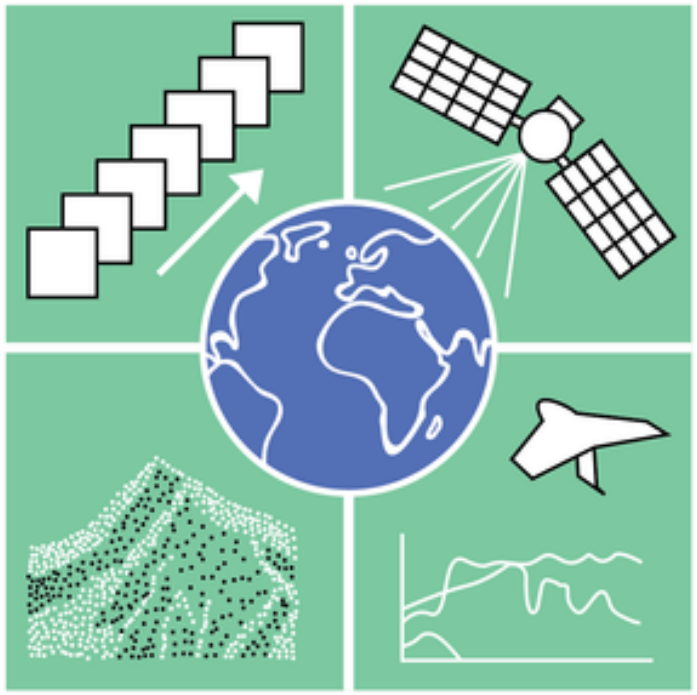

E-learning on time series analysis in remote sensing: the way towards collaborative course development

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Motivation

- Time series analysis is among the most progressive topics in RS
- Constant need for updated learning materials

- Collaboration within the 4EU+ project
- Specific expertise of each partner

4eu+ EUROPEAN UNIVERSITY ALLIANCE

- Base for further collaboration in teaching and research

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Methods of time series analysis

	Module 1 **Methods of Time Series Analysis in Remote Sensing**
Themes	Principles of remote sensing time series
	Large time series datasets in remote sensing
	Time series analysis based on classification
	Trajectory-based analysis
	Spatio-temporal data fusion
	Reference data, validation, and accuracy assessment

	Module 2 **Satellite Multispectral Images Time Series Analysis**	Module 3 **3D/4D Geographic Point Cloud Time Series Analysis**	Module 4 **Airborne Image and Laboratory Spectroscopy Time Series Analysis**
Themes	Principles of multispectral imaging	Principles of 3D/4D geographic point clouds	Principles of imaging and laboratory spectroscopy
	Temporal information in satellite data	Programming for point cloud analysis with Python	Aerial/RPAS hyperspectral data acquisition and pre-processing
	Image processing workflow	Principles and basic algorithms of 3D change detection and analysis	In-situ and laboratory spectroscopy of vegetation
	Multitemporal classification	Time series analysis of 3D point clouds	Machine learning in imaging spectroscopy
	Vegetation change and disturbance detection	Machine learning-based 3D/4D point cloud analysis	Temporal vs. spatial and spectral resolution
	Research-oriented case studies	Research-oriented case studies	Research-oriented case studies

Research-oriented case studies on dynamics of selected ecosystems sensitive to climate and environmental changes using different data sets and relating monitored changes to human activities

