

CHERNOBYL NUCLEAR POWER PLANT ACCIDENT | Long Term Effects on Land Use Patterns

Project | Introduction:

In late April of 1986 a nuclear accident damaged a reactor at the Chernobyl nuclear power plant in Ukraine. This incident was followed by a fire, and coupled released substantial amounts of radioactive material into the environment (NRC.gov).

Hundreds of thousands of individuals living in nearby towns were evacuated starting one day after the accident. At the time of the accident the area surrounding the Chernobyl Plant was mainly used for agriculture, its main products were rye and dairy (Ramsberg, 1986). This disaster killed many people and contaminated thousands others in some cases causing acute radiation sickness (NRC.com). However, the focus of our project is on the long term effects this catastrophe had on the land use patterns around the Chernobyl Nuclear Power Plant facilities using Landsat images.

Project | Methodology:

We used the following data and programs to complete this project:

- a. ERDAS IMAGINE 2011
- b. ArcGIS 10.1 (ArcMap and ArcCatalog)
- c. Landsat 4 image of the area surrounding the Chernobyl Nuclear power plant before April, 1986.
- d. Landsat 7 image of the area surrounding the Chernobyl Nuclear power plant after April, 1986.

Landsat 4 TM reflective bands:

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1	0.45 - 0.52	30
Band 2	0.52 - 0.60	30
Band 3	0.63 - 0.69	30
Band 4	0.76 - 0.90	30
Band 5	1.55 - 1.75	30
Band 6	10.40 - 12.50	120 * (30)
Band 7	2.08 - 2.35	30

http://landsat.usgs.gov/band_designations_landsat_satellites.php

Landsat 7 ETM reflective bands:

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1	0.45 - 0.52	30
Band 2	0.52 - 0.60	30
Band 3	0.63 - 0.69	30
Band 4	0.77 - 0.90	30
Band 5	1.55 - 1.75	30
Band 6	10.40 - 12.50	60 * (30)
Band 7	2.09 - 2.35	30
Band 8	.52 - .90	15

http://landsat.usgs.gov/band_designations_landsat_satellites.php

Spectral Bands

Ground Cover Type:	Natural Color (3,2,1) appears:	False Color: (4,3,2)	In Pseudo Natural Color (7,4,2), appears:
Trees and bushes	Olive Green	Red	Shades of green
Crops	Medium to light green	Pink to red	Shades of green
Wetland Vegetation	Dark green to black	Dark red	Shades of green
Water	Shades of blue and green	Shades of blue	Black to dark blue
Urban areas	White to light blue	Blue to gray	Lavender
Bare soil	White to light blue	Blue to gray	Magenta, Lavender, or pale pink

http://igett.delmars.edu/Resources/Remote%20Sensing%20Technology%20Training/Landsat_bands-sm.pdf

Two images of the area surrounding the Chernobyl Nuclear Power Plant were downloaded from the U.S. Geological Survey website (usgs.com). One pre-explosion image taken in August 1985 and one post-explosion image acquired in August 2001. The 1985 image originally had a resolution of 30 meters, as it came from Landsat 4-5TM, and we resampled it to 60 and 120 meter resolutions using ERDAS. In contrast, the 2001 image we downloaded came from Landsat 7 SLC, its resolution was much higher at 15 meters. For consistency we resampled this image to 30 meter resolution and used it along with 60 and 120 meter resampled images to compare them with those of 1985. Once our images were resampled we classified them by land use/cover using the supervised method. For the following step we used bands 3 and 4 from both the Landsat 4TM and Landsat 7 SLC image to determine the normalized vegetation difference index (NDVI) in each. Finally we compared and analyzed our results.

Finally we will come together to analyze our results and answer the following questions: Are there differences in land use before and after the Chernobyl accident, if so, what are those differences and are they significant? More specifically we are curious to see if vegetation and developed region patterns have changed over time as a result of the Chernobyl's explosion and release of nuclear radiation. We are also curious to see how the resampling of our images affects our classification and NDVI results.

