Mapping the environment from global to local

IOT Freshman Seminar
Thur Oct 25, 2023

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Todays Overview

- Mapping **noise** levels from national to local scale
- Mapping **temperature** from national to local scale

  Exposing **inequalities** between neighborhoods noise and temperature based on race, income, education

- IOT Fails - distributed denial of service attacks (DDoS)

From Last Class

Could we make fine grained maps?

- Could we make detailed maps from house to house of …

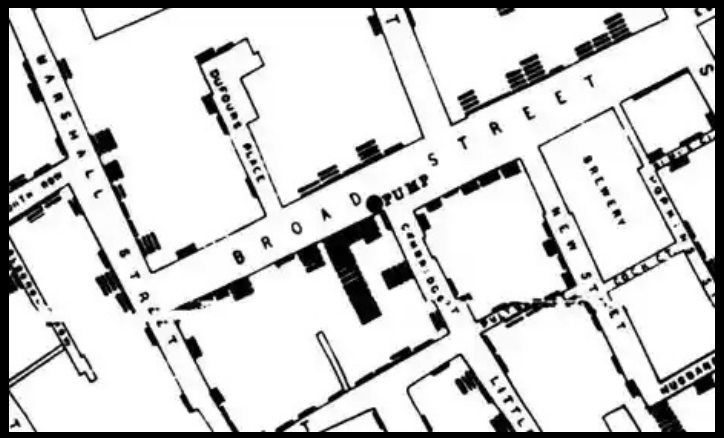
  Noise, pollution, or temperature they experience

- What about maps of

  Per house energy usage, residents temperatures, residents covid status?

- I propose medium resolution maps

  Zip code is too course, per house is too personal. What about a map with a resolution of 3 blocks?



- John Snow mapped Cholera outbreak in London (1854)

Mapping The Environment

Lots of different sensors to measure different dimensions

- Noise Levels
- Temperature

  Especially in urban areas, building and **pavement** retain heat, they act like a radiator

  If there is sufficient tree cover, temperatures can be lowered. Lack of trees results in urban hotspot
- Air Quality/Pollution

  Local sources of pollution like traffic, trains, airplanes, industry … also forrest fire smoke
- Contaminants

  Ground contamination from industry, agricultural pesticides

Take Action

Identify problem areas

Compare and contrast problem areas to social/economic factors. Like: Income, Race, Education

Enact local action to fix identified problems

Mapping The Environment

Barcelona - Noise

- IOT Network was small - maybe 30 sensors
- They measured noise levels reaching up to 100 dB
- Had a big impact on changing city policy to effectively reduce noise

https://www.pbs.org/newshour/nation/urban-noise-pollution-worst-poor-minority-neighborhoods-segregated-cities

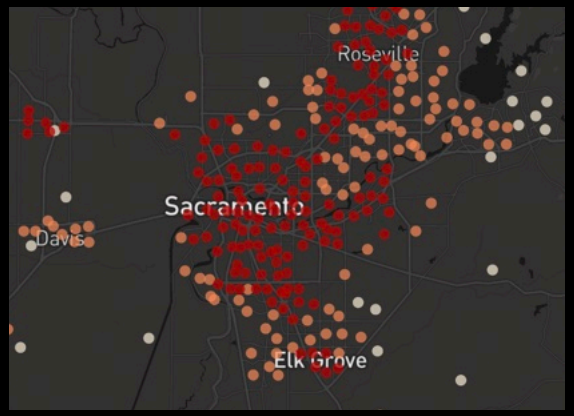
Mapping national noise levels

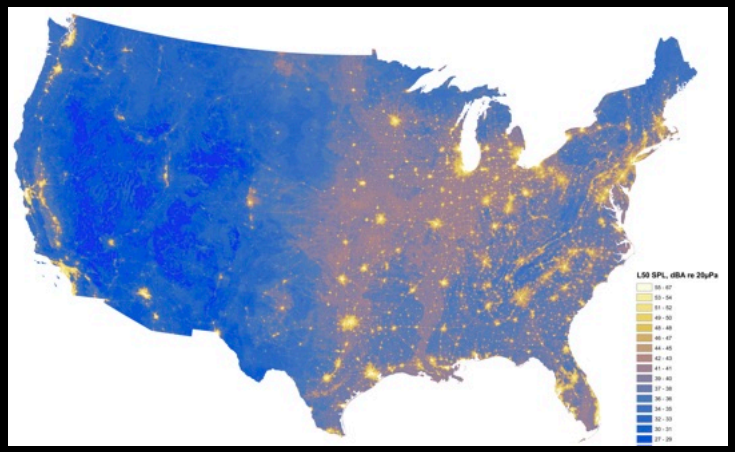
US National Park Service Sound Map

Barcelona case study was a fine grained **local** map

What about a **national** noise level map?

