EMISSION DATA CHALLENGES AT OTAQ

Mobile Sources Technical Review Subcommittee Meeting

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Outline

- Why emission data and models are critical to OTAQ's work
- Background on OTAQ mobile source emission inventories and approach
- New Data Approaches – Examples of what we have tried (thus far)
  - Verizon telematics data for on-road vehicles
  - Marine vessel AIS
- Challenges with Nonroad – HELP!
- Summary

Key Emissions Data and Modeling Uses

- **Compliance Activities -** we gather and analyze data to ensure vehicles, equipment, engines, & fuels comply with the standards and regulations

- **Inform Regulations and Future Actions** - both regulatory and non-regulatory programs make use of emissions, activity data and models

- **Emission Models & Inventories-** MOVES model used by State & Local Govts and many other for a wide range of purposes, including local decisions and to inform future policies

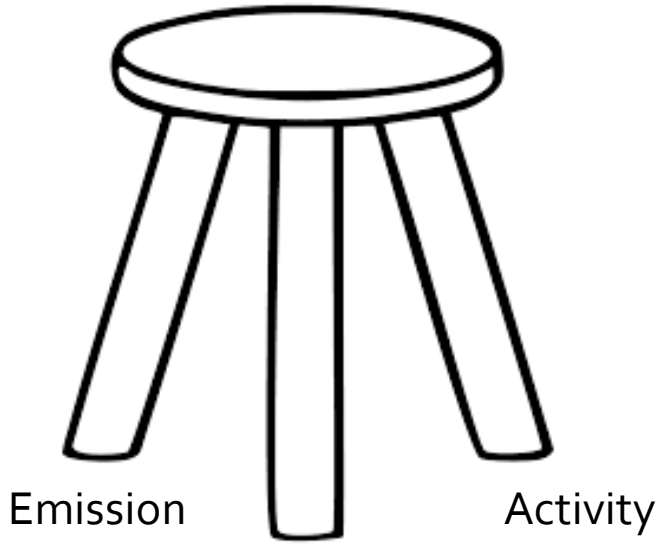
Mobile Source Models for Emission Inventories

- Onroad, nonroad, marine, locomotive and aircraft models estimate:
  - Past, present and future emission inventories
  - More than 180 criteria, GHG, and toxic pollutants
  - Wide variety of operating processes & modes
  - Accounting for evolving technologies, markets, policies, and regulations
  - Temporal allocation to the hour
  - Geographical allocation to county (National Emissions Inventory) and even census block (National Air Toxics Assessment)

Onroad: Traditional Data Sources

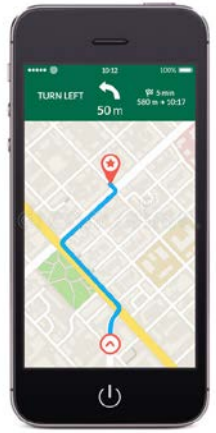
	Type of Data	Major Data Sources
Activity	Vehicle Miles Travelled	• DOT Highway Statistics & • DOE Annual Energy Outlook (AEO) forecasts
	Vehicle driving patterns (speed distributions and driving cycles)	Instrumented vehicles
	Vehicle starts, idle and parking time	Instrumented vehicles
Population	Vehicle Population Numbers	DOT Highway Statistics & DOE AEO forecasts
	Vehicle Characteristics (age, fuel type, regulatory class)	Registration data; Vehicle Inventory and Use Survey (VIUS); DOE AEO forecasts
Emissions	Emissions by operating mode	• Lab studies, certification data, Inspection/Maintenance, Portable Emission Measurement System (PEMS), In-Use Verification Program (IUVP), Heavy-Duty In-Use Testing, SHED test, etc.
	Adjustments (for fuel formulation, temperature, soak time, etc.)	

Emission Inventories



Onroad: Emerging Data Sources

- Portable Emission Measurement Systems (PEMS)
- Portable Activity Measurement Systems (PAMS)
- Telematics and On-Board Diagnostics (OBD)
  - Large scale instrumented vehicle studies
- Location-based services data
  - Compiled from cell phone applications
- Remote Sensing Data (RSD)
- Traffic monitoring data



Data Analytics at OTAQ

Data Magnitude Index Scoring			
Score	**Velocity**	**Variety**	**Volume**
0	Archived	<5	<1TB
1	Hourly	5-10	Terabytes
2	Seconds	10-25	Petabytes
3	Sub-second	25+	Exabytes

