National Oceanography Centre Southampton
University of Southampton and
Natural Environmental Research Council

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Spatial and temporal analysis of extreme sea level events around the UK coast

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Cornish coast Porthleven
5 February 2014

1. Introduction

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Motivation

- '**Footprint**' - the large areas of coastline affected;

- '**Clustering**' - large number of significantly coastal flooding events occurring one after another over a relatively short period of time;

Extreme events are rarely assessed in terms of 'clustering' or 'footprint', despite the fact this leads to amplified flood damages. Extreme events are rarely assessed on an individual basis.

Fundamental lack of understanding of processes.

2. SurgeWatch

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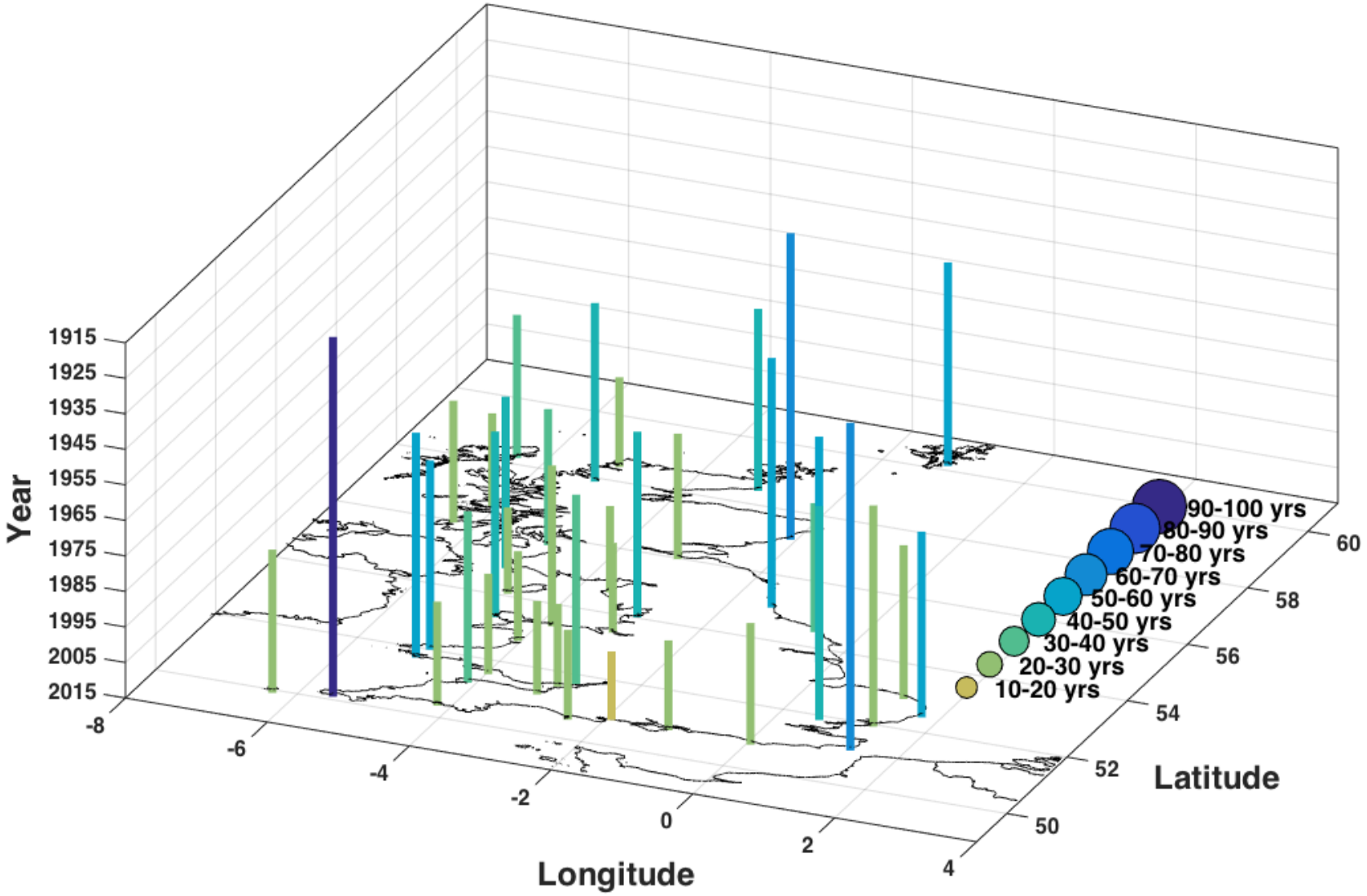
UK National Tide Gauge Network



2. SurgeWatch

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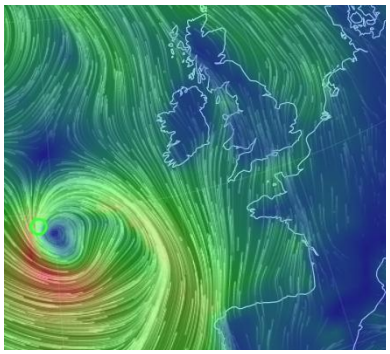
A. Method – Water Level



- Stage 1: Identify high waters ≥ 1 in 5 year EA return level (offset by MSL)
  - **310 HW's** are defined

- Stage 2: Distinguish unique storm events and capture storm tracks.
  - **96** storms are identified

- Stage 3: Determine flood consequences and compile systematic commentaries by event and storm
  - All data is freely available at: www.surgewatch.org

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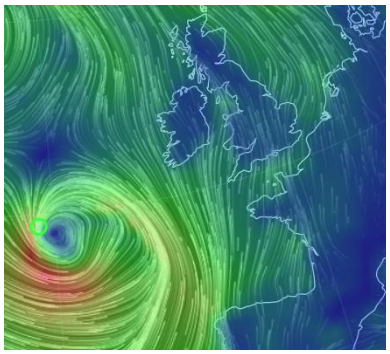
B. Method – Skew Surge



- Stage 1: Identify skew surges ≥ 1 in 5 year return level (GPD – 99.75%)
  - **261 SK's** are defined

- Stage 2: Distinguish unique storm events and capture storm tracks.
  - **111** storms are identified

- Stage 3: Determine flood consequences and compile systematic commentaries by event and storm
  - Some events are the same as HW;
  - Others not.

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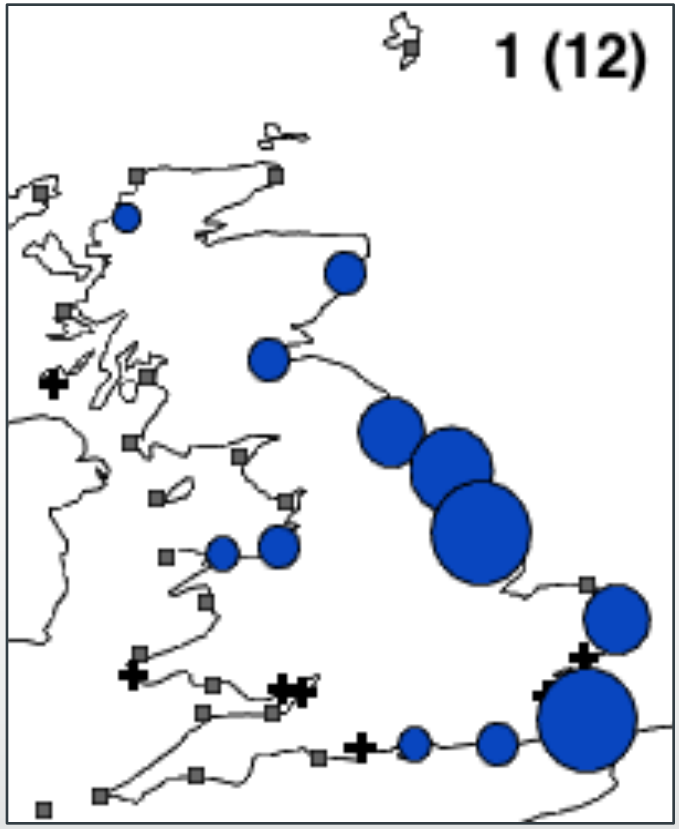
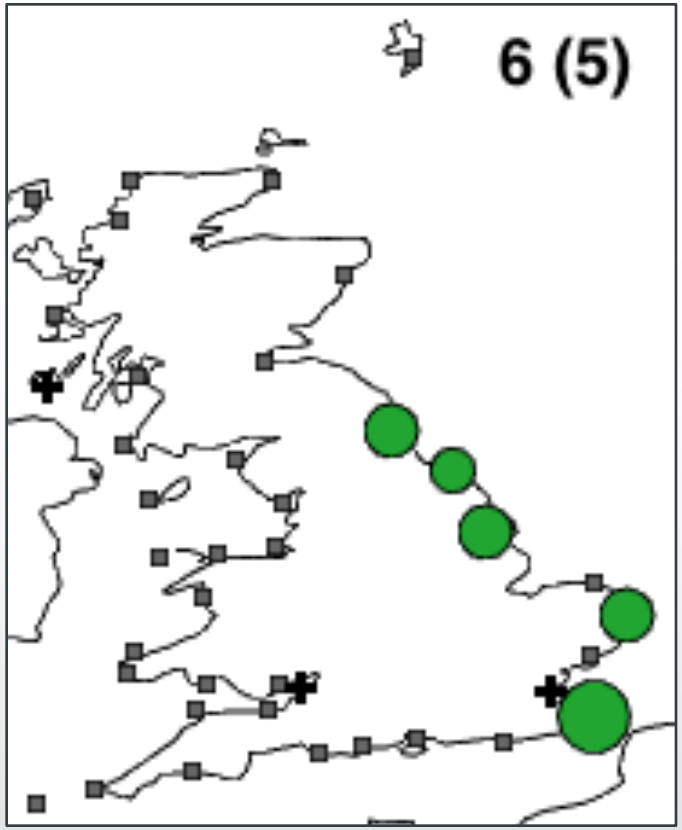
6th December 2013

