

Section 4

What Are We Forecasting?

What is in the Air?

What Are We Forecasting?

Pollutants

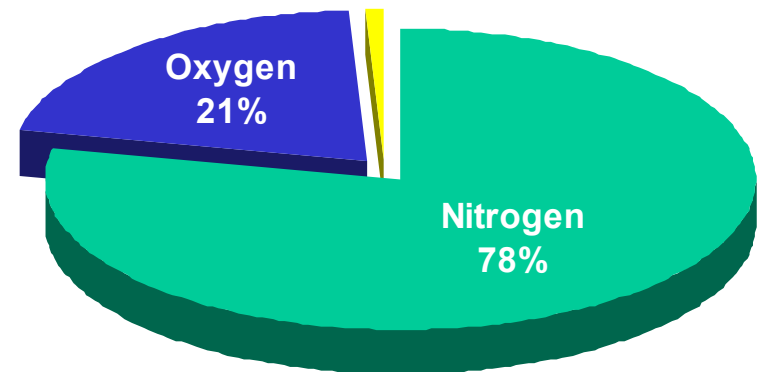
Units of Measure

Averaging Time

Spatial Scale

What is in the Air?

- Mixture of invisible gases, particles, and water
- Nitrogen (78%)
- Oxygen (21%)
- Remaining (1%)
 - Argon
 - Water vapor
 - Carbon dioxide
 - Pollutants
 - Many others



