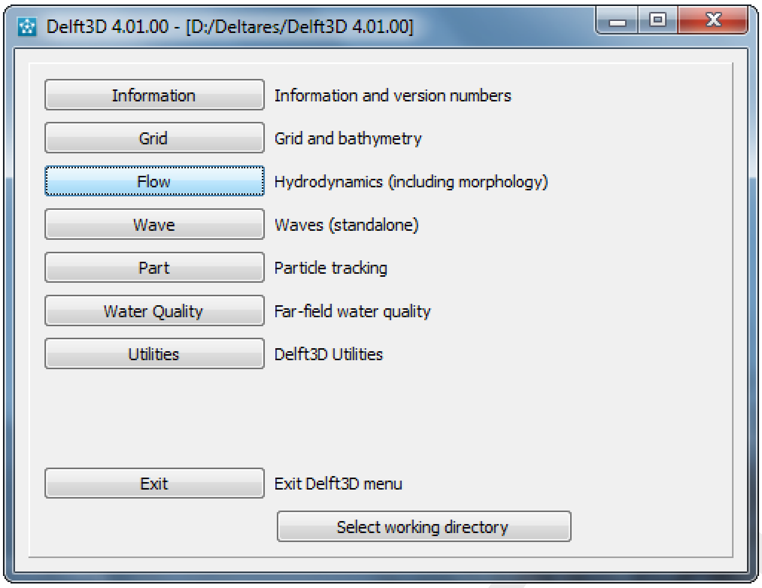

Figure 3.2: *Main window Delft3D-MENU*

Next the selection window for **Hydrodynamics (including morphology)** is displayed for preparing a flow or flow/wave input, to execute a computation in foreground or in batch, to inspect the report files with information on the execution and to visualise the results: Figure 3.2. Delft3D-TIDE is part of the additional tools.

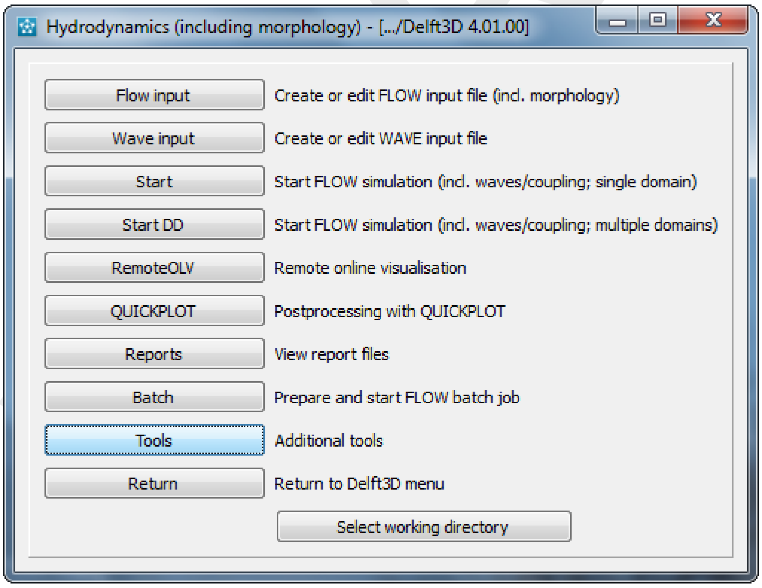

Figure 3.3: *Selection window for Hydrodynamics*

Before continuing with any of the selections of this **Hydrodynamics (including morphology)** window, you must select the directory in which you are going to prepare scenarios and execute computations:

➢ Click the *Select working directory* button.

Next the **Select working directory** window, Figure 3.4, is displayed (your current directory may differ, depending on the location of your Delft3D installation).

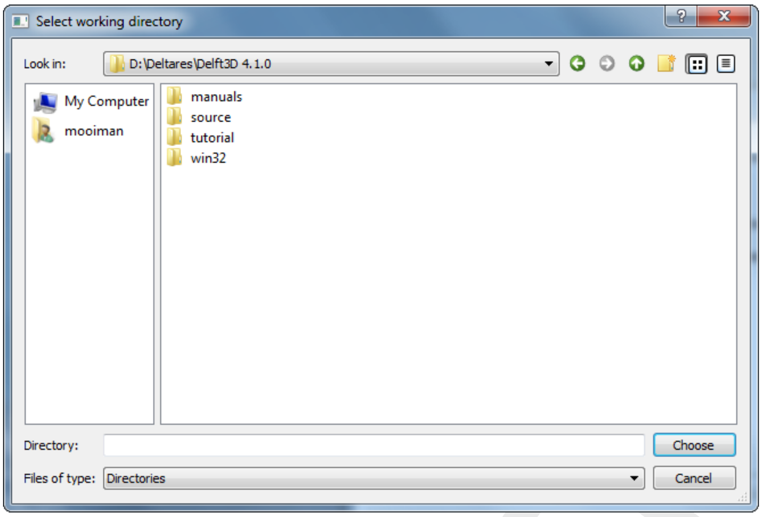

Figure 3.4: Select working directory *window*

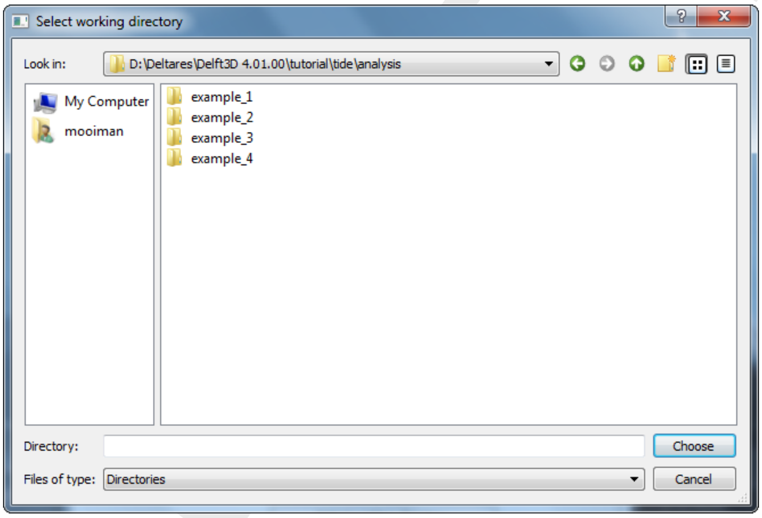

Figure 3.5: Select working directory *window to set the working directory to <tide\analysis\example_1>*

- ➢ Browse to the <Tutorial> sub-directory.
- ➢ Enter the <tide> directory, and next the <analysis> directory.
- ➢ Enter the <example_1> sub-directory and close the **Select working directory** window by clicking *OK*, see Figure 3.5.

Next the **Hydrodynamics (including morphology)** window is re-displayed, but now the changed current working directory is displayed in the title bar, see Figure 3.6.

Remark:

◇ In case you want to start a new project for which no directory exists yet, you can select  in the **Select working directory** window to create a new directory.

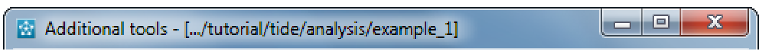

Figure 3.6: *Current working directory*

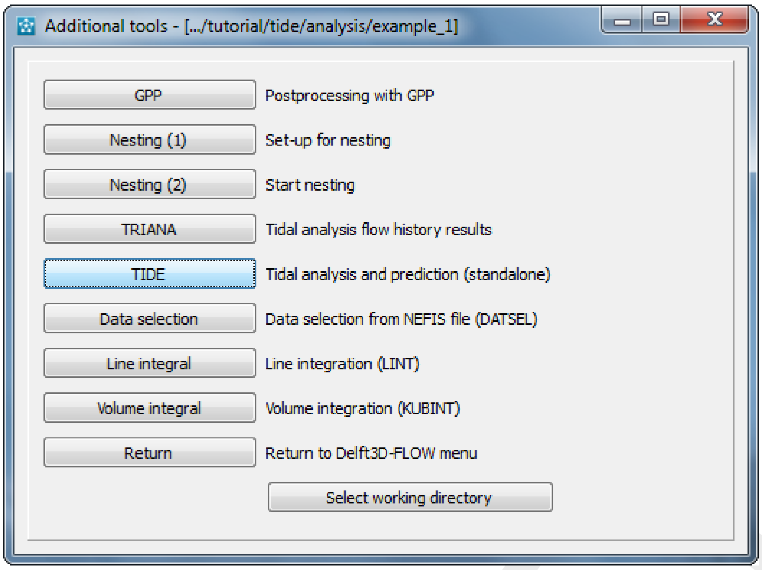

Figure 3.7: *Additional tools for the Delft3D-FLOW module*

In this guided tour through Delft3D-TIDE we limit ourselves to the point where you start Delft3D-TIDE. Hence:

➢ Select *Tools* in the **Hydrodynamics (including morphology)** window.

The **Additional Tools** window is displayed, see Figure 3.7.

The additional tools for Delft3D-FLOW are verifying the input file, nesting (Delft3D-NESTHD 1 and Delft3D-NESTHD 2), tidal analysis of Delft3D-FLOW time-series (Delft3D-TRIANA), tidal analysis and prediction of tides (Delft3D-TIDE), data selection from NEFIS file, linear integration and volume integration, see Figure 3.7.

To start Delft3D-TIDE:

➢ Select *TIDE*.

Next the opening window of Delft3D-TIDE is shown, see Figure 3.8.

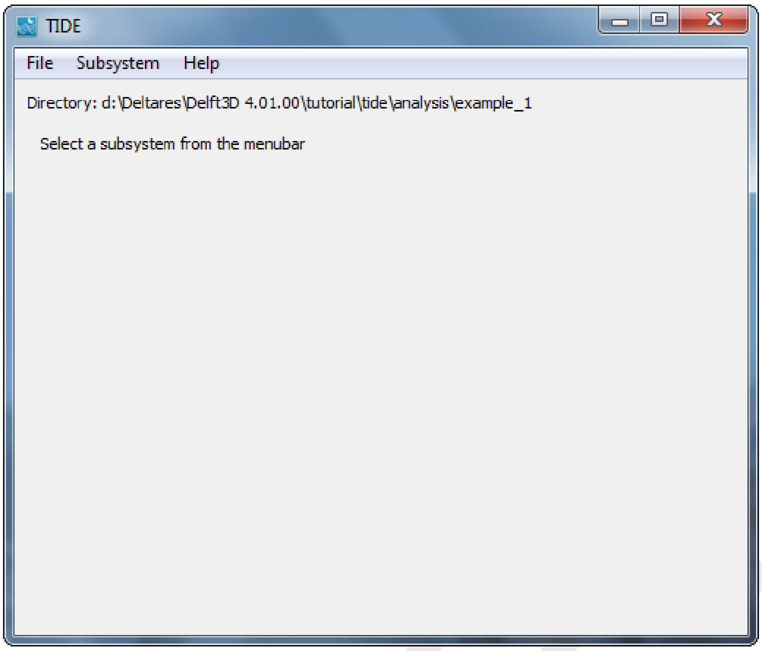

Figure 3.8: *Main window of Delft3D-TIDE*

3.3 Exiting Delft3D-TIDE

Before running Delft3D-TIDE you have to prepare the input files, see section 5.1.2, 5.2.2, 5.3.2 and 5.4.2.

➢ Click *File* → *Quit* to exit Delft3D-TIDE, see Figure 3.9.

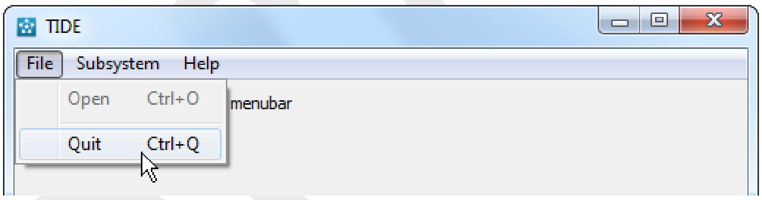

Figure 3.9: *Menu toolbar, option* File → Quit

You will be back in the **Additional tools** window of the Delft3D-MENU program, Figure 3.7.

3.4 Exiting Delft3D

To return to the main **Hydrodynamics (including morphology)** selection window:

➢ Click *Return*

You will be back in the **Hydrodynamics (including morphology)** window of the Delft3D-MENU program, Figure 3.3.

Ignore all other options:

➢ Click *Return* to return to the main window of Delft3D-MENU, Figure 3.2.
➢ Click *Exit*.

The window is closed and the control is returned to the desk top or the command line.

In this Getting Started session you have learned to access the Delft3D-TIDE module as part of the Delft3D-FLOW module.

We encourage users next to read chapter 5 and practice with the tutorial examples given in chapter 7.

4 Menu options

The menu bar contains the items *File*, *Subsystem* and *Help*, see Figure 4.1, each item is discussed in a separate section.

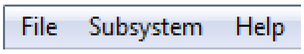

Figure 4.1: *Delft3D-TIDE menu options*

4.1 File menu

On the *File* menu the options *Open* and *Quit* are available see Figure 4.2.

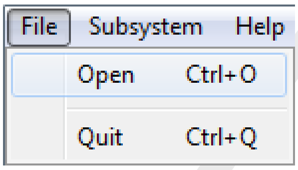

Figure 4.2: *File menu options*

4.1.1 Open

Upon selecting *File* → *Open*, you can open the input files of a subsystem of Delft3D-TIDE. The file selection filters are dependent on the chosen subsystem.

4.1.2 Quit

Upon selecting *File* → *Quit* the Delft3D-TIDE program will close.

4.2 Subsystem menu

On the *Subsystem* menu, the subsystems of Delft3D-TIDE can be selected, see Figure 4.3.

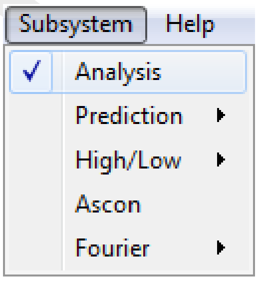

Figure 4.3: *Subsystem menu options*

4.2.1 Analysis

When selecting *Subsystem* → *Analysis* the program to analyse time-series is selected, but first (if needed) the file open window will appear to select the appropriated input files. To start the time series analysis, press the button *Start Analysis*, see Figure 4.4.

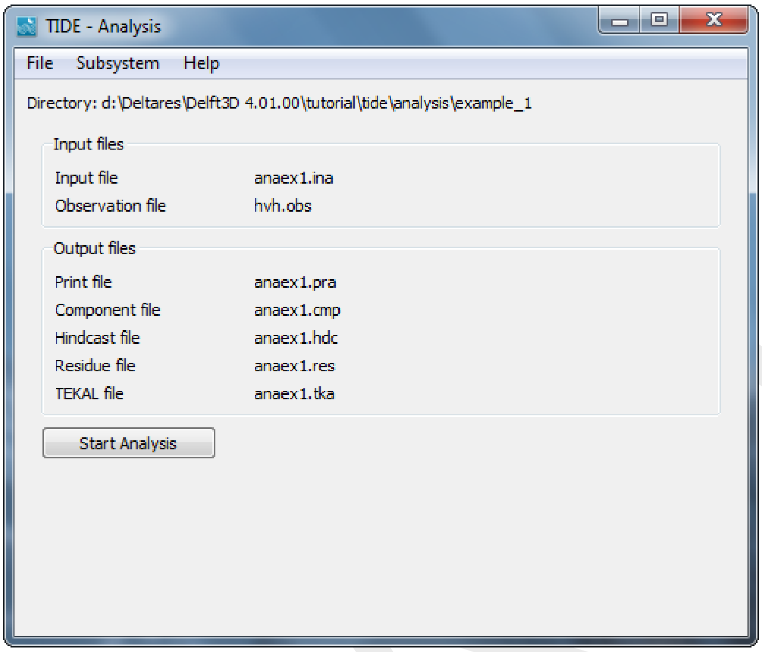

Figure 4.4: ***TIDE - Analysis*** *subsystem window*

4.2.2 Prediction

The subsystem Prediction, to compute the astronomic predictions, consist of two systems,

1 a Graphical User Interface, and
2 a computational core to perform the calculation,

see Figure 4.5.

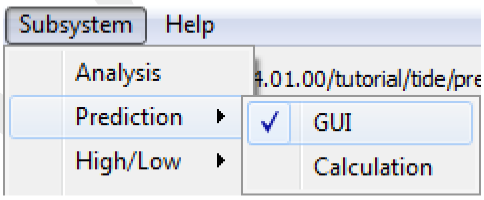

Figure 4.5: *Subsystem Predict menu options*

4.2.2.1 Prediction GUI

When selecting *Subsystem* → *Predict* → *GUI* the user interface program to calculate the predictions is selected, but first (if needed) the file open window appear to select the appropriated input files. To start the prediction user interface, press the button *Start Predict GUI*, see Figure 4.6.

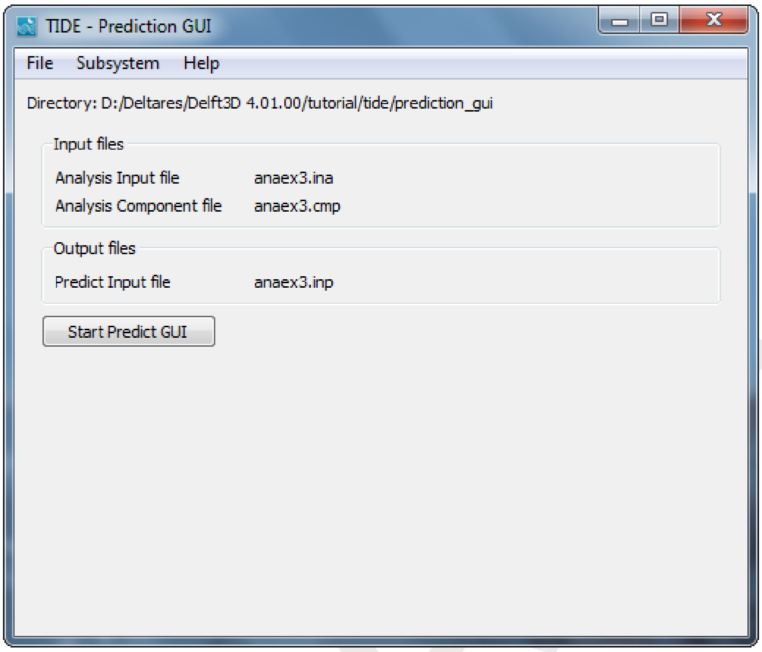

***Figure 4.6: TIDE - Prediction GUI** subsystem window*

4.2.2.2 Prediction Calculation

When selecting *Subsystem* → *Predict* → *Calculation* the program to calculate the predictions is selected, but first (if needed) the file open window appear to select the appropriated input files. To start the calculation of the predictions, press the button *Start Prediction*, see Figure 4.7.

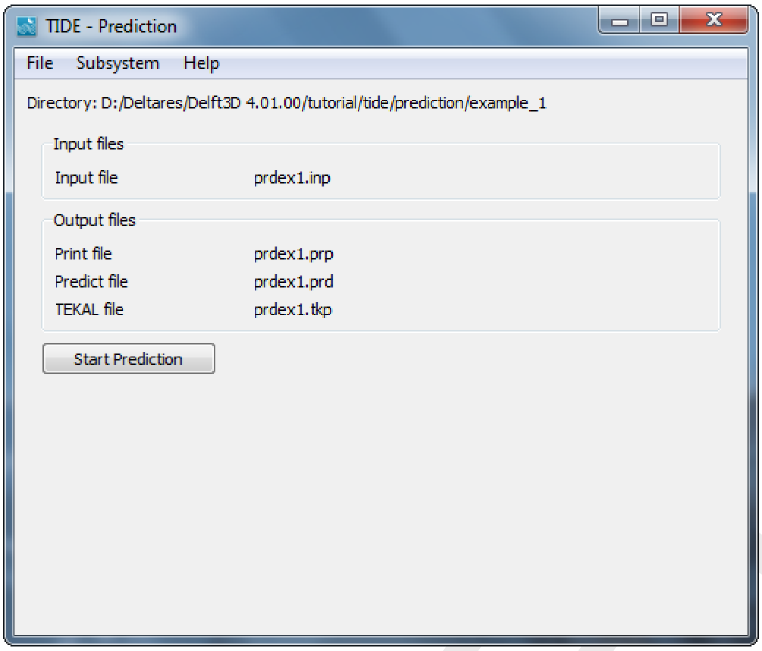

Figure 4.7: ***TIDE - Prediction*** *subsystem window*

4.2.3 High/Low

The subsystem High/Low, to compute the high and low water time tables consist of two systems,

1 a Graphical User Interface, and
2 a computational core to perform the calculation,

see Figure 4.5.

