

Social sensing of extreme weather hazards

Prof Hywel Williams

University of Exeter & Alan Turing Institute

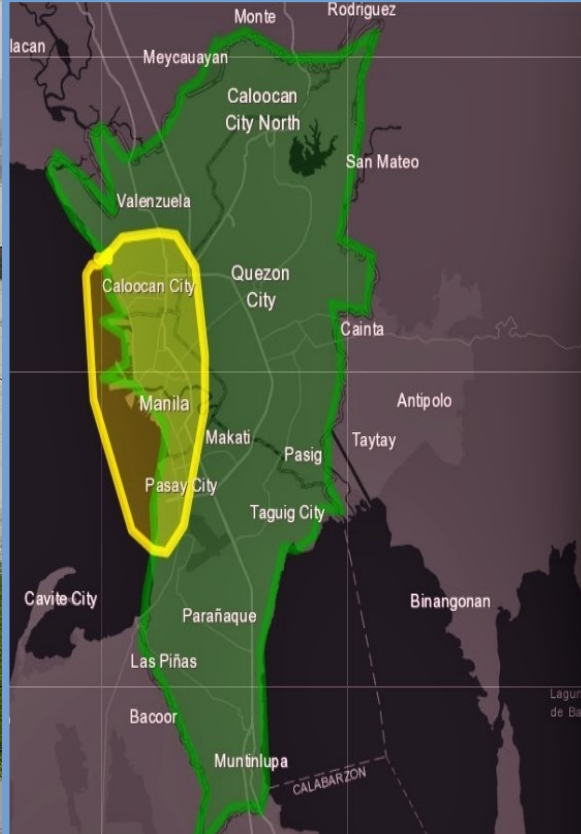
h.t.p.williams@exeter.ac.uk

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1st WMO/WWRP Weather & Society Conference

The
Alan Turing
Institute

UNIVERSITY OF
EXETER



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Impact Matrix

Likelihood	Impact			
	Minimal	Minor	Significant	Severe
High	●	● 2	● 7	● 10
Medium	●	● 1	● 6	● 9
Low	●	●	● 4	● 8
V Low	●	●	● 3	● 5

