Health Impacts

Predicting and responding to changing health issues with climate change

Assignments

Keep working on your projects!

Discussion question:“What do you think of NYU's 2040now campaign?”
https://www.nyu.edu/about/university-initiatives/2040-now.html

Due Friday by midnight

Homework #4 - Dengue fever cases

Due Monday the 17th by midnight

Climate change in the news

Climate change in the news

CLIMATE CHANGE

Buildings Crumble High in the Alps as Permafrost Thaws

Safe access to the world's tallest peaks could disappear as temperatures rise in the Alps

By Alessio Perrone on April 3, 2023

At Rifugio Casati, a four-story building 10,725 feet above sea level in the Italian Alps, **cracks spread across the walls, indoor tiles began to fracture, doors ceased to close properly, and a corner of the terrace sank by more than a foot.**

Rifugio Casati sat on permafrost-rich soil that warming temperatures were thawing. The soil's shifting morphology was straining the building's foundation, and the southern part of the building appeared to be sinking. Rock falls were becoming more frequent on the mountainside, too, and coming closer and closer to the building. **Authorities will have to demolish and rebuild the structure in a more stable position in the next few years.**

In the past few years thawing permafrost has threatened dozens of huts, access trails and cable car poles, caused **millions of dollars to be spent on damages and preventive measures** and prompted some experts to q**uestion the sustainability** of certain high-altitude outposts and activities.

Climate change in the news

MATT SIMON SCIENCE APR 4, 2023 7:00 AM

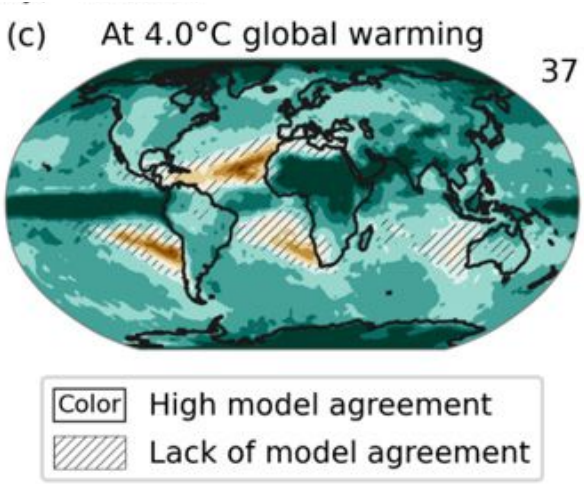
A Toxic Time Bomb Is Ticking in the Arctic

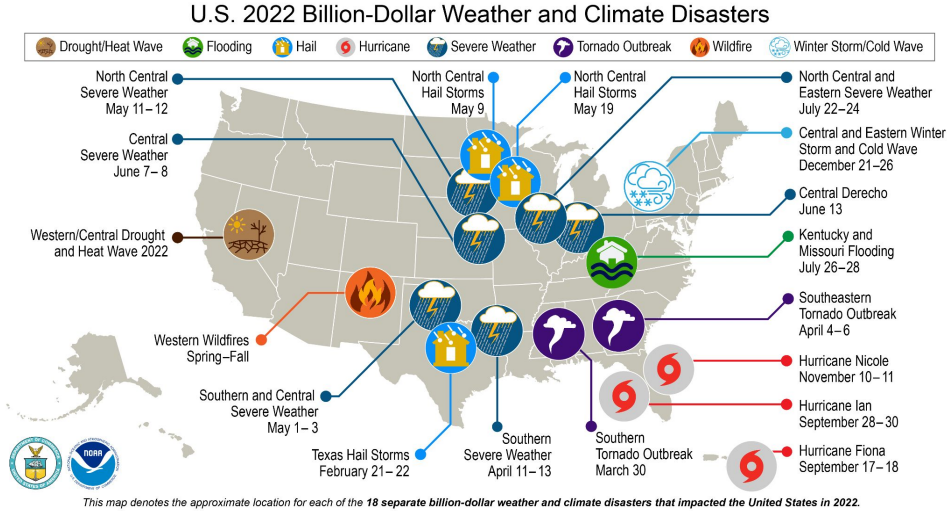
Thousands of contaminated sites are sitting on permafrost that'll soon thaw, a looming disaster that could spread beyond the region.

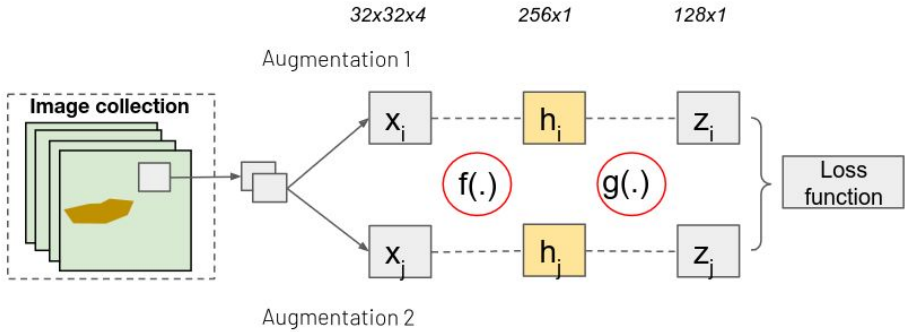
People have been storing toxic materials in permafrost: Oil leaks come from both wells and from pipelines. Radioactive material is buried around military bases. Pesticides like DDT are packed in barrels, then buried. Mining operations are notorious for emitting heavy metals like mercury; other sites are full of arsenic, lead, and other highly toxic elements and compounds.

An alarming new paper in the journal *Nature Communications* estimates that between 13,000 and 20,000 contaminated sites are splayed across Arctic permafrost regions, with 3,500 to 5,200 in areas that'll be affected by thawing soils before the end of the century.

