MOVES
Motor Vehicle Emission Simulator

Update: Revising Start/Soak Relationships for Light-Duty Gaseous Emissions

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June 13, 2018

MOVES Review Work Group Meeting #8

Outline

- **Background**
  - Currently in MOVES
  - Proposed revisions
    - Update to revisions presented at meeting (June 2017)
- **Goal: update start/soak curves**
  - Combine EPA and CARB data
- **Analysis**
  - PEMS results
  - Dynamometer results
- **Results**
  - Compare PEMS, dyno results
  - Development of revised curves

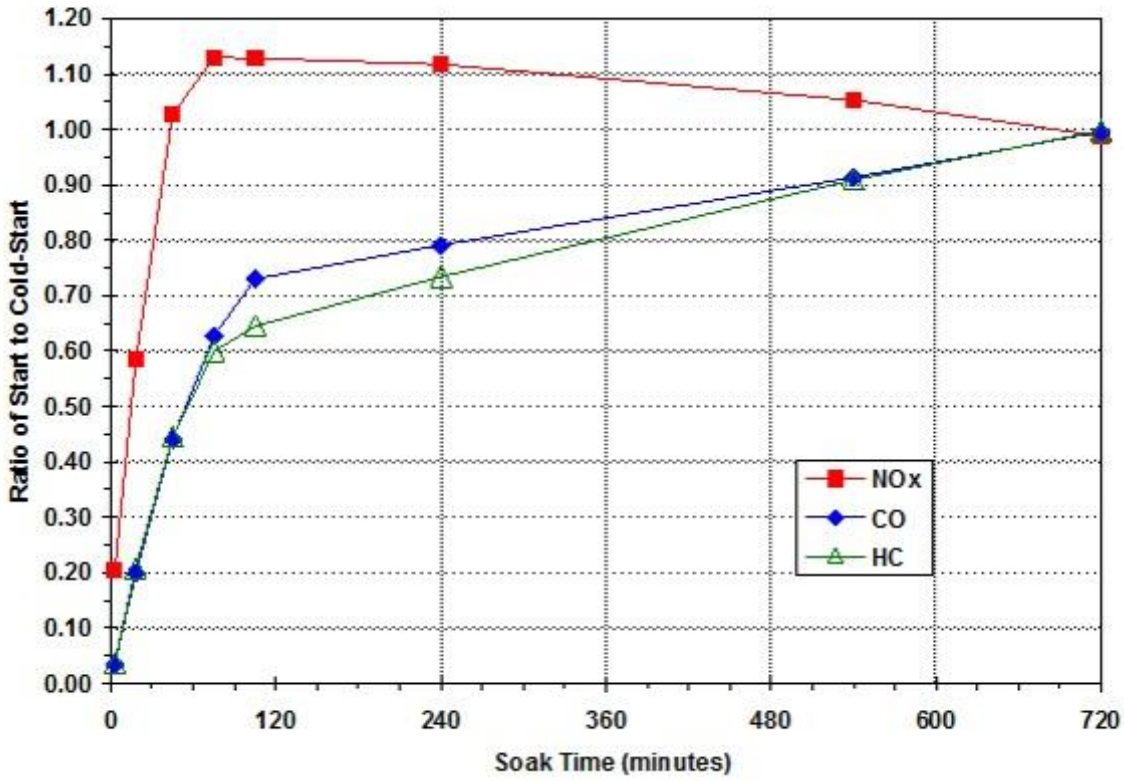
Background

- **Currently in MOVES2014**
  - Start emissions calculated from FTP results
    - "Cold Start" = Bag 1 – Bag 3 (g/start)
      - At "warm ambient" temperature
  - "Operating mode" defined as "soak period"
  - Emission rates vary by soak period
    - 0-6 min to 12+ hours

- **Proposed update**
  - Combine PEMS and dynamometer results
    - PEMS testing by EPA
      - Presented at MRWG meeting, June 2017
      - Updated with data for two additional vehicles
    - Dyno testing by CARB
      - CARB test report: Page 117 of https://www.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf

Soak Curves in MOVES2014

Soak Fractions Applied to Cold-Start Emissions (opModeID = 108) to Estimate Emissions for Shorter Soak Periods (opModeID = 101-107)



Source: Sabate, S. *Methodology for Calculating and Redefining Cold and Hot Start Emissions*. California Air Resources Board, El Monte, CA. March 1996. *Cited IN*: Glover, E.; Carey, P. *Determination of Start Emissions as a Function of Mileage and Soak time for 1981-1993 Model-year Light-Duty Vehicles*. EPA 420-R-01-058. November, 2001.

