Summary of NCAR/ACD WRF-Chem Activities and Development Efforts

Mary Barth

Jeff Lee, Karina Apodaca*, Ave Arellano,
Trude Eidhammer, Louisa Emmons, Alma Hodzic,
Gabriele Pfister, Stacy Walters, Christine Wiedinmyer

Also in group: Xue Xi Tie, Sasha Madronich

Atmospheric Chemistry Division
NCAR

*from Howard University

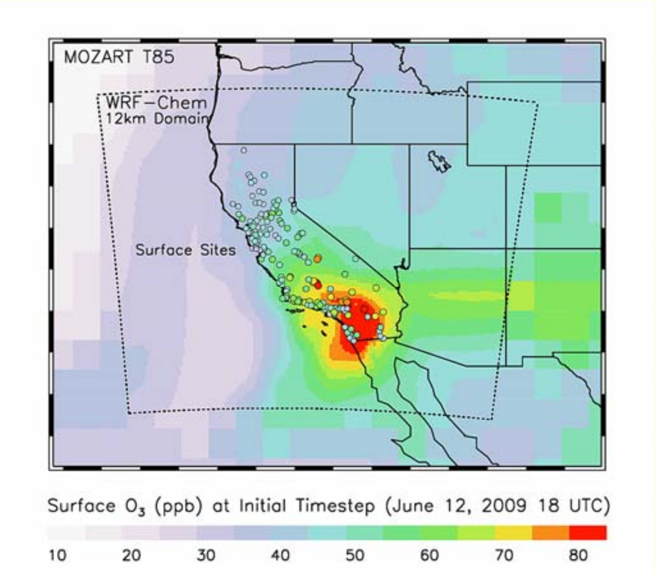
Outline

- **Simulating chemistry on both the global and regional scale**
  - MOZART global model used as boundary and initial conditions – making it easily available to community via the web
  - MOZART chemistry + GOCART aerosols
  - Ensemble data assimilation plans
- **Aerosol-cloud interactions**
  - Southern Rocky Mountains simulations as part of BEACHON
  - Dust-thunderstorm effects
- **North American Monsoon simulation**
  - Scalar Code in V3.1
  - Lightning NOx for future version
  - Aircraft emissions
  - Merging US EPA anthropogenic emissions with Mexico anthropogenic emissions
- Preprocessor for MEGAN and wildfire emissions

Using Global Model Output for Boundary and Initial Conditions in WRF-Chem

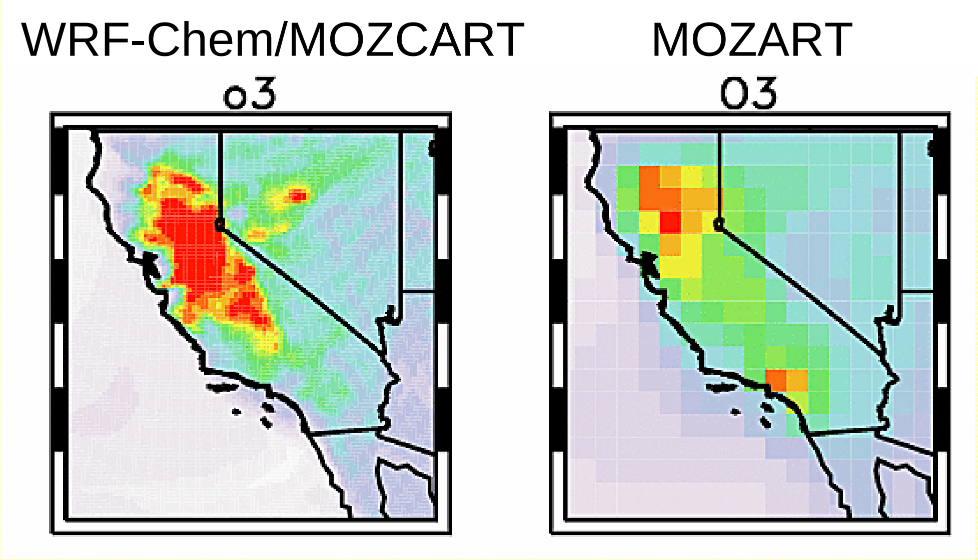
- Instead of using idealized profiles for chemical species, use results from MOZART chemical transport model using MOZBC

- MOZBC is a 2nd preprocessor that is run after real.exe
  - Overwrites wrfinput / wrfbdy fields with MOZART fields
  - Have mapping of species for RADM2, RACM, MADE/SORGAM, CBMZ, MOSAIC 8 and 4 bins, and GOCART
  - Currently creating web page to allow users to obtain MOZBC and its input files, and to download MOZART output www.acd.ucar.edu/wrf-chem/



Implementing MOZART chemistry to have consistency at both the global and regional scale

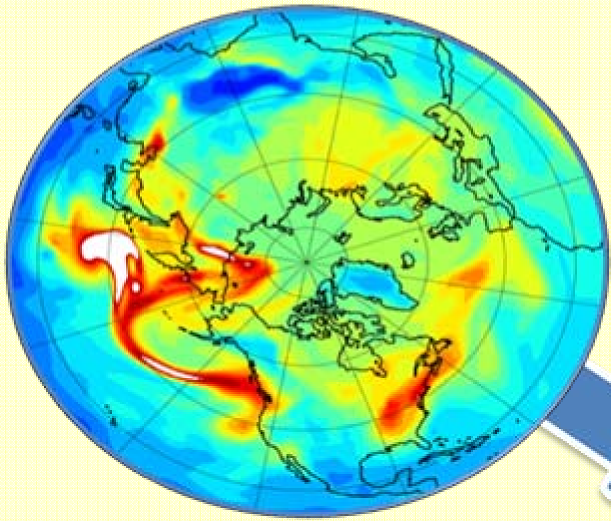
- Have compatible chemical mechanisms and consistent analysis across scales and be able to use common data assimilation capabilities
- MOZART has 85 gas-phase species and 157 reactions
- Implemented in WRF-Chem V3.0 and updating to V3.1



