EPA
United States
Environmental Protection
Agency

SCIENCE

United States Environmental Protection Agency

Air Quality Model Insights Into Nitrogen Dry Deposition Missed by Current Networks

Robin L. Dennis
National Exposure Research Laboratory
Atmospheric Modeling Division, US EPA

NADP Annual Meeting
Madison, WI
October 14-16, 2008

SCIENCE

Air Quality Model Insights into Nitrogen Dry Deposition Missed by Current Networks

Organization of Talk:

What is N deposition now and its forms

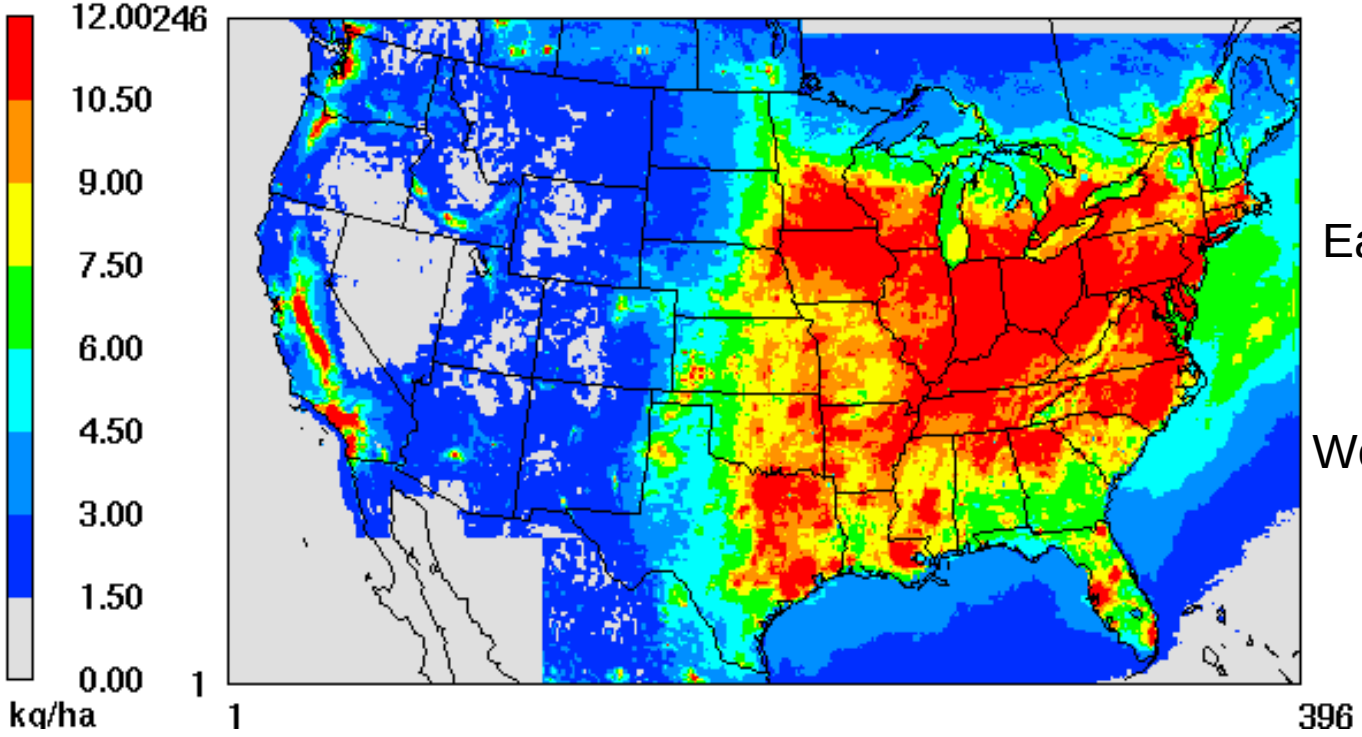
Expected future change in N deposition

Missing components of the total N deposition

What's missing

Can we "fake" it

Inorganic Nitrogen Deposition
(kg-N/ha: oxidized-N + reduced-N)
is High Enough to be of Concern
In the West (where under-predict wet) and in the East

