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Angle and Time of Arrival Characteristics of 3D Air-to-Ground Radio Propagation Environments

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Abstract

A three dimensional (3D) geometric channel model is proposed for ground-to-air (G2A) and air-to-ground (A2G) communication links. A low-elevated ground station (GS) and a high-elevated air station (AS) are taken at foci points of a virtual bounding ellipsoid corresponded from known knowledge of delay of longest propagation path. The effective region of scatterers around the GS is designed on the basis of this ellipsoid truncated by the average rooftop level (or average height of sea waves) and ground plane. Closed-form expressions for joint and marginal probability density functions (PDFs) of angle of arrival (AoA) observed at AS and GS in correspondence with azimuth and elevation angles are derived. Furthermore, closed-form expressions for density of energy with respect to the delay of arriving multipath waves corresponded from both the elevation and azimuth AoA are derived independently when observed from either end of the communication link. Moreover, effect of different physical parameters of the channel on distribution of energy in angular and temporal domains is presented. The comparison of analytical results with results of a notable model is also presented. In order to verify the derived analytical expressions, a comparison of analytical results with the performed simulation results is presented, which shows a good match.

Keywords: Channel Modeling, Air-to-Ground Communication, Ellipsoid, Multipath Channels, Scattering.

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