



Delivering on Quant

Project Canary Emissions Quantification Technology.
Defining the Race to Accuracy.



QUANTIFICATION SCIENTIFIC JOURNEY

01

Quantification V1

02

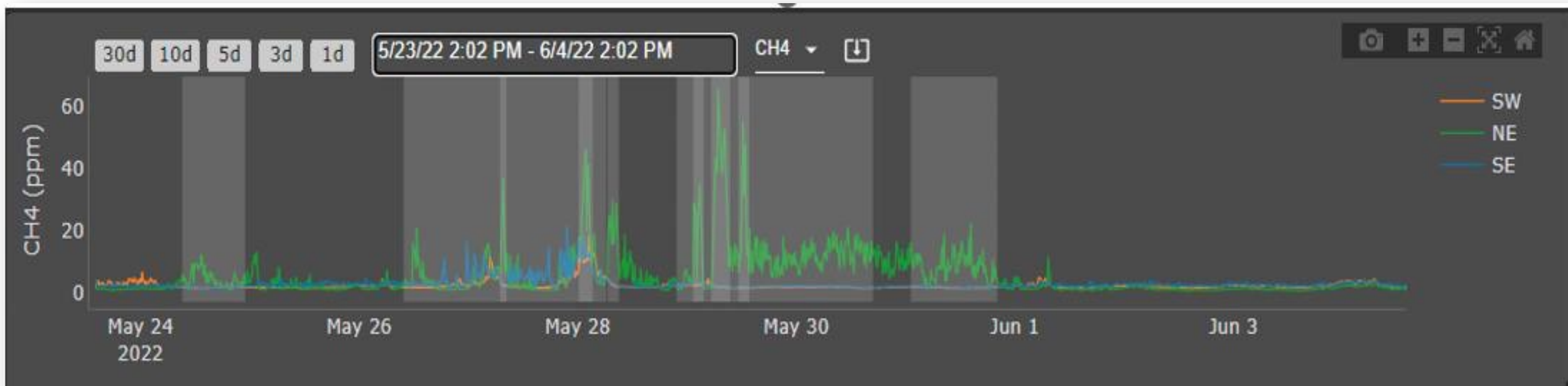
Quantification V2

03

Total Site Emissions

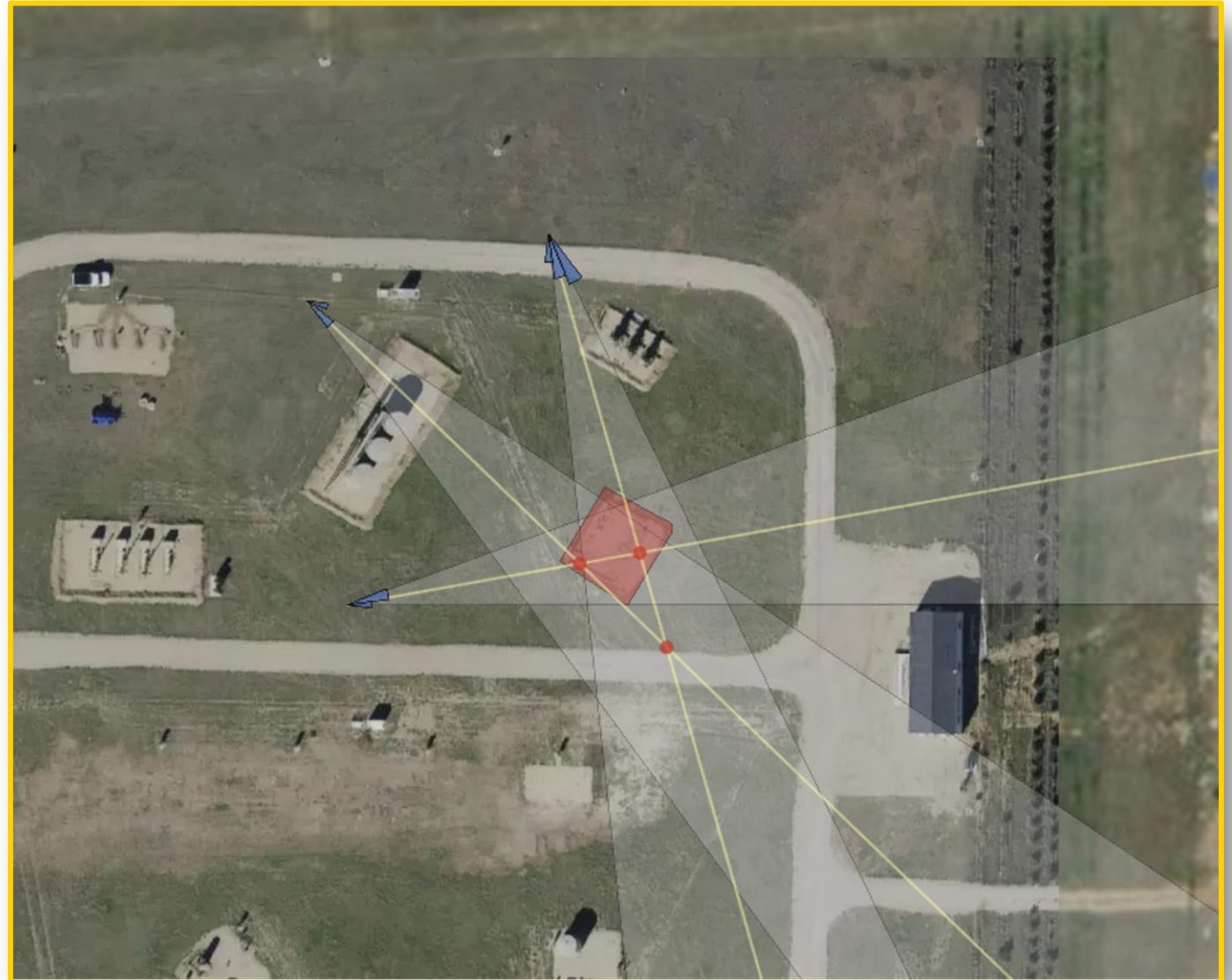
Leak Detection & Intervention

- Emissions event judged on differential over background
- Project Canary notified operator of a methane leak
