THE U.S. EPA COMMUNITY MULTISCALE AIR QUALITY (CMAQ) MODELING SYSTEM –OVERVIEW

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CMAQ Model Peer Review Meeting
R.T.P., NC
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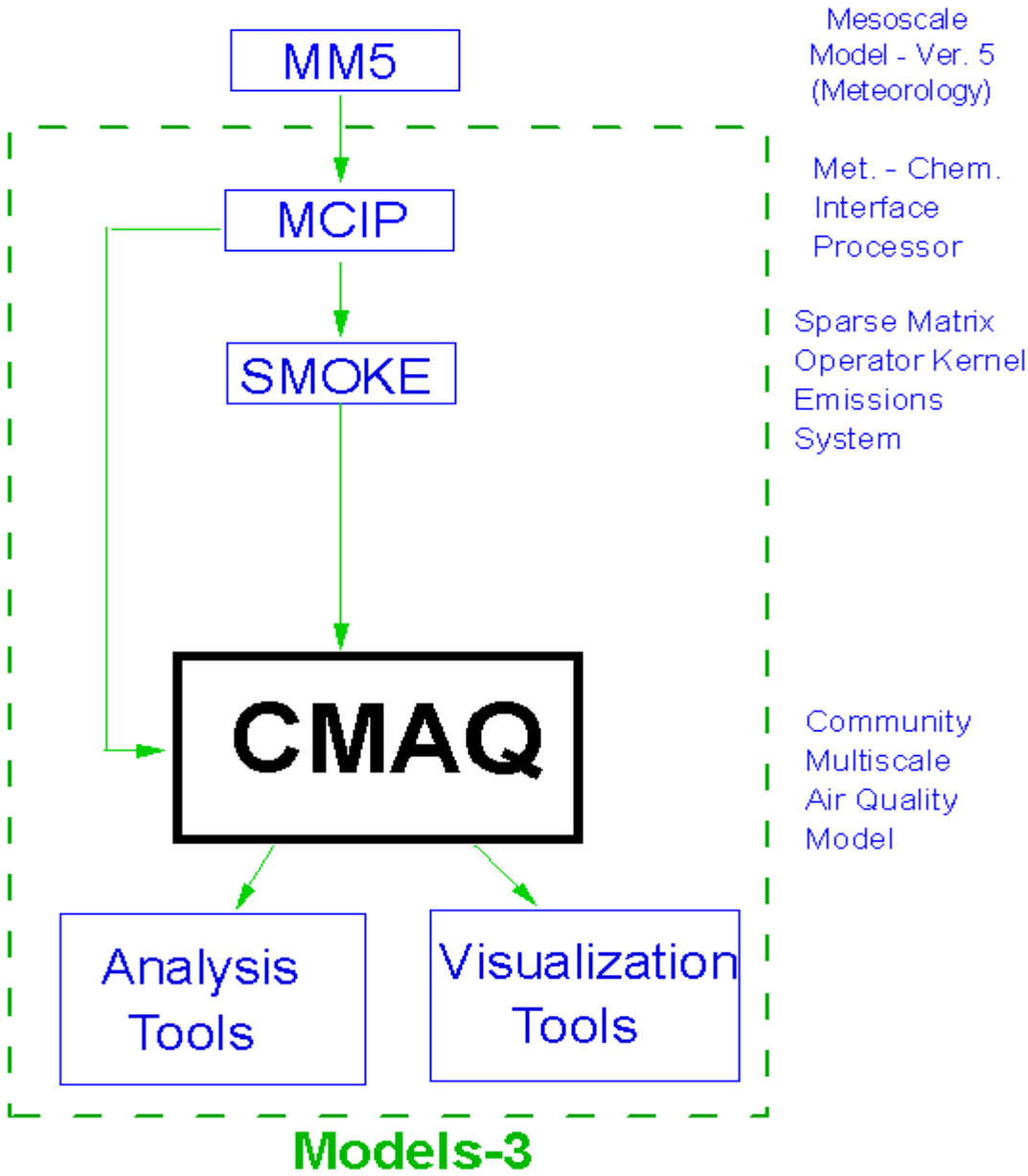
CMAQ Background

