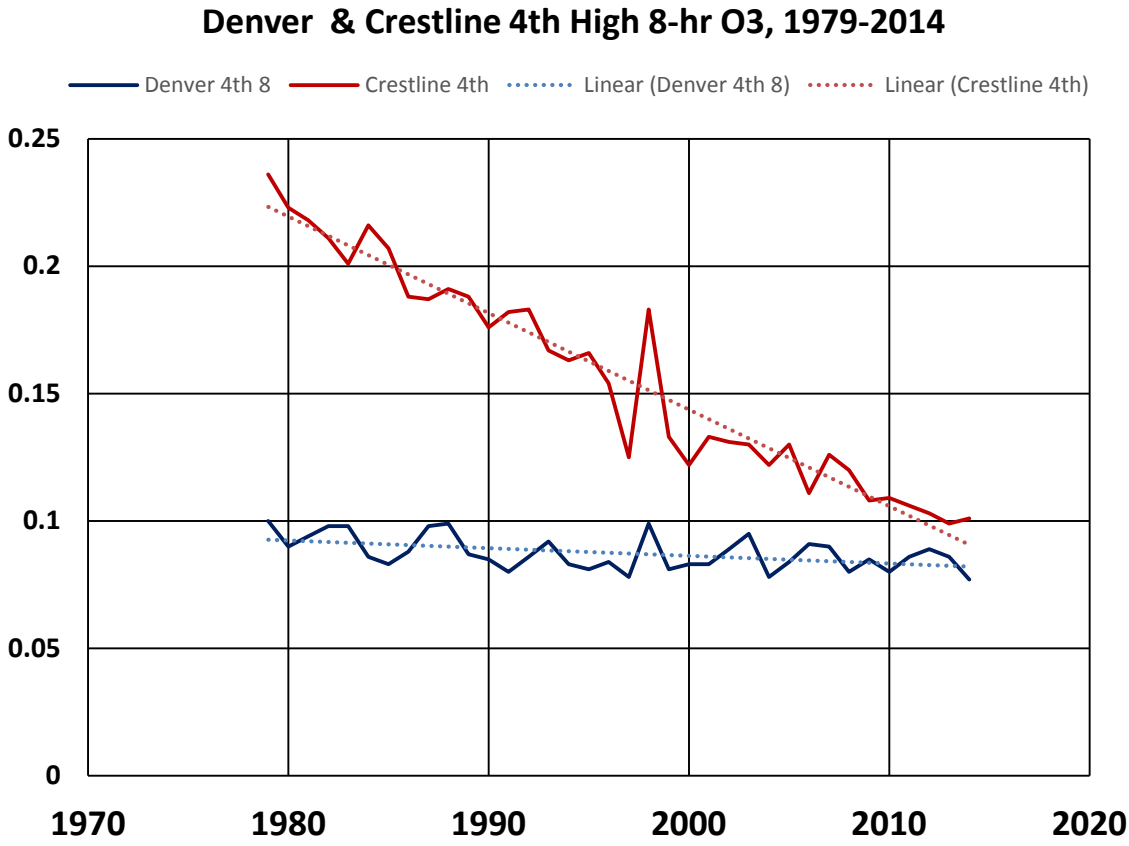
# Recommendations for Monitoring and Modeling Research for use in Ozone Planning

Gail Tonnesen, EPA Region 8

WESTAR Ozone Background and Transport Workgroup call

September 24, 2015

# O3 trends at high elevation sites in the Western US




Why is O3 trend flat in Denver?

Need to understand roles of:

- International and interstate transport
- Wildfires
- Stratospheric O3
- Population growth
- Oil and gas development
- Seasonal variation

# Five Ozone Planning Needs

1. O3 NAAQS planning – requires photochemical modeling for SIP attainment demonstrations.
2. O3 transport SIPs –photochemical source apportionment modeling can be used to quantify US interstate O3 transport.
3. Identification of O3 exceptional events caused by stratospheric intrusion and wildfires – requires observations & data analysis, supplemented with global/regional scale photochemical models and regression models.
4. Identification of international transport of O3 for 179B demonstrations: requires nested global and regional scale photochemical modeling to evaluate international transport of O3.
5. Identification of Rural Transport Areas – combination of data analysis and photochemical modeling.

In the West under CAA, whom to do which ?

Alone or together ?

- States/Locals
- Regional
- Federal

# Monitoring Data Currently Available

A. Federal, State and Local regulatory monitoring networks.

B. Other federal networks: CASTNET, NADP, and IMPROVE.

C. Supplemental Rural Monitoring Studies: 3-State Study (UT, CO, WY) and NV Rural O3 Study.

D. NOAA BAO tower, weekly Ozonesonde at 2 sites in CA and CO, and twice daily temperature and humidity sondes at 19 western sites.

E. Special studies: FRAPPE/DISCOVER-AQ 2014, LVOS 2013, TOLNet.

F. Satellite data for PM, NOx, CO and total column O3.

# Modeling Resources Potentially Available

1. NOAA, NASA and NCAR modeling studies:
    - Global modeling used to provide BC for high resolution regional scale modeling and for analysis of O3 stratospheric intrusion.
    - Regional modeling special studies (wildfires, DISCOVER-AQ)
    - HTAP global modeling intercomparisons.
    - NOAA WRF-CMAQ real time air quality forecasting.
2. EPA research and regulatory modeling and AQMEII intercomparison studies.
3. State modeling studies to support SIP development.
4. Regional Planning Organization and State/Federal regional partnerships support modeling of haze, O3 and NEPA EIS analysis.
5. AQAST and other academic research studies.

