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Experimental identification of receiver-side thermal effects on RSL baseline fluctuations in CML-based precipitation measurements

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Commercial microwave links (CMLs) are increasingly used as opportunistic sensors for precipitation monitoring, providing high spatiotemporal coverage in urban and regional environments. However, the accuracy of attenuation-based rainfall retrieval from CMLs is strongly affected by systematic fluctuations in the received signal level (RSL) baseline, which often exhibits a pronounced 24-hour periodicity even under dry conditions. The physical origin of this periodic baseline variation remains unclear and represents an important source of uncertainty in precipitation measurements.

In this study, we conduct a controlled outdoor experiment to identify the dominant driver of RSL baseline fluctuations. Targeted thermal perturbations were applied to the outdoor units (ODUs) of operational CMLs, while RSL, receiver-side ODU internal temperature, and ambient air temperature were synchronously recorded. By actively modifying the thermal behavior of the receiver ODUs, we demonstrate that the periodic variation of receiver ODU internal temperature is the primary cause of the RSL baseline fluctuation. When the internal temperature periodicity was disrupted, the corresponding RSL periodicity was significantly weakened, and the apparent correlation between RSL and air temperature disappeared. In contrast, heating applied only to transmitter-side ODUs or insufficient thermal perturbation produced no observable effect.

These findings provide the first experimental evidence that receiver-side instrumental thermal dynamics, rather than atmospheric variability along the propagation path, govern the periodic RSL baseline fluctuation in CML observations. The results identify a key source of bias in CML-based precipitation retrieval and offer a physical basis for improving baseline correction and uncertainty characterization in opportunistic rainfall measurements.