Preliminary Opportunistic Sensing of Precipitation Using 5G mmWave Commercial Cellular Equipment

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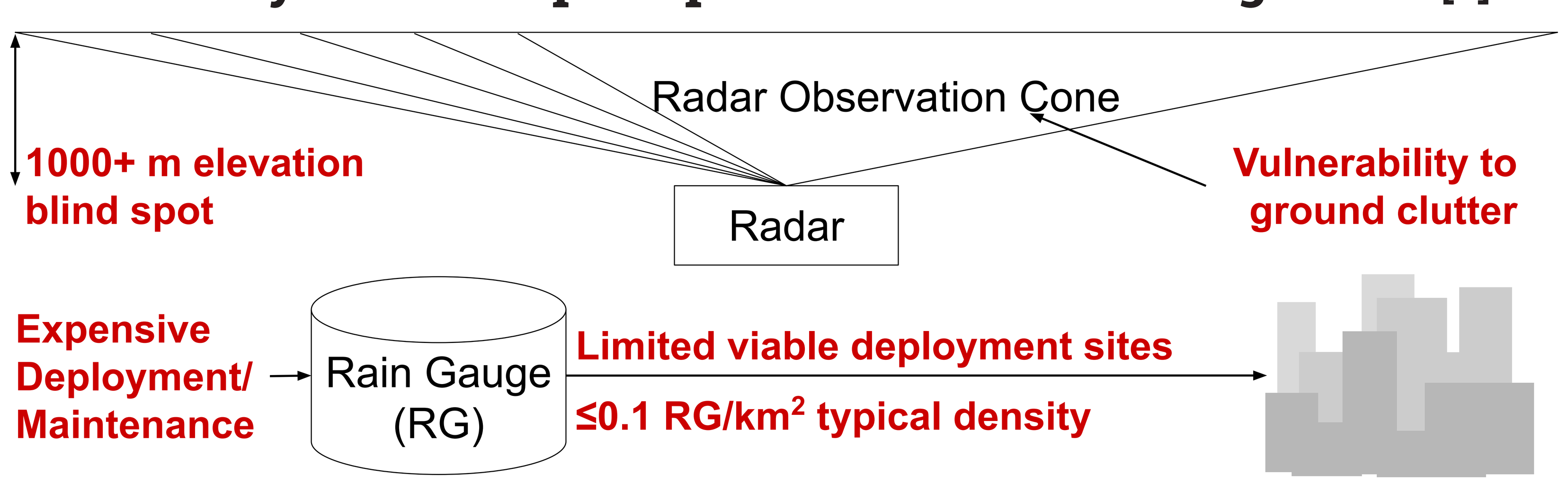
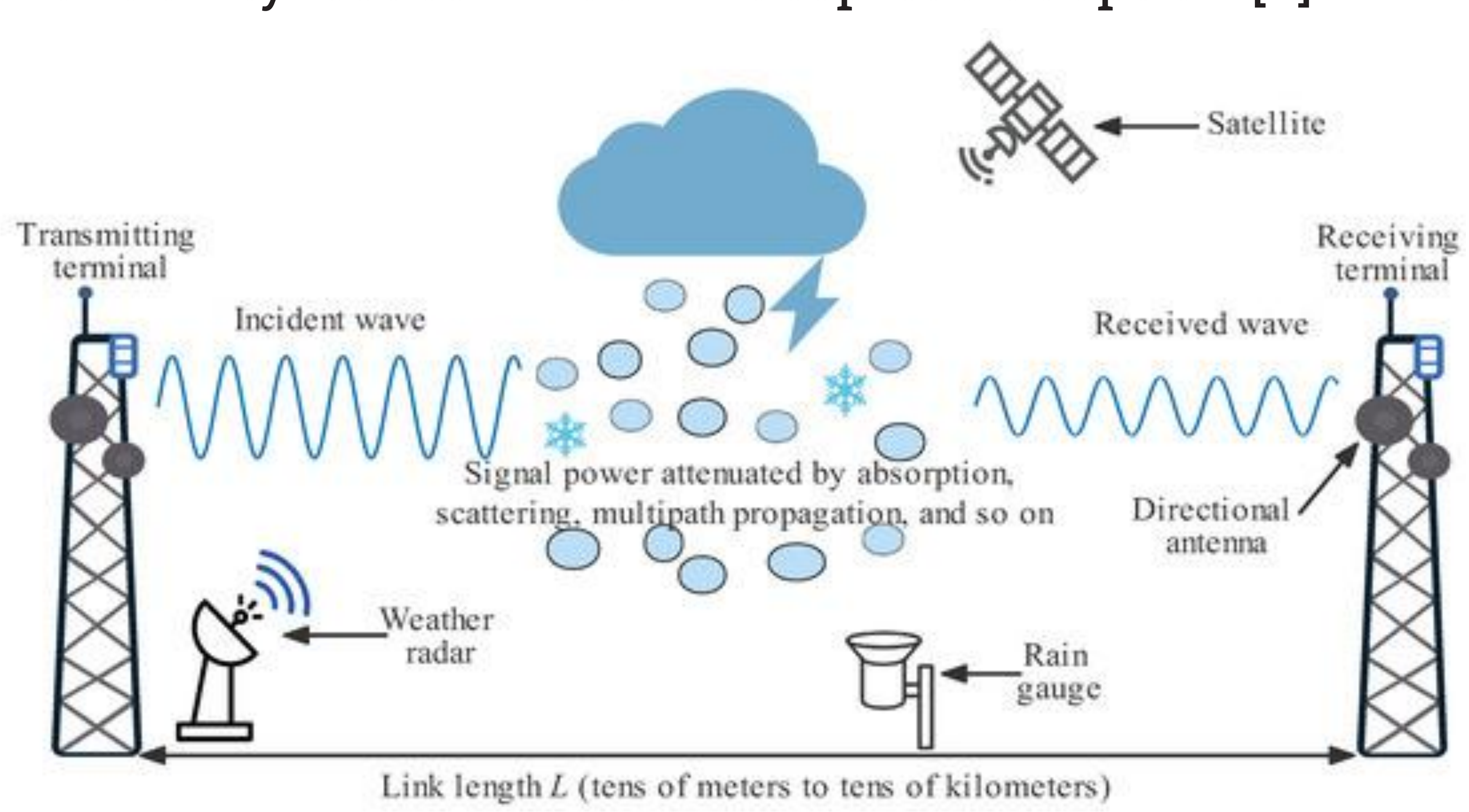
BACKGROUND