Supervised Classification | Introduction:

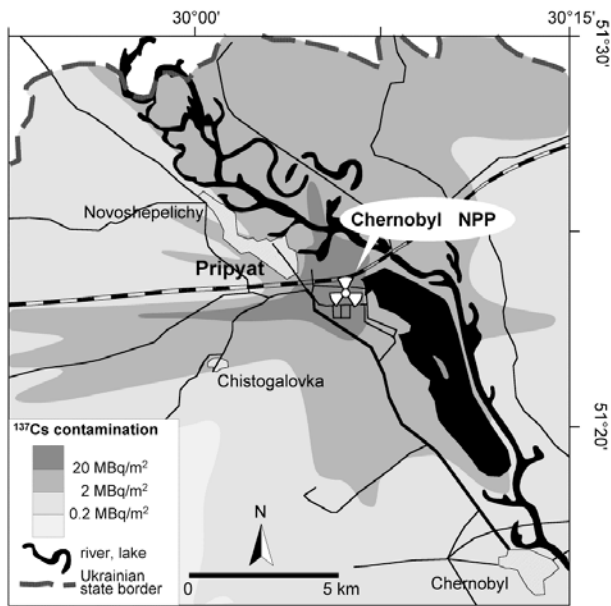


Figure 1 Deposition densities in the Chernobyl exclusion zone
(<http://eo.uit.no/publications/CD-IGARSS-07.pdf>)

The explosion of Chernobyl power plant in April 1986 in Ukraine had caused substantial impacts on the environment. A large amount of radioactive material was released. It was believed then that the radioactive material had widely spread. This incident was followed by a fire, and coupled up to 100 kilometers from the power plant. The most affected areas where there were contaminated with radioactivity. Ecologically, the explosion of Chernobyl power plant not only polluted the air, water sources nearby, and the soil, but it also caused mortality to mostly radiosensitive tree species. The main purpose of this project is to identify natural changes in land cover caused by Chernobyl incident; and to assess the effectiveness of supervised classification and change detection algorithms to detect land cover changes from stacked multispectral Landsat 4 and 7 imageries. released substantial amounts of radioactive material into the environment (NRC.gov) and caused a plenty of radioactive material which were released into the atmosphere widely and deposit within 30-100 km of the power plant. The area was a mixture of agricultural land, forest, marshlands, and urban areas, is a human-free area since then. Beyond 30

km, highest contamination area, flora and fauna have flourished. So that, the accident could affect the local vegetation and contaminated in water, air and

Question:

Are there differences in land use before and after the Chernobyl accident, if so, what are those differences and are they significant?

Supervised Classification | Data and Methodology:

In order to compare two images in two difference times (before and after) of the area surrounding the Chernobyl Nuclear Power Plant as well as to make use of multitude of data from satellite imagery included categorizing land into its various use functions. Landsat images were acquired from the USGS website one Landsat 4 TM image from August 1985, and one Landsat 7 ETM+ image from April 2001. ERDAS IMAGINE 2013 was operated. Prior to the analysis the images were projected to the UTM WGS 1984 zone 35 projection, also stacked all spectral bands together to colorize true-color and false-color images for distinguishment in sampling process. Also used for the normalized difference vegetation index (NDVI) and vegetation indices, brightness, greenness and wetness, were computed for each of the years. The classification comparison for Chernobyl area was based on supervised classification using five major classes: water, forest, agriculture, urban and vegetation. The difficulties in change detection is that change is a continuous variable and includes both gradual

changes, such as seasonal vegetation changes and inter-annual variability, as well as abrupt changes, such as caused by fire or land use conversion. (Corine Davids et al.)

