

Ozone SIP Modeling In The San Joaquin Valley: 75 ppb 8-hr Ozone Standard

Air Quality Planning & Science Division
California Air Resources Board

San Joaquin Valley Public Advisory Workgroup
February 11, 2016

Acknowledgements

- CCOS and CRPAQS
- CARB Staff
 - Atmospheric Modeling and Support Section
 - Meteorology Section
 - Air Quality Planning Branch
 - Mobile Source Analysis Branch
 - Consumer Products and Air Quality Assessment Branch
- District Staff
- University/Scientific collaborators
- US EPA R9/Headquarters

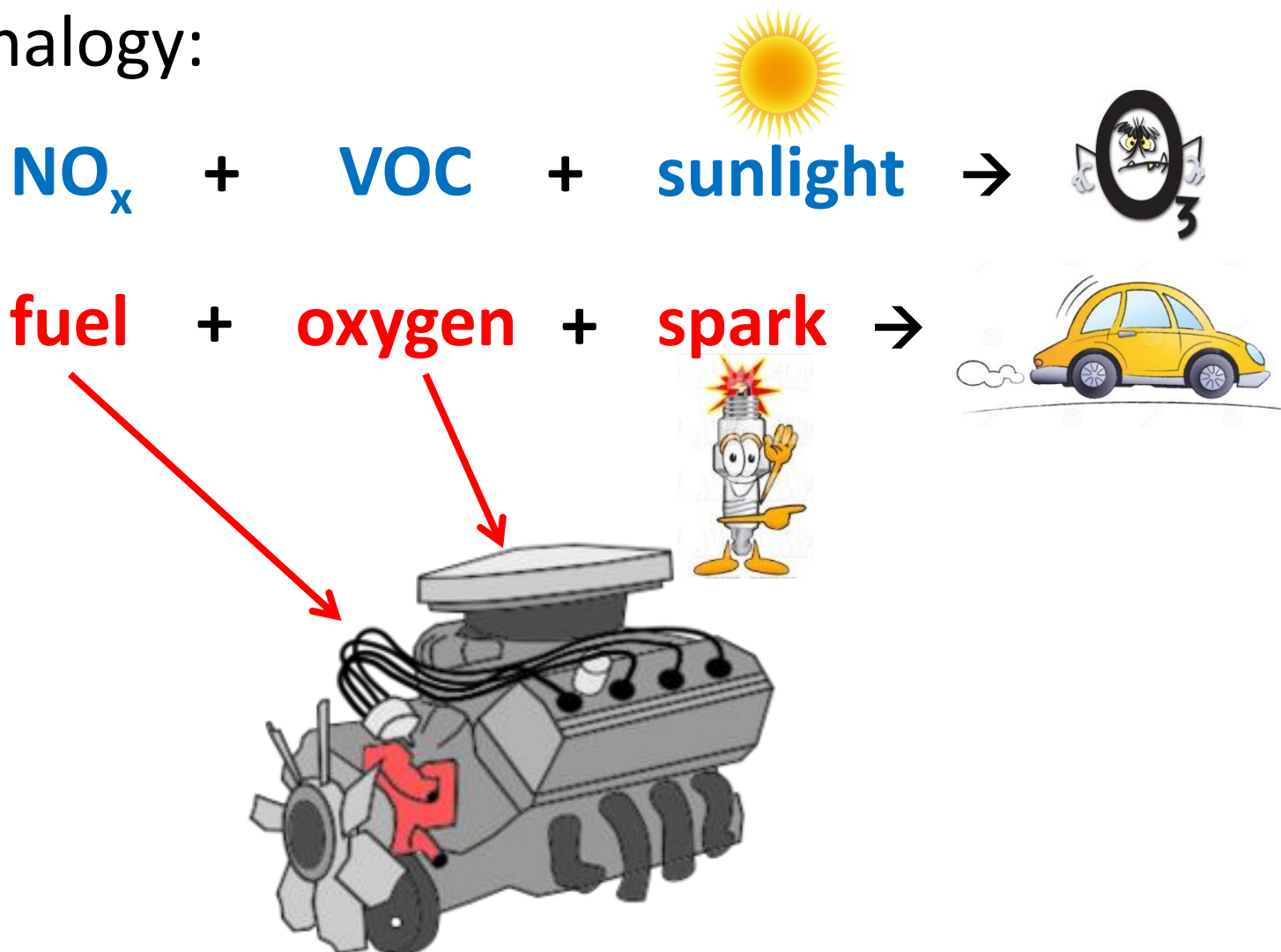
Outline

- Modeling overview
- The ozone SIP modeling process:
 - Model Attainment Demonstration
