Lecture will start at 9:35

Assignments reminder

Keep doing your PMIRO+Q

Would be nice if you did the mid-term course evaluation (sent announcement)

Your third coding assignment is due Friday, March 20th by 8am.

Your project description will be due April 1st by 11:59pm

Climate Change in the News

Trump officials fire 800 employees at weather forecasting and oceans agency

By Ella Nilsen and Tami Luhby, CNN

3 minute read · Updated 10:08 AM EST, Fri February 28, 2025

The terminations are a blow to an agency that has been understaffed for years, even as the climate crisis accelerates and extreme weather becomes more frequent. Critics of the administration's plan to slash the agency — a directive that was outlined in Project 2025 — have said layoffs would further cripple America's ability to accurately forecast hurricanes, tornadoes and other costly, deadly extreme weather.

Meteorologists and computer engineers across NOAA were impacted, including at the Hurricane Research Division, where employees work to increase the accuracy of hurricane forecasts. Andrew Hazelton, a researcher with a PhD in meteorology, was one of the employees terminated Thursday, he said on social media. His role was to evaluate hurricane forecasts and improve the physics in the models that the National hurricane Center uses to track the storms.

"I enjoy meteorology because weather affects everyone, and there's always so much to learn," Hazelton is quoted as saying in his NOAA bio. "Growing up in Florida, I experienced several hurricanes, and it thrills me to be able to study and analyze them in my career."

Other departments in which roles were terminated include the Pacific Tsunami Warning Center, the Great Lakes Environmental Research Laboratory, and the division that develops and improves the United States' weather models.

Zachary Labe was one such modeler that was terminated.

"My job was to strengthen NOAA's use of machine learning and AI for subseasonal-to-decadal weather and climate prediction," Labe said on X.

Climate Change in the News

Farmers depend on climate data. They're suing the USDA for deleting it.

Growing food is a precarious business, and losing access to key information makes it worse.

Alejandra Villa Loarca / Newsday RM via Getty Images

"Farmers are on the front lines of climate change," said Jeff Stein, an associate attorney with the environmental nonprofit Earthjustice, who is representing the plaintiffs. "Purging climate change web pages doesn't make climate change go away. It just makes it harder for farmers to adapt."

"All of a sudden, it's like anything marked with climate is starting to disappear," said Wes Gillingham, the board president of NOFA-NY. According to the complaint, the Farm Service Agency and Farmers.gov, both part of the USDA, removed information about how farmers could access federal loans and technical assistance to start adopting practices that help reduce emissions and sequester carbon, known as climate-smart agriculture.

One tool that allowed farmers to assess their risk level when it came to climate impacts was an interactive map published by the U.S. Forest Service, which combined over 140 different datasets and made them accessible to the general public, said Stein. Land managers could see how climate change is expected to impact natural resources throughout the country; for example, they could look up which watersheds are projected to face the greatest climate impacts and highest demand in the future. But this tool is no longer available. (At the time of writing, a link to information about the map on the Forest Service's website turned up dead.)

Lecture

Climate Change: Human beliefs and how to change them

Machine Learning: Natural Language Processing, Transformer, Topic Clustering

Project Homework

Everything is done by people

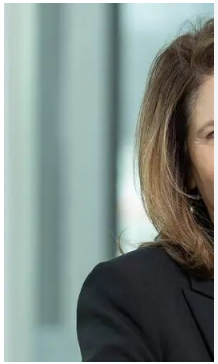
N.Y.U. Chooses Linda Mills as Its Next President

Dr. Mills will become the first woman to head New York University, one of the largest private universities in the country.

Stephen John Brademas Jr. (March 2, 1927 – July 11, 2016). NYU President from 1981 to 1992

Eric Adams, Mayor of New York City since 2022

Everything is done by people



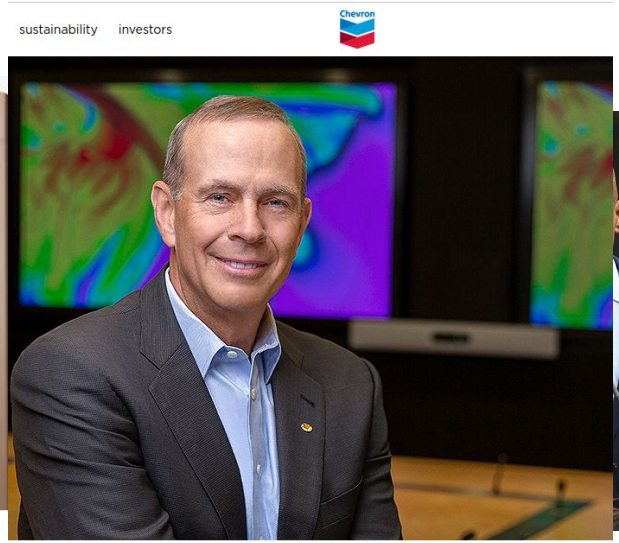
N.Y.U. Chooses L
President

Dr. Mills will become the first
University, one of the largest

Executive Committee

The Shell plc Executive Committee, led by CEO Wael Sawan, is responsible for running Shell's businesses and delivering on its corporate strategy.

Read more →



mike wirth

chairman of the board and chief executive officer

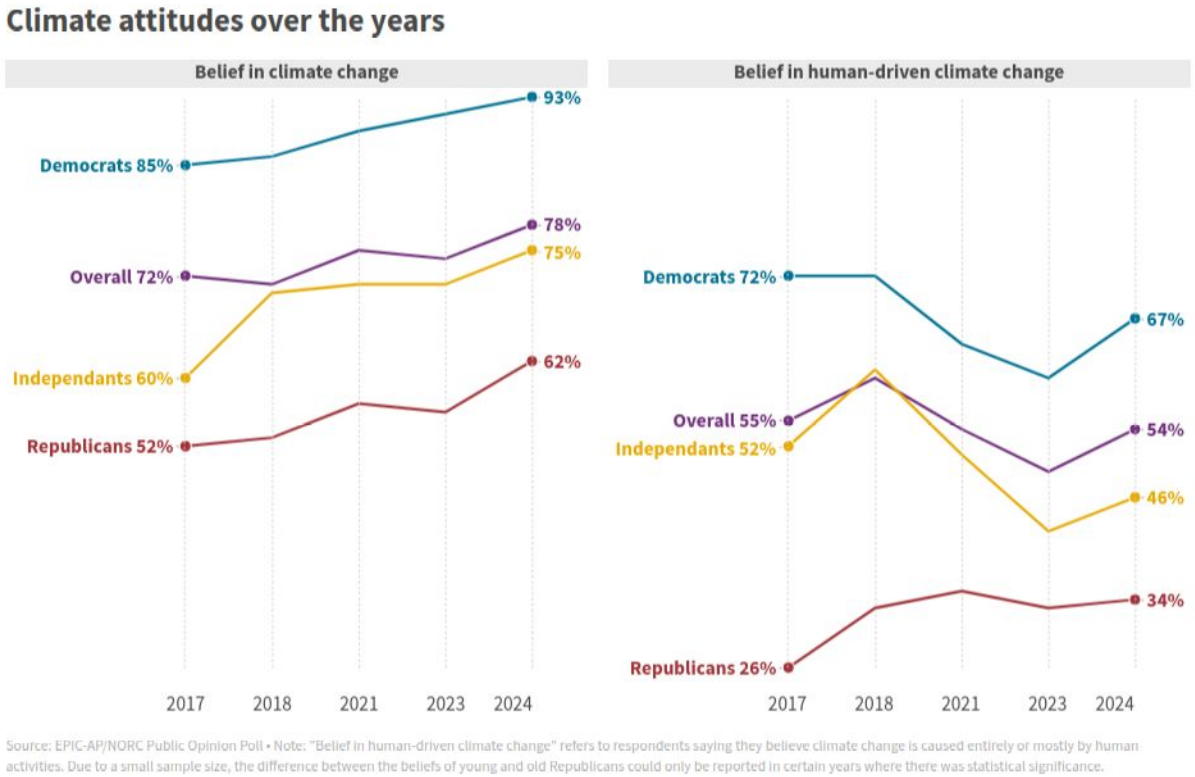
f New York

. (March 2, 1927 – July 11, 2016). NYU President from 1981 to 1992

Everything is done by people

Not just as individuals, but also collectively

What do people think about climate change?



