Introduction to GIS Methods in Economics

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Overview
The plan for today

Digitization of Old Maps

- Geo-reference
- Digitization

NetCDF data

- Using NetCDF in ArcGIS

Interpolation Methods

- Interpolation
- Example: Create Time Series of City Temperature using Interpolation

Further Data Visualization Tools

- Hot Spot Analysis
- Heat Map

Geocoding

- Geocoding through API

From scanned maps to digitized maps

- Digitize a paper map can be rewarding
    - Create new units of observation (e.g. Murdock's Map)
    - Time variation (e.g. Time series of Road construction in Burgess et al. 2015)

- Unfortunately, this is one of those tasks that cannot be automized in ArcGIS

In this section we will show you how to create shapefiles from a paper map

Tips before importing the map

- Always choose a high resolution format
  - Zoom as much as possible your pdf, copy and paste in Paint/Photoshop, save as .tif

- Knowing the coordinate system of the original map would help reducing distortion during georeferencing

Import your map clicking the ⊕, browse to your picture and import without double clicking on it.

How to assign projection to your map

- After importing it, your map is now floating around your working environment

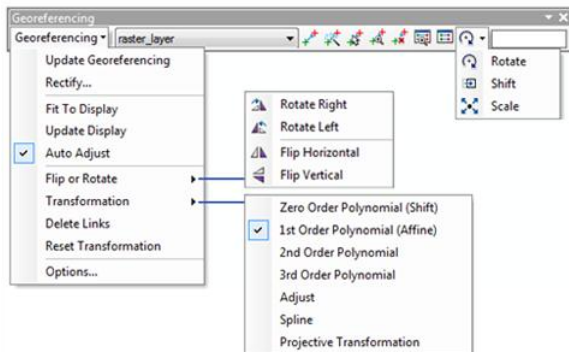- We need to pin down the map to using the georeferencing toolbar

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- (if you do not see the toolbar, right click on the command toolbar and check georeferencing)
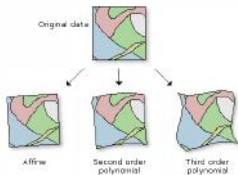
Maps
Georeferencing Toolbar

Interface

Functions you are going to use

- Update Georeferencing: Saves the transformation with the raster.

- Rectify: Creates a new transformed raster dataset.

- Fit To Display: Shifts the raster to the current display extent area.

- Transformation

Functions you are going to use

- Add Control Points ✴ : Allows you to select control points from a layer and add them to the map.
  - Do not start by georeferencing too many points that are close to each other (spatially correlated)
  - First three points are the most important
  - Once you have several links you can try to experiment different Transformations (the more links you have the best it is)
  - If possible, use geographical features that already exist (roads, cities, rivers, etc.)

- View Link ▣ Rectify: Shows links and errors in tabular form.

Maps
Georeferencing Toolbar

Final output
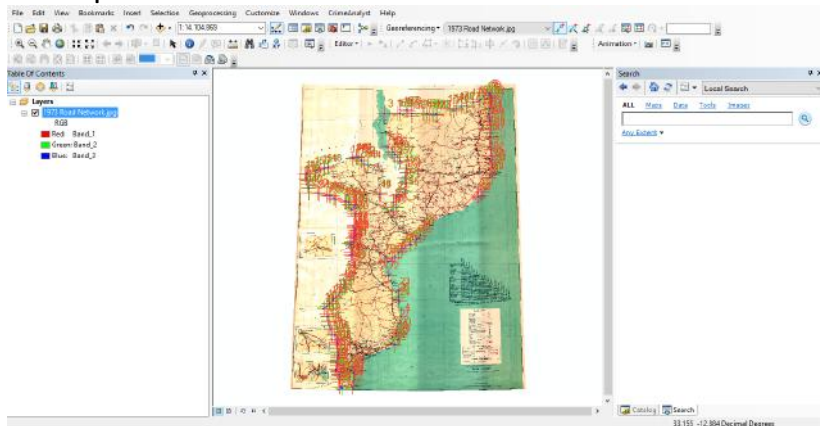
Create a digital version of you map

- Now we have a georeferenced map that we can transform into a shapefile

- Task: we want to create a shapefile of roads at colonial time (1973) in Mozambique

- What should we use?

