The impact of recent climate change on the ecological productivity of forests in Romania

– Scientific report 2020 –

The main objective of this project is to analyze the potential impact of recent climate change on forest productivity in Romania, based on various climatic and remote sensing data, which will be processed over the past three decades (1987–2016) by means of complex geostatistical techniques.

According to the funding application, the project's **specific objectives** are:
1) acquisition of interannual climatic and satellite data in Romania for the 1987–2016 period, necessary to test the hypothesis of the recent climate change impact on forest productivity countrywide;
2) geostatistical processing of trends in forest vegetation density in Romania, in relation to the trends of the main climatic parameters over the past three decades;
3) geostatistical processing of trends in forest biomass in Romania, in relation to the trends of the main climatic parameters over the past three decades;
4) geostatistical processing of trends in net primary productivity of forests in Romania, in relation to the trends of the main climatic parameters over the past three decades;
5) raising awareness on the necessity of interdisciplinary scientific investigations of this important ecoclimatic issue in Romania's scientific/political spheres by disseminating the study's results.

Therefore, in line with the workplan and Gantt diagram presented in the funding application, **during the project's first months, the first objective was partially met, i.e. acquiring satellite data across Romania for the 1987–2016 period**. The climate data that will also be used in the project for the entire Romanian territory, for the same 30-year interval, will be downloaded and processed in the first months of 2021. Thus, by purchasing this second type of data and remote sensing data, which has already been downloaded so far, the project's first concrete objective will be fully achieved. This report features several relevant elements regarding the satellite data downloading process in Romania in the analysed period.

The satellite data used for Romanian territory consisted of multitemporal Landsat imagery, downloaded for the 30 years using the Google Earth Engine platform (GEE, earthengine.google.com) and the tools provided by this international database. In order to cover the 1987–2016 period, two collections of satellite imagery were used, i.e. LANDSAT 5TM Surface Reflectance Tier 1 (LANDSAT/LT05/C01/T1_SR), for the period 1987–2011, and LANDSAT 7TM Surface Reflectance Tier 1 (LANDSAT/LE07/C01/T1_SR), for 2012–2016, in the context of the TM5 satellite mission activity shutdown. The imagery featured in these satellite data

collections represents the reflectance of the Earth's surface (corrected atmospherically and radiometrically) and contains 4 spectral bands in the visible and near-infrared (VNIR) spectral range, 2 bands in short-wave infrared (SWIR) range and one in the thermal infrared (TIR) range.

All this data was downloaded for the summer season (months of June, July and August) of each year (the season with peak biological activity in Romania), using 22 satellite scenes across Romania (Fig. 1). Considering the 22 multispectral satellite scenes and the 16-day temporal resolution of LANDSAT data (revisit time of a given area), on average, 127 satellite images resulted for the summer season, which were processed for each year. This number varied however in certain cases, as some images were removed from the collection due to various technical issues of the sensor or to the unsatisfactory quality of the remote sensing data (Table 1). In total, for the 30 analysed years, 3809 satellite images were processed across Romania's entire territory.

