The Antarctic Sea Ice

ANALYSIS OF SOUTH POLE SEA ICE GROWTH FROM 2000-2015

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INTRODUCTION

One of the widest debated topics of our Eco political world is the topic of climate change. The globe is undoubtedly warming, and many worry about how our ice-capped poles will survive. But within this topic, a conundrum has formed. Over the past several years, the Antarctic sea ice extent (very important to note sea ice and not land ice) appears to be growing. In October of 2014, NASA announced that the southern sea ice sheet had reached its record extent since the beginning of their satellite imaging project started in the 70's that tracked ice growth. As a result, it has become a topic of debate how a warmer globe could produce such a strange result. However, that is a discussion for a different project.

PROBLEM & GOAL

The goal of this project is to address this problem from a data based approach. It is not to answer the possible causes, although it might offer insight. Instead, through the use of GIS software, and image/shapefile data found online, I will try and track this sea ice change over the years, from 2000-2015. In doing so, the problems that should be better clarified are:

1. Are there any consistent annual growth trends over time?
2. Are there any seasonal growth cycle changes within a year (i.e. are the moths where sea ice extent peaks changing)?
3. Are there any regions in Antarctica where growth/ shrinking is more common?

Essentially, this project hopes to visualize and quantify any possible ice growth in the region.

This is something that ArcMap and Arc Scene were made to do. In analyzing the monthly sea ice extent from satellite image data for the years 2000 to 2015, it will be possible to build two static images showing maximum and minimum extent for the years with the most and least ice. Secondly, it will allow for the creation of two animations. While these products will help answer the question above, it might offer insight into other questions. It has been discussed amongst many that the climate change we are currently experiencing has likely altered the weather patterns, and is in fact cause cool air from the continent over the oceans that would otherwise not happen. If these were true, it might be possible to see this in the regions where the ice is growing. Also, if certain regions of the sea ice weren't experiencing as much polar winds, that region might not grow at all, or at the rate of the other regions.

The data for this project was found all with the amazing help of the National Snow & Ice Data Center (NSIDC). http://nsidc.org/data

Figure 1: Showing the sea ice data collection screen of the NSIDC website: http://nsidc.org/data

Within their website is a huge data repertoire for sea and land ice all over the globe, shown in the image above. The data source I selected was the top option, a sea ice index for the North and South Pole. Within the product website of this index includes sea ice anomaly data, annual sea ice data, and sea ice extent data, all given for every month from 1978 to present, and is constantly being updated. Within the sea ice extent link, one is offered a directory containing links for all months. Clicking on any months takes you to their data for that month, for every year. Better yet, the data is in shapefile format, both polygon and polyline. This is shown in the figure below. Something that was confusing for a long period of time (something Dr. Helper and I struggled with for far too long) was the naming system. Within the file name, the S and N represent south and north. Do not pay attention to the date on the right. That represents the date added. Instead, the date of the data in the file is the middle set of numbers in the file name. For instance, the last file in figure 2 says 198409, or September 1984.

extent_N_201309_polygon.zip	0.1 kB	3/9/15, 12:00:00 AM
extent_N_201309_polyline.zip	2.2 kB	3/9/15, 12:00:00 AM
extent_N_201409_polygon.zip	6.0 kB	3/9/15, 12:00:00 AM
extent_N_201409_polyline.zip	2.2 kB	3/9/15, 12:00:00 AM
extent_N_201509_polygon.zip	5.7 kB	10/1/15, 7:20:00 AM
extent_N_201509_polyline.zip	2.0 kB	10/1/15, 7:20:00 AM
extent_S_197909_polygon.zip	5.0 kB	3/9/15, 12:00:00 AM
extent_S_197909_polyline.zip	3.2 kB	3/9/15, 12:00:00 AM
extent_S_198009_polygon.zip	5.1 kB	3/9/15, 12:00:00 AM
extent_S_198009_polyline.zip	3.3 kB	3/9/15, 12:00:00 AM
extent_S_198109_polygon.zip	5.0 kB	3/9/15, 12:00:00 AM
extent_S_198109_polyline.zip	3.2 kB	3/9/15, 12:00:00 AM
extent_S_198209_polygon.zip	5.0 kB	3/9/15, 12:00:00 AM
extent_S_198209_polyline.zip	3.2 kB	3/9/15, 12:00:00 AM
extent_S_198309_polygon.zip	4.9 kB	3/9/15, 12:00:00 AM
extent_S_198309_polyline.zip	3.1 kB	3/9/15, 12:00:00 AM
extent_S_198409_polygon.zip	5.0 kB	3/9/15, 12:00:00 AM
extent_S_198409_polyline.zip	3.3 kB	3/9/15, 12:00:00 AM

Figure 2: An image within the September link showing monthly extent shapefiles

DATA PREPROCESSING

Because this data was in polygon and polyline shapefiles, there was no preprocessing. The only thing needed before directly add the data to ArcMap was to unzip the files by extracting their data.

