

# A Rapid Computer-assisted Systematic Map of Regional Climate Impacts



June 12, 2020

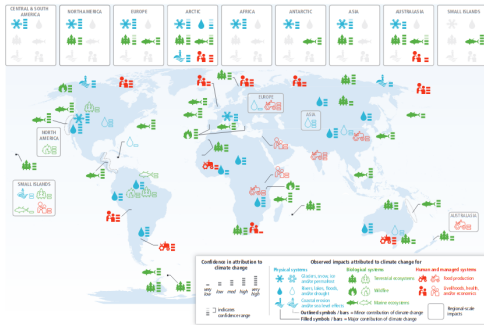
# Outline

Introduction

Data collection

Outcome 1 - Prediction Performance

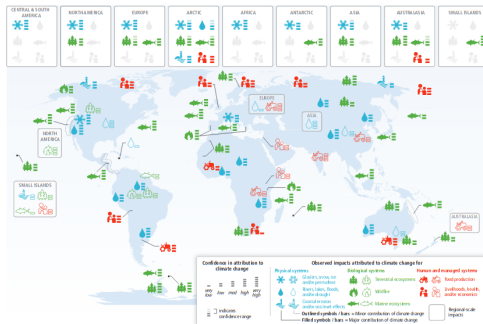
Outcome 2 - Evidence Map



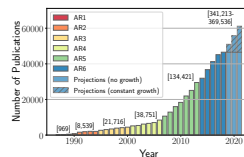
**Figure 18-3** | Global patterns of observed climate change impacts reported since ARI4. Each filled symbol in the top panels indicates a class of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range of confidence in attribution for those region-wide impacts indicated by the bars. Regional-scale impacts where climate change has played a minor role are shown by outlined symbols in a box in the respective region. Sub-regional impacts are indicated with symbols on the map, placed in the approximate area of their occurrence. The impacted areas can vary from specific locations to broad areas such as a major river basin. Impacts on physical (blue), biological (green), and human (red) systems are differentiated by color. This map represents a graphical synthesis of Tables 18-5, 18-6, 18-7, 18-8, and 18-9. Absence of climate change impacts from this figure does not imply that such impacts have not occurred.

## Context

Systematic assessments of the evidence on Climate Change like those conducted by the IPCC are vital.



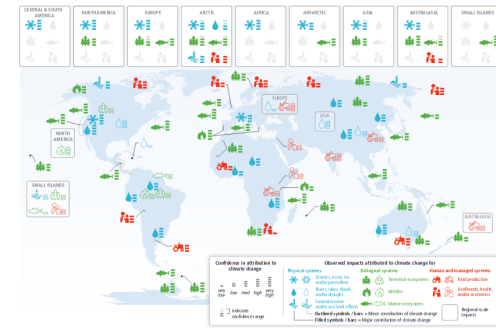
**Figure 10-3** Global patterns of observed climate change impacts registered since 1980. Early flood symbol in the top panels indicates a case of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range of confidence in attribution for those region-wide impacts indicated by the icon. Regional scale impacts where climate change has played a minor role are shown by outlined symbols in a box in the respective region. Sub-regional impacts are indicated with symbols on the map, also indicating the approximate area of their occurrence. The reported area can vary from specific locations to broad areas, such as a major river basin, impacts on physical (blue), biological (green), and human (red) systems are differentiated by color. This map represents a graphical synthesis of Tables 10.5, 10.6, 10.7, 10.8, and 10.9. Absence of climate change impacts from this figure does not imply that such impacts have not occurred.



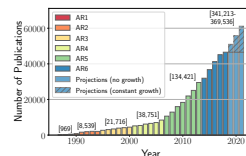
- These are challenged by big literature

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Systematic assessments of the evidence on Climate Change like those conducted by the IPCC are vital.



