

DEM Derivatives

University of Oklahoma/HyDROS Module 2.2

Outline – Day 2



EF5 OVERVIEW DEM DERIVATIVES

- Topographical information
- Digital Elevation Models
- Flow Direction Maps
- Flow Accumulation Maps
- Data sources
- Create basic files for Example 2

RAINFALL AND PET AUTOMATIC CALIBRATION



3.





Topographical information is a key component of any hydrological model

Topographical data tells the model where ridges and valleys, mountains and hills, rivers and streams, and other important features are

Without topographical information, it would be impossible to route water downstream or to produce any forecast of stream flow or soil moisture



Topographical Information



It takes many different forms, but in EF5 we need three pieces of topographical data

- **DEM Digital Elevation Model**
- FDR Flow DiRection (also called DDM in EF5)
- FAC Flow Accumulation (also called FAM in EF5)

These follow a specific order

You always have to start with a DEM An FDR is created from a DEM And the FAC is created from the FDR This DEM \rightarrow FDR \rightarrow FAC process only works in this direction



A DEM is a digital model of the earth's surface created from terrain elevation data

- Stored as a grid of numbers
- Each grid cell has one number and that number is the elevation of the grid cell in the units of the DEM
- These grid cells match *exactly* with the EF5 model grid cells we discussed in Module 2.1







We all know water flows from high points to low points

- So if we have a DEM and we give it to the hydrological model, the model will know where water flows across the entire domain
- In the cartoon, the columns are like an exaggerated DEM
- The arrows mark the direction of the flow of water
- The blue arrows are collecting water from a lot of upstream cells, or area, so we can think of them as sort of a main river channel

The red allows have less area, so we can think of them as "overland cells"







How is a DEM created?

- If the area is small enough, it might be created by direct survey (that is, going out and measuring elevation at many points)
- But usually, remote sensing techniques are used
- The earth's surface is scanned from space to create a DEM
- Done via radar satellite from space
- RADARSAT, SRTM, ASTER







One of the most important characteristics of a DEM is resolution





One of these is at 4km horizontal resolution (~5.2 MB) The other is at 30 arcsecond resolution (~1km at the equator) (~36 MB)

Can you tell the difference?



What if we zoom in?



Now you start to see the difference in the Amazon







Let's zoom in one more time...



If you look carefully at the streams in the yellow box and it becomes clear that the left image is has a lower resolution than the right image

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This exercise demonstrates an important point about resolution:

- In general, the larger the model domain, the coarser the resolution can be
- Hydrologic models require computing power, and the number of cells being modeled is directly related to the computing requirement
- The number of cells being modeled increases as the DEM resolution increases
- To run large areas at high resolution, fast computers or more time to run the model are needed







A flow direction grid, or FDR, is a grid containing values that tell you where water is flowing

Imagine flipping our DEM cartoon forward













Let's keep rotating it until we're looking at it dead-on

Now I have a grid, with the same size, resolution, and extent as my DEM, and this grid exists only to tell me in what direction my water is flowing













But I need a way for a computer to easily read and understand this direction grid

The obvious solution is to assign each direction a number and assign the appropriate number to each grid cell



1	7	5	5	5	7
1	7	6	5	5	7
8	7	7	7	5	6
1	1	1	7	7	7
3	2	1	7	5	7
3	3	3	7	5	5



Flow Direction



This is called a coding scheme



 This is the scheme I used (it's also the scheme in the TauDEM program

There are other schemes out there, though, including the one







1	7	5	5	5	7
1	7	6	5	5	7
8	7	7	7	5	6
1	1	1	7	7	7
3	2	1	7	5	7
3	3	3	7	5	5



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Flow Direction

You probably noticed that some cells flow into two or more other boxes In that case, the computer picks the cell with the

biggest elevation difference (that is, the steepest descent) and the water flows into it















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This is called the eight-direction flow model (or D8)

Flow Direction

Your DEM needs to be larger than the entire river basin you want to model, because the outer edge of FDR cells will not actually have values in the real world, because the computer doesn't know what's outside your DEM





Some important things to keep in mind:











Flow Accumulation



The third and final necessary component is the flow accumulation, or FAC

The FAC is a grid of numbers corresponding to the number of cells flowing into *that cell*





Flow Accumulation



Note all the FAC cells with a value of 5 or greater are in blue

Like we mentioned when we first started discussing DEMs, think of these as cells in the river channel

You may recall we briefly mentioned the TH parameter in EF5 back in Module 2.1

That parameter is the threshold for a river channel cell, so here TH would be 5









So where do we get the DEMs needed to make this cool stuff?

