

WhiteboxToolsTM

WhiteboxTools User Manual

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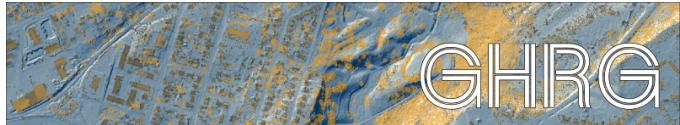
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1. Introduction

WhiteboxTools is an advanced geospatial data analysis platform developed by Prof. John Lindsay ([web-page](#); [jblindsay](#)) at the [University of Guelph's Geomorphometry and Hydrogeomatics Research Group](#) (GHRG). The project began in January 2017 and quickly evolved in terms of its analytical capabilities. *WhiteboxTools* can be used to perform common geographical information systems (GIS) analysis operations, such as cost-distance analysis, distance buffering, and raster reclassification. Remote sensing and image processing tasks include image enhancement (e.g. panchromatic sharpening, contrast adjustments), image mosaicking, numerous filtering operations, simple classification (k-means clustering), and common image transformations. *WhiteboxTools* also contains advanced tooling for spatial hydrological analysis (e.g. flow-accumulation, watershed delineation, stream network analysis, sink removal), terrain analysis (e.g. common terrain indices such as slope, curvatures, wetness index, hillshading; hypsometric analysis; multi-scale topographic position analysis), and LiDAR data processing. LiDAR point clouds can be interrogated (LidarInfo, LidarHistogram), segmented, tiled and joined, analyzed for outliers, interpolated to rasters (DEMs, intensity images), and ground-points can be classified or filtered. *WhiteboxTools* is not a cartographic or spatial data visualization package; instead it is meant to serve as an analytical backend for other data visualization software, mainly GIS.

In this manual, **WhiteboxTools** refers to the standalone geospatial analysis library, a collection of tools contained within a compiled binary executable command-line program and the associated Python scripts that are distributed alongside the binary file (e.g. `whitebox_tools.py` and `wb_runner.py`). **Whitebox Geospatial Analysis Tools** and **Whitebox GAT** refer to the GIS software, which includes a user-interface (front-end), point-and-click tool interfaces, and cartographic data visualization capabilities.

Although *WhiteboxTools* was first developed with to serve as a source of plugin tools for the [Whitebox Geospatial Analysis Tools \(GAT\)](#) open-source GIS project, the tools contained in the library are stand-alone and can run outside of the larger *Whitebox GAT* project. See [Interacting With WhiteboxTools From the Command Prompt](#) for further details. There have been a large number of requests to call *Whitebox GAT* tools and functionality from outside of the *Whitebox GAT* user-interface (e.g. from Python automation scripts). *WhiteboxTools* is intended to meet these usage requirements. For example, a [WhiteboxTools plug-in for QGIS](#) is available.

The current version of *Whitebox GAT* contains many equivalent tools to those found in the *WhiteboxTools* library, although they are developed using the Java programming language. A future version of *Whitebox GAT* will replace these previous tools with the new *WhiteboxTools* backend. This transition will occur over the next several releases. Eventually most of the approximately 450 tools contained within *Whitebox GAT* will be ported to *WhiteboxTools*. In addition to separating the processing capabilities and the user-interface (and thereby reducing the reliance on Java), this migration should significantly improve processing efficiency. This is because [Rust](#), the programming language used to develop *WhiteboxTools*, is generally [faster than the equivalent Java code](#) and because many of the *WhiteboxTools* functions are designed to process data in parallel wherever possible. In contrast, the older Java codebase included largely single-threaded applications.

In addition to *Whitebox GAT*, the *WhiteboxTools* project is related to other GHRG software projects includ-

ing, the [GoSpatial](#) project, which has similar goals but is designed using the Go programming language instead of Rust. *WhiteboxTools* has however superseded the *GoSpatial* project, having subsumed all of its functionality. *GoSpatial* users should now transition to *WhiteboxTools*.

1.1 Why is it named *WhiteboxTools*?

The project name *WhiteboxTools* clearly takes its inspiration from the related project Whitebox GAT. However, the name *Whitebox* is intended to convey opposition to a ‘black box’ system, one for which only the inputs and outputs may be observed and the internal workings may not be scrutinized. *WhiteboxTools* is inspired by the concept of *open-access software*, the tenants of which were described by Lindsay (2014)¹. Open-access software can be viewed as a complimentary extension to the traditional *open-source* software (OSS) model of development. The concept of open access has been previously defined in the context of publishing scholarly literature in a way that removes financial, legal, and technical access barriers to knowledge transfer. Lindsay (2014) argued that the stated goals of reducing barriers associated with knowledge transfer applies equally to the software used in research. Open-access software is distinct from other OSS in that it has an explicitly stated design goal of reducing barriers to the transfer of knowledge to the user community. Direct insight into the workings of algorithm design and implementation allows for educational opportunities and increases the potential for rapid innovation, experimentation with algorithms, and community-directed development. This is particularly important in geomatics because many geospatial algorithms are complex and are strongly affected by implementation details. Also, there are often multiple competing algorithms for accomplishing the same task and the choice of one method over another can greatly impact the outcome of a workflow.

All OSS allow users the opportunity to download the source code and inspect the software’s internal workings. However, traditional OSS often does not lend itself to end-user source code inspection. Open-access software, by comparison, is *designed from the project’s inception in a way that reduces the barriers that typically discourage end-users from examining the algorithm and implementation details associated with specific software artifacts*. *WhiteboxTools* attempts to address some of the barriers to knowledge transfer by allowing users to view the source code associated with each tool directly (e.g. `--viewcode=ExtendVectorLines`). This functionality removes the need to download separate, and often large, project source code files and eliminates the requisite familiarity with the project to identify the code sections related to the operation of the tool of interest. The `viewcode` flag is the embodiment of a design philosophy that is intended to empower the user community. Each tool included in the library has been written in a way to isolate the major functionality within a single file, thereby easing the task of interpreting the code (traditional coding style would split complex code among numerous files). This design goal is also why the developers have chosen to exclude external libraries commonly found in other similarly software (e.g. GDAL), thereby simplifying the installation process and code interpretation. This approach has the potential to encourage further community involvement and experimentation with geospatial analysis techniques.

¹Lindsay, JB. 2014. [The Whitebox Geospatial Analysis Tools project and open-access GIS](#). Proceedings of the GIS Research UK 22nd Annual Conference, The University of Glasgow, 16-18 April, DOI: 10.13140/RG.2.1.1010.8962.

2. Downloads and Installation

WhiteboxTools is a stand-alone executable command-line program with no actual installation. Simply [download the appropriate file for your system](#) and decompress the folder. Pre-compiled binaries can be downloaded from the [Geomorphometry and Hydrogeomatics Research Group](#) software web site for various supported operating systems. Depending on your operating system, you may need to grant the *WhiteboxTools* executable file execution privileges before running it. If you intend to use the Python programming interface for *WhiteboxTools* you will need to have Python 3 installed.

It is likely that *WhiteboxTools* will work on a wider variety of operating systems and architectures than those of the distributed pre-compiled binaries. If you do not find your operating system/architecture in the list of available *WhiteboxTool* binaries, then compilation from source code will be necessary. *WhiteboxTools* can be compiled from the source code with the following steps:

1. Install the Rust compiler; Rustup is recommended for this purpose. Further instruction can be found at this [link](#).
2. Download the *WhiteboxTools* [source code](#). To download the code, click the green Clone or download button on the GitHub repository site.
3. Decompress the zipped download file.
4. Open a terminal (command prompt) window and change the working directory to the *whitebox_tools* sub-folder, which is contained within the decompressed downloaded Whitebox GAT folder:

```
>> cd /path/to/folder/whitebox_tools/
```

5. Finally, use the rust package manager Cargo, which will be installed alongside Rust, to compile the executable:

```
>> cargo build --release
```

Depending on your system, the compilation may take several minutes. When completed, the compiled binary executable file will be contained within the *whitebox_tools/target/release/* folder. Type *./whitebox_tools --help* at the command prompt (after changing the directory to the containing folder) for information on how to run the executable from the terminal.

The '>>' is shorthand used in this document to denote the command prompt and is not intended to be typed.

Be sure to follow the instructions for installing Rust carefully. In particular, if you are installing on Microsoft Windows, you must have a linker installed prior to installing the Rust compiler (*rustc*). The Rust webpage recommends either the **MS Visual C++ 2015 Build Tools** or the GNU equivalent and offers details for each installation approach. You should also consider using **RustUp** to install the Rust compiler.

3. Supported Data Formats

The *WhiteboxTools* library can currently support reading/writing raster data in GeoTIFF (.tif), *Whitebox GAT*(.tas and .dep), ESRI (ArcGIS) ASCII (.txt) and binary (.flt and .hdr), GRASS GIS, Idrisi (.rdc and .rst), SAGA GIS (binary-.sdat and .sgrd-and ASCII formats), and Surfer 7 (.grd) data formats. *The BigTIFF (64-bit) format is not currently supported.* The library is primarily tested using Whitebox raster and GeoTIFF data sets and if you encounter issues when reading/writing data in other formats, you should report the [issue](#). Please note that there are no plans to incorporate third-party libraries, like [GDAL](#), in the project given the design goal of keeping a pure (or as close as possible) Rust codebase without third-party dependencies. This design greatly simplifies installation of the library.

Please note that throughout this manual code examples that manipulate raster files all use the GeoTIFF format (.tif) but any of the supported file extensions can be used in its place.

At present, there is limited ability in *WhiteboxTools* to work with vector geospatial data. Shapefiles geometries (.shp) and attributes (.dbf) can be read and some tools take vector inputs. There is currently no support for writing vector data although this feature is being actively developed. Other vector data formats may be added in the future.

LiDAR data can be read/written in the common [LAS](#) data format. *WhiteboxTools* can read and write LAS files that have been compressed (zipped with a .zip extension) using the common DEFLATE algorithm. Note that only LAS file should be contained within a zipped archive file. The compressed LiDAR format LAZ and ESRI LiDAR format are not currently supported by the library. The following is an example of running a LiDAR tool using zipped input/output files:

```
>>./whitebox_tools -r=LidarTophatTransform -v --wd="/path/to/data/"
-i="input.las.zip" -o="output.las.zip" --radius=10.0
```

Note that the double extensions (.las.zip) in the above command are not necessary and are only used for convenience of keeping track of LiDAR data sets (i.e. .zip extensions work too). The extra work of decoding/encoding compressed files does add additional processing time, although the Rust compression library that is used is highly efficient and usually only adds a few seconds to tool run times. Zipping LAS files frequently results 40-60% smaller binary files, making the additional processing time worthwhile for larger LAS file data sets with massive storage requirements.

4. Interacting With *WhiteboxTools* From the Command Prompt

WhiteboxTools is a command-line program and can be run either by calling it from a terminal application with appropriate commands and arguments, or, more conveniently, by calling it from a script. The following commands are recognized by the *WhiteboxTools* library:

| Command | Description |
|---------------|---|
| --cd, --wd | Changes the working directory; used in conjunction with --run flag. |
| -h, --help | Prints help information. |
| -l, --license | Prints the whitebox-tools license. |

| Command | Description |
|------------------|---|
| --listtools | Lists all available tools, with tool descriptions. Keywords may also be used, --listtools slope. |
| -r, --run | Runs a tool; used in conjunction with --cd flag; -r="LidarInfo". |
| --toolbox | Prints the toolbox associated with a tool; --toolbox=Slope. |
| --toolhelp | Prints the help associated with a tool; --toolhelp="LidarInfo". |
| --toolparameters | Prints the parameters (in json form) for a specific tool; e.g. --toolparameters="FeaturePreservingDenoise". |
| -v | Verbose mode. Without this flag, tool outputs will not be printed. |
| --viewcode | Opens the source code of a tool in a web browser; --viewcode="LidarInfo". |
| --version | Prints the version information. |

Generally, the Unix convention is that single-letter arguments (options) use a single hyphen (e.g. -h) while word-arguments (longer, more descriptive argument names) use double hyphens (e.g. --help). The same rule is used for passing arguments to tools as well. Use the *--toolhelp* argument to print information about a specific tool (e.g. --toolhelp=Clump).

Tool names can be specified either using the snake_case or CamelCase convention (e.g. *lidar_info* or *LidarInfo*).

The following is an example of calling the *WhiteboxTools* binary executable file directly from the command prompt:

```
>>./whitebox_tools --wd='/Users/johnlindsay/Documents/data/' ^
--run=DevFromMeanElev --input='DEM clipped.tif' ^
--output='DEV raster.tif' -v
```

Notice the quotation marks (single or double) used around directories and filenames, and string tool arguments in general. After the *--run* flag, used to call a tool, a series of tool-specific flags are provided to indicate the values of various input parameters. Note that the order of these flags is unimportant. Use the *'-v'* flag (run in verbose mode) to force the tool to print output to the command prompt. Please note that the *whitebox_tools* executable file must have permission to be executed; on some systems, this may require setting special permissions. Also, the above example uses the forward slash character (/), the directory path separator used on unix based systems. On Windows, users should use the back slash character (\) instead. Also, it is sometimes necessary to break (^) commands across multiple lines, as above, in order to better fit with the documents format. Actual command prompts (>>) should be contained to a single line.

5. Interacting With *WhiteboxTools* Through Python Scripting

By combining the *WhiteboxTools* library with a high-level scripting language, such as Python, users are capable of creating powerful stand-alone geospatial applications and workflow automation scripts. In fact, *WhiteboxTools* functionality can be called from many different programming languages. However, given the prevalent use of the Python language in the geospatial fields, the library is distributed with several resources specifically aimed at Python scripting. This section focuses on how Python programming can be used to interact with the *WhiteboxTools* library.

Note that all of the following material assumes the user system is configured with Python 3. The code snippets below are not guaranteed to work with older versions of the language.

5.1 Using the *whitebox_tools.py* script

Interacting with *WhiteboxTools* from Python scripts is easy. To begin, each script must start by importing the *WhiteboxTools* class, contained with the *whitebox_tools.py* script; a new *WhiteboxTools* object can then be created:

```
1 from WBT.whitebox_tools import WhiteboxTools
2
3 wbt = WhiteboxTools()
```

Depending on the relative location of the *WhiteboxTools* directory and the script file that you are importing to, the import statement may need to be altered slightly. In the above script, it is assumed that the folder containing the *WhiteboxTools* files (including the *whitebox_tools* Python script) is named WBT (Line 1) and that the calling script that is importing *WhiteboxTools* is located in the parent directory of WBT. See [An Example WhiteboxTools Python Project](#) for more details on project set-up. The use of *wbt* to designate the *WhiteboxTools* object variable in the above script (Line 3) is just the convention used in this manual and other project resources. In fact, any variable name can be used for this purpose.

The *WhiteboxTools* class expects to find the *WhiteboxTools* executable file (*whitebox_tools.exe* on Windows and *whitebox_tools* on other platforms) within the same directory (WBT) as the *whitebox_tools.py* script. If the binary file is located in a separate directory, you will need to set the executable directory as follows:

```
1 wbt.set_whitebox_dir('/local/path/to/whitebox/binary/')
2 # Or alternatively...
3 wbt.exe_path = '/local/path/to/whitebox/binary/'
```

Individual tools can be called using the convenience methods provided in the *WhiteboxTools* class:

```
1 # This line performs a 5 x 5 mean filter on 'inFile.tif':
2 wbt.mean_filter('/file/path/inFile.tif', '/file/path/outFile.tif', 5, 5)
```

Each tool has a corresponding convenience method. The listing of tools in this manual includes informa-

tion about each tool's Python convenience method, including default parameter values. Parameters with default values may be optionally left off of function calls. In addition to the convenience methods, tools can be called using the `run_tool()` method, specifying the tool name and a list of tool arguments.

```

1 source = "source.tif"
2 cost = "cost.tif"
3 out_accum = "accum.tif"
4 out_backlink = "backlink.tif"
5 args = []
6 args.append("--source='{}'".format(source))
7 args.append("--cost='{}'".format(cost))
8 args.append("--out_accum='{}'".format(out_accum))
9 args.append("--out_backlink='{}'".format(out_backlink))
10 self.run_tool('cost_distance', args)

```

Each of the tool-specific convenience methods collect their parameters into a properly formatted list and then ultimately call the `run_tools()` method. Notice that while internally `whitebox_tools.exe` uses CamelCase (e.g. MeanFilter) to denote tool names, the Python interface of `whitebox_tools.py` uses snake_case (e.g. `mean_filter`), according to Python style conventions. The only exceptions are tools with names that clash with Python keywords (e.g. `And()`, `Not()`, and `Or()`).

The return value can be used to check for errors during operation:

```

1 if wbt.ruggedness_index('/path/DEM.tif', '/path/ruggedness.tif') != 0:
2     # Non-zero returns indicate an error.
3     print('ERROR running ruggedness_index')

```

If your data files tend to be buried deeply in layers of sub-directories, specifying complete file names as input parameters can be tedious. In this case, the best option is setting the working directory before calling tools:

```

1 from whitebox_tools import WhiteboxTools
2
3 wbt = WhiteboxTools()
4 wbt.work_dir = "/path/to/data/" # Sets the Whitebox working directory
5
6 # Because the working directory has been set, file arguments can be
7 # specified simply using file names, without paths.
8 wbt.d_inf_flow_accumulation("DEM.tif", "output.tif", log=True)

```

An advanced text editor, such as VS Code or Atom, can provide hints and autocompletion for available tool convenience methods and their parameters, including default values (Figure 1).

Sometimes it can be useful to print a complete list of available tools:

```

1 print(wbt.list_tools()) # List all tools in WhiteboxTools

```

The `list_tools()` method also takes an optional keywords list to search for tools:

```
19      f arc_sin
20      f arc_tan
21      f aspect
22      f atan2
23      f average_flowpath_slope
24      f average_overlay
25      f average_upslope_flowpath_length
26      f balance_contrast_enhancement
27      f basins
28      f bilateral_filter
29
30
31      f bilateral_filter
32          bilateral_filter(self, input, output, sigma_dist=0.75, sigma_int=1.0,
33          callback=default_callback)
34
35      A bilateral filter is an edge-preserving smoothing filter introduced by Tomasi and Manduchi (1998).
36
37      Keyword arguments:
38
39          input -- Input raster file.
40          output -- Output raster file.
41          sigma_dist -- Standard deviation in distance in pixels.
42          sigma_int -- Standard deviation in intensity in pixels.
43          callback -- Custom function for handling tool text outputs.
44
45      wbt.
```

Autocompletion in Atom text editor makes calling *WhiteboxTools* functions easier.

```

1 # Lists tools with 'lidar' or 'LAS' in tool name or description.
2 print(wbt.list_tools(['lidar', 'LAS']))

```

To retrieve more detailed information for a specific tool, use the `tool_help()` method:

```

1 print(wbt.tool_help("elev_percentile"))

```

`tool_help()` prints tool details including a description, tool parameters (and their flags), and example usage at the command line prompt. The above statement prints this report:

```

ElevPercentile
Description:
Calculates the elevation percentile raster from a DEM.
Toolbox: Geomorphometric Analysis
Parameters:

```

| Flag | Description |
|---------------------------------|---|
| <code>-i, --input, --dem</code> | Input raster DEM file. |
| <code>-o, --output</code> | Output raster file. |
| <code>--filterx</code> | Size of the filter kernel in the x-direction. |
| <code>--filtery</code> | Size of the filter kernel in the y-direction. |
| <code>--sig_digits</code> | Number of significant digits. |

Example usage:

```

>>./whitebox_tools -r=ElevPercentile -v --wd="/path/to/data/" --dem=DEM.tif
>>-o=output.tif --filterx=25

```

A note on default parameter values

Each tool contains one or more parameters with default values. These will always be listed after any input parameters that do not have default values. You do not need to specify a parameter with a default value if you accept the default. That is, unless you intend to specify an input value different from the default, you may leave these parameters off of the function call. However, be mindful of the fact that Python assigns values to parameters based on order, unless parameter names are specified.

Consider the Hillshade tool as an example. The User Manual gives the following function definition for the tool:

```
hillshade(
    dem,
    output,
    azimuth=315.0,
    altitude=30.0,
    zfactor=1.0,
    callback=default_callback)
```

The `dem` and `output` parameters do not have default values and must be specified every time you call this function. Each of the remaining parameters have default values and can, optionally, be left off of calls to the `hillshade` function. As an example, say I want to accept the default values for all the parameters except `altitude`. I would then need to use the named-parameter form of the function call:

```
1 wbt.hillshade(
2     "DEM.tif",
3     "hillshade.tif",
4     altitude=20.0)
```

If I hadn't specified the parameter name for `altitude`, Python would have assumed that the value 20.0 should be assigned to the third parameter, `azimuth`.

5.2 Handling tool output

Tools will frequently print text to the standard output during their execution, including warnings, progress updates and other notifications. Sometimes, when users run many tools in complex workflows and in batch mode, these output messages can be undesirable. Most tools will have their outputs suppressed by setting the `verbose` mode to `False` as follows:

```
1 wbt.set_verbose_mode(False)
2 # Or, alternatively...
3 wbt.verbose = False
```

Alternatively, it may be helpful to capture the text output of a tool for custom processing. This is achieved by specifying a custom `callback` function to the tool's convenience function:

```
1 # This callback function suppresses printing progress updates,
2 # which always use the '%' character. The callback function
3 # approach is flexible and allows for any level of complex
4 # interaction with tool outputs.
5 def my_callback(value):
6     if not "%" in value:
7         print(value)
8
```

```
9 wbt.slope('DEM.tif', 'slope_raster.tif', callback=my_callback)
```

Every convenience function takes an optional callback as the last parameter. The default callback simply prints tool outputs to the standard output without any additional processing. Callback functions can serve as a means of cancelling operations:

```
1 def my_callback(value):
2     if user_selected_cancel_btn: # Assumes a 'Cancel' button on a GUI
3         print('Cancelling operation...')
4         wbt.cancel_op = True
5     else:
6         print(value)
7
8 wbt.breach_depressions('DEM.tif', 'DEM_breached.tif', callback=my_callback)
```

5.3 Additional functions in *whitebox_tools.py*

The *whitebox_tools.py* script provides several other functions for interacting with the *WhiteboxTools* library, including:

```
1 # Print the WhiteboxTools help...a listing of available commands
2 print(wbt.help())
3
4 # Print the WhiteboxTools license
5 print(wbt.license())
6
7 # Print the WhiteboxTools version
8 print("Version information: {}".format(wbt.version()))
9
10 # Get the toolbox associated with a tool
11 tb = wbt.toolbox('lidar_info')
12
13 # Retrieve a JSON object of a tool's parameters.
14 tp = tool_parameters('raster_histogram')
15
16 # Opens a browser and navigates to a tool's source code in the
17 # WhiteboxTools GitHub repository
18 wbt.view_code('watershed')
```

For a working example of how to call functions and run tools from Python, see the *whitebox_example.py* Python script, which is distributed with the *WhiteboxTools* library.

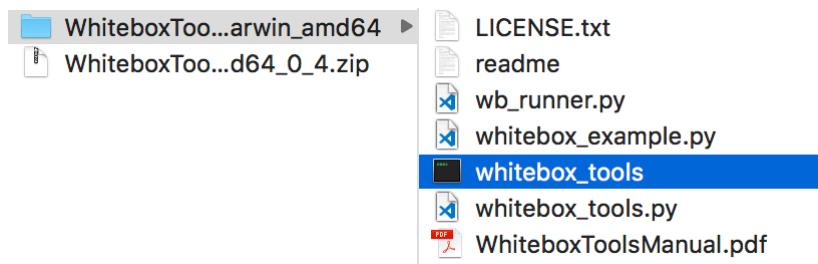
Additional resources for using *WhiteboxTools*' Python interface can be found on the [Tutorials](#) site of the *WhiteboxTools* home page. This site contains in-depth tutorials on topics

such as, '*Interpolating LiDAR data*'.

5.4 An example WhiteboxTools Python project

In this section, we will create a Python project that utilizes the *WhiteboxTools* library to interpolate a LiDAR point-cloud, to process the resulting digital elevation model (DEM) to make it suitable for hydrological applications, and to perform a simple flow-accumulation operation. I suggest using an advanced coding text editor, such as *Visual Studio Code* or *Atom*, for this tutorial, but Python code can be written using any basic text editor.

Begin by creating a dedicated project directory called *FlowAccumExample* and copy *WhiteboxTools* binary file (i.e. the compressed file downloaded from the *Geomorphometry & Hydrogeomatics Research Group* website) into this folder. Using the decompression software on your computer, decompress (i.e. an operation sometimes called *unzipping*) the file into the newly created *FlowAccumExample* directory. You will find the compressed file contains a folder with contents similar to Figure 2.



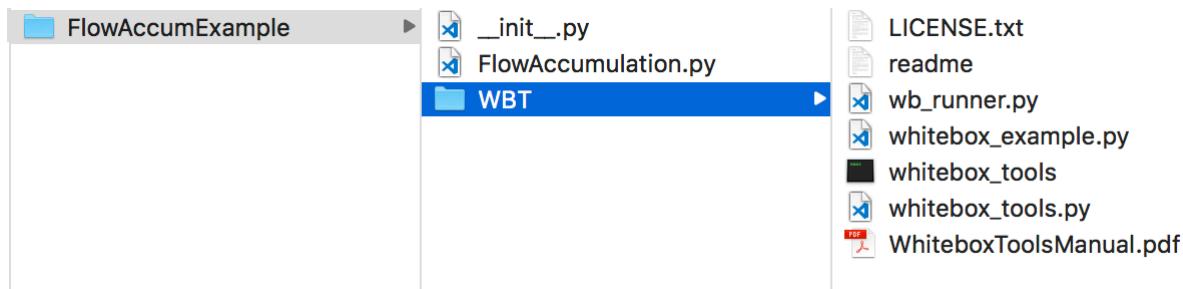
Folder contents of *WhiteboxTools* compressed download file

The folder contains a number of files, including the *WhiteboxTools* executable file, the *whitebox_tools.py* python script, the *WhiteboxTools* Runner (*wb_runner.py*; see below), and this user manual. It is likely that the folder has a name that reflects the operating system and architecture that the binary file was compiled for (e.g. *WhiteboxTools_darwin_amd64*). Rename this directory to *WBT*. Also note, depending on your decompression software, it may be the case that the contents of the *WBT* folder itself contains a sub-directory that actually holds these files. If this is the case, be sure to move the contents of the sub-directory into the *WBT* parent directory.

