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EARS 77 - Environmental Applications of GIS
Professor Jonathan Chipman
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Lab 3 Report - Climate change and Arctic sea ice

The main objective of this lab was to use ArcGIS Pro to map the extent of Arctic sea ice at the North Pole from 1979-2023 and analyze how the areal extent/concentration of sea ice has changed over time (due to climate change). We used raster grids of monthly mean ice concentrations every year of the study's time period from the US National Snow and Ice Data Center (NSIDC), and specifically looked at the data sets from each month of March and September (the high and low points of annual sea ice extent fluctuations).

Before any analysis of the spatiotemporal patterns of the sea ice concentration, I first had to complete a few steps of data preparation, and used the following process in Model Builder (Figure 7): First, I had to mask out all non-ocean, non-ice grid cells, setting them all to null with the conditional spatial analyst tool. I then set the input and output files as parameters, allowing for user-specification. I then added an Iterator to the model to be able to iterate through each raster grid from each year. Second, I had to reproject the data to an equal-area map coordinate system using the Projections and Transformations tool and specify the metrics (cell sizes, resampling technique, registration point) and the name of our preferred output coordinate system. Third, I used spatial interpolation to correct for the polar data gap based on surrounding ice concentration values. To do so, I created a polygon around the polar data gap, extracted the area from the reprojected ice concentration layer using the Extract by Mask tool, converted this extracted data from raster grid format to vector points, and then interpolated between the points with IDW (Inverse Distance Weighting) to fill in the data gap. After this preparation, I moved onto spatial analysis and map/graph creation.

To find the 45-year average September ice concentration in each grid cell, I used the Cell Statistics tool to find the mean. The output of this step is a map of the North Pole (Figure 1) where white pixels represent high average concentrations (%) of ice and blue pixels represent low average concentrations. Based on this map, I'd expect the ice to last the longest further inland, towards Greenland, as the ice concentrations are highest on Greenland's coast (I also added contours based on ice concentrations). Then, to find the change in ice concentrations between time periods, I used the Cell Statistics tool to find the mean ice concentrations between 1979-1983 and 2019-2023, and subtracted the former from the later in the Raster Calculator. The output of this is a map of the percent change of ice concentrations in the area, centered on 1981-2021. Here, white pixels represent areas of low change of ice concentrations, red pixels represent ice loss, and blue pixels represent ice gain (Figure 2). I then used the Band Collection Statistics tool to create a graph, charting Year vs Area of Arctic Ice Extent in September (km^2), and added a trend line (Figure 3). Lastly, using a given python script, I repeated each step for the March data set, and created the same figures with this new data (Figures 4, 5, 6). The graphs representing Year vs Area of Arctic Ice Extent for both September and March showed steady

downward linear trends, indicating a decrease in ice extent between 1981 and 2021, as we expected.

