Spaceborne Vegetation lidar (MOLI)

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A lidar is a generic term for light wave radar using pulse laser for transmitter. The lidar on board satellite can precisely measure the ground level and the forest canopy height and three-dimensional forest structure by analyzing round trip time until a light pulse irradiated from orbit to the ground is reflected at the ground surface and returned to the lidar on orbit. This paper propose the Japan’s first satellite-borne vegetation lidar (MOLI: Multi-footprint Observation Lidar and Imager) mission to investigate the above-ground ground forest biomass (AGB) on a global scale, which plays an important role for carbon cycle and climate change mechanism.
The main purpose of the MOLI mission on board ISS (International Space Station) -JEM (Japanese Experiment Module) is to successfully demonstrate the functional performance of the lidar in space for establishing a vegetation lidar that can acquire canopy height / three-dimensional forest structure information necessary for AGB evaluation with high accuracy. The second objective is to ultimately develop algorithms for highly accurate AGB estimation in high dense tropical forest zone that is inferior in reliability at the present time by merging MOLI data into L-band SAR (ALOS-2 / PALSAR-2 etc.) data and passive spectroscopic data such as GCOM-C / SGLI, and to obtain design guidelines for the practical space-borne lidar in future.
The MOLI proposed here has the function of self-determining the inclination angle and the azimuth angle for reducing the error in the canopy height measurement induced by the ground surface inclination. The output light of the pulse laser is split into two beams and then irradiated as a pair of foot prints on the ground surface. Each footprint diameter on the ground is 25 m, the footprint interval is about 50 m @ along - track, about 43 m @ cross - track. The inclination angle and the azimuth angle are determined from the difference between the trajectory-ground reciprocating time for three closest footprints among a large number of pairs of footprints appearing continuously in the along-track direction on each laser shot and on the ground. Transmission output is 20 mJ / pulse / foot print, repetition frequency 150 Hz, pulse width 7 nsec. The aperture diameter of the receiving optical system is 0.45 m, the detector is two-dimensional Si-APD, the A / D converter is bandwidth 500 MHz, 12 bit resolution. High resolution imager consists of R/G/NIR band, swath width 1000 m, ground resolution 5 m, and acquires information on the size, height, and field data of the canopy. Measurement accuracy of canopy height is <±3 m (<15 m forest height) or <±25% (> 15 m forest height) at ground level inclination angle <30 degrees. The target of AGB observation accuracy is <±20 t / ha (AGB<100 t / ha), <±25% (AGB> 100 t / ha) ,respectively. Field survey is an important work for forest management (forest register), but it comes across many difficulties especially in tropical forest areas. According to our estimate, by implementing MOLI data, a number of AGB field survey and survey costs are able to be reduced by 1/2 (ρ^2: coefficient of determination in two phase regression from ground survey to MOLI estimation) to 1/5 (ρ^2 = 0.8), there is a possibility of drastically reducing the maximum by 1/10 (ρ^2 = 0.9). A disadvantage of MOLI is strongly affected by weather conditions.

On the other hand, L-band SAR (ALOS-2 / PALSAR-2 etc.) is excellent not only for changes of AGB in real time because it can observe all weather, but also for measuring AGB even in steep mountain area because the method of correcting the distortion of data was recently improved very much. Since then, SAR observation is greatly been demanded. However, there is a big disadvantage for L-band SAR observation. Its backscattering signals easily saturate above AGB of 150 t/h in highly dense tropical forests, that is, in the South American Amazon basin, African Congo region, and Southeast Asia region. It will be able, therefore, to be achieved to improve the accuracy of AGB observation in the high dense rainforest region by complementing each other's advantage and disadvantage for MOLI and SAR with each other. Furthermore, realization of MOLI can be expected to work very effectively for JJ-FAST which is early warning system of deforestation using ALOS-2 / PALSAR-2. This logging detection system focuses on the measurement of deforestation area and does not have the function of AGB measurement. The fusion with MOLI data will also be able to precisely calculate the amount of carbon released at the logged place.

Keywords: Lidar, Canopy height , Forest structure, Forest biomass, L-band SAR, Imager