Using your text editor, create a new Python script file, called *FlowAccumulation.py* within the *FlowAccumExample* directory. We will begin by importing the *WhiteboxTools* class from the *whitebox_tools.py* script contained within the *WBT* sub-directory. Unfortunately, Python's module system is only able to import classes and function definitions declared in external Python scripts *if these external files are contained somewhere on the Python path or in the directory containing the script file into which you are importing*. This is important because based on the project structure that we have established, the *whitebox_tools.py* script is actually contained within a sub-directory of the *FlowAccumExample* directory and is therefore not directly accessible, unless you have previously installed the script on the Python path. Another, perhaps easier solution to this problem is to create a file named *_init_.py* (those are two leading and trailing underscore characters) within the *FlowAccumExample* directory. The presence of this empty file will make Python treat the *WBT*

directory as containing packages, in this case, the *whitebox_tools* package. For more information, see the Python documentation on [modules and packages](#).

At this stage, you should have a project directory structure like that of the Figure 3.



Example project set-up

Many operating systems will disallow the execution of files that are downloaded directly from the Internet. As such, it is possible that you will need to explicitly give the *whitebox_tools.exe* permission to execute on your computer (Note: here we are referring to the compiled *WhiteboxTools* binary file and not the similarly named Python script *whitebox_tools.py* also contained in the folder). The procedure for doing this depends on your specific operating system. On MacOS, for example, this is usually achieved using the 'Security & Privacy' tab under 'System Preferences'. To test whether *whitebox_tools.exe* has permission to run on your system, double-click the file. If the file is configured to execute, a command terminal will automatically open and the *WhiteboxTools* help documentation and a listing of the available tools will be printed. If this does not occur, you likely need to give the file permission to execute.

Using your text editor, you may now add the following lines to the *FlowAccumulation.py* file.

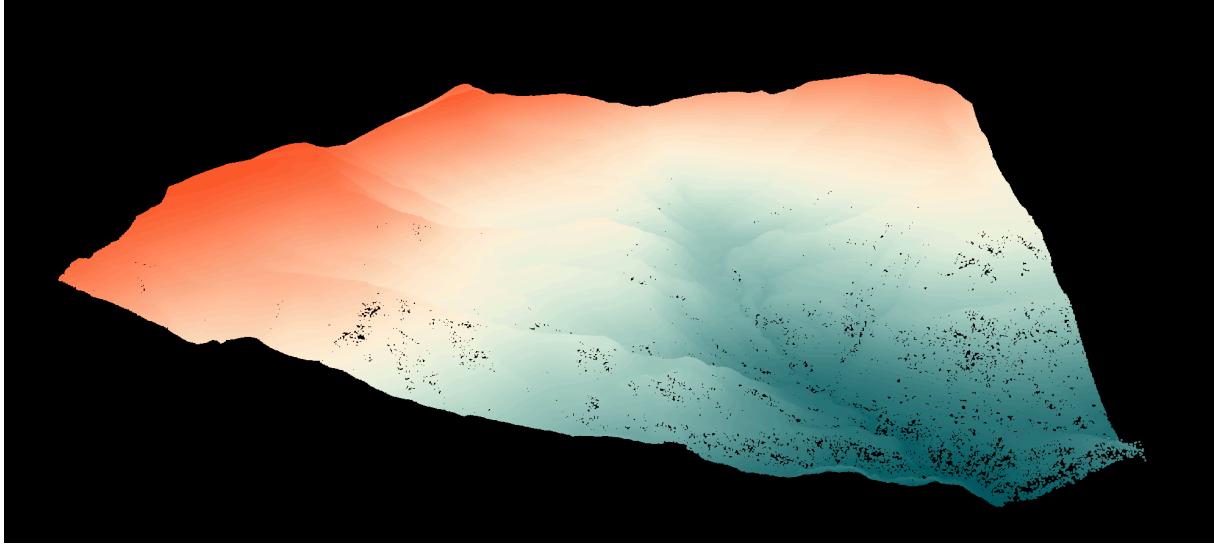
```
1 from WBT.whitebox_tools import WhiteboxTools
2
3 wbt = WhiteboxTools()
```

In the import statement, *WBT* is a reference to the package folder containing the *WhiteboxTools* files; *whitebox_tools* is a reference to the *whitebox_tools.py* script contained within this package folder; and *WhiteboxTools* is a reference to the *WhiteboxTools* class contained within this script file. Please note that if you named your directory containing the *WhiteboxTools* files something other than *WBT*, you would need to alter the import statement accordingly.

Visit the [Geomorphometry and Hydrogeomatics Research Group](#) website and download the St. Elias Mountains and Gulf of Alaska sample data set (*StElisAk.las*) from the *WhiteboxTools* section of the site. This file contains a LiDAR point cloud that has been previously filtered to remove points associated with non-ground returns, mainly trees (Figure 4). Create a sub-directory within the project folder called 'data' and copy *StElisAk.las* into the folder.

Now we can complete our flow accumulation analysis with the following code:

```
1 import os
2 from WBT.whitebox_tools import WhiteboxTools
3
```



St. Elias Mountains LiDAR point cloud, visualized using the plas.io software

```

4 wbt = WhiteboxTools()

5
6 # Set the working directory, i.e. the folder containing the data,
7 # to the 'data' sub-directory.
8 wbt.work_dir = os.path.dirname(os.path.abspath(__file__)) + "/data/"

9
10 # When you're running multiple tools, the outputs can be a tad
11 # chatty. In this case, you may want to suppress the output by
12 # setting the verbose mode to False.
13 # wbt.verbose = False

14
15 # Interpolate the LiDAR data using an inverse-distance weighting
16 # (IDW) scheme.
17 print("Interpolating DEM...")
18 wbt.lidar_idw_interpolation(
19     i="StElisAk.las",
20     output="raw_dem.tif",
21     parameter="elevation",
22     returns="last",
23     resolution=1.0,
24     weight=1.0,
25     radius=2.5
26 )
27
28 # The resulting DEM will contain NoData gaps. We need to fill
29 # these in by interpolating across the gap.
30 print("Filling missing data...")

```

```

31 wbt.fill_missing_data(
32 i="raw_dem.tif",
33 output="dem_nodata_filled.tif",
34 filter=11
35 )
36
37 # This DEM will contain grid cells that have no lower neighbours.
38 # This condition is unsuited for flow-path modelling applications
39 # because these operations assume that each interior cell in the
40 # DEM has at least one downslope neighbour. We'll use an operation
41 # called depression breaching to 'fix' the elevations within the
42 # DEM to enforce continuous flow.
43 print("Performing flow enforcement...")
44 wbt.breach_depressions(
45 dem="dem_nodata_filled.tif",
46 output="dem_hydro_enforced.tif"
47 )
48
49 # Lastly, perform the flow accumulation operation using the
50 # D-infinity flow algorithm.
51 print("Performing flow accumulation...")
52 wbt.d_inf_flow_accumulation(
53 dem="dem_hydro_enforced.tif",
54 output="flow_accum.tif",
55 log=True
56 )
57
58 print("Complete!")

```

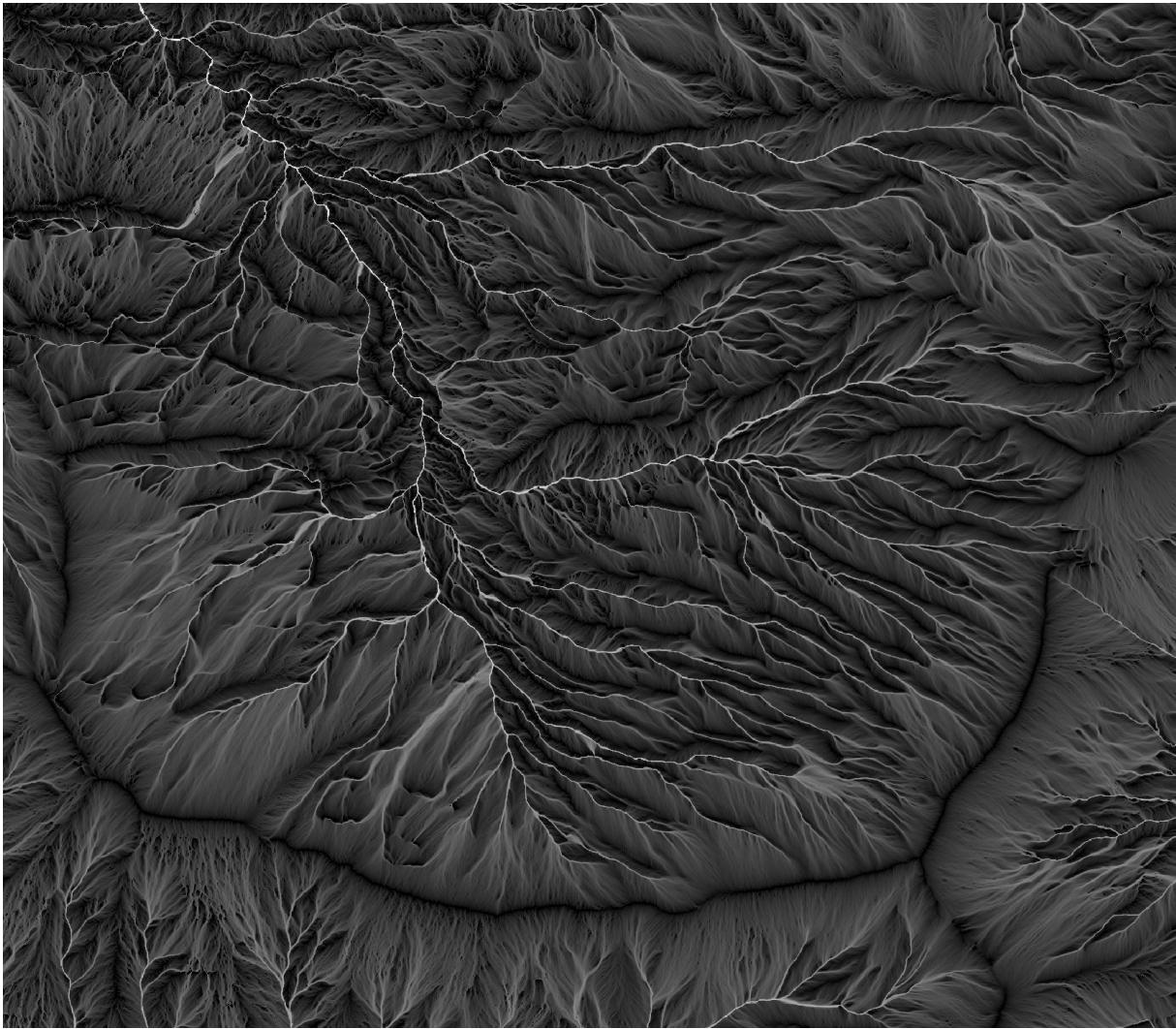
To run the above script, open a terminal (command prompt), *cd* to the script containing folder, and run the following command:

```
>>python FlowAccumulation.py
```

If Python 3 is not your default Python version, substitute `python3` for `python` in the above command line. The final D-infinity flow accumulation raster can be displayed in any GIS software of choice and should look similar to Figure 5.

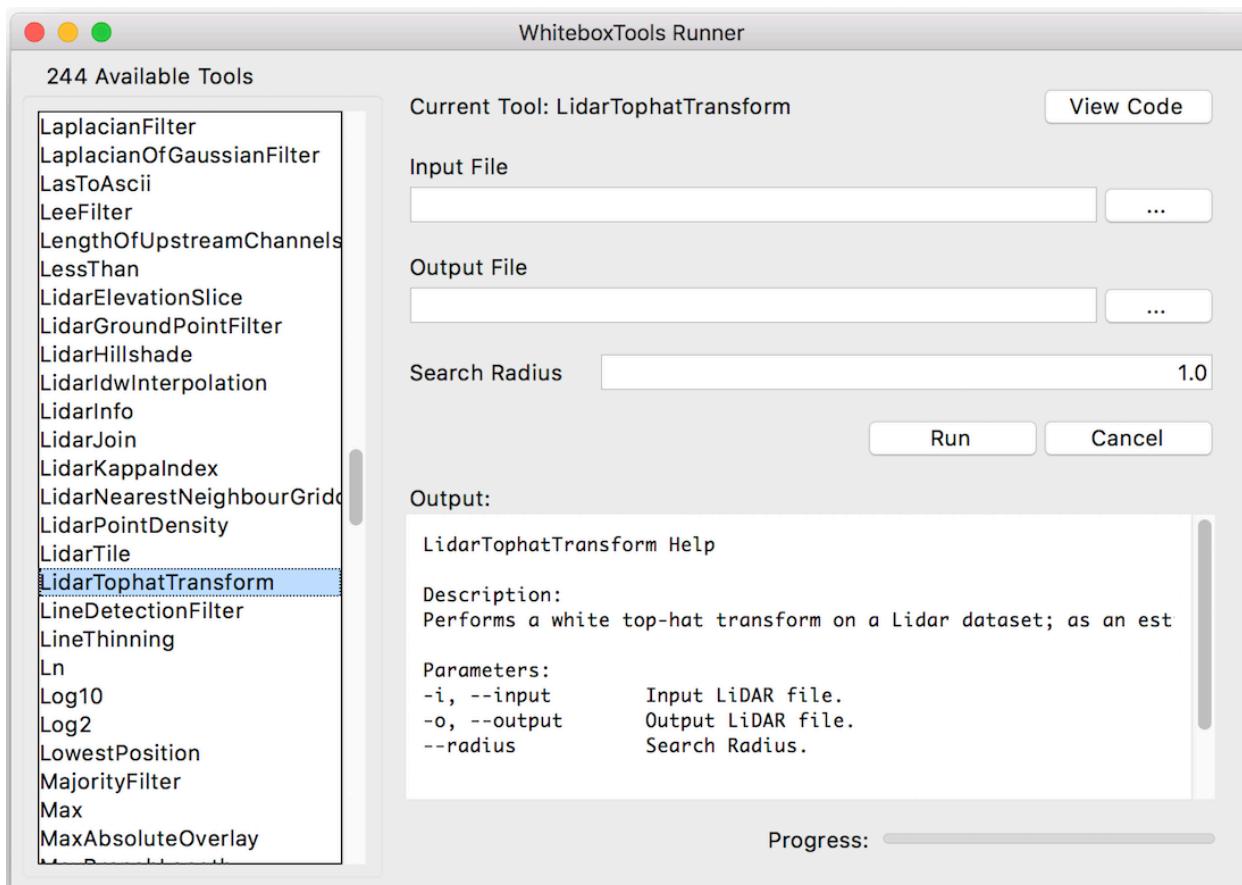
6. WhiteboxTools Runner

There is a Python script contained within the *WhiteboxTools* directory called '`wb_runner.py`'. This script is intended to provide a very basic user-interface, *WhiteboxTools Runner*, for running the tools contained within the *WhiteboxTools* library. The user-interface uses Python's TkInter GUI library and is cross-platform.



Output of the flow accumulation script for the St. Elias Mountains data set.

The user interface is currently experimental and is under heavy testing. Please report any issues that you experience in using it.

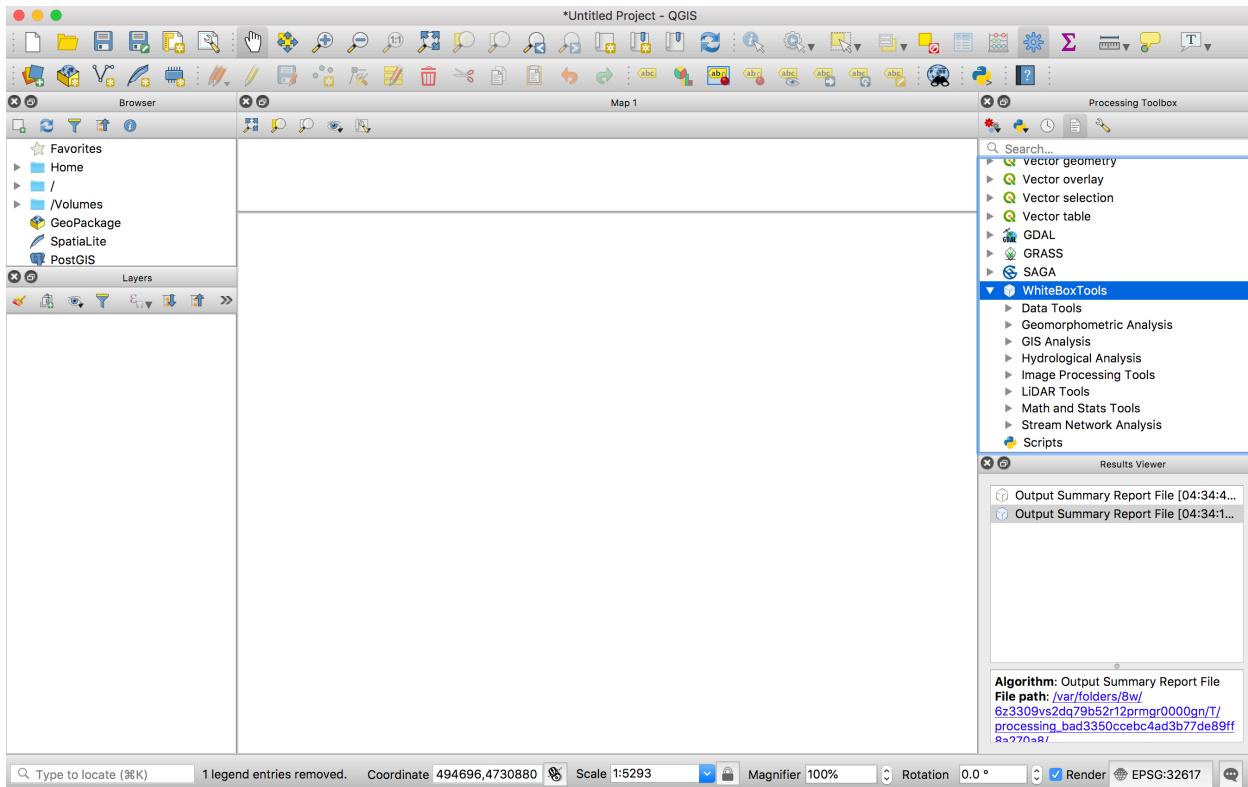


The *WhiteboxTools Runner* user-interface

The *WhiteboxTools Runner* does not rely on the *Whitebox GAT* user interface at all and can therefore be used independent of the larger project. The script must be run from a directory that also contains the '*whitebox_tools.py*' Python script and the '*whitebox_tools*' executable file. There are plans to link tool help documentation in *WhiteboxTools Runner* and to incorporate toolbox information, rather than one large listing of available tools.

7. WhiteboxTools QGIS Plugin

WhiteboxTools functionality can also be accessed conveniently through the popular open-source geospatial software QGIS. QGIS developer [Alexander Bruy](#) maintains a plugin for the toolbox called [Whitebox For Processing](#). Detailed instructions for installing and setting-up the QGIS toolbox can be found on the site.



The *WhiteboxTools QGIS plugin toolbox*

8. Available Tools

Eventually most of *Whitebox GAT*'s approximately 400 tools will be ported to *WhiteboxTools*, although this is an immense task. Opportunities to parallelize algorithms will be sought during porting. All new plugin tools will be added to *Whitebox GAT* using this library of functions.

The library currently contains more than 350 tools, which are each grouped into themed toolboxes including: *Data Tools*, *Geomorphometric Analysis* (i.e. digital terrain analysis), *GIS Analysis*, *Hydrological Analysis*, *Image Analysis*, *LiDAR Analysis*, *Mathematical and Statistical Analysis*, and *Stream Network Analysis*. To retrieve detailed information about a tool's input arguments and example usage, either use the `toolhelp` command from the terminal, or the `tool_help('tool_name')` function from the `whitebox_tools.py` script. The following is a complete listing of available tools, with brief descriptions, tool parameter, and example usage.

8.1 Data Tools

8.1.1 AddPointCoordinatesToTable

Modifies the attribute table of a point vector by adding fields containing each point's X and Y coordinates.

Parameters:

| Flag | Description |
|-------------|--------------------------|
| -i, --input | Input vector Points file |

Python function:

```
add_point_coordinates_to_table(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AddPointCoordinatesToTable -v ^
--wd="/path/to/data/" --input=points.shp
```

8.1.2 ConvertNodataToZero

Converts nodata values in a raster to zero.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
convert_nodata_to_zero(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ConvertNodataToZero -v ^
--wd="/path/to/data/" --input=in.tif -o>NewRaster.tif
```

8.1.3 ConvertRasterFormat

Converts raster data from one format to another.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
convert_raster_format(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ConvertRasterFormat -v ^
--wd="/path/to/data/" --input=DEM.tif -o=output.tif
```

8.1.4 ExportTableToCsv

Exports an attribute table to a CSV text file.

Parameters:

| Flag | Description |
|--------------|------------------------------------|
| -i, --input | Input vector file |
| -o, --output | Output raster file |
| --headers | Export field names as file header? |

Python function:

```
export_table_to_csv(
    i,
    output,
    headers=True,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ExportTableToCsv -v ^
--wd="/path/to/data/" -i=lines.shp -o=output.csv --headers
```

8.1.5 NewRasterFromBase

Creates a new raster using a base image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --base | Input base raster file |
| -o, --output | Output raster file |
| --value | Constant value to fill raster with; either 'nodata' or numeric value |
| --data_type | Output raster data type; options include 'double' (64-bit), 'float' (32-bit), and 'integer' (signed 16-bit) (default is 'float') |

Python function:

```
new_raster_from_base(
    base,
    output,
    value="nodata",
    data_type="float",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NewRasterFromBase -v ^
--wd="/path/to/data/" --base=base.tif -o>NewRaster.tif ^
--value=0.0 --data_type=integer
>>./whitebox_tools ^
-r=NewRasterFromBase -v --wd="/path/to/data/" --base=base.tif ^
-o>NewRaster.tif --value=nodata
```

8.1.6 PolygonsToLines

Converts vector polygons to polylines.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| -i, --input | Input vector polygon file |
| -o, --output | Output vector lines file |

Python function:

```
polygons_to_lines(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PolygonsToLines -v ^
--wd="/path/to/data/" -i=input.shp -o=output.shp
```

8.1.7 PrintGeoTiffTags

Prints the tags within a GeoTIFF.

Parameters:

| Flag | Description |
|-------------|--------------------|
| -i, --input | Input GeoTIFF file |

Python function:

```
print_geo_tiff_tags(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PrintGeoTiffTags -v ^
--wd="/path/to/data/" --input=DEM.tif
```

8.1.8 RasterToVectorPoints

Converts a raster dataset to a vector of the POINT shapetype.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| -i, --input | Input raster file |
| -o, --output | Output vector points file |

Python function:

```
raster_to_vector_points(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RasterToVectorPoints -v ^
--wd="/path/to/data/" --input=points.tif -o=out.shp
```

8.1.9 ReinitializeAttributeTable

Reinitializes a vector's attribute table deleting all fields but the feature ID (FID).

Parameters:

| Flag | Description |
|-------------|-------------------|
| -i, --input | Input vector file |

Python function:

```
reinitialize_attribute_table(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ReinitializeAttributeTable -v ^
--wd="/path/to/data/" -i=input.shp
```

8.1.10 SetNodataValue

Assign a specified value in an input image to the NoData value.

Parameters:

| Flag | Description |
|--------------|-----------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --back_value | Background value to set to nodata |

Python function:

```
set_nodata_value(
    i,
    output,
    back_value=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SetNodataValue -v --wd="/path/to/data/" ^
-i=in.tif -o=newRaster.tif --back_value=1.0
```

8.1.11 VectorLinesToRaster

Converts a vector containing polylines into a raster.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input vector lines file |
| --field | Input field name in attribute table |
| -o, --output | Output raster file |
| --nodata | Background value to set to NoData. Without this flag, it will be set to 0.0 |
| --cell_size | Optionally specified cell size of output raster. Not used when base raster is specified |
| --base | Optionally specified input base raster file. Not used when a cell size is specified |

Python function:

```
vector_lines_to_raster(
    i,
    output,
    field="FID",
    nodata=True,
    cell_size=None,
    base=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=VectorLinesToRaster -v ^
--wd="/path/to/data/" -i=lines.shp --field=ELEV -o=output.tif ^
--nodata --cell_size=10.0
>>./whitebox_tools ^
```

```
-r=VectorLinesToRaster -v --wd="/path/to/data/" -i=lines.shp ^
--field=FID -o=output.tif --base=existing_raster.tif
```

8.1.12 VectorPointsToRaster

Converts a vector containing points into a raster.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input vector Points file |
| --field | Input field name in attribute table |
| -o, --output | Output raster file |
| --assign | Assignment operation, where multiple points are in the same grid cell; options include 'first', 'last' (default), 'min', 'max', 'sum' |
| --nodata | Background value to set to NoData. Without this flag, it will be set to 0.0 |
| --cell_size | Optionally specified cell size of output raster. Not used when base raster is specified |
| --base | Optionally specified input base raster file. Not used when a cell size is specified |

Python function:

```
vector_points_to_raster(
    i,
    output,
    field="FID",
    assign="last",
    nodata=True,
    cell_size=None,
    base=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=VectorPointsToRaster -v ^
--wd="/path/to/data/" -i=points.shp --field=ELEV -o=output.tif ^
--assign=min --nodata ^
--cell_size=10.0
      >>./whitebox_tools ^
-r=VectorPointsToRaster -v --wd="/path/to/data/" -i=points.shp ^
--field=FID -o=output.tif --assign=last ^
--base=existing_raster.tif
```

8.1.13 VectorPolygonsToRaster

Converts a vector containing polygons into a raster.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input vector polygons file |
| --field | Input field name in attribute table |
| -o, --output | Output raster file |
| --nodata | Background value to set to NoData. Without this flag, it will be set to 0.0 |
| --cell_size | Optionally specified cell size of output raster. Not used when base raster is specified |
| --base | Optionally specified input base raster file. Not used when a cell size is specified |

Python function:

```
vector_polygons_to_raster(
    i,
    output,
    field="FID",
    nodata=True,
    cell_size=None,
    base=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=VectorPolygonsToRaster -v ^
--wd="/path/to/data/" -i=lakes.shp --field=ELEV -o=output.tif ^
--nodata --cell_size=10.0
      >>./whitebox_tools ^
-r=VectorPolygonsToRaster -v --wd="/path/to/data/" ^
-i=lakes.shp --field=ELEV -o=output.tif ^
--base=existing_raster.tif
```

8.2 GIS Analysis

8.2.1 AggregateRaster

Aggregates a raster to a lower resolution.

