Drone-borne spectral monitoring of post-mining areas

Erik Herrmann (1), Robert Jackisch (1), Robert Zimmermann (1), Richard Gloaguen (1), Kathleen Lünich (2), Lennart Kieschnik (2)

(1) Helmholtz-Zentrum Dresden-Rossendorf, Helmholtz Institute Freiberg for Resource Technology, Germany
(2) Sächsisches Landesamt für Umwelt, Landwirtschaft und Geologie - Referat 44

HELMHOLTZ INSTITUTE FREIBERG FOR RESOURCE TECHNOLOGY

This presentation participates in OSPP
Outstanding Student Poster & PICO Contest

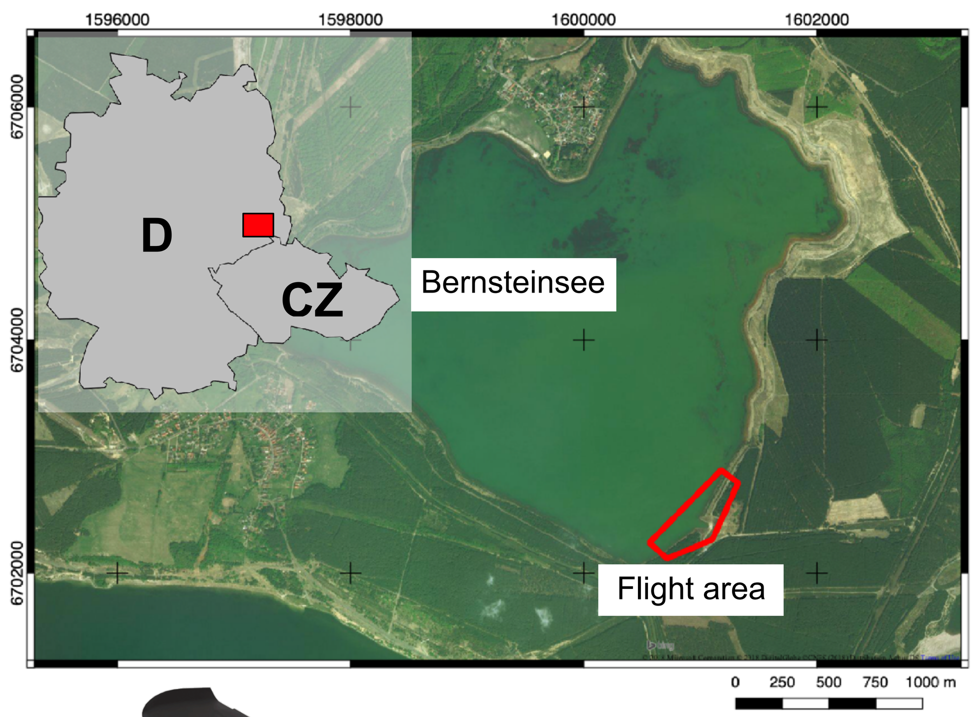
Case study 'Bernsteinsee'

Task
- Monitoring groundwater infiltration into inaccessible mining lake

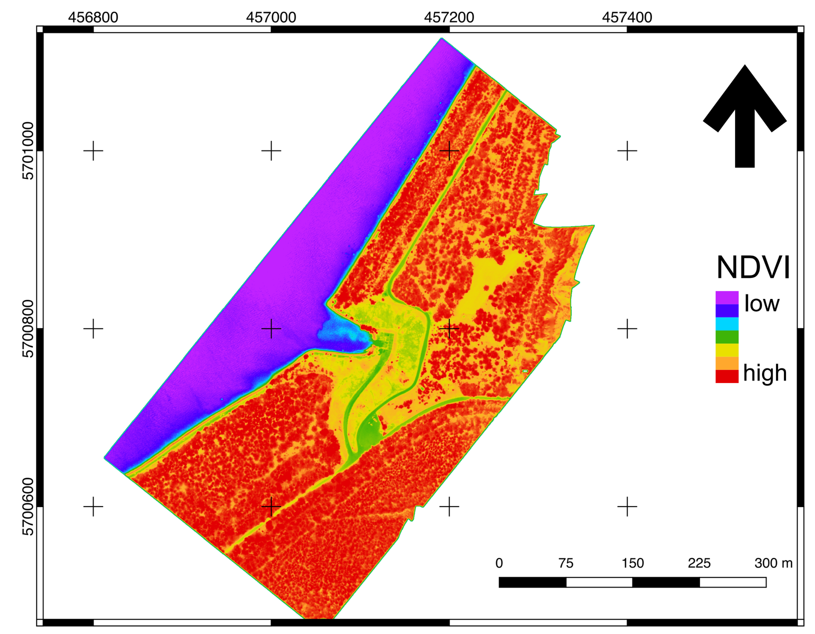
Approach
- Using elevated iron-concentration of lake-water due to leftovers of previous lignite mining, as well as NDVI as proxy. Realised by analyzing 'iron band index' and 'Normalized Difference Vegetation Index' (NDVI).