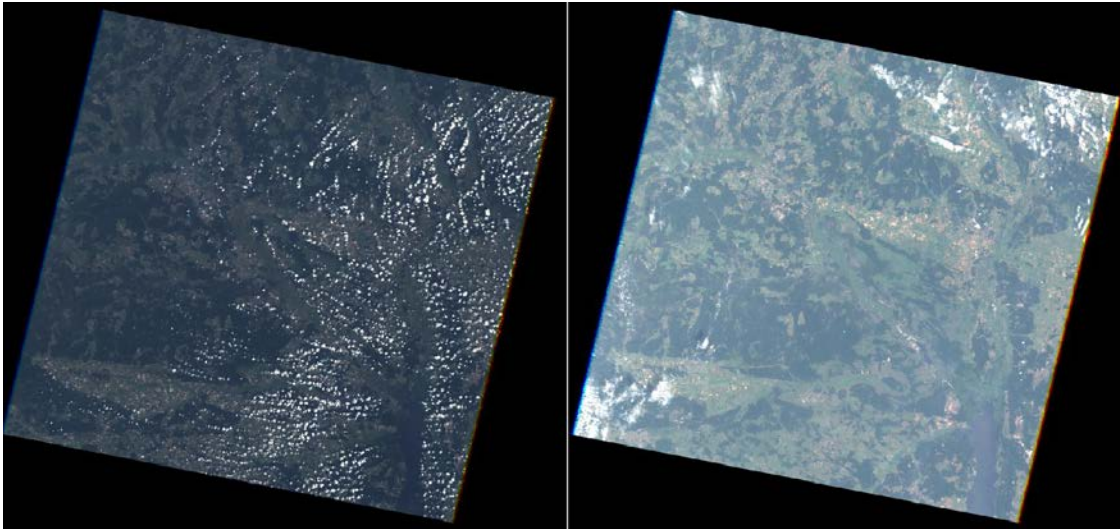


Figure2 stacked True-Color Landsat 4 TM image (left) collected August 1985 and True-Color Landsat 7 ETM image (right) collected August 2001.



Figure 2 subset false color (1-4-7) Landsat 4 TM from 1985 and Landsat 7 ETM+ from 2001 covers study area which less covered by cloud.

1. The first step was download Landsat 4 and Landsat 5 TM from USGS website.

The two satellite images were selected in August 1985 before incident and August 2001 after incident.

2. Unzip two zipped files into folders as TIFF files for each bands.
3. Start ERDAS and open the Viewer. Import .TIFF images into viewer and stack them together using for generate an .IMG file.
4. Import the .IMG file into Viewer, in the viewer click on Classification → Supervised, which opens the tools to be used for the definition of training areas. Use the polygon tool to define training areas for the classes that would be identified.
5. Sampling areas for each classes. Five areas in each class were selected for the validity. Generate a signature file, after selecting sample areas for all five classes, select Signature Editor which provides the necessary functions to generate the signatures and calculate several statistics of each classifications for comparison in the next step.
6. Combine all same sample areas (polygons) into a class, name and color it.
7. Store the final version of your signature file as a .sig file.
8. Repeat through step 4 for all dates and resolutions images using the .sig file from the previous step.
9. Use the signature file for processing all images at any resolution

10. Subset original, supervised classification images.

11. Run Change Detection Tool.

Supervised Classification | Results:

The Chernobyl accident took place during the harvesting season (mid-to-late August). It was found in the study that some areas had been possibly harvested before and some after images taken. Thus, it is possible to find bare and open areas all over the study area. Since the Landsat image from 1985 (Fig. 2) was partly covered by cloud, so that two areas were selected and subset representatively for manipulating change detection. The first area is a small-sized urban and located south of the power plant. Another area is agricultural area located in the area affected by the radioactivity and less covered by the cloud. As shown below, there are three pairs of images between 1985 and 2011 at 30-meter resolution. First pair is a True-Color (3-Red, 2-Green, and 1-Blue) images. The second pair is supervised classification images. The last one is the one when change detection process was applied (left) and highlighted areas of changes (right).

