Sulphur deposition and nitrogen retention changes observing by satellite-based remote sensing indices on Czech watersheds

In a modern society air pollution is a big ecological problem. Air pollutant deposition in Central Europe forest ecosystems has been a major cause of mineral nutrient depletion in near past. Especially acid rains caused mainly by emissions of sulphur dioxide and nitrogen oxide have adverse effects on forest health (Woo, 2009). Many countries in Europe have reduced their atmospheric emissions of sulphur (S) and nitrogen (N) considerably since 1970s (Vestreng and Støren, 2000). Czech Republic was heavily affected, the main source being combustion of locally mined lignite (Hruška et al., 2002). A network of small forested watersheds GEOMON (from GEOchemical MONitoring) was established there in 1994 to measure precipitation and stream chemistry.

Usage of satellite-based remote sensing methods has proven to be beneficial for studying forest health properties by various published studies. According to Coppin et al., (2004) those methods offers (1) consistent and repeatable procedures, (2) less expensive way of obtaining information about land surface and (3) possibility of incorporating information from non-visible parts of the electromagnetic spectrum. One of the most used satellite mission for studying forest health properties, disturbance and recovery is Landsat. Its main advantages are good coverage, sufficient spatial resolution and maybe the most important is its rich archive containing all the images acquired since the year 1972. Data from Landsat in this field were successfully incorporated into the studies dealing with forest health and structure on different scales - from global (Hansen et al., 2013) and continental (White et al., 2017) to regional (Griffiths et al., 2014).

Many studies evaluating forest disturbances using Landsat time-series were carried out, usually taking into account large-scale ecological factors as bark beetle outbreaks (Senf et al., 2015), forest wildfires (White et al., 2017), windthrows (Oeser et al., 2017) and harvesting (White et al., 2017). Much less can be found about effects of disturbances caused by changes in biogeochemistry, such as soil acidification caused by air pollution. These continuous and much more subtle disturbances can be hard to assess via remote sensing since there are many variables which should be accounted for.

For studying forest disturbances, a Disturbance Index (DI) was proposed by Healey et al., (2005). It uses Tasseled Cap (TC) transformations of Landsat bands and their combinations and was tested in both Russia and USA where it produced more accurate change classification than original Landsat reflectance data. The DI was then used in

another studies located in regions with forest disturbances. Eshleman et al., (2009) found a relationship between the change in total dissolved nitrogen concentration and change in DI using linear regression. Slightly different approach was carried out by Deel et al., (2012) by introducing cumulative version of DI for assessing disturbance impacts on forest functioning. They found out that this method produces significant relationships with percent canopy cover at plot-level and with canopy percent N at watershed-level.

The objective of this research was to find out whether changes in measured TIN and sulphur can be observed with chosen remote sensing-based vegetation and disturbance indices on GEOMON sites. In particular, we tested the hypothesis that decrease in sulphur deposition will cause the retention of TIN and this will demonstrate itself in the form of DI decrease (meaning that the forest is likely to be recovering). We expected to see the most pronounced dependency at watersheds most exposed to air pollution in the past.

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