

Methane Monitoring from Small Unmanned Aerial Systems

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Point of contacts:

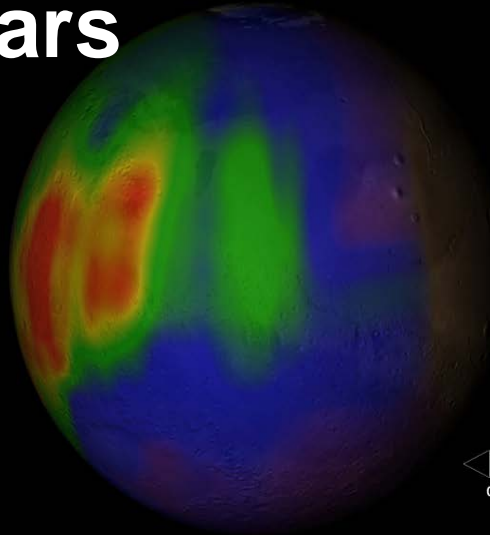
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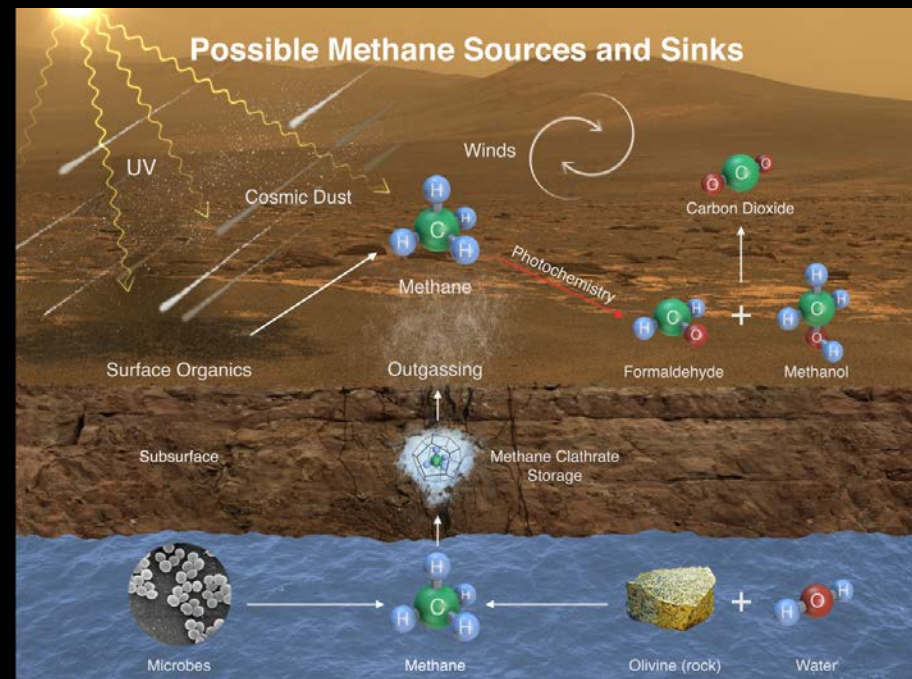
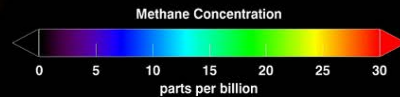


Background

Mars



Methane release:
Northern summer



To get:

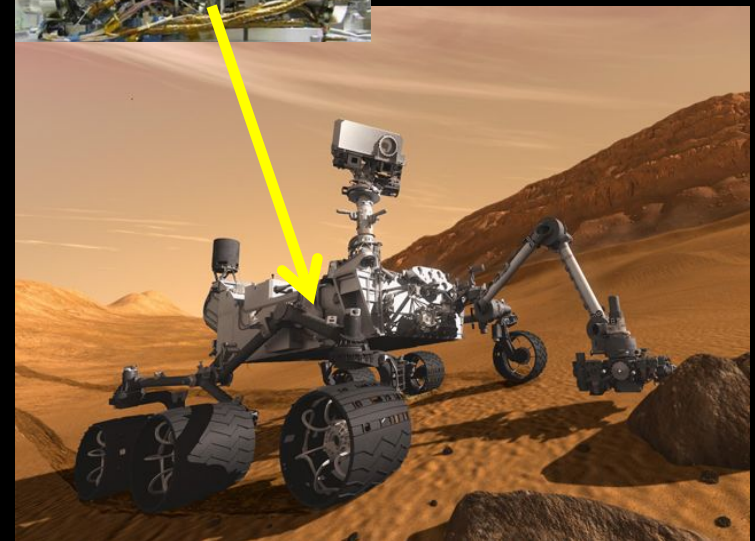


Required NASA investment in:

- Tunable laser spectrometers
- Semiconductor lasers



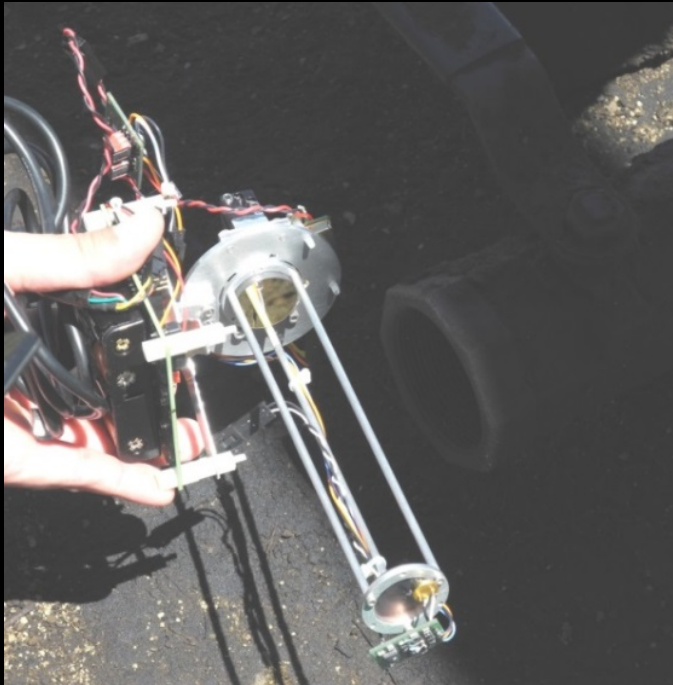
JPL-TLS



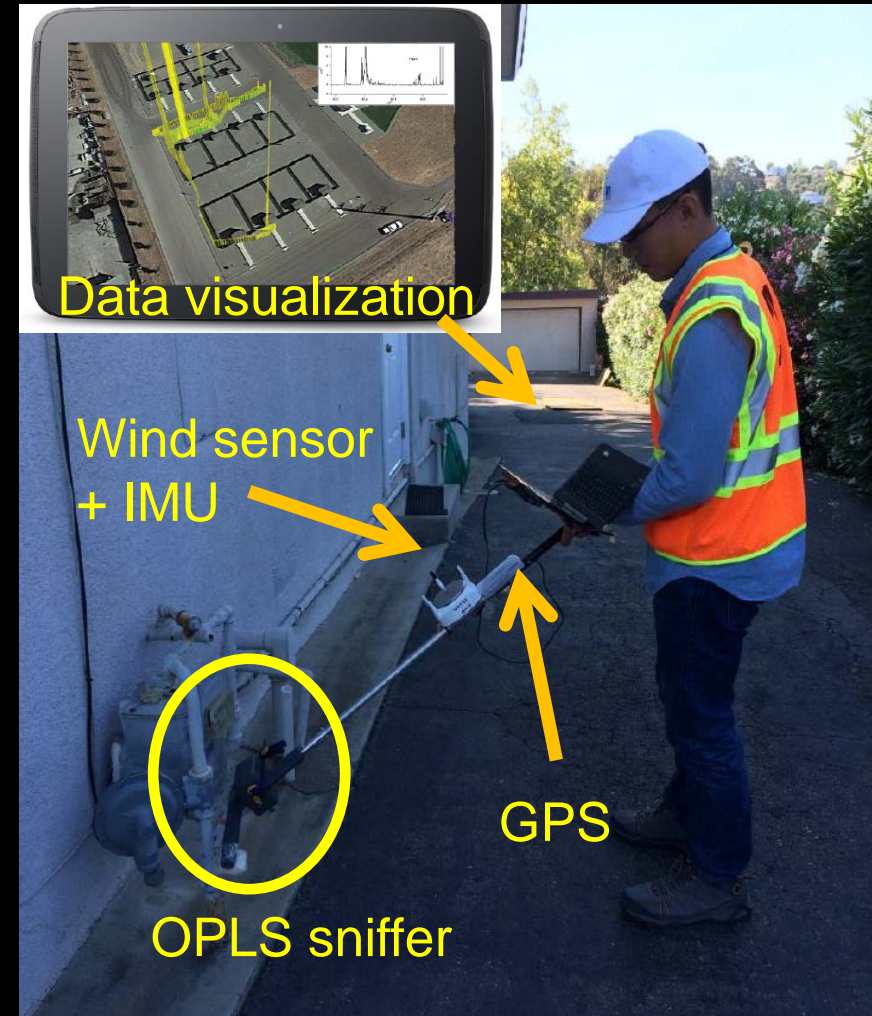
Background

First, need a robust, miniature methane sensing instrument.

