# Characterisation and Modelling of Lightning Strikes as Point Events in Time and Space

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UKRI Engineering and Physical Sciences Research Council


## Outline:

1. Selection of UK lightning case studies
2. Characterisation of lightning strike parameters in time and space
3. Modelling lightning strikes as synthetic point-events produced by a moving source

# Objective

To **model lightning** strikes **as point events** produced by a moving source and **generate synthetic lightning** strike **datasets** representative of real-world lightning data -> **relating** the **model input parameters** to the **characterised physical variables**.

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# 1 Selection of UK lightning case studies

- ATDnet Network for lightning strikes.
- **Two days** increased **lightning activity** over the UK are selected.
- Based on synoptic analyses:
  a) Three supercell thunderstorms on **28 June 2012** (Clark and Webb, 2013).
  b) Three structurally distinct severe thunderstorms on **1 July 2015** (Lewis and Silkstone, 2017).

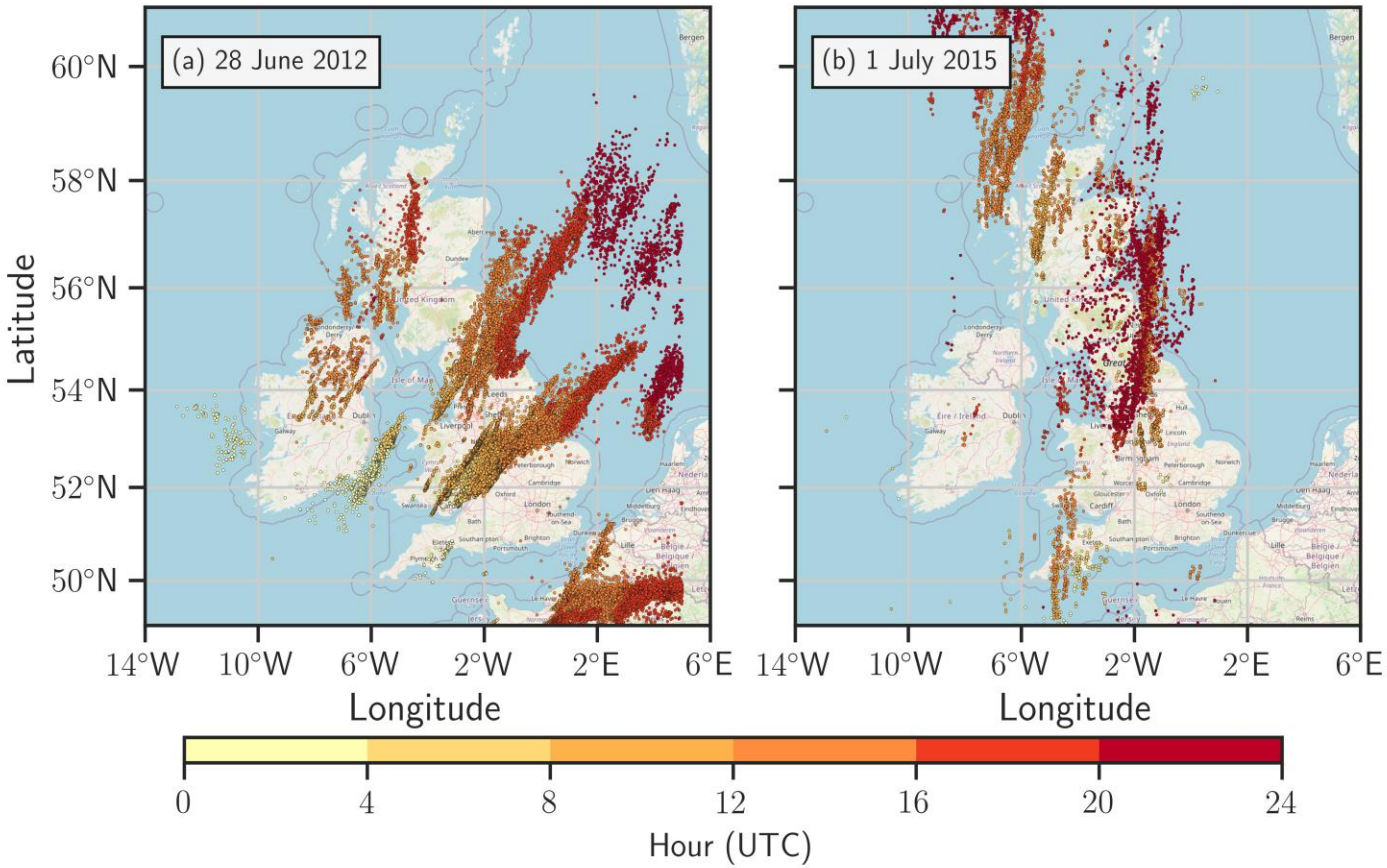


**Fig. 1:** Lightning strikes (a) 28 June 2012 and (b) 1 July 2015 (data from ATDnet network).

# 1 Selection of UK lightning case studies

- **Individual thunderstorms** are then **separated in** the three-dimensional **spatio-temporal space**.