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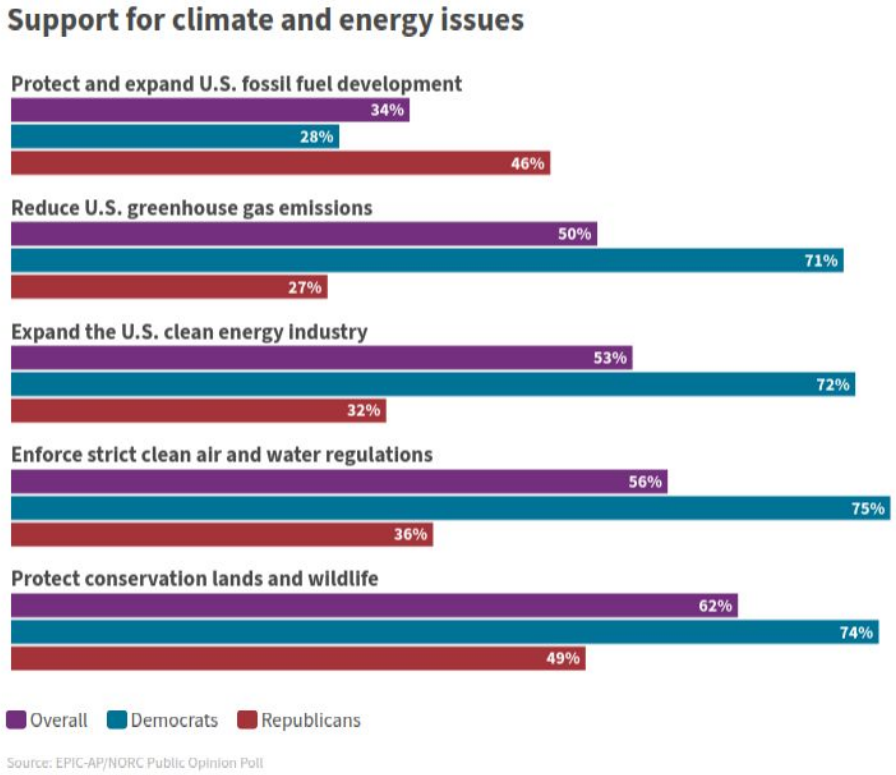

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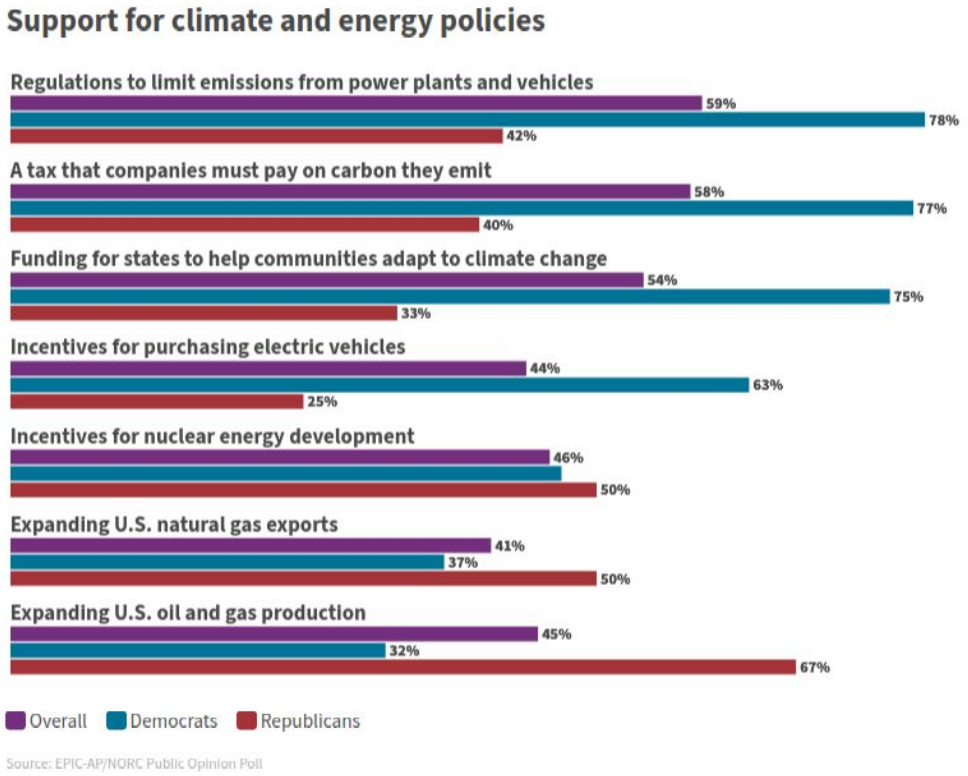

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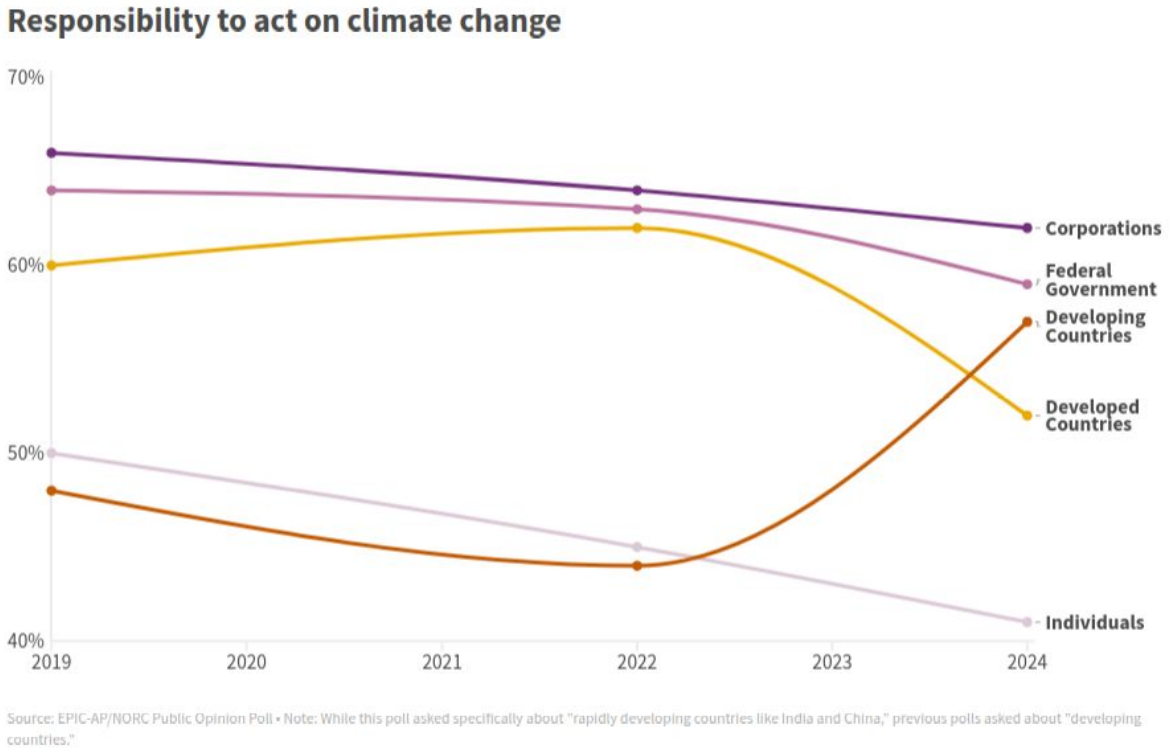

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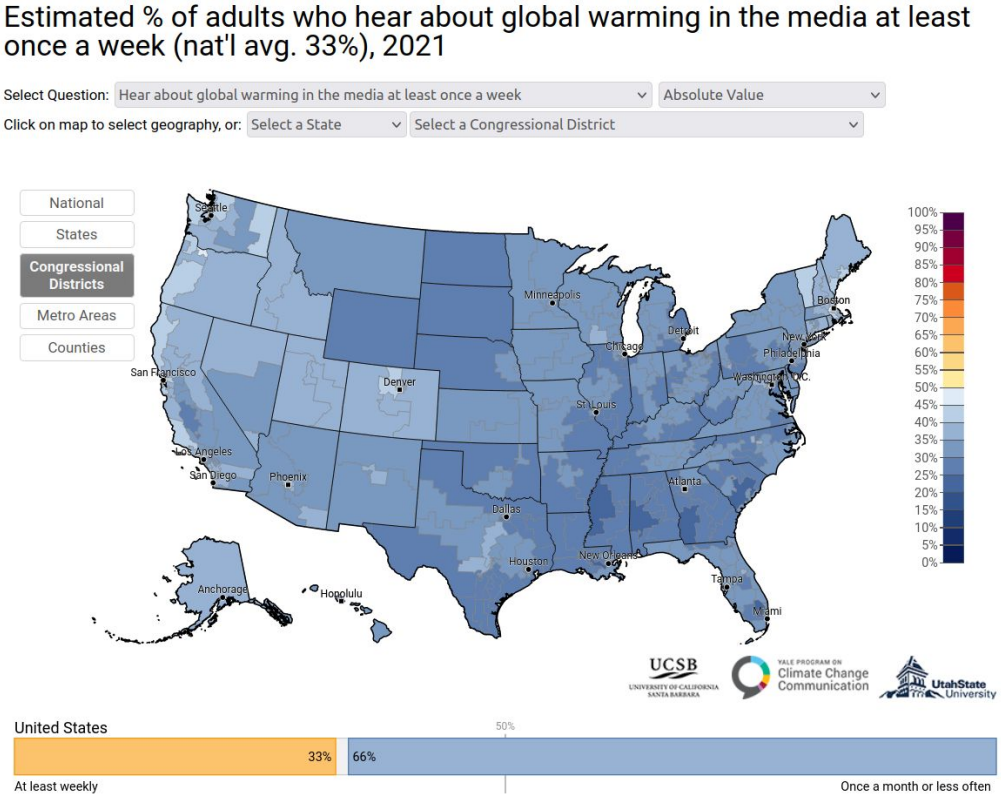

