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Characteristics of New CMAQ Deposition Series of 2002 to 2011 for Critical Loads

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Characteristics of New CMAQ Deposition Series of 2002 to 2011 for Critical Loads

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Improvements to WRF, CMAQ and Emissions

Wet Deposition Trends (Straight CMAQ Output vs Adjusted CMAQ)

Wet Deposition Errors

Dry Deposition Trends Compared to Wet Deposition

Dry Deposition Trends Compared to Air Concentrations

Air Concentration Trends

Summary

Comparisons are annual by year

Improvements to WRF, CMAQ, Emissions

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- 12km CONUS
- Consistent CMAQ version 5.0.2
- Layer 1 at 19m instead of 38m (affects aerodynamic resistance)
- **Meteorology with improved convective parameterization**
- Meteorology recognizing wetlands in the Southeast
- Corrected land-sea mask from NLCD (coastal areas)
- **Bi-directional ammonia flux (includes use of EPIC fertilizer application)**
- **Year specific agricultural NH_3 emissions (EPIC)**
- **Dynamic CAFO NH_3 emissions profile (thermodynamics-based)**
- Mesophyll resistance change (affects NO2 deposition)
- **Year specific lightning NO_X emissions of NO simulated (anchored to strike data)**
- **Land use updated to NLCD (2001 and 2006) (older USGS was 1992)**
- Consistent basis for mobile source emissions (MOVES)

Wet Deposition Characterization

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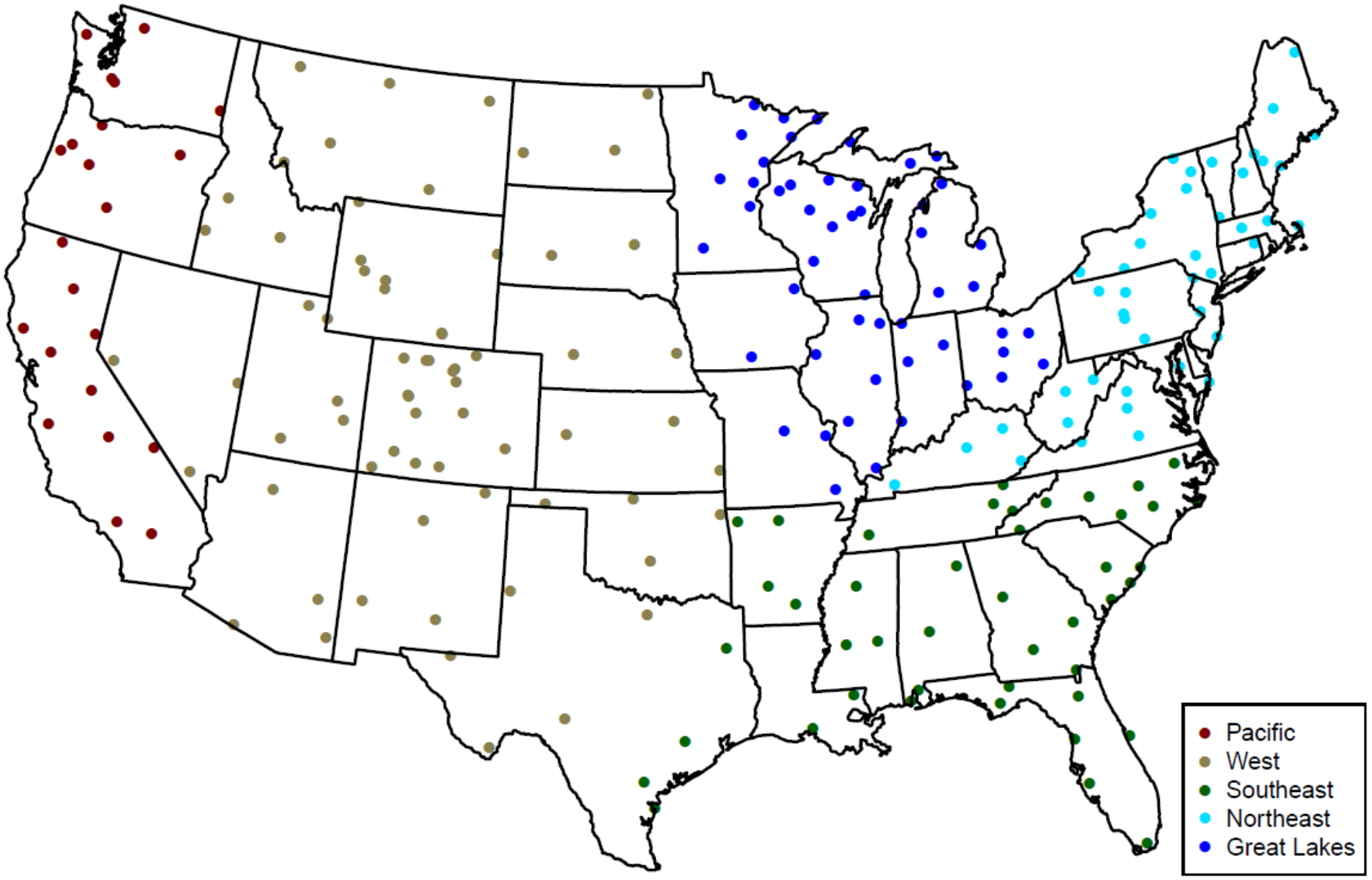
5 US Sub-regions of NADP Sites



Wet Deposition: WRF, PRISM, NADP Precipitation

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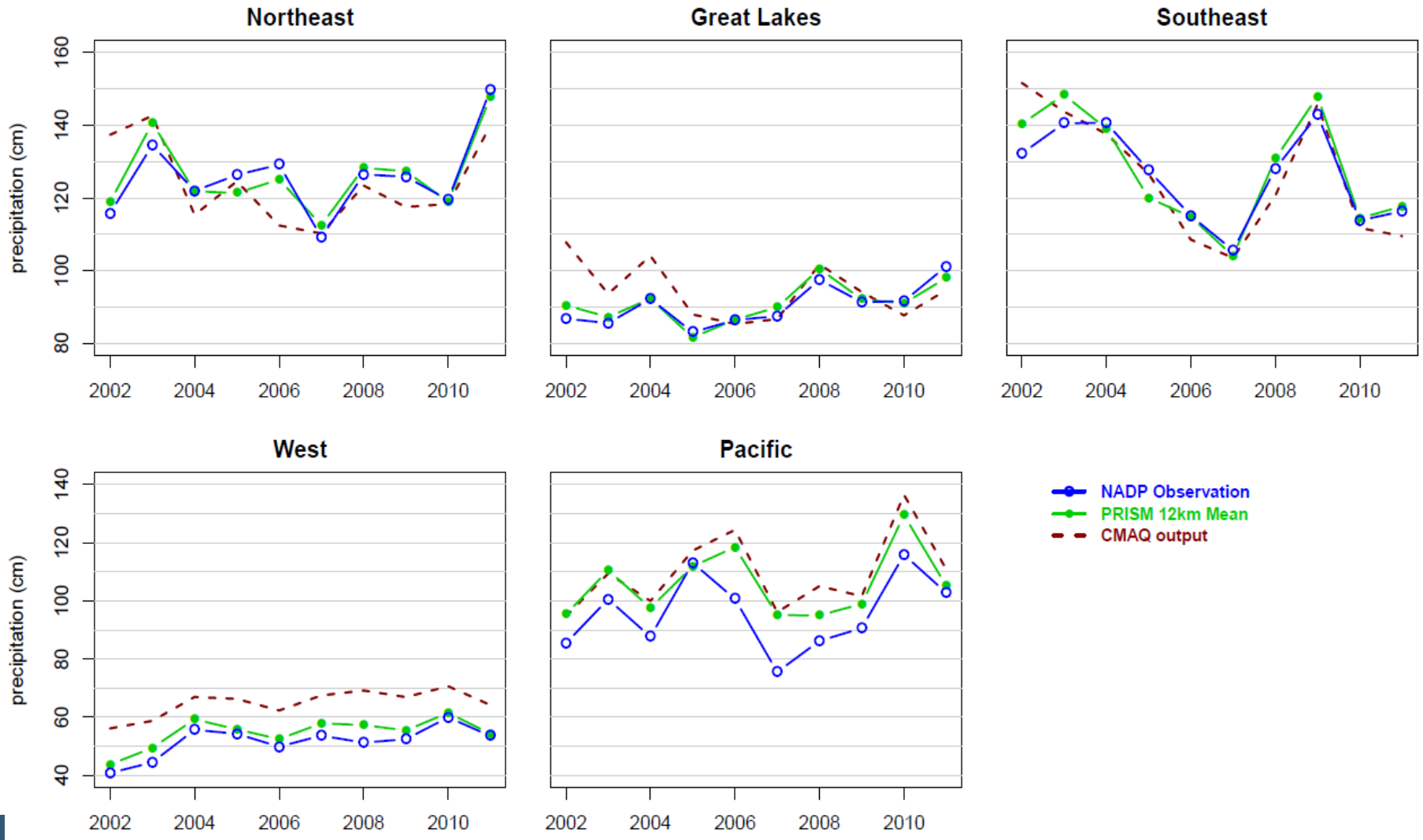
Regional Averages of Annual Total Precipitation (cm)



