

# BEYOND THE SURFACE:

## Leveraging NLP to map global natural hazard impacts

Taís M. N. Carvalho

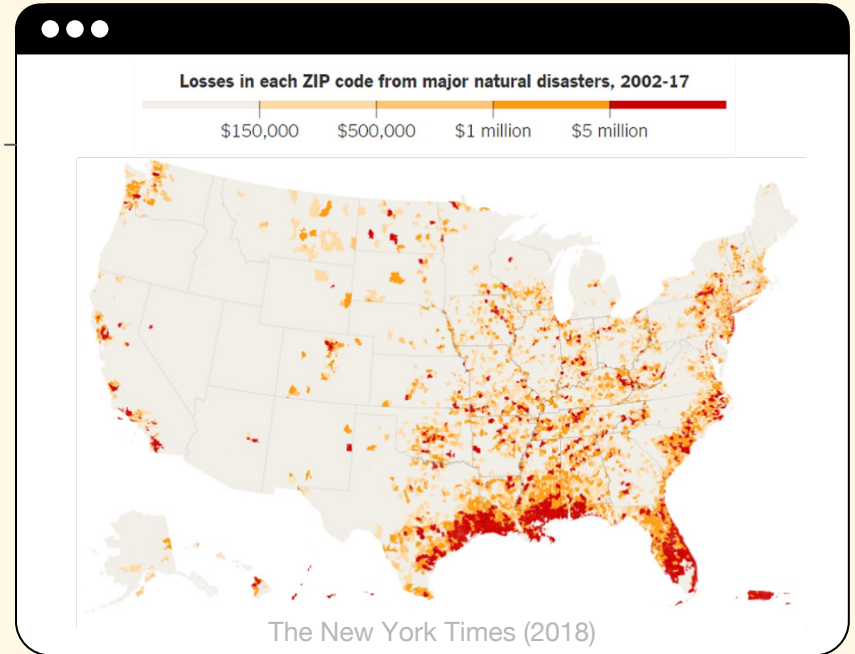
# Impact assessment is needed to:

Identify hot spot areas

Evaluate adaptation measures

Create impact-based forecasting

Validate risk models



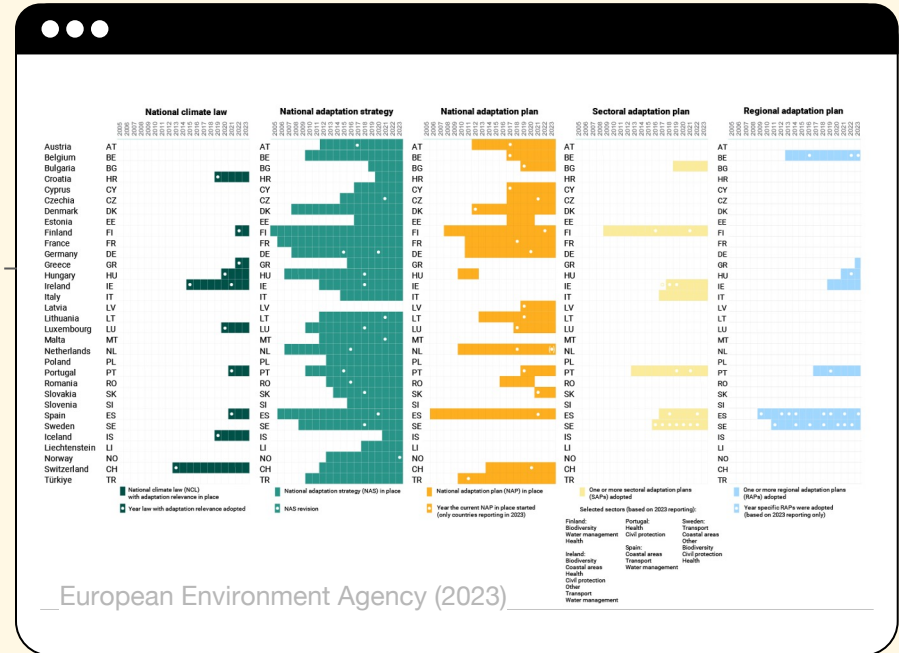
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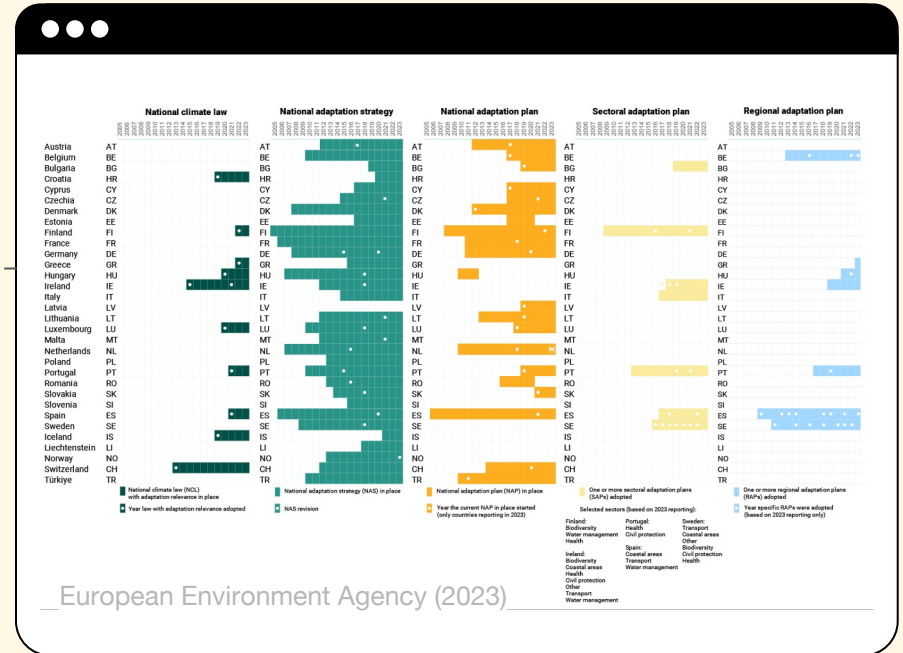
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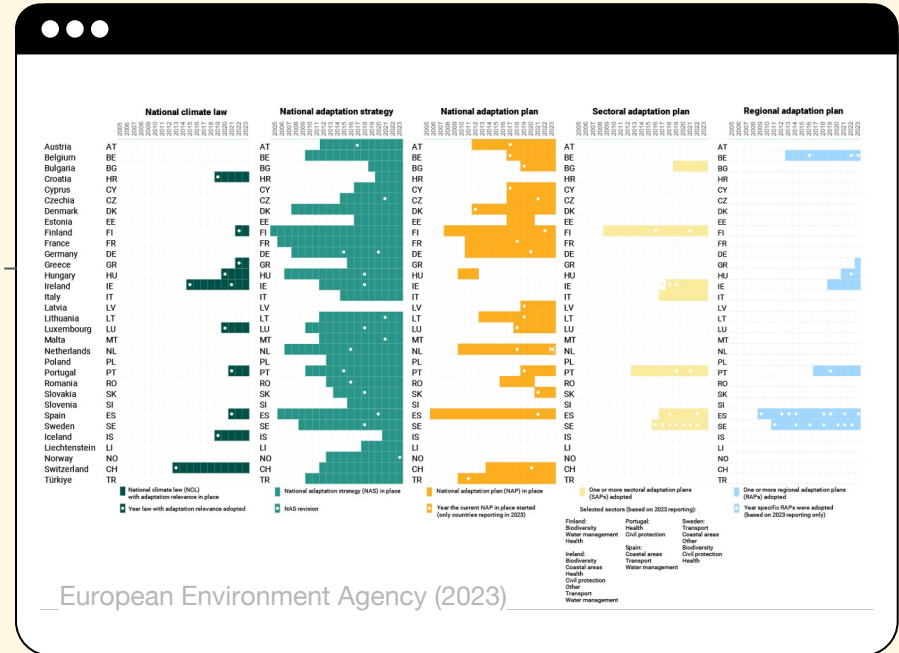
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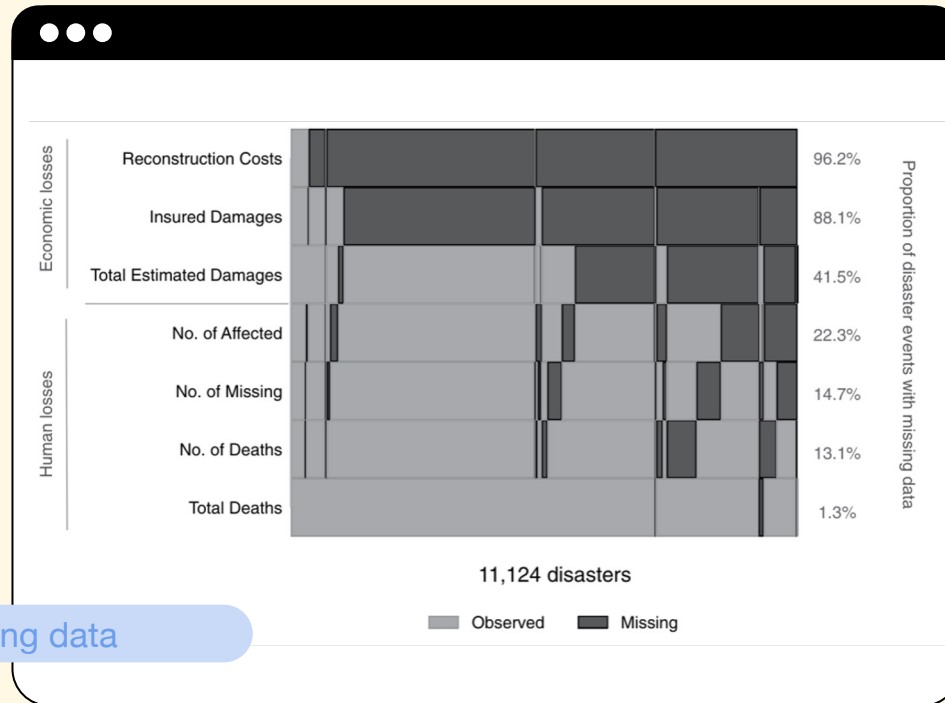
Validate risk models