- Operator analyzed wind emissions data to source the leak to a cooler line and verified using OGI camera
- Operator resolved the operational problem that was causing the leak



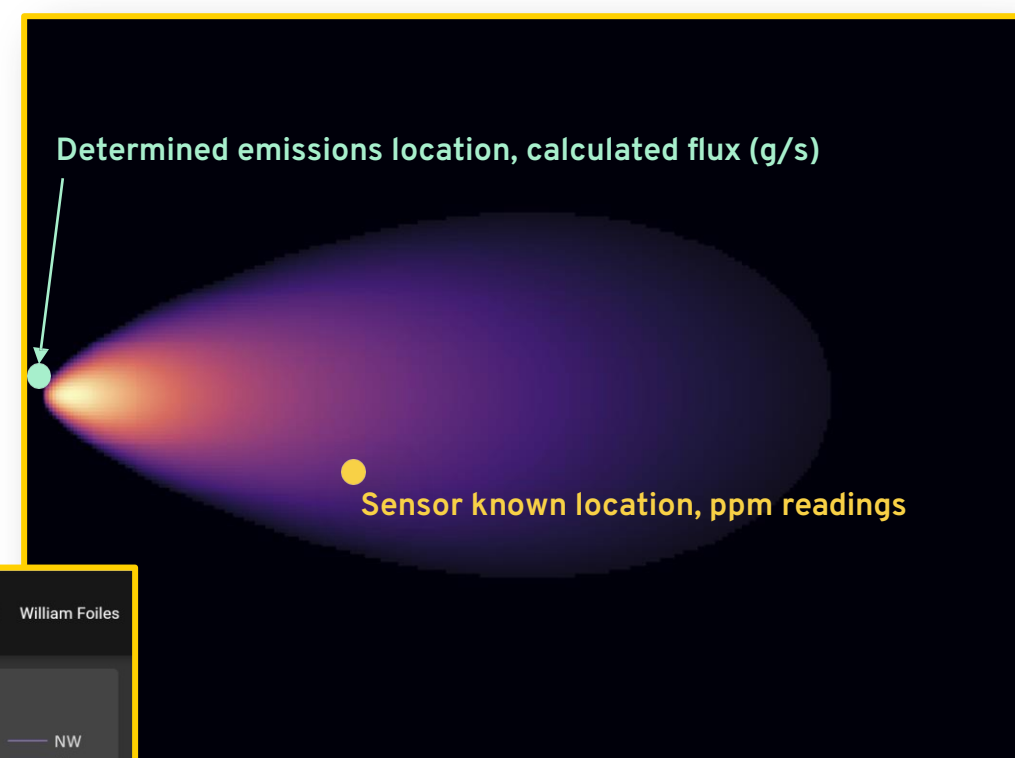
Canary Quant v1: Determine Single Leak Location

- **Localized wind direction** translated into angular geometry to determine possible points of intersection
- Process repeated for next minute of data
- **Weighted centroid of intersection points** to determine location