Luckily, there are several free, good quality DEM sources around the world

We will focus our discussion on SRTM – the Shuttle Radar Topography Mission

This was STS-99 in February 2000





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Sources



SRTM data characteristics

The SRTM data are available around the world at 3 arcsecond (90m) resolution

The original SRTM data have been processed and corrected for hydrological use

One great source for this is the HydroSHEDS program









HydroSHEDS is a World Wildlife Fund project

They provide continent-wide (or sub-continent-wide) DEM, drainage direction, and flow accumulation grids

Other useful data include river networks and drainage basin outlines

Their website is hydrosheds.org





HydroSHEDS



As part of the EF5 training course, we include the necessary river networks and DEMs for certain model examples

The file names work like this: example[number]_[type].zip

So, example2_dem.zip is a .zip file containing the necessary to complete Example 2 in the training





HydroSHEDS



Other important information:

The DEM quality is very good, but not perfect

The river network files are in Esri Shapefile format and the DEMs are in Esri GRID format

Either can be opened in both Esri ArcMap and QGIS







There's also the GTOPO30 project at USGS, which is a 30 arc second (1 km) world DEM derived from SRTM

The raw SRTM data was collected at 1 arc second (30 m), so at 9x the size of the finest HydroSHEDS DEM

Until 2014, this 30 m data was only available in the U.S., but is now being released for the rest of the world as "SRTM-2"

We'll talk more about SRTM-2 later in the training



Example 2





Let's process our own DEM files and create a DDM/FDR and an FAC

Example 2 will be the Bogota River Basin in Colombia upstream of a gauging station at Puente Portillo







In \EF5_training\examples\example2, create a new folder called qgis

This will be our project folder where we do all the processing steps prior to running the model

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Developede					

Module 2.2 / DEM Derivatives



In \EF5 training\data\HydroSHEDS,

Getting Ready

unzip example2_dem.zip to your new qgis folder

Right-click, and click "Extract All..."

Select a Destination and Extract Files

Files will be extracted to this folder:

C:\Users\raceclark\Desktop\EF5_training\examples\example2\ggis

Show extracted files when complete

- Repeat for example2 rivers.zip
- You should now have these files in your agis folder \rightarrow

Browse...











Getting Ready



Once you've extracted the rivers and DEM into your qgis folder, we're ready to get started

First, check again that your qgis folder has the files shown below

Name	Date modified	Туре	Size
퉬 example2_dem	5/14/2015 12:01 PM	File folder	
🌗 info	5/14/2015 12:01 PM	File folder	
example2_rivers.dbf	5/3/2006 12:00 AM	DBF File	7,291 KB
example2_rivers.htm	5/3/2006 12:00 AM	HTML Document	18 KB
example2_rivers.prj	5/3/2006 12:00 AM	PRJ File	1 KB
example2_rivers.sbn	5/3/2006 12:00 AM	SBN File	3,782 KB
example2_rivers.sbx	5/3/2006 12:00 AM	SBX File	112 KB
example2_rivers.shp	5/3/2006 12:00 AM	SHP File	57,804 KB
example2_rivers.shx	5/3/2006 12:00 AM	SHX File	3,432 KB
example2_rivers.xml	5/3/2006 12:00 AM	XML File	11 KB



Module 2.2 / DEM Derivatives

Set up the QGIS Project



Now open QGIS Desktop 2.6.1 and "Add Vector Layer..."

\$ 2				
Project	Edit	View	Layer Settings Plugins Vector Raster	Database Web Processing Help
3 E A			Create Layer	
5 LL -			Add Layer	Add Vector Layer Ctrl+Shift+V
3 10	17		Embed Layers and Groups	Add Raster Layer Ctrl+Shift+R
÷ 117 🖵	Ø		Add from Layer Definition File	Add PostGIS Layers Ctrl+Shift+D
	******		Copy style	Add SpatiaLite Laver Ctrl+Shift+L
Vĩ	றி	۲	Paste style	Add MSSOL Spatial Laver Ctrl+Shift+M
	_	•	Open Attribute Table	Add Oracle Spatial Laver Ctrl+Shift+O
•			// Toggle Editing	Add WMS MMTS Laver Ctrl+Shift+W
Q.			Save Layer Edits	Add WCS Laver

At the prompt, navigate to your qgis folder and select example2_rivers.shp

Next, select "Add Raster Layer..." and from your qgis folder, open the example2_dem folder and then w001001.adf







You should see something like this...



