UNIVERSITÄT BERN

GIS in Archaeology

09 - Terrain Data

Martin Hinz

Institut für Archäologische Wissenschaften, Universität Bern

27/11/24

You can download a pdf of this presentation.

Terrain

Photos by Martin Sattler, Matt Nelson, Pierpaolo Lanfrancotti on Unsplash

Terrain

What is terrain

> *An area of land, when considering its natural features. - Cambridge Dictionary*

- Continually varying surface
  - What varies (for us) is elevation

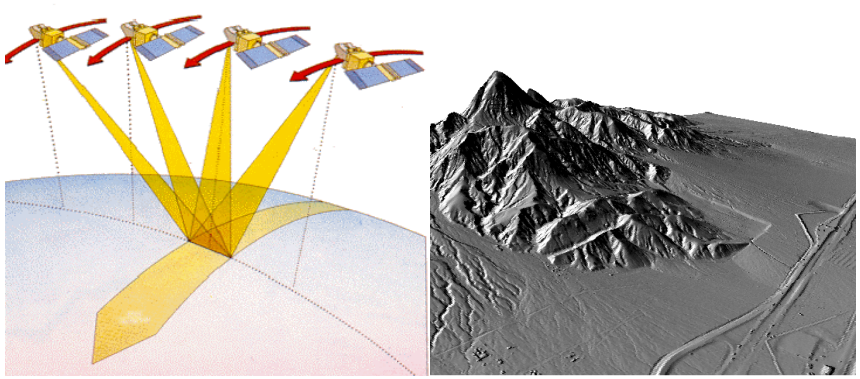
What is terrain analysis

- calculating from the elevations and their spatial structure derived informations
  - Slope
  - Aspect
  - Curvature
  - Land forms
  - Cost Surfaces
  - Visibility
  - ...

sources: Photo by Kasuma F. Gruber on Unsplash; https://digital-geography.com

DEM (Digital Elevation Model)

- DEM: a computer based representation of the terrain as elevation data
- Mostly available as raster data, sometimes as TIN
- large scale: Mostly from remote (satellite) data
- small scale: areal photography or measurements, or even ground based surveys
- methods
  - Radar
  - LiDAR
  - Structure from motion
  - ...



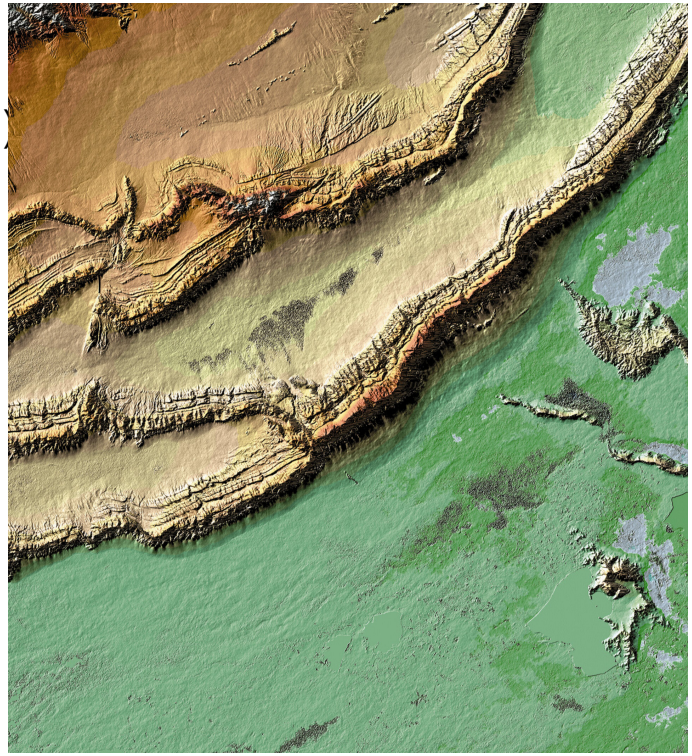
Sources: https://crisp.nus.edu.sg; https://desktop.arcgis.com

DEM can come in EPSG 4326 (WGS 84 lat/lng).

Then might be necessary to reproject the DEM to a projected (meter based) CRS. We cover this in the next session...

DEM Sources

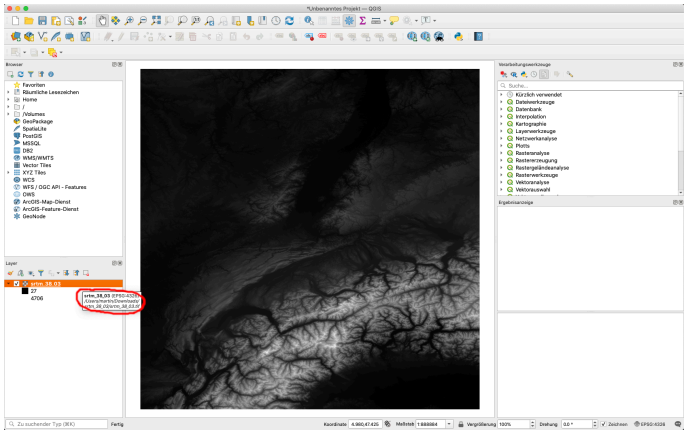
- depends on your region and scale
- GMTED2010 (https://topotools.cr.usgs.gov/gmted_viewer/viewer.htm) 7.5 arc second resolution (~ 225 m along the equator)
- SRTM (e.g. http://dwtkns.com/srtm) 3 arc second resolution (~ 90 meters along the equator)
- ASTER (e.g. https://search.earthdata.nasa.gov/) 3 arc second resolution (~ 30 meters along the equator)
- TanDEM-X (90 m after registration, 12 m only with project submission)
- LiDAR



