

Opposition review of PhD thesis

Title: **UAV remote sensing of hydrological processes and fluvial dynamics**

Dálkový průzkum hydrologických procesů a říční dynamiky pomocí UAV

Author: M.Sc. Theodora Lenzioch

Reviewer: RNDr. Martin Hais, PhD.

The PhD thesis of Theodora Lenzioch is focused on UAS methods and their applications in remote sensing and hydrology. The main aim of the PhD thesis is to investigate the potential of UAS technology for various environmental applications which contain snow hydrology, river restoration and sustainability, wetlands dynamics and bathymetry measurement. The UAS methods represent relatively new research topic, which was developed in last decades but strongly accelerated several years ago. This methods represent very effective and relatively low-cost approach which fulfills a gap between field ground-based monitoring and airborne imagery. UAS imagery together with artificial intelligence tools bring new results for environmental science. I appreciate in this context that Theodora Lenzioch chose above mentioned modern methodic approach relating to the high scientific level.

The PhD thesis consists from very interesting case studies with various topics, datasets and analyses based on UAS imagery and methods. Theodora Lenzioch had this way an opportunity to learn a lot of new information during processing her PhD thesis. I suppose this type of work is much more demanding but also more rewarding than deeply focused study on one problem. The entire PhD thesis is nicely written and the structure is well-arranged. It was surprising to me to separate the published papers to an attachment part, but finally I have to conclude it was very practical for orientation in the structure of the work. The high scientific quality of the PhD thesis is documented by a large number of published papers (6) mostly in *Remote sensing* journal, which is among the best in this field.

I have some specific comments and questions to individual parts (questions or comments to be answered or explained are in bold):

There are differences the Czech and English versions of Abstract. Some information (e.g. several sentences) in the English version are missing.

List of publications included in the thesis (page 8) – it is nice overview of author's publications. There are also mentioned percentages of author's contribution to individual papers. **However, I wonder that the percentage of Theodora Lendzioch contribution to study 5 is 100% even though there are three authors. It is a mistake or both other authors did not contribute to this paper?**

The chapter: 2.3 Assessing peatlands with UAV remote sensing: Monitoring hydrological dynamics – I miss the principle of ground water measurement using remote sensing. **Could you explain it?**

Chapter - RGB system: *UAVs with RGB sensors are easy to operate, relatively inexpensive, and provide high-quality RGB images primarily for dense 3D point cloud creation, orthoimagery (papers II, V, VII), and the development of DEMs (papers I and VI), DSMs (papers III and IV), and Digital Terrain Models (DTMs)* – **How it is possible to create the DTM only from RGB imagery in case of dense forest canopy?**

There are a lot of acronyms in the work, which are not commonly used or used also in another sense. For example SD is usually used for Standard Deviation and it might be confusing to use it for Snow Depth. They should be explained for example in a list apart of the main text.

Chapter - 3.2 Best practices for UAV-based data collection. I appreciate this chapter as a recommendation how to practically acquire UAS data in the field. However, there is not clear what experience is taken from literature and what is your own.

Similarly the chapter 3.3 is a nice overview about best practices of UAV data processing. However, I do not understand this statement: "From DSM outputs, thermal orthomosaics can be generated..." **How can be surface temperatures calculated from DSM?**

Table 4. FLIR DUO R, Infrared Radiation (IR) is mentioned as 1000 nm, but it is NIR not TIR.

If you estimated the snow depth using RGB camera. It was not to fully clear to me how you estimated this parameter in the tree-shadowed area. **Did you used different views of the sensor to eliminate this problem? What do you think about the possibility to estimate snow depth using LiDAR data or to combine RGB with LiDAR data?**

Discussion – Except the method to detect snow depth and LAI I appreciate the discussion of the relationship of both variables and environmental conditions.

The snow depth measurement using UAV bring a new potential how to low-cost way estimate snow supply in a relatively small areas. **How can be applied these results in environmental studies?**

What is the maximal bottom-depth which can be detected using multispectral UAS with respect to water properties (e.g. turbidity)?

I appreciate the new approach to use the UAS methods to granulometric survey. **However, wouldn't be more appropriate to use OBIA (object based image analysis) instead of deep learning as a classification method?**

Summarizing questions to the entire PhD thesis:

There are a lot of very interesting case studies of UAS data applications. However, it is there any new result or finding, which is common for all the studies?

Can you briefly summarize, which questions relating to UAS methods and hydrology seems to be most relevant for future research?

Which results or new methodic approaches of these PhD thesis you consider as a most important in context of remote sensing and hydrology?

Conclusion of the review

Theodora Lenzidoch contributed significantly with her PhD thesis to the basic and applied research. I can state that the aim of the PhD thesis was achieved. The heterogeneity in research studies has the positive effect that the PhD student was not focused solely on one specific topic, but it was needed to cover relatively broad knowledge of solved research problems. The resulting benefit is that Theodora Lenzioch learned a lot of UAS applications and maybe also specific problems in given research topics. In my opinion, except some less important and rather formal mistakes the quality of the PhD thesis is very high and it brings important results for remote sensing and hydrology. I conclude all necessary conditions were fulfilled and it is my pleasure to recommend this thesis for PhD defense.

In České Budějovice, June 14, 2023

RNDr. Martin Hais, PhD.