Multimedia Analysis of Satellite Data in Secondary Schools

Annamária Komáromi
Balassi Bálint Eight Grade Secondary Grammar School, Budapest, Hungary
annamarcsi1015@gmail.com

***Abstract*—We often admire the beauty of satellite images. Nowadays students have the opportunity to become familiar with the preparation of these satellite photos in physics classes, e.g., with the help of the program LEOWorks. This software is developed by the European Space Agency (ESA) for educational purposes, and it can be freely downloaded from the Internet [1]. On the webpages of ESA, the students get know why satellites have to take photos at different optical bands, how we can make spectacular pictures from these photos, what the atmospheric window is, and so on.**

On the webpage of EUMeTrain [2], the students get know about meteorological simulators, which are suitable either to teach something new or to test existing knowledge on the topic of analyzing meteorological satellite data.

There are some other opportunities to use the data of remote sensing satellites in education on the topic of environmental physics, too. These data are usually on the Internet also. For example, on the webpage of NASA one can find instructions on how students should analyze data in connection with global warming, and due to the self-evaluation, they can understand the danger of climate change more deeply; therefore, we can conclude that the use of multimedia is a very effective method in our teaching in this area.

Keywords: satellite images, meteorological simulator, environmental physics, EUMeTrain

I. INTRODUCTION

When using electromagnetic waves in practice, satellites deserve special attention. Remote sensing is – to put it this way – the ‘life and soul’ of every satellite, which includes detecting and sensing the electromagnetic waves it receives and propagates. For career guidance purposes we can inform our students that this topic also leads to Geoinformatics taught as an individual subject in higher education. They can get to know more details about remote sensing and Geoinformatics during their secondary education as well.

II. REMOTE SENSING IN PRACTISE

A. Remote sensing

Remote sensing is a measuring technique when the data collector device has no direct (physical) contact with the observed object.

The most important object of classic remote sensing is the Earth. Humanity has been doing Earth observations, i.e. examining the atmosphere, surface and belly of Earth for thousands of years. Besides the traditional methods of meteorological stations, geodesy and sampling, satellite measurements have become more and more important data sources. Their main advantage is to make various measurements and data collection possible in larger territories, on the other hand, applying them needs special knowledge to be acquired.

The images of remote sensing can be received by recording systems (sensors) based on several operating principles. The physical basis for remote sensing is detecting the spectral distribution and changes of electromagnetic radiation. Passive remote sensing systems mostly measure the radiation from the Sun that is reflected or emitted by the given object, usually in the optic spectrum of visible light and the sectors closest to it (0.4 – 15.0 μm wavelength). Active remote sensing systems (of which radars are the most widely known) detect radiation emitted by themselves and reflected by the objects or surfaces observed mostly in the wavelength of 0,0075 – 0,60 m.

The basis of assessing the images of remote sensing is that different materials reflect or absorb electromagnetic waves to varying degrees. For this reason, materials of the surface, plants or objects can be identified; we can even infer their condition, too.

B. Satellite images

Satellite images contain pixels which show the luminous power and the intensity of the reflected light in a given optic spectrum. In a certain frequency range we can only measure the energy of radiation within the same range. Since materials absorb and reflect radiation of different frequency to different degrees, we make measurements on various frequencies to be able to find the material we are searching for. For example, in Fig.1 we can see the difference between natural and dried-out grass.

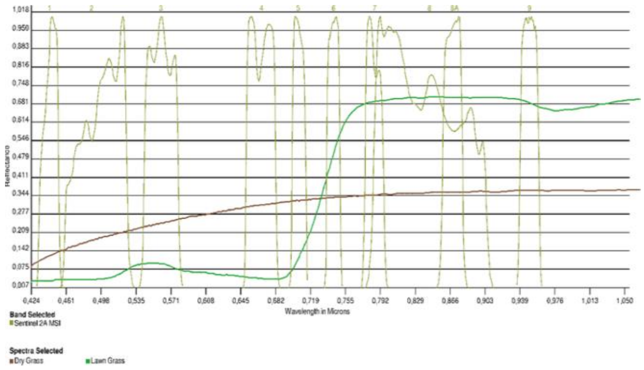

Fig. 1 The reflectance of natural grass (green) and dried-out grass (brown) in % (axis y), on different frequencies (axis x) (source: [3])

During satellite observation of the Earth, we have to pay attention to the fact that the electromagnetic waves from the Sun interact with the atmosphere: certain part of the energy is reflected or absorbed, and a greater dispersion can occur because of the higher humidity level of the atmosphere (clouds) or certain gases (e.g. O_2, NO_2, CO_2). The wavelength ranges where the dispersion and absorption are the smallest are called atmospheric windows.