1: Dover 843 years; **Event 6: Dover 103 years**

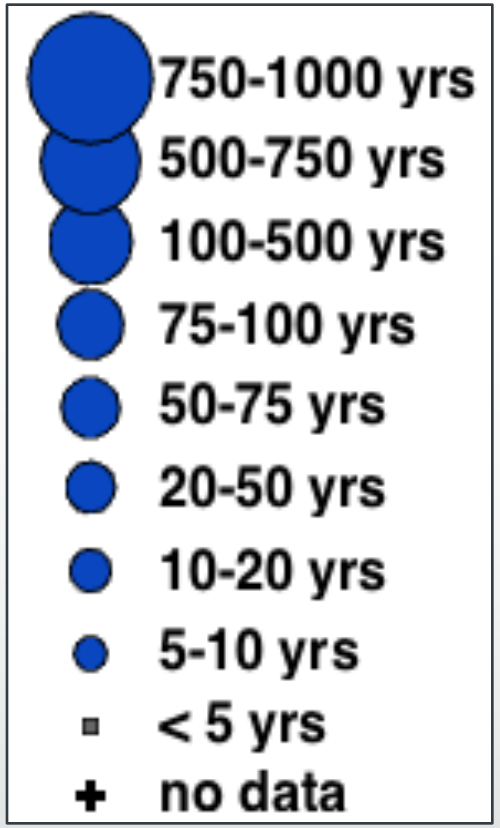
Water level



Skew Surge



Key



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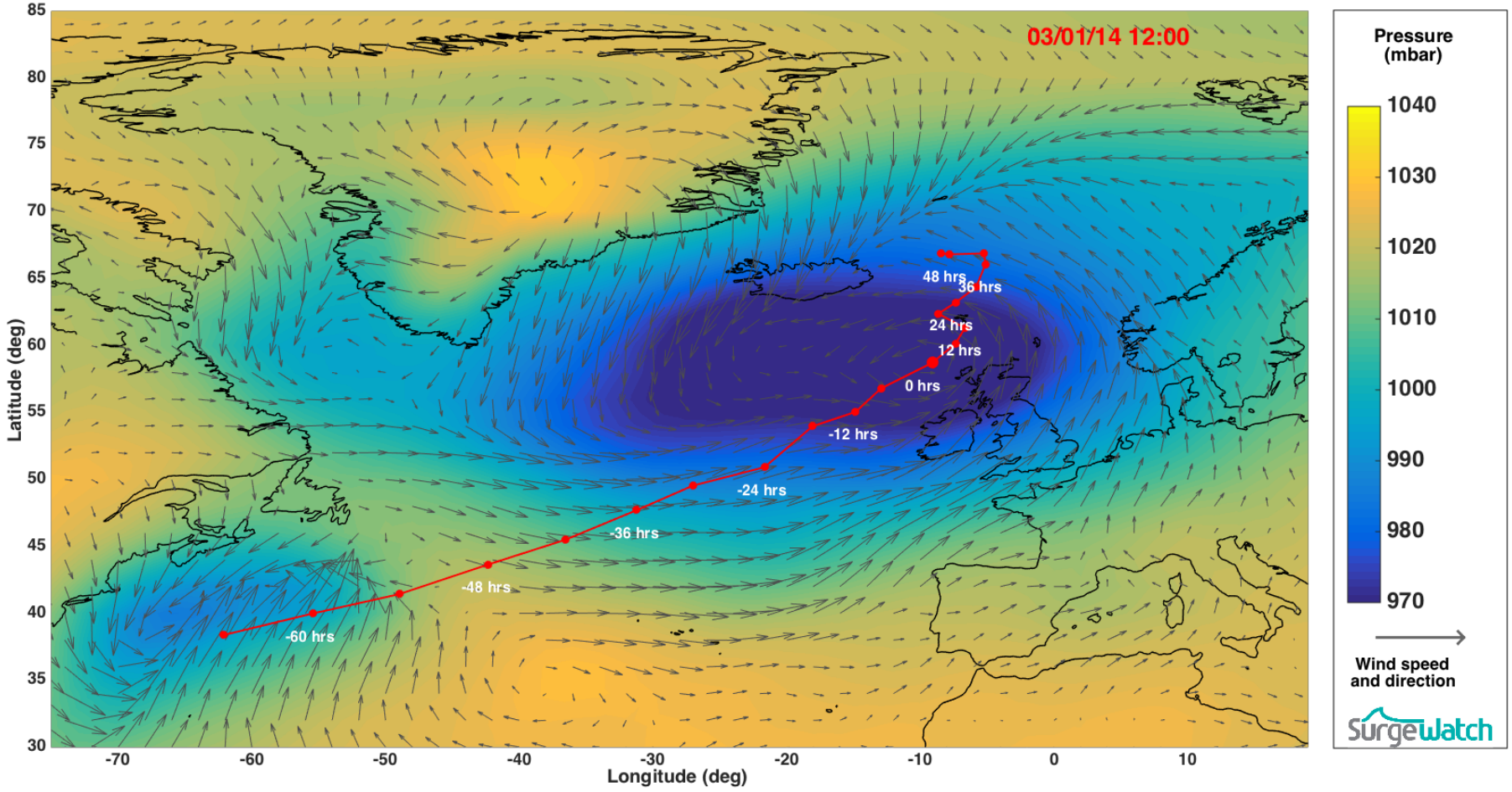
Example Storm track – 3rd January 2014



NOAA 20th Century meteorological Reanalysis
http://www.esrl.noaa.gov/psd/data/20thC_Rean/

