Oil and Gas Monitoring and Settlement Projects

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Briefing to the
Air Quality Control Commission and the
Colorado Oil and Gas Conservation Commission
3/18/2021

COLORADO
Air Pollution Control Division
Department of Public Health & Environment

Topics to be covered

- Oil and Gas Health Information and Response Program
- Colorado Air Monitoring Mobile Laboratory
- “SPODs” / Canisters
- Mark Martinez and Joey Irwin Memorial Public Projects
- Possible additional projects

Oil and Gas Health Information and Response Program (OGHIR)

- 2015 Governor's Oil and Gas Task Force Report
  - Recommendation #31b (part 2)
  - Establish a health complaint and information line and compare the rates of occurrence of health complaints in particular areas to determine if a higher level of response is warranted
- OGHIR works with the Air Pollution Control Division (APCD) to determine which complaints warrant responses
- Additional responses to complaints may include:
  - Oil and gas inspector visit
  - Whole-air canister samples
  - Sensor deployments
  - Colorado Air Monitoring Mobile Lab deployment
  - Combination
- Data are reported to public after validation

Colorado Air Monitoring Mobile Lab (CAMML)

- 2015 Governor's Oil and Gas Task Force Report
  - Recommendation #31b (part 3)
  - Funding for a mobile laboratory that could be dispatched to defined locations to monitor ambient air quality and to help determine potential sources
  - Data to be used in toxicological risk assessments
- CAMML
  - Custom aluminum trailer Mobile Lab
  - Diesel generator or line power (preferred)
  - Volatile organic compounds (VOCs) by GC-FID (GC-MS capable as well) for 55 compounds
    - Integrated 45 minute samples, once per hour
  - Methane, ozone (O_3), oxides of nitrogen (NOx), carbon monoxide (CO), $PM_{2.5}$ and PM_{10} particulates, meteorology

Colorado Air Monitoring Mobile Lab (CAMML)

- CAMML typically deployed for 2-4 weeks at a location
- Ideal goal is to collect measurements during all phases of oil and gas development
  - Baseline, drilling, hydraulic fracturing, millout, flowback, early production
- Ideal location:
  - Within 1000’ of oil and gas development
  - Down-drainage and in predominant wind direction
  - Toward residential areas/complainants
  - Connected to line power

Colorado Air Monitoring Mobile Lab (CAMML)

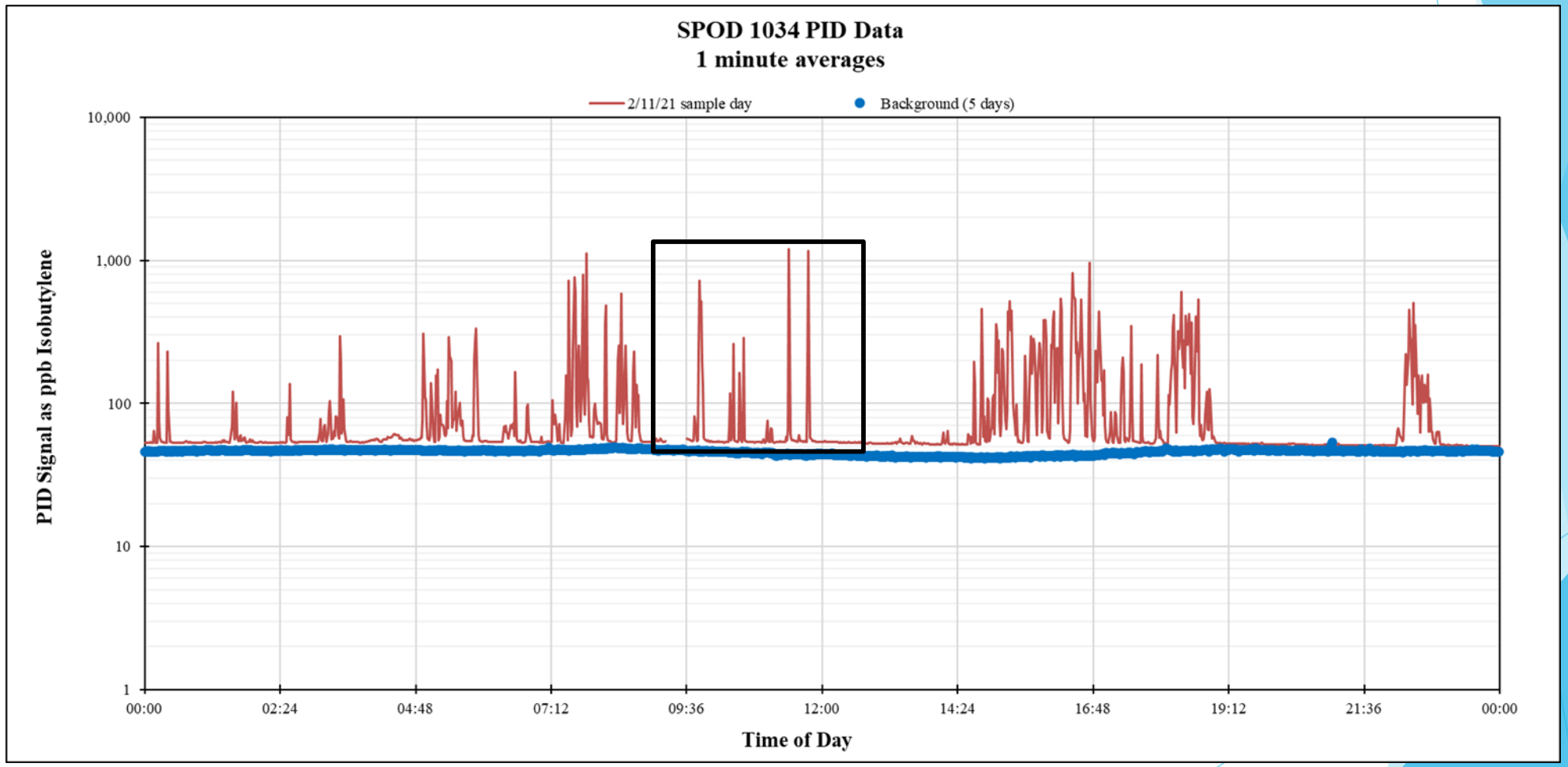
Year	Company Name	Pad Name (Sampling Log)	PAD		CAMML		Distance to Source (ft)	Source Direction (degrees)	Ambient Sampling Start Date	Ambient Sampling End Date	Operational Phase
			LAT	LON	LAT	LON					
2017	Crestone	Woolley Sosa			40.06	-105.06			03/07/2017 13:05	03/23/2017 07:59	Drilling
	Crestone	Waste Connections	40.02	-105.03	40.01	-105.03	1,842	14	06/08/2017 12:06	06/14/2017 08:20	Drilling
	Crestone	Pratt	40.02	-105.02	40.01	-105.02	1,146	34	07/27/2017 16:16	08/14/2017 08:08	Drilling
	Crestone	Pratt	40.02	-105.02	40.01	-105.02	1,147	34	10/13/2017 12:10	10/26/2017 08:46	Hydraulic Fracturing
	Crestone	Pratt	40.02	-105.02	40.01	-105.02	1,146	34	10/26/2017 14:29	11/16/2017 09:10	FlowBack
2018	N/A	Platteville			40.18	-104.73			05/16/2018 09:20	05/23/2018 08:06	Weld County Regional
	N/A	Platteville			40.18	-104.73			08/27/2018 13:07	09/03/2018 12:48	Weld County Regional
	Great Western	Dittmer	40.01	-104.80	40.01	-104.80	1,518	255	09/04/2018 15:19	09/07/2018 10:02	Drilling
	Extraction	Livingston	39.98	-105.04	39.98	-105.04	723	105	10/31/2018 13:13	11/16/2018 09:04	Baseline (Winter)
	Extraction	Rinn Valley	40.13	-105.04	40.13	-105.06	4,310	86	12/20/2018 13:02	01/10/2019 09:16	Flowback
2019	Extraction	Vetting	40.40	-104.66	40.41	-104.66	1,585	197	05/06/2019 10:49	05/26/2019 20:52	Baseline
	Extraction	Vetting	40.40	-104.66	40.41	-104.66	1,590	197	05/26/2019 21:54	06/03/2019 07:34	Hydraulic Fracturing
	Extraction	Livingston	39.98	-105.04	39.98	-105.04	670	103	06/04/2019 13:59	07/05/2019 12:08	Baseline (Summer)
	Extraction	Livingston	39.98	-105.04	39.98	-105.04	674	104	07/08/2019 11:40	09/13/2019 08:53	Drilling
	Extraction	Vetting	40.40	-104.66	40.41	-104.66	1,589	196	07/29/2019 14:57	08/27/2019 07:36	Mill Out
	Extraction	Vetting	40.40	-104.66	40.41	-104.66	1,589	196	10/16/2019 07:32	11/12/2019 19:31	Flowback/Production
	Extraction	Vetting	40.40	-104.66	40.41	-104.66	1,589	197	12/04/2019 14:46	12/20/2019 08:11	Flowback/Production
2020	Extraction	Livingston	39.98	-105.04	39.98	-105.04	675	104	01/29/2020 16:55	02/19/2020 08:12	Hydraulic Fracturing
	Extraction	Livingston	39.98	-105.04	39.98	-105.04	675	104	02/27/2020 17:31	04/02/2020 10:32	Mill Out
	Extraction	Livingston	39.98	-105.04	39.98	-105.04	678	105	04/03/2020 15:56	06/01/2020 05:50	Flowback/Production
	Extraction	Vetting	40.40	-104.66	40.41	-104.66	1,589	197	08/12/2020 04:03	10/09/2020 05:31	Production
2021	Great Western	Ivey	39.97	-104.97	39.97	-104.97	1,035	50	02/03/2021 11:36	02/26/2021 05:12	Drilling
	Cub Creek	Knight	40.20	-105.04	40.20	-105.04	556	76	02/26/2021 00:00		Drilling