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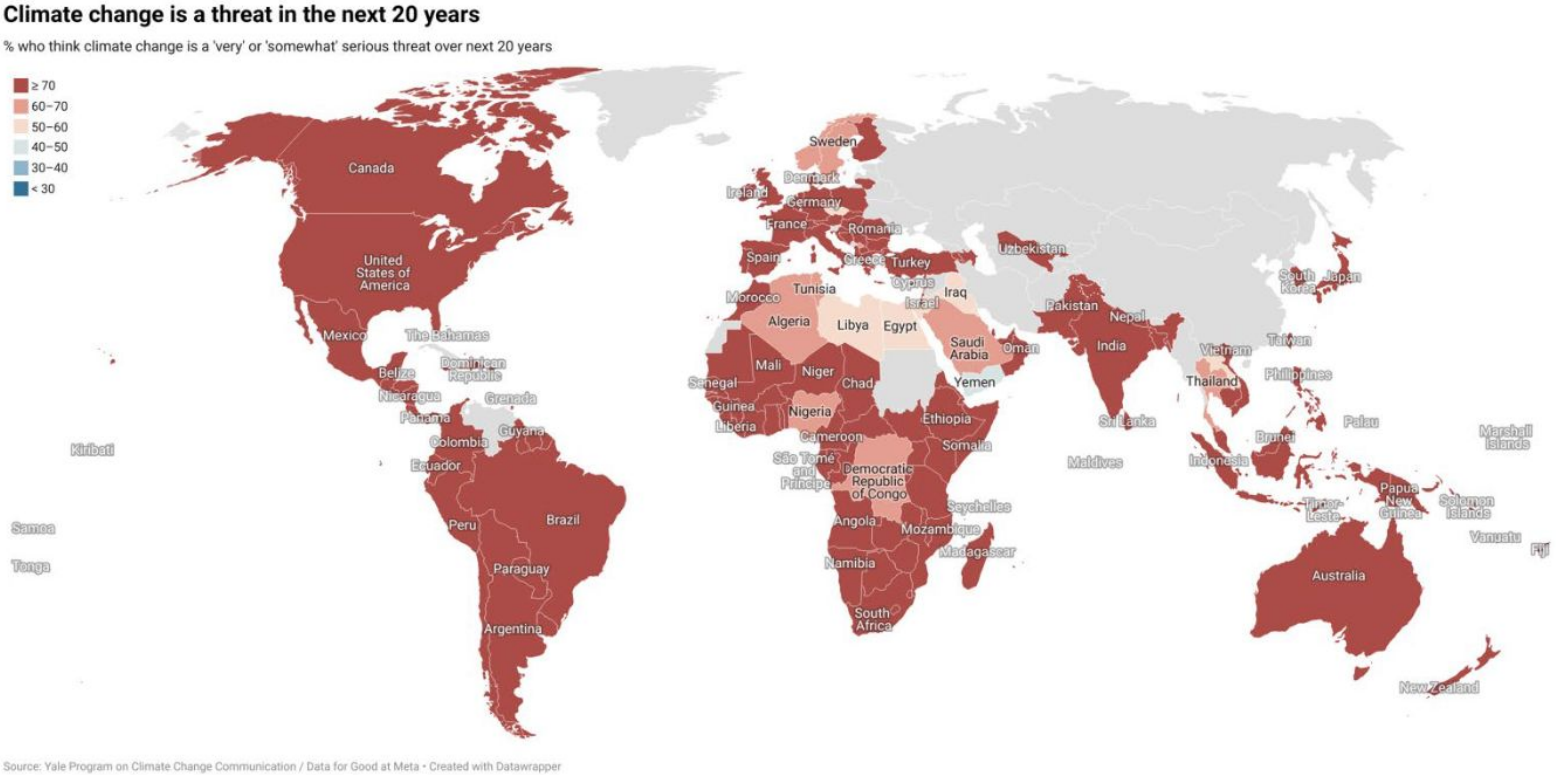

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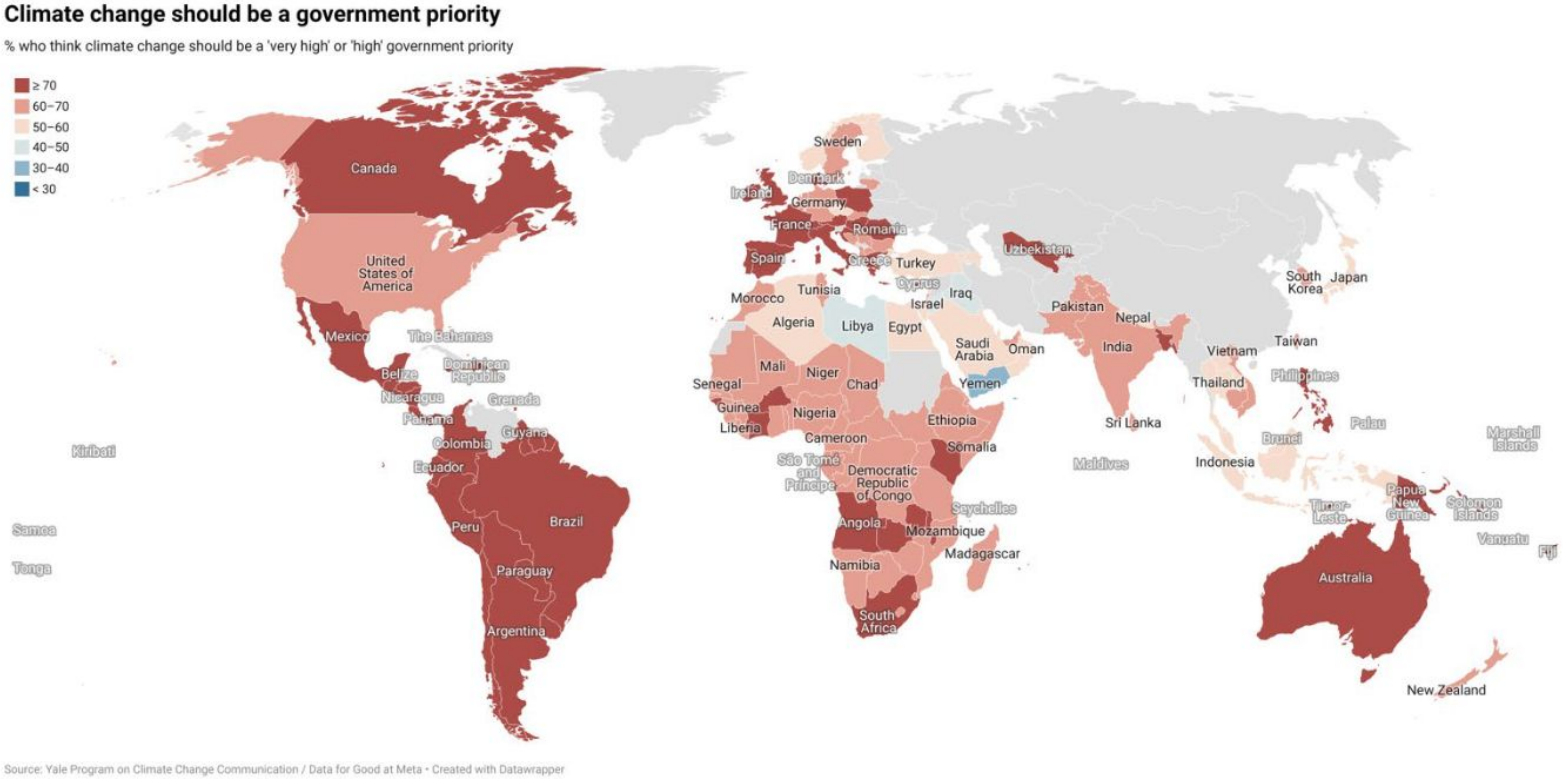

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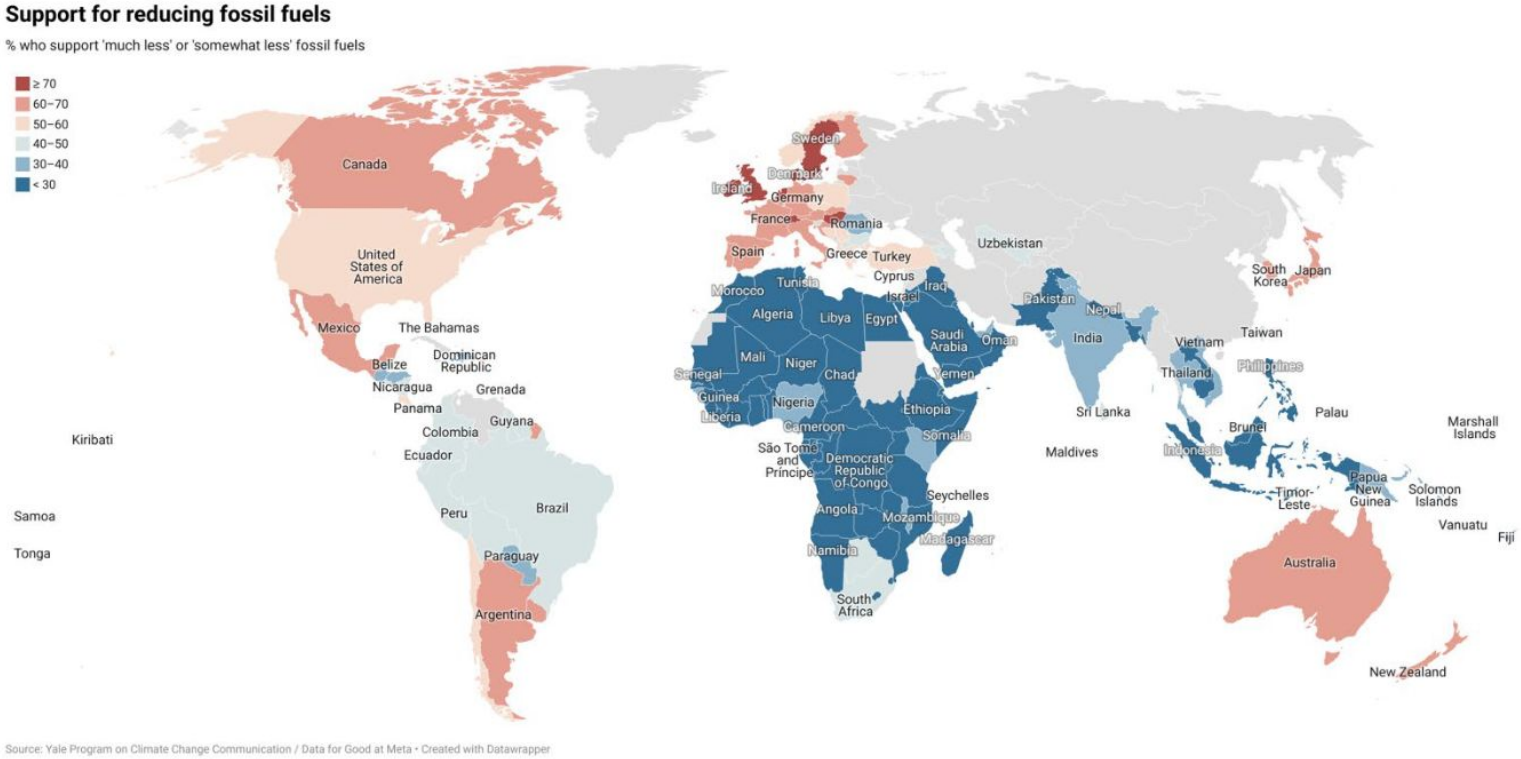


Can we change people's minds?