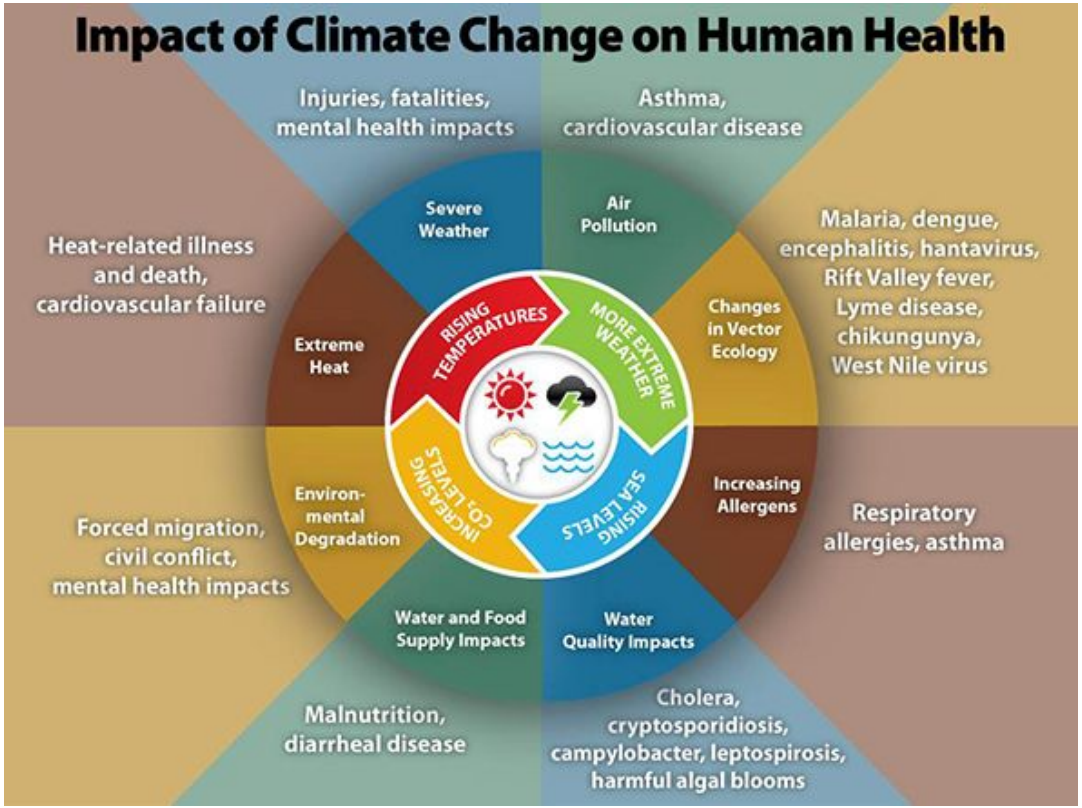
Recap


(c) At 4.0°C global warming
37
Color High model agreement
Lack of model agreement


U.S. 2022 Billion-Dollar Weather and Climate Disasters
Drought/Heat Wave
Flooding
Hail
Hurricane
Severe Weather
Tornado Outbreak
Wildfire
Winter Storm/Cold Wave
North Central Severe Weather May 11–12
Central Severe Weather June 7–8
Western/Central Drought and Heat Wave 2022
Western Wildfires Spring–Fall
Southern and Central Severe Weather May 1–3
Texas Hail Storms February 21–22
North Central Hail Storms May 9
North Central Hail Storms May 19
Southern Severe Weather April 11–13
Southern Tornado Outbreak March 30
North Central and Eastern Severe Weather July 22–24
Central and Eastern Winter Storm and Cold Wave December 21–26
Central Derecho June 13
Kentucky and Missouri Flooding July 26–28
Southeastern Tornado Outbreak April 4–6
Hurricane Nicole November 10–11
Hurricane Ian September 28–30
Hurricane Fiona September 17–18
This map denotes the approximate location for each of the 18 separate billion-dollar weather and climate disasters that impacted the United States in 2022.


32x32x4
256x1
128x1
Augmentation 1
Image collection
x_i
h_i
z_i
f(.)
g(.)
Loss function
x_j
h_j
z_j
Augmentation 2

Health Impacts of Climate Change



cdc.gov

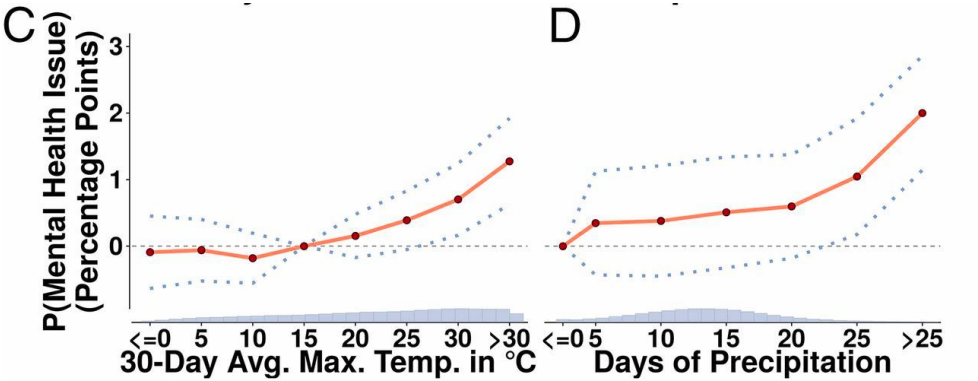
Direct impacts of increasing temperature

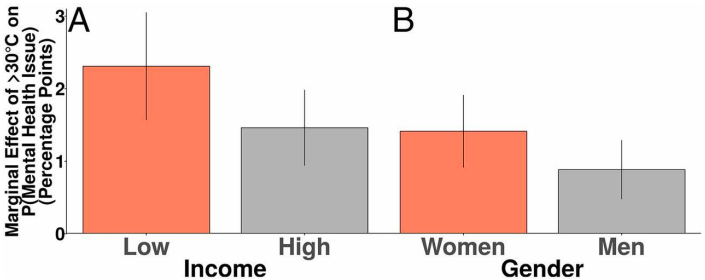
- Many cities have already seen increased deaths from heat waves
- Heat waves are also associated with increased hospital admissions for cardiovascular, kidney, and respiratory disorders
- Urban heat island effect makes heat waves worse
- Better forecasting can help

