CALIFORNIA
AIR RESOURCES BOARD

On-Board Sensing: How Will This Data Be Used for Mobile Source Programs in California?

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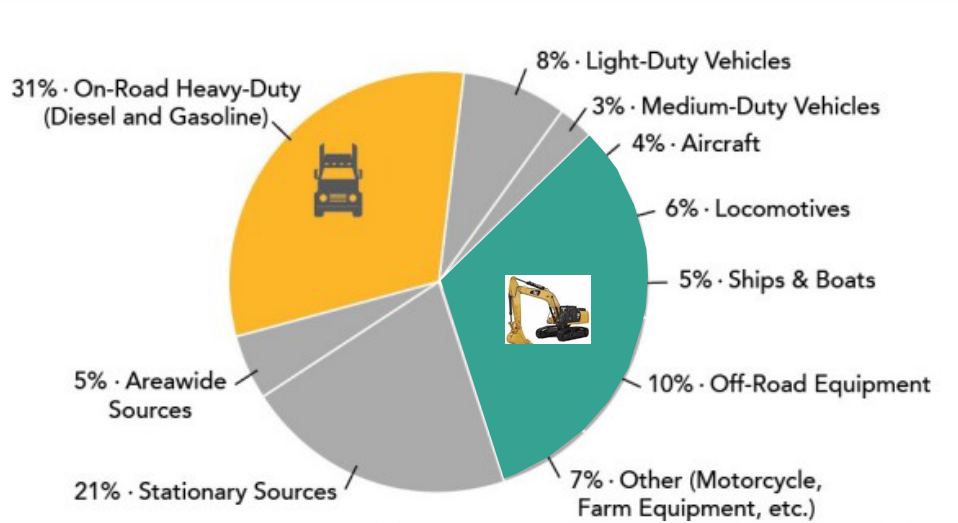
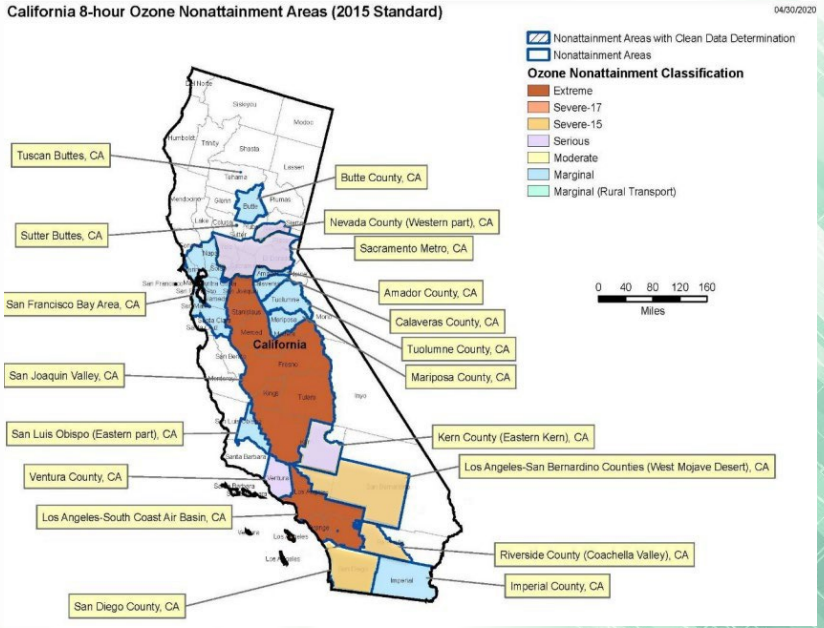
Sources of NOx in California



Source: Facts about the Low NOx Heavy-Duty Omnibus Regulation, 2020



Source: 2022 State SIP Strategy

On-road heavy duty vehicles and off-road equipment contribute **63%** of total NOx emissions in California

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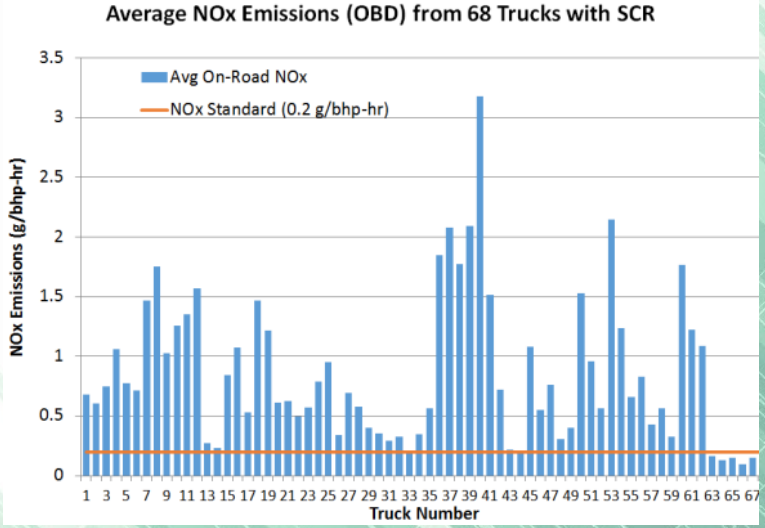
Efforts to lower NOx emissions