What Are We Forecasting – Pollutants

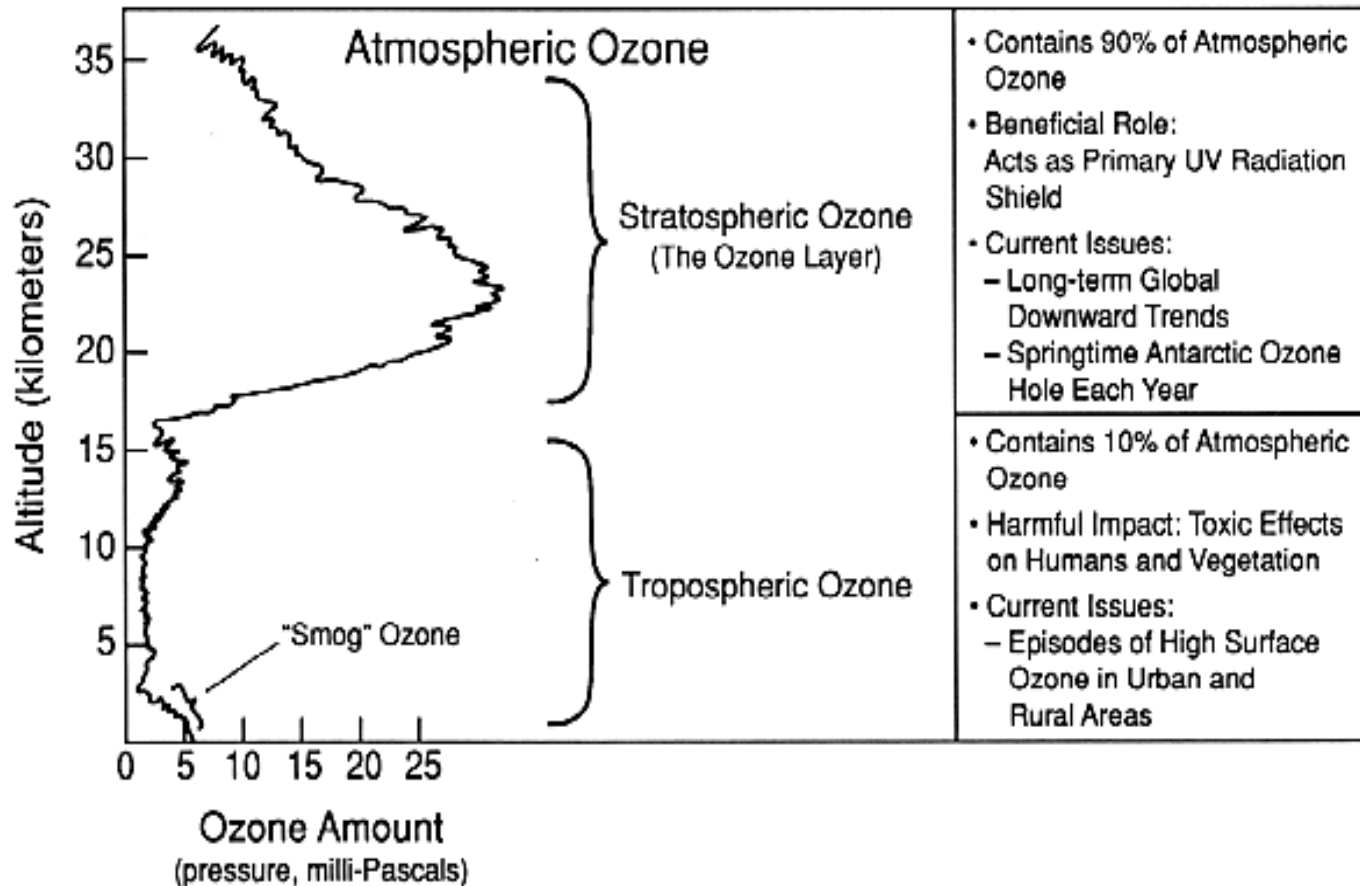
Pollutants of concern

- Ozone (O₃)
 - Particulate Matter (PM)
 - Carbon Monoxide (CO)
 - Sulfur Dioxide (SO₂)
 - Nitrogen Dioxide (NO₂)
 - Toxics
-
- Greenhouse gases (CO₂, others)
 - Ozone-layer depleting gases (CFCs)

Pollutants – Ozone (1 of 3)

- Colorless gas
- Composed of three oxygen atoms
 - Oxygen molecule (O_2) – needed to sustain life
 - Ozone (O_3) – the extra oxygen atom makes ozone very reactive
- Occurs in stratosphere and troposphere
 - Stratospheric ozone helps protect organisms from the sun's harmful ultra-violet radiation.
 - Troposphere ozone occurs naturally, injected from the stratosphere. Ozone is also produced in the troposphere as a secondary pollutant, formed from precursor gases:
 - Nitric oxide – combustion product
 - Volatile organic compounds (VOCs) – evaporative and combustion products

Pollutants – Ozone (2 of 3)



- Contains 90% of Atmospheric Ozone
 - Beneficial Role: Acts as Primary UV Radiation Shield
 - Current Issues:
 - Long-term Global Downward Trends
 - Springtime Antarctic Ozone Hole Each Year
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- Contains 10% of Atmospheric Ozone
 - Harmful Impact: Toxic Effects on Humans and Vegetation
 - Current Issues:
 - Episodes of High Surface Ozone in Urban and Rural Areas

Source: <http://www.al.noaa.gov/WWWHD/Pubdocs/assessment94/common-questions.html>

Pollutants – Ozone (3 of 3)

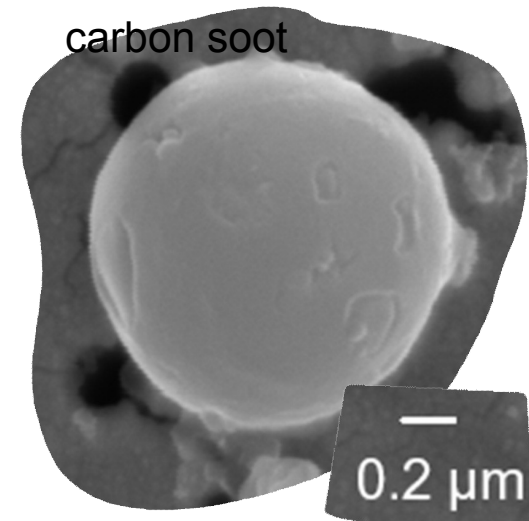
Why forecast ozone (O₃) concentrations

- Severe irritant (reactive)
- Inflames and irritates the respiratory tract, particularly during physical activity; breathing ozone can worsen asthma attacks (symptoms include breathing difficulty, coughing, and throat irritation)
- Damages lung tissue; complete recovery may take several days after exposure
- Damages materials such as rubber, plastics, etc.