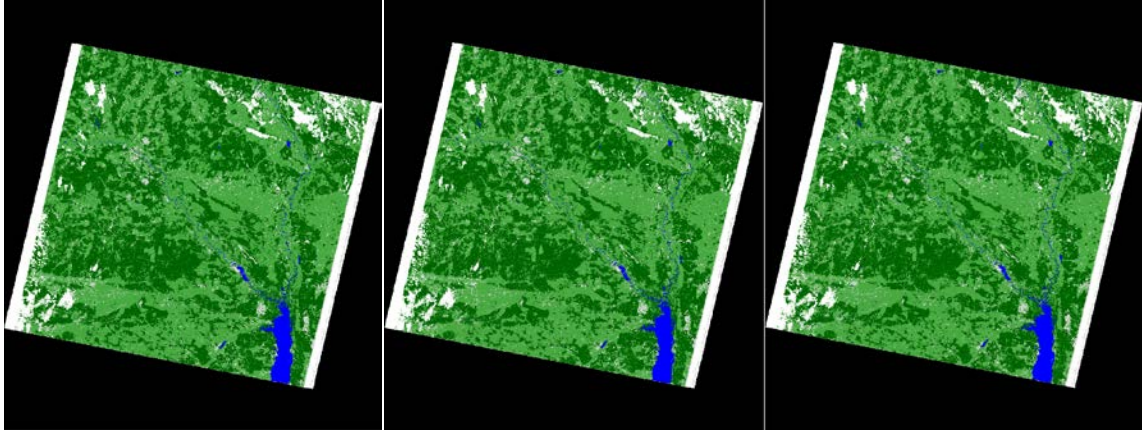


Figure 3 Comparison between sampled and classified images from August 1985 at 30, 60 and 120 meter resolutions, respectively.

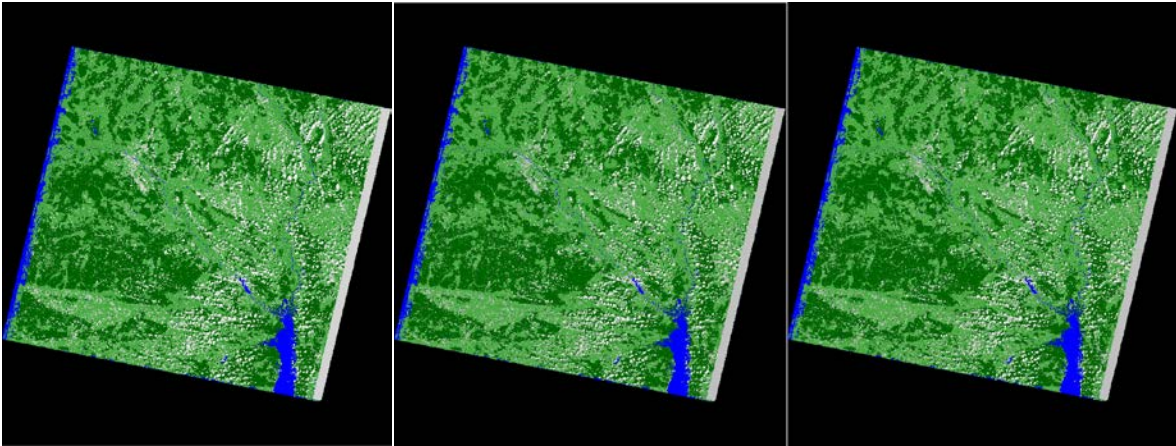


Figure 4 Comparison between sampled and classified images from August 2001 at 30, 60 and 120 meter resolutions, respectively.