Tighter NOx emissions standards

- HD Omnibus reg. (0.02 gNOx/bhp-hr)
- CARB considering to tighten off-road emission standards (Tier 5 rulemaking)

Monitoring real-world emissions

- HD I/M will ensure that highly polluting vehicles are quickly identified and repaired
- HD OBD requires tracking real-world NOx emissions in the REAL data and monitoring performance of SCR system



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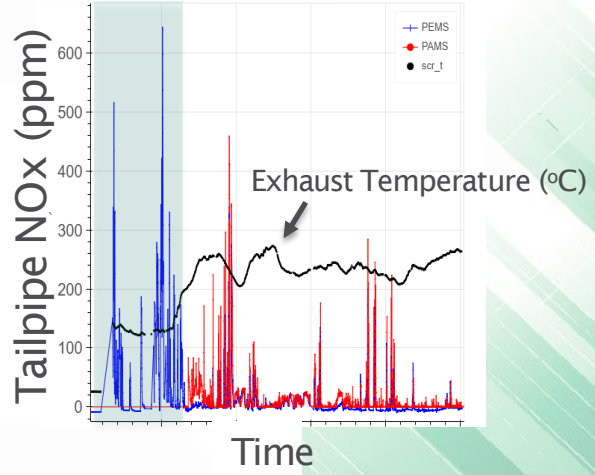
Technological limitations of NOx sensors and OBD NOx data use

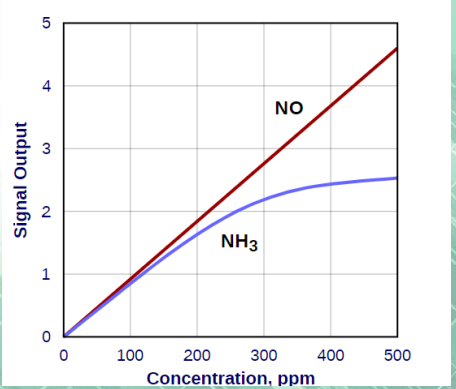
OBD provides a *cost-effective* way to collect real-world activity and emissions data with existing hardware

- Traditional in-use test programs are slow, expensive and yield small sample sizes
- OEMs have access to a wealth of OBD data

On-board NOx sensor technological limitations

- On-board NOx sensors don't measure when sensor is 'cold' (exhaust T<150°C)
- NH_3 cross-sensitivity of electrochemical NOx sensors
- ±10 ppm uncertainty is inadequate to monitor NOx in the [0-10 ppm]





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OBD data streams use in CARB regulatory programs

- HD I/M compliance based on OBD scan result
- CARB needs real-world data to:
  - Understand impacts of current regulations (OBD, GHG P 1,2)
  - Support upcoming regulations & programs (HD I/M, GHG P3, HD Omnibus, Tier 5)
  - Update emission inventories (EMFAC, OFFROAD)
- 4 ongoing CARB OBD sensor-based projects to:
  - Evaluate capacity of NOx sensor to measure over entire duty cycle and boost sensor performance
  - Characterize real-world activity and emissions from HDVs and OREs

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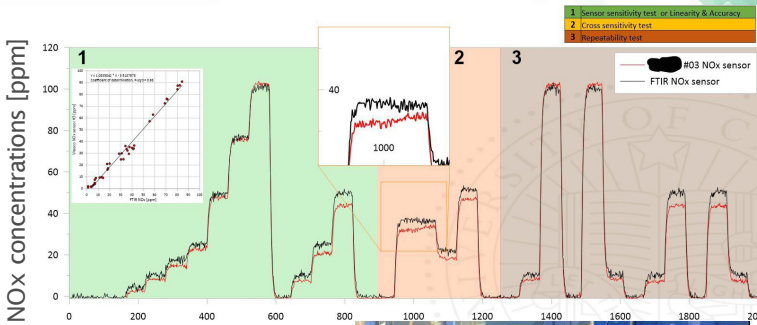
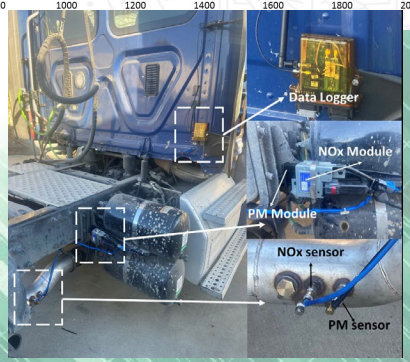
On-board sensor demonstration project

Evaluate the potential of state-of-the-art and innovative sensor technologies in meeting the monitoring needs for recently implemented and future regulatory programs

- Assess measuring capacity of sensors over entire vehicle operation + durability, drift, accuracy, repeatability, etc.
- Examine innovative and advanced technology NOx sensors during real-world operations over a year
- Characterize activity and emissions for current and future programs