2. SurgeWatch

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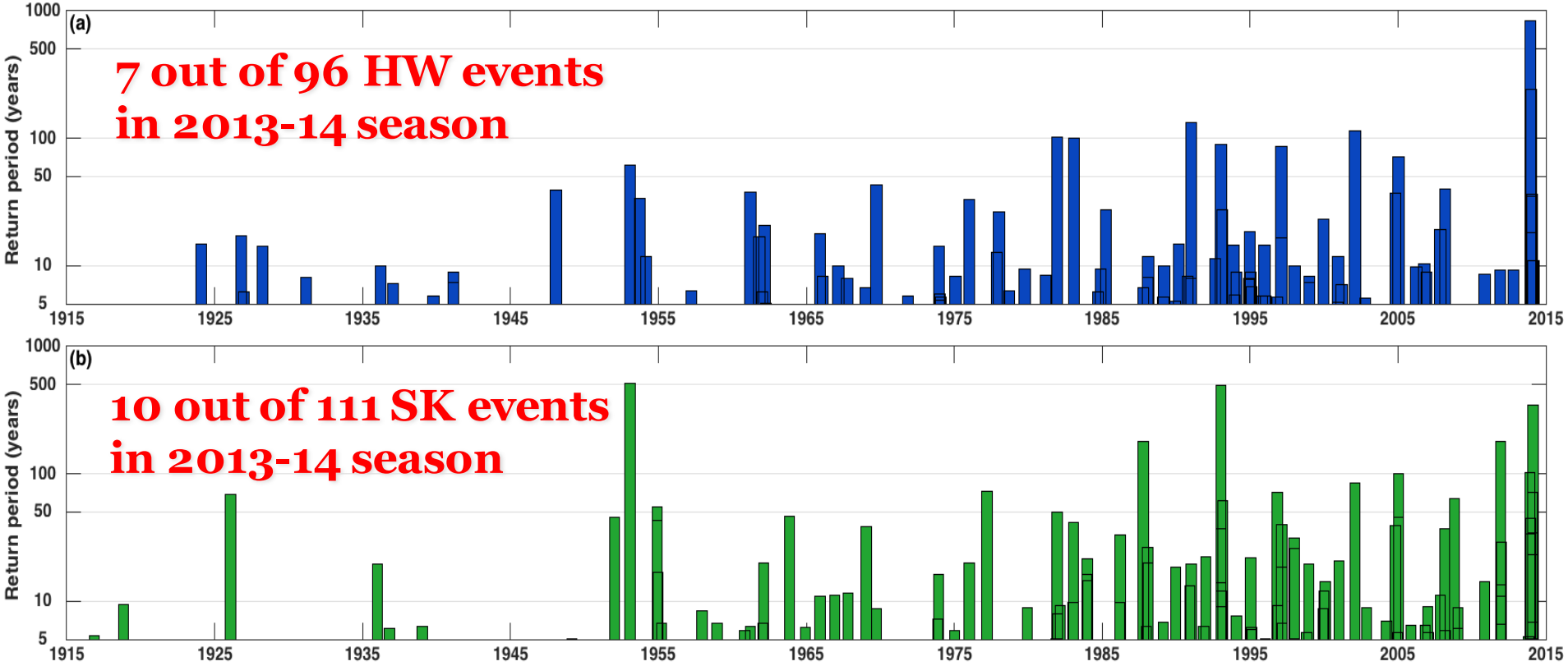
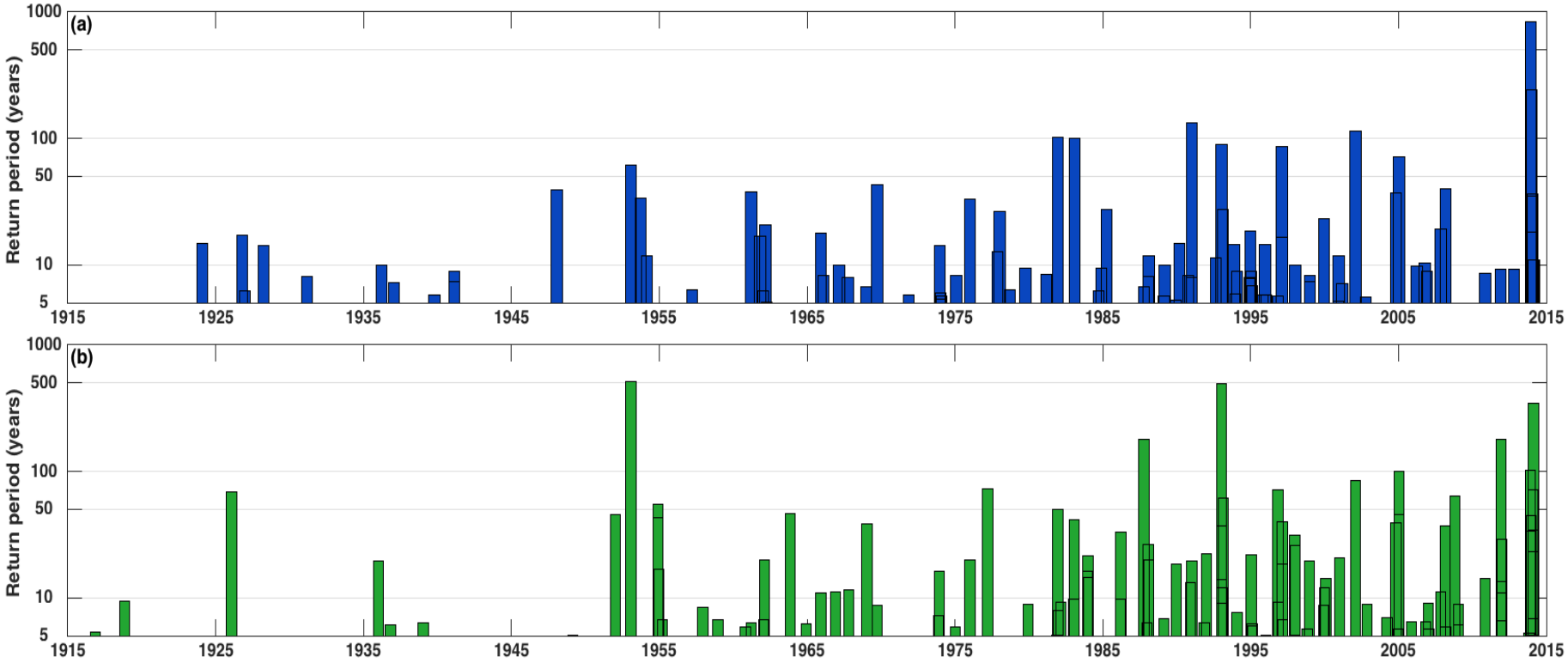
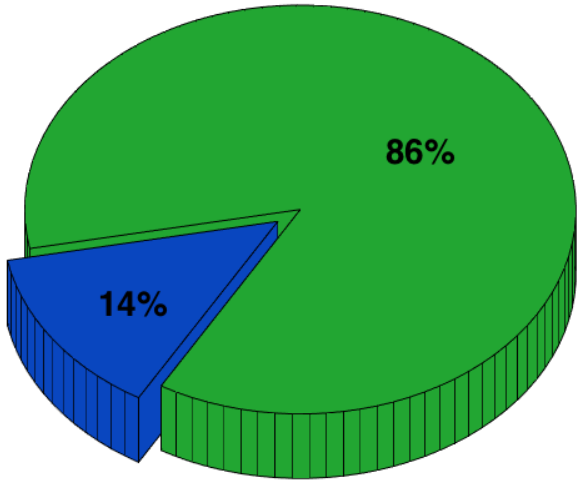


2. SurgeWatch





15 skew surge events lead to water level events

96 skew surge events didn't lead to water level event

3. Spatial Analysis

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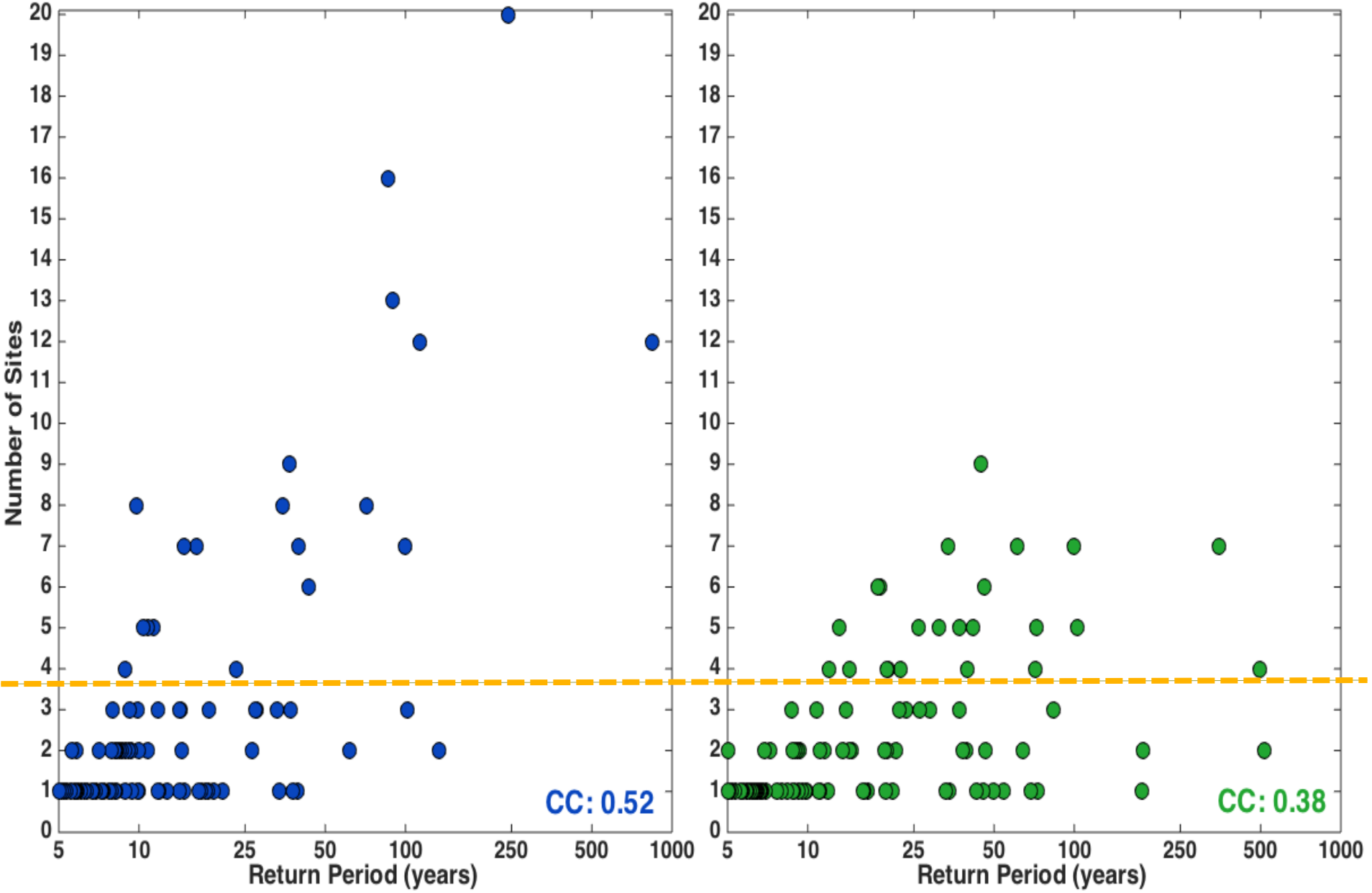

