The vegetation condition changes near Chernobyl based on Landsat TM

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Abstract. The radioactive explosion at the Chernobyl Nuclear Power Plant was one of the greatest anthropogenic disasters in history. The explosion took place on April 26th 1986 near Pripyat. Subsequently, radioactive dust was dispersed over long distances. As a result, a large area has been contaminated, including vegetation cover, which was analyzed in this study. The aim of the research was to explore plant condition near the town of Prypiat before and after the radioactive explosion in Chernobyl. Another goal was to estimate vegetation renewal after the disaster and changes in condition. Landsat TM images from five periods were used: 1984, 1986 (days after the explosion), 1987, 2002/2003 and 2010/2011. After preprocessing, vegetation indices have been calculated: NDVI, SAVI, ARVI, VARI, NDII and MSI. Because of cloud cover on the images, one area has been selected for detailed analysis. In addition, the meteorological conditions in each period have been analyzed. Two indices – NDVI and MSI have been chosen to present the results. The vegetation range and condition near Pripyat has changed after the disaster and at each subsequent date became better than earlier. The best plant condition was noted in 2010/2011, whereas the worst before the disaster – in 1984. For agricultural areas, the best condition was noted in 1986 and 2002/2003. Based on these studies there was no significant deterioration in the vegetation condition connected to the radioactive contamination. A more important factor was weather conditions. In fact, we can say that contamination has no influence on vegetation, the lack of human use of land on the other hand does.

Keywords. Chernobyl, vegetation indices, vegetation condition changes

1. Introduction

The explosion in the nuclear power plant near Chernobyl in 1986 was one of the biggest disasters in human history. Radioactive substances contaminated the environment, especially soils and vegetation cover, which is the subject of this study. Monitoring the effects of the disaster is difficult because of contamination, which has existed for a long time on the analyzed area. Using remote sensing data solves this problem and also makes the analysis of a large area at once possible.

The explosion took place on April 26th 1986 at 1:23 a.m., near the town of Pripyat in Ukraine. One of the effects of the accident was a radioactive cloud containing dust and contaminants, which later moved above Europe.

Contamination of the environment had been noticed just after the explosion. After the incident a lot of people died as a result of the disaster or fell ill with radiation sickness. It was found that the highest concentration of radioactive elements occurred in vegetation cover in 1986. The half-life of iodine is about 8 days, for cesium it is much longer – about 30 years [1]. Despite all of the disaster's effects, the pollution was not as strong as it was expected [2].

Analyses of the contamination changes were conducted in the area near Chernobyl [3, 4]. The remote sensing data were used in a number of research projects, of which most were dedicated to land cover changes [5, 6] or the analysis of vegetation condition [7, 8].

The aim of this research was to analyze the vegetation condition and its changes caused by the disaster and the sudden lack of agricultural use. Data used in this study was Landsat Thematic

Mapper images from five time periods. Five vegetation indices and meteorological data were used in the process of the analysis.

2. Methods

In this study data from five research periods were analyzed: two years before the disaster – 1984, days after the explosion in 1986, the year after – 1987, then about fifteen years after 2002/2003 and almost 30 years after – 2010/2011. Landsat Thematic Mapper images were used in the research. All of them were acquired during vegetation season to make comparison possible.

Firstly, the data were preprocessed – atmospheric correction was done using the Dark Object Subtraction method. Clouds were also masked. Subsequently, the NDVI values were calculated and areas without vegetation (the NDVI values lower than 0.2) were masked.

Then, vegetation indices were calculated – to estimate plant condition: Normalized Difference Vegetation Index [9], Soil Adjusted Vegetation Index [10], Atmospherically Resistant Vegetation Index [11], Visible Atmospherically Resistant Index [12]; to evaluate water content: Normalized Difference Infrared Index [13] and Moisture Stress Index [14]. After that the images of vegetation indices were sliced into classes dependent on the index value. Two of them were selected for a detailed analysis : NDVI and MSI.

One area was selected from the analyzed images for quantity detailed analysis – an area, which in 1984 (before the explosion) was covered with crops. The area was selected, because it was not obscured by clouds in any of the datasets. It is therefore possible to conduct quantitative analysis. Also, this area was representative of most of the agricultural areas near Chernobyl. This area is located south-west from the explosion site – the direction the radioactive cloud was moving [1].

The results were compared with meteorological data from a field station in Chernihiv. Precipitation and temperature were analyzed for each year to compare conditions.

3. Results

The results of the study were maps of spatial distribution of vegetation indices. Based on the NDVI values changes of vegetation condition can be noticed during the analyzed years. In 1984 plant condition was rather poor. After the explosion in 1986 there can be seen an improvement of plant condition (see Table 1 and Figure 1). Plant condition in the year after the disaster (1987) was worse than earlier in 1986. About 15 years later good plant condition was observed on about 70% of the analyzed area.

Table 1. The percentage of Normalized Difference Vegetation Index values for each class on analyzed area.