New Data

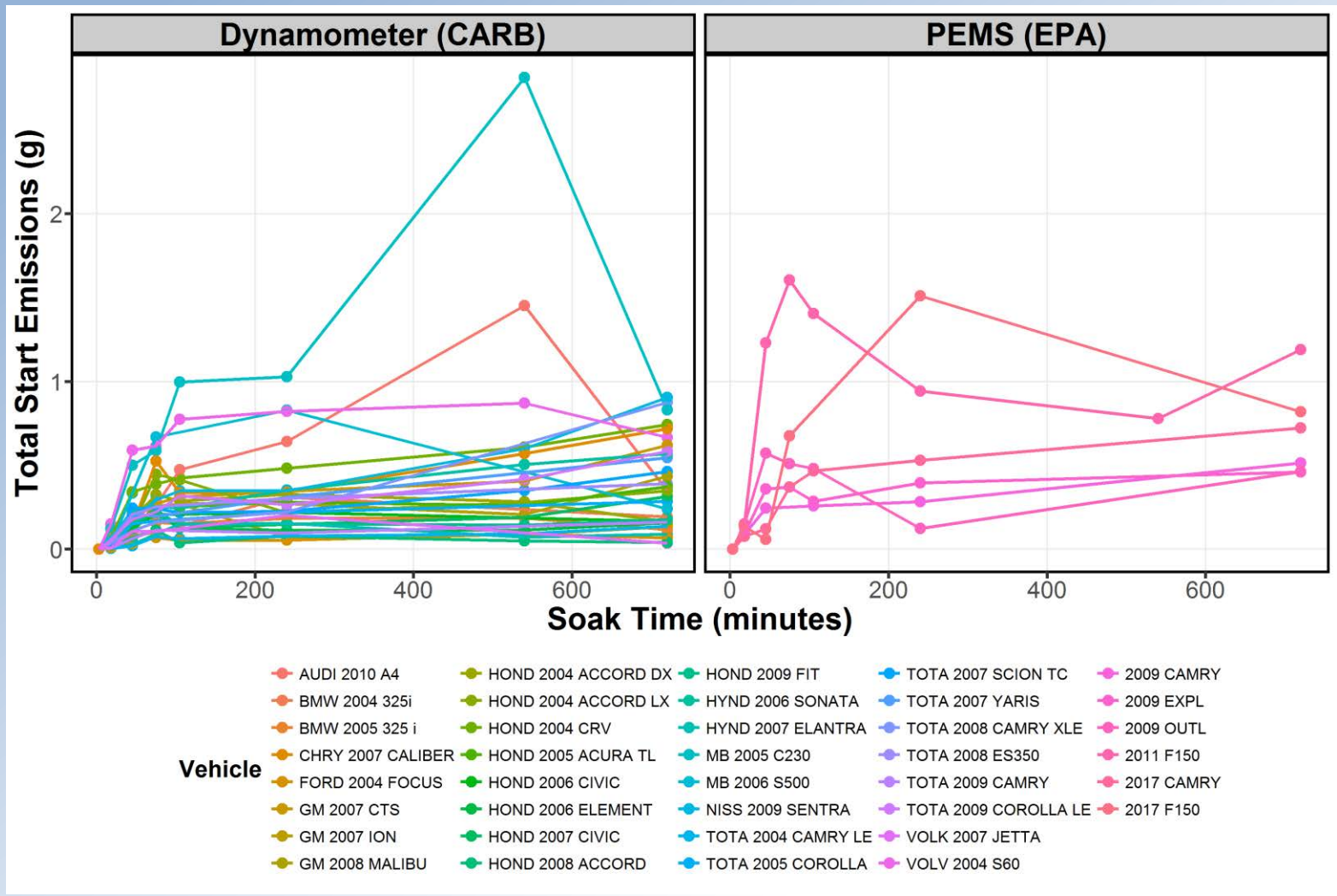
- **EPA in-house project**
  - Measurement method (PEMS)
    - Repeat drives on same route in Ann Arbor, MI with different soak periods
    - Instrument: Sensors SEMTECH-DS
    - Covered in June 2017 presentation
  - **6 vehicles**
    - Tier 2 (5) and Tier 3 (1)

- **Data obtained from CARB**
  - Used in update for EMFAC2017
  - Measurement method
    - Dynamometer cycle aggregates (no “second-by-second” data)
    - California Unified cycle- Phase 1
  - **32 LEV-II vehicles**

