Item #2

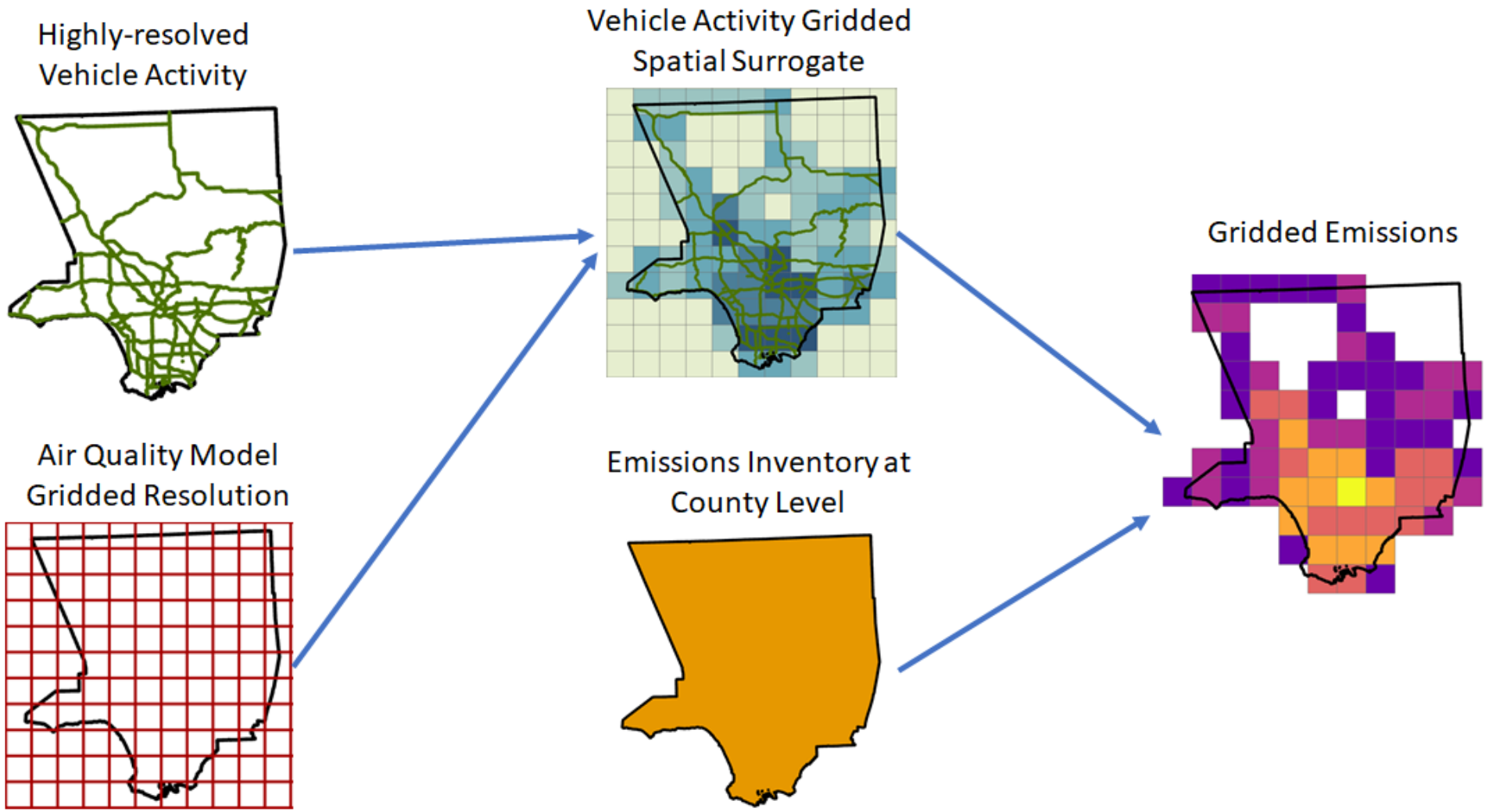
Spatial and Temporal Allocation of Emissions from On-Road Mobile, Ocean Going Vessels and Aircraft

STMPR meeting on Nov. 4, 2021

Eric Praske, Ph.D.
Air Quality Specialist

South Coast Air Quality Management District

Spatial Surrogates to Allocate Emissions



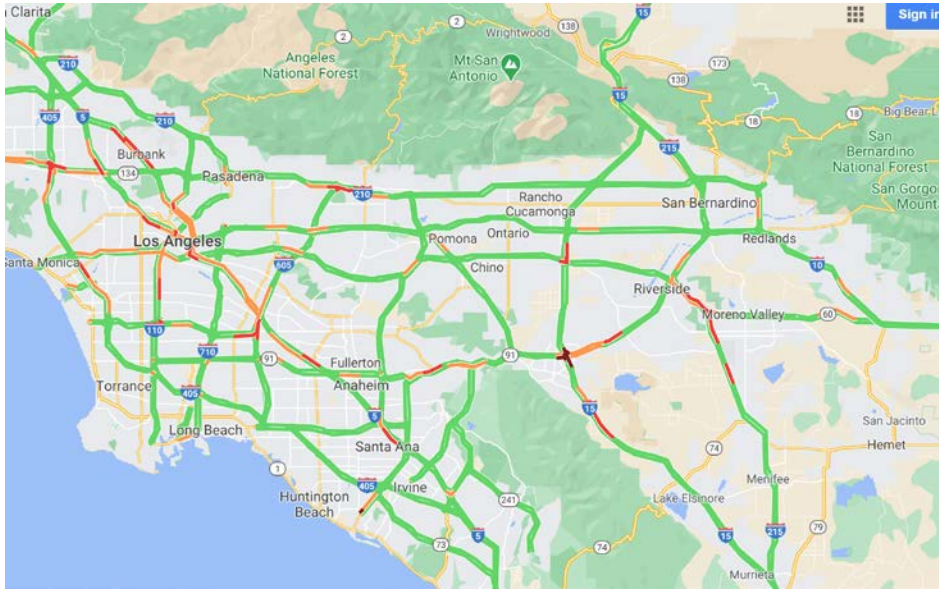
Improvements using Satellite and Sensor Data

- Heavy and light duty vehicles
  - California Department of Transportation (Caltrans) Performance Measurement System (PeMS)
- Ocean-Going Vessels (OGV)
  - Automated Identification System (AIS) as provided by Marine Cadastre
- Aircraft
  - Aircraft Communication Addressing and Reporting System (ACARS) as provided by NOAA MADIS

All data were processed for 2018

On-Road Emissions Allocation for the 2022 AQMP

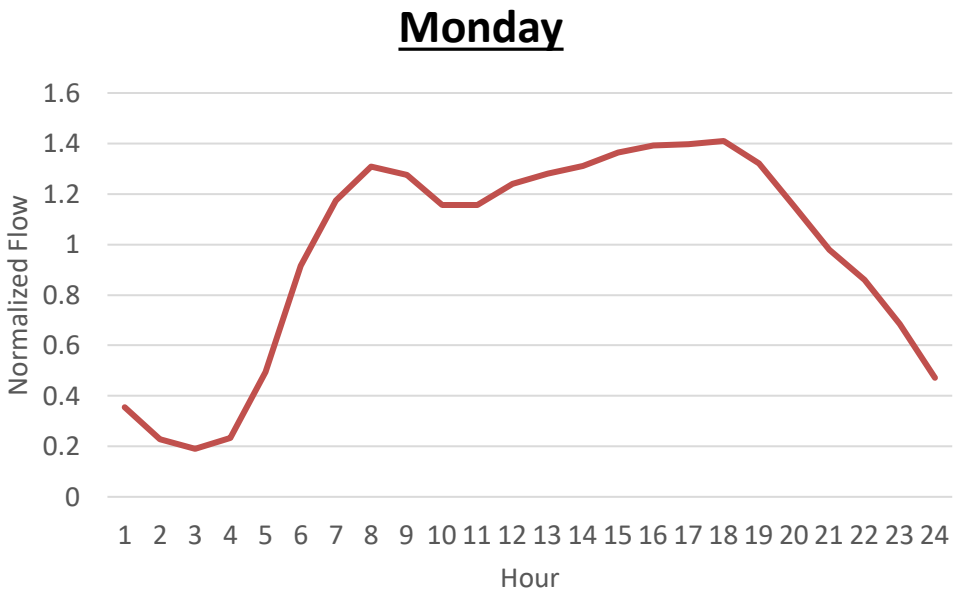
- Based on hourly sensor data
- Light and Medium duty vehicles
  - Same method used in MATES V
  - California Department of Transportation Performance Measurement System (Caltrans PeMS)
  - > 9000 single loop detectors in SCAB
- Heavy duty vehicles
  - New to the 2022 AQMP
  - 2016 AQMP approach used Weight in Motion (WIM) sensors
    - Data was too sparse to use in modeling in 2018 due to offline sensors
    - Only about 20 sensors across the Basin
  - As an alternative to WIM, HD flows can be estimated using single loop detectors
    - Although specificity is lower, coverage is much greater
    - Kwon et al. algorithm has been validated and is implemented on PeMS[1]

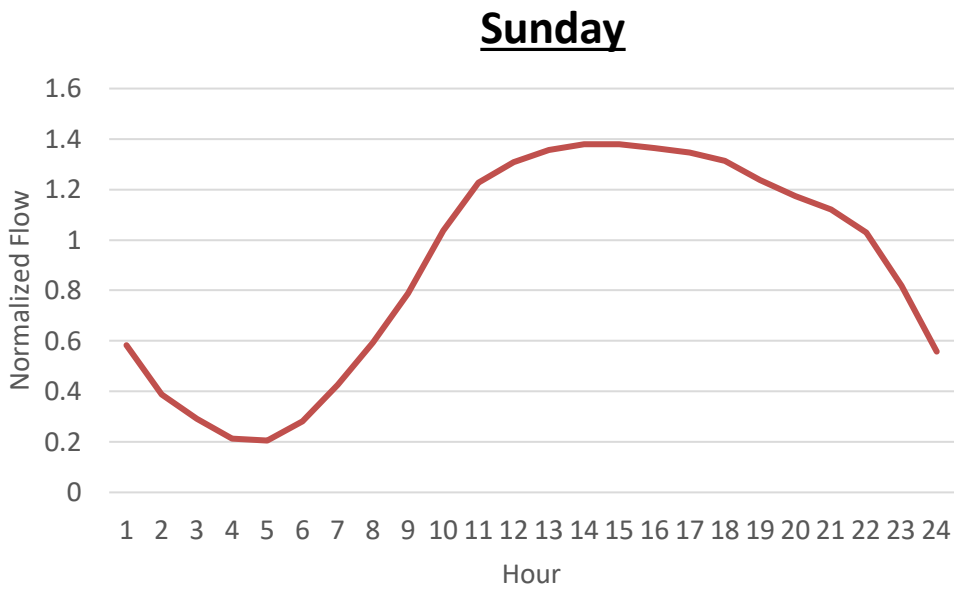


[1] Kwon et al. Transportation Research Record. 2003; https://doi.org/10.3141/1856-11

Caltrans PeMS for Light Duty Vehicles

- Light duty flows follow rush hour pattern during the week, smoother pattern with mid-afternoon peak on weekends

