Adjoint Modeling for Improved Effectiveness of Emission Trading Systems

Seyyed Morteza Mesbah, Mathew Russell , Stephan Schott, and Amir Hakami

Carleton University

Yongtao Hu and **Ted Russell**

Georgia Institute of Technology

Carleton UNIVERSITY

CMAS

Purpose and Outline

- **Using of sensitivity analysis for improved performance of trading systems**
- **Evaluation of the proposed Decision Support System by a case study**

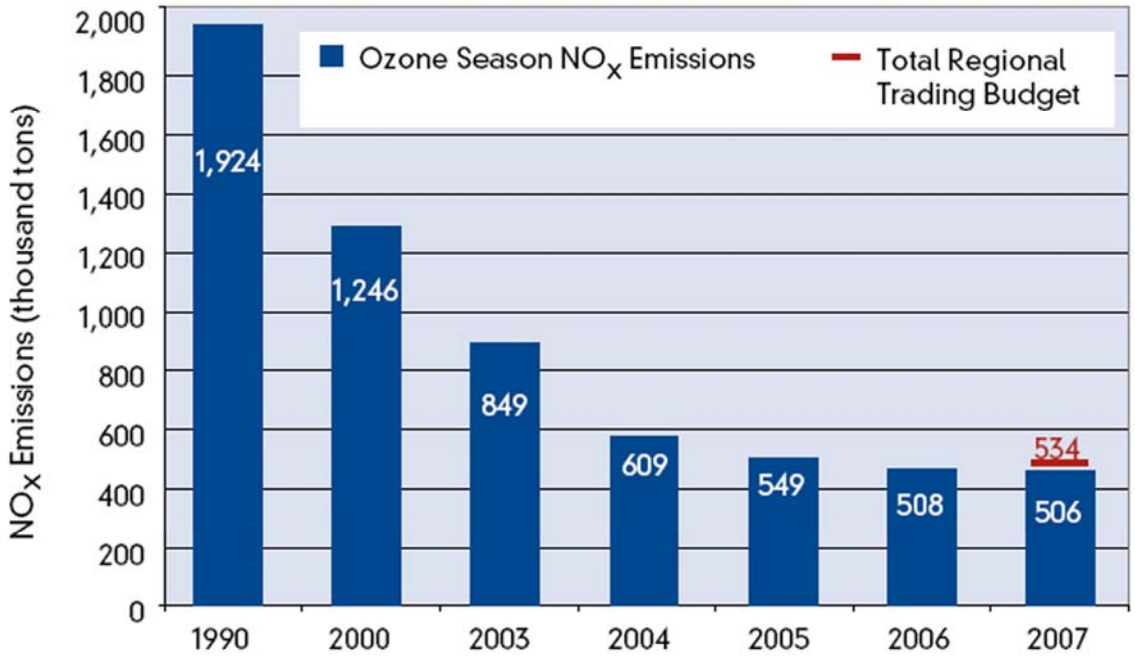
- **Policies to consider:**
  - Command-and-Control (we call this FLAT)
  - No exchange rate (current trading systems – we call this NOEXCHANGE)
  - Sensitivity-based exchange rates (we call this EXCHANGE)

Exchange Rate

- No exchange rate (one to one) under CAIR
  - All emissions are equal
    - Works for long-lived species (GHGs) but not necessarily for ozone
- Sensitivity-based exchange rate:
  - exchange rate = ratio of sensitivities of ozone concentrations with respect to NO_x
    - Distinction based on potential of ozone production at different sources

NO_x Emission Trading System

Clean Air Interstate Regulation (CAIR)