As a primary driving force of the water cycle, rainfall impacts virtually every terrestrial process and ecosystem. Precipitation is a highly dynamic process in both space and time, and **conventional precipitation measurement methods such as rain gauges and satellites struggle to accurately estimate precipitation fields on the ground** [1]



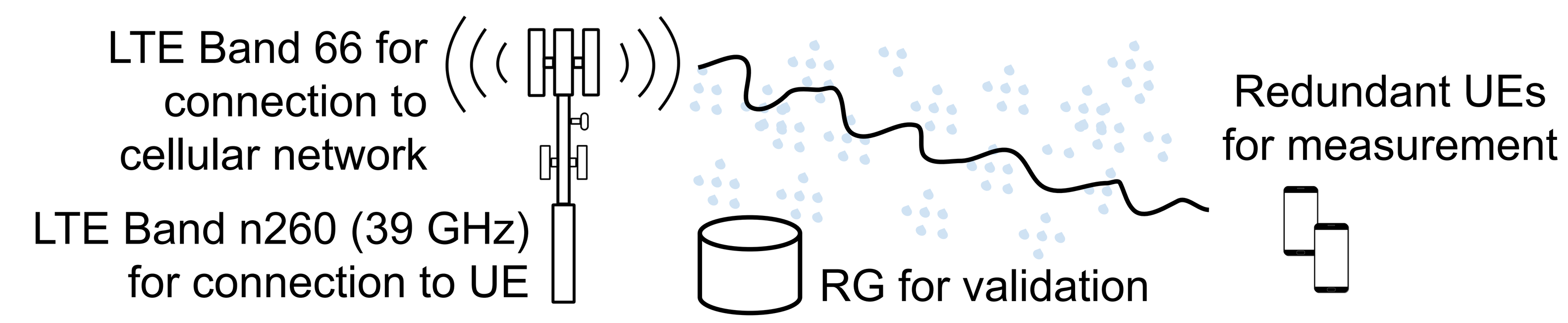
Rain-rate retrieval from Commercial Microwave Links (CMLs) used in cellular network backhaul has emerged as a solution for low-elevation precipitation measurements, as depicted below in the figure from [2]. However, data availability issues hinder widespread adoption [2].



Researchers have begun to investigate using signals from cellular user equipment (UE), i.e. mobile phones, to estimate rain rate at LTE frequencies and below [3]. These studies have shown correlation between cellular signals and precipitation, **but have been unable to perform extraction of rain rate because of the weak, exponential nature of the relationship between rainfall and attenuation at these frequencies.**

OBJECTIVE

To address challenges in precipitation estimation at low frequencies, we will simultaneously measure rainfall and cellular signal attenuation at 39 GHz to estimate rain using data from commercial cellular user equipment.



THEORY

Attenuation-based estimates of precipitation are generally done using the relationship described in ITU-R Rec P.838-1 [4] . While this equation describes an exponential relationship, α is about 0.85 for 39 GHz, so the relationship between rain rate and attenuation is nearly linear at the frequencies used in our experiment.