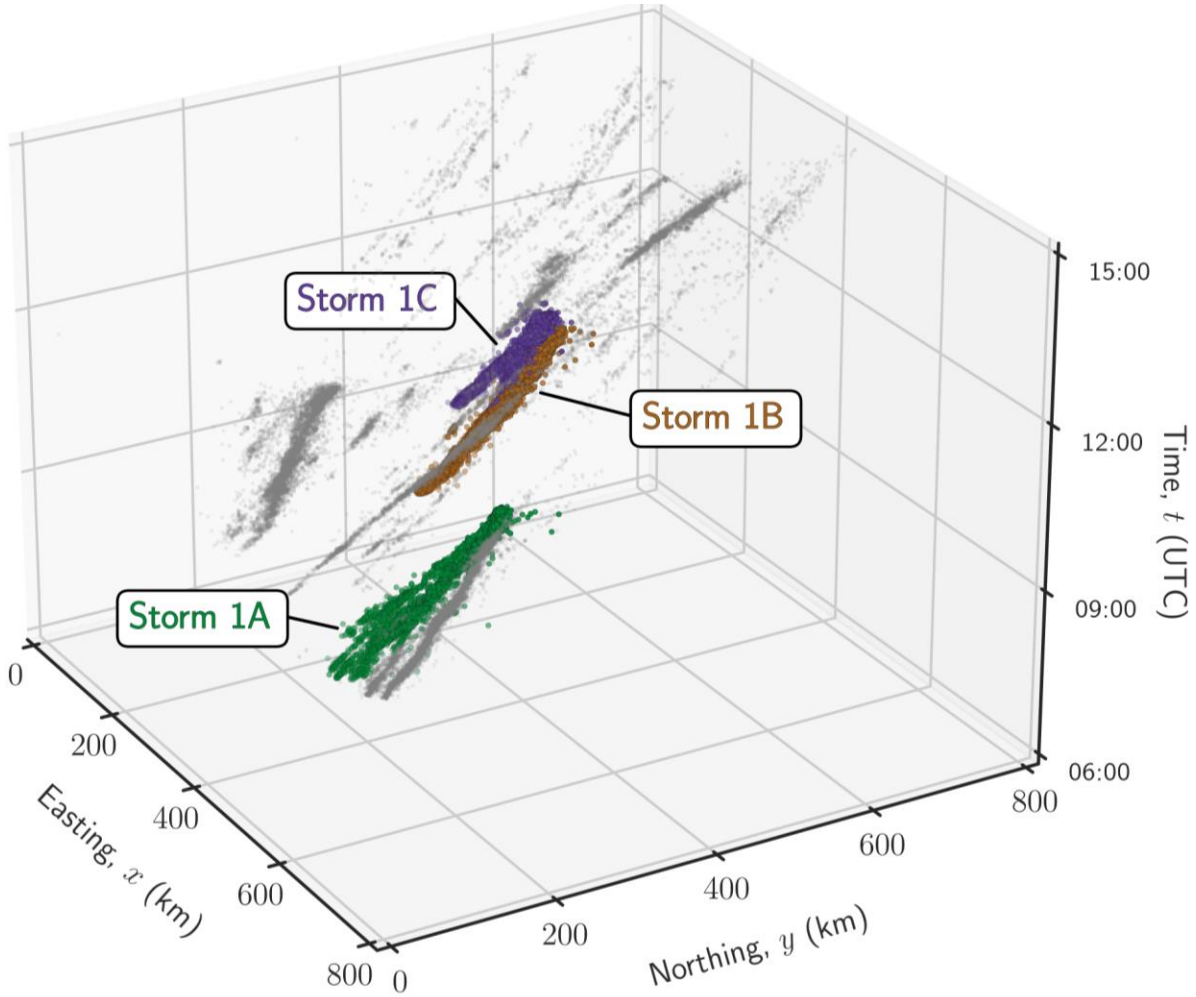


**Fig. 2:** Lightning strikes from 28 June 2012 (Storm 1) separated and assigned to the three supercell thunderstorms.

## 2 Characterisation of lightning strike parameters in time and