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AIR RESOURCES BOARD

Development and Establishment of a Monitoring Network using Portable Emissions AcQuisition System to Quantify Heavy-Duty In-Use Vehicles Emissions in California

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Heavy-Duty Engine Emissions Standards

NOx reduced 97%
HC reduced 89 %
PM reduced 98%

NOx 0.2 g/bhp-hr
HC 0.14 g/bhp-hr
PM 0.01 g/bhp-hr

present

HC 1.3 g/bhp-hr

NOx 6.0 g/bhp-hr

PM 0.6 g/bhp-hr

1987

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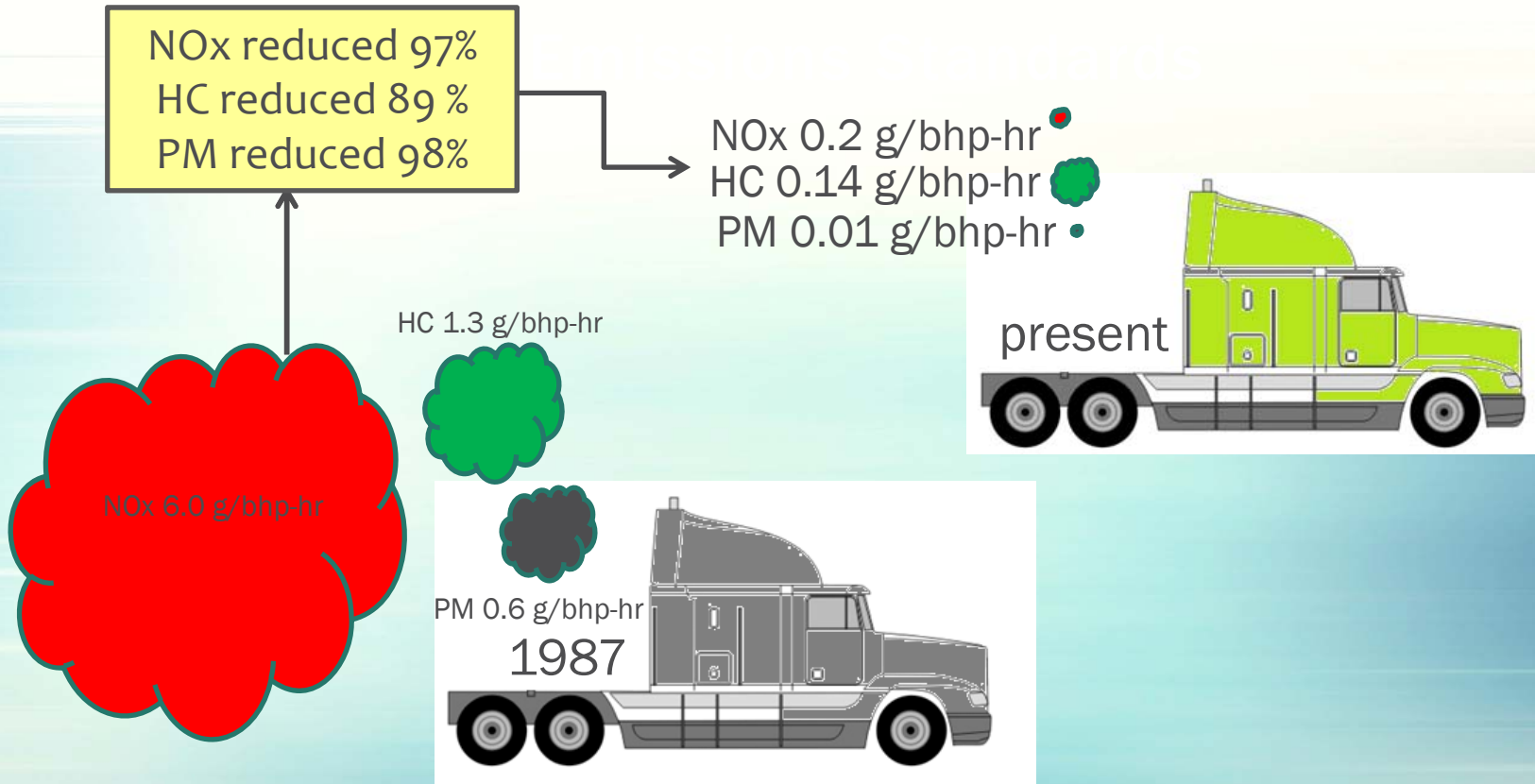
Heavy-Duty In-Use Vehicle Testing Programs

