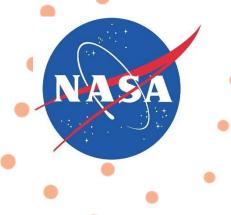


ArcGIS Pro Tutorials for Air Quality Analysis

The Holloway Group @ SAGE Nelson Institute for Environmental Studies University of Wisconsin-Madison Madison, WI 53726







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Introduction

This tutorial will demonstrate how to allocate gridded satellite-derived nitrogen dioxide (NO₂) data over the Continental United States (CONUS) to Chicago metropolitan area census tracts using ArcGIS Pro. It will walk through common tools that can be useful in GIS air quality analysis such as clipping, filtering and allocating data from one format to another. Upon completing this tutorial, you will have a new shapefile containing census tract average NO₂ values, a web map layer of the census tract NO₂ averages and useful skills that can be applied to other GIS air quality applications.

GIS and ArcGIS Pro

A geographic information system (GIS) is a computer system that displays geographically referenced information and has built in tools that allow users to visualize, analyze and manage this data. While there are many different GIS software packages, this tutorial was made using ESRI's ArcGIS Pro version 3.0.2 and 3.0.4 and further tested with version 3.1.2. ArcGIS Pro is a professional grade software the retails for about \$700/year for the basic version and up to \$3,800/year for the advanced version of the software. Future versions of this tutorial will be made with other GIS software packages, but we recommend ArcGIS Pro because it is user friendly, has greatvisualizations and is able to publish web-based maps.

Satellite data is not traditionally provided in standard GIS formats. However, it is useful to have satellite data in a GIS format, to combine with various other data products, to create visually appealing maps, and to provide the first step for the Environmental Protection Agency's (EPA) Environmental Justice (EJ) mapping tool (EJScreen). Additionalinformation on EJScreen can be found in Appendix C.

Requirements

The following are required in order to complete this tutorial:

- ArcGIS Pro v3.0.2 or later
- An ArcGIS online account

Before beginning this tutorial, you should have ArcGIS Pro installed on your computer and stepped through a basic introduction to ArcGIS Pro tutorial. If you haven't, here is one we found useful: https://pro.arcgis.com/en/pro-app/latest/get-started/get-started.htm. To use this tutorial, we do not expect proficiency or experience in ArcGIS Pro, but some level of familiarity may be helpful. If you are already very proficient in ArcGIS Pro, some of the instructions heremight be too basic, but hopefully still helpful.

Uses

While this tutorial walks through a specific example of allocating 1km x 1km gridded satellite-derived

 NO_2 data to Chicago metropolitan census tracts, the steps demonstrated here can be applied to other datasets such as the satellite-derived $PM_{2.5}$ dataset provided by the Atmospheric Composition Analysis Group at Washington University in St. Louis. A list of satellite-derived datasets can be found in Appendix B.

How to Make a Map of Gridded Satellite-Derived NO2 Data

Tutorial 1 was created in November 2022 using ArcGIS Pro 3.0.2 and last tested in November 2023 using ArcGIS Pro 3.0.4. If you are using a different/version of the software, you may encounter different functionality and results.

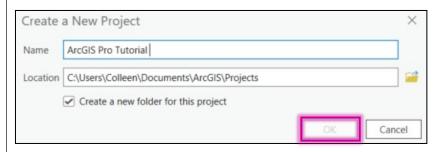
Getting Started

 Download the data for this tutorial <u>here</u> and unzip the folder after it has been downloaded. This folder contains the 2019 census tract shapefiles for Wisconsin, Indiana and Illinois, the U.S. Metropolitan and Micropolitan Corebased Statistics Areas (CBSA) shapefile and a TIFF file of the 1km x 1km gridded 2019 TROPOMI NO₂ data over the contiguous U.S. More information on the data used in this tutorial can be found in Appendix A.

2. Open ArcGIS Pro and create a New Project Map



3. Name the project and choose a Location where it will be saved. Click OK.

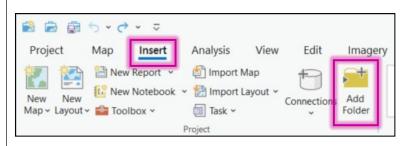


4. A new project map will open.

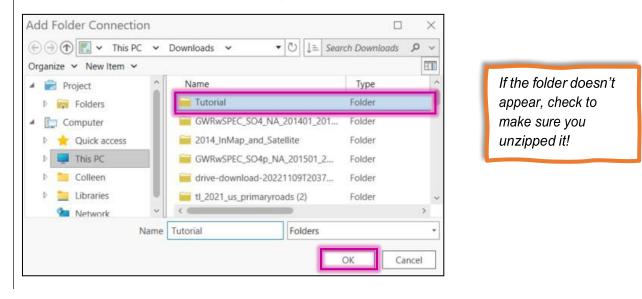
Create a Folder Connection

Let's begin by **Adding a Folder Connection**. While there are several different ways to add data (i.e., shapefiles, netCDF files, .csv files) to a map, this way is the most efficient when all the data is in the same folder or location.

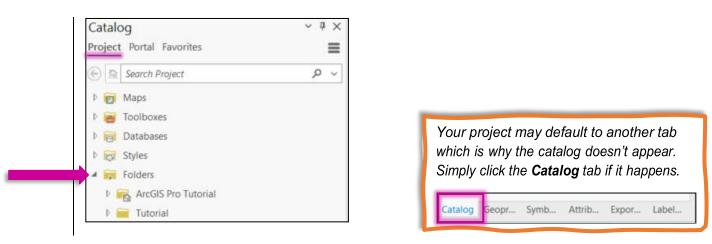
1. From the top ribbon, click the **Insert** tab and select the **Add Folder** icon.



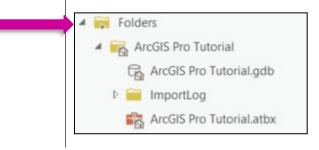
2. The **Add Folder Connection** pop-up window will appear. Navigate to where you downloaded and stored the data folder for this tutorial on your computer. Select the **Tutorial folder** and click **OK**.



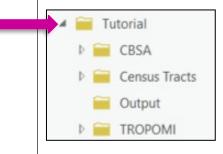
3. Go to the Catalog pane located to the right of the map. Under the Project tab, select the small arrow next to Folders to drop down the folder's content. You will see two separate folders. The first folder with the house icon is the project folder (I named my project ArcGIS Pro Tutorial) and the second folder is the Tutorial folder that we just added. (If the Catalog pane is not present, select the View tab on the top of screen, and click on Catalog Pane under Windows)



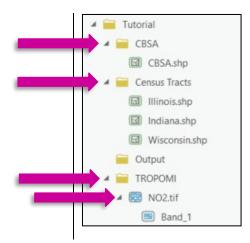
4. Click the arrow next to the project's folder to display its content. The project's geodatabase (ArcGIS Pro Tutorial.gdb) where we will store some of the files made during this tutorial.



5. Click the arrow next to the **Tutorial** folder to display the folder's subfolders.



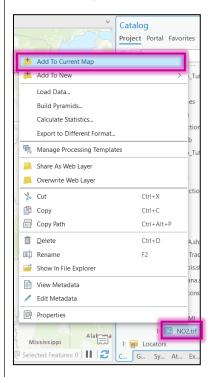
6. Continue to open the subfolders from **Tutorial** by selecting the arrows until all the content is displayed.



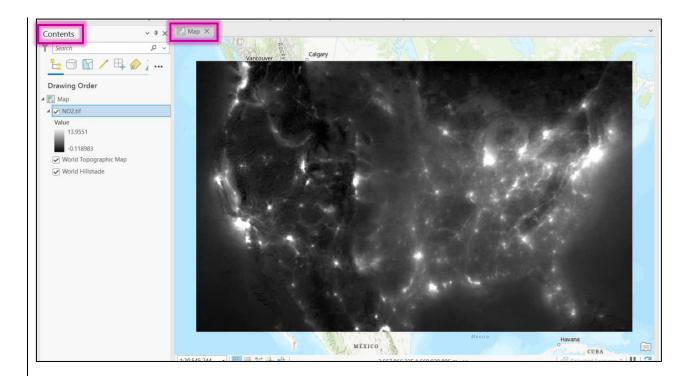
7. You will see the shapefiles (.shp) for CBSA, Illinois, Indiana, and Wisconsin as well as the NO2.tif raster file. The **Output** folder will be empty. This is where you will store some of the additional files made in this tutorial.

