Natural Resources Canada | Ressources naturelles Canada

Emergency Geomatics Service / Service de Géomatique d'Urgence

Improved Flood Extent and Depth mapping toolbox Developer's Guide

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Canada

Contents

Introduction

This user guide describes geoprocessing tools for conflation of flood extent and determination of water depth in flooded areas, and the underlying Python library modules on which the tools are based. The tools are developed in the ArcToolbox environment of ArcGIS. The tools and associated libraries are intended to be incorporated into Natural Resources Canada's Emergency Geomatics Service (EGS) processing environment for near real-time operational mapping of flood extent and depth.

Requirements

- ArcGIS (tested with ArcGIS version 10.3.1)
- ArcGIS license: ArcGIS for Desktop Advanced
- ArcGIS extensions:
- Spatial Analyst (for tools [6] Create Water Surface and [7] Calculate Water Extent and Depth)
- 3D Analyst (for tool [1] Create 3D Flood Extent Points)
- Python 2.7 (tested with version 2.7.9 64-bit provided with ArcGIS version 10.3.1)
- NumPy (tested with version 1.7.1 provided with ArcGIS version 10.3.1)

The following are the system requirements for running the vegetation area flood mapping and merge python software.

- Processor speed: 2.2 GHz minimum; Hyper-threading (HTT) or Multi-core recommended;
- Processor: x86 or x64 with SSE2 extensions;
- Memory: 2 GB minimum;
- Display: 24-bit color depth;
- Screen resolution: 1024 x 768 recommended minimum at normal size (96 dpi);
- Swap space: 500 MB minimum;
- Video / graphics adapter: 64 MB RAM minimum, 256 MB RAM or higher recommended. NVIDIA, ATI, and Intel chipsets supported; 24-bit capable graphics accelerator; OpenGL version 2.0 runtime minimum is required, Shader Model 3.0 or higher is recommended;
- ArcGIS for Desktop 10.3.2 with python;
- ArcGIS license: ArcGIS for Desktop Advanced;
- PCI Geomatica 2015 with python; and
- Python 2.7.5 (64 bit) with the following packages:
- PCI 2015;
- Arcpy 10.3.2;

- Osgeo (GDAL 2.0.2); and
- Numpy v1.8.2.

Setup

Use the following steps to install the vegetation area flood mapping and merge python software:

1. Start with a clean system;
2. Install ArcGIS 3.2 with python;
3. Install ArcGIS Geoprocessing 64 bits (installs python 2.7.5 64 bits);
4. Install PCI Geomatica 2015;
5. Add the following system variable to Windows
   i. Python27 = C:\Python27\ArcGIS10.3\python.exe
   ii. Python27_x64 = C:\Python27\ArcGISx6410.3\python.exe
   iii. Make sure these values are in %PATH%
      C:\Python27\ArcGISx6410.3
      C:\Python27\ArcGISx6410.3\Scripts
      C:\Python27\ArcGISx6410.3\Lib\site-packages
6. Install gdal package for python using the following pip command:
   a. pip install GDAL-2.0.2-cp27-none-win_amd64.whl;
7. Test success of installation using the following commands in a windows command shell:
   a. python
   b. Import arcpy
   c. Import gdal
   d. Import pci

Place all software (*.py, *.ini) from software package in desired folder.

In ArcToolbox panel, right-click on ArcToolbox, select Add Toolbox…, then navigate to the location of the toolbox (FloodTools.pyt and Flood Extent/Depth Processing.pyt).

Tools

This section describes the software components required to run the vegetation area flood mapping and merge python software as well as the usage.

Open Water flood extent mapping tools:

The open water flood mapping python libraries provide a mean to derive open flood extent. This means that the mapped areas are not obstructed by vegetation or radar shadow. Open water products are generated fromRADARSAT-2 data sets. The tools are python tool boxes that integrate with ArcGIS and ArcMap but they can also be called upon as libraries or passed arguments from command line. They are the first step in the process of generating the improved flood extent polygons. The FT0_FloodMaster tool will execute all the processing steps found in subsequent tool FT1 to FT3.

Open Water Software

Summary

Acts as a convenient interface to launch and manage the first 3 tools in the Flood Tools suite, used to produce flood products:

- FT1_R2ReadOrthoMosaic

- FT2_Scale16to8BitSet

- FT3_ExtractFloodExtentAndConvertToVector

Through this interface, one can run just one tool to accomplish what the 3 tools listed above do. Furthermore, it is possible to select and process multiple polarization channels in one run, assigning different water threshold ranges customized for each, rather than have to run the tool separately for every channel. After examining the final output in the 'OWFEP' folder (ie. Open Water Flood Extent Product), it is always possible to supplement the results by running the individual tools separately, such as "FT2_Scale16to8BitSet" to process polarization channels that were not originally selected, and/or "FT3_ExtractFloodExtentAndConvertToVector" to select a different water threshold range, if the original selections of "FT0_FloodMaster" did not produce satisfactory results.

The tool runs in ArcGIS background mode, required to accommodate the mix of 32-bit and 64-bit processing that it performs. It is possible to monitor progress through the "Current Session->Messages" branch of the "Results" panel in ArcCatalog or ArcMap. It supports both a GUI and command-line interface, the latter useful for incorporating it within a larger batch script.