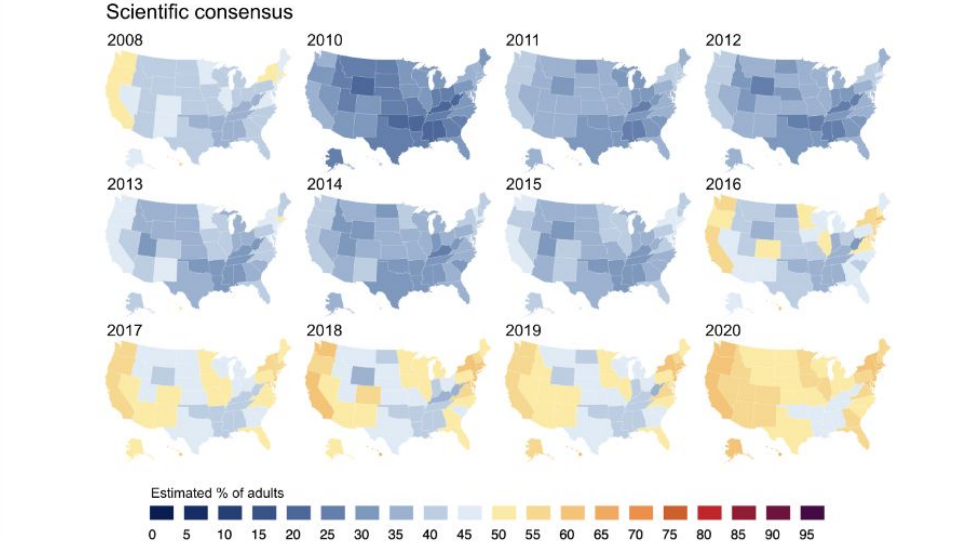


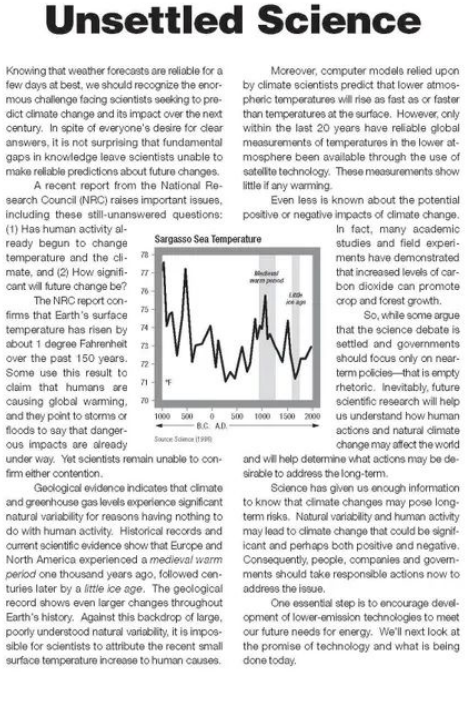
Figure 1. Variations in percentage of Americans by state and over time who think that most scientists think that global warming is happening, 2008–2020.

It's already been happening

https://iopscience.iop.org/article/10.1088/1748-9326/aca702/meta

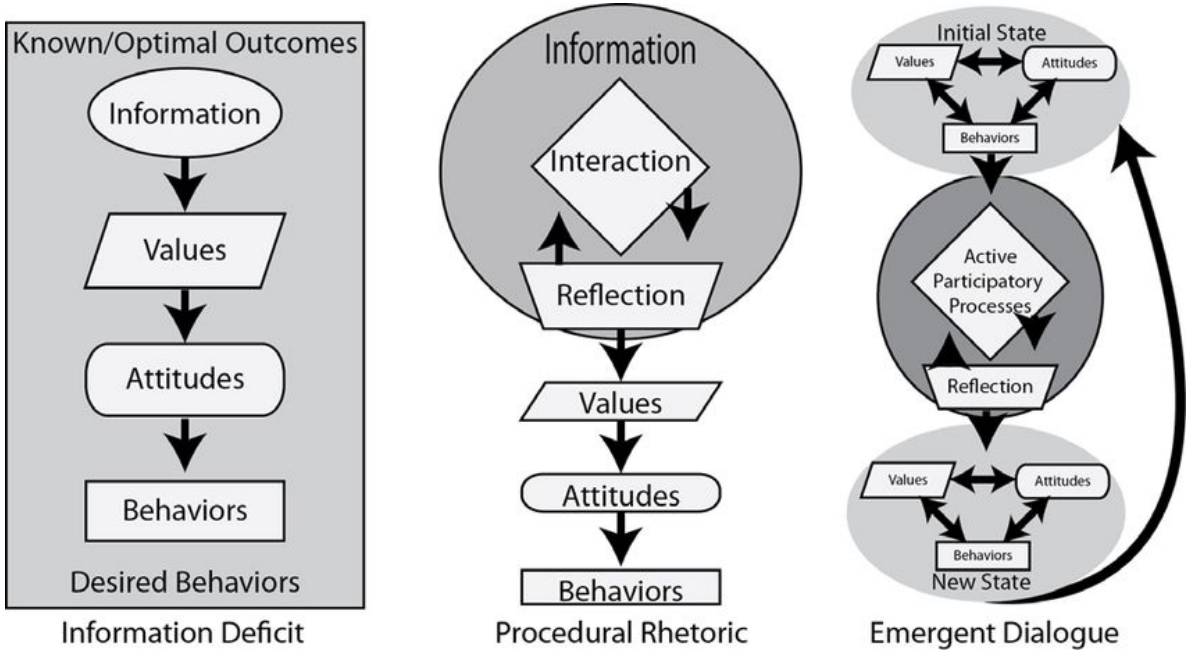
Can we change people's minds?

Oil companies have done it (in the wrong way)



'ExxonMobil's climate "advertorials" – advertisements disguised as editorials – appeared in the op-ed page of the New York Times and other newspapers and were part of what scholars have called "the longest, regular (weekly) use of media to influence public and elite opinion in contemporary America".'

What is effective at changing minds?



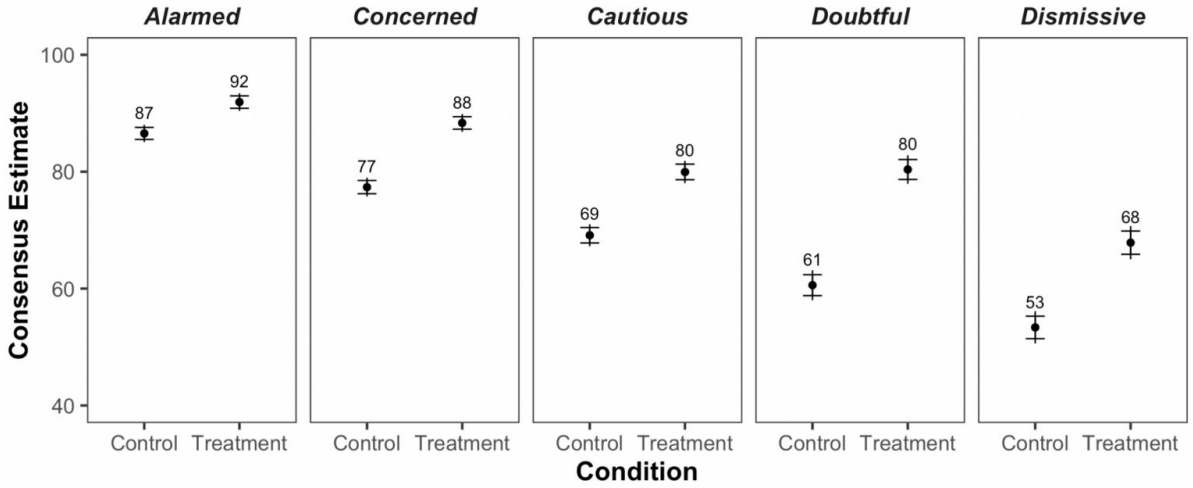
Ways to change minds depends on how you think minds work: The ability to change minds and behaviors can depend simply on providing information, or may require more involved processes of interaction and activations of a sense of identity

Tanenbaum et al., 2013

What is effective at changing minds?