 - Does this approach work?
- The current SJV 8-hour ozone SIP:
 - Tailoring the modeling system for the SJV
 - Modeling results
 - Corroborative work of others
- Next Steps

Modeling Overview

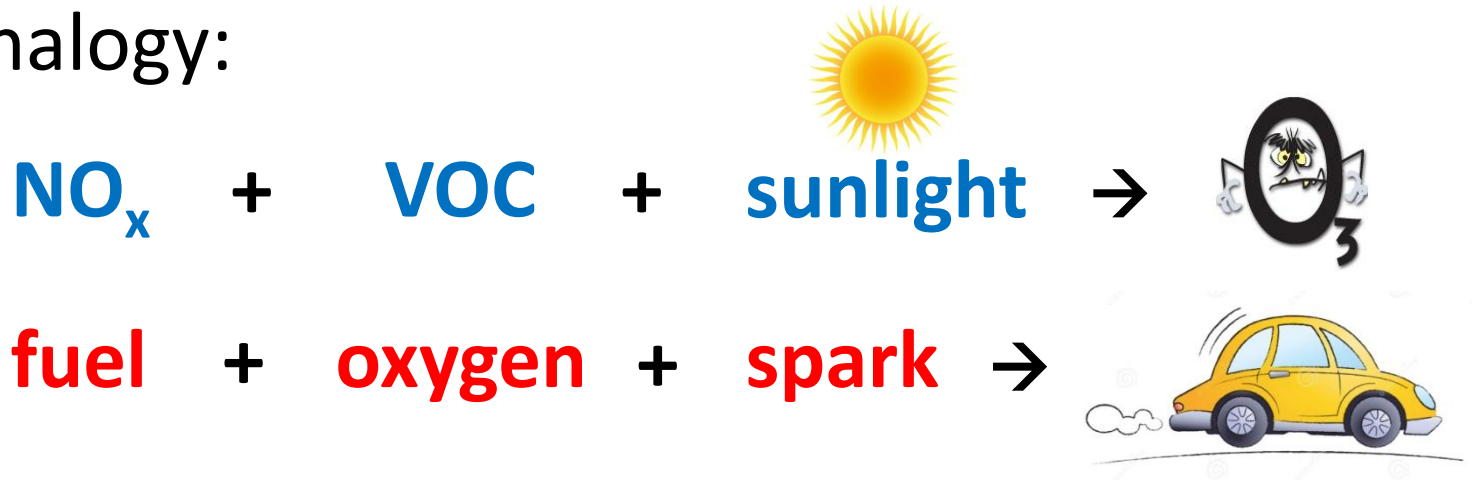
Ozone (surface) Chemistry Refresher

Engine Analogy:



Ozone (surface) Chemistry Refresher

Engine Analogy:



- What does this mean for controlling ozone?
 - Depending on the mixture of NO_x and VOC in the atmosphere, controlling either pollutant independently may be sufficient to reduce ozone or controlling both pollutants simultaneously may be necessary

Modeling Overview

Boundary Conditions

Emissions

human induced
natural (plants)