Wet Deposition: NADP, "Raw", Adjusted CMAQ NO_3

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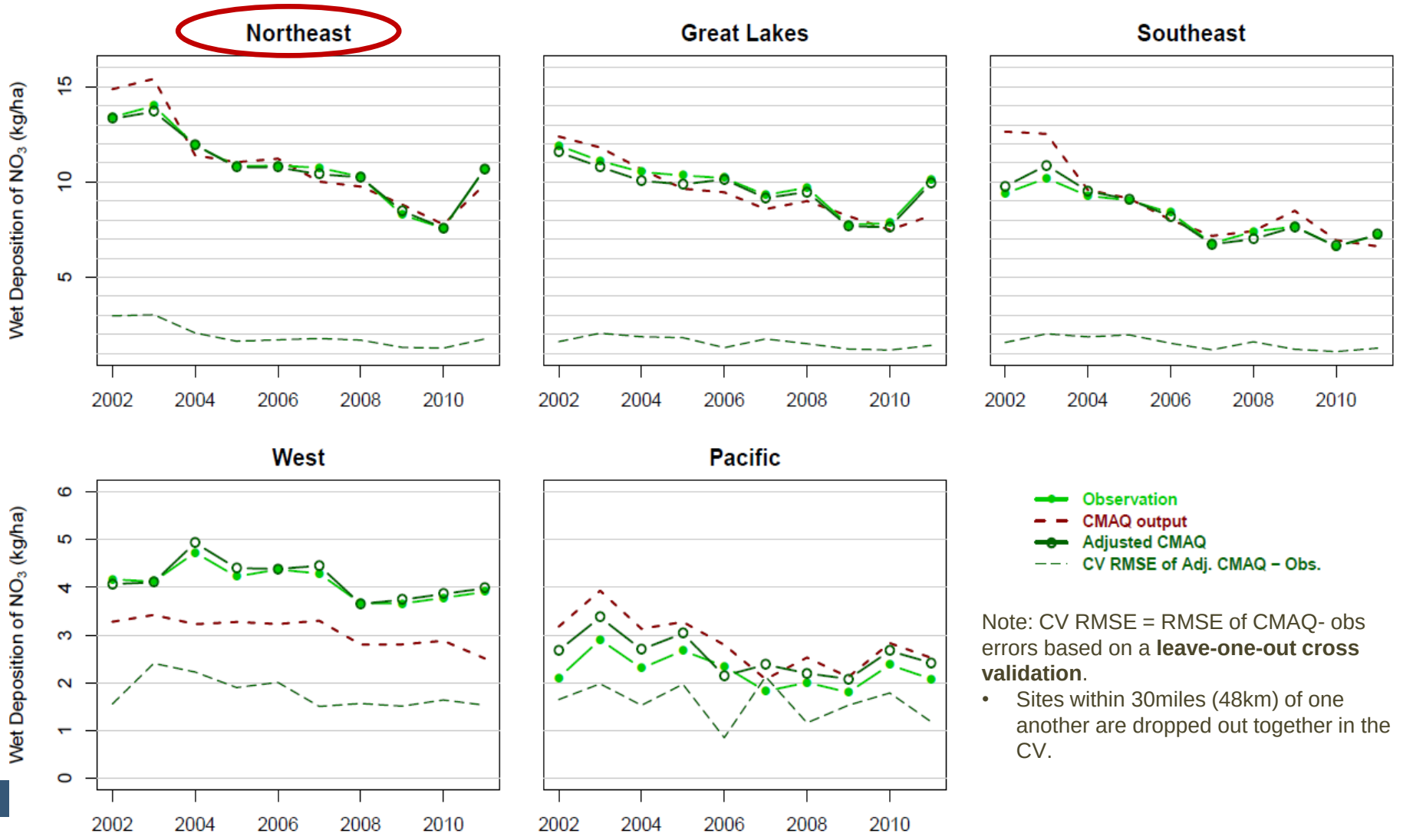
Regional Averages of Annual Total Wet Deposition of NO_3 (kg/ha)



Note: CV RMSE = RMSE of CMAQ- obs errors based on a **leave-one-out cross validation**.

- Sites within 30miles (48km) of one another are dropped out together in the CV.

Wet Deposition: NADP, "Raw", Adjusted CMAQ NH_4

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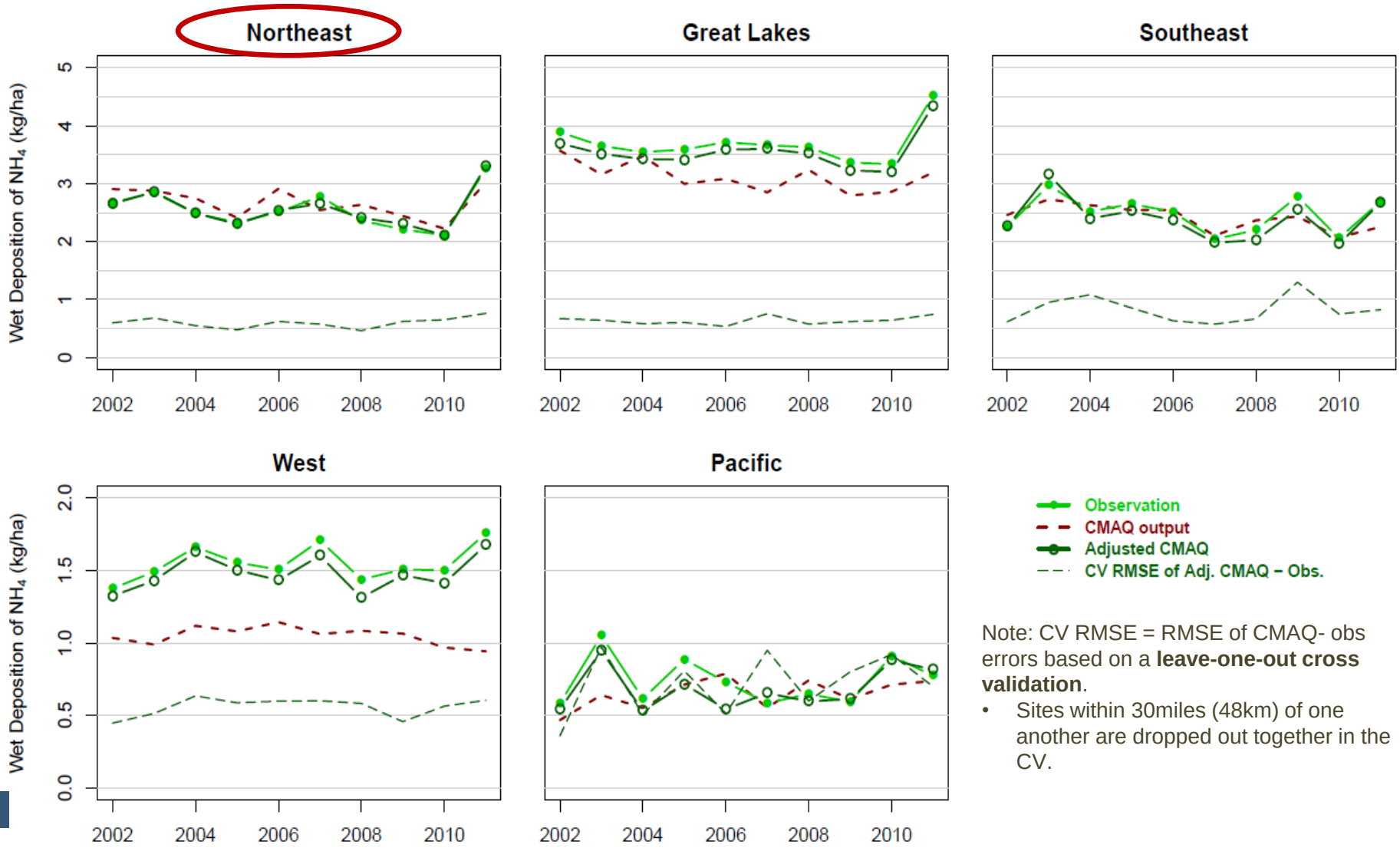
Regional Averages of Annual Total Wet Deposition of NH_4 (kg/ha)



Note: CV RMSE = RMSE of CMAQ- obs errors based on a **leave-one-out cross validation**.

- Sites within 30miles (48km) of one another are dropped out together in the CV.

Wet Deposition: NADP, "Raw", Adjusted CMAQ SO_4

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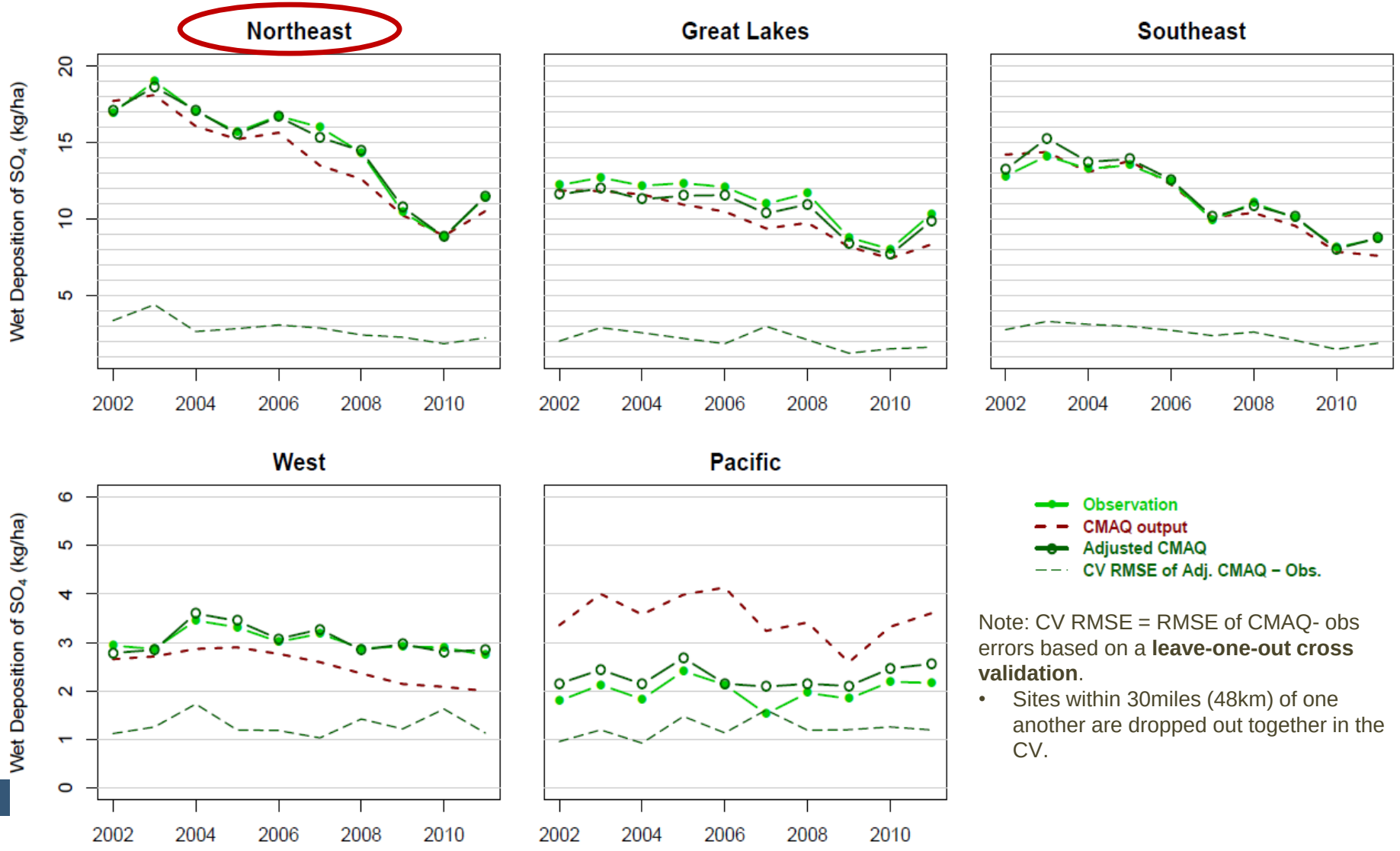
Regional Averages of Annual Total Wet Deposition of SO_4 (kg/ha)



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Wet Deposition Smooth Bias Adjustment NO_3