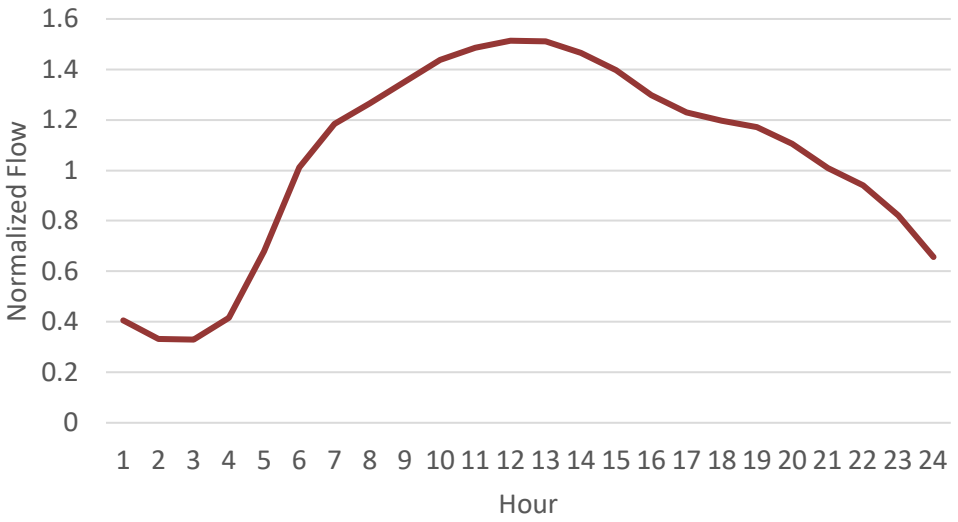




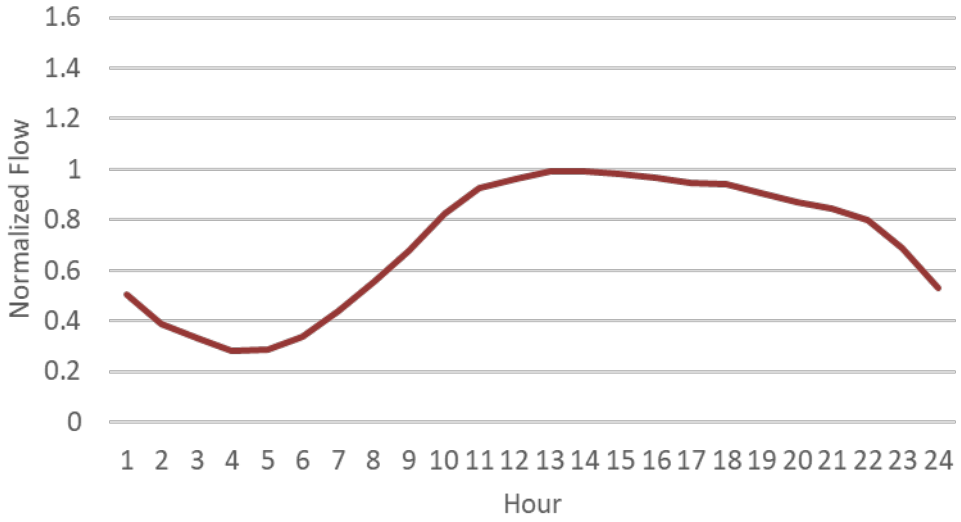
Caltrans PeMS for Heavy Duty Vehicles

- Reduced flow on weekends and holidays
- Flows do not follow rush hour pattern observed in light duty

Monday



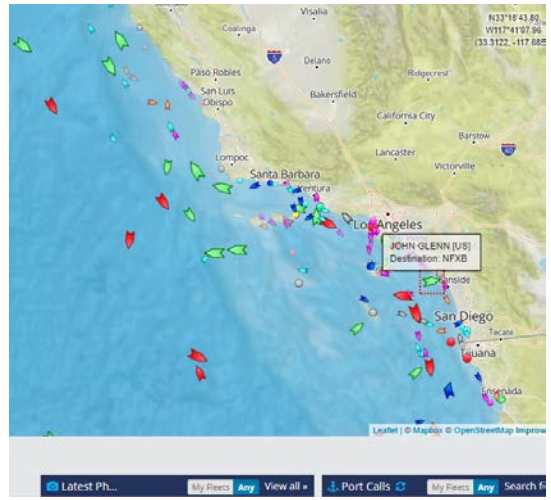
Sunday



Ocean Going Vessel Positioning Data

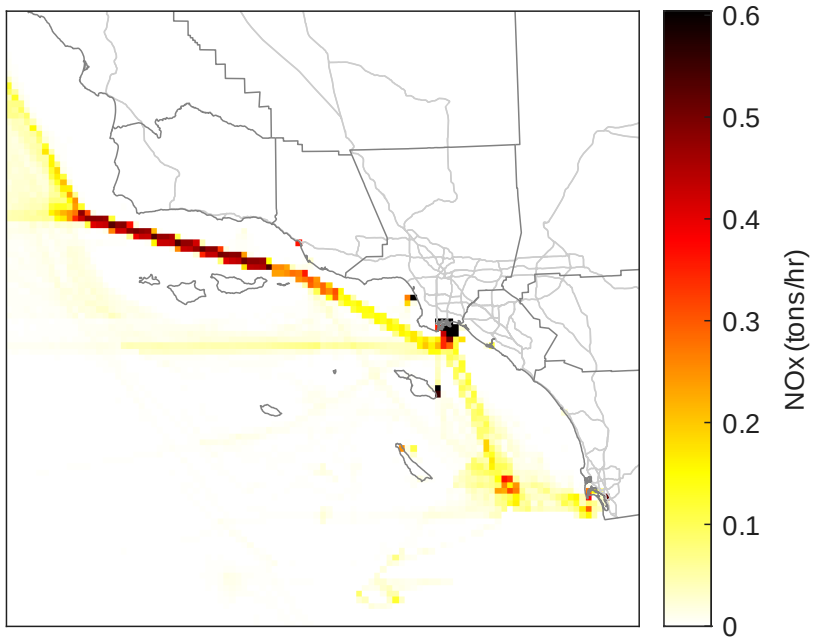
- New approach developed for 2022 AQMP
- AIS transponders communicate speed, position, and operational mode for maritime safety
- Data from Marine Cadastre is downloaded, processed, and allocated to the modeling domain

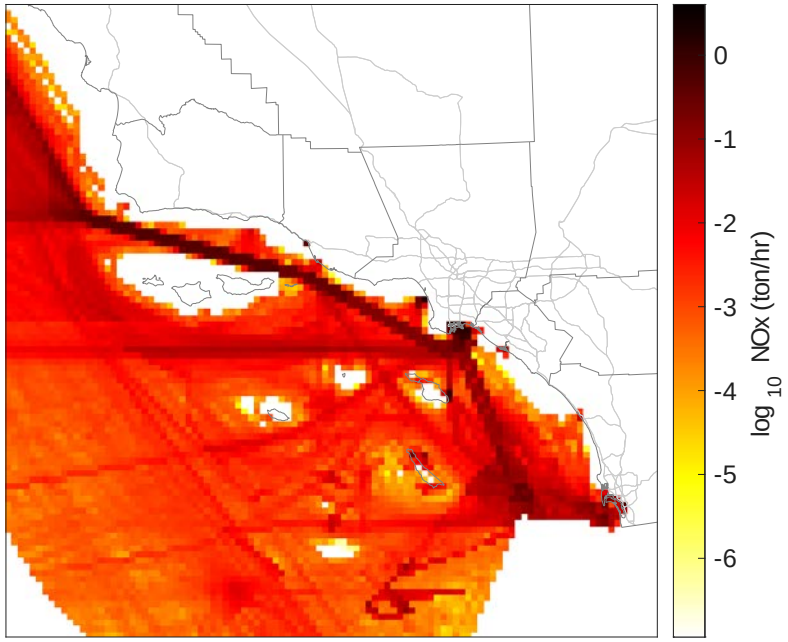
Vessel Types	Operational Modes
Cargo (all types) Military Passenger Tanker	Transit Anchorage Maneuvering Hotelling



Spatial Allocation of Ocean Going Vessel Emissions

- Emissions highest along major shipping channels, but AIS data also resolves emissions from less traveled routes



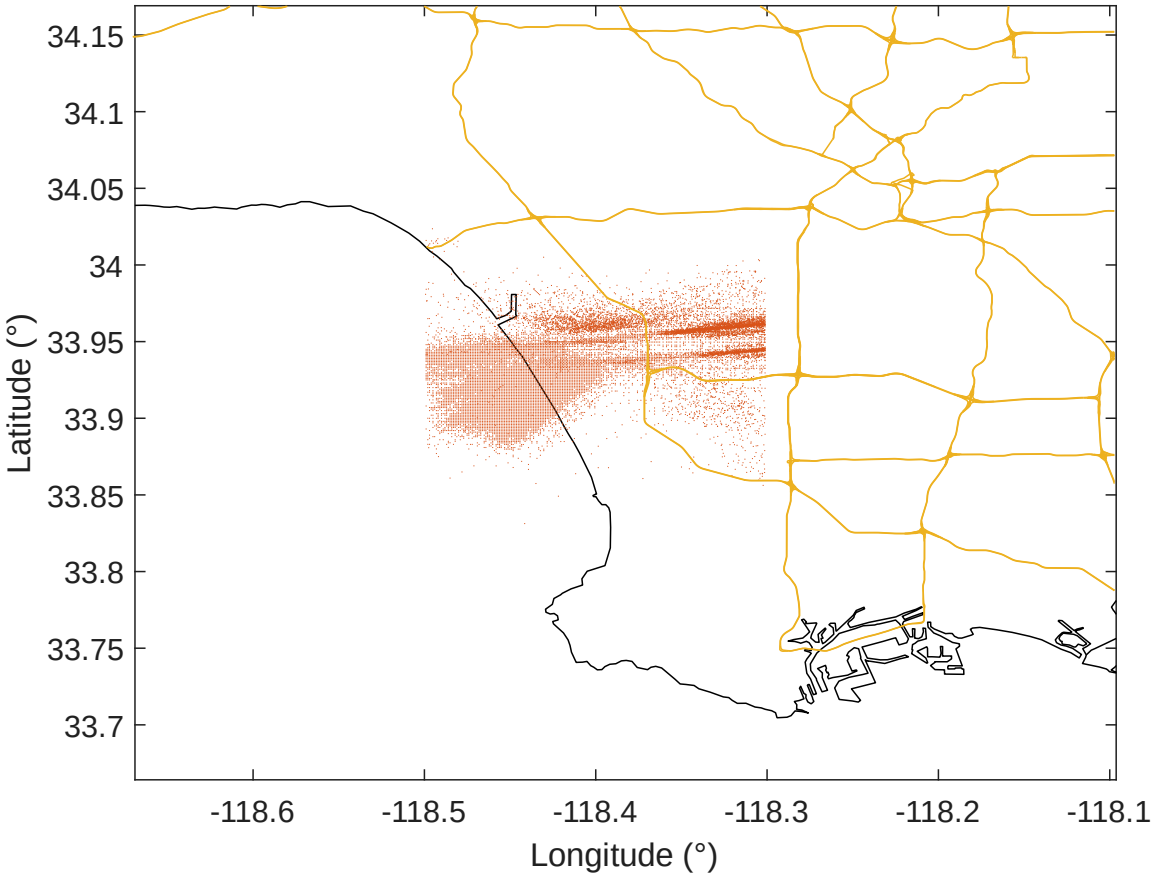


Aircraft Emissions

- New approach developed for 2022 AQMP
- Aviation Environmental Design Tool (AEDT) is Federal Aviation Administration's official model to estimate aircraft emissions
- AEDT segregates emissions into 4 vertical layers:
  - Ground level: Auxiliary Power Unit + Climb/Descend emissions
  - Below 1,000 feet
  - Below Mixing Height
  - Below 10,000 feet
- ACARS data contain coordinates/altitude and are used as spatial surrogate

Aircraft Communication Addressing and Reporting System (ACARS)

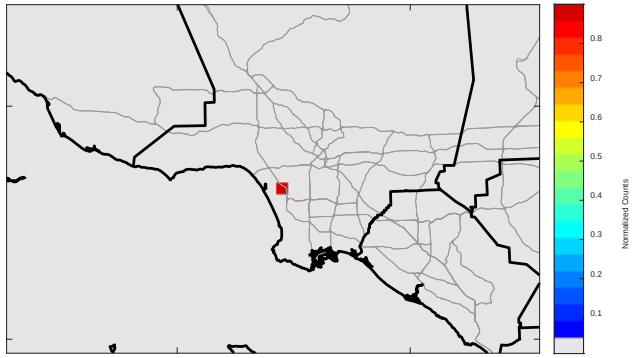
- Raw ACARS pings at LAX with cutoff applied at mixed layer height (~550 m)



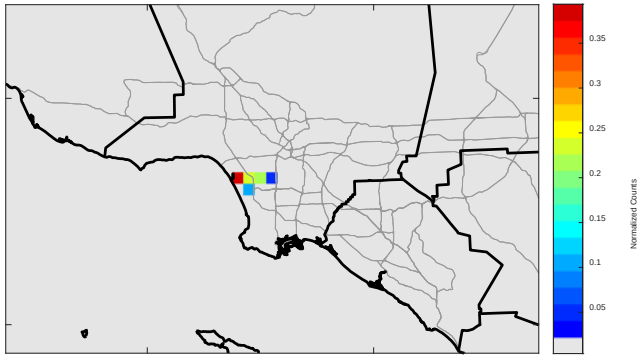
3-Dimensional Aircraft Emission Allocation Factors

- ACARS spatial surrogates at LAX by vertical layer
  - Sum of ACARS pings within each grid cell are normalized to the sum of all pings within the layer

