

“Eye of the Storm”: Social Sensing of Extreme Weather Events Using Social Media

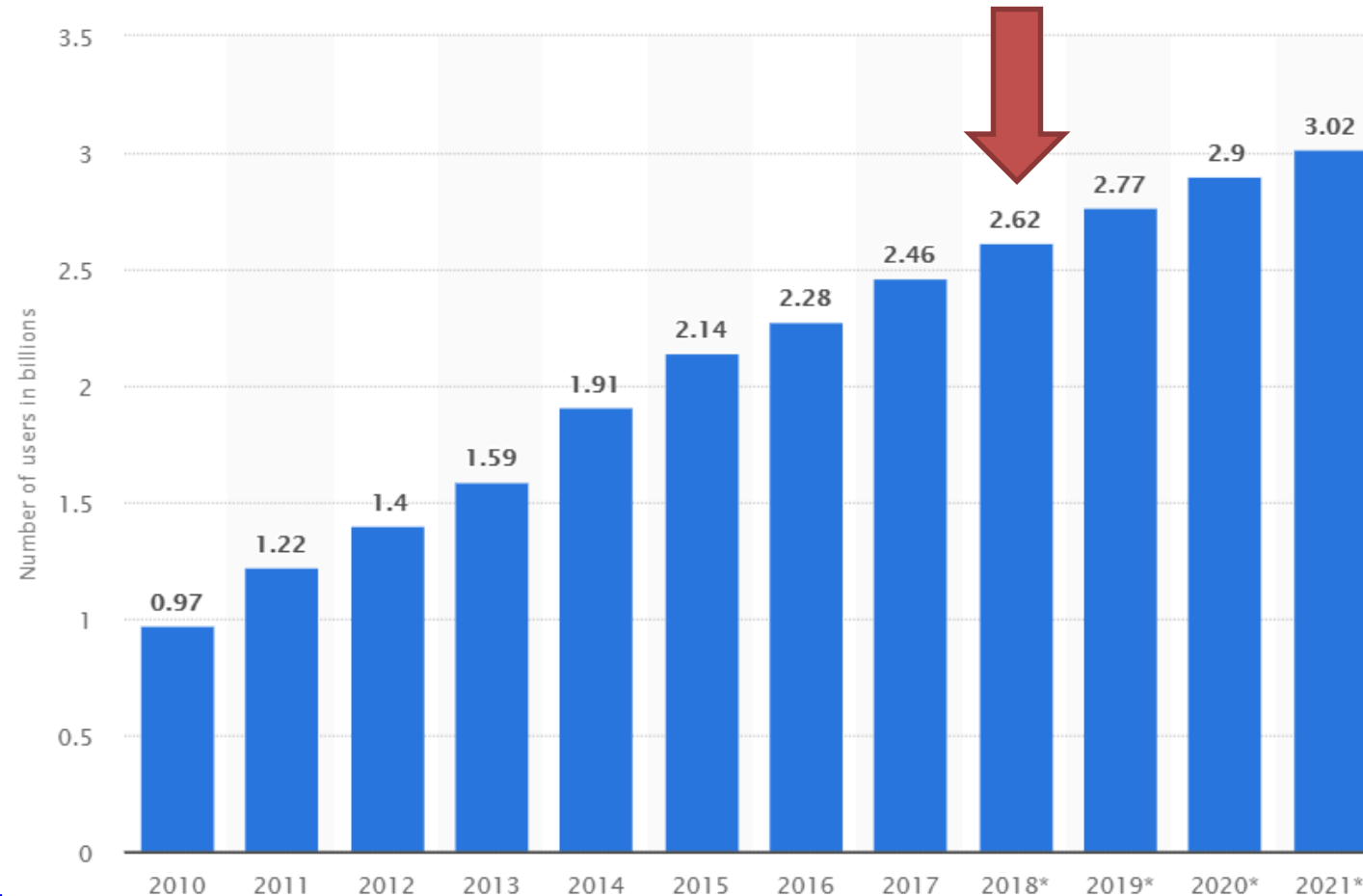
Michelle Spruce

PhD Computer Science

PI – Dr Hywel T. P. Williams

Research undertaken as part of University of Exeter [SEDA Lab](#) (Social & Environmental Data Analysis @ University of Exeter)

Number of social media users worldwide from 2010 to 2021 (in billions)



<https://www.statista.com>



8th November 2018
11am – 3pm

TWEETS IN 4 HOURS

12 517 938

UNITED STATES

145 507

BRAZIL

81 115

TURKEY

60 164

JAPAN

55 940

<https://www.tweetping.net>



Social Sensing



Wildfires



Earthquakes



Hurricanes



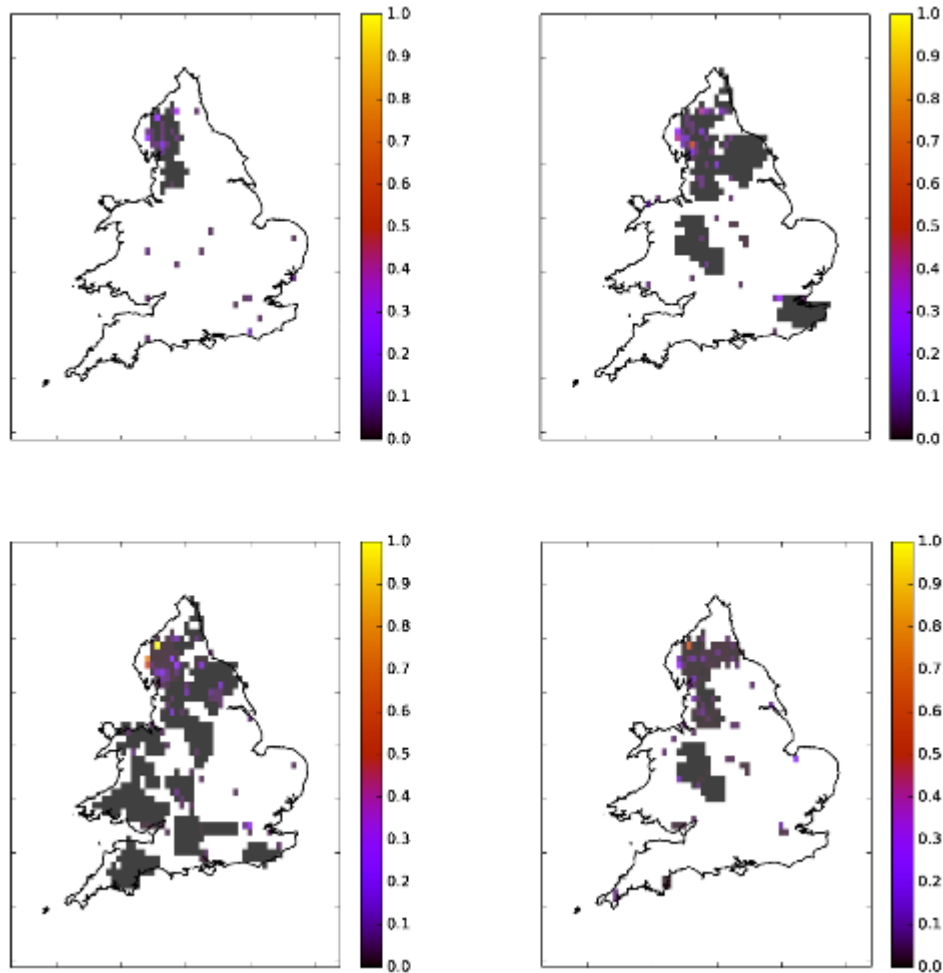
Floods / Heavy Rain



Heatwaves



Social Sensing Floods



Floodiness grid, 64×64 , over England and Wales on 5/12/2015 using $(r, \alpha, T) = (1.0, 0.15, 0.1)$.

Using tweets collected in 1 hour windows. White indicates no tweets. Colour bar units are floodiness relative to daily max. Top left: 10am-11am. Top Right: 1pm-2pm. Bottom Left: 4pm-5pm. Bottom Right: 9pm-10pm.

RESEARCH ARTICLE

Social sensing of floods in the UK

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Abstract

"Social sensing" is a form of crowd-sourcing that involves systematic analysis of digital communications to detect real-world events. Here we consider the use of social sensing for observing natural hazards. In particular, we present a case study that uses data from a popular social media platform (Twitter) to detect and locate flood events in the UK. In order to improve data quality we apply a number of filters (timezone, simple text filters and a naive Bayes 'relevance' filter) to the data. We then use place names in the user profile and message text to infer the location of the tweets. These two steps remove most of the irrelevant tweets and yield orders of magnitude more located tweets than we have by relying on geo-tagged data. We demonstrate that high resolution social sensing of floods is feasible and we can produce high-quality historical and real-time maps of floods using Twitter.

OPEN ACCESS

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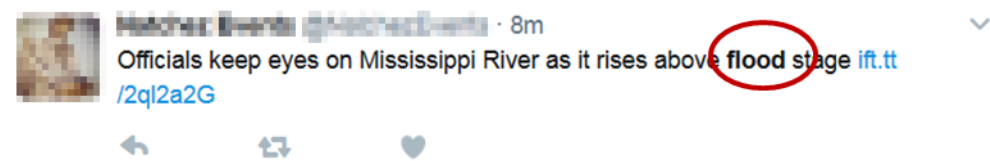
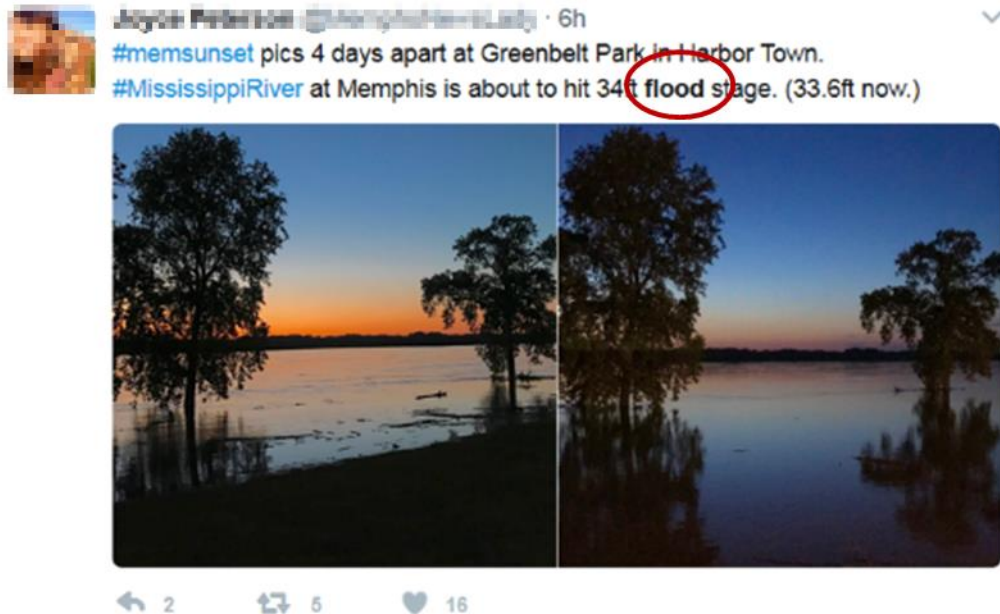
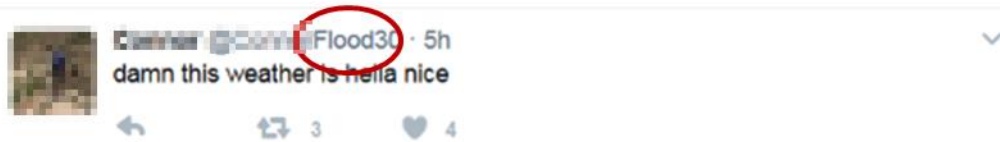
Published: January 31, 2018