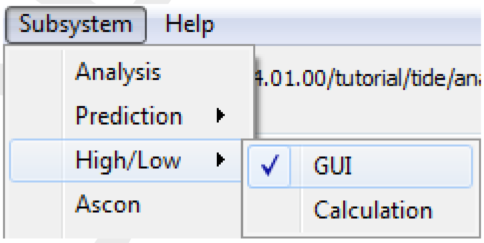

Figure 4.8: *Subsystem High/Low menu options*

4.2.3.1 High/Low GUI

When selecting *Subsystem* → *High/Low* → *GUI* the user interface program to calculate the high and low water level tables is selected, but first (if needed) the file open window appear to select the appropriated input files. To start the user interface, press the button *Start High/Low GUI*, see Figure 4.9.

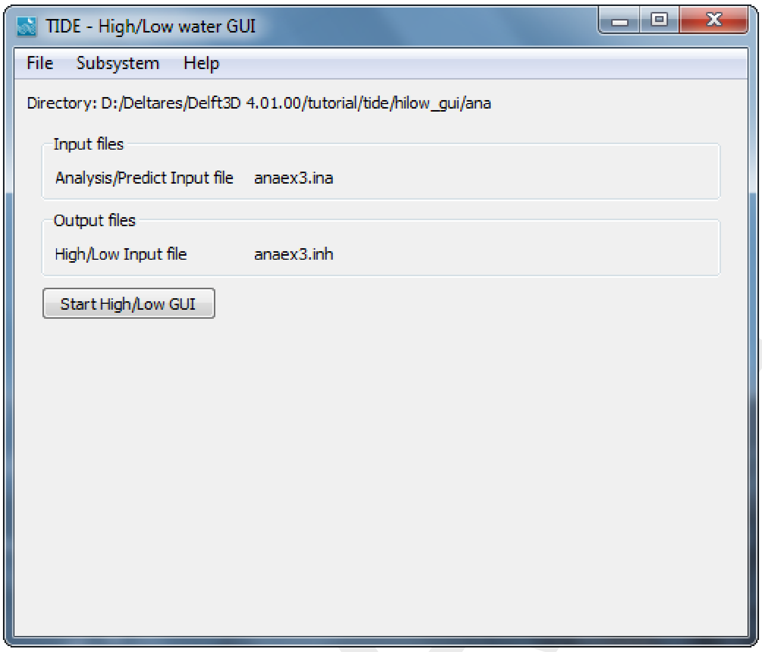

***Figure 4.9: TIDE - High/Low water GUI** subsystem window*

4.2.3.2 High/Low Calculation

When selecting *Subsystem* → *High/Low* → *Calculation* the program to calculate the high and low water level tables is selected, but first (if needed) the file open window appear to select the appropriated input files. To start the calculation of the tide tables, press the button *Start High/Low*, see Figure 4.10.

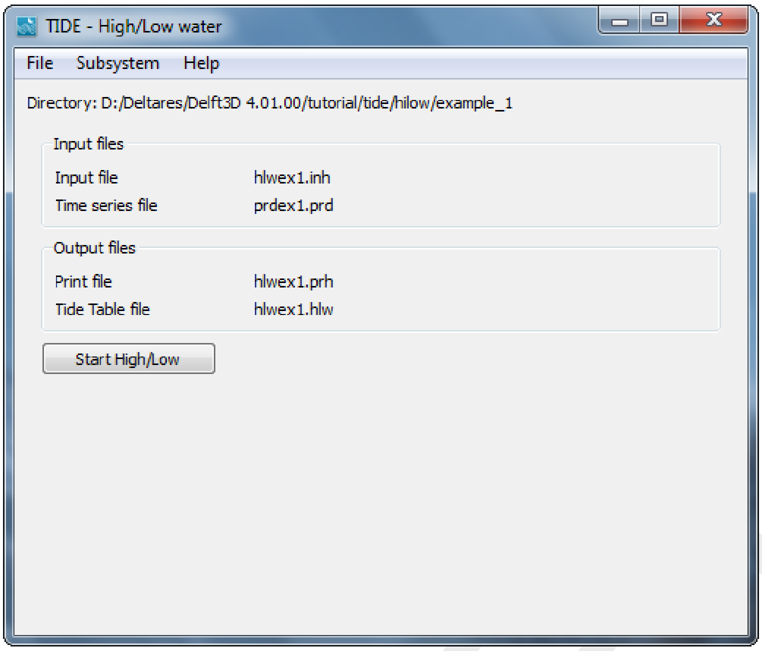

***Figure 4.10: TIDE - High/Low water** subsystem window*

4.2.4 Ascon

When selecting *Subsystem* → *Ascon* the program to analyse time-series is selected, but first (if needed) the file open window appear to select the appropriated input files. To start the calculation of the astronomic constants, press the button *Start Ascon*, see Figure 4.11.

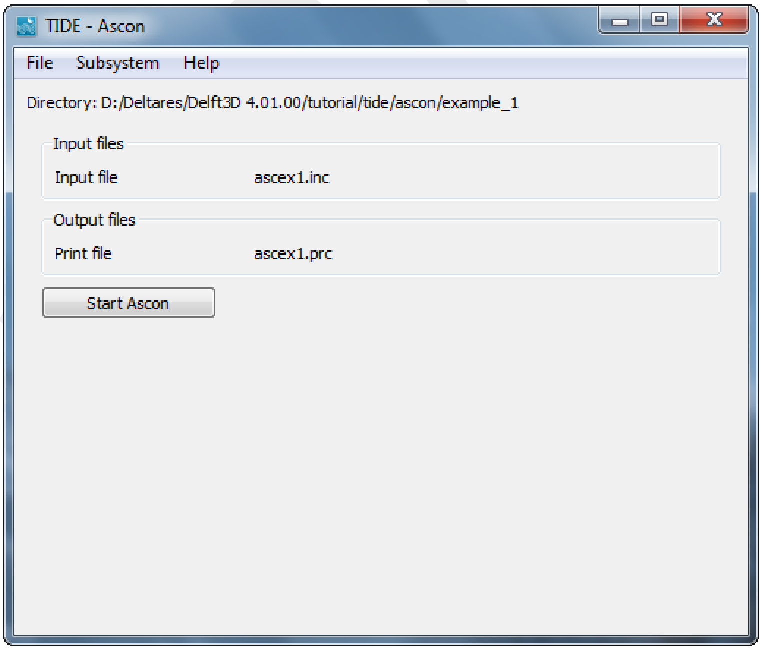

***Figure 4.11: TIDE - Ascon** subsystem window*

4.2.5 Fourier

Two Fourier methods are available to analyse series, you can choose between a Standard Fourier Transform (SFT) or a Fast Fourier Transform (FFT) method, see Figure 4.12.

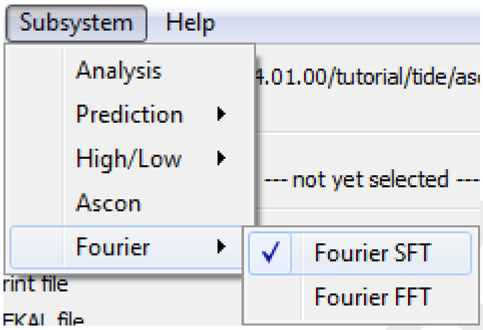

Figure 4.12: *Subsystem Fourier menu options*

4.2.5.1 Standard Fourier Transform

When selecting *Subsystem* → *Fourier* → *Fourier SFT* the program for Standard Fourier Transform is selected, but first (if needed) the file open window appear to select the appropriated input files. To start the standard fourier transform, press the button *Start SFT*, see Figure 4.13.

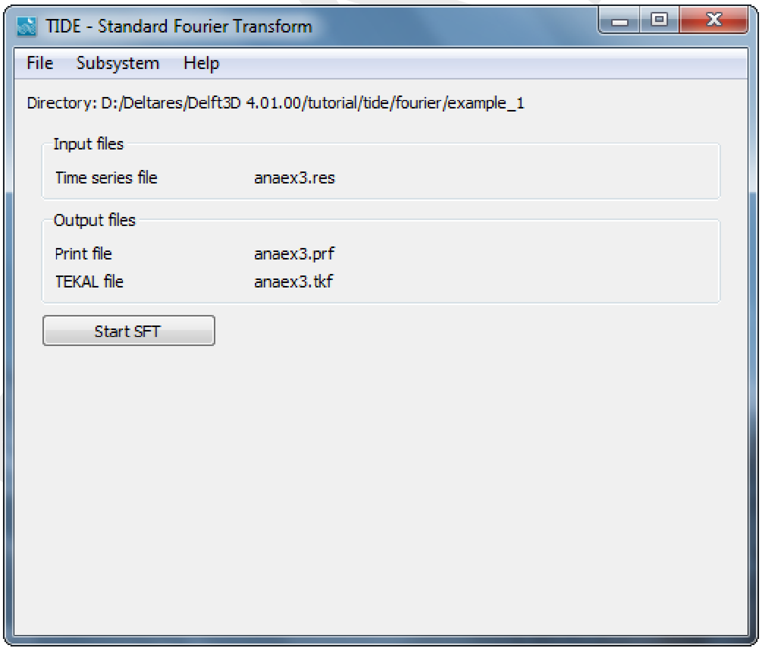

Figure 4.13: TIDE - Standard Fourier Transform *subsystem window*

4.2.5.2 Fast Fourier Transform

When selecting *Subsystem* → *Fourier* → *Fourier FFT* the program for Fast Fourier Transform is selected, but first (if needed) the file open window appear to select the appropriated input files. To start the fast fourier transform, press the button *Start FFT*, see Figure 4.14.

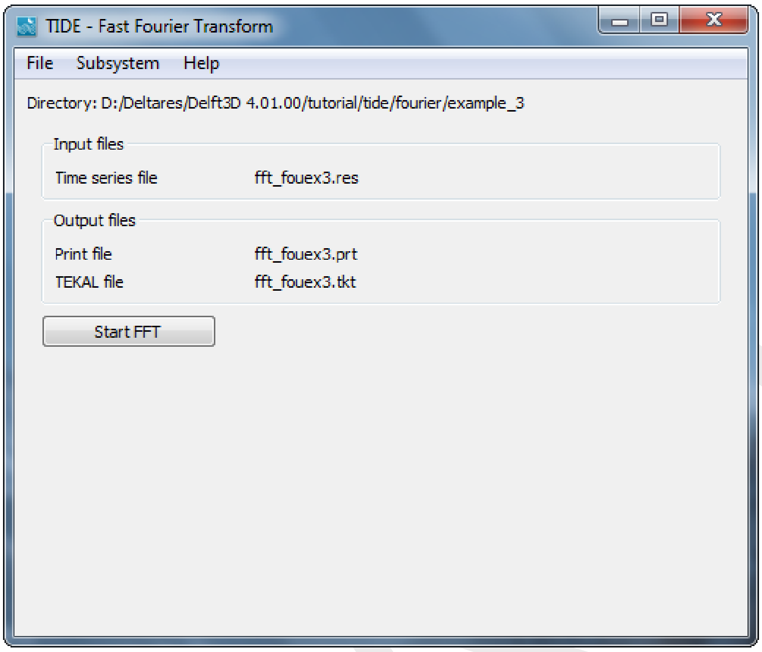

Figure 4.14: TIDE - Fast Fourier Transform *subsystem window*

4.3 Help menu

On the *Help* menu, you can choose to read the user manual or list the version number of Delft3D-TIDE, see Figure 4.15.

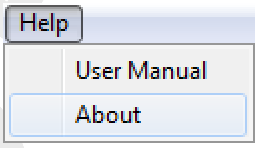

Figure 4.15: *Subsystem menu options*

4.3.1 User Manual

When clicking on the *Help* → *User Manual*, the user manual of Delft3D-TIDE will be displayed.

4.3.2 About

When clicking on the *Help* → *About*, a window will display the current version number of Delft3D-TIDE.

5 General operation of the Delft3D-TIDE subsystems

5.1 ANALYSIS

A rather extensive theoretical background of tidal analysis is given in section 8.3. Special features are discussed in section 8.4. It is advised to refresh your knowledge — if needed — by reading these sections.

5.1.1 Running the system

➢ Start Delft3D-TIDE, see Chapter 3,

ANALYSIS operates in a file oriented way. That means that you have to prepare your input files before you can start the system successfully. From the data on the input files the computational process starts, resulting in a number of output files. The print file with a complete report of the computation provides you with an impression of the results. For file name conventions, see Appendix C.

ANALYSIS needs input data from two files, the input data file (with the required extension <ina>) and the file with observations (with the required extension <obs>), the file descriptions are given in section A.1. Here we expect both input files to be ready for use.

➢ Select *Subsystem* → *Analysis*, see Figure 5.1.

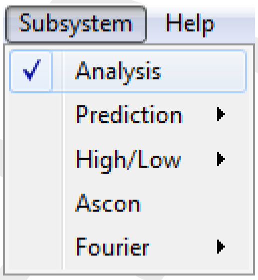

Figure 5.1: *Menu option* Subsystem → Analysis.

If the input files are not yet selected the open file dialog is opened, with the appropriate file filters for the input and observation data, otherwise select the menu option *File* → *Open*. The actual sub-system is shown in the window title, see Figure 5.2.

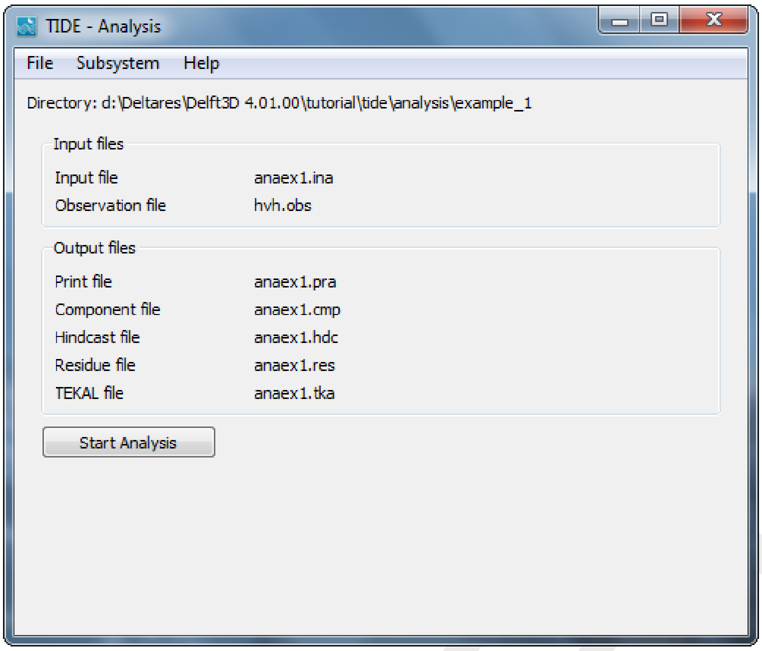

Figure 5.2: *Overview of input and output files for sub-system Analysis*

Below follows a summary of the ANALYSIS output files:

Print file	<*name*.pra>	output print file
Component file	<*name*.cmp>	output file with specific information about tidal components
Hindcast file	<*name*.hdc>	output file with hindcast time-series
Residue file	<*name*.res>	output file with residual time-series
TEKAL file	<*name*.tka>	output file for graphical presentations

where *name* is the filename of the input file <∗.ina>.

Note: Be aware that the input files must satisfy the default extensions as defined for Analysis input files. When this is not the case, please rename the files.

At any time the filenames of the selected input files and the names of the output files are shown, as derived from the name of the input file <∗.ina>. See section 5.1.3 and Figure 5.2.

➢ Press the button *Start Analysis*.

After starting the sub-system the progress will be displayed by the Progress Monitor, see Figure 5.3. At the end of the run a report of the number of warnings and/or fatal errors is shown. For an explanation of these warnings/errors, please browse your print file.

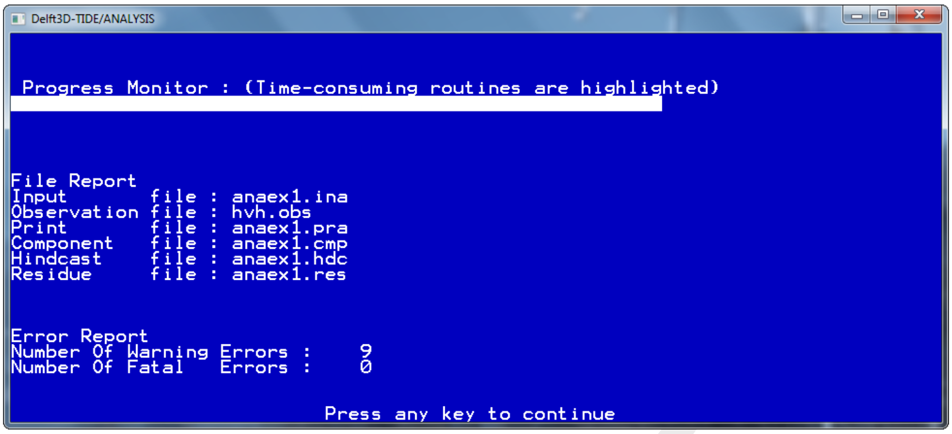

Figure 5.3: *Progress Monitor window for sub-system ANALYSIS*

5.1.2 Input files

ANALYSIS needs input data from two files, the input data file and the file with observations.

As a result of a ANALYSIS computation the processed output files will contain the major characteristics of the performed tidal analysis as well as the tidal station and tidal series itself.

The header lines are directly followed by the data. As the data are read free-formatted there are no conditions with respect to the lay out of the data part of the file. The number of observations per line (a line is a record) is free.

5.1.2.1 Input data file (<∗.ina>)

The input file format is described in section A.1 It is noted that this input data file is also used to prepare a PREDICT input file by using the GUI of the prediction sub-system.

Remark:

◇ The input file <∗.ina> must have at east one line with the '+'-sign.

5.1.2.2 File containing the observations (<∗.obs>)

The <∗.obs> file contains the observations that will be processed in ANALYSIS.

The unit of the observations (meter, centimetre, inches) is free. We advise to choose centimetres as the unit for observations, since the number of printed decimal digits for the results is fixed. So, for centimetres the printed results are actually more accurate.

Remark:

◇ Never use a '+' sign to indicate positive values. It is possible that the record containing this value is identified as a header line. A value without a sign is identified as a positive value.

ANALYSIS enables you to define sub-series for the tidal series on this file. This is important if the series contains gaps or sections with unreliable data, see the description of the input data file in section A.1. The parts between the sub-series, the so-called gaps, are excluded from the computation. Be aware that there is no guarantee that your input specification automatically agrees with the sub-series itself. If start and end time for sub-series are specified incorrectly, it may happen that the input specification for the sub-series is inconsistent with the sub-series of the data on the observations file. As a consequence of this, parts of the (unreliable) gaps will be involved in the harmonic analysis. In order to prevent this we strongly advise to fill the gaps with unrealistic values, e.g. 99999, enabling the system to check whether parts of gaps are involved in the harmonic analysis. (actually each value bigger than 1000 will satisfy) Detection of these unrealistic values will cause the system to abort with an error-message ERROR 21. See the list of messages, section D.1.

5.1.3 Output files

A harmonic analysis produces the following result files:

<∗.pra>	output print file
<∗.cmp>	output file with specific information about tidal components
<∗.hdc>	output file with hindcast time-series
<∗.res>	output file with residual time-series
<∗.tka>	output file for graphical presentations

5.1.3.1 Print file (<∗.pra>)

The print file <∗.pra> starts with an exact echo of the input data file <∗.ina>. Depending on the option chosen by you (see section 5.1.1), this is followed by an extensive Input Interpretation Report. This part of the print file may contain error and/or warning messages. A number of constraints, limits and relations are checked immediately after interpretation. The warnings and errors may interrupt the print output. We strongly advise to scan the print file for messages immediately after the computation has ended.

You may also find some error and/or warning messages as a result of a thorough checks on the consistency of the set of input parameters, see section D.1.