ArcGIS PROCESSING

Determining Area

The first step in this project was to determine what months represent the maximum and minimum month of each year. Because it is the South Pole, the seasons are different, but after some research, it was clear that the usually cold time of year occurs after August and the warm time of year is in after January. In doing so, I measured a four month window, January to April, and August to November. The polygons were used over the polyline as more can likely be determined from the area and not the perimeter. The first step is to open the attribute table, and add a field, labeled with area in the image. Within this new field, using the geometry calculator function, I calculated the area of the polygon for each month in the four month range for each year. Figure 4 illustrates the findings. A second row of areas is shown in figure 3 because the first area was calculated using meters squared, which produced a number too large to be shown. Square kilometers was required. Also, the reason the table contains many

different rows is because the polygon is divided into several parts, as the sea ice is not all connected. These rows were added to make one area and were put into an excel sheet shown in figure 4.
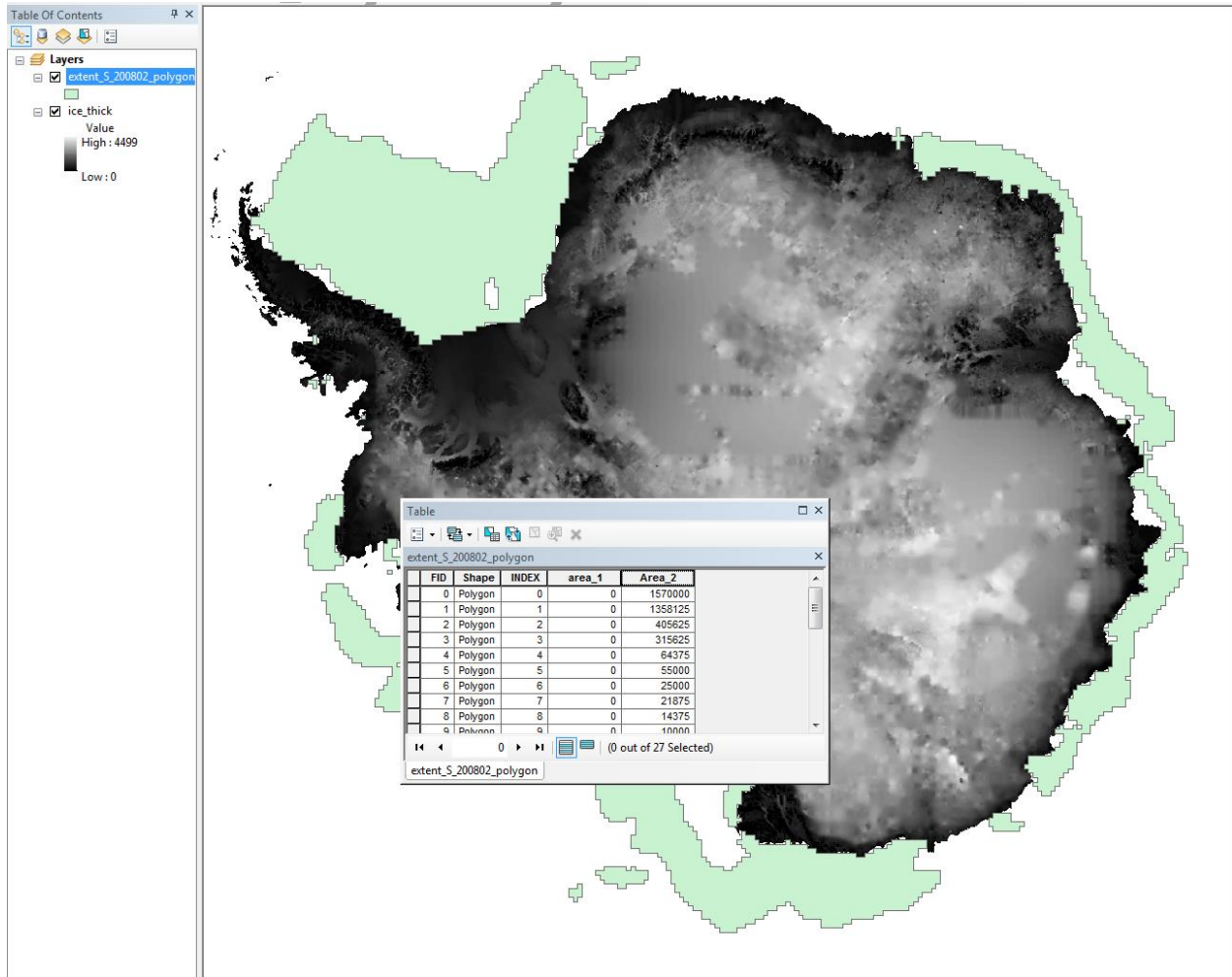

Figure 3: A screen shot in ArcMap illustrating the attribute table with newly calculated areas