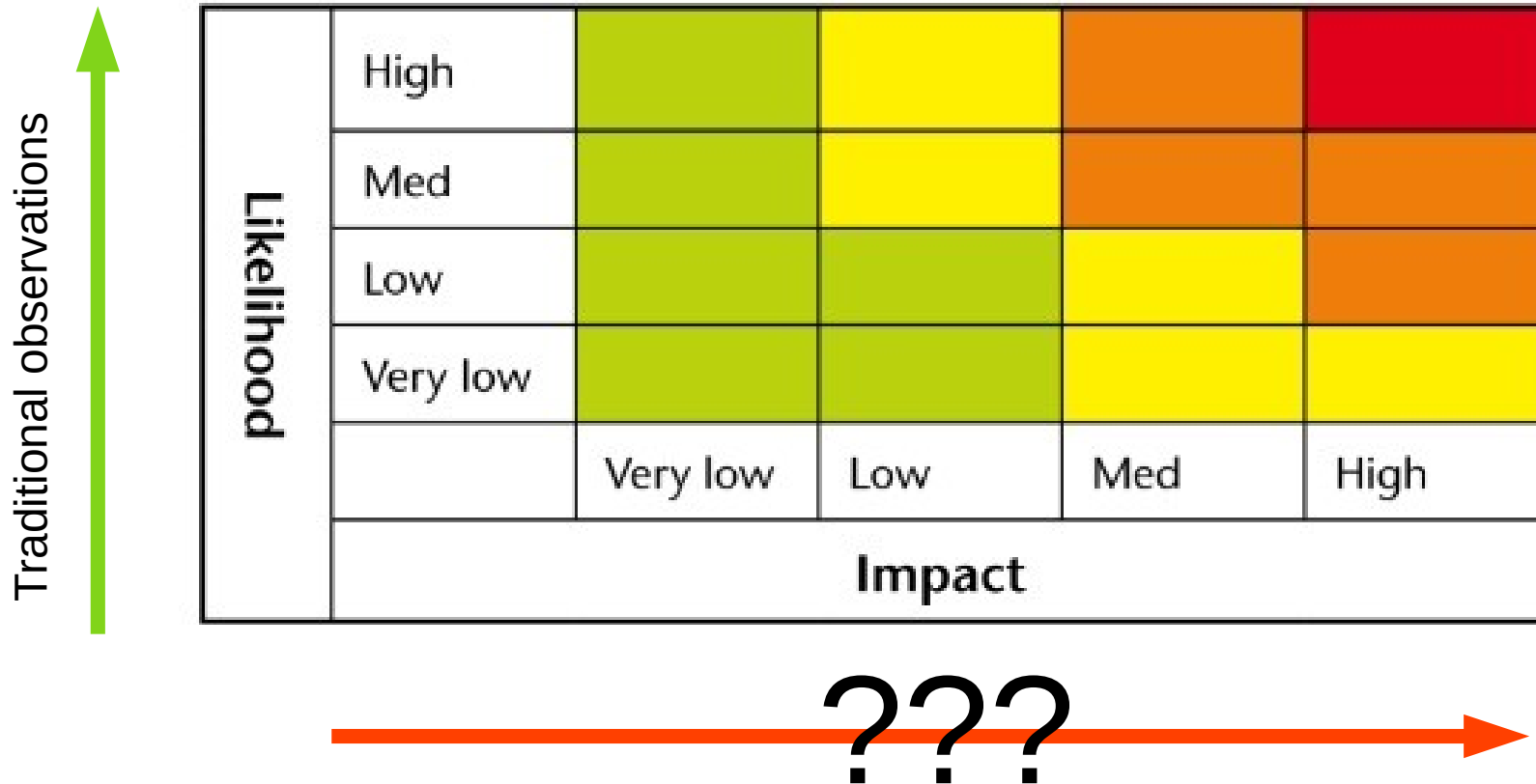
Save Share

Call Feedback

Publish

Close

Impact-based forecasts require validation



Weather affects society: How? How much? When? Where?





facebook

December 2010

550m users	(2010)
1.2bn users	(2013)
1.8bn users	(2016)
>2.8bn users	(2022)



Aero Allergens



Air Pollution



Avalanches



Coastal Flooding



Drought



Earthquakes



Extreme Temperatures



Fluvial Flooding



Snow



Space Weather



Surface Water Flooding



Tsunami



Volcanic Ash



Volcanic Gases



Wildfires



Wind

Social sensing

Real event



Social media



Data analysis



Useful information

Social sensing of floods in the UK

Arthur, Boulton, Shotton & Williams (2018) PLoS ONE 13(1): e0189327.



(a)



Jonas Hey (EGNX)
@PLANEmad1999



Follow

#Calderdale #flooding



RETWEETS

2



3:25 PM - 26 Dec 2015

Yorkshire and The Humber, England



(b)



Richard Bloore
@BlooreR



Follow

Boxing Day flooding: Giant sinkhole shuts M62 motorway fb.me/7SbMrL51f

6:07 PM - 26 Dec 2015



(c)



WYP Contact Centre
@WYP_CCC



Follow

Reports coming through that Halifax Road in Todmorden is still being used despite being flooded. Vehicles are now getting stuck

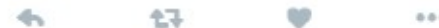
RETWEETS LIKE

3

1



10:21 PM - 25 Dec 2015



Can we detect floods using Twitter?

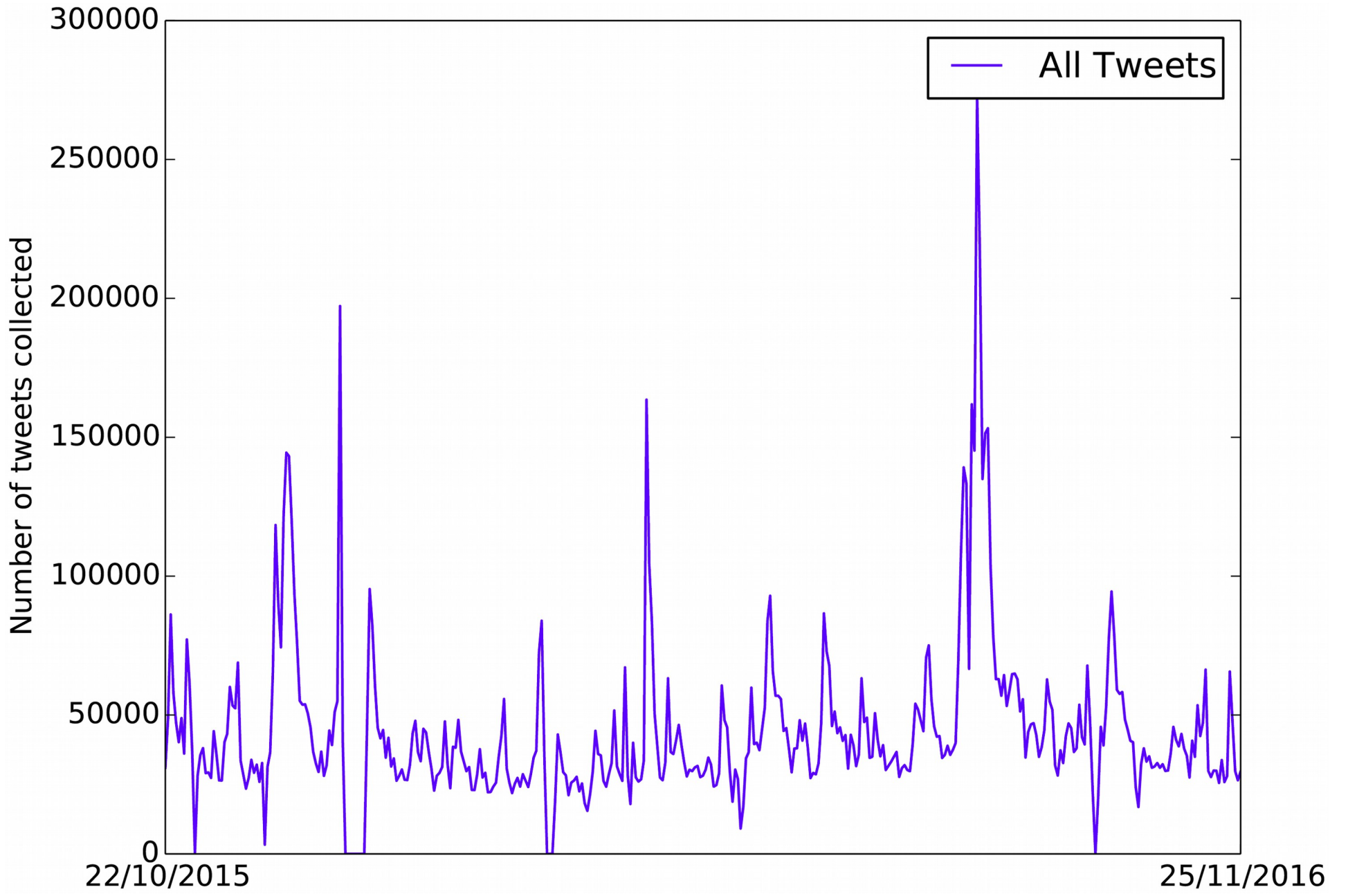
Twitter dataset: 17,828,704 tweets from 2015-2016.

