C-Nav™

C-Tides® Online Software User Manual

Revision 7

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OCEANEERING®

Release Notice

This is the February 2022 release of the C-Tides® Online Software User Manual.

Revision History

Revision	Date	Description	Author
7	02/08/2022	Additional Offset Convention Notes	R. Morton
6	03/07/2018	Updated for C-Tides v2.2.0	C. Thompson
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4	07/22/2016	Updated for C-Tides v2.0.0	C. Thompson
3	06/10/2015	Added C-Tides and C-Tides Data Installation	B. Mathweg
2	11/08/2013	Added troubleshooting section	C. Thompson
1	05/09/2013	Initial document creation	C. Thompson

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Manual Organization

This manual describes how to install, configure, and operate the real-time version of the **Oceaneering® C-Tides®** worldwide tidal data software, the C-Tides® Online application. Sections are organized in a manner that facilitates quick operator orientation.

Section 1 - Overview (Page 11) gives a brief overview of the C-Tides® Online application and its purpose.

Section 2 - Controls (Page 13) gives detailed descriptions of the settings and controls used to run the C-Tides® Online application.

Section 3 - Menus (Page 19) describes the various options and dialogs available via the different menus of the C-Tides® Online application.

Section 4 - Calculations (Page 26) gives a brief description of each of the various values output by the C-Tides® software suite and how they are derived.

Section 5 - Output (Page 28) describes the output format used by the C-Tides® Online application when data is output to either a COM port or to a log file. It also describes in further detail several of the values output by the C-Tides® software.

Appendix A – Vertical Offsets (Page 30) describes the conventions used for vertical offsets.

Appendix B - Plot Functions (Page 32) describes the buttons available on the various plots that can be used to better investigate the plotted data.

Appendix C - Example Plots (Page 33) provides sample plots created by the C-Tides® Online application.

Appendix D - Frequently Asked Questions (Page 36) explains how to resolve a few of the common errors that occur while running the C-Tides® Online application.

Appendix E - Glossary (Page 40) provides definitions for various terms used in this manual.

The user may also be interested in the User Manual for the companion C-Tides® Offline application which post-processes recorded PVT1B data and the C-Tides® software data format saved by the C-Tides® Online application.

Related Documents

CNAV-MAN-019.6 (C-Tides Offline User Manual)

Similar to this manual, the C-Tides® Offline User Manual describes how to configure and operate the C-Tides® Offline application. It is available on the C-Nav™ website at https://www.oceaneering.com/C-Nav/Software/CTides/PDFDownloads/CNAV-MAN-019.6%20%28CTides%20Offline%20Users%20Manual%29.pdf.

CNAV-MAN-022.5 (C-Tides Quick Start Guide)

The C-Tides® Quick Start Guide is a short tutorial explaining the minimum steps required to configure a fresh C-Tides® software installation. It is available on the C-Nav™ website at https://www.oceaneering.com/C-Nav/Software/CTides/PDFDownloads/CNAV-MAN-022.5%20%28CTides%20Quick%20Start%20Guide%29.pdf.

Modelling the global ocean tides: modern insights from FES2004

Details the methodology used to determine the predicted tide values used in the C-Tides® software. It is available on the C-Nav™ website at https://www.oceaneering.com/C-Nav/Software/C-Tides/PDFDownloads/FES2004%20Modern%20Insights.pdf.

Unified Tidal Analysis and Prediction Using the UTide Matlab Functions

Describes the underlying methodology of the UTide harmonic analysis used in the C-Tides® Offline application. It is available at https://www.oceaneering.com/C-Nav/Software/CTides/PDFDownloads/2011Codiga-UTide-Report.pdf.

Manual Conventions

Arial font is used for plain text in this document. *Arial italic* font is used for settings names.

“Arial quoted” font is used for settings values. **Arial Bold** font is used for button names.

Arial Bold Italic font is used for menu items.

Arial Blue font is used for cross-references.

Arial Blue Underline font is used for hyperlinks.

Arial red italic is used for typed commands.

Arial Bold font size 10 is used for captions.

ARIAL BLACK ALL-CAPS font is used for port connection names.

This symbol means Reader Be Careful. It indicates a caution, care, and/or safety situation. The user might do something that could result in equipment damage or loss of data.

This symbol means Danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical and RF circuitry and be familiar with standard practices for preventing accidents.

Important notes are displayed in shaded text boxes.

Please note:
Such note boxes display important information that should not be ignored.

Simple file content is displayed in Courier New Black font in a text box.

```
#Sample File
Version 0.1
```

Section 1 - Overview

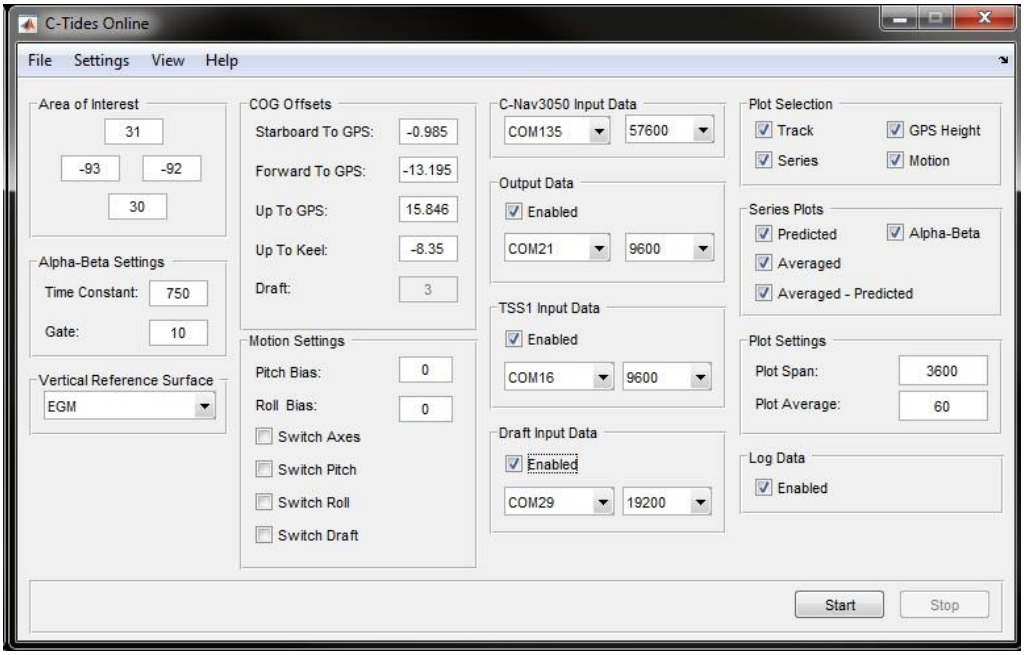

Figure 1: C-Tides Online (Ver 2.2.3 and above)

Introduction

The C-Tides® software is a suite of two programs which enables ocean tidal data to be derived from high accuracy **Oceaneering® C-Nav5000®** or legacy C-Nav3050 GNSS receiver data in real-time, and further processed offline for increased accuracy and harmonic derivations.

The software consists of the C-Tides® Online application, which processes C-Nav5000® receiver data and optional TSS1 and / or draft information to give real-time tidal height about the vertical reference surface. The C-Tides® Offline application can be used to further process the data obtained by the online program to smooth, spike reject, and Doodson filter the data. In addition, the C-Tides® Offline application can generate harmonic analysis constituents for the site and predict tide plots for the area. Comprehensive output files are generated for further analysis by the user.

