**COOPERATIVE RESEARCH CENTRE for SPATIAL INFORMATION – 2**

**UDEM 2 Project 3 Extension**

**AusCoast*VDT* software version 1.20, Grid version 3.0 User Manual version 1.3**

A Coarse Australian Coastal Vertical Datum Transformation Tool for Elevation Data

Software developed by SeaGIS

Documentation developed by CRCSI/FrontierSI

2016-2019

**Revision History**

|  |  |  |  |
| --- | --- | --- | --- |
| **Document Version** | **Date** | **Reviewer** | **Description of changes** |
| 1 | 05/06/2013 | Jessica Keysers | First Draft |
| 2 | 11/06/2013 | James Seager | Second Draft |
| 3 | 02/07/2013 | Jessica Keysers / Nathan Quadros | Third Draft - software updates including map interface, positive depth option, ignore points outside grid. |
| 4 | 19/07/2013 | Jessica Keysers | Fourth Draft – creation of stepped boundary polygon, change default behaviour to write points outside grid to file. |
| 5 | 25/07/2013 | Olivia Wilson /  Grant Hausler / Jessica Keysers | AusCoast*VDT* version 1.08 user manual |
| 6 | 06/08/2013 | Nathan Quadros | Approved for Publication |
| 7 | 16/10/2013 | Jessica Keysers | AusCoast*VDT* version 1.10 user manual  Add disclaimer, separate datums, time restrict grid, add towns to Coast Map. |
| 8 | 16/10/2013 | Nathan Quadros | Approved for Publication |
| 9 | 04/11/2016 | Jessica Keysers | AusCoast*VDT* version 1.20 user manual  Allow input of WGS84 coordinates, automatic recognition of latitude/longitude and easting/northing columns in text input files, add link to CRCSI website on About tab. |
| 10 | 22/10/2019 | Jessica Keysers | New raster data provided by the AHO used to generate the grid file plus handover of tool from FrontierSI to ICSM, hence updates to the documentation |

Table of Contents

[1. Introduction 4](#_Toc466022080)

[1.1 Software Purpose 4](#_Toc466022081)

[1.2 What AusCoast*VDT* does and does not do 4](#_Toc466022082)

[1.3 Licensing 4](#_Toc466022083)

[1.4 Assumptions, Requirements and Recommendations 5](#_Toc466022084)

[Assumptions & Requirements 5](#_Toc466022085)

[Recommendations 6](#_Toc466022086)

[1.5 Accuracy of AusCoast*VDT* 7](#_Toc466022087)

[2. Installing AusCoast*VDT* 8](#_Toc466022088)

[2.1 System Requirements 8](#_Toc466022089)

[2.2 Installation 8](#_Toc466022090)

[Updating the supplied grid file 8](#_Toc466022091)

[3. Using the Software 9](#_Toc466022092)

[3.1 Positive or Negative Depths 10](#_Toc466022093)

[3.2 File Transformation Tab 13](#_Toc466022094)

[3.3 Point Transformation Tab & Coast Map 16](#_Toc466022095)

[3.4 Grid File Tab 18](#_Toc466022096)

[3.5 About Tab 20](#_Toc466022097)

[4. Troubleshooting 21](#_Toc466022098)

[4.1 File Transformation Tab Error Messages 21](#_Toc466022099)

[4.2 Point Transformation Tab Error Messages 24](#_Toc466022100)

[4.3 Performance 24](#_Toc466022101)

[5. Future Work 25](#_Toc466022102)

[6. Acknowledgements 25](#_Toc466022103)

[7. Appendices 26](#_Toc466022104)

[7.1 Creation of the Supplied Vertical Separation Grid from the TPN 26](#_Toc466022105)

[7.2 Creation of the Supplied Vertical Separation Grid Extent Polygon 27](#_Toc466022106)

# Introduction

## Software Purpose

AusCoast*VDT* is an easy to use vertical datum transformation tool applicable to the Australian coast. The tool includes transformations between data referenced to the GRS80/WGS84 ellipsoid (in GDA94/WGS84 coordinates which are assumed to be equivalent) and other vertical datums of user interest (and vice versa). It facilitates the creation of seamless digital elevation models (DEMs) spanning the land‐sea interface which are required to study the impacts of sea level rise and coastal inundation, as well as many other applications.

At the time of development, there were a number of data limitations that prevented the implementation of a high accuracy coastal vertical datum transformation grid for Australia. Despite these limitations, a broad range of coastal applications are increasingly demanding seamless coastal elevation data. Hence the Intergovernmental Committee on Surveying and Mapping (ICSM) Permanent Committee on Tides and Mean Sea Level (PCTMSL) supported the development of a coarse vertical datum transformation grid using available data (an outcome from the 45th meeting of the PCTMSL held in Adelaide, October 2012). The resulting grid and AusCoast*VDT* tool initially provide national coverage at a coarse level (the supplied vertical separation grid has a cell size of 1 minute of arc or ~1.8km depending on latitude), and the grid can be improved in high priority areas, via focused efforts to collect additional data. A very conservative estimate of the accuracy of the tidal separations would be ±0.5m in the vertical and ±1km horizontally. There is currently no other known software package that performs vertical datum transformations for Australian coastal data.

## What AusCoast*VDT* does and does not do

AusCoast*VDT* **DOES** provide file-based (geographic or projected coordinates) vertical transformations via a vertical separation grid file or a block shift, and geographic point-based transformations (typed or map click) via a vertical separation grid file. A coarse vertical separation grid file with fifteen reference surfaces is provided with the tool, along with the capability for users to supply alternative vertical separation grids.

AusCoast*VDT* **does NOT** output horizontal transformations or conversions of input data or apply file format conversions for input files. Using the supplied vertical separation grid does not necessarily retain the height accuracy of input data as the grid is coarse, and only produces outputs to the nearest centimetre.

## Licensing

AusCoast*VDT* is licensed under the [Creative Commons Attribution-Share Alike](http://creativecommons.org/licenses/by-sa/3.0/au/deed.en_GB) CC BY-SA.  
This licence lets others distribute, remix and build upon the work, even for commercial purposes, as long as they credit the original creator/s (and any other nominated parties) and license any new creations based on the work under the same terms. All new derivative works will carry the same licence, so will also allow commercial use. In other words, you agree to share your materials with others, if they will share their new works in return. This licence is often compared to the free software licences, known as ‘copyleft.’

The Disclaimer of Warranty states thatAusCoast*VDT* is provided "as‐is" and without warranty of any kind, express, implied or otherwise, including without limitation, any warranty of merchantability or fitness for a particular purpose. In no event shall the CRC for Spatial Information (CRCSI)/FrontierSI, SeaGIS, the Australian Hydrographic Office (AHO), Geoscience Australia (GA), or the ICSM PCTMSL be held liable for data loss, damages, loss of profits or any other kind of loss while using or misusing this software.

## Assumptions, Requirements and Recommendations

### Assumptions & Requirements

1. The software assumes that the **vertical separations in the grid file** are the height *in metres* ABOVE (*positive value*) the ellipsoid. Hence if a datum sits *below* the ellipsoid the vertical separation value in the grid file will be *negative*. If using a custom grid file, it MUST comply with this requirement.
2. The software assumes that GDA94 and WGS84 ellipsoids and datums are equivalent. The ellipsoid differences are sub-mm, and the datum differences, which depend on the realisation of WGS84 in use (up to ~1.5m), can be disregarded as are significantly less than the resolution and accuracy of the vertical separation grid file. Therefore, the **horizontal coordinate system** of input data MUST be *southern hemisphere GDA94 or WGS84* (files and points) *or the relevant MGA or WGS84 UTM Zone (49-56)* (files only). If data does not comply with this requirement, the user is required to pre-transform their input data (using some other means) in order to use AusCoast*VDT*.
3. Input files MUST be in one of the following **file formats** to use AusCoast*VDT*:
   1. *ASCII*
      1. *XYZ*

No header, delimiter of space, tab or comma (if comma is used, it must immediately follow the data with no space - see Figure 1). Columns 1 and 2 must be latitude/longitude or easting/northing (the software will detect the order). Column 3 must be Z or height, and any additional data columns may follow.

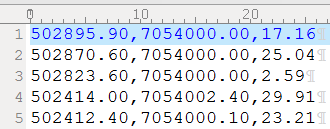


Figure 1. Sample projected dataset listing 5 points separated using a comma delimiter.

* + 1. *ESRI ASCII Raster* (asc)
    2. *Hydrographic Transfer Format* (HTF)
  1. *Common LiDAR Data Exchange Format* (LAS) all versions up to 1.4

1. The **vertical reference** of input files and points MUST be one of the following to use AusCoast*VDT*:
   1. *GRS80 ellipsoid* (GDA94) or WGS84 ellipsoid (WGS84)
   2. *Lowest Astronomical Tide* (LAT)
   3. *Mean Low Low Water* (MLLW)
   4. *Mean Low Water Springs* (MLWS)
   5. *Mean Low Water* (MLW)
   6. *Mean High Low Water* (MHLW)
   7. *Mean Low Water Neaps* (MLWN)
   8. *Australian Height Datum* (AHD)
   9. *Mean Sea Level* (MSL)
   10. *Mean Low High Water* (MLHW)
   11. *Mean High Water Neaps* (MHWN)
   12. *Mean High Water* (MHW)
   13. *Mean High High Water* (MHHW)
   14. *Mean High Water Springs* (MHWS)
   15. *Highest Astronomical Tide* (HAT)
2. The **applicable area** of the *supplied* vertical separation grid (shown in Figure 2) is from *approximately* *20km inland of the coastline to approximately the 500m bathymetric contour*. In some areas, mainly in Queensland, the inland extent is less than 20km based on the available tidal network data. It does not include offshore territories and islands. Hence if using the supplied vertical separation grid, AusCoast*VDT* will only function within the specified area. Data files that sit partly within and partly outside the grid area will be successfully processed however points outside the grid will be written to a separate, untransformed, output file. A zipped extent shapefile of the supplied grid is available as part of the installation and can be found in the installation directory (refer to *section 3.5*).

