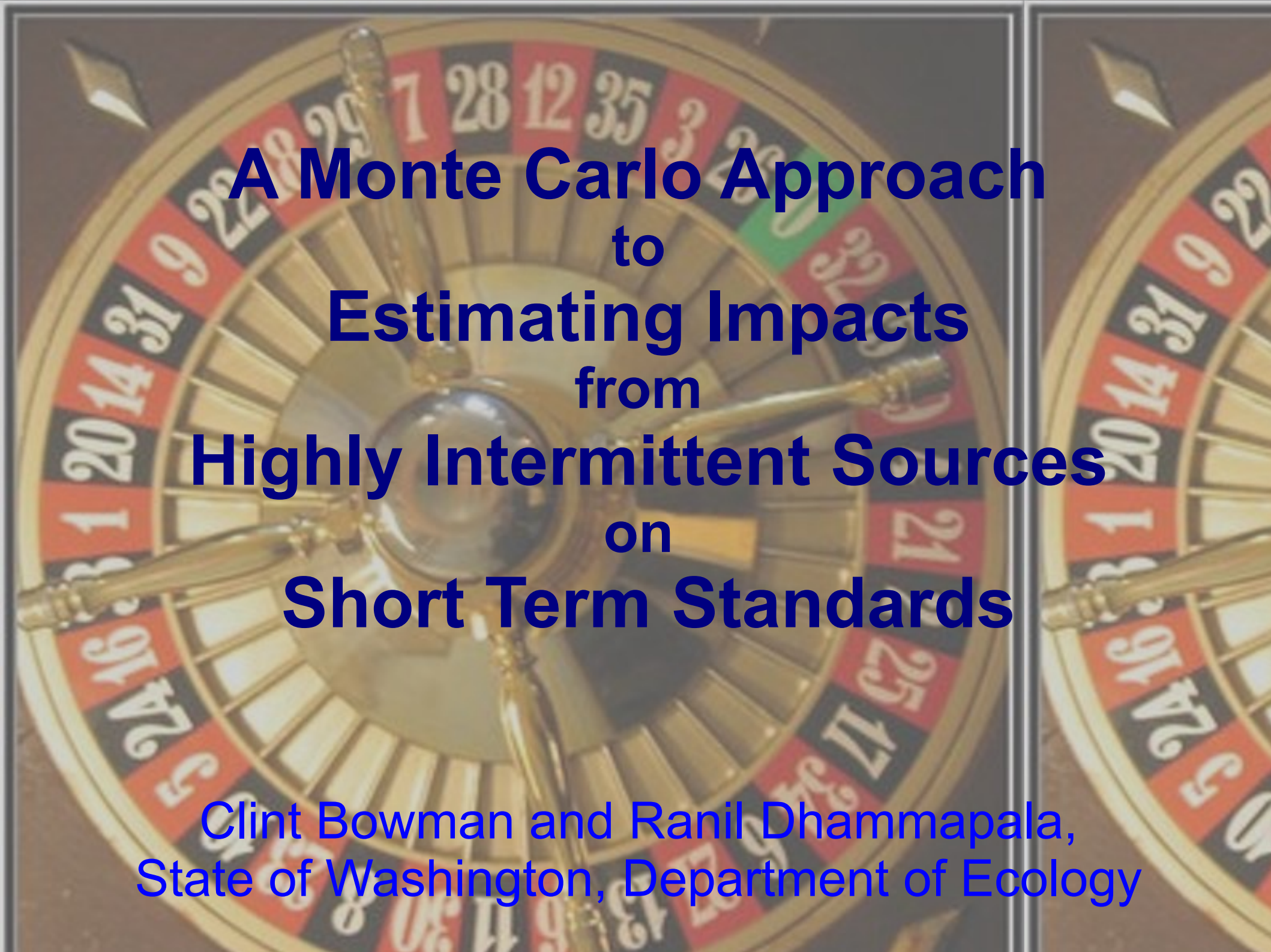

A Monte Carlo Approach to Estimating Impacts from Highly Intermittent Sources on Short Term Standards