- Milder winters resulting from a warming climate can reduce illness, injuries, and deaths associated with cold and snow.

cdc.gov

Weather and mental health

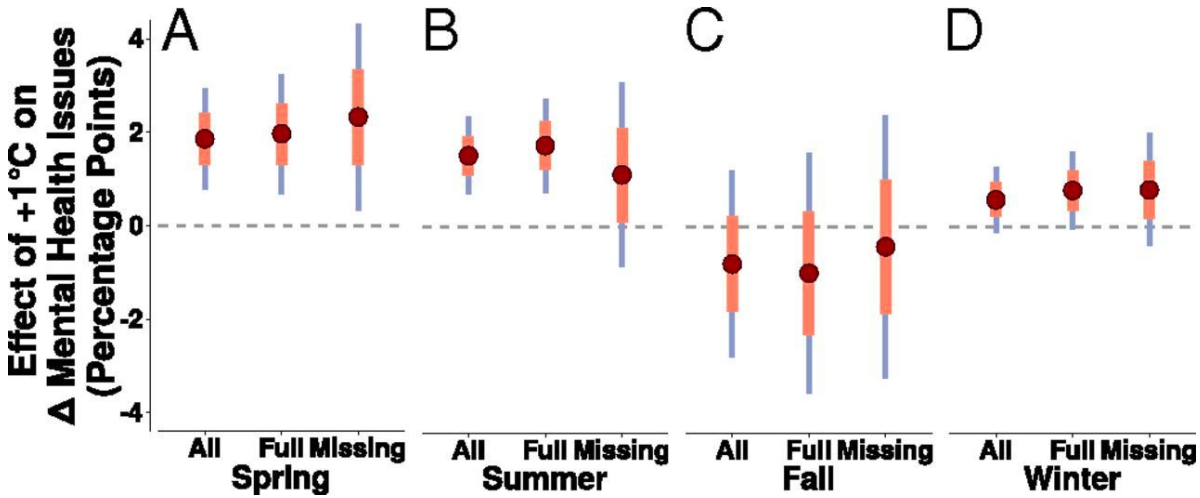




Excessive heat and precipitation are associated with small but significant increases in mental health issues

https://www.pnas.org/doi/10.1073/pnas.1801528115

Weather and mental health



Continued climate change is expected to increase and redistribute mental health issues over time

https://www.pnas.org/doi/10.1073/pnas.1801528115

Weather and mental health

Rising temperatures have been associated with:

- mental fatigue
- aggression
- suicide

Climate change and air quality

- Heat increases smog and ozone and wildfires create pollution
- These changes in air quality are related to diminished lung function, increased hospital visits for asthma, and increases in premature deaths (1,000 to 4,300 additional premature deaths nationally per year by 2050)
- Higher pollen concentrations and longer pollen seasons, causing more people to suffer more health effects from pollen and other allergens

ENVIRONMENT

The Western Wildfires Are Affecting People 3,000 Miles Away

July 21, 2021 · 5:25 PM ET

By Josie Fischels

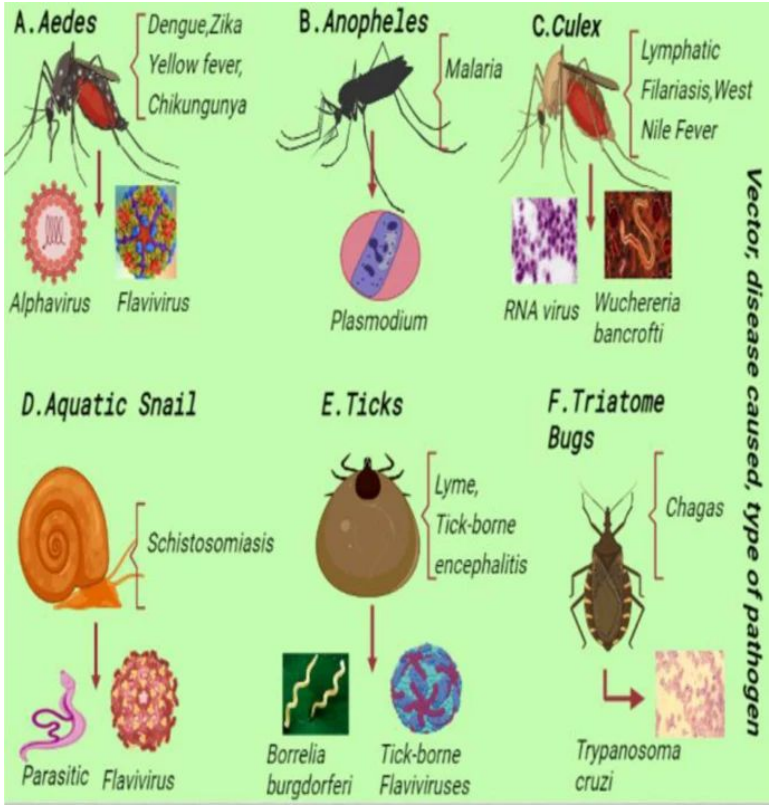
A thick haze hangs over Manhattan on Tuesday. Wildfires in the West, including the Bootleg Fire in Oregon, are creating hazy skies and poor air quality as far away as the East Coast.

Julie Jacobson/AP

cdc.gov

Vector-borne diseases

- Fleas, ticks, and mosquitoes spread pathogens that cause illness
- The impact of these vectors depend on climate, land use, socioeconomic and cultural factors, pest control, access to health care, and human responses to disease risk



https://link.springer.com/article/10.1007/s11831-022-09724-9

Paper Deep Dive

Predicting Future Mosquito Larval Habitats Using Time Series Climate Forecasting and Deep Learning

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The problem

Mosquito habitats will change as a result of changing climates

To adapt local communities to the threat of mosquito-borne viruses and offer preventative measures, knowledge of where mosquitoes will expand to is valuable

Goal: predict where mosquitoes will be in the future.