**Figure 10-3** Global patterns of observed climate change impacts registered since ARI. Early filled symbol in the top panels indicates a class of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range of confidence in attribution for those region-wide impacts indicated by the icon. Regional scale impacts where climate change has played a minor role are shown by unfilled symbols in boxes in the respective region. Sub-regional impacts are indicated with symbols on the map, alongside the approximate area of their occurrence. The reported area can vary from specific locations to broad areas, such as a major river basin, impacts on physical (blue), biological (green), and human (red) systems are differentiated by color. This map represents a graphical synthesis of Tables 10.5, 10.6, 10.7, 10.8, and 10.9. Absence of climate change impacts from this figure does not imply that such impacts have not occurred.



- These are challenged by big literature
- They do not account for uncertainty about what literature is available

# Goal

There are hundreds of thousands of documents potentially relevant to observed climate impacts. We want to be able to do two things:

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  - What type of evidence do they provide?
  - In which locations is there evidence



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  - What type of evidence do they provide?
  - In which locations is there evidence

Once we can do that, we can draw a rough map of the available evidence, and/or aid the production of an *assessment* of the available evidence

## Distribution of labour between humans and machines

A human expert or a team of human experts is best placed to answer those questions for any single document, but they can't look at all potentially relevant documents

We can use labels generated by humans to try to teach a computer what a relevant document looks like, and how to decide in what way it is relevant.

If this works well, we can predict, with some uncertainty, how much evidence there is, and where and on what topic it is.

## Introduction

## Data collection

## Outcome 1 - Prediction Performance

## Outcome 2 - Evidence Map

# We set up our platform to record the relevance and lots of other information about each document

**Query Screener (Query no. 7368) - Welcome, galm, your progress:**

15%

**The reef-building coral *Siderastrea siderea* exhibits parabolic responses to ocean acidification and warming**

232856  
PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES (2014) 10 1098/proc.2014.1856 Document type: Article

Castillo, Karl D. [Univ N Carolina, Dept Marine Sci, Chapel Hill, NC 27599 USA.]; Ries, Justin B. [Univ N Carolina, Dept Marine Sci, Chapel Hill, NC 27599 USA.]; Ries, Justin B. [Northeastern Univ, Dept Marine & Environm Sci, Ctr Marine Sci, Nahant, MA 01908 USA.]; Bruno, John F. [Univ N Carolina, Dept Biol, Chapel Hill, NC 27599 USA.]; Westfield, Isaac T. [Northeastern Univ, Dept Marine & Environm Sci, Ctr Marine Sci, Nahant, MA 01908 USA.]; Westfield, Isaac T. [Univ N Carolina, Dept Marine Sci, Chapel Hill, NC 27599 USA.];

Author keywords: tropical scleractinian coral; calcification; **ocean warming**; ocean acidification; *Siderastrea siderea*; Caribbean

WoS Keywords Plus: CO2 PARTIAL-PRESSURE; CALCIFICATION **response**; SEAWATER ACIDIFICATION; SCLERACTINIAN CORALS; ASTRANGIA POCULATA; SATURATION STATE; IN-SITU; PH; PHOTOSYNTHESIS; TEMPERATURE

**anthropogenic** increases in atmospheric CO2 over this century are predicted to cause global average surface ocean pH to decline by 0.1-0.3 pH units and sea **surface temperature** to increase by 1-4 degrees C. We conducted controlled laboratory experiments to investigate the **impacts** of CO2-induced ocean acidification (pCO2) = 324, 477, 604, 2553 mu atm) and warming (25, 28, 32 degrees C) on the calcification rate of the zooanthellae scleractinian coral *Siderastrea siderea*, a widespread, abundant and keystone reef-builder in the Caribbean Sea. We show that both acidification and warming cause a parabolic **response** in the calcification rate within this coral **species**. Moderate increases in pCO2 and warming, relative to near-present-day values, enhanced coral calcification, with calcification rates declining under the highest pCO2 and thermal conditions. Equivalent responses to acidification and warming were **attenuated** by colonies across reef zones and the parabolic nature of the corals' **response** to these stressors was evident across all three of the experiment's 30-day **observational** intervals. Furthermore, the warming projected by the Intergovernmental Panel on **climate change** for the end of the twenty-first century caused a fivefold decrease in the rate of coral calcification, while the acidification projected for the same interval had no statistically **significant impact** on the calcification rate suggesting that **ocean warming** poses a more immediate threat than acidification for this important coral **species**.