Data
- Multispectral imaging via fixed wing UAV.

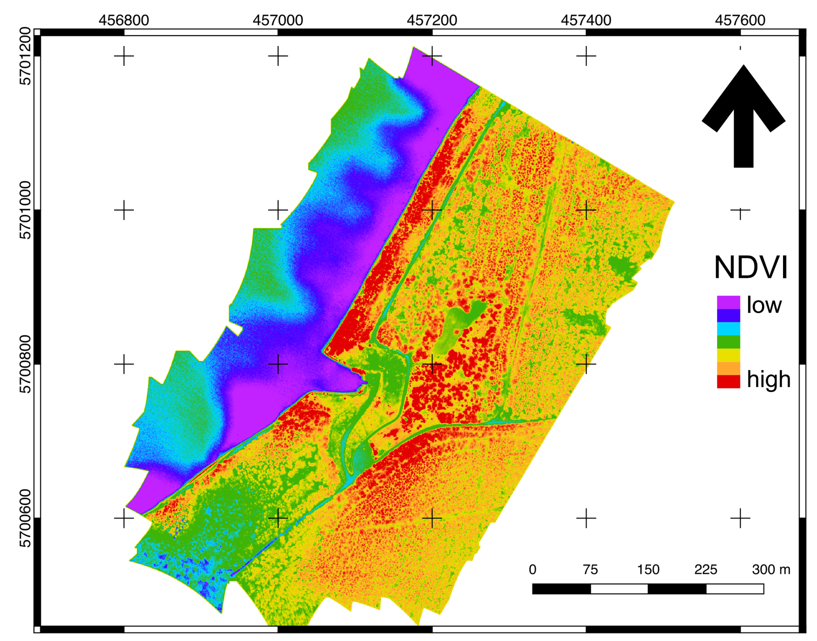
Result
- Water mixture is detected by iron index. During autumn 2018, when overall vegetational water stress level was increased (hot summer 2018), the underground flow path of the water is seen through increased NDVI-values.



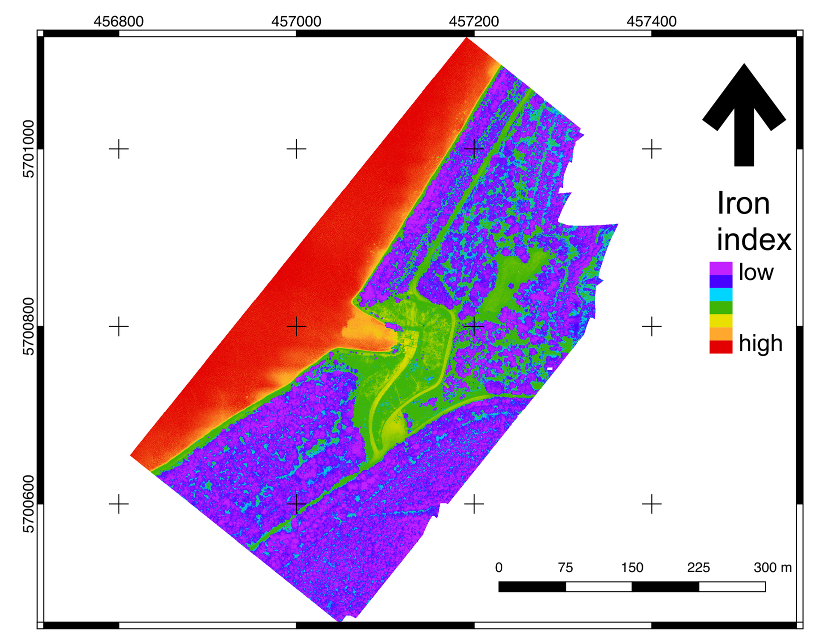
eBee Plus with multispectral camera "Sequoia"