Copyright: © 2018 Arthur et al. This is an open

Introduction

Natural hazards such as floods, wildfires, storms and other extreme weather events cause substantial disruption to human activity and are predicted to increase in frequency and severity as

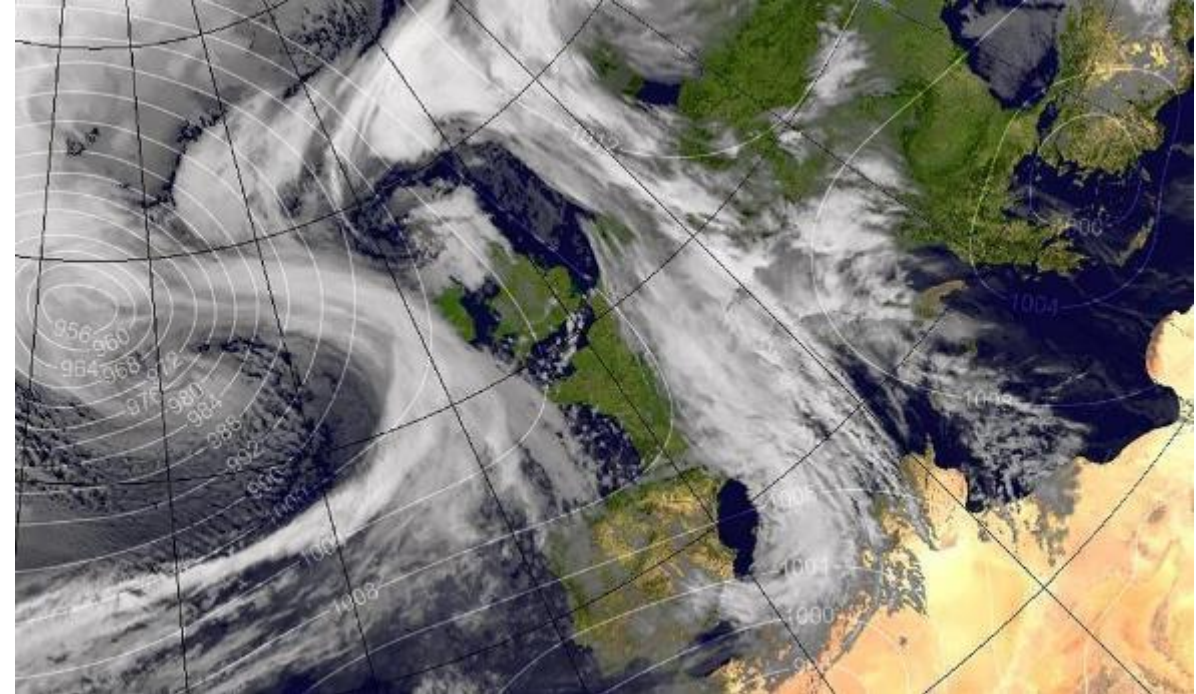
Searching for floods on Twitter...



UK Storm Names 2017/18



Name	Date named	Date of impact on UK and/or Ireland
Aileen	12 September 2017	12 - 13 September 2017
Ex-Hurricane Ophelia	11 October 2017 (Named by NHC)	16 - 17 October 2017
Brian	19 October 2017	21 October 2017
Caroline	5 December 2017	7 December 2017
Dylan	29 December 2017	30 - 31 December 2017
Eleanor	1 January 2018	2 - 3 January 2018
Fionn (F-yunn)	16 January 2018	16 January 2018
David	17 January 2018 (Named by Meteo France)	18 January 2018
Georgina	23 January 2018	24 January 2018
Hector	13 June 2018	13 - 14 June 2018



Likelihood	High				
	Med				
	Low				
	Very low				
		Very low	Low	Med	High
Impact					

<https://www.metoffice.gov.uk/barometer/uk-storm-centre>

News about Storm Hector...and trampoline troubles....

 **Conrad** @conrad1980

Storm Hector has already delivered me a few presents. So far a plant pot, a garden glove, couple empty bags of compost and a cat bed. Have it on good authority that the trampoline may be on it's way 🤔👀 #stormhector

6:39 AM - 14 Jun 2018

1 Like

 **Sharon Williams** @sharonwilliams

Thank you storm hector... it appears I have a heli pad now instead of a trampoline 😂😂



10:34 AM - 14 Jun 2018

 **Metro** @MetroUK

Trampolines go rogue as Storm Hector smashes into Britain with 100mph winds



Trampolines go rogue as Storm Hector smashes into Britain with 100mph win... People are being advised to tie down their garden furniture and trampolines to avoid disruption during rush hour. metro.co.uk

9:10 AM - 14 Jun 2018

3 Retweets 5 Likes

 **Tom** @tom1980

Give over... its not Storm Hector its just a bit blowy

Weather is just weather.

10:30 AM - 14 Jun 2018 from North East, England

 **Aidan Comerford** @AidanComerford · Jun 13

After Storm Doris, we had to apologise for our trampoline in our neighbour's garden. Their kid thought it was a present, cos it was her birthday. To make matters worse, we asked if the trampoline had hurt their dog only to be told that he died at Xmas. #badneighbours #StormHector

12 84 627

 **MayoRoadsafety** @safecounty

Good morning, #mayo It's a wild one out there today with some debris on the road. Storm Hector has arrived and has brought strong gale force winds, so be careful. Take care and remember to tie those trampolines down. @MayoDotIE @MayoCoCo



9:27 AM - 14 Jun 2018

Twitter



- Full Twitter database commercially available (e.g. Twitter Developer Enterprise API)
- Some data available for free via open Twitter **Application Programming Interface (API)**
 - **Streaming API** – up to 1% of all tweets being sent, in real time
 - **Search API** – uses REST protocol, sample of “relevant” tweets based on search filter

<https://developer.twitter.com/en.html>



Collecting Twitter Data (Tweets)

Collect tweets using keywords:

Storm Name Collection: *storm, Ophelia, Ofelia, Opelia, Ohpelia, Opehlia, opheliaireland, Brian, Caroline, Dylan, Eleanor, Fionn, Fion, Georgina, Emma*

Wind Collection: *wind, gale, windstorm, hurricane*



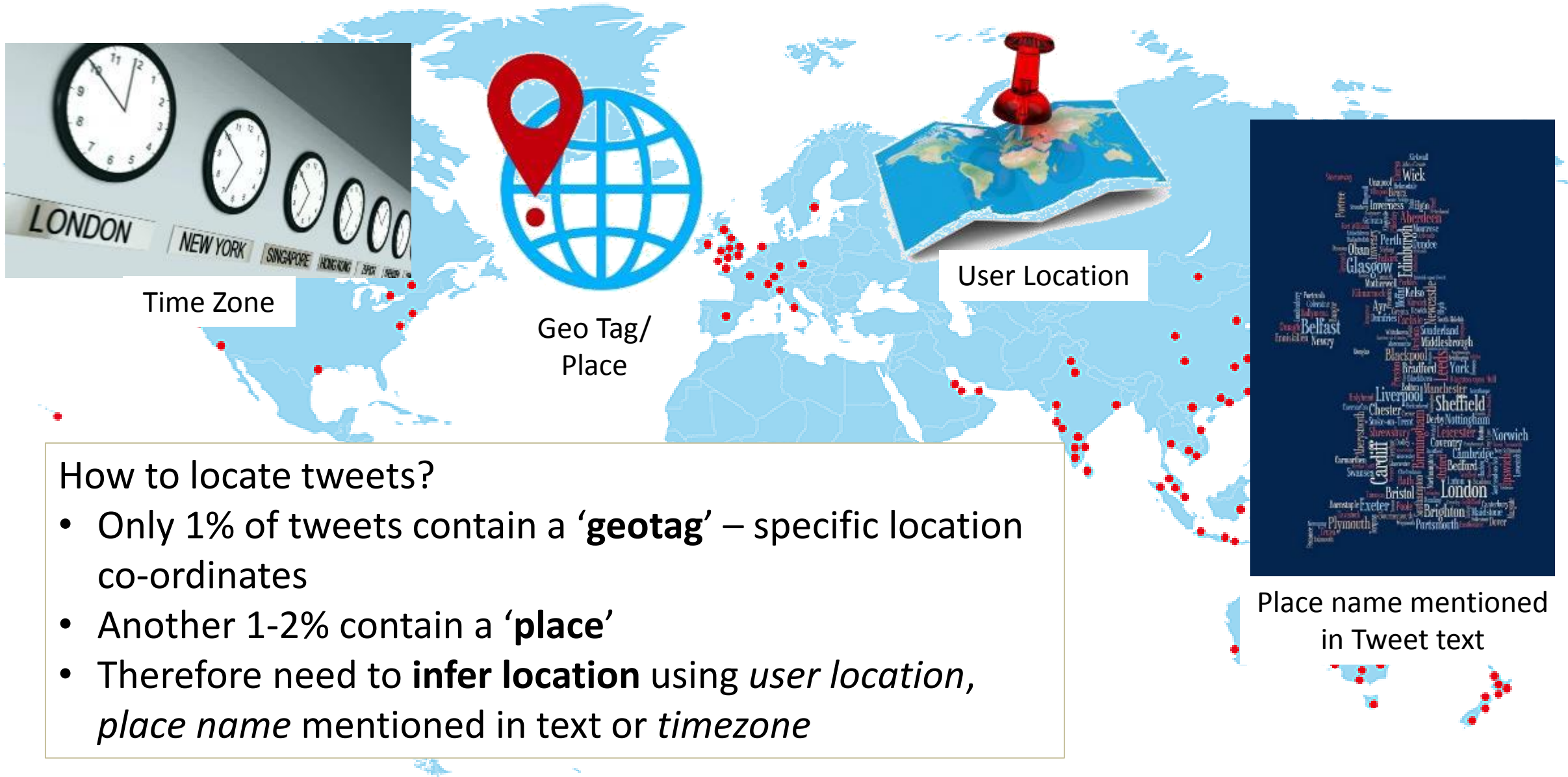
JSON tweet object

```
{
  "text": "RT @PostGradProblem: In preparation
for the NFL lockout, I will be spending twice as much
time analyzing my fantasy baseball team during ...",
  "truncated": true,
  "in_reply_to_user_id": null,
  "in_reply_to_status_id": null,
  "favorited": false,
  "source": "<a href=\"http://twitter.com/\" ...
  "in_reply_to_screen_name": null,
  "in_reply_to_status_id_str": null,
  "id_str": "54691802283900928",

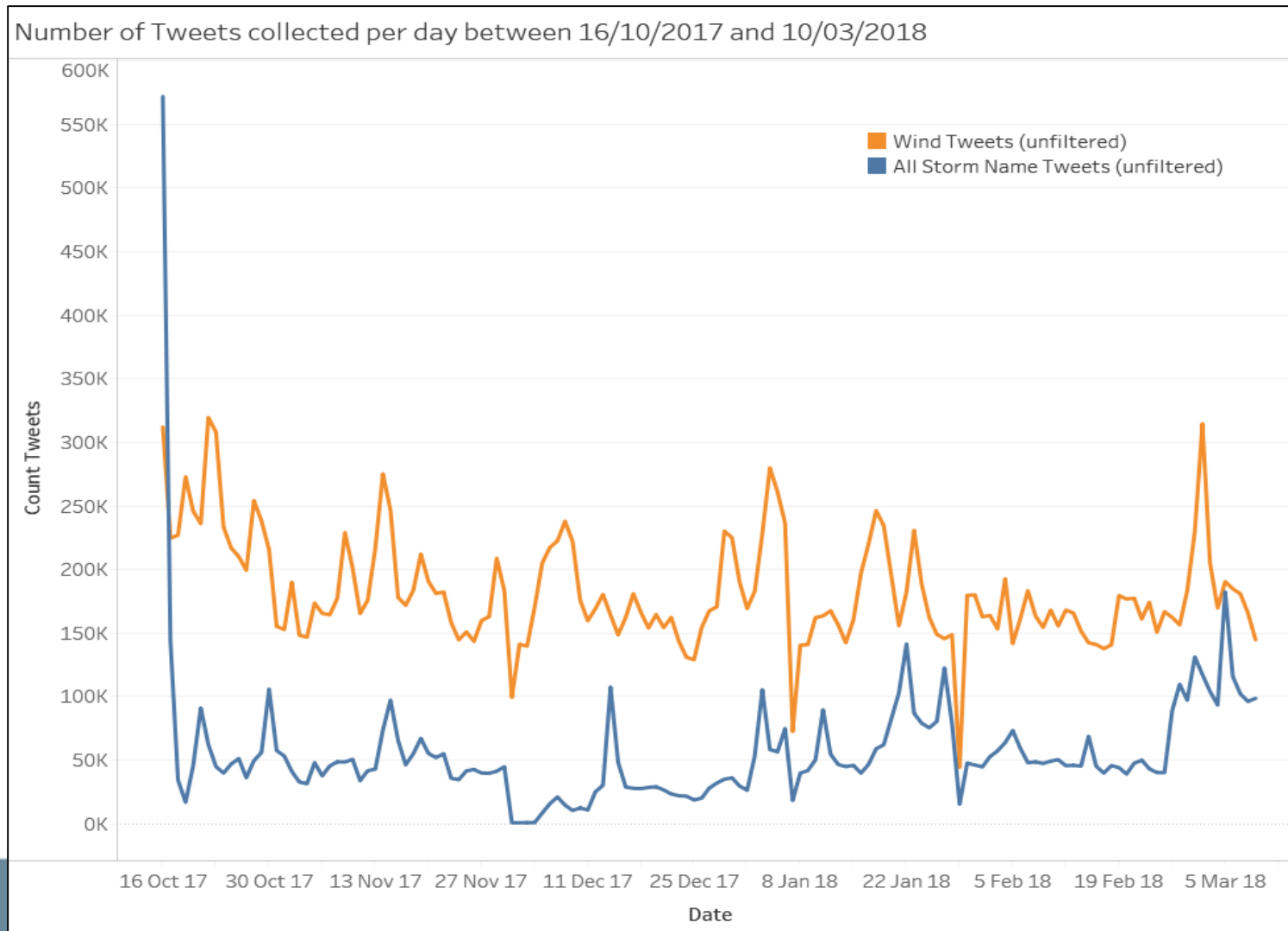
  ...

  "id": 54691802283900930,
  "coordinates": null,
  "geo": null
}
```