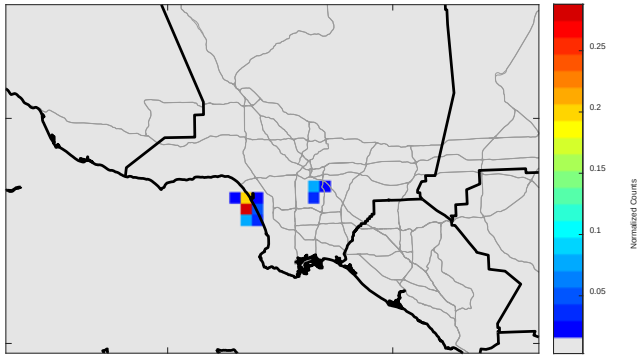
Layer 1



Layer 5

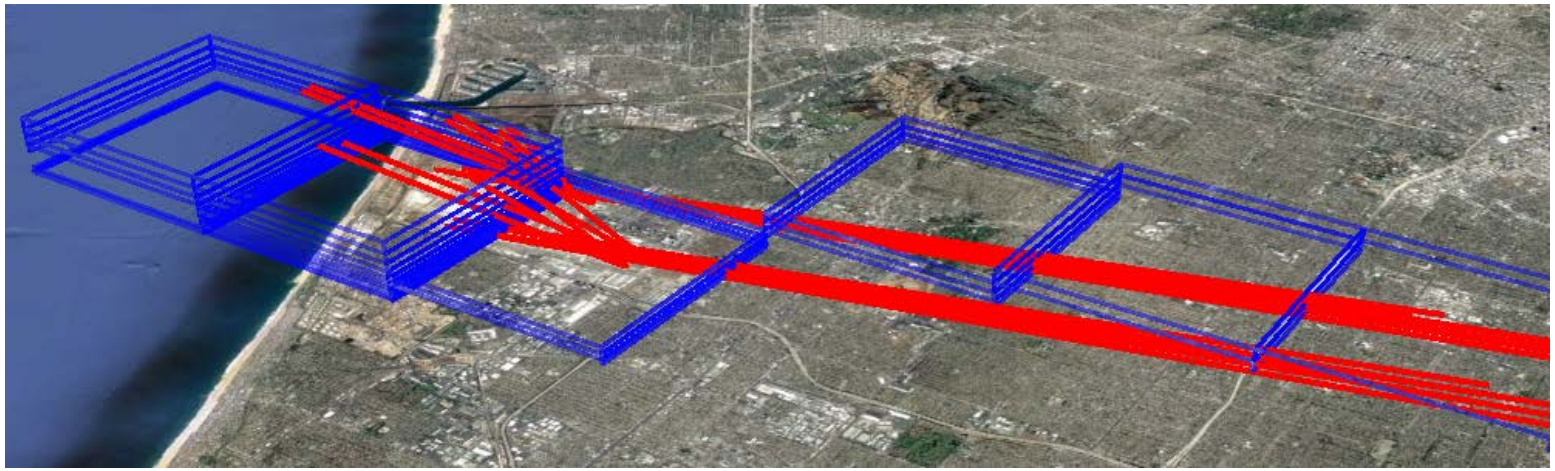


Layer 10



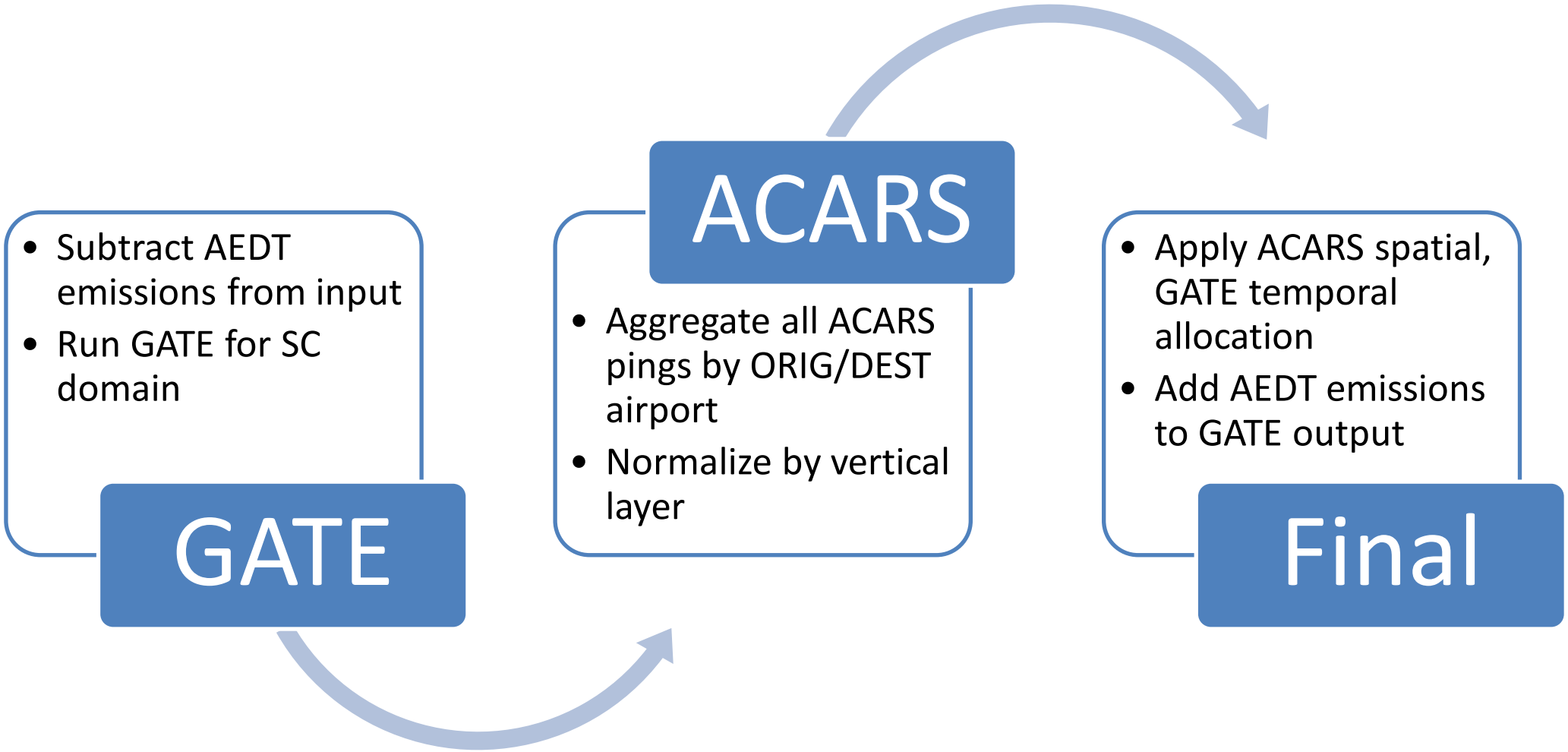
Aircraft Emissions for Smaller Airports

- CARB's Gridded Aircraft Trajectory Emissions (GATE) is used to allocate emissions at small GA airports
  - Computes 3D trajectory of aircraft during landing and takeoff
  - Computes intersection with modeling grid



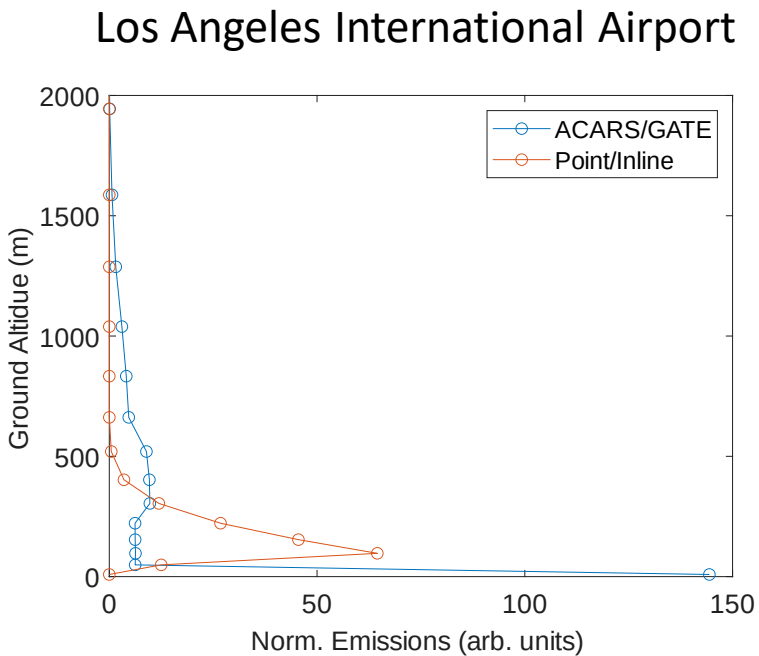
Intersection of LAX flight trajectories with a modeling grid
Source: https://github.com/mmb-carb/GATE_Documentation/blob/master/docs/SCIENCE_GUIDE.md

CMAQ-ready Aircraft Emissions



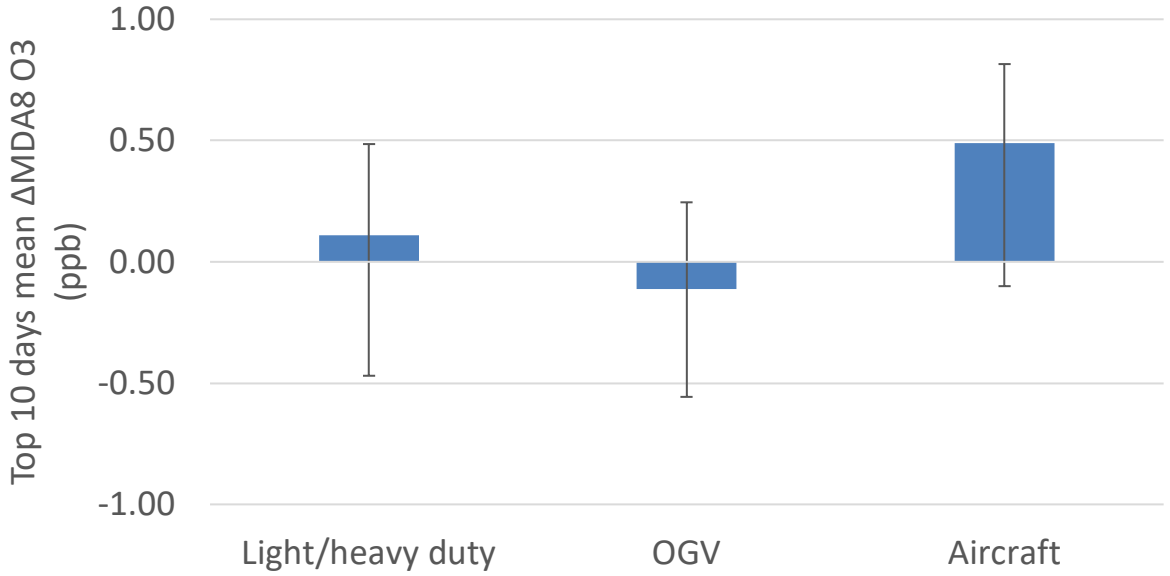
Vertical Allocation of Aircraft Emissions

- Below, emissions within each layer normalized to layer thickness (thicker layers aloft)
- Original method (point/inline) does not have any ground level emissions
  - Highest single-layer emission rate at ground level, consistent with AEDT



Summary and Conclusion

- Improved spatial and temporal accuracy of emissions inventory with sensor and transponder-based data
- Perturbation to mean top 10 days MDA8 O3 was highest for aircraft
  - Primarily due to much greater emissions in layer 1 compared to default
- Change in ozone reflects sensitivity toward each change compared to the 2016 AQMP methods



