

AMOG Surveyor, Mobile Leak Detector



CIRPAS-NRL

- *Natural Gas Leakage Forum*

AMOG-BRI

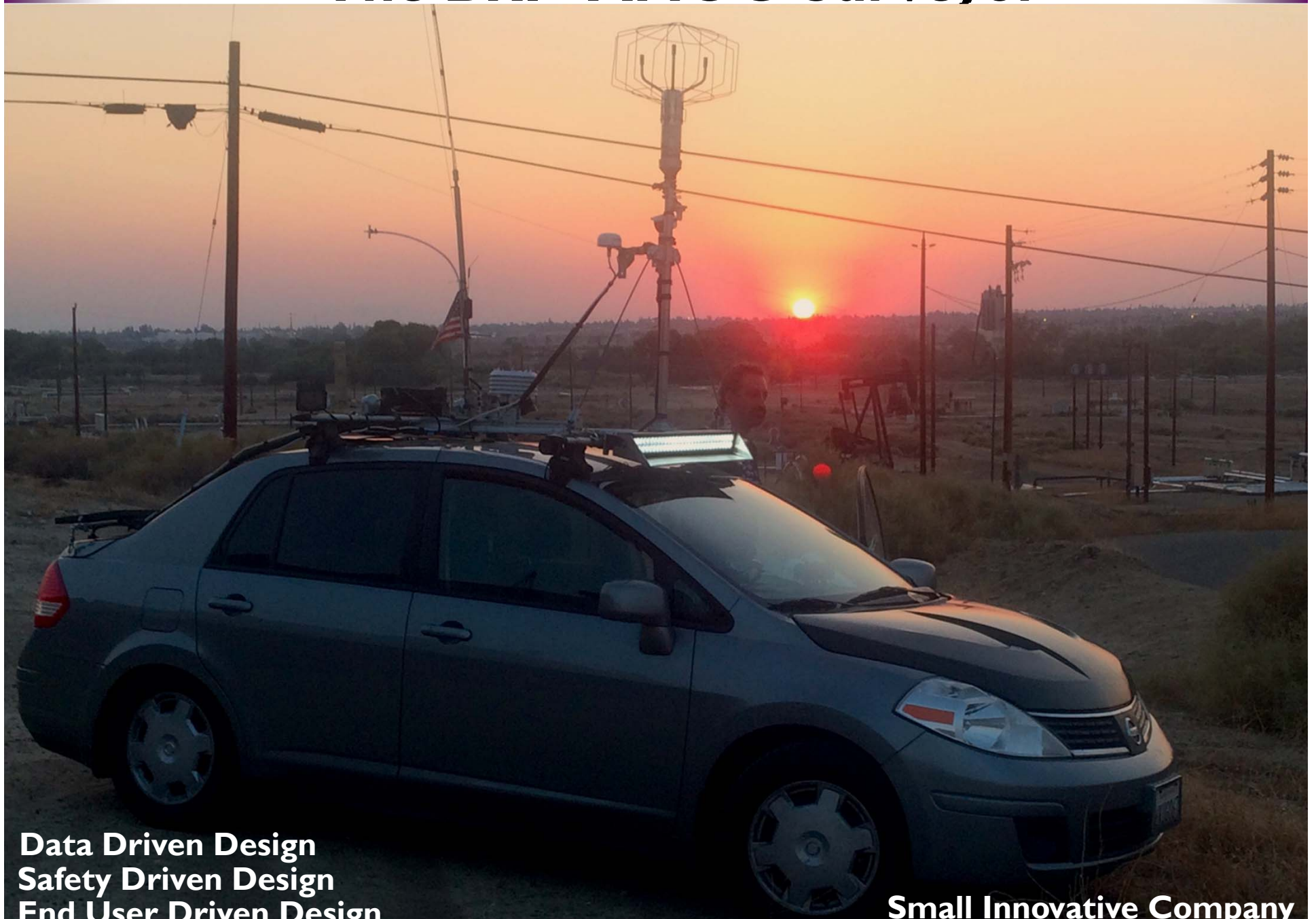
Ira Leifer
Bubbleology Research Intl

Thanks to the support of



BRI

The BRI - AMOG Surveyor



Data Driven Design
Safety Driven Design
End User Driven Design

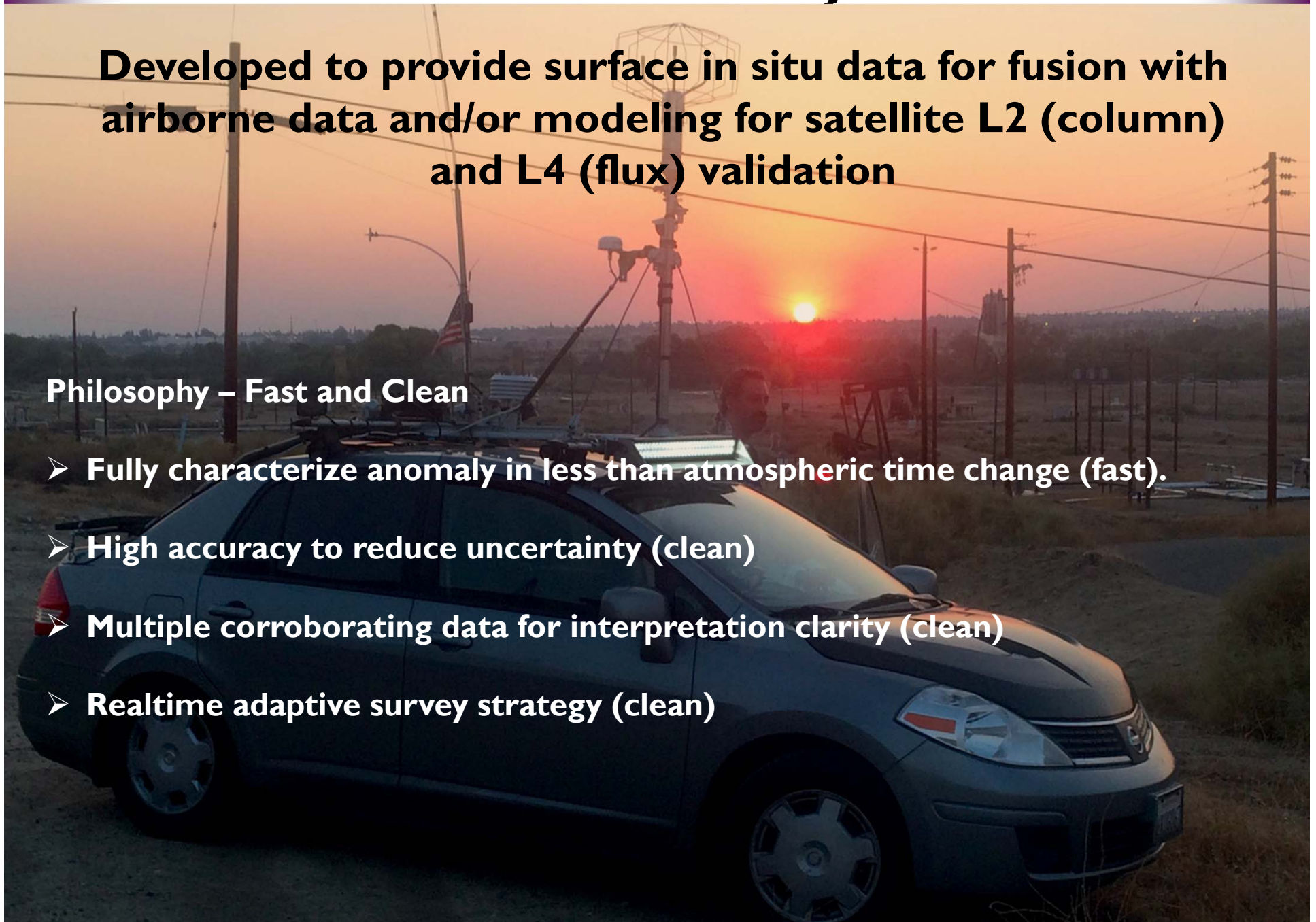
Small Innovative Company

AMOG Surveyor

Developed to provide surface in situ data for fusion with airborne data and/or modeling for satellite L2 (column) and L4 (flux) validation

Philosophy – Fast and Clean

- **Fully characterize anomaly in less than atmospheric time change (fast).**
- **High accuracy to reduce uncertainty (clean)**
- **Multiple corroborating data for interpretation clarity (clean)**
- **Realtime adaptive survey strategy (clean)**



AMOG Surveyor Safety

LIKELIHOOD	VERY HIGH	5		7				
	HIGH	4			8			
	MODERATE	3	3	6	7			1,10
	LOW	2			5			11,12
	VERY LOW	1		9		4		2
			VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	
			1	2	3	4	5	
			CONSEQUENCES					

