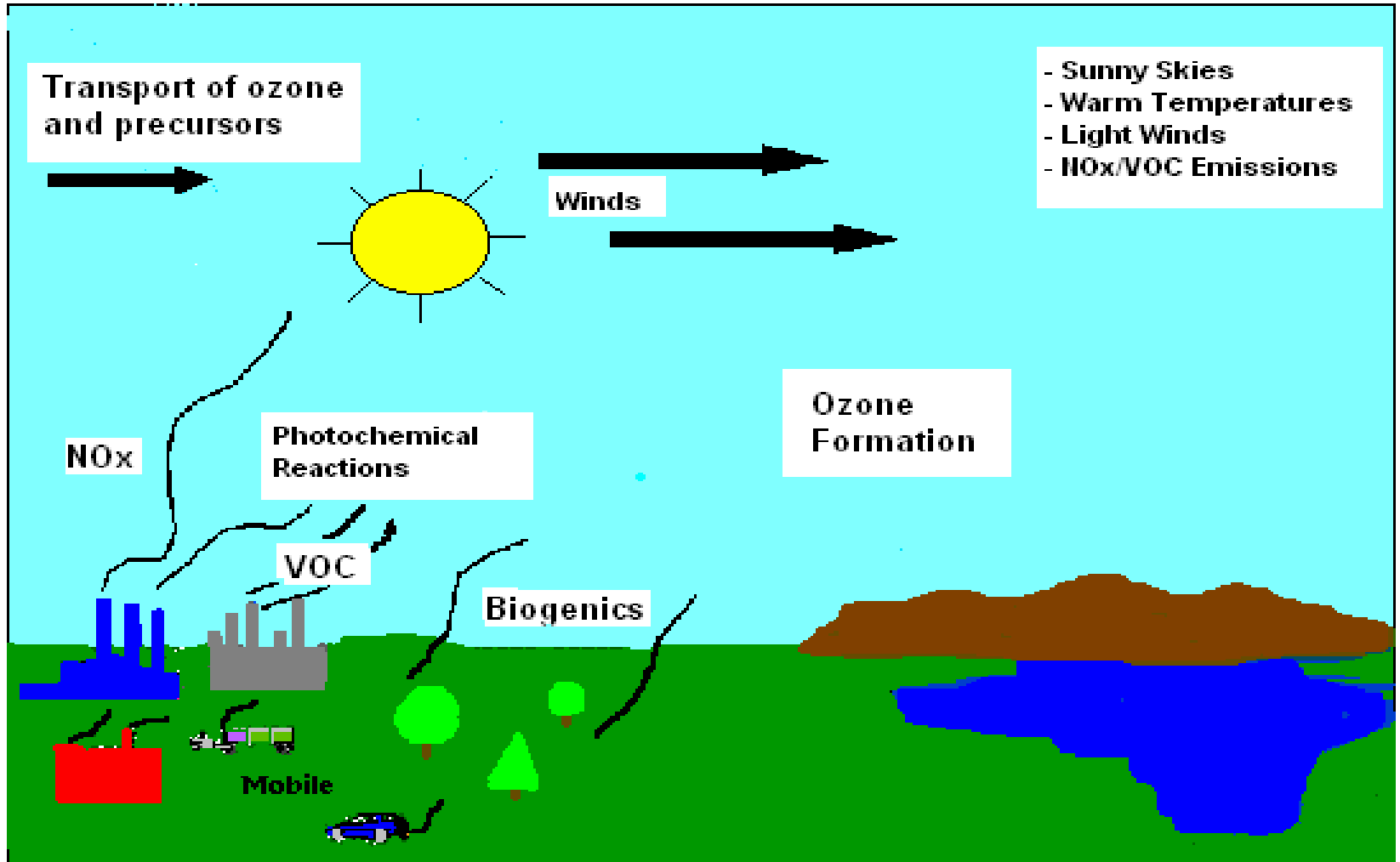


Ozone Modeling for Southern Indiana/ Louisville Area

Air Quality Task Force

July 23, 2004

Ozone Formation



Health Effects from Exposure to Ozone

- **Adverse Health Effects for everyone, especially sensitive people, such as the elderly, active children and people with respiratory problems.**
 - **Difficulty in breathing**
 - **Aggravated/prolonged coughing or chest pains**
 - **Aggravation of asthma, susceptible to respiratory infections**
 - **Repeated exposure can cause chronic and irreversible structural damage to the lungs**
 - **Can cause damage to vegetation**

