A Satellite-Dispersion Modeling System to Downscale Fine Particulate Fields to Near-Road Scale

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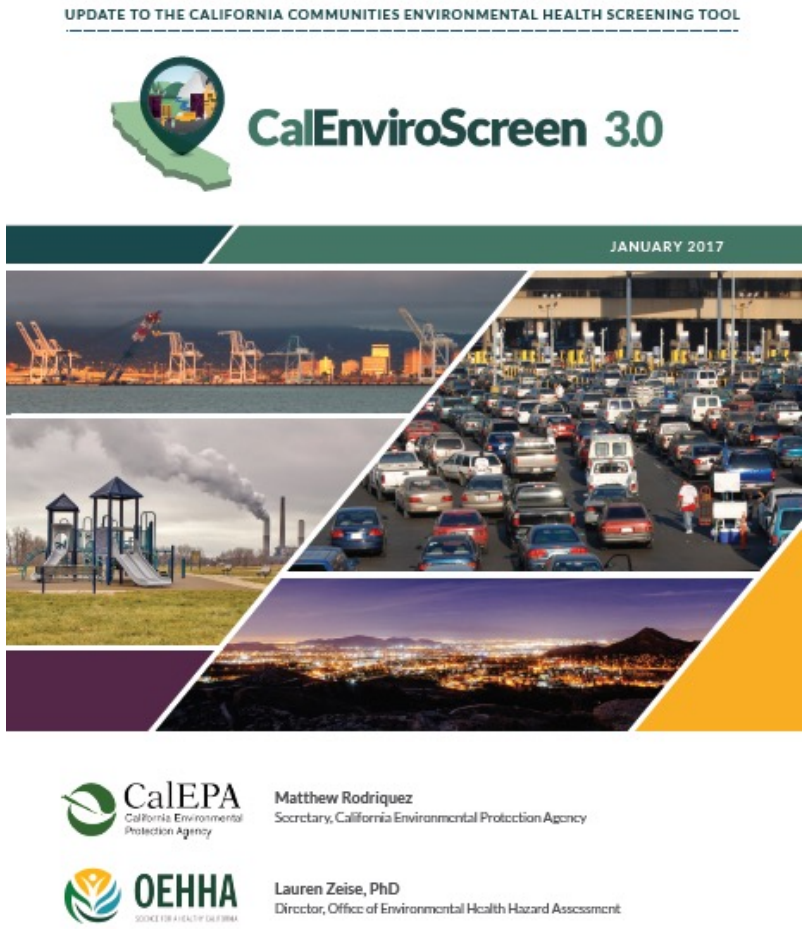
Stakeholders (1)

- **California Air Resources Board**
  - Cal EnviroScreen 3.0
  - U.S. Mexican border issues
  - Cynthia Garcia, Hyung-Joo Lee, Jin Xi (Research Division)
- **California Department of Public Health**
  - Imperial Valley & U.S. Mexican Border Issues (IVAN Network support)
  - UNC Passive Sampling (Bay Area)
  - Paul English (Environmental Health Investigations Branch), Jeff Wagner (Environmental Health Laboratory Branch)

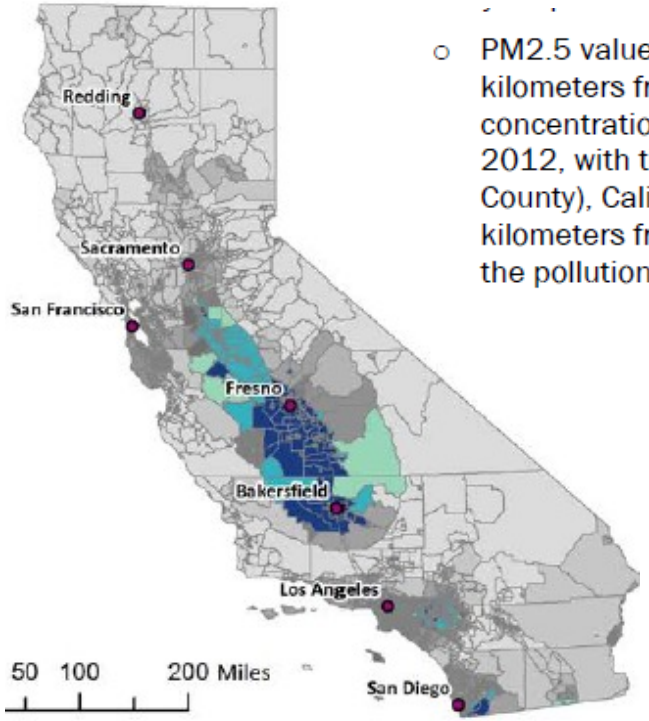
Stakeholders (2)

