E-learning on time series analysis in remote sensing: the way towards collaborative course development

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Abstract
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Abstract

Earth observation programmes run by space agencies provide datasets comprising, among others, multispectral and SAR imagery, enabling monitoring of the Earth´s surface and its resources on various scales (from global to national) and in different time spans. On the national level, aerial images and LiDAR point clouds are acquired annually or over e.g., a 2- to 5-year period to update topographic databases. In addition, selected areas are regularly monitored within environmental, geoscience and other research activities. In these cases, numerous in-situ datasets are also collected, including 3D time series using terrestrial and UAV-borne LiDAR or photogrammetry. Current open data policies have opened up new possibilities in both research and practice. They have been followed by tools suited for processing large datasets with minimal hardware and software requirements on the client side. Along with this and in accordance with the UN Sustainable Development Goal 4 ("Quality Education"), advanced, up-to-date, and quality learning materials must be made available so that both the young generation/future experts and current practitioners can fully benefit from these innovations.

Processing time series of remote sensing (RS) data is challenging when considering various time and spatial scales, the combination of heterogeneous and multimodal data sources, reliability and quality of the results obtained by different processing methods. To provide high-quality learning materials that examine time series in RS from various perspectives, we decided to follow up on our previous collaboration within the 4EU+ Alliance. Joining the specific expertise and knowledge of each involved research group, we developed an e-learning course on Time Series Analysis in RS for Understanding Human-Environment Interactions (E-TRAINEE). There are four main modules in the course. The first one provides a general overview of methods for RS time series analysis, and the other three focus on specific processing steps connected to different types of data:

Module 1: Methods of Time Series Analysis in RS
Module 2: Satellite Multispectral Images Time Series Analysis
Module 3: 3D/4D Geographic Point Cloud Time Series Analysis
Module 4: Airborne Imaging and Laboratory Spectroscopy Time Series Analysis

Each module consists of several themes (see Figure 1) containing a theoretical part, a self-evaluation quiz, and exercises. Moreover, modules 2-4 include two or three case studies with a deeper look into selected research problems. In addition, there is Module 0 summarising basic knowledge in RS, statistics, and programming necessary to follow the course; links to available learning materials are provided.

Datasets and methodologies presented in Modules 1-4 are connected to the past or ongoing research projects of the involved institutions, and are related to the applications of RS in environmental studies, specifically monitoring of vegetation (forest disturbances like drought, bark beetle attacks, or air pollution; changes of relict arctic-alpine tundra vegetation as a possible indicator of climate change) and monitoring of geomorphological features (e.g., landslides, mountain and continental glaciers, sandstone rocks, coastal environments). The practical exercises are based on open software tools such as QGIS, CloudCompare, EnMAP-Box, Google Earth Engine, or scripting in Python or R. The datasets used are either already open (e.g., Copernicus, Landsat programmes) or will be released under a Creative Commons license (LiDAR point clouds, UAV hyperspectral images, laboratory and in-situ spectroradiometer measurements). The whole course is being developed in a git repository allowing for easy and fluent collaborative work on each module, versioning, and sustainable maintenance of the course in the future.

The course is developed and funded within the Erasmus+ Strategic partnership programme (2020-1-CZ01-KA203-078308, 2020-2023). It is currently in the process of finalising the learning materials, fixing overlaps and gaps between the modules, and testing the course with groups of MSc and PhD students. The goal is to fully implement the course in the MSc curricula in geography/geoinformatics of the partner universities (Charles University, Heidelberg University, University of Innsbruck, and University of Warsaw) from the academic year 2023/24 onwards. The first release of the course will also be open to the public starting in August 2023 (for details, visit http://web.natur.cuni.cz/gis/etrainee/). The international collaboration allowed for the creation of rich, research-oriented course content. It enriched the knowledge and experience of all involved partners. The course materials will be continuously updated as all four institutions will actively use the course, and new releases will be made available for public use. Moreover, the course provides a base for online discussions and seminars across the universities that will increase the attractiveness and quality of education.

