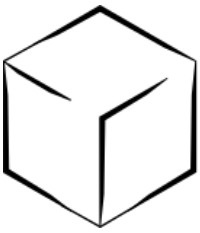

WhiteboxTools User Manual

John B. Lindsay, PhD, University of Guelph

Contents

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Dr. John B. Lindsay © 2017-2018
Geomorphometry and Hydrogeomatics Research Group
University of Guelph
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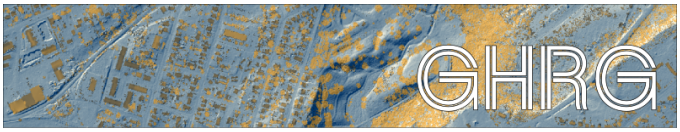


Geomorphometry & Hydrogeomatics Research Group

1. Introduction

WhiteboxTools is an advanced geospatial data analysis platform developed by Prof. John Lindsay (webpage; 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 equivelent 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 it 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.

[1] Lindsay, 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:

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

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

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

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

tion about each tool's Python convienience 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.

```
source = "source.tif"
cost = "cost.tif"
out_accum = "accum.tif"
out_backlink = "backlink.tif"
args = []
args.append("--source='{}'".format(source))
args.append("--cost='{}'".format(cost))
args.append("--out_accum='{}'".format(out_accum))
args.append("--out_backlink='{}'".format(out_backlink))
self.run_tool('cost_distance', args)
```

Each of the tool-specific convenience methods collect their parameters into a properly formated 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:

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

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

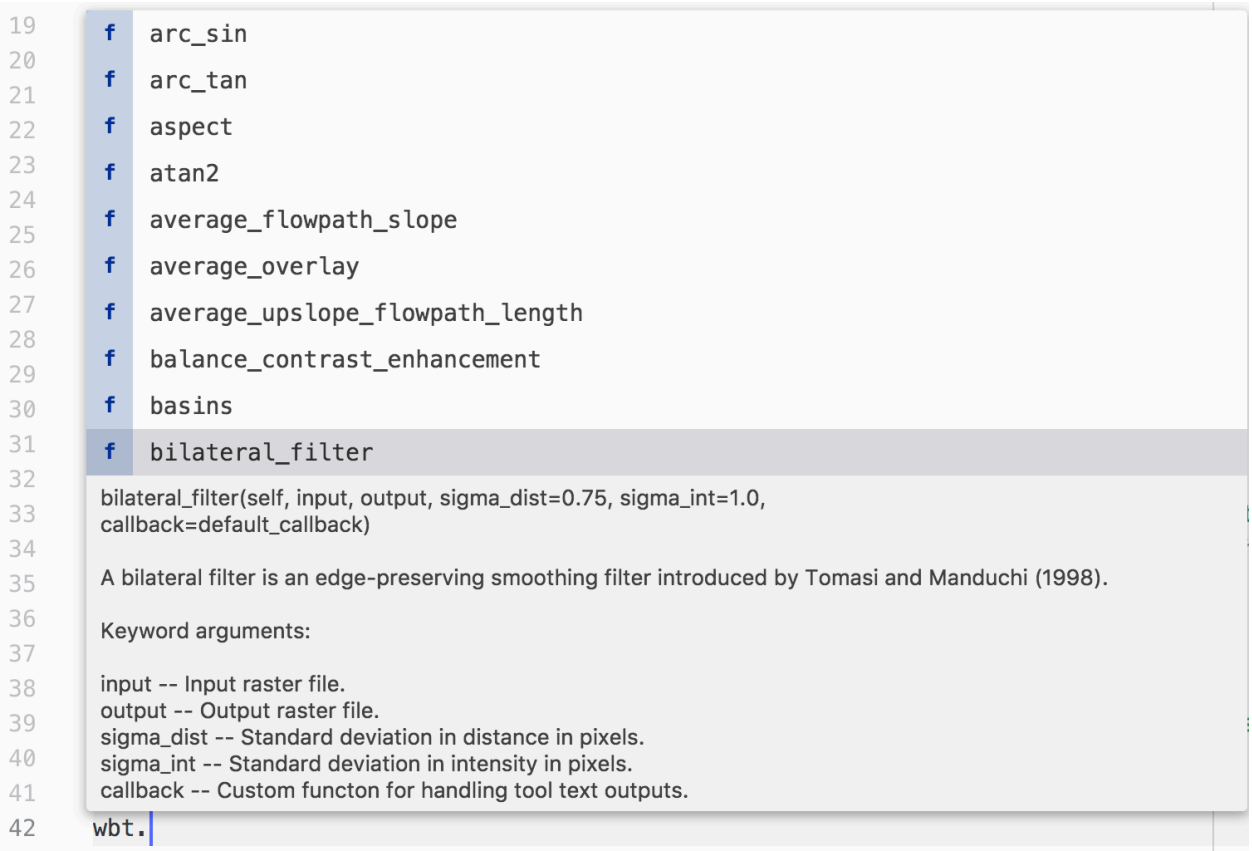
```
from whitebox_tools import WhiteboxTools

wbt = WhiteboxTools()
wbt.work_dir = "/path/to/data/" # Sets the Whitebox working directory

# Because the working directory has been set, file arguments can be
# specified simply using file names, without paths.
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:

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

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



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

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

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

```
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
-----------------  -----------
-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.

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:

```
wbt.hillshade(
"DEM.tif",
"hillshade.tif",
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:

```
wbt.set_verbose_mode(False)
# Or, alternatively...
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:

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

```

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

Every convienience 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:

```
def my_callback(value):
    if user_selected_cancel_btn: # Assumes a 'Cancel' button on a GUI
        print('Cancelling operation...')
        wbt.cancel_op = True
    else:
        print(value)

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:

```
# Print the WhiteboxTools help...a listing of available commands
print(wbt.help())

# Print the WhiteboxTools license
print(wbt.license())

# Print the WhiteboxTools version
print("Version information: {}".format(wbt.version()))

# Get the toolbox associated with a tool
tb = wbt.toolbox('lidar_info')

# Retrieve a JSON object of a tool's parameters.
tp = tool_parameters('raster_histogram')

# Opens a browser and navigates to a tool's source code in the
# WhiteboxTools GitHub repository
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.

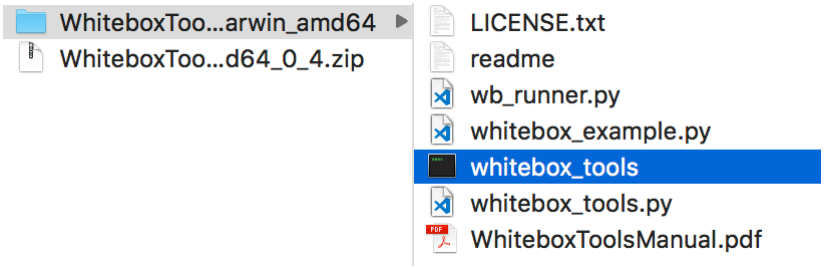
> Additional resources for using *WhiteboxTools*' Python interface can be found on the Tutorials site of the *WhiteboxTools* home page. This site contains in-depth tutorials on topics

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.



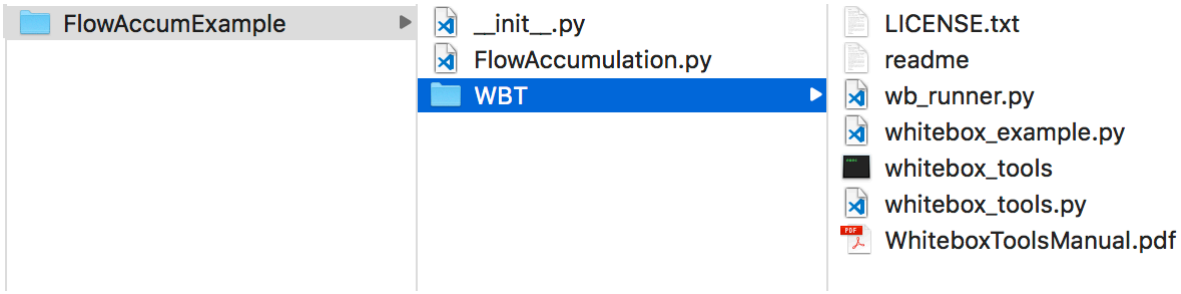
Folder contents of *WhiteboxTools* compressed download file

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.

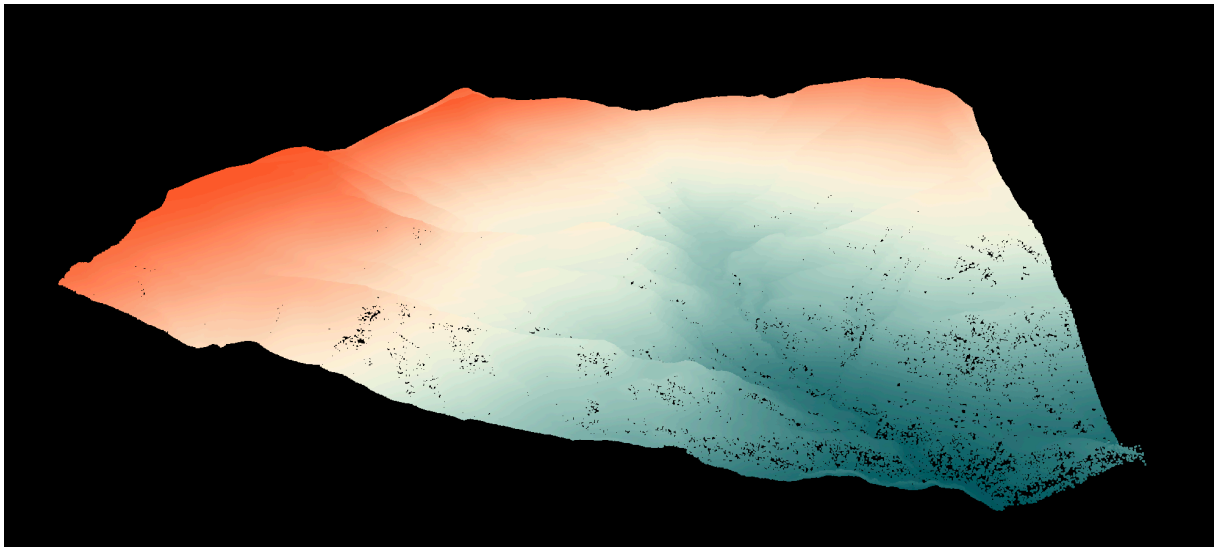
```
from WBT.whitebox_tools import WhiteboxTools

