

# **Adaptive air quality management through operational sensitivity forecasting**

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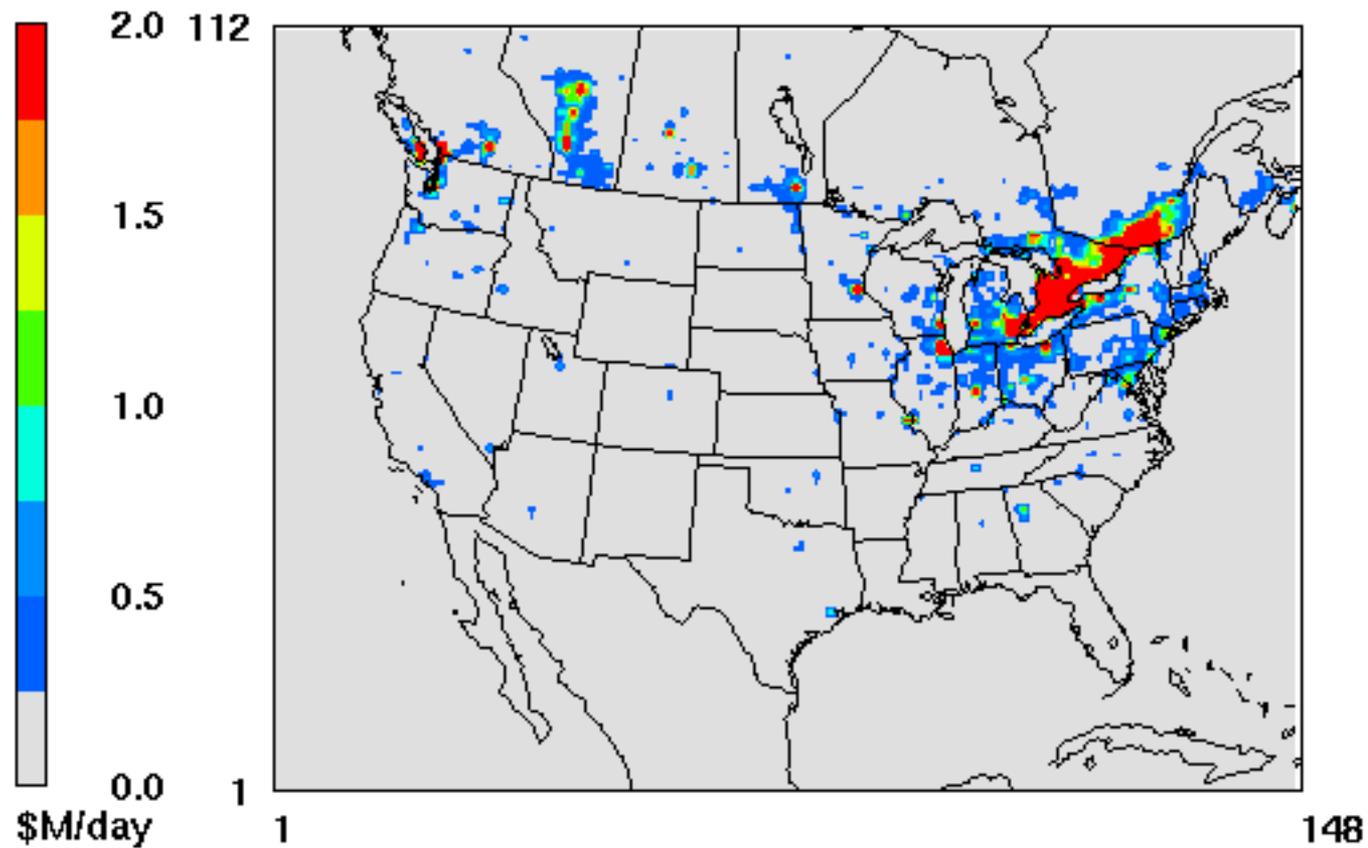
3<sup>rd</sup> IWAQFR Workshop  
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# Air quality management

