FSU activity report: 03/2017 - 12/2017

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LIFE Healthy Forest Meeting, Vitoria, 13 Dec 2017

Outline

1) Action A2.1.6: **Acquisition of hyperspectral imagery**

2) Action B1.1: **Spatial mapping using statistical and machine-learning data analysis**

Action A2.1.6: Acquisition of hyperspectral imagery

Acquisition of hyperspectral imagery

Prior to March 2017

- Hyperspectral imagery was acquired by HAZI in September 2016 for all plots (28 in total)
- Unfortunately, one of the five demonstration plots ("hernani") was not covered by the flight mission
- FSU helped with the planning of the flight routes (Marco Pena)
- Hyperspectral sensors Hyperion-1 was decomissioned in January without prior notice
- Airborne AVIRIS data as a replacement not suitable (price, flights only in US)
- No other spaceborne hyperspectral sensor available

Acquisition of hyperspectral imagery

March 2017 - Now

We decided to acquire spaceborne multispectral Sentinel-2 data as an alternative for Hyperion-1 data.

Aim: Time-series analysis of the vegetation period for 2016 and 2017

Why time-series analysis?

- Due to the offset in both spatial and radiometric-resolution (1m vs. 10m, 126 bands vs. 10 bands) it is not possible to directly compare multispectral images and hyperspectral images.
- Time-series analysis might reveal changes over time of infested trees by using various indices (e.g. vegetation indices).
- Possible trends can still be post-analysed with hyperspectral imagery from September 2016.

Acquisition of hyperspectral imagery

Acquisition period:

- March 2016 - November 2016
- March 2017 - November 2017
- Repetition rate: 10 days

So far we acquired **391 images** (each 500MB) in total resulting combining to ~ **200GB** of raw data.

For every of the 27 plots we have **135** images. These got cropped to the respective plot extent leaving a total of **70 MB** for the complete time-series.

Daphne Meyreiss (student assistant) was in charge of the processing.

Pre-processing (Download, cropping) of all plots is planned to be finished at the end of 2017.

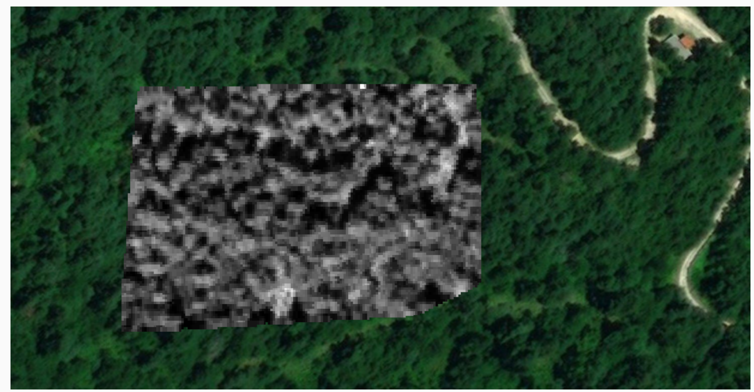
Deliverable contributions:

- Remotely-sensed forest health map (06/2018) *B1*
- Integrated analysis of characterization results at large scale (01/2019) *B1*
- Maps of forest disease potential (10/2018) *B1*

Plot "Caranca" with both hyperspectral airborne and multispectral Sentinel-2 image

Multispectral image (Sentinel-2, 10m)

Hyperspectral image (airborne, 1m)



Action B1.1: Spatial mapping using statistical and machine-learning data analysis

Action B1.1: Spatial mapping

Performance evaluation and hyperparameter tuning of statistical and machine-learning models using spatial data

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Analysis goal: Which model performs best in classifying infested trees (Diplodia Pinea) using environmental variables as predictors?

Predictors: Temperature, precipitation, tree age, soil type, lithology type, pH value, hail damage, elevation, slope

Related work: Iturritxa et al. (2014): Spatial analysis of the risk Monterey pine plantations.

