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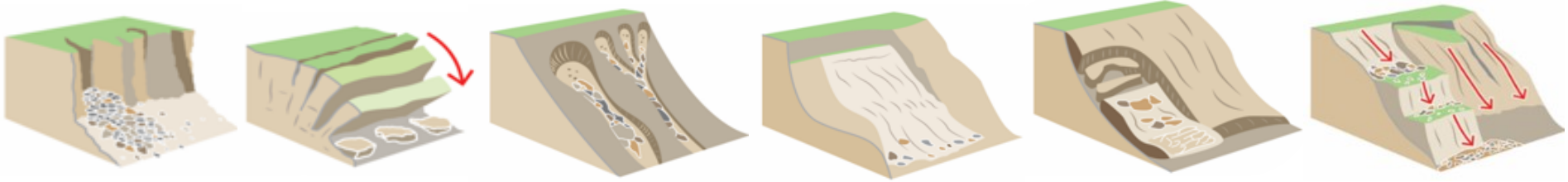
Monitoring landslides in real time on local and global scales

British Geological Survey

What are landslides and what causes them?

- A landslide is a mass movement of material (rock, earth, debris) down a slope.
- When the force of gravity acting on a slope exceeds the resisting forces of a slope, the slope will fail and a landslide occurs.
- Landslides can happen suddenly, slowly or episodically over long periods of time.
- They occur in a wide variety of geological and geomorphological situations.
- Pre-conditioning factors: geology, slope/topography, Quaternary history
- Triggering factors: heavy rainfall, saturated ground, changes in water table, changes to the material's strength through weathering, vegetation change, erosion of the base of a slope, loading of the slope, seismicity, natural/anthropogenic … climate change
- 2004-2016 GFLD, 4862 fatalities globally



Landslide monitoring on the local scale using the Internet of Things

5G RuralDorset

British Geological Survey

WPX : IoT real-time landslide monitoring

- UK Government funded:
  Department for Culture, Media and Sport
- Project led by Dorset Council
- Extension WP led by Bournemouth University

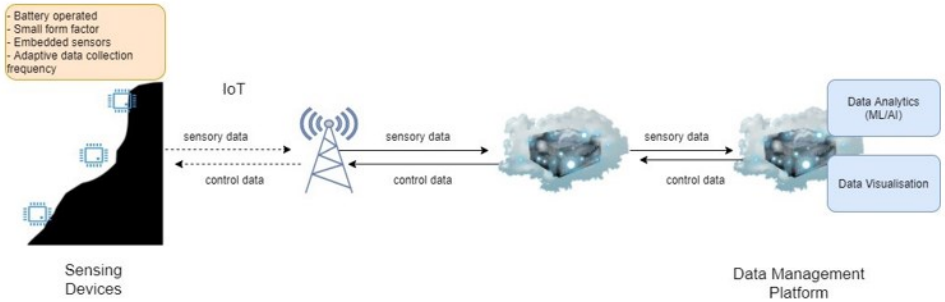
Interdisciplinary:
- Landslide processes
- Coastal processes
- Computer Science
- Commercial mobile technology

https://5gruraldorset.org

Aims:
- IoT sensors to monitor coastal landslides in real time using 5G technology
- Sensors
  - Low cost kit
  - Developed for a large network of sensors
  - Ultra low-power (battery operated)
  - Small and unintrusive
  - NB-IoT wireless communication
  - Big Data Analytics and ML

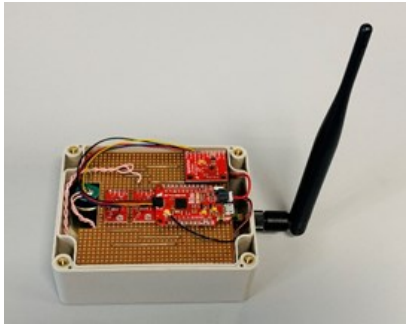
- Local scale: two sites on UK south coast
- Subsurface, surface, EO
- Transferrable, autonomous

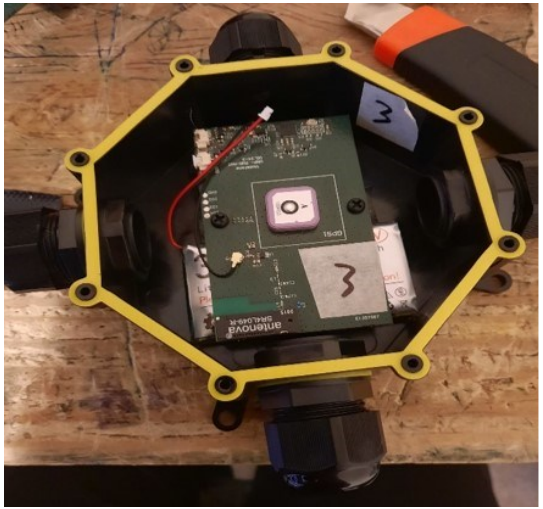
5G RuralDorset: WPX IoT real-time landslide monitoring



Potential sensors detect:

- Movement
- Cracks
- Rock temperature
- Borehole data
- Weather
- Beach thickness