Sensit "SPOD"

- Solar powered system combining real-time meteorological and pollutant concentration measurements to detect emission plumes
- Photoionization Detection (PID) for total volatile organic compounds (T-VOC)
  - Range of 10 – 2,000 ppb (0.010 – 2 ppm)
  - Does not quantify individual compounds
- Integrated cellular service for remote operation
- Optional modules available for triggered canister or tube samples
- Trigger threshold set based on background averages and/or data observations during activity
  - Generally 1 ppm total-VOC signal
  - Can vary from site to site based on observations

Sensit SPOD

- Deployed in response to odor and health concerns near oil/gas or other industrial activity



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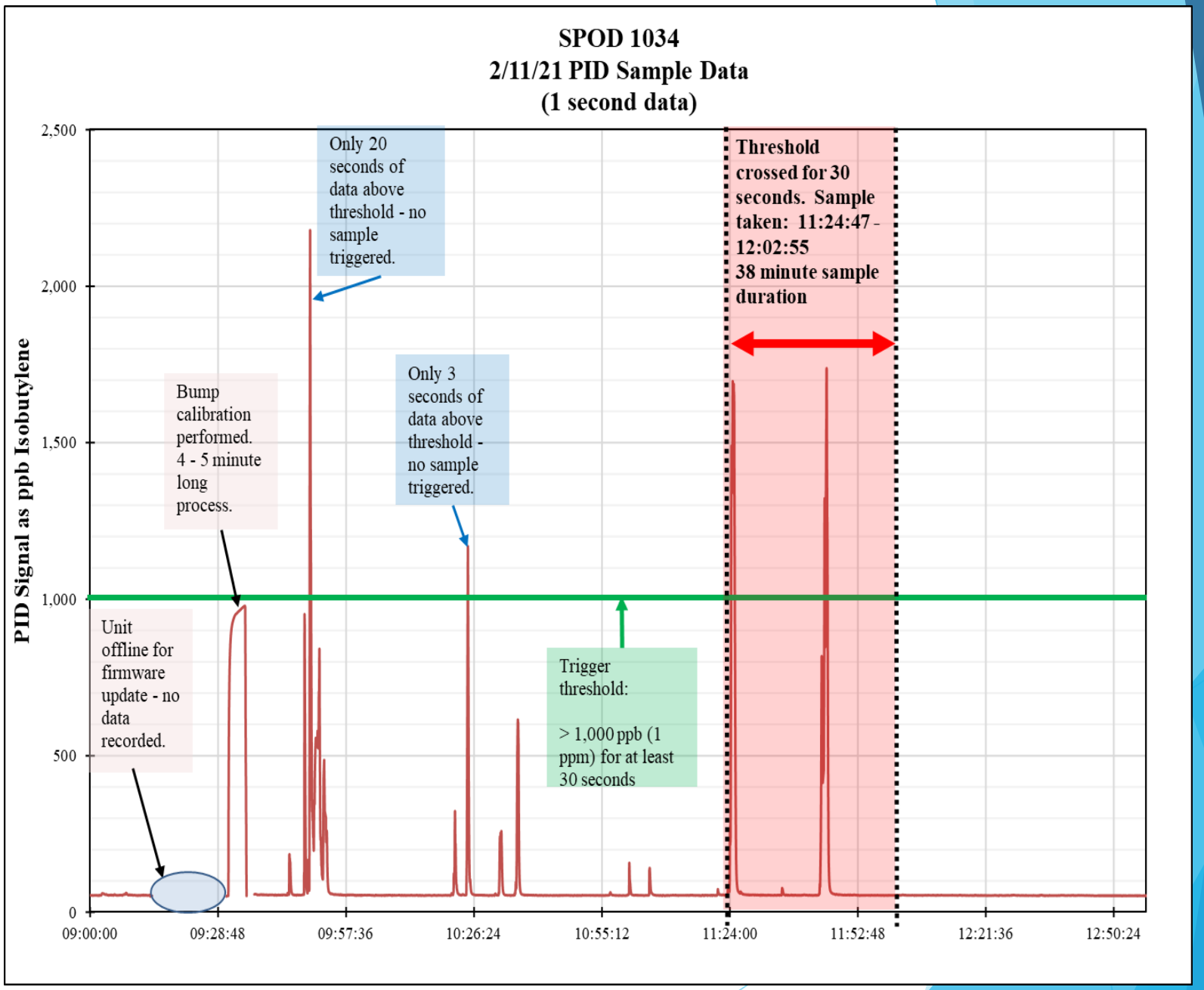
Sensit SPOD