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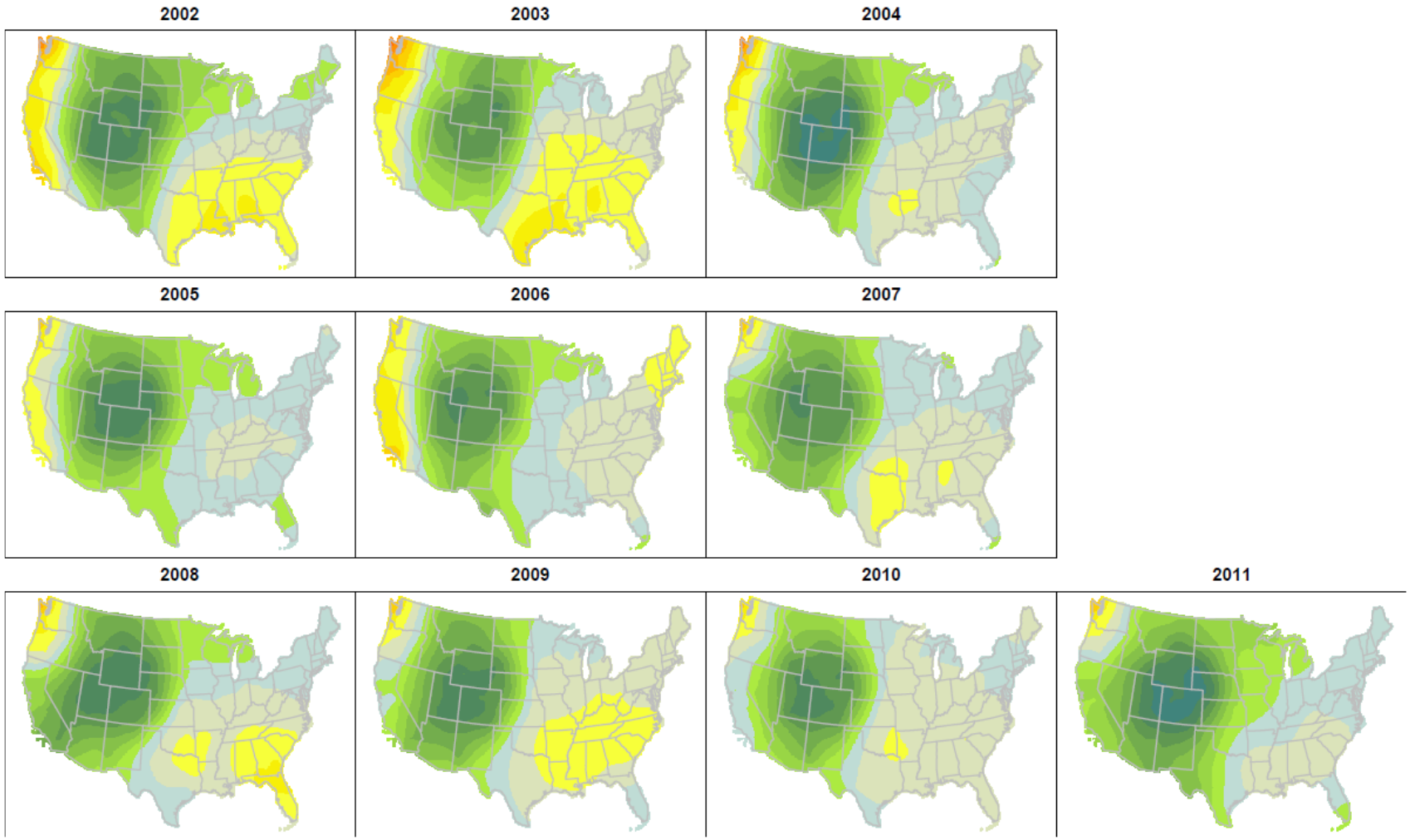
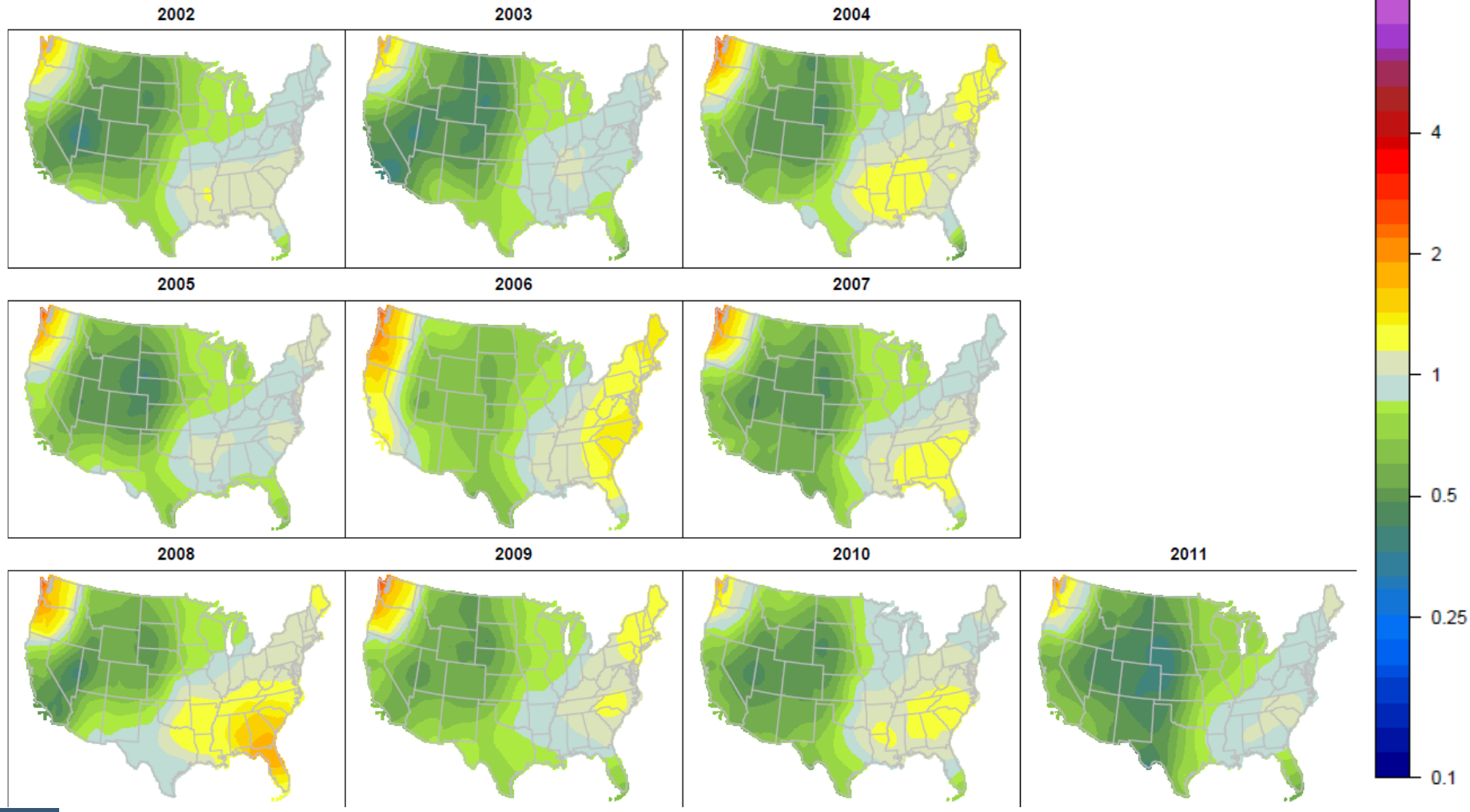
Precip-Adj Model/Obs NO_3



Wet Deposition Smooth Bias Adjustment NH_4

United States Environmental Protection Agency

Precip-Adj Model/Obs NH_4



Wet Deposition Smooth Bias Adjustment SO_4

United States Environmental Protection Agency

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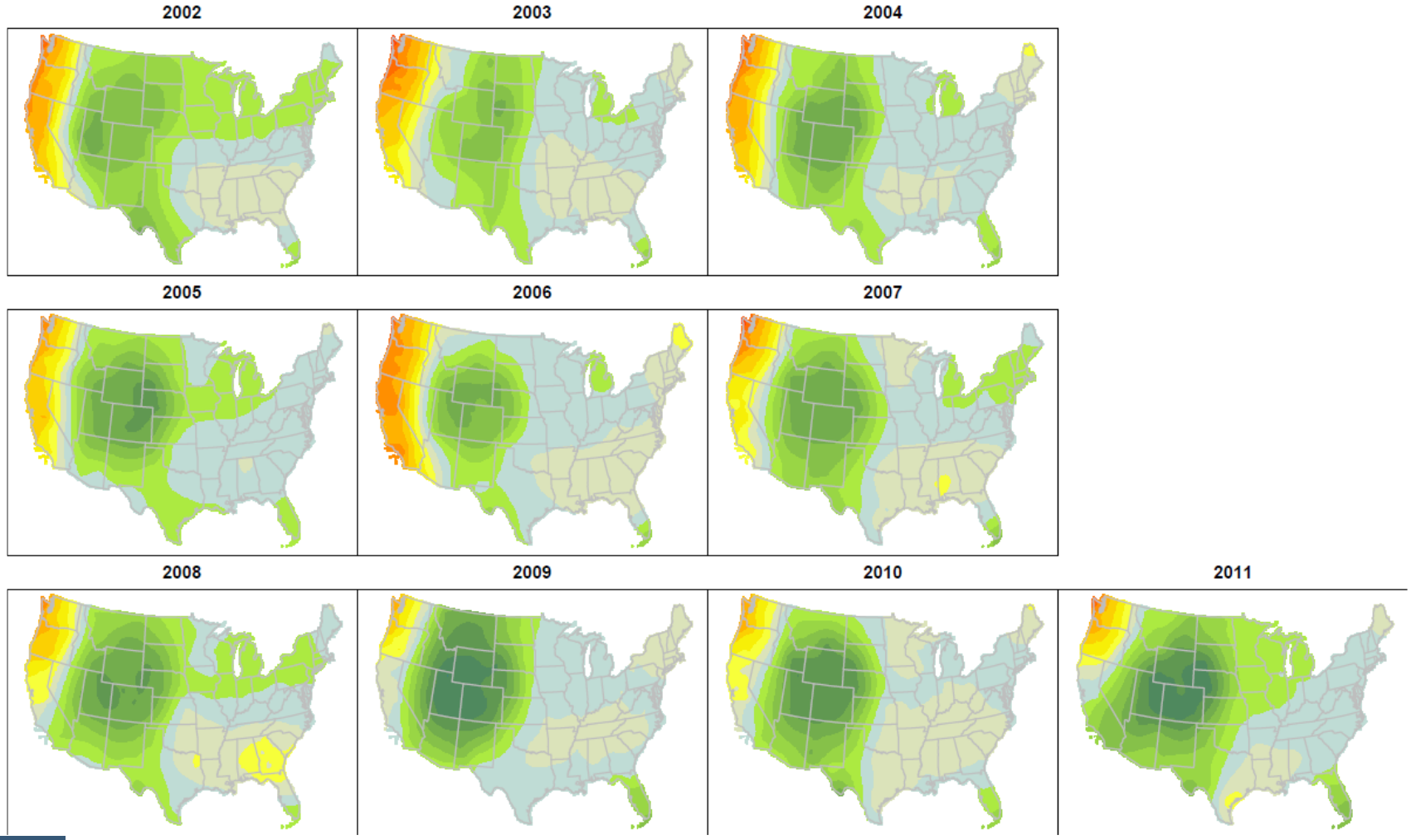