	January	Febuary	March	April		August	September	October	November
2000	4.8	2.8	4.4	7.8		18.6	19.1	18.5	16.2
2001	5.4	3.7	5.1	7.5		18	18.4	18.1	15.8
2002	4.7	2.9	3.9	7		17.4	18.2	18.2	15.9
2003	6.2	3.9	4.8	7.8		18.1	18.6	18.4	16.5
2004	5.8	3.6	4.8	7.8		18.2	19.1	18.6	16.6
2005	4.9	2.9	4.5	7.5		18.3	19.1	18.7	16.8
2006	4.3	2.6	3.4	6.6		18.4	19.4	19	16.8
2007	4.9	2.9	4.1	7		18	19.2	18.7	16.2
2008	6.9	3.9	5.7	8.7		17.9	18.5	18.1	16.6
2009	6	2.9	5	8.4		18.6	19.2	18.6	16.4
2010	4.9	3.2	4	7.3		18.8	19.2	18.8	16.9
2011	4.7	2.5	3.6	6.8		18.2	19	18.5	16.2
2012	5.8	3.6	5	8		18.4	19.4	18.9	16.7
2013	5.8	3.9	5.3	8.1		19	19.8	19.5	17.2
2014	6.7	3.9	5.3	9		19.2	20.1	19.2	16.7
2015	7.5	3.7	5.5	9.1		18	18.7	18.6	16.5

Figure 4: Illustrating the area results of Antarctica in excel

Upon completion, it was determined that at all times, February was the smallest and September was the largest extents of ice for the year. The values from those two months was used to create the final excel graph at the end.

Creation of a Static image

This step has been revised a few times, attempting to make the final presentation more appealing, but I still feel it is was an important process. Using the SCARv3 data from lab 9 of this course, I uploaded the outline of Antarctica as my base layer. All layers must match in their projection, so I used Stereographic South Pole and the datum as WGS 1984. To present this data initially, the map contained outline of all years, hoping that a discernable trend would be noticed. However, as the figure below illustrates, the sea ice change over time was not large enough to make any differences visible.
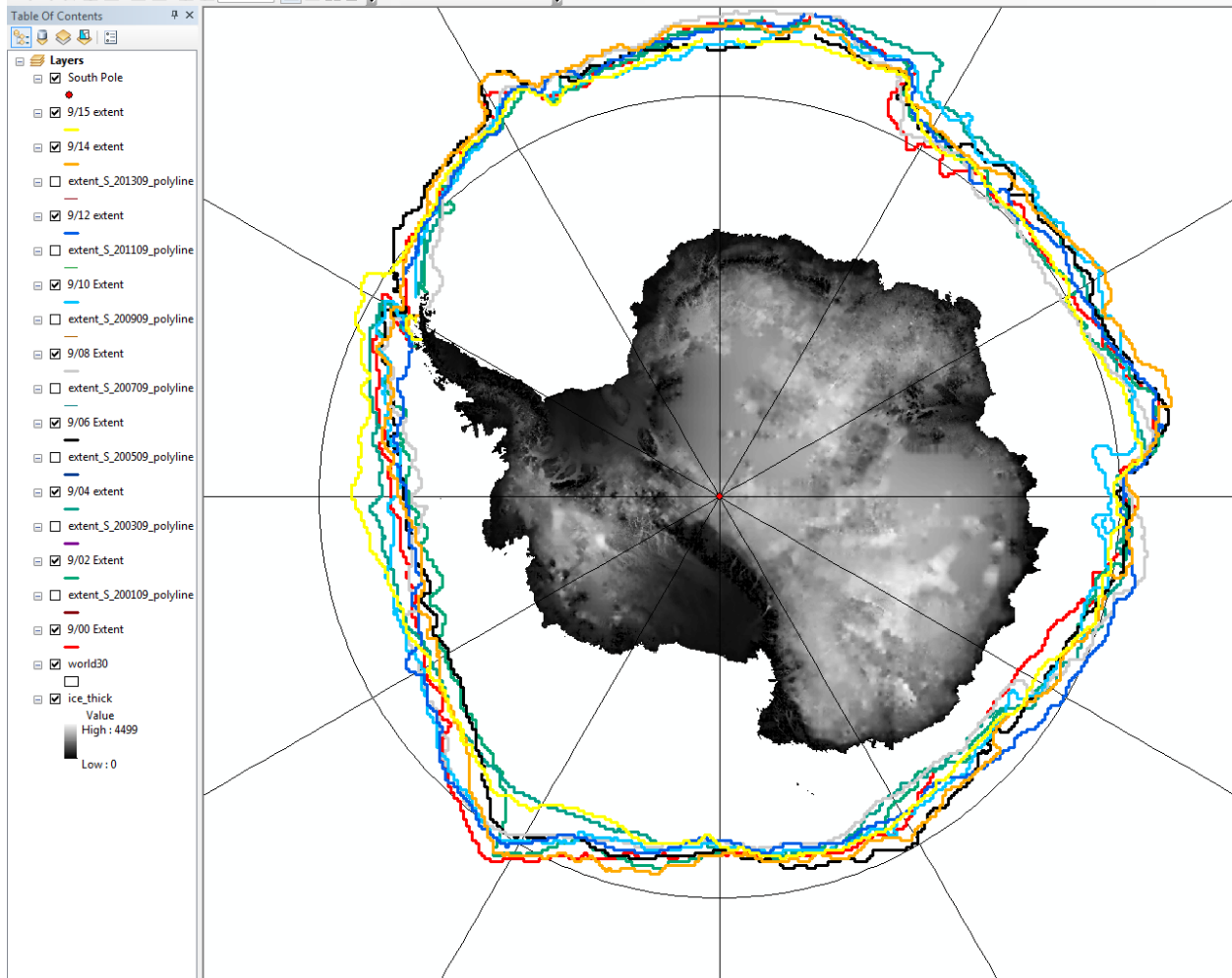
Figure 5: The first attempt in ArcMap to show sea ice change