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Mark Martinez and Joey Irwin Memorial Public Projects Fund

- In April 2020, the Colorado Oil and Gas Conservation Commission (COGCC) assessed an $18.25 million penalty against Kerr-McGee/Occidental Petroleum for the 2017 Firestone, CO explosion that killed two people
- To honor the victims of this tragedy, monies from this penalty have been named to The Mark Martinez and Joey Irwin Memorial Public Projects Fund, and will support projects to “ensure the state of Colorado’s oil and gas operations are conducted in a manner that is protective of the public’s health, safety, welfare, wildlife and the environment”
- Public projects benefiting from this enforcement settlement explore a variety of ways to help state agencies meet their SB 19-181 responsibilities

Public projects awarded

- 3a. **Aerial Survey Project** (Est. cost: $2,000,000)
- 3b. **Mobile Air Monitoring Van** (Est. cost: $1,595,000 for the van, plus $250,000 per year for 2 years of operational expenses)
- 3c. Intrinsically Safe Optical Gas Imaging Cameras (Est. cost: $1,100,000.for 9 cameras and related, necessary equipment)
- 3d. **Satellite and Remote Sensing Technology** (Cost: $1,000,000 per year for two years of E&E Lab work)
- 3e. Methane Emissions Technology Evaluation Center (Cost: $1,100,000 to METEC to help develop and characterize leak detection technologies for flowlines)
- 3f. Gas Detection and Metering Equipment (Est. cost: $300,000 for gas detection and metering equipment)
- 3g. Remote Methane Leak Detectors (Est. cost: $42,000 for leak detectors)
- 3h. Legal Expense Reimbursement (Cost: $50,000 to the Fredrick Firestone Fire Protection District for its legal expenses associated with the Incident)
- 3i. Public Health, Safety, Welfare and Environment Projects (Remaining funds)

3b. Mobile Air Monitoring Van

- "Acquire a mobile air monitoring van to measure pollutants, and help determine and locate leaks. The van would be a supplement not only to CDPHE's CAMML, but also to APCD inspectors. This mobile air monitoring van would be driven past oil and gas facilities and operations, as well as near flowlines/pipelines. As the van detects leaks, measures are taken to specifically locate the leak and promptly notify the responsible operator."
- Vendor selected: FluxSense
- Delivery expected early/mid-July
- Cost: $1,440,058 (including 2-years of licensing/support/maintenance)
- 2-years of FTE/operational costs at $250,000/year also funded
- Can determine emission rates from individual sources with wind lidar
- Can be used on-road in plume sniffer mode
- Technology has been proven, South Coast Air Quality Management District has a few vans and it's been widely used in Europe and now, Asia

Mobile Air Monitoring Van

- Ground-level extractive (pump driven cavity) measurements
  - FTIR (Fourier-Transform Infrared spectrometer) for methane, alkanes, alkenes, ammonia, formaldehyde, carbon monoxide, carbon dioxide
  - DOAS (Differential Optical Absorption Spectrometer) for benzene, toluene, ethylbenzene, xylenes, sulfur dioxide
- Vertical/column measurements
  - SOF (Solar Occultation Flux spectrometer) for total alkanes, alkenes, ammonia
  - SkyDOAS for nitrogen dioxide, sulfur dioxide, formaldehyde
- Other measurements:
  - Wind speed, wind direction, GPS