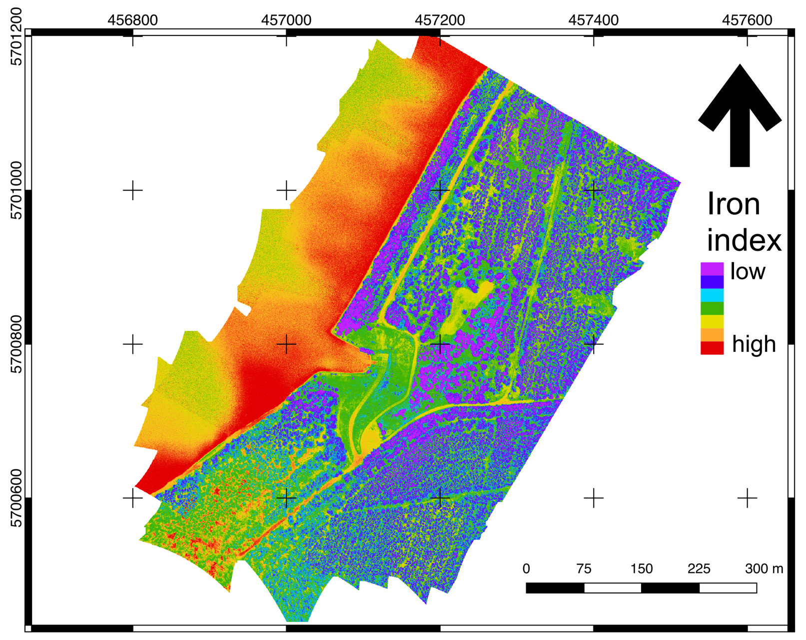
NDVI (summer). Vegetation shows no variation.



NDVI (autumn). Vegetation shows higher chlorophyll activity above water pathway.



Iron index (summer). Water-mixture visible.



Iron index (autumn). Water-mixture not distinguishable with certainty.

Motivation

Anthropogenic exposure and accumulation of mining residuals poses a significant intervention in environment e.g. by artificial pit lakes and waste heaps
→ Monitoring post-mining areas in-situ, enforced by federal law

The dense geochemical sampling and modelling is time consuming and often not fully realisable due to inhibiting circumstances, impeding subsequent geochemical mapping & interpolation → an interpolation map that displays contamination is highly biased by the chosen method → Unmanned aerial systems (UAS) can fill the gap.

We investigate the use of drones to support environmental monitoring.

UAS data processing with MEPHySTO (Jakob et al. 2017)

Conclusion

- UAS seamlessly cover large areas quickly, with high pixel-resolution due to the low flight altitude.
- The limitations in flight time and altitude are more a legal, than a technical issue.
- Technical progression in lightweight multi- and hyperspectral cameras constantly increase the quality and type of acquire-able data.
- UAS monitoring can avoid data gaps in areas where no ground data can be acquired due to inaccessibility.
- Case study 'Bernsteinsee' showed possibility to distinguish waters from different reservoirs based on their relative iron-content.
- Surface NDVI used as proxy to trace groundwater flow of artificial channel.
- Case study 'Litov' showed, that UAS-borne classification maps used as external drift for interpolations increase resolution and fill gaps.
- Ground sampling density can be decreased, without a significant loss of quality, given a high correlation between tested parameters and the used proxy.

Outlook

No shortwave-infrared data have been used in this studies. This part of the electromagnetic spectrum would provide additional information that can be used to determine clay and carbonate minerals.

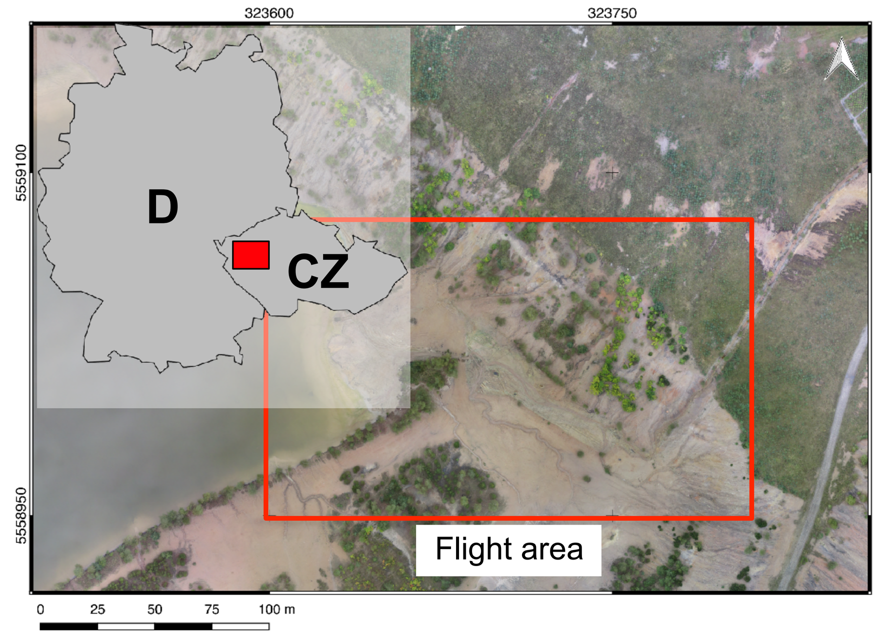
Case study 'Litov'