INDEX	LIKELIHOOD	CONSEQUENCES	
1.	3	5	Partial Engine Power Loss
2.	1	5	Trunk or Engine Fire.
3.	1	3	Short Circuit
4.	1	4	Traffic Accident
5.	1	1	Short Circuit to Chassis
6.	3	2	Instrument Fails to Turn On
7.	3	3	Loss of Inter-Vehicle Communication
8.	1	3	Instrumentation Overheating
9.	2	2	Cryogenic Related Injury
10.	3	1	Car Hits Object
11.	3	1	Traffic Delays
12.	3	1	Route Confusion

AMOG Surveyor Safety

Index	Type	Steps
1.	Partial Engine Power Loss	Redundant Power Management, Increased vehicle power, 0/4 cables
2.	Trunk or Engine Fire	Video Monitors, temperature monitors, in reach fire extinguishers
3.	Short circuit	Vehicle inverter, transfer switch, AC Line metal conduits
4.	Traffic accident	Video, lights, first aid kit, pry bar, bolt cutter (driver side),
5.	Short circuit to chassis	See 3, secondary UPS protection, Chassis ground, Inverter ground line
6.	Instrument fails to turn on	Redundancy where feasible, PC interoperable redundancy,
7.	instrument communication lost	Redundancy, spare serial server, instrument backup, network drive, diagnostics
7.	Loss of inter-vehicle communication	Follow communication plan
8.	Equipment overheating	Temp monitoring, RT alert, run reduced missions
9.	Cryogenic Related Injury	Eye glasses, secured dewar in trunk, exhaust fans, gloves, clear protocol
10.	Car hits object	Video, lights
11.	Traffic delays	GPS, tertiary tablet with GoogleMaps traffic
12.	Route confusion	GPS, last data overlay

Passenger, Driver and Trunk Fire Extinguishers

Performance Gauges

Automated Realtime Display

Multiple Communication Modes (hands free, CB radio)

Visibility (lights) to Other Vehicles

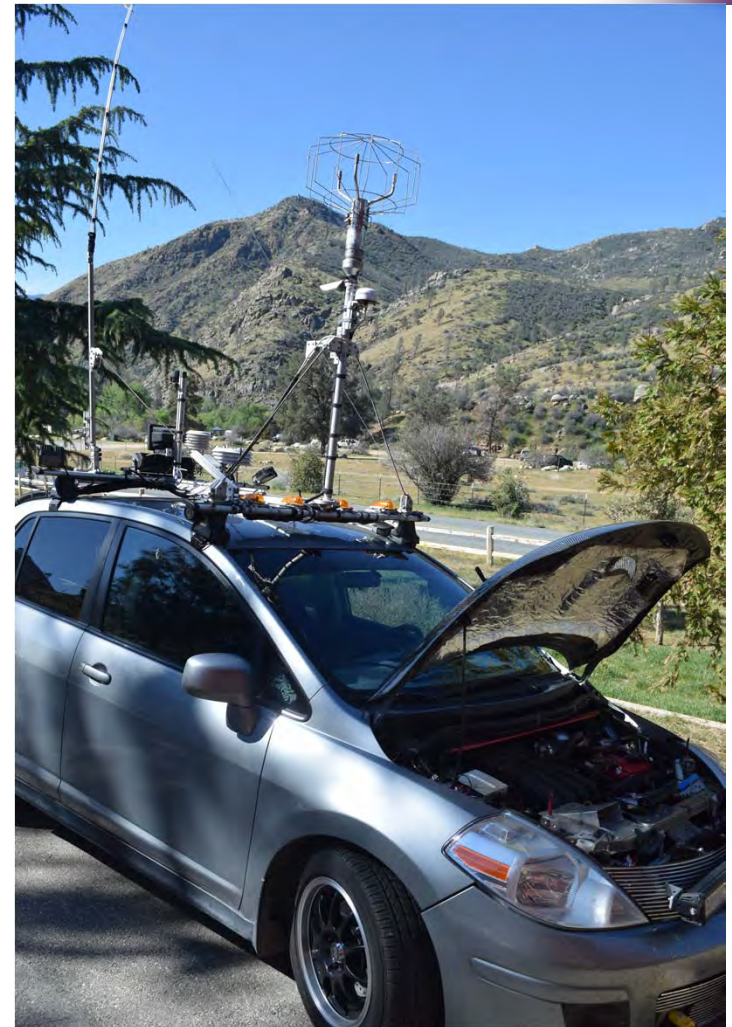
Performance Enhancements

NASA Risk Mitigation Safety Review (2014)

AMOG Development

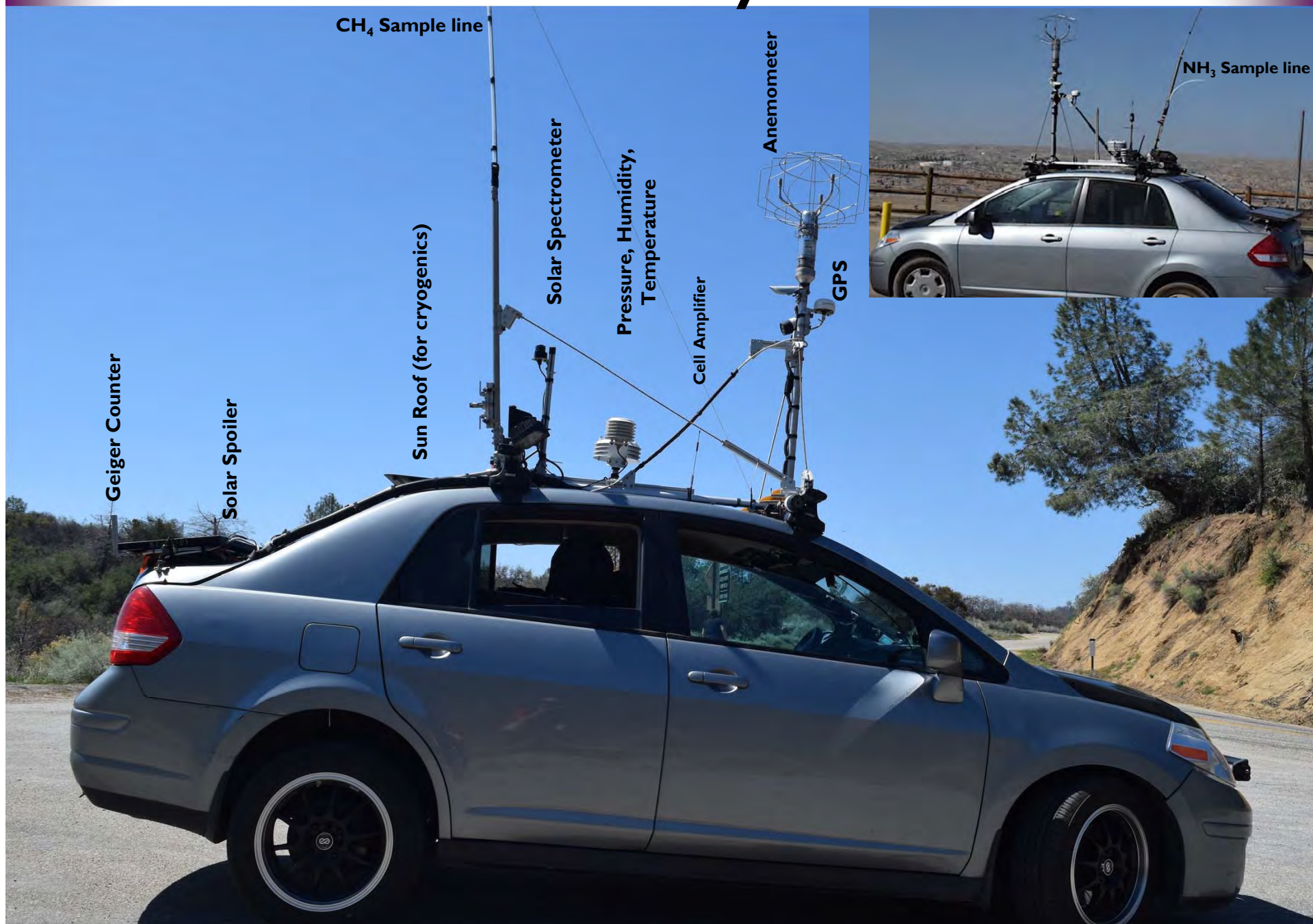


Summer 2013



Spring 2015

AMOG Surveyor - Roof



AMOG New Key Features

Science Infrastructure

2-100Ahr & 1-50Ahr solar gel cells, 3kW Inverter,
 High flow air compressor (for sample line back
 flush, suspension)
 8 or 23 cfm vacuum scroll pump
 1000BaseT network, router, network drive backup
 Touchscreen tablet data integration and
 visualization
 800 W Air Conditioner

