

Extent of Eyjafjallajökull Eruption Ash Plume and Effect on European Air travel

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Introduction

On April 14th, 2010 the Icelandic volcano, Eyjafjallajökull, entered a stage of eruption which sent incredible amounts ash up to 30,000 feet in the air (the typical cruising altitude of commercial jets). Across Europe and around the world, air travel was disrupted as the ash cloud made its way across the continent. The importance of learning the behavior of the airborne ash has become evident in the disastrous effect of the ash.

Purpose:

In order to characterize the behavior of the airborne ash, it is necessary to find the area of the ash plume each day during the eruption and after. Comparing these daily measurements may give insight to the way ash plumes expand and travel. Using flight path data and the digitized ash plumes, it will be possible to determine what flight paths were directly affected by the plume. To help answer these questions, satellite imagery of the plume above Iceland and northern Europe will be taken from the MODIS rapid response system gallery and georeferenced so a polygon may be digitized from its outline.

I. Data Collection:

As part of this project, I needed to find a map of the world with political boundaries; this map was found from the lab 2 folder from this lab. 250m resolution images were obtained from the MODIS rapid response system; they were used for georeferencing the plume. This data was downloaded from <http://rapidfire.sci.gsfc.nasa.gov> as jpeg files along with its world file that defines its location; both of these files had to be stored under the same folder as the same file name in order for arc map to recognize it. These images did not have a spatial reference. Volcano Shapefiles for all of the Northern Hemisphere were found at www.mapcruzin.com; these files were compressed in a zip folder; the .shp files were easily extracted in windows explorer. It was necessary to obtain a more detailed map of Iceland in order to have a more accurate map to georeference the MODIS images to. This political boundary polygon was found at <http://data.geocomm.com/>. The files from this site were .E00 files that were compressed into a .GZ folder. I was not able to download an unzipping software to extract the files on the lab computers, but thankfully, my Macbook laptop was able to unzip the files. After being uncompressed, the files had to be converted to shapefiles which will be discussed in the Data preprocessing section.

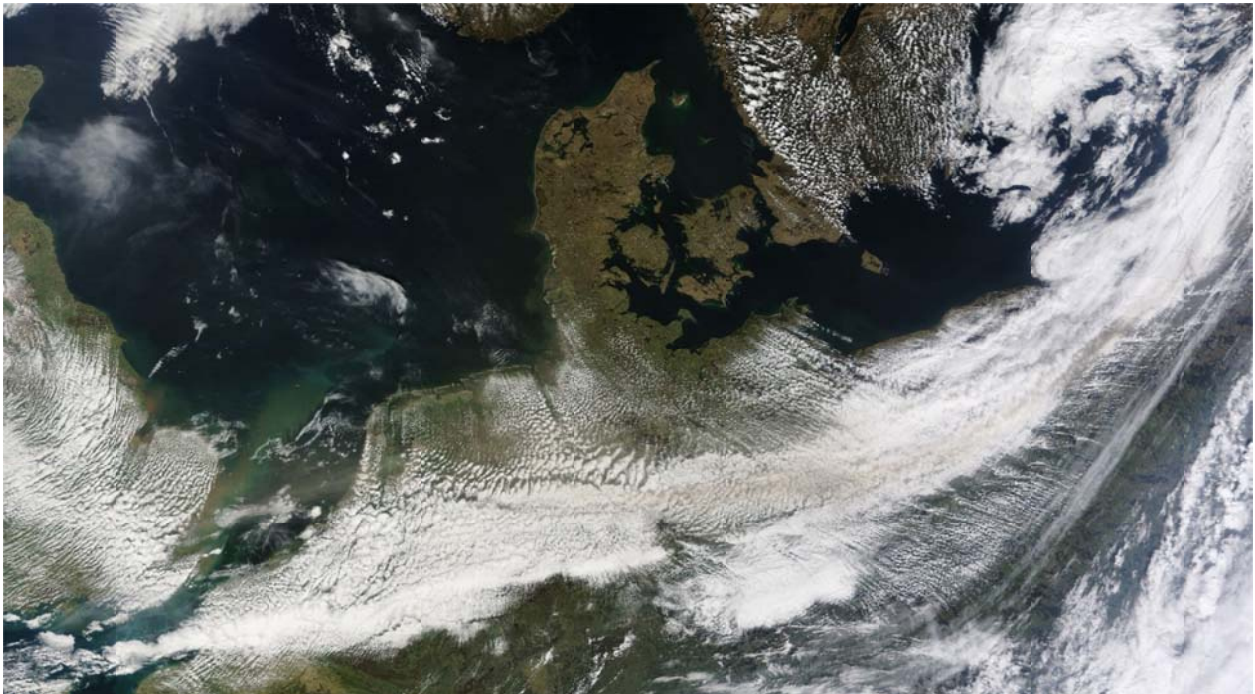


Figure 1: Original MODIS Rapid Response photo of Eyjafjallajökull Ash plume over Northern Europe. From April 15, 2010 provided by NASA