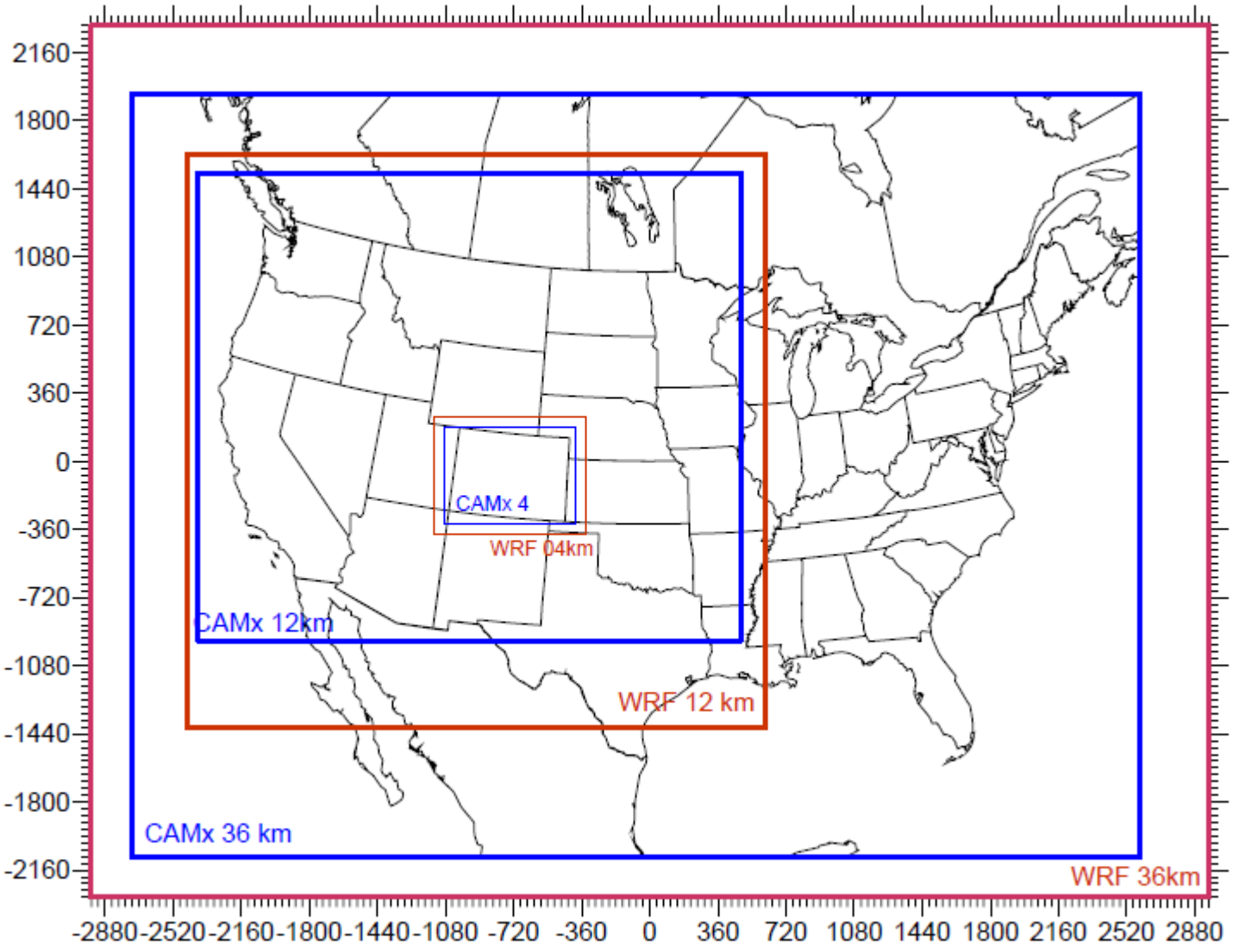
# Key Questions

- What is the State of the Science for modeling O3 in the western US?
- Do we have sufficient monitoring data to evaluate model performance? What additional monitoring would be most useful?
- How well do models perform for O3 in the western US? Need day specific evaluation for:
  - International and Inter-state transport.
  - Stratospheric intrusions and Wildfire.
  - Rural vs. Urban.
- Do we have sufficient resources to complete comprehensive model performance evaluations?
- How best can state, local and federal planners and researchers work together to perform monitoring, modeling and data analysis to support air quality planning needs?

# Nested 36/12/4-km WRF/CAMx Domains

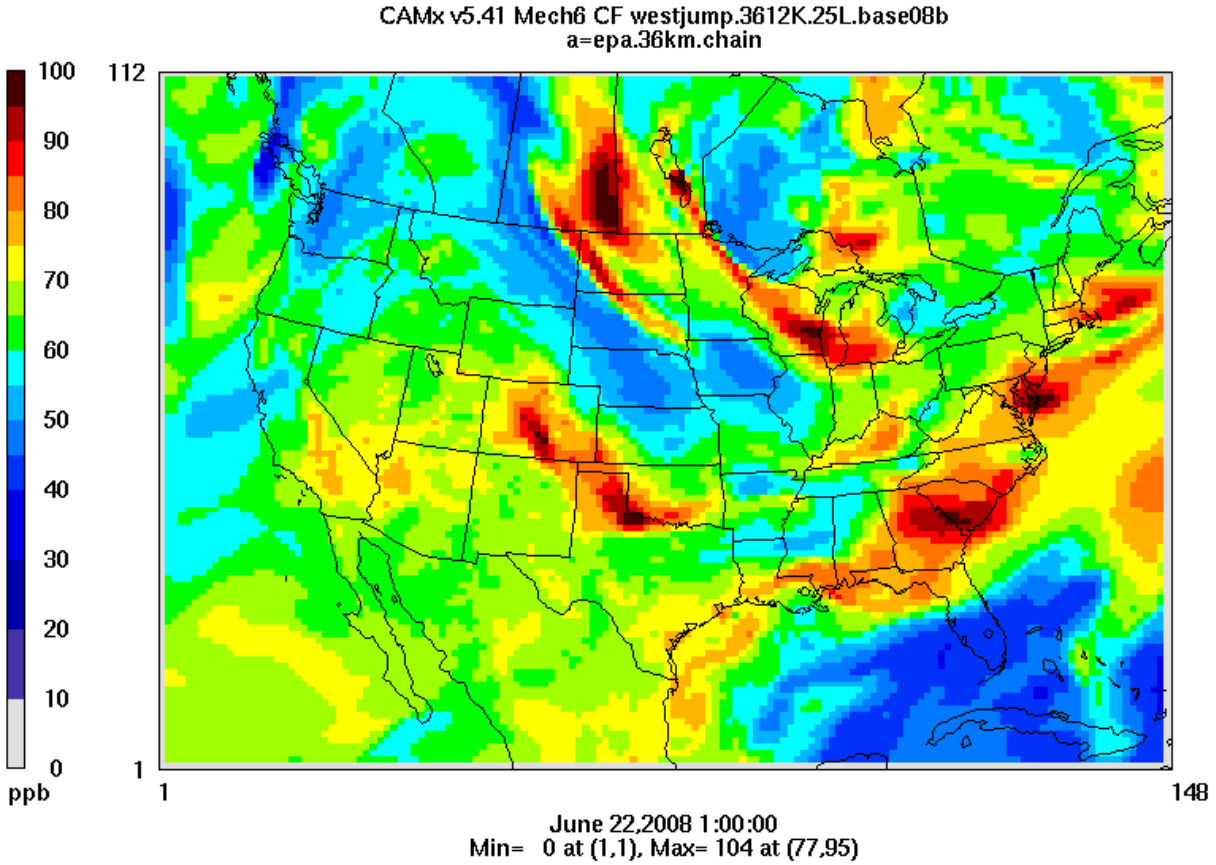
Lateral BC from Global Models

25 CAMx layers from the surface to the lower stratosphere.



# O3 in upper free troposphere is determined primarily by transport from boundaries

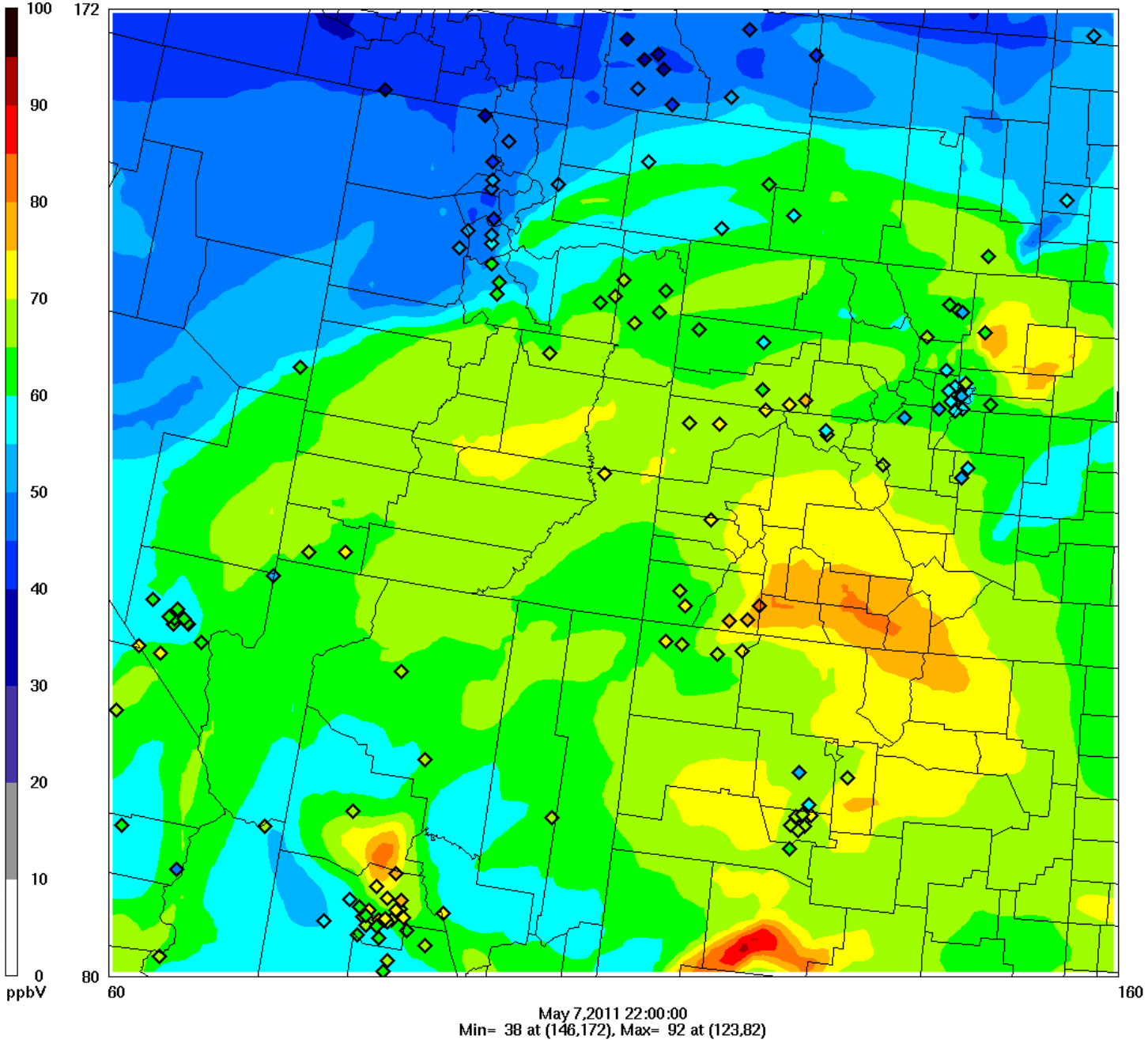
## O3 animation in Layer 21 (6-7 km) 6/22-7/4/2008