Wet Deposition Error

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Wet Deposition Cross Validation RMS Error					
	North East	Great Lakes	South East	West	Pacific
Wet NO_3 (kg-N/ha)	0.68→0.23	0.45→0.23	0.45→0.33	0.45 – 0.33	0.33
% Error	20%→14%	20%→14%	20%→14%	50%	75%
Wet NH_4 (kg-N/ha)	0.4	0.5 – 0.6	0.4 – 0.8	0.4	0.4 – 0.8
% Error	17%	14%	20% -- 40%	33%	100%
Wet SO_4 (kg-S/ha)	1.3 → 0.67	0.67 – 1.0	1.0 → 0.67	0.33 – 0.5	0.3 – 0.5
% Error	20%	17%	20% → 25%	50%	60%

Note: a→b denotes a trend;
a—b denotes a range

Consistent error across eastern US
Larger % error in West
Largest % error in Pacific

Error at Individual NADP Sites
2010 Example

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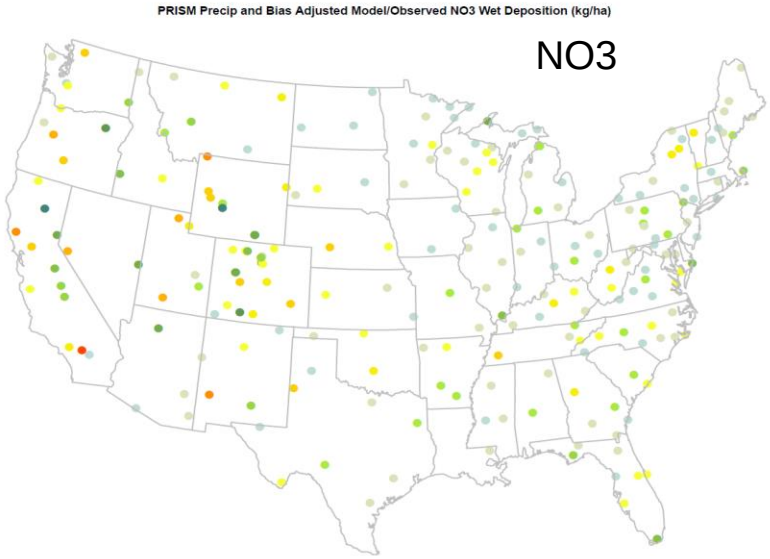
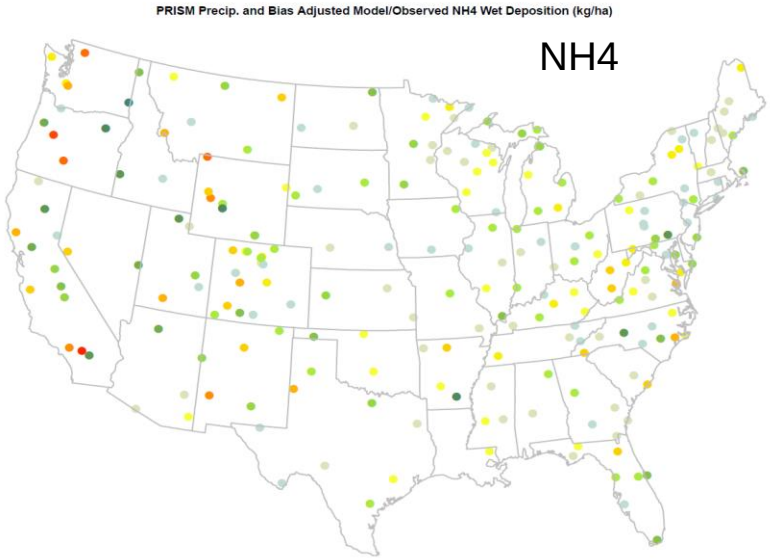
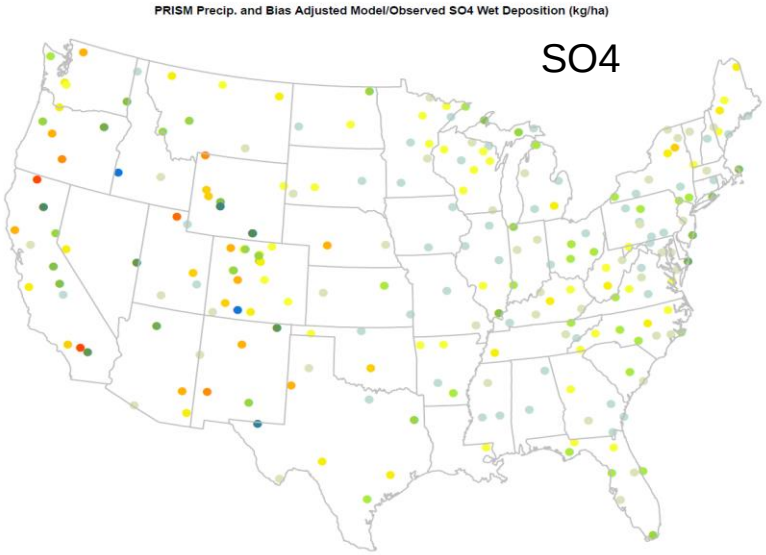
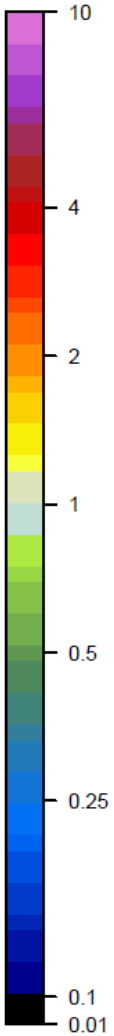


Wet Deposition
Final Bias-Adjusted Model/Observation

2010







Dry vs Wet Deposition Trends: Ox-N

(at NADP Sites)

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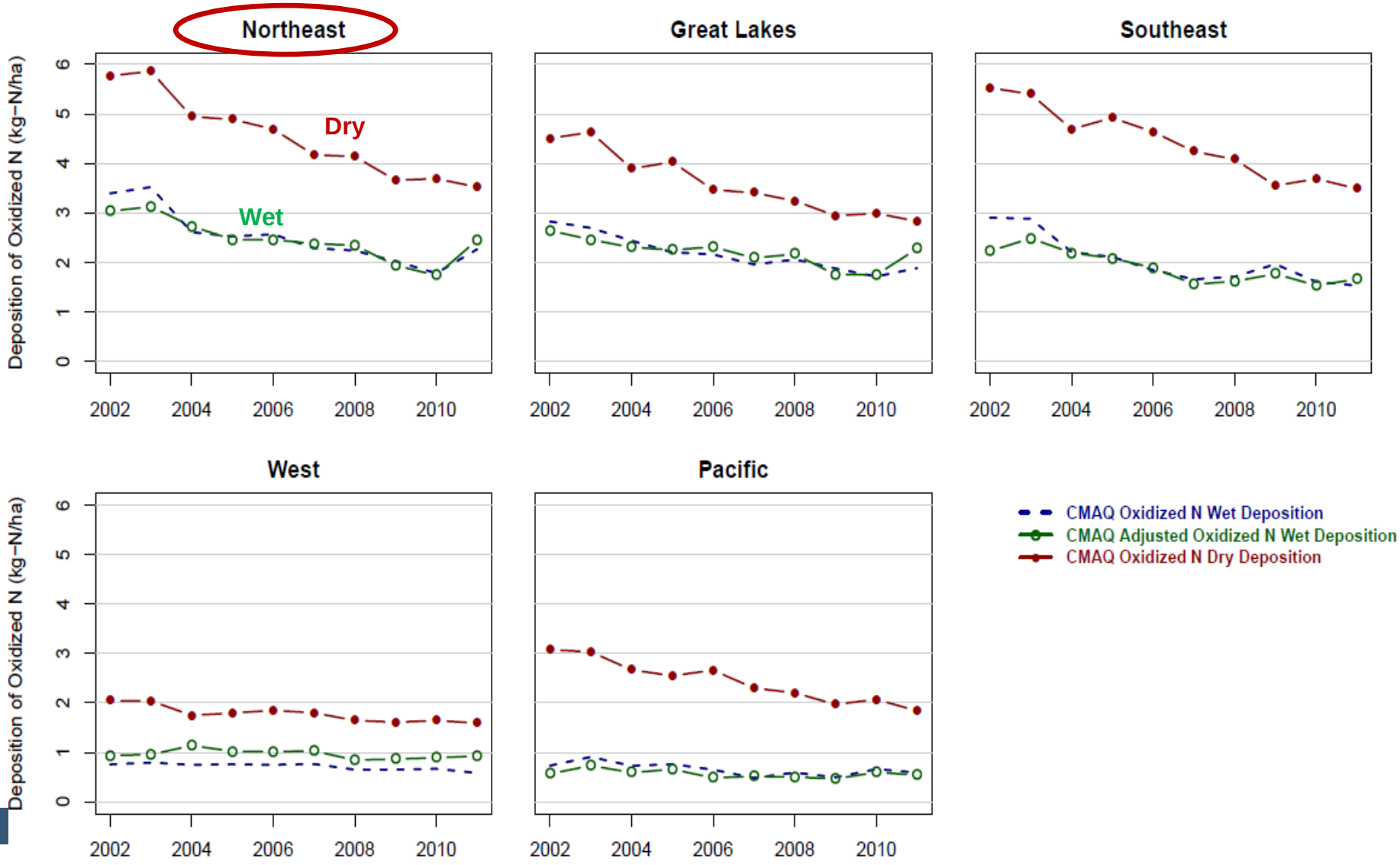

Dry vs Wet Deposition Trends: Red-N

(at NADP Sites)

