Microsoft

FarmVibes: AI, Edge, & IoT For Agriculture

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We need to increase production and decrease environmental impact

Over **820 million** people worldwide suffer from hunger

More than **2 billion** people lack vital nutrients

50% more food is needed by 2050. **40%** food wasted.

31% GHG emissions from agri-food systems, **70%** fresh water use

Data-driven Agri-Food systems

Bringing data to the cloud enables key insights for individuals and organizations.

Agrochemical and Seeds

Agriculture equipment

Agriculture retail, farm coop, agronomist

Farmer

Co-ops

Food processing

Distribution

Retailer

Consumer

30%
of Crop inputs wasted due to lack of reliable data & tools

8x
Increase in farm data generation in next 10 years

>99%
Calories consumed from <1% of plants

500
Hours facility prod downtime, on avg at $25K/hour

3-10%
Commission fee charged by food brokers

$10B
Spend by Big CPG in 2020 for consumer analytics

67%
Consumers want full food ingredient transparency

When this data is shared, we unlock greater efficiencies and productivity across the supply chain.

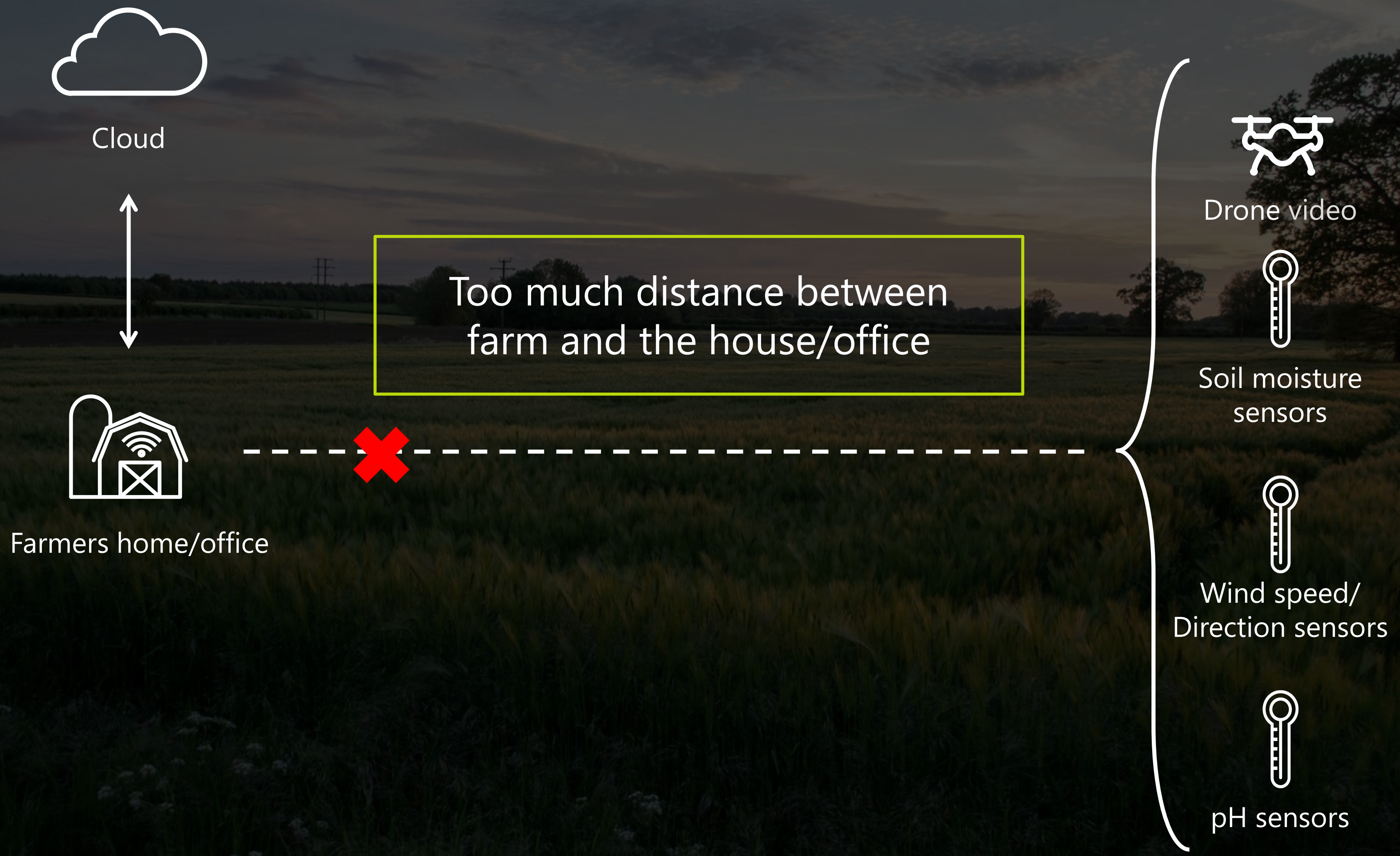
Data-driven agriculture

Precision & regenerative agriculture has been shown to:

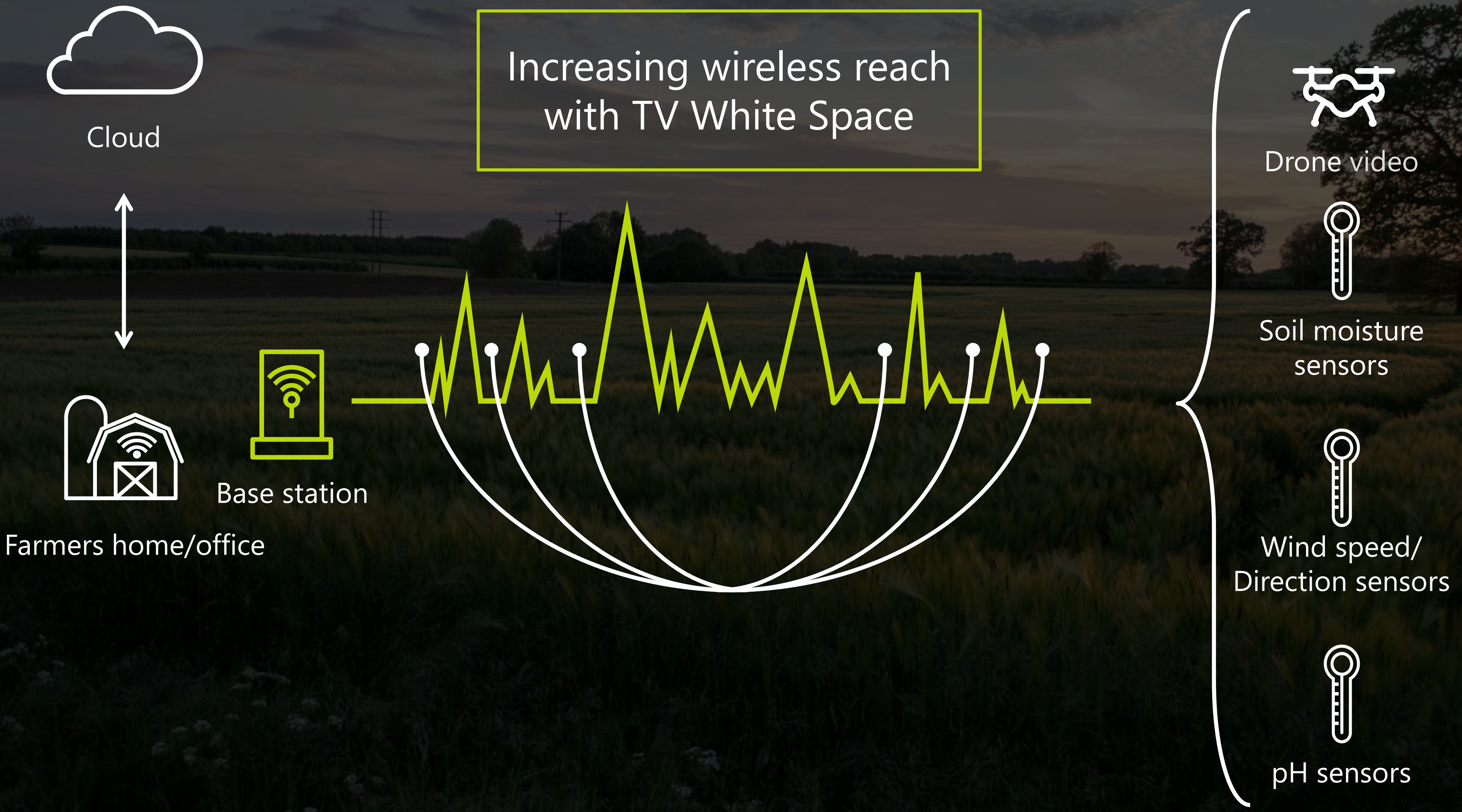
- Improve yield
- Reduce cost
- Ensure sustainability

According to USDA, high cost of manual data collection prevents farmers from using data-driven agriculture.