Add a note to this document

**Add note**

Is this document relevant according to the level 1 criteria shown?

**Yes (1)** **No (2)** **Maybe (3)**

Which Attribution categories is this document relevant to? (hover for more info)

2.1. Climate change attribution **2.2 Trend attribution** 2.3. Attribution to extreme event 2.4. Sensitivity  
2.5. Detection of a regional climate trend (no attribution) 2.6. Null results

In which system are the impacts documented in this study?

3.1. Physical systems **3.2. Biological systems** 3.3. Human and managed systems

What impacts are documented in this study?

**Marine & coastal** 36 Species distribution (marine & coastal) 37 Shifts in phenology (marine & coastal)  
38 Geographical shift (marine & coastal) **40 Changes in warm water corals** 41 Species metabolism (marine & coastal)  
42 Species abundance (marine & coastal) 43 Biome shift (marine & coastal) 44 Biodiversity effects (marine & coastal)  
45 Ocean ecosystem productivity 46 Changes in kelp forests 47 Seagrass 48 Carbon cycle (marine & coastal)  
49 Biogeochemical flows (marine & coastal) 50 Other (marine & coastal)

**Terrestrial and freshwater** 51 Distribution and range shifts (Terrestrial and freshwater)  
52 Shifts in phenology (Terrestrial and freshwater) 53 Mortality and growth 54 Physiology and metabolism  
55 Community composition and interaction 56 Terrestrial carbon cycle 57 Biogeochemical flows (Terrestrial and freshwater)  
58 Pests and diseases 59 Wildfires 60 Other (Terrestrial and freshwater)

In which system are the drivers documented in this study?

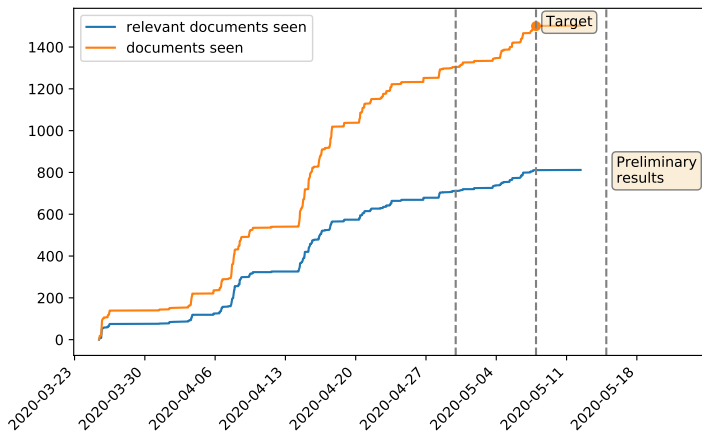
**5.1. Physical systems** 5.2. Biological systems 5.3. Human and managed systems

Which level 6 categories is this document relevant to? (hover for more info)