Brainstorm

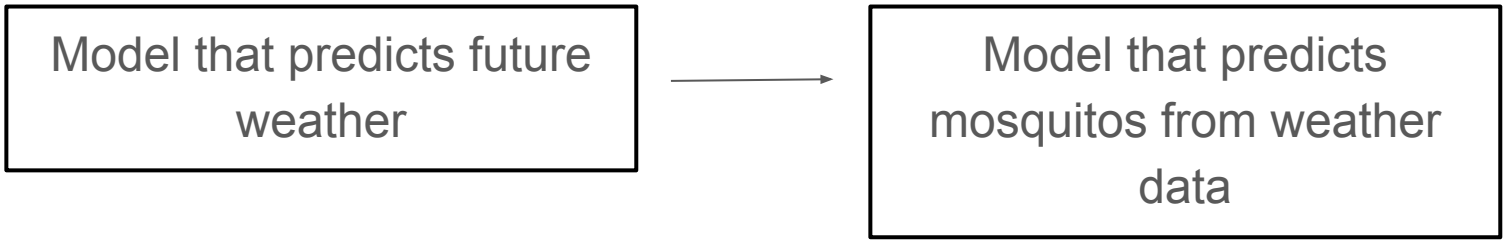
What kind of data would you want to have to be able to approach this problem?

What kind of methods would you apply?

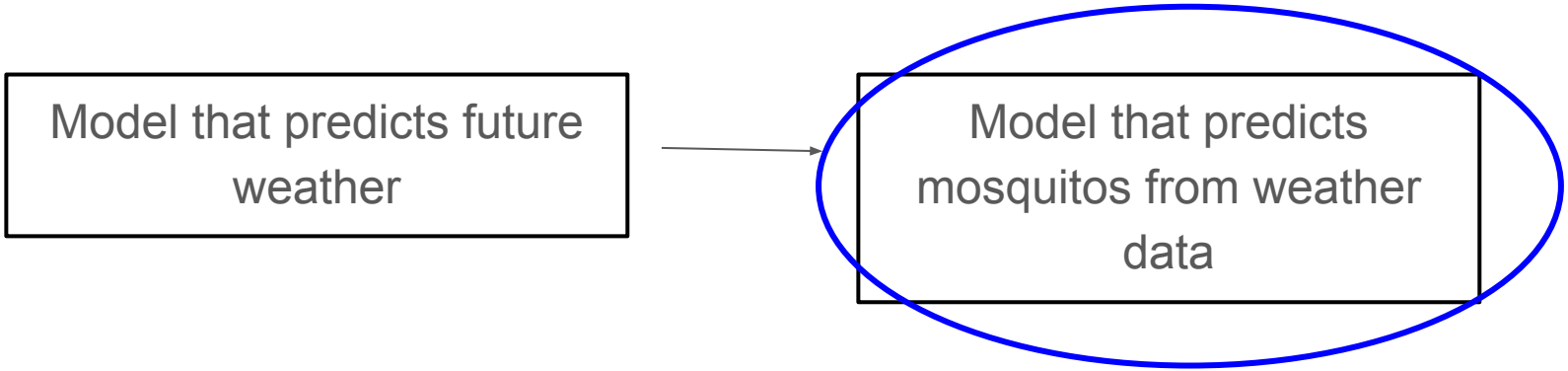
How would you measure success?

What difficulties might you face?

Overall method



Overall method



The data

GLOBE Mosquito Habitat Mapper - a citizen science tool

Provides the count and type of water source (e.g. still vs flowing) in which larvae were observed.

The data

GLOBE Mosquito Habitat Mapper - a citizen science tool

Provides the count and type of water source (e.g. still vs flowing) in which larvae were observed.

Any issues with data collected this way?

The data

Weather data from publicly available archives such as Weather Underground.

Found the monthly averages of daily maximum, mean, and minimum **temperature**, as well as **precipitation** amount and days of precipitation, were collected.

Data problem

Weather variables in their data set only come from airports.

Why is this a potential issue and how can it be resolved?

Data problem

Weather variables in their data set only come from airports.

Why is this a potential issue and how can it be resolved?

“Mosquito larvae records from locations with no airports within a 30-mile vicinity were excluded”
This left 166 data points, starting from ~2019.

The method

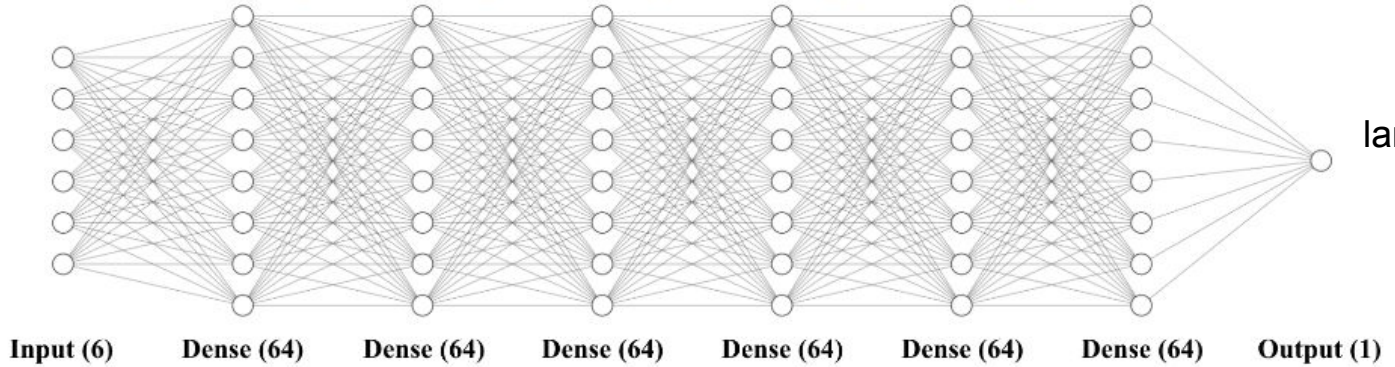
First step, predict larvae count from weather variables + elevation.

The method

First step, predict larvae count from weather variables + elevation.