OTAQ Project	*Data Magnitude Index* Score									
	0	1	2	3	4	5	6	7	8	9
MOVES	X									
Verizon Telematics	X									
HD Activity Data	X									
AIS Marine Model				X						

***Doing* this now**

***Learning* this now**

Prior Generation

State of the Art

Next Generation

Verizon Data Overview

Over 48,000 vehicles and over 39 million trips
gathered over one year period in 2015-16

CALIFORNIA	COLORADO	GEORGIA	ILLINOIS	NEW JERSEY
2,300 vehicles	**7,122 vehicles**	**18,159 vehicles**	**15,261 vehicles**	**5,773 vehicles**
63% cars	*56% cars*	*63% cars*	*61% cars*	*64% cars*
37% trucks	*44% trucks*	*37% trucks*	*39% trucks*	*36% trucks*
2 million trips	**5 million trips**	**14 million trips**	**12 million trips**	**5 million trips**

- **Vehicle Data:** model year, make, manufacturer, engine size, fuel type, vehicle identification number (VIN) stem, and home zip code location of vehicle

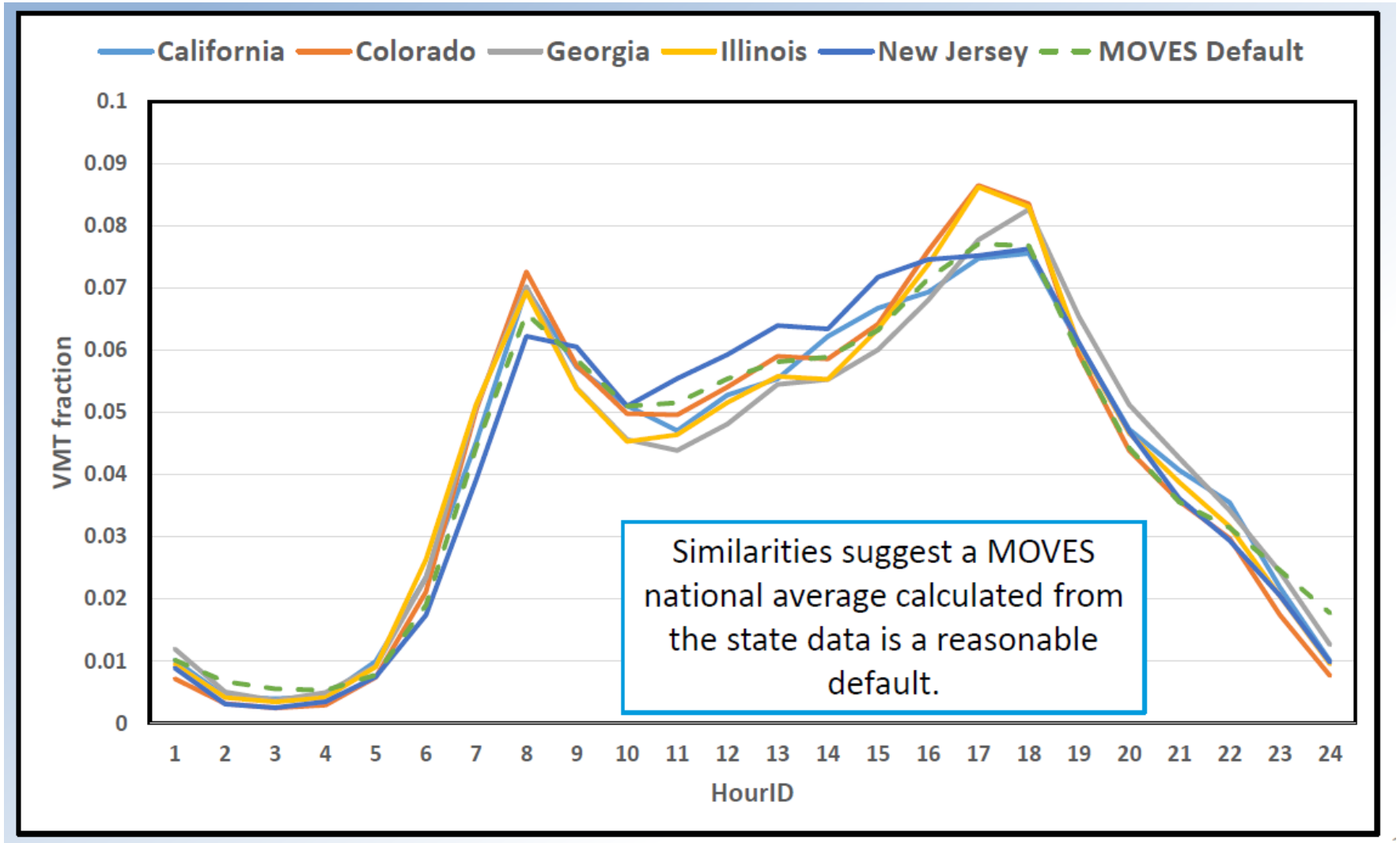
- **Trip Based Data:** start and end times, time in vehicle speed bins, time in engine speed and load bins, engine coolant temperatures, malfunction indicator light (MIL) on, diagnostic trouble codes, etc.

