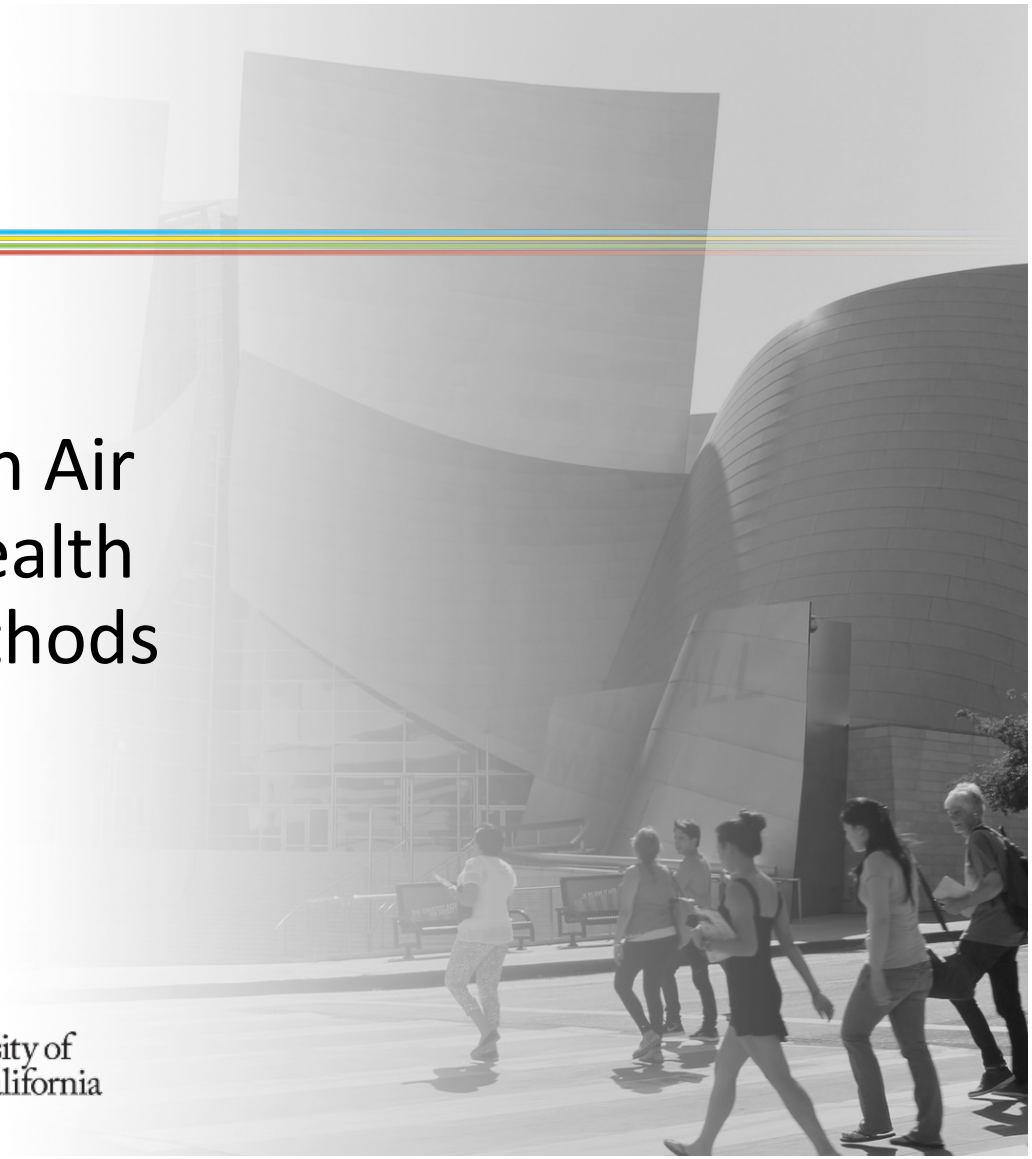
LA100

The Los Angeles 100% Renewable Energy Study



# Impact of LA100 Scenarios on Air Pollution and Consequent Health Impacts: an Overview of Methods


Presenter: Prof. George Ban-Weiss (USC)