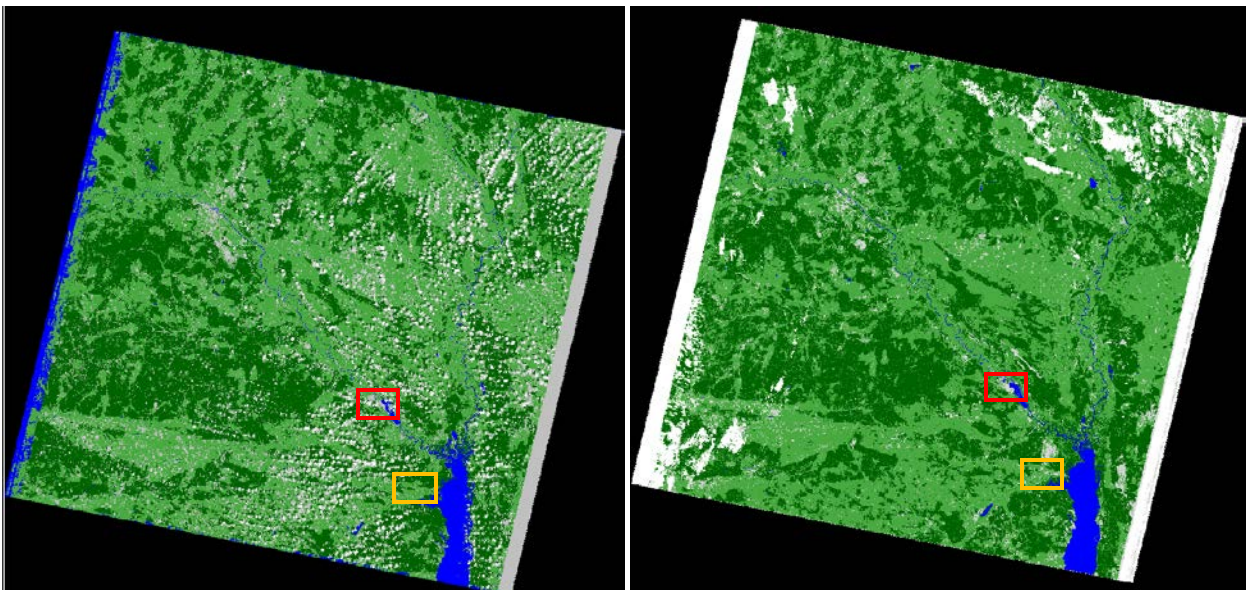


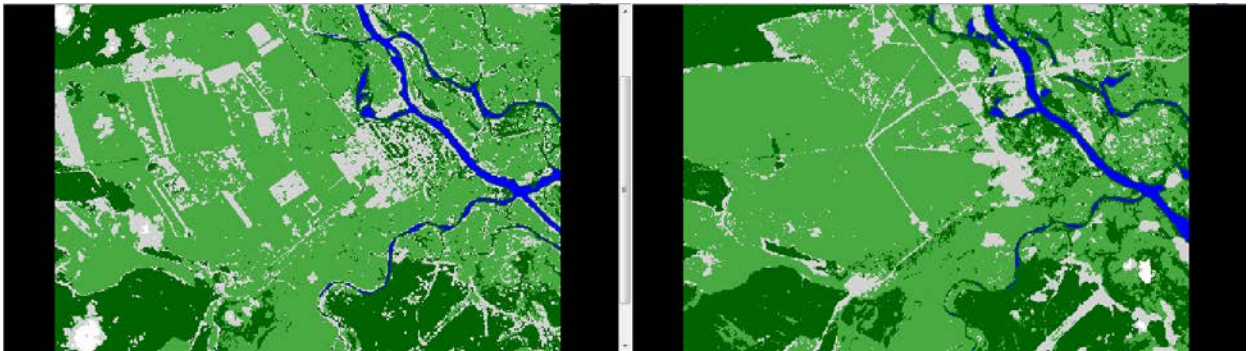
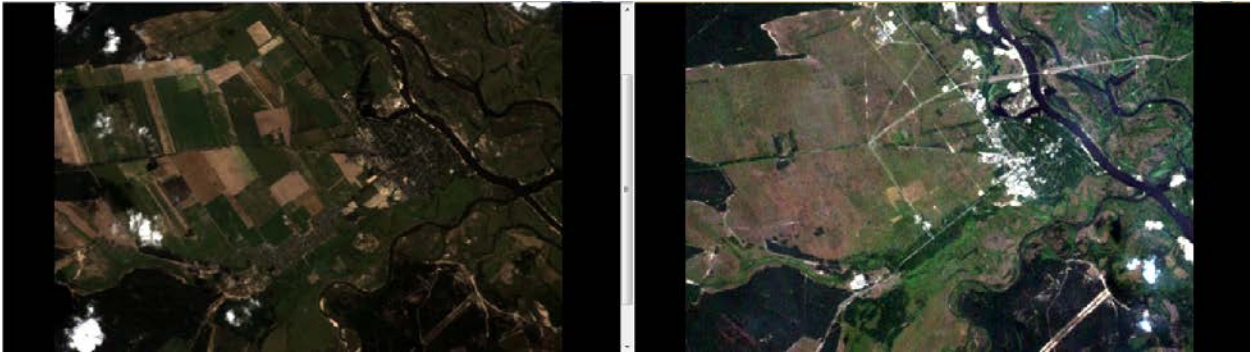
Figure 5 two-sampled areas (in red and orange rectangles) in classified images from 1985 and 2001 at 30 meter resolution.