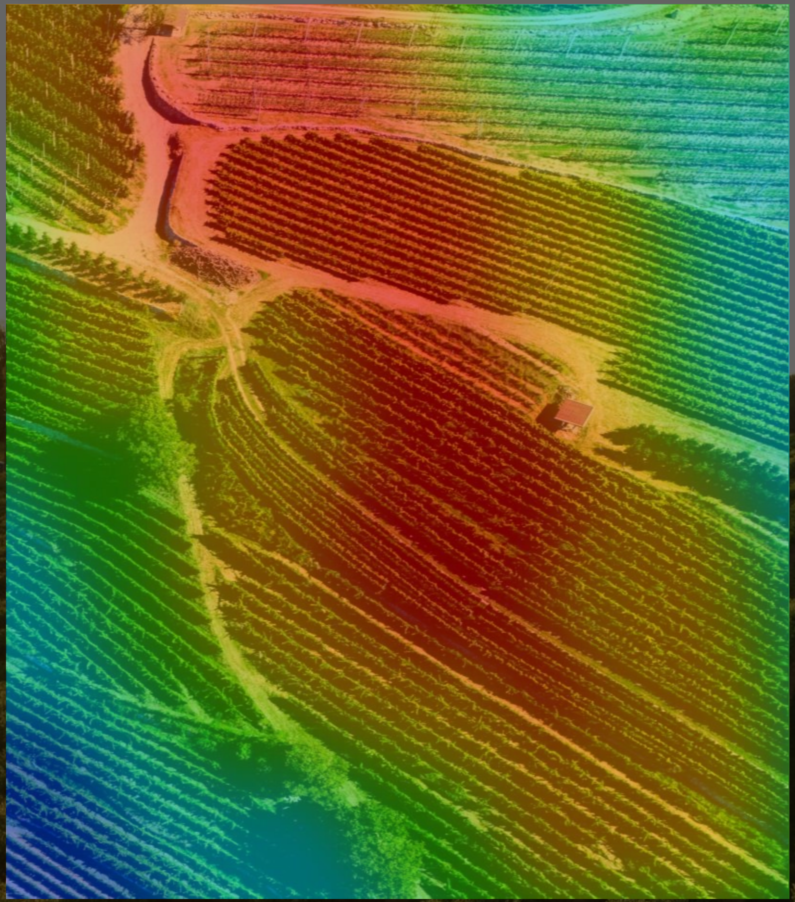
Challenge 1: Connectivity on farms



A solution in white space



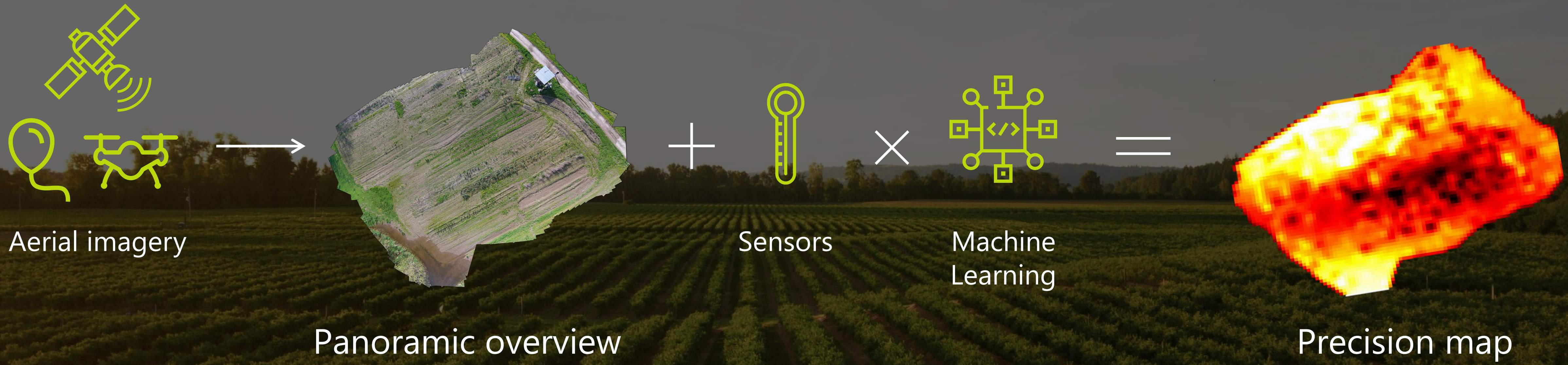
Challenge 2: Sparse sensor deployments



- Physical constraints due to farming practices
- Too expensive to deploy and maintain

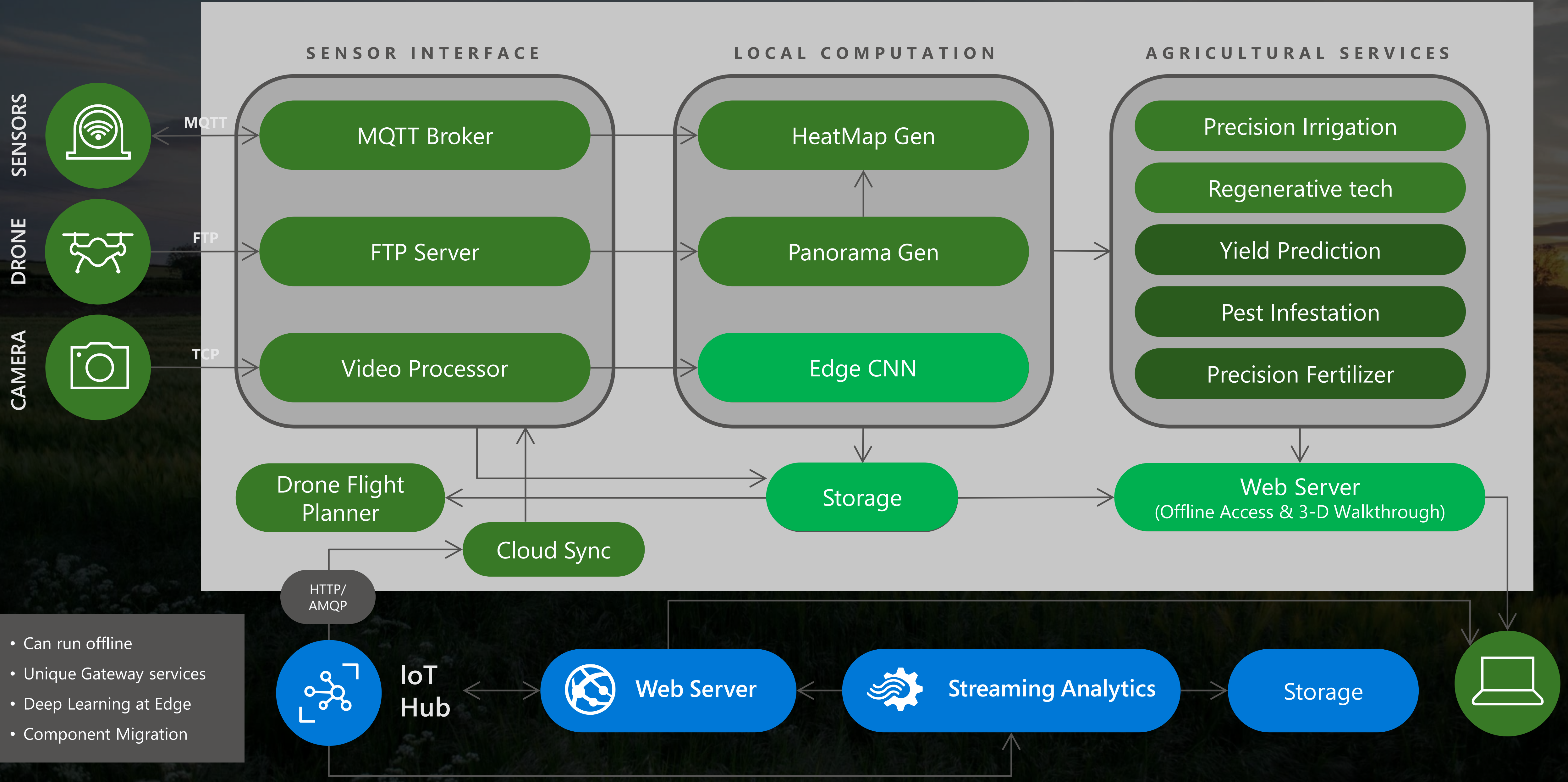
How do we get coverage with a sparse sensor deployment?

Use aerial imagery and AI to enhance spatial coverage



Edge Compute in the Farm

IoT Edge



- Can run offline
- Unique Gateway services
- Deep Learning at Edge
- Component Migration

Deployment

Deployments in several locations including WA, CA, NY

Farm sizes range from 0.5 – 9000 acres

Sensors:

- DJI Drones
- FarmBeats sensor boxes with soil moisture, temperature, wind speed/direction sensors
- IP Cameras to capture IR imagery as well as monitoring

Cloud Components: Azure IoT Suite

Micro-Climate Forecasting

Goal:
Microclimate weather forecasting model based on FarmBeats sensors in the field.

