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Introduction

The distance between capital cities is a variable, researchers are interested in when it comes to explain the diffusion of specific policies across countries (Maggetti and Gilardi, 2016). The objective of this technical paper is to describe how distances between capital cities were calculated for WeSIS and to give a step-by-step visual guide to help other researchers with the procedure in ArcGIS. It will also include all amendments that have been made to the CShapes dataset to meet the WeSIS coding rules and correct minor inconsistencies.

The calculation is based on data provided by CShapes, a dataset collected by Niels Weidmann, Doreen Kruse and Kristian Skrede Gleditsch (2010). It provides historical maps of state boundaries in geographical shapefile format and further information on states such as the capital cities including geographic coordinates and start and end date of a states' existence in the international system. It covers a time period from 1946 to 2016 and includes all states of the COW (Correlates of War Project 2008) and GW (Gleditsch and Ward 1999) country list (Weidmann et al. 2010: 90). Also, boundary adjustments without changes in the existence of involved states are included until 2000 using the Territorial Changes dataset by Tir et al. (1998). CShapes can therefore be used for a wide range of spatial computations and does reflect changes in the international system over time, which researchers using We-

SIS are interested in. Because of its comprehensiveness, both in time and space, and widely used coding via the COW country codes, it is appropriate to be used for WeSIS.

Procedure

The data and distance calculations were processed using the geographical information system ArcGIS provided by ESRI. In the following, the procedure is laid out. For a more detailed instruction on how to realize the different steps in ArcGIS, please also consult the figures in the visual guide.

The list of capital cities was brought to a shapefile format by adding the data from XY using the coordinates given by CShapes (Figures 1 and 2). Since CShapes used the WGS1948 coordinate system for the state boundaries, this was also used for the capital city shapefile. To be able to calculate the distance between capitals in kilometres using an ArcGIS proximity tool, the shapefile was projected to a geodetic WGS1948 Web Mercator Projection using the Project Tool, which is widely used for online visualization (i. a. by Google Maps). The change in projection does however not change the distance calculation, because it does not change the coordinates, just the units of measurement (Figure 3).

The tool with which it is possible to calculate the distances between all capital cities had to meet the following requirements:

- It should be able to calculate the distance between one point of a layer to all other points of the same layer.
- It should export the distance output into a separate text or excel file.
- It must include the curvature of the earth into the calculation (geodesic method).

An appropriate ArcGIS tool based on these requirements proved to be the "Create Near Table" proximity tool with the input features being the sender countries' capital cities and near features being the receiver countries' capital cities. Receiver countries' capital cities are all features except the sender country because it would make no sense to calculate the distance from and to the same city. To apply this tool to the capital city shapefile, a model was created in a new toolbox using the Model Builder (Figures 5 and 6). In the settings it was specified to search in a radius as big as the equator as to cover all areas of the earth and to find a maximum of 254 near features (all 255 capitals listed in the CShapes dataset minus 1, Figure 7 and 8). Please note however that there are no real sender and receiver countries as these are reciprocal data. The terms are used to stick to the WeSIS coding rules.

Amendments to the original data

The following amendments to the original data have been made for reasons that other sources like the German Federal Foreign Office or the Central Intelligence Agency have provided different dates on the validity of the city as a capital city:

- Deleted USSR and Yugoslavia
- Burundi (Bujumbura): Changed end year from 2016 to 2018
- Nigeria (Abuja): Changed start year from 1961 to 1991
- Kazakhstan (Astana): Changed start year from 1991 to 1997
- Malawi (Lilongwe): Changed start year from 1964 to 1974

» Myanmar (Yangon): Changed end year from 2016 to 2006
» Pakistan (Islamabad): Changed start year from 1958 to 1966
» Palau (Koror): Changed end year from 2016 to 2006
» All except Burundi, Myanmar and Palau: Changed end year from 2016 to 2019

Variables

The output table holds the following variables:

cow_code_sender	Sender countries' COW Country Code
country_name_sender	Sender countries' Name
cow_code_receiver	Receiver countries' COW Country Code
country_name_receiver	Receiver countries' name
year	The year for which the value is valid
technical_variable_name	Name of the variable in WeSIS
value	Distance between sender and receiver countries' capital city in the following unit
unit	The unit of measurement, in this case kilometres
scale	The scale of the value, in this case metric
source	The source of the original data, in this case CShapes

Results

The output table holds 64.770 results, that is the distance from 255 capital cities to all other capital cities excluding the capital city of the sender country. It still includes null values since some capital cities are in the list multiple times (e.g. Berlin for the Democratic Republic Germany between 1954 and 1990 and for the unified Federal Republic of Germany between 1990 and 2016), or generally, for countries with changing COW country code (e.g. because of changing borders or a period of dependency between two periods of independence). Other than that, all distances could be calculated and are sorted from the nearest to the farthest capital from the sender countries' capital city. For the upload in WeSIS, all null values and double values have been deleted.

