Flow-Conditioned Parameter Grid Tools 1.0.0 documentation

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1.0.0

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# Welcome to Flow-Conditioned Parameter Grid Tools’ documentation![¶](#welcome-to-flow-conditioned-parameter-grid-tools-documentation)

The Flow-Conditioned Parameter Grid (FCPG) Tools are a Python 3 library to make FCPGs for either two-digit Hydrologic Unit Code (HUC2) regions, four-digit Hydrologic Unit Code (HUC4) regions, or other geospatial tiling schemes. These tools can be used in a Linux-based high performance computing (HPC) environment or locally on your system.

[Conceptual FCPG process flowchart.](_images/CPG_tool_structure.png)

Flowchart of FCPG processing work flow.[¶](#id2)

# Installation[¶](#installation)

Clone the repository using git clone https://code.usgs.gov/StreamStats/FCPGtools.git.

Then change directories, using cd, into the repository and create an Anaconda environment using the supplied FCPGtools\_env.yml file by calling conda env create -f FCPGtools\_env.yml. Activate the FCPG environment using the instructions printed by conda after the environment is created successfully.

Then, install the repository using pip install git+file:<Full Path to the FCPGtools repository>

For example, pip install git+file:/home/<username>/projects/FCPGtools

On a HPC system you may need to load the correct Python module before building the Anaconda environment. This might be done with module load python/anaconda3.

# Dependencies[¶](#dependencies)

Dependencies for this work are largely taken care of via the Anaconda environment specified by the yml file; however, the tools do rely on [TauDEM 5.3.8](https://github.com/dtarb/TauDEM/tree/v5.3.8) [[1]](index.html#taudem), which needs to be installed and visible to your conda environment.

This library works best with GeoTiff files; however, other GDAL-compatible geospatial raster format could also potentially be used.

# Quick Start[¶](#quick-start)

Load the FCPGtools using import FCPGtools as fcpg.

Please refer to the [Cookbook](index.html#cookbook-label) and [Function Documentation](index.html#function-label) for examples and usage.

# Citation[¶](#citation)

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## Cookbook[¶](#cookbook)

Example scripts and work flows for common FCPG tasks on local workstations and HPC environments. These scripts have not been turned into FCPGtools functions because of the variability in HPC, local systems, and input data sets that the FCPGtools may be used with.

### Input Data[¶](#input-data)

To produce a basic FCPG you will need the following data for the same geographic area:

* Flow direction grid, ideally with TauDEM flow directions. Other flow direction formats (e.g. ESRI) can be reclassified to TauDEM flow directions.
* Parameter grid, a precipitation or air temperature grid is likely easiest, the resolution does not need to match your flow direction grid; however, the extent must be at least that of the flow direction grid.

To produce more complex FCPGs from categorical data or that cascade from one upstream hydrologic tile to a downstream tile you will need more data:

* A categorical parameter grid (e.g. land cover).
  + The Watershed Boundary Dataset for the area you are working in. This helps the tools locate areas within geospatial tiles that flow out of the tile and into the next downstream tile.

#### Generate TauDEM Files From An ESRI Flow Direction Grid[¶](#generate-taudem-files-from-an-esri-flow-direction-grid)

Helper script to reclassify an ESRI flow direction grid to TauDEM flow directions and generate a TauDEM flow accumulation grid.

|  |  |
| --- | --- |
| 1 2 3 4 5 6 7 8 9 | import fcpgtools as fcpg  cores = 6 # Computer cores to use. fdr = '' # Input ESRI flow direction grid. fdrTau = '' # Output TauDEM formatted flow direction grid. facTau = '' # Output flow accumulation grid.   fcpg.tauDrainDir(fdr, taufdr) # Reclassify flow directions. fcpg.tauFlowAccum(taufdr, taufac, cores=cores) # Compute flow accumulation. |

#### Batch FCPG Creation on an HPC[¶](#batch-fcpg-creation-on-an-hpc)

This is an example of batch creating FCPG grids from a folder of parameter (precipitation, air temperature, land cover, etc.) grids and a flow direction grid. This example uses two Python scripts. The first script sorts through the parameter grids and submits a Slurm job for each one and the second script, makeFCPG.py, creates the FCPG within the Slurm job. For more information on the Slurm workload manager, see <https://slurm.schedmd.com/overview.html>.

##### Parse parameter grids and submit SLURM jobs[¶](#parse-parameter-grids-and-submit-slurm-jobs)

|  |  |
| --- | --- |
| 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 | import time import sys import os  hpcAccount = 'your\_hpc\_account\_here'  ## The following lines indicate the order of the command line arguments that need to be supplied to this script.  # Check if system arguments were provided if len(sys.argv) > 1:  inDir = sys.argv[1] # Input directory in which to search for parameter rasters  taufdr = sys.argv[2] # Flow direction grid in tauDEM format  taufac = sys.argv[3] # Flow accumulation grid in tauDEM format  workDir = sys.argv[4] # Working directory to save intermediate files  outDir = sys.argv[5] # Output directory to save CPGs  logDir = sys.argv[6] # Directory to save slurm log files  cores = sys.argv[7] # Number of cores to use for each slurm job  accumThresh = sys.argv[8] # Number of cells in flow accumulation grid below which CPG will be set to no data  overwrite = sys.argv[9] # Whether to overwrite existing CPGs  deleteTemp = sys.argv[10] # Whether to delete temporary files  email = sys.argv[11] # Email address to send updates to else:  print('No arguments provided.')  sys.exit(1)  covList = [] #Initialize list of parameter grids  if os.path.isdir(inDir):  #Get all parameter grid files in directory  for path, subdirs, files in os.walk(inDir):  for name in files:  #Check if file is .tif, and if so add it to parameter list  if os.path.splitext(name)[1] == ".tif":  covList.append(os.path.join(path, name)) elif os.path.isfile(inDir):  #Supplied path is a single parameter grid file  covList.append(inDir) else:  print("Invalid parameter grid directory")  print("The following parameter grids were located:") print(\*covList, sep='\n')  for cov in covList: #Iterate through the parameter grids   covname = os.path.splitext(os.path.basename(cov))[0] #Get the name of the parameter   #Create batch job which runs python script  jobfile = os.path.join(workDir, "{0}.slurm".format(str(covname))) # Create path to slurm job file   with open(jobfile, 'w+') as f:    #Write slurm job details  f.writelines("#!/bin/bash\n")  f.writelines("#SBATCH --job-name={0}\n".format(covname)) # set the name of the job  f.writelines("#SBATCH -c 1\n") # cpus per task  f.writelines("#SBATCH -n {0}\n".format(cores)) # number of tasks  f.writelines("#SBATCH --tasks-per-node=20\n") # Set number of tasks per node  f.writelines("#SBATCH -o {0}/slurm-%A.out\n".format(logDir)) # Set log file name   f.writelines("#SBATCH -p normal\n") # the partition you want to use, for this case prod is best  f.writelines("#SBATCH --account={0}\n".format(hpcAccount)) # your account  f.writelines("#SBATCH --time=01:00:00\n") # Overestimated guess at time  f.writelines("#SBATCH --mem=128000\n") #memory in MB  f.writelines("#SBATCH --mail-type=ALL\n") # Send email only for all events  f.writelines("#SBATCH --mail-user={0}\n".format(email))  f.writelines("#SBATCH --exclusive\n") # Require exclusive use of nodes   #Set up python environment for job  f.writelines("module load taudem/5.3.8\n") # load TauDEM  f.writelines("source activate FCPGtools\n") # activate the correct Python environment, you will need to build this using Anaconda.   #Run the Python script  f.writelines("python -u ./makeFCPG.py {0} {1} {2} {3} {4} {5} {6} {7} {8}\n".format(cov, taufdr, taufac, workDir, outDir, cores, accumThresh, overwrite, deleteTemp))    print("Launching batch job for: " + str(covname))   os.system("sbatch {0}".format(jobfile)) #Send command to console   time.sleep(5) #Wait between submitting jobs |

