PhD PROJECT PROPOSAL (FULL) **WAGENINGEN UNIVERSITY/PE&RC**

MAIN RESEARCH GROUP : Laboratory of Geo-Information Science and Remote Sensing

OTHER WU GROUPS INVOLVED : ....

Please read appendix first and fill in with a Personal Computer.

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1. PROJECT LEADER
   Prof. Michael E. Schaepman

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2. PROJECT TITLE (English)
   Mapping of plant functional groups of subalpine and alpine grassland ecosystems using airborne imaging spectroscopy and soil-vegetation-atmosphere radiative transfer modelling.

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3. PROJECT TITLE (Dutch)
   Kartering van functionele plantgroepen van (sub-)alpine graslandecosystemen met behulp van beeldvormende spectroscopie en bodem-vegetatie-atmosfeer stralingsinteractiemodellering.

4a. Duration of the project: from: 01/02/2008 to: 31/01/2012

4b*. If it is a joint project of two (or more) research groups, note that appointments have to be made about dividence of the capacity awarding at graduation. Please be so kind to inform the Research- and Education Department

The C.T. de Wit Graduate School of Production Ecology and Resource Conservation, Research group of Geo-information Science and Remote Sensing

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5. The experiments will be executed in (please mention country):
   - Finland
   - France

6a ANIMAL EXPERIMENTS: will vertebrates be used? NO

6b Are there any other particular ethical issues to be considered with respect to this project NO
If YES please elaborate

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7. PARTICIPANTS PROJECTGROUP AND ESTIMATED TIME INVOLVED

Name + title of the PhD student (if already available)	male/female	Nationality
Lucie Homolova, MSc	Female	Czech Republic

Period of appointment: from: 01/02/2008 to: 31/01/2012 for ......40.......... hours/week
(Year/month/day)

Kind of Appointment: External
5.3 Other

NAME AND TITLE	SPECIALIZATION	ORGANISATION	HOURS/WEEK
Promotor(s):			
Michael E. Schaepman, Prof.	Imaging spectroscopy	WUR, The Netherlands (RSL UZH, Switzerland)	0.5
Co-promotor(s):			
Katja Alanko-Huotari, PhD.	Hyperspectral remote sensing AISA calibration and data processing	Specim, Finland	2
Bogdan Zagajewski, PhD.	Remote sensing Ecology & environmental sciences	Warsaw Univ., Poland	2
Jan G.P.W. Clevers, Dr.	Remote sensing	WUR, The Netherlands	1
Other scientific staff:			
Zbyněk Malenovský, Dr.	Imaging spectroscopy	RSL UZH, Switzerland	0.5
Technicians:			
Not involved			

Financial source(s):
(in case of NWO: please mention NWO-foundation i.e. WOTRO, STW, ALW)

(in case of EU: please mention EU-programme and number)

Hyper-I-Net (Marie Curie research and training network), MRTN-CT-2006-035927

Is the financial support and equipment sufficient to carry out the research and TSP? YES

If NO, please indicate the reason why!

Note: The full financial support guaranteed by the Hyper-I-Net project will cover first three years of the project. The Laboratory of Geo-Information Science and Remote Sensing has committed itself to fund the last year in order to finalize the thesis at Wageningen University.

8. COLLABORATION: with which organisations outside the University will collaboration take place?

Other Universities	: Warsaw University, Fac. of Geography and Regional Studies, Dep. Of Geo-information and Remote Sensing, Remote Sensing of Environment Lab. (Poland)
Private companies	: Specim, Spectral Imaging, Ltd. (Finland)
Research institutes, experimental stations	: none
Ministries, other organisations	: none
International organisations such as FAO, WHO	: none

Remote Sensing Laboratories of University of Zurich (RSL UZH) and Institute of Systems Biology and Ecology, Academy of Sciences of the Czech Republic (ISBE, AS CR) are potential partners to partially collaborate within the scope of proposed PhD project.