Function of frequency and antenna characteristics

Specific Attenuation (dB/km)

$$\gamma_R = kR^{\alpha}$$

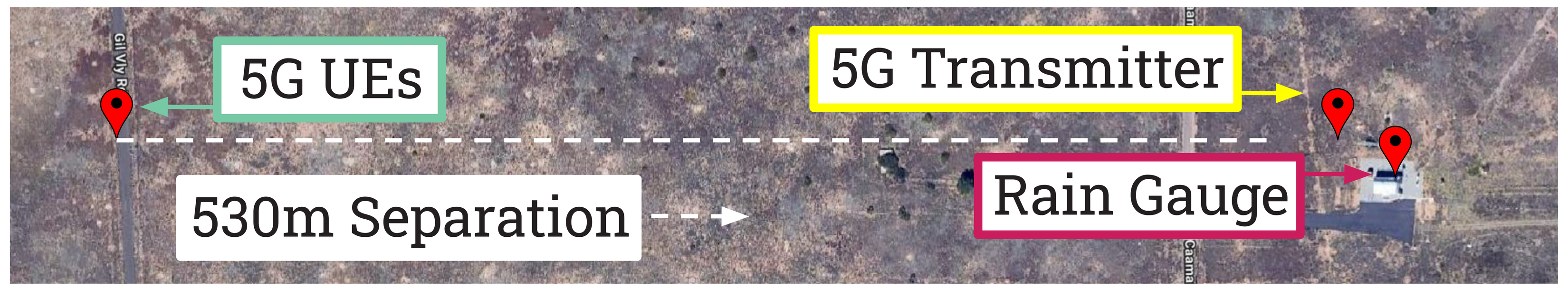
Rain rate

EXPERIMENT SETUP

To take measurements, we mount two 5G mmWave UEs to the interior of a car window parked 530m away from the transmitter and rain gauge. The UEs are connected to a laptop via USB which provides power and data transfer. The laptop power is supplemented with a power bank to enable long data captures. The figures below show the data capture configuration (left) and the transmitter and RG from the point of view of the UEs (right).

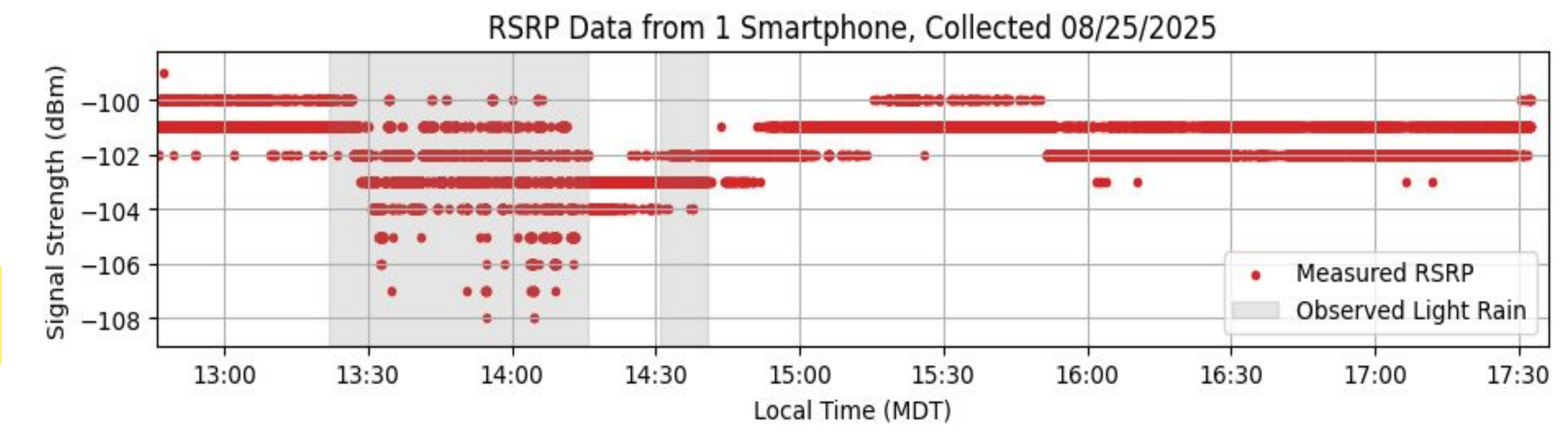
SITE LAYOUT

The experiment setup is located at the Table Mountain field site, located about 6 miles northeast of Boulder. The figure below shows the Google Maps satellite view of the field site overlaid with key experiment features.



INITIAL RESULTS AND NEXT STEPS

The figure below shows data from one UE during the first capture of a rain event using the described measurement system. The figure shows that, for the longer period of rainfall, the reference signal received power (RSRP) data exhibits an increase in variability.



These results indicate that precipitation noticeably affects RSRP in 5G mmWave UE data and prompt the need for more measurements to understand the relationship between those variables. Our next steps are to take data from more rain events and attempt to fit a model relating rain rate and RSRP data. The results of this work could lay the foundation for future next-generation precipitation measurement networks.

ACKNOWLEDGEMENTS

This work was supported in part through SpectrumX, the National Science Foundation (NSF) Spectrum Innovation Center, funded via Award AST 21-32700 and operated under Cooperative Agreement with NSF by the University of Notre Dame.

References