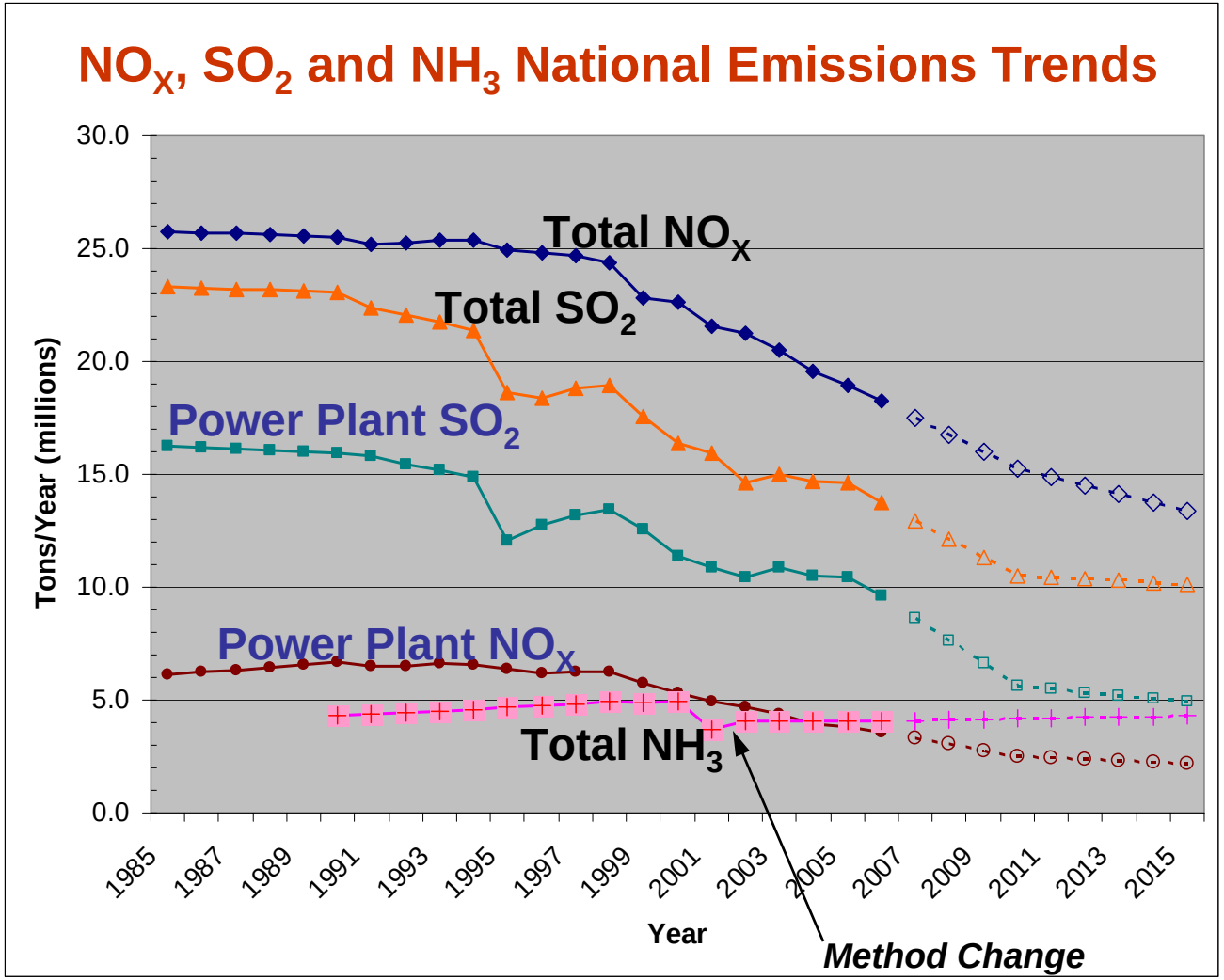


East > 6 kgN/ha?

West > 1.5 kgN/ha

CMAQ 2002 Annual Wet + Dry Total N Deposition at 12-km
EPA Community Multiscale Air Quality model (CMAQ)

NO_X and SO_2 Emissions are Trending Down Due to Clean Air Act Regulations for Human Health In Spite of Growth; NH_3 Emissions are Trending Up

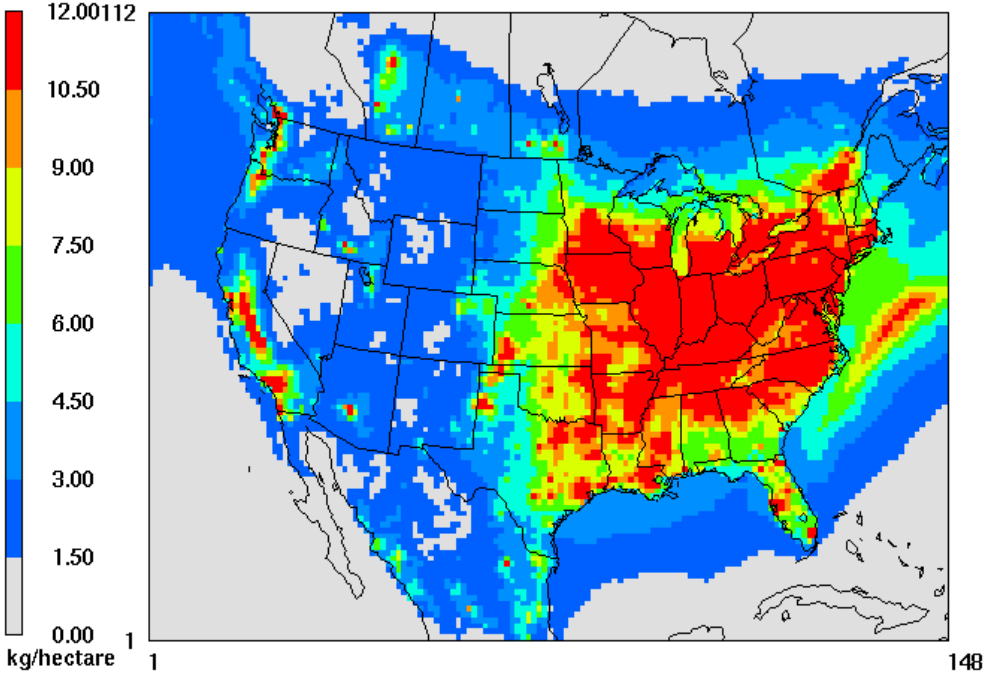


N Deposition will Decrease in the Future (due to CAIR)

(East is the focus of most NO_X emissions reductions)

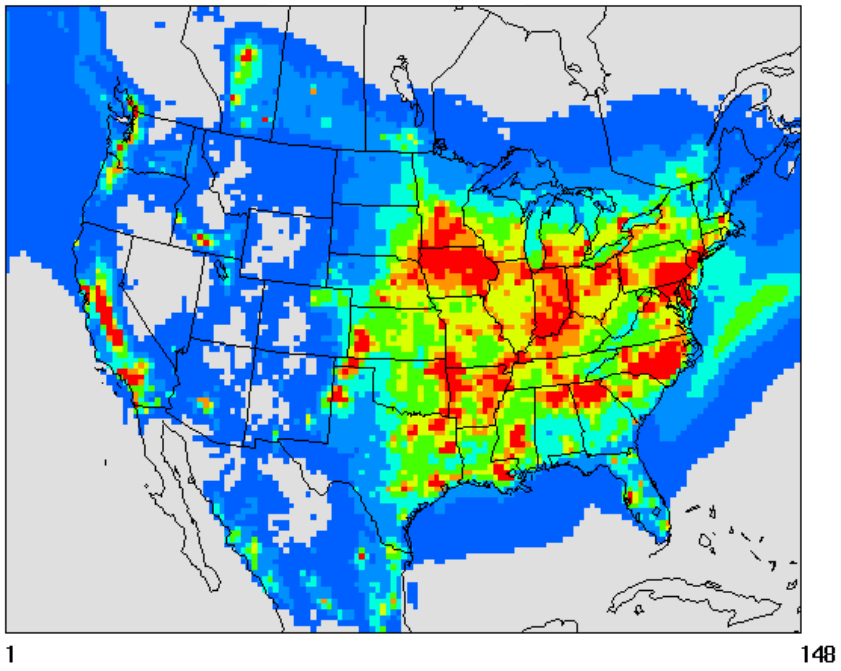
But Levels Will Remain High Enough to be of Concern
And Nitrogen Will Increase in Importance as SO_X is Reduced

