Airborne Measurements of Lightning Locations During Flights in Coastal Thunderstorm Conditions

Lightning poses a significant risk to aircraft safety, especially as the aviation industry transitions from conventional to hybrid and electric aircraft. It is becoming more common to rely on remotely piloted aircraft systems (RPAS), unmanned aerial vehicles (UAVs), and vertical take-off and landing aircraft (VTOLs) for all-weather aerial activities like transportation and the delivery of goods. Important flight operations decisions of postponing or diverting flights due to severe weather are reliant on accurate information about the presence of lightning and its type, location, flash rate, and information about the ambient conditions inducive of lightning. At present, numerous well-established ground and satellite-based methods exist for monitoring lightning activity. At best, aircraft can receive weather updates from ground sources every 2.5 to 5 minutes, but it is not uncommon for updates to be intermittent due to connection and service stability issues. Therefore, an aircraft-mounted lightning locator may be the most practical source of real-time lightning information for pilots. Detailed performance metrics with uncertainties for commercial airborne lightning locating systems are typically not published and the literature investigating such systems is limited. Here, we present airborne lightning measurements obtained using the commercially available Stormscope Weather Mapping System (WX-500 Series 2; ~1 to 100 kHz). This single-station direction-finding sensor was installed on the Convair-580 research aircraft owned and operated by the National Research Council of Canada (NRC) during the 2022 Experiment of Sea Breeze Convection, Aerosols, Precipitation, and Environment (ESCAPE) campaign in Houston, Texas, which targeted convective updrafts (up to 30 m/s). Stormscope performance is assessed through comparisons to high-quality datasets of total lightning activity provided by the Houston Lightning Mapping Array (HLMA; 60 to 66 MHz) and the GOES - Geostationary Lightning Mapper (GLM; 777 nm). Measurements from two thunderstorms near Houston, TX, yielded WX-500 detection efficiencies of 33% and 42% for intracloud flashes, 75% and 64% for cloud to ground flashes, and 53% and 79% for total flashes. The WX-500 bearing measurement was accurate to within ±14° (σ), which improved to ±4° when integration time was increased from 2 to 30 s and clear outliers were ignored. The WX-500 range measurement was overestimated by an average of +74 km (±50 km) when the average true flash distance was 94 km. The WX-500 accurately depicted the boundary of lightning activity at an integration time of 1 min which is sufficient for the circumnavigation of thunderstorms. Also presented are in-flight microphysics data including high-resolution images of single particles within in a lightning producing cell.

Short bio: Zack is a PhD student with the atmospheric research group at the NRC's Flight Research Laboratory. In addition to working with all kinds of flight test data, Zack has significant experience with CFD, two phase flows (experiment + simulation), and ice accretion modelling.