- **South Coast Air Quality Management District**
  - MATES V Planning Support (Long-term health risk study …)
  - Sang-Mi Lee (Planning, Rule Development & Area Sources)
- **Bay Area Air Quality Management District**
  - Model evaluation, emissions determination, BenMAP health risk assessment
  - Saffet Tanrikulu (Planning & Climate Protection)
  - Collaborration w Meytar Sorek Hamer and Bob Chatfieid (NASA AMES)
  - See poster

Use of Satellite-derived PM2.5 Fields for California (Precedent …)



Current version PM2.5 fields, annual averages at census tract level …



- PM2.5 values for census tracts with centers more than 50 kilometers from the nearest monitor were assigned a concentration based on satellite observations for the years 2006-2012, with the exception of the monitor in Portola (Plumas County), California. Satellite data was used for areas beyond 10 kilometers from the Portola monitor due to the localized nature of the pollution in Portola.

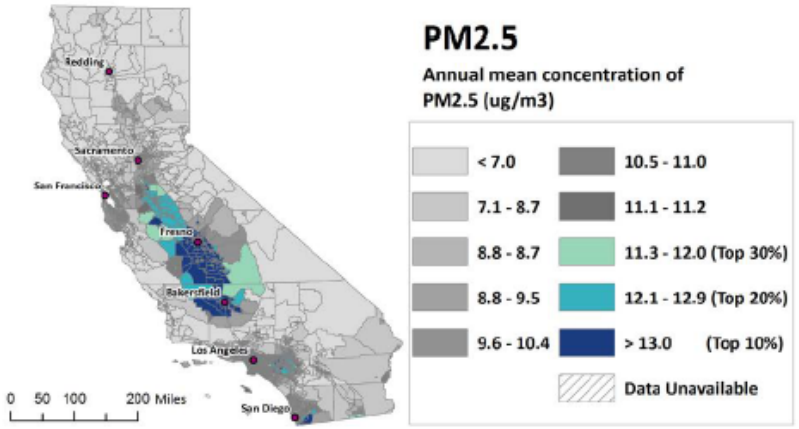
Employs Lee et al. (2016) satellite-derived PM2.5 for areas more than 50 km from monitor (2006 – 2012, Deep Blue 10-km)

Update to current years…
Higher resolution satellite products …

https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

Dispersion Model Downscaling
(Possible use to support CalEnviroScreen)

Annual average PM2.5 pollution concentrations

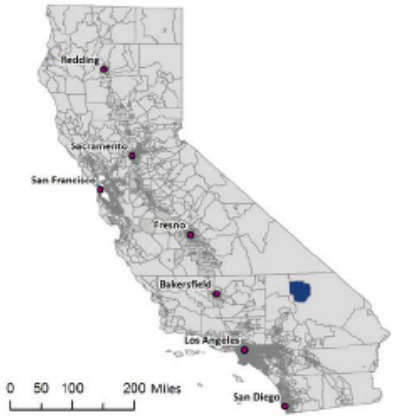


PM2.5

Annual mean concentration of PM2.5 (ug/m3)

< 7.0	10.5 - 11.0
7.1 - 8.7	11.1 - 11.2
8.8 - 8.7	11.3 - 12.0 (Top 30%)
8.8 - 9.5	12.1 - 12.9 (Top 20%)
9.6 - 10.4	> 13.0 (Top 10%)
	Data Unavailable

