WET DEPOSITION OF FINE PARTICULATE MATTER IN WRF-CHEM

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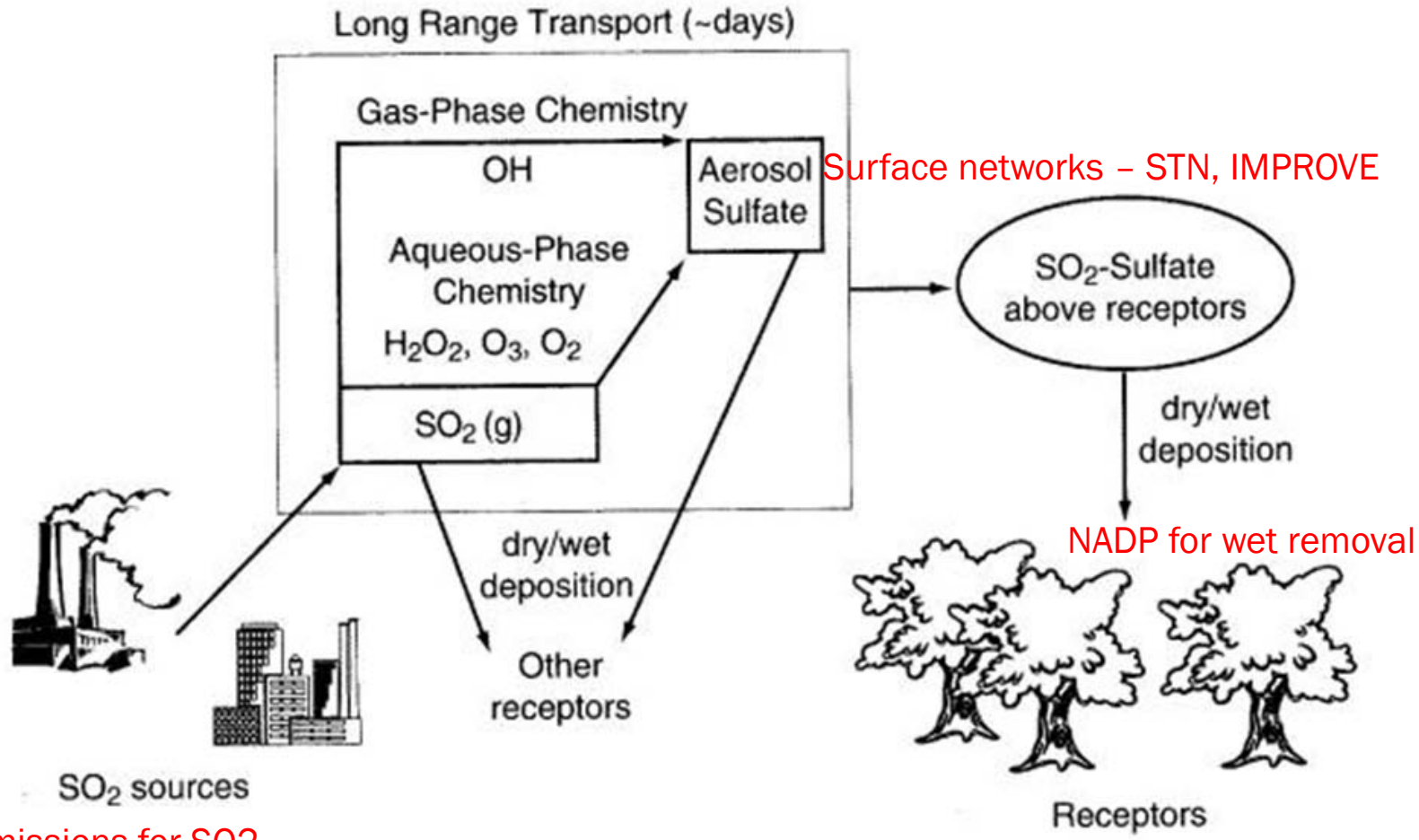
OUTLINE

- Sulfate and removal processes
- Parameterization of wet removal processes in WRF-CHEM
- Evaluation of rain, concentration and the removal rates for sulfate particles using WRF-CHEM3.1.1 with aqueous chemistry
- Preliminary results using WRF-CHEM3.3 with Grell convective rainfall/wet removal
- Concluding remarks

SULFUR SOURCE-SINK RELATIONSHIP



Surface networks – STN, IMPROVE

NADP for wet removal

CEMS emissions for SO2

Seinfeld and Pandis, 2006

AVAILABLE WET DEPOSITION TOOLS IN WRF-CHEM3.3

1) Simple wet removal scheme (G.Grell):

computationally very efficient, limited evaluation, scavenging parameters need tuning,

only for the resolved clouds!

2) Full aqueous chemistry scheme (PNNL, ref. Fahey and Pandis, 2001)

computationally very expensive, only for the resolved clouds!

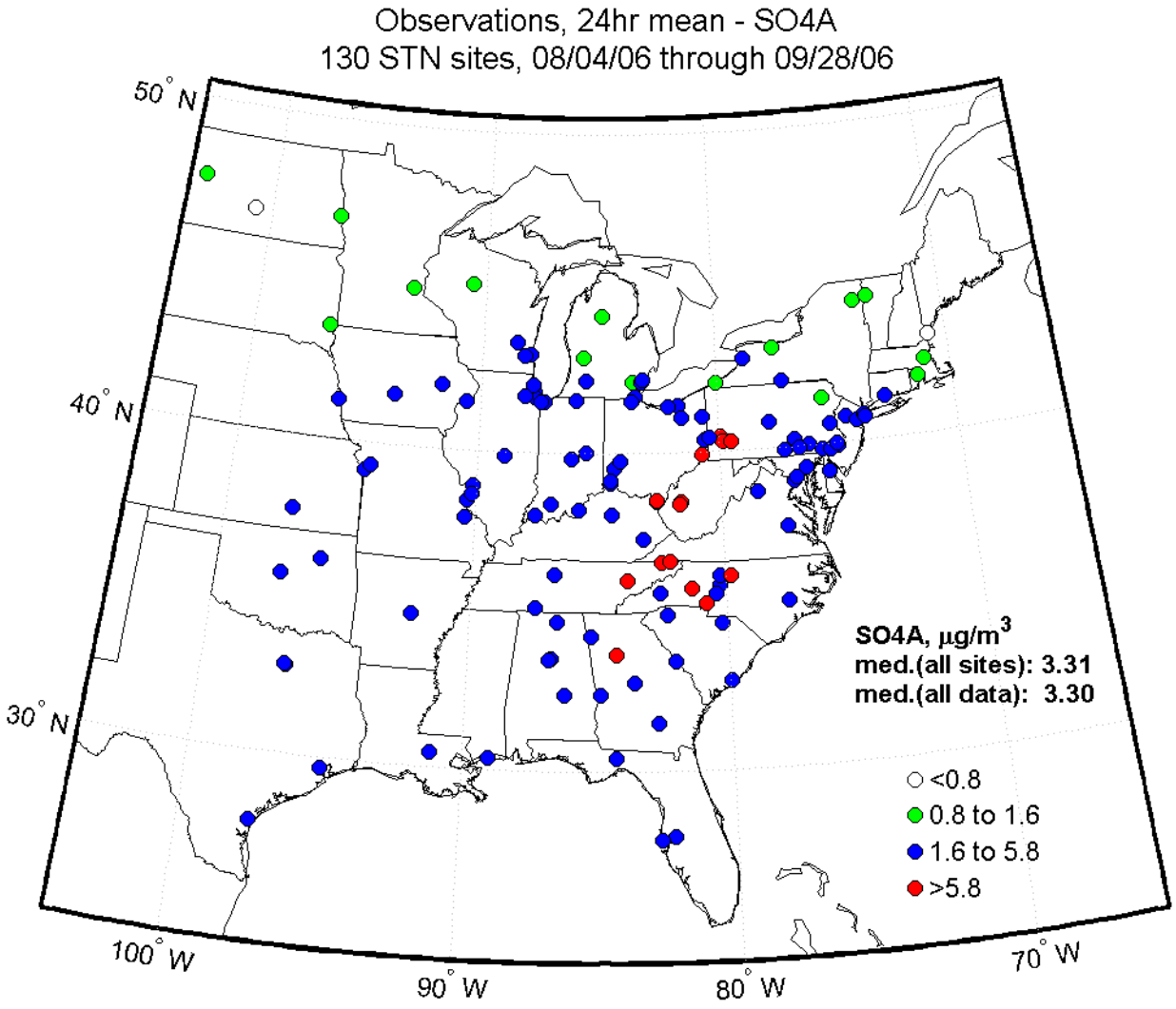
3) Wet removal within convective mixing (G.Grell)

computationally efficient, scavenging parameters need tuning, only for sub-grid clouds!