#Dieselgate

2018
Cummins will recall some 500,000 trucks from the 2010 to 2015 model years due to faulty emissions control systems.

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- **Manufacturer In-Use Testing**
  Heavy-Duty In-Use Testing (HDIUT) Program

- **Smoke and Vehicle Inspections**
  Periodic Smoke Inspection Program (PSIP) &
  Heavy-Duty Vehicle Inspection Program (HDVIP)

- **Laboratory Dynamometer Testing**
  Engine and chassis dynamometer testing

- **On-Road Emissions Measurements**
  Portable Emissions Measurement Systems (PEMS)

- **Roadside and Remote Sensing Measurements**
  Plume capture or remote sensing devices

What is PEAQS?

The Portable Emission Acquisition System, or PEAQS, is a roadside emission measurement system that captures a portion of a passing vehicle's exhaust as it drives through to determine an emission snapshot in real-time.

- Screening tool to help target enforcement activities
- Aid in community air quality monitoring

- Design criteria:
  - ✓ Real-time measurements built-in QA/QC
  - ✓ Portable
  - ✓ Characterize vehicle speed and acceleration
  - ✓ Plug and play operation
  - ✓ Explore low-cost technology
  - ✓ Ability to scale up

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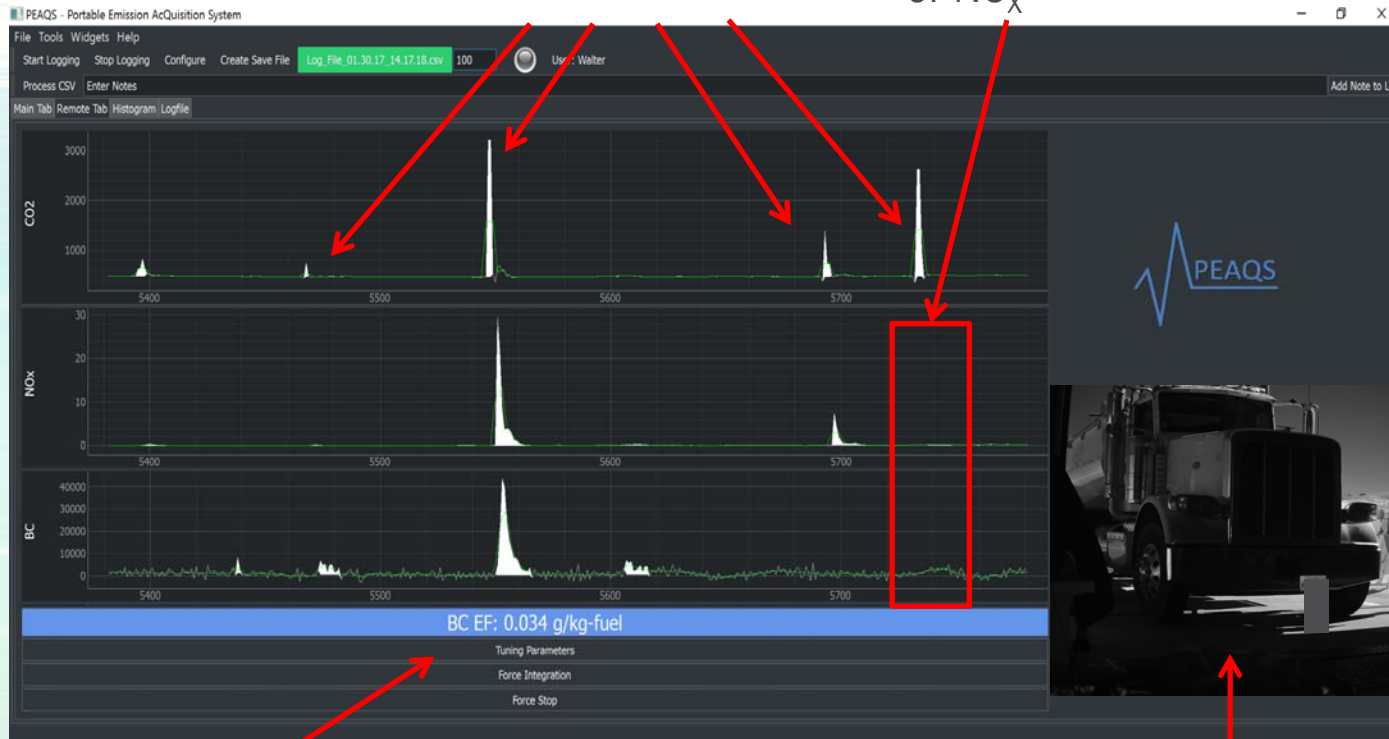https://www.youtube.com/watch?v=5kdsRR7_VVE