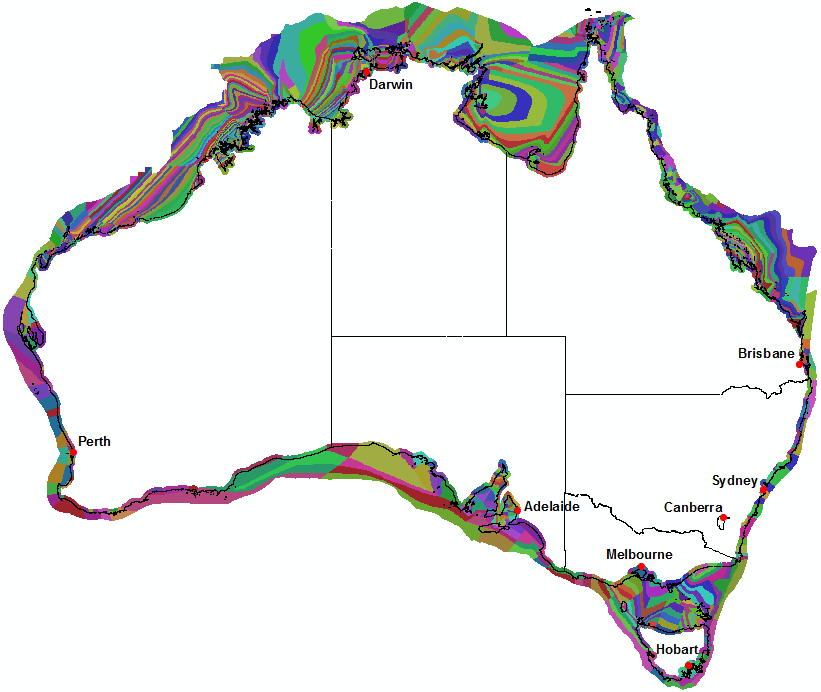


Figure 2. Applicable area of the supplied AusCoast*VDT* vertical separation grid, showing the tidal polygons.

### Recommendations

1. DO NOT use AusCoast*VDT* if your application requires high **accuracy** (better than about +/- 0.5m in the vertical). See *sections 1.5 & 7.1* for more information.
2. Ensure you are aware of the **sign of your data** i.e. whether *depths are negative* values (and hence heights positive) which is the standard for topographic applications, or whether *depths are positive* values (and hence heights negative) which is common for hydrographic applications. Please specify this correctly in the software otherwise incorrect results will occur.

## Accuracy of AusCoast*VDT*

It should be noted that the AHO and ICSM PCTMSL consider the supplied vertical separation grid (AusCoast*VDT*\_VerticalSeparation\_Grid\_*date*.VDTGrid) to be “experimental” and “unsupported” until further work can be done to help verify/improve the method of creation and further determine/improve the accuracy of the grid. The grid is intended as an *initial step towards* accurate coastal vertical datum transformation. It provides national coverage at a coarse level which will then enable improvement in high priority areas via focused efforts to collect additional data.

The binary vertical separation grid supplied with the tool was produced from the AHO’s Australian Charting Vertical Reference Framework (ACVRF) data using the process outlined in *section 7.1*.

There are a number of limitations to consider with regard to the accuracy of the grid and its transformations;

* The *method* used to create the grid was ***experimental***, based on incomplete data at the time of development, and is***unsupported*** by the AHO and ICSM PCTMSL.
* The grid provides *tidal datum separation values onshore* up to 20km inland even though ***tidal datums technically have no physical meaning onshore***. They do however become relevant for example if the land is inundated by floods or tides in the case of storm surge or extreme sea level rise events, or for the processing of LiDAR data to determine shorelines.
* The grid provides *AHD separation values offshore* to the 500m bathymetric contour even though ***AHD does not exist offshore***. The tool requires transformations be applicable offshore as well as on land, and therefore the extrapolation applied by AUSGeoid09 offshore is applied in this tool.
* The software **assumes GDA94 and WGS84 ellipsoids and datums are equivalent**. The ellipsoid differences are sub-mm, and the datum differences, which depend on the realisation of WGS84 in use (e.g. WGS84 (G730), WGS84(G1150)) can be up to ~1.5m. Given this is significantly less than the resolution and accuracy of the vertical separation grid file it can be disregarded.
* The grid considers *MSL and AHD as equivalent* (the ellipsoid separation values are the same), using AUSGeoid09 as a proxy for MSL which is ***not technically accurate***. There are distortions in the 1971 realisation of the AHD caused by holding 30 tide gauges fixed at zero MSL for 1966–68 around the Australian coast and then performing a national level adjustment based on those fixed points. Also, the levelling network in Tasmania was re-adjusted in 1983 based on mean sea level for 1972 (refer to the [Geoscience Australia website](http://www.ga.gov.au/earth-monitoring/geodesy/geodetic-datums/australian-height-datum-ahd.html)). AUSGeoid09 is hence a quasigeoid model containing a gravimetric component as well as a geometric component which accounts for the spatially varying offset between the gravimetric component and the AHD epoch. In addition, AUSGeoid09 was extrapolated offshore where AHD does not apply, and MSL has changed since 1966-68 (and 1972).
* The *precision*of the transformation results the tool provides are ***only to the*** ***nearest centimetre***, regardless of the input data precision.
* The spatial *resolution*of the supplied vertical separation grid file is ***only 1 minute of arc***or ~1.8km depending on latitude, which is not fine enough to represent all coastal features.
* The vertical and horizontal accuracy of the ACVRF data varies with the density of tide station information used. A *very conservative estimate of the accuracy*of the tidal separations would be ***+/‐ 0.5m in the vertical and +/‐ 1km horizontally***(this takes the worst positional accuracy of the tide gauge data used). MSL determined from tide gauge observations is accurate to a few centimetres at the tide gauge for observation periods of at least 1 year. Accurate MSL at a location is guaranteed for observations over a full nodal cycle (18.6 years).
* *AUSGeoid09*is accurate to ***0.06m @ 95% CI***across most of Australia for determining AHDheights from ellipsoid heights (not current MSL heights).
* The *ACVRF provided tidal datum heights relative to LAT*, in order to transform to LAT (and subsequently the other tidal datums) above the ellipsoid; AUSGeoid09 was used as a proxy for ellipsoidal mean sea level. Hence the **inaccuracies of using AUSGeoid09 as a proxy for MSL carry through to all tidal datums**.

# Installing AusCoast*VDT*

## System Requirements

AusCoast*VDT* is a standalone, downloadable *32 bit* application for *Windows XP and above*. It will also run on *64 bit* machines. Ensure you have the appropriate permissions to install software. A *minimum of 50 MB* of disk space is required, which includes the installation and storage of the supplied grid file. When transforming data files, additional disk space will be required. If running the software on a computer with limited memory and/or performance, the software will simply run slower.

## Installation

1. **Uninstall** any previous version of the software via Control Panel > Programs and Features
2. **Download/Request Access** to the AusCoast*VDT* installation package from the [ICSM PCTMSL](https://www.icsm.gov.au/what-we-do/permanent-committee-tides-and-mean-sea-level) website
3. **Run** the AusCoast*VDT* .msi file to install the tool. The AusCoast*VDT* setup wizard will guide you through the installation (The zipped shapefile grid extent is saved to the installation directory as part of the installation)
4. **Download/Request Access** to the current zipped grid file from the [ICSM PCTMSL](https://www.icsm.gov.au/what-we-do/permanent-committee-tides-and-mean-sea-level) website
5. **Unzip** and **Save** the grid file to the executable directory (i.e. the directory in which you have just chosen to install the software, where the AusCoastVDT.exe resides)