Next, the print file continues with a printout of the date-time (from the input file) for the tidal series $H(1:N)$, read from the observation file <∗.obs>, plus an echo of the number of observations.

This is followed by the results. These are printed per instrument and sub-series. For each instrument and sub-series a table is given with, for each tidal component, the astronomical arguments $V_0 + u$ and F for the middle time point of the instrument or sub-series, as computed by the system. This table (or these tables) is followed by a table of the computed tidal amplitudes and phases for the selected set of components.

Notice that there may be a slight difference between the input date-time groups for instruments and sub-series and the printed results. This results from the fact that the computational process requires that the number of observations per instrument or sub-series is odd, which may lead to disappearance of the last observation.

After the table with computed amplitudes and phases you find the computed parameters $VV1$ and $VV2$. They are a measure for the standard deviation of the analysis and are computed in fully independent ways. These two parameters should be (almost) equal for all the printed digits. That is a guarantee for an accurate numerical solution of the amplitudes and phases. A difference in the last printed digit is allowed. When there is a significant difference between $VV1$ and $VV2$ the matrix of normal equations will be added automatically to the print file for a some insight in the numerical process. For most applications the numerical process is sufficiently stable in that it will result in an accurate solution with $VV1 = VV2$. If there is a significant difference between these two parameters, first check your input. There may be errors or inconsistencies in the set of input parameters which will cause the difference between $VV1$ and $VV2$.

The standard deviation represents an estimate for the standard deviation of the residues, that is, the difference of observation and hindcast over the period of analysis. It gives an indication how well the hindcast fits the observed data.

Recapitulating, from $VV1$ and $VV2$ conclusions can be drawn about the numerical accuracy of the solution in terms of the numerical solution method used. The standard deviation indicates how well the mathematical model with the selected set of components fits the provided data (observations).

If you choose the option that provides an accuracy analysis for the computed results a table of estimated mean errors per tidal component (in terms of cosines and sines, see section 8.4.5) will be printed. Ideally the mean errors should have roughly equal magnitude. Components with strongly differing mean errors normally appear in pairs, indicating that the Rayleigh criterion is violated so they could not be resolved independently. You should either apply astronomical coupling of the two, or remove one of them, if coupling is not possible.

Depending on the options chosen, a table with results on the auto-correlation of the residues is next. Ideally, the time-series of the residue will behave like white noise. From the statistical parameters in this table conclusions can be drawn how well the frequency spectrum of the residue corresponds to the ideal white noise.

The print file concludes with a report giving the dynamic memory usage, an error report and a file-report. From the report on memory usage you can derive the memory words for dynamic storage that were unused. This may be useful information when you are considering a rerun with more components and/or more observations.

5.1.3.2 Component file (<∗.cmp>)

The component file <∗.cmp> starts with a copy of the "plus" header lines from the input data file <∗.ina> and the observation file <∗.obs>, which serve as an identification of this file.

The component file <∗.cmp> consists of two blocks of results, one block with results per instrument and the second block with information per sub-series. In the instruments block you will find the time step and the mean level of the observations, which are computed for each instrument separately. If computed ($INFO(4) = 1$), the linear trend for the instrument will be added to this block. The block for sub-series contains one or more tables with the computed amplitudes and phases as well as the applied astronomical arguments $V_0 + u$ and F. These arguments hold for the middle time point of the series and consequently vary per sub-series. Note that one single set of tidal amplitudes and phases is determined, independent of the number of instruments or sub-series. For an explanation of these parameters we refer to the general introduction in section 8.1.

Remark:

◇ The component file with extension CMP can also be used to prepare input files for the Prediction sub-system by making use of the FileSelector (see section 5.1.1).

5.1.3.3 Hindcast file (<∗.hdc>)

The hindcast file <∗.hdc> starts with a copy of the "plus" header lines from the input data file <∗.ina> and the observation file <∗.obs>, which serve as an identification of this file.

Next, you will find the time-series of the computed hindcast. The hindcast is the time-series computed on the basis of the tidal amplitudes and phases that have just been determined. The time-series for the hindcast is computed for the same time period as the tidal series on the <∗.obs> file is defined, so from date-time begin (TB) until date-time end (TE).

5.1.3.4 Residue file (<∗.res>)

The residue file <∗.res> starts with a copy of the "plus" header lines from the input data file <∗.ina> and the observation file <∗.obs>, which serve as an identification of this file.

This header is followed by the time-series of the computed residues. The residues are defined as observations minus hindcasts. The time period for the residues is the same as for the tidal series from the <∗.obs> file, so from date-time begin (TB) until date-time end (TE).

5.1.3.5 Graphics data file (<∗.tka>)

The graphics file <∗.tka> starts with a copy of the "plus" header lines from the input data file <∗.ina> and the observation file <∗.obs>, which serve as an identification of this file.

This file contains the time-series of time, hindcast, observation and residue in the format that is needed for presentation using Delft3D-QUICKPLOT or GPP. The time-series on this file are in original form or corrected for mean, depending on the choice for input parameter INFO(1). You do not need any knowledge about the contents of this file: the formats are set according to the requirements of the Delft3D-QUICKPLOT or GPP systems. Keep in mind that you need this file if you want to do graphics.

5.1.4 Restrictions

In this section we give a complete list of the restrictions of ANALYSIS.

1. The period for harmonic analysis is restricted to 1950-2049.
2. Maximum number of instruments equals 10.
3. Maximum number of sub-series (for whole tidal series) equals 100.
4. Maximum number of components equals 234.
5. Maximum number of groups of coupled components equals 10.
6. Maximum number of sub-components per coupled group equals 10.
7. Minimum number of data per sub-series equals 3.
8. Minimum number of data per instrument equals 3.
9. Maximum memory allocation for dynamic storage equals 550 000 memory words.

5.2 PREDICT

The formula for astronomical tide prediction is:

$$H(t) = A_0 + \sum_{i=1}^{k} A_i F_i \cos\left(\omega_i t + (V_0 + u)_i - G_i\right) \tag{5.1}$$

in which:

$H(t)$ predicted water level at time t

A_0 mean water level
k number of relevant constituents
i index of a constituent
A_i local tidal amplitude of a constituent
F_i nodal amplitude factor
ω_i angular velocity
$(V_0 + u)_i$ astronomical argument
G_i improved kappa number (= local phase lag).

The values for A_0, A_i and G_i for the selected constituents are input variables. The system computes $V_0 + u$ and F for each constituent (for the period of prediction). Output is a time-series $H(t)$.

For a more detailed introduction, see section 8.1 and 8.5.

5.2.1 Running the system

➢ Start Delft3D-TIDE, see chapter 3.

The User Interface will pop up. To set the sub-system to PREDICT:

➢ Select *Subsystem* → *Predict* → *GUI*, see Figure 5.7.

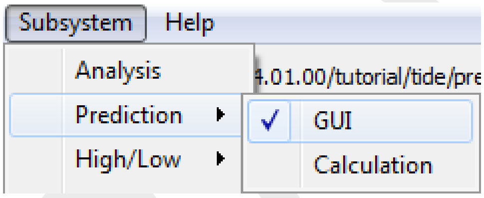

Figure 5.4: *Menu option* Subsystem → Predict → GUI

The actual sub-system is shown as window title.

PREDICT operates in a file oriented way. That means that input files have to be prepared before you can start the system successfully. You can prepare an input file either by editing an already existing PREDICT input file 'by hand' or — in the case predictions have to be prepared with sets of tidal constants resulting from a former ANALYSIS run — by making use of the built-in PREDICT GUI. On the basis of the data on the input file with required mask <∗.inp> the computational process proceeds. After completion of the computation, a number of output files have been produced. The print file <∗.prp> contains a complete report of the computation and provides you with a good impression of the results. The PREDICT GUI may be very useful while preparing a PREDICT input file on the basis of results of a former tidal analysis with ANALYSIS.

Below follows a summary of the PREDICT output files:

<*name*.prp> output print file
<*name*.prd> output file with time-series of predicted values
<*name*.tkp> output file for graphical presentations

where <*name*> is the basename for the input file <*name*.inp>.

Automatic input processing

In order to run PREDICT GUI first make this sub-system the active sub-system by selecting option *Predict* from the *Subsyst* menu in the Main Menu.

The PREDICT GUI extracts necessary information from the pertaining <∗.ina> file and <∗.cmp> file from ANALYSIS in order to create an input file for PREDICT. This sub-system starts an interactive dialogue and is highly self-explanatory. You are led step by step through the system; many pages of useful help texts will be shown on the screen.

For the preparation of an input file for PREDICT, some extra data are needed. The interactive dialogue proceeds as follows:

- ◇ Specification of period for prediction
  The time period for prediction can not be derived from a former analysis. You will be prompted to enter this information.
- ◇ A set of tidal components (with local amplitudes and phases)
  The block of tidal constituents from the <∗.cmp> file in ANALYSIS will be moved in the correct format to the correct place in the input file for PREDICT.
- ◇ Determination of mean levels per sub-series
  In PREDICT you have to split up the time-series for prediction in a number of sub-series, each with its own mean level. From the individual mean levels as computed during tidal analysis, one overall (average) mean level is computed for the whole time-series. For the mean level in the prediction you may agree with the overall mean level as computed in the GUI and shown on the screen. Reply to the prompt by RETURN if you agree with the computed average; otherwise type in the desired mean level.
- ◇ Definition (start/end time) of sub-series
  The system takes care of computing the correct length of the sub-series, taking into account that sub-series do not exceed the length of 1 month duration.

In the PREDICT GUI you can define a new unit for prediction. For example, the **tidal analysis** was done in centimetres, but you prefer **tidal prediction** in meters. For the new unit, the sub-system automatically computes the correct scaling for the tidal constituents. Available units for water levels are centimetres, meters, inches and decimal feet (e.g. 4.1 feet). For velocities corresponding units are available.

Prediction from available input file

In order to run PREDICT first make this sub-system the active sub-system by selecting option *Predict* from the *Subsyst* menu in the Main Menu.

Note: Be aware that the input file should satisfy the default extension as defined for PREDICT input files. If not, please rename the files.

At any time the filenames for the selected input files, can be read as displayed on the main window. In addition the names of the output files are shown, as derived from the name of the input file <∗.inp>, applying the default extensions for result files. See section 5.2.3 and Figure 5.5.

After starting the sub-system the progress will be displayed by the Progress Monitor, see Figure 5.6. At the end of the run a report of the number of warnings and/or fatal errors is shown. For an explanation of these warnings/errors, please browse your print file.

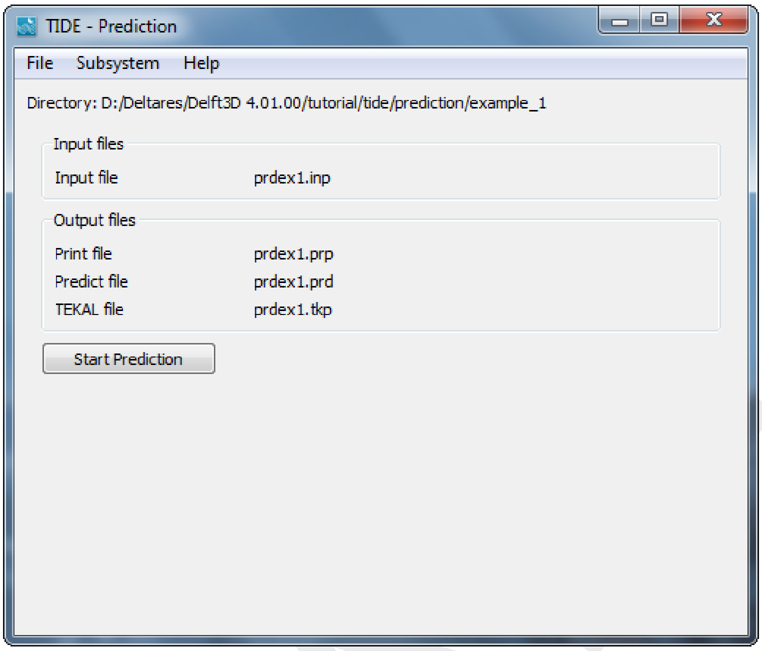

Figure 5.5: *Overview of input and output files for sub-system PREDICT*

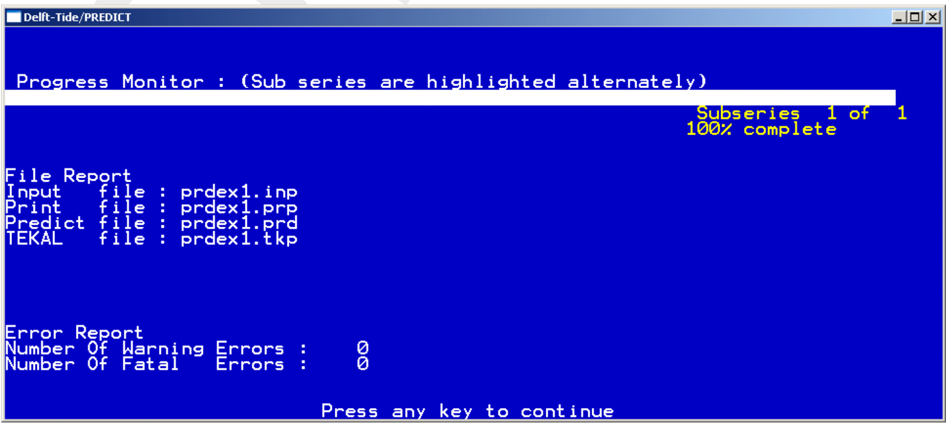

Figure 5.6: *Progress Monitor window for sub-system PREDICT*

5.2.2 Input files

In the cases that a prediction will be performed starting from the results of a former analysis with ANALYSIS, the PREDICT GUI will take care of the format of the <∗.inp> file for PREDICT. If you have to prepare an input file for PREDICT by yourself, it is necessary to know the exact format of the <∗.inp> file, see section A.2 for the format description.

5.2.3 Output files

Computations with PREDICT result in three output files:

<*name*.prp> output print file
<*name*.prd> output file with predictions
<*name*.tkp> output for graphical presentations

5.2.3.1 Print file (<∗.prp>)

The print file starts with an exact copy of the input from the input data file, described in the previous section. Depending on the option chosen by you (see section 5.2.1), this is followed by an Input Interpretation Report. This contains an interpretation of the parameters from the input file <∗.inp>. Some times this print-out may be interrupted by error messages, for example, when built-in restrictions of the software are violated or when the set of input parameters is internally inconsistent.

The print file will continue with the computed time frames for the sub-series. This is followed by the presentation of the results per sub-series. For each sub-series a table of the computed astronomical arguments $V_0 + u$ and the nodal factor F_i for the given set of components is printed, all relative to the middle time point of the sub-series. This is followed by the computed time-series for the prediction for that sub-series. The print file ends with a table of computed minima and maxima per sub-series.

5.2.3.2 Predict file (<∗.prd>)

The PREDICT output file <∗.prd> starts with an exact copy of the "plus" header lines from your input data file to identify the data set. This is followed by the predicted values, 6 values per record line, without any interruption. The transition points of sub-series are not recognisable.

5.2.3.3 TEKAL file (<∗.tkp>)

The TEKAL output file <∗.tkp> starts with an exact copy of the "plus" header lines from your input data file to identify the data set. Next, this output file contains the time-series of time and predicted values in the format needed for presentation on a plotter or on the screen. This data file is required for doing graphics. The predicted time-series on this file is always in original form, so without correction for mean value.

5.2.4 Restrictions

Below, a list of restrictions of PREDICT is given.

1. The period of prediction is restricted to period 1-1-1950 – 31-12-2049.
2. Maximum number of components equals 234.
3. Maximum number of sub-series equals 100.
4. Maximum number of values to be predicted equals 530 000, i.e. a prediction of one year with a time interval of one minue is possible ($530\,000 > 366 \times 24 \times 60$).

There is no explicit restriction on the length of the time period for which predictions can be made in one computation (apart from the first restriction). If the Prediction GUI is used, however, the length of the period to predict is limited to 100 months (100 sub-series of 1 month).

5.3 HILOW

For convenience we refer to the introduction on Tide Tables, see section 8.6.

5.3.1 Running the system

➢ Start Delft3D-TIDE, see Chapter 3.

The User Interface will pop up. To set the sub-system to HILOW:

➢ Select *Subsystem* → *High/Low* → *GUI*, see Figure 5.7.

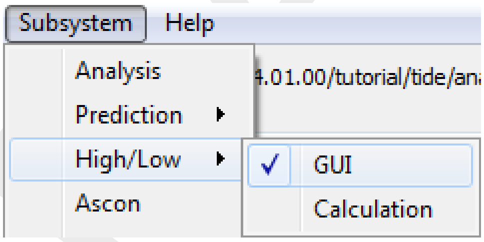

Figure 5.7: *Menu option* Subsystem → High/Low → GUI

The actual sub-system is shown as window title.

Like the other sub-systems, HILOW operates in a file oriented way. That means that input files have to be prepared before you can start the system successfully. You can prepare an input file either by editing an already existing HILOW input file ’by hand’ or — in the case tide tables have to be prepared with results of a former ANALYSIS or PREDICT run — by making use of the built-in HILOW GUI, see section 5.3.1.1. On the basis of the data on the input files the computational process is started. At completion one single output (print) file has been created. Besides the actual results, this output file can provide you with a complete interpretation of the input (Input Interpretation Report), if needed. For filename conventions, see Appendix C.

For HILOW the following file extensions are defined:

<∗.obs>	observed time-series on which tide tables are made
<∗.hdc>	hindcast time-series on which tide tables are made
<∗.prd>	predicted time-series on which tide tables are made
<∗.inh>	input file with computation parameters

<∗.prh>	output print file with input report
<∗.hlw>	output **print** file with tide tables

You can choose from the following options:

1 Automatic input processing
2 HILOW from available input file

5.3.1.1 Automatic input processing

The HILOW GUI may be very useful while preparing a HILOW input file from the results of a former tidal analysis or from the results of a former tidal prediction.

In order to run the HILOW GUI first make this sub-system the active sub-system by selecting option *Subsystem* → *High/Low* → *GUI* from the menu bar.

The GUI can operate in two modes, either from an input file from ANALYSIS or an input file from PREDICT. The HILOW GUI extracts necessary information from the <∗.ina> file or the <∗.inp> file from a PREDICT run in order to create an input file for HILOW.

For loading the input file, select *File*→ *Open* from the menu bar. A file selection window pops up from which the input file is selected.

Note: The operation mode of High/Low is dependent on the file extension, either <∗.ina> or <∗.inp>.

To start the *High/Low GUI* subsystem press the button *Start High/Low GUI*.

The sub-system starts an interactive dialogue and is highly self-explanatory. You are led step by step through the system.

The sub-system can operate in two modes:

1 Using ANALYSIS files for generating hilow-tables for <∗.obs> files or <∗.hdc> (obs = observed and hdc = hindcast)
The HILOW input file is a copy of the ANALYSIS input file. As extra the first file needs to be extended with block filter parameters in order to remove the non-astronomical extremes from the tidal series. The HILOW GUI screens whether or not in the supplied <∗.ina> file (from tidal analysis) the block filter parameters are present. If not, the block filter parameters can be selected from a menu. Defaults can be selected by `RETURN`. Input by you is validated for the legal range. The selected block filter parameters are added on the newly created input file for HILOW.
2 Using PREDICT files for generating HILOW-tables for <∗.prd>-files (= predict files)
The HILOW input file will be generated starting from a PREDICT input file. At the end the needed block filter parameters are asked for (see above). Since the predicted time-series is purely determined by the supplied tidal constituents, resulting in a smooth behaviour, you are advised to select for the block filter parameters the indicated defaults (press `RETURN`).