# GAPS of global databases

- 1 Missing data
- 2 Spatial descriptions vary widely
- 3 Underreporting
- 4 Events are not often updated
- 5 Focus on quantitative impact metrics

# GAPS of global databases



Missing data

Jones, R. L., Guha-Sapir, D., & Tubeuf, S. (2022). Human and economic impacts of natural disasters: can we trust the global data?. *Scientific data*, 9(1), 572.

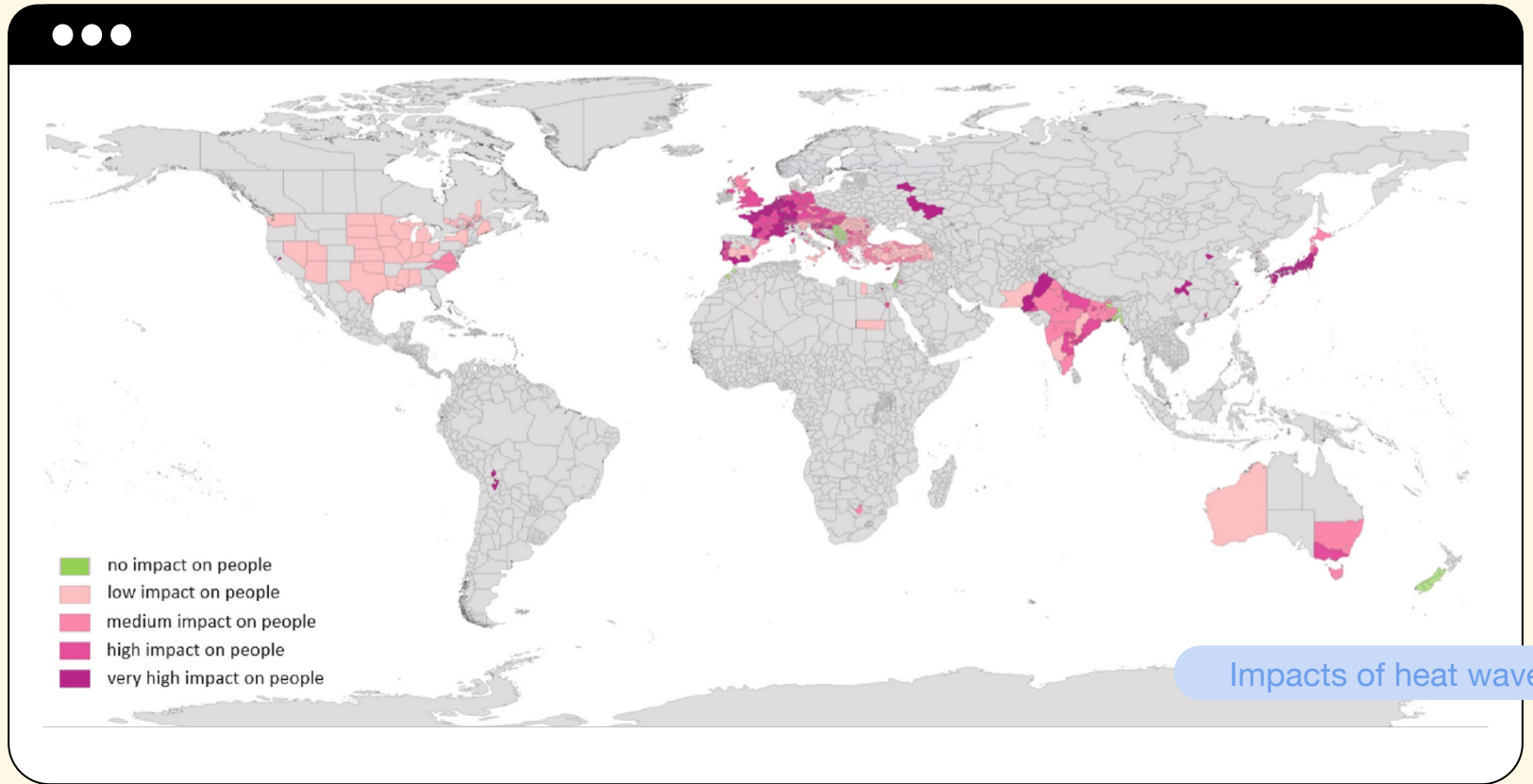
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Donatti, C. I., et al. (2024). Global hotspots of climate-related disasters. *International Journal of Disaster Risk Reduction*, 108, 104488.