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 with 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. Elis 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:

```
import os
from WBT.whitebox_tools import WhiteboxTools

```



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

```
wbt = WhiteboxTools()

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

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

# Interpolate the LiDAR data using an inverse-distance weighting
# (IDW) scheme.
print("Interpolating DEM...")
wbt.lidar_idw_interpolation(
i="StElisAk.las",
output="raw_dem.tif",
parameter="elevation",
returns="last",
resolution=1.0,
weight=1.0,
radius=2.5
)

# The resulting DEM will contain NoData gaps. We need to fill
# these in by interpolating across the gap.
print("Filling missing data...")
```

```
wbt.fill_missing_data(
i="raw_dem.tif",
output="dem_nodata_filled.tif",
filter=11
)

# This DEM will contain grid cells that have no lower neighbours.
# This condition is unsuited for flow-path modelling applications
# because these operations assume that each interior cell in the
# DEM has at least one downslope neighour. We'll use an operation
# called depression breaching to 'fix' the elevations within the
# DEM to enforce continuous flow.
print("Performing flow enforcement...")
wbt.breach_depressions(
dem="dem_nodata_filled.tif",
output="dem_hydro_enforced.tif"
)

# Lastly, perform the flow accumulation operation using the
# D-infinity flow algorithm.
print("Performing flow accumulation...")
wbt.d_inf_flow_accumulation(
dem="dem_hydro_enforced.tif",
output="flow_accum.tif",
log=True
)

print("Complete!")
```

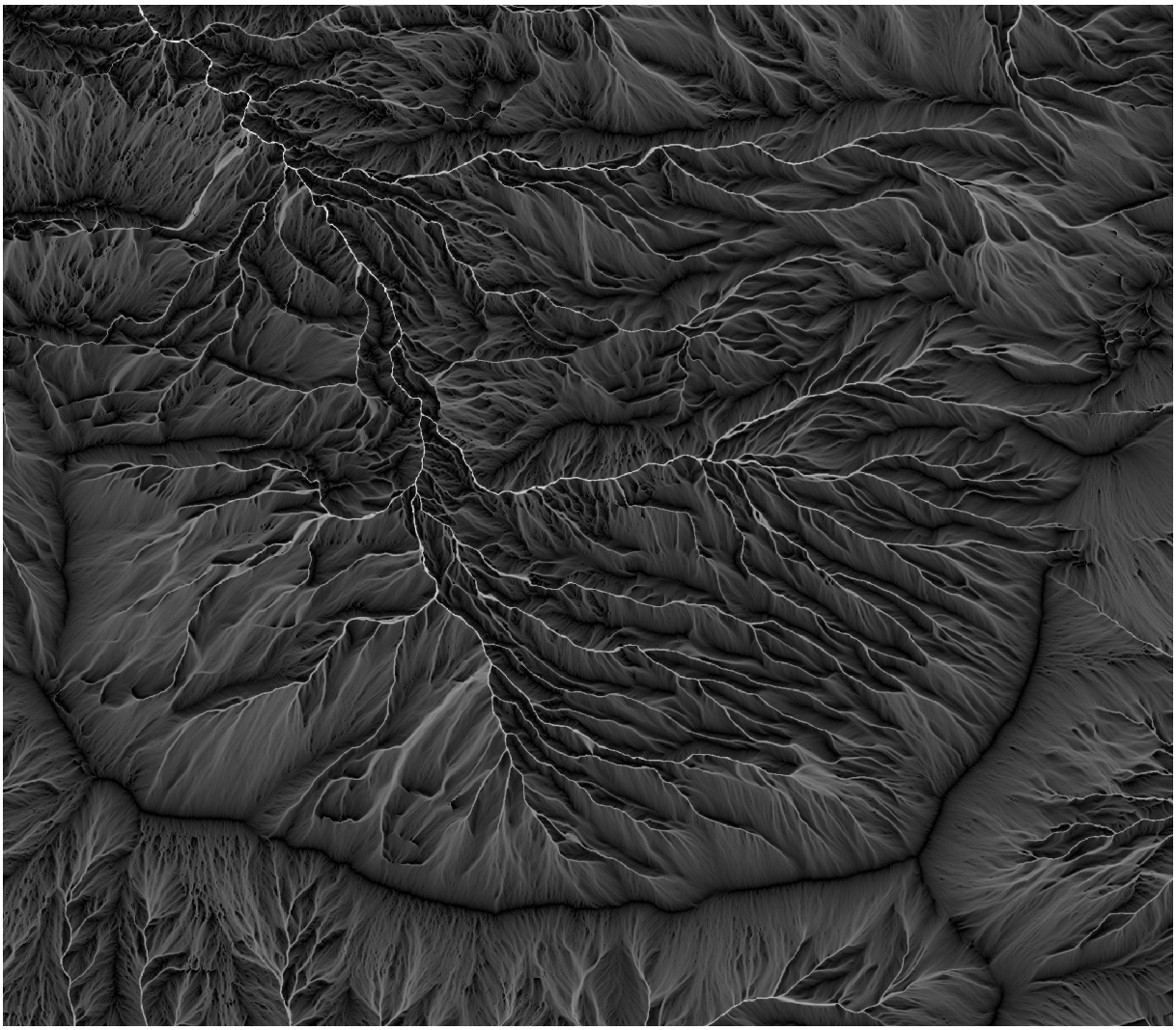
To run the above script, open a terminal (command prompt), *cd* to the script containing folder, and run the following command:

```
>>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.

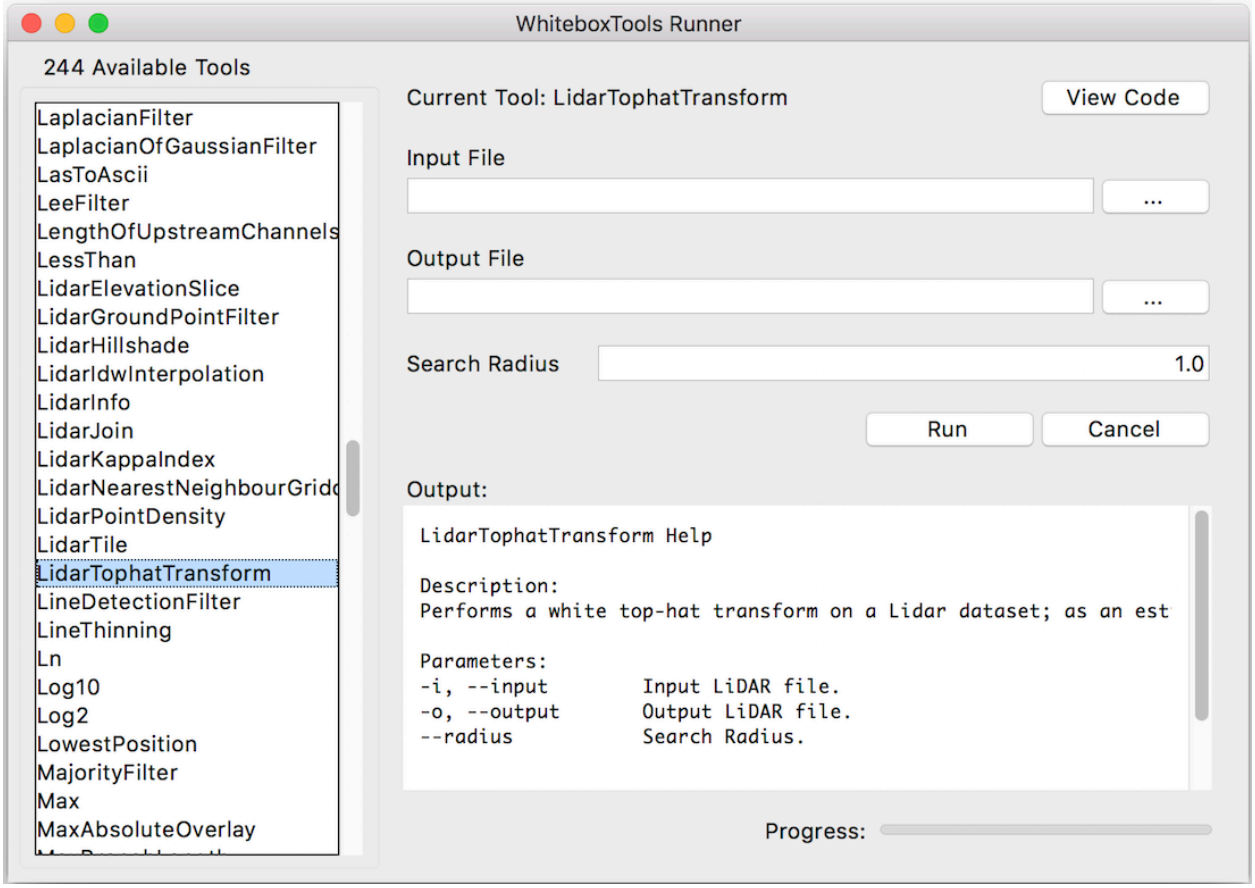
6. WhiteboxTools Runner

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. Elis Mountains data set.

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

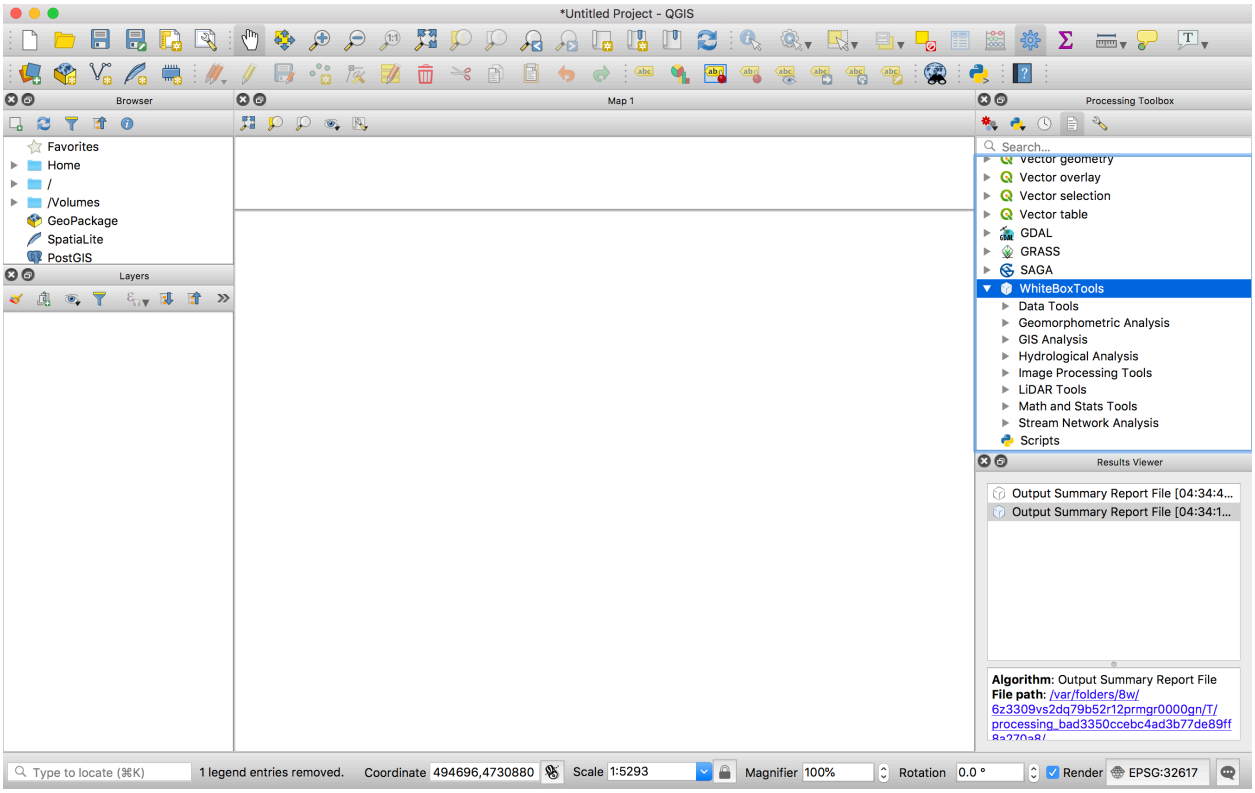


The *WhiteboxTools Runner* user-interface

The *WhiteboxTools Runner* does not rely on the *Whitebox GAT* user interface at all and can therefore be used indepedent 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 370 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

This tool modifies the attribute table of a vector of POINT ShapeType by adding two fields, XCOORD and YCOORD, containing each point's X and Y coordinates respectively.

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

This tool can be used to export a vector's attribute table to a comma separated values (CSV) file. CSV files stores tabular data (numbers and text) in plain-text form such that each row corresponds to a record and each column to a field. Fields are typically separated by commas within records. The user must specify the name of the vector (and associated attribute file), the name of the output CSV file, and whether or not to include the field names as a header column in the output CSV file.

See Also:

`MergeTableWithCsv`

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 JoinTables

This tool can be used to join (i.e. merge) a vector's attribute table with a second table. The user must specify the name of the vector file (and associated attribute file) as well as the *primary key* within the table. The *primary key* (`--pkey` flag) is the field within the table that is being appended to that serves as the identifier. Additionally, the user must specify the name of a second vector from which the data appended into the first table will be derived. The *foreign key* (`--fkey` flag), the identifying field within the second table that corresponds with the data contained within the primary key in the table, must be specified. Both the primary and foreign keys should either be strings (text) or integer values. *Fields containing decimal values are not good candidates for keys.* Lastly, the names of the field within the second file to include in the merge operation can also be input (`--import`). If the `--import` field is not input, all fields in the attribute table of the second file, that are not the foreign key nor FID, will be imported to the first table.

Merging works for one-to-one and many-to-one database relations. A *one-to-one* relations exists when each record in the attribute table corresponds to one record in the second table and each primary key is unique. Since each record in the attribute table is associated with a geospatial feature in the vector, an example of a one-to-one relation may be where the second file contains AREA and PERIMETER fields for each polygon feature in the vector. This is the most basic type of relation. A many-to-one relation would exist when each record in the first attribute table corresponds to one record in the second file and the primary key is NOT unique. Consider as an example a vector and attribute table associated with a world map of countries. Each country has one or more more polygon features in the shapefile, e.g. Canada has its mainland and many hundred large islands. You may want to append a table containing data about the population and area of each country. In this case, the COUNTRY columns in the attribute table and the second file serve as the primary and foreign keys respectively. While there may be many duplicate primary keys (all of those Canadian polygons) each will correspond to only one foreign key containing the population and area data. This is a *many-to-one* relation. The `JoinTables` tool does not support one-to-many nor many-to-many relations.

See Also:

`MergeTableWithCsv`, `ReinitializeAttributeTable`, `ExportTableToCsv`

Parameters:

Flag	Description
--i1, --input1	Input primary vector file (i.e. the table to be modified)
--pkey	Primary key field
--i2, --input2	Input foreign vector file (i.e. source of data to be imported)
--fkey	Foreign key field
--import	Imported field (all fields will be imported if not specified)

Python function:

```
join_tables(
    input1,
    pkey,
    input2,
    fkey,
    import,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=JoinTables -v --wd="/path/to/data/" ^
--i1=properties.shp --pkey=TYPE --i2=land_class.shp ^
--fkey=VALUE --import=NEW_VALUE
```

8.1.6 LinesToPolygons

Converts vector polylines into polygons. Note that this tool will close polygons that are open and will ensure that the first part of an input line is interpreted as the polygon hull and subsequent parts are considered holes. The tool does not examine input lines for line crossings (self intersections), which are topological errors.

See Also:

`PolygonsToLines`

Parameters:

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

Python function:

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

Command-line Interface:

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

8.1.7 MergeTableWithCsv

This tool can be used to merge a vector's attribute table with data contained within a comma separated values (CSV) text file. CSV files stores tabular data (numbers and text) in plain-text form such that each row is a record and each column a field. Fields are typically separated by commas although the tool will also support seimi-colon, tab, and space delimited files. The user must specify the name of the vector (and associated attribute file) as well as the *primary key* within the table. The *primary key* (`--pkey` flag) is the field within the table that is being appended to that serves as the unique identifier. Additionally, the user must specify the name of a CSV text file with either a *.csv or* .txt extension. The file must possess a header row, i.e. the first row must contain information about the names of the various fields. The *foreign key* (`--fkey` flag), that is the identifying field within the CSV file that corresponds with the data contained within the *primary key* in the table, must also be specified. Both the primary and foreign keys should either be strings (text) or integer values. *Fields containing decimal values are not good candidates for keys.* Lastly, the user may optionally specify the name of a field within the CSV file to import in the merge operation (`--import` flag). If this flag is not specified, all of the fields within the CSV, with the exception of the foreign key, will be appended to the attribute table.

Merging works for one-to-one and many-to-one database relations. A *one-to-one* relations exists when each record in the attribute table corresponds to one record in the second table and each primary key is unique. Since each record in the attribute table is associated with a geospatial feature in the vector, an example of a one-to-one relation may be where the second file contains AREA and PERIMETER fields for each polygon feature in the vector. This is the most basic type of relation. A many-to-one relation would exist when each record in the first attribute table corresponds to one record in the second file and the primary key is NOT unique. Consider as an example a vector and attribute table associated with a world map of countries. Each country has one or more more polygon features in the shapefile, e.g. Canada has its mainland and many hundred large islands. You may want to append a table containing data about the population and area of each country. In this case, the COUNTRY columns in the attribute table and the second file serve as the primary and foreign keys respectively. While there may be many duplicate primary keys (all of those Canadian polygons) each will correspond to only one foreign key containing the population and area data. This is a *many-to-one* relation. The `JoinTables` tool does not support one-to-many nor many-to-many relations.

See Also:

`JoinTables`, `ReinitializeAttributeTable`, `ExportTableToCsv`

Parameters:

Flag	Description
-i, --input	Input primary vector file (i.e. the table to be modified)
--pkey	Primary key field
--csv	Input CSV file (i.e. source of data to be imported)
--fkey	Foreign key field
--import	Imported field (all fields will be imported if not specified)

Python function:

```
merge_table_with_csv(
    i,
    pkey,
    csv,
    fkey,
    import=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=MergeTableWithCsv -v ^
--wd="/path/to/data/" -i=properties.shp --pkey=TYPE ^
--csv=land_class.csv --fkey=VALUE ^
--import=NEW_VALUE
>>./whitebox_tools -r=MergeTableWithCsv -v ^
--wd="/path/to/data/" -i=properties.shp --pkey=TYPE ^
--csv=land_class.csv --fkey=VALUE
```

8.1.8 MergeVectors

Combines two or more input vectors of the same ShapeType creating a single, new output vector. Importantly, the attribute table of the output vector will contain the ubiquitous file-specific FID, the parent file name, the parent FID, and the list of attribute fields that are shared among each of the input files. For a field to be considered common between tables, it must have the same `name` and `field_type` (i.e. data type and precision).

Overlapping features will not be identified nor handled in the merging. If you have significant areas of overlap, it is advisable to use one of the vector overlay tools instead.

The difference between `MergeVectors` and the `Append` tool is that merging takes two or more files and creates one new file containing the features of all inputs, and `Append` places the features of a single vector into another existing (appended) vector.

This tool only operates on vector files. Use the `Mosaic` tool to combine raster data.

See Also:

`Append`, `Mosaic`

Parameters:

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

Python function:

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

Command-line Interface:

```
>>./whitebox_tools -r=MergeVectors -v --wd="/path/to/data/" ^
-i='polys1.shp;polys2.shp;polys3.shp' -o=out_file.shp
```

8.1.9 MultiPartToSinglePart

This tool can be used to convert a vector file containing multi-part features into a vector containing only single-part features. Any multi-part polygons or lines within the input vector file will be split into seperate features in the output file, each possessing their own entry in the associated attribute file. For polygon-type vectors, the user may optionally choose to exclude hole-parts from being separated from their containing polygons. That is, with the `--exclude_holes` flag, hole parts in the input vector will continue to belong to their enclosing polygon in the output vector.

See Also:

`SinglePartToMultiPart`

Parameters:

Flag	Description
-i, --input	Input vector line or polygon file
-o, --output	Output vector line or polygon file
--exclude_holes	Exclude hole parts from the feature splitting? (holes will continue to belong to their features in output.)

Python function:

```
multi_part_to_single_part(
    i,
    output,
    exclude_holes=True,
    callback=default_callback)
```

Command-line Interface:

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

8.1.10 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
```

8.1.11 PolygonsToLines

Converts vector polygons into 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
```

8.1.12 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.tiff
```

8.1.13 RasterToVectorLines

This tool converts raster lines features into a vector of the POLYLINE ShapeType. Grid cells associated with line features will contain non-zero, non-NoData cell values. The algorithm requires three passes of the raster. The first pass counts the number of line neighbours of each line cell; the second pass traces line segments starting from line ends (i.e. line cells with only one neighbouring line cell); lastly, the final pass traces any remaining line segments, which are likely forming closed loops (and therefore do not have line ends).

If the line raster contains streams, it is preferable to use the `RasterStreamsToVector` instead. This tool will use knowledge of flow directions to ensure connections between stream segments at confluence sites, whereas `RasterToVectorLines` will not.

See Also:

`RasterToVectorPoints`, `RasterStreamsToVector`

Parameters:

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

Python function:

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

Command-line Interface:

```
>>./whitebox_tools -r=RasterToVectorLines -v ^
--wd="/path/to/data/" -i=lines.tif -o=lines.shp
```

8.1.14 RasterToVectorPoints

Converts a raster dataset to a vector of the POINT shapetype. The user must specify the name of a raster file and the name of the output vector. Points will correspond with grid cell centre points. All grid cells containing non-zero, non-NoData values will be considered a point. The vector's attribute table will contain a field called 'VALUE' that will contain the cell value for each point feature.

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
```

8.1.15 ReinitializeAttributeTable

Reinitializes a vector's attribute table deleting all fields but the feature ID (FID). Caution: this tool overwrites the input file's attribute table.

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
```

8.1.16 RemovePolygonHoles

This tool can be used to remove holes from the features within a vector polygon file. The user must specify the name of the input vector file, which must be of a polygon shapetype, and the name of the output file.

Parameters:

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

Python function:

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

Command-line Interface:

```
>>./whitebox_tools -r=RemovePolygonHoles -v ^
--wd="/path/to/data/" --input=polygons.shp ^
--output=no_holes.shp
```

8.1.17 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
```

8.1.18 SinglePartToMultiPart

This tool can be used to convert a vector file containing single-part features into a vector containing multi-part features. The user has the option to either group features based on an ID Field (`--field` flag), which is a categorical field within the vector's attribute table. The ID Field should either be of String (text) or Integer type. Fields containing decimal values are not good candidates for the ID Field. **If no `--field` flag is specified, all features will be grouped together into one large multi-part vector**.

This tool works for vectors containing either point, line, or polygon features. Since vectors of a POINT ShapeType cannot represent multi-part features, the ShapeType of the output file will be modified to a MULTIPOINT ShapeType if the input file is of a POINT ShapeType. If the input vector is of a POLYGON ShapeType, the user can optionally set the algorithm to search for polygons that should be represented as hole parts. In the case of grouping based on an ID Field, hole parts are polygon features contained within larger polygons of the same ID Field value. Please note that searching for polygon holes may significantly increase processing time for larger polygon coverages.

See Also:

`MultiPartToSinglePart`

Parameters:

Flag	Description
-i, --input	Input vector line or polygon file
--field	Grouping ID field name in attribute table
-o, --output	Output vector line or polygon file

Python function:

```
single_part_to_multi_part(
    i,
    output,
    field=None,
    callback=default_callback)
```

Command-line Interface:

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

8.1.19 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
```

8.1.20 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
```

8.1.21 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 BlockMaximumGridding

Creates a raster grid based on a set of vector points and assigns grid values using a block maximum 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
--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:

```
block_maximum_gridding(
    i,
    field,
    output,
    use_z=False,
    cell_size=None,
    base=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BlockMaximumGridding -v ^
--wd="/path/to/data/" -i=points.shp --field=ELEV -o=output.tif ^
--cell_size=1.0
>>./whitebox_tools -r=BlockMaximumGridding -v ^
--wd="/path/to/data/" -i=points.shp --use_z -o=output.tif ^
--base=existing_raster.tif
```

8.2.3 BlockMinimumGridding

Creates a raster grid based on a set of vector points and assigns grid values using a block minimum 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

Flag	Description
--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:

```
block_minimum_gridding(
    i,
    field,
    output,
    use_z=False,
    cell_size=None,
    base=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=BlockMinimumGridding -v ^
--wd="/path/to/data/" -i=points.shp --field=ELEV -o=output.tif ^
--cell_size=1.0
>>./whitebox_tools -r=BlockMinimumGridding -v ^
--wd="/path/to/data/" -i=points.shp --use_z -o=output.tif ^
--base=existing_raster.tif
```

8.2.4 Centroid

This tool calculates the centroid, or average location, of raster polygon objects. For vector features, use the `CentroidVector` tool instead.

See Also:

`CentroidVector`

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
```

8.2.5 CentroidVector

This can be used to identify the centroid point of a vector polyline or polygon feature or a group of vector points. The output is a vector shapefile of points. For multi-part polyline or polygon features, the user can optionally specify whether to identify the centroid of each part. The default is to treat multi-part features a single entity.

For raster features, use the `Centroid` tool instead.

See Also:

`Centroid`, `Medoid`

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
```

8.2.6 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
```

8.2.7 ConstructVectorTin

This tool 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
```

8.2.8 CreateHexagonalVectorGrid

This tool can be used to create a hexagonal vector grid. The extent of the hexagonal grid is based on the extent of a user-specified base file (any supported raster format, shapefiles, or LAS files). The user must also specify the origin of the grid (x and y coordinates) and the hexagonal cell width.

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
```

8.2.9 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
```

8.2.10 CreateRectangularVectorGrid

This tool can be used to create a rectangular vector grid. The extent of the rectangular grid is based on the extent of a user-specified base file (any supported raster format, shapefiles, or LAS files). The user must also specify the origin of the grid (x and y coordinates) and the grid cell width and height.

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
```

8.2.11 EliminateCoincidentPoints

This tool can be used to remove any coincident, or nearly coincident, points from a vector points file. The user must specify the name of the input file, which must be of a POINTS ShapeType, the output file name, and the tolerance distance. All points that are within the specified tolerance distance will be eliminated from the output file. A tolerance distance of 0.0 indicates that points must be exactly coincident to be removed.

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
```

8.2.12 ExtendVectorLines

This tool can be used to extend vector lines by a specified distance. The user must input the names of the input and output shapefiles, the distance to extend features by, and whether to extend both ends, line starts, or line ends. The input shapefile must be of a POLYLINE base shape type and should be in a projected coordinate system.

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'
```

8.2.13 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
```

8.2.14 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
```

8.2.15 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
```

8.2.16 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
--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 ^
--weight=2.0 --radius=4.0 --min_points=3 ^
--cell_size=1.0
>>./whitebox_tools -r=IdwInterpolation -v ^
--wd="/path/to/data/" -i=points.shp --use_z -o=output.tif ^
--weight=2.0 --radius=4.0 --min_points=3 ^
--base=existing_raster.tif
```

8.2.17 LayerFootprint

This tool creates a vector polygon footprint of the area covered by a raster grid or vector layer. It will create a vector rectangle corresponding to the bounding box. The user must specify the name of the input file, which may be either a Whitebox raster or a vector, and the name of the output file.

If an input raster grid is specified which has an irregular shape, i.e. it contains NoData values at the edges, the resulting vector will still correspond to the full grid extent, ignoring the irregular boundary. If this is not the desired effect, you should reclass the grid such that all cells containing valid values are assigned some positive, non-zero value, and then use the `RasterToVectorPolygons` tool to vectorize the irregular-shaped extent boundary.

See Also:

`MinimumBoundingEnvelope`, `RasterToVectorPolygons`

Parameters:

Flag	Description
-i, --input	Input raster or vector file
-o, --output	Output vector polygon file

Python function:

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

Command-line Interface:

```
>>./whitebox_tools -r=LayerFootprint -v --wd="/path/to/data/" ^
```

```
-i=file.shp -o=outfile.shp
```

8.2.18 Medoid

This tool calculates the medoid for a series of vector features contained in a shapefile. The medoid of a two-dimensional feature is conceptually similar its centroid, or mean position, but the medoid is always a members of the input feature data set. Thus, the medoid is a measure of central tendency that is robust in the presence of outliers. If the input vector is of a POLYLINE or POLYGON ShapeType, the nodes of each feature will be used to estimate the feature medoid. If the input vector is of a POINT base ShapeType, the medoid will be calculated for the collection of points. While there are more than one competing method of calculating the medoid, this tool uses an algorithm that works as follows:

1. The x-coordinate and y-coordinate of each point/node are placed into two arrays.
2. The x- and y-coordinate arrays are then sorted and the median x-coordinate (Med X) and median y-coordinate (Med Y) are calculated.
3. The point/node in the dataset that is nearest the point (Med X, Med Y) is identified as the medoid.