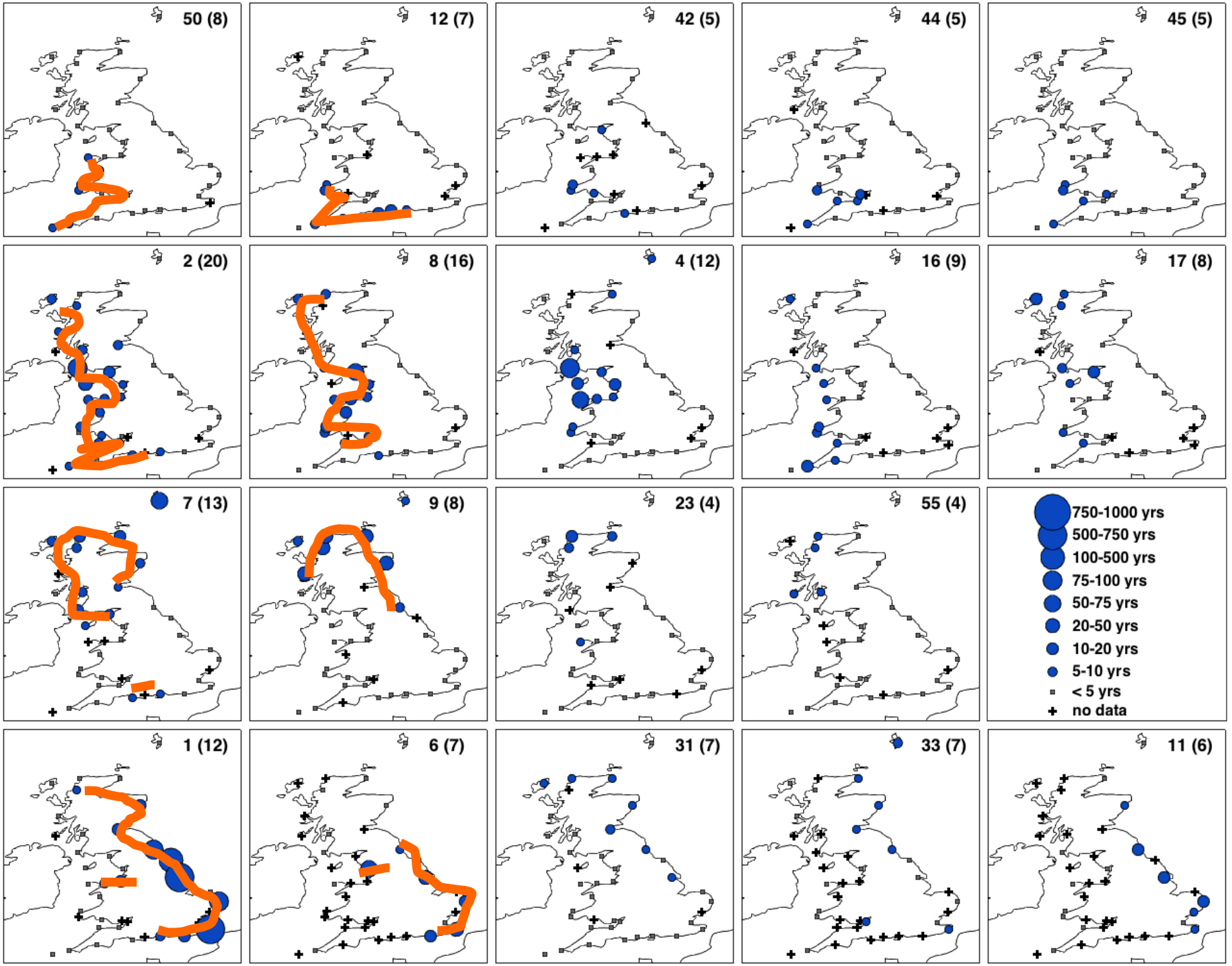
50 (8)
12 (7)
42 (5)
44 (5)
45 (5)
2 (20)
8 (16)
4 (12)
16 (9)
17 (8)
7 (13)
9 (8)
23 (4)
55 (4)
1 (12)
6 (7)
31 (7)
33 (7)
11 (6)
750-1000 yrs
500-750 yrs
100-500 yrs
75-100 yrs
50-75 yrs
20-50 yrs
10-20 yrs
5-10 yrs
< 5 yrs
no data

3. Spatial Analysis

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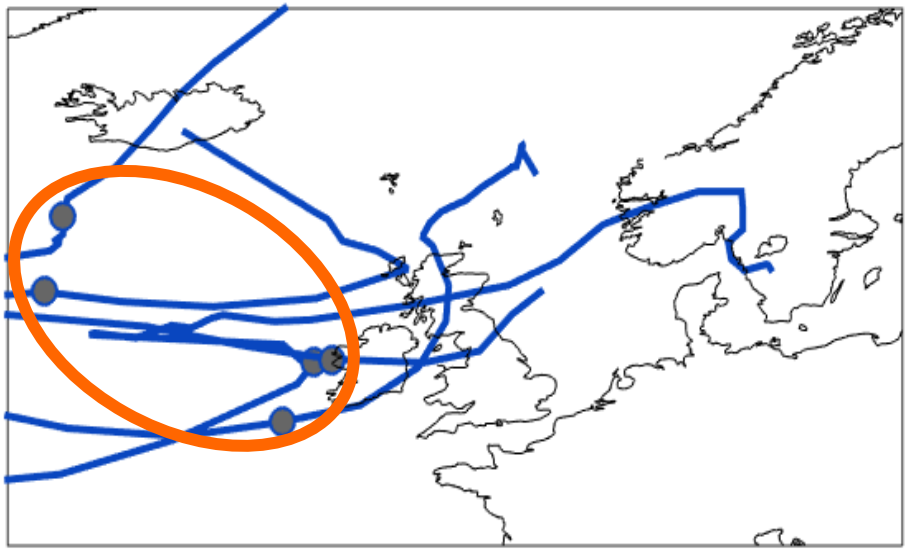
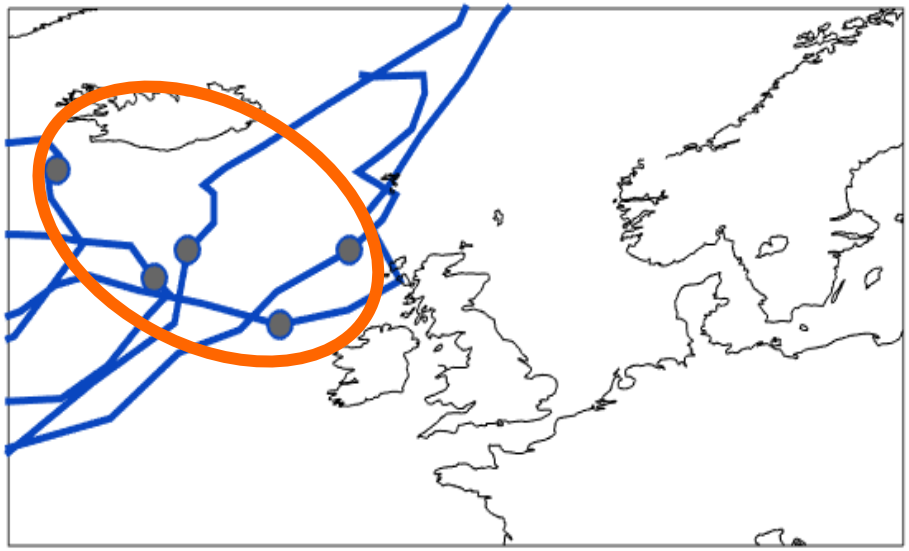
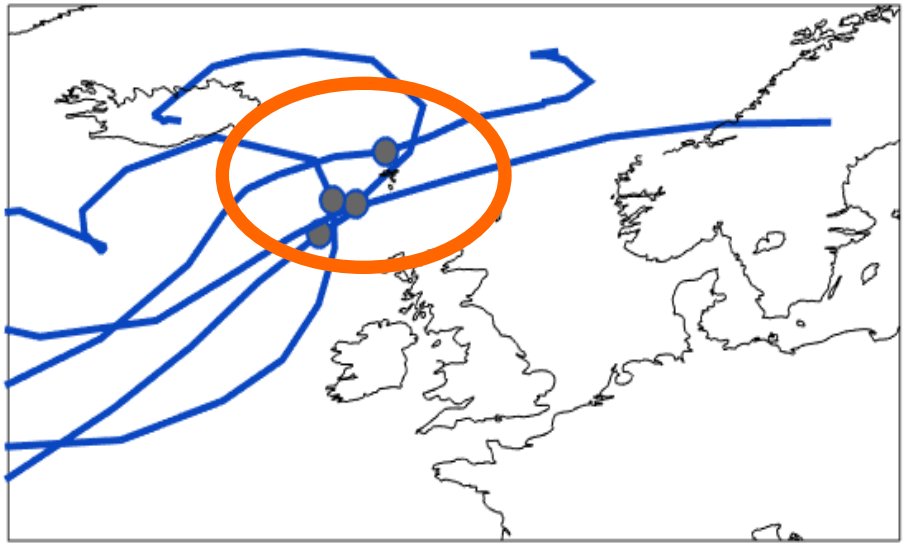
(a) South/West Events