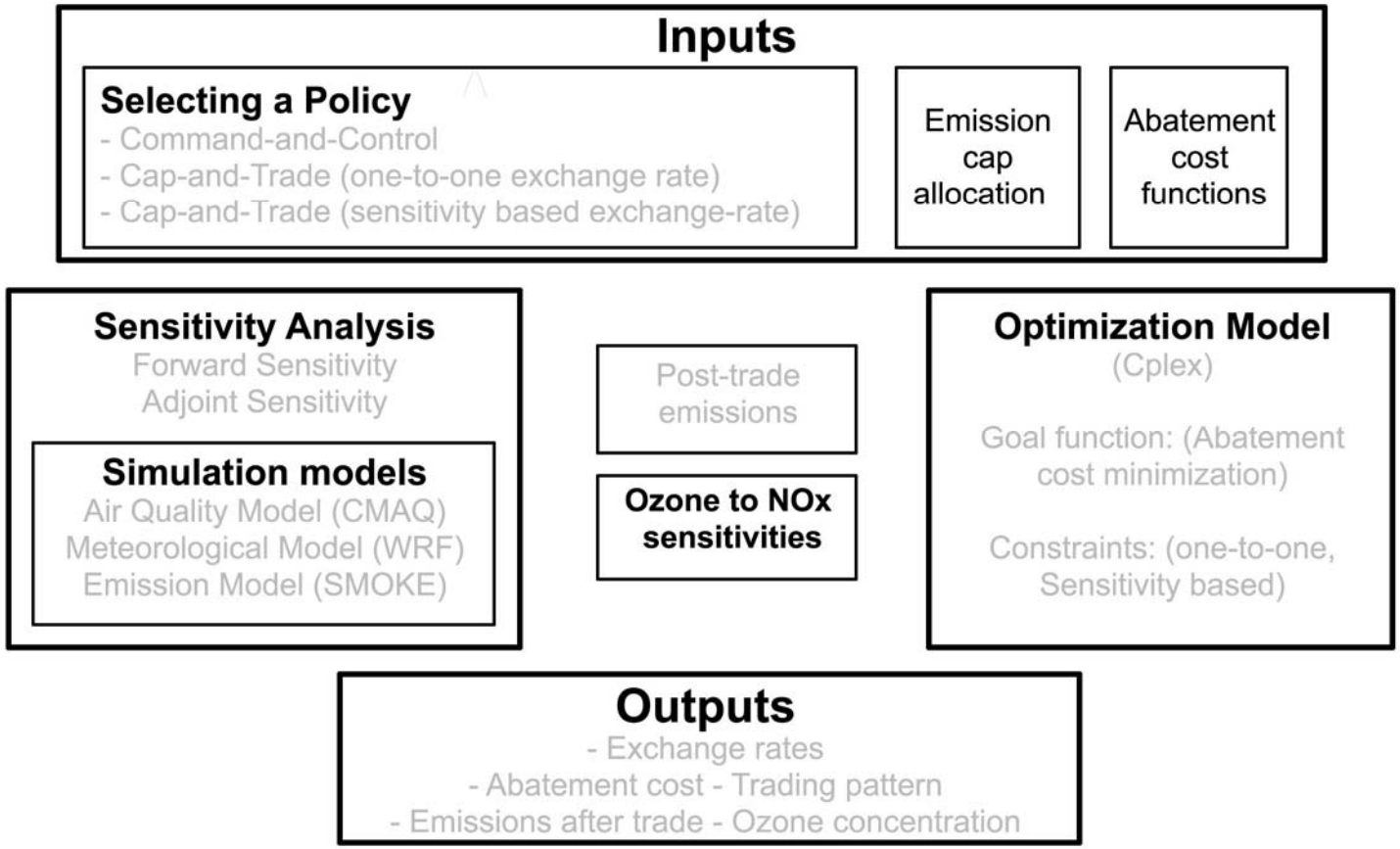


Ozone Season NO_x Emissions from All NBP Sources (EPA)