Parameters:

| Flag | Description |
|--------------|--------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --agg_factor | Aggregation factor, in pixels |
| --type | Statistic used to fill output pixels |

Python function:

```
aggregate_raster(
    i,
    output,
    agg_factor=2,
    type="mean",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AggregateRaster -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif ^
--output_text
```

8.2.2 Centroid

Calculates the centroid, or average location, of raster polygon objects.

Parameters:

| Flag | Description |
|---------------|----------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --text_output | Optional text output |

Python function:

```
centroid(
    i,
    output,
    text_output=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Centroid -v --wd="/path/to/data/" ^
-i=polygons.tif -o=output.tif
```

```
>>./whitebox_tools -r=Centroid ^
-v --wd="/path/to/data/" -i=polygons.tif -o=output.tif ^
--text_output
```

8.2.3 CentroidVector

Identifies the centroid point of a vector polyline or polygon feature or a group of vector points.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input vector file |
| -o, --output | Output vector file |

Python function:

```
centroid_vector(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CentroidVector -v --wd="/path/to/data/" ^
-i=in_file.shp -o=out_file.shp
```

8.2.4 Clump

Groups cells that form physically discrete areas, assigning them unique identifiers.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --diag | Flag indicating whether diagonal connections should be considered |
| --zero_back | Flag indicating whether zero values should be treated as a background |

Python function:

```
clump(
    i,
```

```
        output,
        diag=True,
        zero_back=False,
        callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Clump -v --wd="/path/to/data/" ^
-i=input.tif -o=output.tif --diag
```

8.2.5 ConstructVectorTin

Creates a vector triangular irregular network (TIN) for a set of vector points.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input vector points file |
| --field | Input field name in attribute table |
| --use_z | Use the 'z' dimension of the Shapefile's geometry instead of an attribute field? |
| -o, --output | Output vector polygon file |

Python function:

```
construct_vector_tin(
    i,
    output,
    field=None,
    use_z=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ConstructVectorTIN -v ^
--wd="/path/to/data/" -i=points.shp --field=HEIGHT ^
-o=tin.shp
>>./whitebox_tools -r=ConstructVectorTIN -v ^
--wd="/path/to/data/" -i=points.shp --use_z -o=tin.shp
```

8.2.6 CreateHexagonalVectorGrid

Creates a hexagonal vector grid.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input base file |
| -o, --output | Output vector polygon file |
| --width | The grid cell width |
| --orientation | Grid Orientation, 'horizontal' or 'vertical' |

Python function:

```
create_hexagonal_vector_grid(
    i,
    output,
    width,
    orientation="horizontal",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CreateHexagonalVectorGrid -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.shp --width=10.0 ^
--orientation=vertical
```

8.2.7 CreatePlane

Creates a raster image based on the equation for a simple plane.

Parameters:

| Flag | Description |
|--------------|--|
| --base | Input base raster file |
| -o, --output | Output raster file |
| --gradient | Slope gradient in degrees (-85.0 to 85.0) |
| --aspect | Aspect (direction) in degrees clockwise from north (0.0-360.0) |
| --constant | Constant value |

Python function:

```
create_plane(
    base,
    output,
    gradient=15.0,
    aspect=90.0,
```

```
constant=0.0,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CreatePlane -v --wd="/path/to/data/" ^
--base=base.tif -o>NewRaster.tif --gradient=15.0 ^
--aspect=315.0
```

8.2.8 CreateRectangularVectorGrid

Creates a rectangular vector grid.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --input | Input base file |
| -o, --output | Output vector polygon file |
| --width | The grid cell width |
| --height | The grid cell height |
| --xorig | The grid origin x-coordinate |
| --yorig | The grid origin y-coordinate |

Python function:

```
create_rectangular_vector_grid(
    i,
    output,
    width,
    height,
    xorig=0,
    yorig=0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CreateRectangularVectorGrid -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.shp --width=10.0 ^
--height=10.0 --xorig=0.0 --yorig=0.0
```

8.2.9 EliminateCoincidentPoints

Removes any coincident, or nearly coincident, points from a vector points file.

Parameters:

| Flag | Description |
|--------------|-----------------------------------|
| -i, --input | Input vector file |
| -o, --output | Output vector polygon file |
| --tolerance | The distance tolerance for points |

Python function:

```
eliminate_coincident_points(
    i,
    output,
    tolerance,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=EliminateCoincidentPoints -v ^
--wd="/path/to/data/" -i=input_file.shp -o=out_file.shp ^
--tolerance=0.01
```

8.2.10 ExtendVectorLines

Extends vector lines by a specified distance.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input vector polyline file |
| -o, --output | Output vector polyline file |
| --dist | The distance to extend |
| --extend | Extend direction, 'both ends' (default), 'line start', 'line end' |

Python function:

```
extend_vector_lines(
    i,
    output,
    dist,
    extend="both ends",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ExtendVectorLines -v ^
--wd="/path/to/data/" -i=in_file.shp -o=out_file.shp ^
--dist=10.0 --extend='both ends'
```

8.2.11 ExtractNodes

Converts vector lines or polygons into vertex points.

Parameters:

| Flag | Description |
|--------------|------------------------------------|
| -i, --input | Input vector lines or polygon file |
| -o, --output | Output vector points file |

Python function:

```
extract_nodes(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ExtractNodes -v --wd="/path/to/data/" ^
-i=file.shp -o=outfile.shp
```

8.2.12 ExtractRasterValuesAtPoints

Extracts the values of raster(s) at vector point locations.

Parameters:

| Flag | Description |
|--------------|--------------------------|
| -i, --inputs | Input raster files |
| --points | Input vector points file |

Python function:

```
extract_raster_values_at_points(
    inputs,
    points,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ExtractRasterValuesAtPoints -v ^
--wd="/path/to/data/" -i='image1.tif;image2.tif;image3.tif' ^
-points=points.shp
```

8.2.13 FindLowestOrHighestPoints

Locates the lowest and/or highest valued cells in a raster.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output vector points file |
| --out_type | Output type; one of 'area' (default) and 'volume' |

Python function:

```
find_lowest_or_highest_points(
    i,
    output,
    out_type="lowest",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FindLowestOrHighestPoints -v ^
--wd="/path/to/data/" --input=DEM.tif -o=out.shp ^
--out_type=highest
```

8.2.14 IdwInterpolation

Interpolates vector points into a raster surface using an inverse-distance weighted scheme.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| -i, --input | Input vector Points file |
| --field | Input field name in attribute table |
| --use_z | Use z-coordinate instead of field? |
| -o, --output | Output raster file |
| --weight | IDW weight value |

| Flag | Description |
|--------------|---|
| --radius | Search Radius |
| --min_points | Minimum number of points |
| --cell_size | Optionally specified cell size of output raster. Not used when base raster is specified |
| --base | Optionally specified input base raster file. Not used when a cell size is specified |

Python function:

```
idw_interpolation(
    i,
    field,
    output,
    use_z=False,
    weight=2.0,
    radius=None,
    min_points=None,
    cell_size=None,
    base=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=IdwInterpolation -v ^
--wd="/path/to/data/" -i=points.shp --field=ELEV -o=output.tif ^
--assign=min --nodata ^
--cell_size=10.0
      >>./whitebox_tools -r=IdwInterpolation ^
-v --wd="/path/to/data/" -i=points.shp --field=FID ^
-o=output.tif --assign=last --base=existing_raster.tif
```

8.2.15 Medoid

Calculates the medoid for a series of vector features contained in a shapefile.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input vector file |
| -o, --output | Output vector file |

Python function:

```
medoid(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Medoid -v --wd="/path/to/data/" ^
-i=in_file.shp -o=out_file.shp
```

8.2.16 MinimumBoundingBox

Creates a vector minimum bounding rectangle around vector features.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input vector file |
| -o, --output | Output vector polygon file |
| --features | Find the minimum bounding rectangles around each individual vector feature |

Python function:

```
minimum_bounding_box(
    i,
    output,
    features=True,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MinimumBoundingBox -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.shp --features
```

8.2.17 MinimumConvexHull

Creates a vector convex polygon around vector features.

Parameters:

| Flag | Description |
|-------------|-------------------|
| -i, --input | Input vector file |

| Flag | Description |
|--------------|---|
| -o, --output | Output vector polygon file |
| --features | Find the hulls around each vector feature |

Python function:

```
minimum_convex_hull(
    i,
    output,
    features=True,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MinimumConvexHull -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.shp --features
```

8.2.18 PolygonArea

Calculates the area of vector polygons.

Parameters:

| Flag | Description |
|-------------|---------------------------|
| -i, --input | Input vector polygon file |

Python function:

```
polygon_area(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PolygonArea -v --wd="/path/to/data/" ^
--input=points.shp
```

8.2.19 PolygonLongAxis

This tool can be used to map the long axis of polygon features.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --input | Input vector polygons file |
| -o, --output | Output vector polygon file |

Python function:

```
polygon_long_axis(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PolygonLongAxis -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.shp
```

8.2.20 PolygonPerimeter

Calculates the perimeter of vector polygons.

Parameters:

| Flag | Description |
|-------------|---------------------------|
| -i, --input | Input vector polygon file |

Python function:

```
polygon_perimeter(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PolygonPerimeter -v ^
--wd="/path/to/data/" --input=points.shp
```

8.2.21 PolygonShortAxis

This tool can be used to map the short axis of polygon features.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --input | Input vector polygons file |
| -o, --output | Output vector polygon file |

Python function:

```
polygon_short_axis(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PolygonShortAxis -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.shp
```

8.2.22 RasterCellAssignment

Assign row or column number to cells.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| -a, --assign | Which variable would you like to assign to grid cells? Options include 'column', 'row', 'x', and 'y' |

Python function:

```
raster_cell_assignment(
    i,
    output,
    assign="column",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RasterCellAssignment -v ^
--wd="/path/to/data/" -i='input.tif' -o=output.tif ^
--assign='column'
```

8.2.23 Reclass

Reclassifies the values in a raster image.

Parameters:

| Flag | Description |
|----------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --reclass_vals | Reclassification triplet values (new value; from value; to less than), e.g. '0.0;0.0;1.0;1.0;1.0;2.0' |
| --assign_mode | Optional Boolean flag indicating whether to operate in assign mode, reclass_vals values are interpreted as new value; old value pairs |

Python function:

```
reclass(
    i,
    output,
    reclass_vals,
    assign_mode=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Reclass -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif ^
--reclass_vals='0.0;0.0;1.0;1.0;1.0;2.0'
>>./whitebox_tools ^
-r=Reclass -v --wd="/path/to/data/" -i='input.tif' ^
-o=output.tif --reclass_vals='10;1;20;2;30;3;40;4' ^
--assign_mode
```

8.2.24 ReclassEqualInterval

Reclassifies the values in a raster image based on equal-ranges.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --interval | Class interval size |
| --start_val | Optional starting value (default is input minimum value) |

| Flag | Description |
|-----------|--|
| --end_val | Optional ending value (default is input maximum value) |

Python function:

```
reclass_equal_interval(
    i,
    output,
    interval=10.0,
    start_val=None,
    end_val=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ReclassEqualInterval -v ^
--wd="/path/to/data/" -i='input.tif' -o=output.tif ^
--interval=10.0 --start_val=0.0
```

8.2.25 ReclassFromFile

Reclassifies the values in a raster image using reclass ranges in a text file.

Parameters:

| Flag | Description |
|----------------|---|
| -i, --input | Input raster file |
| --reclass_file | Input text file containing reclass ranges |
| -o, --output | Output raster file |

Python function:

```
reclass_from_file(
    i,
    reclass_file,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ReclassFromFile -v ^
--wd="/path/to/data/" -i='input.tif' ^
--reclass_file='reclass.txt' -o=output.tif
```

8.2.26 TinGridding

Creates a raster grid based on a triangular irregular network (TIN) fitted to vector points.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input vector points file |
| --field | Input field name in attribute table |
| --use_z | Use the 'z' dimension of the Shapefile's geometry instead of an attribute field? |
| -o, --output | Output vector polygon file |
| --resolution | Output raster's grid resolution |

Python function:

```
tin_gridding(
    i,
    output,
    resolution,
    field=None,
    use_z=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TINGridding -v --wd="/path/to/data/" ^
-i=points.shp --field=HEIGHT -o=tin.shp ^
--resolution=10.0
>>./whitebox_tools -r=TINGridding -v ^
--wd="/path/to/data/" -i=points.shp --use_z -o=tin.shp ^
--resolution=5.0
```

8.2.27 VectorHexBinning

Hex-bins a set of vector points.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input base file |
| -o, --output | Output vector polygon file |
| --width | The grid cell width |
| --orientation | Grid Orientation, 'horizontal' or 'vertical' |

Python function:

```
vector_hex_binning(
    i,
    output,
    width,
    orientation="horizontal",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=VectorHexBinning -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.shp --width=10.0 ^
--orientation=vertical
```

8.3 GIS Analysis => Distance Tools

8.3.1 BufferRaster

Maps a distance-based buffer around each non-background (non-zero/non-nodata) grid cell in an input image.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --size | Buffer size |
| --gridcells | Optional flag to indicate that the 'size' threshold should be measured in grid cells instead of the default map units |

Python function:

```
buffer_raster(
    i,
    output,
    size,
    gridcells=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BufferRaster -v --wd="/path/to/data/" ^
-i=DEM.tif -o=output.tif
```

8.3.2 CostAllocation

Identifies the source cell to which each grid cell is connected by a least-cost pathway in a cost-distance analysis.

Parameters:

| Flag | Description |
|--------------|--|
| --source | Input source raster file |
| --backlink | Input backlink raster file generated by the cost-distance tool |
| -o, --output | Output raster file |

Python function:

```
cost_allocation(
    source,
    backlink,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CostAllocation -v --wd="/path/to/data/" ^
--source='source.tif' --backlink='backlink.tif' ^
-o='output.tif'
```

8.3.3 CostDistance

Performs cost-distance accumulation on a cost surface and a group of source cells.

Parameters:

| Flag | Description |
|----------------|--------------------------------------|
| --source | Input source raster file |
| --cost | Input cost (friction) raster file |
| --out_accum | Output cost accumulation raster file |
| --out_backlink | Output backlink raster file |

Python function:

```
cost_distance(
    source,
    cost,
    out_accum,
```

```
    out_backlink,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CostDistance -v --wd="/path/to/data/" ^
--source=src.tif --cost=cost.tif --out_accum=accum.tif ^
--out_backlink=backlink.tif
```

8.3.4 CostPathway

Performs cost-distance pathway analysis using a series of destination grid cells.

Parameters:

| Flag | Description |
|-------------------|---|
| --destination | Input destination raster file |
| --backlink | Input backlink raster file generated by the cost-distance tool |
| -o, --output | Output cost pathway raster file |
| --zero_background | Flag indicating whether zero values should be treated as a background |

Python function:

```
cost_pathway(
    destination,
    backlink,
    output,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CostPathway -v --wd="/path/to/data/" ^
--destination=dst.tif --backlink=backlink.tif ^
--output=cost_path.tif
```

8.3.5 EuclideanAllocation

Assigns grid cells in the output raster the value of the nearest target cell in the input image, measured by the Shih and Wu (2004) Euclidean distance transform.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
euclidean_allocation(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=EuclideanAllocation -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.3.6 EuclideanDistance

Calculates the Shih and Wu (2004) Euclidean distance transform.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
euclidean_distance(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=EuclideanDistance -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.4 GIS Analysis => Overlay Tools

8.4.1 AverageOverlay

Calculates the average for each grid cell from a group of raster images.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |

Python function:

```
average_overlay(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AverageOverlay -v --wd='/path/to/data/' ^
-i='image1.dep;image2.dep;image3.tif' -o=output.tif
```

8.4.2 ClipRasterToPolygon

Clips a raster to a vector polygon.

Parameters:

| Flag | Description |
|----------------------|------------------------------------|
| -i, --input | Input raster file |
| --polygons | Input vector polygons file |
| -o, --output | Output raster file |
| --maintain_dimension | sMaintain input raster dimensions? |

Python function:

```
clip_raster_to_polygon(
    i,
    polygons,
    output,
    maintain_dimensions=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ClipRasterToPolygon -v ^
--wd="/path/to/data/" -i=raster.tif --polygons=poly.shp ^
-o=output.tif --maintain_dimensions
```

8.4.3 CountIf

Counts the number of occurrences of a specified value in a cell-stack of rasters.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |
| --value | Search value (e.g. countif value = 5.0) |

Python function:

```
count_if(
    inputs,
    output,
    value,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CountIf -v --wd='/path/to/data/' ^
-i='image1.dep;image2.dep;image3.tif' -o=output.tif ^
--value=5.0
```

8.4.4 ErasePolygonFromRaster

Erases (cuts out) a vector polygon from a raster.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --input | Input raster file |
| --polygons | Input vector polygons file |
| -o, --output | Output raster file |

Python function:

```
erase_polygon_from_raster(
    i,
    polygons,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ErasePolygonFromRaster -v ^
--wd="/path/to/data/" -i='DEM.tif' --polygons='lakes.shp' ^
-o='output.tif'
```

8.4.5 HighestPosition

Identifies the stack position of the maximum value within a raster stack on a cell-by-cell basis.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |

Python function:

```
highest_position(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HighestPosition -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
-o=output.tif
```

8.4.6 LowestPosition

Identifies the stack position of the minimum value within a raster stack on a cell-by-cell basis.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |

Python function:

```
lowest_position(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LowestPosition -v --wd='/path/to/data/' ^
-i='image1.tif;image2.tif;image3.tif' -o=output.tif
```

8.4.7 MaxAbsoluteOverlay

Evaluates the maximum absolute value for each grid cell from a stack of input rasters.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |

Python function:

```
max_absolute_overlay(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxAbsoluteOverlay -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
-o=output.tif
```

8.4.8 MaxOverlay

Evaluates the maximum value for each grid cell from a stack of input rasters.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |

Python function:

```
max_overlay(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxOverlay -v --wd='/path/to/data/' ^
-i='image1.tif;image2.tif;image3.tif' -o=output.tif
```

8.4.9 MinAbsoluteOverlay

Evaluates the minimum absolute value for each grid cell from a stack of input rasters.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |

Python function:

```
min_absolute_overlay(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MinAbsoluteOverlay -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
-o=output.tif
```

8.4.10 MinOverlay

Evaluates the minimum value for each grid cell from a stack of input rasters.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |

Python function:

```
min_overlay(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MinOverlay -v --wd='/path/to/data/' ^
-i='image1.tif;image2.tif;image3.tif' -o=output.tif
```

8.4.11 PercentEqualTo

Calculates the percentage of a raster stack that have cell values equal to an input on a cell-by-cell basis.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --inputs | Input raster files |
| --comparison | Input comparison raster file |
| -o, --output | Output raster file |

Python function:

```
percent_equal_to(
    inputs,
    comparison,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PercentEqualTo -v --wd='/path/to/data/' ^
-i='image1.tif;image2.tif;image3.tif' -o=output.tif
```

```
-i='image1.tif;image2.tif;image3.tif' --comparison='comp.tif' ^
-o='output.tif'
```

8.4.12 PercentGreaterThan

Calculates the percentage of a raster stack that have cell values greater than an input on a cell-by-cell basis.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --inputs | Input raster files |
| --comparison | Input comparison raster file |
| -o, --output | Output raster file |

Python function:

```
percent_greater_than(
    inputs,
    comparison,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PercentGreaterThan -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
--comparison='comp.tif' -o='output.tif'
```

8.4.13 PercentLessThan

Calculates the percentage of a raster stack that have cell values less than an input on a cell-by-cell basis.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --inputs | Input raster files |
| --comparison | Input comparison raster file |
| -o, --output | Output raster file |

Python function:

```
percent_less_than(
    inputs,
    comparison,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PercentLessThan -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
--comparison='comp.tif' -o='output.tif'
```

8.4.14 PickFromList

Outputs the value from a raster stack specified by a position raster.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --inputs | Input raster files |
| --pos_input | Input position raster file |
| -o, --output | Output raster file |

Python function:

```
pick_from_list(
    inputs,
    pos_input,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PickFromList -v --wd='/path/to/data/' ^
--pos_input=position.tif -i='image1.tif;image2.tif;image3.tif' ^
-o=output.tif
```

8.4.15 WeightedOverlay

Performs a weighted sum on multiple input rasters after converting each image to a common scale. The tool performs a multi-criteria evaluation (MCE).

Parameters:

| Flag | Description |
|---------------|--|
| --factors | Input factor raster files |
| -w, --weights | Weight values, contained in quotes and separated by commas or semicolons. Must have the same number as factors |
| --cost | Weight values, contained in quotes and separated by commas or semicolons. Must have the same number as factors |
| --constraints | Input constraints raster files |
| -o, --output | Output raster file |
| --scale_max | Suitability scale maximum value (common values are 1.0, 100.0, and 255.0) |

Python function:

```
weighted_overlay(
    factors,
    weights,
    output,
    cost=None,
    constraints=None,
    scale_max=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=WeightedOverlay -v ^
--wd='/path/to/data/' ^
--factors='image1.tif;image2.tif;image3.tif' ^
--weights='0.3;0.2;0.5' --cost='false;false;true' -o=output.tif ^
--scale_max=100.0
```

8.4.16 WeightedSum

Performs a weighted-sum overlay on multiple input raster images.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --inputs | Input raster files |
| -w, --weights | Weight values, contained in quotes and separated by commas or semicolons |
| -o, --output | Output raster file |

Python function:

```
weighted_sum(
    inputs,
    weights,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=WeightedSum -v --wd='/path/to/data/' ^
-i='image1.tif;image2.tif;image3.tif' --weights='0.3;0.2;0.5' ^
-o=output.tif
```

8.5 GIS Analysis => Patch Shape Tools

8.5.1 EdgeProportion

Calculate the proportion of cells in a raster polygon that are edge cells.

Parameters:

| Flag | Description |
|---------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --output_text | flag indicating whether a text report should also be output |

Python function:

```
edge_proportion(
    i,
    output,
    output_text=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=EdgeProportion -v --wd="/path/to/data/" ^
-i=input.tif -o=output.tif --output_text
```

8.5.2 ElongationRatio

Calculates the elongation ratio for vector polygons.

Parameters:

| Flag | Description |
|-------------|---------------------------|
| -i, --input | Input vector polygon file |

Python function:

```
elongation_ratio(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ElongationRatio -v ^
--wd="/path/to/data/" --input=points.shp
```

8.5.3 FindPatchOrClassEdgeCells

Finds all cells located on the edge of patch or class features.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
find_patch_or_class_edge_cells(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FindPatchOrClassEdgeCells -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif
```

8.5.4 PerimeterAreaRatio

Calculates the perimeter-area ratio of vector polygons.

Parameters:

| Flag | Description |
|-------------|---------------------------|
| -i, --input | Input vector polygon file |

Python function:

```
perimeter_area_ratio(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PerimeterAreaRatio -v ^
--wd="/path/to/data/" --input=points.shp
```

8.5.5 RadiusOfGyration

Calculates the distance of cells from their polygon's centroid.

Parameters:

| Flag | Description |
|---------------|----------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --text_output | Optional text output |

Python function:

```
radius_of_gyration(
    i,
    output,
    text_output=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RadiusOfGyration -v ^
--wd="/path/to/data/" -i=polygons.tif -o=output.tif ^
--text_output
```

8.5.6 ShapeComplexityIndex

Calculates overall polygon shape complexity or irregularity.

Parameters:

| Flag | Description |
|-------------|---------------------------|
| -i, --input | Input vector polygon file |

Python function:

```
shape_complexity_index(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ShapeComplexityIndex -v ^
--wd="/path/to/data/" --input=points.shp
```

8.6 Geomorphometric Analysis

8.6.1 Aspect

Calculates an aspect raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
aspect(
    dem,
    output,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Aspect -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.6.2 DevFromMeanElev

Calculates deviation from mean elevation.

Parameters:

| Flag | Description |
|--------------------|--|
| -i, --input, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
dev_from_mean_elev(
    dem,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DevFromMeanElev -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--filter=25
```

8.6.3 DiffFromMeanElev

Calculates difference from mean elevation (equivalent to a high-pass filter).