Enforcing that there is scientific consensus

Estimates of the scientific consensus across conditions and audience segments



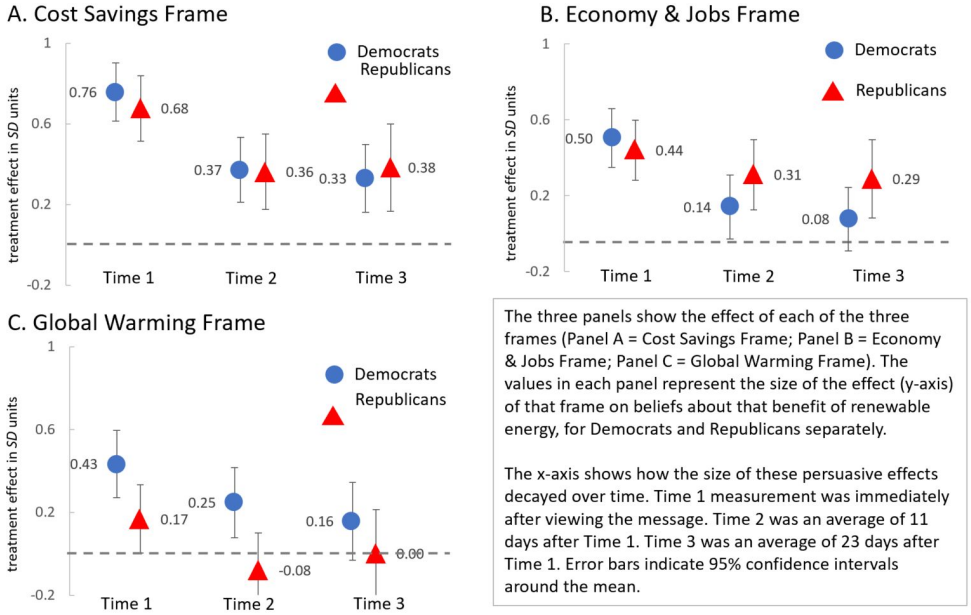
Note. Vertical error bars represent 95% confidence intervals. Horizontal error bars represent 83% confidence intervals to facilitate visual comparisons of significant differences at $p = .05$. Values are means adjusted for pre-treatment estimates of the scientific consensus.

"We delivered a consensus message (i.e., "97% of climate scientists have concluded that human-caused global warming is happening") to members of five of the six U.S. climate audiences. We found that all audiences – from *Alarmed* to *Dismissive* – updated their beliefs about the scientific consensus."

https://climatecommunication.yale.edu/publications/communicating-the-scientific-consensus-on-climate-change-diverse-audiences-and-effects-over-time/

What is effective at changing minds?

Emphasizing co-benefits



The three panels show the effect of each of the three frames (Panel A = Cost Savings Frame; Panel B = Economy & Jobs Frame; Panel C = Global Warming Frame). The values in each panel represent the size of the effect (y-axis) of that frame on beliefs about that benefit of renewable energy, for Democrats and Republicans separately.

The x-axis shows how the size of these persuasive effects decayed over time. Time 1 measurement was immediately after viewing the message. Time 2 was an average of 11 days after Time 1. Time 3 was an average of 23 days after Time 1. Error bars indicate 95% confidence intervals around the mean.

University of CINCINNATI

YALE PROGRAM ON Climate Change Communication

What is effective at changing minds?

Changing actions can change beliefs

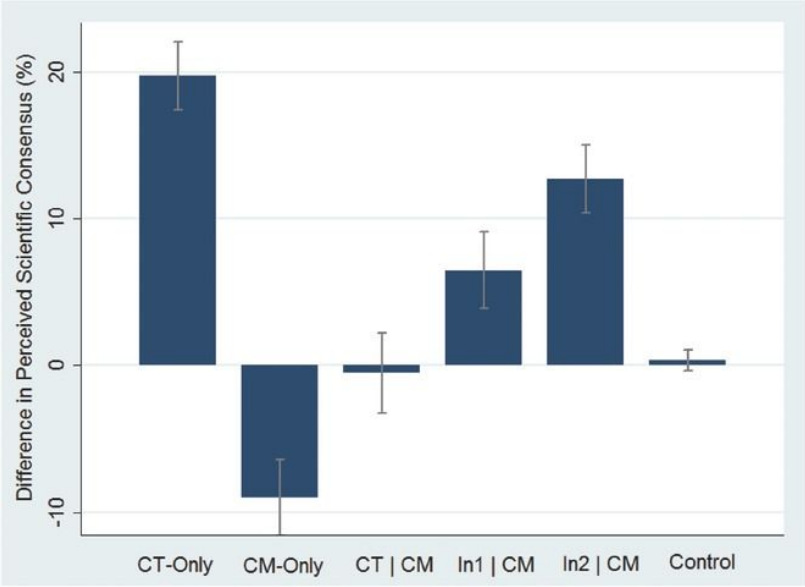
In fact, taking action with concrete solutions can actually help change minds. “Belief and action are connected,” said anthropologist Ben Orlove, co-director of the Earth Institute’s Center for Research on Environmental Decisions. “Belief is often a basis for action. But once you’re committed to a course of action, you tend to find lots of reasons for why you did it.”

Hayhoe told a story that illustrates just this point. For years, her colleague argued the science of climate change with his father who was a long-time doubter, but he was never able to change his father’s mind. Finally the local community offered a big rebate to get solar panels, so the father installed them on his house. One year later, after telling everyone what a good deal it was and how much money he had saved, the father came to Hayhoe’s colleague and said, “You know, that climate thing might be real after all.”

https://news.climate.columbia.edu/2017/08/09/what-changes-minds-about-climate-change/

What is effective at changing minds?

‘Inoculation’ against known misinformation



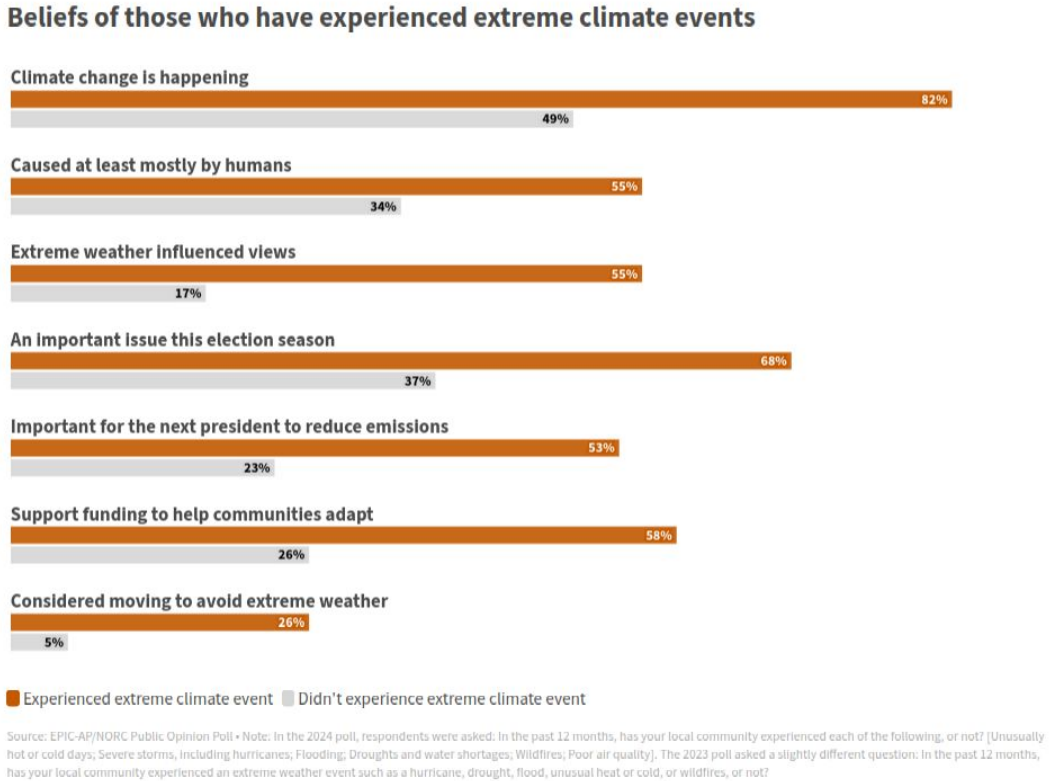
Note: CT = Consensus Treatment, CM = Counter-Message, In1 = General Inoculation, In2 = Detailed Inoculation. Error bars represent 95% confidence intervals.

Letting people know that politically-motivated actors are spreading misinformation about climate change (In1 and In2) can reduce the impact of that misinformation.

https://onlinelibrary.wiley.com/doi/full/10.1002/gch2.201600008

What is effective at changing minds?

