Simulating Deposition with a Regional Air Quality Model for the Rocky Mountain Atmospheric Nitrogen and Sulfur Study (RoMANS)

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U.S. Department of the Interior

CIRA ***Cooperative Institute for Research in the Atmosphere***

introduction

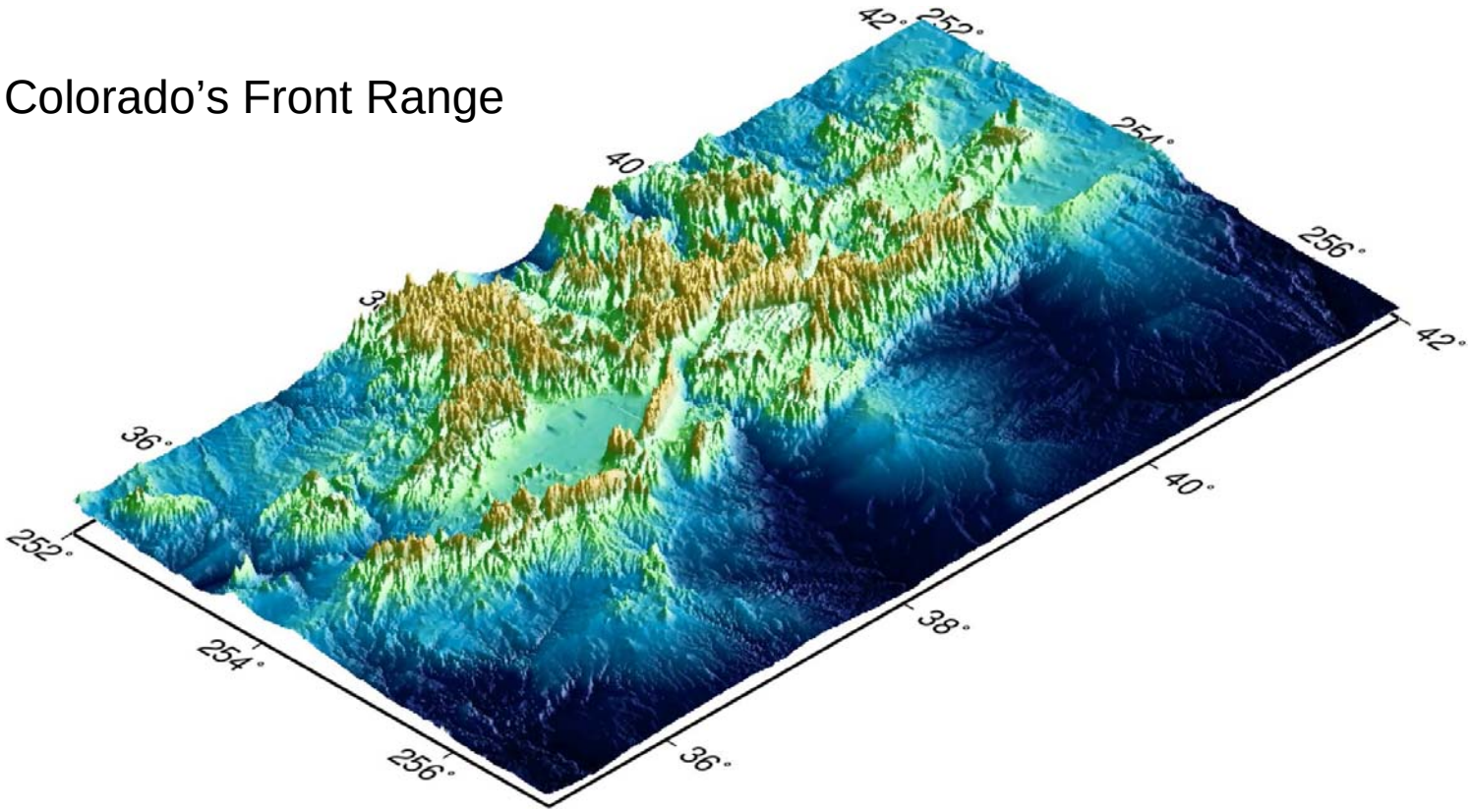
- CAMx is being used to simulate the spring and summer 2006 RoMANS field campaigns

- RoMANS CAMx runs:
  - 'base case' simulation
  - tracer simulations
  - N and S source apportionment simulations

- Modeling system consists of:
  - emission inventory
  - MM5 – mesoscale met model
  - CAMx – chemical transport model

deposition in complex terrain

Colorado's Front Range



deposition flux = (concentration) * (v_d or Λ)

v_d = dry dep velocity

Λ = wet dep scavenging

deposition in complex terrain

- ~2/3 of N deposition at RMNP is wet (ROM406 monitor)

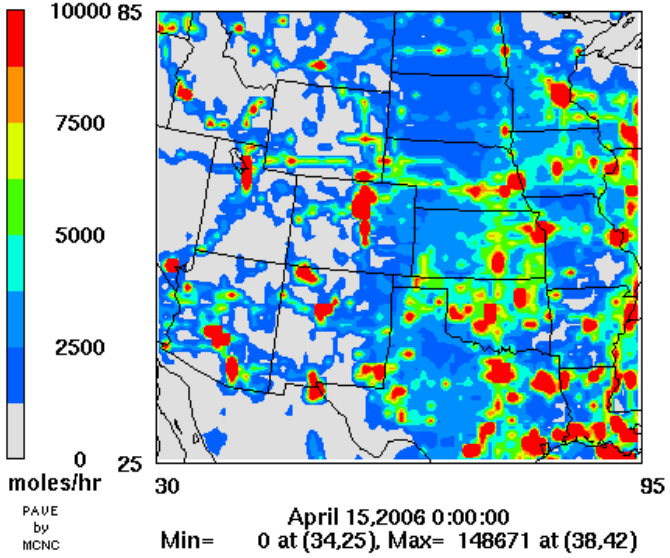
- Difficult to get clouds and precip correct:
  - sub-grid orographic and convective clouds
  - difficult to simulate weak synoptic regimes

- Does grid scale resolve important transport paths?