Local → National





Mapping national noise levels

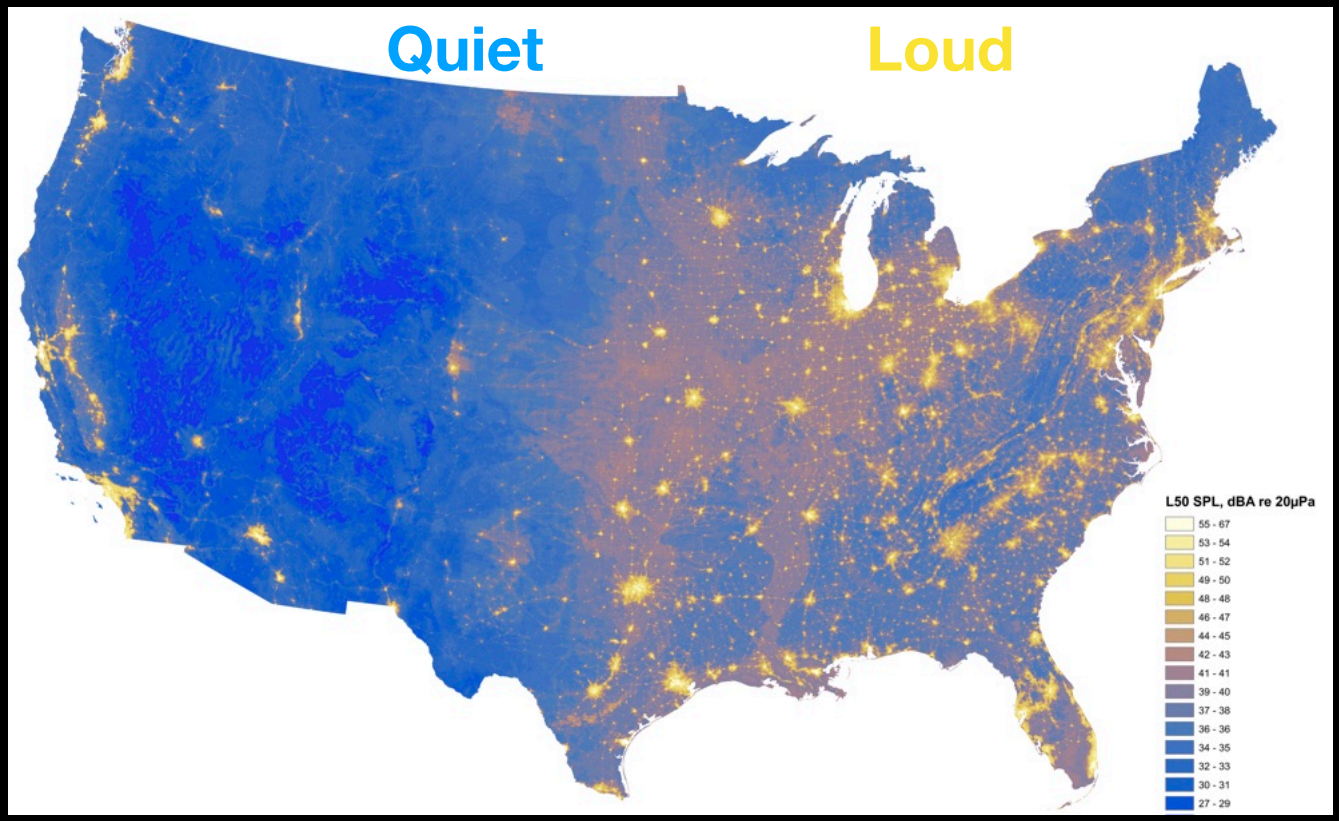
US National Park Service Sound Map

- https://www.nps.gov/subjects/sound/soundmap.htm
- 1.5 million hours of sound measurements across **492** **locations**, including urban areas and national forests
- Modeling based on topography, climate and human activity (similar to weather modeling)
- Generally, the models allow to fill in the gaps between measurement locations
- The underlying resolution of these modeled maps is a 270 meter grid

Mapping national noise levels

US National Park Service Sound Map

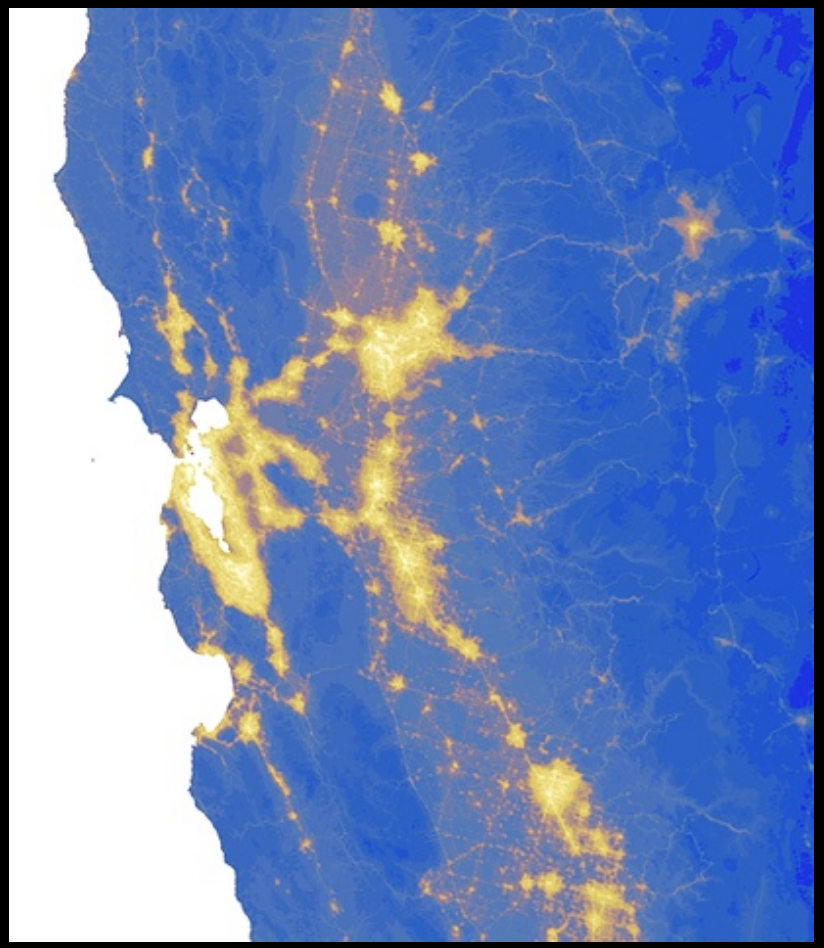
- Noise levels across the united states
- You could guess, urban areas are noisy



Mapping national noise levels

US National Park Service Sound Map

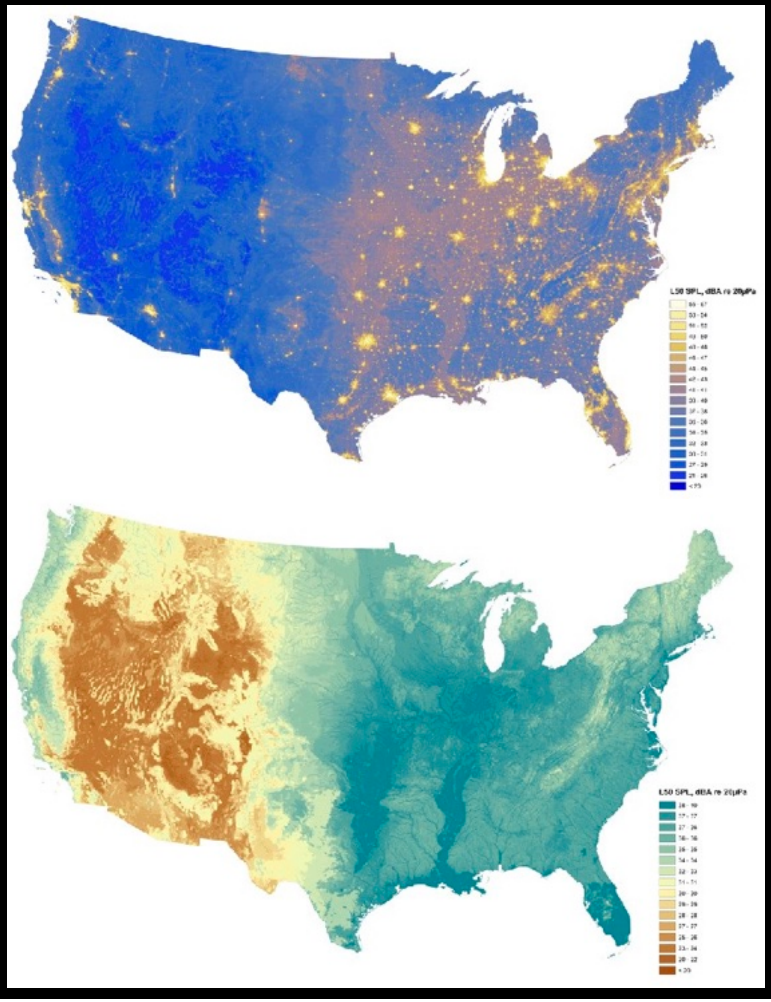
- Tells us what we already know
- Cities like San Fran, Berkeley, Oakland, and Sacramento are noisy
- The I-5 highway corridor is also noisy. This map almost predicts where highways are
- Yet, the raw data allows us to quantify the actual levels
- Can be used to take action to actively reduce noise levels in problem areas



