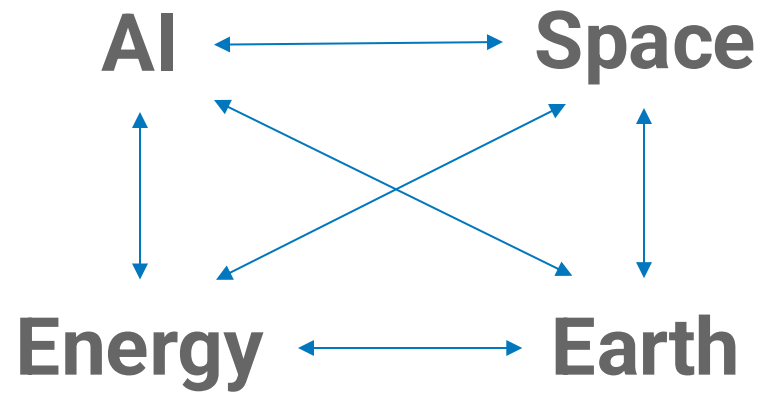




AI + Space + Energy + Earth

John Platt, Google Fellow

March 27, 2025

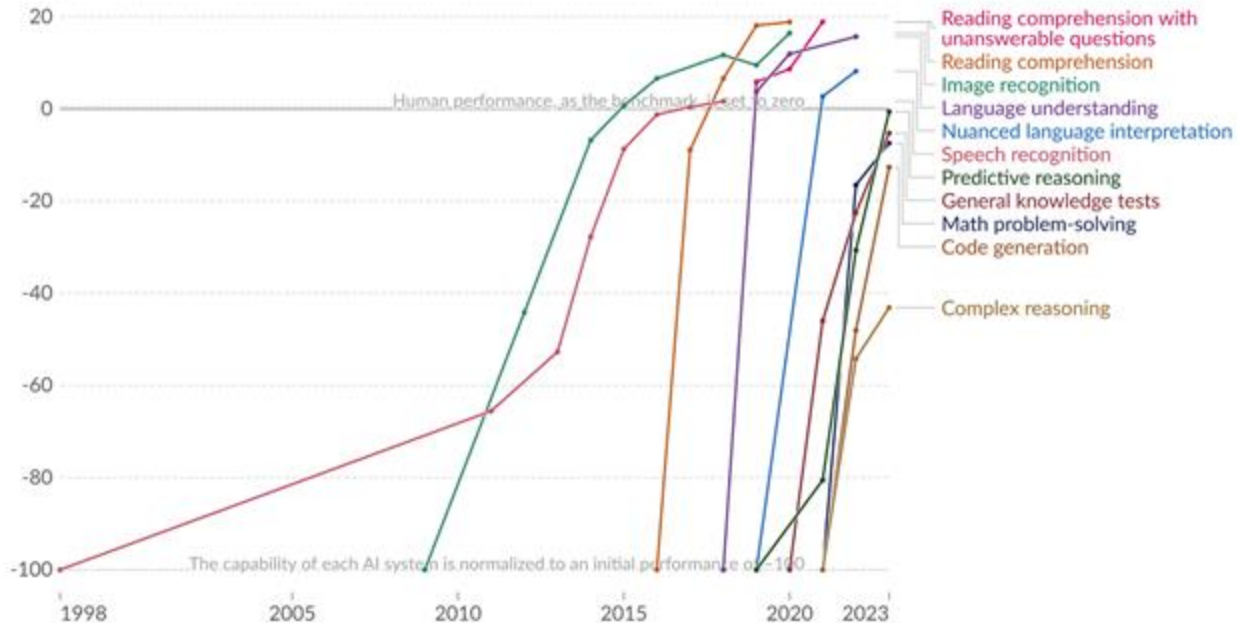


AI scaling

Test scores of AI systems on various capabilities relative to human performance



Within each domain, the initial performance of the AI is set to -100. Human performance is used as a baseline, set to zero. When the AI's performance crosses the zero line, it scored more points than humans.



Data source: Kiela et al. (2023)

OurWorldInData.org/artificial-intelligence | CC BY

Note: For each capability, the first year always shows a baseline of -100, even if better performance was recorded later that year.

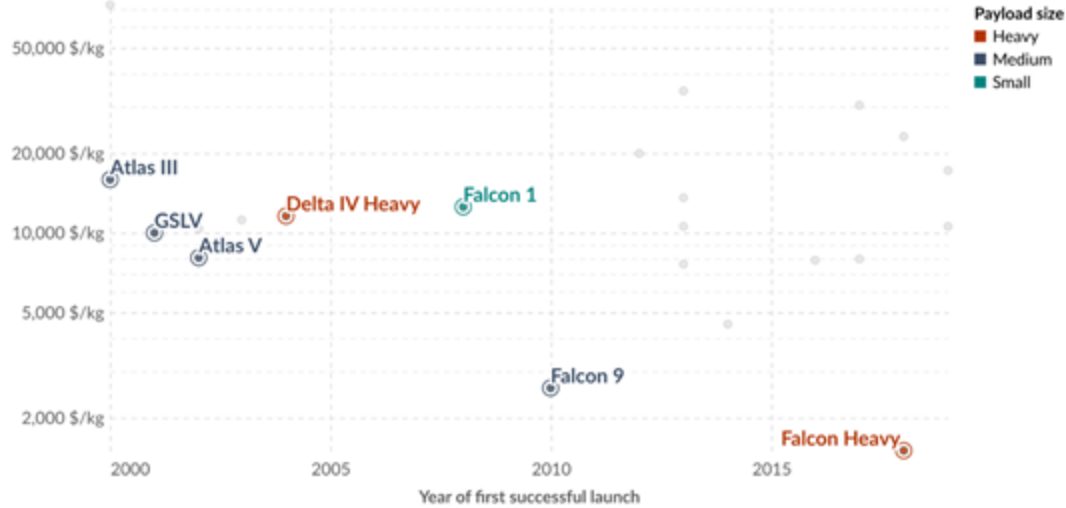
Space learning curve

Cost of space launches to low Earth orbit

Our World
in Data

Cost to launch one kilogram of payload mass to low Earth orbit¹ as part of a dedicated launch. This data is adjusted for inflation.