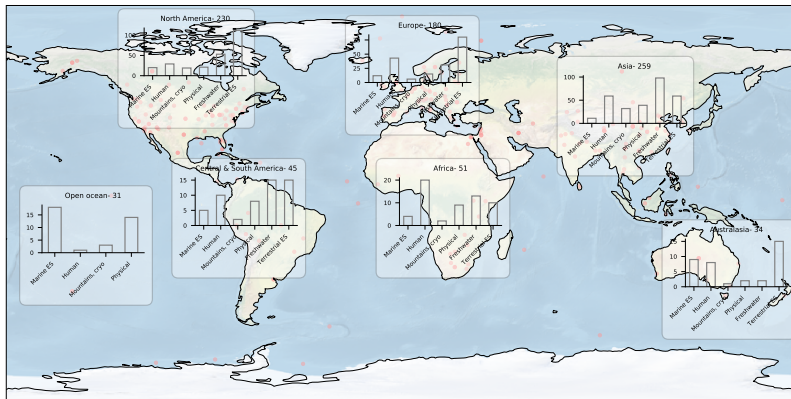
01 CO2 concentration 02 Air or land surface temperature changes 03 Extreme temperature 04 Radiation  
05 Changes in precipitation 06 Humidity 07 Aridity/dryness 08 Changes in strong precipitation  
09 Atmospheric/marine circulation or teleconnections 10 Wind speed 11 Storms 12 Seasonality 13 Other (physical systems)  
14 Sea level change 15 Coastal flooding **16 Sea surface temperature** **17 Ocean acidification** 18 Oxygen content  
19 Water quality/chemistry (oceans) 20 Other (oceans)

21 Water temperature (freshwater) 22 Water quality/chemistry (freshwater) 23 Soil moisture

During the first couple of months of lockdown we screened 1500 documents



This already constitutes a useful information gathering exercise



Introduction

Data collection

Outcome 1 - Prediction Performance

Outcome 2 - Evidence Map

# Support Vector Machines

- We train SVMs to predict binary outcomes for relevance, and for each category
- SVMs build a hyperplane which best separates the features of data points of different classes
- Our features are 1-2 word ngrams taken from the document titles and abstracts

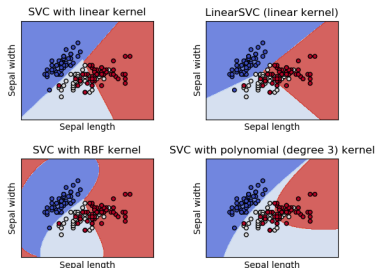
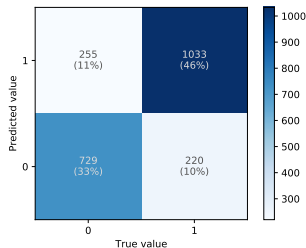
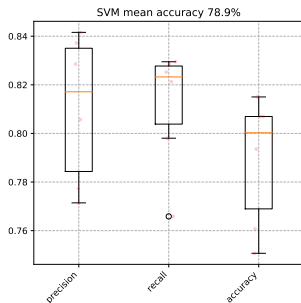


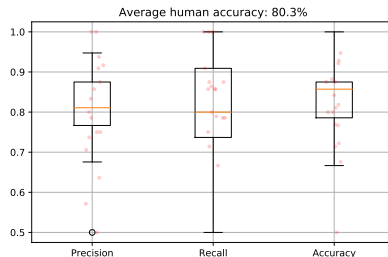
Figure: Source:  
[https://scikit-learn.org/stable/auto\\_examples/svm/plot\\_iris\\_svc.html](https://scikit-learn.org/stable/auto_examples/svm/plot_iris_svc.html)



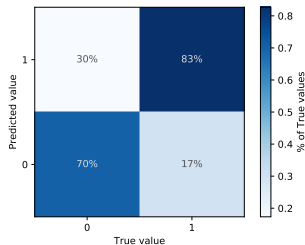
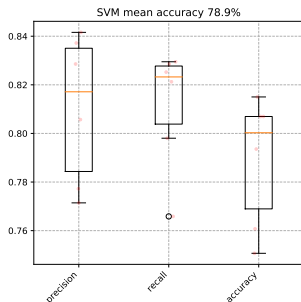
## We predict the relevance of a document most of the time



This has been steadily increasing by using the model itself as a "second pair of eyes" to check for errors, and I expect it to increase further (partly due to different criteria for inclusion at different stages of the project)

