Use of Satellite Remote Sensing Data to Support Air Quality Decision-making

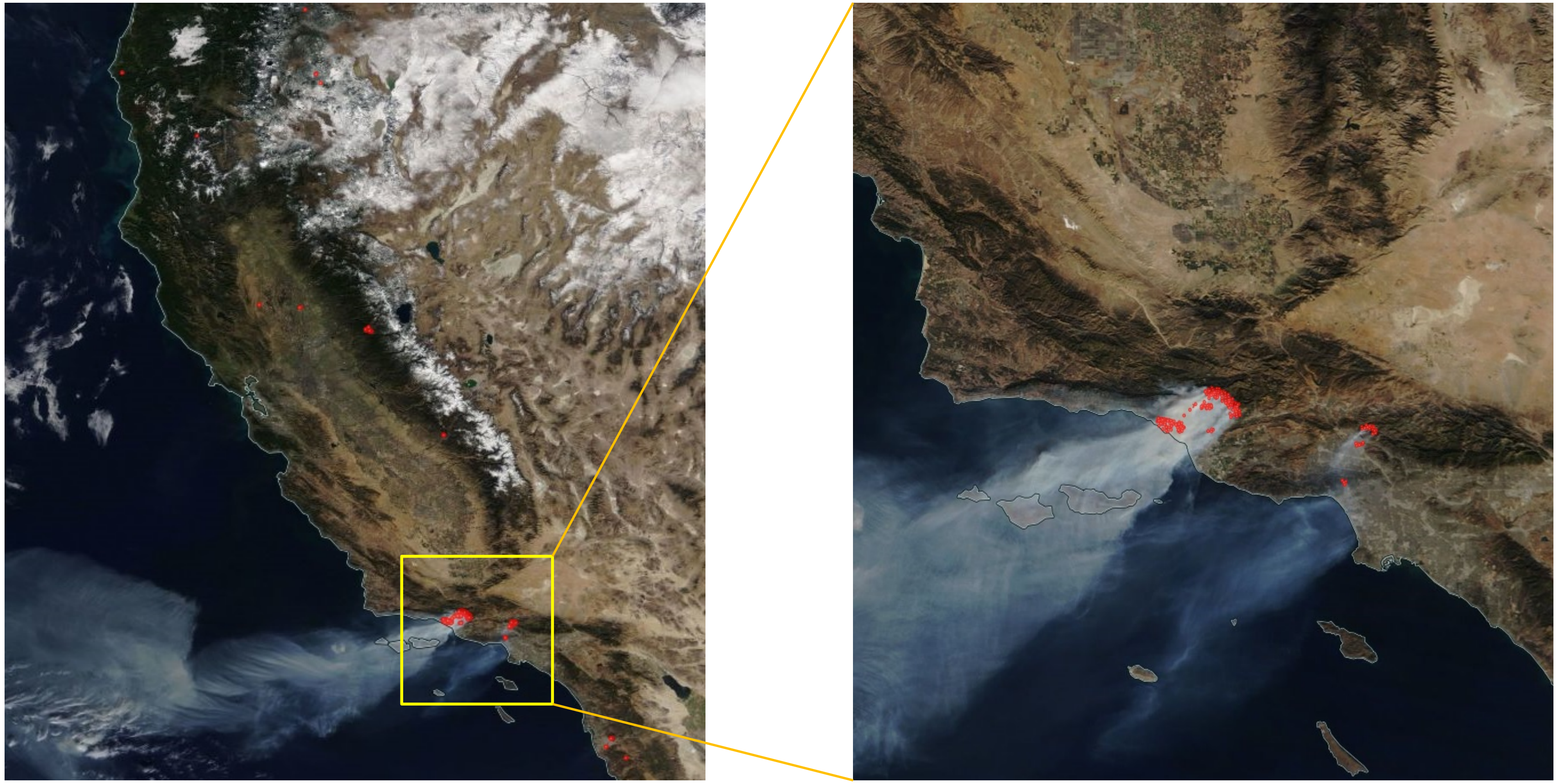
JULY 26, 2018

CALIFORNIA AIR RESOURCES BOARD

Outline

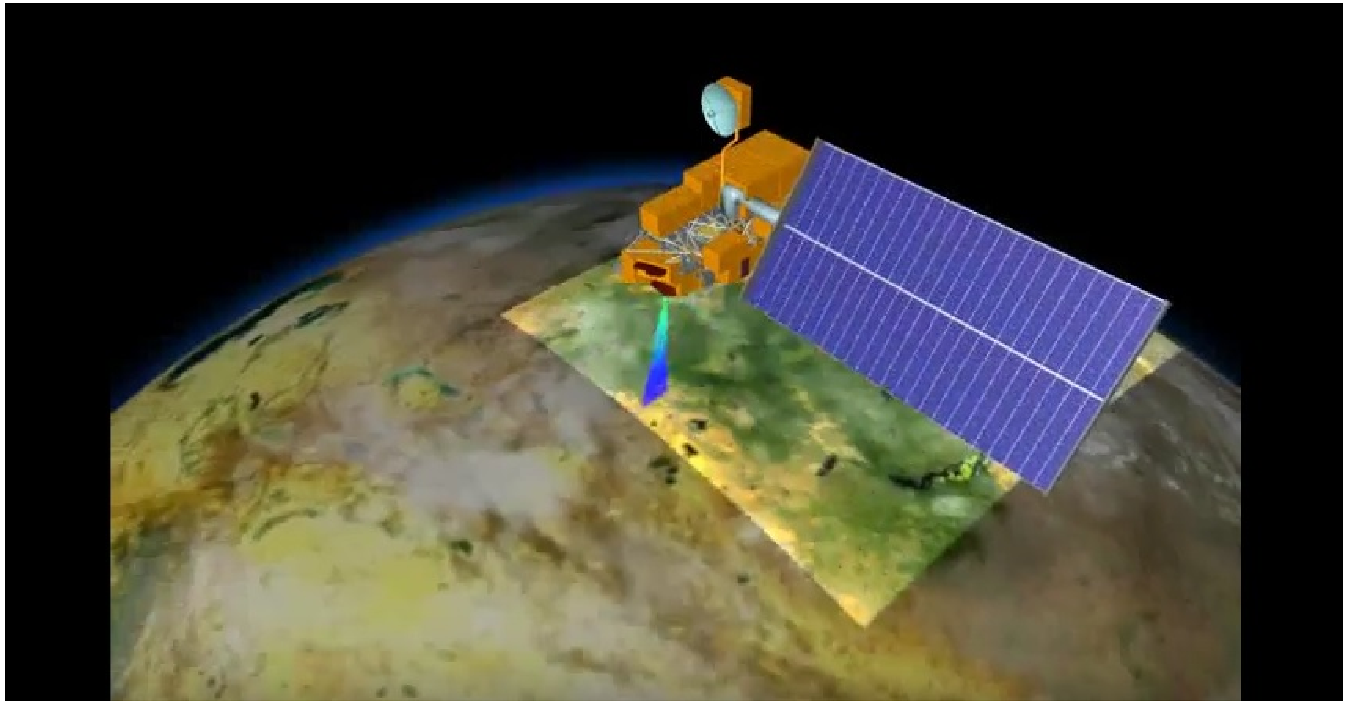
- Overview of air quality data from satellites
- Uses of satellite data for California programs
- Next-generation satellite instruments

Wildfire Smoke Tracking



Thomas Fire (December 6, 2017, NASA)

How Satellite Sensors Work



Video: NASA

Sensor Observations

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Atmosphere

+

Surface

Satellite Data for Air Quality Estimates

- Advantages
  - Wide spatial coverage (complementing ground monitors)
  - Cost-effective, consistent observations globally
- Limitations
  - Daytime and cloud-free conditions
  - Snapshot in time (if not geostationary satellite)
  - Column measurements (difficult to correlate column O_3 to ground O_3)

