

Big Data Analytics Lecture

# Multimodal Analysis of Geo-social Media Data for Improved Disaster Management

**From Science to Digital Practice**

Basic  
Human  
Needs



WiFi  
Battery



LET'S EAT GRANDMA.  
LET'S EAT, GRANDMA.  
COMMAS SAVE LIVES



Liban : Vidéo aérienne par drone qui documente les destructions sur le port de Beyrouth au quatrième jour après l'explosion.  
60 personnes restent portées disparues.

[Translate Tweet](#)



2:42 PM · Aug 8, 2020 · Twitter Web App

# Motivation ::: Big Data



# Social Media in Crisis Management

# Estimating Disaster and Damage Footprints

- **Current approaches:** temporal lag, limited resolution, lacking information for change detection
- **Crowdsourced data:** instant availability, in-situ information
- **...but:** uncertainty, unstructured and non-standardised information



Source: Resch, B. , Usländer, F. and Havas, C. (2017) Combining Machine-learning Topic Models and Spatio-temporal Analysis of Social Media Data for Disaster Footprint and Damage Assessment. Cartography and Geographic Information Science (CaGIS), DOI: 10.1080/15230406.2017.1356242

# Fast, Geo-located, Multi-media Information

2021-07-17  
17:16:38

Dramatische Szene spielen sich gerade in Hallein ab. Die Altstadt ist überflutet. Es wurde Zivilschutzalarm ausgerufen und die Bevölkerung soll in den Häusern bleiben. Alle laufenden Infos über den Link in der Bio! #wissenmachtwach #salzburg #hallein #igershallein #unwetter #hochwasser

instagram  
account



# Fast, Geo-located, Multi-media Information

2021-06-29  
03:41:57

Land unter in Stuttgart. 😞 Gestern Nacht haben Starkregen und schwere Sturmböen in Stuttgart und der Region viel Chaos angerichtet. Wassermassen und Sturmschäden sorgten für zahlreiche Einsätze von Feuerwehr und Polizei. Auch die S-Bahn musste den Betrieb einstellen.\n\nAm Messpunkt Schnarrenberg fielen in einer Stunde 42 Liter Wasser auf den Quadratmeter. „Das ist sehr viel“, erklärt die Dame vom Deutschen Wetterdienst. „Der Wert liegt über der Schwelle zum extrem heftigen Starkregen.“ In der Region werden ebenfalls hohe Werte gemessen: 37 Liter in Backnang.\n\nAlarm auch an der Oper: Der Sturm hat Teile des Dachs abgedeckt, Kupferteile fallen auf den Vorplatz. Auch eine Statue zerschellt am Boden. Intendant Viktor Schoner sagt: „Ich stehe unter dem Dach und werde ganz schön nass.“ 250 Gäste seien zur Zeit des Unwetters bei einem Liederabend in der Oper gewesen, niemand sei verletzt worden. \n\nDen ganzen Artikel und weitere Bilder findet Ihr im Link in der Bio.\n\n#Unwetter #Wasser #Oper #Stuttgart \n\n© Lichtgut/Julian Rettig (1), Fotoagentur Andreas Rosar (2), Jonas Schöll (3), Lichtgut/Leif Piechowski (4+5), 7atkuell.de/Kevin Lermer

instagram  
account



# Fast, Geo-located, Multi-media Information

Die #Aare ist in Aarburg bereits über Ufer  
#Hochwasser

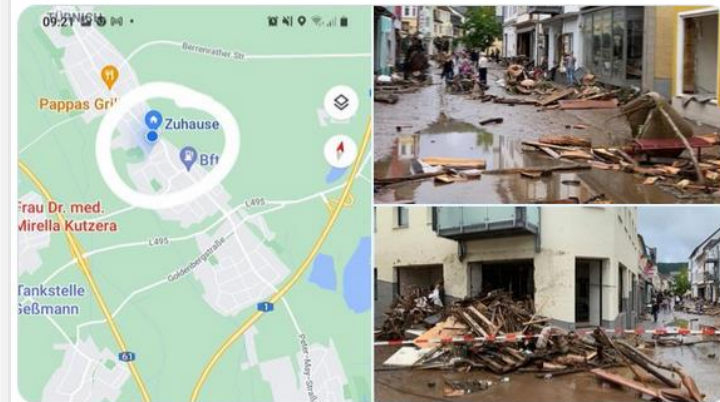
Translate Tweet



7:19 AM · Jul 15, 2021 from Aarburg, Schweiz · Twitter for Android

Oh ja schön zu sehen , ... auch das gehört zum Leben .  
Ich bin in der Nachbarschaft und helfe beim aufräumen  
nach der Flutkatastrophe in meinem Ort

Translate Tweet



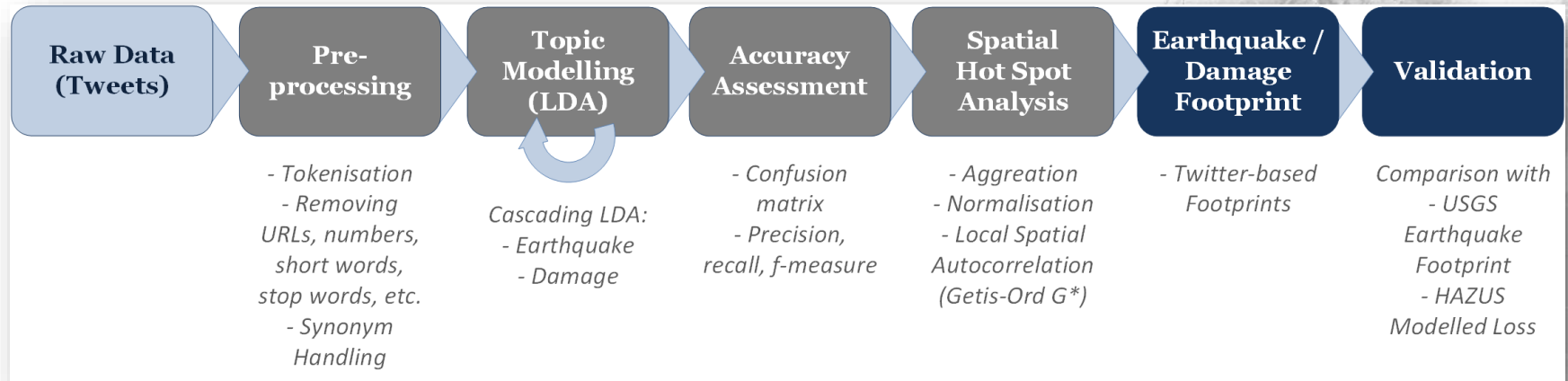
Sir Henry J. M.

12:53 PM · Jul 18, 2021 from Erfstadt, Deutschland · Twitter for Android



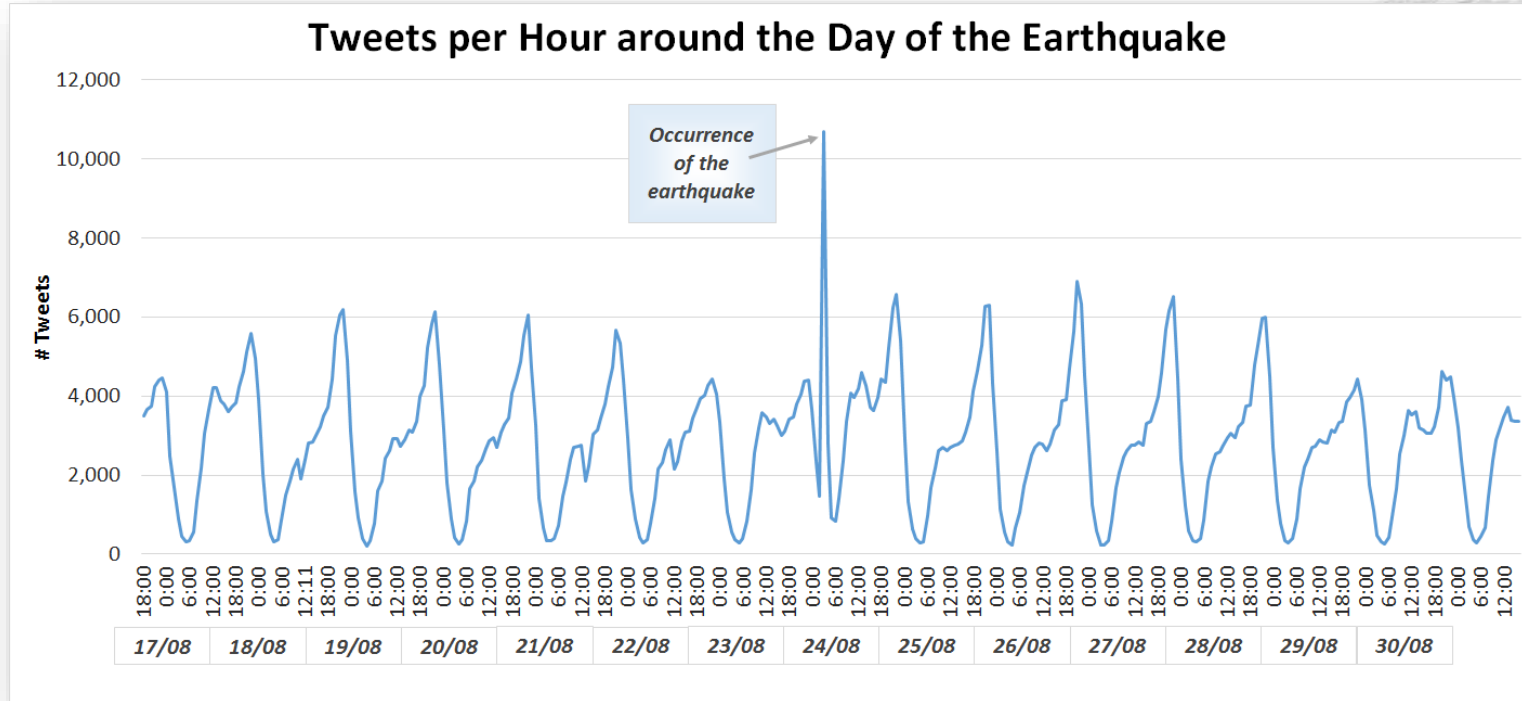
# Estimating Disaster and Damage Footprints

- Where do *relevant* social media posts *cluster*?



