Approaches to forest biomass estimation by synthetic aperture radars

Kazuo Ouchi[1]

[1] National Defense Academy

http://www.jpgu.org/meeting/

There are two approaches proposed to estimate forest biomass by synthetic aperture radar (SAR) polarimetric data. The first is to use the regression curve computed from the correlation between the ground-truth biomass and backscatter radar cross section (RCS). The second method is a new technique to utilize the correlation between the texture information in SAR images and ground-truth biomass.

The RCS method is based on the observation that the RCS in SAR images increases with the forest biomass, and the unknown biomass is computed from the regression curve derived from this relation. However, the RCS saturates above some biomass levels and the saturation biomass depends on tree species, areas, radar wavelengths, and incidence angles. A report is presented that the L-band and P-band RCS saturate at 100 tons/ha and 200 tons/ha respectively for coniferous forests at incidence angles from 45-50 degrees. Other report indicates that in the mixed forests of Hawaii the C-band, L-band and P-band RCS saturation levels are approximately 20, 40 and 100 tons/ha respectively.

The second method based on the texture analysis is newly developed by the authors' group. In the SAR images of spatial resolution of around several tens meters, the images of individual trees are fallen into a single image pixel, and as a result the SAR images constitute noise-like intensity fluctuation known as speckle. Speckle obeys Gaussian statistics and does not carry information about the scatterers (trees). In high-resolution SAR images, on the other hand, individual tress are, to certain extent, identified, and the information such as branches, trunks and structures, is carried into the image pixels. Such textures images are known to follow non-Gaussian statistics.

In our study, an algorithm is developed to estimate forest biomass from the texture information in the Pi-SAR (Polarimetric-interferometric SAR) images of the coniferous forests in Tomakomai, Hokkaido, Japan. Pi-SAR, developed jointly by NICT and JAXA, is an airborne high-resolution SAR equipped with X-band polarimetric and interferometric antennas and L-band polarimetric antennas. We collected the ground-truth data including tree species, height, DBH (diameter at Breast Height) and soil moisture, over 40 districts in 2002, 2003 and 2005. The Pi-SAR data we used are L-band collected on 2002/11/07. Some biomass data were collected in different years from the Pi-SAR data acquisition, but they were converted to the corresponding time of 2002/11 using the equations of tree growth supplied by the local office of forest management.

First, a probability density function (PDF) which fits best to the data is sought among the K-distribution, Weibull distribution, log-normal distribution, inverse Gausian and Rayleigh distribution. Using AIC (Akaike Information Criterion) and least-square criterion, it is found that best-fitted PDF for all polarizations is the K-distribution, followed by the Weibull distribution. Further, the order parameter of the K-distribution in the HV cross-polarization data increases with increasing forest biomass with the high correlation coefficient of 0.89. For the case of the Tomakomai forests, the Pi-SAR RCS saturation level is approximately 40 tons/ha and it is not possible to measure the biomass beyond this saturation value. The method based on the order parameter, however, can estimate biomass up to around 100 tons/ha. Using the regression curve derived from this relation, the biomass values are estimated and compared with those measured on ground in 2005. The model accuracy of 85% is obtained.

In order to use the texture information, polarimetric SAR needs to be of high-resolution, but by combining this technique with the RCS method, the accuracy of estimating forest biomass by SAR should be expected to improve further.