Characterisation and Modelling of Lightning Strikes in Time and Space

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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.

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1 Selection of UK lightning case studies

- Lightning strike spatial and temporal data **over the United Kingdom** is recorded by the ATDnet network.

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1 Selection of UK lightning case studies

- To identify individual thunderstorms, **two days of** increased **lightning activity** are selected **as case studies** 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).

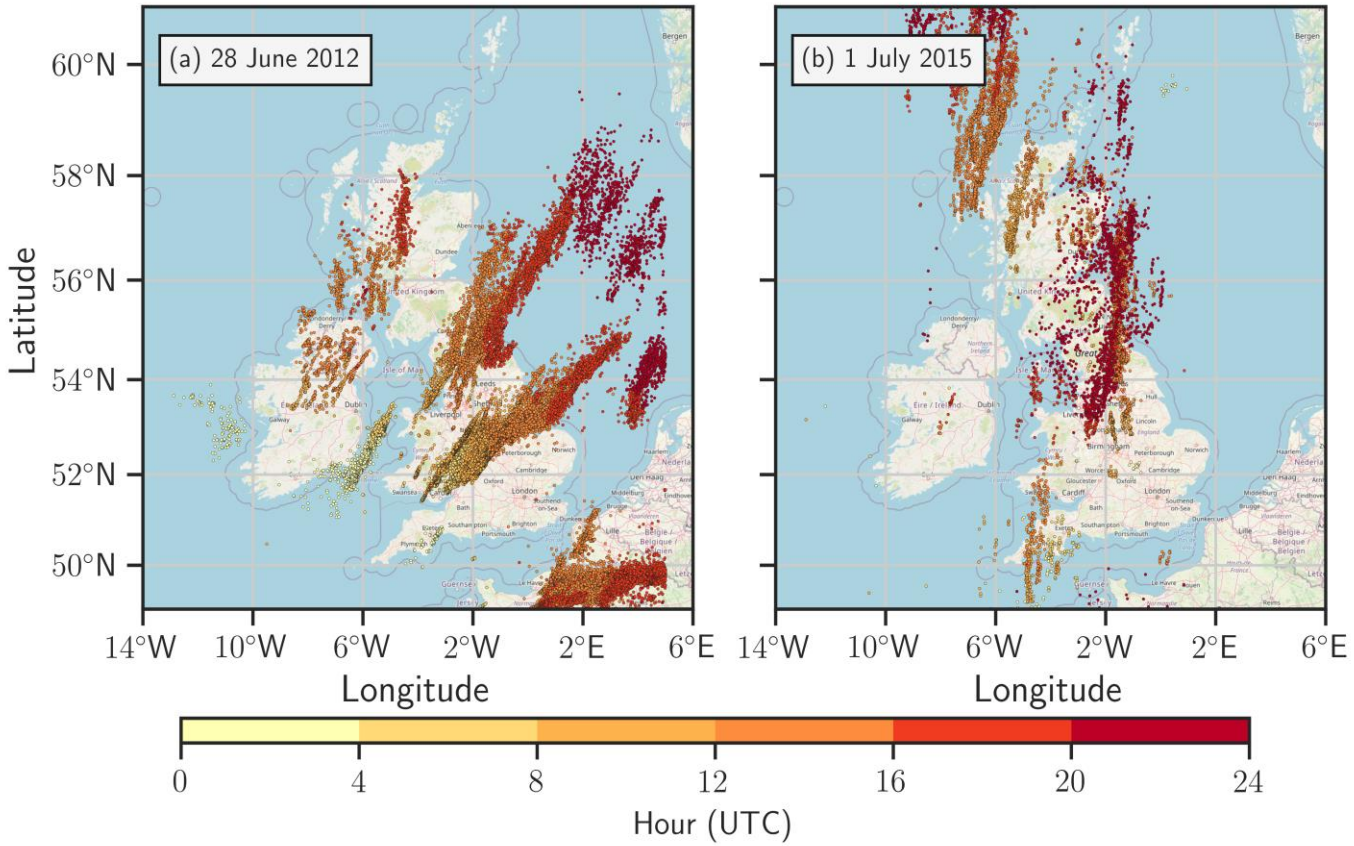

Fig. 1.1. Recorded lightning strike data over (a) 28 June 2012 and (b) 1 July 2015 by the ATDnet network.