OTAQ Use of Verizon Telematics Data

- This dataset provides our broadest set of activity data for light-duty vehicles

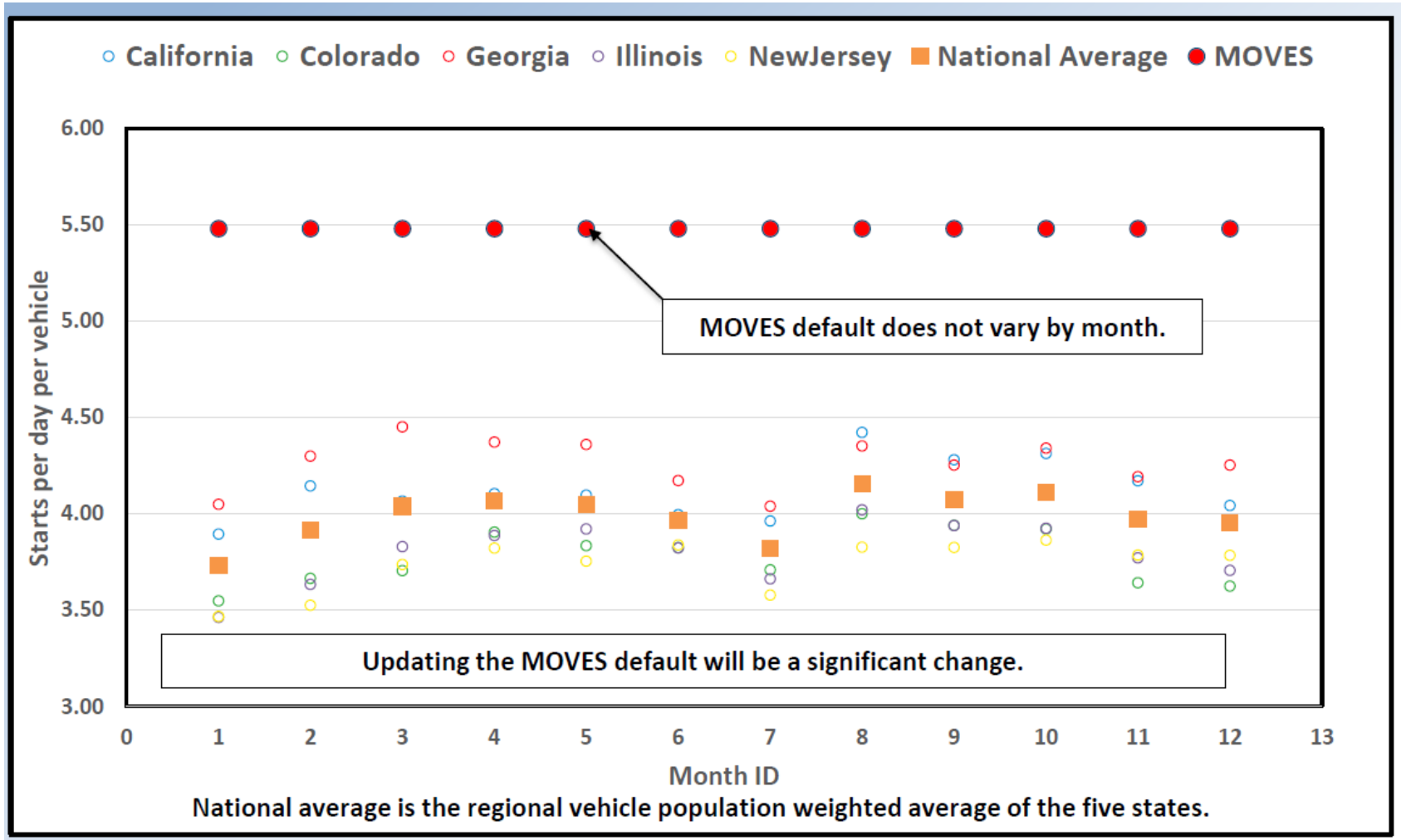
- We are conducting analyses to validate and/or update MOVES default values for areas such as the following:
  - Vehicle miles traveled during each hour of the day for weekdays and weekends
  - Vehicle speeds
  - Soak periods and starts by time of day
  - Time spent idling
  - Activity by geographic location, such as urban and rural locations