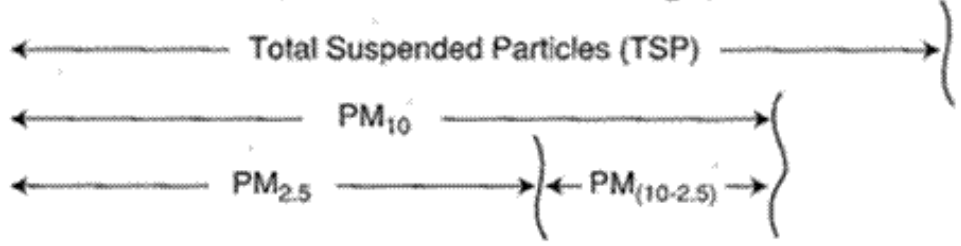
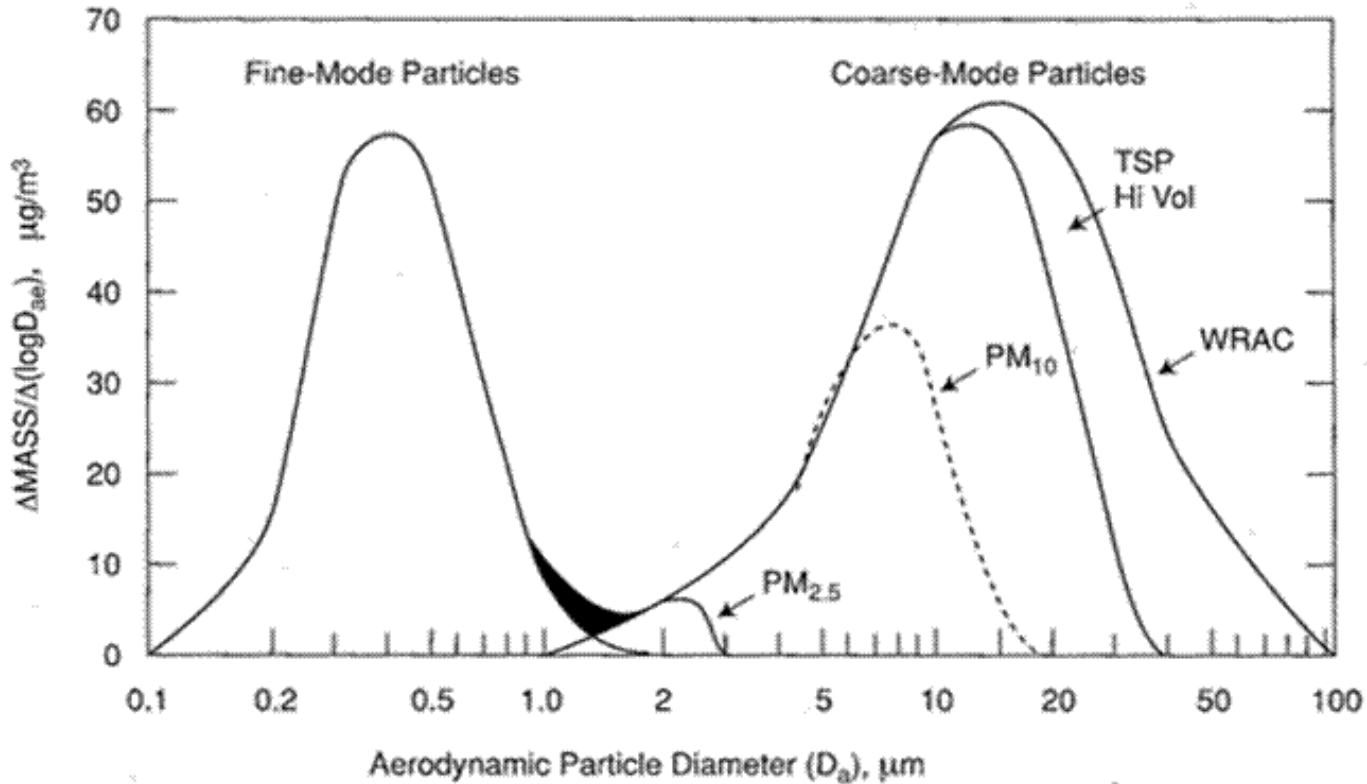
Pollutants – Particulate Matter (1 of 3)

- Complex mixture of solid and liquid particles
- Composed of many different compounds
- Both a primary (directly emitted) and secondary pollutant (formed in the atmosphere)
- Sizes vary tremendously
- Particle sizes:
 - Ultra-fine particles ($<0.1 \mu\text{m}$)
 - Fine particles (0.1 to $2.5 \mu\text{m}$)
 - Coarse particles (2.5 to $10 \mu\text{m}$)
- Formed in many ways

Ultra-fine fly-ash or
carbon soot



Pollutants – Particulate Matter (2 of 3)



Section 4 – What Are We Forecasting?