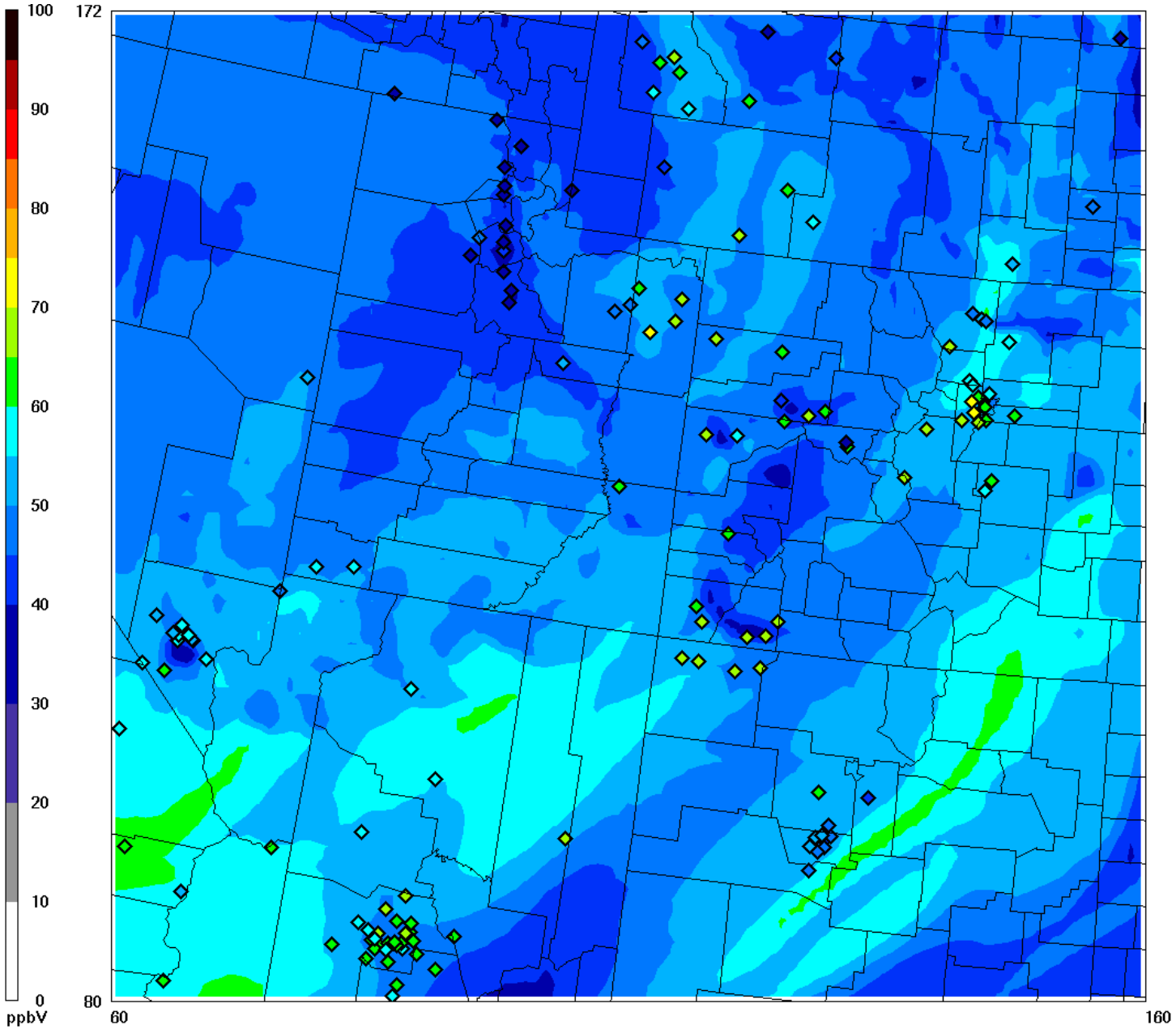
# Case Study #1
# Preliminary results from 2011 CMAQ Modeling

- BC data derived from GEOS-Chem.
- Larger set of rural O3 data available in 2011 from the 3-state air quality study.
- What can we learn from spatial patterns of model performance for hourly O3 data?
- How do these results inform the discussion of needs for additional monitoring and modeling work?

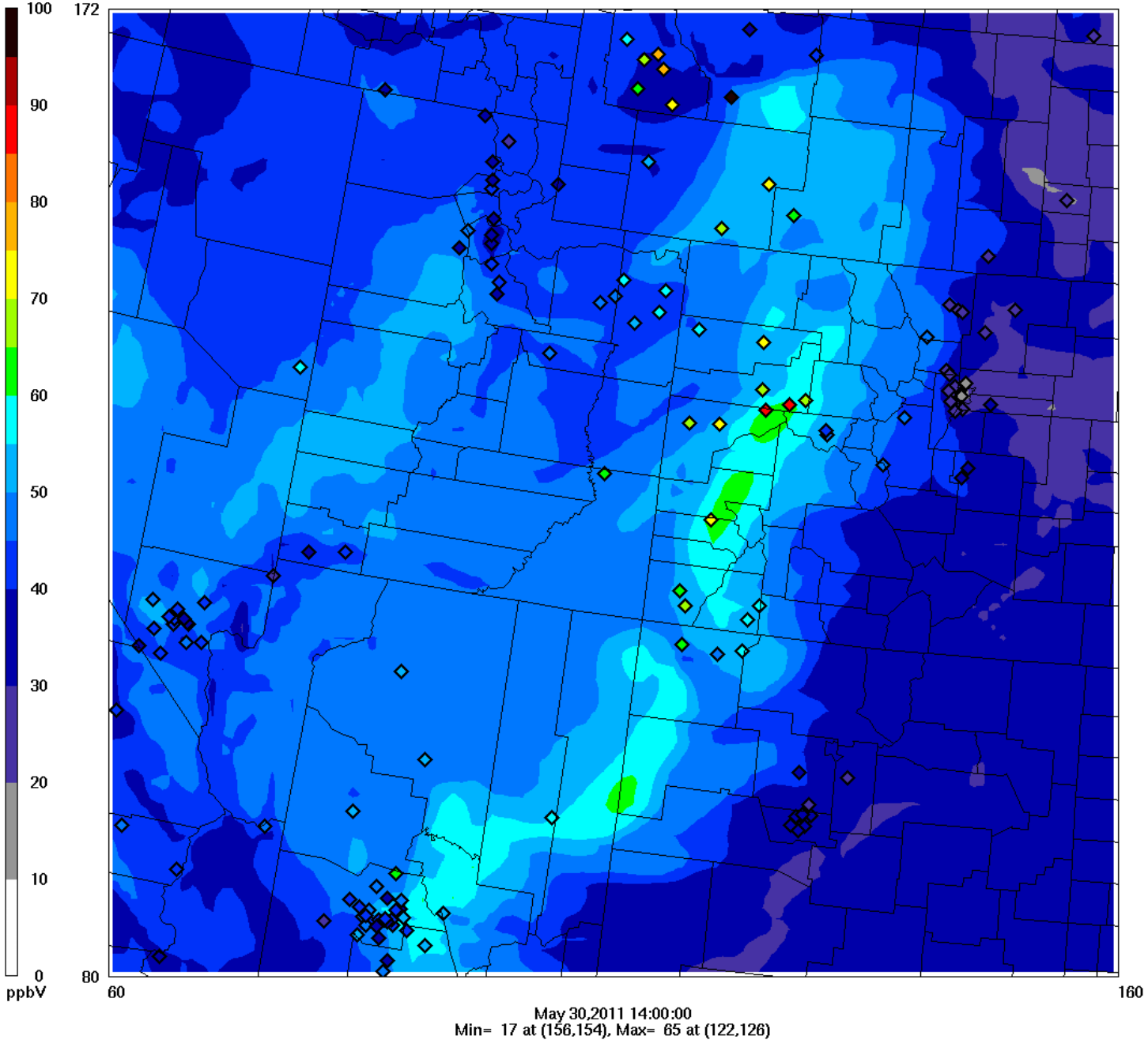
# CMAQ performs well for elevated regional O3 on May 7, 3 pm