- 1970's – Urban Airshed Models
- 1980's – Regional Models
  - Regional Oxidant Model (ROM)
  - Regional Acid Deposition Model (RADM)
    - Driven by MMx meteorological model
- 1990's
  - Multiscale Model
    - Community Multiscale Air Quality Model (CMAQ)
      - MM5 meteorology model, SMOKE emissions model
      - 1998- first public release; annual releases since


MM5
Mesoscale Model - Ver. 5 (Meteorology)
MCIP
Met. - Chem. Interface Processor
SMOKE
Sparse Matrix Operator Kernel Emissions System
CMAQ
Community Multiscale Air Quality Model
Analysis Tools
Visualization Tools
Models-3

CMAQ Chemical Transport Model
September 2003 Release

- Advection
  - Piecewise parabolic method (PPM)
  - Bott scheme
  - *Layer-dependent horizontal advection time-stepping*
- Vertical Diffusion
  - Eddy-diffusivity (K_z)
  - Asymmetric Convective Model (ACM)
- Horizontal Diffusion
  - Eddy-diffusivity with K_h grid size dependent

- Cloud Processes
  - Aqueous chemistry and sub-grid clouds adapted from RADM
  - Simple grid-resolved cloud scheme at all grid resolutions
  - *Updates to Henry's Law constants (Seinfeld and Pandis, 1998)*
  - *New timestep calculation in aqueous chemistry process*
  - *Revisions to washout of coarse model aerosol number concentration*
    - *Preserves aerosol diameter during the washout process*

- Plume in Grid
  - Embedded Lagrangian plume with gas-phase photochemistry *(aerosols now being added – in 2004 model release)*
- Dry deposition
  - RADM dry deposition model
  - M3dry: Adjunct to the PX Land Surface Model

- Gas-phase Chemical Mechanisms
  - RADM2
  - CB4
  - SAPRC99
  - All mechanisms linked to aerosol module and aqueous chemistry
  - *$N_2O_5 + H_2O \rightarrow 2HNO_3$*
    - *Eliminated gas-phase rxn from all mechanisms by zeroing rate constant (defer to heterogeneous pathway)*
  - *Eliminated advection/diffusion of fast-reacting species (CB4-only)*

- Gas-phase Chemistry Solvers
  - Quasi-steady state approximation (QSSA)
  - SMVGEAR
  - Modified Euler Backward Iterative (MEBI) method for all mechanisms
  - *Euler Backward Iterative (EBI) gas-phase chemistry solver for CB4*

Aerosol Model (Aero3)

- Lognormal size distribution (σ_g and D_g)
  - Aitken mode (0-0.1 μm)
  - Accumulation mode (0.1-2.5 μm) } PM2.5
  - Coarse (PM10 - PM2.5)
- Aerosol processes:
  - Nucleation
  - Coagulation
  - ISORROPIA semivolatile equilibrium model
  - Clouds - CCN, aqueous chemistry, wet deposition

- Aerosol chemistry
  - Inorganic: Sulfate,Nitrate, Ammonium
  - Secondary anthropogenic and biogenic organic
    - *SOA algorithm modified to make the gas-particle partitioning reversible*
    - *Eliminated SOA production from anthropogenic alkenes*
    - *Adjusted yields of semi-volatiles from alkanes and aromatics*
    - *Modified gas-phase monoterpene reaction rates in RADM2 and CB4*

- Speciated primary emissions
  - Elemental carbon, organic carbon, sulfate, nitrate
  - *Future: wildfire emissions, soil and fugitive dust, sea salt*
- Heterogeneous reaction of N_2O_5 -> HNO_3
  - *Modified reaction probability based on Riemer (2003)*