Add the Data to the Map

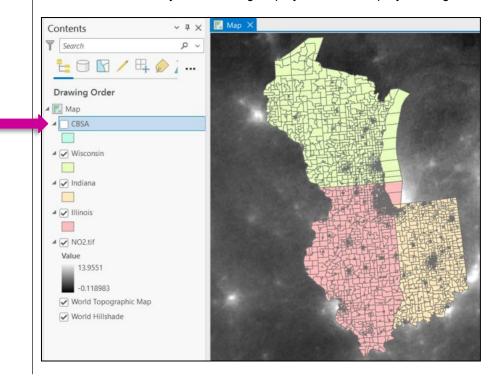
1. Add the **NO2.tif** file to the map. To add the files to the map, either click and drag the file onto the map, or right-click on the file and select **Add to Current Map**.



2. The NO2.tif layer will appear on the Map and in the Contents, pane located to the left of the map.



3. Add Illinois.shp, Indiana.shp, Wisconsin.shp and CBSA.shp



4. Hide the **CBSA** layer from being displayed on the map by clicking the box to the left of the layer.

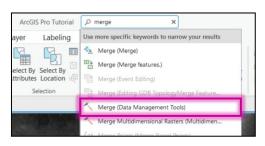
The colors of each layer may be different than the ones shown here. Do not worry about the colors of each layer!

Merging Shapefiles

1. Merge the three census tract layers (**Wisconsin**, **Indiana**, and **Illinois**) into one layer. While there are different ways of accessing the tools used in this tutorial, it is easiest to use the **Command Search** located above the top ribbon.

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2. In the Command Search, type "merge" and select Merge (Data Management Tools).



3. In the **Merge Geoprocessing** window under the **Parameters** tab, select the arrow to drop down the **Input Datasets** and select all three of the state shapefiles starting with **Wisconsin** followed by **Indiana** and **Illinois**.

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Input Datasets 🕢	0	
Wisconsin		~
Indiana		· • 6
Illinois		· • 6

4. As a result of adding the **Input Datasets**, the **Output Dataset** will update to **Wisconsin_Merge**. If you click on this box, it will show you the path where the output dataset is saved. By default, it is the project's geodatabase (**.gdb**). We will use the default.

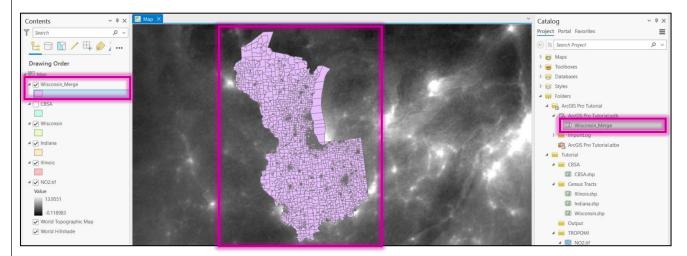
Out	tput Dataset	-
Tu	torial\ArcGIS Pro Tutorial.gdb\Wisconsin_Merge	F

The first state you selected as the **Input Dataset** will be the default output _**Merge** name

5. The **Field Map** contains a list of all the fields every layer. Click the **Reset** icon to ensure that all the layer's fields are included and click **Run**.

Output Fields (+)	Source Properties	
STATEFP (3)	Merge Rule First ~	
COUNTYFP (3)	Wisconsin	
TRACTCE (3)	STATEFP ~	
GEOID (3)		
NAME (3)	Indiana	
NAMELSAD (3)	STATEFP ~	
MTFCC (3)		
FUNCSTAT (3)		
ALAND (3)	Illinois STATEFP v	
AWATER (3)	SIATEPP	
INTPTLAT (3)		
INTPTLON (3)	Add New Source 🗸	The (3) next to the attributes in th
Add source informa	ation to output	Output Fields indicate that three

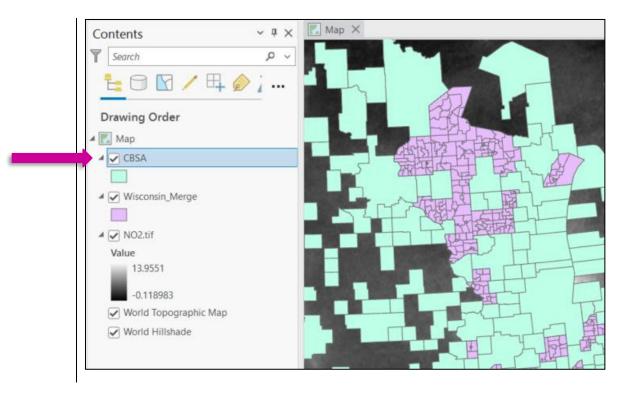
6. The new **Wisconsin_Merge** layer will be added to the **Map** and to the **Contents** pane. We can also click on the project's geodatabase in the **Catalog** and see it saved as a feature class layer there as well.



7. **Remove** the **Wisconsin**, **Indiana**, and **Illinois** layers as they will no longer be needed. To remove a layer, right-click on the layer in the **Contents** pane and select **Remove**.

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Contents	Copy
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Map	Add Error Layers
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	Create Chart >
CBSA	🗎 New Report
Visconsin	Joins and Relates >
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🔺 🖌 Indiana	Zoom To Make Visible
▲ 🖌 Illinois	Selection >
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World Topographic Map	😼 Configure Pop-ups
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	📄 View Metadata
	🖊 Edit Metadata
	Properties

8. In the **Contents** pane, click the box next to the left of **CBSA** layer to turn it back on. Then click and drag this layer up above the **Wisconsin_Merge** and **NO2.tif** so it is on top and appears above it in the **Contents** and on the **Map**.

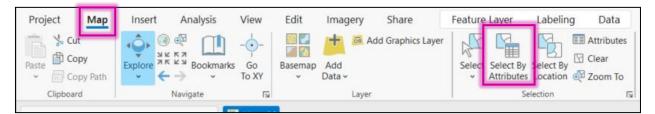


Selecting Attributes

Let's select all the census tracts from **Wisconsin_Merge** that are within the Chicago metropolitan area as defined by the **CBSA** layer.

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p to step 7 fror	n this section.							
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1. From the top ribbon select the Map tab. Under the Selection group, click on Select By Attributes .



2. In the Select By Attributes pop-up window, for the Input Rows, select CBSA and keep the Selection Type, New Selection.

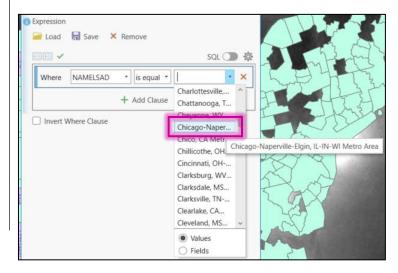
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CBSA	~	
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3. Under expression, click on Select a field the select NAMELSAD

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4. Keep the second box as, **is equal** and for the third box, scroll down and select "Chicago-Naperville-Elgin, IL-IN-WI"

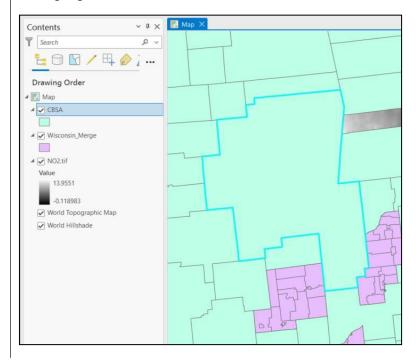
Note: To select more than one attribute in the future, click on **Add Clause**, change **And** to **Or** and repeat this step for all desired attributes/locations.



