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Warsaw, 10 September 2014

Review of the PhD thesis of Mgr. Jan Mišurec
Supervisor: Dr. Lucie Kupkova

To whom it may concern

Dear Madam/Sir,

I would like to express my gratitude for the trust and entrusting me with the assessment of the dissertation. It was a pleasure to read the thesis *Influence of atmospheric and topographic correction on the accuracy of canopy chlorophyll content estimation of Norway spruce stands*, because it is one of the most developing issues of hyperspectral remote sensing of vegetation, and PhD thesis is interesting and well-prepared.

Presented PhD thesis of Mr. Jan Mišurec (supervised by RNDr. Lucie Kupková) was prepared in the frame of activities of the Univerzita Karlova v Praze, Přírodovědecká Fakulta, Katedra Aplikované Geoinformatiky a Kartografie. The thesis consists of 107 pages divided into nine following chapters: Acknowledgements, Abstract, 1. Introduction, 2. Theoretical background, 3. Study sites, 4. Data, 5. Retrieval of Norway spruce canopy chlorophyll content using radiative transfer approach, 6. Quantification of the impact of the used atmospheric correction technique on the resulting reflectance data, 7. Results, 8. Discussion, 9. Synthesis and conclusions, References, Appendices.

The thesis is properly planned and relationships between introduction, background chapters, research methods, results and conclusions are appropriate.

The first chapter is an introduction and covers foreword, state of art of atmospheric correction and goals, hypothesis and research questions, which are important from scientific point of view:

1) What is the effect of the use of different atmospheric correction methods on the final canopy chlorophyll content estimation accuracy?
2) Are the sophisticated physically-based methods of atmospheric correction substitutable by the simple empirical based methods as for the chlorophyll estimation accuracy?
3) Does the canopy chlorophyll content estimation accuracy depend on the flight geometry (e.g. on orientation of the image flight lines)?
4) What is the influence of the use of cross-track illumination (BRDF) and topographic effects corrections in addition to classical atmospheric correction? Does the use of BRDF and topographic correction increase the canopy chlorophyll content accuracy?

The main goal was to compare the performance different atmospheric correction methods performed on airborne hyperspectral sensors with tuning and improvements of cross-track illumination and topographic effects removal. The second goal was an analysis of chlorophyll content basing on field and airborne level acquired data.

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The second chapter focuses on theoretical background (imaging spectroscopy, spectral properties of vegetation and retrievals of vegetation variables, atmospheric corrections, BRDF modeling and spectra similarity assessment methods). The chapter is good prepared and properly presented. I would like to see more statistical methods (e.g. tests).

Third and fourth chapters describe research areas and hyperspectral airborne data and images, which were used for analyses. I haven't any significant comments to this part of thesis, but the author could add:

- geographical coordinates, it would be better for international readers.
- numbers of bands of RGB compositions,
- maps of research targets (it isn't the best solution to present a table with tree codes, e.g. E6, H11).

5th chapter: *Retrieval of Norway spruce canopy chlorophyll content using radiative transfer approach* covers important part of the thesis. I think that this part could be added to theoretical background. Author should refer to literature (few tables don't present source materials, e.g. table 5.2, figures 5.3-5.6 and it isn't clear if the author based on his experience or a literature review?), but this chapter is very interesting and good presented.

These same comments I have got to the following (6th) chapter: *Quantification of the impact of the used atmospheric correction technique on the resulting reflectance data*. It should be more details for the figure 6.1, because both water absorption minima are shifted of different ATCOR models. I think it is an error. The chapter is clearly prepared and used methods are proper.

Results, it is one of the most interesting parts of the thesis. The chapter is properly prepared, but I think that the Author should be more carefully:

- I think that the figure 7.1 contains an error, because a systematic offset is caused by a reference target, which was used to analyses. It should be proofed,
- axes of all graphs should be described,
- why reflectance is higher than 1?
- decimal values in tables should be decreased (in dozens a 4th decimal digit doesn't play a role),
- spectral curves should be analysed by statistical tests, e.g. Figure 7.3, because several similar characteristics look alike,
- wrong x-axis description on Figure 7.4 (should be nanometers in place micrometers).

The above comments are no significant trifles compared to the quality of the results which obtained the Author.

The chapter (*Discussion*) shows a big scientific potential of the Author, because a presented analysis is properly referred to other authors and to the particular results. Analyses confirmed that:

- important effects of atmospheric correction of hyperspectral imagery on the quantitative canopy chlorophyll content estimation accuracy,

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- factors which may have influenced the obtained results are properly discussed,
- discussion of the potential interpretation of the obtained results and its consequences is interesting.

The final chapter: *Synthesis and conclusions* summarizes the key milestones and achievements. It is prepared in a clear and transparent style.

The main achievements confirm goals and can be defined as the:

- canopy chlorophyll content estimation accuracy is partially influenced by the choice of the method of atmospheric correction,
- absolute canopy chlorophyll content estimation accuracy is slightly lower in case of the data corrected by the FODIS-based method in comparison with the use of ATCOR-4 correction,
- classical ATCOR-4 based atmospheric correction can be substituted by the FODIS based atmospheric correction,
- BRDF correction leads to the significant improvement of the canopy chlorophyll content estimation accuracy and thus it seems to be a very important step in hyperspectral image data pre-processing in case of quantitative vegetation studies.

Final comments and remarks:

- presented PhD thesis is a very valuable source of empirical hyperspectral modeling of vegetation, where the chlorophyll content in leaves plays the most important role,
- the thesis is written in a clear and understandable style,
- documentary material allows to evaluate each stage of analyses and it increases the very high value of PhD thesis,
- numerous literature sources are an important part of the job,
- analyses and description parts show a significant potential of the Author, who is very well prepared to carry out advanced researches,
- overall rating of the PhD thesis is very high, the work is a benchmark for this type of studies,
- after few editorial works PhD thesis should be published as a very good example of high-value analysis of Imaging Spectroscopy.

I recommend to accept the thesis for the defense as a very good thesis and after a successful defese to award Jan Mišurec the title Rerum Naturalium Doctor (RNDr.).

Yours sincerely

B Zagajewski

Assoc. Prof. Dr. Bogdan Zagajewski
Head of the Department