	Cloud
	Urban, Open, Bare, Developed Areas
	Agriculture, Swamp, Low density forest
	Forest
	Water

Figure 6 attribute table of classified areas

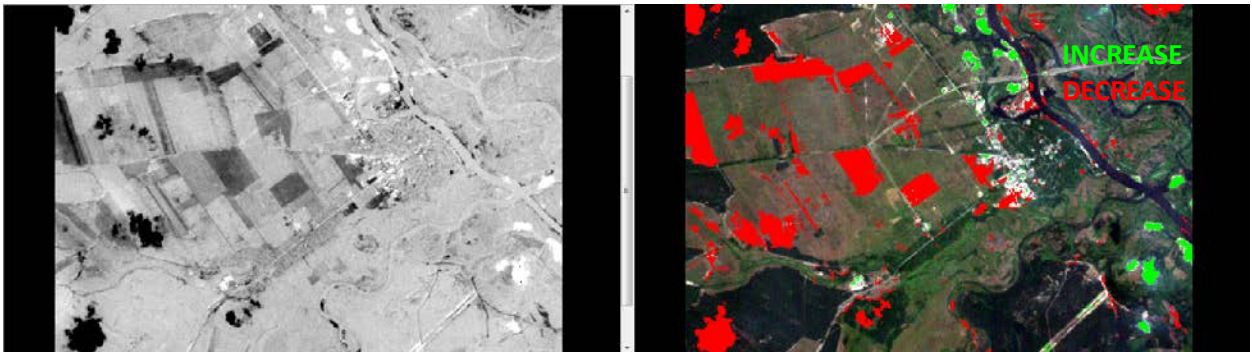
1985

2001



Change Detection 1985 & 2001

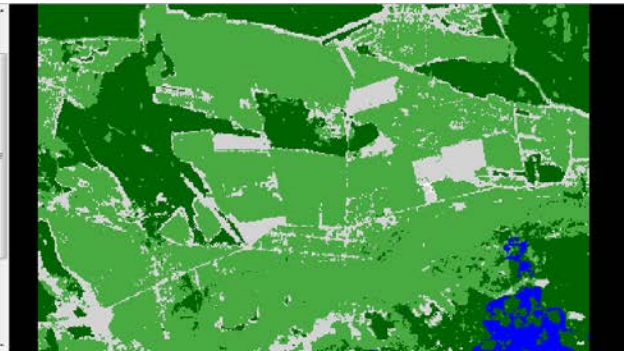
Highlighted Change Detection 1985 & 2001



From urban-zone images above, visually, satellite images, 1985 image (left) seems to have more bare, open, marshland and swamp areas than 2001 image (right). Urban zone is looked brighter. This can be assumed that the urban area was abandoned and left over only buildings which reflect the ray quite well. The second pair, supervised classification shows differences between two images quite clear. Bright green represents agriculture, swamp and low-density forest. All areas used to be urban, field-crop, bare and open areas turned to green instead. The last pair also indicates the same result. Red areas represent decreasing and green is supposed to indicate an increase of land use. In this case, green-color polygons are cloud in the study area. Briefly, there are differences in land use before and after the Chernobyl incident.