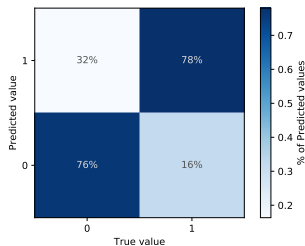
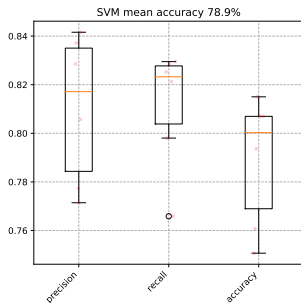


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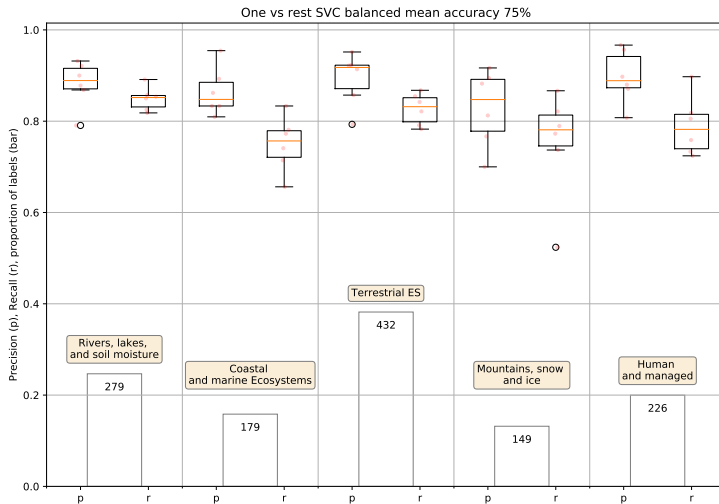
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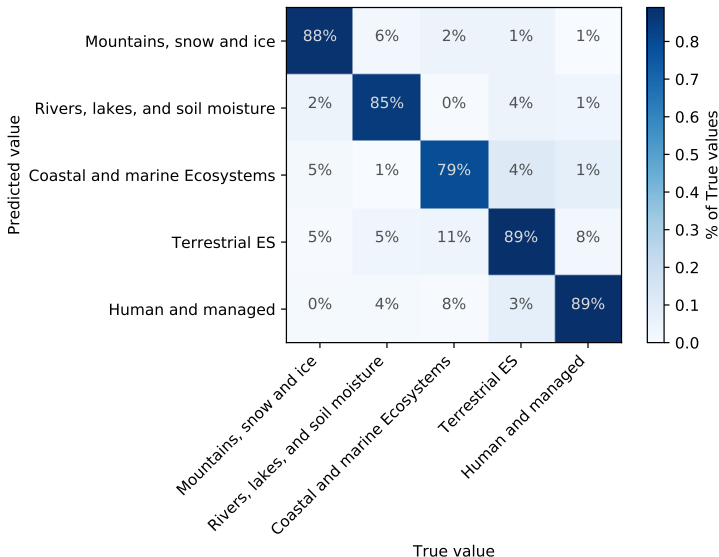
This has been steadily increasing by using the model itself as a "second pair of eyes" to check for errors, and I expect it to increase further (partly due to different criteria for inclusion at different stages of the project)

We can clearly identify what impact category a document is related to

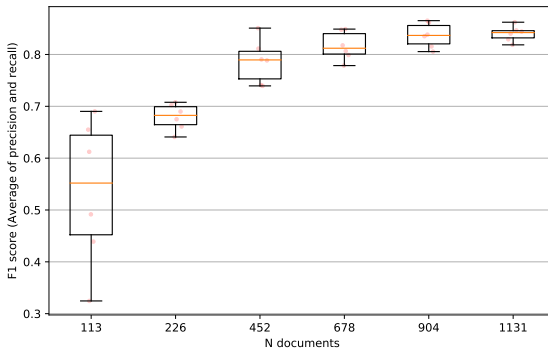


**Figure:** Precision (how many documents predicted to be in a category actually had that label) and Recall (how many documents with a label were predicted to be in that category) for each broad impact category