4) Aqueous chemistry paremeterization from CMAQ (ref. Walcek & Taylor, 1986), implemented by J.Kazil (NOAA/CSD)

faster than the full aq.chem (2), only for the sub-grid clouds, not in the official version!

DAILY SULFATE CONCENTRATIONS – STN OBSERVATIONS



DAILY SULFATE CONCENTRATIONS – MODEL/OBS.

WRF-CHEM settings:

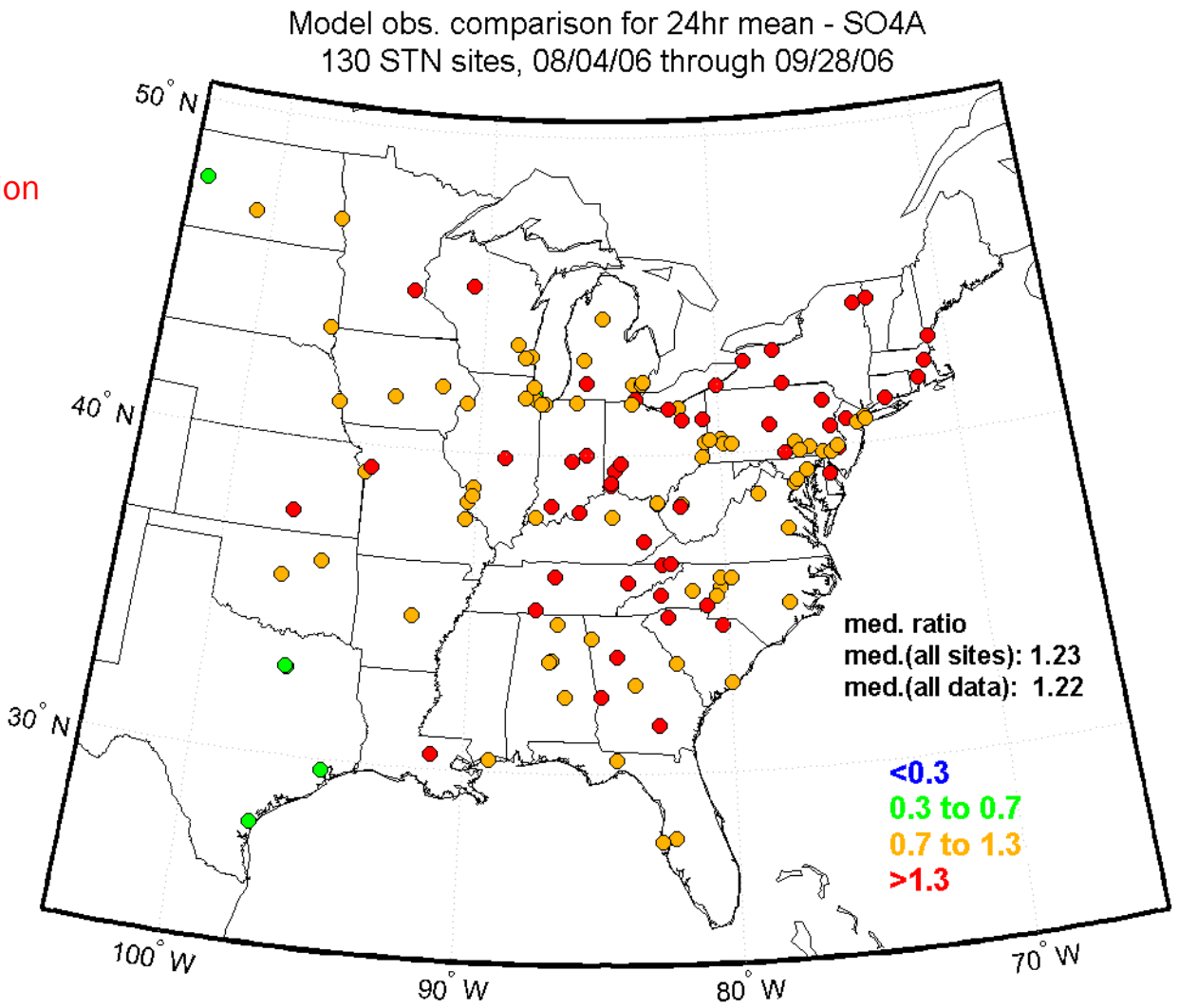
Version 3.1.1

RACM_ESRL gas chemistry:

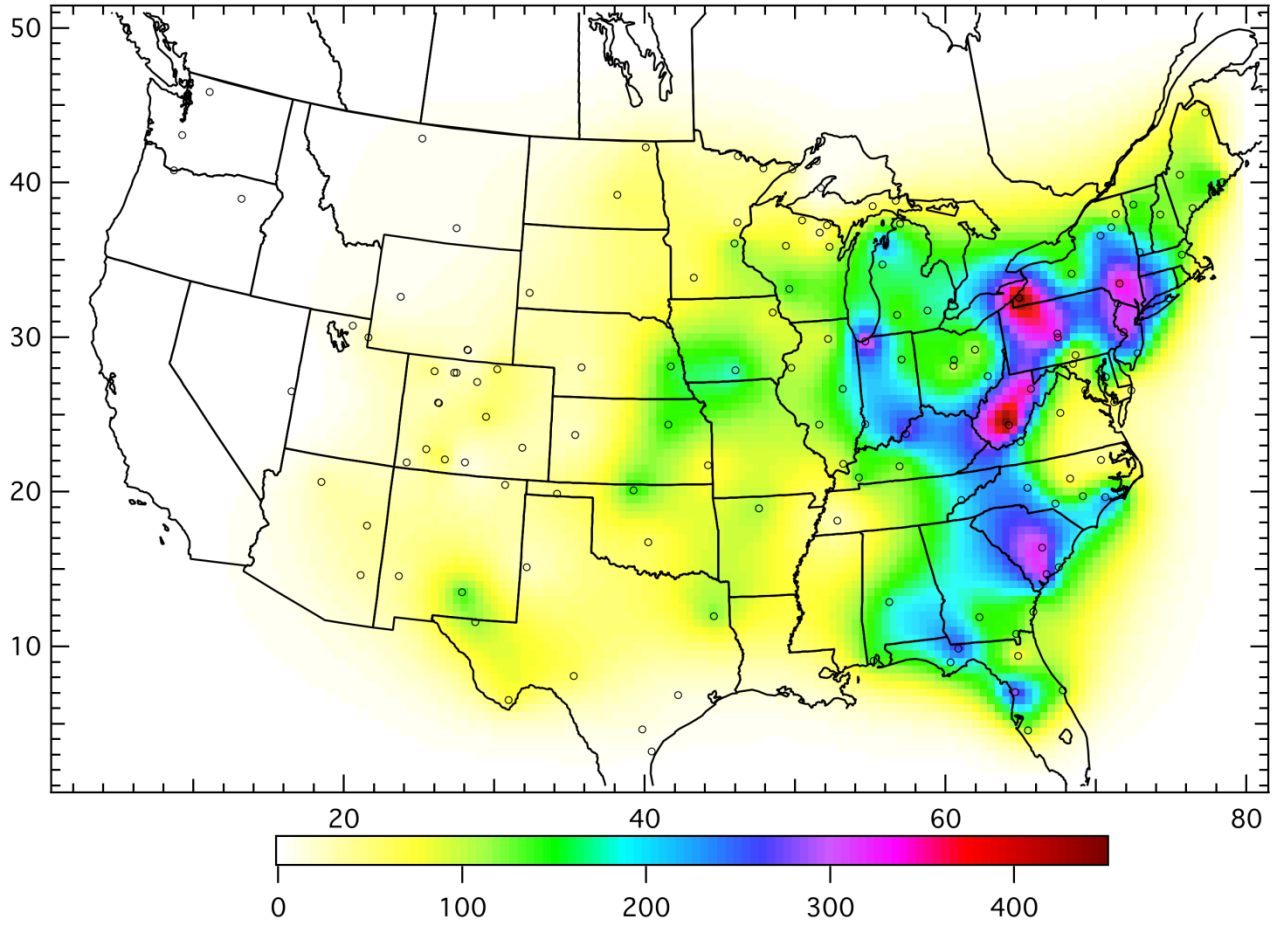
GOCART SO2->SO4 conversion

Cloud fraction

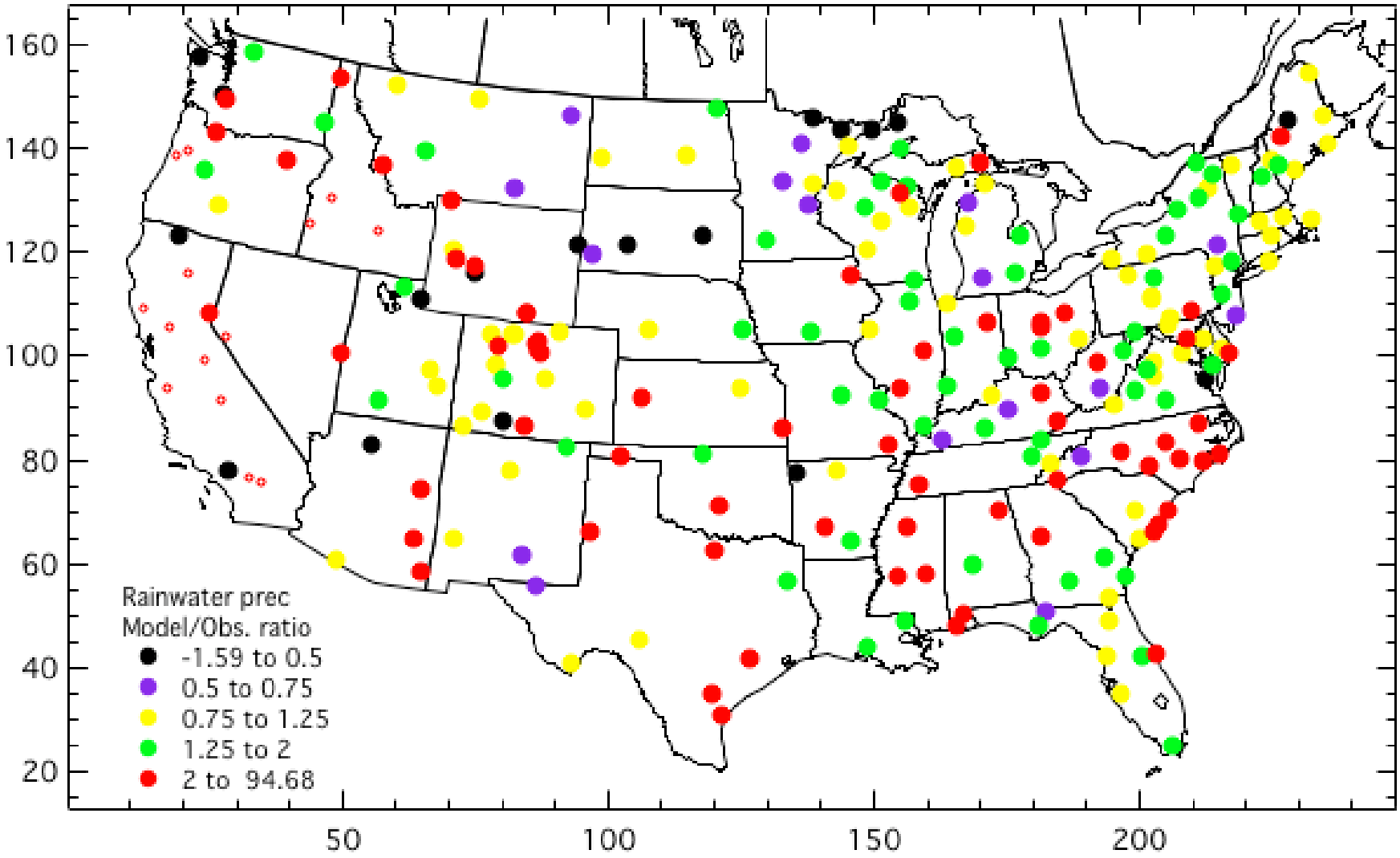
No wet removal!



NADP OBSERVED SULFATE WET REMOVAL, AUGUST, 2006, (mg/m^2/month)



NADP NETWORK, EVALUATION OF RAINFALL



Model/Observed Total Rainfall (August 2006)

WRF-CHEM 3.1.1

MODEL-OBSERVED SO4 WET DEPOSITION (AUGUST 2006)

WRF-CHEM settings:

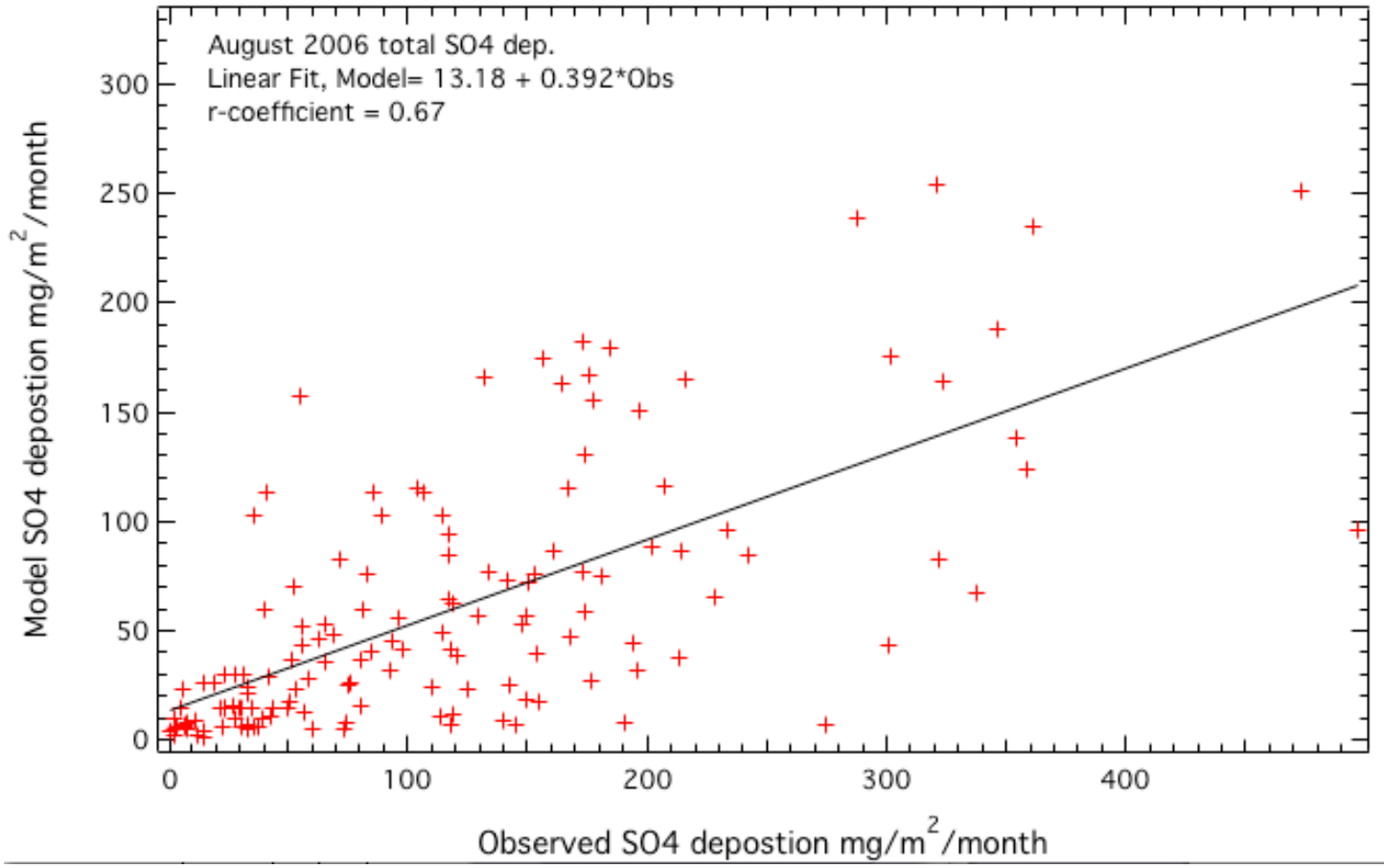
Version 3.1.1

Gas chemistry:

RADM_KPP

CMAQ aqueous chemistry

with wet removal

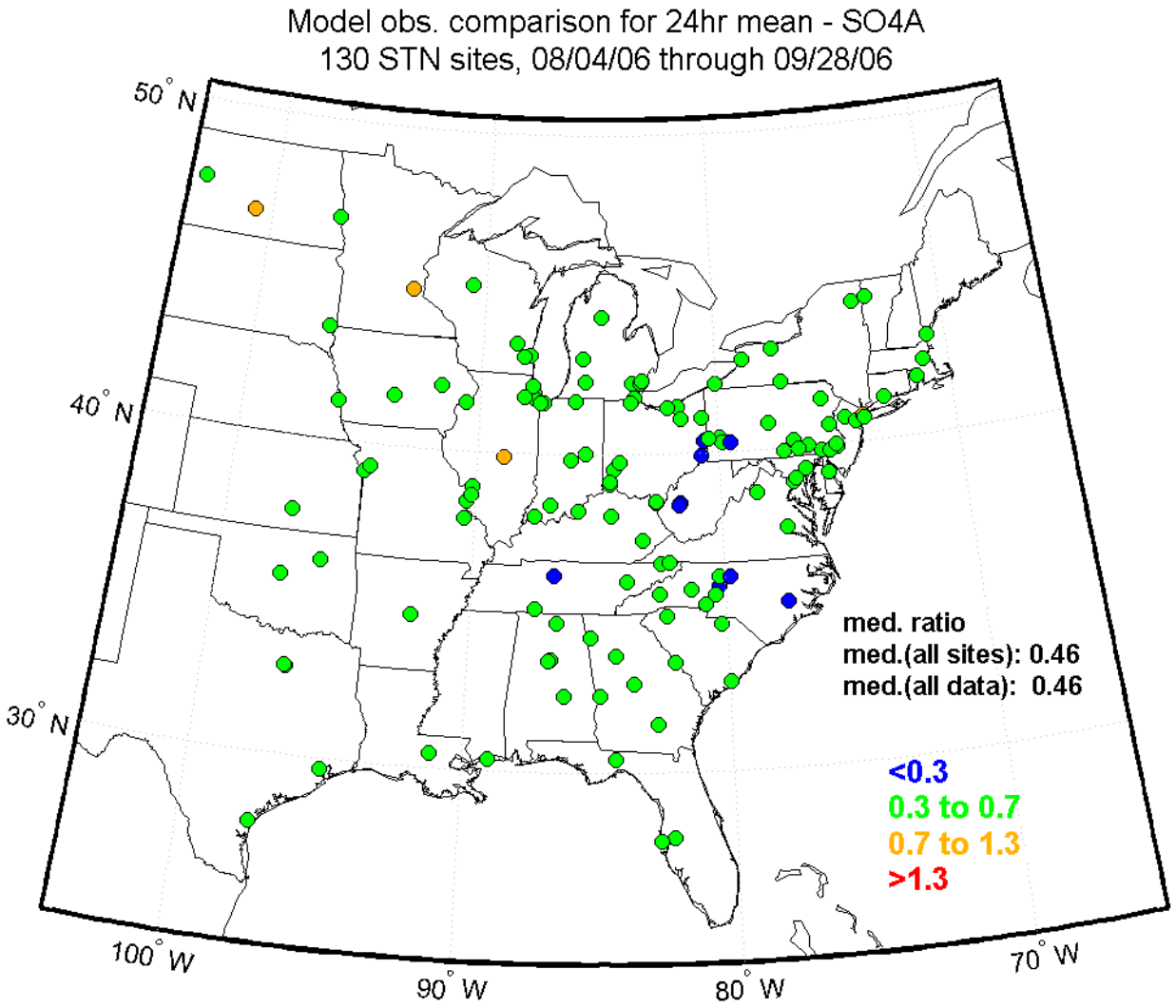


WET REMOVAL STATISTICS FOR MAY-SEPTEMBER, 2006

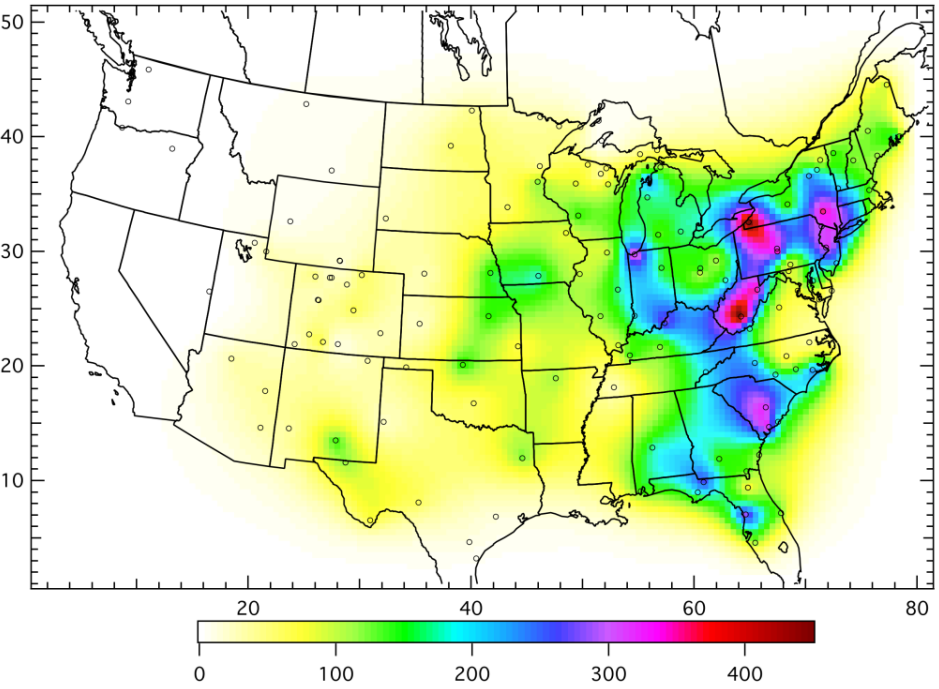
Month	Precipitation r coeff.	Precipitation mod/ob median	SO4 wet dep. r coeff.	SO4 wet dep. mod/ob median
May	0.66	1.35	0.73	0.61
June	0.78	1.30	0.76	0.47
July	0.67	1.12	0.78	0.41
August	0.51	1.51	0.67	0.54
September	0.72	0.98	0.70	0.56
May-Sept.	0.81	1.25	0.86	0.55

WRF-CHEM 3.1.1

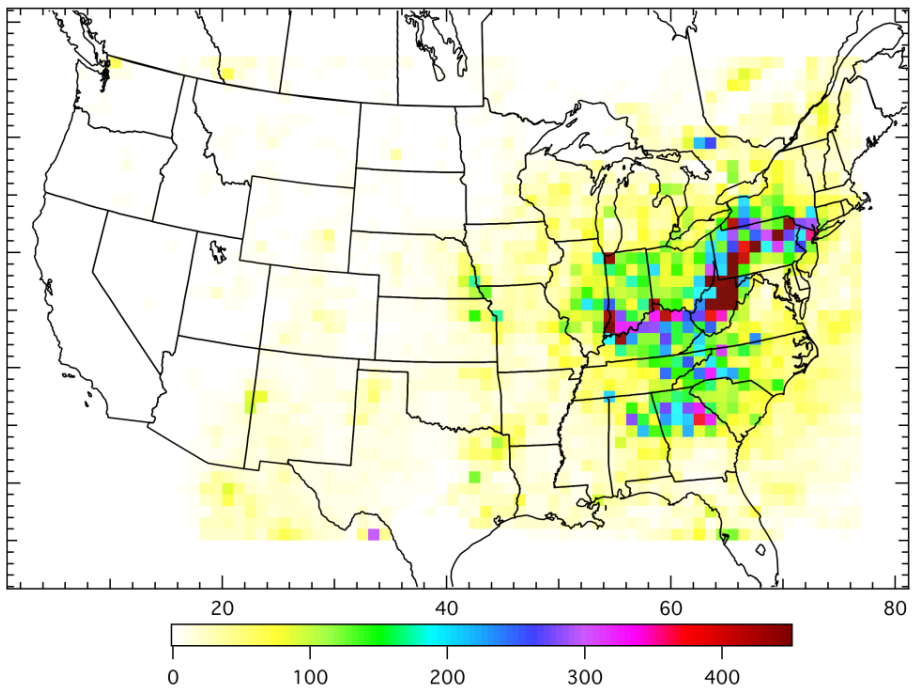
DAILY SULFATE CONCENTRATIONS, WRF-CHEM3.3 WITH WET REMOVAL (CMAQ AQ.CHEM)



SULFATE WET REMOVAL, AUGUST, 2006 (mg/m^2/month)