Compute Quantity & Duration of Single Leak

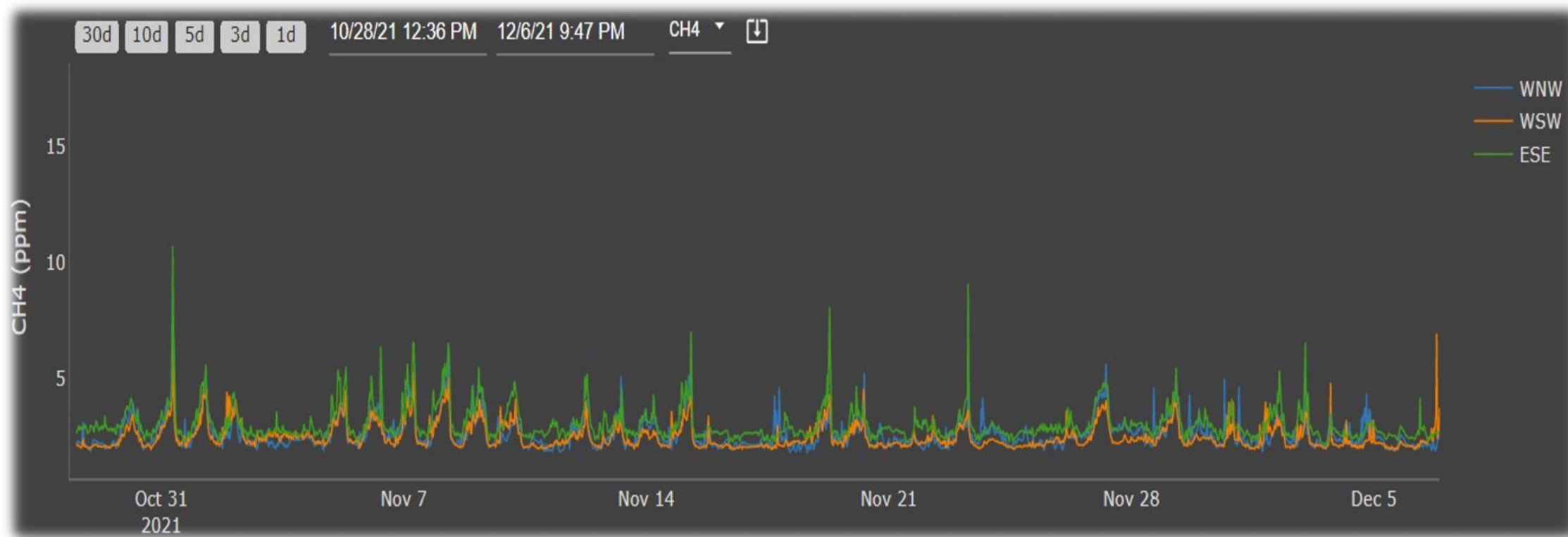
- Use physics dispersion models: Gaussian plume, FEAST, Brookhaven National Lab coefficients
- Determine point in time **flux (g/s)**



- **Duration of emission** key to total mass values ($\text{g/s} * \text{sec}$)
- Once event is triggered, algorithm looks for confirmation of ending

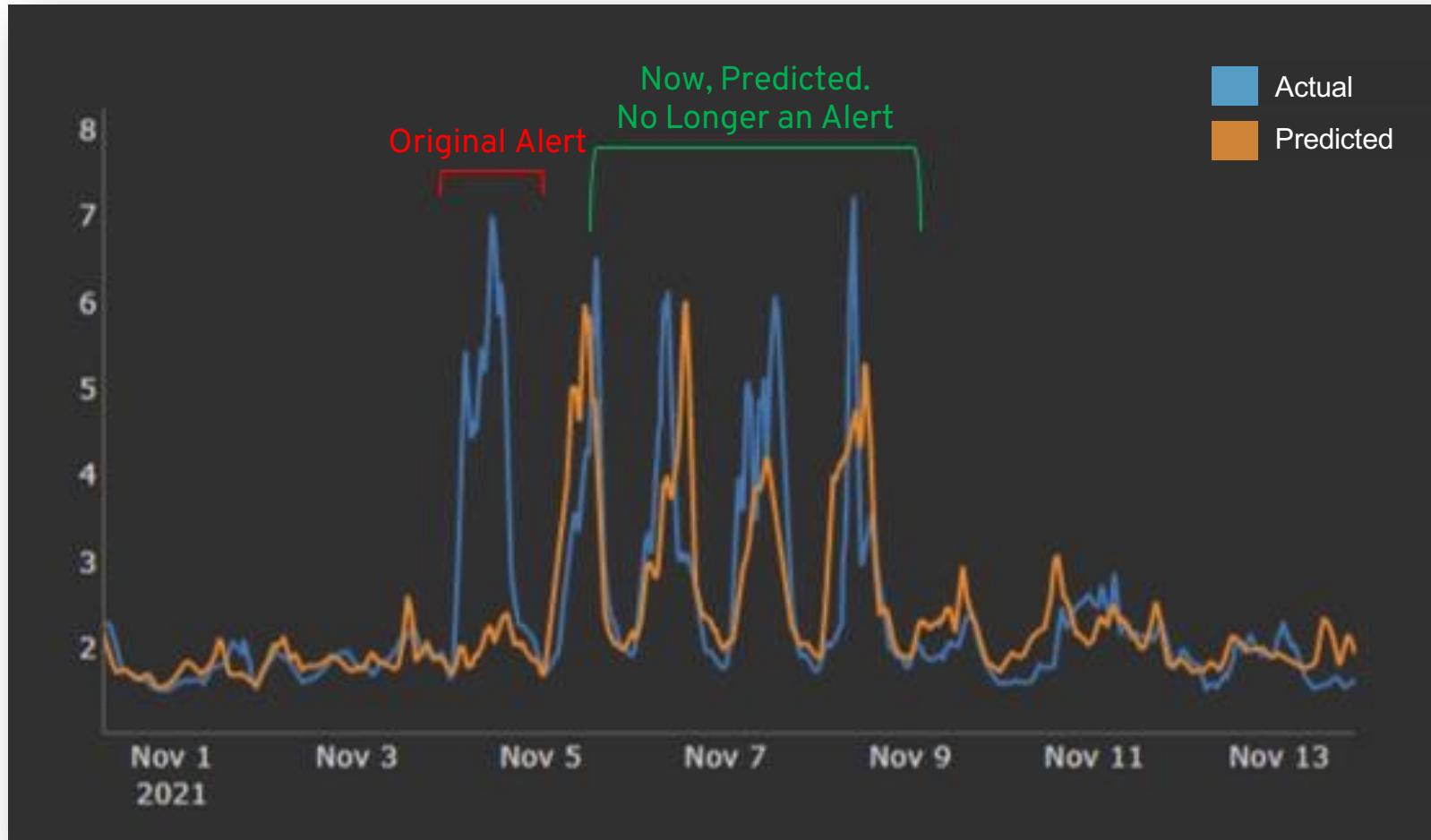
But... Diurnal Patterns?