Parameters:

| Flag | Description |
|--------------------|--|
| -i, --input, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
diff_from_mean_elev(
    dem,
    output,
```

```
filterx=11,
filtery=11,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DiffFromMeanElev -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--filter=25
```

8.6.4 DirectionalRelief

Calculates relief for cells in an input DEM for a specified direction.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --azimuth | Wind azimuth in degrees |
| --max_dist | Optional maximum search distance (unspecified if none; in xy units) |

Python function:

```
directional_relief(
    dem,
    output,
    azimuth=0.0,
    max_dist=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DirectionalRelief -v ^
--wd="/path/to/data/" -i='input.tif' -o=output.tif ^
--azimuth=315.0
```

8.6.5 DownslopeIndex

Calculates the Hjerdt et al. (2004) downslope index.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --drop | Vertical drop value (default is 2.0) |
| --out_type | Output type, options include 'tangent', 'degrees', 'radians', 'distance' (default is 'tangent') |

Python function:

```
downslope_index(
    dem,
    output,
    drop=2.0,
    out_type="tangent",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DownslopeIndex -v --wd="/path/to/data/" ^
--dem=pointer.tif -o=dsi.tif --drop=5.0 --out_type=distance
```

8.6.6 DrainagePreservingSmoothing

Reduces short-scale variation in an input DEM while preserving breaks-in-slope and small drainage features using a modified Sun et al. (2007) algorithm.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --filter | Size of the filter kernel |
| --norm_diff | Maximum difference in normal vectors, in degrees |
| --num_iter | Number of iterations |
| --reduction | Maximum Amount to reduce the threshold angle by (0 = full smoothing; 100 = no smoothing) |
| --dfm | Difference from median threshold (in z-units), determines when a location is low-lying |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
drainage_preserving_smoothing(
    dem,
    output,
    filter=11,
    norm_diff=8.0,
    num_iter=5,
    reduction=80.0,
    dfm=0.15,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DrainagePreservingSmoothing -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif --filter=15 ^
--norm_diff=20.0 --num_iter=4 --reduction=90.0 --dfm=0.15
```

8.6.7 ElevAbovePit

Calculate the elevation of each grid cell above the nearest downstream pit cell or grid edge cell.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
elev_above_pit(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ElevAbovePit -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.6.8 ElevPercentile

Calculates the elevation percentile raster from a DEM.

Parameters:

| Flag | Description |
|--------------------|--|
| -i, --input, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |
| --sig_digits | Number of significant digits |

Python function:

```
elev_percentile(
    dem,
    output,
    filterx=11,
    filtery=11,
    sig_digits=2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ElevPercentile -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif --filter=25
```

8.6.9 ElevRelativeToMinMax

Calculates the elevation of a location relative to the minimum and maximum elevations in a DEM.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
elev_relative_to_min_max(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ElevRelativeToMinMax -v ^
```

```
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.6.10 ElevRelativeToWatershedMinMax

Calculates the elevation of a location relative to the minimum and maximum elevations in a watershed.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --dem | Input raster DEM file |
| --watersheds | Input raster watersheds file |
| -o, --output | Output raster file |

Python function:

```
elev_relative_to_watershed_min_max(
    dem,
    watersheds,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ElevRelativeToWatershedMinMax -v ^
--wd="/path/to/data/" --dem=DEM.tif --watersheds=watershed.tif ^
-o=output.tif
```

8.6.11 FeaturePreservingDenoise

Reduces short-scale variation in an input DEM using a modified Sun et al. (2007) algorithm.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --filter | Size of the filter kernel |
| --norm_diff | Maximum difference in normal vectors, in degrees |
| --num_iter | Number of iterations |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
feature_preserving_denoise(
    dem,
    output,
    filter=11,
    norm_diff=8.0,
    num_iter=5,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FeaturePreservingDenoise -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif --filter=15 ^
--norm_diff=20.0 --num_iter=4
```

8.6.12 FetchAnalysis

Performs an analysis of fetch or upwind distance to an obstacle.

Parameters:

| Flag | Description |
|--------------|------------------------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --azimuth | Wind azimuth in degrees in degrees |
| --hgt_inc | Height increment value |

Python function:

```
fetch_analysis(
    dem,
    output,
    azimuth=0.0,
    hgt_inc=0.05,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FetchAnalysis -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif --azimuth=315.0
```

8.6.13 FillMissingData

Fills nodata holes in a DEM.

Parameters:

| Flag | Description |
|--------------|---------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filter | Filter size (cells) |
| --weight | IDW weight value |

Python function:

```
fill_missing_data(
    i,
    output,
    filter=11,
    weight=2.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FillMissingData -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif --filter=25 ^
--weight=1.0
```

8.6.14 FindRidges

Identifies potential ridge and peak grid cells.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --line_thin | Optional flag indicating whether post-processing line-thinning should be performed |

Python function:

```
find_ridges(
    dem,
    output,
```

```
line_thin=True,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FindRidges -v --wd="/path/to/data/" ^
--dem=pointer.tif -o=out.tif --line_thin
```

8.6.15 Hillshade

Calculates a hillshade raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --azimuth | Illumination source azimuth in degrees |
| --altitude | Illumination source altitude in degrees |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
hillshade(
    dem,
    output,
    azimuth=315.0,
    altitude=30.0,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Hillshade -v --wd="/path/to/data/" ^
-i=DEM.tif -o=output.tif --azimuth=315.0 --altitude=30.0
```

8.6.16 HorizonAngle

Calculates horizon angle (maximum upwind slope) for each grid cell in an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --azimuth | Wind azimuth in degrees |
| --max_dist | Optional maximum search distance (unspecified if none; in xy units) |

Python function:

```
horizon_angle(
    dem,
    output,
    azimuth=0.0,
    max_dist=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HorizonAngle -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif --azimuth=315.0
```

8.6.17 HypsometricAnalysis

Calculates a hypsometric curve for one or more DEMs.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --inputs | Input DEM files |
| --watershed | Input watershed files (optional) |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
hypsomeric_analysis(
    inputs,
    output,
    watershed=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HypsometricAnalysis -v ^
--wd="/path/to/data/" -i="DEM1.tif;DEM2.tif" ^
--watershed="ws1.tif;ws2.tif" -o=outfile.html
```

8.6.18 MaxAnisotropyDev

Calculates the maximum anisotropy (directionality) in elevation deviation over a range of spatial scales.

Parameters:

| Flag | Description |
|-------------|---|
| -i, --dem | Input raster DEM file |
| --out_mag | Output raster DEVmax magnitude file |
| --out_scale | Output raster DEVmax scale file |
| --min_scale | Minimum search neighbourhood radius in grid cells |
| --max_scale | Maximum search neighbourhood radius in grid cells |
| --step | Step size as any positive non-zero integer |

Python function:

```
max_anisotropy_dev(
    dem,
    out_mag,
    out_scale,
    max_scale,
    min_scale=3,
    step=2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxAnisotropyDev -v ^
--wd="/path/to/data/" --dem=DEM.tif --out_mag=DEVmax_mag.tif ^
--out_scale=DEVmax_scale.tif --min_scale=1 --max_scale=1000 ^
--step=5
```

8.6.19 MaxAnisotropyDevSignature

Calculates the anisotropy in deviation from mean for points over a range of spatial scales.

Parameters:

| Flag | Description |
|-----------|--------------------------|
| -i, --dem | Input raster DEM file |
| --points | Input vector points file |

| Flag | Description |
|--------------|---|
| -o, --output | Output HTML file |
| --min_scale | Minimum search neighbourhood radius in grid cells |
| --max_scale | Maximum search neighbourhood radius in grid cells |
| --step | Step size as any positive non-zero integer |

Python function:

```
max_anisotropy_dev_signature(
    dem,
    points,
    output,
    max_scale,
    min_scale=1,
    step=1,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxAnisotropyDevSignature -v ^
--wd="/path/to/data/" --dem=DEM.tif --points=sites.shp ^
--output=roughness.html --min_scale=1 --max_scale=1000 ^
--step=5
```

8.6.20 MaxBranchLength

Lindsay and Seibert's (2013) branch length index is used to map drainage divides or ridge lines.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --log | Optional flag to request the output be log-transformed |

Python function:

```
max_branch_length(
    dem,
    output,
    log=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxBranchLength -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.6.21 MaxDifferenceFromMean

Calculates the maximum difference from mean elevation over a range of spatial scales.

Parameters:

| Flag | Description |
|-------------|---|
| -i, --dem | Input raster DEM file |
| --out_mag | Output raster DIFFmax magnitude file |
| --out_scale | Output raster DIFFmax scale file |
| --min_scale | Minimum search neighbourhood radius in grid cells |
| --max_scale | Maximum search neighbourhood radius in grid cells |
| --step | Step size as any positive non-zero integer |

Python function:

```
max_difference_from_mean(
    dem,
    out_mag,
    out_scale,
    min_scale,
    max_scale,
    step=1,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxDifferenceFromMean -v ^
--wd="/path/to/data/" --dem=DEM.tif --out_mag=DEVmax_mag.tif ^
--out_scale=DEVmax_scale.tif --min_scale=1 --max_scale=1000 ^
--step=5
```

8.6.22 MaxDownslopeElevChange

Calculates the maximum downslope change in elevation between a grid cell and its eight downslope neighbors.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
max_downslope_elev_change(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxDownslopeElevChange -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=out.tif
```

8.6.23 MaxElevDevSignature

Calculates the maximum elevation deviation over a range of spatial scales and for a set of points.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| --points | Input vector points file |
| -o, --output | Output HTML file |
| --min_scale | Minimum search neighbourhood radius in grid cells |
| --max_scale | Maximum search neighbourhood radius in grid cells |
| --step | Step size as any positive non-zero integer |

Python function:

```
max_elev_dev_signature(
    dem,
    points,
    output,
    min_scale,
    max_scale,
    step=10,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxElevDevSignature -v ^
```

```
--wd="/path/to/data/" --dem=DEM.tif --points=sites.tif ^
--output=topo_position.html --min_scale=1 --max_scale=1000 ^
--step=5
```

8.6.24 MaxElevationDeviation

Calculates the maximum elevation deviation over a range of spatial scales.

Parameters:

| Flag | Description |
|-------------|---|
| -i, --dem | Input raster DEM file |
| --out_mag | Output raster DEVmax magnitude file |
| --out_scale | Output raster DEVmax scale file |
| --min_scale | Minimum search neighbourhood radius in grid cells |
| --max_scale | Maximum search neighbourhood radius in grid cells |
| --step | Step size as any positive non-zero integer |

Python function:

```
max_elevation_deviation(
    dem,
    out_mag,
    out_scale,
    min_scale,
    max_scale,
    step=1,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxElevationDeviation -v ^
--wd="/path/to/data/" --dem=DEM.tif --out_mag=DEVmax_mag.tif ^
--out_scale=DEVmax_scale.tif --min_scale=1 --max_scale=1000 ^
--step=5
```

8.6.25 MinDownslopeElevChange

Calculates the minimum downslope change in elevation between a grid cell and its eight downslope neighbors.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
min_downslope_elev_change(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MinDownslopeElevChange -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=out.tif
```

8.6.26 MultiscaleRoughness

Calculates surface roughness over a range of spatial scales.

Parameters:

| Flag | Description |
|-------------|---|
| -i, --dem | Input raster DEM file |
| --out_mag | Output raster roughness magnitude file |
| --out_scale | Output raster roughness scale file |
| --min_scale | Minimum search neighbourhood radius in grid cells |
| --max_scale | Maximum search neighbourhood radius in grid cells |
| --step | Step size as any positive non-zero integer |

Python function:

```
multiscale_roughness(
    dem,
    out_mag,
    out_scale,
    max_scale,
    min_scale=1,
    step=1,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MultiscaleRoughness -v ^
```

```
--wd="/path/to/data/" --dem=DEM.tif --out_mag=roughness_mag.tif ^
--out_scale=roughness_scale.tif --min_scale=1 --max_scale=1000 ^
--step=5
```

8.6.27 MultiscaleRoughnessSignature

Calculates the surface roughness for points over a range of spatial scales.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| --points | Input vector points file |
| -o, --output | Output HTML file |
| --min_scale | Minimum search neighbourhood radius in grid cells |
| --max_scale | Maximum search neighbourhood radius in grid cells |
| --step | Step size as any positive non-zero integer |

Python function:

```
multiscale_roughness_signature(
    dem,
    points,
    output,
    max_scale,
    min_scale=1,
    step=1,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MultiscaleRoughnessSignature -v ^
--wd="/path/to/data/" --dem=DEM.tif --points=sites.shp ^
--output=roughness.html --min_scale=1 --max_scale=1000 ^
--step=5
```

8.6.28 MultiscaleTopographicPositionImage

Creates a multiscale topographic position image from three DEVmax rasters of differing spatial scale ranges.

Parameters:

| Flag | Description |
|--------------|---|
| --local | Input local-scale topographic position (DEVmax) raster file |
| --meso | Input meso-scale topographic position (DEVmax) raster file |
| --broad | Input broad-scale topographic position (DEVmax) raster file |
| -o, --output | Output raster file |
| --lightness | Image lightness value (default is 1.2) |

Python function:

```
multiscale_topographic_position_image(
    local,
    meso,
    broad,
    output,
    lightness=1.2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MultiscaleTopographicPositionImage -v ^
--wd="/path/to/data/" --local=DEV_local.tif --meso=DEV_meso.tif ^
--broad=DEV_broad.tif -o=output.tif --lightness=1.5
```

8.6.29 NumDownslopeNeighbours

Calculates the number of downslope neighbours to each grid cell in a DEM.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
num_downslope_neighbours(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NumDownslopeNeighbours -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.6.30 NumUpslopeNeighbours

Calculates the number of upslope neighbours to each grid cell in a DEM.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
num_upslope_neighbours(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NumUpslopeNeighbours -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.6.31 PennockLandformClass

Classifies hillslope zones based on slope, profile curvature, and plan curvature.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --slope | Slope threshold value, in degrees (default is 3.0) |
| --prof | Profile curvature threshold value (default is 0.1) |
| --plan | Plan curvature threshold value (default is 0.0) |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
pennock_landform_class(
    dem,
    output,
```

```
slope=3.0,
prof=0.1,
plan=0.0,
zfactor=1.0,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PennockLandformClass -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif --slope=3.0 ^
--prof=0.1 --plan=0.0
```

8.6.32 PercentElevRange

Calculates percent of elevation range from a DEM.

Parameters:

| Flag | Description |
|--------------------|--|
| -i, --input, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
percent_elev_range(
    dem,
    output,
    filterx=3,
    filtery=3,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PercentElevRange -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif --filter=25
```

8.6.33 PlanCurvature

Calculates a plan (contour) curvature raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
plan_curvature(
    dem,
    output,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PlanCurvature -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.6.34 Profile

Plots profiles from digital surface models.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| --lines | Input vector line file |
| --surface | Input raster surface file |
| -o, --output | Output HTML file |

Python function:

```
profile(
    lines,
    surface,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Profile -v --wd="/path/to/data/" ^
--lines=profile.shp --surface=dem.tif -o=profile.html
```

8.6.35 ProfileCurvature

Calculates a profile curvature raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
profile_curvature(
    dem,
    output,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ProfileCurvature -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.6.36 RelativeAspect

Calculates relative aspect (relative to a user-specified direction) from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --azimuth | Illumination source azimuth |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
relative_aspect(
    dem,
    output,
    azimuth=0.0,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RelativeAspect -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif --azimuth=180.0
```

8.6.37 RelativeStreamPowerIndex

Calculates the relative stream power index.

Parameters:

| Flag | Description |
|--------------|--|
| --sca | Input raster specific contributing area (SCA) file |
| --slope | Input raster slope file |
| -o, --output | Output raster file |
| --exponent | SCA exponent value |

Python function:

```
relative_stream_power_index(
    sca,
    slope,
    output,
    exponent=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RelativeStreamPowerIndex -v ^
--wd="/path/to/data/" --sca='flow_accum.tif' ^
--slope='slope.tif' -o=output.tif --exponent=1.1
```

8.6.38 RelativeTopographicPosition

Calculates the relative topographic position index from a DEM.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

| Flag | Description |
|-----------|--|
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
relative_topographic_position(
    dem,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RelativeTopographicPosition -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--filter=25
```

8.6.39 RemoveOffTerrainObjects

Removes off-terrain objects from a raster digital elevation model (DEM).

Parameters:

| Flag | Description |
|--------------------|-----------------------|
| -i, --input, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --filter | Filter size (cells) |
| --slope | Slope threshold value |

Python function:

```
remove_off_terrain_objects(
    dem,
    output,
    filter=11,
    slope=15.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RemoveOffTerrainObjects -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=bare_earth_DEM.tif ^
```

```
--filter=25 --slope=10.0
```

8.6.40 RuggednessIndex

Calculates the Riley et al.'s (1999) terrain ruggedness index from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
ruggedness_index(
    dem,
    output,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RuggednessIndex -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.6.41 SedimentTransportIndex

Calculates the sediment transport index.

Parameters:

| Flag | Description |
|------------------|--|
| --sca | Input raster specific contributing area (SCA) file |
| --slope | Input raster slope file |
| -o, --output | Output raster file |
| --sca_exponent | SCA exponent value |
| --slope_exponent | Slope exponent value |

Python function:

```
sediment_transport_index(
    sca,
    slope,
    output,
    sca_exponent=0.4,
    slope_exponent=1.3,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SedimentTransportIndex -v ^
--wd="/path/to/data/" --sca='flow_accum.tif' ^
--slope='slope.tif' -o=output.tif --sca_exponent=0.5 ^
--slope_exponent=1.0
```

8.6.42 Slope

Calculates a slope raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
slope(
    dem,
    output,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Slope -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.6.43 SlopeVsElevationPlot

Creates a slope vs. elevation plot for one or more DEMs.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --inputs | Input DEM files |
| --watershed | Input watershed files (optional) |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
slope_vs_elevation_plot(
    inputs,
    output,
    watershed=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SlopeVsElevationPlot -v ^
--wd="/path/to/data/" -i="DEM1.tif;DEM2.tif" ^
--watershed="ws1.tif;ws2.tif" -o=outfile.html
```

8.6.44 StandardDeviationOfSlope

Calculates the standard deviation of slope from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster DEM file |
| -o, --output | Output raster DEM file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
standard_deviation_of_slope(
    i,
    output,
    zfactor=1.0,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StandardDeviationOfSlope -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.6.45 TangentialCurvature

Calculates a tangential curvature raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
tangential_curvature(
    dem,
    output,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TangentialCurvature -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.6.46 TotalCurvature

Calculates a total curvature raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zfactor | Optional multiplier for when the vertical and horizontal units are not the same |

Python function:

```
total_curvature(
    dem,
    output,
    zfactor=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TotalCurvature -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.6.47 Viewshed

Identifies the viewshed for a point or set of points.

Parameters:

| Flag | Description |
|--------------|------------------------------------|
| --dem | Input raster DEM file |
| --stations | Input viewing station vector file |
| -o, --output | Output raster file |
| --height | Viewing station height, in z units |

Python function:

```
viewshed(
    dem,
    stations,
    output,
    height=2.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Viewshed -v --wd="/path/to/data/" ^
--dem='dem.tif' --stations='stations.shp' -o=output.tif ^
--height=10.0
```

8.6.48 VisibilityIndex

Estimates the relative visibility of sites in a DEM.

Parameters:

| Flag | Description |
|--------------|--|
| --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --height | Viewing station height, in z units |
| --res_factor | The resolution factor determines the density of measured viewsheds |

Python function:

```
visibility_index(
    dem,
    output,
    height=2.0,
    res_factor=2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=VisibilityIndex -v ^
--wd="/path/to/data/" --dem=dem.tif -o=output.tif ^
--height=10.0 --res_factor=4
```

8.6.49 WetnessIndex

Calculates the topographic wetness index, $\ln(A / \tan(slope))$.

Parameters:

| Flag | Description |
|--------------|--|
| --sca | Input raster specific contributing area (SCA) file |
| --slope | Input raster slope file |
| -o, --output | Output raster file |

Python function:

```
wetness_index(
    sca,
    slope,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=WetnessIndex -v --wd="/path/to/data/" ^
--sca='flow_accum.tif' --slope='slope.tif' -o=output.tif
```

8.7 Hydrological Analysis

8.7.1 AverageFlowpathSlope

Measures the average slope gradient from each grid cell to all upslope divide cells.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
average_flowpath_slope(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AverageFlowpathSlope -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.7.2 AverageUpslopeFlowpathLength

Measures the average length of all upslope flowpaths draining each grid cell.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
average_upslope_flowpath_length(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AverageUpslopeFlowpathLength -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.7.3 Basins

Identifies drainage basins that drain to the DEM edge.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --d8_pntr | Input raster D8 pointer file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
basins(
    d8_pntr,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Basins -v --wd="/path/to/data/" ^
--d8_pntr='d8ptr.tif' -o='output.tif'
```

8.7.4 BreachDepressions

Breaches all of the depressions in a DEM using Lindsay's (2016) algorithm. This should be preferred over depression filling in most cases.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --max_depth | Optional maximum breach depth (default is Inf) |
| --max_length | Optional maximum breach channel length (in grid cells; default is Inf) |

Python function:

```
breach_depressions(
    dem,
    output,
    max_depth=None,
    max_length=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BreachDepressions -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.7.5 BreachSingleCellPits

Removes single-cell pits from an input DEM by breaching.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
breach_single_cell_pits(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BreachSingleCellPits -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif
```

8.7.6 D8FlowAccumulation

Calculates a D8 flow accumulation raster from an input DEM.

Parameters:

| Flag | Description |
|-----------|-----------------------|
| -i, --dem | Input raster DEM file |

| Flag | Description |
|--------------|---|
| -o, --output | Output raster file |
| --out_type | Output type; one of 'cells', 'specific contributing area' (default), and 'catchment area' |
| --log | Optional flag to request the output be log-transformed |
| --clip | Optional flag to request clipping the display max by 1% |

Python function:

```
d8_flow_accumulation(
    dem,
    output,
    out_type="specific contributing area",
    log=False,
    clip=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=D8FlowAccumulation -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.dtifep ^
--out_type='cells'
>>./whitebox_tools -r=D8FlowAccumulation -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--out_type='specific catchment area' --log --clip
```

8.7.7 D8MassFlux

Performs a D8 mass flux calculation.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| --dem | Input raster DEM file |
| --loading | Input loading raster file |
| --efficiency | Input efficiency raster file |
| --absorption | Input absorption raster file |
| -o, --output | Output raster file |

Python function:

```
d8_mass_flux(
    dem,
```

```
loading,
efficiency,
absorption,
output,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=D8MassFlux -v --wd="/path/to/data/" ^
--dem=DEM.tif --loading=load.tif --efficiency=eff.tif ^
--absorption=abs.tif -o=output.tif
```

8.7.8 D8Pointer

Calculates a D8 flow pointer raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
d8_pointer(
    dem,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=D8Pointer -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.7.9 DInfFlowAccumulation

Calculates a D-infinity flow accumulation raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --out_type | Output type; one of 'cells', 'sca' (default), and 'ca' |
| --threshold | Optional convergence threshold parameter, in grid cells; default is infinity |
| --log | Optional flag to request the output be log-transformed |
| --clip | Optional flag to request clipping the display max by 1% |

Python function:

```
d_inf_flow_accumulation(
    dem,
    output,
    out_type="Specific Contributing Area",
    threshold=None,
    log=False,
    clip=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DInfFlowAccumulation -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--out_type=sca
>>./whitebox_tools -r=DInfFlowAccumulation -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--out_type=sca --threshold=10000 --log --clip
```

8.7.10 DInfMassFlux

Performs a D-infinity mass flux calculation.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| --dem | Input raster DEM file |
| --loading | Input loading raster file |
| --efficiency | Input efficiency raster file |
| --absorption | Input absorption raster file |
| -o, --output | Output raster file |

Python function:

```
d_inf_mass_flux(
    dem,
    loading,
    efficiency,
    absorption,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DInfMassFlux -v --wd="/path/to/data/" ^
--dem=DEM.tif --loading=load.tif --efficiency=eff.tif ^
--absorption=abs.tif -o=output.tif
```

8.7.11 DInfpPointer

Calculates a D-infinity flow pointer (flow direction) raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
d_inf_pointer(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DInfpPointer -v --wd="/path/to/data/" ^
--dem=DEM.tif
```

8.7.12 DepthInSink

Measures the depth of sinks (depressions) in a DEM.