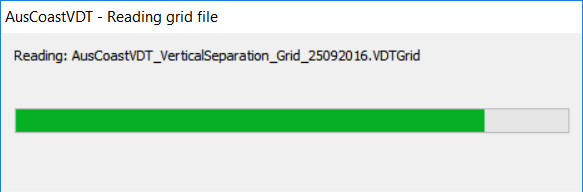
### Updating the supplied grid file

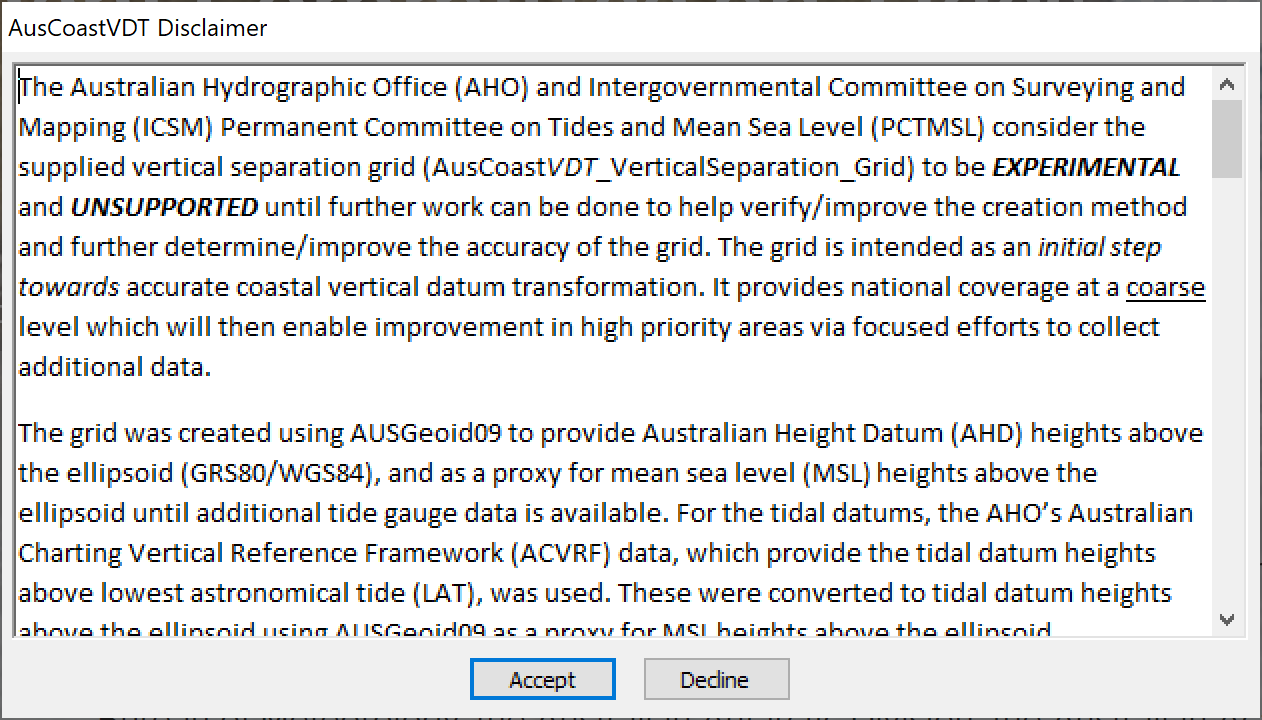
When warned by AusCoast*VDT* to update the grid file (refer to *section 3.4*);

1. **Check** that a new grid is available on the [ICSM PCTMSL](https://www.icsm.gov.au/what-we-do/permanent-committee-tides-and-mean-sea-level) website
2. **Delete** the outdated grid file from the executable directory
3. **Download/Request Access** to the current zipped version of the grid file from the [ICSM PCTMSL](https://www.icsm.gov.au/what-we-do/permanent-committee-tides-and-mean-sea-level) website
4. **Unzip** and **Save** the new grid file to the executable directory (replacing the deleted grid)
5. **Run** the software. It will first try to load the previously used grid file, but if there is no previously used grid file (e.g. as it was deleted), it will try to load a grid file in the same directory as the executable (i.e. the new grid if saved correctly to the executable directory where the AusCoastVDT.exe resides)

# Using the Software

To **run** the software, *double click* the AusCoast*VDT* icon or run from the *Start Menu*. If there is a grid in the executable directory or the previously used grid exists, the message “Reading Grid File” will appear with a progress bar. Once the grid file has loaded, an *AusCoastVDT Disclaimer* window will appear (it may be hidden behind other open windows). You MUST **Accept** the disclaimer which includes the limitations of the supplied grid and software license, before you can access the tool. If you **Decline**, the software will close.





If the previous grid file can’t be found, the message “Cannot open grid file” will appear. Click **OK**, then **Accept** the disclaimer, and go to the *Grid file* tab to load a grid (refer to section 3.4).

D:\CRCSI_Dropbox\Dropbox\Coastal and Business Projects\Projects\04_2013_AusCoastVDT\Docs\images\cantopengrid.tif

After the disclaimer is accepted, the user interface will appear. The user interface has a *global positive/negative depth setting*, plus four tabs; *File Transformation*, *Point Transformation* (and *Coast Map* window), *Grid File*, and *About*. These are explained in the following sections.

## Positive or Negative Depths



Above the tabs, the tool asks the user to specify whether the depths of their data are *negative or positive* **Relative to the vertical reference** of their data. The standard in topographic surveying is to use negative values for depths (and hence positive values for heights), while the standard for hydrographic surveying is to use positive values for depths (and hence negative values for heights) – see Figure 3. It is recognised that there may be low points on land that are below the reference surface (e.g. AHD). Using the topographic surveying standard of negative values for depths, such points may usually be considered ‘negative heights’ as they are actually on land, however within the AusCoast*VDT* terminology they are referred to as depths.

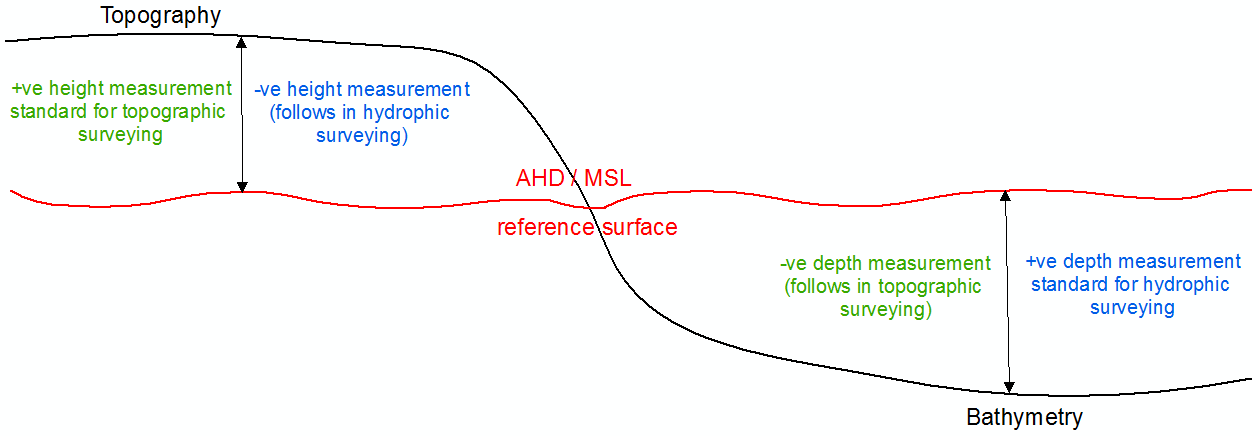


Figure 3. The use of positive and negative depth measurements.

Selecting **Depths negative/Heights positive** implies that you are most likely dealing with topographic data*.* Selecting **Depths positive/Heights negative** implies you are most likely dealing with hydrographic data. Depths negative/Heights positive is the *default*. This is a *global* setting that applies to file, block shift and point transformation and needs to be set correctly otherwise incorrect results will occur. Following are some examples of the way the software operates with positive and negative depths/heights.

If e.g. **Depths negative/Heights positive** is selected, input data is referenced to MSL, and the user wishes to output data referenced to LAT, AusCoast*VDT* performs the following two transformations;

1. Input MSL height/depth **+** grid separation MSL to Ellipsoid = Ellipsoid height/depth
2. Ellipsoid height/depth **–** grid separation LAT to Ellipsoid = Output LAT height/depth

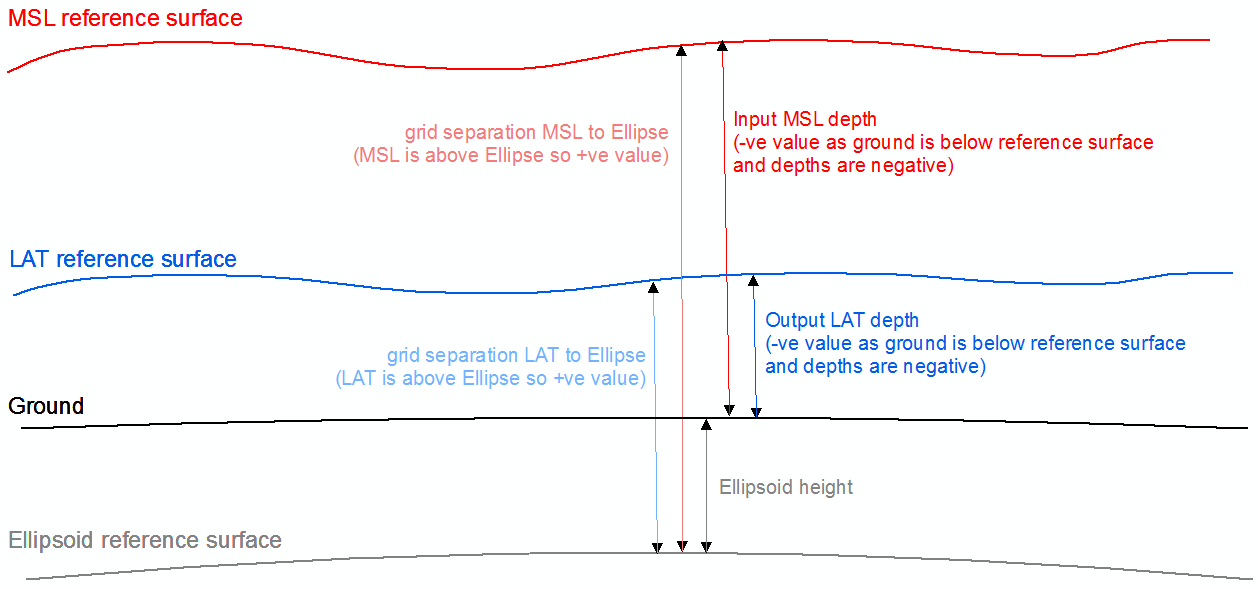


Figure 4. Depths are negative and ground is below reference surface.