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# Impacts go beyond human and economic losses

Impacts of Natural Hazards on **Primary Health Care Facilities** of Iran: A 10-Year Retrospective Survey

[Ali Ardalan](#)<sup>a</sup>, [Hani Mowafi](#), and [Homa Yousefi, Khoshsabeghe](#)<sup>a</sup>

ORIGINAL ARTICLE



**Post-disaster health impact of natural hazards in the Philippines in 2013**

Miguel Antonio Salazar<sup>1</sup>, Arturo Pesigan<sup>2</sup>, Ronald Law<sup>3</sup> and Volker Winkler<sup>1\*</sup>

Impact of natural hazards on morbidity and **physical incapacity** of vulnerable groups in Mexico

[Alejandro Lome-Hurtado](#)<sup>a</sup>  , [Piran C.L. White](#)<sup>b</sup>, [Julia M. Touza](#)<sup>b</sup>



Climate-related hazards and **Indian food supply**: Assessing the risk using recent historical data

[Francesca Harris](#)<sup>a b</sup>  , [Giriraj Amarnath](#)<sup>c</sup>, [Edward JM Joy](#)<sup>a b</sup>, [Alan D Dangour](#)<sup>a b</sup>, [Rosemary F Green](#)<sup>a b</sup>

**Vulnerability and resilience of power systems infrastructure to natural hazards and climate change**

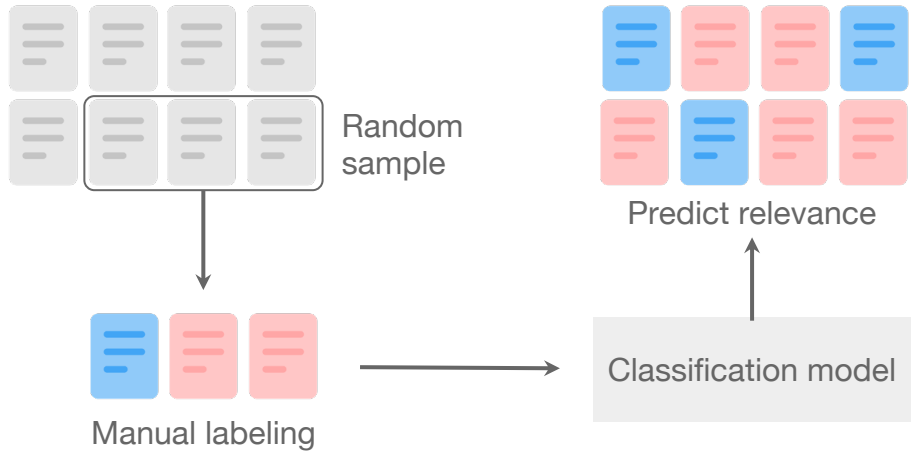
[Amy E. Schweikert](#), [Mark R. Deinert](#) 

**When hazards become disasters: coastal fishing communities in Bangladesh**

[Mohammad Mahmudul Islam](#)<sup>a</sup>  <sup>a</sup>, [Papia Begum](#)<sup>a</sup>, [Amany Begum](#)<sup>a</sup> and [Johannes Herbeck](#)<sup>b</sup> 

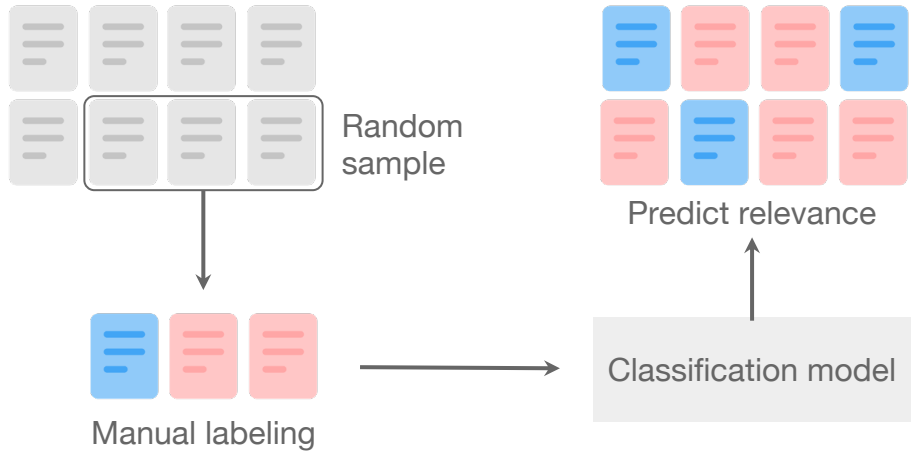
# Information extraction from **SCIENTIFIC PAPERS**

## 1 Detect relevant papers

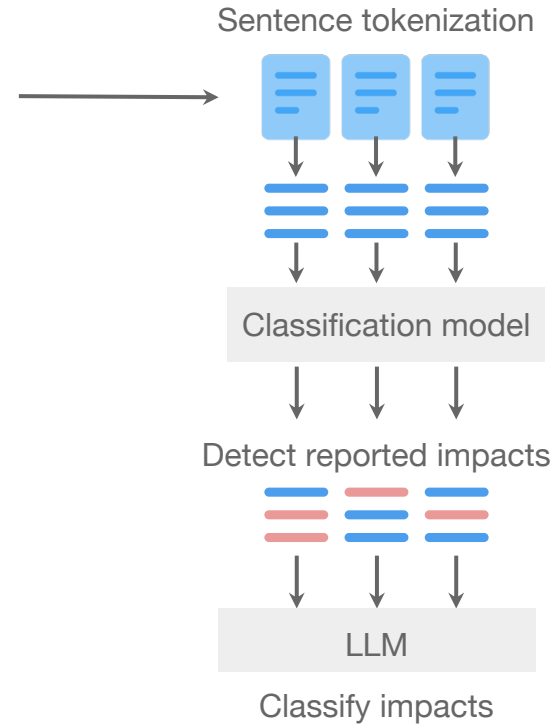


# Information extraction from **SCIENTIFIC PAPERS**

## 1 Detect relevant papers



## 2 Extraction and classification of impacts



# Selecting **RELEVANT PAPERS**

Identify potential relevant papers



**Query search**

PubMed

Science Direct

general

drought

flood

storm

heatwave

coldwave

mass movement

wildfire

**AND**

social

water availability

food production

health and wellbeing

cities & infrastructure

economic sectors



# Selecting **RELEVANT PAPERS**

storm

storm! OR superstorm!  
OR wind?storm! OR  
snow?storm! OR  
blizzard! OR derecho  
OR winter?storm! OR  
hail OR  
extra?tropical?storm  
OR thunderstorm! OR  
tornado! OR  
tropical?cyclone OR  
storm surge! OR  
hurricane! OR typhoon

**AND**

health and wellbeing

health! OR well?being OR ill OR illness OR disease! OR syndrome! OR  
infect! OR medical! OR disabilit! OR death! OR fatalit! OR died OR  
casualties OR “loss of life” OR injur! OR infectious disease! OR cholera OR  
giardiasis OR cryptosporidiosis OR leptospirosis OR "(obes! OR  
over?weight OR under?weight OR hunger OR stunting OR wasting OR  
undernourish! OR undernutrition OR anthropometr! OR malnutrition OR  
malnour! OR anemia OR anaemia OR ""micro?nutrient!"" OR diabet!) OR  
mental OR depress! OR !stress! OR anx! OR ptsd OR psycho! OR  
psychiatric! OR !trauma! OR post-traumatic OR suicide! OR solastalgi! OR  
“air quality” OR “air pollution” OR PM2.5 OR “fine particulate” OR asthma  
OR displacem! OR relocation! OR migration OR refugee! OR homeless! OR  
emergency shelter