5. Click **Apply** and then **OK**.

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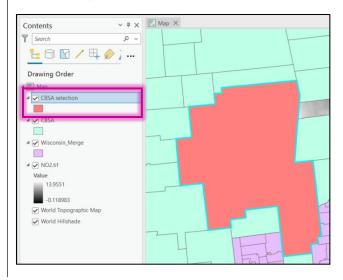
6. On the **Map** from the **CBSA** layer, click the "**Chicago-Naperville-Elgin, IL-IN-WI**" will be selected and highlighted.



7. Let's make this selection into a new layer. From the **Contents** pane, right-click on the **CBSA** layer since that is the layer we selected from. Go to **Selection** and click **Make Layer from Selected Features**.

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1 B.	58	Zoom To Make Visible		
		Selection	>	Zoom To Selection
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▲ ΛΜ	1	Labeling Properties		Clear Selection
		Convert Labels	>	Switch Selection
	1	Symbology		Select All
	5	Disable Pop-ups		Select Visible Features
	曝	Configure Pop-ups		Make Layer From Selected Features
		Data	>	Make this the only selectable layer
		Sharing	>	Annotate Selected Features
		View Metadata		Attribute Table Showing Selection
	1	Edit Metadata		6 1 12
	2	Properties		

8. A new layer called CBSA selection will appear in the Contents pane and on the Map.



- 9. Hide the old **CBSA** layer by selecting the box to the right of its name in the **Contents** pane.
- 10. From the top ribbon, ensure you are still on the **Map** tab. Under the **Selection** group, click **Clear**. It is important to remember to clear anytime you are done with a selection.

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Selecting by Location

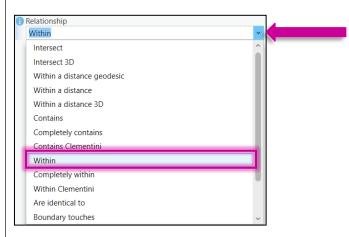
1. Now, you'll want to select all the census tracts from **Merge** that fall within the **CBSA selection** layer. From the top ribbon select the **Map** tab and under the **Selection** group, click on **Select by Location**.

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Project Map	Insert	Analysis	View	Edit	Imagery	Share	Feature Layer	Labeling	Data
Paste	Explore	Bookmarks	Go To XY	Basemap		Add Graphics Layer	Select Select B	Select By	Attributes Clear Zoom To
Clipboard		Navigate	N		Lay	er		Selection	5

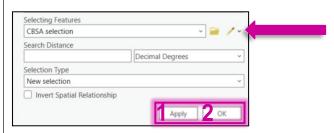
2. In the **Select by Location** pop-up window, click the arrow to drop down the input options and use **Merge** as your **Input Features**.

Select By Location	? ×
Input Features 😔	
Wisconsin_Merge	· · ·
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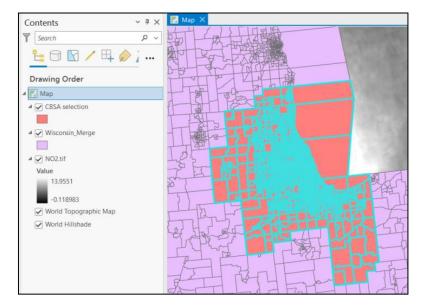
3. Under **Relationship**, click the arrow to drop down the different relationship options and select **Within**.



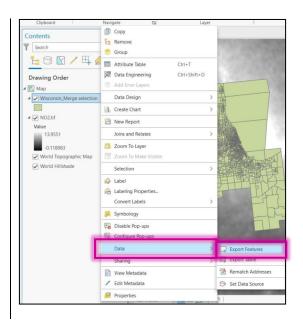
4. Under Selecting Features use the drop-down arrow to select CBSA selection. Leave the Search Distance and Selection Type with the default. Click Apply and then OK.



5. All the census tracts from **Wisconsin_Merge** that are within the **CBSA selection** layer will be selected and highlighted.



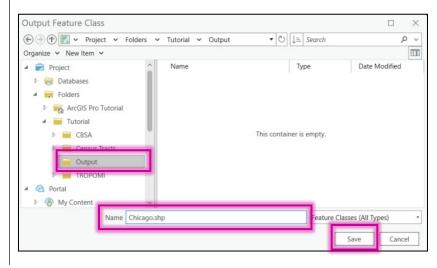
- 6. Make this selection into a new layer like before by right-clicking on **Wisconsin_Merge** from the **Contents** pane and under **Selection**, select **Make Layer from Selected Features**. Remember to **Clear** this selection after!
- 7. Remove the Wisconsin_Merge, CBSA and CBSA selection layers.
- 8. Let's save the **Wisconsin_Merge selection** as a shapefile. From the **Contents** pane, right-click on the layer. Select **Data** and then **Export Features.**



9. For the **Input Features**, make sure it is **Wisconsin_Merge selection**. Then click on the folder icon next to the **Output Feature Class**.

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Wisconsin_Merg_ExportFeature	Control 1

10. From the **Output Feature Class** pop-up window, navigate to the **Tutorial Output** folder. **Name** the file "**Chicago.shp**" and click **Save**.



11. Click on the **Output Feature Class** box and confirm the file is being saved in the **Output** folder and the file type is a shapefile (**.shp**). Select **OK** to finish exporting features.

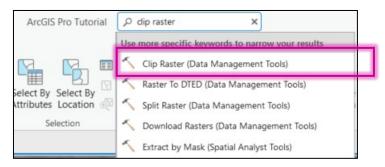


- 12. The **Chicago** shapefile will be added to the **Output** folder and the new layer will be added to the **Contents** pane and the **Map**.
- 13. Remove Wisconsin_Merge Selection from the Contents pane.

Clip the NO₂ Gridded Data

Since the NO2.tif file is so large, we'll want to crop it down to cover just the Chicago metropolitan area.

1. In the **Command Search**, type "clip raster" and select the **Clip Raster (Data Management Tool)**.



2. This will open the **Clip Raster Geoprocessing** window. For the **Input Raster**, choose **NO2.tif** and for the **Output Extent**, choose **Chicago**.



- 3. The **Rectangle** will automatically update. Leave the **Use Input Features for Clipping Geometry** unchecked.
- 4. Click on the Folder icon next to the Output Raster Dataset

Dutput Raster Dataset	
NO2_Clip	

5. Navigate back to the project's geodatabase (.gdb) and name the file "Chicago_NO2". Click Save.

Output Raster Dataset							\times
€ () () ArcGIS Pro Tutorial	•	U	↓=	Search		Q	~
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 Project Databases Folders ArcGIS Pro Tutorial ArcGIS Pro Tutorial.gdb ArcGIS Pro Tutorial.gdb backups GpMessages ImportLog Tutorial Computer Quick access 	This c	cont	aine	Type r is empty.	Date	Modifie	ed
Name Chicago_NO2				Rasters (All L	ocal Types)	Cancel	•

6. Leave the **NoData Value** with the default and keep the **Maintain Clipping Extent** unchecked. Click **Run**.

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🕞 Run 💌

7. The new clipped Chicago_NO2 layer will appear in the Contents pane, on the Map and in the Catalog.

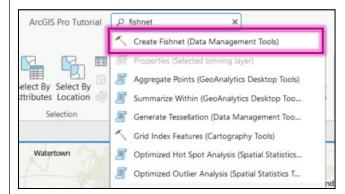


8. Remove the NO2.tif layer from the map.

Create a Fishnet (Gridded Shapefile)

Now you'll make a shapefile grid of Chicago_NO2.

1. In the Command Search type "fishnet" and select Fishnet (Data Management Tool).



2.

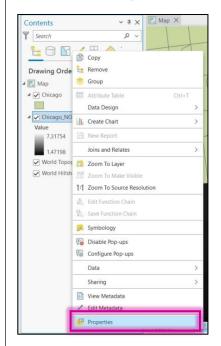
The **Create Fishnet Geoprocessing** window will appear. Next to the **Output Feature Class** click the **Folder** icon. Navigate to the **Tutorial Output** folder and name it "**ChicagoGrid.shp**". Click **Save**.