Digital elevation model Bachu, China. Source: https://www.esa.int

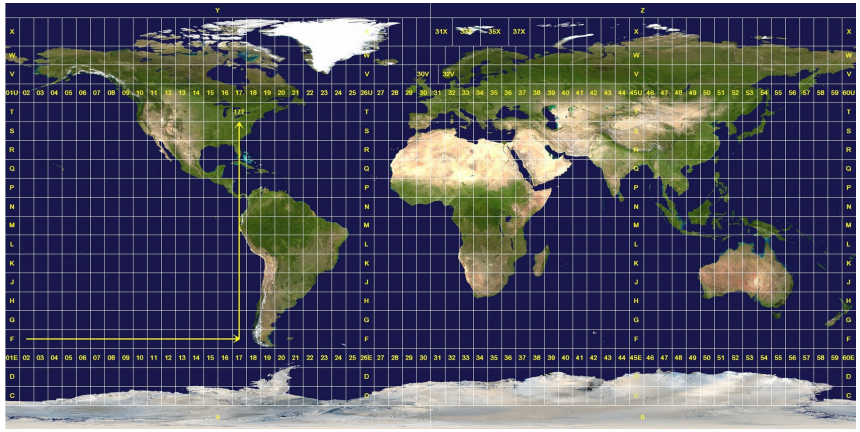
Lets get some DEM

- Go to http://dwtkns.com/srtm to get some SRTM data of a location of the world of your choice
- Click on one of the tiles
- Click on 'Download GeoTIFF'
- Wait till it has finished and open it in QGIS
- Check what CRS it comes in (remember?)



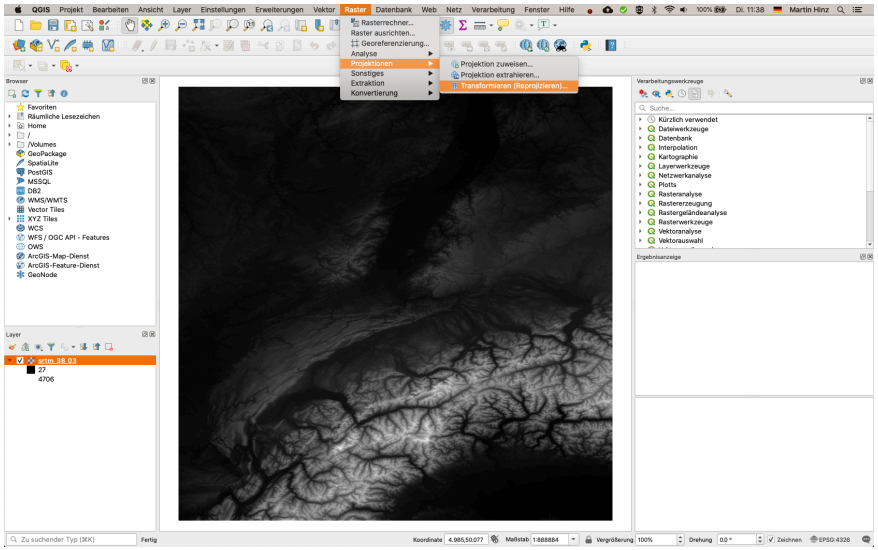
Reproject Raster

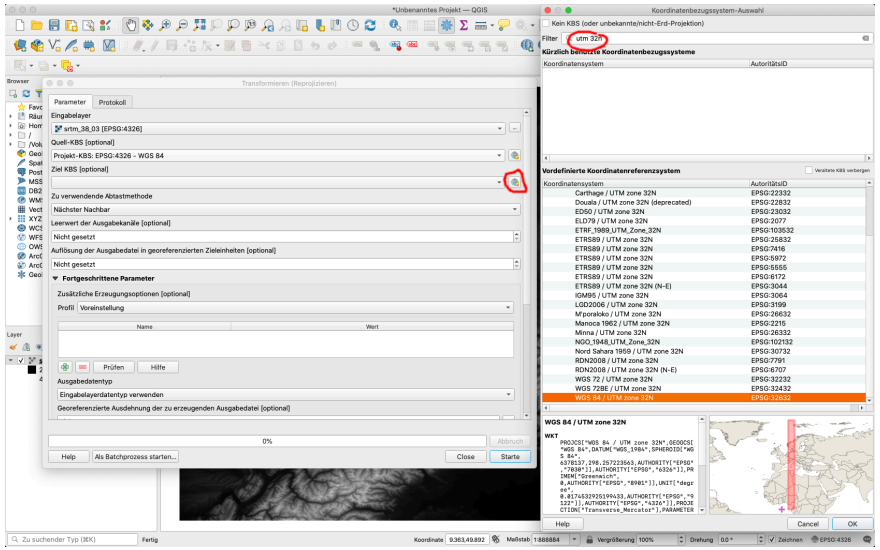
- the SRTM Tile comes in EPSG 4236 (WGS 84 Lat/Lng), which is degree based and unprojected
- to work with the DEM, we have to reproject it to a meter based projection system
- (Raster Reprojection always comes with smoothing/blurring data and loss of precision!)
- which to choose depends on the location you have choosen to download
- a good choice for projected CRS is Universal Transverse Mercator (UTM)
- for the GIS Projection, you need to know
  - the number of the Zone you are in
  - if you are north or south of the Equator



Reproject to UTM using QGIS

- I selected the SRTM tile around Switzerland
- With that, I am at 32 N(orth)
- Go to 'Raster > Projection > Transform (Reproject)'
- Select your input Raster and CRS
- Select your output CRS
  - search for in my case "utm 32N"
  - select the WGS 84 variant
- click on 'Run'
- Save your new Raster

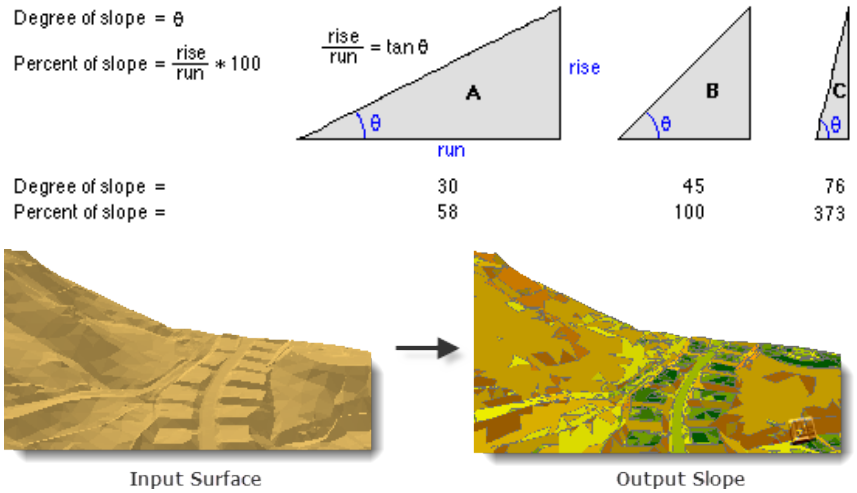




Slope

- Identifies the slope (gradient, or rate of maximum change in z-value) from each cell of a raster surface.
- can be given in degree or in percentage