Collaborators: Dr. Garvin Heath (NREL)

Dr. Jiachen Zhang (USC)

Emma Tome (UC Berkeley & NREL)


LA DWP Los Angeles Department of Water & Power | NREL Transforming ENERGY | USC University of Southern California

# Agenda

- Recap and Background
  - Recap of prior AG presentation of air quality and public health
- Goals and Methods

# AG Meeting #6: August 16, 2018

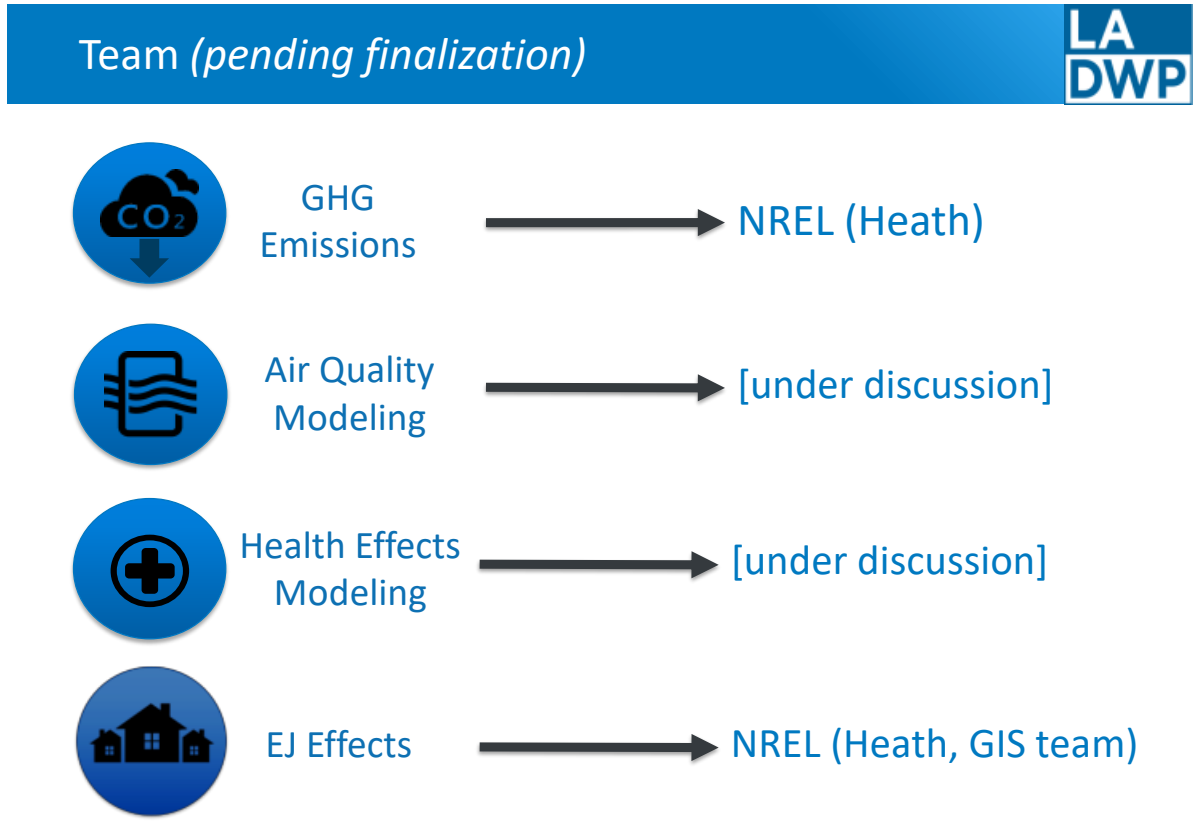
The context and methods were presented at a high level for **air quality and public health**

## Goals for Presentation

- Establish familiarity with our methods
  - More detailed for GHG emissions analysis
  - General approach for air quality, public health, and environmental justice
- Demonstrate how environmental modeling will meet the City Council Motions
- Convey timing of environmental modeling (follows main modeling and analytical tasks of the study)
- **Use your questions and comments to clarify and improve the study!**

# Leads for Each Environmental Modeling Component

Contracted with University of Southern California (USC) for air quality and public health modeling