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PEAQS Front-End

Captured Truck Exhaust Plumes

No Measurable BC or NO_X

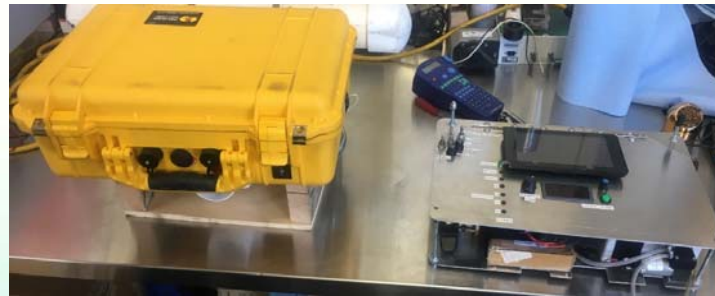CO_2

NOx

BC

Most Recent Valid EF_{BC}

Vehicle Image

$$EF \ (g_P(kg_{Fuel})^{-1}) = \frac{\int_i^j (P_j - P_i)dt}{\int_i^j (CO_{2_j} - CO_{2_i})dt} \times w_c$$

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PEAQS Versions

'Mid-Grade System'

'Laboratory Grade System'
Instrumentation In Trailer

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PEAQS Field Deployments

- PEAQS deployed at 6 locations across California

- >10,000 valid vehicular plumes measured

  - California Department of Food and Agriculture, Truckee
  - Port of Oakland
  - Stockton, CA Intermodal Railyards
  - Port of Los Angeles
  - Cottonwood- California Highway Patrol Weigh Station
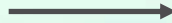 - Caldecott Tunnel – Oakland, CA

PEAQS In the Field

Inside Facility

PEAQS has measured
> 10,000 vehicles

Wilmington,
CA: Port of Los
Angeles

Truckee, CA: California
Department of Food &
Agriculture (CDFA) Truckee

Roadside

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PEAQS Results

|	Average			Median		
All units in g / kg fuel						
	AE-51 BC	AE-33 BC	NO$_x$	AE-51 BC	AE-33 BC	NO$_x$
CDFA Truckee	0.18	0.26	20.2	0.02	0.12	4.51
COTTONWOOD	0.04	0.05	6.6	0.004	0.01	2.20
POLA	0.04	0.03	7.2	0.01	0.01	2.13
Port of Oakland	0.03	0.06	11.3	0.01	0.03	9.47

- Above values are for all valid plume captures during all sampling conducted at each location
- POLA includes information from December 2016 and April 2017

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Emissions Trend: Black Carbon
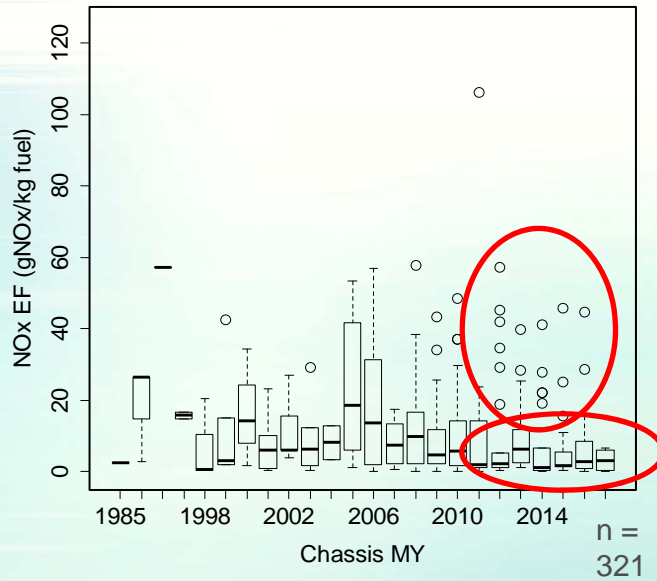
Cottonwood CHP Station April 2017