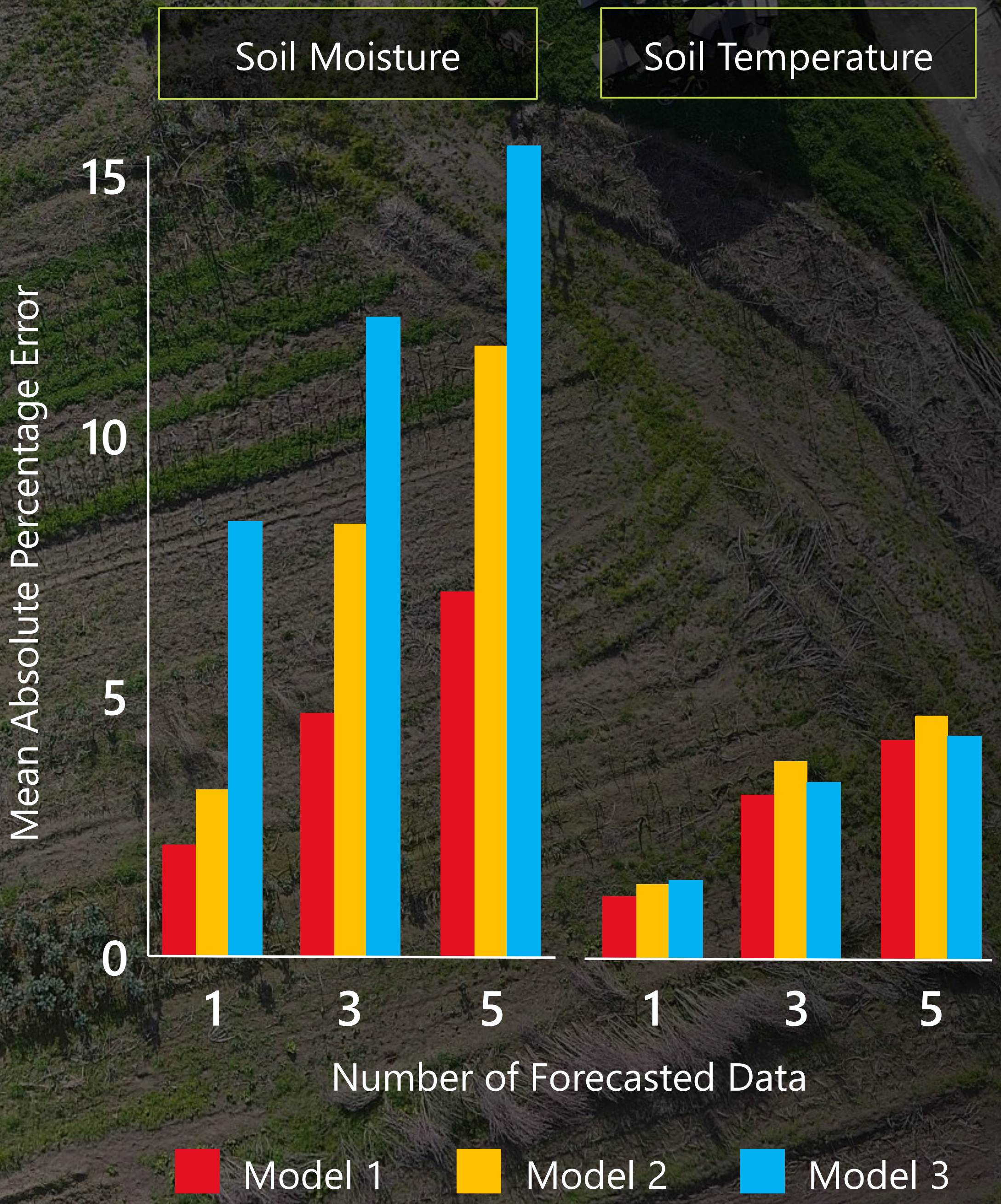
Impact:
Knowing microclimate enables better modeling of plant diseases, application timing, and risk management.

Challenges:
Forecast important variables for accurate plant disease prediction, not included in current weather forecasts (results shown).

Results:
Soil moisture & temperature forecasting error less than 10%.

Forecast for low temp was 42 degrees. Micro-Climate forecast was 31 degrees in lower areas of the field. Actual was 30 degrees. Instead of spraying grass herbicide, the farmer waited and avoided large crop damage in some of the most productive areas.

*The **lower the error,** the better the prediction.