II. Data Preprocessing:

The .E00 files of the political boundary of Iceland that were downloaded from <http://data.geocomm.com/> had to be converted into a .shp file in order to be used in ArcMap. Using ArcCatalog, I opened the Toolbox and selected Coverage tools and went through “Conversion” > “to coverage” > “Import from interchange file”. The first file that I imported into the project was the World Map file which is in GCS WGS 1984. All data that was imported thereafter, was projected “on-the-fly” into this coordinate system. Although the source for the political boundary of Iceland polygon was originally in Clarke 1866, it was projected on the fly in WGS 1984. Since there were no excessively complicated calculations in this project, it was okay to leave these layers as projected on the fly.

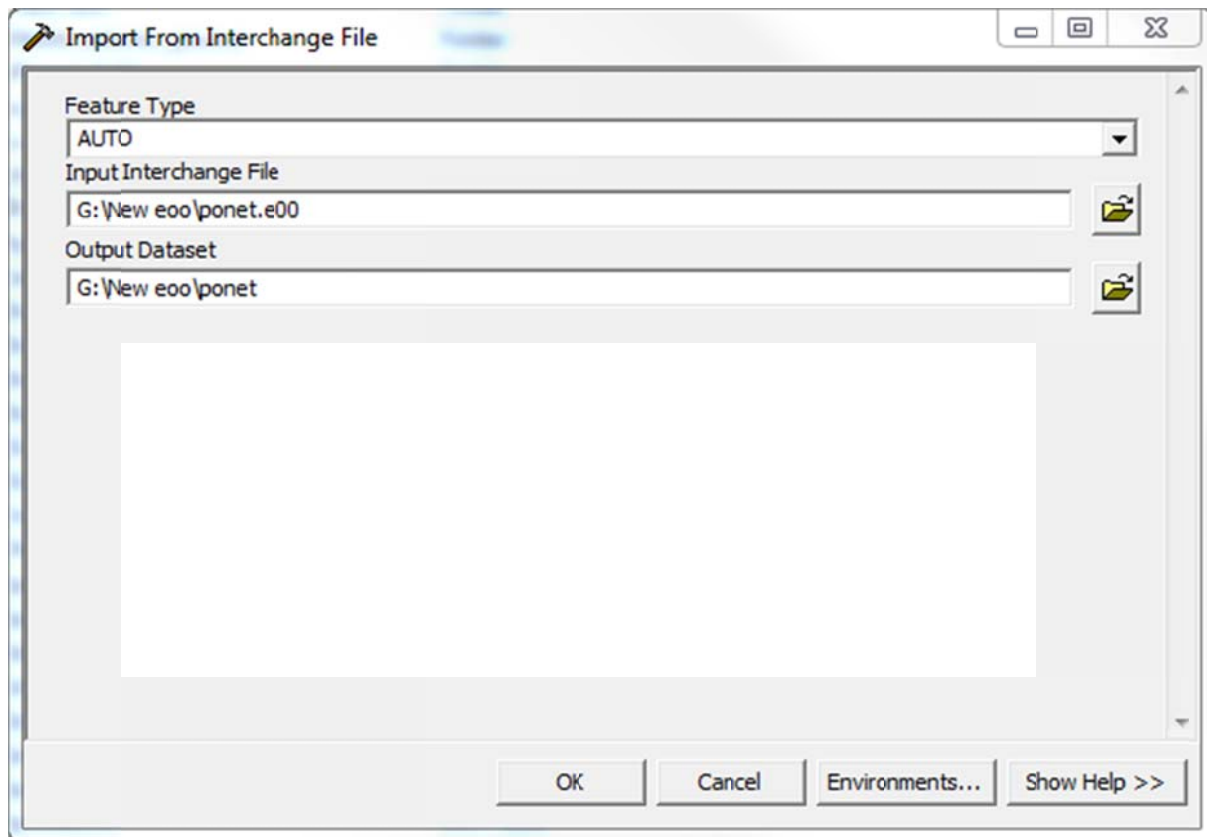


Figure 2: Using the Import from Interchange File tool under Coverage tools to convert .E00 file into .shp file to be used in ArcGIS

III. ArcGIS Processing:

The volcano shapefile that was downloaded from mapcruzin.com contained all of the volcanoes in the Northern hemisphere. In order to narrow down the number of volcanoes to those only in Iceland, I used the Select by location tool and specified that I only wanted the volcano points that were within the Iceland polygon. After these points were selected I exported them to create a new shapefile that was automatically added to the map project. From these points I went to the attribute table and selected the Eyjafjallajokull volcano and carried out the same steps as above.