- Alerts based on any concentration change from baseline emissions resulted in too many false alarms
- We recorded and tracked diurnal patterns on sites
- Determined that emissions consistently rise at night was due to atmospheric changes
- The model must account for this predictable change in concentration



Smart Alerts & Canary Quant v2:

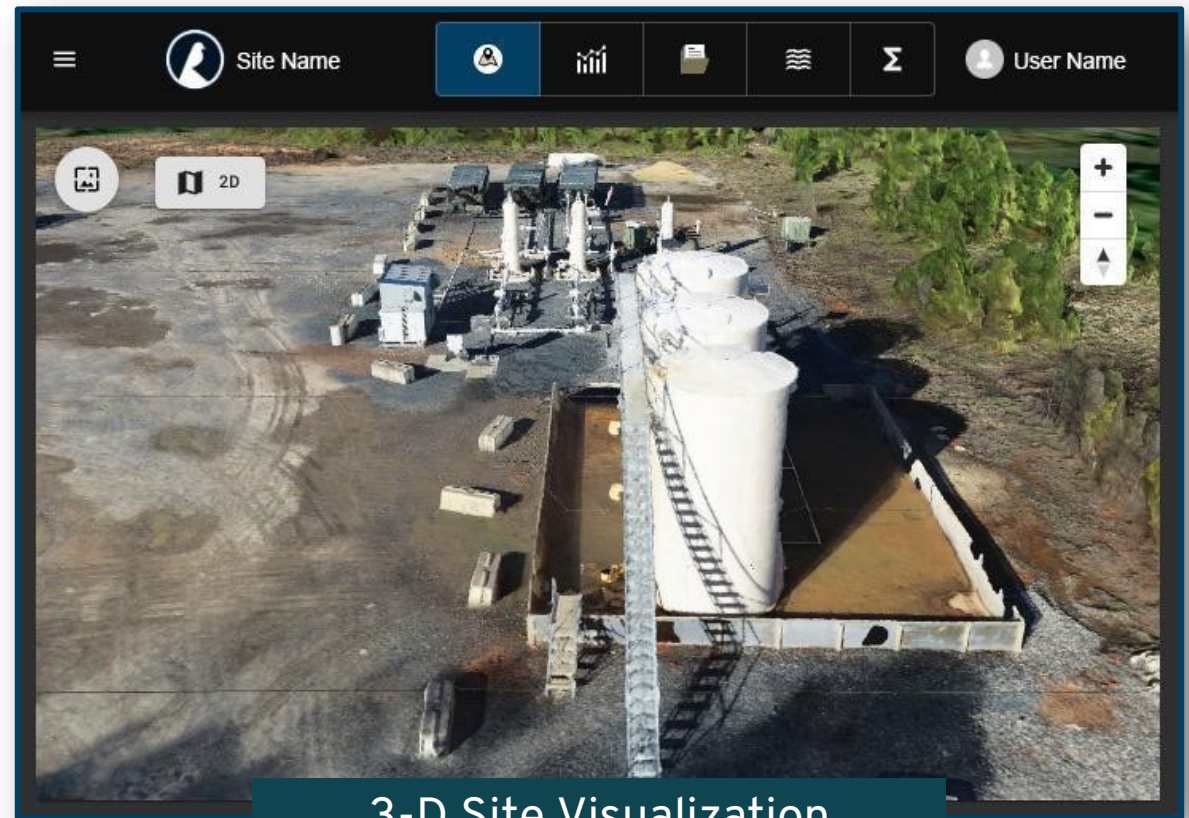
Machine Learning Excludes Routine Fluctuations