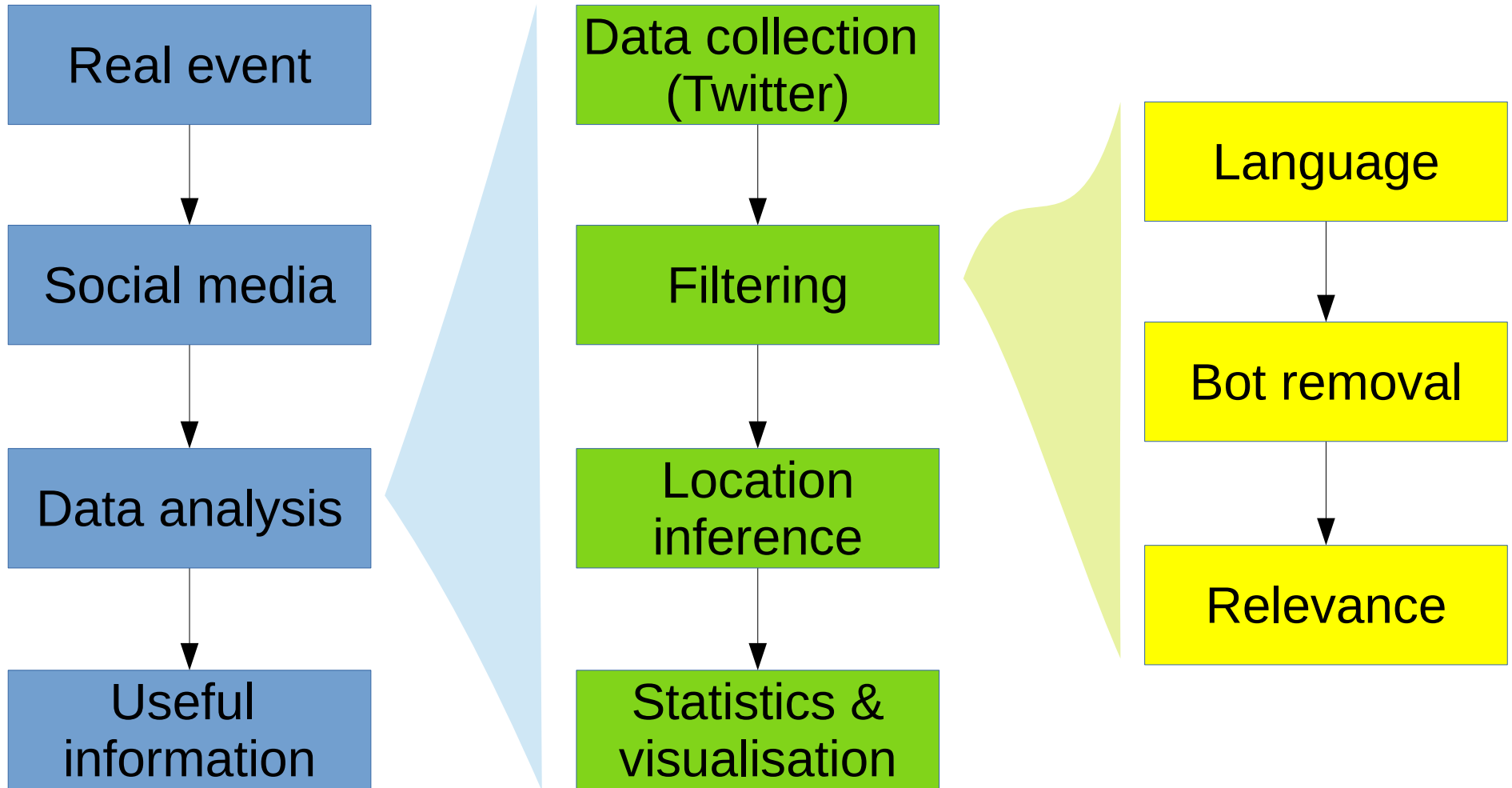
Keywords: “flood”, “flooded”, “flooding”