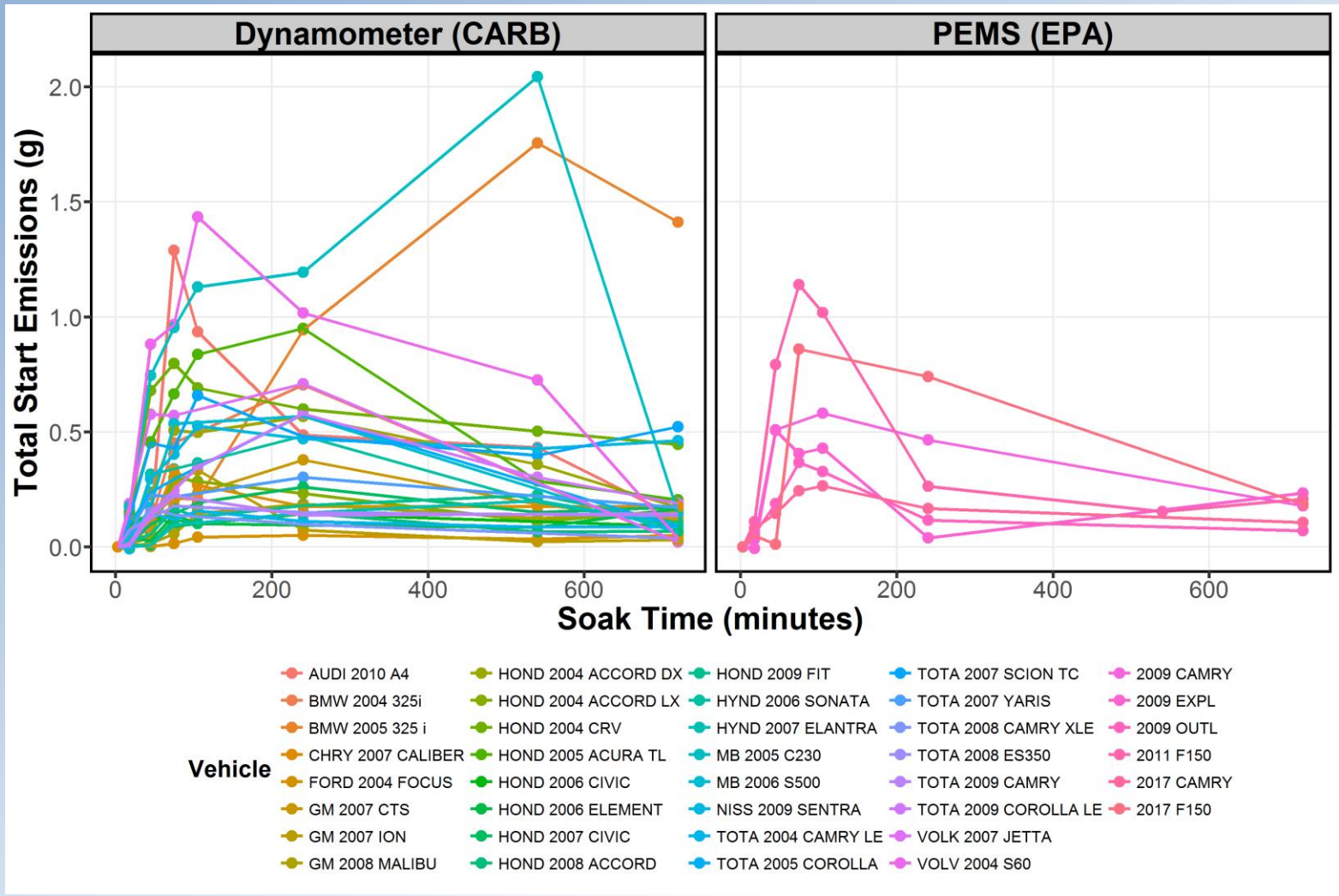
Data Quality Analysis

- **EPA PEMS Results**
  - As discussed in June 2017 presentation, ensured capture of start operation
    - Evaluated catalyst and oil temperatures, along with cumulative emissions
- **CARB Dynamometer Results**
  - Assign to MOVES soak periods
  - Verified that emission levels were comparable to PEMS results
- **Analysis**
  - Average g/start for each vehicle for each soak time
    - See next slides

