**Part II GIS Skills Course 2022**

**Lecture 2 Outline**

Given the amount of material I cover in this course, I can’t produce the same level of exercise guide for Lecture 2 that I did for 1. The topics we are going to cover today are rich and interesting, but nuanced, and to explain properly I’d need to take a writing sabbatical and write this course into its own book! Instead, this guide serves as an overview of Lecture 2 and points you to additional resources.

Our first lecture centered around familiarizing you with GIS principles and basic tools. Exercise #1 - Hazard assessment at Guagua Pichincha – as the main vehicle for teaching these core skills. The second half of this course is meant to expand on these core skills, providing you with depth and breadth in your approach to GIS. However, keep in mind that these Lectures are merely introductions – I can’t teach you everything you need to know to be competent with GIS in 4 hours. Take the lessons I impart here and in future lessons as jumping off points! Make your own maps, make mistakes, and experiment. You’ll find your way! And if you get lost these tools are here to help you course correct.

With that in mind, I’m going to outline my plan for Lecture 2, which includes several smaller exercises aimed at expanding on different elements of our geospatial “toolkit.” I’ll focus on expanding our **analytical** toolkit, **advanced visualization,** and more **computational approaches** (e.g., Python, Model Builder, Google Earth Engine**)** to GIS**.**

**Exercise #2: Fluid Geochemistry @ Guagua Pichincha**

A generic problem all geoscientists using GIS face is the need to import non-georeferenced attribute data, often in the form a spreadsheet like a CSV. How do you display this data on a map and spatially analyze it? We will explore this using another hypothetical scenario, where we are tasked with analyzing the chemistry of fluids measured at Guagua Pichincha (G.P.). This need may arise from concerns about the quality and kinds of hydrothermal activity at the summit, motivating fresh research questions. For instance, are there hotspots of ions of interest like SO4, reflecting increased shallow magmatic activity? These kinds of signals may be useful for us in interpreting where shallow hydrothermal activity is centralized, or it may give us clues as to the spatial variability in the magma feeding these hydrothermal systems. We may be asked to produce a literal “hot spot” map of the region, showing where chemicals of interest are in their highest concentrations. Do these hot spots co-vary? Even if you aren’t a geochemist, these kinds of operations are useful for any geoscientist!

To answer these research questions, we need to:

* Identify relevant geochemical data
* Georeference maps of sampling location
* Extract spatial location of sample points
* Import un-georeferenced geochemical data
* Perform a spatial join of geochemical layer and sample layer
* Interpolate between sample points to generate a “hot spot” map of fluid geochemistry.
* How do data points cluster?

Key terms and concepts:

* *Spatial Join*: operation that takes two input datasets and produces one output dataset sharing the same spatial properties as the inputs, forming a bigger dataset. This increases the number of feature attributes using a condition like a foreign key. This method uses same conceptual and computational framework as SQL databases.
  + See Chapter 3.4 (pg.172) of Huisman and de by (2009): <https://webapps.itc.utwente.nl/librarywww/papers_2009/general/principlesgis.pdf>
* *Geostatistics*: Statistical methods applied to geospatial data. Its own subdiscipline requiring specialized methods, as geographic data violates the independence assumption required by most classical statistical methods. This arises from an observation made about spatial data termed *spatial autocorrelation*. In classical probability theory, the occurrence of event A does not affect the probability of occurrence of event B. However, in geographic data, the probability of event B taking place increases if event A occurs close by.
  + For more, see excellent free resource by de Smith: <https://www.spatialanalysisonline.com/HTML/index.html>
* *Interpolation*: predictive analytical procedure, which seeks to estimate underlying surface connecting discrete points. Generates a fine rectangular grid covering the study region, and then estimates the surface value of each cell in the grid based on spatial distribution and attribute variation in input data. Critically, *geostatistical interpolation* and *deterministic interpolation* are different families of interpolation models. Geostatistical interpolation assumes the source data points for the operation reflect a specific statistical sample e.g., kriging. *Deterministic* methods (more common) differ by having their weighting scheme (how much does X vary with distance?) determined by model choice and parameters used by user, so offers more direct user control e.g., Natural neighbor, Inverse Distance Weighting (IDW), Minimum curvature.
  + See Chapter 6 (Surface and Field Analysis) of de Smith: <https://www.spatialanalysisonline.com/HTML/index.html>
  + See Chapter 11 of QGIS *Gentle Introduction to GIS*: <https://docs.qgis.org/3.22/en/docs/gentle_gis_introduction/spatial_analysis_interpolation.html>

Data source:

Marini, L., Agostini, A., Cioni, R., Guidi, M. and Leon, O., 1991. Guagua Pichincha volcano, Ecuador: fluid geochemistry in volcanic surveillance. Journal of Volcanology and Geothermal Research, 46(1-2), pp.21-35.