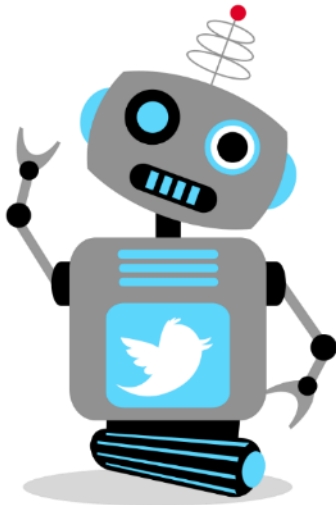




- Tweets collected 16th October 2017 – 10th March 2018
- Over 35 million individual Tweets collected



Method – relevance filter



Bot filter

- Remove usernames known to be automated 'Twitter bots'



Weather station filter

- Remove tweets with known weather station structure



Irrelevant Term filter

- Exclude tweets containing terms such as: 'cook up a storm', 'wind up', 'throw caution to the wind', etc)



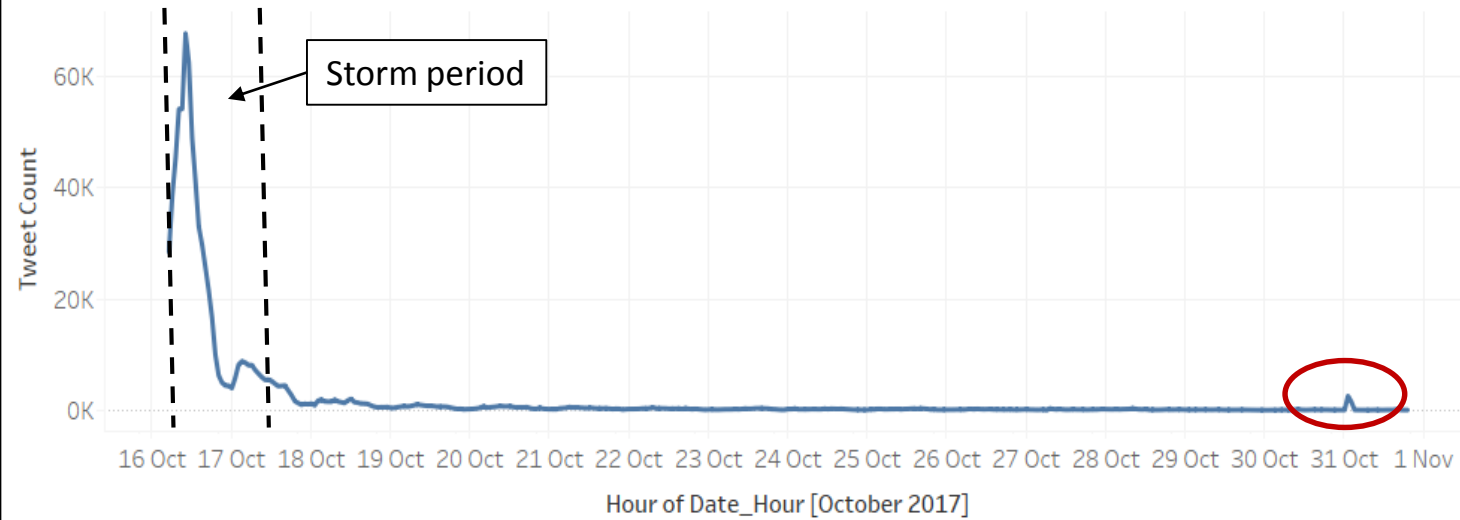
Machine learning

- Created training corpus using 5000 labelled tweet examples
- Apply **Naïve Bayes** algorithm to remove tweets based on training corpus

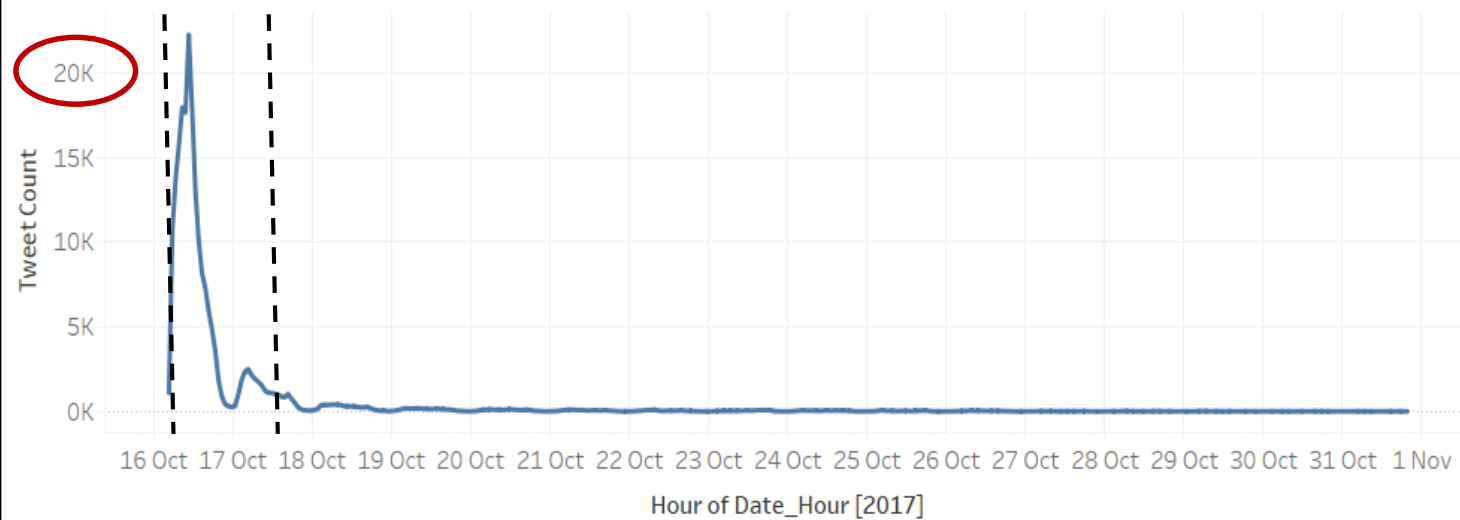


"ophelia" tweets: 16/10/2017 - 31/10/2017

All Ophelia Tweets (Unfiltered)