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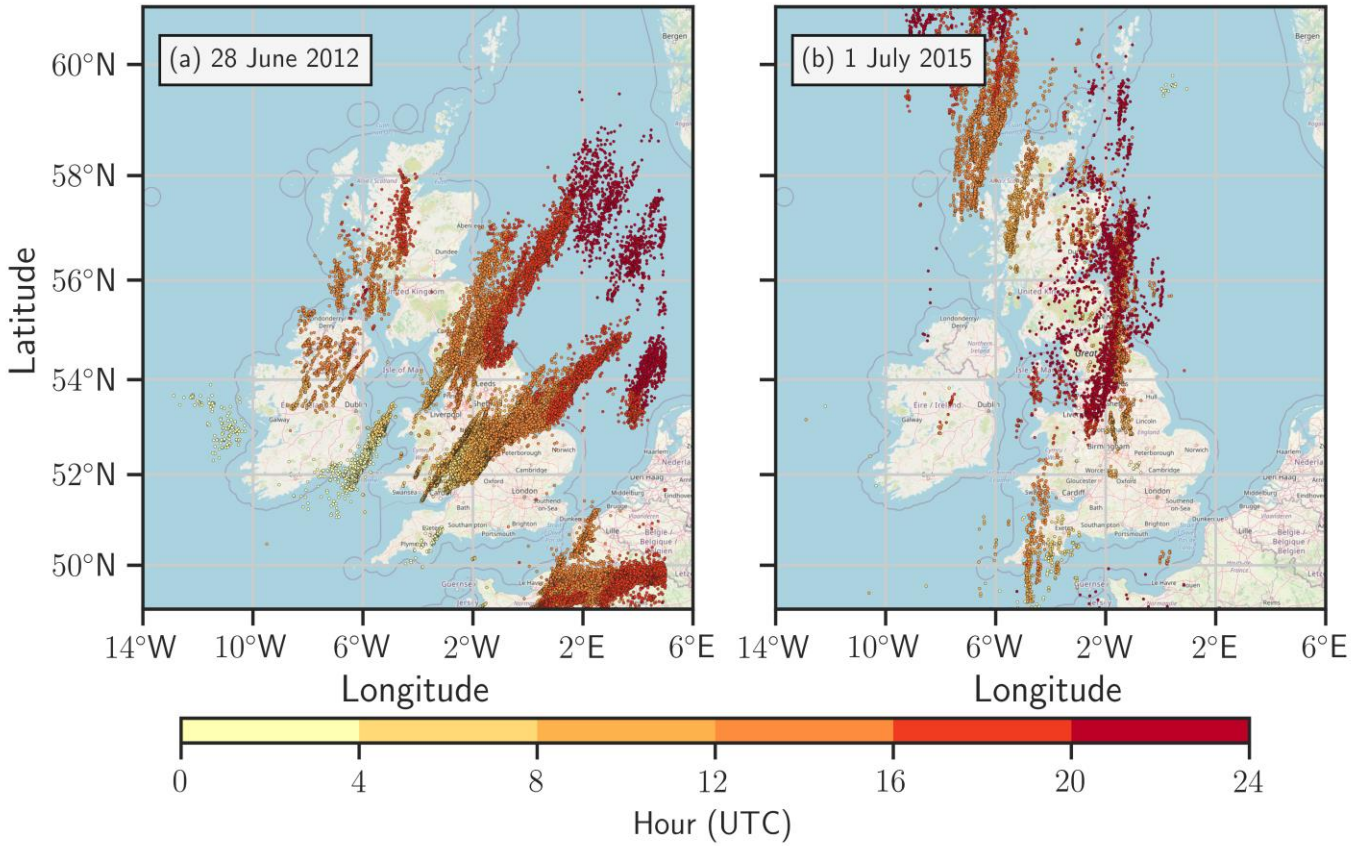
1 Selection of UK lightning case studies

- Each case study **uses the synoptic analyses to identify** individual thunderstorms by:

  1. Geographic **locations** and **times** of occurrence.
  2. Data from **Doppler radars**.
  3. Observations of **other natural hazards** (e.g., hail).



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1 Selection of UK lightning case studies