Meteorology

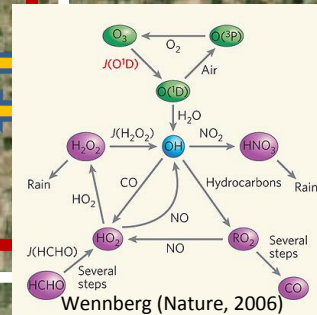
Winds, temp., Mixing Height

Chemistry

NO_x, VOCs, ozone

BCs

External conditions



Numerical representation of atmospheric processes

$$\frac{\partial(\overline{\mathcal{P}}_i J_i)}{\partial t} + m^2 \overline{\mathcal{V}}_i \cdot \left(\frac{\overline{\mathcal{P}}_i \overline{\mathcal{V}}_i J_i}{m^2} \right) + \frac{\partial(\overline{\mathcal{P}}_i \overline{\mathcal{V}}_i J_i)}{\partial x^3} - m^2 \frac{\partial}{\partial x^2} \left[\frac{\overline{\mathcal{P}}_i}{m^2} (\hat{K}^{21} \frac{\partial \overline{\mathcal{Q}}_i}{\partial x^2}) \right] - m^2 \frac{\partial}{\partial x^2} \left[\frac{\overline{\mathcal{P}}_i}{m^2} (\hat{K}^{22} \frac{\partial \overline{\mathcal{Q}}_i}{\partial x^2}) \right] - \frac{\partial}{\partial x^3} \left[\overline{\mathcal{P}}_i (\hat{K}^{21} \frac{\partial \overline{\mathcal{Q}}_i}{\partial x^2}) \right] - m^2 \frac{\partial}{\partial x^2} \left[\frac{\overline{\mathcal{P}}_i}{m^2} (\hat{K}^{21} \frac{\partial \overline{\mathcal{Q}}_i}{\partial x^2}) \right] - m^2 \frac{\partial}{\partial x^2} \left[\frac{\overline{\mathcal{P}}_i}{m^2} (\hat{K}^{22} \frac{\partial \overline{\mathcal{Q}}_i}{\partial x^2}) \right] - \frac{\partial}{\partial x^3} \left[\overline{\mathcal{P}}_i (\hat{K}^{21} \frac{\partial \overline{\mathcal{Q}}_i}{\partial x^2}) + \hat{K}^{22} \frac{\partial \overline{\mathcal{Q}}_i}{\partial x^2} \right] = J_i R_q(\overline{\mathcal{V}}_1, \dots, \overline{\mathcal{V}}_s) + J_i Q_q + \frac{\partial(\overline{\mathcal{P}}_i J_i)}{\partial t} \Big|_{\text{out}} + \frac{\partial(\overline{\mathcal{P}}_i J_i)}{\partial t} \Big|_{\text{in}} + \frac{\partial(\overline{\mathcal{P}}_i J_i)}{\partial t} \Big|_{\text{pump}}$$

Modeling Overview (*cont.*)

Emissions

- Models require hourly emissions for each grid cell
- Inventory details presented at September 30, 2015 PAW
- California's EI is one of the most complete and robust in the world

Meteorology

- Generated using a 3-D numerical model
- Very time consuming to exercise and fine-tune

Chemistry

- Chemistry (or chemical mechanism) plays a central role in air quality modeling
- Describes the photochemical reactions that take place in the atmosphere and that lead to ozone formation