Mapping national noise levels

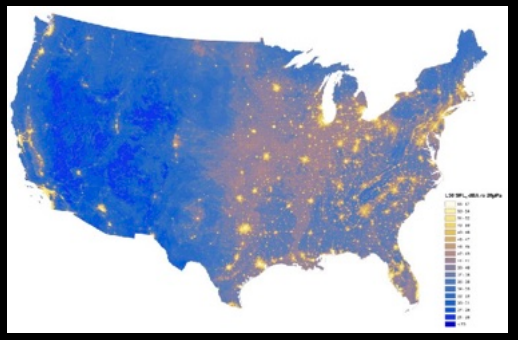
US National Park Service Sound Map

- Noise level measurements (top)
- They then made a model (like a weather forecast)
- To determine “natural” noise levels
- Without human generated noise
  - Red is really quiet, green is still quiet but louder because of rustling leaves, wind, and flowing water
  - Conclude: humans make lots of noise !!!



Mapping national noise levels

Compare the national noise map to census data



Ask the question

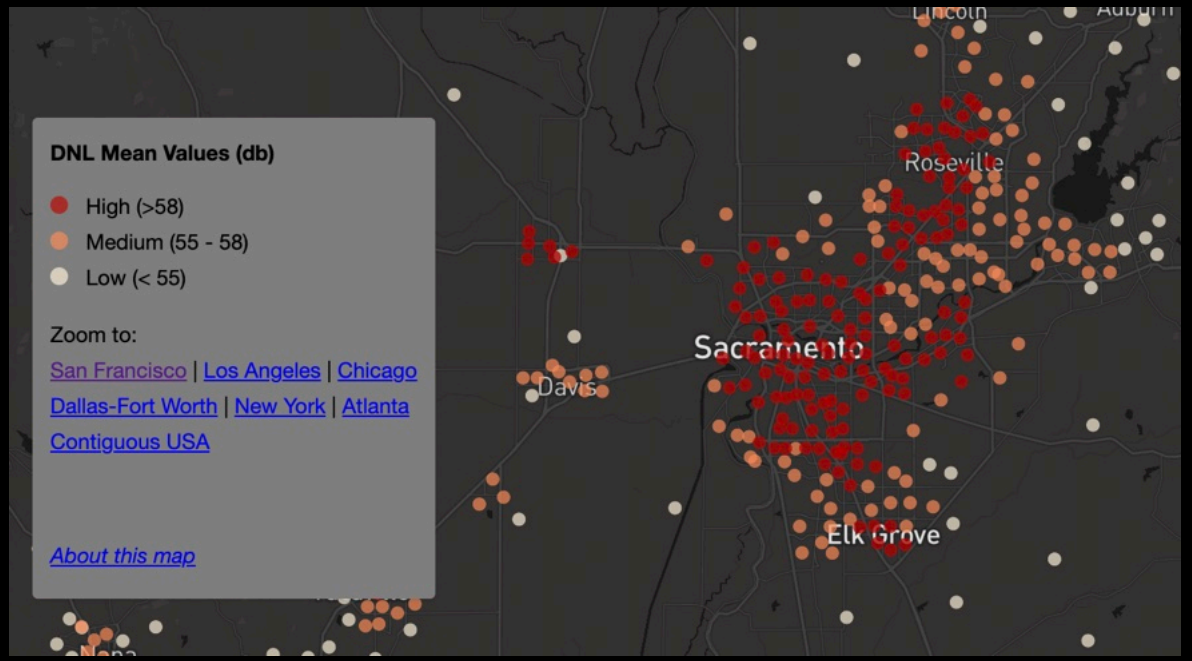
> “is more noise associated with lower income or minority groups?”

> Here we can transform raw neutral data into social/political data!

Mapping national noise levels

Why worry about noise?

- US National Park Service Noise Map is being used by many organizations to examine noise equity
- For example, UC Berkeley - Noise Map
- https://nature.berkeley.edu/morellofroschlab/about/



- https://www.ncei.noaa.gov/access/crn/overview.html

https://puttinglocaldatatowork.urban.org/grantee/university-california-berkeley

Mapping national noise levels

Compare the national noise map to census data

(A) anthropoenic nighttime **noise**

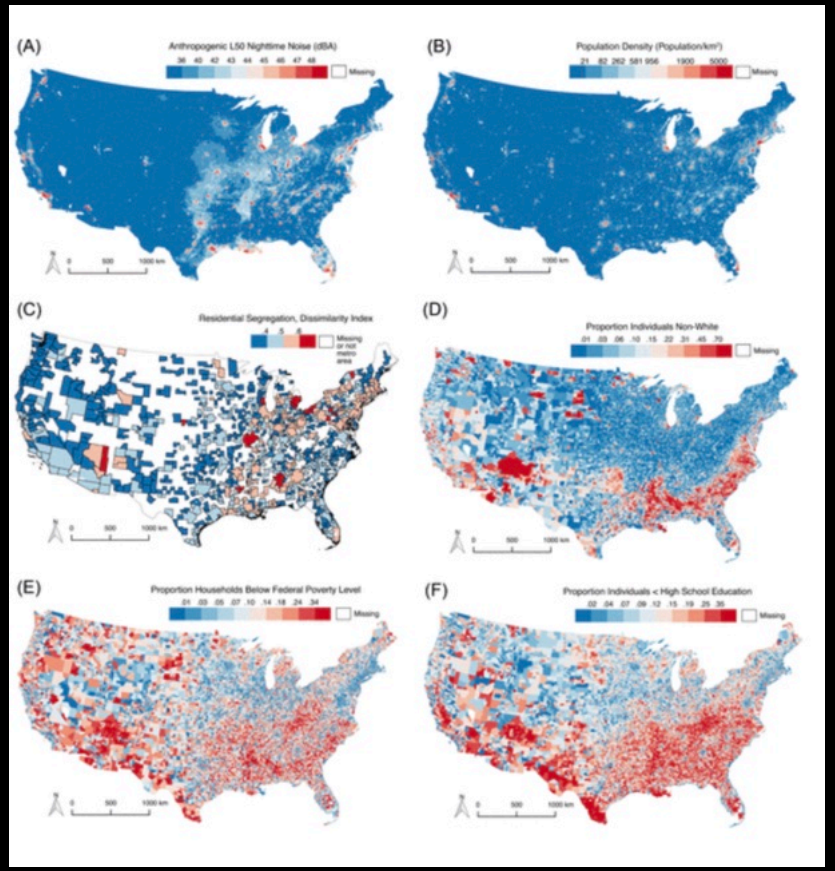
(B) **population** density

(C) racial residential **segregation** (urban only)