2001



Wet + Dry Total N Deposition
CMAQ 36-km
(wet + dry + normal year average)

2020



Wet + Dry Total N Deposition
CMAQ 36-km
(wet + dry + normal year average)

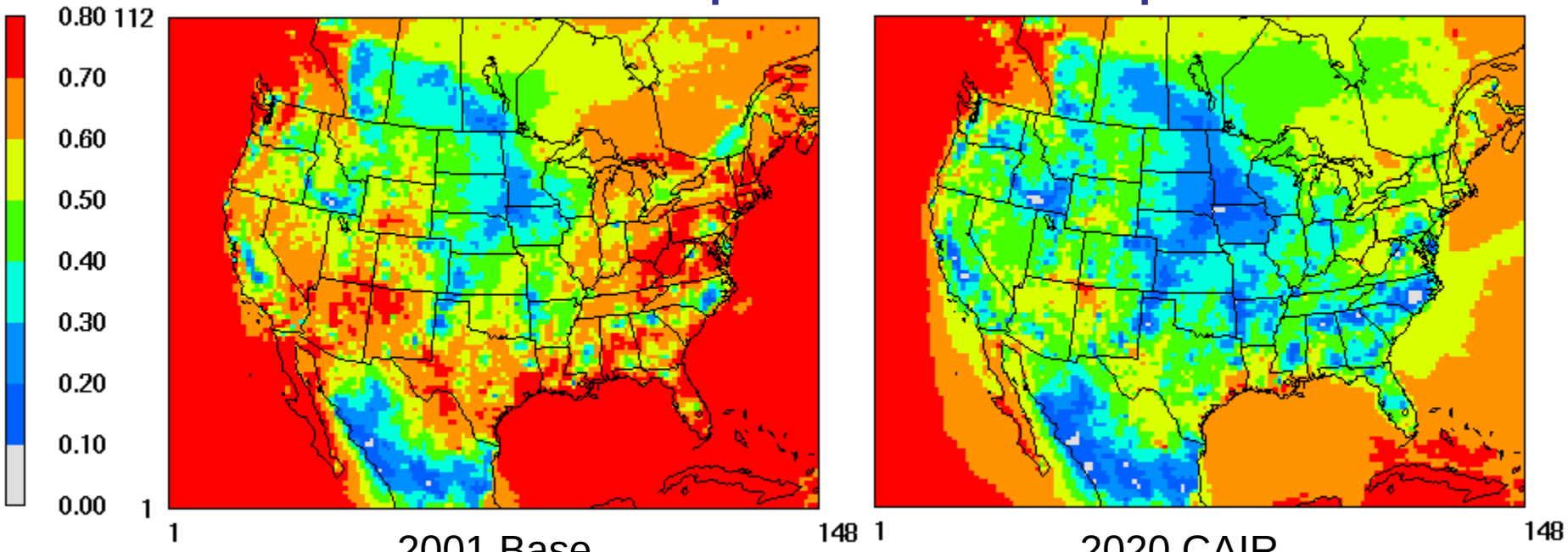
A Shift in Form is also Expected

United States Environmental Protection Agency

Today Ox-N is Dominant Form of N-Deposition in Most Non-Agricultural Places

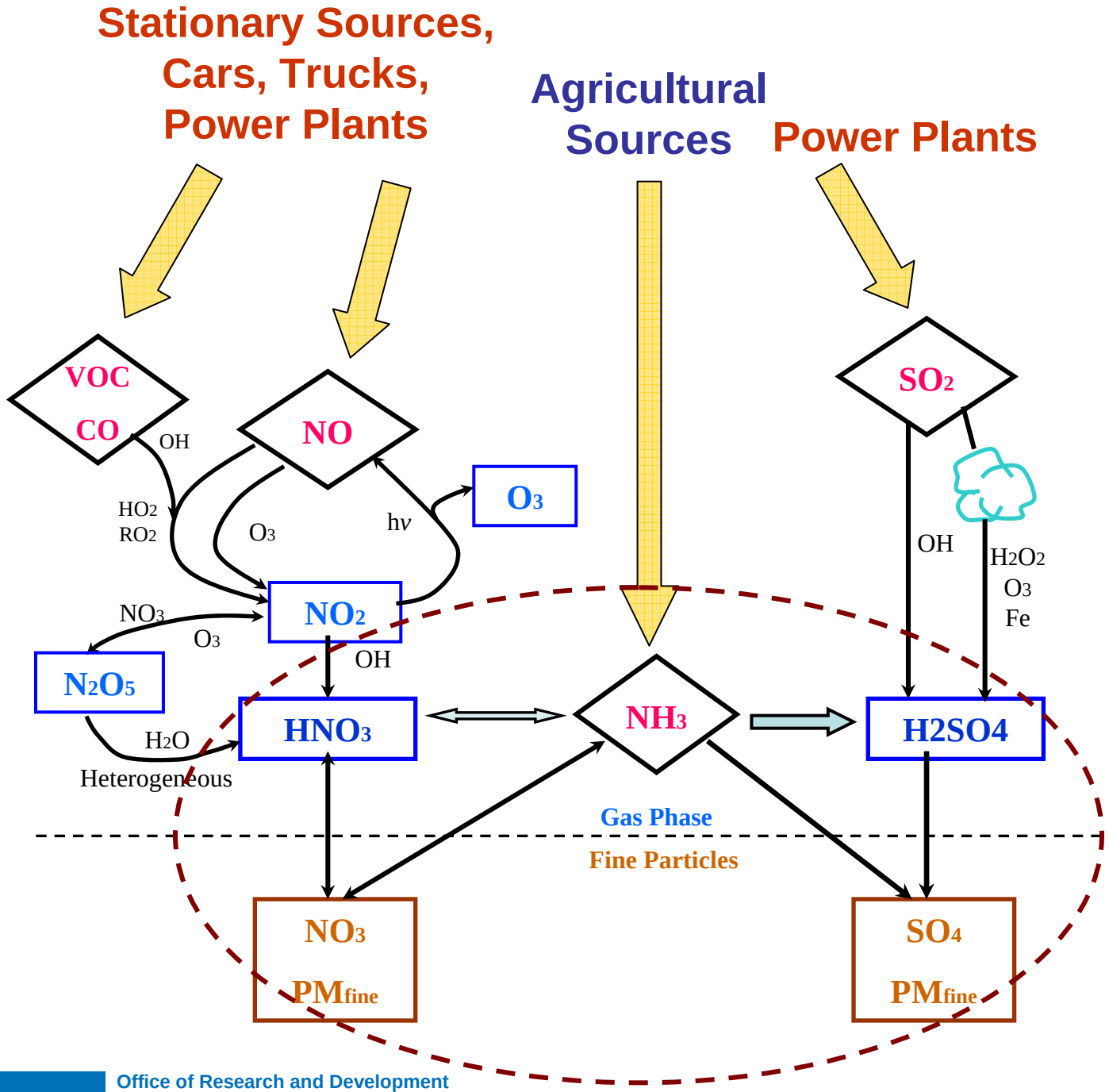
However, Ammonia Deposition will Increase in Importance in the Future