##### Generate a FCPG given a parameter and FDR grid[¶](#generate-a-fcpg-given-a-parameter-and-fdr-grid)

makeFCPG.py

|  |  |
| --- | --- |
| 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 | import FCPGtools as fcpg import os import datetime import sys  print("Starting {0}".format(datetime.datetime.now()))  # Set up Inputs paramRast = sys.argv[1] # Path to parameter raster with name in format of "source\_var\_dd\_mm\_yyyy.tif" taufdr = sys.argv[2] # Path to tauDEM flow direction grid with in format of "taufdrXXXX.tif", where XXXX is a HUC code of any length taufac = sys.argv[3] # Path to tauDEM flow accumulation grid workDir = sys.argv[4] # Path to working directory outDir = sys.argv[5] # Path to output directory for FCPG files cores = int(sys.argv[6]) # Number of cores to use  accumThresh = int(sys.argv[7]) # Number of cells in flow accumulation grid below which FCPG will be set to no data overwrite = fcpg.parsebool(sys.argv[8]) # Whether to overwrite CPGs or not  deleteTemp = fcpg.parsebool(sys.argv[9]) # Whether to delete temporary files  print("Starting FCPG process for:") print("Parameter Raster: {0}".format(paramRast)) print("Flow Driection Grid: {0}".format(taufdr)) print("Flow Accumulation Grid: {0}".format(taufac)) print("Working Directory: {0}".format(workDir)) print("Output Directory: {0}".format(outDir)) print("Number of Cores: {0}".format(cores)) print("Accumulation Threshold: {0} cells".format(accumThresh)) print("Overwrite Existing CPG: {0}".format(overwrite)) print("Delete Temporary Files: {0}".format(deleteTemp))  #Get name of input parameter without extention paramName = os.path.splitext(os.path.basename(paramRast))[0]   #Get HUC number from tau flow direction raster name try:  HUC = os.path.splitext(os.path.basename(taufdr))[0].split("taufdr")[1] except:  print("Error - Flow direction raster has inappropriate name")  #Prepare some file paths to things which will be created rprjFile = os.path.join(workDir, paramName + "\_HUC" + HUC + "rprj.tif") #Create filepath for reprojected parameter file accumFile = os.path.join(workDir, paramName + "\_HUC" + HUC + "accum.tif") #Create filepath for accumulated parameter file nodataFile = os.path.join(workDir, paramName + "\_HUC" + HUC + "nodata.tif") #Create filepath for parameter no data file nodataaccumFile = os.path.join(workDir, paramName + "\_HUC" + HUC + "accumnodata.tif") #Create filepath for parameter accumulated no data file zeronodataFile = os.path.join(workDir, paramName + "\_HUC" + HUC + "zeronodata.tif") #Create filepath for parameter zeroed no data file CPGFile = os.path.join(outDir, paramName + "\_HUC" + HUC +"\_FCPG.tif") #Create filepath for parameter FCPG file  if os.path.isfile(CPGFile) & (overwrite == False):  print("Error: Specified FCPG file exists and will not be overwritten") else:  #Run the FCPG tools  print("Calling resample function {0}".format(datetime.datetime.now()))  fcpg.resampleParam(paramRast, taufdr, rprjFile, resampleMethod="bilinear", cores=cores) #Resample and reprojected parameter raster  print("Calling flow accumulation function {0}".format(datetime.datetime.now()))  fcpg.accumulateParam(rprjFile, taufdr, accumFile, outNoDataRast=nodataFile, outNoDataAccum=nodataaccumFile, zeroNoDataRast=zeronodataFile, cores=cores) #Accumulate parameter  print("Calling make\_cpg function {0}".format(datetime.datetime.now()))  if os.path.isfile(nodataaccumFile):  #If no data accumulation file was created, use it in call to create FCPG  fcpg.make\_cpg(accumFile, taufac, CPGFile, noDataRast=nodataaccumFile, minAccum=accumThresh) #Create parameter FCPG with no data raster.  else:  fcpg.make\_cpg(accumFile, taufac, CPGFile, minAccum=accumThresh) #Create parameter FCPG without no data raster.    if deleteTemp:  try:  #Delete temporary files  os.remove(rprjFile)  os.remove(accumFile)  os.remove(nodataFile)  os.remove(nodataaccumFile)  except:  print("Warning: Unable to delete temporary files") print("Finished {0}".format(datetime.datetime.now())) |

#### Cascade FCPG results between geospatial tiles[¶](#cascade-fcpg-results-between-geospatial-tiles)

Watersheds or hydrologic units, e.g. the [Watershed Boundary Dataset](https://www.usgs.gov/core-science-systems/ngp/national-hydrography/watershed-boundary-dataset?qt-science_support_page_related_con=4#qt-science_support_page_related_con), are often used as geospatial tiling schemes for digital elevation models. These pose a challenge for FCPGs as downstream accumulated area and parameter grids must be corrected with values from upstream geospatial tiles to be accurate. This section contains examples for cascading flow between HUC4s and larger HUC2s or other geospatial tiling schemes.