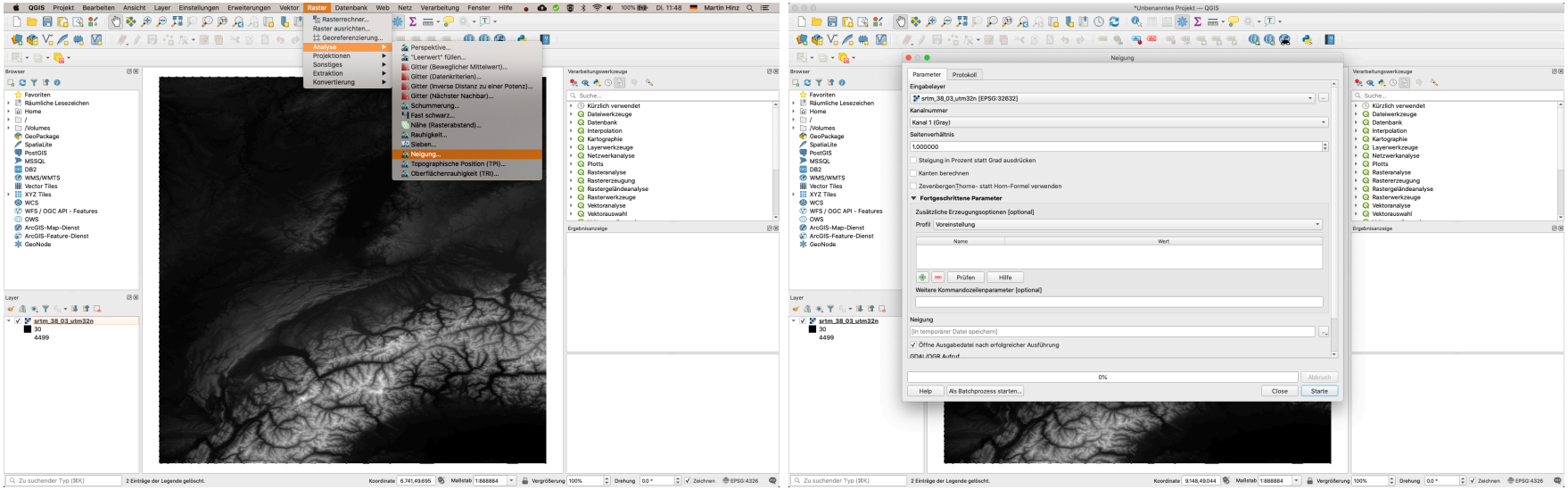
> *Conceptually, the tool **fits a plane to the z-values of a 3 x 3 cell neighborhood** around the processing or center cell. The slope value of this plane is calculated ... The lower the slope value, the flatter the terrain - ArcGIS*



Source: https://desktop.arcgis.com

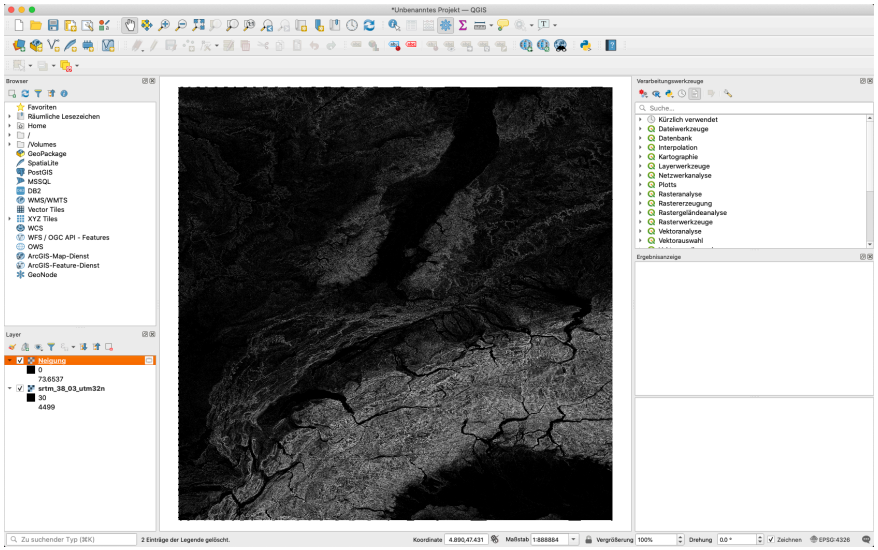
Calculating Slope in QGIS

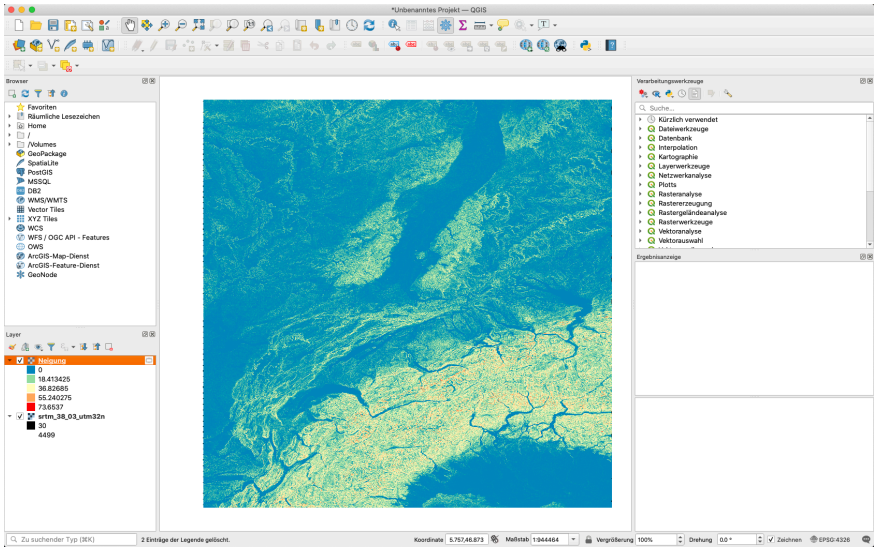
- Go to 'Raster > Analysis > Slope'
- You could select to calculate percent instead of degree
- usually you do not need to change anything
- Click Run