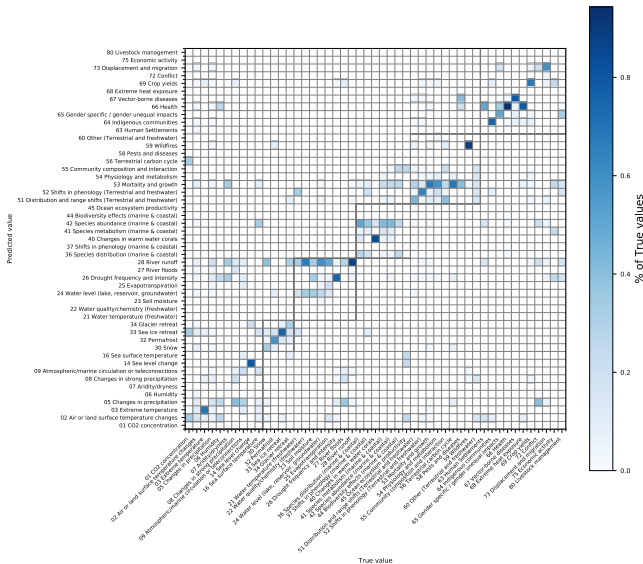
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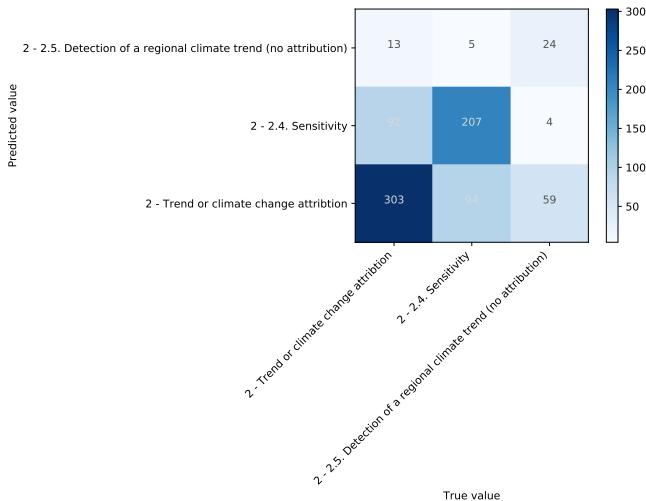
Accuracy increased and uncertainty decreased with the number of labels available



We are also broadly correct on subcategories - impressive given the amount of data and the complexity of the coding scheme



# Getting attribution correct is harder, but we have fewer labels





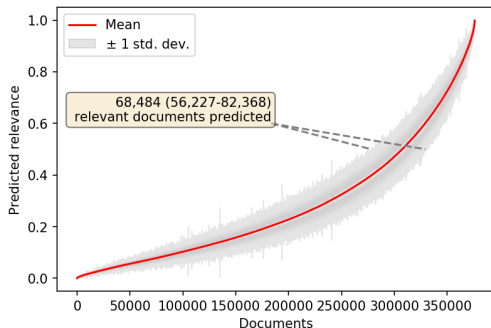
## Introduction

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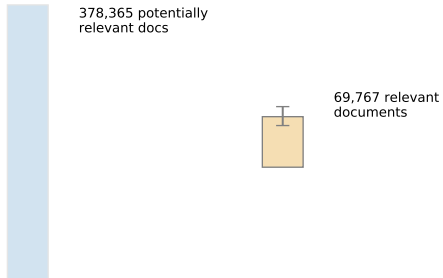
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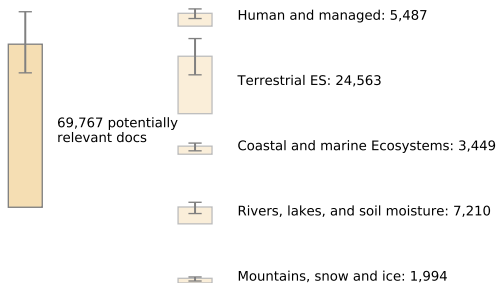
## Outcome 2 - Evidence Map