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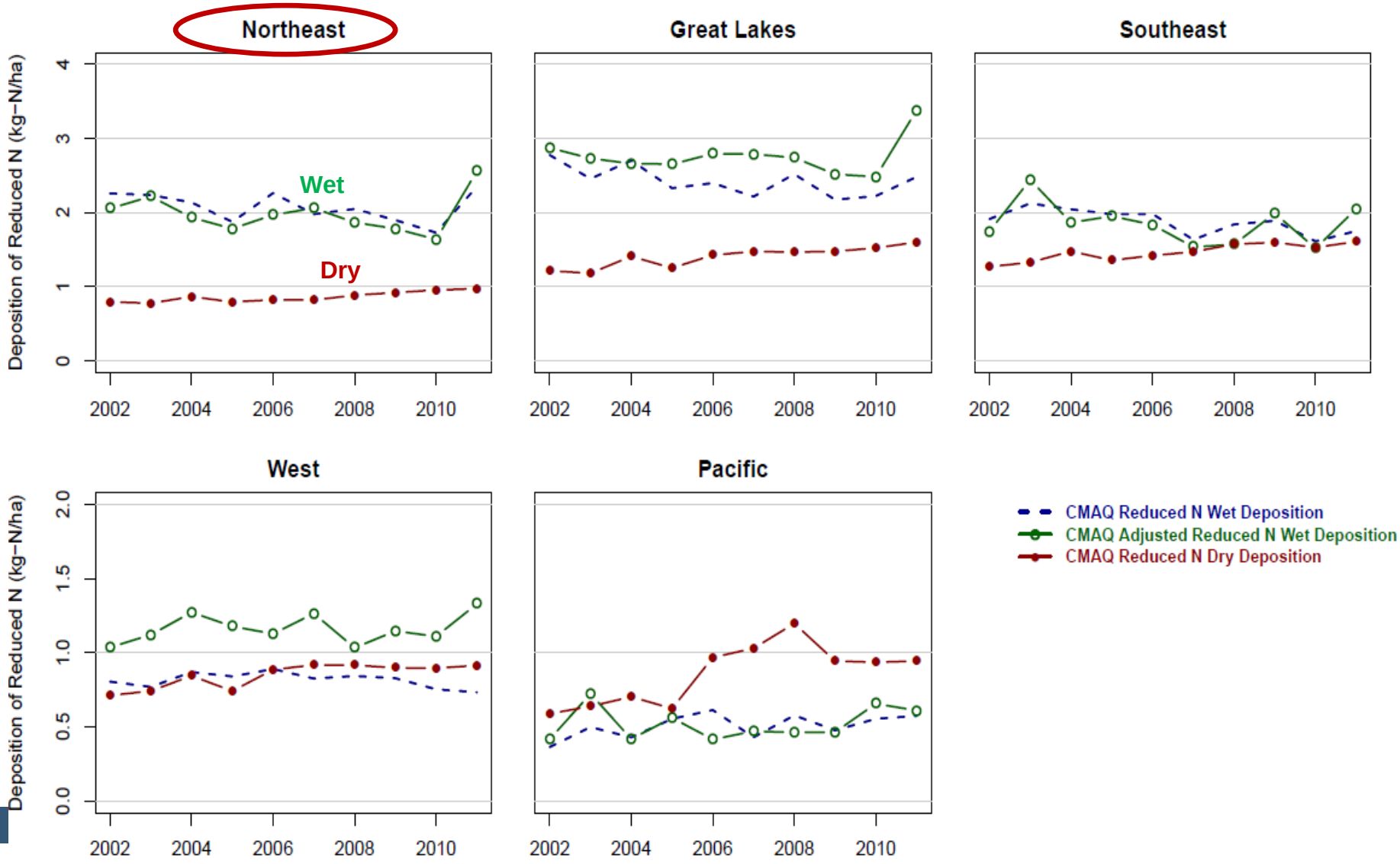

Dry vs Wet Deposition Trends: Sulfur

(at NADP Sites)

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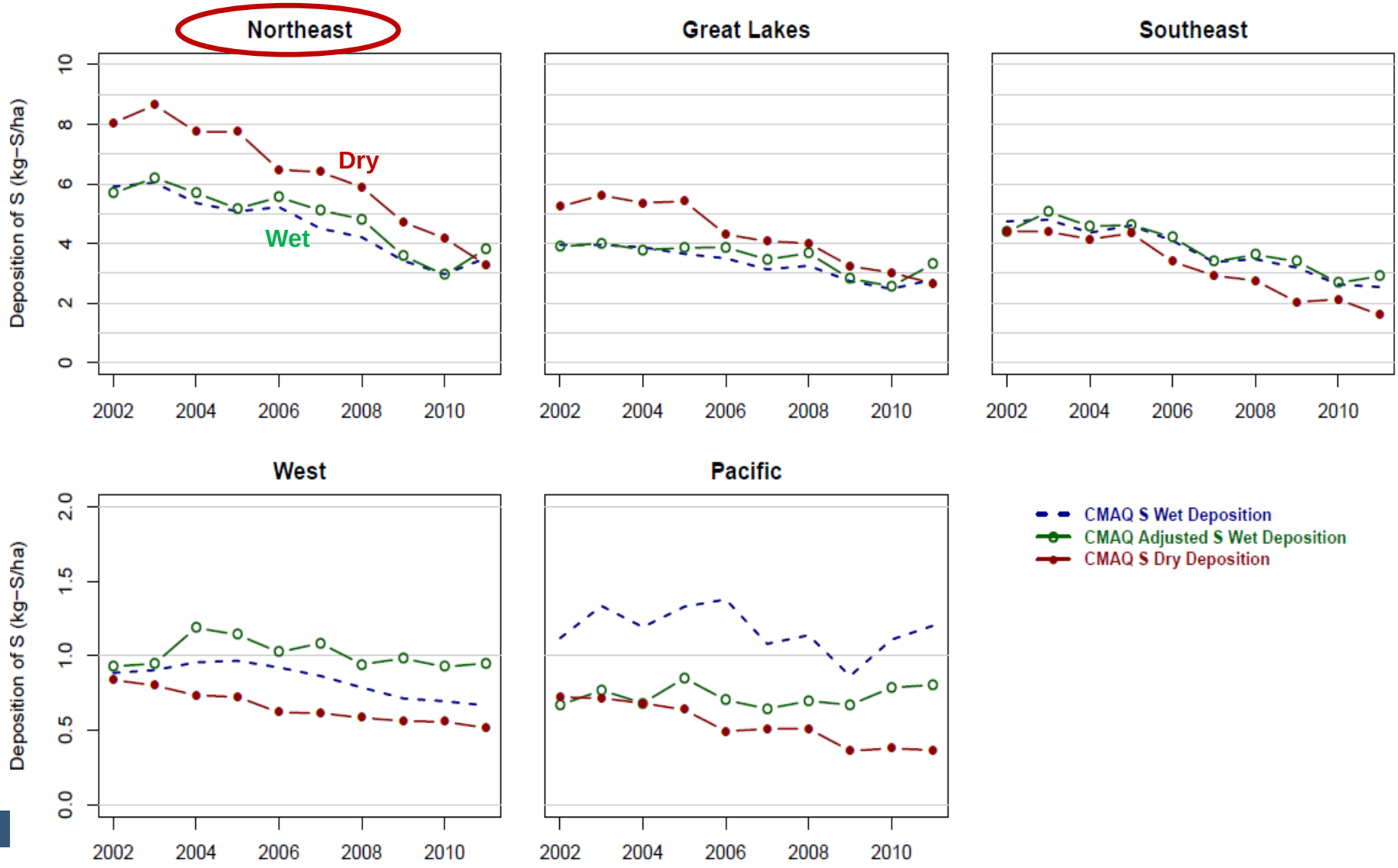
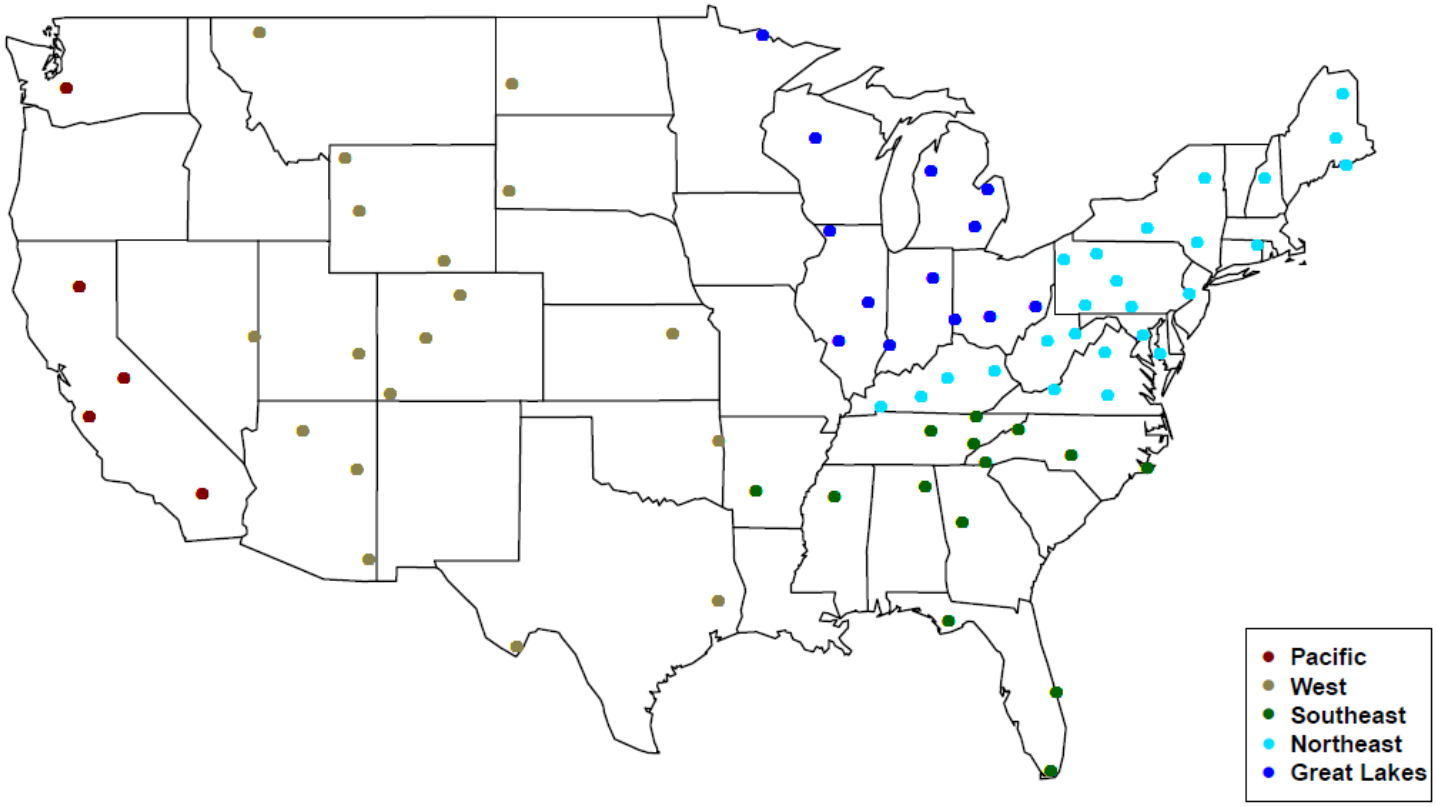


5 US Sub-regions of CASTNET Sites



n = 77 sites

Dry vs Air Concentration Trends
Ox-N &TNO_3-N Dry to TNO_3 Air
(at CASTNET Sites)