Ozone Isopleths and Preliminary Carrying Capacity Estimates

Item #3

Scientific, Technical & Modeling Peer Review (STMPR)
Advisory Group Meeting

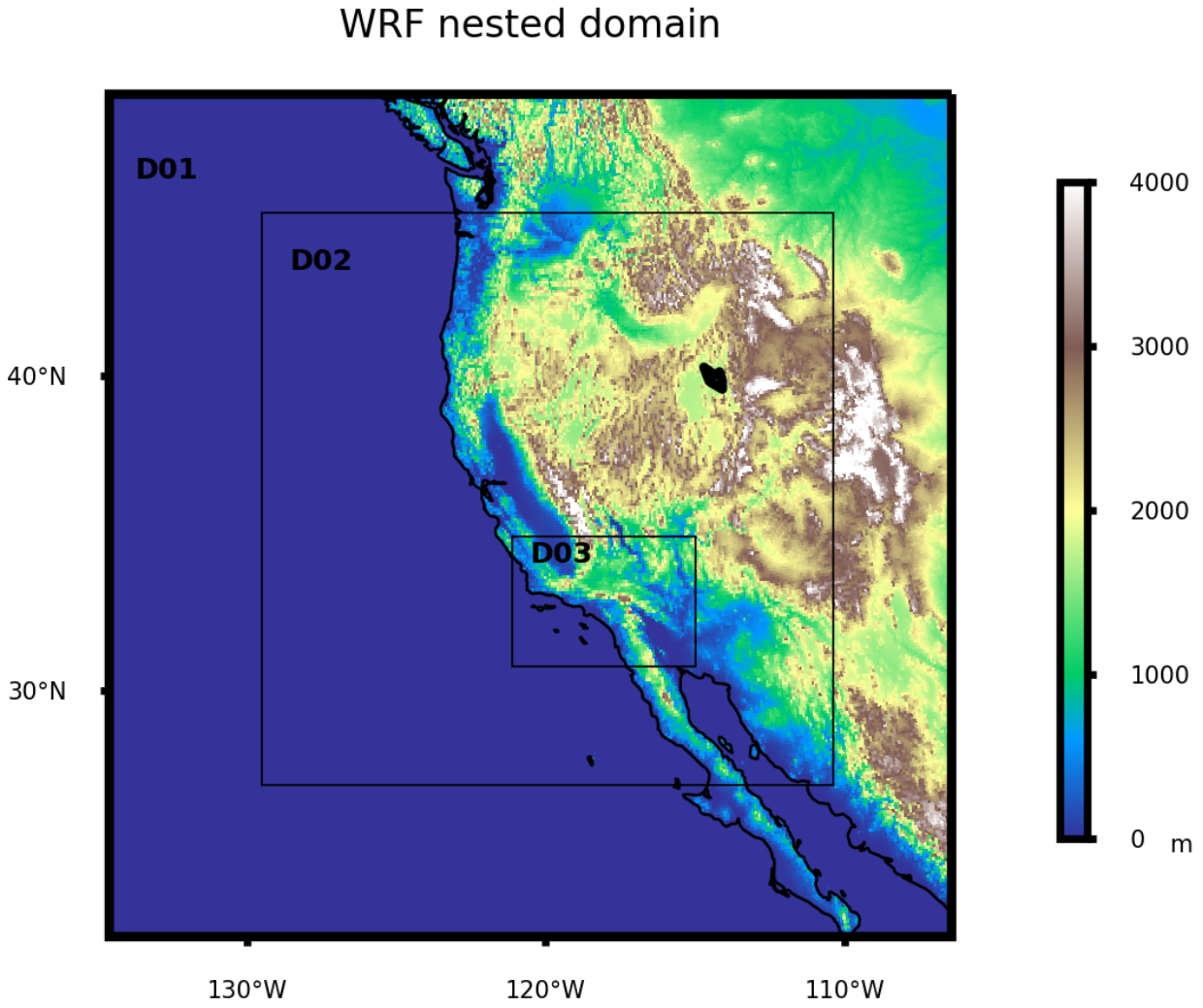
November 4, 2021

WRF-CMAQ-SMOKE Modeling System

- Weather Research and Forecast (WRF) v4.0.3
  - North American Region Re-analysis with The Group for High Resolution Sea Surface Temperature (GHRSST) updates
  - Yonsei University (YSU) boundary layer and Unified Noah Land Surface Model schemes
  - Nested modeling with three domains - 36, 12 and 4 km grid spacing
- Community Multiscale Air Quality (CMAQ) v5.2.1
  - Chemical mechanism: State Air Pollution Research Center (SAPRC) SAPRC07tc
  - Aerosol mechanism: “aero6”
  - Point sources using inline modeling
  - Two nested domains 12 km and 4 km
- Sparse-Matrix Operational Kernel Emissions (SMOKE) v4.8 used to generate gridded emissions of anthropogenic emissions (except for on-road sources and aircraft)

WRF-CMAQ-SMOKE Modeling System (Cont'd)

- EMFAC2017 with travel activity data from the SCAG's 2020 Regional Transportation Plan
- Ozone Simulation
  - 2018 May 1 to September 30, 2018
- PM2.5 simulation
  - 2018 January 1 to December 31, 2018



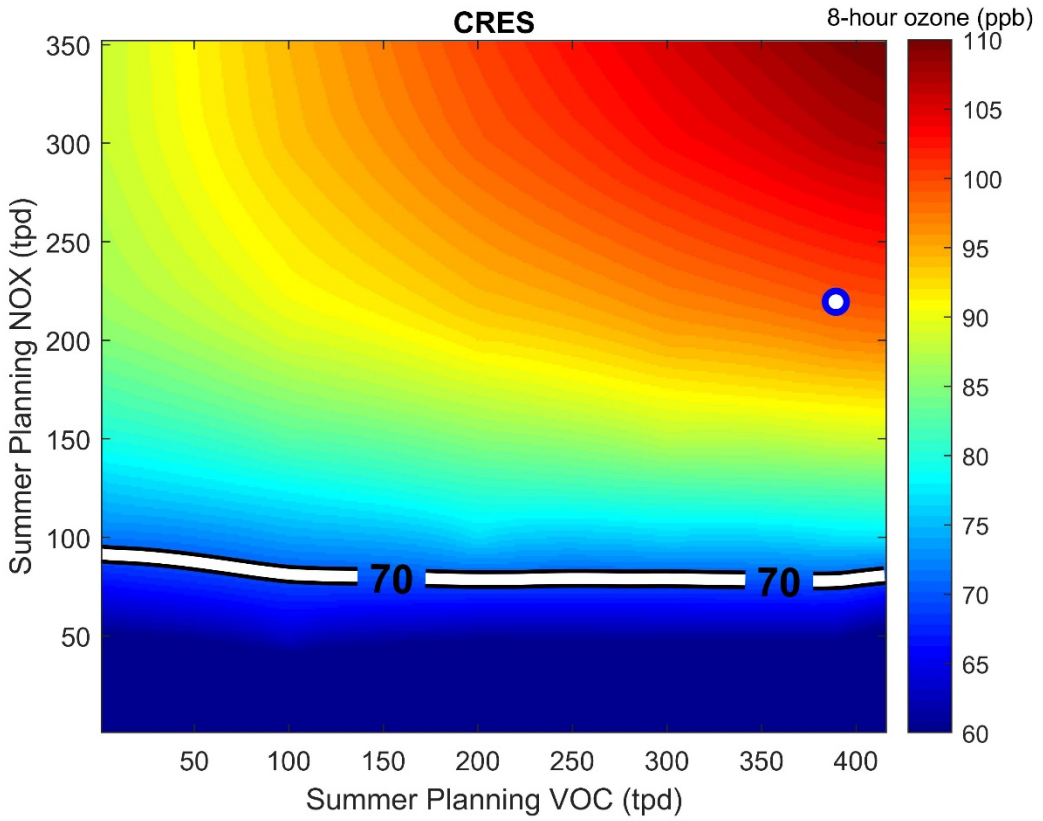
Development of Ozone Isopleths

- CMAQ nested domains
  - 12 km including the entire California and portions of neighboring states and northern Mexico
  - 4km is the AQMP analysis domain
- Basin total anthropogenic VOC and NOx emissions used as x and y axis, respectively
- Simulations were conducted with NOx and VOC emissions in 50 tons per day (tpd) increments with MatLab spatial interpolation function
  - Emission reductions were assumed to occur equally in the entire modeling domain
- Preliminary basin total summer planning emissions

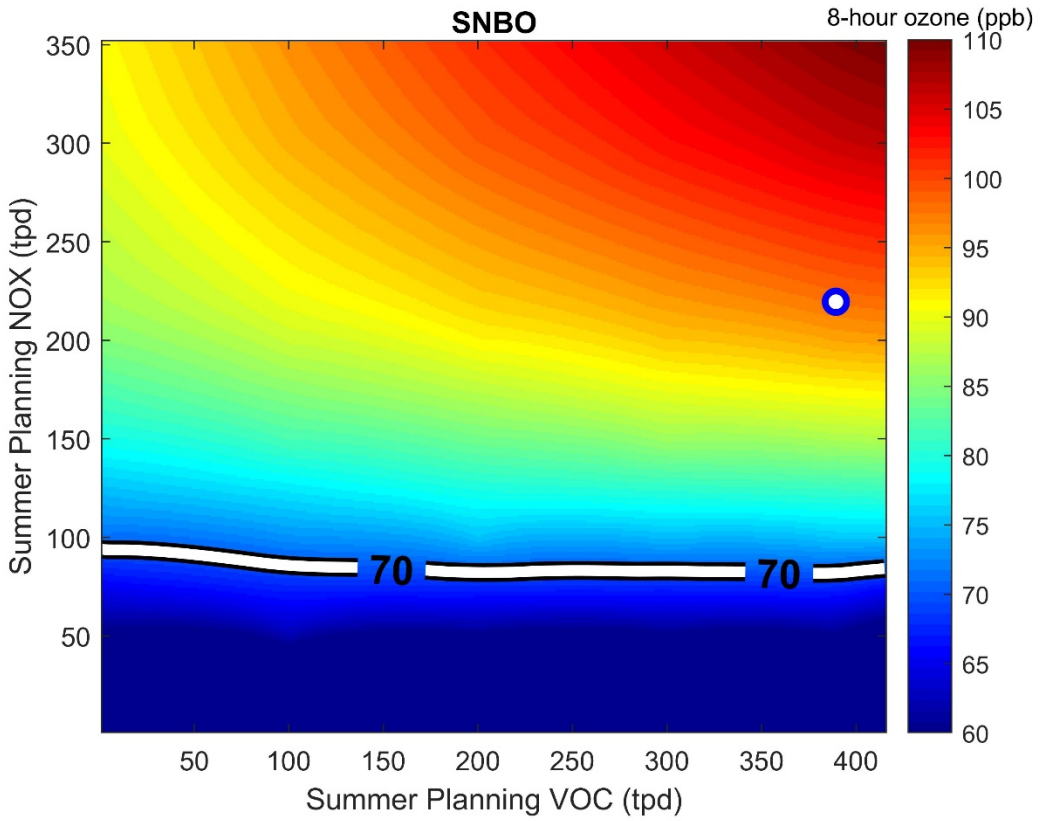
Year	VOC (tpd)	NOx (tpd)
2018	417	347
2037	389	220