Let's go ahead and save our QGIS project – I named mine example2.qgs and saved it in my qgis folder



Set up the QGIS Project



Now we're going to add our gauge location to the map

Our gauge is named "Puente Portillo" and it's on the Bogota River in the nation of Colombia

Create a shapefile layer...



Click "OK" when the dialog box appears \rightarrow

%		New Vec	tor Layer	?	×
Type -					
Poi	nt			Polygon	
File encod	ling	System			-
EPSG:43	26 - WGS 84			Specify CRS	
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Name					
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Set up the QGIS Project



Then you'll be asked to save your new layer – I named mine gauge_loc.shp

10	Save layer as			×	
⊕ ⊙ - ↑ 🛽	▹ EF5_training ▷ examples ▷ example2 ▷ qgis ▷	× ¢	Search qgis	٩	
Organize 🔻 Ne	w folder			⊞ ▼ @	
🔶 Favorites	▲ Name	Date modified	Туре	Size	
📃 Desktop	🔰 example2_dem	5/14/2015 12:01 PM	File folder		11
🗼 Downloads	🍑 info	5/14/2015 12:01 PM	File folder		-4
🖳 Recent places	example2_rivers.shp	5/3/2006 12:00 AM	SHP File	57,804 KB	Project Edit View Layer Settings Plugins Vector
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T I2 2 22 4			- 11		

Then turn on "Toggle Editing" → ▲ ▲ A pencil will appear to the left of "gauge_loc"

Module 2.2 / DEM Derivatives







Now use the "Coordinate:" box at the lower right of the QGIS window to zoom in to the gauge location

			Advanced interface	~
Scoordinate:	-70.76,-0.68	cale	1:23,805,347 🔻 🗶 Render	EPSG:4326

We are looking for <u>-74.6</u>, <u>4.45</u>

As you zoom in, the numbers in the box get more precise (there will be more numbers to the right of the decimal)

We know the river is somewhere in the mountains in NW South America, which appear as white on the DEM



Set up the QGIS Project

Once you're satisfied with how you've zoomed in, select "Add Feature" →

Your cursor will become a circle with crosshairs

Click once at the point on the map where the "Coordinate:" box says -74.6, 4.45









Set up the QGIS Project

- A small box will appear
- Type "1" in the box and click "OK"
- A dot will appear on the map where you just clicked

Click the pencil above the "Layers" pane of QGIS to turn editing off, and at the pop-up, click "Save"











Let's review what we've done and why we've done it

So far, we've set up our QGIS project

- 1. We've extracted our DEM into our project's folder
- 2. We've also done that with our river network
- 3. We've created a shapefile that contains one feature, a point at the location of our river gauge

These three pieces of information are all we need to create hydrologically-conditioned topographical grids for EF5

Now on to the next step: Identifying the Basin Extent



Identifying the Basin Extent

In the "Layers" pane, drag "example2_rivers" above "w001001" so that the rivers are plotted on top of the DEM

- Now we want to "Select features using an expression"
- In the "Expression" part of the dialog box, type UP_CELLS >
- Note how you see "Expression is invalid" at the bottom of the box in red

<u>%</u>	Select by expression - example2_rivers ? ×
Function list	Selected function help
Search ⊕ Operators ⊕ Conditionals ⊕ Math ⊕ Conversions ⊕ Date and Time ⊕ String ⊕ Color	
▼ Operators = + - / Expression	* ^ ()
UP_CELLS >	()) ())
Output preview: Expression	n is invalid (more info) E Select Close







Identifying the Basin Extent



Now type a number after UP_CELLS >, like UP_CELLS > 1000 and the red text goes away

Click "Select" and you should also see some rivers change color in QGIS

When you pick larger numbers, you see only larger rivers highlighted

When you pick smaller numbers, many more rivers will be highlighted

You want to pick a threshold that is small enough to capture the character of the river you're modeling, plus its major tributaries, but not so small that you've highlighted almost every river. Try to capture the main river channel and the major tributaries.