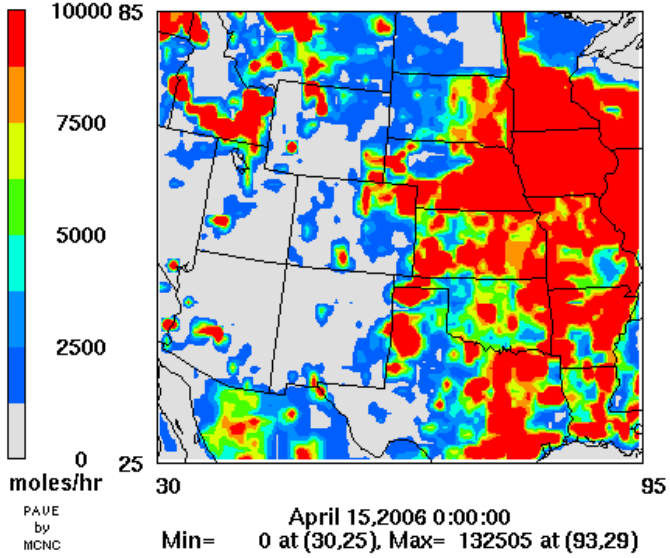
emission inventory

- Update the WRAP 2002 inventory for RoMANS 2006
- Primarily interested in nitrogen sources:

NOx

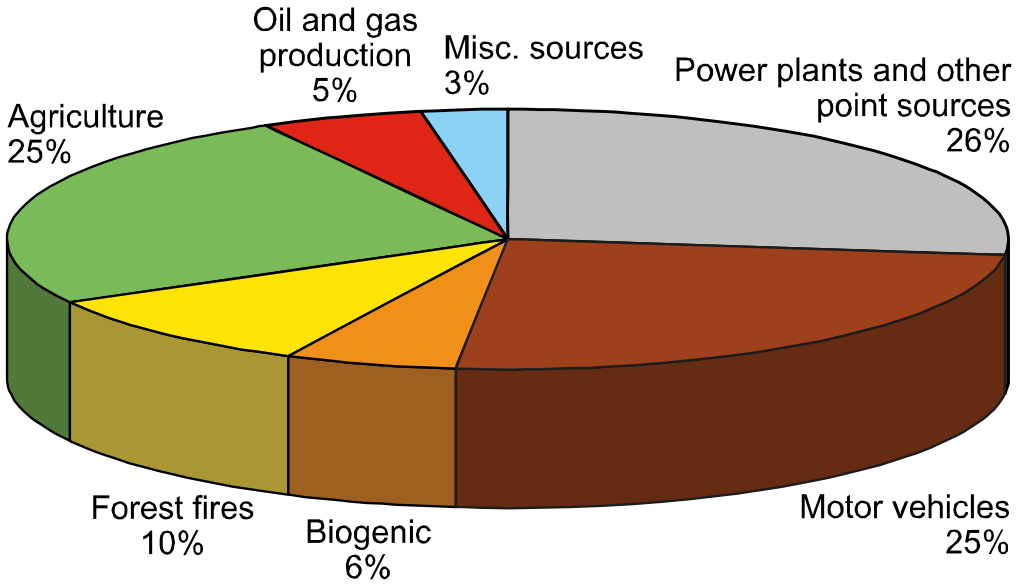


NH3



emission inventory

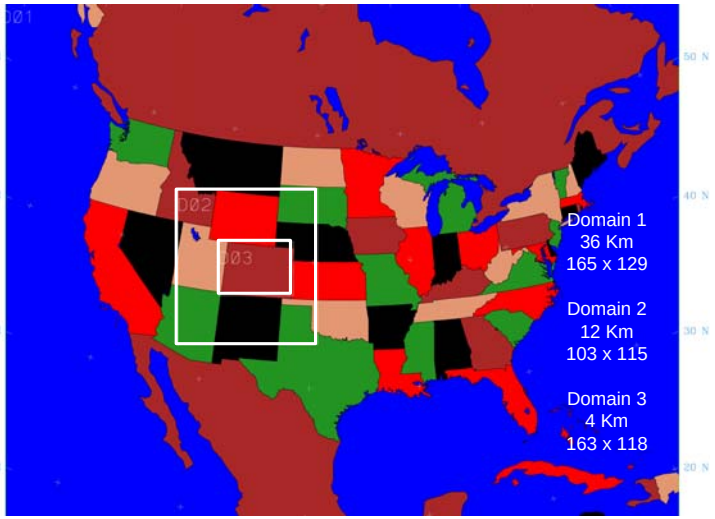
N emissions in Colorado:



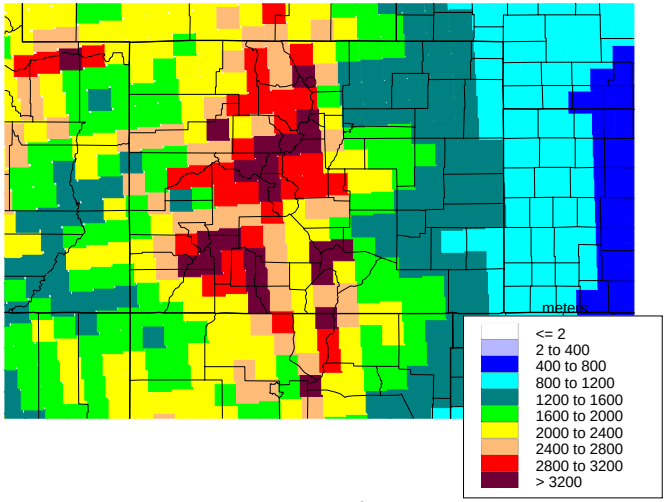
meteorology from MM5

- Nested grids at 36/12/4 km
- IC/BC's from NARR (3hr, 32 km)
- Analysis nudging at 36 km, obs nudging at 4 km
- Physics options: Reisner 2 microphysics, Kain-Fritsch cumulus parameterization (36 and 12 km), MRF PBL, NOAH LSM

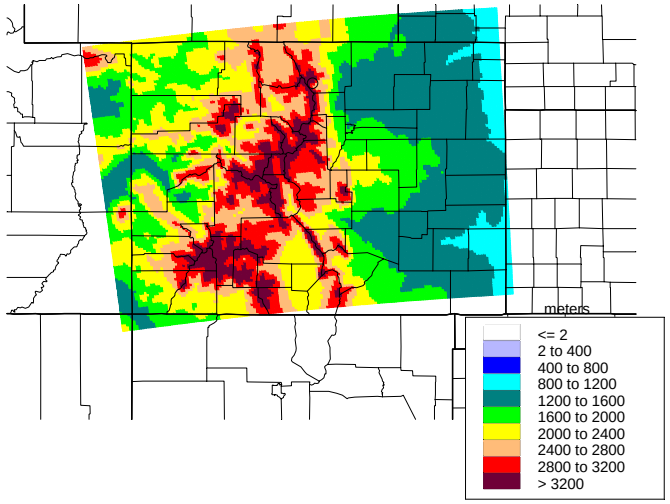
meteorology from MM5



MM5 36-Km Terrain



MM5 4-Km Terrain



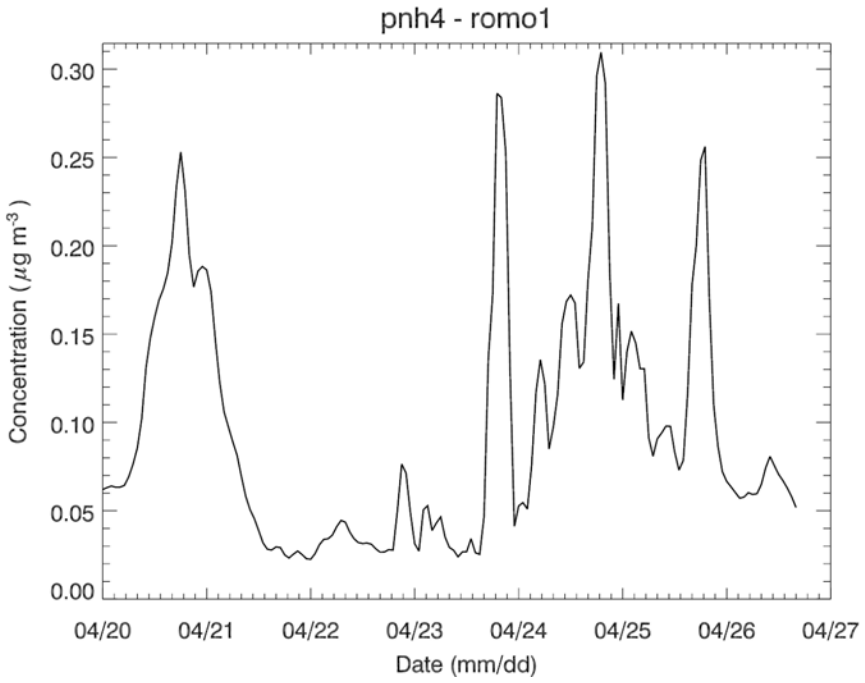
concentrations and depositions from CAMx

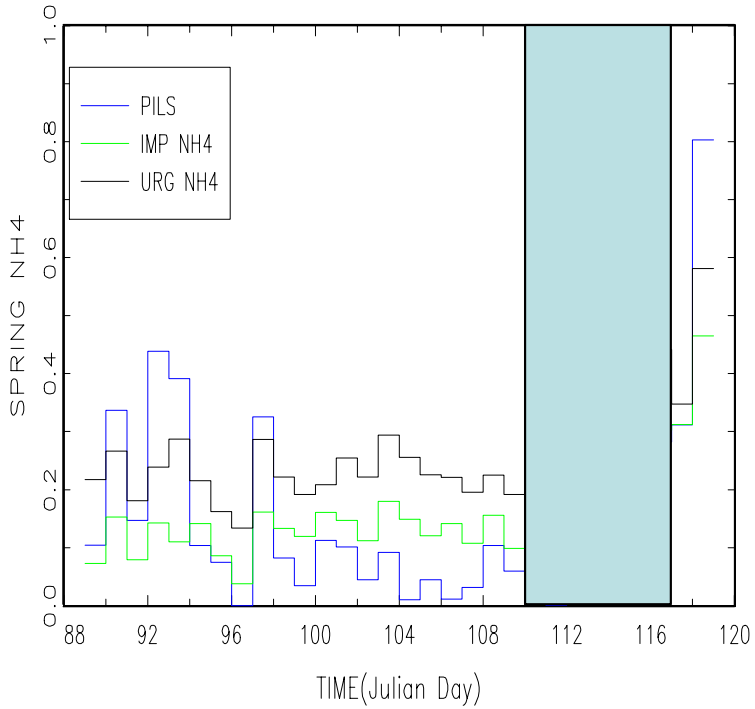
- N species simulated: NOx, NH3, RNO3, PAN, NH4, NO3
- Options: PPM advection, CB-4v3 chemistry, 2-way nesting (36/12/4 km)
- dry deposition limitations:
  - no transient wetted surfaces
  - enhanced turbulence from terrain gradients – assume 'flat earth'
  - filtering by leading edges of forest canopies