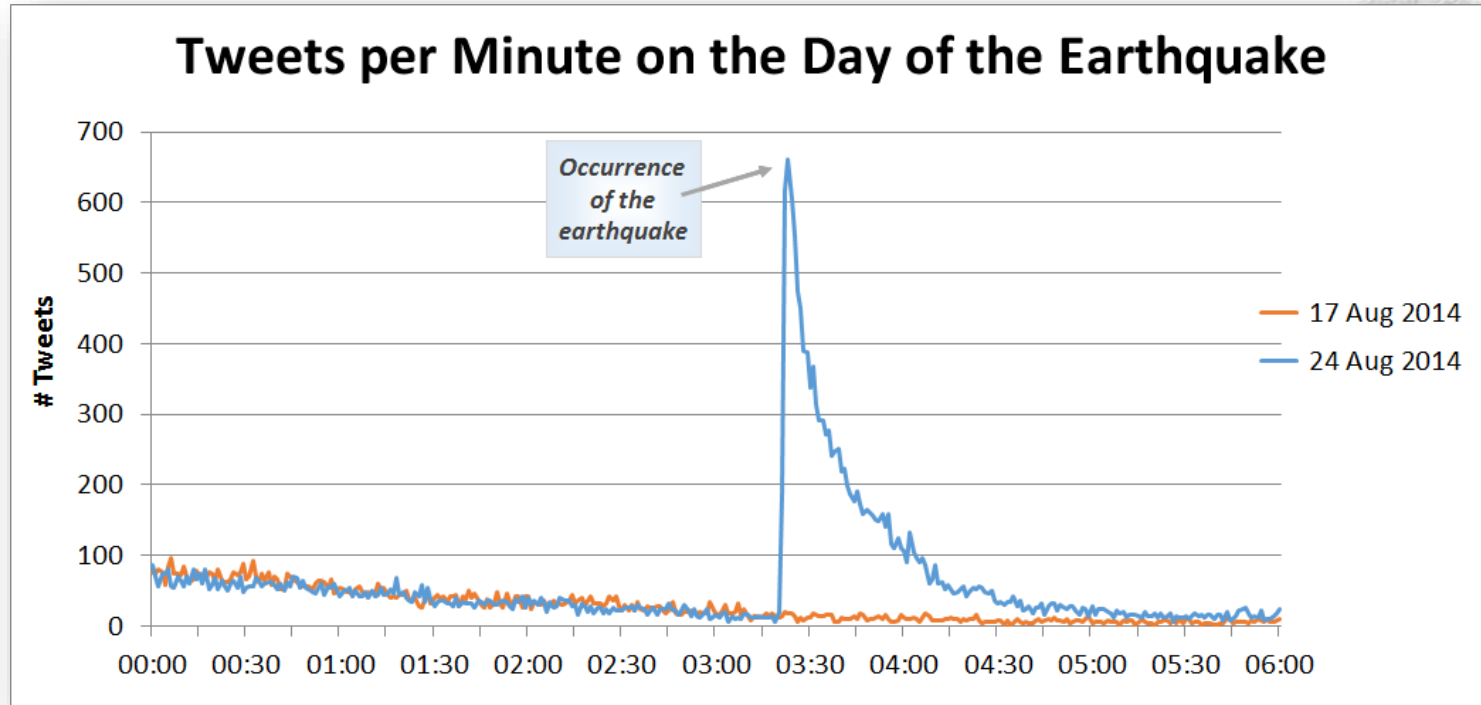
Source: Resch, B., Usländer, F. and Havas, C. (2017) Combining Machine-learning Topic Models and Spatio-temporal Analysis of Social Media Data for Disaster Footprint and Damage Assessment. Cartography and Geographic Information Science (CaGIS), DOI: 10.1080/15230406.2017.1356242

# Estimating Disaster and Damage Footprints



Source: Resch, B., Usländer, F. and Havas, C. (2017) Combining Machine-learning Topic Models and Spatio-temporal Analysis of Social Media Data for Disaster Footprint and Damage Assessment. Cartography and Geographic Information Science (CaGIS), DOI: 10.1080/15230406.2017.1356242

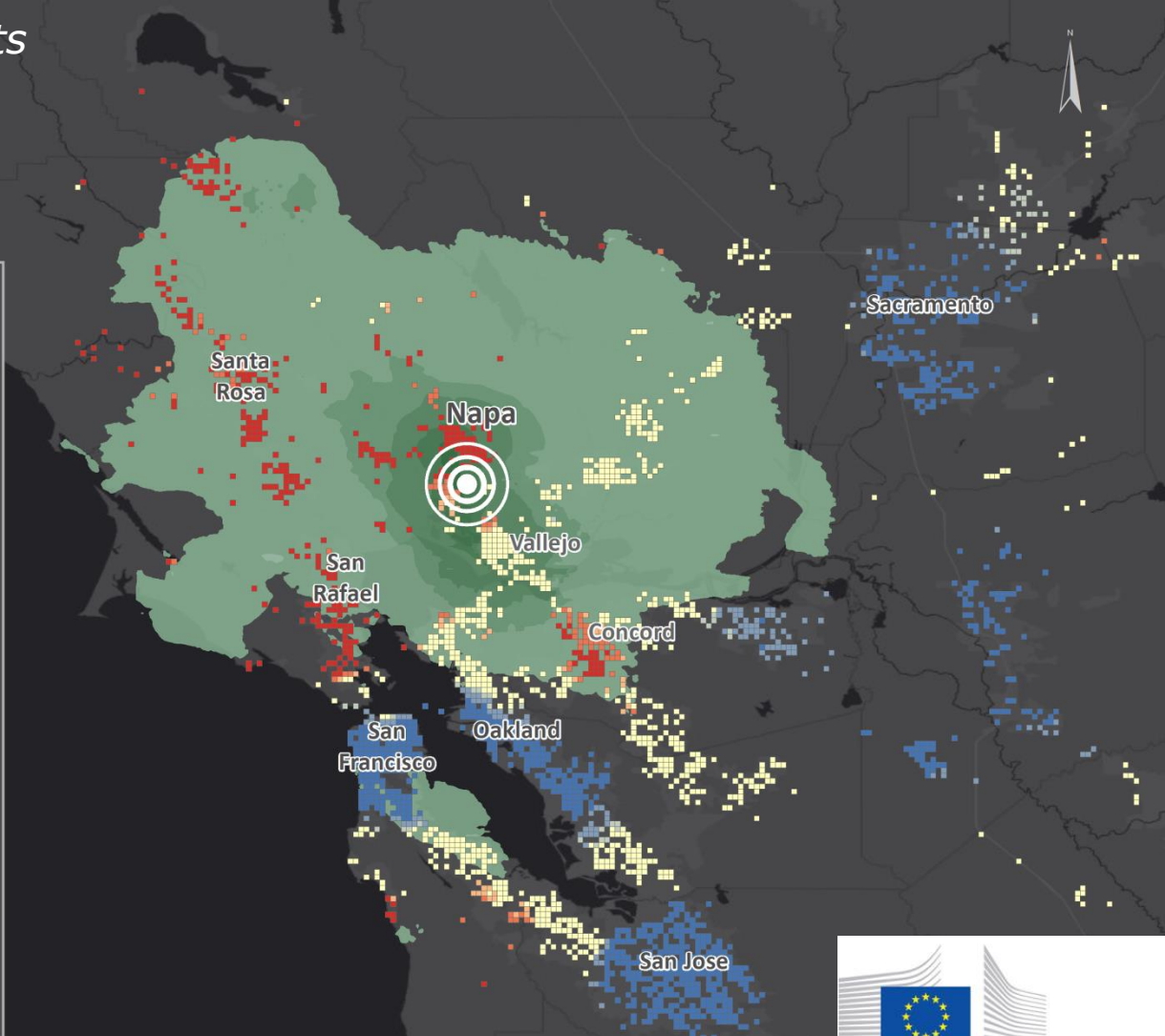
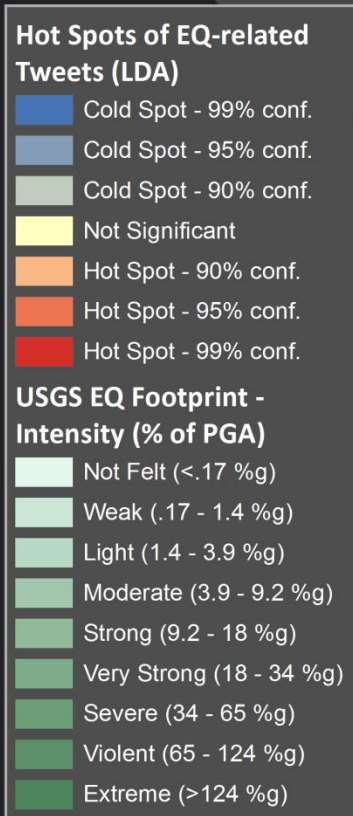
# Estimating Disaster and Damage Footprints



Source: Resch, B. , Usländer, F. and Havas, C. (2017) Combining Machine-learning Topic Models and Spatio-temporal Analysis of Social Media Data for Disaster Footprint and Damage Assessment. Cartography and Geographic Information Science (CaGIS), DOI: 10.1080/15230406.2017.1356242

# Napa Valley Earthquake

1,012,650 Tweets



Source: Resch, B., Usländer, F. and Havas, C. (2018) Combining Machine-learning Topic Models and Spatio-temporal Analysis of Social Media Data for Disaster Footprint and Damage Assessment. Cartography and Geographic Information Science (CaGIS), DOI: 10.1080/152230406.2017.1356242