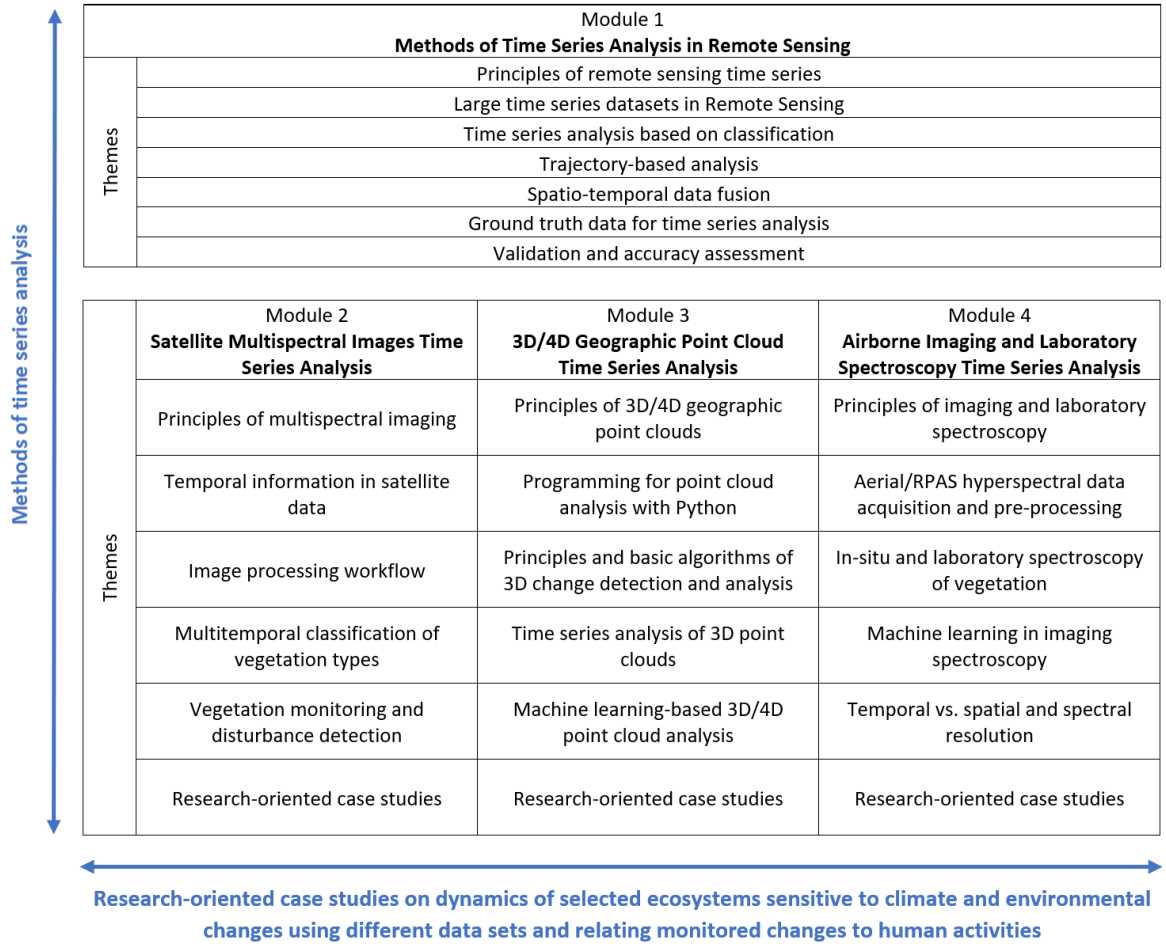

Figure 1. The course structure and content of the modules. All modules relate to methods of time series analysis. They are applied to different datasets and demonstrated on specific case studies.