space

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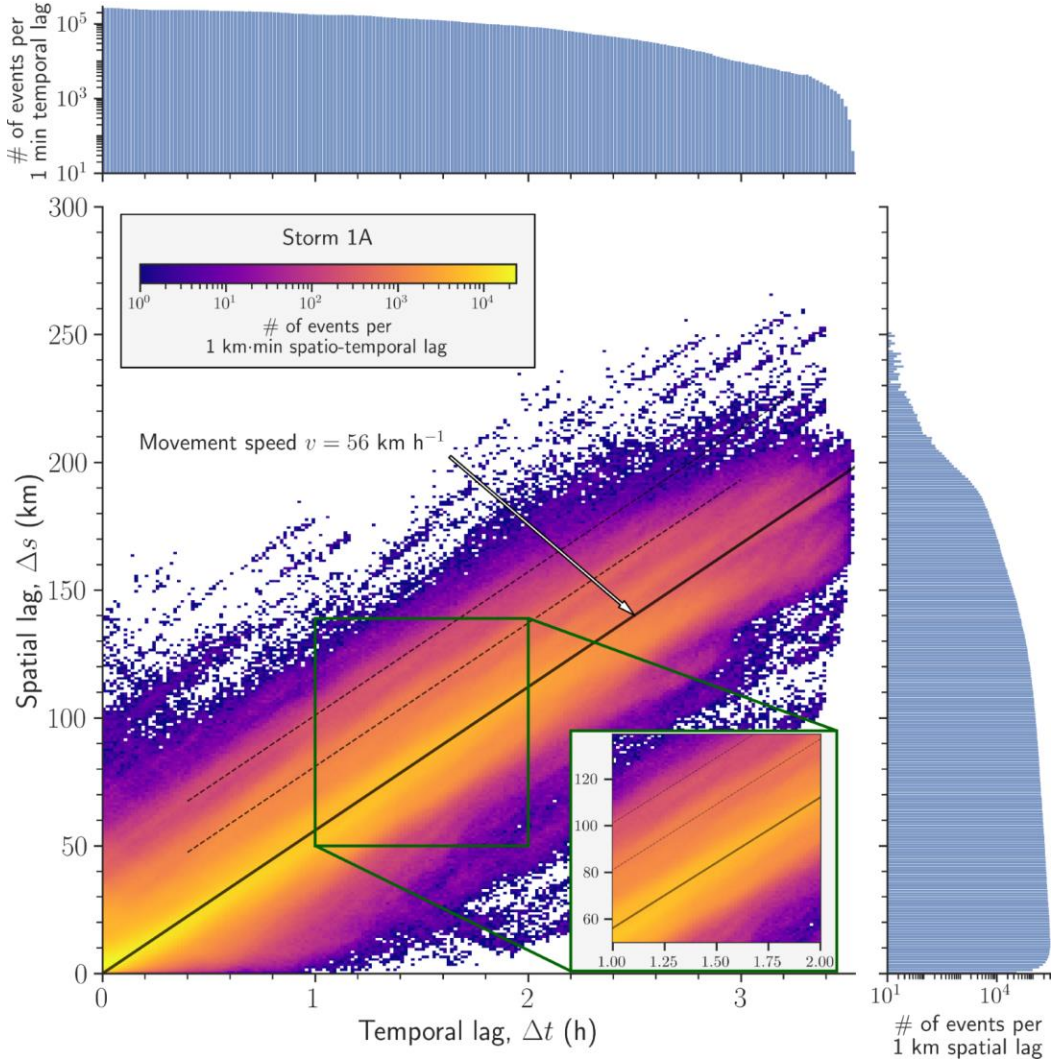


**Fig. 3:** Least-squares linear-fit solution to lightning strike dataset spatial and temporal lags for Storm 1A (28 June 2012).

