

Scaling up assessments of regional impacts of climate change: a rapid, computer-assisted systematic map

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August 13, 2021

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

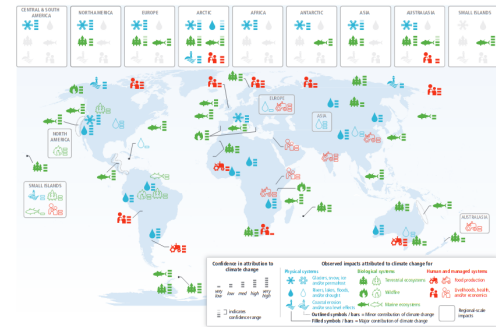


Figure 18-3 Global patterns of observed climate change impacts reported since ARI. Each filled symbol in the map panels indicates a class of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range 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, 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 18.5, 18.6, 18.7, 18.8, and 18.9. Absence of climate change impacts from this figure does not mean that such impacts have not occurred.

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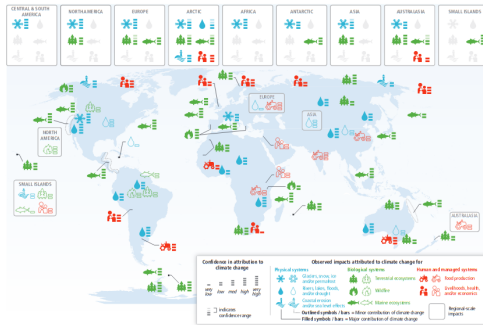
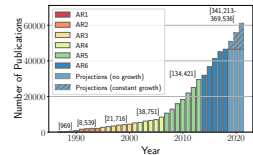


Figure 18-3 Global patterns of observed climate change impacts reported since ARI. Each filled symbol in the top panels indicates a class of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range of confidence in attribution for those region-wide impacts indicated by the color. Regional scale impacts where climate change has played a minor role are shown by outlined symbols (a line in the respective region). Sub-regional impacts are indicated with symbols on the map indicating the approximate area of their occurrence. The reported areas 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 indicate that such impacts have not occurred.



► These are challenged by big literature Callaghan et al. (2020)

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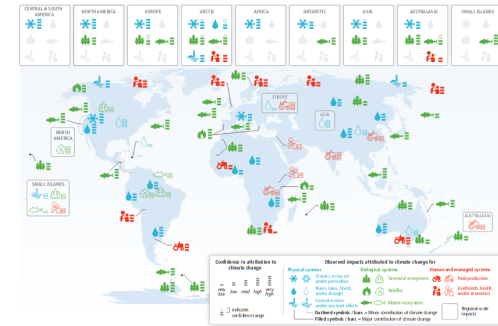
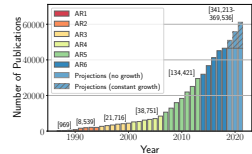


Figure 18-3 Global patterns of observed climate change impacts reported since ARI. Each filled symbol in the map panels indicates a class of systems for which climate change has played a major role in observed changes in at least one system within that class across the respective region, with the range of confidence in attribution for those region-wide impacts indicated by the color. Regional scale impacts where climate change has played a minor role are shown by outlined symbols (a line in the respective region). Sub-regional impacts are indicated with symbols on the map indicating the approximate area of their occurrence. The reported areas 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 indicate that such impacts have not occurred.



- These are challenged by big literature Callaghan et al. (2020)
- They do not account for uncertainty about what literature is available

Process

1. Broad **search** in literature databases (Web of Science & Scopus) for literature on climate impacts
2. Hand **screen and code** documents to include only documents on observed climate impacts, and code the type of impacts and type of evidence
3. Combine this training data with the categorisation of documents in **AR5**
4. Use supervised **machine learning** to predict the inclusion and impact type of 100s of thousands of remaining documents
5. Use named entity recognition to extract **geographical locations** from titles and abstracts
6. Map entities to grid cells and combine with **WGI style D&A** of temperature and precipitation trends at the grid cell level
7. Describe **evidence gluts and gaps** at a grid cell level

Query

Screening & Labelling

JupyterLab

Home Feed | ResearchGate | Scoping

apsis.mcc-berlin.net/scoping/screen_doc/5178/1/1/8

Apps | gensim doc2v... | Table of Eligib... | Pacenti TubeL... | New Tab | Install django-... | Tutorial