9. SUMMARY

Grasslands are dominant vegetation ecosystems in subalpine and alpine areas and they are characterized by a high biodiversity (species variability and structural heterogeneity). Mapping of biodiversity is one of the key elements to study ecosystem functioning and its role in the global environment. According to the theory of ecosystem functional diversity, plant species can be grouped into plant functional groups (PFGs), based on their functional role within the ecosystem. Plant functional groups can be identified according to easily measurable plants "soft traits", e.g. leaf area index, period of photosynthetic activity at canopy level, specific leaf area (SLA), dry matter content, nitrogen concentration, leaf phenology related to pigments concentration. Current advances in remote

sensing technologies allow quantitative mapping of vegetation biochemical and structural properties and thus some of the canopy "soft traits" may be estimated from remote sensing observations. The physically-based methods, retrieving vegetation properties from remote sensing data by means of canopy radiative transfer model inversion, have been successfully applied to forest and agricultural canopies; however, less attention has been paid to natural grassland ecosystems. The current challenges of ecological-based remote sensing applications are: accurate estimation of at-surface reflectance quantities from remote sensing measurements, appropriate parameterization of canopy radiative transfer models taking into account canopy architecture, and last but not least solving the inversion of canopy radiative transfer models to avoid multiple solutions. All these aspects will be covered during the research.

The main objective is to identify plant functional groups of subalpine and alpine grassland ecosystems, based on canopy biochemical and structural properties estimated from airborne imaging spectroscopy data of very high spatial resolution using inversion of canopy radiative transfer models. The research, however, will deeply focus on the following aspects: i) evaluation and potential use of complementary downwelling irradiance data recorded at the sensor level for estimation of at-surface reflectance quantities, ii) optical and structural heterogeneity of subalpine and alpine grassland ecosystems in the leaf-canopy modelling domain, iii) retrievals of selected biochemical/structural vegetation properties from airborne imaging spectroscopy data, and iv) combination of derived biochemical and structural vegetation properties for mapping of plant functional groups in subalpine and alpine grassland ecosystems.

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10. DETAILED DESCRIPTION OF RESEARCH AREA AND PLAN (MAX 2500 WORDS + 1 PAGE LITERATURE LIST)

10.1. Introduction, including history and background

Broader context

Vegetated surfaces are important components of the global environment. Vegetation ecosystems contribute to the biomass primary production, biochemical cycles and interactions between land surface and atmosphere (e.g. gas and energy exchange, photosynthesis, CO_2 cycle, carbon sequestration, etc.). Recently a lot of effort has been spent to monitor environmental components, including vegetation cover, their interactions and changes from local to global level. An example of activities supporting monitoring of environmental components are the Global Earth Observing System of Systems (GEOSS, 2008) and its European contribution, GMES initiative (GMES, 2008). The remote sensing techniques provide a valuable source of information for the global monitoring initiatives. Satellite and airborne remote sensing are non-destructive tools for spatial and temporal monitoring of the Earth surface from local to global scale. From the 1980's the concept and technologies of hyperspectral remote sensing (often called imaging spectroscopy) have been developed. The advantage of imaging spectroscopy over traditional multispectral remote sensing is more detailed and continuous spectral information and therefore it provides possibility to derive more information about surfaces observed. A number of imaging spectroscopy based methods have been developed to estimate quantitative vegetation biochemical (e.g. chlorophyll content), structural (e.g. leaf area index), and radiation (e.g. fraction of absorbed photosynthetic active radiation) properties. Reliable estimates of vegetation biochemical and structural properties can be used for a variety of ecological, agricultural and meteorological applications. Airborne remote sensing based products are used as i) bio-indicators of the actual state of vegetation and tools to assess impacts of environmental stress on vegetation ecosystems, ii) inputs into eco-physiological dynamic models that simulate energy and mass exchange and predict development of ecosystems under variable climate conditions , iii) validation data for satellite-based remote sensing products operating at global scale.