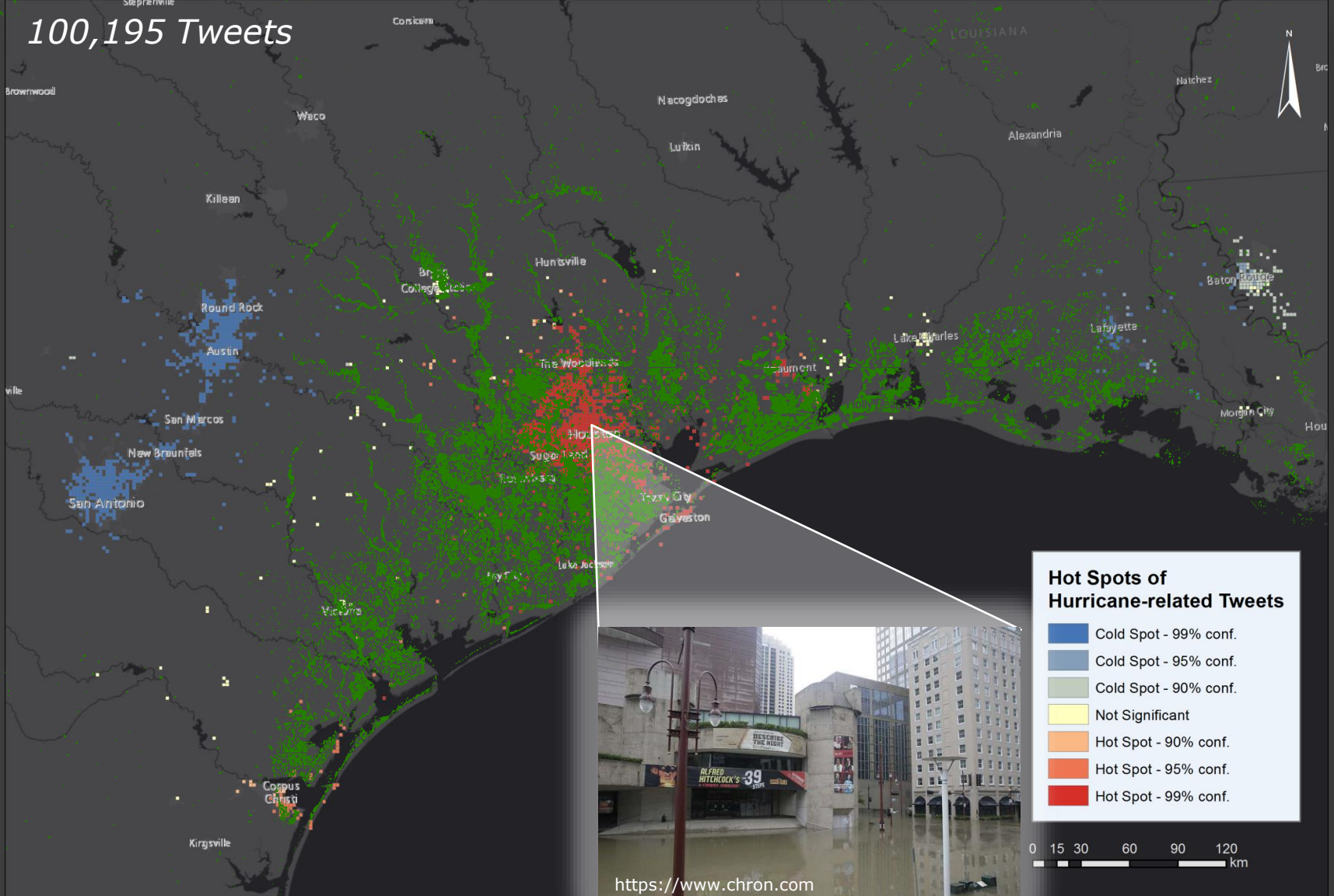


European Commission

Horizon 2020  
European Union funding  
for Research & Innovation

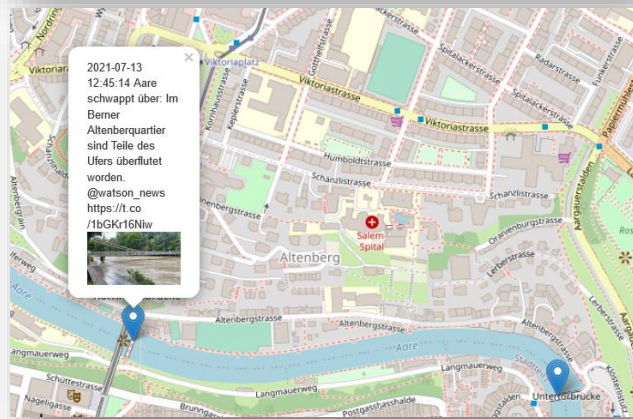
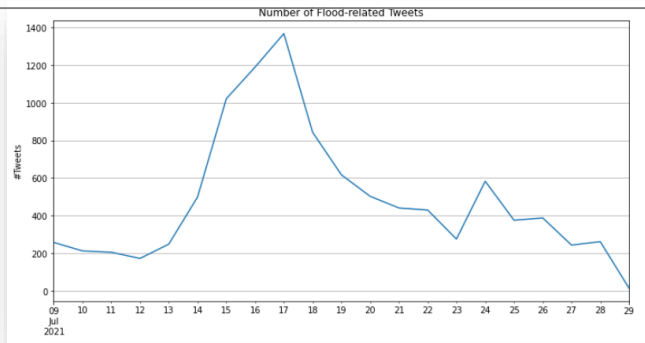
# Hurricane Harvey 2017

100,195 Tweets



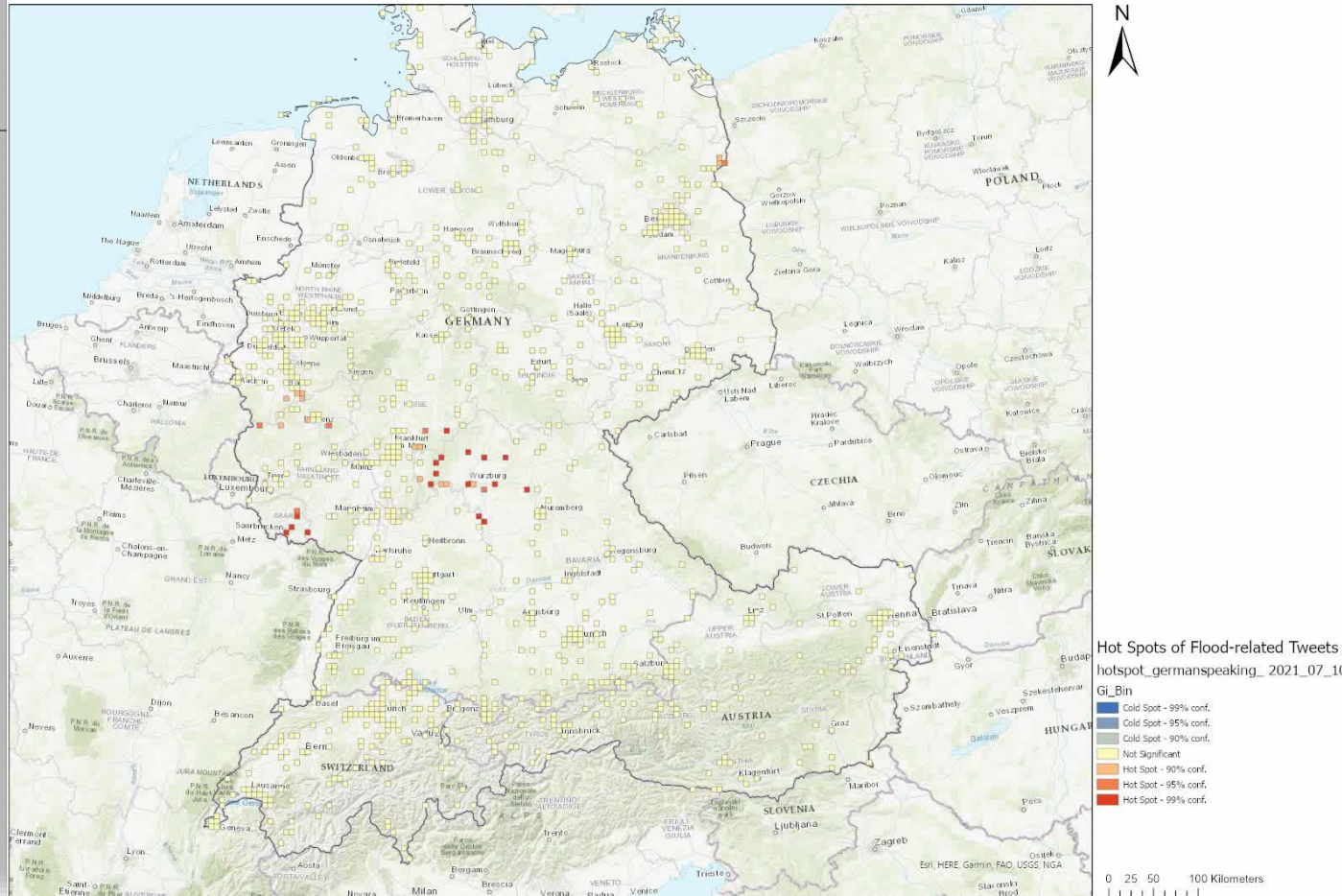
<https://www.chron.com>

# Fast, Geo-located, Multi-media Information



Fast,

# Hot spots of daily aggregated tweets 2021-07-10

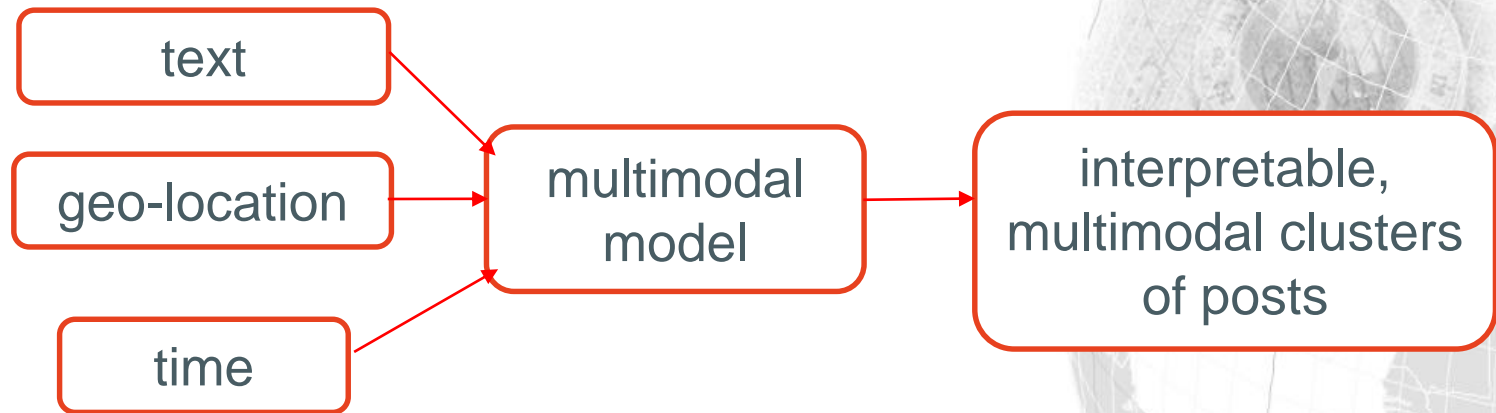


# Multi-modal Machine Learning



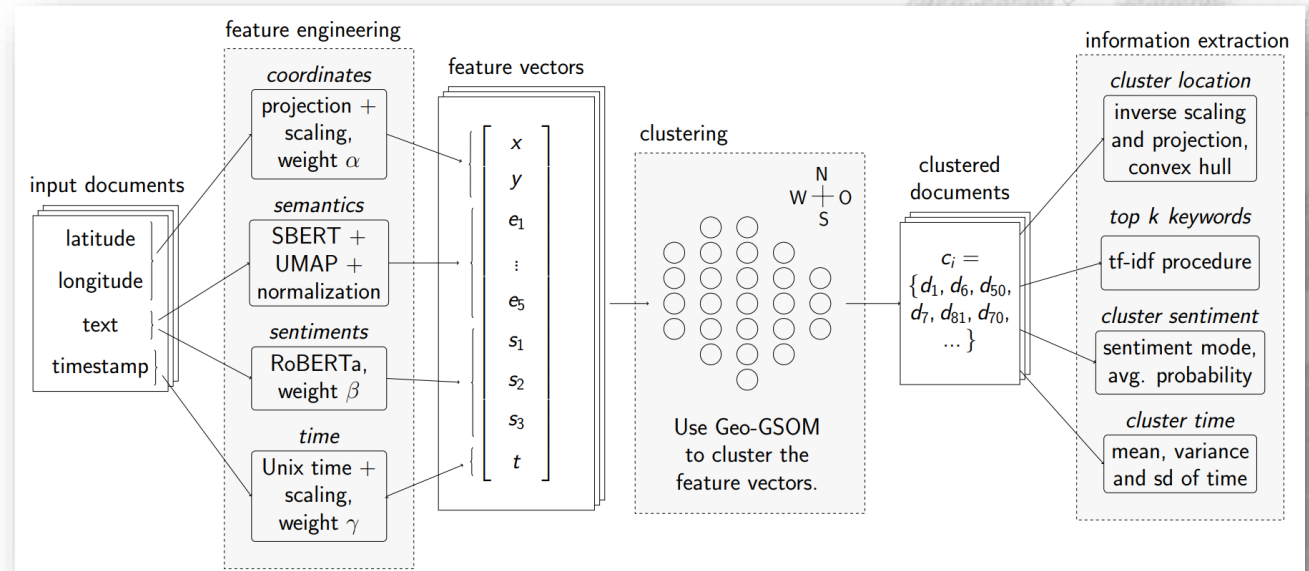
# Multi-modal Machine Learning

- Integrating semantic topic and sentiments of text, the geo-location and the posting time