Projects | Home | Categories | Queries | galm | Add Reference Manually

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

100%

<< >>

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/rspb.2014.1856 Document type: Article

Castillo, Karl D. [John N Carolina, Dept Marine Sci, Chapel Hill, NC 27599 USA.], Ries, Justin B. [John 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. [John 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. [John 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; ASTRAGALIA 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 μatm) and warming (25, 28, 32 degrees C) on the calcification rate of the zooxanthellate 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 **inhibited** 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 35 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 Acidity/bases 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

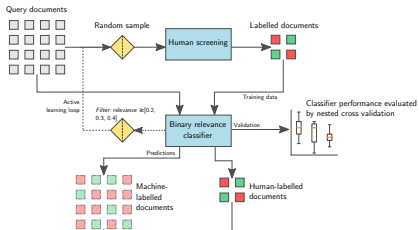
24 Water level (lake, reservoir, groundwater) 25 Evapotranspiration 26 Drought frequency and intensity 27 River floods

28 River runoff 29 Other (Rivers, lakes and soil moisture)

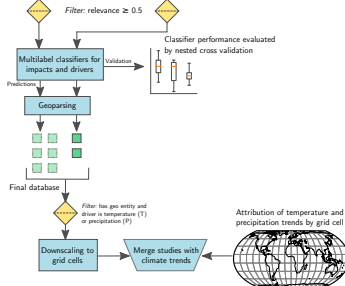
30 Snow 31 Landslides/instability 32 Permafrost 33 Sea ice retreat 34 Glacier retreat 35 Other (mountains, snow and ice)

Process

1. Identification of relevant impacts studies



2. Classification and location of climate impacts

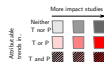


Results:

After merging studies with climate trends, we characterise each study by the proportion of its gridcells which show attributable trends



And each grid cell by the presence of attributable trends in temperature (T) and precipitation (P) and the number of studies on impacts



Basic ML I - text as data

We can build a set of features is from a TFIDF weighted set of unigrams and bigrams from the documents' abstracts

Winter and spring warming result in delayed spring phenology on the Tibetan Plateau

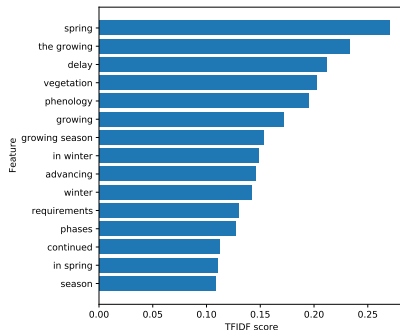
climate change has caused advances in spring phases of many plant species. Theoretically, however, strong warming in winter could slow the fulfillment of chilling requirements, which may delay spring phenology. This phenomenon should be particularly pronounced in regions that are experiencing rapid temperature increases and are characterized by highly temperature-responsive vegetation. To test this hypothesis, we used the Normalized Difference Vegetation Index ratio method to determine the beginning, end, and length of the growing season of meadow and steppe vegetation of the Tibetan Plateau in Western China between 1982 and 2006. We then correlated observed phenological dates with monthly temperatures for the entire period on record. For both vegetation types, spring phenology initially advanced, but started retreating in the mid-1990s in spite of continued warming. Together with an advancing end of the growing season for steppe vegetation, this led to a shortening of the growing period. Partial least-squares regression indicated that temperatures in both winter and spring had strong effects on spring phenology. Although warm springs led to an advance of the growing season, warm conditions in winter caused a delay of the spring phases. This delay appeared to be related to later fulfillment of chilling requirements. Because most plants from temperate and cold climates experience a period of dormancy in winter, it seems likely that similar effects occur in other environments. Continued warming may strengthen this effect and attenuate or even reverse the advancing trend in spring phenology that has dominated climate-change responses of plants thus far.

PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA (2010) 22151 - 22156
10.1073/pnas.1012490107 Document type: Article

Yu, Haijing [Chinese Acad Sci, Kunming Inst Bot, Key Lab Biodivers & Biogeog, Kunming 650204, Peoples R China.]; Yu, Haijing [World Agroforestry Ctr, E Asia Program, Kunming 650204, Peoples R China.]; Luedeling, Elke [World Agroforestry Ctr, Nairobi 00100, Kenya.]; Xu, Jianchu [World Agroforestry Ctr, E Asia Program, Kunming 650204, Peoples R China.]; Xu, Jianchu [Chinese Acad Sci, Kunming Inst Bot, Key Lab Biodivers & Biogeog, Kunming 650204, Peoples R China.];

WoS Keywords Plus: climate-change; VEGETATION INDEX; TREE PHENOLOGY; SNOW DEPTH; AVHRR; VARIABILITY; LATITUDES; regions; EUROPE; CHINA

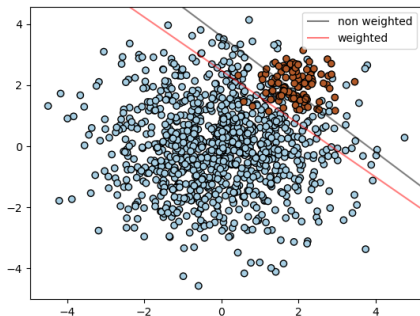
Document id: 38721



We discard very uncommon and very common features, leaving us with a vocabulary of 7,394 unique features.

Basic ML II - Support Vector Machines

SVMs try to fit a hyperplane through the multidimensional feature space (represented below in 2D) that best separates the classes in the training data.



With SVMs we ignore word order and context (bag of words assumption).

Machine learning - BERT

BERT (Bidirectional Representations from Transformers) is trained (by Google) on huge text corpora, and can be **“fine tuned”** on custom tasks.

1 - **Semi-supervised** training on large amounts of text (books, wikipedia..etc).

The model is trained on a certain task that enables it to grasp patterns in language. By the end of the training process, BERT has language-processing abilities capable of empowering many models we later need to build and train in a supervised way.

Semi-supervised Learning Step

Model:



Dataset:



Objective:

Predict the masked word
(language modeling)

2 - **Supervised** training on a specific task with a labeled dataset.

Supervised Learning Step

Model:
(pre-trained
in step #1)



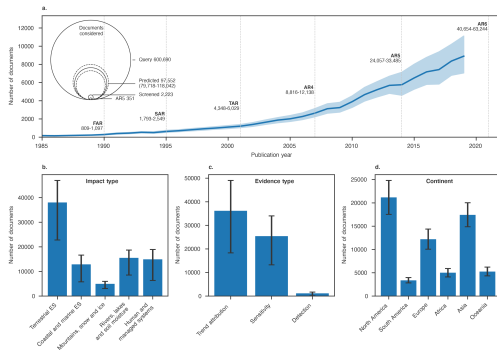
Dataset:

Email message	Class
Buy these pills	Spam
Win cash prizes	Spam
Dear Mr. Atreides, please find attached...	Not Spam



Figure: Source: <https://jalammr.github.io/illustrated-bert/>

Results



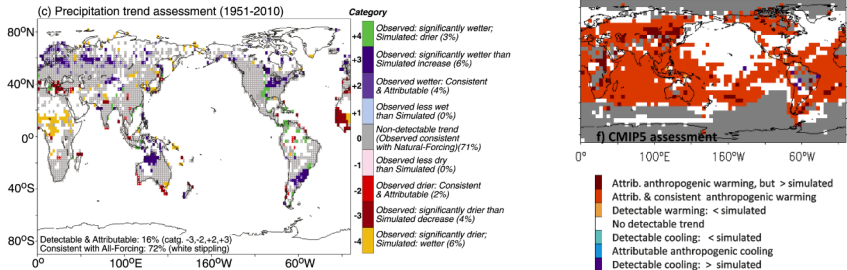
- ▶ We identify nearly 100,000 documents likely to be relevant
- ▶ We can predict impact type, attribution type, and location

From here we focus on “Trend attribution” documents, that is, documents attributing impacts to a trend in a climate variable, and specifically focus on trends driven by temperature and precipitation

Synthesizing impacts evidence with quantitative detection and attribution evidence