Fraction of Total Deposition as Ox-N Deposition



2001 Base
CMAQ 36-km

2020 CAIR
CMAQ 36-km



The Partitioning Between Gases and Particles, Which Is Determined by Ammonia Availability, Greatly Affects Dry Deposition Rates

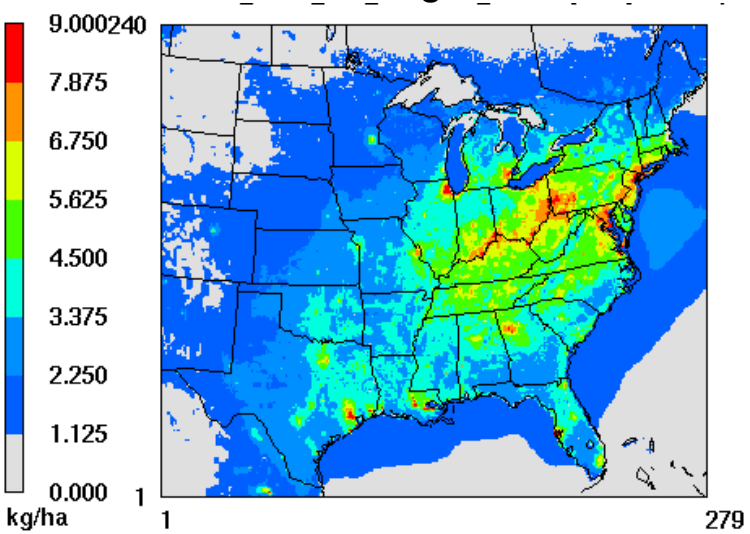
***Also*, All Components of NO_Y Deposit, Not Just HNO_3 and aNO_3^-**

For Critical Loads We Need Total Deposition

- However, We are unable to empirically estimate total deposition based on monitoring measurements
- We are missing measurements in networks (e.g., CASTNet) that are needed to infer nitrogen dry deposition for a number of species (missing air concentration measurements)
  - For Oxidized-N
    - Only measure HNO_3 and particulateNO_3^-
    - Missing NO, NO_2, PAN, higher PANs, HONO and N_2O_5
  - For Reduced-N
    - Only measure particulateNH_4^+
    - Missing NH_3

For Ox-N: Measure HNO_3 and aNO_3^-

2002 Oxidized-N Deposition
Annual kg-N/ha

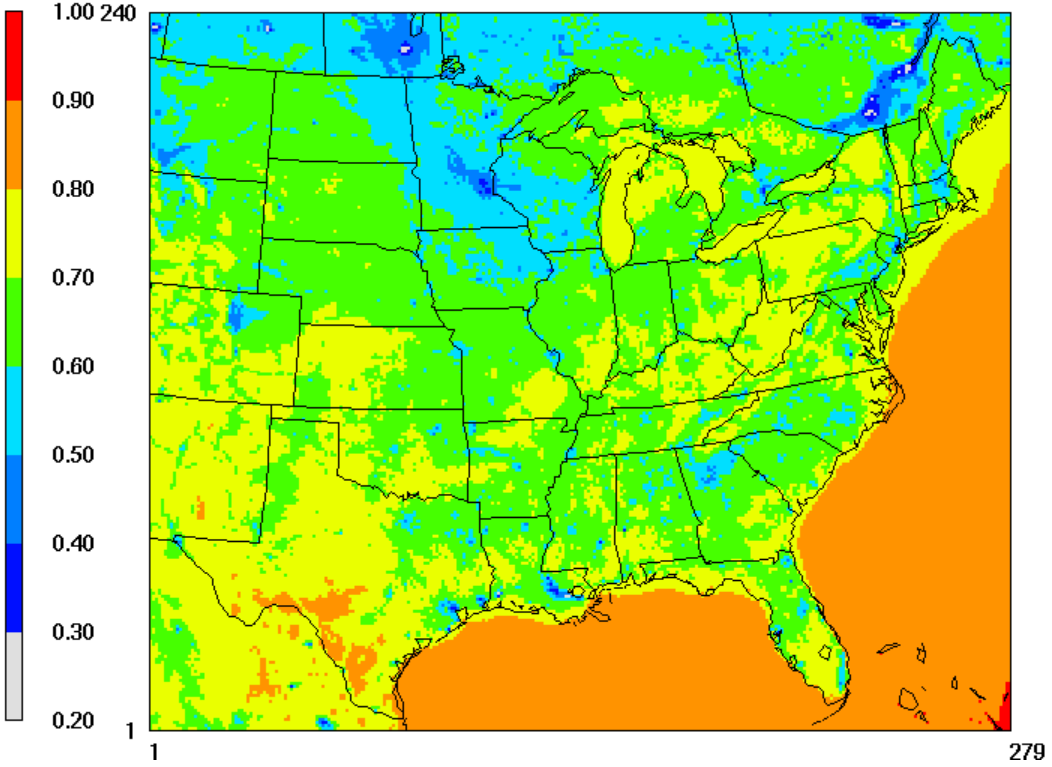


Fraction Captured:

Rural areas: 60-80%
(Missing 20-40%)

Urban areas: 30-70%
(Missing 30-70%)

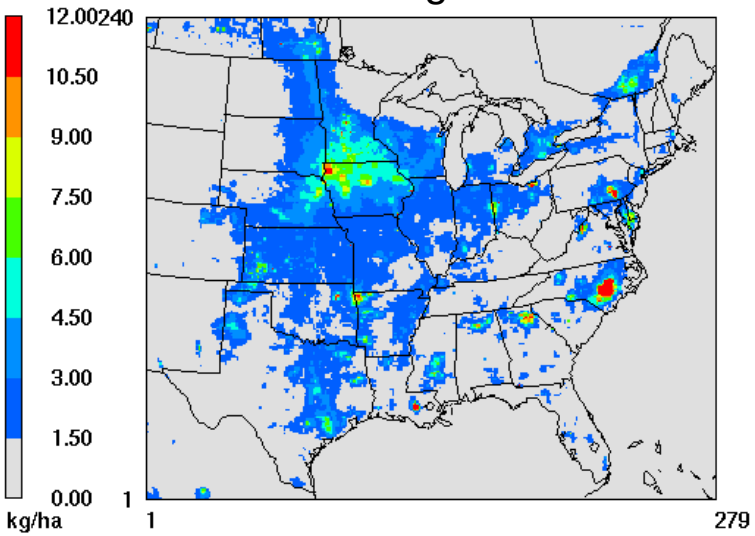
Fraction of Oxidized-N Dry Deposition Associated with Species Measured by Networks (CASTNet)
2002 | 12km CMAQ



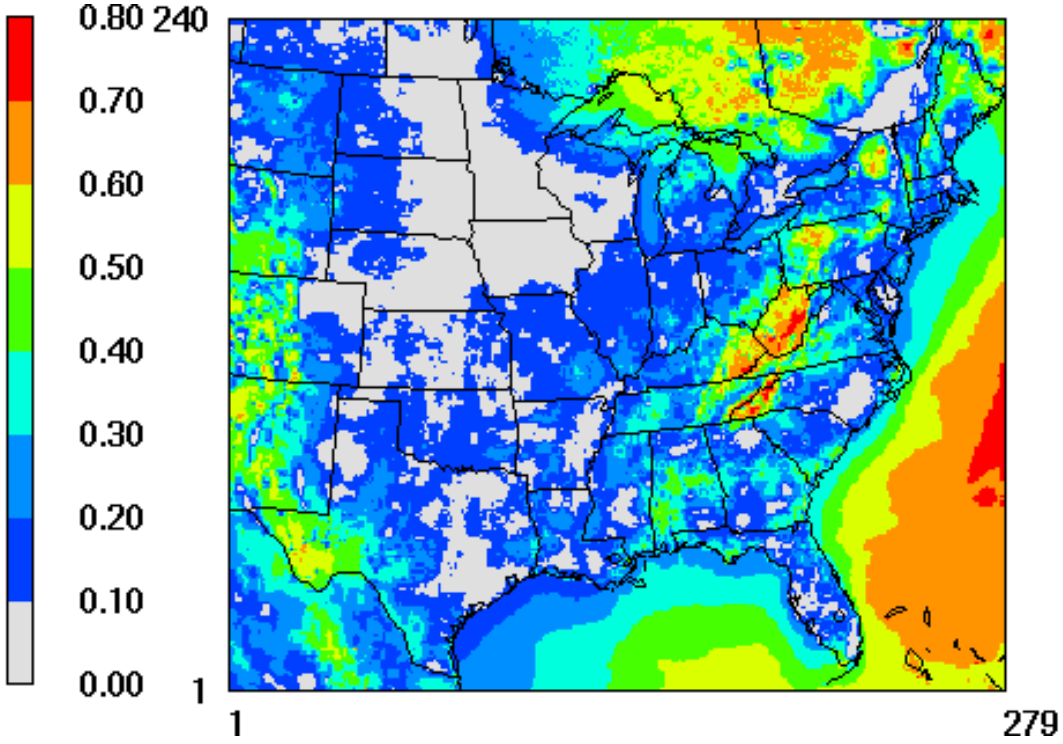
For Red-N: Measure only aNH_4^+

United States Environmental Protection Agency

2002 Reduced-N Deposition
Annual kg-N/ha



Fraction of Reduced-N Dry Deposition Associated with Species Measured by Networks (CASTNet) 2002 | 12km CMAQ



Fraction Captured:

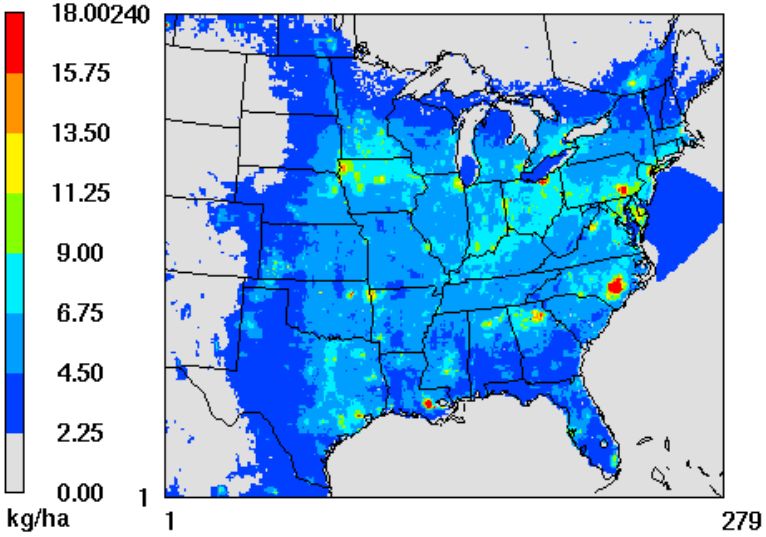
High emission areas: 2-20%
(Missing 80-98%)

Low emission areas: 50-80%
(Missing 20-50%)