Flood dataset: Known flood events in England & Wales (Flood Forecasting Centre).

Method: Correlate Tweets per day vs Floods per day







Filtering improves data quality

- Filter by timezone (UK) and language (English)
- Remove “bot” accounts and retweets
- Filter for relevance [Text-based Naive Bayes classifiers trained on thousands of human-annotated examples]

	All	Filtered
Tweets Remaining	17828704	122281
Correlation	0.206	0.673

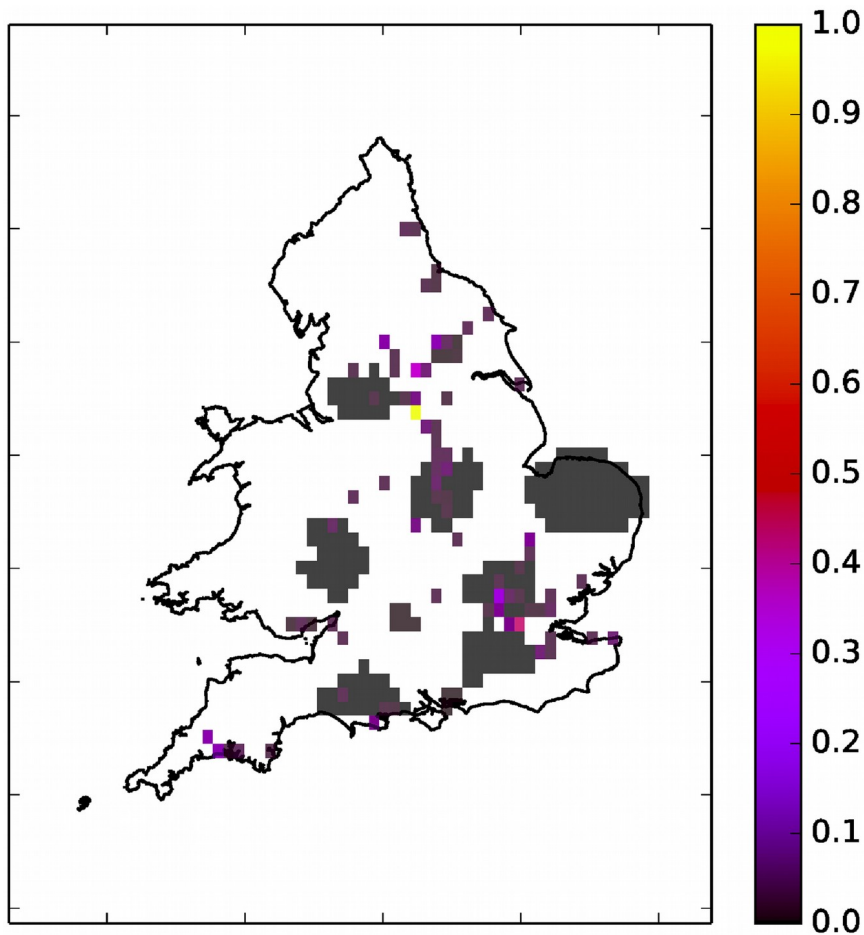
Temporal correlation: Tweets per day vs Floods per day