Personal experience with the effects of climate change

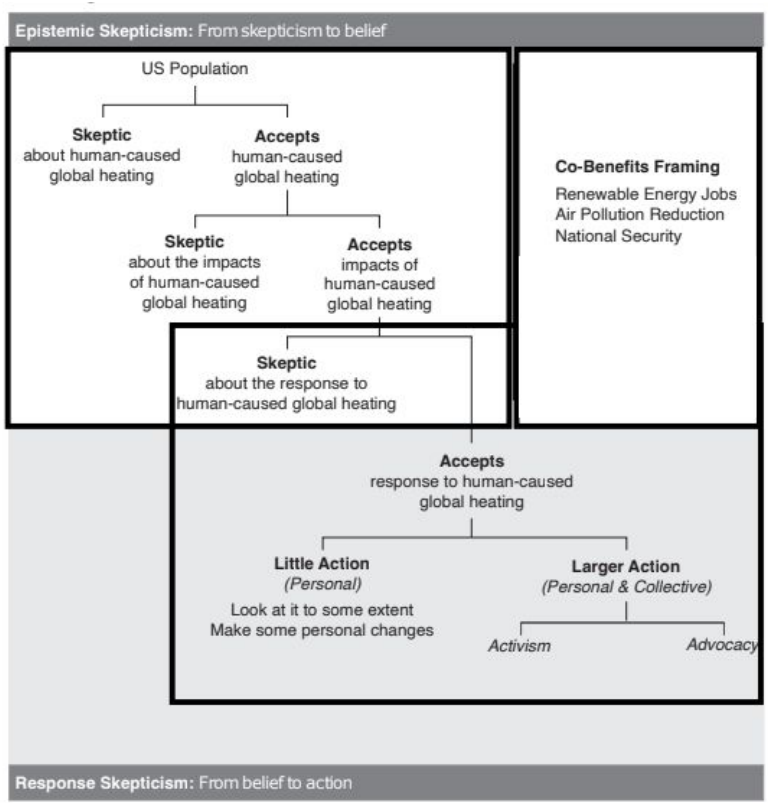


Three ways to get a broader social mobilization:

Shift the skeptics to belief

Shift the believers to action

Leverage co-benefits to get policy support



https://aronclimatecrisis.net/resources/

Natural Language Processing

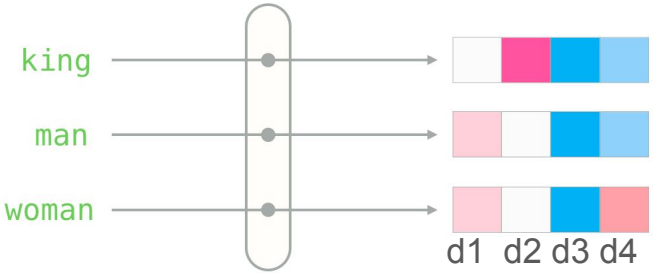
NLP requires building algorithms that can make sense of text.

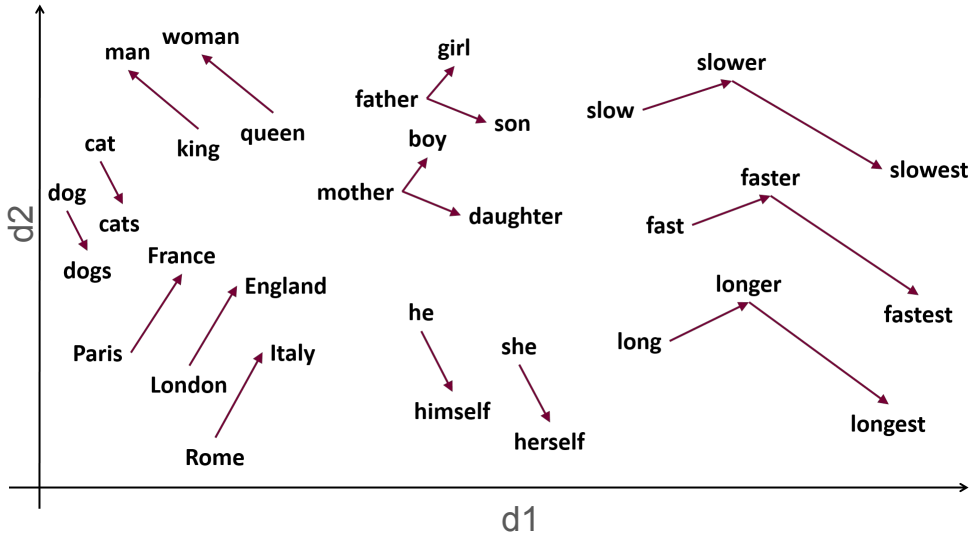
NLP tasks can be incredibly challenging due to the diverse ways in which people use language and how language relates to the real world.

https://datasciencedojo.com/blog/natural-language-processing-applications/

Natural Language Processing

Requirement: Represent meaning as a vector of numbers





Natural Language Processing

Requirement: Represent meaning as a vector of numbers

Simplest approach = represent words in terms of how often they co-occur with other words.

	Roses	are	red	Sky	is	blue
Roses	1	1	1	0	0	0
are	1	1	1	0	0	0
red	1	1	1	0	0	0
Sky	0	0	0	1	1	1
is	0	0	0	1	1	1
Blue	0	0	0	1	1	1

What are the limitations of this?

Modern Approach

BERT: “Bidirectional Encoder Representations from **Transformers**”

Use a “Large Language Model” (LLM)

Attention Is All You Need

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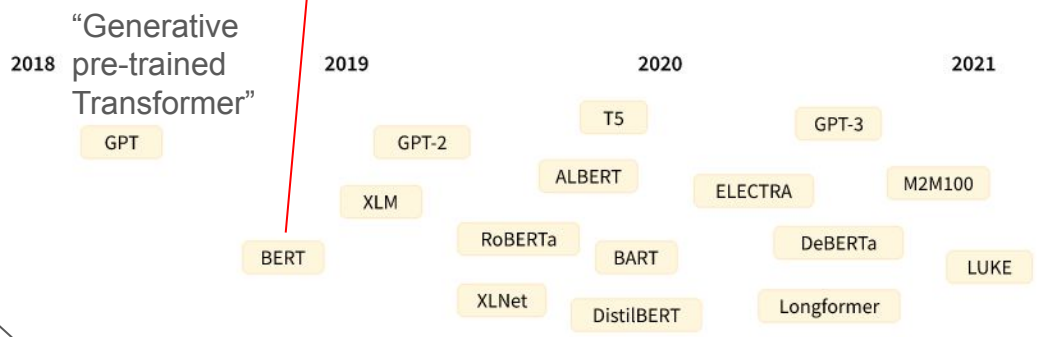
Abstract

The dominant sequence transduction models are based on complex recurrent or convolutional neural networks that include an encoder and a decoder. The best performing models also connect the encoder and decoder through an attention mechanism. We propose a new simple network architecture, the Transformer, based solely on attention mechanisms, dispensing with recurrence and convolutions entirely. Experiments on two machine translation tasks show these models to be superior in quality while being more parallelizable and requiring significantly less time to train. Our model achieves 28.4 BLEU on the WMT 2014 English-to-German translation task, improving over the existing best results, including ensembles, by over 2 BLEU. On the WMT 2014 English-to-French translation task, our model establishes a new single-model state-of-the-art BLEU score of 41.0 after training for 3.5 days on eight GPUs, a small fraction of the training costs of the best models from the literature.

Here are some reference points in the (short) history of Transformer models:

“Generative pre-trained Transformer”



The Transformer architecture was introduced in June 2017. The focus of the original research was on translation tasks. This was followed by the introduction of several influential models, including:

“Foundation Models”

As we saw previously, we can use transfer learning/fine-tuning on a pre-trained model to solve tasks where data is limited.

Foundation models take this idea to the extreme.

— WHAT IS A FOUNDATION MODEL?

In recent years, a new successful paradigm for building AI systems has emerged: Train one model on a huge amount of data and adapt it to many applications. We call such a model a foundation model.

— WHY DO WE CARE?

Foundation models (e.g., GPT-3) have demonstrated impressive behavior, but can fail unexpectedly, harbor biases, and are poorly understood. Nonetheless, they are being deployed at scale.

Our Mission

The Center for Research on Foundation Models (CRFM) is an interdisciplinary initiative born out of the Stanford Institute for Human-Centered Artificial Intelligence (HAI) that aims to make fundamental advances in the study, development, and deployment of foundation models.

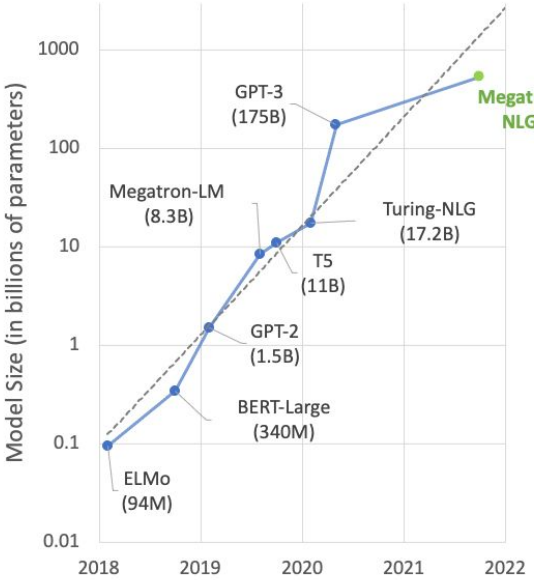
We are an interdisciplinary group of faculty, students, post-docs, and researchers spanning 10+ departments who have a shared interest in studying and building responsible foundation models.

CRFM has the following thrusts:

- **Research.** We will conduct interdisciplinary research that lays the groundwork of how foundation models should be built to make them more efficient, robust, interpretable, multimodal, and ethically sound.
- **Artifacts.** We will train and release foundation models, code, tools, and also ensure that the full training pipeline is reproducible and scientifically rigorous.
- **Community.** We will invite universities, companies, and non-profits to convene and work together to develop a set of professional norms for how to responsibly train and deploy foundation models.

Essentially, foundation models *learn good representations*.

