EO Project Overview: Hyperspectral Unmixing

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Title: Exploring hyperspectral imagery for unmixing vegetation classes

Abstract: Terrestrial ecosystems are often highly complex, with interactions between topography, soil composition, and climate creating fine-scale mosaics of vegetation cover. This leads to mixed pixels as spatial resolutions common in satellite imagery, and therefore unmixing vegetation cover is needed to fully capture vegetation dynamics. Imaging spectroscopy provides enhanced spectral feature resolution and may therefore be beneficial in distinguishing between relatively similar vegetation classes as compared to broad-band imagery. To this end, numerous narrowband indices have been developed to enhance the relationships with specific vegetation properties. In this project, you will explore the capabilities of hyperspectral imagery for mapping vegetation class fractions in California. You may explore the use of hyperspectral indices to enhance mapping efforts, and draw comparisons to Landsat-based analyses. You may further use the Landsat imagery to explore the effect of acquisition date on model performance.

1) Specifying the scope of the project

a) Specify a research question or hypotheses, around which you can develop one or two main objectives (e.g., one related to methods, one related to LULC or global change processes). You may wish to refine the objectives presented to you with the topics

1) How can narrowband indices derived from hyperspectral imagery be used to better map vegetation class fractions as compared to multispectral imagery?

Please note, a modification of the second research question may still be undertaken, current version:
2) Using multi-temporal multispectral imagery, explore how acquisition date (e.g. of phenological effects or land use) can influence accuracy of the regression.

b) *Search for relevant literature in your project context. Stick to recent publications in established journals, (e.g. Remote Sensing of Environment, Remote Sensing, Applied Earth Observation and Geoinformation, IEEE JSTARS).*

Cooper et al. (2020): Disentangling fractional vegetation cover: Regression-based unmixing of simulated spaceborne imaging spectroscopy data. Remote Sensing of Environment, 246. DOI: 10.1016/j.rse.2020.111856

Roberts et al. (2018): Hyperspectral vegetation indices. In: Hyperspectral indices and image classifications for agriculture and vegetation.

Jänicke, C., Okujeni, A., Cooper, S., Clark, M., Hostert, P. and van der Linden, S., 2020. Brightness gradient-corrected hyperspectral image mosaics for fractional vegetation cover mapping in northern California. Remote Sensing Letters, 11(1), pp.1-10.

Reference on regression based unmixing

Okujeni, A., van der Linden, S., Suess, S., Hostert, P., 2017. Ensemble learning from synthetically mixed training data for quantifying urban land cover with support vector regression. IEEE J. Sel. Top. Appl. Earth Observ. Remote Sens. 10, 1640–1650.

tbc

c) *Evaluate the relevance of selected publications in more detail after you made a first selection and discuss this with your group. Go through the papers and identify aspects of the study which deserve further research. These should also guide you towards further relevant studies, or you may look at studies that cite a particular publication of interest.*

In discussion…

2) Defining data requirements and methods

a) Specify the exact study area (location, extent) and time frame relevant for your analysis.

Location:
North of Santa Rosa, California (regard figure 1)

Extend:
EPSG:32610 - WGS 84 / UTM zone 10N – Projected
496664.7622136182617396,4261664.8695335863158107 :
568665.9213084551738575,4276665.0152994897216558