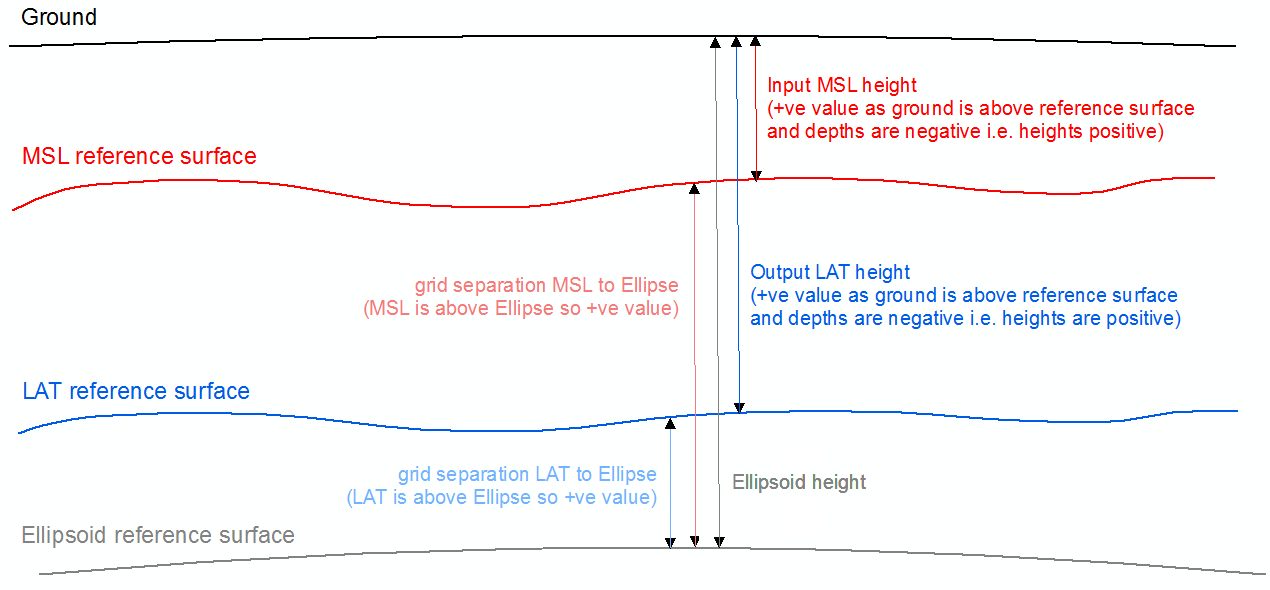


Figure 5. Depths are negative and ground is above reference surface.

If e.g. **Depths negative/Heights positive** is selected and a *block shift* is used instead of a grid transformation, AusCoast*VDT* does either of the following depending whether the block shift value entered is positive or negative;

1. Input height/depth **+** block shift

*or*

1. Input height/depth **+** (- block shift)

 If e.g. **Depths positive/Heights negative** is selected, input data is referenced to MSL, and the user wishes to output data referenced to LAT, AusCoast*VDT* performs the following two transformations;

1. Input MSL height/depth **–** grid separation MSL to Ellipsoid = Ellipsoid height/depth
2. Ellipsoid height/depth **+** grid separation LAT to Ellipsoid = Output LAT height/depth

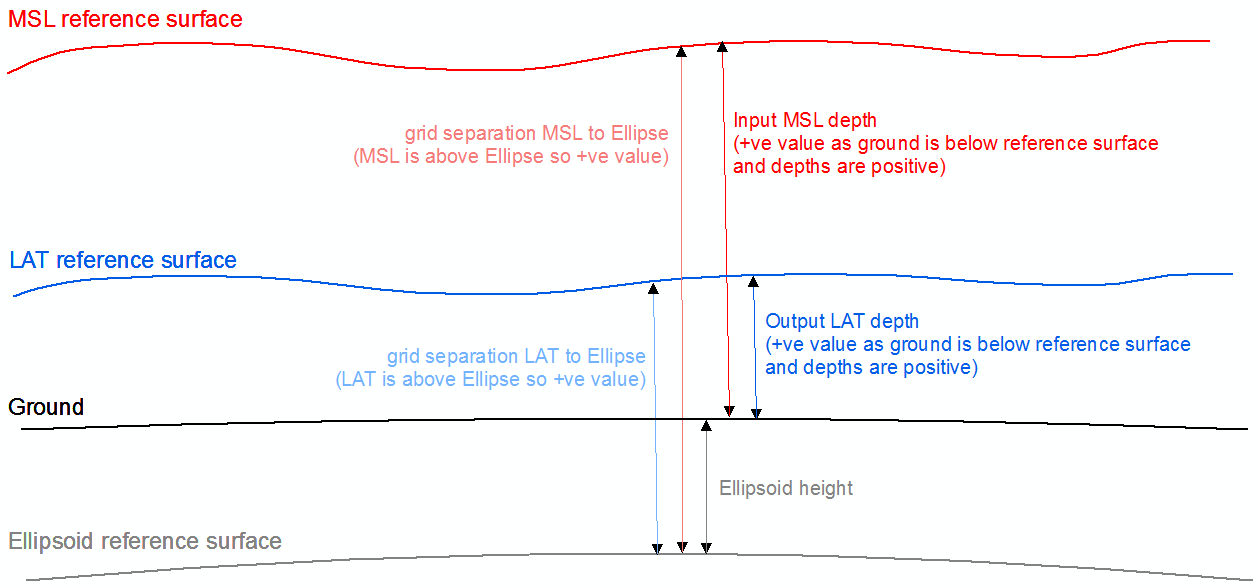


Figure 6. Depths are positive and ground is below reference surface.

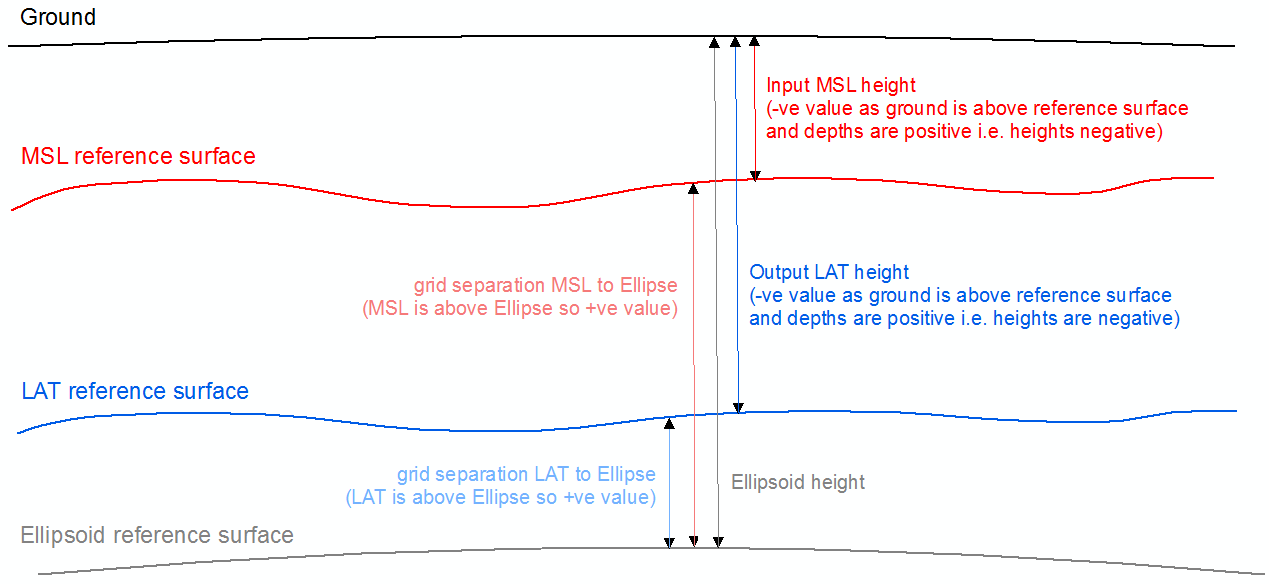


Figure 7. Depths are positive and ground is above reference surface.

If e.g. **Depths positive/Heights negative** is selected and a *block shift* is used instead of a grid transformation, AusCoast*VDT* does either of the following depending whether the block shift value entered is positive or negative;

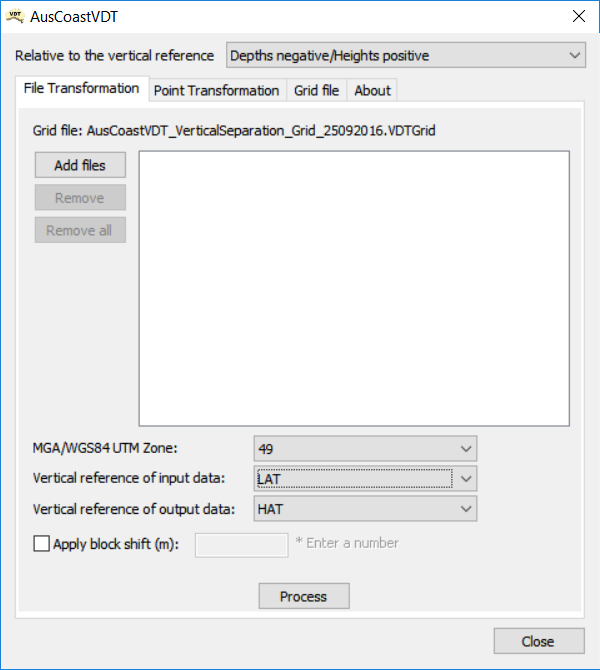
1. Input height **–** block shift

*or*

1. Input height **–** (- block shift)

## File Transformation Tab

This part of the tool is for the transformation of elevation *data files* of the appropriate format (refer to *section 1.3*).