Energy consumption of foundation models



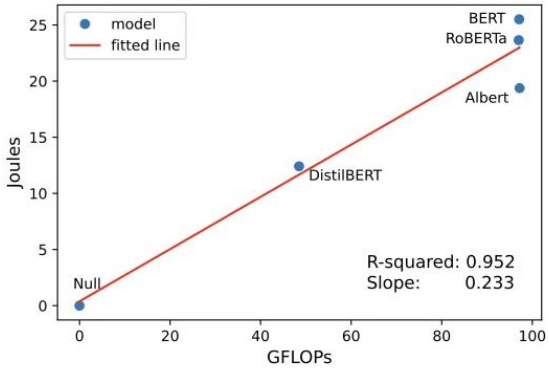
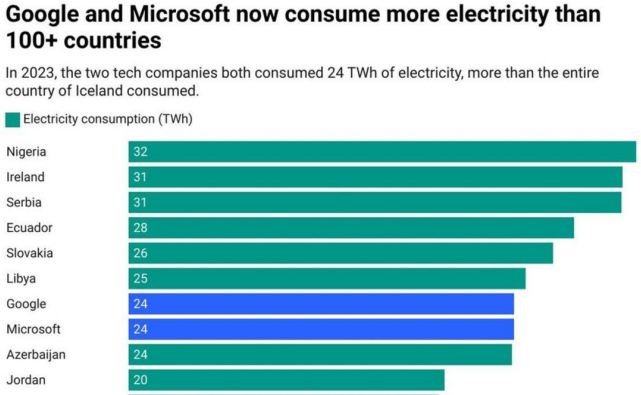


Fig 5: Regression line on CPU energy consumption per step

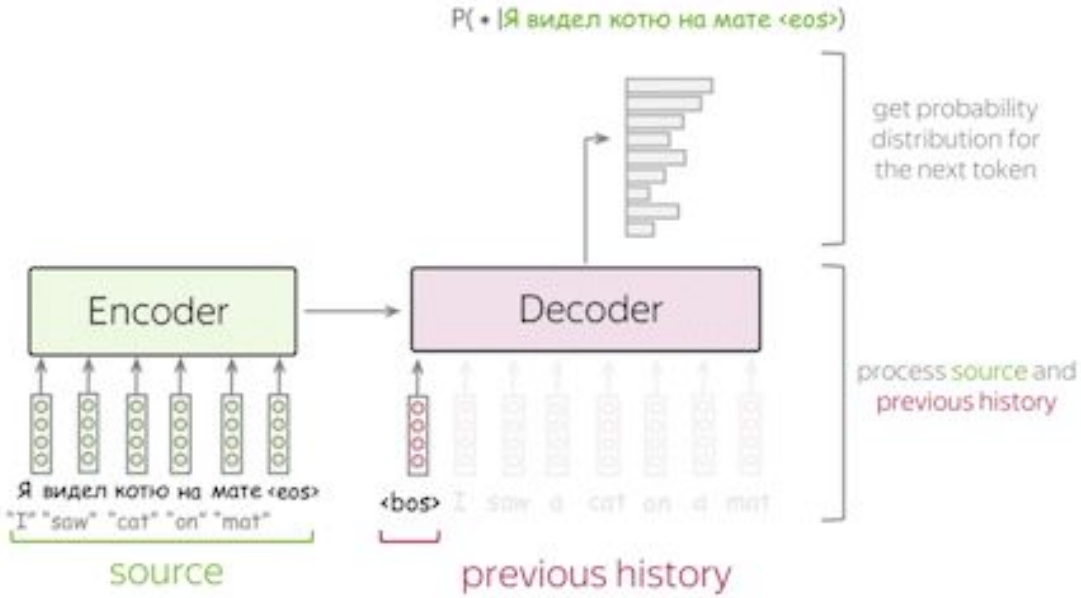


Nvidia

Google and Microsoft consume more electricity than 100+ countries (Image credit: Michael Thomas)

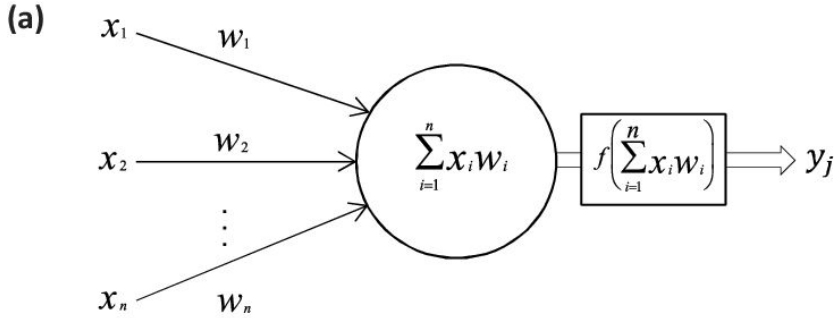
Architecture of a Large Language Model

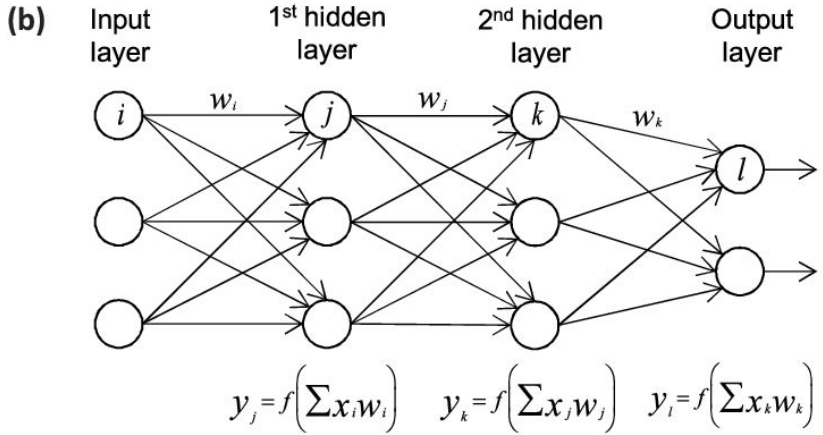
Many language tasks are “sequence to sequence” problems that can be solved with an encoder and decoder. The encoder and decoder are each artificial neural networks



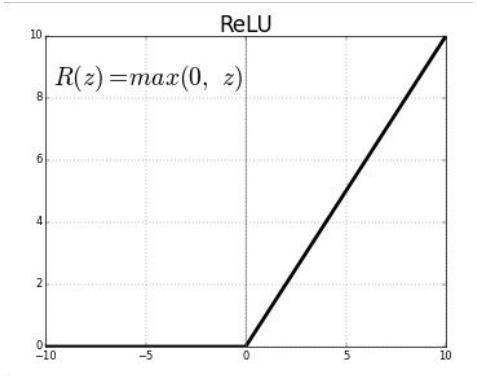
https://lena-voita.github.io/nlp_course/seq2seq_and_attention.html

Neural networks



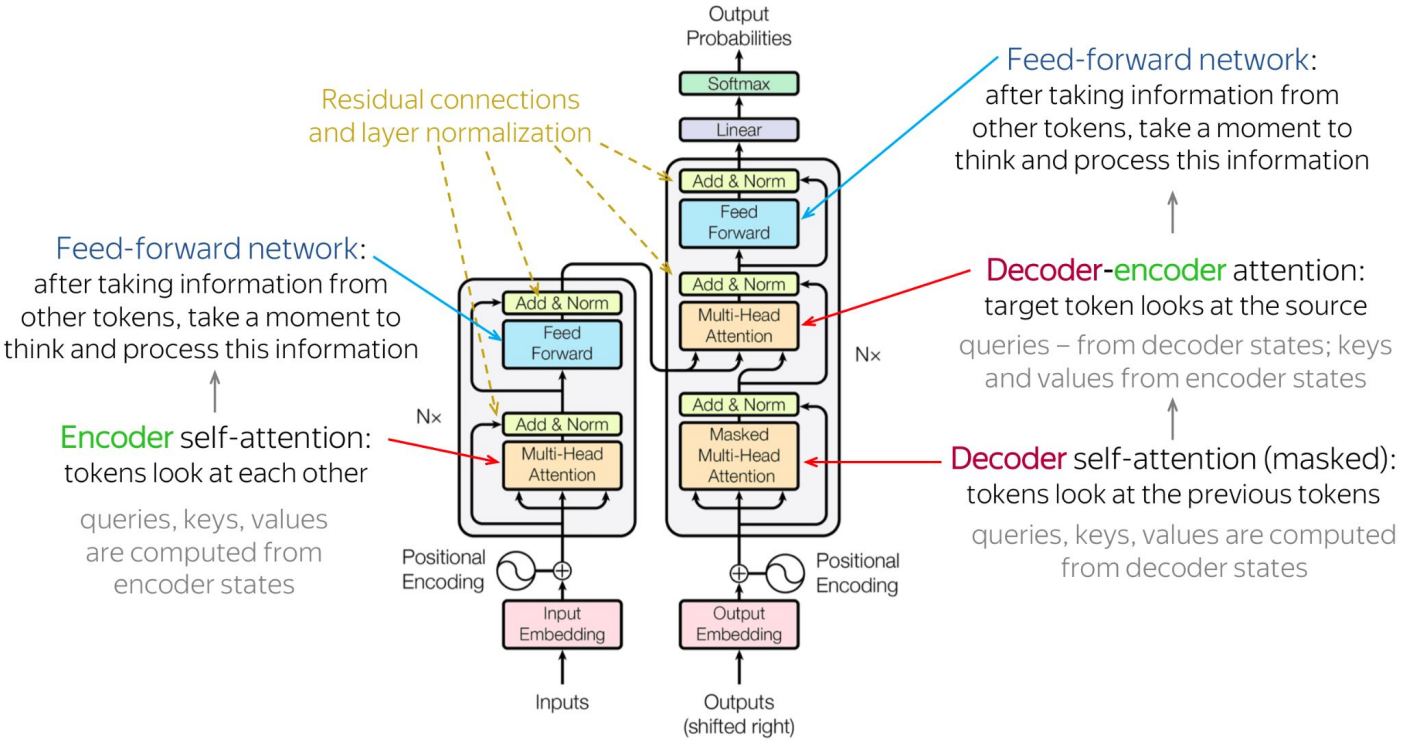


Basic or “vanilla” networks multiple weights by node activity, sum these values, and rectify the sum.