Open-Path Laser Spectrometer (OPLS)



Before



After

Vision: Pipeline & facilities



< 2.5 kg VTOL



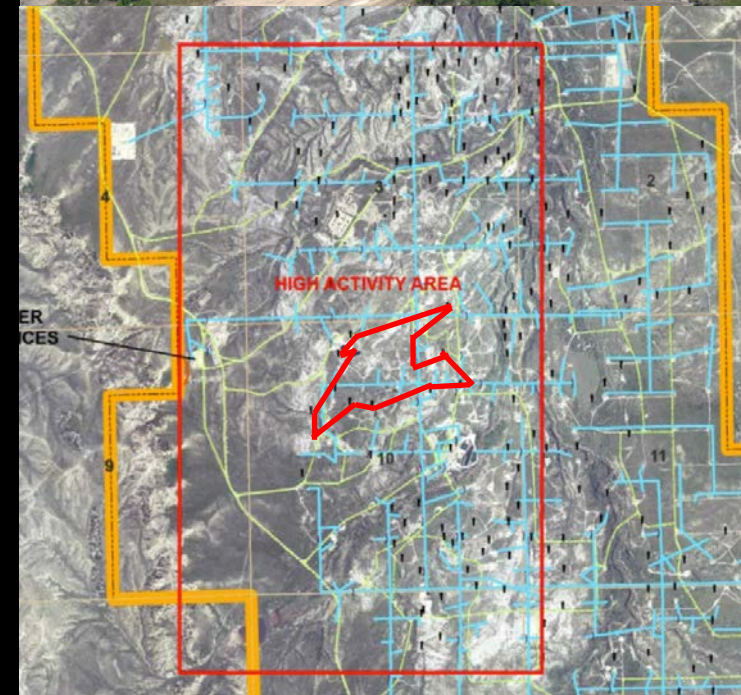
Fixed-wings &
Hybrid fixed-wing/VTOL

Types of operations:

- Surveillance
- Localization
- Quantification

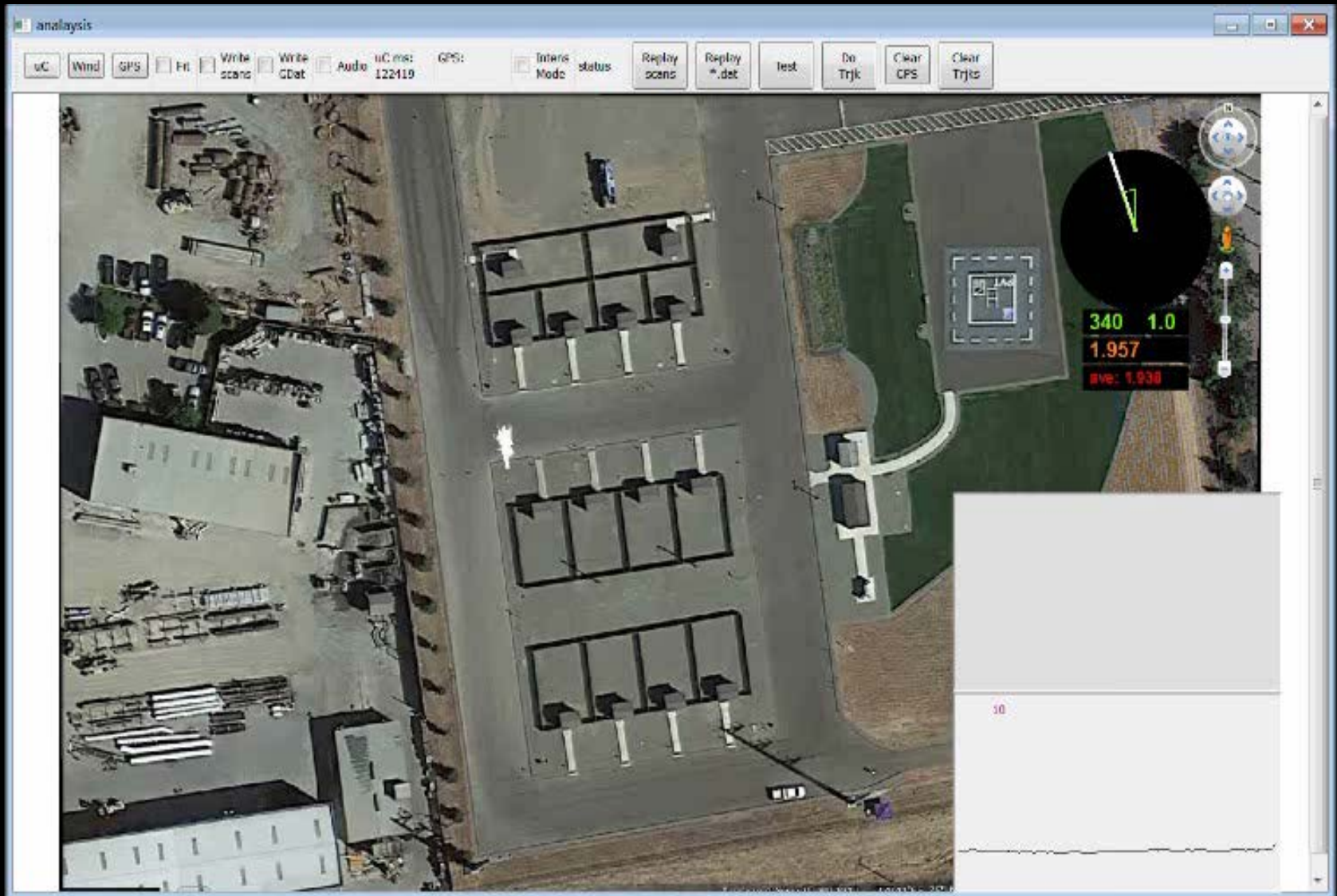
Movie_A:Wells [Christensen_movies\sim_wells.mp4](#)

RMOTC Storage Facility



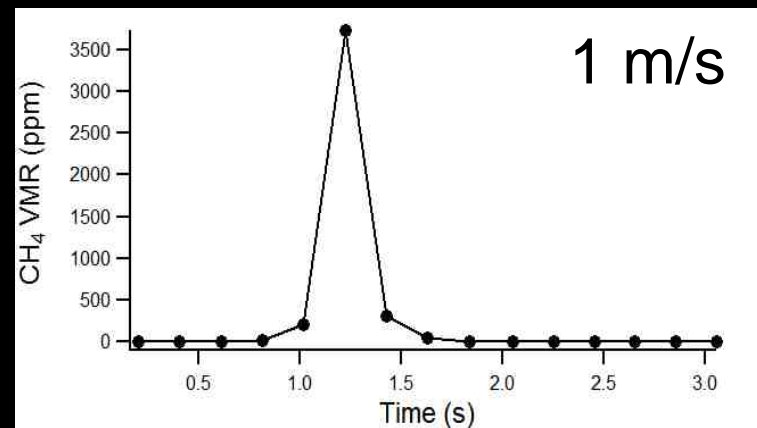
100 wells, 10 m/s well-to-well,
30-s surveillance at each well →
40 wells per flight.