# Multi-modal Machine Learning

- **Cluster feature vectors** in n-dimensional space
- **Multi-language** support
- **Output:** cluster map with clear topic, sentiment, location and time

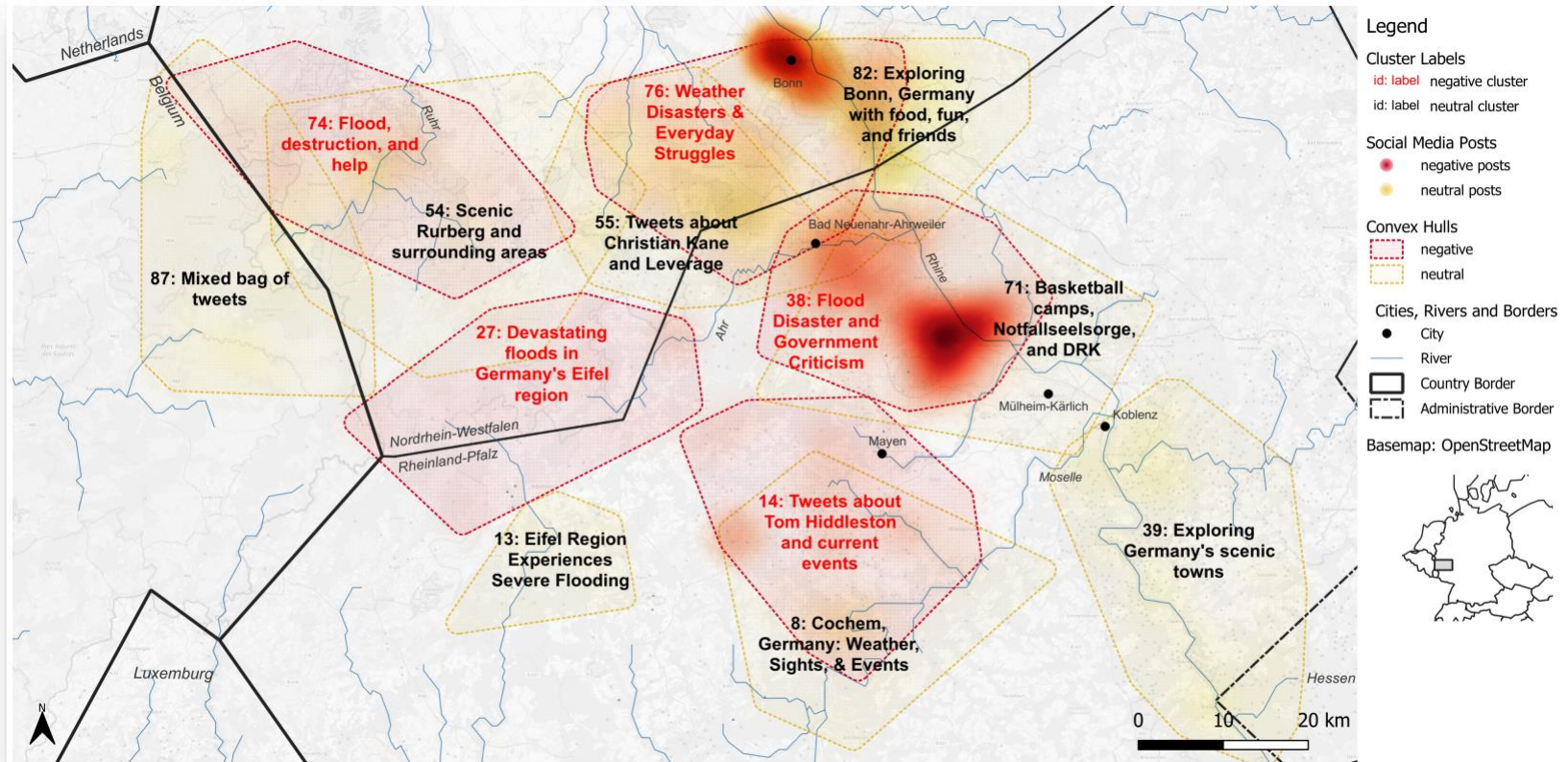


# Multi-modal Machine Learning

- **Automated topic labelling**  
*Llama2*
- Labelling of **BERTopic outputs** (single words associated with semantic topics)

ID	Sentiment	Disaster relevant information	Mean time
8	neutral	Flood warning in Germany, especially in the Eifel region. Rescue services are on high alert.	2021-07-15 20:50
13	neutral	Updates on current flood situation in Eifel region, Germany.	2021-07-19 06:04
14	negative	Severe weather warning in Germany, with heavy rain and thunderstorms expected.	2021-07-16 14:42
27	negative	Damage and displacement caused by floods in Schuld and Bad Münstereifel, Germany.	2021-07-17 02:56
38	negative	Request for help from people affected by floods in Germany.	2021-07-20 10:22
39	neutral	Reports of flooding, landslides, and road closures in Germany.	2021-07-13 22:57
54	neutral	Updates on rescue operations and aid distribution in flooded regions of Germany.	2021-07-15 15:43
55	neutral	Flood warning and evacuation alert in the Voreifel region due to heavy rainfall and rising river levels.	2021-07-15 16:06
71	neutral	Deployments by volunteer fire department and rescue service in Mayen-Koblenz area, Germany.	2021-07-21 20:35
74	negative	Impact of floods on people's lives in Germany.	2021-07-20 11:01
76	negative	Power outages and evacuation requests due to severe weather in Rhine Valley, Germany.	2021-07-15 10:59
82	neutral	Evacuation alerts due to overfilled dams in Wuppertal, Rheinbach, and Radevormwald, Germany.	2021-07-15 20:20
87	neutral	Updates on flood situation in Belgium and Netherlands, including rising water levels and evacuations.	2021-07-15 11:42

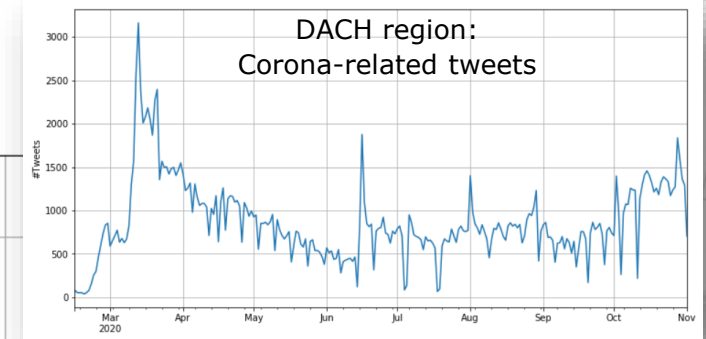
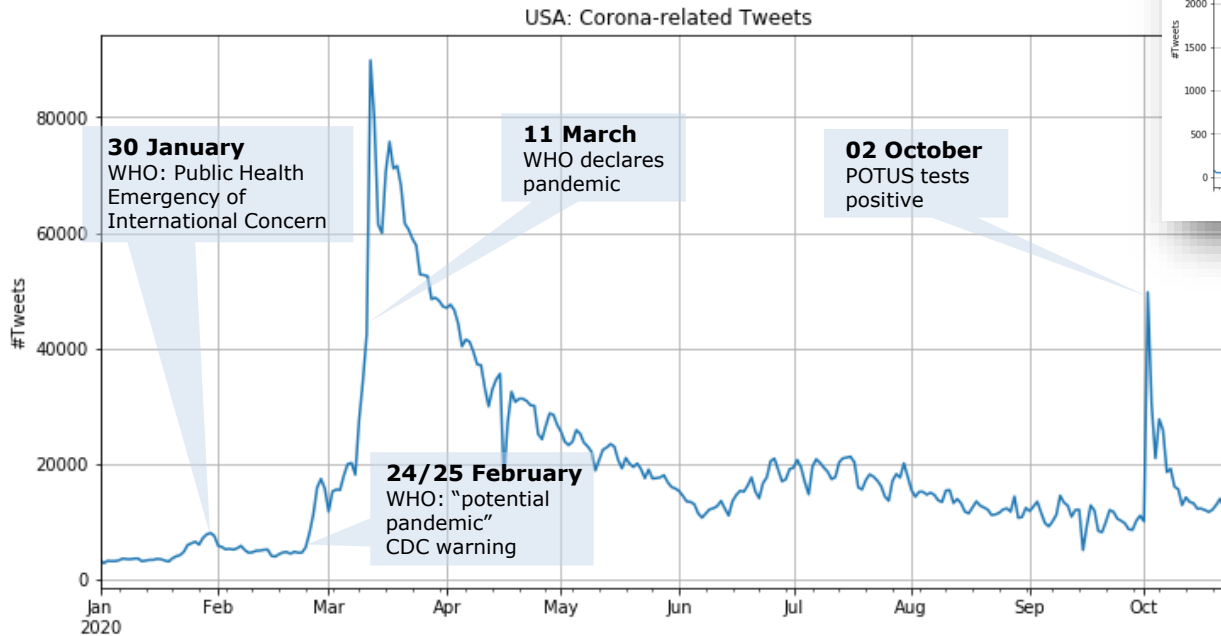
# Multi-modal Machine Learning