(D) non-Hispanic, nonwhite **race/ ethnicity**

(E) **poverty**

(F) less than high school **education**

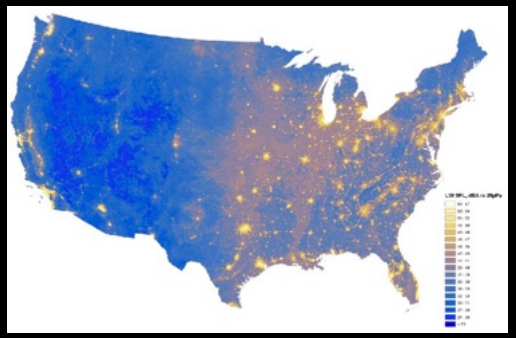


(chiefly of pollution or environmental change) originating in human activity.

https://ehp.niehs.nih.gov/doi/10.1289/EHP898

Mapping national noise levels

Compare the national noise map to census data such as income and race



- In both rural and urban areas, **affluent** communities were **quieter**.
- Neighborhoods with median annual incomes **below** $25,000 were nearly 2 decibels **louder** than neighborhoods with incomes above $100,000 per year.
- Nationwide, communities with 75 percent black residents had median nighttime noise levels of 46.3 decibels – 4 decibels louder than communities with no black residents.
- A 10-decibel increase represents a doubling in loudness of a sound (dB is a log scale), so these are big differences.
- Thus, nationwide, communities with 75 percent black residents were almost 50% more noisy

https://www.pbs.org/newshour/nation/urban-noise-pollution-worst-poor-minority-neighborhoods-segregated-cities

Mapping national noise levels

Why worry about noise?

Is noise in poorer and minority neighborhoods just a nuisance?

Should people just deal with it?

Mapping national noise levels

Why worry about noise?

- A growing body of evidence links noise from a variety of sources, including air, rail and road traffic, and industrial activity to **adverse health outcomes**.
- Studies have found that kids attending school in louder areas have more behavioral problems and perform worse on exams.
- Adults exposed to higher noise levels report higher levels of annoyance and importantly sleep disturbances.

Mapping national noise levels

Why worry about noise?

- Since evolution programmed the human body to respond to noises as threats, noise exposures activate our natural flight-or-fight response.
- Noise exposure triggers the release of stress hormones, which can raise our heart rates and blood pressure even during sleep.
- Long-term consequences of these reactions include high blood pressure, Type 2 diabetes, cardiovascular disease and lower birth weight.

What kinds of natural noises are loud and could signal danger?

The majority of natural ‘loud’ noises is not actually loud compared to human created noise

Mapping national noise levels

Why worry about noise?

- As with other types of pollution, multiple factors help explain why some social groups are more exposed to noise than others

  Lack of enforcement of regulations in marginalized neighborhoods

  Lack of capacity to engage in land use decisions and environmental policies results in failure to adequately protect vulnerable communities

  This may lead to placing noise generating **industrial** facilities, **highways** and **airports** in poorer communities

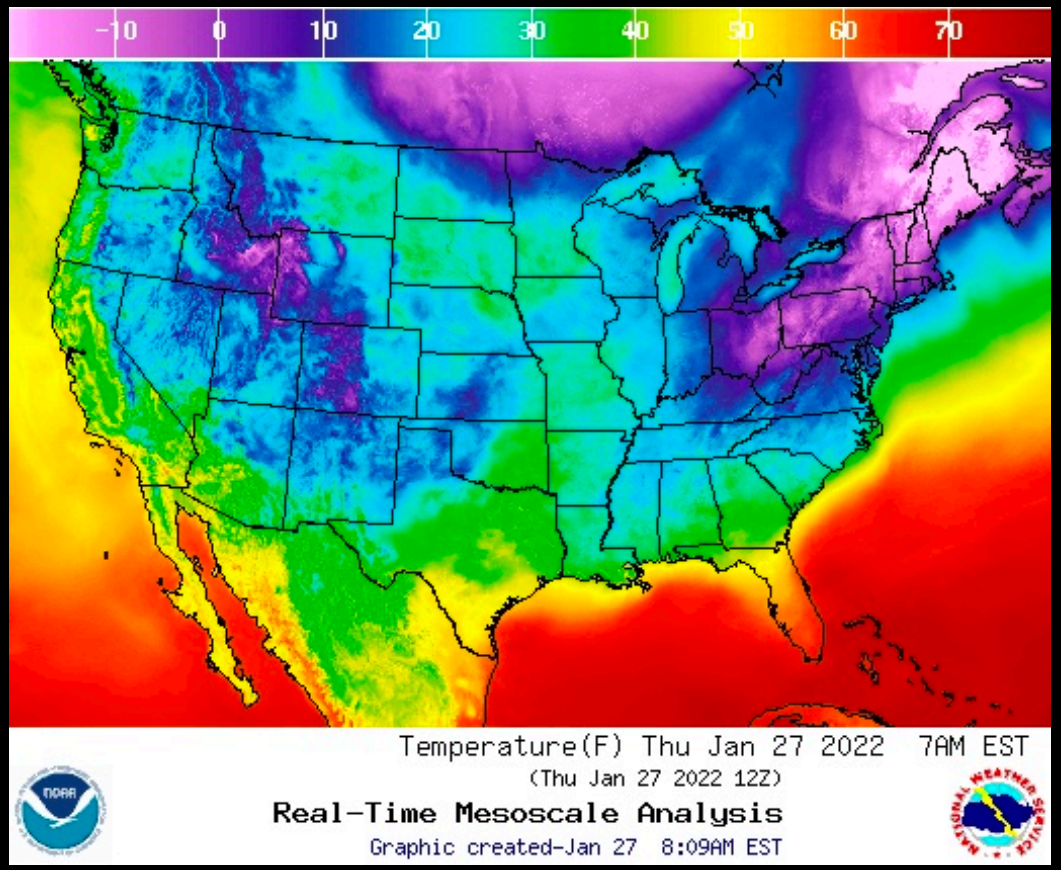
- Do you see this pattern? Poor communities have more noise?

Mapping local temperature

Mapping local temperature

NOAA is already mapping all of North America

- https://digital.weather.gov/
- NOAA: National Oceanic and Atmospheric Administration
- Updated every hour
- How is this map made?



Mapping local temperature

NOAA is already mapping all of North America

- USCRN: US Climate Reference Network
- https://www.ncei.noaa.gov/access/crn/overview.html
- Measure multiple parameters at 5 minute intervals
- Transmit data via satellite (every 5 minutes)
- This takes power so they use solar
- Great Basin, Utah
- Cloud computation aggregates all of this data and make the national map. It creates a new map every hour.
- How many stations and where?