##### Cascade Four-Digit Hydrologic Regions[¶](#cascade-four-digit-hydrologic-regions)

This script provides an example work flow of how to cascade the last (maximum) accumulated area values from an upstream basin, e.g. HUC 1002 – Upper Missouri, to the first cell of a downstream basin, e.g. HUC 1003 – Missouri-Marias. The process creates a json file containing the values to be cascaded, creates a weighting grid of ones for the downstream region, inserts the upstream value into the weighting grid at the correct location, and accumulates the weighting grid using the downstream flow direction grid to produce an adjusted flow accumulation grid for the downstream region. This process can be repeated for each parameter grid and then used with make\_fcpg() to create FCPGs corrected for upstream basins.

###### Example HUC-4 Cascading Work Flow[¶](#example-huc-4-cascading-work-flow)

|  |  |
| --- | --- |
| 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 | import FCPGtools as fcpg # Import the tools.  import geopandas as gpd  # Define the file input and output paths and the upstream region. upstreamFACfltau = '' # Upstream flow accumulation grid from TauDEM. upstreamFDRfltau = '' # Upstream flow direction grid in TauDEM format. downstreamFACfltau = '' # Downstream flow accumuation grid from TauDEM. downstreamFDRfltau = '' # Downstream flow direction grid in TauDEM format. updateDict = '' # Path to the update dictionary to create. downstreamFACWeight = '' # Path to the downstream FAC weighting grid. This is where the upstream value will be inserted. downstreamAdjFAC = '' # Path to output the adjusted FAC weighting grid. wbdPth = '' # Path to the watershed boundary dataset for the HUC-2 region you are working in. cores = 6 #Number of cores to use for fcpg.adjustFAC() function  # Define upstream and downstream basins. upstream = '' downstream = ''  # Load the WBD. layer = 'WBDHU12' # HUC12 WBD layer with ToHUC codes. wbd = gpd.read\_file(wbdPth, layer = layer) # Load the WBD to a geodataframe.  # Convert HUC12 and ToHUC codes to 4-digit codes., wbd['HUC4'] = wbd.HUC12.map(fcpg.getHUC4) wbd['ToHUC4'] = wbd.ToHUC.map(fcpg.getHUC4)  # Find basins that contain pour points. pourBasins = fcpg.makePourBasins(wbd,upstream,downstream)  # Find pour points between the upstream and downstream basins. pourPoints = fcpg.findPourPoints(pourBasins, upstreamFACfltau, upstreamFDRfltau, plotBasins = True)  # Create update dictionary from the pour points. newX,newY,maxFAC = zip(\*pourPoints) fcpg.createUpdateDict(newX,newY,maxFAC,upstream,updateDict)  # Update the downstream basin using the update dictionary. fcpg.adjustFAC(downstreamFACfltau,downstreamFACWeight,updateDict,downstreamFDRfltau,downstreamAdjFAC, cores=cores) # note that this tool will create downstreamFACWeight if it does not exist based on downstreamFACfltau, see function documentation. |

##### Cascade Two-Digit Hydrologic Regions[¶](#cascade-two-digit-hydrologic-regions)

This script provides an example work flow of how to cascade the last (maximum) accumulated area value from an upstream region, e.g. Region 14 – Upper Colorado, to the first cell of a downstream region, e.g. Region 15 – Lower Colorado. For this example, it is assumed that the user is working with ESRI-produced flow direction grids. Because of the differences in the encoding of flow directions calculated with ESRI tools and flow directions calculated with TauDEM, the FCPG tools require flow direction data to be converted to TauDEM encoding if they are not already. The process creates a json file containing the value to be cascaded, creates a weighting grid of ones for the downstream region, inserts the upstream value into the weighting grid at the correct location, and accumulates the weighting grid using the downstream flow direction grid to produce an adjusted flow accumulation grid for the downstream region. This process can be repeated for each parameter grid and then used with make\_fcpg() to create FCPGs corrected for upstream regions.

###### Example HUC-2 Cascading Work Flow[¶](#example-huc-2-cascading-work-flow)

|  |  |
| --- | --- |
| 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 | import FCPGtools as fcpg # Import the tools.   # Define the file input and output paths and the upstream region. upstreamFDRflesri = '' # Upstream flow direction grid in ESRI format. downstreamFDRflesri = '' # Downstream flow direction grid in ESRI format. upstreamFACfltau = '' # Upstream flow accumulation grid from TauDEM. upstreamFDRfltau = '' # Upstream flow direction grid in TauDEM format. downstreamFACfltau = '' # Downstream flow accumuation grid from TauDEM. downstreamFDRfltau = '' # Downstream flow direction grid in TauDEM format. region = '' # Hydrologic region to make the update dictionary for. updateDict = '' # Path to the update dictionary to create. downstreamFACWeight = '' # Path to the downstream FAC weighting grid. This is where the upstream value will be inserted. downstreamAdjFAC = '' # Path to output the adjusted FAC weighting grid. cores = 8 #Number of cores to use for fcpg.adjustFAC() function  # convert ESRI flow directions to TauDEM flow directions. fcpg.tauDrainDir(upstreamFDRflesri, upstreamFDRfltau) fcpg.tauDrainDir(downstreamFDRflesri, downstreamFDRfltau)  # Accumulate upstream FDR grid. fcpg.tauFlowAccum(upstreamFDRfltau, upstreamFACfltau)  # Create the update dictionary to move data between HUC2 regions. x,y,d,w = fcpg.findLastFACFD(upstreamFACfltau, upstreamFACfltau) fcpg.createUpdateDict(x,y,d,region,updateDict)  # Make a grid of ones based on the downstream grid. fcpg.makeFACweight(downstreamFDRfltau,downstreamFACWeight)  # Create the updated flow accumulation grid with information from the upstream HUC inserted into the source grid. fcpg.adjustFAC(downstreamFDRfltau,downstreamFACWeight,  updateDict,downstreamFDRfltau,downstreamAdjFAC,cores=cores) |

#### Detect Missing FCPGs[¶](#detect-missing-fcpgs)

Helper script to iterate through geospatial tiles, HUC4 basins in this example, and to check for completed FCPGs. This is useful if you have many FCPGs to process.