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

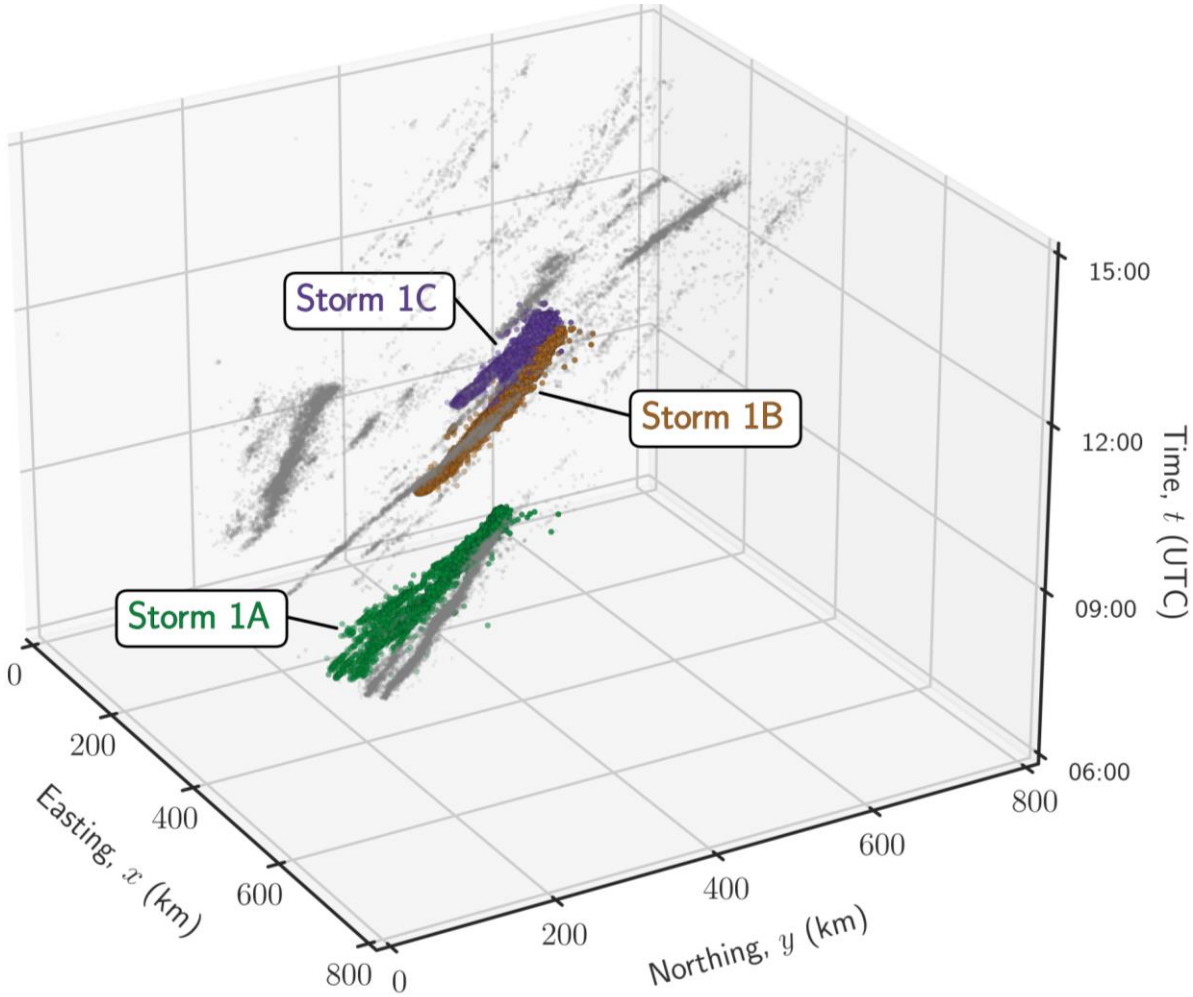

Fig. 1.2. Lightning strikes from 28 June 2012 (Storm 1) separated and assigned to the three supercell thunderstorms.

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2 Characterisation of lightning strike parameters in time and space

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

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2 Characterisation of lightning strike parameters in time and space

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

1. **Movement speed**.