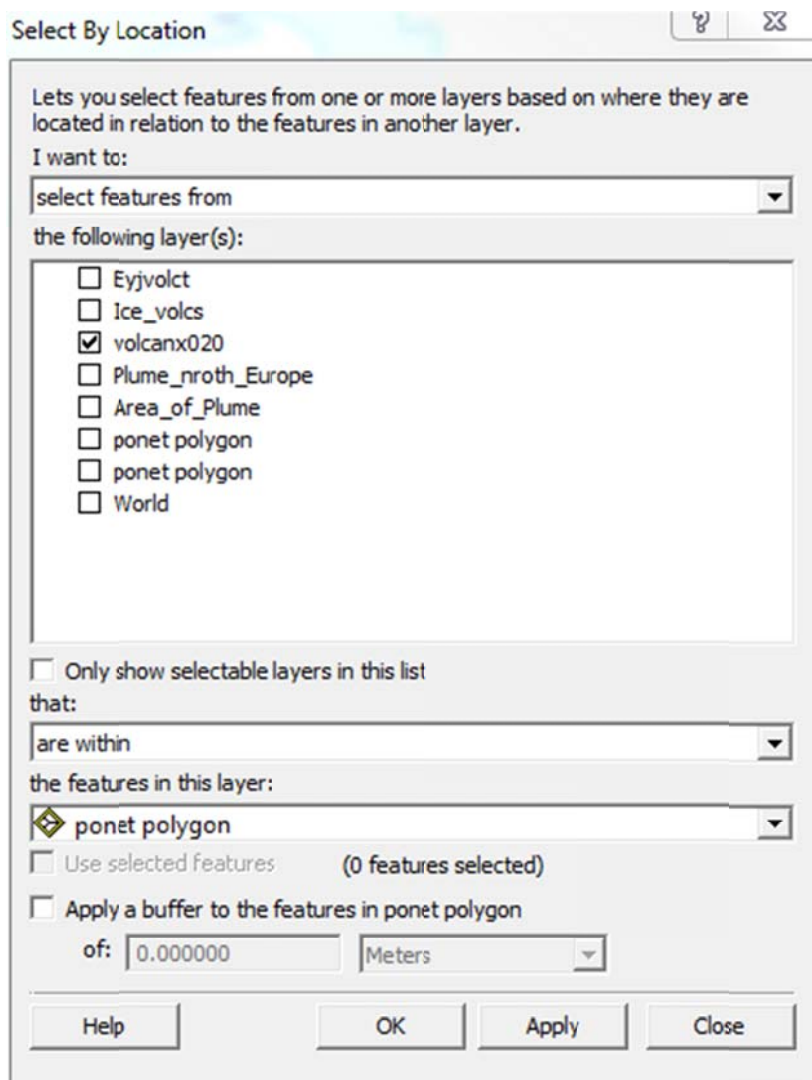


Figure 3: Selecting only volcanoes that are within the Iceland polygon.

Georeferencing:

The MODIS images that were downloaded from NASA did not have any spatial references so it was necessary to georeference the images onto the preexisting WGS_1984 map in order to determine the extent of the Volcanic ash plume. When the Images were first imported into ArcMap without any spatial reference, they plotted where the world file that was downloaded with it indicated. These coordinates did not match up with the projection of the project. I had to “Zoom to layer” in order to be able to view the image at all. Next I had to choose the image I wanted to georeference in the drop down menu of the georeferencing toolbar. From there, I used the “add control points” tool to select a point on the jpeg and select the corresponding point on the Iceland polygon. This is where the more detailed map of Iceland came into play and made for a more accurate match between the picture and map. In order to see the Iceland polygon underneath the image, the transparency of the image was set to 30%.