Instead, since the goal of the image is to show how obvious the trends in sea ice growth was, a map for the September and February was made, with the maximum layer and minimum layer added, again in polyline form. In addition, to illustrate if there is a true, continuous trend, the 2000 layer and 2015 layers were added as polygons. If the ice continuously grows, there would ideally be an obvious size difference. The top layer was set to 50% transparency for visibility.
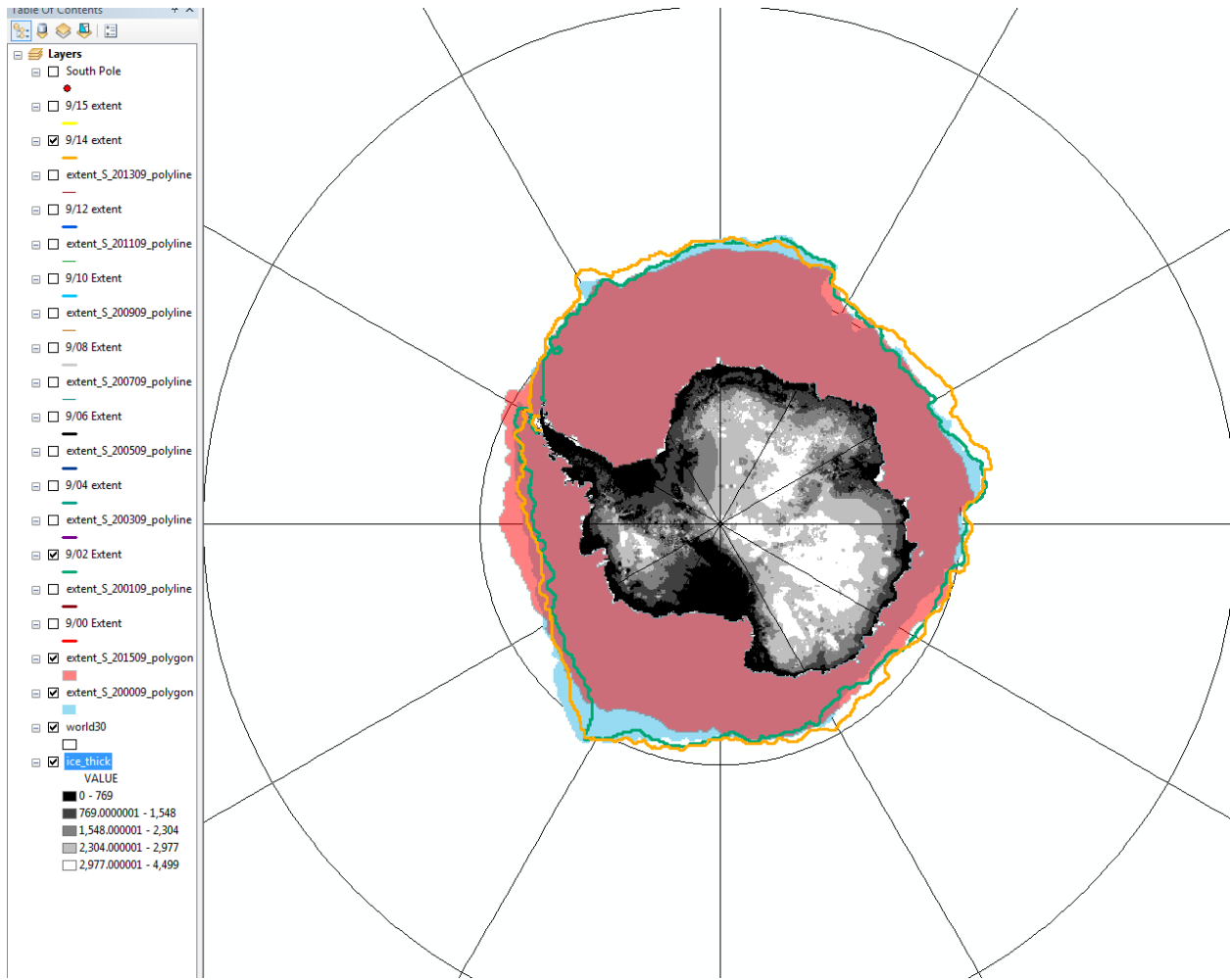
Figure 6: The final version in ArcMap of the Maximum ice extent

This was done twice, once for February and again for September. After adding an appropriate color scheme, a title, scale bar, grid lines and legend were added. The two final maps are visible at the bottom.