Use a feedforward artificial neural network

weather and elevation



larvae count

Contains 21,313 parameters
>> 166*6

The method

Next, make a model that can predict future weather

The method

Next, make a model that can predict future weather

The data: Average summer temperature for each of the 48 contiguous states from 1979-2021

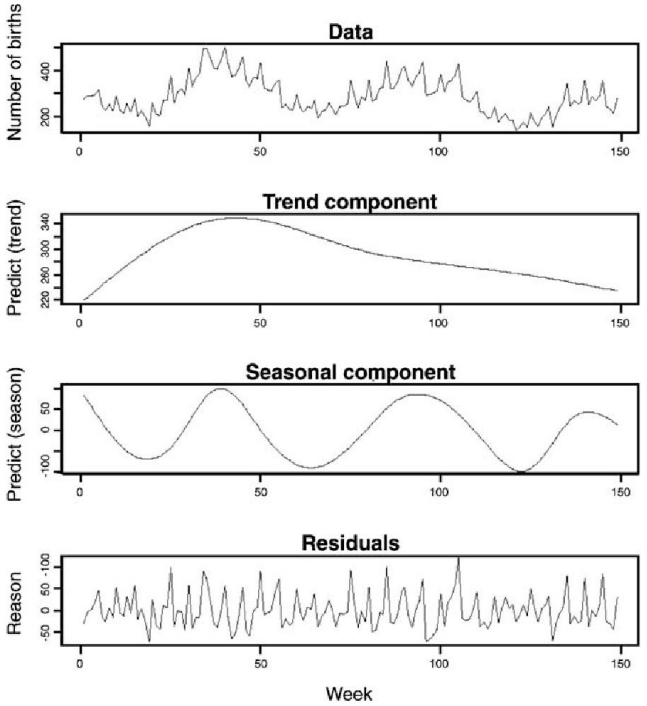
Time Series Analysis

A data analysis technique based on data that

-is sampled at regular intervals

-has some discernable trends

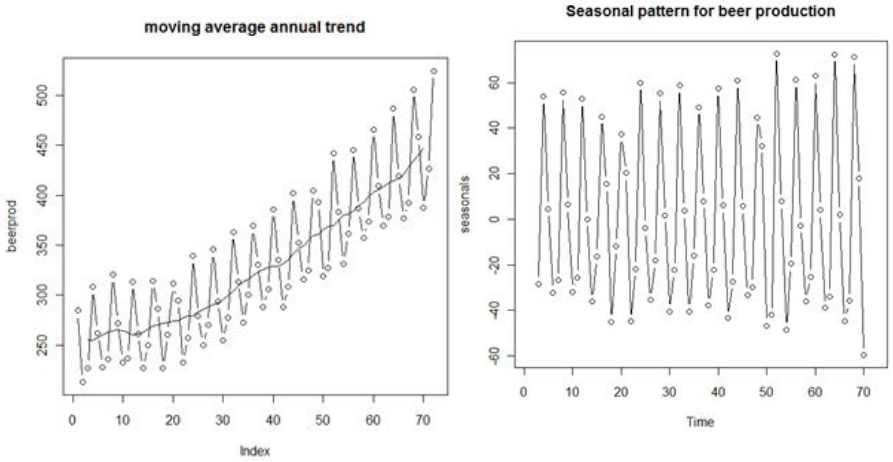
-can be univariable

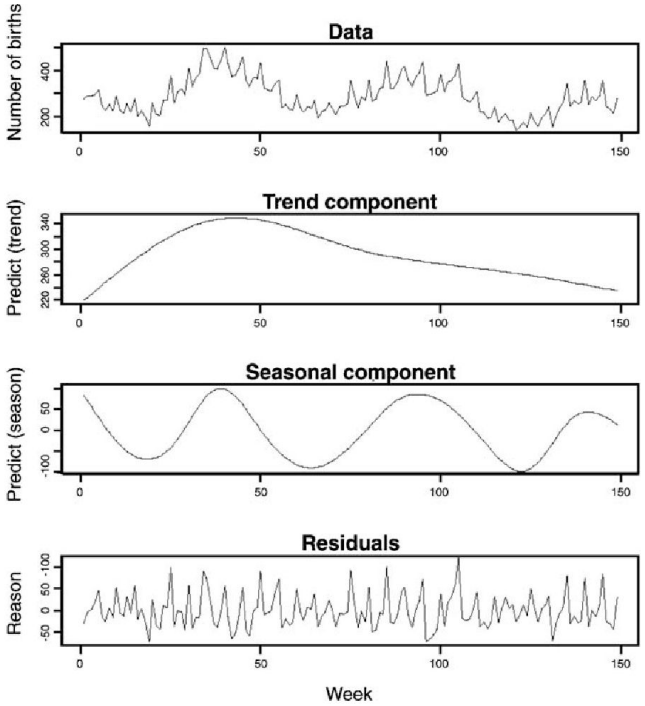


Zeger et al 2016

Time Series Analysis

Identifying trends and patterns
with smoothing and subtraction





stat.psu.edu

Time Series Analysis

Auto-regressive approaches

Autoregressive (AR) Models

A common approach for modeling univariate time series is the autoregressive (AR) model:

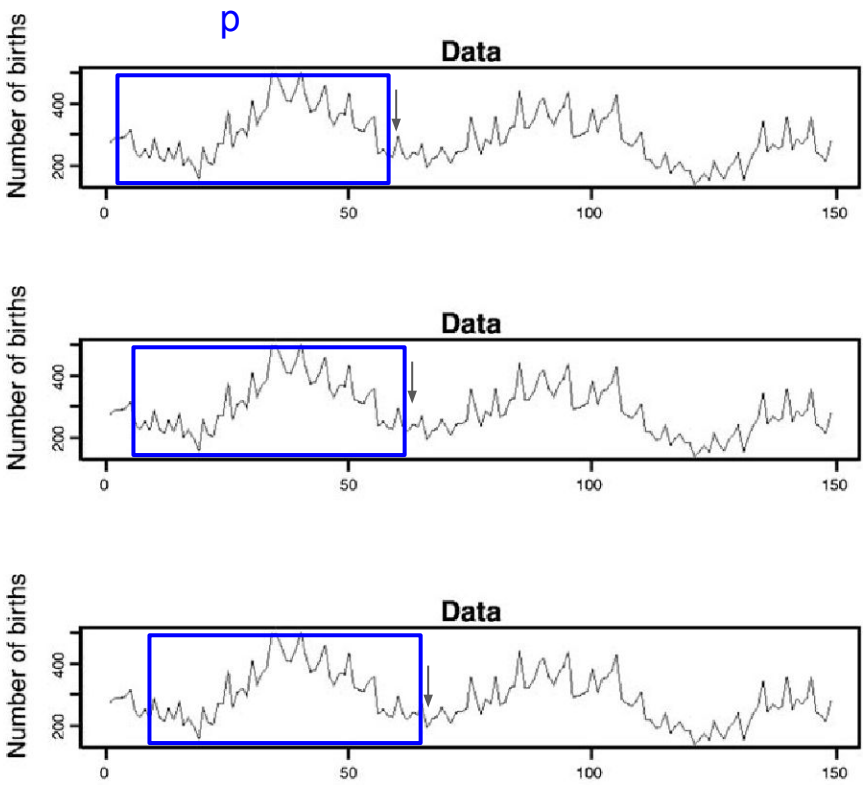
$$X_t = \delta + \phi_1 X_{t-1} + \phi_2 X_{t-2} + \cdots + \phi_p X_{t-1} + A_t$$

where X_t is the time series, A_t is white noise, and

$$\delta = \left(1 - \sum_{i=1}^{p} \phi_i\right) \mu,$$

with μ denoting the process mean.

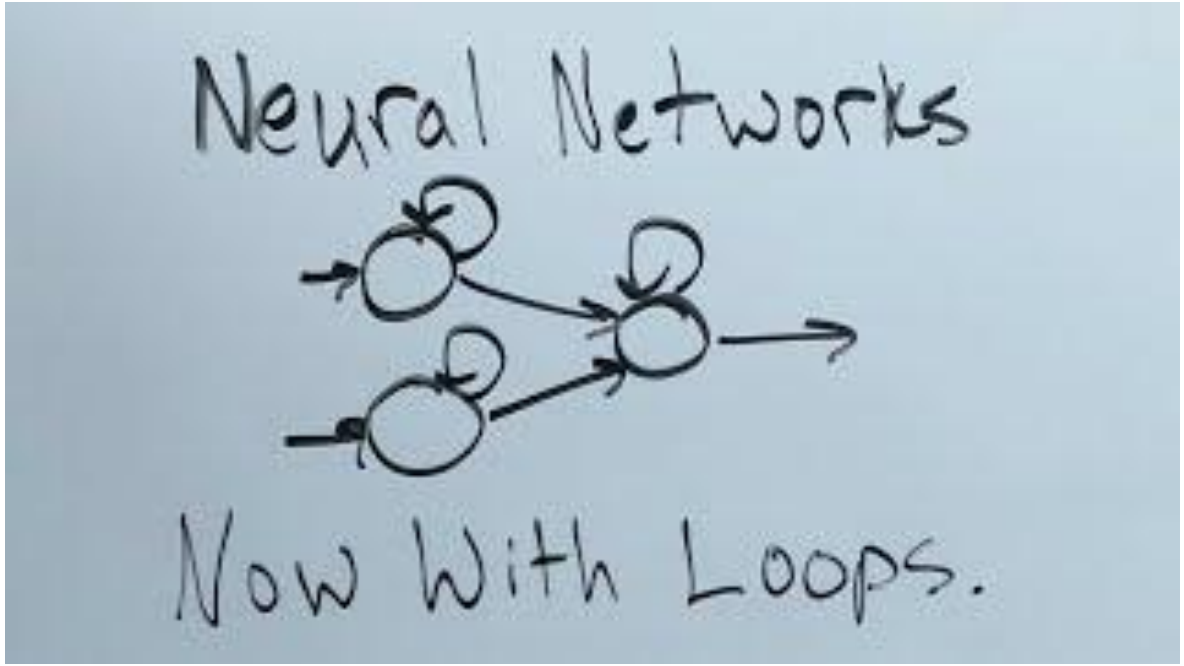
An autoregressive model is simply a linear regression of the current value of the series against one or more prior values of the series. The value of p is called the order of the AR model.



https://www.itl.nist.gov/div898/handbook/pmc/section4/pmc444.htm

Time Series Analysis

Recurrent neural networks



Time Series Analysis

Recurrent neural networks

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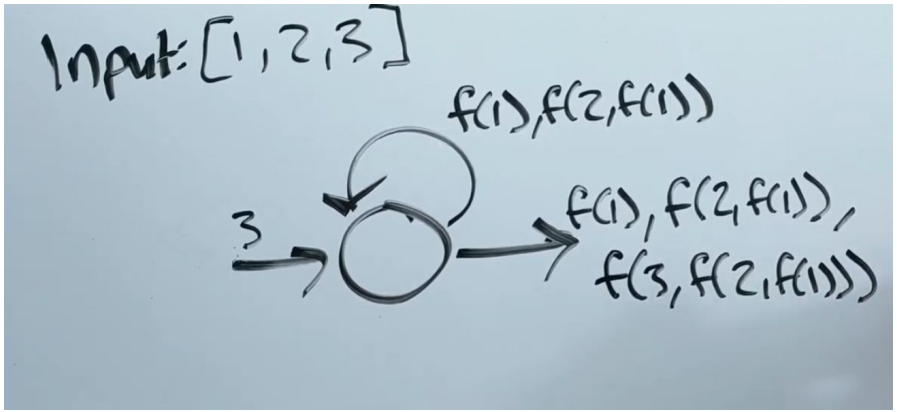
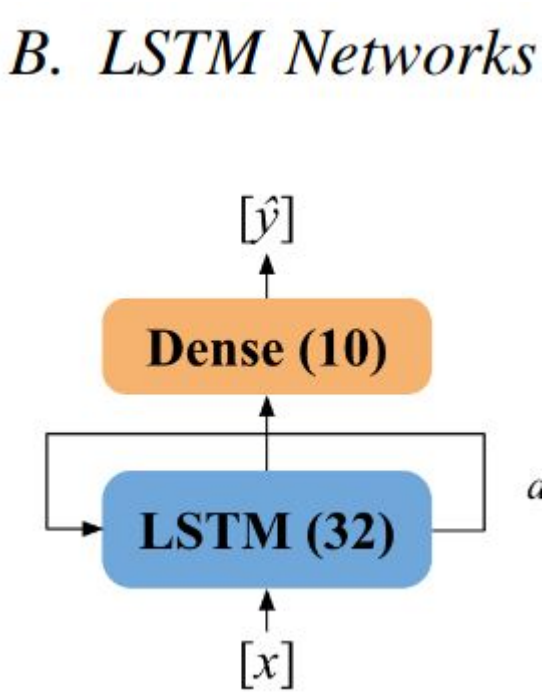