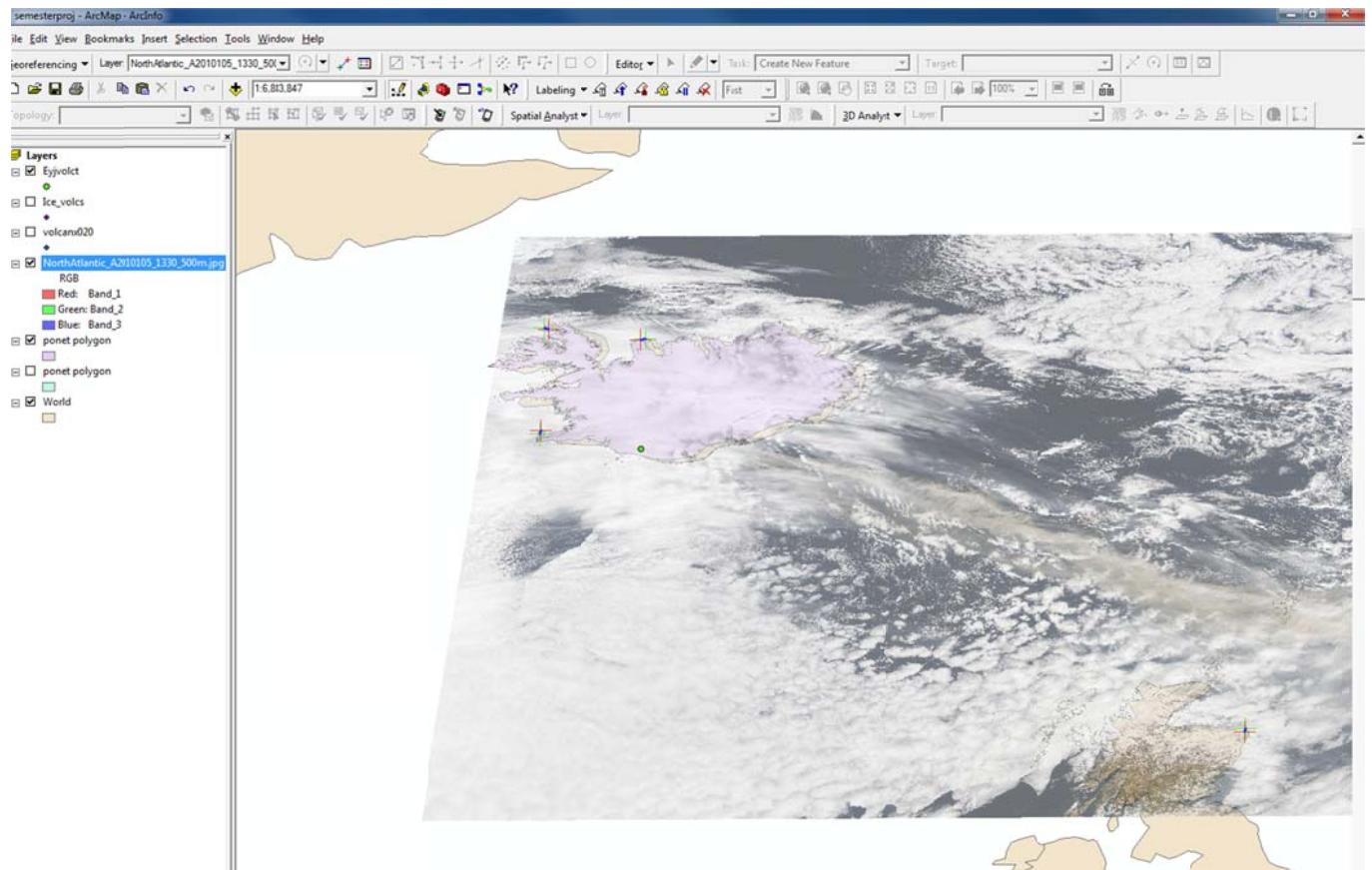


Figure 4: Middle of Process of georeferencing jpeg image. More control points were selected after the screenshot was taken. Image has transparency of 30%

Once all control points were selected, the image was rectified in order to make the

georeferencing permanent. This same process was carried out for the MODIS image above Northern Europe.

Digitizing:

Once the image of the plume was georeferenced, I could digitize the outline of the plume. To be able to digitize, it is necessary to create a new geodatabase where the polygons that are being created can be stored. To do this, I right-clicked on the folder I wanted the geodatabase to be stored in and navigated to “new” > “Personal Geodatabase”. Once the Geodatabase was created I had create a new feature dataset that would hold the feature classes. When creating the Feature dataset, I had to set the coordinate system to that of the Arcmap project, which was WGS 1984.