Performance

Cool Air Ram, Throttle controller
 Carbon fiber hood w/air intakes
 Catback high flow exhaust
 Strut tower bar, Racing Struts,
 Sway bar, ladder brace
 Airbag suspension (auto leveling)
 Lightweight (Enkei) plus-1 rims
 Low rolling resistance, wide tires
 Performance gauges
 Double 0/4 cable

Science

Garmin18 (2)–GPS, GLONASS, etc.
 2D Sonic Anemometer (Vaisala)
 0.2hPA Pressure (+ Redundant)
 0.01C Temperature
 Solar Insolation (Davis)
 Solar Spectra (380-1050 nm, 1 nm
 Ocean Optics)
 O₃ (1ppb, 0.25 Hz)
 NO, NO_x (25 ppt, 10.1 Hz)
 NH₃ (0.2ppb, 1 Hz)
 OCS, CO
 CO₂, CH₄, H₂O



AMOG Surveyor Trunk Package

23-CFM Scroll Vacuum Pump (10Hz GHG, 1 Hz NH₃)

Thermal and Sound Insulation (=30 mph road noise)

FGGA ICOS CRDS (LGR)

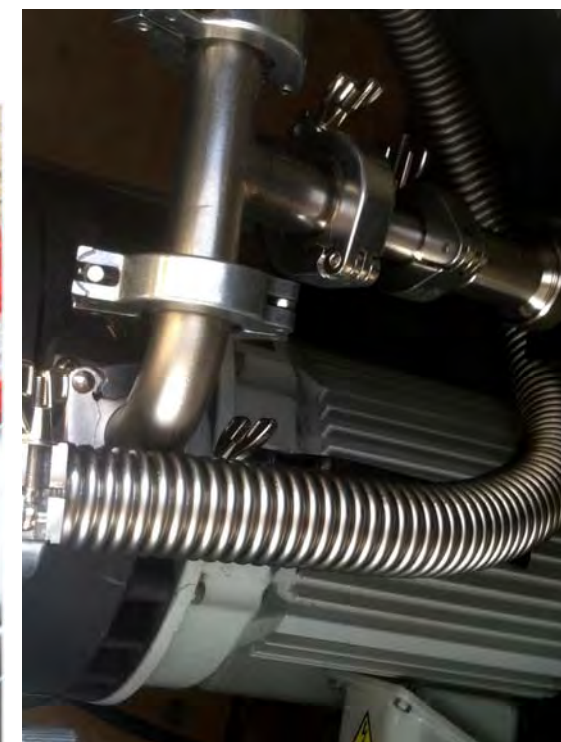
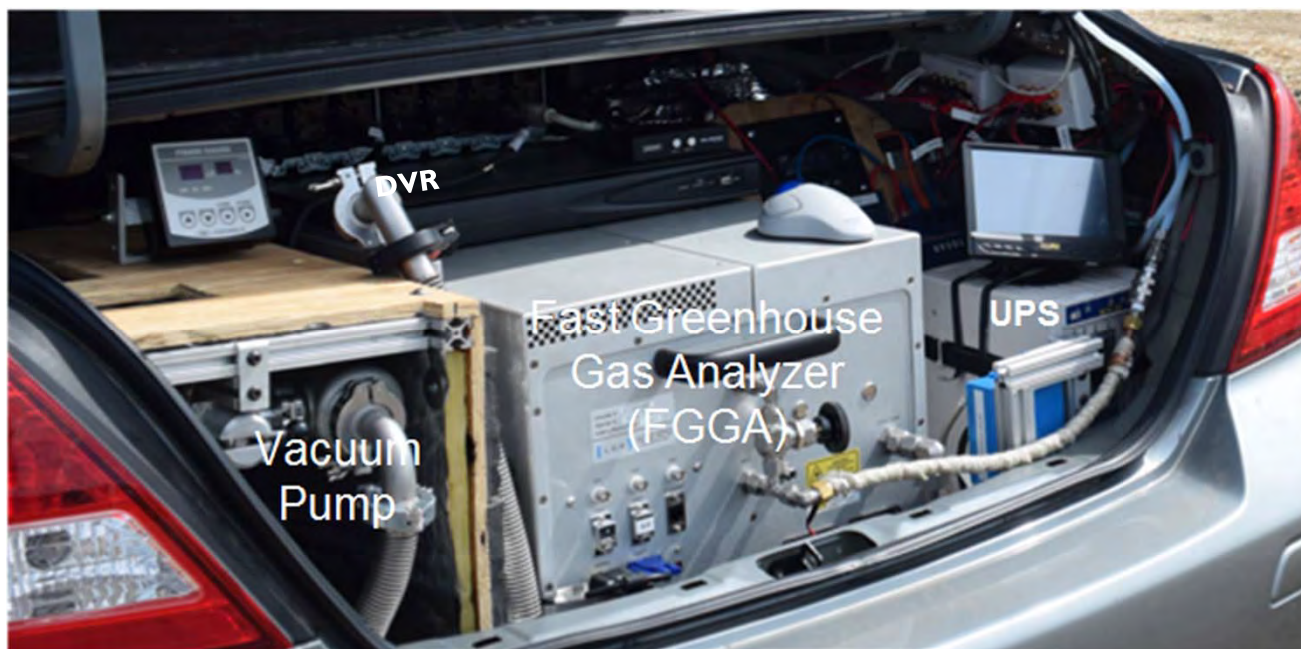
High speed data network, ethernet serial servers (multiple PC)

450 cfm exhaust fans (Vacuum Box Zone / Analyzer Zone)