For Red-N and Ox-N Measurements

United States Environmental Protection Agency

2002 Red-N + Ox-N Deposition
Annual kg-N/ha

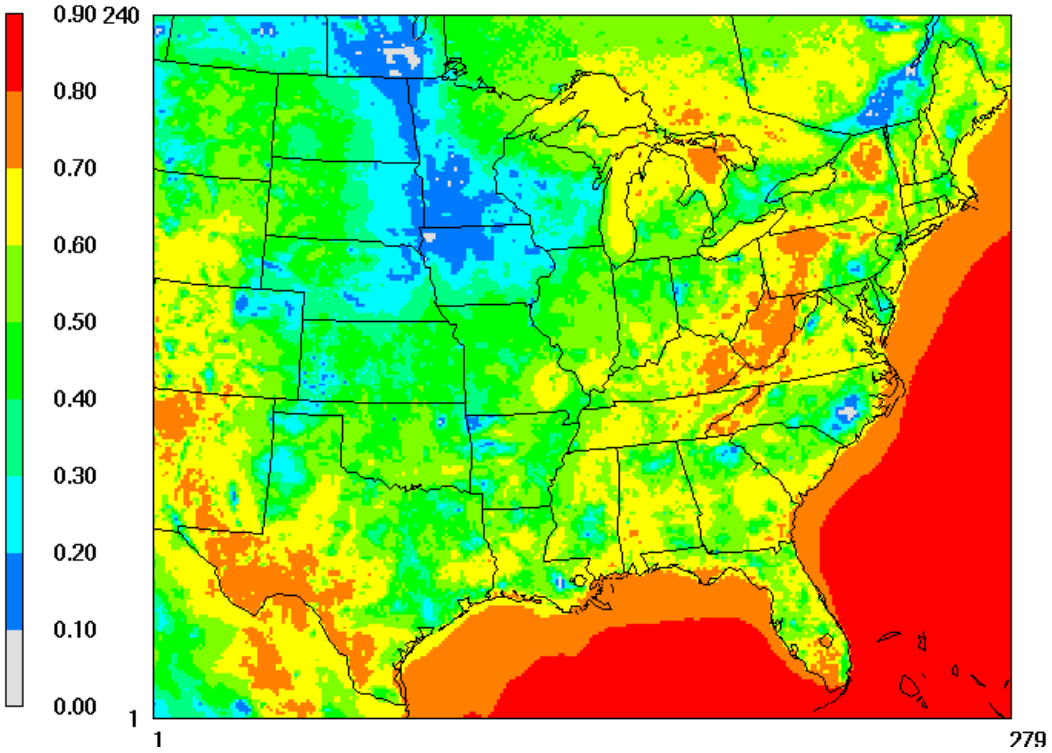


Fraction Captured:

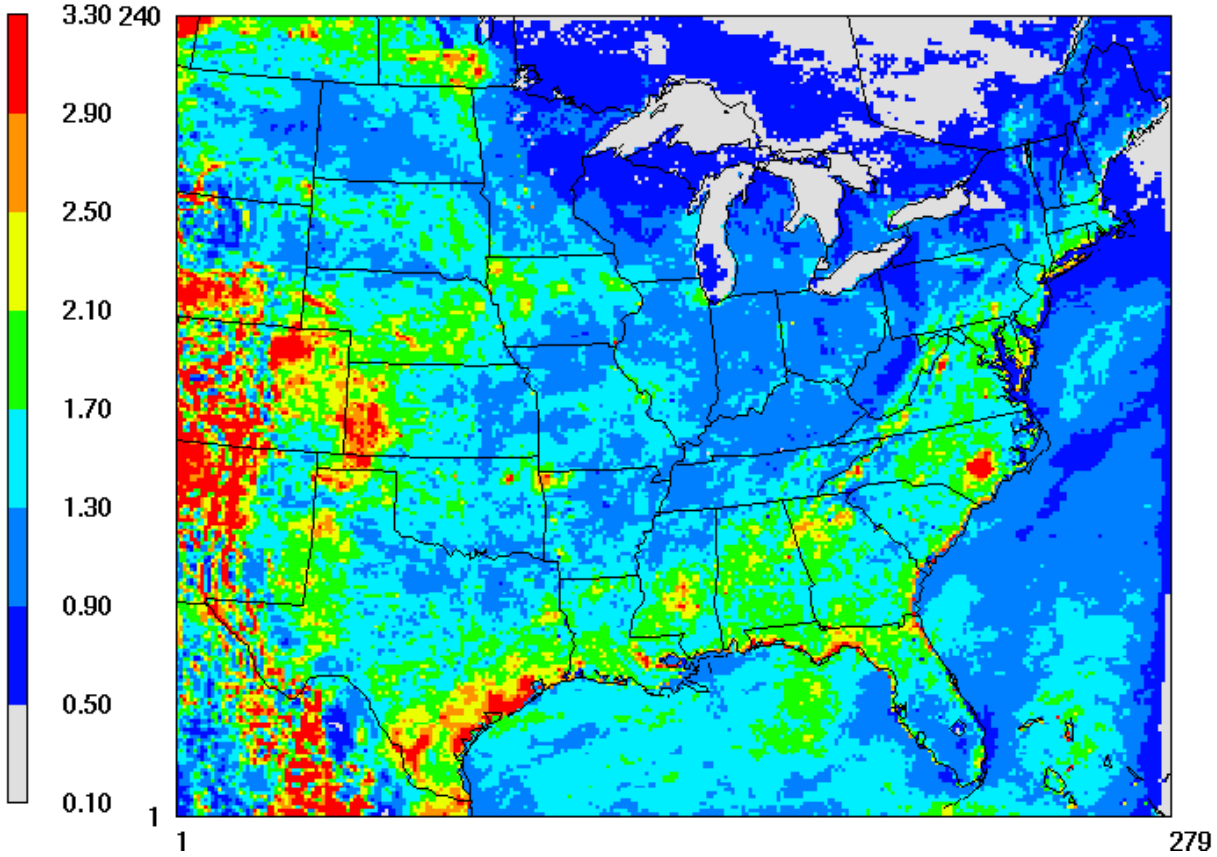
Best we do: ~75%
(Missing ~25%)

Worst we do: ~5%
(Missing ~95%)

Fraction of Total-N Dry Deposition Associated with Species Measured by Networks (CASTNet)
2002 | 12km CMAQ



Can We Fake Total Deposition With a Multiplier on Wet Deposition? Can you just Double Wet Deposition to get Dry?