Multiple Pollutants Can be Estimated Using Satellite Data

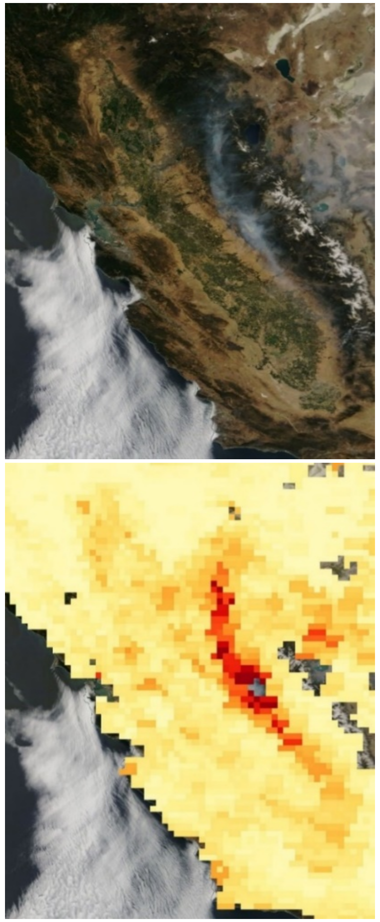
Pollutant	Satellite	Product	Resolution
Criteria pollutants			
AOD (for PM2.5)	MODIS	Standard MAIAC	10 and 3 km 1 km
	VIIRS		6 km
	MISR		4.4 km
NO_2	OMI	Standard/BEHR	13 × 24 km
SO_2	OMI		13 × 24 km
CO	AIRS		50 km
	MOPITT		22 km
O_3	OMI (dominated by stratospheric O_3)		13 × 24 km
Other pollutants			
CH_4	AIRS		50 km
	GOSAT		10 km
HCHO	OMI		13 × 24 km
CO_2	OCO-2		1.29 × 2.25 km
NH_3	TES		5 × 8 km
	CrIS		14 km

California Applications

- Complementary to ground monitors and research tools
  - Screen for pollution hotspots
  - Track progress
  - Augment research studies

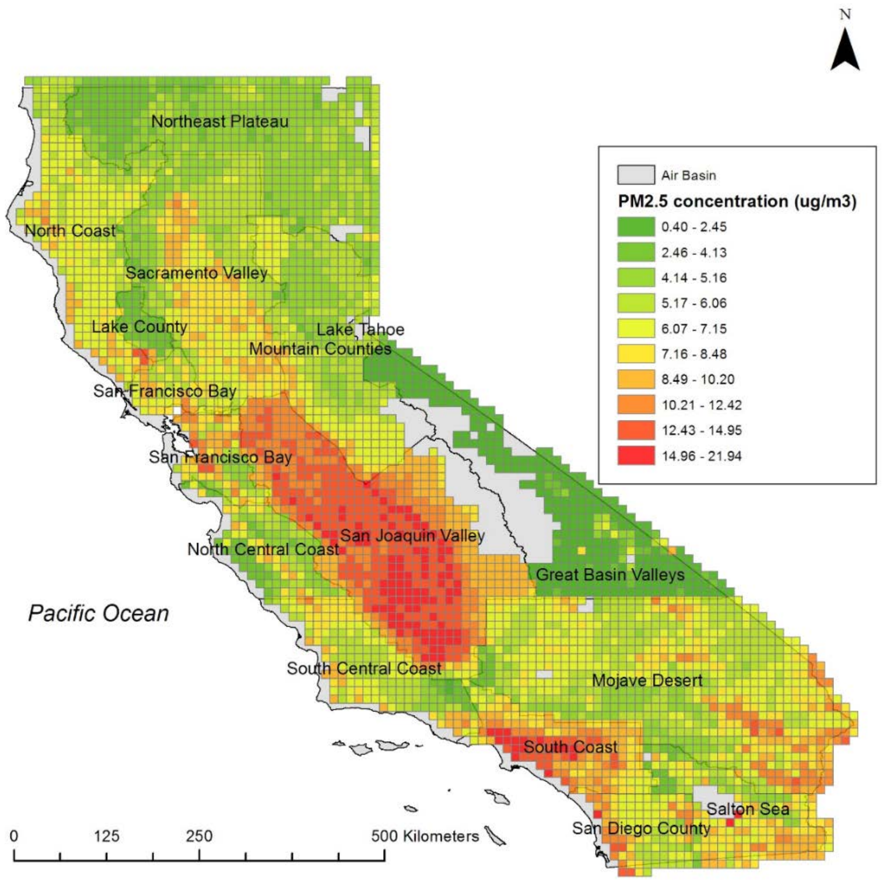
Satellite Data for PM2.5 Estimation

- Aerosol optical depth (AOD)
  - Light extinction (scattering and absorption) by aerosol
  - Particle abundance in the atmospheric column
- Statistical models to relate AOD to PM2.5
  - Ground-based PM2.5 monitors required for the calibration
  - Combination with meteorology and land use parameters (as emission proxies)
- Fills in the spatial gaps for PM2.5



