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Path-average rainfall estimation from optical extinction measurements using a large-aperture scintillometer

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The potential of a near infrared large-aperture boundary layer scintillometer as path-average rain gauge is investigated. The instrument was installed over a 2.4 km path in Benin as part of the AMMA Enhanced Observation Period during 2006 and 2007. Measurements of the one-minute average received signal intensity were collected for 6 rainfall events during the dry season and 16 events during the wet season. Using estimates of the signal base level just before the onset of the rain events, the optical extinction coeffcient is estimated from the path-integrated attenuation for each minute. The corresponding path-average rain rates are computed using a power-law relation between the optical extinction coeffcient and rain rate obtained from measurements of raindrop size distributions with an optical spectropluviometer. Comparisons of five-minute rainfall estimates with measurements from two nearby rain gauges show that the temporal dynamics are generally captured well by the scintillometer. However, the instrument has a tendency to underestimate rain rates and event total rain amounts with respect to the gauges. It is shown that this underestimation can be explained partly by systematic differences between the actual and the employed mean power-law relation between rain rate and specific attenuation, partly by unresolved spatial and temporal rainfall variations along the scintillometer path. Occasionally, the signal may even be lost completely. It is demonstrated that if these effects are properly accounted for, by employing appropriate relations between rain rate and specific attenuation and by adapting the path length to the local rainfall climatology, scintillometer-based rainfall estimates can be within 20% of those estimated using rain gauges. These results demonstrate the potential of large-aperture scintillometers to estimate path-average rain rates at hydrologically relevant scales.