Ratio of Dry Deposition to Wet Deposition of Total N
(CMAQ 2002 | 12 km)

Maybe only In the Midwest

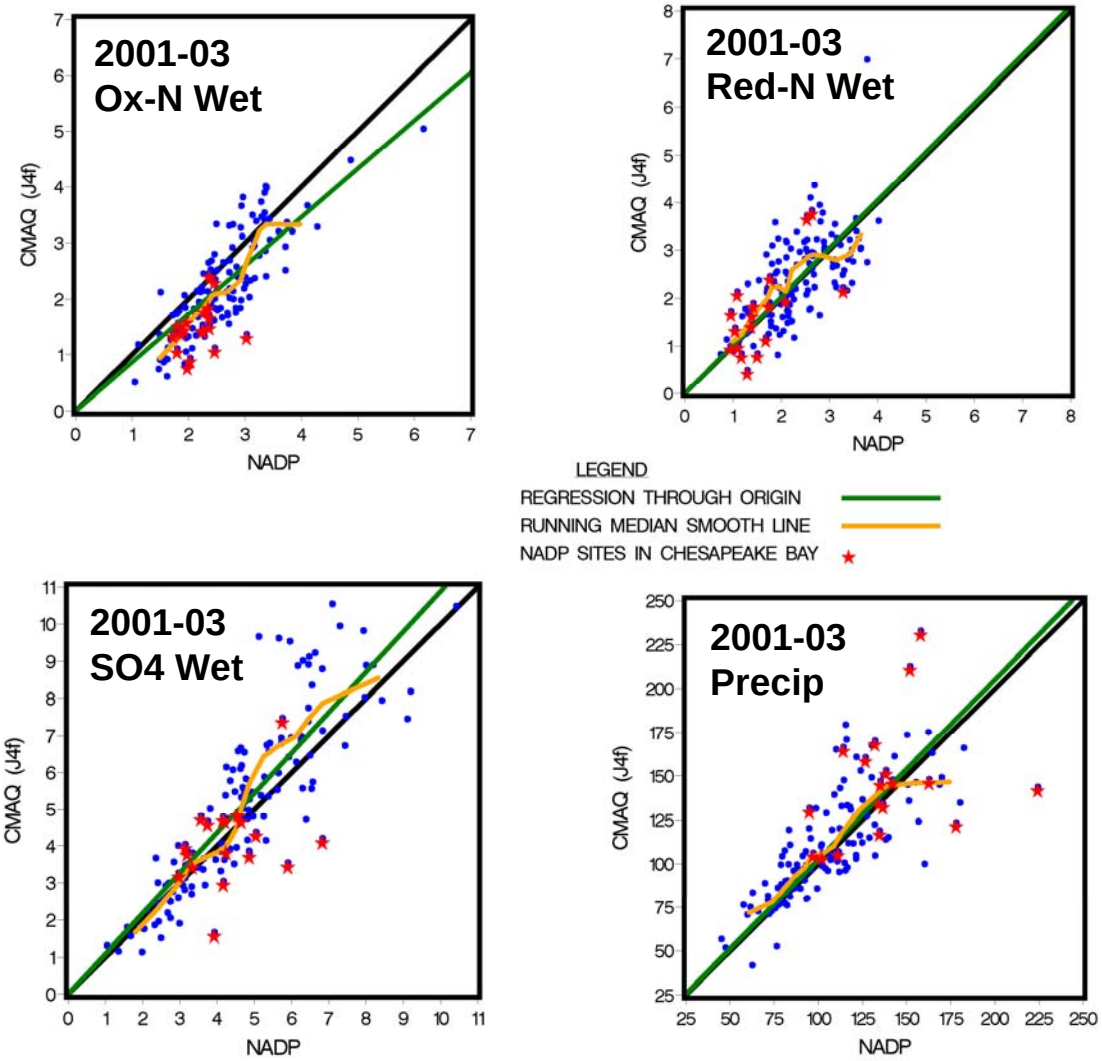
East is tricky

Not in the West

Use model for Guidance

Air Deposition Models Are Not Perfect
Models are Not Calibrated / Not Empirical

Results will Change when Incorporate Better Science, Such as NH_3 Bi-Directional Exchange