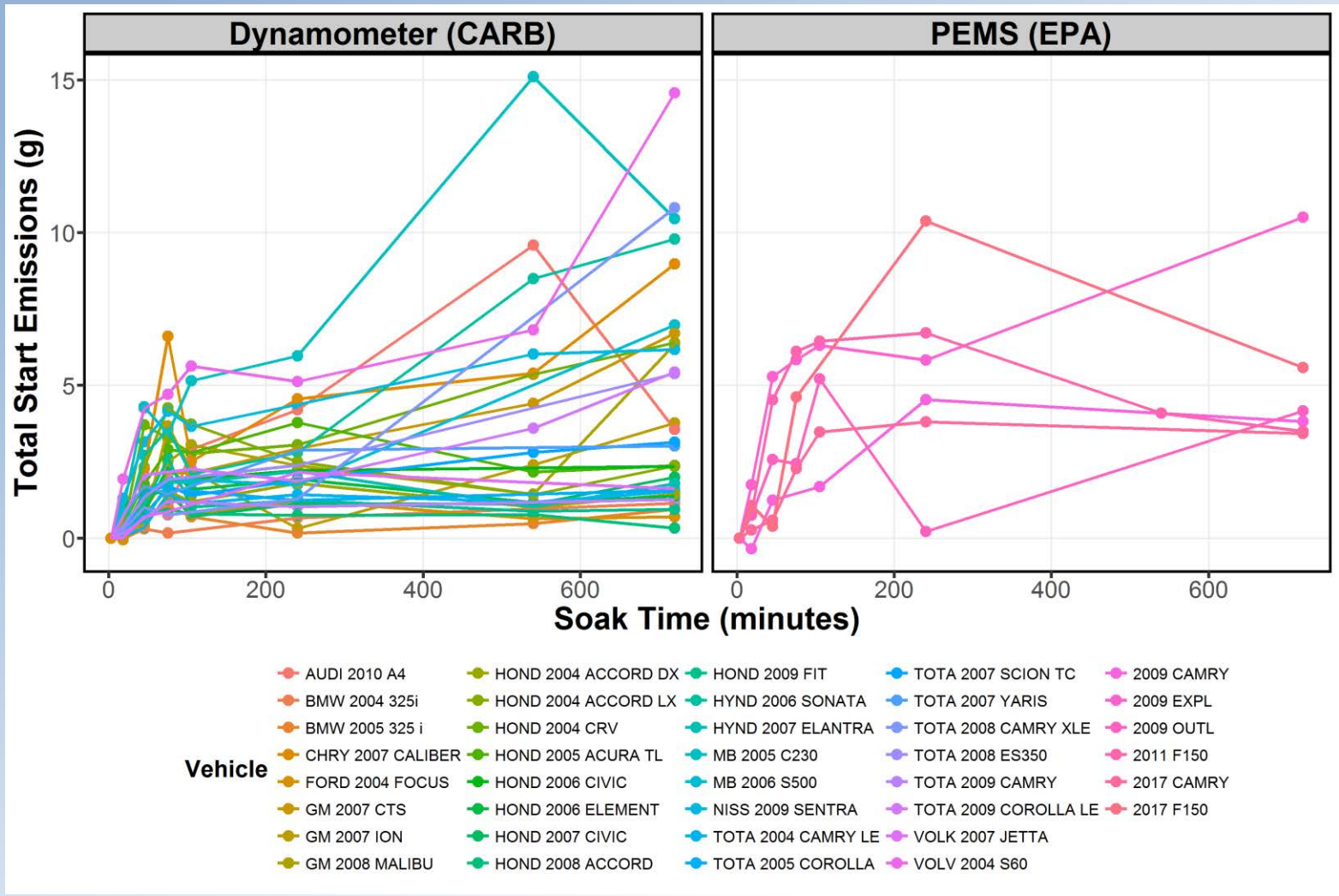
THC: Average start emissions (g)
by method and vehicle