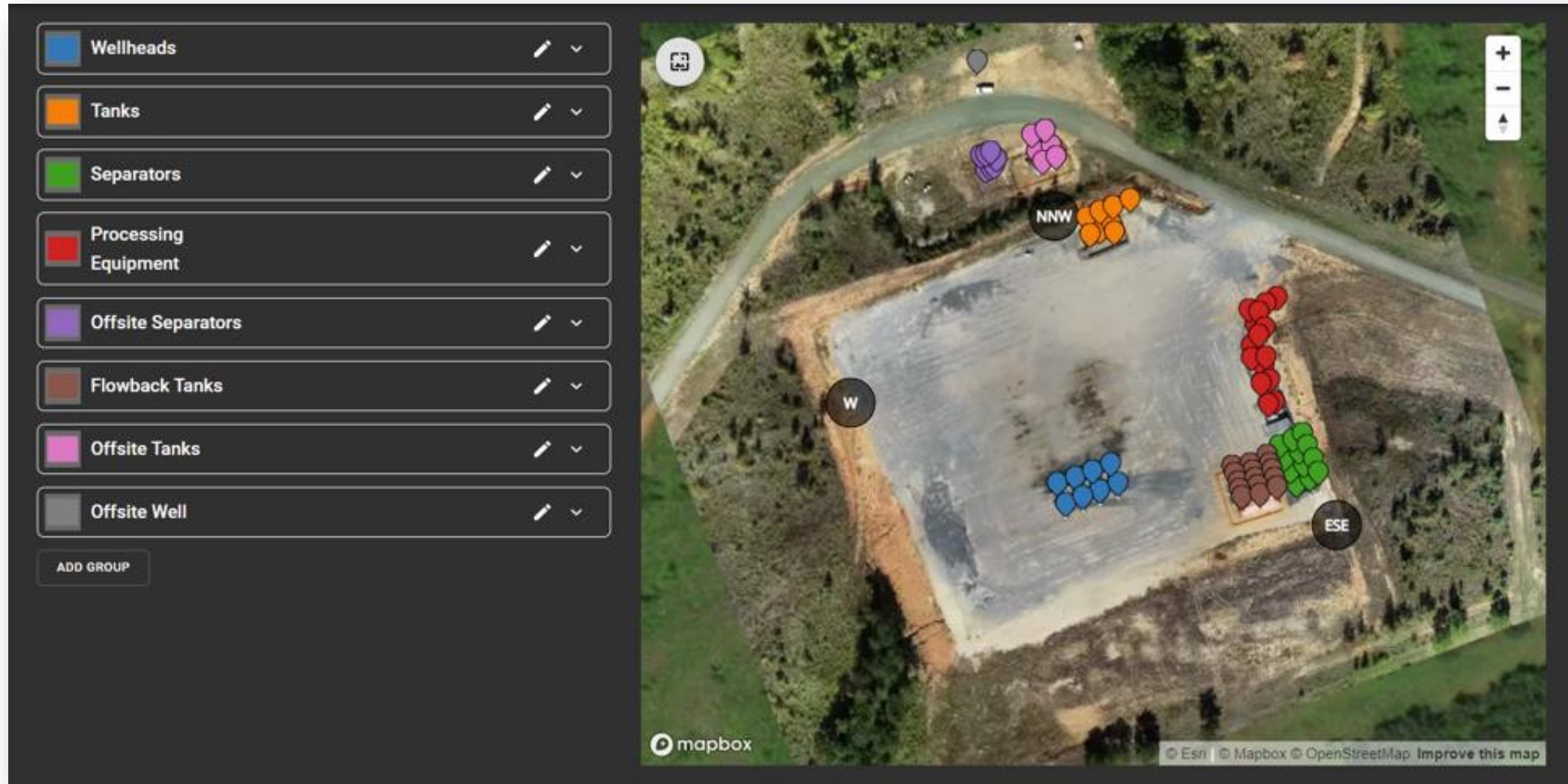
1. Integrating human training allows model to learn to predict better
2. Better predictions leads to more refined alarms
3. More refined alarms lead to more actionable alarming

What About Multiple, Simultaneous Emission Sources?

- 1 High-resolution drone imagery of well pad
- 2 Strategic Canary device placements
- 3 Precise GIS mapping of on-site and off-site emission sources
- 4 Site emissions-performance data (30 days minimum)