Grassland ecosystems and plant functional groups

Grasslands are the dominant vegetation ecosystem in subalpine and alpine areas and they are characterized by high biodiversity (species variability and structural heterogeneity). Quantifying biological diversity helps to understand how the ecosystems are functioning. Biodiversity has been originally quantified simply as the number of species. Mapping of individual species, however, is hardly possible within ecosystems with high species variability and at larger scales. In the last few decades the concept of functional diversity (Smith et al., 1997) has been developed as an alternative approach to species mapping. The plant species are grouped into plant functional groups (PFGs), according to their functional role within an ecosystem. The functioning of individual species is determined by "hard traits", which are the abilities to capture and conserve resources or withstand environmental stress. Direct measurement of "hard traits" is mostly impossible. Instead easily measurable "soft traits" are used. "Soft traits" are often morphological signs, e.g. leaf area index, period of photosynthetic activity, specific leaf area, dry matter content, nitrogen concentration, leaf phenology related to pigment concentration, etc. (Lavorel et al., 2002). Airborne imaging spectroscopy offers potential to estimate some of the "soft" plant traits and to identify plant functional groups by combining remote sensing based products of canopy properties. An operational methodological approach to map plant functional groups would provide a tool for ecologists to monitor PFGs distribution in space and time, use the products of imaging spectroscopy for vegetation dynamic modelling, and predict ecosystem development under variable climate conditions.

Retrievals of vegetation properties from remote sensing data

A number of methods based on empirical and physical approaches have been developed to estimate vegetation properties from imaging spectroscopy data. The empirical methods build statistical relationship between spectral signatures, usually transformed into vegetation indices, and vegetation parameters using field measurements. The empirical methods are easy to implement, however, they have been recognized as less universal, sensor, species, and site dependent (Colombo et al., 2003). Alternative solutions to the empirical methods are physically-based methods. The physically-based methods use leaf and canopy radiative transfer (RT) models to simulate radiation interactions inside canopies, taking into account their structural, biochemical, and spectral properties. RT models have to be inverted in order to estimate canopy biochemical and structural properties, using a variety of algorithms to solve the inverse problem, e.g. minimization approach, look-up tables, and neural networks (Kimes et al., 2000). The inverse problem can be solved only if its solution exists and is unique. Measurement and model uncertainties, however, often lead to multiple solutions, because combination of several model inputs may correspond to almost identical spectral signatures (Combal et al., 2003). Measurement uncertainties are attributed to post-processing of image data, including radiometric, geometric, and especially atmospheric corrections. Model uncertainties are related to assumptions on the canopy definition; variability of leaf optical properties and their up-scaling to the canopy level, parameterization of canopy architecture, contribution of soil, non-green, and understory elements. Despite the above mentioned issues, the use of physically-based methods was successfully demonstrated for estimation chlorophyll content and leaf area index of forests (Meroni et al., 2004; Zarco-Tejada et al., 2004; Schlerf et al., 2006) and agricultural crops (Koetz et al., 2005). Less attention, however, paid to natural grassland ecosystems (Darvishzadeh et al., 2008).

Atmospheric correction and downwelling irradiance data

Accurate estimation of at-surface reflectance quantities is crucial for physically-based retrievals of quantitative canopy parameters from remote sensing observations. Remote sensing data are severely influenced by the atmosphere, as the light is being absorbed and scattered by atmospheric molecular and aerosol particles on its path sun – surface – sensor. Several operational physically-based methods are currently available for atmospheric correction of hyperspectral remote sensing data. Each method, however, relies on different atmospheric database and uses different strategies to estimate the atmospheric components (e.g. water vapour retrieval). Ben-Dor et al. (2005) evaluated the performance of 6 physically-based atmospheric correction methods against a synthetic AVIRIS dataset. They reported spectral difference up to 26% in reflectance units between different methods and either overestimation (up to 60%) or underestimation (up to 15%) in water vapour content retrieval on a pixel-by-pixel basis. This study showed that accurate estimation of at-surface reflectance quantities is still a challenging task in optical airborne remote sensing. The accuracy of retrieved at-surface reflectance quantities can be potentially improved by using ancillary information about downwelling solar irradiance recorded at the aircraft level. Some airborne hyperspectral sensors (e.g. AISA, CASI) are being operated together with an ancillary downwelling irradiance sensor, which records total hemispherical irradiance at the sensor level simultaneously with the image data acquisition. The downwelling irradiance data, however, are rarely used for atmospheric correction directly due to their sensitivity towards continuous aircraft's motion (Choi et al., 2001).