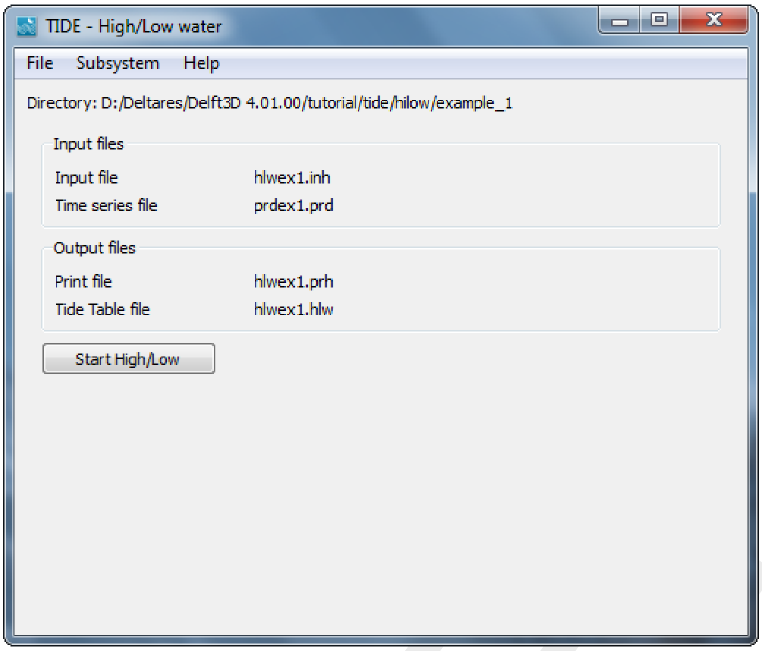

Figure 5.8: *Overview of input and output files for sub-system HILOW*

5.3.1.2 HILOW from available input file

HILOW needs input data from two files, the input data file <∗.inh> and the file with the time-series to be processed for high/low water computations; <∗.obs>, <∗.hdc> or <∗.prd>.

In order to run HILOW first make this sub-system the active sub-system by selecting option *Subsystem* → *High/Low* → *Calculation* from the menu bar. The required input files should be loaded from the *File* → *Open* menu.

Note: Be aware that the input files should satisfy the default extension as defined for HILOW input files. If not, please rename the files.

The selected filenames are listed in the **TIDE - High/Low water** window. The names of the output files are shown, as derived from the name of the input file <∗.inh>, applying the default extensions for result files. See section 5.3.3 and Figure 5.8.

By pressing the button *Start High/Low* the subsystem will start. After starting the subsystem the progress will be displayed by the Progress Monitor, see Figure 5.9. At the end of the run report the number of warning and/or fatal errors is shown. For an explanation of these warnings/errors, please browse your print file.

5.3.2 Input files

The format for the observation time-series file <∗.obs> is described in section A.1 and for the input file <∗.inh> is described in section A.3.

Figure 5.9: *Progress Monitor window for sub-system HILOW*

5.3.2.1 Time-series files <∗.obs>, <∗.prd> or <∗.hdc>

This file contains the time-series for which the Tide Tables will be made, executing HILOW. Usually high/low water tables are generated for

- ◇ observations (e.g. as analysed in ANALYSIS)
- ◇ hindcasts (e.g. an output series of ANALYSIS)
- ◇ predicted time-series (e.g. an output series of PREDICT)

These data-files contain the time-series that will be processed in HILOW.

5.3.2.2 Input data file (<∗.inh>)

In this section we discuss the data on the input data file of HILOW.

The input file for HILOW is identical to the input file of ANALYSIS. It is therefore possible to use the same input file for both the ANALYSIS and the HILOW computation. The header lines of the input file of ANALYSIS, however, may contain specific information about that ANALYSIS run. It is therefore advised to use the HILOW GUI to copy the input file of an ANALYSIS run to the input file of a HILOW run, because during the input processing a step is included to change the header lines in the input file from specific ANALYSIS information to specific HILOW information. For a description of the HILOW input file see section A.3.

5.3.3 Output files

There are two output files, one output print file, <∗.prh>, containing the Input Report followed by some computational results and a second print file with the computed Tide Tables, <∗.hlw>. Notice that the second file is also a print file.

5.3.3.1 Print file (<∗.prh>)

At each new print page, the "plus" header lines from the <∗.inh> file and <∗.obs>, <∗.hdc>, <∗.prd> file are inserted for identification.

The print file <∗.prh> first gives an exact echo of the input data file. Next, the Input Interpretation Report is printed. This part may be interrupted by error messages, for example when built-in limitations of the software are violated, or if the set of input parameters is inconsistent.

5.3.3.2 Tide table file (<∗.hlw>)

At each new print page, the "plus" header lines from the <∗.inh> file and <∗.obs>, <∗.hdc> or <∗.prd> file are inserted for identification.

Finally the computed tide tables are printed, <∗.hlw>. These have the form of well-structured tables for times and values of High Waters (HW) and Low Waters (LW). Next to the dates, a number is printed. This equals the number of hours elapsed until 0:00 hours that day. Each year at 1 January 0:00 hours this value is reset to zero.

5.3.4 Restrictions

HILOW is subject to five restrictions. Here, restrictions are only listed for the relevant input data on the input data file.

1 The time-series must lie between 1 January 1950 and 31 December 2049.
2 The maximum number of data in the processed time-series equals 18 000 (Nobs $\leq$ 18 000).
Note: that processing one full year of half-hourly data (2*8 760/2*8 784 values), or a half year of 15 minute data, does not pose any problems.
3 The maximum number of instruments equals 10.
4 The maximum number of sub-series equals 10.

Remark:
- ◇ Restrictions 5 to 9 of section 5.1.4, ANALYSIS, also apply. When preparing an input file specifically for the HILOW computation or using the HILOW GUI, you will not confront these restrictions (no coupling, 1 component only, no very short sub-series).

5.4 ASCON

The present sub-system calculates the frequencies and the time dependent astronomical arguments $V_0 + u$ and F for any or all of the 234 internally available constituents and for any number of date-time groups. The calculations are based on the Schureman-formulae, with $T = 0$ equal to 1 January 1900, 00:00 GMT. For a definition and explanation of these factors and their use in the tidal formula, you are referred to section 8.1.

Remark:
- ◇ ASCON is a standalone sub-system. It is also incorporated in ANALYSIS and PREDICT, where the same quantities are needed.

5.4.1 Running the system
◇ Start Delft3D-TIDE, see Chapter 3.

The User Interface will pop up. Like the other sub-systems, ASCON operates in a file oriented way. That means that you have to prepare your (single) input file before you can start the system successfully. To set the sub-system to ASCON

➢ Select *Subsystem* → *Ascon* from the menu bar, see Figure 5.10.

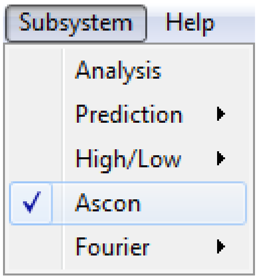

Figure 5.10: Subsytem→ Ascon *selected*

If the input files are not yet selected the open file dialog is opened, with the appropriate file filter for the input file, otherwise select the menu option *File* → *Open*. The actual sub-system is shown as window title.

On the basis of the data on the input files the computational process is started . At completion one single output (print) file has been created. For filename conventions, see Appendix C.

For ASCON the following extensions are defined:

<∗.inc>	input file with date-time groups.
<∗.prc>	output print file with astronomical arguments.

ASCON needs input data from the input file <∗.inc> only. Here we expect this input file to be ready for use.

Be aware that the input file should satisfy the default extension as defined for ASCON input files. If not, please rename the files.

At any time the filenames for the selected input files, can be read from the File Report as displayed on the lower half of the screen. In addition the names of the output files are shown, as derived from the name of the input file <∗.inc>, applying the default extensions for result files. See Appendix C and Figure 5.11.

After starting the sub-system the progress will be displayed by the Progress Monitor, see Figure 5.12. At the end of the run areport of the number of warnings and/or fatal errors is shown. For an explanation of these warnings/errors, please browse your print file.

5.4.2 Input files

A description of the ASCON input file is given in section A.4.

5.4.3 Output file

Only one output (print) file is produced, <∗.prc>.

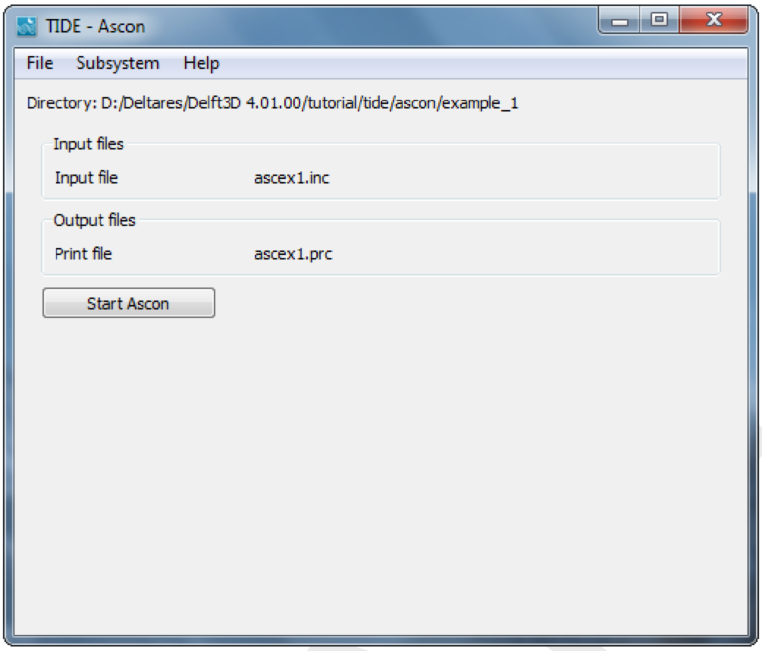

Figure 5.11: *Overview of input and output files for subsystem ASCON*

Figure 5.12: *Progress Monitor window for sub-system ASCON*

Print file (<∗.prc>)

The print file, <∗.prc>, for ASCON starts with an echo of the "plus" header lines of the input file, discussed in section A.4.

Next, a (series of) table(s) follows which present the astronomical arguments $V_0 + u$ and F as well as the angular frequency for the selected set of components. The quantity $V_0 + u$ is defined with respect to Greenwich (V_0 is the astronomical phase for the Greenwich meridian). For an explanation of $V_0 + u$ and F, see section 8.1.

5.4.4 Restrictions

ASCON is subject to two restrictions

1 The date-time groups must lie between 1 January 1950 and 31 December 2049.
2 The set of components is limited to the 234 internally available components.

5.5 FOURIER

FOURIER incorporates a rather straight-forward Fourier analysis of time-series. Within a Delft3D-TIDE environment the major application of this sub-system lies in the Fourier analysis of time-series of residuals as they result from a tidal analysis by ANALYSIS. The location of the peaks in the Fourier spectrum give information where tidal constituents may be missing. By absence of relevant information about the major tidal constituents, FOURIER may be useful when applied on observational time-series to obtain a global impression with respect to the major tidal constituents.

The TIDE package offers two methods for Fourier analysis:

1 Sub-system FOUR: Standard Fourier Transform (SFT)
2 Sub-system FFT: Fast Fourier Transform (FFT)

5.5.1 Standard Fourier Transform (SFT)

In FOURIER based on standard Fourier analysis the evaluation of the Fourier spectrum is done by a numerical approximation of the Fourier integrals. Drawback of this method is it's poor performance for long time-series, since the computing time is proportional to the square of the number of data. Therefore the practical application of this method is restricted to time-series of some hundreds of involved data. Although the original time-series may be much longer, the sub-system features the selection of a sub-series (see below).

FOUR features:

a. Selection of sub-series $F(n_1 : n_2)$ as part of the read-in time-series $F(1 : n)$.
b. Restriction of Fourier spectrum to relevant tidal bands.
c. Restriction of the Fourier spectrum $S(0 : wmax)$ to the sub spectrum $S(w_1 : w_2)$.

Dealing with long time-series, options above may result in a considerable speed-up of the computational process.

Note: Nowadays computer performance for FOURIER transformation is not a issue any more. E.g. option a) wit a period of 355 or 369 days can be combined with option c) with $S(0° : 180°)$ assuming $\Delta t = 1h$.

Ad a. Selection of sub-series $F(n_1 : n_2)$ ***[synodic periods]***

From the read-in time-series $F(1 : n)$ a relevant part $F(n_1 : n_2)$ may be selected for Fourier analysis. You will be prompted for adequate values for n_1 and n_2. FOURIER supports the selection of synodic periods. In the field of tidal analysis a time interval will be referred to as a synodic period if it encloses multiples of the major tidal periods, so the periods of the major tidal constituents. FOURIER includes following synodic periods: 15.0, 29.5, 30.0, 355.0 and 369.0 days.

For the Fourier analysis of time-series of residuals it's preferable to take the length of the period for analysis (almost) equal to a synodic period. The reason for this is that, as easily can be derived, for a synodic period the Fourier spectrum will contain the major tidal frequencies. After the selection of the start of the time-series ($= n_1$) the system automatically proceeds with the computation of the relevant synodic periods. After this the resulting values for n_2 will pop up in a menu, supporting you by the selection of a relevant synodic period.

Ad b. Tidal bands

The computation of the Fourier spectrum may be restricted to one or more tidal bands, ranging from tidal band 0 to 12. In the field of tidal analysis a tidal band contains the tidal constituents with the same diurnality. e.g. tidal band 2 contains the tidal constituents 'occurring' approximately twice a 24 hour's day, with M_2 as the most well-known constituent. Tidal band 0 contains the long-periodical constituents. As mentioned the restriction of the Fourier analysis to tidal bands may result in a considerable speed-up of the computational process.

Ad c. Sub spectrum $S(w1 : w_2)$

Here the computation of the Fourier spectrum may be restricted to a part of the frequency band, from frequency w_1 until w_2. Frequencies w_1 and w_2 are to be input by you.

Of course the maximum frequencies should not exceed the so-called Nyquist frequency, defined as:

$$f_{Nyquist} = \frac{180}{\Delta t} \qquad [degrees/hour]$$

E.g. for a time step of $\Delta t = 1$ hour the Nyquist frequency = 180 degrees/hour.

5.5.2 Fast Fourier Transform (FFT)

The Fast Fourier Transform features it's superior computational speed. Especially for long time-series (many thousands of time steps) the Fast Fourier Method may be very useful. The implemented FFT method is the so-called Markel and Ritea method.This method expects the number of data to be a power of two. If the number of data on the user-provided data set is not a power of two, the time-series will be extended by adding zeroes, until the number of data equals the next power of two. From the definition of the Fourier Transform it is easy to see that adding zeroes will not affect the resulting Fourier spectrum. It will only increase the spectral density, resulting in more frequencies per unit.

FFT only features the selection of sub-series $F(n_1 : n_2)$, see above. The definition of the computational Fast Fourier Transform does not allow the selection of tidal bands or sub spectra. At the other hand the Fast Fourier Transform is that fast, that this speed-increasing options are hardly needed.

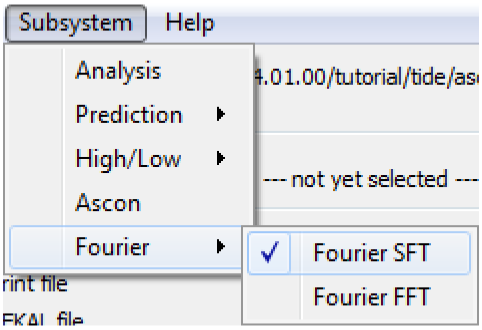

Figure 5.13: *Menu* Subsystem → Fourier → Fourier SFT

5.5.3 Running the system

Slightly different from the other sub-systems, FOURIER does not expect the input parameters to be present on a file.

Here the input parameters like time step, options etc. should be entered in an interactive dialogue.

At completion next output files will be created for *Standard Fourier Transform*:

<*name*.prf> output print file for SFT
<*name*.tkf> output file for graphical presentations for SFT

For *Fast Fourier Transform* output files below will be created:

<*name*.prt> output print file for FFT
<*name*.tkt> output file for graphical presentations for FFT

➢ Start Delft3D-TIDE, see Chapter 3.

The User Interface will pop up. In order to run FOURIER first make this sub-system the active sub-system by selecting option *Fourier* from the *Subsystem* menu in the Main Menu, see Figure 5.13.

At any time the filenames for the selected input files, can be read from the File Report as displayed on the lower half of the screen. In addition the names of the output files are shown, as derived from the name of the input file, applying the default extensions for result files.

The time-series for Fourier analysis will be read from an external data set.

The format of this data set should be like the well-known TIDE-format of the <∗.res> files from ANALYSIS.

5.5.4 Restrictions

FOURIER is subject to one restriction.

1 Number of time-series: $n \leq 550\,000$.

6 Graphics

ANALYSIS, PREDICT and both FOURIER sub-systems create column oriented TEKAL data files, <∗.tka> and <∗.tkp> files. As these files contain an appropriate header for the Delft3D-QUICKPLOT and GPP graphics programs, these files can easily be processed by Delft3D-QUICKPLOT and GPP.

Delft3D-QUICKPLOT and GPP may be activated from the Delft3D-MENU. Select *Utilities* in the main window, next *QUICKPLOT* or *GPP*.

From the TEKAL data files of ANALYSIS time-series can be plotted of observations, hindcast and residuals. From the TEKAL data files from PREDICT the time-series of the tidal prediction can be plotted. From the TEKAL data files of FOURIER the spectral series can be plotted of the residuals. For the application of Delft3D-QUICKPLOT and GPP, we refer to the respective User Manuals (QUICKPLOT UM, 2013; GPP UM, 2013).

7 Tutorial

For each of the subsystems are tutorials given. These examples are part of the tutorials as distributed with Delft3D.

7.1 ANALYSIS

For the ANALYSIS subsystem 4 examples are given.

7.1.1 Example 1

Tidal Station	Hook of Holland
Location	Coastal station North Sea
Period	year 1980, month of April
Number of components	37
Number of coupling groups	3
Number of instruments	1
Number of sub-series	1
Trend/ linear variation	no
Accuracy analysis	no
Graphics file	no

Remarks:

◇ The dataset with the observations contains hourly data for all of 1980. Only the data for the month of April are used in the tidal analysis.

◇ The print file of this example contains a number of warning for the violation of the Rayleigh criterion. This example represents the situation that there are constituents which are formally too close in frequency ($\Delta\omega = 0.4715$, requiring an observation length of $360/(24 \times 0.4711) = 31.9$ days). You should either apply astronomical coupling (see section 8.3.4), or drop one of the two constituents. Given the nature of the least squares solution method, however, a 90 % satisfaction of the Rayleigh criterion is almost always acceptable. This is the example here. If the computation is redone with observation length 32 days or more, the Rayleigh criterion is formally satisfied (no warnings). In the present example, the results will be practically the same.

7.1.2 Example 2

Tidal Station	Hook of Holland
Location	Coastal station North Sea
Period	full year 1980
Number of components	60
Number of coupling groups	0
Number of instruments	1
Number of sub-series	1
Trend/linear variation	no
Accuracy analysis	no
Graphics file	yes; with correction for mean level

Remark:

◇ The hindcast file <anaex2.hdc> will be used for HILOW Example 7.3.2.

7.1.3 Example 3

Tidal Station	Centre Point of the Bermuda Triangle
Period	1 – 30 June 1989
Number of components	29
Number of coupling groups	3
Number of instruments	2
Number of sub-series	1
Trend/ linear variation	yes
Accuracy analysis	yes
Graphics file	yes; without correction for mean level

Remarks:
- ◇ See the second remark of Example 7.1.1.
- ◇ The residuals <anaex3.res> will be used for FOURIER Example 7.3.1

7.1.4 Example 4

Tidal Station	Atlantis (Lost Continent)
Location	Atlantic Ocean
Period	Full year 2024
Number of components	38
Number of coupling groups	0
Number of instruments	2
Number of sub-series	6
Trend/ linear variation	no
Accuracy analysis	no
Graphics file	no

Remark:
- ◇ See the second remark of Example 7.1.1. Formal satisfaction of the Rayleigh Criterion requires an observation length of 365 days ($360/(24\times0.0411) = 365$). In the present observation series the month of January is not present which reduces the length to 334 days ($\Delta\omega = 360/(24 \times 334) = 0.0449$).

7.2 PREDICT

For the PREDICT subsystem 2 examples are given.

7.2.1 Example 1

Tidal Station	Atlantis (Lost Continent)
Location	Atlantic Ocean
Period	1 - 30 June 2027
Time step	30 minutes
Number of components	38
Number of sub-series	1

Remark:
- ◇ The prediction file <prdex1.prd> will be used for HILOW Example 7.3.1.