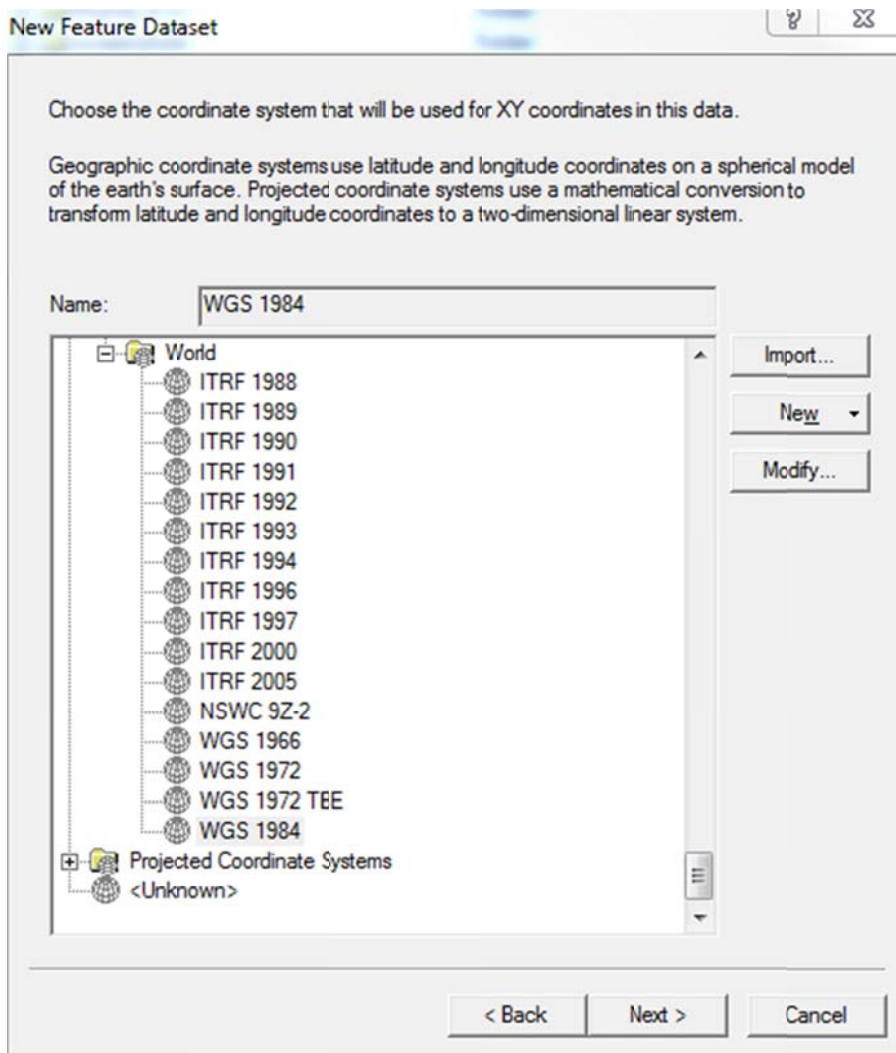


Figure 5: Defining the XY coordinate system one the Feature Dataset

Next, a feature class was created for the polygon that would encompass the ash plume. Since I was digitizing a polygon, I set the field: “type of feature stored in Feature class” to polygons. The rest of the properties that were set when creating the feature class are provided in the figure below.

