1st EnMAP User Workshop

Demonstrating the Capabilities of the EnMAP-Box for Agricultural Applications - Examples from Northern Kazakhstan

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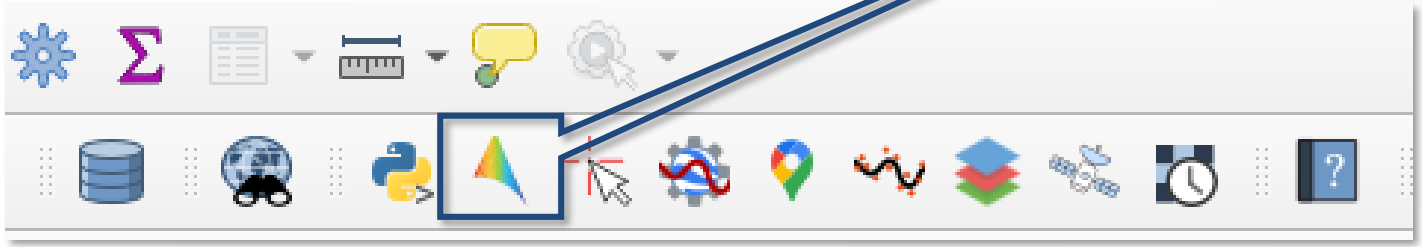
Dept. of Geography | LMU Munich

Session: Applications - Vegetation
Place: Online via WebEx
Time: 10:10-10:20 UTC+2

Introduction to the EnMAP-Box

EnMAP
Our Earth in more than just colour.

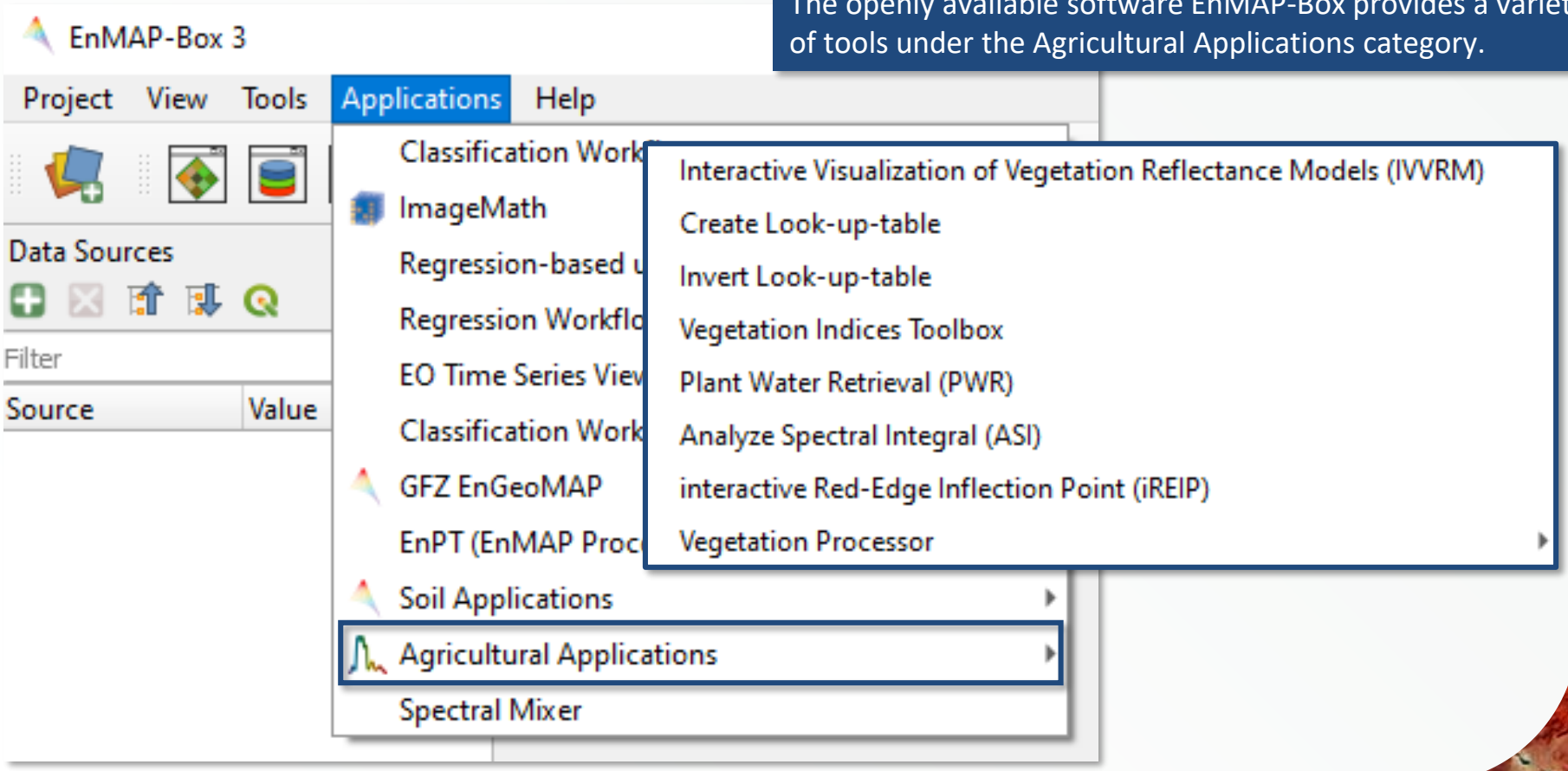


https://enmap-box.readthedocs.io/

JAKIMOW, B., JANZ, A., THIEL, F., OKUJENI, A., HOSTERT, P. & VAN DER LINDEN, S. (2023): EnMAP-Box: Imaging spectroscopy in QGIS. *SoftwareX*, Volume 23, 101507.

EnMAP-Box | Agri-Apps

The openly available software EnMAP-Box provides a variety of tools under the Agricultural Applications category.