Orchestrates all of the steps required to produce output, called from the GUI when the user presses the OK button or from function "main()" at the bottom of this module when command line interface has been defined and the script is run in batch from the command line.

In this implementation, "execute" performs the following:

- Validates all incoming parameters

  - verifies that workspace directory exists, is accessible, and contains ZIP files

  - verifies that DEM file exists and is accessible

  - verifies that Projection has been passed

  - verifies that Pixel Spacing has been passed and consists of comma-delimited pair of numbers

  - verifies that at least one 16-bit polarized SAR Image file has been selected

  - verifies that at least one 8-bit scaled and filtered SAR Image file has been selected

  - verifies that all required polarizations and water thresholds are present and properly defined

  - if a processing mask is to be applied, verifies that file exists and is accessible

- Calls "FT1_R2ReadOrthoMosaic" tool to:

  - create "Raw" directory if it doesn't exist, move ZIP files to that directory and unpacks them

  - create "Orthos" directory if it doesn't exist, and uses DEM to generate orthorectified versions of raw RADARSAT images and reprojects

  - create "Mosaic" directory if it doesn't exist, and mosaics individual orthorectified images together

  - create separate mosaicked images for each polarization channel (eg. HH, HV) for passing to second tool in suite

- Calls "FT2_Scale16to8BitSet" tool to:

  - create "Scratch", "Scaled" and "Scaled_Unfiltered" folders if they do not already exist, and sets the arcpy working/scratch directories to point to "Scratch" for those tools that implictly require a working space for temporary files

    - process each selected 16-Bit SAR Image:

    - gathers MIN and MAX 16-bit pixel values

- stretches image to only include non-NoData values and translates each pixel to 8-bit equivalent values

- creates non-filtered image for inclusion in map (brighter so better for visual products)

- applies 3x3 moving rectangle "median" filter to smooth out to smooth out pixel values and reduce speckles in image that will be passed to downstream 3rd tool in suite

deletes temporary files/directories

- Calls "FT3_ExtractFloodExtentAndConvertToVector" tool to:

  - create "Scratch" and "OWFEP" (Open Water Flood Extent Polygons) folders if they do not already exist, and sets the arcpy working/scratch directories to point to "Scratch" for those tools that implictly require a working space for temporary files

  - process each selected 8-Bit Scaled Filtered SAR Image:

    - determines MIN and MAX water threshold values and generates range

    - processes each threshold value in range:

      - defines target shapefile name for each threshold value

      - applies CON tool to SAR image to identify flood pixels, those that are <= threshold value

      - applies 5x5 moving rectangle "majority" filter to smooth out pixel values and thereby reduce number of polygons to be created

      - converts raster to vector polygon shapefile

      - eliminates polygons that represent non-flooded regions

      - calculates area in hectares for each flood polygon

      - removes polygons that are smaller than specified value and saves resultant to target shapefile

- This shapefile will be manually inspected by user to determine if it should be passed to subsequent tools in the Flood Tools suite
- Deletes temporary files/directories

FT0_FloodTools Tool can be executed from command line instead of a GUI. Function "main()" allows the FT0_FloodTools module to be run as a script in batch, called from the command line or managing script rather than through a Toolbox in ArcCatalog or ArcMap, thereby bypassing the GUI interface provided by the Toolbox. In this way, the application can be added to a processing chain, overseen by an orchestrating parent process, without requiring manual intervention between steps. It uses argparse to exchange parameters with the command line.

Parameters

No.	Name	Description	Required	Data Type
1	-h	Help	N	String
2	-dem	Digital elevation model file	Y	String
3	-mask	Processing mask	N	String

4	-mps	Minimum polygon size	N	String
5	-pix	Output pixel size	N	String
6	-pol	Polarization to be processed	N	String
7	-proj	Output projection	N	String
8	-stretch	Contrast stretching method for 8 bit rescaling	N	String
9	-ws	Workspace path	Y	String
10	-wt	Open water thresholds values	N	String

Parameters that take a file name will accept either relative or absolute paths.

-h, Optional

--help

Show this help message and exit.

-dem DEMFILE, Mandatory

--demfile DEMFILE

Digital Elevation Model (DEM) File. Used during orthorectification to correct pixel distortion in SAR images caused by layover, foreshortening and so on. Areal coverage must be larger than images to which it will be applied.

Example: D:\Floods\BaseData\QC\DEM\QC_Richelieu_UTM18_DEM_30.img

-mask PROCESSINGMASK, Optional

--procmask PROCESSINGMASK

Processing Mask. Optional mask used to clip the flood extent to a buffer surrounding the subject water body / Area Of Interest, thereby restricting output to a specific region. Can either be a raster or vector. If raster format (.img, .tif, or grid), must be of type integer where 1='area to process' and the remainder is set to NO DATA (zero values will not work). If not passed, water found throughout the full frame / mosiac will be incorporated in the final flood product.

Example: D:\Floods\BaseData\QC\ProcessingMask\QC_Richelieu_Mask_7p5km.shp

-mps MINPOLYGONSIZE, Optional

--minpolysize MINPOLYGONSIZE

Minimum Polygon Size (ha). Establishes a minimum area, in hectares, that a water polygon must meet or exceed to be incorporated in the final flood product. Used to exclude what could be considered 'noise' and retain areas of significance within the image. To keep all polygons, simply set the value to 0. Is required by the tool, however if not passed, will default to a value of 2.5.