The human eye also works as a sensor, and it was evolved due to the fact that its measurement range is in an atmospheric window. Moreover, the Sun emits light with the highest energy in this particular frequency range, so our eyes need the lowest sensibility here. All the color images our eyes are used to are developed by integrating the pictures according to the color mixing patterns. When selecting images from a spectral band (the exponent colors can be red, green and blue 'RGB'), the perceived RGB image shows pictures realistically.

III. Applications of Remote Sensing in Classeroom

A. *Evaluation of a spectral index*

At this point we can discuss the spectral index, too. Spectral indexes are derived quantities, which we calculate from data measured on different wavelengths.

We can characterize different objects with spectral indexes, e.g. buildings or the vegetation. If needed, we can get a more detailed analysis. Indexes are based on theoretical models. One of the most widespread index of this type is NDVI (Normalized Differenced Vegetation Index) [19], which is used to identify the healthy greenery. This is calculated from the intensity data in red (R) and near-infrared (NIR) spectrums in the following way: NDVI=(NIR-R)/(NIR+R).

With the support of the European Union and ESA an educational software was developed, providing secondary school students and teachers with information about satellite measurements. This program is called LEOWorks, which demonstrates the basic steps of analyzing satellite data in details and it also helps students edit satellite images. One can find the freely downloadable program on website LEOWorks [1].

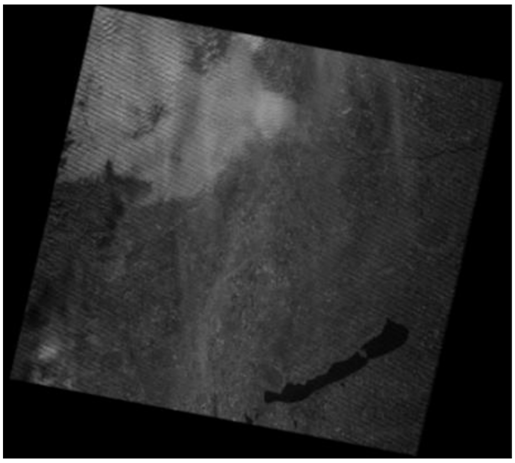

Fig. 2 Satellite image of Balaton Uplands and its region (source: USGS [4])

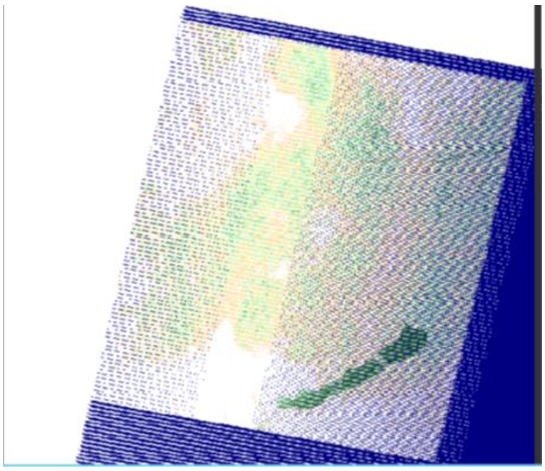

Fig. 3 The NDVI image of Balaton Uplands and its region made with the Leoworks program (source: work of my ninth graders in school)

In picture of Figure 3. we can see an image edited by my students of ninth grade, which they demonstrated in their presentation at the national secondary school team competition called 'Physics for Everyone'. This image depicts the vegetation cover of Balaton Uplands and its region, i.e. the map form of the NDVI rates. The image was edited with the help of Leoworks program by using freely downloadable satellite photos (see Figure 2) from website USGS [4].

B. *Other application of remote sensing in classroom*

The data we collect through satellite remote sensing can be used in a number of ways in the classroom. One of the pressing problems of our age is the rising sea levels due to global warming. It can be more effective, if students work with the data of different measurements themselves. Online data of scientific measurements are available for students, too. On the following website: https://www.jpl.nasa.gov/edu/teach/activity/graphing-sea-level-trends/, we can find guidelines to help them work with this topic in class as well as a detailed description of the necessary equipment and the procedure of the given task. Through these tasks students can get an insight into the work of a researcher and the topic of Environmental Physics.

It is notable that when I asked my 17-year old students in Physics class if they knew the reason why different weather forecasts in the media were often controversial, nobody knew the correct answer, i.e. forecasts of different meteorological institutions are based on different mathematical models. This is why I find it important to dedicate one or two classes to meteorology. It is also useful to make students familiar with the EUMeTrain's website [2], where students can get to know meteorological simulators, which are suitable for either teaching something new or testing existing knowledge on the topic of analyzing meteorological satellite data.

EUMeTrain holds week-long events frequently throughout the year, where experts give online presentations about new applications of meteorological satellite data on different themes. In the collection of case studies on EUMeTrain some natural phenomena or photos of some natural disasters can make the idea more understandable for students. For instance, when talking about Kármán vortices in class, we can see a perfect example of a satellite image of a swirling vortex in Figure 4.

Fig. 4 Satellite image of a swirling vortex (source: [5])

ACKNOWLEDGMENT

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