# Selecting **RELEVANT PAPERS**

Identify potential relevant papers



## Query search

PubMed **13 968 results**

Science Direct **47 684 results**

general

drought

flood

storm

heatwave

coldwave

mass movement

wildfire

**AND**

social

water availability

food production

health and wellbeing

cities & infrastructure

economic sectors

# Selecting **RELEVANT PAPERS**

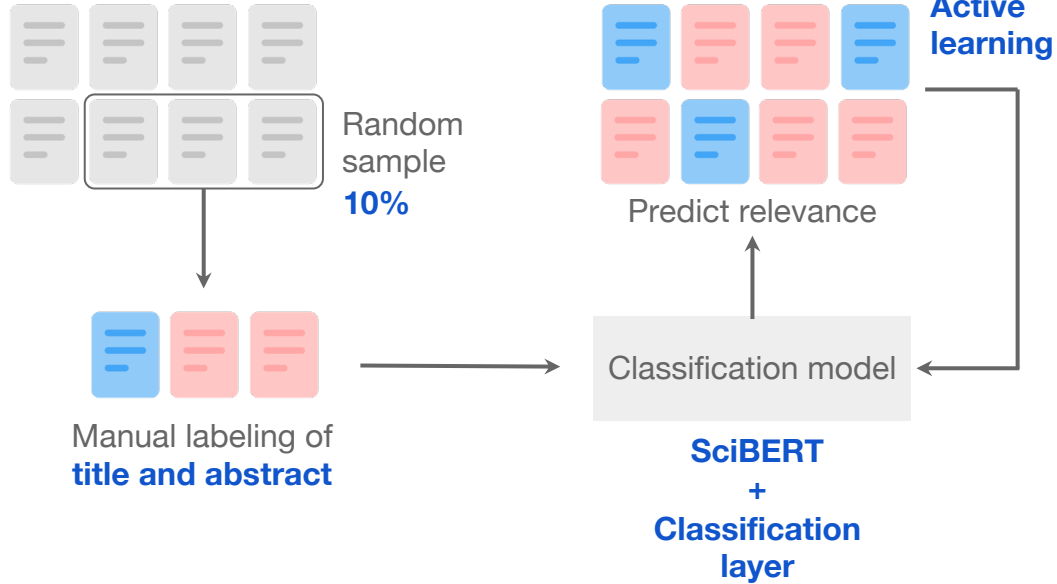
Detect relevant papers



Manual labeling of  
**title and abstract**

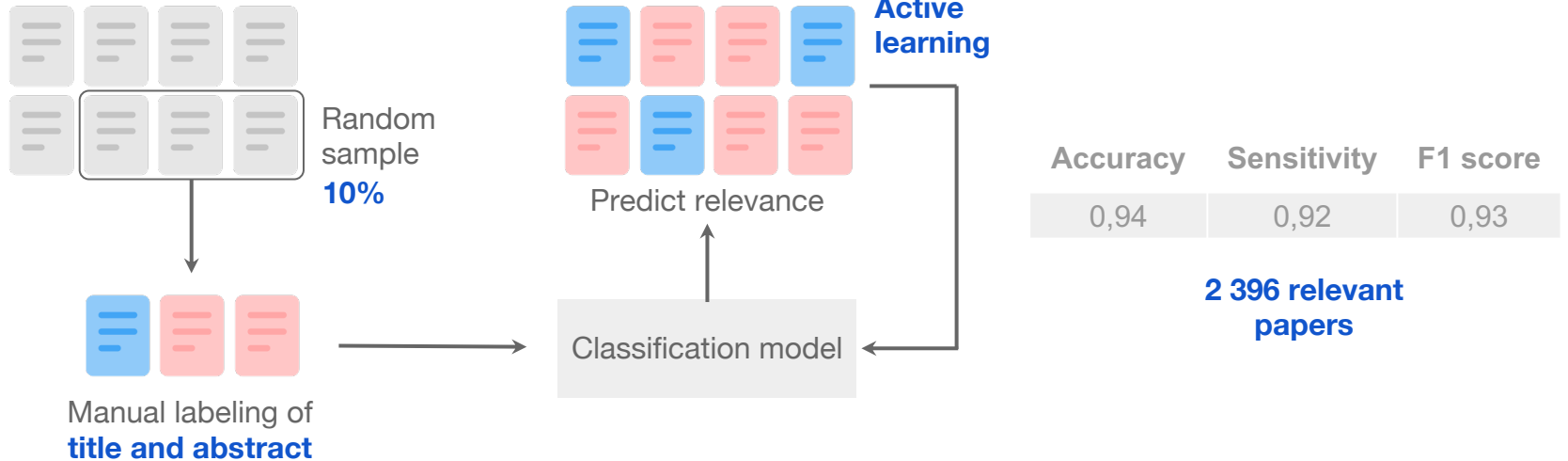
# Selecting **RELEVANT PAPERS**

Detect relevant papers



# Selecting **RELEVANT PAPERS**

Detect relevant papers





**Weather and Climate Extremes**

journal homepage: [www.elsevier.com/locate/wace](http://www.elsevier.com/locate/wace)



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**Agricultural and food security impacts from the 2010 Russia flash drought**



Eric Hunt<sup>a,\*</sup>, Francesco Femia<sup>b</sup>, Caitlin Werrell<sup>b</sup>, Jordan I. Christian<sup>c</sup>, Jason A. Otkin<sup>d</sup>, Jeff Basara<sup>e,f</sup>, Martha Anderson<sup>g</sup>, Tyler White<sup>h</sup>, Christopher Hain<sup>b</sup>, Robb Randall<sup>1</sup>, Katie McGaughey<sup>j</sup>

<sup>a</sup> Atmospheric and Environmental Research, Inc., Lexington, MA, USA  
<sup>b</sup> The Center for Climate and Security, An Institute of the Council on Strategic Risks, Washington, D.C, USA  
<sup>c</sup> School of Meteorology, University of Oklahoma, Norman, OK, USA  
<sup>d</sup> Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison, Madison, WI, USA  
<sup>e</sup> School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK, USA  
<sup>f</sup> Agricultural Research Services, Hydrology and Remote Sensing Laboratory, U.S. Department of Agriculture, Beltsville, MD, USA  
<sup>g</sup> Department of Political Science, University of Nebraska-Lincoln, Lincoln, NE, USA  
<sup>h</sup> Marshall Space Flight Center, Earth Science Branch, National Aeronautics and Space Administration, Huntsville, AL, USA  
<sup>i</sup> CCDC Army Research Laboratory, Atmospheric Science Center, White Sands Missile Range, NM, USA  
<sup>j</sup> Foreign Agricultural Service, United States Department of Agriculture, Washington, D.C. USA