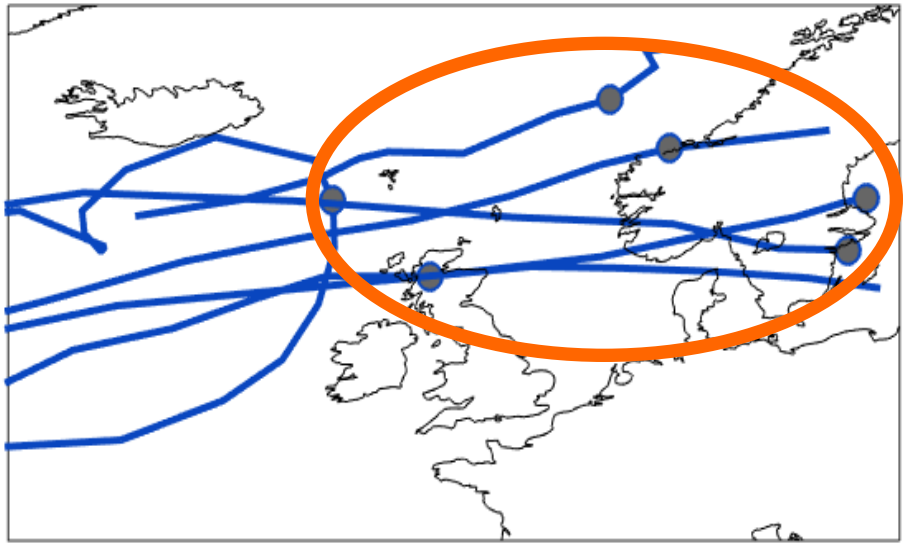
(b) West Events



(c) North Events



(d) East Events



3. Spatial Analysis

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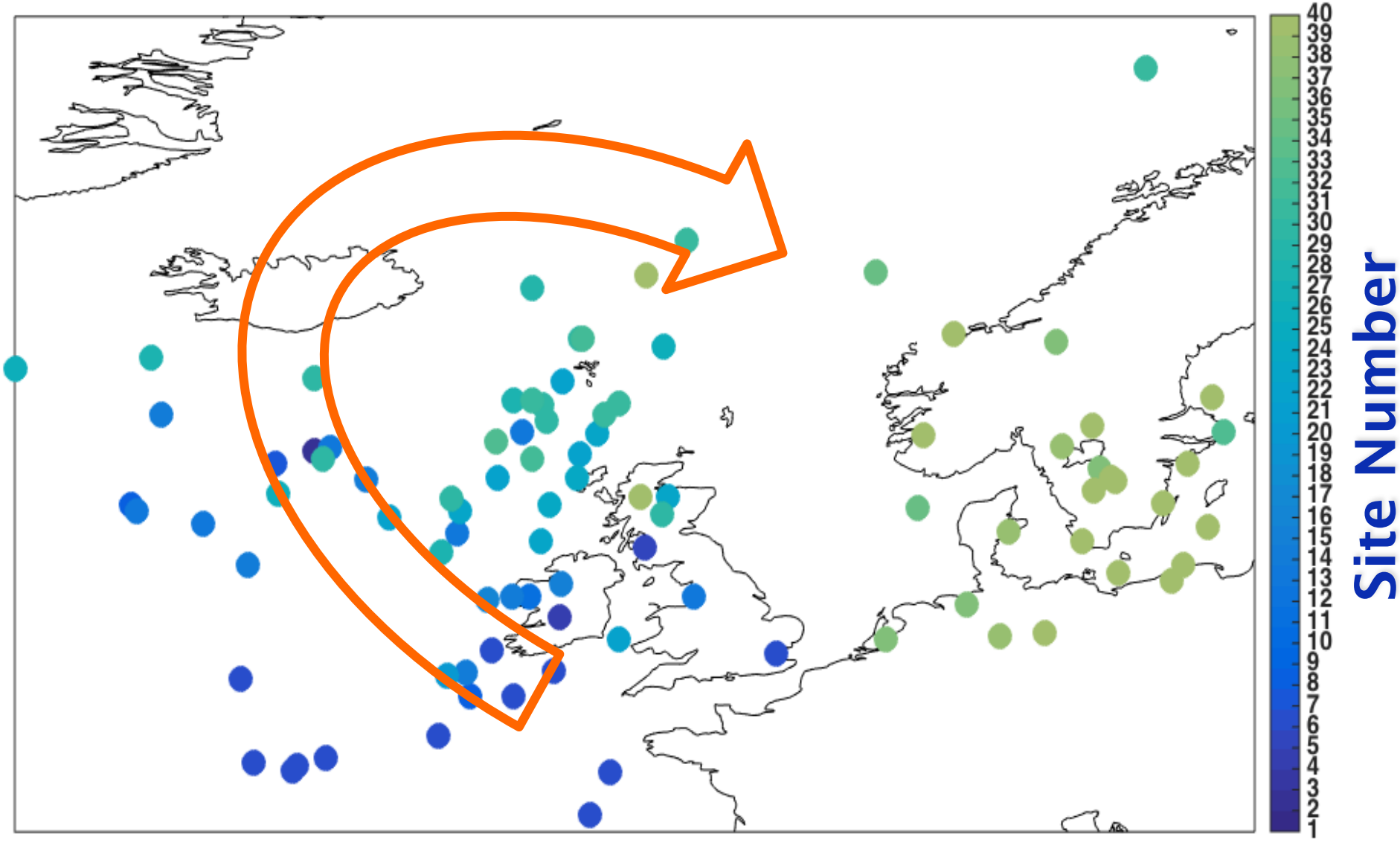
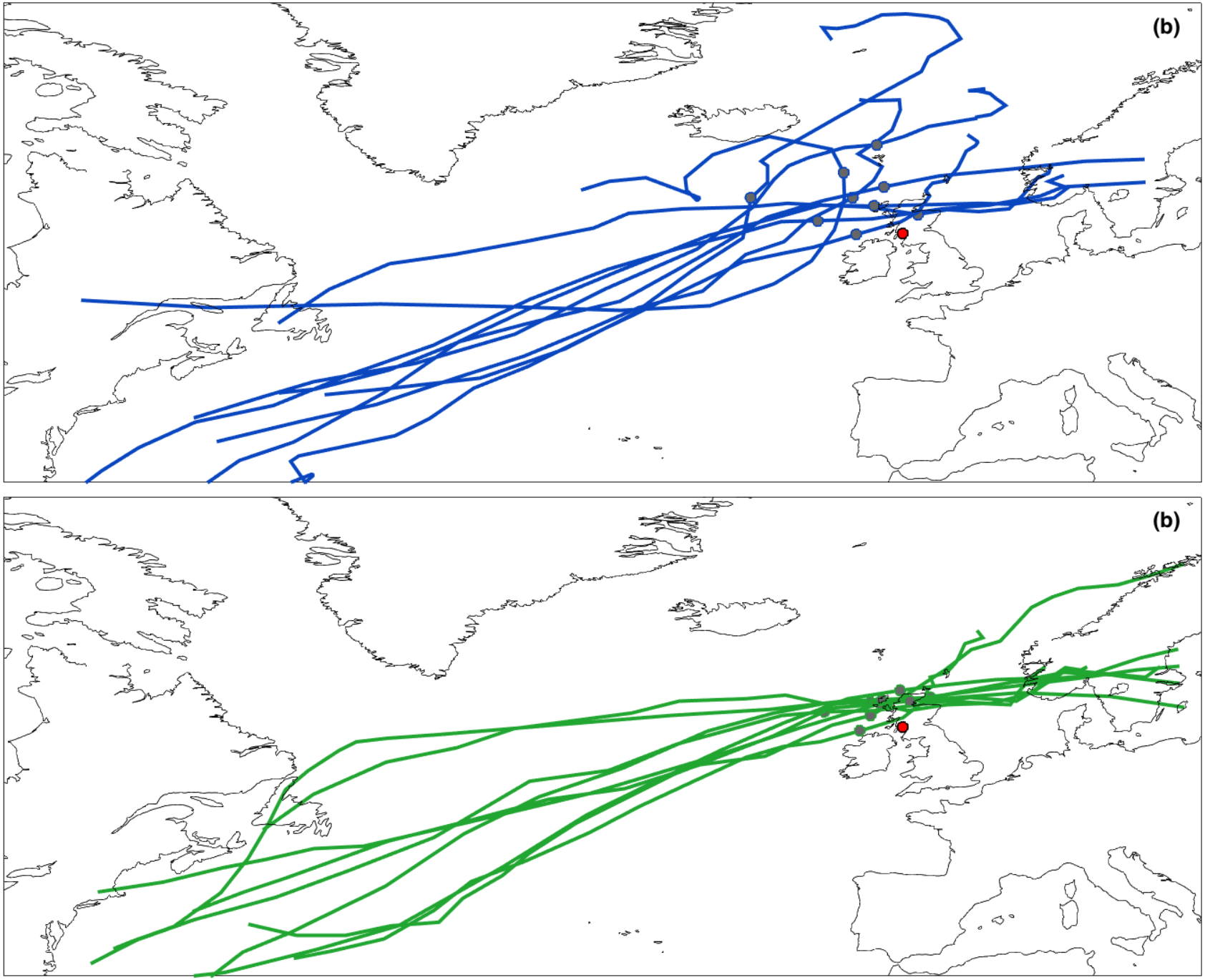