Ozone Isopleths – Inland San Bernardino

Crestline



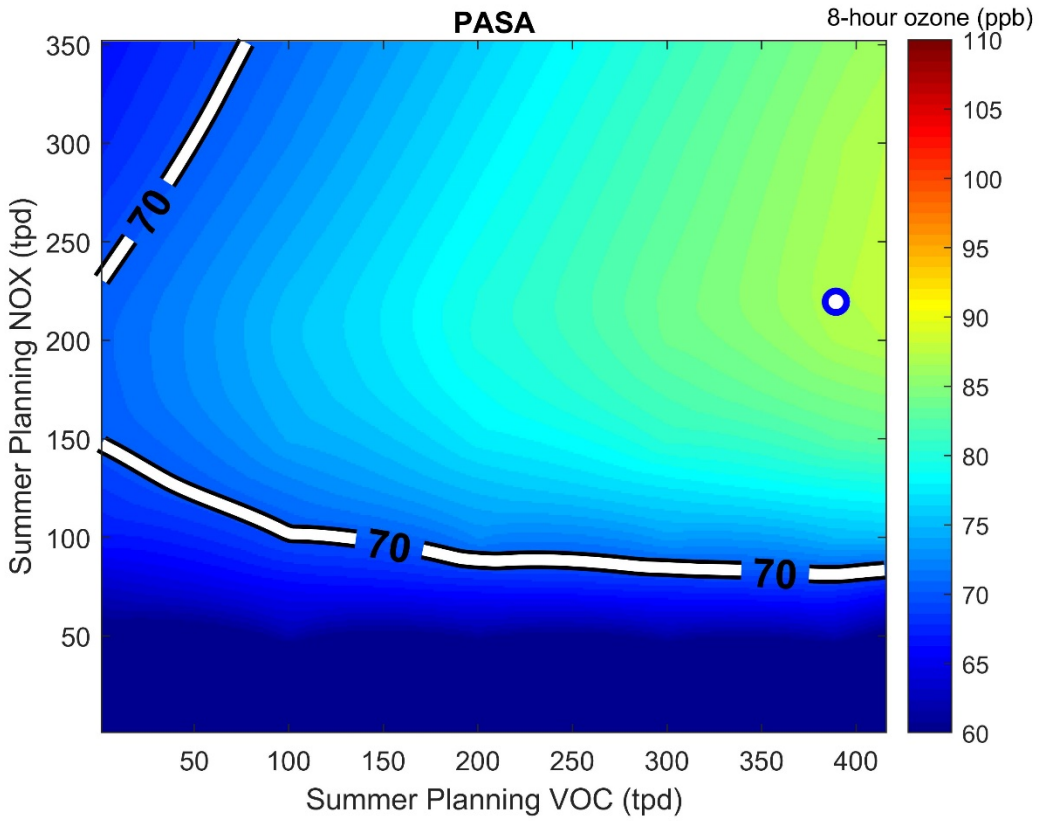
San Bernardino



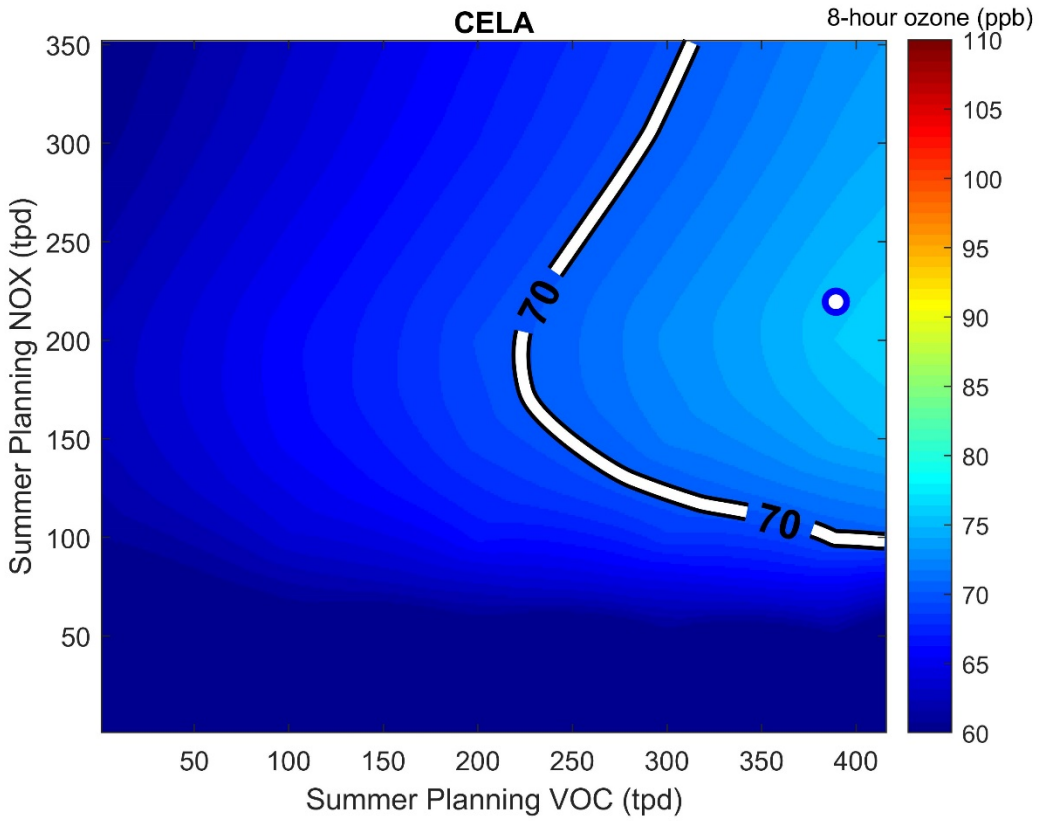
- Upper right corner represents 2018 condition
- Blue dot represents 2037 business-as-usual (BAU)