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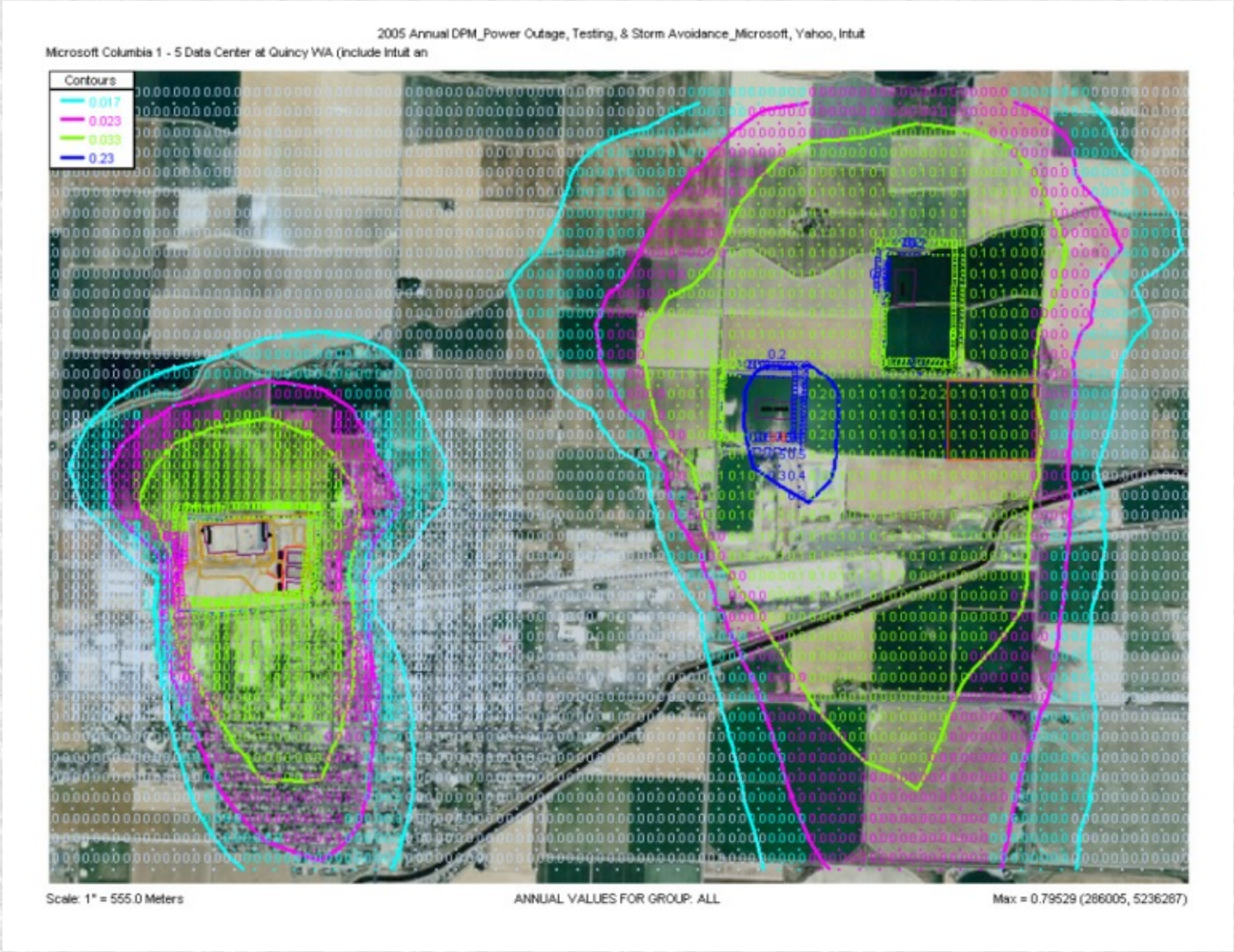
Estimating Impacts from Highly Intermittent Sources on Short Term Standards

- Problem Description
- Modeling Approaches
- Support for Statistical Approach
- Recipe
- Compute Requirements

Problem Description

- Multiple megawatt generators at each data center
- Multiple data centers in small communities
  - Wenatchee
  - Moses Lake
  - Quincy

Annual Diesel PM



Problem Description (2)

- Standard defined over several years
- Standard defined as percentile (98th)
- Sources are highly intermittent (1 – 2 % duty cycle)
- Ground level impact dependent on meteorology
- Source operation not correlated with dispersion conditions