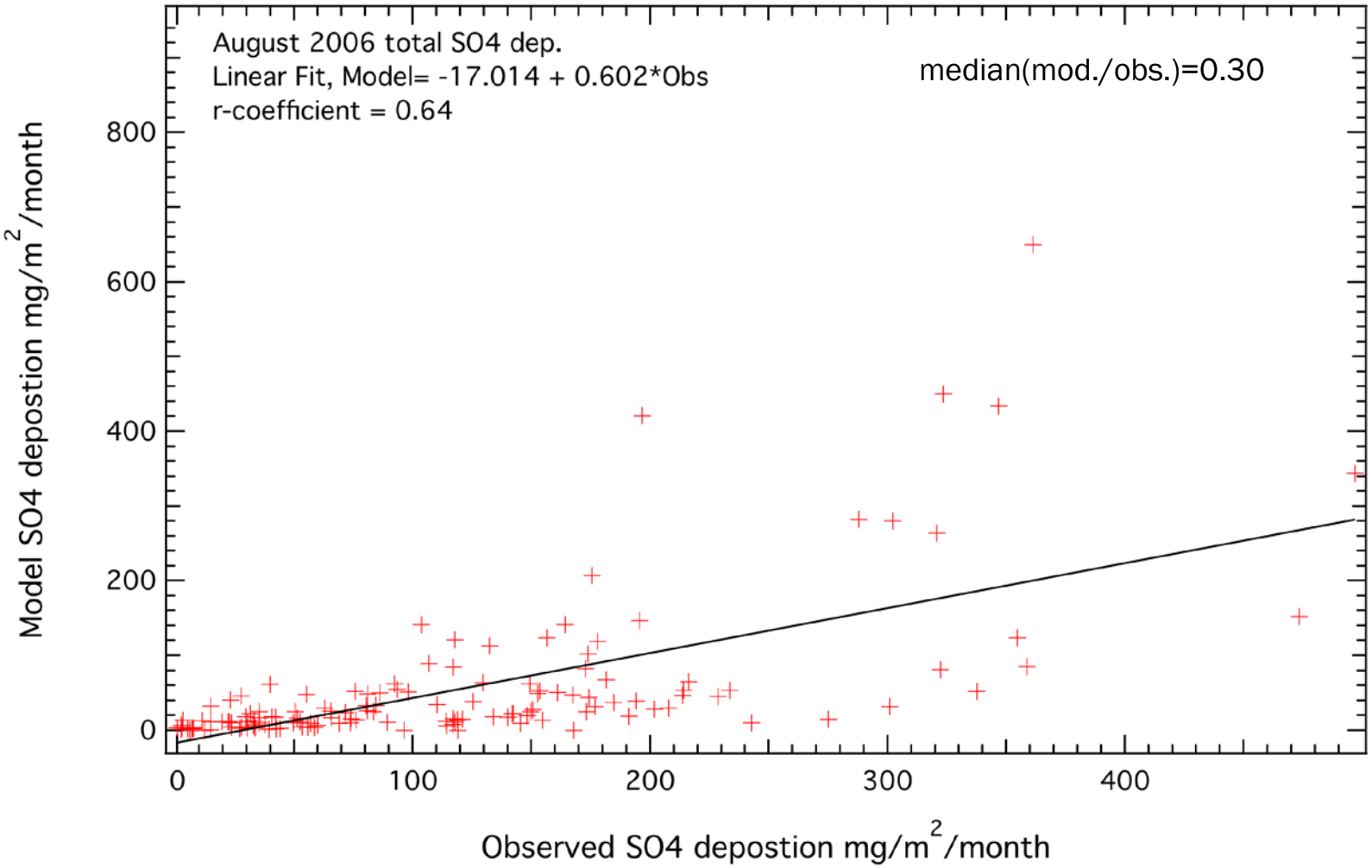


Observations



WRF-CHEM3.3, convective wet removal (Grell scheme)

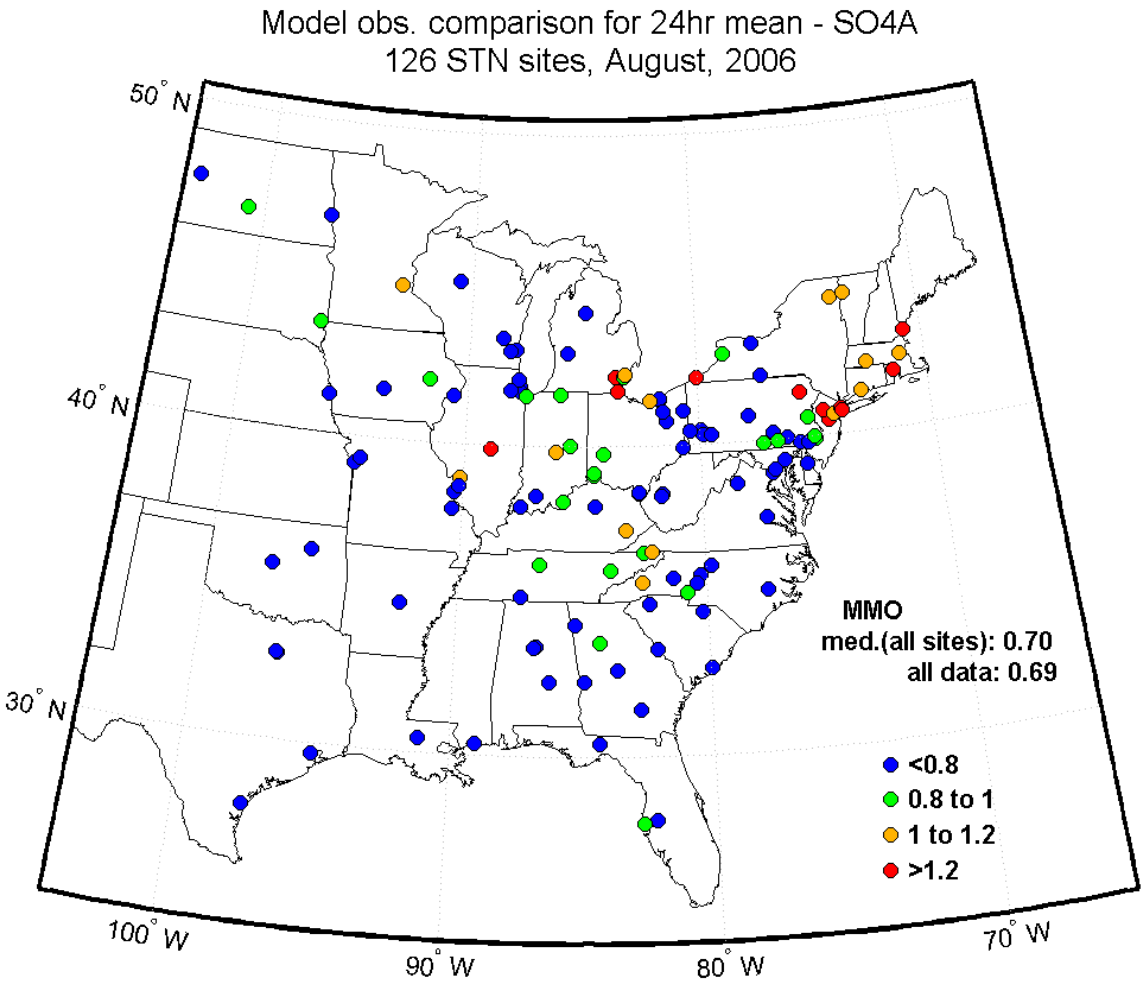
MODEL-OBSERVED SO4 WET DEPOSITION (AUGUST 2006)

