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 Workshop
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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

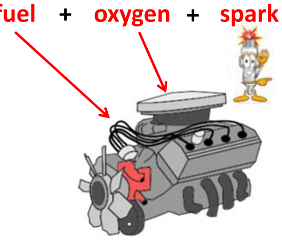
- Modeling overview
- The ozone SIP modeling process:
  - Model Attainment Demonstration
  - Does this approach work?
- The current SJV 8-hour ozone SIP:
  - Tailoring the modeling system for the SJV
  - Corroborative work of others
  - Modeling results
- Next Steps

Modeling Overview

Ozone (surface) Chemistry Refresher

Engine Analogy:

fuel + **oxygen** + **spark** → 



Adapted from Professor Mike Kleeman (UC Davis) O_3 cartoon from: http://forces.si.edu/atmosphere/02_05_02.html

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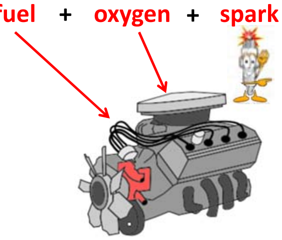
fuel + **oxygen** + **spark** → 



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Ozone (surface) Chemistry Refresher

Engine Analogy:

NO_x + VOC + sunlight → 

fuel + oxygen + spark → 

- 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

O_3 cartoon from: http://forces.si.edu/atmosphere/02_05_02.html

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human induced
natural (plants)

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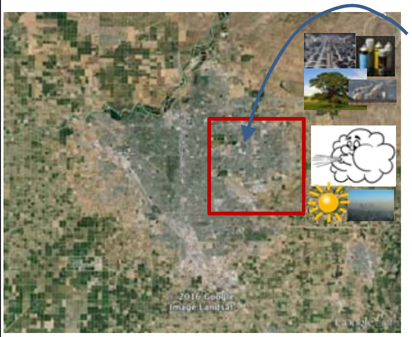

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Meteorology
Winds, temp.,
Mixing Height

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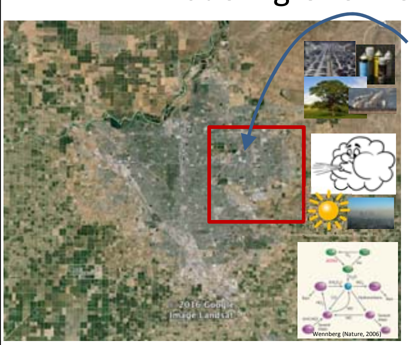

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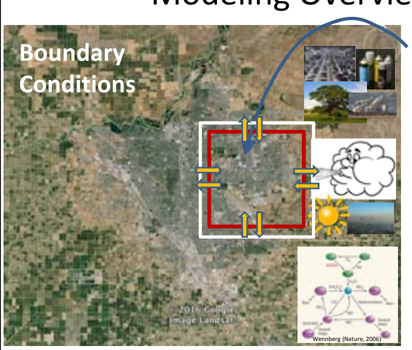

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NOx, VOCs, ozone

BCs
External
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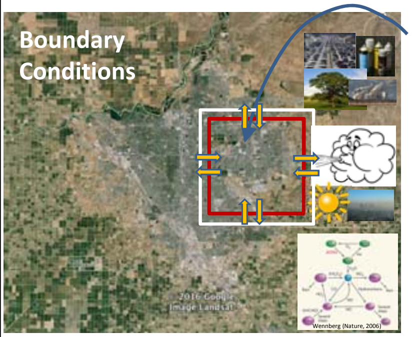

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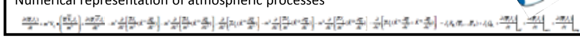
Numerical representation of atmospheric processes



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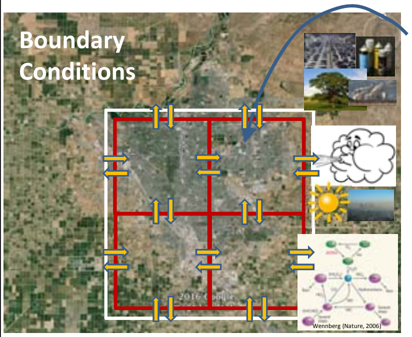

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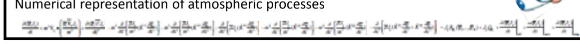