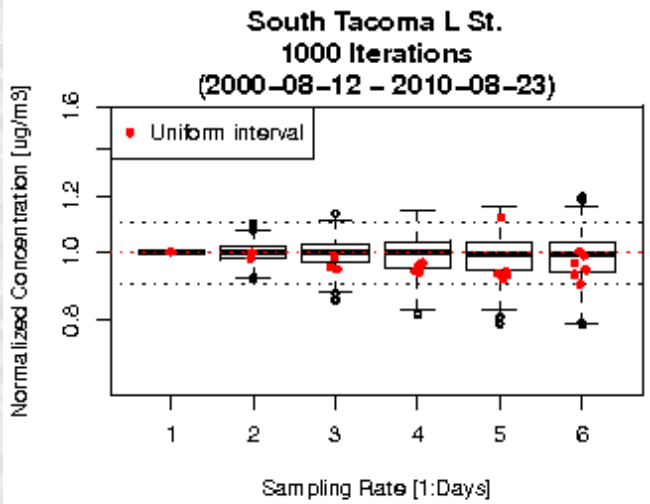
Modeling Approaches Deterministic

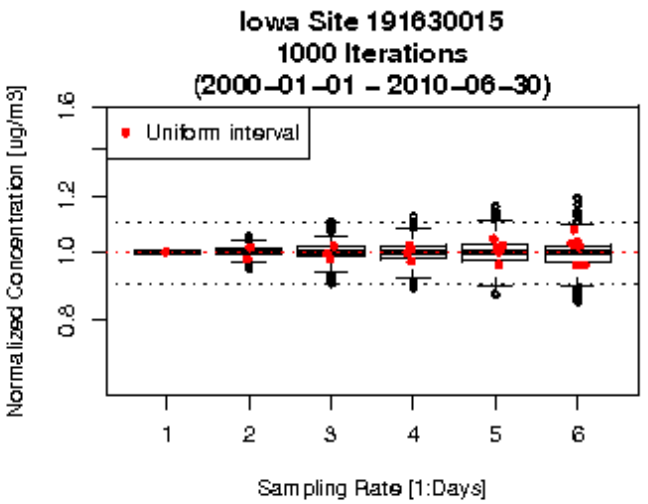
- Screen—expected emission rate for each mode
  - Pass if highest impact is below NAAQS
  - Pass if 8th high of each year is less than NAAQS
  - Pass if running 3-year average of 8th high < NAAQS
- Refined(1)—specify day of week and times
  - Lowers probability that high emissions mode lands on poor dispersion day
  - But meteorology doesn't understand day of week
- Refined(2)—step through days of week
  - Still misses many possible combinations of emissions and meteorology

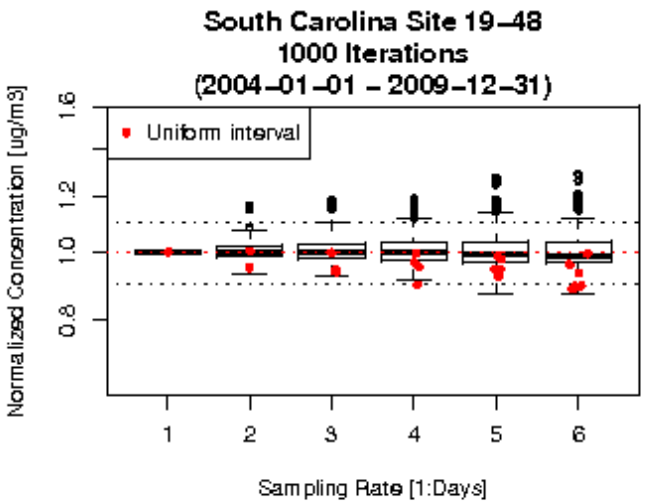
Rely on Recent Experience

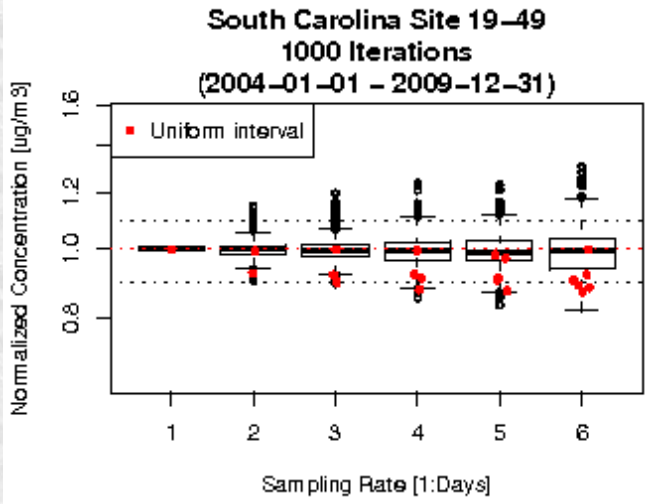
Chronology

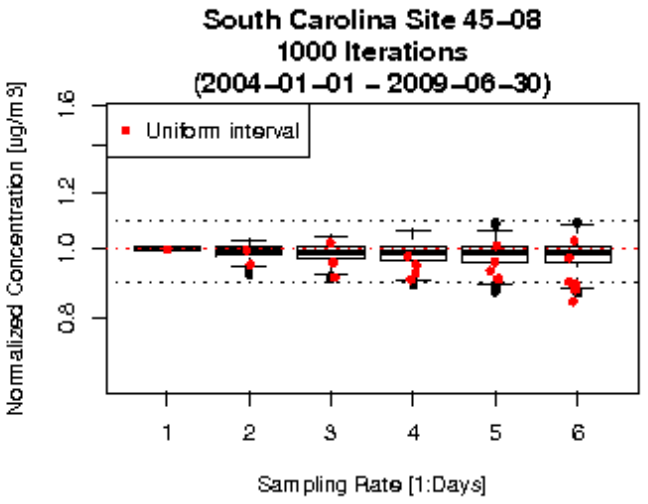
- Investigated effects of sampling frequency on computed 98^{th} percentile (1:1 to 1:6 day rates)
- Applied Monte Carlo to sample observed daily concentrations
- Applied same Monte Carlo method to model output with similar results
- Monte Carlo method seemed appropriate to apply to evaluate impacts of intermittent sources on a statistically-based metric