See Also:

`CentroidVector`

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
```

8.2.19 MinimumBoundingBox

This tool delineates the minimum bounding box (MBB) for a group of vectors. The MBB is the smallest box to completely enclose a feature. The algorithm works by rotating the feature, calculating the axis-aligned bounding box for each rotation, and finding the box with the smallest area, length, width,

or perimeter. The MBB is needed to compute several shape indices, such as the Elongation Ratio. The `MinimumBoundingEnvelop` tool can be used to calculate the axis-aligned bounding rectangle around each feature in a vector file.

See Also:

`MinimumBoundingCircle`, `MinimumBoundingEnvelope`, `MinimumConvexHull`

Parameters:

Flag	Description
-i, --input	Input vector file
-o, --output	Output vector polygon file
--criterion	Minimization criterion; options include 'area' (default), 'length', 'width', and 'perimeter'
--features	Find the minimum bounding rectangles around each individual vector feature

Python function:

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

Command-line Interface:

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

8.2.20 MinimumBoundingCircle

This tool delineates the minimum bounding circle (MBC) for a group of vectors. The MBC is the smallest enclosing circle to completely enclose a feature.

See Also:

`MinimumBoundingBox`, `MinimumBoundingEnvelope`, `MinimumConvexHull`

Parameters:

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

Flag	Description
--features	Find the minimum bounding circle around each individual vector feature

Python function:

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

Command-line Interface:

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

8.2.21 MinimumBoundingEnvelope

This tool delineates the minimum bounding axis-aligned box for a group of vector features. The is the smallest rectangle to completely enclose a feature, in which the sides of the envelope are aligned with the x and y axis of the coordinate system. The `MinimumBoundingBox` can be used instead to find the smallest possible non-axis aligned rectangular envelope.

See Also:

`MinimumBoundingBox`, `MinimumBoundingCircle`, `MinimumConvexHull`

Parameters:

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

Python function:

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

Command-line Interface:

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

```
--wd="/path/to/data/" -i=file.shp -o=outfile.shp --features
```

8.2.22 MinimumConvexHull

This tool creates a vector convex polygon around vector features. The convex hull is a convex closure of a set of points or polygon verticies and can be may be conceptualized as the shape enclosed by a rubber band stretched around the point set. The convex hull has many applications and is most notably used in various shape indices. The Delaunay triangulation of a point set and its dual, the Voronoi diagram, are mathematically related to convex hulls.

See Also:

`MinimumBoundingBox`, `MinimumBoundingCircle`, `MinimumBoundingEnvelope`

Parameters:

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

8.2.23 NearestNeighbourGridding

Creates a raster grid based on a set of vector points and assigns grid values using the nearest neighbour.

Parameters:

Flag	Description
-i, --input	Input vector Points file
--field	Input field name in attribute table

Flag	Description
--use_z	Use z-coordinate instead of field?
-o, --output	Output raster file
--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
--max_dist	Maximum search distance (optional)

Python function:

```
nearest_neighbour_gridding(
    i,
    field,
    output,
    use_z=False,
    cell_size=None,
    base=None,
    max_dist=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=NearestNeighbourGridding -v ^
--wd="/path/to/data/" -i=points.shp --field=ELEV -o=output.tif ^
--cell_size=1.0
>>./whitebox_tools -r=NearestNeighbourGridding ^
-v --wd="/path/to/data/" -i=points.shp --use_z -o=output.tif ^
--base=existing_raster.tif --max_dist=5.5
```

8.2.24 PolygonArea

This tool calculates the area of vector polygons, adding the result to the vector's attribute table (AREA field). The area calculation will account for any holes contained within polygons. The vector should be in a projected coordinate system.

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=polygons.shp
```

8.2.25 PolygonLongAxis

This tool can be used to map the long axis of polygon features. The long axis is the longer of the two primary axes of the minimum bounding box (MBB), i.e. the smallest box to completely enclose a feature. The long axis is drawn for each polygon in the input vector file such that it passes through the centre point of the MBB. The output file is therefore a vector of simple two-point polylines forming a vector field.

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
```

8.2.26 PolygonPerimeter

This tool calculates the perimeter of vector polygons, adding the result to the vector's attribute table (PERIMETER field). The area calculation will account for any holes contained within polygons. The vector should be in a a projected coordinate system.

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=polygons.shp
```

8.2.27 PolygonShortAxis

This tool can be used to map the short axis of polygon features. The short axis is the shorter of the two primary axes of the minimum bounding box (MBB), i.e. the smallest box to completely enclose a feature. The short axis is drawn for each polygon in the input vector file such that it passes through the centre point of the MBB. The output file is therefore a vector of simple two-point polylines forming a vector field.

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
```

8.2.28 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'
```

8.2.29 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
```

8.2.30 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)
--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
```

8.2.31 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
```

8.2.32 SmoothVectors

This tool smooths a vector coverage of either a POLYLINE or POLYGON base ShapeType. The algorithm uses a simple moving average method for smoothing, where the size of the averaging window is specified by the user. The default filter size is 3 and can be any odd integer larger than or equal to 3. The larger the averaging window, the greater the degree of line smoothing.

Parameters:

Flag	Description
-i, --input	Input vector POLYLINE or POLYGON file
-o, --output	Output vector file
--filter	The filter size, any odd integer greater than or equal to 3; default is 3

Python function:

```
smooth_vectors(
    i,
    output,
```

```
    filter=3,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SmoothVectors -v --wd="/path/to/data/" ^
-i=in_file.shp -o=out_file.shp --filter=9
```

8.2.33 TinGridding

Creates a raster grid based on a triangular irregular network (TIN) fitted to vector points and linear interpolation within each triangular-shaped plane.

See Also:

`LidarTINGridding`, `ConstructVectorTIN`

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 raster 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
```

8.2.34 VectorHexBinning

The practice of binning point data to form a type of 2D histogram, density plot, or what is sometimes called a heatmap, is quite useful as an alternative for the cartographic display of of very dense points sets. This is particularly the case when the points experience significant overlap at the displayed scale. The `PointDensity` tool can be used to perform binning based on a regular grid (raster output). This tool, by comparison, bases the binning on a hexagonal grid.

The tool is similar to the `CreateHexagonalVectorGrid` tool, however instead will create an output hexagonal grid in which each hexagonal cell possesses a `COUNT` attribute which specifies the number of points from an input points file (Shapefile vector) that are contained within the hexagonal cell.

In addition to the names of the input points file and the output Shapefile, the user must also specify the desired hexagon width (w), which is the distance between opposing sides of each hexagon. The size (s) each side of the hexagon can then be calculated as, s = w / [2 x cos(PI / 6)]. The area of each hexagon (A) is, A = 3s(w / 2). The user must also specify the orientation of the grid with options of horizontal (pointy side up) and vertical (flat side up).

See Also:

`LidarHexBinning`, `PointDensity`, `CreateHexagonalVectorGrid`

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
```

8.2.35 VoronoiDiagram

This tool creates a vector Voronoi diagram for a set of vector points. The Voronoi diagram is the dual graph of the Delaunay triangulation. The tool operates by first constructing the Delaunay triangulation and then connecting the circumcenters of each triangle. Each Voronoi cell contains one point of the input vector points. All locations within the cell are nearer to the contained point than any other input point.

A dense frame of 'ghost' (hidden) points is inserted around the input point set to limit the spatial extent of the diagram. The frame is set back from the bounding box of the input points by 2 x the average point spacing. The polygons of these ghost points are not output, however, points that are situated along the edges of the data will have somewhat rounded (paraboloic) exterior boundaries as a result of this edge condition. If this property is unacceptable for application, clipping the Voronoi diagram to the convex hull may be a better alternative.

This tool works on vector input data only. If a Voronoi diagram is needed to tesselate regions associated with a set of raster points, use the `EuclideanAllocation` tool instead. To use Voronoi diagrams for gridding data (i.e. raster interpolation), use the `NearestNeighbourGridding` tool.

See Also:

`ConstructVectorTIN`, `EuclideanAllocation`, `NearestNeighbourGridding`

Parameters:

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

Python function:

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

Command-line Interface:

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

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 LineIntersections

This tool identifies points where the features of two vector line layers intersect. The user must specify the names of two input vector line files and the output file. The output file will be a vector of POINT ShapeType. If the input vectors intersect at a line segment, the beginning and end vertices of the segment will be present in the output file. A warning is issued if intersection line segments are identified during analysis. If no intersections are found between the input line files, the output file will not be saved and a warning will be issued.

Each intersection point will contain `PARENT1` and `PARENT2` attribute fields, identifying the instersecting features in the first and second input line files respectively. Additionally, the output attribute table will contain all of the attributes (excluding `FID`s) of the two parent line features.

Parameters:

Flag	Description
--i1, --input1	Input vector polyline file
--i2, --input2	Input vector polyline file
-o, --output	Output vector point file

Python function:

```
line_intersections(
    input1,
    input2,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LineIntersections -v ^
--wd="/path/to/data/" --i1=lines1.shp --i2=lines2.shp ^
-o=out_file.shp
```

8.4.7 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
```

8.4.8 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
```

8.4.9 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
```

8.4.10 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
```

8.4.11 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
```

8.4.12 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' --comparison='comp.tif' ^
-o='output.tif'
```

8.4.13 PercentGreaterThan

Calculates the percentage of a raster stack that have cell values greather 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'
```

8.4.14 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'
```

8.4.15 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
```

8.4.16 Polygonize

This tool outputs a vector polygon layer from two or more intersecting line features contained in one or more input vector line files. Each space enclosed by the intersecting line set is converted to polygon added to the output layer. This tool should not be confused with the `LinesToPolygons` tool, which can be used to convert a vector file of polylines into a set of polygons, simply by closing each line feature. The `LinesToPolygons` tool does not deal with line intersection in the same way that the `Polygonize` tool does.

See Also:

`LinesToPolygons`

Parameters:

Flag	Description
-i, --inputs	Input vector polyline file
-o, --output	Output vector polygon file

Python function:

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

Command-line Interface:

```
>>./whitebox_tools -r=Polygonize -v --wd="/path/to/data/" ^
-i='lines1.shp;lines2.shp;lines3.shp' -o=out_file.shp
```

8.4.17 SplitWithLines

This tool splits the lines or polygons in one layer using the lines in another layer to define the breaking points. Intersection points between geometries in both layers are considered as split points. The input layer (`--input`) can be of either POLYLINE or POLYGON ShapeType and the output file will share this geometry type. The user must also specify an split layer (`--split`), of POLYLINE ShapeType, used to bisect the input geometries.