- Regional haze
  - Visibility estimates in deciviews

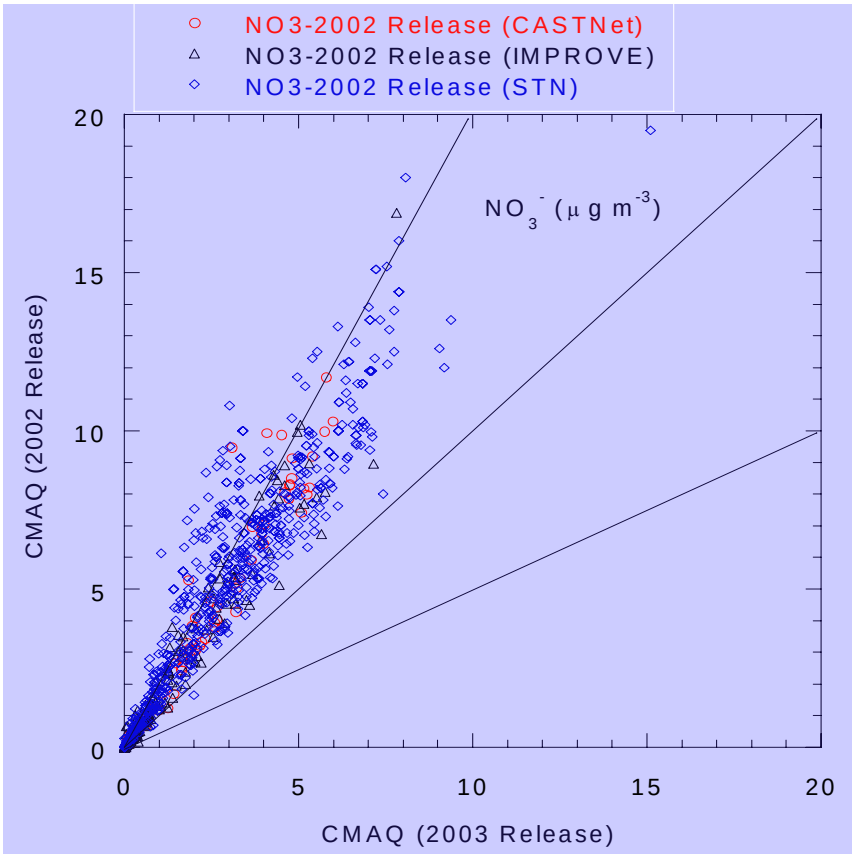
    deciView = 10 ln (β_{ext} / 0.01)

- Meteorology Chemistry Interface Processor (MCIP2)
  - MM5v3 compatible
  - Surface and PBL parameters passed through
  - Compatible w/ PX LSM and M3dry
  - *Updates for wintertime conditions; effects of snow cover on deposition*
  - *New dry deposition species: N2O5, NO3, aldehydes*
- Emissions
  - Sparse Matrix Operator Kernel Emissions (SMOKE)
  - Biogenic Emissions Inventory System (BEIS3)

