

### **DEPT. OF NATURAL CMAQ/BenMAP-based Health-Benefits Analysis in** Support of the Georgia SIPs for O<sub>3</sub> and PM<sub>25</sub> GFORGIA Amit Marmur

Annı Mannul

5<sup>th</sup> Annual CMAS Conference, October 16-18, 2006



- Overview of BenMAP
- Summary of O<sub>3</sub> and PM<sub>2.5</sub> sensitivity analysis
- Quantifying the health benefits from O<sub>3</sub> and PM<sub>2.5</sub> control strategies
- Preliminary findings and future research

Benefits Analysis with BenMAP: A US-EPA Environmental Benefits Mapping and Analysis Program

Modeled (or measured) reductions in pollutant levels



BenMAP

U.S. Version

Environmental Benefits Mapping and Analysis Program

Reduced morbidity, mortality, health costs



- Population based GIS
- Measured or modeled AQ data
  - examine benefits of various control strategies using AQ modeling
  - examine benefits of reducing measured ambient concentrations to specific levels
- Concentration-response functions, incident rates and valuation estimates to quantify changes in health endpoints and associated \$-benefits
- Can produce estimates at the population grid scale, county, state, or national level





#### **Reasons to Assess Benefits**

- Evaluate and prioritize various attainment strategy options
- Consider air quality management across multiple pollutants and regions
- Communicate impacts to decision-makers, stakeholders and public



#### Health Effects Quantified in BenMAP

Health endpoint	PM	Ozone
Mortality	+	+
Chronic Bronchitis	+	
Nonfatal heart attacks	+	
Hospital admissions	+	+
Asthma ER visits	+	+
Acute respiratory symptoms	+	+
Asthma attacks	+	+
Work loss days	+	
Worker productivity		+
School absence rates		+

#### Current Mean Values for Health Effects (2000 \$)

- Premature death:
- Chronic bronchitis:
- Heart attacks
- Hospital admissions:
- ER visits:
- Acute bronchitis
- Respiratory symptoms
- Asthma attacks
- Work loss days
- School loss days
- \* WTP: Willingness to pay
- \*\* COI: Cost of illness

\$6.3 million (WTP)\* \$340,000 (WTP) \$67,000-\$141,000 (COI)\*\* \$7,000 - \$18,000 (COI) \$300 (COI) \$360 (WTP) \$15 - \$50 (WTP) \$40 (WTP) \$100 (COI) \$75 (COI)



## Summary of O<sub>3</sub> and PM<sub>2.5</sub> sensitivity analysis

# **Emission Sensitivities**

- Sensitivity of ozone (ppb) and  $PM_{2.5}$  (µg/m<sup>3</sup>)
  - Summer Episode: May 25 June 25, 2002 (2009)
  - Winter Episode: Nov 19 Dec 19, 2002 (2009)
- Regional 10% Emission Reductions
  - Mobile (on-road/non-road), area, non-EGU
  - NOx, VOCs, SO<sub>2</sub>, NH<sub>3</sub>, and primary carbon (PC)
  - Atlanta (full & sub), Macon (full & sub), Chattanooga (full & sub), Floyd County
- Point Emission Reductions
  - Additional SCRs (NO<sub>x</sub>) and Scrubbers (SO<sub>2</sub>) at seven largest Power Plants in Georgia

# Sensitivity of PM<sub>2.5</sub> in Atlanta (FS#8/E.Rivers)

Sensitivity	Summer (µg/m³)	Winter (µg/m³)	Annual (µg/m³)	Annual (ng/m <sup>3</sup> /TPD)
10% Atlanta PC	0.19	0.36	0.25	85.7
10% Atlanta SO2	0.02	0.01	0.01	1.9
10% Atlanta NOx	0.03	-0.02	0.00	-0.09
10% Atlanta NH3	0.06	0.15	0.09	22.5
10% Atlanta VOCs	0.00	0.01	0.01	0.11
2 Scrubbers at Bowen	0.19	0.07	0.091	0.50
4 Scrubbers at Branch	0.15	0.03	0.098	0.63
2 Scrubbers at McDonough	0.11	0.07	0.070	1.39
4 Scrubbers at Scherer	0.38	0.04	0.150	0.56
4 Scrubbers at Hammond	0.05	0.04	0.030	0.42
1 Scrubbers at Wansley	0.09	0.06	0.044	0.44
2 Scrubbers at Yates	0.05	0.06	0.037	0.71



