# Effects of Climate Change on Human Health in a U.S. Population: Current and Future Impacts

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# Objectives

- **Define more precisely the interrelationships among**
  - changes in climate and meteorological conditions,
  - air pollution, and
  - heat- and cold-related morbidity severe enough to warrant clinical contact.

- **A secondary objective is to evaluate heat-related morbidity in a vulnerable population: children and adults under economic disadvantage.**

- **The focus of this presentation is on asthma and myocardial infarction (MI) hospital admissions in North Carolina, with particular emphasis on the Charlotte Metropolitan Statistical Area.**

# Data

- **Meteorological Data**
  - The National Climatic Data Center archives surface and upper-air data over the U.S.

- **Air Quality Data**
  - AQS measurements of ambient concentrations of ozone, $PM_{10}$, carbon monoxide, and $NO_2$.

- **Health Data**
  - Morbidity measures include asthma and MI hospital admissions.
  - A second Medicaid database will be constructed and used as an index of asthma-related morbidity in a vulnerable population. Medicaid data will include asthma-related emergency room visits, hospital admissions, physician visits, and medication use (rescue and anti-inflammatory medication) and their economic costs. These data will be obtained at the county and ZIP Code levels.

# North Carolina Population Map
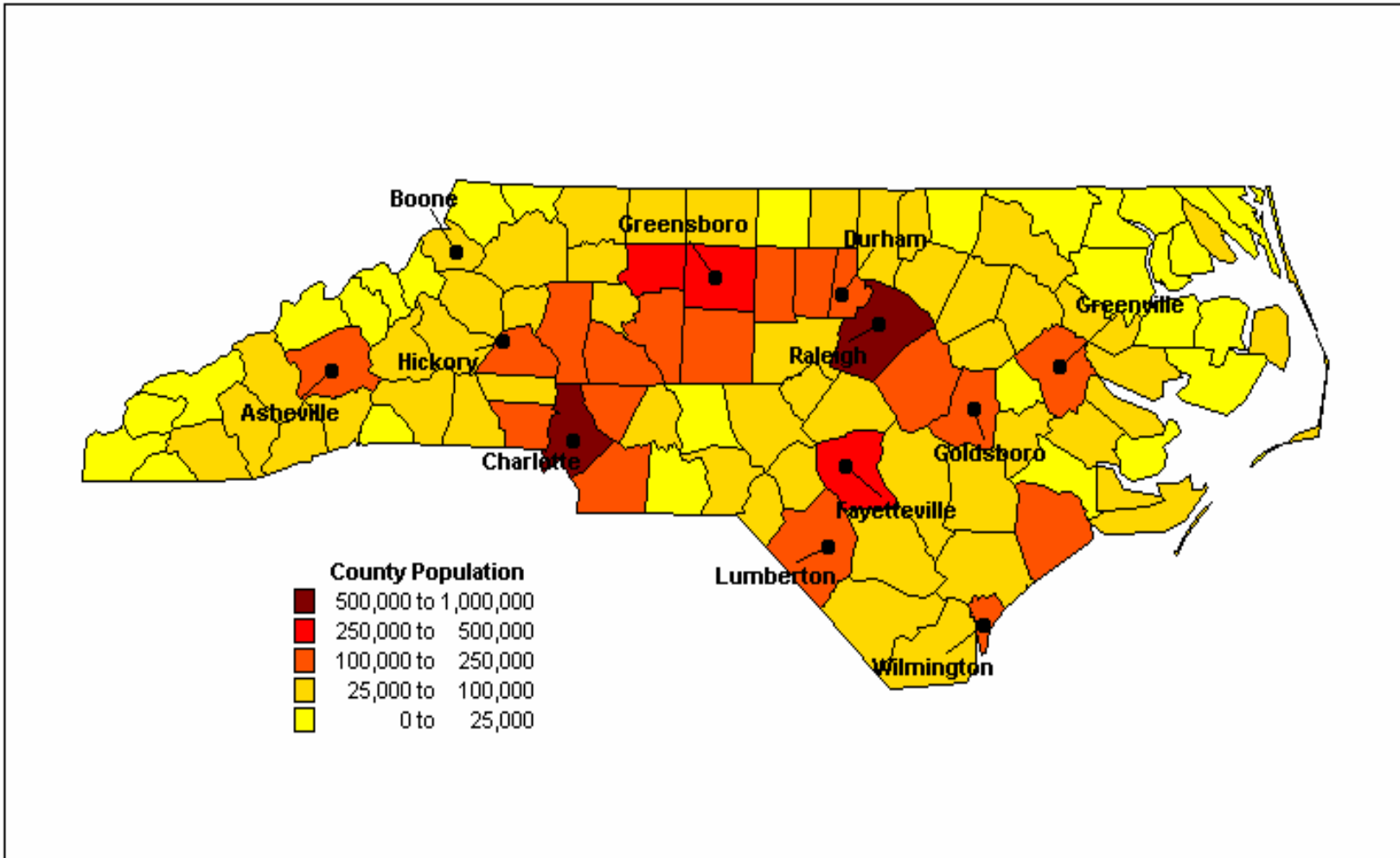
# The Concept of Air Mass

- **What is an air mass?**
- **How is it related to basic meteorological parameters (temperature, pressure, winds, etc.)?**
- **How is it different from analysis of basic meteoro-logical parameters?**
  - Source
  - Duration
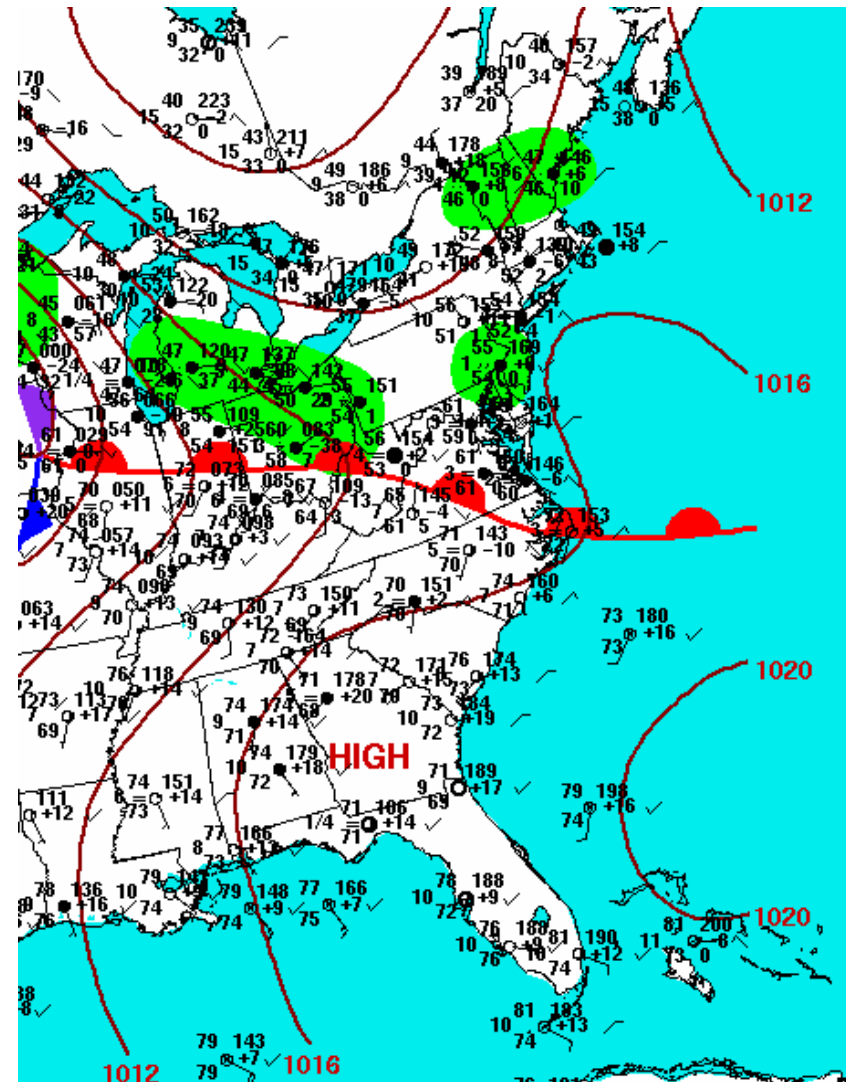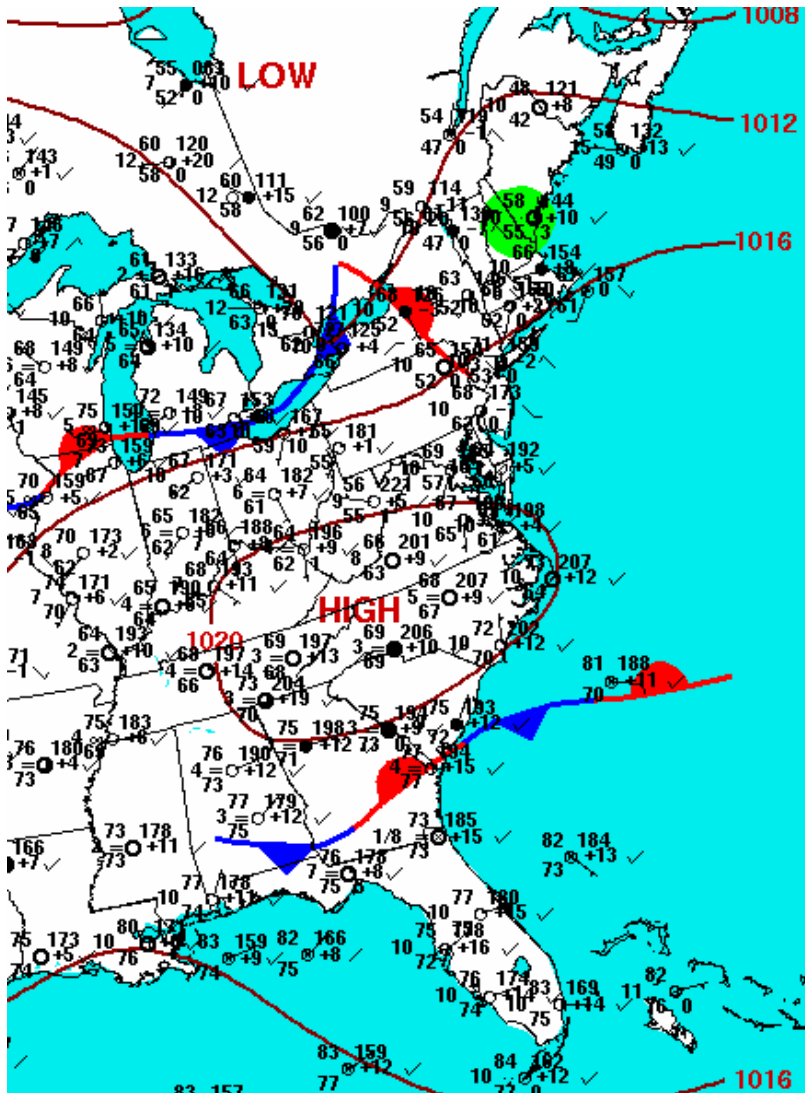  - Spatial coverage
- **Synoptic classification**