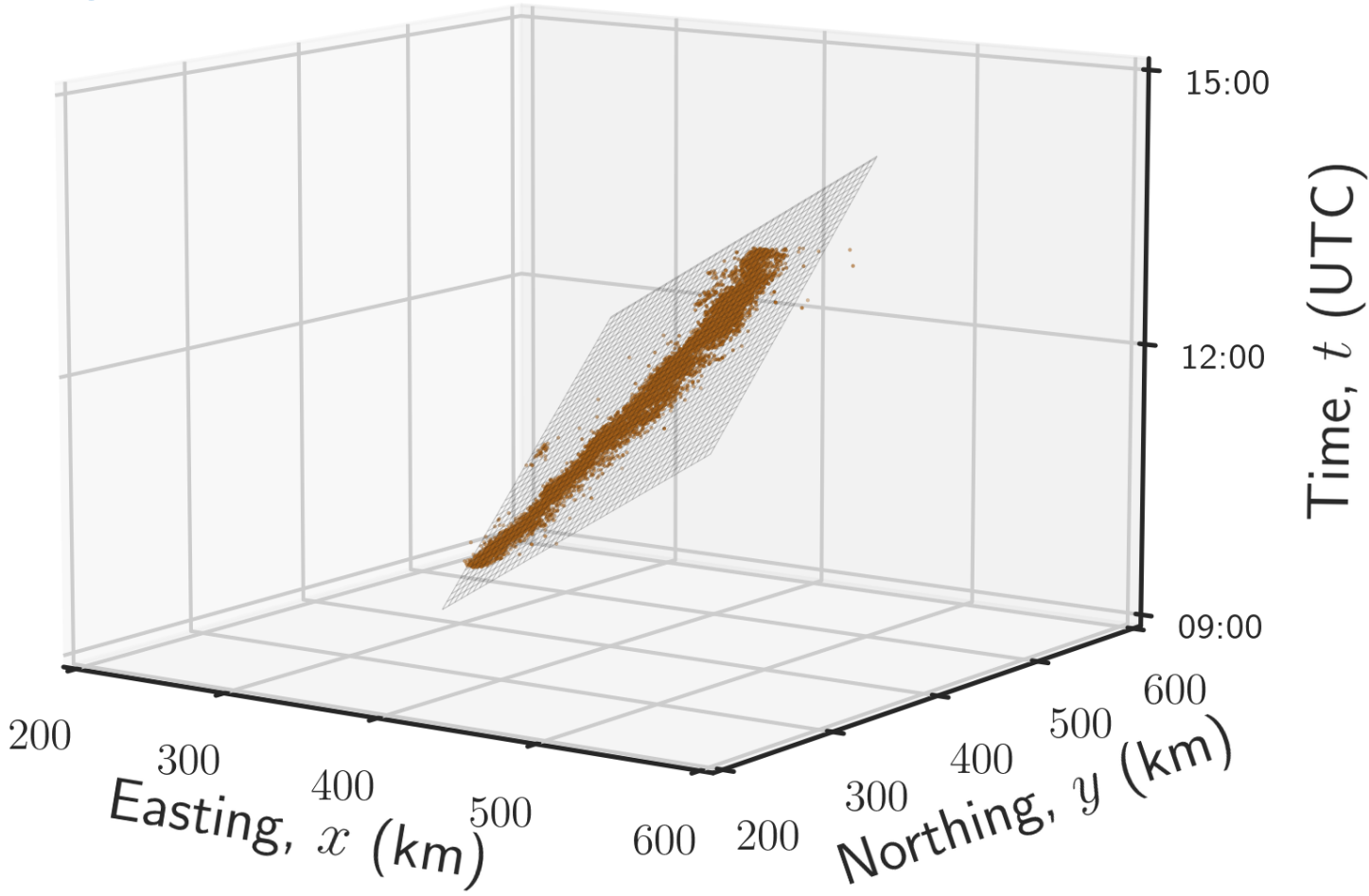

Fig. 2.1. Least-squares plane-fit solution to lightning strike dataset for Storm 1B (28 June 2012). Estimated movement speed 47 km h^{-1}.

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2 Characterisation of lightning strike parameters in time and space