Port of Los Angeles April 2017
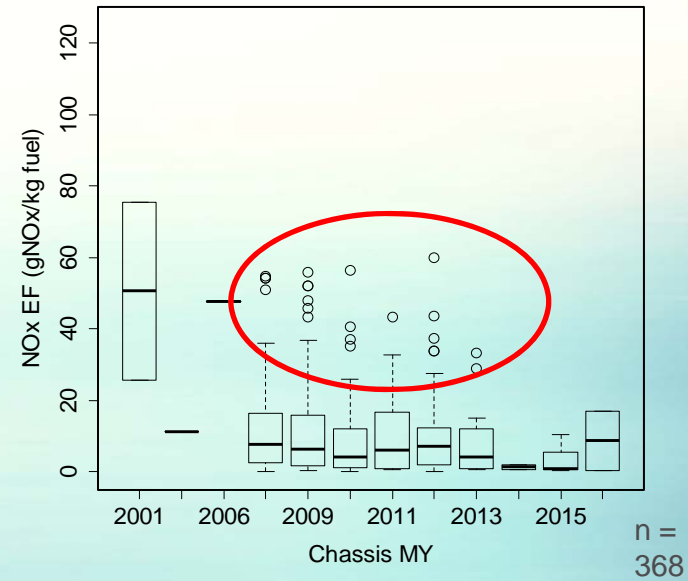

n = 142

n = 90
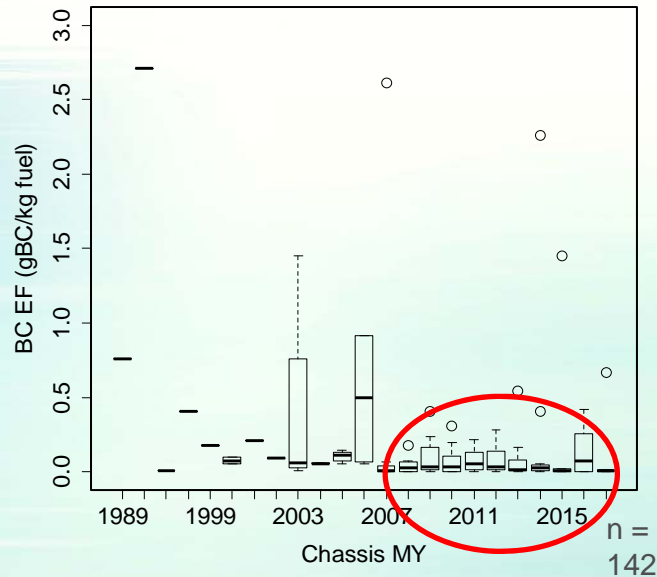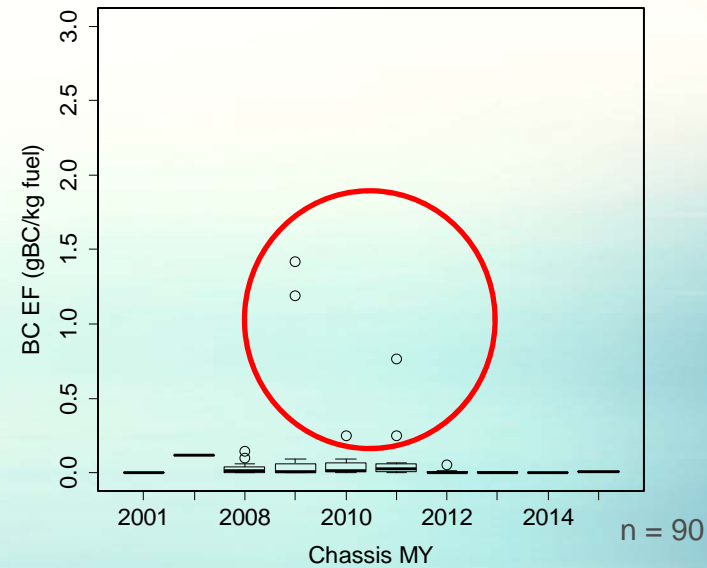
- Lower average BC emissions at Port of Los Angeles relative to Cottonwood Weigh Station
- Majority of vehicles measured had BC < detection limit (total n >1,000 at each site)
- BC emissions driven by 'high emitters'