Photos on July 20, 2017 (NASA WorldView)

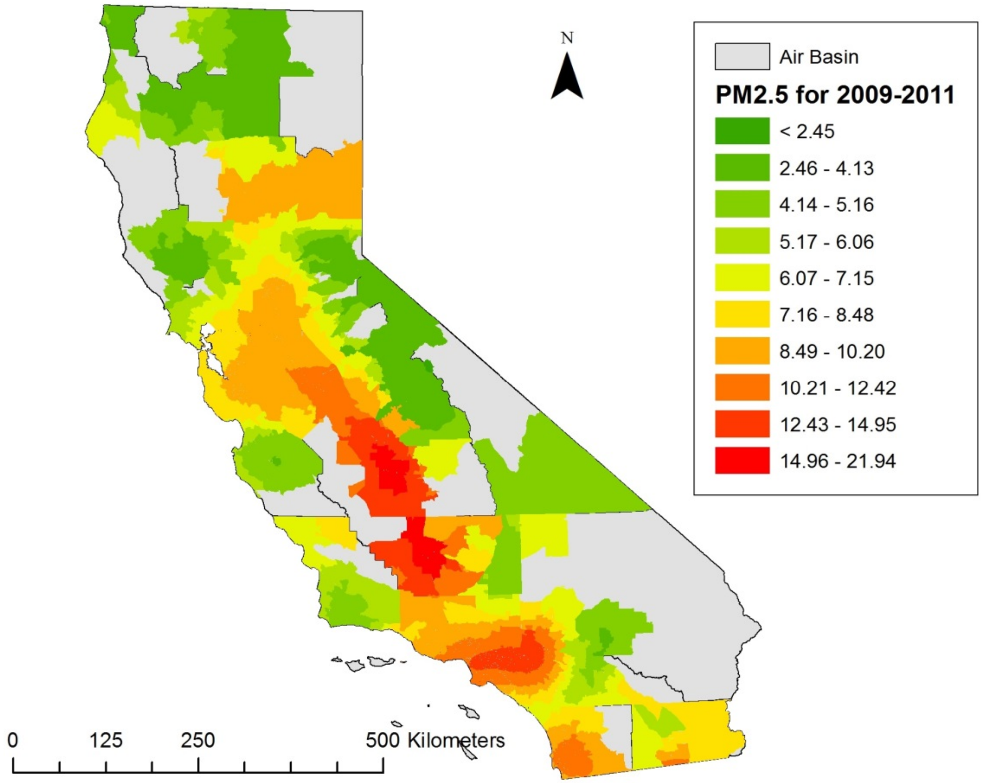
PM2.5 at 10-km Resolution



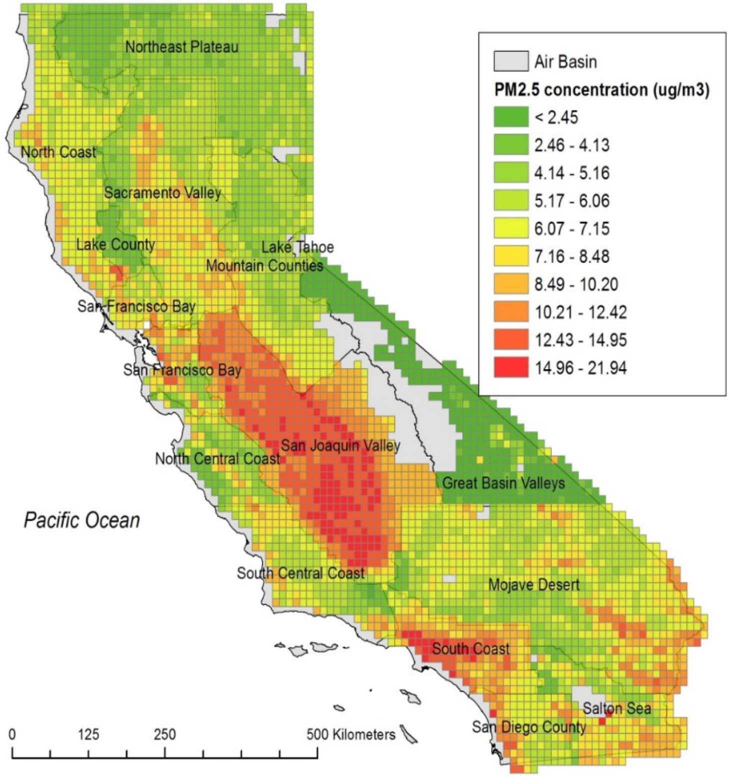
- MODIS AOD for 2006-2012
- Higher PM2.5 estimated in
  - More populated areas (e.g., LA, SF, and SD)
  - San Joaquin Valley (particularly Southern SJV)
  - U.S.-Mexico border areas
- Incorporated into CalEnviroScreen 3.0