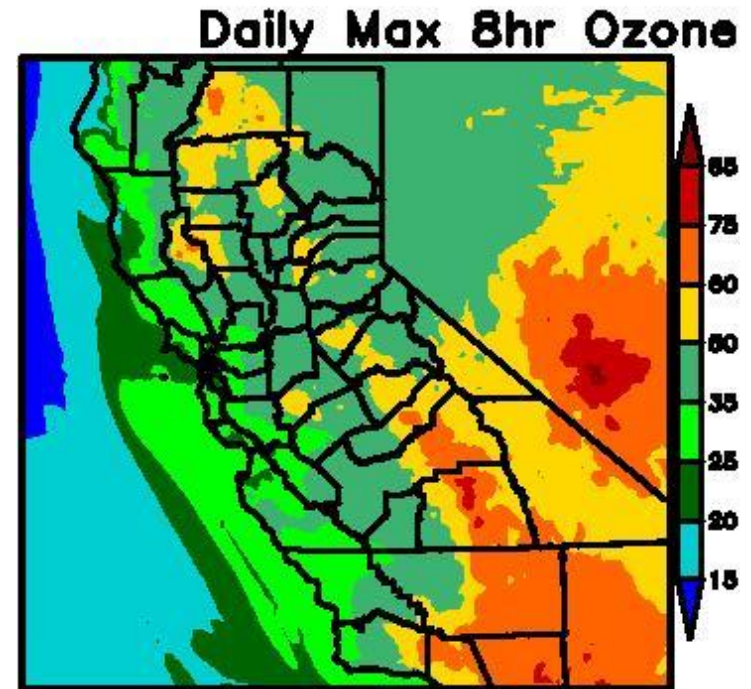
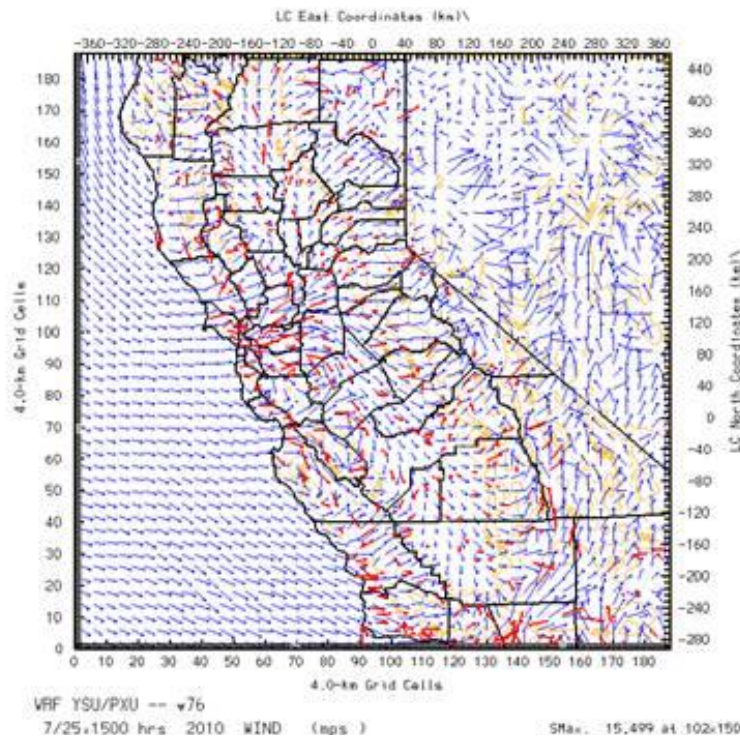
Boundary Conditions

- Derived from global models to provide time- and space-varying information
- Capture the transport of external emissions that could affect modeling region