Example:

2.0

-pix PIXELSPACE, Optional

--pixelspace PIXELSPACE

Pixel Spacing. Comma-delimited pair of numbers that identify the resolution in meters of each pixel in the orthorectified image, in the X and Y directions, respectively. Ideally its compatible with the DEM cell size. Is required by the tool, but if not passed, will use a default value of "12.5,12.5".

Example:

"30,30"

-pol POLARIZATION, Optional

--polarization POLARIZATION

Polarization Channel. Identifies which channel is to be processed. Must be a channel that has been captured in the raw SAR image, and must be one of the following supported values:

- 'HH'
- 'HV'
- 'VV'
- 'VH'
- 'ALL'

Value "ALL" indicates that all polarizations are to be processed. Will establish which 16-bit polarized SAR images, 8-bit scaled filtered SAR images, and default water thresholds are to be created and assigned, such as:

Mosaic\20160510_UTM16_mos_HH.tif

Scaled\20160510_UTM16_mos_HH_8bit_MED3x3.tif

['HH', 10, 12]

If not passed, will use default value of "HH" if captured, or first polarization encountered otherwise.

Example: HV

-proj PROJECTION, Optional

--projection PROJECTION

Projection. Used to reproject the incoming SAR images to the desired projection. Will typically be comprised of two elements, the first being the code used to identify the projection, and the second being PCI Geomatica's code for the datum (such as 'D000' for WGS84 and 'D122' for NAD83). Must be compatible with the images, DEMs and masks to be used. Precise spacing within the string is required for it to be accepted by the reprojection function. Is required by the tool, but if not passed, will use a default value of "CanLCC E008".

Example: "UTM 14 D122"

-stretch CONTRASTSTRETCH, Optional

--contraststretch CONTRASTSTRETCH

Contrast Stretch. Linear stretching algorithm used to convert incoming 16-bit SAR images to 8-bit. Must be one of the following supported values: - 'Min-Max Range' - 'Min-90% Max Range' - '95%

Confidence Interval' - '99% Confidence Interval' First two options are ones that should be most commonly used. If not passed, will use default value of "Min-Max Range".

Example: "Min-90% Max Range"

-ws WORKSPACE, Mandatory

--workspace WORKSPACE

Root directory immediately below which SAR ZIP files will be found and processing will take place. As this script calls other tools in the Flood Tools suite, they will create the subdirectories that they require if they are not already present, including 'Mosaic', 'Ortho', 'OWFEP', 'Raw', 'Scaled', 'Scaled_Unfiltered' and 'Scratch'. ZIP files will be moved and unpacked in the 'Raw' directory, RADARSAT images will be reprojected and orthrectified in the 'Ortho' directory, mosaicked in the 'Mosaic' directory, scaled from 16-bit to 8-bit and filtered in the 'Scaled' directory, placed unfiltered into the 'Scaled_Unfiltered' directory, then finally transformed from raster to vector polygon shapefiles, filtered and optionally clipped in the 'OWFEP' directory.

Example: D:\Floods\QC_Richelieu\20110507_225926_F6F

-wt WATERTHRESHOLD, Optional

--waterthreshold WATERTHRESHOLD

Water Threshold(s). Sets of polarizations and corresponding minimum and maximum water thresholds that will be used to create a series of output flood products. A set is required for each polarization identified by the "-pol" flag (or for the default polarization established by the tool when "-pol" isn't passed). The minimum and maximum water thresholds define the endpoints for a range of thresholds that will be used to generate products. Bit values from 0 to each threshold will be classified as water in the 8-bit images to be created. While these are required by the tool, if not passed, default values will be assigned as follows:

- ['HH', 10, 12]
- ['HV', 4, 6]
- ['VV', 4, 6]
- ['VH', 10, 12]

When passed, must be expressed as nested Python list(s) within double-quotes.

Examples:

"[['HH', 10, 12]]"

"[['HH', 10, 12], ['HV', 4, 6]]"

Pre-conditions

Post conditions

Errors

Ortho mosaicking tool

Is the first tool called in the procedure used to generate Flood Products. Starting in the workspace root directory where raw SAR imagery has been placed as ZIP file packages (either manually or automatically by the RS2Pull application), creates all subdirectories it requires if they are not already present (Raw, Ortho, Mosaic), moves the ZIP files to the Raw folder and unpacks them, then uses the DEM to orthorectify, reprojects, mosaics and finally separates the resultant into individual files that each represent one of the polarization channels (eg. HH, HV). This work will serve as the starting point for the second tool to be applied (FT2_Scale16to8BitSet).

Parameters

No.	Name	Description	Required	Data Type
1	-h	Help	N	String
2	-dem	Digital elevation model file	Y	String
3	-pix	Output pixel size	N	String
4	-proj	Output projection	N	String
5	-ws	Workspace path	Y	String

Parameters that take a file name will accept either relative or absolute paths.

-h, Optional

--help

Show this help message and exit.

-dem DEMFILE, Mandatory

--demfile DEMFILE

Digital Elevation Model (DEM) File. Used during orthorectification to correct pixel distortion in SAR images caused by layover, foreshortening and so on. Areal coverage must be larger than images to which it will be applied.