Creating an Animation

As mentioned above, presenting all the yearly data in one format was a very difficult challenge. It was a bit too much to look at in one image. So instead, the idea of an ArcScene animation was introduced. ArcScene functions similarly to ArcMap, with the added benefit of being able to animate your layers. There are several animation styles to choose from, but in this instance, a Group Animation was required. Within ArcScene, select the animation toolbar. It is very important to note that once you click on any animation, it will instantly create it based on the layers you already have. Therefore, it was necessary for me to have all of my yearly polygons in my table of contents.
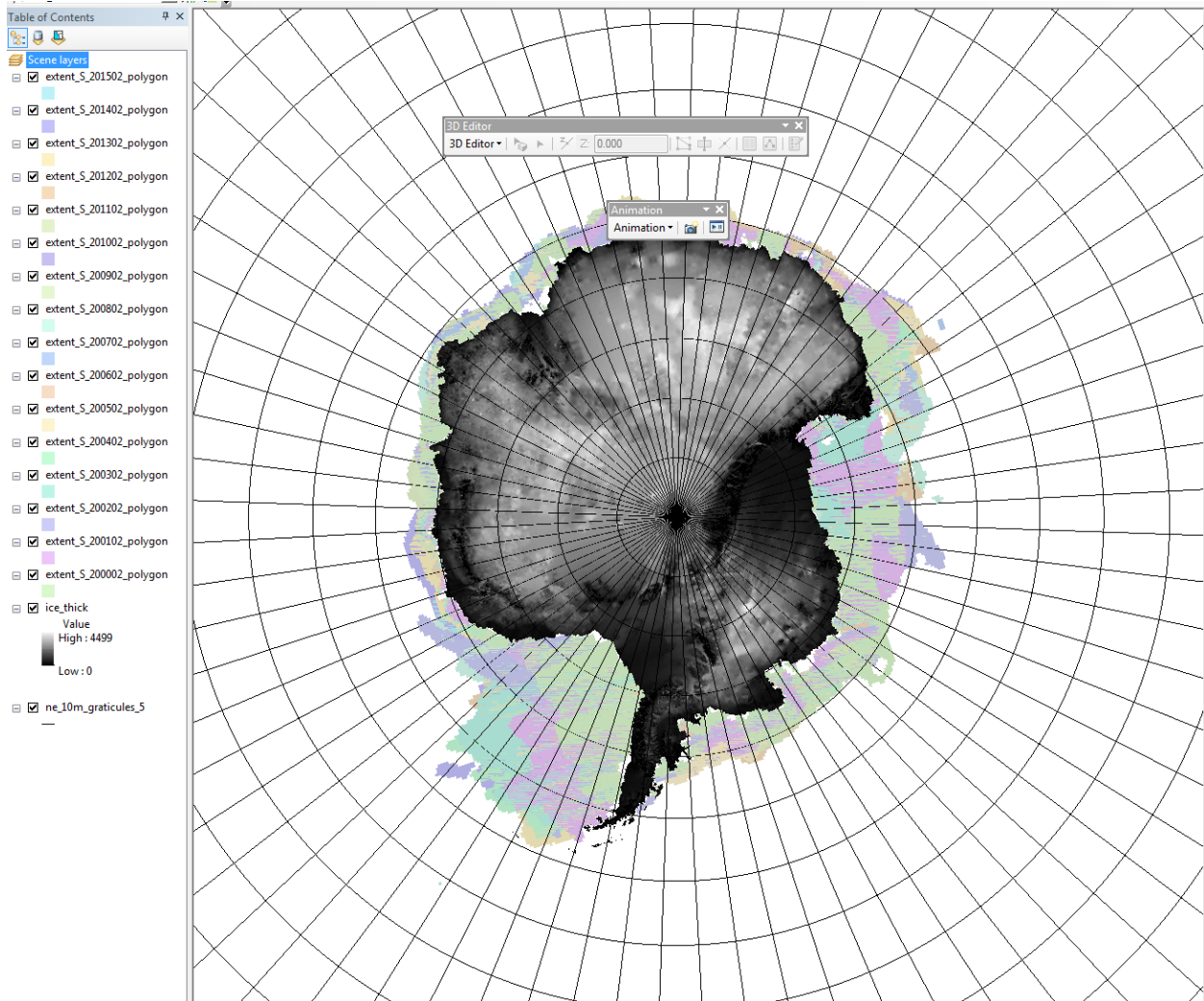
Figure 7: A screen shot of ArcScene showing all layers needed