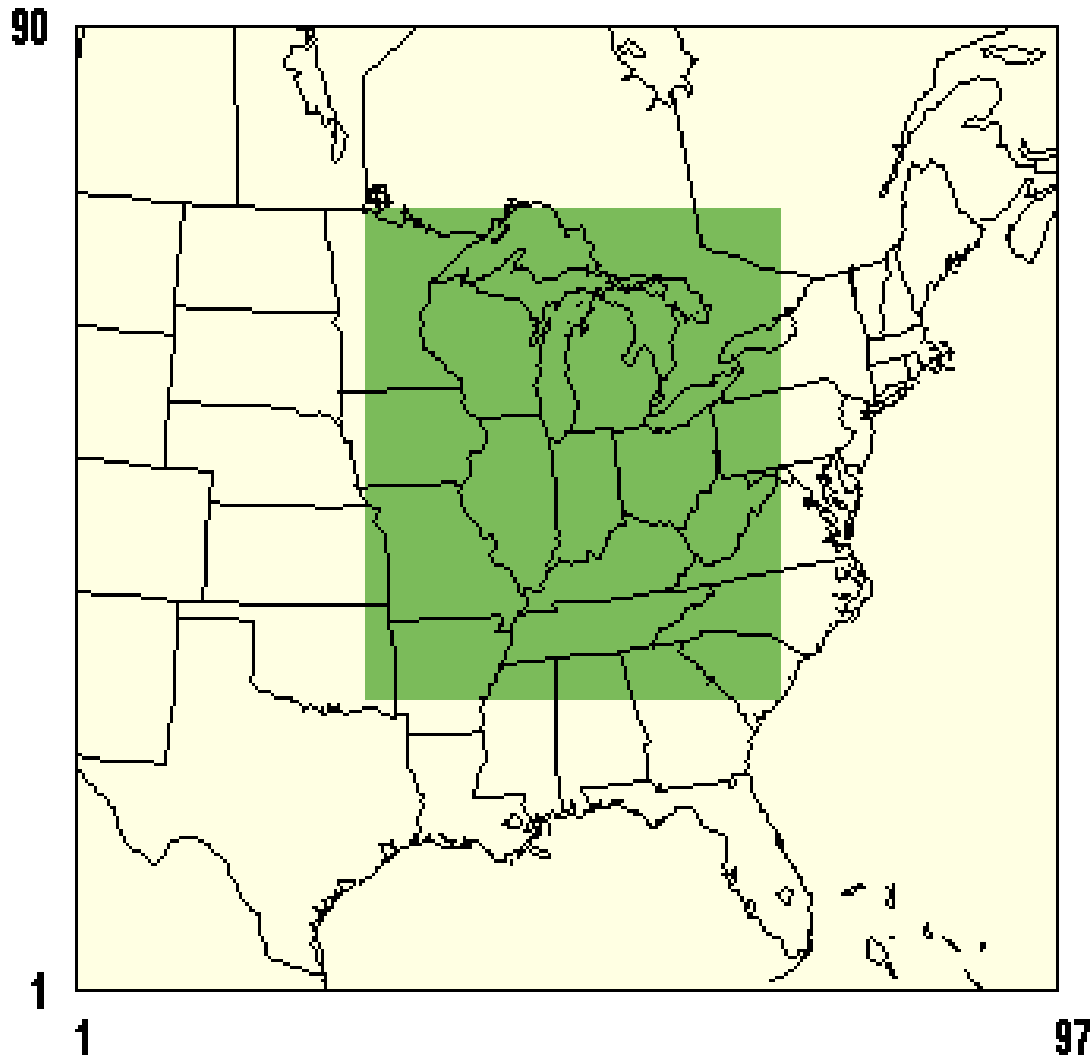
Factors for Modeling Ozone

- **Photochemical Model - CAMx version 4.**
- **Emissions - Inventories of nitrogen oxides (NO_x) and volatile organic compounds (VOC) sources (precursors or main ingredients to production of ozone)**
- **Meteorology - Surface and upper air data.**
- **Chemistry - Photochemical reactions.**
- **Grid Size - 36, 12, or 4 kilometers (22.3, 7.4 or 2.5 miles).**
- **Land Use - 11 land use categories (Urban, rural, water).**
- **Elevations - Terrain.**
- **Vegetation - Grassy, Forests, lush vegetation, etc.**
- **Albedo of surface - Reflectivity of the earth's surface.**