NOx: Average start emissions (g)
by method and vehicle



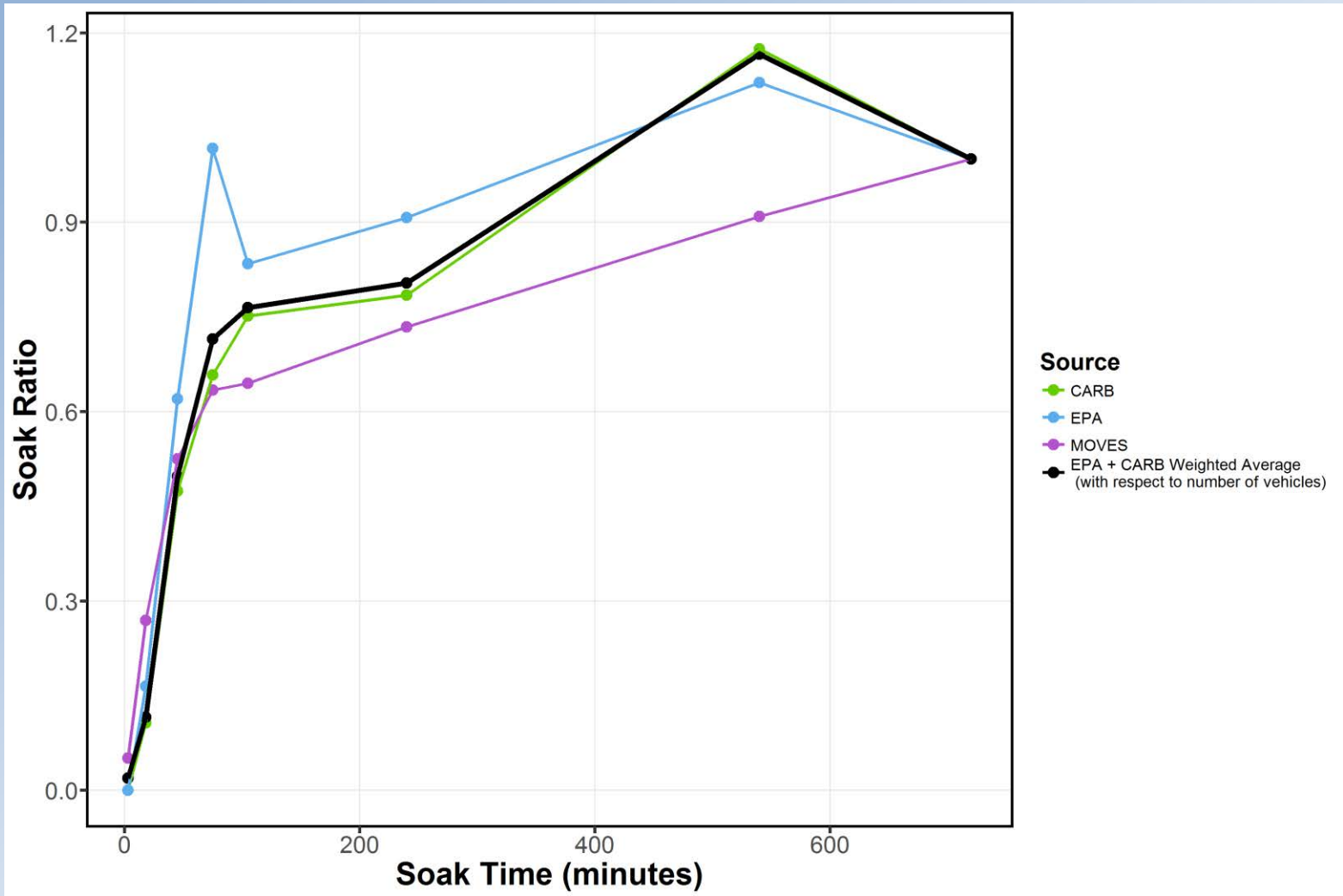
CO: Average start emissions (g)
by method and vehicle