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

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

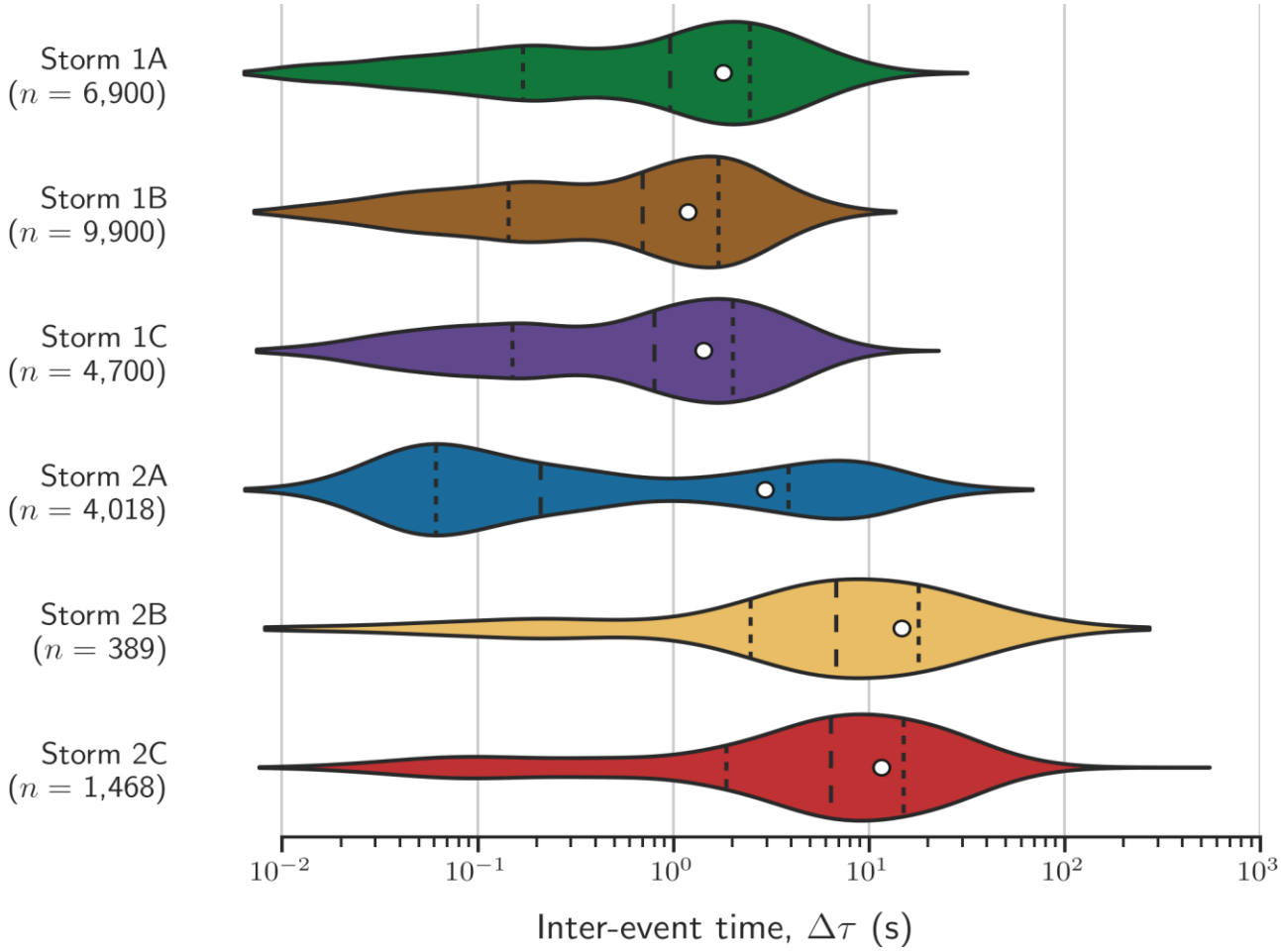

Fig. 2.2. Violin plots of inter-event time $\Delta\tau$ distributions for all six selected thunderstorms.

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2 Characterisation of lightning strike parameters in time and space

- From six thunderstorms chosen (three each for 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**.