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Emissions Trend: Nitrogen Oxides
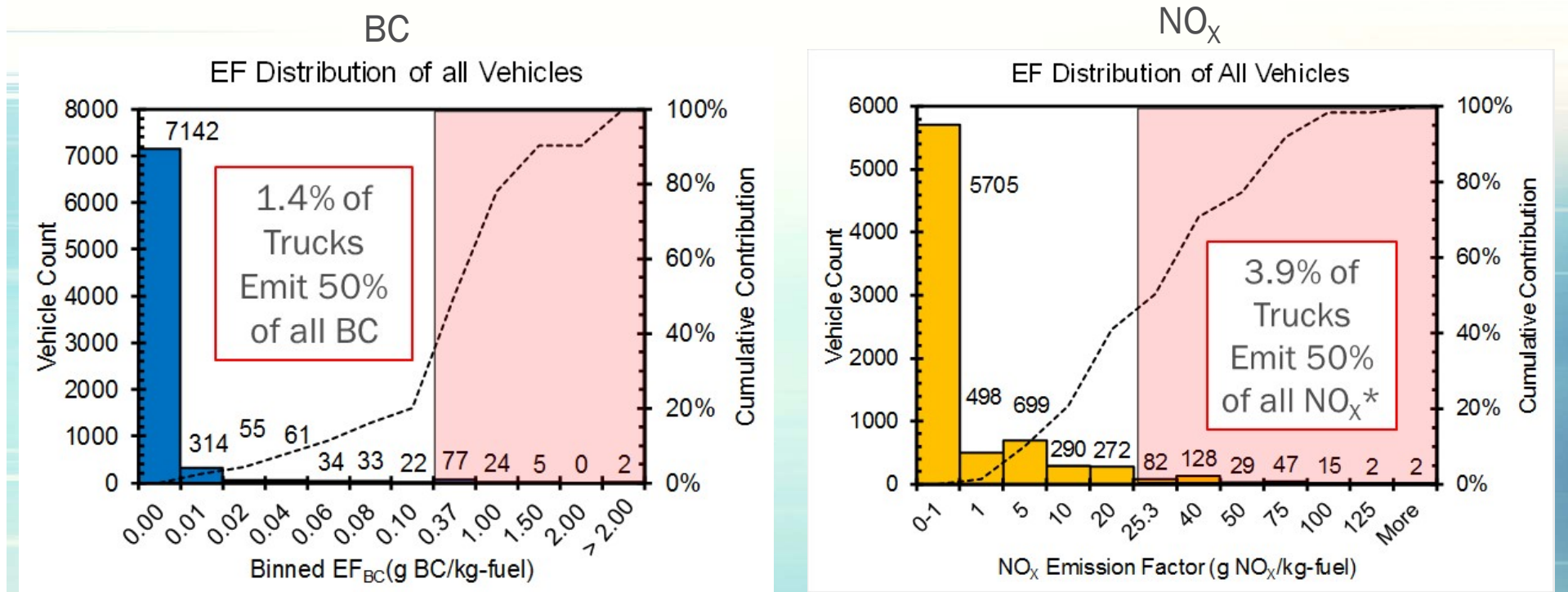
Cottonwood CHP Station April 2017

Port of Los Angeles April 2017

- **Broader model year distribution at Cottonwood**
- **NO_X emissions decrease with MY 2010+ MY**
- **NO_X emission averages driven by 'high emitters'**

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# PEAQS Application: "Highest Emitter" Identification

Build-in library to dynamically update with emissions data to determine top percentile

Data collected by PEAQS during 2016-2017

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High Emitting Vehicle Determinations