The appropriate value varies from basin to basin, but here let's try UP_CELLS > 400

Click "Close"

Now we are going to use the "Coordinate:" box, our gauge location, and our highlighted rivers to try to find the edges of our basin in latitude and longitude

You don't have to be perfect, but it is better to pick too much area instead of too little

In other words, err on the side of including excess area



Clipping a DEM



Here's an idea of what to look for \rightarrow





Clipping a DEM



Let's pick some nice round numbers for this

- The left, or west edge... 75 deg W (or -75 deg)
- The right, or east edge... 73 deg W (or -73 deg)
- The top, or north edge... 6 deg N
- The bottom, or south edge... 4 deg S

There are two advantages to these edges:

- 1. They're much larger than the actual edges of the river basin, so we erred on the side of caution!
- 2. They're round numbers, so if we need to do any calculations later, it will be easy!

Now go to the "Raster" menu, "Projections" and click "Warp (Reproject)..."



Clipping a DEM



On this screen, click "Select..." by "Output file" and then save to your qgis directory – I use the name clipped_dem.tif

Then check "Resampling method" and pick "Near"

Check "No data values" and type -32768

Then click the pencil icon below "Load into canvas when finished"

🔏 Warp	(Reproject)	? ×
Batch mode (for processing	g whole directory)	
Input file	w001001 💌	Select
<u>O</u> utput file		Select
Source SRS	EPSG:4326	Select
Target SRS		Select
Resampling method	Near	•
No data values	0	
Mask layer		Select
Memory used for caching	20MB	×
Width 3000	Height 3000	
Use multithreaded warping	implementation	
Load into canvas when finish	ed	
gdalwarp -overwrite -s_srs EPS \Users\racedark\Desktop\EF5_ example2_dem\w001001.adf	G:4326 C: training\examples\examp	ole2\qgis\
ОК	Close	Help



Module 2.2 / DEM Derivatives

Clipping a DEM

Now you should be able to type in the text box at the bottom

After -r near, type -te -75 4 -73 6 -tr 0.02 0.02

"-te" tells QGIS the extent of the grid in latitude and longitude, so we type the left border, then the bottom, then the right, and then the top

And "-tr" tells QGIS the resolution of the grid in degrees – we are going to use 0.02 degrees in each direction, ~2 km



Load into canvas when finished gdalwarp -overwrite -s_srs EPSG:4326 -r near -te -75 4 -73 6 -tr 0.02 0.02 |dstnodata -32768 -of GTiff C: \Users\racedark\Desktop\EF5_training\examples\example2\qgis\ example2_dem\w001001.adf C:/Users/racedark/Desktop/EF5_training/examples/example2/qgi s/clipped_dem.tif OK Close Help









Click "OK", "OK", "OK", and then "Close"





Filtering and Clipping Rivers



Now right-click example2_rivers and select "Save As..."

Click "Browse" and then save in your qgis directory as large_rivers.shp

Check "Save only selected features"

And check "Extent (current: user defined)"

Then type in the appropriate values for north, south, east, and west, the same as we used before, and click "OK"

Į	Save v	rector layer as	?
Format ESRI Sha	apefile		
Save as C:/Users	/raceclark/Desktop/EF5_training	/examples/example2/qgis/large_rivers.shp	Browse
CRS Layer CF	lS		
WGS 84			Change
Encoding		System	•
X Save only selec	cted features		
Skip attribute o	reation		
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West -75	North 6 South 4	East -73	
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▼ Datasource Op	otions		
Layer Options			
Custom Option	1S		



Review



Let's review again

- We already set up the QGIS project
- Then we filtered out smaller rivers
- We used that information to determine the extent of our river basin
- Then we clipped the DEM to that extent and reduced its resolution to make the model run faster
- Finally, we saved the filtered rivers (which are also now on the same exact extent as our DEM)

Now on to the next step: Repairing the DEM





When we change the resolution of a DEM, we tend to break things

We create "pits" or "sinks" that didn't exist in the original data

In "Processing Toolbox", open "TauDEM (hydrologic analysis)" and then "Basic Grid Analysis tools", and then double-click "Pit Remove"

Pick "clipped_dem" in the "Elevation Grid" drop down box and for "Pit Removed Elevation Grid" click the "..." and "Save to file..."