Calculating Slope Result

- The resulting slopes range between 0 and 74°
- You can change the symbology of the layer
- a good choice might be the inverse spectral color ramp
- archaeological significance:
  - flatter areas are better suited for building and agriculture

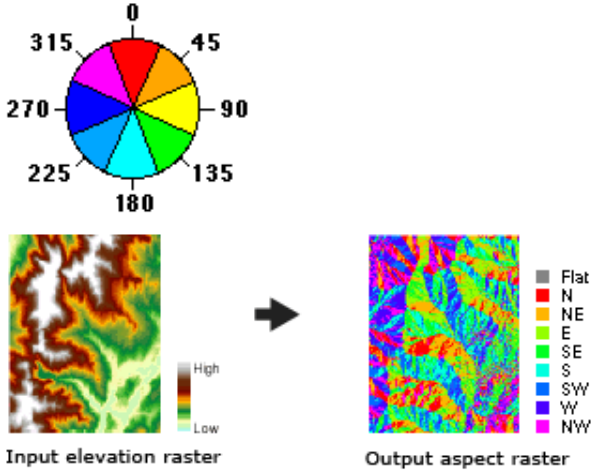


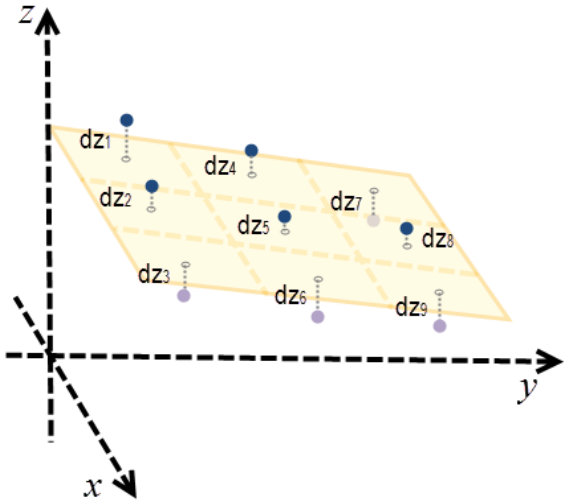


Aspect

- The aspect of terrain refers to the direction it's facing in
- The pixels will have a value from 0-360° measured in degress from north indicating the azimuth
- Flat areas having no downslope direction are given a value of 9999.

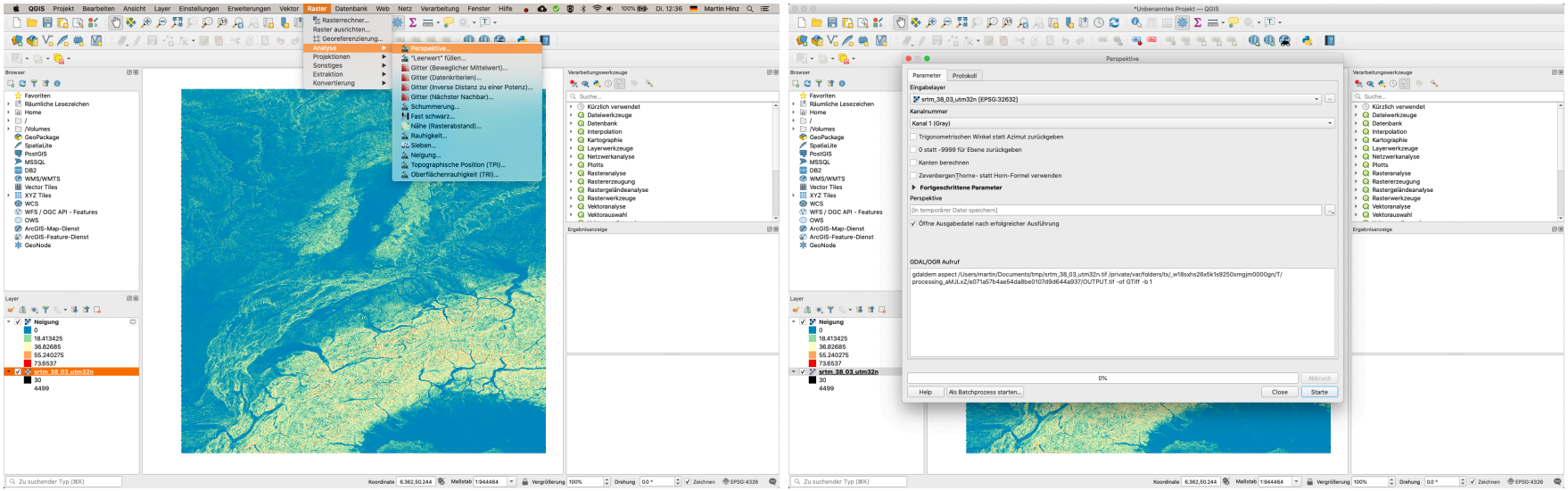
> *Also here, the tool **fits a plane to the z-values of a 3 x 3 cell neighborhood** around the processing or center cell. Then the direction is calculated in which the plane is facing.*