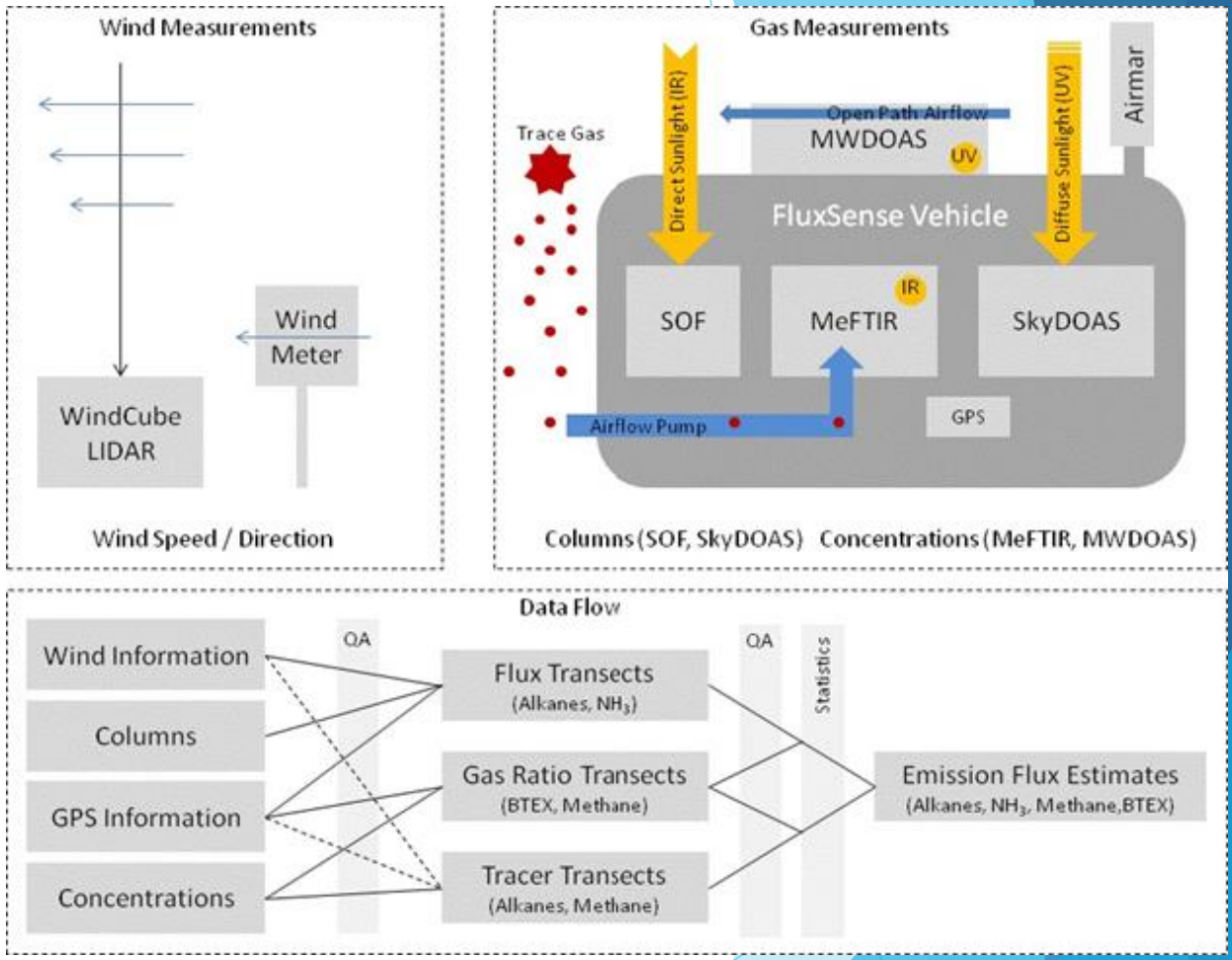
Mobile Air Monitoring Van

FluxSense

Method	SOF	SkyDOAS	MeFTIR	MWDOAS
Compounds	Total alkane, carbon-number alkenes NH_3, CO	NO_2 SO_2 HCHO	Alkane, CH_4, C_2H_4, C_3H_6, C_4H_8, NH_3, CO, CO_2, N_2O	BTEX SO_2
Principle	Remote sensing	Remote sensing	Extractive	Open path multi-reflection cell
Measured unit	Vertical path integrated concentration	Vertical path integrated concentration	Concentration	Concentration
Sensitivity	0.1-5 mg/m²	0.1-5 mg/m²	1-10 ppb	0.2-3 ppb
Flux limit	0.2-1 kg/h	1kg/h	0.2-2 kg/h	0.15-0.25 kg/h
Wind Speed	1.5-12 m/s	1.5-12 m/s	1-12 m/s	1-12 m/s
Time response	1-5 sec	1-5 sec	5-15 sec	1-30 sec

Mobile Air Monitoring Van

- Combination of measurement types allows for not only detection of emissions, but also flux calculations to estimate the rate of emissions
- Potential leaks that are found will be shared with the operators
- Multiple loops at different times around a facility can be used for statistical analyses of variable emissions



3a. Aerial Survey Project

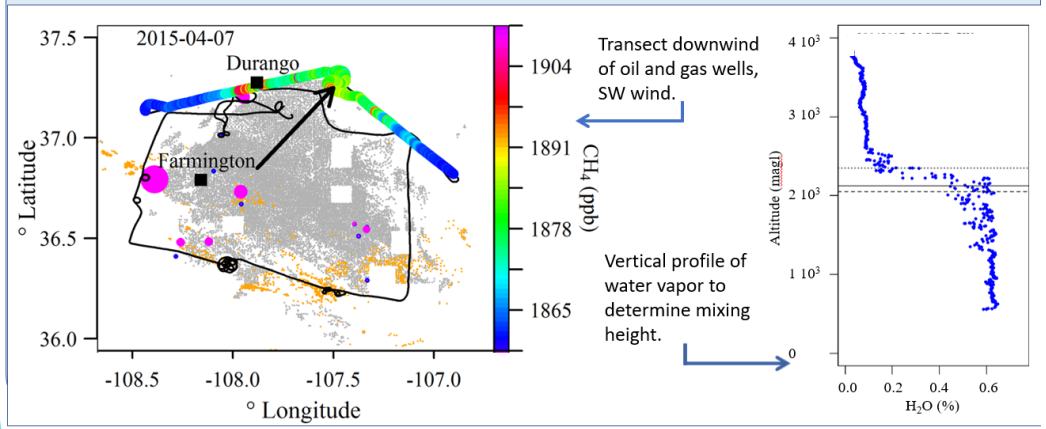
- "Perform aerial surveys at least once per year for two years in the D-J Basin, which is part of the North Front Range ozone non-attainment area. Aerial surveys have the potential to identify and significantly reduce leaks from pipelines/flowlines, production pads, tanks, central gathering facilities, compressor stations. Identifying and resolving these leaks not only results in reduced exposure to organic compounds that can affect public health and emissions of ozone precursors, it prevents the economic waste of the product."
- Cost: $2,000,000 original, $2,769,000 with additional proposal (under 3i)
- 4 phases
  - 1. University of AZ / JPL
  - 2. Colorado State University – METEC
  - 3. Scientific Aviation
  - 4. University of CO / University of MD

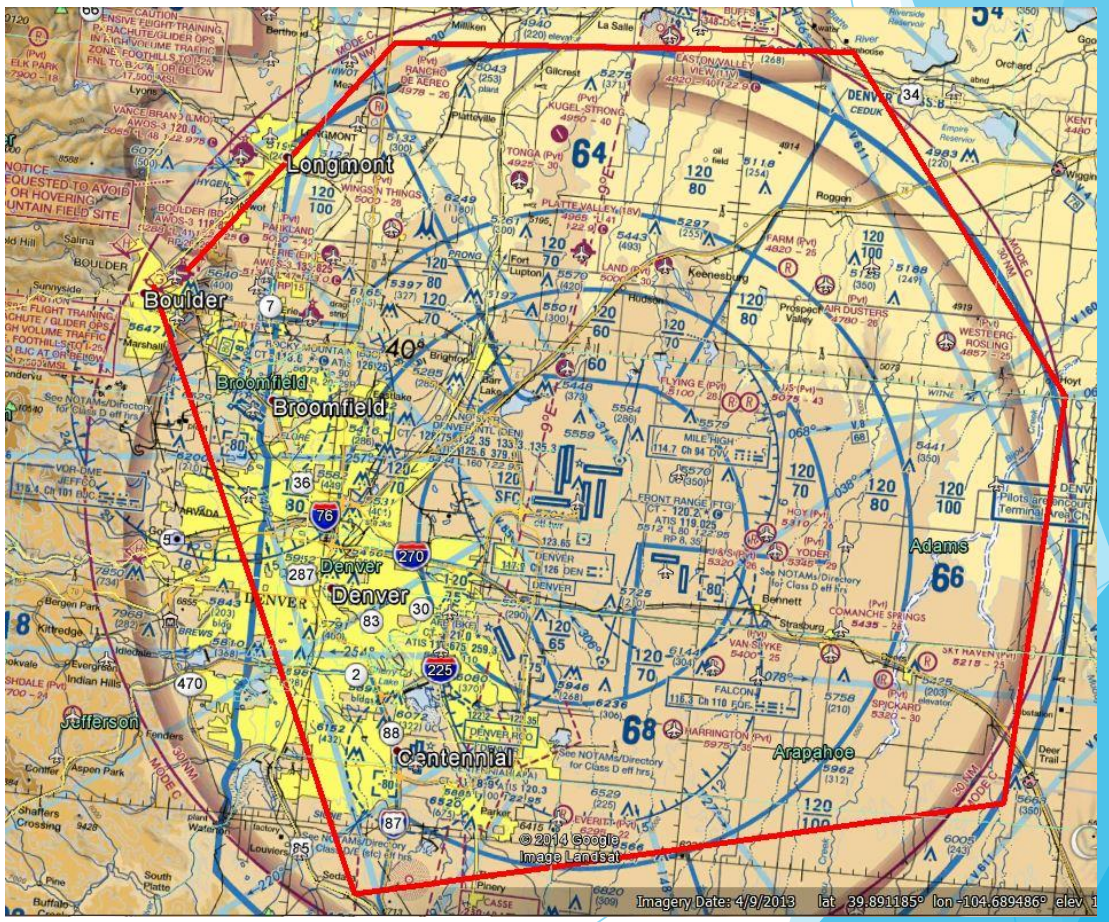
Previous DJ Basin Methane Flux Efforts

- Non-CDPHE efforts
  - Petron/Scientific Aviation (NOAA GMD, 2014)
  - Pieschl (NOAA, CSD 2018)
- 2020 CDPHE with Scientific Aviation