concentrations and depositions from CAMx

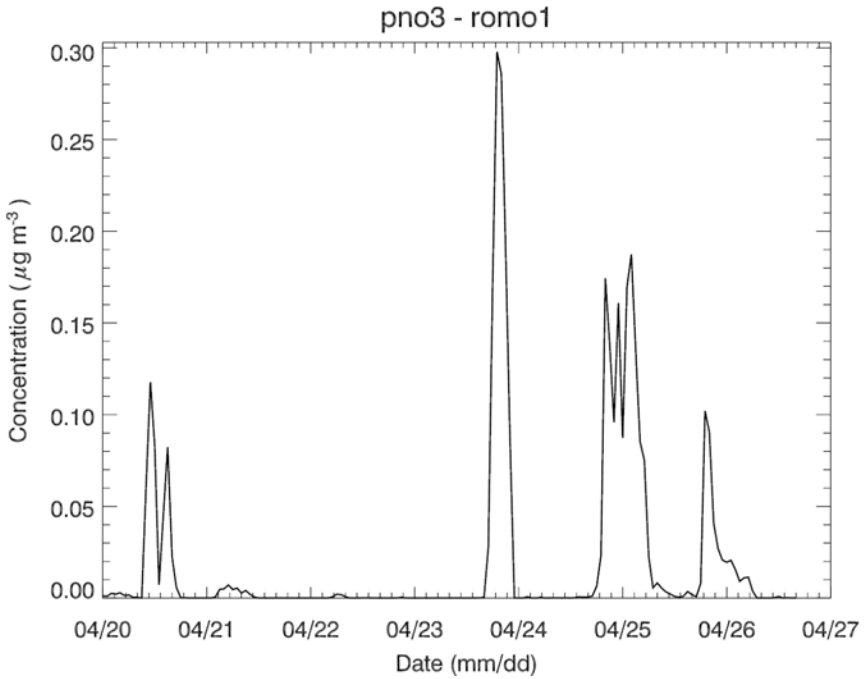
- wet deposition limitations:
  - only cloud water and precipitation are effective scavengers
  - rain drops and cloud drops are only one size
  - assume equilibrium between ambient concentration and cloud droplet
  - acidity of cloud water doesn't change (pH~5)