Modeling Process

- **Lake Michigan Air Directors Consortium (LADCO) consists of a group of professionals who coordinate activities and provide modeling/inventory assistance to Midwest states for photochemical modeling.**
- **Indiana, Illinois, Michigan, Wisconsin, Ohio and U.S. EPA Region V are involved in modeling the Midwest states and Lake Michigan area.**
- **LADCO has divided up modeling responsibilities among the states.**
- **All states use the same type of computers and CAMx model to model different emission control strategies.**

Midwest Modeling Domain



Photochemical Model

- **Comprehensive Air Quality Model with extensions, version 4 (CAMx4)**
- **Model use is intended for regional modeling but can be used for more local emission control strategies.**
- **CAMx4 requires more advanced computing equipment and storage capacities.**
- **Modeling runs can take days to complete.**

Emission Types

- **Point Sources (Elevated / Low Level) of NO_x and VOC**
 - **Elevated include utilities and large industry with high stack heights.**
 - **Low Level include smaller industry with smaller stack heights.**
- **Area Sources include commercial businesses, gas stations, residential.**
- **Mobile Sources include on-road (automotive) and non-road (airplanes, trains, construction, farming, lawn mowing equipment, etc.)**
- **Biogenic or naturally occurring emissions from trees, plants, grass, etc.**

Emission Inputs into CAMx

- **Point, area and mobile source inventories of nitrogen oxides (NO_x) and volatile organic compounds (VOCs), using latest available quality assured information, are input into the model through various files.**
- **Point source inventories are taken from U.S. EPA's National Emissions Inventory (NEI).**
- **Inventories are created from emission statements from states, traffic patterns, emissions monitoring and emissions modeling.**
- **Emission estimates of biogenic emissions are determined and input into the model.**
- **Emission files are quality assured and merged for input into the CAMx4 model.**

Meteorology

- **LADCO and Midwest states select specific high ozone “episode days” to base the photochemical model runs.**
- **All meteorology is taken at both the surface and different layers of the atmosphere during an episode and processed through Mesoscale Model (MM5).**
- **Meteorological parameters used include:**
 - **Temperatures**
 - **Wind Directions and Wind Speeds**
 - **Water Vapor**
 - **Clouds**
 - **Rain**
 - **Pressure**
- **Horizontal and vertical extent of meteorology is taken into account with MM5 and made ready for CAMx4.**

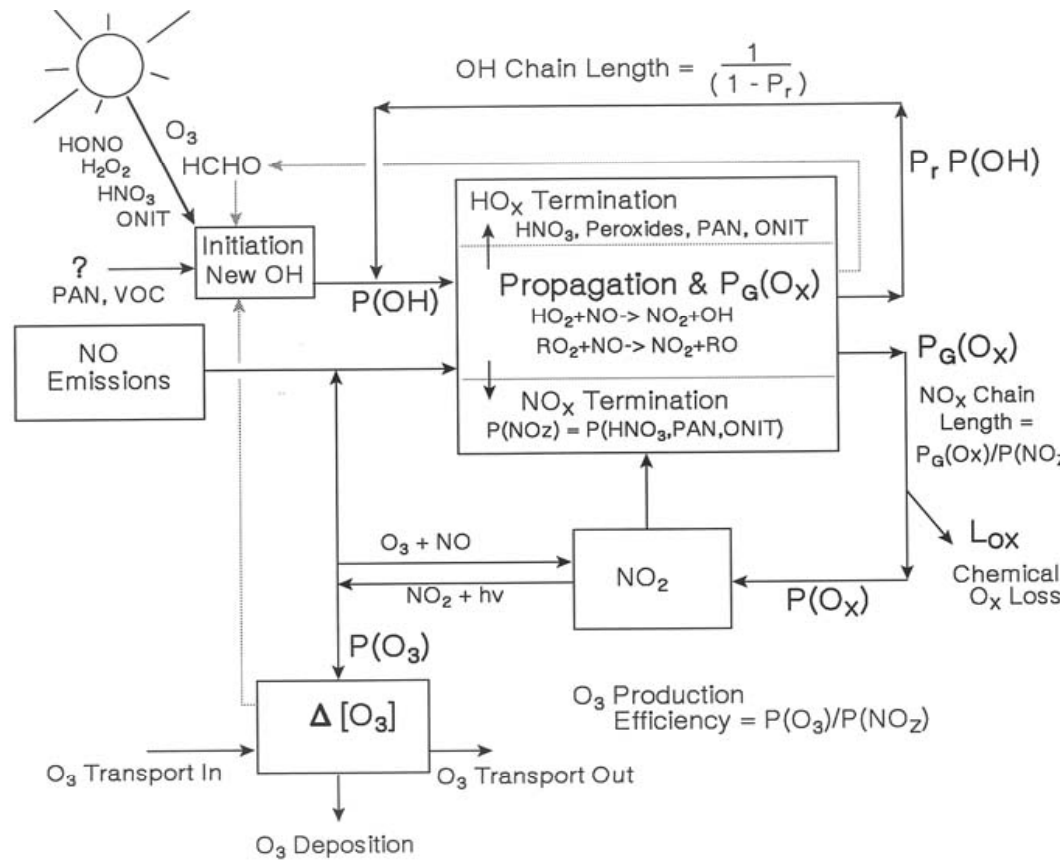
Ozone Conducive Conditions for Southern Indiana/Louisville area