Location inference

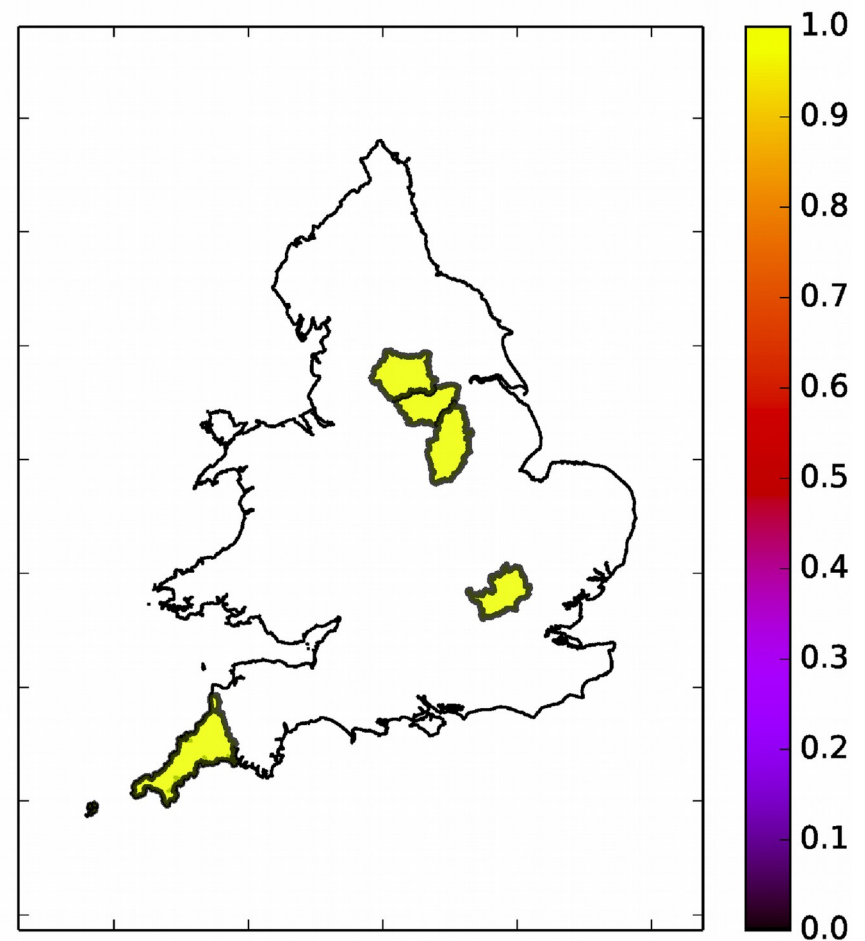


Why use inference?
<1% tweets have GPS coordinates
<5% tweets have bounding boxes
Inference can locate 40-70% tweets.

Validation



Social "floodiness" normalised by population density.



Known floods in Flood Forecasting Centre database.

Other case studies



Aero Allergens



Air Pollution



Avalanches



Coastal Flooding



Drought



Earthquakes



Extreme Temperatures



Fluvial Flooding



Snow



Space Weather



Surface Water Flooding



Tsunami



Volcanic Ash



Volcanic Gases



Wildfires



Wind

Young, J.C., Arthur, R., Spruce, M.D., Williams, H.T.P. (submitted) Social sensing of **flood impacts in India**: a case study of Kerala 2018.

Spruce, M.D., Arthur, R., Robbins, J., & Williams, H. T. P. (2021) Social sensing of **high-impact rainfall events worldwide**: a benchmark comparison against manually curated impact observations. *Natural Hazards & Earth System Science*, 21, 2407–2425.

Weaver, I. S., Williams, H. T. P., & Arthur, R. (2021). A **social Beaufort scale to detect high winds** using language in social media posts. *Scientific Reports*, 11(1), 1-13.

Young, J. C., Arthur, R., Spruce, M., & Williams, H. T. P. (2021). Social sensing of **heatwaves**. *Sensors*, 21(11), 3717.

Spruce, M., Arthur, R., & Williams, H. T. P. (2020) Using social media to measure **impacts of named storm events** in the United Kingdom and Ireland. *Meteorological Applications*, 27(1), e1887.

Cowie, S., Arthur, R., & Williams, H. T. P. (2018) @choo: tracking **pollen and hayfever** in the UK using social media. *Sensors*, 18(12), 4434.

Arthur, R., Boulton, C., Shotton, H. & Williams, H. T. P. (2018) Social sensing of **floods** in the UK. *PLoS One*, 13, 1.

Boulton, C. A., Shotton, H. & Williams, H. T. P. (2016) Using social media to detect and locate **wildfires**. *Proc. 1st Int. Workshop on Social Web for Environmental and Ecological Monitoring (SWEEM) at ICWSM 2016, Cologne, Germany (AAAI)*.

SOCIAL SENSING



Social Sensing - Mozilla Firefox


https://release-1-1-1.dtmxl3q3i7oix.amplifyapp.com/map?selected=monmouthshire&lat=54.23312964750767&lng=2.241210937500004

SOCIAL SENSING (development)

