SUOMEN GEODEETTISEN LAITOKSEN TIEDONANTOJA

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2014:1

ABSTRACT BOOK OF THE FINNISH REMOTE SENSING DAYS 2013

by

Mika Karjalainen, Matti Mõttus, Jaan Praks, Kari Luojus, Matias Takala, Miia Salminen, Robin Berglund, and Timo Kumpula (editors)

Finnish Remote Sensing Days
23-24 October 2013, Espoo Finland

Abstract book of the Finnish Remote Sensing Days 2013

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Foreword

The Finnish Remote Sensing Club is an informal society consisting of experts from various fields, such as remote sensing, photogrammetry, space technology, and GIS. The main objective of the Remote Sensing Club is to annually organize the Finnish Remote Sensing Days, where people from academic institutions and companies can gather together and discuss about recent activities and advances in their field.

In 2013, the Remote Sensing Club was hosted by the Finnish Geodetic Institute, and the Remote Sensing Days took place on 23-24 October 2013 in DIPOLI Congress Centre, Otaniemi, Espoo (see http://www.kaukokartoituskerho.fi/2013/ for more information). In this two-day event, there were about 100 participants and altogether 46 oral and poster presentations.

This book contains nearly all abstracts of the presentations given in the event. The organizing committee would like to thank all sponsors, presenters, and participants. Without you the event would not have been possible. See you next year at the Finnish Remote Sensing Days 2014!

On behalf of the Finnish Remote Sensing Club
In Masala, 2 January 2014

Mika Karjalainen

Opening session of the Finnish Remote Sensing Days on 23 October 2013

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The programme of the Finnish Remote Sensing Days 2013

Finnish Remote Sensing Days
23-24 October 2013, Espoo Finland

www.kaukokartoituskerho.fi/2013

Venue:

DIPOLI Congress Centre, Otaniemi, Espoo
Otakaari 24, 02150 Espoo (Otaniemi)
2nd Floor, Halls 4A+4B

Hosted by:

Kauko Kartoitus Kerho

FINNISH GEODETIC INSTITUTE

Programme:

Wednesday, 23 October 2013

0830 **Registration**

0900 **Plenary session**, Chair: Mika Karjalainen
- 0900-0905 Welcome
- 0905-0925 **Ali Nadir Arslan**: Copernicus User Forum Finland **(Invited, no abstract)**
- 0925-0945 **Miranda Saarentaus**: ESA IAP activities - space data integration **(Invited, no abstract)**
- 0945-1005 **Tuomas Häme**: ReCover, A Concept for Tropical Forest Assessment for REDD: Results of Mexico service case
- 1005-1025 **Jouni Pulliainen**: Feasibility of Satellite Observations to Monitor Cryospheric Processes Based on Monitoring Programs and Campaign Activities at the Sodankylä Supersite, Northern Finland

1025-1100 **Coffee break**

1100 **Session1, Snow & Water**, Chair: Kari Luojus
- 1100-1120 **Juval Cohen**: Near Real-Time Flood Mapping in Finland Using X-Band SAR
- 1120-1140 **Jenni Attila**: The use of MERIS and MODIS data for monitoring coastal WFD water bodies
- 1140-1200 **Juha Lemmetyinen**: Airborne SAR Acquisitions in Northern Finland in Support of the CoreH2O Mission
- 1200-1220 **Timo Ryyppö**: FMI-ARC Ground Station: Current and Future Satellite Missions
- 1220-1240 **Kari Luojus**: Assessment of Snow Water Equivalent Estimates of CMIP5 Climate Model Simulations and Satellite-Based Data

1240-1340 **Lunch**

1340- **Session2, Spectral reflectance**, Chair: Eija Honkavaara
- 1340-1400 **Olli Nevalainen**: Chlorophyll and nitrogen estimation with hyperspectral LiDAR
- 1400-1420 **Xiaochen Zou**: Inversion of a radiative transfer model for estimating crop LAI, leaf mean tilt angle and chlorophyll from airborne hyperspectral data
- 1420-1440 **Eija Honkavaara**: Towards improved uncertainty and traceability of Earth Observation in Finland

1440-1500	**Presentations from sponsors & introduction to posters**
1500-1600	**Poster Bazar**

1600-	**Session3, Forest1**, Chair: Matti Mõttus
1600-1620	**Lauri Korhonen**: Laser-Assisted Selection of Field Plots for an Area-Based Forest Inventory
1620-1640	**Jari Vauhkonen**: Rethinking single-tree remote sensing: Histogram matching of remotely sensed and field-measured tree size distributions
1640-1700	**Aarne Hovi**: Real and simulated waveform recording LiDAR data in boreal juvenile forest vegetation
1700-1720	**Teemu Mutanen**: Relasphone - mobile application with the relascope functionality
1720-1740	**Matti Mõttus**: Imaging spectroscopy of a boreal forest
1800 -2300	**Sauna**, Micronova, Tietotie 3, Otaniemi

Thursday, 24 October 2013

0920-	**Session4, EU/ESA projects**, Chair: Sari Metsämäki
0920-0940	**Heikki Astola**: HRL Forest Mapping of Lot 1 Countries in GIO Land Project
0940-1000	**Kirsi Karila**: Land-use change mapping in Mekong Delta, Vietnam
1000-1020	**Yrjö Rauste**: Mapping Selective Logging in Tropical Forest with Satellite SAR Data
1020-1040	**Sari Metsämäki**: Northern Hemisphere snow mapping in GlobSnow: first results for NPP/VIIRS and comparison with NASA global snow maps (No abstract available)
1040-1100	**Coffee break**
1100-	**Session5, RS methods**, Chair: Jaan Praks
1100-1120	**Stefan Simis**: Shipborne remote sensing
1120-1140	**Lauri Markelin**: Geometric orientation of UAV images using computer vision algorithms
1140-1200	**Lingli Zhu**: 3D Railway environment modeling from multiple data sources
1200-1220	**Teemu Öhman**: Multidisciplinary Remote Sensing Analysis of Lunar Impact Crater Kepler
1220-1340	**Lunch**
1340-	**Session6, Forest2**, Chair: Mika Karjalainen
1340-1400	**Jon Atherton**: Linking hyperspectral remote sensing observations of vegetation to the underlying physiological controls through a mechanistic modelling framework
1400-1420	**Tuure Takala**: Impact of forest structure induced illumination variation on canopy PRI
1420-1440	**Petri Varvia**: A Bayesian approach to retrieval of canopy LAI from hyperspectral remote sensing data
1440-1500	**Jaan Praks**: On spaceborne X-band SAR capability to retrieve forest height
1500-1510	**Closing of the RSD2013**

Poster presentations:

- **Maria Gritsevich**: Physical properties of meteoroids according to Middle and Upper atmosphere radar measurements
- **Maria Gritsevich**: FIGIFIGO: An Advanced Portable System for Spectropolarimetry
- **Emmihenna Jääskeläinen**: Exploiting UV range in SMAC atmospheric correction for SAL product of CM-SAF
- **Paula Litkey**: MEX Gateway with LASlib Functions for Point Cloud Data Transfer between Matlab and Binary Storage Formats
- **Petr Lukeš**: Assessing the Performance of a Leaf Optics Model for Boreal Tree Species
- **Mikhail Mednik**: Estimating Total Phosphorus in River Luga and Luga Bay in the North-Western region of Russia using Landsat 5 (TM) Satellite Imagery
- **Maris Nikopensius**: Seasonal reflectance dynamics of common understory types in hemi-boreal forests, Järvselja, Estonia
- **Jaan Praks**: Towards Finnish Earth Observation satellites
- **Evgeny Panidi**: Remote Sensing Monitoring and Joint Analysis of Northern Eurasia Climate and Vegetation Dynamics
- **Evgeny Panidi**: Remote Sensing Activities at Saint-Petersburg State University
- **Teemu Mutanen**: North State - Enabling intelligent Copernicus services for carbon and water balance modelling of northern forest ecosystems
- **Kairi Raabe**: Does leaf angle distribution change as a function of height and season for broadleaf tree species common to Estonia and Finland?
- **Jaakko Seppänen**: Soil Moisture Remote Sensing Experiments with Satellite and Airborne radiometers in Southwest Finland
- **Markus Törmä**: SYKE's Processing chain for Landsat TM/ETM-Images
- **Markus Törmä**: Vegetation Phenological Features from Daily MODIS NDVI Time-series
- **Teemu Öhman**: Topographic Analysis of the Circumferential Graben around Alba Mons, Mars

The event is organized by:

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ITÄ-SUOMEN YLIOPISTO

Abstracts of the oral presentations:

ReCover, A Concept for Tropical Forest Assessment for REDD: Results of Mexico service case

Tuomas Häme[(1)], Laura Sirro[(1),] Yrjö Rauste[(1)], Jarno Hämäläinen[(2)]

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This paper presents the main results of the ReCover project in state Chiapas, the study site in Mexico. The results include wall-to-wall forest mapping of the state in 1990, 1995, 2000, 2005, 2010, 20111, and 2012. The mapping includes monitoring of deforestation, degradation, reforestation, and recovery. Also results of a study in which potential of optical and radar data are presented. In the comparison the performance of Landsat, RapidEye, Envisat ASAR and ALOS PALSAR data were evaluated in the classification of IPCC compatible land cover classes. The overall accuracy of the maps for forest – non-forest classes varied between 76 % of ASAR to and 94 % of RapidEye. The differences between the user's and producer's accuracies were usually less than five per cent. The accuracies of the maps that were made using optical data were higher than the accuracies that were obtained using SAR data. However, L-band SAR seems competitive in forest – non-forest classification.

Evaluation of the reliability of the estimation is one of the key focuses of ReCover. For this purpose, a statistical concept that applies two phase sampling was developed. The first phase sample is a wall-to-wall map with data of 10 - 30 meter resolution. The second phase is a sample within VHR images that are collected from 1-3 % of the area of interest. The VHR data sample provides reliable information on the accuracy of the wall-to-wall mapping. VHR data are also used to train the models in wall-to-wall mapping but the training data are not used for the accuracy assessment.

The ReCover project (2010-2013) under the Framework Program 7 of the European Union develops beyond state-of-the-art service capabilities to support fighting deforestation and forest degradation in the tropical region in the context of the REDD process (Reducing Emissions from Deforestation and Forest Degradation). The ReCover project specifically contributes to the reduction of errors in the estimation of terrestrial carbon balance that result from uncertain rates of tropical deforestation. This is achieved by developing and implementing satellite image based methods for the monitoring of tropical forests. The need for effective use of these techniques is motivated by the fact that many developing countries lack human resources and funding for detailed forest inventories.

The services are based on the service level agreements. This ensures a close cooperation with the service providers and users in Mexico, Guyana, Colombia, DRC, and Fiji. The satellite data applied include ERS-2 SAR, Envisat ASAR, ALOS PALSAR and AVNIR-2, Terra MODIS, RapidEye, Landsat and several VHR satellite data. Target variables are IPCC compatible land cover classes and their changes as well as biomass and degradation.

Feasibility of Satellite Observations to Monitor Cryospheric Processes Based on Monitoring Programs and Campaign Activities at the Sodankylä Supersite, Northern Finland

Jouni Pulliainen(1), Juha Lemmetyinen(1), Anna Kontu(1), Kirsikka Heinilä(2), Miia Salminen(1,2), Kimmo Rautiainen(1), Juval Cohen(1), Leena Leppänen(1), Henna-Reetta Hannula(1), Juho Vehviläinen(1)

(1)Finnish Meteorological Institute (FMI), Finland
(2)Finnish Environment Institute (SYKE), Finland

Intensive campaign activities for the remote sensing of snow cover and soil processes have been carried out in the Sodankylä region since 2006. The objective has been to investigate the feasibility of space-borne instruments operating at optical and microwave regions for the monitoring of snow and soil processes in boreal forest and sub-arctic environment. The Sodankylä in situ observations also facilitate the analysis of the effect of snow and soil processes to carbon cycling (as CO_2 and CH_4 flux measurement time-series are also available for different ecosystems). The Sodankylä site is equipped with tower-based reference instruments of present and planned cryosphere-observing satellites. The systems provide time-series of reference observations on a continuous basis. They include multi-channel microwave radiometers (SodRad systems since 2009; reference to AMSR and SSM/I, [1,2]), the L-band ESA Elbara-II microwave radiometer (since 2010; reference to SMOS), the ESA SnowScat X/Ku-band scatterometer (during 2009-2013; reference to CoReH2O) and VIS/NIR spectroradiometer (since 2006; reference to AATSR, MODIS, VIIRS, Sentinel-2/3 etc.) [3,4]. An essential part in experimental activities has been the production of comprehensive in situ reference data sets from automatic sensor networks, including a full set of atmospheric profile observations, and from regular manual observations (e.g. snow pit observations for the snow pack vertical stratigraphy).

The time-series from tower-based observations are accompanied with airborne and space-borne data sets. The employed airborne instruments include AISA imaging spectrometer, X/Ku-band SnowSAR (ESA's airborne SAR for simulating CoReH2O) and HUT-2D L-band airborne imaging synthetic aperture radiometer [5,6]. A major campaign activity in Sodankylä has been ESA's multi-year NoSREx that focused to the analysis of the feasibility of CoReH2O mission to retrieve information on snow water equivalent (SWE).