The above image shows the window I needed before making an animation. The animation toolbar is shown as well. The grid lines shown were downloaded from http://www.naturalearthdata.com/downloads/10m-physical-vectors/10m-graticules/. With all layers present, I clicked on the Animation drop down menu on the animation toolbar. In the drop down menu, select Create Group Animation. This will pull up a window, shown below.
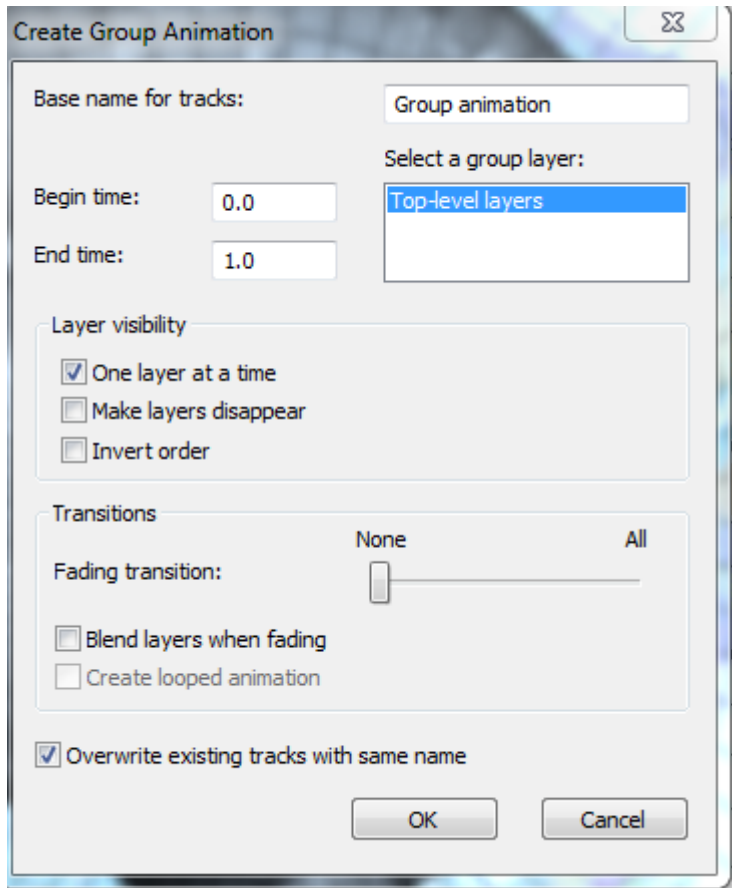
Figure 8: Screen shot of Create Group Animation Window

In this window, since I wanted to show frame by frame images by themselves, I selected one layer at a time, and make layers disappear. Clicking ok creates your animation. To edit this animation, under the animation drop down window, select Animation Manager. The window that you will pull up is shown below. Within this manager, select tracks, which the below image also shows.
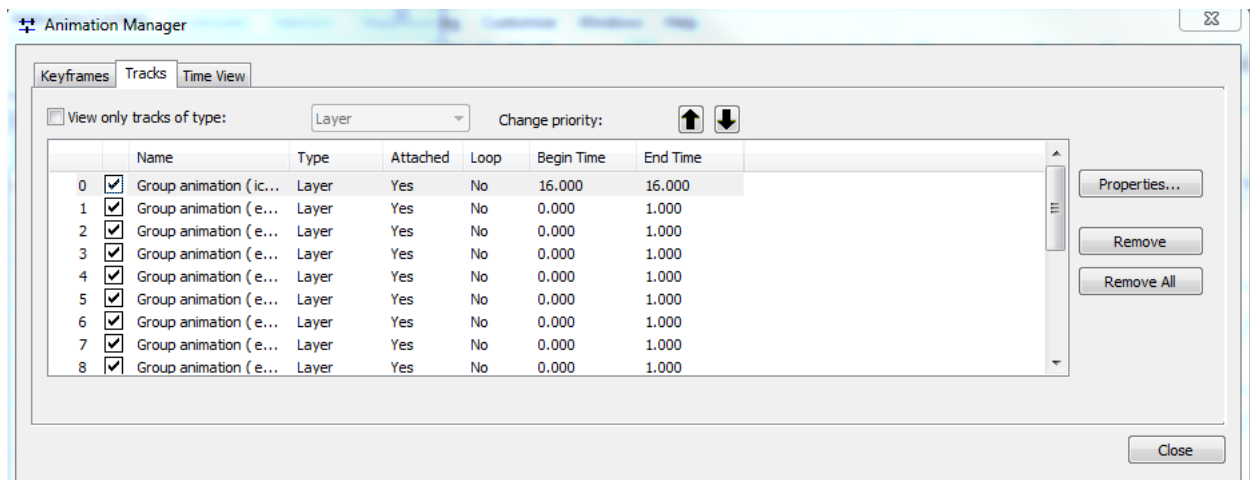

Figure 9: Screen shot of the Animation Manager window

Within tracks, you will see each of your layers. You may also edit the time the image arrives and how long it lasts. The system is not at all straight forward, but it is easy to use once you get it. For instance, in the image, the top most layer was my Antarctica layer. I wanted it to be present at all times. One would think then the start time is 0 and the end time is however long the video was, in this case 16 seconds. But for whatever reason, that does not work. Instead, I put 16 for both, and it worked. For the remaining images, I wanted them to last for 1 second only. I had to keep the beginning time as zero, and set the end time to 1 second to do this. I cannot explain this, but it worked. To play the animation, click the play button on the far right of the animation toolbar to pull up Animation Controls window, shown below.