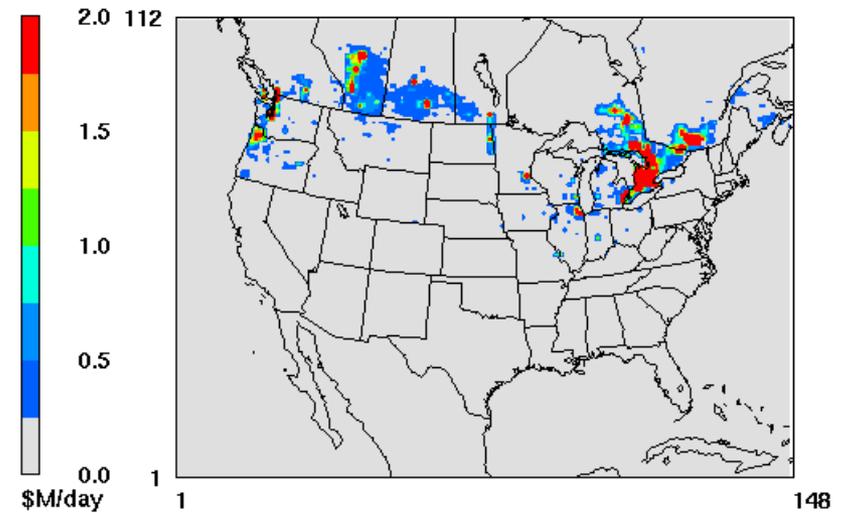
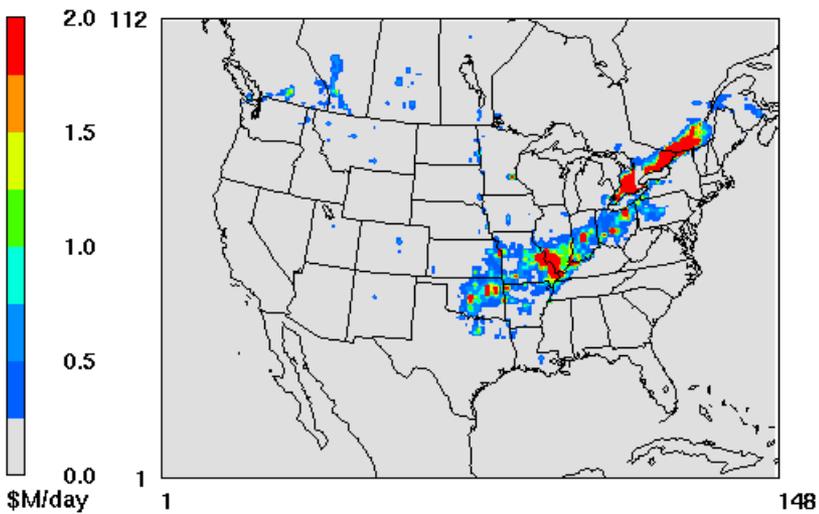
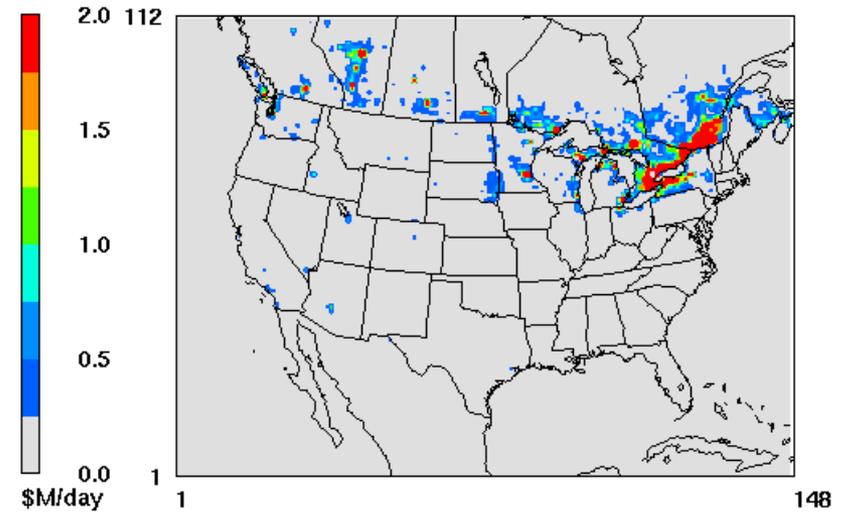
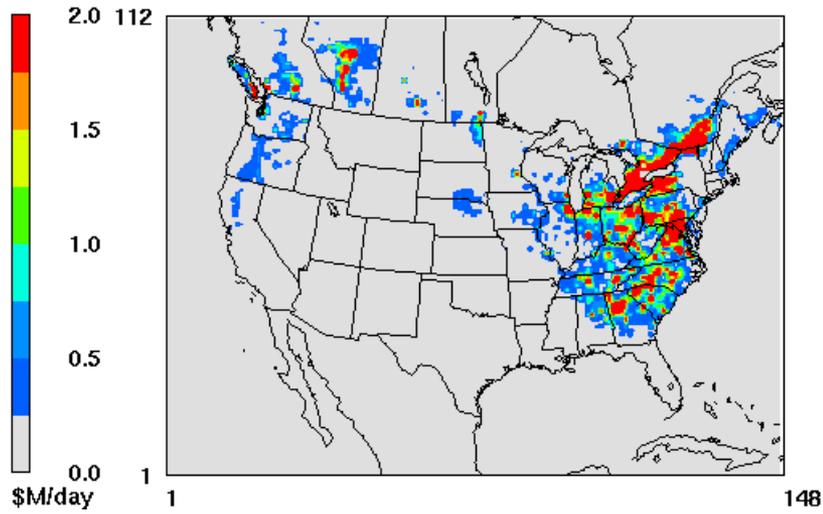
- Models are used for long-term or short-term predictions
  - Long-term planning (e.g. strategy design)
  - Short-term prediction (public warning, etc)
- Can we do short-term planning?