Deployment type	Duration	HDDVs	ORDE Types
Short Term	4 weeks	100 HDDVs	20 ORDEs
Long Term	1 year	20 HDDVs	20 ORDEs
		15 with state of art NOx sensors 5 with emerging technology NOx sensors	
Target		2018 or newer model years	Engines meeting Tier 4 standard, Power ratings 56~560kW (75~750hp), Equip with SCR & DPF



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Optional low NOx vehicle measurement project

Characterize real-world NOx, NH_3, and CO_2 emissions of HD Natural Gas vehicles that meet the optional low NOx (0.02g/bhp-hr) standard

- Collect real-world vehicle activity and emissions data to inform CARB HDV regulations
  - Instrument 100 NG vehicles (drayage, transit, refuse, delivery) for 4 weeks
- Conduct PEMS testing on 4 NG vehicles to assess accuracy of sensor in real-world
- Identify excessive emitters and characterize their emissions

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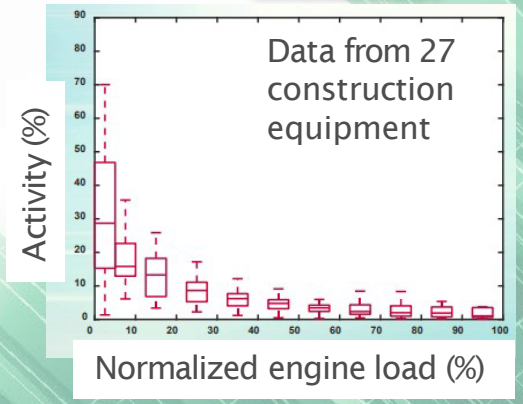
Off-road OBD concept demonstration

Establish a requirement for off-road engines that parallels the REAL requirements for on-road engines

- Conduct data analysis (using existing datasets) and propose binning structure for off-road REAL NOx and GHG tracking
- Recommended bin structure should yield useful data for the whole range of diverse off-road equipment types and power ranges



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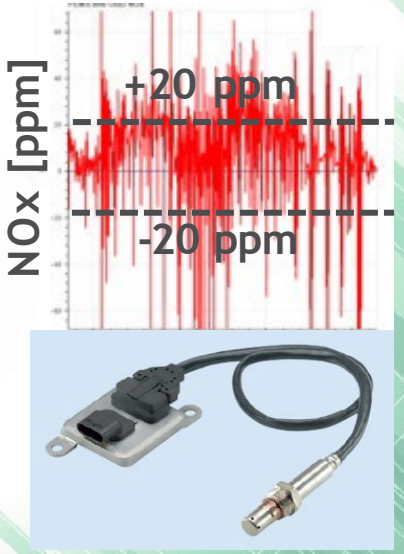
On-board NOx sensor performance project

Evaluate the performance of on-board NOx sensors that are available in the market and commercialization-intent development

- Determine noise factors that adversely impact NOx sensor performance (spikes, negative concentrations, drift)
- Develop correction algorithms to improve sensor performance
- Evaluate effectiveness of developed correction algorithms on a diesel engine
- Characterize impacts of NOx sensor aging on its performance



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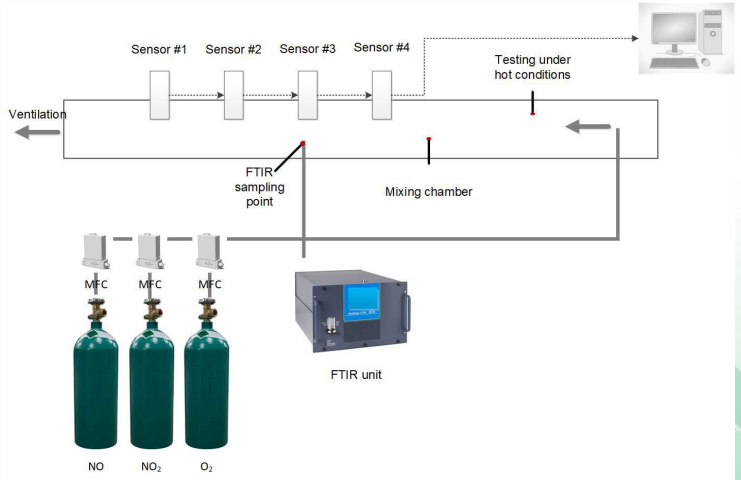
Summary of CARB OBD sensor-based projects

- Understand impacts of implemented regulations by tracking real-world emission trends for NOx & GHG from diesel and NG vehicles
- Evaluate capacity of NOx sensors to measure over entire vehicle operation and at low concentrations
- Boost performance of state-of-the-art NOx sensor using correction algorithms
- Inform on-road programs (HD I/M, OBD REAL, HD Omnibus, and GHG phase 3) using real-world activity and emissions data
- Inform off-road Tier 5 rulemaking using (scarce) real-world activity and emissions data from off-road equipment
- Inform emissions inventories (EMFAC, OFFROAD)

OSAR Evaluation and Calibration Laboratory at UCR



High flow bench to simulate exhaust conditions while calibrating and comparing with an FTIR and PM (miniCAST)

- NO 0-200ppm
- NO_2 0-200ppm
- H_2O 6%
- O_2 3%-18%

In Partnership with EmiSense

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