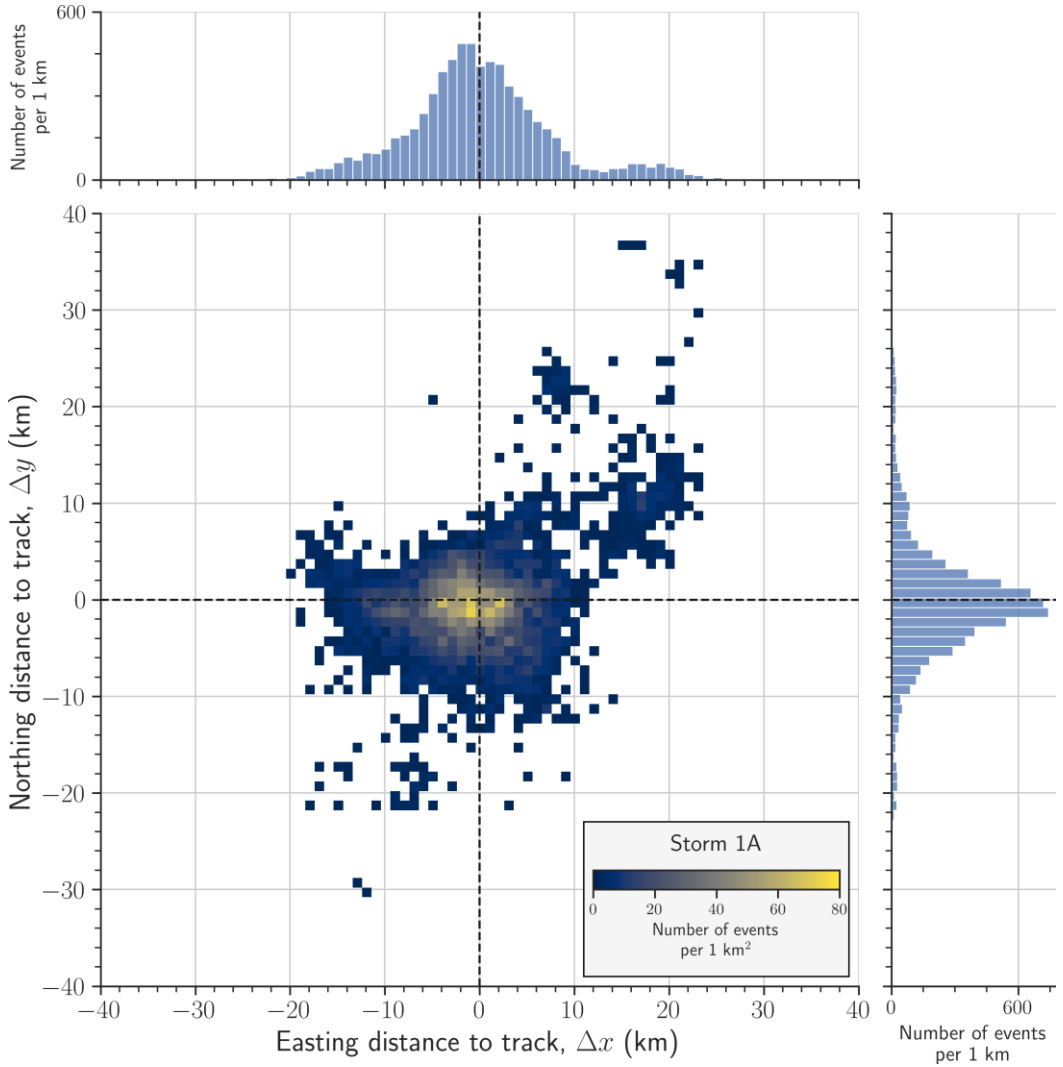

Fig. 2.3. 2D spatial count of lightning strikes per 1 km^2 of easting and northing distances to the movement track in natural time for Storm 1A (28 June 2012).

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

- Using modeled physical variables, the following **procedure** is used **to generate** a single **synthetic lightning strike dataset**:

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

- Using modeled physical variables, the following **procedure** is used **to generate** a single **synthetic lightning strike dataset**:
    - Select **movement speed** and generate **inter-event time** and **location** datasets.

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

- Using modeled physical variables, the following **procedure** is used **to generate** a single **synthetic lightning strike dataset**:

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 2 & 3 for desired number of lightning values.