Sodankylä experiments have enabled the development and validation modeling approaches to describe space-borne microwave and optical observations of ground-snow-forest canopy system. In general, the parametrization of models has been investigated concerning the influence of soil frost (or soil dielectric constant), snowpack characteristics (density, gain size, SWE, temperatature), and forest canopy characteristics (closure, tree height). As an outcome, novel models to describe e.g. scene brightness temperature at the microwave region and scene reflectance at the visible region have been developed. For example, in case of optical data the combined use of high-resolution airborne lidar data and AISA-imaging spectrometer data enabled the development of model to describe the quantitative effect forest closure and tree height to optical-range reflectance observations over snow covered landscapes, which is relevant for the feasibility of Sentinel-2 and Sentinel-3 for the snow monitoring. Analogously, tower-based Elbara-II data facilitated the development of models to predict the influence of soil frost to L-band brightness temperature. This led to the development of a methodology to map the evolution of seasonal frost from SMOS data for a hemispheric application (both northern Eurasia and North America). Another example is the analysis of the sensitivity of passive and active microwave observations to SWE, snow grain size and snow density. This indicates the overall feasibility of microwave observations to SWE retrieval. Additionally, the passive microwave and optical data sets from Sodankylä have been used to rectify forward modeling approaches in the ESA DUE GlobSnow project for the needs of the improvement of the global mapping of SWE and snow extent.

Near Real-Time Flood Mapping in Finland Using X-Band SAR

Juval Cohen(1)

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Synthetic Aperture Radar (SAR) satellite data have been widely used for water and flood mapping in recent years. The capability to operate in almost all weather conditions and during both day time and night time, and the sensitivity of the microwave band to water are the key factors that make SAR data useful for monitoring flood events. The high spatial resolution of SAR data, which can be as accurate as 1m with the new generation of X-band instruments, allows a generation of flood maps at very high spatial resolution.
The Finnish Meteorological Institute’s Arctic Research Centre (FMI-ARC) has hosted a satellite reception station in Sodankylä since 2003. The newest addition to FMI-ARC’s missions is an Italian Cosmo SkyMed (CSK) satellite constellation operated by e-GEOS. This constellation has 4 satellites with identical X-band SAR instrument onboard, which enables frequent observations of regions experiencing flooding. Using a dedicated user terminal, FMI-ARC has the capability to plan, order and distribute CSK images with less costs compared to orders directly from e-GEOS.

FMI has been successfully producing flood maps based on CSK images since autumn 2012. The processing chain consists of tools for image pre-processing, actual flood analysis and the generation of output products. Most of these tools can be run in automation thus significantly reducing processing and product generation time requirements. The time between satellite acquisition and output product has been reduced to less than 6 hours. The recognition of floods is based on the low radar return from smooth open water bodies that behave as specular reflectors and appear dark in SAR images. The general steps of the flood analysis are (1) radiometric calibration of the SAR image, (2) geometric- and topographic correction, (3) choice of the optimal threshold value, which determines the boundary between flooded and non-flooded areas, (4) masking of natural water bodies, (5) appropriate filtering in order to reduce noise and (5) writing of requested output georeferenced products.

The current algorithm works very well in non-forested areas, but the presence of vegetation emerging above the water surface may increase the radar backscatter and thus prevent the recognition of floods under vegetation. Additional investigation is currently being carried out in order to extend the algorithm to also include forested areas.

The use of MERIS and MODIS data for monitoring coastal WFD water bodies

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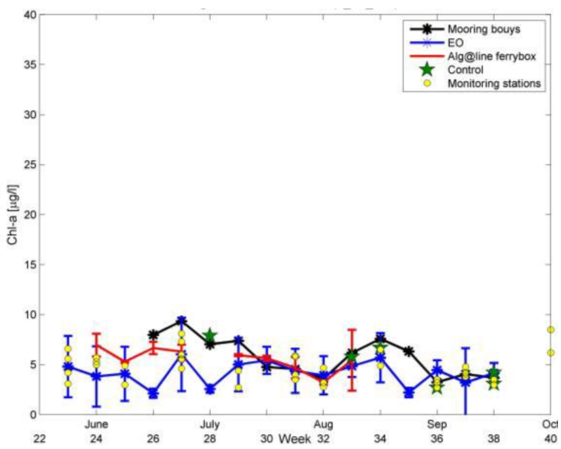
The reporting activities required by the EU water framework directive (WFD) and the marine strategy framework directive (MSFD) necessitate comprehensive collection of monitoring information from water bodies of Finland and adjacent water areas, including definitions of the status of these water bodies. The inclusion of EO methods with other efficient techniques of measuring the state of Baltic Sea can assist in providing required monitoring actions, particularly in areas out of reach of traditional methods. In addition to EO data, currently available data consists of ferrybox transect measurements, traditional monitoring stations and mooring buoys.

The northern Baltic Sea is characterized by fragmented coastline and thousands of islands of various sizes. Among the satellite instruments available now and in the forthcoming years, MERIS (MEdium Resolution Imaging Spectrometer) and its follow-up instrument OLCI (Ocean Land Colour Instrument onboard Sentinel-3) can provide the best functionality for the estimation of parameters related to chl-a and turbidity. This is related to both the spatial resolution of 300m as well as the band combination of MERIS and OLCI.

The Alg@line ferrybox system provides in real-time information on the water quality with high-frequency automated sampling onboard eight merchant ships on the Baltic Sea. Alg@line devices measure chl-a and in summertime also cyanobacteria (phycocyanin fluorescence from ca. 5 m below the surface. The system includes a sequence water sampler storing 24 water samples along the route.

The comparison results are presented using extensive historical dataset of monitoring station in situ and EO data match-ups from years 2003-2011. The comparison is made on coastal waters of Finland showing time series (Fig.1) and histograms calculated using EO, Alg@line, mooring buoys and traditional monitoring station data on WFD water bodies. Histograms showing the chl-a distribution for 6 year period on WFD water bodies show the tendency of improvements in the water quality. Part of the validation is made using MERIS and MODIS (The Moderate Resolution Imaging Spectroradiometer) satellite instrument data.



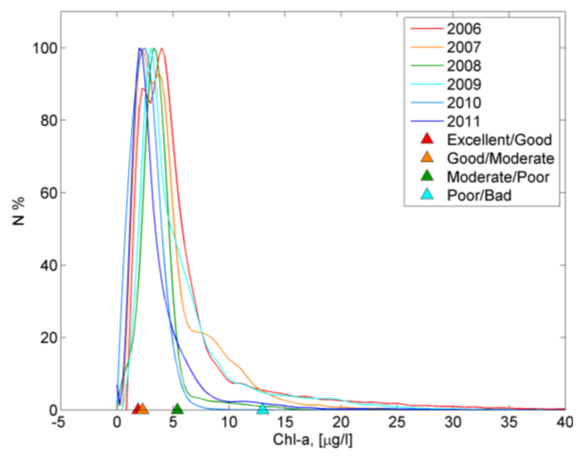


Fig 1. Time series showing weekly mean and standard deviation of EO (MODIS, blue), ferrybox (red), mooring buoys (black). Control measurements from mooring buoys (green stars) and monitoring stations (yellow dots).

Fig 2. Histograms of EO (MERIS) chl-a concentrations for WFD classification period from years 2006-2011.The triangles represent the WFD class limits for ecological classification.

Airborne SAR acquisitions in northern finland in support of The CoReH2O mission

J. Lemmetyinen(1), J. Pulliainen(1), A. Kontu(1), J.Cohen(1), A. Meta(2), E. Imbembo,(2) A. Coccia(2), H. Rott(39, M.Schneebeli(4), M. Proksch(4), C. Derksen(5), D. Schüttemeyer(6), M. Kern(6) and M. Davidson(6),

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4. ***WSL Institute for Snow and Avalanche Research (SLF), Davos, Switzerland***
5. ***Environment Canada***
6. ***ESA-ESTEC, Noordwijk, The Netherlands***

The proposed CoReH2O (Cold Regions Hydrology High-Resolution Observatory) mission, one of the candidates for the 7th Earth Explorer Core mission by the European Space Agency (ESA), aims to provide information on Snow Water Equivalent (SWE) over land at an unprecedented spatial resolution. In recent years, numerous experimental campaigns have been conducted in support of the mission scientific goals. In the winter season of 2011-2012, ESA launched an experimental campaign in Northern Finland using the SnowSAR instrument, an airborne SAR designed to operate on the same X- and Ku frequency bands as CoReH2O. The campaign follows a successful test flight in the same region in March 2011. Three test sites were chosen for the acquisitions; the main test site at the Finnish Meteorological Institute Arctic Research Centre (FMIARC), near the town of Sodankylä in Northern Finland, represents a typical boreal forest/taiga environment. The landscape is dominated by coniferous forests, lakes and wetlands (bogs). Snow cover typically persists for five months during winter; the measured 30 –year average of maximum SWE in the region is over 180 mm. The main test site is also the location of the ESA NoSREx (Nordic Snow Radar Experiment) campaign, a three-year effort to measure X- to Ku band backscatter of snow cover from a fixed location using the SnowScat scatterometer. The presence of the ground-based scatterometer, as well as an extensive archive of space-borne TerraSAR-X (X-band) acquisitions from the site, offers good opportunities for instrument cross-calibration. A second test site over land was chosen from the Saariselkä tundra region, 150 km north from the main test site. The general topography was varying with several low-lying tundra hills. In contrast to the main test site, the region represents a sparsely vegetated and rocky tundra landscape, with significant variability in snow distribution due to topography and wind drift effects, making the site ideal for high-resolution airborne acquisitions. A third test site was chosen over sea ice; the aim was to provide first images of X- to Ku band backscatter of snow cover on sea ice, a secondary mission goal of CoReH2O. TerraSAR-X acquisitions were also made from these sites as a reference to the airborne observations. Over ten data acquisition flights were conducted at the main test site; each airborne mission attempted to cover the same area using a mosaic of up to 30 flight transects, each ca 7 km long. Acquisitions were timed to correspond closely to the planned CoreH2O revisit times during two phases of the mission (3 and 15-day revisit time), thus demonstrating the mission concept both spatially and in time. The acquisitions represent a range of snow conditions, from early season shallow fresh snow to a late winter snow pack condensed by several melt-refreeze events. The last airborne acquisitions took place close to the maximum snow conditions of the season. Results indicate that the influence of increasing snow cover can be detected in the X and Ku band radar signatures. First retrieval experiments with the baseline CoReH2O retrieval algorithm match in situ observations of SWE with good accuracy over non-vegetated areas. For densely vegetated areas, the forest canopy masks out the signal from snow cover and the retrieval cannot be performed. The tundra site was visited twice, first in early winter and for a second time in mid-winter conditions. Acquisitions indicate a high spatial variability in snow cover especially during the last acquisition, with a significant increase in SWE. A single acquisition was performed over the sea ice site; although no retrieval attempts of SWE over sea ice were made, we show first results of the backscatter signal variations with snow cover properties over the ice.

FMI-ARC Ground Station: Current and Future Satellite Missions

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Finnish Meteorological Institute's Arctic Research Centre (FMI-ARC) has hosted a satellite reception station in Sodankylä since 2003. Today, two X-band antennas with 2.4 m and 7.3 m diameters combined with northern location (67°N, 27°E) enable data reception from several polar satellites up to over ten overpasses per day for a satellite. Most of the data are received via Direct Downlink, but using the 7.3 meter antenna's high data rate (up to 320 MBps), it is also possible to receive orbital data dumps and high resolution data from Synthetic Aperture Radars (SAR). For data archiving and distributing there is a state-of-the-art server building with 10 Gbps data link to the outside world.
Current missions are Terra, Aqua and Aura, part of the NASA's Earth Observing Mission (EOS), Suomi NPP which is a continuator for EOS mission, and Chinese Fengyun-3A. FMI-ARC receives data from instruments operating in visible and infrared region. Tehy are useful for operational and research purposes. For example MODIS (onboard Terra and Aqua) data are used to create ice charts for the Baltic Sea.
The newest addition to FMI-ARC's missions is an Italian Cosmo SkyMed (CSK) satellite constellation operated by e-GEOS. The constellation has 4 satellites with identical SAR instruments onboard. CSK SAR instruments open new ways to monitor the Earth as they provide a resolution up to less than one meter and are independent of cloud and illumination conditions. For example, CSK SAR instruments have been successfully used to map flooded areas in spring 2013. As e-GEOS is a commercial company, all the CSK images come with a price and must be ordered beforehand. Using dedicated user terminal, FMI-ARC has a capability to plan, order and distribute CSK acquitisions and images. FMI-ARC has an exclusive right to sell CSK images in Finland and the price for Finnish customers is about less than half compared to orders directly from e-GEOS.
The operating system is very flexible, and new satellites can be easily programmed if proper configuration (frequency, modulation, ect.) is available. As a result of co-operation with China Meteorological Administration (CMA) National Satellite Meteorological Center (NSMC), FMIARC will begin reception and processing of Fengyun-3B data later in autumn 2013. FMI-ARC is also a candidate for ESA's Sentinel Collaborative Ground Segment. The collaborative status would give access to local Sentinel data for FMI and other institutes as well.