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- From six thunderstorms chosen (three each for the two dates) and their lightning strikes, **three physical variables** can be **estimated**:

1. Movement speed.
2. **Inter-event time distribution**.

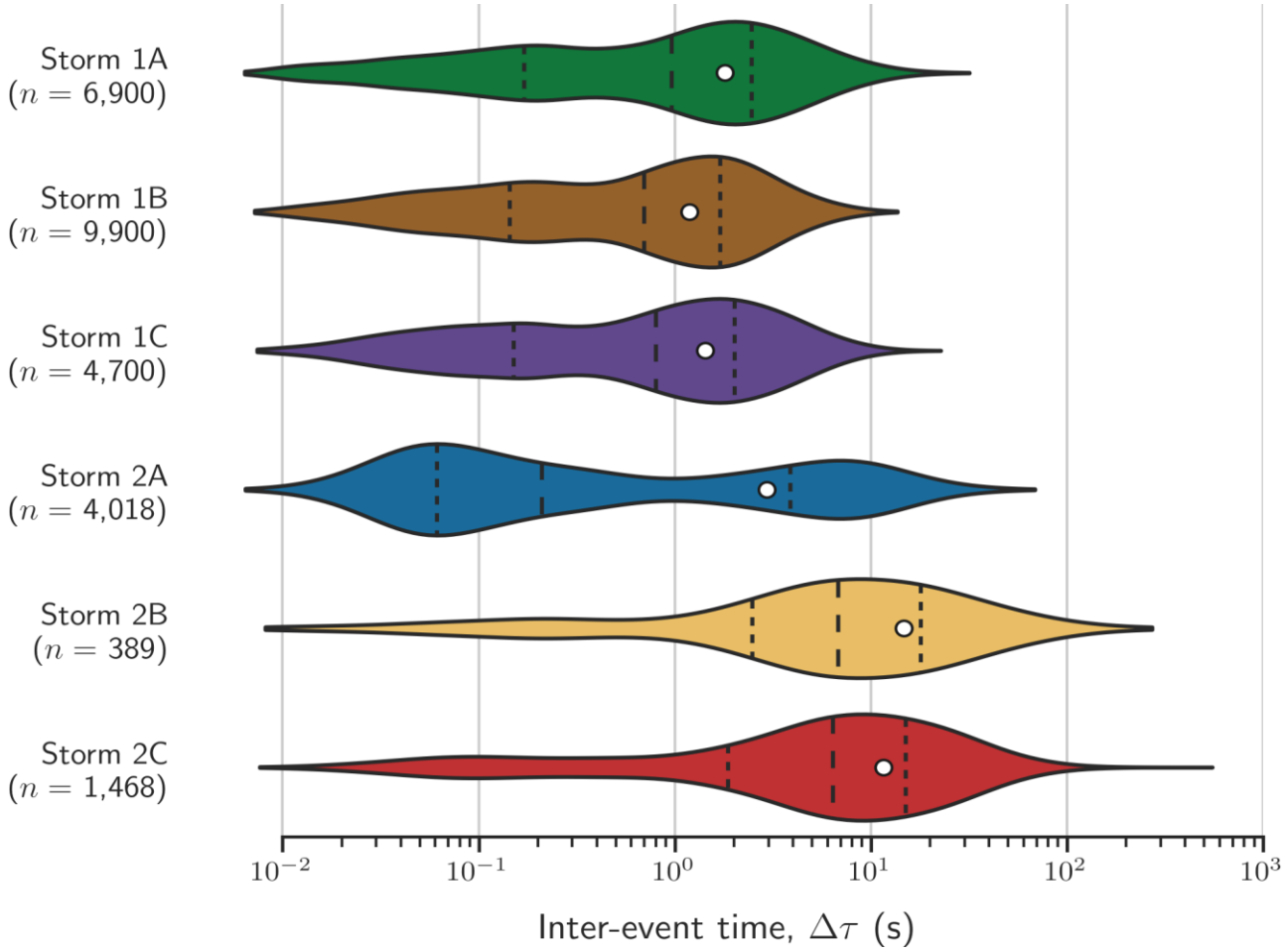


**Fig. 4.** Violin plots of inter-event time $\Delta\tau$ distributions for all six selected thunderstorms.

# 2 Characterisation of lightning strike parameters in time and space

- From six thunderstorms chosen (three each for the two dates) and their lightning strikes, **three physical variables** can be **estimated**:

1. Movement speed.
2. Inter-event time distribution.
3. **Spatial spread about the storm track.**

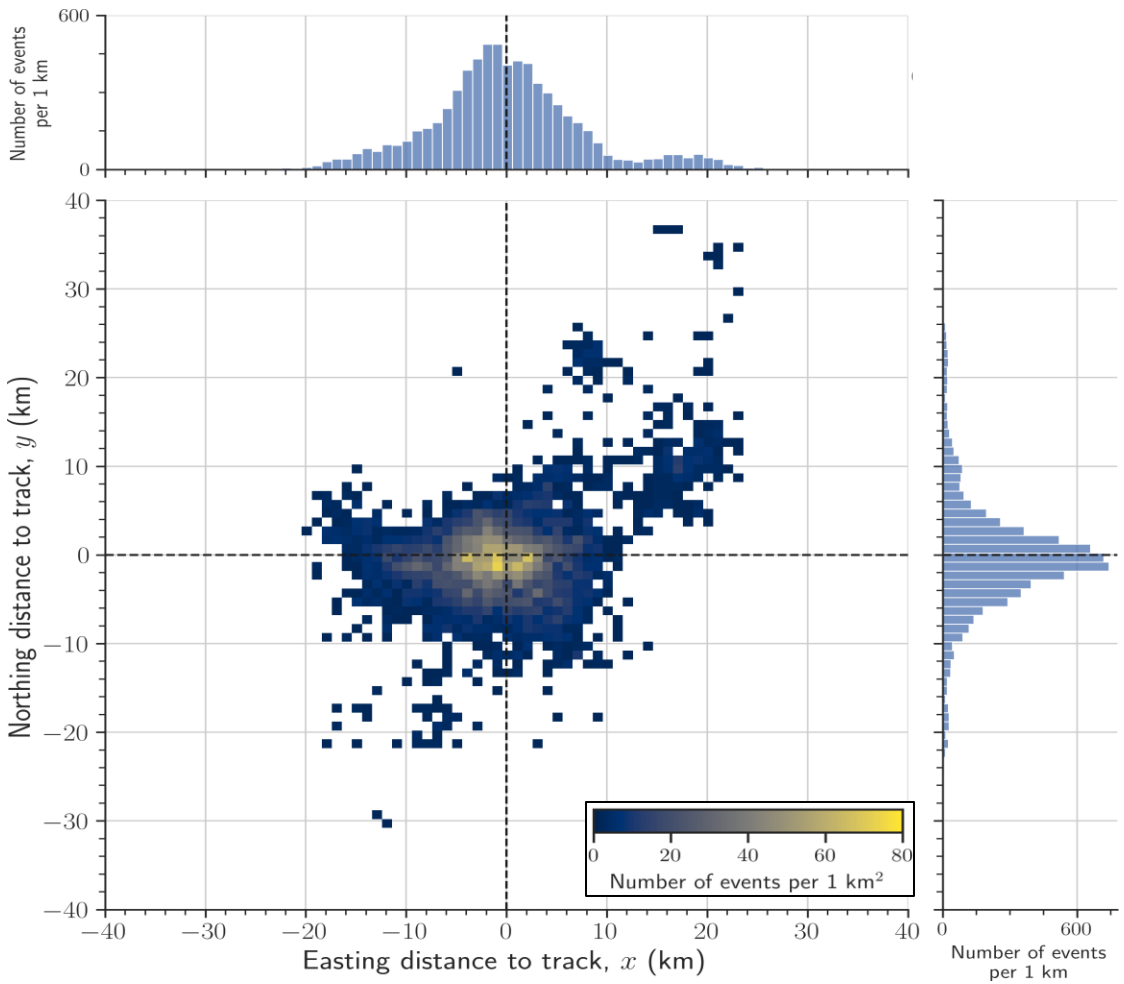


**Fig. 5:** 2D spatial count of lightning strikes per 1 km$^2$ of easting and northing distances to the movement track in natural time for Storm 1A (28 June 2012).

# 3 Modelling lightning strikes as synthetic point-events produced by a moving source

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- Select **movement speed** and generate **inter-event time** and **spatial spread** datasets.