Geoproce	ssing	~ Ŧ ×
	Create Fishnet	\oplus
Parameters	Environments	?
Output Fea	ature Class	
ChicagoG	rid.shp	i

3. Under **Template Extent**, select the arrow next to **Default** and select **Chicago_NO2**. This will automatically fill in the rest of the extent, the **Y-Axis Coordinate**, and the **Opposite corner of Fishnet** groups.

* Fishnet Origin Coordinate]
Х	Υ	
 Template Extent 	Default 🗸	
← 0	Default	
• 0	Current Display Extent	
* Y-Axis Coordinate	As Specified Below	
х	Browse	
* Cell Size Width	Same As layer:	
	Chicago	
* Cell Size Height	NO2_Chicago	
* Number of Rows		

4. To find the values used in **Number of Rows** and **Number of Columns**, from the **Contents** pane, rightclick on **Chicago_NO2** and select **Properties**.



5. From the Chicago_NO2: Layer Properties pop-up window, click on the Source tab. Select the arrow to the left of Raster Information to see the number of Rows and Columns. Click OK to close out of the Layer Properties.

General					1^
Metadata	✓ Data Source			Set Data Source	1
Source	Data Type	File Geod	latabase Raster		
Elevation	Database	C:\Users\	Colleen\Documents\ArcGIS\Proj	ects\MyProject143\MyPr	
Display	Name	NO2_Clip	, ,		
Cache	Vertical Units	Meter			
Processing Templates	✓ Raster Inform	nation			l
Relates	Columns		188		
heidies	Rows		230		
	Number of Ba	nds	1		
-	Cell Size X		1000		
	Cell Size Y		1000		
	Uncompresse	d Size	337.81 KB		l.

6. Return to the Create Fishnet tab to fill in the Number of Rows and Number of Columns values.

230
188

After you fill in the Number of Rows and Columns, the Cell Size Height and Width will disappear.

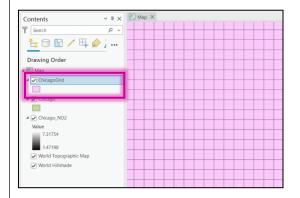
7. Under Opposite corner of Fishnet, keep the X and Y values and, uncheck the Create Label Points.

X	843000	Y	341000
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8. Under Geometry Type, select Polygon. Click Run.

Geometry Type	
Polygon	v
	🕟 Run 👻

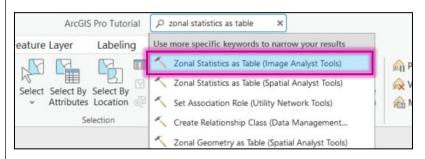
9. The new ChicagoGrid shapefile layer will appear on the Map and in the Contents pane.



Zonal Statistics as Table

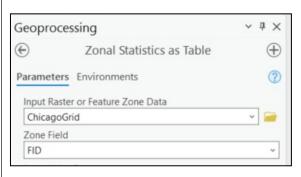
Now you'll want to translate the values of the gridded **Chicago_NO2** raster dataset to the **ChicagoGrid** layer.

1. In the Command Search, type "zonal statistics as table" and select Zonal Statistics as Table (Image Analyst Tools or Spatial Analyst Tools)



Depending on your ArcGIS Pro License, this could determine which tools you have access to and which one you select

2. In the **Zonal Statistics as Table Geoprocessing** window, for **Input Raster or Feature Zone Data**, choose **ChicagoGrid** and for **Zone Field**, select **FID**.



3. For the Input Value Raster select Chicago_NO2 and keep the default name for Output Table as ZonalSt_Chicago (or ZonalSt_Chicago1). Click in the box of the Output Table to confirm it is being saved in the project'sgeodatabase. If not, use the Folder to navigate to it.

Input Value Raster	
Chicago_NO2 ~	
Output Table	
Tutorial\ArcGIS Pro Tutorial.gdb\ZonalSt Chicago	

4. Use the arrow to drop down the **Statistics Type** menu and select **Mean**. Leave **Calculate Circle Statistics** and **Process as Multidimensional** unchecked. **Click Run**.

Mean	
Calculate Circular Statistics	
Process as Multidimensional	
_ Process as multidimensional	Run

5. The ZonalSt_Chicago table will appear in the Contents pane under Standalone Tables.

Co	ontents	~	ņ	×
7	Search		Q	×
1		- 6		•
C	Drawing Order			
4	🚺 Map			
4	ChicagoGrid			
4	Chicago			
.4	Chicago_NO2			
	Value			
	7.31754			
	World Topographic Ma	p		
	✓ World Hillshade			
4	Standalone Tables			
	ZonalSt_Chicago			

Join

Now you'll want to join the values of the **ZonalSt_Chicago** table to the **ChicagoGrid** layer.

1. From the **Contents** pane, right-click on **ChicagoGrid** and select **Joins and Relates** and then click **Add Join**.

Clipboard	Navigate 🖬	Layer
Contents	🖺 Сору	
Y Search	Ex Remove	
Search	ᡷ Group	
E 🖯 🖌	Attribute Table Ctrl+T	
Drawing Orde	Data Engineering Ctrl+Shift+D	
-	Add Error Layers	
Map	Data Design	>
Chicagoond		
▲ 🖌 Chicago	Create Chart	>
- Chicago	New Report	
A Chicago_NO	Joins and Relates	> 🕅 Add Join
Value	Zoom To Layer	Remove Join
7.31754	🕅 Zoom To Make Visible	Remove All Joins
1.47198	Selection	> 🛃 Add Spatial Join
World Topog	💫 Label	Add Relate
Vorld Hillsh	Labeling Properties_	Remove Relate
✓ Standalone Tab	Convert Labels	> Remove All Relates
IIII ZonalSt_Chi	Symbology	
	Disable Pop-ups	
	强 Configure Pop-ups	
	Data	>
	Sharing	>
	View Metadata	
	 View Metadata Zdit Metadata 	

2. A new Add Join pop-up window will appear. For the Input Table, select ChicagoGrid if it did not default to that already. For the Input Join Field, choose FID.

Add Join	? ×
Input Table	
ChicagoGrid	* 📔
🚯 Input Join Field	
FID	*

3. For Join Table, select ZonalSt_Chicago and the Join Table Field, as FID. Leave Keep All Target Features checked, and Index Joined Fields unchecked. Click OK.

loin Table Field	
FID	
 Keep All Target Features 	
Index Joined Fields	

4. Confirm the join worked by looking at the **ChicagoGrid Attribute Table**. In the **Contents** pane, rightclick on **ChicagoGrid** and select **Attribute Table**.

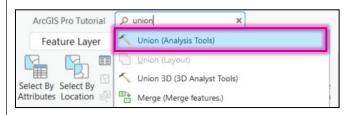
Clipboard		Navigate	2	Lay
Contents Y Search		Copy Remove Group		
1 🗄 🖸 🕅 🦯 E		Attribute Table	Ctrl+T	
Drawing Order	1.000	Data Engineering Add Error Layers	Ctrl+Shift+D	
ChicagoGrid		Data Design		>
	h	Create Chart		>

5. You will see that each attribute from the grid now contains the value from the **Chicago_NO2** raster layer as indicated by the **MEAN** column.

Field: 📰 Add 🕎 Calculate Selection: 🎬 Select By Attribu								Attribute
4	FID	Shape	Id	OBJECTID *	FID	COUNT	AREA	MEAN
1	0	Polygon	0	1	0	1	1000000	1.521538
2	1	Polygon	0	2	1	1	1000000	1.488406
3	2	Polygon	0	3	2	1	1000000	1.502382
4	3	Polygon	0	4	3	1	1000000	1.521614
5	4	Polygon	0	5	4	1	1000000	1.519743

Union

1. You'll want to calculate how much of each census tract is within each grid cell of **ChicagoGrid**. In the **Command Search**, type "union" and select **Union (Analysis Tools)**.



2. In the **Union Geoprocessing** window, the **Input Features** will be **Chicago** and **ChicagoGrid**. Use the default **Chicago_Union**.