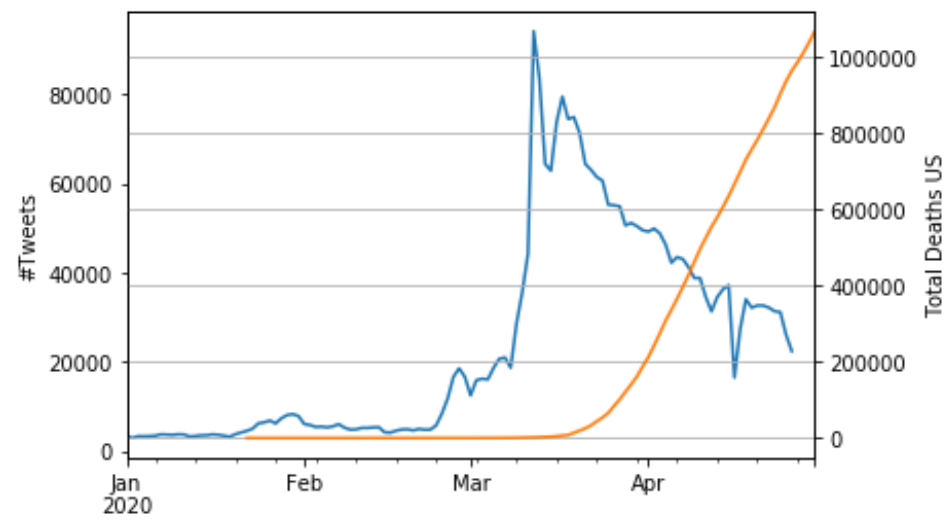
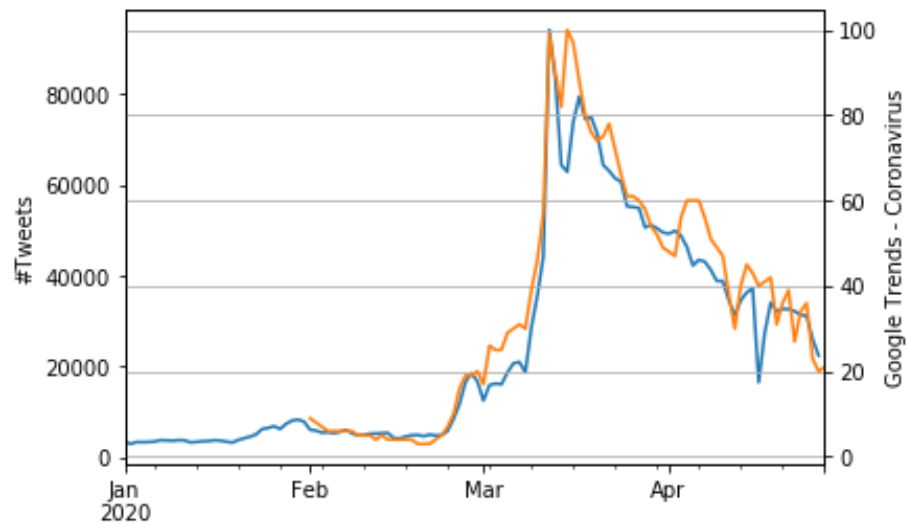
# Spatio-temporal Epidemiology

# Geo-social Media ::: COVID-19

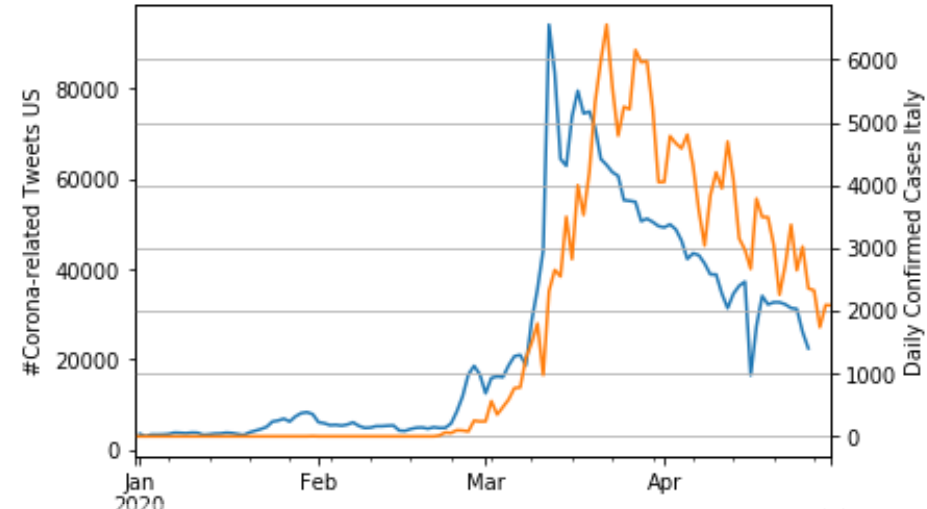
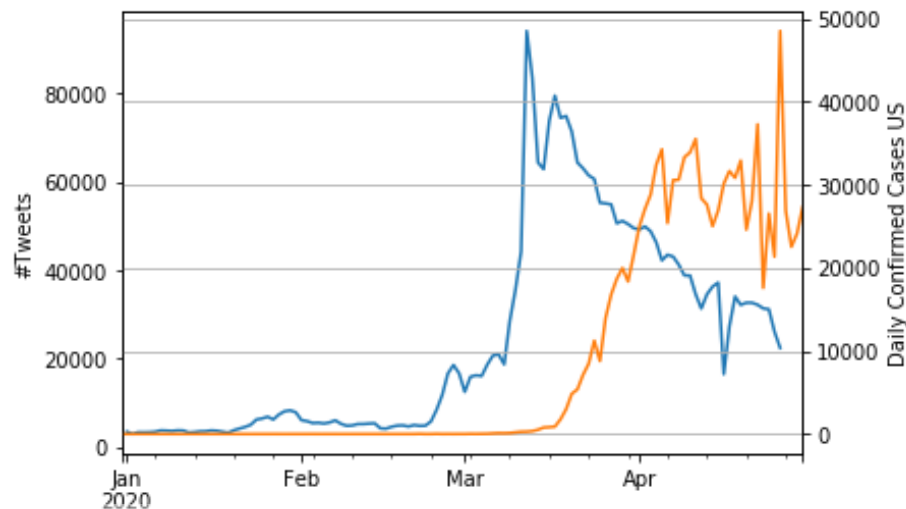
## ■ USA/DACH: COVID-19 related tweets (keyword-filtered)



Kogan, N.E., Clemente, L., Liautaud, P., Kaashoek, J., Link, N.B., Nguyen, A.T., Lu, F.S., Huybers, P., Resch, B., Havas, C., Petutschnig, A., Davis, J., Chinazzi, M., Mustafa, B., Hanage, W.P., Vespignani, A. and Santillana, M. (2021) An Early Warning Approach to Monitor COVID-19 Activity with Multiple Digital Traces in Near Real-Time. Science Advances.

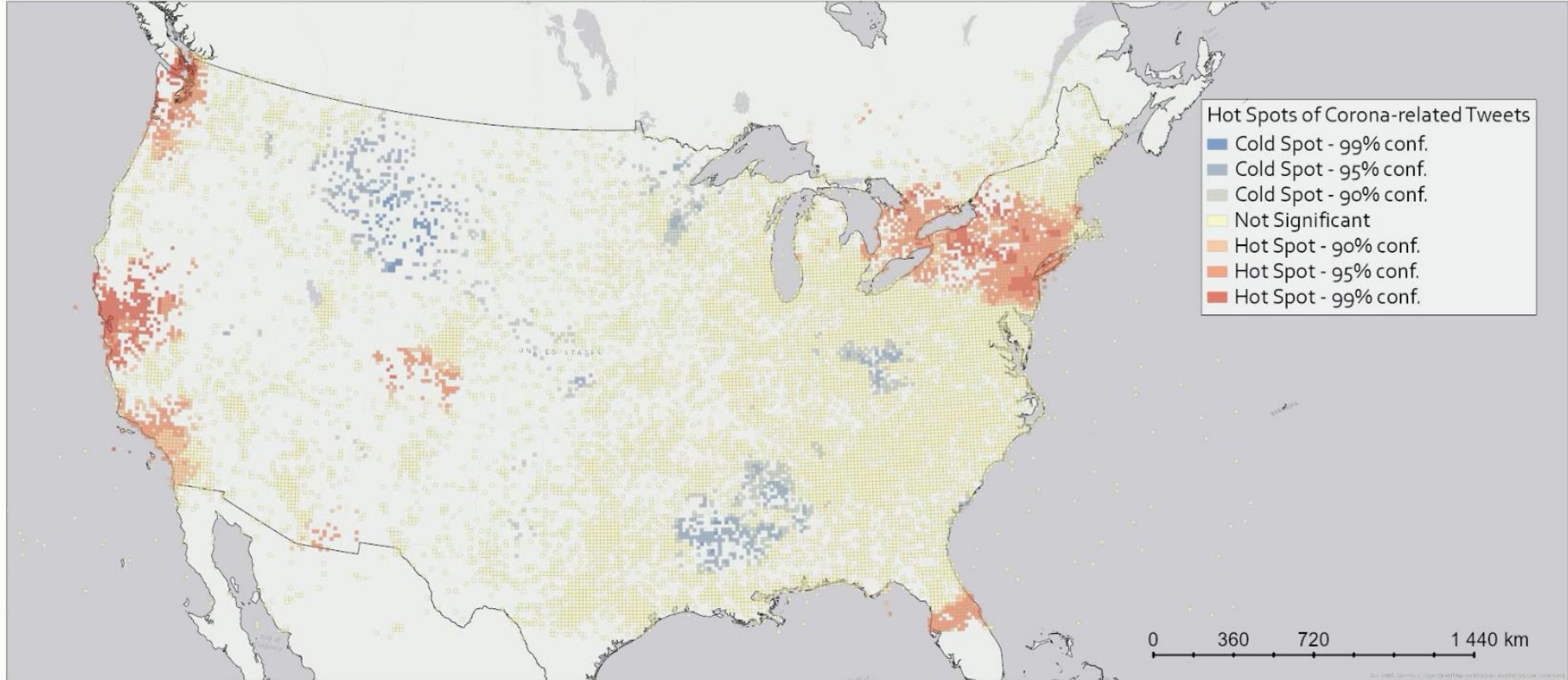


## Social Media COVID-19: Comparison with other Data



# Social Media ::: COVID-19 Hot Spots

Hot Spots of Weekly Aggregated Tweets (2020-04-07 - 2020-04-14)