Heated Teflon main sample lines

All-Direction 1080P DVR

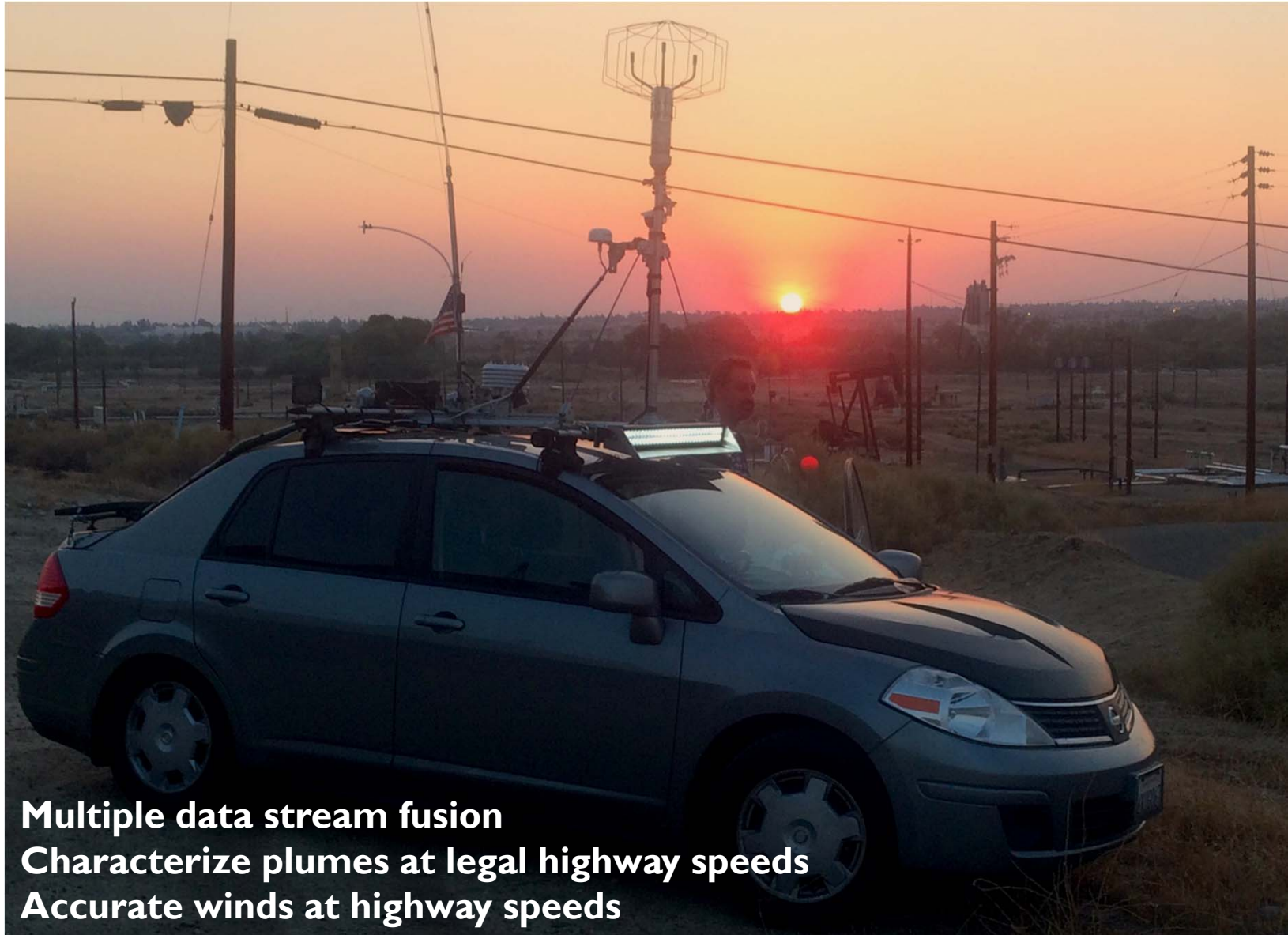
Solar Spoiler reduces solar heating



AMOG Surveyor – Realtime Data



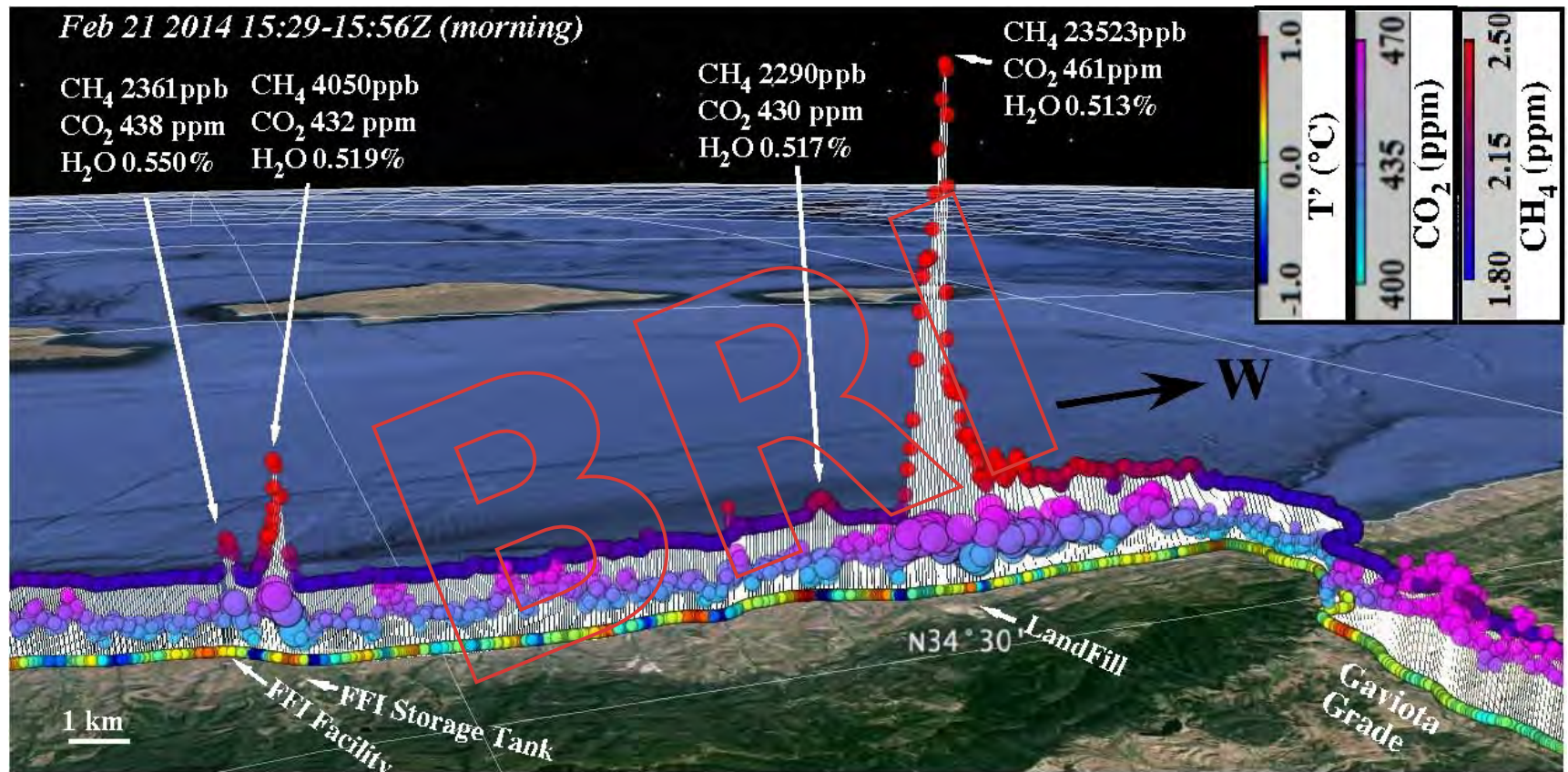
Initial AMOG Surveyor Tests



Multiple data stream fusion
Characterize plumes at legal highway speeds
Accurate winds at highway speeds

Tajiguas LandFill (Coastal Cal)

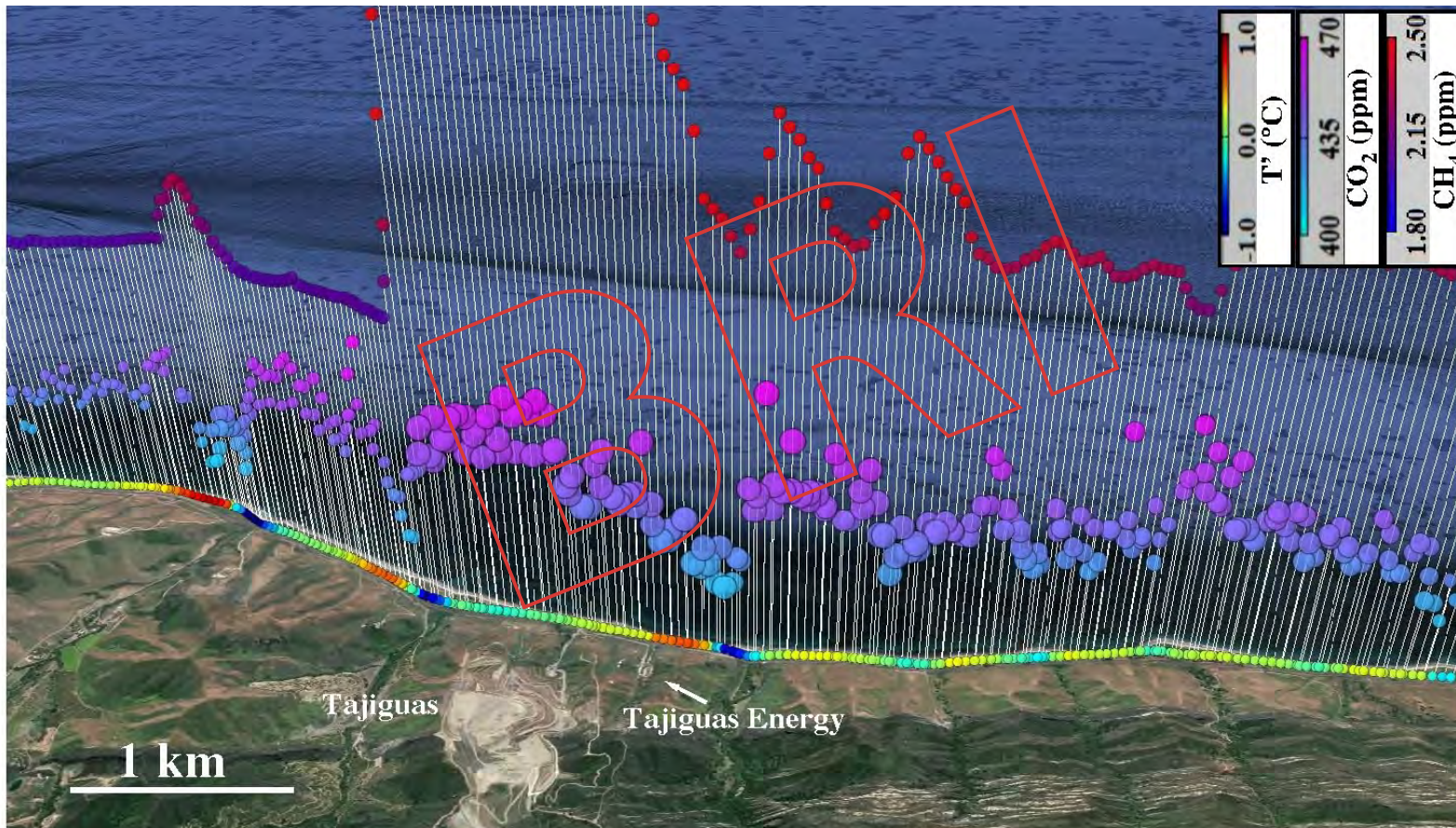
Tajiguas Landfill appeared to be inactive early February, leading to concerns the leak was fixed. 2/21/14 AM, values to 23.5 ppm were observed in a plume of kilometer scale. CH₄ and CO₂ uncorrelated.