Ge	oprocessing			~ 4 ×
O		Union		\oplus
Par	ameters Environr	nents		(?)
In			Ranks	U U
In	put Features 📀 Chicago	v 🚝	Ranks	
In			Ranks	

3. From the **Output Feature Class**, click on the box to see the file's output location. Make sure it is <u>the</u> <u>project geodatabase</u>. Keep the default **Chicago_Union** name.



4. Keep the Attributes To Join as All Attributes and keep Gaps Allowed checked. Click Run.

Attributes To Join	
All attributes	~
Gaps Allowed	

5. A new Chicago_Union layer will appear on the map and in the Contents pane.

Calculate Area

1.

Next, you'll calculate the area of each of the individual pieces of the census tract from **Chicago_Union**. Open the **Chicago_Union Attribute Table** and select the **Add** icon.

Chicago_Union X							
Fiel	d: 📰 Add	🔄 Calculate					
- 24	OBJECTID *	Shape *	FID_W				
1	1	Polygon					
2	2	Polygon					
3	3	Polygon					
4	4	Polygon					
5	5	Polygon					
6	6	Polygon					
7	7	Polygon					
8	8	Polygon					
0	~						

- Name the Field Name "CT_Area" which stands for "Census Tract Area". Double-click on the Data Type and select Double. Double-click in the blank box in the Number Format column, then click on the three dots that appear and select Numeric.
 - 28

Currer	nt Layer	Chicago_U	nion •					
	Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format
			ZonalSt_Chicago_OBJECTID	OBJECTID	Long	~		Numeric
	 Image: A start of the start of		ZonalSt_Chicago_FID	FID	Long	~		Numeric
			ZonalSt_Chicago_COUNT	COUNT	Double	~		Numeric
			ZonalSt_Chicago_AREA	AREA	Double	1		Numeric
			ZonalSt_Chicago_MEAN	MEAN	Double	~		Numeric
		 Image: A start of the start of	Shape_Length	Shape_Length	Double	V		Numeric
		~	Shape_Area	Shape_Area	Double	~		Numeric
Г			CT_Area		Double			Numeric

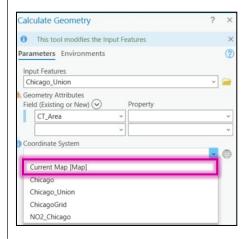
3. After selecting **Numeric**, a **Number Forma**t pop-up window will appear. Keep the default settings and select **OK**.

lumber Format			×
Category Numeric		•	
Rounding			
Decimal places	6	Ŷ	
O Significant digits	6		
Alignment • Left			
O Right	12		
Show thousands see Pad with zeros Show plus sign	eparators		
Suffix (optional)		•	
General options for the	display of	numbers	
		ОК	Cancel

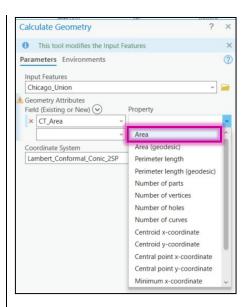
- 4. To save the changes, either right-click on the **CT_Area** row and select **Save** or exit out of the **Fields:Chicago_Union** and select **Save**.
- 5. From the Chicago_Union Attribute Table, scroll over to locate the CT_Area column. Right-click on the CT_Area column header and select Calculate Geometry.

	↑ Sort Ascending
-+-	↓ ↓ Sort <u>D</u> escending
	Custom Sort
	Hide Field
+	Freeze/Unfreeze Field
	Calculate Field
	Calculate Geometry
	Statistics
-T	5 Summarize
es; 0 1	Fields
	🕎 Delete
a CT_A	rea ^
8 <n< td=""><td>uli > 0</td></n<>	uli > 0
8 <n< td=""><td>-11</td></n<>	-11
8 <n< td=""><td>ull></td></n<>	ull>
	ter al la

6. In the pop-up Calculate Geometry window, under Coordinate System select Current Map [Map].



7. After selecting this, the **Coordinate System** will say **Lambert_Conformal_Conic_2SP** which is the projection of the data. Then from the **Geometry Attributes**, drop down the menu under **Property** and select **Area**.



8. For the Area Unit, select Square Kilometers since this is the unit the gridded data is in. Click OK.

	This tool modifies the Input Features		
a	meters Environments		
101	ut Features		
-	nicago_Union	~	
iec	ometry Attributes		Ĩ
iel	ld (Existing or New) 📀 Property		
	CT_Area ~ Area		
	×		
re	a Unit		
S	quare Kilometers	_	
	iquare Kilometers Iectares		
Н		_	
H	lectares		
H S S	lectares iquare Meters	_	
H S S S	lectares iquare Meters iquare Statute Miles		
H S S Ir	ectares iquare Meters iquare Statute Miles iquare International Nautical Miles		
H S S Ir S	ectares iquare Meters iquare Statute Miles iquare International Nautical Miles nternational Acres		
H S S Ir S	ectares iquare Meters iquare Statute Miles iquare International Nautical Miles nternational Acres iquare International Yards		
H S S Ir S S S	ectares iquare Meters iquare Statute Miles iquare International Nautical Miles nternational Acres iquare International Yards iquare International Feet		
H S S Ir S S S S	eccares iquare Meters iquare Statute Miles iquare International Nautical Miles nternational Acres iquare International Yards iquare International Feet iquare US Survey Miles		
H S S Ir S S S S U	eccares iquare Meters iquare Statute Miles iquare International Nautical Miles nternational Acres iquare International Yards iquare International Feet iquare US Survey Miles iquare US Survey Nautical Miles		

We are using Square Kilometers to match the units of the gridded data

9. The CT_Area column will be filled with the area.

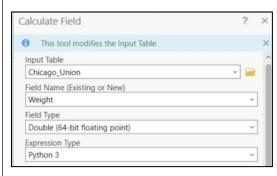


Note that the column appears with a lot of 1s. These 1's are just the area of the grid boxes that did not contain any census tracts. Right click on the **CT_Area** header to sort the data or click anywhere on the map within the Chicago metropolitan area and you will see the **CT_Area** in the pop-up window.

10. Now you'll calculate the weight of each area by multiplying the **CT_Area** with the **MEAN**. Select **Calculate** from the **Chicago_Union Attribute Table**

	Chicago_Uni	on X	
Fie	ld: 📰 Add	📳 Calcu	late
	OBJECTID *	Shape *	FID_W
1	1	Polygon	
2	2	Polygon	
3	3	Polygon	

11. In the Calculate Field pop-up window, under Field Name, type "Weight". For the Field Type, select Double (64-bit floating point). If there is no Field Type box, click out of Field Name and then the box will appear. Keep the Expression Type, Python 3.



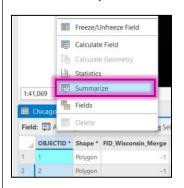
12. From Fields, double click on CT_Area. Then, click on the * next to Insert Values. Lastly, from Fields double-click on MEAN (it will fill in the Weight as ZonalSt_Chicago_Mean). The expression will be under the Weight =. Select Apply then OK.

FID COUNT AREA	 .as_integer_ratio() .capitalize() .center() 	Î
MEAN Shape_Length Shape Area CT_Area	.conjugate() .count() .decode() .denominator()	~
Insert Values	* * / + - =	
Weight =		
<pre>!CT_Area!*!ZonalSt</pre>	:_Chicago_MEAN!	

13. The new Weight column will be calculated and added to Chicago Union.

Summary Statistics

1. From the Chicago_Union Attribute Table, right-click on OBJECTID and select Summarize. This tool will allow you to calculate the sum of the CT_Area and Weight for each census tract from all of the individual parts.



2. In the **Summary Statistics** pop-up window, ensure that the **Input Table** is **Chicago_Union**. For the **Output Table**, ensure the output path is the geodatabase and change the **Output Table** name to **Statistics**.

Summary Statistics	?	×
Input Table		
Chicago_Union	× 📔	
1 Output Table		
Statistics	<u></u>	

3. For Fields, select CT_Area and Weight and for the Statistic Type choose Sum for both. For the Case Field select GEOID. Click OK.