Launch cost per kilogram of payload (constant 2021 US\$ per kilogram)



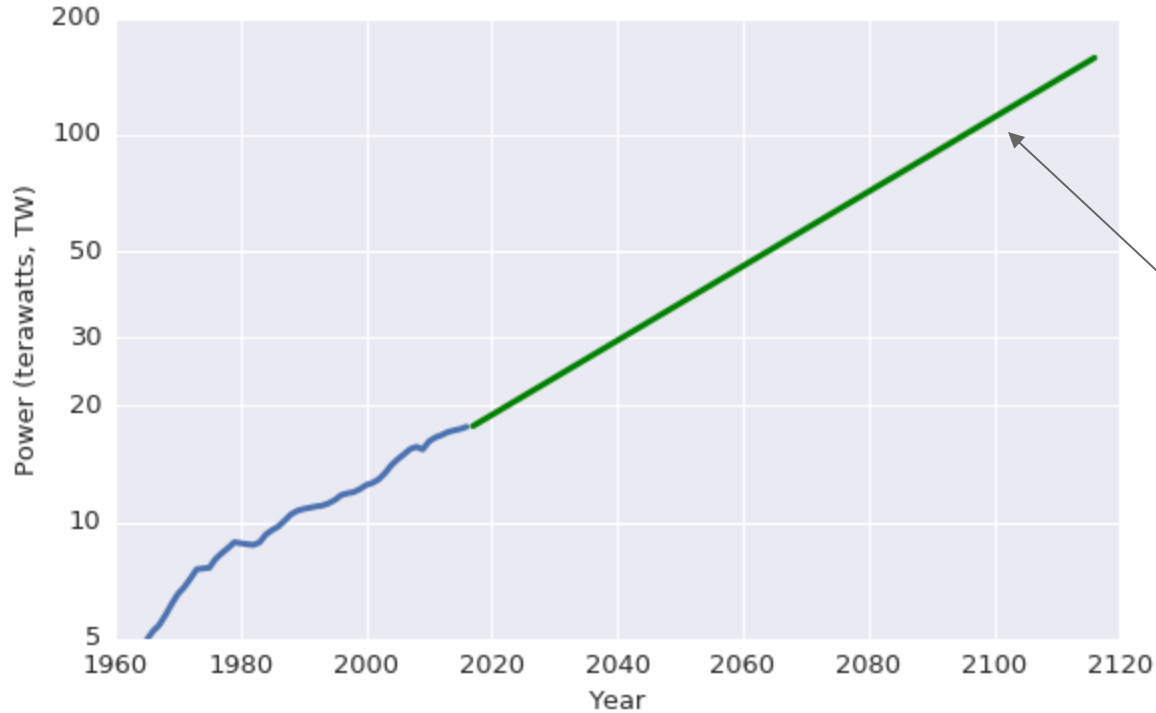
Data source: CSIS Aerospace Security Project (2022)

OurWorldinData.org/space-exploration-satellites | CC BY

Note: Small vehicles carry up to 2,000 kg to low Earth orbit¹, medium ones between 2,000 and 20,000 kg, and heavy ones more than 20,000 kg. This data is expressed in constant 2021 US\$.

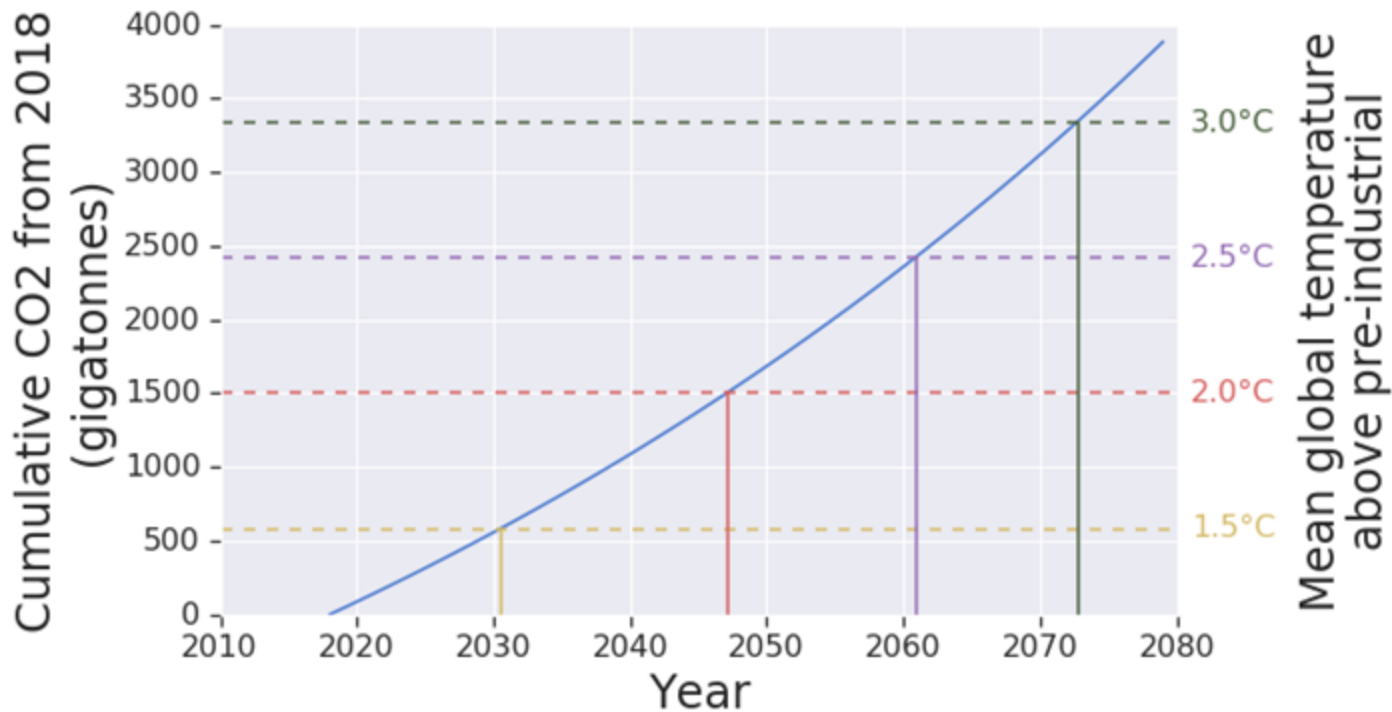
1. Low Earth orbit: A low Earth orbit (LEO) is an Earth-centered orbit with an altitude of 2,000 kilometers or less (approximately one-third of Earth's radius). This is the orbit where most artificial objects in outer space live. LEOs are often used for satellites, including those for communication, Earth observation, and space stations due to their proximity to Earth's surface, facilitating shorter communication times and detailed surface imaging.