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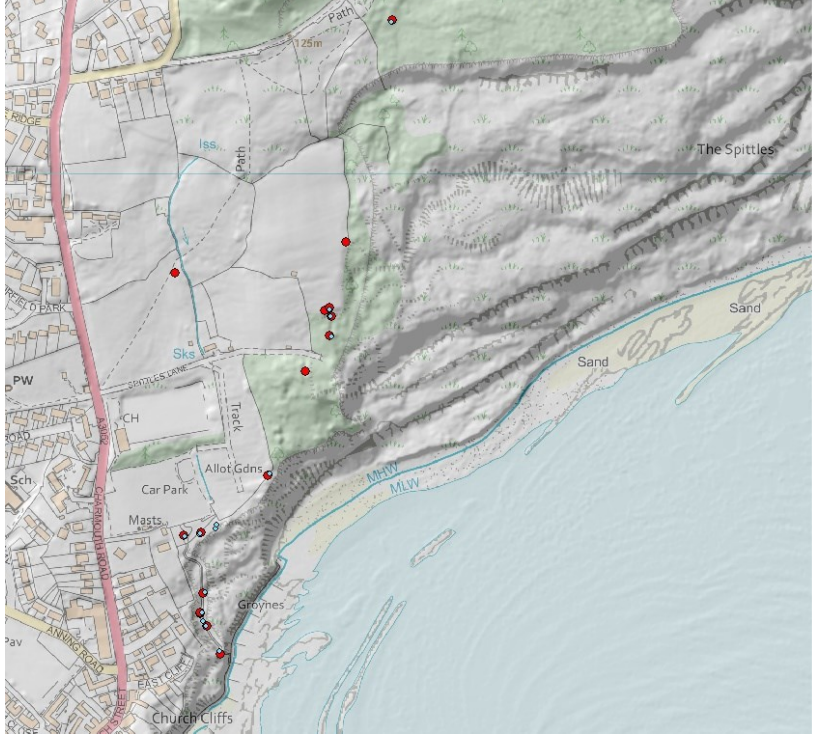
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Greystones
Burton Cliff

Summary and lessons learned

- Project closed June 2022
- R&D, technology readiness
- Interdisciplinary working – investing time in a common understanding
- Implications of battery life - network connectivity, temperature, data sampling frequency, data transfer rate
- Working in the coastal environment
- Publicly accessible locations – local security or opportunity to engage
- Sensors are replaceable/disposable (low cost) but consider environmental impact of this

Global Landslide Detector

British Geological Survey

Global Landslide Detector

Partners and expertise

Landslide Expertise

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BGS British Geological Survey

Computer Scientists

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HAMAD BIN KHALIFA UNIVERSITY
عضو في مؤسسة قطر
Member of Qatar Foundation

Earthquake and social media specialists

Rémy Bossu
Julien Roch

CSEM EMSC

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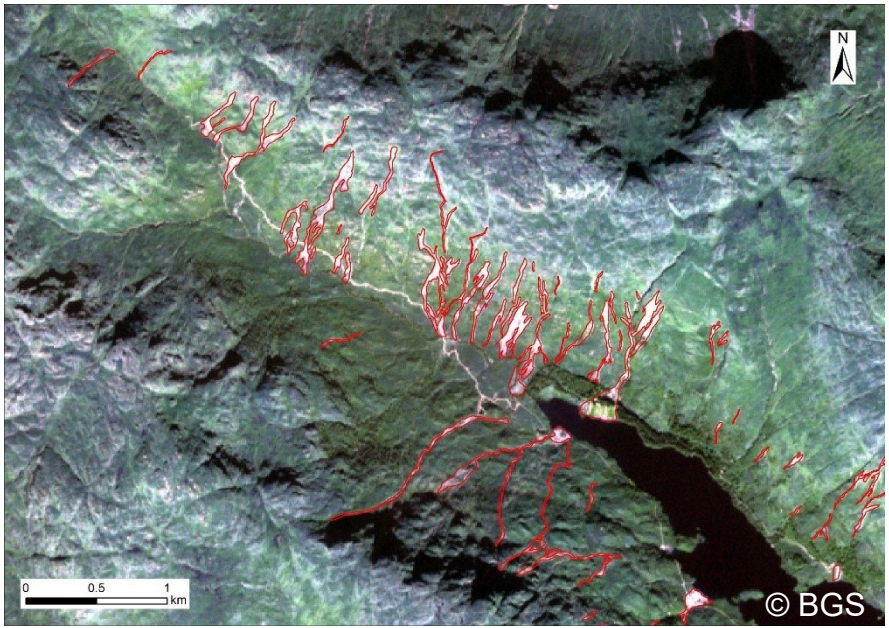
Context

- Data Latency
  - Time lag between disaster and data becoming available for response
  - Satellites collect imagery, their responding communities activate the Disasters Charter and process the data
  - Hindered due to cloud cover (i.e. rainfall/volcanoes), satellite return path/route, image quality and processing time
  - Several hours to several days
- Impacts not discovered until reported through location-dependent frameworks, news media coverage or satellite data acquisition