Example: Panorama

Water puddle

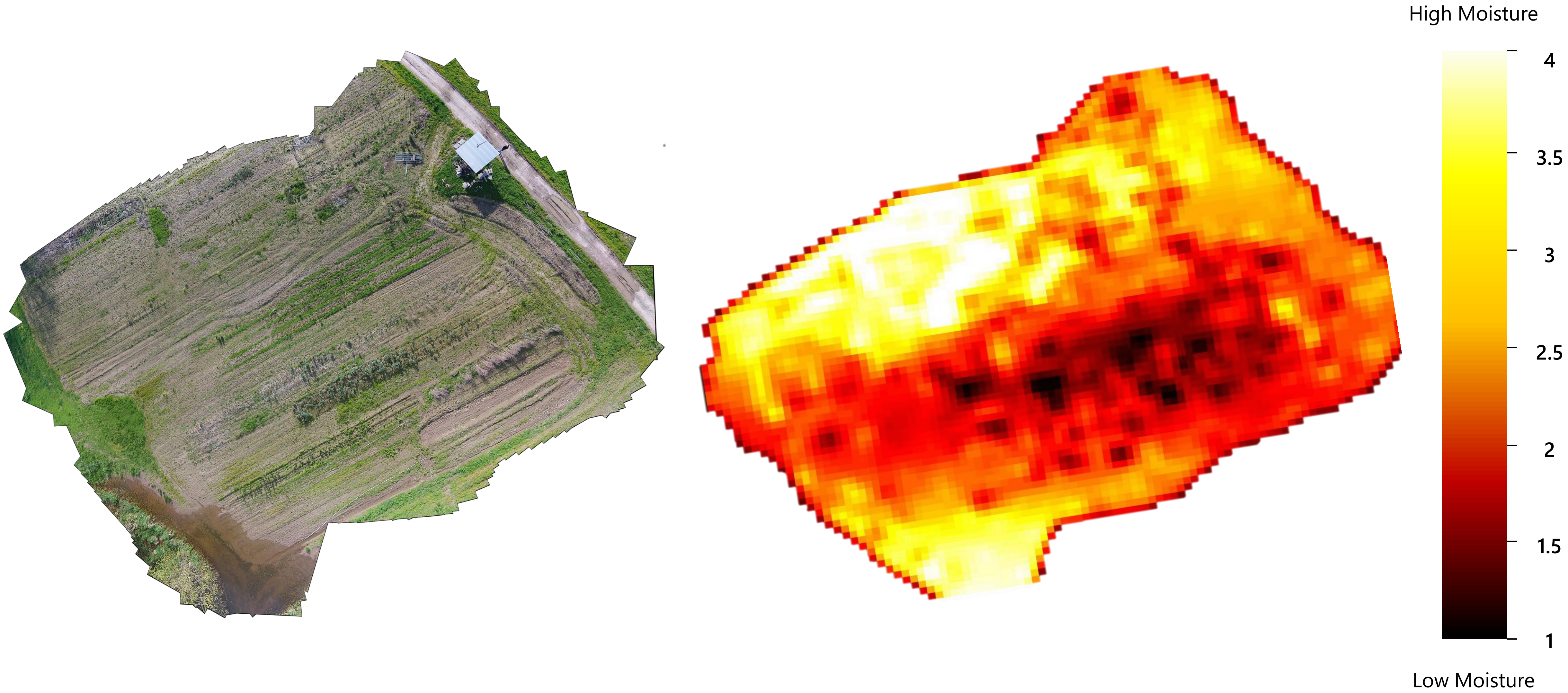
Cow excreta

Cow herd

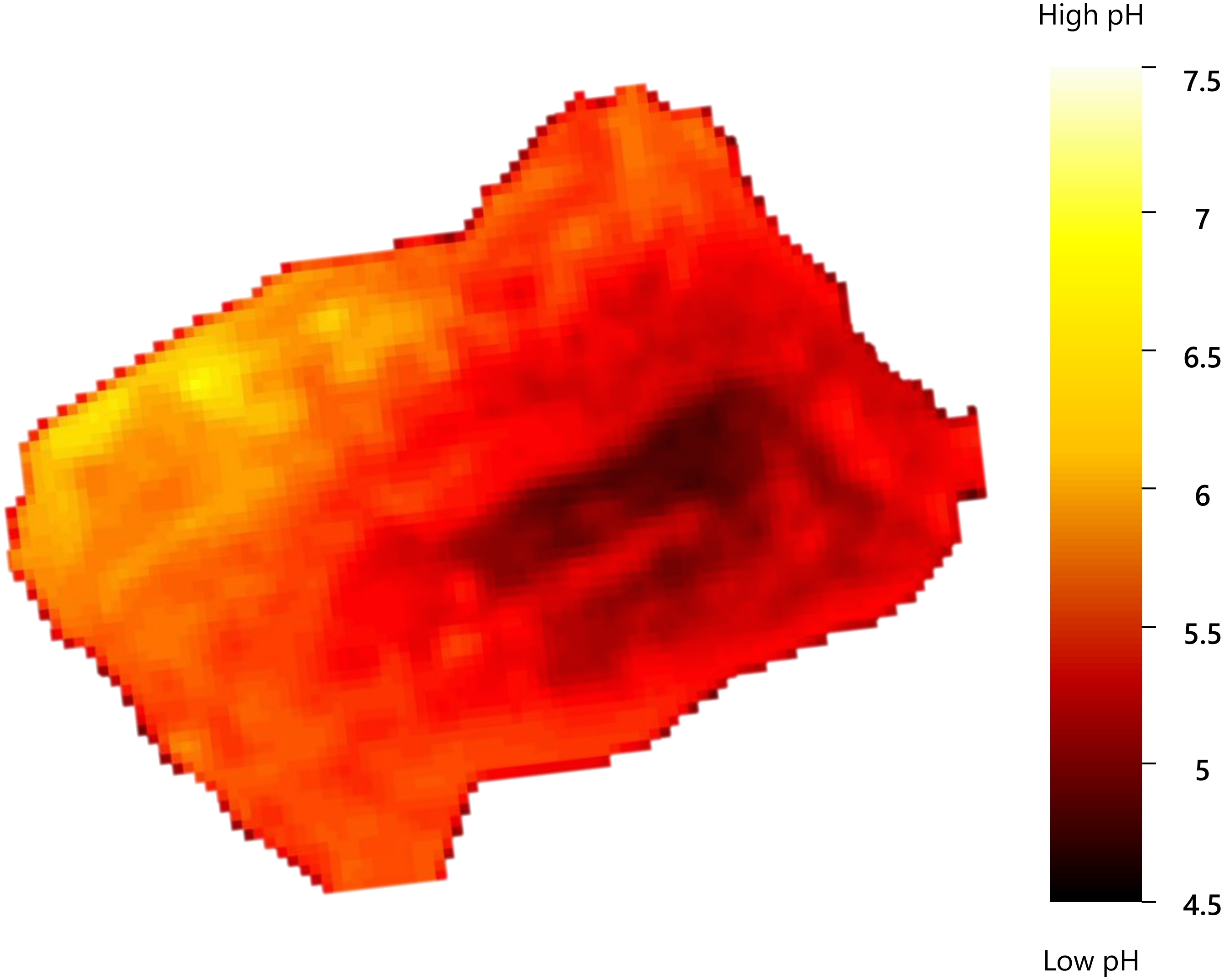
Stray cow

Precision Map: Panorama Generation

Precision Map: Moisture



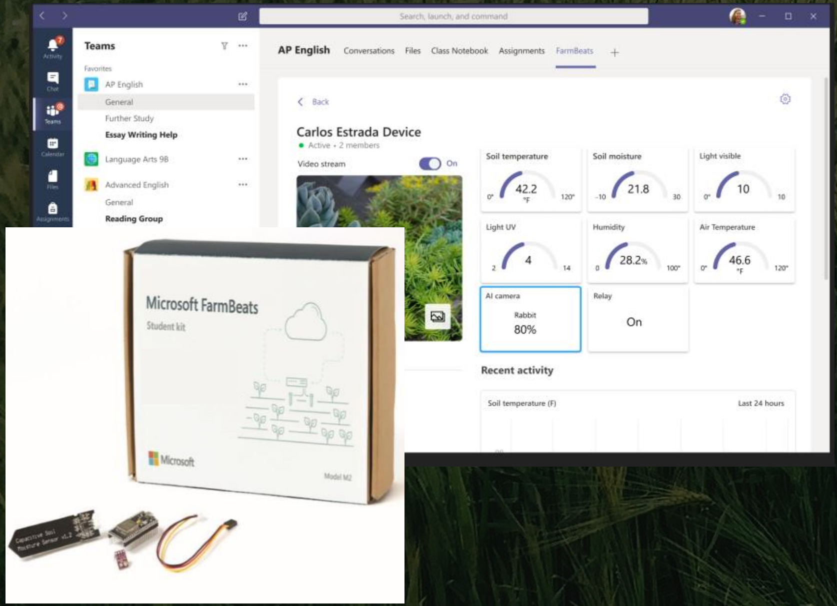
Precision Map: pH



Application: Cow-Shed Monitor