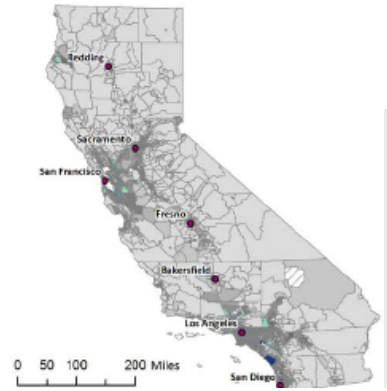
Proxies for diesel and road-traffic pollution concentrations



Diesel PM

Diesel PM emissions from on-road and non-road sources for a 2012 summer day in July (kg/day)

0 - 3	17 - 19
4 - 7	20 - 23
8 - 11	24 - 27 (Top 30%)
12 - 13	28 - 36 (Top 20%)
14 - 16	> 36 (Top 10%)



Traffic Density

Vehicle-km per hour divided by total road length (2013)

< 273	701 - 851
274 - 389	852 - 1,055
390 - 493	1,056 - 1,370
494 - 587	1,371 - 1,919
588 - 700	> 1,920
	Data Unavailable

Questions

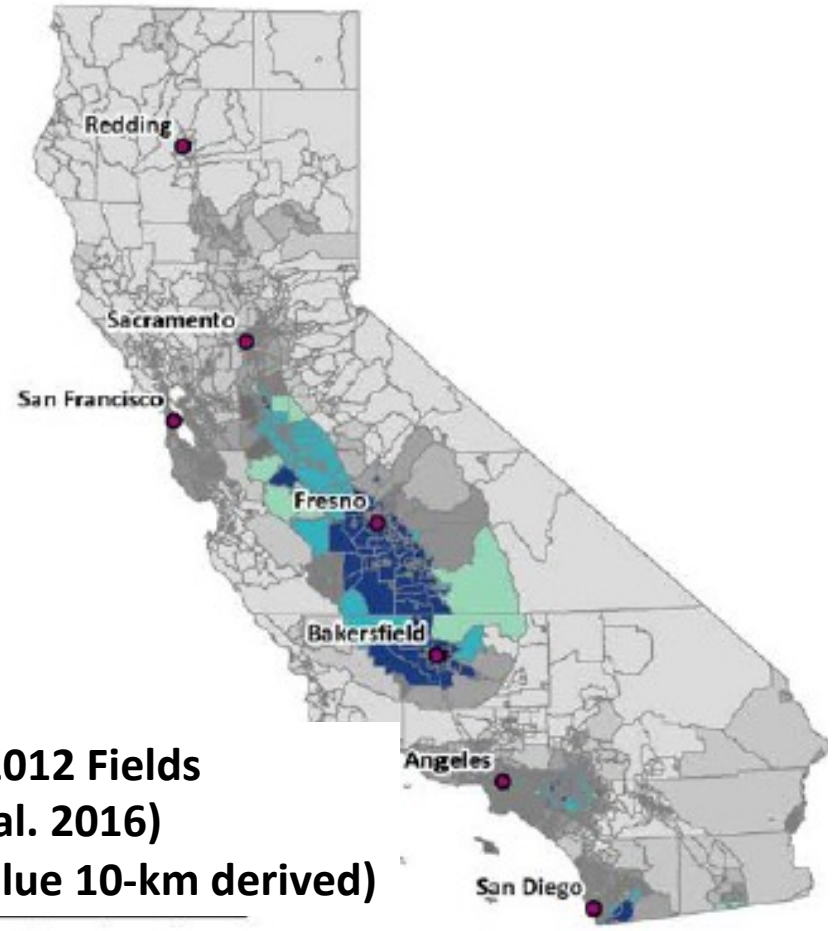
- Can dispersion modeling downscaling system provide a useful, direct estimate of underlying PM2.5, diesel and ultrafine particulate fields at census tract scale?
- Can system be designed to be practical for end-user application?