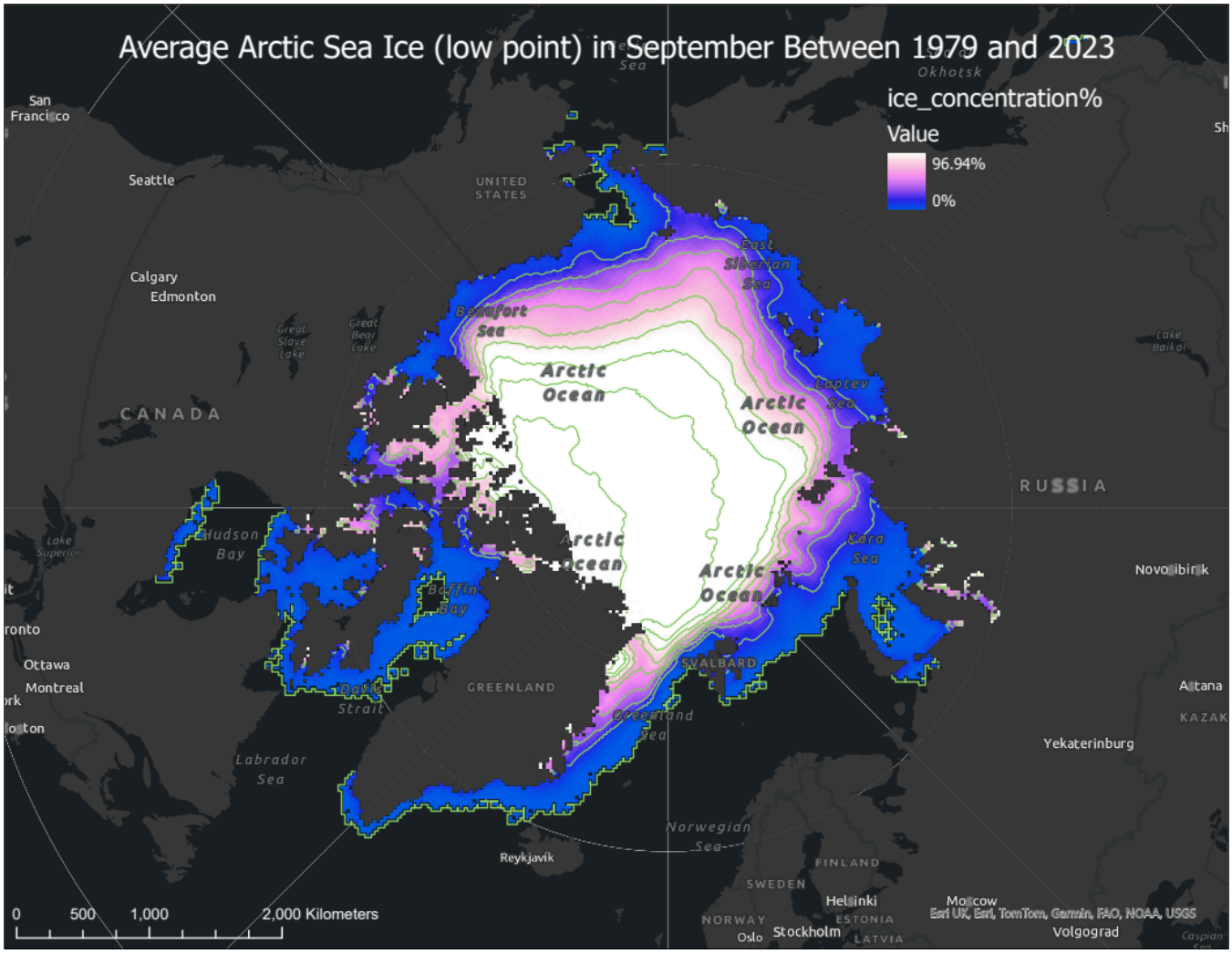

Figure 1: Average Arctic Sea Ice in September (low point) between 1979-2023.