NDVI values	Research period				
	1984	1986	1987	2002/2003	2010/2011
less than 0	0%	0%	0%	0%	0%
0-0.2	30%	5%	12%	1%	16%
0.2-0.4	46%	31%	49%	29%	32%
0.4-0.6	24%	49%	39%	60%	42%
0.6-0.8	0%	15%	0%	10%	10%

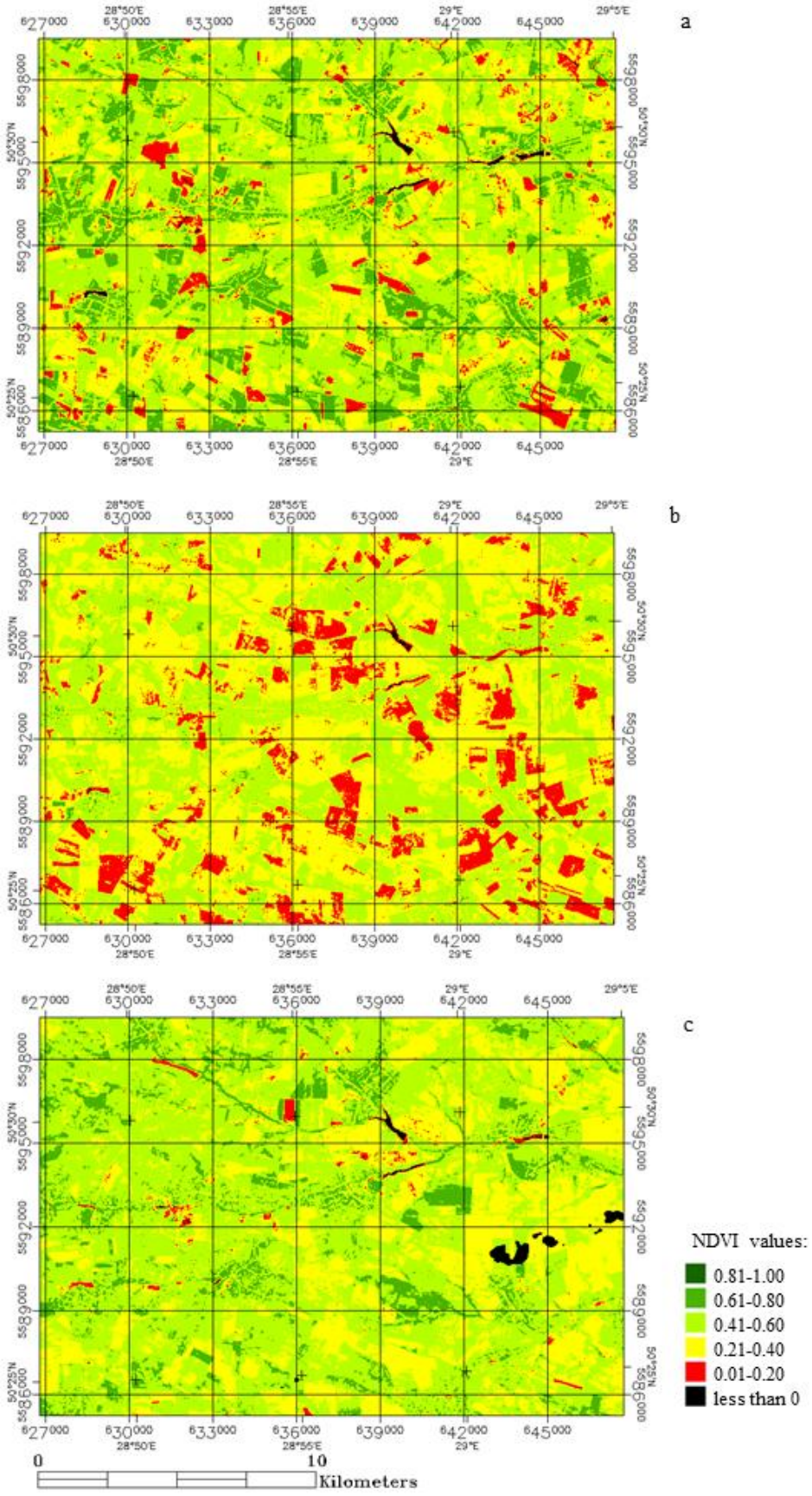

Figure 1. Spatial distribution of NDVI in (a) 1986, (b) 1987, (d) 2002/2003 on analyzed area.