Is modifying emission behavior in the short term (a day) worth the effort?

# Influence on Canadian mortality



# Variability of influence on Canadian mortality



# Adaptive but targeted emission modification

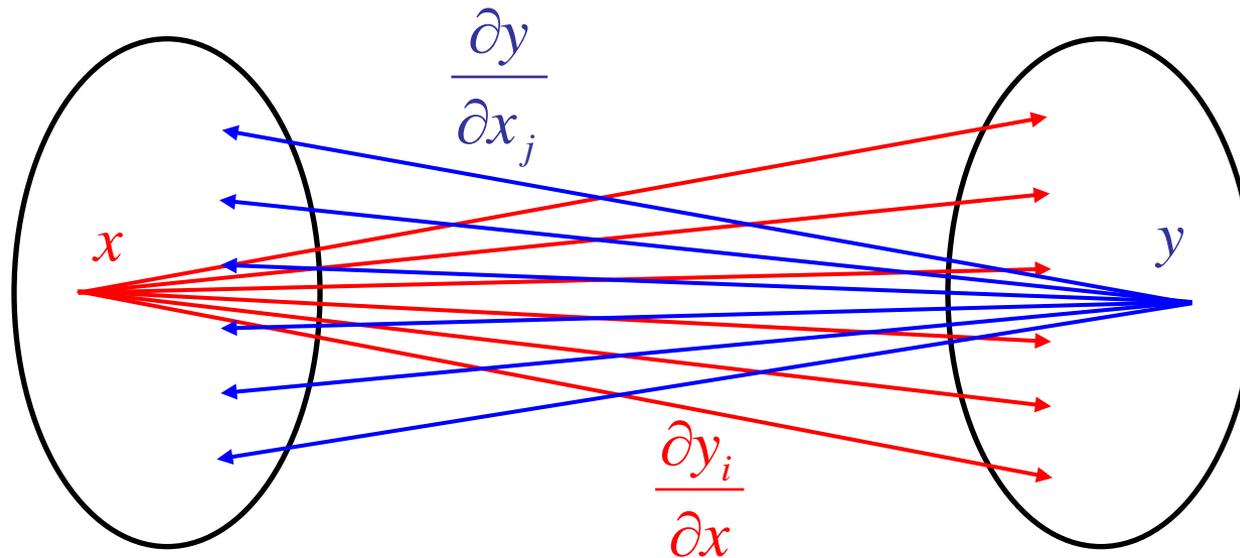
- In cases where forecast leads to control measures, these efforts usually pay limited attention to effectiveness
- Sensitivity analysis can guide short-term measures.