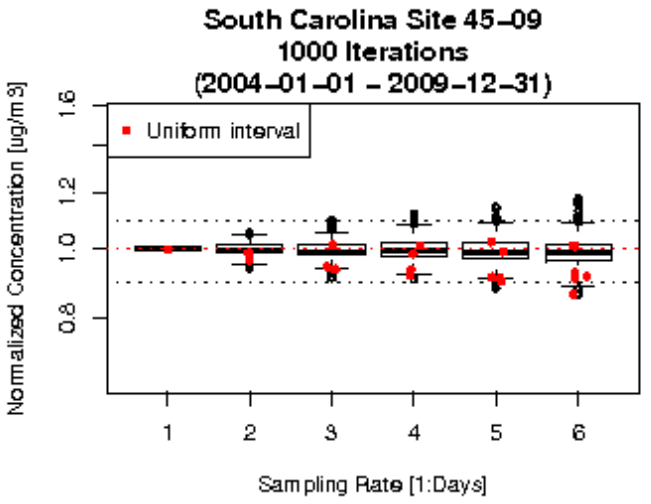

South Tacoma L St.
1000 Iterations
(2000-08-12 - 2010-08-23)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]

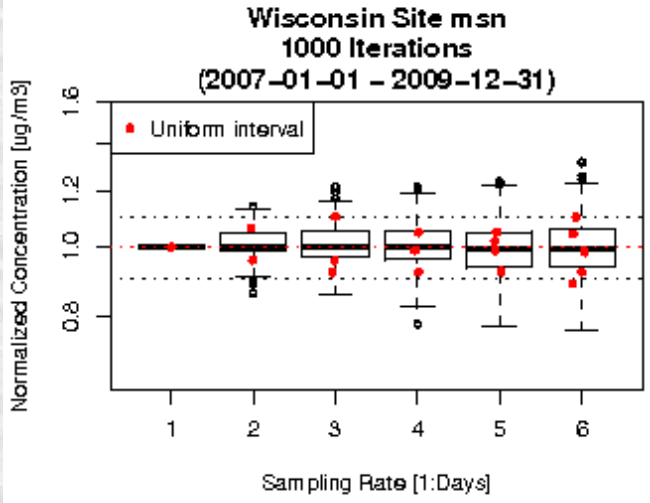

Iowa Site 191630015
1000 Iterations
(2000-01-01 - 2010-06-30)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]

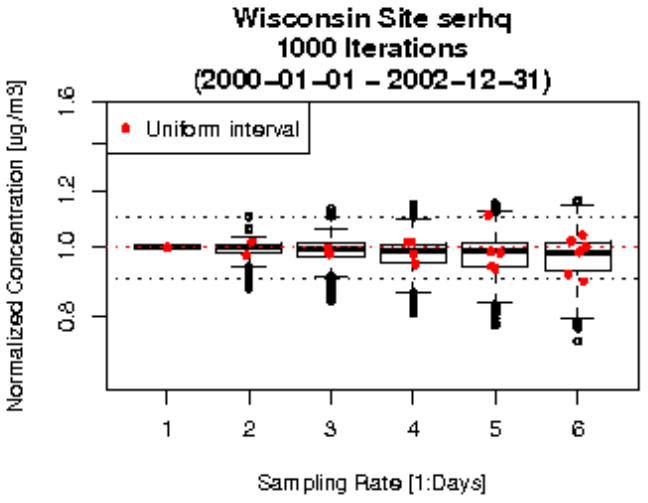

South Carolina Site 19-48
1000 Iterations
(2004-01-01 - 2009-12-31)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]

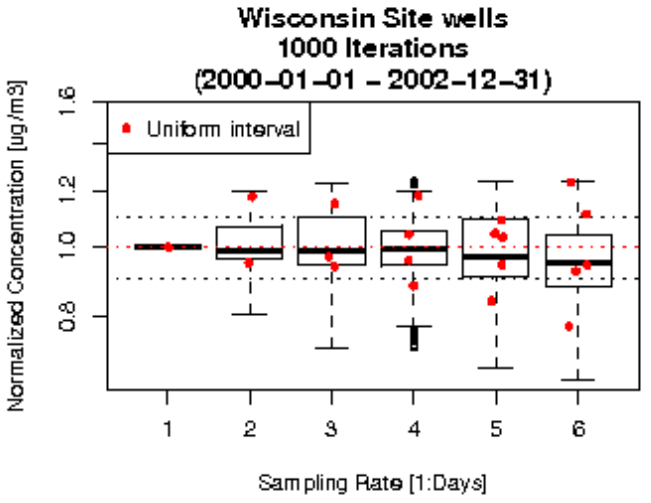

South Carolina Site 19-49
1000 Iterations
(2004-01-01 - 2009-12-31)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]