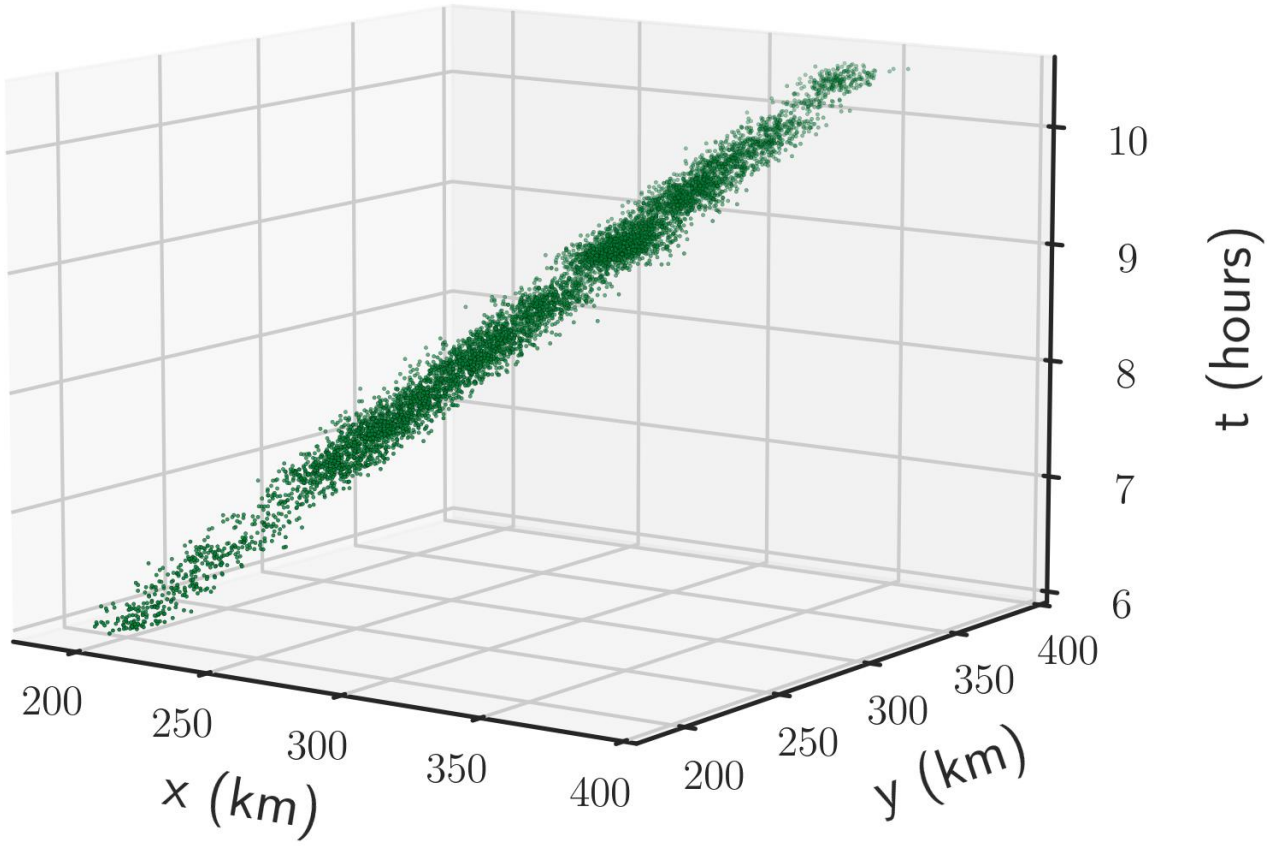

Fig. 3.1. A single run of the spatio-temporal model to produce a lightning strike dataset representative of Storm 1A (28 June 2012).

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

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

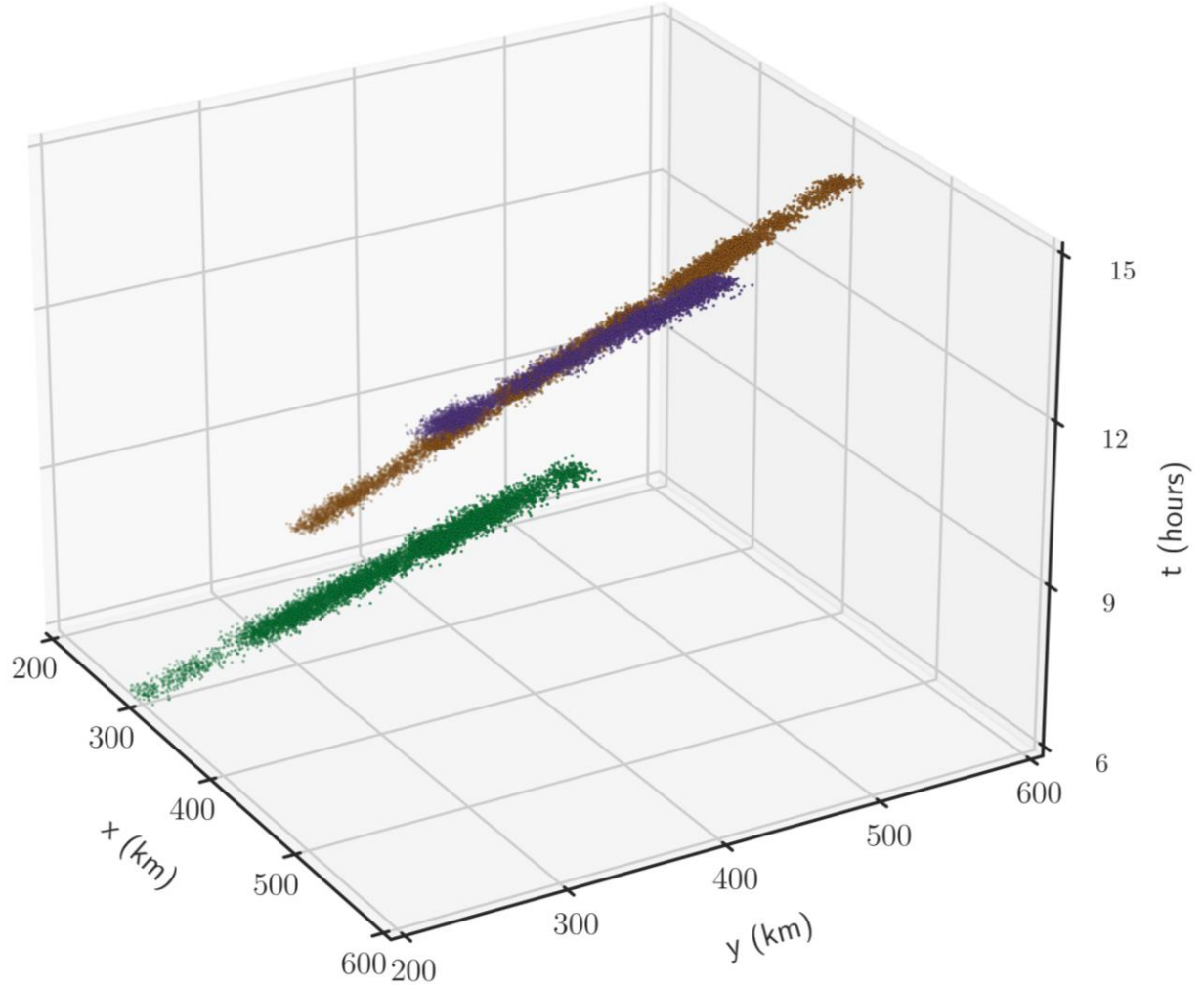

Fig. 3.2. Multiple runs of the spatio-temporal model to produce a lightning strike dataset representative of Storms 1A, 1B, 1C (28 June 2012).