# Humanitarian Safety ::: HUMAN+

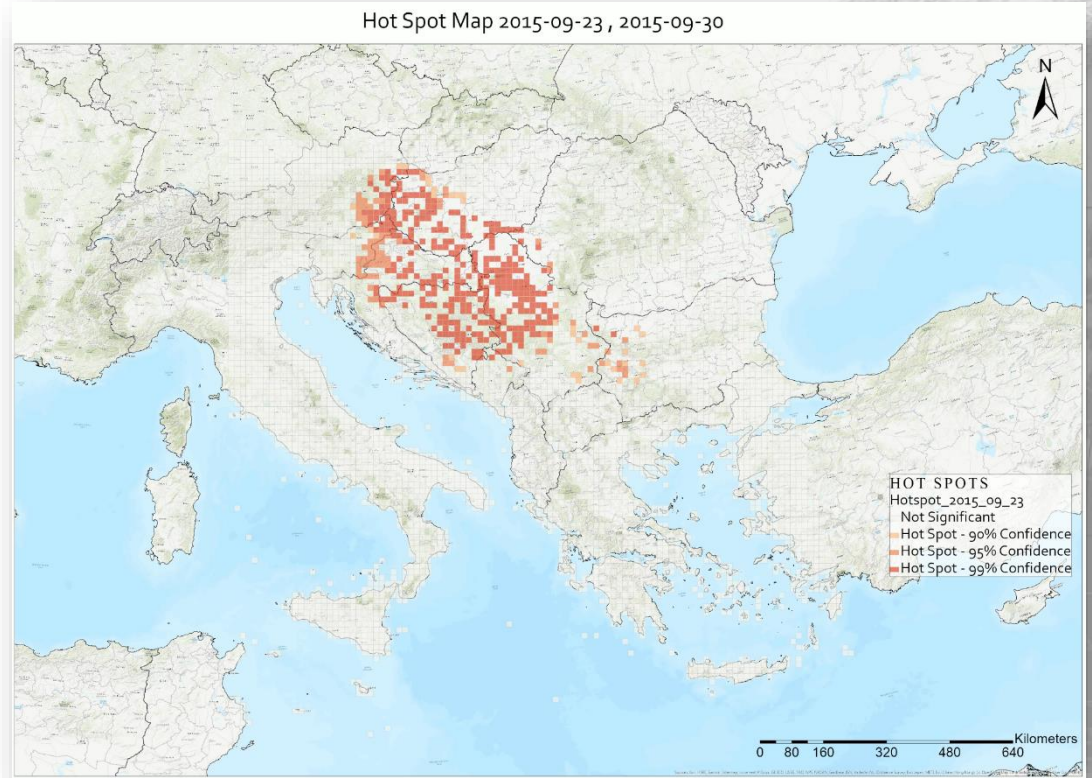
# HUMAN+ ::: Motivation

- Challenges through **intensified refugee movements** of the last few years
- ➔ **Humanitarian safety** through better reception, transfer, supply & accommodation
- ➔ **Integrated** situational awareness

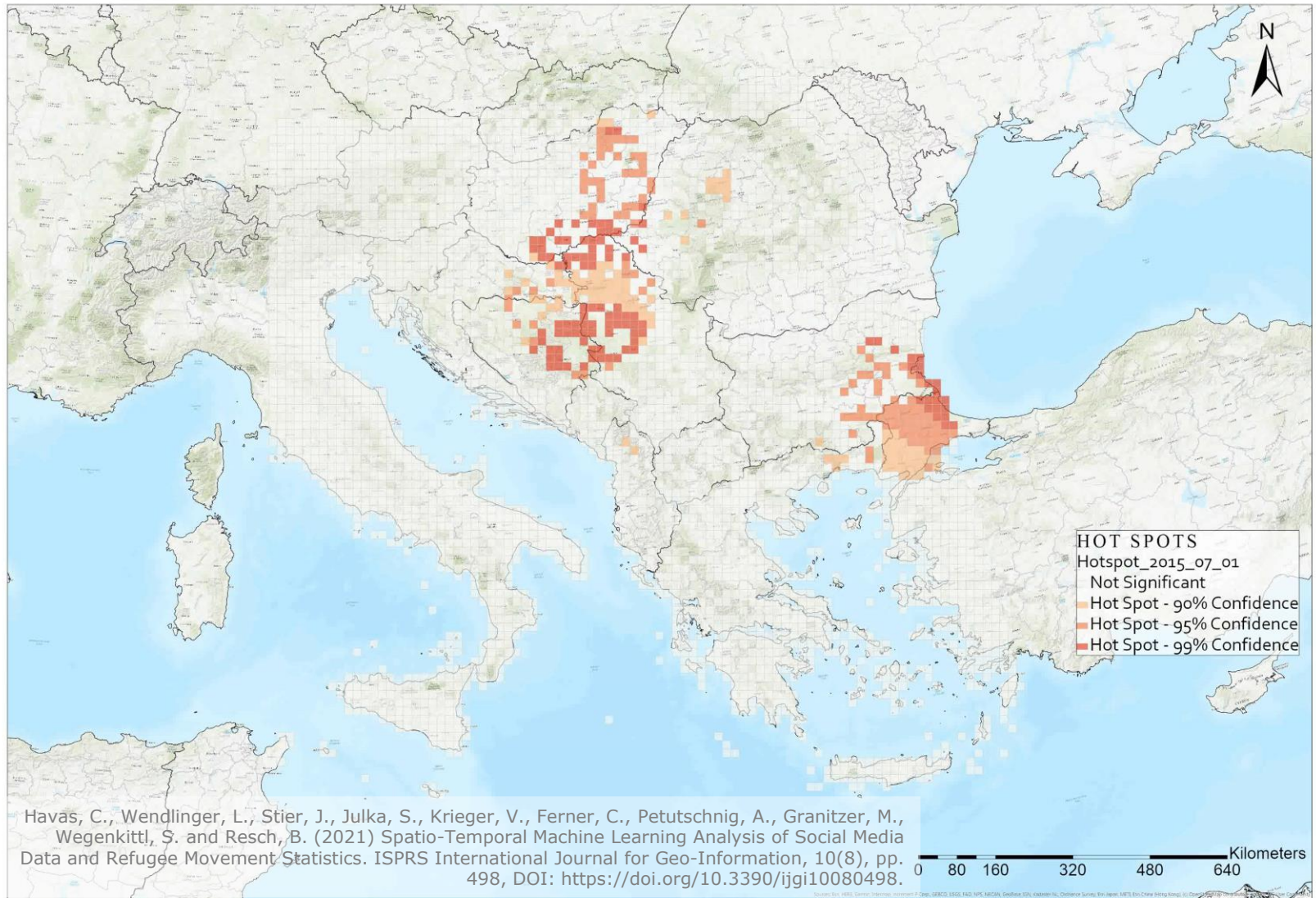


# HUMAN+ ::: Social Media Analysis

- Change of spatial focus areas over time
- Hot spots clearly visible



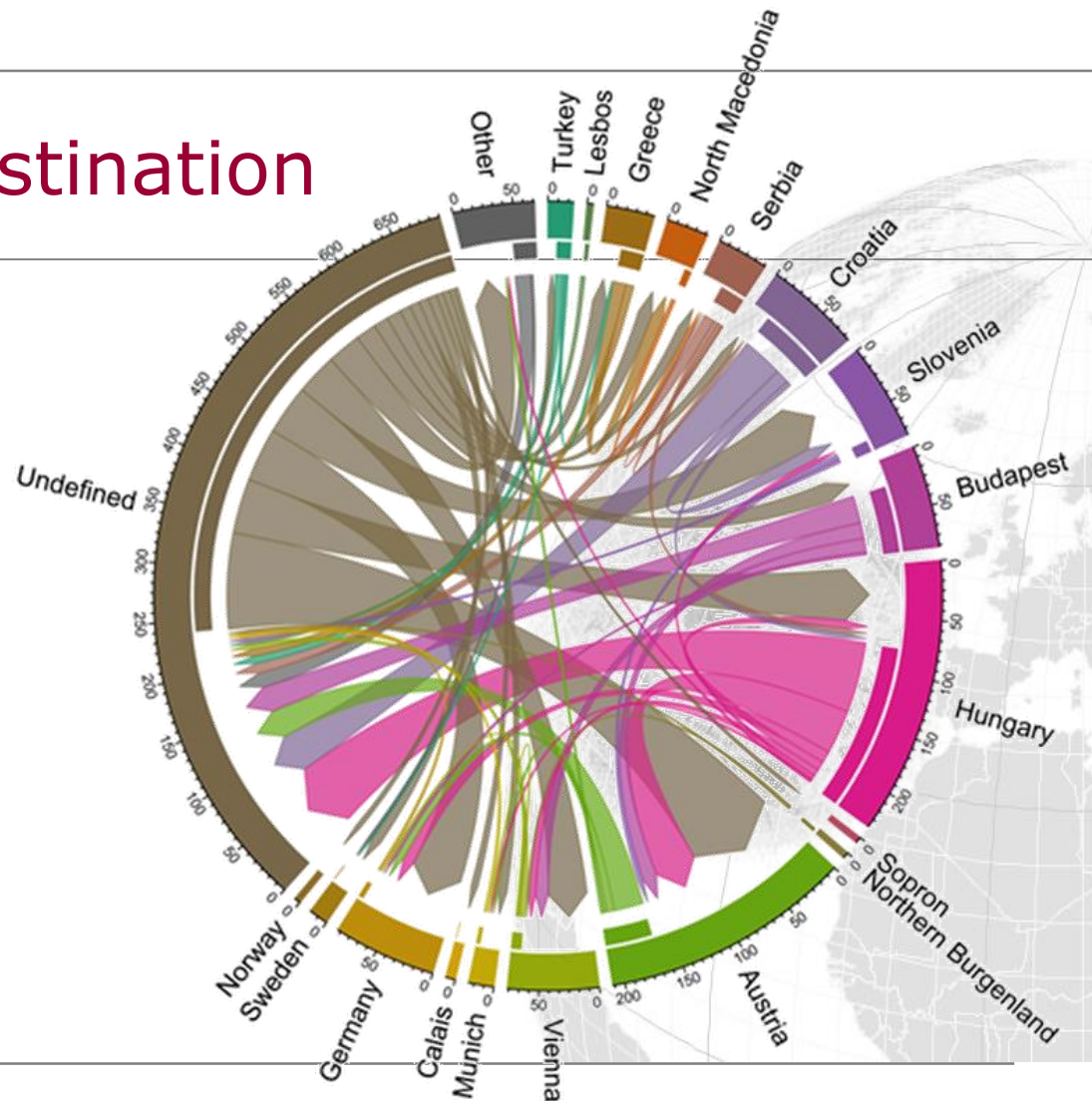
# Hot Spot Map 2015-07-01 , 2015-07-08



Havas, C., Wendlinger, L., Stier, J., Julka, S., Krieger, V., Ferner, C., Petutschnig, A., Granitzer, M., Wegenkittl, S. and Resch, B. (2021) Spatio-Temporal Machine Learning Analysis of Social Media Data and Refugee Movement Statistics. *ISPRS International Journal for Geo-Information*, 10(8), pp. 498, DOI: <https://doi.org/10.3390/ijgi10080498>.