7.2.2 Example 2

Tidal Station	Hook of Holland
Location	Coastal station North Sea
Period	1999 November 1 until 2000 February 29
Time step	60 minutes
Number of components	60
Number of sub-series	4

7.3 HILOW

For the HILOW subsystem 3 examples are given.

7.3.1 Example 1

Input time-series	Atlantis (Lost Continent); prediction
Location	Atlantic Ocean
Period	1 – 30 June 2027
Time step	30 minutes

Remark:
- ◇ The prediction file <prdex1.prd> comes from PREDICT Example 7.2.1 .

7.3.2 Example 2

Input time-series	Hook of Holland; hindcast
Location	Coastal station North Sea
Period	Full year 1980
Time step	60 minutes

Remarks:
- ◇ It is noted once again that the HILOW input file is equal to the ANALYSIS input file: if an analysis has been performed, the same input file can be used for tide tables of either the observed or the hindcast series.
- ◇ Although the full year is available, the input file is prepared to generate the tables of High and Low water for the month of April only. This is comparable to the ANALYSIS Example.
- ◇ The hindcast file <anaex2.hdc> comes from ANALYSIS Example 7.1.2.

7.3.3 Example 3

Input time-series	Centre Point Bermuda Triangle; observed water level series
Period	1 – 30 June 1989.
Time step	60 minutes

Remark:
- ◇ This is the observation series analysed in ANALYSIS Example 7.1.3.

7.4 ASCON

For the ASCON subsystem 2 examples are given.

7.4.1 Example 1

Tidal Station	Centre Point of the Bermuda Triangle
Number of components	29
Astronomical arguments for the following Date-Time groups	1999, January 1 , 00:00:00 GMT 2000, January 1 , 00:00:00 GMT 2001, January 1 , 00:00:00 GMT

7.4.2 Example 2

Tidal Station	Hook of Holland
Location	Coastal station North Sea
Number of components	60
Astronomical arguments for the following Date-Time group	2049, December 31, 00:00:00 GMT

7.5 FOURIER

For the FOURIER subsystem 3 examples are given.

7.5.1 Example 1

Tidal Station	Centre Point of the Bermuda Triangle
Character of the data	Residue file from example 3 of analysis
Length of generated time-series	30.0 days
Length of analysed time-series	29.5 days from start (=suitable period)
Fourier option	tidal bands 0, 2, 4, 6 and 8

The examples 7.5.2 and 7.5.3 are related to artificial time-series for an adequate test of the Standard Fourier Transform and the Fast Fourier Transform.

The generic formulae for the artificial time-series reads:

$$F(t) = \sum_{i=1}^{n} A_i \cos(\omega_i t)$$

7.5.2 Example 2

Character of the data	Artificial
Parameters in generic formulae	ω_1 = 15.5 degr/h, A1 = 10 cm ω_2 = 16.5 degr/h, A2 = 20 cm ω_3 = 28.5 degr/h, A3 = 30 cm
Length of generated time-series	30 days (=720 data points)
Length of analysed time-series	30 days (=720 data points)
Time step (minutes)	60 minutes
Applied Fourier Method	Standard Fourier Method
Fourier option	full spectrum analysis

7.5.3 Example 3

Character of the data	Artificial
Parameters in generic formulae	ω_1 = 21.97 degr/h, A1 = 10 cm
	ω_2 = 43.94 degr/h, A2 = 20 cm
	ω_3 = 109.86 degr/h, A3 = 30 cm
Length of generated time-series	682.67 days (=16384 data points)
Length of analysed time-series	682.67 days (=16384 data points)
Time step (minutes)	60 minutes
Applied Fourier Method	Fast Fourier Transform

8 Conceptual description

8.1 Mathematical representation of the tide

The astronomical tide observed in oceans and seas is directly or indirectly the result of gravitational forces acting between the sun, moon, and earth. The influence of other celestial bodies is negligibly small.

The most important motions for the tide are the earth's rotation around its axis (1 day), the moon's orbit around the earth (27.32 days), and the earth's orbit around the sun (365.25 days).

The observed tidal motion can be described in terms of a series of simple harmonic constituent motions, each with its own characteristic frequency ω (angular velocity). The amplitudes A and phases G of the constituents vary with the positions where the tide is observed.

In this representation by means of the primary constituents, compound and higher harmonic constituents may have to be added. This is the case in shallow water areas for example. where advection, large amplitude to depth ratio, and bottom friction give rise to non-linear interactions. For a list of primary and compound constituents, see Appendix B.

The general formula for the astronomical tide is:

$$H(t) = A_0 + \sum_{i=1}^{k} A_i F_i \cos\left(\omega_i t + (V_0 + u)_i - G_i\right) \qquad (8.1)$$

in which:

$H(t)$	water level at time t
A_0	mean water level over a certain period
k	number of relevant constituents
i	index of a constituent
A_i	local tidal amplitude of a constituent
F_i	nodal amplitude factor
ω_i	angular velocity
$(V_0 + u)_i$	astronomical argument
G_i	improved kappa number (= local phase lag)

F and $(V_0 + u)$ are **time-dependent** factors which, together with ω, can easily be calculated and are generally tabulated in the various tidal year books. V_0 is the phase correction factor which relates the local time frame of the observations to an internationally agreed celestial time frame. V_0 is frequency dependent. F and u are slowly varying amplitude and phase corrections and are also frequency dependent. For most frequencies they have a cyclic period of 18.6 years. A_0, A_i and G_i are **position-dependent**: they represent the local character of the tide.

If for a specific location A_0, A_i and G_i are known, the above formula can be used to predict the local water level $H(t)$ at any time.

Conversely, if at a location a series of tidal observations $W(t_j)$ is known, the above formula can be used in a least squares analysis to estimate the constants A_0, A_i and G_i.

8.2 Tidal current

The tidal current (horizontal tide) and the water level (vertical tide) are two appearances of the same tidal phenomenon. The local behaviour of the current components can also be described in terms of a series of simple harmonic constituents. So, Equation (8.1) holds also for currents, with generally the same constituents (same ω, frequency), but with its own values for A_0, A_i and G_i.

Tidal analysis of current component registrations is analogous to analysis of water level observations. With A_0, A_i and G_i known for the components of a current vector, a prediction of the tidal current can again be made for any given period in the past or future.

Remarks:

- In the remainder of this User Manual only water levels are mentioned. **All sub-systems and all theory apply equally well to the scalar components of current observations**. Since the (tidal) current is a vector quantity, you must first split it into orthogonal components, e.g. North and East current components.
- These scalars can then be treated just as water levels. This holds for all concepts in this manual: tidal analysis, sets of components, tidal prediction, tables of times and values of tidal current extremes, graphics, etc.

8.3 Tidal analysis

8.3.1 Mathematical model

Starting from a series of e.g. hourly or half-hourly tidal height registrations $W(t_j)$, ANALYSIS can be used to determine the constants A_0, A_i and G_i. On the basis of one month of data a good characterisation of the tide can already by given. A drawback of such short series is the fact that not all important tidal constituents (tidal components) can be resolved independently. With observations of longer duration, such as one year, also longer period constituents and various small constituents can be determined explicitly and independently.

A key part of the analysis is the proper selection of the set of constituents which is assumed to give a proper representation of the tide. Equation (8.1) with the set of assumedly important tidal constituents forms the **mathematical model of the tide** that you prescribe. Knowledge and information about the nature of the local tide, together with the sampling rate and duration of the observations are essential in order to develop a good mathematical model.

As a result of non-resolvable very long period constituents or non-astronomical phenomena such as wind, the mean water level may vary slowly. Also, the position of the registration instrument may gradually change. To take account of such motions, if present, you may include an extra term Bt to the analysis formula Equation (8.1), representing a trend.

In the case that the model is formulated in terms of k relevant constituents, a total of $(2k+1)$ unknowns A_0, A_i and G_i must be determined (or $(2k+2)$ unknowns, if Bt is included). This is realised by minimisation of the quantity:

$$\sum_j (W(t_j) - H(t_j))^2 , \tag{8.2}$$

using a least squares technique.

We have now — partly implicitly — touched upon four essential aspects of the formulation of the mathematical model that require further attention:

1 the measurement interval (Nyquist condition)

2 the total duration of the registration (Rayleigh Criterion)
3 astronomical coupling of constituents
4 the least squares solution technique

8.3.2 Nyquist condition (measurement interval)

In section 8.1 the general formula for the astronomical tide is given (Equation (8.1)). The tide is prescribed as the sum of a series of single harmonic functions, each with its own frequency, local amplitude and local phase (lag) or improved kappa number. The tidal frequencies that are present in the tidal observation fix the frequencies in the tidal model.

The mathematical model requires that the measurement interval (W_t) is at most half the smallest wave period (T_{min}) that is present in the signal. This is called the Nyquist criterion:

$$\Delta t \leq \frac{1}{2} T_{min} \tag{8.3}$$

In the oceans and in coastal seas the discernable tidal frequencies are generally smaller than 180°/hour. This means that they correspond to wave periods that are larger than 120 minutes. So, a measurement interval of $W(t) = 60$ minutes (1 hour) will satisfy.

In complicated river and estuarine situations much higher frequencies may occur. The water level in the Gironde river in France is characterised by periodic fluctuations with frequencies of 720 degrees per hour, which are of tidal origin. These frequencies correspond to wave periods of 30 minutes, requiring a tidal measurement interval of 15 minutes or less.

In practice, the absence of tidal energy at the 12th-diurnal band, with frequencies roughly 180°/hour (see Appendix B), forms a guarantee that a measurement interval of 60 minutes is satisfactory.

8.3.3 Rayleigh criterion

The duration of a tidal observation — generally called the observation "length" — will vary from case to case. This means that the resolvability of independent constituents, each having its own fixed frequency, varies from situation to situation as well:

"In order to be able to resolve all constituents accurately, their frequencies must differ from one another by at least:

$$\Delta\omega = \frac{360^\circ}{T} \tag{8.4}$$

in which T is the duration of the observation in hours".

This criterion is known as the **Rayleigh criterion**.

$\Delta\omega$ is also the smallest Fourier frequency component that can be resolved for a given time-series.

In practice the observation length is given and cannot easily be changed. The Rayleigh criterion then restricts the number of constituents that can be prescribed independently. For example, with a 30 days registration, the Rayleigh criterion requires:

$$\Delta\omega = \frac{360}{30 \times 24} = \frac{360}{720} = 0.5 \tag{8.5}$$

Similarly, registrations of 180 and 360 days duration lead to a Rayleigh criterion of 0.08333 and 0.04166 degrees per hour, respectively.

Appendix B lists all available tidal constituents and their frequencies in order of increasing frequencies. It is clear that in most tidal analysis computations the Rayleigh criterion will drastically restrict the choice of constituents that can be included.

8.3.4 Astronomical coupling

Very often a tidal registration series has a length of only one month. In many waters, however, a proper description of the tide requires the inclusion of tidal constituents that can only be resolved from half a year or a year of data. Simple inclusion of these components in the mathematical model of the local tide will imply a violation of the Rayleigh criterion and lead to unreliable results.

In the Delft3D-TIDE system you may resolve the related constituents in a coupled sense. Let us assume the situation of one main component and several sub-components which are too close in the frequency domain. You must **prescribe the amplitude and phase relations** between the two or more constituents involved. In the numerical solution one "lumped" constituent is resolved. Afterwards, the prescribed relations are applied again to determine the separate amplitudes and phases. We note that this system presupposes that the main component is essentially larger than the sub-components.

$$H(t) = A_0 + \sum_{i=1}^{k} A_i F_i \cos\left(\omega_i t + (V_0 + u)_i - G_i\right) \tag{8.6}$$

$$i \neq \upsilon_\xi, \ldots, \upsilon_\xi + \lambda_\xi$$

$$\xi = 1, 2, \ldots.., \tau$$

$$H(t) = A_0 + \sum_{\xi=1}^{\tau} A_{\upsilon_\xi} F_{\upsilon_\xi} \cos\left(\omega_{\upsilon_\xi} t + (V_0 + u)_{\upsilon_\xi} - G_{\upsilon_\xi}\right) \tag{8.7}$$

where:

τ	number of groups of astronomically coupled constituents.
ξ	sequence number of the group.
λ_ξ	number of sub-components in group ξ, solved together with the main component of group ξ.
υ_ξ	index; $1 \leq \upsilon_\xi \leq \lambda_\xi$.

Appendix B gives a list of the astronomical couplings that may have to be made in case of short observation series. Well known are the couplings (K1, P1), (N2, NU2), and (S2, K2). In practice you should always try to use amplitude and phase relations based on a long period analysis of a neighbouring station. Only if such information is not available, you may resort to equilibrium tide relations given in Appendix B (amplitude relation is prescribed, phase relation is equal to zero).

Remarks:

- ◇ You should always resolve the constituents of these three groups independently, if the series is sufficiently long. It is strongly advised not to perform an analysis on a series that is shorter than 30 days, e.g. 15 days. In such an analysis too many constituents have to be coupled, which makes the mathematical model too rigid.
- ◇ The best results are obtained with observation periods corresponding to the so-called synodic periods of one month, six months, and one year.

8.3.5 Least squares solution technique

Assuming the choice of the mathematical model for the tide fixed (k constituents, a mean A_0 and a linear trend B_0), the model is numerically solved by means of a least squares technique. This is based on the minimisation of the quantity:

$$\sum_{i=1}^{N} \left(W(t_i) - H(t_i)\right)^2 , \tag{8.8}$$

where N is the number of observations, and $W(t_i)$ is the value of the observation at t_i. The solution involves a linear system of $(2k + 1)$ or $(2k + 2)$ equations, solved by LU-decomposition. For good resolution, N should be much larger than $(2k + 2)$. This is one of the reasons why you should try to minimise the number of constituents that enter in the tidal model. That is also directly in line with the aim of tidal analysis:

"extracting the local amplitudes and local phases of those constituents, that together give a good description of the deterministic tidal part of an observation".

8.4 Special features

8.4.1 Trends

As a result of non-resolvable very long period constituents or non-astronomic phenomena such as wind, the mean water level may vary slowly. Also, the position of the registration instrument may gradually change. To take into account of such motions, **if present**, you may include an extra term $B_0 t$ to the analysis formula Equation (8.1), representing a trend.

8.4.2 Astronomically coupled constituents

Depending on the duration of the registration there may be constituents with a difference in frequency that is too small for proper resolution of both constituents. In these cases the smallest is linked to a corresponding main constituent and solved implicitly as part of this main constituent. Afterwards the two constituents are decomposed using astronomical relations or nearby information about the relative importance of the two. For a detailed description, see section 8.3.4 above.

8.4.3 Registration gaps or unreliable data parts (sub-series)

In case of failure of the recording instrument, or otherwise partly unreliable data, sub-series are defined, which are separated by gaps. These gaps cover the time periods of the unreliable data. With separate values for F and $(V_0 + u)$ per sub-series, A_0, B_0, A_i and G_i are determined excluding the gaps.

8.4.4 Multiple instruments

A special case arises if for the registration more than one instrument is used in succession. The instrument sub-series, which my have different sampling intervals, are separated by non-zero or zero length gaps. For each sub-series a set of values A_{0j} and B_{0j} is determined, while the one set A_i, G_i is again based on the complete registration.

8.4.5 Accuracy analysis

The tidal analysis includes the computation of a standard deviation as an indication of the quality of the analysis. If the proper input options are specified, additional quantities are determined which enable a thorough quality assessment of the results: a median error per constituent, and auto-correlation function of the residue for various time lags.

The median error is defined by:

$$\varepsilon_i = \sqrt{\frac{VV2 \times L_i}{N - Z}} \tag{8.9}$$

ε_i	mean error in i-th unknown
$VV2$	standard deviation of the residuals
L_i	i-th main diagonal element of the inverted solution matrix
N	number of observations used
Z	total number of unknowns

It is noted that in the actual solution of the matrix the equation in amplitudes and phases is rewritten in one in terms of cosine and sine functions:

$$A\cos(\omega t - \psi) = A\cos\psi\cos\omega t + a\sin\psi\sin\omega = a\cos\omega t + b\sin\omega t \tag{8.10}$$

ε_i	is the mean error for one of the elements of the unknowns $\{A_{0j}, B_{0j}, a_k, b_k\}$.

In the print file of a tidal analysis (extension <∗.pra>), values for the two parameters $VV1$ and $VV2$ are given. Parameter $VV1$ is related to the numerical condition number of the linear system of equations from which the tidal constituents are solved. Parameter $VV2$ represents the standard deviation of the residuals.

8.5 Tidal prediction

The character of the tide at a given location in determined by the local values of the set A_0, A_i and G_i. If this set, or the main part of it, is known from literature or as the result of the ANALYSIS part of TIDE, a prediction of tidal heights for any given period can be made. Commonly used time intervals are 5, 6, 10, 15, 30 or 60 minutes. Time variation of the astronomical fluctuations F and u over the considered period can be accounted for, and a linear trend may be included.

Remark:

◇ In literature A_i and G_i are given in the local time zone of the station involved. Using PREDICT will then also result in a prediction given in local time. This is in line with ANALYSIS, where sets of A_i and G_i in **local time** are determined on the basis of an observation series in **local time**.

The following two publications give (very small) sets of amplitudes and phases for a large number of coastal stations world-wide: UKHO (annual), these only give data for O1, K1, M2 and S2 and SHOM (1982), contains data for at most the following 10 constituents: SA, Q1, O1, K1, N2, M2, S2, MN4, M4, and MS4. However the *Table des marées des grands ports du monde* (SHOM, 1982) is no longer in force since 2000.

8.6 Tide tables

Using a time-series of predicted or observed tidal heights with the corresponding time frame as input, HILOW determines the times and heights of high and low water. Taking account of the diurnal, semi-diurnal, or mixed character of the tide via windowing, a special filter technique is applied to ignore incidental peaks or measuring errors. Registration gaps and tide gauge replacements are automatically taken care of. The results present the time and heights of high and low water per day. For each sub-series some statistical information, i.e. average level, maximal and minimal levels, and mean rise and fall, is added.

Remark:

◇ The present approach to the preparation of tide tables is essentially different from the generally used procedure, since it is not based on the differentiation of Equation (8.1). This has the advantage that any **observed** tidal series, including meteorological effects, can be processed as well. When processing **observed** series, the Delft3D-TIDE option to detect physical extremes (measurement errors, etc.) is very useful, see item A.3 (filter parameters).

References

Delft3D IM, 2013. *Delft3D Installation Manual*. Deltares, 4.01 ed.

GPP UM, 2013. *Delft3D-GPP User Manual*. Deltares, 2.14 ed.

QUICKPLOT UM, 2013. *Delft3D-QUICKPLOT User Manual*. Deltares, 2.14 ed.

SHOM, 1982. "Table des marées des grands ports du monde." Brest. Service Hydrographique et Océanographique de la Marine (SHOM). No 540.

UKHO (annual). "Admiralty Tide Tables (4 volumes)." United Kingdom Hydrographic Office (UKHO), NP 201-204.

A Input file formats

A description of the input file formats of the subsystems ANALYSIS, PREDICT, HILOW and ASCON. For FOURIER no input file format need to be described.

A.1 ANALYSIS

ANALYSIS needs input data from two files, the input data file (with the required extension <ina>) and the file with observations (with the required extension <obs>).

Input may often be entered in free format, but must sometimes be entered in fixed format. Free format means that it makes no difference where you put the input on the line, taking into account the order. Fixed format means that the input should be placed in a certain column range (column fields). Text format means that you may enter any text, but left justified on the input line (start in column 1). Pay attention to the maximum number of characters on input, which may vary per input record.

In the input file several date-time groups for start and end of time periods have to be entered. A date-time group consists of a date, followed by the time and separated by two blanks. The date should be entered in a `yymmdd` format and the time in a `hhmmss` format. So, the complete format for the date-time group is: `yymmdd␣␣hhmmss`.

A date-time group should always be entered left justified on the input line, like text input. For example, for a time-series starting at October 20, 1989, 14:55:00 you should specify on the input line:

```
891020  145500
```

The input is subdivided into a number of separate items. For each item the number of required input lines will be specified, providing you with just that extra bit of information necessary for a complete understanding of the input description.

The input description will be understood more easily if you consult the input example at the end of this section from time to time.

Below we give a systematic, record for record, explanation for the input data file. The input parameters are printed in bold type, immediately followed by an explanation. If needed, the limitation of the sub-system with respect to input parameters is indicated.