Assessment of Snow Water Equivalent Estimates of CMIP5 Climate Model Simulations and Satellite-Based Data

Kari Luojus(1),*, Jouni Pulliainen(1), Juval Cohen(1) , Matias Takala(1), Juha Lemmetyinen(1), Tuomo Smolander(1), Jaakko Ikonen(1)

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The European Space Agency (ESA) GlobSnow project has produced a daily hemisphere-scale satellite-based snow water equivalent (SWE) data record spanning more than 30-years. The GlobSnow SWE record, based on methodology by Pulliainen [1] utilizes a data-assimilation based approach for the estimation of SWE which was shown to be superior to the approaches depending solely on satellite-based data [2]. The GlobSnow SWE data record is based on the time-series of measurements by two different space-borne passive radiometers (SMMR and SSM/I) measuring in the microwave region, spanning from 1980 to present day at a spatial resolution of approximately 25 km.

We briefly present the efforts taking place for further enhancement of the satellite-based SWE retrieval and the way this transfers to the reliability of the long-term SWE climate record. The development of SWE retrieval are focused on application of a new HUT multi-layer snow emission model and variational snow density scheme for SWE retrieval and efforts carried out to improve the homogeneity of the long-term record of weather station-based snow depth observations that are applied within the SWE retrieval scheme.

We also present the comparison of GlobSnow satellite-based SWe dataset with climate model simulations from the CMIP5 archive. The objective of this work is to investigate the performance of the CMIP5 models in capturing the evolution of hemispheric scale snow conditions for the period of 1980 to 2012. The climate model simulations on snow cover extent, snow depth and snow water equivalent are evaluated against the GlobSnow SWE record. The future projections of the CMIP5 model simulations on snow cover are also investigated.

The results indicate a decreasing trend in spring time hemispherical snow mass for the period of 1980 to 2012 in remote-sensing based data record. The inter-comparison of satellite-based record and climate model simulations show differences in spring time Hemispherical scale snow conditions. Similar trends of decreasing snow cover are also seen in the investigated CMIP5 models, although there is a notable variance between different models. Some of the models capture the overall hemispherical snow mass more accurately than others. In general the winter months (December, January and February) seem to be rather well captured, while the spring season, (March, April and May) appears more challenging for the climate models. Also the inter-annual variability of snow cover is higher in the observation-based record, compared with climate models.

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[1] Pulliainen, J. Mapping of snow water equivalent and snow depth in boreal and sub-arctic zones by assimilating space-borne microwave radiometer data and ground-based observations. Remote Sensing of Environment. 101: 257-269. DOI: 10.1016/j.rse.2006.01.002.

[2] Takala, M., Luojus, K., Pulliainen, J., Derksen, C., Lemmetyinen, J., Kärnä, J.-P, Koskinen, J., Bojkov, B., "Estimating northern hemisphere snow water equivalent for climate research through assimilation of space-borne radiometer data and ground-based measurements", Remote Sensing of Environment, Vol. 115, Issue 12, 15 December 2011, Pages 3517-3529, ISSN 0034-4257, DOI: 10.1016/j.rse.2011.08.014.

Chlorophyll and nitrogen estimation with hyperspectral LiDAR

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The first prototype of a full waveform terrestrial hyperspectral LiDAR instrument has been developed and constructed in the Finnish Geodetic Institute (FGI) [1]. The instrument efficiently combines the benefits of passive and active remote sensing sensors. It is able to produce 3D point clouds with spectral information included for every point which offers great potential in the field of remote sensing of environment. This study investigated the ability of the instruments in vegetation remote sensing.
The investigation was conducted by evaluating chlorophyll and nitrogen sensitive vegetation indices for Scots pine shoots and oat samples using hyperspectral LiDAR data and validating their performance in chlorophyll and nitrogen estimation. The amount of chlorophyll and nitrogen in vegetation are an important indicator of vegetation photosynthetic capacity and stress.
Chlorophyll and nitrogen estimation was performed by calculating 28 published vegetation indices to ten Scots pine shoots and oat samples with varying health. Reference data was acquired by accurate laboratory chlorophyll and nitrogen concentration analysis. The performance of the indices was determined by linear regression and leave-one-out cross-validation.
The results indicate that the hyperspectral LiDAR instrument holds a good capability to estimate vegetation biochemical parameters such as the chlorophyll and nitrogen concentration. The results were good especially with the Scots pine shoot dataset.
The instrument holds much potential in various environmental applications and provides a significant improvement over single wavelength LiDAR or passive optical systems for environmental remote sensing.

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Inversion of a radiative transfer model for estimating crop LAI, leaf mean tilt angle and chlorophyll from airborne hyperspectral data

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Accurate quantification of leaf biochemical and vegetation canopy biophysical variables is important for crop monitoring applications [1]. Leaf area index (LAI) and leaf mean tilt angle (MTA) are important canopy structure parameters which affect absorbed photosynthetically active radiation and, therefore, many biological and physical processes in plant canopy [2][3]. Leaf chlorophyll content and canopy chlorophyll indicate vegetation physiological status, health, stress, photosynthetical capacity and productivity [2]. The aim of this study is to investigate the potential of widely used PROSAIL (PROPECT+SAIL) model to estimate LAI, MTA and chlorophyll for six crop species in Helsinki, Finland.

LAI, leaf chlorophyll and spectral data were sampled for 162 plots of six species. LAI was measured optically using SunScan instrument. Leaf chlorophyll content was determined with the SPAD-502 device. Canopy spectral reflectance was acquired by AISA Eagle II airborne imaging spectrometer. Finally, estimating the species-specific MTA by LAI-2000 and photographic method [3] gave us a unique dataset including all canopy structural variables required for model inversion.

PROSAIL model was inverted with canopy spectral reflectance by means of a look-up table (LUT). To build the LUT, 100,000 parameters combinations were generated and used in forward calculation. To solve the inversion problem, we considered the influence of cost function, multiple solutions strategy selection, spectral sampling scheme and the distribution of LUT variables for the inversion accuracy. The correlation coefficient between MTA and spectral reflectance was calculated at each waveband. As predicted by model simulations, we detected a narrow wavelength band in the red edge spectral region where canopy reflectance is dominated by MTA. Finally, the model estimated LAI, MTA and chlorophyll values were compared with those determined in situ.

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Towards improved uncertainty and traceability of Earth Observation in Finland

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European Metrology for Earth Observation and Climate (MetEOC) is the European Union Joint Research Project in the European Metrology Research Program (EMRP) running in 2011-2014. "Major objectives of this research project are to improve the uncertainty and traceability throughout all stages of data production: pre-flight and post-launch calibration and validation and all the intermediate processing steps. The technical scope required spans the full electro-magnetic spectrum and entails the evolution of laboratory-based metrology into field (and space) situations whilst maintaining, and in some cases improving, the uncertainty available from nominally primary standards and facilities." The project has as partners from eight National Metrological Metrology Institutes and four unfunded partners; the project is led by National Physical Laboratory. The Finnish Institute Centre for Metrology and Accreditation (MIKES), the Metrology Research Institute of Aalto University, and the Finnish Geodetic Institute (FGI) are the partners in this project from Finland. http://www.emceoc.org/index.html
The FGI has a Researcher Excellence Grant "SI-traceable reflectance measurement by UAVs" belonging to the MetEOC project. Objective of the project is to develop a SI-traceable procedu-re for reflectance data generation in local area applications using spectral image data collected by an UAV [1]. The entire SI-traceable procedure includes availability of a SI-traceable reflectance standard in an accredited laboratory, transfer of the SI-traceable reflectance to the measurement site and finally, transfer of the SI-traceable reflectance to the UAV output data.
In this presentation, our objective is to present and assess the traceability chain that is being developed for local area remote sensing in Finland in co-operation with FGI and MIKES. Transfer of the SI-traceable reflectance to the FGI was implemented by using a reference spectralon panel, which radiance factors and hemispherical reflectance were calibrated using multiple illumination and viewing geometries with the gonioreflectometer at Metrology Re-search Institute of Aalto University [2]. In summer 2013, we have carried out SI-traceable UAV reflectance measurements of gravels at Sjökulla, agricultural parcels in Vihti test site and pine forest in Evo forest test site.
The FGI is maintaining calibration and validation test sites for remote sensing in Finland, including the Sjökulla test field. By the means of the new UAV-based method, it is possible to establish new cal/val test sites anywhere, for example, invariant test sites such as parking lots or adhoc test sites, such as agricultural parcels, water or forest.

ACKNOWLEDGEMENTS: This research has been supported by the EMRP research program.

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Laser-Assisted Selection of Field Plots for an Area-Based Forest Inventory

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Field measurements conducted on sample plots are a major cost component in airborne laser scanning (ALS) based forest inventories, as field data is needed to obtain reference variables for the statistical models. The ALS data also provides an excellent source of prior information that may be used in the design phase of the field survey to reduce the size of the field data set. In the current study, we acquired two independent modeling data sets: one with ALS-assisted and another with random plot selection. A third data set was used for validation. One canopy height and one canopy density variable were used as a basis for the ALS-assisted selection (Fig. 1). Linear regression models for stem volume were fitted separately for four different strata using the two data sets separately. The results show that the ALS-assisted plot selection helped to decrease the root mean squared error (RMSE) of the predicted volume. Although the differences in RMSE were relatively small, models based on random plot selection showed larger mean differences from the reference in the independent validation data. Furthermore, a data decimation experiment showed that 30 well placed plots should be enough for reliable predictions.

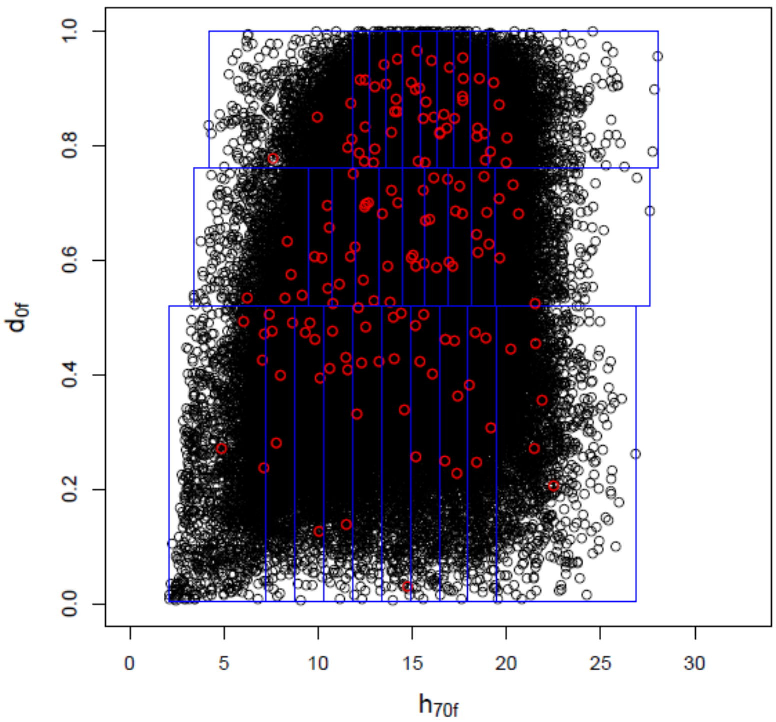

Fig. 1. Example of the use of two laser variables (d_{0f} and h_{70f}) for plot selection. The plot shows the five pre-selected candidate plots in each ALS stratum.

Rethinking single-tree remote sensing: Histogram matching of remotely sensed and field-measured tree size distributions

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A new approach to relate remotely sensed (RS) and field-measured tree size distributions was developed based on the well-known histogram matching technique to map the transformation between two cumulative distribution functions (CDFs). In the present case, such transformation is modeled using RS observations of forest stand structure.
The observed distribution of crown areas was corrected for the censoring effect caused by overlapping tree crowns. An approach previously tested with simulated, error-free data [1] was found to reduce bias in the stem number estimates, when the underlying assumptions on spatial pattern and autocorrelation were met. The transformation between the CDFs of crown area and stem diameter was described by a polynomial mixed-effects model, and the random stand effects were correlated against height and density metrics derived by airborne laser scanning (ALS).
An application of the proposed approach to the prediction of basal area and stem number is presented using ALS observations from Scots pine stands and a minor number of field plots for model development. Interestingly, corresponding predictions could potentially be derived using angle count samples and passive optical imagery as field reference and RS data, respectively, indicating a potential to reduce data costs for coarse predictions of stem size distributions.

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Real and simulated waveform recording LiDAR data in boreal juvenile forest vegetation

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Airborne small-footprint LiDAR is replacing field measurements in regional-level forest inventories, but auxiliary field work is still required for the optimal management of young stands. Waveform (WF) recording sensors can provide a more detailed description of the vegetation compared to discrete return (DR) systems through accurate characterization of the backscattered signal. Furthermore, knowing the signal shape facilitates comparisons between real data and those obtained with simulation tools. We performed calibration and quantitative validation of a Monte Carlo ray tracing (MCRT) based LiDAR simulator against real data, and used simulations and real data to study small-footprint WF recording LiDAR for the classification of boreal juvenile forest vegetation. The simulations were based on geometricoptical models of three species: birch (*Betula pendula* Roth), raspberry (*Rubus idaeus* L.), and fireweed (*Epilobium angustifolium* L.). Simulated WF features were in good agreement with the real data (differences of -19–11% in radiometric features, -0.23–0.45 m in mean height), and relative interspecies differences were preserved. We used simulated data to study the effects of sensor parameters on the classification between the three species. An increase in footprint size improved the classification accuracy up to 0.30–0.36 m diameter, while the emitted pulse width and the WF sampling rate had minor effects. Finally, we used real data to classify four silviculturally important vegetation functional groups (conifers, broadleaved trees, low vegetation (green), low vegetation (barren) + abiotic material). Classification accuracies of 68.1–86.7% (kappa 0.50–0.80) showed small improvement compared to existing studies on DR LiDAR and passive optical data. The results on simulator validation serve as a basis for the future use of simulation models e.g. in LiDAR survey planning or in the simulation of synthetic training data, while the other findings clarify the potential of small-footprint WF data for characterizing vegetation in intensively managed forest stands at seedling and sapling stages in the boreal region.