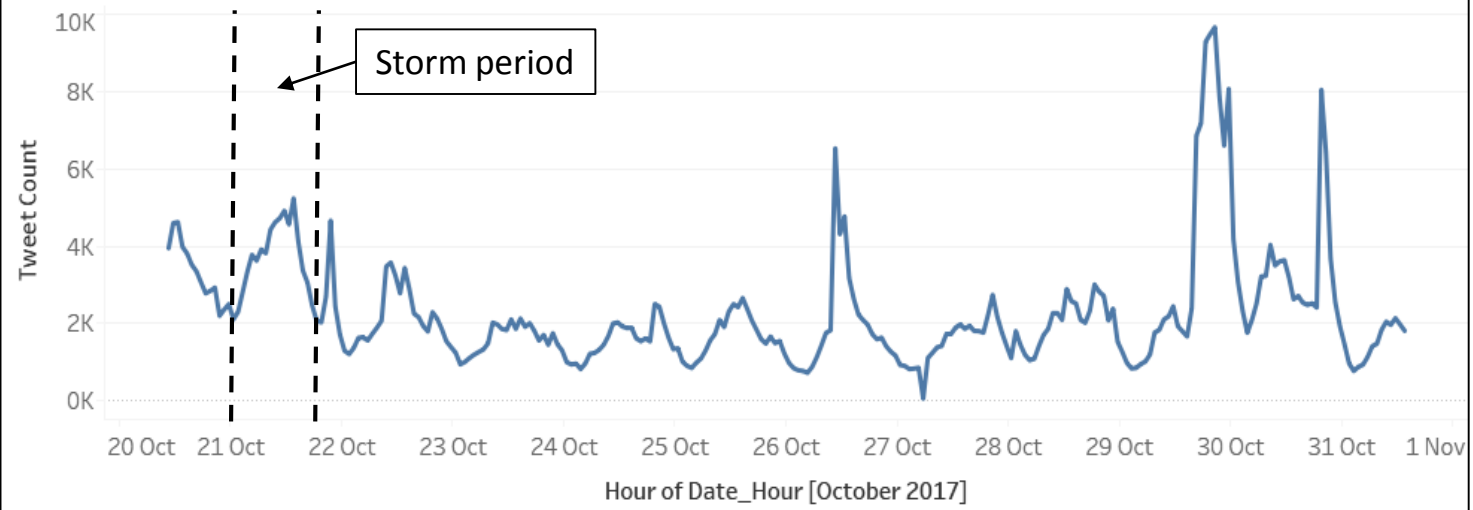


Filtered for relevance

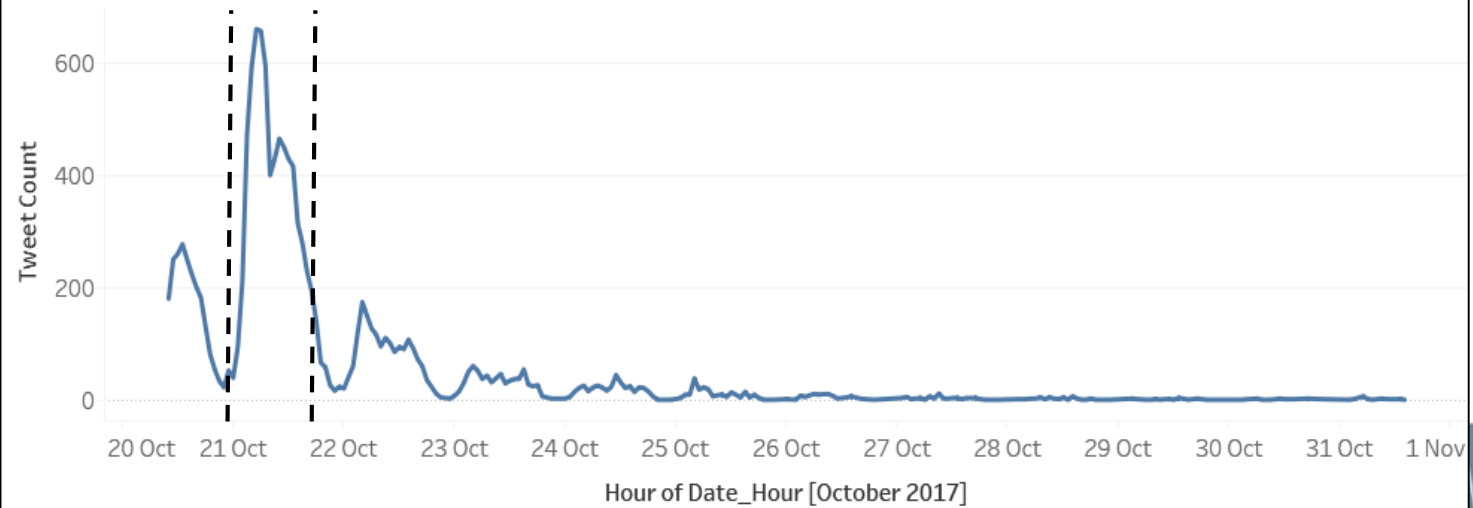


"Brian" tweets - 20/10/2017 - 01/11/2017

All Brian Tweets - Unfiltered

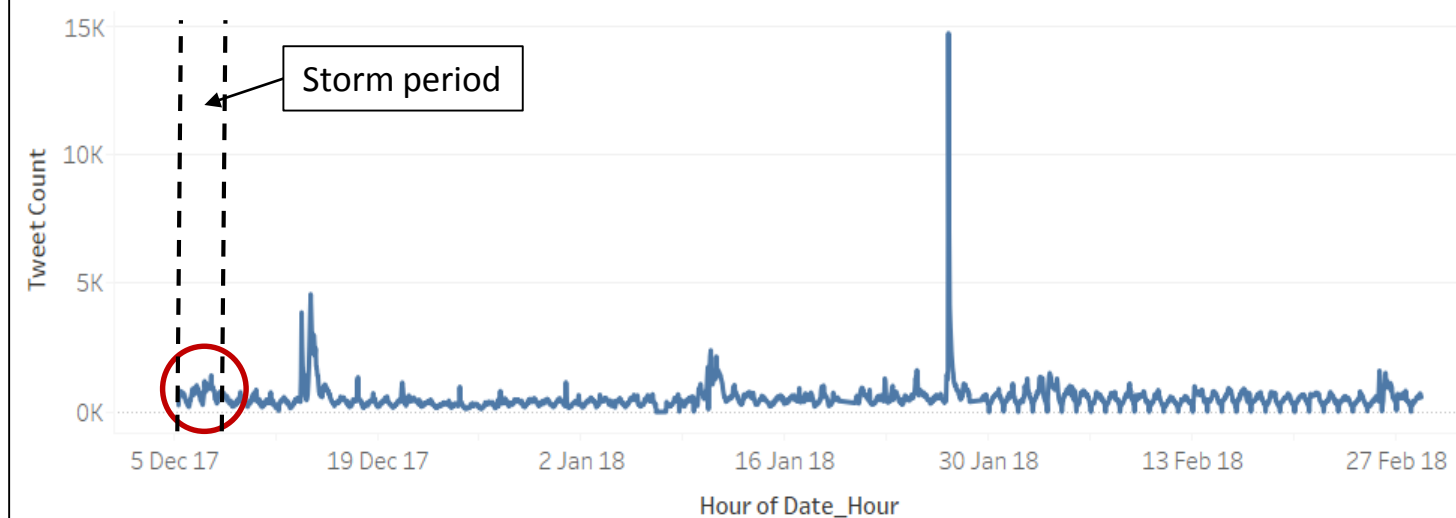


Filtered

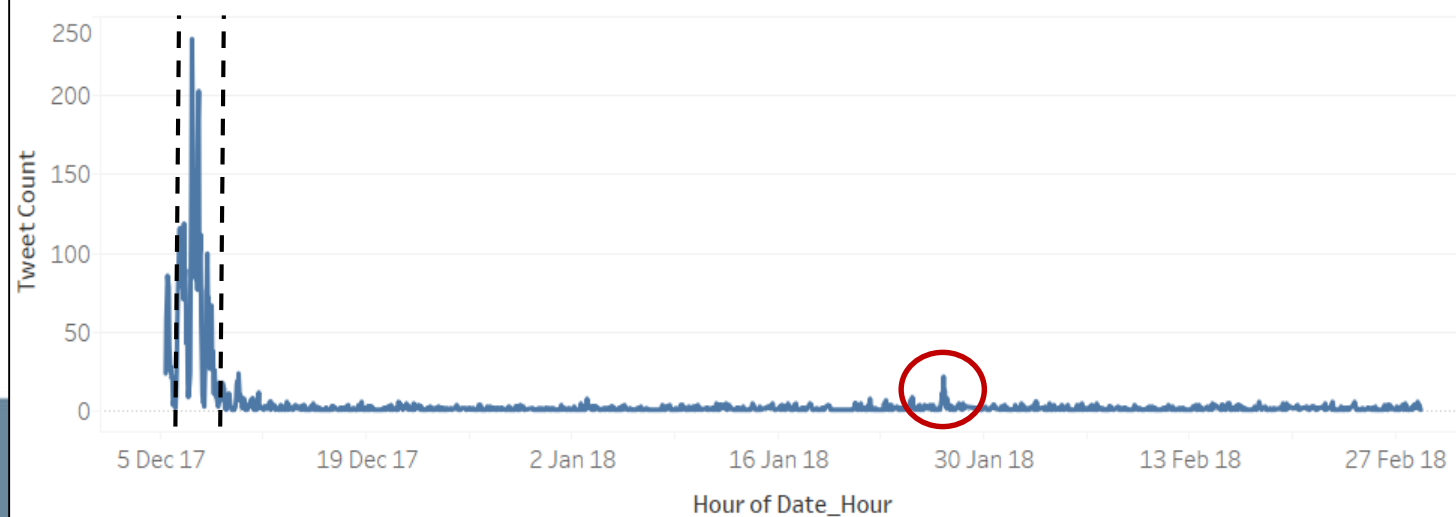


"caroline" tweets: 05/12/2017 - 28/02/2018

All Caroline Tweets (Unfiltered)



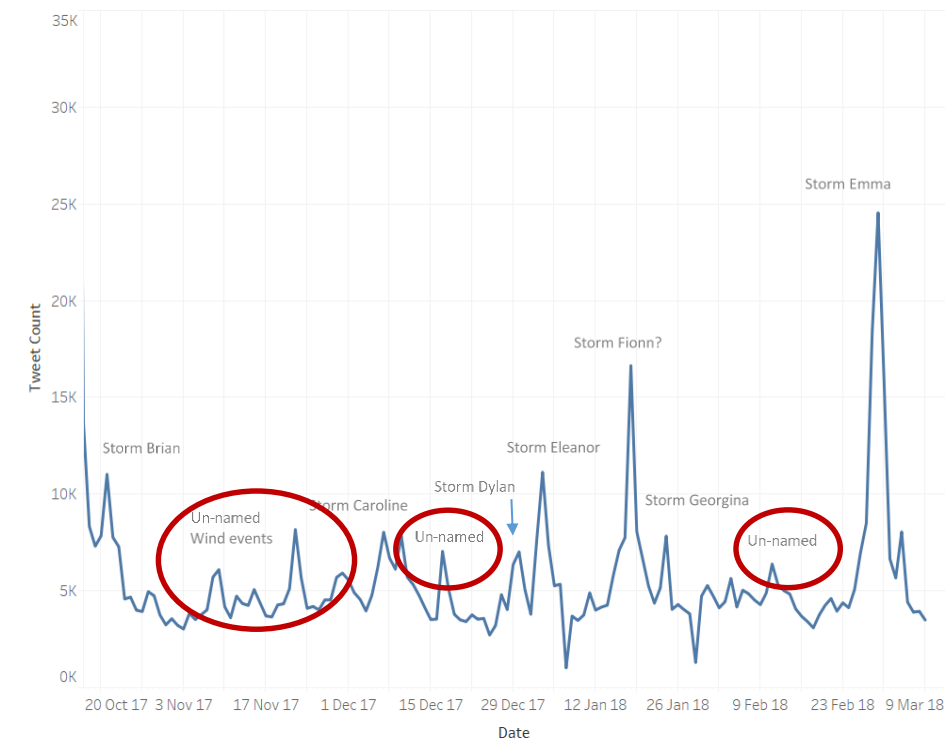
Filtered for relevance



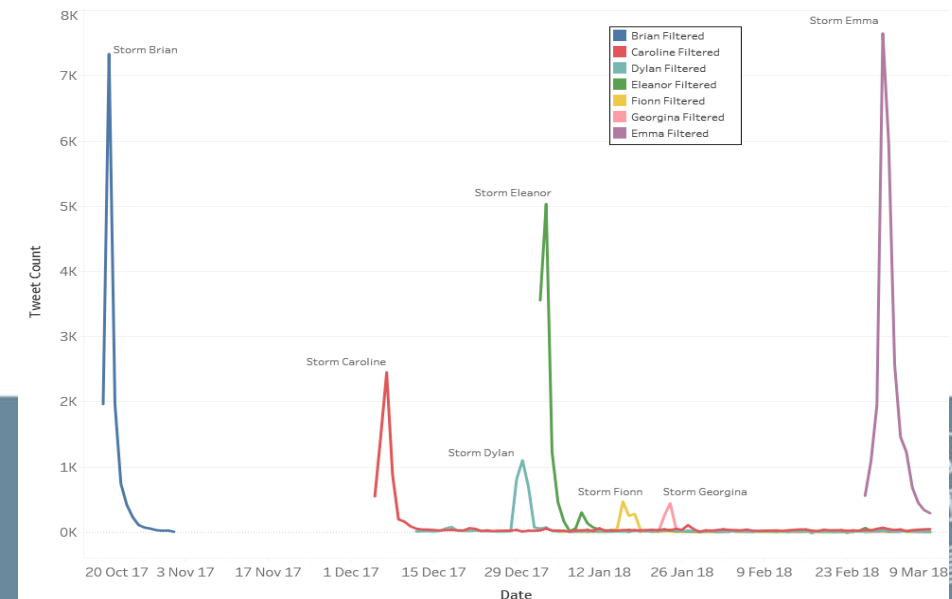
Wind tweets (filtered for relevance) versus Named storm tweets (filtered for relevance)

- Peaks in wind tweets coincide with peaks in named storm tweets
- Also peaks in wind tweet activity at other times to named storm events – are these ‘extreme weather events’? Or just windy days?