Fossil Fuel Industrial Facility CH₄ and CO₂ plumes are well correlated.

Tajiguas LandFill (Multiple data streams)

CO₂ weakly correlated with CH₄ and spatially relates to Tajiguas Landfill, unassociated with energy plant (to west)



Cool temperature anomaly correlate with valleys, warm with hills and also with CO_2 minima suggesting flushing/mixing of cooler, cleaner interior air into coastal boundary layer.

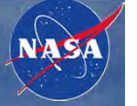


Pipeline Leak Survey Movie



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Airborne Data Fusion



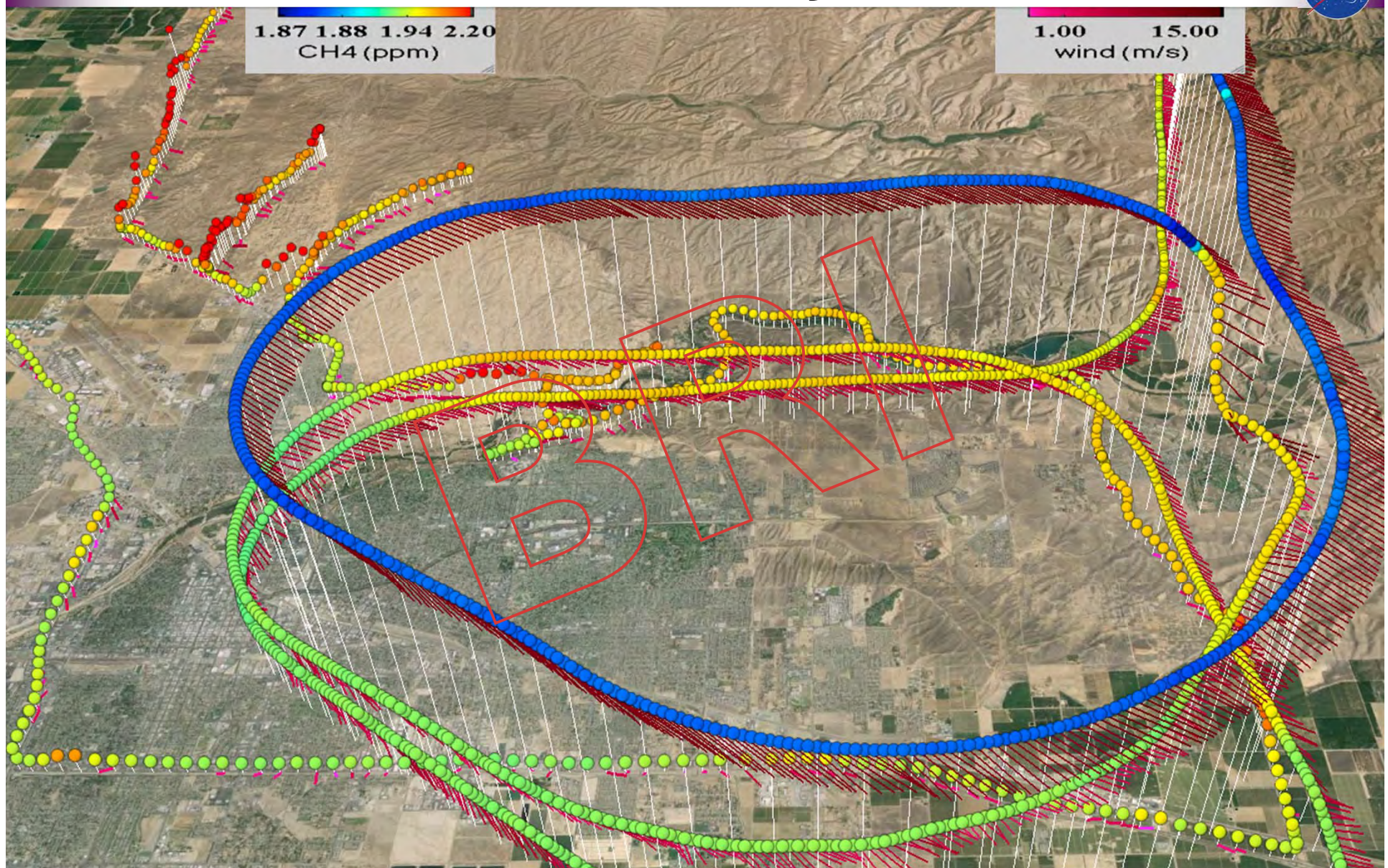
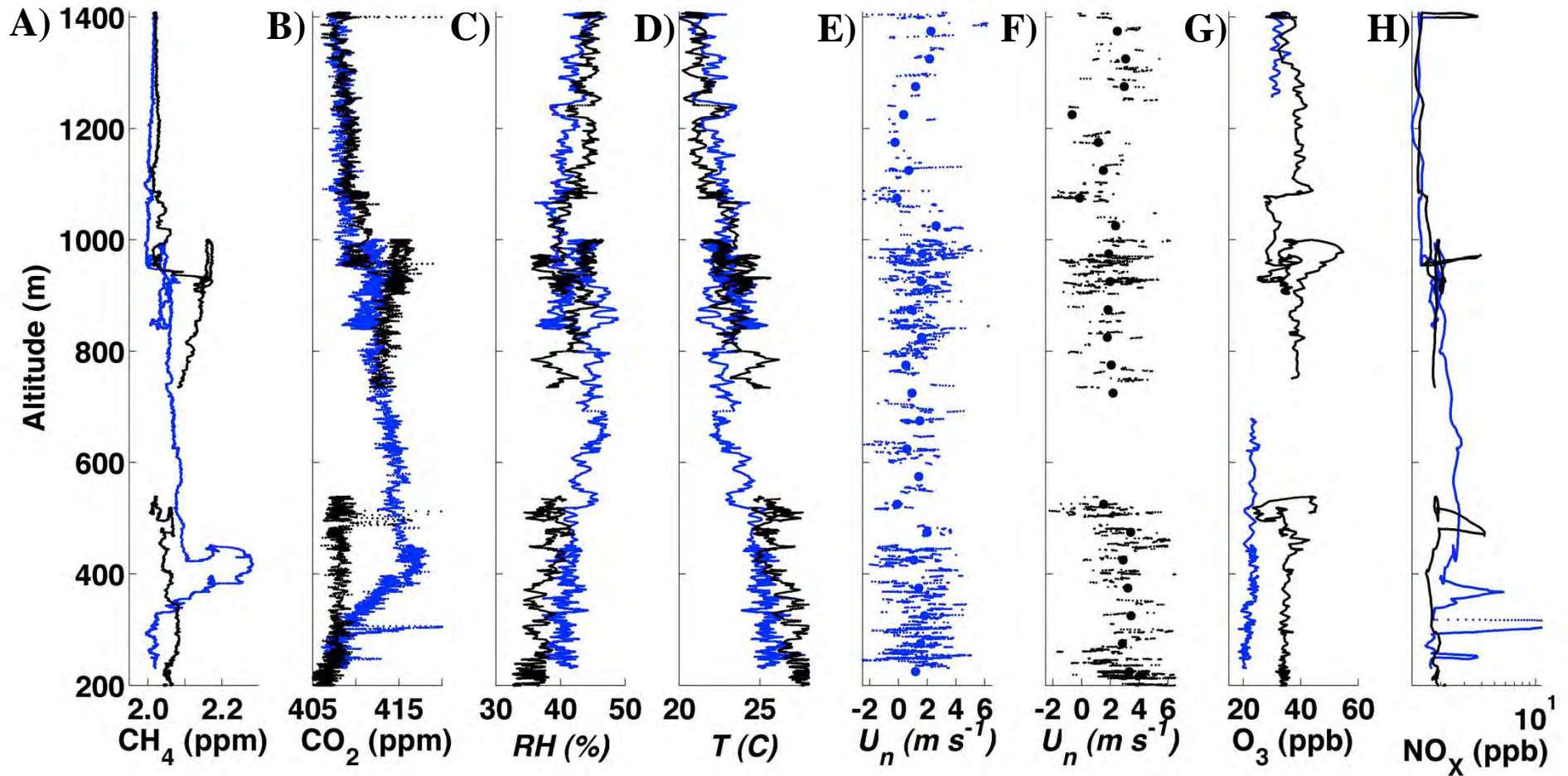


Fig. S20. Combined AJAX and AMOG winds and **A)** *in situ* methane, CH₄, for Kern River oil fields for prevailing wind conditions. Data key on panels.