Lee et al. (2016) Enhancing the applicability of satellite remote sensing for PM2.5 estimation using MODIS deep blue AOD and land use regression in California, United States, *Environmental Science & Technology*

Satellite Data Fill in Gaps Where Ground Monitoring is Sparse

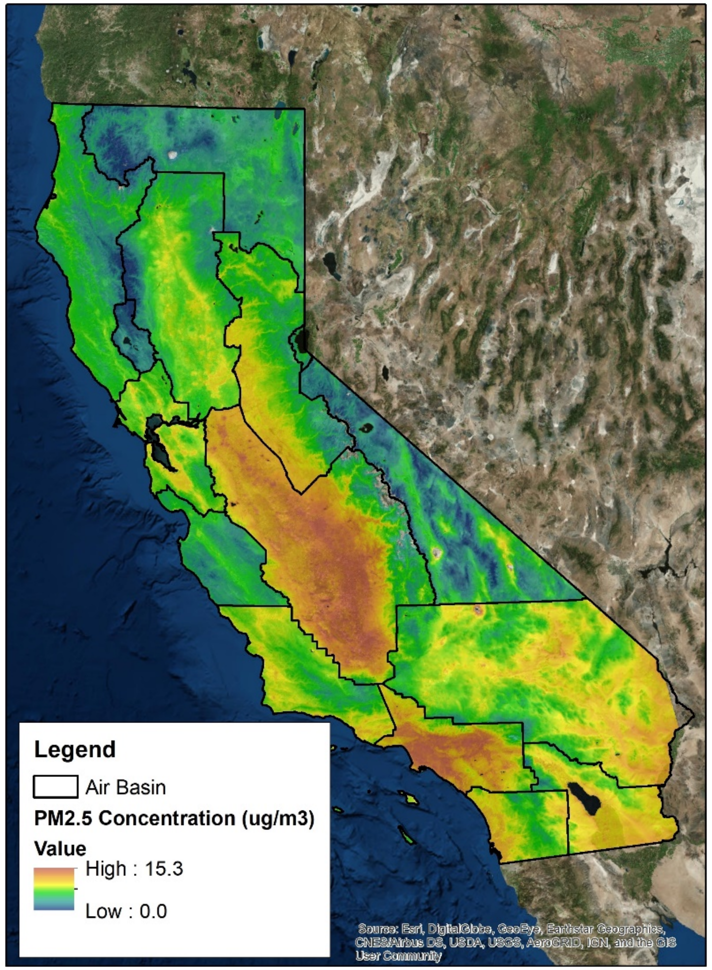


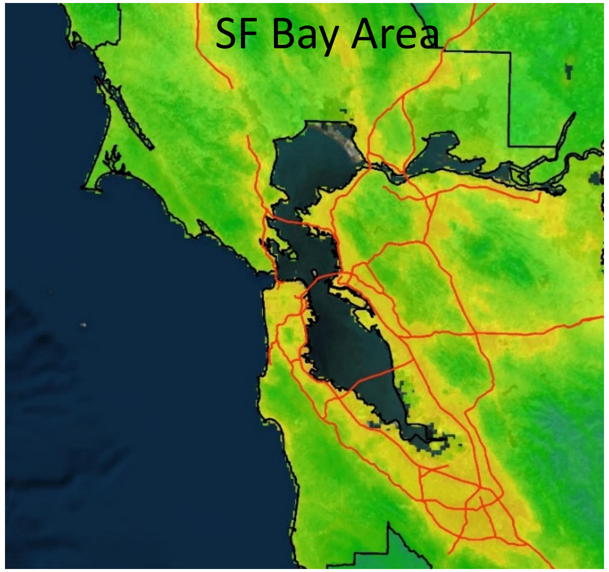
CalEnviroScreen 2.0