Courtesy G. Pfister

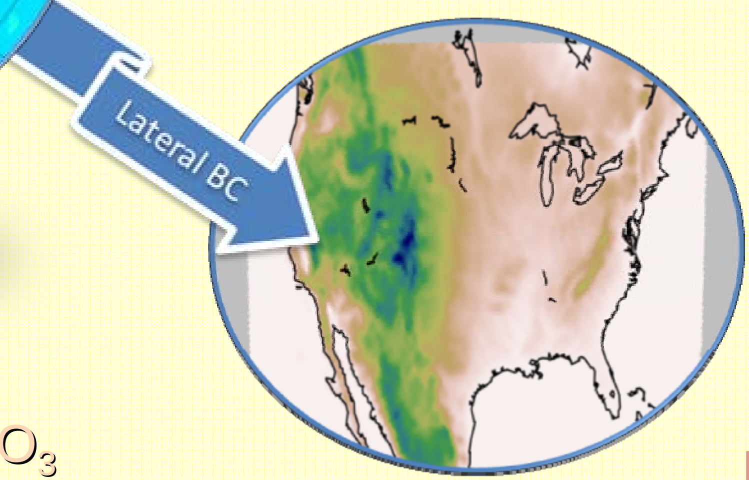
Research-Based Regional to Global NWP with Chemistry

CAM-Chem/DART



- using ensemble-based DA approach
- one-way coupling of online models
- driven by perturbations in emissions, initial conditions, (multi-physics), (multi-chemistry)
- using 20-40 ensemble members

WRF-Chem/DART



OBSERVATIONS

Rawinsondes
ACARS
AIRCRAFT
SATWINDS
MOPITT CO
MODIS AOD

TES CO, O_3
IASI CO, O_3
OMI NO_2, O_3
GOME O_3

APPLICATIONS

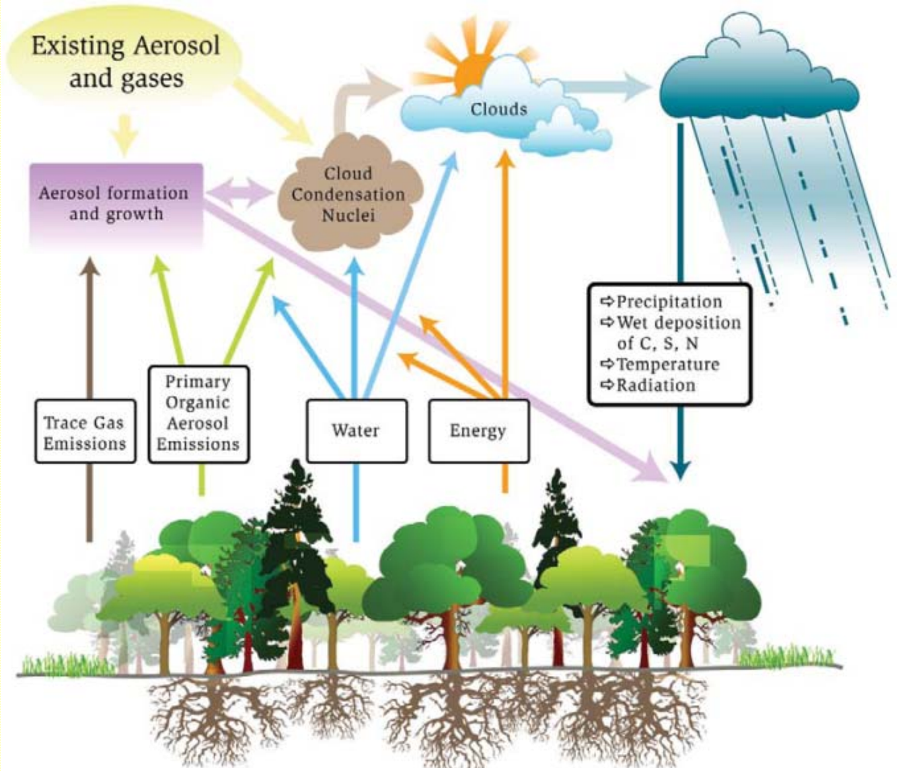
Chemical OSSEs
Chemical Weather
Field campaign support

In collaboration with
NCAR/IMAGe &
NCAR/MMM

Aerosol-cloud interactions

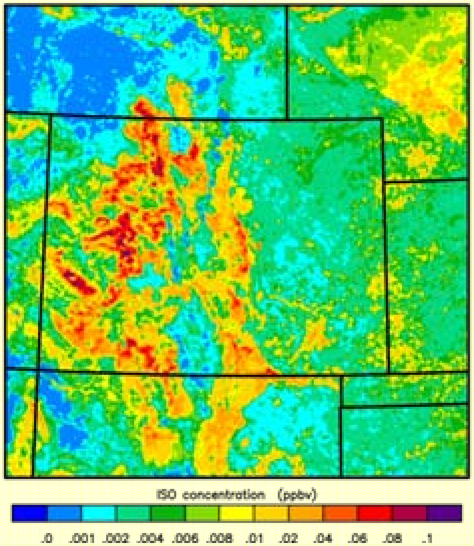
- Southern Rocky Mountains simulations as part of BEACHON
  www.tiimes.ucar.edu/beachon

Investigate connections between the biogenic emissions, gas-phase oxidants, aerosols, CCN, and clouds