Pollutants – Particulate Matter (3 of 3)

Why forecast particulate matter (PM) concentrations

- Aggravates heart diseases
- Associated with cardiac arrhythmias and heart attacks
- Aggravates lung diseases such as asthma and bronchitis
- Increases susceptibility to respiratory infections
- Affects visibility

Pollutants – Carbon Monoxide (1 of 2)

- Colorless, odorless, poisonous gas
- Produced by incomplete combustion of carbon
- Typically comes from transportation sources, also from wood-burning stoves, incinerators, and industrial sources

Pollutants – Carbon Monoxide (2 of 2)

Why forecast carbon monoxide (CO) concentrations

- CO inhibits the blood's ability to carry oxygen to body tissues, including vital organs such as the heart and brain
- When inhaled, CO combines with the oxygen carrying hemoglobin of the blood to form carboxyhemoglobin (COHb).
- Once combined with the hemoglobin, that hemoglobin is no longer available for transporting oxygen.

Source: <http://biology.about.com/library/blco.htm>

Pollutants – Sulfur Dioxide

Sulfur dioxide (SO_2) is a gas from combustion of the sulfur contained in the coal and oil. (e.g., energy generation, steel mills, refineries, smelters).

Why forecast sulfur dioxide (SO_2) concentrations

- Aggravates existing respiratory and cardiovascular diseases
- Converts to sulfuric acid which, with SO_2 , burn sensitive tissues in the nose and lungs
- Large component of acid rain
- Contributes to formation of particulate matter (PM)

Pollutants – Nitrogen Dioxide

- Brown, highly reactive gas
- NO_x generated in combustion of fossil fuels. The product is mostly NO, with 2–10% of the NO_x being NO₂. NO₂ is further produced by oxidation of NO in the atmosphere. So NO₂ is both a primary and secondary
- Precursor to ozone (O₃) and acid rain

Why forecast nitrogen dioxide (NO₂) concentrations

- Irritates lungs
- Lowers resistance to respiratory infection

Pollutants – Toxics (1 of 2)

- Air toxics (hazardous air pollutants)
 - Known or suspected to cause cancer
 - Can cause other serious health effects
 - Some are products of combustion
- 188 hazardous air pollutants include
 - Benzene (motor fuel, oil refineries, chemical processes)
 - Perchloroethylene (dry cleaning, degreasing)
 - Chloroform (solvent in adhesive and pesticides, by-product of chlorination processes)

Pollutants – Toxics (2 of 2)

- Not generally forecasted
 - Health criteria differ from major pollutants
 - No AQI-like standards
 - Cancer/non-cancer benchmarks (long-term exposures)
 - Short-term exposure limits
 - Monitoring is a challenge
 - Data usually not available in real-time
 - Example: Dioxin requires 28 days of sampling to acquire measurable amounts in ambient air
 - Toxics are often localized near a source