Installation

Instructions for installing the C-Tides® Online application and its dependencies can be found in the C-Tides® Quick Start Guide, available on either the installation thumb drive or our website https://www.oceaneering.com/positioningsolutions/customer-access-and-resources/.

Section 2 - Controls

Area of Interest

The C-Tides® Online application reads large, worldwide databases in the form of MATLAB .mat files. They cannot all be held in memory simultaneously. On the other hand, the user only operates in a local area (AOI), not the whole world. The purpose of this panel is to extract the AOI from the worldwide databases.

Enter the northern, eastern, southern, and western extents of the AOI. Ideally, the smallest AOI possible should be entered. However, an AOI that is too small will prevent processing of the data. The difference in AOI values should be no less than the selected Vertical Reference Surface (Page 13). For example, if using MSS the AOI should be no smaller than 2-minutes by 2-minutes in size.

Note:
If the vessel wanders outside of the extracted AOI, the C-Tides® Online application will stop processing until the vessel returns to within the AOI.

The maximum AOI allowed is 10 degrees by 10 degrees. The AOI only needs to be extracted once, unless the extents are changed. The AOI will automatically be extracted when needed.

Vertical Reference Surface

Choose the *Vertical Reference Surface* (VRS) for processing. All surfaces are referenced at the centimetric level to WGS84. The default VRS is “MSS”.

The MSS model is based on satellite altimetry readings that utilize a 10 km beam. Because of this, the vessel must be 10 kilometers from the nearest land mass to use MSS. MSS data is available in 2-minute by 2-minute grid intervals.

The EGM model is the EGM08 geoidal model. EGM most closely approximates MSL where there are no geographic influences on tides. While there is no minimum distance from land requirement to use EGM; the vessel must be in water with a depth of at least 10 meters, preferably 25 meters. EGM data is available in 2-minute by 2-minute grid intervals.

Alpha-Beta Settings

Tidal heights are smoothed with a double-sided alpha-beta filter; however, the unsmoothed tidal height is always available.

The *Constant* determines the alpha-beta parameters. The higher the *Constant*, the heavier the filtering. The *Constant* value can be any number between 0 and 1500 seconds.

Height outliers are rejected with a *Gate*; the difference in meters between the predicted tide and the actual tide height. The smaller the *Gate*, the more values will be rejected. A valid *Gate* value is between 0 and 20 meters.

Center of Gravity Offsets

Vessel offsets are entered in meters with respect to the center of gravity (COG) of the vessel. For COG measurements to the GPS, the convention is positive starboard, forward, and up while negative is port, aft, and down. For COG to keel the convention is positive up and negative down. It would be highly unusual for the COG to be below the keel, thus COG to keel is almost always negative.

The draft, ie keel to waterline by convention is positive which aligns it with the C-Tides convention of positive up. A more detailed graphic and example are given in Appendix A

Once the C-Tides® Online application has started *Forward to GPS*, *Starboard to GPS*, *Up to GPS*, and *Up to Keel* are fixed, but *Draft* can be changed. If a TSS1 string is received, then all dimensions are used in the pitch and roll computations. If not (i.e. no TSS1 string), then *Forward to GPS* and *Starboard to GPS* are ignored.

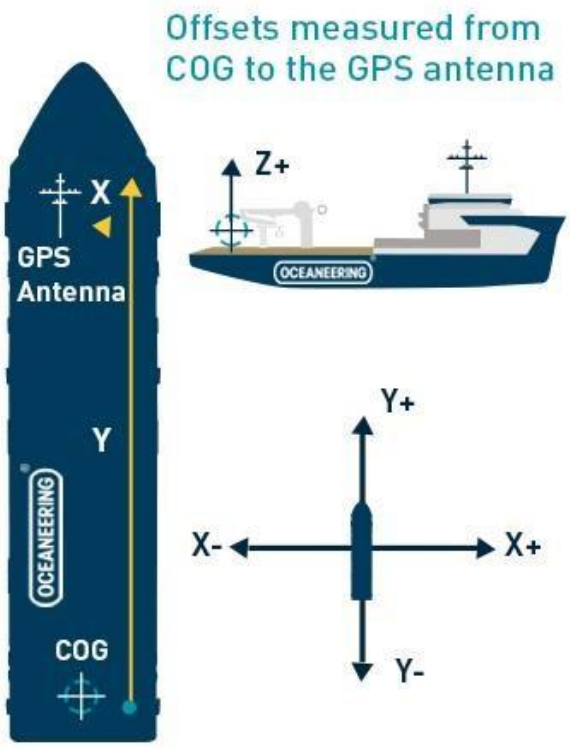

Figure 2: COG Offset Sign Conventions

See Figure 14: COG Offsets Plot (Page 32) for a graphical depiction of vessel vertical offsets.

Note:
The COG can be any navigation reference point (NRP), but it is advisable that it be as close to the physical center of gravity as possible, recognizing that the COG changes with dynamics and ballasting.

Motion Settings

If a pitch and roll motion sensor is calibrated, the calibration values can be entered here. The values entered here are added to the pitch and roll values read from the TSS1 string.

The axes or rotation senses of the motion sensors may not be consistent with the convention used by the C-Tides® software. These conventions can be mapped with these checkboxes. It is useful to plot *Motion* (see Plot Selection (Page 16))

while moving the motion sensors or observing the pitch and roll of the vessel at sea in order to ensure that the mapping is correct.

Plot Selection

The four plots that can be produced by the C-Tides® Online application are selected or deselected in the Plot Selection panel. The four plots are:

- Track plot of the vessel's progress A series plot of raw antenna height
- A series plot of tidal height variations
- Vessel offsets orientated by the pitch, roll, and draft measurements

The latter plot can be useful to see the mapping between the axis orientation and rotation senses of the motion sources and their interpretation in the C-Tides® Online application (see Motion Settings (Page 15)). The plots can be minimized and they can be deleted and restarted without loss of data by un-checking and checking the plot selection checkboxes.

Warning:
"X"-ing out of a plot is ineffective as it will restart as long as the plot is selected in the Plot Selection panel.

Series Plots

This panel allows the user to select (or deselect) the desired series to be plotted in the tidal height Series plot.

Input

The *C-Nav5000 Input Data* port is the only port required to operate the C-Tides® Online application. Optionally, the user can configure a TSS1 string input, a draft string input, and / or an output string. The baud rate choices for all ports are:

- 1200
- 2400
- 4800
- 9600
- 19200
- 38400
- 57600
- 115200

All ports are set to no parity, 8 data bits, and 1 stop bit (“8:N:1”). Check the optional port checkboxes before starting the data stream(s) if TSS1, draft, or output is required.

Note:
MATLAB is known to have difficulties with some serial-to-Ethernet devices. In some instances, the ports will not appear at all in the list of available ports, in other instances they will appear but take a long time to open.

Note:
COM ports cannot be changed once the C-Tides® Online application has been started.

Draft Input

The C-Tides® Online application has two methods of applying draft data to the tidal calculations: static and real-time data input.

To use a static draft value, ensure the *Draft Input Data* is disabled and enter the desired value in the *Draft* field of the Center of Gravity Offsets (Page 14). This value can be manually changed after the C-Tides® application has started.

To use a real-time input stream, enable the *Draft Input Data* and configure the serial port details. Then configure the details of the draft input string in the Configure Draft Message (Page 19) dialog. The C-Tides® application will read the draft value (as well as option pitch and roll values) from the serial port.