Future Farmers of America + FarmBeats + FarmVibes

The Microsoft TechSpark initiative is bringing precision agriculture and AI to classroom with **FarmBeats student kits.**



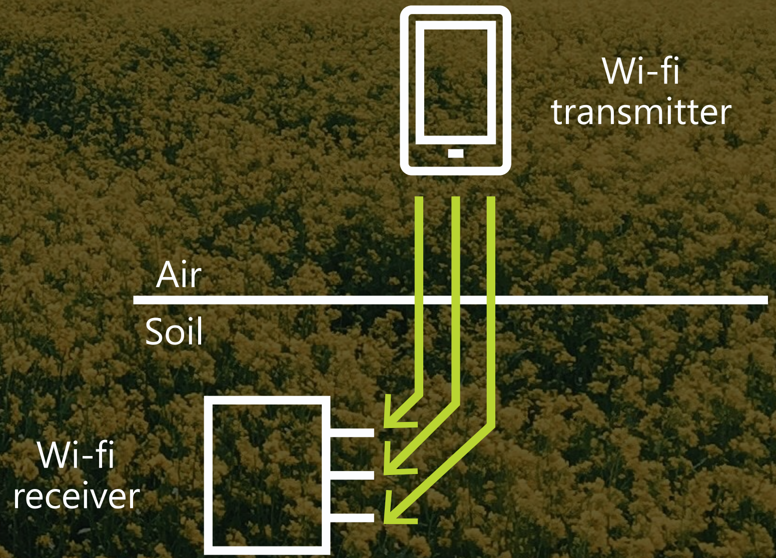
Affordable sensing
low-cost soil moisture and EC sensing using Wi-Fi