Each split geometry's attribute record will contain `FID` and `PARENT_FID` values and all of the attributes (excluding `FID`'s) of the input layer.

Parameters:

Flag	Description
-i, --input	Input vector line or polygon file

Flag	Description
--split	Input vector polyline file
-o, --output	Output vector file

Python function:

```
split_with_lines(
    i,
    split,
    output,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=SplitWithLines -v --wd="/path/to/data/" ^
--input=polygons.shp --split=lines.shp -o=out_file.shp
```

8.4.18 SumOverlay

This tool calculates the sum for each grid cell from a group of raster images.

Warning:

Each of the input rasters must have the same spatial extent and number of rows and columns.

See Also:

`WeightedSum`

Parameters:

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

Python function:

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

Command-line Interface:

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

8.4.19 WeightedOverlay

This tool performs a weighted overlay on multiple input images. It can be used to combine multiple factors with varying levels of weight or relative importance. The WeightedOverlay tool is similar to the WeightedSum tool but is more powerful because it automatically converts the input factors to a common user-defined scale and allows the user to specify benefit factors and cost factors. A benefit factor is a factor for which higher values are more suitable. A cost factor is a factor for which higher values are less suitable. By default, WeightedOverlay assumes that input images are benefit factors, unless a cost value of 'true' is entered in the cost array. Constraints are absolute restriction with values of 0 (unsuitable) and 1 (suitable). This tool is particularly useful for performing multi-criteria evaluations (MCE).

Notice that the algorithm will convert the user-defined factor weights internally such that the sum of the weights is always equal to one. As such, the user can specify the relative weights as decimals, percentages, or relative weightings (e.g. slope is 2 times more important than elevation, in which case the weights may not sum to 1 or 100).

NoData valued grid cells in any of the input images will be assigned NoData values in the output image. The output raster is of the float data type and continuous data scale.

Warning:

Each of the input rasters must have the same spatial extent and number of rows and columns.

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
```

8.4.20 WeightedSum

This tool performs a weighted-sum overlay on multiple input raster images. If you have a stack of rasters that you would like to sum, each with an equal weighting (1.0), then use the `SumOverlay` tool instead.

Warning:

Each of the input rasters must have the same spatial extent and number of rows and columns.

See Also:

`SumOverlay`

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 CompactnessRatio

The compactness ratio is an indicator of polygon shape complexity. The compactness ratio is defined as the polygon area divided by its perimeter. Unlike some other shape parameters (e.g. `ShapeComplexityIndex`), compactness ratio does not standardize to a simple Euclidean shape. Although widely used for landscape analysis, compactness ratio, like its inverse, the `PerimeterAreaRatio`, exhibits the undesirable property of polygon size dependence (Mcgarigal et al. 2002). That is, holding shape constant, an increase in polygon size will cause a change in the compactness ratio.

The output data will be contained in the input vector's attribute table as a new field (COMPACT).

See Also:

`PerimeterAreaRatio`, `ShapeComplexityIndex`, `RelatedCircumscribingCircle`

Parameters:

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

Python function:

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

Command-line Interface:

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

8.5.2 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
```

8.5.3 ElongationRatio

This tool can be used to calculate the elongation ratio for vector polygons. The elongation ratio values calculated for each vector polygon feature will be placed in the accompanying database file (.dbf) as an elongation field (ELONGATION).

The elongation ratio (E) is:

```
E = 1 - S / L
```

Where S is the short-axis length, and L is the long-axis length. Axes lengths are determined by estimating the minimum bounding box.

The elongation ratio provides similar information as the Linearity Index. The ratio is not an adequate measure of overall polygon narrowness, because a highly sinuous but narrow polygon will have a low linearity (elongation) owing to the compact nature of these polygon.

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=polygons.shp
```

8.5.4 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
```

8.5.5 HoleProportion

This calculates the proportion of the total area of a polygon's holes (i.e. islands) relative to the area of the polygon's hull. It can be a useful measure of shape complexity, or how discontinuous a patch is. The user must specify the name of the input vector file and the output data will be contained within the input vector's database file as a new field (HOLE_PROP).

See Also:

`ShapeComplexityIndex`, `ElongationRatio`, `PerimeterAreaRatio`

Parameters:

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

Python function:

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

Command-line Interface:

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

8.5.6 LinearityIndex

This tool calculates the linearity index of polygon features based on a regression analysis. The index is simply the coefficient of determination (r-squared) calculated from a regression analysis of the x and y coordinates of the exterior hull nodes of a vector polygon. Linearity index is a measure of how well a polygon can be described by a straight line. It is a related index to the `ElongationRatio`, but is more efficient to calculate as it does not require finding the minimum bounding box. The Pearson correlation coefficient between linearity index and the elongation ratio for a large data set of lake polygons in northern Canada was found to be 0.656, suggesting a moderate level of association between the two measures of polygon linearity. Note that this index is not useful for identifying narrow yet sinuous polygons, such as meandering rivers.

The only required input is the name of the file. The linearity values calculated for each vector polygon feature will be placed in the accompanying attribute table as a new field (LINEARITY).

See Also:

`ElongationRatio`, `PatchOrientation`

Parameters:

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

Python function:

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

Command-line Interface:

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

8.5.7 PatchOrientation

This tool calculates the orientation of polygon features based on the slope of a reduced major axis (RMA) regression line. The regression analysis use the vertices of the exterior hull nodes of a vector polygon. The only required input is the name of the vector polygon file. The orientation values, measured in degrees

from north, will be placed in the accompanying attribute table as a new field (ORIENT). The value of the orientation measure for any polygon will depend on how elongated the feature is.

Note that the output values are polygon orientations and not true directions. While directions may take values ranging from 0-360, orientation is expressed as an angle between 0 and 180 degrees clockwise from north. Lastly, the orientation measure may become unstable when polygons are oriented nearly vertical or horizontal.

See Also:

`LinearityIndex`, `ElongationRatio`

Parameters:

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

Python function:

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

Command-line Interface:

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

8.5.8 PerimeterAreaRatio

The perimeter-area ratio is an indicator of polygon shape complexity. Unlike some other shape parameters (e.g. shape complexity index), perimeter-area ratio does not standardize to a simple Euclidean shape. Although widely used for landscape analysis, perimeter-area ratio exhibits the undesirable property of polygon size dependence (Mcgarigal et al. 2002). That is, holding shape constant, an increase in polygon size will cause a decrease in the perimeter-area ratio. The perimeter-area ratio is the inverse of the compactness ratio.

The output data will be displayed as a new field (P-A_RATIO) in the input vector's database file.

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=polygons.shp
```

8.5.9 RadiusOfGyration

This can be used to calculate the radius of gyration (RoG) for the polygon features within a raster image. RoG measures how far across the landscape a polygon extends its reach on average, given by the mean distance between cells in a patch (Mcgarigal et al. 2002). The radius of gyration can be considered a measure of the average distance an organism can move within a patch before encountering the patch boundary from a random starting point (Mcgarigal et al. 2002). The input raster grid should contain polygons with unique identifiers greater than zero. The user must also specify the name of the output raster file (where the radius of gyration will be assigned to each feature in the input file) and the specified option of outputting text data.

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
```

8.5.10 RelatedCircumscribingCircle

This tool can be used to calculate the related circumscribing circle (Mcgarigal et al. 2002) for vector polygon features. The related circumscribing circle values calculated for each vector polygon feature will be placed in the accompanying attribute table as a new field (RC_CIRCLE).

Related circumscribing circle (RCC) is defined as:

`RCC = 1 - A / Ac`

Where `A` is the polygon's area and `Ac` the area of the smallest circumscribing circle.

Theoretically, `RelatedCircumscribingCircle` ranges from 0 to 1, where a value of 0 indicates a circular polygon and a value of 1 indicates a highly elongated shape. The circumscribing circle provides a measure of polygon elongation. Unlike the `ElongationRatio`, however, it does not provide a measure of polygon direction in addition to overall elongation. Like the `ElongationRatio` and `LinearityIndex`, `RelatedCircumscribingCircle` is not an adequate measure of overall polygon narrowness, because a highly sinuous but narrow patch will have a low related circumscribing circle index owing to the compact nature of these polygon.

Note: Holes are excluded from the area calculation of polygons.

Parameters:

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

Python function:

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

Command-line Interface:

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

8.5.11 ShapeComplexityIndex

This tool provides a measure of overall polygon shape complexity, or irregularity, for vector polygons. Several shape indices have been created to compare a polygon's shape to simple Euclidean shapes (e.g. circles, squares, etc.). One of the problems with this approach is that it inherently convolves the characteristics of polygon complexity and elongation. The Shape Complexity Index (SCI) was developed as a parameter for assessing the complexity of a polygon that is independent of its elongation.

SCI relates a polygon's shape to that of an encompassing convex hull. It is defined as:

```
SCI = 1 - A / Ah
```

Where `A` is the polygon's area and `Ah` is the area of the convex hull containing the polygon. Convex polygons, i.e. those that do not contain concavities or holes, have a value of 0. As the shape of the polygon becomes more complex, the SCI approaches 1. Note that polygon shape complexity also increases with the greater number of holes (i.e. islands), since holes have the effect of reducing the lake area.

The SCI values calculated for each vector polygon feature will be placed in the accompanying database file (.dbf) as a complexity field (COMPLEXITY).