Further Remarks

Concerning the validity of the calculated distances, it became clear that the coordinates provided by the CShapes dataset do not perfectly match coordinates from other sources, for example Google Maps. There are minor round-off errors (for example Berlin 13.400 E, 52.516 N according to CShapes and 13.377 E, 52.516 N according to Google Maps) and this has minor implications for the distance calculation. For example, the distance between Berlin and Wellington, New-Zealand (which is the farthest away) calculated using the CShapes data is five kilometres shorter that the distance on Google Maps. However, with a total distance of over 18,000 kilometres, this is a deviation of 0.03 percent. The distance between Berlin and Prague (which is the nearest) is less than one kilometre shorter than the distance on Google Maps. Overall, the divergent coordinates only result to very small differ-

ences in the calculation of distances and it does not change the rank of distances from one capital to the others.

Visual Guide

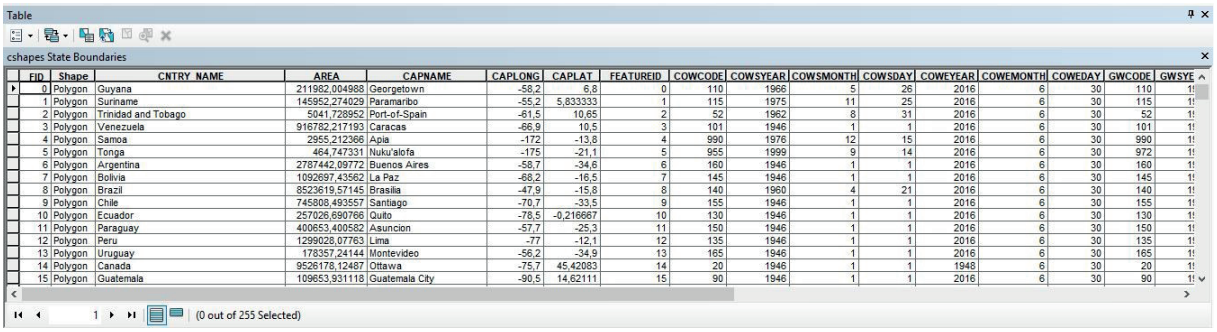

Figure 1
When opening the CShapes Data in ArcGIS, this is the attribute table that comes with it. This table was exported to a CSV file to add the coordinates back to the document as a shapefile.