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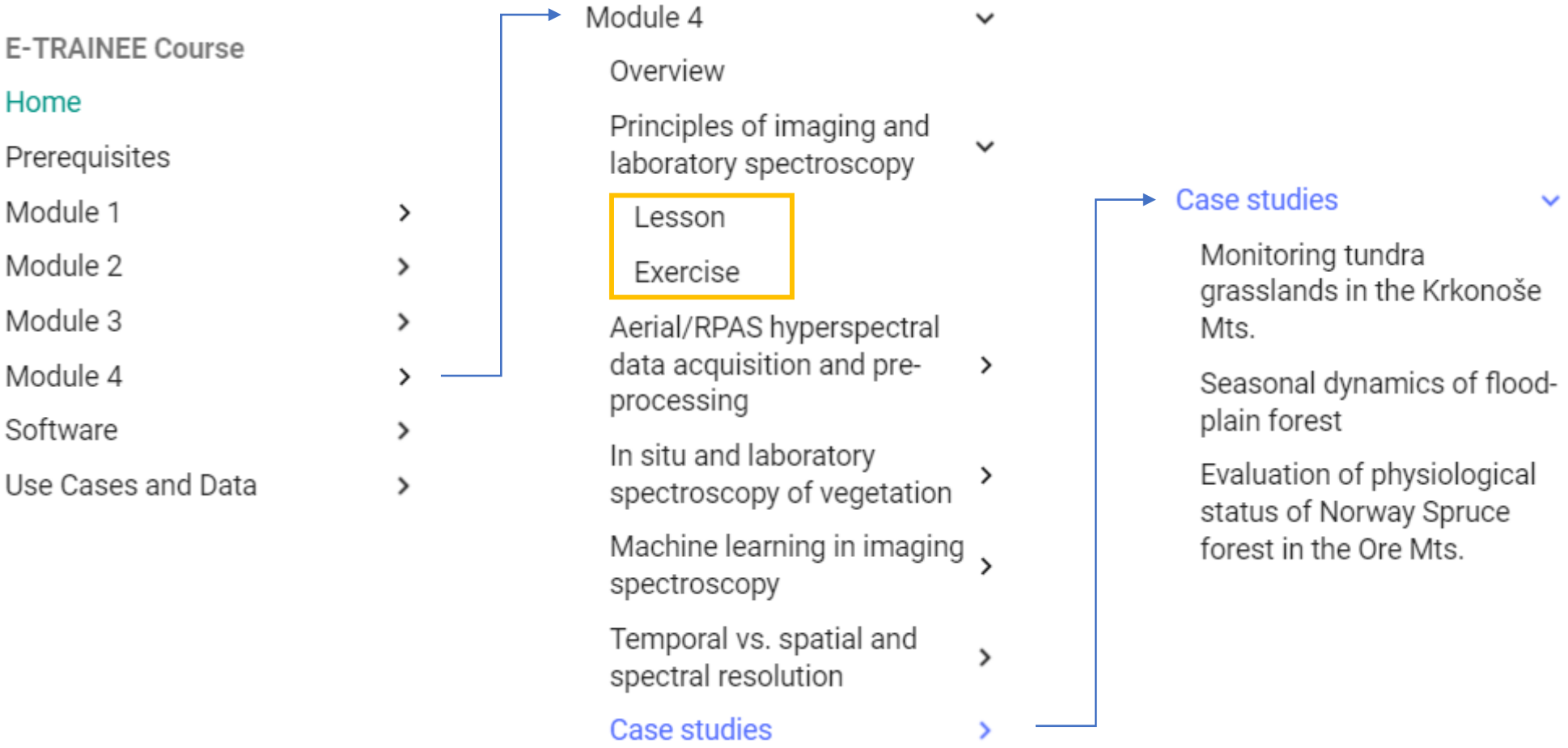
Structure of the course and modules



Prerequisites

- The course is designed for MSc level students
- Elementary knowledge of statistics, remote sensing, and programming (Python, R) is required
- List of required knowledge and links to existing tutorials is provided

Programming in Python

If you are new to Python, you might look into this tutorial on Python Code Fundamentals by Earth Lab.

Advanced tutorials or material can be found among the following resources: * Online course on Practical Python Programming by David Beazley * Online course/textbook on Use Data for Earth and Environmental Science in Open Source Python by Earth Lab

Lessons

- Theoretical introduction to each theme
- Supported with examples from research projects and a list of references
- Self-evaluation quiz at the end of each lesson

Quiz

Question 1. Match the temporal resolution with the satellite sensor:

16 days	26 days	5 days	less than 1 day

A. Advanced Very High Resolution Radiometer	B. MultiSpectral Instrument	C. Enhanced Thematic Mapper+	D. New AstroSat Optical Modular Instrument