10.2. Hypothesis and objectives

The research hypothesis is that plant functional groups of subalpine and alpine grassland vegetation exhibit the similar biochemical and structural properties, which can be estimated from airborne hyperspectral images, and used for identification of plant functional groups.

Based on the main hypothesis the following objectives were formulated:

1. To evaluate the potentials of downwelling hemispherical irradiance data (FODIS) for radiative transfer simulations of at-sensor upwelling hemispherical-conical radiance and for improved estimation of at-surface reflectance quantities - hemispherical directional reflectance factor.
2. To evaluate natural variability of leaf optical properties and biochemical constituents within the observed study area of sub- and alpine grassland ecosystems.
3. To use leaf-canopy radiative transfer modelling to indentify the most sensitive leaf and canopy biochemical and structural parameters influencing final simulated canopy reflectance quantities (hemispherical directional reflectance factor).
4. To estimate selected canopy structural (leaf area index) and biochemical (chlorophyll, water and dry matter content) parameters from airborne hyperspectral images of very high spatial resolution adopting already existing algorithms for inversion of canopy radiative transfer model.
5. To combine estimated canopy structural and biochemical parameters to classify natural plant functional groups of sub- and alpine grassland ecosystems.
6. To compare differences between classification of plant functional groups derived from remote sensing products of canopy biochemical and structural properties and classifications based on traditional approaches such as unsupervised classification or spectral unmixing.

Based on the research objectives the following research questions were formulated:

1. How the accuracy of estimated at-surface hemispherical directional reflectance factor changes when downwelling irradiance data (FODIS) are being used as an input into atmosphere radiative transfer modelling?
2. Objective 2 and 3 together should answer the following research question: what is the natural variability of leaf optical properties and selected leaf biochemical constituents and how do the leaf and canopy properties influence simulation of canopy reflectance quantities (hemispherical directional reflectance factor?
3. How accurately can multiple canopy biochemical and structural parameters be estimated from airborne hyperspectral data of high spatial resolution using already existing algorithms for inversion of a canopy radiative transfer model?
4. Objective 5 and 6 should answer the following research question: Does the combination of remote sensing based biochemical and structural canopy parameters identify natural plant functional groups of grassland ecosystems and how does this approach differ from traditional classification approaches such as unsupervised classification or spectral unmixing?

Each research question will result in a peer-reviewed scientific publication.

10.3. Research methodology

The overall research methodology of the proposed project is shown at figure 1. A detailed description of methodological steps and requirements follows.

Imaging spectroscopy data – spatial and spectral resolution requirements

Monitoring of biochemical and structural parameters of natural ecosystems with high structural complexity requires an appropriate spectroradiometer capable to capture required spatial and spectral details. Rahman et al. (2003) proposed an optimal pixel size of 6m for mapping of grasslands and chaparral ecosystem functions. Mapping of highly heterogeneous alpine grasslands would require very high spatial details, images with pixel size less than 5 m. Hyperspectral data, containing a high number of narrow spectral bands, provide continuous and precise radiometric information about observed land surfaces. The detailed spectral information can detect small changes in canopy reflectance and in canopy specific absorption features, caused by leaf pigments and water content. The airborne imaging spectroradiometer AISA Dual (Specim Ltd.) fulfils the requirements of suitable spectral sampling, covering visible, near, and short wave infra-red part of the electromagnetic spectra, and high spatial resolution. The AISA dual images will be radiometricaly and geometrically corrected using CaliGeo software and atmospherically corrected using ATCOR-4 software package (Richter, 2008).