Prepare your ground

- Add all the necessary layers you want to work with in the Map Project to ArcMap.
    - e.g. 2011 shapefile of roads in Mozambique

- Add the new, empty Shapefile Layer you created in ArcCatalog to which you want to add Features.
    - In our case we would create an empty line shapefile
- Add the Editor Toolbar to Your Tools
-

Prepare your ground

- Create Feature : open the Create Features window so that you can create new features

Maps
Digitizing you georeferenced map

Start Drawing

- Straight Segment ✏: create a vertex each time you click.

- Trace ⬚▾: create segment by following existing features.
  - Very useful in case you have underlying feature that overlaps with your map

- Finish a sketch: right click on last vertex, click on Finish Sketch ⬚. Or short cut: press F2.

- Attribute 🗔: opens attribute window so you can modify the attribute values of the selected feature
  - Very important to fill in information on the feature (e.g. road condition, paved/unpaved)

Maps
Digitizing you georeferenced map

Final shapefile

NetCDF Data
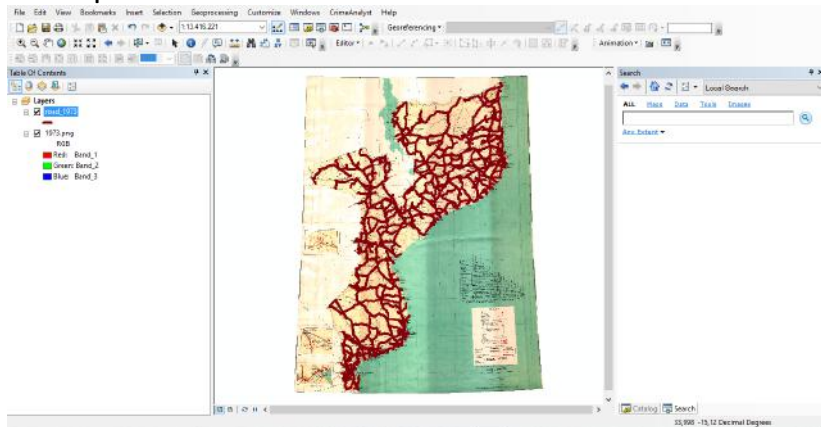
Network Common Data Form

- File format for storing multidimensional scientific data
- *e.g. Temperature, Humidity, Pressure, Wind speed etc.*
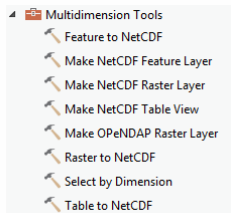- Each variable can be displayed through a dimension [like Time]

NetCDF in ArcGIS

- Unpack the NetCDF
- Create raster from NetCDF
- Generate tables from NetCDF

What tool to use?

- **Multidimension Tools**

Multidimension toolbox

Example of NetCDF data
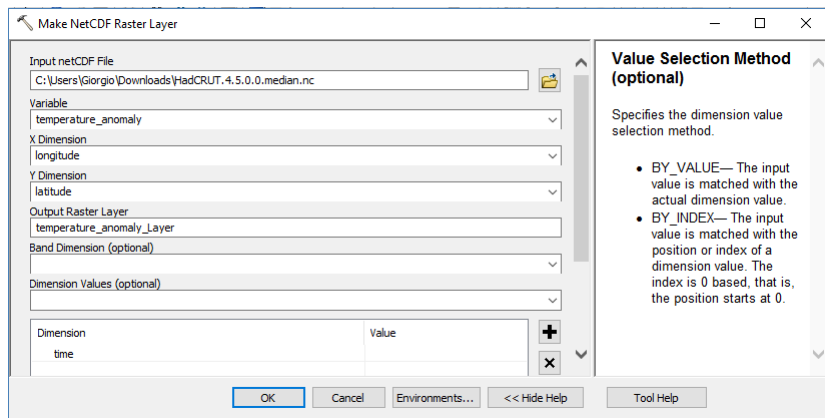
- https://www.metoffice.gov.uk/hadobs/hadcrut4/data/4.5.0.0/download.html
- Download HadCRUT.4.5.0.0.median_netcdf.zip