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Context

- Reporting landslides and their impacts (damage and loss) varies globally
- Reflects range of physical and socio-economic drivers and contexts
- News media attention is not uniformly distributed; reporting biases; factual accuracy; not reporting at all due to prioritisation of other news
- Quantifying (globally) landslide hazards and associated impacts is an underestimation
- This underestimation feeds through to landslide databases, especially in areas where landslide susceptibility mapping does not exist

- National and regional landslide databases established in many countries
- Not consistent in their application i.e. science research, landslide susceptibility maps, DRR, planning, forecasting models, documenting impacts of climate change
- Databases vary depending wealth, politics and governance, education, insurance, landslide strategies and the availability of institutions willing/able to maintain them

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Context

Social Media data:

- Rich source of human information: text, videos, photographs, timestamps, coordinates
- 2021: 3.78 billion social media users worldwide
- Imperfect and very noisy data!
- Difficult to extract relevant and timely information
- BUT! data are in large quantities, in near-real time and at spatial densities that exceed conventional sensor networks = Social Sensors
- Perceptions of ‘reliable data’ evolving to include unstructured data, including social media
- Acquiring disaster data through these platforms has gathered pace in the last decade

- Could allow responders to understand what is happening on the ground in real time (biases!)
- Complement other data sources and DRR workflows plus many other beneficiaries e.g. landslide databases

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Landslides information on social media

Edit profile

BGS Landslides
@BGSLandslides

Supporting landslides research at the British Geological Survey. Help inform the National Landslide Database for the UK.
RTs ≠ endorsement or confirmation

Keyworth, Nottingham, UK bgs.ac.uk/landslides Joined July 2012

819 Following **2,528** Followers

Tweets Tweets & replies Media Likes

Dr Phil Collins @PhilCollins_UK · Feb 19
Landslip at Barton-on-Sea today pic.twitter.com/GmtBO6g9we
Reply Retweeted Favorite Flag media

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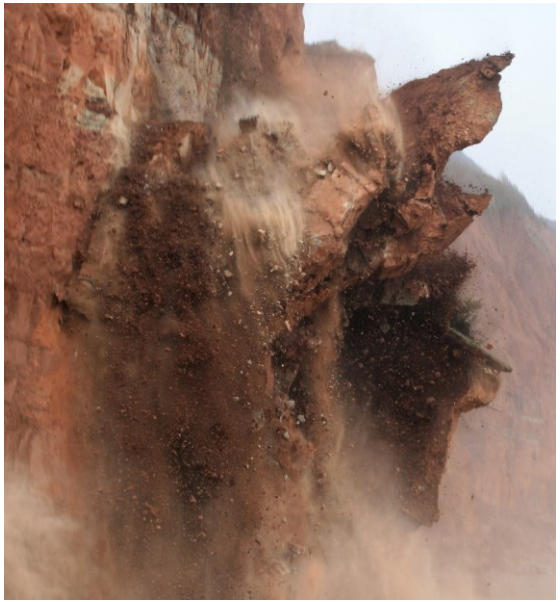
Landslides information on social media



Hive Beach Cafe
@HiveBeachCafe

Follow

The awesome power of the waves at Hive Beach...photo courtesy of David J.Powell pic.twitter.com/R77ni5iQWb

Reply Retweet Favorite More

Greater Anglia
@greateranglia

Follow

Some of the works that took place over the weekend to repair the landslip between Manningtree and Ipswich. JA pic.twitter.com/lGE1vpRusp

Reply Retweeted Favorite More

RETWEETS 12 FAVORITE 1

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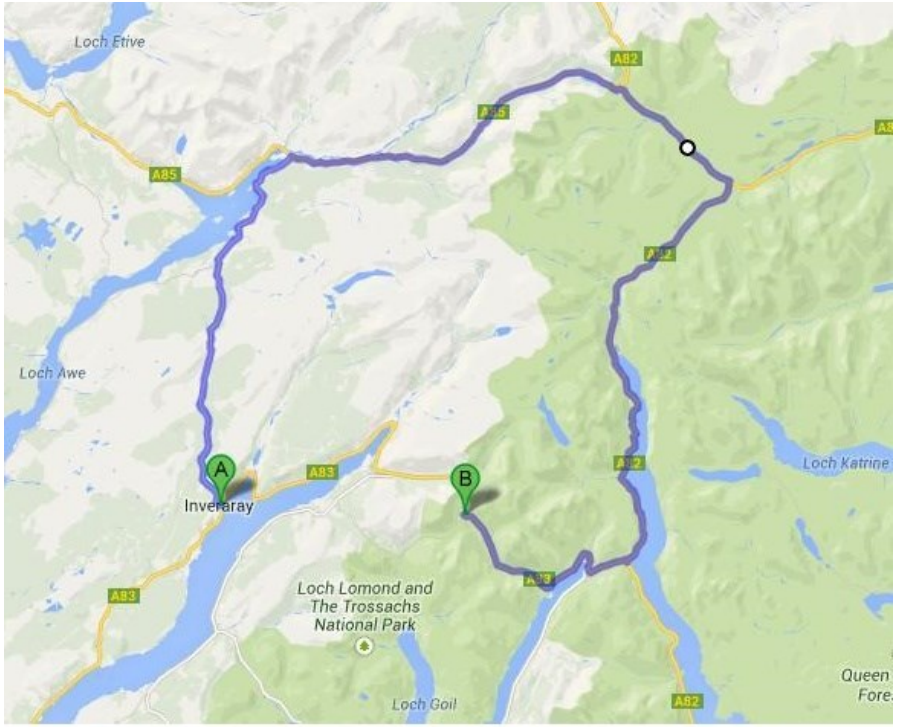
Landslides information on social media