From Barth et al. 2005 BAMS

Isoprene (ppbv) at surface



Courtesy T. Eidhammer

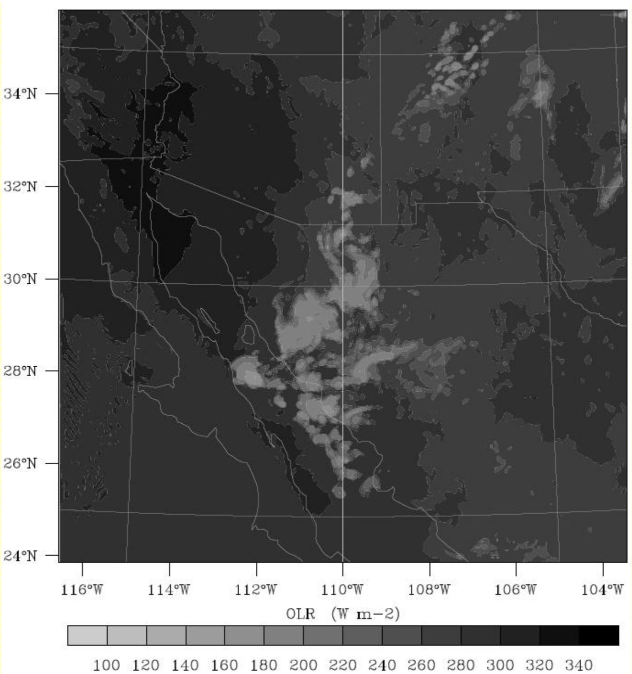
Aerosol-cloud interactions

- Dust-thunderstorm effects

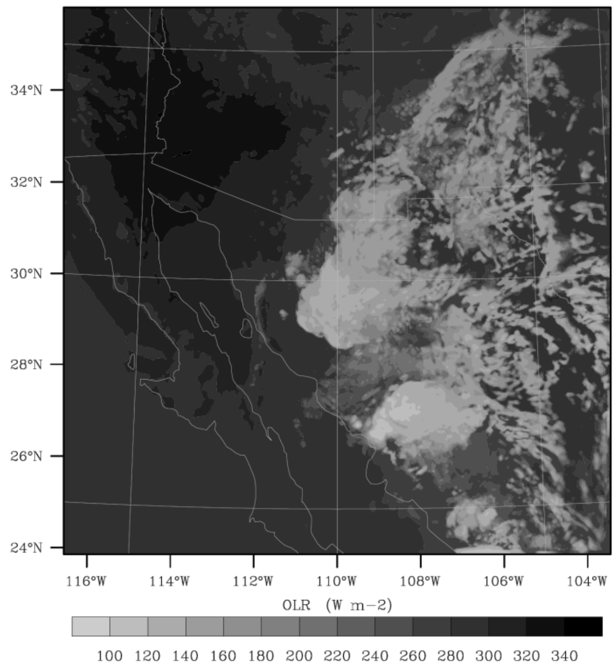
Role of dust on thunderstorm characteristics (precipitation) during North American Monsoon thunderstorms

Outgoing Longwave Radiation

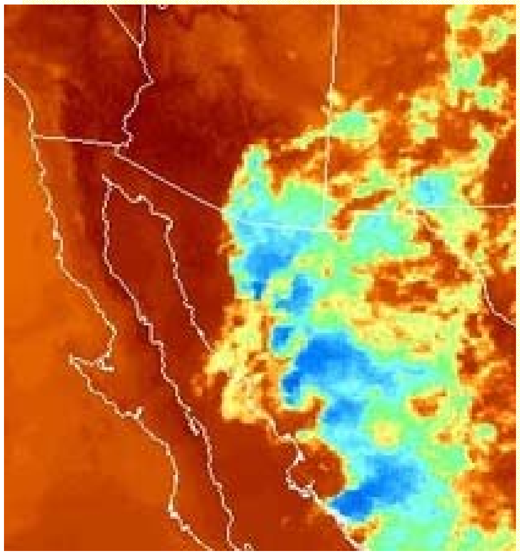
WRF only, Lin mphys



WRF-Chem, Lin mphys
with aerosol-cloud interactions



IR satellite Obs



Courtesy K. Apodaca

Aerosol-cloud interactions

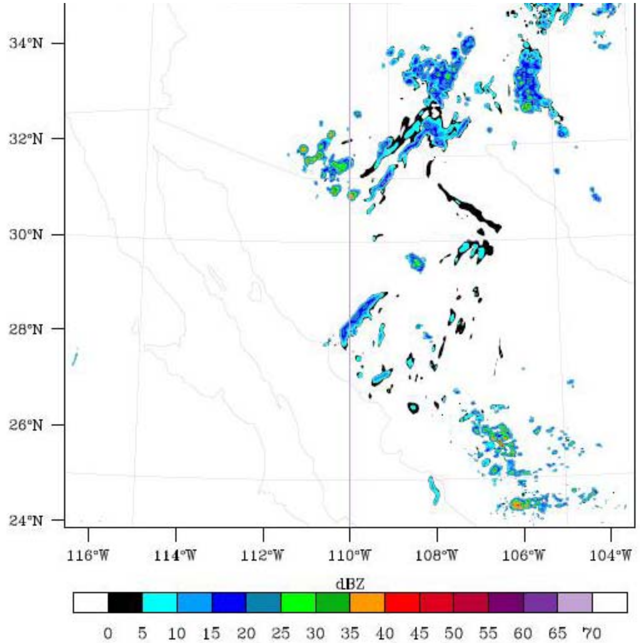
- Dust-thunderstorm effects

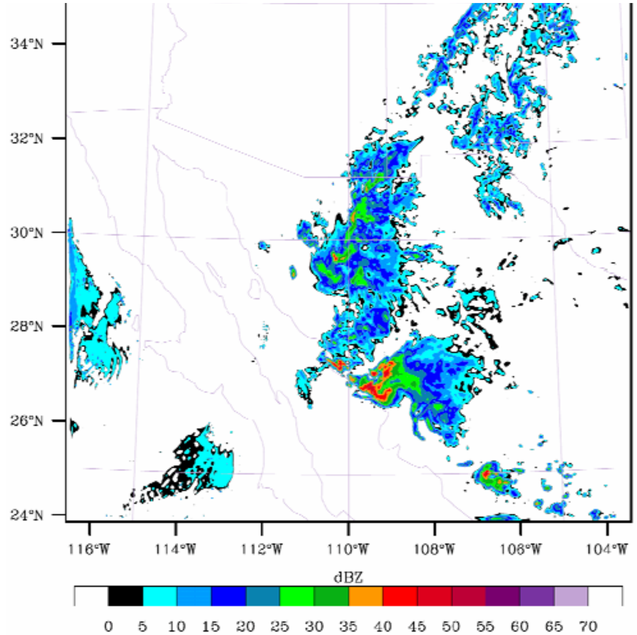
  Role of dust on thunderstorm characteristics (precipitation) during North American Monsoon thunderstorms