Then pick an appropriate location and name (l used corrected_dem.tif)



Fixing the DEM

Hydros Willing College

Now click "Run"

When the process completes you'll have a new "Pit Removed **Elevation Grid**" in your "Layers" panel

🔏 Pit Remove	×	
Parameters Log Help]	
Elevation Grid		
clipped_dem [EPSG:4326]	▼	
Pit Removed Elevation Grid		
C:/Users/raceclark/Desktop/EF5_training/examples/example2/qgis/corrected_dem.tif		
0%]	
е — — — — — — — — — — — — — — — — — — —	Run Close	

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Converting Rivers

NASA

Now we want to "burn" our rivers into the corrected DEM to make sure the model knows where the streams are

Go to the "Raster" menu, "Conversion" and "Rasterize (Vector to Raster)..."

Select "large_rivers" for the input file

And for the output file, I chose rasterized_rivers.tif

Click okay on the pop-up warning

🧏 Rasterize (Vector to raster) ? 🗙
Input file (shapefile)
Attribute field
Qutput file for rasterized vectors (raster) e2/qgis/rasterized_rivers.tif Select
 Keep existing raster size and resolution
Raster size in pixels
Width 3000 + Height 3000 +
 Raster resolution in map units per pixel
Horizontal 1.00000000
Load into canvas when finished
gdal_rasterize -a ARCID -ts 3000 3000 -l large_rivers C:/Users/raceclark/Desktop/EF5_training/examples/example2/qgis/large_rivers.shp C:/Users/raceclark/Desktop/EF5_training/examples/example2/qgis/rasterized_rivers .tif
OK Close Help



Converting Rivers



Click the pencil icon down near the bottom

In the text box, delete -a ARCID -ts 3000 3000 and replace it with -burn -10 te -75 4 -73 6 -tr 0.02 0.02

We are telling QGIS to write the number -10 every pixel in which a river occurs, using the same extent and resolution as the DEM we already created

🧭 Rasterize (Vector to raster) ? 🗙
Input file (shapefile)
Attribute field
Output file for rasterized vectors (raster) 2/qgis/rasterized_rivers.tif Select
Keep existing raster size and resolution
Raster size in pixels
Width 3000 Height 3000
Raster resolution in man units per nivel
Horizontal 1 0000000
X Load into canvas when finished
gdal_rasterize -burn -10 -te -75 4 -73 6 -tr 0.02 0.02 -l large_rivers
C:/Users/racedark/Desktop/EF5_training/examples/example2/qgis/large_rivers.shp C:/Users/racedark/Desktop/EF5_training/examples/example2/qgis/rasterized_rivers
.uf
OK Close Help



Module 2.2 / DEM Derivatives

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Let's add the rivers to the DEM...

Now remember the dark cells have values of -10

You should see something like this \rightarrow

Click "OK", "OK", and then "Close"

Burning Rivers







Module 2.2 / DEM Derivatives

"Raster Calculator"

In the "Raster" menu, select

Burning Rivers

In the "Output Layer" box, save the file as burned_dem.tif

In "Raster bands", double-click the "Pit Removed Elevation Grid"

In the box at the bottom, after Pit Removed Elevation Grid@1, type +()*3 then move your cursor between the parentheses and double-click "rasterized_rivers@1"

			Ras	ter calcu	lator				? ×	
Raster bands —				-Result lay	er]	
"Pit Removed Elevation Grid@1" "clipped_dem@1" "rasterized_rivers@1"				Output layer amples/exa			xample2	ample2/qgis/burned_dem		
"w001001@1"				Current	layer extent					
				X min	-75.00000	•	XMax	-73.00000	-	
				Columns	100	•	Rows	100	•	
				Output fo	ormat	GeoTIFF		·	•	
				🗙 Add r	esult to project	:				
Operators -										
+	*	sqrt	si	n	^	acos		(
-	1	cos	as	in	tan	atan)		
<	>	=	<	-	>=	AND		OR		
Raster calculator expression "Pit Removed Elevation Grid@1"+("rasterized_rivers@1")*3										
pression valid								ОК	Cancel	



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Burning Rivers



Click "OK" and you should see this \rightarrow

- We basically lowered the elevation of each pixel in the river channel by 30 meters
- This is called "burning the rivers into the DEM"

To be safe, we're going to remove pits one last time





Module 2.2 / DEM Derivatives

Creating the Final DEM

In "Recently used algorithms", double-click "Pit Remove"