Energy use increases



2100 = 113 TW
≈ US power
rate for 11.2
billion people

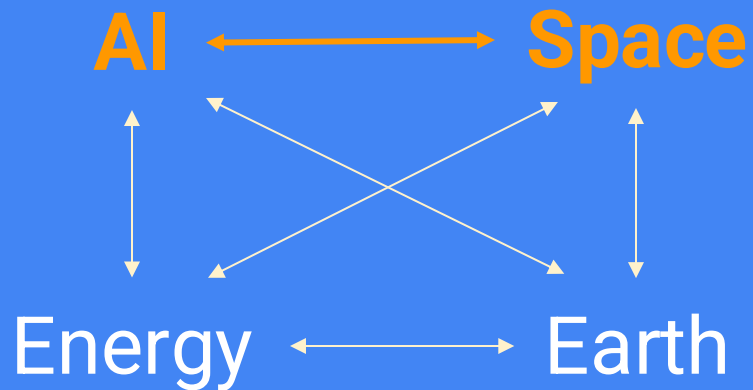
Limitations of climate system



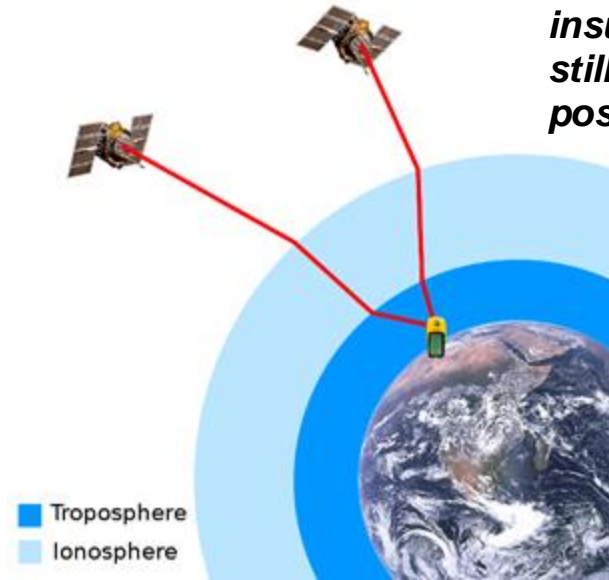
In this talk

- Measuring ionosphere from phones
- Assessing solar potential of residences
- FireSat
- Some thoughts about large language models

Mapping the Ionosphere from phones



The Ionosphere problem



The existing Klobuchar model is insufficient. Ionospheric distortion is still one of the largest sources of position error.

Satellite signals are refracted by electron density in the ionosphere.

This distorts the perceived location of the satellite and degrades GPS accuracy.

Monitoring Stations have many advantages over **Phones**...
apart from their number.