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<p><b>ARTICLE INFO</b></p> <p><b>Keywords:</b>          Food security          Flash drought          Wheat          Heat wave          Russia</p>	<p><b>ABSTRACT</b></p> <p>The flash drought and its associated heat wave that affected western Russia in the summer of 2010 had significant cascading agricultural and socioeconomic impacts. Drought indicators sensitive to soil moisture and evapotranspiration (ET) showed that the flash drought began in June 2010, then intensified rapidly and expanded to cover much of western Russia. By early July, almost all of the major wheat producing regions of Russia were experiencing extreme water stress to the winter and spring wheat crops. The timing of the onset of the flash drought was particularly devastating as the period of most rapid intensification overlapped with the flowering stage for both the winter and spring wheat crops. As a result, wheat yields in Russia were reduced by over 70 percent in top wheat producing oblasts and total wheat production was reduced by 20 million metric tons (MT) compared to the previous seasons. In fulfillment of its recently adopted Food Security Doctrine, the Russian government banned the export of wheat in early August 2010 to preserve wheat for its own consumption. Further compounding matters on a global scale, the significant reduction in wheat production in Russia coincided with wheat production issues in places like western Australia, which led to a large drop in global wheat stocks. The sharp drop in global wheat stocks coincided with a rapid increase in wheat prices across the globe. The rapid increase in wheat prices, partly resulting from the rapid intensification of drought in Russia, led to increased prices for wheat flour and bread in many countries throughout the world. This ultimately led to an increase in poverty and civil unrest in countries like Mozambique and Egypt with a history of inequality and poverty.</p>
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The 2010 heat wave across western Russia was an extreme climate event that led to profound environmental, economic, and societal impacts. For historical context, the summer of 2010 was likely the warmest for western Russia in the last half millennium (Barriopedro et al., 2011) and the drought was the worst in the last century (Wielton 2011). While evidence is not fully conclusive as to how great a role climate change played in driving conditions in the summer of 2010 in Russia, Rahmstorf

and Coumou (2012) found there was an 80% chance that the event was directly linked to climate change by using Monte Carlo simulations. Daily record high surface temperature values exceeding 32°C were reached for Moscow and the surrounding region by mid-to late-July and persisted until the second week of August (Barriopedro et al., 2011; Grumm and R.H., 2011).

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\* Corresponding author. 2021 Transformation Dr., Suite 1250, Lincoln, NE, 68508, USA.  
 E-mail address: [ehunt@ser.com](mailto:ehunt@ser.com) (E. Hunt).

Journal

Title

Abstract

Text

reference

journal  
 paperTitle  
 doi  
 pmid  
 publicationYear  
 source

Agricultural and food security impacts from the 2010 Russia flash drought

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Prompt

LLM

# Prompt engineering

Title + Abstract

```
prompt = f"""  
{title + abstract}
```

```
---
```

Using only information from the text above, answer the query.

Query: For every hazard event investigated in the study, detect the hazard type (answer must be one of ['Drought', 'Flood', 'Storm', 'Heatwave', 'Coldwave', 'Mass movement', 'Wildfire']), the location where it happened (country, region, state, city) and date in which the hazard happened (start Year, Month, and Day, and end Year, Month, and Day), only if mentioned in the text. If end Year, Month, and Day are not mentioned, repeat the values for start Year, start Month, and start Day. Provide the answer in JSON format.

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Here is an example of how the structure of the JSON must be:

```
"hazardDescription": [{"hazard": "Storm", "startYear": 2013, "startMonth": 12, "startDay": 21, "endYear": 2014,  
"endMonth": 1, "endDay": 1, "country": "Canada", "state": "", "state": "Ontario", "city": "Toronto"}]
```

```
""""
```

LLM

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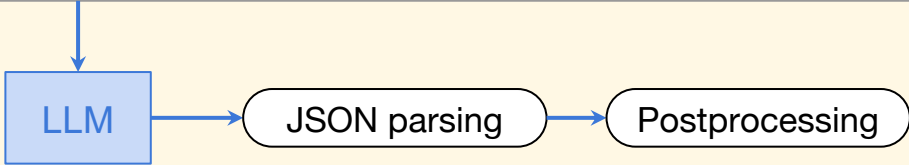
Title + Abstract

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## Agricultural and food security impacts from the 2010 Russia flash drought

Eric Hunt<sup>a,\*</sup>, Francesco Femia<sup>b</sup>, Caitlin Werrell<sup>b</sup>, Jordan I. Christian<sup>c</sup>, Jason A. Otkin<sup>d</sup>, Jeff Basara<sup>e,f</sup>, Martha Anderson<sup>g</sup>, Tyler White<sup>h</sup>, Christopher Hain<sup>b</sup>, Robb Randall<sup>i</sup>, Katie McGaughey<sup>j</sup>

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**Keywords:**  
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Flash drought  
Wheat  
Heat wave  
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Hazard type

Drought  
Heatwave

Location

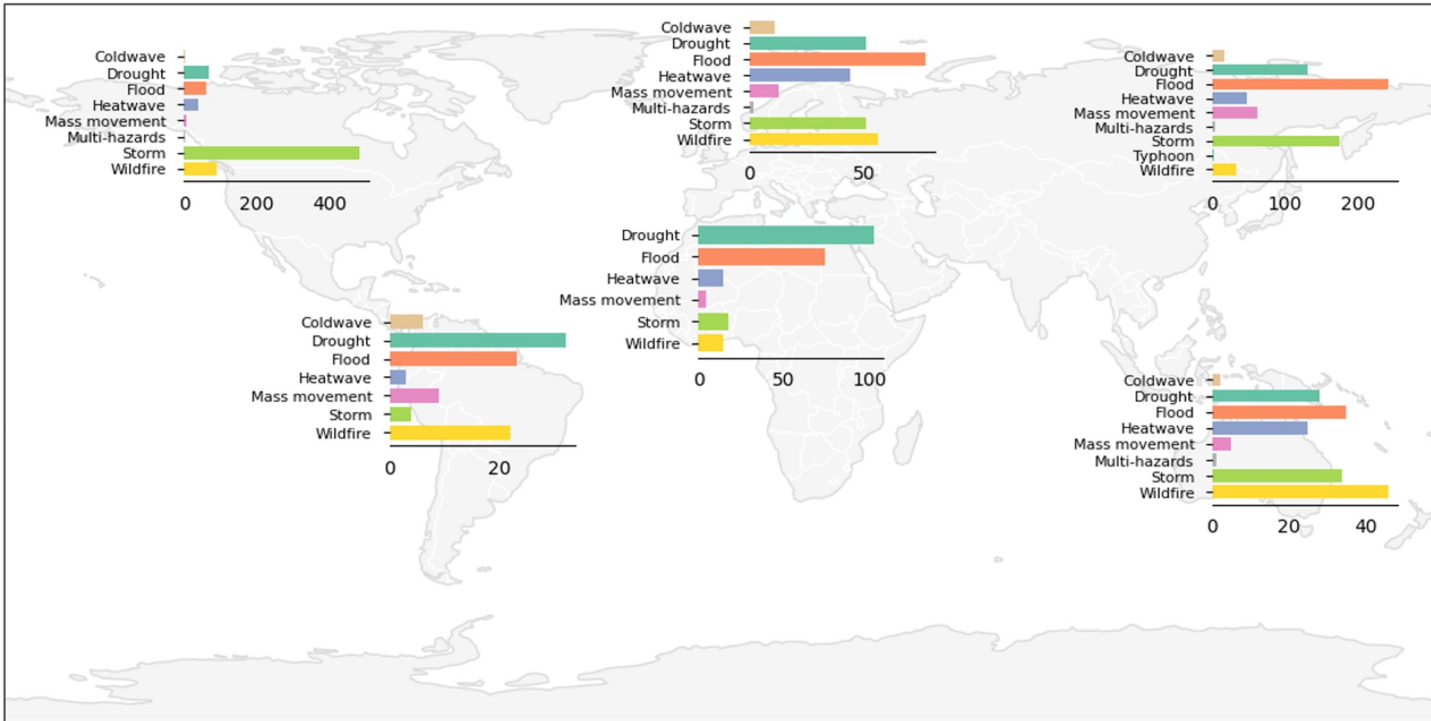
Country:  
Russia  
Region:  
western Russia

Date

Start date: 06/2010  
End date:  
MM/2010

\* Corresponding author. 2021 Transformation Dr., Suite 1250, Lincoln, NE, 68508, USA.  
E-mail address: [ehunt@ser.com](mailto:ehunt@ser.com) (E. Hunt).