Vision: Neighborhood sUAS leak survey

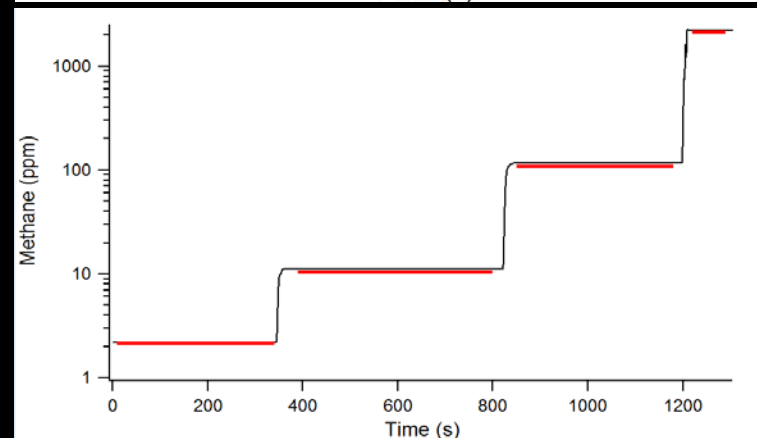


Prescriptive operation \approx Autonomous operation

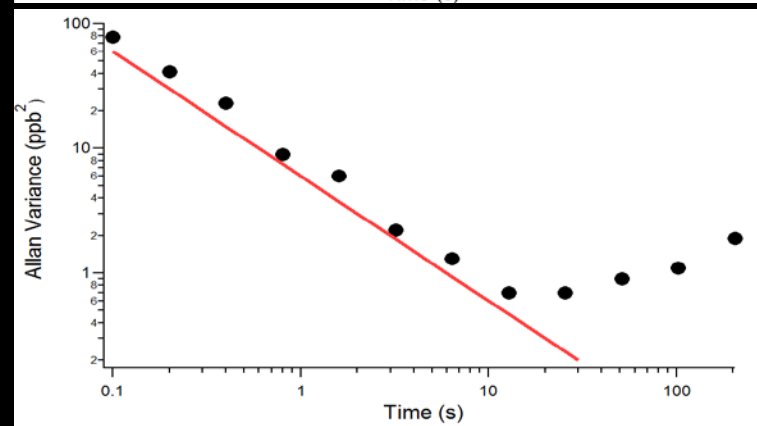
Performance



Response time

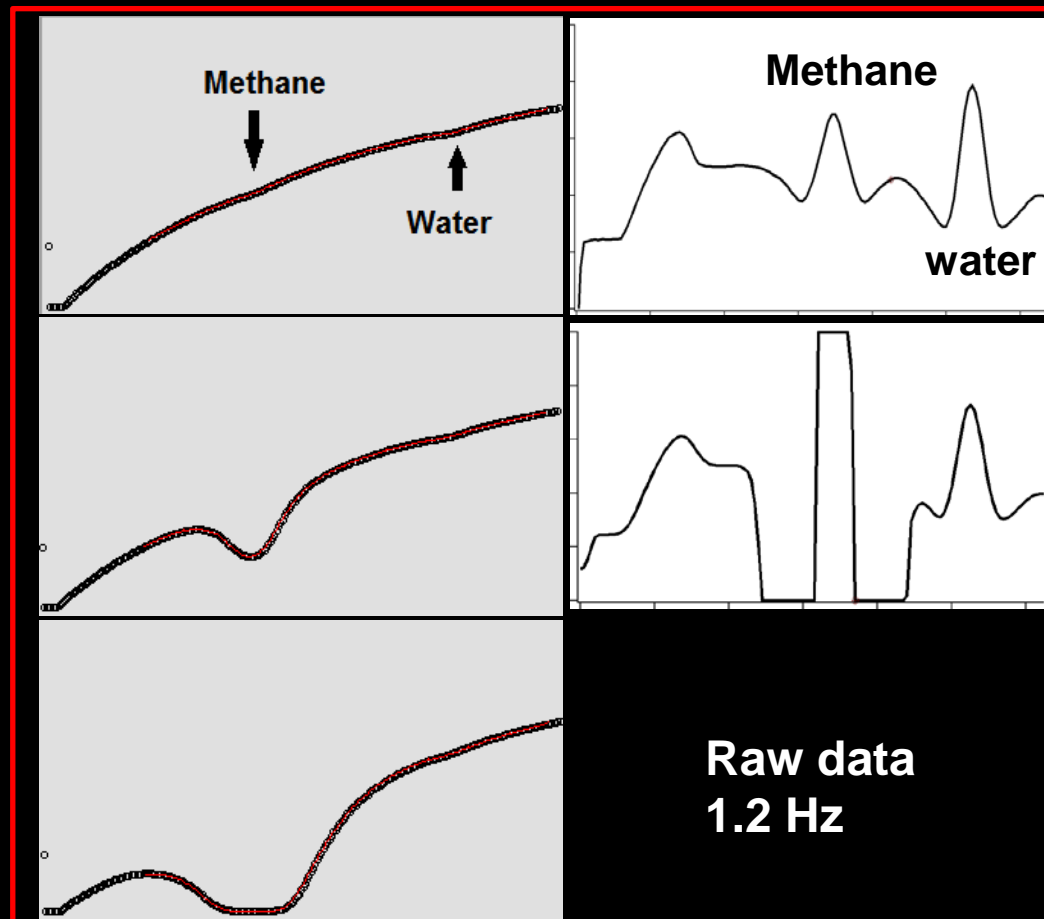
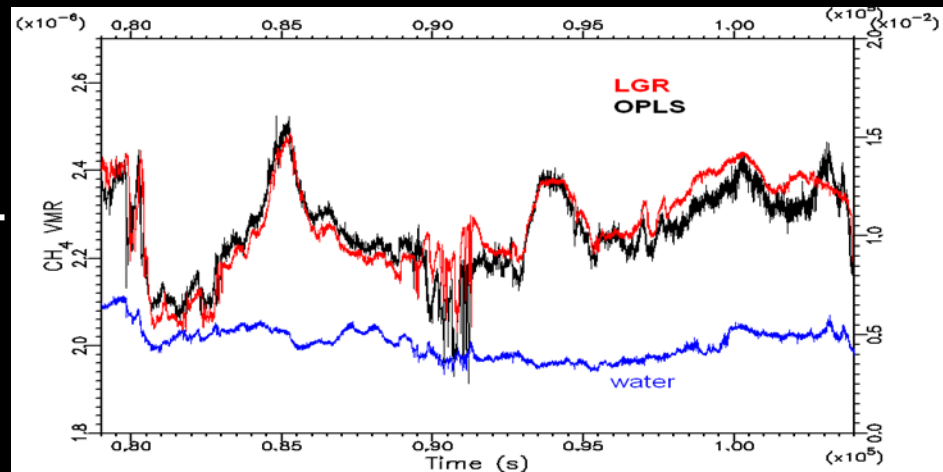