This worked analysed the influence of the predictor variables using parametric models (GLM, GAM) while the current analysis compared statistical and machine-learning models focusing on predictive performance.

Action B1.1: Spatial mapping

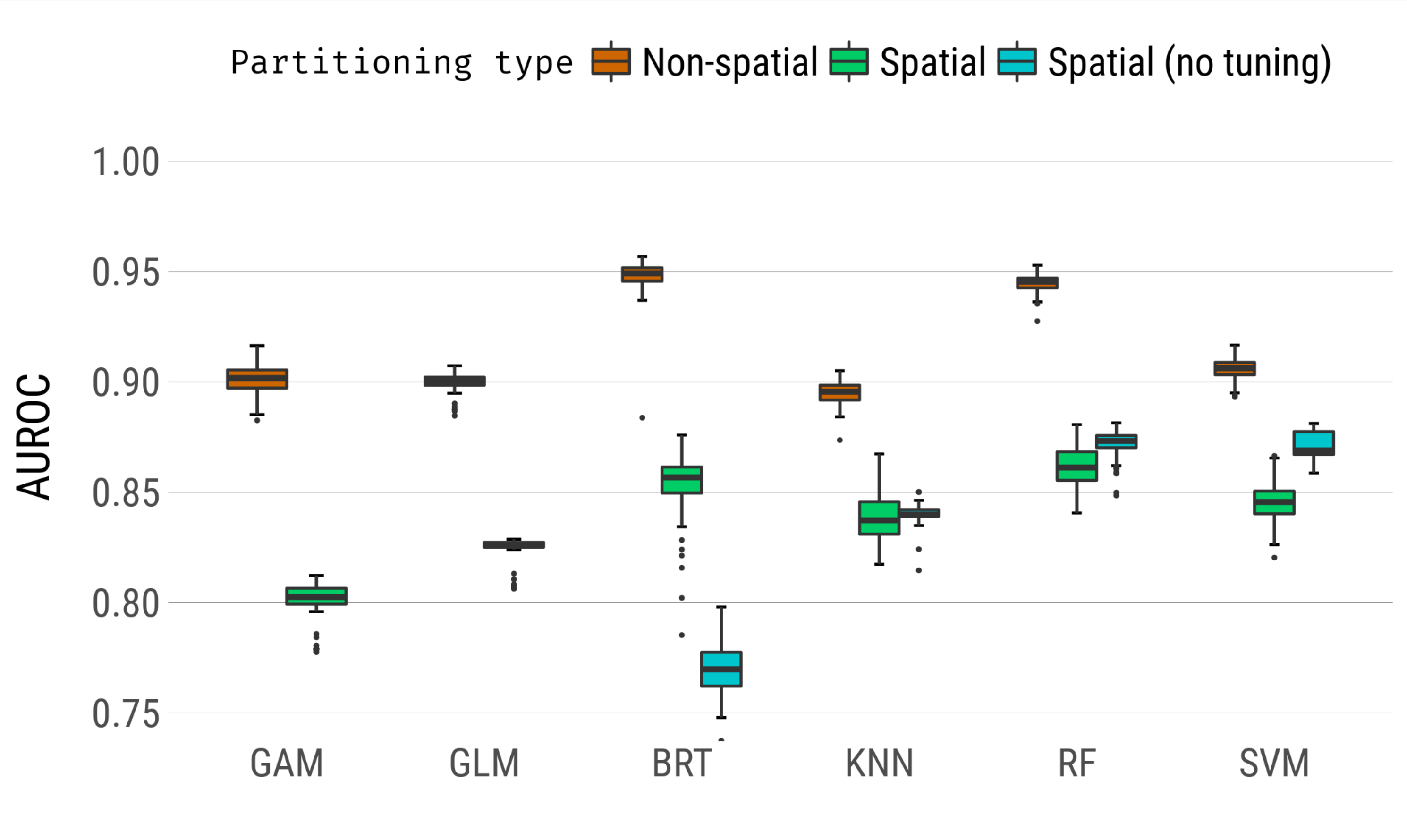
Key Points:

- State-of-the-art parametric and non-parametric models (BRT, GAM, GLM, KNN, RF, SVM)
- Accounting for spatial autocorrelation by using bias-reduced **spatial cross-validation**
- Extensive **hyperparameter tuning** of machine-learning models to ensure best possible performance results

>>> "How-to" guide for bias-reduced spatial model comparison analysis.