You cannot add a netCDF file using the button

How to import NetCDF data?

- load a world map shapefile to see what is where

- right click on `temperature_anomaly_Layer1` → `Properties...`

- select the `NetCDF` tab

- under `Dimension Values`, click on `Value` and select the point in time from the drop down menu you are interested in

Why interpolating?

- To predicts values for cells in a raster from a limited number of sample data points.

- It can be used to predict unknown values for any geographic point data

- elevation, rainfall, pollution, etc

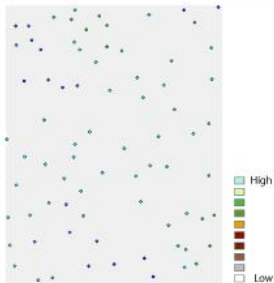**Assumption**

- Good option if objects/points are spatially correlated

What is interpolation?

Input elevation point data
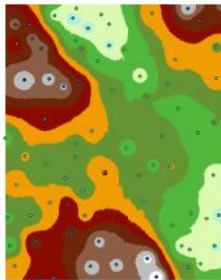
Interpolated elevation surface

What is interpolation?

Input rainfall point data
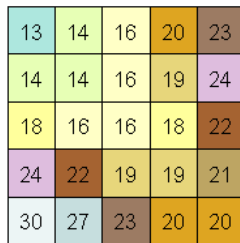
Interpolated rainfall surface

What is interpolation?

Point locations of ozone monitoring stations
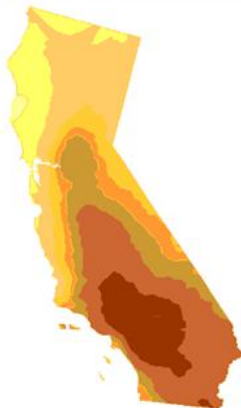
Interpolated prediction surface

Interpolation

To access the following tools, you need to authorize the **Geostatistical Analyst** license.

Different Methods of Interpolation

- Many methods exist

- Check the following link for a complete list of options
  http://desktop.arcgis.com/en/arcmap/10.6/extensions/
  geostatistical-analyst/
  an-introduction-to-interpolation-methods.htm

- Appropriate method is application-specific

Idea

- "Objects close to one another are more likely to be alike"

- IDW uses the measured values surrounding the prediction location

- IDW assumes that each measured point has a local influence that diminishes with distance

- greater weights to points closest to the prediction location

Interpolation

Inverse Distance Weighted (IDW) Interpolation

Maria Waldinger (2017) "The Economic Effects of Long-Term Climate Change - Evidence from the Little Ice Age,".

Motivation
Literature on effects of short-term climate variation on economic outcomes but little evidence on long-term effects of climate change.

Contribution
Using Little Ice Age in 1500 as natural experiment. Combining annual temperature data and population counts to generate a panel data set for 2120 European cities. Negative effect of climate shock on city size, decreased crop yields, and increased crop prices. Effect mitigated by access to trade.