Validate What is Already in MOVES



For example, the Verizon data showed similar vehicle miles travelled at each hour of the day compared to the current MOVES defaults

Develop New Inputs for Future Versions of MOVES



For example, we plan to reduce the number of starts per day in a future version of MOVES

Future Evaluations Using Verizon Data

- **Evaluation of malfunction indicator lights (MILs)**
  - What fraction of vehicles have the light on? How long does it stay on? What diagnostic areas have the highest occurrence rates?

- **Advanced Evaporative Model**
  - Model each vehicle in the dataset throughout the year to evaluate the evaporative emissions of each specific vehicle and compare it to the fleet-average approach in MOVES

- Data does not include second-by-second data, which limits its applicability

Marine Vessel Automatic Identification System (AIS)

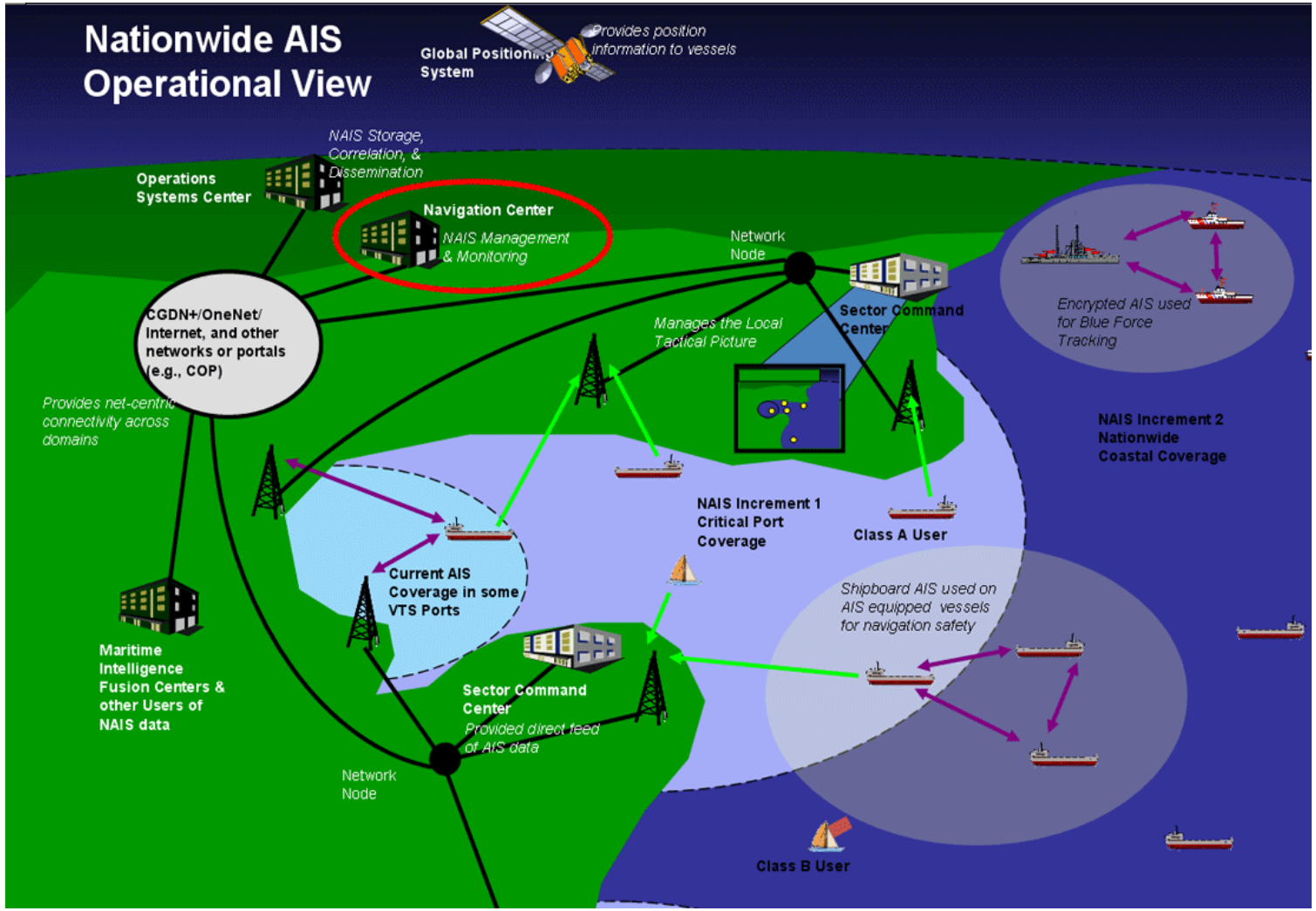


Image from U.S. Coast Guard Navigation Center: https://www.navcen.uscg.gov/?pageName=NAISmain

- AIS is a maritime navigation and safety communication protocol
- Required on all ships of 1,600 gross tons or more
- Broadcast of ship ID, position, heading, speed, and additional ship information
- Received by other ships, ground based towers, and satellites
- Messages in US waters aggregated over 5 minute intervals, yields ~1.3 billion records in a year