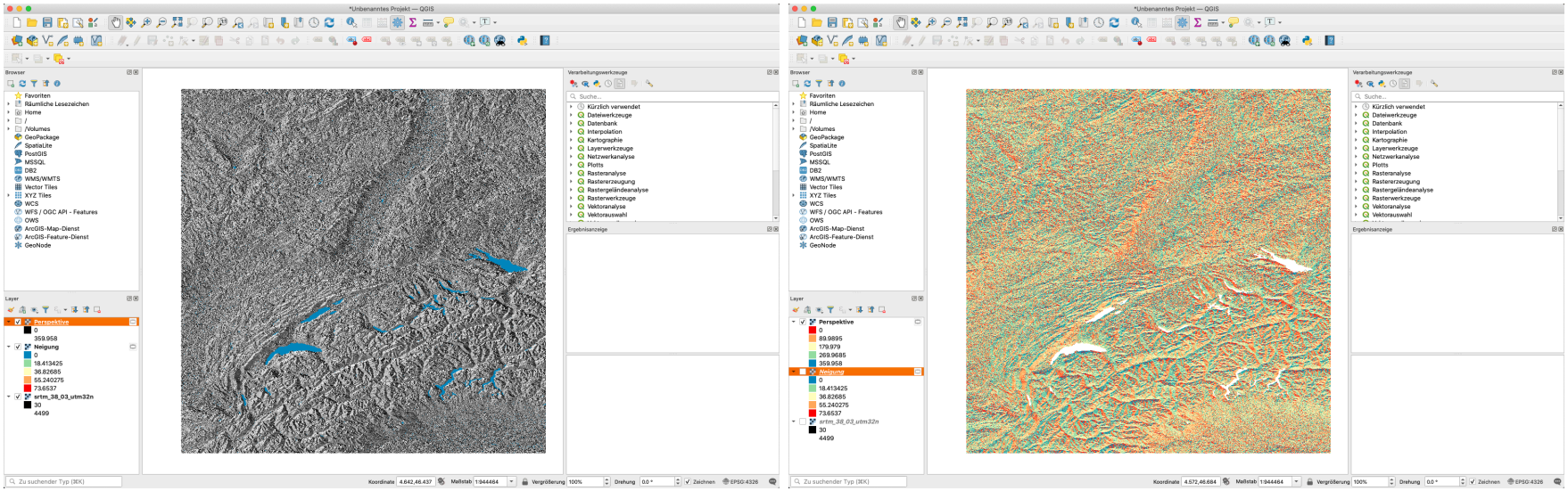
Calculating Aspect in QGIS

- Go to 'Raster > Analysis > Aspect' (Perspektive)
- You could select to calculate the trigonometric angle (n, e, s, w)
- usually you do not need to change anything
- Click Run



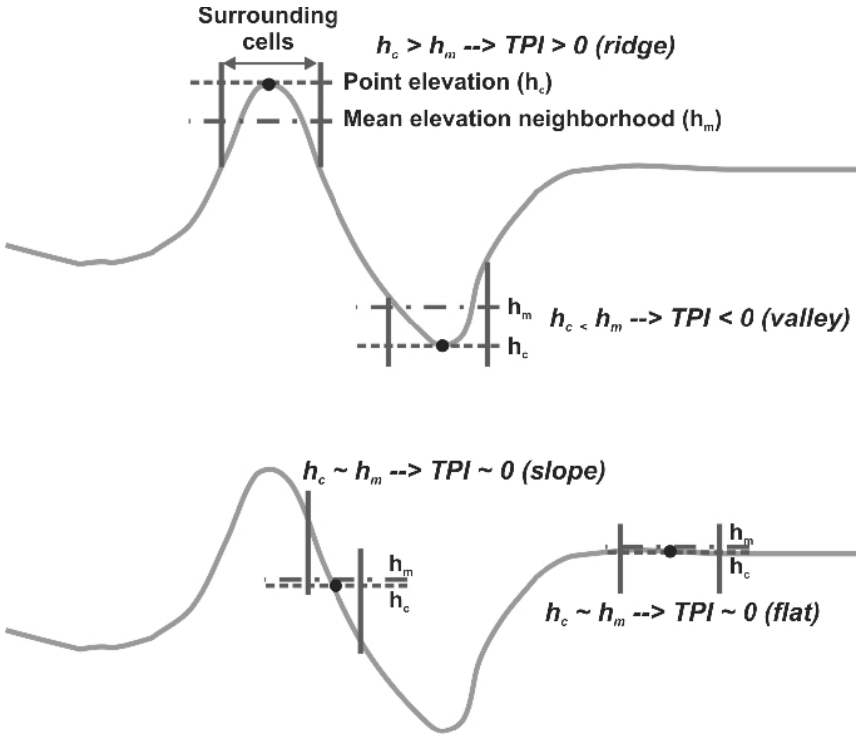
Calculating Aspect Result

- The resulting angles range between 0 and 359.9999°
- You can change the symbology of the layer
- a good choice might be again the spectral color ramp
- archaeological significance:
  - south-facing areas (on northern hemisphere) get more sun, maybe more likely for agriculture?