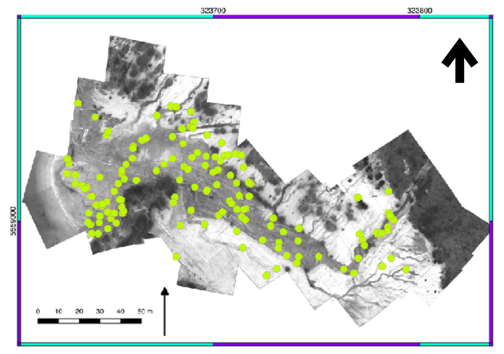
Task
- Obtain a high resolution map with quantitated values

Challenge
- Renaturated waste heap from former lignite mining in Czech Republic drains acidic waters (pH 2–4).

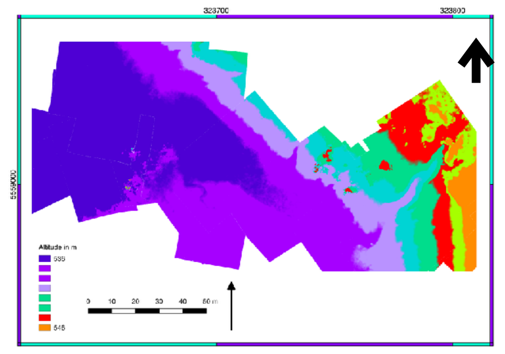
Approach
- Drone-borne data showing high correlation to the tested parameters, are used as external drift to improve quantitative geochemical models, based on ground truth.

Data
- Ground sampling measurement, along with a digital surface model (DSM), obtained from multispectral drone-borne data.

