Ray tracing of VHF radio wave propagation affected by equatorial and low latitude ionospheric phenomenon

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VHF radio waves at 48.25 MHz transmitted from Malaysia TV station (geog. 3N, 101E) were received at Tateyama observatory (geog. 35N, 140E) located at about 5200 km from the transmitter.

The VHF radio waves were frequently observed mainly in the afternoon (JST) in spring and fall although the frequency of the radio waves is much higher than the critical frequency of ionosphere.

Propagation path of the VHF radio waves contain the ionosphere whose magnetic dip angle are about 0 to 40 degree.

For propagation mechanism of VHF radio waves, many important post-sunset ionospheric phenomena occur in the equatorial and low latitude ionosphere.

Namely, VHF radio waves may be affected by equatorial spread F and/or equatorial ionization anomaly.

Actually, the receiving level of the radio waves fluctuated drastically with the time scale of hours to several tens minutes.

Although the propagation path of the VHF radio waves may be frequently disturbed by such equatorial ionospheric phenomena, it is not obvious whether the receiving level of the VHF radio waves can be affected by the irregularities since the frequency of the radio waves is much higher than the plasma frequency disturbed by the phenomena.

We performe propagation simulation using ray-tracing method to investigate propagation mechanism of the VHF radio waves and effect of such ionospheric irregularities for the receiving level.

We used a set of two dimensional ray-tracing equations for the polar coordinate system to consider curvature of the earth.

The equations are numerically integrated with the 4th-order Runge-Kutta method with adaptive step control.

Ionospheric refractive indices for the radio waves are approximately calculated for a cold collisionless plasma composed of electron.

We make use of IRI model for ionosphric profile to investigate seasonal and diurnal variation of the receiving level.

For given ionospheric profile, the radio waves which are transmitted with any given elevation angle propagate in the ionosphere and are gradually refracted.

Although the radio waves panetrate the ionosphere since refraction is not sufficient for most elevation angles, radio waves which transmitted with near horizontal elevation angles can be reflected in the ionosphere and returned onto the ground.

Then, the reflected radio waves can received at some locations on far from the transmitter.

We evaluate the receiving level of the radio waves by the hestgram of the locations on ground.

We call the hestgram 'ray density distribution'.

As the simulation result, the VHF radio waves would be received at the locations between about 5000 to 3000 km from the transmitter in the afternoon in spring and fall.

The result is consistent with our observational results mentioned above.

The result also suggests that the receiving level of the radio waves fluctuates drastically by ionospheric diurnal variation.

The region in which equatorial ionization anomaly appears locates just across the propagation path of the radio waves and then the reflection height of the radio waves fluctuate.

Thus, according to local time dependence of equaorial ionization anomaly, the great circle distance which can receive the radio waves lengthen and shorten, then the receiving level fluctuates.

The ray density distributions which are calculated for each local time have typical shape.

Therefore, time variation of the receiving level can reflect the typical shape since the ray density distribution sweep the ground.

While we also investigate effects of ionospheric irregularities for the receiving level.

We suppose that plasma bubble, plasma depletion, as equatorial ionospheric irregularities occur on propagation path of the radio waves.

The region in which plasma bubble appear have approximatelly refractive index of unity.

The simulation result suggested that such ionospheric irregularities also influence on receiving level of the radio waves.