← **Calibrated scientific instrument**

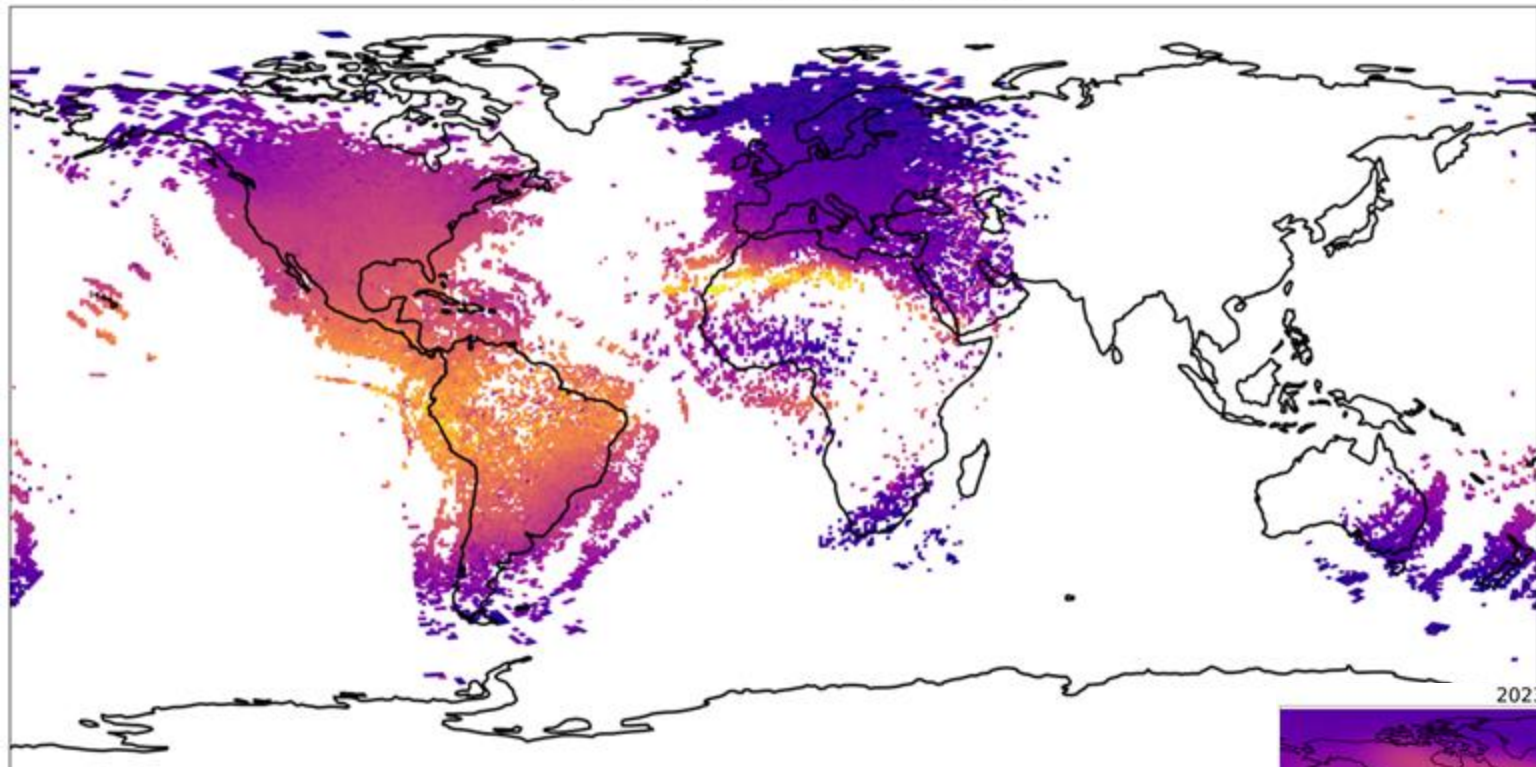
← **Big expensive antenna**

← **Clear view of the sky**

Ubiquitous →



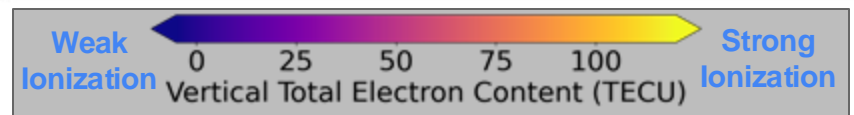
2023-10-13 20:00:00



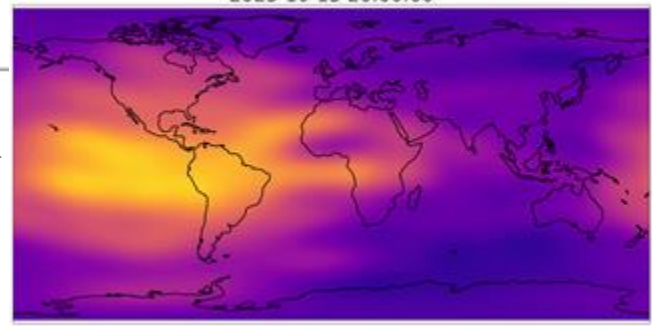
Using
Phones



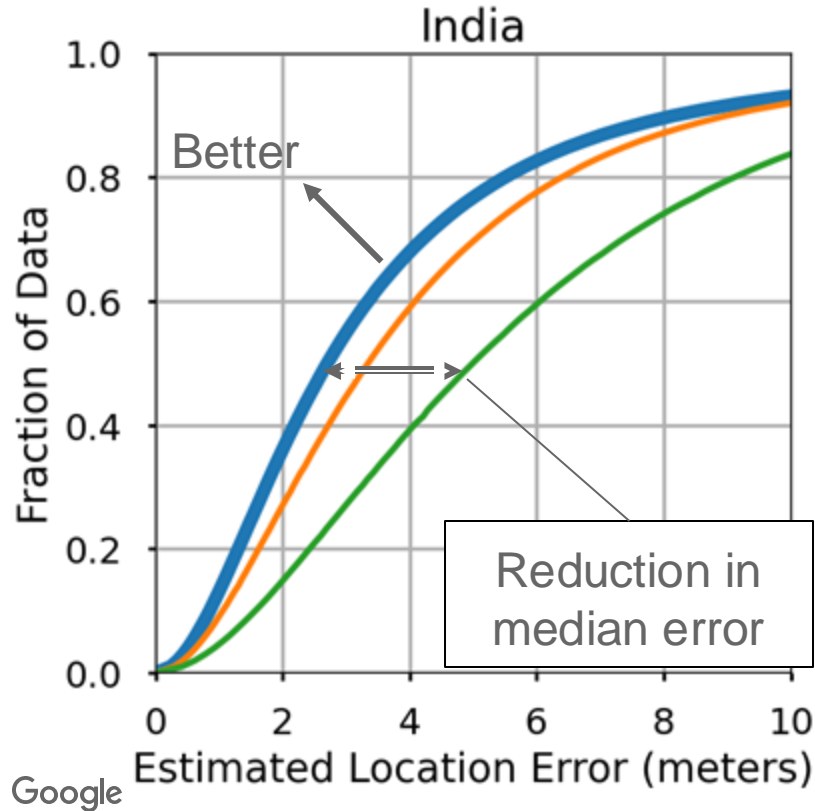
2023-10-13 20:00:00



Using
Monitoring
Stations



In places like India, with few **Monitoring Stations**, using **Phones** provides better performance.



Ionosphere Map

- From **Phones**
- From **Monitoring Stations**
- Klobuchar Model - Used for phone navigation today



[nature](#) > [articles](#) > [article](#)

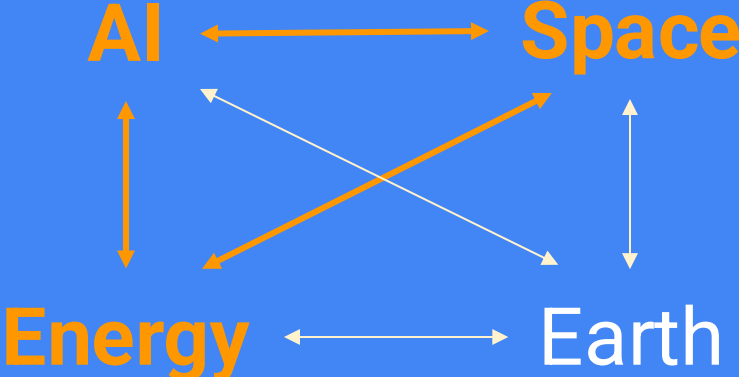
Article | [Open access](#) | Published: 13 November 2024

Mapping the ionosphere with millions of phones

[Jamie Smith](#), [Anton Kast](#), [Anton Geraschenko](#), [Y. Jade Morton](#), [Michael P. Brenner](#), [Frank van Diggelen](#) & [Brian P. Williams](#) 

[Nature](#) **635**, 365–369 (2024) | [Cite this article](#)