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=polygons.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

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:

```
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

This tool can be used to calculate the downslope index described by Hjerdt et al. (2004). The downslope index is a measure of the slope gradient between a grid cell and some downslope location (along the flowpath passing through the upslope grid cell) that represents a specified vertical drop (i.e. a potential head drop). The index has been shown to be useful for hydrological, geomorphological, and biogeochemical applications.

The user must specify the name of a digital elevaton model (DEM) raster. This DEM should be have been pre-processed to remove artifact topographic depressions and flat areas. The user must also specify the head potential drop (d), and the output type. The output type can be either '`tangent`', '`degrees`', '`radians`', or '`distance`'. If '`distance`' is selected as the output type, the output grid actually represents the downslope flowpath length required to drop d meters from each grid cell. Linear interpolation is used when the specified drop value is encountered between two adjacent grid cells along a flowpath traverse.

Notice that this algorithm is affected by edge contamination. That is, for some grid cells, the edge of the grid will be encountered along a flowpath traverse before the specified vertical drop occurs. In these cases, the value of the downslope index is approximated by replacing d with the actual elevation drop observed along the flowpath. To avoid this problem, the entire watershed containing an area of interest should be contained in the DEM.

Grid cells containing NoData values in any of the input images are assigned the NoData value in the output raster. The output raster is of the float data type and continuous data scale.

Reference:

Hjerdt, K.N., McDonnell, J.J., Seibert, J. Rodhe, A. (2004) *A new topographic index to quantify downslope controls on local drainage*, **Water Resources Research**, 40, W05602, doi:10.1029/2004WR003130.

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

This tool implements a modified form of the algorithm described by Sun, Rosin, Martin, and Langbein (2007) '*Fast and effective feature-preserving mesh denoising*'. This implimentation varies the threshold angle between neighbouring grid cell normal vectors, used during the smoothing operation. The threshold is varied as a function of how low-lying a site is. This varying smoothing level better preserves small drainage features, such as ditches, rills, gullies, etc., which would otherwise be smoothed over.

See Also:

`FeaturePreservingDenoise`

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

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
--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

This tool implements a modified form of the algorithm described by Sun, Rosin, Martin, and Langbein (2007) Fast and effective feature-preserving mesh denoising.

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:

```
hypsometric_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, a metric of roughness described by Grohmann et al., (2011).

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='d8pntr.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 inifinity
--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 DInfPointer

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=DInfPointer -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 inifinity
--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 thr 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 LongestFlowpath

This tool delineates the longest flowpaths for given a group of subbasins or watersheds. Flowpaths are initiated along drainage divides and continue along the D8-defined flow direction until either the subbasin outlet or DEM edge is encountered. Each input subbasin/watershed will have an associated vector flowpath in the output image. `LongestFlowpath` is similar to the `r.lfp` plugin tool for GRASS GIS. The length of the longest flowpath draining to an outlet is related to the time of concentration, which is a parameter used in certain hydrological models.

The user must input the filename of a digital elevation model (DEM), a basins raster, and the output vector. The DEM must be depressionless and should have been pre-processed using the `BreachDepressions` or `FillDepressions` tool. The *basins raster* must contain features that are delineated by categorical (integer valued) unique indentifier values. All non-NoData, non-zero valued grid cells in the basins raster are interpreted as belonging to features. In practice, this tool is usual run using either a single watershed, a group of contiguous non-overlapping watersheds, or a series of nested subbasins. These are often derived using the `Watershed` tool, based on a series of input outlets, or the `Subbasins` tool, based on an input stream network. If subbasins are input to `LongestFlowpath`, each traced flowpath will include the full upstream length, including the portions of the longest flowpaths that are contained within nested areas. Therefore, this can be a convienent method of delineating the longest flowpath to each bifurcation in a stream network.

The output vector file will contain fields in the attribute table that identify the associated basin unique identifier (*BASIN*), the elevation of the flowpath source point on the divide (*UP_ELEV*), the elevation of the outlet point (*DN_ELEV*), the length of the flowpath (*LENGTH*), and finally, the average slope along the flowpath (*AVG_SLOPE*).

See Also:

`MaximumUpslopeFlowpath`, `BreachDepressions`, `FillDepressions`, `Watershed`, `Subbasins`

Parameters:

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

Python function:

```
longest_flowpath(
    dem,
    basins,
    output,
    callback=default_callback)
```

Command-line Interface:

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

8.7.33 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
```

8.7.34 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

Flag	Description
-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
```

8.7.35 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
```

8.7.36 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
```

8.7.37 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
```

8.7.38 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
```

8.7.39 StochasticDepressionAnalysis

Preforms 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
--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
```

8.7.40 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='d8pntr.tif' ^
--streams='streams.tif' -o='output.tif'
```

8.7.41 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='d8pntr.tif' --streams='streams.tif' ^
-o='output.tif'
```

8.7.42 TraceDownslopeFlowpaths

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

Parameters:

Flag	Description
--seed_pts	Input vector seed points file

Flag	Description
--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
```

8.7.43 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'
```

8.7.44 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='d8pntr.tif' --pour_pts='pour_pts.shp' ^
-o='output.tif'
```

8.8 Image Processing Tools

8.8.1 ChangeVectorAnalysis

Change Vector Analysis (CVA) is a change detection method that characterizes the magnitude and change direction in spectral space between two times. A change vector is the difference vector between two vectors in n-dimensional feature space defined for two observations of the same geographical location (i.e. corresponding pixels) during two dates. The CVA inputs include the set of raster images corresponding to the multispectral data for each date. Note that there must be the same number of image files (bands)

for the two dates and they must be entered in the same order, i.e. if three bands, red, green, and blue are entered for date one, these same bands must be entered in the same order for date two.

CVA outputs two image files. The first image contains the change vector length, i.e. magnitude, for each pixel in the multi-spectral dataset. The second image contains information about the direction of the change event in spectral feature space, which is related to the type of change event, e.g. deforestation will likely have a different change direction than say crop growth. The vector magnitude is a continuous numerical variable. The change vector direction is presented in the form of a code, referring to the multi-dimensional sector in which the change vector occurs. A text output will be produced to provide a key describing sector codes, relating the change vector to positive or negative shifts in n-dimensional feature space.

It is common to apply a simple thresholding operation on the magnitude data to determine 'actual' change (i.e. change above some assumed level of error). The type of change (qualitatively) is then defined according to the corresponding sector code. Jensen (2005) provides a useful description of this approach to change detection.

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
--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
-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

This modified k-means algorithm is similar to that described by Mather (2004). The main difference between the traditional k-means and this technique is that the user does not need to specify the desired number of classes/clusters prior to running the tool. Instead, the algorithm initializes with a very liberal overestimate of the number of classes and then merges classes that have cluster centres that are separated by less than a user-defined threshold. The main difference between this algorithm and the ISODATA technique is that clusters can not be broken apart into two smaller clusters.

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
--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

This tool will create an image mosaic from one or more input image files using one of three resampling methods including, nearest neighbour, bilinear interpolation, and cubic convolution. The order of the input source image files is important. Grid cells in the output image will be assigned the corresponding value determined from the first image found in the list to possess an overlapping coordinate.

Resample is very similar in operation to the Mosaic tool. The Resample tool should be used when there is an existing image into which you would like to dump information from one or more source images. If the source images are more extensive than the destination image, i.e. there are areas that extend beyond the destination image boundaries, these areas will not be represented in the updated image. Grid cells in the destination image that are not overlapping with any of the input source images will not be updated, i.e. they will possess the same value as before the resampling operation. The Mosaic tool is used when there is no existing destination image. In this case, a new image is created that represents the bounding rectangle of each of the two or more input images. Grid cells in the output image that do not overlap with any of the input images will be assigned the NoData value.

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

Resample is very similar in operation to the Mosaic tool. The Resample tool should be used when there is an existing image into which you would like to dump information from one or more source images. If the source images are more extensive than the destination image, i.e. there are areas that extend beyond the destination image boundaries, these areas will not be represented in the updated image. Grid cells in the destination image that are not overlapping with any of the input source images will not be updated, i.e. they will possess the same value as before the resampling operation. The Mosaic tool is used when there is no existing destination image. In this case, a new image is created that represents the bounding rectangle of each of the two or more input images. Grid cells in the output image that do not overlap with any of the input images will be assigned the NoData value.

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
--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 seperate 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
--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 mattching.

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

Reference: P. Kovesi 2010 Fast Almost-Gaussian Filtering, Digital Image Computing: Techniques and Applications (DICTA), 2010 International Conference on.

The tool is somewhat modiied from Dr. Kovesi's original Matlab code in that it works with both greyscale and RGB images (decomposes to HSI and uses the intensity data) and it handles the case of rasters that contain NoData values. This adds complexity to the original 20 additions and 5 multiplications assertion of the original paper.

Also note, for small values of sigma (< 1.8), you should probably just use the regular GaussianFilter tool.

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 filter based on a median 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
--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

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
-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

Flag	Description
--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
-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 an efficient median filter based on Huang, Yang, and Tang's (1979) method.

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
-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
--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

Flag	Description
-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

NoData values in the input image are ignored during the convolution operation. This can lead to unexpected behavior at the edges of images (since the default behavior is to return NoData when addressing cells beyond the grid edge) and where the grid contains interior areas of NoData values. Normalization of kernel weights can be useful for handling the edge effects associated with interior areas of NoData values. When the normalization option is selected, the sum of the cell value-weight product is divided by the sum of the weights on a cell-by-cell basis. Therefore, if the kernel at a particular grid cell contains neighboring cells of NoData values, normalization effectively re-adjusts the weighting to account for the missing data values. Normalization also ensures that the output image will possess values within the range of the input image and allows the user to specify integer value weights in the kernel. However, note that this implies that the sum of weights should equal one. In some cases, alternative sums (e.g. zero) are more appropriate, and as such normalization should not be applied in these cases.

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',

Flag	Description
	'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

This tool can be used to reduce vignetting within an image. Vignetting refers to the reducuction of image brightness away from the image centre (i.e. the principal point). Vignetting is a radiometric distortion resulting from lens characteristics. The algorithm calculates the brightness value in the output image (BVout) as:

BVout = BVin / [cosˆn(arctan(d / f))]

Where d is the photo-distance from the principal point in millimetres, f is the focal length of the camera, in millimeters, and n is a user-specified parameter. Pixel distances are converted to photo-distances (in millimetres) using the specified image width, i.e. distance between left and right edges (mm). For many cameras, 4.0 is an appropriate value of the n parameter. A second pass of the image is used to rescale the output image so that it possesses the same minimum and maximum values as the input image.

If an RGB image is input, the analysis will be performed on the intensity component of the HSI transform.