OnTheWight @onthewight · Mar 5
Did you see unique Hexacopter footage we published yesterday of landslide at Headon Warren? wig.ht/2bFS pic.twitter.com/jxjhzp4041
Reply Retweet Favorite Flag media

Traffic Scotland @trafficscotland · Mar 5
Highlands: #A83 is CLOSED at Rest & Be Thankful due to a landslip. The diversion route is around 57 miles long: pic.twitter.com/kGPcHWAga2

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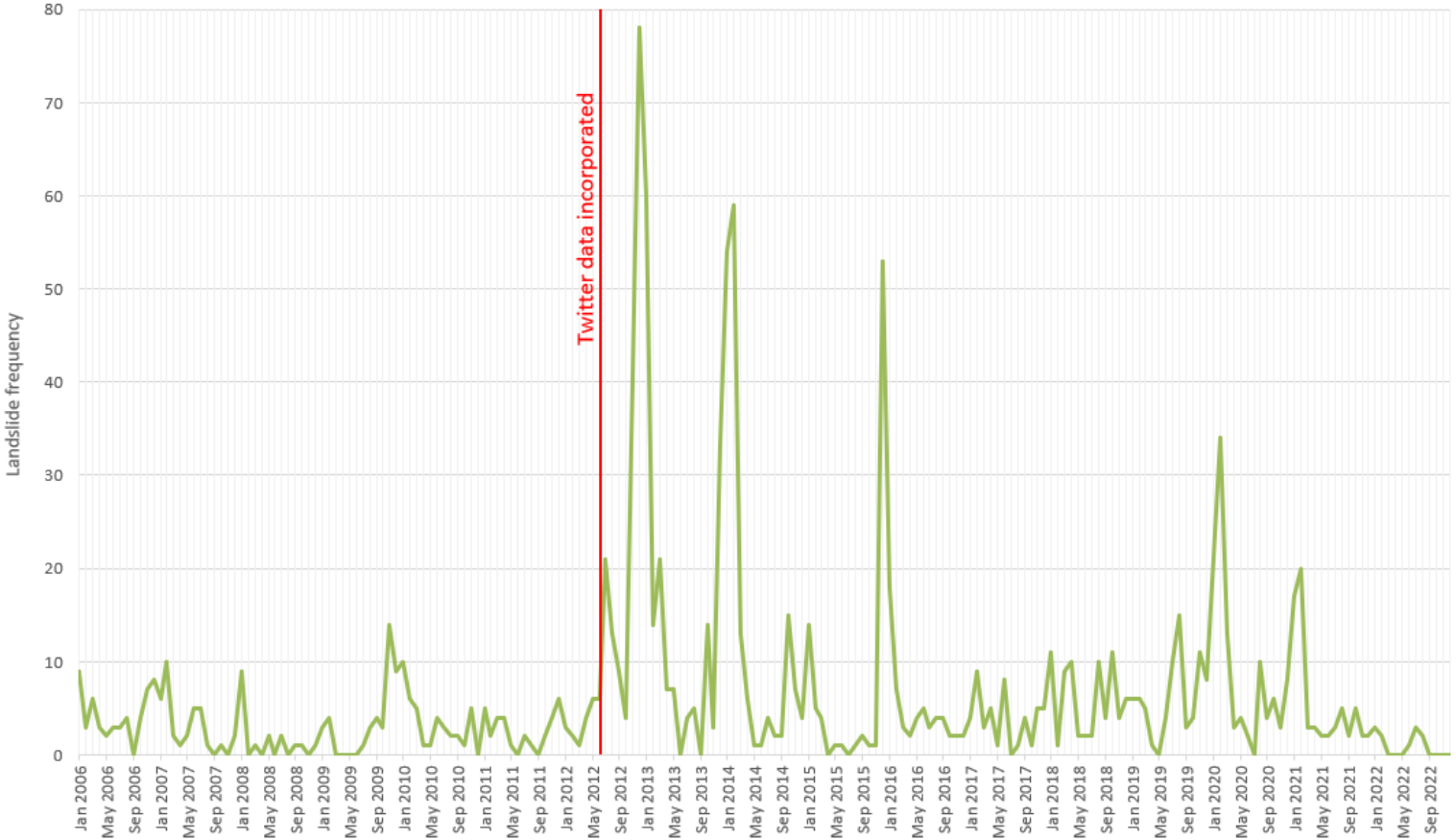
UK Landslides captured in the BGS National Landslide Database: January 2006 to October 2022



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Aims:

To train a computer model to identify landslide features in photographs.