# Spatial Synoptic Classification

- **Sheridan Spatial Synoptic Classification system (2001) (**sheridan.geog.kent.edu/ssc.html**)**
- **Classification (air mass) types**
  - DM: Dry Moderate (mild and dry – Eastern and Central U.S.)
  - DP: Dry Polar (very cold temperatures – Advection from Canada)
  - DT: Dry Tropical (hottest and driest conditions at any location)
  - MM: Moist Moderate (warmer and more humid than MP)
  - MP: Moist Polar (cloudy, humid, and cool)
  - MT: Moist Tropical (warm and very humid)
  - Tr Transition (one air mass giving way to another)
  - MT+: Moist Tropical+ (upper limits of the MT)
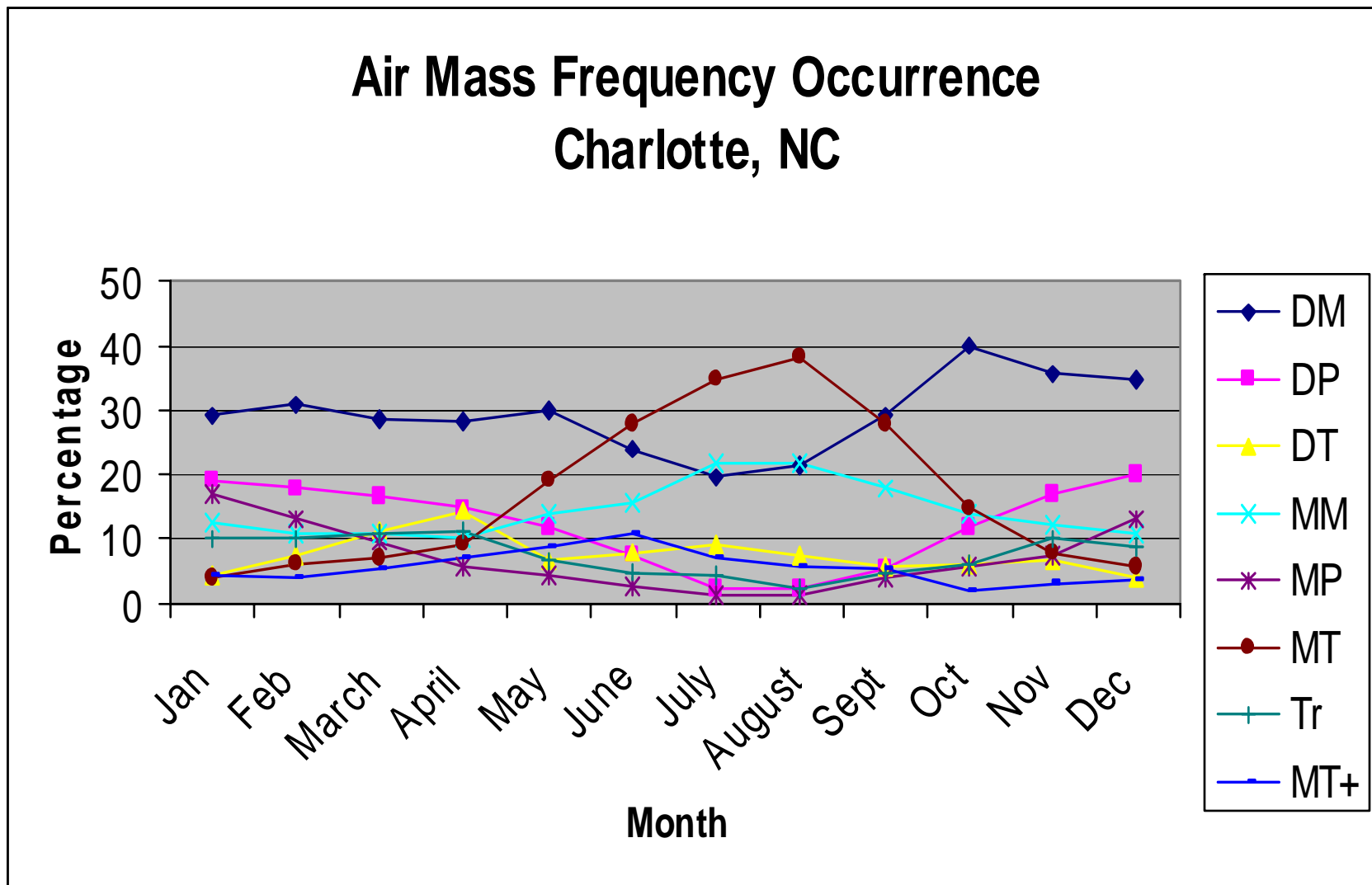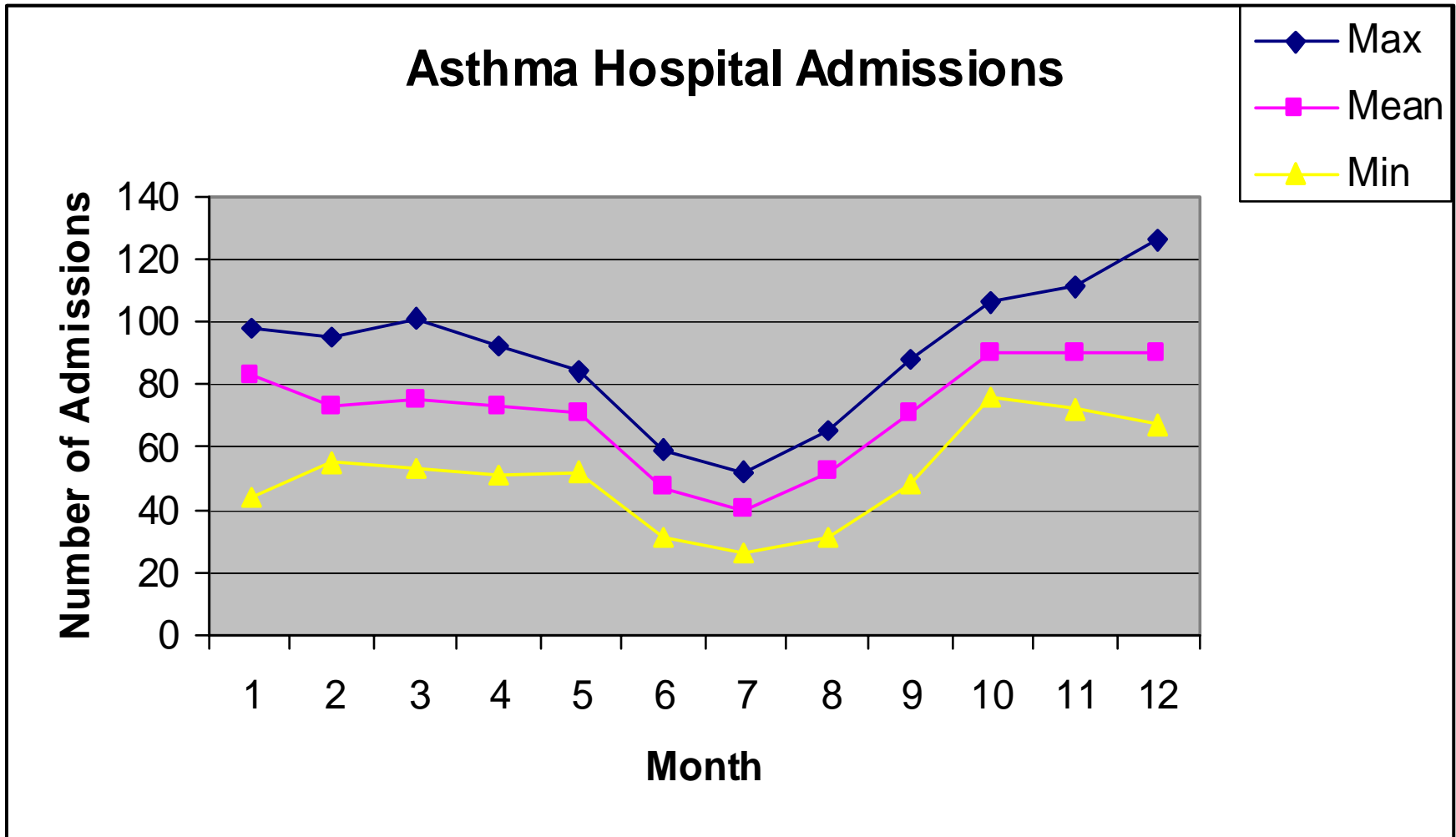
# DM and DT Air Mass
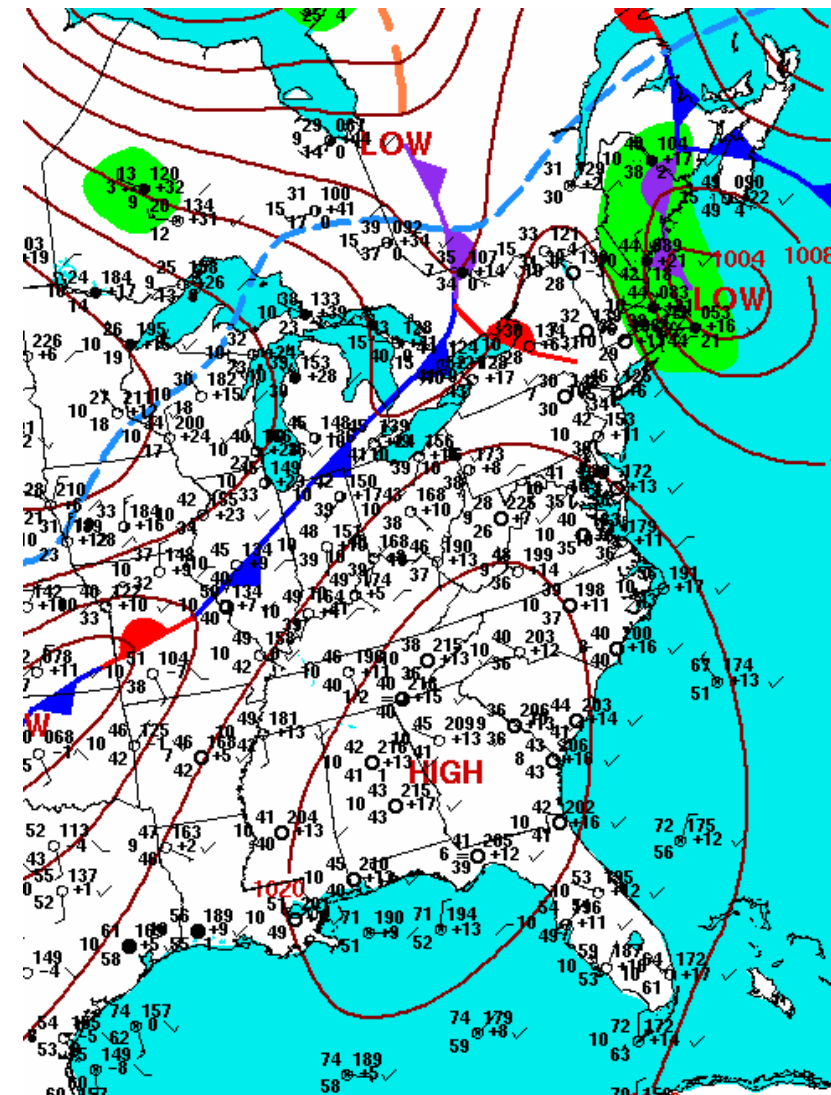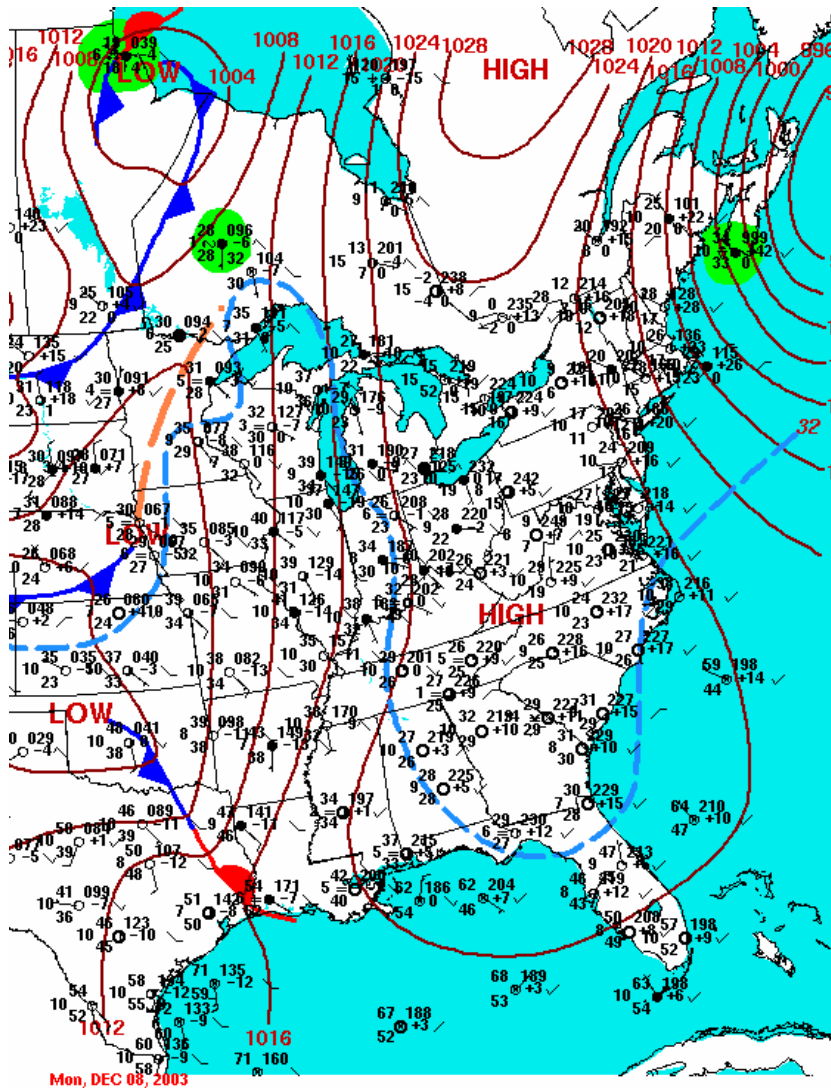
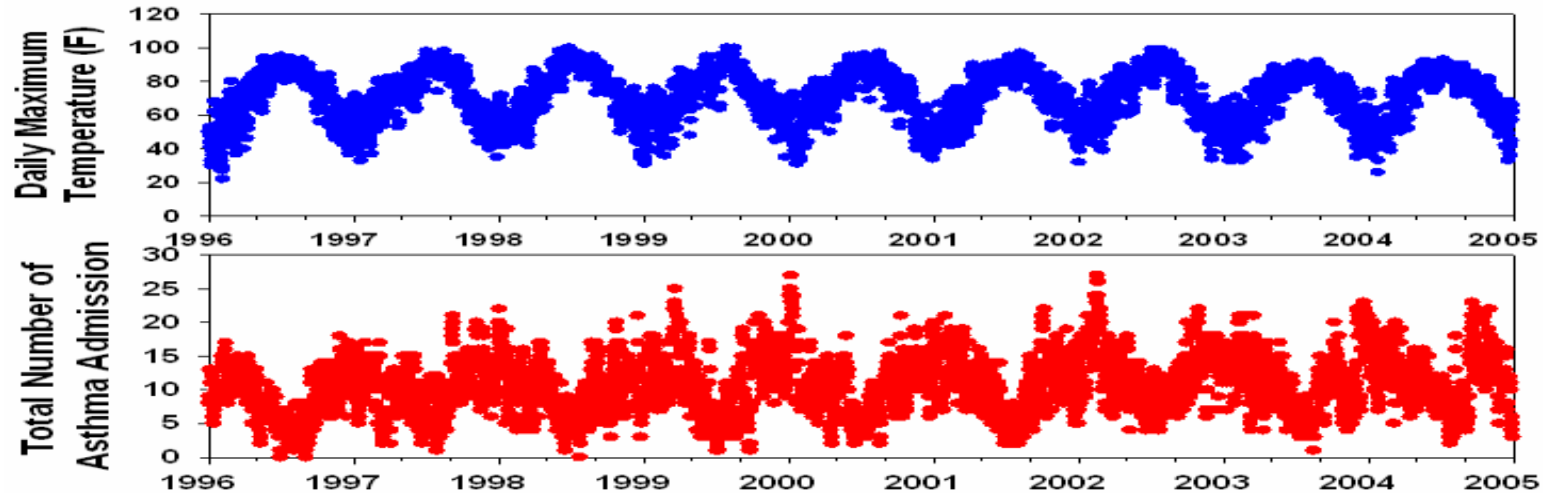# MT and MT+ Air Mass