Solar potential of residences

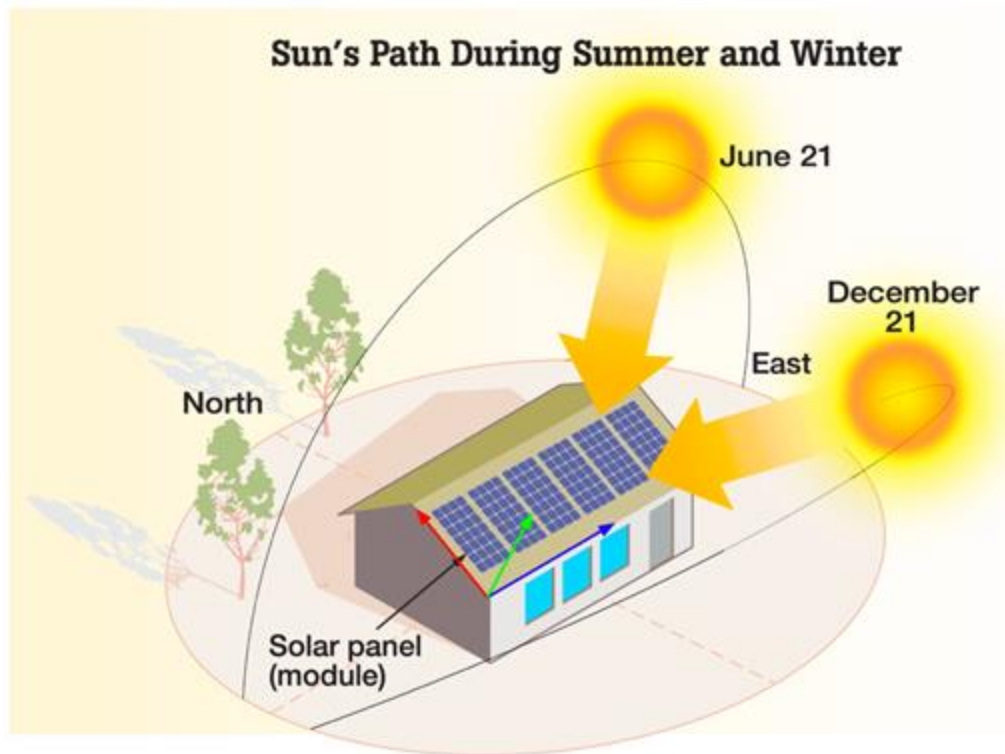


Project Sunroof

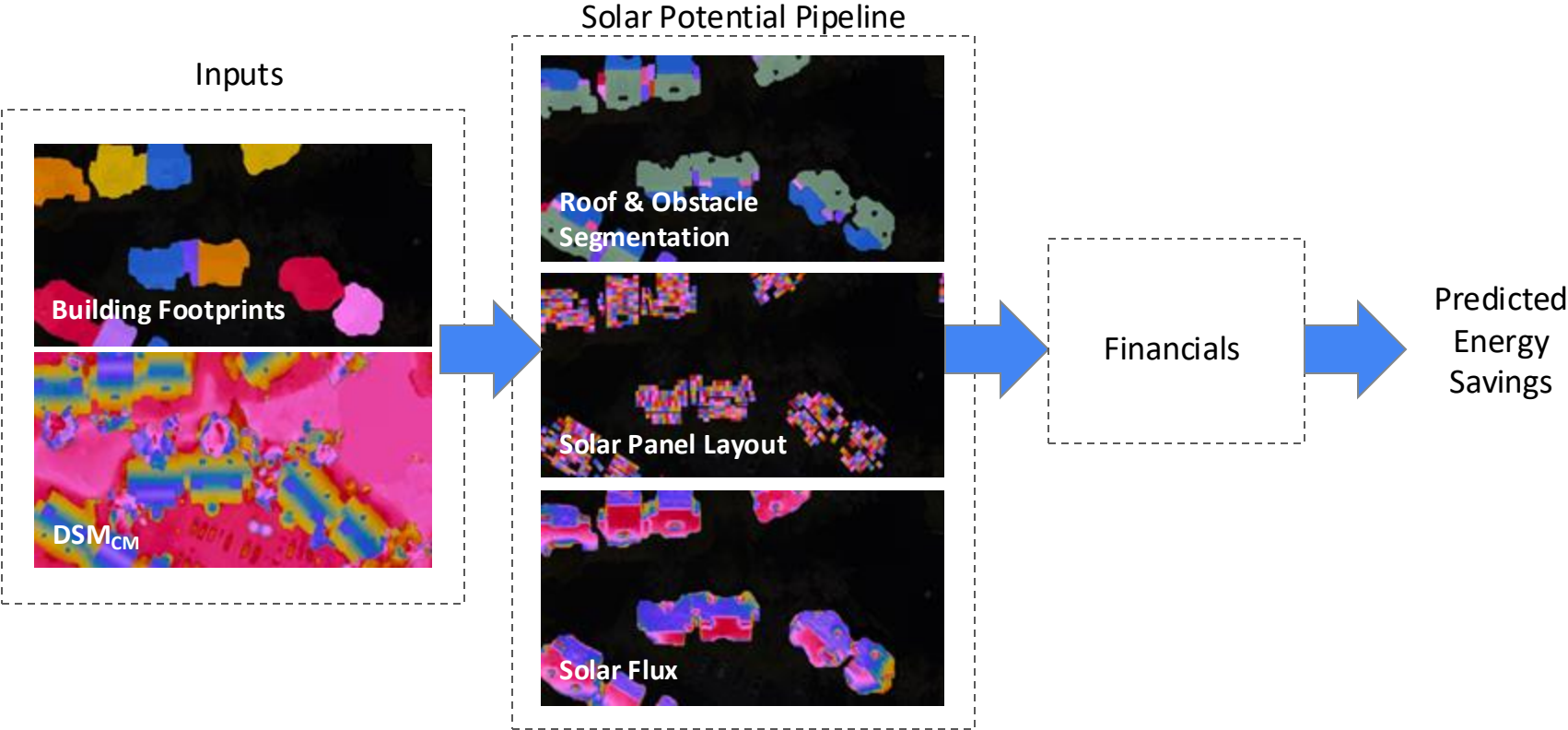


Initially launched in 2016, Google's Project Sunroof estimates the solar potential of individual buildings.