Note:
If both a TSS1 string and a draft string containing pitch and roll are configured. The TSS1 values will override the draft string values.

Start / Stop PVT1B

The C-Nav5000® receiver must be programmed to output PVT1B at 1Hz.

> ***Warning***:
> Any additional messages being output from the C-Nav5000® receiver could cause issues reading data.

Pressing the **Start** button in the C-Tides® Online application will open the serial port(s) and start processing real-time data. If **Start** does not begin the data stream, check the port configurations. The **Stop** button will shut down the processing and close the serial port(s).

Plot Settings

Plot Span determines the number of records plotted in the various plots. The *Plot Span* can be set from 60 seconds to 3600 seconds.

Tidal height data is averaged based on the *Plot Average* period. The *Plot Average* can be set from 10 seconds to 3600 seconds.

The averaged value is the average of 1-second tidal height for the selected period prior to the current event. Outliers are not gated.

Both *Plot Average* and *Plot Span* can be changed once the C-Tides® Online application has started.

Section 3 - Menus

File

Quit

Selecting ***Quit*** will close the C-Tides® Online application.

> ***Note***:
> The C-Tides® Online application cannot be closed while actively processing. Press **Stop** and then ***Quit*** to close the C-Tides® Online application.

Settings

Import Settings

Loads a configuration from a previously saved instance of the C-Tides® Online application.

Export Settings

Saves the current configuration of the C-Tides® Online application to file.

Reset Settings

Resets all settings to default.

Configure Draft Message

If using real-time draft input, this will open a dialog to configure the fields of the draft message. The real-time draft input string must be a NMEA-like CSV string. The string must have a *Message ID* and it must be the first field of the string.

Figure 3: Draft Message Settings Dialog

Enter the *Message ID* of the input string, it cannot be left blank. Then enter the field number for each desired data field: *Draft Field*, *Pitch Field*, and *Roll Field*. The field numbering starts at 1 and is the field of the *Message ID*.

If any of the fields contains a checksum, select it in the *Checksum* drop-down. Otherwise set to "None."

If the input string does not contain a pitch and / or roll value or the user does not need to decode them, simply set the field(s) to "0."

Note:
For example, the following input string would use the settings shown in Figure 3: Draft Message Settings Dialog (Page 20):

*DLM,8.5,3.3,0.15,12,6,9.7*AB*

The draft value would be "8.5", pitch "3.3", and roll "0.15". The rest of the values are ignored.

Query Available Serial Ports

When the C-Tides® Online application is first opened, it will automatically search for available serial ports. If a new serial port is added after the C-Tides® Online

application has been opened, pressing ***Query Available Serial Ports*** will tell the C-Tides® Online application to look again for available serial ports, allowing the newly added port to be used.

View

Plot Surfaces

Plot Surfaces will produce the following contour plots of the selected AOI:

- EGM
- MSS
- The difference between EGM and MSS

Sample surface plots can be found in Appendix B - Example Plots (Page 30).

Plot Constituents

Plot Constituents will produce plots of the amplitude and phase for the 14 tidal constituents (28 plots total). A 29th plot estimates LAT (Lowest Astronomic Tide) with respect to MSL by amplifying ISLW (Indian Spring Low Water, computed as the sum of the amplitudes of 4 tidal constituents) by a factor empirically-derived and verified in the VORF area. The quality of this estimate is 2 to 3 decimeters. Appendix A - Plot Functions (Page 29) offers advice about examining and saving the plots. These plots consume memory. After inspection and before processing data, they should be deleted individually with the **X** or en masse with ***View / Close All Plots***. They can be re-plotted at any time.

Sample surface plots can be found in Appendix B - Example Plots (Page 30).

Close All Plots

Closes all open plots and dialogs. The same functionality can be achieved by pressing **Control + W** in the main C-Tides® Online application screen.

> ***Note***:
> While they will be closed initially, any plots currently chosen in Plot Selection (Page 16) will reopen automatically while data is being processed.

Show Log

Opens the ***Log Data*** dialog, which displays the last 500 log messages output by the C-Tides® Online application. These messages can be status updates, error messages, or the results of calculations.

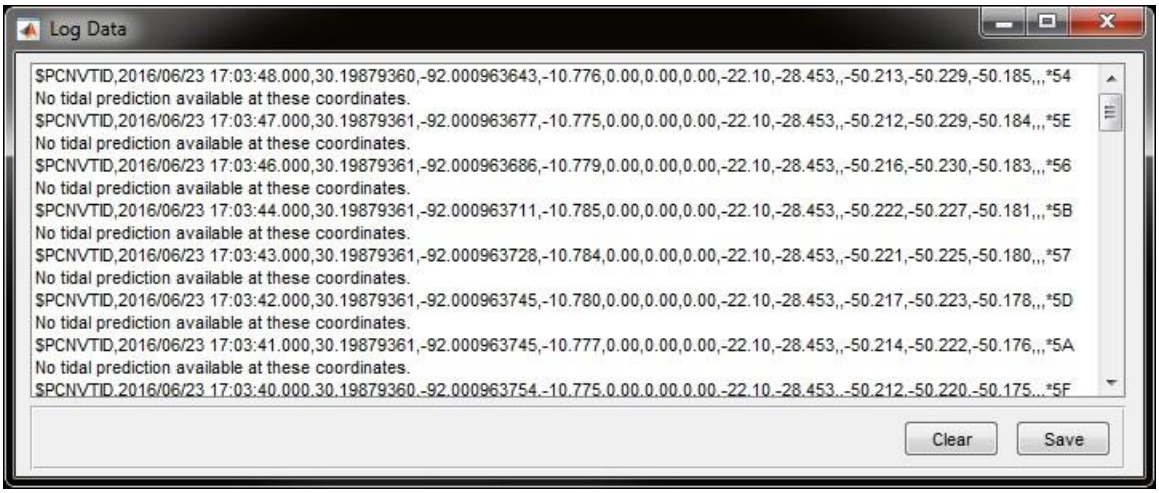

Figure 4: Log Data Dialog

Help

Show Help

Selecting the ***Show Help*** menu or pressing **F1** will display a brief set of instructions to run the C-Tides® Online application. The same instructions can be found in the C-Tides® Quick Start Guide, available on either the installation thumb drive or our website http://www.cnav.com/support.

> ***Note***:
> Pressing **F1** in any dialog will display help for that particular dialog.