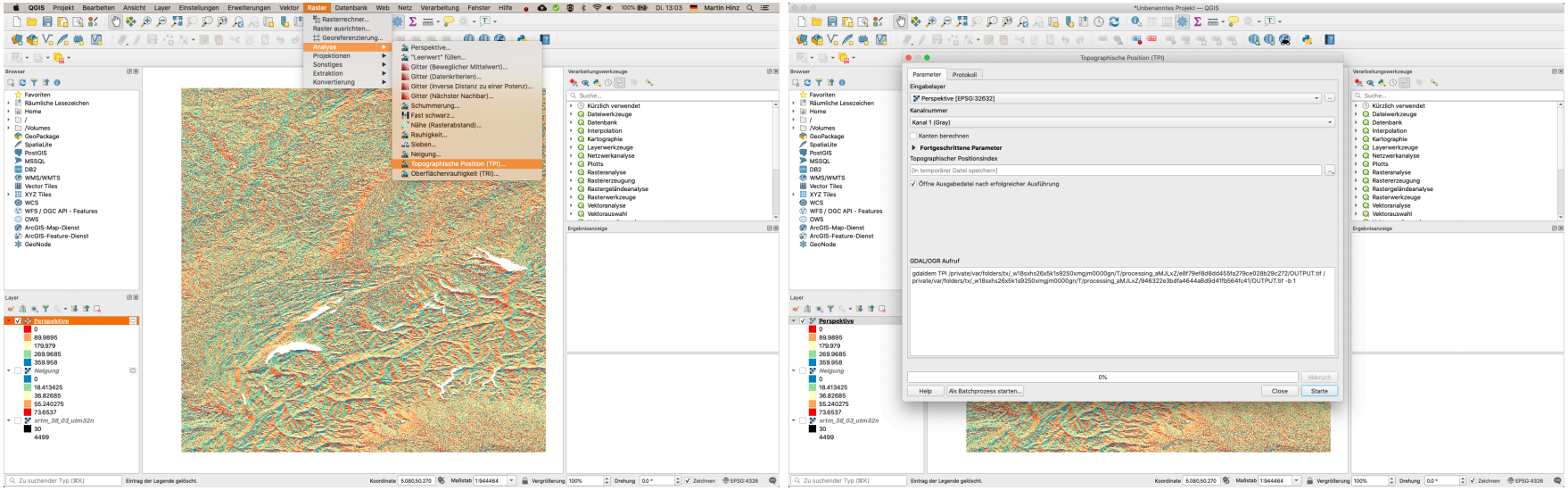
TPI

- Topographic Position Index (TPI) is defined as the difference between the elevation at a cell and the average elevation in a cell that surrounds it within a predetermined radius (Weiss, 2001)
- TPI values **above zero** show locations that are **higher** than the average, e.g. ridges
- **negative TPI** values represent locations that are **lower** e.g. valleys
- TPI **values near zero** are either **flat** areas **or** areas of **constant slope**



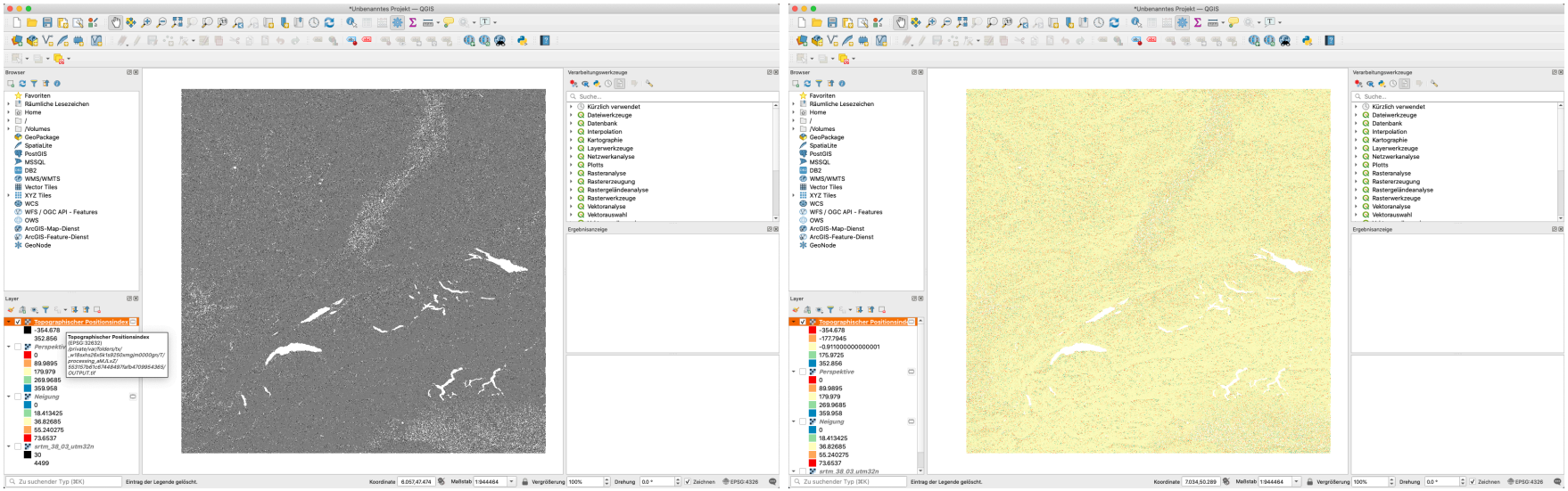
Calculating TPI in QGIS

- Go to 'Raster > Analysis > Topographical Position (TPI)'
- you actually can't change anything here
- Click Run