Site 23: Millport



4. Temporal Analysis

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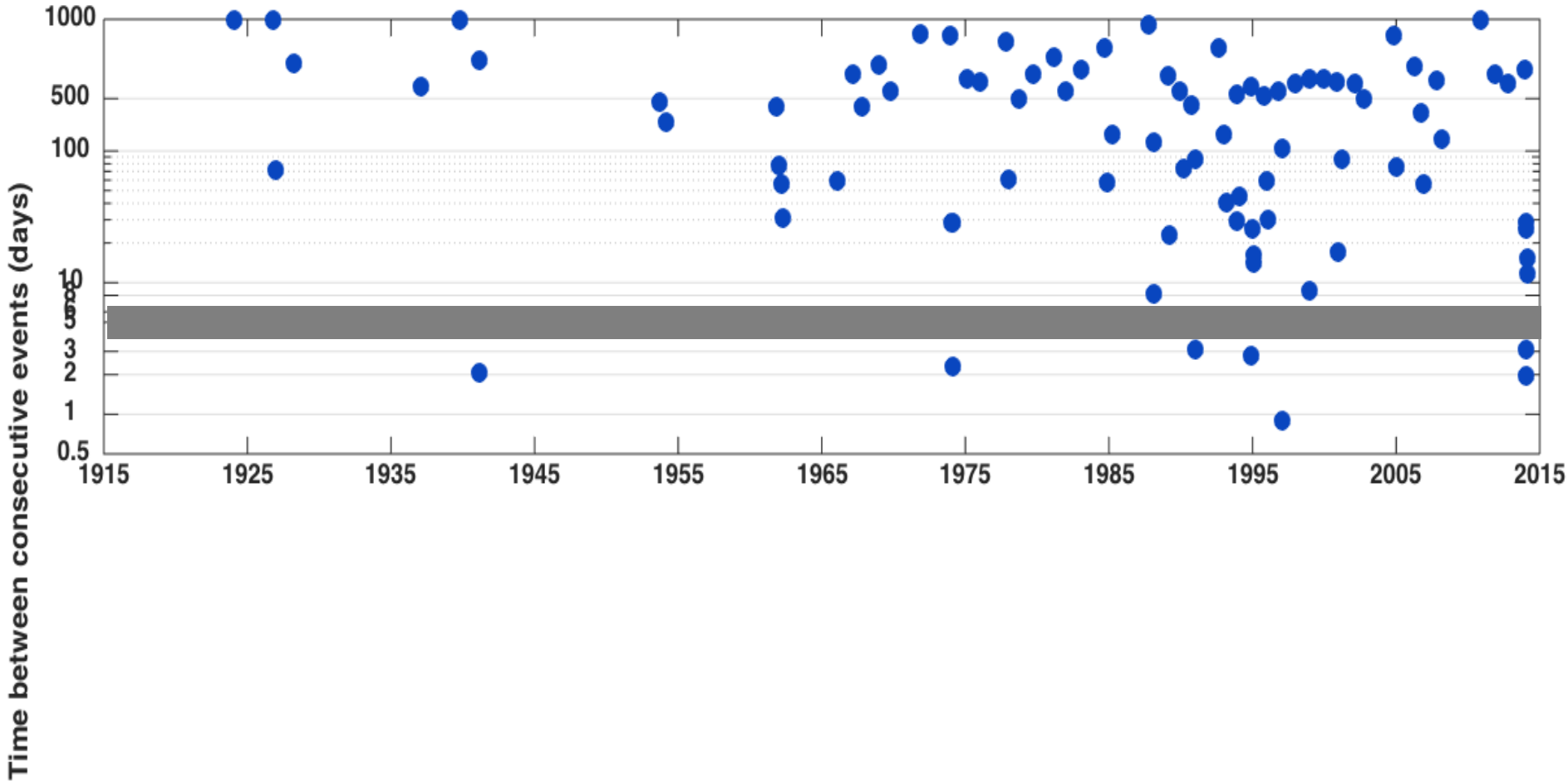

4. Temporal Analysis

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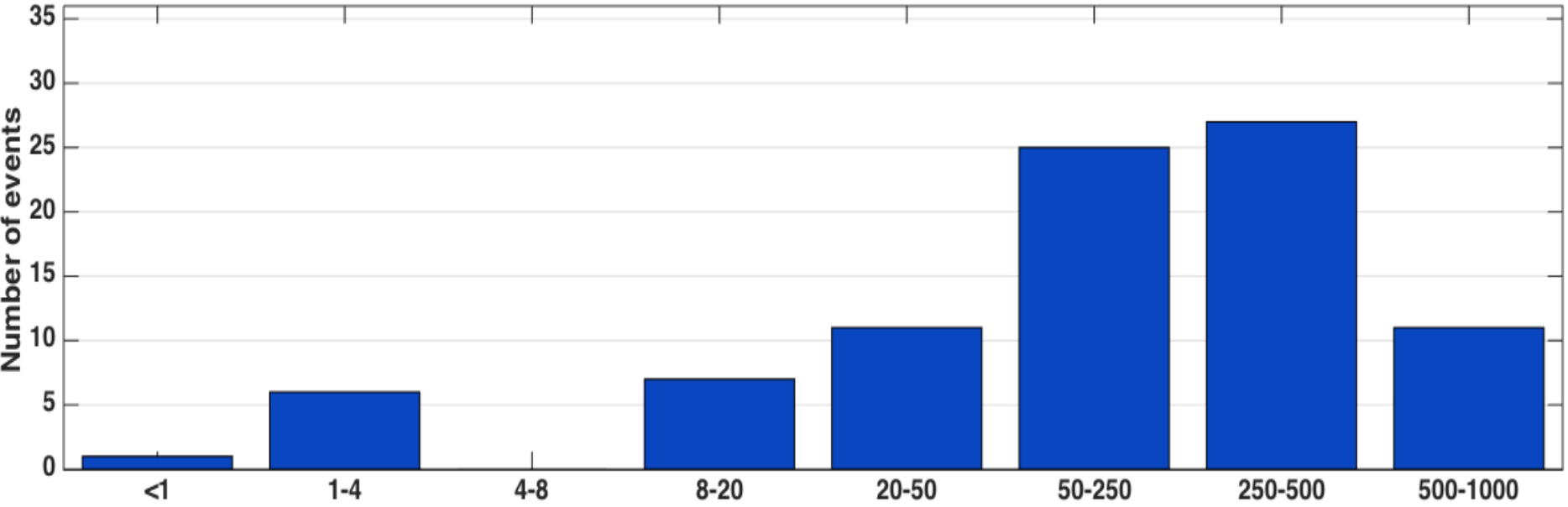