Parameters:

| Flag | Description |
|-------------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zero_background | Flag indicating whether the background value of zero should be used |

Python function:

```
depth_in_sink(
    dem,
    output,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DepthInSink -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif --zero_background
```

8.7.13 DownslopeDistanceToStream

Measures distance to the nearest downslope stream cell.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| -i, --dem | Input raster DEM file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |

Python function:

```
downslope_distance_to_stream(
    dem,
    streams,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DownslopeDistanceToStream -v ^
--wd="/path/to/data/" --dem='dem.tif' --streams='streams.tif' ^
-o='output.tif'
```

8.7.14 DownslopeFlowpathLength

Calculates the downslope flowpath length from each cell to basin outlet.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --d8_pntr | Input D8 pointer raster file |
| --watersheds | Optional input watershed raster file |
| --weights | Optional input weights raster file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
downslope_flowpath_length(
    d8_pntr,
    output,
    watersheds=None,
    weights=None,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DownslopeFlowpathLength -v ^
--wd="/path/to/data/" --d8_pntr=pointer.tif ^
-o=flowpath_len.tif
>>./whitebox_tools ^
-r=DownslopeFlowpathLength -v --wd="/path/to/data/" ^
--d8_pntr=pointer.tif --watersheds=basin.tif ^
--weights=weights.tif -o=flowpath_len.tif --esri_pntr
```

8.7.15 ElevationAboveStream

Calculates the elevation of cells above the nearest downslope stream cell.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| -i, --dem | Input raster DEM file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |

Python function:

```
elevation_above_stream(
    dem,
    streams,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ElevationAboveStream -v ^
--wd="/path/to/data/" --dem='dem.tif' --streams='streams.tif' ^
-o='output.tif'
```

8.7.16 ElevationAboveStreamEuclidean

Calculates the elevation of cells above the nearest (Euclidean distance) stream cell.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| -i, --dem | Input raster DEM file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |

Python function:

```
elevation_above_stream_euclidean(
    dem,
    streams,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ElevationAboveStreamEuclidean -v ^
--wd="/path/to/data/" -i=DEM.tif --streams=streams.tif ^
-o=output.tif
```

8.7.17 Fd8FlowAccumulation

Calculates an FD8 flow accumulation raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --out_type | Output type; one of 'cells', 'specific contributing area' (default), and 'catchment area' |
| --exponent | Optional exponent parameter; default is 1.1 |
| --threshold | Optional convergence threshold parameter, in grid cells; default is infinity |
| --log | Optional flag to request the output be log-transformed |
| --clip | Optional flag to request clipping the display max by 1% |

Python function:

```
fd8_flow_accumulation(
    dem,
    output,
    out_type="specific contributing area",
    exponent=1.1,
    threshold=None,
    log=False,
    clip=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FD8FlowAccumulation -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--out_type='cells'
>>./whitebox_tools -r=FD8FlowAccumulation -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--out_type='catchment area' --exponent=1.5 --threshold=10000 ^
--log --clip
```

8.7.18 Fd8Pointer

Calculates an FD8 flow pointer raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
fd8_pointer(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FD8Pointer -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.7.19 FillBurn

Burns streams into a DEM using the FillBurn (Saunders, 1999) method.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| --dem | Input raster DEM file |
| --streams | Input vector streams file |
| -o, --output | Output raster file |

Python function:

```
fill_burn(
    dem,
    streams,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FillBurn -v --wd="/path/to/data/" ^
--dem=DEM.tif --streams=streams.shp -o=dem_burned.tif
```

8.7.20 FillDepressions

Fills all of the depressions in a DEM. Depression breaching should be preferred in most cases.

Parameters:

| Flag | Description |
|-----------|-----------------------|
| -i, --dem | Input raster DEM file |

| Flag | Description |
|--------------|--|
| -o, --output | Output raster file |
| --fix_flats | Optional flag indicating whether flat areas should have a small gradient applied |

Python function:

```
fill_depressions(
    dem,
    output,
    fix_flats=True,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FillDepressions -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif ^
--fix_flats
```

8.7.21 FillSingleCellPits

Raises pit cells to the elevation of their lowest neighbour.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
fill_single_cell_pits(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FillSingleCellPits -v ^
--wd="/path/to/data/" --dem=DEM.tif -o>NewRaster.tif
```

8.7.22 FindNoFlowCells

Finds grid cells with no downslope neighbours.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
find_no_flow_cells(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FindNoFlowCells -v ^
--wd="/path/to/data/" --dem=DEM.tif -o>NewRaster.tif
```

8.7.23 FindParallelFlow

Finds areas of parallel flow in D8 flow direction rasters.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| --d8_pntr | Input D8 pointer raster file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |

Python function:

```
find_parallel_flow(
    d8_pntr,
    streams,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FindParallelFlow -v ^
```

```
--wd="/path/to/data/" --d8_pntr=pointer.tif ^
-o=out.tif
>>./whitebox_tools -r=FindParallelFlow -v ^
--wd="/path/to/data/" --d8_pntr=pointer.tif -o=out.tif ^
--streams='streams.tif'
```

8.7.24 FlattenLakes

Flattens lake polygons in a raster DEM.

Parameters:

| Flag | Description |
|--------------|----------------------------------|
| -i, --dem | Input raster DEM file |
| --lakes | Input lakes vector polygons file |
| -o, --output | Output raster file |

Python function:

```
flatten_lakes(
    dem,
    lakes,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FlattenLakes -v --wd="/path/to/data/" ^
--dem='DEM.tif' --lakes='lakes.shp' -o='output.tif'
```

8.7.25 FloodOrder

Assigns each DEM grid cell its order in the sequence of inundations that are encountered during a search starting from the edges, moving inward at increasing elevations.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
flood_order(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FloodOrder -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.7.26 FlowAccumulationFullWorkflow

Resolves all of the depressions in a DEM, outputting a breached DEM, an aspect-aligned non-divergent flow pointer, and a flow accumulation raster.

Parameters:

| Flag | Description |
|-------------|---|
| -i, --dem | Input raster DEM file |
| --out_dem | Output raster DEM file |
| --out_pntr | Output raster flow pointer file |
| --out_accum | Output raster flow accumulation file |
| --out_type | Output type; one of 'cells', 'sca' (default), and 'ca' |
| --log | Optional flag to request the output be log-transformed |
| --clip | Optional flag to request clipping the display max by 1% |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
flow_accumulation_full_workflow(
    dem,
    out_dem,
    out_pntr,
    out_accum,
    out_type="Specific Contributing Area",
    log=False,
    clip=False,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FlowAccumulationFullWorkflow -v ^
--wd="/path/to/data/" --dem='DEM.tif' ^
```

```
--out_dem='DEM_filled.tif' --out_pntr='pointer.tif' ^
--out_accum='accum.tif' --out_type=sca --log --clip
```

8.7.27 FlowLengthDiff

Calculates the local maximum absolute difference in downslope flowpath length, useful in mapping drainage divides and ridges.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --d8_pntr | Input D8 pointer raster file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
flow_length_diff(
    d8_pntr,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FlowLengthDiff -v --wd="/path/to/data/" ^
--d8_pntr=pointer.tif -o=output.tif
```

8.7.28 Hillslopes

Identifies the individual hillslopes draining to each link in a stream network.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
hillslopes(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Hillslopes -v --wd="/path/to/data/" ^
--d8_pntr='d8pntr.tif' --streams='streams.tif' ^
-o='output.tif'
```

8.7.29 ImpoundmentIndex

Calculates the impoundment size resulting from damming a DEM.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output file |
| --out_type | Output type; one of 'depth' (default), 'volume', and 'area' |
| --damlength | Maximum length of the dam |

Python function:

```
impoundment_index(
    dem,
    output,
    damlength,
    out_type="depth",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ImpoundmentIndex -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=out.tif ^
--out_type=depth --damlength=11
```

8.7.30 Isobasins

Divides a landscape into nearly equal sized drainage basins (i.e. watersheds).

Parameters:

| Flag | Description |
|--------------|----------------------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --size | Target basin size, in grid cells |

Python function:

```
isobasins(
    dem,
    output,
    size,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Isobasins -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif --size=1000
```

8.7.31 JensonSnapPourPoints

Moves outlet points used to specify points of interest in a watershedding operation to the nearest stream cell.

Parameters:

| Flag | Description |
|--------------|--|
| --pour_pts | Input vector pour points (outlet) file |
| --streams | Input raster streams file |
| -o, --output | Output vector file |
| --snap_dist | Maximum snap distance in map units |

Python function:

```
jenson_snap_pour_points(
    pour_pts,
    streams,
    output,
    snap_dist,
```

```
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=JensonSnapPourPoints -v ^
--wd="/path/to/data/" --pour_pts='pour_pts.shp' ^
--streams='streams.tif' -o='output.shp' --snap_dist=15.0
```

8.7.32 MaxUpslopeFlowpathLength

Measures the maximum length of all upslope flowpaths draining each grid cell.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
max_upslope_flowpath_length(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaxUpslopeFlowpathLength -v ^
--wd="/path/to/data/" -i=DEM.tif ^
-o=output.tif
>>./whitebox_tools -r=MaxUpslopeFlowpathLength -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=output.tif --log ^
--clip
```

8.7.33 NumInflowingNeighbours

Computes the number of inflowing neighbours to each cell in an input DEM based on the D8 algorithm.

Parameters:

| Flag | Description |
|--------------|-----------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |

Python function:

```
num_inflowing_neighbours(
    dem,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NumInflowingNeighbours -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.7.34 RaiseWalls

Raises walls in a DEM along a line or around a polygon, e.g. a watershed.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| -i, --input | Input vector lines or polygons file |
| --breach | Optional input vector breach lines |
| --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --height | Wall height |

Python function:

```
raise_walls(
    i,
    dem,
    output,
    breach=None,
    height=100.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RaiseWalls -v --wd="/path/to/data/" ^
-i=watershed.shp --dem=dem.tif -o=output.tif ^
--height=25.0
>>./whitebox_tools -r=RaiseWalls -v ^
--wd="/path/to/data/" -i=watershed.shp --breach=outlet.shp ^
--dem=dem.tif -o=output.tif --height=25.0
```

8.7.35 Rho8Pointer

Calculates a stochastic Rho8 flow pointer raster from an input DEM.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
rho8_pointer(
    dem,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Rho8Pointer -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif
```

8.7.36 Sink

Identifies the depressions in a DEM, giving each feature a unique identifier.

Parameters:

| Flag | Description |
|-------------------|---|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
sink(
    dem,
    output,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Sink -v --wd="/path/to/data/" ^
--dem=DEM.tif -o=output.tif --zero_background
```

8.7.37 SnapPourPoints

Moves outlet points used to specify points of interest in a watershedding operation to the cell with the highest flow accumulation in its neighbourhood.

Parameters:

| Flag | Description |
|--------------|--|
| --pour_pts | Input vector pour points (outlet) file |
| --flow_accum | Input raster D8 flow accumulation file |
| -o, --output | Output vector file |
| --snap_dist | Maximum snap distance in map units |

Python function:

```
snap_pour_points(
    pour_pts,
    flow_accum,
    output,
    snap_dist,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SnapPourPoints -v --wd="/path/to/data/" ^
--pour_pts='pour_pts.shp' --flow_accum='d8accum.tif' ^
-o='output.shp' --snap_dist=15.0
```

8.7.38 StochasticDepressionAnalysis

Performs a stochastic analysis of depressions within a DEM.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --dem | Input raster DEM file |
| -o, --output | Output file |
| --rmse | The DEM's root-mean-square-error (RMSE), in z units. This determines error magnitude |

| Flag | Description |
|--------------|---|
| --range | The error field's correlation length, in xy-units |
| --iterations | The number of iterations |

Python function:

```
stochastic_depression_analysis(
    dem,
    output,
    rmse,
    range,
    iterations=1000,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StochasticDepressionAnalysis -v ^
--wd="/path/to/data/" --dem=DEM.tif -o=out.tif --rmse=10.0 ^
--range=850.0 --iterations=2500
```

8.7.39 StrahlerOrderBasins

Identifies Strahler-order basins from an input stream network.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
strahler_order_basins(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StrahlerOrderBasins -v ^
```

```
--wd="/path/to/data/" --d8_pntr='d8ptr.tif' ^
--streams='streams.tif' -o='output.tif'
```

8.7.40 Subbasins

Identifies the catchments, or sub-basin, draining to each link in a stream network.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --d8_pntr | Input D8 pointer raster file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
subbasins(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Subbasins -v --wd="/path/to/data/" ^
--d8_pntr='d8ptr.tif' --streams='streams.tif' ^
-o='output.tif'
```

8.7.41 TraceDownslopeFlowpaths

Traces downslope flowpaths from one or more target sites (i.e. seed points).

Parameters:

| Flag | Description |
|-------------------|---|
| --seed_pts | Input vector seed points file |
| --d8_pntr | Input D8 pointer raster file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
trace_downslope_flowpaths(
    seed_pts,
    d8_pntr,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TraceDownslopeFlowpaths -v ^
--wd="/path/to/data/" --seed_pts=seeds.shp ^
--flow_dir=flow_directions.tif --output=flow_paths.tif
```

8.7.42 UnnestBasins

Extract whole watersheds for a set of outlet points.

Parameters:

| Flag | Description |
|--------------|--|
| --d8_pntr | Input D8 pointer raster file |
| --pour_pts | Input vector pour points (outlet) file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
unnest_basins(
    d8_pntr,
    pour_pts,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=UnnestBasins -v --wd="/path/to/data/" ^
--d8_pntr='d8pntr.tif' --pour_pts='pour_pts.shp' ^
-o='output.tif'
```

8.7.43 Watershed

Identifies the watershed, or drainage basin, draining to a set of target cells.

Parameters:

| Flag | Description |
|--------------|--|
| --d8_pntr | Input D8 pointer raster file |
| --pour_pts | Input vector pour points (outlet) file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
watershed(
    d8_pntr,
    pour_pts,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Watershed -v --wd="/path/to/data/" ^
--d8_pntr='d8ptr.tif' --pour_pts='pour_pts.shp' ^
-o='output.tif'
```

8.8 Image Processing Tools

8.8.1 ChangeVectorAnalysis

Performs a change vector analysis on a two-date multi-spectral dataset.

Parameters:

| Flag | Description |
|-------------|---|
| --date1 | Input raster files for the earlier date |
| --date2 | Input raster files for the later date |
| --magnitude | Output vector magnitude raster file |
| --direction | Output vector Direction raster file |

Python function:

```
change_vector_analysis(
    date1,
    date2,
    magnitude,
    direction,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ChangeVectorAnalysis -v ^
--wd="/path/to/data/" ^
--date1='d1_band1.tif;d1_band2.tif;d1_band3.tif' ^
--date2='d2_band1.tif;d2_band2.tif;d2_band3.tif' ^
--magnitude=mag_out.tif --direction=dir_out.tif
```

8.8.2 Closing

A closing is a mathematical morphology operating involving an erosion (min filter) of a dilation (max filter) set.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
closing(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Closing -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.8.3 CreateColourComposite

Creates a colour-composite image from three bands of multispectral imagery.

Parameters:

| Flag | Description |
|--------------|--|
| --red | Input red band image file |
| --green | Input green band image file |
| --blue | Input blue band image file |
| --opacity | Input opacity band image file (optional) |
| -o, --output | Output colour composite file |
| -enhance | Optional flag indicating whether a balance contrast enhancement is performed |

Python function:

```
create_colour_composite(
    red,
    green,
    blue,
    output,
    opacity=None,
    enhance=True,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CreateColourComposite -v ^
--wd="/path/to/data/" --red=band3.tif --green=band2.tif ^
--blue=band1.tif -o=output.tif
>>./whitebox_tools ^
-r=CreateColourComposite -v --wd="/path/to/data/" ^
--red=band3.tif --green=band2.tif --blue=band1.tif ^
--opacity=a.tif -o=output.tif
```

8.8.4 FlipImage

Reflects an image in the vertical or horizontal axis.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

| Flag | Description |
|-------------|---|
| --direction | Direction of reflection; options include 'v' (vertical), 'h' (horizontal), and 'b' (both) |

Python function:

```
flip_image(
    i,
    output,
    direction="vertical",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FlipImage -v --wd="/path/to/data/" ^
--input=in.tif -o=out.tif --direction=h
```

8.8.5 IhsToRgb

Converts intensity, hue, and saturation (IHS) images into red, green, and blue (RGB) images.

Parameters:

| Flag | Description |
|--------------|--|
| --intensity | Input intensity file |
| --hue | Input hue file |
| --saturation | Input saturation file |
| --red | Output red band file. Optionally specified if colour-composite not specified |
| --green | Output green band file. Optionally specified if colour-composite not specified |
| --blue | Output blue band file. Optionally specified if colour-composite not specified |
| -o, --output | Output colour-composite file. Only used if individual bands are not specified |

Python function:

```
ihs_to_rgb(
    intensity,
    hue,
    saturation,
    red=None,
    green=None,
    blue=None,
    output=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=IhsToRgb -v --wd="/path/to/data/" ^
--intensity=intensity.tif --hue=hue.tif ^
--saturation=saturation.tif --red=band3.tif --green=band2.tif ^
--blue=band1.tif
>>./whitebox_tools -r=IhsToRgb -v ^
--wd="/path/to/data/" --intensity=intensity.tif --hue=hue.tif ^
--saturation=saturation.tif --composite=image.tif
```

8.8.6 ImageStackProfile

Plots an image stack profile (i.e. signature) for a set of points and multispectral images.

Parameters:

| Flag | Description |
|--------------|---------------------------------|
| -i, --inputs | Input multispectral image files |
| --points | Input vector points file |
| -o, --output | Output HTML file |

Python function:

```
image_stack_profile(
    inputs,
    points,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ImageStackProfile -v ^
--wd="/path/to/data/" -i='image1.tif;image2.tif;image3.tif' ^
--points=pts.shp -o=output.html
```

8.8.7 IntegralImage

Transforms an input image (summed area table) into its integral image equivalent.

Parameters:

| Flag | Description |
|-------------|-------------------|
| -i, --input | Input raster file |

| Flag | Description |
|--------------|--------------------|
| -o, --output | Output raster file |

Python function:

```
integral_image(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=IntegralImage -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif
```

8.8.8 KMeansClustering

Performs a k-means clustering operation on a multi-spectral dataset.

Parameters:

| Flag | Description |
|------------------|---|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |
| --out_html | Output HTML report file |
| --classes | Number of classes |
| --max_iterations | Maximum number of iterations |
| --class_change | Minimum percent of cells changed between iterations before completion |
| --initialize | How to initialize cluster centres? |
| --min_class_size | Minimum class size, in pixels |

Python function:

```
k_means_clustering(
    inputs,
    output,
    classes,
    out_html=None,
    max_iterations=10,
    class_change=2.0,
    initialize="diagonal",
    min_class_size=10,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=KMeansClustering -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
-o=output.tif --out_html=report.html --classes=15 ^
--max_iterations=25 --class_change=1.5 --initialize='random' ^
--min_class_size=500
```

8.8.9 LineThinning

Performs line thinning a on Boolean raster image; intended to be used with the RemoveSpurs tool.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
line_thinning(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LineThinning -v --wd="/path/to/data/" ^
--input=DEM.tif -o=output.tif
```

8.8.10 ModifiedKMeansClustering

Performs a modified k-means clustering operation on a multi-spectral dataset.

Parameters:

| Flag | Description |
|------------------|------------------------------|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |
| --out_html | Output HTML report file |
| --start_clusters | Initial number of clusters |
| --merger_dist | Cluster merger distance |
| --max_iterations | Maximum number of iterations |

| Flag | Description |
|----------------|---|
| --class_change | Minimum percent of cells changed between iterations before completion |

Python function:

```
modified_k_means_clustering(
    inputs,
    output,
    out_html=None,
    start_clusters=1000,
    merger_dist=None,
    max_iterations=10,
    class_change=2.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ModifiedKMeansClustering -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
-o=output.tif --out_html=report.html --start_clusters=100 ^
--merger_dist=30.0 --max_iterations=25 --class_change=1.5
```

8.8.11 Mosaic

Mosaics two or more images together.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --inputs | Input raster files |
| -o, --output | Output raster file |
| --method | Resampling method; options include 'nn' (nearest neighbour), 'bilinear', and 'cc' (cubic convolution) |

Python function:

```
mosaic(
    inputs,
    output,
    method="cc",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Mosaic -v --wd='/path/to/data/' ^
-i='image1.tif;image2.tif;image3.tif' -o=dest.tif ^
--method='cc
```

8.8.12 NormalizedDifferenceVegetationIndex

Calculates the normalized difference vegetation index (NDVI) from near-infrared and red imagery.

Parameters:

| Flag | Description |
|--------------|---|
| --nir | Input near-infrared band image |
| --red | Input red band image |
| -o, --output | Output raster file |
| --clip | Optional amount to clip the distribution tails by, in percent |
| --osavi | Optional flag indicating whether the optimized soil-adjusted veg index (OSAVI) should be used |

Python function:

```
normalized_difference_vegetation_index(
    nir,
    red,
    output,
    clip=0.0,
    osavi=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NormalizedDifferenceVegetationIndex -v ^
--wd="/path/to/data/" --nir=band4.tif --red=band3.tif ^
-o=output.tif
>>./whitebox_tools ^
-r=NormalizedDifferenceVegetationIndex -v --wd="/path/to/data/" ^
--nir=band4.tif --red=band3.tif -o=output.tif --clip=1.0 ^
--osavi
```

8.8.13 Opening

An opening is a mathematical morphology operating involving a dilation (max filter) of an erosion (min filter) set.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
opening(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Opening -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.8.14 RemoveSpurs

Removes the spurs (pruning operation) from a Boolean line image.; intended to be used on the output of the LineThinning tool.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --iterations | Maximum number of iterations |

Python function:

```
remove_spurs(
    i,
    output,
    iterations=10,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RemoveSpurs -v --wd="/path/to/data/" ^
--input=DEM.tif -o=output.tif --iterations=10
```

8.8.15 Resample

Resamples one or more input images into a destination image.

Parameters:

| Flag | Description |
|---------------|---|
| -i, --inputs | Input raster files |
| --destination | Destination raster file |
| --method | Resampling method; options include 'nn' (nearest neighbour), 'bilinear', and 'cc' (cubic convolution) |

Python function:

```
resample(
    inputs,
    destination,
    method="cc",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Resample -v --wd='/path/to/data/' ^
-i='image1.tif;image2.tif;image3.tif' --destination=dest.tif ^
--method='cc'
```

8.8.16 RgbToIhs

Converts red, green, and blue (RGB) images into intensity, hue, and saturation (IHS) images.

Parameters:

| Flag | Description |
|---------|---|
| --red | Input red band image file. Optionally specified if colour-composite not specified |
| --green | Input green band image file. Optionally specified if colour-composite not specified |
| --blue | Input blue band image file. Optionally specified if colour-composite not specified |

| Flag | Description |
|--------------|--|
| --composite | Input colour-composite image file. Only used if individual bands are not specified |
| --intensity | Output intensity raster file |
| --hue | Output hue raster file |
| --saturation | Output saturation raster file |

Python function:

```
rgb_to_ihs(
    intensity,
    hue,
    saturation,
    red=None,
    green=None,
    blue=None,
    composite=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RgbToIhs -v --wd="/path/to/data/" ^
--red=band3.tif --green=band2.tif --blue=band1.tif ^
--intensity=intensity.tif --hue=hue.tif ^
--saturation=saturation.tif
>>./whitebox_tools -r=RgbToIhs -v ^
--wd="/path/to/data/" --composite=image.tif ^
--intensity=intensity.tif --hue=hue.tif ^
--saturation=saturation.tif
```

8.8.17 SplitColourComposite

This tool splits an RGB colour composite image into separate multispectral images.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input colour composite image file |
| -o, --output | Output raster file (suffixes of '_r', '_g', and '_b' will be appended) |

Python function:

```
split_colour_composite(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SplitColourComposite -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif
```

8.8.18 ThickenRasterLine

Thickens single-cell wide lines within a raster image.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
thicken_raster_line(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ThickenRasterLine -v ^
--wd="/path/to/data/" --input=DEM.tif -o=output.tif
```

8.8.19 TophatTransform

Performs either a white or black top-hat transform on an input image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

| Flag | Description |
|-------------|---|
| --variant | Optional variant value. Options include 'white' and 'black' |

Python function:

```
tophat_transform(
    i,
    output,
    filterx=11,
    filtery=11,
    variant="white",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TophatTransform -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --filter=25
```

8.8.20 WriteFunctionMemoryInsertion

Performs a write function memory insertion for single-band multi-date change detection.

Parameters:

| Flag | Description |
|----------------|---|
| --i1, --input1 | Input raster file associated with the first date |
| --i2, --input2 | Input raster file associated with the second date |
| --i3, --input3 | Optional input raster file associated with the third date |
| -o, --output | Output raster file |

Python function:

```
write_function_memory_insertion(
    input1,
    input2,
    output,
    input3=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=WriteFunctionMemoryInsertion -v ^
--wd="/path/to/data/" -i1=input1.tif -i2=input2.tif ^
-o=output.tif
```

8.9 Image Processing Tools => Filters

8.9.1 AdaptiveFilter

Performs an adaptive filter on an image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |
| --threshold | Difference from mean threshold, in standard deviations |

Python function:

```
adaptive_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    threshold=2.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AdaptiveFilter -v --wd="/path/to/data/" ^
-i=DEM.tif -o=output.tif --filter=25 --threshold = 2.0
```

8.9.2 BilateralFilter

A bilateral filter is an edge-preserving smoothing filter introduced by Tomasi and Manduchi (1998).

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --sigma_dist | Standard deviation in distance in pixels |
| --sigma_int | Standard deviation in intensity in pixels |

Python function:

```
bilateral_filter(
    i,
    output,
    sigma_dist=0.75,
    sigma_int=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BilateralFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif ^
--sigma_dist=2.5 --sigma_int=4.0
```

8.9.3 ConservativeSmoothingFilter

Performs a conservative-smoothing filter on an image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
conservative_smoothing_filter(
    i,
    output,
    filterx=3,
    filtery=3,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ConservativeSmoothingFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --filter=25
```

8.9.4 CornerDetection

Identifies corner patterns in boolean images using hit-and-miss pattern matching.