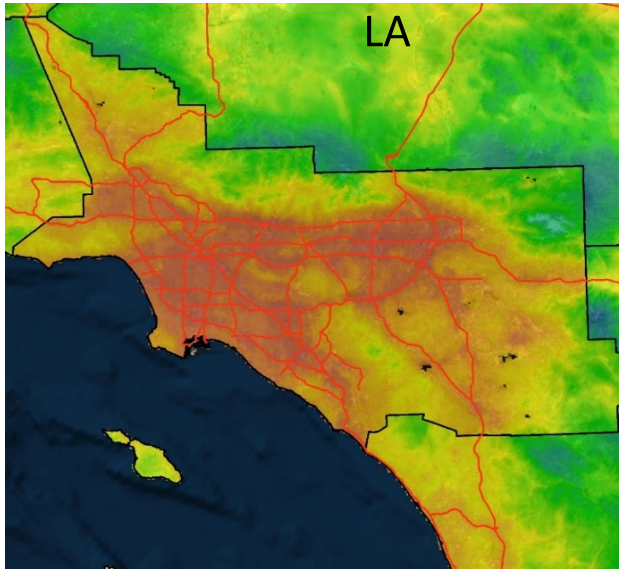


CalEnviroScreen 3.0

Next Step: PM2.5 at 1-km Resolution *





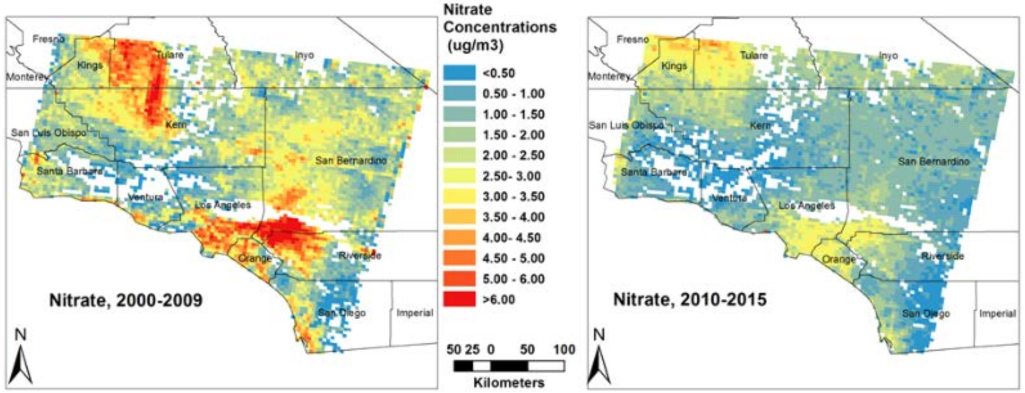


- Community-level PM2.5 distribution for 2016
- Higher PM2.5 estimated in higher populated and traffic areas
- Potential to track progress in AB 617 communities

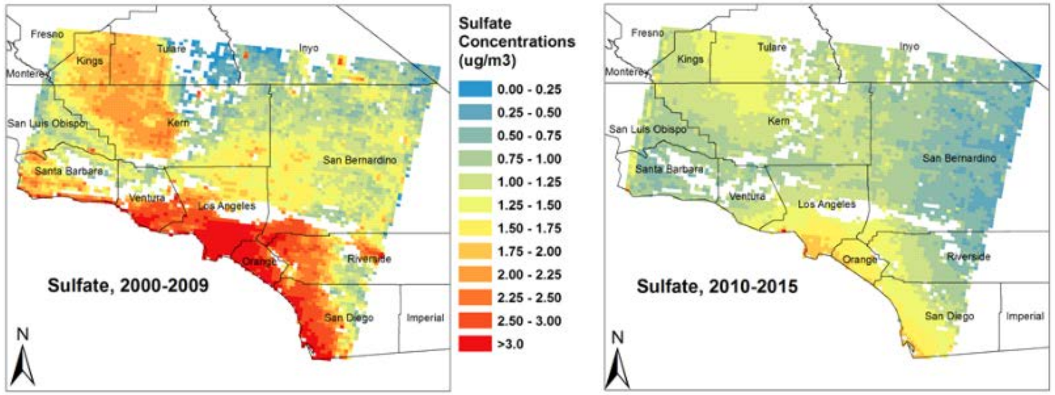
* Note: Preliminary results. Work in progress (2018)