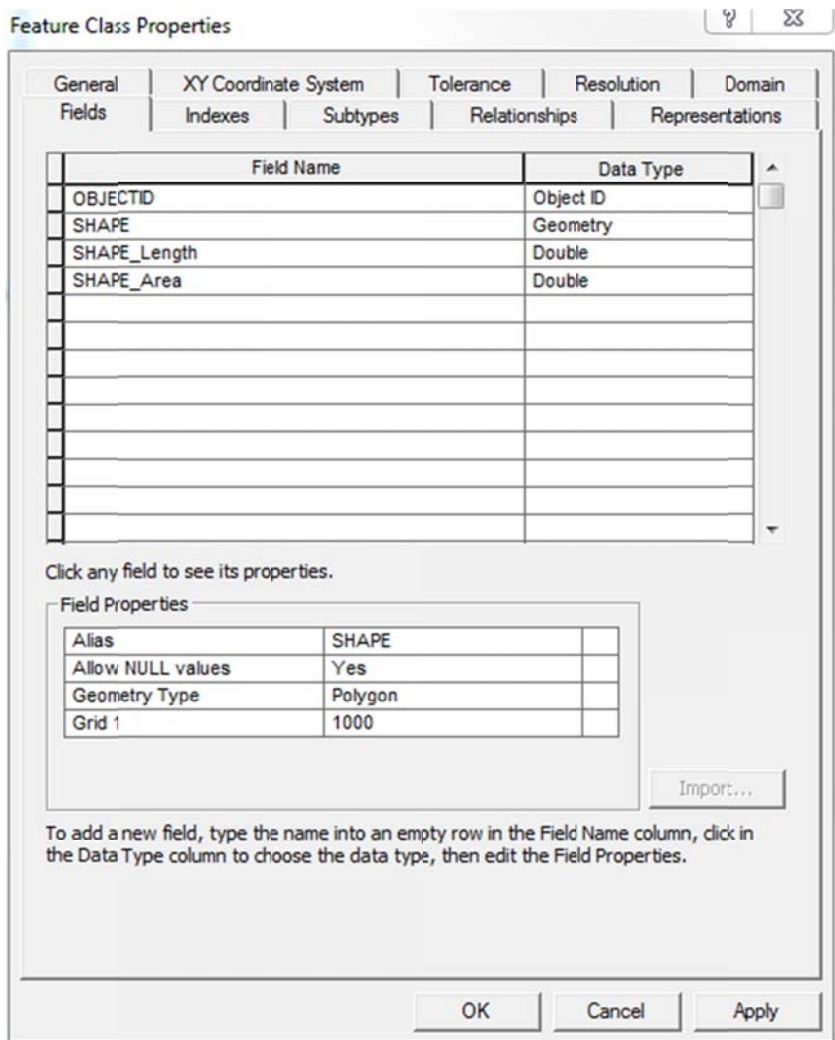


Figure 6: Fields specified in Plume polygon feature class.

Once the geodatabase and featureclass were created, I could go to the Editor toolbar and start editing. I selected the geodatabase that was created earlier; using the sketch tool, I digitized around the ash plume in the satellite image; this was not too difficult since the ash plume was quite noticeable in the image.