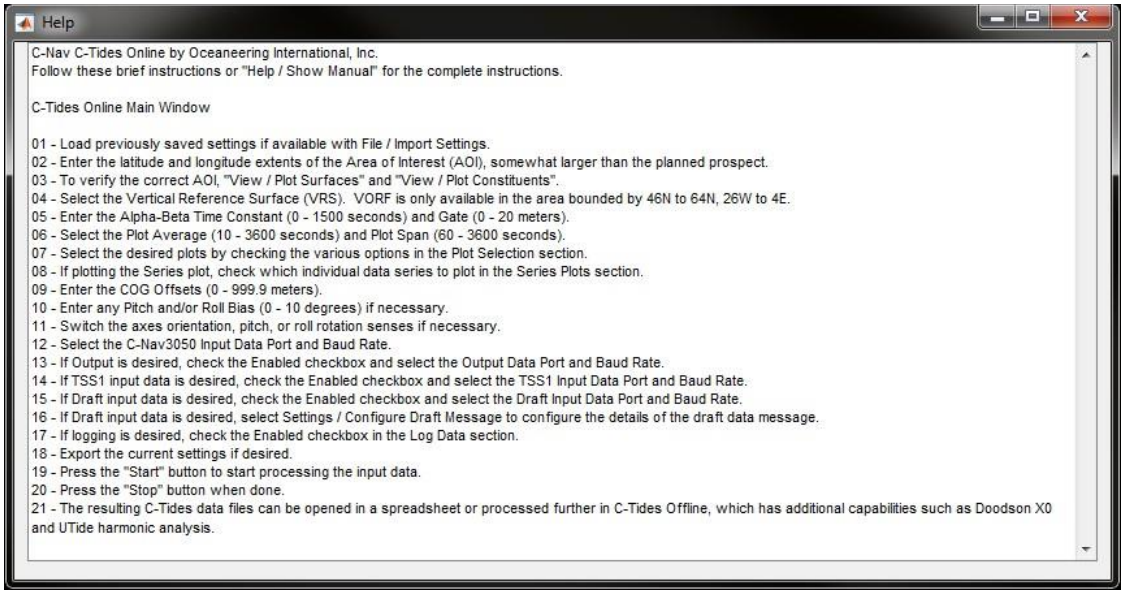

Figure 5: Help Dialog

Show Manual

Opens the current C-Tides® Online User Manual.

> ***Note***:
> A PDF reader must be installed to open the C-Tides® Online User Manual.

C-Nav Dongle Check

Information about the currently connected dongle can be found in the ***C-Nav Dongle Check*** dialog.

Figure 6: C-Nav Dongle Check Dialog

About

Support contact information for C-Nav™ can be found by selecting ***About***. The current version number, contact information, etc. to assist the operator should problems arise can also be found in this dialog.

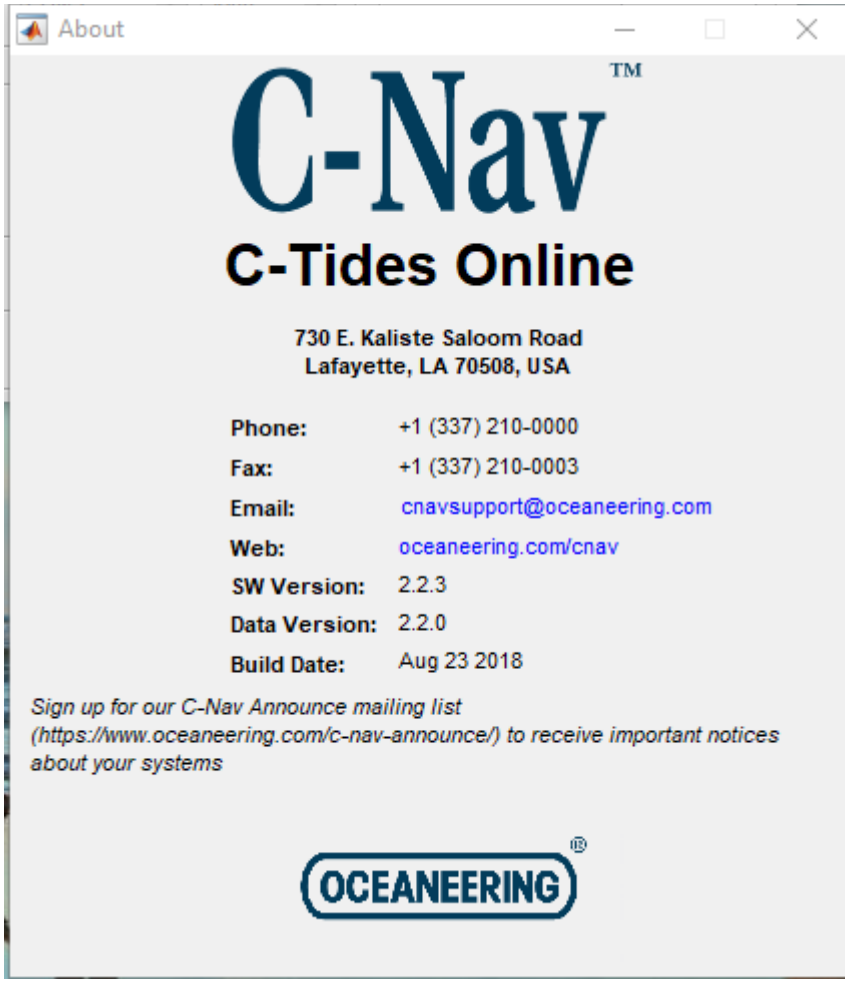

Figure 7: About Dialog

Section 4 - Calculations

The C-Tides® software calculates several values useful when dealing with tides. Below are some details about each.

Predicted Tide

The predicted tide values are derived from an independent solution that is detailed in the paper *FES 2004 Modern Insights*, available on the C-Nav™ website. The values are based on a combination of MSS and tide gauge values around the world. Within the C-Tides® software, the values are interpolated to the coordinates of the C-Nav5000® receiver. This value is typically within 50 cm any of the Vertical Reference Surface (Page 13) models. The value is output in meters.

Calculated Tidal Height

The calculated tidal height is derived based on the real-time ellipsoidal height of the C-Nav5000® receiver, the Center of Gravity Offsets (Page 14) adjusted for any pitch, roll, or draft movement, and the selected Vertical Reference Surface (Page 13). The result gives the user the tidal height above the selected VRS in meters.

Filtered Tidal Height

Using the *Time Constant* and *Gate* settings, the C-Tides® software will perform an alpha-beta filtering technique on the calculated tidal height. The result is a smoothed tidal height above the selected VRS in meters.

Averaged Tidal Height

Using the *Plot Average* setting, calculates an average of the filtered tidal heights. The result is a tidal height above the selected VRS in meters.

Averaged Tidal Height Minus Predicted Tide

A simple subtraction of the average tidal height value by the predicted tide value. The result is given in meters.

Doodson XO

The Doodson XO filter process is useful for deriving a local VRS approximating

MSS, valid during the period of observations. The value is the separation between the Doodson XO derived VRS and the selected VRS in meters. This value is only available via post-processing in the C-Tides® Offline application.

Note:
The Doodson XO value is provided for reference and QC purposes only. It is not used in any of the C-Tides® calculations.

UTide

The UTide harmonic analysis process will make an estimate of the 14 highest order harmonics of the measured tide. The calculation requires a minimum of three days of data. The value output for each epoch is the tidal height resulting from the use of the 14 harmonic parameters above the VRS in meters. This value is only available via post-processing in the C-Tides® Offline application.

Section 5 - Output

The C-Tides® software can log the processed data to a sequence of daily ASCII NMEA-like files with a C-Tides' extension. The C-Tides® software also optionally streams processed data over a serial port in the same format. The following is the format of both the logged files and serial data stream. The letters correspond to the column headings in a spreadsheet created when the file is opened as a CSV file.

A. Message ID
B. UTC Timestamp
C. Latitude
D. Longitude
E. Height
F. Heave
G. Pitch
H. Roll
I. Draft
J. Vertical Reference Surface
K. Predicted tide
L. Calculated tidal height
M. Alpha-beta filtered tidal height
N. Averaged tidal height
O. Averaged tidal height minus predicted tide
P. Reserved for Doodson X0 computed in the C-Tides® Offline application
Q. Reserved for UTide harmonic analysis computed in the C-Tides® Offline application

Note:
The last field of the output string will contain a checksum.