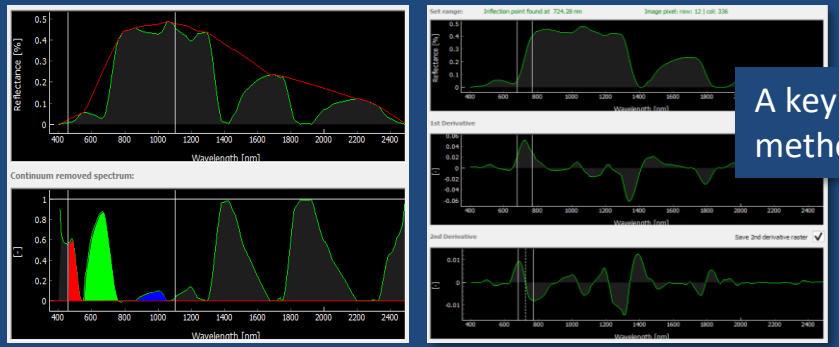
EnMAP-Box | Agri-Apps

Agriculturally relevant information can be derived from hyperspectral data in the EnMAP-Box via diverse methods:

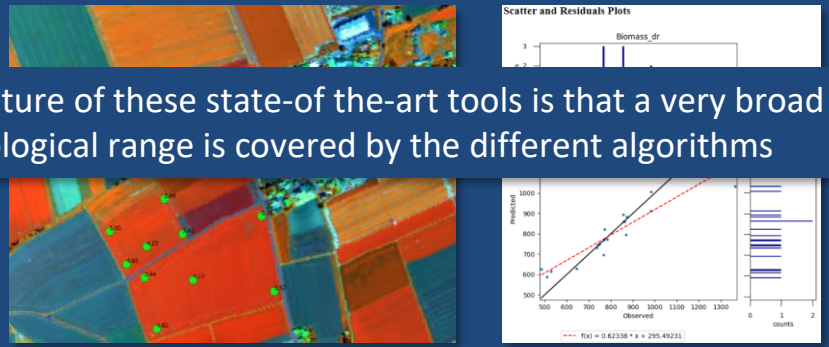
HUMBOLDT INNOVATION
CONNECTING SCIENCE AND SOCIETY

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Parametric Methods (e.g. Indices, ASI, iREIP)

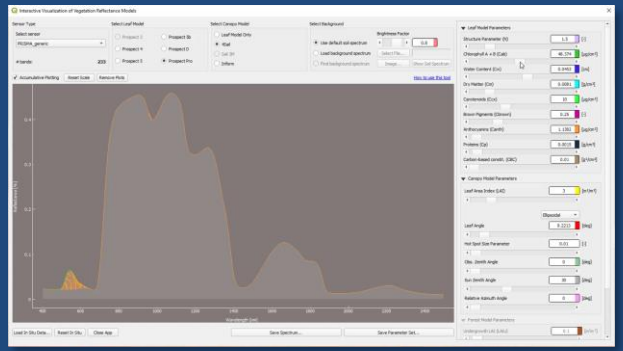


Non-Parametric Methods (e.g. Regression Workflow)

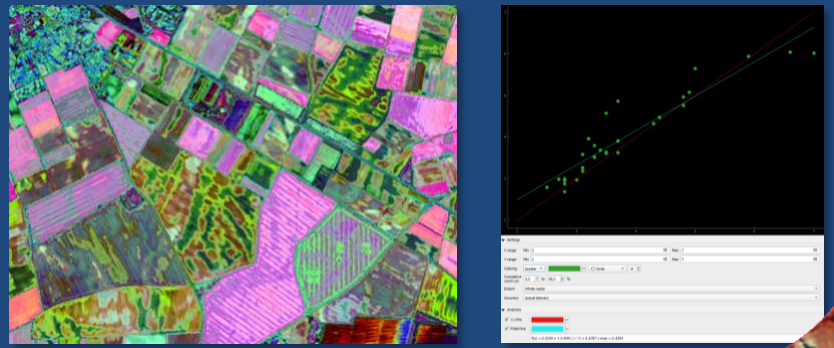


A key feature of these state-of the-art tools is that a very broad methodological range is covered by the different algorithms

Physically-Based Methods (e.g. IVVRM, PWR, Invert LUT)



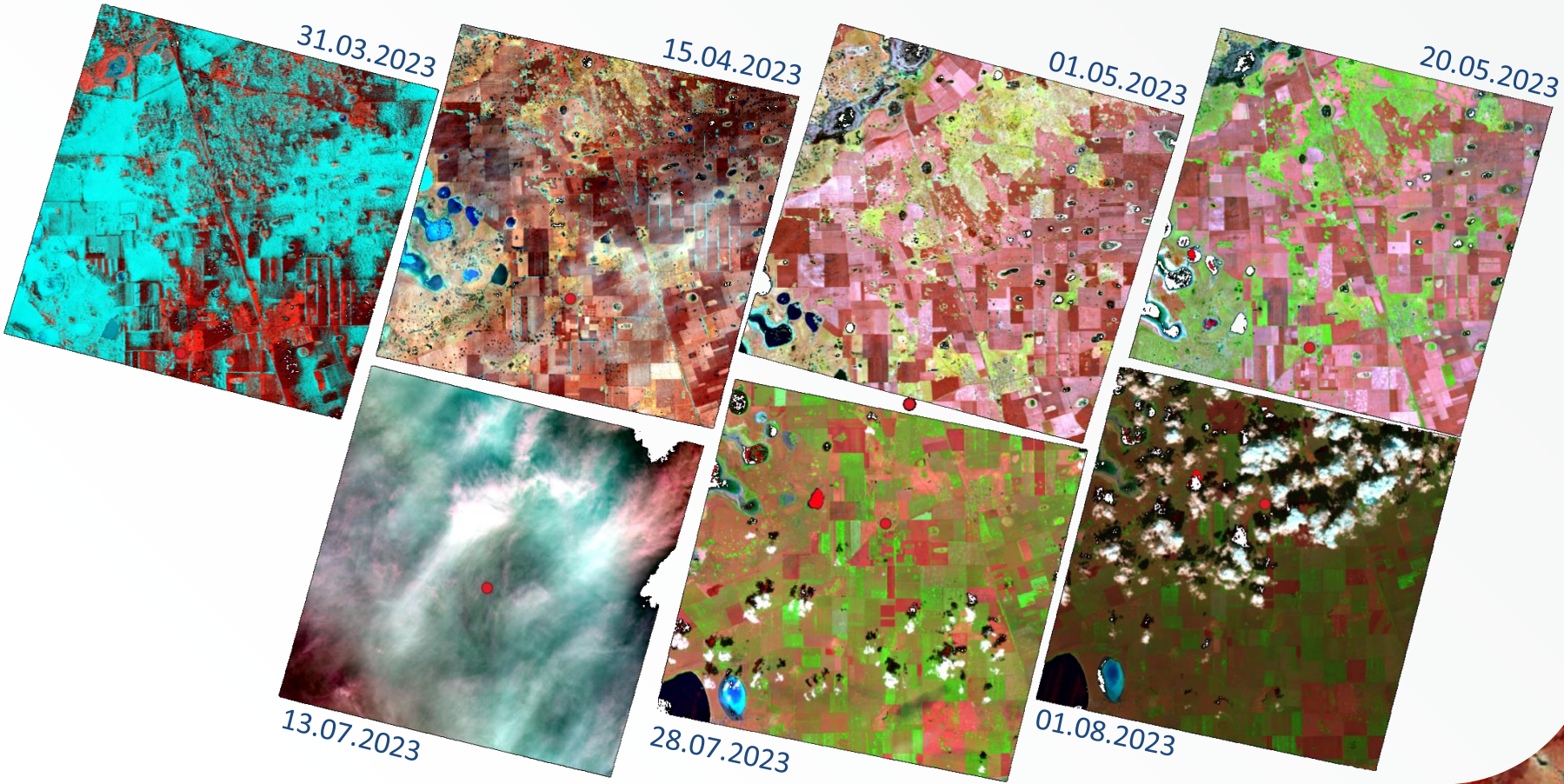
Hybrid Methods (e.g. ANN Vegetation Processor)