To apply this to social media to extract and locate landslide photographs in real time.

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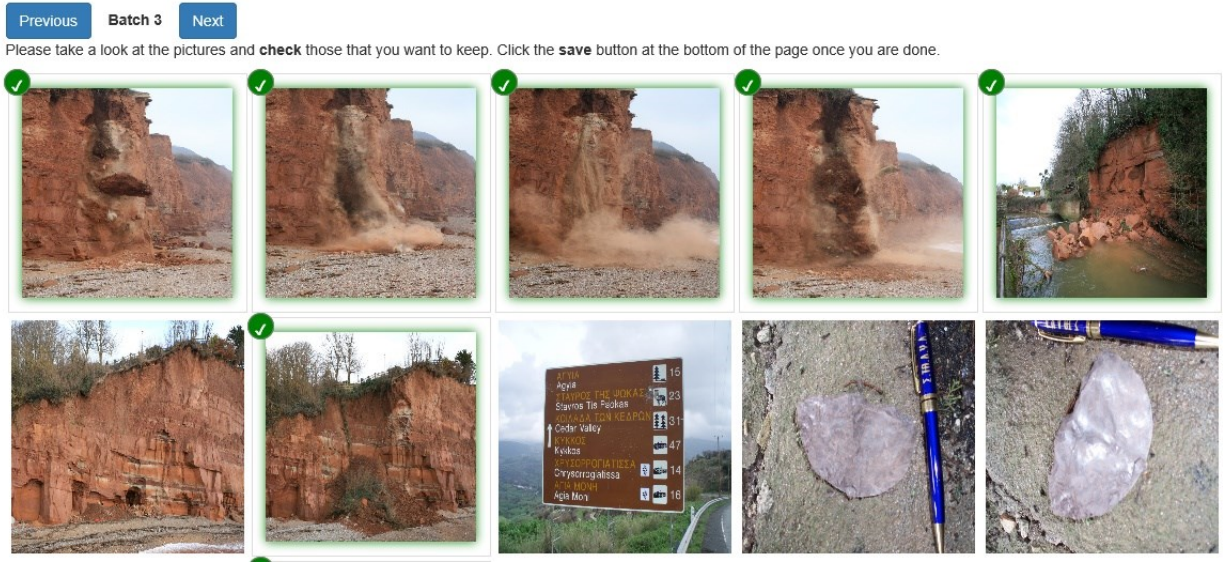
Training the model

- Developed new landslide identification methodology for this application
- 11,737 images in the training set analysed by three geoscientists independently
- Images from Twitter, Google images and the BGS's Geoscenic images database
- Not all landslide images



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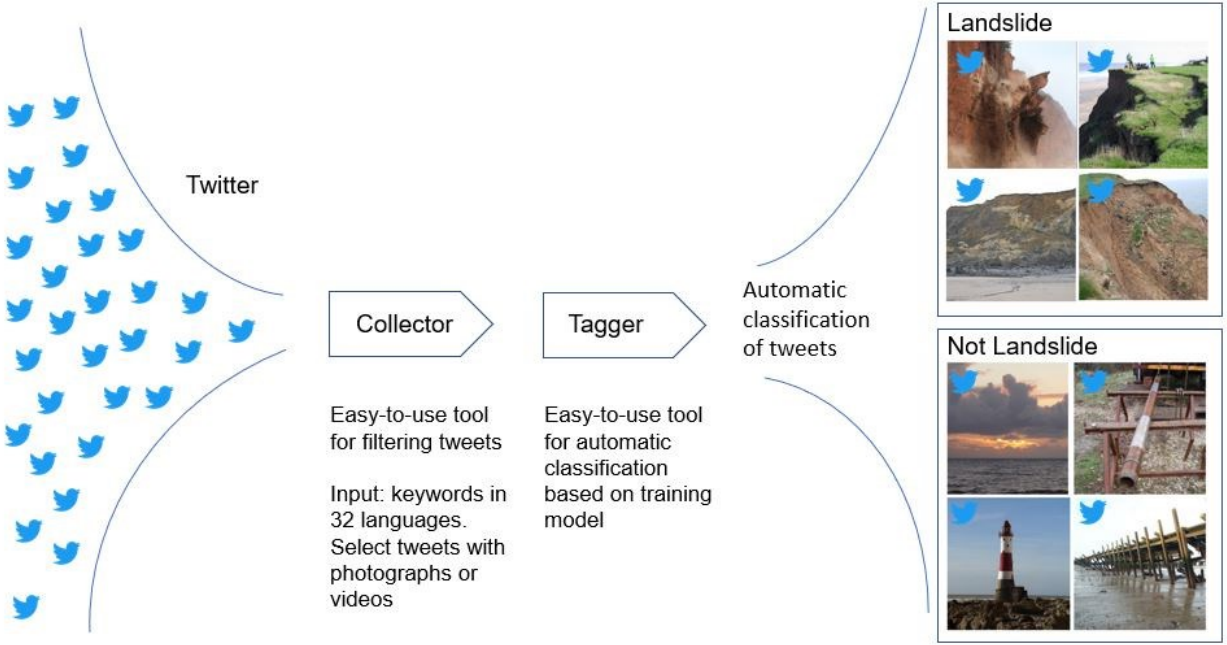
The Live Model