Header lines (**$1 \leq$ **number of lines** ≤ 20**)

It is advised to start the input data file with header lines in which you can include some relevant information for this analysis run. Relevant information may be the time period of the observations, the name of the tidal station, the geographical position of the tidal station, etc. Header lines are recognised by the system by the first character of a record. The first character of a header line has to be '+' or '$*$'.

If the first character of a header line is '+', this header line will be copied to the output files. If the first character of a header line is '$*$', this header line will not be copied to the output files.

For example in case of ANALYSIS the 'plus header lines' on the <$*$.ina> file will include relevant notes on the tidal analysis, the origin of applied set of components, coupling of components, etc.

The 'plus header lines' for the time-series with observations, <∗.obs> file, may include relevant information about the tidal station, for example geographical position, coastal/offshore station, number of instruments, quality of measured data, etc.

HEADER(1) (text)
. . . . . .
HEADER(Nheader) (text)

HEADER(i) is the i-th header line at the start of the input data file ($Nheader \leq 20$). The maximum information per line is 255 characters.

Tidal series (4 lines)

Nobs (free)
TB (fixed)
TE (fixed)
UNIT (text)

Nobs — is the total number of observations to be read from the <∗.obs> file (file with observations). Reading always start from the first observation on the <∗.obs> file. Since the observation file also starts with a five-line identification header, this is the first number on the sixth line of the <∗.obs> file. From the <∗.obs> file the tidal series $H(Nobs)$ will be read.

TB — is the date-time group of the first observation $H(1)$ of the observation time-series. The date-time should be entered in the format given above: `yymmdd␣␣hhmmss`, left justified on the input line.

TE — is the date-time group of the last observation $H(Nobs)$ of the observation time-series. The date-time should be entered in the format given above: `yymmdd␣␣hhmmss`, left justified on the input line.

UNIT — is the description (text) for the unit of the observations. This text is only used for generating appropriate header lines in the output files. No internal conversions will follow. The maximum number of characters is 8. Example: CM WATER.

Options (1 line)

INFO(1:5) (free)

INFO is an option array with 5 options.

INFO(1)
- = 0: no GRAPHICS data file will be created. You do not intend to present the results in graphical form.
- = 1: a GRAPHICS data file will be created with the original time-series of the observations, with the hindcast and with the residue.
- = 2: same as INFO(1)=1 but time-series above are corrected for mean level per instrument.

  Explanation:
  The three time-series are plotted in one frame. For scaling purposes, it is desirable that the time-series to be plotted have approximately the same mean value. The mean levels for observation and hindcast are the same; per definition the mean of the residue in tidal analysis equals zero. So, if the mean of observation (hindcast) differs significantly from zero, application of this last option will allow a better scaling of the graphical output.

INFO(2)	= 0:	matrix of normal equations will not be printed.
	= 1:	matrix of normal equations will be printed; provides some extra information in case of numerical problems.
INFO(3)	= 0:	no accuracy analysis.
	= 1:	an accuracy analysis will be performed, comprising the estimation of mean errors for amplitudes and phases as well as the auto-correlation of the residue.
INFO(4)	= 0:	it is assumed that there is no linear change (linear trend) in the mean level of the observations.
	= 1:	a linear change of mean level will be computed for each instrument.
INFO(5)		inactive option

Selection of component set ($Ncomp + 1$ lines)

Ncomp (free)
COMP(1) (text)
. . . . . .
COMP(*Ncomp*) (text)

Ncomp	is the total number of selected *main components*. Condition: $Ncomp \leq 234$.
COMP(i)	represents the name of component i from the selected set of components. The components should be selected from the list of the 234 internally available tidal components, see Appendix B.

The name of each component should be entered in upper cast, and be left justified on a new line, resulting in *Ncomp* input lines for the set of components.

In principle, this set may be entered in any order of tidal frequency. A good habit, however, is to provide the components in order of increasing tidal frequency. There is an important exception in case of coupled components. For a group of coupled components the sub-components only appear in the following lines:

Groups of coupled components ($Ncoupl + 1$ lines)

Ncoupl (free)

Ncoupl	is the total number of coupled groups in the set of components. In section 8.3.4 you will find under which conditions coupling of components is required. Condition: $0 \leq Ncoupl \leq 10$. If $Ncoupl > 0$ a series of input lines follow in order to prescribe the coupling in detail. If $Ncoupl = 0$, no coupling will be applied.

The next input line(s) each define one group of coupled components. On each input line the name of the main component is followed by the names of the sub-components and the prescribed amplitude and phase relations.

MAIN(1) SUB(1,Nsub(1)) RHO(1,Nsub(1)) PSI(1,Nsub(1))
. . .
MAIN(*Ncoupl*) SUB(*Ncoupl*,Nsub(*Ncoupl*)) RHO(*Ncoupl*,Nsub(*Ncoupl*)) PSI(*Ncoupl*,Nsub(*Ncoupl*)) (one record!)

MAIN(i)	is the name of the main component for group i.
SUB(i,j)	is the name of the sub-component j for group i.

RHO(i,j)	is the estimated amplitude ratio between sub-component j of group i and the main component of group i. It is the amplitude of sub-component j divided by that of its main component.
PSI(i,j)	is the phase difference between sub-component j of group i and the main component of group i. It is the estimated astronomical phase of component j minus that of its main component, see also section 8.3.4 and Appendix B.
Nsub(i)	is the total number of sub-components for group i. Condition: $Nsub(i) \leq 10$ for each coupling group i.

Each well-defined group of coupled components will fit on one input line!

The items on input lines for coupling are not bound to column fields. The format is completely free; only the order of the items is important.

Instruments ($2Nins + 2$ ***lines)***

Nins	(free)
N1(1)	(free)
N2(1)	(free)
...	...
N1(*Nins*)	(free)
N2(*Nins*)	(free)

Nins	is the total number of instruments involved in the measurement of the selected tidal series. Condition: $Nins \leq 10$.
N1(i)	is the sequence number of the first observation of instrument i.
N2(i)	is the sequence number of the last observation of instrument i.

These sequence numbers are related to and must correspond to the sequence numbers in the time-series $H(Nobs)$ that will be analysed.

T1ins	(fixed)
T2ins	(fixed)
...	...
T1Nins	(fixed)
T2Nins	(fixed)

T1ins	is the date-time group of the first observation of instrument 1.
T2ins	is the date-time group of the last observation of instrument 1.
T1Nins	is the date-time group of the first observation of the last instrument.
T2Nins	is the date-time group of the last observation of the last instrument.

Sub-series ($2Nsub + 1$ lines)

Nsub (free)

Nsub	is the total number of sub-series in the selected tidal series. Condition: $Nsub \leq 10$. The minimum is 1 (one single series; no gaps; one instrument).

T1sub (fixed)
T2sub (fixed)
. . .
T1Nsub (fixed)
T2Nsub (fixed)

T1sub	is the date-time group of the first observation of sub-series 1.
T2sub	is the date-time group of the last observation of sub-series 1.
T1Nsub	is the date-time group of the first observation of the last sub-series.
T2Nsub	is the date-time group of the last observation of the last sub-series.

In the case that a simple one instrument series without any gaps has to be analysed, these date-time groups will be equal to TB and TE, respectively.

Block filter parameters (1 line)

Afilter Nfilter Mfilter (free)

Afilter, *Nfilter* and *Mfilter* are filter parameters for sub-system HILOW, used for smoothing purposes. It is used to separate tidal and non-tidal extremes in the time-series. These procedures are mainly important for data from measurements, which may contain instrumentation errors and meteorological effects.

Afilter	Weight factor for block filter. Range: 0.01 $\leq$ *Afilter* $\leq$ 1.0 Default: 0.2
Nfilter	Measure for the width of the block filter in terms of the number of values preceding or following. The width of the filter follows from: 2*Nfilter* $+ 1$. Range: 1 $\leq$ *Nfilter* $\leq$ 6 Default: 2
Mfilter	Number of iterations for the block filter. Range: 1 $\leq$ *Mfilter* $\leq$ 3 Default: 2

We advise to start with the indicated default values for the filter parameters. In almost all situations these defaults will satisfy, and give only real tidal maxima and minima. If this is not the case, for instance if meteorological effects have given rise to extra extremes in the observed time-series that you are considering, rerun the computation with larger values of the filter parameters.

In ANALYSIS the block filters are not used. With this extra input line, this input file will also and without changes serve as the input file for high/low water computations with HILOW, either for the present observation series, or the corresponding hindcast series.

Examples input files

The Tutorial ANALYSIS Example 3 <anaex3.ina> file:

```
+ Deltares
+ p.o. box 177 2600 MH Delft
+ TIDE Analysis and prediction of tides
+ Example 3 from Tutorial ANALYSIS
+ TIDAL ANALYSIS Centre point Bermuda Triangle, JUNE 1989
* ===================================================
  720
890601  000000
890630  230000
CM WATER
    1    0    1    1    0
   26
2Q1
Q1
O1
M1
K1
J1
OO1
3MS2
MNS2
MU2
N2
M2
L2
S2
MSN2
2SM2
MO3
M3
2MNS4
MN4
M4
SN4
MS4
3SM4
3MO5
M6
 3
S2    K2    0.284    0.00
N2    NU2   0.194    0.00
K1    P1    0.328    0.00
    2
    1  168  181  720
890601  000000
890607  230000
890608  120000
890630  230000
    2
890601  000000
890607  230000
890608  120000
890630  230000
  0.2    2    2
```

The Tutorial ANALYSIS Example 4 <anaex4.ina> file:

```
+ Deltares
+ p.o. box 177 2600 MH Delft
+ TIDE Analysis and prediction of tides
+ Example 4 from Tutorial ANALYSIS
```

```
+ TIDAL ANALYSIS, year 2024
* ================================================================
8784
240101  000500
241231  230000
M WATER
0 0 0 0 0
38
SA
SSA
MSM
MM
MS0
KO0
MFM
2Q1
SIGMA1
Q1
RO1
O1
M1
PI1
K1
P1
J1
OO1
O2
MU2
N2
NU2
OP2
M2
L2
S2
K2
NO3
MO3
M3
SO3
MK3
SK3
MN4
M4
MS4
M6
2MS6
0
2
1    1594    1597   8784
240101  000500
240307  090500
240307  120000
241231  230000
6
240201  120500
240307  090500
240307  120000
240416  140000
240417  130000
240607  080000
240607  160000
240724  090000
240724  110000
241009  090000
241009  120000
241231  230000
```

```
0.2 2 2
```

A.2 PREDICT

If you have to prepare an input file for PREDICT by yourself, it is necessary to know the exact format of the <∗.inp> file.

At some places, input data can be entered in free format, but elsewhere it may need to be entered in fixed format. Free format means that it makes no difference where you put the input on the line, as long as you take into account the order in which it is supplied. Fixed format means that the input should be placed in certain column ranges (column fields). Text format means any text, as long as it is left justified on the input line (start in column 1). Pay attention to the maximum number of characters on input, which may vary per input.

In the input file several date-time groups for start and end of time periods have to be entered. A date-time group consists of a date, followed by the time and separated by two blanks. The date should be entered in a `yymmdd` format and the time in a `hhmmss` format. So, the complete format for the date-time group is: `yymmdd␣␣hhmmss`. A date-time group should always be entered left justified on the input line, like text input. For example, for a time-series starting at October 20, 1989, 14:55:00 you should specify on the input line:

```
891020  145500
```

The input is subdivided in a number of separate items. For each item the number of required input lines will be specified. This should provide you with just that extra bit of information necessary for a complete understanding of the input description.

The input description will be understood more easily if you consult the input example at the end of this section from time to time.

Below we give a systematic, record for record, explanation of the structure of the input data file. The input parameters are printed in bold character type, immediately followed by an explanation of the input. If needed, the limitation of the sub-system with respect to the input parameters is indicated.

Header lines ($1 \leq$ number of lines ≤ 20)

It is advised to start the input data file with header lines in which you can include some relevant information for this prediction run. Relevant information may be the time period of the observations, the name of the tidal station, the geographical position of the tidal station, etc. Header lines are recognised by the system by the first character of a record. The first character of a header line has to be '+' or '∗'.

If the first character of a header line is '+', this header line will be copied to the output files. If the first character of a header line is '∗', this header line will not be copied to the output files.

HEADER(1) (text)
...   ...
HEADER(Nheader) (text)

HEADER(i) is the i-th header line at the start of the input data file ($Nheader \leq 20$) The maximum information per line is 255 characters.

Time period for prediction (3 lines)

TB (fixed)
TE (fixed)
UNIT (text)

TB — is the date-time group of the first observation $H(1)$ of the observation time-series. The date-time should be entered in the format given above:
`yymmdd␣␣hhmmss`,
left justified on the input line.

TE — is the date-time group of the last observation $H(Nobs)$ of the observation time-series. The date-time should be entered in the format given above:
`yymmdd␣␣hhmmss`,
left justified on the input line.

UNIT — is the description (text) for the unit of the observations. This text is only used for generating appropriate header lines in the output files. No internal conversions will follow. The maximum number of characters is 8. Example: CM WATER.

Nobs — is the total number of observations to be read from the <∗.obs> file (file with observations). Reading always start from the first observation on the <∗.obs> file. Since the observation file also starts with a five-line identification header, this is the first number on the sixth line of the <∗.obs> file. From the <∗.obs> file the tidal series $H(Nobs)$ will be read.

Names, amplitudes and phases of the component set ($Ncomp + 1$ lines)

The station dependent amplitudes and phases may come from the Admiralty Tide Tables (UKHO (annual)), but are often originating from ANALYSIS. In that case it is advised to use the PREDICT Input Processor.

Ncomp (free)
COMP(1) A(1) G(1) (fixed)
. . . . . .
COMP(*Ncomp*) A(*Ncomp*) G(*Ncomp*) (fixed)

Ncomp — is the total number of components that you want to use in the prediction. There is no restriction on the number: all 234 internally available components may be used.

COMP(i) — represent the names of the selected set of components. All components have to be chosen from the set of available components in Appendix B. The format is A8. They **must** be entered in upper cast (capital letters).

A(i) — represents the amplitudes for the station. The unit in which the amplitudes are expressed fixes the unit of the prediction time-series that will be produced. Format: F10.3.

G(i) — represents the station's phases or improved Kappa-numbers. The unit in which they MUST be entered is degrees. Format: F10.1.

This set may be entered in any order of tidal frequency. It is the convention to provide them in order of increasing tidal frequency, since this simplifies visual checks.

As stated above, **the parameters on this input line are bound to specific column fields**. The name of each component must be entered in the leftmost 8 columns of the record; the amplitude A in columns 9–18 and the phase G in column field 19–28. Always use a floating point representation when entering these values; only then it does not matter where you put the value within the assigned column field.

Time step in prediction (1 line)

DELT

DELT	is the time step to be applied in the prediction. The unit of the time step is MINUTES.

Sub-series to be used in prediction (Nsub+1 lines)

Nsub (free)
T1sub(1) A(1) B(1) (fixed)
. . . . . .
T1sub(Nsub) A (Nsub) B (Nsub) (fixed)

Nsub	is the number of sub-series to be used in the prediction (minimum value: 1). The prediction series should be split up in more than one sub-series if a prediction for a long time period is made. This is related to the fact that the component-dependent so-called nodal factors u and F ("constant for the period of prediction"), which are computed by the system, are actually slowly varying with time. Most of these nodal factors have a cycle period of about 18.61 years. For prediction periods exceeding two months, you should subdivide the period in blocks of at maximum two months. The system then computes u and F per sub-series, which **improves the accuracy** of the prediction.
T1sub(1)	is the date-time group of the first observation of the first sub-series.
A(1)	is the mean level for the first sub-series.
B(1)	(in units per hour) indicates the linear change with time of the first sub-series. The format of the record is: A6, 2X, A6, F10.3, F10.3.
T1sub(Nsub)	is the date-time group of the first observation of the last sub-series.
A (Nsub)	is the mean level for the last sub-series.
B (Nsub)	(in units per hour) indicates the linear change with time of the last sub-series. The format of the record is: A6, 2X, A6, F10.3, F10.3

The linear trend is defined with respect to the MIDDLE TIME POINT of the period of the (sub)series. In most cases the linear trend will be zero. When the linear trend is non-zero, however, and you split up the period to be predicted in a number of sub-series, you should be aware that this will result in a **(linear) change of the mean level per sub-series too!**. This means that you have to adjust the mean levels of the sub-series in your input accordingly, in order to effect the correct transition from one sub-series to the next.

This looks more difficult than it is. A simple check to see if you have prescribed the correct mean levels given your linear change, is to make a prediction with all amplitudes equal to zero. This should result in a monotonously increasing (positive trend) or decreasing (negative trend) straight line. The presence of jumps at the transition of sub-series, easily detected from your output file <∗.prp>, requires reconsideration of the mean levels that you applied in those sub-series. A similar, slightly more complicated situation occurs if the linear trend information comes from a computation with ANALYSIS, in which more than one instrument (more than one trend) played a role.

Remark:

◇ You don't have to specify the end of the entered sub-series. Each sub-series ends one time step before the first value of the next sub-series, resulting in a continuous overall series.

As stated above, *the parameters (T1, A ,B) on these input lines are bound to specific column fields.* Parameter T1sub is a date-time group, so should be entered in the 14 leftmost columns.

Parameter A should be in column field 15–24 and parameter B in column field 25–34.

Always use a floating point representation when entering values for A and B; only then it does not matter where you put the value in the assigned column field.

Remark:

◇ The PREDICT Input Processor automatically generates sub-series of length 1 month.

Example input file

The Tutorial PREDICT Example 2 <prdex2.inp> file:

```
+ Deltares
+ p.o. box 177 2600 MH Delft
+ TIDE Analysis and prediction of tides
+ Example 2 from Tutorial PREDICTION
+ PREDICTION HOOK OF HOLLAND , 51 59 NB  04 07 EL   NOV 1999-FEB 2000
* ========================================================================
991101  000000
000229  230000
CM
60
SA          10.350     183.9
MS0          2.410      42.1
2Q1           .524      31.3
Q1           3.988     146.4
O1           9.974     190.4
M1            .455      41.4
P1           3.336     348.3
S1           1.328     285.1
K1           7.666       3.7
3MKS2         .782     325.6
3MS2         1.462     318.0
OQ2          1.489     359.7
MNS2         2.278     186.8
2ML2S2       1.681     355.9
NLK2         1.552      68.0
MU2          7.806     204.8
N2          11.777      57.9
NU2          4.474      55.6
MSK2          .521     271.6
MPS2         1.504     168.8
M2          77.405      85.7
MSP2         1.543      53.1
MKS2         1.735     245.1
LABDA2       2.769      97.6
2MN2         7.105     289.6
T2           1.339     131.5
S2          18.797     144.9
K2           5.273     149.1
MSN2         1.722     355.0
2SM2         2.127      24.3
SKM2          .972      18.7
2MK3          .695     188.4
MK3           .935     291.2
3MS4         1.661     244.6
MN4          6.063     133.8
2MLS4        2.086     317.7
M4          16.503     162.3
2MKS4        1.455     294.2
SN4           .925     249.5
3MN4         1.396     356.2
MS4         10.433     217.9
```

```
MK4           2.301     212.0
2MSN4         1.502      58.4
S4            1.073     288.6
3MK5          1.353     210.2
2MP5           .808     301.7
3MO5          1.625      14.1
3MNS6         1.083     226.7
4MS6          1.288     251.0
2MN6          2.187      98.2
2MNU6          .987     100.7
M6            4.245     129.8
2MS6          3.607     188.0
2MK6          1.018     173.5
3MN8          1.627     193.7
M8            2.270     225.5
2MSN8         1.417     259.4
3MS8          3.154     277.9
2(MS)8        1.300     337.5
2(MS)N10       .016      37.8
60.
4
991101  000000  4.20       0.
991201  000000  4.20       0.
000101  000000  4.20       0.
000201  000000  4.20       0.
```

A.3 HILOW

Input files for HILOW are generated by either ANALYSIS or PREDICT.

Remark:
◇ Only if you prepare the input file”by hand”, the remainder of this section is important

At the beginning of the file, header lines are expected. The number of header lines that can be included in the files is not fixed, but should at least be one and not exceed 20.

