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Characterisation and modelling of lightning strikes as point events in time and space

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Lightning, a spatio-temporal phenomenon, comprises of individual strikes with specific occurrence times and spatial coordinates. This study models and characterises lightning strikes from single thunderstorms, treating each strike as a point event. Utilising real-world datasets, we characterise and model lightning strikes' physical properties. Our analysis involves two severe UK thunderstorm systems, selected based on published synoptic analyses. These systems enable subdivision of the lightning dataset into subsets, each representing a distinct thunderstorm. Our two major storm systems feature three thunderstorms each: Storm system A with 7955, 11988, and 5655 strikes over the English Midlands on 28 June 2012; Storm system B with 4218, 455, and 1926 strikes characterised over the northern England on 1-2 July 2015. These six datasets exemplify individual thunderstorms and a total of three physical attributes are : movement speed, lightning inter-event time distribution, and spatial spread about the storm track. Applying least-squares plane and linear fits in the spatio-temporal and lag spaces, we estimate movement speeds of 47-59 km/h and 67-111 km/h for Storm systems A and B, respectively. The inter-event time distribution ranges from 0.01 to 100 seconds, with density peaks around 0.1 seconds and at 1-10 seconds. Autocorrelation analysis in natural time reveals significant autocorrelation in all storms, varying from short-range to long-range. For spatial spread, calculated as the distance from the storm track to the strikes, we employ a linear filter to establish the storm track. This analysis yields typical spatial spreads up to 80 km in either northing or easting dimensions, with an outlier of 226 km in the northing dimension for one storm. The paper concludes with a synthetic lightning strike model. This model allows selection of individual storms' starting points, directions, and movement speeds, generating point events based on our characterisation findings. This comprehensive study of lightning strikes in time and space accurately reflects severe thunderstorms' behaviour and informs statistical models for simulating lightning events.