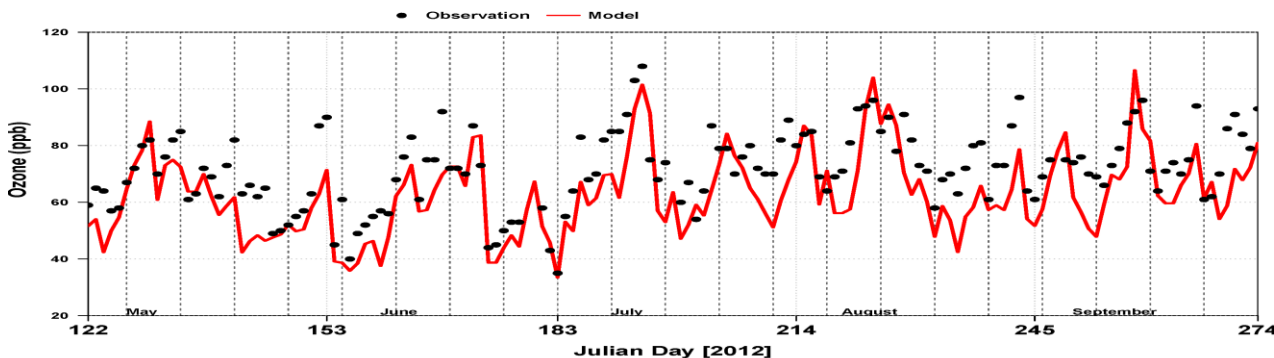
Photochemical Model

- Mathematical representation of our best knowledge about atmospheric processes

Modeling Overview (*cont.*)



Daily Maximum 8-hour ozone at Clovis [May – September, 2012]



Model performance is critical for ground-truthing the modeling (does the model reasonably reproduce the observed ozone?)