South Carolina Site 45-08
1000 Iterations
(2004-01-01 - 2009-06-30)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]


South Carolina Site 45-09
1000 Iterations
(2004-01-01 - 2009-12-31)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]


Wisconsin Site msn
1000 Iterations
(2007-01-01 - 2009-12-31)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]


Wisconsin Site serhq
1000 Iterations
(2000-01-01 - 2002-12-31)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]

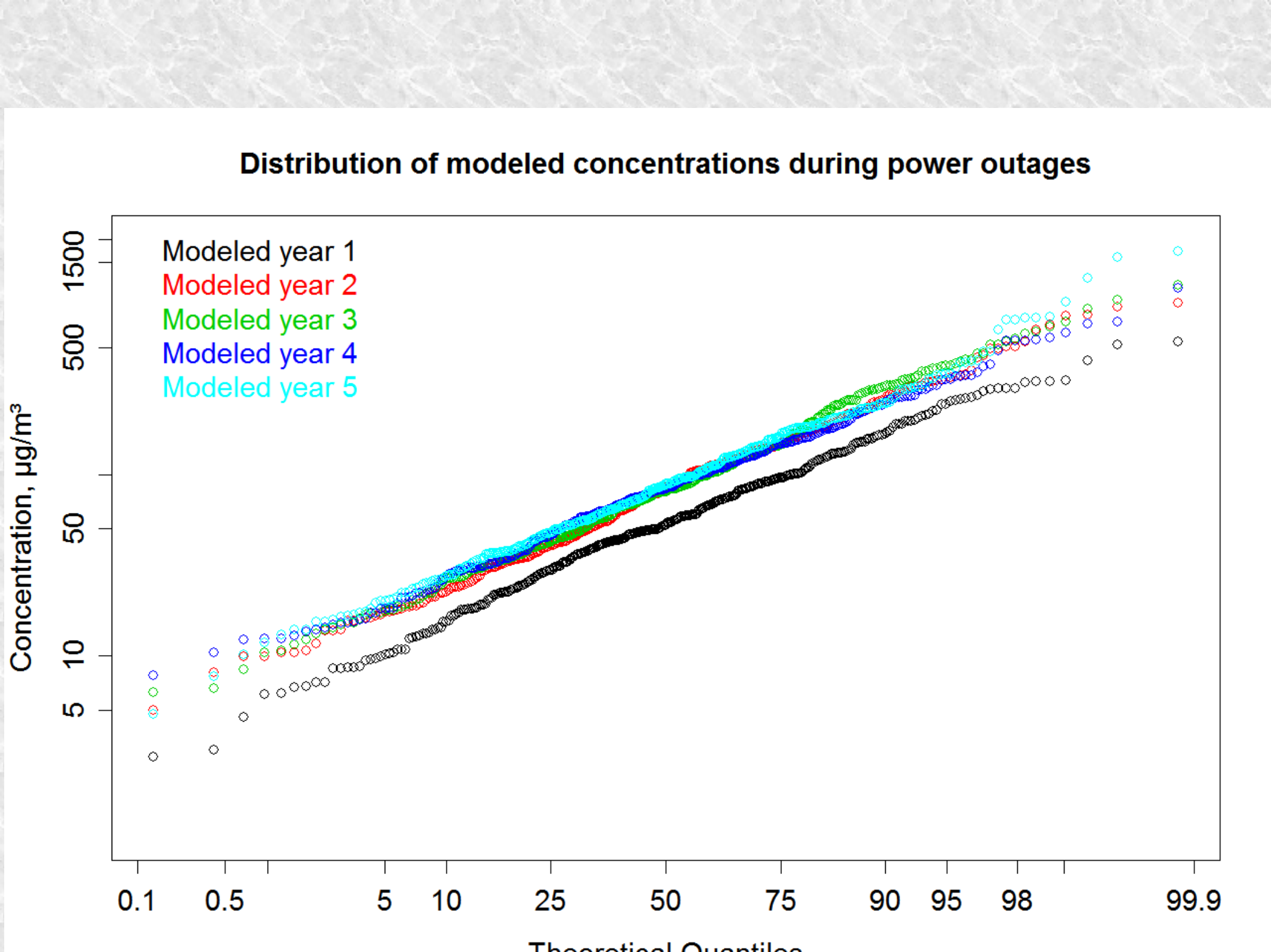

Wisconsin Site wells
1000 Iterations
(2000-01-01 - 2002-12-31)
Uniform interval
Normalized Concentration [ug/m3]
Sampling Rate [1:Days]