Monmouthshire: Exceedance probability 0.43%

14 Tweets 0 Ignored

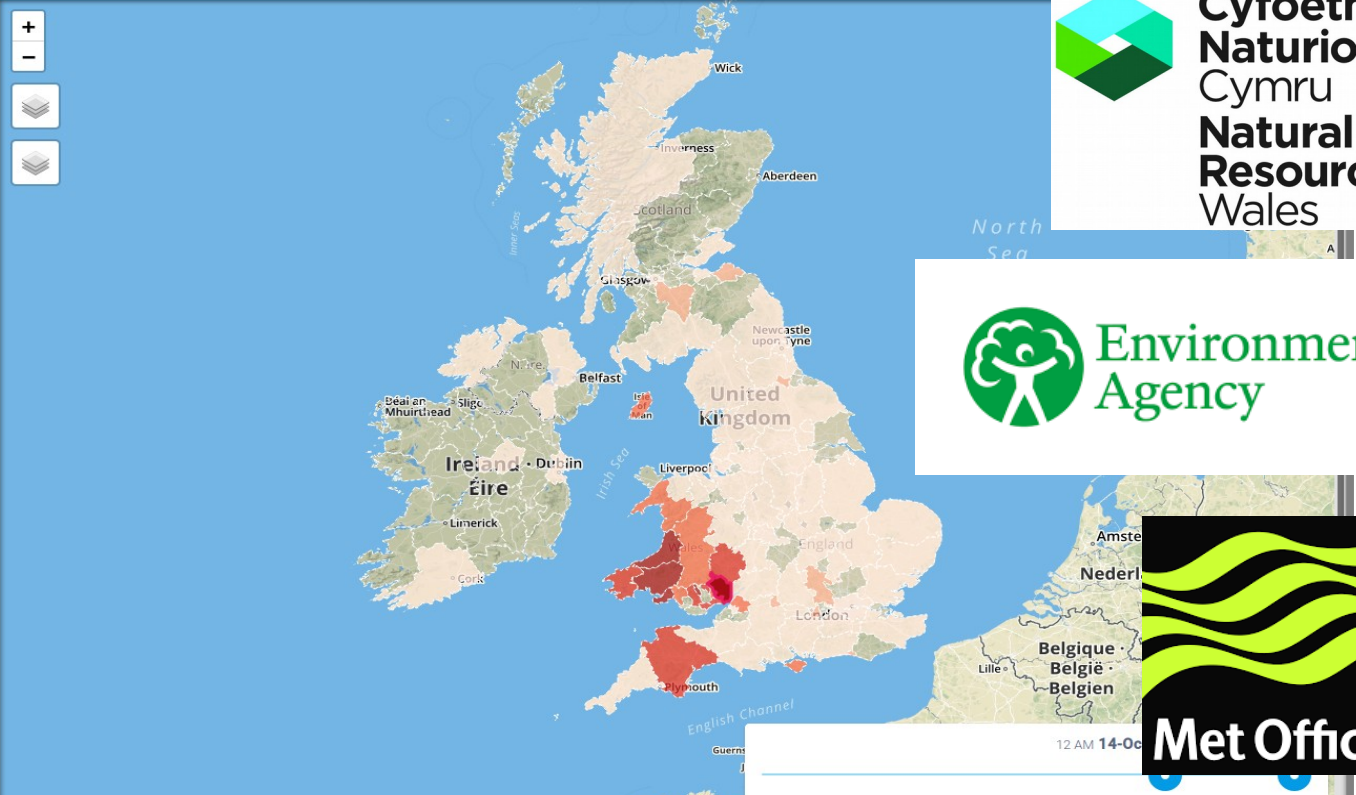
Tracey Williamson @Tracey_Dams
The Usk in flood on Saturday, flowing through Abergavenny. The power of water, not to be underestimated.