1. Set **initiation point**.
2. Given **inter-event time**, **speed** and **direction**, **move along the track**.
3. Given easting and northing, **place a lightning strike** point event.
4. Repeat steps 2 & 3 for desired number of lightning values.

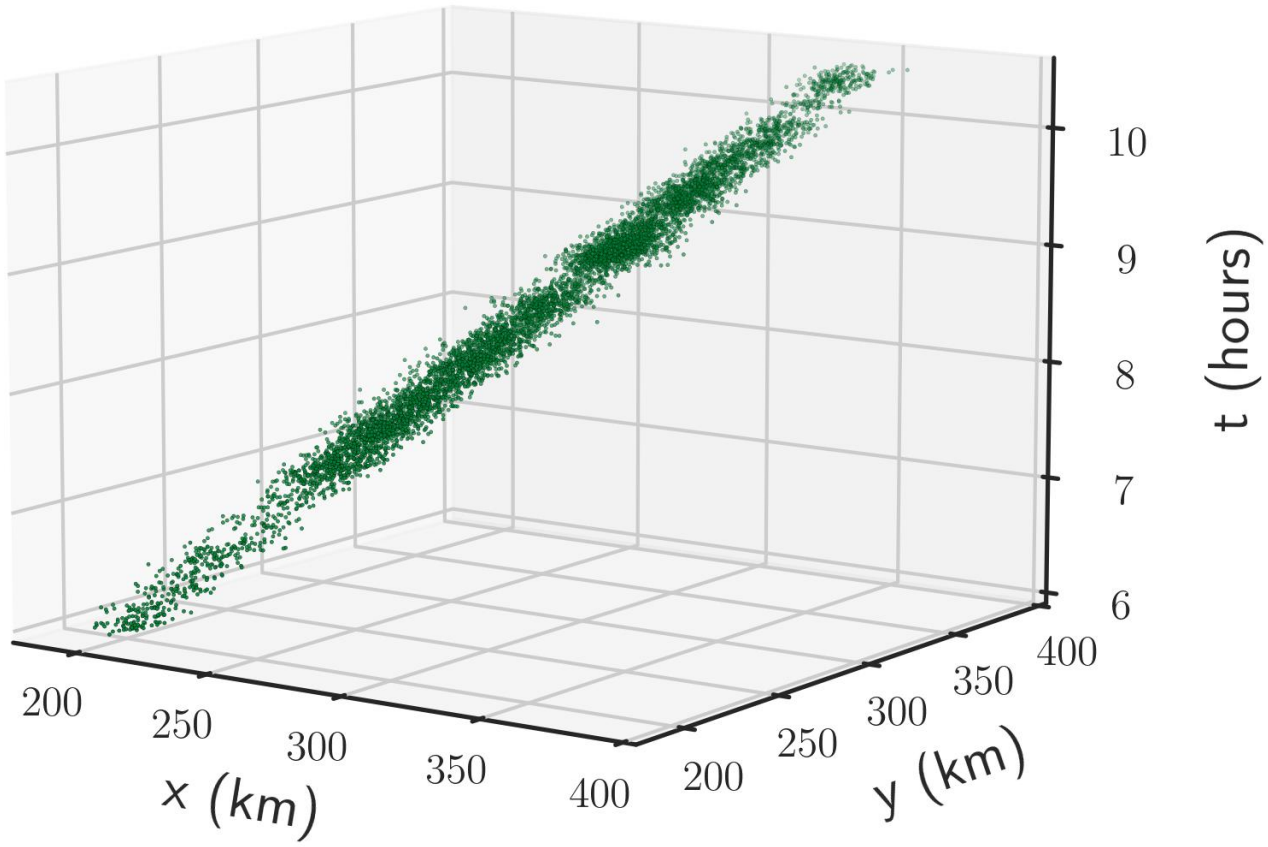


**Fig. 6:** Spatio-temporal model to produce a lightning strike dataset representing Storm 1A (28 June 2012).

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- **Multiple runs** of the procedure, using different physical variables, can produce multiple storms - a **synthetic storm-system**.