Can forecast pollution episodes be averted?

# Adjoint or backward sensitivity analysis

Inputs/Sources

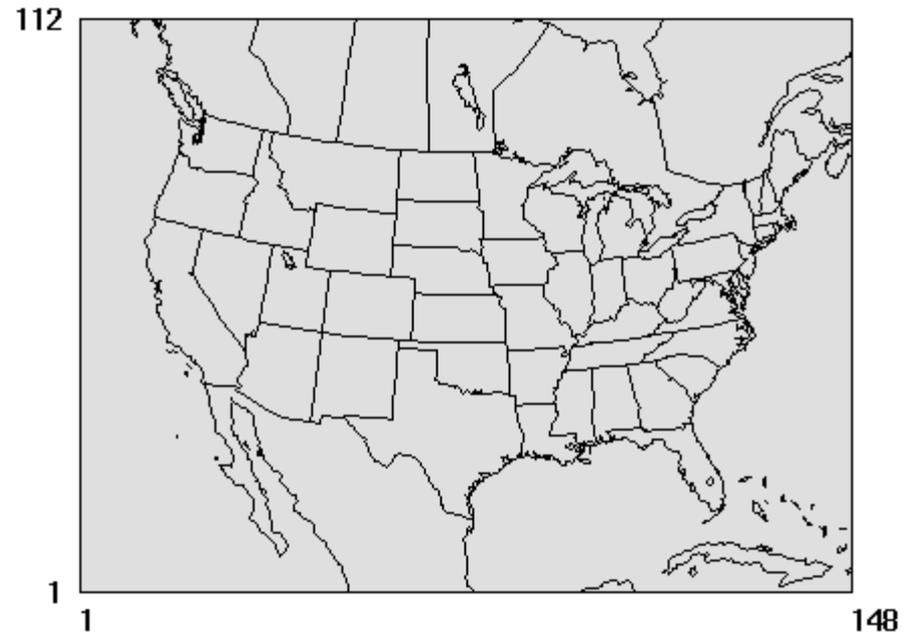
Outputs/Receptors



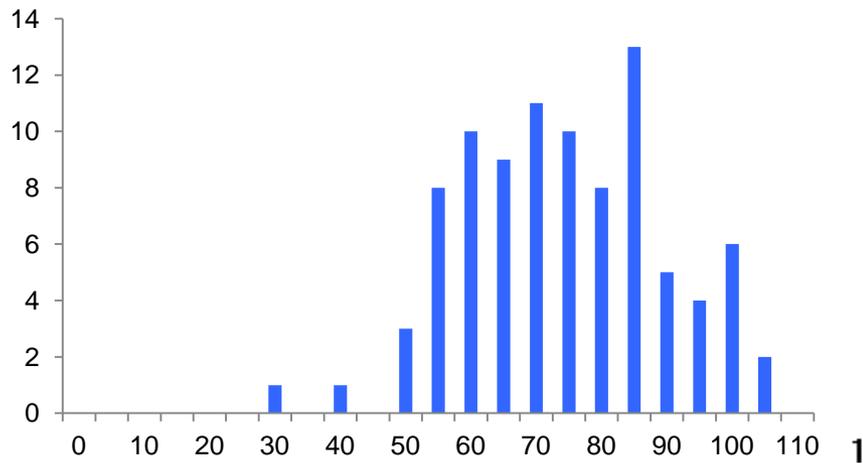
- Backward analysis is efficient for calculating sensitivities of a small number of outputs with respect to a large number of inputs. Forward analysis is efficient for the opposite case.
- **Complementary methods (Source-based vs. Receptor-based), each suitable for specific types of problems.**

# CMAQ Adjoint simulations

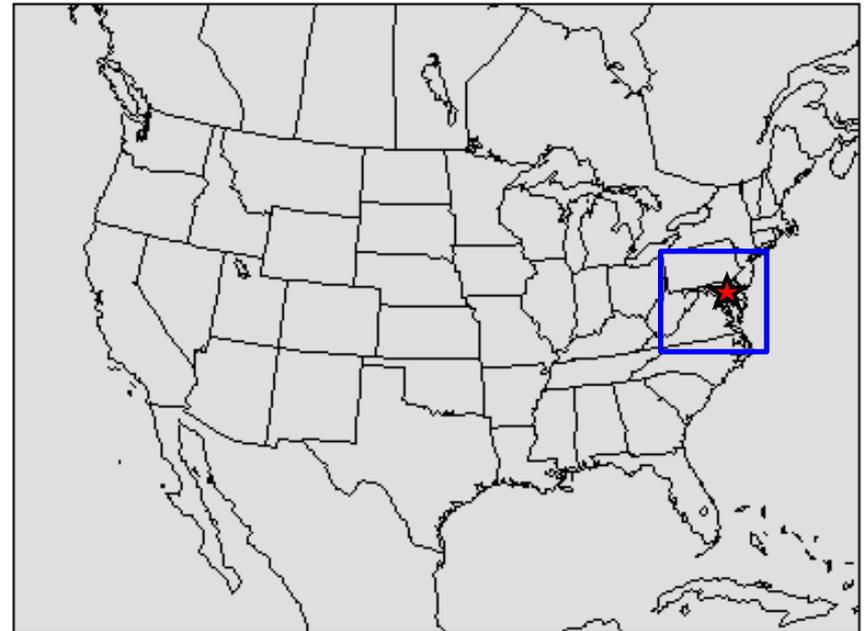
- Continental domain
  - 36 km resolution
  - 13 vertical layers
- Summer of 2007
- Gas-phase CMAQ with adjoint sensitivity
  - SAPRC-99 chemistry
- Sensitivities of ozone to  $\text{NO}_x$  emissions