Approx. 4000 km to the East, Center Coordinates: 54.17° N | 69.53° E

Test Site North Kaz: Location

EnMAP | Hyperspectral Time-Series



EnMAP | Hyperspectral Time-Series

31.03.2023

15.04.2023

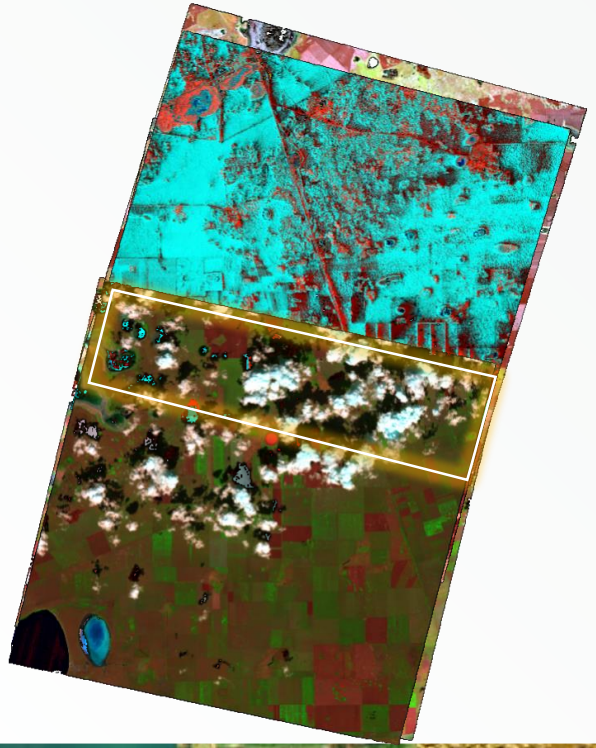
01.05.2023

20.05.2023

13.07.2023

28.07.2023

01.08.2023

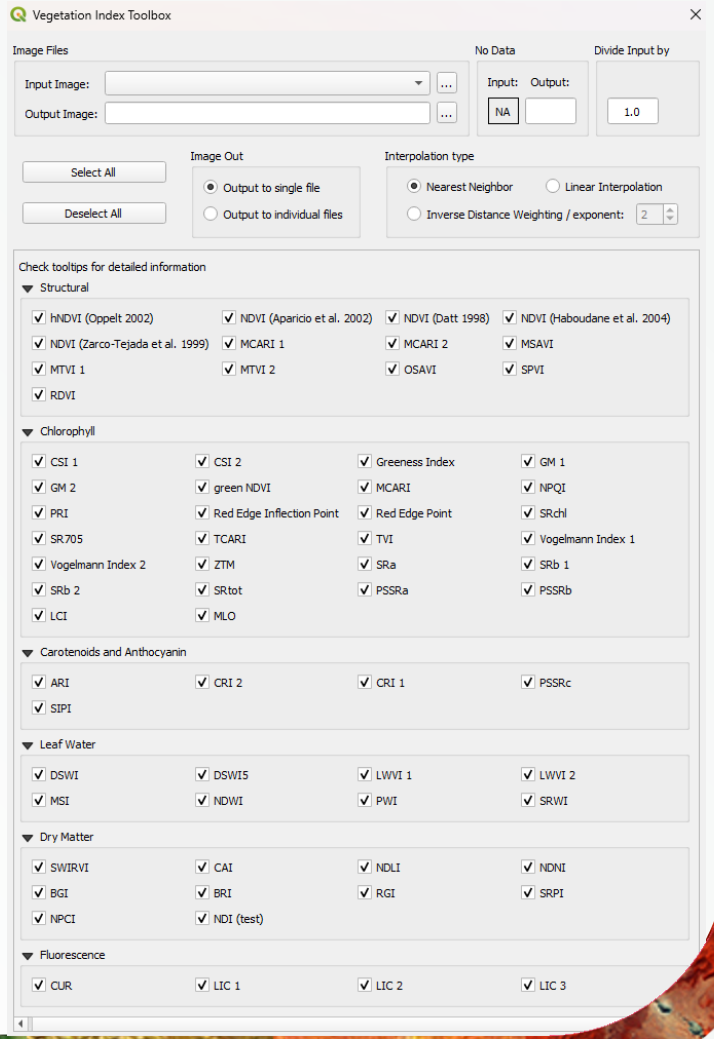


EnMAP-Box | Empirical Methods

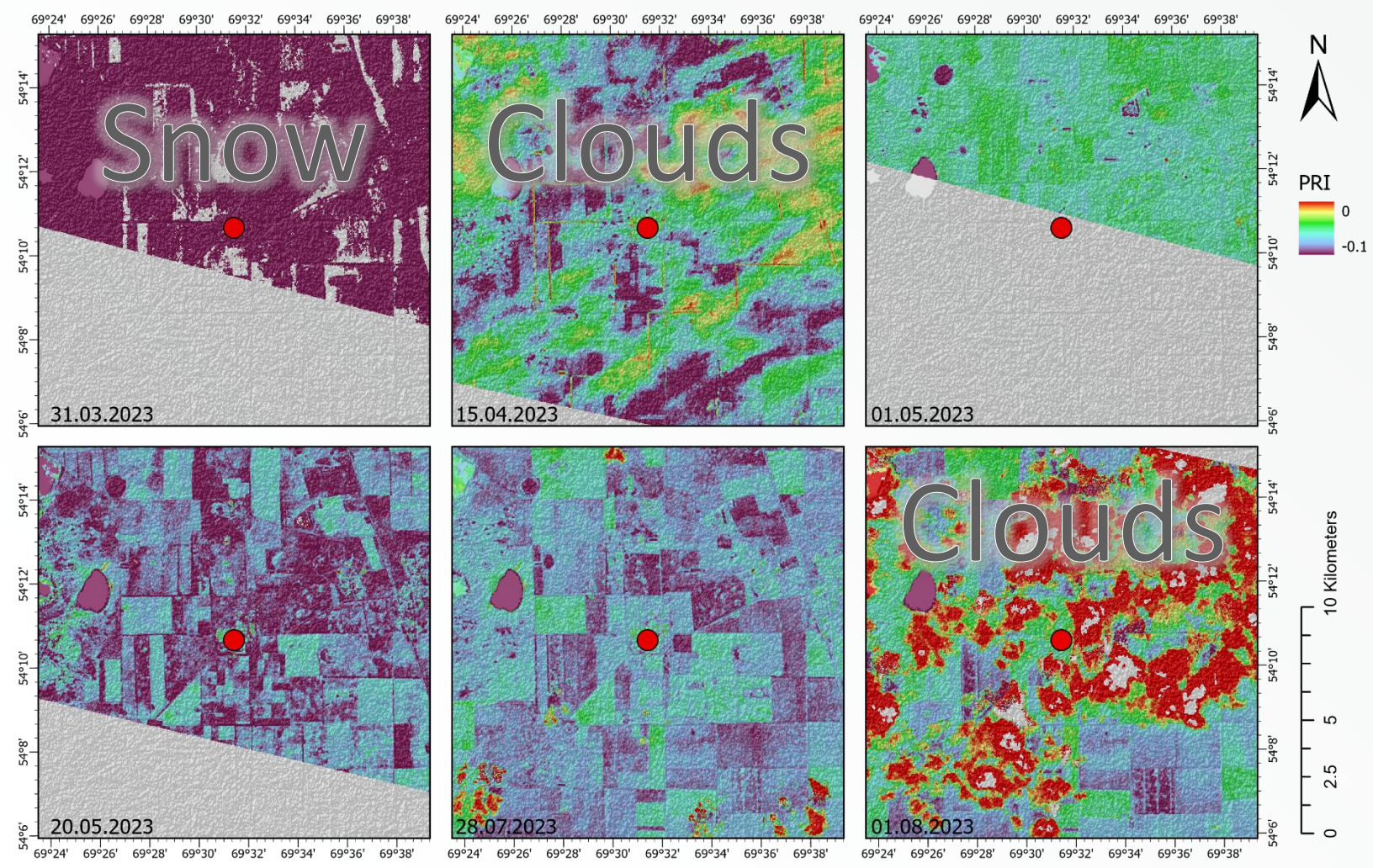
Some tools, such as the ***"Agricultural-Indices-Collection"***, the ***"Analyze-Spectral-Integral"*** or the ***"Interactive-Red-Edge-Inflection-Point"*** tool support traditional parametric methods.

The ***"Regression-Workflow"*** can be applied to train a collection of machine learning algorithms for non-parametric retrievals.

Both, parametric and non-parametric approaches usually are applied in conjunction with flight-parallel in-situ measurements for calibration of empirical models.