Regional Flux Quantification

- Flight path encloses entire source region (~100 x 75 km).
- In one flight, can capture upwind and downwind transects, and vertical profiles to determine mixing layer height.





Images courtesy Scientific Aviation

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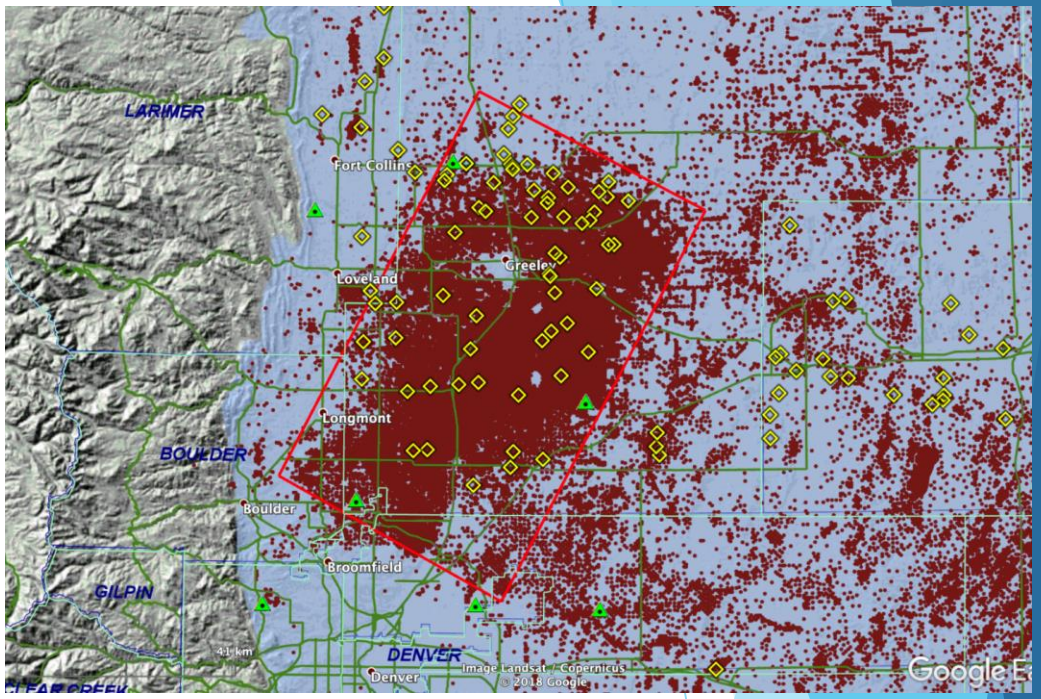
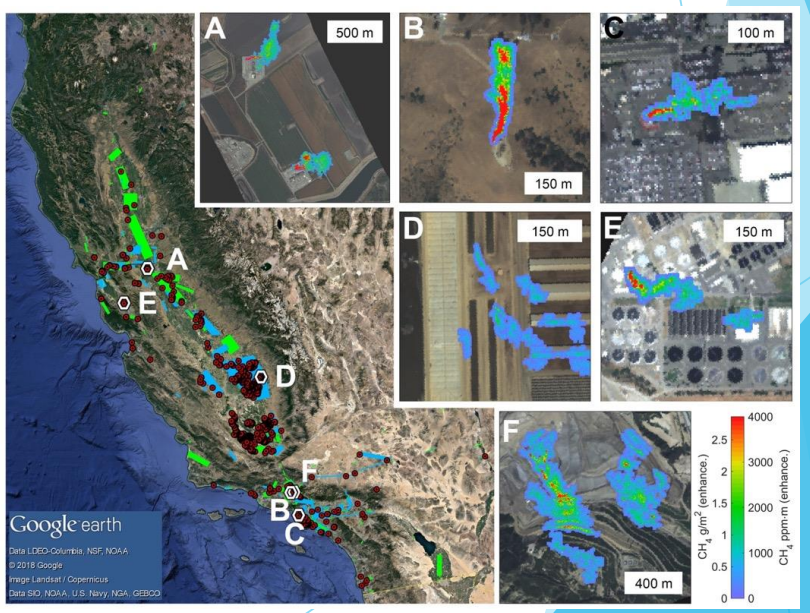
Aerial Survey Phase 1
University of Arizona/JPL

- Optical method for ethane only, no VOCs
  or ethane
- Confined to densest part of the DJ basin
- Sees point source plumes > 10 kg/hour
  or 90 tons/year continuous
- Will see a variety of emission sources, including landfills, utility leaks, and confined animal feeding operations
- Phase 1a, baseline June 2021
- Phase 1b, concentrated effort Sept/Oct 2021
- Provides data for ground truth efforts (phase 2)
- Future efforts in other basins (i.e. Piceance)?
- Dovetails with California Air Resources Board and US Climate Alliance efforts in CA, UT, TX (Permian Basin), etc.