Paper examples: temperature interpolation

Temperature Interpolation. Waldinger, 2017

Temperature Reconstruction for Moscow 1520-1750

Moscow Temperature Changes 1520-1750
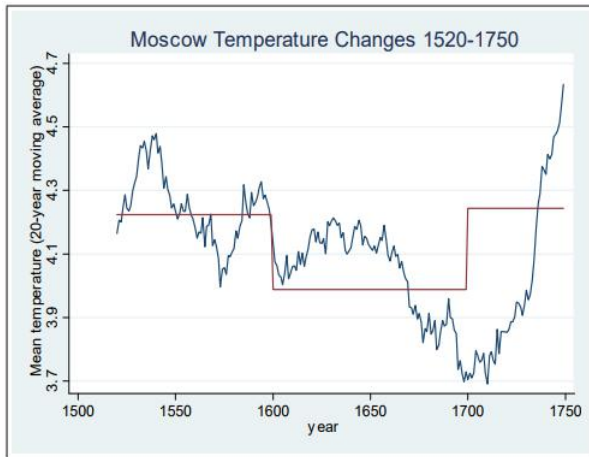
How can we replicate a similar dataset for temperature at city-level?

Example of Loop in Python
Create Time Series of City Temperature using Interpolation

Objective

- Want to create annual mean temperature deviations for European capital cities

- Show how to
    - import data from text file,
    - filling up missing value using IDW interpolation
    - extract raster value to points

- Iterate from 1985 to 2007

- Script: interpolation_example.py

Example of Loop in Python
Create Time Series of City Temperature using Interpolation

**Data**

- European 1400 Year Spring-Summer Temperature Reconstructions (Guiot et al. 2012 data)

- Data reconstructing Temperature deviations for 600-2007.
  117 proxy records, including tree-rings, documentaries, pollen assemblages, and ice cores. Grid size 5°x5°. Data are °C anomalies relative to the 1961–1990 average.

- https://www.ncdc.noaa.gov/paleo-search/study/10426

Example of Loop in Python

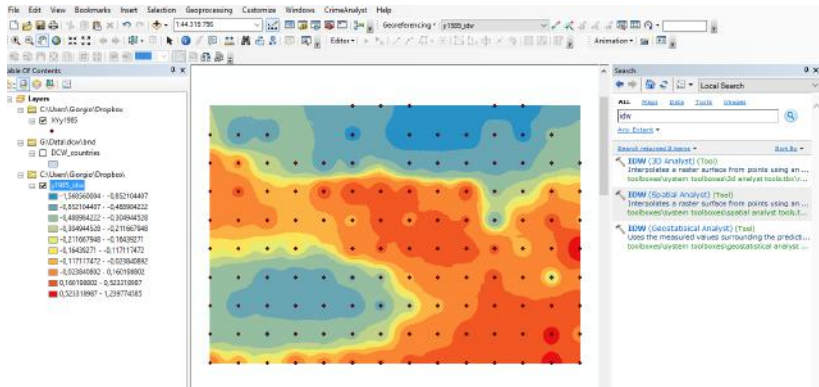Create Time Series of City Temperature using Interpolation

Observation Points
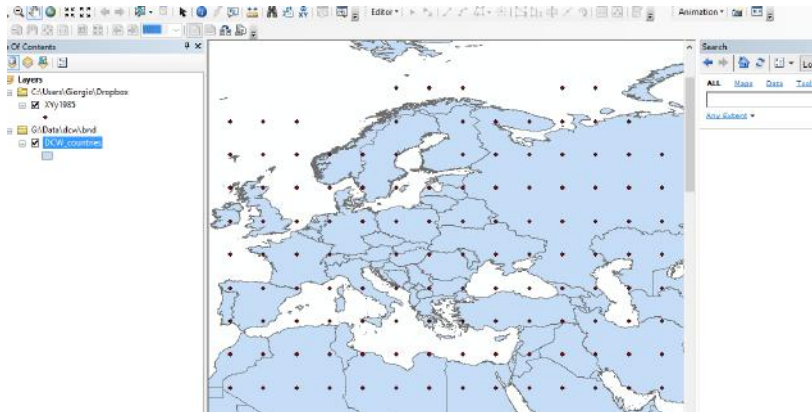
Example of Loop in Python