Linearity



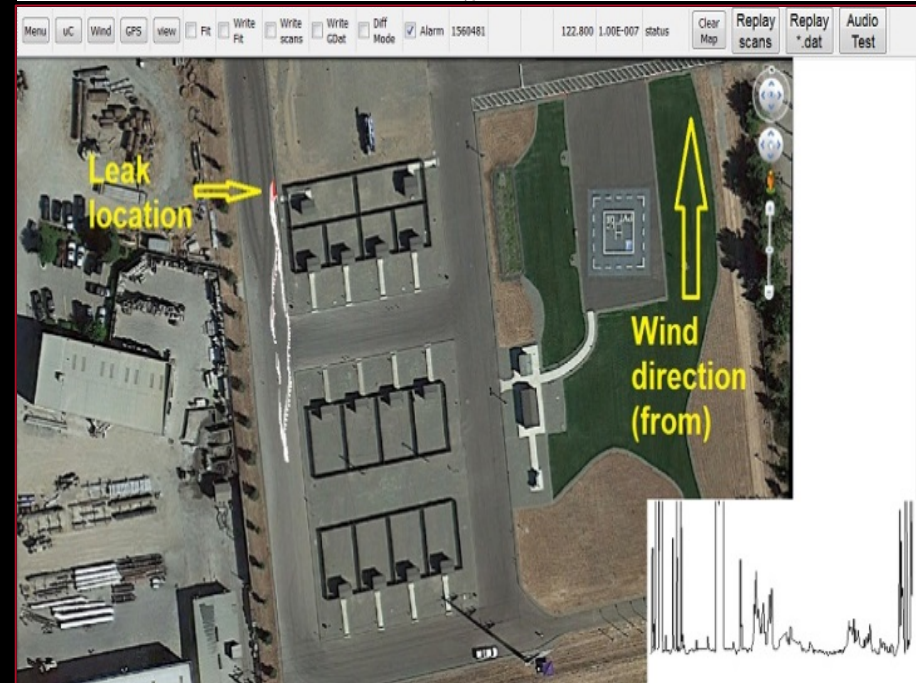
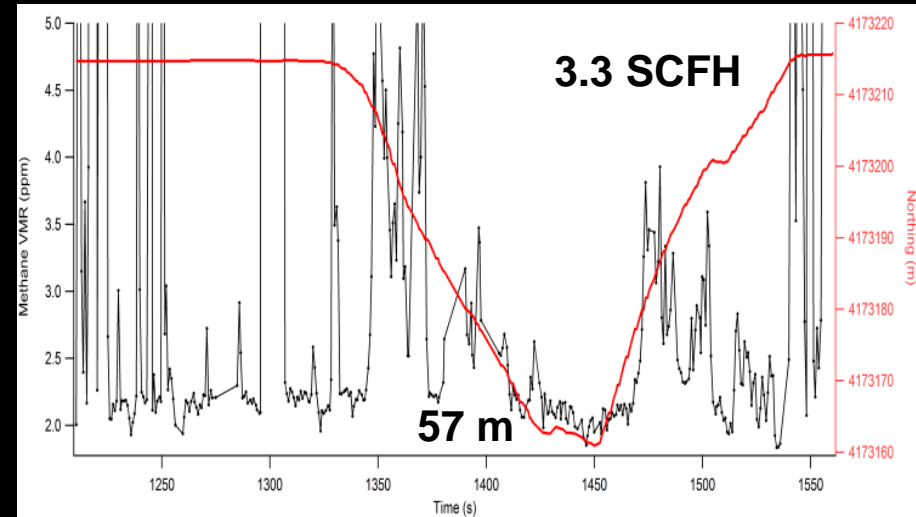
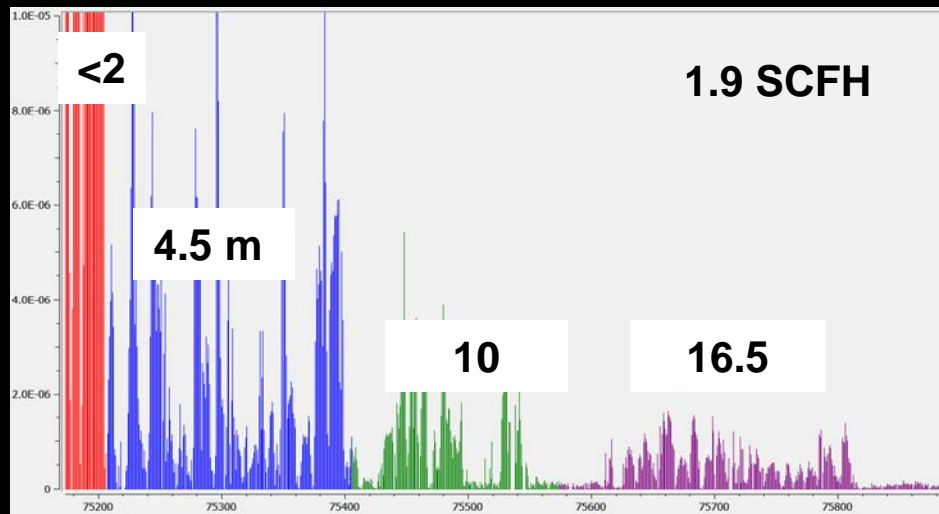
Stability

Inter-comparisons



Data: Foot surveys

Learn behavior and signature of plumes in suburban setting



sUAS: Logistics

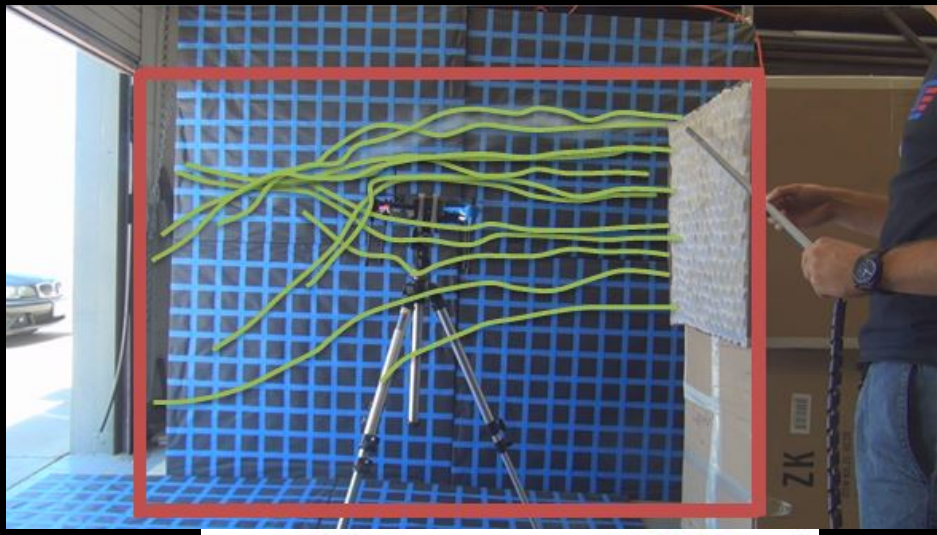
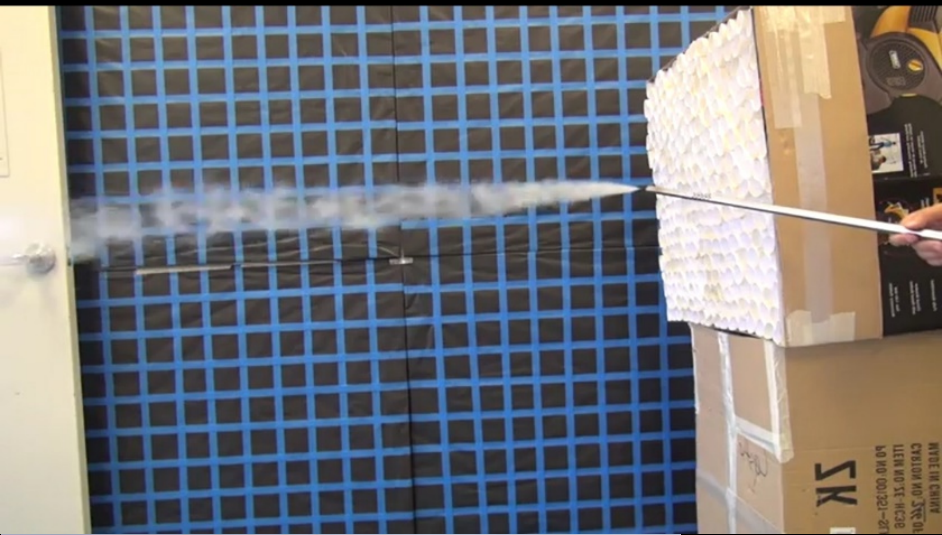