Example: D:\Floods\BaseData\QC\DEM\QC_Richelieu_UTM18_DEM_30.img

-pix PIXELSPACE, Optional

--pixelspace PIXELSPACE

Pixel Spacing. Comma-delimited pair of numbers that identify the resolution in meters of each pixel in the orthorectified image, in the X and Y directions, respectively. Ideally its compatible with the DEM cell size. Is required by the tool, but if not passed, will use a default value of "12.5,12.5".

Example:

"30,30"

-proj PROJECTION, Optional

--projection PROJECTION

Projection. Used to reproject the incoming SAR images to the desired projection. Will typically be comprised of two elements, the first being the code used to identify the projection, and the second being PCI Geomatica's code for the datum (such as 'D000' for WGS84 and 'D122' for NAD83). Must be compatible with the images, DEMs and masks to be used. Precise spacing within the string is required for it to be accepted by the reprojection function. Is required by the tool, but if not passed, will use a default value of "CanLCC E008".

Example: "UTM 14 D122"

-ws WORKSPACE, Mandatory

--workspace WORKSPACE

Root directory immediately below which SAR ZIP files will be found and processing will take place. As this script calls other tools in the Flood Tools suite, they will create the subdirectories that they require if they are not already present, including 'Mosaic', 'Ortho', 'OWFEP', 'Raw', 'Scaled', 'Scaled_Unfiltered' and 'Scratch'. ZIP files will be moved and unpacked in the 'Raw' directory, RADARSAT images will be reprojected and orthrectified in the 'Ortho' directory, mosaicked in the 'Mosaic' directory, scaled from 16-bit to 8-bit and filtered in the 'Scaled' directory, placed unfiltered into the 'Scaled_Unfiltered' directory, then finally transformed from raster to vector polygon shapefiles, filtered and optionally clipped in the 'OWFEP' directory.

Example: D:\Floods\QC_Richelieu\20110507_225926_F6F

Pre-conditions

Post conditions

Errors

Rescaling Tool

Summary

Is the second tool called in the procedure used to generate Flood Products. Starting in the workspace root directory, creates all subdirectories it requires if they are not already present (Scaled, Scaled_Unfiltered, Scratch), then processes one or more polarized image files (HH, HV, VV, VH), selected from those that were produced by the FT1_R2ReadOrthoMosaic tool and placed in the Mosaic subdirectory. Processing includes transforming from 16-bit to 8-bit, and applying a 3x3 rectangular median filter to smooth the results in an attempt to reduce the speckle noise, thereby reducing the number of 'holes' and associated polygons that will be generated by the third tool in the procedure that uses the images produced herein

Parameters

No.	Name	Description	Required	Data Type
1	-h	Help	N	String

2	-img16	16 Bit orthorectified Radarsat image	Y	String
8	-stretch	Contrast stretching method for 8 bit rescaling	N	String
9	-ws	Workspace path	Y	String

Parameters that take a file name will accept either relative or absolute paths.

-h, Optional

--help

Show this help message and exit.

-img16 IMAGE16BIT, Mandatory

--images16bit IMAGE16BIT

16-bit Polarized Image(s). One or more 16-bit polarized images produced by the "FT1_R2ReadOrthoMosaic" tool. These images should reside in the 'Mosaic' subdirectory, and when more than one is passed, each should represent a different polarization channel (HH, HV, VV, VH) and must be expressed as a quoted semi-colon delimitted string.

Example:
"D:\Floods\QC_Richelieu\20110507_225926_F6F\Mosaic\20110507_225926_UTM18_mos_HH.tif;D:\Floods\QC_Richelieu\20110507_225926_F6F\Mosaic\20110507_225926_UTM18_mos_HV.tif"

-stretch CONTRASTSTRETCH, Optional

--contraststretch CONTRASTSTRETCH

Contrast Stretch. Linear stretching algorithm used to convert incoming 16-bit SAR images to 8-bit. Must be one of the following supported values: - 'Min-Max Range' - 'Min-90% Max Range' - '95% Confidence Interval' - '99% Confidence Interval' First two options are ones that should be most commonly used. If not passed, will use default value of "Min-Max Range".

Example: "Min-90% Max Range"

-ws WORKSPACE, Mandatory

--workspace WORKSPACE

Workspace. Root directory that contains the 'Mosaic' subdirectory where the "FT1_R2ReadOrthoMosaic" tool has placed polarized SAR images during the first step of producing a Flood Product. Script will create subdirectories 'Scaled', 'Scaled_Unfiltered' and 'Scratch', if they are not already present, and will transform the polarized image files identified by the "-img" flag from 16-bit to 8-bit, producing both filtered images in the 'Scaled' folder by applying a 3x3 median smoothing algorithm, and unfiltered images in the 'Scaled_Unfiltered' folder.

Example: D:\Floods\QC_Richelieu\20110507_225926_F6F

Usage Notes

- Due to th

Pre-conditions

Post conditions

Errors

Open water flood extraction tool

Summary

Is the third tool called in the procedure used to generate Flood Products. Starting in the workspace root directory, creates all subdirectories it requires if they are not already present (OWFEP, Scratch), then processes one or more 8-bit filtered image files (HH, HV, VV, VH), selected from those that were produced by the FT2_Scale16to8BitSet tool and placed in the Scaled subdirectory. Processing includes establishing which pixels represent flooded areas and jetisoning those that aren't, applying a 5x5 rectangular majority filter to smooth the results in an attempt to reduce the number of polygons that will be generated, converting from raster to vector polygon, eliminating non-flood regions from the vector polygon shapefile, then finally removing all flood polygons that are smaller than a specified minimum size.