Field 🕑	Statistic Type	
CT_Area	~ Sum	
Weight	~ Sum	
	~	
Case Field 😔		
GEOID		,

4. The **Statistics** table will appear in the **Contents** pane under the **Standalone Tables**. Right-click on it and select **Open Table** and click **Calculate**. *Note: values may be rounded differently than below.*

Fi	eld: 📰 Add	Calculate	Selection: 🖷	Select By Attribu	utes 🕀 Zoon
	OBJECTID *	GEOID	FREQUENCY	SUM_CT_Area	SUM_Weight
1	1		19139	18688.701689	39664.692038
2	2	17031010100	4	0.375906	2.217005
3	3	17031010201	3	0.499351	2.971086
4	4	17031010202	3	0.348195	2.069019
5	5	17031010300	2	0.467236	2.781852
6	6	17031010400	5	1.139676	6.814355
7	7	17031010501	2	0.200085	1.197478

The FREQUENCY is how many portions of a grid cells fell within the census tract and was used in the calculation

5. In the Calculate Field pop-up window, for the Input Table, make sure it is Statistics. For the Field Name (Existing or New), type "NO2". Change the Field Type to Double (64-bit floating point). Keep the Expression Type, Python 3.

Calculate Field	?	×
This tool modifies the Input Table		×
Input Table		^
Statistics	× 🚞	
Field Name (Existing or New)		
NO2	v	
Field Type		
Double (64-bit floating point)	~	
Expression Type		
Python 3	~	

 From Fields, double click on SUM_Weight. Then, click on the / next to Insert Values. Lastly, from Fields double-click on SUM_CT_Area. The expression will be under the NO2 =. Select Apply then OK.

OBJECTID GEOID FREQUENCY	.as_integer_ratio() .capitalize() .center()	Î
SUM_CT_Area	.conjugate()	
SUM_Weight	.count() .decode() .denominator()	~
Insert Values	* / + - =	
NO2 =		
!SUM_Weight!/!SUM_CT_Are	a!	_

7. After the calculation is performed, you'll see the new column **NO2** appear in the **Statistics** table. *Note: Calculated values may be different.*

Fi	eld: 🗊 Add	Calculate	Selection:	Select By Attribu	utes 🥷 Zoom	To to S
4	OBJECTID *	GEOID	FREQUENCY	SUM_CT_Area	SUM_Weight	NO2
1	1		19139	18688.701688	39664.692038	2.122389
2	2	17031010100	4	0.375906	2.217005	5.897761
3	3	17031010201	3	0.499351	2.971086	5.949897
4	4	17031010202	3	0.348195	2.069019	5.942121
5	5	17031010300	2	0.467236	2.781852	5.953841
6	6	17031010400	5	1.139676	6.814355	5.979204
7	7	17031010501	2	0.200085	1,197478	5.984856
8	8	17031010502	4	0.178555	1.07022	5.993769
0		+703+0+0503	~		4 4 6 7 9 9 1	6.074070

The first row is missing a GEOID since these are all the grid cell pieces that did not overlap with a census tract.

8. Now you'll **Join** the together the **Statistics** table with **Chicago**. In the **Contents** pane, right-click on **Chicago** and select **Joins and Relates** and then **Add Join**. Change the **Input Join Field** to **GEOID** and the **Join Table** to **Statistics**. Click **OK**.

Add Join	? ×
Input Table	
Chicago	~ 🧎
Input Join Field	
GEOID	×
Join Table	
Statistics	× 🚞
Join Table Field	
GEOID	~
✓ Keep All Target Features	
Index Joined Fields	

9. Open the **Chicago Attribute Table** and slide down to the end of the columns. You will see all the **Statistics** table attributes here.

Field:	Add 🕎 C	alculate Selec	tion: 🚰 Select By A	Attributes 🝭 Zoo	m To 📲 Swi	tch 🗐 Cle	sar 🜄 Delete 🛔				
LAND	AWATER	INTPTLAT	INTPTLON	Shape_Length	Shape_Area	OBJECTID	GEOID	FREQUENCY	SUM_CT_Area	SUM_Weight	NO2
1 9507162	3172636	+42.5153483	-087.8351198	0.237911	0.002485	2200	55059002000	36	22.635245	75.569508	3.33857
2 0280451	998001	+42.5733633	-088.0883291	0.146625	0.001237	2212	55059002905	20	11.256221	29.538533	2,62419
3 3 344186	89863	+42.6314748	-087.9098880	0.384812	0.00762	2185	55059000601	91	69.296221	213.880614	3.08640
4 0850687	1352074	+42.5202466	-088.0919354	0.228247	0.002433	2213	55059002906	37	22.159242	59.064172	2.66544
5 868039	0	+42.5805617	-087.8335364	0.049517	0.000095	2191	55059001100	6	0.866325	2.927174	3.37884
6 1788285	0	+42.5827909	-087,8473597	0.061877	0.000196	2192	55059001200	7	1.78476	5.898261	3.30479
7 1841178	0	+42.5848766	-087.8694898	0.071439	0.000202	2193	55059001300	5	1.837542	6.018014	3.27503
8 3734444	0	+42.5743054	-087.8718516	0.086706	0.000409	2194	55059001400	8	3.727073	12.062958	3.23657
0 1110000			007.050000	0.0077704	0.000455			-		107010	

Save as a Shapefile

1. Now that all the data is calculated, the next step is the save this as a new shapefile. From the **Contents** pane, right-click on **Chicago**. Select **Data** and **Export Features**.

Contents Search	_	Copy Remove Group							
Drawing Orc		Attribute Table Data Engineering	Ctrl+T Ctrl+Shift+D						
Map		Add Error Layers Data Design		>					
Chicago ChicagoGi ChicagoGi		Create Chart New Report		>					
NO2_Chic World Top		Joins and Relates Zoom To Layer		>					
World Hill Standalone T ZonalSt_f	Selection			>	_ III Statistics III Chicag				
E Statistics		Label Labeling Properties Convert Labels		>	TEFP	COL		TRACTCE	G
	-	Symbology Disable Pop-ups				059 059 059		002000 002905 000601	55
		Configure Pop-ups		>		059 Expo	rt Featu	002906	55
		Sharing View Metadata		>		Ехро	rt Table atch Ado		
	/	Edit Metadata Properties			-		ata Sou		

2. Make sure the **Input Features** is **Chicago**. For the **Output Feature Class**, click on the **Folder** icon. Navigate back to the **Tutorial Output** folder and name it "**Chicago_NO2.shp**".

Export Features	? ×
Parameters Environments	(?)
Input Features	
Chicago	× 🚞
Output Feature Class	
Chicago_NO2.shp	
> Filter	
> Fields	
> Sort	

3. Click **OK**. The new **Chicago_NO2** shapefile will be added to the **Contents** pane and the Map. **Remove** all other layers and tables except for **Chicago_NO2** (You may leave World Topographic Map and World Hillside).

Contents ♥ × Image:	Search P Image: Search P Image: Search P Image: Search Image: Search Im	7	
Image: Second secon	Image: Second secon	Contents v 1	A X Map X
Drawing Order	Drawing Order	Search P	
Chicago_NO2 World Topographic Map	Chicago_NO2 World Topographic Map		
Chicago NO2 World Topographic Map	Chicago_NO2 World Topographic Map		PLATER TRA
		Map Chicago_NO2 World Topographic Map	

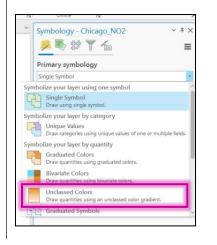
Symbology

Now that you have allocated the gridded NO₂ data onto the Chicago metropolitan area census tracts, it is time to map it. In this section of the tutorial, you will have your own creative freedom to design the map however you'd like. You'll step through different techniques and methods to help make your map visually appealing.