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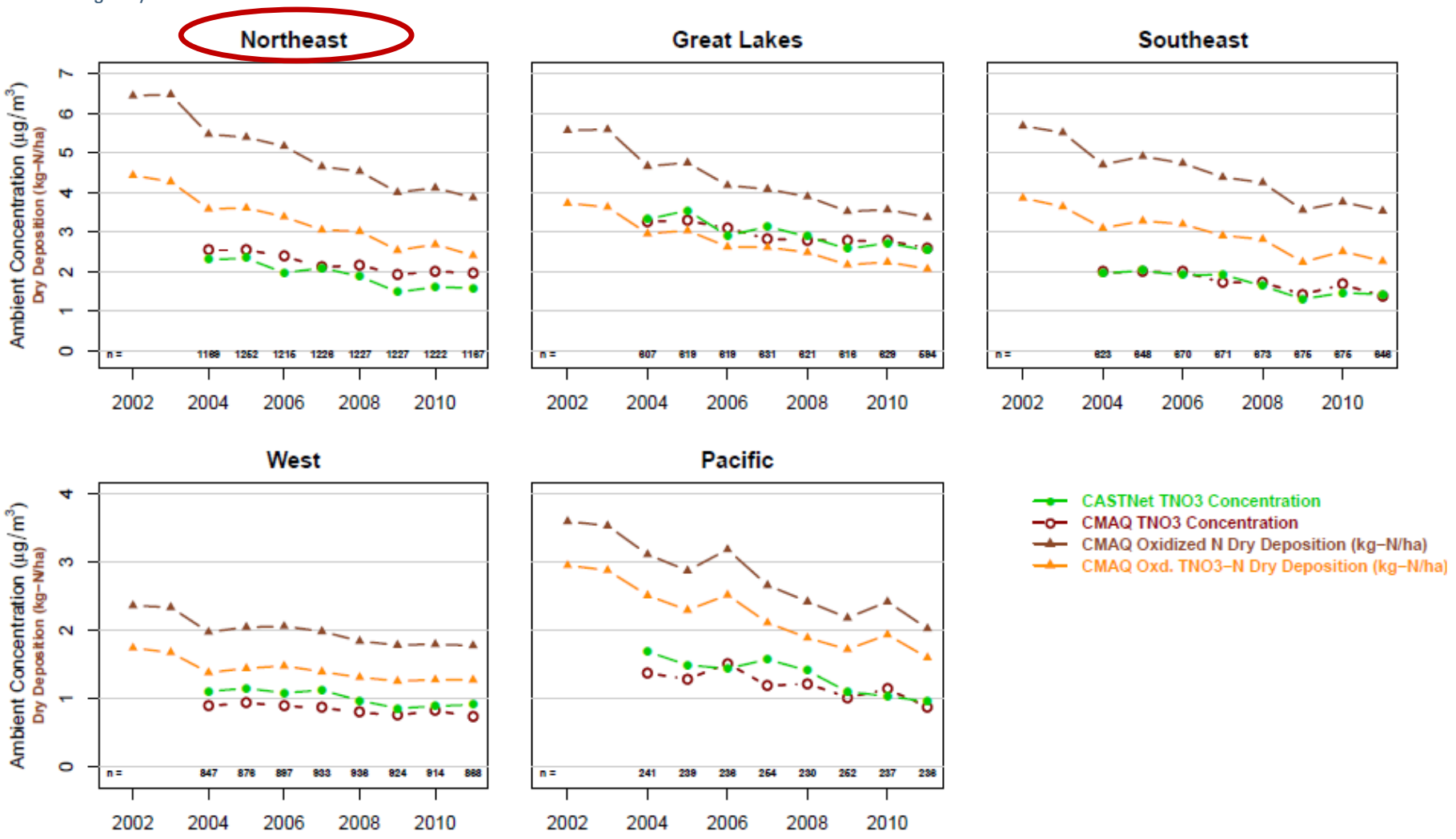

Dry vs Air Concentration Trends
T-S &SO_2-S Dry to SO_2 Air
(at CASTNET Sites)

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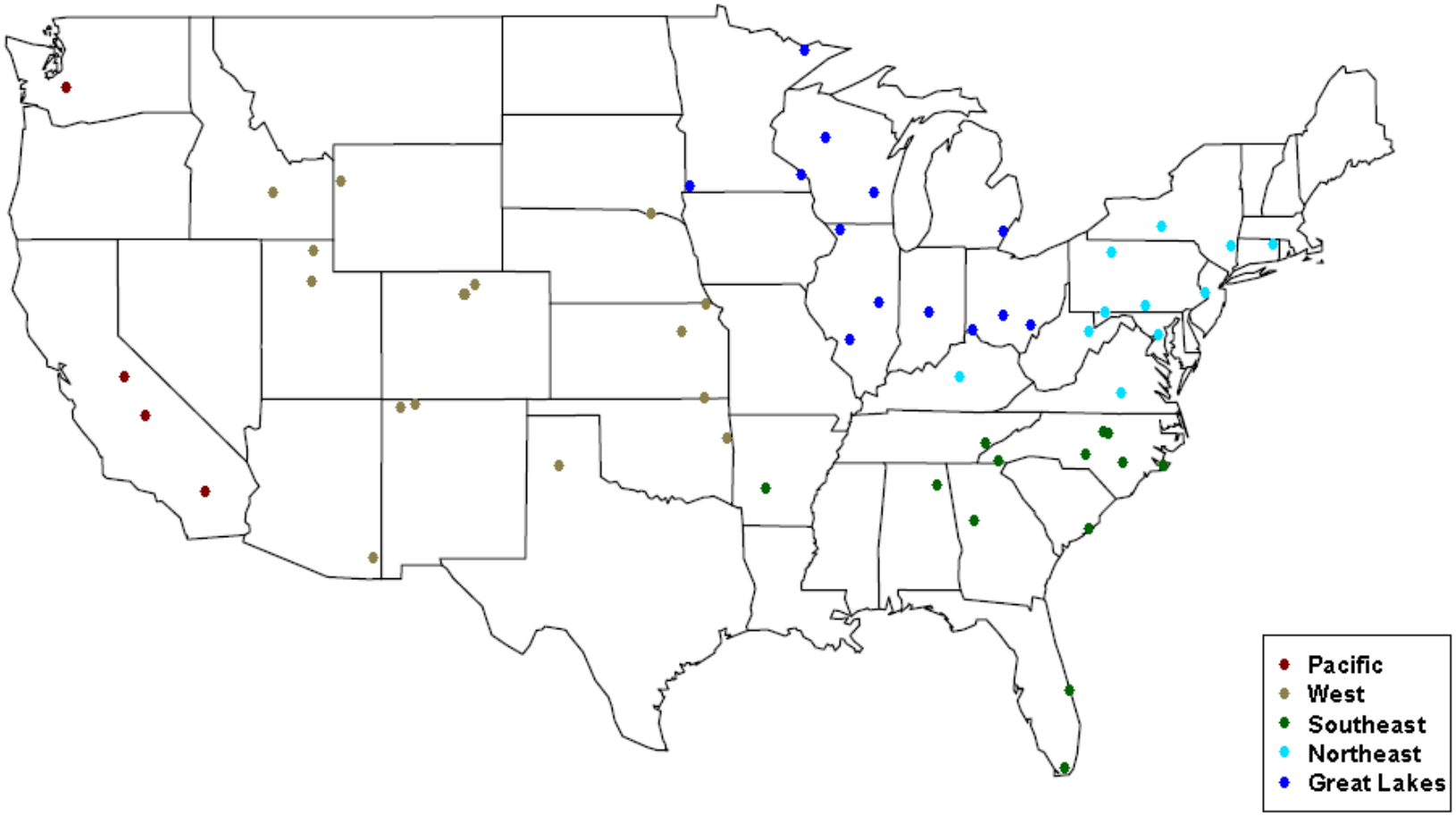
5 US Sub-regions of AMON Sites



Air Concentration Trends
NH_3 (*AMON*)

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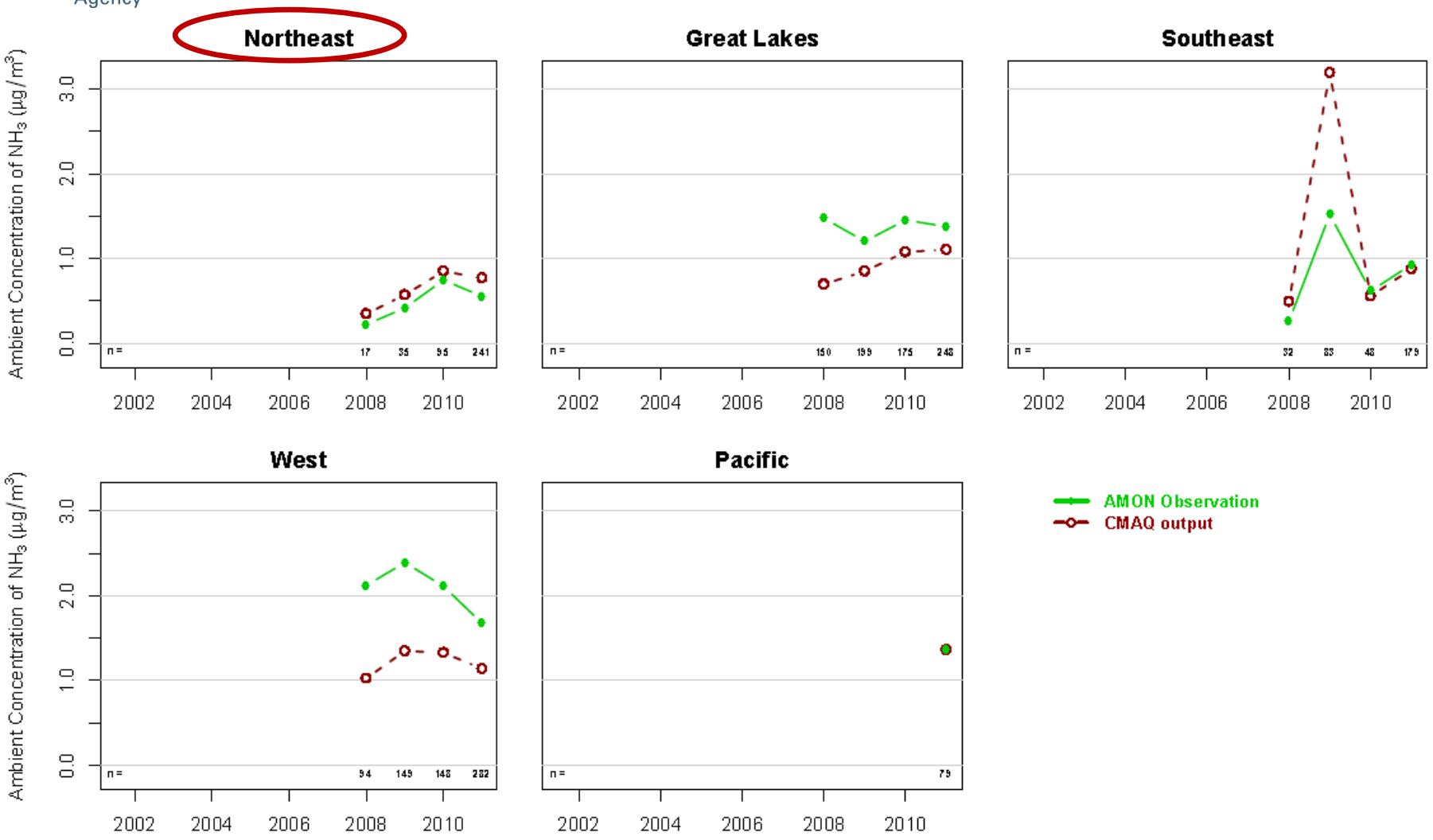