|  |  |
| --- | --- |
| 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 | import os  HUClist = ["1002", "1003", "1004"] # HUC4 geospatial tiles to search over.  inDir = "../data/cov/static" # Source parameter grid folder.  FCPGdir = "../FCPGs" # Output FCPG folder.  covList = [] #Initialize list of parameter grids.  # iterate through all source parameter grids. if os.path.isdir(inDir):   for path, subdirs, files in os.walk(inDir):  for name in files:  #Check if file is .tif or .vrt file, and if so add it to covariate list  if os.path.splitext(name)[1] == ".tif" or os.path.splitext(name)[1] == ".vrt":  covList.append(os.path.join(path, name))   print("The following covariate files were located in the specified directory:")  print(covList)   missingList = [] #Initialize list of missing files   # iterate through source parameter grids and test if FCPGs have been created.  for cov in covList:   covname = os.path.splitext(os.path.basename(cov))[0] #Get the name of the parameter grid   if os.path.isdir(FCPGdir):  for HUC in HUClist:  #Create the file name corresponding to the HUC and parameter grid  FCPGFile = os.path.join(FCPGdir, HUC,covname + "\_HUC" + HUC +"\_FCPG.tif") #Create filepath for parameter FCPG file   if not os.path.isfile(FCPGFile):  print("Missing File: {0}".format(FCPGFile))  missingList.append(FCPGFile)     else:  print("Error FCPG directory does not exist: {0}".format(FCPGdir))    print("{0} missing files found".format(len(missingList)))  else:  print("Error input directory does not exist: {0}".format(inDir)) |

## Function Documentation[¶](#module-tools)

ExtremeUpslopeValue(*fdr*, *param*, *output*, *accum\_type='MAX'*, *cores=1*, *fac=None*, *thresh=None*)[¶](#tools.ExtremeUpslopeValue)

Wrapper for the TauDEM D8 Extreme Upslope Value function [[1]](index.html#taudem).

Parameters

**fdr**str

Path to a flow direction grid in TauDEM format.

**param**str

Path to parameter raster to run through the D8 Extreme Upslope Value tool

**output**str

Path to output raster file.

**accum\_type**str (optional)

Either “MAX” or “MIN.” Defaults to “MAX.”

**cores**int (optional)

Number of cores to run this process on. Defaults to 1.

**fac**str (optional)

Path to a flow accumulation raster. Defaults to None.

**thresh**int (optional)

Threshold values, in the same units as fac to mask output to stream channels. Defaults to None.

**mpiCall**str (optional)

The command to use for mpi, defaults to mpiexec.

**mpiArg**str (optional)

Argument flag passed to mpiCall, which is followed by the cores parameter.

Returns

**output**raster

Raster of either the maximum or minumum upslope value of the parameter grid supplied to the function.

FindDownstreamCellTauDir(*d*, *x*, *y*, *w*)[¶](#tools.FindDownstreamCellTauDir)

Find downstream cell given the flow direction of a reference cell using TauDEM flow directions.

Parameters

**d**int

Flow direction of the reference cell.

**x**float

Horizontal coordinate (either projected or unprojected).

**y**float

Vertical coordinate (either projected or unprojected).

**w**float

Cell size, in map units.

Returns

**x**float

Horizontal coordinate of the downstream cell.

**y**float

Vertical coordinate of the downstream cell.

accumulateParam(*paramRast*, *fdr*, *accumRast*, *outNoDataRast=None*, *outNoDataAccum=None*, *zeroNoDataRast=None*, *cores=1*, *mpiCall='mpiexec'*, *mpiArg='-n'*)[¶](#tools.accumulateParam)

Accumulate a parameter grid using TauDEM AreaD8 [[1]](index.html#taudem).

Parameters

**paramRast**str

Raster of parameter values to accumulate; this file is modified by the function.

**fdr**str

Flow direction raster in TauDEM format.

**accumRast**str

File location to store accumulated parameter values.

**outNoDataRast**str (optional)

File location to store parameter no data raster.

**outNoDataAccum**str (optional)

File location to store accumulated no data raster.

**zeroNoDataRast**str (optional)

File location to store the no data raster filled with zeros.

**cores**int (optional)

The number of cores to use for parameter accumulation. Defaults to 1.

**mpiCall**str (optional)

The command to use for mpi, defaults to mpiexec.

**mpiArg**str (optional)

Argument flag passed to mpiCall, which is followed by the cores parameter.

Returns

**accumRast**raster

Raster of accumulated parameter values.

**outNoDataRast**raster

Raster of no data values.

**outNoDataRast**raster

Raster of accumulated no data values.

Notes

If outNoDataRast, outNoDataAccum, and zeroNoDataRast inputs are all supplied it will set any “no data” values in the basin to zero and save that raster as zeroNoDataRast. It will then save a raster with all no data values set to one and other values set to zero (outNoDataRast) and use tauDEM to accumulate it (outNoDataAccum). It will then accumulate the parameter from the zeroNoDataRast, and a subsequent correction will be needed in the make\_fcpg() function based on the values in the outNoDataAccum raster.

If some of the output file locations for handling no data values aren’t supplied or “no data” values aren’t present in the parameter grid, it will simply accumulate the parameter grid. If “no data” values are present, this will result in them being propagated downstream.

accumulateParams(*paramRasts*, *fdr*, *outWorkspace*, *cores=1*, *appStr='accum'*, *mpiCall='mpiexec'*, *mpiArg='-n'*)[¶](#tools.accumulateParams)

Batch version of [accumulateParam()](#tools.accumulateParam).

Parameters

**paramRasts**list

List of input parameter raster paths to accumulate along the supplied fdr.

**fdr**str

Path to the flow direction raster.

**outWorkspace**str

Path to the output directory for accumulation rasters.

**cores**int (optional)

Number of cores to use. Defaults to 1.

**appStr :str (optional)**

String of text to append to accumulated parameter filenames. Defaults to “accum.”

**mpiCall**str (optional)

MPI program to use to execute the program, defaults to mpiexec.

**mpiArg**str (optional)

Argument to pass to mpiCall, defaults to -n.

Returns

**fileList**list

List of file paths to accumulated parameter rasters.

adjustFAC(*facWeighttemplate*, *downstreamFACweightFl*, *updateDictFl*, *downstreamFDRFl*, *adjFACFl*, *cores=1*, *mpiCall='mpiexec'*, *mpiArg='-n'*)[¶](#tools.adjustFAC)

Generate an updated flow accumulation grid (FAC) given an update dictionary produced by [createUpdateDict()](#tools.createUpdateDict).

Parameters

**facWeighttemplate**str

Path to a FDR or FAC grid used to make the FAC weighting grid.

**downstreamFACweightFl**str

Path to output the FAC weighting grid.

**updateDictFl**str

Path to update dictionary used to update the FAC weighting grid.

**downstreamFDRFl**str

Path to downstream FDR to use when computing the adjusted FAC grid.