Support for Statistical Approach

- Numerical experiments
- Previous application to problems in:
  - Physical sciences
  - Engineering
  - Biology
  - Applied statistics
  - Finance
  - Telecommunications

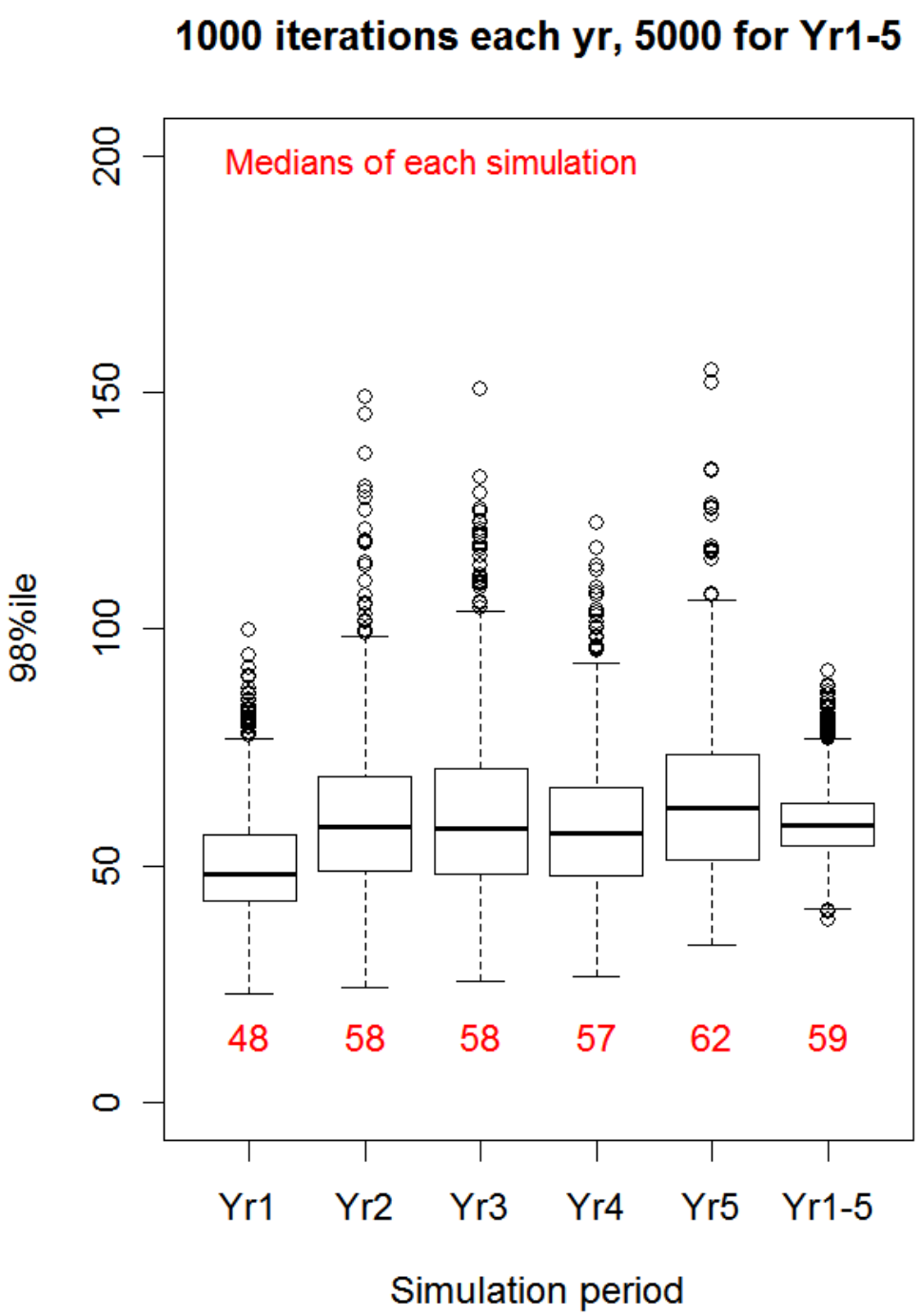
Statistical Experiments

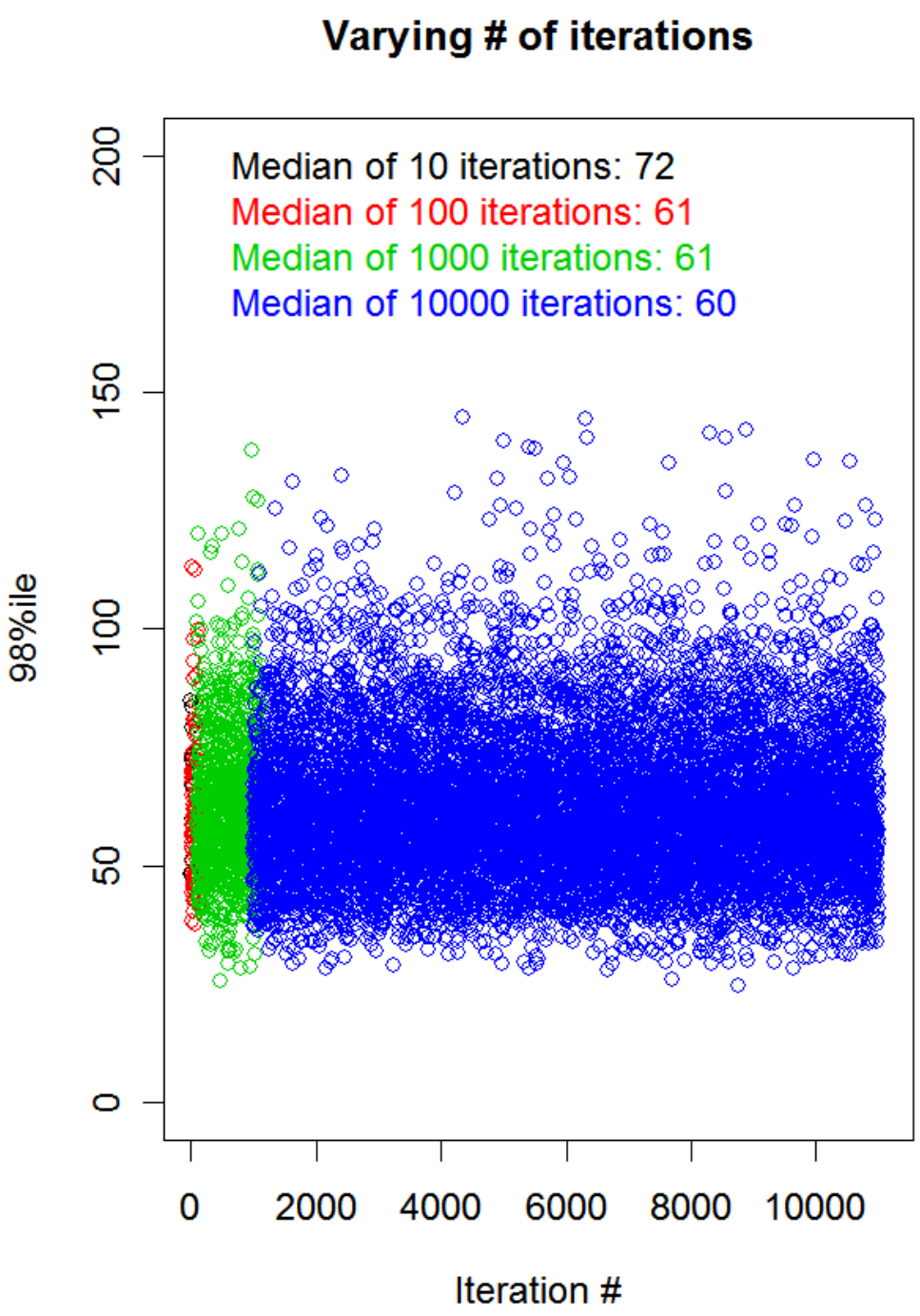
- Generate a log-normally distributed dataset of 1825 observations corresponding to five years of daily observations
- Define operating modes (emission rates and number of days per year)
- Sample the distribution (without replacement) according to the defined modes, compute 98^{th} percentile, and repeat
- Determine effect on computed 98^{th} percentile of varying number of samples drawn


Distribution of modeled concentrations during power outages
Modeled year 1
Modeled year 2
Modeled year 3
Modeled year 4
Modeled year 5
Concentration, µg/m³
5
10
50
500
1500
0.1
0.5
5
10
25
50
75
90
95
98
99.9
Theoretical Quantiles

Mode Definitions

Mode	% Power	Days/Year
Weekly	51	12
Monthly	7.6	12
Semi-A	23	2
Annual	23	2
Outage	100	8


1000 iterations each yr, 5000 for Yr1-5
Medians of each simulation
98%ile
0
50
100
150
200
48
58
58
57
62
59
Yr1
Yr2
Yr3
Yr4
Yr5
Yr1-5
Simulation period