At the top of the *File Transformation* tab, the tool **states the grid file in use**. It *defaults to the last grid used*.To change the grid file, use the *Grid File* tab; refer to *section 3.4*.

To transform files, *click* **Add files** and navigate to and open the files you wish to transform. The tool accepts *single or multiple files* which may be of the *same or multiple formats* (as specified in *section 1.3*), from *single or multiple directory locations*, and can be of *different horizontal coordinate systems*. However, if one of the horizontal systems is grid coordinates, input files MUST be in the same MGA/UTM zone except if **HTF** format (HTF format input files may be of different MGA/UTM zones as the zone is read from the file itself).Input files MUST be of the *same vertical reference system*.

If a file is added in error, it can be removed by highlighting it in the list and *clicking* **Remove**. Alternatively, the user can *click* **Remove all** files from the transformation list.

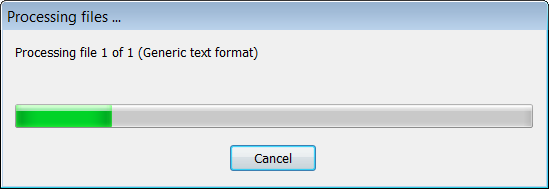
Once the files to be transformed have been added to the list, *if the data is in grid coordinates*, the user MUST specify the **MGA/WGS84 UTM Zone** using the *drop down list*. If the files are in geographic coordinates the zone selected is *ignored*. The tool *automatically detects* whether the horizontal coordinates of input files are geographic or grid, so the MGA/UTM zone will NOT affect results if input is in geographic coordinates. Also, if input data is in the **HTF** format, the MGA/UTM zone specified *within the file* will be used in preference to the one specified by the user. As HTF has provision for either/or both geographic and grid coordinates, if there are geographic coordinates present, the software uses those in preference to avoid the need for grid to geographic conversion.

Next the user MUST select the **Vertical reference of input data** using the *drop down list*. For each transformation, all input files MUST be referenced to the *same vertical reference system*.

The user MUST also select the **Vertical reference of output data** (i.e. the vertical reference surface they wish to transform data to) using the *drop down list*. This MUST be *different* to the input vertical reference. Although the same vertical reference surface can be selected, for input and output, when the user clicks *Process* the software will give an error message and will NOT proceed if they are the same.

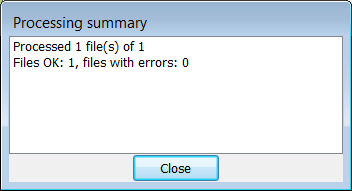
If you do not wish to use a vertical separation grid to apply the transformation, you can instead *tick* **Apply block shift (m)**. If the block shift option is ticked, the vertical references of input and output data are *disabled*. *Type a value in metres* to apply to input data as a block shift (refer to *section 3.1 to see* how the value is applied). The block shift value can be negative. It will be rounded to the *nearest centimetre*.

*Click* the **Process** button to transform data using the parameters specified. If an error message appears, adjust your parameters as required (refer to *section 4.1*). If parameters are acceptable, a progress indicator will appear which shows a *count of files* being transformed (i.e. ‘Processing file 3 of 7’), while the progress bar shows the progress through the *current* file.



During the **transformation** process, the interpolation method used is *bilinear*, and *Redfearn’s equations* are used for conversion from geographic to grid coordinates where required.

When the transformations are complete, a **Processing summary** will appear, indicating the *number of processed files* (i.e. ‘Processed 5 file(s) of 5’) and whether there were any *errors* (i.e. ‘Files OK: 5, files with errors: 0’). This is also output as a log file (“log.txt”) which is automatically written to the same directory as the *last file processed*. The log file will be *overwritten* every time a new file is processed in the same directory as an existing log file. To retain the log file, rename it before running the tool again for files in that directory.



**Note.** Each file is processed point by point. Points thatfall **outside the vertical separation grid extent** will be written to a *separate*, *untransformed* output. A *transformed* *file will also be output* and will contain the transformed values of processed points that were **inside** the grid extent. The processing summary and log file will contain a count of the points that fell outside the grid extent. The transformation of any other input files will *proceed* as normal.

**Output files** are saved in the *same location as each original input file*, with the same input format and horizontal coordinates. The transformed heights are output to the *nearest centimetre*. The output file name is the *same as the original file name with the addition of an underscore and the vertical reference* at the end if a grid file was used. E.g. if transforming a file ‘xxx.las’ from AHD to MHW, for transformed points *inside* the grid extent the output name would be “xxx\_MHW.las”, and for untransformed points *outside* the grid extent the output name would be “xxx\_AHD.las”. If a block shift was used an un*derscore and the block shift in metres* are attached to the end of the file name e.g. “xxx\_BlockShift\_4m.las”.

**Note.** The **HTF format** allows data lines that do NOT have X and/or Y and/or Z coordinates (according to the format specification the number can just be replaced with a ‘\*’).  If the software comes across an instance of an incomplete coordinate it *does not transform the line*, it just *writes it directly* to the untransformed (outside the grid extent) output file and processing proceeds. The **HTF format** also allows data lines that are marked as a rejected sounding. Such lines are *copied* into only the *untransformed* (outside the grid extent) output file. Within the sounding section of a **HTF file** there can be comment lines that start with a ‘;’.  If a comment line is encountered it is *copied* into *both the transformed* (inside the grid extent) and *untransformed* (outside the grid extent) files.

A **usage log file** (“Application Log.txt”) will be output to the executable directory of the software when file transformation is performed. One line will be written to this text file for each single/batch file transformation. If the file already exists, a new line will be appended to the file for each subsequent single/batch file transformation. The file size is capped and will be reset at 10MB so as not to slow down your system. The ICSM PCTMSL may contact you to request the log file in order to use the usage statistics in reporting, with your consent.

The data recorded in the log file is;

* Date and time of transformation <tab>
* Input datum <tab>
* Output datum <tab>
* Formats (comma separated list) <tab>
* Total points transformed <tab>
* Grid file name <tab>
* Depths positive/negative (depths –ve = 1, depths +ve = –1)

For example;

09/10/2013 20:49 NULL Block Shift HTF 10 AusCoastVDT\_VerticalSeparation\_Grid\_25092013.VDTGrid 1

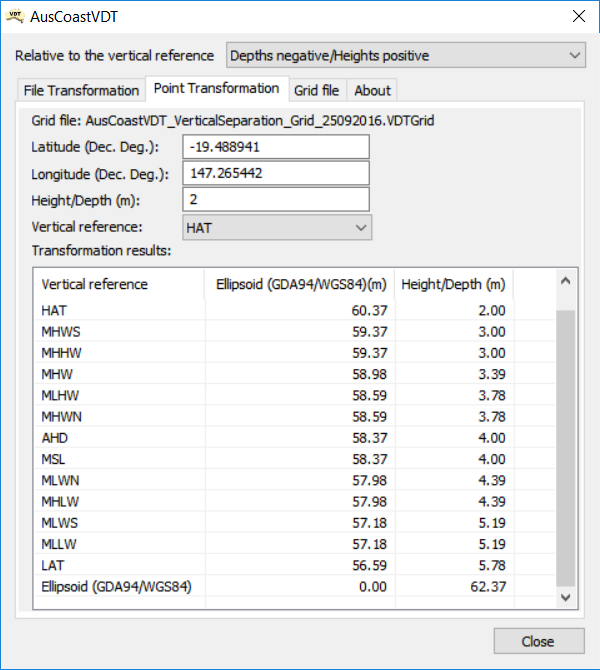
13/10/2013 18:08 NULL Block Shift ESRI ASCII Grid, Generic text, HTF, LAS 4504438 AusCoastVDT\_VerticalSeparation\_Grid\_25092013.VDTGrid 1

13/10/2013 18:11 MHWN Ellipsoid (GDA94) Generic text 2724711 AusCoastVDT\_VerticalSeparation\_Grid\_25092013.VDTGrid 1

13/10/2013 18:15 MHWN Ellipsoid (GDA94) LAS 61 AusCoastVDT\_VerticalSeparation\_Grid\_25092013.VDTGrid -1

## Point Transformation Tab & Coast Map

This part of the tool is for the transformation of *single point* elevation data.

 D:\CRCSI_Dropbox\Dropbox\Coastal and Business Projects\Projects\04_2013_AusCoastVDT\Docs\images\CoastMap.tif

When the *Point Transformation* tab is selected, the *Coast Map* automatically appears. At the top of the *Point Transformation* tab, the tool **states the grid file in use**. It *defaults to the last grid used*. To change the grid file, use the *Grid File* tab (refer to *section 3.4*).