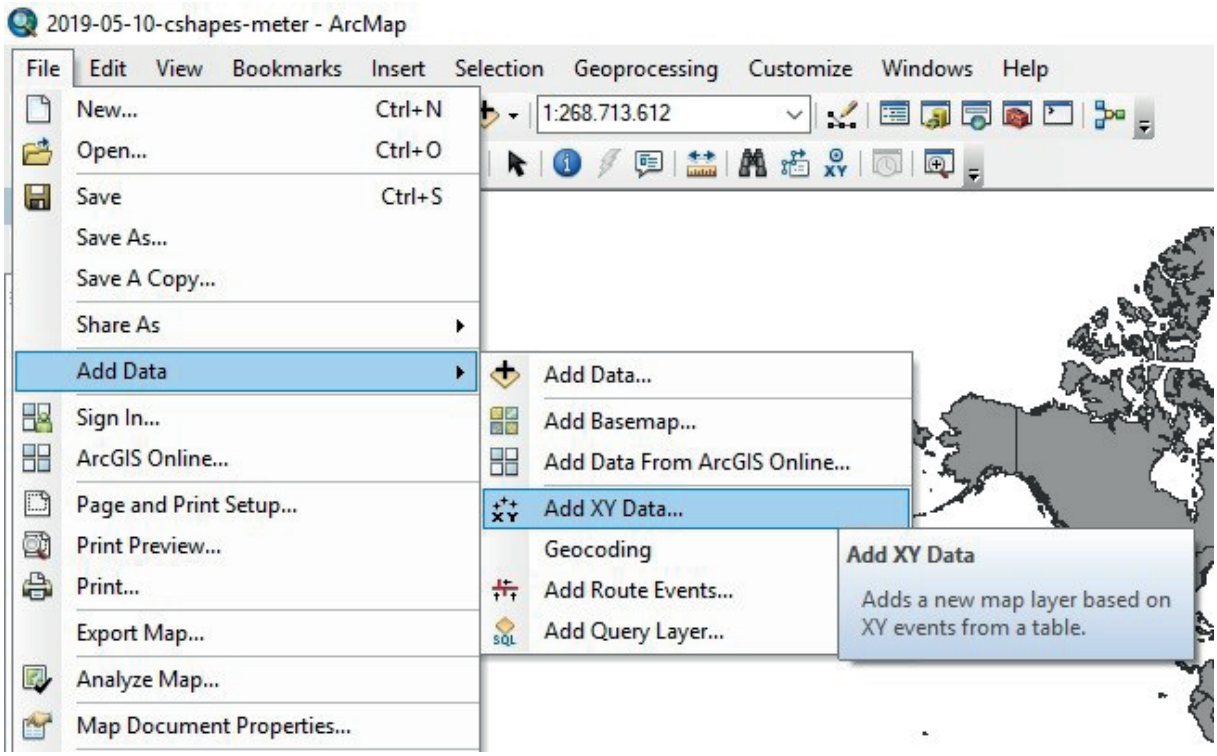

Figure 2
The exported coordinates and capital city names where then added as a shapefile by "Add XY Data..."

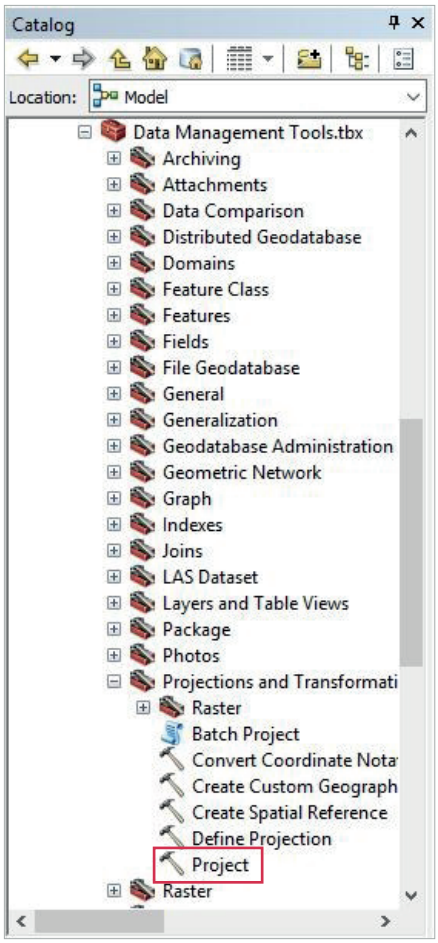

Figure 3
The tool "Project" can be found in the System Toolbox under Data Management Tools/Projections and Transformations.