# Hazard distribution





## Agricultural and food security impacts from the 2010 Russia flash drought

Eric Hunt<sup>a,\*</sup>, Francesco Femia<sup>b</sup>, Caitlin Werrell<sup>b</sup>, Jordan I. Christian<sup>c</sup>, Jason A. Otkin<sup>d</sup>, Jeff Basara<sup>e,f</sup>, Martha Anderson<sup>g</sup>, Tyler White<sup>h</sup>, Christopher Hain<sup>b,i</sup>, Robb Randall<sup>l</sup>, Katie McGaughey<sup>j</sup>

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Russia

### ABSTRACT

The flash drought and its associated heat wave that affected western Russia in the summer of 2010 had significant cascading agricultural and socioeconomic impacts. Drought indicators sensitive to soil moisture and evapotranspiration (ET) showed that the flash drought began in June 2010, then intensified rapidly and expanded to cover much of western Russia. By early July, almost all of the major wheat producing regions of Russia were experiencing extreme water stress to the winter and spring wheat crops. The timing of the onset of the flash drought was particularly devastating as the period of most rapid intensification overlapped with the flowering stage for both the winter and spring wheat crops. As a result, wheat yields in Russia were reduced by over 70 percent in top wheat producing oblasts and total wheat production was reduced by 20 million metric tons (MT) compared to the previous seasons. In fulfillment of its recently adopted Food Security Doctrine, the Russian government banned the export of wheat in early August 2010 to preserve wheat for its own consumption. Further compounding matters on a global scale, the significant reduction in wheat production in Russia coincided with wheat production issues in places like western Australia, which led to a large drop in global wheat stocks. The sharp drop in global wheat stocks coincided with a rapid increase in wheat prices across the globe. The rapid increase in wheat prices, partly resulting from the rapid intensification of drought in Russia, led to increased prices for wheat flour and bread in many countries throughout the world. This ultimately led to an increase in poverty and civil unrest in countries like Mozambique and Egypt with a history of inequality and poverty.

### 1. Introduction

The 2010 heat wave across western Russia was an extreme climate event that led to profound environmental, economic, and societal impacts. For historical context, the summer of 2010 was likely the warmest for western Russia in the last half millennium (Barriopedro et al., 2011) and the drought was the worst in the last century (Welton 2011). While evidence is not fully conclusive as to how great a role climate change played in driving conditions in the summer of 2010 in Russia, Rahmstorf

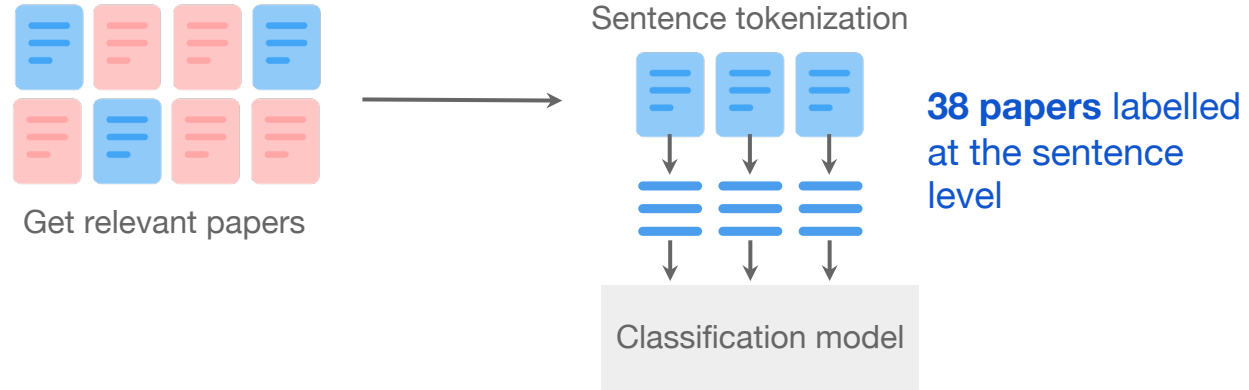
and Coumou (2012) found there was an 80% chance that the event was directly linked to climate change by using Monte Carlo simulations. Daily record high surface temperature values exceeding 32°C were reached for Moscow and the surrounding region by mid-to late-July and persisted until the second week of August (Barriopedro et al., 2011; Grumm and R H, 2011).

A flash drought is a drought that develops and intensifies more rapidly than usual (Otkin et al., 2018) and is typically associated with a lack of precipitation combined with above average temperatures,

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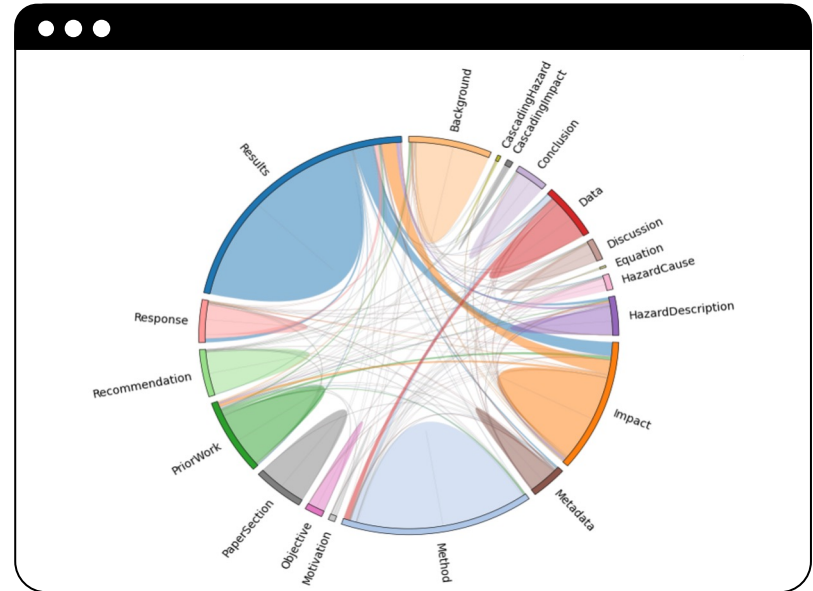
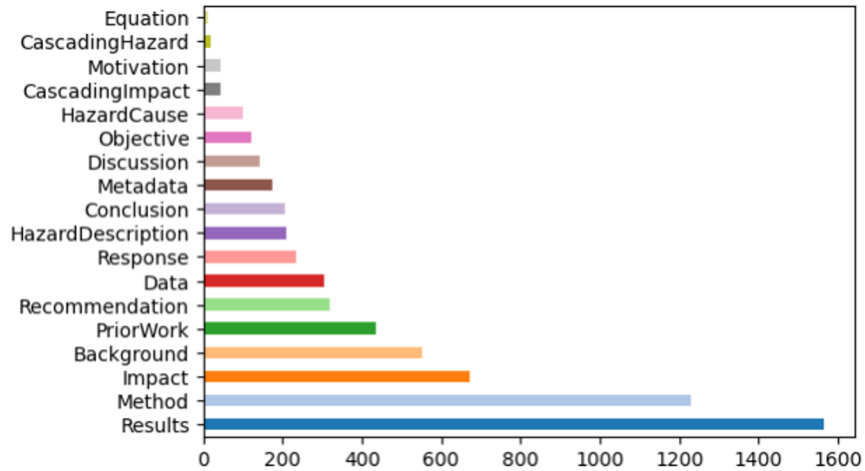
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E-mail address: [ehunt@ser.com](mailto:ehunt@ser.com) (E. Hunt).