Relasphone - mobile application with the relascope functionality

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The Relasphone is a forest measurement tool on a mobile phone (www.relasphone.fi). The Relasphone application has been developed to help forest owners and timber brokers make forest measurements. The application is based on relascope functionality, but has several unique features as well, such as:

Forest area Measurements can be assigned to a forest area. Results are presented in averages over the measurements from the area.

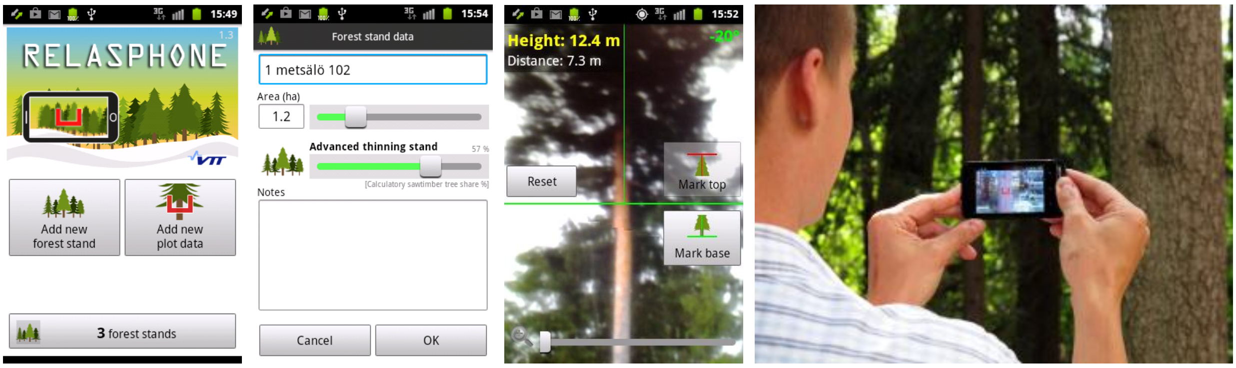
Latitude The volume is determined for the softwood tree types (pine and spruce) in both the Northern and the Southern Finland based on latitude [1].

Tree height The application includes a tool to help the user to determine tree heights.

Monetary value In addition to volumes, the application also presents monetary value of timber. The value is based on the share of logs and fibres and the current prices of logs.

Manual calibration The application applies a relascope factor of two. The user may manually calibrate and fine-tune the relascope for accurate results in case the unreliable (zoom or fov angle) values provided by the camera API.

For the time being, Android version of the application is currently available and downloadable from the Google Play[2]. The Relasphone could be integrated or interfaced in the future for example with remote sensing or participatory sensing applications.



(a) Start screen (b) Background info (c) Height measure (d) Demonstration

Figure 1: Screenshots from the application, (a), (b) and (c), and a use case demonstration (d).

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Imaging spectroscopy of a boreal forest

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When sufficiently high spectral and spatial resolutions are used [1], remote sensing can be used to obtain information on vegetation biochemistry and functioning. The required resolutions, both spatial and spectral, are provided by the technology known as imaging spectroscopy (IS, also known as hyperspectral remote sensing). IS instruments record the radiation field in narrow contiguous spectral bands. Besides biochemistry, the canopy reflectance signal is strongly affected by vegetation structure [2]. Thus, it is expected that canopies with different species composition, age, and nutrient availability can be separated using IS.
The data provided by imaging spectrometers differ in their technical characteristics. The spatial resolution of sensors ranges from tens of centimeters (airborne instruments) to hundreds of meters (moderate-resolution spaceborne imagers). Thus, using high spatial resolution IS, it is possible to measure the signal arriving from different parts of a tree crown. The spectral resolution achievable by modern airborne is similar to that of field spectroadiometers, that is 3–10 nm. However, IS instruments are limited by the energy arriving at the sensor: to maintain reasonable signal levels, spatial resolution can be only increased at the expense of spectral resolution.
We used two different measurement configurations when acquiring airborne IS data above a southern boreal forest in Hyytiälä, Finland. First, the sensor was flown at a high altitude with high spectral resolution resulting in pixel sizes in the order of tree crown dimensions. Next, the same area was covered with sub-meter resolution, but with decreased spectral resolution. A number of narrowband spectral vegetation indices were calculated from IS data with different spatial and spectral resolutions, and spectra retrieved from both sunlit and shaded canopy areas. These indices, associated with various biochemical components and processes in plant leaves, were then correlated with a forestry GIS containing information on site fertility, species composition, and stand development stage.
The results indicate that forests with different species composition, nutrient availability and age structure can be separated from IS data. The best technical characteristics of IS data required for studying boreal forests was found to include a high signal-to-noise ratio and a reasonable spectral resolution. While the high spatial resolution of airborne data improved the correlation, average stand-level reflectance factors also provided a good result.

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HRL Forest Mapping of Lot 1 Countries in GIO Land Project

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The objective of European Copernicus programme, previously known as the Global Monitoring for Environment and Security (GMES) land monitoring service is to provide land cover information to users in the field of environmental and other terrestrial applications. Initial operations of the service (GIO land) focus on four components, three of which are coordinated by EEA - the pan-European and local components, and the in-situ component.
Initial activities around the pan-European component include providing: a land cover change product between 2006 and 2012, and a land cover product for 2012; and five pan-European high-resolution layers on land cover characteristics - artificial surfaces, forest areas, agricultural areas (permanent grasslands), wetlands, and water bodies. Eionet countries have the opportunity to participate in GIO land pan-European activities.
GIO land builds on the pre-cursor Copernicus-related FP7 project geoland2, which addressed amongst other both the local component (i.e. the Urban Atlas) and the continental component. For the continental component, the methodologies for 5 thematic High Resolution on Land Cover characteristics: impervious areas, forests, permanent grasslands, wetlands and water bodies were developed, and a wall to wall imperviousness layer with reference year 2009 was produced as well. These methodological developments have been instrumental for the preparation of the implementation of GIO land (http://www.eea.europa.eu/themes/landuse/gioland/gio-land).
VTT Technical Research Centre of Finland is participating in GIO Land project as a subcontractor to Metria AB (Sweden) for providing pre-processed EO (Earth Observation) data and HRL (High Resolution Layer) Forest maps for GIO Land Lot1 countries Finland, Estonia, Latvia, Lithuania and Iceland. The HRL forest mapping results of project Phase 1 consisting of the tree cover density (TCD) and forest type (FTY) maps of Estonia (96% coverage) and Iceland (100% coverage) were delivered in June 2013, and accepted by EEA in July 2013. The accuracy assessment included in the delivery report showed 2.1% omission, and 4.7% commission error for Estonian forest/non-forest mapping. For forest type map (conifer, broadleaved, non-forest) the overall classification accuracy was 96.9%. For the Iceland the corresponding figures were: 4.2% (omission error), 17.9% (commission error), and 76.2 (FTY overall classification acc.). The project continues with Phase 2 activities including the mapping of Latvia, Lithuania and parts of Finland.

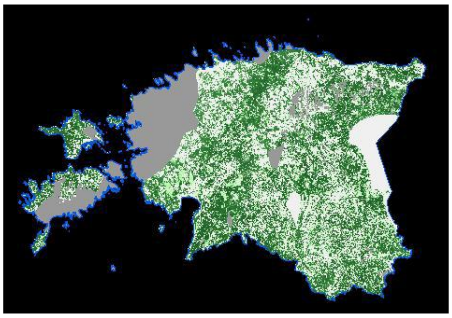

Figure 1. Forest Type (FTY) map of Estonia

Land-use change mapping in Mekong Delta, Vietnam

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This study is done in co-operation with European Space Agency (ESA) and United Nations International Fund for Agricultural Development (UN-IFAD). UN-IFAD is supporting Vietnam to develop long-term strategies for natural climate change adaptation and trying to define the rice growing areas that need to transit to other land uses as a result of increasing salinity currently and through forecasting based on sea level rise and reduced river flow.
The objective of this study is to obtain up-to-date information and identify long term changes in land-use. Changes are especially studied for rice, other crops and aquaculture. This can be further used to evaluate the effect of sea level rise and salinity intrusion to land-use in the study area, Tra Vinh and Ben Tre provinces in Vietnam's Mekong Delta, which is a crucial rice production area in the country and in the world.
An EO dataset of SAR and optical images covering a time period of around 30 years was acquired from the area. Three time series from 37 ENVISAT ASAR Wide Swath images (2005, 2009 and 2011) were formed. In addition, 4 Landsat images (1979- 2009) and 14 SPOT images (1987-2008) were used in the land-use change mapping. Unsupervised ISODATA classification method was applied to each dataset separately. Different types of rice, aquaculture, settled areas, urban areas and water were detectable in the images (Fig 1.). KOMPSAT very high resolution images and field data were used in the validation of the classification results.

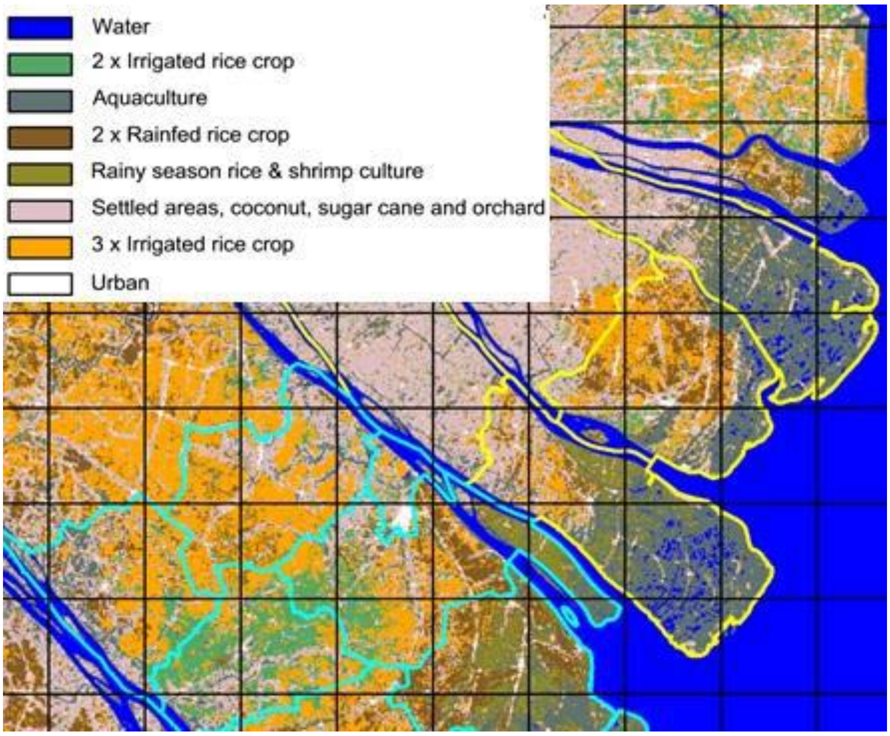

Fig 1. Land-use map from 2011 ENVISAT ASAR time series

Mapping Selective Logging in Tropical Forest with Satellite SAR Data

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Selective logging is considered to cause forest degradation since it can reduce forest biomass for a longer period of time. Selective logging in the Republic of the Congo is conducted by following sustainable forest management. It is well controlled and documented and therefore offers an opportunity to test methods for mapping of forest degradation.
The objective of this study was to develop methods to effectively apply SAR data for the mapping of selective logging. The SAR data that were used in the project were acquired by ALOS PALSAR, Envisat ASAR and TerraSAR-X sensors. All elaborated techniques used are physically justified and based on microwave scattering phenomena, and utilize contextual, spectral, textural and statistical information of backscattered signal.
Mapping of selectively logged forest from dual-polarised (HH, HV) ALOS PALSAR data was based on multi-temporal change detection of cross-polarised signature from two years: 2007 and 2010. The algorithm also used additional land cover classification that was produced from 2010 dual-polarisation SAR data and contextual information from the detected network of newly constructed forest roads. The product obtained was a map of selectively logged forest area between the years 2007 and 2010. The ALOS PALSAR based map of selectively logged forest has spatial resolution of 12.5 m. Another map of selective logging was done with dual-polarised (HH, VV) TerraSAR-X spotlight data utilizing a similar multi-temporal approach.
Validation against optical VHR data showed high user's accuracy (95 %) for the ALOS/PALSAR-derived map of selectively logged forest. However, the area of selectively logged forest was under-estimated by 37.5 %. Overall accuracy was 70.4 %, but this figure was affected by the limited size of the validation area, which was chosen to include a large portion of selectively logged area. User’s accuracy was also very high (approaching 100 %) in the TerraSAR-X-based mapping of selectively logged forest, but the overall accuracy was 53.6 %.
Mapping of forest degradation due to selective logging with only Envisat ASAR data did not result in conclusive results. Newly constructed major forest roads could be visually detected in two scene pairs, but detection was not very clear. ASAR data availability in the study area did not allow using longer time-series before and after the logging operations.
ALOS-type L-band radar data could be applied in an operational system of selective logging detection over country-wide datasets, with proven potential to map newly constructed forest roads. If an under-estimation of area of selectively logged forest of about 40 % is not acceptable for selectively logged forest delineation, the L-band derived maps of selectively logged area and new roads can be used in a wider system to pin-point areas of recent logging activity. The detected areas can then be covered by satellite or airborne optical data or ground surveys. The L-band map of areas with logging activity can also be used for stratification for additional surveys from ground reference or other data.
This study was carried out in project GSE Forest Monitoring/REDD Extension coordinated by GAF/Germany and funded by the European Space Agency ESA.