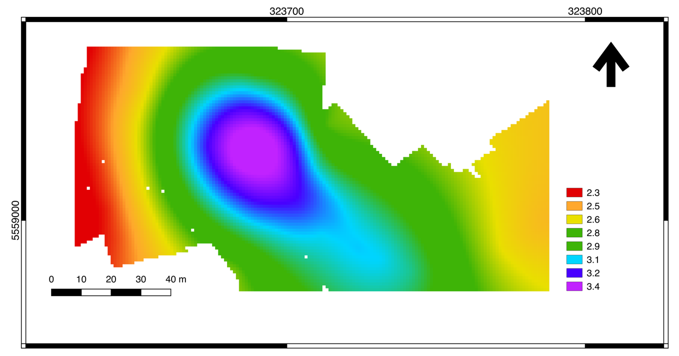




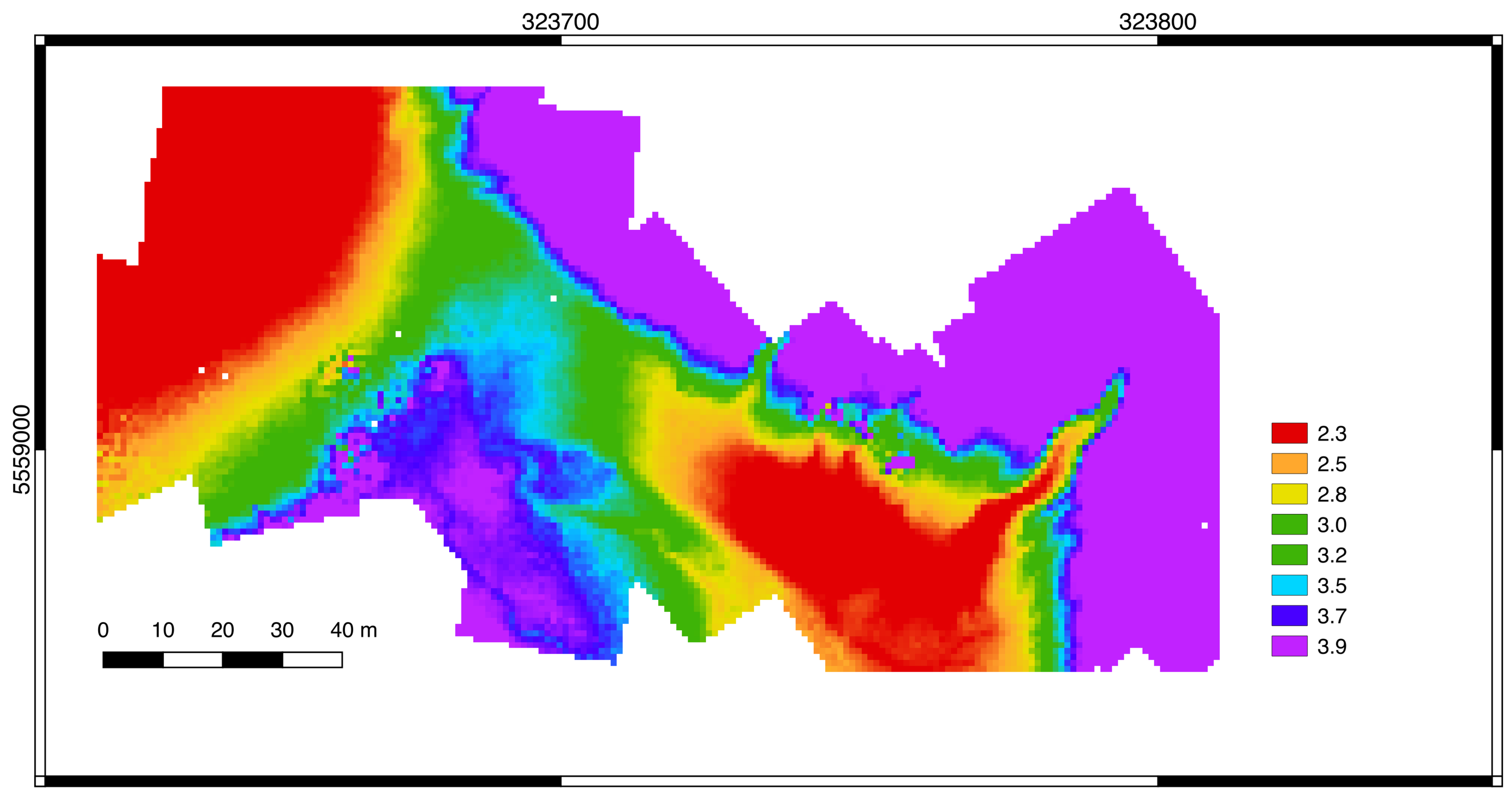
Sampling locations from geochemical data (Jackisch et al. 2018)



Digital surface model from drone-borne acquisitions



Universal kriging interpolation of pH –> no external drift



Universal kriging interpolation of pH-values with DSM as external drift - Use of UAS data as external drift can result in a high resolution interpolation map, taking local condition higher into account than interpolation methods without additional grid information.

- Jackisch, R.; Lorenz, S.; Zimmermann, R.; Möckel, R.; Gloaguen, R. Drone-Borne Hyperspectral Monitoring of Acid Mine Drainage: An Example from the Sokolov Lignite District. *Remote Sens.* **2018**, *10*, 385.
- Jakob, S.; Zimmermann, R.; Gloaguen, R. The Need for Accurate Geometric and Radiometric Corrections of Drone-Borne Hyperspectral Data for Mineral Exploration: MEPHySTo—A Toolbox for Pre-Processing Drone-Borne Hyperspectral Data. *Remote Sens.* **2017**, *9*, 88.
- Tucker, C.J. Red and Photographic Infrared Linear Combinations for Monitoring Vegetation. Remote Sens. Environ. **1979**, 8, 127–150.
- van Ruitenbeek, F. J. A. *et al.* Mapping white micas and their absorption wavelengths using hyperspectral band ratios. *Remote Sens. Environ.* (2006). doi:10.1016/j.rse.2006.02.012
- Hunt, G. R., & Ashley, R. P. (1979). Spectra of Altered Rocks in the Visible and near Infrared. Economic Geology.

LANDESAMT FÜR UMWELT, LANDWIRTSCHAFT UND GEOLOGIE | Freistaat SACHSEN

SN CZ Ahoj sousede. Hallo Nachbar. Interreg V A / 2014 – 2020

Europäische Union. Europäischer Fonds für regionale Entwicklung. Evropská unie. Evropský fond pro regionální rozvoj.

Erik Herrmann | Helmholtz Institute Freiberg for Resource Technology | e.herrmann@hzdr.de | www.hzdr.de/hif