# Baltimore



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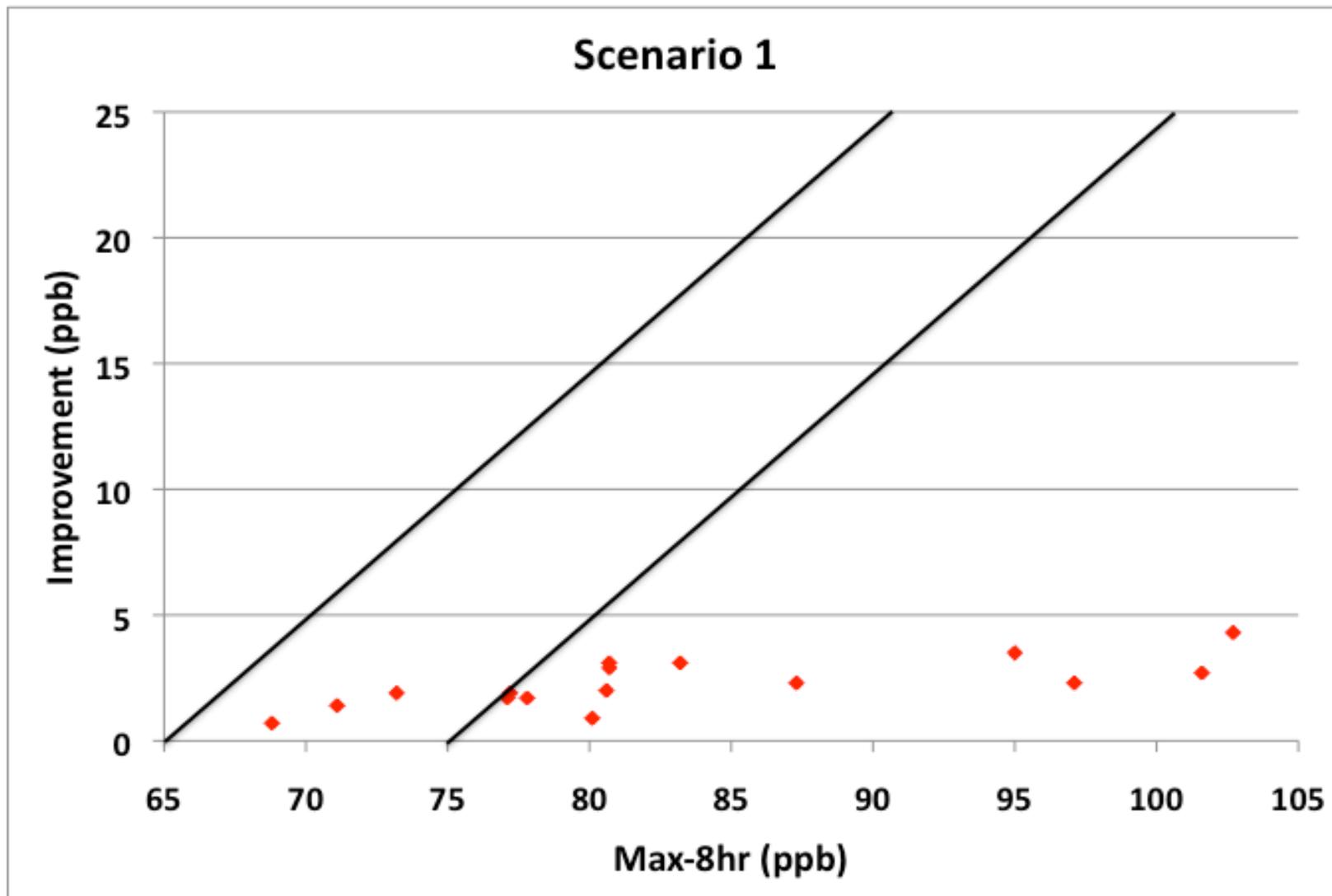
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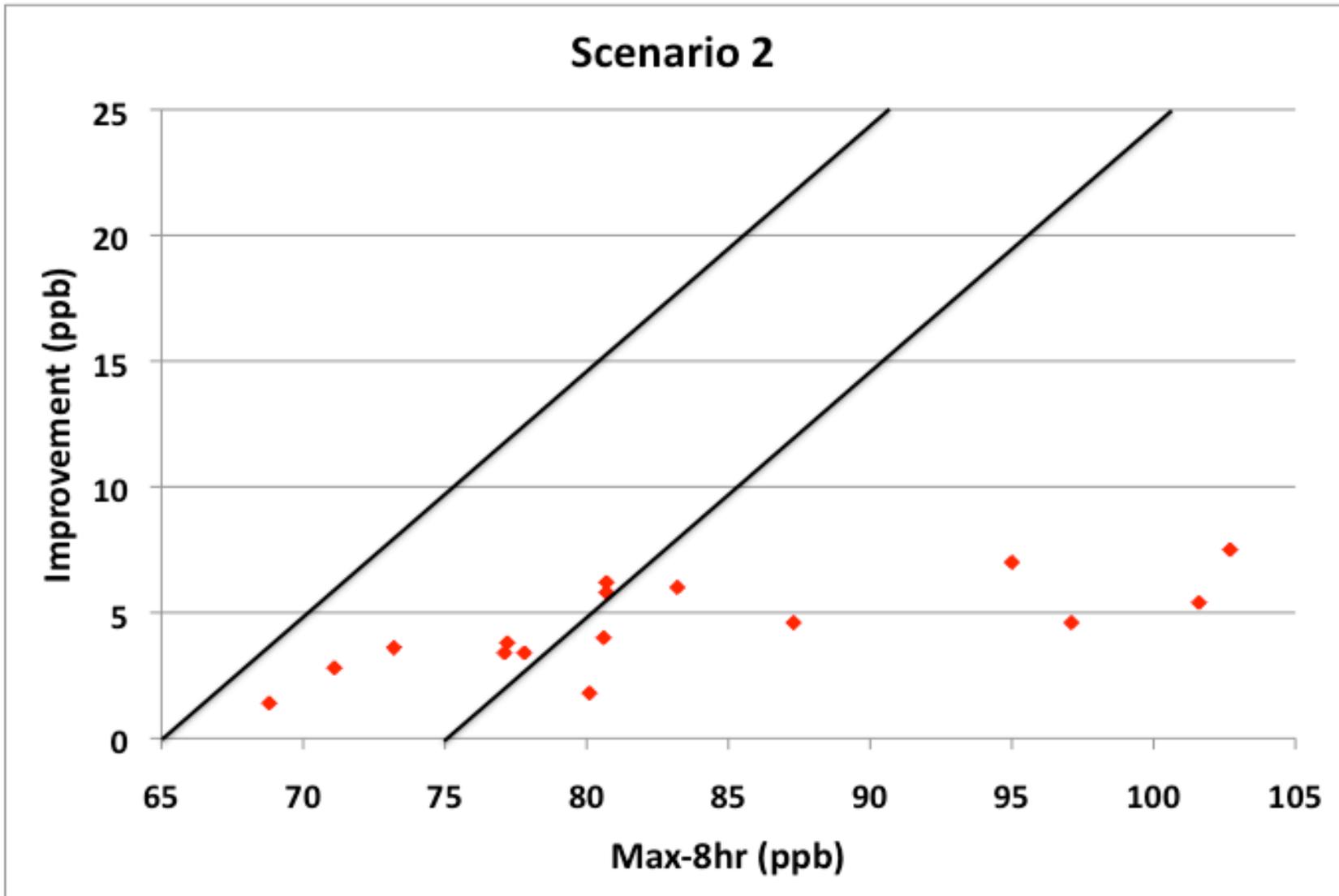
# Methodology