Geo-Tag All Possible Leak Locations

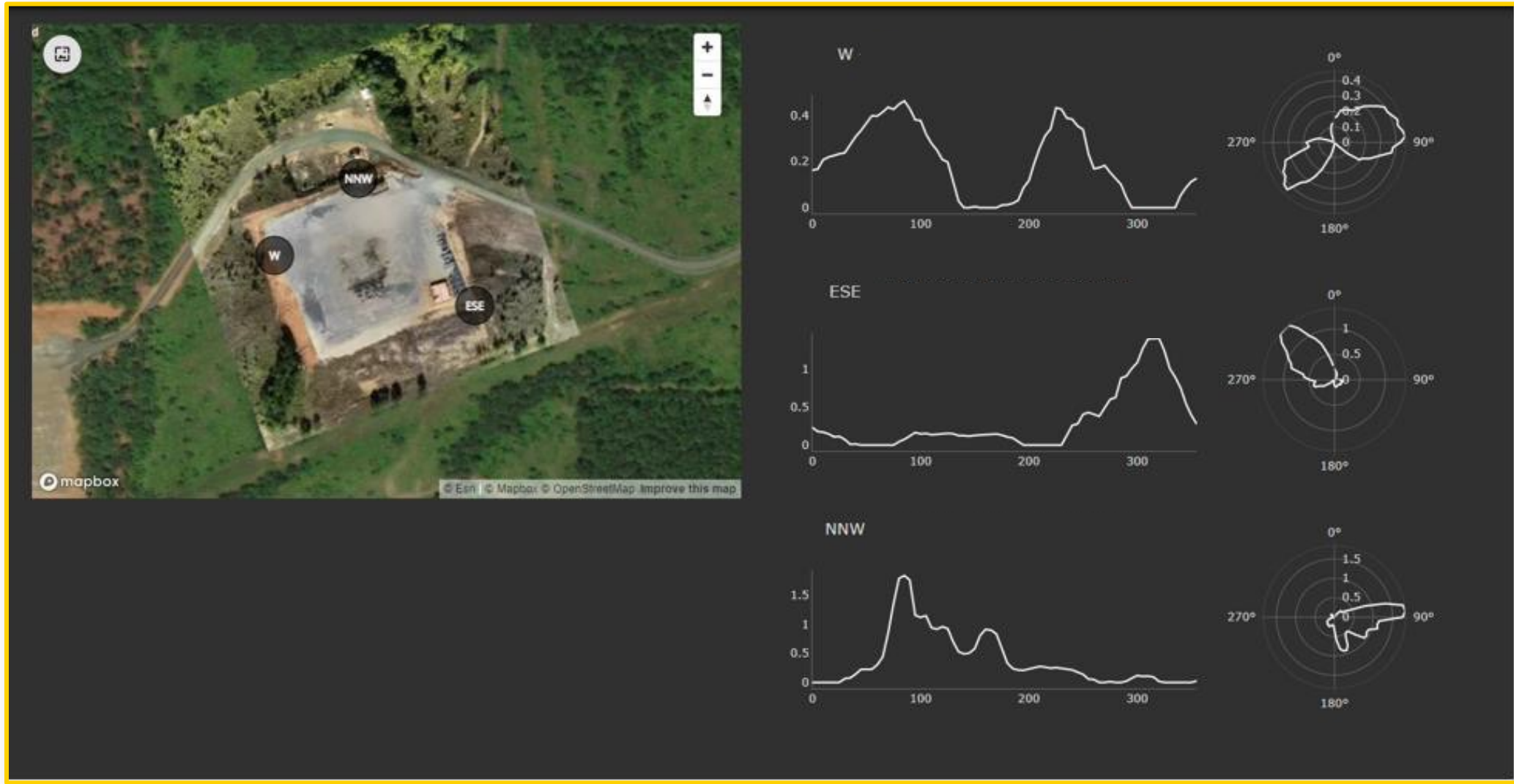


Build Wind & Concentration Models Per Device



- Build relationship between measured concentration above baseline vs the wind direction for each device
- Create 36 10-degree wind buckets and find the average methane concentration above baseline for each bucket when the wind blows from that direction