# Frequency of Air Mass Types



Air Mass Frequency Occurrence
Charlotte, NC

# Asthma Admissions
# Charlotte, NC



Asthma Hospital Admissions

Legend: Max, Mean, Min

Y-axis: Number of Admissions (0 to 140)
X-axis: Month (1 to 12)

# Time Series (Charlotte)



- Time series of daily maximum temperature and daily asthma hospital admissions in Charlotte (1996-2005).
- Interannual variability (as well as day-to-day variability) is greater in the hospital admissions data.
- Seasonal cycle is clear in the multiyear time series.

# General Linear Regression Model

- **Study the regression relationship between ozone and $PM_{10}$ and asthma and MI hospitalizations for different air masses**

- **Use a B-spline function with 24 knots to adjust for nonlinear seasonal effect and long term trend. Also adjust for differences in meteorological variables and day of the week.**

- **Two modeling strategies:**
    - Joint modeling of ozone/$PM_{10}$ and air mass
    - Two-stage model
        - **Ozone/$PM_{10}$ and air mass**
        - **Ozone/$PM_{10}$ and asthma/MI hospitalizations**

# Pollutant – Air mass (Example: Charlotte)
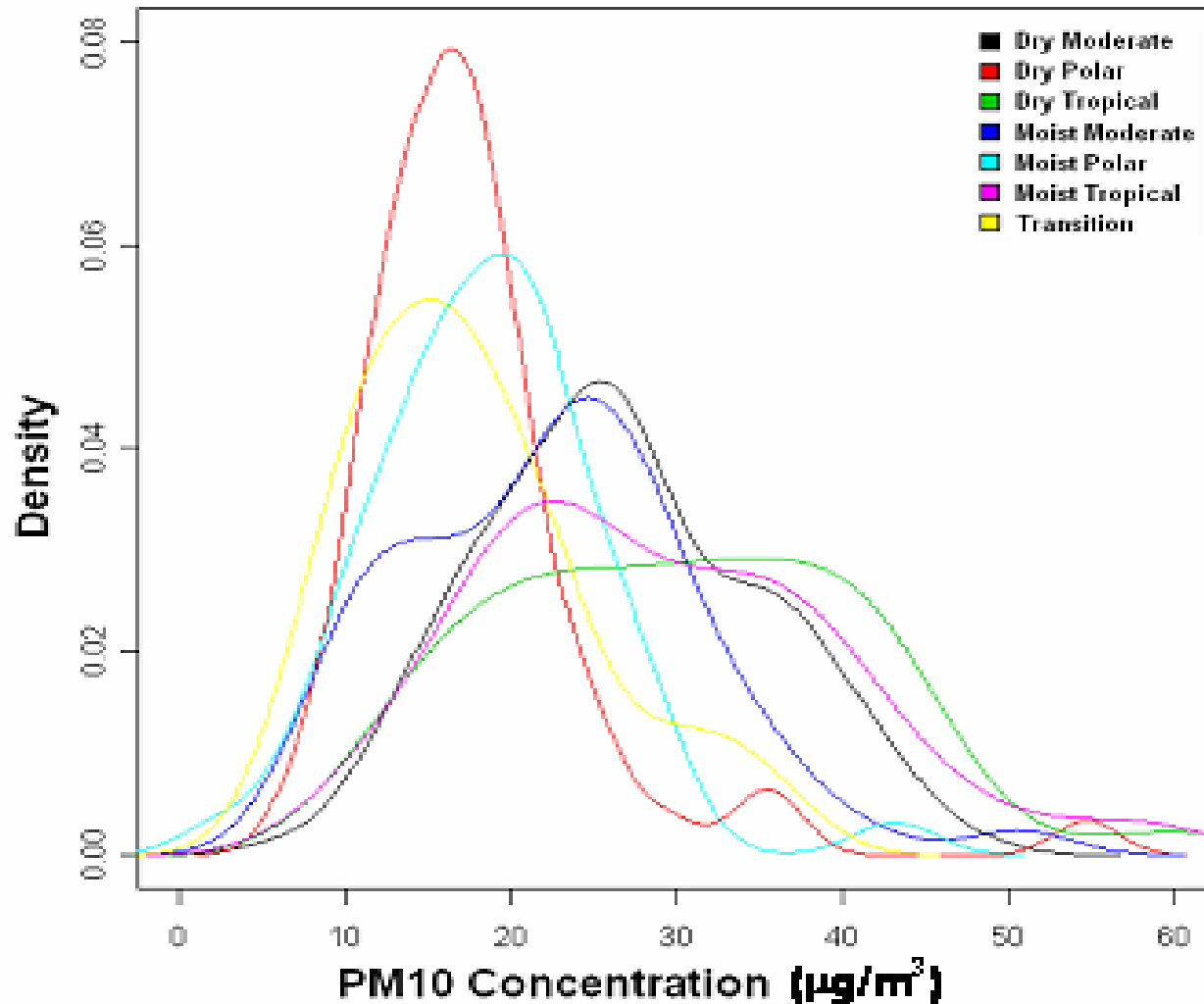## (Similar conclusions for Raleigh, Asheville, Wilmington, Greensboro)
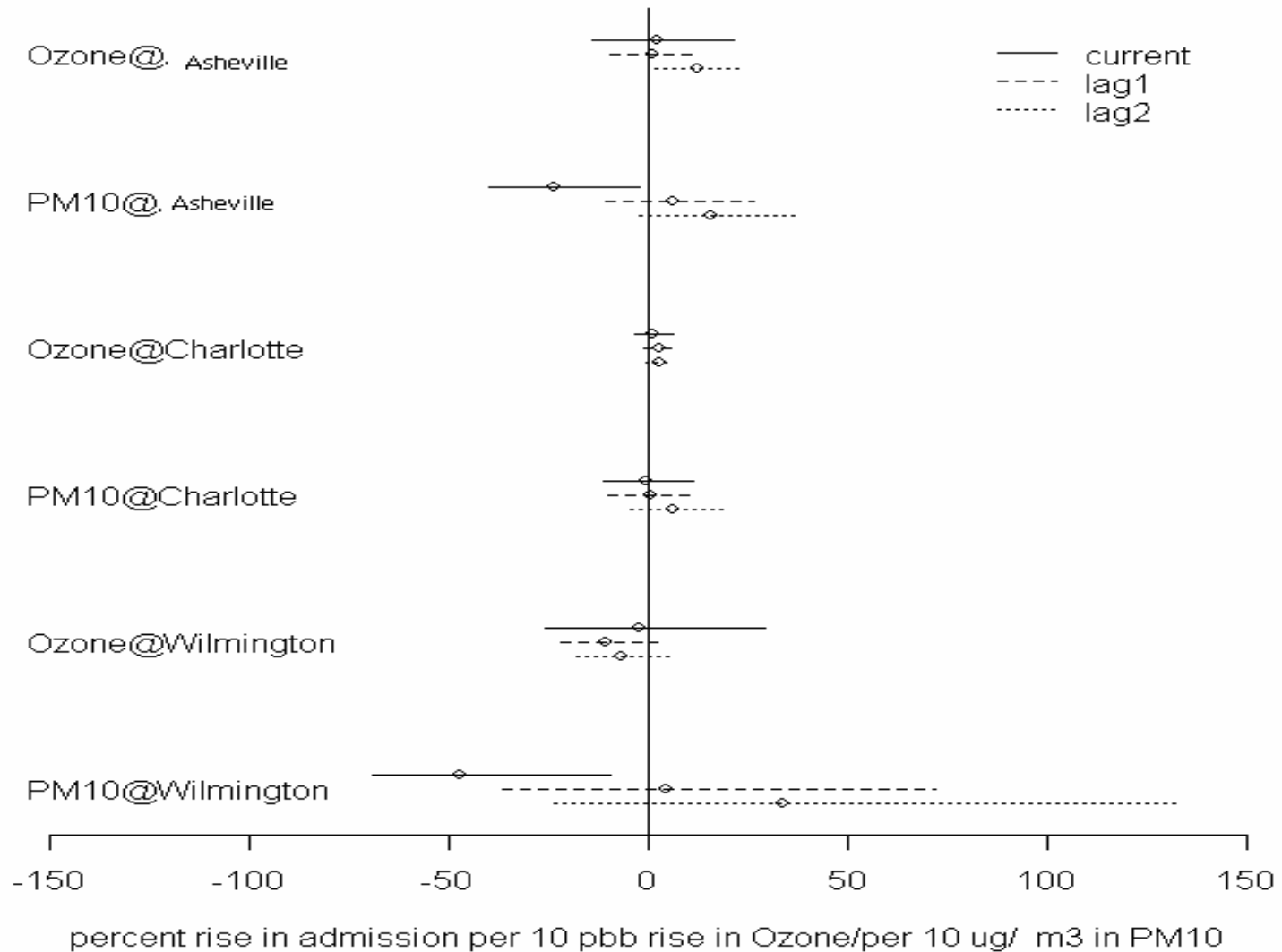## Ozone: Dry Tropical, Dry Moderate, Moist Tropical
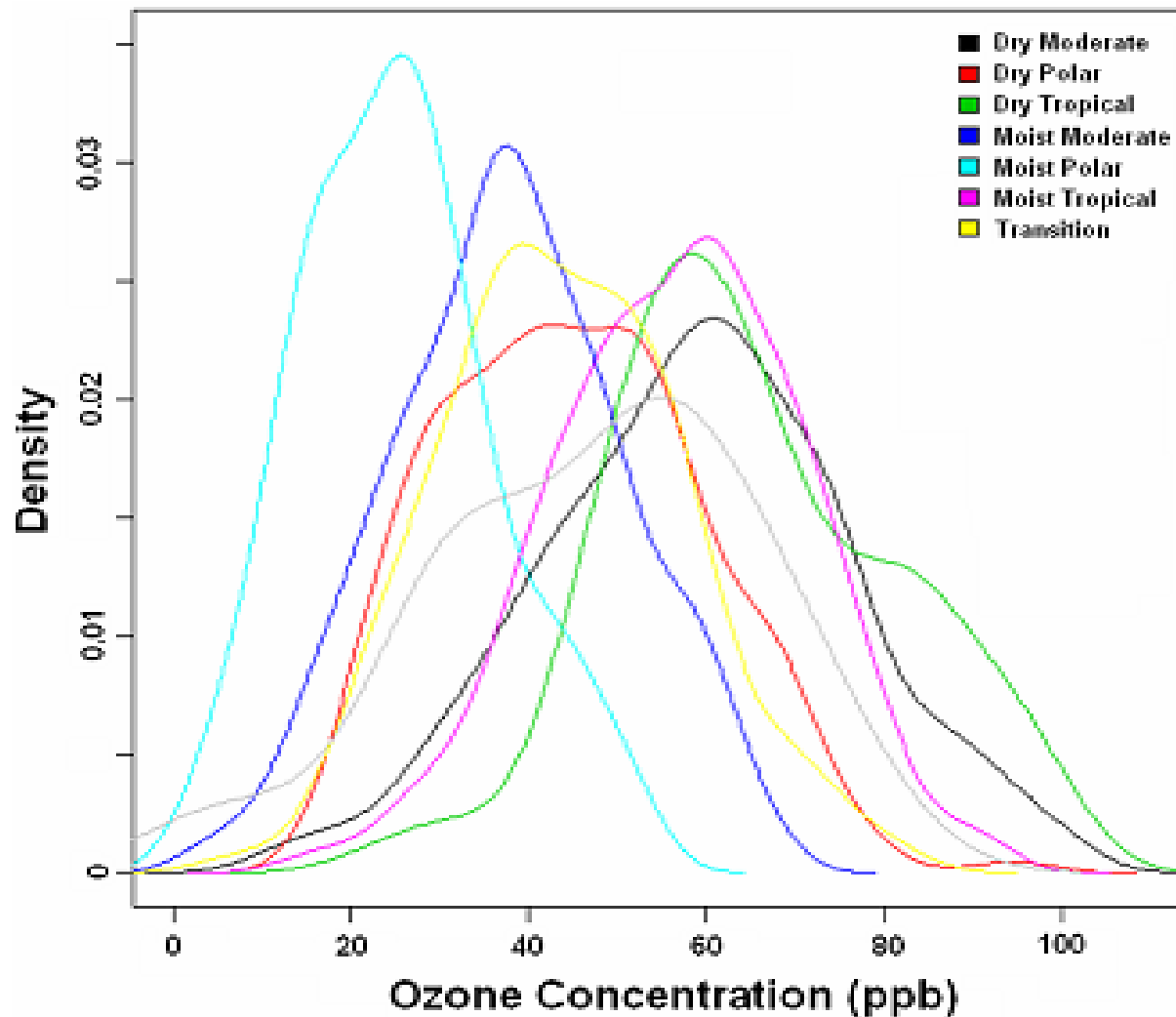
# Pollutant – Air mass (Example: Charlotte)