Parameters:

| Flag | Description |
|--------------|---------------------|
| -i, --input | Input boolean image |
| -o, --output | Output raster file |

Python function:

```
corner_detection(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CornerDetection -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --sigma=2.0
```

8.9.5 DiffOfGaussianFilter

Performs a Difference of Gaussian (DoG) filter on an image.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --sigma1 | Standard deviation distance in pixels |
| --sigma2 | Standard deviation distance in pixels |

Python function:

```
diff_of_gaussian_filter(
    i,
    output,
    sigma1=2.0,
    sigma2=4.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DiffOfGaussianFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --sigma1=2.0 ^
--sigma2=4.0
```

8.9.6 DiversityFilter

Assigns each cell in the output grid the number of different values in a moving window centred on each grid cell in the input raster.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
diversity_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DiversityFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --filter=25
```

8.9.7 EdgePreservingMeanFilter

Performs a simple edge-preserving mean filter on an input image.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filter | Size of the filter kernel |
| --threshold | Maximum difference in values |

Python function:

```
edge_preserving_mean_filter(
    i,
    output,
    threshold,
    filter=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=EdgePreservingMeanFilter -v ^
--wd="/path/to/data/" --input=image.tif -o=output.tif ^
--filter=5 --threshold=20
```

8.9.8 EmbossFilter

Performs an emboss filter on an image, similar to a hillshade operation.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --direction | Direction of reflection; options include 'n', 's', 'e', 'w', 'ne', 'se', 'nw', 'sw' |
| --clip | Optional amount to clip the distribution tails by, in percent |

Python function:

```
emboss_filter(
    i,
    output,
    direction="n",
    clip=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=EmbossFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --direction='s' --clip=1.0
```

8.9.9 FastAlmostGaussianFilter

Performs a fast approximate Gaussian filter on an image.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --sigma | Standard deviation distance in pixels |

Python function:

```
fast_almost_gaussian_filter(
    i,
    output,
    sigma=1.8,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FastAlmostGaussianFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --sigma=2.0
```

8.9.10 GaussianFilter

Performs a Gaussian filter on an image.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --sigma | Standard deviation distance in pixels |

Python function:

```
gaussian_filter(
    i,
    output,
    sigma=0.75,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=GaussianFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --sigma=2.0
```

8.9.11 HighPassFilter

Performs a high-pass filter on an input image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
high_pass_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HighPassFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.9.12 HighPassMedianFilter

Performs a high pass median filter on an input image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |
| --sig_digits | Number of significant digits |

Python function:

```
high_pass_median_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    sig_digits=2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HighPassMedianFilter -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif --filter=25
```

8.9.13 KNearestMeanFilter

A k-nearest mean filter is a type of edge-preserving smoothing filter.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |
| -k | k-value in pixels; this is the number of nearest-valued neighbours to use |

Python function:

```
k_nearest_mean_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    k=5,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=KNearestMeanFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --filter=9 ^
-k=5
>>./whitebox_tools -r=KNearestMeanFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --filtery=7 ^
```

```
--filtery=9 -k=5
```

8.9.14 LaplacianFilter

Performs a Laplacian filter on an image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --variant | Optional variant value. Options include 3x3(1), 3x3(2), 3x3(3), 3x3(4), 5x5(1), and 5x5(2) (default is 3x3(1)) |
| --clip | Optional amount to clip the distribution tails by, in percent |

Python function:

```
laplacian_filter(
    i,
    output,
    variant="3x3(1)",
    clip=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LaplacianFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif ^
--variant='3x3(1)' --clip=1.0
```

8.9.15 LaplacianOfGaussianFilter

Performs a Laplacian-of-Gaussian (LoG) filter on an image.

Parameters:

| Flag | Description |
|--------------|------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --sigma | Standard deviation in pixels |

Python function:

```
laplacian_of_gaussian_filter(
    i,
    output,
    sigma=0.75,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LaplacianOfGaussianFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --sigma=2.0
```

8.9.16 LeeFilter

Performs a Lee (Sigma) smoothing filter on an image.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |
| --sigma | Sigma value should be related to the standarad deviation of the distribution of image speckle noise |
| -m | M-threshold value the minimum allowable number of pixels within the intensity range |

Python function:

```
lee_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    sigma=10.0,
    m=5.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LeeFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=9 --sigma=10.0 ^
-m=5
>>./whitebox_tools -r=LeeFilter -v --wd="/path/to/data/" ^
```

```
-i=image.tif -o=output.tif --filtery=7 --filtery=9 ^
--sigma=10.0 -m=5
```

8.9.17 LineDetectionFilter

Performs a line-detection filter on an image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --variant | Optional variant value. Options include 'v' (vertical), 'h' (horizontal), '45', and '135' (default is 'v') |
| --absvals | Optional flag indicating whether outputs should be absolute values |
| --clip | Optional amount to clip the distribution tails by, in percent |

Python function:

```
line_detection_filter(
    i,
    output,
    variant="vertical",
    absvals=False,
    clip=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LineDetectionFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --variant=h ^
--clip=1.0
```

8.9.18 MajorityFilter

Assigns each cell in the output grid the most frequently occurring value (mode) in a moving window centred on each grid cell in the input raster.

Parameters:

| Flag | Description |
|-------------|-------------------|
| -i, --input | Input raster file |

| Flag | Description |
|--------------|--|
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
majority_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MajorityFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.9.19 MaximumFilter

Assigns each cell in the output grid the maximum value in a moving window centred on each grid cell in the input raster.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
maximum_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MaximumFilter -v --wd="/path/to/data/" ^
```

```
-i=image.tif -o=output.tif --filter=25
```

8.9.20 MeanFilter

Performs a mean filter (low-pass filter) on an input image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
mean_filter(
    i,
    output,
    filterx=3,
    filtery=3,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MeanFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filterx=25 --filtery=25
```

8.9.21 MedianFilter

Performs a median filter on an input image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |
| --sig_digits | Number of significant digits |

Python function:

```
median_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    sig_digits=2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MedianFilter -v --wd="/path/to/data/" ^
-i=input.tif -o=output.tif --filter=25
```

8.9.22 MinimumFilter

Assigns each cell in the output grid the minimum value in a moving window centred on each grid cell in the input raster.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
minimum_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MinimumFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.9.23 OlympicFilter

Performs an olympic smoothing filter on an image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
olympic_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=OlympicFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.9.24 PercentileFilter

Performs a percentile filter on an input image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |
| --sig_digits | Number of significant digits |

Python function:

```
percentile_filter(
    i,
    output,
```

```
filterx=11,
filtery=11,
sig_digits=2,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PercentileFilter -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif --filter=25
```

8.9.25 PrewittFilter

Performs a Prewitt edge-detection filter on an image.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --clip | Optional amount to clip the distribution tails by, in percent |

Python function:

```
prewitt_filter(
    i,
    output,
    clip=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PrewittFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --clip=1.0
```

8.9.26 RangeFilter

Assigns each cell in the output grid the range of values in a moving window centred on each grid cell in the input raster.

Parameters:

| Flag | Description |
|-------------|-------------------|
| -i, --input | Input raster file |

| Flag | Description |
|--------------|--|
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
range_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RangeFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.9.27 RobertsCrossFilter

Performs a Robert's cross edge-detection filter on an image.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --clip | Optional amount to clip the distribution tails by, in percent |

Python function:

```
roberts_cross_filter(
    i,
    output,
    clip=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RobertsCrossFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --clip=1.0
```

8.9.28 ScharrFilter

Performs a Scharr edge-detection filter on an image.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --clip | Optional amount to clip the distribution tails by, in percent |

Python function:

```
scharr_filter(
    i,
    output,
    clip=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ScharrFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --clip=1.0
```

8.9.29 SobelFilter

Performs a Sobel edge-detection filter on an image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --variant | Optional variant value. Options include 3x3 and 5x5 (default is 3x3) |
| --clip | Optional amount to clip the distribution tails by, in percent (default is 0.0) |

Python function:

```
sobel_filter(
    i,
    output,
    variant="3x3",
    clip=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SobelFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --variant=5x5 --clip=1.0
```

8.9.30 StandardDeviationFilter

Assigns each cell in the output grid the standard deviation of values in a moving window centred on each grid cell in the input raster.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
standard_deviation_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StandardDeviationFilter -v ^
--wd="/path/to/data/" -i=image.tif -o=output.tif --filter=25
```

8.9.31 TotalFilter

Performs a total filter on an input image.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

| Flag | Description |
|-----------|--|
| --filterx | Size of the filter kernel in the x-direction |
| --filtery | Size of the filter kernel in the y-direction |

Python function:

```
total_filter(
    i,
    output,
    filterx=11,
    filtery=11,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TotalFilter -v --wd="/path/to/data/" ^
-i=image.tif -o=output.tif --filter=25
```

8.9.32 UnsharpMasking

An image sharpening technique that enhances edges.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --sigma | Standard deviation distance in pixels |
| --amount | A percentage and controls the magnitude of each overshoot |
| --threshold | Controls the minimal brightness change that will be sharpened |

Python function:

```
unsharp_masking(
    i,
    output,
    sigma=0.75,
    amount=100.0,
    threshold=0.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=UnsharpMasking -v --wd="/path/to/data/" ^
```

```
-i=image.tif -o=output.tif --sigma=2.0 --amount=50.0 ^
--threshold=10.0
```

8.9.33 UserDefinedWeightsFilter

Performs a user-defined weights filter on an image.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| --weights | Input weights file |
| -o, --output | Output raster file |
| --center | Kernel center cell; options include 'center', 'upper-left', 'upper-right', 'lower-left', 'lower-right' |
| --normalize | Normalize kernel weights? This can reduce edge effects and lessen the impact of data gaps (nodata) but is not suited when the kernel weights sum to zero |

Python function:

```
user_defined_weights_filter(
    i,
    weights,
    output,
    center="center",
    normalize=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=UserDefinedWeightsFilter -v ^
--wd="/path/to/data/" -i=image.tif --weights=weights.txt ^
-o=output.tif --center=center --normalize
```

8.10 Image Processing Tools => Image Enhancement

8.10.1 BalanceContrastEnhancement

Performs a balance contrast enhancement on a colour-composite image of multispectral data.

Parameters:

| Flag | Description |
|--------------|-----------------------------------|
| -i, --input | Input colour composite image file |
| -o, --output | Output raster file |
| --band_mean | Band mean value |

Python function:

```
balance_contrast_enhancement(
    i,
    output,
    band_mean=100.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BalanceContrastEnhancement -v ^
--wd="/path/to/data/" --input=image.tif -o=output.tif ^
--band_mean=120
```

8.10.2 CorrectVignetting

Corrects the darkening of images towards corners.

Parameters:

| Flag | Description |
|----------------|---|
| -i, --input | Input raster file |
| --pp | Input principal point file |
| -o, --output | Output raster file |
| --focal_length | Camera focal length, in millimeters |
| --image_width | Distance between photograph edges, in millimeters |
| -n | The 'n' parameter |

Python function:

```
correct_vignetting(
    i,
    pp,
    output,
    focal_length=304.8,
    image_width=228.6,
    n=4.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CorrectVignetting -v ^
--wd="/path/to/data/" -i=input.tif --pp=princ_pt.shp ^
-o=output.tif --focal_length=304.8 --image_width=228.6 ^
-n=4.0
```

8.10.3 DirectDecorrelationStretch

Performs a direct decorrelation stretch enhancement on a colour-composite image of multispectral data.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input colour composite image file |
| -o, --output | Output raster file |
| -k | Achromatic factor (k) ranges between 0 (no effect) and 1 (full saturation stretch), although typical values range from 0.3 to 0.7 |
| --clip | Optional percent to clip the upper tail by during the stretch |

Python function:

```
direct_decorrelation_stretch(
    i,
    output,
    k=0.5,
    clip=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DirectDecorrelationStretch -v ^
--wd="/path/to/data/" --input=image.tif -o=output.tif -k=0.4
```

8.10.4 GammaCorrection

Performs a sigmoidal contrast stretch on input images.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

| Flag | Description |
|---------|-------------|
| --gamma | Gamma value |

Python function:

```
gamma_correction(
    i,
    output,
    gamma=0.5,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=GammaCorrection -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif --gamma=0.5
```

8.10.5 GaussianContrastStretch

Performs a Gaussian contrast stretch on input images.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --num_tones | Number of tones in the output image |

Python function:

```
gaussian_contrast_stretch(
    i,
    output,
    num_tones=256,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=GaussianContrastStretch -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif ^
--num_tones=1024
```

8.10.6 HistogramEqualization

Performs a histogram equalization contrast enhancement on an image.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --num_tones | Number of tones in the output image |

Python function:

```
histogram_equalization(
    i,
    output,
    num_tones=256,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HistogramEqualization -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif ^
--num_tones=1024
```

8.10.7 HistogramMatching

Alters the statistical distribution of a raster image matching it to a specified PDF.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| --histo_file | Input reference probability distribution function (pdf) text file |
| -o, --output | Output raster file |

Python function:

```
histogram_matching(
    i,
    histo_file,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HistogramMatching -v ^
--wd="/path/to/data/" -i=input1.tif --histo_file=histo.txt ^
-o=output.tif
```

8.10.8 HistogramMatchingTwoImages

This tool alters the cumulative distribution function of a raster image to that of another image.

Parameters:

| Flag | Description |
|----------------|-----------------------------|
| --i1, --input1 | Input raster file to modify |
| --i2, --input2 | Input reference raster file |
| -o, --output | Output raster file |

Python function:

```
histogram_matching_two_images(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HistogramMatchingTwoImages -v ^
--wd="/path/to/data/" --i1=input1.tif --i2=input2.tif ^
-o=output.tif
```

8.10.9 MinMaxContrastStretch

Performs a min-max contrast stretch on an input greytone image.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --min_val | Lower tail clip value |
| --max_val | Upper tail clip value |
| --num_tones | Number of tones in the output image |

Python function:

```
min_max_contrast_stretch(
    i,
    output,
    min_val,
    max_val,
    num_tones=256,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MinMaxContrastStretch -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif ^
--min_val=45.0 --max_val=200.0 --num_tones=1024
```

8.10.10 PanchromaticSharpening

Increases the spatial resolution of image data by combining multispectral bands with panchromatic data.

Parameters:

| Flag | Description |
|--------------|---|
| --red | Input red band image file. Optionally specified if colour-composite not specified |
| --green | Input green band image file. Optionally specified if colour-composite not specified |
| --blue | Input blue band image file. Optionally specified if colour-composite not specified |
| --composite | Input colour-composite image file. Only used if individual bands are not specified |
| --pan | Input panchromatic band file |
| -o, --output | Output colour composite file |
| --method | Options include 'brovey' (default) and 'ihs' |

Python function:

```
panchromatic_sharpening(
    pan,
    output,
    red=None,
    green=None,
    blue=None,
    composite=None,
```

```
method="brovey",
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PanchromaticSharpening -v ^
--wd="/path/to/data/" --red=red.tif --green=green.tif ^
--blue=blue.tif --pan=pan.tif --output=pan_sharp.tif ^
--method='brovey'
>>./whitebox_tools -r=PanchromaticSharpening ^
-v --wd="/path/to/data/" --composite=image.tif --pan=pan.tif ^
--output=pan_sharp.tif --method='ihs'
```

8.10.11 PercentageContrastStretch

Performs a percentage linear contrast stretch on input images.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --clip | Optional amount to clip the distribution tails by, in percent |
| --tail | Specified which tails to clip; options include 'upper', 'lower', and 'both' (default is 'both') |
| --num_tones | Number of tones in the output image |

Python function:

```
percentage_contrast_stretch(
    i,
    output,
    clip=0.0,
    tail="both",
    num_tones=256,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PercentageContrastStretch -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif --clip=2.0 ^
--tail='both' --num_tones=1024
```

8.10.12 SigmoidalContrastStretch

Performs a sigmoidal contrast stretch on input images.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --cutoff | Cutoff value between 0.0 and 0.95 |
| --gain | Gain value |
| --num_tones | Number of tones in the output image |

Python function:

```
sigmoidal_contrast_stretch(
    i,
    output,
    cutoff=0.0,
    gain=1.0,
    num_tones=256,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SigmoidalContrastStretch -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif --cutoff=0.1 ^
--gain=2.0 --num_tones=1024
```

8.10.13 StandardDeviationContrastStretch

Performs a standard-deviation contrast stretch on input images.

Parameters:

| Flag | Description |
|-----------------|-------------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --clip, --stdev | Standard deviation clip value |
| --num_tones | Number of tones in the output image |

Python function:

```
standard_deviation_contrast_stretch(
    i,
    output,
    stdev=2.0,
    num_tones=256,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StandardDeviationContrastStretch -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif --stdev=2.0 ^
--num_tones=1024
```

8.11 LiDAR Tools

8.11.1 BlockMaximum

Creates a block-maximum raster from an input LAS file. When the input/output parameters are not specified, the tool grids all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|--------------|---------------------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output file |
| --resolution | Output raster's grid resolution |

Python function:

```
block_maximum(
    i=None,
    output=None,
    resolution=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BlockMaximum -v --wd="/path/to/data/" ^
-i=file.las -o=outfile.tif --resolution=2.0"
./whitebox_tools ^
-r=BlockMaximum -v --wd="/path/to/data/" -i=file.las ^
-o=outfile.tif --resolution=5.0 --palette=light_quant.plt
```

8.11.2 BlockMinimum

Creates a block-minimum raster from an input LAS file. When the input/output parameters are not specified, the tool grids all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|--------------|---------------------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output file |
| --resolution | Output raster's grid resolution |

Python function:

```
block_minimum(
    i=None,
    output=None,
    resolution=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BlockMinimum -v --wd="/path/to/data/" ^
-i=file.las -o=outfile.tif --resolution=2.0"
./whitebox_tools ^
-r=BlockMinimum -v --wd="/path/to/data/" -i=file.las ^
-o=outfile.tif --resolution=5.0 --palette=light_quant.plt
```

8.11.3 ClassifyOverlapPoints

Classifies or filters LAS points in regions of overlapping flight lines.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --resolution | The size of the square area used to evaluate nearby points in the LiDAR data |
| --filter | Filter out points from overlapping flightlines? If false, overlaps will simply be classified |

Python function:

```
classify_overlap_points(
    i,
    output,
    resolution=2.0,
    filter=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ClassifyOverlapPoints -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.las ^
--resolution=2.0
```

8.11.4 ClipLidarToPolygon

Clips a LiDAR point cloud to a vector polygon or polygons.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --input | Input LiDAR file |
| --polygons | Input vector polygons file |
| -o, --output | Output LiDAR file |

Python function:

```
clip_lidar_to_polygon(
    i,
    polygons,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ClipLidarToPolygon -v ^
--wd="/path/to/data/" -i='data.las' --polygons='lakes.shp' ^
-o='output.las'
```

8.11.5 ErasePolygonFromLidar

Erases (cuts out) a vector polygon or polygons from a LiDAR point cloud.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --input | Input LiDAR file |
| --polygons | Input vector polygons file |
| -o, --output | Output LiDAR file |

Python function:

```
erase_polygon_from_lidar(
    i,
    polygons,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ErasePolygonFromLidar -v ^
--wd="/path/to/data/" -i='data.las' --polygons='lakes.shp' ^
-o='output.las'
```

8.11.6 FilterLidarScanAngles

Removes points in a LAS file with scan angles greater than a threshold.

Parameters:

| Flag | Description |
|--------------|----------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --threshold | Scan angle threshold |

Python function:

```
filter_lidar_scan_angles(
    i,
    output,
    threshold,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FilterLidarScanAngles -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--threshold=10.0
```

8.11.7 FindFlightlineEdgePoints

Identifies points along a flightline's edge in a LAS file.

Parameters:

| Flag | Description |
|--------------|------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output file |

Python function:

```
find_flightline_edge_points(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FindFlightlineEdgePoints -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las"
```

8.11.8 FlightlineOverlap

Reads a LiDAR (LAS) point file and outputs a raster containing the number of overlapping flight lines in each grid cell.

Parameters:

| Flag | Description |
|--------------|---------------------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output file |
| --resolution | Output raster's grid resolution |

Python function:

```
flightline_overlap(
    i=None,
    output=None,
    resolution=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FlightlineOverlap -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=2.0"
./whitebox_tools -r=FlightlineOverlap -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=5.0 --palette=light_quant.plt
```

8.11.9 LasToAscii

Converts one or more LAS files into ASCII text files.

Parameters:

| Flag | Description |
|--------------|-------------------|
| -i, --inputs | Input LiDAR files |

Python function:

```
las_to_ascii(
    inputs,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LasToAscii -v --wd="/path/to/data/" ^
-i="file1.las, file2.las, file3.las" -o=outfile.las"
```

8.11.10 LasToMultipointShapefile

Converts one or more LAS files into MultipointZ vector Shapefiles. When the input parameter is not specified, the tool grids all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|-------------|------------------|
| -i, --input | Input LiDAR file |

Python function:

```
las_to_multipoint_shapefile(
    i=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LasToMultipointShapefile -v ^
--wd="/path/to/data/" -i=input.las
```

8.11.11 LidarColourize

Adds the red-green-blue colour fields of a LiDAR (LAS) file based on an input image.

Parameters:

| Flag | Description |
|--------------|-------------------------|
| --in_lidar | Input LiDAR file |
| --in_image | Input colour image file |
| -o, --output | Output LiDAR file |

Python function:

```
lidar_colourize(
    in_lidar,
    in_image,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarColourize -v --wd="/path/to/data/" ^
--in_lidar="input.las" --in_image="image.tif" ^
-o="output.las"
```

8.11.12 LidarConstructVectorTin

Creates a vector triangular irregular network (TIN) fitted to LiDAR points.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input LiDAR file (including extension) |
| -o, --output | Output raster file (including extension) |
| --returns | Point return types to include; options are 'all' (default), 'last', 'first' |
| --exclude_cls | Optional exclude classes from interpolation; Valid class values range from 0 to 18, based on LAS specifications. Example, --exclude_cls='3,4,5,6,7,18' |
| --minz | Optional minimum elevation for inclusion in interpolation |

| Flag | Description |
|--------|---|
| --maxz | Optional maximum elevation for inclusion in interpolation |

Python function:

```
lidar_construct_vector_tin(
    i=None,
    output=None,
    returns="all",
    exclude_cls=None,
    minz=None,
    maxz=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarConstructVectorTIN -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--returns=last --exclude_cls='3,4,5,6,7,18'
```

8.11.13 LidarElevationSlice

Outputs all of the points within a LiDAR (LAS) point file that lie between a specified elevation range.

Parameters:

| Flag | Description |
|---------------|---|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --minz | Minimum elevation value (optional) |
| --maxz | Maximum elevation value (optional) |
| --class | Optional boolean flag indicating whether points outside the range should be retained in output but reclassified |
| --inclassval | Optional parameter specifying the class value assigned to points within the slice |
| --outclassval | Optional parameter specifying the class value assigned to points within the slice |

Python function:

```
lidar_elevation_slice(
    i,
    output,
```

```
minz=None,
maxz=None,
cls=False,
inclassval=2,
outclassval=1,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarElevationSlice -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--minz=100.0 --maxz=250.0
>>./whitebox_tools ^
-r=LidarElevationSlice -v -i="/path/to/data/input.las" ^
-o="/path/to/data/output.las" --minz=100.0 --maxz=250.0 ^
--class
>>./whitebox_tools -r=LidarElevationSlice -v ^
-i="/path/to/data/input.las" -o="/path/to/data/output.las" ^
--minz=100.0 --maxz=250.0 --inclassval=1 --outclassval=0
```

8.11.14 LidarGroundPointFilter

Identifies ground points within LiDAR dataset using a slope-based method.

Parameters:

| Flag | Description |
|--------------------|---|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --radius | Search Radius |
| --min_neighbours | The minimum number of neighbouring points within search areas. If fewer points than this threshold are identified during the fixed-radius search, a subsequent kNN search is performed to identify the k number of neighbours |
| --slope_threshold | Maximum inter-point slope to be considered an off-terrain point |
| --height_threshold | Inter-point height difference to be considered an off-terrain point |
| --classify | Classify points as ground (2) or off-ground (1) |
| --slope_norm | Perform initial ground slope normalization? |

Python function:

```
lidar_ground_point_filter(
    i,
    output,
```

```
radius=2.0,
min_neighbours=0,
slope_threshold=45.0,
height_threshold=1.0,
classify=False,
slope_norm=True,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarGroundPointFilter -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--radius=10.0 --min_neighbours=10 --slope_threshold=30.0 ^
--height_threshold=0.5 --classify --slope_norm
```

8.11.15 LidarHexBinning

Hex-bins a set of LiDAR points.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input base file |
| -o, --output | Output vector polygon file |
| --width | The grid cell width |
| --orientation | Grid Orientation, 'horizontal' or 'vertical' |

Python function:

```
lidar_hex_binning(
    i,
    output,
    width,
    orientation="horizontal",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarHexBinning -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.shp --width=10.0 ^
--orientation=vertical
```

8.11.16 LidarHillshade

Calculates a hillshade value for points within a LAS file and stores these data in the RGB field.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input LiDAR file |
| -o, --output | Output file |
| --azimuth | Illumination source azimuth in degrees |
| --altitude | Illumination source altitude in degrees |
| --radius | Search Radius |

Python function:

```
lidar_hillshade(
    i,
    output,
    azimuth=315.0,
    altitude=30.0,
    radius=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarHillshade -v --wd="/path/to/data/" ^
-i="input.las" -o="output.las" --radius=10.0
>>./whitebox_tools ^
-r=LidarHillshade -v --wd="/path/to/data/" -i="input.las" ^
-o="output.las" --azimuth=180.0 --altitude=20.0 --radius=1.0
```

8.11.17 LidarHistogram

Creates a histogram from LiDAR data.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input LiDAR file |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |
| --parameter | Parameter; options are 'elevation' (default), 'intensity', 'scan angle', 'class' |
| --clip | Amount to clip distribution tails (in percent) |

Python function:

```
lidar_histogram(
    i,
    output,
    parameter="elevation",
    clip=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarHistogram -v --wd="/path/to/data/" ^
-i="file1.tif, file2.tif, file3.tif" -o=outfile.htm ^
--contiguity=Bishops1
```

8.11.18 LidarIdwInterpolation

Interpolates LAS files using an inverse-distance weighted (IDW) scheme. When the input/output parameters are not specified, the tool interpolates all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input LiDAR file (including extension) |
| -o, --output | Output raster file (including extension) |
| --parameter | Interpolation parameter; options are 'elevation' (default), 'intensity', 'class', 'scan angle', 'user data' |
| --returns | Point return types to include; options are 'all' (default), 'last', 'first' |
| --resolution | Output raster's grid resolution |
| --weight | IDW weight value |
| --radius | Search Radius |
| --exclude_cls | Optional exclude classes from interpolation; Valid class values range from 0 to 18, based on LAS specifications. Example, --exclude_cls='3,4,5,6,7,18' |
| --minz | Optional minimum elevation for inclusion in interpolation |
| --maxz | Optional maximum elevation for inclusion in interpolation |

Python function:

```
lidar_idw_interpolation(
    i=None,
    output=None,
    parameter="elevation",
    returns="all",
    resolution=1.0,
```

```
    weight=1.0,
    radius=2.5,
    exclude_cls=None,
    minz=None,
    maxz=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarIdwInterpolation -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=2.0 --radius=5.0"
./whitebox_tools ^
-r=LidarIdwInterpolation --wd="/path/to/data/" -i=file.las ^
-o=outfile.tif --resolution=5.0 --weight=2.0 --radius=2.0 ^
--exclude_cls='3,4,5,6,7,18' --palette=light_quant.plt
```

8.11.19 LidarInfo

Prints information about a LiDAR (LAS) dataset, including header, point return frequency, and classification data and information about the variable length records (VLRs) and geokeys.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input LiDAR file |
| -o, --output | Output HTML file for summary report |
| --vlr | Flag indicating whether or not to print the variable length records (VLRs) |
| --geokeys | Flag indicating whether or not to print the geokeys |

Python function:

```
lidar_info(
    i,
    output=None,
    vlr=False,
    geokeys=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarInfo -v --wd="/path/to/data/" ^
-i=file.las --vlr --geokeys"
./whitebox_tools -r=LidarInfo ^
```

```
--wd="/path/to/data/" -i=file.las
```

8.11.20 LidarJoin

Joins multiple LiDAR (LAS) files into a single LAS file.