Estimating Solar Potential



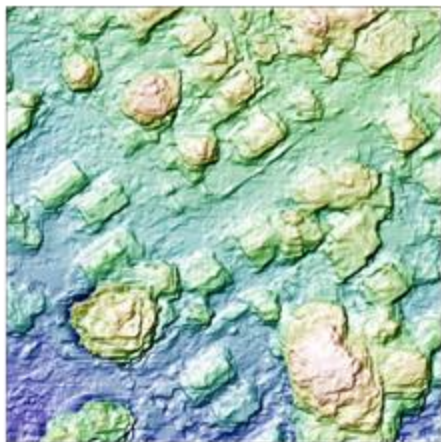
Sunroof Pipeline



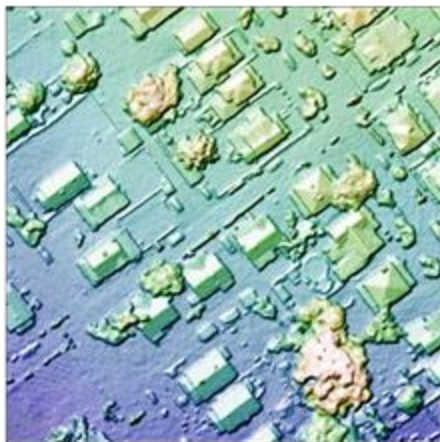
Available Data and its Coverage



RGB_{SM}



DSM_{SM}



DSM_{CM}

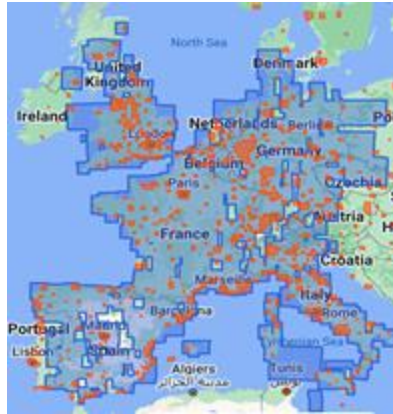


RGB_{CM}

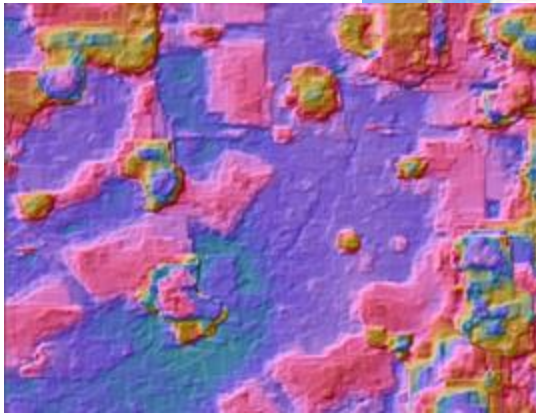
Centimeter scale (CM) data covers only 1/10th the area covered by sub-meter scale (SM) data. Unfortunately, Sunroof cannot operate on SM scale data directly.

Generating high quality Digital Surface Maps

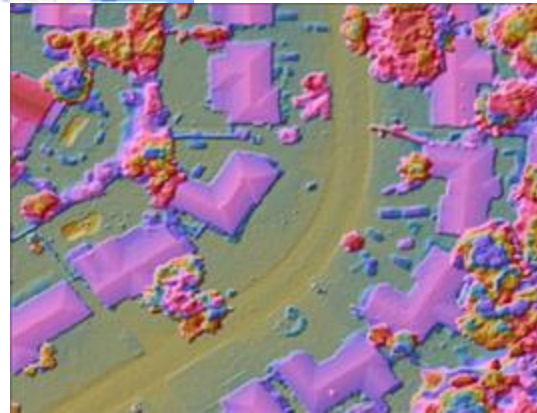
High quality maps have limited availability



Blue: Low quality coverage
Orange: High quality coverage

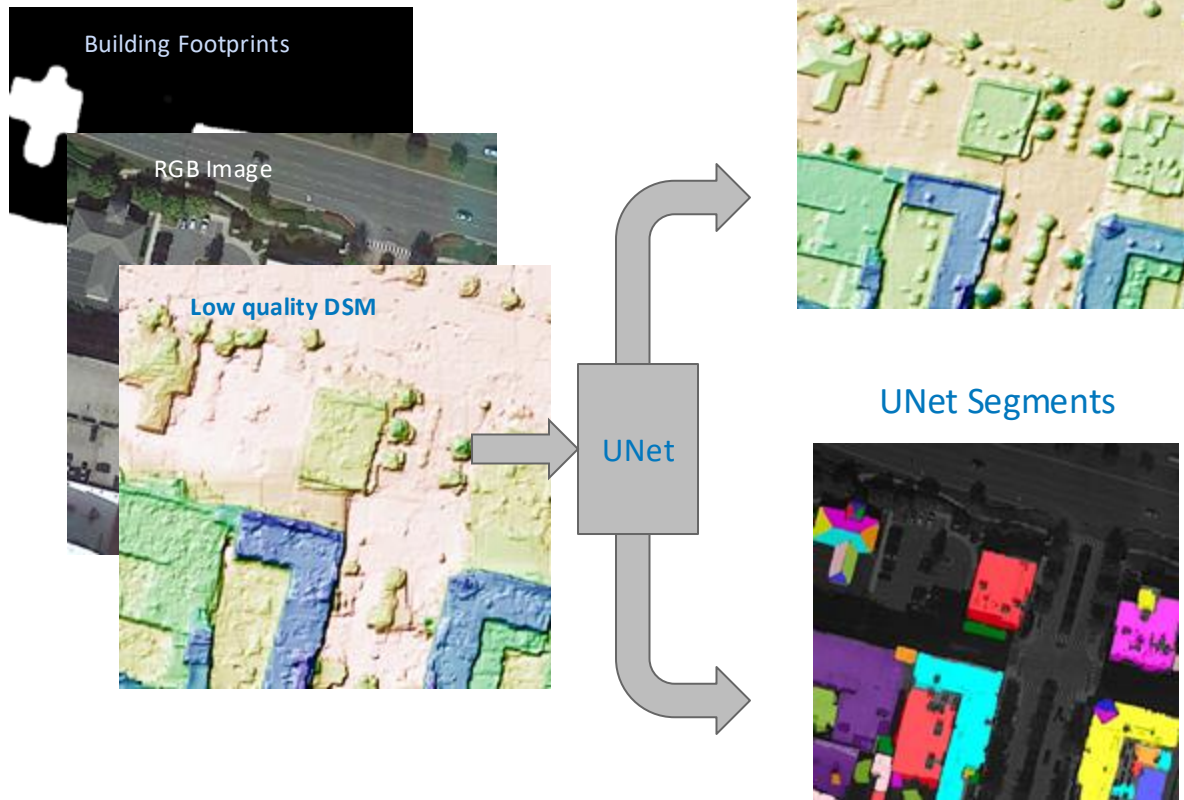


Low quality (DSM)