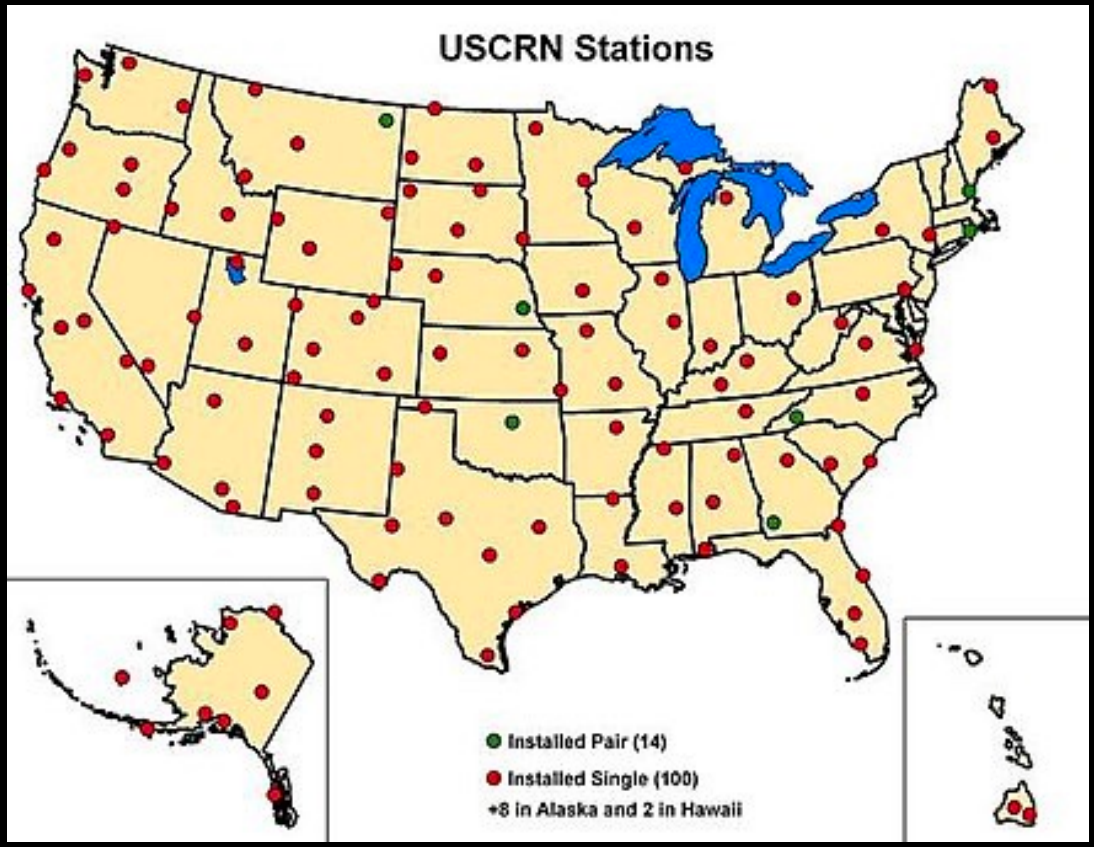
https://www.ncei.noaa.gov/access/crn/overview.html

Mapping local temperature

The NWS and NOAA already map all of North America

- How many stations and where?
- About 143 stations in the US
- Completed in 2008

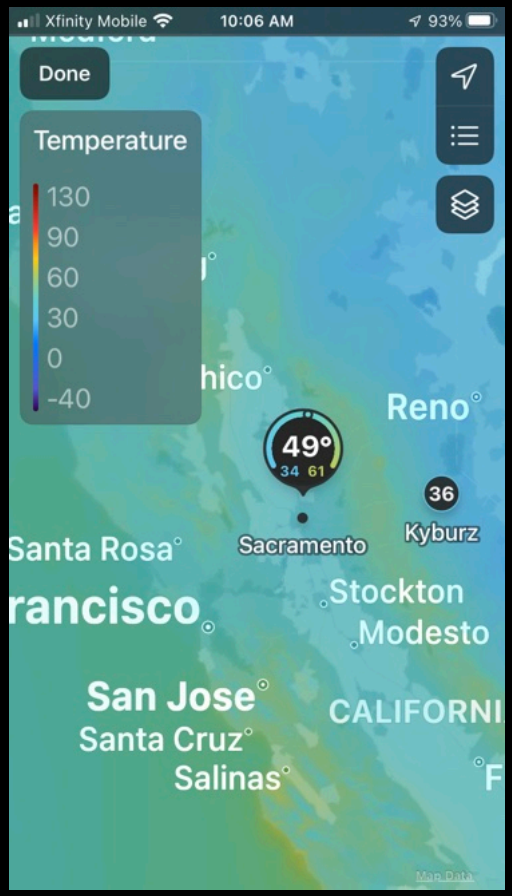
The network consists of 114 commissioned stations in the contiguous United States, 21 stations in Alaska (with a plan to eventually have a total of 29), and 2 stations in Hawaii



Mapping local temperature

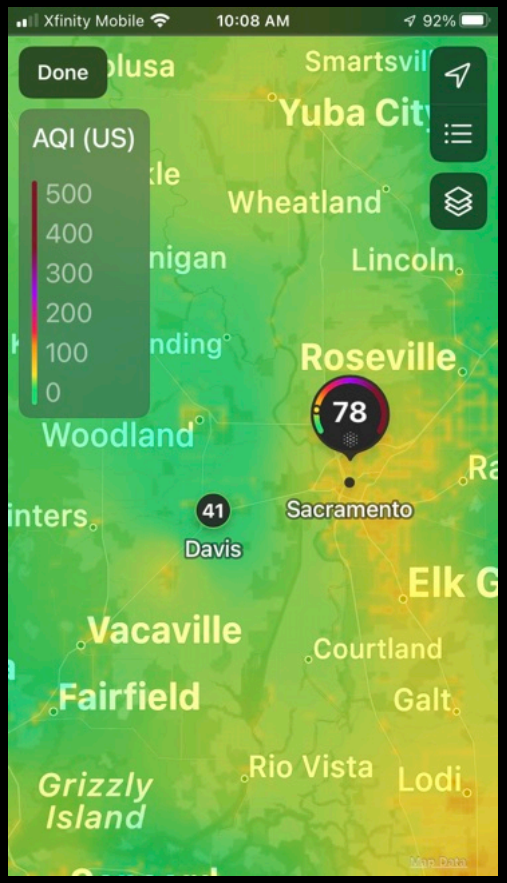
The NWS and NOAA already map all of North America

- Pretty amazing that with only 143 stations we get detailed local information.
- They fill in the gaps between stations with **models** that incorporate terrain, human influence, and expected values based on previous data
- Although this does not measure the ground temperature block by block, it is critical/useful/political data used to inform us about changes in our climate



Much More Than Just Temperature

- Air Quality Index, measure ‘particulates’ in air like dust, smoke, pollutants
- For temperature they measure air temperature (with a thermometer)
- For ground temperature they use an infrared laser



Max/Min Temperature
Probability of Precip.
Weather
Hazards
Temperature
Dewpoint
Wind Speed & Direction
Wind Gust
Sky Cover
Amount of Precip.
Snow Amount
Ice Accumulation
Wave Height
Apparent Temperature
Relative Humidity

What about these maps at a local level?