- **Analysis of 8-hour ozone exceedance days in Southern Indiana/Louisville show typical weather conditions are:**
 - **Temperatures from the mid 80s to mid 90s or higher (occasional exceedances have occurred at upper 70s/lower 80s)**
 - **No cloud cover or scattered clouds (exceedances have occasionally occurred with broken clouds)**
 - **Wind speeds from calm to approximately 15 miles per hour (exceedances have occasionally occurred with winds exceeding 15 miles per hour)**
 - **Wind directions from the south, southwest and southeast (exceedances have occasionally occurred with winds from the north and east)**

Chemistry

- **Photochemical reactions involve direct sunlight, warm temperatures, light winds and NO_x and VOC emissions.**
- **Photochemical reactions break down NO_x and VOC emissions. This releases oxygen molecules which can attach to other free oxygen molecules to form ozone (O₃)**
- **Lighter winds allow less mixing of the atmosphere and enable the pollutants to interact more.**
- **Initial (existing pollutant concentrations in the area) and boundary conditions (ozone and ozone precursor concentrations transported into the modeling grid) play a big role in ozone development over the grid.**

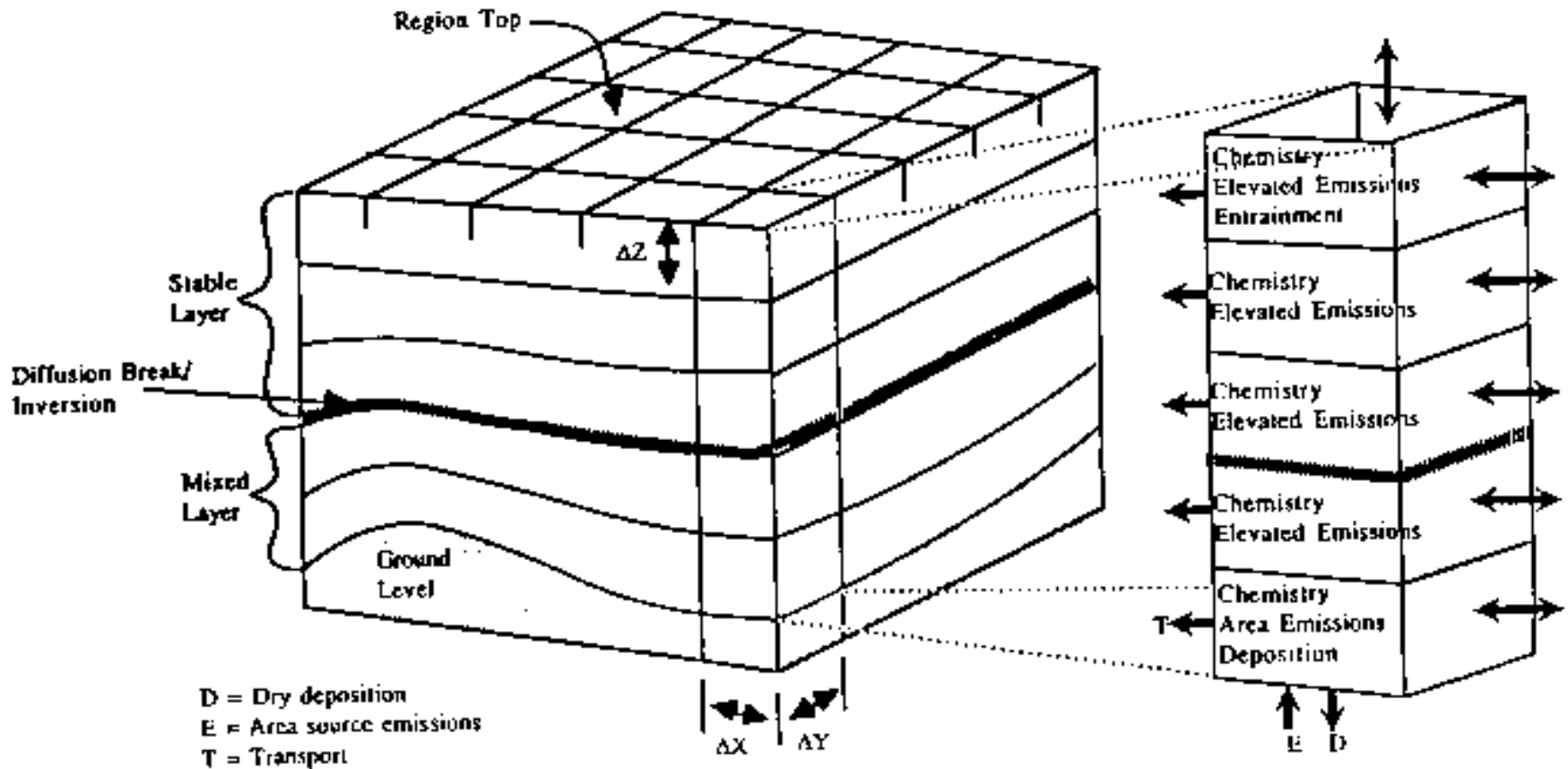
Photochemical Reactions that produce Ozone (O₃)