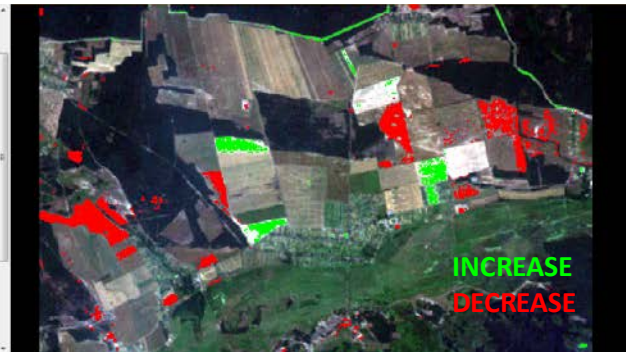
1985

2001



Change Detection 1985 & 2001

Highlighted Change Detection 1985 & 2001



From agriculture-zone images, 1985 image (left) looks more green than 2001 image (right). This can be concluded that the area was neglected during the incident occurring. The vegetation died off after that. It can be noticed that the land cover and allocative patterns in the area were changed. To prove that the classified images were correct, we employed the Change Detection Tool. Four bright areas were found occurred which could be assumed to be bare areas without any land covers. Secondly, grey color still represents bright areas, anyway forest area (on the left – dark green) seems to be increased from 1985. The third pair is showing more or less the same as the first and the second pairs.

Supervised Classification | Conclusion:

According to the project questions, some changes in land use were found when the 1985 (before the incident) and 2001 (after the incident) images were brought for comparing. Urbanization has been neglected and transformed in the urban-zone, while forest and bare areas were found increased in the agricultural-zone.

However, there are some limitations which might be the causes of the accuracy of the interpretation in this analysis. Firstly, only one year image after the incident (2001) was taken into the consideration. Actually, to see how changes had been developed the year by year images after the incident should be taken into account. Secondly, the cloud and haze on the day the images were taken is the main obstacle in interpretation.

Project | Conclusion:

Once the three of us finished manipulating our data we identified significant differences in land use before and after the Chernobyl accident. Our NDVI analysis showed a vegetation decrease of 377,863 hectares (931.6 acres) from 1985 to 2001. We also identified 53,708 hectares (131 acres) of re-vegetated areas, meaning areas that were not vegetated in 1985 but were in 2001. We suspect some of these re-vegetated areas pertain to towns that were populated in 1985 and abandoned by 2001, which allowed for wild vegetation growth. We also analyzed the decrease in vegetation from 1985 to

2001, and came to a conclusion based on our supervised classification. We believe this refers to the indicated increase in bare areas in 2001, which in 1985 were used for agriculture and therefore vegetated.

Finally, we looked at how the resampling of our images affected our analysis after manipulating our data. The distortion we noticed was minimal and it was in terms of our total area of analysis. Our 30 meter resolution image for 1985 had an area of 3,372,148 hectares (8,332,759 acres), after resampling to 60 meters and 120 meters that area changed to 3,372,112 hectares (8,332,670) and 3,372,140 hectares (8,332,739) respectively. The area changed similarly when we resampled our image from 2001; the 30 meter image was 3,066,860 hectares (7,578,376 acres), 60 meter image became 3,066,760 hectares (7,578,129 acres) and the 120 meter image area was 3,066,830 hectares (7,578,302 acres). We believe part of the reason why the area between the 1985 and 2001 in the 30 meter image is different is because it was distorted when we resampled it to 30 meter resolution from the original 15 meter resolution, as explained in the resampling methodology.

Supervised Classification | References:

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http://igett.delmar.edu/Resources/Remote%20Sensing%20Technology%20Training/Landsat_bands-sm.pdf