- Twitter data harvests tweets that contain an image in association with landslide terminology; this has been done in multiple languages
- Over 3 million images extracted so far



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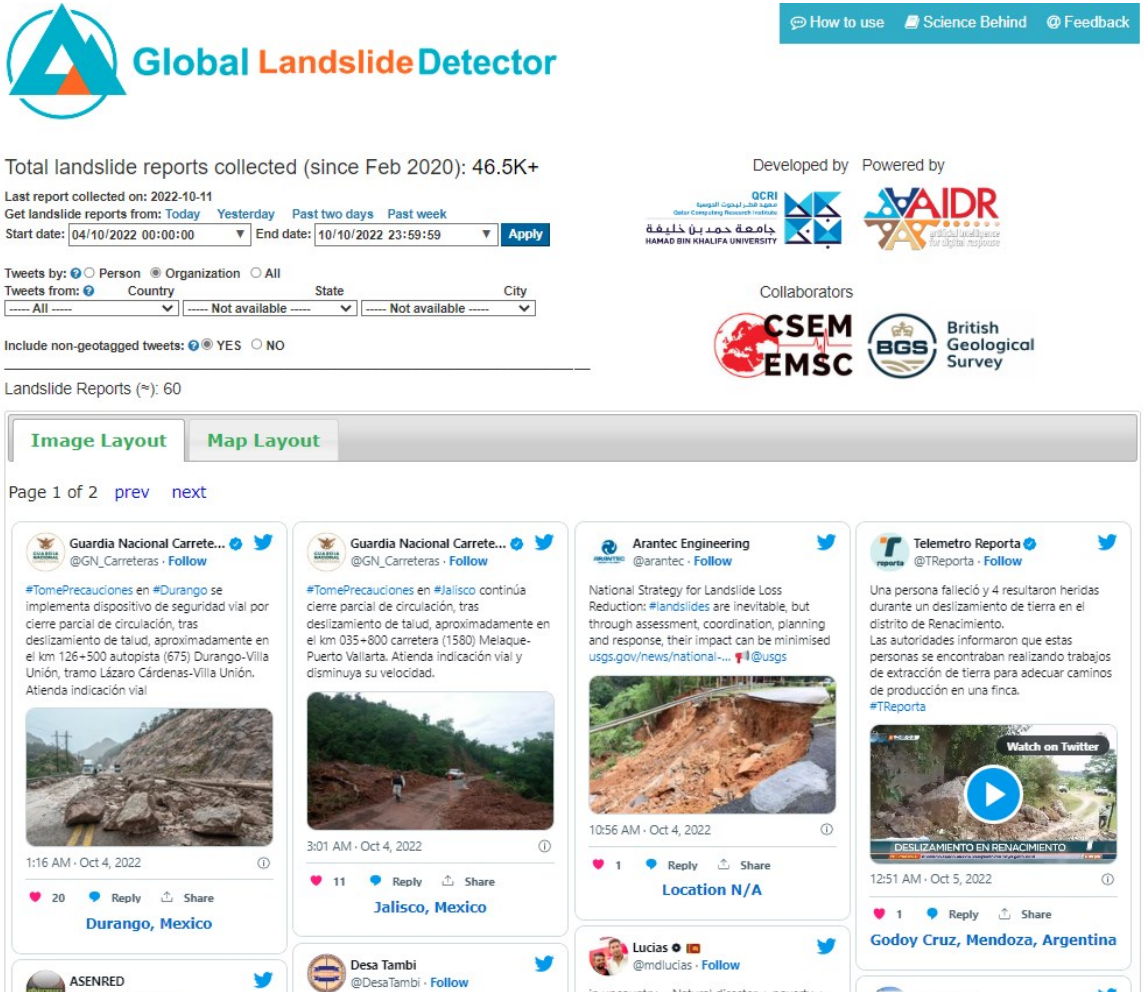
The Live Model: Images