What Are We Forecasting – Units of Measure

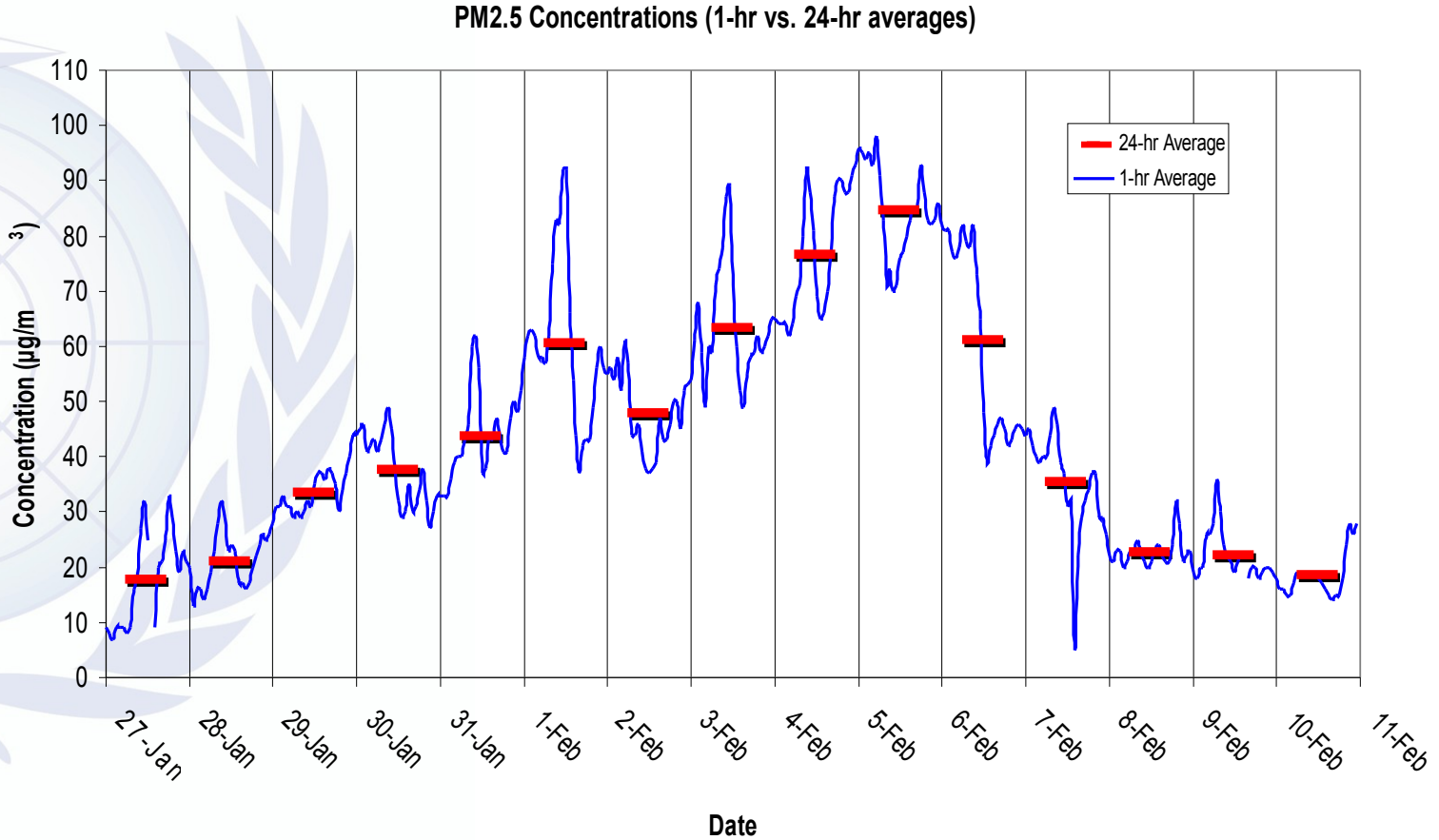
Pollution is reported in several ways

- Concentration
 - Amount of a particular material in large amount of air
 - Reported as mixing ratios: ppm, ppb, volume/volume
 - Parts per million (ppm) 1 in 1,000,000
 - Parts per billion (ppb) 1 in 1,000,000,000
- Mass
 - Weight of impurity in a volume of air
 - Microgram per cubic meter ($\mu\text{g}/\text{m}^3$) ($\mu\text{g}=10^{-6}\text{g}$)
 - Milligram per cubic meter (mg/m^3)
- Air Quality Indices
 - Health-related, normalized scaling system
 - Physical units removed
 - Example: Healthy, Unhealthy, Very Unhealthy
 - Air Pollution Index (API), Air Quality Index (AQI), Pollutant Standards Index (PSI)

What Are We Forecasting – Averaging Time (1 of 3)