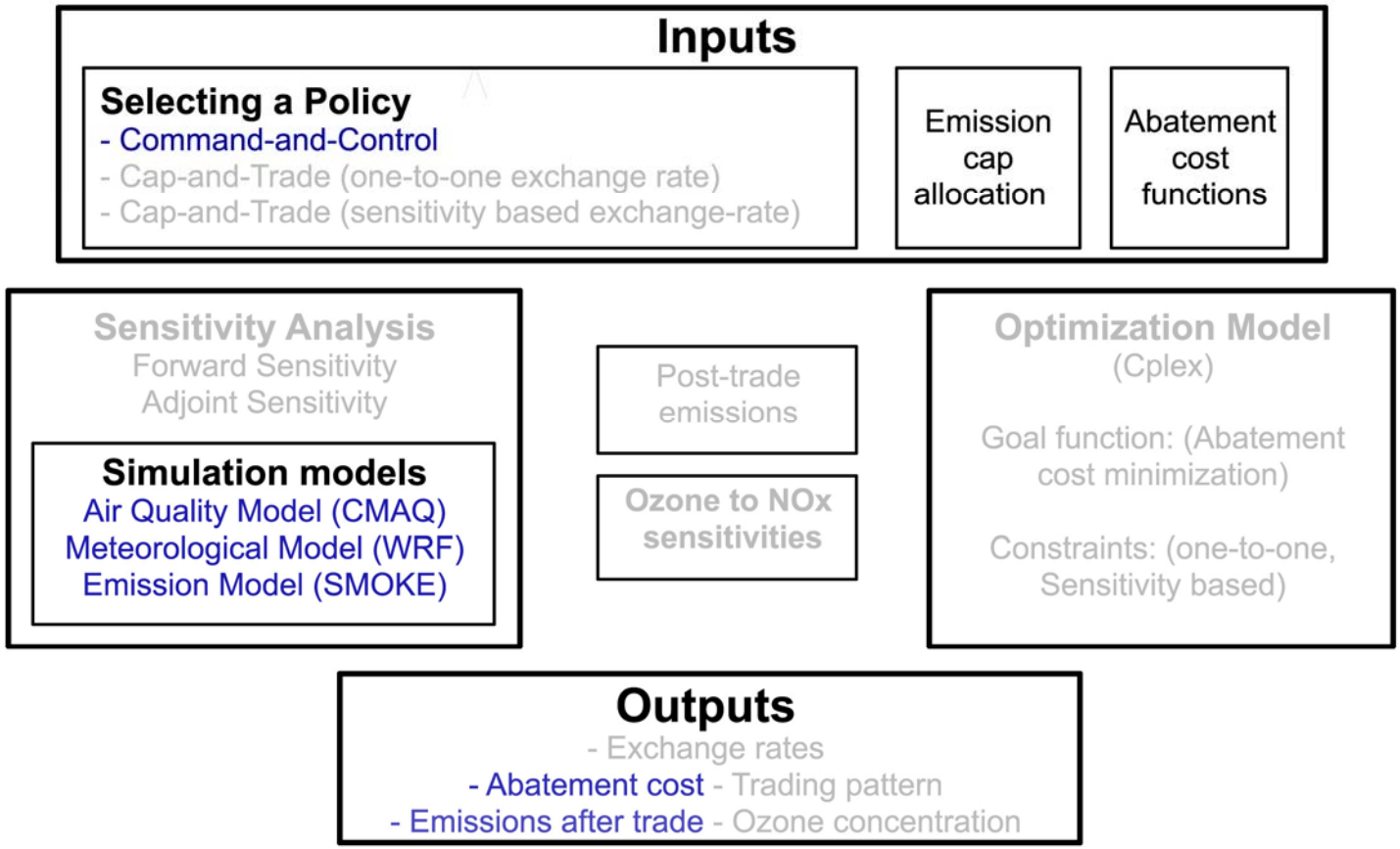
Trading as an Optimization Problem

- Emission trading systems can be modeled as an optimization problem.
  - Optimizing environmental performance constrained by abatement costs
  - Optimizing Abatement costs constrained by air quality constraints (This is what is presented)