The tool can transform *point heights in geographic coordinates* within the grid file extent. Using the *Point Transformation* tab *type* the **Latitude** (remember the negative for the southern hemisphere) and **Longitude** of the point to be transformed in *decimal degrees*. *Type* the **Height/Depth** in *metres* of the point to be transformed and select its **Vertical reference** using the *drop down list*. When a latitude and longitude are typed into the *Point Transformation* tab, the point is drawn on the **Coast Map** as a green dot if it is inside the transformation grid or as a red dot if it is outside the grid. The map will pan to display the point if necessary.

Alternatively, use the **Coast Map** to specify the point to transform. Towns are displayed on the Coast Map to assist with location. *Double right click* on the map and the latitude and longitude of the mouse position are copied into the *Point Transformation* tab. If a green dot appears at the point clicked, it is inside the transformation grid; otherwise if a red dot appears the point is outside the grid and will not be transformed. The transformation of a point clicked on the map uses the **Height/Depth** and **Vertical reference** specified on the *Point Transformation* tab. A height MUST be entered to enable double right click on the map.

As the values are typed/edited or added via map click, the tool automatically generates the **Transformation results** (if the point is inside the grid). These are displayed as a tabular diagram including the columns;

* **Vertical reference** surface which each separation value is relative to. The vertical reference surfaces are always *displayed in height order*. The tidal datums stay in their order (the diurnal and semidiurnal pairs may switch), while the ellipsoid moves up or down depending on location. The order *reverses* to indicate *depths are positive*.
* **Ellipsoid (GDA94/WGS84)(m)** which is the vertical separation in metres between the GRS80 ellipsoid (GDA94)/WGS84 ellipsoid (WGS84) and each *vertical reference* surface at the point entered. Hence for the ‘Ellipsoid (GDA94/WGS84)’ vertical reference, the separation is always zero. A negative value indicates the ellipsoid surface is *above* the datum in question.
* **Height/Depth (m)** which is the height/depth in metres of the point entered above/below (depending on the user’s depth setting) each *vertical reference* surface.
  + If *Depths negative/Heights positive*, a negative depth result indicates the point entered is *below* the vertical reference surface in question. If *Depths negative/Heights positive*, a positive height result indicates the point entered is *above* the vertical reference surface in question.
  + If *Depths positive/Heights negative*, a positive depth result indicates the point entered is *below* the vertical reference surface in question. If *Depths positive/Heights negative*, a negative height result indicates the point entered is *above* the vertical reference surface in question.
  + If an *alternate* grid to the one *supplied* with the tool is being used (i.e. a grid that does not provide all fifteen surfaces), the transformation results for the unknown surfaces will be zeros (mimicking the ellipsoid-ellipsoid separation).

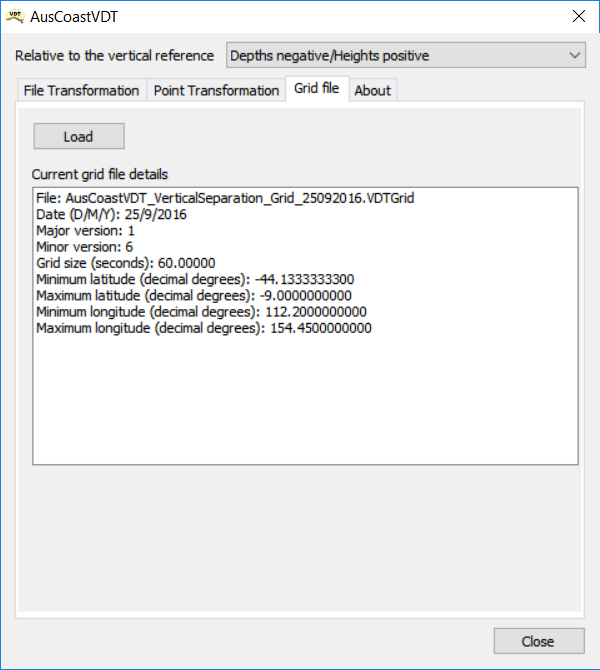
The **Coast Map** opens automatically when the user selects the *Point Transformation* tab. There will be a slight delay the first time this tab is opened as the coast and town data is loaded. The map can be re-sized and the main window and map window positioned to suit.  The size and position of the tab and map windows are remembered. If the map does not display, it means the coast or town data file cannot be found however the point transformation tab will work as usual. To solve this issue, re-download and re-install the software. The following allow navigation in the Coast Map;

* To **transform a point** *double right click* on the map and the latitude and longitude of the mouse position are copied into the *Point Transformation* tab (a Height/Depth must already be entered).
* Zoom in out with the *mouse wheel*, or use the **Zoom In**, **Zoom Out** buttons.
* The **Fit** button fits the map view to the extent of the grid.
* To **pan**, *left click and drag*.
* The **Lat, Lon** (latitude and longitude) of the current mouse position are displayed in decimal degrees.
* The **X Span** is the distance across the map in kilometres, in the middle of the current map view.  This value depends on the current zoom and on latitude. It provides an indication of scale.
* An inside/outside grid message with a green or red box is provided for the *current mouse position*.

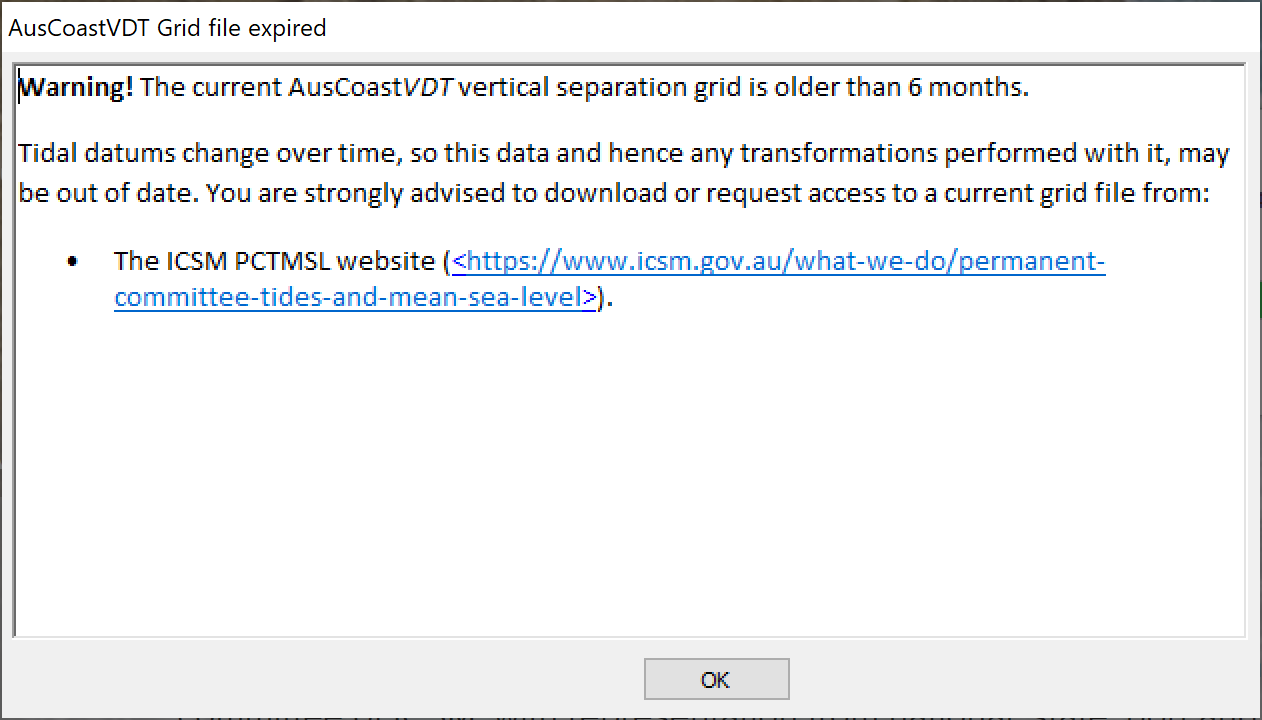
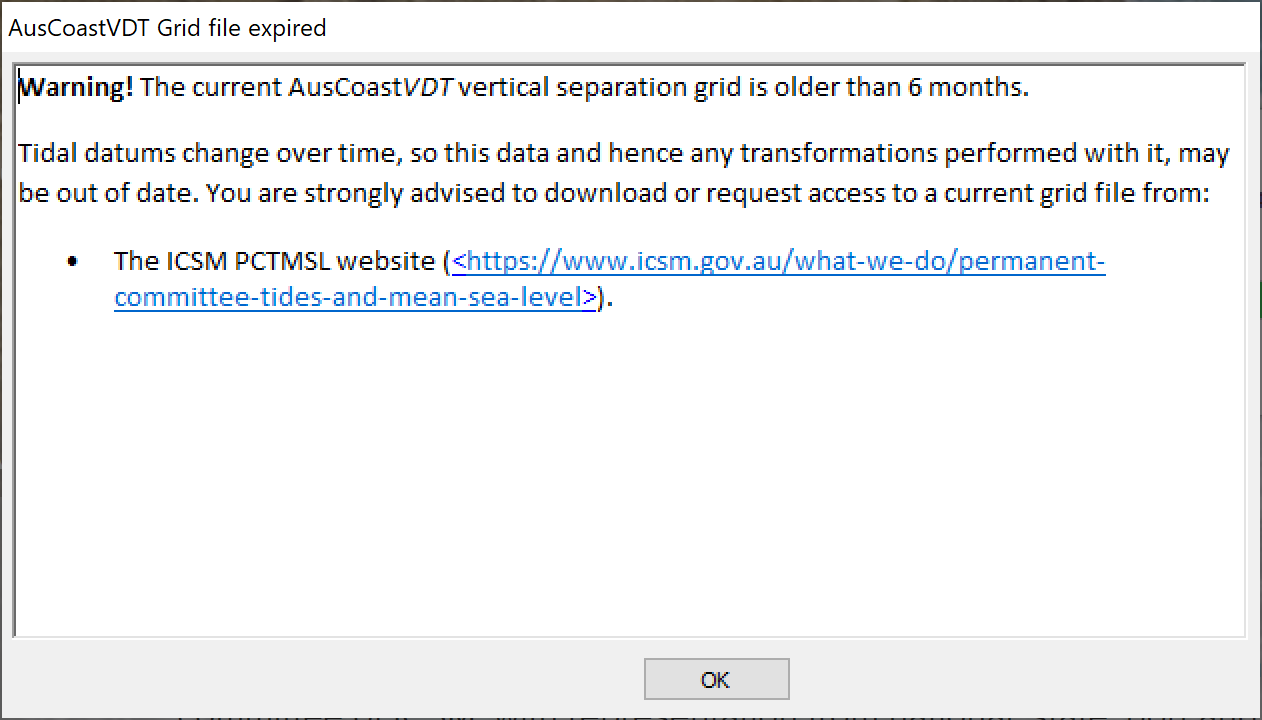
**Note.** If a point location *outside the grid file extent* is entered, the transformation results will be *empty* and a note will appear above the transformation results - “\*The requested position is not within the current grid” (refer to *section 4.2*).