Wind Tweets (filtered for relevance)



All Named Storms Tweets (filtered for relevance)



Hover over a county
Last Update: Tue Oct 31 2017 23:00:00 GMT+0000 (Greenwich Mean Time)

Daily Star ✓
@Daily_Star

9:25 PM - Oct 20, 2017


[@mike-miller](#)

9:44 PM - Oct 20, 2017



9:47 PM - Oct 20, 2017

100-5
5-2.5
2.5-1
1-0.5
0.5

21/10/2017 00:00:00 - 21/10/2017 23:00:00

Storm Brian Tweets 21st October 2017

Hover over a county
Last Update: Tue Oct 31 2017 23:00:00 GMT+0000 (Greenwich Mean Time)

Showing 100 Tweets from devon: Exceedence probability 0.1%



Weather - big waves as Storm Brian hits Ilfracombe seaside town this morning. [#storm](#) [#waves](#) [#weather](#) [#sea](#) [#stormy](#)...
[ift.tt/2yE6du5](#) [pic.twitter.com/r5tlvcyodf](#)

9:35 AM - Oct 21, 2017

♡ 1 👤 See guy harrop's other Tweets



Disruption as Storm Brian hits Dorset - travel and weather updates [fb.me/wi9uaU8l](#)

9:37 AM - Oct 21, 2017

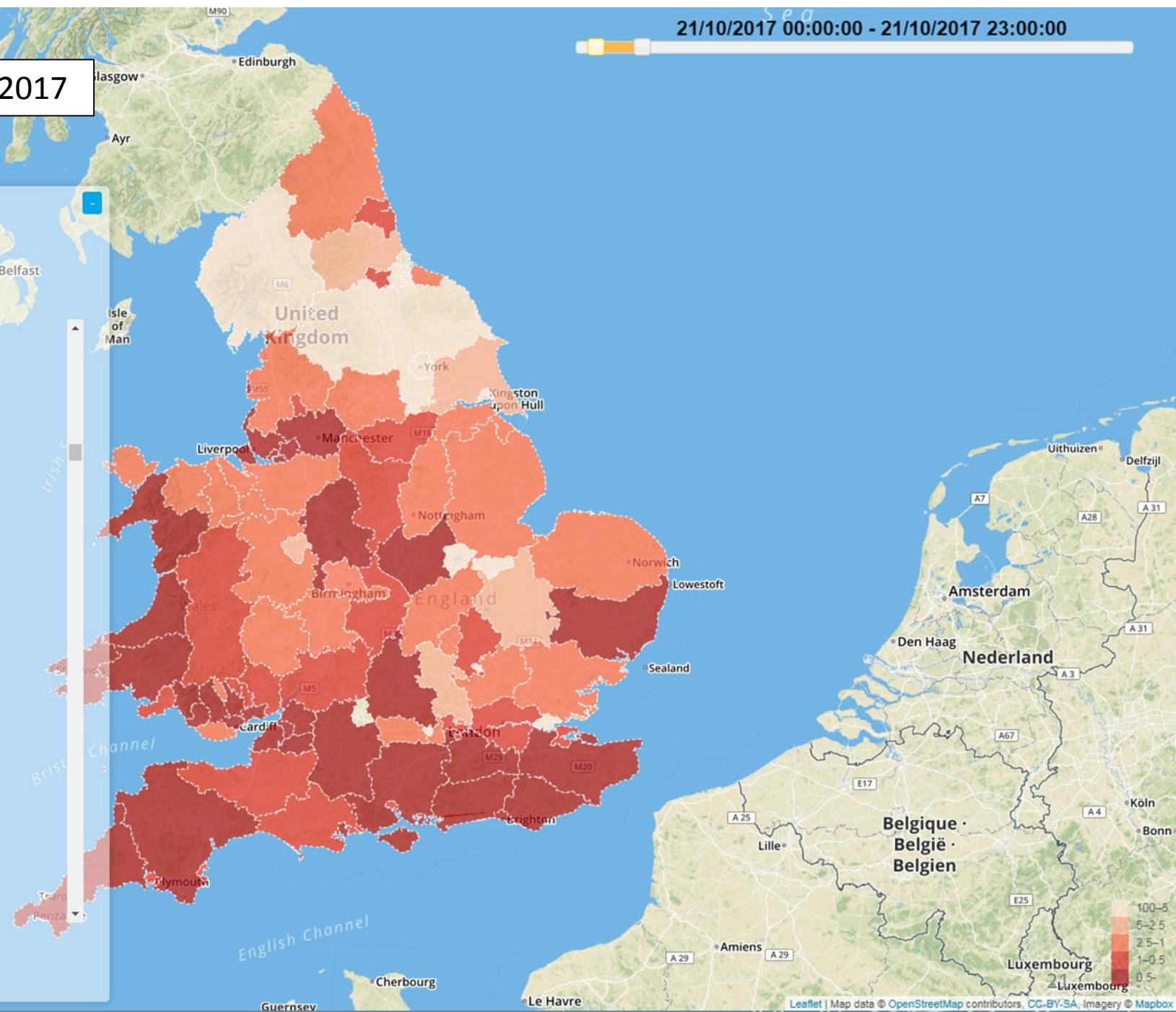
♡ 👤 See sarah stevens's other Tweets



Storm Brian almost claimed one little dog that got a bit too close for comfort [bit.ly/2yYDpxW](#)

9:38 AM - Oct 21, 2017

♡ 5 👤 See Plymouth Live's other Tweets



22/10/2017 00:00:00 - 22/10/2017 23:00:00

Storm Brian Tweets 22nd October 2017

Hover over a county
Last Update: Tue Oct 31 2017 23:00:00 GMT+0000 (Greenwich Mean Time)

Showing 38 Tweets from devon: Exceedence probability 1.44%



Heritage Railway Magazine

@HeritageRailMag

Trains through Dawlish cancelled due to Storm Brian

<fb.me/8Dk2zqG5X>

6:54 AM - Oct 22, 2017



See Heritage Railway Magazine's other Tweets



Steve Shapland

@SteveShapland

Storm Brian: Readers send in pictures of huge waves at Westward Hol and Ilfracombe

northdevongazette.co.uk/news/pictures-...

6:59 AM - Oct 22, 2017



See Steve Shapland's other Tweets



Charlotte

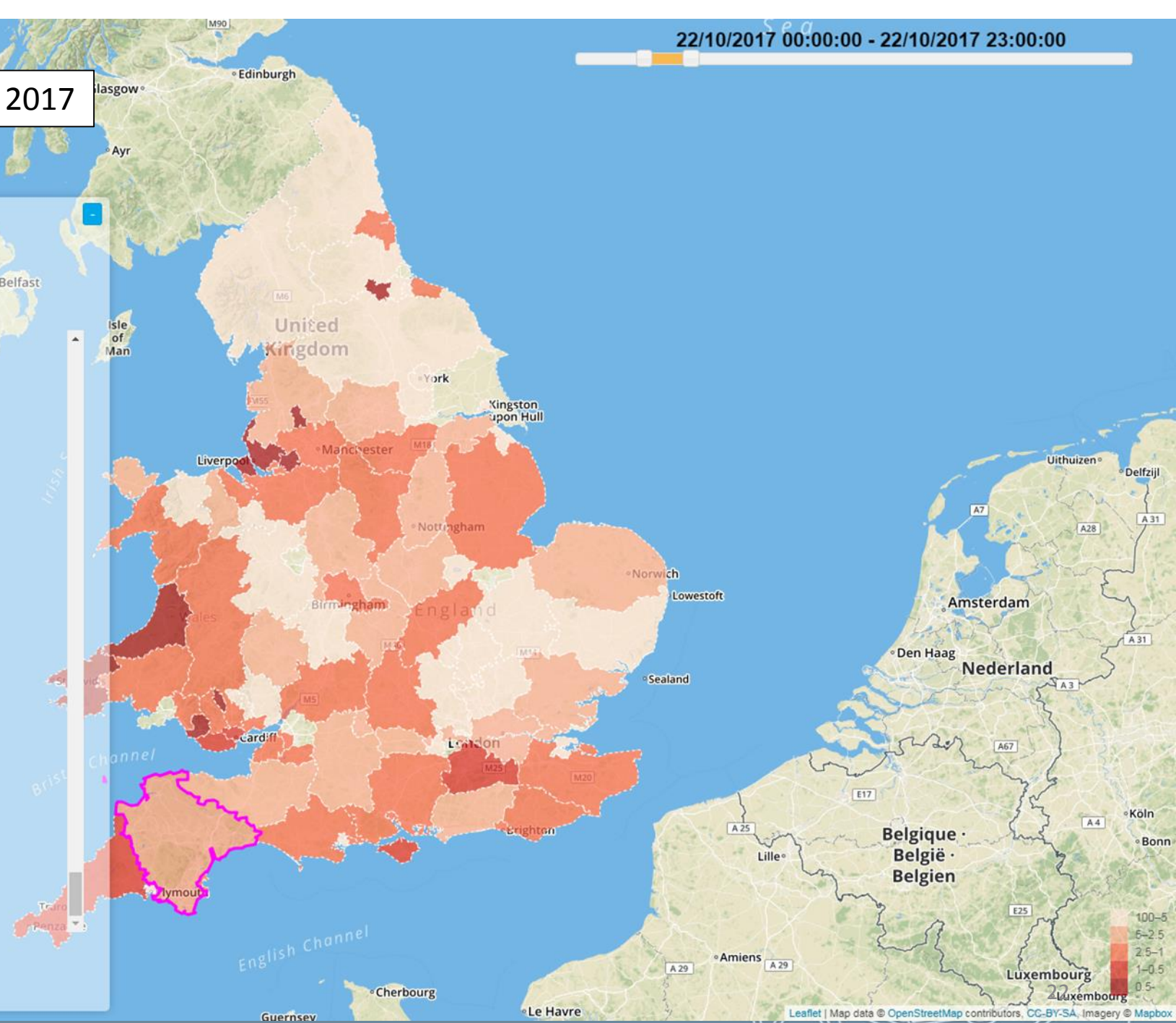
@Charlotte1990

Storm Brian can calm down if it wants?? I'm trying to sleep!

12:56 AM - Oct 22, 2017



See Charlotte's other Tweets



23/10/2017 00:00:00 - 23/10/2017 23:00:00

Storm Brian Tweets 23rd October 2017

Hover over a county
Last Update: Tue Oct 31 2017 23:00:00 GMT+0000 (Greenwich Mean Time)

Showing 15 Tweets from devon: Exceedence probability 4.64%



Good Monday afternoon to you all on twitter. Hope everyone remembered to keep safe from the treacherous storm Brian.

3:14 PM - Oct 23, 2017

♡ 1 See Matthew's other Tweets



Storm Brian storm-chasing snappers abuse the coastguard teams who are trying to protect them - Cornwall Live
cornwalllive.com/news/cornwall-...