Shipborne remote sensing

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Reliable in situ validation data is (or ought to be) an important component to validation of aquatic remote sensing, particularly when the water body has complex optical properties such as in coastal seas and estuaries. Above-surface remote-sensing reflectance (R_{rs}) can be collected both from offshore moorings and ships. The use of moving ships (e.g. ferries) is attractive as it adds a spatial component to the observations, but faces particular challenges concerning the viewing geometry (sun glint), and quality control.

We present results from three field seasons where R_{rs} was recorded from moving ships, using a custom built 3-sensor package mounted on a turning platform which compensates sensor viewing azimuth for ship course and sun position. A new method [1] was developed to (1) derive the highly variable sky radiance reflectance factor (2.5-8% of sky radiance) under continuously changing light, wind, and wave conditions, and to (2) identify substandard measurement conditions (e.g. unstable illumination). The algorithm minimizes the 'fingerprint' of atmospheric gas absorption features in R_{rs}, which proved to be the only solution thus far to automatically process clear-water R_{rs} under variable illumination and wave conditions. Due to variable measurement conditions, more than half of the measurements could be automatically discarded using the automated R_{rs} processing method, on the optically challenging (high sun zenith angles, high absorption, low reflectance) waters of the Baltic Sea. The remaining R_{rs} spectra compared favourable to subsurface irradiance reflectance measured at anchor stations. The method is now being implemented in the Alg@line ferry-based observation network on the Baltic Sea, and will contribute to the validation of remote sensing imagery.

Development of the automated reflectance unit R*flex* has been supported by EU FP7 projects PROTOOL (www.protool-project.eu) and WaterS (www.mywaters.eu). R*flex* hardware description, free software, documentation, and computer code for R_{rs} signal processing can be obtained through sourceforge.net/p/rflex/wiki/Home/.

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Geometric orientation of UAV images using computer vision algorithms

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More and more images are collected from unmanned aerial vehicles (UAV) for various purposes. Perquisite for most of the applications is that the exterior orientation of the images has to be solved. The easiest solution is to have a precise GNSS-INS receiver recording the image capture positions and rotations. Unfortunately small payload of the many UAV platforms restricts the use of these high-end instruments. One simple and almost automatic solution is to use computer vision algorithms such as sift [1] to find common tie points between images and then solve the exterior orientation of the images based on structure from motion (SFM) algorithm. VisualSFM [2] is free software with GUI for 3D reconstruction of images using SFM. It does not require any additional information for solving the 3D reconstruction, but image positions or ground control points (GCP) can be used to convert the solution to the desired coordinate system.
Finnish Geodetic Institute (FGI) has had multiple UAV campaigns during 2012-2013 with various commercial RGB cameras and with a special Fabry Perot Interferometer (FPI)-based spectrometric camera developed by the VTT Technology Research Center in Finland. The target areas have varied from well-defined flat areas such as FGI's permanent Metsähovi remote sensing test field, to lakes and agricultural fields and to highly 3D structures like forests. The images were collected in various block structures from conventional vertical imaging configuration to goniometric oblique-looking cross flight lines to collect multiple view data. Fig. 1 shows an example of UAV image block collected from Vihti agricultural fields.
In this study, the VisualSFM is used to solve the initial exterior orientation of the UAV images, and the solution is transformed to desired coordinate system either by using approximate image positions or by measuring GCPs from the images. These orientations can be used as is, or forwarded to other photogrammetric software systems for further processing for example to create ortho images, image mosaics or dense digital surface models (DSM). We will present the assessment of performance of VisualSFM in various target areas.

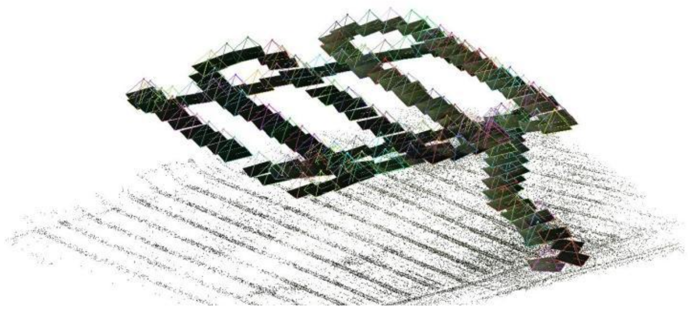

Figure 1. Example UAV image block from Vihti.

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3D Railway environment modeling from multiple data sources

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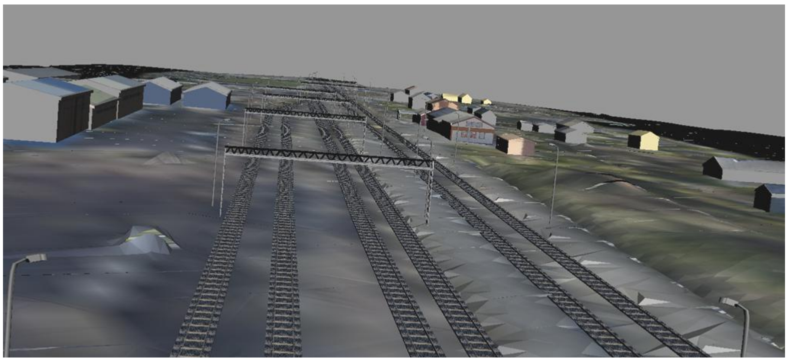
As increasing demands in advanced visualization, road environment 3D modeling has become a highlighted topic from remote sensing and computer vision communities. Study of city modeling has been for decades. However, railway environment modeling as a special case of detailed city modeling has been paid little attention due to the complexity of the terrain and scene. 3D reconstruction from those areas has been very challenge work, especially for high resolution, walk through visualization. The challenges lie in: i) Complex terrain results in the difficulty of data acquisition, especially for ground–based data collection; ii) Complex environment leads to the difficulty in 3D reconstruction work.
This paper addressed an entire railway environment modeling from MLS and ALS. The railway environment contains various objects: e.g. ground /railroads, buildings, powerlines and pylons, street / traffic lights, trees and so on. ALS and MLS have different scan geometry and provide different point density as well as the different resolution of the data. We make full use of different advantages from ALS and MLS for different object modeling. Both data render complementary characteristics, especially for the buildings. Building models were reconstructed by the walls from MLS and the roofs from ALS. As regards with powerlines and pylons, they are able to be detected from both data if ALS provides enough dense points, in our case, 49.62 points/m2. However, MLS has a range limitation e.g. 50m from the trajectory for better accuracy. If the direction of powerlines make turns, complete powerline modeling from MLS would be difficult. It depends on the local environment and data quality. In this paper, we developed the algorithm for powerlines only from ALS data. For the poles, I would recommend to utilize MLS data for modeling detail geometry. Some basic conclusions as follows:
1. An entire railway environment was successfully reconstructed from ALS and MLS.
2. Automatic algorithms for building modeling from both ALS and MLS were developed. The accuracy of building detection from ALS is 93.55% for test data.
3. Powerlines and pylons were extracted from ALS. A good result was achieved based on two points: one is the dense point cloud; another is the clear cutoff edge between the powerlines and the surrounding environment.
4. An algorithm for ground model simplification has been proposed. The reduction of points is up to 99.42% of the original size of points. It is very beneficial to model post processing: 3D visualization. And also, for different applications it is especially flexible for the users to select the ground level of detail.



Multidisciplinary Remote Sensing Analysis of Lunar Impact Crater Kepler

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The last decade has witnessed nine successful missions by five different space agencies, in some ways revolutionizing our understanding of the Moon. We have utilized a wide selection of datasets to gain a deeper insight into impact crater formation process and the crustal composition of the Moon. Our primary datasets include NASA's Lunar Reconnaissance Orbiter Narrow Angle Camera (NAC, ~0.5 m/px), Lunar Orbiter Laser Altimeter (LOLA, both points and DEM (~59 m/px)), Diviner radiometer rock abundance (~235 m/px), Mini-RF synthetic aperture S-band (12.6 cm, ~15 m/px) radar accompanied by Arecibo P-band (70 cm, 400 m/px) radar, Moon Mineralogy Mapper (M^3) imaging VIS–NIR spectrometer (85 channels, 140 m/px) flown as a guest instrument on India's Chandrayaan-1 mission, Japan's Kaguya Terrain Camera (TC, ~7.4 m/px), and NASA's Clementine UV–VIS (~119 m/px) data.

Kepler is a well-preserved, ~31 km wide and ~2.7 km deep complex impact crater in eastern Oceanus Procellarum on the nearside of the Moon. Earlier studies demonstrated the target rocks beneath ~500 m of mare basalts (now seen to be composed of distinct layers of separate lava flows) to have a noritic composition, consistent with Imbrium basin ejecta. Our analysis of the asymmetric distribution of Kepler's ejecta rays and the ejected impact melt ponds imply a projectile trajectory from the southeast, with an impact angle of ~45°. Similarly, on the crater floor, the impact melt-rich deposits have an asymmetric distribution, with smooth deposits (lower clast content) dominating the northern and western floor, whereas hummocky material (higher clast content) prevails on the southern and eastern floor. Morphometry of the flow-like impact melt deposits on the crater wall and flank implies yield strength of ~1–10 kPa, and modeling with MELTS suggests effective viscosity of ~40 Pa·s at ~1275°C with ~30 vol.-% clasts. These values are consistent with other lunar impact melt flows and terrestrial analogs.

M^3 data revealed the impact melt rocks to have a gabbroic composition, contrasting the noritic composition of the crater wall. Thus, a more Ca-rich, gabbroic target rock must be present at the depth of ~1–4 km. In addition, a previously unidentified splash-like exposure of similar Ca-rich material is seen on the southeastern (i.e., uprange) crater wall and flank, only observable in high spectral resolution VIS–NIR data. The origin of this melt-rich deposit is unknown, but it may be related to a late-stage collapse of the central uplift or the northern and western walls, resulting in "sloshing" the melt on the opposite crater wall and flank.

Radar, Diviner and NAC data indicate the presence of buried boulders, largely coinciding with an asymmetric halo seen in some of the M^3 bands, and broadly consistent with the extent of the continuous ejecta blanket seen, for example, in LOLA and TC data. This implies the presence of glass-bearing impact breccia, similar to suevite in terrestrial impact craters. Further away, a radar-dark halo with very few surface boulders emerges. Such radar-dark zones are known around other lunar craters as well, but their exact formation mechanism remains enigmatic.

Our multidisciplinary analysis has identified several entirely new geologic features in an impact crater that has been well-known and studied for centuries. Our work demonstrates the benefits of combining high-resolution datasets covering a broad spectral range, and serves as a template for future studies in planetary remote sensing. Such studies pave the way for our return to the surface of the Moon using robotic, teleoperated, and eventually also manned rovers.

Linking hyperspectral remote sensing observations of vegetation to the underlying physiological controls through a mechanistic modelling framework

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Physiological remote sensing signals such as the Photochemical Reflectance Index (PRI) and sun-induced chlorophyll fluorescence (SIF) contribute to the apparent reflectance of leaves and canopies. Measurements of these signals are intricately connected to the efficiency of photosynthesis and the potential for developing global products derived from satellite observations, such as GOSAT-SIF, is high. However there are significant knowledge gaps in the interpretation of such signals that limit their use when trying to infer photosynthetic rate. The accurate simulation of these signals requires a thorough understanding of the biochemical and physical principles that govern the observations. By building mechanistic models based on physical laws as well as biochemical and physiological understanding it is possible to go some way to addressing such knowledge gaps.

A coupled radiative transfer -physiological model is presented that predicts changes in leaf reflectance caused by chlorophyll fluorescence. The current model operates on timescales of minutes to seconds. The physiological model is based on the dynamics of the energy flow through photosystem II [1] and the radiative transfer component is based on the PROSPECT leaf level model [2]. The model successfully reproduced the transient dynamics of reflectance (due to superimposed fluorescence effects) over timescales of seconds to minutes on exposure of a leaf to full sunlight conditions. We are currently developing a modelling framework to i. extend the coupled model to enable the simulation of PRI; ii. upscale the model to the canopy scale; iii. extend the model to run on seasonal time-scales based on an improved physiological model. Further experimental work is needed to extend the model to PRI simulations. The challenges associated with upscaling relate to both temporal (physiological) and spatial (physical) issues. To validate and calibrate the canopy scale model a detailed measurement campaign will take place over the 2014 and 2015 seasons.