# CMAQ biased low for elevated regional O3 on May 9, 5 pm LDT

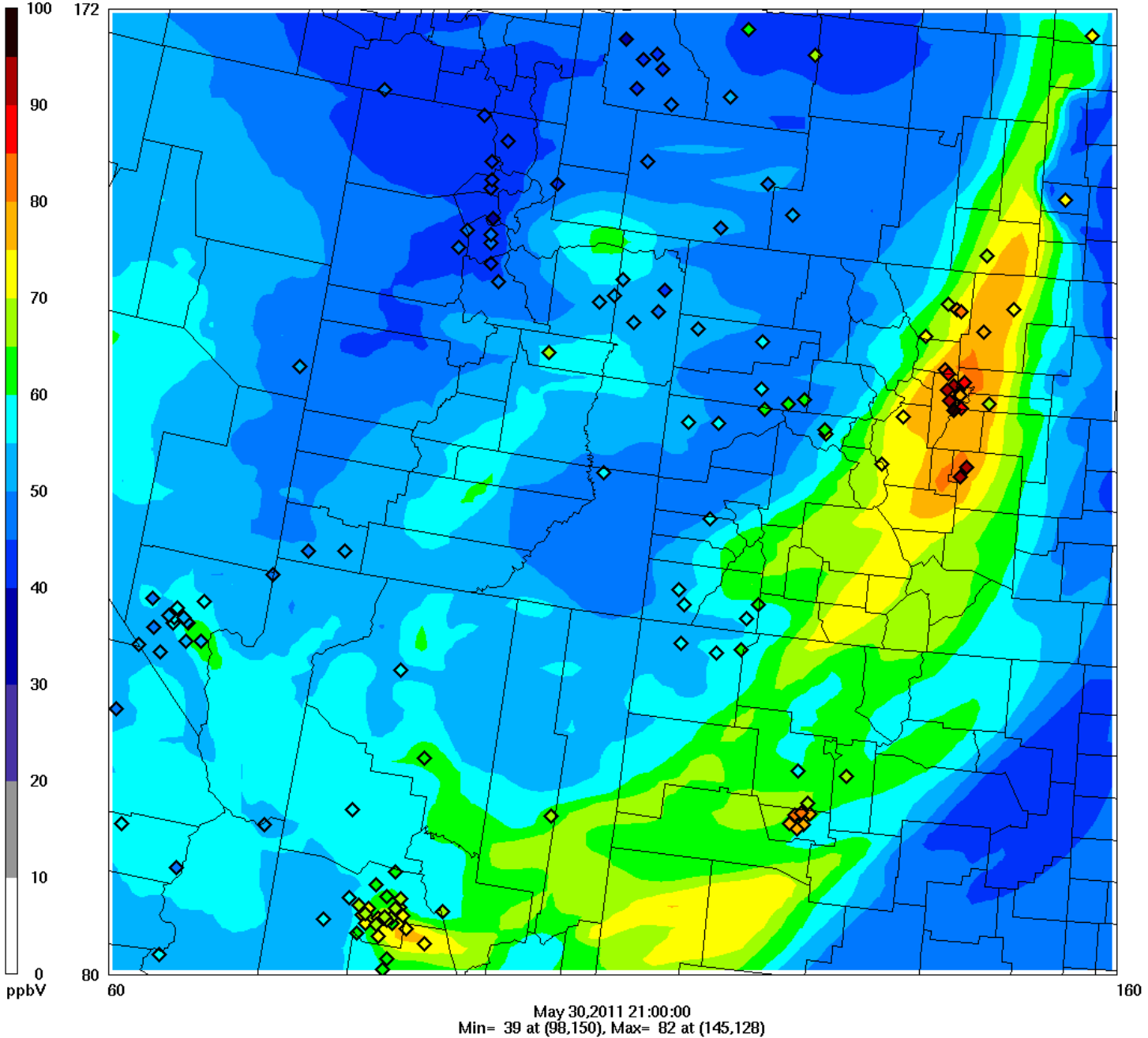


# CMAQ biased low in morning at rural sites on May 30



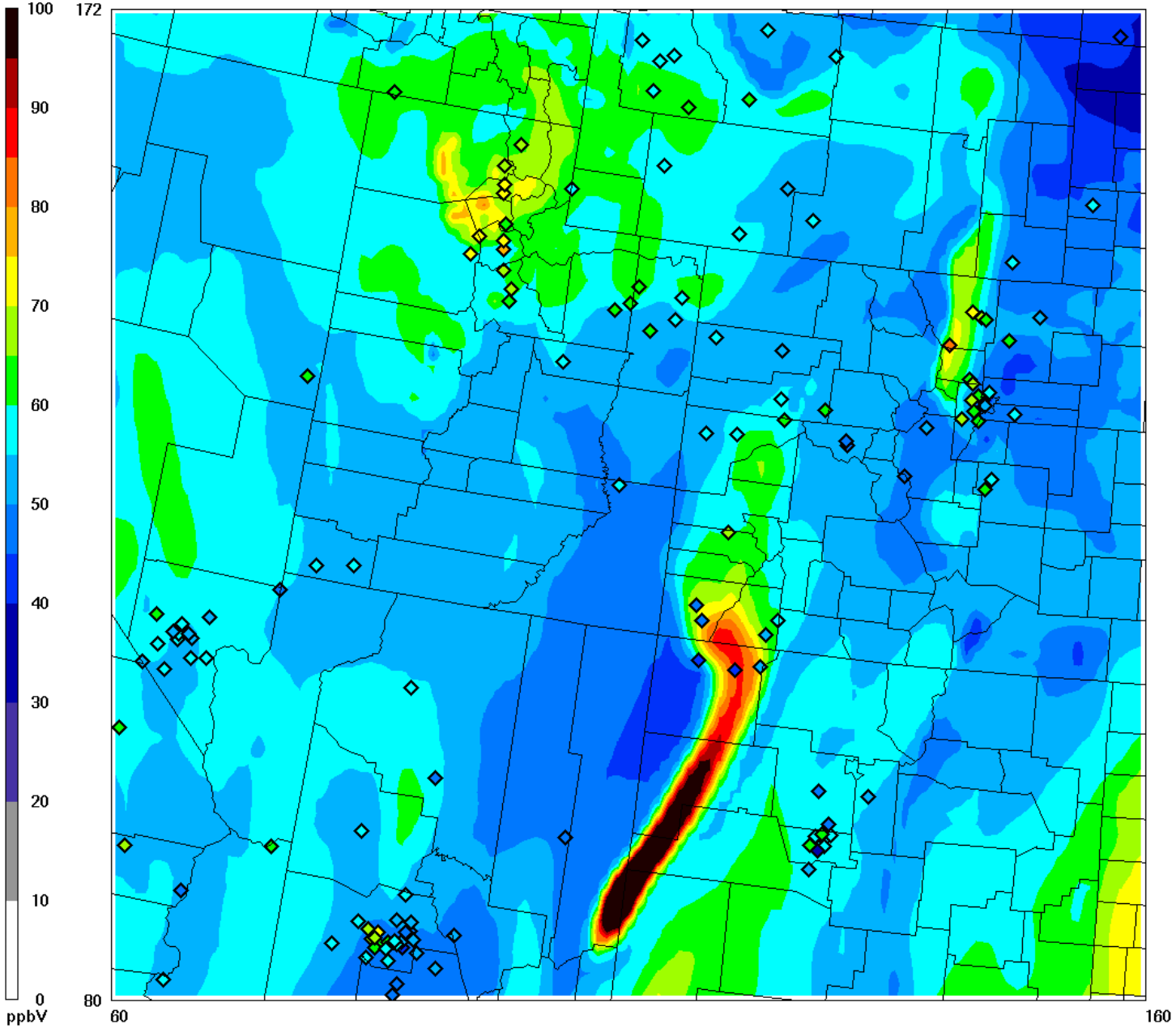

7 am LDT

# CMAQ matches the regional high O3 on May 30 but low bias at urban sites



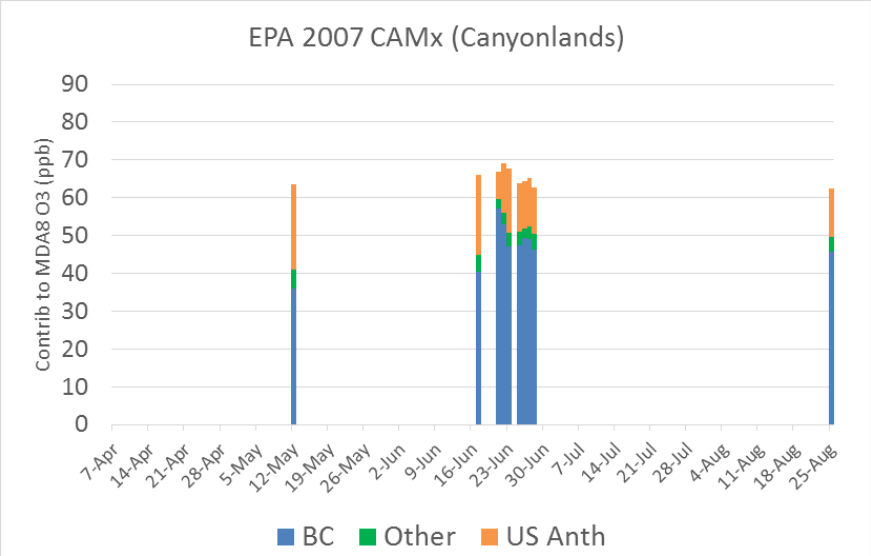

2 pm LDT

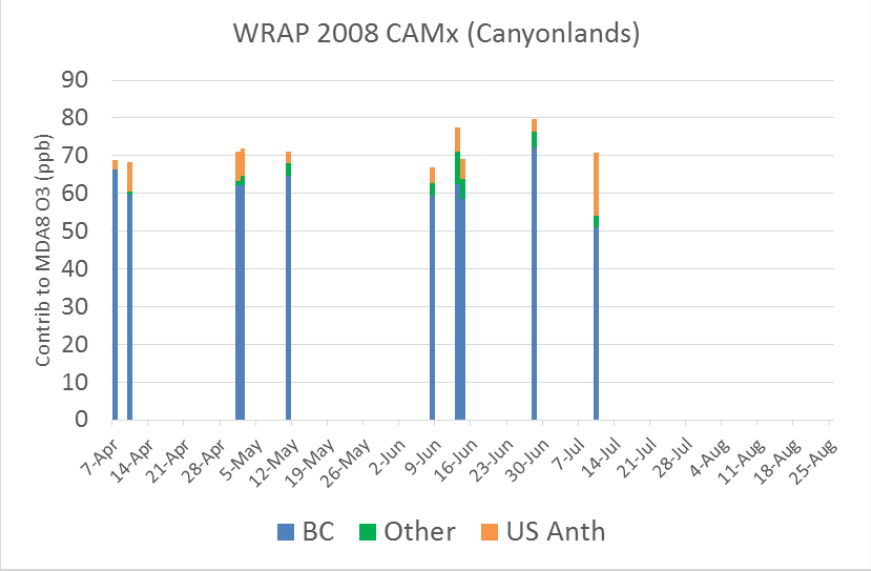