Create Time Series of City Temperature using Interpolation
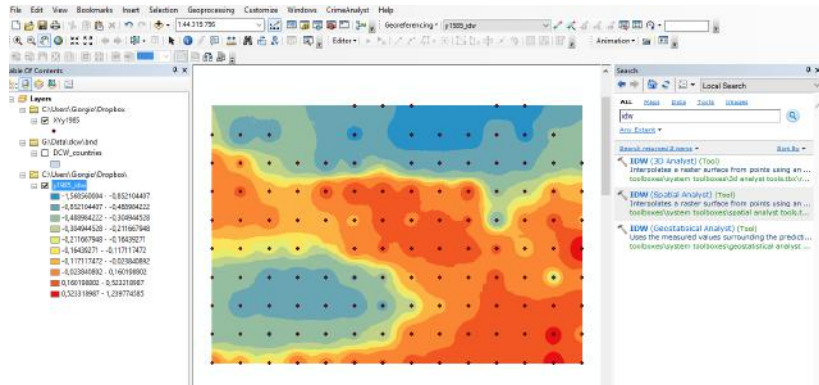
IDW Raster

Example of Loop in Python
Create Time Series of City Temperature using Interpolation

IDW Raster - Search Neighborhood: Standard
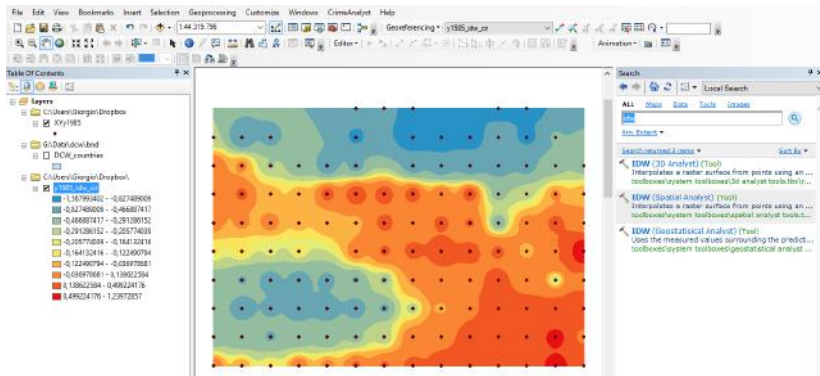
Example of Loop in Python
Create Time Series of City Temperature using Interpolation

IDW Raster - Search Neighborhood: Smooth

Data Visualization Tools

How to visualize Spatial Pattern in your data

- Heat Map
- Hot Spot Maps

Advantages

- Help you detecting spatial patterns: cluster, spatial correlations
- Appreciated by policy-makers and practitioners

Heat Map
- Represents the geographic density of features on a map

- Useful for layers with a large number of features

Heat Map in ArcGIS
- **Point Density**: calculates the density of point features around each raster cell.

- **Line Density**: calculates the density of line features within a radius around each output cell.

- **Kernel Density**: algorithm to calculate density of point features around each neighborhood. The algorithm determines the default search radius (bandwidth), which allows for better weighting of highly dense points and smoother outputs.
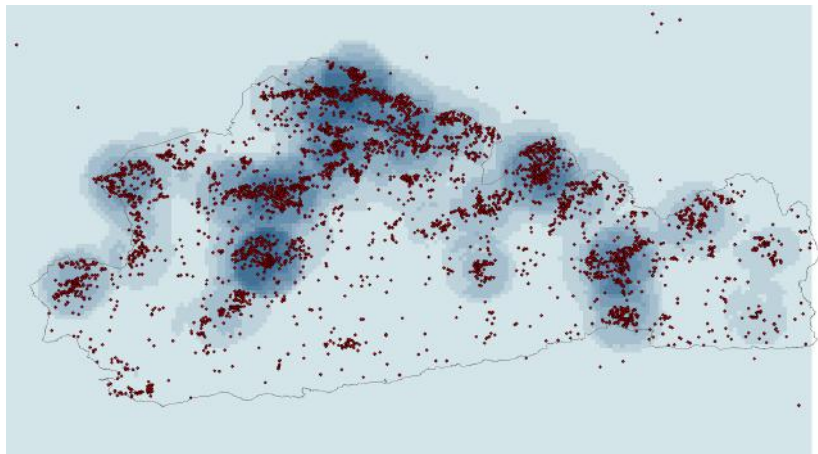
Data source