The method

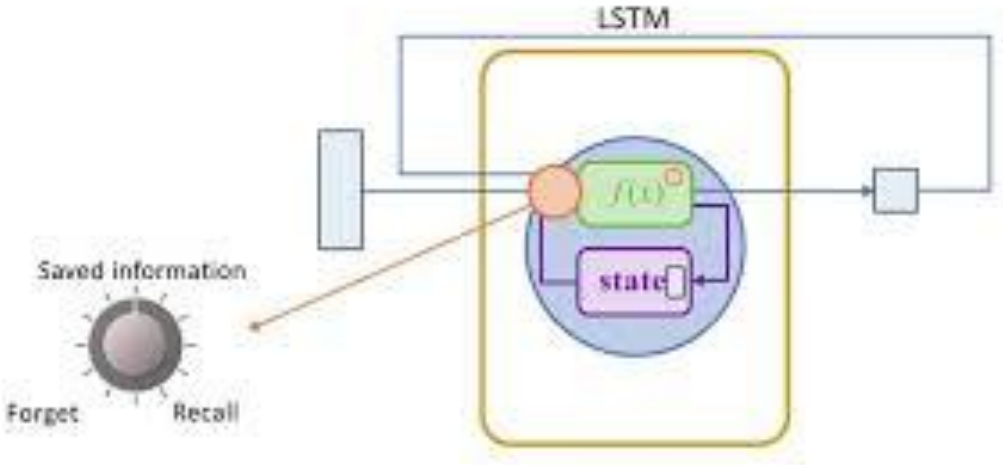
Use a recurrent neural network to predict annual weather variables.

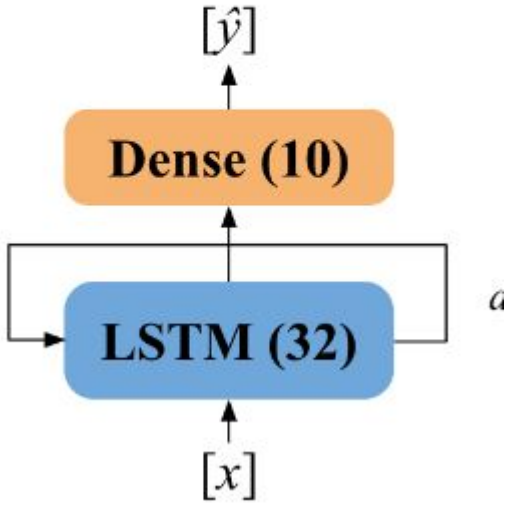
Inputs are temperature and precipitation for each location for the past 20 years and model is built to predict temperature and precipitation for 10 years forward.



The method

"Long Short Term Memory" networks

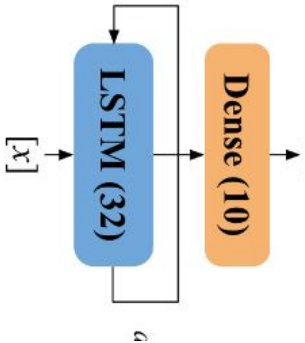


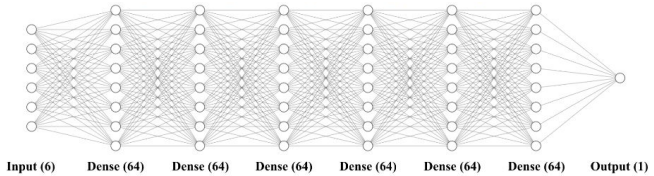


The method

Model that predicts future weather

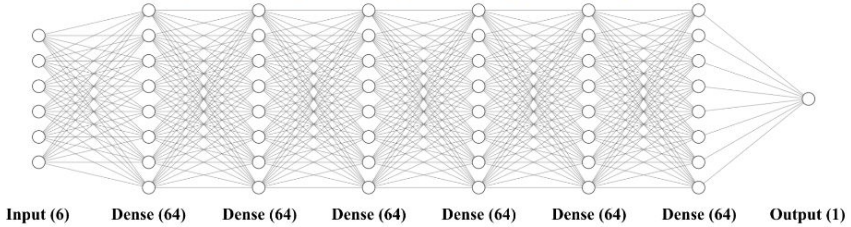
Model that predicts mosquitos from weather data

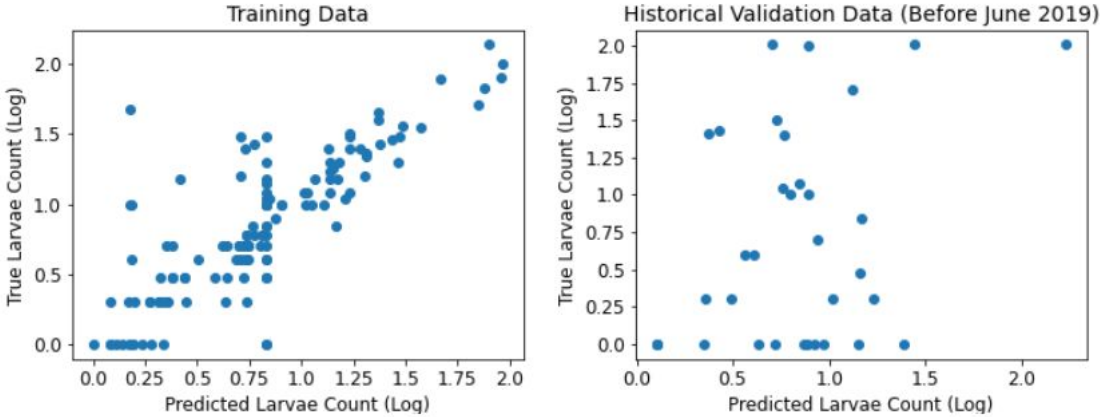




Results

ANN trained to predict mosquito larvae count from weather data:





	Training	Validation
R	0.888	0.489
P	1.26E-45	1.44E-3

Results

Recurrent model that predicts future weather

?