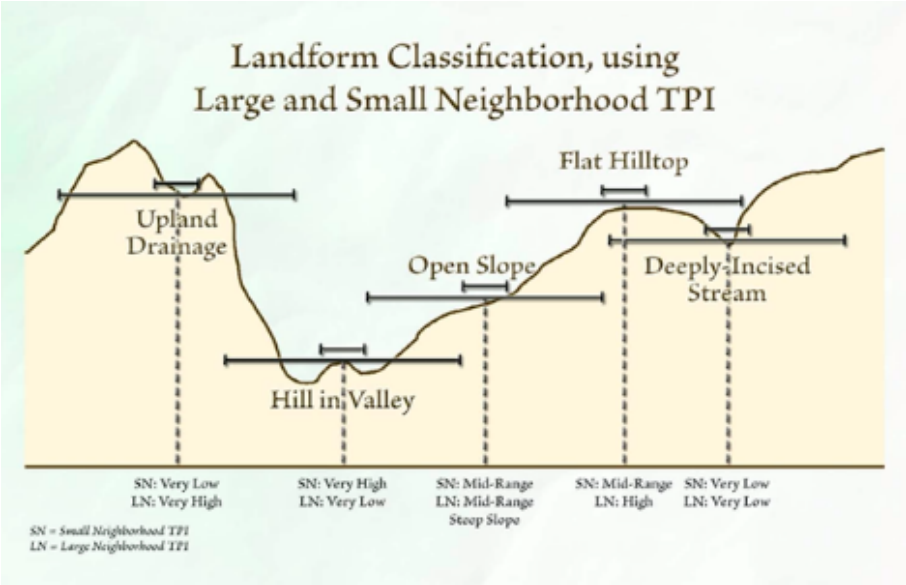
Calculating TPI Result

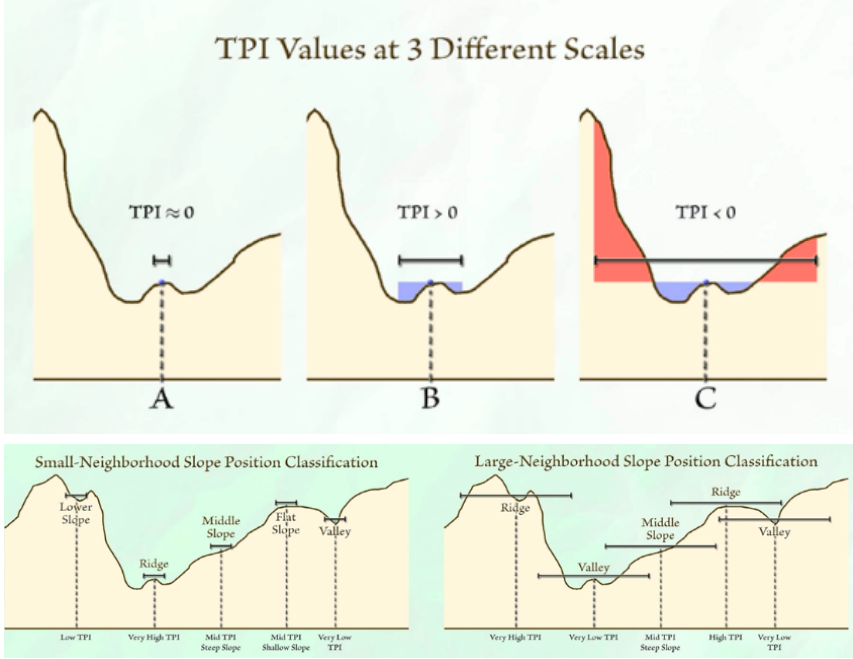
- The resulting angles range between ~ +/- 350 m
- You can change the symbology of the layer
- a good choice might be again the spectral color ramp
- archaeological significance:
  - ridges and peaks provide better control over areas: maybe preferred settlemen locations



Landforms

- significance of the TPI depends strongly on size of the neighborhood
- comining TPI from different neighborhood sizes reveals more 'natural' land form structures



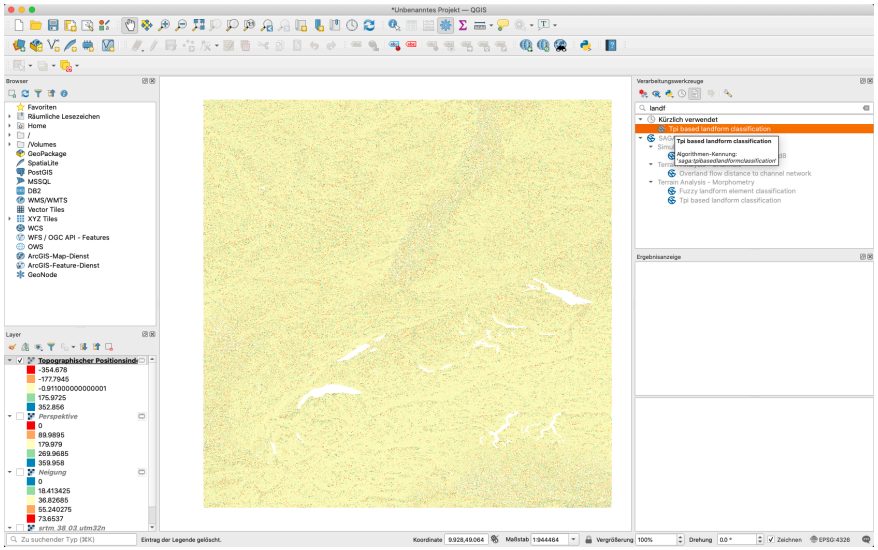


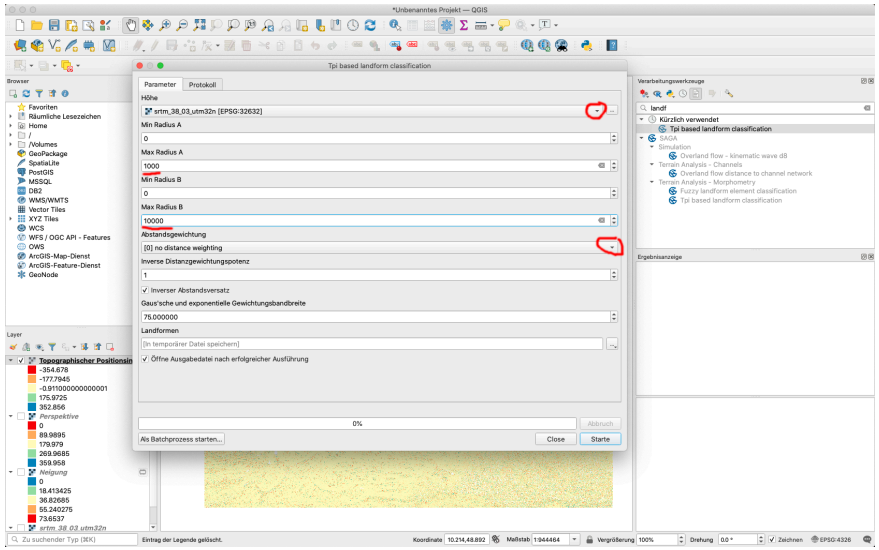
Source: http://www.jennessent.com

Calculating Landforms in QGIS

- Not available from the menue

- Open the Toolbox 
- Start typing 'landform', find 'Tpi based landform classification'
- Open the tool
- select the correct layer
- you can define the radii, 100 m does not make too much sense with our resolution...
- you could also define a weighting according to distance and related parameters
- **Do not now click on Run** ...this might take a while...