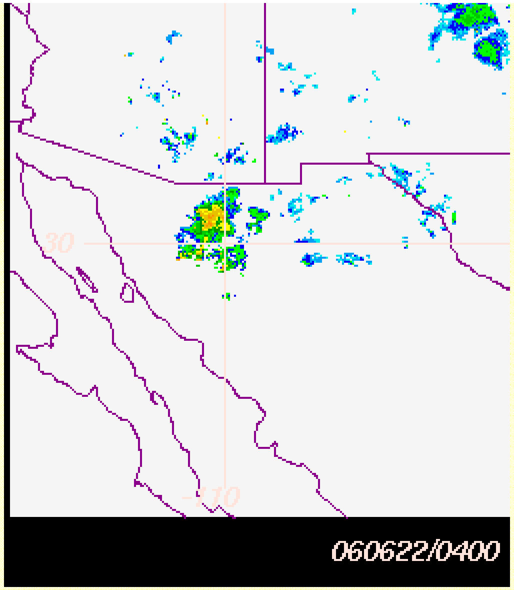
WRF only, Lin mphys — WRF-Chem, Lin mphys — Observed

Reflectivity

with aerosol-cloud interactions







Courtesy K. Apodaca

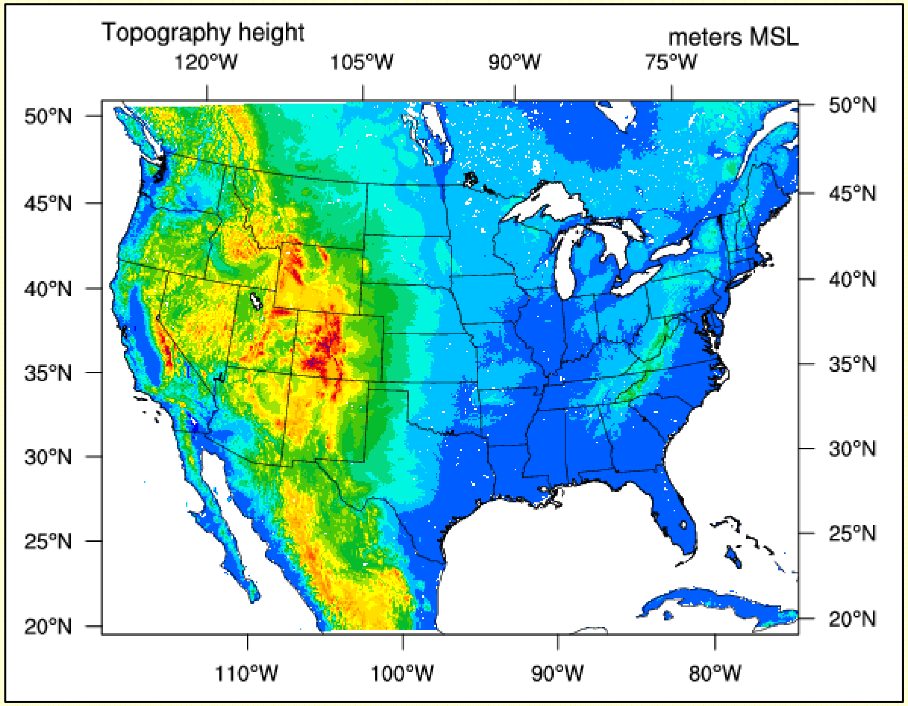
North American Monsoon simulation

- Understanding the formation of an ozone enhancement in the upper troposphere during the North American monsoon period

  Hypothesis: convective transport of precursors + lightning $NO_x \rightarrow O_3$

- Investigate the role of heat waves and wild fires in ozone formation at the surface

➢ High resolution WRF-Chem simulation ($\Delta x = \Delta y = 4$ km) over the contiguous US and most of Mexico during the summer of 2006



configuration details and preliminary evaluation given in Hodzic et al poster

Additions and Modifications made to WRF-Chem V3.0.1.1 for the North American Monsoon simulation

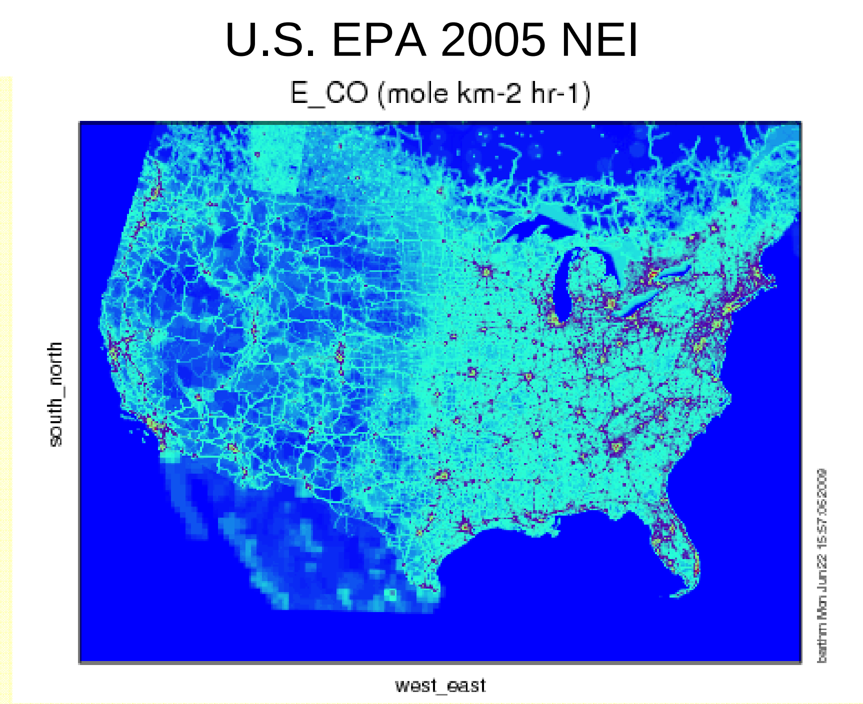
- Aircraft emissions
- Merging US EPA anthropogenic emissions with Mexico anthropogenic emissions
- Scalar Code in V3.1
- Lightning NO_x for future WRF-Chem version