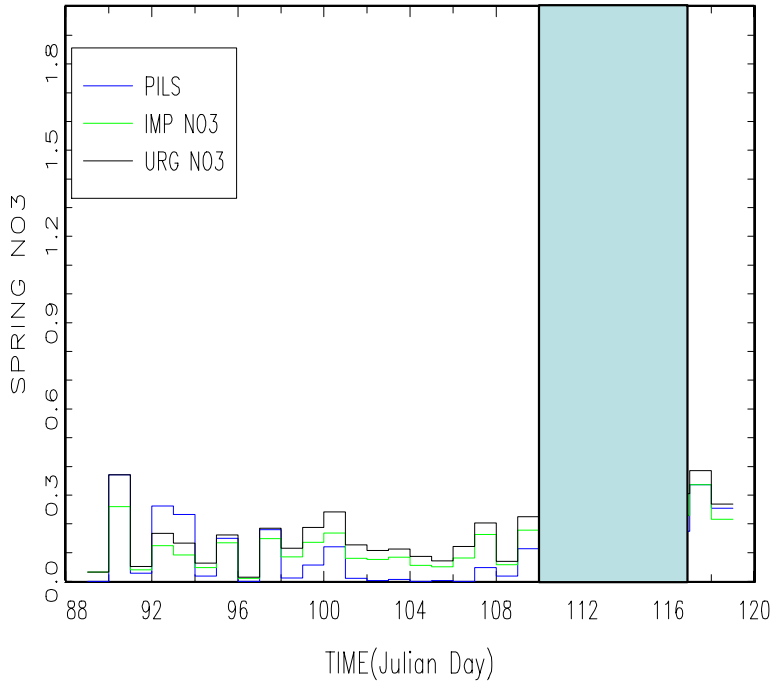
particulate ammonium at core site



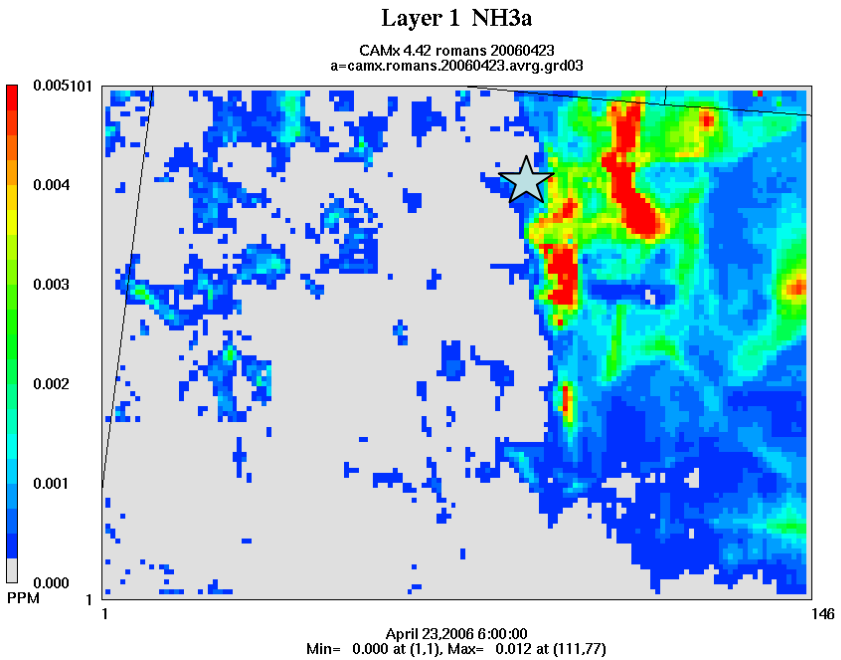


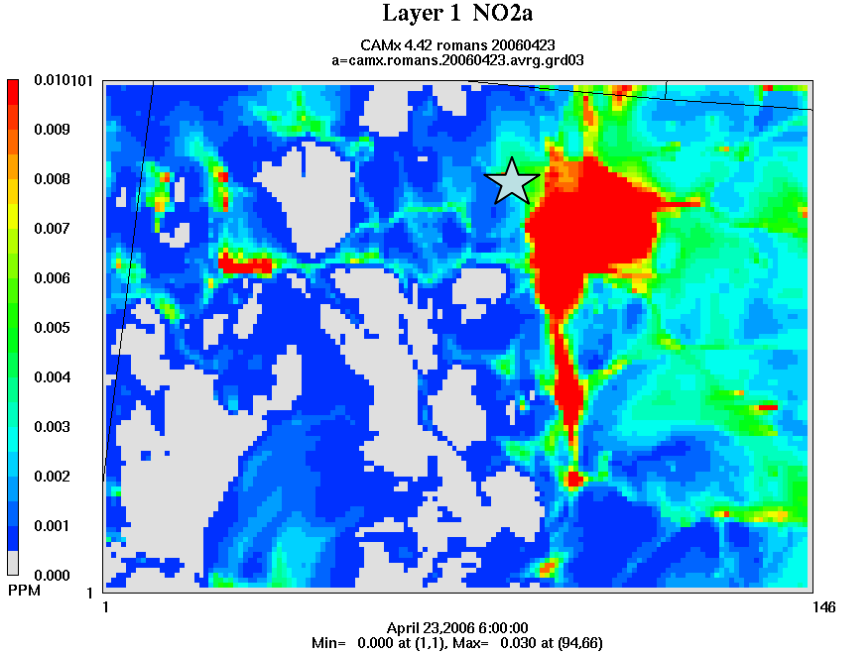
particulate nitrate at core site





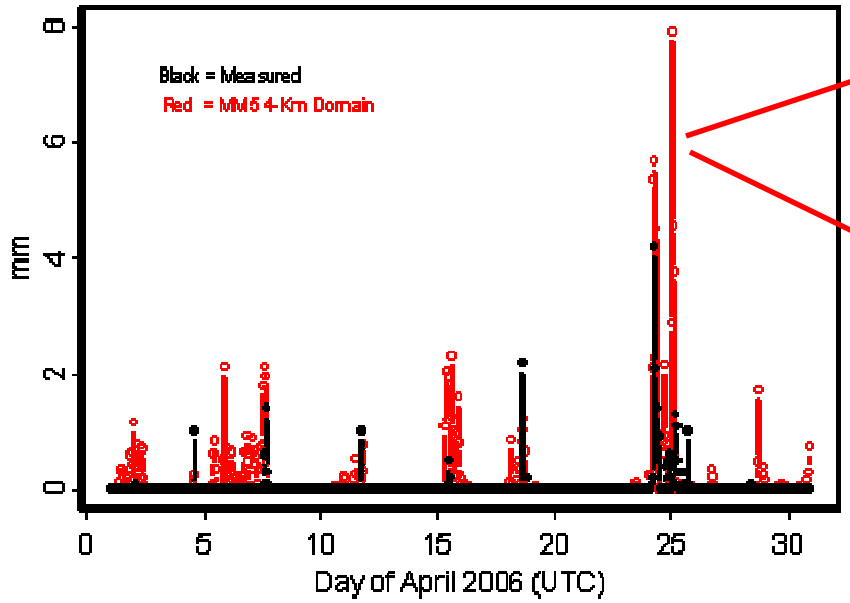
example concentrations (4 km Colorado)