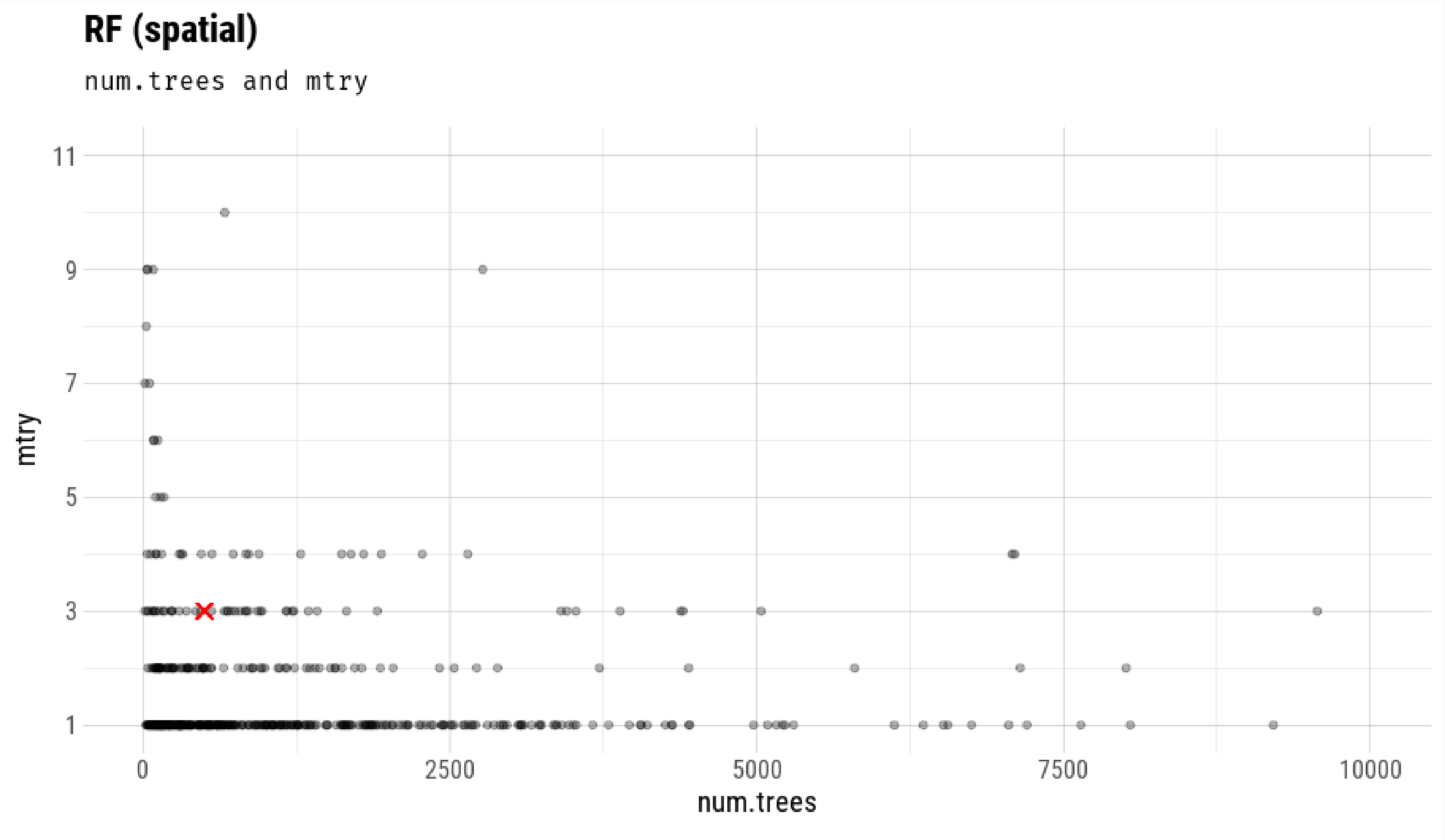
Action B1.1: Spatial mapping

Performance results



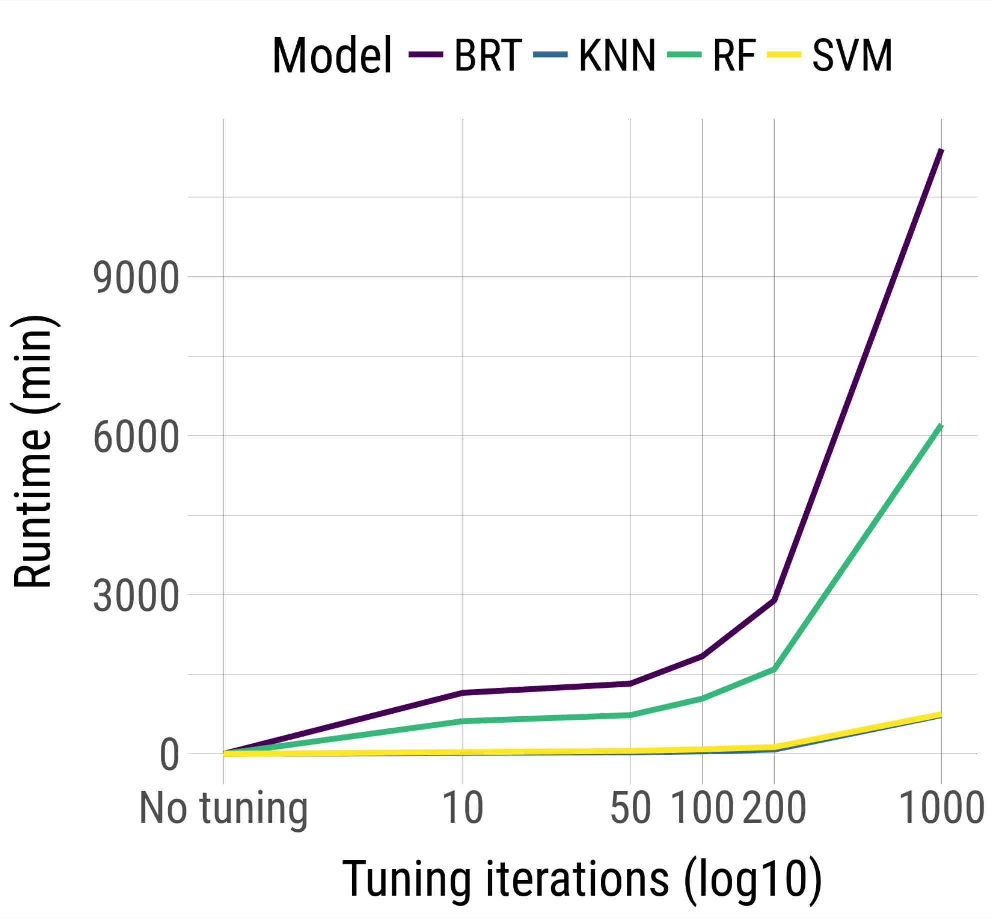
Action B1.1: Spatial mapping

Exemplary hyperparameter tuning result



Action B1.1: Spatial mapping

Runtime comparison



Action B1.1: Spatial mapping

Ridge regression analysis of hyperspectral data

Goal: Find vegetations indices which reveal a pattern in defoliation of infested trees