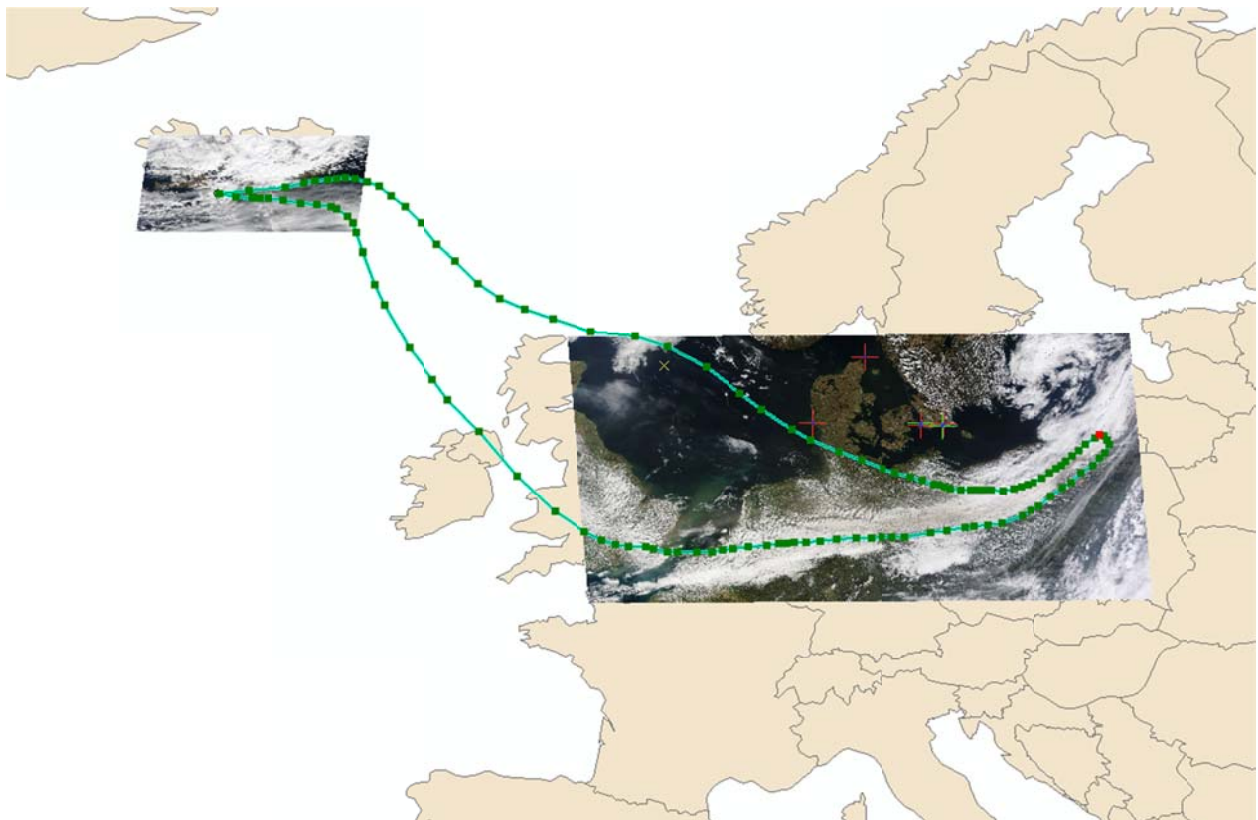


Figure 7: Digitizing process showing vertices used to create plume polygon.

From the image above, it can be seen that there is an area that had to be inferred since there was no satellite imagery for that area from the same day.

Calculating the Area of the Ash Plume.

In order to calculate the area of the ash plume from the volcano, it is necessary to create a new field in the attribute table of the polygon. After making the Area_Plume field, I calculated the geometry of the polygon. I used the coordinate system of the data frame in order to be able to express the value in square kilometers.

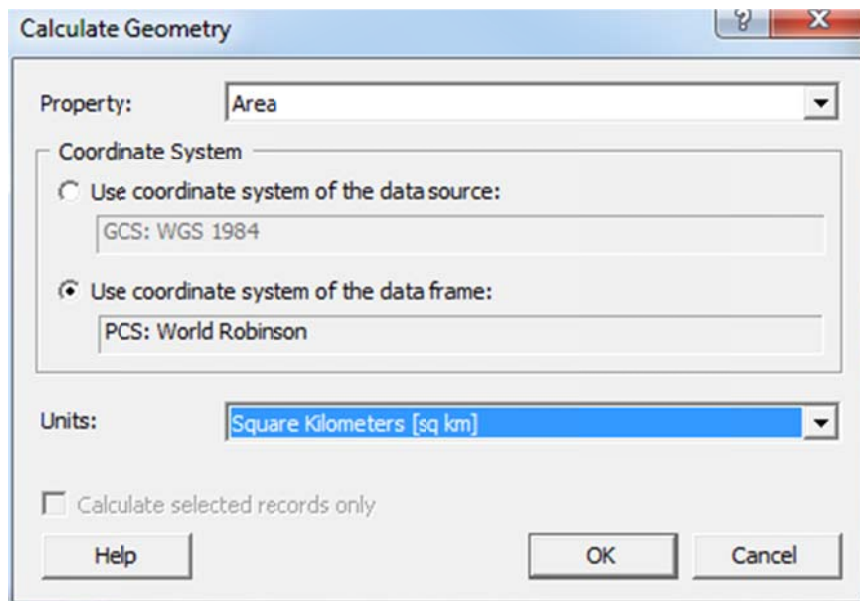


Figure 8: Calculating Area of plume polygon

Using Multiple days of digitized plume polygons to find a rate of plume expansion.

If I was able to digitize multiple days of the plume's extent, I could have compared the area of each polygon and determine at what rate it had expanded. To do this, I would follow the same steps that I used to find the area of the April 16th plume for the other days. Next, I could easily compare the sizes of the polygons by creating a graph in excel showing the percentage change in area for each day, or an average of the increase of square kilometers per day

Using flight path information to visualize effect of ash plume on commercial airtravel.

If I was able to find either a line shapefile or even a map of European and transatlantic flights that I could georeference then digitize, I could then use the select feature and "select features by location" from the flightpath shapefile and tell the program to select feature that intersect with the ash plume polygon. This would give the flightpaths that are directly affected by the ash plume.

IV. Results

Area and Perimeter of Ash plume on April 16th, 2010

	Area	Perimeter
Ash Plume (April 16th)	1,200,188 sq. km	7,411 km

Conclusion:

Determining the area of the Ash plume from the continuous eruption of the Eyjafjallajokull volcano can help Europe prepare for a similar situation in the future. It has been postulated that the recent eruption of Eyjafjallajokull may trigger an eruption from its larger nearby neighbor, the Katla volcano. Recording and evaluating the plume size and movement across Europe is an invaluable way to help prepare citizens and airlines for a possible repeat of this past years disaster. Unfortunately, with the data that was available to me, I was not able to compile an extensive map of the ash plume over the course of the eruption. I was only able to accurately digitize the plume extent on April 16th since it was the only day that had satellite images of both Iceland and Northern Europe. Visualizing the plume's interaction with European flight paths can also help airlines prepare for a probable eruption of the Katla volcano.