- Fuel-based emission factors corresponding to possible exceedances of emission standards as a function of <u>vehicle power.</u>
- A typical HD vehicle (~ 65,000 lbs) will have exceeded the model year (MY) 2010 emission standards (of 0.2 g NOx/bhp-hr and 0.01 g PM/bhp-hr) by three times when fuel-based emission factors are <u>9.3 g NOx/kg fuel</u> and <u>0.11 g PM/kg fuel</u> when measured using the roadside plume measurement approach.
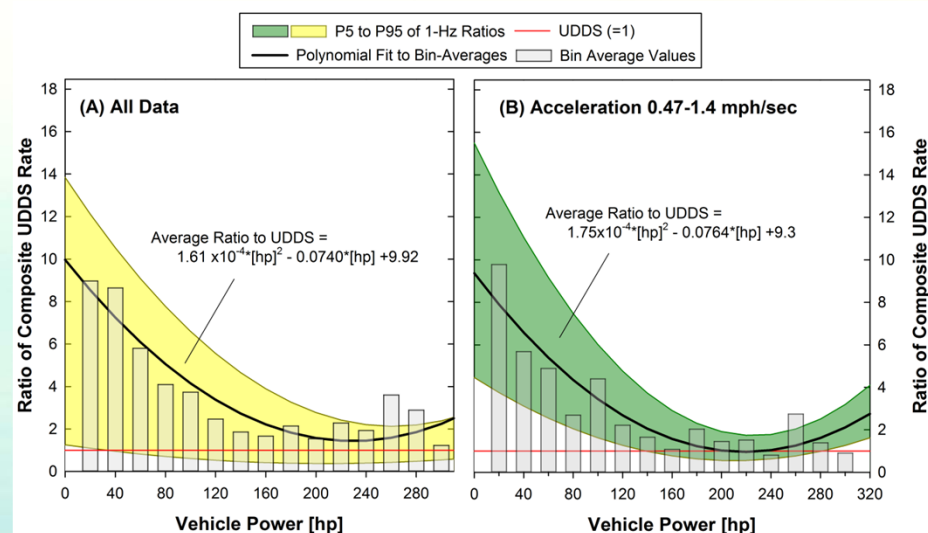
Please note, those threshold values depend on vehicle driving activities.

A Side Successful Story of PEAQS

During the November 2016 filed campaign, PEAQS helped to 'identify' Glider Kits

	[a] Snap Idle		Driving Through		
	Opacity	BC	BC	[b] $NO_{X,i}$	[c] $NO_{X,f}$
	%	g/kg fuel	g/kg fuel		
Glider Kit 1	11.5	0.84	0.025	0.01	1.37
Glider Kit 2	89.3	60	0.21	27.7	39.6

a. SAE J1667
b. g NO_X/ kg fuel on arrival (< 1 mph, decelerating)
c. g NO_X / kg fuel as vehicle departed

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Summary and Next Steps

- PEAQS is an important emissions measurement tool
  - Provide a large quantity of data in a cost-effective way
  - Identify "high emitting" vehicles through roadside plume capture
  - Provide emissions trends
- Next step is to expand measurement to multiple locations across CA through small, lower cost applications
  - Get PEAQS out on roadways across CA to 10 locations
  - Create emissions database structure and procedure for fast data communication

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Questions?

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PEAQS Information Video:
Youtube.com → "PEAQS"

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Backup Slides

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Data Validation

- Data must meet multiple criteria:
  - Valid pollutant peaks co-aligned with CO_2 peak
  - LIDAR tripped
  - Vehicle image captured
  - Valid vehicle speed
- Adaptive background subtraction and peak detection
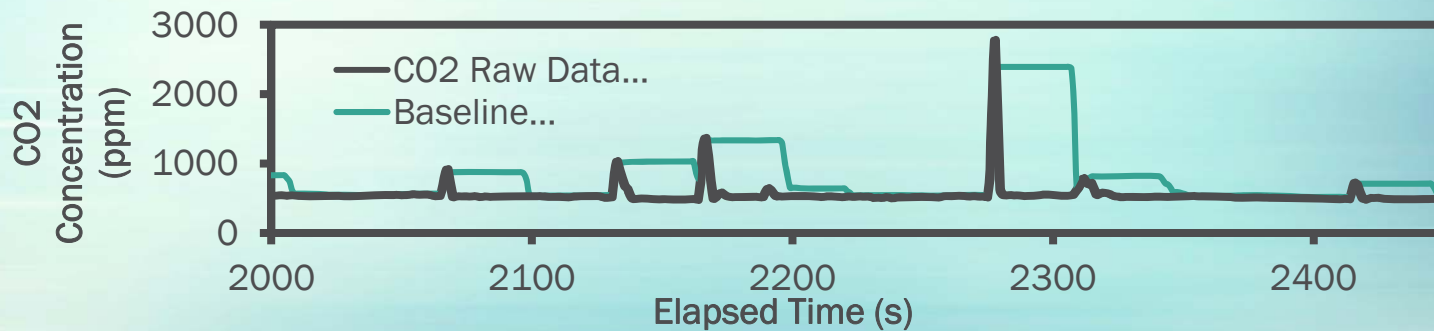
PEAQS Features

- Automatic ER pairing with License Plate
- Build-in library (dynamically update with emissions data to determine percentile)
- Threshold value flag

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