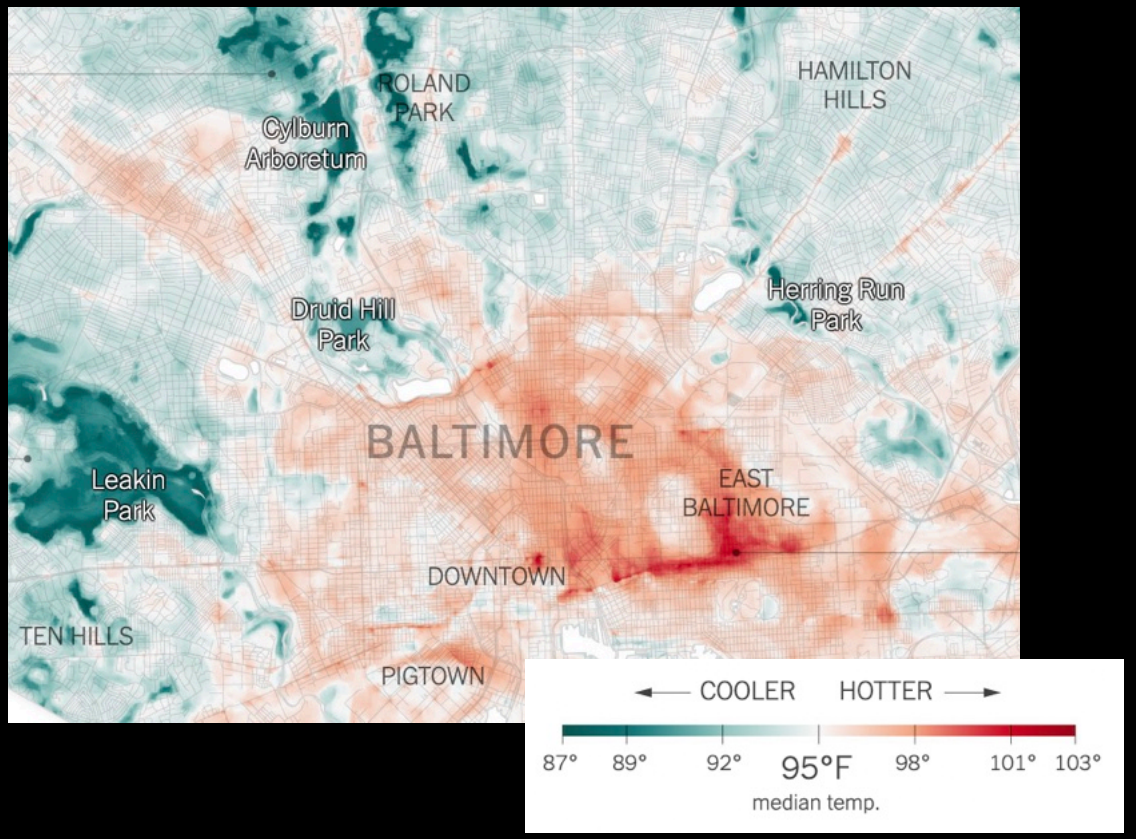
Neighborhood by neighborhood

https://www.nytimes.com/interactive/2019/08/09/climate/city-heat-islands.html?searchResultPosition=2

What about these maps at a local level?

Neighborhood by neighborhood (data from community volunteers)

- New York Times (2019) “Summer in the City Is Hot, but Some Neighborhoods Suffer More”
- One day in Baltimore, MD
- **Cooler**: Neighborhoods next to parks and those with plenty of **tree** cover saw significantly cooler temperatures on a hot summer afternoon: as low as 87°F.
- **Hotter**: On the same day, residential neighborhoods east of downtown saw hotspots reach over 101°F.



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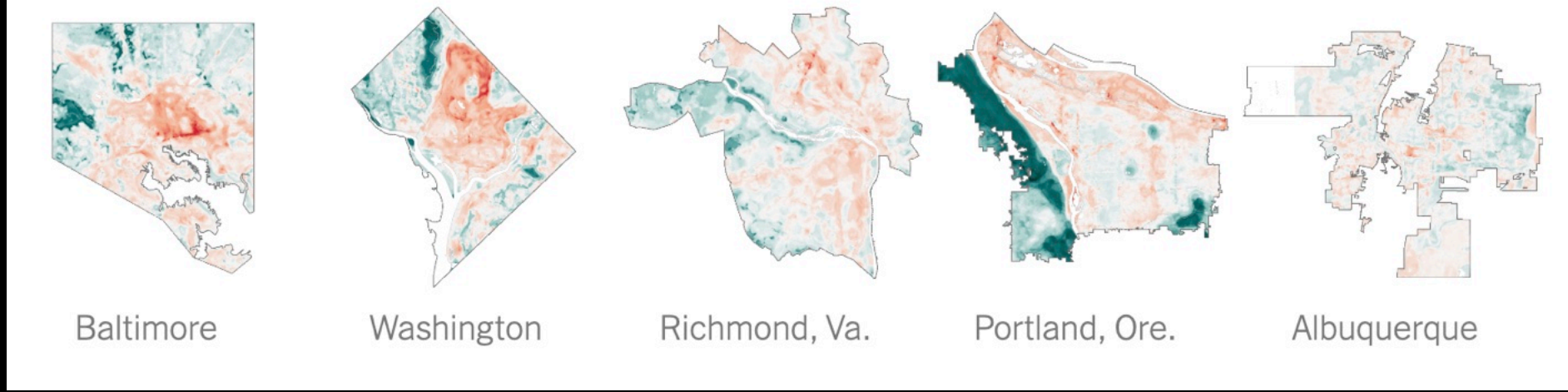


What about these maps at a local level?

Baltimore - We already knew this but now we have the data

- Cooler

- Hotter

What about these maps at a local level?

Baltimore

- The city plans to increase its tree canopy to cover 40 percent of the city, up from 28 percent in 2015
- The city is also trying to turn some of its vacant lots into permanent green spaces.
- When abandoned or derelict homes are demolished, the land beneath them is sometimes used for **parking**. But by turning those lots into small parks, Baltimore can increase the amount of vegetation and make neighborhoods cooler.
- Open more community cooling centers to give more people without air-conditioning a way to escape the heat. Allow at risk communities more safety.

What about these maps at a local level?

- Conclusion is almost always the same

  Temperatures on a scorching summer day can vary as much as **20 degrees** across different parts of the same city

  With poor or minority neighborhoods often bearing the brunt of that heat.