The Ozone SIP Modeling Process

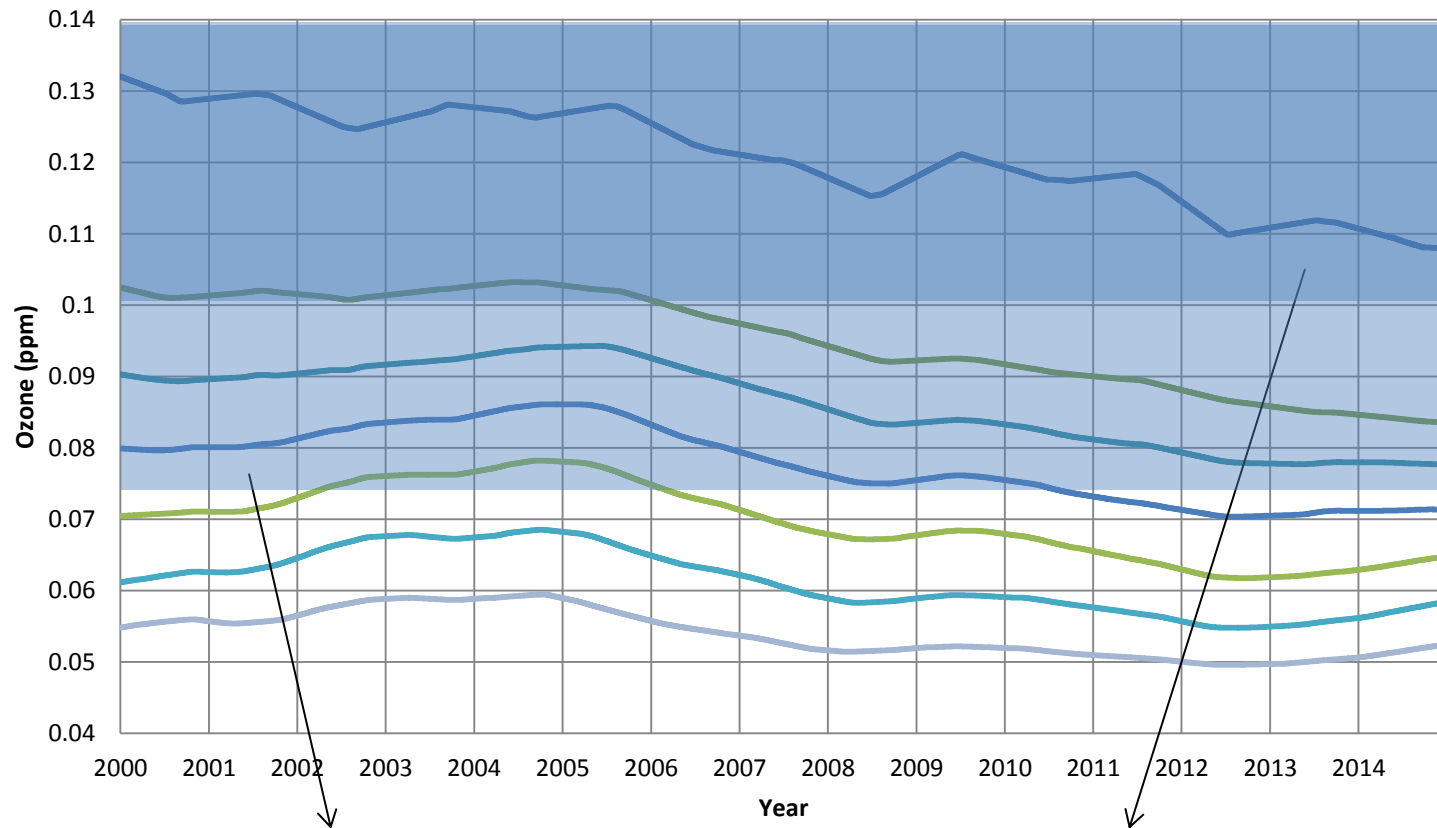
The Ozone SIP Modeling Process

Model Attainment Demonstration

- Originally (1-hr ozone), models used in an absolute sense (20+ years ago)
 - Simulate a base year to show model reproduces observations
 - Simulate a future year episode and use output directly
- Transitioned to using models in a relative sense
 - Through many scientific studies it was determined that using the relative change in the model was a more appropriate use of the models
 - Future year O_3 / Base year O_3
 - We call this relative change a Relative Response Factor (RRF)
 - Tie the relative change to an ozone concentration using the Design Value (RRF x DV)
 - Recently improved upon this approach by accounting for the differences in the observed rate of change in peak ozone compared to lower ozone levels

Model Attainment Demonstration

**Trends in Annual Percentiles of the
Daily Max. 8-Hr Ozone in the San Joaquin Valley Air Basin**
(three-year averages for percentiles 40, 50, 60, 70, 80, 90, and Max)



EPA 2008 RRF method
(focused on average response)

EPA 2014 RRF method
(focused on peak response)

Percentile	%Change 2000 to 2015
100 (max)	18
90	18
80	14
70	11
60	8
50	4
40	4

Model Attainment Demonstration

- Projecting the average DV to the future requires three model simulations:
 1. **Base year** simulation (2012): assessing model performance
 2. **Reference year** simulation (2012): used in RRF calculation
 - Same as base year simulation except no wildfire emissions, Chevron fire, etc.
 3. **Future year** simulation (2031): used in RRF calculation
 - Same as reference year, except anthropogenic emissions are for the future year (e.g., same meteorology and calendar)
- Future Year Design Value:

$$DV_F = DV_R \times RRF$$

- DV_F = Future Year Design Value
- DV_R = Reference Year Design Value

Does the RRF approach work?

- 2007 Valley 8-hr O₃ SIP (84 ppb)
 - Projected attainment by 2023
 - On target for attainment with several sites already in attainment
- 2013 Valley 1-hr O₃ SIP (124 ppb)
 - Projected attainment by 2017
 - Currently in attainment
- 2 recent peer-reviewed studies
 - Pegues et al. (2012, JAWMA) – Dan Cohan's group (Rice University)
 - Investigated the predictive ability of SIP modeling for attainment of the 1997 8-hr ozone standard (84 ppb) in 12 regions classified as moderate (attainment year of 2009)
 - Foley et al. (2015, AE) – US EPA
 - Simulated change in Design Value from 2002 to 2005 at 619 monitors throughout the continental US
 - Findings from the two studies suggest that the relative based approach used in SIP modeling is robust and generally conservative in predicting attainment of the ozone standard