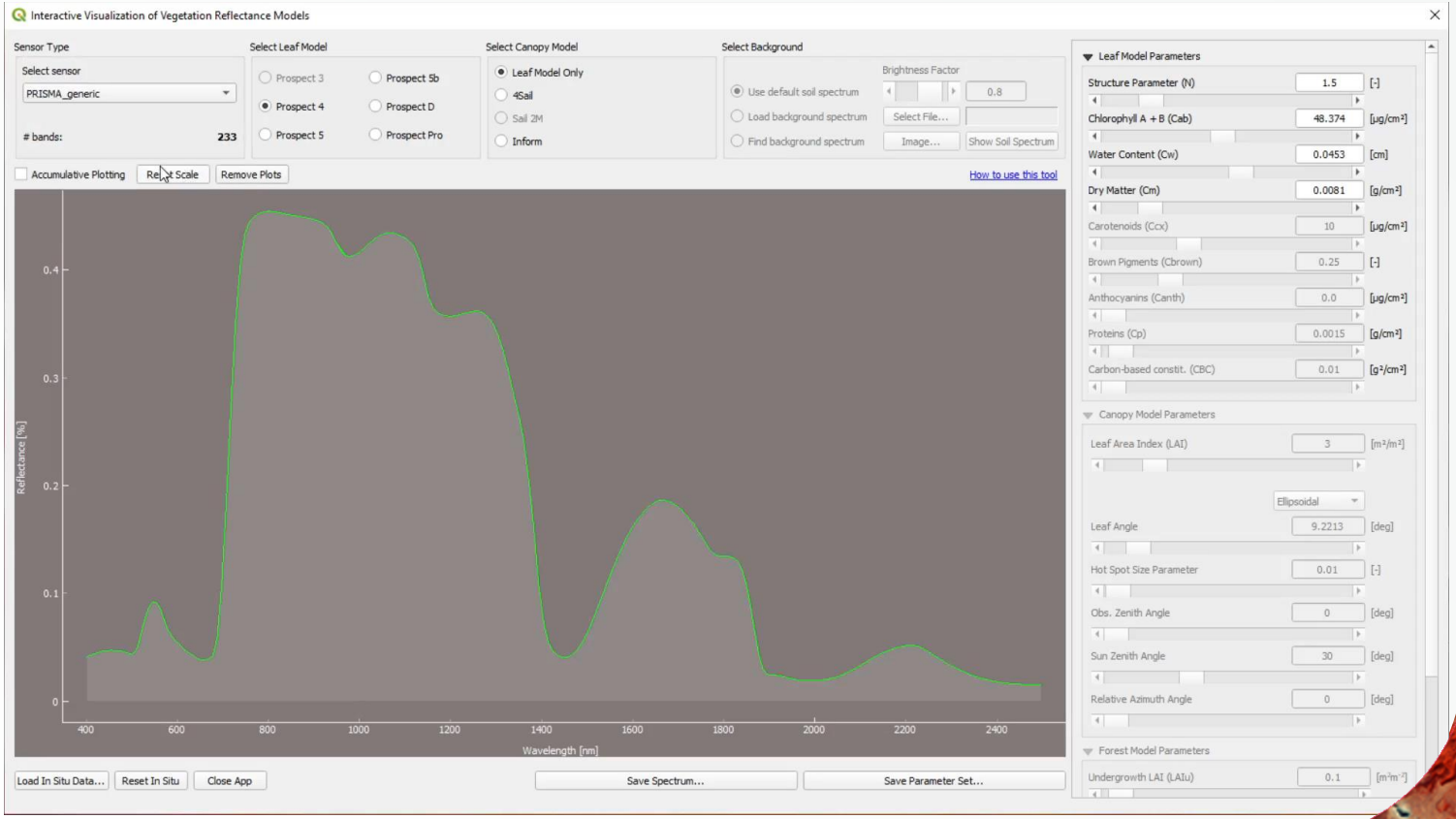


EnMAP-Box | Empirical Methods

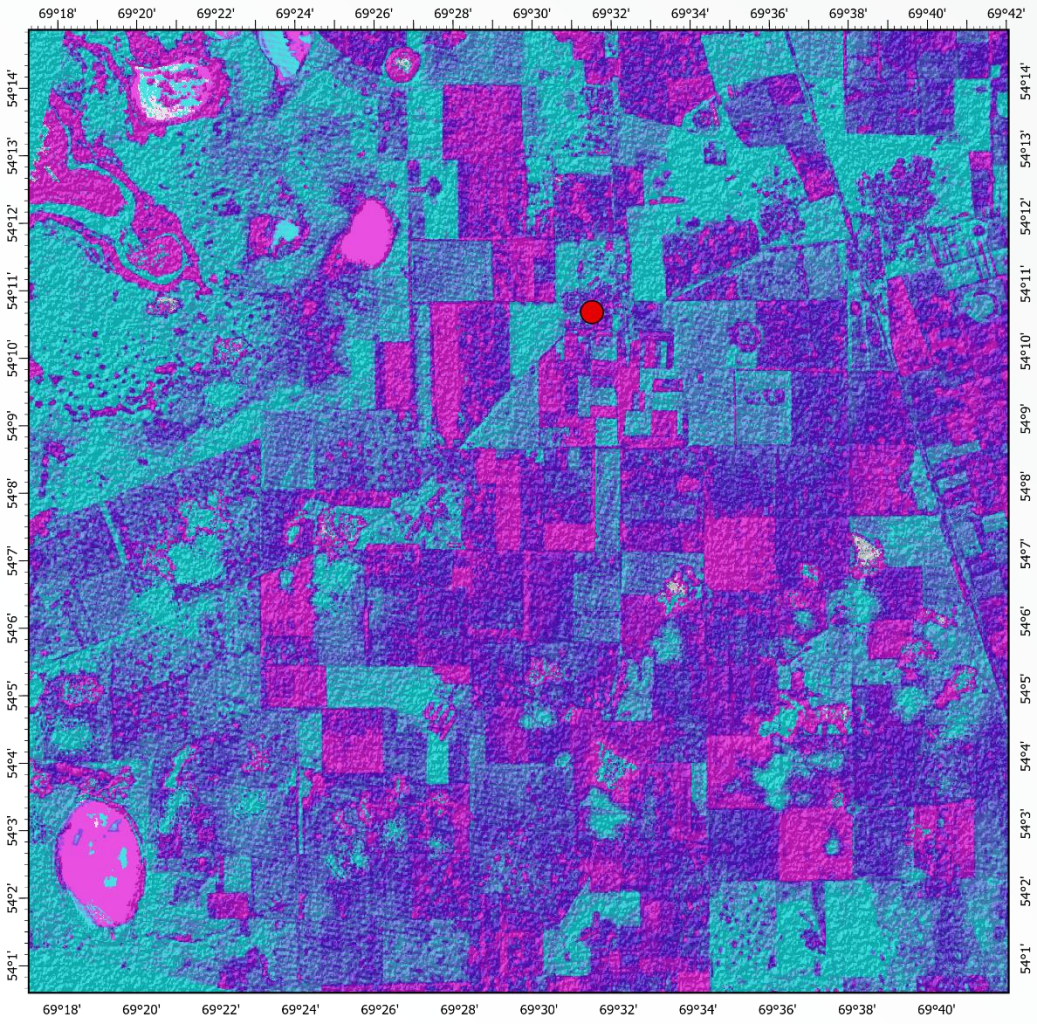


EnMAP-Box | Physically-Based Methods

With the ***"Interactive-Visualization-of-Vegetation-Reflectance-Models (IVVRM)"***, the ***"Plant-Water-Retrieval (PWR)"*** and the ***"Invert-Look-Up-Table"*** tools, also physically-based approaches that do not rely on in-situ data for calibration are available in the EnMAP-Box.



EnMAP-Box | Physically-Based Methods



N

28.07.2023

North-Kaz Agricultural Experimental Station

PWR [cm]