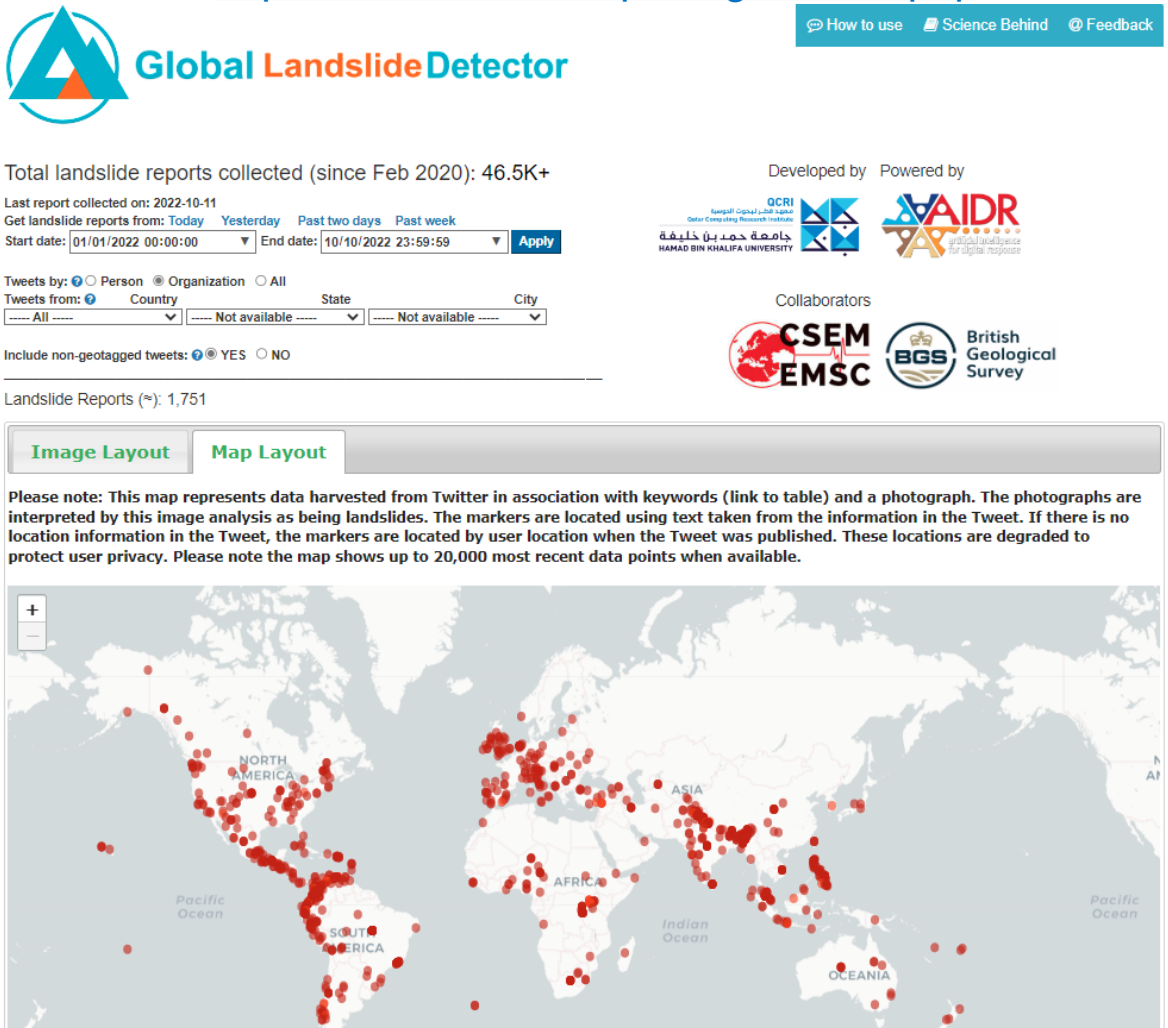
https://landslide-aidr.qcri.org/service.php

Feedback please!



The Live Model: Map

https://landslide-aidr.qcri.org/service.php



Feedback please!

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Results

- System online February 2020 to monitor live Twitter data stream
- ~3.8 million image URLs deemed unique and downloaded for further analysis
- ~46,500 photographs deemed as landslides worldwide (as of Oct 2022)
- Corresponds to 1% of the collected images
- Highlights the challenging nature of the problem

Ofli, F., Qazi, U., Imran, M., Roch, J., Pennington, C., Banks, V., & Bossu, R. (2022). A Real-time System for Detecting Landslide Reports on Social Media using Artificial Intelligence. https://arxiv.org/pdf/2202.07475v1.pdf

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Next steps

- Engagement
  - Stakeholder – DRR, landslides research, databases…
  - Workshops
  - Collaborations
- Future iterations
  - Keywords – more languages – technical and cultural words
  - Other social media platforms
  - Improve the map – ethics
- Funding

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Thank you and please provide feedback!

landslides@bgs.ac.uk

https://landslide-aidr.qcri.org/service.php

https://doi.org/10.1016/j.ijdrr.2022.103089

Training the model: methodology and assumptions

The decision-making process differs from conventional landslide identification, including landslide-type nomenclature assignment, and makes assumptions as follows:

- No contextual knowledge or previous understanding of the landslide
- One photograph of the event
- The model aims to capture contemporary landslides
- The model aims to recognise zones of depletion (where the material has come from) and accretion (where it has been deposited)
- The landslide is the major component of the image
- For borderline cases, ask: would the end user be concerned by the image being returned as a landslide?
- The model cannot discriminate scale without using more sophisticated object detection or image segmentation techniques