**adjFACFl**str

Path to output the adjusted FAC raster.

**cores**int (Optional)

Number of cores to use. Defaults to 1.

**mpiCall**str (optional)

MPI program to use to execute the program, defaults to mpiexec.

**mpiArg**str (optional)

Argument to pass to mpiCall, defaults to -n.

Returns

**adjFACFl**raster

Adjusted flow accumulation raster at adjFACFl

adjustParam(*updatedParam*, *downstreamParamFL*, *updateDictFl*, *adjParamFl*)[¶](#tools.adjustParam)

Generate an updated parameter grid given an update dictionary from [createUpdateDict()](#tools.createUpdateDict).

Parameters

**updatedParam**str

Name of the parameter to update.

**downstreamParamFL**str

Path to downstream parameter grid to update.

**updateDictFl**str

Path to update dictionary to use.

**adjParamFl**str

Path to output adjusted parameter file.

Returns

**adjParamFl**raster

Adjusted parameter raster that can be accumulated prior to FCPG creation.

applyMult(*inRast*, *mult*, *outRast*)[¶](#tools.applyMult)

Multiply input raster by mult.

Parameters

**inRast**str

Path to input raster.

**mult**str

Path to multiplier raster.

**outRast**str

Path to output raster.

Returns

**outRast**raster

Input raster multiplied by the multiplier raster.

binarizeCat(*val*, *data*, *nodata*, *outWorkspace*, *baseName*, *ext*, *profile*)[¶](#tools.binarizeCat)

Turn a categorical raster (e.g. land cover type) into a set of binary rasters, one for each category in the supplied raster, zero for areas where that class is not present, 1 for areas where that class is present, and -1 for regions of no data in the supplied raster. See also [cat2bin()](#tools.cat2bin).

Parameters

**data**np.array

Numpy array of raster data to convert to binary.

**val**int

Raster value to extract binary for from data.

**nodata**int or float

Raster no data value.

**outWorkspace**str

Path to folder to save binary output rasters to.

**baseName**str

Base name for the output rasters.

**ext**str

File extension for output rasters.

**profile**dict

Rasterio metadata dictionary decribing the properties used to create the output raster.

Returns

**catRaster**str

Filepath to the binary raster created.

cat2bin(*inCat*, *outWorkspace*, *par=True*)[¶](#tools.cat2bin)

Turn a categorical raster (e.g. land cover type) into a set of binary rasters, one for each category in the supplied raster, zero for areas where that class is not present, 1 for areas where that class is present, and -1 for regions of no data in the supplied raster. Wrapper on [binarizeCat()](#tools.binarizeCat).

Parameters

**inCat**str

Input catagorical parameter raster.

**outWorkspace**str

Workspace to save binary raster output files.

**par**bool

Use parallel processing to generate binary rasters.

Returns

**fileList**list

List of filepaths to output files.

changeNoData(*inRast*, *newNoData*, *updateDict={'compress': 'LZW', 'profile': 'GeoTIFF', 'tiled': True, 'sparse\_ok': True, 'num\_threads': 'ALL\_CPUS', 'bigtiff': 'IF\_SAFER'}*)[¶](#tools.changeNoData)

Update raster no data value to a new value.

Parameters

**inRast**str

Path to input raster file.

**newNoData**str

New no data value for the raster.

**updateDict**dict (optional)

Dictionary of Rasterio parameters used to create the updated raster.

Returns

None

createUpdateDict(*x*, *y*, *upstreamFACmax*, *fromHUC*, *outfl*, *replaceDict=True*)[¶](#tools.createUpdateDict)

Create a dictionary for updating downstream FAC and parameter grids using values pulled from the next grid upstream.

Parameters

**x**list

Horizontal coordinate(s) for where the update needs to happen in the downstream grid.

**y**list

Vertical coordinate(s) for where the update needs to happen in the downstream grid.

**upstreamFACmax**list

Value(s) to insert into the downstream FAC grid.

**fromHUC**str

The upstream HUC that the values are coming from.

**outfl**str (path)

Path to where to save the json of this dictionary. The convention is to name this by the downstream HUC.

**replaceDict**bool (optional)

Replace the update dictionary instead of updating with a new value. Defaults to True.

Returns

**updateDict**dict

Update dictionary that is also written to outfl.

d8todinfinity(*inRast*, *outRast*, *updateDict={'dtype': 'float32', 'compress': 'LZW', 'profile': 'GeoTIFF', 'tiled': True, 'sparse\_ok': True, 'num\_threads': 'ALL\_CPUS', 'nodata': - 1, 'bigtiff': 'IF\_SAFER'}*)[¶](#tools.d8todinfinity)

Convert TauDEM D-8 flow directions to D-Infinity flow directions.

Parameters

**inRast**str

Path to a TauDEM D-8 flow direction raster.

**outRast**str

Path to output the TauDEM D-Infinity flow direction raster.

**updateDict**dict (optional)

Dictionary of Rasterio parameters used to write out the GeoTiff.

Returns

**outRast**str

Path to output the TauDEM D-Infinity flow direction raster.

decayAccum(*ang*, *mult*, *outRast*, *paramRast=None*, *cores=1*, *mpiCall='mpiexec'*, *mpiArg='-n'*)[¶](#tools.decayAccum)

Decay the accumulation of a parameter raster.

Parameters

**ang**str

Path to flow angle raster from the TauDEM D-Infinity flow direction tool.

**mult**str

Path to raster of multiplier values applied to upstream accumulations, 1 corresponds to no decay, 0 corresponds to complete decay.

**outRast**str

Path to output raster for decayed accumulation raster.

**paramRast**str (optional)

Raster of parameter values to accumulate. If not supplied area will be accumulated. Defaults to None.

**cores**int (optional)

Number of cores to use. Defaults to 1.

**mpiCall**str (optional)

The command to use for mpi, defaults to mpiexec.

**mpiArg**str (optional)

Argument flag passed to mpiCall, which is followed by the cores parameter.

Returns

**outRast**raster

Decayed accumulation raster, either area or parameter depending on what is supplied to the function.

dist2stream(*fdr*, *fac*, *thresh*, *outRast*, *cores=1*, *mpiCall='mpiexec'*, *mpiArg='-n'*)[¶](#tools.dist2stream)

Compute distance to streams.

Parameters

**fdr**str

Path to flow direction raster in TauDEM format.

**fac**str

Path to flow accumulation raster.

**thresh**int

Accumulation threshold for stream formation in number of grid cells.

**outRast**str

Path to output the distance raster.

**cores**int (optional)

The number of cores to use. Defaults to 1.