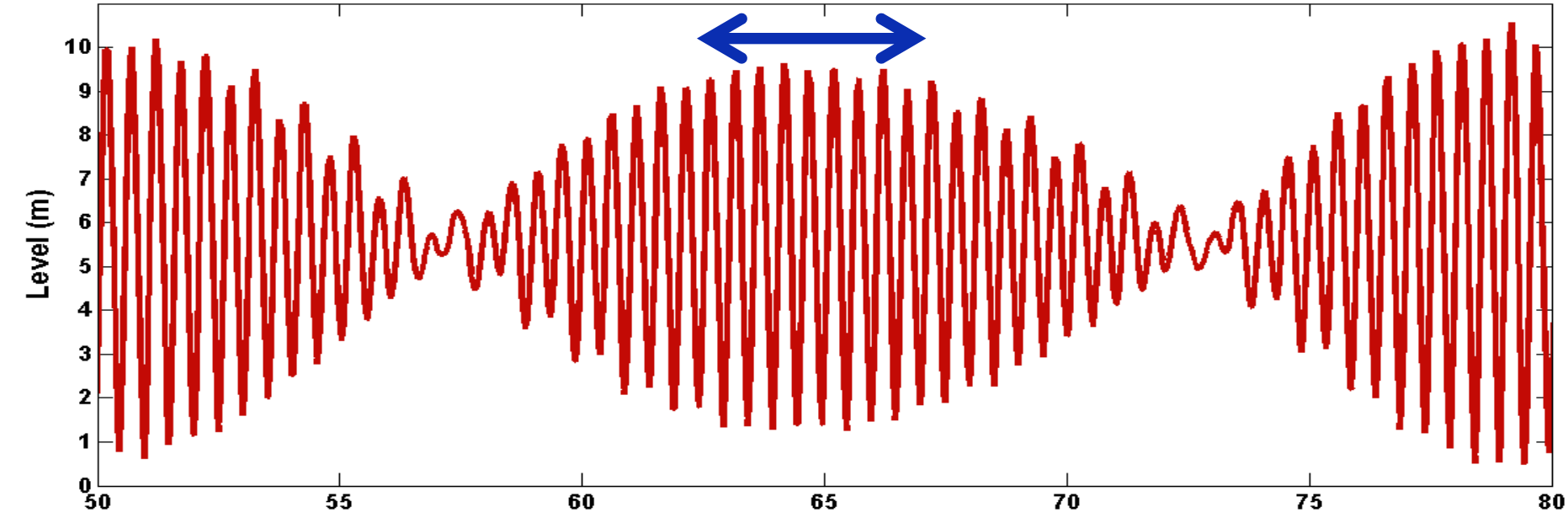

4. Temporal Analysis

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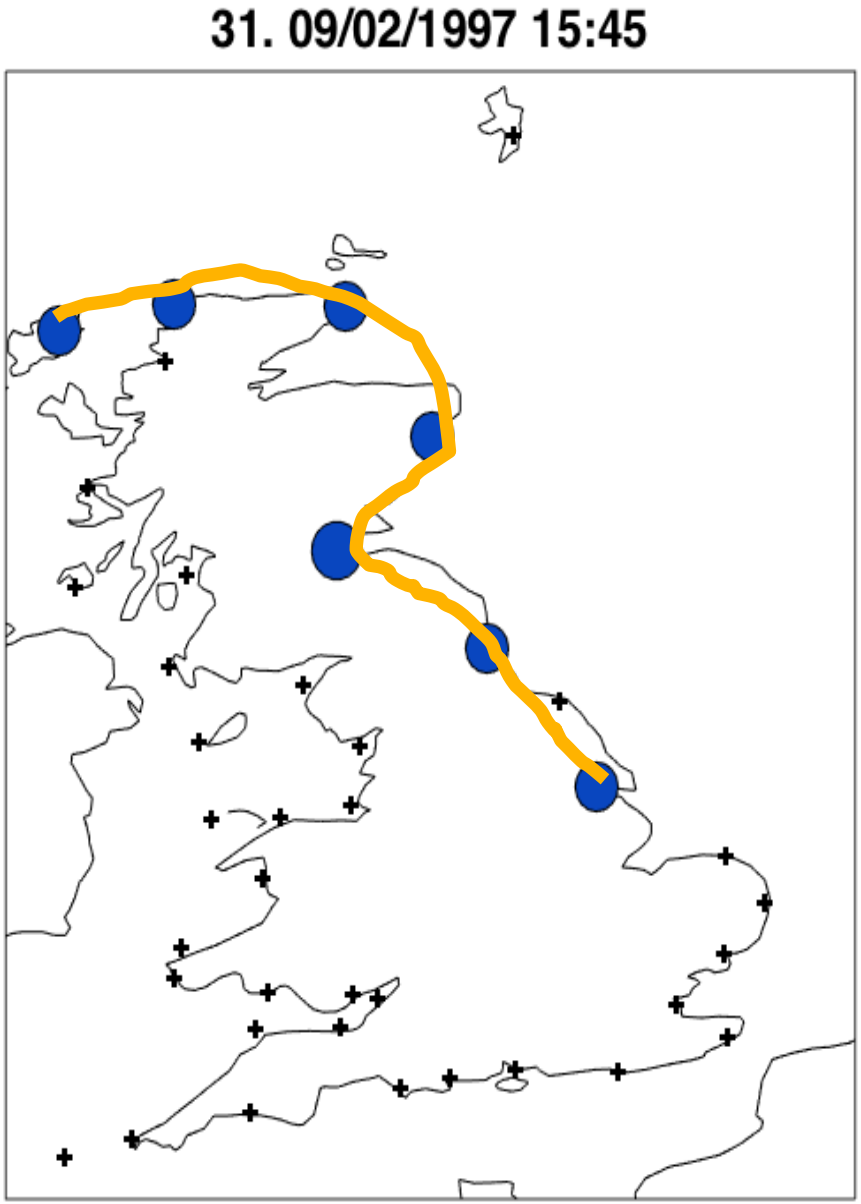

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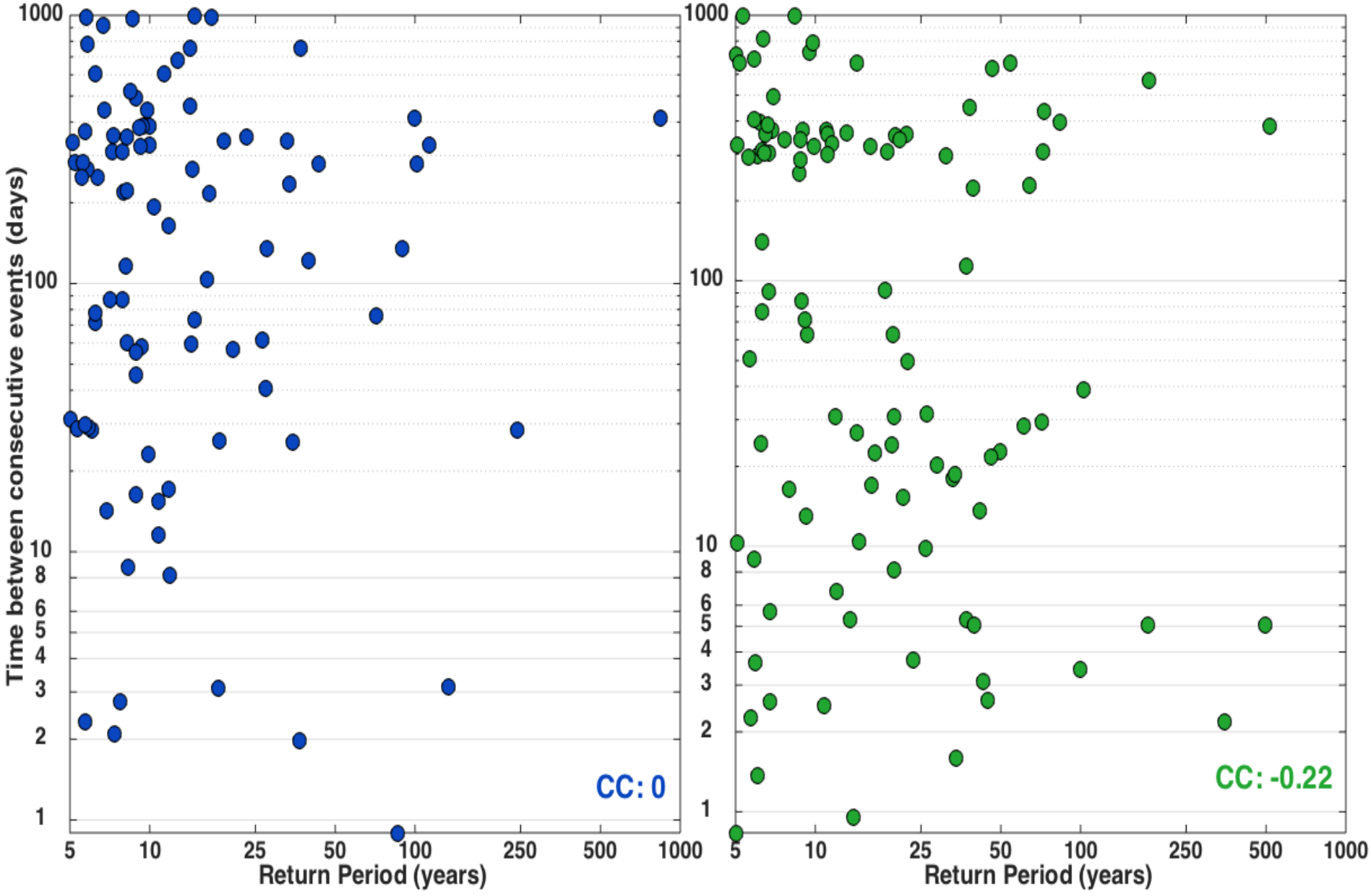