4 11:05 PM - Oct 14, 2018

See Tracey Williamson's other Tweets

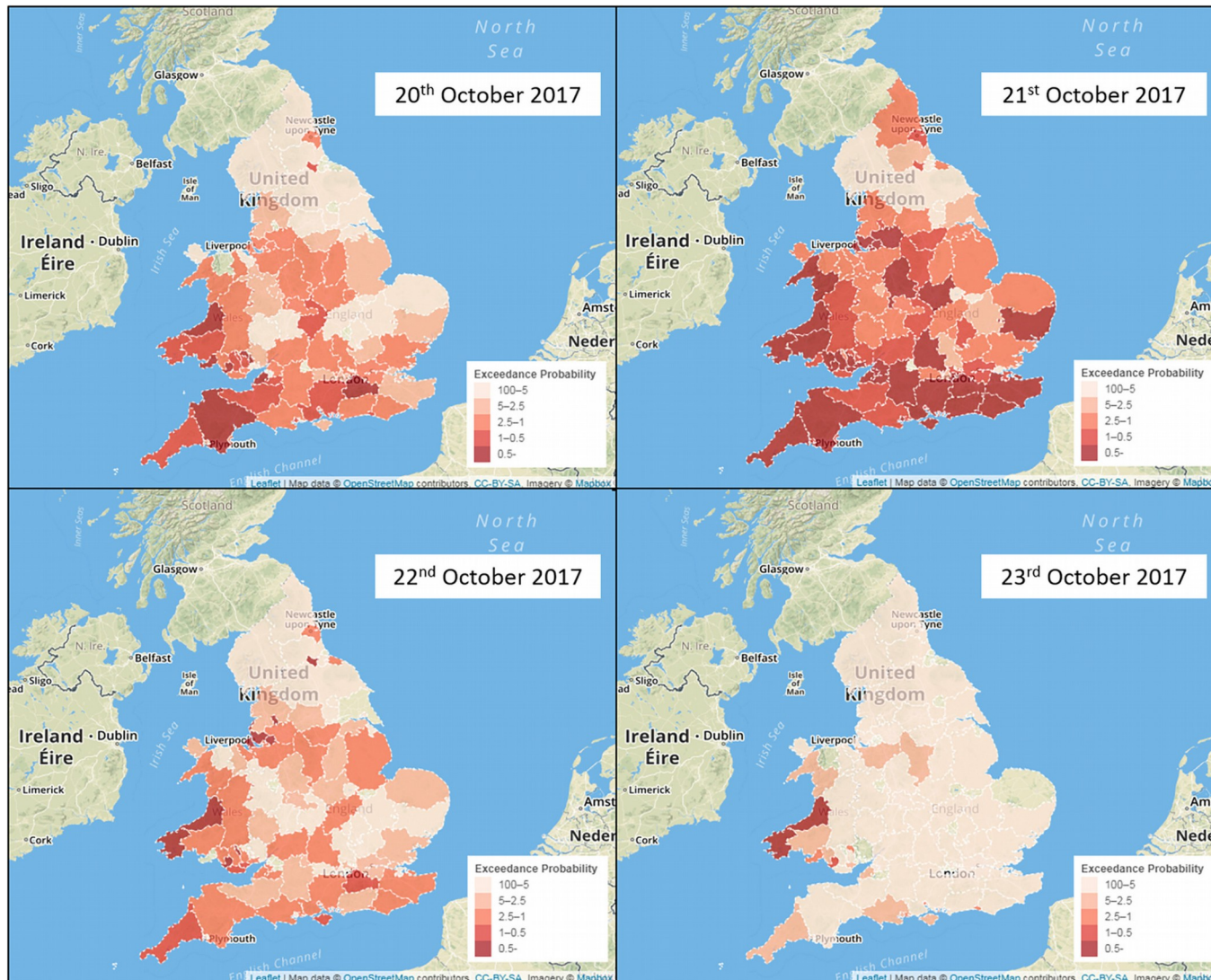
South Wales Horse @southwaleshorse



DEMO

Social impacts of named storms in the UK

Spruce, Arthur, Williams (2020) Meteorological Applications, 27(1), e1887.



Can we observe **impacts** of extreme weather?

Dataset: >100m tweets during 2017/2018 storm season (8 named storms)

Storm Brian (2017) observed by social sensing.

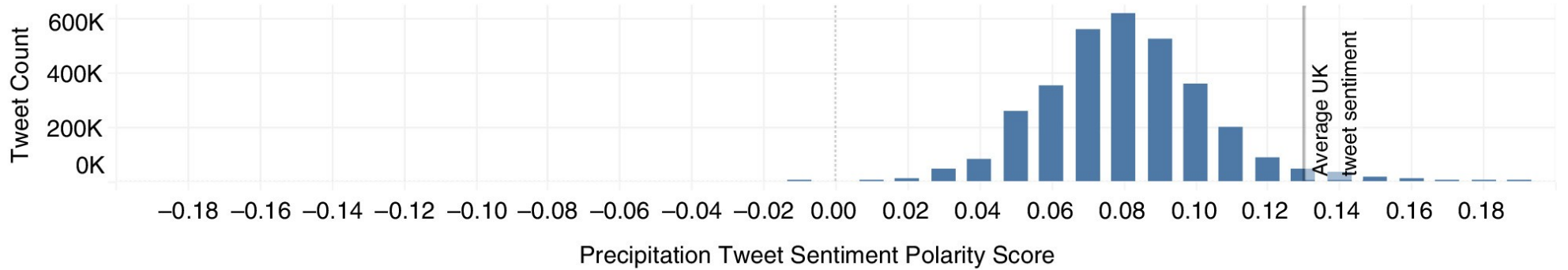
Social content during Storm Brian

Category	Tweet Text Examples	Sentiment Score
Humour	<i>"Brian? What kind of name is that for a storm? Everyone knows Brian is a snail."</i>	0.60
	<i>"Am I the only one to find it really hard to take a storm called #Brian seriously?"</i>	-0.21
	<i>"And Brian? Really? Storm Rambo or Terminator would be far better than #StormBrian"</i>	0.27
Damage	<i>"This is the scene this morning as the waves have damaged the Harbour Office during Storm Brian."</i>	-0.26
	<i>"Storm Brian damage causes floodlight damage. Revised home game vs @ChesterCityFC"</i>	-0.40
	<i>"Scaffolding in Helsby High Street BLOWN OVER by #StormBrian high winds"</i>	0.00
Disruption	<i>"Train delay: National Rail have warned of delays due to high winds from Storm Brian"</i>	-0.25
	<i>"Storm Brian latest - tree blocks railway lines and hovercraft suspended"</i>	-0.41
	<i>"Major motorway was CLOSED after Storm Brian floods carriageway"</i>	-0.02
Warnings	<i>'#StormBrian could lead to travel disruption this weekend.'</i>	-0.06
	<i>'Storm Brian set to batter UK with heavy rain and 70mph winds.'</i>	-0.20
	<i>'Take care on the coast folks. Waves are quite high with #StormBrian'</i>	0.16
Observations	<i>"It's really windy out there!"</i>	0.20
	<i>"Storm Brian seems to have arrived now..."</i>	0.00
	<i>"Storm Brian just brought in the heaviest rain shower I've ever seen.....it really scared our 2 cats."</i>	-0.29