## Grid File Tab

This part of the tool is for *viewing grid file information* and/or *loading a new grid file*.



The *Grid File* tab provides the **Current grid file details** including the *file name*, the *date the binary grid file was created*, *version information* for the grid (specified at creation), the grid *cell size*, and the *extent* of the grid file. Alternatively, it states “No grid file loaded”. This information should help manage grid versions including the addition of local area, fine resolution grids. To ensure the most current data is in use, each grid will ‘expire’ six months from the date of creation. The software will warn the user that the grid should be updated when it reaches 6 months old. A new version of the supplied grid will be available from the [ICSM PCTMSL](https://www.icsm.gov.au/what-we-do/permanent-committee-tides-and-mean-sea-level) website. If you are part way through a project when the expiry date is approaching and need to keep using the same grid file for consistency, you may. The warning can be ignored.



When the tool starts, it *loads the previously used grid file*. Ifthere was no previously used grid file (e.g. after installation), it will try to load a grid file that exists in the *same directory as the executable* e.g. the suppliedvertical separation grid file that you have downloaded and saved. The tool also provides the option to **Load** any alternative grid that may be available, for example a local area, finer resolution grid.

The vertical separation **grid file provided** with AusCoast*VDT* *(AusCoastVDT\_VerticalSeparation\_Grid\_25092016.VDTGrid* - note the date may change) is a *binary* format grid in *GDA94 geographic coordinates*. This grid should be saved in the installation directory of the software. A zipped shapefile of the grid extent also exists in the installation directory as part of the installation. The grid covers an area from less than or equal to 20km inland of the coastline (defined by GA’s GEODATA Coast 100km 2004 data), to approximately the 500m bathymetric contour (defined by the ACVRF data). It has fourteen datums whose heights are referenced to the GRS80/WGS84 ellipsoid, hence the tool transforms input data in either direction between these fourteen separation surfaces (fifteen including the ellipsoid);

|  |  |
| --- | --- |
| * LAT * MLLW * MLWS * MLW * MHLW * MLWN * AHD | * MSL * MLHW * MHWN * MHW * MHHW * MHWS * HAT |

AHD and MSL values are the same in the supplied grid as explained in section 1.5. To **create a new** binary vertical separation **grid** file from a text file in the appropriate format (see *section* 7.1, step *6* for the required text format), download/request access to the instructions from the [ICSM PCTMSL](https://www.icsm.gov.au/what-we-do/permanent-committee-tides-and-mean-sea-level) website.

## About Tab

This part of the tool is for *viewing version information, finding help,* and/or *sending feedback or making an enquiry* about AusCoast*VDT*.



The *About* tab provides **information** about the AusCoast*VDT* *version,* *date of creation* and *developers*, as well as *how to get help*. *Click* the **Help** button to access this user manual.

If you have feedback or questions regarding AusCoast*VDT* please use the **Send feedback/question email** button (if you use an email client) or contact the AHO at [hydro.rac@defence.gov.au](mailto:hydro.rac@defence.gov.au) or the ICSM PCTMSL at [icsm@ga.gov.au](mailto:icsm@ga.gov.au) (please do not use the CRCSI contact email address as it is no longer monitored). The AHO are best placed to answer questions regarding the tidal datums and tidal data used to create the vertical separation grid, while the ICSM are best placed to answer questions regarding the software.

If you wish to download the current grid file or create a new binary vertical separationgrid file from a text file in the appropriate format, click **Download or create a grid file** to be taken to the ICSM PCTMSL website.

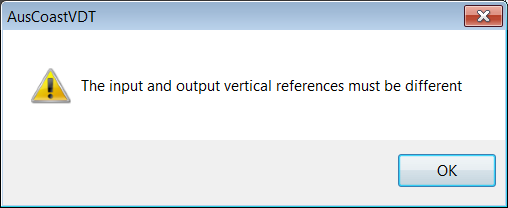
To view the polygon extent of the *supplied* grid click **Link to supplied grid extent shapefile**. This will take you to a folder in the installation directory containing a zip folder of the shapefile. Unzip the file and load it into appropriate (GIS) software to view the extent of the supplied grid.

# Troubleshooting

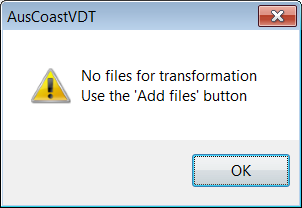
## File Transformation Tab Error Messages

When **Process** is clicked but before processing can begin the following *warnings may* appear;

* “The input and output vertical references must be different”
  + *Click* **OK** and ensure the input and output vertical references selected are correct – they MUST be different for transformation to occur.

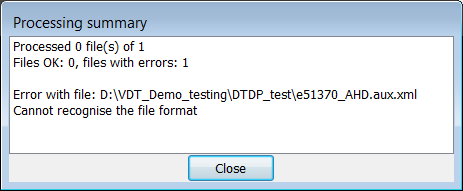


* “No files for transformation. Use the ‘Add files’ button”
  + *Click* **OK** and *click* **Add files** to add some data for transformation.

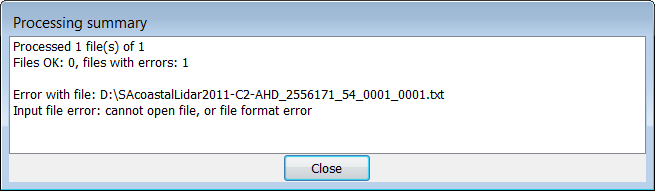


After **Processing files ...** the following *error messages may* appear in the **Processing summary / Log file**;

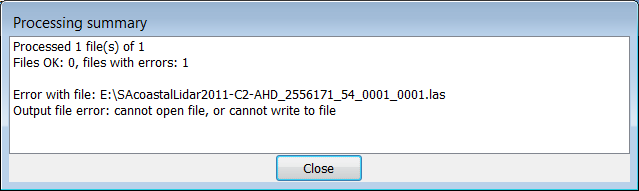
* " Error with file: ......... Cannot recognise the file format"
  + Note the name of the file/s with the error. *Click* **Close** to return to the tool interface. Any other input files not referred to in the error message will have processed successfully. This error occurs if the tool cannot recognise the input file format. This may occur for example if the user chooses ‘All Files’ when adding data and inputs a non-recognised format, or if an ASCII XYZ file is added that contains less than the required three fields or does not have valid coordinate values.



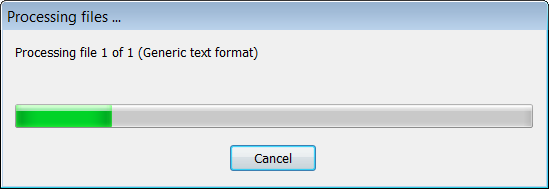
* "Error with file: ......... Input file error: cannot open file, or file format error"
  + Note the name of the file/s with the error. *Click* **Close** to return to the tool interface. Any other input files not referred to in the error message will have processed successfully. This error occurs if there is a problem reading the data for example if the file is corrupt, or there is a corrupt line of data. There will still be an output for the failed file/s however it will only contain transformed values for any points successfully processed BEFORE the first erroneous point was reached.

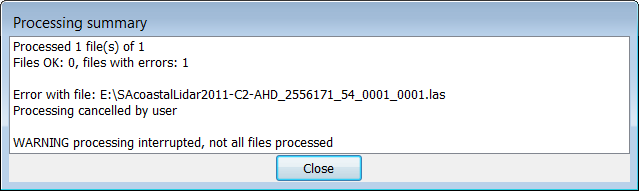


* "Error with file: ......... Output file error: cannot open file, or cannot write to file"
  + Note the name of the file/s with the error. *Click* **Close** to return to the tool interface. Any other input files not referred to in the error message will have processed successfully. This error occurs if there is a problem producing the output at the input location for example if the location is read only or there is not enough disk space to write to.