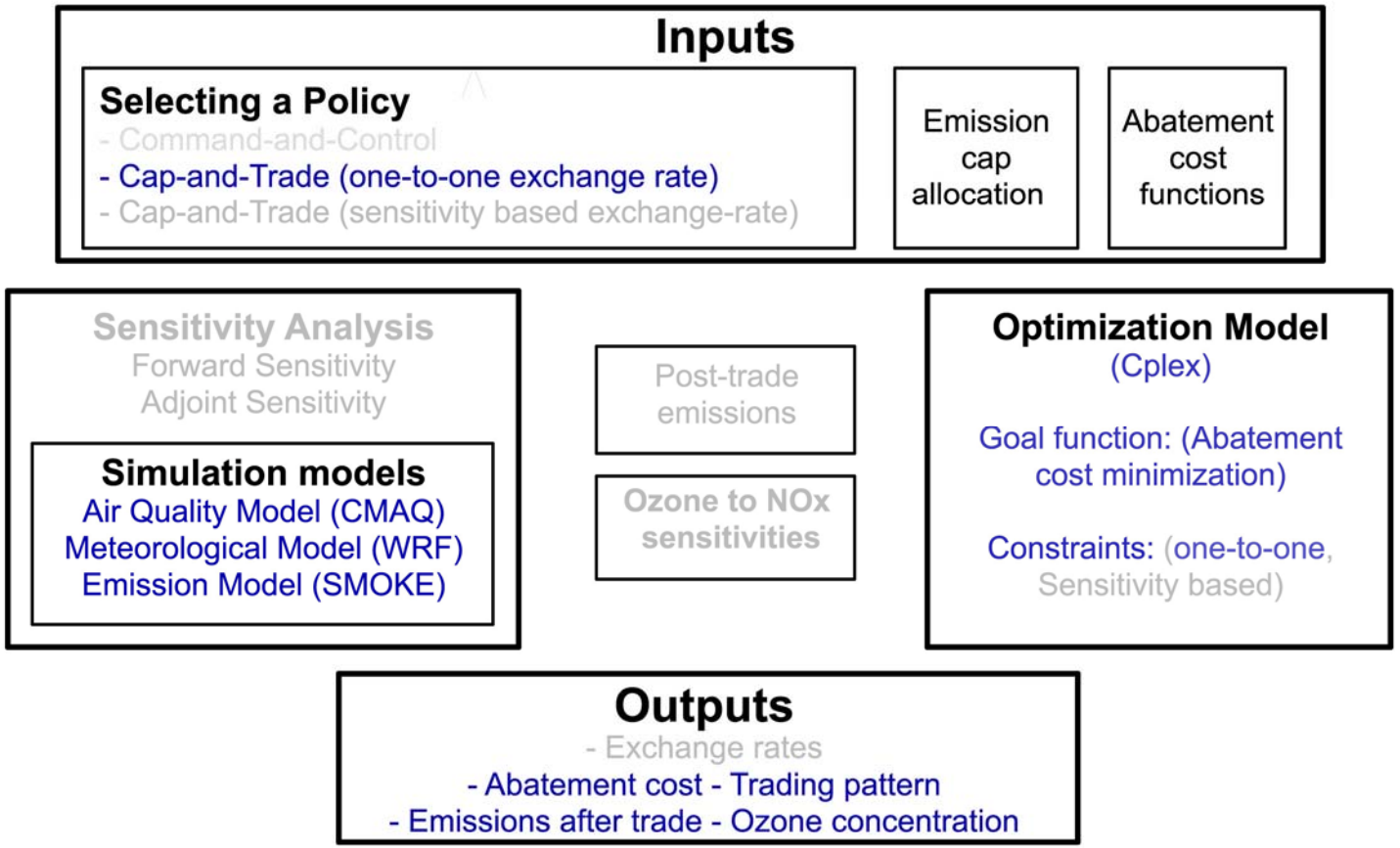
Proposed Decision Support System



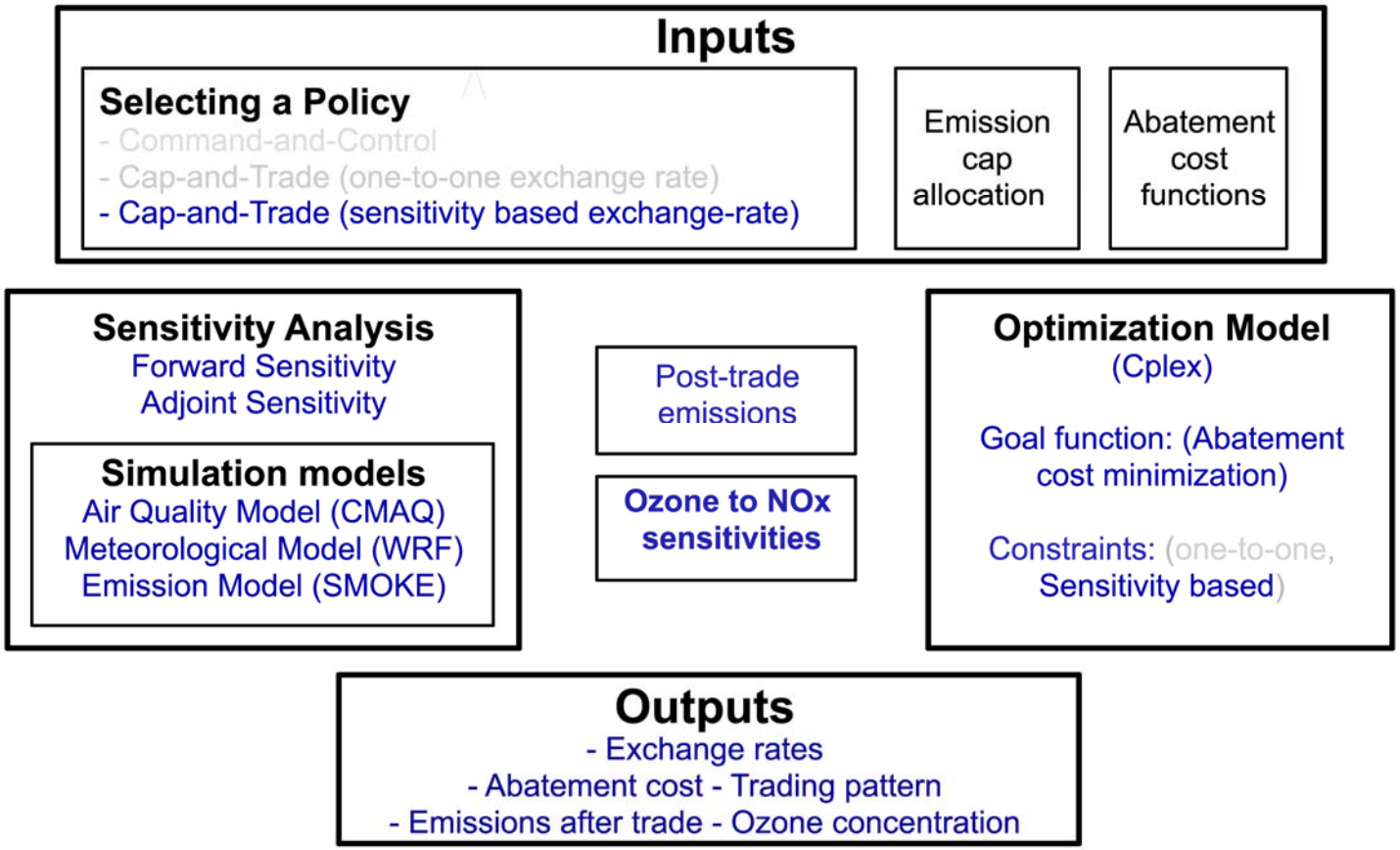
Proposed Decision Support System



Proposed Decision Support System

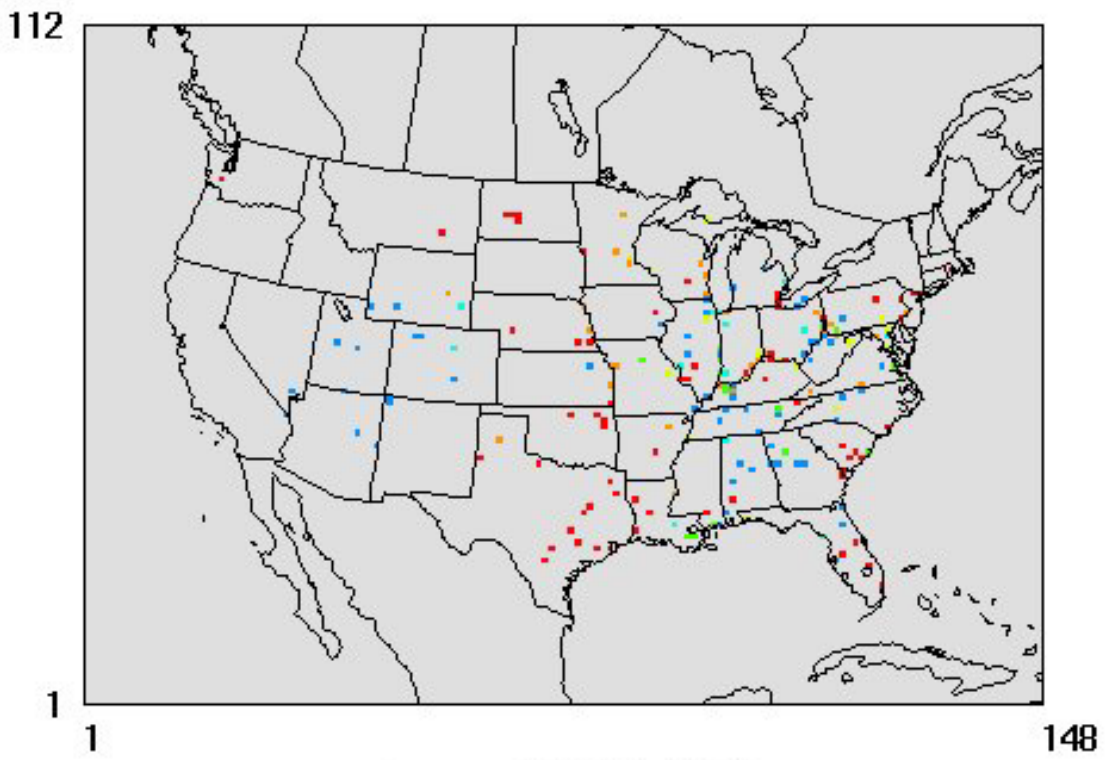


Proposed Decision Support System



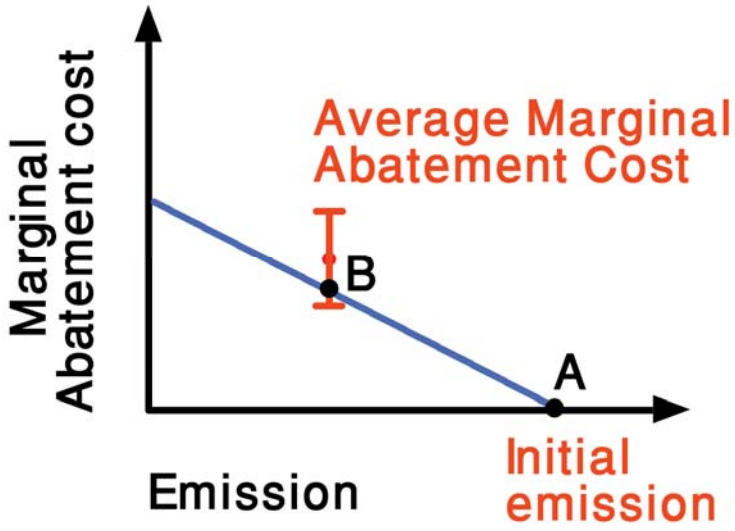
Case Study

- Domain: Continental North America
- Point Sources:
  - Top 200 Power plants
  - Date: 3 days in June 2007
- Adjoint objective function defined as average concentration in areas with ozone concentration more than 60 ppb



Assumptions

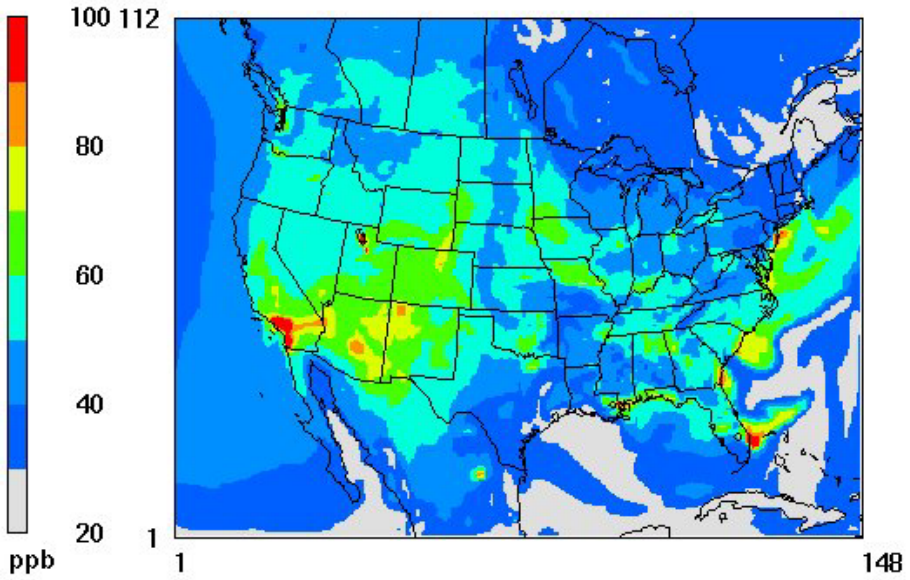
- Abatement cost functions
- AMAC: Normal distribution (719$/ton, 200)
  - (Rezek and Campbell, 2007)
- Initial permit allocation: (30% reduction)