# CMAQ biased high for wild fire O3 in June



# Case Study #2 Uncertainty in model estimates of U.S. Background

## CAMx simulations for 2007 and 2008 at Canyonlands National Park – Eastern UT



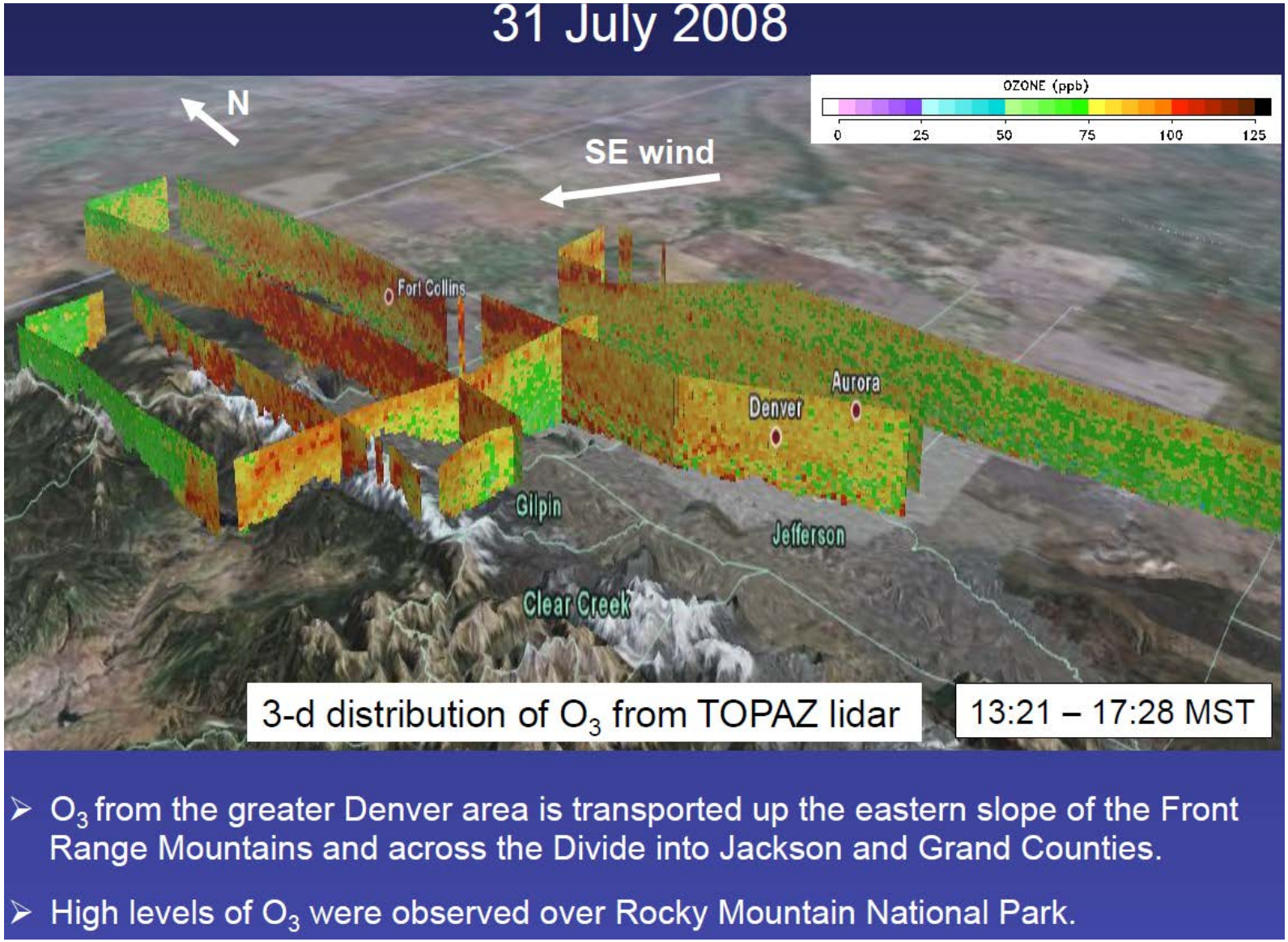

EPA 2007 CAMx model: BC contributions of 36-57 ppb; still substantial U.S. anthropogenic contribution to O3.

WRAP 2008 CAMx model: BC contributions of 50-72 ppb, much larger than OAQPS modeling.