- 16 days in summer
- Sensitivity of Baltimore to each source calculated
- Top 10% locations (sources) modify their emissions by the following:
  - Scenario 1: 5% point + 8% mobile
  - Scenario 2: 10% point + 15% mobile
  - Scenario 3: 15% point + 25% mobile

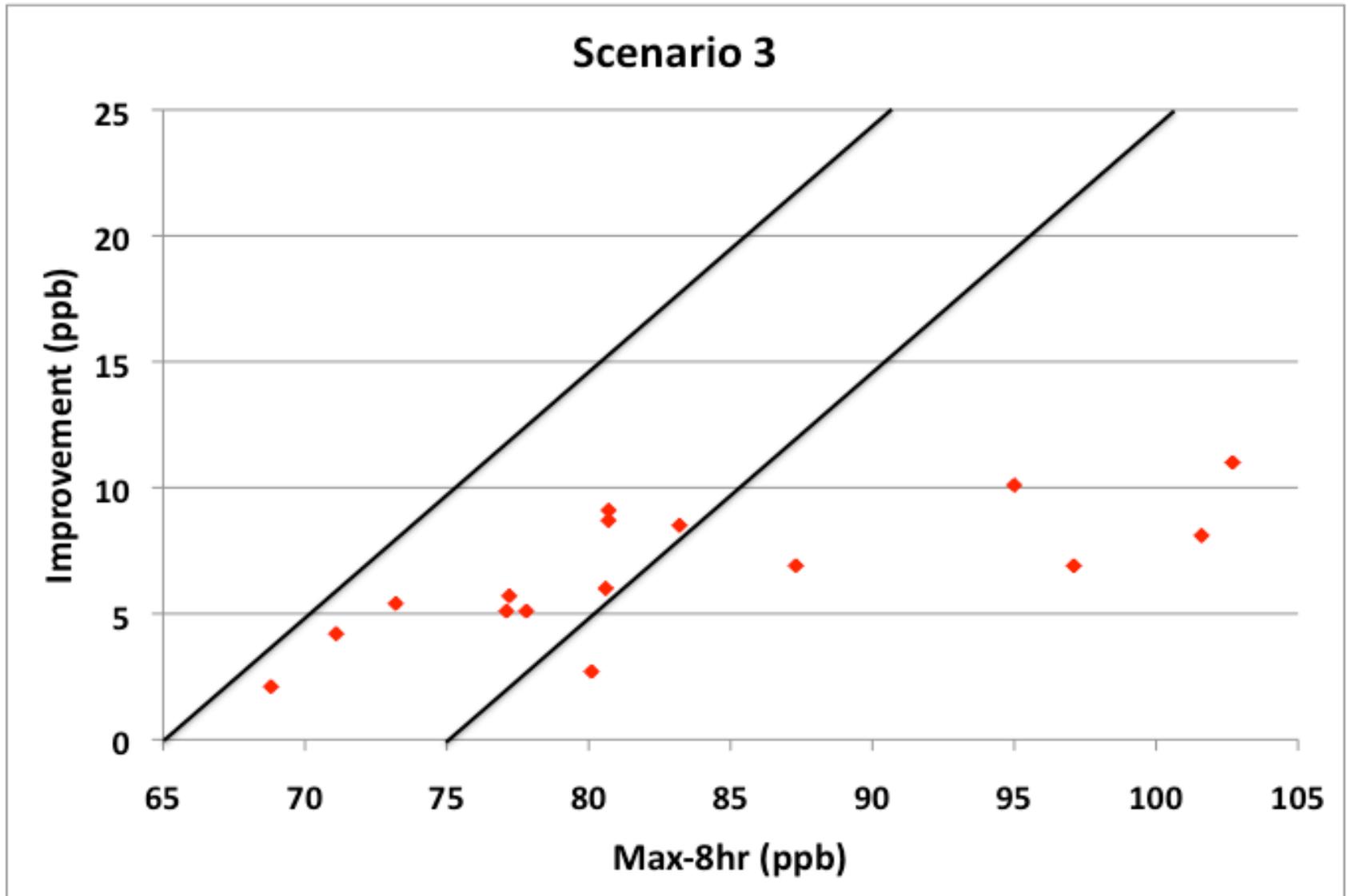
# Baltimore 8-hr max ozone



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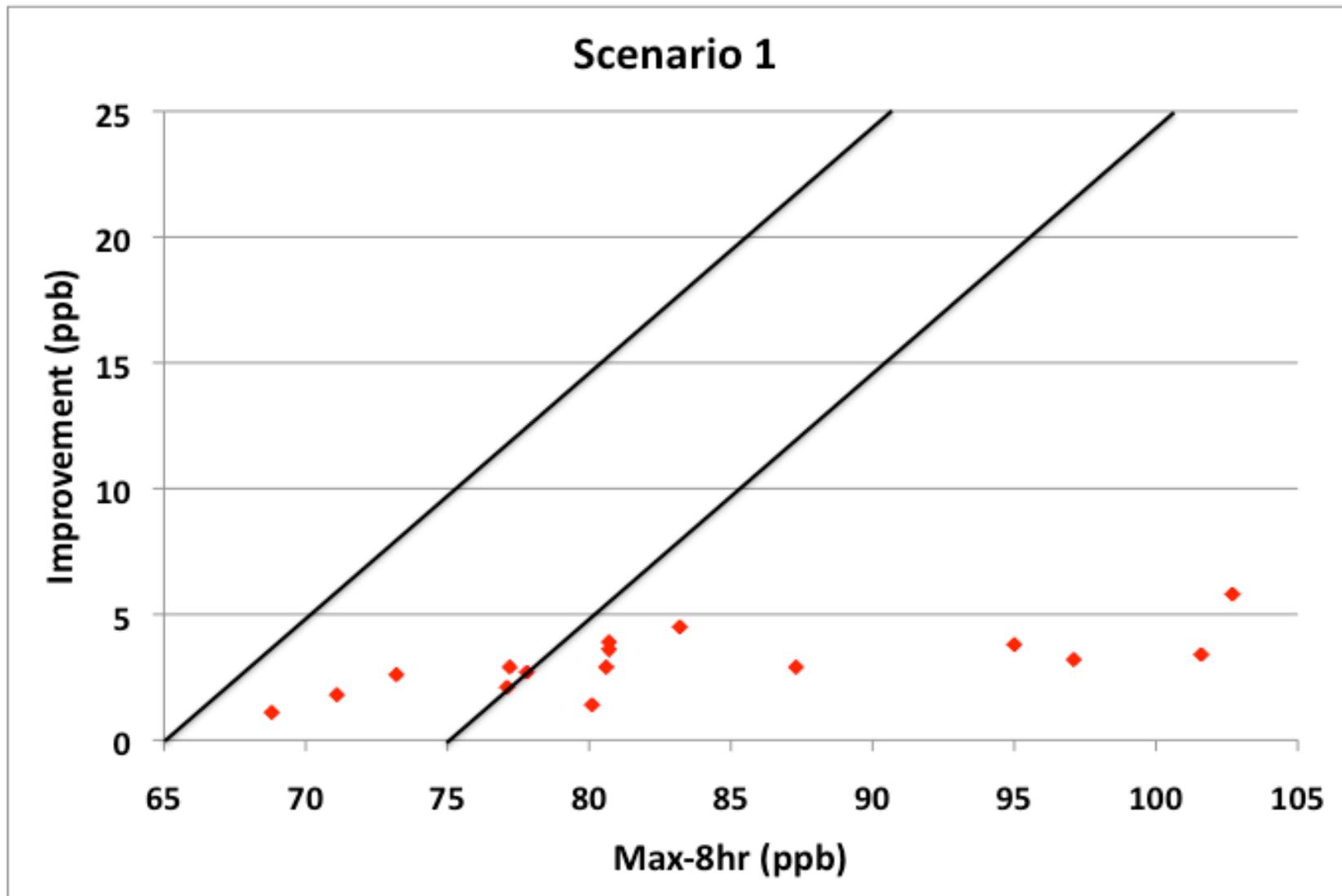
# Baltimore 8-hr max ozone