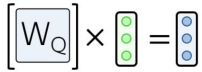
Vieira et al.

Transformer architecture



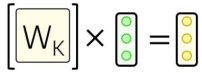
Transformer architecture

Each vector receives three representations (“roles”)



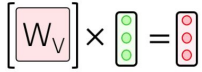
Query: vector **from** which the attention is looking

“Hey there, do you have this information?”



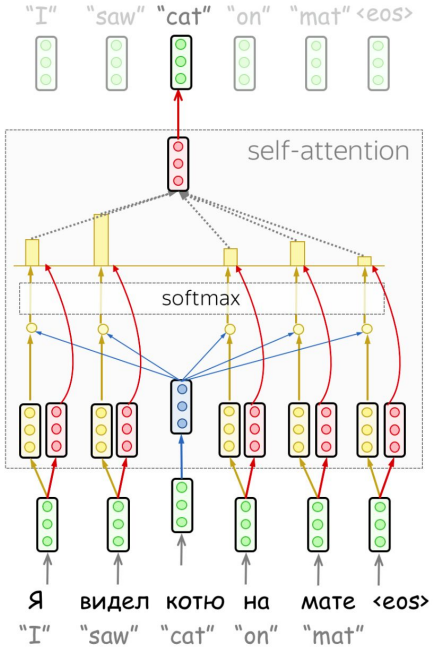
Key: vector **at** which the query looks to compute weights

“Hi, I have this information – give me a large weight!”



Value: their weighted sum is attention output

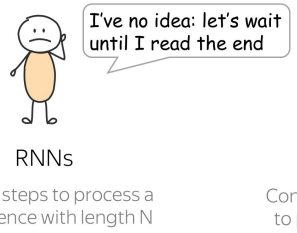
“Here’s the information I have!”



Key insight: combine information across words. This is known as “self-attention”.

I arrived at the bank after crossing the … …street? …river?

What does **bank** mean in this sentence?



RNNs

O(N) steps to process a sentence with length N

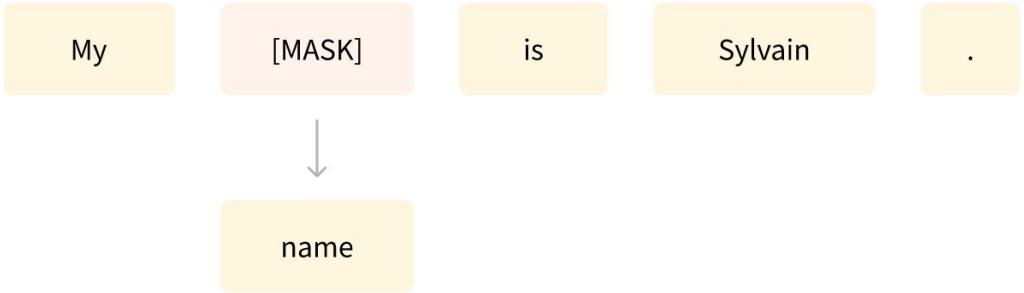
Transformer

Constant number of steps to process any sentence

LLMs can be trained on many different tasks

For example: language translation or next word prediction (ChatGPT)

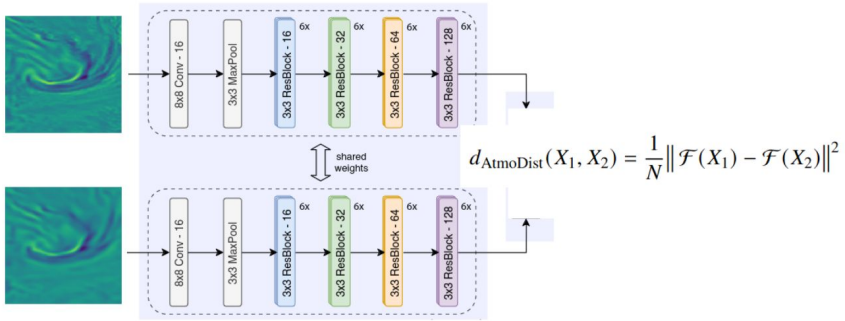
BERT is trained with a “masking” task: predict hidden word.

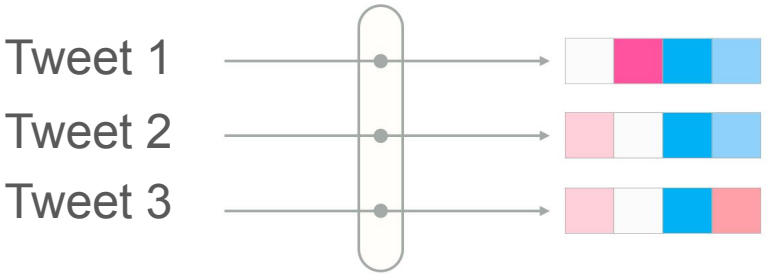


The LLM gives us a new representation

This is also known as the “embedding space”

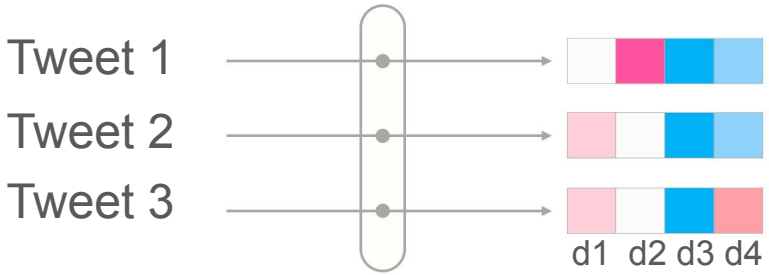
	Roses	are	red	Sky	is	blue
Roses	1	1	1	0	0	0
are	1	1	1	0	0	0
red	1	1	1	0	0	0
Sky	0	0	0	1	1	1
is	0	0	0	1	1	1
Blue	0	0	0	1	1	1

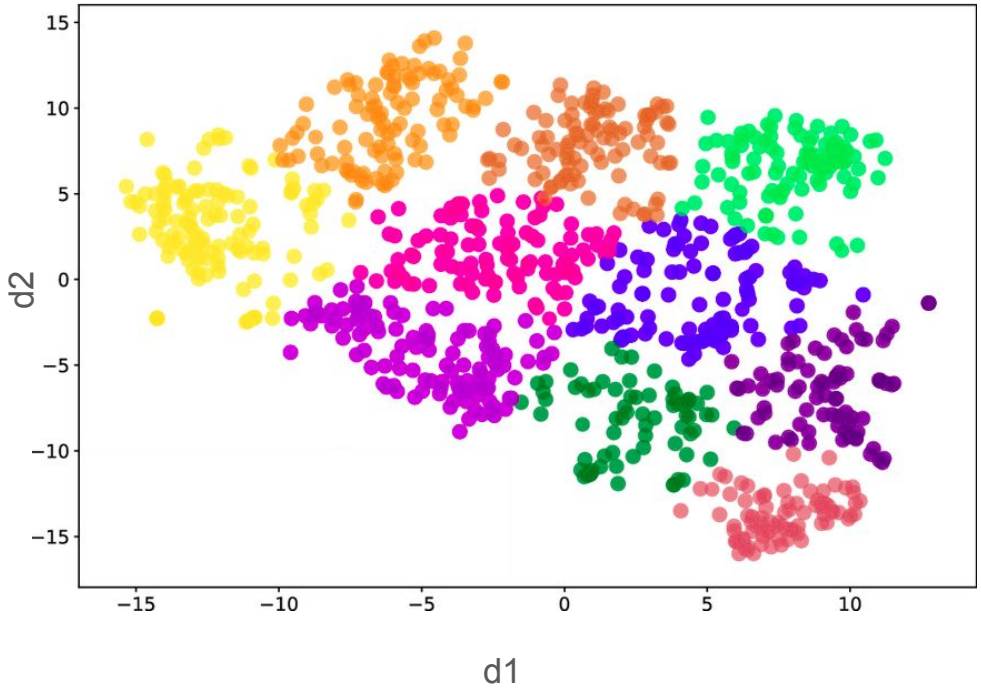




The LLM gives us a new representation

We can do things in that space, like unsupervised clustering





The output of the clustering gives us a new “topic” based representation we can use for downstream tasks

For your reading and your homework:

In machine learning settings where hyperparameters need to be set, data is typically divided into three subsets:

Training - data you actually pass to the algorithm that it uses to update weights

Validation - data you use to test the performance of models with different hyperparameters

Test - data you use to evaluate your model once you have decide on the hyperparameters

Project Plan Homework

Each member of your team should submit the same document to Brightspace by 11:59pm on April 1st.

The document should include:

A team name you make up

The names of all team members

A summary of your project plan (details on next slide)

A statement verifying that you have downloaded, opened, and explored the dataset you plan to use

I will provide feedback about your plan the day after it is due

Project Plan Homework

Summary: Do a modified PMIRO for your own research.

State the **problem** you will try to solve and how it relates to climate change. Describe the **methods** you will try on the problem and why they are appropriate for the data you have chosen (include the specific data you will be working with). State how your planned work is **substantial** enough for the project. Describe how you will **evaluate** the model for your results. Discuss **issues you anticipate** encountering (will a lot of data cleaning be required, will you need to do a lot of hyperparameter testing, are you working with something you've never used before, etc).

Projects - Reminder

Rough guidelines for creating a **substantial** project:

- Compare multiple methods and/or hyperparameters
- Use at least one method that isn't in scikit-learn (Rijul will be going through PyTorch code in labs)
- Explore feature importance methods
- Create your own dataset from multiple sources
- Use multiple evaluation methods
- Include advanced visualizations and/or a dashboard (but it better be really good)
- etc

Look at last week's slides!