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Impact of forest structure induced illumination variation on canopy PRI

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Photochemical reflectance index (PRI) has been widely studied as an indicator of photosynthetic activity of vegetation. The light use efficiency (LUE) quantifying this activity is known to have a strong temporal-seasonal dependency caused by e.g. temperature and incident light-level changes. Since PRI has also a dependency from e.g. pigment pool sizes in a seasonal timescale, the longer term PRI-LUE relationship has been an important subject in recent studies such as [1]. However, PRI also has various sources of uncertainty in short-term or instantaneous timescale. While PRI is principally defined at leaf-level, it is often estimated at a larger scale, from above the vegetation canopy. This measurement geometry induces additional sources of variation to the PRI signal, introducing increased uncertainty in PRI-LUE relationship as well as spatial dependency. The most significant of these sources are background signals (e.g. soil), canopy structure, illumination and view geometry [2]. Therefore, the canopy-level PRI derived from remotely sensed observations cannot be directly compared to the leaf-level PRI in most cases. To retrieve a true PRI signal of the measured canopy elements, carrying the closest resemblance to the leaf-level PRI, the apparent variation in the observed canopy signal (induced by the extraneous factors such as canopy structure and measurement geometry) has to be accounted for.
A number of studies have also been recently conducted to improve the estimation of canopy-scale PRI and to reduce the apparent variation in the PRI signal, so that more comparable estimates to the leaf-level PRI can be retrieved from remote sensing observations. In this study, we focused on the variation caused by incident light differences within the forest canopy mainly due to its internal structure, and introduced a new analytical approach for the determination of the true PRI in a boreal forest canopy, using high resolution airborne imaging spectroscopic data. First, by applying the standard PRI relation to various canopy locations we derived the canopy PRI that also included the apparent variation in the overall signal. We then estimated the spectral irradiance composition (direct and diffuse irradiance components) for both sunlit and shaded canopy locations, based on sunlit and shaded road surface locations adjacent to the sampled forest canopies, and by using their irradiance components as first order approximations of the leaf-level illumination conditions. From the apparent canopy PRI and irradiance components together, we can quantify the contribution of the apparent signal on canopy PRI and assess its impact on the true PRI. Early results have indicated that the applied PRI correction using the real data is roughly in agreement with previous studies, but in our approach it is also easily overestimated, leading to an overcorrection of the PRI of bright canopy elements.

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A Bayesian approach to retrieval of canopy LAI from hyperspectral remote sensing data

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Hyperspectral satellite imaging provides finer-grained spectral information on vegetation than traditional multispectral instruments. However, so far, the full information contained in hyperspectral data has not been utilized. Previous research on retrieval of LAI from hyperspectral data has concentrated on building narrowband vegetation indices that correlate with LAI. Fully utilizing the information carried by hyperspectral data in LAI estimation is possible with a physically-based canopy reflectance model. Canopy reflectance models, however, contain several other unknown variables in addition to LAI. The uncertainty in the unknown model parameters is a substantial error source. In this work, we model the hyperspectral measurements (i.e. bidirectional reflectance factors, BRF) with the PARAS model [1], and cast the LAI estimation problem in the Bayesian inversion framework. The Bayesian approach is chosen because it allows taking into account the uncertainties in the model parameters.
In Bayesian inversion [2], the measurements and all the unknown variables of the observation model are modeled as random variables. A prior density, containing a priori information on the unknowns, is formed. Bayes theorem is then used to update the prior density with the information carried by the data. The solution of the inverse problem is a posterior probability density that describes the probabilities of all the possible solutions. Various point estimates, such as mode, median and mean, and other statistical measures, such as credible intervals, can be computed from the posterior density. In this work, a Markov chain Monte Carlo (MCMC) method was used for this purpose. MCMC methods are random sampling methods that, while computationally expensive, are remarkably powerful and suitable for sampling from very complicated distributions.
The feasibility of the proposed approach is tested with EO-1 Hyperion data captured during 2010 in Hyytiälä. The data consist of both homogenous and mixed boreal coniferous and deciduous forests imaged at three different occasions during the growing season. The estimates are compared to field-measured LAI values. Credible intervals for the estimates are calculated to quantify the precision of the estimates. The computed 90% credible intervals contained the field-measured LAI in nearly all cases.

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On spaceborne X-band SAR capability to retrieve forest height

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This paper discusses the possibility to use spaceborne X-band radar interferometry for forest height mapping. Polarimetric SAR interferometry is a promising technique for forest parameter retrieval, such as forest height and forest extinction coefficient. These parameters can be further used for forest above ground biomass estimation. Naturally, emphasis is on the use of longer wavelengths, such as P-band, e.g. recently accepted BIOMASS mission of European Space Agency. However, shorter wavelengths can provide relevant information, especially in low biomass forests. Forest parameter retrieval accuracy is particularly high when additional information about the ground location is available. This was demonstrated in our previous work where airborne E-SAR interferometric images and accurate LIDAR-measured ground elevation model were used to estimate forest tree height and extinction at X-band [1]. The method was later applied also to spaceborne TanDEM-X data [?].
The key issue of forest tree height estimation under different seasonal conditions appears to be variability in forest extinction coefficient, as it influences the correction that should be made to estimated interferometric phase centre height due to penetration of radiowaves into forest canopy. In this work, we concentrate to study the extinction coefficient variability in boreal forest.
In this work, a set of 10 TanDEM-X SAR satellite image pairs, acquired during summer and autumn 2011 over southern Finland, was used to evaluate the potential tree height retrieval performance and temporal stability of the method. Random Volume over Ground [2] model was used as a theoretical framework to calculate estimates for forest extinction coefficient and also estimates for ground reflection contribution. Also the tree height retrieval performance was evaluated. The test site of this study is located in southern Finland close to Kirkkonummi near the Helsinki region. The interferometric image dataset gathered for the study consists of 10 TanDEM-X CoSSC scenes, with acquisition conditions covering period from fully leaved forest in summer to totally leafless deciduous forest in late autumn. Digital elevation model derived from airborne laser scanning by Finnish National Land Survey in 2008 was used as a reference data in the study.
Our results show, that spaceborne TanDEM-X and TerraSAR-X satellite image pairs are suitable for forest height retrieval, but as expected, the accuracy of the method is lower than in the case of airborne measurement. Also the radar signal penetration depth into the forest varies seasonally and this variation should be taken into account when estimating tree height with SAR interferometry.

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Abstracts of the poster presentations:

Physical properties of meteoroids according to Middle and Upper atmosphere radar measurements

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We introduce a novel approach to reliably interpret the meteor head echo scattering measurements detected by the 46.5 MHz Middle and Upper atmosphere (MU) radar system near Shigaraki, Japan. The data reduction steps include determining the exact trajectory of the meteoroids entering the observation volume of the antenna beam and calculating meteoroid mass and velocity as a function of time. The model is built using physically based parameterization. The considered observation volume is narrow, elongated in the vertical direction, and its area of greatest sensitivity covers a circular area of about 10 km diameter at an altitude of 100 km above the radar. Over 100000 meteor head echoes have been detected over past years of observations. Most of the events are faint with no alternative to be detected visually or with intensified video (ICCD) cameras. In this pioneer study we are focusing on objects which have entered the atmosphere with almost vertical trajectories, to ensure the observed luminous segment of the trajectory is as complete as possible, without loss of its beginning or end part due to beam-pattern related loss of signal power.

FIGIFIGO: An Advanced Portable System for Spectropolarimetry

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We provide an overview of Finnish Geodetic Institute Field Goniospectrometer FIGIFIGO, an portable automated system for polarised multiangular reflectance measurements, which has been developed and improved in FGI. FIGIFIGO can be operated both on field under sunlight conditions (hemispherical directional reflectance factor, HDRF), and in laboratory using artificial illumination (bidirectional reflectance factor, BRF). The instrument design is primarily for field operation, as the total weight of the system has been kept as low as possible, at around 40 kg, and all critical components are designed to withstand field conditions. The instrument is highly automated and can be operated by two persons. Instrument setup is fast and only takes about 10 minutes. A typical measurement of full hemisphere (200-400 spectra) takes about 15 minutes after setup.
The primary instrument of FIGIFIGO is an ASD FieldSpec Pro FR optical fiber spectroradiometer (350-2500 nm), which is housed inside a rugged casing along with lead acid batteries, electronics and an electric motor. The motor is used to drive a telescopic measurement arm (1.55-2.65 m) from vertical to ±90° for the zenith angle adjustment. The azimuth angle is adjusted by turning the whole device around the sample. The sample is viewed by downward looking optics mounted to the top of the measurement arm and the optics are connected to the spectroradiometer by a 3 meter optical fiber. In addition to regular optics, a set of polarizing optics have been constructed using a Glan Thompson polarizer inside a rotator. The polarizing optics can be used to measure the sample with two or more polarization directions. The whole system is controlled by LabVIEW control software running in a rugged laptop.
During measurements FIGIFIGO is positioned next to the sample and calibrated for current illumination conditions using a Labsphere Spectralon reference panel. The system measures the current GPS position and time, and calculates the Sun zenith and azimuth angles. A hemispherical (fish eye) camera is used to measure the direction of the measurement plane relative to the Sun direction (sensor azimuth direction). Inclinometer is used to measure the zenith angle of the measurement arm (sensor zenith direction). The sample surface is measured from several azimuth directions by moving FIGIFIGO around the sample, and simultaneously a silicon pyranometer is used to record the illumination conditions, clouds, haze, and other atmospheric disturbances.
After the measurements the data are processed using FGI Reflectance toolbox for Matlab that takes in all the sensor data, does interpolations to match the spectra and the direction data, calculates BRF from the measured HDRF data using the diffuse measurements, corrects the spectra with the pyranometer data, and then outputs the data to a library format for easy processing. The library files are stored in the FGI Reflectance Library.

Exploiting UV range in SMAC atmospheric correction for SAL product of CM-SAF

Emmihenna Jääskeläinen, FMI

The surface albedo product SAL, processed by the CM-SAF project, is based on NOAA/AVHRR and METOP/AVHRR instrument data. In order to estimate the surface albedo, the effect of the atmosphere has to be removed from the observed surface reflectances. Currently the atmospheric correction is carried out using the SMAC algorithm, which is designed to be fast technique and hence especially useful when huge amounts of data have to be processed. The main input parameter needed is the aerosol optical depth at wavelength 550 nm. Unfortunately, reliable AOD values are not available globally for the time range of interest from the climate point of view. Therefore the current CLARA-SAL time series 1982-2009 was calculated using a constant AOD=0.1 assumption, which permits postprocessing by reverse engineering. For the future versions of the SAL time series a better solution for the atmospheric correction estimation is sought for. Deriving both the atmosphere and surface properties using just the visible and near infrared channel reflectances is an ill posed problem, as there are more unknowns than independent measured parameters. If AOD at the UV wavelength range is known, the AOD at wavelength 550 can be estimated from it. Adding an additional independent measured quantity (AOD at UV range) in the system should improve the surface albedo estimation accuracy at the red and NIR channels. We demonstrate the effect of including UV data in the AVHRR processing chain on the basis of a few case studies. A few typical AOD values are chosen and the SMAC algorithms is calculated by deriving the input values for the AOD at 550 in three different ways: 1) the AOD values are calculated on the basis of the AOD values in the UV range, 2) the true AOD values and 3) the constant value 0.1. Results from these three simulations are then compared. So far preliminary results from these comparisons have been promising.

MEX Gateway with LASlib Functions for Point Cloud Data Transfer between Matlab and Binary Storage Formats

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Laser scanning data are stored in several different formats, both in general text formats and in binary. General text formats are easily accessed with different processing tools, but they are not efficient for storing large datasets. Binary formats provide efficient means for both data storage and fast I/O operations, but they require the use of special, often vendor-specific, tools. This limits inter-operability between different data processing tools and slows down the general workflow when data needs to be transformed to another format.

Open access binary formats, like ASPRS .las [1] and ASTM .e57 [2] allow users to develop their own tools packages and libraries. One of such packages is LASTools [3], which provides compression of .las data into .laz format. The LASTools package also includes source code for its openly accessible functionalities as a LASlib library under LGPL.

In the Finnish Geodetic Institute, an extensive part of the point cloud processing and related research is carried out with the MATLAB (MathWorks Inc., Natick, MA, USA). In MATLAB, testing and development of new algorithms and visualization is fast. We are now incorporating LASlib import and export functionalities into MATLAB utilising LASlib and mex interfaces.

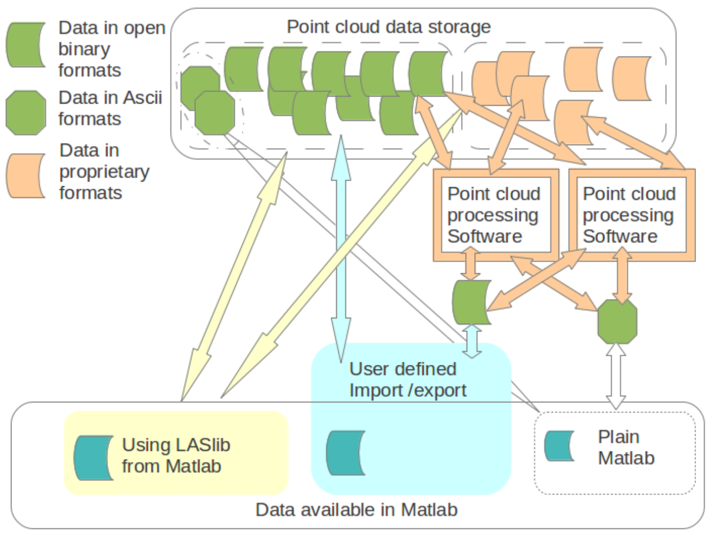

Figure 1. Different possibilities of bringing point cloud data into MATLAB workspace. Yellow arrows present the proposed method.