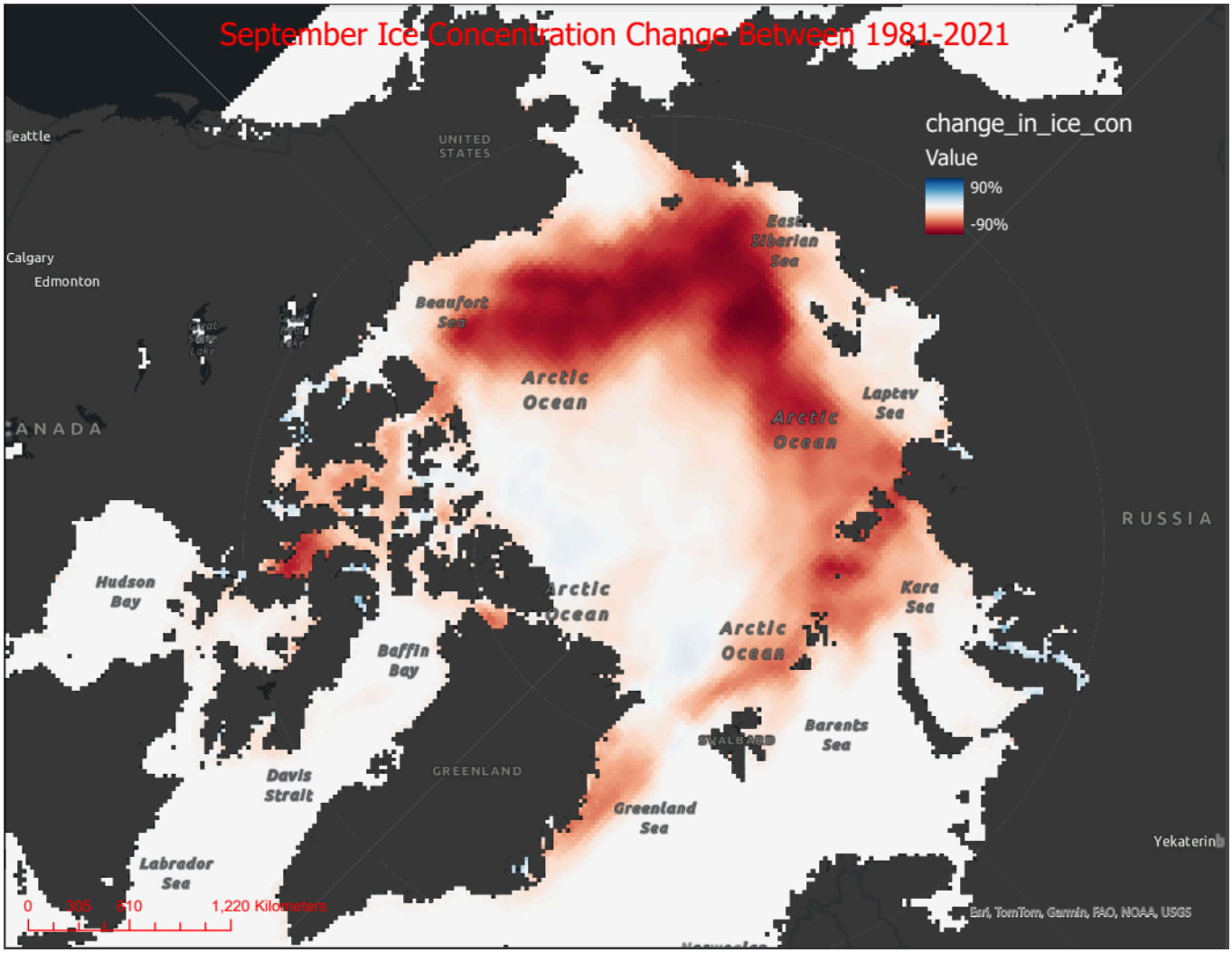

Figure 2: Change (%) in September Ice Concentration between 1981-2021.