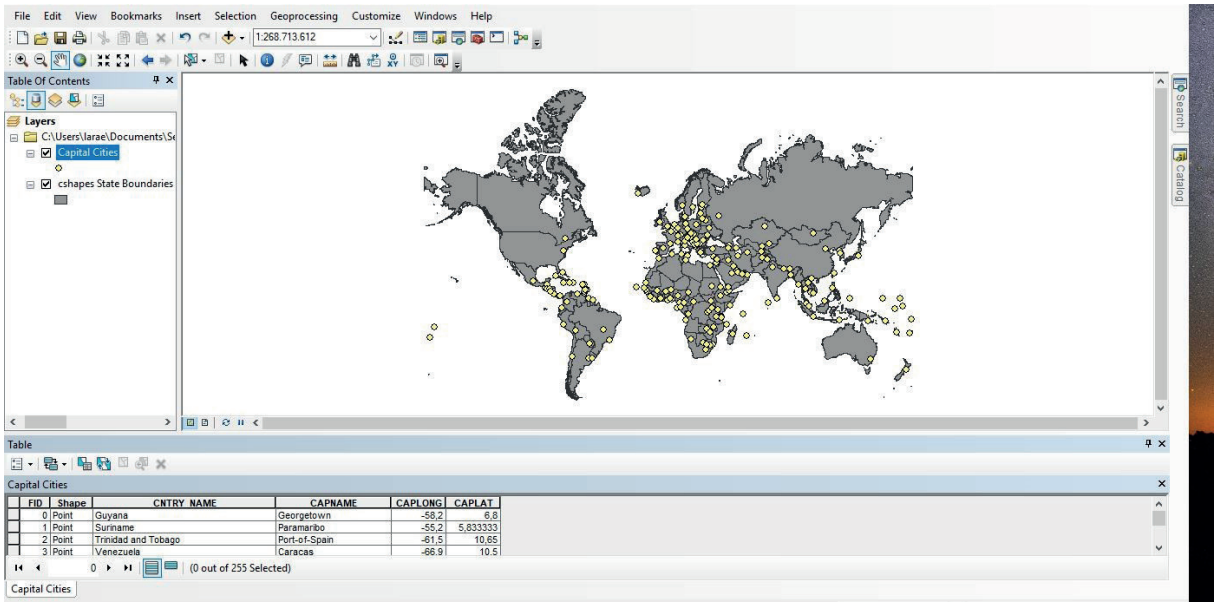

Figure 4
This is how the result should look like with the changed projection and added capital cities.

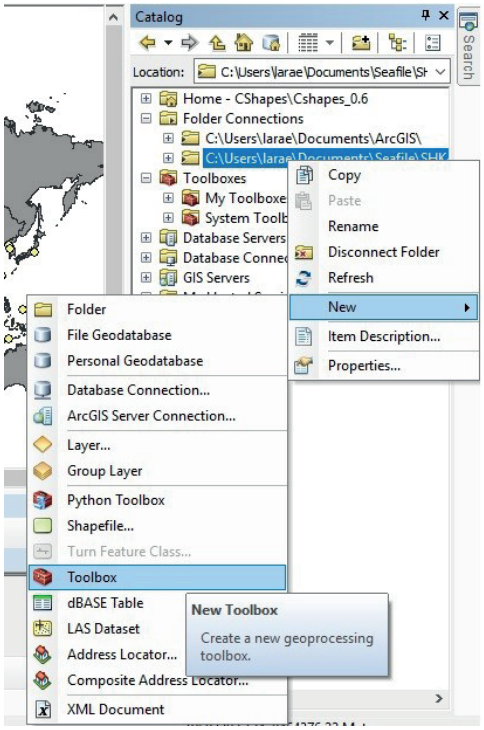

Figure 5
To apply the "Generate Near Table" tool, a toolbox has to be created in a new folder. In the toolbox, a new model is added.

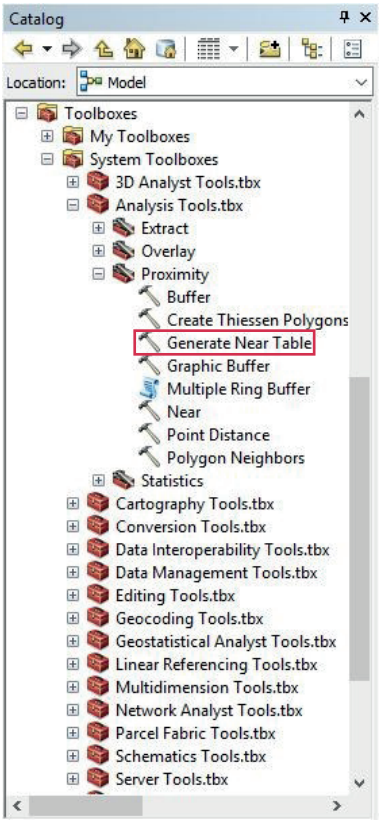

Figure 6
The "Generate Near Table" tool is added to the previously created model by drag and drop.