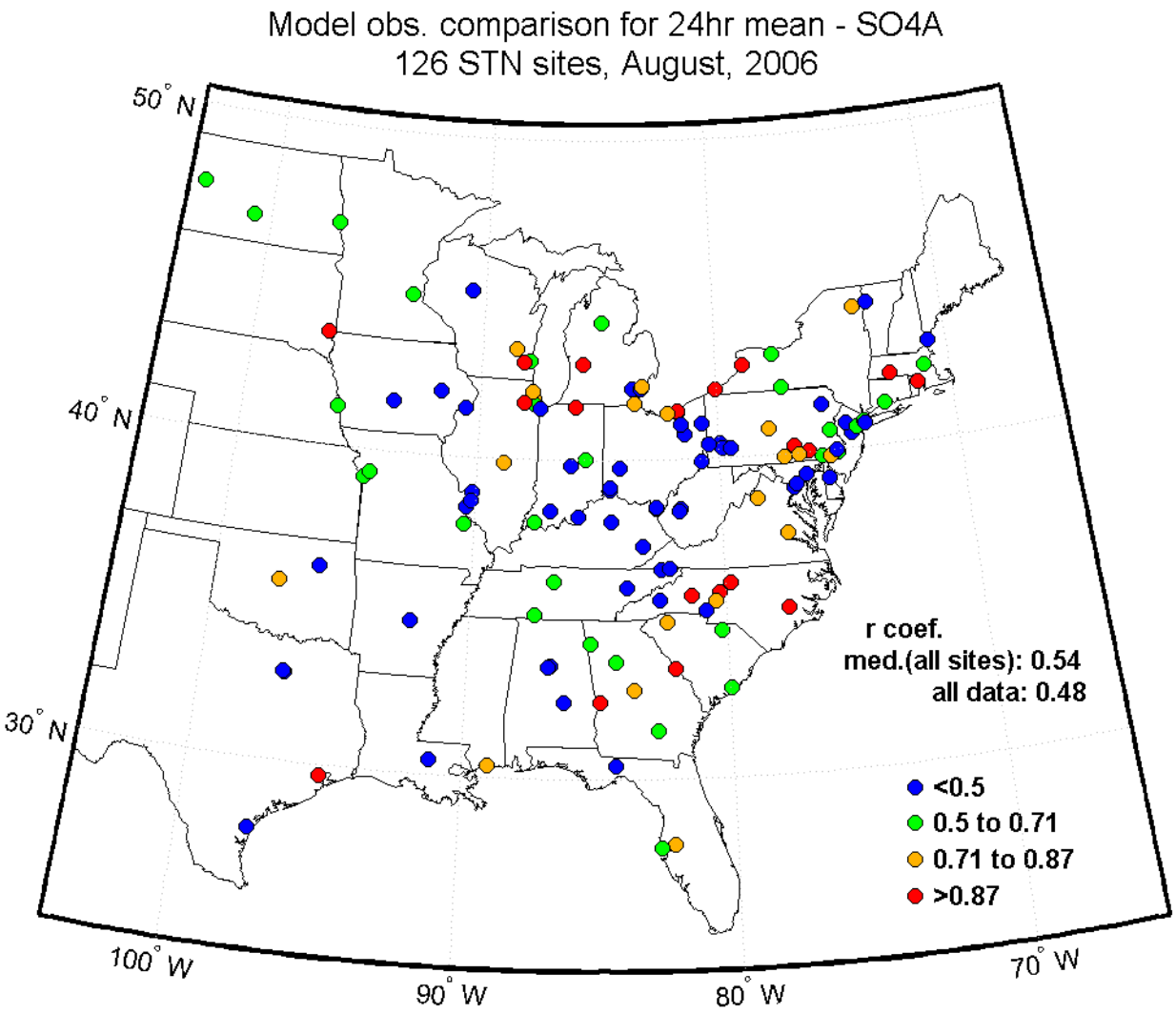


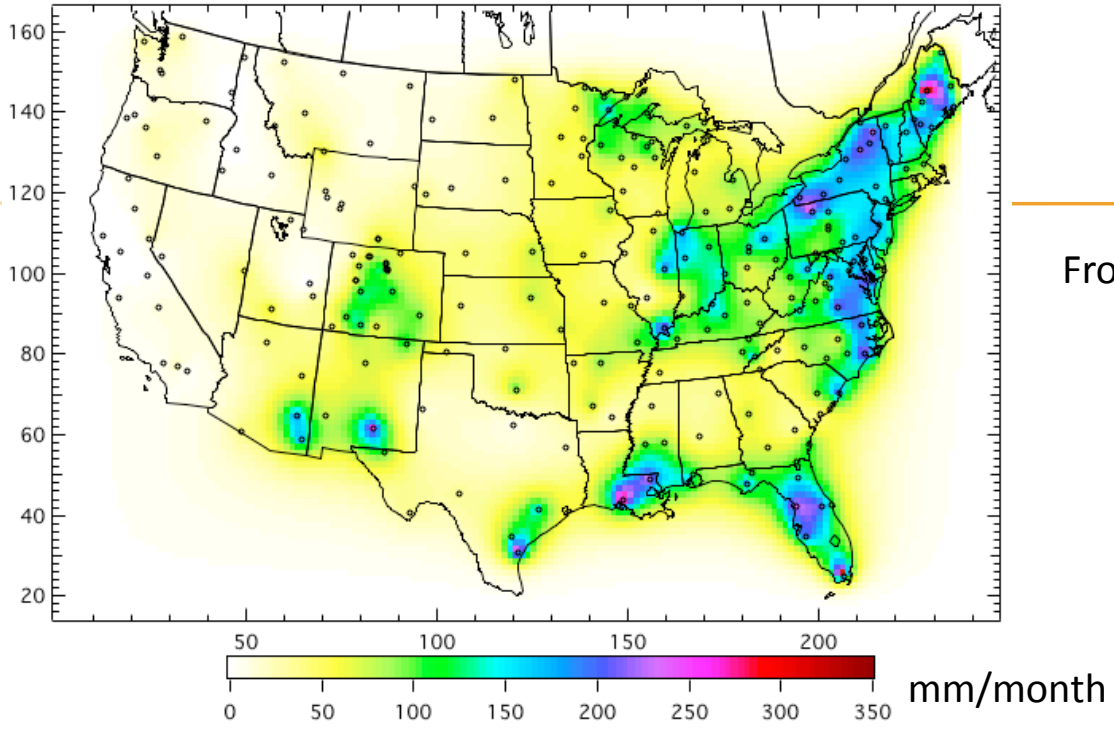
WRF-CHEM 3.3 with convective only wet removal (Grell scheme)

CONCLUDING REMARKS

- Reasonable correlations for rain and wet removal, still sulfate removal and concentrations are under-estimated
- Strong need for extensive evaluation of wet removal in WRF-CHEM different scales, resolved and sub-grid precipitation
- Improvement of sulfate simulations – cloud phase conversion, wet and dry removal
- CMAQ aqueous chemistry needs to be coupled to resolved clouds as well
- Role of cloud fraction (SO2->SO4 conversion, feedback on radiation and photolysis)
- Implementation of wet removal for other gaseous and particle species

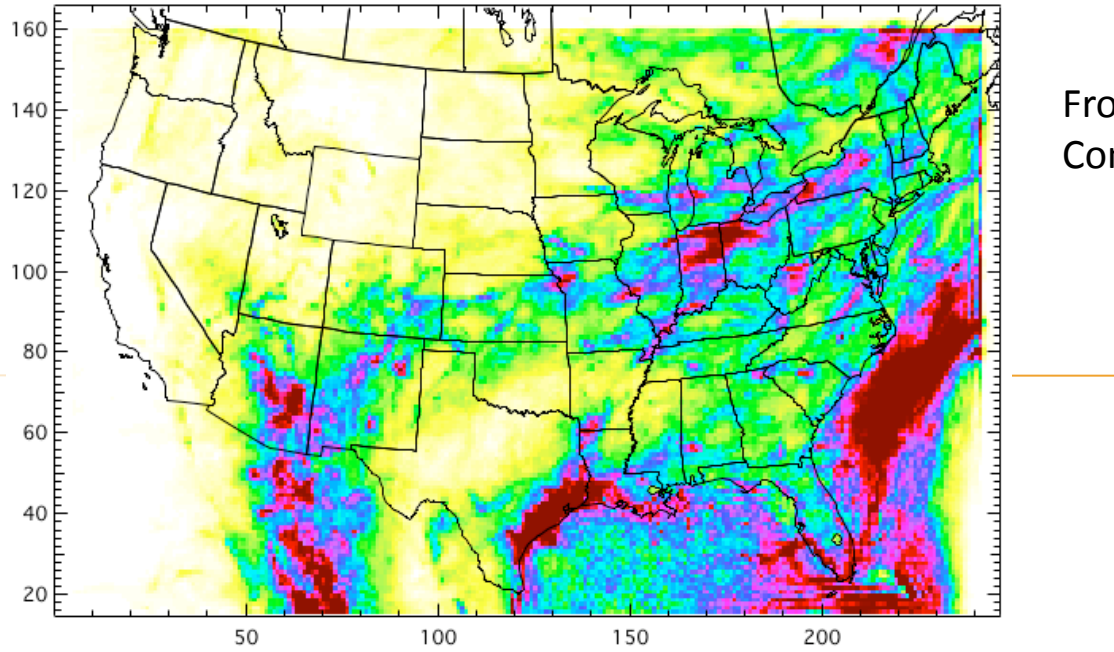

Model obs. comparison for 24hr mean - SO4A
126 STN sites, August, 2006
50° N
40° N
30° N
100° W
90° W
80° W
70° W
MMO
med.(all sites): 0.70
all data: 0.69
<0.8
0.8 to 1
1 to 1.2
>1.2


Model obs. comparison for 24hr mean - SO4A
126 STN sites, August, 2006
50° N
40° N
30° N
100° W
90° W
80° W
70° W
r coef.
med.(all sites): 0.54
all data: 0.48
<0.5
0.5 to 0.71
0.71 to 0.87
>0.87