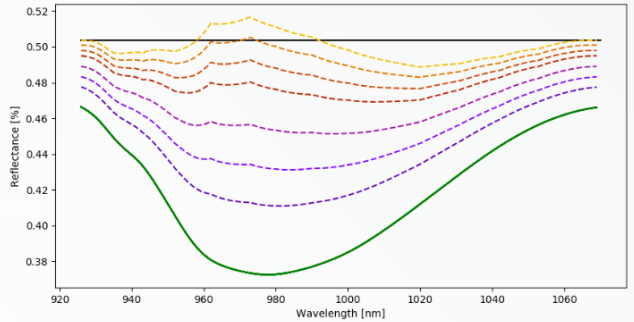
0.05

0

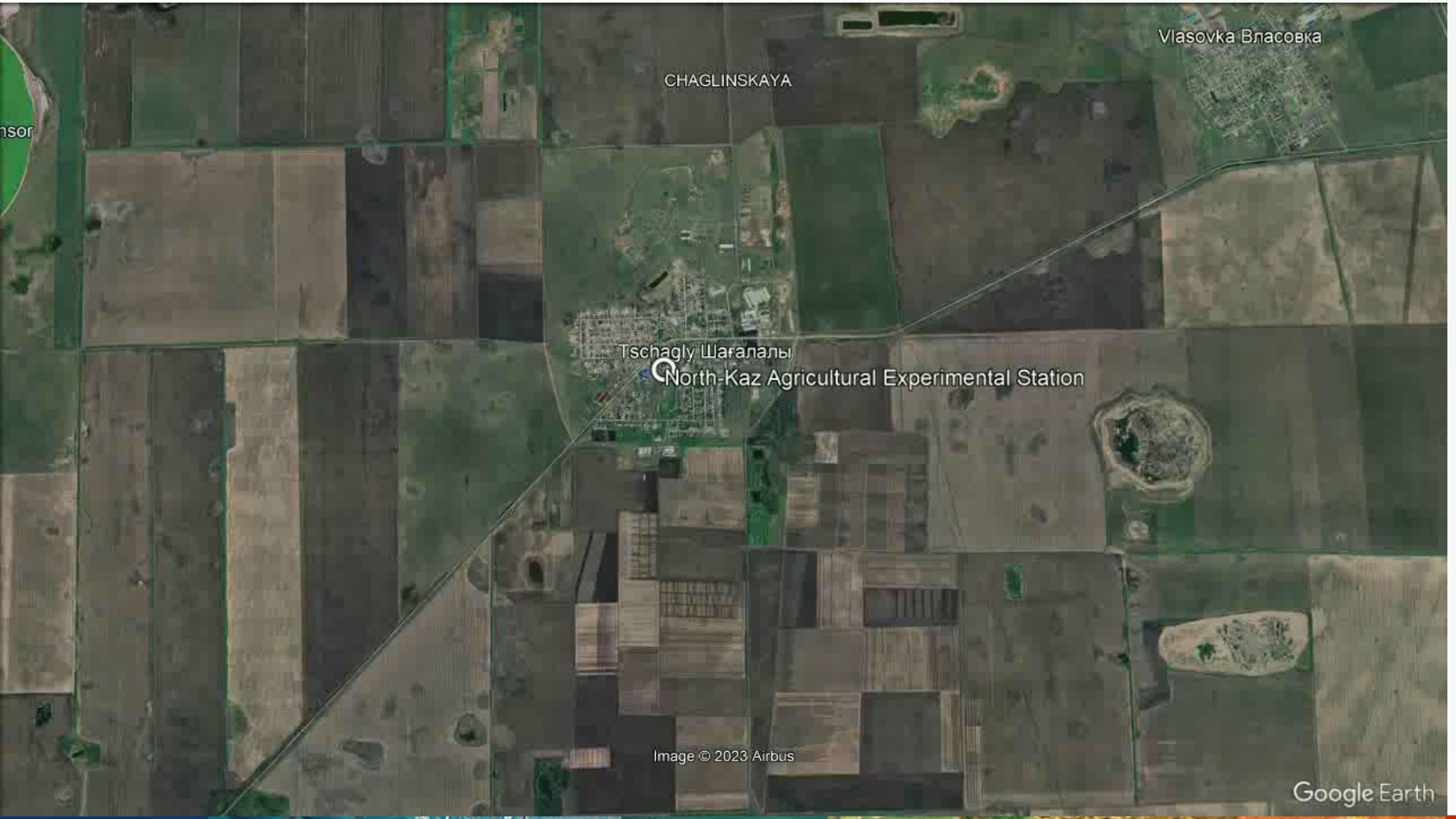
10 Kilometers

0 2.5 5

$$R' = \frac{R_0}{e^{-\alpha * d}}$$

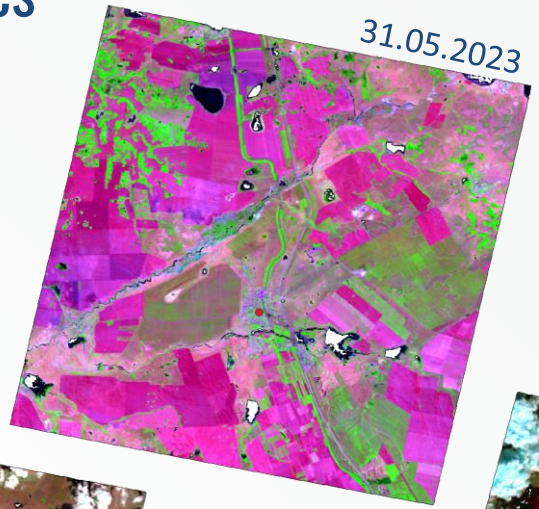


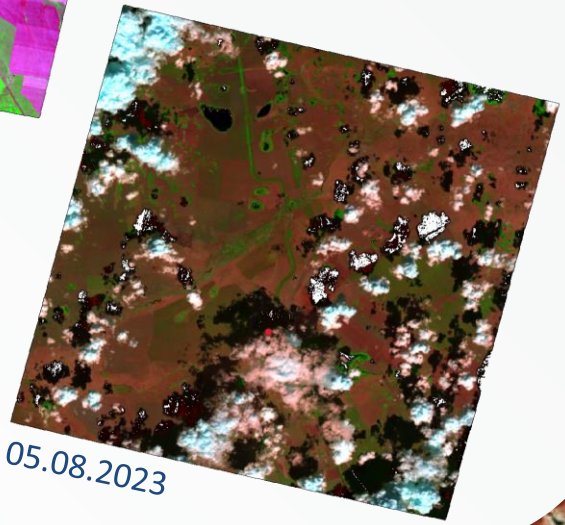
Approx. 300 km further to the South, Center Coordinates: 54.69° N | 70.99° E