High quality DSM

Superresolution for DSM and roof segmentation





Google Maps Platform - Solar API

Before



After



Google



Vishal Batchu
Research Engineer



Carl Elkin
Software Engineer



Ross Goroshin
Research Scientist



Varun Gulshan
Research Scientist



Betty Peng
Software Engineer



Jordan Raisher
Software Engineer



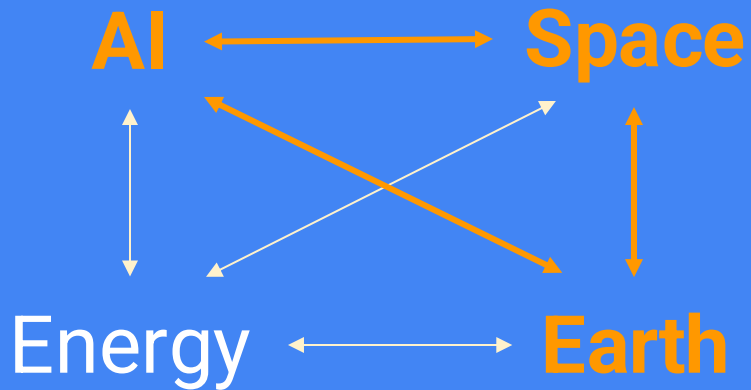
William Rucklidge
Software Engineer



Alex Wilson
Software Engineer

<https://arxiv.org/abs/2408.14400>

FireSat: quickly detecting wildfires from space



Global trend towards more wildfires

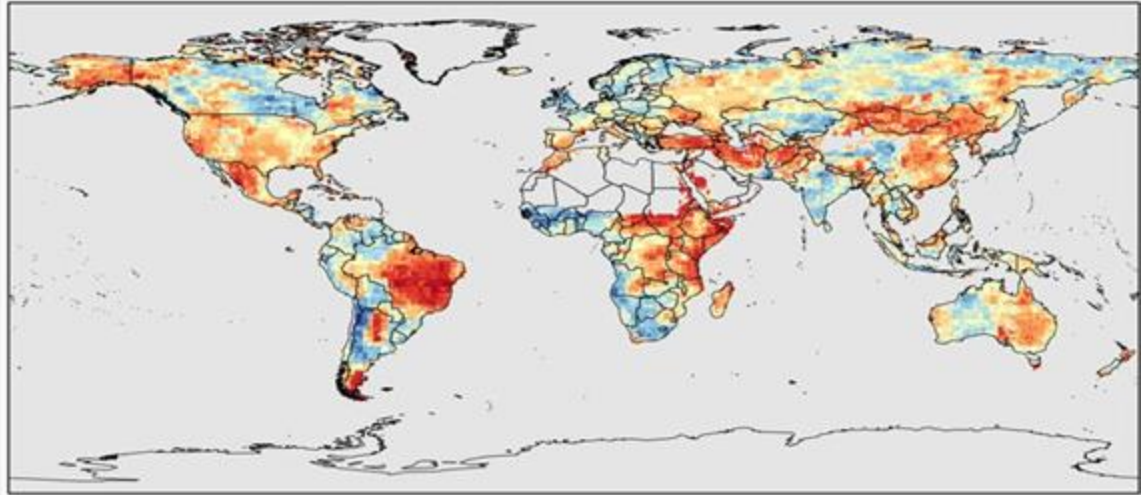
We expect a 15-50% increase for US fires from 2020 levels

Global

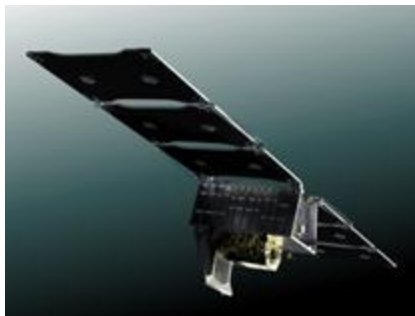
- 330,000 deaths/year (smoke)
- \$100B/year in direct loss
- \$300B/year in indirect damage
- \$15B/year today for suppression

US:

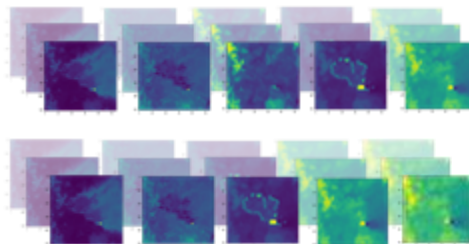
- About 20% of above numbers
- Growing ~15-50% this century.



Idea: Wildfire Ignition Detection



Real-time Satellite imagery



Ignition detection using
machine learning



Realtime data sharing with fire
agencies

What the US has now

Weekly, 30m resolution
includes IR band



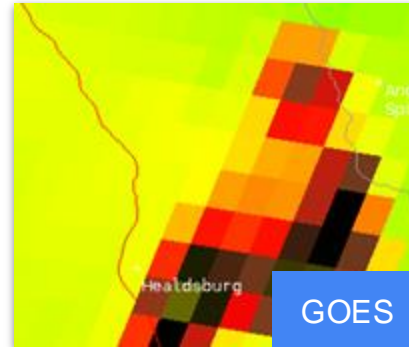
Can see small hot fires ($\sim 20\text{m}^2$)

12 hours, $\sim 500\text{m}$ resolution
includes IR band



Can see medium fires ($\sim 5\text{km}^2$)

10 minutes, 2km resolution
includes IR band



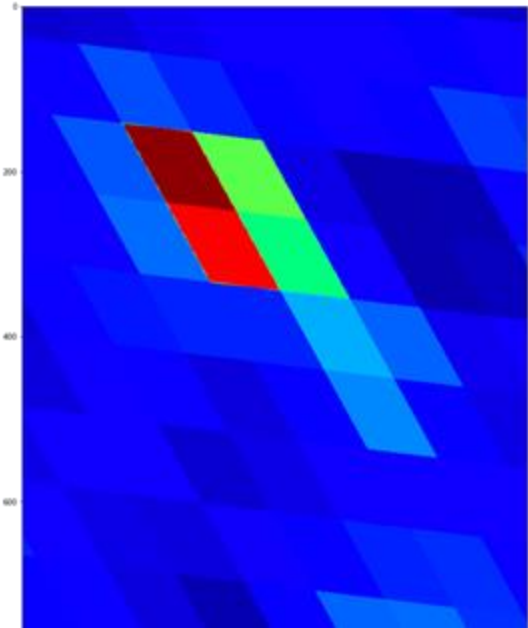
Can see large fires (~ 1 hectare)