Satellite-Informed PM2.5 Fields for California (Procedure)

- Al-Hamdan et al. (2009, 2014)
- Based on AOD->PM2.5 regression model
- 3-km resolution fields for California for 2016
- Dark Target 3-km satellite AOD product (MODIS, AQUA satellite)
- Meteorological co-variates in regression
- Bias Correction, QA/QC, B-spline smoothing

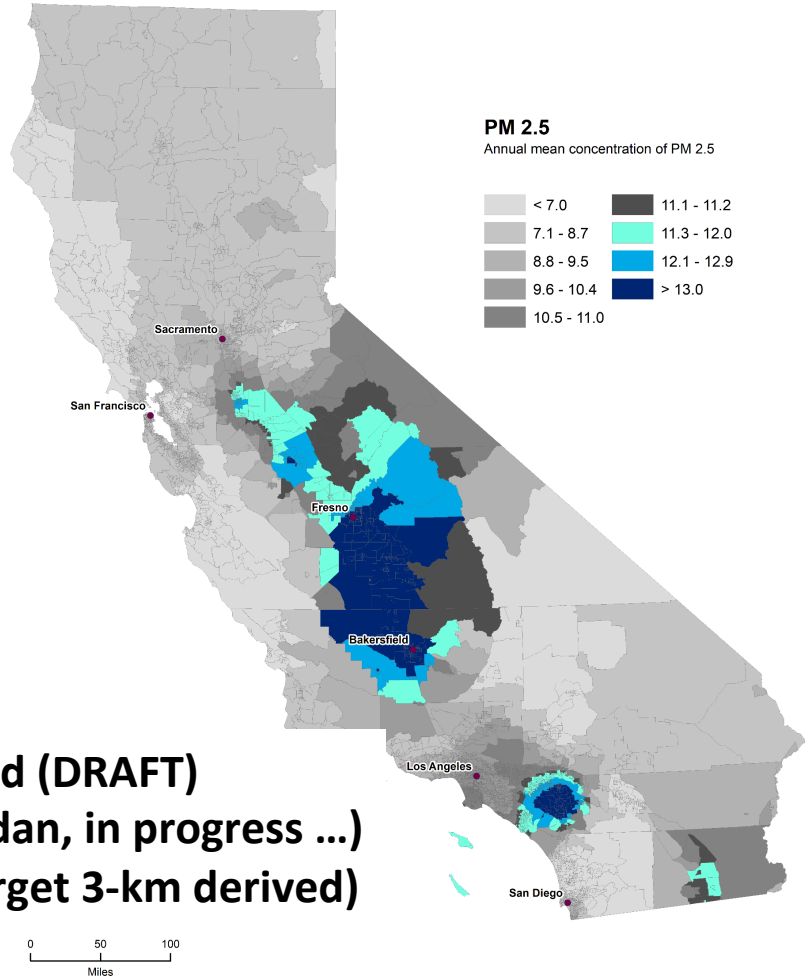
Satellite-Informed PM2.5 Fields for California (by Census Tract)

Current version in Cal EnviroScreen (2006 – 2012)



2006 - 2012 Fields
(Lee et al. 2016)
(Deep Blue 10-km derived)

DRAFT Results (2016)



2016 Field (DRAFT)
(Al-Hamdan, in progress …)
(Dark Target 3-km derived)

Dispersion Modeling Downscaling (Procedure)

- **Define area of interest:** single or set of daily, gridded satellite-derived PM25 concentrations
- **$PM25_{SAT}$**: Satellite-derived PM25 concentration (24-hour avg.) over area of interest
- **$PM25_{DM}$**: Dispersion model estimated PM25 concentration (24-hour avg.) over area of interest
- **< >** - spatial average over area of interest

(1) Dispersion model estimated field …

$$PM25_{DM}(x,y) = PM25_{REG,DM,P} + PM25_{REG,DM,S} + PM25_{LOC,DM,P}(x,y).$$

Regional: LBM Model **Local**: Line-Source Model

Dispersion model field sum of **regional** & **local** contributions

Regional: LBM model
Local: Line-source model

(2) Scale dispersion model field to match satellite

$$PM25(x,y) = PM25_{DM}(x,y) \times [PM25_{SAT} / \langle PM25_{DM} \rangle]$$

Scale dispersion model field
So average over area of interest
Matches satellite-derived value.

