Estimation of water vapor variation with digital terrestrial television broadcasting wave

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This paper is devoted to develop the humidity estimation method by using the atmospheric propagation delay of digital television (DTV) radio-wave. Detailed structure of refractive index is dominantly determined by the temporal and spatial variation of atmospheric water vapor by detecting the propagation delay between DTV transmission and receiving antennas. Previous studies was severely annoyed by the oscillator noise of the transmitter and receiver. Due to the strong phase noise, the propagation delay has not been derived precisely.

This study invented a breakthrough method to solve these problems by detecting two DTV stations signal simultaneously. This method uses two receivers nearby and far away from DTV antenna.

Firstly, each receiver processes the subtraction of pilot signal between two DTV stations. In the next step, the subtraction of the above differential signal between two receivers removes the most of error due to oscillator fluctuations. The receiver system is consisted of software radio receivers and Rubidium oscillators. CP (continuous pilot) and SP (scattering pilot) is extracted from OFDM (orthogonal frequency-division multiplexing) carrier of DTV signal.

Prior to field experiment, the precision of receiver is investigated by comparing the results of two collocated receiver systems at Uji Campus of Kyoto University. Three evaluation test was conducted by detecting DTV signal transmitted from Ikoma station. In the first test, phase difference of CP signals neighboring DTV channel is detected, and found the system noise is much larger by 30 dB than the atmospheric propagation delay.

In order to decrease the system noise, this study developed two new methods to integrate many differential signals of SP from single or double station(s), whose frequency is separated by a constant value of 6 MHz or 3 MHz. Both method show excellent improvement of phase error reduction. The system error of propagation delay significantly decreased to 5.47 mm and 7.80 mm, respectively.

This promising method is very useful to monitor horizontal variation of humidity in the boundary layer and expected to proceed to field test very soon.

Keywords: water vaper, digital television, atmospheric propagation delay, atmospheric boundary layer, localized heavy rain