<https://www.sciencedirect.com/science/article/abs/pii/0377027391900739>

**Exercise #3: Landslide Risk Near Quito**

Raster data, which provides continuous coverage of data over a region, is helpful for performing powerful spatial calculations at regional or even global scales. Manipulating raster data is therefore one of the most powerful skills that can help you understand how environmental processes impact a particular region. Near Quito, there is substantial relief in the mountains overlooking the city. There is also an active volcano, and substantial precipitation. What risk do landslides pose to particular areas of the city? Are these risks more pronounced in some areas than others? By leveraging the powerful *Raster Calculator*, we can find a way to address these questions in an illustrative exercise.

NOTE: The output file this exercise produces is not meant to be an accurate landslide risk map. Rather, I am showing you how to work with specific tools and datasets and performing a simple Raster Calculation for illustrative purposes. A real landslide risk analysis would be much more mathematically and geologically complex!

To address this question, we need to:

* Import precipitation data
* Calculate Raster Slope
* Use raster calculator to determine compound risk of landslide given probability of landslide is some function of precipitation rate and slope

Key terms and concepts:

*Raster Calculator:* Powerful tool that lets you perform calculations based on existing pixel values in any number of raster layers. Allows you to stack, subtract, multiply, and otherwise mathematically transform raster layers, producing new layers that can further your analysis. Uses a simple syntax that allows you to create complex logical and mathematical methods for calculation.

Data Sources:

Tropical Rainfall Measurement Mission (TRMM) Version 7. I obtained the version used in this practical from NASA GSFC: <https://disc.gsfc.nasa.gov/information/tools?title=Giovanni>

Topography data used to calculate slope is the same SRTM 1-arc second DEM used in other exercises. Sources from NASA EarthData: <https://earthdata.nasa.gov>

**Advanced Materials**

XYZ Tiles (Base maps)

If you are interested in having aces to different base maps, add the HTML links provided below under the XYZ Tiles dropdown, found under the Browser panel. Right click on XYZ Tiles and select “New Connection.”

* Bing Virtual Earth: [http://ecn.t3.tiles.virtualearth.net/tiles/a{q}.jpeg?g=1](http://ecn.t3.tiles.virtualearth.net/tiles/a%7bq%7d.jpeg?g=1)
* CartoDB Dark Matter <http://basemaps.cartocdn.com/dark_all/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* CartoDB Positron <http://basemaps.cartocdn.com/light_all/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* ESRI Boundary Places <https://server.arcgisonline.com/ArcGIS/rest/services/Reference/World_Boundaries_and_Places/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Grey (Dark) <http://services.arcgisonline.com/ArcGIS/rest/services/Canvas/World_Dark_Gray_Base/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Grey (Light) <http://services.arcgisonline.com/ArcGIS/rest/services/Canvas/World_Light_Gray_Base/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI National Geographic <http://services.arcgisonline.com/ArcGIS/rest/services/NatGeo_World_Map/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Ocean <https://services.arcgisonline.com/ArcGIS/rest/services/Ocean/World_Ocean_Base/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Satellite <https://server.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Standard <https://server.arcgisonline.com/ArcGIS/rest/services/World_Street_Map/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Terrain <https://server.arcgisonline.com/ArcGIS/rest/services/World_Terrain_Base/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Topo World <http://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* ESRI Transportation <https://server.arcgisonline.com/ArcGIS/rest/services/Reference/World_Transportation/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D>
* Google Maps <https://mt1.google.com/vt/lyrs=m&x=%7Bx%7D&y=%7By%7D&z=%7Bz%7D>
* Google Satellite <https://mt1.google.com/vt/lyrs=s&x=%7Bx%7D&y=%7By%7D&z=%7Bz%7D>
* Google Satellite Hybrid <https://mt1.google.com/vt/lyrs=y&x=%7Bx%7D&y=%7By%7D&z=%7Bz%7D>
* Google Terrain <https://mt1.google.com/vt/lyrs=t&x=%7Bx%7D&y=%7By%7D&z=%7Bz%7D>
* Google Terrain Hybrid <https://mt1.google.com/vt/lyrs=p&x=%7Bx%7D&y=%7By%7D&z=%7Bz%7D>
* Open Weather Map Clouds <http://tile.openweathermap.org/map/clouds_new/%7Bz%7D/%7Bx%7D/%7By%7D.png?APPID=ef3c5137f6c31db50c4c6f1ce4e7e9dd>
* Open Weather Map Temperature <http://tile.openweathermap.org/map/temp_new/%7Bz%7D/%7Bx%7D/%7By%7D.png?APPID=1c3e4ef8e25596946ee1f3846b53218a>
* Open Weather Map Wind Speed <http://tile.openweathermap.org/map/wind_new/%7Bz%7D/%7Bx%7D/%7By%7D.png?APPID=f9d0069aa69438d52276ae25c1ee9893>
* Open Street Map [https://tile.openstreetmap.org/{z}/{x}/{y}.png](https://tile.openstreetmap.org/%7bz%7d/%7bx%7d/%7by%7d.png)
* Open Street Map HOT <http://tile.openstreetmap.fr/hot/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Open Street Map Monochrome <http://tiles.wmflabs.org/bw-mapnik/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Open Street Map Standard <http://tile.openstreetmap.org/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Open Topo Map <https://tile.opentopomap.org/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Stamen Terrain <http://tile.stamen.com/terrain/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Stamen Toner <http://tile.stamen.com/toner/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Stamen Toner Light <http://tile.stamen.com/toner-lite/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Stamen Watercolor <http://tile.stamen.com/watercolor/%7Bz%7D/%7Bx%7D/%7By%7D.jpg>
* Strava All <https://heatmap-external-b.strava.com/tiles/all/bluered/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Strava Run <https://heatmap-external-b.strava.com/tiles/run/bluered/%7Bz%7D/%7Bx%7D/%7By%7D.png?v=19>
* Wikimedia Hike Bike Map <http://tiles.wmflabs.org/hikebike/%7Bz%7D/%7Bx%7D/%7By%7D.png>
* Wikimedia Map <https://maps.wikimedia.org/osm-intl/%7Bz%7D/%7Bx%7D/%7By%7D.png>