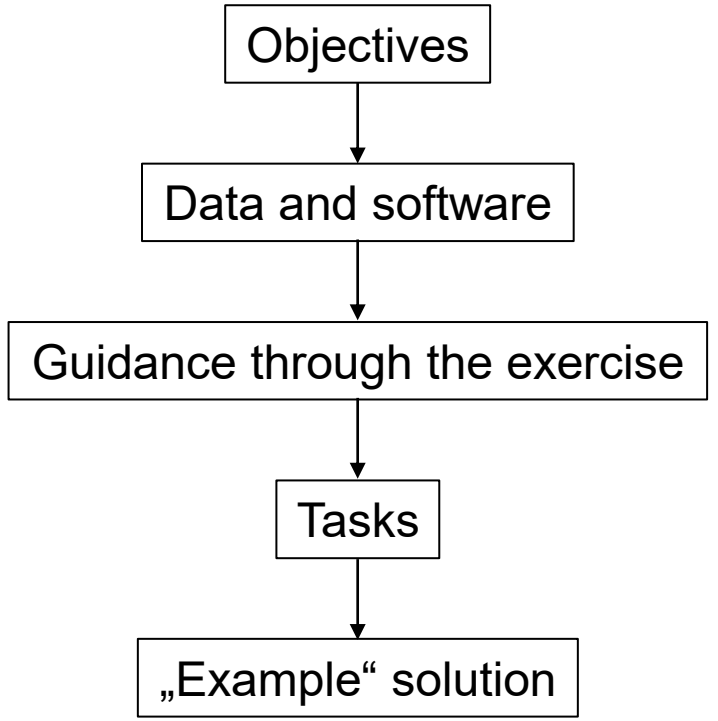
Which of the following attributes is not contained in laser scanning point clouds without performing fusion operations?

- XYZ (coordinate)
- Intensity (LIDAR backscatter)
- RGB (color)

What is the special property of 4D point clouds compared to multitemporal point clouds in general?

Exercises

- Goal: to practise selected tasks learnt in the lesson
- Based on open datasets or datasets collected within the research projects of the involved partners
- „Example“ solution provided
- In case of multiple exercises, the recommended and optional are suggested



Tutorial 1: Raster Time Series in Python using xarray

This Jupyter notebook introduces Python's `xarray`, a package for processing large multi-dimensional arrays (Hoyer and Hamman 2017) and shows how to use it for handling and analysing a S
xarray as well

Tutorial 2 (
Timeseries

As a straightf
QGIS GEE Tim

Overview:

- Load a fe
  `T1_sampl`
  for S2 clo

Tutorial 3 (optional): Explore temporal profiles of a vegetation index in Python with pandas

Export temporal profiles of a vegetation index from GEE via QGIS and explore them in Python

In this tutorial we explore temporal profiles of Sentinel-2 Normalized Difference Vegetation Index (NDVI). Sample points for different landcover classes are used. They are all located around the village of Obergurgl (Central Alps, Tyrol, Austria).

Tutorial 4 (optional): Exploring and processing a Sentinel-2 time series using the GRASS GIS temporal framework

This tutorial shows how an entire workflow for Sentinel-2 optical image time series can be implemented in GRASS GIS. This includes the search and download of scenes from the Copernicus Open Access Hub, a number of preparatory steps within the GRASS GIS temporal framework and, finally, the exploration and analysis of a Space-Time Raster Dataset (STRDS).

Case studies

- Complex practical exercises or theoretical lessons mostly based on completed research projects

- Module 2

  Case study: Monitoring tundra grasslands (Karkonosze)

  Case study: Effects of pollution in Ore Mountains

  Case study: Forest disturbance detection (Tatras)

Module 3

Multitemporal 3D change analysis at an active rock glacier

Time series-based change analysis of sandy beach dynamics

Module 4

Monitoring tundra grasslands in the Krkonoše Mts.

Seasonal dynamics of flood-plain forest

Evaluation of physiological status of Norway Spruce forest in the Ore Mts.

Software

- Open or free software licenses are used

Software

- CloudCompare
- EnMAP-Box
- Python
- QGIS
- R

EnMAP-Box

General description

EnMAP-box is a QGIS plugin for working with imaging spectroscopy remote sensing data: https://www.enmap.org/data_tools/enmapbox/

It is a free and open source software released under the GNU General Public License.