Dispersion Modeling Downscaling
(Example: December 8, 2016 @ Riverside CA)

Given …

Satellite-derived value @ area of interest on December 8 , 2016

= 19.6 µg/m3

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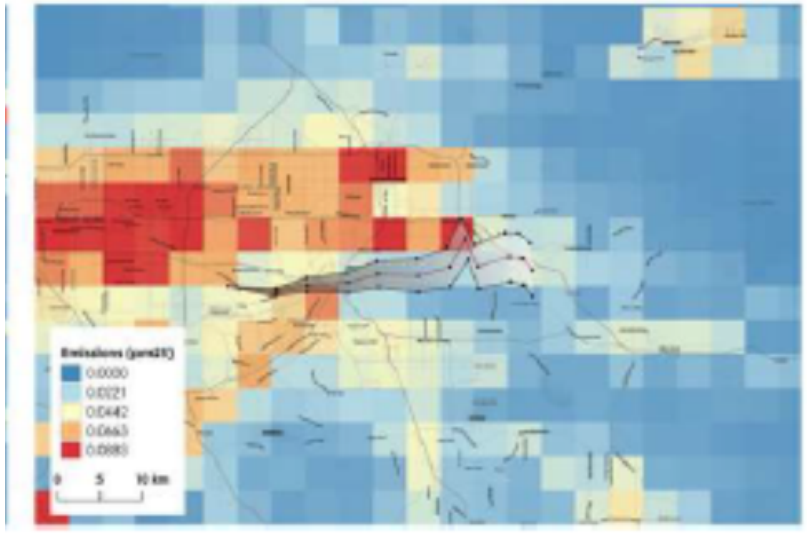
Step 1
- **LBM Model**
- **Regional PM2.5**



LBM calculated back-trajectories
(example: hour 0700 LST Dec. 8, 2016)

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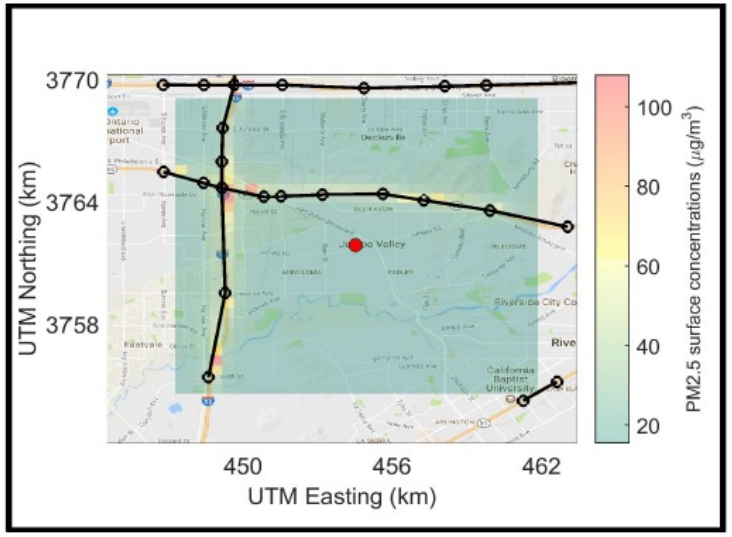
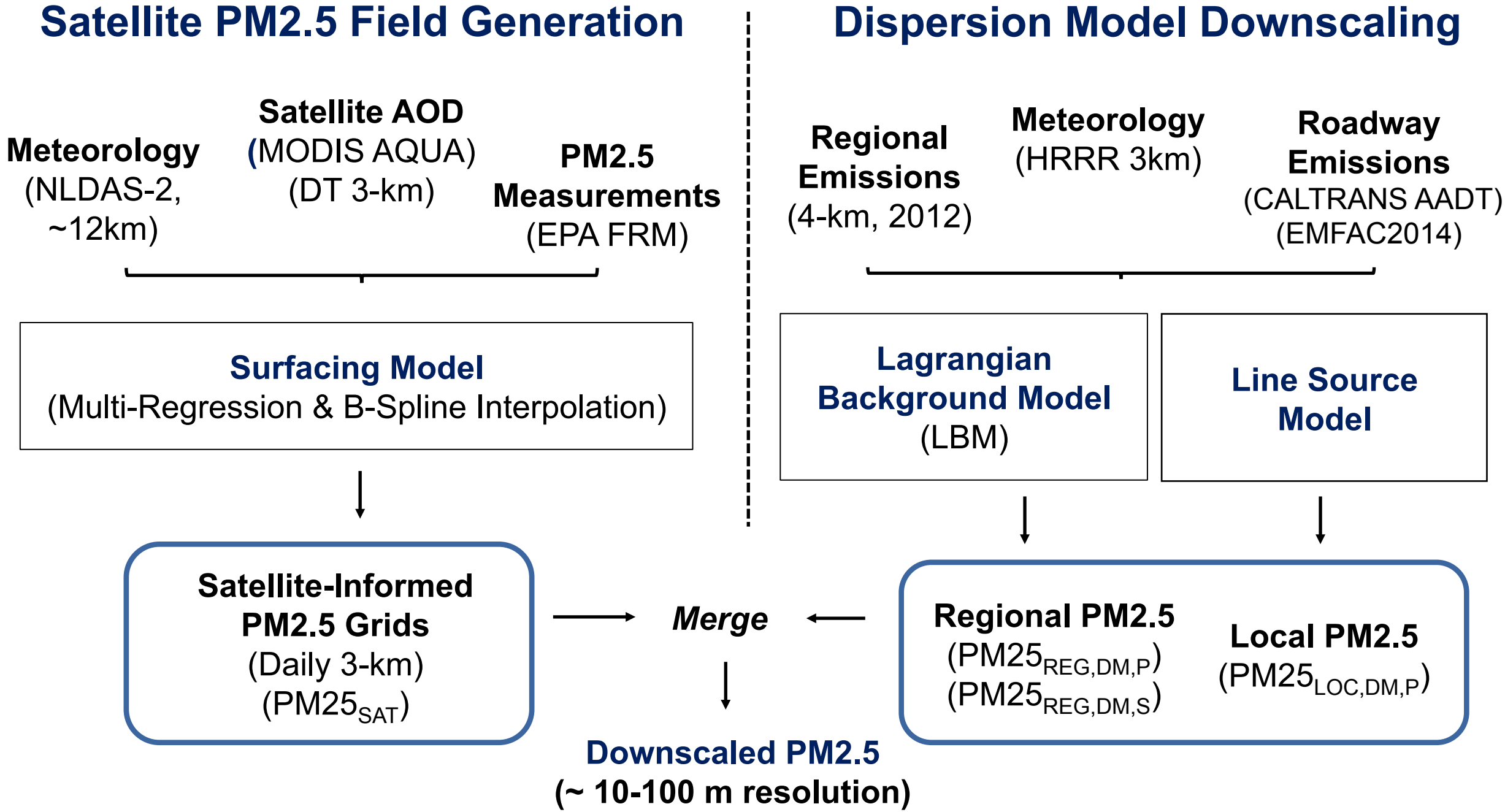
Step 2:
- **Line Source Model: Local PM2.5**
- **Scaling to match satellite-value**