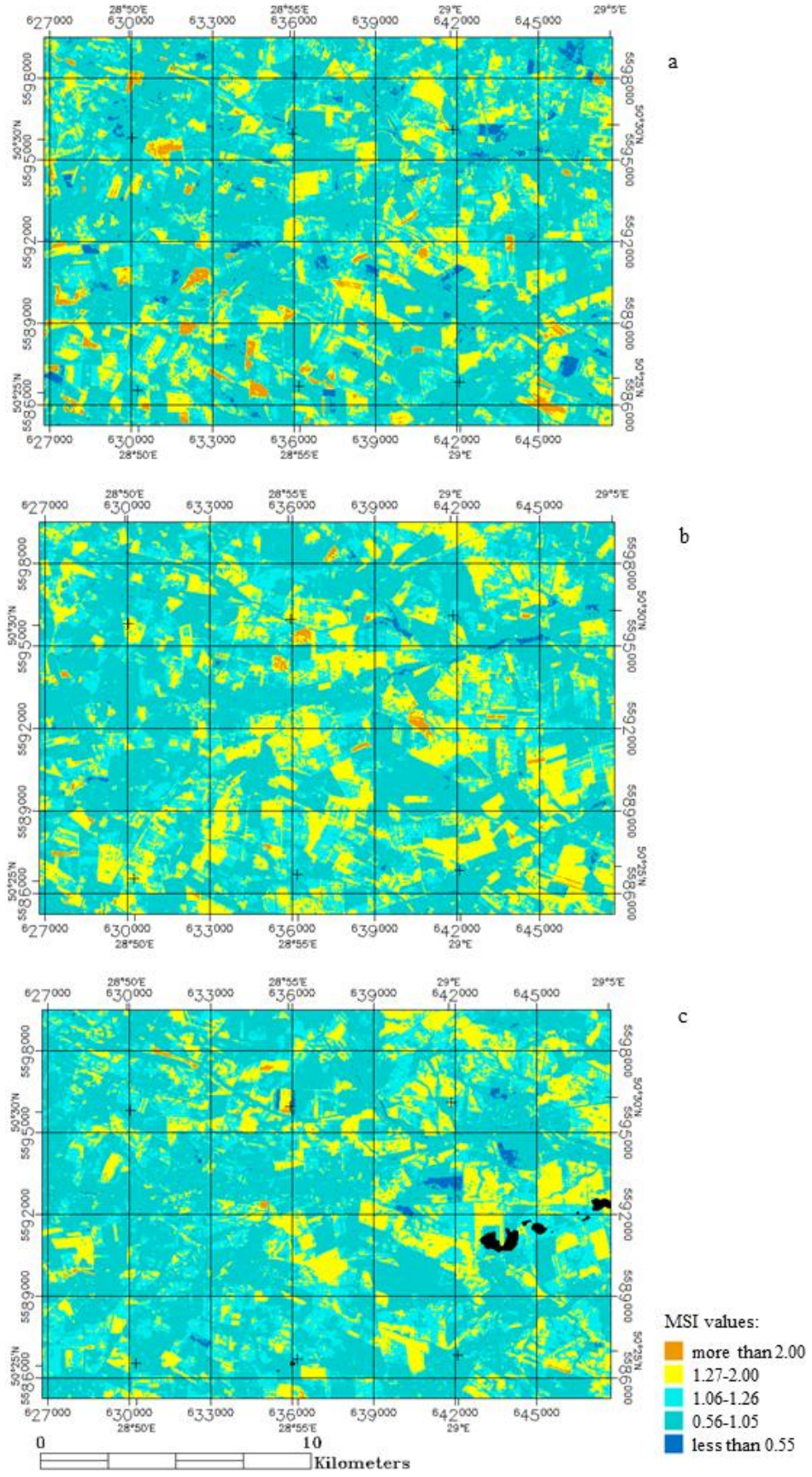

Figure 2. Spatial distribution of MSI in (a) 1986, (b) 1987, (d) 2002/2003 on analyzed area.

Moisture Stress Index, which shows water stress, was analyzed to check the wetness on analyzed area. Optimum water content was noticed just after the explosion (1986 and 1987) and in 2002/2003 (see Table 2 and Figure 2). In two other research periods water deficits were observed.

Table 2. The percentage of Moisture Stress Index values for each class on analyzed area.

MSI values	Research period				
	1984	1986	1987	2002/2003	2010/2011
more than 2	16%	2%	1%	0%	11%
1.27-2	52%	18%	24%	19%	32%
1-1.27	15%	22%	27%	29%	24%
0.5-1	16%	56%	48%	51%	30%
less than 0.5	0%	2%	0%	1%	1%

To compare the results with meteorological condition amount of precipitation and average temperature in research periods was analyzed. It appears that lower NDVI values can be connected to the lower temperature in mentioned research periods. Vegetation condition was not directly related to the amount of precipitation.

4. Conclusions

The presented studies showed the changes in vegetation condition after the explosion in Chernobyl. There were no direct changes in vegetation condition related to the explosion and contamination, which was also the conclusion of another study [2]. The worst plant condition was noticed in 1984, and the best in 1986. Worse plant condition was also in 1987, but the changes were small and probably related to lower temperature. Furthermore, more significant differences in plant condition were noticed in different research periods.

It was not possible to define what influenced the condition the most. Based on the conducted studies it can be concluded that vegetation state was not related to the contamination. Meteorological parameters like precipitation and temperature had a greater impact on plant condition. Analyzed vegetation is in better condition without human intervention than during agricultural use.

Using remote sensing data makes it possible to compare vegetation condition before and after nuclear explosion in Chernobyl. Further research should concern detailed analysis of a bigger area.

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