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Assessing the Performance of a Leaf Optics Model for Boreal Tree Species

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Reliable information on leaf pigment and nutrient content and their variation can be obtained non-destructively from reflectance and transmittance spectra of leaves. Such information is required in complex models describing canopy function, canopy light absorption, as well as for the interpretation of remote sensing data. However, field measurements of leaf optical, biochemical and structural properties are time-consuming, often resulting in limited sample size. An alternative is to use leaf level radiative transfer models such as PROSPECT [1]. This model computes relationships between leaf spectra, biochemistry and structure, and requires only few input parameters (e.g. chlorophyll a+b content, dry matter content, equivalent water thickness) and structure (leaf structure parameter). When run in inverse mode, the model can be used to retrieve leaf structural and biochemical parameters from leaf spectra. Nevertheless, the model has been validated mainly for broadleaves with flat surface, the performance of the model for coniferous tree species of boreal region remains largely unknown.
We measured the reflectance and transmittance spectra of leaves of typical tree species in boreal Europe – Scots pine (*Pinus sylvestris* L.), Norway spruce (*Picea abies* (L.) Karsten) and Silver birch (*Betula pendula* Roth) – using a spectroradiometer coupled with an integration sphere. Measurements were calculated to hemispherically integrated reflectance and transmittance factors. Simultaneously, we measured leaf biochemical composition, water content and specific leaf area. Two different canopy positions (sunlit and shaded) were sampled [2]. The database was used to assess the performance of the PROSPECT model in forward mode and to estimate the accuracy of parameter inversion.
Highest accuracy in forward simulations of leaf optical properties was achieved for birch leaf samples. The accuracy of PROSPECT simulations for coniferous needle samples was relatively poor. The PROSPECT structural parameter N was significantly correlated with sample specific leaf area, thickness and reflectance to transmittance ratio at 800 nm. The inversion of the PROSPECT model produced similar accuracy for all tree species with an average relative RMSE (including error propagation of the whole processing chain) around 30% for chlorophylls, carotenoids and dry matter content. The most accurate retrieval was achieved for leaf water content of birch with a relative RMSE of 12%. The spectral data collected in our experiment is freely available in the SPECCHIO online database (http://www.specchio.ch/).

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Estimating Total Phosphorus in the Luga River, Luga Bay and the Gulf of Finland in the North-Western region of Russia using Landsat 5 (TM) Satellite Imagery

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Keywords: Remote sensing; Landsat 5 (TM); Total Phosphorus; Chlorophyll-a; Eutrophication; Luga River; Gulf of Finland

Application of remote sensing data from Landsat 5 (TM) provides wide range of opportunities to determine the level of total phosphorus (Tot-P) in the Gulf of Finland. This method was originally described and previously applied for a Chinese river [1, 2] and also adapted and applied for the rivers flowing into the Baltic Sea in Sweden [1].
The research shows that division band TM1 by band TM3 of Landsat 5 (TM) can provide good estimation results of Secchi Depth [1, 2]. There are also studies that suggest that TM1 of Landsat 5 (TM) can be a good predictor for calculating Secchi Depth [1, 2]. Chl-a content in the water can be estimated using the ratio of TM2 and TM3 of Landsat 5 (TM) [2, 3]. Chl-a has a strong linear relationship with P, since the growth of phytoplankton is dependent on the phosphorus and nitrogen content [1, 2].
The results suggest that the calculation of Secchi Depth, Chl-a and TM1 Landsat sensor 5 (TM), can describe the level of Tot-P [1, 2]. This method uses the ratio of bands TM1/TM, TM2/TM3, TM3/TM2 and TM1 values from Landsat 5 (TM) [1, 2, 3].
Application of the model for the River Luga, Luga Bay and the Gulf of Finland has showed that it is able to explain about 67 % of the variance in the simulated values for Tot-P. For further research is necessary to collect more ground-based measurements [2], which will be consistent in time with the information registered from satellites and collect more detailed weather conditions, climate statistics and temporal factors that may have an impact on the results.

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Seasonal reflectance dynamics of common understory types in hemi-boreal forests, Järvselja, Estonia

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Spectral properties and seasonal dynamics of understory layers in boreal forests are not yet fully understood. In this work the seasonal reflectance dynamics in European hemi-boreal forests are studied. The data for this study was collected at Järvselja Training and Experimental Forestry District (Estonia, 27.26°E 58.30°N). Measurements were taken in three different stands. The silver birch (*Betula Pendula Roth*) stand grows on typical brown gley-soil and its understory vegetation is dominated by a mixture of several grass species. The scots pine (*Pinus sylvestris*) stand grows on a bog with understory vegetation composed of sparse labrador tea, cotton grass, and a continuous Sphagnum moss layer. The third stand, Norway spruce (*Picea abies*), grows on a *Gleyi Ferric Podzol* site with understory vegetation either partially missing or consisting of mosses [1].
The sampling design was similar to the study by Rautiainen et al. [3] in northern European boreal forests. At each study site, a 100 m long permanent transect was marked with flags. In addition, four intensive study plots (1 m × 1 m) were marked next to the transects at 20 m intervals. The field campaign lasted from May to October 2013. For each site the fractional cover of understory and understory spectra were estimated ten times i.e. every 2 to 3 weeks. Results from Järvselja forest were compared with the seasonal profiles from boreal forests in Hyytiälä, Finland [2].

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Towards Finnish Earth Observation satellites

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Small and very small satellites (1-50 kg) are an emerging technology worldwide, which is now changing the way of space technology is made and used. Throughout the history of space technology, launch of a satellite has been expensive and the price per kilogram has not reduced significantly. This has been implying significant quality assurance costs in a typical space technology project, as failure is not an option.
However, due to rapid development of mobile electronics and sensor technology, the size and weight of measurement and communication systems has been shrinking rapidly. This development has induced also a new branch of space technology, which concentrates on satellites weighing only few kilograms. Reduced mass brings smaller launch costs and allows taking higher risks. Tens of universities around the world are nowadays building satellites in their laboratories out of consumer grade electronic components, and they carry out successful scientific missions with a fraction of cost compared to traditional space industry projects. Collaboration and common standards in this area have made it possible for small countries to launch their own scientific and educational satellite missions. Also Finland follows the trend, and Aalto University currently builds its first nanosatellites. This effort aims to establish a continuous series of nanosatellite missions, which strive towards high-level scientific work and cutting-edge technological development, as well as extensive interdisciplinary cooperation both in academia and the commercial sector.
These small satellite projects have already helped form a consortium of Finnish universities and space industry and has pursued international relationships with four foreign universities. It has joined the forces of Finnish universities and R&D institutions in creating new kind of space research and business and formed a new international cooperation network.
The conference presentation will give an overview of satellite projects currently ongoing in Aalto University.

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Remote Sensing Monitoring and Joint Analysis of Northern Eurasia Climate and Vegetation Dynamics

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Analysis of the last 12 years climate changes shows that climate change in northern Eurasia is not homogeneous in space and time. The research highlights the ability of climate change remote monitoring. The relevance of research consists in temperature changes learning opportunities development under the conditions of sparse network of the ground observation stations in northern Eurasia. NDVI was selected as a research tool. NDVI [1] and surface air temperature [2] trends for the warmer months of the year were mapped (Fig. 1).
There is a negative trend in surface air temperature in July and August within the space from White Sea to Taimyr. In september the trend is replaced by a positive. In accordance with the marked climatic changes the tundra is retreating and the area occupied by shrubs (by IGBP classification) is reducing in the region. In eastern Siberia the positive trend of temperatures in July and August changes to negative in September and there is an increasing of forest and shrubs area and rising its area to the north.
The geographical distribution of NDVI trends repeats the surface air temperature trends in general. And this fact suggests the possibility of using NDVI in the climate monitoring. In particular the NDVI trends map can confirm the existence of designated regions with the same type of climate variability and indicate its boundaries in remote areas more clearly.

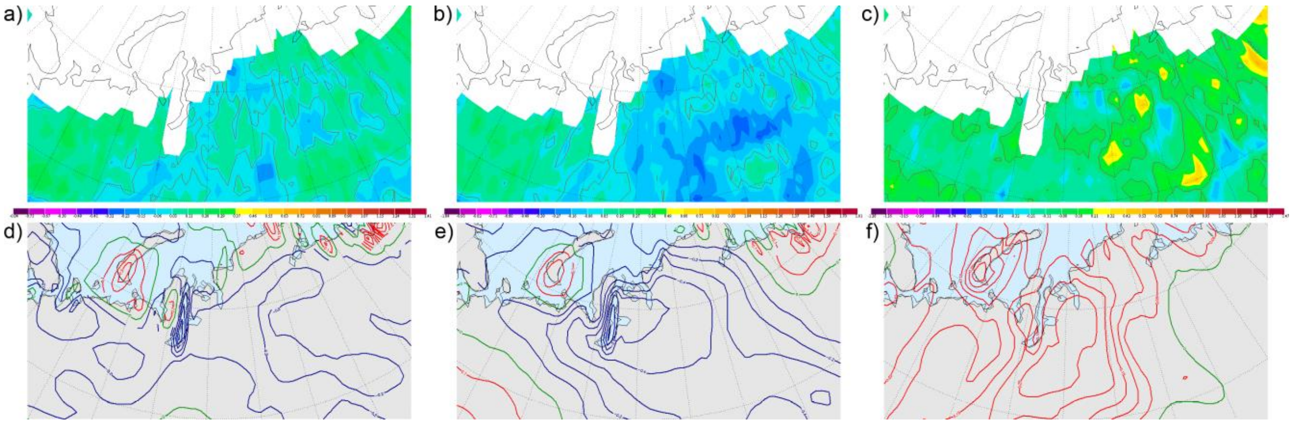

Figure 1: Maps of the 2000-2012 NDVI linear trend coefficients (a, b, c) and the surface air temperature linear trend coefficients (d, e, f) on July (a, d), August (b, e) and September (c, f).

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Remote Sensing Activities at Saint-Petersburg State University

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The Space and Geoinformation Technologies Resource Center (RC) was created in 2012, at the St. Petersburg State University (www.sgt.spbu.ru). Center is intended to solve the problems of the north-western region monitoring, provide information, new technologies and spatial data obtaining and processing possibilities for the education and monitoring and territory development research projects of SPbSU.
RC includes such main elements as:
- UniScan-24™ ground station for remote sensing data receiving (www.scanex.ru);
- the information processing center equipped with the specialized processing software;
- GLONASS/GPS reference stations integrated with the automatic weather stations network;
- server infrastructure for Web portals and geoportals development.

UniScan-24 allows to collect multi-, hyperspectral and radar data of different spatial resolution (from 1 km/pix to 0.7 m/pix) from such satellites as Terra, Aqua, IRS, CARTOSAT, SPOT, EROS, Landsat, RADARSAT. As UniScan owner the RC has possibility of remote sensing data receiving for the lower cost than the case of order from the central archives. The data become available for analysis in near real-time (0.1 to 0.5 hours after uploading). In the first phase of RC activity there is receiving data from 4 satellites (Terra, Aqua, SPOT 5, EROS A).
RC operates series of software for the processing of remote sensing data and GIS research (e.g. ENVI™, ERDAS™, PHOTOMOD™, PHOTOMOD Radar™, ArcGIS™, MapInfo™, GIS Map™, Easy Trace™, ScanEx Image Processor™). This software allows to perform a wide range of activities related to the remote sensing data usage and the GIS development, from topographic maps update (up to scale of 1:10 000) to rapid detection and monitoring of oil spills on land and shelf in the areas of oil extraction and in the aquatory.
GLONASS/GPS reference stations network is the instrument for satellite geodetic measurements. It consists of the complex of the constantly running satellite receivers with a rigidly fixed antennas, mobile base station, hardware-software management complex. The network allows the measure the coordinates of objects with subcentimeter accuracy and provides a solution of such problems as: topographic and geodetic investigations, precise satellite images reference providing, study of surface deformation, seismic monitoring etc.
RC collaborates with GeoScan LLC (www.plaz.aero) – the developer of airborn remote sensing technology that includes superlight UAV GeoScan-101 and Agisoft PhotoScan Pro processing software. Analysis of data collecting results in the frame of joint SPbSU – GeoScan project shows that the technology allows automatic creation of orthophotos up to 3.7 cm/pix spatial resolution with 3D control points RMS of 12 cm.
Another important area of investigations is the development of the interactive geospatial web services and geoportals. The RC staff participates in development of the hybrid Web services technology for remote sensing data geoprocessing. The last mentioned study was partially supported by RFBR, research project No. 13-05-12079 ofi_m.

North State - Enabling intelligent Copernicus services for carbon and water balance modelling of northern forest ecosystems

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North State is an EU FP7 project focusing on Copernicus (http://copernicus.eu/) services, the project will last three years on 2013-2016.

Boreal forest is the largest terrestrial biome and will be strongly affected by climate warming, which is predicted to be strongest at high latitudes, with significant impacts on the European economy. North State will demonstrate how innovative methods applied to the new Sentinel data streams can be combined with models to monitor carbon and water fluxes for pan-boreal Europe, with intensive study sites in Finland, Iceland and Russia. This will reduce the high uncertainty in current estimates of flux rates.

Key model parameters will be derived from Sentinel and other EO data, in situ and ancillary data, including relevant FP7 and ESA CCI projects.

The project brings together leading experts and organisations, including an SME experienced in developing value adding services, needed to address key research challenges that require innovative remote sensing methods: adaptation of the carbon and water cycle models for effective use of EO data; effective pre-processing and data management techniques to exploit high temporal frequency time series; assessing the potential of hyper-spectral data; developing powerful data fusion techniques; and developing an intelligent, automated framework to learn from and interpret multi-source data to address a key societal problem.