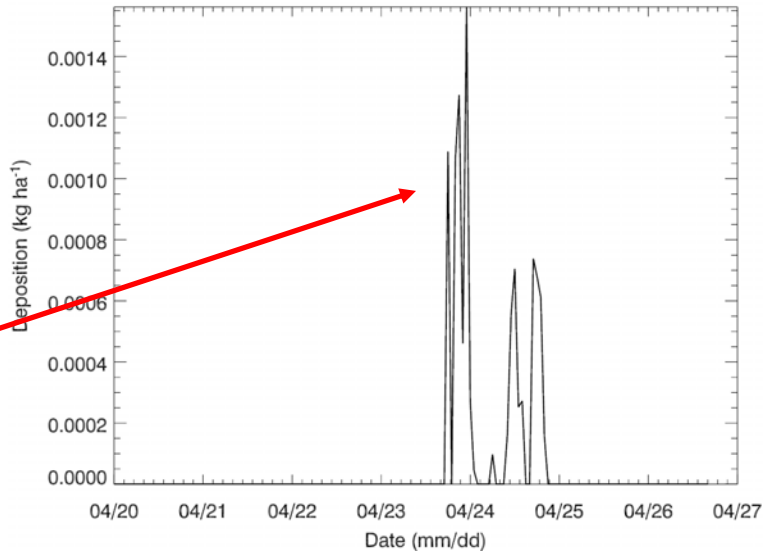


simulated wet deposition

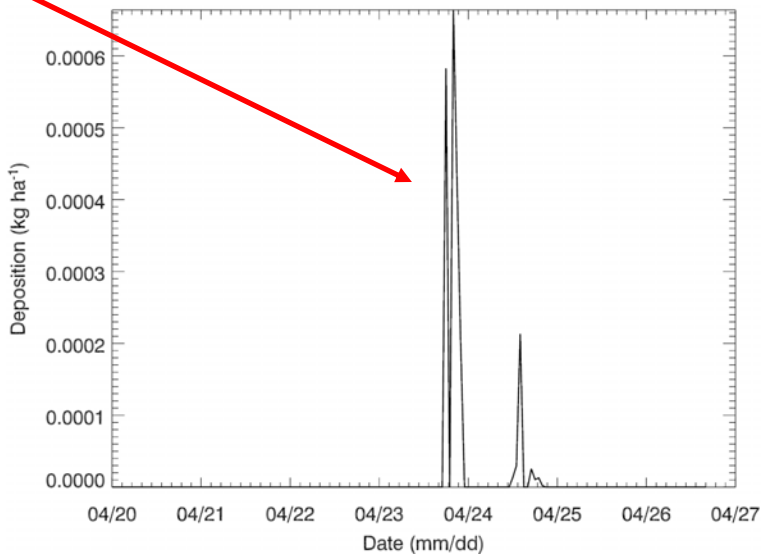
predicted and observed precip:



wet dep ammonium:



wet dep nitrate:

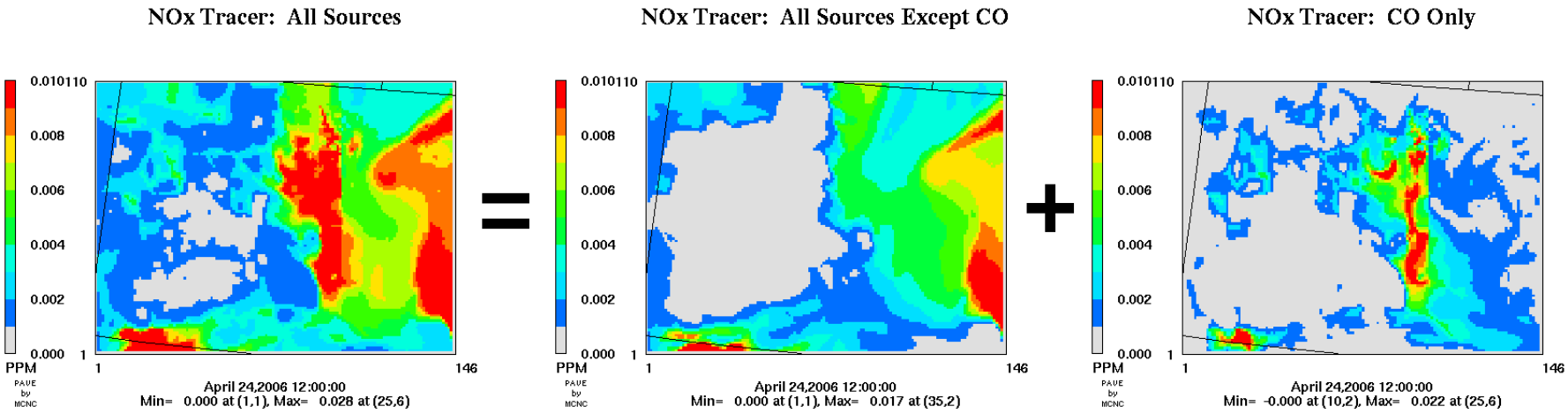


tracer simulations

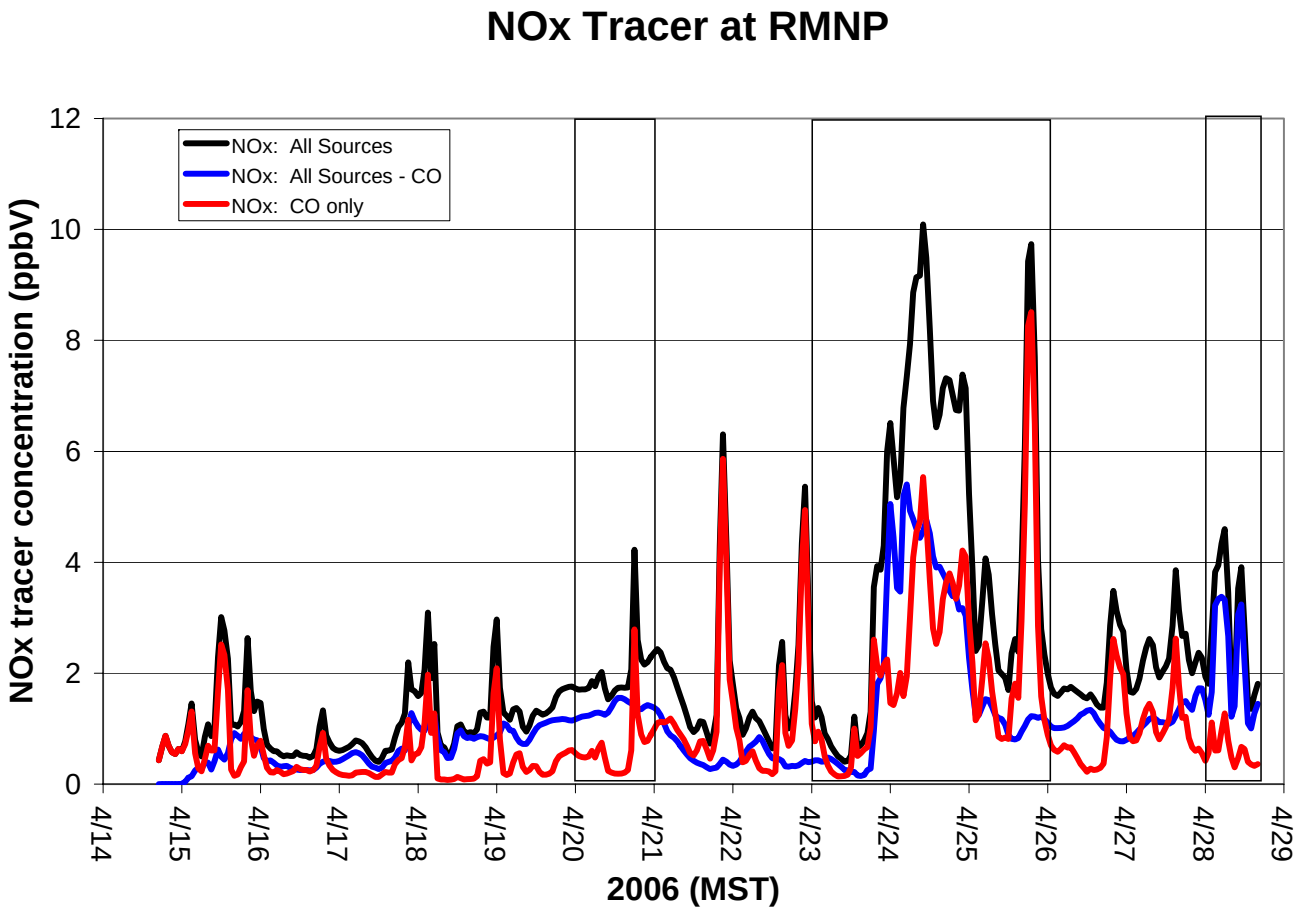
- Simulate the maximum potential impact of a source region using conserved tracers
- Tracers for NOx and NH3 emissions
- Tracers characteristics:
  - conserved
  - scaled to match 'real' emissions
  - same plume rise behavior

tracer simulations

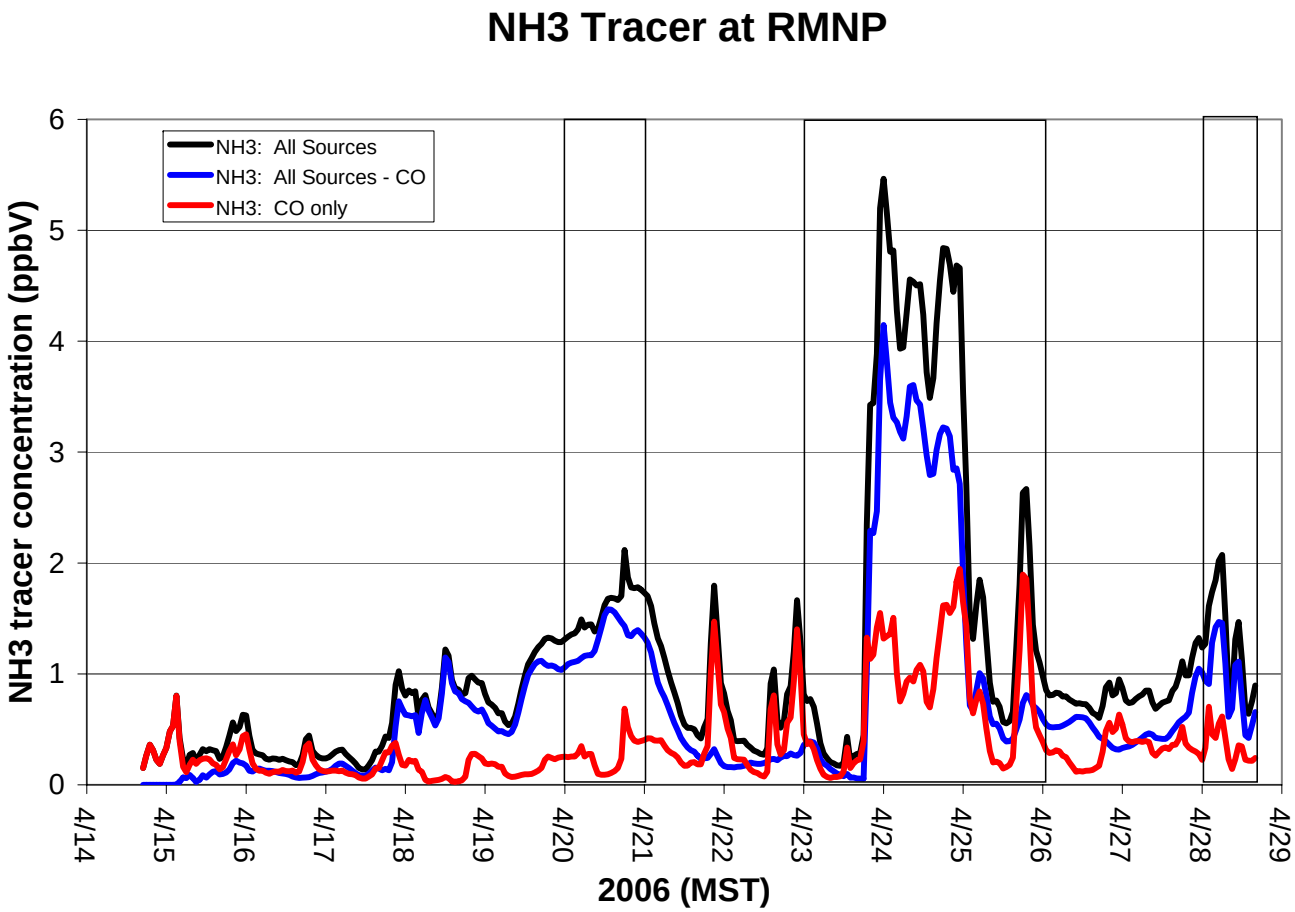
Colorado vs. outside of Colorado:



tracer simulations



tracer simulations



tracer simulations

NOx tracer

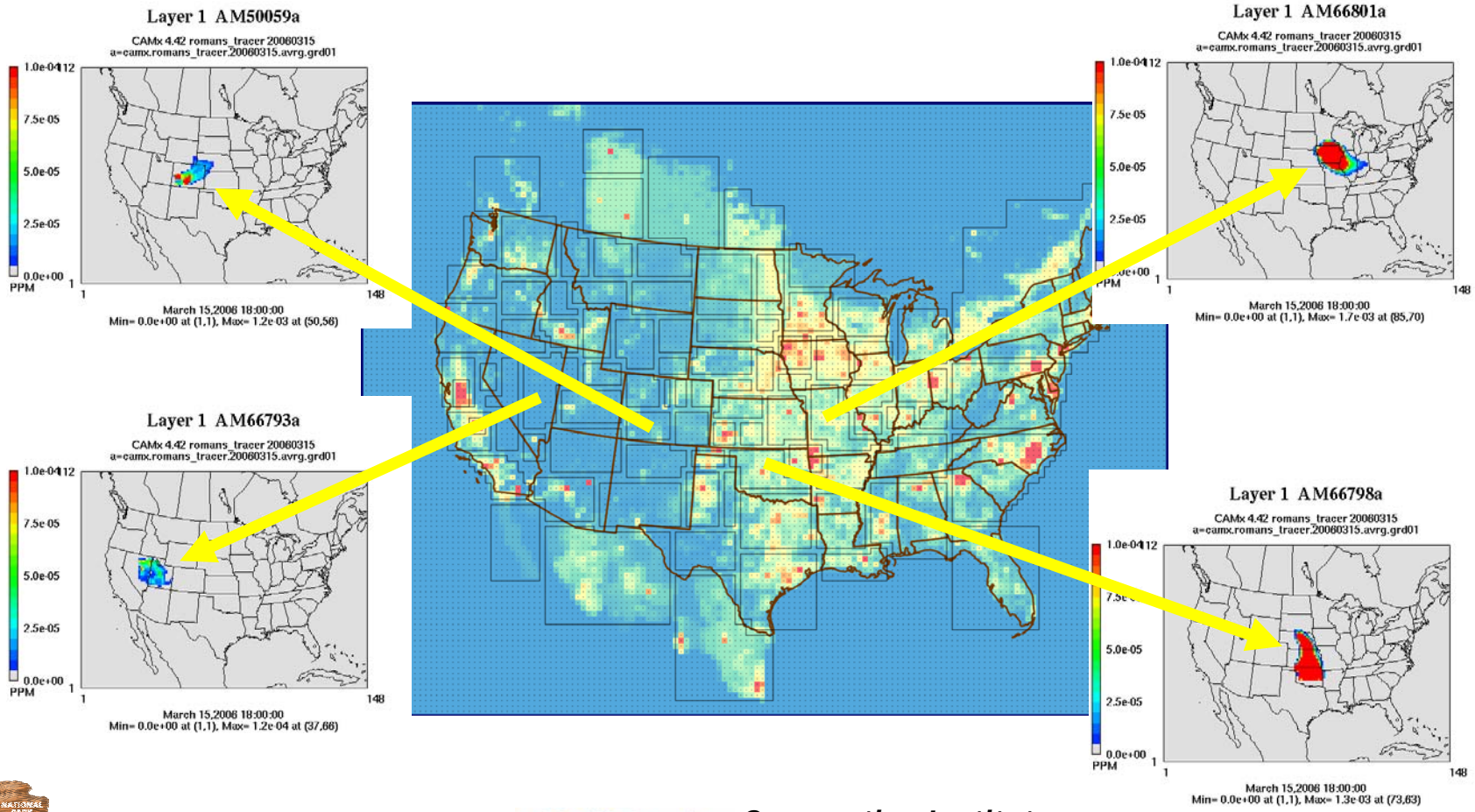
	All Sources	All Sources - CO	CO only
average (ppb):	2.17	1.11	1.06
average (%):		51.1%	48.9%

NH3 tracer

	All Sources	All Sources - CO	CO only
average (ppb):	1.12	0.73	0.38
average (%):		65.6%	34.4%

tracer simulations

~90 ammonia tracers:



summary

- CAMx simulates major episodes that occur during last week of April, but ammonium and nitrate concentrations too low.
- MM5 captures major precipitation event on April 23-25; timing is generally ok, but magnitude overpredicted.
- Strong concentration gradients evident at Continental Divide, near core monitoring site.
- Need to evaluate other species (NOx, NH3, HNO3, SO2, SO4) and other sites.

summary

- Conserved tracer simulation indicates that ~1/2 of the NOx and ~1/3 of NH3 that impact RMNP are from Colorado sources.

- Refine tracer simulations:
  - more source regions ~90
  - estimate deposition losses