# Air Quality Extreme Events and Projected Trends for the Southwestern United States

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**Project Context**

- Established to assess impacts of climate variability and change on human and natural systems in the Southwest
- Air quality initiative: help air quality planners and managers understand links between climate and pollutants to improve decision-making capabilities

**Research Needs**

- Focus on ozone and particulate matter (PM)
  - NAAQS regulations
  - Known detrimental effects (health, environment, visibility)
- Cities in the Southwest are often close to violating federal standards
  - Local climate and weather conditions often determine whether levels are exceeded
- Probabilities of exceedances, now and in the future

**Objectives**

Meet research needs regarding extreme events and future conditions by:
- Characterizing ozone and PM air quality exceedances under current conditions using extreme value methods
- Downscaling climate model scenarios to determine probable changes in ozone/PM meteorology and resulting changes in return levels

**Background: Predicted Changes**

- Climate
  - Warmer: 5-6°C projected for West by 2100
  - Less certainty with precipitation; more model-dependent
- Air quality
  - Ozone-focused
  - Globally: uncertain
  - Western US: higher ozone (Prather et al. 2002; Leung and Gustafson 2005)

**Data**

- Ozone and PM data
  - Local, state, and federal environmental agencies
  - Ozone: maximum daily 8-hr average
  - PM: 24-hour average PM10
- GCM scenarios: Hadley Centre's HadCM3; SRES A2 and B2 scenarios
- NCEP reanalysis meteorological variables
- Tucson, AZ

**Methods: Extreme Values**

- Central Limit vs. Extreme Types Theorem
  - Normal vs. GEV/GP distributions
- Used to estimate:
  - Return Period

        - Probability that threshold is exceeded in a given time period
    - Return Level
        - Magnitude of the return period
- Applied using R-source ExtRemes (Gilleland and Katz 2004 / NCAR)

**Methods: Statistical DownScaling Model** (SDSM - Wilby et al. 2002)

- Combines stochastic weather generator and regression-based approaches
- Model calibrated using observational predictors / predictand
- Modeled relationships and GCM predictors generate future scenarios
- 1990-2001 / 2002-2050 / 2051-2099

**Results: SDSM Calibration and Verification**

- Calibration: 1990-1995
    - Observed predictand (ozone/PM) and NCEP climate predictors
- Verification: 1996-2001
    - Observed and modeled output

**Conclusions**

Characterization of air quality exceedances under current climate conditions:

- Ozone:
    - 1-yr return period for exceedances (80 ppb)
    - 100-yr return level = 90 ppb
- PM:
    - 10-yr return period for exceedances (150 ug/m3)
    - 100-yr return level = 207 µg/m3

Downscaled GCM projections applied to air quality:

- SDSM models correspond well with observed validation period air quality
    - Mean, max ozone
    - Mean PM
- Ozone
    - Monthly means increase 4-5 ppb in summer and autumn
    - Increases in summer seasonal max up to 10 ppb
- PM
    - Summer monthly mean increases up to 9 µg/m3
    - Winter decreases (but within confidence interval)

Modeled climate influence on future extreme events:

- Ozone
    - Increases in return levels at 1-yr (10%), 10-yr (13%), and 100-yr (17%) return periods by 2099
    - Quadrupling of exceedance rate/yr by 2099
- PM
    - Projected decreases from 1990-2001 to 2002-2050
    - No change 2002-2050 to 2051-2099
    - 21st-century 100-yr return levels below NAAQS

**Future Research**

- Compare return levels and climate sensitivity with other Southwest cities
- Modification of PM calibration period, statistical methods, or threshold for better simulation of extremes
- Incorporation of emissions scenarios / chemical transport