Ozone Isopleths – Western Basin

Pasadena

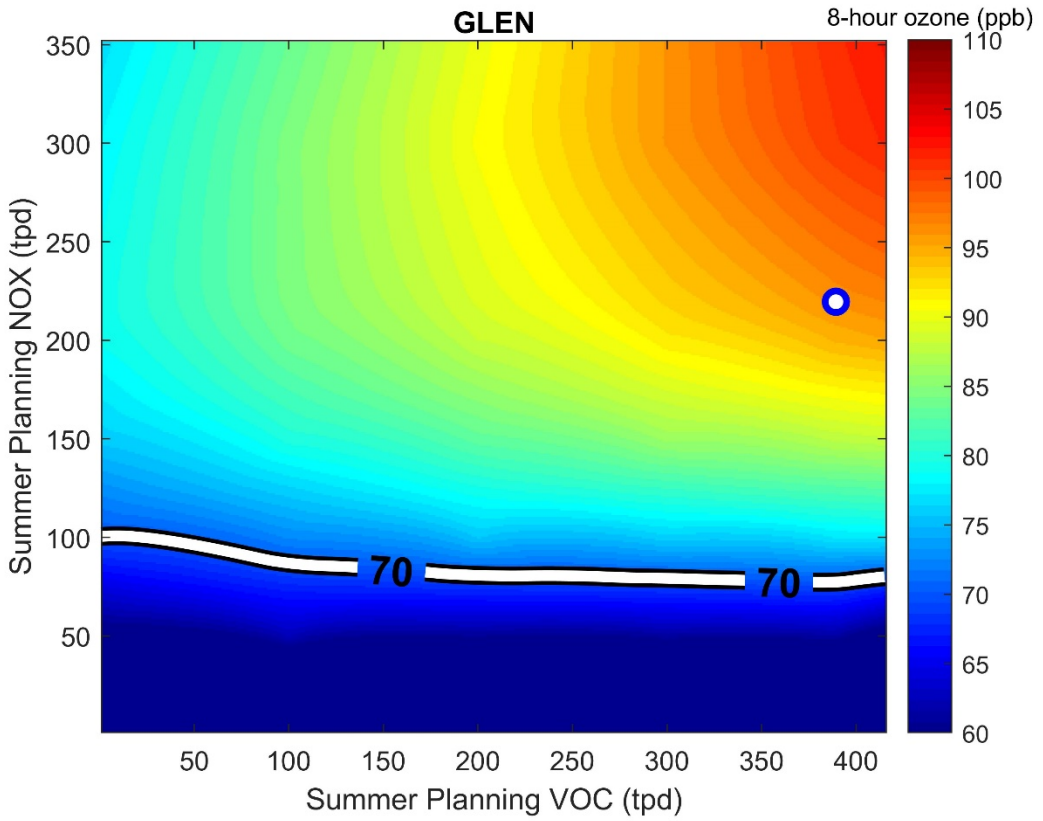


Central Los Angeles

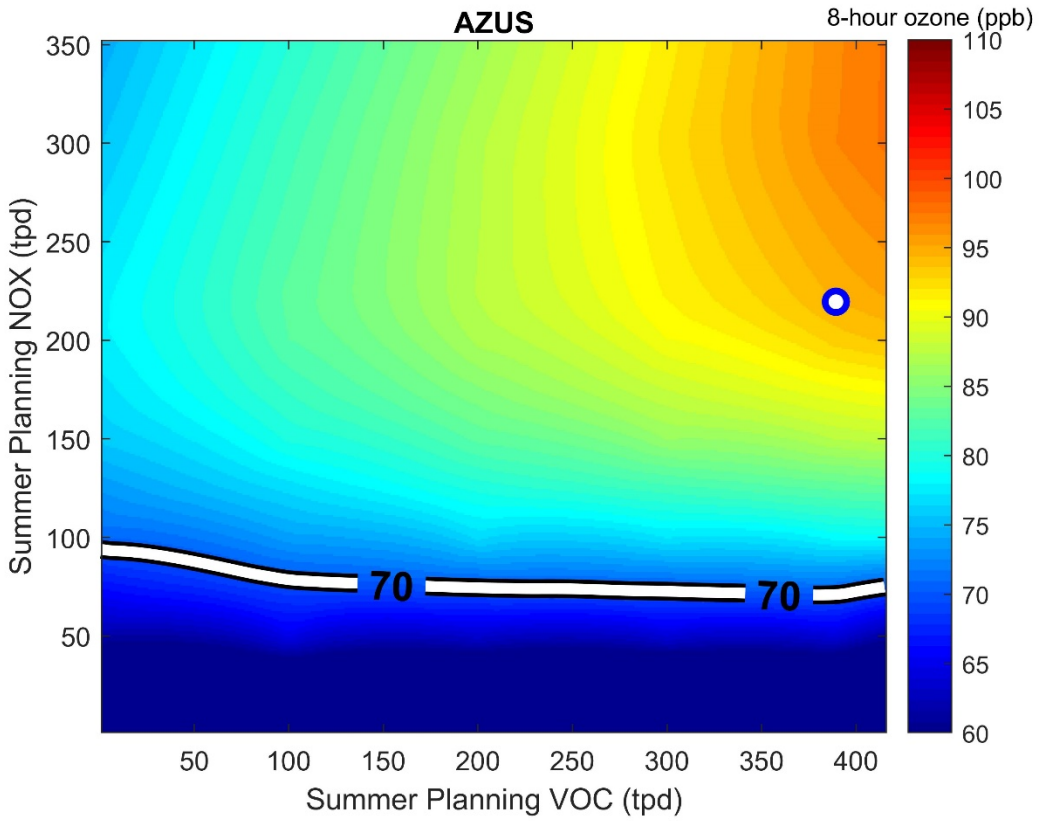


Ozone Isopleths – Foothill Area

Glendora

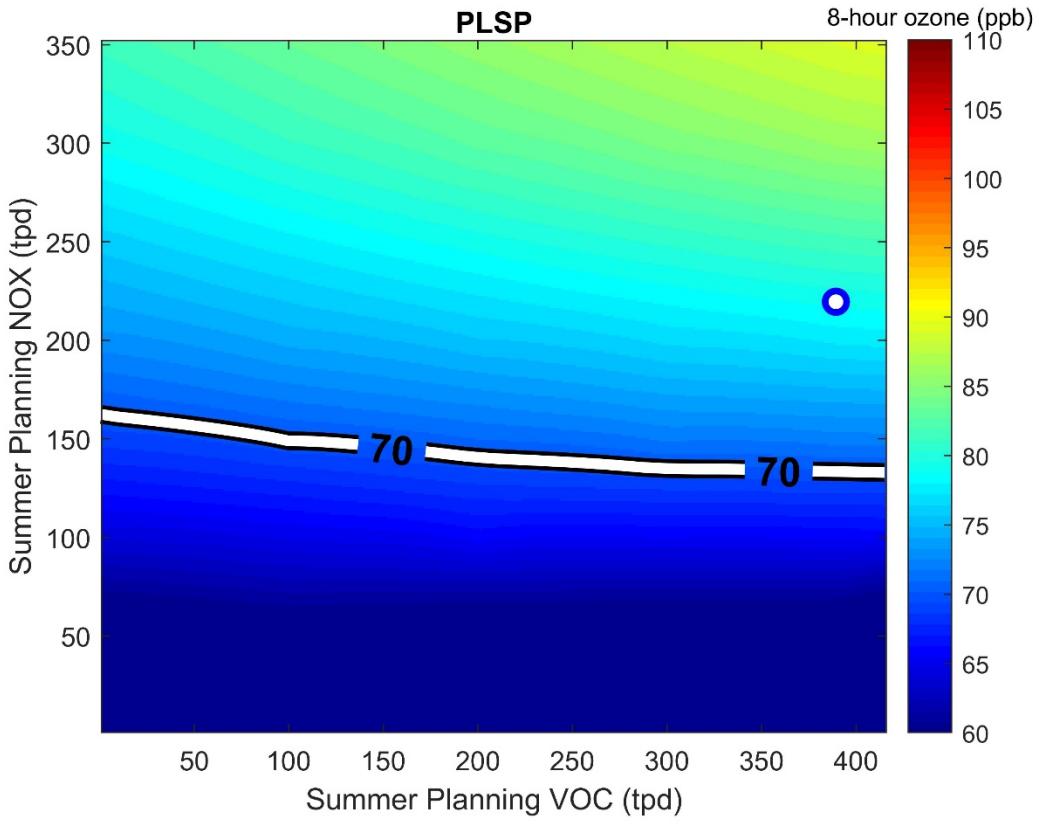


Azusa

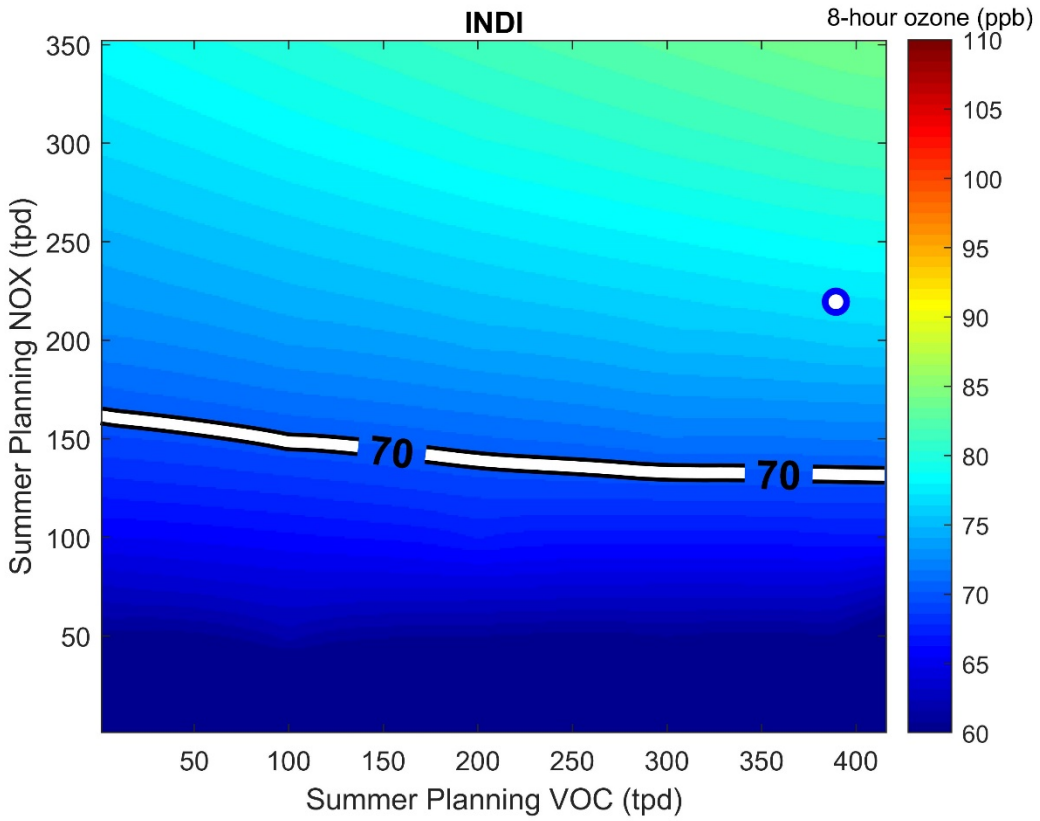


Ozone Isopleths – Coachella Valley

Palm Springs



Indio



2022 Air Quality Management Plan

- 2022 AQMP focuses on attaining the 70 ppb 8-hour ozone National Ambient Air Quality Standard (NAAQS)
  - South Coast Air Basin's (SCAB) attainment due – 2037
  - Coachella Valley's attainment due – 2032
- Preliminary baseline NOx emissions in SCAB in 2037 are 224 tpd
- Preliminary NOx carrying capacity* in SCAB in 2037 is 60 – 70 tpd

*Carrying capacity is the maximum allowable emissions to attain NAAQS

Factors Influencing Carrying Capacity

Lateral boundary values

- Transport from the central valley and Mexico

Controls in adjacent air basins

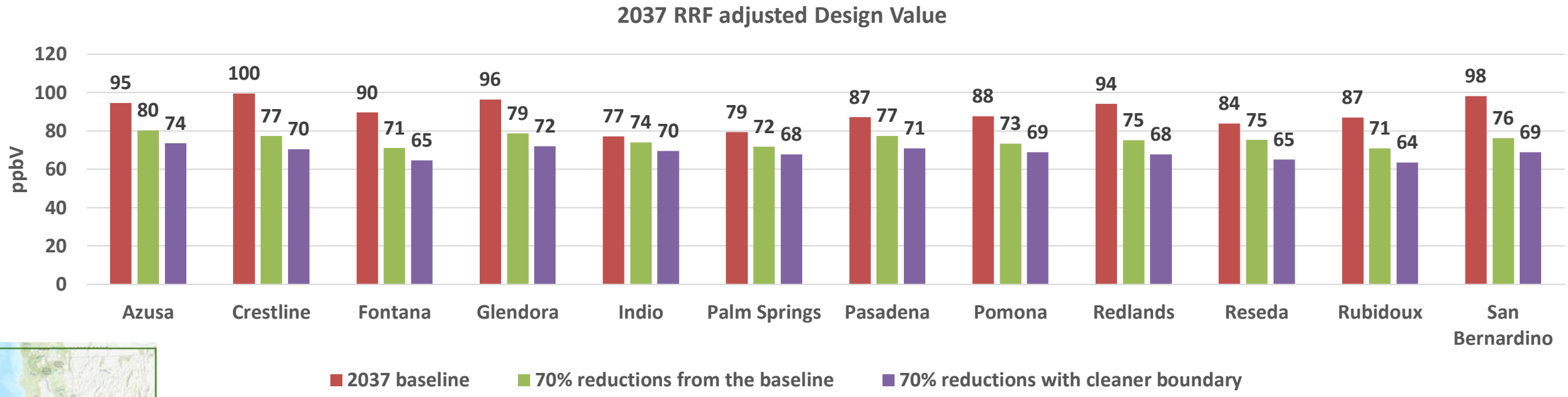
- Kern, Ventura, Santa Barbara and San Diego

Category specific vs. across-the-board reductions

- Final attainment scenario relies on control factors developed for individual source category

Lateral Boundary Values

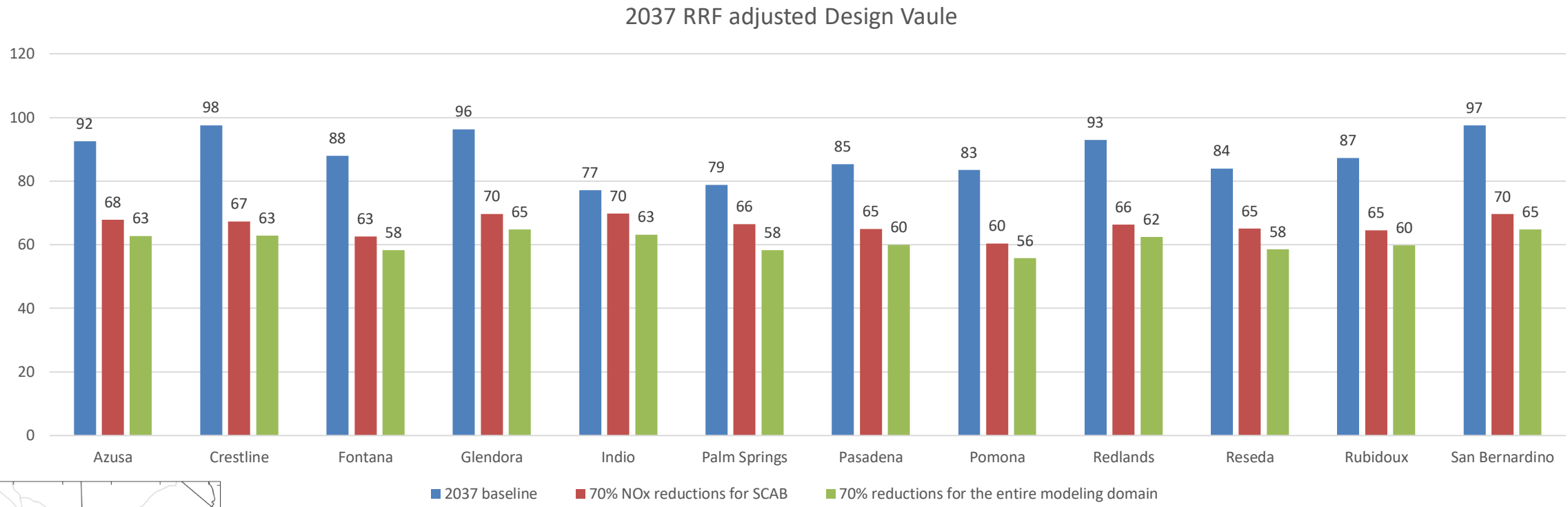
- With approximately 70% reductions beyond the baseline condition, the 2037 Design Value (DV) is reduced by 17 ppb at Glendora
  - If all of CA, neighboring states and Mexico reduced emissions by 70% beyond future baseline conditions, the 2037 DV will be reduced by up to another 7 ppb

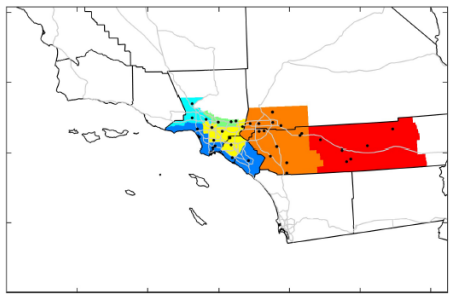


*RRF is Relative Response Factor defined as the ratio of model predictions for future to base year

Controls in Adjacent Air Basins

- The same level of controls in adjacent air basins can lower the DV by up to **5** ppb





* Emissions inventory and lateral boundary values used in the simulations shown in the previous and this slides are different

Summary and Preliminary Carrying Capacity

- Transport from neighboring air basins/states/countries significantly affects attaining the NAAQS in South Coast
- Ozone responds to emission reductions differently, depending on the source of emissions
  - Final attainment scenario relies on control profiles specified for individual source category
- Glendora and San Bernardino are expected to have the highest ozone level in the future attainment year
- Preliminary carrying capacity is expected to be in the range of 60-70 tons of NOx

South Coast AQMD Socioeconomic Impact Assessment and Scope of 2022 AQMP Socioeconomic Report

Socioeconomic Analysis Unit
Ryan Finseth, Ph.D.
Paul Stroik, Ph.D.
Brian Vlasich
Shah Dabirian, Ph.D.

South Coast Air Quality Management District
2022 Air Quality Management Plan

Science, Technical, and Modeling Peer Review Advisory Group
Socioeconomic Analysis Meeting #1
November 4, 2021

South Coast AQMD Socioeconomic Team

South Coast AQMD Socioeconomic Team

Shah Dabirian, Ph.D.
Program Supervisor
AQMD since 1992

Ryan Finseth, Ph.D.
AQMD since 2018

Paul Stroik, Ph.D.
AQMD since 2018

Brian Vlasich
AQMD since 1999

Education

Economics Degrees

- Claremont McKenna College (Mr. Vlasich)
- Cornell University (Dr. Finseth)
- University of California at Irvine (Dr. Stroik)
- University of Wyoming (Dr. Dabirian)

Experience

- Collectively developed over 100 Socioeconomic Impact Analyses for the Air Quality Management Plans and South Coast AQMD rules

Publications

- Climate Policy
- Land Economics
- Journal of Air and Waste Management Association
- Journal of Environmental Management
- Uncertainty in Artificial Intelligence

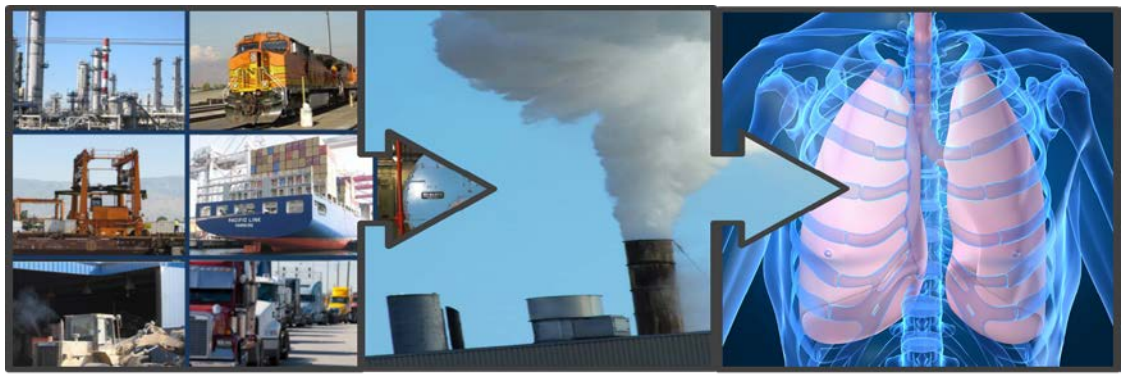
Academia

- Past and present lecturers at Northern Illinois University, California State University at Fullerton, University of Montana, and other local universities