Modeled View of the Wind and Concentration Relationship



Simulate Plumes from Every Leak Source Under Every Wind Condition

Wind SSE



Wind NW



Model simulates 10,000 plumes per hour per device

Generate Von Mises Distributions of Each Source Point on Each Device

Single Source Distribution

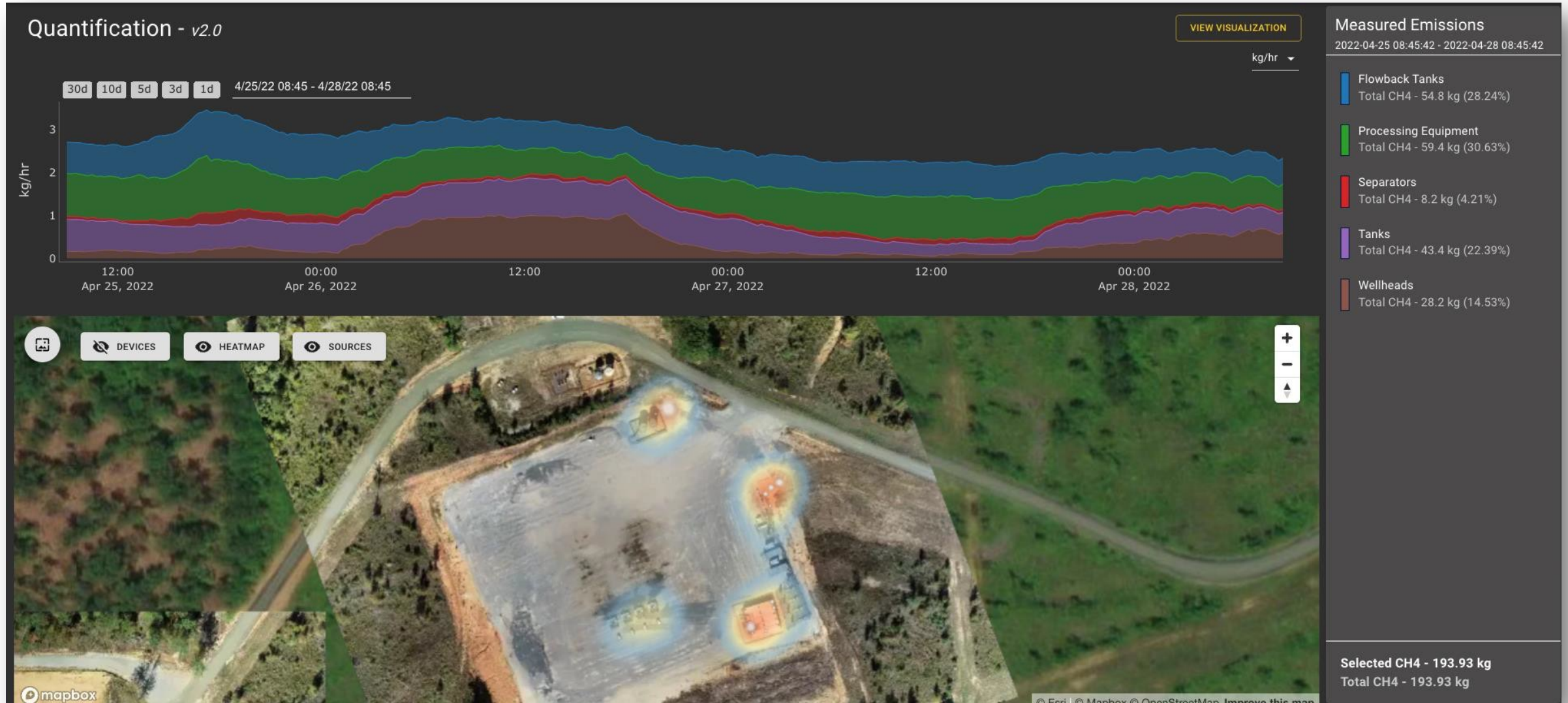


Use Von Mises Distributions to Best Fit the Wind/PPM Relationship

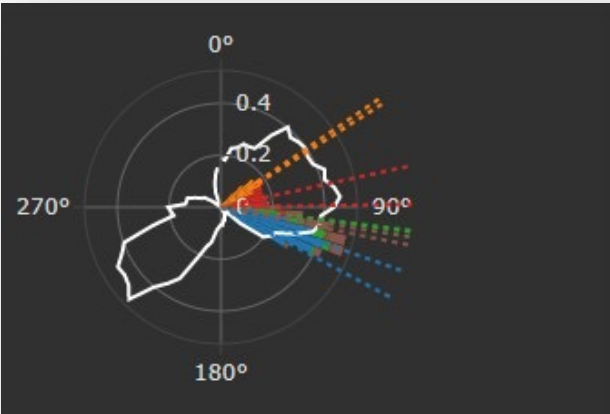
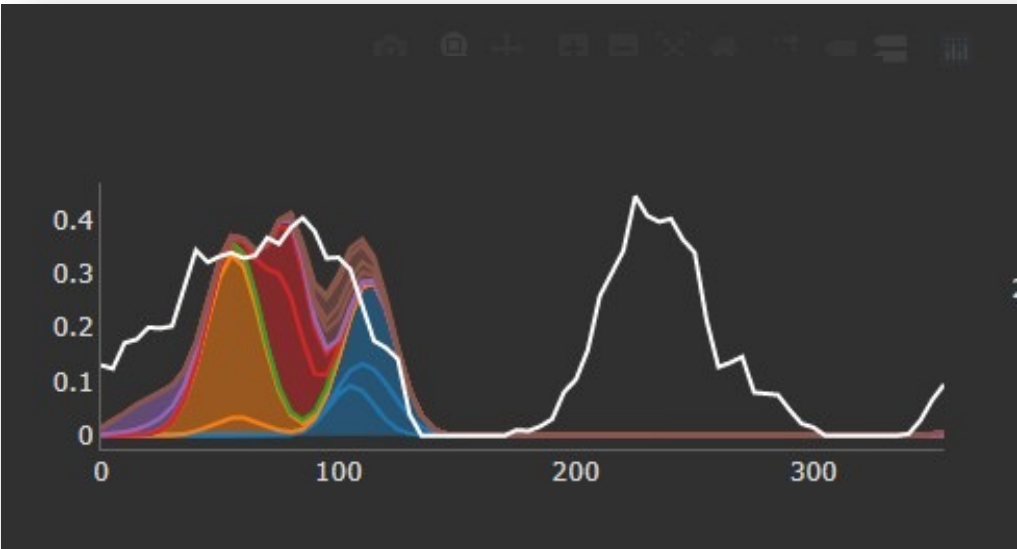
All Sources Distributions, “Maximize Area Under the Curves”



