Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PEM27-P01 Room:Convention Hall Time:May 26 18:15-19:30

Water vapor estimation using digital terrestrial broadcasting wave

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We, National Institute of Information and Communications Technology (NICT), are developing a water vapor measurement system using digital terrestrial broadcasting wave. Radio waves are delayed due to water vapor through propagation. Water vapor can be retrieved by measuring this time delay. If the humidity increases by 1 %, radio waves delay by about 17 ps during propagating 5 km distance. Very precise measurements (at least several tens of pico-second order) are needed for the effective observations. Radio waves used for digital terrestrial broadcasting are modulated with OFDM, and known signals (SP signals) are embedded. Complex delay profiles are calculated using these known signals. Using the phase of delay profile, we can measure propagation delay with precise accuracy (pico-second order). When we consider the accuracy with order of sub-nano seconds, phase fluctuations of local oscillators at radio tower and receivers are essential error factors. So we measure the propagation delay at two receiving points on the same line including the radio tower. Each result includes phase fluctuations of local oscillators at radio tower and receivers. Phase fluctuation of local oscillator at radio tower will be canceled out by taking the difference. We can estimate water vapor between two receiving points by synchronization between their local oscillators.

We are developing a real-time delay (phase of delay profiles) measurement system with software-defined radio technique. We have improved this system and maximum number of channels which can be processed in real-time has expanded to 5. Measurement accuracy of this system is evaluated, and the time resolution of measured delay time is found to about 50 ps. We plan to use CATV to synchronize the local oscillators at different sites. Signals pass-through in the CATV network are the same RF signals as that transmitted from the radio tower, and they can be also processed with the system mentioned above. Phase fluctuations of local oscillators at both sites are canceled out using the signals pass-through in CATV as references. Each signal pass-through in CATV has its own delay due to the difference of network path. We have developed the method to correct it. The precision of synchronization is less than 100 ps, and in-house test is going on to improve it. We are planning demonstration experiments to estimate water vapor using two receiving stations in next summer. We will use optical fiber synchronization method, which is already established by NICT, to evaluate CATV synchronization. We investigate miniaturization of measurement system using DSP board for the multi-point measurement in the future.

Keywords: water vapor, radio wave, propagation delay, digital terrestrial broadcasting