**mpiCall**str (optional)

The command to use for mpi, defaults to mpiexec.

**mpiArg**str (optional)

Argument flag passed to mpiCall, which is followed by the cores parameter.

Returns

**outRast**raster

Raster with values of D-8 flow distance from each cell to the nearest stream.

findLastFACFD(*facfl*, *fl=None*)[¶](#tools.findLastFACFD)

Find the coordinate of the greatest cell in facfl, return the value from fl at that point.

Parameters

**facfl**str

Path to a flow accumulation grid.

**fl**str (optional)

Path to an accumulated parameter file. Defaults to None. If None, the facfl is queried.

Returns

**x**float

Horizontal coordinate of the greatest FAC cell.

**y**float

Vertical coordinate of the greatest FAC cell.

**d**float

Value from the parameter grid queried.

**w**float

Cell size of the grid.

Notes

This can be used to find the flow direction of the FAC cell with the greatest accumulation value or the parameter value of the cell with the greatest accumulation value.

findPourPoints(*pourBasins*, *upfacfl*, *upfdrfl*, *plotBasins=False*)[¶](#tools.findPourPoints)

Finds unique pour points between two HUC4s.

Parameters

**pourBasins**GeoDataframe

GeoDataframe of the HUC12 basins that flow into the downstream HUC4. Used to clip the upstream FAC grid to identify pour points.

**upfacfl**str

Path to the upstream flow accumulation grid.

**upfdrfl**str

Path to the upstream tauDEM flow direction grid.

**plotBasins**bool (Optional)

Boolean to make plots of upstream HUC12s and identified pour points. Defaults to False.

Returns

**finalPoints**list

List of tuples containing (x,y,w). These pour points have not been incremented downstream and can be used to query accumulated (but not FCPGed) upstream parameter grids for information to cascade down to the next hydrologic region / geospatial tile downstream.

getFeatures(*gdf*)[¶](#tools.getFeatures)

Helper function to parse features from a GeoPandas GeoDataframe in such a manner that Rasterio can handle them.

Parameters

**gdf**GeoDataframe

GeoPandas GeoDataframe with a geometry column.

Returns

**features**geoJSON

GeoJSON representation of geometry features from the input GeoDataFrame.

getHUC4(*HUC12*)[¶](#tools.getHUC4)

Helper function to return HUC4 representation from a HUC12 identifier.

Parameters

**HUC12**str

Text representation of the HUC12 identifier.

Returns

**HUC4**str

HUC4 identifier.

loadJSON(*infl*)[¶](#tools.loadJSON)

Load dictionary stored in a JSON file.

Parameters

**infl**str

Path to the JSON to be loaded.

Returns

**dictionary**dict

Dictionary that was loaded.

loadRaster(*fl*, *returnMeta=False*, *band=1*)[¶](#tools.loadRaster)

Helper function to load raster data and metadata.

Parameters

**fl**str

Path to the raster file to load.

**returnMeta**bool (Optional)

Return the raster metadata. Defaults to False.

**band**int (Optional)

Band to read from the raster. Defaults to one.

Returns

**dat**np.array

Numpy array of the data in the selected raster band.

**meta**dict

Dictionary of raster metadata.

makeDecayGrid(*d2strm*, *k*, *outRast*)[¶](#tools.makeDecayGrid)

Create a decay raster where grid cell values are computed as the inverse number of grid cells, \(\frac{dx}{n+k\*dx}\), where n is the distance from the d2strm raster and from each grid cell to the nearest stream, k is the constant applied to the stream distance values, and dx is the cell size of the raster.

Parameters

**d2strm**str

Path to raster of flow distances from each grid cell to the nearest stream.

**k**float

Constant applied to decay factor denominator; this has units equal to the horizontal map units in the d2strm raster.

**outRast**str

Output file path for decay grid.

Returns

**outRast**raster

Raster file with grid cells values representing weights decaying as a function of the distance to stream.

makeFACweight(*ingrd*, *outWeight*)[¶](#tools.makeFACweight)

Make FAC weighting grid of ones based on the extents of the input grid. No-data cells are persisted.

Parameters

**ingrd**str

Path to input raster from which to generate the weighting grid from.

**outWeight**str

Path to the output weighting raster generated.

Returns

**outWeight**raster

Raster of the same extent and resolution as the input grid, but filled with ones where data exist. No-data cells are persisted.

makePourBasins(*wbd*, *fromHUC4*, *toHUC4*, *HUC12Key='HUC12'*, *ToHUCKey='TOHUC'*)[¶](#tools.makePourBasins)

Make geodataframe of HUC12 basis flowing from fromHUC4 to toHUC4.

Parameters

**wbd**GeoDataframe

HUC12-level geodataframe projected to the same coordinate reference system (CRS) as the flow accumulation (FAC) and flow direction (FDR) grids being used.

**fromHUC4**str

HUC4 string for the upstream basin.

**toHUC4**str

HUC string for the downstream basin.

**HUC12Key**str (optional)

Column name for HUC codes to process down to HUC4 codes, defaults to ‘HUC12’.

**ToHUCKey**str (optional)

Column name for the column that indicates the downstream HUC for each row of the dataframe, defaults to ‘TOHUC’.

Returns

**pourBasins**GeoDataframe

HUC12-level geodataframe of units that drain from fromHUC4 to toHUC4.

make\_fcpg(*accumParam*, *fac*, *outRast*, *noDataRast=None*, *minAccum=None*)[¶](#tools.make_fcpg)

Create a flow-conditioned parameter grid using accumulated parameter and area rasters. See also [make\_fcpgs()](#tools.make_fcpgs).

Parameters

**accumParam**str

File location of the accumulated parameter data raster.

**fac**str

File location of the flow accumulation raster.

**outRast**str

File location of the output flow-conditioned parameter grid.

**noDataRast**str

File location of the accumulated parameter no data raster.

**minAccum**float

Value of flow accumulation below which the CPG values will be set to no data

Returns

**outRast**raster

Flow-conditioned parameter grid file where grid cell values represent the mean upstream value of the paramter.

make\_fcpgs(*accumParams*, *fac*, *outWorkspace*, *minAccum=None*, *appStr='FCPG'*)[¶](#tools.make_fcpgs)

Batch version of [make\_fcpg()](#tools.make_fcpg).

Parameters

**accumParams**list

List of accumulated parameter rasters to create FCPGs from.

**fac**str

Path to the flow accumulation raster.

**outWorkspace**str

Path to an output directory for produced FCPGs.