Air Quality Management Plan

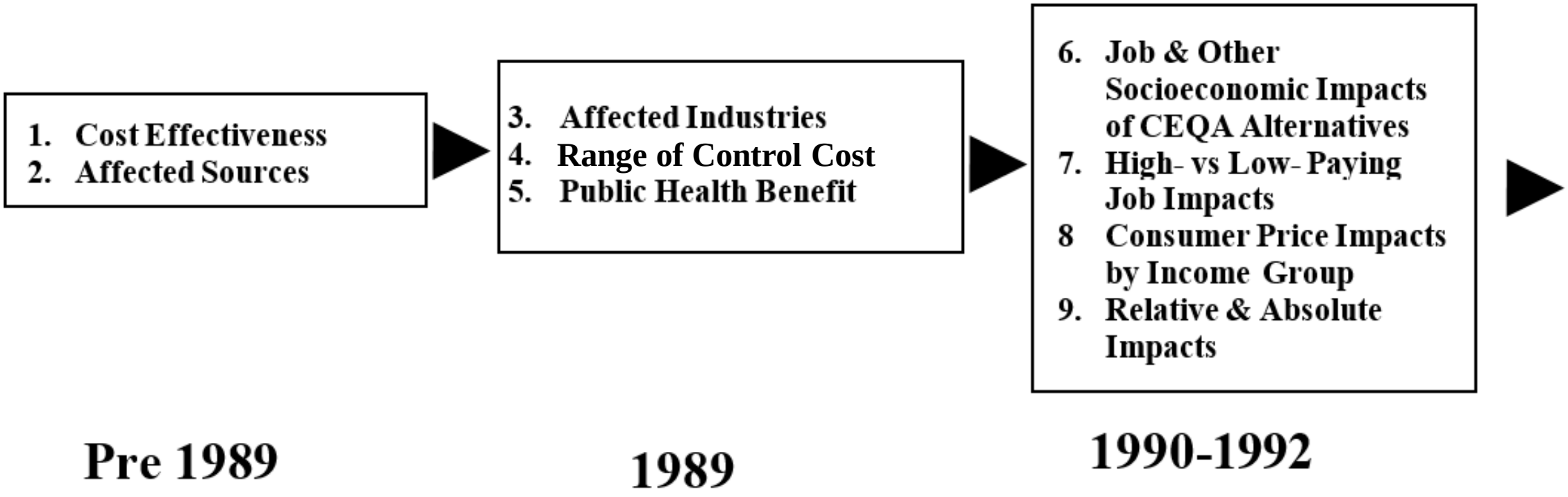
- **AQMP:** Plan to attain National Ambient Air Quality Standards
  - **Ozone**: Extreme nonattainment for 1997, 2008, and 2015 8-hour ozone standards, and 1979 1-hour ozone standard*
  - **PM2.5**: Serious nonattainment for 2006 24-hour and 2012 annual PM2.5 standards (2020 data indicates South Coast Air Basin met 24-hour standard – redesignation request pending)
- **2022 AQMP:** Focuses on attaining 2015 8-hour ozone standard by 2037

- **AQMP Socioeconomic Report** quantifies:
  - Incremental costs and/or savings of AQMP control measures
  - Regional benefits from air-quality improvements (reduced ozone and PM2.5)
  - Regional macroeconomic impacts (e.g. jobs) from associated costs and benefits

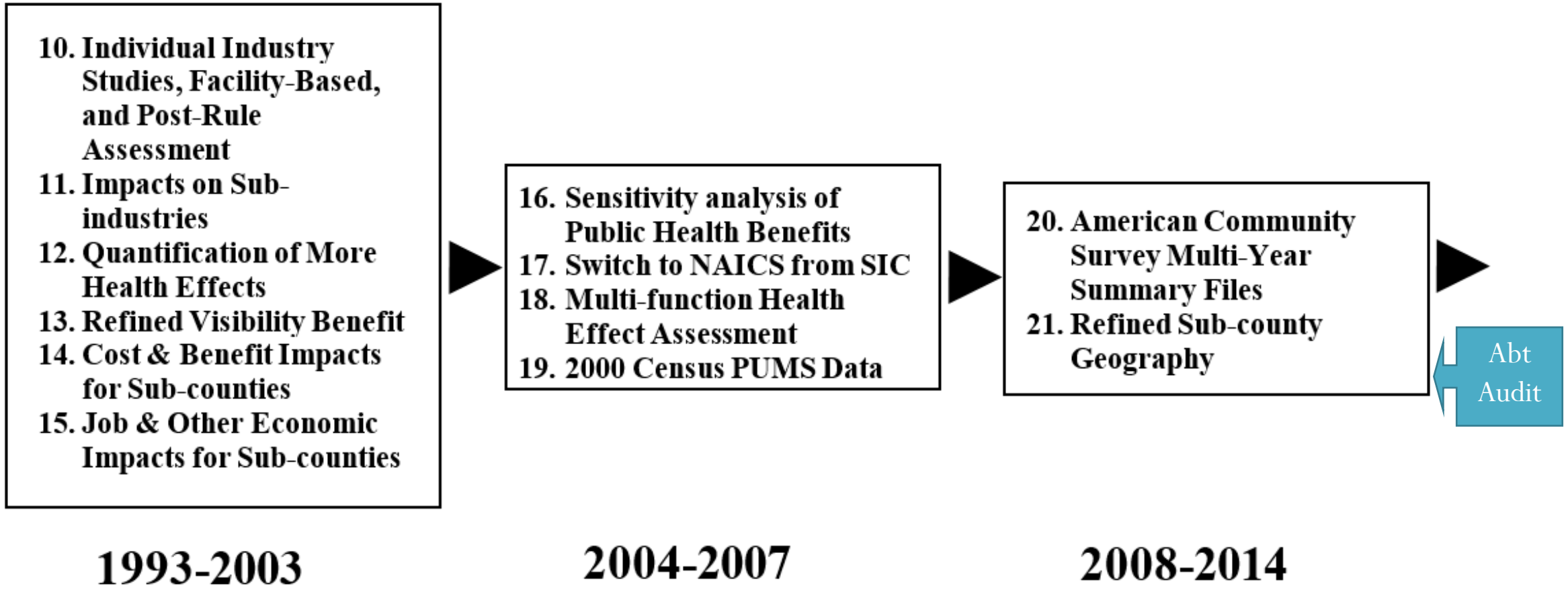


* 1979 1-hour ozone standard has been revoked.

Socioeconomic Analysis Evolution (1/3)



Socioeconomic Analysis Evolution (2/3)



Socioeconomic Analysis Evolution (3/3)

22. LCF & DCF Cost-Effectiveness
23. Improve Uncertainty Analysis
24. Increase the Transparency of the Analyses
25. Enhance Documentation Clarity
26. Evaluation of Macroeconomic Modeling of Public Health and other Non-Market Benefits
27. Enhance Health Benefits and Environmental Justice Analysis
28. Further Update Health Benefits and Valuation Literature
29. Update Literature Review for Visibility, Material, and Agricultural Benefits
30. Evaluate the Use of other Modeling Tools (EMSI) to Supplement the REMI Model for Small Scale Impacts
31. Monitored U.S. EPA Economy-Wide Modeling Panel Discussions and Recommendations

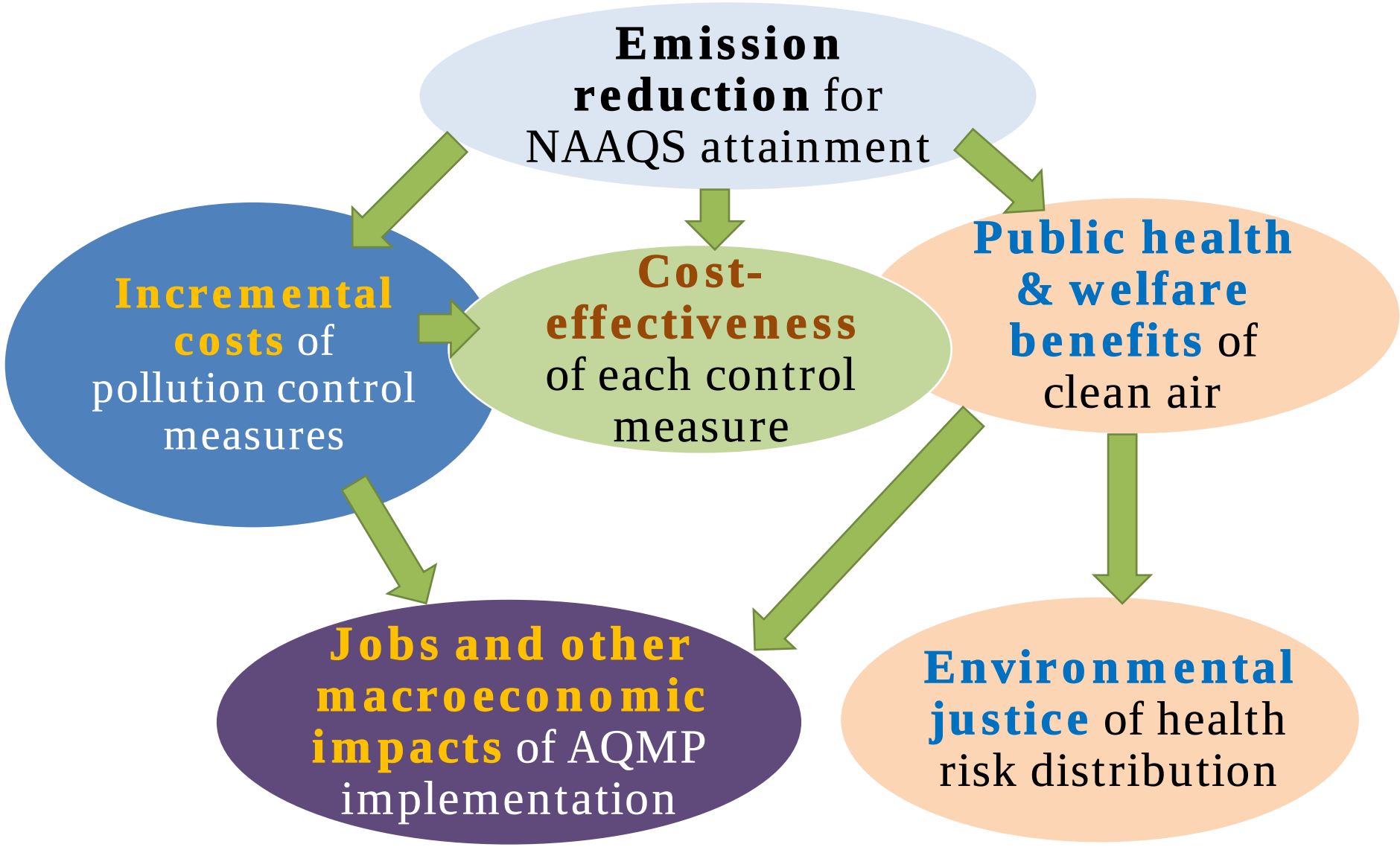
2015-2020

Future Improvements

32. Update Best Practices for Estimating Small Business Impacts using EDD database
33. Expand Job Impacts by Race and Ethnicity, etc. using REMI's SEI Module

Post 2020

AQMP Socioeconomic Analysis

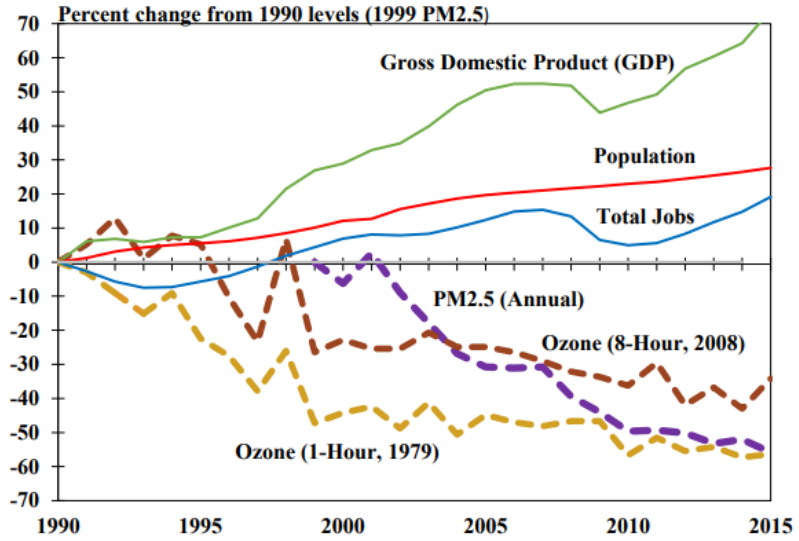


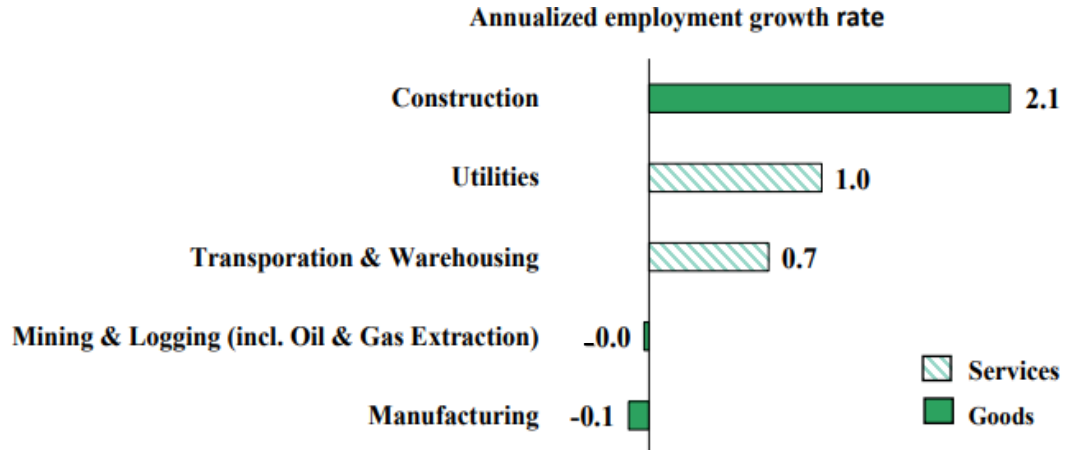
AQMP Socioeconomic Report Chapters

- Executive Summary
- Chapter 1: Introduction
- Chapter 2: Control Measures Compliance Cost
- Chapter 3: Public Health and Other Benefits
- Chapter 4: Jobs and Other Macroeconomics Impacts
- Chapter 5: Sub-Regional Distribution of Impacts
- Chapter 6: Environmental Justice
- Chapter 7: CEQA Alternatives