Parameters:

| Flag | Description |
|--------------|-------------------|
| -i, --inputs | Input LiDAR files |
| -o, --output | Output LiDAR file |

Python function:

```
lidar_join(
    inputs,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarJoin -v --wd="/path/to/data/" ^
-i="file1.las, file2.las, file3.las" -o=outfile.las"
```

8.11.21 LidarKappaIndex

Performs a kappa index of agreement (KIA) analysis on the classifications of two LAS files.

Parameters:

| Flag | Description |
|----------------|---------------------------------|
| --i1, --input1 | Input LiDAR classification file |
| --i2, --input2 | Input LiDAR reference file |
| -o, --output | Output HTML file |

Python function:

```
lidar_kappa_index(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarKappaIndex -v ^
--wd="/path/to/data/" --i1=class.tif --i2=reference.tif ^
-o=kia.html
```

8.11.22 LidarNearestNeighbourGridding

Grids LAS files using nearest-neighbour scheme. When the input/output parameters are not specified, the tool grids all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input LiDAR file (including extension) |
| -o, --output | Output raster file (including extension) |
| --parameter | Interpolation parameter; options are 'elevation' (default), 'intensity', 'class', 'scan angle', 'user data' |
| --returns | Point return types to include; options are 'all' (default), 'last', 'first' |
| --resolution | Output raster's grid resolution |
| --radius | Search Radius |
| --exclude_cls | Optional exclude classes from interpolation; Valid class values range from 0 to 18, based on LAS specifications. Example, --exclude_cls='3,4,5,6,7,18' |
| --minz | Optional minimum elevation for inclusion in interpolation |
| --maxz | Optional maximum elevation for inclusion in interpolation |

Python function:

```
lidar_nearest_neighbour_gridding(
    i=None,
    output=None,
    parameter="elevation",
    returns="all",
    resolution=1.0,
    radius=2.5,
    exclude_cls=None,
    minz=None,
    maxz=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarNearestNeighbourGridding -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
```

```
--returns=last --resolution=2.0 --radius=5.0"
./whitebox_tools ^
-r=LidarNearestNeighbourGridding --wd="/path/to/data/" ^
-i=file.las -o=outfile.tif --resolution=5.0 --radius=2.0 ^
--exclude_cls='3,4,5,6,7,18'
```

8.11.23 LidarPointDensity

Calculates the spatial pattern of point density for a LiDAR data set. When the input/output parameters are not specified, the tool grids all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input LiDAR file (including extension) |
| -o, --output | Output raster file (including extension) |
| --returns | Point return types to include; options are 'all' (default), 'last', 'first' |
| --resolution | Output raster's grid resolution |
| --radius | Search Radius |
| --exclude_cls | Optional exclude classes from interpolation; Valid class values range from 0 to 18, based on LAS specifications. Example, --exclude_cls='3,4,5,6,7,18' |
| --minz | Optional minimum elevation for inclusion in interpolation |
| --maxz | Optional maximum elevation for inclusion in interpolation |

Python function:

```
lidar_point_density(
    i=None,
    output=None,
    returns="all",
    resolution=1.0,
    radius=2.5,
    exclude_cls=None,
    minz=None,
    maxz=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarPointDensity -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=2.0 --radius=5.0"
./whitebox_tools ^
-r=LidarPointDensity -v --wd="/path/to/data/" -i=file.las ^
```

```
-o=outfile.tif --resolution=5.0 --radius=2.0 ^
--exclude_cls='3,4,5,6,7,18' --palette=light_quant.plt
```

8.11.24 LidarPointStats

Creates several rasters summarizing the distribution of LAS point data. When the input/output parameters are not specified, the tool works on all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|-------------------|--|
| -i, --input | Input LiDAR file |
| --resolution | Output raster's grid resolution |
| --num_points | Flag indicating whether or not to output the number of points raster |
| --num_pulses | Flag indicating whether or not to output the number of pulses raster |
| --z_range | Flag indicating whether or not to output the elevation range raster |
| --intensity_range | Flag indicating whether or not to output the intensity range raster |
| --predom_class | Flag indicating whether or not to output the predominant classification raster |

Python function:

```
lidar_point_stats(
    i=None,
    resolution=1.0,
    num_points=True,
    num_pulses=False,
    z_range=False,
    intensity_range=False,
    predom_class=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarPointStats -v ^
--wd="/path/to/data/" -i=file.las --resolution=1.0 ^
--num_points
```

8.11.25 LidarRemoveDuplicates

Removes duplicate points from a LiDAR data set.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --include_z | Include z-values in point comparison? |

Python function:

```
lidar_remove_duplicates(
    i,
    output,
    include_z=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarRemoveDuplicates -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las"
```

8.11.26 LidarRemoveOutliers

Removes outliers (high and low points) in a LiDAR point cloud.

Parameters:

| Flag | Description |
|--------------|---------------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --radius | Search Radius |
| --elev_diff | Max. elevation difference |

Python function:

```
lidar_remove_outliers(
    i,
    output,
    radius=2.0,
    elev_diff=50.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarRemoveOutliers -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--radius=10.0 --elev_diff=25.0
```

8.11.27 LidarSegmentation

Segments a LiDAR point cloud based on normal vectors.

Parameters:

| Flag | Description |
|------------------|---|
| -i, --input | Input LiDAR file |
| -o, --output | Output file |
| --dist, --radius | Search Radius |
| --norm_diff | Maximum difference in normal vectors, in degrees |
| --maxzdiff | Maximum difference in elevation (z units) between neighbouring points of the same segment |

Python function:

```
lidar_segmentation(
    i,
    output,
    radius=5.0,
    norm_diff=10.0,
    maxzdiff=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarSegmentation -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--radius=10.0 --norm_diff=2.5 --maxzdiff=0.75
```

8.11.28 LidarSegmentationBasedFilter

Identifies ground points within LiDAR point clouds using a segmentation based approach.

Parameters:

| Flag | Description |
|------------------|--|
| -i, --input | Input LiDAR file |
| -o, --output | Output file |
| --dist, --radius | Search Radius |
| --norm_diff | Maximum difference in normal vectors, in degrees |

| Flag | Description |
|------------|---|
| --maxzdiff | Maximum difference in elevation (z units) between neighbouring points of the same segment |
| --classify | Classify points as ground (2) or off-ground (1) |

Python function:

```
lidar_segmentation_based_filter(
    i,
    output,
    radius=5.0,
    norm_diff=2.0,
    maxzdiff=1.0,
    classify=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarSegmentationBasedFilter -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--radius=10.0 --norm_diff=2.5 --maxzdiff=0.75 --classify
```

8.11.29 LidarThin

Thins a LiDAR point cloud, reducing point density.

Parameters:

| Flag | Description |
|-----------------|---|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --resolution | The size of the square area used to evaluate nearby points in the LiDAR data |
| --method | Point selection method; options are 'first', 'last', 'lowest' (default), 'highest', 'nearest' |
| --save_filtered | Save filtered points to separate file? |

Python function:

```
lidar_thin(
    i,
    output,
    resolution=2.0,
    method="lowest",
```

```
    save_filtered=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarThin -v --wd="/path/to/data/" ^
-i=file.las -o=outfile.las --resolution=2.0, --method=first ^
--save_filtered
```

8.11.30 LidarThinHighDensity

Thins points from high density areas within a LiDAR point cloud.

Parameters:

| Flag | Description |
|-----------------|---|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --resolution | Output raster's grid resolution |
| --density | Max. point density (points / m ³) |
| --save_filtered | Save filtered points to separate file? |

Python function:

```
lidar_thin_high_density(
    i,
    output,
    density,
    resolution=1.0,
    save_filtered=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarThinHighDensity -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--resolution=1.0 --density=100.0 --save_filtered
```

8.11.31 LidarTile

Tiles a LiDAR LAS file into multiple LAS files.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input LiDAR file |
| --width_x | Width of tiles in the X dimension; default 1000.0 |
| --width_y | Width of tiles in the Y dimension |
| --origin_x | Origin point X coordinate for tile grid |
| --origin_y | Origin point Y coordinate for tile grid |
| --min_points | Minimum number of points contained in a tile for it to be saved |

Python function:

```
lidar_tile(
    i,
    width_x=1000.0,
    width_y=1000.0,
    origin_x=0.0,
    origin_y=0.0,
    min_points=2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarTile -v -i=/path/to/data/input.las ^
--width_x=1000.0 --width_y=2500.0 --min_points=100
```

8.11.32 LidarTileFootprint

Creates a vector polygon of the convex hull of a LiDAR point cloud. When the input/output parameters are not specified, the tool works with all LAS files contained within the working directory.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output vector polygon file |

Python function:

```
lidar_tile_footprint(
    output,
    i=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarTileFootprint -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.shp
```

8.11.33 LidarTinGridding

Creates a raster grid based on a Delaunay triangular irregular network (TIN) fitted to LiDAR points.

Parameters:

| Flag | Description |
|---------------|--|
| -i, --input | Input LiDAR file (including extension) |
| -o, --output | Output raster file (including extension) |
| --parameter | Interpolation parameter; options are 'elevation' (default), 'intensity', 'class', 'scan angle', 'user data' |
| --returns | Point return types to include; options are 'all' (default), 'last', 'first' |
| --resolution | Output raster's grid resolution |
| --exclude_cls | Optional exclude classes from interpolation; Valid class values range from 0 to 18, based on LAS specifications. Example, --exclude_cls='3,4,5,6,7,18' |
| --minz | Optional minimum elevation for inclusion in interpolation |
| --maxz | Optional maximum elevation for inclusion in interpolation |

Python function:

```
lidar_tin_gridding(
    i=None,
    output=None,
    parameter="elevation",
    returns="all",
    resolution=1.0,
    exclude_cls=None,
    minz=None,
    maxz=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarTINGridding -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--returns=last --resolution=2.0 --exclude_cls='3,4,5,6,7,18'
```

8.11.34 LidarTophatTransform

Performs a white top-hat transform on a Lidar dataset; as an estimate of height above ground, this is useful for modelling the vegetation canopy.

Parameters:

| Flag | Description |
|--------------|-------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --radius | Search Radius |

Python function:

```
lidar_tophat_transform(
    i,
    output,
    radius=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarTophatTransform -v ^
--wd="/path/to/data/" -i="input.las" -o="output.las" ^
--radius=10.0
```

8.11.35 NormalVectors

Calculates normal vectors for points within a LAS file and stores these data (XYZ vector components) in the RGB field.

Parameters:

| Flag | Description |
|--------------|-------------------|
| -i, --input | Input LiDAR file |
| -o, --output | Output LiDAR file |
| --radius | Search Radius |

Python function:

```
normal_vectors(
    i,
    output,
    radius=1.0,
```

```
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NormalVectors -v --wd="/path/to/data/" ^
-i="input.las" -o="output.las" --radius=10.0
```

8.11.36 SelectTilesByPolygon

Copies LiDAR tiles overlapping with a polygon into an output directory.

Parameters:

| Flag | Description |
|------------|---|
| --indir | Input LAS file source directory |
| --outdir | Output directory into which LAS files within the polygon are copied |
| --polygons | Input vector polygons file |

Python function:

```
select_tiles_by_polygon(
    indir,
    outdir,
    polygons,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SelectTilesByPolygon -v ^
--indir='/path/to/lidar/' --outdir='/output/path/' ^
--polygons='watershed.shp'
```

8.12 Math and Stats Tools

8.12.1 AbsoluteValue

Calculates the absolute value of every cell in a raster.

Parameters:

| Flag | Description |
|-------------|-------------------|
| -i, --input | Input raster file |

| Flag | Description |
|--------------|--------------------|
| -o, --output | Output raster file |

Python function:

```
absolute_value(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AbsoluteValue -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.2 Add

Performs an addition operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
add(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Add -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.3 And

Performs a logical AND operator on two Boolean raster images.

Parameters:

| Flag | Description |
|--------------|--------------------|
| --input1 | Input raster file |
| --input2 | Input raster file |
| -o, --output | Output raster file |

Python function:

```
And(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=And -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.4 Anova

Performs an analysis of variance (ANOVA) test on a raster dataset.

Parameters:

| Flag | Description |
|--------------|--------------------------------------|
| -i, --input | Input raster file |
| --features | Feature definition (or class) raster |
| -o, --output | Output HTML file |

Python function:

```
anova(
    i,
    features,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Anova -v --wd="/path/to/data/" ^
-i=data.tif --features=classes.tif -o=anova.html
```

8.12.5 ArcCos

Returns the inverse cosine (arccos) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
arc_cos(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ArcCos -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.6 ArcSin

Returns the inverse sine (arcsin) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
arc_sin(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ArcSin -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.7 ArcTan

Returns the inverse tangent (arctan) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
arc_tan(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ArcTan -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.8 Atan2

Returns the 2-argument inverse tangent (atan2).

Parameters:

| Flag | Description |
|--------------|--|
| --input_y | Input y raster file or constant value (rise) |
| --input_x | Input x raster file or constant value (run) |
| -o, --output | Output raster file |

Python function:

```
atan2(
    input_y,
    input_x,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Atan2 -v --wd="/path/to/data/" ^
```

```
--input_y='in1.tif' --input_x='in2.tif' -o=output.tif
```

8.12.9 AttributeCorrelation

Performs a correlation analysis on attribute fields from a vector database.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
attribute_correlation(
    i,
    output=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AttributeCorrelation -v ^
--wd="/path/to/data/" -i=file.shp -o=outfile.html
```

8.12.10 AttributeHistogram

Creates a histogram for the field values of a vector's attribute table.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| --field | Input field name in attribute table |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
attribute_histogram(
    i,
    field,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AttributeHistogram -v ^
--wd="/path/to/data/" -i=lakes.shp --field=HEIGHT ^
-o=outfile.html
```

8.12.11 AttributeScattergram

Creates a scattergram for two field values of a vector's attribute table.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| --fieldx | Input field name in attribute table for the x-axis |
| --fieldy | Input field name in attribute table for the y-axis |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |
| --trendline | Draw the trendline |

Python function:

```
attribute_scattergram(
    i,
    fieldx,
    fieldy,
    output,
    trendline=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=AttributeScattergram -v ^
--wd="/path/to/data/" -i=lakes.shp --fieldx=HEIGHT ^
--fieldy=area -o=outfile.html --trendline
```

8.12.12 Ceil

Returns the smallest (closest to negative infinity) value that is greater than or equal to the values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
ceil(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Ceil -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.13 Cos

Returns the cosine (cos) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
cos(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Cos -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.14 Cosh

Returns the hyperbolic cosine (cosh) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
cosh(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Cosh -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.15 CrispnessIndex

Calculates the Crispness Index, which is used to quantify how crisp (or conversely how fuzzy) a probability image is.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input raster file |
| -o, --output | Optional output html file (default name will be based on input file if unspecified) |

Python function:

```
crispness_index(
    i,
    output=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CrispnessIndex -v --wd="/path/to/data/" ^
-i=input.tif
>>./whitebox_tools -r=CrispnessIndex -v ^
--wd="/path/to/data/" -o=crispness.html
```

8.12.16 CrossTabulation

Performs a cross-tabulation on two categorical images.

Parameters:

| Flag | Description |
|----------------|--|
| --i1, --input1 | Input raster file 1 |
| --i2, --input2 | Input raster file 1 |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
cross_tabulation(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CrossTabulation -v ^
--wd="/path/to/data/" --i1="file1.tif" --i2="file2.tif" ^
-o=outfile.html
```

8.12.17 CumulativeDistribution

Converts a raster image to its cumulative distribution function.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
cumulative_distribution(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=CumulativeDistribution -v ^
--wd="/path/to/data/" -i=DEM.tif -o=output.tif
```

8.12.18 Decrement

Decreases the values of each grid cell in an input raster by 1.0 (see also InPlaceSubtract).

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
decrement(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Decrement -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.19 Divide

Performs a division operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
divide(
    input1,
    input2,
    output,
```

```
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Divide -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.20 EqualTo

Performs a equal-to comparison operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
equal_to(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=EqualTo -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.21 Exp

Returns the exponential (base e) of values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
exp(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Exp -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.22 Exp2

Returns the exponential (base 2) of values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
exp2(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Exp2 -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.23 ExtractRasterStatistics

Extracts descriptive statistics for a group of patches in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------------------------|
| -i, --input | Input data raster file |
| --features | Input feature definition raster file |
| -o, --output | Output raster file |
| --stat | Statistic to extract |

| Flag | Description |
|-------------|------------------------|
| --out_table | Output HTML Table file |

Python function:

```
extract_raster_statistics(
    i,
    features,
    output=None,
    stat="average",
    out_table=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ExtractRasterStatistics -v ^
--wd="/path/to/data/" -i='input.tif' --features='groups.tif' ^
-o='output.tif' --stat='minimum'
>>./whitebox_tools ^
-r=ExtractRasterStatistics -v --wd="/path/to/data/" ^
-i='input.tif' --features='groups.tif' ^
--out_table='output.html'
```

8.12.24 Floor

Returns the largest (closest to positive infinity) value that is less than or equal to the values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
floor(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Floor -v --wd="/path/to/data/" ^
-i='input.tif' -o='output.tif'
```

8.12.25 GreaterThan

Performs a greater-than comparison operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|---------------|--|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |
| --incl_equals | Perform a greater-than-or-equal-to operation |

Python function:

```
greater_than(
    input1,
    input2,
    output,
    incl_equals=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=GreaterThan -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif ^
--incl_equals
```

8.12.26 ImageAutocorrelation

Performs Moran's I analysis on two or more input images.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --inputs | Input raster files |
| --contiguity | Contiguity type |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
image_autocorrelation(
    inputs,
    output,
    contiguity="Rook",
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ImageAutocorrelation -v ^
--wd="/path/to/data/" -i="file1.tif, file2.tif, file3.tif" ^
-o=outfile.html --contiguity=Bishops
```

8.12.27 ImageCorrelation

Performs image correlation on two or more input images.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --inputs | Input raster files |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
image_correlation(
    inputs,
    output=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ImageCorrelation -v ^
--wd="/path/to/data/" -i="file1.tif, file2.tif, file3.tif" ^
-o=outfile.html
```

8.12.28 ImageRegression

Performs image regression analysis on two input images.

Parameters:

| Flag | Description |
|----------------|---|
| --i1, --input1 | Input raster file (independent variable, X) |

| Flag | Description |
|-----------------|---|
| --i2, --input2 | Input raster file (dependent variable, Y) |
| -o, --output | Output HTML file for regression summary report |
| --out_residuals | Output raster regression residual file |
| --standardize | Optional flag indicating whether to standardize the residuals map |

Python function:

```
image_regression(
    input1,
    input2,
    output,
    out_residuals=None,
    standardize=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ImageRegression -v ^
--wd="/path/to/data/" --i1='file1.tif' --i2='file2.tif' ^
-o='outfile.html' --out_residuals='residuals.tif' ^
--standardize
```

8.12.29 InPlaceAdd

Performs an in-place addition operation ($\text{input1} += \text{input2}$).

Parameters:

| Flag | Description |
|----------|-------------------------------------|
| --input1 | Input raster file |
| --input2 | Input raster file or constant value |

Python function:

```
in_place_add(
    input1,
    input2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=InPlaceAdd -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif'"
```

```
>>./whitebox_tools ^
-r=InPlaceAdd -v --wd="/path/to/data/" --input1='in1.tif' ^
--input2=10.5'
```

8.12.30 InPlaceDivide

Performs an in-place division operation ($\text{input1} /= \text{input2}$).

Parameters:

| Flag | Description |
|----------|-------------------------------------|
| --input1 | Input raster file |
| --input2 | Input raster file or constant value |

Python function:

```
in_place_divide(
    input1,
    input2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=InPlaceDivide -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif'
>>./whitebox_tools ^
-r=InPlaceDivide -v --wd="/path/to/data/" --input1='in1.tif' ^
--input2=10.5'
```

8.12.31 InPlaceMultiply

Performs an in-place multiplication operation ($\text{input1} *= \text{input2}$).

Parameters:

| Flag | Description |
|----------|-------------------------------------|
| --input1 | Input raster file |
| --input2 | Input raster file or constant value |

Python function:

```
in_place_multiply(
    input1,
    input2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=InPlaceMultiply -v ^
--wd="/path/to/data/" --input1='in1.tif' ^
--input2='in2.tif'"
>>./whitebox_tools -r=InPlaceMultiply -v ^
--wd="/path/to/data/" --input1='in1.tif' --input2=10.5'
```

8.12.32 InPlaceSubtract

Performs an in-place subtraction operation ($\text{input1} -= \text{input2}$).

Parameters:

| Flag | Description |
|----------|-------------------------------------|
| --input1 | Input raster file |
| --input2 | Input raster file or constant value |

Python function:

```
in_place_subtract(
    input1,
    input2,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=InPlaceSubtract -v ^
--wd="/path/to/data/" --input1='in1.tif' ^
--input2='in2.tif'"
>>./whitebox_tools -r=InPlaceSubtract -v ^
--wd="/path/to/data/" --input1='in1.tif' --input2=10.5'
```

8.12.33 Increment

Increases the values of each grid cell in an input raster by 1.0. (see also InPlaceAdd).

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
increment(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Increment -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.34 IntegerDivision

Performs an integer division operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
integer_division(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=IntegerDivision -v ^
--wd="/path/to/data/" --input1='in1.tif' --input2='in2.tif' ^
-o=output.tif
```

8.12.35 IsNoData

Identifies NoData valued pixels in an image.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
is_no_data(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=IsNoData -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.36 KappaIndex

Performs a kappa index of agreement (KIA) analysis on two categorical raster files.

Parameters:

| Flag | Description |
|----------------|----------------------------------|
| --i1, --input1 | Input classification raster file |
| --i2, --input2 | Input reference raster file |
| -o, --output | Output HTML file |

Python function:

```
kappa_index(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=KappaIndex -v --wd="/path/to/data/" ^
```

```
--i1=class.tif --i2=reference.tif -o=kia.html
```

8.12.37 KsTestForNormality

Evaluates whether the values in a raster are normally distributed.

Parameters:

| Flag | Description |
|---------------|---|
| -i, --input | Input raster file |
| -o, --output | Output HTML file |
| --num_samples | Number of samples. Leave blank to use whole image |

Python function:

```
ks_test_for_normality(
    i,
    output,
    num_samples=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=KSTestForNormality -v ^
--wd="/path/to/data/" -i=input.tif -o=output.html ^
--num_samples=1000
>>./whitebox_tools -r=KSTestForNormality -v ^
--wd="/path/to/data/" -i=input.tif -o=output.html
```

8.12.38 LessThan

Performs a less-than comparison operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|---------------|---|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |
| --incl_equals | Perform a less-than-or-equal-to operation |

Python function:

```
less_than(
    input1,
    input2,
    output,
    incl_equals=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LessThan -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif ^
--incl_equals
```

8.12.39 ListUniqueValues

Lists the unique values contained in a field within a vector's attribute table.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| --field | Input field name in attribute table |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
list_unique_values(
    i,
    field,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ListUniqueValues -v ^
--wd="/path/to/data/" -i=lakes.shp --field=HEIGHT ^
-o=outfile.html
```

8.12.40 Ln

Returns the natural logarithm of values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
ln(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Ln -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.41 Log10

Returns the base-10 logarithm of values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
log10(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Log10 -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.42 Log2

Returns the base-2 logarithm of values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
log2(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Log2 -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.43 Max

Performs a MAX operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
max(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Max -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.44 Min

Performs a MIN operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
min(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Min -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.45 Modulo

Performs a modulo operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
modulo(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Modulo -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.46 Multiply

Performs a multiplication operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
multiply(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Multiply -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.47 Negate

Changes the sign of values in a raster or the 0-1 values of a Boolean raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
negate(
    i,
    output,
```

```
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Negate -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.48 Not

Performs a logical NOT operator on two Boolean raster images.

Parameters:

| Flag | Description |
|--------------|--------------------|
| --input1 | Input raster file |
| --input2 | Input raster file |
| -o, --output | Output raster file |

Python function:

```
Not(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Not -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.49 NotEqualTo

Performs a not-equal-to comparison operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
not_equal_to(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NotEqualTo -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.50 Or

Performs a logical OR operator on two Boolean raster images.