Go here … New York Times (2020)

https://www.nytimes.com/interactive/2020/08/24/climate/racism-redlining-cities-glob
warming.html?searchResultPosition=4

1) Red Lining Maps From the 1930's
Marked certain neighborhood "risky" because residents were black

2) White neighborhoods tend to be much cooler today

3) Formerly redlined areas have less tree cover

4) Redlined neighborhoods have more paved surfaces, like roads and parking lots, tha
absorb and radiate heat (heat island)

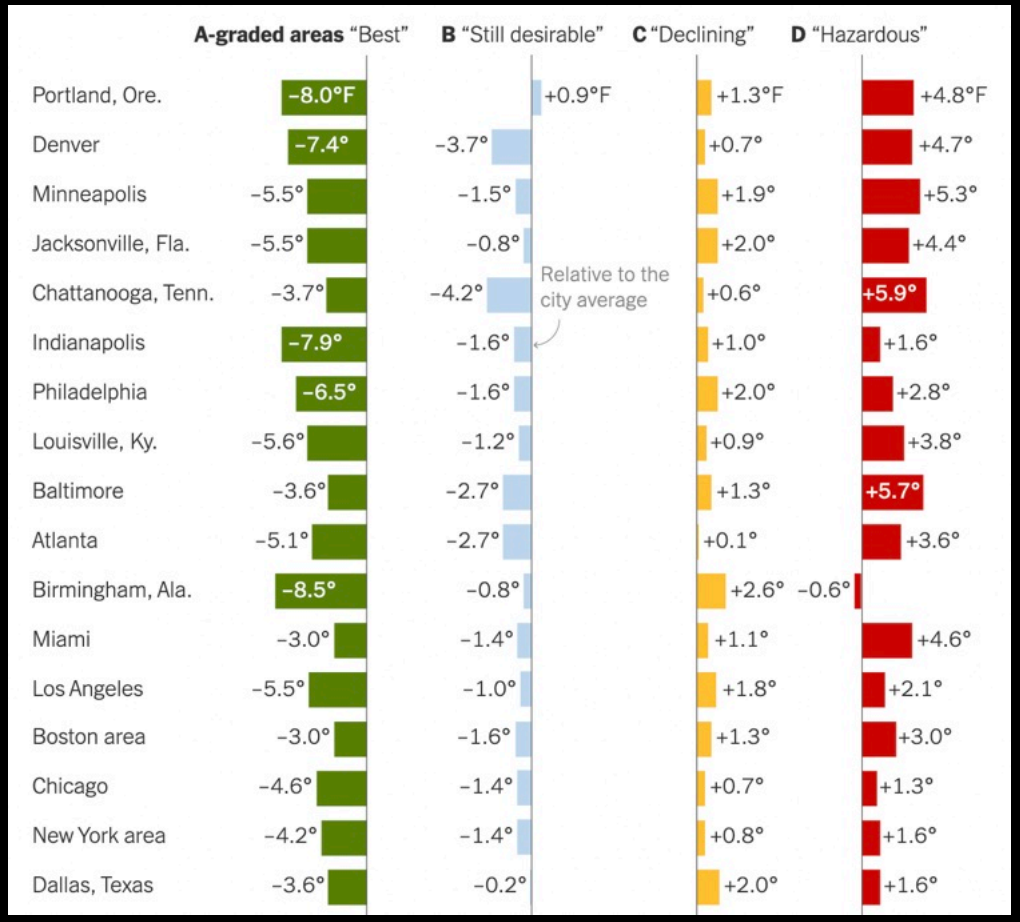
5) Thus, redlined neighborhoods are much hotter

Conclusion is almost always the same

- Nationwide, the pattern is consistent
- Cities, neighborhoods assigned lower grades by the federal government in the 1930s are hotter today
- “A” grade areas are cooler than “D” hazardous areas.
- **Sources**:

Tree cover and paved surface data are from the National Land Cover Database 2016.

Temperature values are derived from NASA/U.S.G.S. Landsat thermal data



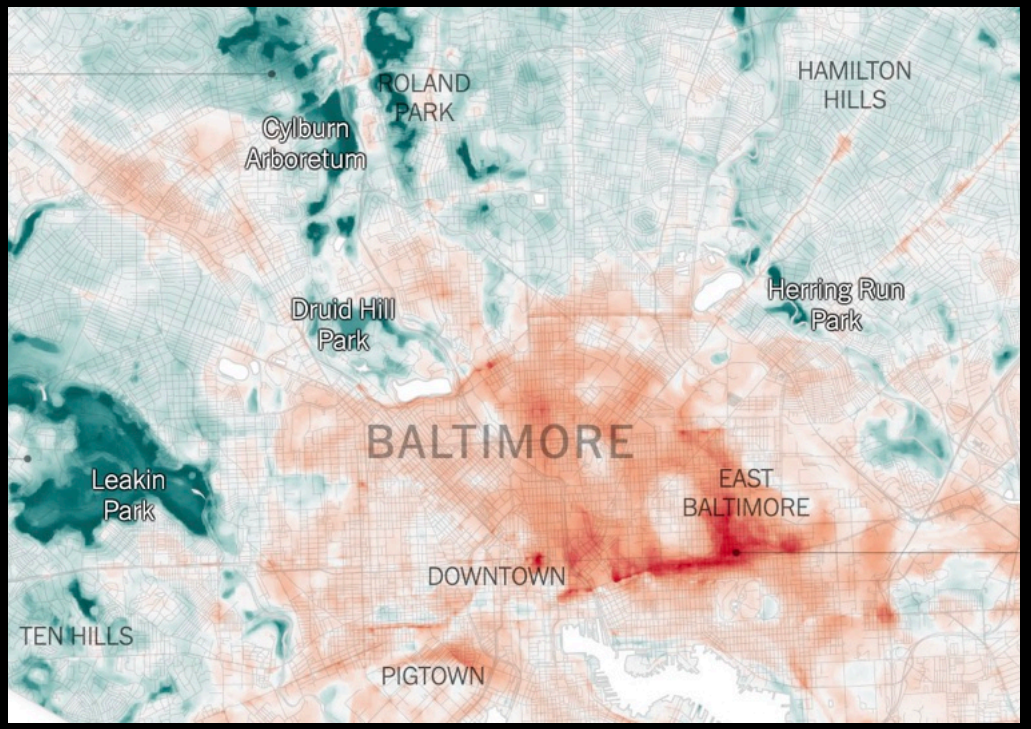
A personal story

This disparity makes it tough for some neighborhoods

- To escape the heat, Sparkle Veronica Taylor, a 40-year-old Gilpin resident, often walks with her two young boys **more than a half-hour** across Richmond to a tree-lined park in a **wealthier** neighborhood.
- Her local playground lacks shade, leaving the gyms and slides to bake in the sun.
- The trek is grueling in summer temperatures that regularly soar past 95 degrees, but **it's worth it to find a cooler play area**, she said.
- *"The heat gets really intense, I'm just zapped of energy by the end of the day," said Ms. Taylor, who doesn't own a car. "But once we get to that park, I'm struck by how green the space is. I feel calmer, better able to breathe. Walking through different neighborhoods, there's a stark difference between places that have lots of greenery and places that don't."*

What about these maps at a local level?