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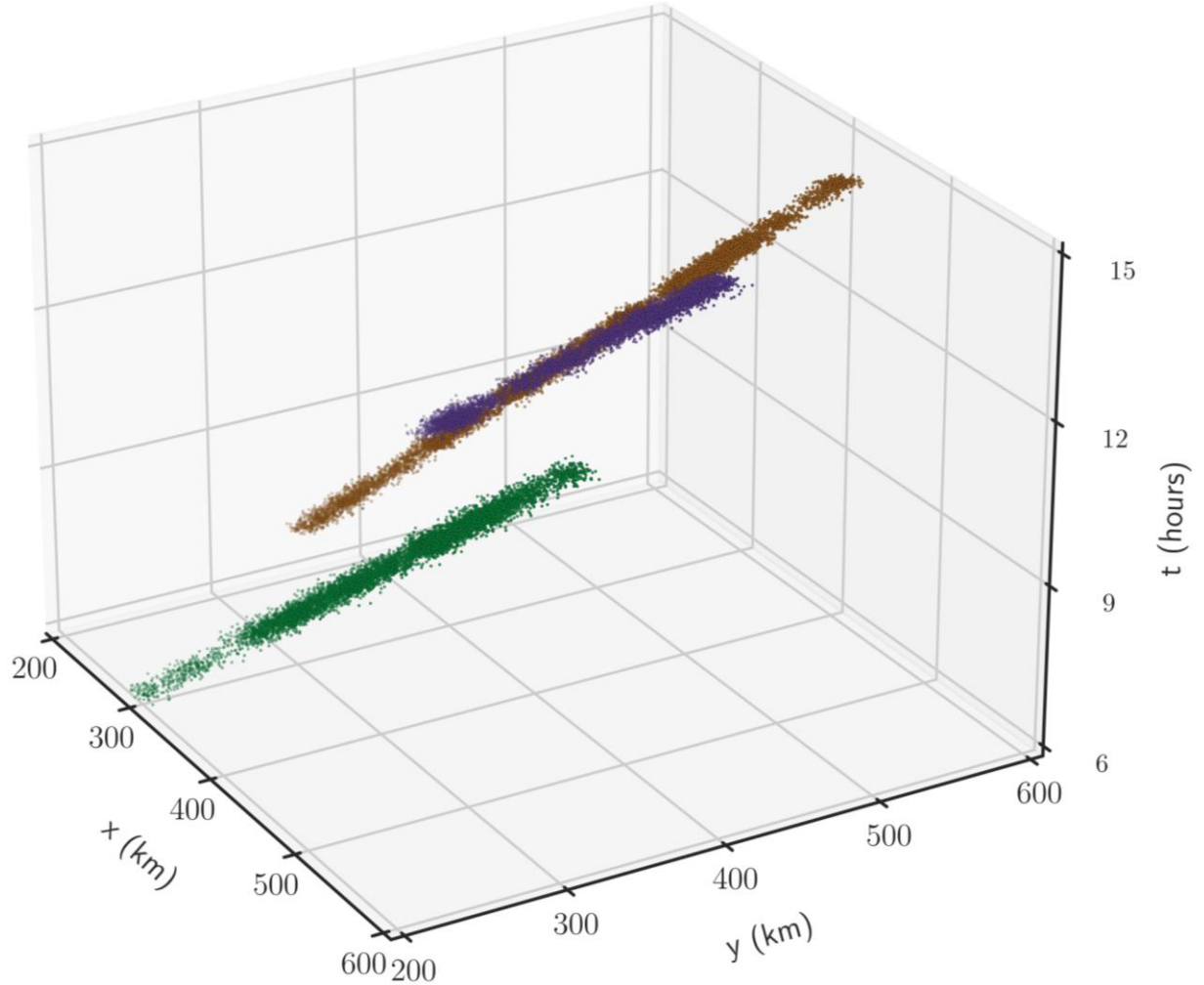
3 Modelling lightning strikes as synthetic point-events produced by a moving source.

- Such a **model allows us to generate synthetic datasets** that would be **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).



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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)**.

Any questions and/or suggestions – uldis.zandovskis@kcl.ac.uk