Surface AMOG vertical profile data for **A)** methane, CH₄, **B)** CO₂, **C)** relative humidity, *RH*, **D)** temperature, **E)** *T*, **F)** normal winds, *U_n*, **G)** Ozone, O₃, and **H)** nitrogen oxides, NO_x, for 2 June 2015 in the San Joachim Valley (Delano-).

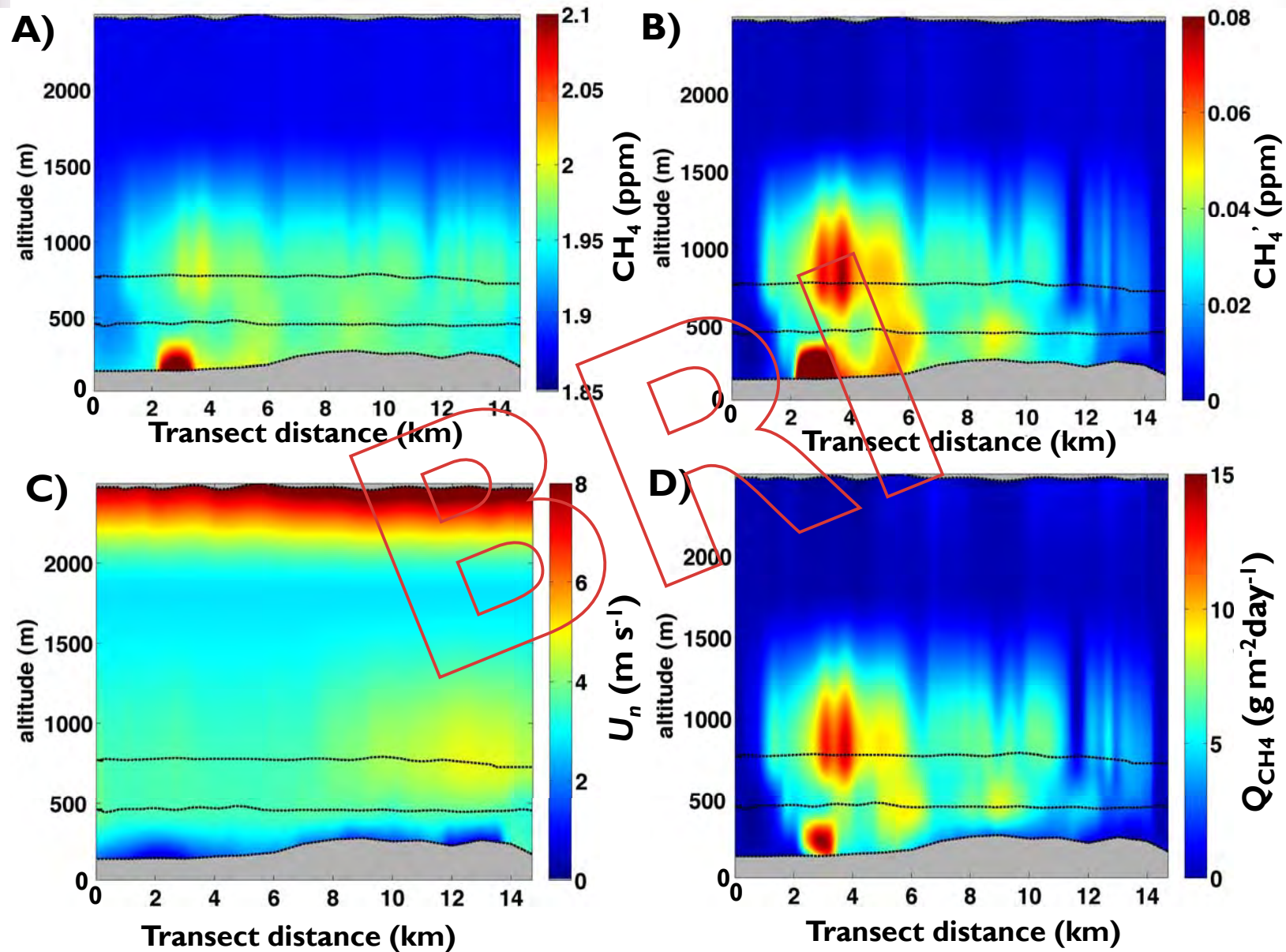


Fig. S18. Interpolated, fused AJAX and AMOG data, for curtain α for **A)** CH₄, **B)** CH₄ anomaly, CH₄'. **C)** Interpolated, fused normal winds, U_n, and **D)** CH₄ flux, Q_{CH₄}, for the Kern River & Kern Front oil fields. Data key on panels.

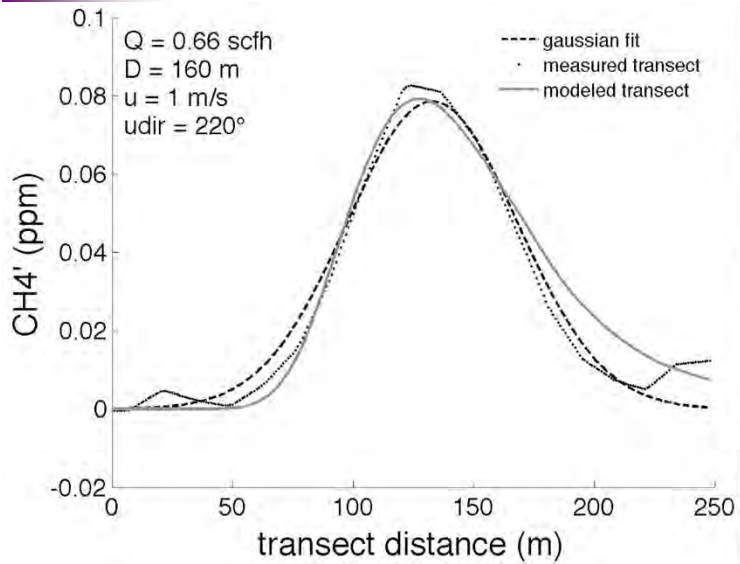
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AMOG Pipeline Leak Detection