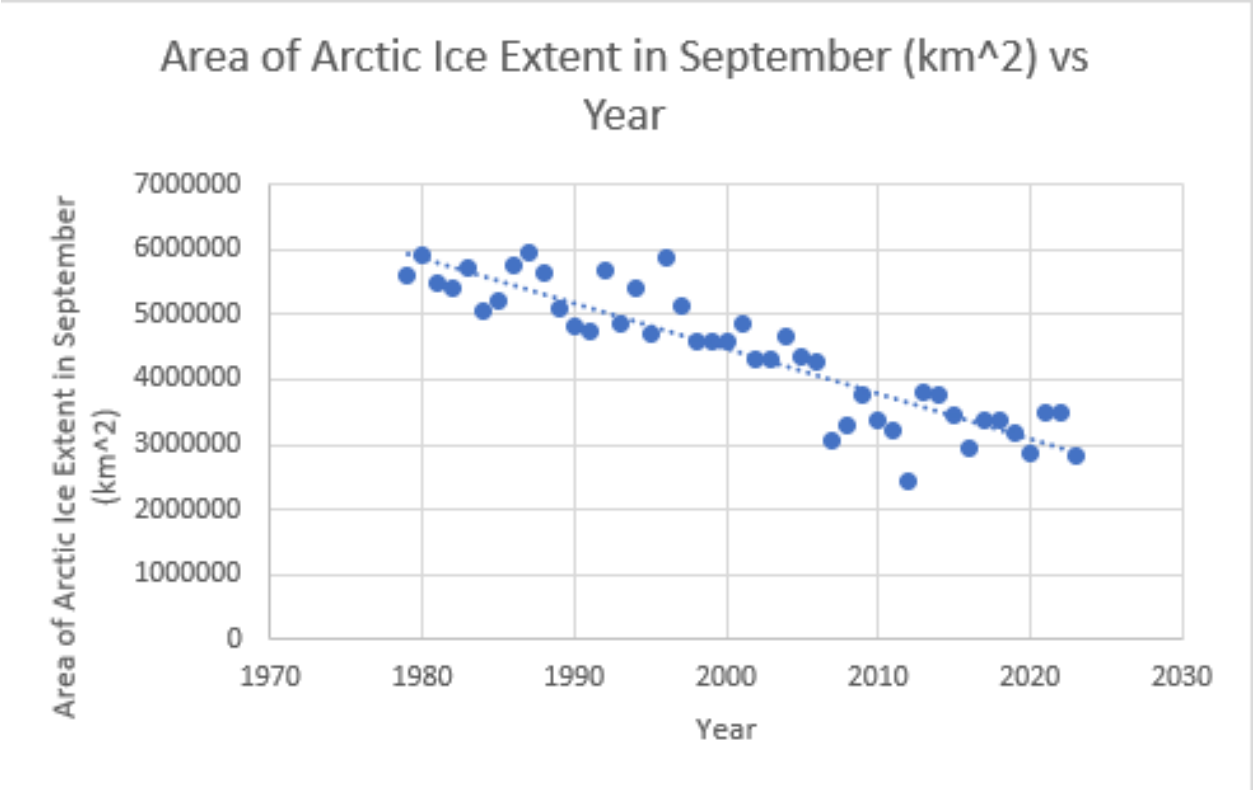

Figure 3: Area of Arctic Ice Extent in September (km^2) vs Year.