**minAccum**int (optional)

Minimum accumulation value below which the output FCPG will be turned to no data values. Defaults to None.

**appStr**str (optional)

String of text to append to filenames of the produced FCPG grids.

Returns

**fileList**list

List of file paths to the produced FCPGs.

maskStreams(*inRast*, *streamRast*, *outRast*)[¶](#tools.maskStreams)

Mask areas not on the stream network.

Parameters

**inRast**str

Path to the input raster to mask.

**streamRast**str

Path to the stream raster where all non-stream cells are set to no data.

**outRast**str

Path to output raster file.

Returns

**outRast**raster

Raster with non-stream cells set to the no data value from inRast.

parsebool(*b*)[¶](#tools.parsebool)

Parse a boolean argument from the command line.

Parameters

**b**str

String of either True or False.

Returns

**res**bool

True if b is “True” or False if b is not “True.”

queryPoint(*x*, *y*, *grd*)[¶](#tools.queryPoint)

Query grid based on a supplied point.

Parameters

**x**float or int

Horizontal coordinate in grid projection.

**y**float or int

Vertical coordinate in grid projection.

**grd**str

Path to raster to query based on the supplied x and y coordinates.

Returns

**value**float or int

Value queried from the supplied raster.

resampleParam(*inParam*, *fdr*, *outParam*, *resampleMethod='bilinear'*, *cores=1*, *forceProj=False*, *forceProj4='"+proj=aea +lat\_1=29.5 +lat\_2=45.5 +lat\_0=23 +lon\_0=-96 +x\_0=0 +y\_0=0 +ellps=GRS80 +datum=NAD83 +units=m +no\_defs"'*)[¶](#tools.resampleParam)

Resample, re-project, and clip the parameter raster based on the resolution, projection, and extent of the of the flow direction raster supplied. See also [resampleParams()](#tools.resampleParams).

Parameters

**inParam**str

Path to the input parameter data raster

**fdr**str

Path to the flow direction raster

**outParam**str

Path to the output file for the resampled parameter raster.

**resampleMethod**str (optional)

resampling method, either ‘bilinear’ or ‘nearest neighbor’. Bilinear should generally be used for continuous data sets such as precipitation while nearest neighbor should generally be used for categorical datasets such as land cover type. Defaults to bilinear.

**cores**int (optional)

The number of cores to use. Defaults to 1.

**forceProj**bool (optional)

Force the projection of the flow direction raster. This can be useful if the flow direction raster has an unusual projection. Defaults to False.

**forceProj4**str (optional)

Proj4 string used to force the flow direction raster. This defaults to USGS Albers, but is not used unless the forceProj parameter is set to True.

Returns

**outParam**raster

Resampled, reprojected, and clipped parameter raster.

resampleParams(*inParams*, *fdr*, *outWorkspace*, *resampleMethod='bilinear'*, *cores=1*, *appStr='rprj'*, *forceProj=False*, *forceProj4='"+proj=aea +lat\_1=29.5 +lat\_2=45.5 +lat\_0=23 +lon\_0=-96 +x\_0=0 +y\_0=0 +ellps=GRS80 +datum=NAD83 +units=m +no\_defs"'*)[¶](#tools.resampleParams)

Batch version of [resampleParam()](#tools.resampleParam).

Parameters

**inParam**list

List of input parameter raster paths.

**fdr**str

Path to the flow direction raster.

**outWorkspace :**

Path to the output directory for the resampled rasters.

**resampleMethod**str (optional)

Resampling method, either bilinear or nearest neighbor. Defaults to bilinear.

**cores :**

Number of cores to use. Defaults to 1.

**appStr**str (optional)

String of text to append to the input parameter filenames. Defaults to “rprj.”

**forceProj**bool (optional)

Force the projection of the flow direction raster. This can be useful if the flow direction raster has an unusual projection. Defaults to False.

**forceProj4**str (optional)

Proj4 string used to force the flow direction raster. This defaults to USGS Albers, but is not used unless the forceProj parameter is set to True.

Returns

**fileList**list

Paths to resampled, reprojected, and clipped parameter rasters.

saveJSON(*dictionary*, *outfl*)[¶](#tools.saveJSON)

Save dictionary to JSON file.

Parameters

**dictionary**dict

Dictionary to be saved.

**outfl**str

Path for where to generate the JSON

Returns

None

tauDrainDir(*inRast*, *outRast*, *updateDict={'compress': 'LZW', 'sparse': True, 'tiled': True, 'blockysize': 256, 'blockxsize': 256, 'driver': 'GTiff', 'nodata': 0}*)[¶](#tools.tauDrainDir)

Reclassifies ESRI flow directions into TauDEM flow directions.

Parameters

**inRast**str

Path to a raster encoded with ESRI flow direction values.

**outRast**str

Path to output a raster with flow directions encoded for TauDEM. File will be overwritten if it already exists.

**updateDict**dict (optional)

Dictionary of Rasterio raster options used to create outRast. Defaults have been supplied, but may not work in all situations and input file formats.

Returns

**outRast**raster

Reclassified flow direction raster at the path specified above.

tauFlowAccum(*fdr*, *accumRast*, *cores=1*, *mpiCall='mpiexec'*, *mpiArg='-n'*)[¶](#tools.tauFlowAccum)

Wrapper for TauDEM AreaD8 [[1]](index.html#taudem) to produce a flow acculation grid.

Parameters

**fdr**str

Path to a flow direction raster in TauDEM format.

**accumRast**str

Path to output the flow accumulation raster.

**cores**int (optional)

Number of cores to use. Defaults to 1.

**mpiCall**str (optional)

The command to use for mpi, defaults to mpiexec.

**mpiArg**str (optional)

Argument flag passed to mpiCall, which is followed by the cores parameter.

Returns

**accumRast**raster

Raster of accumulated parameter values at the path specified above.

updateDict(*ud*, *upHUC*, *varName*, *val*)[¶](#tools.updateDict)

Update dictionary created using [createUpdateDict()](#tools.createUpdateDict) with a parameter value.

Parameters

**ud**str

Path to the update dictionary to add a parameter to.

**upHUC**str

Name of the upstream HUC that the parameter corresponds to.

**varName**str

Name to use for the parameter.

**val**list, int or float

Value to add to the upstream dictonary.

Returns

**ud**json

Update dictionary written back out to ud.

updateRaster(*x*, *y*, *val*, *grd*, *outgrd*)[¶](#tools.updateRaster)

Insert value into grid at location specified by x,y; writes new raster to output grid.

Parameters

**x**list or float

Horizontal coordinate in map units.