- Not automated and optimized IOT
- These maps are generated with precision sensors
- But are manually operated
- A fews 10’s of sensors are put in place for one day of measurements

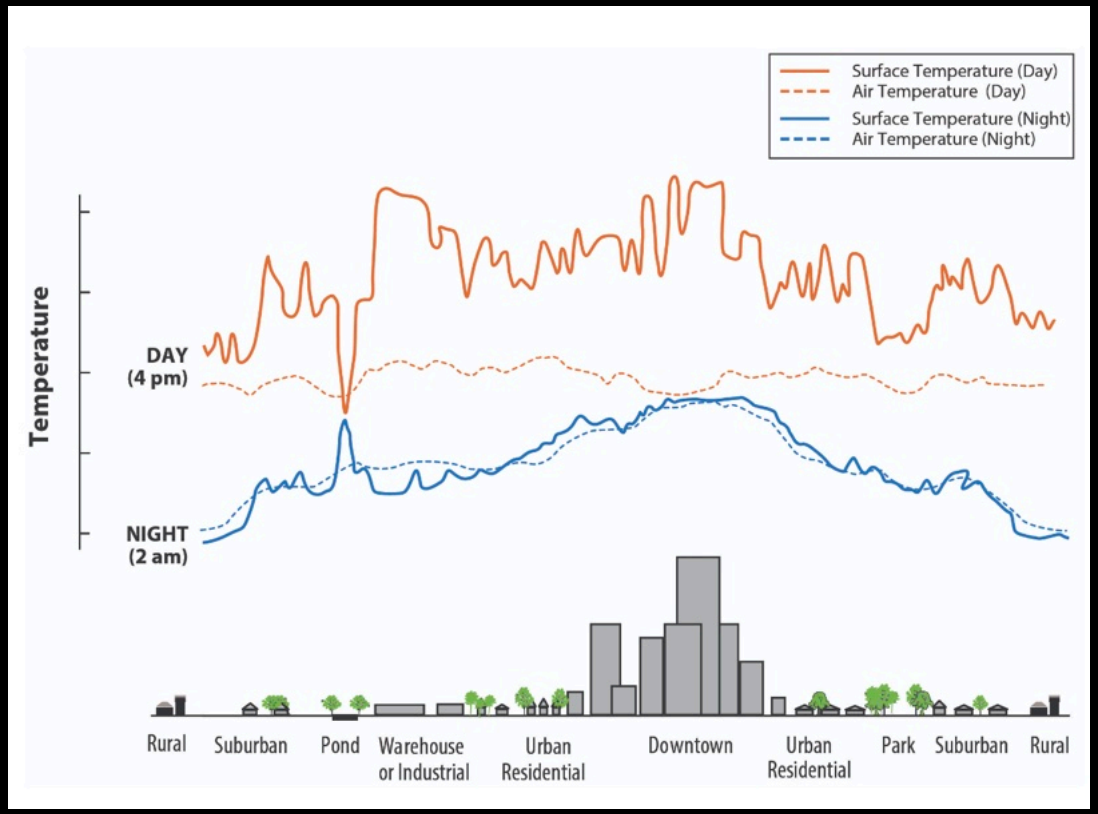


This data is important because it has prompted cities to admit the problem and start enacting change

Heat Islands

EPA has some great information

https://www.epa.gov/heatislands/learn-about-heat-islands



Conclude

- National Park Service noise map
- It has inspired the creation of noise monitoring stations (not covered .. Chicago)
- NOAA has an IOT with remote sensors and satellite communication to generate maps (10’s of measurements) every hour
- Both noise and atmosphere maps allow complex predictive **models** to be created (a noise or weather forecast)
- Cities are starting to measure fine grained temperature (pollution, etc) to enact policy to improve lives
- All of this mapping data can be used to track changes in not just the climate but pollution including noise. E.g. track the evolution of noise pollution like global warming

From Last Class

Could we make fine grained maps?

- Could we make detailed maps from house to house of …

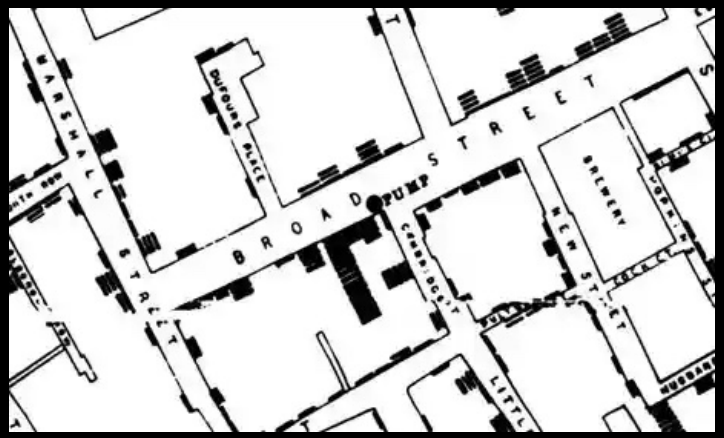
  Noise, pollution, or temperature they experience

- What about maps of

  Per house energy usage, residents temperatures, residents covid status?

- I propose medium resolution maps

  Zip code is too course, per house is too personal. How about a map with a resolution of 3 blocks?



- John Snow mapped Cholera outbreak in London (1854)

IOT Fail - 2014 to Present

Hacking smart devices to send spam emails

IOT Fail - 2014 to Present

Hacking smart devices to send 750,000 spam emails

- Over 100,000 home “smart things” were hacked to send spam email and flood websites
- This included routers, media centers, televisions, and even kitchen appliances like a fridge
- **Personal computers** can be unknowingly compromised to form robot-like "botnets" that can be used to launch large-scale cyberattacks.
- Cyber criminals have begun to commandeer home routers, smart appliances and other components of the **Internet of Things (IoT)** and transform them into "thingbots" to carry out the same type of malicious activity.
- Note: Only 25% of emails came from “things”, 75% was from routers and traditional computers
- This was possible because email and web browsing is often included as a feature of a smart thing.
- Even the **Arduino nano** we will be using can send email

You can help

Do not use default password!

IOT Fail - 2014 to Present

Hacking smart devices to send 750,000 spam emails

- Although individuals who had their “things” hacked did not exactly suffer
- This lack of IOT security enabled a massive and completely untraceable spam email and web browsing campaign
- **distributed denial-of-service attack (DDoS attack)**, the incoming traffic flooding the victim originates from **many different sources**. Simply attempting to block a single source is insufficient as there are multiple sources

- We are all familiar with “Security updates” on our phones and laptops, right?
- But what about security updates for your “smart” toaster or fridge?
- Right now this is not common but we might see this becoming more normal
  - e.g. IOT smart-home device companies just don’t do it!!!

IOT Fail - 2014 to Present

Distributed denial-of-service attack (DDoS attack)

September 2016 was a busy year for hackers

The **Krebs on Security** website reached 620 Gbit/s

French **web host** OVH reached 1 Tbit/s

DDoS attack against Dyn (**an internet service provider**) made many popular websites inaccessible including:

Twitter, Reddit, Netflix, Airbnb, GitHub and many others

Rutgers **University**

DDoS attacks were also notable in Brazil, Taiwan, Costa Rica and India

This included Liberia's entire internet infrastructure

No Cell Service = No 911

No Cell Service = No 911

Need a dedicated satellite link

- $200 to buy the device, $15-20/month subscription
- About 20 text messages per month (needs to be connected to smart-phone via bluetooth)
- **OK Button**, send GPS coordinates via text/email to friends/ family
- **SOS Button**, alerts local search and rescue and they come to your coordinates (even with a helicopter)
- More satellites! Two main companies maintain their own satellite network. Spot has 24 and Garmin has 66
- Generally available anywhere on the globe … check if it is true