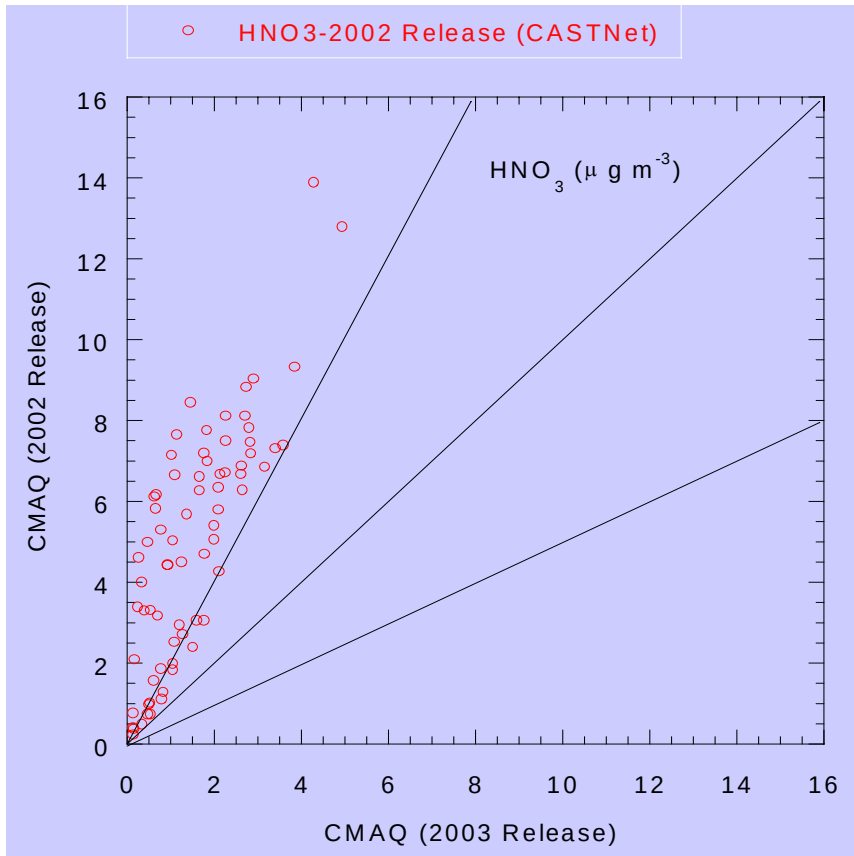
- *Change in order of time-splitting science processes*

Previous Order	*New Order*
advection	*vertical diffusion*
mass adjustment	*advection*
horiz. diffusion	*mass adjustment*
vert. diffusion	*horiz. diffusion*
clouds	*clouds*
chemistry	*chemistry*
aerosols	*aerosols*