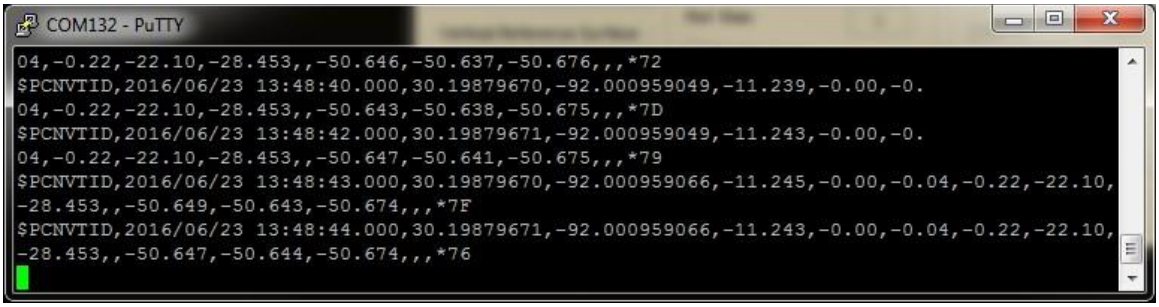

Figure 8: Output Stream

Appendix A - Vertical Offsets

Getting the vertical offsets correct is essential to making accurate tide measurements. In C-Tides its always the same if the direction is UP the sign is positive.

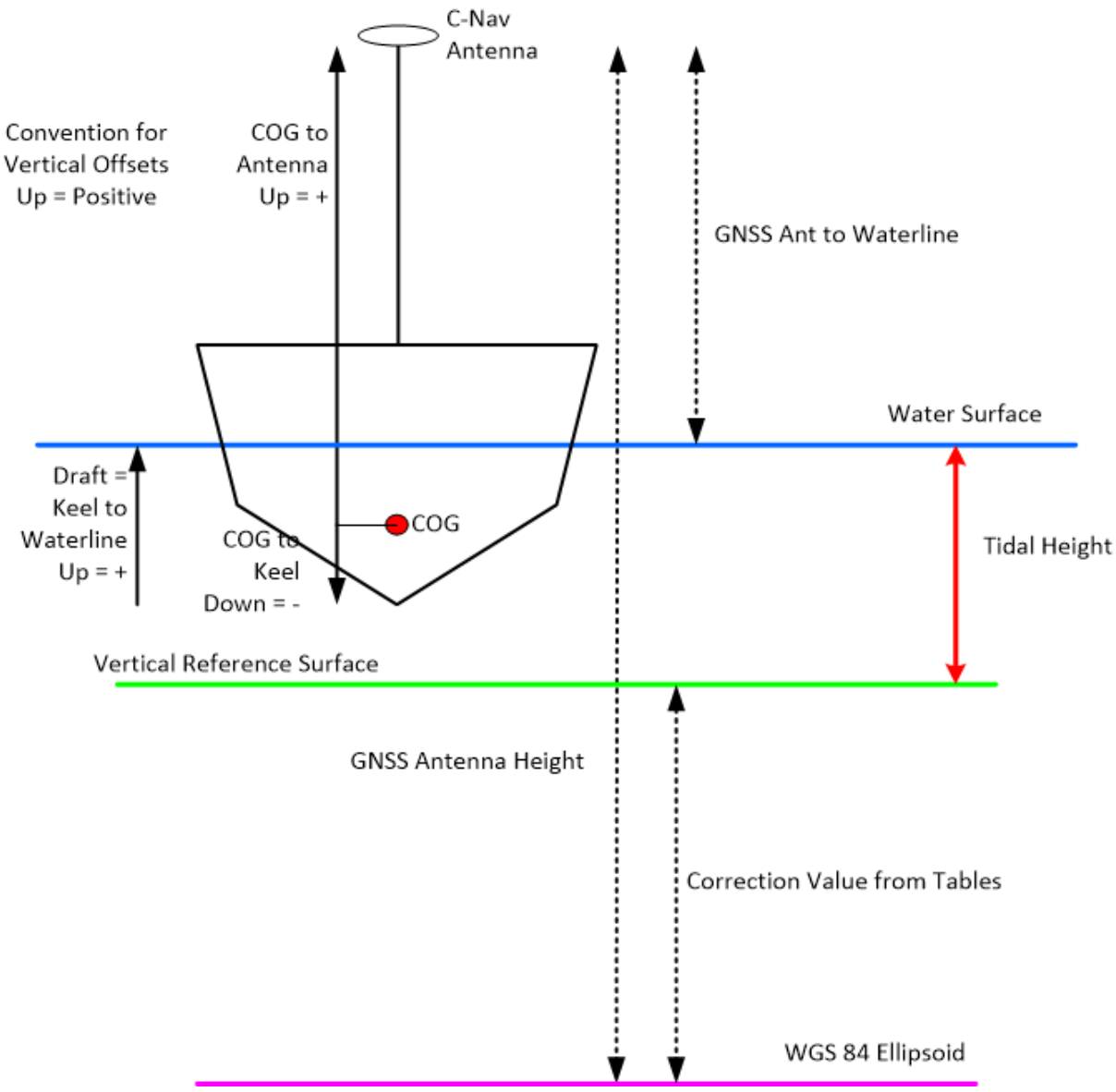

Figure 14: Vertical Offsets

COG Fig 14 Example

COG to Antenna = 20m (Up so Positive)

COG to Keel = -3m (Down so Negative)

Draft = 5m (Up Keel to Waterline so Positive)

What we need for ongoing calculations is the antenna to waterline distance. This should be a constant if the draft remains the same.

Waterline to Antenna = COG to Antenna - (Draft + COG to Keel)
= 20 – (5 + (-3))
= 20 – (5 -3)
= 20 – 2
= 18

Now we can derive tidal height.

GNSS Antenna height above the WGS Ellipsoid (from GNSS receiver) – WGS Ellipsoid to Sea Surface Reference (from internal tables) - GNSS antenna to Waterline.

The Ellipsoid to Sea Surface is derived either from the MSS table or the Geoid Tables.

Error Checking of the Offset values and signs.

There are two pointers that indicate an offset error.

If the mean of the measured tide is offset from the mean of the predicted tide this is a pointer. Ie if the positive peak measured tide is +5 and the negative peak measured tide is – 8, offsets should be checked.

If a Doodson plot can be made, it should run along the mean of the measured tide. If its offset from the mean, offsets should be checked.