# Final Points Made at AG #6

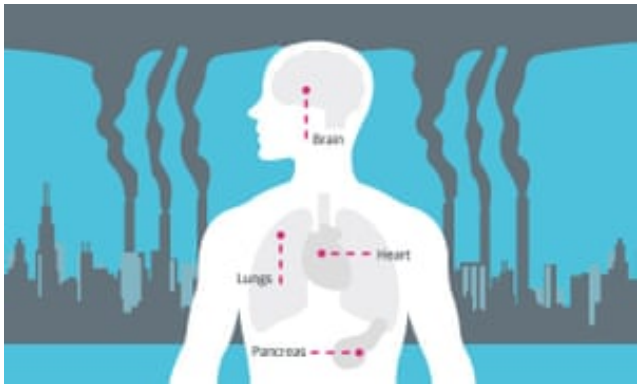
Will be elaborated in the next slides

## Air Quality and Public Health Modeling: Final Points

- We plan to evaluate the 100% RE scenarios for air quality and public health benefits that show discernable changes to air emissions (compared to baseline and amongst themselves)
  - Criteria for scenario selection will be discussed further in a next AG meeting
- We will consider emissions transported into the basin from nearby sources, some of whose operations could be affected by the changes to the LADWP assets considered in this study
- Changes to health effects will be discerned at a spatial resolution to match with neighborhoods identified as EJ neighborhoods (see next slides)

# Air Pollutants and Health Effects of Concern

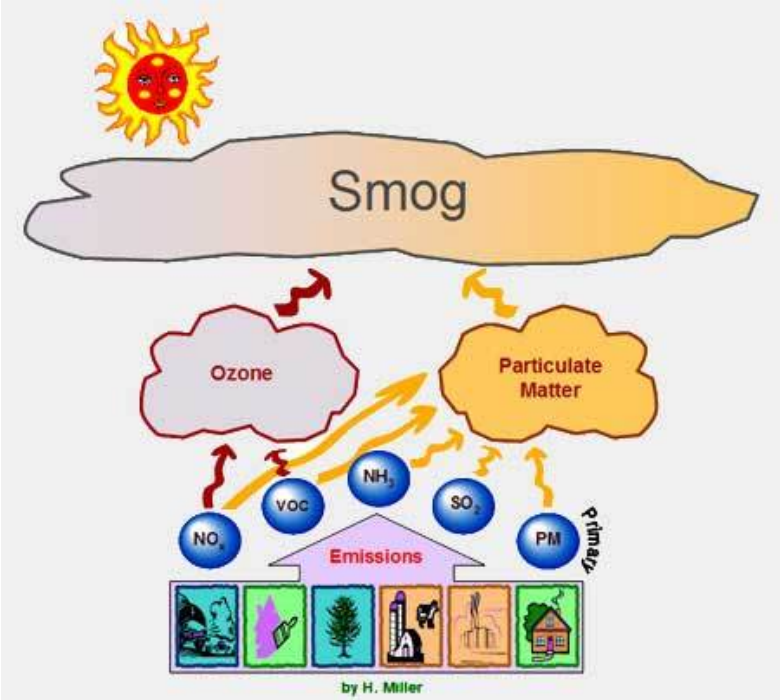
- The South Coast Air Basin (SoCAB) is out of compliance (AKA "nonattainment") with the National Ambient Air Quality Standards (NAAQS) for two key pollutants:
  - **Ozone ($O_3$)**
  - **Particulate matter (PM)**, especially "fine PM" = $PM_{2.5}$
- Health effects with the greatest damages in monetary terms are premature mortality from long-term exposure to $PM_{2.5}$ (1st) and ozone (2nd)
  - There are also numerous "morbidity" effects, which are health effects not including death, e.g., asthma, heart attacks, respiratory diseases
- Note that ozone, and many $PM_{2.5}$ species, are "secondary" pollutants (i.e., formed via chemical reactions in the atmosphere)




Source: https://www.theguardian.com/sustainable-business/2016/jul/05/how-air-pollution-affects-your-health-infographic