# Detecting **impacts**



# Sentence annotation

6,585 labelled sentences





## Agricultural and food security impacts from the 2010 Russia flash drought

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<sup>h</sup> Marshall Space Flight Center, Earth Sciences Branch, National Aeronautics and Space Administration, Huntsville, AL, USA

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### ARTICLE INFO

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Wheat  
Heat wave  
Russia

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Hazard Description

Prior Work

Hazard Cause

Background

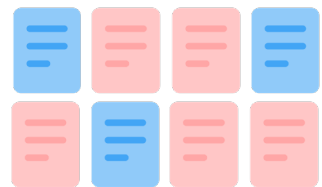
Impact

Background

\* Corresponding author. 2021 Transformation Dr., Suite 1250, Lincoln, NE, 68508, USA. E-mail address: [ehunt@ser.com](mailto:ehunt@ser.com) (E. Hunt).



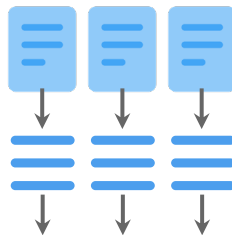
# Detecting **impacts**



Get relevant papers



Sentence tokenization



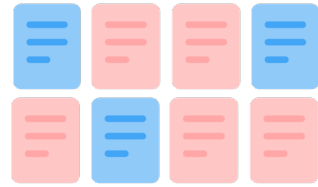
**38 papers** labelled  
at the sentence  
level