Test Site Astana: Location

EnMAP | Hyperspectral Time-Series





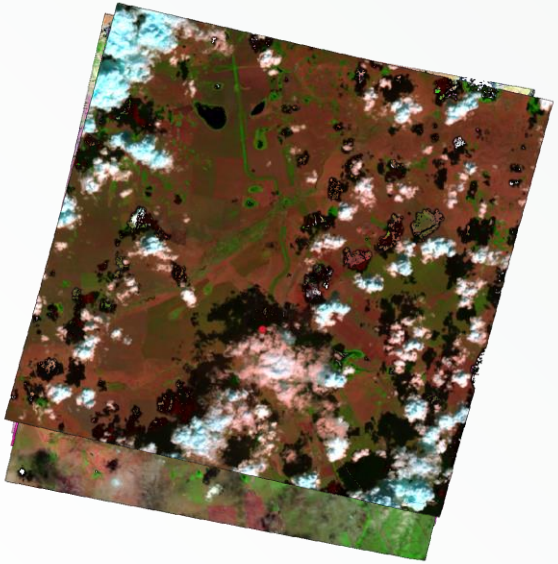
EnMAP | Hyperspectral Time-Series

30.04.2023

31.05.2023

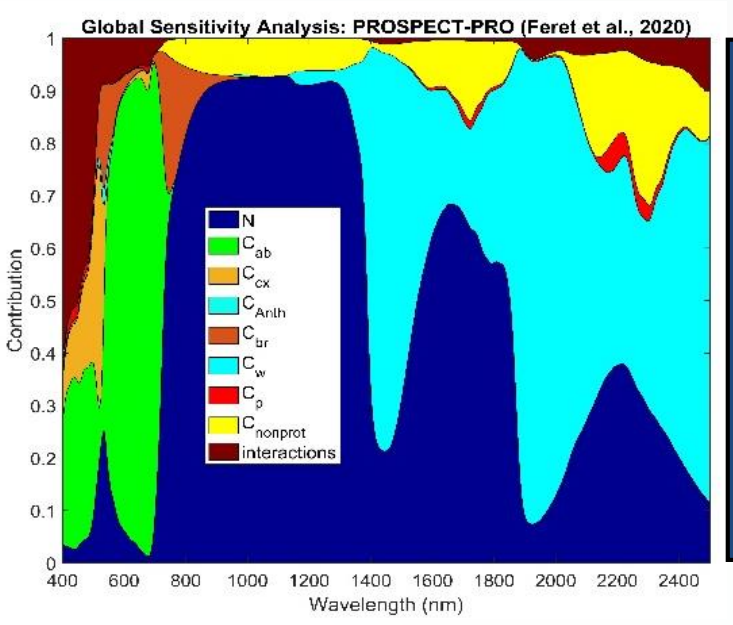
24.07.2023

05.08.2023

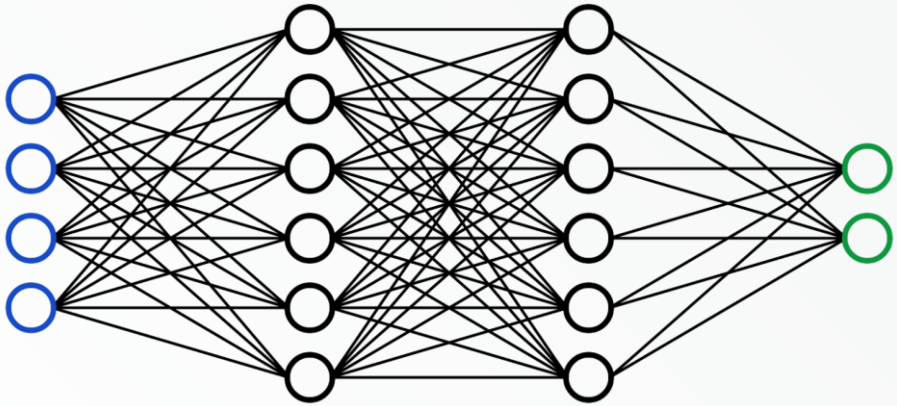


EnMAP-Box | Hybrid Methods

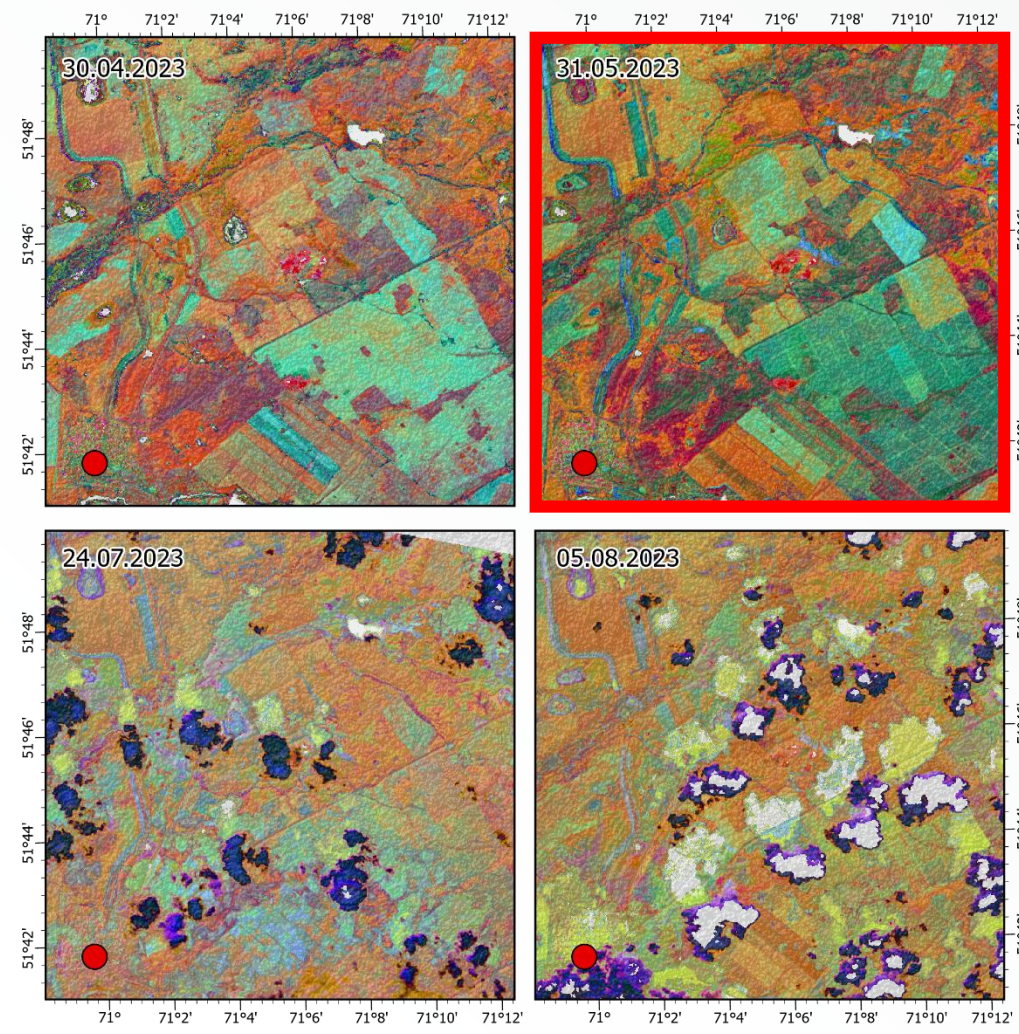
Combining the transferability and predictive power of physically-based approaches with the computational efficiency of machine learning, the *"ANN-Vegetation-Processor"* enables the application of so-called hybrid retrieval strategies, where models are trained purely based on simulated data. In-Situ data nonetheless is often used for validation of hybrid retrievals.