Header lines are recognised by the system by the first character of a record, **the first character of a header line has to be ’+’ or** ’∗’.

The header lines are directly followed by the data. As the data are read free-formatted there are no conditions with respect to the layout of the data part of the file.

Remark:
◇ Never use a ’+’ sign to indicate positive values. It is possible that the record containing this value is identified as a header line. A value without a sign is identified as a positive value.

The number of observations per line (a line is a record) is free. The unit of the observations (metre, centimetre, inches) is free. We advise to choose centimetres as the unit for observations, since the number of printed decimal digits for the results is fixed. So, for centimetres the printed results are actually more accurate. Input data may sometimes be entered in free format but has at other times to be entered in fixed format. Free format means that it makes no difference where you put the input on the line, as long as you take into account the order in which it is supplied. Fixed format means that the input should be placed in certain column ranges (column fields). Text format means any text, as long as it is left justified on the input line (start in column 1). Pay attention to the maximum number of characters on input, which may vary per input.

In the input file several date-time groups for start and end of time periods have to be entered. A date-time group consists of a date, followed by the time and separated by two blanks. The date should be entered in a `yymmdd` format and the time in a `hhmmss` format. So, the complete format for the date-time group is: `yymmdd␣␣hhmmss`. A date-time group should always be entered left justified on the input line, like text input. For example, for a time-series starting at October 20, 1989, 14:55:00 you should specify on the input line:

```
891020  145500
```

The input is subdivided in a number of separate items. For each item the number of required input lines will be specified. This should provide you with just that extra bit of information necessary for a complete understanding of the input description.

The input description will be understood more easily if you consult the input **example at the end of this section from time to time**.

Below, we give a systematic, record for record, explanation of the structure of the input data file. The relevant input parameters are printed in bold character type, immediately followed by an explanation of the input. If needed, the limitation of the sub-system with respect to the input parameters is indicated.

Header lines ($1 \leq$ ***number of lines*** ≤ 20***)***
It is advised to start the input data file with header lines in which you can include some relevant information for this analysis run. Relevant information may be the time period of the observations, the name of the tidal station, the geographical position of the tidal station, etc. Header lines are recognised by the system by the first character of a record. The first character of a header line has to be '+' or '$*$'.

If the first character of a header line is '+', this header line will be copied to the output files. If the first character of a header line is '$*$', this header line will not be copied to the output files.

HEADER(1)	(text)
...	...
HEADER(Nheader)	(text)

HEADER(i) is the i-th header line at the start of the input data file ($Nheader \leq 20$) The maximum information per line is 255 characters.

Tidal series (4 lines)

Nobs	(free)
TB	(fixed)
TE	(fixed)
UNIT	(text)

Nobs is the total number of observations to be read from the <∗.obs> file (file with observations). Reading always start from the first observation on the <∗.obs> file. Since the observation file also starts with a five-line identification header, this is the first number on the sixth line of the <∗.obs> file. From the <∗.obs> file the tidal series $H(Nobs)$ will be read.

TB is the date-time group of the first observation $H(1)$ of the observation time-series. The date-time should be entered in the format given above:

	`yymmdd␣␣hhmmss`, left justified on the input line.
TE	is the date-time group of the last observation $H(Nobs)$ of the observation time-series. The date-time should be entered in the format given above: `yymmdd␣␣hhmmss`, left justified on the input line.
UNIT	is the description (text) for the unit of the observations. This text is only used for generating appropriate header lines in the output files. No internal conversions will follow. The maximum number of characters is 8. Example: CM WATER.

Options (1 line)

INFO(1:5) (free)

INFO is an option array with 5 options, used only in ANALYSIS (The explanation of INFO( ) is not further explained here). You must enter a line with 5 integer numbers here.

Selection of component set ($Ncomp + 1$ lines)

Remarks:

- ◇ If this is a new and specially made HILOW -input file, just enter: “1”.
- ◇ If this is a new and specially made HILOW -input file, just enter: “M2”. Then proceed to the line with *Ncoupl*.

Ncomp (free)
COMP(1) (text)
... ...
COMP(*Ncomp*) (text)

Ncomp	is the total number of selected *main components*. Condition: $Ncomp \leq 234$.
COMP(i)	represents the name of component i from the selected set of components. The components should be selected from the list of the 234 internally available tidal components, see Appendix B.

The name of each component should be entered in upper cast, and be left justified on a new line, resulting in *Ncomp* input lines for the set of components.

In principle, this set may be entered in any order of tidal frequency. A good habit, however, is to provide the components in order of increasing tidal frequency.

Groups of coupled components ($1 + Ncoupl$ lines)

Remark:

- ◇ If this is a new and specially made HILOW-input file, just enter: “0”. Then proceed to the line with *Nins*.

Ncoupl (free)

Ncoupl	is the total number of coupled groups in the set of components. In section 8.3.4 you will find under which conditions coupling of components is required. Condition: $0 \leq Ncoupl \leq 10$. If $Ncoupl > 0$ a series of input lines follow in order to prescribe the coupling in detail. If $Ncoupl = 0$, no coupling will be applied.

The next input line(s) each define one group of coupled components. On an input line the name of the main component is supposed to be followed by the names of the sub-components and the prescribed amplitude and phase relations.

MAIN(1) SUB(1,Nsub(1)) RHO(1,Nsub(1)) PSI(1,Nsub(1))
. . .
MAIN(*Ncoupl*) SUB(*Ncoupl*,Nsub(*Ncoupl*)) RHO(*Ncoupl*,Nsub(*Ncoupl*)) PSI(*Ncoupl*,Nsub(*Ncoupl*)) (one record!)

MAIN(i)	is the name of the main component for group i.
SUB(i,j)	is the name of the sub-component j for group i.
RHO(i,j)	is the estimated amplitude ratio between sub-component j of group i and the main component of group i. It is the amplitude of sub-component j divided by that of its main component.
PSI(i,j)	is the phase difference between sub-component j of group i and the main component of group i. It is the estimated astronomical phase of component j minus that of its main component.
Nsub(i)	is the total number of sub-components for group i.

Condition: Nsub(i) $\leq$ 10 for each coupling group i.

Each well-defined group of coupled components will fit on one input line!

The items on input lines for coupling are not bound to column fields. The format is completely free; only the order of the items is important.

Instruments ($2Nins + 2$ ***lines)***

Nins	(free)
N1(1)	(free)
N2(1)	(free)
. . .	. . .
N1(*Nins*)	(free)
N2(*Nins*)	(free)

Nins	is the total number of instruments involved in the measurement of the selected tidal series. Condition: $Nins \leq 10$.
N1(i)	is the sequence number of the first observation of instrument i.
N2(i)	is the sequence number of the last observation of instrument i.

These sequence numbers are related to and must correspond to the sequence numbers in the time-series H(1:Nobs) that forms the basis for the Tide Tables.

T1ins	(fixed)
T2ins	(fixed)
. . .	. . .
T1*Nins*	(fixed)
T2*Nins*	(fixed)

T1ins	is the date-time group of the first observation of instrument 1.
T2ins	is the date-time group of the last observation of instrument 1.
T1*Nins*	is the date-time group of the first observation of the last instrument.
T2*Nins*	is the date-time group of the last observation of the last instrument.

Sub-series ($2\mathrm{Nsub} + 1$ ***lines)***

Nsub	(free)

Nsub	is the total number of sub-series in the selected tidal series. Condition: $Nsub \leq 10$. The minimum is 1 (one single series; no gaps; one instrument).

T1sub (fixed)
T2sub (fixed)
. . . . . .
T1Nsub (fixed)
T2Nsub (fixed)

T1sub	is the date-time group of the first observation of sub-series 1.
T2sub	is the date-time group of the last observation of sub-series 1.
T1Nsub	is the date-time group of the first observation of the last sub-series.
T2Nsub	is the date-time group of the last observation of the last sub-series.

In the case that a simple one instrument series without any gaps has to be analysed, these date-time groups will be equal to TB and TE, respectively.

Block filter parameters (1 line)

Afilter Nfilter Mfilter (free)

Afilter, Nfilter and Mfilter above are block filter parameters. The block filter is used to separate tidal and non-tidal extremes in the time-series. These procedures are mainly important for data from measurements, which may contain instrumentation errors and meteorological effects.

Afilter	Weight factor for block filter Range: $0.01 \leq Afilter \leq 1.0$ Default: 0.2
Nfilter	Measure for the width of the block filter in terms of the number of values . preceding or following. The width of the filter follows from: $2Nfilter + 1$ Range: $1 \leq Nfilter \leq 6$ Default: 2
Mfilter	Number of iterations for the block filter. Range: $1 \leq Mfilter \leq 3$ Default: 2

We advise to start with the indicated default values for the filter parameters. In almost all situations these defaults will satisfy, and give only real tidal maxima and minima. If this is not the case, for instance if meteorological effects have given rise to extra extremes in the observed time-series that you are considering, rerun the computation with larger values of the filter parameters.

Example input file

The Tutorial HILOW Example 1 <hlwex1.inh> file:

```
+ Deltares
+ p.o. box 177 2600 MH Delft
+ TID Analysis and prediction of tides
+ Example 1 from Tutorial HILOW
+ HIGH/LOW WATER COMPUTATION
```

```
* ATLANTIS  10 00 N 00 00 EL (dt=30 min)
* ==================================================================
 1440
270601  000000
270630  233000
M WATER
0 0 0 0 0
38
SA
SSA
MSM
MM
MS0
KO0
MFM
2Q1
SIGMA1
Q1
RO1
O1
M1
PI1
K1
P1
J1
OO1
O2
MU2
N2
NU2
OP2
M2
L2
S2
K2
NO3
MO3
M3
SO3
MK3
SK3
MN4
M4
MS4
M6
2MS6
  0
  1
  1       1440
270601  000000
270630  233000
  1
270601  000000
270630  233000
 0.2 2 2
```

A.4 ASCON

In this section we will discuss the data on the input data file of ASCON. Unless otherwise stated the input is in free format. Do mind the order of entering the data. Text input should be always be entered left justified on the input line.

Apart from the identification header, the main input consists of date-time groups. A date-time group consists of a date, followed by the time and separated by two blanks. The date should be entered in a `yymmdd` format and the time in a `hhmmss` format. So, the complete format for the date-time group is: `yymmdd␣␣hhmmss`. A date-time group should always be entered left justified on the input line, like text input. For example, for a time-series starting at October 20, 1989, 14:55:00 you should specify on the input line:

```
891020  145500
```

The input is subdivided in a number of separate items. For each item the number of required input lines will be specified, providing you with the information necessary for a complete understanding of the input description.

Understanding the input description will be easier if read the example at the end of this section from time to time.

The input parameters are printed in bold character type, immediately followed by an explanation of the input. If needed, the limitation of the sub-system with respect to the input parameters is indicated.

Header lines ($1 \leq$ number of lines ≤ 20)

It is advised to start the input data file with header lines in which you can include some relevant information for this analysis run. Relevant information may be the time period of the observations, the name of the tidal station, the geographical position of the tidal station, etc. Header lines are recognised by the system by the first character of a record. The first character of a header line has to be '$+$' or '$*$'.

If the first character of a header line is '+', this header line will be copied to the output files. If the first character of a header line is '$*$', this header line will not be copied to the output files.

HEADER(1) (text)
. . . . . .
HEADER(Nheader) (text)

HEADER(i) is the i-th header line at the start of the input data file ($Nheader \leq 20$). The maximum information per line is 255 characters.

Date time groups for $V_0 + U$ and F (var.)

TI (fixed)

TI represents the date-time group (`yymmdd␣␣hhmmss`) for which the astronomical arguments $V_0 + u$ and F will be computed. You can specify as many date-time groups as you like, However one date-time group per input line, Format: I6,2X,I6.

Selection of component set (Ncomp lines)

COMP(1) (text)
. . . . . .
COMP(*Ncomp*) (text)

COMP(i) represents the name of component i from the selected set of components. The components should be selected from the list of available tidal components in Appendix B.

The name of each component should be entered in upper cast and left justified on a new line, resulting in *Ncomp* input lines for the set of components.

This set of components MUST be entered in order of increasing frequency.

Example input file

The Tutorial ASCON Example 1 <ascex1.inc> file:

```
+ Deltares
+ p.o. box 177 2600 MH Delft
+ TIDE Analysis and prediction of tides
+ Example 1 from Tutorial ASCON
+ ASTRONIMICAL ARGUMENTS Centre point Bermuda Triangle
+ FOR 01/01/1999,01/01/2000 AND 01/01/2001
* ===================================================================
990101  000000
000101  000000
010101  000000
2Q1
Q1
O1
M1
K1
P1
J1
OO1
3MS2
MNS2
MU2
N2
NU2
M2
L2
S2
K2
MSN2
2SM2
MO3
M3
2MNS4
MN4
M4
SN4
MS4
3SM4
3MO5
M6
```

A.5 FOURIER

No specific file formats needed.

B List of tidal components (internal component base)

The set of components can be divided in primary components, which appear in the equilibrium tide (No land masses; only one deep ocean), and compound components. The latter are linear combinations of primary components. The names and frequencies of all 234 internally available components of TIDE are given below. For the primary components the relative magnitude in the equilibrium tide is given as well. For the selection of components in an analysis input file, relative importance in neighbouring stations is often a guideline. For North Sea circumstances, the set of 60 constituents given in the example just preceding section A.3 is a good choice. For components that may appear as sub-components in astronomical coupling in case of short series, *the equilibrium amplitude relation* with their main component is given as well. The *equilibrium phase relation* is equal to zero.

Remark:

◇ In case astronomical coupling is necessary, you should always first try to use amplitude and phase relations based on a long period analysis of a neighbouring station. Only if such information is not available, you may resort to the equilibrium tide relations given below.

Component Name	Angular Frequency (degr/hour)	Amplitude in equilibrium tide	Amplitude coupling relation
SA	0.0410686	0.01156	
SSA	0.0821373	0.07281	
MSM	0.4715211	0.01579	
MM	0.5443747	0.08254	
MSF	1.0158958	0.01369	
MS0	1.0158958		
MF	1.0980331	0.15647	
KO0	1.0980331		
MK0	1.0980331		
SNU	1.4874169		
SN	1.5602705		
MSTM	1.5695542	0.00569	
MFM	1.6424078	0.02996	
2SM	2.0317916		
MSQM	2.1139289	0.00478	
MQM	2.1867825	0.00396	
2SMN	2.5761663		
2OK1	12.8450025		
2Q1	12.8542862	0.00955	$0.025 \times$ O1
NJ1	12.8542862		
SIGMA1	12.9271398	0.01152	
MUK1	12.9271398		
NUJ1	12.9271398		
Q1	13.3986609	0.07343	$0.191 \times$ O1
NK1	13.3986609		
RO1	13.4715145	0.01395	$0.036 \times$ O1
NUK1	13.4715145		
O1	13.9430356	0.38358	
TAU1	14.0251728	0.00504	
MP1	14.0251728		
M1B	14.4874103	0.01065	$0.350 \times$ M1A
M1C	14.4920521		

Component Name	**Angular Frequency (degr/hour)**	**Amplitude in equilibrium tide**	**Amplitude coupling relation**
M1A	14.4966939	0.02964	
M1	14.4966939	0.03150	0.082 $\times$ O1
NO1	14.4966939		
CHI1	14.5695476	0.00580	
LP1	14.5695476		
PI1	14.9178647	0.01028	
TK1	14.9178647		
P1	14.9589314	0.17543	0.328 $\times$ K1
SK1	14.9589314		
S1	15.0000000	0.00416	
K1	15.0410686	0.53496	
MO1	15.0410686		
SP1	15.0410686		
PSI1	15.0821353	0.00109	
RP1	15.0821353		
FI1	15.1232059	0.00755	
KP1	15.1232059		
THETA1	15.5125897	0.00578	
LABDAO1	15.5125897		
J1	15.5854433	0.03022	0.079 $\times$ O1
MQ1	15.5854433		
2PO1	15.9748272		
SO1	16.0569644		
OO1	16.1391017	0.01939	0.051 $\times$ O1
2KO1	16.1391017		
UPSILON1	16.6834764	0.00372	
KQ1	16.6834764		
2MN2S2	26.4079379		
3MKS2	26.8701753		
2NS2	26.8794590		
3MS2	26.9523126		
OQ2	27.3416964		
MNK2	27.3416964		
EPSILON2	27.4238337	0.00671	
MNS2	27.4238337		
2ML2S2	27.4966873		
MNUS2	27.4966873		
MNK2S2	27.5059710		
2MS2K2	27.8039339		
O2	27.8860711		
NLK2	27.8860711		
2MK2	27.8860711		
2N2	27.8953548	0.02303	0.132 $\times$ N2
MU2	27.9682084	0.02776	0.031 $\times$ M2
2MS2	27.9682084		
SNK2	28.3575922		
NA2	28.3986628		
N2	28.4397295	0.17398	0.191 $\times$ M2
KQ2	28.4397295		
NB2	28.4807962		
NU2	28.5125831	0.03304	0.194 $\times$ N2

Component Name	Angular Frequency (degr/hour)	Amplitude in equilibrium tide	Amplitude coupling relation
3MSN2	28.6040041		
2KN2S2	28.6040041		
OP2	28.9019669		
MSK2	28.9019669		
GAMMA2	28.9112506	0.00273	
ALFA2	28.9430356	0.00313	
MPS2	28.9430356		
MA2	28.9430356		
M2	28.9841042	0.90872	
KO2	28.9841042		
MSP2	29.0251728		
MB2	29.0251728		
DELTA2	29.0662415		
MKS2	29.0662415		
M2(KS)2	29.1483788		
2SN(MK)2	29.3734880		
LABDA2	29.4556253	0.00466	$0.005 \times$ M2
SNM2	29.4556253		
2MN2	29.5284789		
L2	29.5284789	0.02663	$0.029 \times$ M2
L2A	29.5284789	0.02569	
L2B	29.5377626	0.00704	$0.274 \times$ L2A
2SK2	29.9178627		
T2	29.9589333	0.02476	$0.059 \times$ S2
S2	30.0000000	0.42248	
KP2	30.0000000		
R2	30.0410667	0.00366	$0.009 \times$ S2
K2	30.0821373	0.12004	$0.284 \times$ S2
MSNU2	30.4715211		
MSN2	30.5443747		
ZETA2	30.5536584	0.00134	
ETA2	30.6265120	0.00702	
KJ2	30.6265120		
MKN2	30.6265120		
2KM(SN)2	30.7086493		
2SM2	31.0158958		
SKM2	31.0980331		
2MS2N2	31.0887494		
2SNU2	31.4874169		
2SN2	31.5602705		
SKN2	31.6424078		
MQ3	42.3827651		
NO3	42.3827651		
MO3	42.9271398		
2MK3	42.9271398		
2MP3	43.0092771		
M3	43.4761563	0.01780	
NK3	43.4807981		
SO3	43.9430356		
MP3	43.9430356		
MK3	44.0251728		

Component Name	Angular Frequency (degr/hour)	Amplitude in equilibrium tide	Amplitude coupling relation
SP3	44.9589314		
2MQ3	44.5695476		
SK3	45.0410686		
2SO3	46.0569644		
K3	45.1232059		
4MS4	55.9364168		
2MNS4	56.4079379		
3MK4	56.8701753		
MNLK4	56.8701753		
3MS4	56.9523126		
MSNK4	57.3416964		
MN4	57.4238337		
MNU4	57.4966873		
2MLS4	57.4966873		
2MSK4	57.8860711		
M4	57.9682084		
2MKS4	58.0503457		
SN4	58.4397295		
3MN4	58.5125831		
2SMK4	58.9019669		
MS4	58.9841042		
MK4	59.0662415		
2SNM4	59.4556253		
2MSN4	59.5284789		
SL4	59.5284789		
S4	60.0000000		
SK4	60.0821373		
2SMN4	60.5443747		
3SM4	61.0158958		
2SKM4	61.0980331		
MNO5	71.3668693		
3MK5	71.9112440		
3MP5	71.9933813		
M5	72.4649024		
MNK5	72.4649024		
2MP5	72.9271398		
MSO5	72.9271398		
3MO5	73.0092771		
MSK5	74.0251728		
3KM5	74.1073101		
2(MN)S6	84.8476674		
3MNS6	85.3920421		
4MK6	85.8542796		
2NM6	85.8635632		
4MS6	85.9364168		
2MSNK6	86.3258006		
2MN6	86.4079379		
2MNU6	86.4807915		
3MSK6	86.8701753		
M6	86.9523126		
MSN6	87.4238337		

Component Name	Angular Frequency (degr/hour)	Amplitude in equilibrium tide	Amplitude coupling relation
MNK6	87.5059710		
4MN6	87.4966873		
MKNU6	87.5788246		
2(MS)K6	87.8860711		
2MS6	87.9682084		
2MK6	88.0503457		
2SN6	88.4397295		
3MSN6	88.5125831		
MKL6	88.5947204		
2SM6	88.9841042		
MSK6	89.0662415		
S6	90.0000000		
2MNO7	100.3509735		
2NMK7	100.9046319		
M7	101.4490066		
2MSO7	101.9112440		
MSKO7	103.0092771		
2(MN)8	114.8476674		
3MN8	115.3920421		
3MNKS8	115.4741794		
M8	115.9364168		
2MSN8	116.4079379		
2MNK8	116.4900752		
3MS8	116.9523126		
3MK8	117.0344499		
2SNM8	117.4238337		
MSNK8	117.5059710		
2(MS)8	117.9682084		
2MSK8	118.0503457		
3SM8	118.9841042		
2SMK8	119.0662415		
S8	120.0000000		
2(MN)K9	129.8887361		
3MNK9	130.4331108		
4MK9	130.9774855		
3MSK9	131.9933813		
4MN10	144.3761463		
M10	144.9205210		
3MSN10	145.3920421		
4MS10	145.9364168		
2(MS)N10	146.4079379		
2MNSK10	146.4900752		
3M2S10	146.9523126		
4MSK11	160.9774855		
M12	173.9046253		
4MSN12	174.3761463		
5MS12	174.9205210		
3MNKS12	175.4741794		
4M2S12	175.9364168		

C Filename conventions

When you execute the TIDE software you will be prompted for the names of data files to be selected from file lists in menu boxes.

