Case Studies of Air Pollution Monitoring in Urban Atmospheres: Los Angeles and Tehran

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Outline

• Case Study: Los Angeles
• Case Study: Tehran

Kerman, Iran
Case Study: Los Angeles

Dense fog over the Los Angeles Civic Center, 1955. Note that the buildings project above the base of the inversion layer, while the smog remains below.

Protests at Pasadena City Hall on November 9, 1954, following fifteen days of smog in October.
Successful Emissions Reductions

Long-term monitoring valuable to quantify success of emissions reductions, but, struggles to provide information for process-level understanding.

Ryerson et al. (2013), J. Geophys. Res.
California Nexus Field Study, Summer 2010

Ryerson et al. (2013), J. Geophys. Res.
# Twin Otter Payload

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## Composition
- Optical properties
- Hygroscopicity
- Physical properties
A Tour of Los Angeles
Spatial Map of Composition and Water-Uptake Ability

Hersey et al. (2013), J. Geophys. Res.
Case Study: Tehran, Iran

Objective: Use any accessible data available freely to examine aerosol characteristics in the greater Tehran region:

In doing so, we address three questions:

(i) How do topography and geography impact visibility at three sites in the greater Tehran area?
(ii) How do column aerosol extinction and composition of aerosol vary in the greater Tehran area over the course of a typical year?
(iii) What is a typical weekly cycle of low-level pollution levels in Tehran?
Data Toolbox for 2000-2009

Surface: NOAA NCDC stations, radiosonde data
Satellite: MODIS, MISR, OMI, TOMS
Reanalysis Data: Modern-Era Retrospective Analysis for Research and Applications (MERRA)
Model: GOCART
Weekday-Weekend Effects on Visibility
(Mehrababad Data)

Visibility anomaly = average deviation from the climatological mean for each season.

- Winter
- Spring
- Summer
- Fall

Weekend
Cleaning the Tehran Atmosphere During the Winter (Mehrabad Data)

(Average visibility during 2 days after rain) - (Average visibility during 2 days before rain)

Frequency is defined as the sum of the number of trajectories that passed through each point on the map divided by the number of trajectories analyzed.
Seasonal Fire Activity

Fire density across the region increases in the spring and summer months to the north.

Fire days per 0.5°x0.5° box per month
Annual Profile of Columnar Satellite Data

Smoke + Dust + Aerosol Swelling

(a)

(b)

(c)

(d)

MODIS TERRA
MODIS AQUA
DEEP BLUE
MISR
TOMS

Sea Salt
Black Carbon
Organics
Sulfate
Fine Dust
Coarse Dust

Month

J F M A M J J A S O N D
Dust as a Vehicle for Toxic Species

Dust in Iran... Also, Consequences for the Water Cycle

Figures courtesy of Tom Painter and Daniel Rosenfeld
Value of long-term monitoring networks

EPA IMPROVE: Aerosol Monitoring

NADP: Precipitation Monitoring
Thank you
- Significant contribution from stagnant trajectories (E) at low levels during DJF
- Least important source regions northwest (B) and east (D)
- Influence of trajectories originating from the dust-rich region between the west and south of Tehran (A) felt most at upper levels
Snapshot of Regional Dust in June 2006
Surface and Airborne Measurements

- MASE I
- MASE II
- E-PEACE
- NICE
- PACO
- CalNex
- TACO
- ICARTT
- DC3
- SEAC\(^4\)RS
- GoMACCS
Eastern Pacific Emitted Aerosol Cloud Experiment (E-PEACE): July-August 2011

Principal Investigators
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Lynn Russell (Scripps Inst. Oceanography)
Haflidi Jonsson (NPS)

Russell et al. (2013), BAMS
R/V Point Sur Smoke Operations

U.S. Army "Smoke/Fog Generator"
c.a. 1980

E-Bay price: $100 ea.

Sponsor: Sea Spray Foundation
Point Sur 6:25 PDT
Point Sur 12:45 PDT
Advected track from 6:25 PDT
Advected track from 12:45 PDT
Aerosols directly interact with solar radiation via absorbance and scattering

Optical Properties = f (size, shape, composition)
Aerosol Effects: Public Health

Aerosol Effects: Climate and the Hydrologic Cycle

Clean (Less CCN)

Polluted (More CCN)

(1st indirect effect) Twomey (1977)

(2nd indirect effect) Albrecht (1989)

Suppressed precipitation generation

Less efficient collision coalescence

Twomey (1977)

Albrecht (1989)
Aerosols and Climate Change

Largest uncertainty: aerosols
Fine atmospheric particles — smaller than one-thirtieth of the diameter of a human hair — were identified more than 20 years ago as the most lethal of the widely dispersed air pollutants in the United States. Linked to both heart and lung disease, they kill an estimated 50,000 Americans each year. But more recently, scientists have been puzzled to learn that a subset of these particles, called secondary organic aerosols, has a greater total mass, and is thus more dangerous, than previously understood.
What is the nature of the mysterious organic fraction?
1952 Haagen-Smit discovers ozone formation mechanism:
Nitrogen oxides + organic vapors + sunlight

1950-1970: Growing Environmental Concerns
1970: Birth of Environmental Protection Agency (EPA)

Major Environmental Regulations:
The Clean Air Act of 1963
Motor Vehicle Act (1965)
The Clean Air Act Amendments of 1966
The Air Quality Act of 1967
The Clean Air Act Amendments of 1970
The Clean Air Act Amendments of 1977
The Clean Air Act Amendments of 1990