Sensitivity	Avg response (ppb)	ppt/TPD reduction
10% Atlanta NO <sub>x</sub> (20 counties)	1.36	35.7
10% Atlanta NO <sub>x</sub> (5 counties)	0.95	41.1
10% Atlanta VOC (20 counties)	0.08	1.5
10% Atlanta VOC (5 counties)	0.07	2.2
2 SCRs at Plant McDonough	0.42	60.4
4 SCRs at Plant Scherer	0.41	13.7
2 SCRs at Plant Branch	0.07	4.6
3 SCRs at Plant Hammond	0.03	2.2
2 SCRs at Plant Yates	0.11	9.9



# Health benefits assessments for the O<sub>3</sub> and PM<sub>2.5</sub>SIPs

# Preliminary estimate of \$ benefits (all GA) from NO<sub>x</sub> and VOC controls in Atlanta (20 counties)





Health endpoint	O <sub>3</sub> metric used	% of \$-benefits* (% w/o mortality)
Hospital Admissions, Respiratory	24-hr mean; 1-hr max	1.0 (30.0)
Emergency Room Visits, Respiratory	24-hr mean; 8-hr max; 5-hr mean; 1-hr max	0.0 (0.1)
Mortality	24-hr mean; 1-hr max	96.5 (n/a)
School absences	8-hr mean; 1-hr max	1.3 (36.6)
Minor Restricted Activity Days	1-hr max	1.1 (33.3)

\* - Hubbell et al., EHP 113, 73-82, 2005 (based on ambient data)

\_\_\_\_\_ Georgia Environmental Protection Division \_\_\_\_\_

#### Reductions in exposure (ppb\*person/TPD) to various O<sub>3</sub> metrics







## **(Solution of the set of the set**

Percentage increase in daily non-accidental mortality per 10-ppb increase in mean 24-hr O<sub>3</sub>\*



\* - Bell et al., The Exposure-Response curve for ozone and risk of mortality and the adequacy of current ozone regulations, EHP 114, 532-536, 2006.

#### **Issues to consider (2): Nighttime exposure**

**Ozone (O<sub>3</sub>) Metric Comparison\*** 



\* - Darrow et al., International conference on environmental epidemiology and exposure (ISEE/ISEA), Paris, France, 2006.

## **Issues to consider (3): Model performance** Summer Winter



# **\$** benefits from various O<sub>3</sub> control scenarios









#### PM<sub>2.5</sub> exposure and benefits

Sensitivity	Sensitivity¹ (ng/m³/TPD)	<b>∆exposure<sup>2</sup></b> (μg/m3)*person/TPD	million-\$- benefit/TPD <sup>2</sup>
10% Atlanta PC	85.7	324,000	78.0
10% Atlanta SO <sub>2</sub>	1.9	11,700	2.96
10% Atlanta NO <sub>x</sub>	-0.09	2,820	0.75
10% Atlanta NH <sub>3</sub>	22.5	95,600	23.2
10% Atlanta VOC	0.11	5,40	0.14
2 Scrubbers at Bowen	0.50	4,160	1.10
4 Scrubbers at Branch	0.63	4,420	1.22
2 Scrubbers at McDonough	1.39	7,970	2.07
4 Scrubbers at Scherer	0.56	5,950	1.62
4 Scrubbers at Hammond	0.42	4,740	1.28
1 Scrubbers at Wansley	0.44	4,640	1.26
2 Scrubbers at Yates	0.71	5,570	1.53

1- calculated for the 3x3 matrix surrounding FS#8/E.Rivers sites

2- state totals



Change in PM<sub>2.5</sub> due to a 10% NO<sub>x</sub> reduction in Atlanta (20 county)



Georgia Environmental Protection Division



# Summary, preliminary findings and future research

- A coupled CMAQ/BenMAP model was used to estimate the health benefits of various O<sub>3</sub> and PM<sub>2.5</sub> control strategies.
- For PM<sub>2.5</sub> related benefits, consistency was observed and benefits were reported for all cases examined.
- For O<sub>3</sub>, the choice of CR function (different O<sub>3</sub> metrics) and season/threshold had a substantial impact on the benefits quantification process. **Issues**:
  - Ozone season or year-round effects/benefits? Threshold?
  - Reduced nighttime exposure patterns not accounted for in BenMAP
    - Preliminary evidence suggests no (significant) association between nighttime  $O_3$  and health outcomes
    - Are 24-hr RRs a reflection of peak  $O_3$  levels?
  - Model performance
- Even under the most beneficial O<sub>3</sub> control scenario (\$340,000/ton), O<sub>3</sub> related benefits were still substantially lower (per-ton) than PM<sub>2.5</sub> benefits (\$140,000-\$78,000,000/ton).



## **Contact Information**

# Amit Marmur, Ph.D. **Georgia Dept. of Natural Resources** 4244 International Parkway, Suite 120 Atlanta, GA 30354 amit\_marmur@dnr.state.ga.us 404-363-7072