It responds to the Lund declaration and the recommendations of the Space Advisory Group. It will strengthen European leadership in the provision of EO-based services and will be a paradigm for exploiting opportunities offered by the new generation of EO satellites in developing products for future Copernicus services

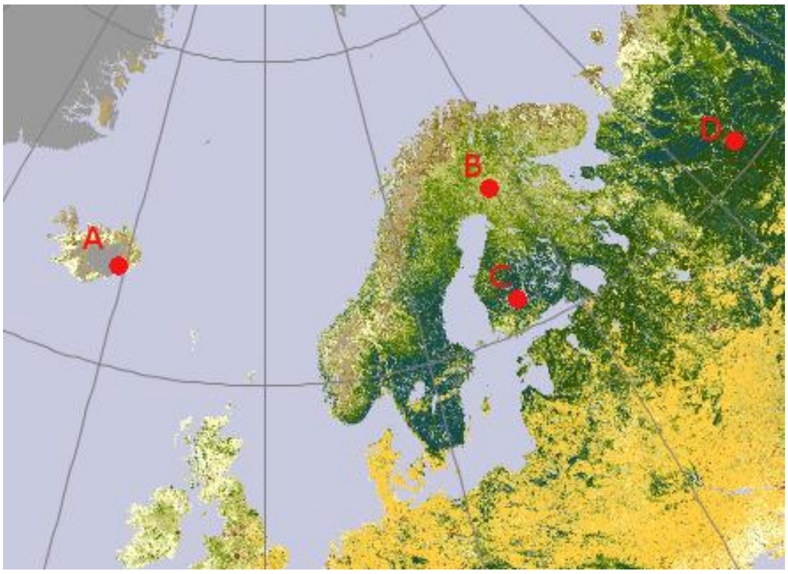

Figure 1: The four study sites in the North State. The boreal forest is depicted in green. (A: Hallormsstadur, Iceland; B: Sodankylä, Finland; C: Hyytiälä, Finland; D: Pechora-Ilych nature reserve, Komi republic, Russia) Image source: NASA.

Does leaf angle distribution change as a function of height and season for broadleaf tree species common to Estonia and Finland?

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Leaf inclination angle distribution is a key parameter in determining the transmission and reflection of radiation by vegetation canopies. It has been previously observed that leaf inclination angle might change gradually from more vertical in the upper canopy and in high light habitats to more horizontal in the lower canopy and in low light habitats [1]. Despite its importance, relatively few measurements on actual leaf angle distributions have been reported for different tree species. Even smaller number of studies have dealt with the possible seasonal changes in leaf angle distribution [2].
In this study the variation of leaf inclination angle distributions was examined both temporally throughout the growing season and vertically at different heights of trees. We report on leaf inclination angle distributions for five deciduous broadleaf species found commonly in Estonia as well as in Finland: grey alder (*Alnus incana*), Silver birch (*Betula pendula Roth*), chestnut (*Castanea*), Norway maple (*Acer platanoides*), and aspen (*Populus tremula*). The angles were measured using the leveled camera method [3], with the data collected at several separate heights and four times during the period of May–September 2013.
The leveled camera method was additionally tested in terms of sensitivity to different users. Ten people were asked to measure the leaf angles for four different species. The results indicate the method is quite robust in providing coinciding distributions irrespective of the user and level of previous experience with the method. However, certain caution must be exercised when measuring long narrow leaves.

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Soil Moisture Remote Sensing Experiments with Satellite and Airborne radiometers in Southwest Finland

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Reliable global coverage soil moisture measurements are important for understanding of global hydrological processes. Launched in November 2009, European Space Agency's Soil Moisture and Ocean Salinity (SMOS) satellite is the first satellite for global monitoring of soil moisture. [1] The sole instrument on SMOS for both soil moisture and ocean salinity retrieval is Microwave Imaging Radiometer by Aperture Synthesis (MIRAS). It utilizes aperture synthesis to achieve a ground resolution of 30 to 50 km. Most SMOS ground pixels cover several land usage classes and vegetation types, making both soil moisture retrieval and performance validation challenging.
In August 2013 an airborne measurement campaign was started over the Hypöistenkoski test area in Western Finland. The goal of this campaign is to expand knowledge of the SMOS soil moisture retrieval capabilities in different terrain types, utilizing data from our airborne L-band 2-dimensional synthetic aperture radiometer HUT-2D, an airborne L-band interferometric radiometer designed, manufactured and tested by Helsinki University of Technology [2]. HUT-2D is a synthetic aperture radiometer, operating at the same frequency (1.4 GHz) as MIRAS [1]. During this campaign HUT2D is operated at 3 km altitude, giving it ground resolution of approximately 300 meters.
This paper presents results of the soil moisture retrievals made with HUT-2D and SMOS, and examines differences in moisture retrieval in different scales and surface types. Remote sensed moistures are compared to in situ measurements of soil moisture and soil moisture models. Calculations of the terrain emission were based on the L-MEB biosphere emission model [3].

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SYKE's Processing chain for Landsat TM/ETM-Images

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The first Landsat remote sensing satellite was launched 1972. So far, there have been eight satellites and the newest one was launched during spring 2013. Technically, especially Thematic Mapper and Enhanced Thematic Mapper –images from Landsats 4, 5 and 7 combine reasonably good spatial resolution with good combination of channels and large image size.

In order to make these images more user-friendly at Finnish Environment Institute SYKE and Finnish environment administration, cloud-free image mosaics are needed. The aim of this study has been to develop processing chain for archived Landsat TM/ETM-images from USGS, which would read images to required format, make radiometric correction, remove unwanted areas from images and mosaic them. This processing chain should be able to process hundreds or thousands of images easily and automatically, requiring as little manual work as possible. This processing chain is based on functionality of Matlab and Erdas Imagine. The geometric correction provided by USGS is quite good and therefore this subject can be left out from processing.

To be more specific, the processing chain consists of following steps:

- Image import: Matlab-function studies the Landsat TM/ETM-images in directory to be imported and makes text-files for each scene. Erdas Imagine batch model is using this text-file to read tif-files of individual channels to on Erdas Imagine img-file consisting of all channels.
- Radiometric correction: Pixel digital numbers are transformed to top-of-atmosphere reflectances, taking into account Sun elevation angle and Earth-Sun distance.
- Removal of unwanted areas: These areas are like clouds, their shadows and shadowed areas due to topographic variations. Cloud detection is based on idea that clouds are bright and cold, i.e. cloud if blue channel > threshold and blue channel / TIR channel > threshold. Snowy areas and some other targets are removed from clouds using Normalized Difference Snow and Moisture Indices. Resulting cloud mask is bufferized first symmetrically and then to the direction of shadows in order to cover also shadows. Problem is that there are plenty of thin or hazy clouds which are not detectable using this method. For these cases, shadow is detected by finding targets which are dark and do not belong to water-mask. Then these shadows are bufferized first symmetrically and then to the direction of the cloud. Another cause for shadows is topographic variations and these areas detected using digital elevation model. First, the surface normal and Sun position vectors are computed and the angle between them computed. If this angle is over 85 degrees, then the areas is in shadow and to be removed from image.
- Tasselled Cap: Tasselled Cap-images Brightness, Greenness and Wetness are computed from TM/ETM-images, in order to transform image data to features which are related to physical properties of targets, and it is hoped that this would decrease the effects of atmospheric variability.
- Mosaicking: Reflectance images are merged to image mosaics using histogram matching with IMAGE2000 mosaic and then selecting pixel according to highest vegetation index value. Mosaicking of Tasselled Cap images is done using maximum Greenness as criterion.

Vegetation Phenological Features from Daily MODIS NDVI Time-series

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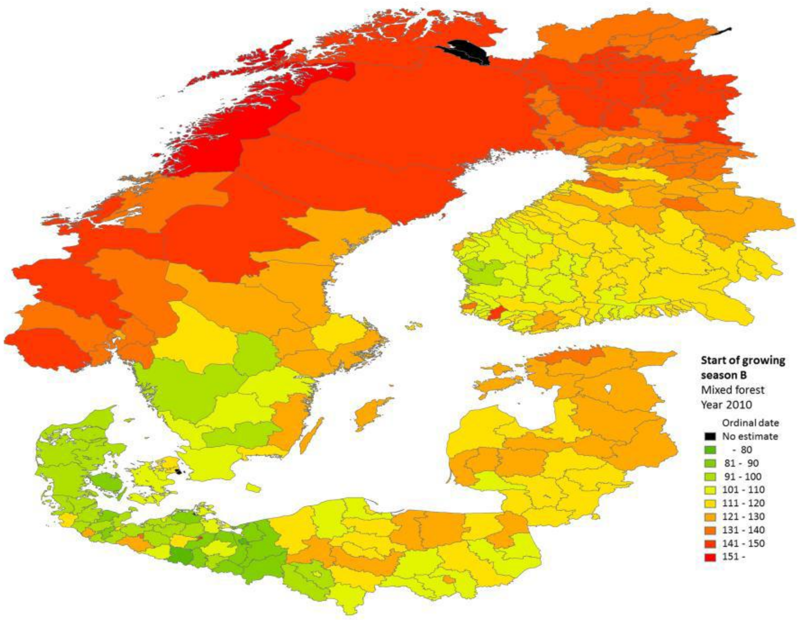
Information concerning the start and end of vegetation growing season has its use in environmental monitoring like studying nutrient leaching or climate change. This article presents methods to estimate important dates of vegetation growing season, namely start, maximum and end of growing season for different administrative areas and land cover types. It is based on Normalized Difference Vegetation Index time series computed from daily MODIS-images. Following features are computed:

1. Start of growing season A: Day of start of rapid increase in NDVI corresponding to the start of flux growing season (nutrient fluxes start to flow in plants).
2. Start of growing season B: Day when NDVI goes over defined threshold corresponding to birch bud-burst.
3. Day of maximum NDVI
4. End of growing season: Day when NDVI decreases below threshold corresponding to birch leaf yellowing.
5. Length of growing season A: feature 4 - feature 1
6. Length of growing season B: feature 4 - feature 2
7. Quality estimate for feature 1.
8. Quality estimate for feature 2.
9. Quality estimate for feature 4.

The latest version of the product has been made for Baltic Sea drainage basin and years 2001 – 2010. Phenological features are computed for land cover types: agricultural areas, coniferous forest, deciduous forest, mixed forest and open wetland (open bogs). The used administrative units are hydrological drainage basins in Finland and NUTS3-areas for other areas.



Topographic Analysis of the Circumferential Graben around Alba Mons, Mars

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Alba Mons, previously known as Alba Patera, is a very shallow volcanotectonic complex on the northern slope of Tharsis rise, Mars. Alba Mons has a diameter of ~1400 km (east–west) × ~1000 km (north–south) km, but a relief of only ~7 km, making it distinctly different from the other shield volcanoes in the Tharsis region or anywhere else on the planet [1, and references therein]. The very gently-sloped Alba Mons, with its extensive lava flows and graben, is also morphologically notably different from the old highland volcanoes, but has topographic and gravity/topography admittance signatures similar to those of the Elysium rise. Further, the circumferential arrangement of graben and normal faults bears substantial resemblance to Venusian coronae. We have used various topographic datasets to measure the vertical components of the offsets (throws) of the circumferential graben to provide us with estimates of the horizontal extension and the extensional strain that have affected Alba Mons. This enables us to assess the validity of the different formation models proposed for the graben, and provides further insight into the evolution of this unique volcanotectonic feature.
Our topographic datasets include NASA's Mars Global Surveyor Mars Orbiter Laser Altimeter (MOLA) point and digital elevation model (DEM, ~350 m/px) data, ESA's Mars Express High-Resolution Stereo Camera (HRSC) DEMs produced by the German Aerospace Center (DLR, 75–150 m/px) and, most importantly, higher resolution DEMs created with NASA's Ames Stereo Pipeline (ASP) software using stereo images from HRSC (~20–125 m/px) and Mars Reconnaissance Orbiter Context Camera (CTX, ~6 m/px). For photogeologic reference, we also used Mars Odyssey Thermal Emission Imaging System daytime mosaic (THEMIS, 100 m/px).
The apparent throws of the graben were measured and analyzed separately for the outwards- and inwards-facing faults, and 60° fault angle was assumed in the calculations.
Alba Mons displays notable asymmetry in its topography. This asymmetry can also be seen in the distribution of the circumferential graben. The western graben zone is narrower and more arcuate and located higher on the flank, whereas the eastern graben are wider, more linear, and located lower on the mid-flank [1]. The western side is also different in that there the throw differences between the inwards-and outwards-facing faults are negligible, whereas everywhere else the outwards-facing faults display larger total cumulative throws than the inwards-facing ones. The throw asymmetry is consistent with graben origin due to some uplift mechanism, rather than by subsidence. In particular, the calculated extensional strain of ~0.5–2% matches the predictions of the late-stage sill-inflation model proposed by McGovern et al. [1]. A significant proportion (10–40%) of the observed topography of Alba Mons can be accounted for by the throw difference between the inwards- and outwards-facing faults.
Based on comparisons between the different datasets, all of the available topographic datasets have their pros and cons, and in areally extensive studies the best results are obtained by using them all, combined with photogeologic sanity checks. However, for detailed analysis, CTX DEMs produced with, for example, the free ASP software provide the best currently available Martian topographic dataset.

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