Downscaled Dec. 8 field


Satellite PM2.5 Field Generation
Dispersion Model Downscaling
Meteorology
(NLDAS-2,
~12km)
Satellite AOD
(MODIS AQUA)
(DT 3-km)
PM2.5
Measurements
(EPA FRM)
Regional
Emissions
(4-km, 2012)
Meteorology
(HRRR 3km)
Roadway
Emissions
(CALTRANS AADT)
(EMFAC2014)
Surfacing Model
(Multi-Regression & B-Spline Interpolation)
Lagrangian
Background Model
(LBM)
Line Source
Model
Satellite-Informed
PM2.5 Grids
(Daily 3-km)
(PM25SAT)
Merge
Regional PM2.5
(PM25REG,DM,P)
(PM25REG,DM,S)
Local PM2.5
(PM25LOC,DM,P)
Downscaled PM2.5
(~ 10-100 m resolution)

Next steps …

System up and running, onward …

- **Fine-tune internal physics**: Satellite AOD-PM2.5 & Dispersion Modeling
- **Increase computational efficiency** (implement on multi-processors)
- **Define case-studies** for evaluation & applications

Further details …

- “A Satellite-Dispersion Modeling System to Generate High-Resolution Downscaled PM2.5 Field”. Presented at the 16th Annual CMAS Conference, Chapel Hill, NC, October 23-25, 2017.

  https://www.cmascenter.org/conference//2017/abstracts/freedman_satellite-dispersion_2017.pdf

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