2003 release vs 2002 release



Aerosol Nitrate

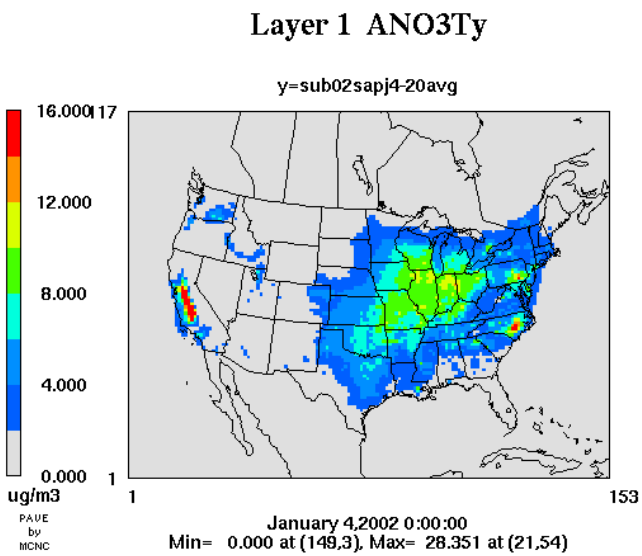


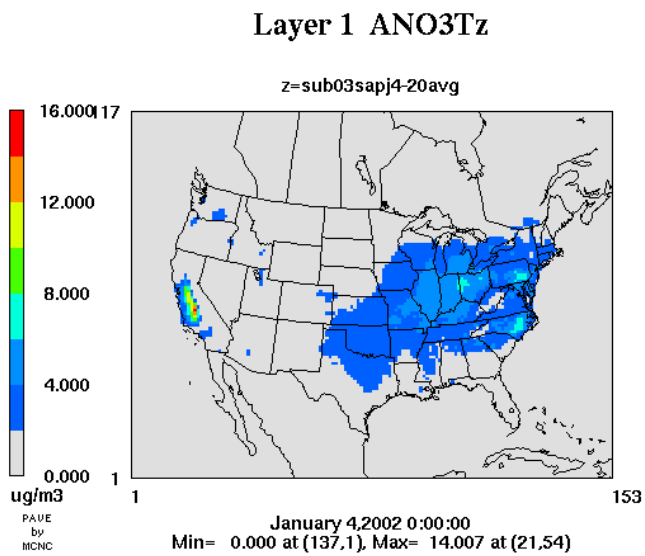
Gas Phase Nitric Acid

January 4 – 20, 2002

CMAQ02 vs CMAQ03 - Nitrate

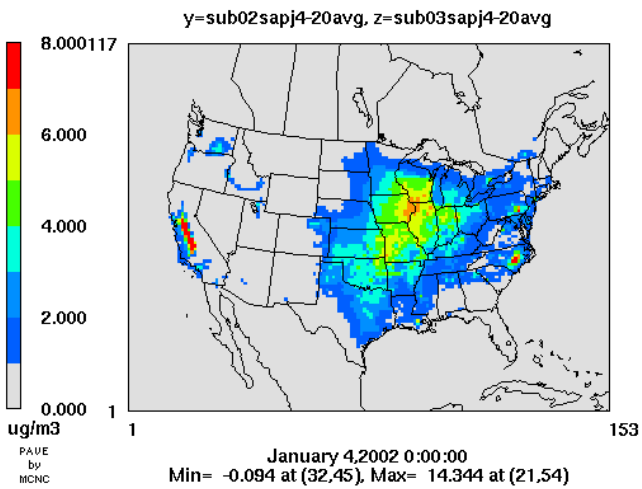
Nitrate Aerosol CMAQ02

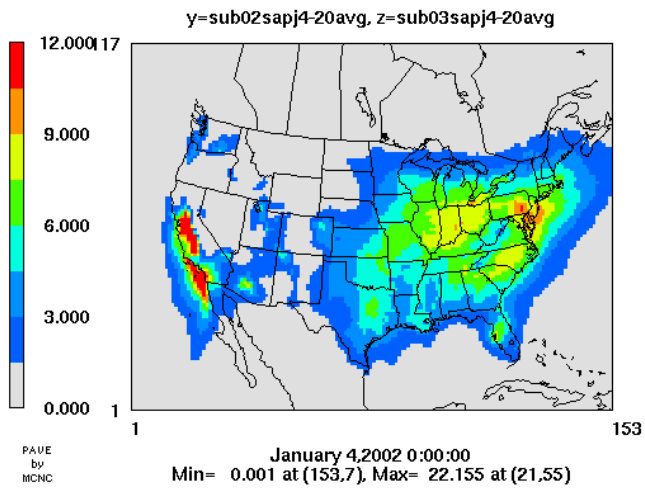




Nitrate Aerosol CMAQ03

Nitrate Aerosol diff

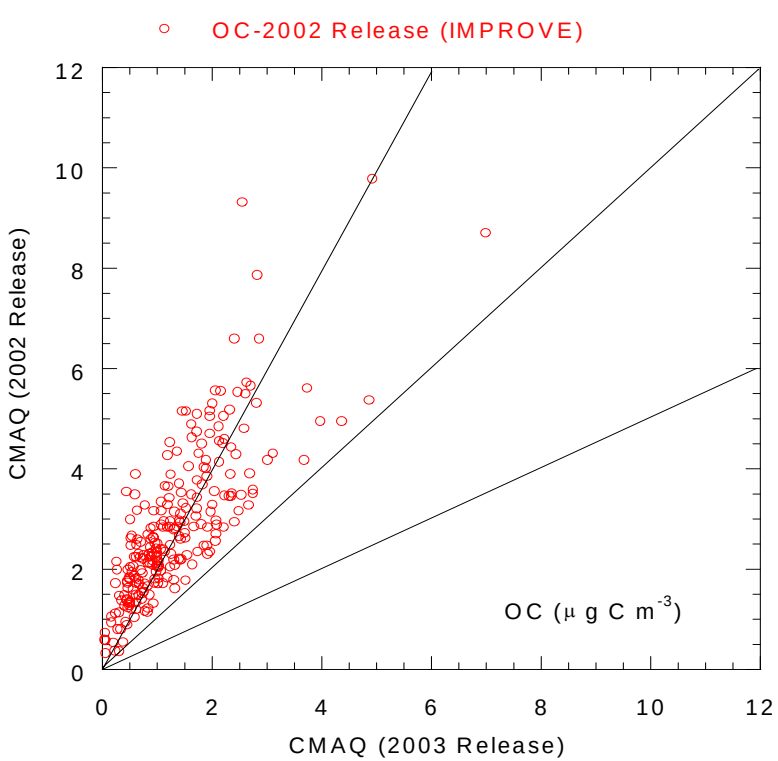