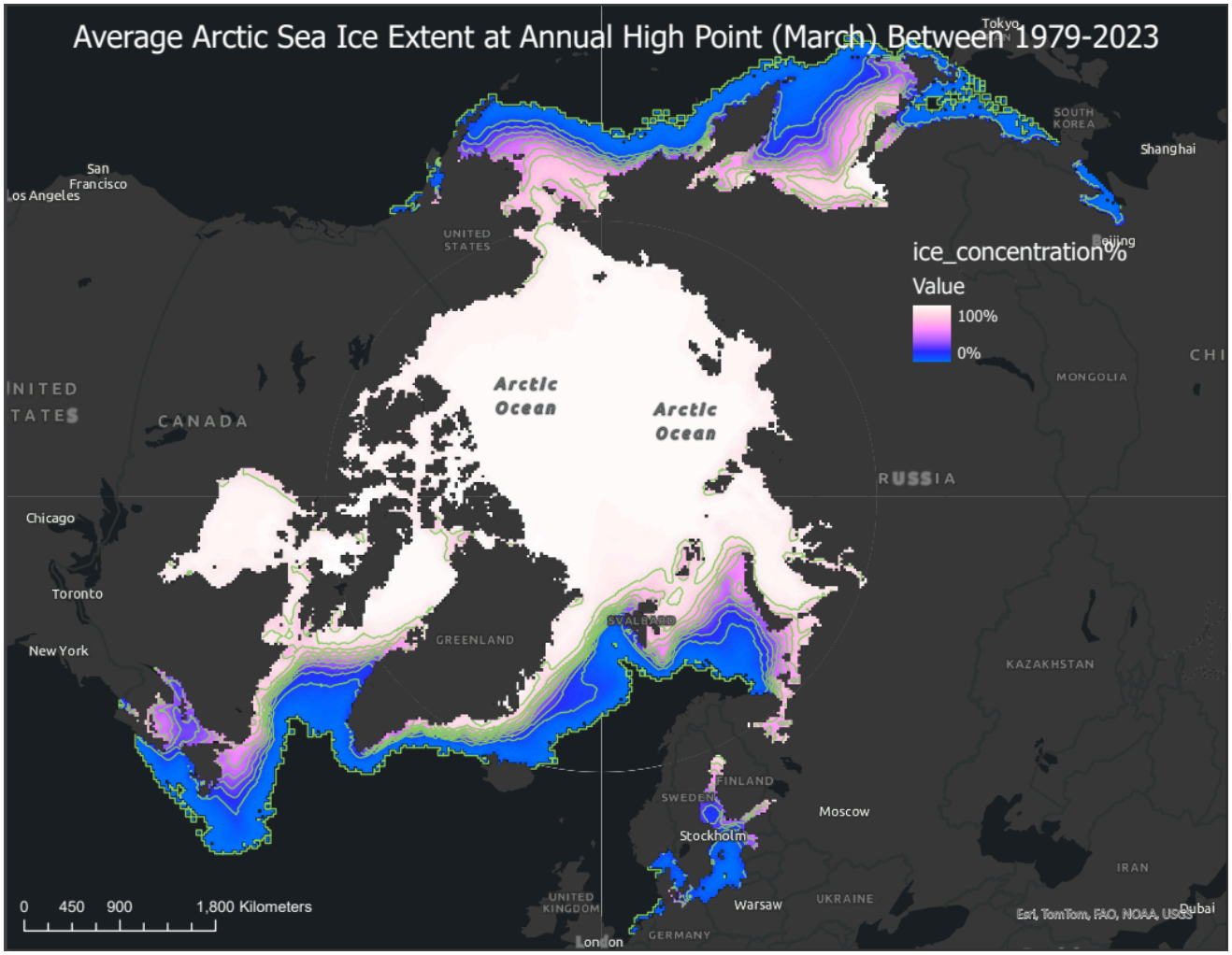

Figure 4: Average Arctic Sea Ice in March (high point) between 1979-2023.