Summary/Conclusions

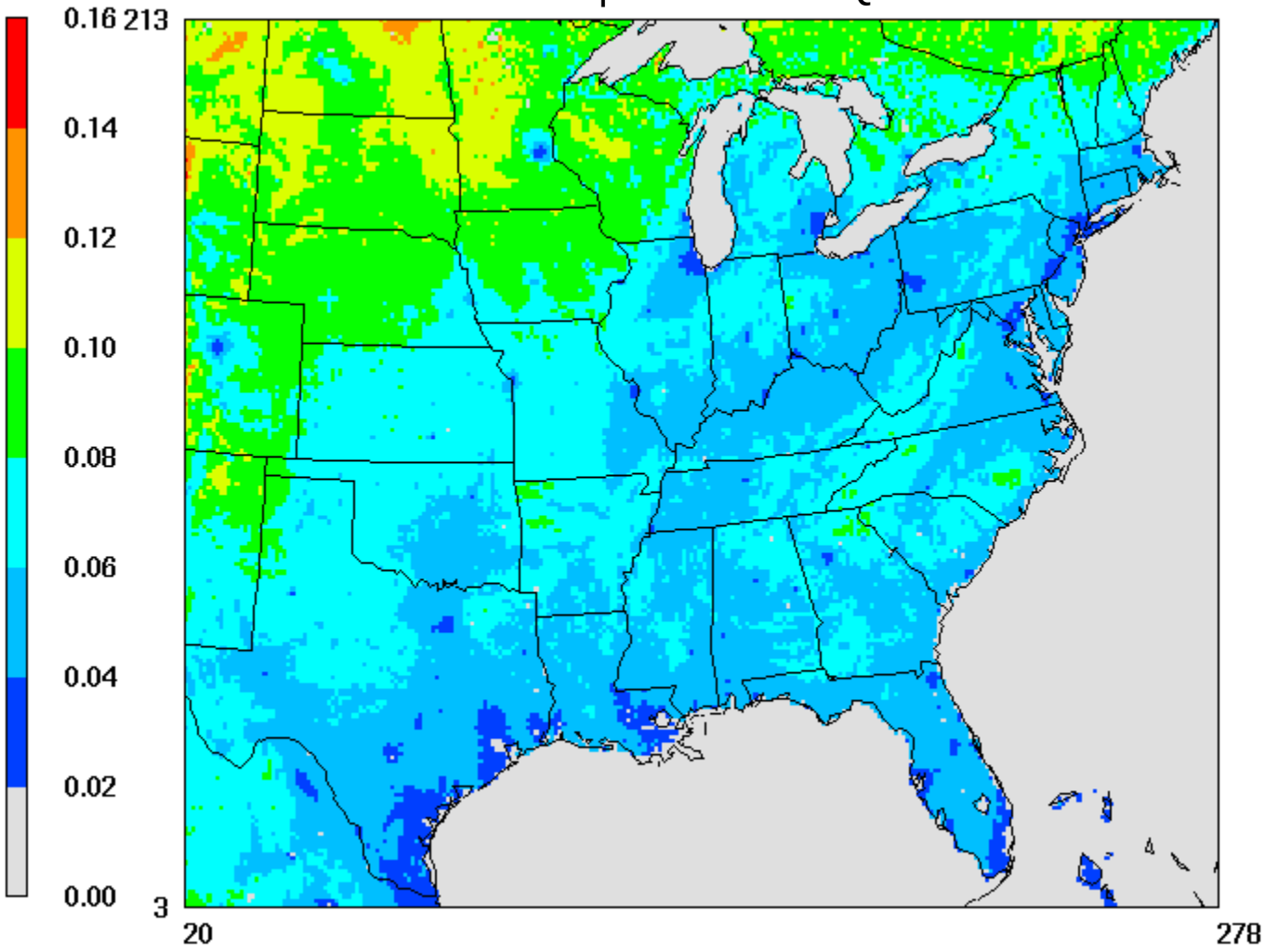
- N-Deposition important to critical loads is expected to change
  - Parts associated with NO_X will reduce
  - Parts associated with ammonia will increase in importance
- We are not measuring everything we need to quantify a complete deposition budget
  - Can't establish a baseline
  - Can't track change
  - Models can help, but not replace measurements
- We need to work on the best ways to use air deposition models and data to further the goals and support of critical loads

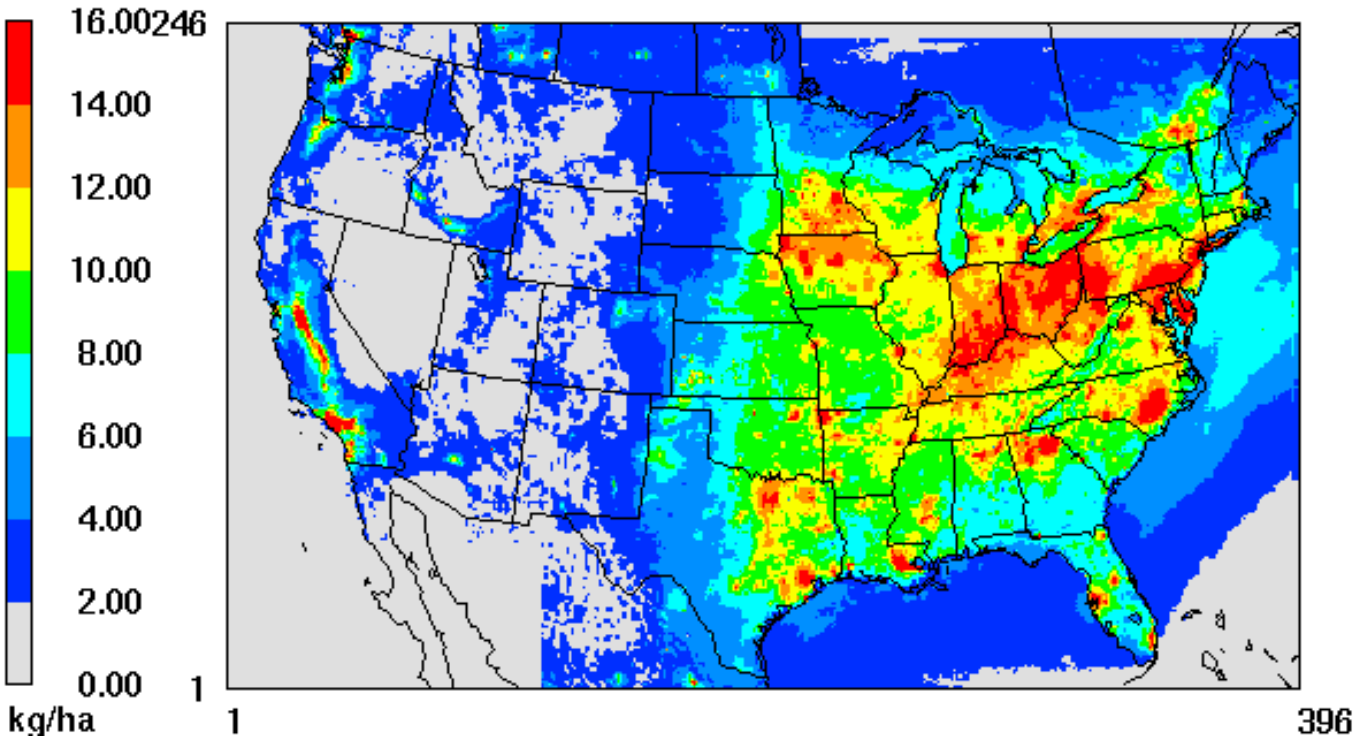
United States Environmental Protection Agency

Extra Slides

United States Environmental Protection Agency

Fraction of Ox-N Dry Deposition Associated With PANs
2002 | 12km CMAQ





CMAQ 2002 Annual Wet + Dry Total N Deposition at 12-km
EPA Community Multiscale Air Quality model (CMAQ)