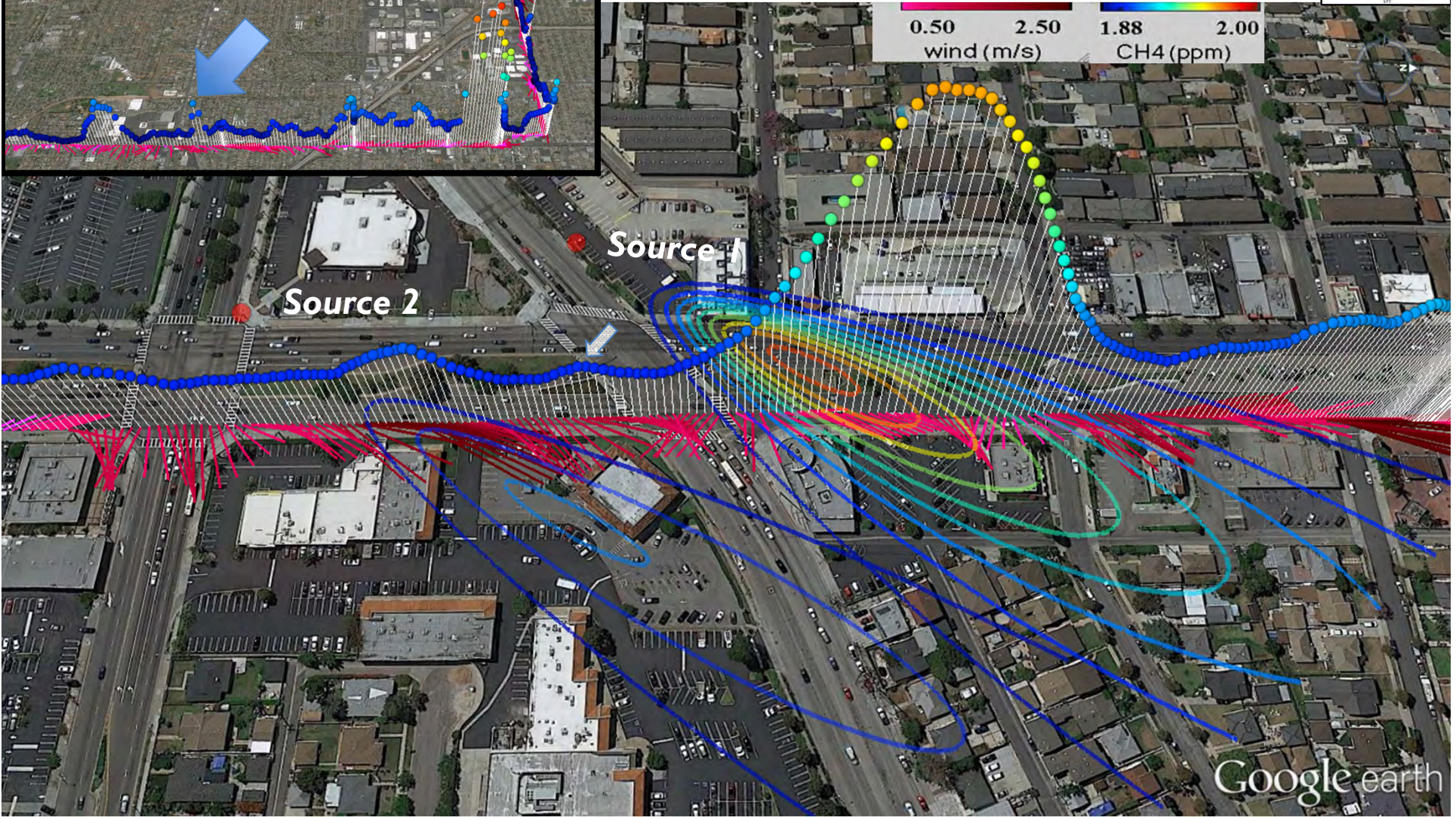
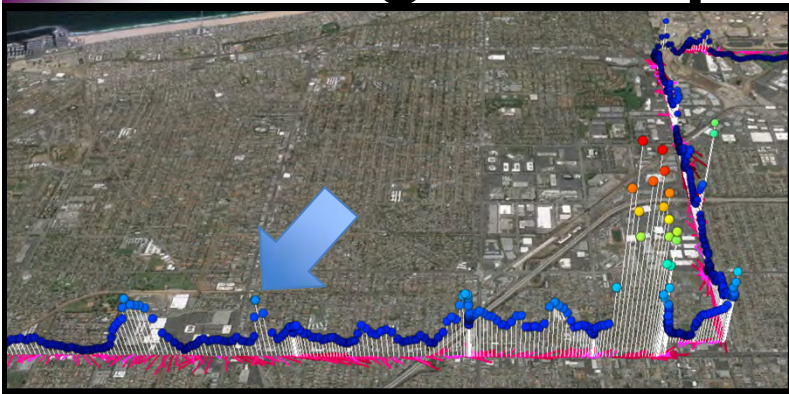
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El Segundo Pipeline Leak

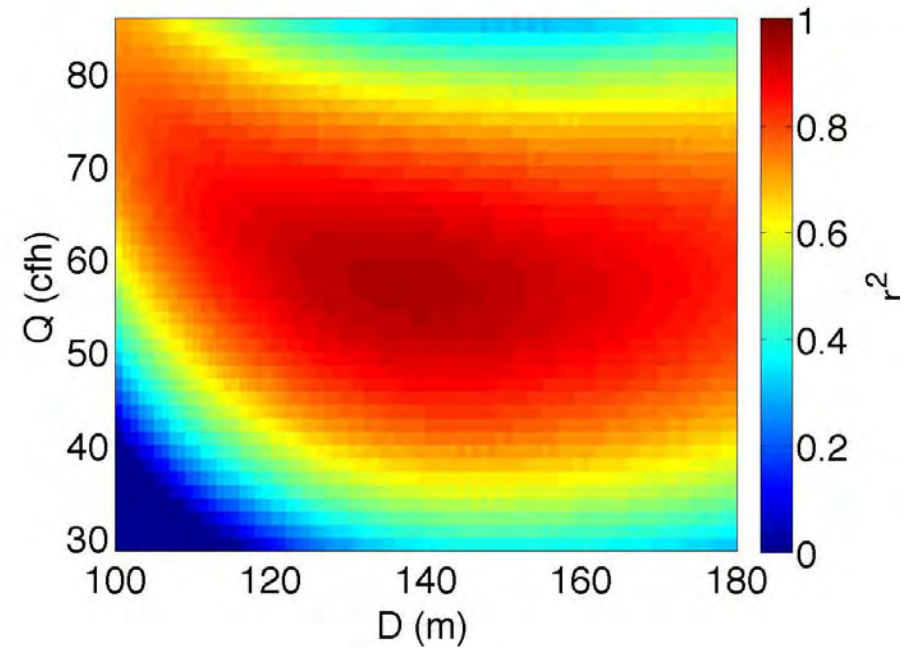
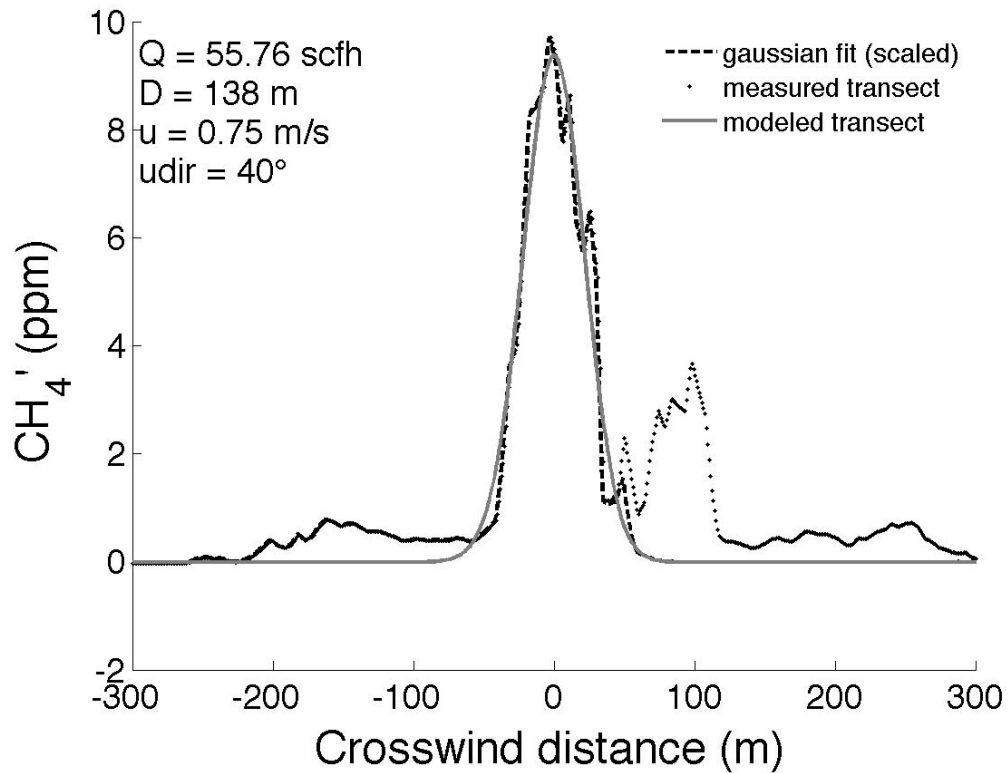


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El Segundo Pipeline Leak Source Inversions