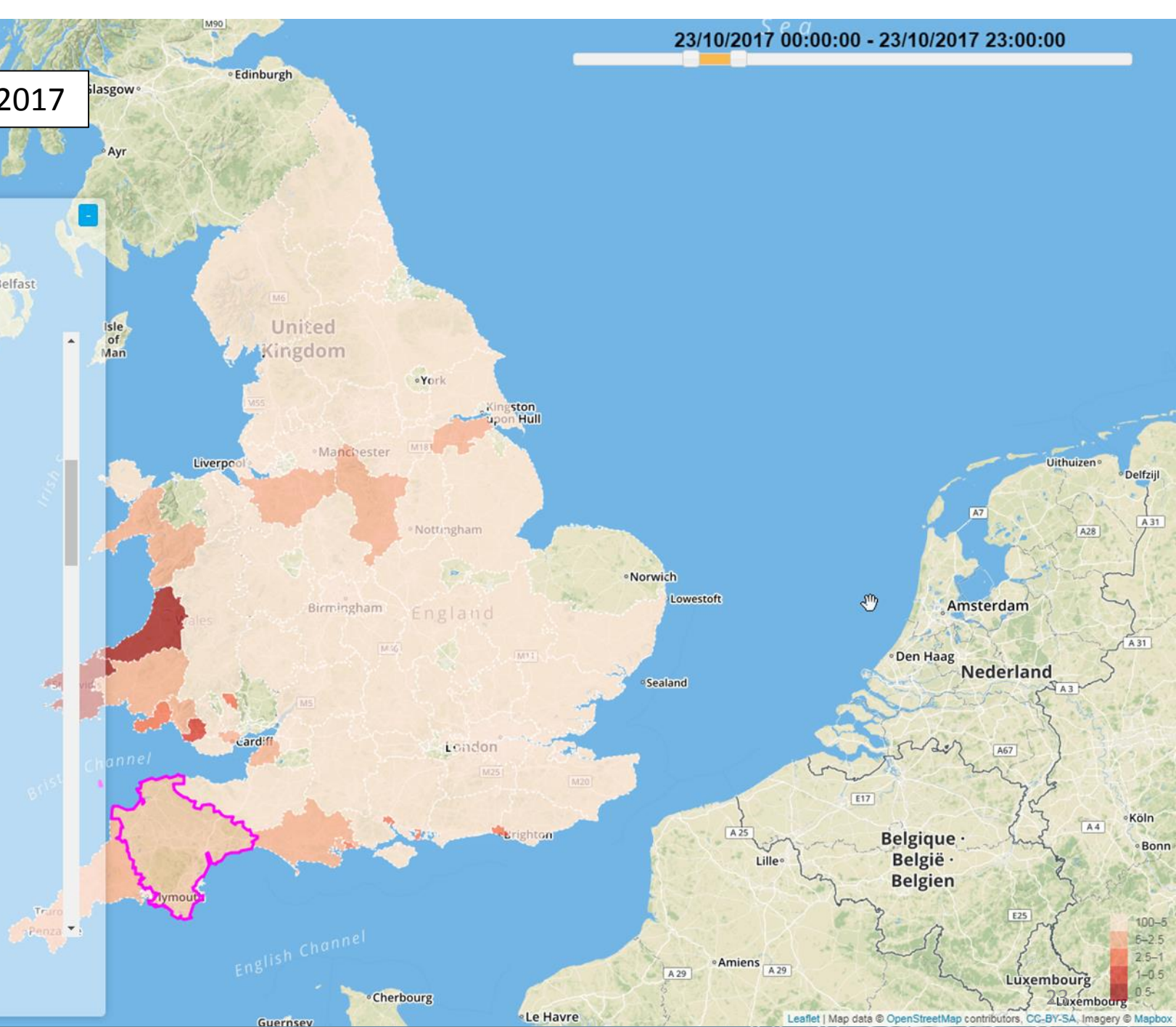
2:20 PM - Oct 23, 2017

♡ 1 See Mike Coulson #BlockFBPE



Abi, Si, Toby (2 years) & Rex (4 months) have been keeping warm and cosy with their herdy hats in Cornwall despite Storm Brian! 🐾 pic.twitter.com/ff6eXB16L3

12:00 PM - Oct 23, 2017



24/10/2017 00:00:00 - 24/10/2017 23:00:00

Storm Brian Tweets 24th October 2017

Hover over a county
Last Update: Tue Oct 31 2017 23:00:00 GMT+0000 (Greenwich Mean Time)

Showing 2 Tweets from devon: Exceedence probability 37.72%



All calm after storm Brian, on the Roseland Peninsula near Gerrans in Cornwall [#southwestcoastpath](#) [#Cornwall](#)
[pic.twitter.com/kgrP61IDk2](#)

3:46 PM - Oct 24, 2017

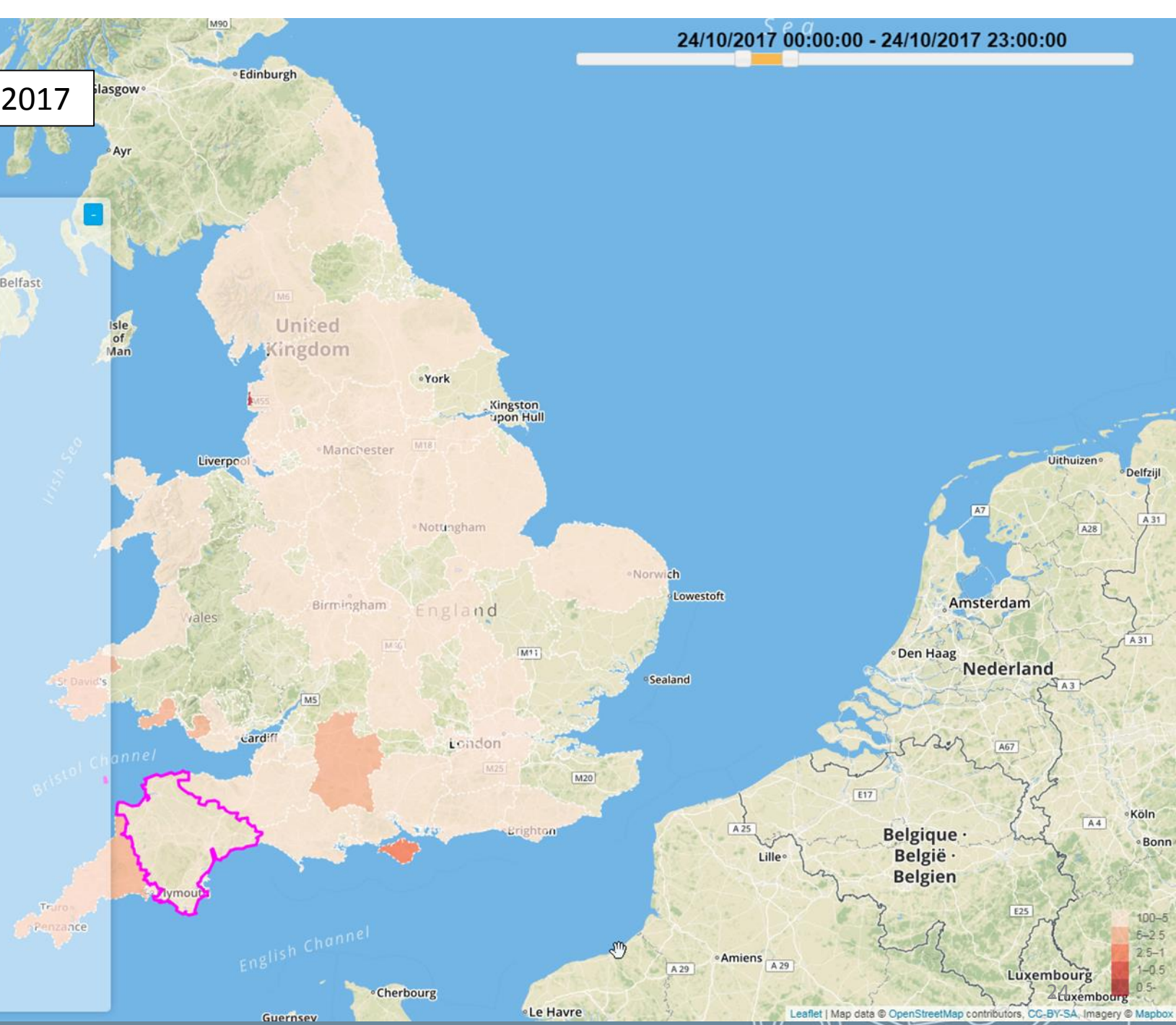
♥ 11 👤 See Jeff pearce's other Tweets



Riding [#Brian](#) 🚲 [@timbonthon](#) [#StormBrian](#) [#ohbrian](#)
[#naughtyBrian](#) [pic.twitter.com/OTNrKXtxGm](#)

6:48 AM - Oct 24, 2017

♥ 20 👤 See ANDREW COTTON's other Tweets



25/10/2017 00:00:00 - 25/10/2017 23:00:00

Storm Brian Tweets 25th October 2017

Hover over a county
Last Update: Tue Oct 31 2017 23:00:00 GMT+0000 (Greenwich Mean Time)

Showing 7 Tweets from devon: Exceedence probability 9.28%



Our two day ride at the weekend was severely disrupted due to storm Brian which cut us back to a very windy and...
fb.me/92D0zbSZo

6:17 PM - Oct 25, 2017

See Adventure Clydesdale's other Tweets



Large parts of #Bournemouth's defunct £3.2m artificial surf reef have washed up in the wake of Storm Brian.

ow.ly/2zvN30g62aK

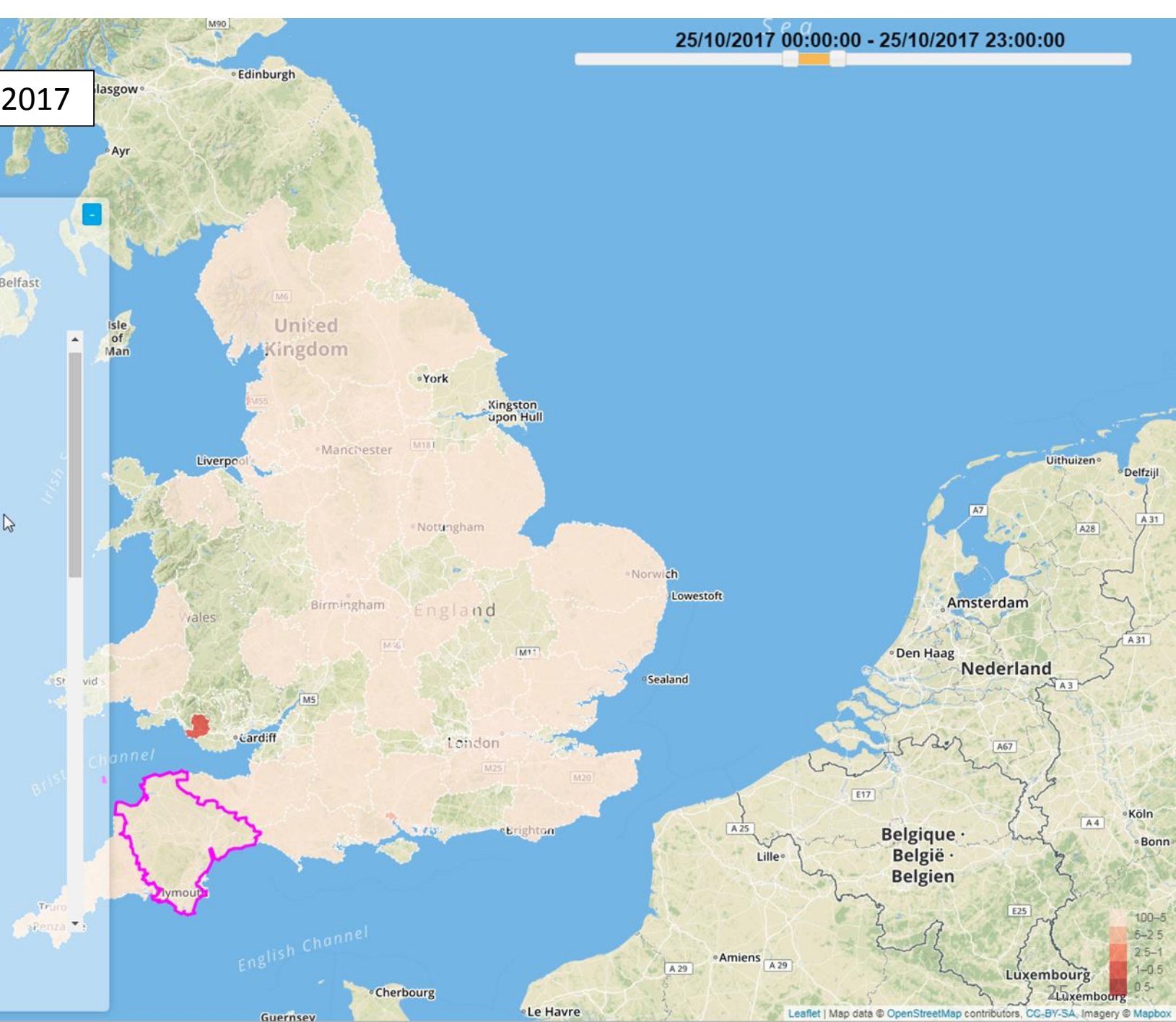
2:50 PM - Oct 25, 2017

See Metro Rod Dorset's other Tweets



So my cousin wanted a photo of Croyde, so that's exactly what I did for them :) Storm Brian... instagram.com/p/BarM29vIrRY/

2:52 PM - Oct 25, 2017 · South West, England



Sentiment Analysis

- Can we use social media posts to infer how a person feels about an event?