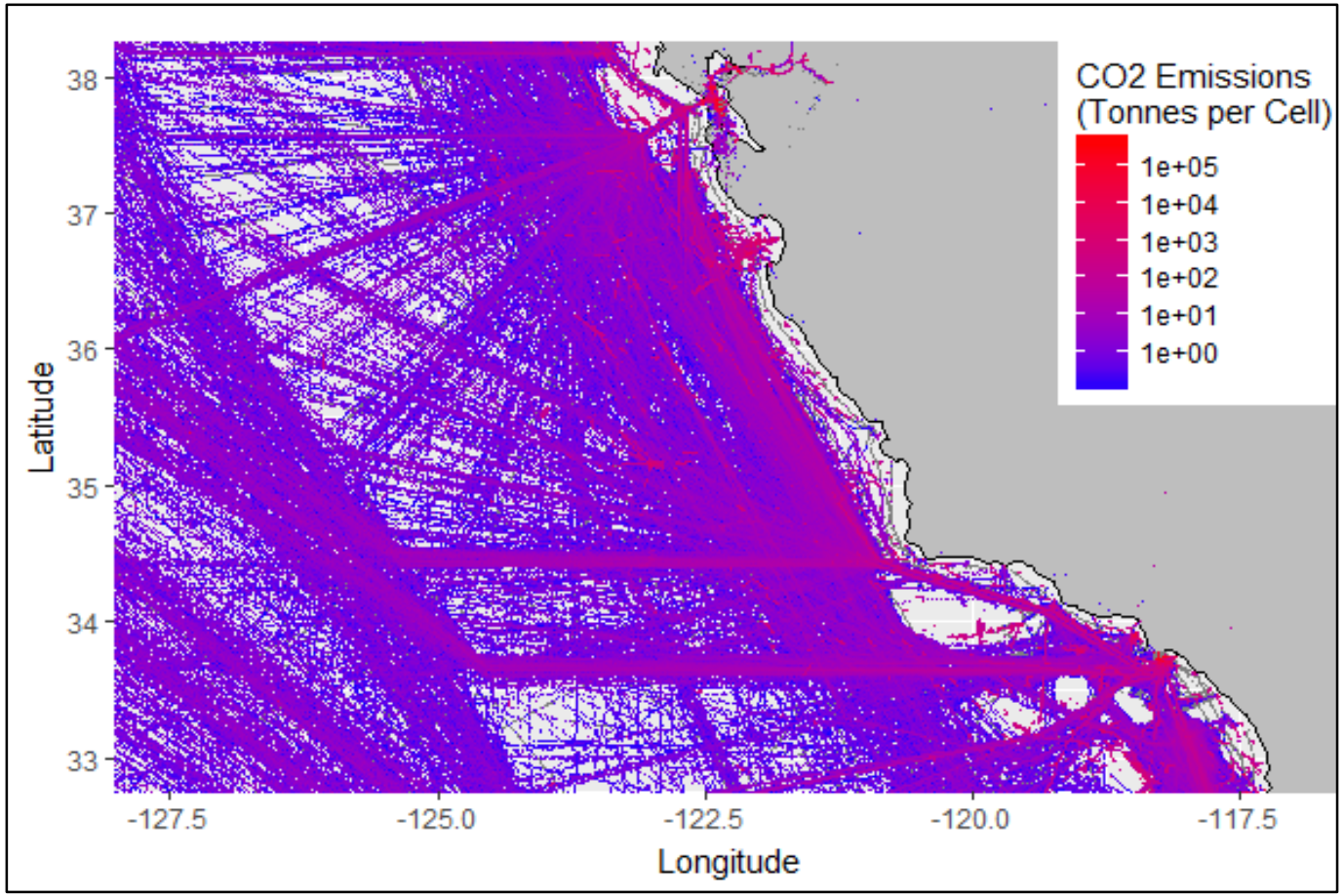
AIS Data for Emissions Modeling

Strengths

- Most comprehensive source of ship activity data available
- Allows calculation of emissions at highest level of detail
- Results can then be aggregated to any desired spatial or temporal scale

Limitations

- Large data sets are cumbersome to transfer and store
- Data QA and analysis cannot be done by hand, requires programming/scripting tools
- Logistical and privacy concerns with making full data sets publicly available



Heatmap of estimated CO2 emissions off the coast of southern California for the first six months of 2017, colors are presented on a log scale.

Current & Future Uses of Marine AIS for Emissions Modeling

Current EPA uses

- Activity data for the 2015 baseline inventory of the EPA Port Everglades Partnership
- Basis for the marine emissions inventory for the 2017 EPA National Emissions Inventory
- Planned basis for EPA's next marine emissions model

AIS use by outside stakeholders

- Emissions inventory developed for the Third IMO Greenhouse Gas Study (2014)
- Commercial marine inventory for midwestern states in the 2014 NEI
- Environment and Climate Change Canada's Marine Emissions Inventory Tool (MEIT) is based on AIS data

Future Opportunities

- Potential for real-time emissions estimates on a ship-by-ship basis
- Use of machine learning tools to identify operational behaviors that impact emissions

Nonroad Equipment Sectors

>150 million nonroad products in the U.S. in 2017

- **Recreational**
  Examples: ATVs, golf carts, snowmobiles
- **Construction**
  Examples: excavators, pavers, skid-steer loaders
- **Industrial**
  Examples: aerial lifts, forklifts
- **Lawn/Garden (residential & commercial)**
  Examples: lawn mowers, snowblowers
- **Agriculture**
  Examples: agricultural tractors, balers, combines
- **Commercial**
  Examples: generator sets, pressure washers
- **Logging**

  Examples: chain saws, shredders
- **Airport Support**

  Ground support equipment only (*aircraft not included*)
- **Underground Mining**
- **Oil Field**
- **Pleasure Craft**

  Inboards, outboards (*commercial marine not included*)
- **Railroad**

  Railroad maintenance equipment only (*locomotives not included*)