For "Elevation Grid", select "burned_dem"

Use the "..." button and click "Save to file..." to save your Pit Removed Elevation Grid as dem.tif in your qgis folder

This is the final DEM

(I recommend <u>removing</u> the old "Pit Removed Elevation Grid" from the Layers panel to avoid confusion) Do this by right-clicking on it and selecting "Remove"

Pit Remove		×
Parameters Log Help		
Elevation Grid burned_dem [EPSG: 4326] Pit Removed Elevation Grid C:/Users/raceclark/Desktop/EF5_training/examples/example2/qgis/dem.tif	▼	
Open output file after running algorithm		
0%		
	Run	Close





Review



Let's review again

- 1. We set up our QGIS project with rivers, a gauge outlet, and a DEM
- 2. We used the gauge outlet and the rivers to identify the edges of our river basin
- 3. We resampled the DEM to a new resolution and extent
- 4. We used our filtered rivers to "burn" the streams back into the resampled DEM, while also removing the pits and other errors

Now on to the next step: Creating flow direction and flow accumulation maps





In "Processing Toolbox", open "TauDEM (hydrologic analysis)", then open "Basic Grid Analysis tools" and finally double-click "D8 Flow Directions"

For "Pit Filled Elevation Grid" select "Pit Removed Elevation Grid"

By "D8 Flow Direction Grid", select "..." and then "Save to file..."

Save the file as flow_dir.tif in your qgis folder



Creating a Flow Direction



Click "Run" and remove "D8 Slope" from your "Layers" panel...

You should see what's on the lower right

D8 Flow Directions	×
Parameters Log Help	
Pit Filled Elevation Grid Pit Removed Elevation Grid [EPSG:4326] D8 Flow Direction Grid C:/Users/racedark/Desktop/EF5_training/examples/example2/qgis/flow_dir.tif	· · · · · · · · · · · · · · · · · · ·
Open output file after running algorithm D8 Slope Grid	
[Save to temporary file]	
Open output file after running algorithm	
0%	
	Run Close



Module 2.2 / DEM Derivatives

Converting the Flow Direction



We need to convert this to a format EF5 can read

In the "Raster" menu, select "Conversion" and then "Translate (Convert Format)..."

In "Input Layer", select "D8 Flow Direction Grid"

In "Output file", save this file as fdr.tif in your qgis folder

Then click the pencil at the bottom and type -ot Float32 in place of -of GeoTIFF after gdal_translate

Click "OK", "OK", and "Close"

This is your final flow direction grid

%	Franslate (Convert format) ? ×
Batch mode (for processing whole directory)
<u>I</u> nput Layer	D8 Flow Direction Grid 💌 Select,,,
<u>O</u> utput file	/examples/example2/qgis/fdr.tif Select.,,
Target SRS	EPSG:4326 Select
Outsize	25%
No data	0
Expand	Gray 💌
Srcwin	
Prjwin	
Sds	
▼ □ <u>C</u> reation	Options
Profile Defau	lt 👻
Name	Value + -
	Validate
	Help
V Londinto	ne where finished
	s when inished
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Help

Close

OK

Module 2.2 / DEM Derivatives

Creating an FAC

Finally, it's time to create the FAC

In the "Processing Toolbox", go to "TauDEM (hydrologic analysis)" and then "Basic Grid Analysis tools" and then "D8 Contributing Area"

Select "fdr" for the "D8 Flow Direction Grid" and then save the "D8 Contributing Area Grid" as fac.tif in your qgis folder

D8 Contributing Area		2	×
rameters Log Help			_
28 Flow Direction Grid			
fdr [EPSG:4326]			
Outlets Shapefile [optional]			
[Not selected]	•		
Weight Grid [optional]			
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Check for edge contamination			
D8 Contributing Area Grid			
C:/Users/raceclark/Desktop/EF5_training/examples/example2/qgis/fac.tif			
Open output file after running algorithm			
0%			
	Run	Close	





Creating an FAC



Click "Run"

You should get something like this \rightarrow

The lighter the color, the more cells are contributing to the flow at that point

What's really important is that the gauge point, in the red box, looks like the river flowing into it properly follows the path of the original rivers shapefile







Mode Layer selection

View Tree



In QGIS I can use the "Identify Features" tool to find the value of the FAC at the outlet point