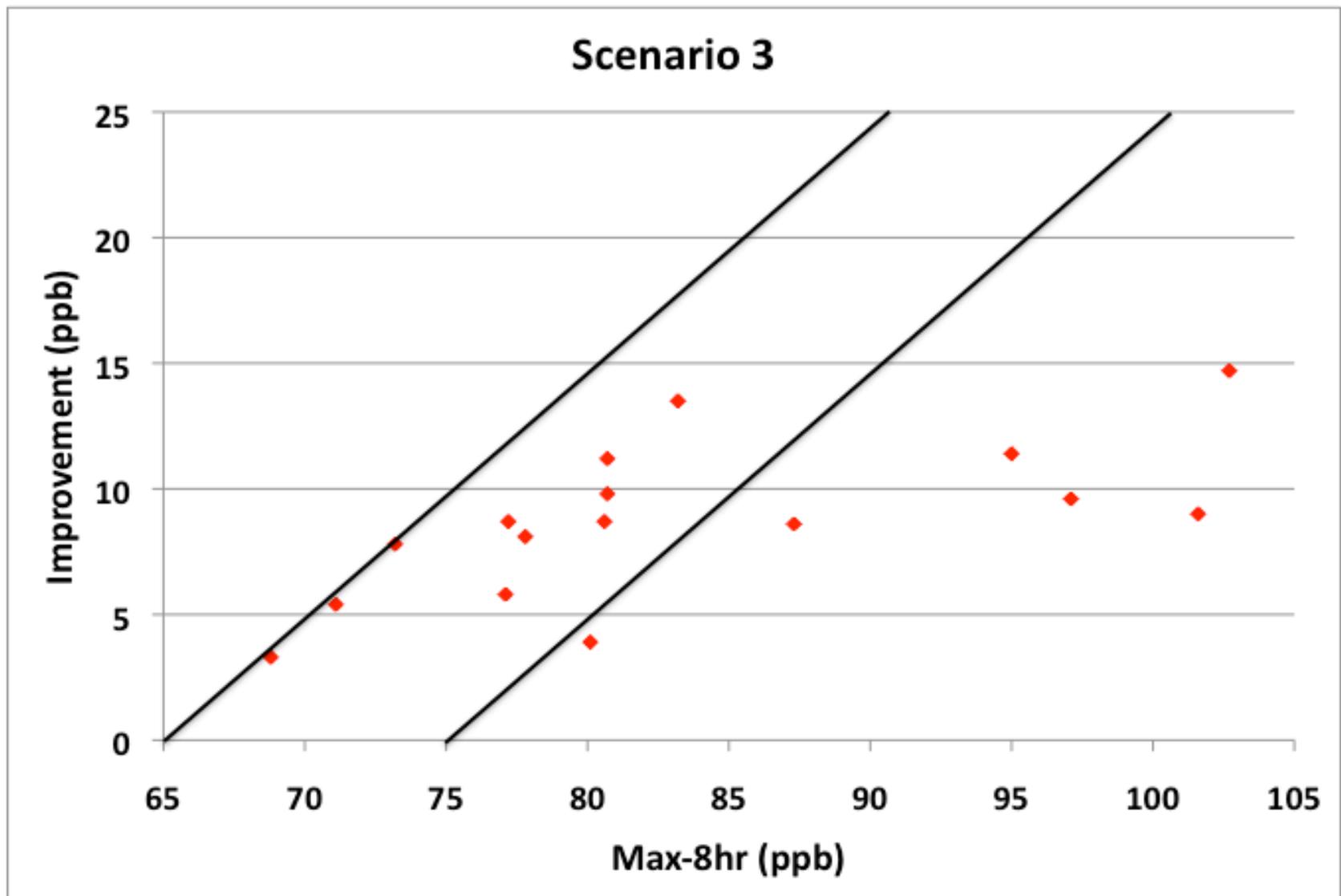
# Spatio-temporal selectivity

- Adding temporal sensitivities
- Top **5%** locations (sources) modify their emissions by the following:
  - Scenario 1: 5% point + 8% mobile
  - Scenario 2: 10% point + 15% mobile
  - Scenario 3: 15% point + 25% mobile

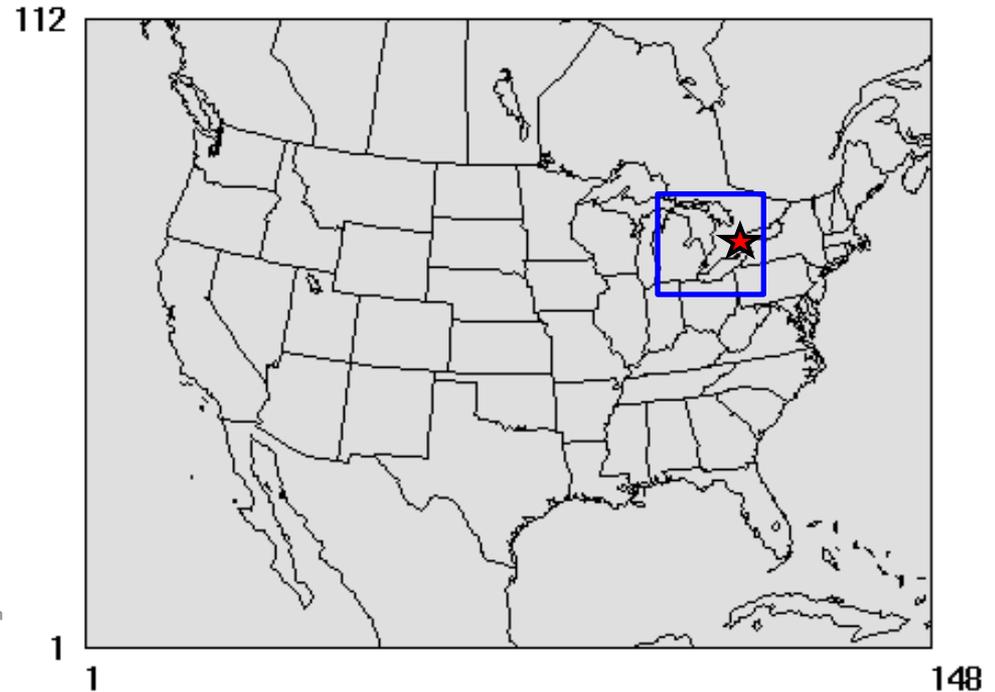
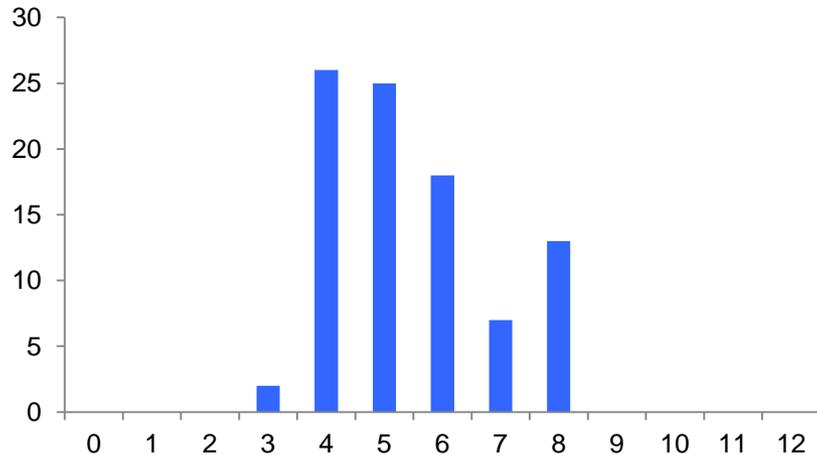
# Baltimore: hourly emission modification