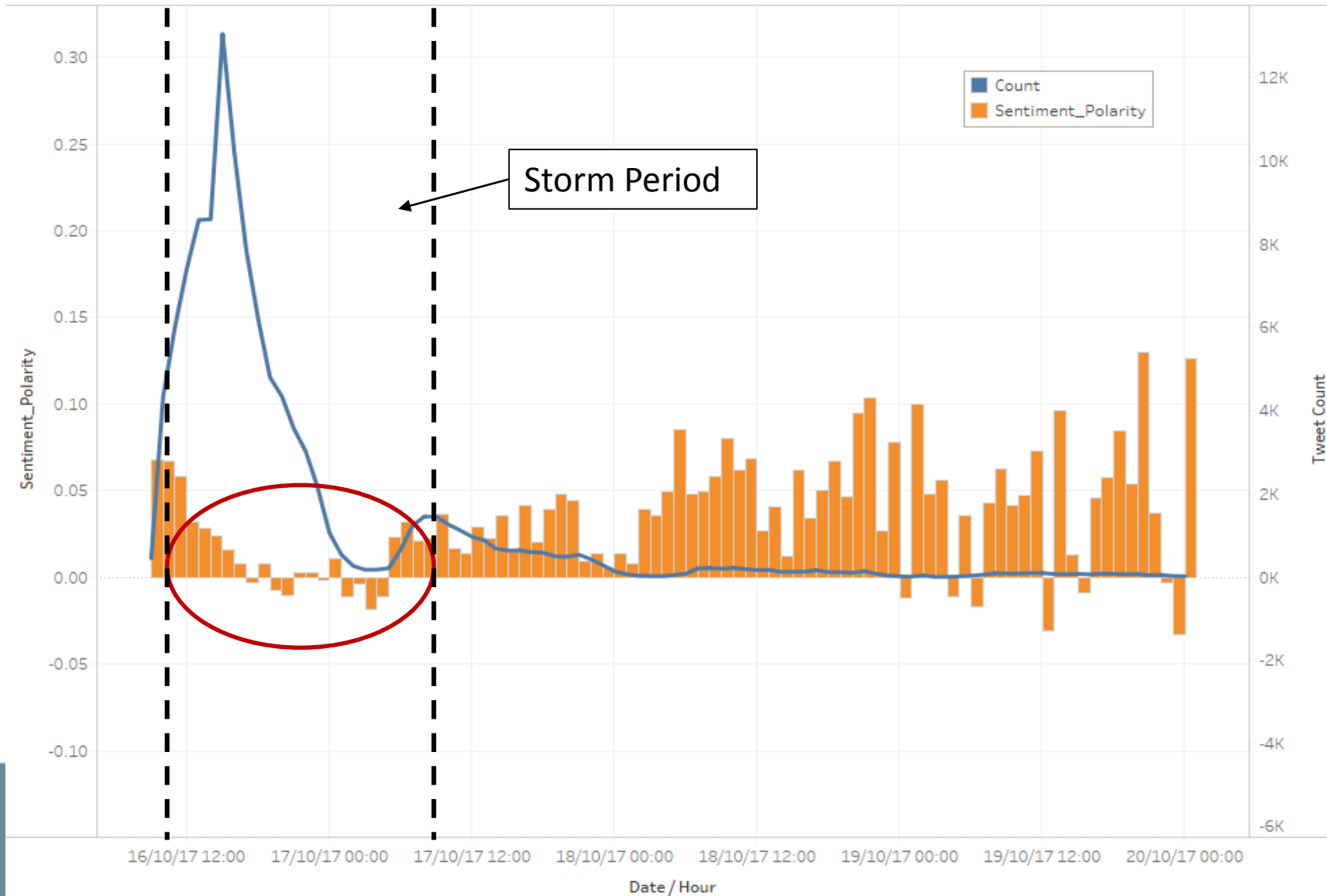
Machine Learning / Natural Language processing – use tweets as training data, assign tweet to sentiment

Lexicon based – look up to dictionary of sentiment words



Measuring the Sentiment of 'Ophelia'

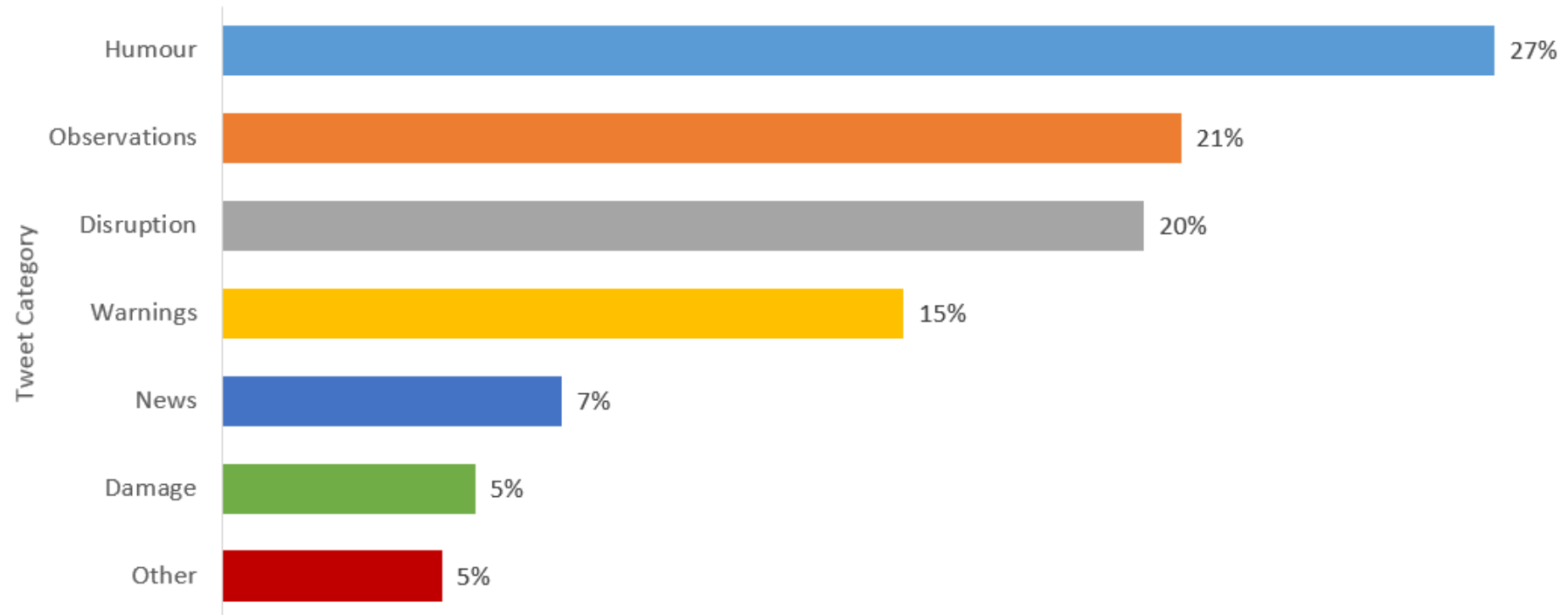
Ex-Hurricane Ophelia Twitter Sentiment: Filtered "ophelia" tweets vs average tweet sentiment score (per hour)



Categorising Tweets

Filtered tweets are manually labelled into categories:

Storm Brian - Categorisation of Tweets During Period of Storm Impact
21/10/2017 - 22/10/2017



Humour



Bishop Philip
@biphursey

Follow

Brian? What kind of name is that for a storm?
Everyone knows Brian is a snail.

7:38 am - 21 Oct 2017



Rach
@Rach_Fleming14

Follow

And Brian? Really? Storm Rambo or
Terminator would be far better than
[#StormBrian](#)

10:34 am - 21 Oct 2017



Ben Fletcher
@BFam

Follow

With all due respect, how are we supposed to
take a life/building/infrastructure threatening
storm seriously when it's called Brian?!

8:44 am - 20 Oct 2017



Phil Perry
@the_jiller

Follow

So storm Brian.. "he's a very naughty boy" if it
causes any damage! [#StormBrian](#)

9:26 AM - 21 Oct 2017



Warnings

 **Rail Professional**
@RailProMag [Follow](#)

Storm Brian could lead to travel disruption this weekend
[railpro.co.uk/news/storm-bri ...](http://railpro.co.uk/news/storm-bri...)

6:05 PM - 20 Oct 2017

 **West Dorset DC**
@WestDorsetDC [Follow](#)

Take care on the coast folks. Waves are quite high with [#StormBrian](#) 🌊



Environment AgencySW @EnvAgencySW
This wave hitting East Beach at West Bay shows why wave watching is a really bad idea. Don't do it [#stormbrian](#) ...od-warning-information.service.gov.uk/warnings

10:54 AM - 21 Oct 2017 from [Bridport, England](#)

 **Report UK**
@ReportUK [Follow](#)

Storm Brian set to batter UK with heavy rain and 70mph winds. [#D21](#) goo.gl/T8PVnE



10:00 AM - 21 Oct 2017



Disruption



The News Hub
@PortsmouthNewsHub

Follow

Storm Brian latest - tree blocks railway lines and hovercraft suspended bit.ly/2xbWh7L
#Portsmouth

10:18 AM - 21 Oct 2017



NewsHandle
@NewsHandle_News

Follow

Major motorway was CLOSED after Storm Brian floods carriageway
newshandle.com/major-motorway ...



4:15 AM - 22 Oct 2017



Bro. Peter Mearns
@Bro_Peter_Mearns

Follow

Storm Brian is causing train delays at Bristol Temple Meads.



Storm Brian is causing train delays at Bristol Temple Meads
Winds are expected to reach speeds of 70mph
bristolpost.co.uk

4:11 AM - 22 Oct 2017



Winchester Today
@winchestertoday

Follow

Great South Run events scheduled for Saturday (5k and junior races) cancelled due to Storm Brian. ** SUNDAY'S MAIN RACE STILL ON **

5:54 PM - 20 Oct 2017





Kantrell Networks

@KantrellNetworks

Follow

Scaffolding in Cobham High Street BLOWN OVER by [#StormBrian](#) high winds



This is the damage Storm Brian has caused in Cobham Hig...