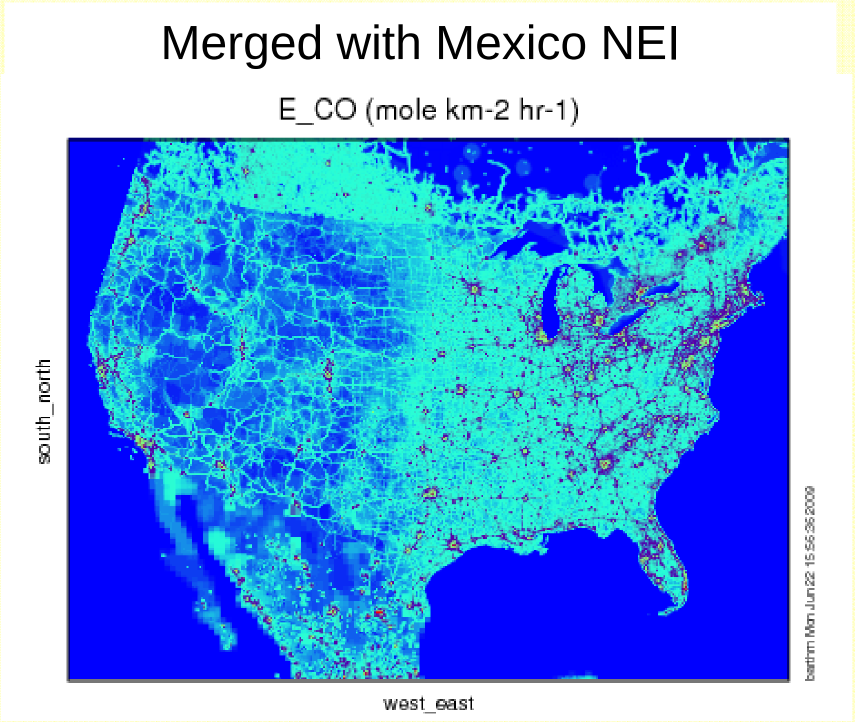
Modified Emissions for the North American Monsoon simulation

- Aircraft emissions

  1999, 1x1° annual average (Baughcum, Boeing); courtesy L. Emmons

- Merging US EPA anthropogenic emissions with Mexico anthropogenic emissions





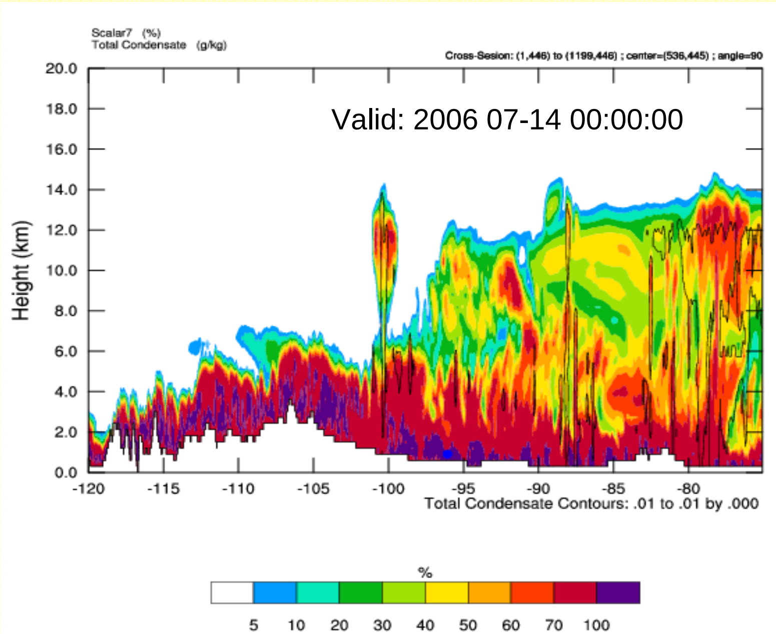
Thanks to S. McKeen for 2005 EPA emissions

