FOREST BIOMASS RETRIEVAL FROM LIDAR AND RADAR

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ABSTRACT

Estimates of regional and global forest biomass and forest structure are essential for understanding and monitoring ecosystem responses to human activities and climate change. The use of lidar and radar instruments to measure forest structure attributes such as height and biomass are being considered for future Earth Observation satellite missions. Data from these sensors contain information relevant to different aspects of the biophysical properties of the vegetation canopy including above ground biomass. Large footprint lidar makes a direct measurement of the heights of scatterers in the illuminated footprint and can yield information about the vertical profile of the canopy. Synthetic Aperture Radar (SAR) is known to sense the canopy volume, especially at longer wavelengths and is useful for estimating biomass. Interferometric SAR (InSAR) has been shown to yield some forest canopy height information. There is much interest in exploiting these technologies separately and together to get important information for carbon cycle and ecosystem science.

The planned NASA new mission DESDynI (Deformation, Ecosystem Structure and Dynamics of Ice) will provide global systematic lidar sampling data and complete global coverage of L-band high-resolution SAR and InSAR data for vegetation 3D structure mapping. This requires some new data processing and fusion technologies. What is the proper lidar sampling design and how to expand the vegetation spatial structural parameters estimated at lidar footprints to global spatial coverage in high resolution need to be resolved. Models designed to simulate lidar and radar response from a variety of forest canopies can help answer these questions. In this paper we present an overview of our spatially explicit lidar and radar models and their use for examining the questions above. Laser Vegetation Imaging Sensor (LVIS) data, SRTM (Shuttle Radar Topography Mission) and PALSAR (Phased Array type L-band Synthetic Aperture Radar) on board of The Advanced Land Observing Satellite "Daichi" (ALOS) data over our test site were also used in the study.

The test site is the mixed hardwood and softwood forest of Northern Experimental Forest (NEF), Howland, Maine (45^{o}15'N, 68^{o}45'W). This site was the location of the NASA Forest Ecosystem Dynamics (FED) Multi-sensor Aircraft Campaign in 1990 and intensive SIR-C/XSAR experiments in 1994. The natural stands in this boreal--northern hardwood transitional forest consist of hemlock-spruce-fir, aspen-birch, and hemlock-hardwood mixtures. Every tree in a 200m by 150m area was measured for its location, dbh, and species in 1990, and was re-measured in 2003-2004, and 2006. LVIS data were acquired in the summer of 2003 as part of a NASA Terrestrial Ecology Program aircraft campaign. PALSAR data were obtained in 2006 and 2007.

Lidar waveform model and LVIS data were both used to study the impact of lidar sampling rates on forest biomass estimation accuracy, and the results showed that more samples are needed to get more accurate biomass estimations. Preliminary results showed that for estimation of biomass within a 50m by 50m pixel, four lidar samples with footprint size of 25m might be required. Extending lidar measurements from lidar sampling sites to regional area requires more aggregation of the data due to the factor that these two instruments are not sensing the same parts of the canopy from a single shot or pixel. From both model simulations and real data analyses it seems that 100m pixel size mapping can be realized by using 25m footprint lidar and 20m-30m resolution SAR with sufficient samplings o flidar and repeat passes of SAR.