Reasons for modeled differences are not fully understood

# Case Study #3

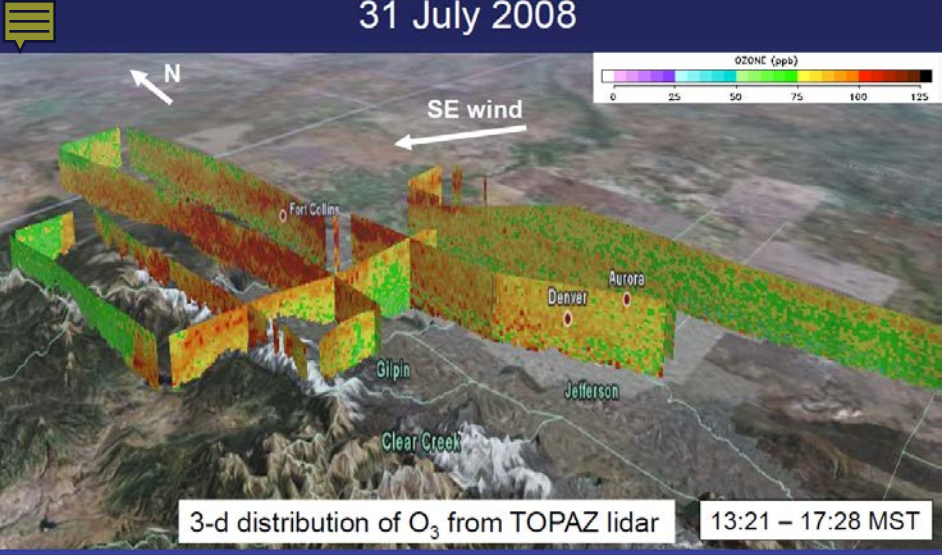
## Comparison of aircraft O3 lidar and CAMx model



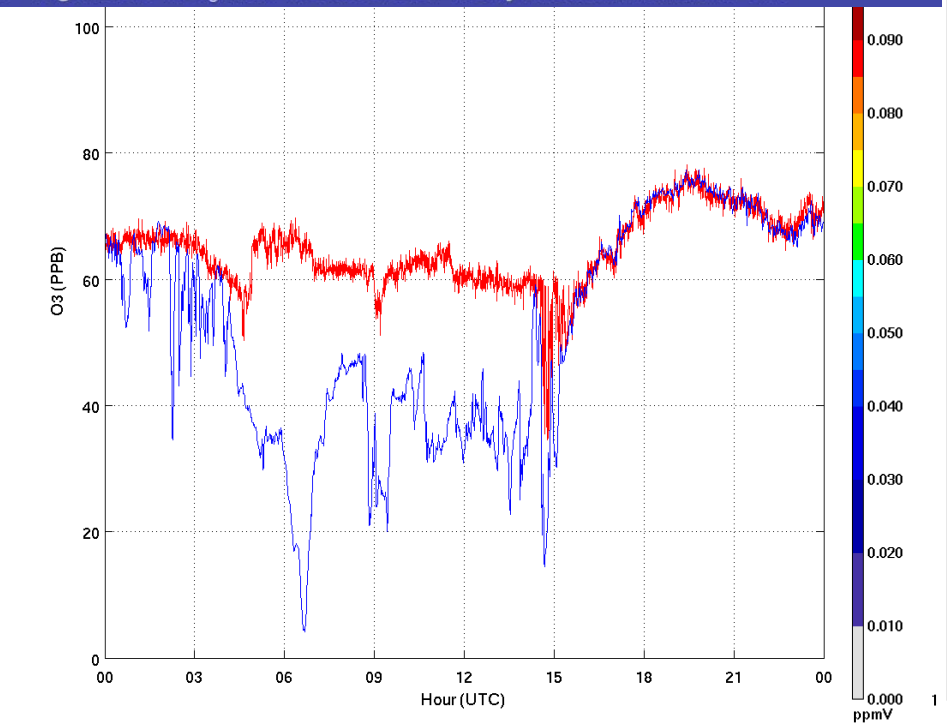

- $O_3$ from the greater Denver area is transported up the eastern slope of the Front Range Mountains and across the Divide into Jackson and Grand Counties.
- High levels of $O_3$ were observed over Rocky Mountain National Park.

Data and slide from Chris Senff and Andy Langford, NOAA/ESRL

# July 31, 2008, CAMx correctly simulates high O3 NW of Denver

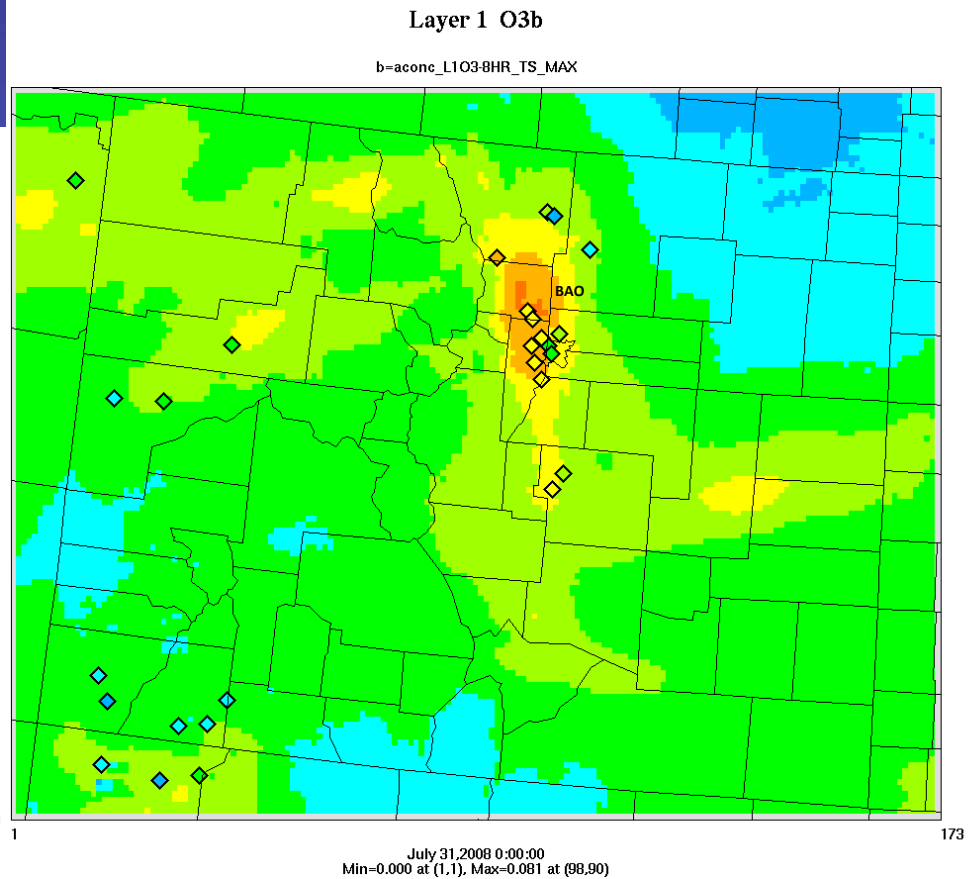



- $O_3$ from the greater Denver area is transported up the eastern slope of the Front Range Mountains and across the Divide into Jackson and Grand Counties.
- High levels of $O_3$ were observed over Rocky Mountain National Park.