Grid Selection for CAMx Modeling

- **Grids are determined on the size of each cell. A 36 kilometer (km) grid represents each grid cell of 36 km long and 36 km wide.**
- **36 km grids replicate, through modeling, the ozone that was observed during the ozone episode.**
- **More refined grids of 12 km and 4 km can be used for modeling emission control strategies.**
- **Refined grids of 12 km or 4 km require additional emissions, meteorological and chemistry information for each grid cell. This requires additional computation time on the computer.**
- **12 km grids may be used in Southern Indiana/ Louisville ozone modeling.**

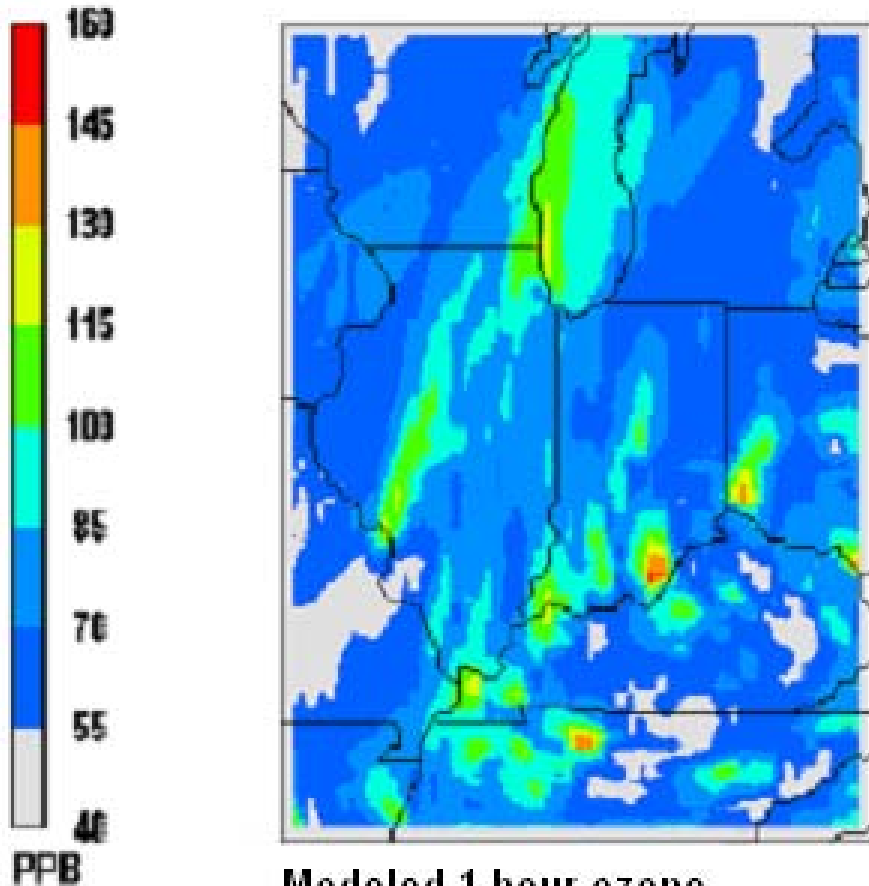
Grid Structure - Vertical and Horizontal