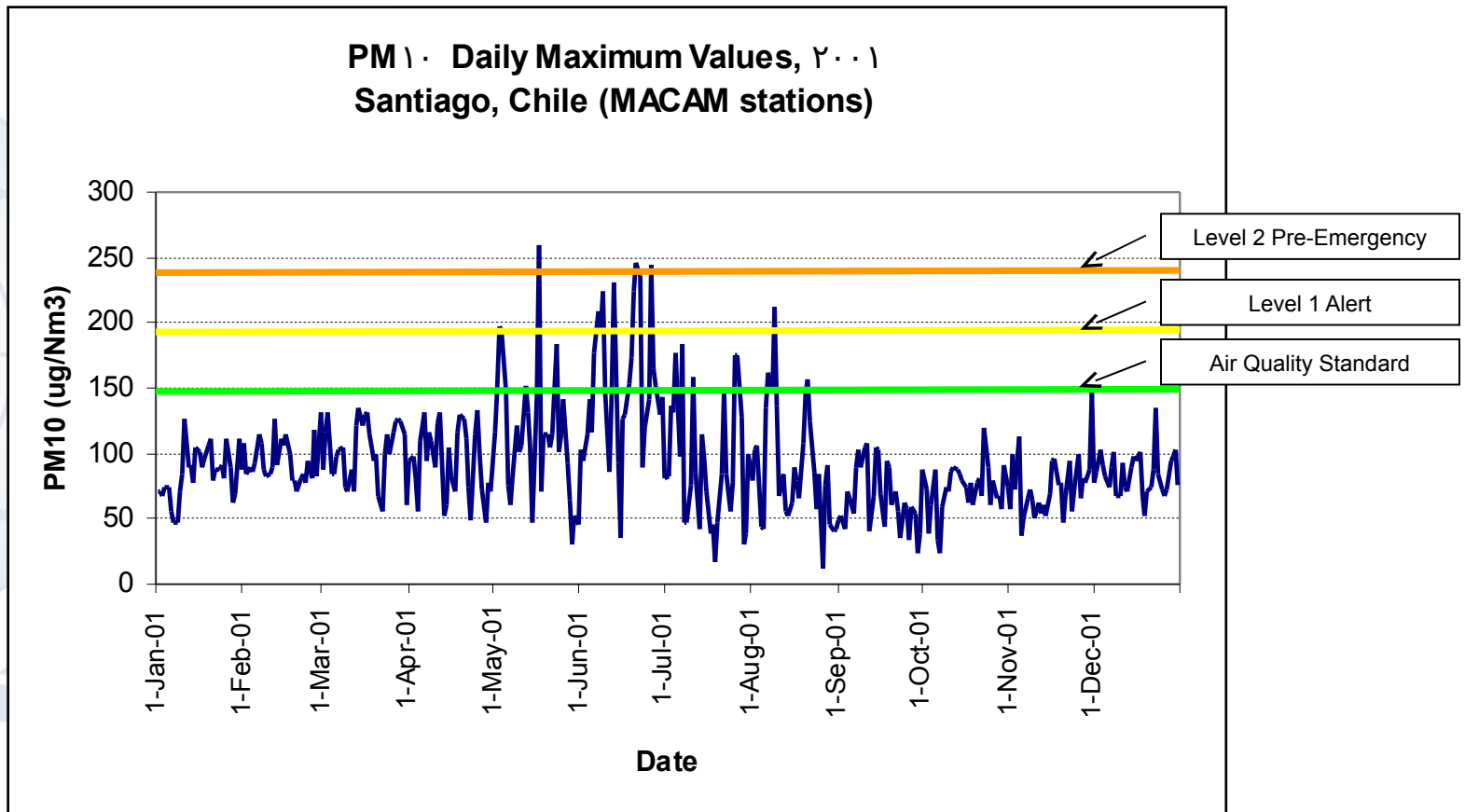
- Pollutant concentrations are reported as time-averaged values
- Examples include
 - Hourly
 - 8-hr
 - 24-hr/Daily
 - Seasonal
- Forecast objective and standards need to be considered to determine which averaging should be used
- Based on the averaging period used, different meteorological processes and information will need to be considered during forecasting

What Are We Forecasting – Averaging Time (2 of 3)



Section 4 – What Are We Forecasting?