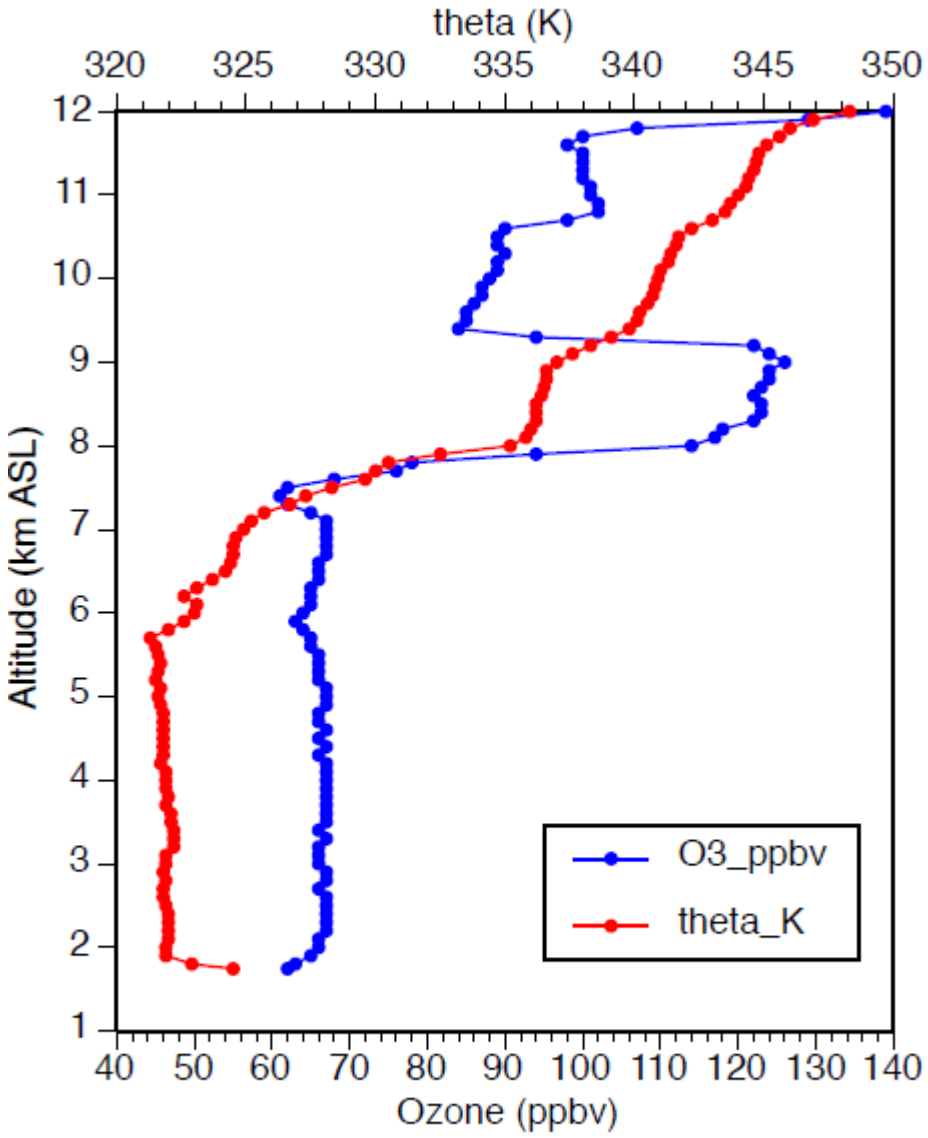

July 31 Model daily max 8-hr average O3



Ozonesonde on July 30th, 2008 shows layer of high ozone from about 8 to 9 km ASL. TOPAZ aircraft flight was below the intrusion layer.

CAMx has elevated O3 layer at 5.8 to 7.4 km AGL (see next slide).

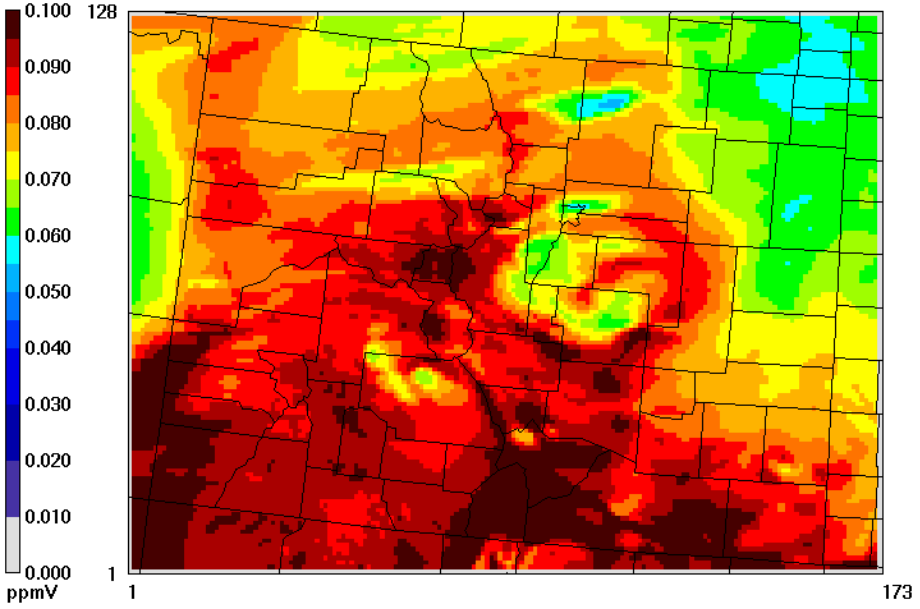
Does the stratospheric O3 layer reach the surface on July 30-31?