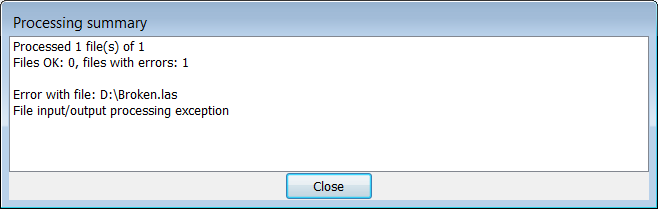


* "Error with file: ......... Processing cancelled by user" / "WARNING processing interrupted, not all files processed"
  + Note the name of the file with the error. *Click* **Close** to return to the tool interface. Any other input files above this item in the input list will have processed successfully. Files below this item in the input list will not have processed. This error occurs if the user *clicks* the **Cancel** button on the **Processing files ...** dialog.There will still be an output for the failed file however it will only contain transformed values for any points successfully processed BEFORE the cancel button was clicked.

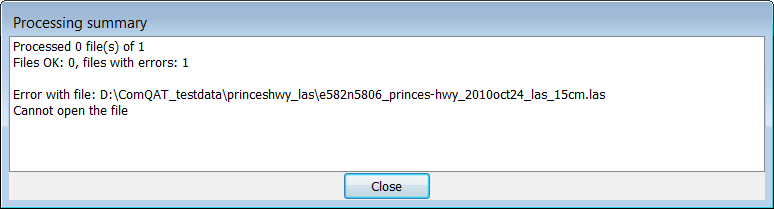




* "Error with file: ......... File input/output processing exception"
  + Note the name of the file/s with the error. *Click* **Close** to return to the tool interface. Any other input files not referred to in the error message will have processed successfully. This error occurs if there is an input/output file error with a LAS format file.



* "Error with file: ......... Cannot open the file"
  + Note the name of the file/s with the error. *Click* **Close** to return to the tool interface. Any other input files not referred to in the error message will have processed successfully. This error occurs if the file is open in another program.



If performing a block shift and no value is **typed for Apply block shift**;

* “\* Enter a number”
  + *Type* a valid value in metres for the block shift. The block shift value can be negative. It will be rounded to the *nearest centimetre*.

## Point Transformation Tab Error Messages

If a **location outside the grid file** extent is typed or clicked, the transformation results table will be empty and a message will appear just above the table informing the user that;

* “\*The requested position is not within the current grid”
  + *Type or click* a latitude and longitude within the area of the current grid file.

A value outside the appropriate range or containing an invalid character is **typed for Latitude**;

* “\* Range [-90 .. 90]”
  + *Type* a valid value for Latitude that is within the above range.

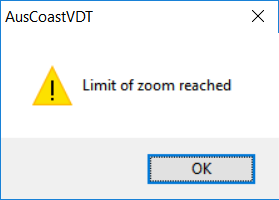
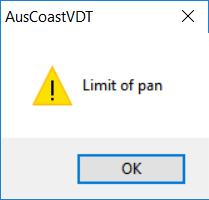
A value outside the appropriate range or containing an invalid character is **typed for Longitude**;

* “\* Range [-180 .. 180]”
  + *Type* a valid value for Longitude that is within the above range.

No value is **typed for Height/Depth**;

* “\* Enter a number”
  + *Type* a valid value for Height/Depth (m).

The **zoom or pan limits** of the Coast Map have been reached;

* + *Click OK* and zoom or pan back within the limits of the map.

## Performance

The performance of the software will depend on:

* Size of the vertical separation grid file in use (i.e. the number of grid nodes)
* Specifications of the host computer (i.e. disk and processor speed, memory)
* Type of input/output (i.e. text or binary – text formats are considerably slower)
* Amount of data in the input file; that is the amount of extra data besides the minimum X, Y, Z that must be read and written (i.e. HTF files can have a lot of additional data and metadata)

# Future Work

Further testing should be done to help verify/improve the method of creation of the vertical separation grid, and to further determine/improve its vertical accuracy.Future work will also include identification (by the ICSM PCTMSL and users of the tool) of high priority areas to target for future upgrade. Additional data collection will be required in high priority areas, which will allow upgrade via the approach outlined in the previous [‘Vertical Datum Transformations across the Littoral Zone’ report](http://www.crcsi.com.au/assets/Uploads/Files/Vertical-Datum-Transformations-Across-the-Littoral-Zone-v1-3.pdf). Additional smaller area, finer resolution vertical separation grids can be created and added to the ICSM PCTMSL website to download separately to the tool. The interface provides the option to change the grid to any other available grid. The tool could also be expanded to cover offshore islands if adequate data to produce the vertical separation grid becomes available.

# Acknowledgements

* Jim Seager of SeaGIS for the programming and technical software development of AusCoast*VDT.*
* Jessica Keysers and Nathan Quadros of the Cooperative Research Centre for Spatial Information (CRCSI)/FrontierSI for development of the functional requirements, creation of the supplied vertical separation grid, management of the software development, and documentation.
* Zarina Jayaswal of the Australian Hydrographic Office (AHO) for supplying the data required to build the vertical separation grid, liaising with the ICSM PCTMSL, and providing advice. As well as taking over production of the grid from FrontierSI towards the end of 2019.
* The Intergovernmental Committee on Surveying and Mapping (ICSM) Permanent Committee on Tides and Mean Sea Level (PCTMSL) for supporting the development and providing advice, and Lesley Waterhouse for organising upload of the tool and grids to the PCTMSL website. As well as taking over management of the software from FrontierSI towards the end of 2019.
* The Australian Government Department of the Environment (DoE) for funding the project.

# Appendices

## Creation of the Supplied Vertical Separation Grid from the ACVRF (using ArcMap)

1. Australian Charting Vertical Reference Framework (ACVRF) data received as ESRI Grid rasters from the AHO, trimmed to cover the same area published in previous grid versions (to minimise the size of the vertical separation grid for performance, the published AusCoastVDT area shapefile was used to cover coastal areas to 20km inland). Tidal values are relative to LAT.
2. AUSGeoid09
   1. *Select by Location* AUSGeoid09 points from GAs 1min grid which intersect the AusCoastVDT area shapefile
   2. Export to a new point dataset
   3. Create and calculate fields for latitude and longitude
   4. Removed all irrelevant AUSGeoid09 attributes
3. *Extract Multi Values to Points* using the AUSGeoid09 data (from step 2) as input points and all tide rasters as input rasters
4. *Export* the AUSGeoid09 attribute table with tide attributes (from step 3) to .dbf and open in Excel
5. For separation values relative to the ellipsoid as opposed to LAT, perform calculations as follows;
   1. AHDGRS80/WGS84 = AUSGeoid09

These values are the same in the current TPN and hence supplied grid

* 1. MSLGRS80/WGS84 = AUSGeoid09 = LATGRS80 + MSLLAT
  2. LATGRS80/WGS84 = AUSGeoid09 - MSLLAT
  3. MLLWGRS80/WGS84 = LATGRS80 + MLLWLAT
  4. MLWSGRS80/WGS84 = LATGRS80 + MLWSLAT
  5. MLWGRS80/WGS84 = LATGRS80/WGS84 + MLWLAT
  6. MHLWGRS80/WGS84 = LATGRS80/WGS84 + MHLWLAT
  7. MLWNGRS80/WGS84 = LATGRS80/WGS84 + MLWNLAT
  8. MLHWGRS80/WGS84 = LATGRS80/WGS84 + MLHWLAT
  9. MHWNGRS80/WGS84 = LATGRS80/WGS84 + MHWNLAT
  10. MHWGRS80/WGS84 = LATGRS80/WGS84 + MHWLAT
  11. MHHWGRS80/WGS84 = LATGRS80/WGS84 + MHHWLAT
  12. MHWSGRS80/WGS84 = LATGRS80/WGS84 + MHWSLAT
  13. HATGRS80/WGS84 = LATGRS80/WGS84 + HATLAT
  14. *\*AHS tide rasters provide ISLW but AusCoastVDT doesn’t currently accommodate that\**

1. Formatted properly (8 decimals for lat/long, 3 decimals for vertical separations, columns in correct order) and saved as tab delimited .txt and then deleted headings
   1. Column order is Latitude, Longitude, LAT, MLLW, MLWS, MLW, MHLW, MLWN, AHD, MSL, MLHW, MHWN, MHW, MHHW, MHWS, and HAT. The vertical separations fields in the grid file will always be in tidal datum height order, from left (LAT) to right (HAT) although diurnal and semi-diurnal pairs may switch.
   2. Save the final version as “AusCoastVDT\_VerticalSeparation\_Grid\_25092019.txt” (date will change)
2. Final txt file then converted to binary .VDTGrid format which should be saved in the installation directory (see “[AusCoastVDT\_CreateBinaryGrid\_Oct2016.pdf](http://www.crcsi.com.au/library/resource/auscoastvdt-createbinarygrid-oct2016)”)

## Creation of the Supplied Vertical Separation Grid Extent Polygon from Original TPN data

1. Created a TIN from the grid of points (the AUSGeoid09 points which intersected the TPN polygons in step 7 of section 7.1)
2. Extracted the TIN edges of the data (as lines)
3. Calculated the lengths of the TIN edge lines in metres
4. Deleted any edge lines greater than 1918m (i.e. those that aren’t 0/360 or 90/180 degrees to points)
5. Converted line features to polygons (i.e. 1min grid squares)
6. Dissolved all of the polygons into a single **stepped** extent polygon
   1. Final version “AusCoastVDT\_GridExtent.shp” is zipped and saved at the AusCoastVDT tool installation location