- `https://data.police.uk/data/`
    - dowload the data for Surrey, March 2019
    - force boundaries are from here:
      `https://data.police.uk/data/boundaries/`
    - We have treated the data for you and assigned a weight of 10 to all violent and sexual crime, 5 to Criminal damage and arson, and 1 to all other type of crime (theft, drugs etc.)
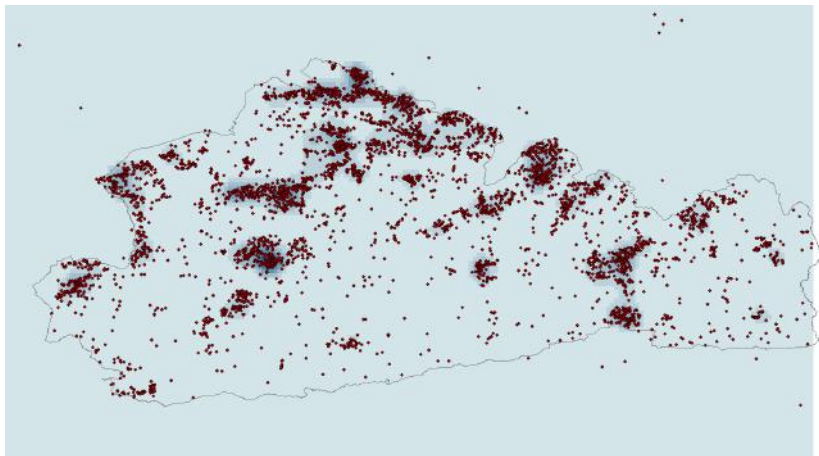
Point Density

Data Visualization Tools
Heat Map

Kernel Density
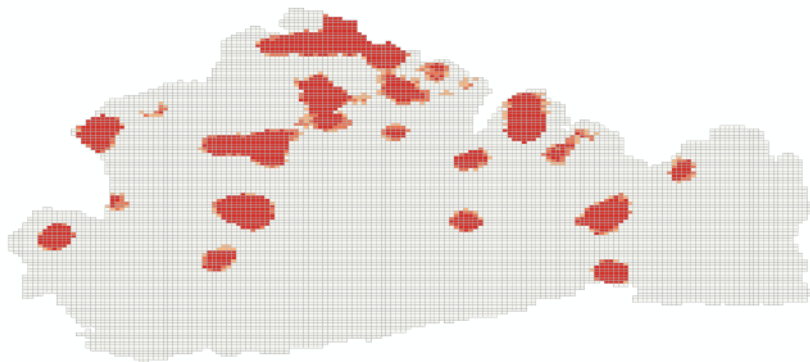
Hot Spot Analysis

- Identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots).

- Indicate whether the observed spatial clustering of high or low values is more pronounced than one would expect in a random distribution of those same values.

Optimized Hot Spot Analysis

Geocoding outside GIS

Geocoding through API

- Imagine you have a list of city and villages to which you want to attach the corresponding GPS coordinates

- We present a STATA script scraping information from
  http://www.geonames.org

  - See here to register for a free account (need to enable free web services)
    http://www.geonames.org/export/web-services.html
  - Additional dofile geocoding via Google Maps (give you free budget of $300/year, after using this, need to buy credit, requires credit card to sign up, but will not charge unless you explicitly ask it to)

- Requires installation of libjson, insheetjson packages in STATA

- Let us have a look at the dofile