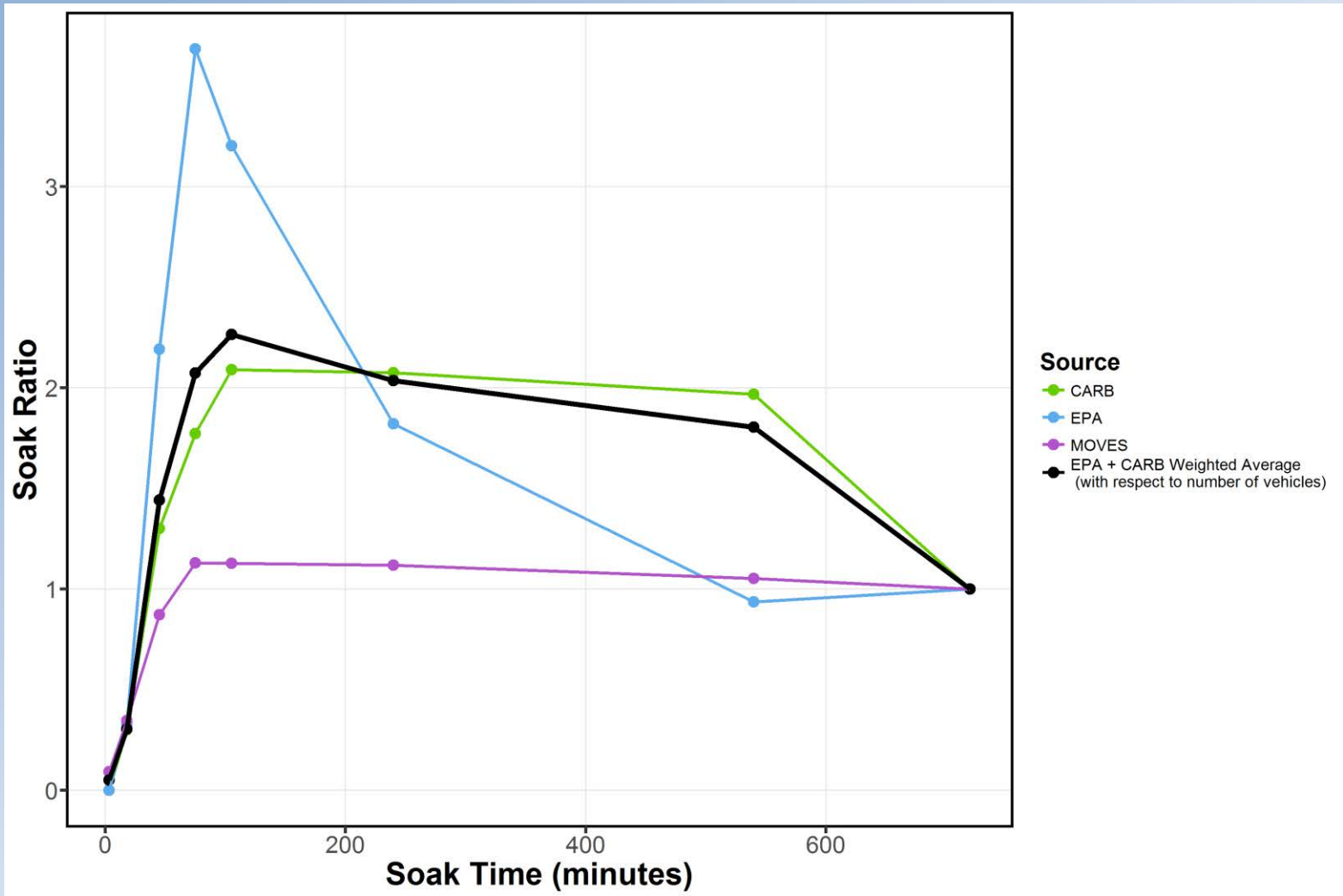
Developing Soak Ratios

- **Average mass results**
  - By vehicle
  - By operating mode
- **Correct for running-exhaust emissions**
  - By subtracting result for 0-6 minute soak period
  - By vehicle
  - By operating mode
- **Average results across vehicles**
  - Separately for EPA and CARB fleets
- **Calculate intermediate ratios**
  - Normalize all soak periods to “cold start”
  - By dividing by the opModeID 108 emissions
- **Calculate final ratios**
  - Combine CARB and EPA results as a weighted average
  - By number of vehicles in each soak period