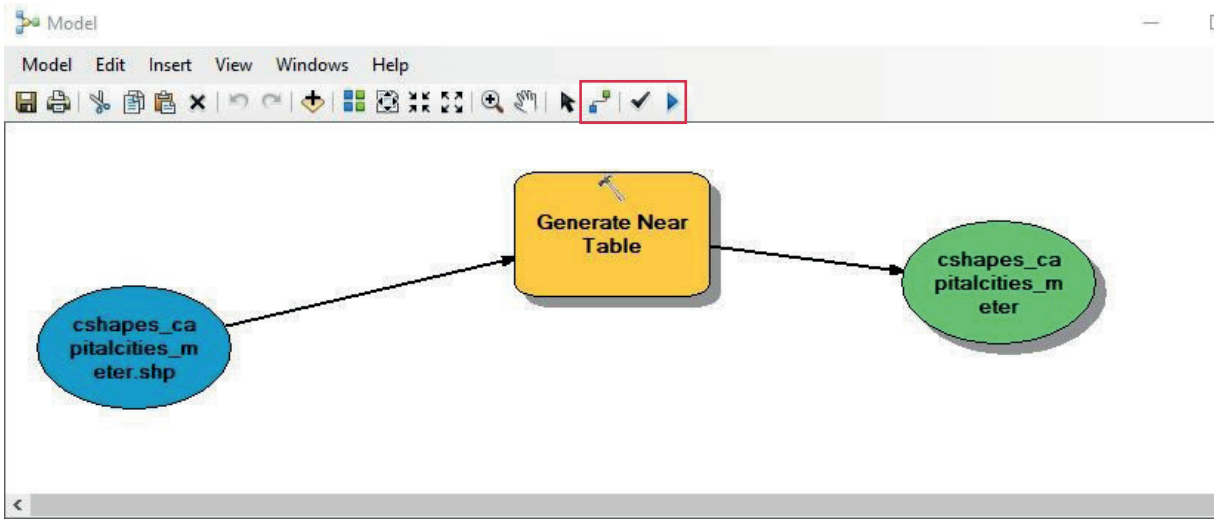

Figure 7
This is how the model should look like. The items turn coloured when input and output features are defined and connected to the tool (yellow item). The input table, illustrated in blue, is the capital city shapefile. The table in which the output will be saved in, is depicted in green. By right clicking on the yellow item, further instructions can be defined (Figure 8). When all settings are clear, the model runs by clicking on the blue start symbol in the task bar.

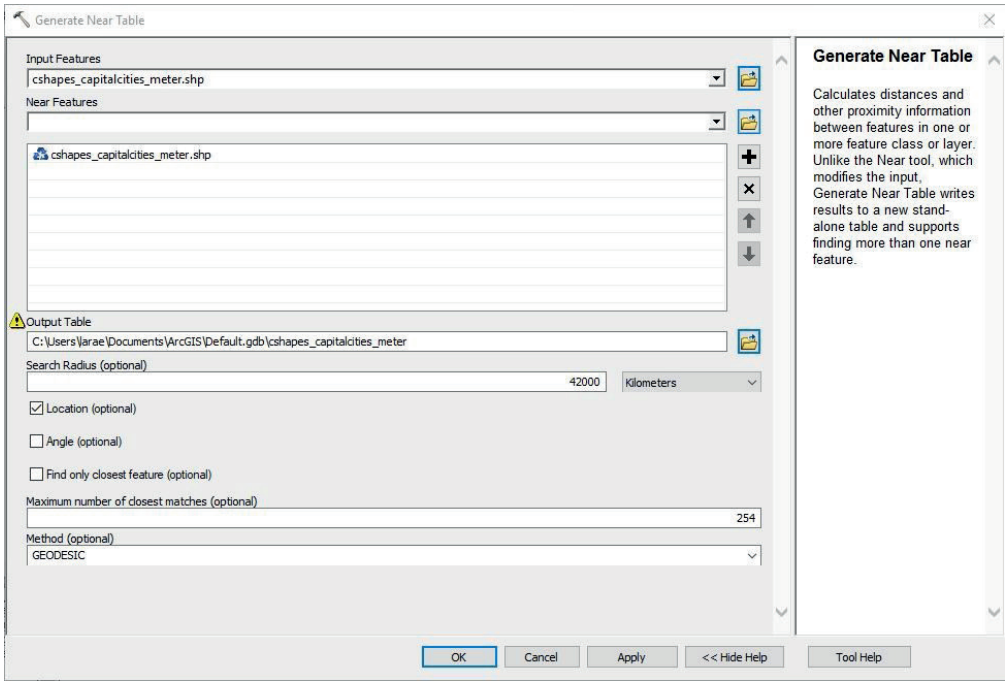

Figure 8
This is the window opened by right clicking on the tool. "Find only closest feature" has to be unchecked to find all near features. A search radius and the maximum number of closest matches has to be defined. The tool finds as many near features as are defined by the maximum number. As we want all features of the layer to be found (except the feature that is already the input feature), this is what has to inserted here. For the curvature of the earth to be included in the calculation, the geodesic method has to be checked.

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