WMS Connections

WMS (Web Map Service) connections are like XYZ Tile Connections. These give you access to image “base maps,” often with more specialized applications. I’ll highlight a few examples of WMS services. They for you: search online for WMS links from your preferred data provider (e.g., national geological survey).

* British Geology <http://ogc.bgs.ac.uk/fcgi-bin/exemplars/BGS_Bedrock_and_Superficial_Geology/wms>?
* US Active Mines <https://mrdata.usgs.gov/services/active-mines?version=1.3.0>

WFS Connections

Web Feature Services (WFS) provide connections to underlying datasets with features includes. This differs sharply from WMS connections, which import a still “image,” of underlying data. A layer imported by WFS includes all underlying vector/raster data as a distinct layer. Examples below:

* Smithsonian Institution Global Volcanism Program <https://webservices.volcano.si.edu/geoserver/ows?version=2.0.0>
* World Mineral Deposits <https://mrdata.usgs.gov/services/wfs/ofr20051294?version=1.1.0>

Python in QGIS – Further Learning

Learning how to use Python in QGIS effective takes a lot of time! Here are some resources I’ve found useful.

<https://anitagraser.com/pyqgis-101-introduction-to-qgis-python-programming-for-non-programmers/pyqgis-101-creating-functions-to-load-geopackage-layers/>

<https://www.qgistutorials.com/en/docs/getting_started_with_pyqgis.html>

<https://locatepress.com/ppg3>

<https://anitagraser.com/pyqgis-101-introduction-to-qgis-python-programming-for-non-programmers/>

Google Earth Engine

To run my example GEE code, generating a global cumulative rainfall layer for the year 2017, you can access the script here: <https://code.earthengine.google.com/64e577d1f3e1f63be06f9449a7e8476f>

Further GEE learning links can be found here:

<https://developers.google.com/earth-engine/guides>

<https://developers.google.com/earth-engine/guides/getstarted>

<https://geemap.org>

<https://courses.spatialthoughts.com/end-to-end-gee.html>

**Final Further Learning Tip**

Ujaval Gandhi provides (in my opinion) the world’s best, most accessible geospatial training academy. He offers course on QGIS, Python, GEE, and Remote Sensing. Each of his courses are detailed, professional, and come with an official certification (e.g., the Advanced QGIS course I took with him came with an official QGIS certificate endorsed by the QGIS software developer consortium).

I highly recommend you view his offerings and consider taking a course with him ☺

<https://spatialthoughts.com/>