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Limitations

- This system does not replace expert survey. Data come from any social media user.
- Each photograph is analysed in isolation.
- The model does not discriminate landslide type - zones of depletion/ accretion. Excludes where the landslide debris has been removed by coastal or fluvial erosion or remediated
- The model aims to show contemporary landslides
- There must be a clear representation of a landslide as the major component of the image
- The model does not to discriminate scale. Images labelled as landslides may be very small (<1m and not strictly a landslide); aerial photographs including multiple landslide events are not captured
- The model is not intended to be used in isolation during a disaster scenario but could complement existing workflows providing new data coupled with an understanding of the above limitations and data biases (e.g. mobile coverage, widespread use of social media, population density)
- Locational accuracy of landslide tweets is automated and still a work in progress

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Locating the landslides

- Images are located using text taken from the Tweet.
- If there is no information in the Tweet, then shared location is used (geo-tag or place label)
- These are free form text provided by the user.
- Use an approach based on Named-Entity-Recognition (NER) and then look up in an address dictionary
- Based on methodology from Qazi et al. (2020). Several improvements since this publication.
- Perform proper performance (i.e. accuracy) evaluation.

Qazi, U., Imran, M. and Ofli, F. (2020) GeoCoV19: A Dataset of Hundreds of Millions of Multilingual COVID-19 Tweets with Location Information. Computer Science, ACM SIGSPATIAL Special, v 12, pp 6-15.

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Verification

- Randomly sampled 3,600 images that were deemed relevant and non-duplicate by the system and labelled them as landslide and non-landslide images.
- System-predicted landslides compared to expert annotations

	True	False
Landslide (positives)	123	39
Not-landslide (negatives	3395	43

- This quantitative verification exercise showed that the demonstrator model can detect landslide reports with Accuracy=98%, Precision=76%, Recall (Sensitivity)=74%, and F1-score=75%.

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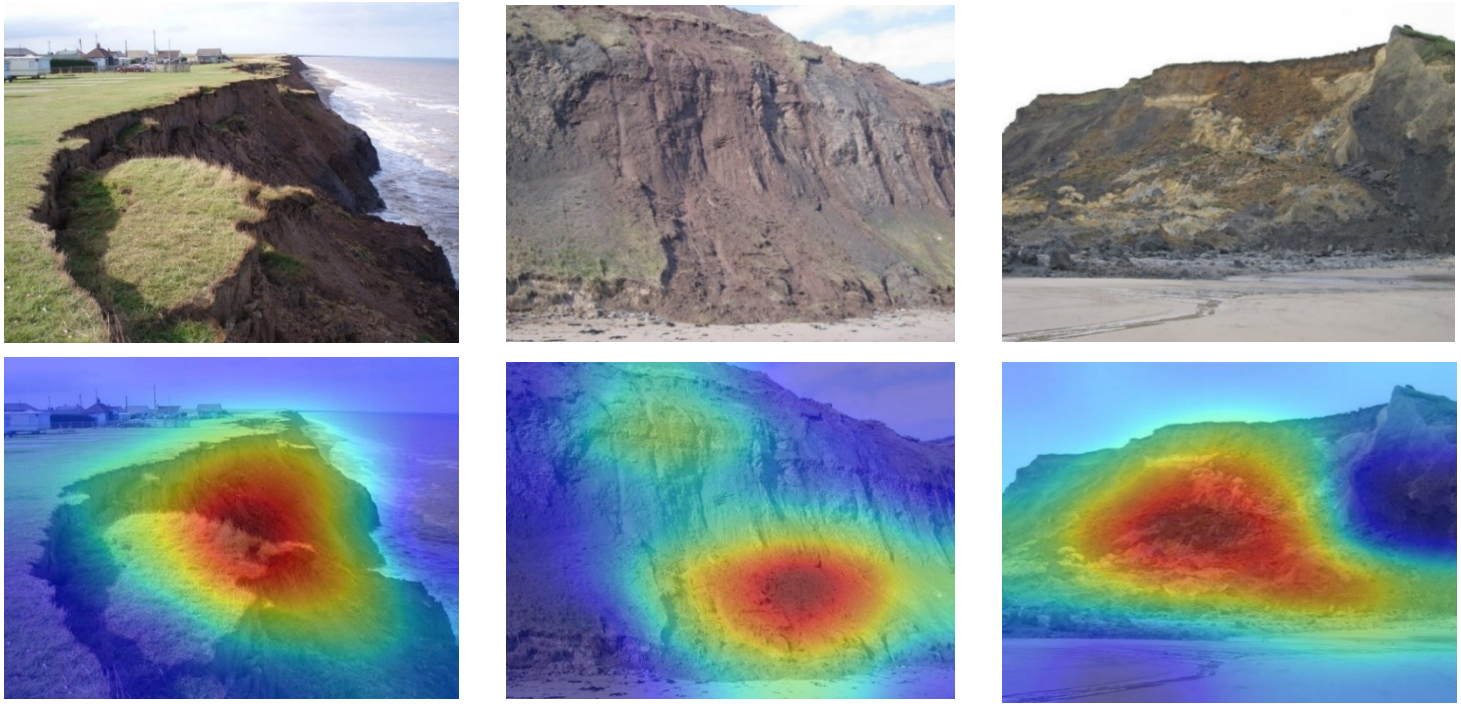
Qualitative verification: Landslide



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