Training



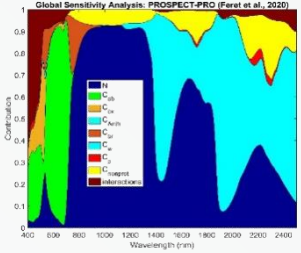
EnMAP-Box | Hybrid Methods



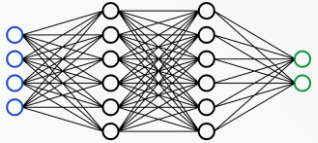
ANN Output

- Red: C_m
- Green: C_{ab}
- Blue: LAI

Research and Production Center for Grain Farming

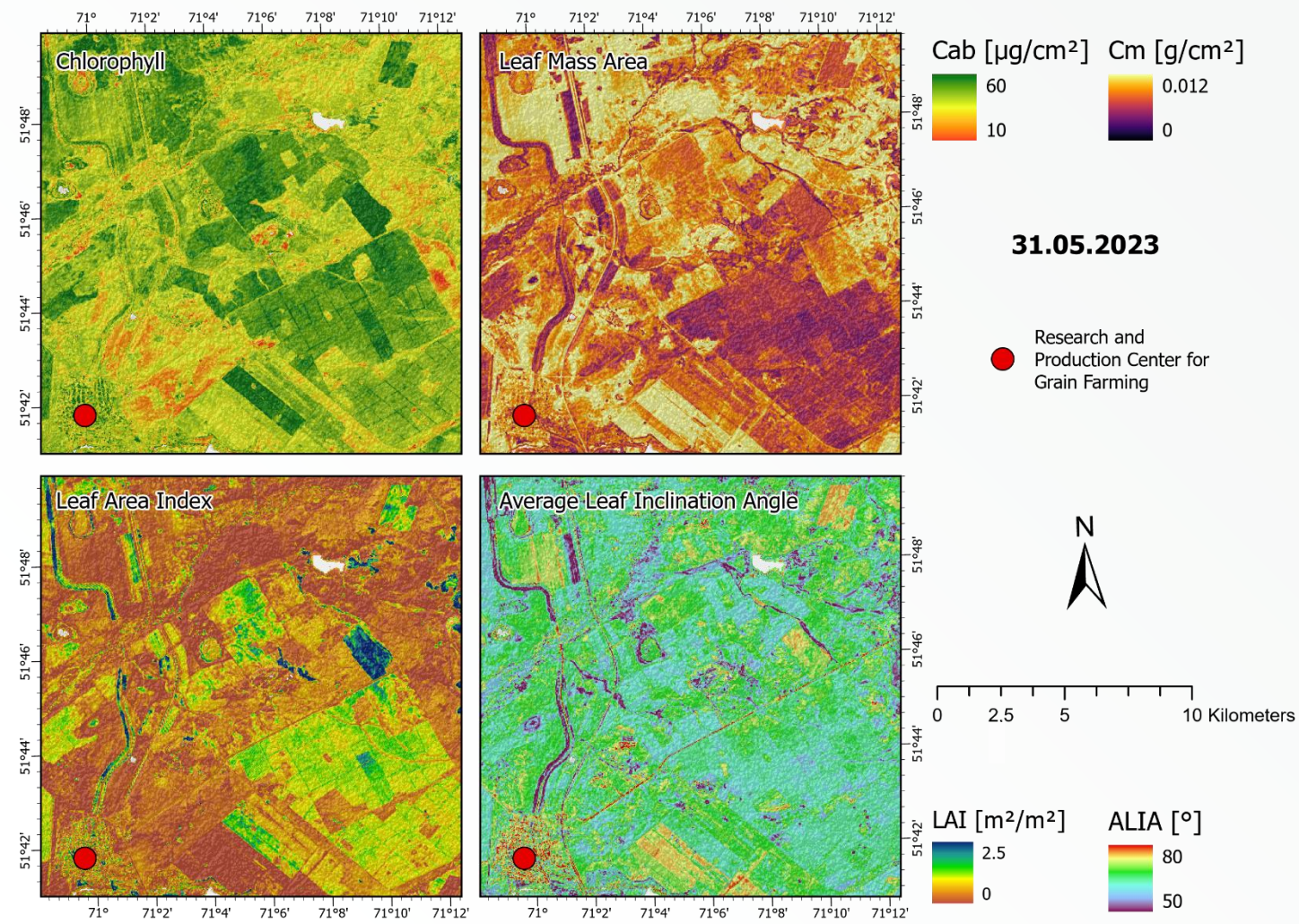


Training



N

0 2.5 5 10 Kilometers



EnMAP-Box | Hybrid Methods

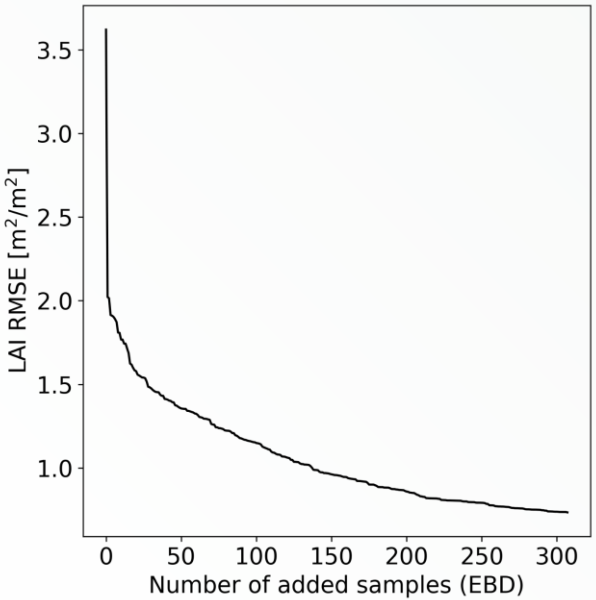
EnMAP-Box | Active Learning

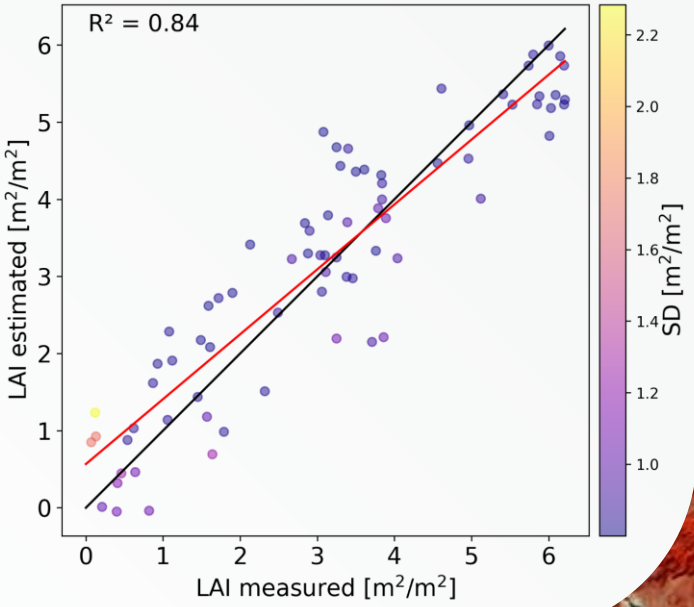
The machine learners that are applied as part of the hybrid retrieval workflow are very sensitive to the structure of the training data. Some of them for example do not cope well with redundancy in the training samples.

Active Learning (AL) takes a huge data base, which e.g. has been generated using reflectance models, and streamlines it by selecting only the most relevant samples. This can either be done internally or with help of independent in-situ data.

By applying AL, the training data base becomes smaller but more meaningful and more tailored to the target variable.

AL will soon be integrated into the hybrid retrieval tools in the EnMAP-Box.





EnMAP | Conclusions

- The EnMAP-Box provides apps in a very user-friendly way that cover the full range of available methodologies, from simple parametric approaches up to advanced hybrid techniques.
- Active learning heuristics enable the optimization of training data by removing redundancies and thus largely contribute to increased performance of variable retrievals via machine learning. They will soon be included in the EnMAP-Box.
- Hyperspectral data is still sparse, especially time-series are hard to achieve.
- It therefore is an advantage that the EnMAP-Box is open also towards other data sources, such as PRISMA.
- We should also be open-minded towards opening the EnMAP-Box algorithms for future missions (e.g. CHIME).

1st EnMAP User Workshop

Thank You for Your Attention!

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www.geographie.uni-muenchen.de

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