What Are We Forecasting – Averaging Time (3 of 3)



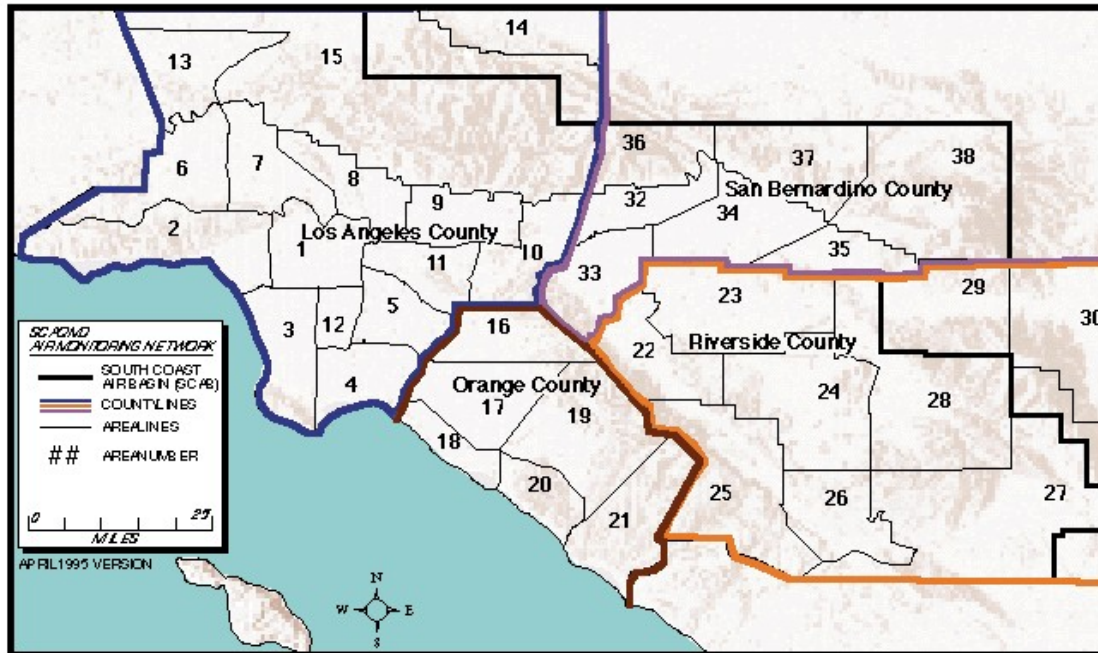
Ulriksen and Merino (2003)

What Are We Forecasting – Spatial Scale (1 of 2)

- Scales
 - Regional or mesoscale (10 km – 400 km)
 - Urban or sub-regional (10 km)
 - Neighborhood or single site (< 5 km)
 - Forecast scale needs to match local air quality scale
- Forecast zone
 - Several may exist in an area
 - Areas with complex terrain, meteorology, and emission patterns are subject to multiple forecast zones
- Metrics
 - Maximum of all sites in forecast zone
 - Multi-site average
 - Others

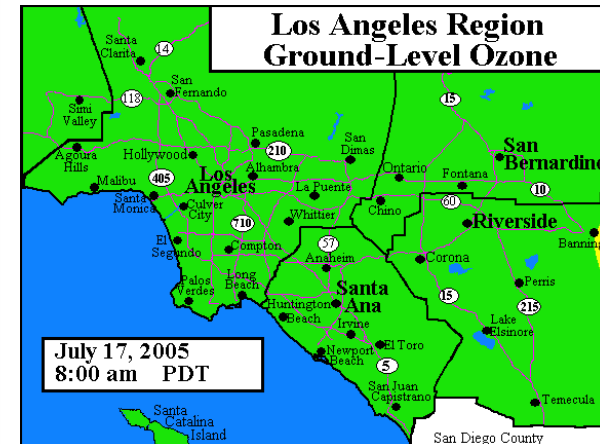
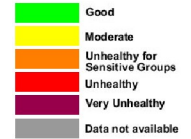
What Are We Forecasting – Spatial Scale (2 of 2)

Local forecast regions



Los Angeles, California, USA Forecast Regions

Hourly ozone maps of Air Quality Index



Summary

- Pollutants of concern
 - Major (ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide)
 - Toxics
- Toxics are difficult to forecast because of uncertainties in emissions and their chemical change in the atmosphere
- What are we forecasting?
 - Units of measure
 - Averaging time
 - Spatial scale