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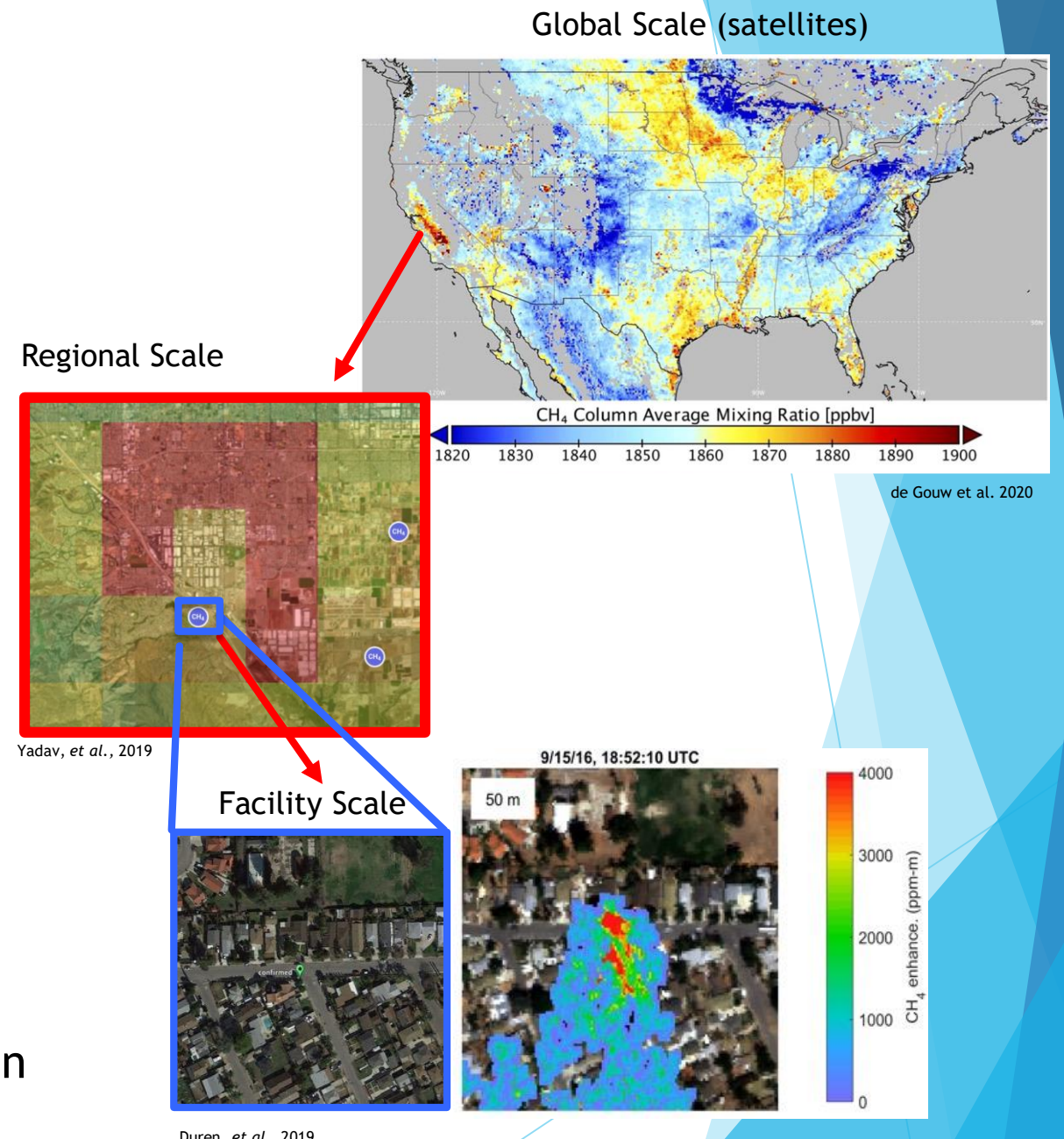
Aerial Survey Phase 1 Goals

- Work Products:
  - Raw data within 24 hours
  - Quantified plumes
  - GIS interface

- Goals
  - Super Emitter identification (point sources > 10 kg/hr)
  - Multiple overflights to evaluate frequency of intermittent emissions
  - Association with Activity Data from phase 2
  - Assessment of fractions of allowed vs. fugitive emissions (in cooperation with operators in phase 2)



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Aerial Survey Phase 2
Colorado State University

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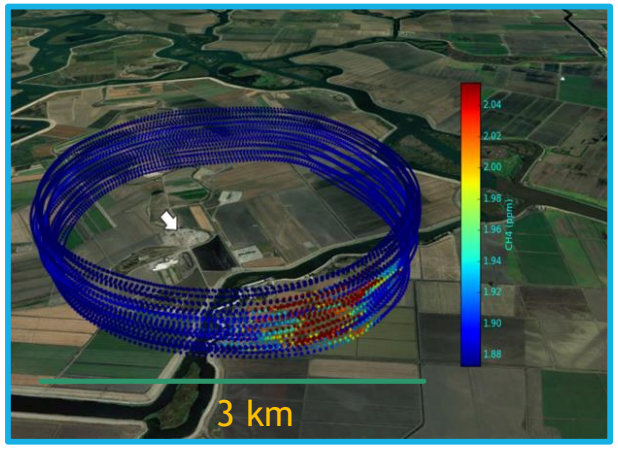
UNIVERSITY OF WYOMING

- Efforts
  - Compile current inventory data
  - Reach out to operators willing to collaborate
  - Compile activity data from operators
  - 2+ mobile lab ground teams will follow up on Phase 1 surveys to confirm and validate Methane Emissions Evaluation Tool model inputs
  - Supported by APCD mobile labs and Oil and Gas (O&G) inspection team



SCIENTIFIC AVIATION

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Aerial Survey Phase 2 Goals

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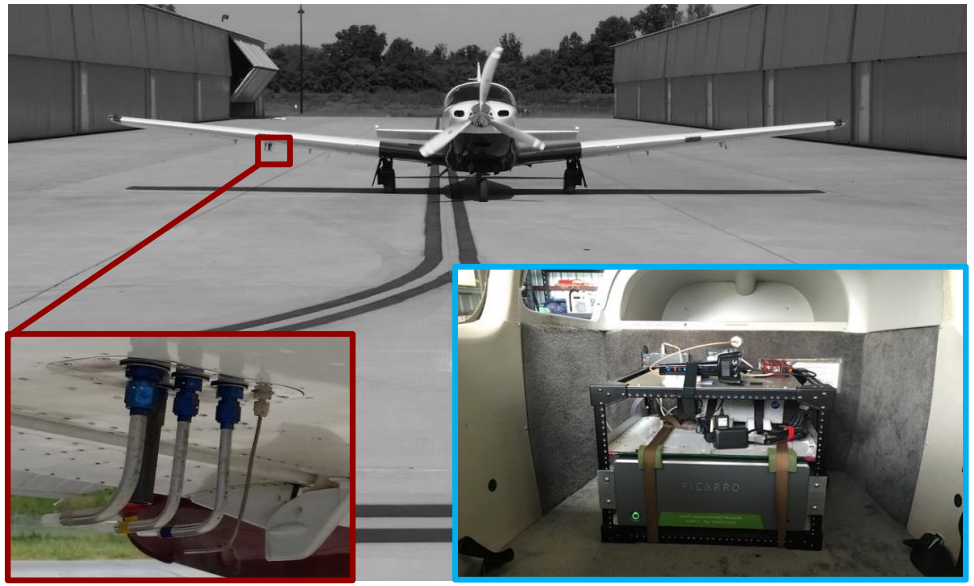
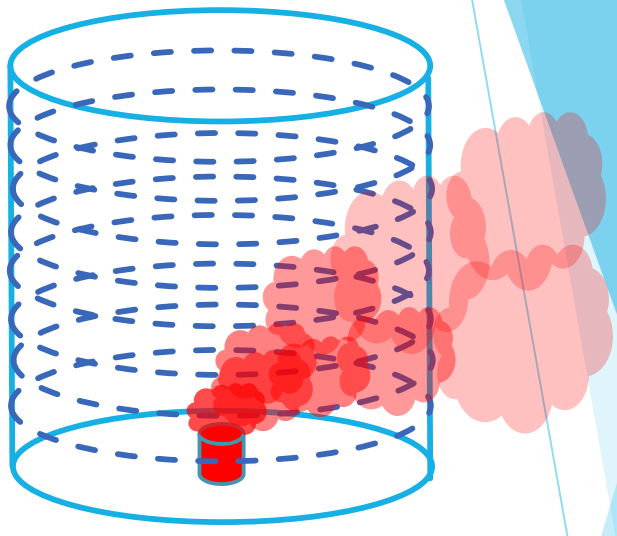
- Work Products:
  - Populate the Methane Emissions Evaluation Tool (MEET)
    - Bottom up methane inventory
    - Activity data from cooperating operators
    - Field Checks on MEET Model Inputs
  - Populated and evaluated MEET model will be handed over to the APCD for future use and updates
  - Identification of oil and gas industry representative facility subset for ongoing monitoring?