Satellite Data Show Progress in Major PM2.5 Components Over 15 Years

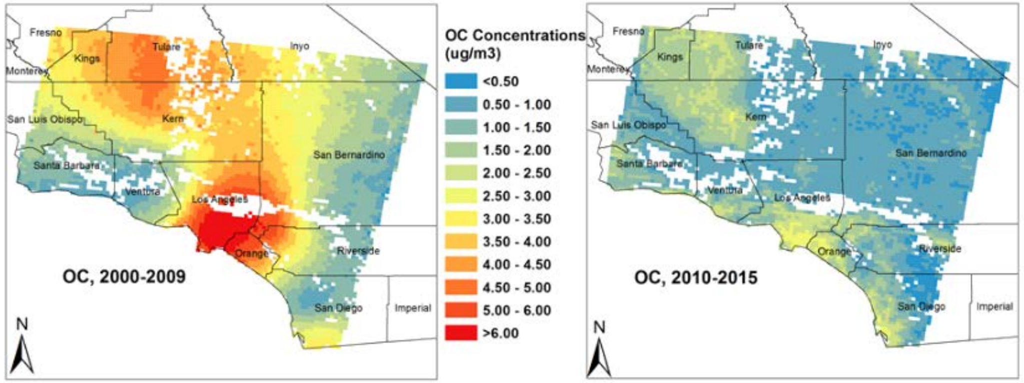
Nitrate



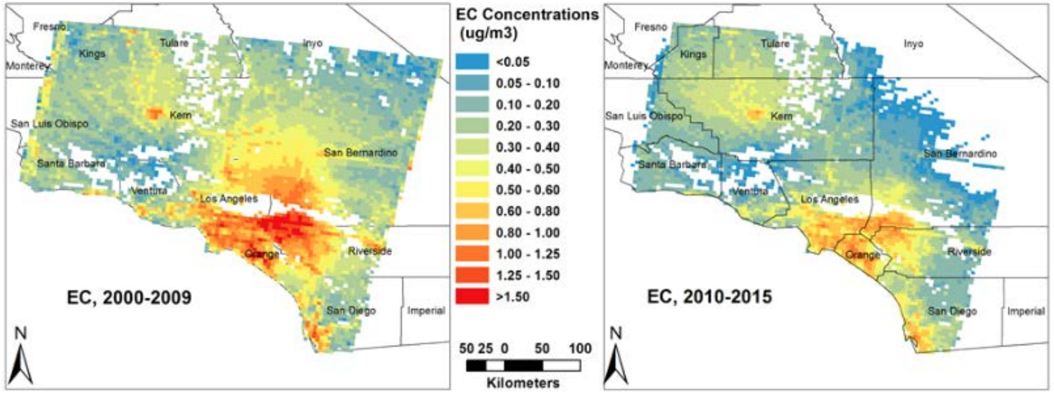
Sulfate



Organic Carbon



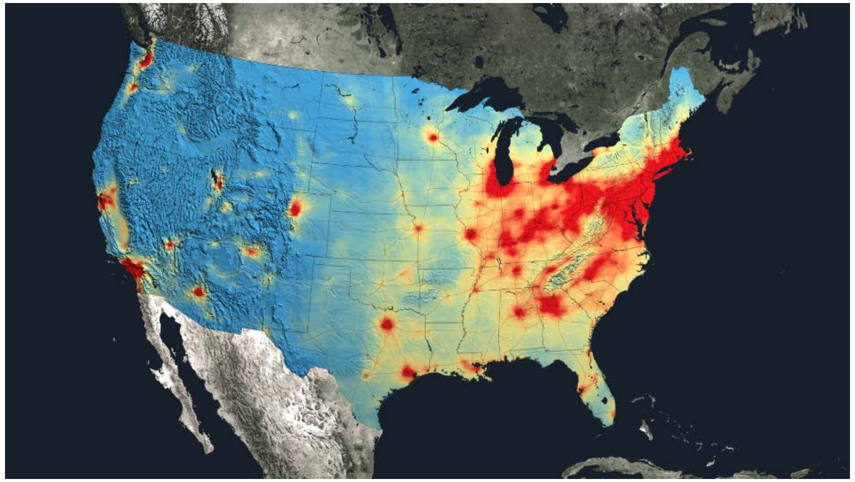
Elemental Carbon



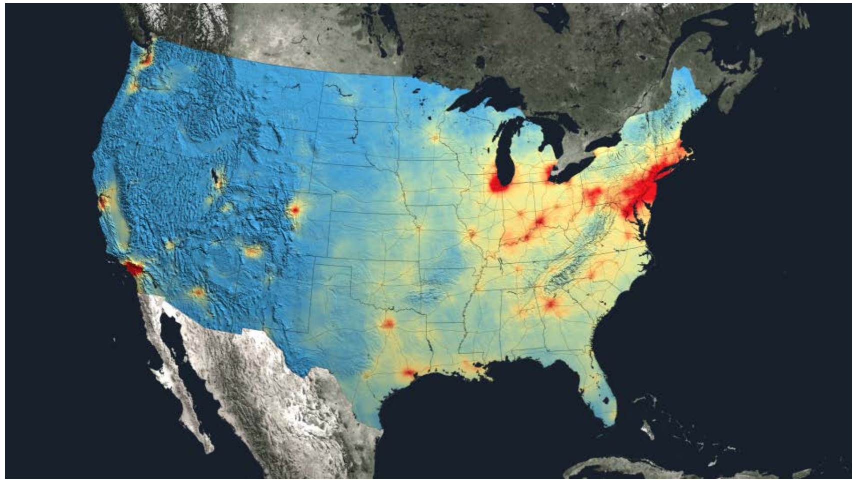
Meng et al. (2018) Estimating $PM_{2.5}$ speciation concentrations using prototype 4.4 km-resolution MISR aerosol properties over Southern California, *Atmos. Environment*

Current California Satellite Research

- Health studies
- EJ analyses
- Identification of ammonia, methane, and NO_X sources



NO_2 in 2005



NO_2 in 2011

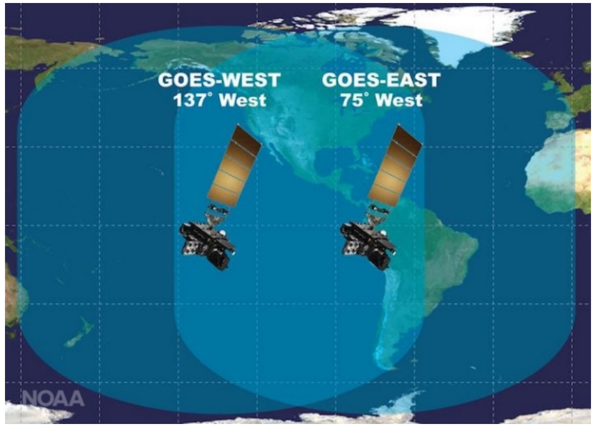
High

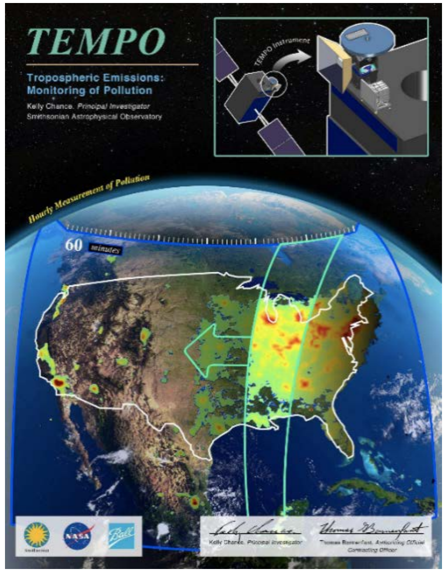
Low

Photos: NASA

Next-Generation Satellite Instruments

- NOAA GOES-16 satellite AOD
  - Every 15 minutes (daytime) at 2-km resolution
  - Diurnal variability in PM2.5
  - Pollution source tracking
- NASA satellites after 2020
  - MAIA – daily particle size and composition
  - TEMPO – hourly PM2.5, NO_2, HCHO and ground ozone
  - Enhanced source identification and pollutant transport
- Commercial satellites





Conclusions

- Satellite remote sensing is a powerful and cost-effective tool to:
  - Screen for air pollution hotspots
  - Fill spatial gaps in ground monitoring networks – CalEnviroScreen
  - Track progress – AB 617 and SIPs
- Both ground and satellite resources are critically needed due to their different spatial and temporal scales
- Next-generation satellite sensors will greatly expand our capabilities to support CARB’s programs

Thank you

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