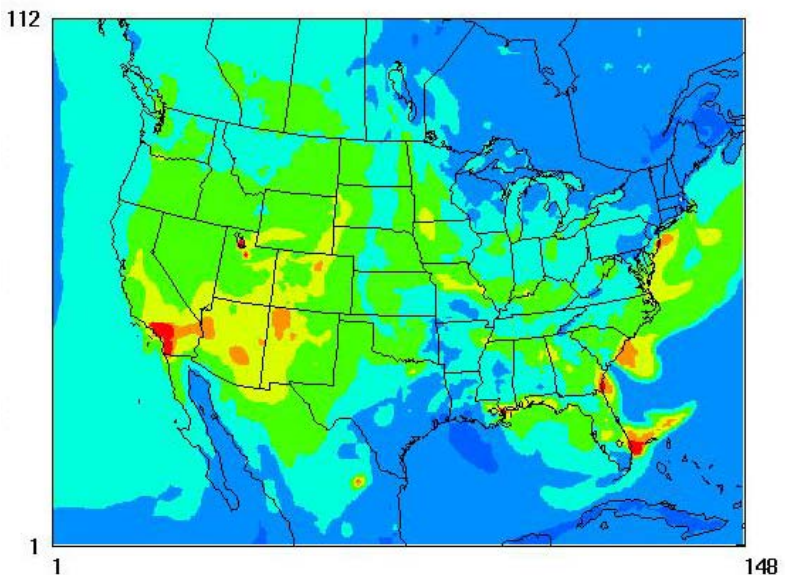
Command-and-Control

Ozone Concentration:

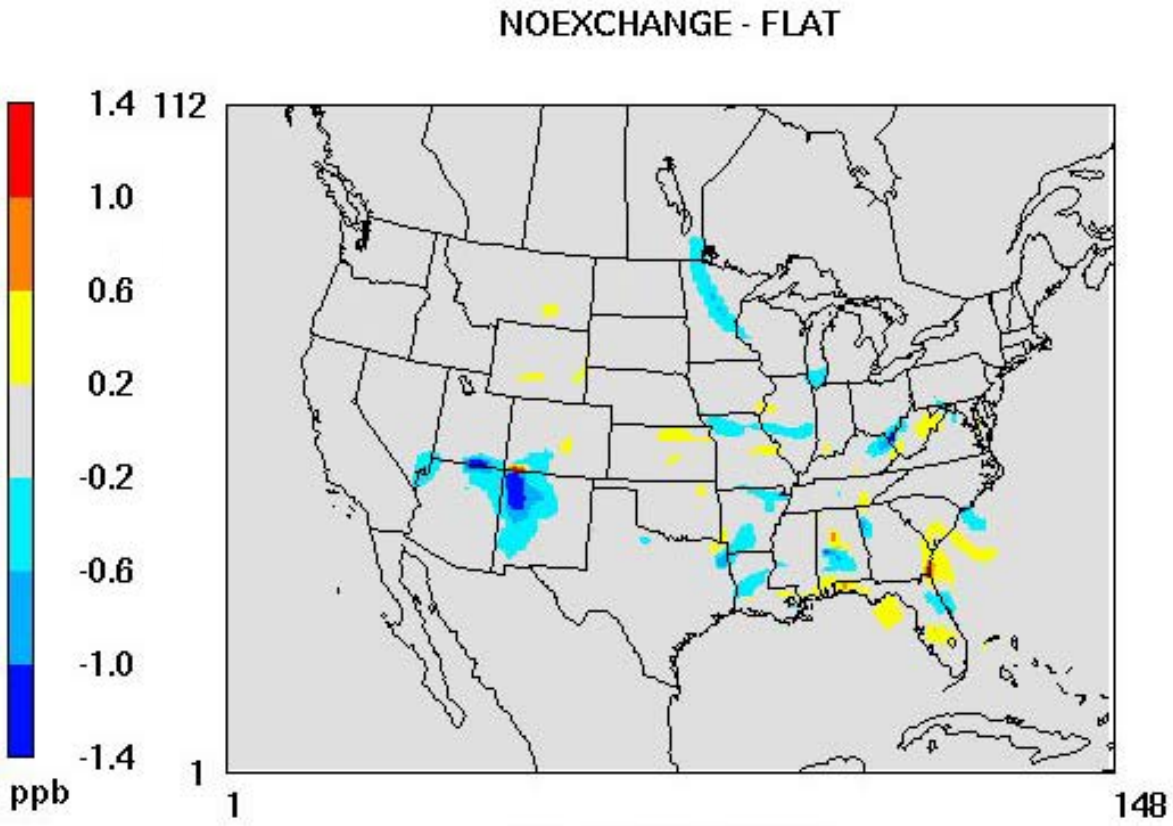
After

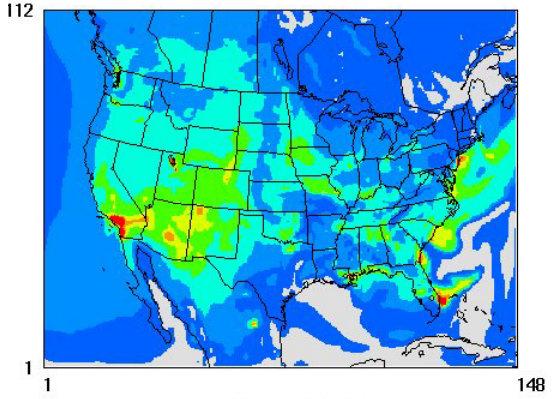


Before

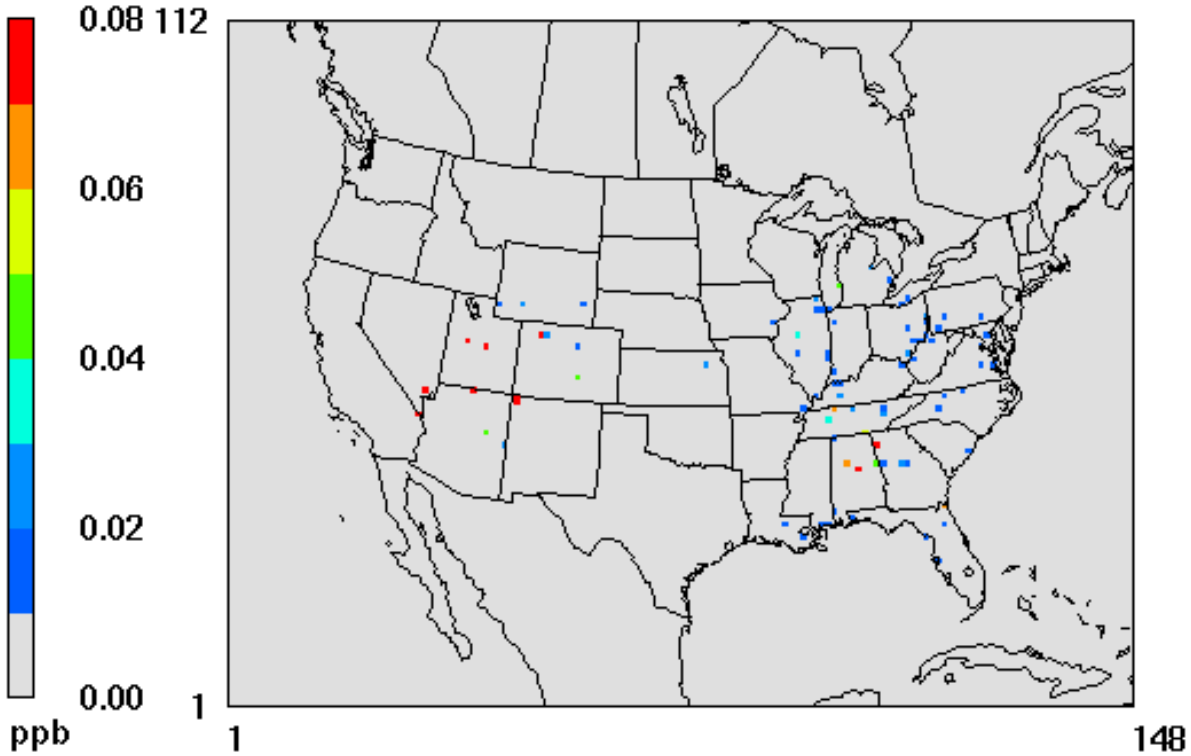


No-Exchange Trading

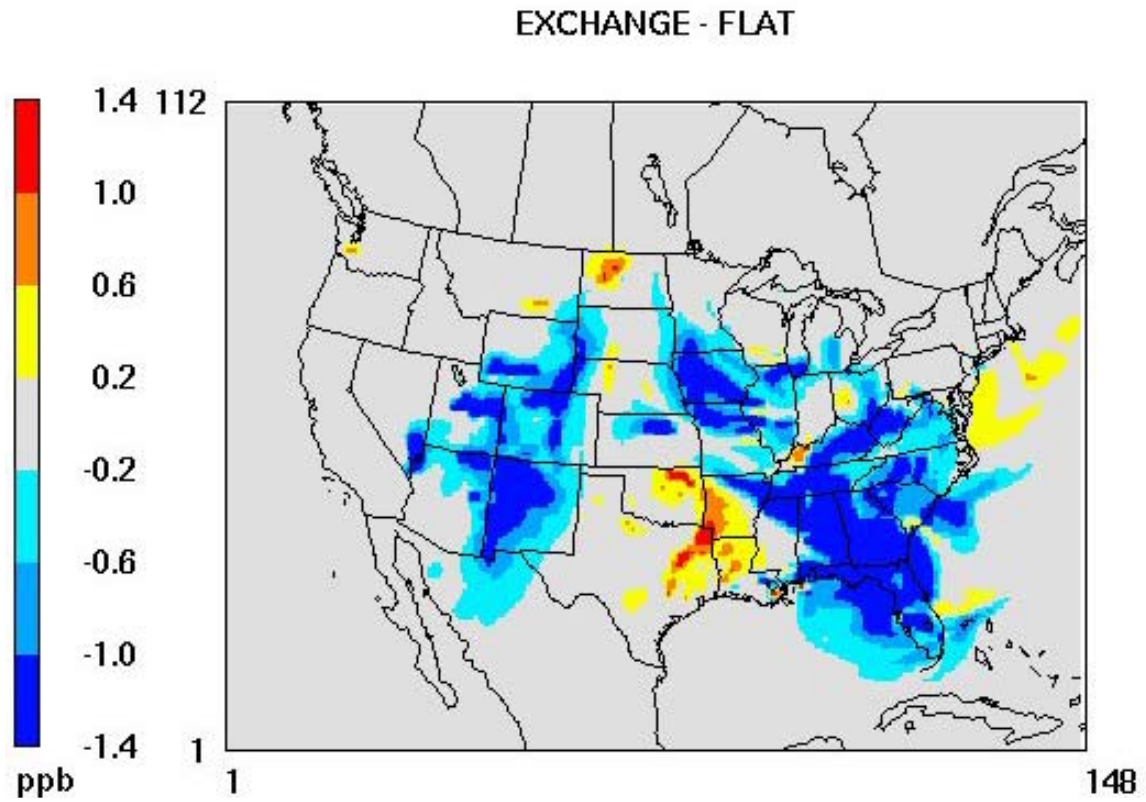


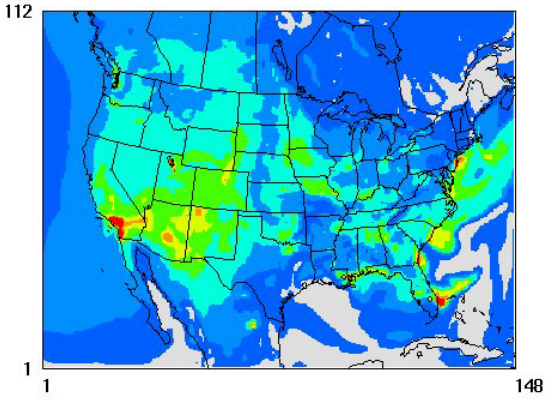


Sensitivity-Based cap-and-trade

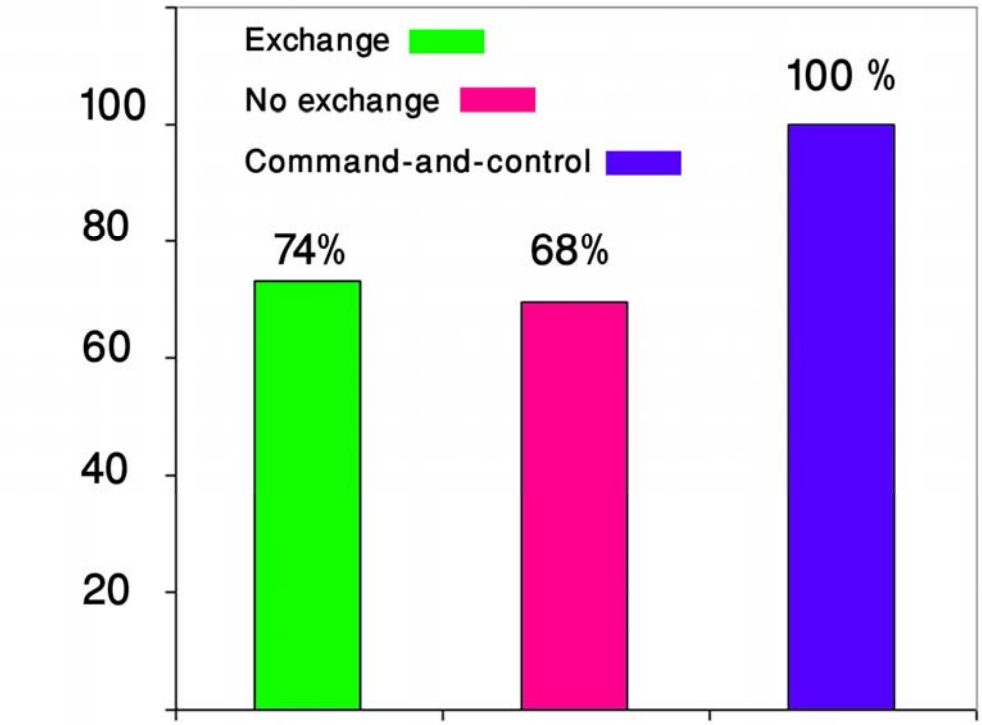


Sensitivity-Based Trading





Costs



Total Abatement Costs

Disadvantages

- Exchange rates need to be calculated over a long period
  - Computationally demanding
- Complexity
- Equity
  - How can you convince people that their grass is just not as green?
- Unwanted subsidy to major contributors

Conclusion

- Sensitivity-based (or exchange rate) trading offers potentially significant environmental benefits.
- Total abatement costs remain comparable
- The concept can be used (at least qualitatively) towards establishing trading guidelines.
- Equity and implementation concerns need to be investigated.

Acknowledgements

- National Science and Engineering Research Council of Canada (NSERC)