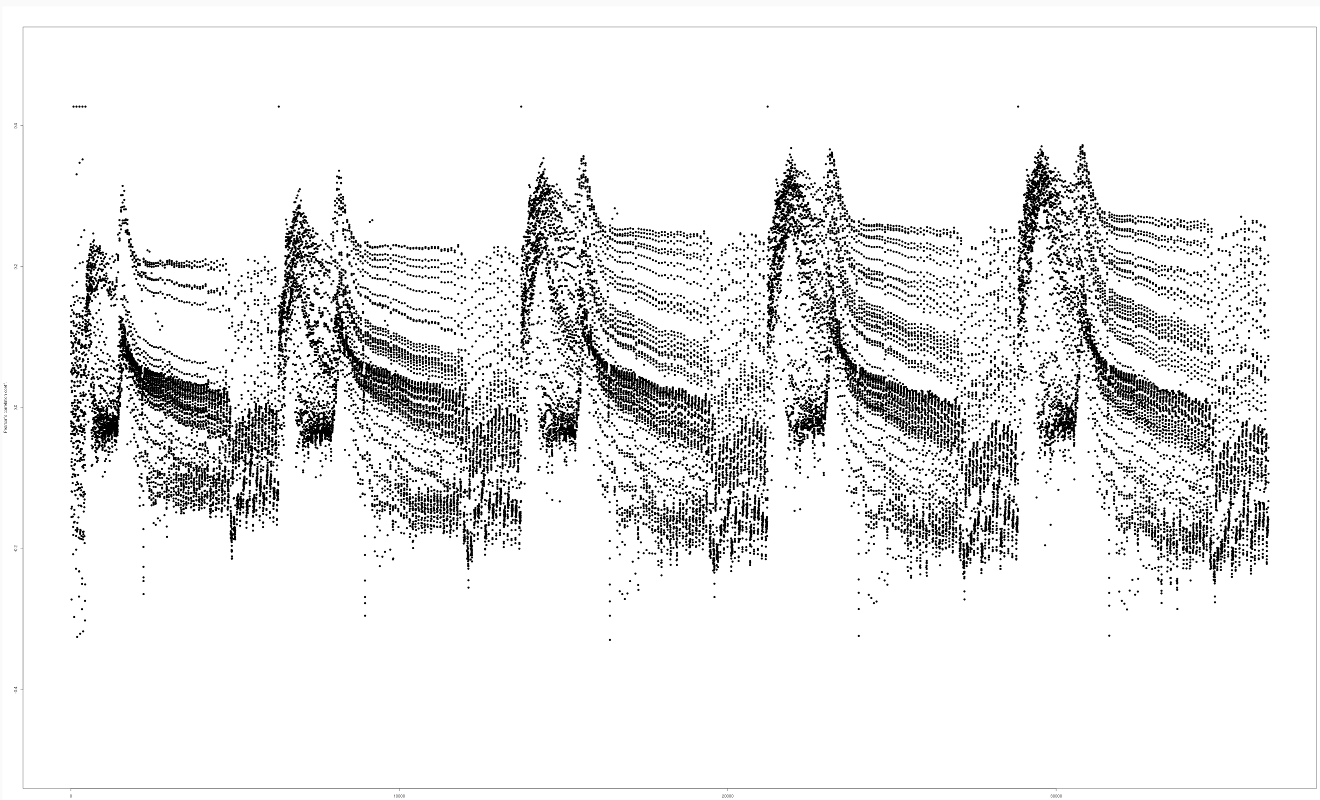
Approach: Calculate all possible vegetation indices + narrow band indices ($\frac{B \quad B}{B \quad B}$) on different resolutions (1m - 5m). This results in a data set with 30k+ variables which are modelled using ridge regression (M. Pena).