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
--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 enhancment 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 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
```

8.11.2 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'
```

8.11.3 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'
```

8.11.4 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
```

8.11.5 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"
```

8.11.6 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
```

8.11.7 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"
```

8.11.8 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.

This tool can be used in place of the `LasToShapefile` tool when the number of points are relatively high and when the desire is to represent the x,y,z position of points only. The z values of LAS points will be stored in the z-array of the output Shapefile. Notice that because the output file stores each point in a single multi-point record, this Shapefile representation, while unable to represent individual point classes, return numbers, etc, is an efficient means of converting LAS point positional information.

See Also:

`LasToShapefile`

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
```

8.11.9 LasToShapefile

This tool converts one or more LAS files into a POINT vector. When the input parameter is not specified, the tool grids all LAS files contained within the working directory. The attribute table of the output Shapefile

will contain fields for the z-value, intensity, point class, return number, and number of return.

This tool can be used in place of the `LasToMultipointShapefile` tool when the number of points are relatively low and when the desire is to represent more than simply the x,y,z position of points. Notice however that because each point in the input LAS file will be represented as a separate record in the output Shapefile, the output file will be many time larger than the equivalent output of the `LasToMultipointShapefile` tool. There is also a practical limit on the total number of records that can be held in a single Shapefile and large LAS files approach this limit. In these cases, the `LasToMultipointShapefile` tool should be preferred instead.

See Also:

`LasToMultipointShapefile`

Parameters:

Flag	Description
-i, --input	Input LiDAR file

Python function:

```
las_to_shapefile(
    i=None,
    callback=default_callback)
```

Command-line Interface:

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

8.11.10 LidarBlockMaximum

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:

```
lidar_block_maximum(
    i=None,
    output=None,
    resolution=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarBlockMaximum -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=2.0"
./whitebox_tools -r=LidarBlockMaximum -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=5.0 --palette=light_quant.plt
```

8.11.11 LidarBlockMinimum

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:

```
lidar_block_minimum(
    i=None,
    output=None,
    resolution=1.0,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarBlockMinimum -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=2.0"
./whitebox_tools -r=LidarBlockMinimum -v ^
--wd="/path/to/data/" -i=file.las -o=outfile.tif ^
--resolution=5.0 --palette=light_quant.plt
```

8.11.12 LidarClassifySubset

This tool classifies points within a user-specified LiDAR point cloud (`--base`) that correpond with points in a subset cloud (`--subset`). The subset point cloud may have been derived by filtering the original point cloud. The user must specify the names of the two input LAS files (i.e. the full and subset clouds) and the class value (`--subset_class`) to assign the matching points. This class value will be assigned to points in the base cloud, overwriting their input class values in the output LAS file (`--output`). Class values should be numerical (integer valued) and shoud follow the LAS specifications below:

Classification Value	Meaning
0	Created never classified
1	Unclassified3
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Reserved
9	Water
10	Rail
11	Road Surface
12	Reserved
13	Wire – Guard (Shield)
14	Wire – Conductor (Phase)
15	Transmission Tower
16	Wire-structure Connector (e.g. Insulator)
17	Bridge Deck
18	High Noise

The user may optionally specify a class value to be assigned to non-subset (i.e. non-matching) points (`--nonsubset_class`) in the base file. If this parameter is not specified, output non-sutset points will have the same class value as the base file.

Parameters:

Flag	**Description**
--base	Input base LiDAR file
--subset	Input subset LiDAR file
-o, --output	Output LiDAR file
--subset_class	Subset point class value (must be 0-18; see LAS specifications)
--nonsubset_class	Non-subset point class value (must be 0-18; see LAS specifications)

Python function:

```
lidar_classify_subset(
    base,
    subset,
    output,
    subset_class,
    nonsubset_class=None,
    callback=default_callback)
```

Command-line Interface:

```
>>./whitebox_tools -r=LidarClassifySubset -v ^
--wd="/path/to/data/" --base="full_cloud.las" ^
--subset="filtered_cloud.las" -o="output.las" ^
--subset_class=2
```

8.11.13 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"
```

8.11.14 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
--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'
```

8.11.15 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

Flag	Description
	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
```

8.11.16 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

Flag	Description
	than this threshold are idenfied 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=True,
    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
```

8.11.17 LidarHexBinning

The practice of binning point data to form a type of 2D histogram, density plot, or what is sometimes called a heatmap, is quite useful as an alternative for the cartographic display of of very dense points sets. This is particularly the case when the points experience significant overlap at the displayed scale. The `LidarPointDensity` tool can be used to perform binning based on a regular grid (raster output). This tool, by comparison, bases the binning on a hexagonal grid.

The tool is similar to the `CreateHexagonalVectorGrid` tool, however instead will create an output hexagonal grid in which each hexagonal cell possesses a `COUNT` attribute which specifies the number of points from an input points file (LAS file) that are contained within the hexagonal cell. The tool will also calculate the minimum and maximum elevations and intensity values and outputs these data to the attribute table.

In addition to the names of the input points file and the output Shapefile, the user must also specify the desired hexagon width (w), which is the distance between opposing sides of each hexagon. The size (s)

each side of the hexagon can then be calculated as, s = w / [2 x cos(PI / 6)]. The area of each hexagon (A) is, A = 3s(w / 2). The user must also specify the orientation of the grid with options of horizontal (pointy side up) and vertical (flat side up).

See Also:

`VectorHexBinning`, `LidarPointDensity`, `CreateHexagonalVectorGrid`

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
```

8.11.18 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
```

8.11.19 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=Bishopsl
```

8.11.20 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
```

8.11.21 LidarInfo

This tool can be used to print basic information about the data contained within a LAS file, used to store LiDAR data. The reported information will include including data on the 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
```

8.11.22 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"
```

8.11.23 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
```

8.11.24 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'
```

8.11.25 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
```

8.11.26 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

Flag	Description
--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
```

8.11.27 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"
```

8.11.28 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
```

8.11.29 LidarSegmentation

Segments a LiDAR point cloud based on normal vectors.

Parameters:

Flag	Description
-i, --input	Input LiDAR file
-o, --output	Output file

Flag	Description
--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
```

8.11.30 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
--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
```

8.11.31 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 seperate 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
```

8.11.32 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 seperate 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
```

8.11.33 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
```

8.11.34 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
```

8.11.35 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'
```

8.11.36 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
```

8.11.37 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
```

8.11.38 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
-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

Flag	Description
--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
--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)
--i2, --input2	Input raster file (dependent variable, Y)
-o, --output	Output HTML file for regression summary report
--out_residuals	Output raster regression resdidual 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 (input1 += 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 (input1 /= 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 (input1 *= 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 (input1 -= 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 witin 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

This tool can be used to create a random sample of grid cells. The user specifies the base raster file, which is used to determine the grid dimensions and georeference information for the output raster, and the number of sample random samples (n). The output grid will contain n non-zero grid cells, randomly distributed throughout the raster grid, and a background value of zero. This tool is useful when performing statistical analyses on raster images when you wish to obtain a random sample of data.

Only valid, non-nodata, cells in the base raster will be sampled.

Parameters:

Flag	Description
-i, --base	Input raster file

Flag	Description
-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

This tool can be used to interpolate a trend surface from a raster image. The technique uses a polynomial, least-squares regression analysis. The user must specify the name of the input raster file. In addition, the user must specify the polynomial order (1 to 10) for the analysis. A first-order polynomial is a planar surface with no curvature. As the polynomial order is increased, greater flexibility is allowed in the fitted surface. Although polynomial orders as high as 10 are accepted, numerical instability in the analysis often creates artifacts in trend surfaces of orders greater than 5. The operation will display a text report on completion, in addition to the output raster image. The report will list each of the coefficient values and the r-square value. Note that the entire raster image must be able to fit into computer memory, limiting the use of this tool to relatively small rasters. The Trend Surface (Vector Points) tool can be used instead if the input data is vector points contained in a shapefile.

Numerical stability is enhanced by transforming the x, y, z data by their minimum values before performing the regression analysis. These transform parameters are also reported in the output report.

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

This tool can be used to interpolate a trend surface from a vector points file. The technique uses a polynomial, least-squares regression analysis. The user must specify the name of the input shapefile, which must be of a 'Points' base ShapeType and select the attribute in the shapefile's associated attribute table for which to base the trend surface analysis. The attribute must be numerical. In addition, the user must specify the polynomial order (1 to 10) for the analysis. A first-order polynomial is a planar surface with no curvature. As the polynomial order is increased, greater flexibility is allowed in the fitted surface. Although polynomial orders as high as 10 are accepted, numerical instability in the analysis often creates artifacts in trend surfaces of orders greater than 5. The operation will display a text report on completion, in addition to the output raster image. The report will list each of the coefficient values and the r-square value. The Trend Surface tool can be used instead if the input data is a raster image.

Numerical stability is enhanced by transforming the x, y, z data by their minimum values before performing the regression analysis. These transform parameters are also reported in the output report.

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 topolography 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

This tool converts a raster stream file into a vector file. The user must specify 1) the name of the raster streams file, 2) the name of the D8 flow pointer file, and 3) the name of the output vector file. Streams in the input raster streams file are denoted by cells containing any positive, non-zero integer. A field in the vector database file, called STRM_VAL, will correspond to this positive integer value. The database file will also have a field for the length of each link in the stream network. The flow pointer file must be calculated from a DEM with all topographic depressions and flat areas removed and must be calculated using the D8 flow pointer algorithm. The output vector will contain PolyLine features.

Parameters:

Flag	Description
--streams	Input raster streams file
--d8_pntr	Input raster D8 pointer file
-o, --output	Output vector 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.shp
>>./whitebox_tools -r=RasterStreamsToVector -v ^
--wd="/path/to/data/" --streams=streams.tif --d8_pntr=D8.tif ^
-o=output.shp --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
--streams	Input raster streams file
-o, --output	Output raster file
--min_length	Minimum tributary length (in map units) used for network prunning
--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
-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 enchancements.* 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.

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 their 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 particularly, 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 programers 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 GIS[1] 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 signifcant 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.