Motivation: existing sensors are expensive

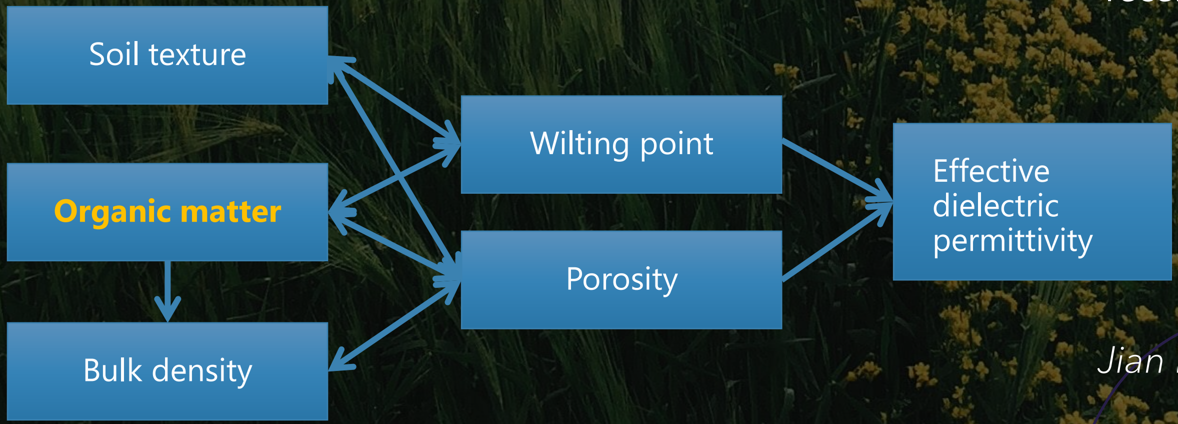
- ~100s of dollars

Strobe design: Wi-Fi cards with 2+ antennas

- Relative time-of-flight and amplitude



Results: Strobe can accurately detect moisture and EC change in soil



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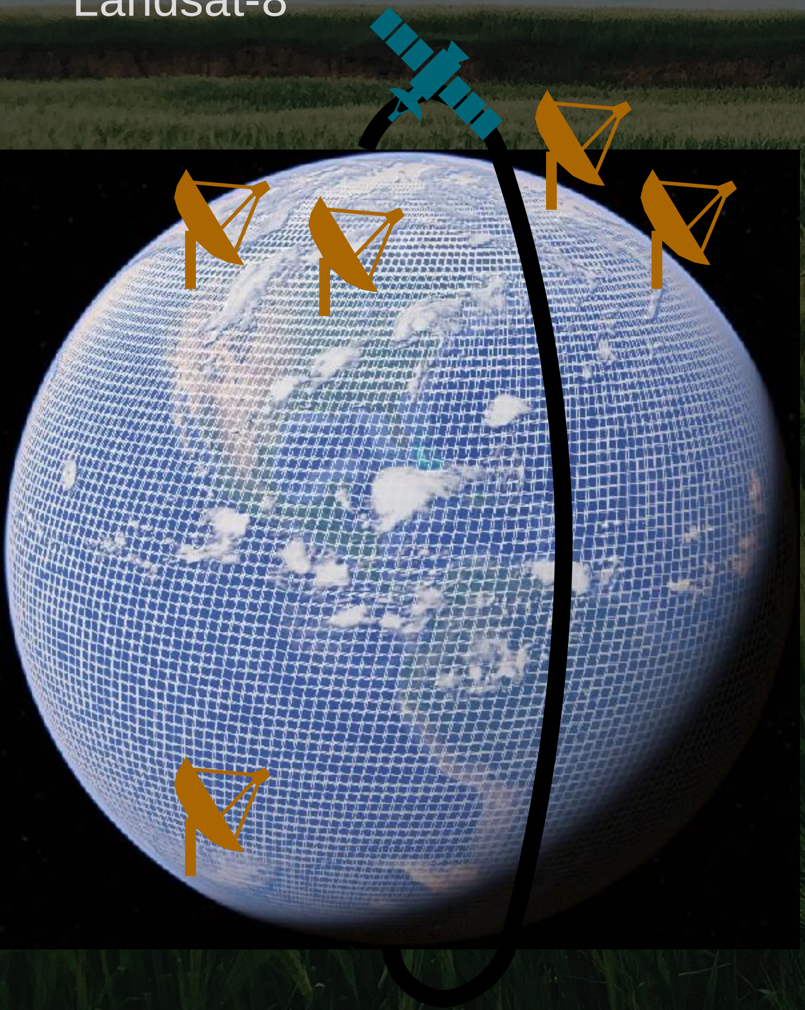
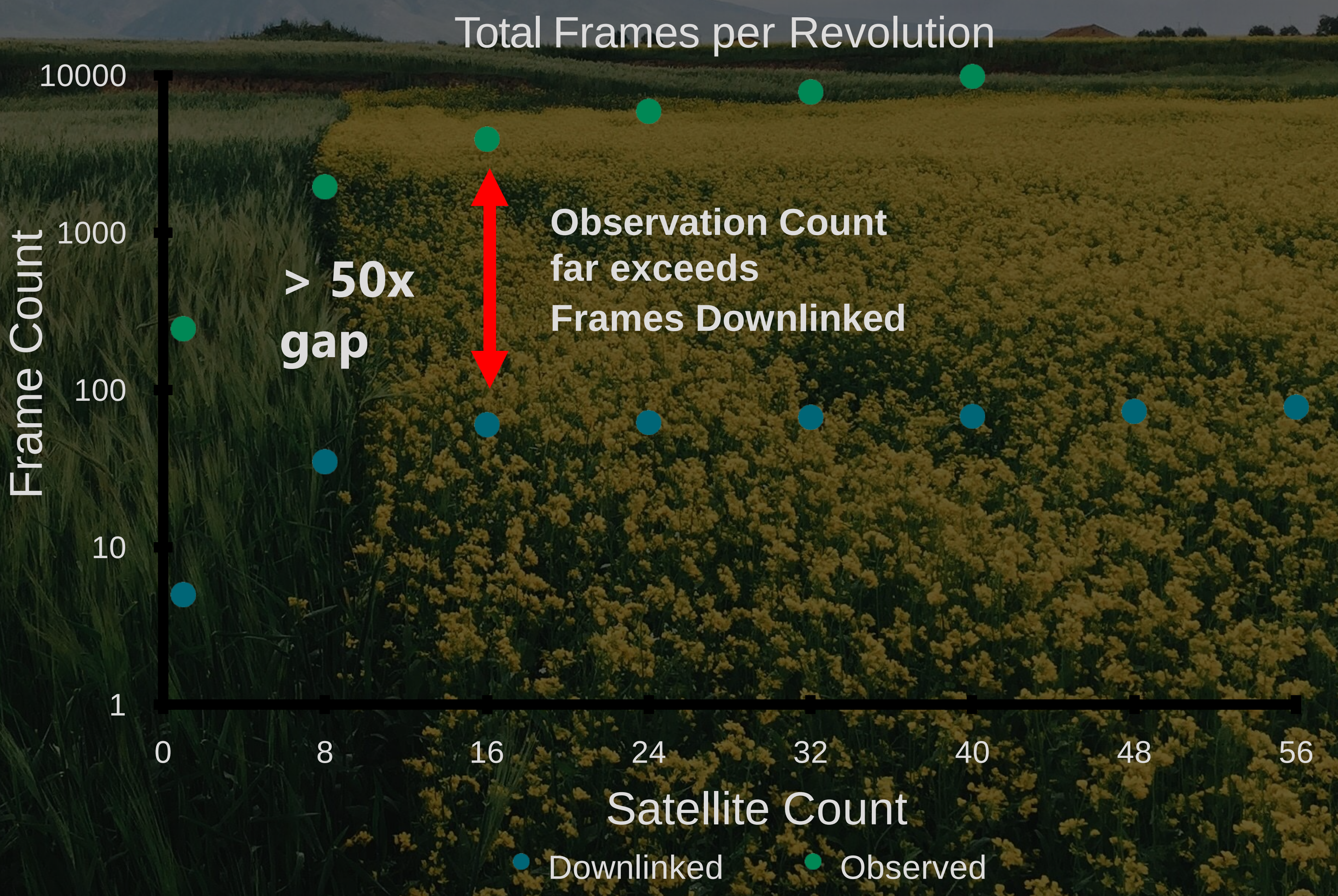
Edge in Space: The Downlink Bottleneck

