Towards Up-To-Date Wide-Area Information About Forest Resources

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The state of the forests is an important global environmental indicator, and the changes in the forest recourses and in the forest health status, can be considered as central factors in environmental monitoring, as they are linked to the global climate change and Earths carbon cycle. The far-reaching aim of the proposed research is to improve the methods currently used in mapping of forest resources i.e. to provide frequently, forest status related, wide-area information by using Synthetic Aperture Radar (SAR) satellite images coupled with information derived from Airborne Laser Scanning (ALS), airborne X/P-band SAR (CASMSAR), profiling scatterometer (Tomoradar) data.

Remote sensing instruments, which are typically used in mapping of forests, are: laser scanners, aerial images, optical satellite images, SAR images, and hyper/multispectral images. One can find the current status of these techniques in forest biomass estimation e.g. in Koch (2010). Clearly the most important step forward in the past years has been the use of Airborne Laser Scanning (ALS) in forest inventories (e.g. the latest Marcus Wallenberg Prize was awarded for the research related to ALS based forest inventories). However, wide-area ALS data acquisition is still rather expensive and the time interval between the consecutive nation-wide ALS surveys (taking Finland as an example) might be carried out in 5 years or so. Therefore, there appears to be niche for other techniques in forest resources mapping as well. Being able to acquire images through clouds, SAR enables constant and frequent imaging of the target area, which is an important characteristic in time-critical mapping tasks. A lot of research has been carried out in the matter of using SAR data in mapping of forests mostly based on the intensity information, which clearly has limitations, such as, the saturation effect. However, according to recent results, elevation data extracted from SAR data appears to be the key to improve the estimation accuracy.

Basically, there are two approaches to extract elevation information from the SAR images: 1) SAR interferometry (INSAR) or 2) radargrammetry. If the elevation values of the ground surface are accurately known e.g. using ALS derived a Digital Terrain Model (DTM), then the X-bands or C-bands interferometric or radargrammetric height can be related to the forest canopy height and accordingly to the stem volume. Examples of the use of INSAR data for forest canopy height estimation has been provided by Kellndorfer et al. (2004), who used the C-bands interferometric heights from the Shuttle Radar Topography Mission (SRTM) to estimate the forest canopy height. Similar results using the SRTM X-band data were presented by Solberg et al. (2010), who also estimated the above-ground biomass based on SRTM elevation values. Perko et al. (2010) and Karjalainen et al.(2011) have showed that X-band stereo SAR satellite data have potential for application in the estimation of forests biomass. Because accurate lidar based DTMs are available only in limited areas of the world, other means to derive elevation of ground surface are needed. One of the most promising techniques is the use of the longer radar wavelengths (P-band), which penetrate forest canopy and thus provide information about ground surface elevation.

The objective of the project is to develop efficient canopy measuring techniques based on satellite-derived elevation and surface models including

(1) Canopy height model extraction from laser derived elevation model subtracted from satellite given DSM (Sentinel-1 C-band interferomertry and stereo-radargrammetry)

(2) Canopy height model extraction from Chinese airborne SAR equipped with X- and P-bands (CASMSAR)
(3) Verification of canopy height models with field data and UAV-based radar profiler (Tomoradar development of FGI, improved version of the known HUTSCAT profiling scatterometer system)

面向最新的森林资源广域信息

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森林资源状况是一项全球性环境的重要指标，森林资源以及森林的健康状况的变化被视为环境监测的核心因素，因为它们都与全球气候变化和地球碳循环相关联。提出对目前森林资源测图方法改进的研究具有深远意义，即利用合成孔径雷达（Synthetic Aperture Radar， SAR）卫星影像联合机载激光扫描（Airborne Laser Scanning， ALS）、机载X/P波段SAR（CASMSAR）多次获取森林情况相关的广域信息和谱散射（层析雷达）数据。

通常用于森林测图的遥感设备有：激光扫描仪、航空影像、光学卫星影像、SAR影像和超/多光谱影像。人们发现目前这些技术用于森林生物量的估计，如：Koch（2010）。显然，在过去几年最为重要的一步是利用机载激光扫描（ALS）进行森林资源清查（如：最新的Marcus Wallenberg奖授予了基于ALS的森林清查相关研究）。然而，广域的ALS数据获取依然十分昂贵，连续的全国范围内的ALS测量（以芬兰为例）需要持续五年左右。因此，这也为其它技术在森林资源测图方面的应用提供机会。由于可以穿透云层，SAR可以常年和频繁地对目标区域成像，这对于执行应急测绘任务十分重要。许多利用SAR数据进行森林测图的研究都是基于强度信息，很明显，存在局限性，比如饱和效应。然然而，最近的研究结果表明，从SAR数据中提取的高程数据是提高估计精度的关键所在。

一般而言，利用SAR影像获取高程信息有两种方法：1）合成孔径雷达干涉测量（InSAR）2）雷达摄影测量。如果精确的地表高程值已知，如通过ALS获取数字地面模型（DTM），再利用X波段或C波段干涉或摄影测量技术获得的高度是与森林冠层的高度和相应的树干体积相关。Kellndorfer等人（2004）提供了一个使用干涉数据估计树冠高度的例子，他们利用航天飞机地形测绘任务（SRTM）的C波段干涉高程估计森林树冠高度。Solberg等人（2010）使用SRTM的X波段数据获得了相似的结果，他们基于SRTM的高程信息同时还估计了地表的生物量。Perko等人（2010）和Karjalainen等人（2011）展示了星载X波段SAR立体数据在估计森林生物量应用方面的巨大潜力。由于只能在有限的区域通过精确的激光雷达获得DTM，因此有必要利用其它手段获取地表高程。利用可以穿透森林冠层的长波长

项目的目的是基于卫星获取的高程和表面模型，发展高效的树冠测量技术，包括：
（1）从卫星获取的DSM（Sentinel-1 C波段SAR干涉测量或者立体摄影测量）中减去激光获取的高程模型，从而得到树冠高度模型。
（2）利用装备了X波段和P波段传感器的中国机载SAR系统（CASMSAR）获取树冠高度模型。
（3）用野外实测数据和基于无人机（UAV）的雷达剖面仪（FGI研发的层析雷达，是HUTSCAT谱散射系统的改进版本）验证树冠高度。　　（P波段）SAR获取地面高程信息是一项很有前途的技术。