Air Concentration: 2011 Time Series NH_3 (*AMON*)

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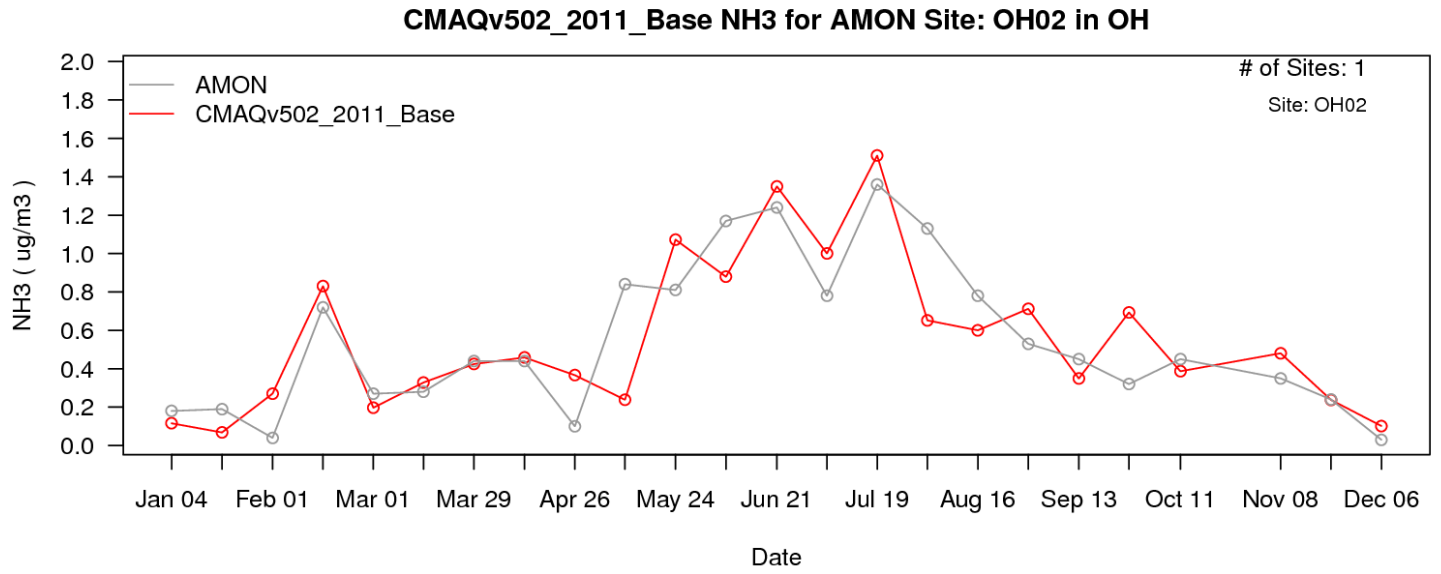

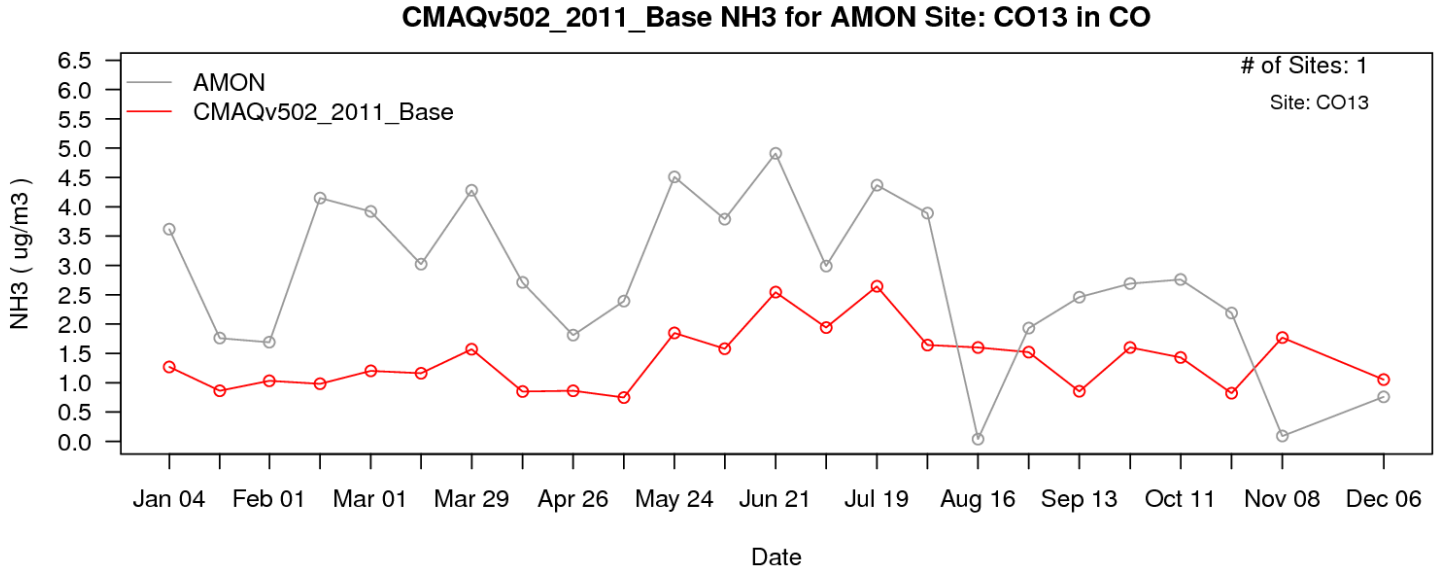

Summary

- Model performing fairly well at large scale, especially in eastern half of CONUS
  - Capturing the main trends well, except for 2002
- Balance between wet and dry deposition improved, with better “raw” wet deposition (more confidence)
- Still not getting the west very well.
  - Continues to need attention
- Check western boundary condition inputs
- Ammonia better than expected (pleased)
  - But still looking to improve performance (more sites help)

Future Directions

- Upcoming (CMAQ 5.1 released next fall)
  - Organic N estimates (oxidized portion)
  - Soil NO (new algorithm)
  - Nonvolatile nitrate enhancement
  - Updated BEIS biogenic emissions
  - Bi-directional formulation allowed for all species, with Mosaic (land-cover specific deposition) output option
- Farther in Future
  - Cloud impaction
  - Connection to throughfall and mosaic
  - Use hemispheric CMAQ for BC's

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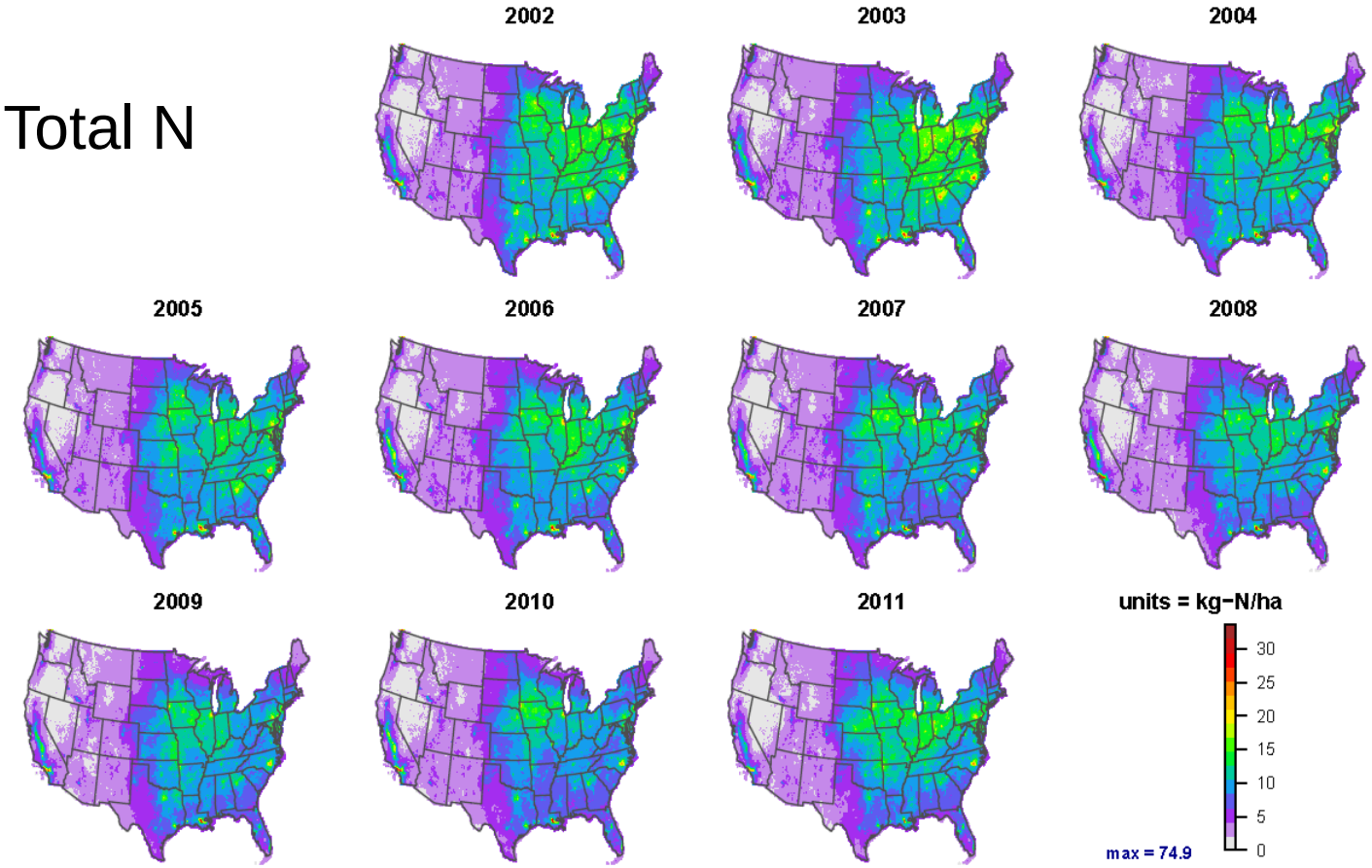
Thanks

Total N



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Extra Slides

Air Concentration Trends
TNO_3 (*CASTNET*)