Parameters:

| Flag | Description |
|--------------|--------------------|
| --input1 | Input raster file |
| --input2 | Input raster file |
| -o, --output | Output raster file |

Python function:

```
Or(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Or -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.51 Power

Raises the values in grid cells of one rasters, or a constant value, by values in another raster or constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
power(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Power -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.52 PrincipalComponentAnalysis

Performs a principal component analysis (PCA) on a multi-spectral dataset.

Parameters:

| Flag | Description |
|----------------|---|
| -i, --inputs | Input raster files |
| --out_html | Output HTML report file |
| --num_comp | Number of component images to output; <= to num. input images |
| --standardized | Perform standardized PCA? |

Python function:

```
principal_component_analysis(
    inputs,
    out_html,
    num_comp=None,
    standardized=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=PrincipalComponentAnalysis -v ^
--wd='/path/to/data/' -i='image1.tif;image2.tif;image3.tif' ^
--out_html=report.html --num_comp=3 --standardized
```

8.12.53 Quantiles

Transforms raster values into quantiles.

Parameters:

| Flag | Description |
|-----------------|---------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --num_quantiles | Number of quantiles |

Python function:

```
quantiles(
    i,
    output,
    num_quantiles=4,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Quantiles -v --wd="/path/to/data/" ^
-i=DEM.tif -o=output.tif --num_quantiles=5
```

8.12.54 RandomField

Creates an image containing random values.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --base | Input raster file |
| -o, --output | Output raster file |

Python function:

```
random_field(
    base,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RandomField -v --wd="/path/to/data/" ^
--base=in.tif -o=out.tif
```

8.12.55 RandomSample

Creates an image containing randomly located sample grid cells with unique IDs.

Parameters:

| Flag | Description |
|---------------|--------------------|
| -i, --base | Input raster file |
| -o, --output | Output raster file |
| --num_samples | Number of samples |

Python function:

```
random_sample(
    base,
    output,
    num_samples=1000,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RandomSample -v --wd="/path/to/data/" ^
--base=in.tif -o=out.tif --num_samples=1000
```

8.12.56 RasterHistogram

Creates a histogram from raster values.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --input | Input raster file |
| -o, --output | Output HTML file (default name will be based on input file if unspecified) |

Python function:

```
raster_histogram(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RasterHistogram -v ^
--wd="/path/to/data/" -i="file1.tif" -o=outfile.html
```

8.12.57 RasterSummaryStats

Measures a rasters average, standard deviation, num. non-nodata cells, and total.

Parameters:

| Flag | Description |
|-------------|-------------------|
| -i, --input | Input raster file |

Python function:

```
raster_summary_stats(
    i,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RasterSummaryStats -v ^
--wd="/path/to/data/" -i=DEM.tif
```

8.12.58 Reciprocal

Returns the reciprocal (i.e. $1 / z$) of values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
reciprocal(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Reciprocal -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.59 RescaleValueRange

Performs a min-max contrast stretch on an input greytone image.

Parameters:

| Flag | Description |
|---------------|-----------------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --out_min_val | New minimum value in output image |
| --out_max_val | New maximum value in output image |
| --clip_min | Optional lower tail clip value |
| --clip_max | Optional upper tail clip value |

Python function:

```
rescale_value_range(
    i,
    output,
    out_min_val,
    out_max_val,
    clip_min=None,
    clip_max=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RescaleValueRange -v ^
--wd="/path/to/data/" -i=input.tif -o=output.tif ^
--out_min_val=0.0 --out_max_val=1.0
>>./whitebox_tools ^
-r=RescaleValueRange -v --wd="/path/to/data/" -i=input.tif ^
-o=output.tif --out_min_val=0.0 --out_max_val=1.0 ^
--clip_min=45.0 --clip_max=200.0
```

8.12.60 RootMeanSquareError

Calculates the RMSE and other accuracy statistics.

Parameters:

| Flag | Description |
|-------------|--|
| -i, --input | Input raster file |
| --base | Input base raster file used for comparison |

Python function:

```
root_mean_square_error(  
    i,  
    base,  
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RootMeanSquareError -v ^  
--wd="/path/to/data/" -i=DEM.tif
```

8.12.61 Round

Rounds the values in an input raster to the nearest integer value.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
round(  
    i,  
    output,  
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Round -v --wd="/path/to/data/" ^
```

```
-i='input.tif' -o=output.tif
```

8.12.62 Sin

Returns the sine (sin) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
sin(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Sin -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.63 Sinh

Returns the hyperbolic sine (sinh) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
sinh(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Sinh -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.64 Square

Squares the values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
square(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Square -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.65 SquareRoot

Returns the square root of the values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
square_root(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SquareRoot -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.66 Subtract

Performs a differencing operation on two rasters or a raster and a constant value.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --input1 | Input raster file or constant value |
| --input2 | Input raster file or constant value |
| -o, --output | Output raster file |

Python function:

```
subtract(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Subtract -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.67 Tan

Returns the tangent (tan) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
tan(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Tan -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.68 Tanh

Returns the hyperbolic tangent (tanh) of each values in a raster.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
tanh(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Tanh -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.69 ToDegrees

Converts a raster from radians to degrees.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
to_degrees(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ToDegrees -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.70 ToRadians

Converts a raster from degrees to radians.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
to_radians(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ToRadians -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif
```

8.12.71 TrendSurface

Estimates the trend surface of an input raster file.

Parameters:

| Flag | Description |
|--------------|----------------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --order | Polynomial order (1 to 10) |

Python function:

```
trend_surface(
    i,
    output,
    order=1,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TrendSurface -v --wd="/path/to/data/" ^
-i='input.tif' -o='output.tif' --order=2
```

8.12.72 TrendSurfaceVectorPoints

Estimates a trend surface from vector points.

Parameters:

| Flag | Description |
|--------------|---|
| -i, --input | Input vector Points file |
| --field | Input field name in attribute table |
| -o, --output | Output raster file |
| --order | Polynomial order (1 to 10) |
| --cell_size | Optionally specified cell size of output raster. Not used when base raster is specified |

Python function:

```
trend_surface_vector_points(
    i,
    field,
    output,
    cell_size,
    order=1,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TrendSurfaceVectorPoints -v ^
--wd="/path/to/data/" -i='input.shp' --field=ELEV ^
-o='output.tif' --order=2 --cell_size=10.0
```

8.12.73 Truncate

Truncates the values in a raster to the desired number of decimal places.

Parameters:

| Flag | Description |
|----------------|--|
| -i, --input | Input raster file |
| -o, --output | Output raster file |
| --num_decimals | Number of decimals left after truncation (default is zero) |

Python function:

```
truncate(
    i,
    output,
    num_decimals=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Truncate -v --wd="/path/to/data/" ^
-i='input.tif' -o=output.tif --num_decimals=2
```

8.12.74 TurningBandsSimulation

Creates an image containing random values based on a turning-bands simulation.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --base | Input base raster file |
| -o, --output | Output file |
| --range | The field's range, in xy-units, related to the extent of spatial autocorrelation |
| --iterations | The number of iterations |

Python function:

```
turning_bands_simulation(
    base,
    output,
    range,
    iterations=1000,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TurningBandsSimulation -v ^
--wd="/path/to/data/" --base=in.tif -o=out.tif --range=850.0 ^
--iterations=2500
```

8.12.75 Xor

Performs a logical XOR operator on two Boolean raster images.

Parameters:

| Flag | Description |
|--------------|--------------------|
| --input1 | Input raster file |
| --input2 | Input raster file |
| -o, --output | Output raster file |

Python function:

```
xor(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=Xor -v --wd="/path/to/data/" ^
--input1='in1.tif' --input2='in2.tif' -o=output.tif
```

8.12.76 ZScores

Standardizes the values in an input raster by converting to z-scores.

Parameters:

| Flag | Description |
|--------------|--------------------|
| -i, --input | Input raster file |
| -o, --output | Output raster file |

Python function:

```
z_scores(
    i,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ZScores -v --wd="/path/to/data/" ^
-i=DEM.tif -o=output.tif
```

8.13 Stream Network Analysis

8.13.1 DistanceToOutlet

Calculates the distance of stream grid cells to the channel network outlet cell.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
distance_to_outlet(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=DistanceToOutlet -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=DistanceToOutlet -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.2 ExtractStreams

Extracts stream grid cells from a flow accumulation raster.

Parameters:

| Flag | Description |
|-------------------|---|
| --flow_accum | Input raster D8 flow accumulation file |
| -o, --output | Output raster file |
| --threshold | Threshold in flow accumulation values for channelization |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
extract_streams(
    flow_accum,
    output,
    threshold,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ExtractStreams -v --wd="/path/to/data/" ^
--flow_accum='d8accum.tif' -o='output.tif' --threshold=100.0 ^
--zero_background
```

8.13.3 ExtractValleys

Identifies potential valley bottom grid cells based on local topography alone.

Parameters:

| Flag | Description |
|--------------|--|
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --variant | Options include 'lq' (lower quartile), 'JandR' (Johnston and Rosenfeld), and 'PandD' (Peucker and Douglas); default is 'lq' |
| --line_thin | Optional flag indicating whether post-processing line-thinning should be performed |
| --filter | Optional argument (only used when variant='lq') providing the filter size, in grid cells, used for lq-filtering (default is 5) |

Python function:

```
extract_valleys(
    dem,
    output,
    variant="Lower Quartile",
    line_thin=True,
    filter=5,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ExtractValleys -v --wd="/path/to/data/" ^
--dem=pointer.tif -o=out.tif --variant='JandR' ^
--line_thin
>>./whitebox_tools -r=ExtractValleys -v ^
--wd="/path/to/data/" --dem=pointer.tif -o=out.tif ^
--variant='lq' --filter=7 --line_thin
```

8.13.4 FarthestChannelHead

Calculates the distance to the furthest upstream channel head for each stream cell.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
farthest_channel_head(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FarthestChannelHead -v ^
```

```
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=FarthestChannelHead -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.5 FindMainStem

Finds the main stem, based on stream lengths, of each stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
find_main_stem(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=FindMainStem -v --wd="/path/to/data/" ^
--d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=FindMainStem -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.6 HackStreamOrder

Assigns the Hack stream order to each tributary in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
hack_stream_order(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HackStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=HackStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.7 HortonStreamOrder

Assigns the Horton stream order to each tributary in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
horton_stream_order(
    d8_pntr,
```

```
streams,
output,
esri_pntr=False,
zero_background=False,
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=HortonStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=HortonStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.8 LengthOfUpstreamChannels

Calculates the total length of channels upstream.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
length_of_upstream_channels(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LengthOfUpstreamChannels -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=LengthOfUpstreamChannels -v ^
```

```
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.9 LongProfile

Plots the stream longitudinal profiles for one or more rivers.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| --dem | Input raster DEM file |
| -o, --output | Output HTML file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
long_profile(
    d8_pntr,
    streams,
    dem,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LongProfile -v --wd="/path/to/data/" ^
--d8_pntr=D8.tif --streams=streams.tif --dem=dem.tif ^
-o=output.html --esri_pntr
```

8.13.10 LongProfileFromPoints

Plots the longitudinal profiles from flow-paths initiating from a set of vector points.

Parameters:

| Flag | Description |
|-----------|------------------------------|
| --d8_pntr | Input raster D8 pointer file |
| --points | Input vector points file |
| --dem | Input raster DEM file |

| Flag | Description |
|--------------|---------------------------------------|
| -o, --output | Output HTML file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
long_profile_from_points(
    d8_pntr,
    points,
    dem,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LongProfileFromPoints -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --points=stream_head.shp ^
--dem=dem.tif -o=output.html --esri_pntr
```

8.13.11 RasterStreamsToVector

Converts a raster stream file into a vector file.

Parameters:

| Flag | Description |
|--------------|---------------------------------------|
| --streams | Input raster streams file |
| --d8_pntr | Input raster D8 pointer file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
raster_streams_to_vector(
    streams,
    d8_pntr,
    output,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RasterStreamsToVector -v ^
```

```
--wd="/path/to/data/" --streams=streams.tif --d8_pntr=D8.tif ^
-o=output.tif
>>./whitebox_tools -r=RasterStreamsToVector -v ^
--wd="/path/to/data/" --streams=streams.tif --d8_pntr=D8.tif ^
-o=output.tif --esri_pntr
```

8.13.12 RasterizeStreams

Rasterizes vector streams based on Lindsay (2016) method.

Parameters:

| Flag | Description |
|--------------|-------------------------------------|
| --streams | Input vector streams file |
| --base | Input base raster file |
| -o, --output | Output raster file |
| --nodata | Use NoData value for background? |
| --feature_id | Use feature number as output value? |

Python function:

```
rasterize_streams(
    streams,
    base,
    output,
    nodata=True,
    feature_id=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RasterizeStreams -v ^
--wd="/path/to/data/" --streams=streams.shp --base=raster.tif ^
-o=output.tif
```

8.13.13 RemoveShortStreams

Removes short first-order streams from a stream network.

Parameters:

| Flag | Description |
|-----------|------------------------------|
| --d8_pntr | Input raster D8 pointer file |

| Flag | Description |
|--------------|--|
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --min_length | Minimum tributary length (in map units) used for network pruning |
| --esri_pntr | D8 pointer uses the ESRI style scheme |

Python function:

```
remove_short_streams(
    d8_pntr,
    streams,
    output,
    min_length,
    esri_pntr=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=RemoveShortStreams -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
```

8.13.14 ShreveStreamMagnitude

Assigns the Shreve stream magnitude to each link in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
shreve_stream_magnitude(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
```

```
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=ShreveStreamMagnitude -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=ShreveStreamMagnitude -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.15 StrahlerStreamOrder

Assigns the Strahler stream order to each link in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
strahler_stream_order(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StrahlerStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=StrahlerStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.16 StreamLinkClass

Identifies the exterior/interior links and nodes in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
stream_link_class(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StreamLinkClass -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=StreamLinkClass -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.17 StreamLinkIdentifier

Assigns a unique identifier to each link in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
stream_link_identifier(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StreamLinkIdentifier -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=StreamLinkIdentifier -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.18 StreamLinkLength

Estimates the length of each link (or tributary) in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --linkid | Input raster streams link ID (or tributary ID) file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
stream_link_length(
    d8_pntr,
    linkid,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StreamLinkLength -v ^
```

```
--wd="/path/to/data/" --d8_pntr=D8.tif --linkid=streamsID.tif ^
--dem=dem.tif -o=output.tif
>>./whitebox_tools ^
-r=StreamLinkLength -v --wd="/path/to/data/" --d8_pntr=D8.tif ^
--linkid=streamsID.tif --dem=dem.tif -o=output.tif --esri_pntr ^
--zero_background
```

8.13.19 StreamLinkSlope

Estimates the average slope of each link (or tributary) in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --linkid | Input raster streams link ID (or tributary ID) file |
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
stream_link_slope(
    d8_pntr,
    linkid,
    dem,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StreamLinkSlope -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --linkid=streamsID.tif ^
--dem=dem.tif -o=output.tif
>>./whitebox_tools ^
-r=StreamLinkSlope -v --wd="/path/to/data/" --d8_pntr=D8.tif ^
--linkid=streamsID.tif --dem=dem.tif -o=output.tif --esri_pntr ^
--zero_background
```

8.13.20 StreamSlopeContinuous

Estimates the slope of each grid cell in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -i, --dem | Input raster DEM file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
stream_slope_continuous(
    d8_pntr,
    streams,
    dem,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=StreamSlopeContinuous -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --linkid=streamsID.tif ^
--dem=dem.tif -o=output.tif
>>./whitebox_tools ^
-r=StreamSlopeContinuous -v --wd="/path/to/data/" ^
--d8_pntr=D8.tif --streams=streamsID.tif --dem=dem.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.21 TopologicalStreamOrder

Assigns each link in a stream network its topological order.

Parameters:

| Flag | Description |
|-----------|------------------------------|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |

| Flag | Description |
|-------------------|---|
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
topological_stream_order(
    d8_pntr,
    streams,
    output,
    esri_pntr=False,
    zero_background=False,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TopologicalStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif
>>./whitebox_tools -r=TopologicalStreamOrder -v ^
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^
-o=output.tif --esri_pntr --zero_background
```

8.13.22 TributaryIdentifier

Assigns a unique identifier to each tributary in a stream network.

Parameters:

| Flag | Description |
|-------------------|---|
| --d8_pntr | Input raster D8 pointer file |
| --streams | Input raster streams file |
| -o, --output | Output raster file |
| --esri_pntr | D8 pointer uses the ESRI style scheme |
| --zero_background | Flag indicating whether a background value of zero should be used |

Python function:

```
tributary_identifier(
    d8_pntr,
    streams,
    output,
```

```
esri_pntr=False,  
zero_background=False,  
callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=TributaryIdentifier -v ^  
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^  
-o=output.tif  
>>./whitebox_tools -r=TributaryIdentifier -v ^  
--wd="/path/to/data/" --d8_pntr=D8.tif --streams=streams.tif ^  
-o=output.tif --esri_pntr --zero_background
```

9. Contributing

If you would like to contribute to the project as a developer, follow these instructions to get started:

1. Fork the *WhiteboxTools* project (<https://github.com/jblindsay/whitebox-tools>)
2. Create your feature branch (git checkout -b my-new-feature)
3. Commit your changes (git commit -am 'Add some feature')
4. Push to the branch (git push origin my-new-feature)
5. Create a new Pull Request

Unless explicitly stated otherwise, any contribution intentionally submitted for inclusion in the work shall be licensed **as above** without any additional terms or conditions.

If you would like to contribute financial support for the project, please contact [John Lindsay](#). We also welcome contributions in the form of media exposure. If you have written an article or blog about *WhiteboxTools* please let us know about it.

10. Reporting Bugs

WhiteboxTools is distributed as is and without warranty of suitability for application. If you encounter flaws with the software (i.e. bugs) please report the issue. Providing a detailed description of the conditions under which the bug occurred will help to identify the bug. *Use the Issues tracker on GitHub to report issues with the software and to request feature enhancements.* Please do not email Dr. Lindsay directly with bugs.

11. Known Issues and Limitations

- There is limited support for reading, writing, or analyzing vector data yet. Plans include native support for the ESRI Shapefile format and possibly GeoJSON data.

- The LAZ compressed LiDAR data format is currently unsupported although zipped LAS files (.zip) are.
- There is no support for reading waveform data contained within or associated with LAS files.
- File directories cannot contain apostrophes (' e.g. ./John's data/) as they will be interpreted in the arguments array as single quoted strings.
- The Python scripts included with **WhiteboxTools** require Python 3. They will not work with Python 2, which is frequently the default Python version installed on many systems.

12. License

The **WhiteboxTools** library is distributed under the [MIT license](#), a permissive open-source (free software) license.

The MIT License (MIT)

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13. Frequently Asked Questions

13.1 Do I need Whitebox GAT to use WhiteboxTools?

No you do not. You can call the tools contained within *WhiteboxTools* completely independent from the *Whitebox GAT* user interface using a Remote Procedure Call (RPC) approach. In fact, you can interact with the tools using Python scripting or directly, using a terminal application (command prompt). See [Interacting With WhiteboxTools* From the Command Prompt*](#) for further details.

13.2 How do I request a tool be added?

Eventually most of the tools in *Whitebox GAT* will be ported over to *WhiteboxTools* and all new tools will be added to this library as well. Naturally, this will take time. The order by which tools are ported is partly a function of ease of porting, existing infrastructure (i.e. raster and LiDAR tools will be ported first since there is currently no support in the library for vector I/O), and interest. If you are interested in making a tool a higher priority for porting, email [John Lindsay](#).

13.3 Can WhiteboxTools be incorporated into other software and open-source GIS projects?

WhiteboxTools was developed with the open-source GIS [Whitebox GAT](#) in mind. That said, the tools can be accessed independently and so long as you abide by the terms of the [MIT license](#), there is no reason why other software and GIS projects cannot use *WhiteboxTools* as well. In fact, this was one of the motivating factors for creating the library in the first place. Feel free to use *WhiteboxTools* as the geospatial analysis engine in your open-source software project.

13.4 What platforms does WhiteboxTools support?

WhiteboxTools is developed using the Rust programming language, which supports a [wide variety of platforms](#) including MS Windows, MacOS, and Linux operating systems and common chip architectures. Interestingly, Rust also supports mobile platforms, and *WhiteboxTools* should therefore be capable of targeting (although no testing has been completed in this regard to date). Nearly all development and testing of the software is currently carried out on MacOS and we cannot guarantee a bug-free performance on other platforms. In particular, MS Windows is the most different from the other platforms and is therefore the most likely to encounter platform-specific bugs. If you encounter bugs in the software, please consider reporting an issue using the GitHub support for issue-tracking.

13.5 What are the system requirements?

The answer to this question depends strongly on the type of analysis and data that you intend to process. However, generally we find performance to be optimal with a recommended minimum of 8-16GB of memory (RAM), a modern multi-core processor (e.g. 64-bit i5 or i7), and an solid-state-drive (SSD). It is likely that *WhiteboxTools* will have satisfactory performance on lower-spec systems if smaller datasets are being processed. Because *WhiteboxTools* reads entire raster datasets into system memory (for optimal performance, and in recognition that modern systems have increasingly larger amounts of fast RAM), this tends to be the limiting factor for the upper-end of data size successfully processed by the library. 64-bit operating systems are recommended and extensive testing has not been carried out on 32-bit OSs. See "[What platforms does WhiteboxTools support?](#)" for further details on supported platforms.

13.6 Are pre-compiled executables of WhiteboxTools available?

Pre-compiled binaries for *WhiteboxTools* can be downloaded from the [Geomorphometry and Hydrogeomatics Research Group](#) software web site for various supported operating systems. If you need binaries for other operating systems/system architectures, you will need to compile the executable from source files. See [Installation](#) for details.

13.7 Why is WhiteboxTools programmed in Rust?

I spent a long time evaluating potential programming language for future development efforts for the *Whitebox GAT* project. My most important criterion for a language was that it compile to native code, rather than target the Java virtual machine (JVM). I have been keen to move Whitebox GAT away from Java because of some of the challenges that supporting the JVM has included for many Whitebox users. The language should be fast and productive—Java is already quite fast, but if I am going to change development languages, I would like a performance boost. Furthermore, given that many, though not all, of the algorithms used for geospatial analysis scale well with concurrent (parallel) implementations, I favoured languages that offered easy and safe concurrent programming. Although many would consider C/C++ for this work, I was looking for a modern and safe language. Fortunately, we are living through a renaissance period in programming language development and there are many newer languages that fit the bill nicely. Over the past two years, I considered each of Go, Rust, D, Nim, and Crystal for Whitebox development and ultimately decided on Rust. [See [GoSpatial](#) and [lidario](#).]

Each of the languages I examined has its own advantages of disadvantages, so why Rust? It's a combination of factors that made it a compelling option for this project. Compared with many on the list, Rust is a mature language with a vibrant user community. Like C/C++, it's a high-performance and low-level language that allows for complete control of the system. However, Rust is also one of the safest languages, meaning that I can be confident that *WhiteboxTools* will not contain common bugs, such as memory use-after-release, memory leaks and race conditions within concurrent code. Importantly, and quite uniquely, this safety is achieved in the Rust language without the use of a garbage collector (automatic memory management). Garbage collectors can be great, but they do generally come with a certain efficiency trade-off that Rust does not have. The other main advantage of Rust's approach to memory management is that it allows for a level of interaction with scripting languages (e.g. Python) that is quite difficult to do in garbage collected languages. Although **WhiteboxTools** is currently set up to use an automation approach to interacting with Python code that calls it, I like the fact that I have the option to create a *WhiteboxTools* shared library.

Not everything with Rust is perfect however. It is still a very young language and there are many pieces still missing from its ecosystem. Furthermore, it is not the easiest language to learn, particularly for people who are inexperienced with programming. This may limit my ability to attract other programmers to the Whitebox project, which would be unfortunate. However, overall, Rust was the best option for this particular application.

13.8 Do I need Rust installed on my computer to run WhiteboxTools?

No, you would only need Rust installed if you were compiling the *WhiteboxTools* codebase from source files.

13.9 How does WhiteboxTools' design philosophy differ?

Whitebox GAT is frequently praised for its consistent design and ease of use. Like *Whitebox GAT*, *WhiteboxTools* follows the convention of *one tool for one function*. For example, in *WhiteboxTools* assigning the links in a stream channel network their Horton, Strahler, Shreve, or Hack stream ordering numbers requires running separate tools (i.e. *HortonStreamOrder*, *StrahlerStreamOrder*, *ShreveStreamMagnitude*, and *HackStreamOrder*). By contrast, in GRASS GIS¹ and ArcGIS single tools (i.e. the *r.stream.order* and *Stream Order* tools respectively) can be configured to output different channel ordering schemes. The *WhiteboxTools* design is intended to simplify the user experience and to make it easier to find the right tool for a task. With more specific tool names that are reflective of their specific purposes, users are not as reliant on reading help documentation to identify the tool for the task at hand. Similarly, it is not uncommon for tools in other GIS to have multiple outputs. For example, in GRASS GIS the *r.slope.aspect* tool can be configured to output slope, aspect, profile curvature, plan curvature, and several other common terrain surface derivatives. Based on the *one tool for one function* design approach of *WhiteboxTools*, multiple outputs are indicative that a tool should be split into different, more specific tools. Are you more likely to go to a tool named *r.slope.aspect* or *TangentialCurvature* when you want to create a tangential curvature raster from a DEM? If you're new to the software and are unfamiliar with it, probably the later is more obvious. The *WhiteboxTools* design approach also has the added benefit of simplifying the documentation for tools. The one downside to this design approach, however, is that it results (or will result) in a large number of tools, often with significant overlap in function.

¹ NOTE: It's not my intent to criticize GRASS GIS, as I deeply respect the work that the GRASS developers have contributed. Rather, I am contrasting the consequences of *WhiteboxTools'* design philosophy to that of other GIS.