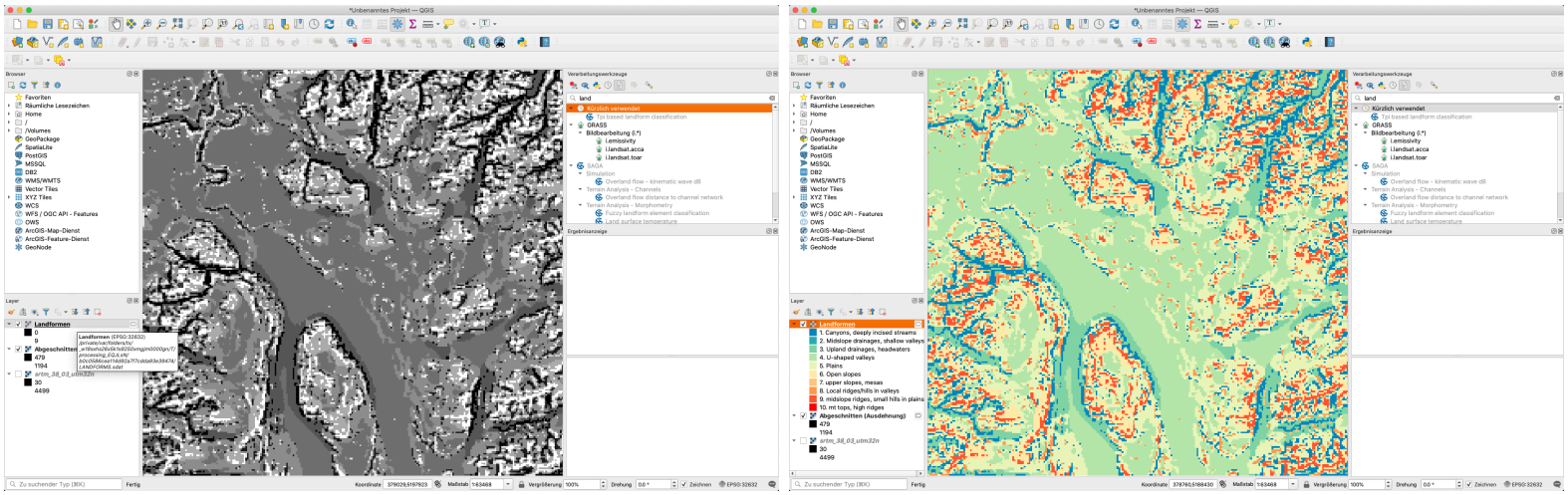




Calculating Landforms Result

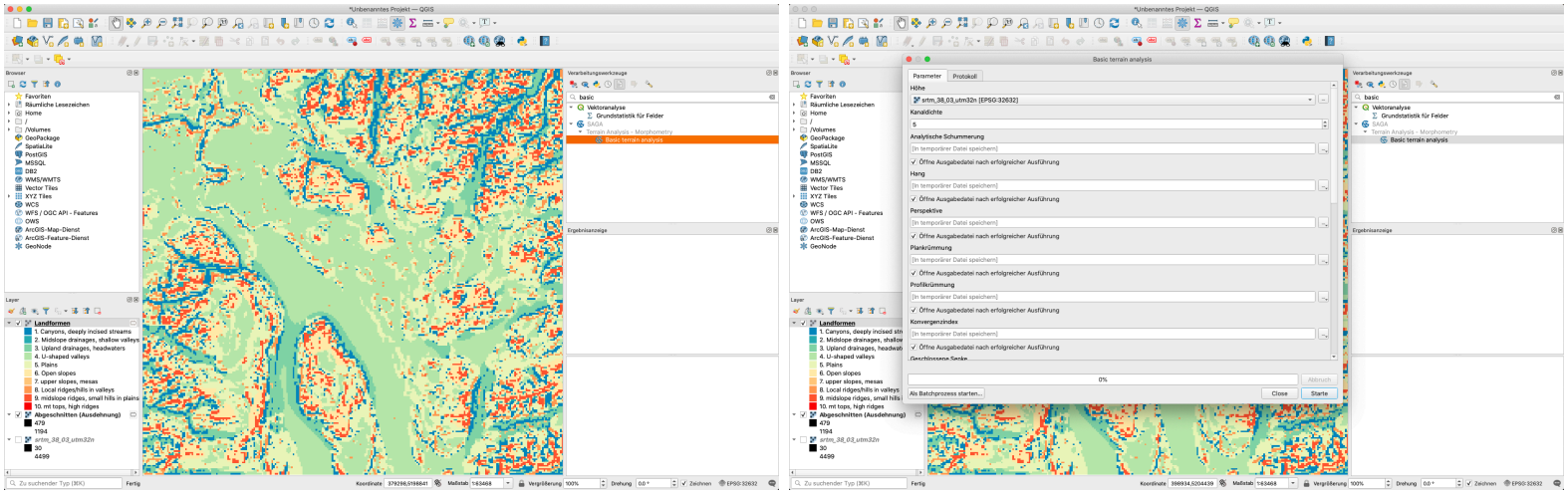
- The calculation might take quite a while
- the result is a raster with up to 10 classes:
- a good choice might be to download this style and use it
- archaeological significance:
  - different classes of landscape attracts different usage

1. Canyons, deeply incised streams
2. Midslope drainages, shallow valleys
3. Upland drainages, headwaters
4. U-shaped valleys
5. Plains
6. Open slopes
7. Upper slopes, mesas
8. Local ridges/hills in valleys
9. Midslope ridges, small hills in plains
10. Mountain tops, high ridges



'Basic Terrain Analysis'

- for Landforms, we actually were using another GIS within QGIS: SAGA GIS
- SAGA is a very good tool for morphometric (Terrain) Analysis
- It offers eg. a small tool that achieve all of the above and much more. It is called 'Basic terrain analysis'
- You might like to try it out



What We've Covered

- Basics of Terrain Analysis
- Slope
- Aspect
- TPI
- Landforms

More Terrain Analysis using SAGA

Olaya, V. (2004): A Gentle Introduction to SAGA GIS.
http://downloads.sourceforge.net/saga-gis/SagaManual.pdf

Homework

- Get the SRTM data from Ireland
- calculate the TPI
- send me a screen shot

Any questions?

Source: https://www.instagram.com/sadtopographies

You might find the course material (including the presentations) at

https://github.com/BernCoDALab/gia

You can see the rendered presentations at

https://berncodalab.github.io/gia

You can contact me at

martin.hinz@unibe.ch