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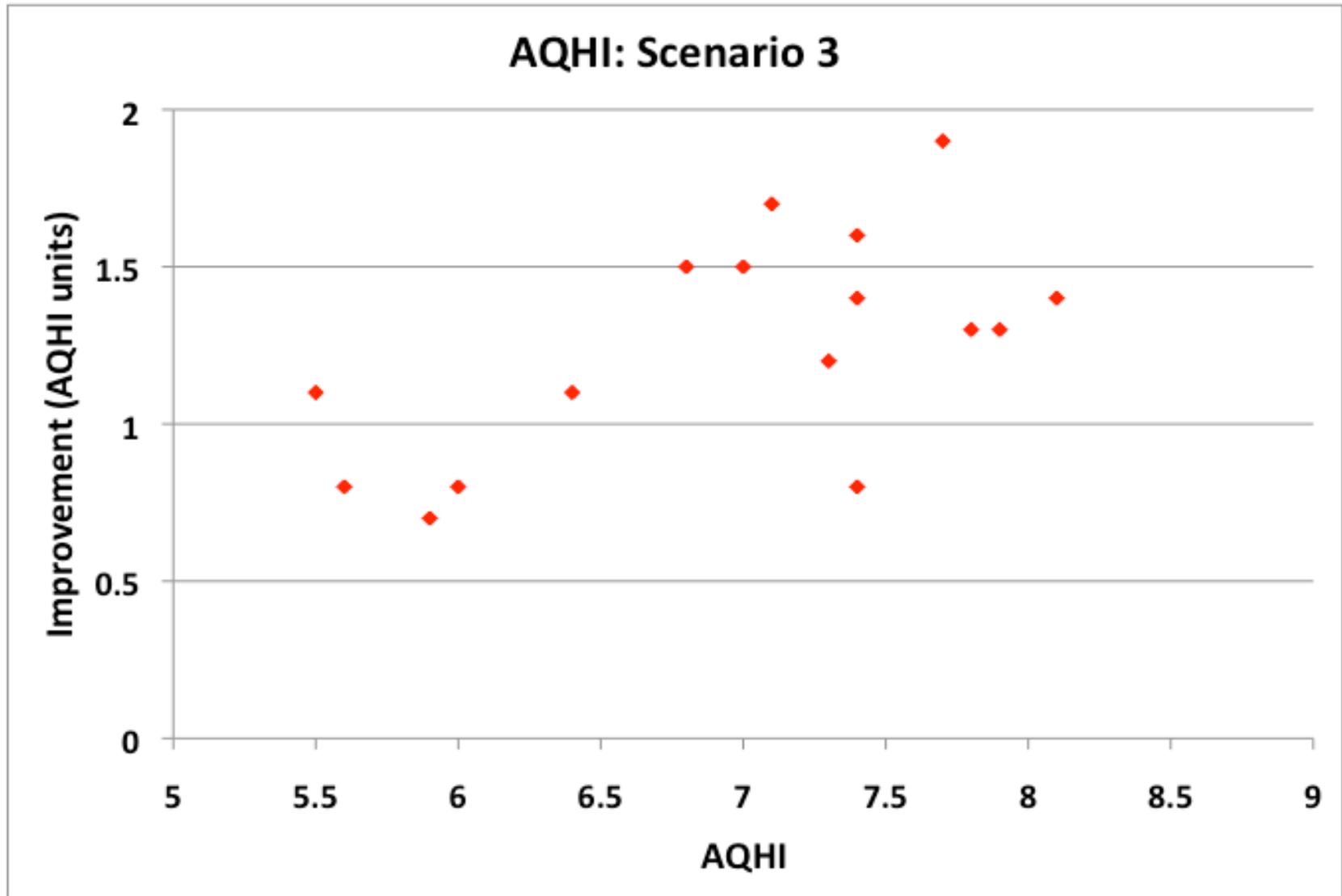


# AQHI in Toronto



$$\text{AQHI (summer)} = 10 \cdot (0.101 \cdot \text{NO}_2 + 0.104 \cdot \text{O}_3) / 12.8$$

# AQHI: hourly emission modification



# Challenges/Issues

- The model predicts some improvement, but how can you confirm that?
- Emission behavior modification on a fluctuating basis is not desirable
- At moderate levels of aggressiveness, impacts are not sufficiently large to consistently move the receptor into attainment

# Next Steps

- Should be done at high resolution!
- How different the effectiveness is for various receptors?
- Impact of regional planning

# Conclusions/thoughts

- Short-term emission behavior modification can have sizeable impact; however, the impact is not large enough to significantly increase attainment likelihood
- Adjoint sensitivities can guide the short-term, operational management
- Temporal selectivity is an important component of the increased effectiveness.
- The method may be more effective for longer forecast windows (> 1 day)

Comments, questions?