Daily, 3-5m resolution
No IR band

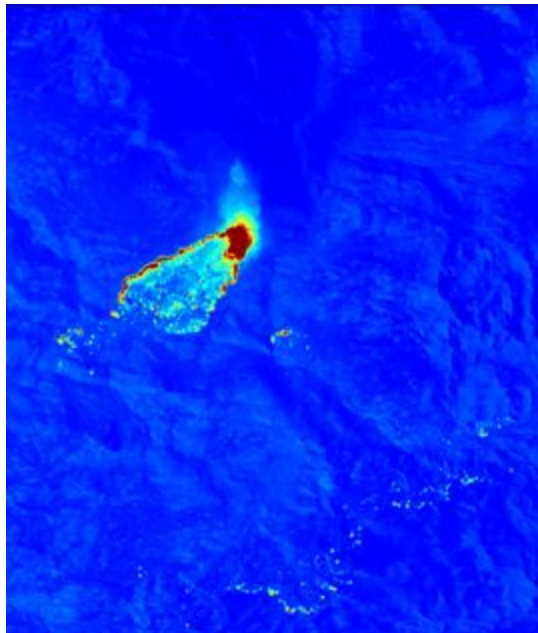
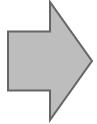


Can see fires *sometimes*

Today vs FireSat (Real Imagery)



GOES (2km by 2km)



Aerial (50m by 50m)

FireSAT: Specs

Goal: Take 50m res. image of the earth every 20 minutes to detect/track small fires.

Constellation costs have come down significantly over the last 15 years, this opens up a lot of potential opportunity.

50+

satellites in full
constellation

20 min

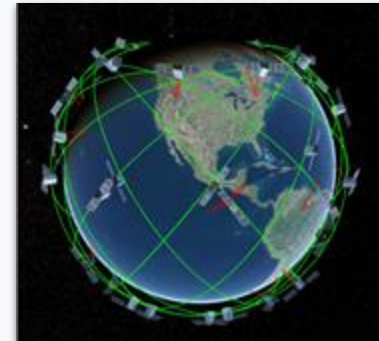
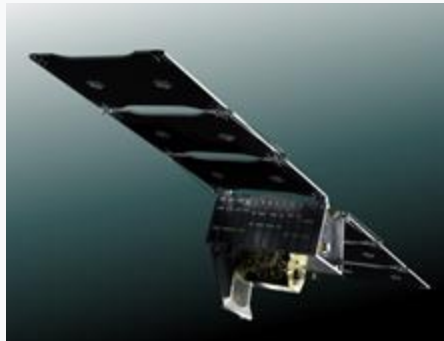
avg revisit time for
anywhere on Earth

50m

resolution
compared to 2km
today

6

Band channels
covering red
through infrared



Using AI-based superresolution

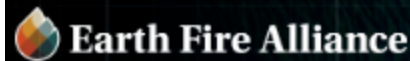


Launched first satellite: 14 March 2025



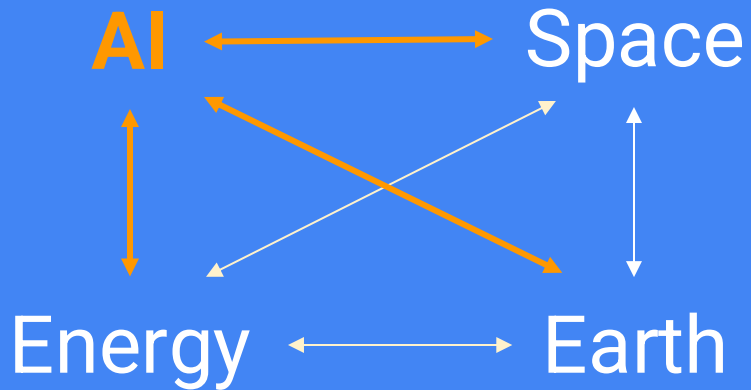
Photo courtesy of SpaceX

Partnerships with



- Image calibration will take between 1-12 weeks
- Build AI analysis pipeline using data from first satellite
- Operational pipeline planned for trio launched in 2026

Reflections on use of AI





Deep learning for space/aeronautics/Earth systems

- Prediction of complex systems
- Super-resolution
- Fill-in missing data
- Solving inverse problems

How can reasoning agents help space / aeronautics / Earth?

Dramatically speed up building software systems

The image shows a Jupyter Notebook interface with two main panels. The left panel contains a code cell with the following Python code:

```
[e] import matplotlib.pyplot as plt
import seaborn as sns

plt.figure(figsize=(18, 8))
sns.heatmap(schema_counts_pivot, annot=False, cmap='viridis', fet=".94")
plt.title('Schema Type Distribution Across Website Sections')
plt.xlabel('Schema Types')
plt.ylabel('Website Sections')
plt.xticks(rotation=45, ha='right')
plt.show()
```

Below the code is a heatmap visualization titled "Schema Type Distribution Across Website Sections". The x-axis is labeled "Schema Types" and the y-axis is labeled "Website Sections". The heatmap shows a distribution of schema types across various website sections, with a color scale ranging from 0.00 to 0.04.

The right panel shows a reasoning agent's response to the prompt: "Reasoning: Create a heatmap to visualize the schema type distribution across website sections using the schema_counts_pivot DataFrame." The agent's response includes the following code:

```
generate the new visualization in the notebook:
Okay, let's generate the new visualization in your notebook. Here's the code:

# Import necessary libraries
import re
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt

# Assuming your DataFrame is named 'df'
# 1. Extract URL Categories
def categorize_url(url):
    if re.search(r'/blog/', url, re.IGNORECASE): # Case-insensitive
        return 'blog'
    elif re.search(r'/products/', url, re.IGNORECASE):
        return 'product'
    elif re.search(r'/collections/', url, re.IGNORECASE):
        return 'collection'
    else:
        return 'page'

Enter a prompt here
```

Future of LLMs and agents for space is wide open