Downwelling solar irradiance data

The AISA imaging spectroradiometer can be combined with the FODIS - Fiber Optic Downwelling Irradiance Sensor, which is placed on top of an aircraft and records hemispherical downwelling irradiance simultaneously with image acquisition. Continuous information about changes in incoming solar irradiance reaching the aircraft level is provided along the flight line. The recorded downwelling signal, however, is sensitive for continuous aircraft motions, which prevents direct use of ancillary irradiance data for any atmospheric correction. First, the FODIS signal sensitivity for aircraft motions will be examined by means of i) comparison of FODIS signal and aircraft's navigation data, and ii) outdoor measurements with the FODIS sensor taken under pre-defined sun-sensor geometry settings. Second, the FODIS measurements will be compared with simulated hemispherical irradiance using the MODTRAN atmosphere RT model (Berk et al., 2003). FODIS data will be then used as an input into atmosphere RT modelling to assess changes in accuracy of estimated at-surface hemispherical directional reflectance factor.

Canopy radiative transfer modelling and inversion techniques

The PROSPECT model (Jacquemoud et al., 1990) is widely used radiative transfer model, which simulates leaf optical properties (reflectance and transmittance) based on 4 input parameters: structural parameter N, chlorophyll (Cab), water (Cw), and dry matter (Cm) content. In the updated version of the model (Feret et al., 2008) total content of carotenoids (Cxc) is included as an additional input. The PROSPECT model is then coupled with a canopy RT model, which means that the simulated leaf optical properties are being used as direct inputs into canopy RT modelling. A large variety of canopy RT models is currently available and their intercomparison is presented by Widlowski (2007). Models based on numeric solutions of radiative transfer (ray tracing models) are computationally intensive thus use of alternative analytical solutions is preferred in this study. One of the models using analytical solution, and potentially suitable for this study, is the 4SAIL2 model (Verhoef et al., 2007), the most recent member of the SAIL family of canopy reflectance models. The 4SAIL2 model is relatively simple to parameterize; however, it doesn't provide advanced features to include spatial heterogeneity of simulated canopies. Another alternative is the DART (Discrete Anisotropic Radiative Transfer) model (Gastellu-Etchegorry et al., 2004), simulating RT transfer of heterogeneous 3D landscapes covering the visible, short and thermal infra-red domain using the discrete ordinate approach. The parameterization of the selected canopy RT model will be based on laboratory and field measurements of leaf optical properties, biochemical constituents, and canopy structure of sub- and alpine grassland ecosystems.

The concept of coupled leaf-canopy RT modelling allows to estimate chlorophyll, water, and dry matter content, canopy leaf area index and vegetation fraction cover, which are the direct model inputs, by model inversion. The look-up table (LUT) approach will be used to store simulated canopy spectra in a database, which overcomes computationally demanding iterative optimization techniques. The model (LUT) inversion will be carried out by minimizing a merit function, defined as difference between the canopy reflectance, derived from airborne imaging spectroscopy data, and simulated reflectance, stored in the LUT. This methodological approach has been used for instance by Koetz (2004) and Meroni (2004) to estimate canopy biochemical and structural properties. A priori knowledge about canopy architecture and field measurements of selected leaf biochemical properties will be used to constraint the inversion in order to partially eliminate multiple solutions

Test site and data acquisition plan

The subalpine and alpine grassland ecosystems in the French Alps (Col du Lautaret, Vallee le Guisane, 45° 2'8.34"N, 6°24'3.96"E) have been proposed as the experimental test site for this research. AISA Dual airborne images and ancillary field data were acquired during the summer 2008, joining the EcoChange field campaign organized by Wageningen University. Data for the evaluation of the FODIS sensor were acquired during the ISSI Air campaign, a joint activity between Specim, Technical Research Centre of Finland and Pöyry. Due to weather constraints, however, not all of the required data were collected. As an alternative solution, the data from the EcoChange campaign or already existing data from ISBE, AS CR can be used. Several ground-based outdoor measurements with the AISA – FODIS system, under controlled sun-sensor geometry conditions, are planned during the research period at Specim.

