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Analysis of land-use/land-cover change in the Carpathian region based on remote sensing techniques

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Abstract

In the last few years serious flood events occurred at the watershed of the river Tisza (both in Hungary and in Ukraine). One of the reasons of these floods is heavy precipitation at the region, which may result in severe runoff consequences because of the significant change in land-use/land-cover. In this paper land-use/land cover change occurred during the last decade have been analysed for the subcatchments of the upper river basin of Tisza. Remotely sensed datasets observed by NOAA and NASA satellites are available for this period. According to the results forest area on the upper subcatchments of the river has decreased by about 5% on average, while about 10–20% less forest area has been detected in case of the Eastern subcatchments from 1992/1993 to 2000/2001.

Keywords: Land-use/land-cover change; Satellite measurements; Upper basin of the river Tisza; Flood events; Deforestation

1. Introduction

After a 20–30-year-long dry period in the last few years several serious flood events (Autumn, 1998; Spring, 1999, 2000, and 2001) occurred at the watershed of the Ukrainian and Hungarian parts of the river Tisza. The water level at many stations exceeded the previous historical record values during these recent floods. For instance, Fig. 1 presents the annual maximum water level and the annual number of days above 1st order flood warning at Vasarosnameny (at river Tisza, Hungary) between 1991 and 2001. The positive decadal tendency in water level change is obvious, and the time series illustrate the considerable increase in very high water level (exceeding flood warning levels) frequency after 1998.

Because of severe social, economical consequences of recent floods, enhanced public interest appeared to analyse and clarify the complex relationships between flood events and their possible reasons. In order to fulfil this demand several aspects of recently increased flood frequency and intensity must be scientifically investigated. They include recent very intense clear cutting of forest at headwaters (on steep slopes of the Eastern Carpathian Mountains), increased frequency of storms with intense precipitation, change in annual precipitation distribution over subcatchments, longer and colder winter with considerable snow accumulation, regional effect of global warming, etc. In this paper one of the potential effects is analysed, namely, the land-cover/land-use change of the upper part of the Tisza river basin. This area is shared by four countries (i.e., Romania, Ukraine, Slovakia, Hungary), the analysis presented here is accomplished on a subcatchment basis. For the separation of the watershed areas of tributary streams of the river Tisza the HYDRO1k Elevation Derivative Database (Verdin and Jenson, 1996) has been used. In

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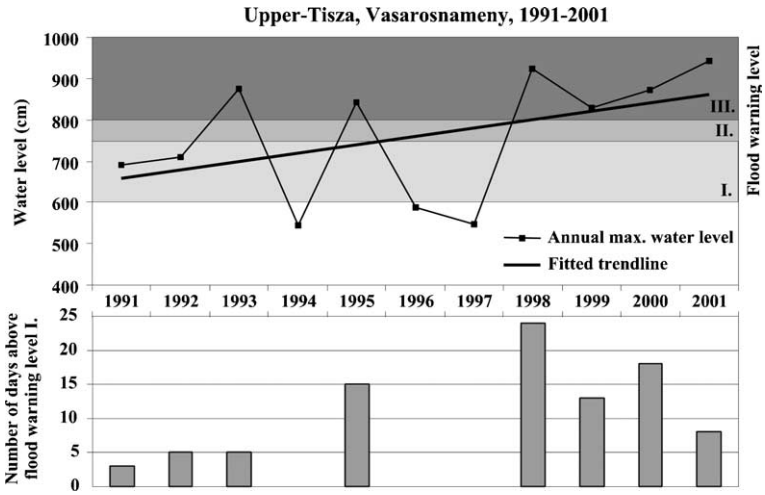

Fig. 1. Annual maximum water level and the number of days above 1st order flood warning at the river Tisza, Vasarosnameny, 1991–2001.

case of a 28,000 km^2 large area it is obviously impossible to rely solely on ground-based measurements to estimate land-cover change. Therefore, remotely sensed satellite information must be considered, which guarantee appropriate spatial coverage for the selected subcatchments. In order to compare land-use/land-cover characteristics between 1992–1993 and 2000–2001 the NOAA Global Land Cover Characteristics Data Base (Loveland et al., 2000) and the MODIS Land Cover Product (Friedl et al., 2002) have been applied.

The aim of the analysis presented here is to answer whether or not the forest area at the headwaters of the river Tisza noticeably decreased during the last decade. First, the datasets are presented followed by the description of the applied methodology. Then, the results and finally, the conclusions are provided in this paper.

2. Data

Boundaries of the subcatchments are determined on the base of the HYDRO1k Elevation Derivative Database. Remotely sensed land cover information is compared using the NOAA Global Land Cover Characteristics Data Base (for 1992/1993) and the MODIS Land Cover Product (for 2000/2001).

2.1. HYDRO1k elevation derivative database

HYDRO1k is a hydrological database (Verdin, 1997) with 1 km spatial resolution developed by the US Geological Survey's (USGS) Earth Resources Observation System Data Center from the USGS 30″ digital elevation model (GTOPO30) of the world (Verdin and Jenson, 1996). HYDRO1k contains 8 hydrological data sets for each continent, namely, hydrologically correct digital elevation model (DEM), derived flow directions, flow accumulations, slope, aspect, compound topographic (wetness) index, streamlines, and basins (Jenson and Domingue, 1988). In order to select the 7 subcatchments of the headwater of the river Tisza the basin data set (derived from streamlines and flow directions) has been used (Jenson, 1991). The geographical locations of the analysed subcatchments are shown on Fig. 2. One of the seven areas (No. 1) is located in Romania, two of them (Nos. 6 and 7) are in Slovakia and the others (Nos. 2–5) can be found in Ukraine. Fig. 3 presents the area-ratio of each subcatchment compared to the total area of the watershed of the Upper-Tisza river outside of Hungary. 18%, 54%, and 28% of the total area is located in Romania, in Ukraine, and in Slovakia, respectively.

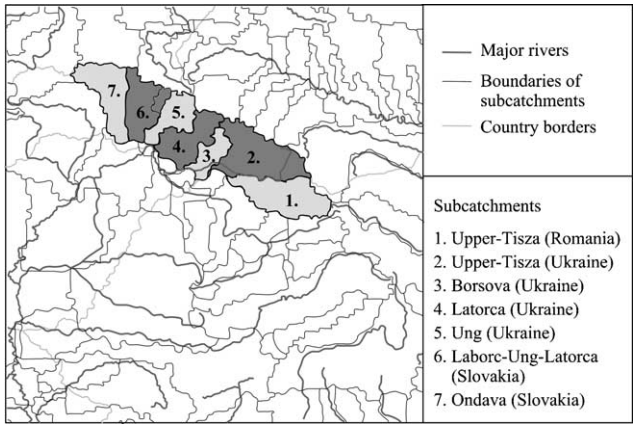

Fig. 2. Geographical location of the selected subcatchments of the Tisza river basin.