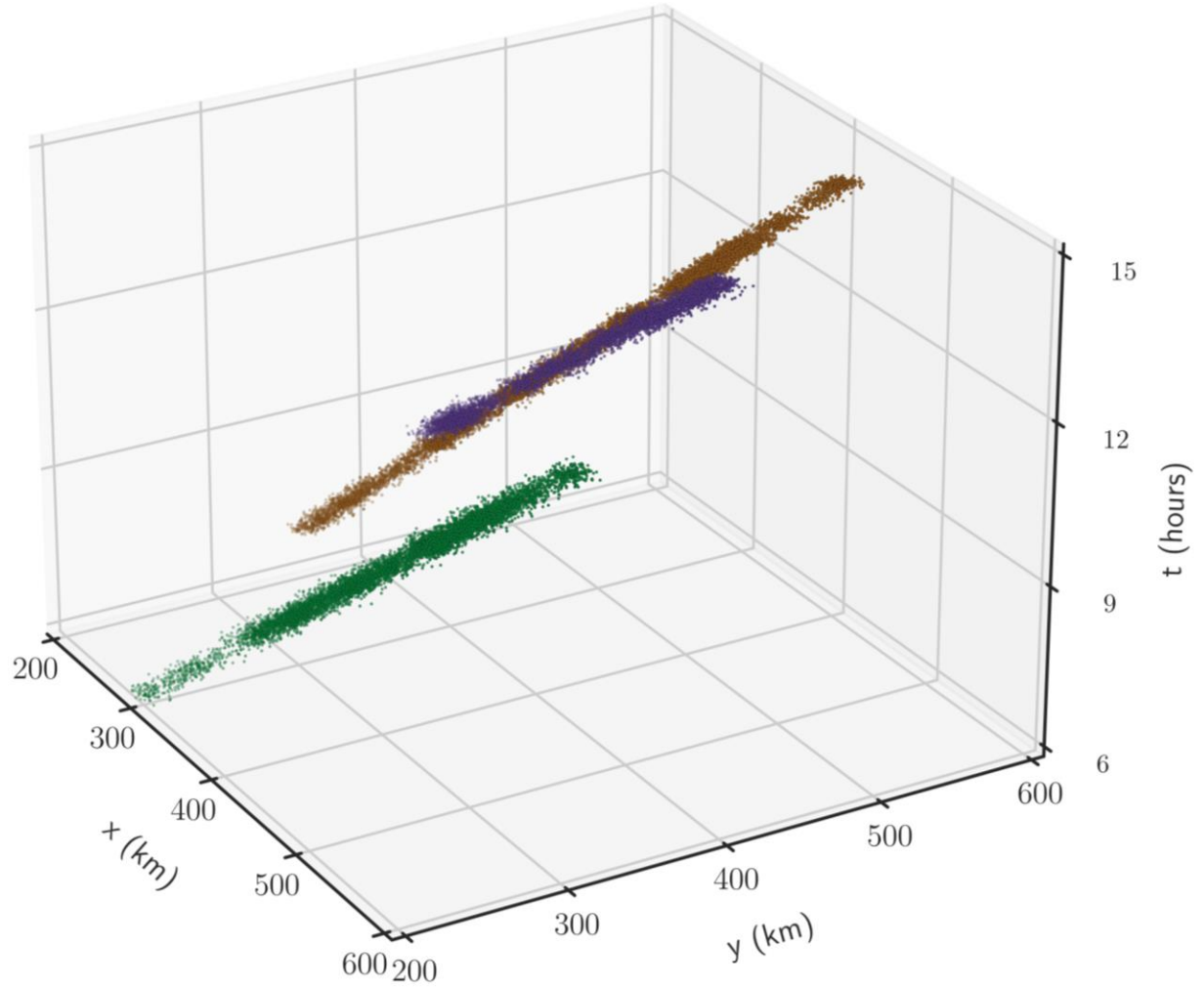


**Fig. 7:** Spatio-temporal model to produce a lightning strike dataset representative of Storms 1A, 1B, 1C (28 June 2012).

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- Such a **model allows us to generate synthetic datasets** that are **representative of lightning strike clusters** (in time and space).
- **Can extend idea to other** natural hazards for various applications (e.g. performance analysis of spatio-temporal clustering methodologies).