**Lockheed Indago at dry Lakebed
and Caltech**

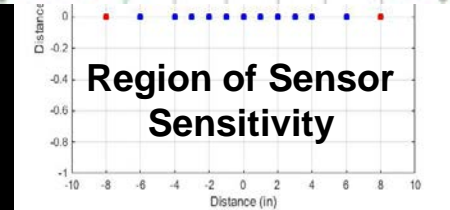


3DR Iris at Merced grassland

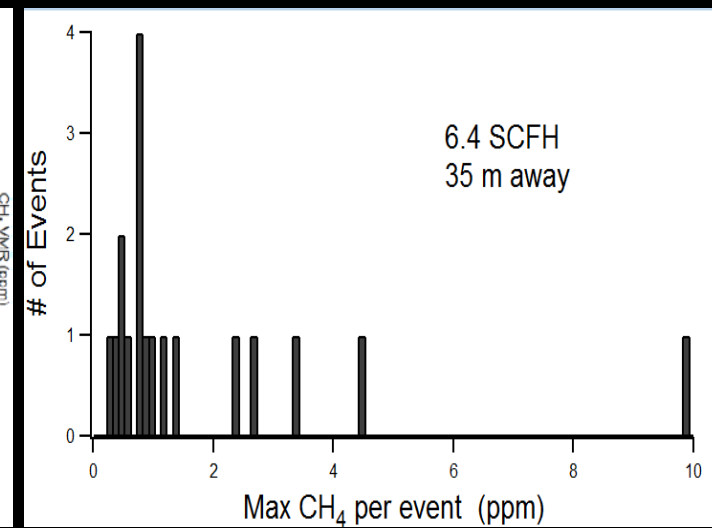
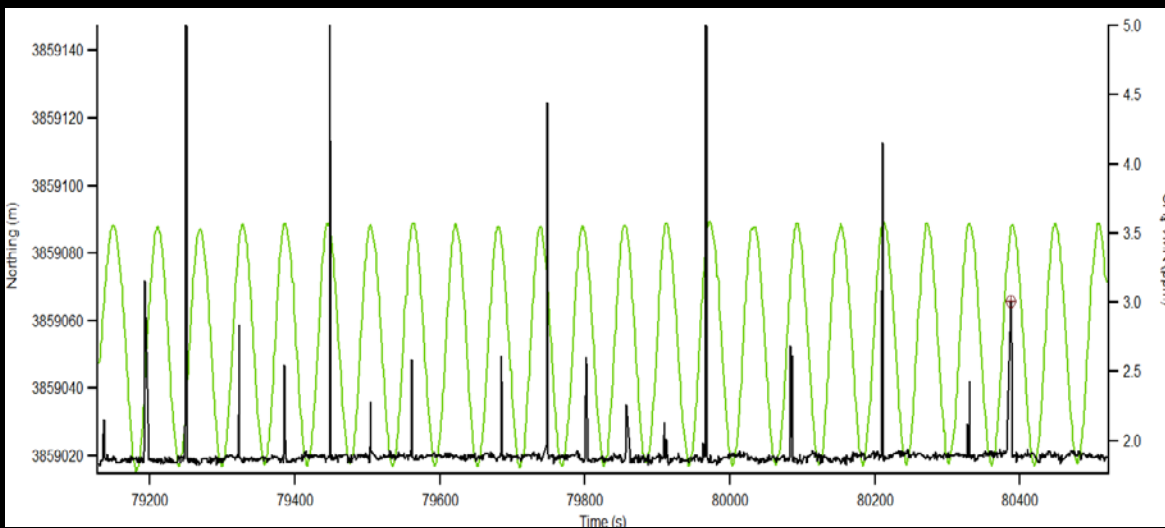
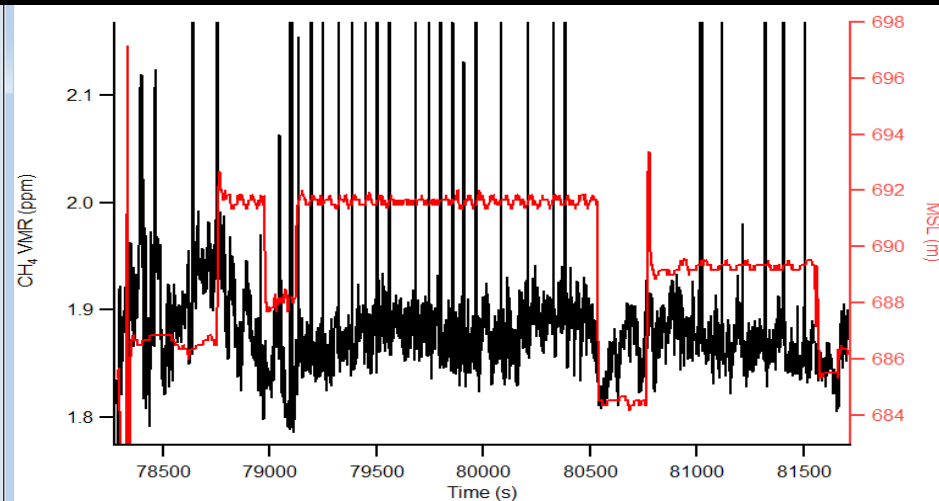
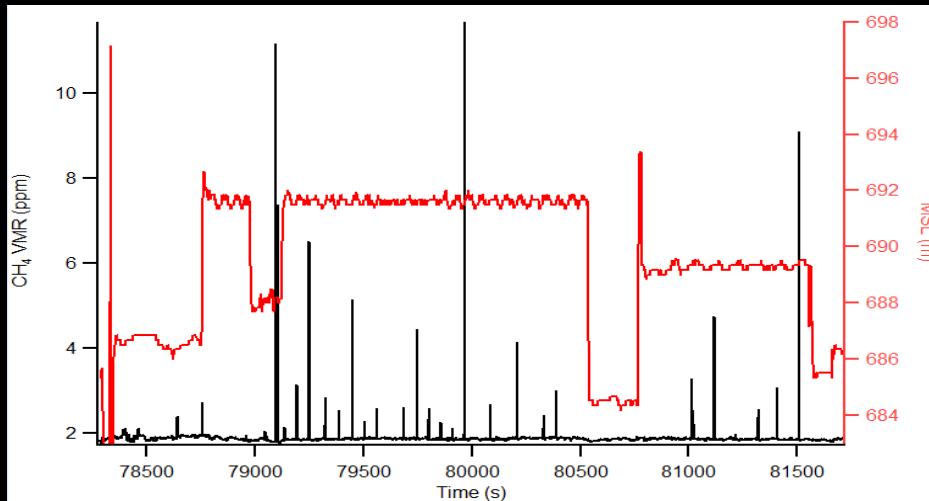
sUAS: Prop-wash