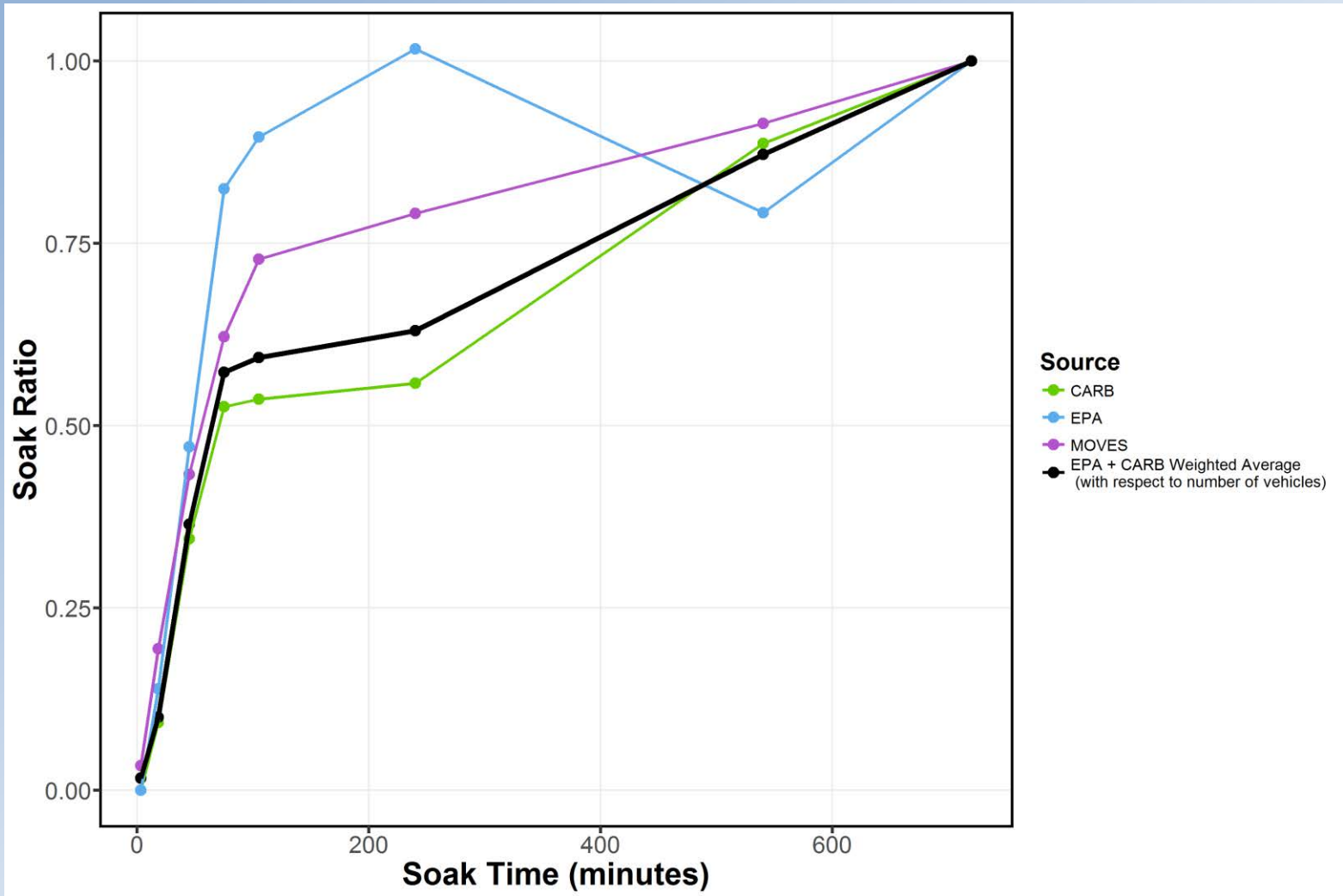
THC: Proposed Soak Ratios



NOx: Proposed Soak Ratios



CO: Proposed Soak Ratios

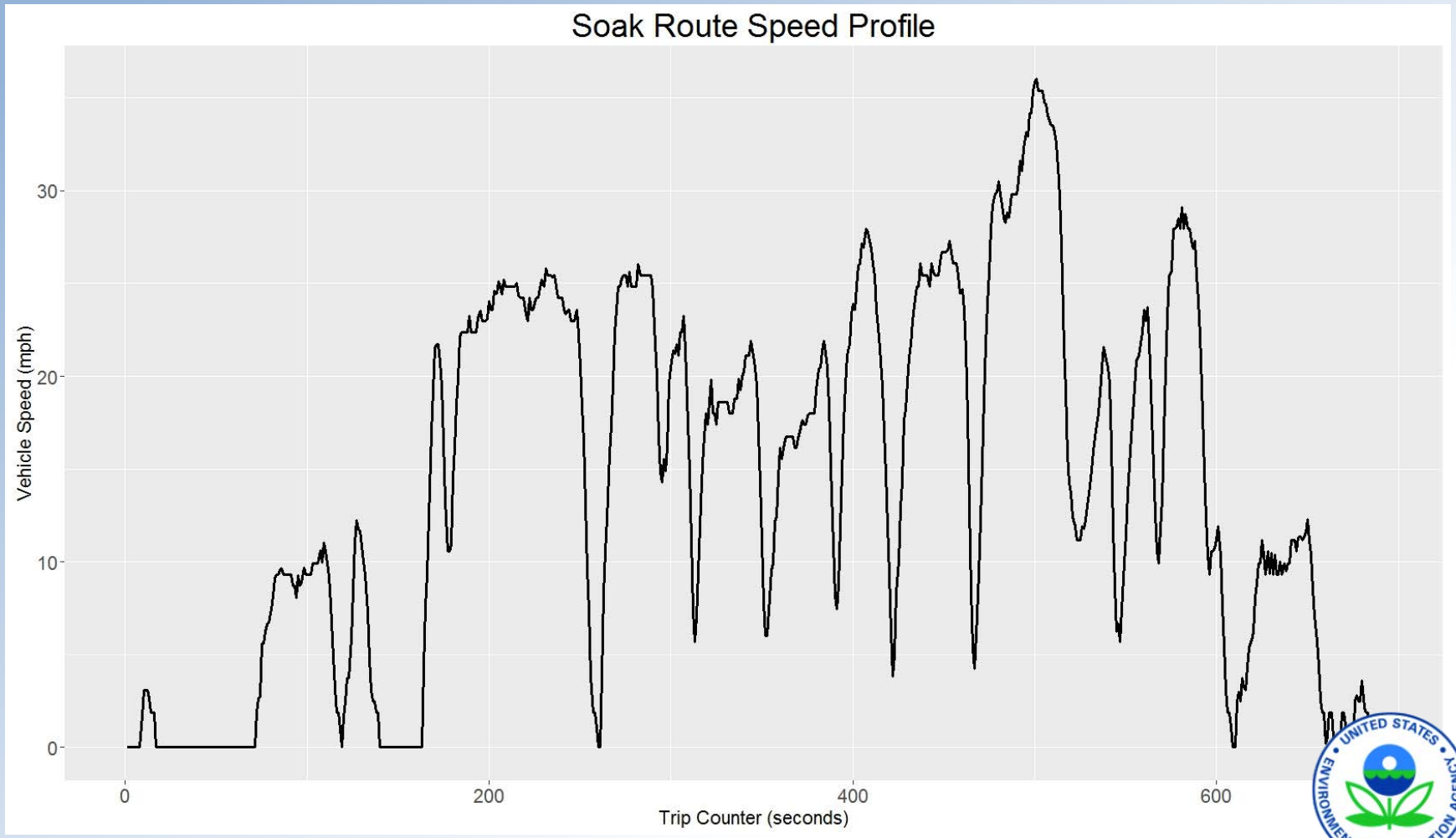


Summary and Conclusions

- **Start/soak relationships differ from older results**
  - NOx emissions highest at shorter soak periods
- **We propose to update MOVES rates**
  - For model years 2004 and later
  - Using revised soak curves based on PEMS and Dyno data