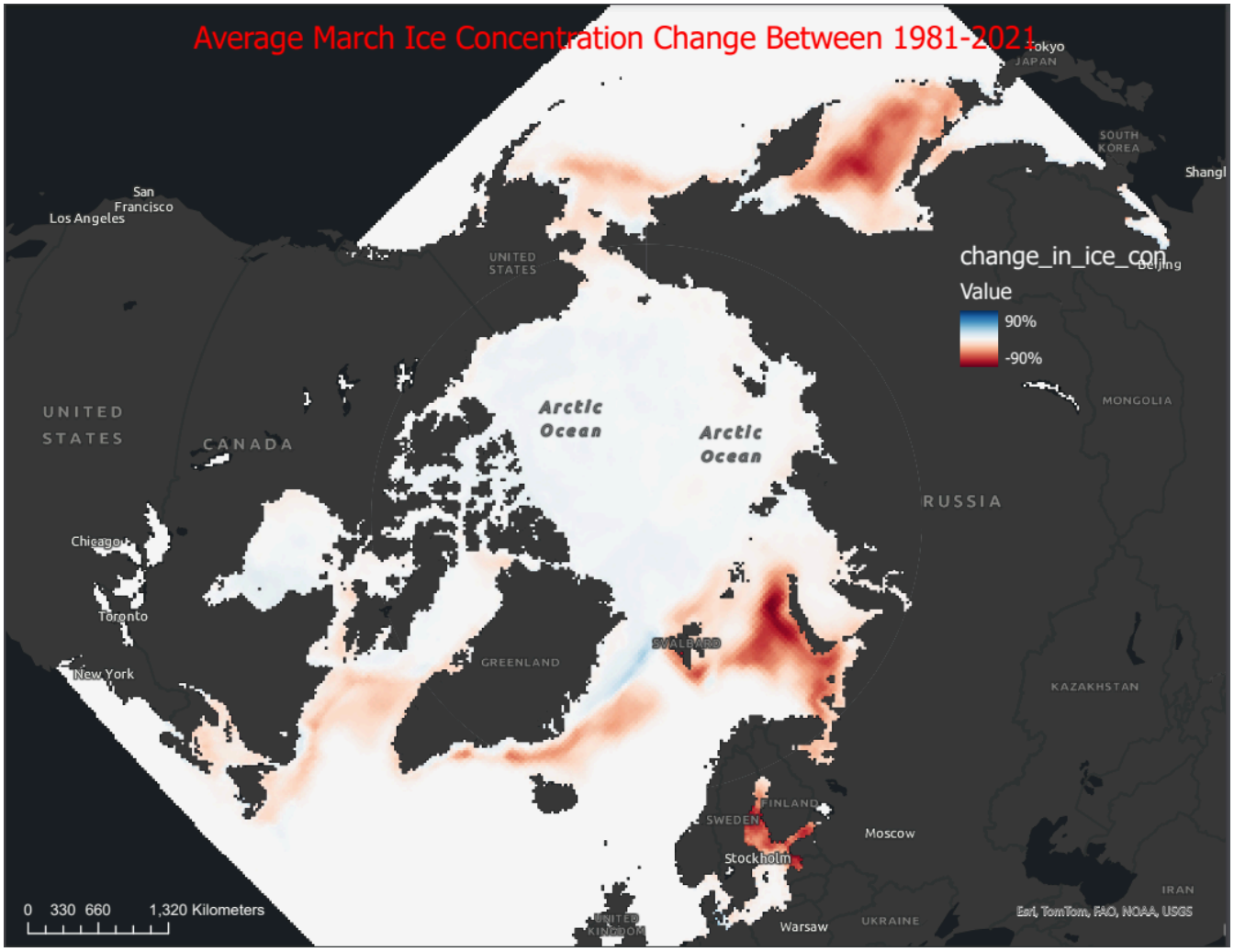

Figure 5: Change (%) in March Ice Concentration between 1981-2021.

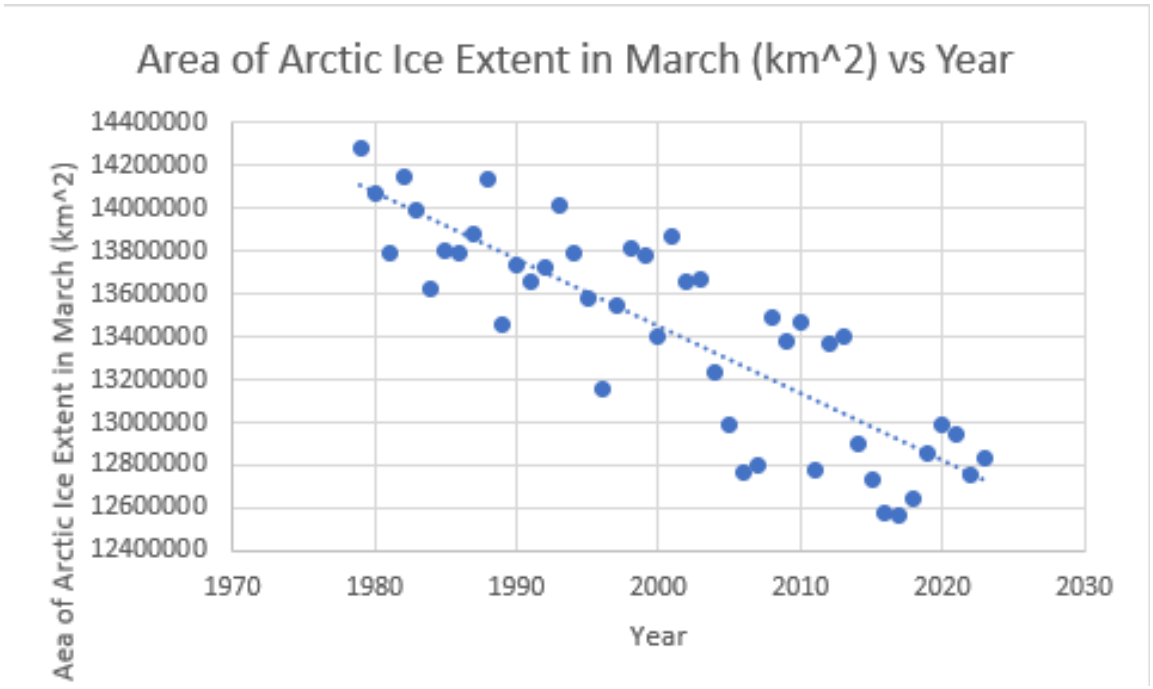

Figure 6: Area of Arctic Ice Extent in March (km^2) vs Year.

file:///D:/CLASSES/EARS_77/RebeccaRisch/Lab_3/mask_reproject_and_infill_MODEL.svg

Figure 7: Model used to prepare data for spatial analysis.