Parameters

No.	Name	Description	Required	Data Type
1	-h	Help	N	String
2	-img8	Rescaled 8 bit radar image	Y	String
3	-mask	Processing mask	N	String
4	-mps	Minimum polygon size	N	String
5	-ws	Workspace path	Y	String
6	-wt	Open water thresholds values	N	String

Parameters that take a file name will accept either relative or absolute paths.

-h,	Optional
--help	Show this help message and exit.

-img8 IMAGE8BIT, Mandatory

--image8bit IMAGE8BIT

8-bit Scaled Filtered Image(s). One or more 8-bit scaled filtered images produced by the "FT2_Scale16to8BitSet" tool. These images should reside in the 'Scaled' subdirectory, and each should represent a different polarization channel (HH, HV, VV, VH). When more than one image is passed, must be as a quoted semi-colon delimitted string.

Example:
"D:\Floods\QC_Richelieu\20110507_225926_F6F\Scaled\20110507_225926_UTM18_mos_HH_8bit_MED3x3.tif;D:\Floods\QC_Richelieu\20110507_225926_F6F\Scaled\20110507_225926_UTM18_mos_HV_8bit_MED3x3.tif"

-mask PROCESSINGMASK, Optional

--procmask PROCESSINGMASK

Processing Mask. Optional mask used to clip the flood extent to a buffer surrounding the subject water body / Area Of Interest, thereby restricting output to a specific region. Can either be a raster or vector. If raster format (.img, .tif, or grid), must be of type integer where 1='area to process' and the remainder is set to NO DATA (zero values will not work). If not passed, water found throughout the full frame / mosiac will be incorporated in the final flood product.

Example: D:\Floods\BaseData\QC\ProcessingMask\QC_Richelieu_Mask_7p5km.shp

-mps MINPOLYGONSIZE, Optional

--minpolysize MINPOLYGONSIZE

Minimum Polygon Size (ha). Establishes a minimum area, in hectares, that a water polygon must meet or exceed to be incorporated in the final flood product. Used to exclude what could be considered 'noise' and retain areas of significance within the image. To keep all polygons, simply set the value to 0. Is required by the tool, however if not passed, will default to a value of 2.5.

Example:

2.0

-ws WORKSPACE, Mandatory

--workspace WORKSPACE

Root directory immediately below which SAR ZIP files will be found and processing will take place. As this script calls other tools in the Flood Tools suite, they will create the subdirectories that they require if they are not already present, including 'Mosaic', 'Ortho', 'OWFEP', 'Raw', 'Scaled', 'Scaled_Unfiltered' and 'Scratch'. ZIP files will be moved and unpacked in the 'Raw' directory, RADARSAT images will be reprojected and orthrectified in the 'Ortho' directory, mosaicked in the 'Mosaic' directory, scaled from 16-bit to 8-bit and filtered in the 'Scaled' directory, placed unfiltered into the 'Scaled_Unfiltered' directory, then finally transformed from raster to vector polygon shapefiles, filtered and optionally clipped in the 'OWFEP' directory.

Example: D:\Floods\QC_Richelieu\20110507_225926_F6F

-wt WATERTHRESHOLD, Optional

--waterthreshold WATERTHRESHOLD

Water Threshold(s). Sets of polarizations and corresponding minimum and maximum water thresholds that will be used to create a series of output flood products. A set is required for each polarization identified by the "-pol" flag (or for the default polarization established by the tool when "-pol" isn't passed). The minimum and maximum water thresholds define the endpoints for a range of thresholds that will be used to generate products. Bit values from 0 to each threshold will be classified as water in the 8-bit images to be created. While these are required by the tool, if not passed, default values will be assigned as follows:

- ['HH', 10, 12]
- ['HV', 4, 6]
- ['VV', 4, 6]
- ['VH', 10, 12]

When passed, must be expressed as nested Python list(s) within double-quotes.

Examples:

"[['HH', 10, 12]]"

"[['HH', 10, 12], ['HV', 4, 6]]"

Usage Notes

- Due to th

Pre-conditions

Post conditions

Errors

Flooded Vegetation mapping tools:

The vegetation area flood mapping and merge python libraries and tools provide a means to derive flooded vegetation and merged open water products from RADARSAT-2 data sets. These libraries have been integrated into the ArcMap processing environment via the FloodTools.pyt tool box. They are labeled FT4_FloodVegExtraction and FT5_OpenFloodVeg_merge.

Flooded Vegetation Software

Summary

Is the fourth tool called in the procedure used to generate Flood Products. Starting in the workspace root directory, creates all subdirectories it requires if they are not already present (scratch, outdir, logs), then processes one or more polarized image files (HH, HV), present in the required ./raw directory. A DEM and a shapefile representing treed vegetation mask are to be provided with full path. Some required files are required to be place in a directory called ./seeds, these files includes should be three shapefiles representing training areas for non flooded vegetation(veg_non_flood.shp), flooded vegetation (veg_flood.shp) and open water (water.shp) can be used to overwrite the default tresholds values suggested by the GUI.