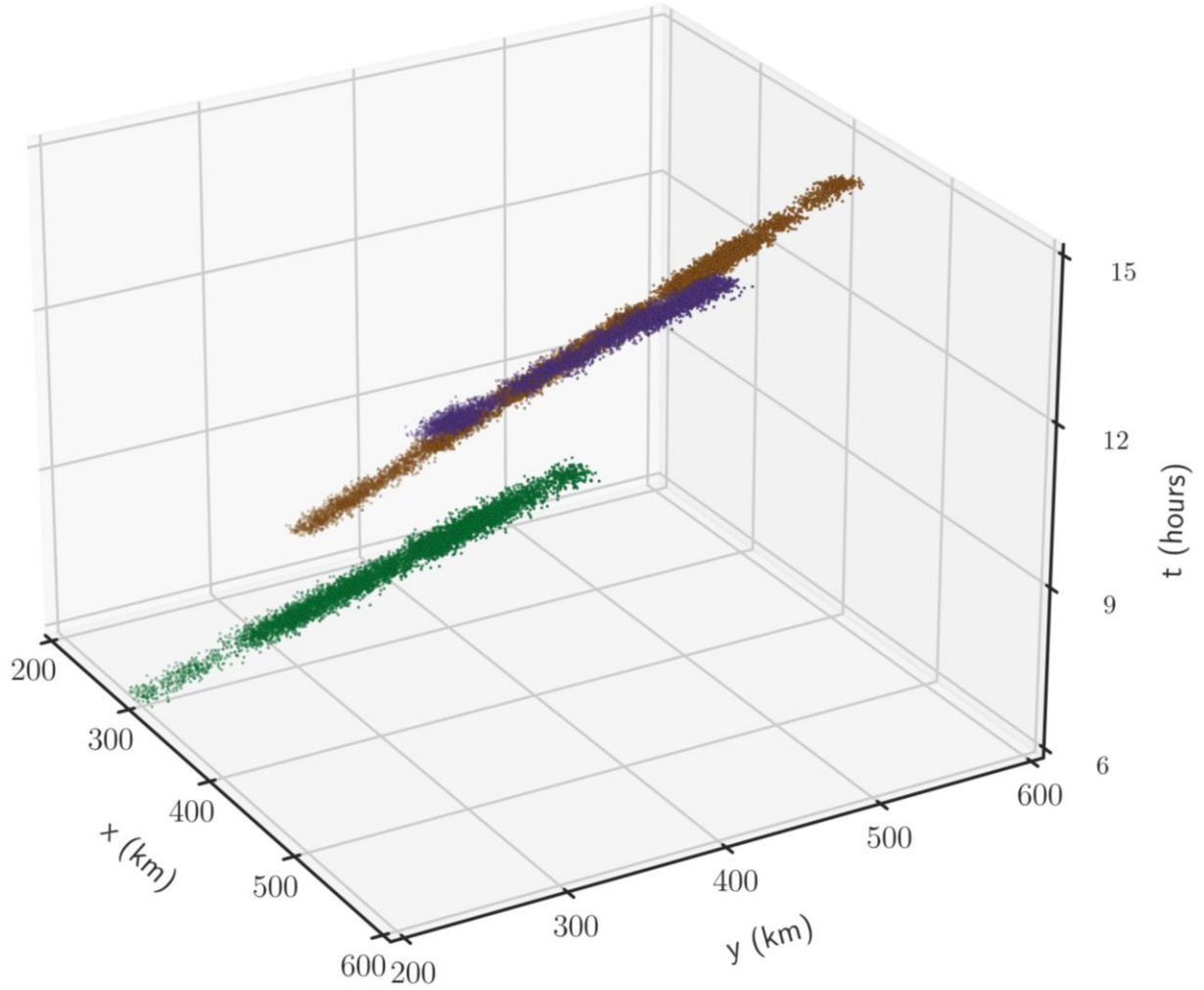


**Fig. 7:** Spatio-temporal model to produce a lightning strike dataset representative of Storms 1A, 1B, 1C (28 June 2012).

# Summary and main conclusions

- Using **synoptic analyses**, two case studies of increased lightning activity are analysed **to assign lightning strikes to individual thunderstorms**.
- **Physical variables are characterised** using the lightning strikes as point-event datasets.
- A **spatio-temporal model** is created to generate single- or multiple-run synthetic datasets **representative of lightning strike** spatial-temporal **clusters** (storms).

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(Publication in preparation for submission to NHESS)