Current and Future Efforts for Nonroad Emissions Modeling

- Goal - to improve the nonroad inventory so that air quality modeling can better reflect ozone, PM and air toxics emissions from nonroad sources

- EPA plans to release MOVES2014b in summer 2018 that includes several nonroad specific updates
  - population growth rates, diesel fuel sulfur levels, and Tier 4 emission rates

- EPA is working towards major updates in the 2020+ time frame to improve activity, populations, geographic allocation, emission rates, etc.

Nonroad Data Challenges

- High-quality nonroad population, activity, and emissions data to inform nonroad emissions inventory modeling is hard to find:
  - Most nonroad equipment are **not registered or surveyed**
  - **Real-world measurement methods are not widely applied** to the nonroad sector
  - **Limited data** on how activity varies by geographic region, fuel type, age, engine size, season;
  - **Very little information** on operating mode-specific emissions and chemical speciation profiles
- Challenge of **collecting nonroad data is further exacerbated** by the large diversity of equipment types and usage patterns both within and between equipment categories

Nonroad Data Opportunities

- Public and private fleet managers are increasingly using on-board telematics (e.g., Global Positioning Systems and PAMS) and fleet management software to collect and **analyze vast amounts of real-world activity data** from some types of nonroad equipment

- Deploying **PEMS** on nonroad equipment **facilitates a greater understanding** of emissions and engine loads during real-world operations. **Laboratory testing** of engines used in nonroad equipment also provides important insights.

- Performing **speciation analysis** on modern gasoline and diesel equipment can augment nonroad emission modeling

Summary

- High quality emission data and models are essential for OTAQ
- New data sources, approaches, and computing tools provide the opportunity to vastly improve mobile source data & models
- Nonroad (land-based, marine, rail, air) are particularly challenging
- OTAQ looking to MSTR Subcommittee for input over the next several years for new ideas and advice