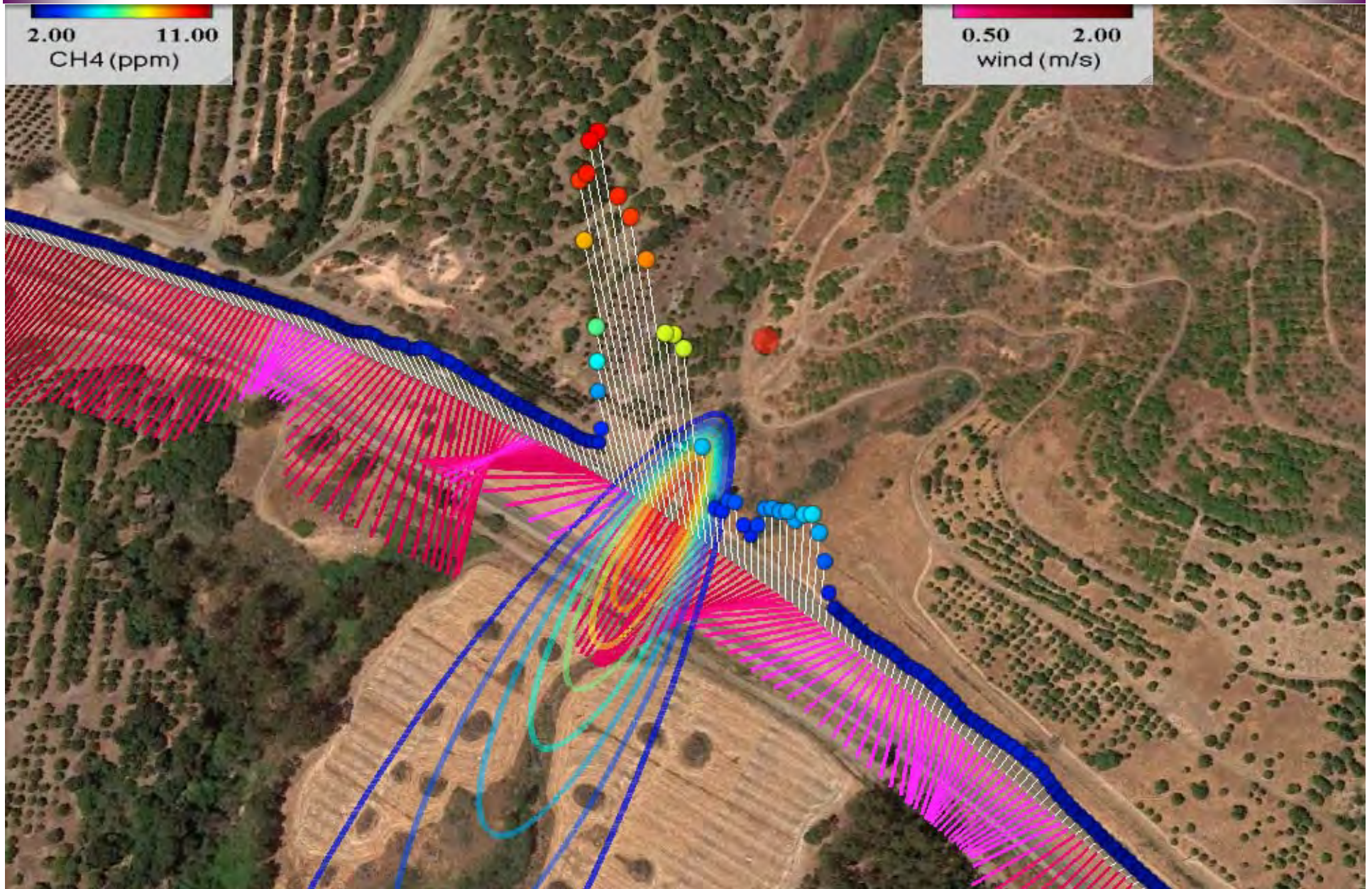


US 101 Pipeline Leak



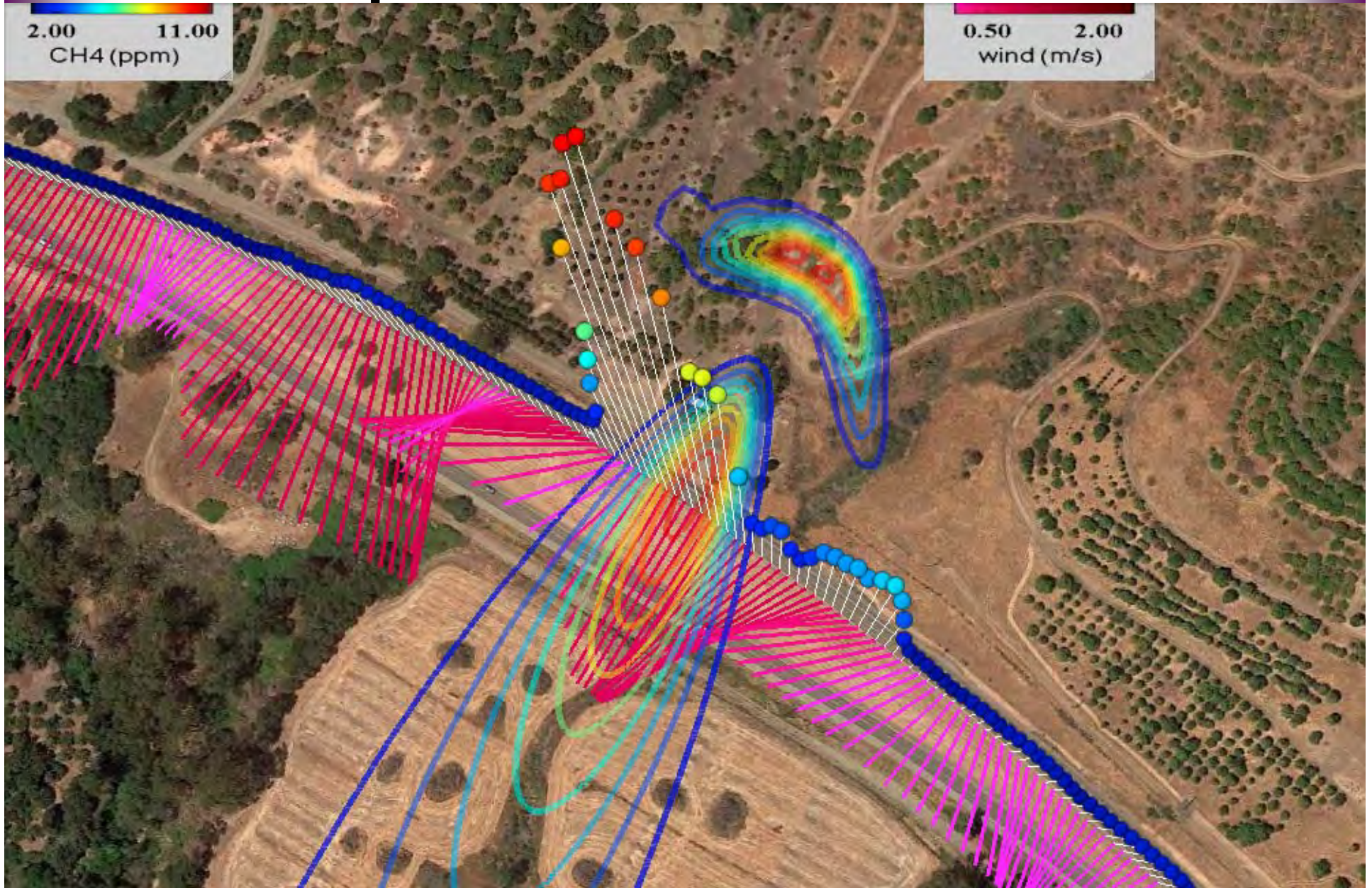
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US 101 Pipeline Leak



BRI

El Capitan Monte Carlo Inversion



Mobile Ground Validation of AVIRIS-NG CH₄ retrievals for fugitive emission plumes from a working oil field



On 4 Sept. 2014 the more sensitive AVIRIS-NG detected many CH₄ plumes using a Matched Filter (MF) approach (Fig 1). In total these plumes account for a small fraction of overall Kern emissions.

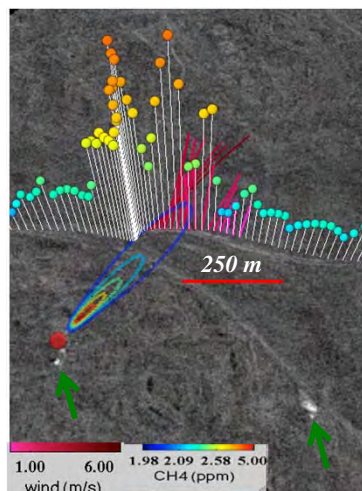


Fig. 1. AVIRIS-NG retrieved CH₄ plume in the Kern oil field on 4 Sept. that Gaussian plume inversion (1-plume shown) of concurrent *in situ* data suggests ~1 kton yr⁻¹. AVIRIS-NG CH₄ retrieval by David Thompson, JPL

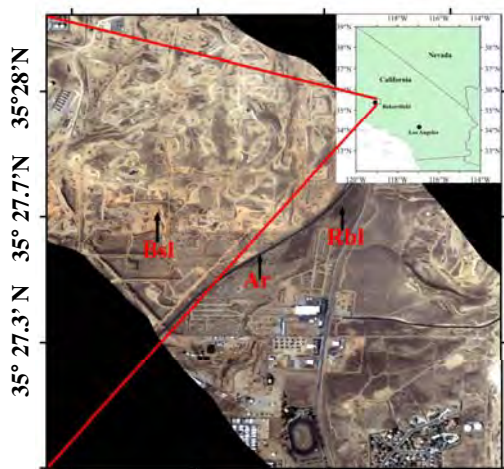


Fig. 2. AVIRIS-NG true color Kern oil field imagery, with example scene element pixels noted. Inset shows S. California location.

Take Aways

- **Fast Data collection critical (and economic)**
- **End-user – Engineering Design Iterations created high functional platform**
- **Platform is highly adaptable**
- **Platform meets NASA Safety and Performance Criteria**
- **Production model 2017**