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3D Geolocation of Simulated Lightning Sources from Low-Earth Orbit

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The recent removal of the Lightning Imaging Sensor from the International Space Station has left an observational gap in lightning detection from low-Earth orbit (LEO). However, new studies have demonstrated the potential for 3D geolocation of lightning sources using orbiting sensors. The Cubespark mission concept aims to take advantage of these developments by deploying a constellation of satellites with radio frequency (RF) sensors and optical imagers to not only map lightning locations, but also to collect bi-spectral flash images. These new capabilities include mapping storm charge structure, flash channel structure, and distinguishing microphysical processes throughout flash development, helping link microphysics and convective processes with overall flash and storm structure around the globe from LEO.

In this study, we simulate lightning RF sources in the very high frequency (VHF) band, extrapolate their signals to space-based detection using an improved ionospheric model, and reconstruct their 3D locations using a time-of-arrival (TOA) minimization algorithm. Various constellation configurations, locations, and atmospheric conditions are considered in order to identify and quantify the three main sources of geolocation error: geometric, ionospheric, and instrumental effects. The promising results of this study emphasize the potential of space-based 3D lightning mapping under diverse conditions. 3D resolution is shown to be better than 1-2 km in many cases, enabling new global applications in meteorology and climate sciences. Here we present a selection of these geolocation results as seen from space alongside recent advancements, paving the way for a future generation of LEO lightning mappers.