Appendix B - Plot Functions

Expand to full screen

Save in 16 formats

Print

Zoom in

Zoom out

Pan

Rotate 3D figure

Mark coordinates

Reset to original view …right click with cursor in plot

Appendix C - Example Plots

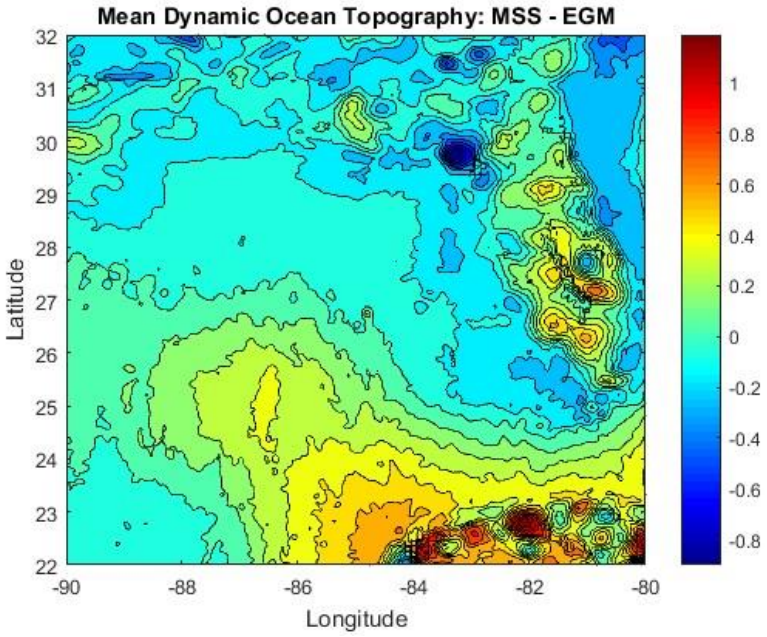

Figure 9: MSS - EGM Surface Plot

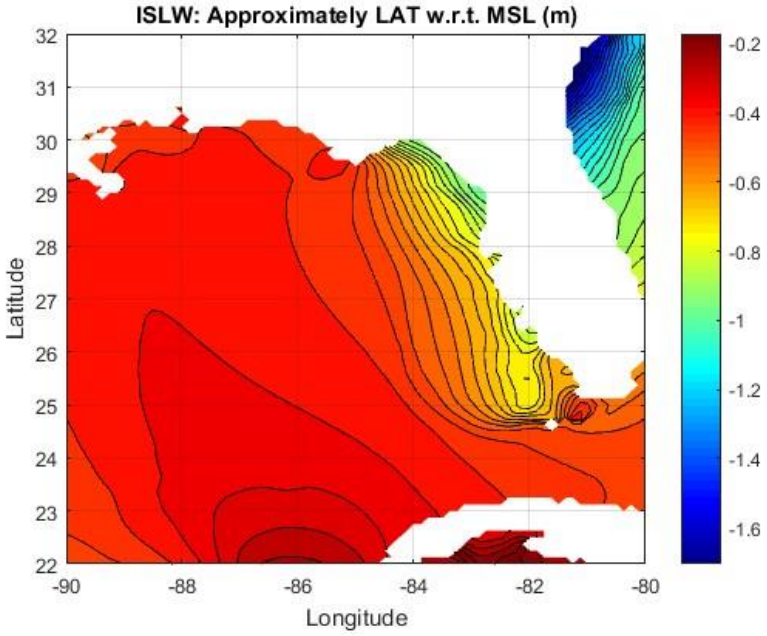

Figure 10: Amplified ISLW Constituents Plot

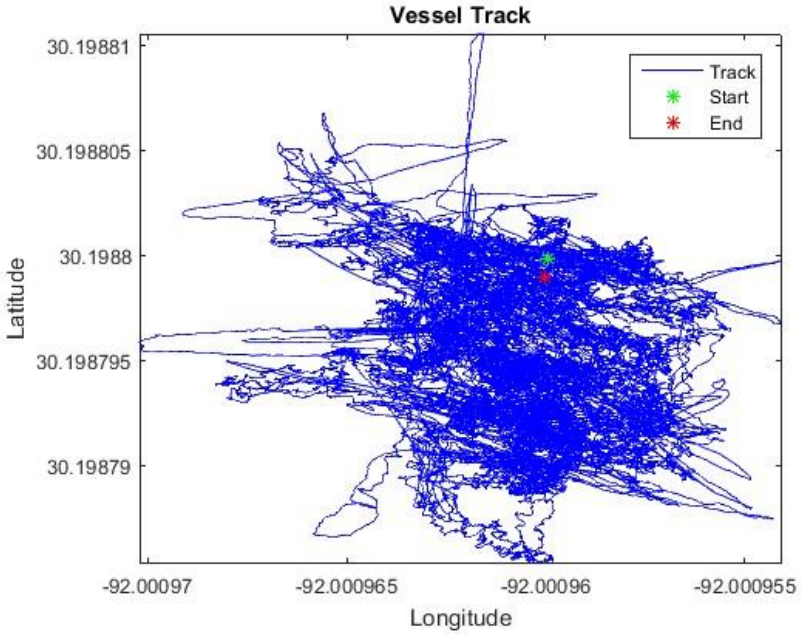

Figure 11: Vessel Track Plot

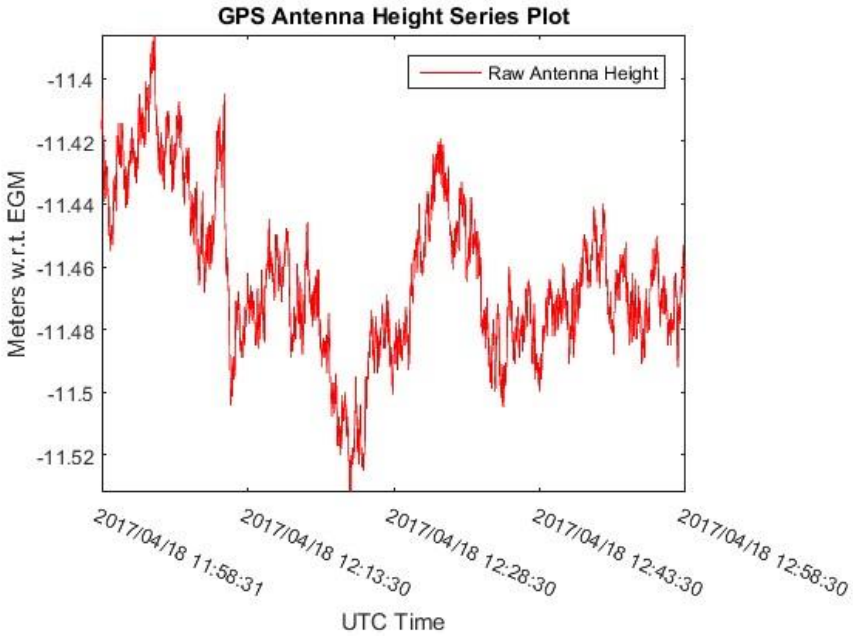

Figure 12: GPS Antenna Height Plot

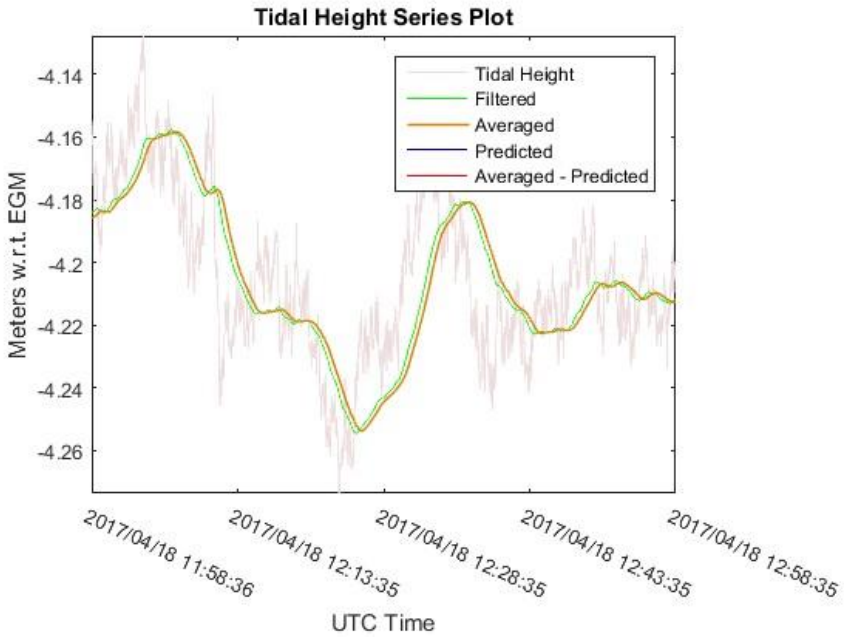

Figure 13: Tidal Height Series Plot

Appendix D - Frequently Asked Questions

When I start the C-Tides® application, I get an error message about the MATLAB Runtime?