## (Similar conclusions for Raleigh, Asheville, Wilmington, Greensboro)

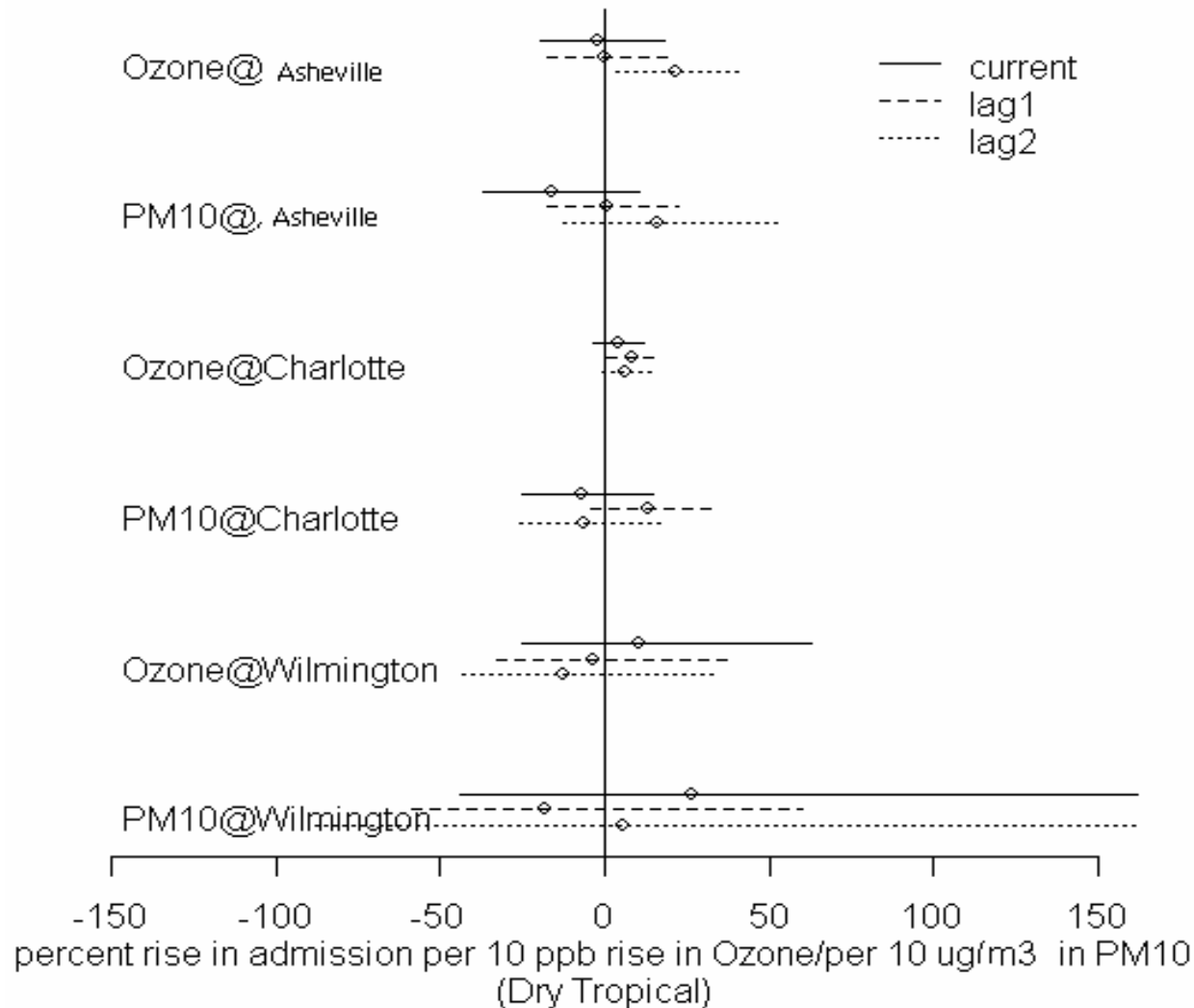## PM$_{10}$: Dry Tropical, Moist Tropical, Dry Moderate