The Current SJV 8-Hour Ozone SIP

The Current SJV 8-Hour Ozone SIP

- Wouldn't be where we are today without the groundwork laid by CCOS / CRPAQS:
 - Develop a statewide Integrated Transportation Network and a system for updating the network
 - Improve spatial and temporal distribution of area sources, including agricultural-related sources
 - Improve the estimation of emissions from PM and VOC from cooking; livestock ammonia; and ammonia and NO_x from soil
 - Characterize and quantify air emissions from dairies; evaluate technologies to improve the management and treatment of dairy manure in the San Joaquin Valley
 - Conduct technical analyses comparing emissions inventories and air measurements to guide inventory improvements
 - Characterize cotton gin PM emissions
 - Evaluate trends in composition and reactivity of VOC from motor vehicles

The Current SJV 8-Hour Ozone SIP

CCOS / CRPAQS (cont.)

- Peer review and determination of the chemical mechanism best suited for ozone modeling
- Updated mass consistency adjustment for AQ models
- Independent verification of the applicability of SAQM for ozone SIP modeling in the SJV
- Verification of the ability of seasonal modeling to reproduce model performance for intensively monitored episodes
- A framework to facilitate quantitative evaluation of meteorological data

The Current SJV 8-Hour Ozone SIP

SIP Modeling Timeline

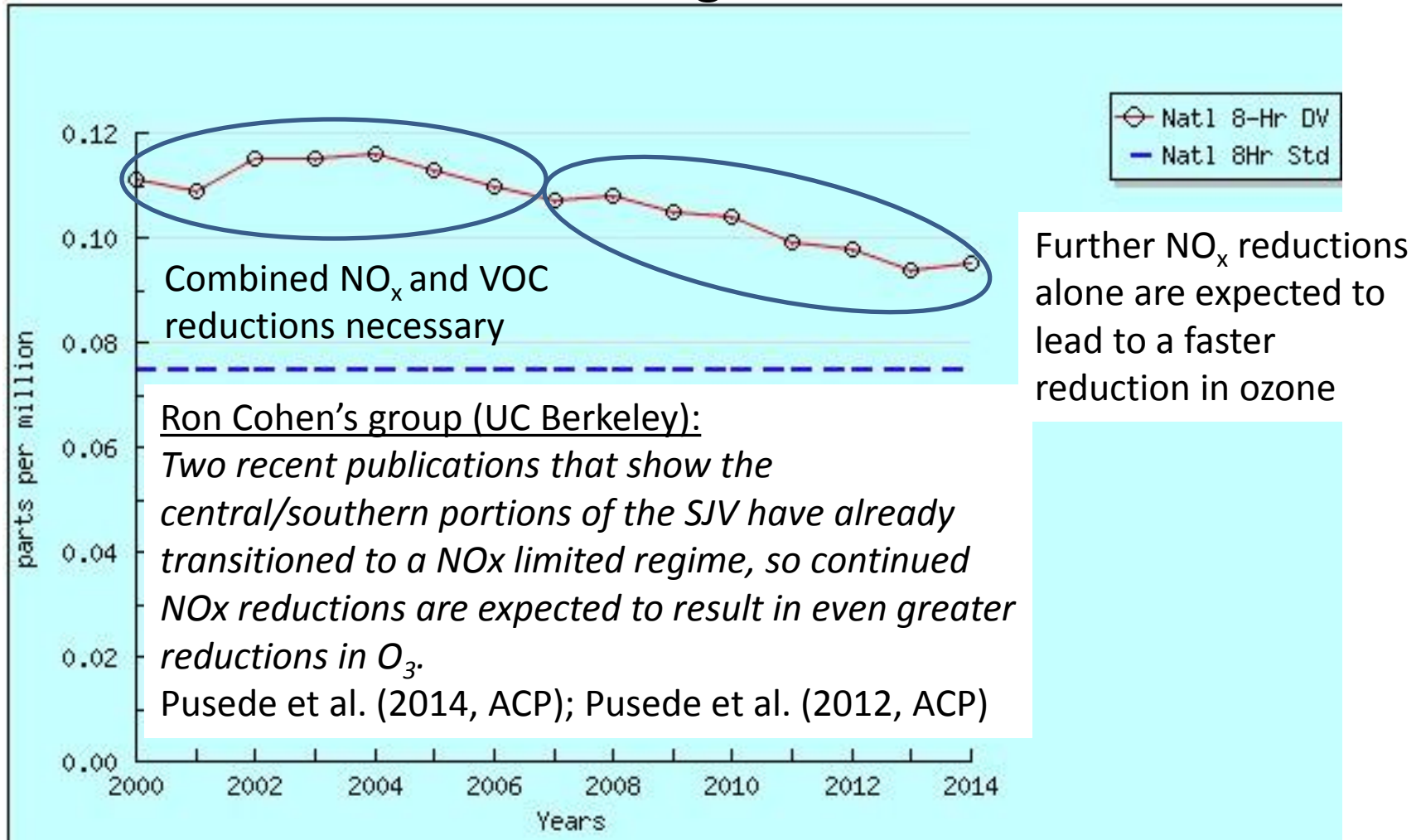
- SIP modeling process begins well in advance (2-3 years) before a SIP is due.
- Requires hundreds of modeling simulations to properly reflect observed meteorology and air quality patterns.
- Must reflect ongoing improvements to emission inventory (iterative process).