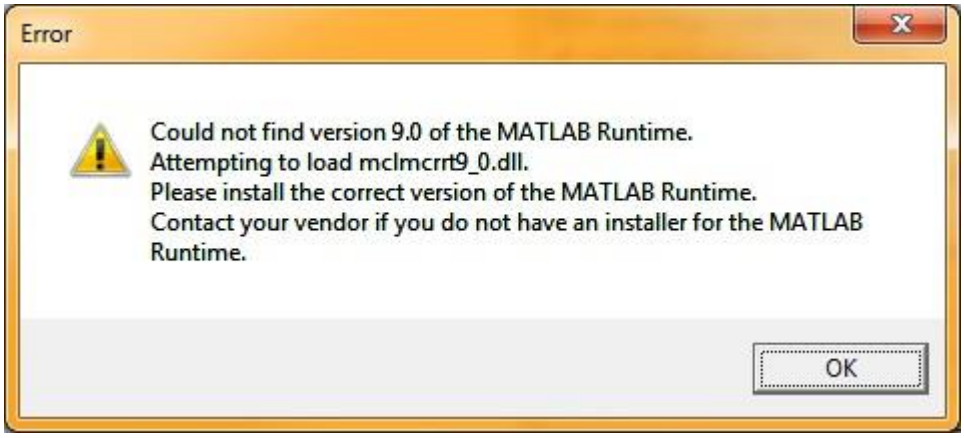

Figure 15: Missing MATLAB Runtime Error Dialog

This occurs when the proper MATLAB Compiler Runtime has not been installed. Please follow the instructions in the C-Tides® Quick Start Guide, available on either the installation thumb drive or our website https://www.oceaneering.com/positioning-solutions/customer-access-andresources/.

When I try to extract an AOI, why do I get the error message "Can't find "XXXX.mat" on path"?

Figure 16: Sample Error Dialog

There are three possible reasons for this error.

1. The C-Tides Data package was not properly installed. Ensure that the C-Tides Data is installed into the same directory as the C-Tides® Online application.
2. The *Area of Interest* is too large. Ideally, the AOI should be as small as possible around the desired location. Select a smaller bounding area.
3. The MATLAB runtime has run out of system memory. Restart the C-Tides® Online application.

My computer made a ding sound while C-Tides was running, and now the application doesn't seem to be doing anything.

The ding sound indicates that the MATLAB Runtime has triggered an unexpected error that caused the C-Tides® software to stop execution. It is best to close the application and send the error to C-Nav™ Support for further troubleshooting.

To close the application, press **Ctrl + C** in the busy dialog window. This will allow you to then close the main C-Tides® application window.

All errors are logged to a diagnostic log file. The most recent diagnostic log file can be found at:

C:\Users\{USERNAME}\AppData\Local\C-Nav\C-Tides\

When I start the PVT1B input, why do I get the error message "PVT1B data timeout"?

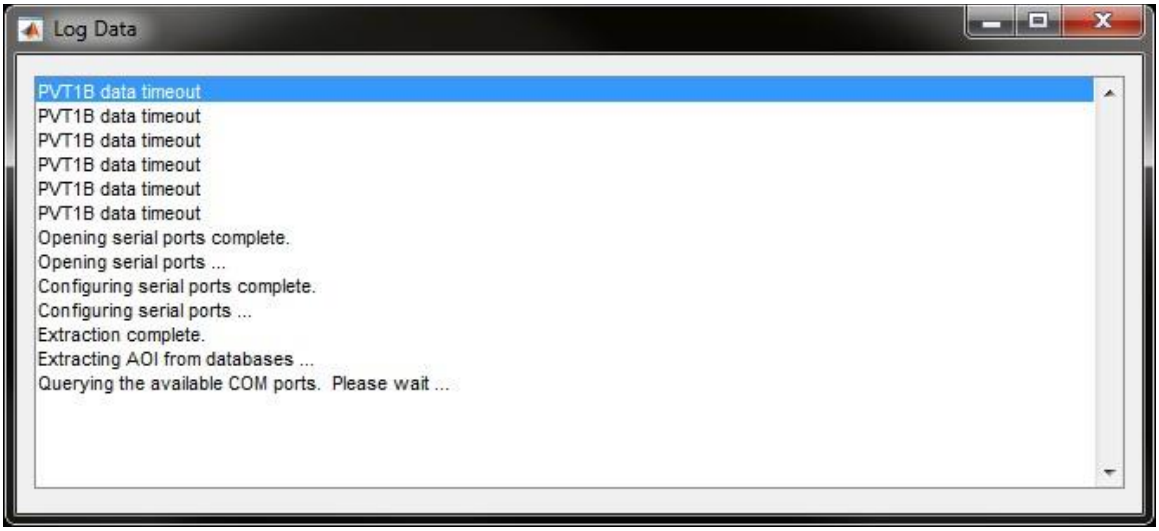

Figure 17: PVT1B Data Timeout in Log Data Dialog

This occurs when the C-Tides® Online application does not receive enough data to properly decode. Check the C-Nav5000® receiver output settings and ensure PVT1B is scheduled for at least 1Hz and that the baud rates match.

When I start the PVT1B input, why are there gaps in the output time?

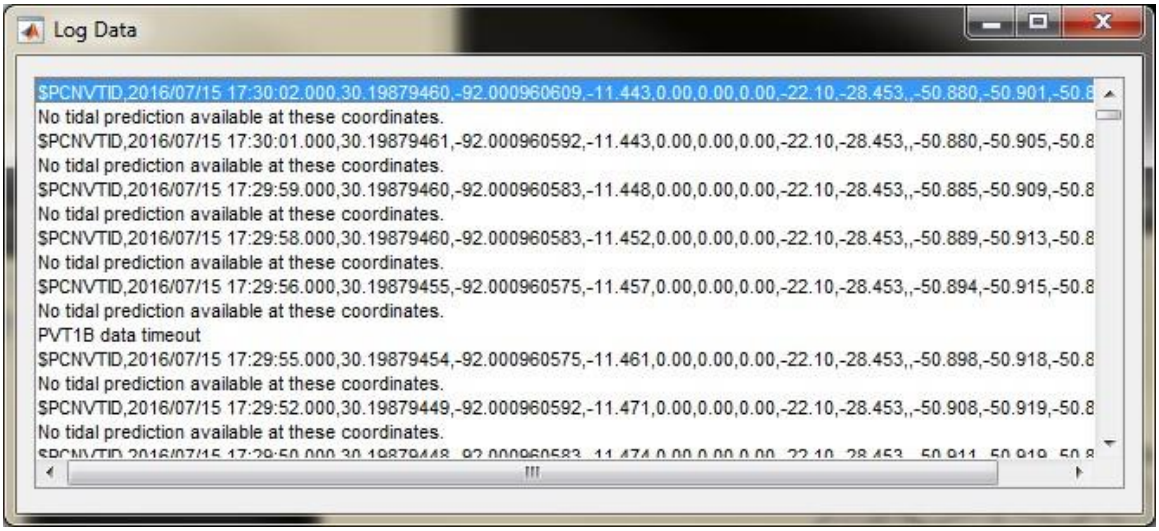

Figure 18: PVT1B Data With Gaps in Log Data Dialog

This occurs when the C-Nav5000® receiver has more messages scheduled on the serial port than the PVT1B. Check the C-Nav5000® receiver output settings and ensure that only PVT1B is scheduled for at least 1Hz.