For TIDE the following (compulsory) extensions are defined:

C.1 ANALYSIS

Input files:

<∗.ina>	for an input file of ANALYSIS
<∗.obs>	for the file with the time-series of observations

Output files:

<∗.pra>	for the print file with report and error messages of ANALYSIS
<∗.cmp>	for the file with the tidal constants
<∗.hdc>	for the file with the time-series of the hindcast
<∗.res>	for the file with the time-series of residuals
<∗.tka>	for the file with the plot data of ANALYSIS

C.2 PREDICT-GUI

Input:

◇ Manual input

Input files:

<∗.ina>	File according the analysis input file
<∗.cmp>	Result file with components from the sub-system ANALYSIS

Output file:

<∗.inp>	File suitable as input file for subsystem PREDICT

C.3 PREDICT

Input file:

<∗.inp>	for an input file of PREDICT

Output files:

<∗.prp>	for the print file with report and error messages of PREDICT
<∗.prd>	for the file with the predicted time-series
<∗.tkp>	for the file with the plot data of PREDICT

C.4 HILOW-GUI

Input:

◇ Manual input

Input file:

<∗.ina/inp> File according the ANALYSIS/PREDICT input file

Output file:

<∗.inh> File suitable as input file for subsystem HILOW

C.5 HILOW

Input file:

<∗.inh> for an input file of HILOW

Output files:

<∗.prh> for the print file
<∗.hlw> for the file with tide tables

C.6 ASCON

Input file:

<∗.inc> for an input file of ASCON

Output file:

<∗.prc> for the output file of ASCON

C.7 FOURIER

Standard Fourier Transform

Input:

◇ Manual input

Input file:

<∗.res> Time-series result file from ANALYSIS
\- Manual input

Output file:

<∗.prf> for the print file of Standard Fourier Transform
<∗.tkf> for file with plot data of Standard Fourier Transform

Fast Fourier Transform

Input:

◇ Manual input

Input file:

<∗.res>	Time-series result file from ANALYSIS

Output file:

<∗.prt>	for the print file of Fast Fourier Transform
<∗.tkt>	for file with plot data of Fast Fourier Transform

D Messages from Delft3D-TIDE

Error messages, warnings and/or Informative messages are given for all the 5 subsystems e.g. ANALYSIS, PREDICT, HILOW, ASCON and FOURIER.

D.1 ANALYSIS

In the ANALYSIS messages on fatal errors and warnings are automatically generated. Both result from a thorough overall screening of the individual input parameters. Finally the consistency of the whole input set is checked.

If fatal errors have been found the program will abort after printing all the error messages on the print file <∗.pra>. Therefore, if any errors have occurred, check the Input Interpretation Report thoroughly.

In case of warnings the program will continue normally with the computation. The warnings are often not that serious that they will abort the computational process. On the other hand, they deserve your attention because something may be wrong. This holds especially for the warnings regarding the time interval of the data and those on the violation of the Rayleigh criterion. Warnings are also added to the print file <∗.pra>. In the editor you can easily search for the keywords ERROR and WARNING in order to find all error messages respectively warnings.

D.1.1 Error messages

A list of all error messages is given below. Only the first line of the error message on your print file is printed here. The error messages in the Input Interpretation Report on the PRA-file contain much more information. The explanations should guide you in the interpretation of the error. The remedies give hints and advice on how to remove the error.

ERROR 1	**INCORRECT TIMESPEC FOR TIDAL SERIES**
Explanation:	The end of the tidal series H(1:Nobs) precedes the start of the series.
Remedy:	Verify the input; ensure that the start time precedes the end time.
ERROR 2	**NUMBER OF MAIN COMPONENTS TOO LARGE**
Explanation:	The actual number of main components exceeds 234.
Remedy:	Reduce the number of main components to less than or equal to the maximum available 234 components.
ERROR 3	**TOO MANY GROUPS IN COUPLED COMPONENTS**
Explanation:	The actual number of coupled groups of components should not exceed 10.
Remedy:	Reduce the number of groups to less than or equal to 10 by leaving out the ones you consider less important.
ERROR 4	**MAIN COMPONENT IN COUPLED GROUP INCORRECT**
Explanation:	The indicated group contains a main component that is not present in the group of selected main components (Ncomp).
Remedy:	Verify the name of the selected main component.

ERROR 5	**NUMBER OF COUPLED COMPONENTS PER GROUP TOO LARGE**
Explanation:	The indicated group contains more than 10 sub-components.
Remedy:	Reduce the number of sub-components to less than or equal to 10 by leaving less important ones out of the computation.
ERROR 6	**COUPLED GROUP CONTAINS ILLEGAL SUB-COMPONENT**
Explanation:	The indicated group contains a sub-component that is not present in the list of tidal constituents.
Remedy:	Verify the names of the sub-components that you want to be included in this group.
ERROR 7	**OVERLAP IN COUPLED GROUP OF COMPONENTS**
Explanation:	One or more sub-components are included in more than one group. This results in a non-unique and therefore illegal situation.
Remedy:	Redefine the indicated groups.
ERROR 8	**NUMBER OF INSTRUMENTS TOO LARGE**
Explanation:	Actual number of instruments (Nins) exceeds 10.
Remedy:	If possible, reduce the number of instruments to less than or equal to 10, for example by shortening the observation length.
ERROR 9	**NUMBER OF SUBSERIES TOO LARGE**
Explanation:	Actual number of sub-series (Nsub) exceeds 10.
Remedy:	See the remedy for Error 9.
ERROR 10-13	**INACTIVE ERROR MESSAGES**.
ERROR 14	**MISSING INPUT LINE FOR BLOCK FILTER PARAMETERS**
Explanation:	Although the filter parameters are not used, the system expects this input line.
Remedy:	Add this input line. See section A.1.
ERROR 15	**INPUT TIMESPECS FOR FIRST SUB-SERIES INCORRECT**
Explanation:	First sub-series lies before start of tidal series (TB)
Remedy:	Verify and adjust date-time for first sub-series.
ERROR 16	**INPUT TIMESPECS FOR LAST SUBSERIES INCORRECT**
Explanation:	Last sub-series lies after end of tidal series (TE)
Remedy:	Verify and adjust date-time for last sub-series.
ERROR 17	**INPUT TIMESPECS FOR SUB-SERIES INCORRECT**
Explanation:	The subsequent time levels (start and end time) for the instruments are not monotonously increasing; some sub-series may be partly overlapping or ill-placed.
Remedy:	Verify and adjust date-time for sub-series.

ERROR 18 **SELECTED COMPONENT NOT ALLOWED**

Explanation: The indicated component does not belong to the internal component base listed in Appendix B. The component may be misspelled. Note that the names of components must be given in upper cast (capital letters).

Remedy: Correct the spelling. Compare the frequency of the component with the list of names and frequencies in Appendix B, or remove this component from the set.

ERROR 19 **COMPONENTS WITH SAME FREQUENCY**

Explanation: The two indicated components in your selected set have same tidal frequency. That is not permitted.

Remedy: Remove one of the indicated components.

ERROR 20 **INPUT AND DATA SET ARE INCONSISTENT W.R.T. SUB-SERIES**

Explanation: In the input file you have specified date-time groups for beginning and end of the sub-series. These time specifications should agree with the actual sub-series as present on your <∗.obs> file. In case of inconsistent specification parts of the gaps (periods between sub-series) may become involved in the harmonic analysis.

To enable the sub-system to check for this situation we advise to fill the gaps with unrealistic large numbers (say, 99999 or actually any number $>$ 1000). During the computation the sub-series will be checked for these unrealistic numbers. Presence of these numbers indicates that parts of gaps are involved in the sub-series, resulting in the error message above.

Remedy: Check the Input Interpretation Report on your <∗.pri> file.

Make the time specifications for the sub-series on your input file consistent with the <∗.obs> file.

Note: if the values of the real observations exceed 1000, e.g. when they are given in e.g. millimetres, or have a very high mean, we suggest an overall offset for the observations to realise values below 1000. Of course, the mean level and the hindcast should afterwards be adjusted for the applied correction.

ERROR 21 **READ-ERROR ON OBS FILE**

Explanation: While reading the <∗.obs> file a read error occurred. Normally this means that the system tries to read numbers and find characters on the file. <∗.obs> files start with at least 1, and at most 20 header lines, to identify the file.

Remember that you should start header lines with a '+' or a '∗'. If more than 20 header lines have been inserted, the situation above will occur.

Remedy: Check the (number of) header lines at the start of the <∗.obs> file. Check the Input Interpretation Report.

ERROR 22	**END OF FILE ON OBS FILE**
Explanation:	While reading the <∗.obs> file the system concluded that the prescribed number of data on the input file (Nobs) was not available on the <∗.obs> file. Normally this means that the value for Nobs is incorrect; you may also have "lost" the last part of your observation file.
Remedy:	Verify and ensure that at least 1 header line is present on the <∗.obs> file. Adjust the value for Nobs in the input file INA if this does not correspond to the number of observations present on the <∗.obs> file.

ERROR 23	**DYNAMIC MEMORY ALLOCATION EXCEEDED**
Explanation:	In the system all data are allocated dynamically in a large dynamic memory, resulting in optimal use of available memory. In Section 5.5 the limitations of the system were discussed. These summarised limits should be read as individual limits, however, that is, a limit for the number of components, a limit for the number of sub-series, etc. All these individual limits are checked in the software. There is also an overall memory limit, called the dynamic memory limit. This limit corresponds to an overall maximum of 200 000 memory words.
Remedy:	Adjust the input parameters of section A.1 where possible and feasible, in order to reduce the dynamic memory required. First candidates for reduction are Nobs, Ncomp, Nsub and Nins.

D.1.2 Warnings

Below two (non-fatal) warnings are discussed. Read the explanation carefully. Remember that the software proceeds normally with the computation after detecting warnings.

WARNING 1	**RAYLEIGH CRITERION VIOLATED**
Explanation:	The two indicated components are too close in frequency. The Rayleigh criterion states that for independent resolution of all components the minimum frequency difference (expressed in degrees per hour) for neighbouring tidal components should be $360/T$, where T (in hours) is the effective length of the analysis period, see section 8.3.3. The effective length T equals the difference between the start date-time of the first sub-series and the end date-time of the last sub-series. This criterion does not always have to be applied so rigorously. Given the nature of the least squares solution technique, a 10 % violation of the criterion will generally not invalidate the results. See also the chapter on theory chapter 8.
Remedy:	If the violation is large, consider coupling of the two components involved (if astronomically related), or removal of the less important one of the two.

WARNING 2	**TIME STEP MAY BE INCORRECT**
Explanation:	From the input specifications for each instrument the time step (measurement interval) will be reconstructed. For you, the correct specification of sequence numbers and corresponding time specifications for the instruments is always a rather error-prone affair. Fortunately, the software provides a check to see whether the computed time step satisfies one of the time steps commonly used in tidal analysis. These are time steps of 10, 15, 30 or 60 minutes. In the output this appears as Δt = 0.1666, 0.2500, 0.5000 or 1.0000 hours. If one of the computed time steps is not exactly equal to one of these built-in time steps a warning will be printed. Due to limited accuracy of computers it is possible that the fourth decimal differs from these built-in time steps. In that case, the warning should be ignored.
Remedy:	Convince yourself whether the warning is caused by incorrect input specification of date-time groups, or whether the clock of the recording instrument has been off. In the latter case, the time step is correct (the system can correct for this instrument error!). In the first case, correct the input.

D.2 PREDICT

In PREDICT six error messages are implemented, and no warnings. After a complete screening of the input data the system will abort if any errors are detected. A list of the detected errors is added to the print file $<$∗.prp$>$.

ERROR 1	**END TIME $<$ BEGIN TIME**
Explanation	This error arises when the input specification indicates that the date-time group (TB) of the start of the prediction is later in time then the date-time group (TE) for the end.
Remedy	Verify and adjust the date-time groups.

ERROR 2	**NUMBER OF COMPONENTS SHOULD BE BETWEEN 1 AND 234**
Explanation	The number of components (Ncomp) exceeds the maximum available number of components in the internal component base (=234).
Remedy	Select any number of components in the range 1–234. Note that the names of the components must be spelled conform the list in Appendix B.

ERROR 3	**NUMBER OF SUBSERIES SHOULD BE BETWEEN 1 AND 100.**
Explanation	You chose a number of sub-series (Nsub) not between 1 and 100.
Remedy	Reduce the number of sub-series. If necessary, define sub-series longer than two months (some loss of accuracy), or make several computation runs.

ERROR 4	**TIME LEVEL FOR SUBSERIES OUT OF RANGE**
Explanation	The date-time for the start of one of the sub-series (T1sub) is outside the time range TB – TE for the prediction.
Remedy	Verify your input and ensure that the start times of the sub-series lie within the time range TB – TE of the prediction.

ERROR 5	**START OF SUBSERIES SHOULD BE ON A FULL HOUR OR A MULTIPLE OF THE TIME STEP AFTER A FULL HOUR.**
Explanation	Each sub-series is supposed to start on a full hour or any number of integer time steps after a full hour.
Remedy	Adjust the date-time for the start of the concerned sub-series.

ERROR 6	**COMPONENT xx NOT IN INTERNAL COMPONENT BASE.**
Explanation	The system does not recognise the component. Maybe the name of the component is misspelled. Names should be entered in upper cast.
Remedy	Check the spelling of the component by comparing with Appendix B. If necessary, replace it by the component from the database that has the same or comparable frequency.

D.3 HILOW

In this section the list of possible error messages of HILOW is given. All error messages will cause the sub-system to abort. Again, only error messages related to relevant input will be listed.

D.3.1 Error messages

ERROR 1	**NUMBER OF OBSERVATIONS EQUALS ./ SHOULD BE LESS THAN 18000.**
Explanation	The number of values (Nobs) that you specified in the input file exceeds 18 000.
Remedy	Restrict the number of observations in HILOW, either by shortening the series, or dropping every other half hourly value if applicable. Hourly values suffice in the determination of tide tables. Note that a full year of half-hourly values corresponds to Nobs = 17 520 (17 568 for a leap year).

ERROR 2	**TOO MANY INSTRUMENTS**
Explanation	Actual number of instruments (Nins) exceeds 10.
Remedy	If possible, reduce the number of instruments to less than or equal to 10, for example by shortening the observation length.

ERROR 3	**TOO MANY SUBSERIES**
Explanation	Actual number of sub-series (Nsub) exceeds 10.
Remedy	See the remedy for Error 2.

ERROR 4	**NO FILTER PARAMETERS PROVIDED**
Explanation	The input line for the 3 filter parameters is missing.
Remedy	Add the input line for the filter parameters, see section A.3.

ERROR 5	**FILTER PARAMETERS INCORRECT**
Explanation	While reading the filter parameters, the system detected a read error. In this situation the most likely explanation is that you did not enter integer numbers for Mfilter and Nfilter.
Remedy	Choose integer values for filter parameter Mfilter and Nfilter.

D.3.2 Info messages

The sub-system may generate some informative messages for the block filter.

MESSAGE 1	**BLOCK FILTER PAR. 1 OUT OF RANGE (RESET ON DEFAULT=0.2).**
MESSAGE 2	**BLOCK FILTER PAR. 2 OUT OF RANGE (RESET ON DEFAULT=2).**
MESSAGE 3	**BLOCK FILTER PAR. 3 OUT OF RANGE (RESET ON DEFAULT=2).**

Parameters 1, 2, and 3 refer to *Afilter*, *Mfilter* and *Nfilter*, resp. If the default does not satisfy, verify their ranges, see the example input file in item A.3.

D.4 ASCON

ASCON contains three error messages.

ERROR 1	**ALL TIME-DATES INCORRECT**
Explanation	Date-time groups in input were specified incorrectly or not present at all.
Remedy	Adjust or add date-time group(s) for computing the $V_0 + u$ and F.

ERROR 2	**ALL SUPPLIED COMPONENTS INCORRECT.**
Explanation	Components missing or misspelled.
Remedy	Adjust or add components, see Appendix B.

ERROR 3	**COMPONENT xx NOT IN INTERNAL COMPONENT BASE.**
Explanation	The system does not recognise the component. Maybe the name of the component is misspelled. Names should be entered in upper cast.
Remedy	Check the spelling of the component. If necessary, replace it by the component from the database that has the same or comparable frequency.

Remark:

◇ The constituent names must be entered in order of increasing frequency.

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D.5 FOURIER

No errors or warnings are listed.

E Content of the TIDE tutorial cases

A list of the input files of the tutorial cases is given below.

E.1 ANALYSIS

For sub-system ANALYSIS in directory <tutorial\tide\analysis>

- sub-directory <example_1> with files:
  - <anaex1.ina>
  - <hvh.obs>
- sub-directory <example_2> with files:
  - <anaex2.ina>
  - <hvh.obs>
- sub-directory <example_3> with files:
  - <anaex3.ina>
  - <bermud.obs>
- sub-directory <example_4> with files:
  - <anaex4.ina>
  - <atlantis.obs>

E.2 PREDICT

For sub-system PREDICT in directory <tutorial\tide\prediction>

- sub-directory <example_1> with file:
  - <prdex1.inp>
- sub-directory <example_2> with file:
  - <prdex2.inp>

E.3 HILOW

For sub-system HILOW in directory <tutorial\tide\hilow>

- sub-directory <example_1> with files:
  - <hlwex1.inh>
  - <prdex1.prd>
- sub-directory <example_2> with files:
  - <hlwex2.inh>
  - <anaex2.hdc>
- sub-directory <example_3> with files:
  - <hlwex3.inh>
  - <bermuda.obs>

E.4 ASCON

For sub-system ASCON in directory <tutorial\tide\ascon>

- sub-directory <example_1> with file:
  - <ascex1.inc>
- sub-directory <example_2> with file:
  - <ascex2.inc>

E.5 FOURIER

For sub-system FOURIER in directory <tutorial\tide\fourier>

- sub-directory <example_1> with file:
  - <anaex3.res>
- sub-directory <example_2> with file:
  - <sft_fouex2.res>
- sub-directory <example_3> with file:
  - <fft_fouex3.res>

Deltares systems

PO Box 177
2600 MH Delft
Rotterdamseweg 185
2629 HD Delft
The Netherlands

+31 (0)88 335 81 88
sales@deltaressystems.nl
www.deltaressystems.nl