The drainage area of the Bogota at Puente Portillo is

Click the "Identify Features" icon \rightarrow

Then at the lower left, a new pane called "Identify Results" appears

Use the drop-down menu to select "View" as "Table"

Now click a white cell near your gauge point, and on the popup menu, select "D8 Contributing Area Grid"

- 62 -

Check the FAC

about 6,000 km²



Identify Results 10000000000000

•

BX

4 F

Help

Auto open form





Scroll to the right in the "Identify Results" pane until you reach the "Value" column

- I got a "Value" of 1075
- So, 1075 grid cells are draining into the point I selected
- Each grid cell is 2 km on a side, or 4 km²
- 1075 times 4 km² yields 4250 km²

We should get an area somewhere between 5000 and 6000 km² and the shortfall is probably due to changing the resolution of the DEM







Save your QGIS project in your qgis folder and exit QGIS

Out of all the files now in your qgis folder, we care about dem.tif, fac.tif, and fdr.tif

Copy these three files to EF5_training\examples \example2\basic

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Prepare Files for EF5



Now open the control.txt file in the example2 folder

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[Basic] DEM=basic\dem. DDM=basic\ddm. FAM=basic\fac. PROJ=geographi ESRIDDM=false SelfFAM=true	tif tif tif .c					^

Our first job is to check the Basic block

- This block tells EF5 where the topographical information is stored relative to the location of control.txt
- So, DEM= should be the file path to the DEM, and so on
 - control.txt is in the example2 folder, and from there to find my DEM, DDM/FDR, and FAC, I simply enter the basic folder and the appropriate files are inside



Prepare Files for EF5



- **PROJ=geographic** tells EF5 that all three files (DEM, DDM/ FDR, and FAC) are in the geographic projection (and we know they are, because we used latitude and longitude to add the gauge outlet)
- ESRIDDM=false tells EF5 what coding scheme is used in the DDM/FDR file; since it is false we are saying we used the TauDEM coding scheme (1, 2, 3, 4, 5, etc.) and not the ArcMap coding scheme (1, 2, 4, 8, 16, etc.)
- Finally, SelfFAM=true means that the lowest value of any cell in the FAC is 1 (in other words, a cell counts itself in the FAC generation process); you can test this by looking in the "Layers" panel of QGIS, which shows that the lowest FAC value is 1

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<u>F</u> ile <u>E</u> dit F <u>o</u> rmat <u>V</u> iew <u>H</u> elp	
[Basic]	^
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DDM=basic\ddm.tif	
FAM=basic\fac.tif	
PROJ=geographic	
ESRIDDM=false	
SelfFAM=true	



Prepare Files for EF5



From EF5_training\data\Observations, copy
puente_portillo.csv to EF5_training\examples
\example2\obs

This file is the observed time series of daily discharge at the Puente Portillo station between 1 January 1998 and 31 December 2010

- The first column is the date and time
- The second column is the discharge value in cubic meters per second

EF5 supports 3 formats for reading in observed time series

- YYYY/MM/DD HH:UU:SS (like in the puente_portillo.csv example)
- YYYY-MM-DD HH:UU:SS (so dashes instead of slashes)
- MM-DD-YYYY
- MM/DD/YYYY
- Note that Y = year, M = month, D = day, H = hour, U = minute, and S = second

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5	1,	/4/199	8 0:00				5.6
6	1,	/5/199	8 0:00				5.2
7	1,	/6/199	8 0:00			4	4.9
8	1,	/7/199	8 0:00				13
9	1,	/8/199	8 0:00				5.8
10	1,	/9/199	8 0:00				5.3
11	1/:	10/199	8 0:00				5.1
12	1/:	11/199	8 0:00				5.9
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We've added files to the basic folder and to the obs folder

The output folder will be filled with the model results after the simulation

We will fill pet and precip in Module 2.3

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The next module is

Rainfall and PET

You can find it in your \EF5_training\presentations directory

Module 2.2 References

EF5 Training Doc 3 – Processing DEMs and Derivatives, (March 2015).

EF5 Training Doc 6 – Properties of Example Basins, (March 2015).

Jenson, S. K. and J. O. Domingue, (1988). Extracting topographic structure from digital elevation data for geographic information system analysis. *Photogrammetric Engineering and Remote Sensing*, 54: 11, 1593-1600. (Paper 9 – DEM Processing.pdf)

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Module 2.2 / DEM Derivatives