Download and installation

Follow the instructions for installing the EnMAP-box QGIS plugin Manual for installing the plugin

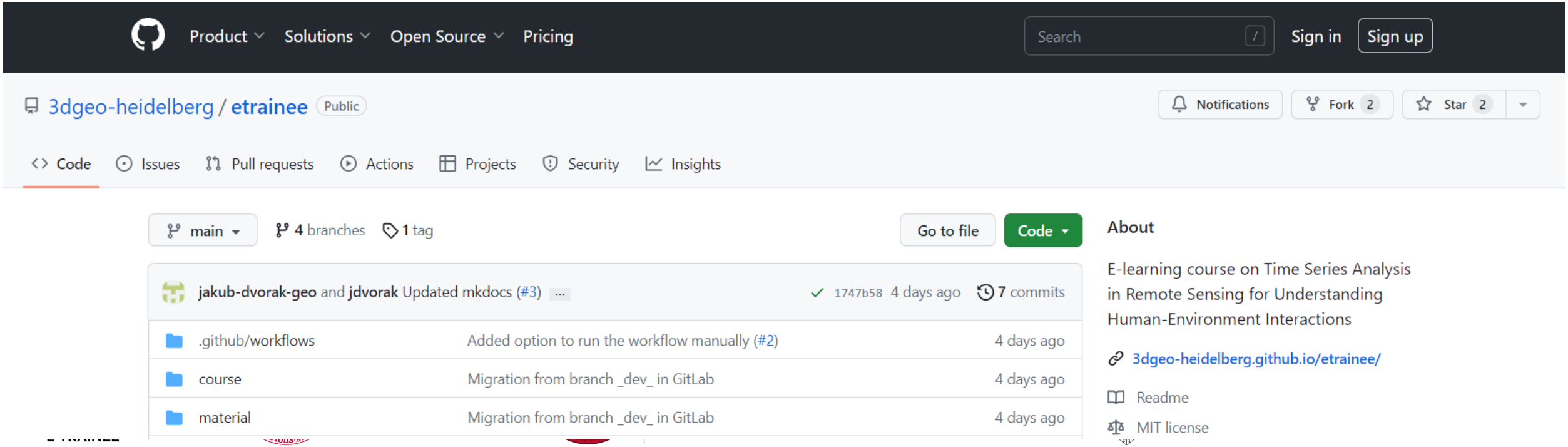
You need to install QGIS and required Python packages first.

Getting started / external material

Introduction to the EnMAP-box and how to handle spectral libraries can be found on the EnMAP-box workshop tutorial website. Description of the specific software functions can be found in the User Manual.

Implementation

- Development in a Git repository – allows for easy and collaborative work
- Final implementation on GitHub + deployed website
- Course provided under the CC BY-SA 4.0 license, associated code is under the MIT license



Course publication and maintenance

- Pre-release (v0.1): June 2023
- Completed course(v1.0): September 2023

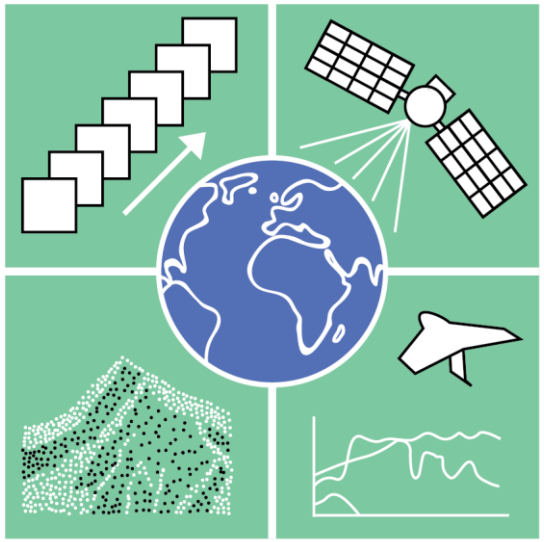
https://3dgeo-heidelberg.github.io/etrainee/

Updates

- Small correctios continuously
- New releases connected to the extension of the course
  - By the start of a new semester
  - After acknowledgement of all partners

Conclusion and outlook

- The course will be fully implemented in the curricula of all 4 universities from the academic year 2023/24
- Not only collaborative development but also teaching (live online lectures)
- Motivation for student mobilities
- Open for everyone
  - MSc students in geography, geomatics, environmental studies
  - Practitioners, e.g., application of RS in nature conservation
- Base for further collaboration in education, e.g., summer schools



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