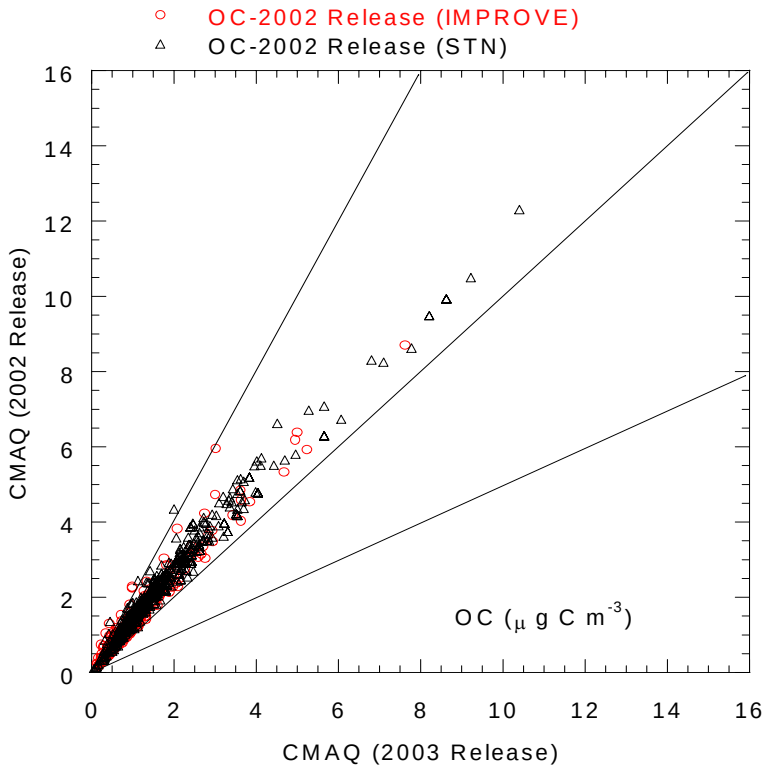
Total Nitrate diff

Average concentrations January 4 – 20, 2002

Organic Carbon Aerosol



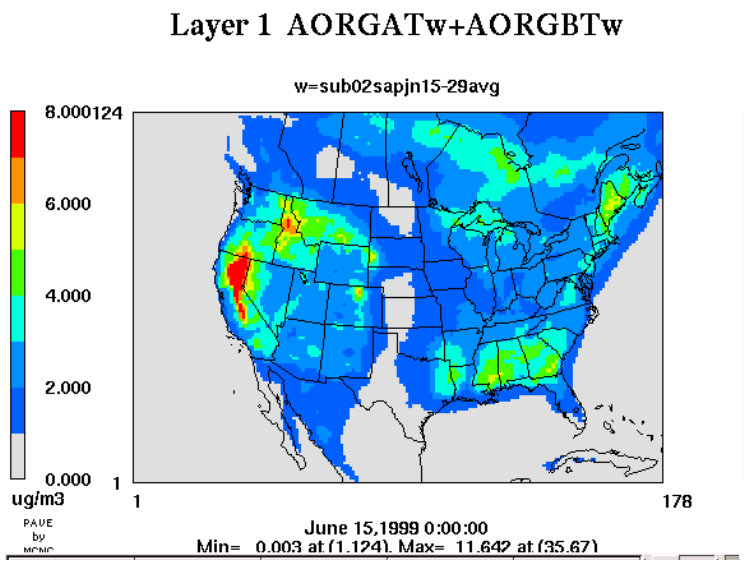
June 15 – 29, 1999

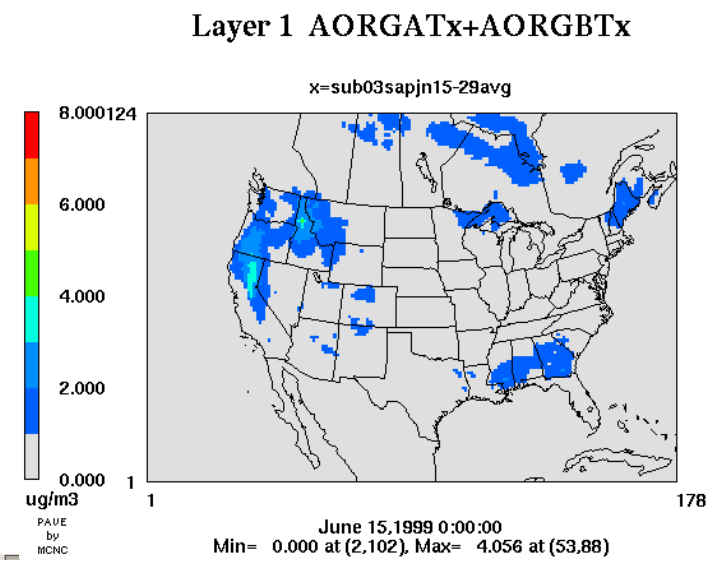


Jan. 4 - 20, 2002

CMAQ02 vs CMAQ03 - SOA

Total SOA CMAQ02

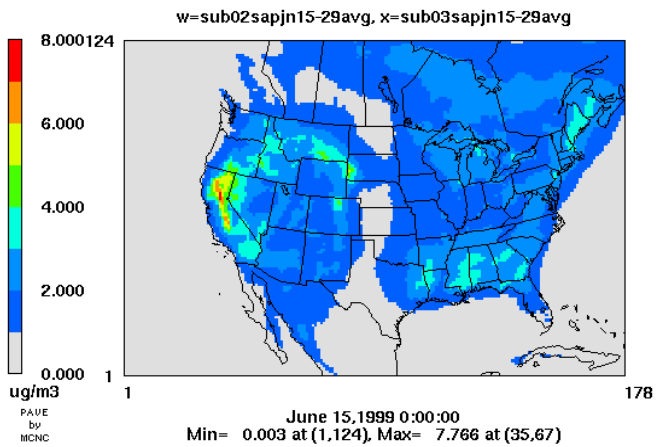


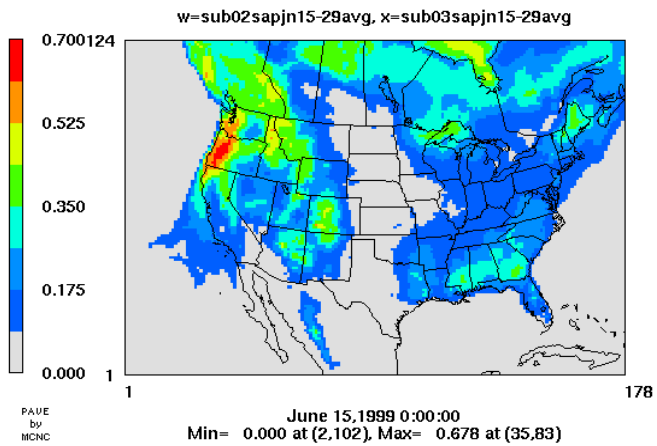


Total SOA CMAQ03

ayer 1 (AORGATw+AORGBTw)-(AORGATx+AORGayer 1 (AORGATx+AORGBTx)/(AORGATw+AORG

Total SOA diff





Total SOA Ratio: 03/02

Average concentrations June 15 – 29, 1999

Outreach

- Community Modeling and Analysis (CMAS) Center at UNC-CH/CEP
  - User support
  - Training
  - Help desk
  - Annual Workshop
  - Support for CMAQ model public releases
  - Web site and electronic resources