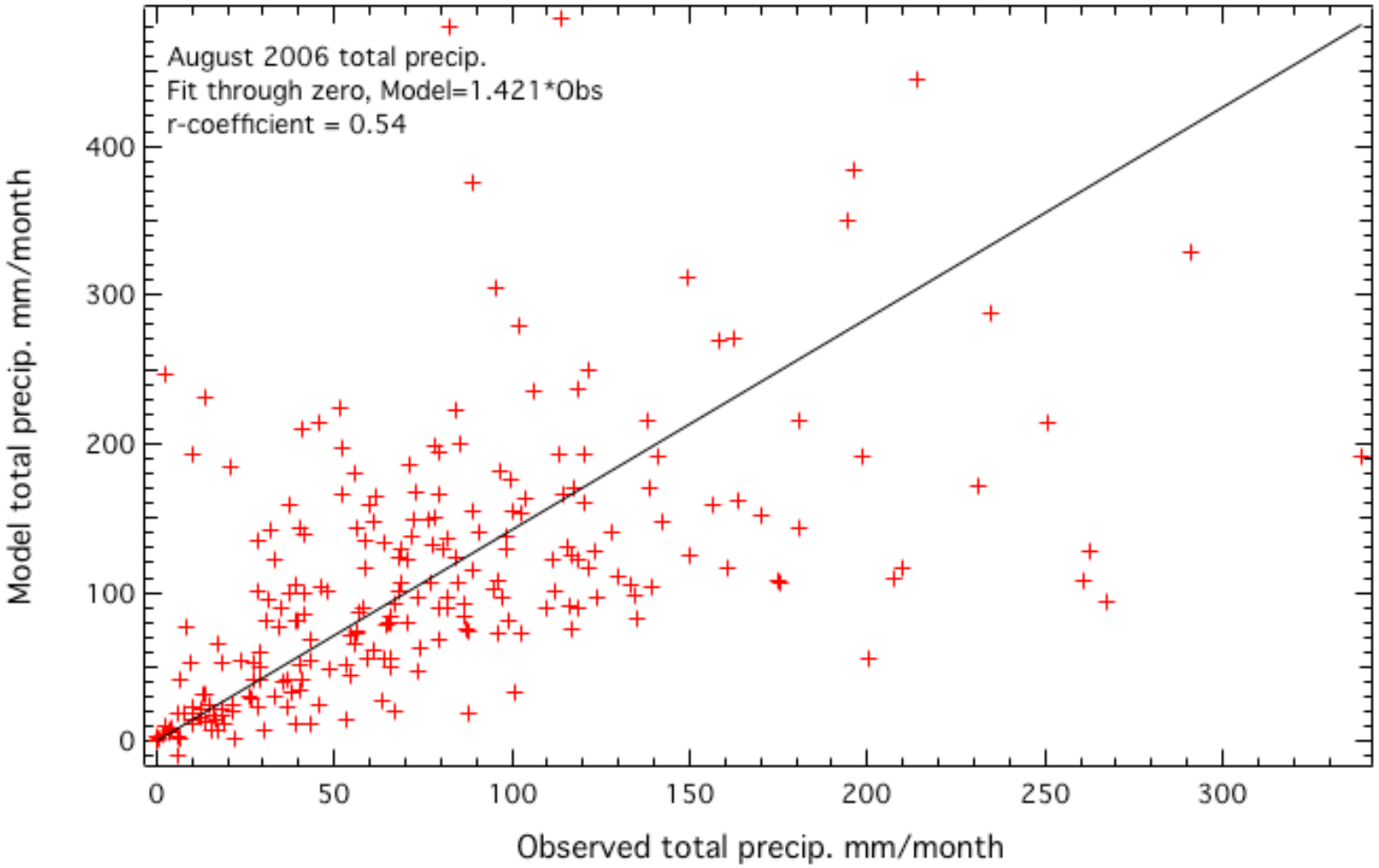
July 2006 rainfall totals

From NADP/NTN network

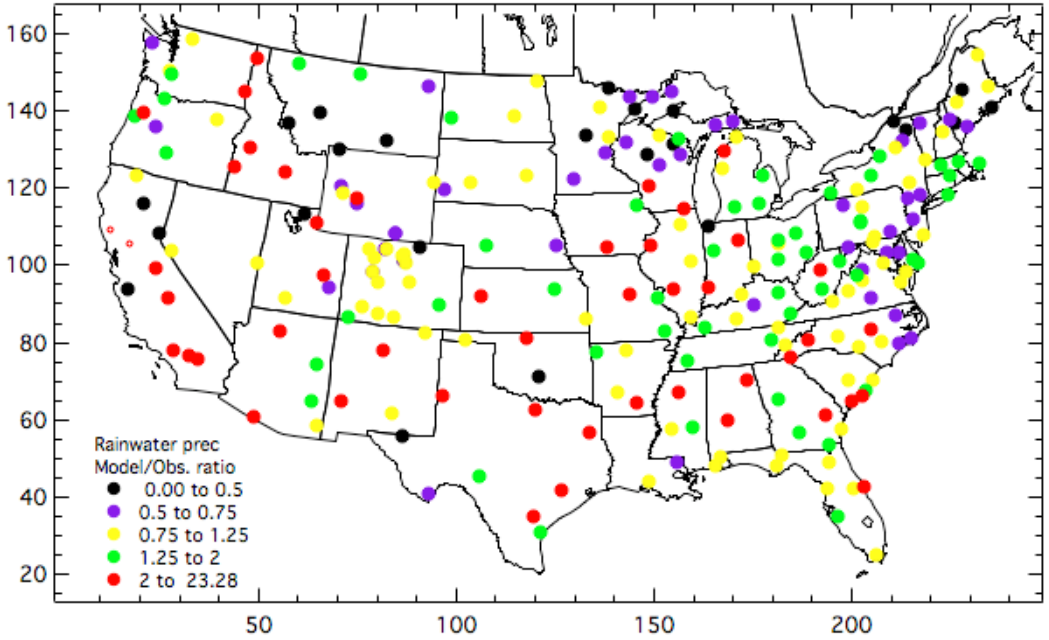


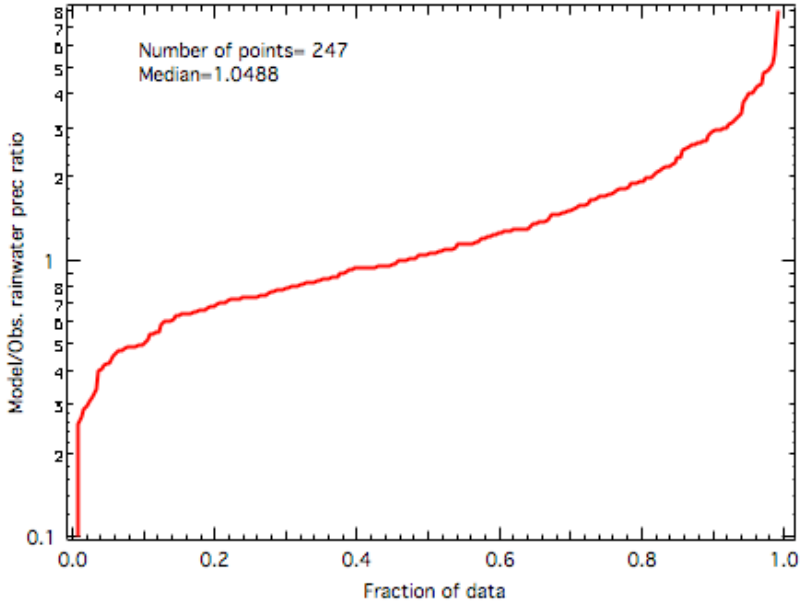
From Jan's 20km WRF/Chem
Convective plus Nonconvective