The EGS process module (EGS_process.py) is a python wrapper script used to process RADARSAT-2 data in order to derive flooded vegetation products. The python script processes RADARSAT-2 data within an input directory. The script can be run in component testing mode were the generated products are compared to known results. As well, it can be

run using seeds to automatically determine the thresholds for open water and flooded vegetation. The resulting flooded vegetation product is in a geotiff format. The following python scripts are required.

- veg_flood_process.py
- EGS_utility.py
- ortho_mosaic.py

The vegetation area flood module (veg_flood_process.py) contains a class used to derive vegetation flood area products from RADARSAT-2 datasets. This class contains the methods required to generate vegetation flood area products from RADARSAT-2 datasets. The following functionality is performed by this class:

- Orthorectified RADARSAT-2 data is filtered to reduce speckle and also preserve edges;
- Scaled the filtered image from linear to DB;
- Thresholds are applied that determine if the filtered areas are either open water or flooded vegetation. A low threshold is applied for open water areas and a high threshold for flooded vegetation areas;
- The resulting flooded vegetation and open water areas are then logically combined with a vegetation land cover product in order to create a flooded vegetation product; and
- Resulting flooded vegetation area product is exported as in geotiff format.

The EGS utility module (EGS_utility.py) contains a class containing utilities that are required for EGS processing of RADARSAT-2 imagery. The following functionality is performed by this class:

- Creates a list of the channel numbers for a specified PCIPIX file;
- Compares two lists of channels and determines the difference;
- Add 8 bit channel to PCIPIX file;
- Add 32 bit channel to PCIPIX file;
- Get geo-transform within file;
- Logs differences in vector files;
- Logs differences in raster files;
- Logs histogram;
- Setup logger; and
- Issue error messages.

The orthorectify mosaic module (ortho_mosaic.py) contains a class used to import, orthorectify, mosaic and export of RADARSAT-2 imagery. The following functionality is performed by this class:

- Imports the image and all auxiliary information from a source file;
- Import RADARSAT-2 imagery and metadata;
- Orthorectify RADARSAT-2 imagery;
- Creates image mosaic from a set of georeferenced images; and
- Exports image data.

Parameters

EGS_process.py has input parameters that can be added as command line arguments or read from a config file. The input parameters are listed in the table below:

Table 1 Parameter List for EGS_process.py

No.	Name	Description	Required	Data Type
1	indir	RADARSAT-2 data input directory	Y	String
2	inadir	Ancillary data directory	Y	String
3	wdir	Working directory	Y	String
4	outdir	Output products directory	Y	String
5	logdir	Log file directory	Y	String
6	land_cover	Land cover file	Y	String
7	aoi_file	Area of Interest (AOI) file	Y	String
8	imp_im	Import imagery: 1 to process, 0 to skip	Y	Integer
9	or_im	Orthorectify imagery: 1 to process, 0 to skip	Y	Integer
10	fl_im	Filter imagery: 1 to process, 0 to skip	Y	Integer
11	sc_im	Scale imagery: 1 to process, 0 to skip	Y	Integer
12	th_im	Threshold imagery: 1 to process, 0 to skip	Y	Integer
13	im_veg	Create flooded vegetation product: 1 to process, 0 to skip	Y	Integer
14	im_pro	Image projection	Y	String
15	im_pix_x	Image pixel spacing in x	Y	Float
16	im_pix_y	Image pixel spacing in y	Y	Float
17	v_th	Vegetation threshold	Y	Float
18	ow_th	Open water seed	N	Float
19	th_cal	Calculate threshold	N	Integer
20	ow_seed	Open water seed	N	String

21	fv_seed	Flood Vegetation seed	N	String
22	nfv_seed	Non-Flood Vegetation seed	N	String
23	m	Defines processing mode: "production" will delete all intermediate files	N	String
24	h	Shows help and exit	N	String
25	c	Config file containing all required parameters	N	String
26	v	verbose	N	String
27	t	Test mode	N	String
28	refr_file	Reference raster file	N	String
29	refp_file	Reference PCIDSK file	N	String
30	refp2_file	Reference ortho PCIDSK file	N	String

Usage:

FT4_FloodVegExtraction.py [-h]

-ws WORKSPACE -veg_mask FILE -proj "PROJECTION"

-pix VALUE [-veg_tresh VALUE] [-ow_tresh VALUE]

Parameters:

Parameters that take a file name will accept either relative or

absolute paths.

-h, Optional

--help

Show this help message and exit.

-ws WORKSPACE, Mandatory

--workspace WORKSPACE

Workspace. Root directory that contains the /raw folder in which the SAR ZIP files will be found. Processing will take place here. Script will create subdirectories 'Scratch' and 'VEGFEP' if they are not already present. ZIP files in the 'Raw' directory, reproject and orthrectify the SAR images in the 'Scratch' directory, and mosaic the reprojected images in the .pix file associated. The script is also looking for a ./Seeds directory to train the flooded vegetation tresholds

Example: B:\\Projects\\GRIP_Flood\\DEV\\2011_05_07\

-veg_mask VEGMASK, Mandatory

--veg_mask VEGMASK

Mask file or arborecent type land cover. Path and name of file used during the identification of the flooded vegetation zones during the processing. Areal coverage must be larger than images to which it will be applied.

