ELECTROMAGNETIC WAVE PROPAGATION THROUGH A 2-D INHOMOGENEOUS ATMOSPHERE

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Radio occultation methods are gaining increasing importance for sounding planetary atmospheres. For the Earths atmosphere, Global Positioning System (GPS) satellites serve as the signal sources for the radio occultation measurements. By studying the signal that passes through the inhomogeneous atmosphere, and is received by a Low Earth Orbit (LEO) satellite, useful information about the atmosphere can be obtained, such as the refractivity, temperature at altitudes where water vapor is negligible, and with additional data, temperature and water vapor at levels where water vapor is significant. Multiple-phase-screen techniques are often used as an efficient computational method for solving the problem of wave propagation through an inhomogeneous atmosphere. In multiple-phase-screen techniques, the atmosphere is first divided up into a finite set of regions that are separated by parallel phase screens. The inhomogeneities in the vertical gradient of the atmospheres refractive index that occur between two successive phase screens are then treated as a phase correction factor on the phase screens. Fast Fourier Transform (FFT) techniques are then used to propagate the field between the phase screens.

In previous studies, the incident GPS signal was treated as a plane wave and the phase screens were defined as parallel planes in the rectangular coordinate system. However, because of the finite distance between the GPS satellite and the Earth, the incident plane wave approximation is not suitable. If the finite distance to the GPS satellite is accounted for, then the incident wave will exhibit a rapidly varying phase on the first planar phase screen. In order to overcome this problem, we have developed a new method to model the forward EM wave propagation through an inhomogeneous atmosphere, in which the waves emanate from a 2-D line source and the propagation is studied in the cylindrical coordinate system. In this method, a 2-D line source that is placed at the origin of a cylindrical coordinate system is used to represent the GPS satellite. Phase screens are then defined at constant radial distances, thereby providing cylindrical phase screens. Since the cylindrical phase screens are centered about the origin, the phase will be constant, instead of varying rapidly as is the case for a planar phase screen. This new cylindrical, 2-D approach better matches the physical phenomenology of the cylindrical waves that are produced by a 2-D source that is located at a finite distance from the Earth, thereby leading to improvements in the accuracy and efficiency for this 2-D propagation problem.

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