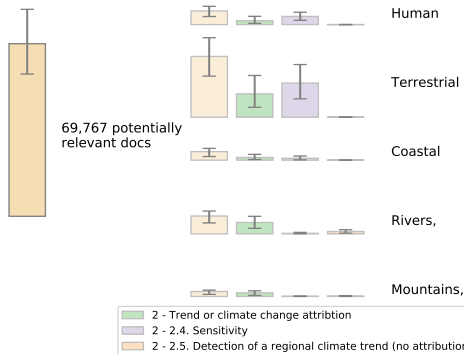
We predict tens of thousands of additional documents relevant according to the criteria we defined



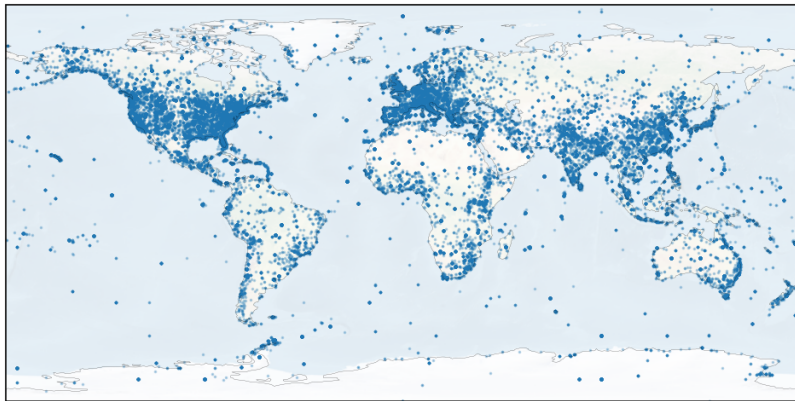
- We train 6 classifiers on random partitions of the labelled dataset
- This gives us 6 estimates for each unseen document
- The mean and standard deviation of these estimates give us an idea, with some uncertainty, of how many documents are in each category
- There must be a better way to incorporate what we know from our test statistics into our uncertainty ranges, but I can't figure it out



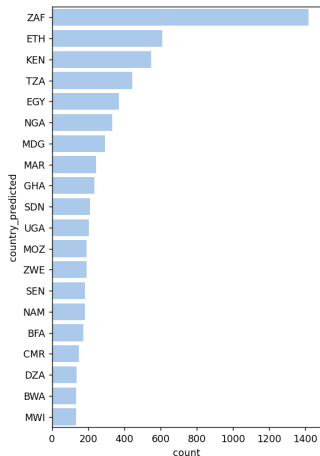




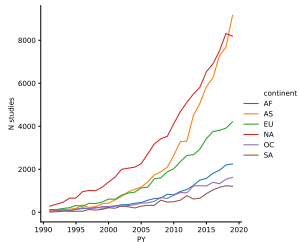
The studies predicted to be relevant cover a much broader array of places,  
but geographic imbalances persist



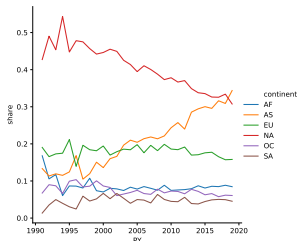
We have around 7,500 place names (from 3,250 unique documents predicted to have mentioned a location in Africa). These are also not evenly distributed.