**Flight
test
with
smoke
sensor**

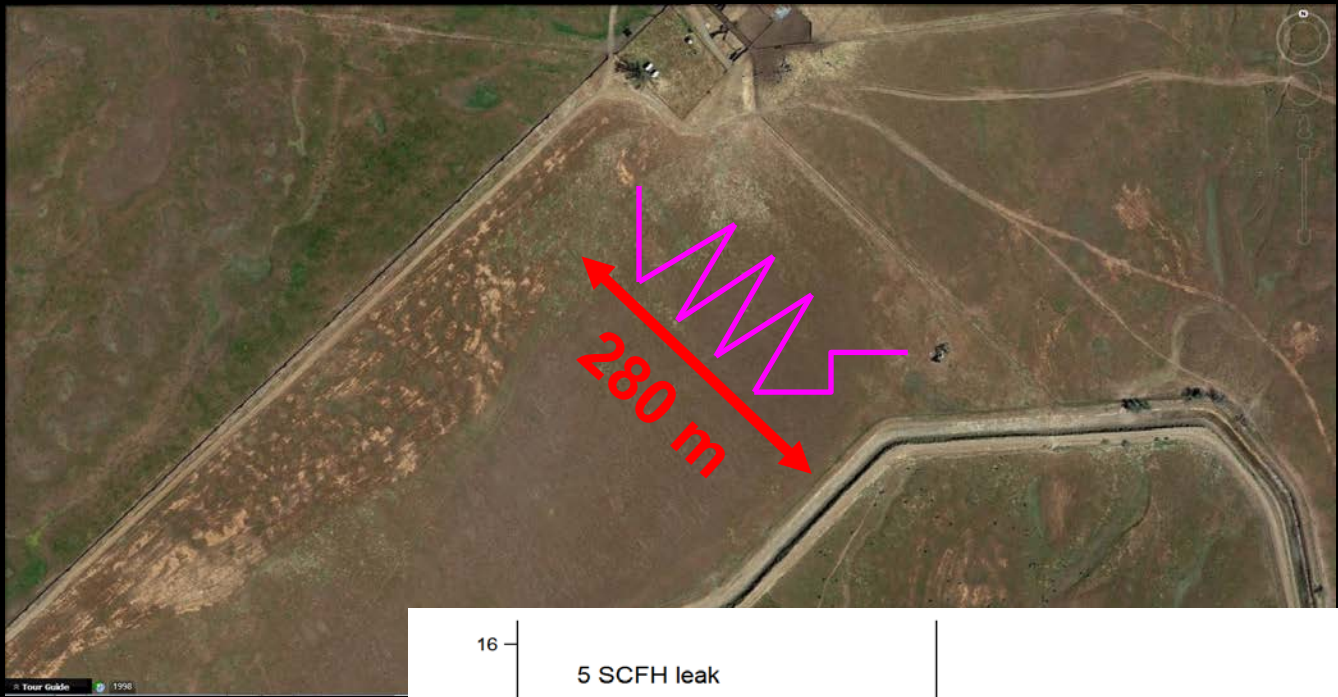


sUAS: Flight Data

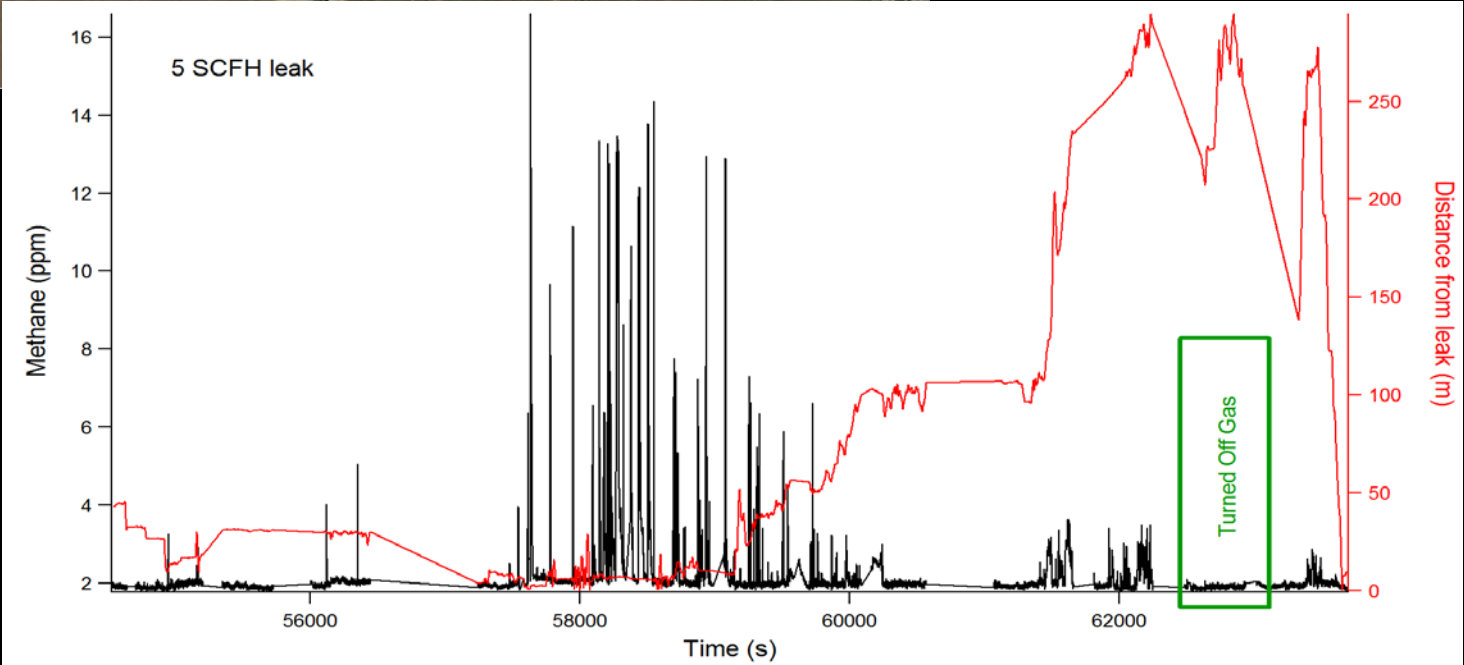


Movie_B: **Orbital**Christensen_movies\orbit_20151105_backtraj.mp4

sUAS: Horizontal

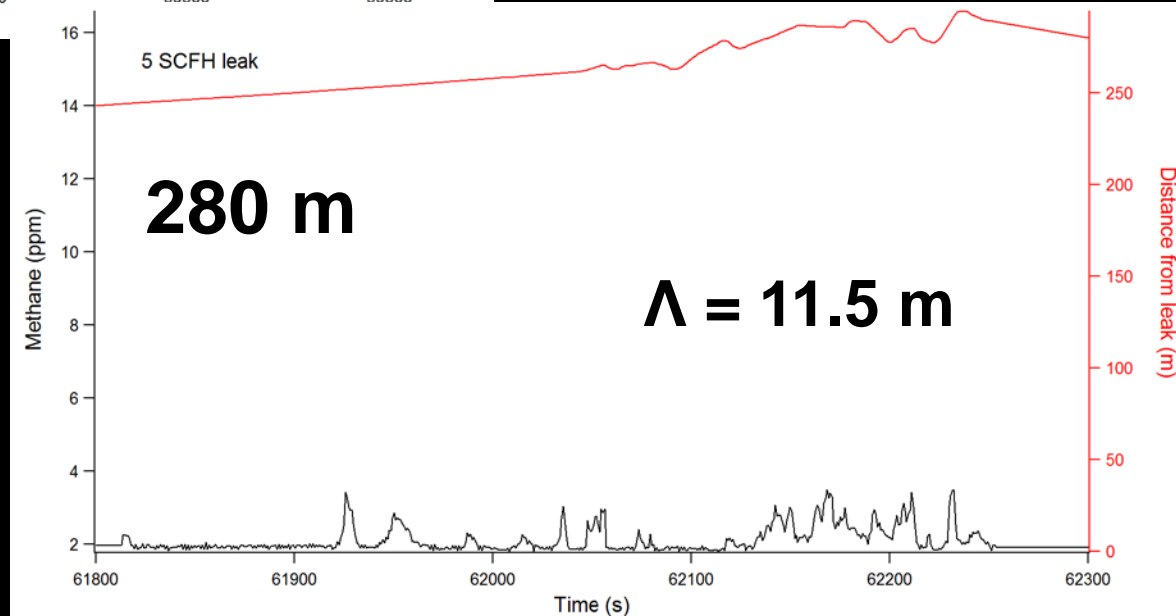
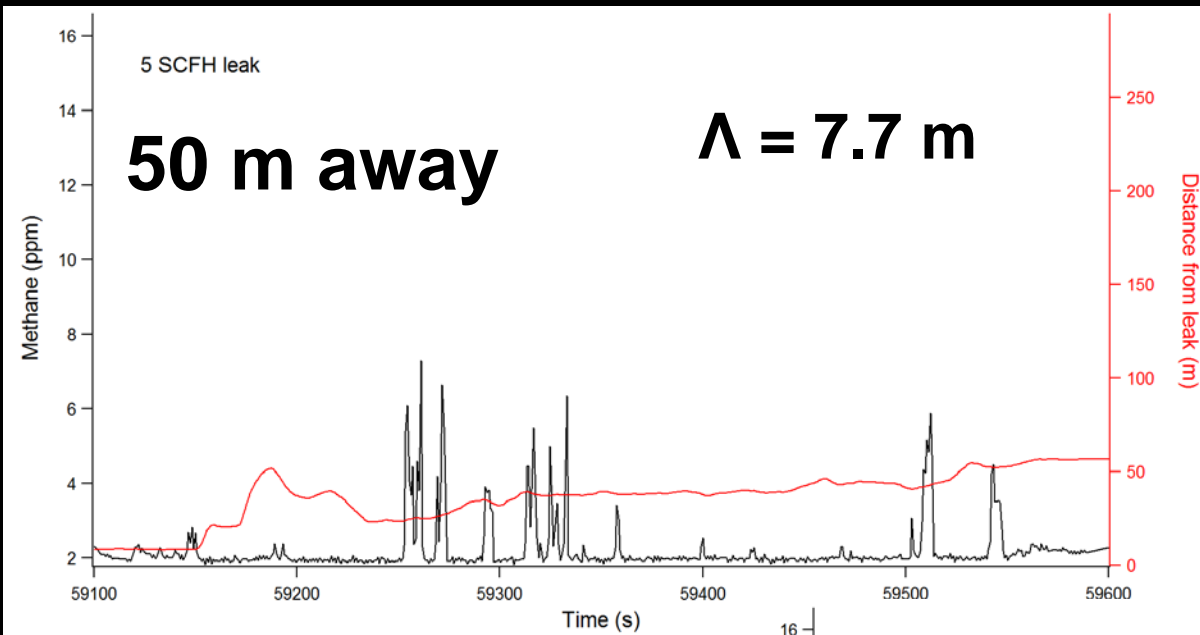