Implementation of PBL, Stratosphere, and Horizontal Boundary Tracers

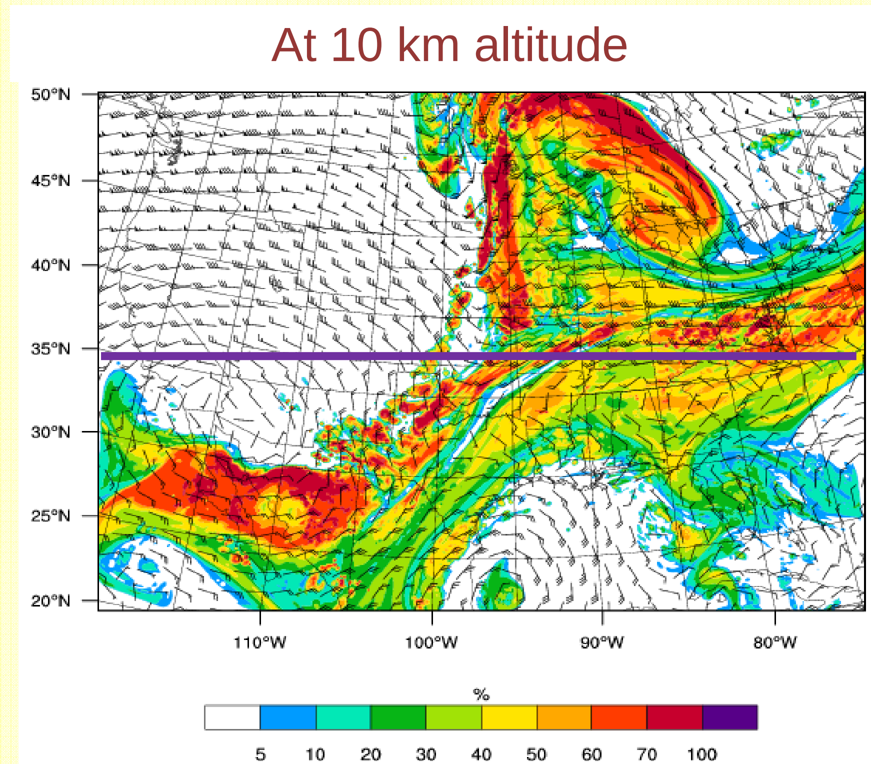
1) Horizontal boundary tracers– represents air coming into domain
   - Set to 1 at the lateral boundaries; initially 0 within model domain
2) Planetary boundary layer tracers
   - Set to 1 between surface and PBL Height; initially 0 above PBL
3) Stratosphere tracers
   - Set to 1 between the thermal tropopause and the top of the model domain; initially 0 below the tropopause

Each pair of tracers has 1 passive scalar and 1 scalar that decays with a time scale of 1 day – this allows an estimate of the age of air

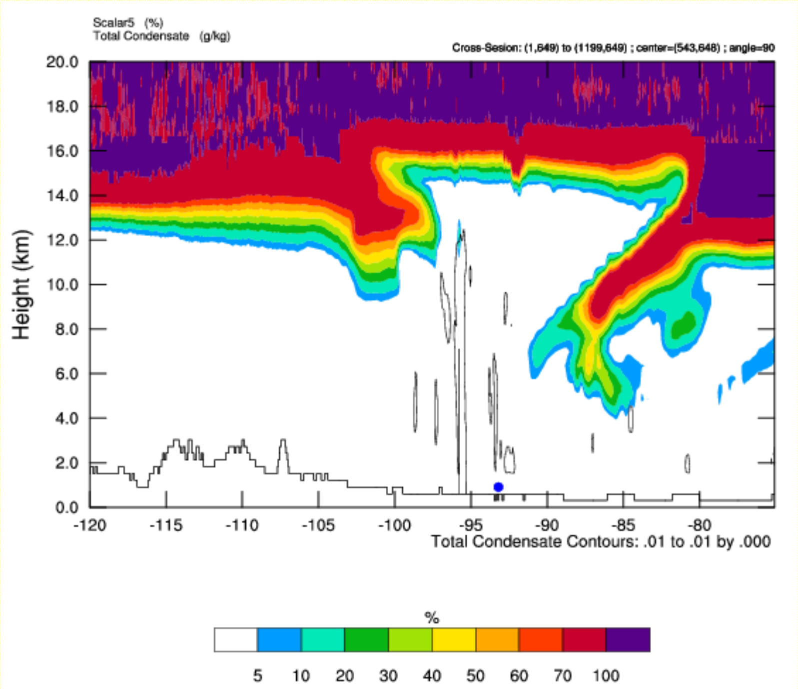
PBL Tracer 4 days into NAM Simulation



West-East cross-section through center of domain

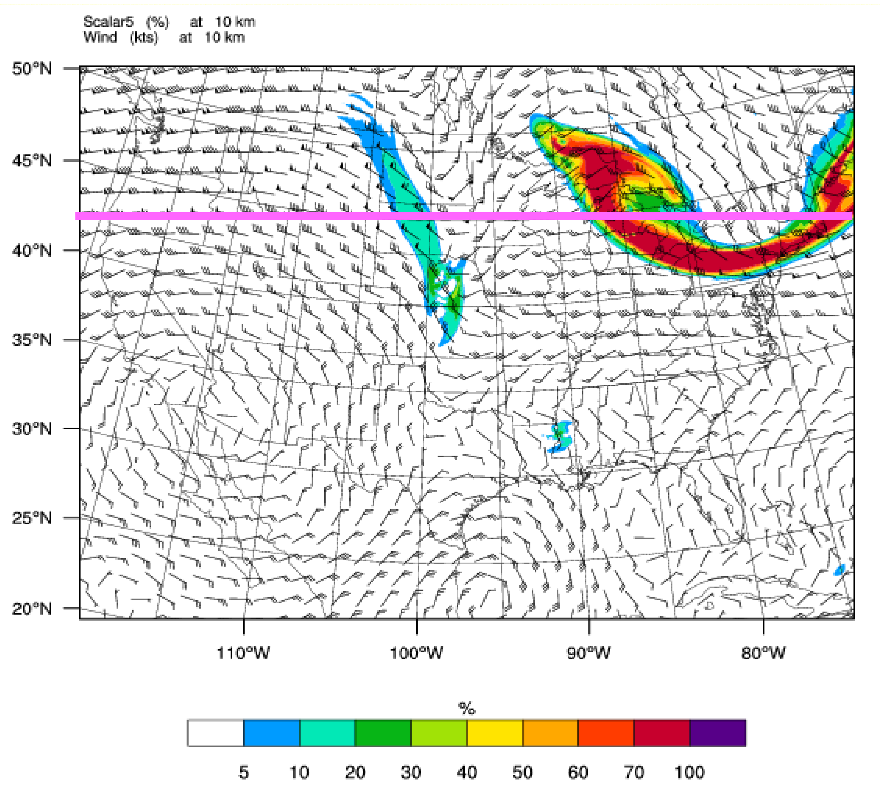


Stratosphere Tracer 4 days into NAM Simulation



West-East cross-section through 45N, 100W

At 10 km altitude



Implementation of Lightning-NO_x Parameterization for Cloud Resolving Scales

1) Lightning flash rate is predicted:

   $FR = 5.7x10^{-6}\ w_{max}^{4.5}$ (Price and Rind, 1992)

2) Partitions between intracloud (IC) and cloud-to-ground (CG) flashes based on Boccippio et al. (2001) climatology

3) Distributes NO horizontally within reflectivity > 20 dBZ

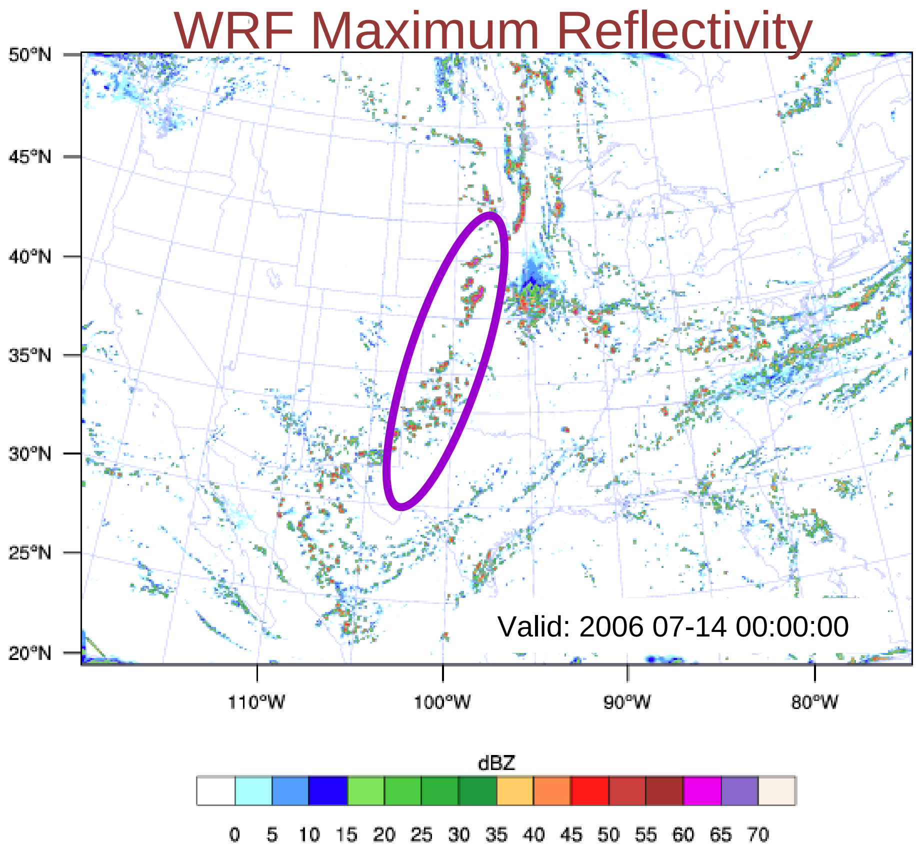
4) Distributes NO vertically using a Gaussian distribution

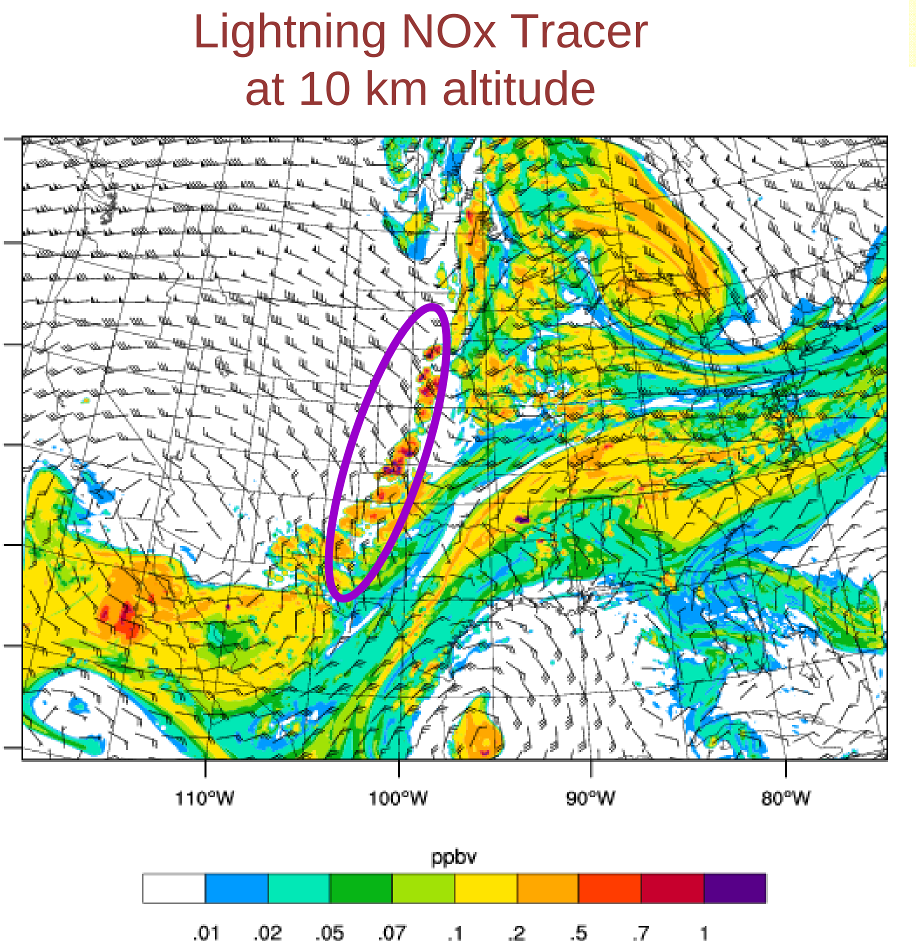
5) Amount of NO produced per flash

   - 330 moles NO/flash for both CG and IC flashes (Schumann and Huntrieser, 2007)