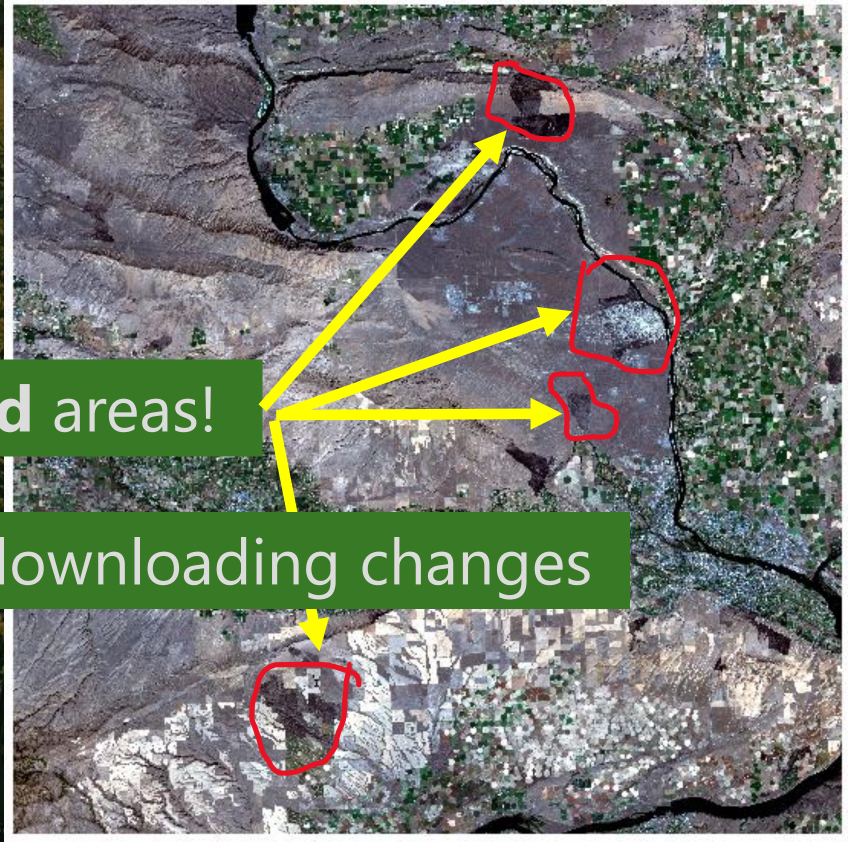




Key idea: Filter Out Low Value Data at Edge

09/2018, reference image

10/2018, captured image,

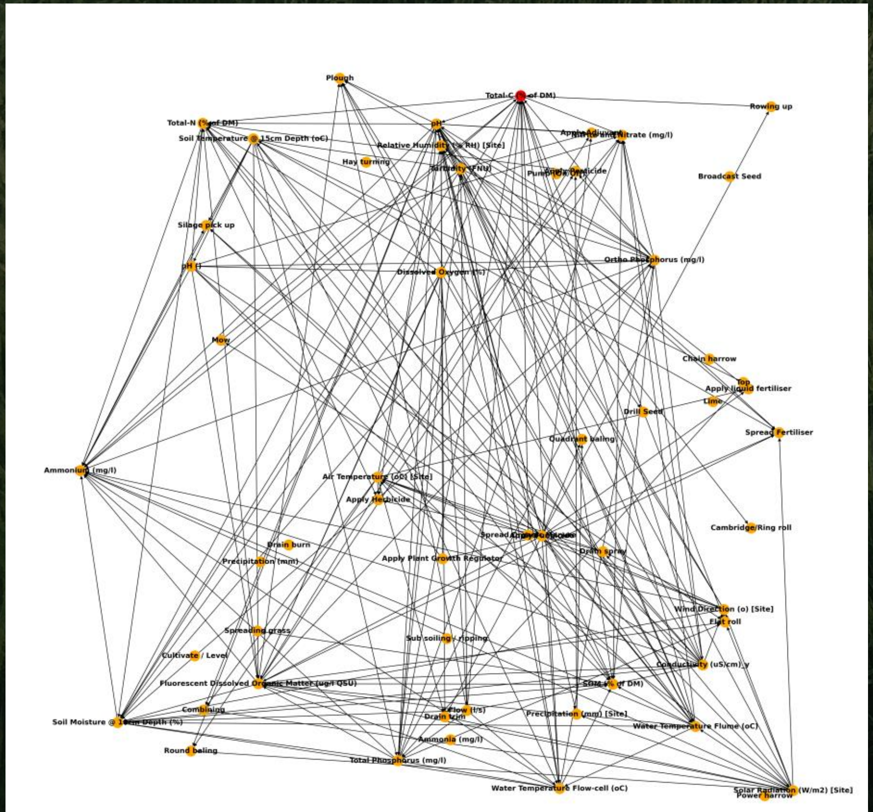


Only download **changed** areas!

Potential: **16.5x** compression when only downloading changes

Soil Carbon Modeling

Accurately models 78.6 % in changes in soil carbon using weather drivers, green house gas emissions, soil macro-nutrient information for test farms



Causal Graph

Our Goal:

1. Model cause-and-effect relationship among soil processes.
2. Identify factors that cause changes in soil carbon.
3. Customizing process models for region-specific modeling

Machine Learning Paradigm:

Explicitly learn **cause and effect** relationships.

Incorporate **spatial-temporal** correlations.

Use **domain knowledge** to guide learning.

Example of Discovered Relations:

Discovered Causal Relations	Reasoning
Soil Temperature → Soil Carbon	Higher temperatures decomposes organic carbon
Soil Nitrogen → Soil Carbon	Nitrogen and Carbon co-metabolize in soil
Dissolved Oxygen → Soil Carbon	Dissolved oxygen in soil improves the organic matter content

Microsoft

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