# July 31, O3 1-hr average 4 pm MDT

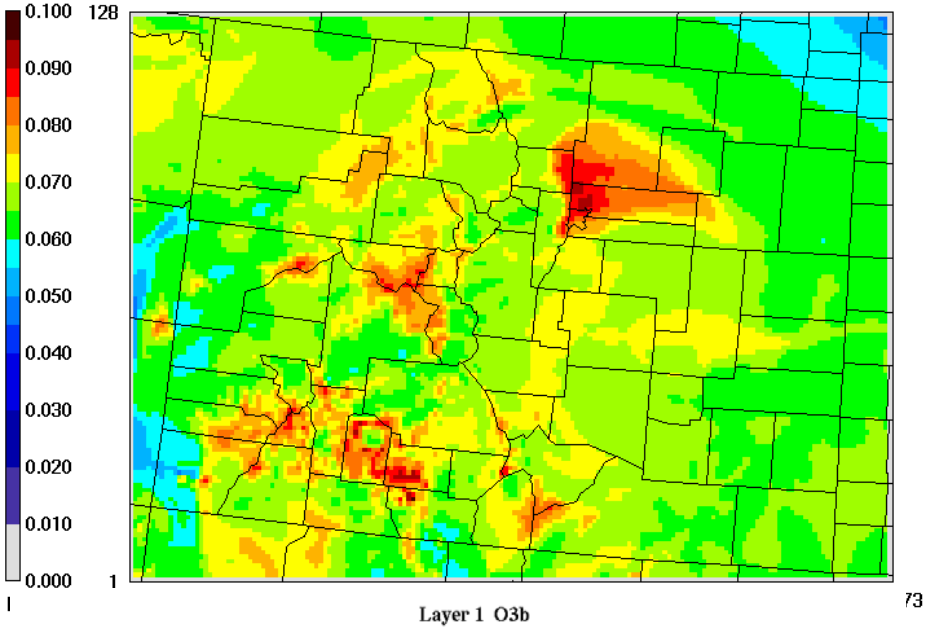
Layer 21 O3

5800 to 7400 m AGL




Layer 19 O3

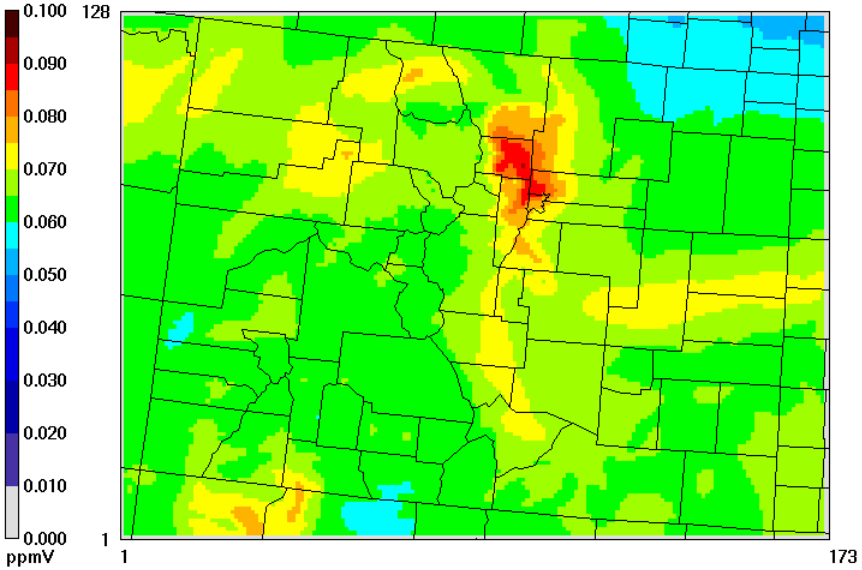
3850 to 4460 m AGL

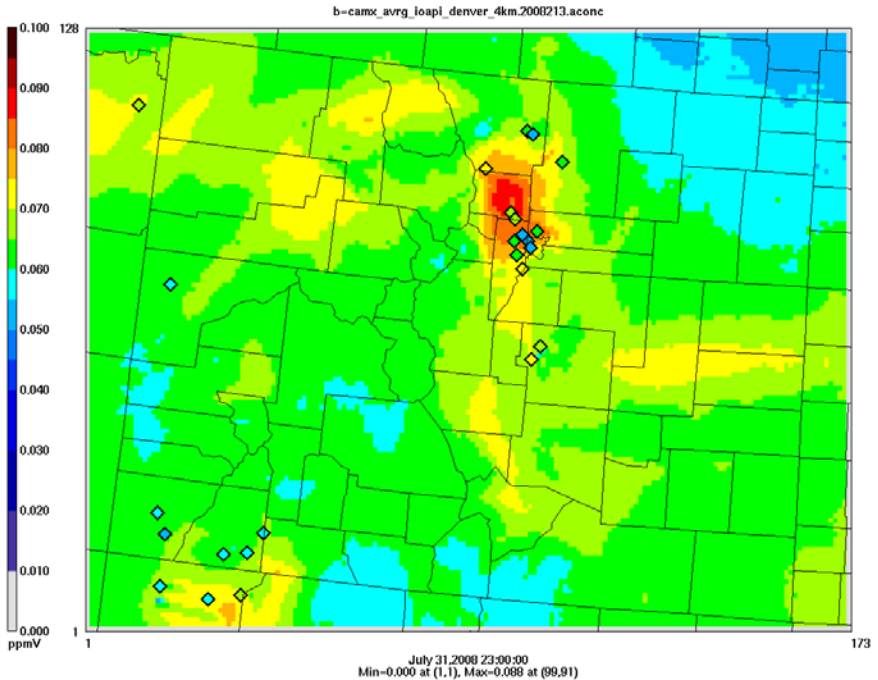



Layer 1 O3b

Layer 15 O3

2130 to 2530 m AGL

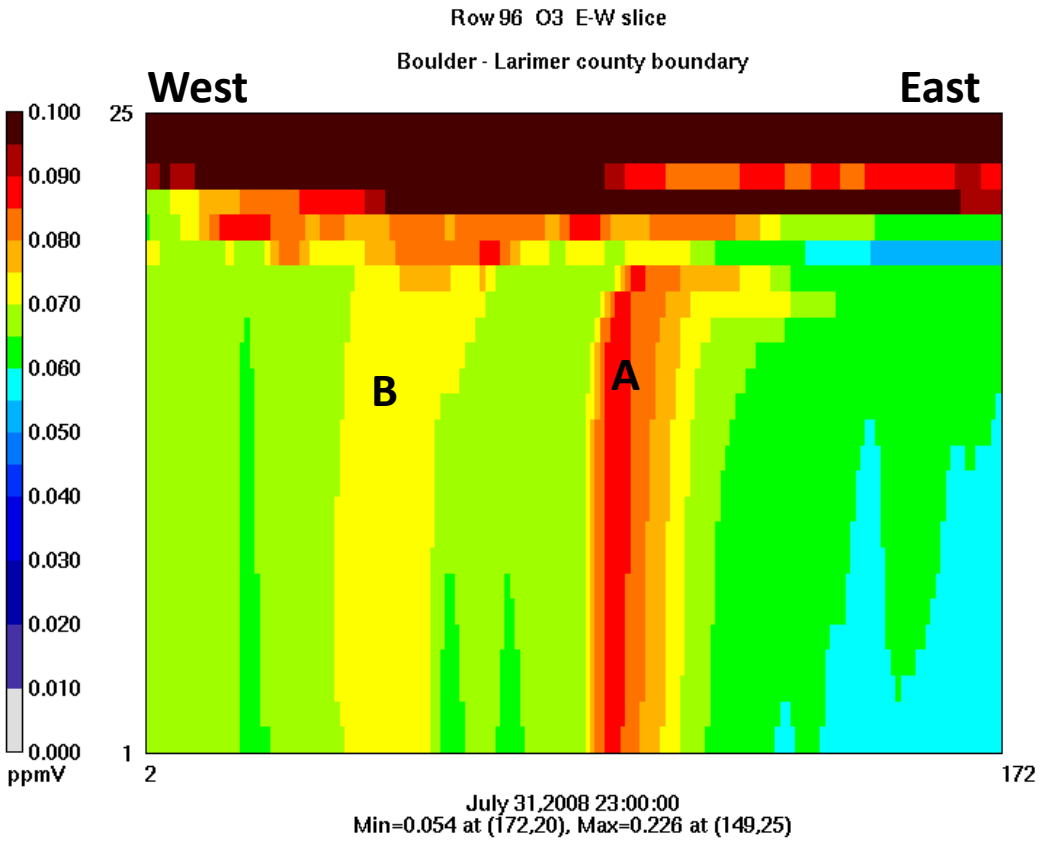


# Model Vertical Profiles – July 31, 4 pm MDT

A: Column of O3 (red) 80-90 ppb moves from Denver to the NW to Rocky Mountain NP.

B: Column of O3 (yellow) 70-75 ppb moves east from UT to NW Colorado.



# Comparison of 2008 CDPHE O3 model with aircraft O3 lidar profiles

- Key Findings:
  - The CAMx model performs well on three high O3 days in July 2008.
  - Stratospheric O3 layer is observed and modeled on July 30-31.
  - Uncertain if the stratospheric O3 reaches the surface.
- Significance:
  - Uncertainty in stratospheric contribution to surface O3.
  - Increased vertical resolution might be needed in CAMx in the free troposphere to simulate more accurately the exchange of O3 between the free troposphere and the PBL.

# Strategies for Improving the State of the Science for modeling O3 in the western US

- More monitoring data to improve characterization background $O_3$ and to evaluate the accuracy of model-based estimates of USB:
  - More measurements to improve characterization of vertical $O_3$ profiles.
  - Network of $O_3$ LIDAR vertical profiles (NASA TOLNET pilot study)
  - More ground based $O_3$ and precursor measurements in rural areas.
- Perform comprehensive model evaluation studies using new monitoring data to assess contributions to background $O_3$.
  - Do global models accurately estimate BC inflow?
  - Do regional models accurately simulate natural sources of $O_3$ from wildfires and biogenic precursors?
  - Do regional models accurately simulate vertical mixing of $O_3$?
  - Need projections of future trends in global O3.
- Increase state/federal & planner/researcher collaborations to improve modeling and data analysis for O3 transport, wildfires, and stratospheric intrusion.

# EPA plans to improve BGO3 estimates

- Looking for collaborations with the community at large:
  - State partners, Regional Organizations, Federal partners, academic/stakeholder groups
- Need for additional data collection to enable thorough model performance evaluations:
  - Targeted measurements in areas especially influenced by background.
  - Additional routine non-surface measurements of ozone / precursors (e.g., lidar, satellite, sondes).
  - Continuous dynamic evaluations of models' ability to predict trends.
- Better integration between the global and regional modeling communities:
  - EPA expects to begin hemispheric CMAQ modeling in near-future.
  - Work with HTAP to incorporate best available global runs into regional boundary conditions.

# Potential opportunities for collaboration

- Formation of special issue workgroups
  - Stratospheric intrusion workgroup, WRAP-based forums, RPO calls, others?
- NASA Air Quality Applied Science Team (AQAST)
  - Partner atmospheric scientists with AQ managers to leverage earth science tools
  - Continually looking for new AQ issues for investigation
  - Led by Daniel Jacob (Harvard)
- CENRS Air Quality Research Subcommittee
  - Group devoted to improving information exchange between research and policy on air quality issues (e.g., background ozone)
  - Also tasked with enhancing the effectiveness and productivity of U.S. air quality research.
  - Currently chaired by John Daniel (NOAA ESRL)
- Others?

Questions?

# Goals of the Ozone Stratospheric Intrusion Workgroup

- Develop standardized technical methods for analysis of SI.
- Promote collaboration and data sharing between the states and federal researchers in analysis of SI exceptional events.
- Promote archiving of key data sets.
- Reduce effort needed to prepare and review SI exceptional events demonstration packages.

- The workgroup cannot specify criteria for approval of exceptional events or make determinations of whether flagged data can be approved by EPA.
- Cannot make recommendations on policy or how EPA could use this information.

# Workgroup Resources

- Monthly conference calls.
- State meteorologist and modelers
- RAQMS globals scale forecast model (Brad Pierce, NOAA)
- Lidar Pilot study – continuous O3 profiles (Mike Newchurch, UAB; NOAA Boulder Lidar group).
- NASA AJAX aircraft program (Emily Yates, NASA)
- Workgroup membership is limited to government employees but can request information from outside experts. Consultation with the public would trigger the Federal Advisory Committee Act.

# BAO Tower July 2008 RH

Low relative humidity on July 30-31st indicates possible transport of stratospheric air to the surface.