Classification model

**+44 000** sentences  
reporting **impacts**

Accuracy	Sensitivity	F1 score
0,92	0,93	0,91

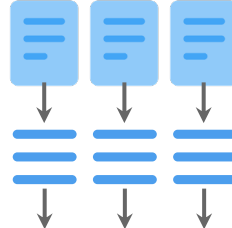
# Detecting impacts



Get relevant papers

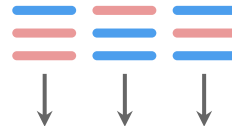


Sentence tokenization



Classification model

Detect reported impacts



LLM

Classify impacts and extract specific information

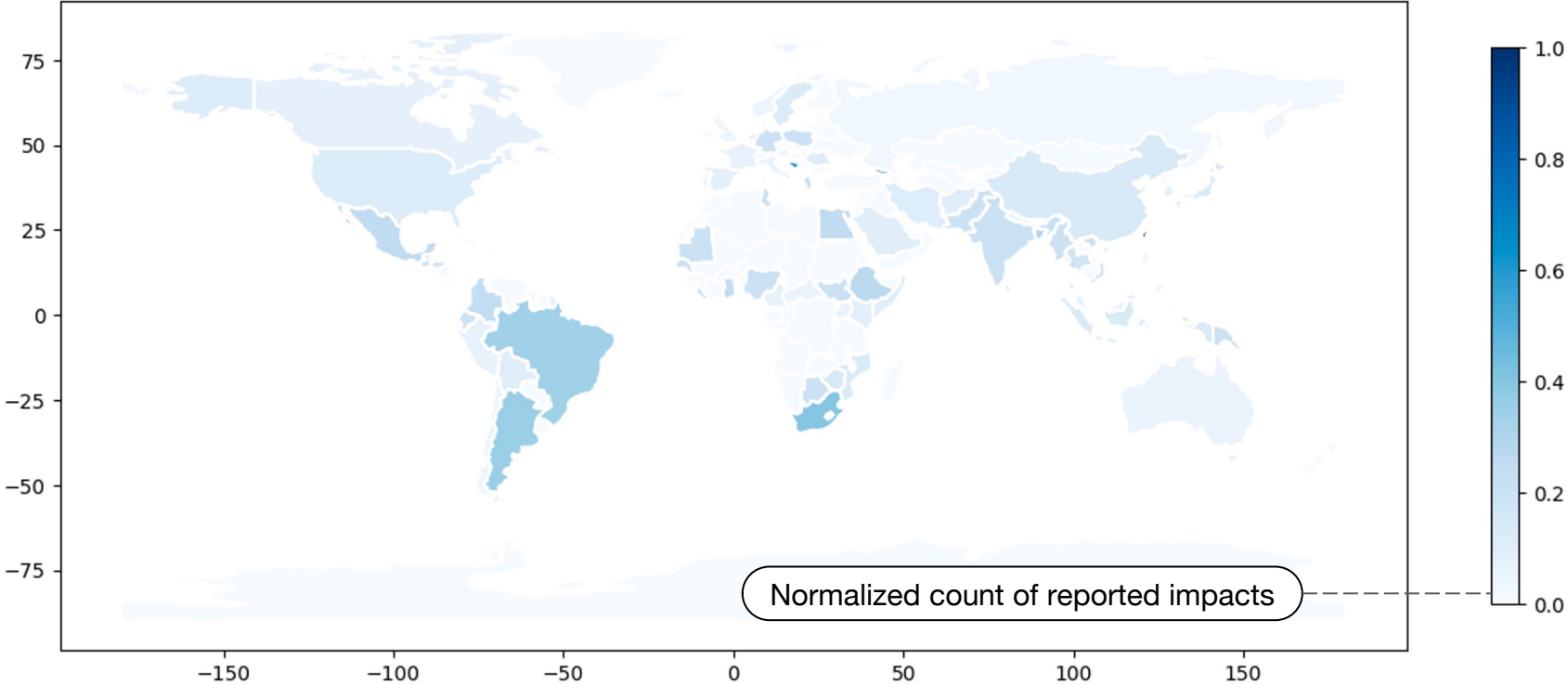
# Detecting impacts



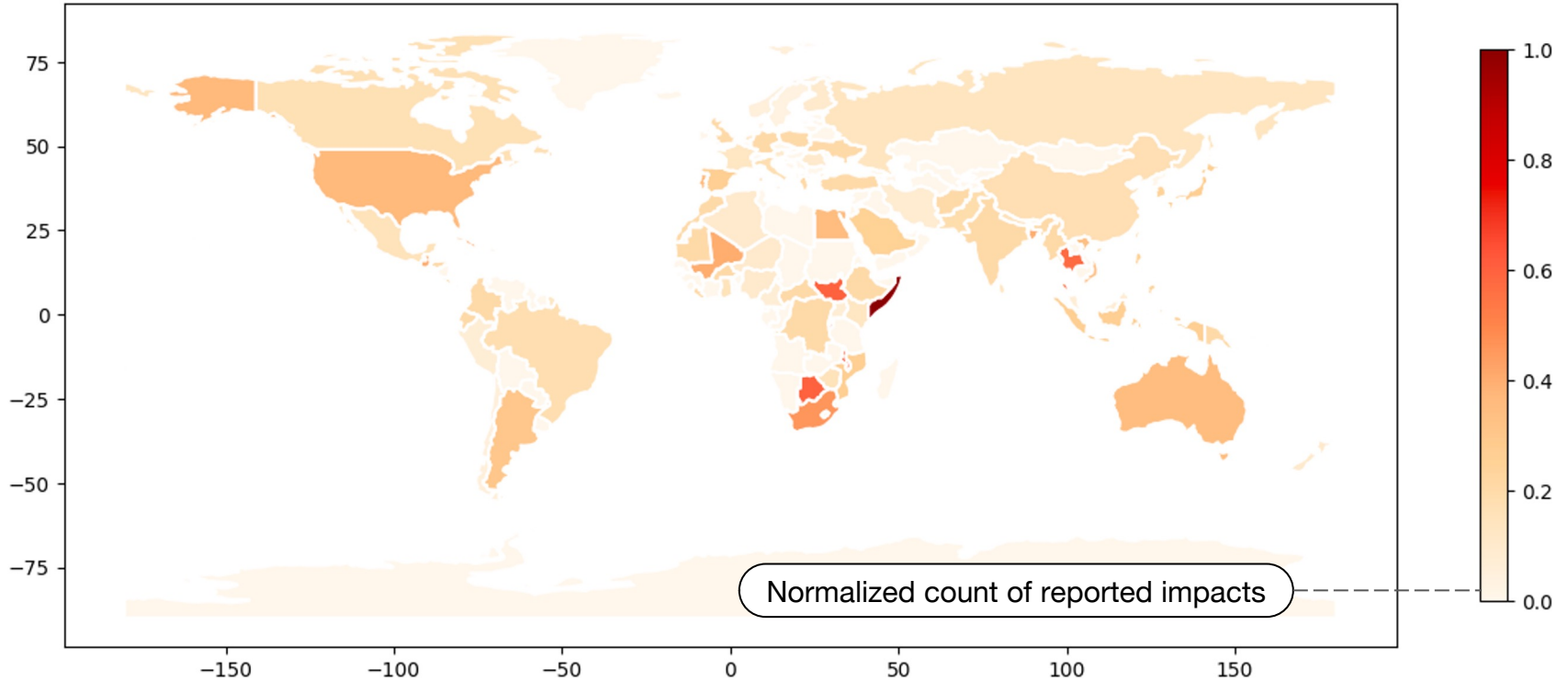
# Detecting impacts



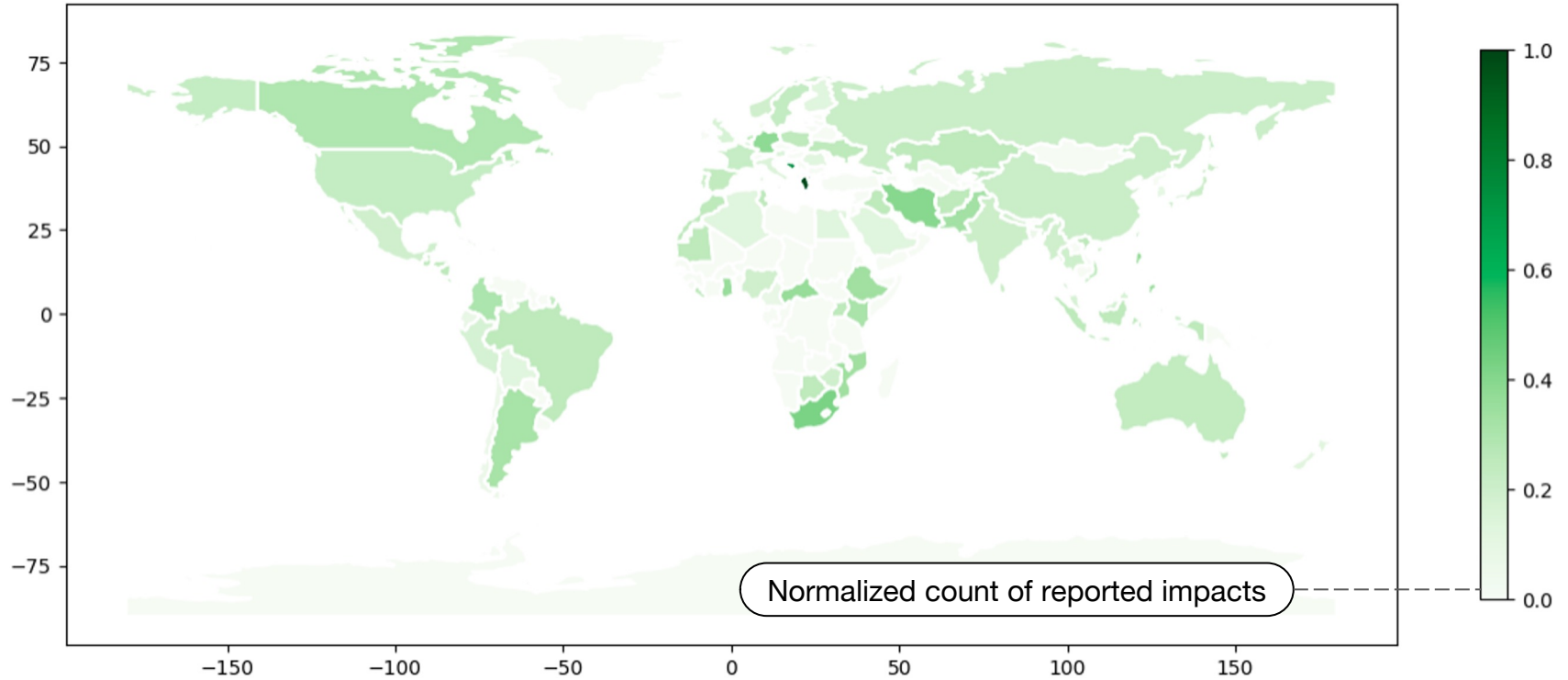
# Water availability impacts



# Health impacts



# Economic impacts



# Final database

hazardDescription
hazardType
location
date

location
country
region
state
city
latitude
longitude

reference
journal
paperTitle
doi
pmid
publicationYear
source

date
startDate
endDate

value
minValue
maxValue

generallImpacts	
humanDeaths	value, location, annotation, reference
animalDeaths	value, location, annotation, reference
numberAffected	value, location, annotation, reference
numberDisplaced	value, location, annotation, reference
numberHomeless	value, location, annotation, reference

healthImpacts	
qualitative	description, location, reference
quantitative	disease, icdCode, value, unit, location, annotation, reference

economicImpacts	
qualitative	description, location, reference
quantitative	value, currency, sector, location, annotation, reference

infrastructureImpacts	
qualitative	description, location, reference
quantitative	infraType, value, unit, location, annotation, reference

agricultureImpacts	
qualitative	description, location, reference
quantitative	crop, cropld, value, unit, location, annotation, reference

waterImpacts	
qualitative	description, location, reference
quantitative	value, sourceType, location, annotation, reference

socialImpacts	
qualitative	description, location, reference



## Get in touch!

tais.carvalho@informatik.uni-leipzig.de