Why is there no predicted data in my AOI?

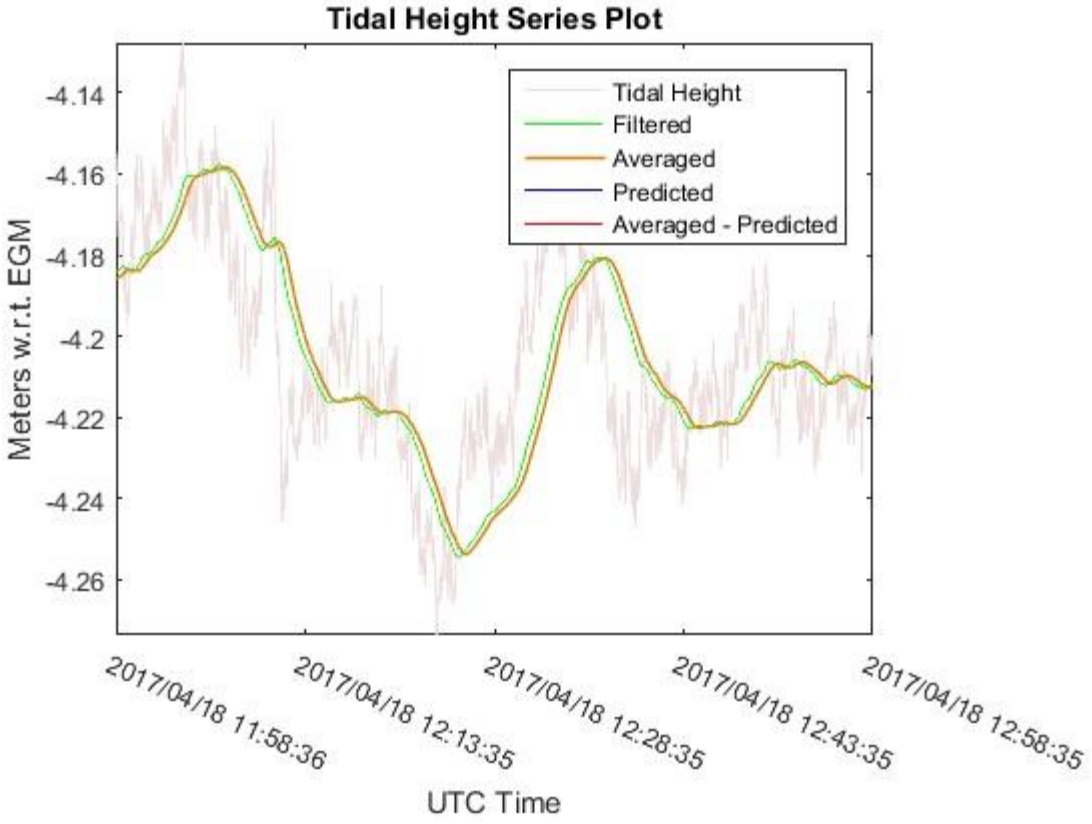

Figure 19: Missing Predicted Data

Tidal prediction data availability varies by the selected model. Each model of the C-Tides® application has a slightly different area:

- To use the MSS model, the vessel must be 10 kilometers from the nearest land mass.
- To use the EGM model, the vessel must be in water with a depth of at least 10 meters. It is preferable to have a depth of at least 25 meters.

Appendix E - Glossary

AOI (**A**rea **o**f **I**nterest) An AOI is a rectangle bounded by two latitudes and two longitudes and which covers the prospect (survey) and any port calls the vessel may make. If the C-Tides® Offline application is used for tidal predictions, the extracted AOI must cover location (latitude / longitude) for the prediction.

C-Nav5000 The C-Nav5000® GNSS receiver has expanded capabilities including RTK, 1PPS output, etc. The C-Nav5000® GNSS receiver includes dual frequency precision GNSS receiver, with two additional channels for receiving SBAS signals and an L-Band demodulator for reception of C-Nav™ subscription signals. For more information, go to oceaneering.com/cnav.

COG (**C**enter **O**f **G**ravity) The COG is the point at which the mass or weight of a vessel is evenly distributed. A low COG contributes to vessel stability. The COG is the point with the least heave on the vessel.

EGM (**E**arth **G**ravitational **M**odel) EGM is one of several geoidal models (e.g. EGM96, EGM08). The EGM models are a collaboration among the National Geospatial-intelligence Agency (NGA), the NASA Goddard Space Flight Center (GSFC), and Ohio State University. The C-Tides® software uses EGM08.

Geoid The geoid is that geopotential surface that on average approximates MSL. The geoid defines the horizontal. Due to the dynamics of ocean currents, MSL / MSS are not horizontal.

Geopotential The geopotential at a point is the acceleration of gravity at that point times the distance to the center of the Earth. At the surface of the Earth it is

	approximately 62 million meters squared per seconds squared, which is 62 million Joules / kilogram, or 62 million Geopotential Units (GPU).
Geopotential Surface	A geopotential surface is a surface around the Earth (like layers of an onion) in which the geopotential is constant. A satellite in space will orbit in a geopotential surface. Geopotential surfaces are neither parallel nor equally spaced. The vertical is everywhere perpendicular to the geopotential surface.
Height	Refers to the raw antenna height above (or below) the reference ellipsoid.
ISLW	(**I**ndian **S**pring **L**ow **W**ater) ISLW is a tidal datum originally used as a chart datum in Indian and later in Australia and elsewhere. It is lower than MSL by the sum of the amplitudes of the constituents M2, S2, K1 and O1.
LAT	(**L**owest **A**stronomic **T**ide) The lowest level of tide that can be predicted to occur over an 18.6 year period without regard to meteorological conditions. LAT is not utilized in the C-Tides® software with the exception of the parameter plot output where an approximation of its relationship to the chosen VRS is given. This approximation is derived empirically from VORF data, and is a good fit in that geographical area. Its accuracy in other parts of the world is unknown.
MSL	(**M**ean **S**ea **L**evel) MSL is a tidal datum that is the average of tidal heights observed at a tide gauge over an 18.6-year cycle during which the plane of the moon with respect to the Earth (Lunar Orbital Plane) rotates 360 degrees with respect to the plane of the Earth with respect to the sun (Ecliptic Plane), thus averaging out the effects of the sun and the moon.

MSS	(**M**ean **S**ea **S**urface) MSS is a model that combines satellite altimetry with tide gauges to extend MSL over the entire sea surface.
NRP	(**N**avigation **R**eference **P**oint) The NRP is any convenient point on the vessel from which to measure the dimension to other points of interest. It is recommended that the NRP be as close as possible to the COG.
SET	(**S**olid **E**arth **T**ides) The Earth's crust flexes during the day with solar and lunar gravity-induced tides, resulting in a distance variance from the earth's surface to its center by as much as 40cm in height. The C-Nav5000® receiver corrects for these variations by employing real-time integrated SET corrections in its CCS positioning algorithm.
VRS	(**V**ertical **R**eference **S**urface) The different types of VRS used in the C-Tides® software are EGM and MSS.

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