Merced Vernal Pools

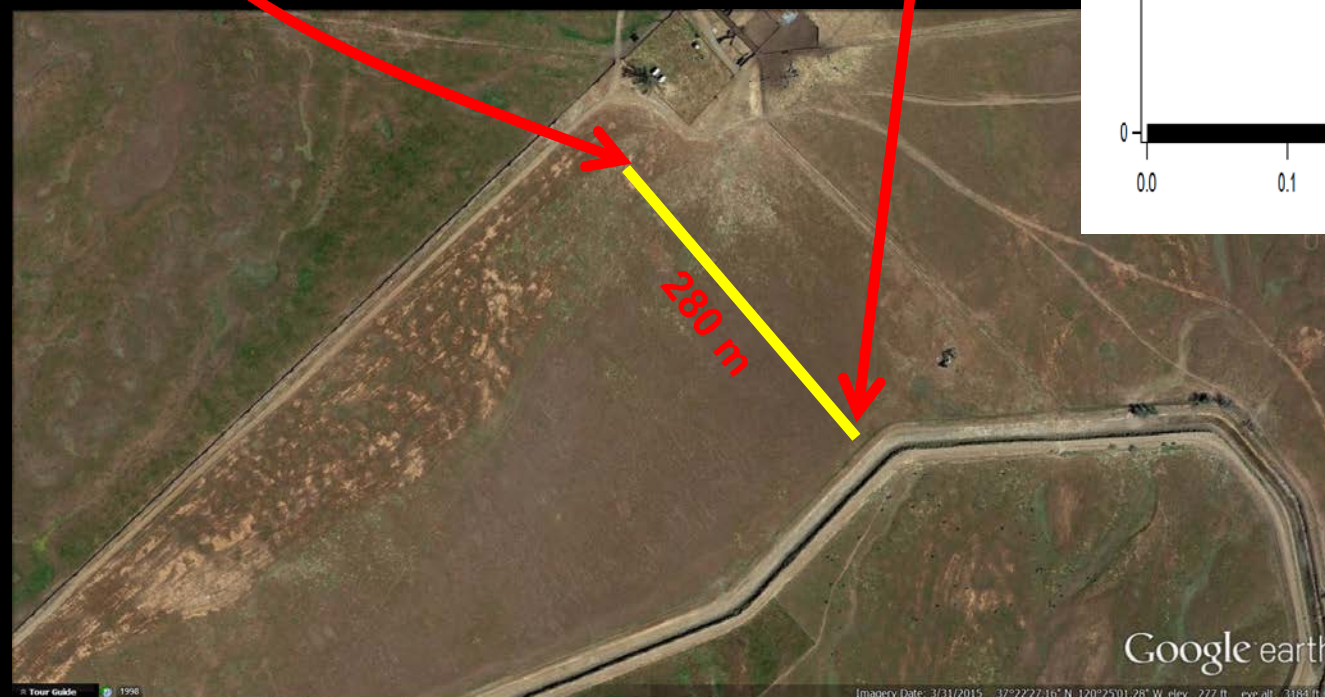
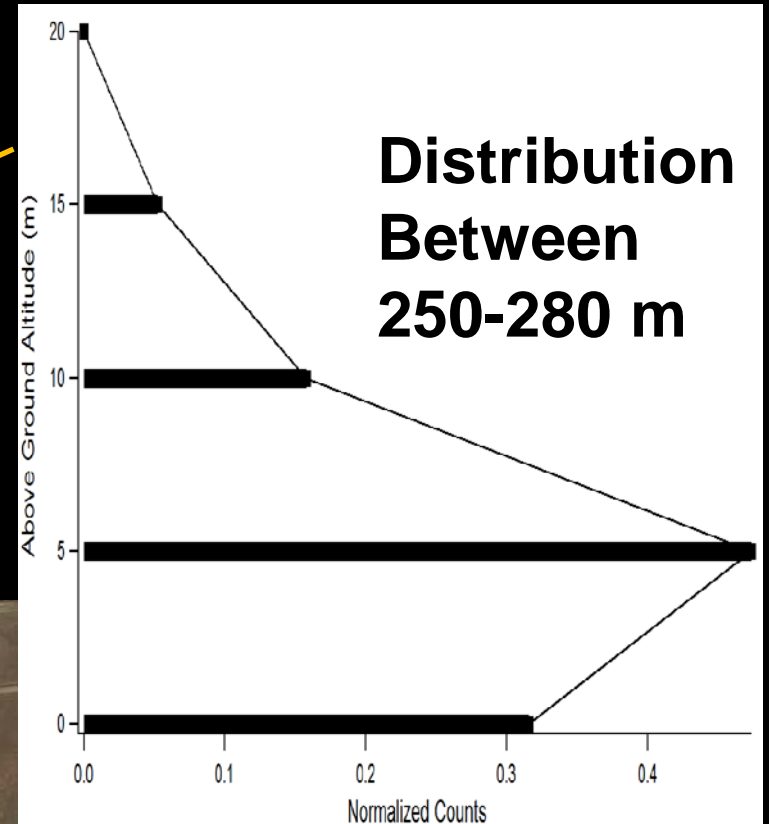
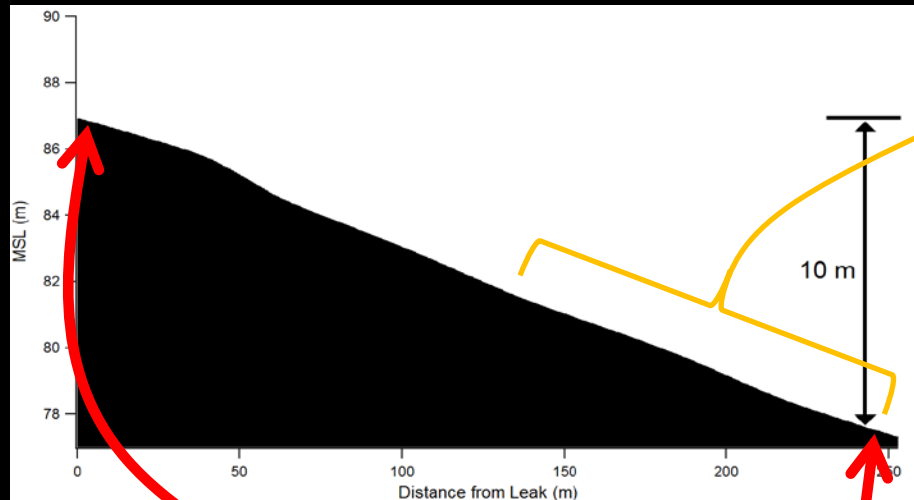


sUAS: Horizontal

Define
characteristic
length, λ ,
as a measure of
data 'sharpness'



