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FREE-SPACE LASER COMMUNICATIONS FOR SATELLITE DOWNLINKS: MEASUREMENTS OF THE ATMOSPHERIC CHANNEL

Abstract

Future satellite communications can benefit greatly from the usage of frequencies in the optical spectrum. These allow data-rates comparable to fibre optical communications and provide additional advantages over traditional radio-frequency carriers like more power efficiency, small weight and size, and usage of frequency bands without ITU regulation, all meeting the demands on satellite payloads. However, optical satellite downlinks are affected by the degradation of signal quality due to atmospheric turbulence. In fact, a profoundly verified channel model for this scenario does not exist yet, as there is no satisfying database of channel measurements so far. To contribute in disposing this lack of data, the Optical Communications Group (OCG) at DLR performed laser downlinks from the Japanese OICETS to the DLR optical ground station in Oberpfaffenhofen (OGS-OP) near Munich, Germany, in 2006 and 2009. The trials in 2006 were under cooperation of JAXA, NICT and DLR, whereas in 2009 they were part of a downlink-campaign comprising JAXA, NICT, ESA, NASA/JPL, and DLR. Measurements of intensity scintillations and wavefront distortions were undertaken that show the development of atmospheric turbulence over the elevation angle. Measurement devices like the differential image motion monitor, turbulence profiler, and Shack-Hartmann-wavefront sensor were applied. Furthermore, power vectors over time were recorded with a PIN diode. The most important metrics derived from the measurements are Fried parameter, scintillation index, and intensity correlation length. Altogether, these measurements may form the basis of a future channel model. The applied communication scheme was a 50-Mbit/s on-off keying at a wavelength of 847 nm. Bit-error rates were recorded in parallel to the atmospheric measurements. The Receiving antenna was a 40-cm Cassegrain telescope in the optical ground station. The receiver front end consisted of a free-space coupled APD. Optical tracking was used on satellite and ground station side. To reduce uplink scintillations, two spatially separated beacon laser emitting at 808 nm were employed at the OGS. Nine trials out of eighteen could be performed successfully while the others were hindered by cloud blockage. The elevation angle above horizon ranged between 1 and 55 . The present paper contains a description of the experiments in 2006 and 2009 and highlights the results of the measurements. The setup of the optical ground station is outlined as well as the measurement devices and results.