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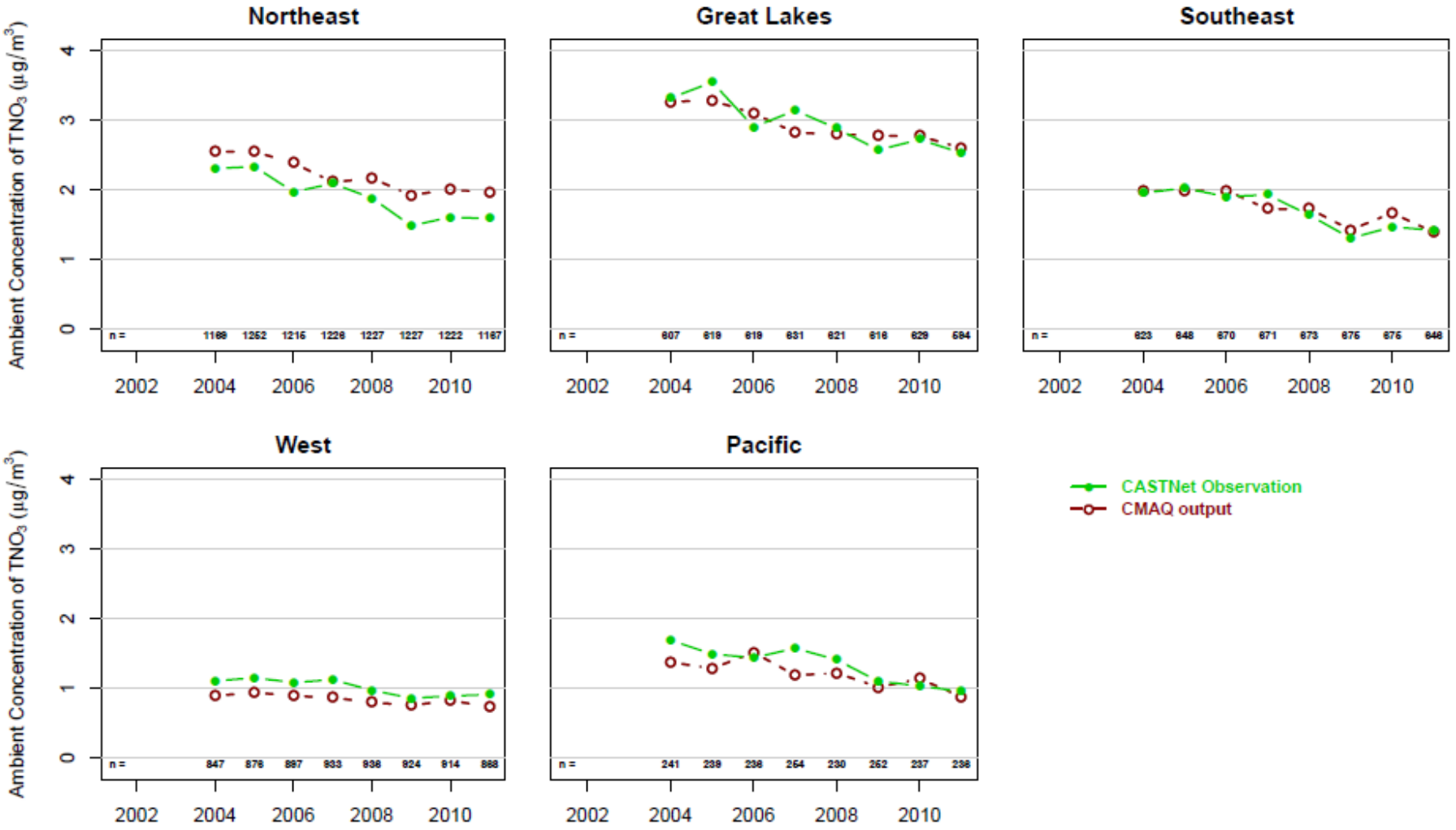

Air Concentration Trends
SO_2 (*CASTNET*)

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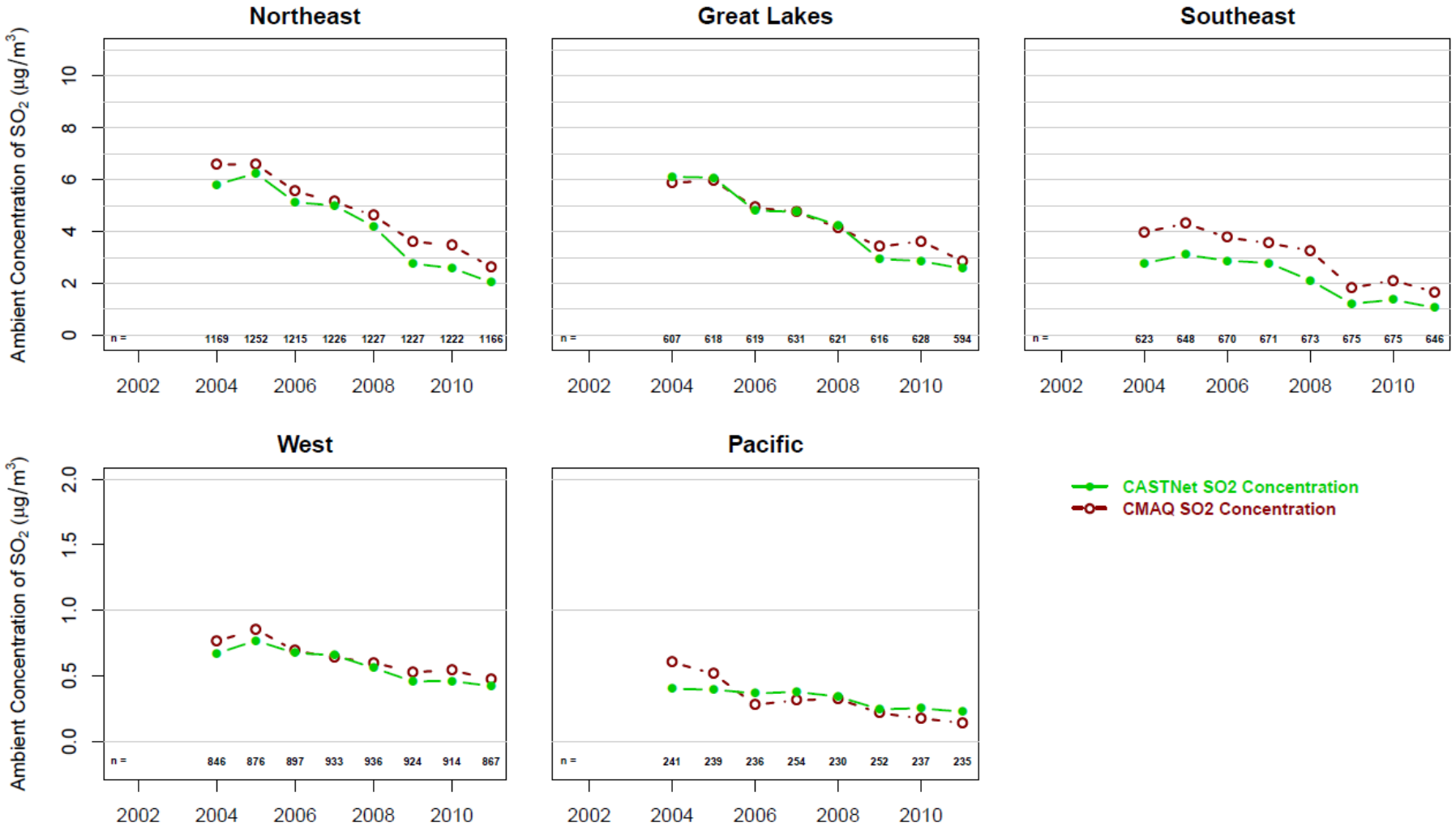

Dry vs Air Concentration Trends
T-S & SO_2-S Dry to SO_4 Air

Air Concentration Trends
HNO_3

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Air Concentration Trends
SO_4

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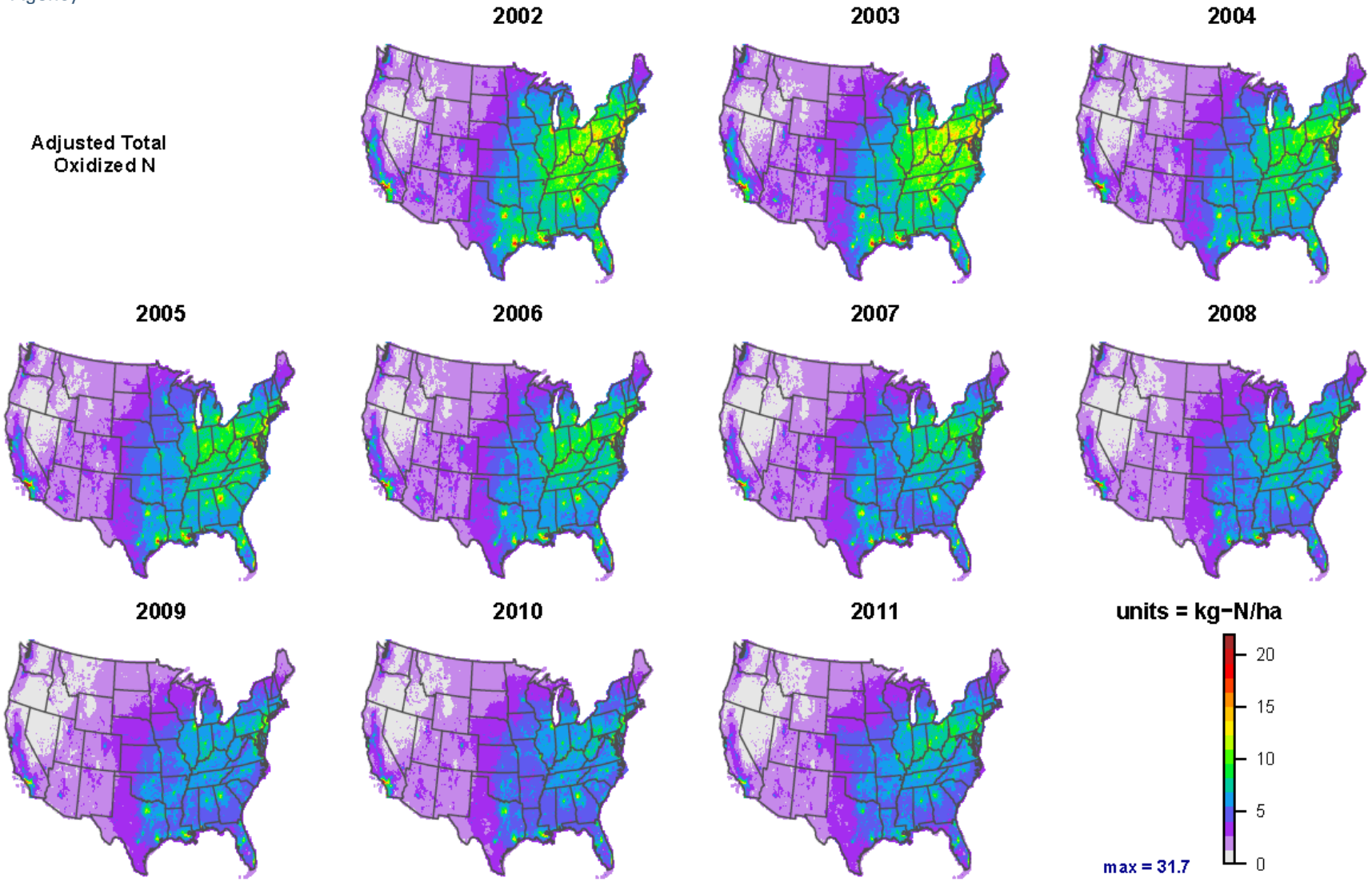
Adjusted Total
Oxidized N



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Adjusted Total
Reduced N