5. Conclusions

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- Developed a new frame work for looking at extreme sea level events – 'Event Analysis' and used this to create a new database for the UK - SurgeWatch;
- Insight into the spatial footprint of events and temporal clustering of events;
- Footprint – broadly 4 typical footprints; importantly footprints can affect two stretches of coastline;
- Clustering – reasonably rare; water level do not have events between 4-8 days, due to spring/neap tidal cycle; footprint of consecutive events usually differs.

6. Papers

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1. Wadey, M.P., **Haigh, I.D.,** Brown, J.M., **2014. A century of sea level data and the UK's 2013/14 storm surges: an assessment of extremes and clustering using the Newlyn tide gauge record.** Ocean Science, 10, 1031-1045.

2. **Haigh, I.D.,** Wadey, M.P., Gallop, S.L, Loehr, H., Nicholls, R.J., Horsburgh, K., Brown, J.M, and Bradshaw, E., **2015. A user-friendly database of coastal flooding in the United Kingdom 1915-2014.** Scientific Data, 2, Article number: 150021.

3. **Haigh, I.D.,** Nicholls, R.J., Horsburgh, K., Brown, J.M, and Bradshaw, E., **2015. A spatial and temporal assessment of extreme sea level events around the coastline of the UK.** Special Issue Frontiers in Marine Science.

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3. SurgeWatch – Stage 1

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Stage 1: Identified high waters ≥ 1 in 5 year return level

Step 1a: Separated measured sea level records into tidal and non-tidal components using T-Tide

Step 1b: Extracted twice daily observed and predicted high waters and calculated skew surges

Step 1c: Calculated mean sea level trends and offset the extracted high waters relative to 2008

SUPLEMENTARY DATASET: additional mean sea level values from PSMSL

DATASET 1: Hourly/15 minute sea level records National Tide Gauge Network

DATASET 2: EA extreme sea level exceedance probabilities (Batstone, 2011)

Step 1d: Assigned the offset high waters return periods

Step 1e: Stored information associated with the 310 high waters that ≥ the 1 in 5-year return level

3. SurgeWatch – Stage 1

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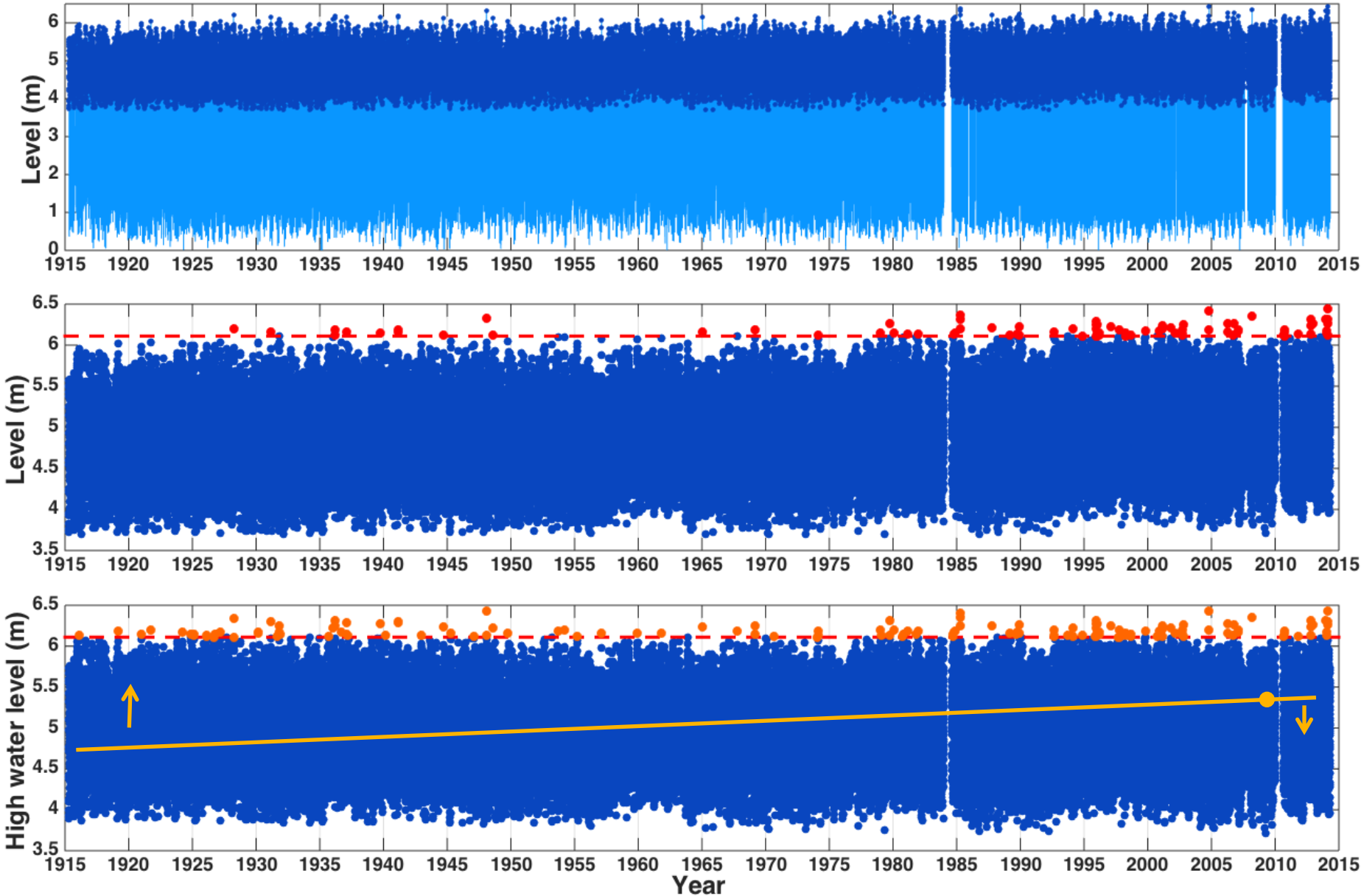
Example: Newlyn



3. SurgeWatch – Stage 2

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Stage 1: The 310 high waters that ≥ the 1 in 5-year return level

Stage 2: Distinguished unique storm events and captured storm tracks

Step 2a: Used simple storm window approach to assign high waters to events

Step 2b: Used meteorological data to check each of the storms distinguished in step 2a and correct events wrongly identified

Step 2c: Captured meteorological information (.e.g. storm track) associated with each of the 96 distinct storm events

DATASET 3: Mean sea level pressure & wind fields – 20th Century Reanlysis (1915 – 2014)

3. SurgeWatch – Stage 3

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Stage 2: **96 Distinct storm events**

Stage 3: Determined whether coastal flooding occurred or not and compiled systematic event commentaries

Step 3a: Used dates of 96 events as chronological base to investigate whether historical documentation exists for concurrent coastal flood

Step 3b: Compiled event commentaries with pictorial and tabula display of data from stages 1 and 2.

1. Journal papers;
2. Professional reports;
3. Journalistic reports (websites);
1. Other online sources (blogs)