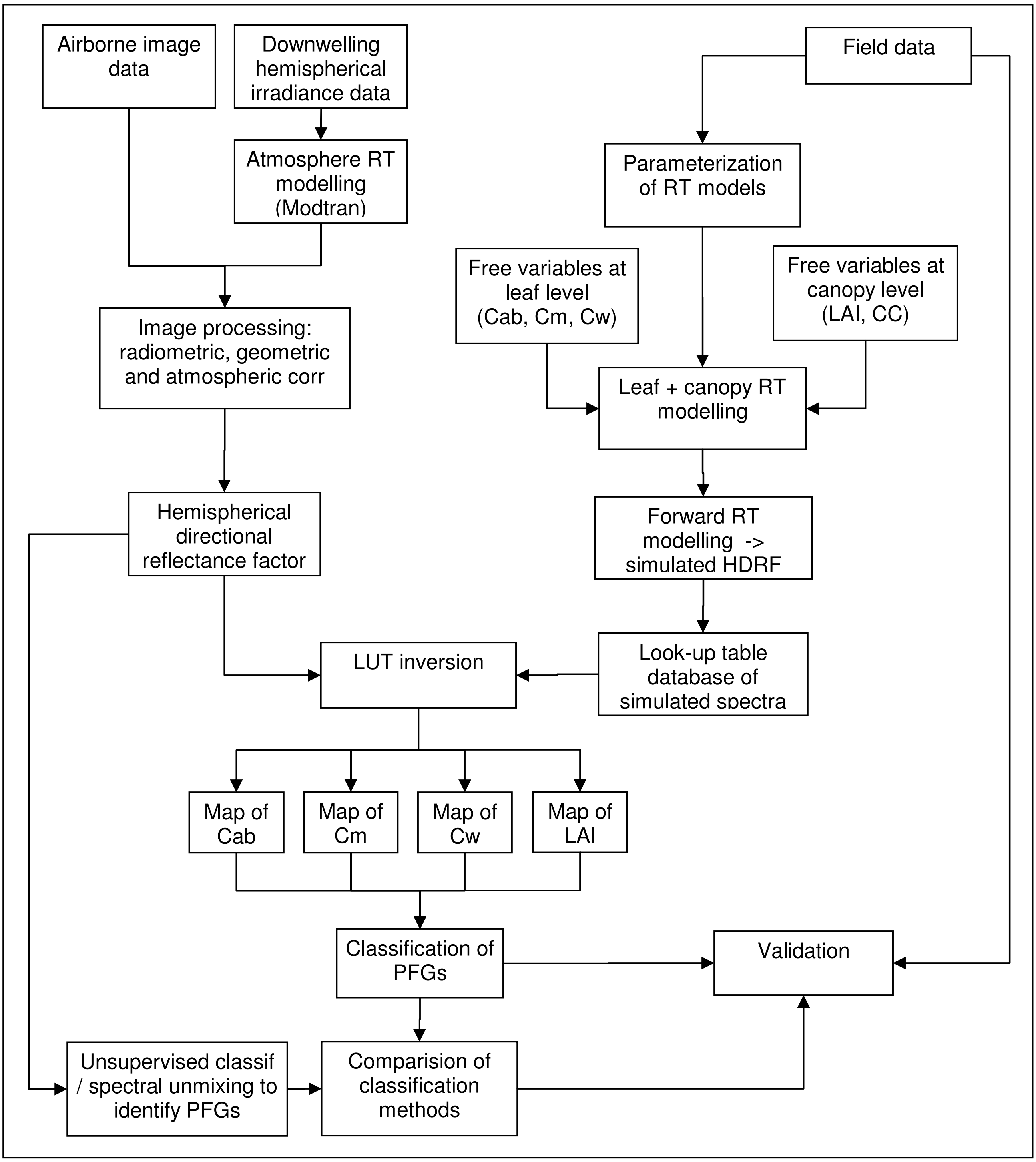

Figure 1. Detailed flowchart of the methodological approach. RT – radiative transfer, LUT – look up table, LAI – leaf area index, CC – canopy closure, Cab – chlorophyll a+b content, Cm – dry matter content, Cw – water content, HDRF – hemispherical directional reflectance factor, PFG – plant functional group