1. Right-click on the Chicago_NO2 layer in the Contents pane and select Symbology.

Contents v a Search p La Contents v a Drawing Order Map	E Remove	
 Chicago_NO2 	Data Design	>
	Create Chart	>
World Topographic Map World Hillshade	🗎 New Report	
U world Hillshade	Joins and Relates	>
	🛤 Zoom To Layer	
	Zoom To Make Visible	
	Selection	>
	🔊 Label	
	Labeling Properties	
	Convert Labels	>
	🔀 Symbology	
	Disable Pop-ups	
	Configure Pop-ups	
	Data	>
	Sharing	>
	View Metadata	
	🖌 Edit Metadata	
	Properties	

2. In the **Symbology** pane, click the arrow under **Primary symbology** to see the various mapping options. Select **Unclassed Colors**.



3. For the **Field**, select **NO2** and change the **Color scheme** to one that you like. For this example, I picked **Viridis**.

Primary syml		≡
Unclassed Colo	rs	•
Field	NO2	• ×
Normalization	<none></none>	
Color scheme		均 •
Upper label	1.7	
Lower label	7.2	
Template		

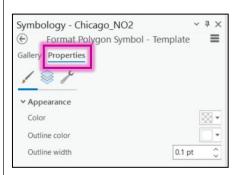
4. Your map will plot the **NO2** values by color.

Contents	~ # ×	Map ×	
Y Search	~ م		
<u>t</u> 🗇 🕅 / 🛱 🆉	i		
Drawing Order			
🔺 🂽 Map			
Chicago_NO2		一 医洪道道道	
NO2 7.2 World Topographic Map World Hillshade			

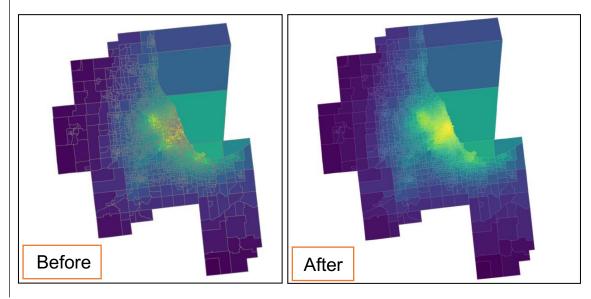
5. The thickness of the census tract border makes it difficult to see the details on the map. To change this, click the **square icon** to the right of **Template**.

<u>></u> 🔊 1			≡
Primary sym	bology		
Unclassed Colo	rs		
Field	NO2	•	X
Normalization	<none></none>	-	
Color scheme		•	嶽
Upper label	1.7		
Lower label	7.2		
Template			

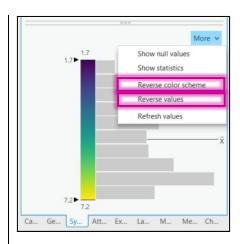
6. Under **Properties**, you can change the **Outline color** and **Outline width**. For this example, I changed the **Outline Color** to white and the **Outline width** to 0.1 pt. Click **Apply** to show these changes on the map.



7. The map will update.



8. Notice in the **Contents** pane that the low values are labeled at the top of the color bar and the high values are labeled at the bottom. You can easily switch this by clicking **More** in the lower **Symbology** pane. Then select **Reverse color scheme** and **Reverse values**.



9. The map will stay the same, but the labels on the color bar will switch so the large number is on the top.

Co	ontents	~	д	×
٣	Search		Q	~
	<u>t</u> e © 🛛 ∕ Щ 🤌	1		
0	Drawing Order			
4	🚺 Map			
4	Chicago_NO2			
	NO2			
	7.2			

Hiding Attributes

- 1. Open the Chicago_NO2 Attribute Table. Right-click on one of the column headers and select Fields.
- 2. Under the **Visible** column, I am choosing to select **Shape**, **GEOID**, **NAME**, and **NO2** to be visible. You may or may not want to select more attributes to be visible.

CL	irrent Layer	Chicago_N	102	
1	Visible	Read Only	Field Name	Alias
			FID	FID
			Shape	Shape
			STATEFP	STATEFP
			COUNTYFP	COUNTYF
I			TRACTCE	TRACTCE
	~		GEOID	GEOID
			NAME	NAME

Note that **Shape** and **Name** must be selected in order to export the map in the next step

3. In the NO2 row, click on the three dots next to Numeric.

			NO2	NO2	Double			Numeric	
--	--	--	-----	-----	--------	--	--	---------	--

4. In the **Number Format** pop-up window, under **Rounding**, change the **Decimal places** to "2" and click **OK**.

Category Numeric		-	
Rounding			
Decimal places	2	0	
Significant digits	2	0	
Right	0	\$	
C Left		^	
	maratore		
Show thousands se	eparators		
 Show thousands see Pad with zeros Show plus sign 	eparators		
Pad with zeros		Ŧ	

5. Exit out of the **Fields:Chicago_NO2** table and **Save** the updates. To see the changes, click on any census tract polygon from the map to open the attribute pop-up window.

Ρ	op-up		~ 🗆 ×
С	hicago	_NO2 - 8810.07	
	GEOID	17197881007	
	NAME	8810.07	
	NO2	3.34	

Export Map as a Web Layer

1. Now we will export the map as a web layer so it can be used online in various applications like EJSCREEN for example. From the **Contents** pane, right-click on **Map** and select **Properties**.

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2. Under General, check the box next to Allow assignment of unique numeric IDs for sharing web layers. Select OK.

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3. Right-click on Chicago_NO2. Select Sharing and then Share As Web Layer.

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4. In the **Share As Web Layer** window to the right of the map, give the web layer a **Name**, write a brief **Summary** and a few **Tags.** Click **Analyze.** If no errors or warnings are found, click **Publish**.

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5. Open a web browser to view your ArcGIS **Content** tab. (At UW Madison this can be found at <u>https://uw-mad.maps.arcgis.com/home/index.html</u>

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6. Here you will see the Chicago_NO2 web layer we just published. Right now, the sharing level is Owner only. You can change this by clicking on the icon, but this is not required to port or view map in **EJScreen**.

Chicago_NO2	🧕 Feature Layer (hosted) 🔻	Ô
Chicago_NO2	Service Definition	ô

7. Click on the **Chicago_NO2 Feature Layer (Hosted**). Scroll to the bottom of the page and locate **URL**. Copy the **URL**.

URL	🖸 View
https://services.arcgis.com/HRPe58bUyBc	Ê

EJScreen

1. In a new tab, go to <u>https://www.epa.gov/ejscreen</u> and Launch the EJScreen Tool.



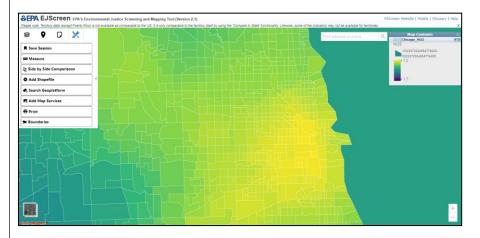
2. Click on the Tools icon and select Add Map Services.



3. In the Add Map Services pop-up window, paste the URL from the published NO2_Chicago web layer. Select Add to Map.



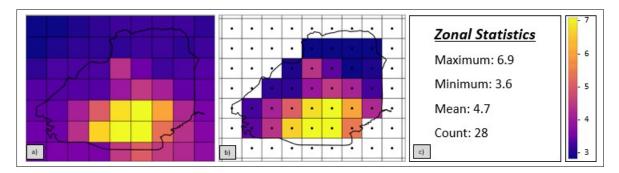
4. The Chicago_NO2 map will be added.



FAQ

Q: Why don't we use Zonal Statistics as Table to directly calculate the census tract average value?

A: **Zonal Statistics as Table** is a great tool and sometimes a great solution. However, this all depends on the type of data that is being used. Zonal Statistics works by finding the centroid of each grid cell and uses that to assign a value to the polygon. Since there are census tracts that are smaller than 1km, sometimesthe gridded data's centroid doesn't fall within the census tract polygon and therefore no calculation is made. Other times, in larger polygons such as counties, the polygon boundary may include many grid cells but not the centroid of each grid cell.