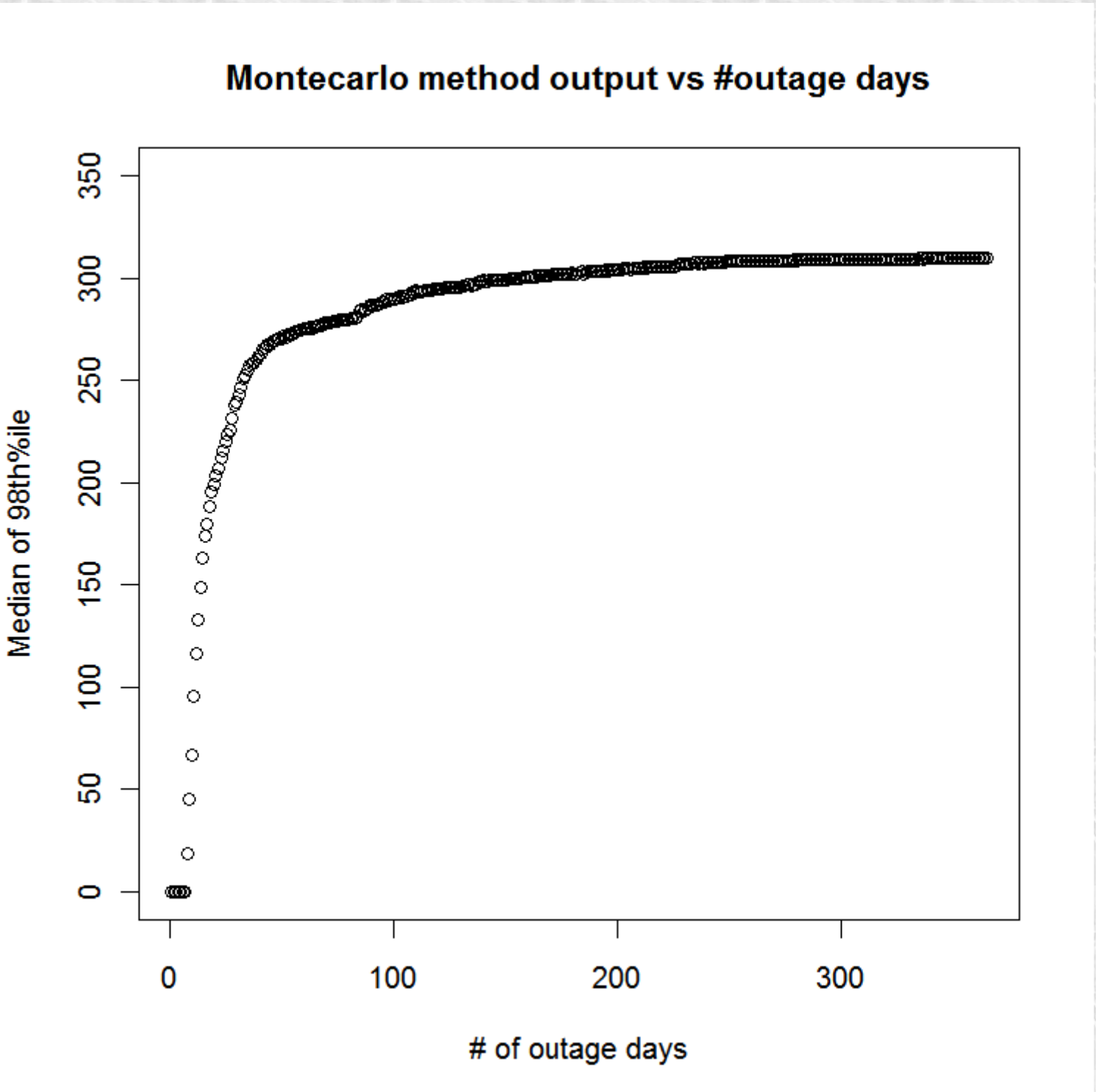

Varying # of iterations
Median of 10 iterations: 72
Median of 100 iterations: 61
Median of 1000 iterations: 61
Median of 10000 iterations: 60
98%ile
0
50
100
150
200
0
2000
4000
6000
8000
10000
Iteration #

Modeling Requirements

- Define all distinct modes of operation
  - Power levels
  - Duty cycle
- Run AERMOD for each mode
  - Save hourly output in POST file
- Define daily maxima at each receptor for each day of run

Example of Run times

- AERMOD required 75 hours for 15 modes
- Perl script processing *.POST files – 35 hours
- R script for samples 65 hours
  - There has been a 2 – 5 times speedup since this benchmark was run


Montecarlo method output vs #outage days
Median of 98th%ile
0
50
100
150
200
250
300
350
0
100
200
300
# of outage days

Recipe

- Define Modes
- Run Dispersion Model
- Retrieve Daily Maxima
- Randomly Select Days
- Compute 98^{th} Percentile
- Repeat 1000 Times
- Compute Median