Final Result: Quantified Total Site Emissions



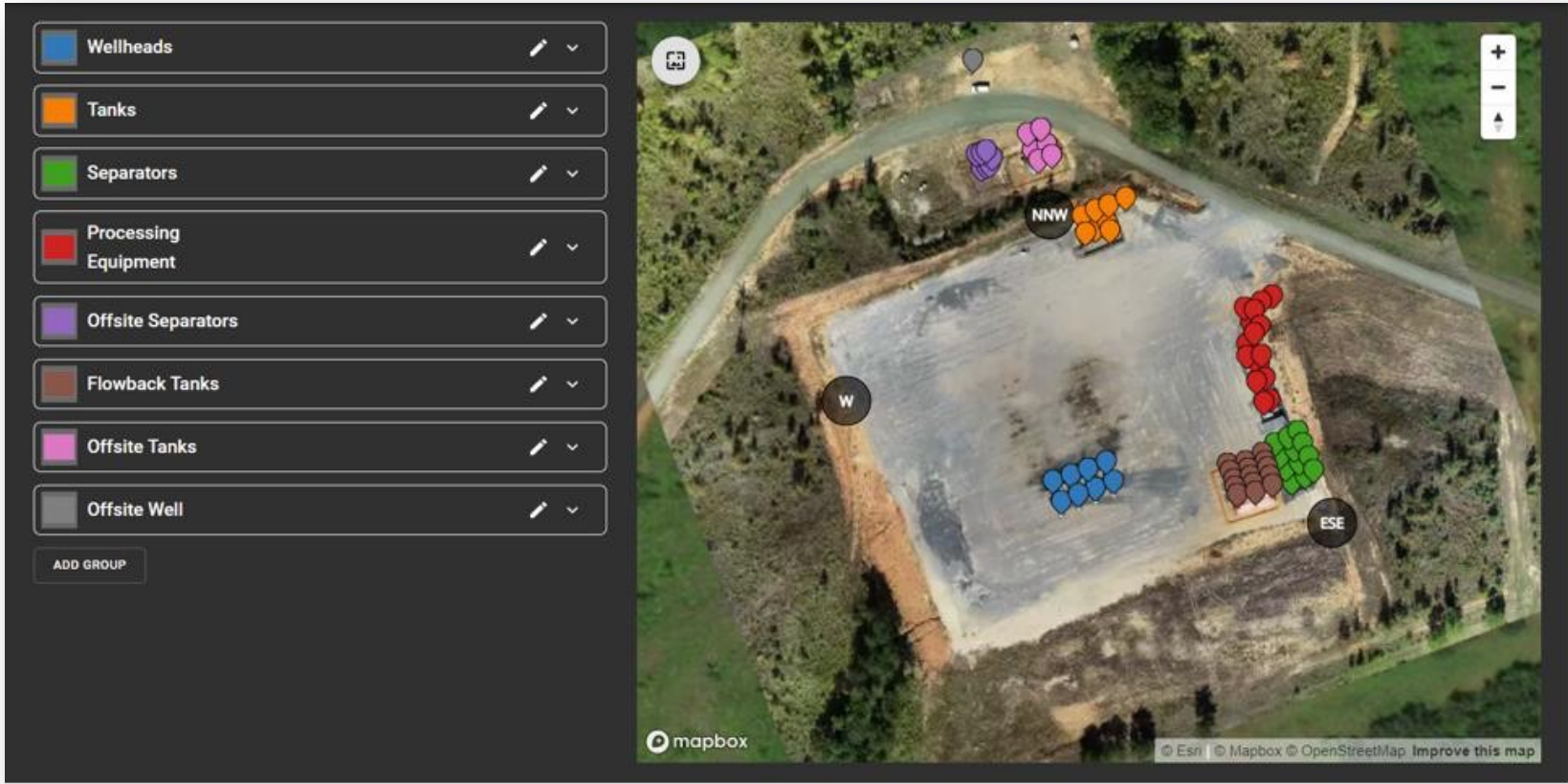
What About the Curve with No Plume?



Offsite Emissions: Neighboring Pad



Source Attribution: Compare to Operational Events



Operational insights: Operators tie emissions data in with operational data from SCADA system

Start	Duration	Condition
07/12/2022 20:22	198 min	9.9 (60m Avg) >= 5 ppm CH4
05/31/2022 06:07	242 min	13.6 (60m Avg) >= 5 ppm CH4
05/31/2022 03:06	112 min	6.0 (60m Avg) >= 5 ppm CH4
05/30/2022 23:51	154 min	5.9 (60m Avg) >= 5 ppm CH4
05/30/2022 20:26	149 min	18.1 (60m Avg) >= 5 ppm CH4
05/30/2022 20:14	795 min	Smart Alert Triggered
05/16/2022 00:23	2:58	Source Attribution: Processing Equipment
05/15/2022 04:51	431 min	11.4 (60m Avg) >= 5 ppm CH4
05/14/2022 19:26	868 min	Smart Alert Triggered
05/14/2022 19:00	367 min	11.7 (60m Avg) >= 5 ppm CH4
05/14/2022 03:07	61 min	5.0 (60m Avg) >= 5 ppm CH4
05/14/2022 01:14	102 min	5.7 (60m Avg) >= 5 ppm CH4

Next-Gen Canary: Emissions Data Reconciliation

Project Canary
SENSE



Satellite



Aerial | Tighter Spot Checks



Drones | Hi-Fidelity Spot Check



Canary SENSE

The Climate Data Platform



- Centralized emissions data from all sources from ground to air in one Canary SENSE™ Platform
- Data ingestion, reconciliation, characterization
- Meet regulatory requirements (EPA, state, SEC)
- Improve corporate sustainability reporting
- De-risk contracts (LNG, hydrogen, utilities)



THANK YOU

QUESTIONS ABOUT CANARY QUANT AND THE FUTURE
OF EMISSIONS TRACKING & REPORTING?

OUR TEAM IS HERE TO HELP: INFO@PROJECTCANARY.COM

PROJECT
CANARY