Example demonstrating zonal statistics calculations. a) An example of a gridded dataset over a polygon. b) the black dots represent the center of the grid cell, and the white cells are excluded from calculations as the center does not fall within the polygon. c) The statistics are calculated. In this example 28 cells were used in the calculation.

Q: Why can't we resample the 1km x 1km data to ensure there is a centroid in each census tract?

A: While resampling the data to a finer grid would ensure that every cell has a centroid, this would introduce errors and uncertainties in the data, which are already gridded to the highest resolution appropriate for the satellite dataset.

Appendix A

Data

The data folder for this tutorial contains the 2019 census tract shapefiles for Illinois, Indiana, and Wisconsin, the U.S. Metropolitan and Micropolitan area. These files were downloaded from the U.S. Census Bureau, <u>https://www.census.gov/cgi-bin/geo/shapefiles/index.php</u>, originally as "tl 2019, 17 tract" "tl 2019, 18 tract" "tl 2019, 55 tract" "tl 2019, us chea" but the names were

"tl_2019_17_tract", "tl_2019_18_tract", "tl_2019_55_tract", "tl_2019_us_cbsa", but the names were changed to Illinois, Indiana, Wisconsin and CBSA before being added to the data folder for this tutorial.

	Census Tract Shapefile (Illinois, Wisconsin, Indiana)						
Field	Length	Туре	Description				
STATEFP	2	String	Current state Federal Information Processing Standards (FIPS) code				
COUNTYFP	3	String	Current county FIPS code				
TRACTCE	6	String	Current census tract code				
GEOID	11	String	Census tract identifier; a concatenation of Current state FIPS code, county FIPS code, and census tract code				
NAME	7	String	Current census tract name, this is the census tract code converted to an integer or integer plus 2-character decimal if the last two characters of the code are not both zeros.				
NAMELSAD	20	String	Current translated legal/statistical area description and the census tract name				
MTFCC	5	String	MAF/TIGER feature class code (G5020)				
FUNCSTAT	1	String	Current functional Status				
ALAND	14	Number	Current land area				
AWATER	14	Number	Current water area				
INTPTLAT	11	String	Current Latitude of the internal point				
INTPTLON	12	String	Current Longitude of the internal point				

Source: TIGER/Line Shapefiles Technical Documentation

	Metropolitan Statistical Area/Micropolitan Statistical Area (CBSA)						
Field	Length	Туре	Description				
CSAFP	3	String	Current combined statistical area code, if applicable				
CBSAFP	5	String	Current metropolitan statistical area/micropolitan statistical area code				
GEOID	5	String	Metropolitan statistical area/micropolitan statistical area identifier, metropolitan statistical area/micropolitan statistical area code				
NAME	100	String	Current metropolitan statistical area/micropolitan statistical area name				
NAMELSAD	100	String	Current name and the translated legal/statistical area description for metropolitan statistical area/micropolitan statistical area				
LSAD	2	String	Current legal/statistical area description code for metropolitan statistical area/micropolitan statistical area				
MEMI	1	String	Current metropolitan/micropolitan status indicator				
MTFCC	5	String	MAF/TIGER feature class code (G3110)				
ALAND	14	Number	Current land area				
AWATER	14	Number	Current water area				

INTPTLAT	11	String	Current Latitude of the internal point
INTPTLON	12	String	Current Longitude of the internal point

Source: TIGER/Line Shapefiles Technical Documentation

The **NO2.tif** provides a 2019 average of the tropospheric vertical column density (VCD) of NO₂ from the TROPOMI instrument. These data have a native resolution of 3.5 km x 7 km (January – August 2019) and 3.5 km x 5 km (August – December 2019) and were regridded to 1 km x 1 km using the Wisconsin Horizontal Interpolation Program for Satellites (WHIPS, <u>https://sage.nelson.wisc.edu/data-and-models/wisconsin-horizontal-interpolation-program-for-satellites-whips/</u>). TROPOMI NO₂ data were filtered with a quality assurance value of 0.75 or greater. More information about TROPOMI NO₂ can be found in the product User Manual (<u>https://sentinel.esa.int/documents/247904/2474726/Sentinel-5P-Level-2-Product-User-Manual-Nitrogen-Dioxide.pdf</u>).

Citing the Data

The following are citations for the datasets:

2019 TIGER/Line Shapefiles (machine readable data files) / prepared by the U.S. Census Bureau, 2019

We wish to thank the University of Wisconsin-Madison for the use and development of the Wisconsin Horizontal Interpolation Program for Satellites (WHIPS). WHIPS was developed by Tracey Holloway, Jacob Oberman, Peidong Wang, Eliot Kim, and other students and staff, with funding from the NASA Air Quality Applied Science Team (AQAST), the NASA Health and Air Quality Applied Sciences Team (HAQAST), and the State of Texas Air Quality Research Program (AQRP).

Appendix B

Where to Download Satellite Data for Air Quality

Gridded tropospheric NO2 from OMI and TROPOMI instruments, from 2006 onward

https://sage.nelson.wisc.edu/data-and-models/datasets/satellite-data-for-air-quality/

Gridded estimates of surface PM2.5

https://sites.wustl.edu/acag/datasets/surface-pm2-5/

As more satellite data for air quality become available, we do our best to keep an up-to-date list of products on the Holloway Group page,

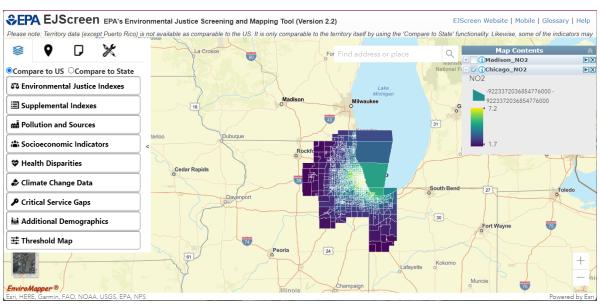
https://hollowaygroup.org/data-models

Additional NASA and satellite-related products can be found through HAQAST, https://haqast.org/data-and-tools/

Appendix C

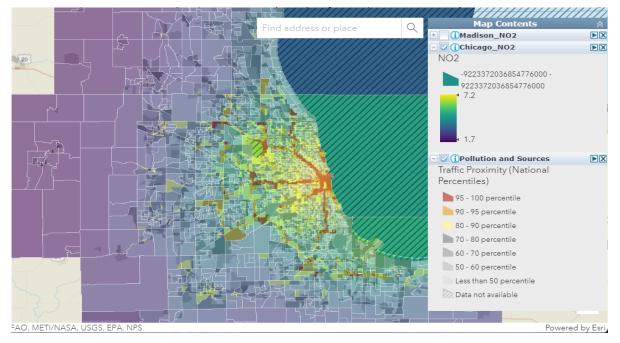
EJScreen

The Environmental Protection Agency (EPA) created an online mapping tool that allows users to visualize environmental and demographic socioeconomic indicators in a selected area within the U.S.



https://www.epa.gov/ejscreen/what-ejscreen

EJScreen Homepage (with created map layer)



Example of EJScreen "Traffic Proximity" layer and created map layer "Chicago_NO2."

Glossary

CBSA	Core-Based Statistical Area
Coordinate System (Geographic)	Uses latitude and longitude to identify locations.
Coordinate System (Projected)	Used feet and meters to express x and y coordinates.
Double (64-bit floating point)	How many bits represent a floating-point number.
Geodatabase	Primary data structure for ArcGIS and used for editing and data management.
NetCDF File	Network Common Data Form. Support sharing of array-oriented scientific data.
Raster file	Spatial data models that define space as an array of equally sized cells, arranged in rows and columns, and composed of single or multiple bands.
Shapefile	A simple, nontopological format for storing the geometric location and attribute information of geographic features.
TIFF	"Tag Image File Format," computer file for storing raster graphics and other image related information. TIFF files are more complex than shapefiles.
ТКОРОМІ	Tropospheric Monitoring Instrument aboard the Copernicus Sentinel-5 Precursor satellite. Collects data on trace gases and aerosols.
VCD	Vertical Column Density, useful in interpreting the concentration of trace gases.