Example:

D:\BaseData\Floods\VegMask\Richelieu_vegetationMask.shp

-DEM DEM , Mandatory

--DEM DEM

Digital elevation model fororthorectification processPath and name of file used duringthe orthoretification of the inputimagery. Areal coverage must be larger thanimages to which it will be applied.

Example:D:\BaseData\Floods\ON\DEM\CDED_Richelieu_Validation_UTM18_NAD83.tif

-pix PIXELSPACE, Optional

--pixelspace PIXELSPACE

Pixel Spacing. Comma-delimited pair of numbers that identify the resolution in metres of each pixel in the orthorectified image, in the X and Y directions, respectively. If not passed, will use a default value of "12.5,12.5".

Example: 30,30

-proj PROJECTION, Optional

--projection PROJECTION

Projection. Used to reproject the incoming SAR images to the desired projection. Will typically be comprised of two elements, the first being the code commonly used to identify the projection, and the second being PCI Geomatica's code for the datum (such as 'D000' for WGS84 and 'D122' for NAD83).

Examples: UTM 14 D122 or CanLCC E008

-veg_tresh VEG_TRESH Optionnal

--veg_tresh VEG_TRESH

Used to define the vegetation threshold necessary to differentiate unflooded vegetation from flooded vegetation. A default value is defined in the script so it can be omitted. If three training shapefiles required are present in the .\input_anc folder and if they are named veg_flood.shp; veg_non_flood.shp water.shp the script will use the training areas provided.

-water_tresh WATER_TRESH Optionnal

--water_tresh WATER_TRESH

Defines the treshold value to differentiate the open water extent from the flooded vegetation lower value. Can be entered manually or overridden by supplying a shapefile (water.shp) into the .\Seeds folder.

Usage Notes

- Due to the quantity of input parameters, running the process using the configuration file is more convenient. If the configuration has the same base name as the python script (i.e. EGS_process.ini), then the configuration parameter (c) is not required to be defined.
- Ensure that the projection defined by im_pro is correct for the region of interest.
- Ensure that the pixel spacing defined by im_pix_x and im_pix_y is correct for the data being processed.
- Ensure that input files defined by land_cover and aoi_file cover the same region as the data being processed and are in the same projection as defined by im_pro.
- By defining the process parameters, just the specified processes can be run when repeating a process for debugging purposes.
- The threshold values (i.e. v_th, ow_th) can be set manually or can be determined automatically by supplying seed vector locations for open water (ow_seed), flooded vegetation (fv_seed) and non-flooded vegetation (nfv_seed).
- If seed vector locations cannot distinguish between flooded and non-flooded vegetation the process will alert the user, give reason and stop processing.
- Review the 'README' for EGS_process.py located in Appendix B for running examples, usage, description of directory structure and component testing.

Pre-conditions

- The working directory (work_dir), output directory (output_dir) and the log directory (log_dir) must have read/write permissions. Input RADARSAT-2 file must be located in the directory defined by input directory parameter (indir). The vegetation land cover product defined by the land cover parameter (land_cover) must be located in the directory defined by ancillary data directory parameter (inadir). If automatic threshold mode is selected (th_cal), the defined seed files (ow_seed, fv_seed, nfv_seed) must be located in the ancillary input directory (inadir). If component test mode is selected (t), the defined reference files must be located where defined by the test parameters (refr_file, refp_file, refp2_file). The defined projection (im_pro) must be the same as the projection of the vegetation land cover product (land_cover).

Post-conditions

- Follow-up by running tool [2] Merge Processing, which will merge the flooded vegetation and open water products.

Limitations

- The quality of the output flooded vegetation product depends to a large degree on the ability to distinguish flooded vegetation and non-flooded vegetation within the imagery. Horizontal transmit, horizontal receive (HH) polarization has beam selected because it maximizes canopy penetration and enhances the contrasts between flooded vegetation and non-flooded vegetation. In some regions this contrast may be limited due to a number of factors including the complexity of the vegetation structure. In these cases, the threshold used to distinguish between two regions has to be set very precisely.

Input

- RADARSAT-2 data;
- Vegetation land cover product (land_cover);
- Open water seed shapefile (ow_seed)); required in calculating threshold mode (th_cal);
- Flood vegetation seed shapefile (fv_seed); required in calculating threshold mode (th_cal);

- Non-flood vegetation seed shapefile (nfv_seed)); required in calculating threshold mode (th_cal);
- Reference flood vegetation product (refr_file)); required in test mode (t);
- Reference imported RADARSAT-2 product in PCIPIX format (refp_file); required in test mode (t); and
- Reference orthorectified working file in PCIPIX format (refp2_file); required in test mode (t).

Output

- Flooded vegetation map in geotiff format; and
- Log file.

Errors

Table 2 Error List for EGS_process.py

Error Message	Solution
Missing parameters	Ensure that all stated parameters are defined.
File must exist in order to…	Ensure that stated file exists.
File must exist when run comparison test	Ensure that stated file exists.
Seed polygons must be modified or threshold values must…	Modify seed polygons or provide threshold values.