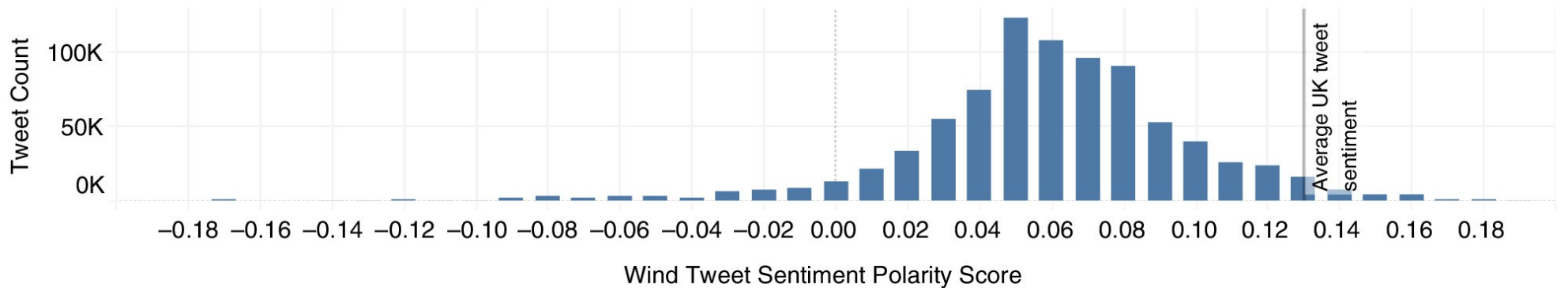


Sentiment by hazard (all storms)

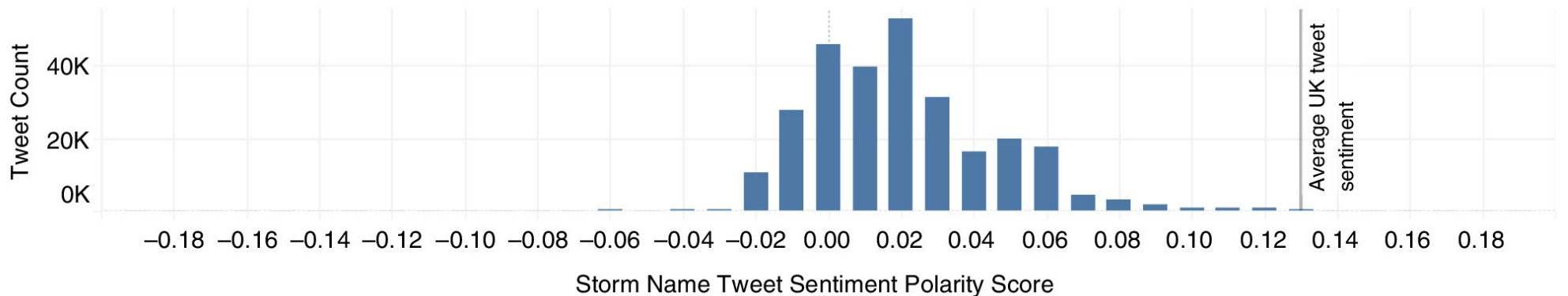
Precipitation Tweet Sentiment



Wind Tweet Sentiment



Storm Names Tweet Sentiment



Discussion (1): Known knowns

Social sensing can detect & locate extreme weather events.

Weather impacts can be observed & characterised.

Operational value for meteorologists: situation awareness, impact-based forecast validation.



Celina Curry
"Crowd"

Discussion (2): Known unknowns

Methods can be improved. Social media landscape always changing. Continual work-in-progress.

Limitations: Data volume is patchy. Data sources are few – mostly Twitter, others are private. Demographic bias. Noise.

Opportunities: Better impact measurement. Image and video content. Global reach. Automated monitoring of impacts.



Discussion (3): Weather and society

People will tell you everything – you just need to listen!

People talk most about impacts that are important to them.

Social sensing vs citizen science

- Social sensing: People as sensors, unsolicited, high volume, unstructured
- Citizen science: People as participants, solicited, low volume, structured

Both approaches needed to understand how weather affects people.



Acknowledgements



Rudy
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Shotton



Sophie
Cowie



Chris
Boulton



James
Young



EPSRC

Engineering and Physical Sciences
Research Council

E · S · R · C
ECONOMIC
& SOCIAL
RESEARCH
COUNCIL



**Cyfoeth
Naturiol**
Cymru
**Natural
Resources**
Wales



FLOODFORECASTINGCENTRE

a working partnership between



Environment
Agency



Met Office



(c) Imperial Boy

Contact: h.t.p.williams@exeter.ac.uk