# **Remote sensing for forest applications – different applications with different requirements**

Accurate data about the forests are required both for forest management, environmental monitoring, and global climate research. Local data can be collected using field surveys to derive, e.g., stem volume, biomass, tree species and basal area. Remote sensing (RS) is the common term for deriving complete, accurate and updated such data, from platforms not in physical contact with the forest to be monitored. Air and satellite borne platforms are suitable to acquire data for large regions, hence enabling automatic mapping to lower costs per area, but also bringing the challenge of providing sufficient resolution and accuracy. Aerial photographs and optical satellite images are two-dimensional (2D) projections of the forest that provide for example spectral data about tree species and land types. The use of several photographs or images can enable stereomatching, where images acquired from slightly different locations can be used to derive height information for each location. However, since this is only a single height value per pixel, it is often denoted 2.5D, where height information cannot be derived for many vertical locations. 3D data have the advantage over 2D of being a better descriptor of volumetric variables such as stem volume and biomass. To collect true 3D data, a laser scanner can be used on an airplane or helicopter. The laser scanner is an active device, transmitting a narrow coherent electromagnetic signal of a single wavelength. In the irregular heterogeneous forest canopy, this causes multiple returns, which enables a 3D reconstruction of stems, branches and leaves. Although airplanes can cover large areas, only satellite based techniques can provide frequent RS data over very large areas, or sufficiently frequent data, to perform continuous forest monitoring. Satellite missions carrying active sensors, e.g., synthetic aperture radar, can acquire such suitable data all year round. However, radar acquisitions are rarely true 3D, and e.g. tomography would be required to enable 4D with time as fourth dimension.

RS research normally need field reference data to train estimators and evaluate RS predictions. A straightforward method is linear regression modelling, which can be used to estimate model parameters for variables acquired with RS. Other, semi-empirical methods might instead assume, e.g., a physical model where a certain height acquired with RS must correspond to a certain magnitude of the interesting variable, e.g., biomass. In such cases, field data are only used for evaluation.

To make useful RS applications, different research questions should be addressed with different methods and RS techniques. Two current research questions are monitoring of forest changes and mapping tree species. The latter is a slowly changing forest variable, possible to determine with 2D data, and therefore the longer time frame enables the use of rarely acquired RS data with higher resolution. For forest changes, however, some applications require much shorter response time (i.e., days or weeks), e.g., due to storm hazards and illegal logging, and hence accepting somewhat lower spatial resolution. For monitoring purposes, this enforces a need of near-continuous data, with time as a crucial dimension.

Further research includes investigation of the influence of environmental conditions, the challenge of lower spatial resolution, better use of high temporal resolution, and inconsistent dataflows.