Merge Software

Summary

Is the fifth tool called in the procedure used to generate Flood Products. Starting in the workspace root directory, creates all subdirectories it requires if they are not already present (scratch, MERGEFEP, logs), then proceeds to merge the results of the input open water flood polygon extent as specified by the user (.shp) with the output of the step #4 the floodded vegetation mapping algotithm. This tool will mosaic the results (.tif) from step #4 that are found in the VEGFEP folfer in the workspace. Intermediate files are written in the scratch folder. Output files in .tif, .shp and .pix format are written in the MERGEFEP folder.

The EGS merge module (EGS_merge.py) is a python wrapper script used to merge flooded vegetation and open water products. The python script processes RADARSAT-2 data within an input directory. The script can be run in component testing mode were the generated products are compared to known results. The resulting merged product is in geotiff format. The following python scripts are required.

- veg_open_merge.py
- EGS_utility.py

The vegetation open water merge module (veg_open_merge.py) contains a class used to merge the flooded vegetation and open water products. This class contains the methods required to generate the merged product. The following functionality is performed by this class:

- Import flooded vegetation and open water products into a PCIPIX file;
- Merge products;

- Filter to remove small holes and areas; and
- Export resulting merged flooded area product as a geotiff.

Parameters

EGS_merge.py has input parameters that can be added as command line arguments or read from a config file. The input parameters are listed in the table below:

Table 3 Parameter List for EGS_merge.py

No.	Name	Description	Required	Data Type
1	indir	RADARSAT-2 data input directory	Y	String
2	wdir	Working directory	Y	String
3	outdir	Output products directory	Y	String
4	logdir	Log file directory	Y	String
5	vf_file	Vegetation flood file	Y	String
6	ow_file	Open water flood file	Y	String
7	hole_size	Filter size for holes and areas (hectares)	Y	Float
8	H	Shows help and exit	N	String
9	C	Config file containing all required parameters	N	String
10	V	verbose	N	String
11	T	Test mode	N	String
12	refr_file	Reference vector file	N	String
13	refp_file	Reference PCIDSK file	N	String
14	refp2_file	Reference ortho PCIDSK file	N	String

Usage:

FT5_OpenFloodVeg_merge.py [-h] -ws WORKSPACE -open_water FILE -min_poly_size "2.5 Ha"

Parameters:

Parameters that take a file name will accept either relative or absolute paths.

-h, Optional

--help

Show this help message and exit.

-ws WORKSPACE, Mandatory

--workspace WORKSPACE

Workspace. Root directory that the tool will use to find flooded vegetation files, mosaic them using the ./Scratch workspace. $_vegflood.tif files should be located in a VEGFEP folder in order to be located and mosaicked properly. _vegflood.tif is used as a keyword to identify files to be processed. Use accordingly.

Example:

B:\\Projects\\GRIP_Flood\\DEV\\2011_05_07\

-open_water Optionnal

--open_water

Defines the open water extent shape file to be used for merging with the extracted flooded vegetation areas. The open_water file must be a of the shape_file (.shp) type and must already be mosaiked if it was generated from more than one frame. The normal output of tool FT1 to FT3 is expected by this tool. User is free to feed an edited or clead up shape file.

-min_poly_size Optionnal

--min_poly_size

Defines the minimum polygon size for the identified flooded vegetation areas Polygons smaller than the specified size will be deleted. Hole will be filled.

-pix PIXELSPACE, Optional

--pixelspace PIXELSPACE

Pixel Spacing. Comma-delimited pair of numbers that identify the resolution in metres of each pixel in the orthorectified image, in the X and Y directions, respectively. If not passed, will use a default value of "12.5,12.5".

Example: 30,30

Usage Notes

- Running the process using the configuration file is convenient. If the configuration has the same base name as the python script (i.e. EGS_merge.ini), then the configuration parameter (c) is not required to be defined.
- Setting the hole size parameter (hole_size) to ‘1’ hectare generates reasonable results.
- Ensure that input files defined by vf_file and ow_file cover the same region and are in the same projection.

- Review the 'README' for EGS_merge.py located in Appendix B for running examples, usage, description of directory structure and component testing.

Pre-conditions

- The working directory (work_dir), output directory (output_dir) and the log directory (log_dir) must have read/write permissions. The vegetation flood file (vf_file) and open water flood file (ow_file) must be located in the directory defined by input directory parameter (indir). If component test mode is selected (t), the defined reference files must be located where defined by the test parameters (refv_file, refp_file, refp2_file). The products to be merged must be in the same projection and covering the same region.

Post-conditions

- None

Limitations

- The quality of the merged product depends on how well the input vegetation flood extent and open water flood products capture the actual flooded area.

Input

- Vegetation flood file (vf_file);
- Open water flood file (ow_file);
- Reference merge vector product (refv_file)); required in test mode (t);
- Reference imported RADARSAT-2 product in PCIPIX format (refp_file); required in test mode (t); and
- Reference orthorectified working file in PCIPIX format (refp2_file); required in test mode (t).

Output

- Merged flooded vegetation and open water product in raster format (i.e. geotiff);
- Merged flooded vegetation and open water product in vector format (i.e. shapefile); and
- Log file.

Errors

Table 4 Error List for EGS_merge.py

Error Message	Solution
Missing parameters	Ensure that all stated parameters are defined.
File must exist in order to…	Ensure that stated file exists.
File must exist when run comparison test	Ensure that stated file exists.