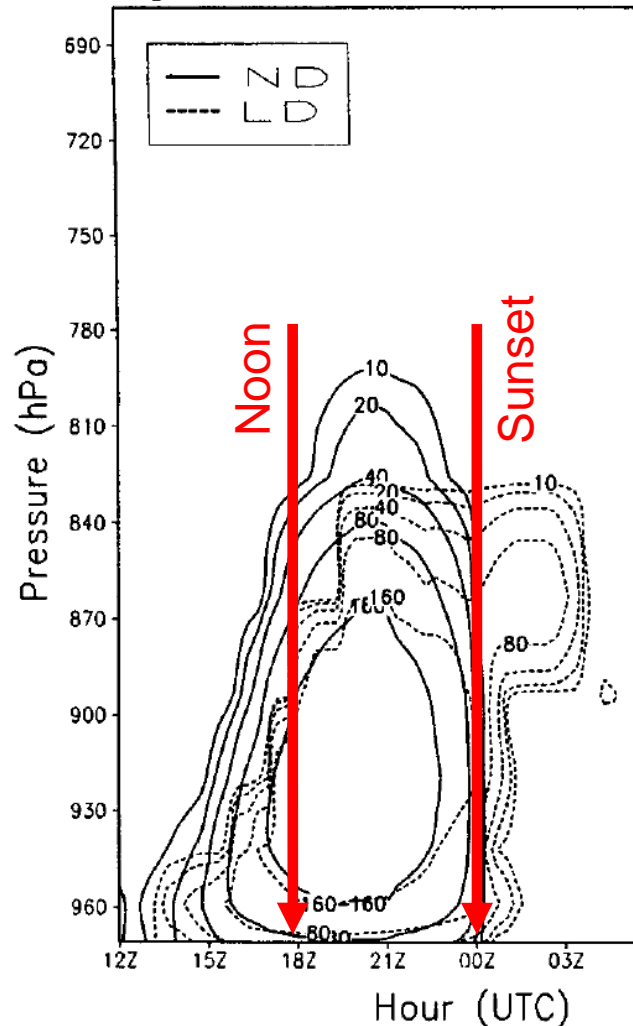
sUAS: Vertical



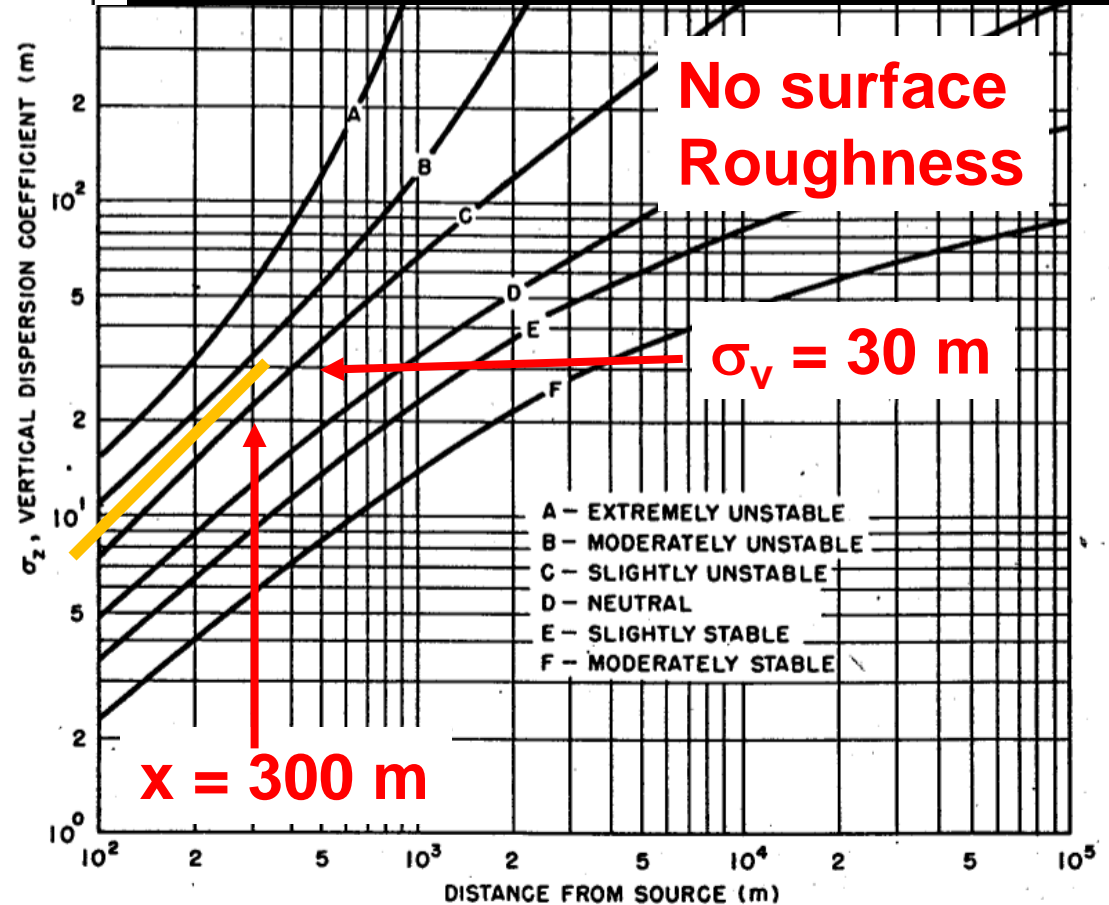
sUAS: Vertical

Hong and Pan, *Monthly Weather Rev.*, 1996

a) $K_z t (m^2/s)$ AUG 9&10



Vertical mixing during day

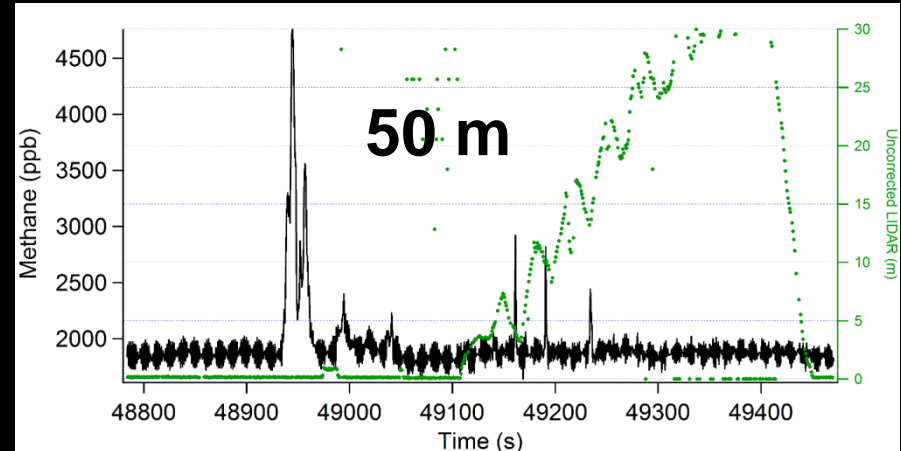


Gaussian concentration profile

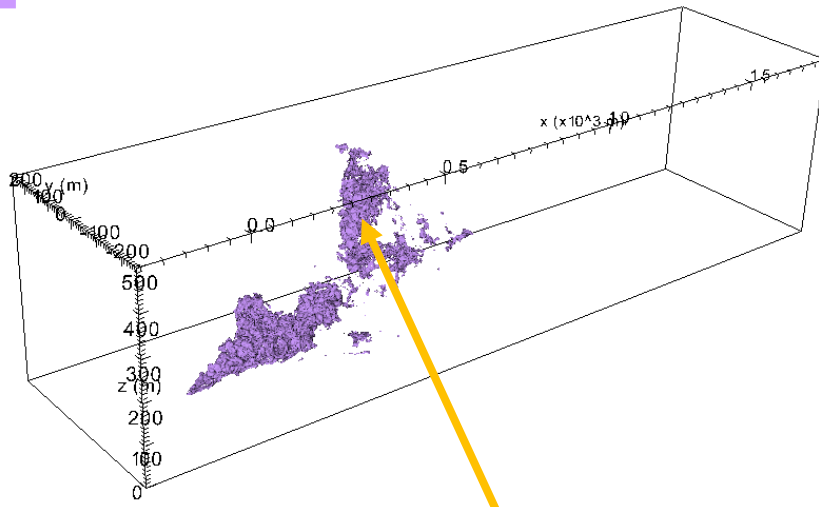
sUAS: Gaussian plume model insufficient

2-m LES Modeling

- Convection
- Surface topology



Contour
Var: ch4(ppb)



Convection

Georgios Matheou (JPL)
5 m/s, mid-lat, noon, 6 SCFH.
Passive scalar. Thermals are
< 10% of area

Conclusions

- **Flown OPLS on two different VTOLS < 2.5 kg**
 - Demonstrated 20 ppb s⁻¹ noise
 - 250 g OPLS
 - Expect plug-n-play system by end of 2016
- **Building knowledge on how to deploy sUAS-OPLS**
 - Right now, VTOLS; 2nd half of 2016, Fixed-wings/hybrids
 - Folding in understanding from LES modeling
 - convection
 - topology
 - Performing surveillance, localization, quantification