Results

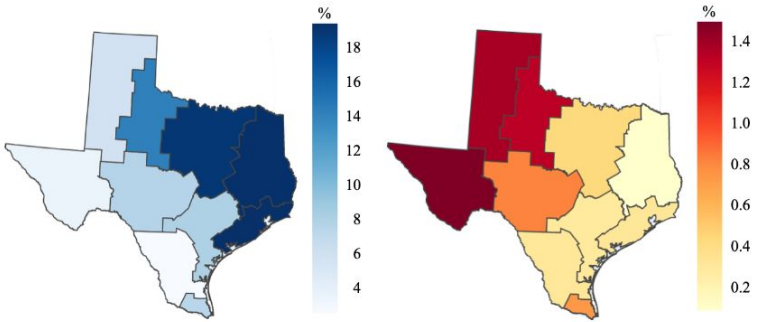


Fig. 7: Meteorological Changes in Texas Climate Divisions (2030-2050). These maps show climate forecasts for precipitation (left) and temperature (right) as a percent change.

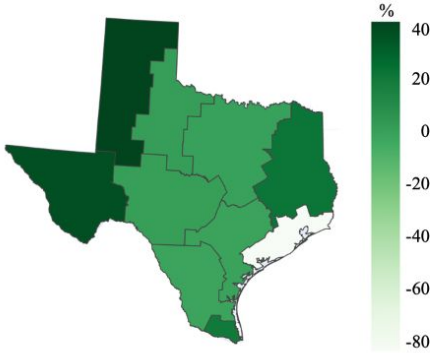


Fig. 6: Percent Change in Larvae Abundance in Texas Climate Divisions (2030-2050).

Model estimates fairly high mosquito rates in high elevation areas, which don't currently have mosquitos

Results

A. United States Mosquito Larvae Abundance Forecasts

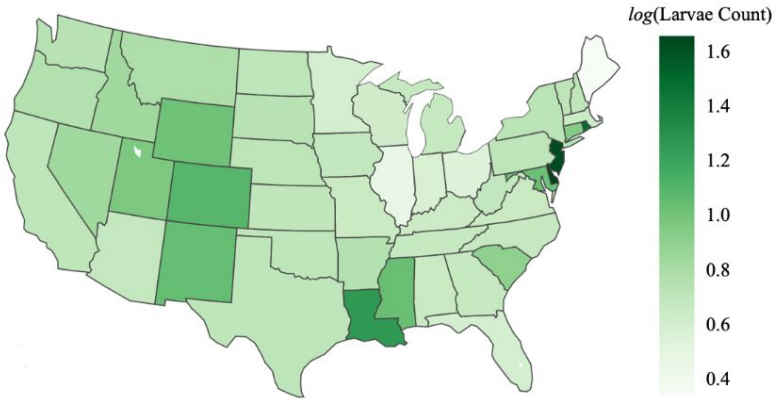


Fig. 5: Larvae Abundance by State in 2050. This map displays the model's projections for larvae abundance colored on a logarithmic scale.

Model estimates fairly high mosquito rates in high elevation areas, which don't currently have mosquitos

Paper Deep Dive

Predicting Future Mosquito Larval Habitats Using Time Series Climate Forecasting and Deep Learning

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ravnoorbedi@gmail.com

What would you do differently?

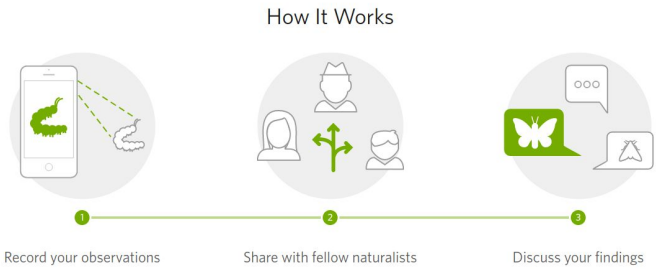
Further resources

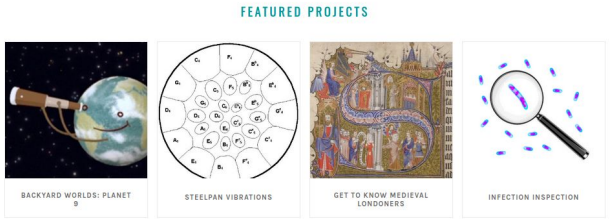
Citizen science websites:

https://www.inaturalist.org/

https://observer.globe.gov/about/citizen-science

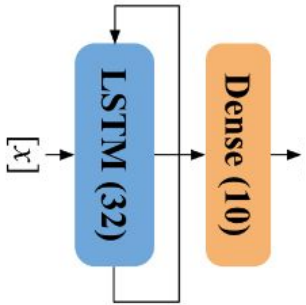
https://www.zooniverse.org/

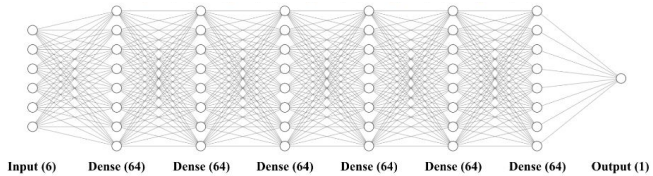




Game: https://www.earthislandgame.com/game

Summary


[x]
LSTM (32)
Dense (10)


Input (6)
Dense (64)
Dense (64)
Dense (64)
Dense (64)
Dense (64)
Dense (64)
Output (1)