# How Are Ozone and $PM_{2.5}$ Formed?

- Ozone forms in the presence of nitrogen oxides (NOx), volatile organic compounds (VOCs), and sunlight
- Particulate matter is both directly emitted ("primary PM") and also formed in the atmosphere ("secondary PM") via *numerous* complex pathways
- Both form urban "smog," which LA has long tried to control




Source: https://www.cumbriacrack.com/2011/04/21/defra-puts-uk-on-smog-alert/

# Project Goals

**Overarching questions:**

1) How could future scenarios of renewable energy adoption by LADWP change LA's air pollutant emissions and concentrations?
   - Pollutants of focus are $O_3$ and $PM_{2.5}$
2) How could changes in $O_3$ and $PM_{2.5}$ concentrations alter deleterious health consequences from air pollution exposure within LADWP service territory?

Through evaluating impacts of selected LA100 scenarios, we aim to identify the sectors and source types affected by LA100 scenarios that could contribute most to overall air pollutant reductions.

# Overarching Method for Answering Research Questions

1) Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time
2) Creating emissions inventories that project air pollutant emissions under selected LA100 scenarios
3) Predicting future ozone and $PM_{2.5}$ concentrations with the emissions created in step 2 using a state-of-the-science, open-source air quality model
4) Assessing changes in health impacts from exposure to ozone and $PM_{2.5}$
5) Presentation of air quality and public health results, and handoff of results for evaluation of effects on environmental justice

While air quality modeling is challenging, time-consuming, and a computing resource-intensive step, **developing the emissions inventory** (steps #1 and 2) is actually the most time-consuming and critical step

# 1) Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time (part 1)

- An air pollutant emissions inventory specifies where, when, and how much of each pollutant is emitted
- Current inventory will be based on the official 2012 South Coast Air Quality Management District (SCAQMD) dataset, which is the latest available
  - This was the baseline inventory for the 2016 Air Quality Management Plan
  - 2012 is the same base year of meteorology for the LA100 study as a whole
  - SCAQMD has provided raw inventory files needing processing
  - This answers a question asked in AG #6 about what baseline inventory we would use

# 1) Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time (part 2)

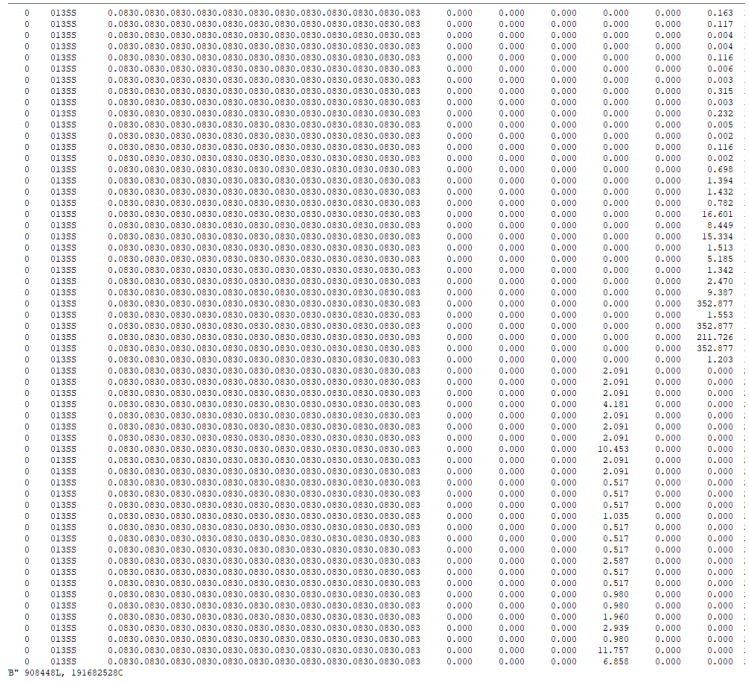
- Inventories include emissions from all sources
  - All source types: mobile sources (on-road and off-road), point sources (e.g., power plants, large industrial sources), and area sources (individually small but collectively significant)
  - There are ~2,500 source categories and >3 million individual sources
- Hourly emissions for the entire year of 2012 at 4km x 4km resolution
- Includes all pollutants relevant to formation of ozone and $PM_{2.5}$ (e.g., NOx, volatile organic compounds, ammonia, sulfur dioxide, and primary particulate matter)

