Sap flow measurement for Japanese cedar throughout the year with three techniques and related problem

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Forests cover about 66% of land area of Japan, and Japanese cedar (*Cryptomeria japonica*) occupies 18% of total forested area. In Kyushu Island, south-western part of Japan, the water balance of Japanese cedar stand has been made clear quantitatively by using eddy-covariance method and sap flow technique (Kumagai et al., 2014; Shimizu et al., 2015). Meanwhile, except these studies, very few measurements of sap flow have been carried out throughout the year, although Japanese cedar is the most representative planted species in the larger part of Japan. Recently, newly developed techniques, that is heat ratio method (HRM, Burgess et al., 2001) and heat field deformation method (HFD, Nadezhdina et al., 2012), have been available in Japan. Considering the background mentioned above, we preliminarily compared these new methods with traditional thermal dissipation method (TDM, Granier, 1985) for a mature Japanese cedar planted at the central part of Japan. (Iida et al., 2015a). In this study, we show the results of measurement with HRM, HFD and TDM throughout the year. And we point out the common problem of three techniques: calculated sap flow becomes smaller when a single sensor is used for relatively long period (i.e., more than 10 months).

We conducted measurements in a mature stand of Japanese cedar, whose age is 63, within Tsukuba Experimental Watershed located in southern part of Mt. Tsukuba, Japan. We picked up a tree of Japanese cedar whose height is 24.9 m and diameter at breast height is 40.4 cm, and installed sensors of TDP, HRM and HFD. We used handmade sensors for TDM (e.g., Iida et al., 2015b) and sensors for HRM and HFD manufactured by ICT international Pty Ltd (type SFM1 and HFD8, respectively). The length of TDM sensor was 20 mm, and the sap flux density was computed as mean value along the sensor length by the calibration equation proposed by Granier (1985). The width of sapwood was 44 mm, and additional TDM sensor was inserted into the sapwood at the depth from 20 to 40 mm. On the other hand, the length of HRM sensor was 35 mm, and the sap flow movement was detected at the depths of 12.5 and 27.5 mm. For HFD, the sensor length was 96 mm, and the depths of sap flow detected were 20, 30, 40, 50, 60, 70, 80 and 90 mm.

The values of sap flux density by HFD showed high correlation with vapor pressure deficit (VPD). Generally, conifer canopy has large aerodynamic conductance due to the needle leaf, and therefore has high coupling with the ambient air. Thus, the high correlation with VPD is reasonable. Similar trends were confirmed for TDP and HRM. However, the relationships changed with time, and sap flux densities had become gradually smaller since the sensor installation. The clear deterioration was found at 10-months after the installation, in common to TDP, HRM and HFD. This may be induced by wounding or air embolism, which cause disruption in water flow around the sensors (e.g., Moore et al., 2010). Therefore, to obtain the whole-year dataset of sap flow, attentions must be paid for any deteriorations by checking the relationships between sap flow and VPD.

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