**y**list of float

Vertical coordinate in map units.

**val**int or float

Value to insert into raster at grd.

**grd**str

Path to raster to be updated.

**outgrd**str (path)

Path to write updated raster to.

Returns

**dat**raster

Raster dataset written to grdout.

buildNC(*inDir*, *outFile*, *metaDict*, *cl=9*, *profile=None*)[¶](#netCDFmaker.buildNC)

Build netCDF file from a stack of GeoTiffs.

Parameters

**inDir**str

Directory with geotiff files to be converted, specified as ‘/dir/here/\*.tif’

**outFile**str

Output filename with ‘.nc’ included.

**metaDict**dict

Metadata dictionary used to populate fields in the netCDF. See Notes below for a description of fields to include.

**cl**int

Compression level, 1-9. A higher value will result in a smaller output file, but will take longer.

**profile**dict (optional)

Projection parameters to make the NetCDF file CF compliant. Defaults to USGS Albers Equal Area if nothing is supplied.

Returns

**NetCDF**file

A NetCDF file at *outFile*.

Notes

*Metadata Dictionary*

The metadata dictionary is expecting a particular set of keys to specify the metadata fields within the netCDF file being generated. These fields were chosen to make the resulting netCDF file compliant with the Climate and Forecast and the Data Discovery metadata conventions. Fields are described below, many descriptions are the same as <http://cfconventions.org/Data/cf-conventions/cf-conventions-1.7/cf-conventions.html#description-of-file-contents> or <http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery_1-3>.

title

A succinct description of what is in the dataset.

institution

Specifies where the original data was produced.

source

The method of production of the original data. If it was model-generated, source should name the model and its version, as specifically as could be useful. If it is observational, source should characterize it (e.g., “surface observation” or “radiosonde”).

id

An identifier for the data set, provided by and unique within its naming authority. The combination of the “naming authority” and the “id” should be globally unique, but the id can be globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters.

naming\_authority

The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Example: ‘edu.ucar.unidata’.

references

Published or web-based references that describe the data or methods used to produce it.

comment

Miscellaneous information about the data or methods used to produce it.

history

Provides an audit trail for modifications to the original data. Well-behaved generic netCDF filters will automatically append their name and the parameters with which they were invoked to the global history attribute of an input netCDF file. We recommend that each line begin with a timestamp indicating the date and time of day that the program was executed.

license

Provide the URL to a standard or specific license, enter “Freely Distributed” or “None”, or describe any restrictions to data access and distribution in free text.

acknowledgement

A place to acknowledge various types of support for the project that produced this data.

metadata\_link

A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute.

date\_created

The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date\_created. The ISO 8601:2004 extended date format is recommended, as described in the Attribute Content Guidance section.

creator\_type

Specifies type of creator with one of the following: ‘person’, ‘group’, ‘institution’, or ‘position’. If this attribute is not specified, the creator is assumed to be a person.

creator\_email

The email address of the person (or other creator type specified by the creator\_type attribute) principally responsible for creating this data.

creator\_name

The name of the person (or other creator type specified by the creator\_type attribute) principally responsible for creating this data.

creator\_url

The URL of the person (or other creator type specified by the creator\_type attribute) principally responsible for creating this data.

creator\_institution

The institution of the creator; should uniquely identify the creator’s institution. This attribute’s value should be specified even if it matches the value of publisher\_institution, or if creator\_type is institution.

publisher\_type

Specifies type of publisher with one of the following: ‘person’, ‘group’, ‘institution’, or ‘position’. If this attribute is not specified, the publisher is assumed to be a person.

publisher\_name

The name of the person (or other entity specified by the publisher\_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.

publisher\_email

The email address of the person (or other entity specified by the publisher\_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.

publisher\_url

The URL of the person (or other entity specified by the publisher\_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.

publisher\_institution

The institution that presented the data file or equivalent product to users; should uniquely identify the institution. If publisher\_type is institution, this should have the same value as publisher\_name.

var\_name

Variable name given to the dataset. For example minimum temperature would be Tmin.

units

Unit value associated with quantity described by the dataset.

add\_offset

Offset value use with the data, usually 0.0 if no offset is used with the data.

standard\_name

Short name associated with the dataset.

long\_name

More descriptive name associated with the dataset.

grid\_mapping

The way data values are mapped to a grid, usually ‘crs’.

scale\_factor

Numeric value the data are scaled by to save space, usually 1.0 if data are not scaled.

coverage\_content\_type

An ISO 19115-1 code to indicate the source of the data (image, thematicClassification, physicalMeasurement, auxiliaryInformation, qualityInformation, referenceInformation, modelResult, or coordinate).

*Profile*

The projection parameters needed and values for USGS Albers Equal Area (AEA) are supplied below.

grid\_mapping\_name (‘albers\_conical\_equal\_area’)

The name of the projection to use as a string.

standard\_parallel ([45.5, 29.5])

Parallels for the projection as a list of floats. May differ for non-AEA projections; however, this work should be done with equal-area projections.

latitude\_of\_projection\_origin (23.0)

Origin latitude as a float.

longitude\_of\_central\_meridian (-96.0)

Central Meridian as a float.

false\_easting (0)

Flase easting parameter as a float.

false\_northing (0)

False northing parameter as a float.

semi\_major\_axis (6378137.0)

Ellipse parameter as a float.

inverse\_flattening (298.257222101)

Ellipse parameter as a float.

unit (‘m’)

Map units to use for the projection as a string.

wkt

Well known text (WKT) representation of the above projection parameters, e.g. ‘PROJCS[“USA\_Contiguous\_Albers\_Equal\_Area\_Conic\_USGS\_version”, GEOGCS[“GCS\_North\_American\_1983”, DATUM[“D\_North\_American\_1983”, SPHEROID[“GRS\_1980”,6378137.0,298.257222101]], PRIMEM[“Greenwich”,0.0], UNIT[“Degree”,0.0174532925199433]], PROJECTION[“Albers”], PARAMETER[“False\_Easting”,0.0], PARAMETER[“False\_Northing”,0.0], PARAMETER[“Central\_Meridian”,-96.0], PARAMETER[“Standard\_Parallel\_1”,29.5], PARAMETER[“Standard\_Parallel\_2”,45.5], PARAMETER[“Latitude\_Of\_Origin”,23.0], UNIT[“Meter”,1]]’

## References[¶](#references)

1

David Tarboton. TauDEM Version 5.3.8. https://github.com/dtarb/TauDEM/tree/v5.3.8, 2016. Accessed: 2020-05-19.

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