# 1) Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time

We obtained the latest state-of-the-art source-oriented emissions from SCAQMD

Challenges:

- Raw emissions are large (37 GB), compiled in hundreds of txt files each with different formatting
- Reading and spatially allocating emissions from on-road mobile sources took ~40 hours for our server (and more time for chemical speciation)
- There’s no documentation for the raw emissions, so we have to rely on personal communication with SCAQMD experts



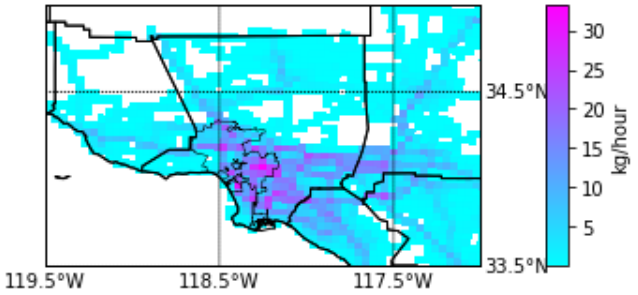
For example, the file for most area sources has >900,000 lines. Each line of the file represents emissions from a specific source in a grid cell.

# 1) Constructing a model-ready emissions inventory from source-oriented raw emissions for “current” time

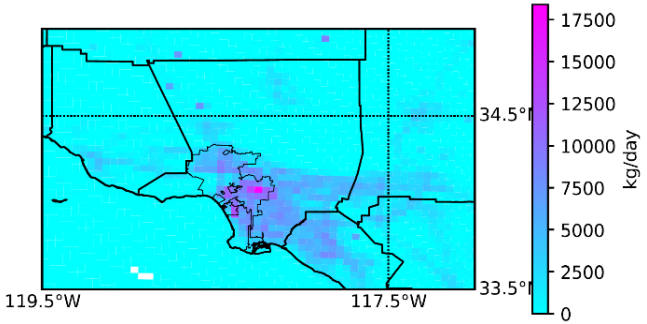
Procedure:

- Raw emissions import
- Spatial allocation
- Temporal allocation
- Chemical speciation
  - 6 species =>73 species
    (e.g., $NO_x$ => NO, $NO_2$, HONO)
- Unit conversion
- Aggregate emissions from different sources

Example map for on-road mobile-source NOx emissions at 08:00 LST on Jan 01, 2012




Example map for annual average CO emissions from all source types



# 2) Creating emissions inventories that project air pollutant emissions under various future renewable energy adoption pathways

The climate/air pollution model is very computationally expensive, so we can carry out simulations for only ~four scenarios including a "current" one

Below are scenarios currently recommended to analyze - **We welcome your feedback!**

- If the scenario definitions change, we will be able to adapt to choose the best ones until January 2020

| Scenario Name | NATURAL GAS / RECS (power) | ELECTRIFICATION of light-duty vehicles and buses, and buildings |
|---|---|---|
| 1. CURRENT (2012) | N/A | N/A |
| 2. LA-Leads/Emissions Free (Moderate Load Electrification) | NO | Moderate |
| 3. LA-Leads/Emissions Free (High Load Electrification) | NO | High |
| 4. SB100 (High Load Electrification) | YES | High |

- Effects of **electrification** can be isolated by comparing:
  "LA-Leads (Moderate Load Electrification)" with "LA-Leads (High Load Electrification)"
- Effects of **removing natural gas power plants** can be isolated by comparing"
  "SB100 (High Load Electrification)" with "LA-Leads (High Load Electrification)"

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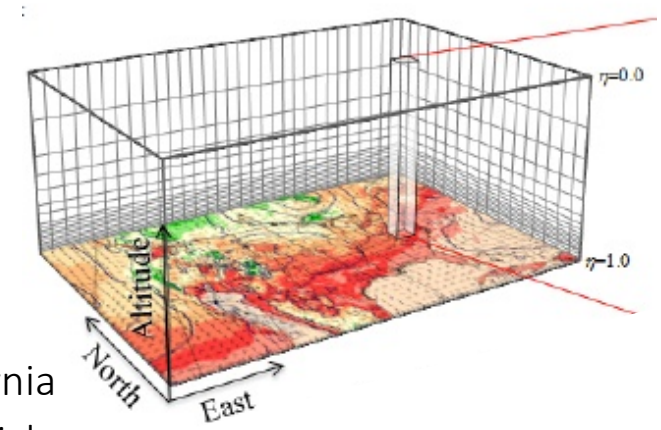
Future emissions for the LA100 scenarios of focus will be created using "current" as a base, and then altering emissions per sector using outputs from various models run by NREL, as follows:

1. **Power sector:** We will use hourly power generation profiles from NREL electric sector models to generate emissions. We will attempt to use specific emission factors for four use phases: start up, ramp, partial load, full load.
2. **Transportation sector:** NREL transportation team will project light-duty (LD) EV adoption and bus electrification. We will scale LD emissions based on projected EV adoption (normalized to total vehicles in DWP territory).
    a) LA100-caused changes in this sector are expected to lead to the largest changes to air quality of all sectors considered in this study.
3. **Building sector:** ResStock and ComStock models will project future hourly on-site natural gas consumption. We will scale building-level emissions (focusing on high emitters) using these outputs.
4. **Industrial sector:** Port of LA and LAX emissions will be scaled based on renewable energy adoption (as informed by NREL).

# 3) Predicting future ozone and $PM_{2.5}$ concentrations using a state-of-the-science air quality model

- We use a fully coupled climate – chemistry model to simulate how changes in emissions will alter atmospheric concentrations of ozone and $PM_{2.5}$
- Weather Research and Forecasting coupled to Chemistry model (WRF-Chem v3.7) is a 3D, gridded, photochemical air quality model developed by the National Center for Atmospheric Research (run by the National Science Foundation)
- The WRF model is an open-source, community model commonly used by scientists and regulators; e.g., https://ruc.noaa.gov/wrf/wrf-chem/Real_time_forecasts.htm
- The Ban-Weiss group at USC has implemented several modifications to the model to enable accurate simulations of climate and air pollutant concentrations for Southern California
  - Described and used in ~7 recent peer-reviewed journal articles

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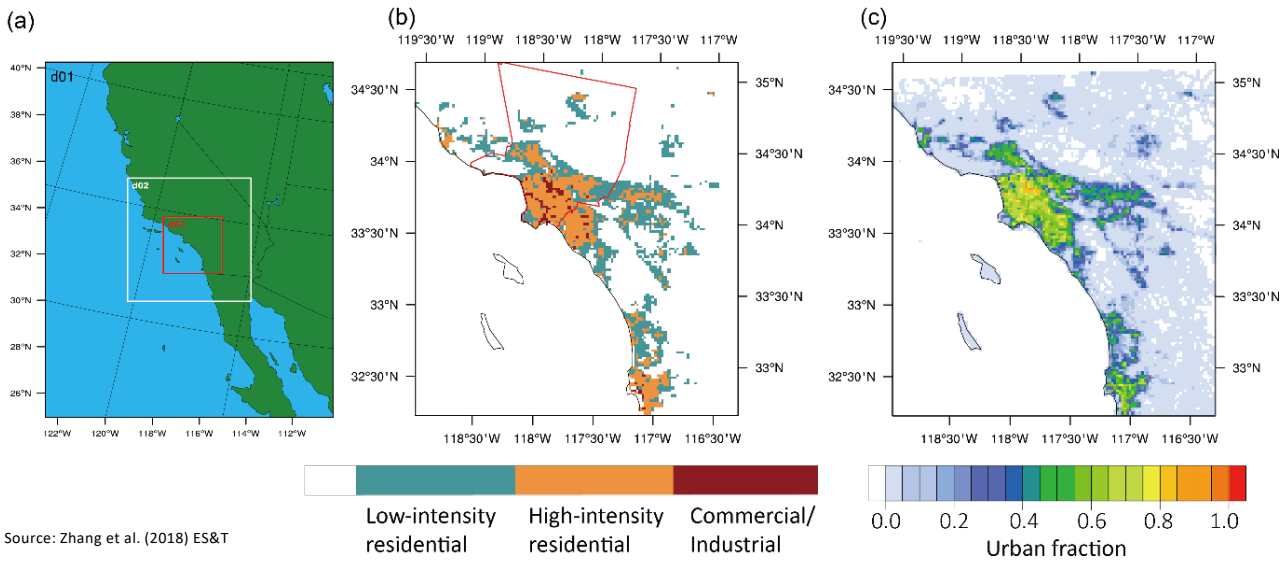
# 3) Assessing future ozone and $PM_{2.5}$ concentrations using a state-of-the-science air quality model