Map of Eyjafjallajökull Ash Plume and Affected European Airspace April 16th, 2010

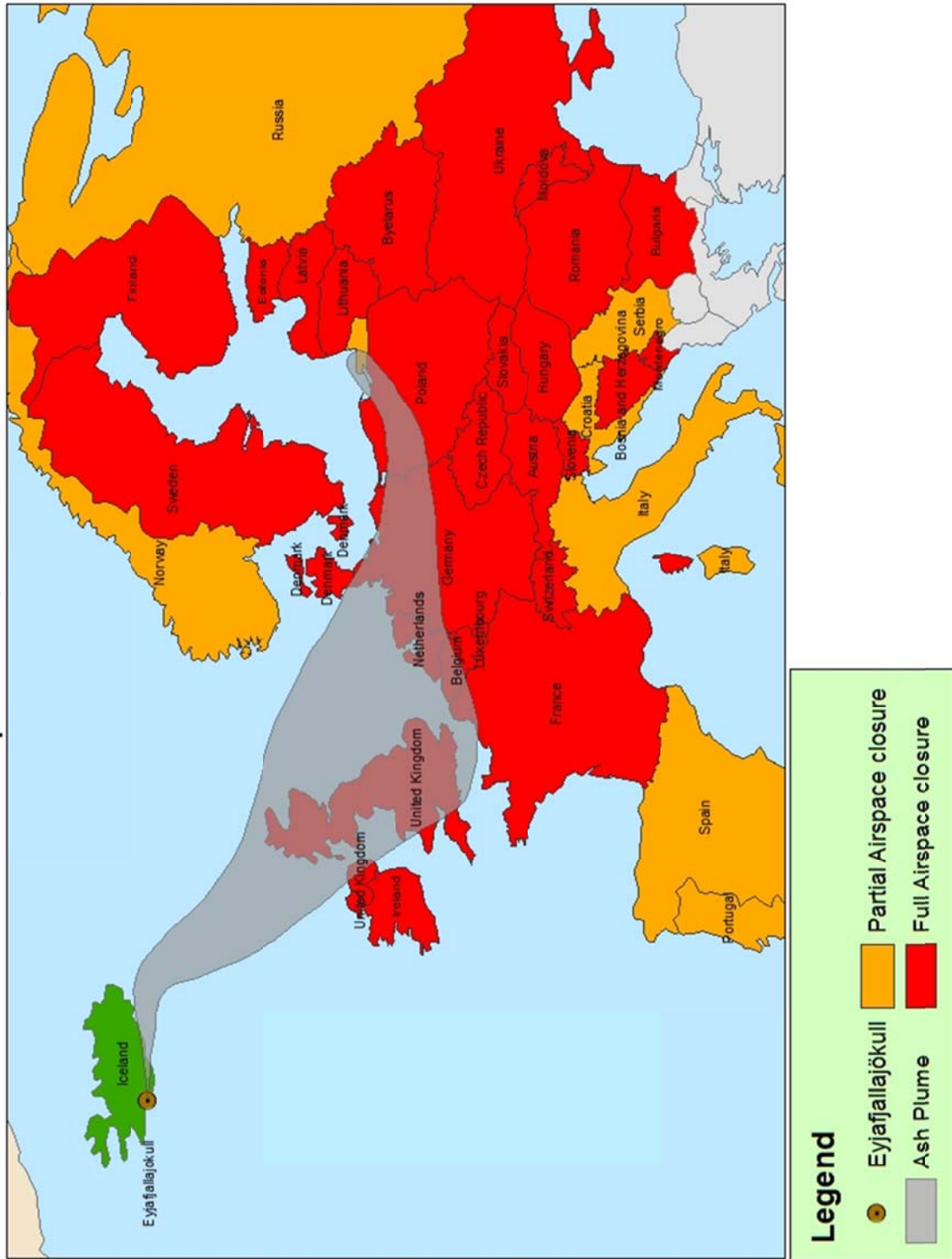


Figure 9: A final map showing the volcanic ash plume along with how European airspace was affected.