# Tweets: Origin-Destination

- **# of tweets**
  - ◆ Hungary → Austria
  - ◆ Balkans → Austria
  - ◆ Austria → Germany
- ➔ Austria as central transit/target country
- ➔ Relatively large portion with origin OR destination



# The Practice ::: AIFER FEx

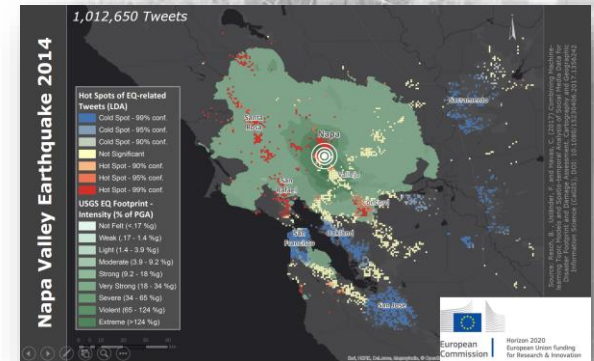
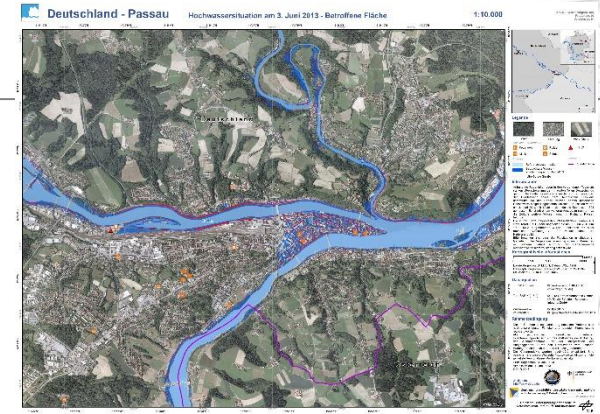
# AI in Disaster Management

- **900 action forces**, 4 disaster areas
  - **Realistic crisis management board: S1-S5** doubled
    - ◆ Region of Salzburg, Red Cross, Johanniter, THW, Fire Brigade
    - ◆ Tech support through project staff
  - **DIGITAL crisis management center in the iDEAS:lab Salzburg**
- **Goal: evaluating the usefulness and usability of the AIFER information layers**



# AI in Disaster Management

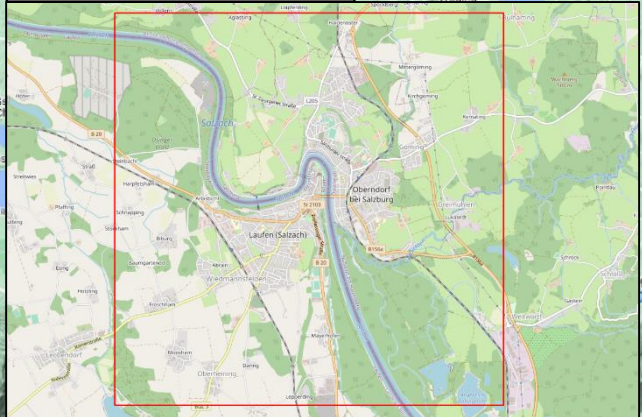
- Analysis of **heterogeneous big data**
- **Automation** of the analysis of EO and Web data
- Quantification of the **spatial extent and affected areas**



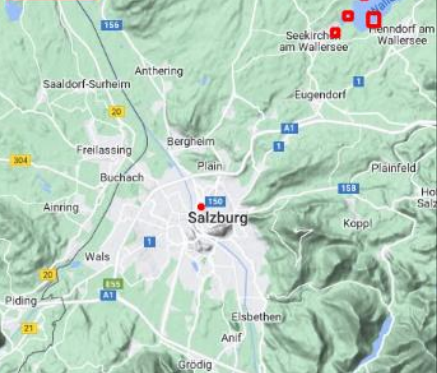


# AIFER FEX ::: Disaster Sites (EA)

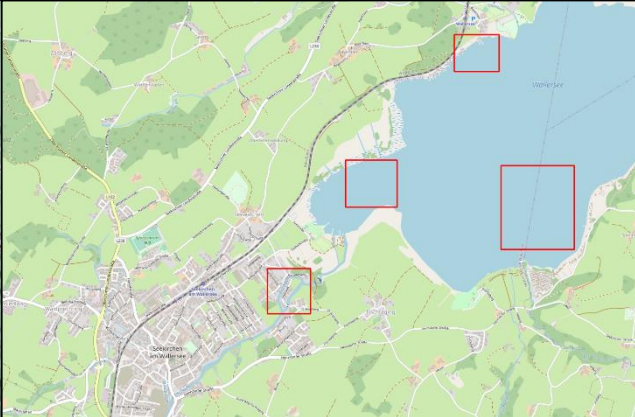
EA Oberndorf / Laufen



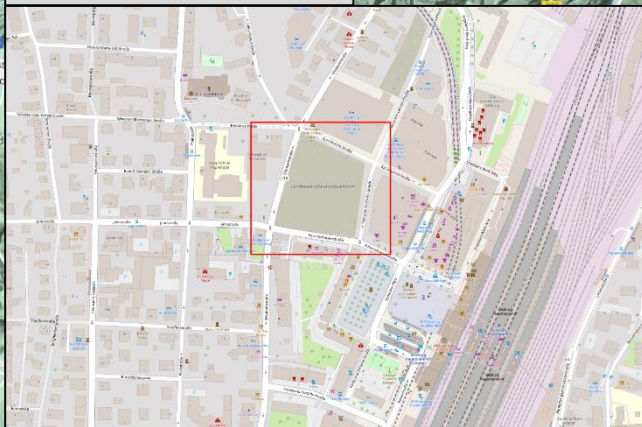
Oberndorf bei Salzburg



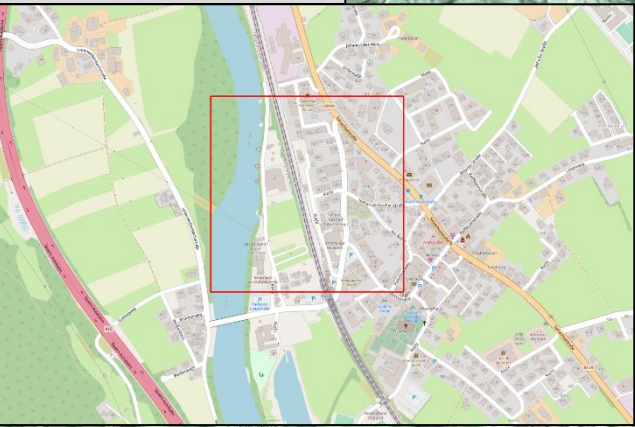
EA Seekirchen



EA Salzburg Stadt



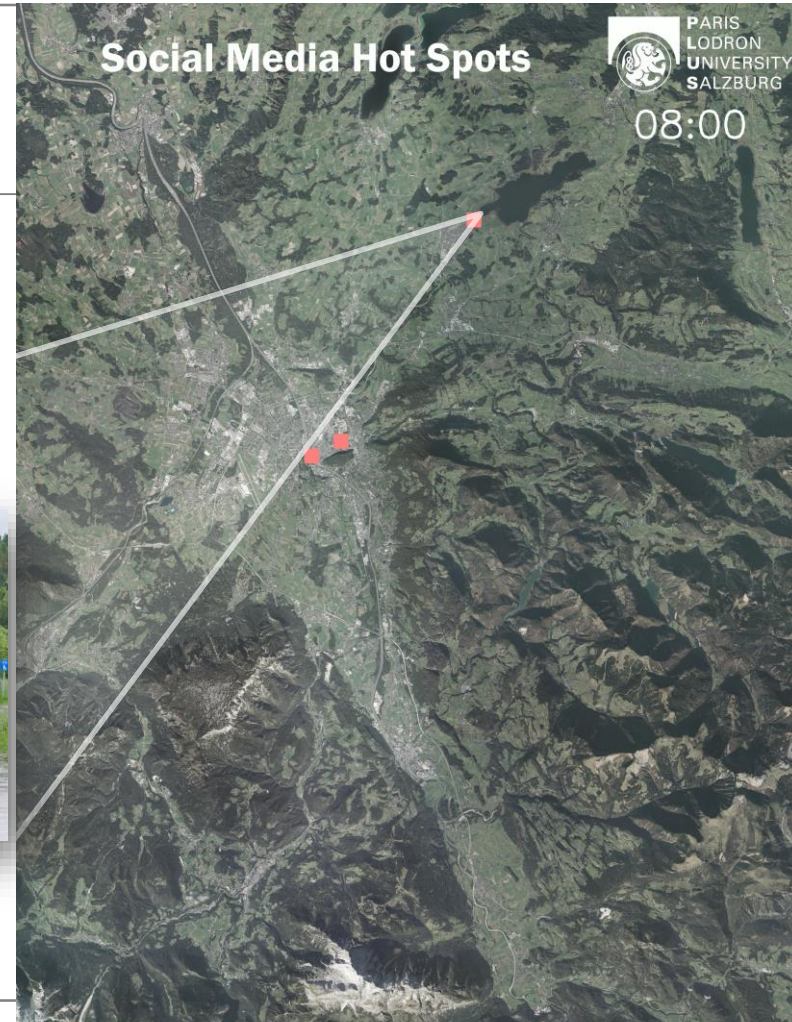
EA Kuchl



# Geo-social Media Hotspots

- Temporally changing spatial **disaster areas**  
→ **Hotspots**
- **Single posts** (Text, images, videos)

2023-04-29T10:14:00: Das Strandbad in #seekirchen braucht H  
🙏 #Hochwasser #hilfe