- Lightning NO_x tracers;   IC and CG flashrate counters

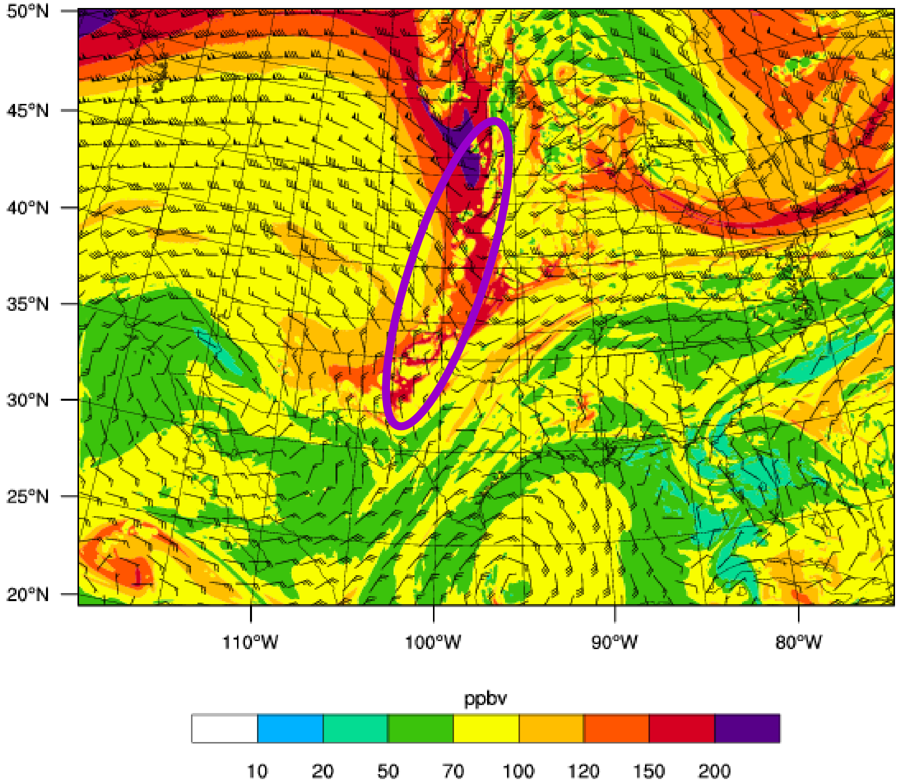
Lightning NO_x Tracer 4 days into NAM Simulation



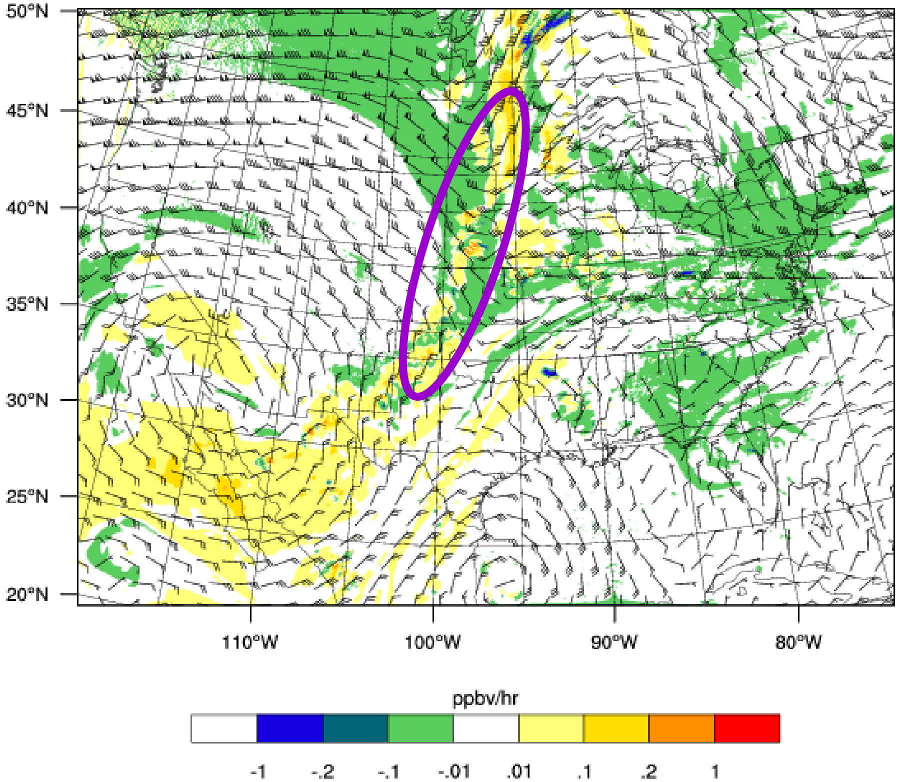


Ozone and O_3 Production 4 days into NAM Simulation

O_3 at 10 km altitude



Rate of Change in O_3 due to Chemistry at 10 km altitude



Preprocessor for MEGAN and wildfire emissions

- Currently:
  - To run MEGAN, you need to contact Christine Wiedinmyer who will get you the required land-use, vegetation information, etc. for your domain and grid resolution
  - Wildfire emissions also require preprocessing to get locations, size of fires + vegetation information
- Working on:
  - Preprocessor that the user can run
  - Hopefully will be ready this year
- Also:
  - Fire emissions from C. Wiedinmyer will soon be available on the web

Issue with running MEGAN emissions

NEWS FLASH

- Currently:

MEGAN called every biogenic emission time step (e.g. 30 min):

→ mebio emission rates

→ chem = chem + mebio*dt/(ρ dz)

Where dt = meteorology time step (e.g. 1 minute)

→not enough biogenic emissions being added into chem

- Solution:

Call MEGAN every meteorology time step

We are working on re-writing code to have ability to get emission rates at a different time step than the meteorological time step

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- Preprocessor for MEGAN and wildfire emissions
- Correction for MEGAN emissions