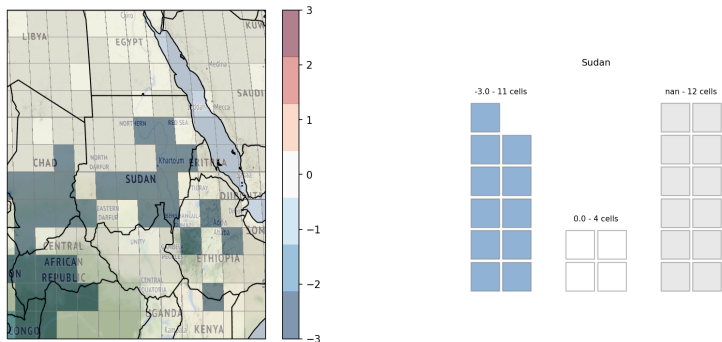
We know from detection and attribution studies whether observed trends in temperature and precipitation are attributable to human influence on the climate.

Knutson et al. (2013); Knutson and Zeng (2018) show this on a grid cell level



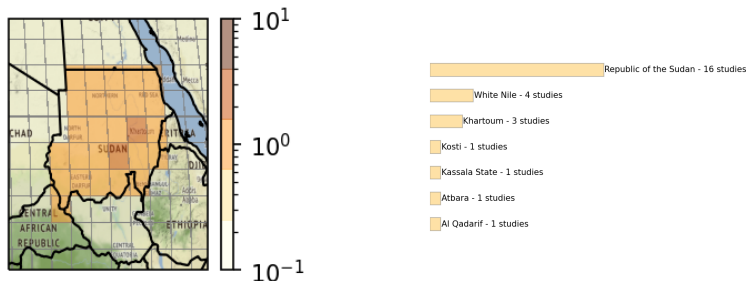
We can combine this with information from our database of impacts evidence, in which the locations, and the climate drivers have been predicted

Synthesising impacts with D&A evidence



- ▶ 11 out of 27 gridcells in Sudan contain a reduction in rainfall attributable to human influence on the climate
- ▶ Each study referring to Sudan (as the smallest identifiable geographical entity) and predicted to document impacts driven by precipitation refers to a place where around 41% of the gridcells are known to have anthropogenic changes in precipitation

Synthesising impacts with D&A evidence



- ▶ 7 studies refer to Sudan (as the smallest identifiable geographical entity), and Sudan has 27 gridcells
- ▶ We apportion these studies to the relevant gridcells, calculating that each gridcell in Sudan has $\frac{7}{27}$ studies referring to it
- ▶ We do the same for each further geographical entity

Conclusions

- ▶ We identify a large body of evidence about climate impacts, including 17,273 studies documenting impacts in areas where we know at least a part of which are changing due to human influence on the climate (11,089 studies where the majority of gridcells show attributable trends)
- ▶ What we know about the effects of a changing climate on human and natural systems does not always match with what we know about how (and where) humans are driving changes in climate variables

But,

- ▶ Current results only show studies in Web of Science, so definitely do not show all relevant studies
- ▶ Although our query returned all papers in the relevant AR5 section, it may still miss potentially relevant literature.
- ▶ Study identification is approximate and uncertain, trends in studies may not correspond to trends attributed
- ▶ Geoparsing is also inexact, and is unable to grasp fuzzy geographical content e.g. "Western China"
- ▶ In large parts of the world, we do not even know reliably if precipitation and temperature are changing

Summary - Scaling up assessments of regional impacts of climate change: a rapid, computer-assisted systematic map

- ▶ In a large collaborative coding exercise, we examined thousands of papers *potentially* relevant to understanding observed impacts of climate change
- ▶ We used machine learning to identify tens of thousands of studies *likely* to be relevant.
- ▶ We predicted the sector, climate driver, evidence type and location for each of these studies
- ▶ We used the location and predicted climate driver to synthesise this information with existing quantitative Detection and Attribution knowledge.

Takeaways

- ▶ Machine learning can inform and support global environmental assessments
- ▶ We have lots of evidence of observed impacts of climate change, including 17,000 studies documenting impacts in areas we know are changing due to human influence on the climate
- ▶ What we know about the effects of a changing climate on human and natural systems does not always match with what we know about how (and where) humans are driving changes in climate variables

Thanks!

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Bibliography

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