    - For HC, CO, NOx
    - Use HC curve for particulate matter (PM) rates, as we have done for MOVES2014
  - For "warm" to "hot" starts only (opModeID 101-107)
  - **NOT** updating Cold-start rates themselves (opModeID 108)
    - Still based on FTP results

Extra Slides

EPA Drive Route



Speed Trace
California Unified Cycle

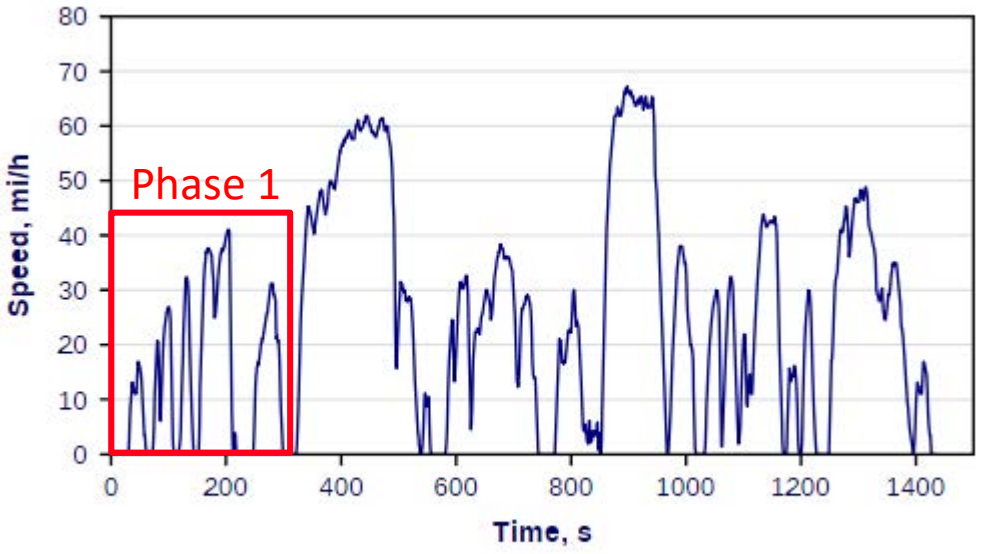


Figure 1. California Unified Cycle—Phase 1 + 2