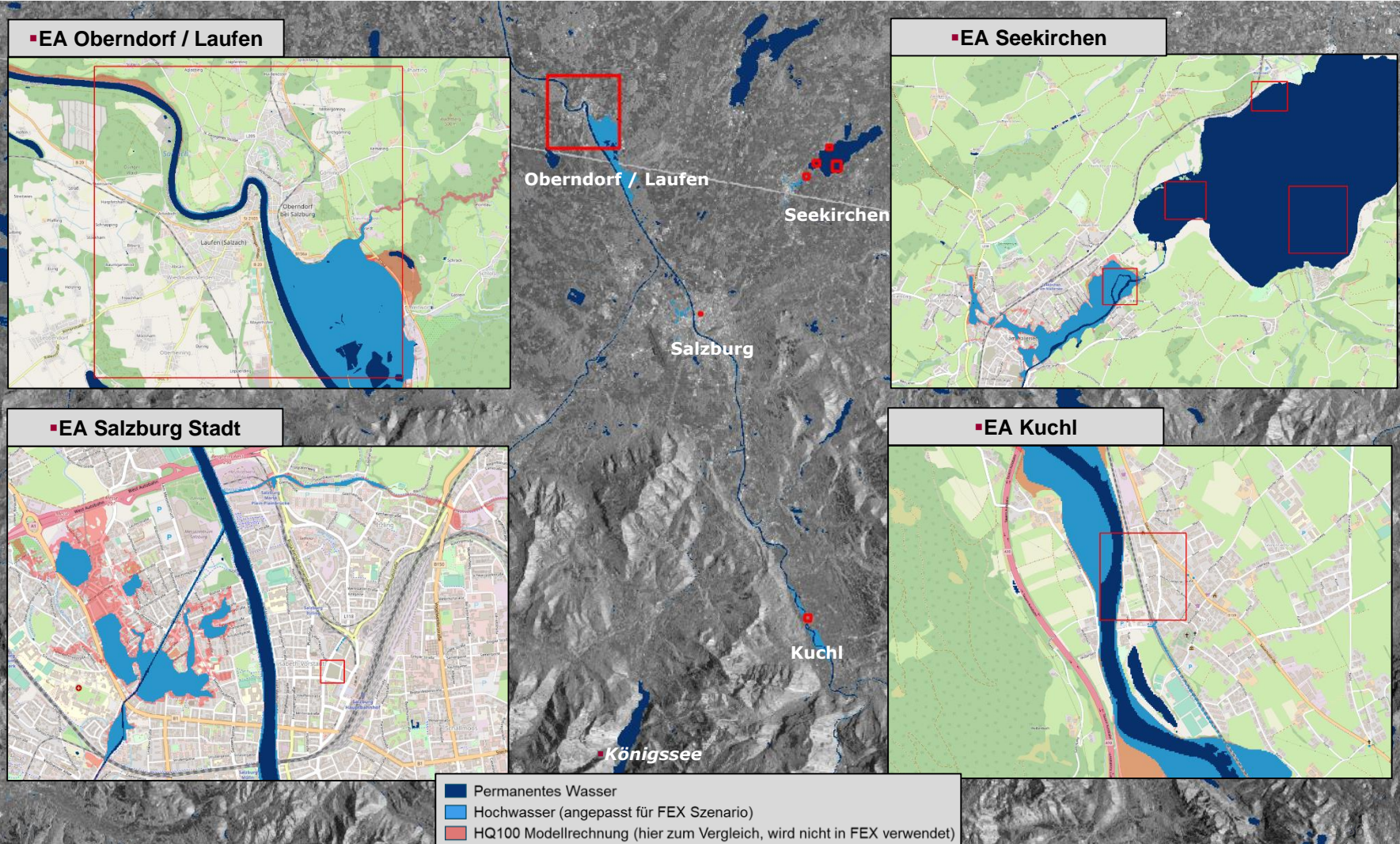
# AIFER FEx ::: Social Media Reporters

- **Live Reports**  
from the field
- **Direct  
integration**  
into the COP



**AIFER**  
Artificial Intelligence for Emergency Response

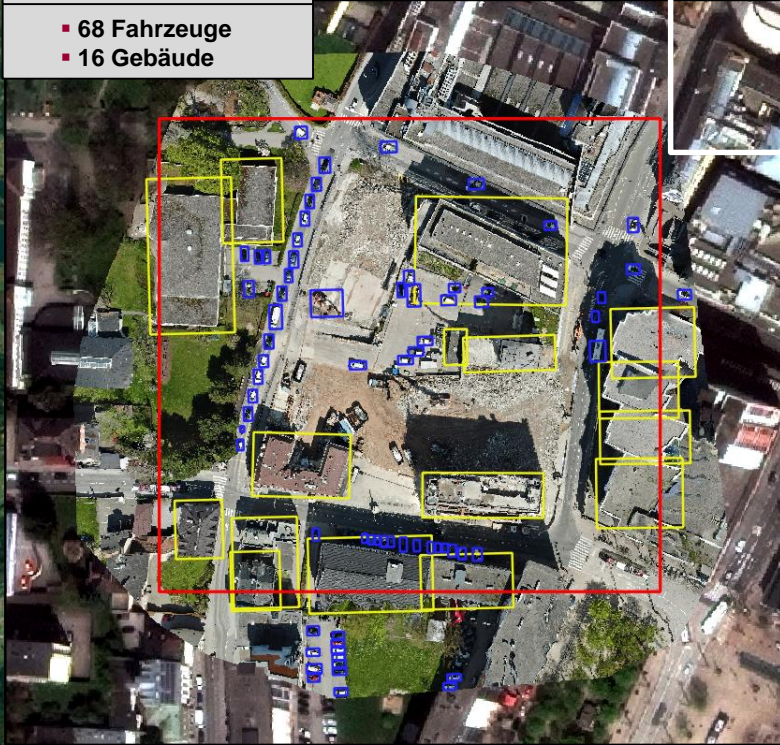
# AIFER FEX ::: Flood Monitoring Using Radar Satellites



# AIFER FEx ::: Optical Satellite and Drone Imagery

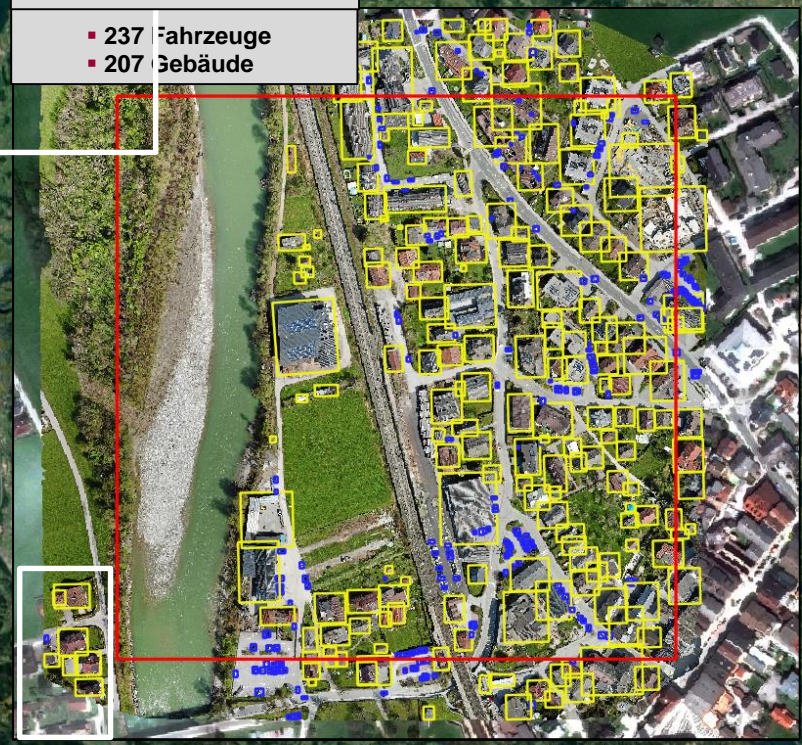
## EA Salzburg Stadt

- 68 Fahrzeuge
- 16 Gebäude



## EA Kuchl

- 237 Fahrzeuge
- 207 Gebäude



▪ Dronenbild vom 22.04.2023

□ Satellitenaufnahme

□ Gebäude

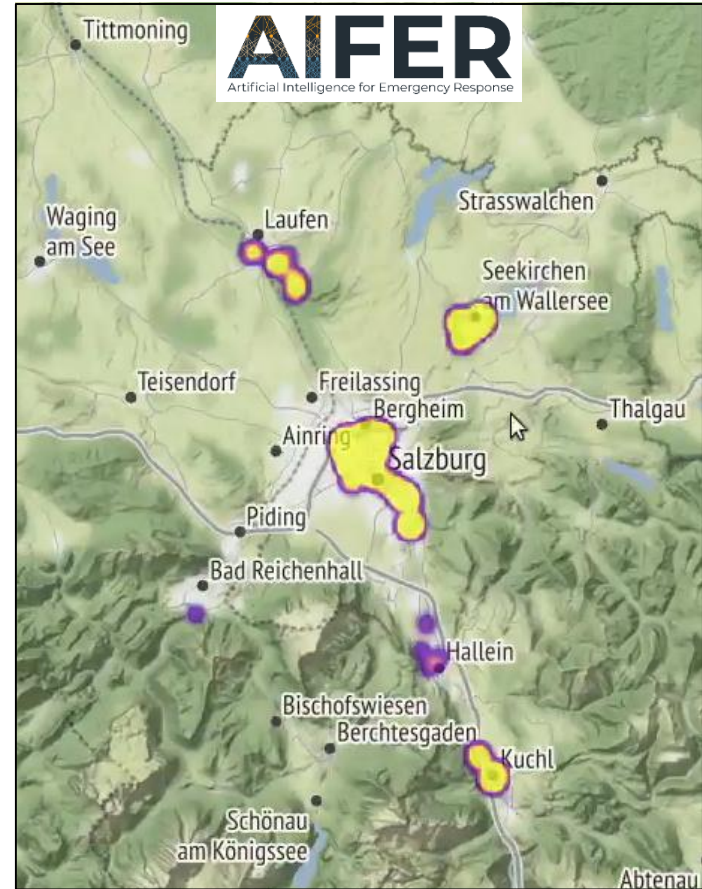
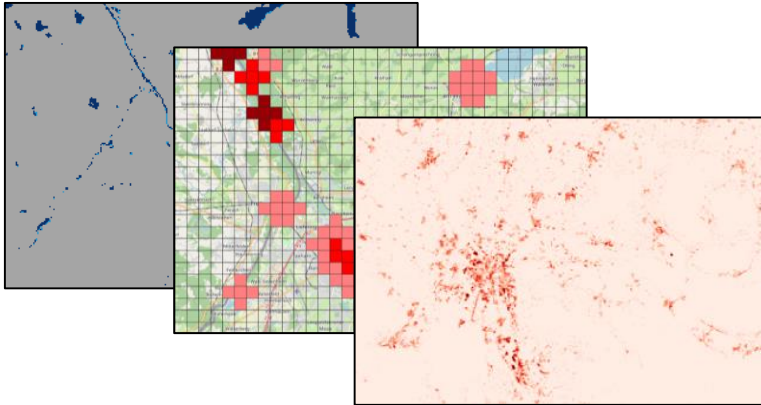
□ Dronenbefliegung

□ Fahrzeuge

# AIFER FEx ::: Information Fusion

- Verschneidung heterogener Informationsebenen:

- ◆ Hochwassermasken (Satellit)
- ◆ Twitter Hotspots



# AIFER FEx ::: Interactive, Digital 3D Model



wird geladen... Betrachterhöhe 745,27 Meter

Source: Airbus, USGS, NGA, NASA, CGIAR, NLS, OS, NMA, Geodatastyrelsen, GSA, GSI and the GIS User Community | © Land Salzburg | © DLR 2023 | © AIFER | Esri Community Maps Contributors, Esri, HERE, Garmin, Foursquare, GeoTechnologies, Inc, METI/NASA, USGS

Powered by Esri

# AI in Disaster Management ::: Field Exercise



<https://service.salzburg.gv.at/lkorj/detail?nachrid=68452>

13 December 2023



# Geo-social Media Analytics ::: In Action

- **Worldwide** availability, Modelling the **spatial spread** of crisis situations
- **Continuous** data stream, **real-time** situation reports
  - ♦ Initial installation: ~ 6 hours
  - ♦ Max. update frequency: ~ half-hourly
- **Intuitive** information visualisation
- **Transferability** between use cases and geographic regions
- **Simple integration** of information into DM processes
  - ♦ Generation of decision support information for staff **together with users**



# *The Future* From **Research** into **Practice**



- Challenge: efficient use of digital information  
**DIGITAL TRANSFORMATION OF DM PROCESSES**
- Goal: integration into DM processes through  
**CONTINUOUS TRAINING!**
  - Training and educational film:  
<https://www.youtube.com/watch?v=F5JXu7Du42A>

<https://nmsconsulting.com/wp-content/uploads/2020/06/digital-transformation.jpg>

Big Data Analytics Lecture

# **Multimodal Analysis of Geo-social Media Data for Improved Disaster Management**

**From Science to Digital Practice**