Source: Zhang et al. (2018) ES&T

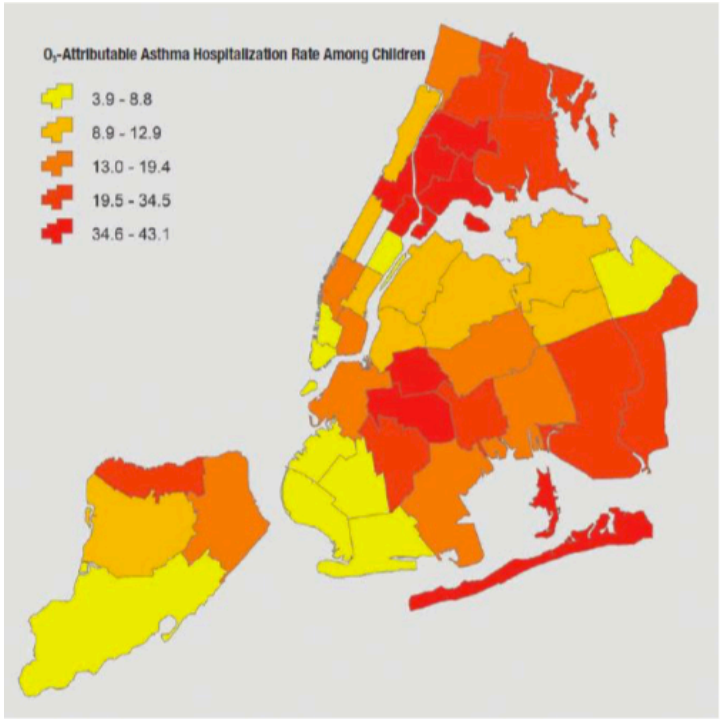
- Model spatial resolution uses 2km x 2km grid cells for inner domain of LA
- We will identify and run simulations for four to six ~2-week episodes with "typical" (2012) meteorology and pollutant concentrations for each season
  - This approach has been common in regulatory air quality modeling
  - 2012 is the same year of meteorology used for power sector and loads modeling in LA100
- Results will be translated to annual mean changes for health effects analysis

# 4) Assessing changes in health impacts from exposure to ozone and $PM_{2.5}$

## Morbidity (Ozone & $PM_{2.5}$)

- We will quantify morbidity health effects that are the same **health indicators used in the CalEnviro Screen**, specifically
  - Emergency department visits for asthma (resulting from $O_3$ and $PM_{2.5}$ ) and
  - Emergency department visits for cardiovascular causes ($PM_{2.5}$)
- Use established methods from Environmental Protection Agency that are commonly used by regulatory agencies to quantify public health impacts of proposed changes to air pollution regulations
  - Likely model we will use: US EPA's Environmental Benefits Mapping and Analysis Program (BenMAP), which is also used by SCAQMD

## ED Visits, Asthma, New York City




Source: Ito et al. 2007
https://www.epa.gov/sites/production/files/2014-10/documents/hia_for_benmap_webinar_8.7.13.pdf

# 5) Presentation of results

- Spatial maps displaying air pollutant ***emissions*** from primary sectors, per scenario analyzed
  - These are the results that will be ready to present by the March 2020 AG meeting ("Preliminary GHG and Air Pollution Results")
- Ozone and $PM_{2.5}$ annual average concentrations, and rates of premature morbidity and (hopefully) mortality under analyzed scenarios, are to be presented at June 2020 AG meeting
- Each of these outcomes will be presented as both absolute results for the reference case scenario and the differences between the selected LA100 scenarios and reference case
- We will also present spatially averaged results for the LADWP service territory

# Questions?


The Los Angeles 100% Renewable Energy Study