# In which locations is there evidence? What impacts does it document? Since when has there been evidence?

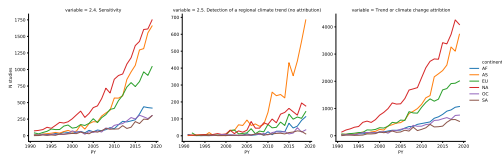


- More studies on Asia than North America since 2018
- Africa now more frequently studied than South America and Oceania

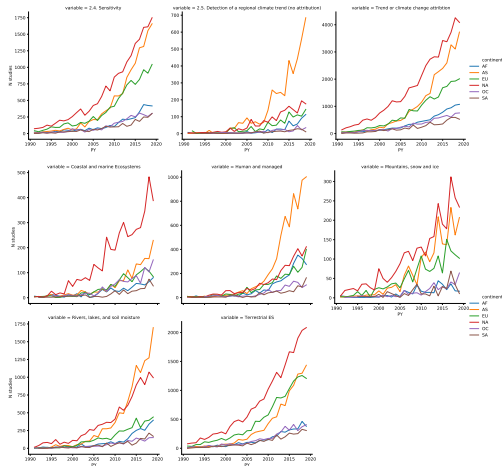




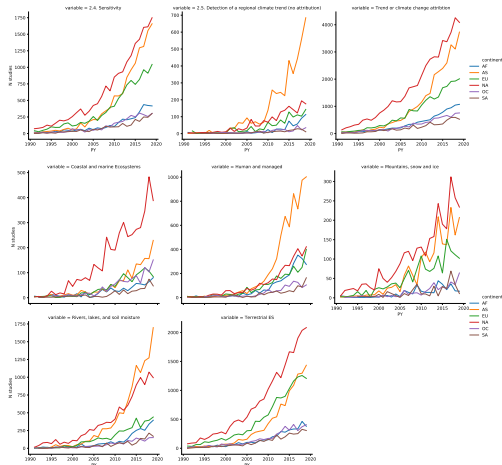
- Lots of the new studies on Asia have been about Detection (is there a regional climate trend)



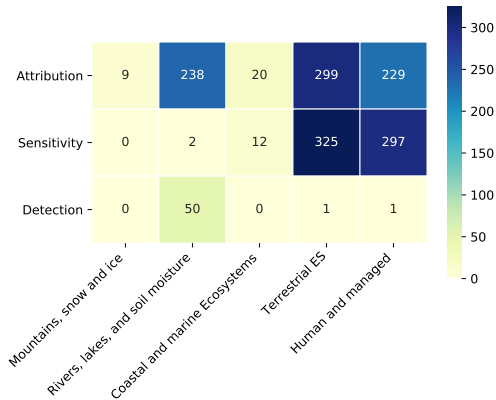
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- Lots of the new studies on Asia have been about Detection (is there a regional climate trend)
- There is also more literature on human impacts and the water cycle in Asia
- On human impacts, Africa is as much studied as anywhere apart from Asia



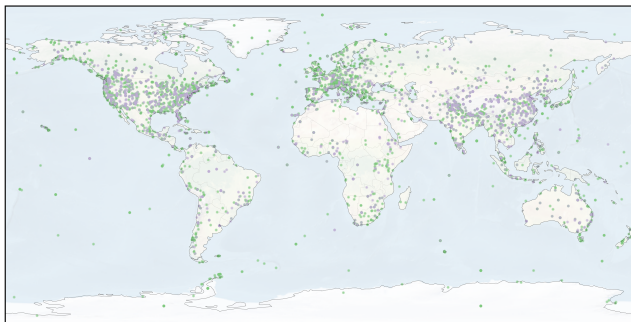
## Study types



- Most literature is on terrestrial ecosystems
- There's also a lot of attribution, as well as detection, literature on rivers, lakes and soil.
- There's a large chunk on human and managed systems, although the majority examines sensitivity rather than attribution



## Combining data with climate models



● 6 - Temperature - mean\_prediction

● 6 - Precipitation - mean\_prediction

# Outlook

## So far

- Data collection
- Coding scheme
- Coding
- Learning and predictions
- Collation of results

## Still to come

- Further data checking
- Investigating distribution of evidence and comparing with IPCC
- Predicting drivers and mapping driver-impact pathways
- Write up
- Interactive map

## References

Sippel, S., Meinshausen, N., Fischer, E. M., Székely, E., and Knutti, R. (2020). Climate change now detectable from any single day of weather at global scale. *Nature Climate Change*, 10(January).