Updates to Previous (2007) SIP modeling approach

- Modeling an entire ozone season vs. a few episodic days
- Expanded modeling domain
- Latest chemistry representation
- Updated air quality and weather models reflecting the latest science
- Improved representation of air quality on the boundaries of the modeling domain

Ozone Formation in the Valley

8-hr Ozone Design Value Trend



Model Results

Emissions Summary

CEPAM v1.02 summer inventory for SJV Air Basin

	2012 (tpd)	2031 (tpd)
NO_x (total)	341	130
Stationary Sources	42.7	29.7
Areawide Sources	4.7	4.9
On-road motor vehicles	187.7	45.1
Other Mobile Sources	105.8	50.7
ROG (total)	339	298
Stationary Sources	86.3	101.9
Areawide Sources	147.0	152.7
On-road motor vehicles	60.5	18.3
Other Mobile Sources	105.2	43.3
Biogenic ROG (May – September Average)*	1323	1323

*Biogenic emissions from MEGAN v2.04 tailored to California (updated EFs, LAI)

Base Year Design Values

Site	2012 Design Value [ppb]	2013 Design Value [ppb]	2014 Design Value [ppb]	Base Year Weighted Design Value [ppb]
Clovis	98	94	95	95.7
SequoKingCan	95	93	91	93.0
Fresno-Drmnd	95	94	88	92.3
Parlier	92	92	92	92.0
Fresno-Grld	94	89	89	90.7
Arvin	91	89	88	89.3
Fresno-Sky2	92	88	87	89.0
Edison	93	86	84	87.7
Baker-5558Ca	89	86	85	86.7
Portrvlle-Ne	90	88	81	86.3

Future Year Design Values

Site	Base Year Weighted Design Value [ppb]	RRF	Future Year Design Value [ppb]
Clovis	95.7	0.7822	74
SequoKingCan	93.0	0.7007	65
Fresno-Drmnd	92.3	0.7747	71
Parlier	92.0	0.7444	68
Fresno-Grld	90.7	0.7922	71
Arvin	89.3	0.7302	65
Fresno-Sky2	89.0	0.7715	68
Edison	87.7	0.746	65
Baker-5558Ca	86.7	0.7629	66
Portrvlle-Ne	86.3	0.7345	63

Next Steps

- Unmonitored Area Analysis
- Carrying Capacity simulations/plots
 - Estimating attainment of the new 70 ppb standard
- Weight of Evidence
- Modeling Protocol

Thank You!

Questions?