Bistatic remote sensing of the atmosphere and Earth's surface using GNSS radio occultation signals

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Bistatic scheme using the Global Navigational Satellite System (GNSS) signals is regarded as an innovative remote sensing technique for studying the Earth's environment and could complement investigations using radiometers and radars. In this contribution the relationships between the Doppler shifts, its derivation with respect to time, the eikonal acceleration, and refractive attenuations of the direct and reflected signals are established for bistatic remote sensing. These connections allow recalculating the derivative of the Doppler shifts (or the phase delays) on time to the refractive attenuation (reflectivity cross-section) and open a new avenue for potentially measuring the total absorption in the atmosphere at low elevation angles using the surface reflections. The fundamental characteristics of bistatic remote sensing of the Earth's surface such as the phase delay, reflection coefficient, reflectivity cross-section, and Doppler shift of the reflected signals relative to the direct signals are obtained in analytical forms by taking into account the refraction and absorption effects in the atmosphere. Difference in the Doppler frequencies of the reflected and direct signals is proportional to the difference of the modified refractive index at the radio ray perigee and at the Earth's surface. The obtained analytical results are in good agreement with the measurements data obtained during the MIR/GEO (wavelengths 2 and 32 cm), and CHAMP (wavelengths 19 and 24 cm) radio occultation experiments. Detecting the reflected signals in radio occultation data has opened new perspectives for bistatic radio-holographic monitoring of the Earth's surface at low elevation angles. Experimental results of the propagation effects at low elevation angles are of great importance for fundamental theoretical investigation of radio waves propagation. The work is partly supported by RFBR grant No. 10-02-01015-a.