Figure 10: Screen shot of the Animation Controls window

This was again done for both February and September. The animations were submitted separately.

DISCUSSION & CONCLUSION

As can be seen by the graph, animation, and static map, the total ice change over time was rather minimal. The average maximum area for the time frame observed was 19.0625 km^2. The ice did peak in 2014, but actually fell to a below average number in 2015. At no point was the minimum sea ice extent or maximum sea ice extent ever in a different month, nor were any regions of Antarctica growing or shrinking in any noticeable trend that was different form the rest of the continent. Based on the graph, there is a possible upward trend in the maximum line, but the minimum line varies radically. Overall, it is surprising that Antarctica is not shrinking in a warming globe, but it is certainly not expanding a lot either. When we consider the rate at which the Artic melts, the globe on average is still losing ice.
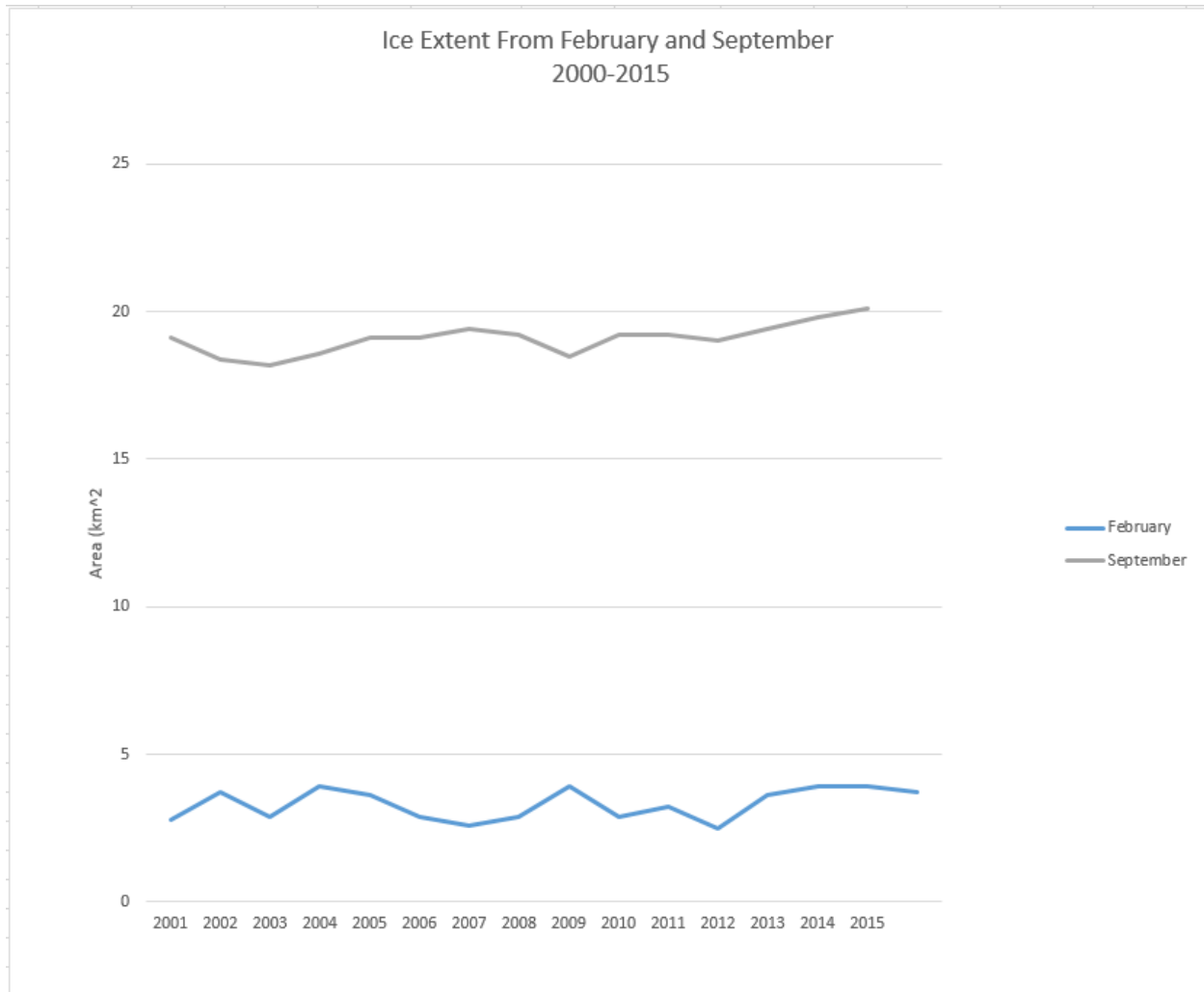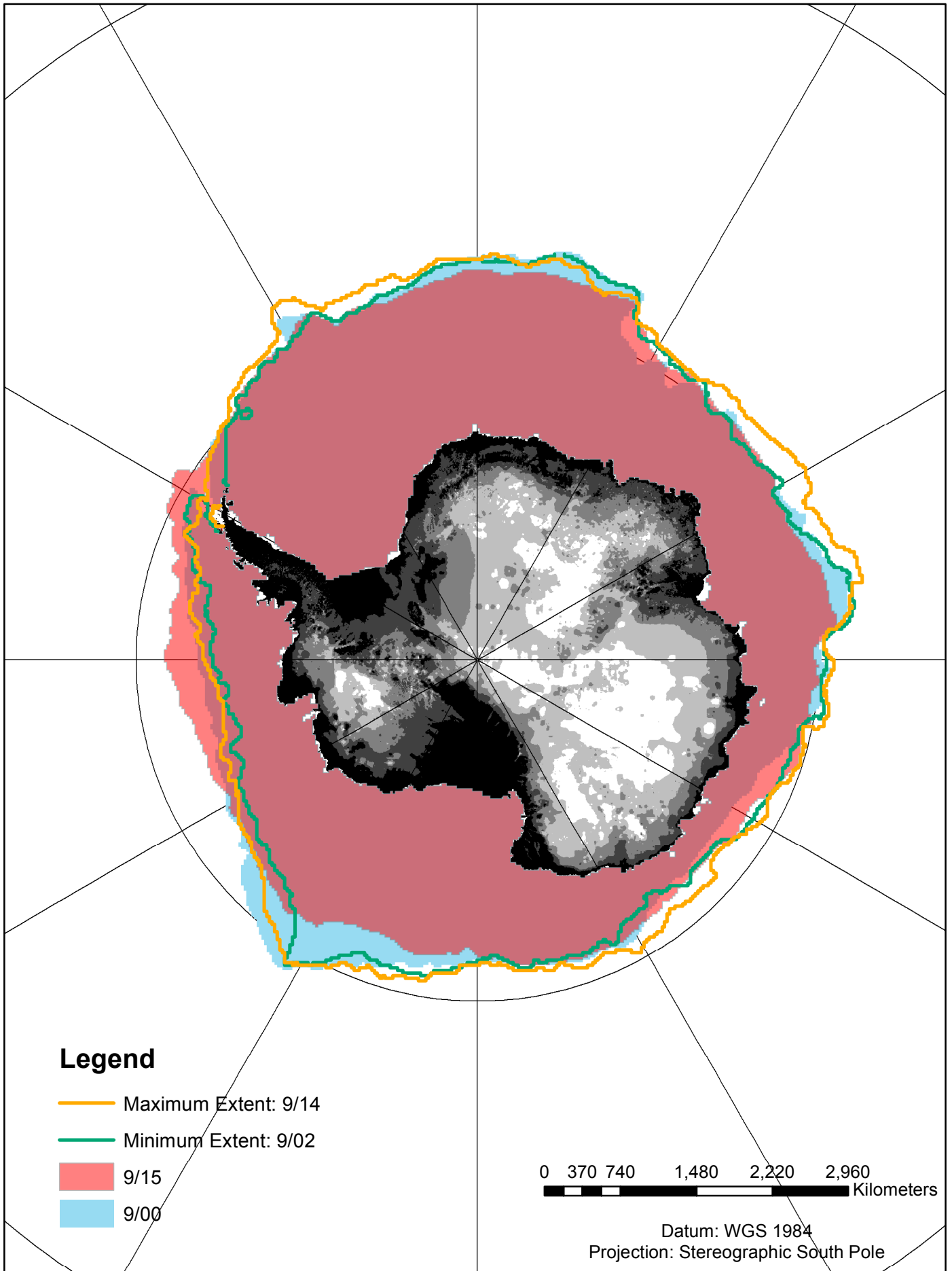
Figure 11: Final graph, showing all area data for February and September over time in km^2

Maximum Annual Sea Ice Extent: 2000-2015

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12/2/2015

Legend

— Maximum Extent: 9/14

— Minimum Extent: 9/02

█ 9/15

█ 9/00

0   370 740   1,480   2,220   2,960
Kilometers

Datum: WGS 1984
Projection: Stereographic South Pole

Minimum Annual Sea Ice Extent: 2000-2015

Mitchell Riegler
12/2/2015

Legend

- 2/00
- 2/15
- Minimum Extent: 2/02
- Maximum Extent: 2/14

0 220 440 880 1,320 1,760
Kilometers

Datum: WGS 1984
Projection: Stereographic South Pole