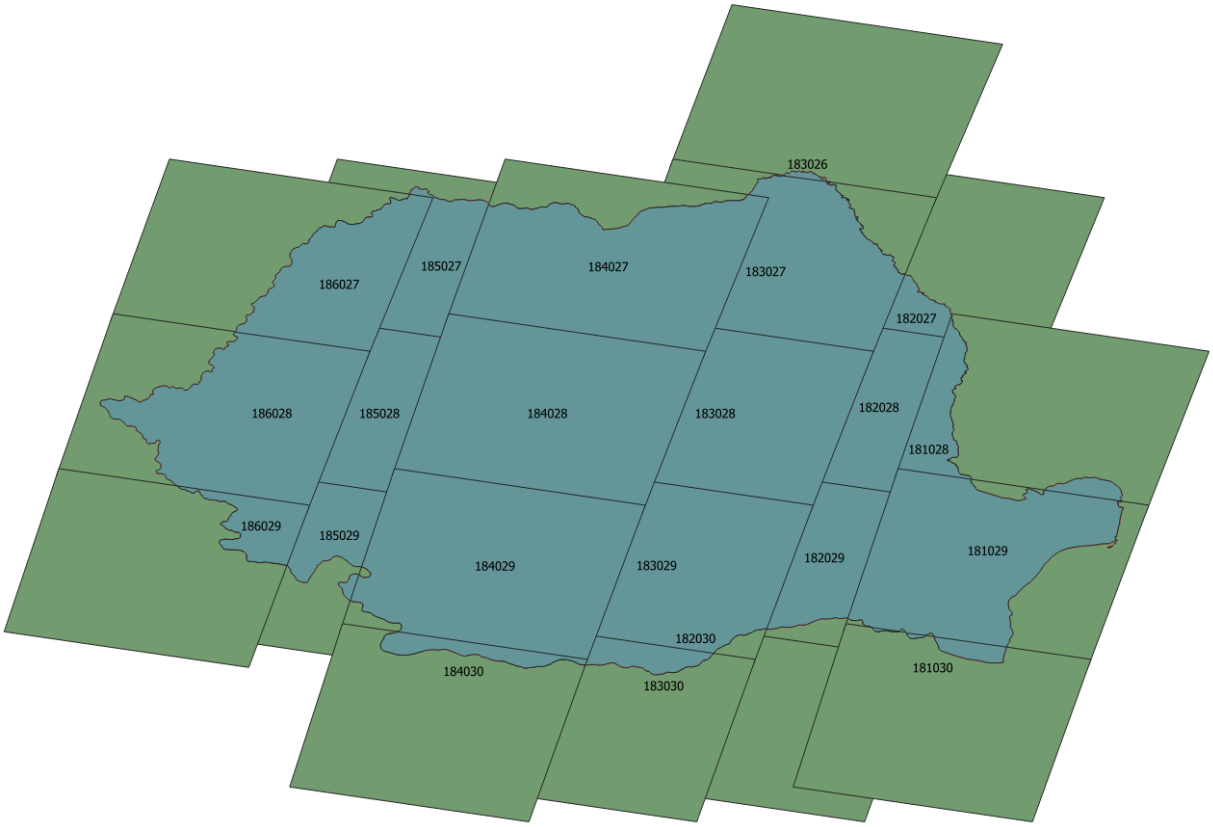

Fig. 1. LANDSAT satellite scenes that were used to download remote sensing data across Romania's entire territory

The final annual remote sensing data was obtained based on the median pixel values of all satellite images downloaded for the summer season, within the same satellite scene. Considering that, in certain situations, the number of valid images in a collection was not sufficient for a high degree

of spatial coverage, it was necessary to manually process each year individually in order to choose the most appropriate option. On this topic, in two cases (2002 and 2005) it was necessary to replace the images in collection TM5 with the corresponding ones of TM7 (Fig. 2), as a result of the fact that, in 2002 and 2005, there was no reliable TM5 satellite data across large areas in Romania (technical errors or other causes).

a. b.

Fig. 2. Example of TM5 image (a.) replacement with TM7 (b.) in 2002 (with red – missing information), in order to obtain a high number of valid pixels (and, thus, reliable satellite information) in this year

All previously mentioned data was obtained by completing four stages. In the first stage (I), Romania's boundary was uploaded onto the GEE platform, which was subsequently used for the selection of satellite scenes and for obtaining the final mosaic.

In the second phase (II), the necessary function for applying the cloud-masking to the LANDSAT TM5-TM7 image collection was created by adapting the template provided by GEE (https://developers.google.com/earth-engine/datasets/catalog/LANDSAT_LT05_C01_T1_SR). This function consists of applying two distinct masks – the first removes pixels classified as "clouds" and their shadow in the Spectral Indices Pixel Quality Band, and the second removes fixed-pattern noise from the border of each satellite scene.

Both the boundary and the masking function were used in the third phase (III) – satellite imagery selection and processing. In this phase, the cloud-masking function (in the summer season, 01.06.–31.08., of each year) presented in the previous phase (II) was applied by selecting a filter for a cloud cover degree of 100%. This filter value was chosen in order to select as large a number of satellite images as possible in the chosen timeframe, considering that in the end the median value of each pixel was computed from the annual collections in order to obtain a mosaic for each spectral band.

In the final phase (IV), each mosaiced spectral band was then exported for each year at a spatial resolution of 30 m in a WGS84 projection, and subsequently reprojected into Pulkovo 1942(58) / Stereo70 (EPSG: 3844), representative for Romania's territory.

Table 1. Number or satellite images processed every year across Romania, based on remote sensing data quality downloaded in the period 1987–2016

Year	Number of satellite images	Year	Number of satellite images	Year	Number of satellite images
1987	135	1997	138	2007	143
1988	125	1998	126	2008	95
1989	102	1999	149	2009	151
1990	128	2000	116	2010	111
1991	121	2001	100	2011	113
1992	130	2002	137	2012	147
1993	144	2003	103	2013	140
1994	138	2004	109	2014	136
1995	141	2005	92	2015	155
1996	133	2006	118	2016	133

Note: number of valid satellite images (which were processed in order to extract final annual satellite data, based on the median value of satellite pixels) for every year nationally, which depended on various technical (errors) or atmospheric (cloud cover) obstacles encountered throughout Romania in the period 1987–2016

In terms of **deliverables** obtained so far, two papers were presented at international conferences (held in Romania), related to the project's research topic:

1) **Prăvălie R**., 2020. *Forest perturbations across the planet. A major pathway of global land degradation*. International Conference "Dimitrie Cantemir", 40th Edition, October 24, Iași, Romania;

2) **Prăvălie R**., Bandoc G., 2020. *Spatio-temporal trends in land susceptibility to degradation in Romania due to climate change, vegetation degradation and anthropogenic pressures*. International Conference "Present Environment and Sustainable Development", 15th Edition, November 21, Iaşi, Romania.

Also, in accordance with the activities featured in the funding application, a **website** that features up-to-date information on this postdoctoral project was recently created.

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