Ch. 1: Introduction

- Historical regional air quality and economy
- Air quality attainment challenges
- Health effects of air pollution
- Economic outlook of potentially affected industries
  - Covid-19 impacts
- Baseline of 2022 AQMP socioeconomic analysis
- Evolution of South Coast AQMD socioeconomic analysis





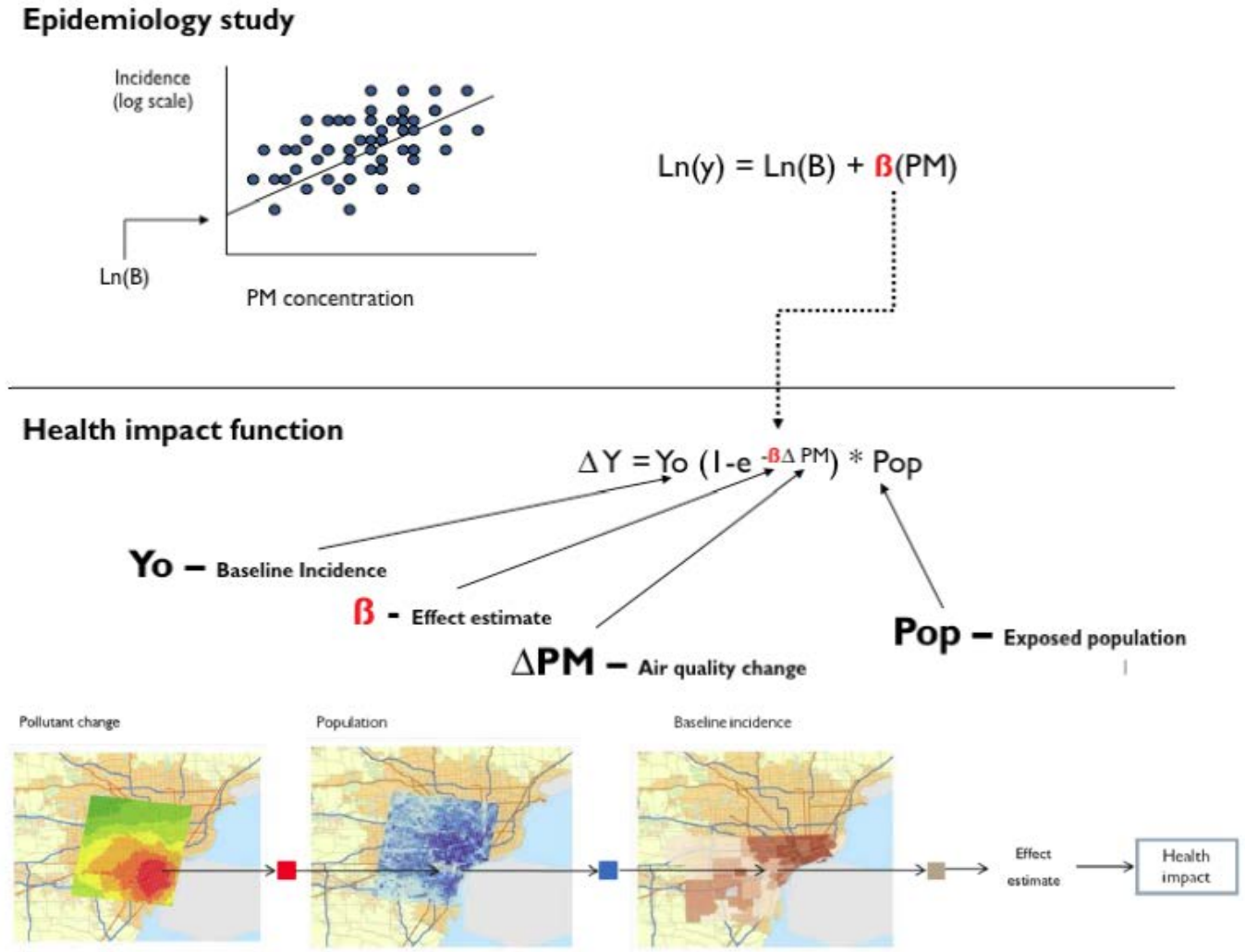
2016 AQMP Socioeconomic Report charts

Ch. 2: Control Measures Compliance Cost

- Compliance costs:
  - Compiled by South Coast AQMD staff
  - Capital, operating and maintenance, and administrative costs/savings through time
  - Incremental (i.e., relative to the baseline costs)
  - Expressed in present value and constant dollars
- Estimated costs by:
  - Control measure
  - Source and jurisdiction
    - South Coast AQMD stationary/mobile sources, and CARB mobile sources
  - Affected industry sectors
  - Small businesses (if data available)
- Cost effectiveness by control measure (using both discounted and levelized cash flow analysis)

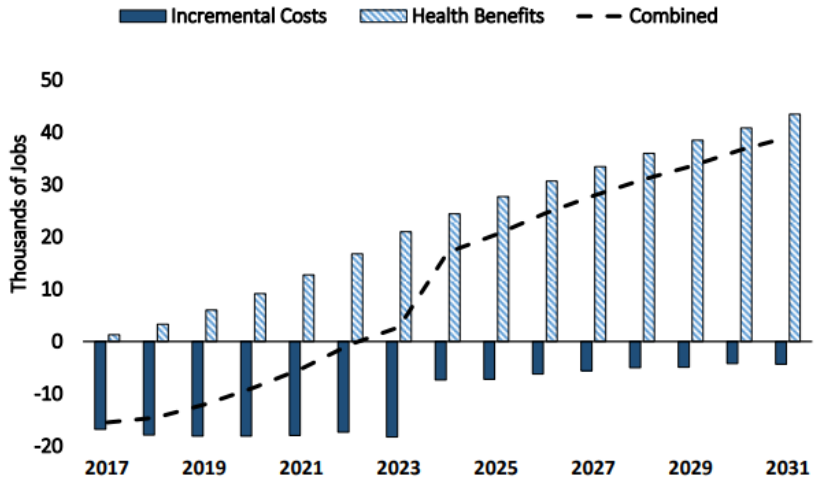
Ch. 3: Public Health and Other Benefits

- Main tool: U.S. EPA's Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE)
  - In-house estimates of pollutant concentration changes
  - Concentration-response functions and health benefit valuation review to be updated if applicable
- Qualitative discussion of visibility, material, and agriculture benefits
  - Due to uncertain confidence in underlying modeling and/or outdated literature



Ch. 4 & 5: Macroeconomics Impacts

- Main tool: REMI Policy Insight Plus model
  - Aggregate and sub-regional macroeconomic impacts
  - SEI module allows for impacts by gender and race
- Job impacts from incremental compliance costs and public health benefits
  - Increased cost of doing business
  - Increased demand for low-to-zero emission technologies and pollution control equipment
  - Reduced healthcare spending and increased worker productivity
  - Increased regional labor pool due to better amenity of clean air
- Job impact and sectoral distribution
- Competitiveness impacts by industry sector
  - Cost of production (for those who cannot pass through costs)
  - Delivery prices (for those who can pass through costs)



2016 AQMP Socioeconomic Report charts

Ch. 6: Environmental Justice Analysis

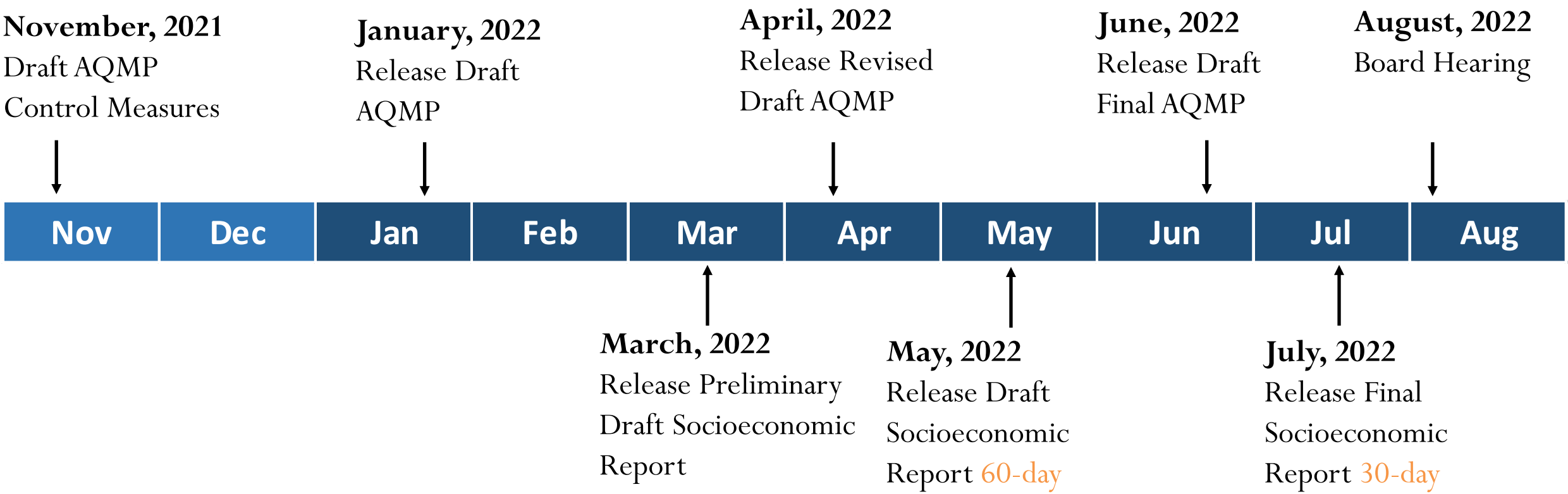
Environmental justice discussion and analysis will also be explicitly folded into every chapter of the AQMP document

- Environmental justice community screening and designation
  - To be based off CalEnviroScreen 4.0
    - Each community is a census tract
    - 2016 AQMP SIA explored several variations of CalEnviroScreen:
      - All included poverty status, toxic cancer risk, and PM2.5 and ozone air quality indicators
      - Variations included demographic (e.g. age, education, unemployment, etc.) and non-air related environmental indicators (e.g. drinking water, pesticides, toxic releases, etc.)
- Distributional analysis
  - Quantified health benefits and valuation: EJ and non-EJ areas
  - 2016 AQMP SIA also included distributional analysis using inequality indices
    - Inter- and intra-area changes in health risk inequality
    - Concerns about accessibility to the public
    - Seek STMPR input whether to retain for 2022 AQMP

Ch. 7: CEQA Alternatives

- California Environmental Quality Act (CEQA) requires analysis of range of alternatives to AQMP sufficient to permit a reasoned choice among proposed and alternative approaches
- Descriptions of each alternative
  - List of control measures included in each
- Compliance costs/savings and job impacts by alternative

Preliminary AQMP and Socioeconomic Impact Assessment Timeline



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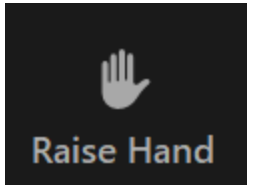
How to Raise Your Hand to Speak

ZOOM: Click on the “Raise Hand” button at the bottom of your screen.



TELECONFERENCE: Dial *9 to “raise your hand”

Your name will be called when it is your turn to speak and the meeting host will unmute your line.