Aerial Survey Phase 3
Scientific Aviation

- Efforts Spread over 4+ years
  - Support Phase 1 and 2 efforts
  - Aircraft and Drone
- Ongoing Flux/Mass Balance efforts for comparison with NOAA efforts
- Targeted spirals over high emitting facilities
- Identify representative subset of DJ basin facilities?



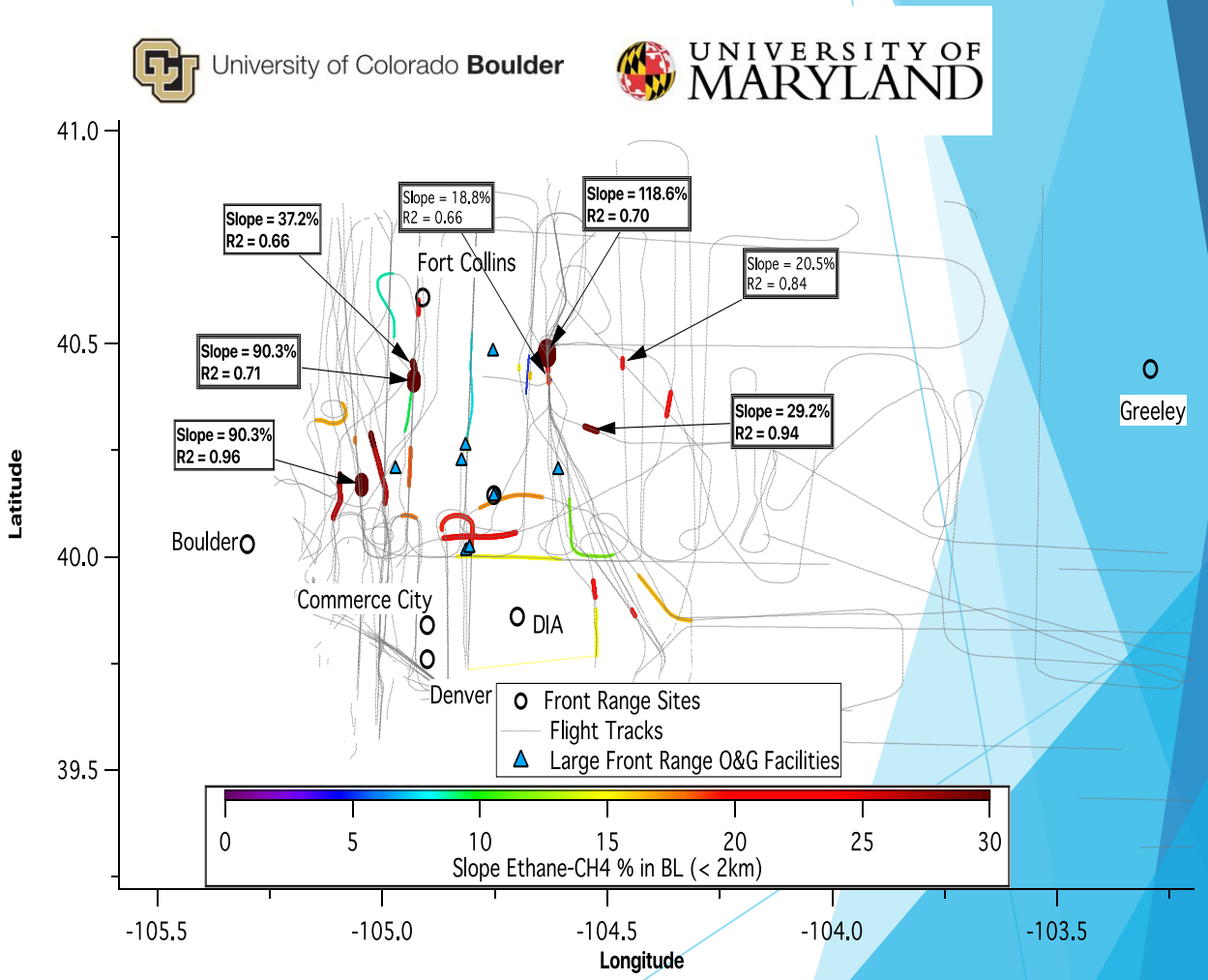
SCIENTIFIC AVIATION



- Dual-antenna differential GPS
- Aspen Avionics flight data computer
- All aircraft equipped with temperature, winds, pressure, and relative humidity measurements
- Three rearward facing gas inlets under the starboard wing
- Available trace-gas analyzers for methane, CO_2, CO, ethane, O_3, and NO_2, and whole air samples for VOC analysis
- Picarro: methane 1 ppbv precision @ 5s; CO_2 150 ppbv precision @ 5s; H_2O 6 ppmv precision @ 5s

Aerial Survey Phase 4
University of Colorado, Boulder

- University of Maryland Cessna 402B
- CAMS-2 fast-ethane measurements (Alan Fried, CU)
- PTR-TOF-MS for fast benzene, toluene, ethylbenzene, xylenes (BTEX) measurements
- Picarro Methane measurement
- Meteorology, NOx, carbon dioxide
- Detailed look at methane/ethane ratios
- Support Phase 2 ground efforts
- Comparison with 2014 FRAPPE measurements
- Synthesis report for ethane/methane measurements



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3d. Satellite and Remote Sensing Technology

- "Over the past two years, an E&E Lab Research Fellow (embedded at CDPHE) and the team of faculty and researchers at University of Chicago have been working closely with CDPHE to identify opportunities to leverage new technology and advanced analytics to improve air quality. The E&E Lab is developing machine learning models to help CDPHE improve effectiveness and efficiency of monitoring and inspections through better resource targeting. The E&E Lab is also supporting CDPHE in assessing opportunities emerging from advances in remote sensing (e.g., satellite, drone and aircraft-mounted sensors), which are poised to drastically lower the cost of emissions monitoring while improving measurement precision. The E&E Lab is working with CDPHE to create proofs-of-concept and develop policies to leverage state-of-the-art technology to help achieve emissions reductions; and to measure the impact and effectiveness of the technology-informed approach to enforcement."
- Cost: $2,000,000
- 2-year project