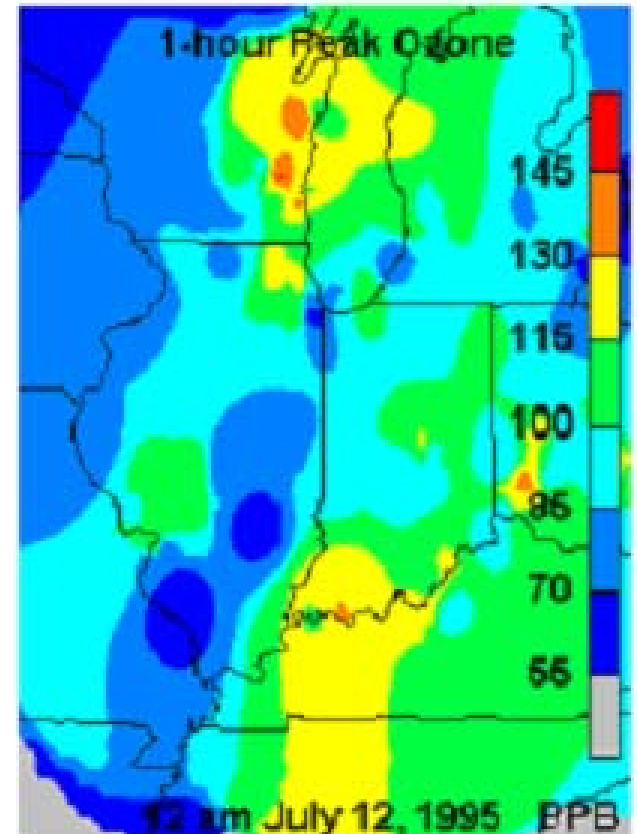
Steps in Developing and Using CAMx

- **Build files of emissions and meteorological conditions.**
- **Conduct basecase modeling runs to test the model on how well it is performing (model performance).**
 - **8-hour ozone concentrations are modeled.**
 - **The concentrations are compared with monitored ozone concentrations.**
 - **If the modeled concentrations do not match the monitored concentrations, improvements are made to emission estimates or meteorological files to improve the model performance.**
 - **After necessary improvements are made, CAMx is run again and model performance is evaluated.**

CAMx versus AirNow Comparison



Modeled 1-hour ozone concentrations for July 12, 1995



Observed 1-hour ozone concentrations for July 12, 1995

Steps in Developing and Using CAMx

(continued)

- **Model performance is judged in several ways:**
 - **Modeled versus observed ozone and ozone precursors at upwind/downwind sites, statistical evaluations, weekday/weekend comparisons, etc.**
- **Once model performance is at an acceptable level from the basecase runs, sensitivity runs are made.**
- **Sensitivity runs are model runs that reduce a certain pollutant to determine the effect of that pollutant's reduction on ozone.**
- **Different percentage reductions (i.e. 15%, 30%, 60%) are modeled.**

Steps in Developing and Using CAMx

(continued)

- **Once basecase and sensitivity runs have been made and performance is acceptable, emission control strategy runs are made.**
- **Once emission control strategies are decided upon for the area, the reduction in emissions will be estimated for each emission control strategy.**
- **Resulting modeled concentrations are compared with 8-hour ozone standards to determine attainment status.**
- **Future year modeling runs are made with projected emissions to show that emission reductions made will show attainment by federally established dates.**

How modeling can help Southern Indiana/Louisville area?

- Modeling results and analysis of previous ozone exceedance days can shed light on whether efforts should be concentrated on control of NO_x or VOC sources or mobile sources or combination of both.**
- Some areas are NO_x limited, which indicates that VOC controls do not lower overall ozone concentrations significantly, however NO_x controls do lower ozone.**
- Some areas are VOC limited, which indicates that NO_x controls do not lower overall ozone concentrations significantly, however VOC controls do lower ozone.**

Modeling Update

- **Revised emissions and meteorological files from LADCO are available now.**
- **CAMx4 model updates will be released in late summer 2004.**
- **Ozone modeling as well as PM_{2.5} modeling is scheduled to be conducted over the next year.**
- **Depending on model performance, updated emissions and meteorological files may become available in fall of 2004.**