Data sets: Demonstration plots (Laukiz I, Laukiz II, Oiartzun, Luiando)

Action B1.1: Spatial mapping

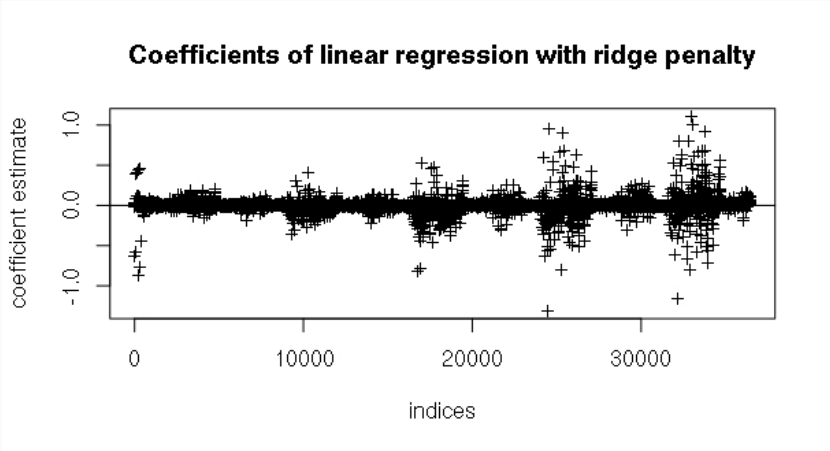
Ridge regression analysis of hyperspectral data

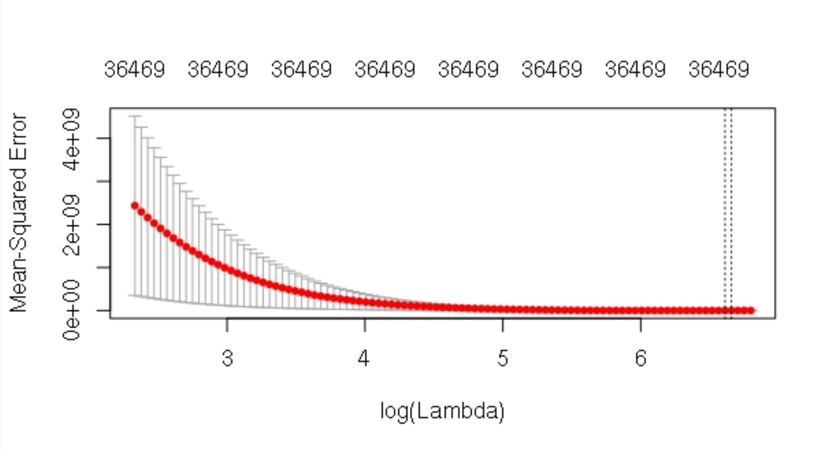
Pearson's correlation coefficient between more than 30.000 indices and the observed defoliation in the field (Laukiz I)



Action B1.1: Spatial mapping

Ridge regression analysis of hyperspectral data





Action B1.1: Spatial mapping

Milestone and deliverable contributions

- Guide with the identification and characterization of invasive and pathogenic agents (10/2018) *B1 Deliverable*
- Integrated analysis of characterization results at large scale (01/2019) *B1 Deliverable*
- Developed model of forest disease potential (10/2018) *B1 Milestone*
- Data for spatial analysis compiled (10/2018) *B1 Milestone*
- Final selection of algorithm for remotely-sensed forest health mapping (10/2018) *B1 Milestone*
- Design and study of algorithms (10/2018) *B3 Milestone*

Outlook

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- Modeling of pathogen **Armillaria** using environmental variables as predictors and utilizing the winning algorithm of the model comparison analysis (Random Forest)
- Model comparison analysis of **defoliation** using hyperspectral indices as predictors including hyperparameter tuning
- Time-series analysis of acquired **Sentinel-2 data**
- Analysis of **new in-situ data** acquired by NEIKER in October 2017 (received this week)