Methane Remote Sensing Technology

- For the past three years, the University of Chicago's Energy & Environment Lab (E&E Lab) has worked with CDPHE to investigate how advances in remote sensing technology can be applied to find and reduce methane emissions from the oil and gas sector
- E&E Lab will:
  - Use machine learning techniques on facility-level data from CDPHE and public sources to predict oil and gas facilities most likely to emit methane (applying predictive analytics)
  - Partner with remote sensing data provider to conduct airborne methane emissions monitoring of oil and gas facilities and assess study feasibility
  - Evaluate remote sensing technologies and develop a report summarizing findings
- Proposed randomized controlled trial (RCT) design:
  - Conduct targeted airborne methane emissions monitoring campaign of selected regions
  - Use remote sensing data to identify facilities with likely emissions
  - Evaluate the role of various interventions that provide information and/or regulation on operator actions and methane emissions
  - Conduct a survey of operators to understand emissions response and operator decision making process
- The proposed studies aim to generate data that could be used to inform regulatory strategies going forward

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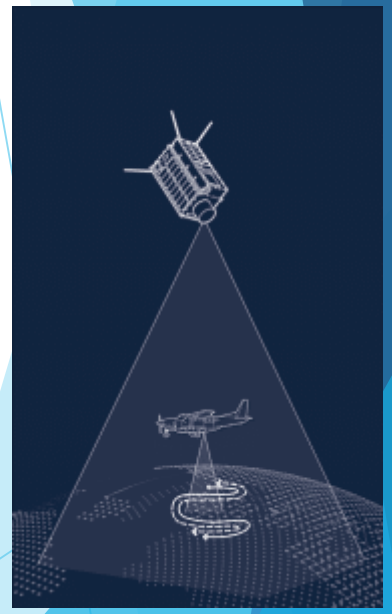
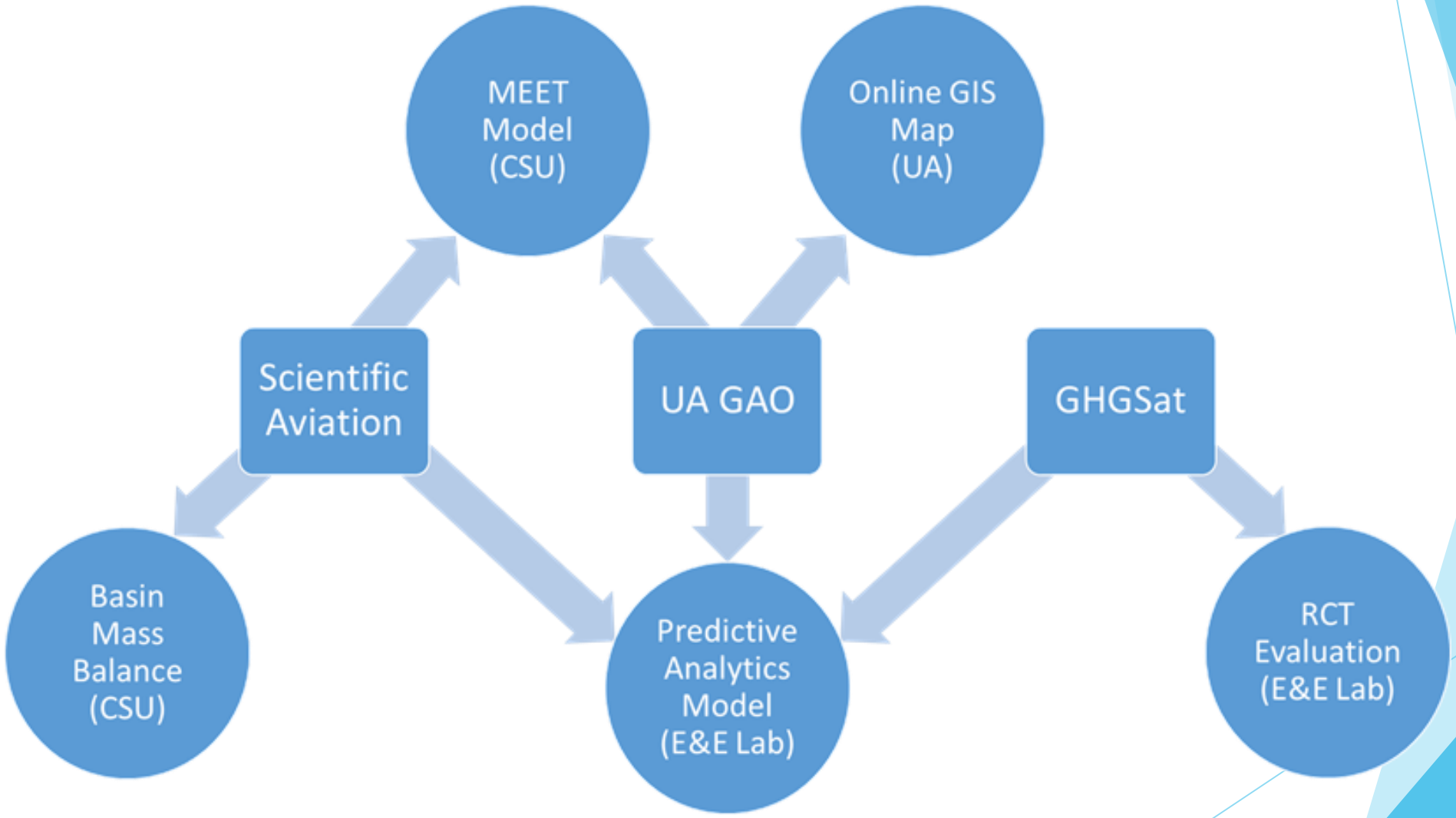


Upcoming Remote Sensing Airborne Campaigns



Possible additional projects under discussion

- Additional instrumentation for the Colorado Air Monitoring Mobile Laboratory (CAMML) (est. $450k)
  - Good candidate for funding, but needs more definition as to what is being requested and SOP's
- Research VOC/BTEX Emissions from Class II Injection Well Facility Operations (est. $?)
  - Good candidate for funding
- Expand understanding of cumulative environmental and public health impacts (est. $2.5M)
  - Maybe more ripe for discussion in a couple of years
- Data Warehouse Project (est. $2M +$100k ongoing)
  - Useful, but not well defined and ongoing costs a concern
- Joint Project with COGCC/CDPHE Data ($?)
  - Not a good level of comfort for support
- Purchase Benzene, Methane, Ethane Analyzer Network (est. $2M equipment + staff needed)
  - Not a good level of comfort for support
- Purchase SPOD Fleet and/or Surveillance Cameras (est. $8k/unit, up to 10 units)
  - Not a good level of comfort for support due to lack of staffing to operate
- Identify specific processes on site responsible for fugitive emissions (est. $?)
  - Too far outside of scope

Questions?