Video from the scene shows the shocking damage caused in the 'scary' incident

getsurrey.co.uk

4:53 PM - 21 Oct 2017



Jeff Hopkins

@JeffHopkinsUK

Follow

Oh cheers Brian mate, where have you put the roof to my shed? [#StormBrian](#) [#Canton](#) [#Cardiff](#)

6:53 AM - 22 Oct 2017 from [Cardiff, Wales](#)



RedFM News

@RedFMNews

Follow

A major clean up operation is continuing in Cork in the aftermath of Storm Brian and Storm Ophelia

2:15 PM - 22 Oct 2017 from [Cork, Ireland](#)

Damage



Heart Wales News

@heartwalesnews

Follow

This is the scene in [#Tenby](#) this morning as the waves have damaged the Harbour Office during Storm Brian. [#HeartNews](#)



9:44 AM - 21 Oct 2017

heart



Independent.ie ✓

@Independent_ie

Follow

#VIDEO: Mayo waterfall blown upwards in Storm Brian gusts [indo.ie/Ekja30g2Ofw](https://www.independent.ie/uk-ireland/ireland/mayo-waterfall-blown-upwards-in-storm-brian-gusts-38484811.html)



10:20 AM - 22 Oct 2017



Irish Apple Growers

@IrishAppleGroup

Follow

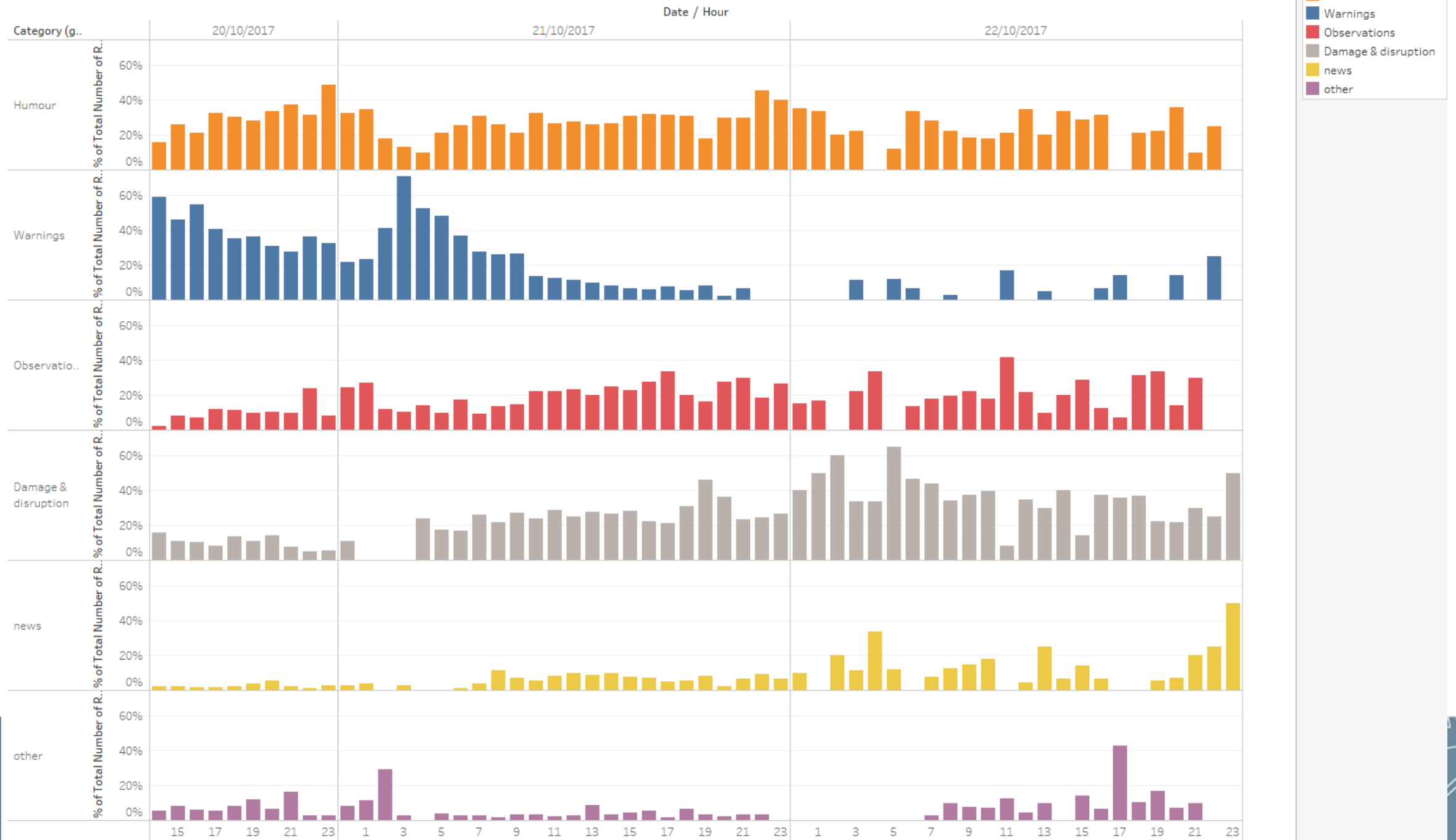
First storm #Ophelia knocked all the apples. Then flooding from #brian swept them into one corner of the orchard. Never saw the likes of it.



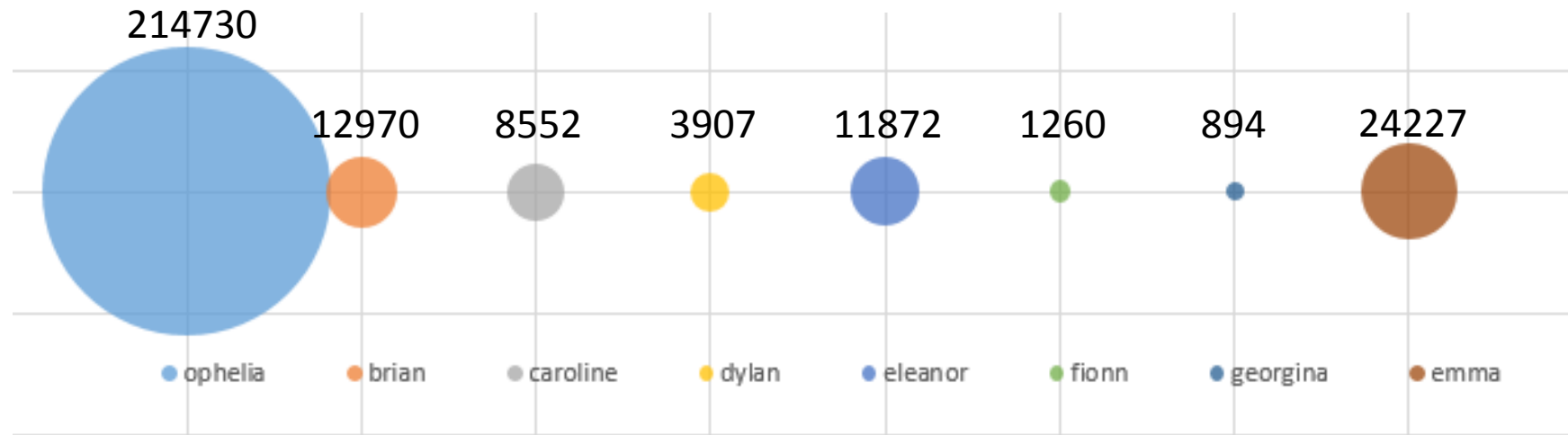
1:30 PM - 23 Oct 2017



Storm Brian categories during impact period of storm



Which named storms caused the most discussion on Twitter?



Size of circle represents number of relevant tweets for each storm



Is the 'social power' of a storm determined by its name, or by the impacts of the weather experienced?

"[Social] power is the ability to influence or outright control the behaviour of people"¹

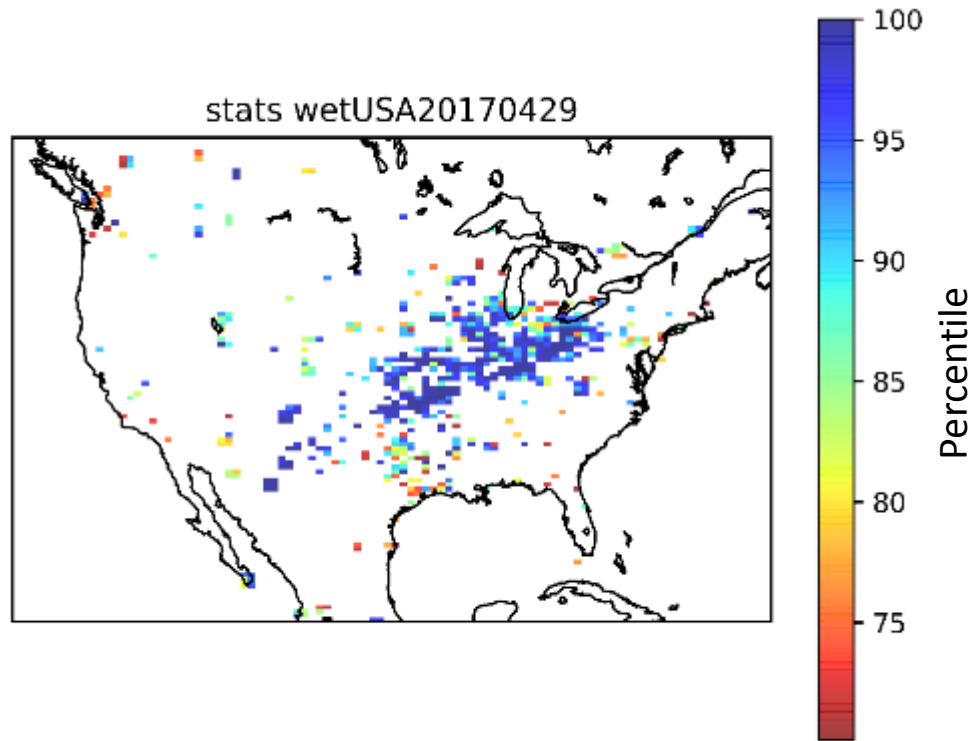


¹[https://en.wikipedia.org/wiki/Power_\(social_and_political\)](https://en.wikipedia.org/wiki/Power_(social_and_political))

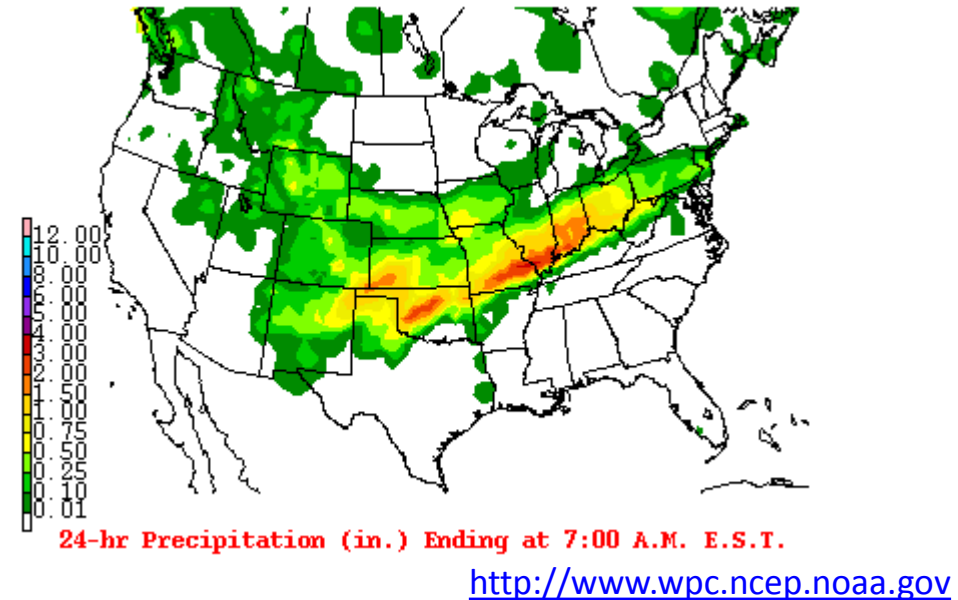


Applying model outside the UK

Searching for heavy rainfall and flooding...



Locations with number of 'heavy rainfall' tweets above the 70th percentile on 29th April 2017
Blue indicates unusually high number of tweets about rainfall/flooding



Rainfall radar for the USA at 7am on 29th April 2017
Areas shaded red were most affected by heavy rainfall

♪ ♪ “Everywhere you go, always tweet the weather with you....” ♪ ♪

Thank you



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SEDA Lab: <http://sites.exeter.ac.uk/seda-lab/>