# Percent Asthma Hospital Admissions Rise (All Data)



percent rise in admission per 10 pbb rise in Ozone/per 10 ug/ m3 in PM10

# Percent Rise in Asthma Hospital Admissions (Dry Tropical Air)



percent rise in admission per 10 ppb rise in Ozone/per 10 ug/m3 in PM10 (Dry Tropical)
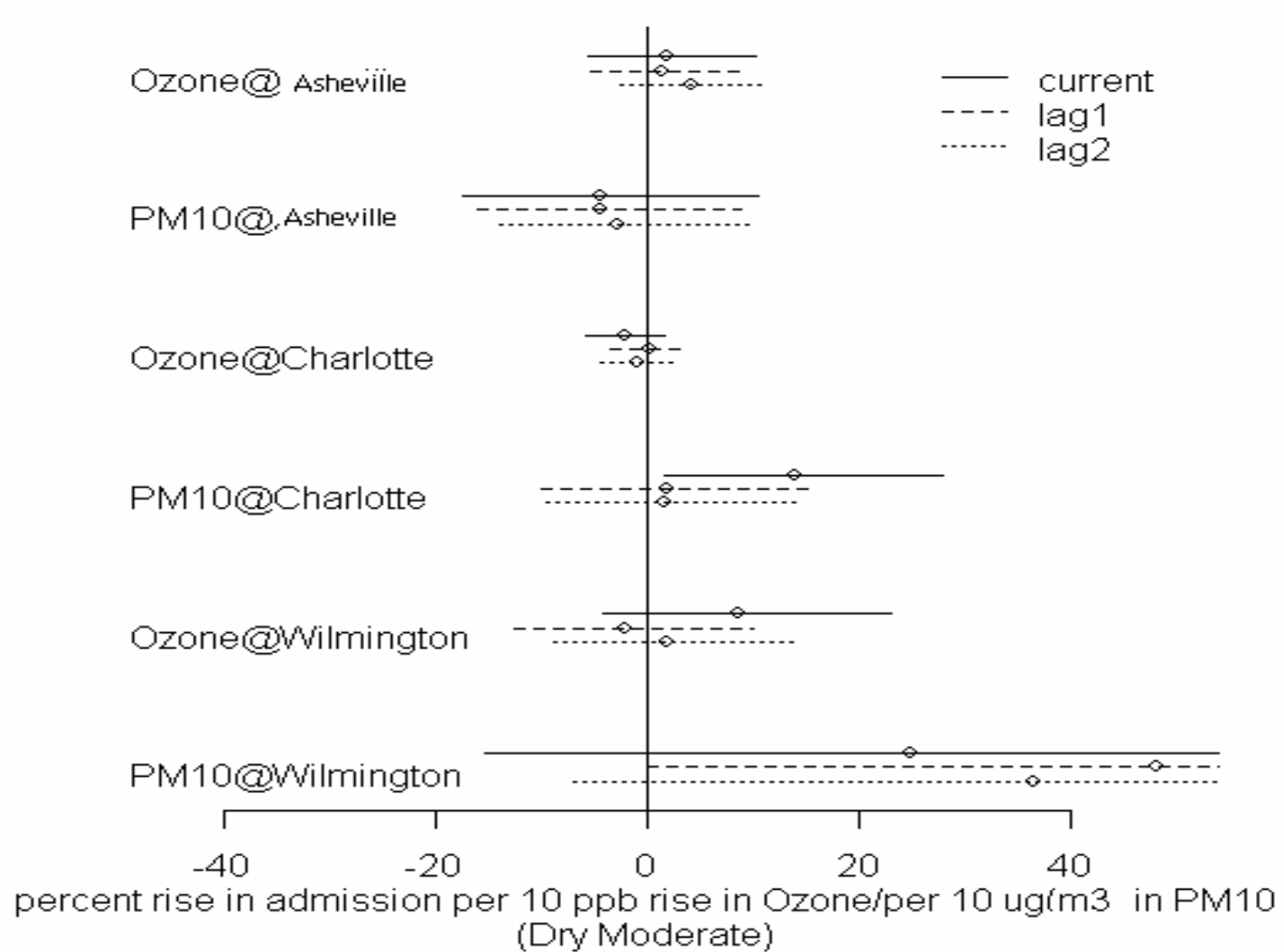
# Percent Rise in Asthma Hospital Admissions (Moist Tropical Air)
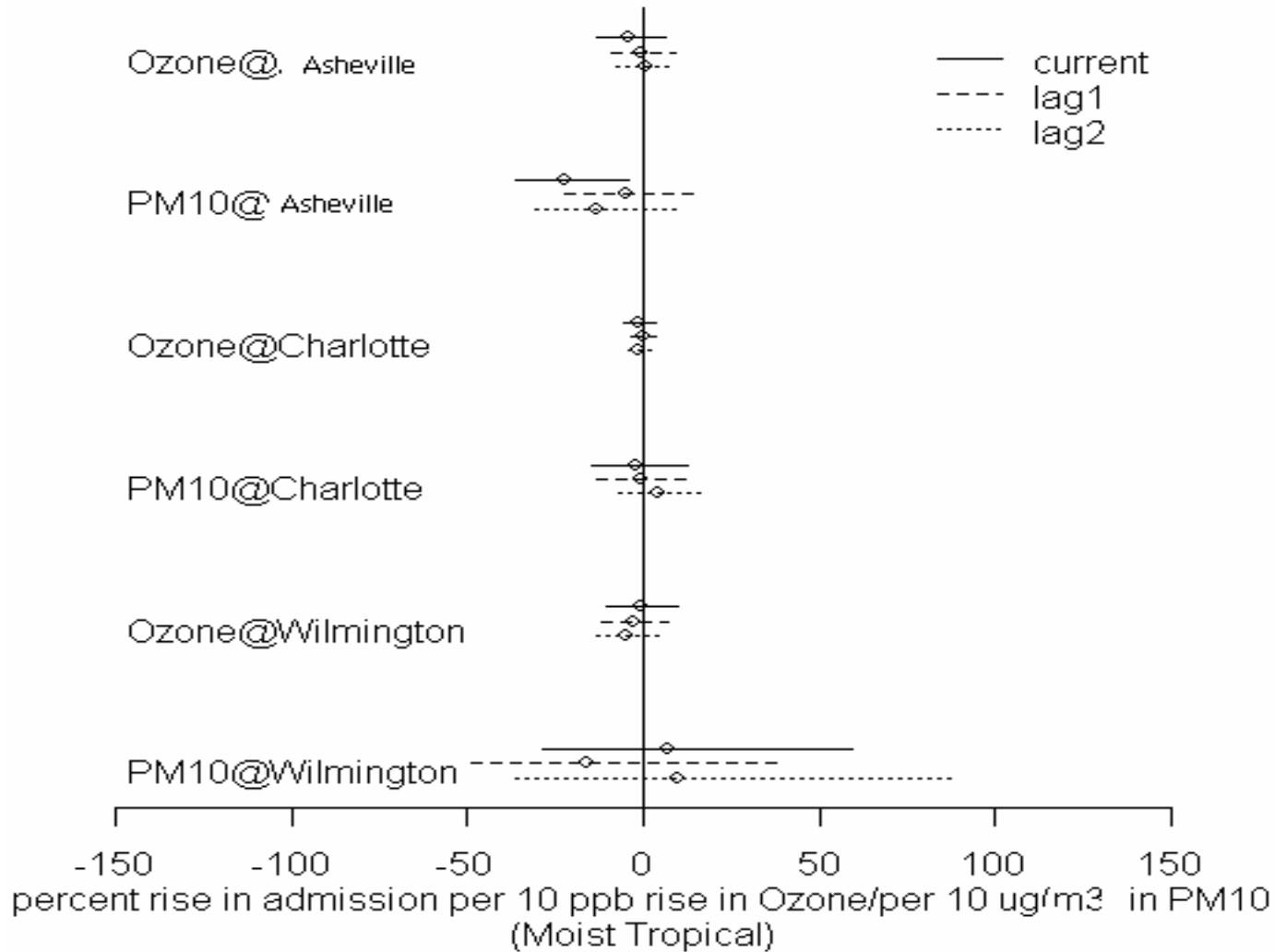
# Percent Rise in Asthma Hospital Admissions
## (Dry Moderate Air)

# Summary

- **Used ten years of data related to daily asthma and myocardial infarction hospital admissions, air quality, and weather patterns in a number of cities in North Carolina.**

- **Weather is classified using the Spatial Synoptic Classification system in terms of eight air mass types.**

- **We use a Generalized Linear Model (GLM) to study the relationship between air pollutants and asthma and MI hospital admissions under different air mass types.**

- **The distributions of ozone and $PM_{10}$ concentrations were examined for different air mass types.**

# Conclusions

- **The Dry Tropical, Moist Tropical, and Dry Moderate air masses are the three weather types associated with episodes of high ozone and $PM_{10}$ concentrations in North Carolina.**

- **Air masses affect the formation, transport, and transformation of air pollutants. Therefore, the distributions of air pollutant concentrations are different under different air masses.**

- **Current, Lag 1-day and lag 2-day ozone and $PM_{10}$ are positively related to asthma admissions for some cities under the Dry Tropical and the Dry Moderate air masses.**

  - Asheville: DT (lag 2-day, Ozone & PM10)

  - Charlotte: DT (lag 1-day and Lag 2-day, Ozone); DM (Current, PM10)

  - Wilmington: DM (Lag 1-day and 2-day PM10)

- **The "day-of-week" effect is substantial, and adjusted for in modeling. Mondays and Tuesdays have more asthma hospital admissions than other days of the week.**

- **The "day-of-week" effect for myocardial infarction hospital admissions is not as strong as for asthma hospital admissions.**

# Work in Progress

- **Projection of future climate patterns**
  - Ten years (2010-2019)
  - MM5 model simulations
- **Air quality modeling for selected seasons**
- **Air masses in the future climate**
- **Probability density functions: ozone/air mass**
- **Analyses of air mass, air pollution, and morbidity in vulnerable population of Medicaid enrollees for 2000-2006**
- **Projection of trends in hospitalizations for asthma and MI in general population and in Medicaid enrollees**
- **Collaboration with the State of North Carolina**
  - Health Impacts (Real Time)

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