10.4. Innovative aspects

First main innovative aspect of the research is the evaluation of the downwelling irradiance data, which are acquired simultaneously with the airborne remote sensing observations, for improved atmospheric radiative transfer modelling and more accurate retrievals of at-surface reflectance quantities (hemispherical directional reflectance factor). Second innovative aspect is to use vegetation properties (such as LAI, Cab, Cw), derived from airborne hyperspectral data by means of inverse canopy radiative transfer modelling, for identification of functionally similar groups of subalpine and alpine grass species (plant functional groups). We will also expand the applicability of some of the already existing retrieval methods to natural sub- and alpine grassland ecosystems, which are studied less frequently than forest and agricultural canopies.

11. TIME TABLE OF THE PROJECT AND WORK PROGRAMME

11.1. Project time table

Table 1. The time plan of the proposed PhD project. The training and networking activities are marked with blue colour.

1st year (Feb 2008 – Jan 2009)	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
Literature review, proposal, management												
Data collection, field work												
RS and field data processing												
Eval fodis data quality – angular dependency												
IDL programming course	*											
PHYSENSE workshop, Finland						*						
2nd Hyper-I-Net summer school								*				
2nd year (Feb 2009 – Jan 2010)	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
Eval fodis data quality – atmosphere RTM												
1st manuscript preparation (Fodis study)												
RS and field data processing												
Canopy RTM parameterization												
Canopy RT modelling – sensitivity study												
2nd manuscript preparation (sensitivity study)												
Scientific writing course	*											
6th EARSeL workshop, Israel		*										
3rd Hyper-I-Net summer school								*				
3rd year (Feb 2010 – Jan 2011)	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
2nd manuscript preparation (sensitivity study)												
LUT generation												
Retrievals of canopy parameters												
3rd manuscript preparation (retrievals)												
An international scientific meeting ?												
4th year (Feb 2011 – Jan 2012)	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
3rd manuscript preparation (retrievals)												
PFGs mapping + validation												
Unsupervised classif./spectral unmixing												
4th manuscript preparation (PFGs mapping)												
Finishing PhD thesis												
Final Hyper-I-Net workshop	*											

11.2. Workplan

The PhD project is proposed with the framework of the EU Marie Curie Research and Training Network HYPER-I-NET (http://hyperinet.eu) which is a joint collaboration of 15 different research institutes, universities and small companies, key players in imaging spectroscopy within Europe. For this position, the candidate will be appointed by Specim Ltd (Finland), Warsaw University (Poland) and Wageningen University. Most of the research, however, will be realized outside The Netherlands. The Hyper-I-Net consortium agreement guarantees the cooperation between the collaborating organisations (WUR, Specim and Warsaw University) within the duration of the first three years of the PhD project. The partners agreed to continue the cooperation during the last year of the project in order to successfully finalise the proposed PhD project. The Hyper-I-Net project framework also gives opportunities of short-term research visits at other collaborating organisation.

Project supervision
The supervision team consist of:

- Prof. Michael E. Schaepman (WUR -> RSL UZH) is the principal coordinator (promoter) of the proposed project. His role will be the overall coordination of the project, with the scientific emphasis on airborne imaging spectroscopy and its application
- Dr. Jan G.P.W. Clevers (WUR) is project's co-promotor. He will be the daily supervisor during the last year of the project in Wageningen. He will mainly provide support in respect of PhD organisation and administration at WUR.
- Dr. Katja Alanko-Huotari (Specim, FI) is project's co-promotor. She will be the daily supervisor during the research period in Finland. She will guarantee technical support in respect of AISA airborne sensor, calibration facility and data post-processing. She will mainly coordinate the part of the research related to evaluation of the FODIS sensor.
- Dr. Bogdan Zagajewski (WU, PL) is project's co-promotor. He will be the daily supervisor during the research period in Poland. He will provide consultancy for field measurement of plant characteristics and hyperspectral image processing.