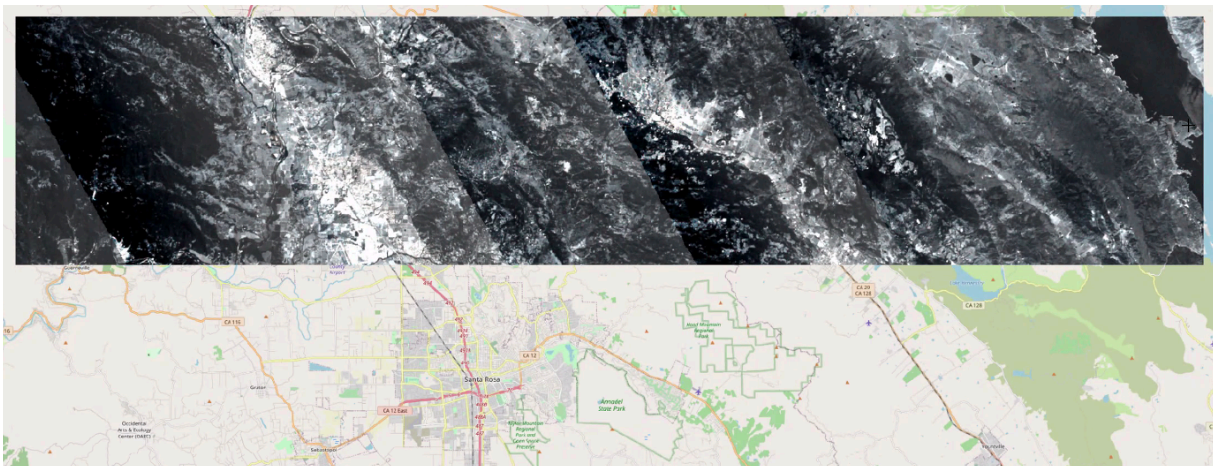

Fig. 1: Overview of the study area (Data provided by HU Berlin Earth Observation department, 2021 and Open Street Map, 2021)

Time frame hyperspectral (EnMAP):
2013-06-07

Time frame Landsat:
2013-06-07 (?)

b) Define the sensor and data product of your choice (e.g. Landsat BOA, Sentinel-2 BOA).

Landsat and simulated EnMAP

c) Develop a class catalogue including clear and precise class definitions. You may consider a hierarchical approach and aggregate thematically irrelevant classes wherever it appears useful.

The hierarchical approach of Cooper et al. (2020) as shown in table 1 seems suitable as reference material for our methodology – modifications might be applied during the analysis.

Table 1
Hierarchical vegetation classes.

Level 1				Vegetation			Non-Vegetation
Level 2			Woody Vegetation			Non-woody Vegetation	Non-Vegetation
Level 3		Trees			Shrubs	Non-woody Vegetation	Non-Vegetation
Level 4	Needleleaf		Broadleaf		Shrubs	Non-woody Vegetation	Non-Vegetation

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d) Define the required temporal resolution (e.g. 5-yearly, annual, intra-annual).

For research question one a single date acquisition is sufficient. For the second research question, an intra-annual temporal resolution will be used.

e) Choose a suitable method (e.g. compositing, spectral-temporal metrics, time series analysis).

Using a single regional model for regression-based unmixing (as opposed to single regional models for ecoregions) to map vegetation class fraction across the entire study area should be sufficient.

3) Investigate study area and screen data:

a) Connect to the HU-Desktop using the instructions posted on Moodle. The data for your project will be found on the "O" drive: O:\SS21_EO. For now this includes shapefiles delineating your study region.

Hyperspectral data was inspected and overlayed with an OSM map (regard figure 1 above). Yet, the Landsat imagery is still missing on the "O" drive.

b) Look at your study site in Google Earth. Note the different vegetation types and patterns as well as how they change over time. You may also search online for other relevant data sources which may provide further context to your study, e.g. climate maps, fire frequency, or existing land cover maps.

SWATH width 12km (lines 240km x 12km), light time lag (minutes) between 10:31 UTC and 15:21 UTC due to data acquisition method (flight).

Different types of land-covers:

Vegetation:
Referring to Cooper et al. 2020 “Mediterranean climate forests woodlands, and shrublands.”
Broad-leaved and coniferous forests

For Cropping (e.g. vineyards, apple plantations, wheat etc.) also referring to the California natural resources agency (2021):
https://data.cnra.ca.gov/dataset/crop-mapping-2014 [2021-06-19]

Non-vegetation:
urban (*if time permits different urban land cover classes*)
infrastructure (*if time permits different urban land cover classes*)
water
soil

Pattern for second research question: Dry season / drought, fires, growing season and harvest of crops

c) To screen all available image data, you may also visit the USGS EarthExplorer or any other data distribution service you might know. Browse through the available data for your study region and time frame. What is the image availability for your time period? How about cloudiness in the study region? Any other limiting factors?

The simulated EnMAP imagery can be found in the “O” drive already, and the Landsat data will be placed there “this week”. The more details of the EnMAP pre-processing and simulation can be found in Jaenike et al., 2020.

For 2013-06-02 a good Landsat image is available in Google Earth (yet, not full extend of study area).