Modeling Overview *(cont.)*

<u>Emissions</u>
- 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

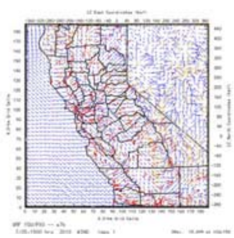
<u>Meteorology</u>
- Generated using a 3-D numerical model
- Very time consuming to exercise and fine-tune

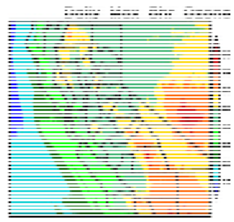
<u>Chemistry</u>
- Chemistry (or chemical mechanism) plays a central role in air quality modeling
- Describes the photochemical reactions that take place in the atmosphere and that lead to ozone formation

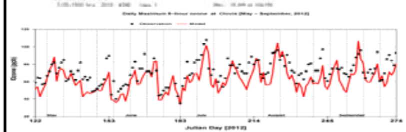
<u>Boundary Conditions</u>
- Derived from global models to provide time- and space-varying information
- Capture the transport of external emissions that could affect modeling region

<u>Photochemical Model</u>
- Mathematical representation of our best knowledge about atmospheric processes

Modeling Overview *(cont.)*







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

The Ozone SIP Modeling Process

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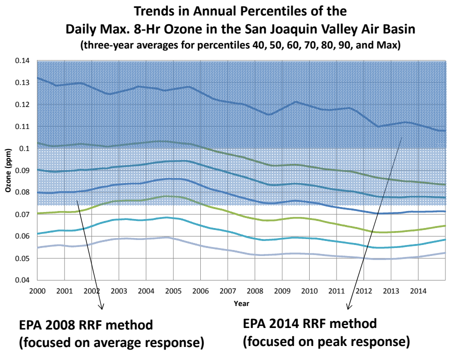
Model Attainment Demonstration

- 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



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 8-hr O_3 SIP (84 ppb)
  – Projected attainment by 2023
  – On target for attainment with several sites already in attainment
- 2013 1-hr O_3 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 NOx 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

<u>CCOS / CRPAQS *(cont.)*</u>

- 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

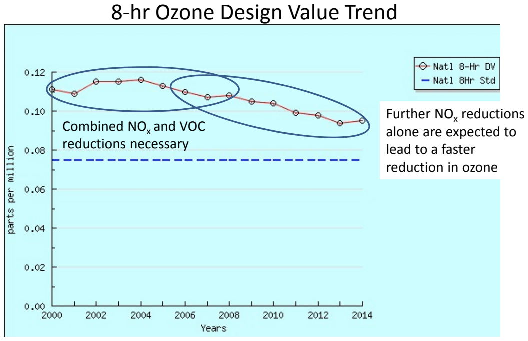
- SIP modeling process begins well in advance (2-3 years) before a SIP is due.
- Requires hundreds of modeling simulations to properly reflect observed meteorology and air quality patterns.
- Must reflect ongoing improvements to emission inventory (iterative process).

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



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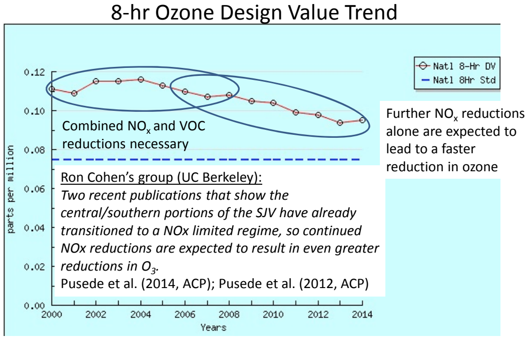

Model Results

Emissions Summary

CEPAM v1.03 summer inventory for SJV Air Basin

	2012 (tpd)	2031 (tpd)
NO_x (total)	**341**	**130**
Stationary Sources	43	30
Areawide Sources	5	5
On-road motor vehicles	188	45
Other Mobile Sources	106	51
ROG (total)	**338**	**296**
Stationary Sources	85	100
Areawide Sources	147	153
On-road motor vehicles	61	18
Other Mobile Sources	45	25
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	95	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	85	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	0.7729	74
SequoKingCan	93.0	0.7038	65
Fresno-Drmnd	92.3	0.7713	71
Parlier	92.0	0.7513	69
Fresno-Grld	90.7	0.7813	70
Arvin	89.3	0.7242	64
Fresno-Sky2	89.0	0.7685	68
Edison	87.7	0.7398	64
Baker-5558Ca	86.7	0.7573	65
Portrvlle-Ne	86.3	0.7328	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?