The challenging part of the proposed project will be to set-up and keep regular supervision while collaborating institutions are located in different countries. The regular progress meetings with the particular daily supervisor will be guaranteed on a monthly basis and further supervision will be driven by current requirements. Irregular meetings with remaining supervisors will be guaranteed via teleconferences. More extensive meetings with all supervisors will be organized during the Hyper-I-Net meetings, where all parties are expected to participate. Prof. Schaepman will be appointed at the University of Zurich, but any changes in continuation and quality of supervision are not expected.

Technical facilities and know-how

Specim will support technical knowledge of airborne imaging spectroscopy, sensor calibration and data post-processing. Wageningen University will support imaging spectroscopy application, flight campaign planning, canopy radiative transfer modelling, and implementation of retrieval techniques for estimation of canopy biochemical and/or structural properties. University of Warsaw will support field measurements of vegetation properties and image processing techniques such as classification. External sources will be needed to supply knowledge of atmosphere radiative transfer modelling and atmospheric correction of remote sensing data. Potential support can be expected from R. Richter (DLR – German Aerospace centre) or D. Schläpfer (RSL UZH). Ancillary support is expected from a canopy radiative transfer model provider. Prof. Wout Verhoef is available in the Netherlands for consulting canopy RT modelling.

Technical equipment and facilities needed to carry out the research will be mostly provided by collaborating organisations. Specim will provide access to the hyperspectral sensor AISA together with the downwelling irradiance sensor FODIS, their calibration facility, and post-processing software CaliGeo. Wageningen and Warsaw University will support field and laboratory spectroscopic measurements, e.g. field spectroradiometer, integrating sphere. For the field assessment of atmospheric conditions a sunphotometer is required, which can be provided either by RSL UZH or ISBE, AS CR. Specim and WUR will provide data analyses tools, e.g. ENVI/IDL. Leaf and canopy radiative transfer model codes will be provided via WUR.

The potential risks of the proposed project are bad weather condition, which can affect cancellation or postponing of airborne and field data collection. The back-up solutions are i) potential data acquisition during the summer 2009, ii) use already available data sets collected by ISBE, AS CR.

Plan of presenting the scientific outcomes:

Four scientific papers are expected to be published in international peer-reviewed journals. The results will be presented at least at two international conferences and during the Hyper-I-Net dedicated workshops. Hyper-I-Net provides a networking environment and opportunities to share the scientific results with the European hyperspectral community. Participation to scientific workshops, meetings, specialized training and short-term research visits are expected during the PhD project.

12. SOCIETAL SIGNIFICANCE

Remote sensing is a non-destructive tool for fast, spatially precise mapping of land surface properties and monitoring of land surface changes in time and space. The importance of remote sensing increases with scientific, societal and political demands to understand processes and interactions within our environment. The remote sensing observations and their derived products provide information about current status of terrestrial and aquatic ecosystems, support decision-making, provide inputs for climatic and eco-physiological modelling. Efforts to estimate and quantify vegetation properties using imaging spectroscopy data and radiative transfer modelling have been carried out mainly for homogenous agricultural crops and forest ecosystems; however, less attention has been paid to heterogeneous grassland ecosystems. We will expand the applicability of airborne imaging spectroscopy and inversion of canopy radiative transfer models to natural heterogeneous subalpine and alpine grassland ecosystems.

Our research will contribute to the domain of remote sensing data pre-processing, particularly to atmospheric correction of airborne images. Reliable removal of the effect caused by atmospheric absorption and scattering, and accurate estimation of at-surface reflectance quantities are crucial for any quantitative remote sensing based application. In this context, we will evaluate the potential applicability of downwelling irradiance data, which are acquired simultaneously with image data, for improved estimates of at-surface reflectance quantities.

13. SIGNATURE

Chairman of the Research Group
Name:
Dr. Jan Clevers

Signature:

Wageningen, 31-03-2009

Project leader
Name:
Prof. Michael E Schaepman

Signature:

Zürich (CH), 30.3.2009

14. POTENTIAL REFEREES

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