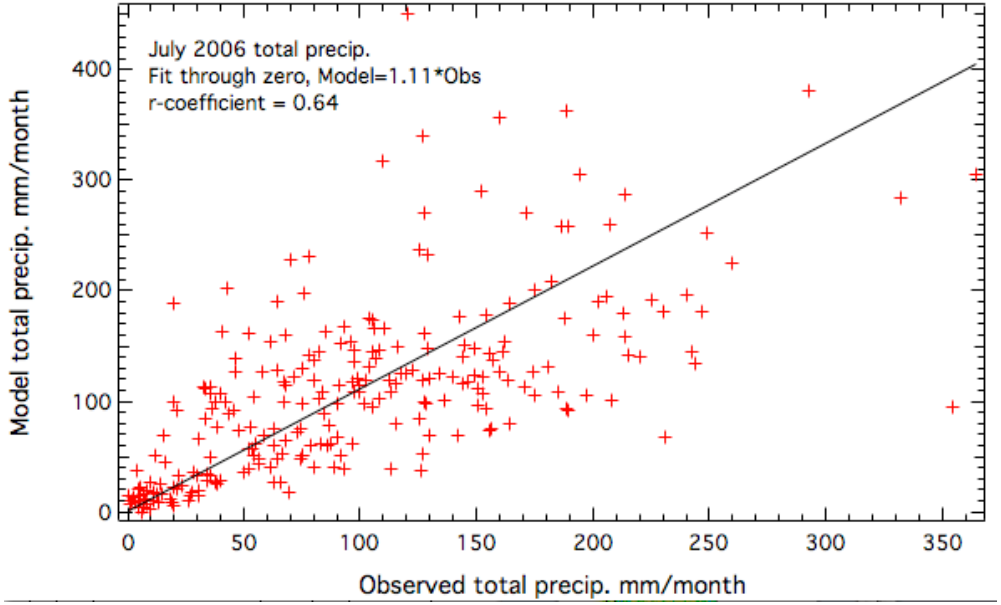
NADP NETWORK, EVALUATION OF RAINFALL

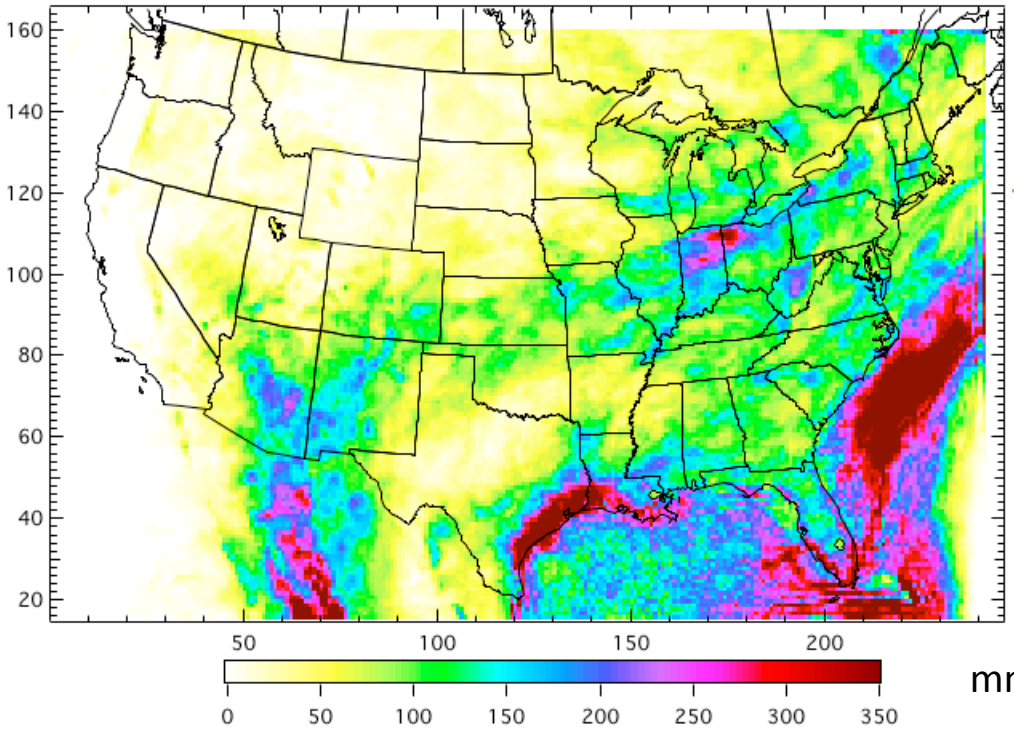


Model/Observed Total Rainfall (July 2006)



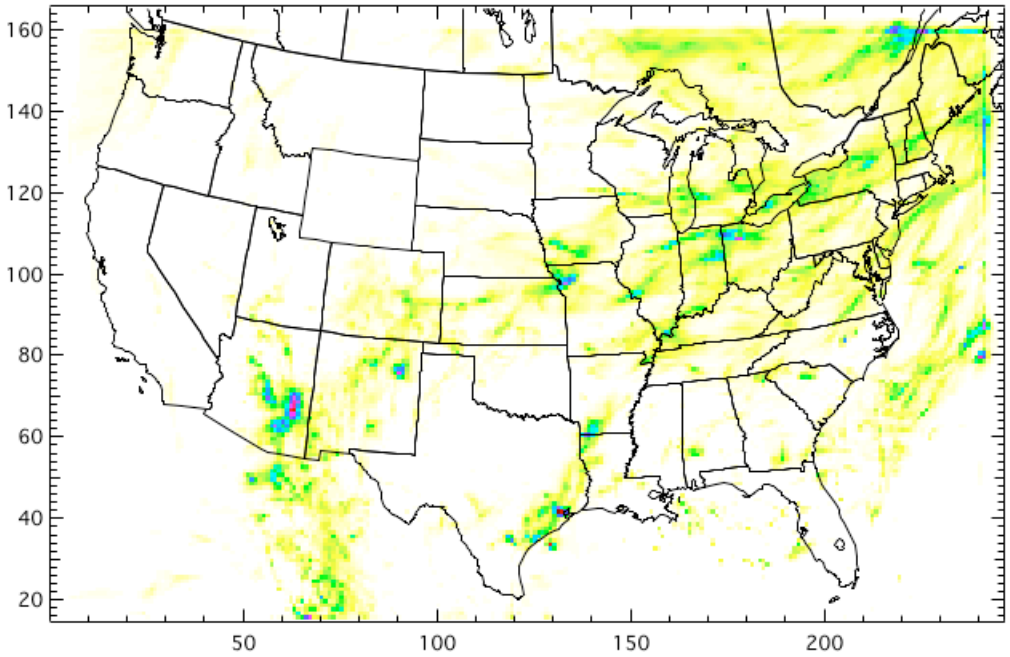






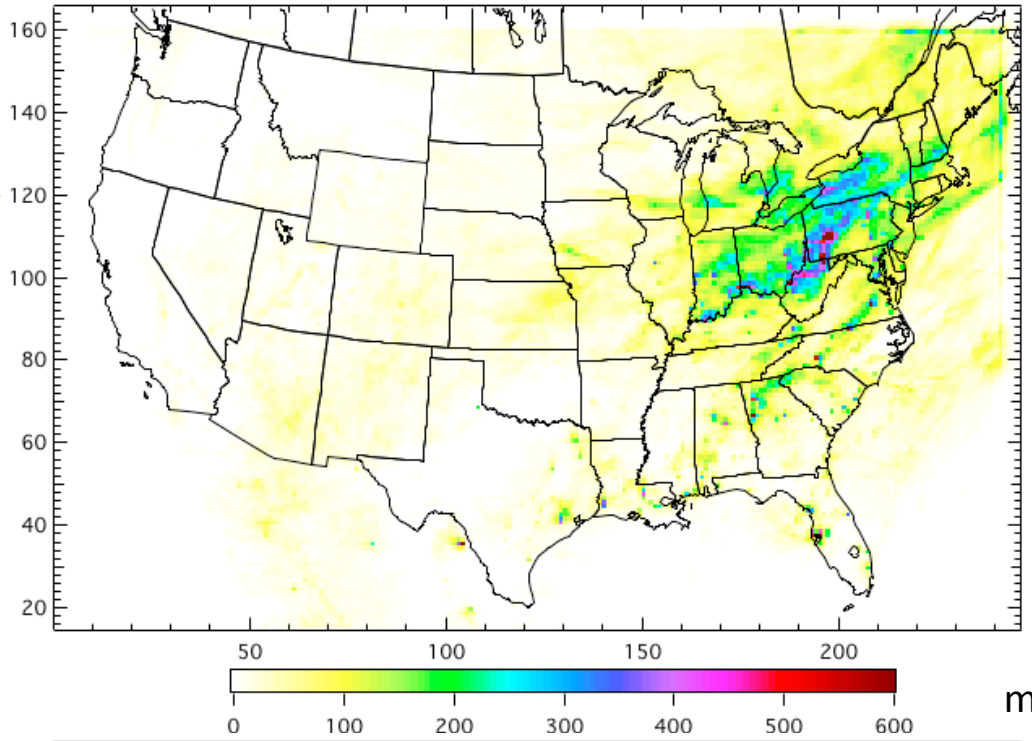
WRF/Chem July 2006 total Convective Rainfall

mm/month



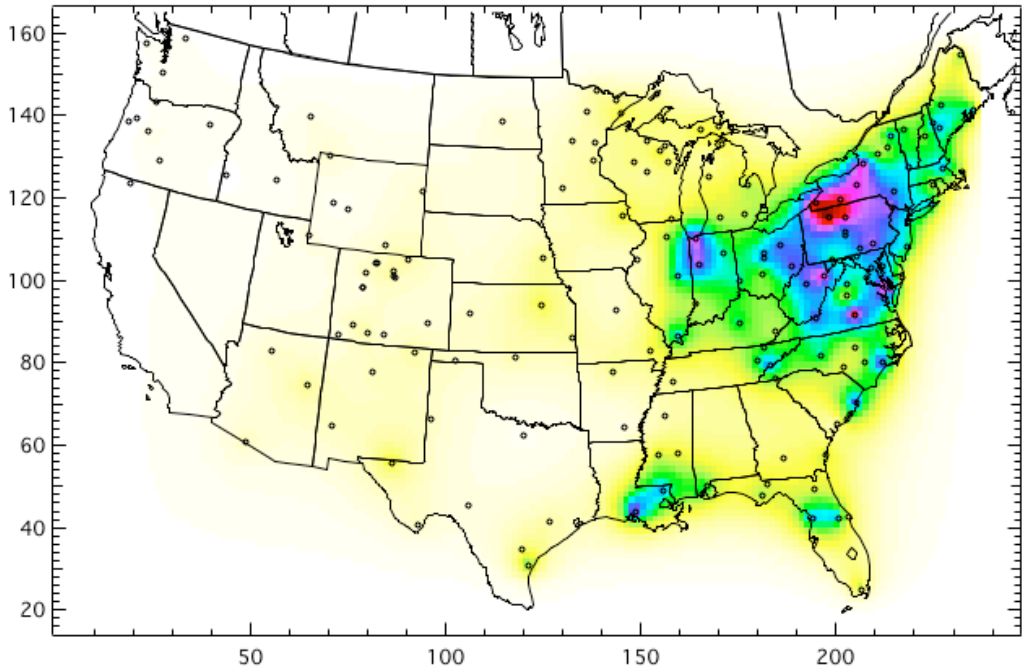
WRF/Chem July 2006 total Nonconvective Rainfall

July 2006 SO4 wet deposition



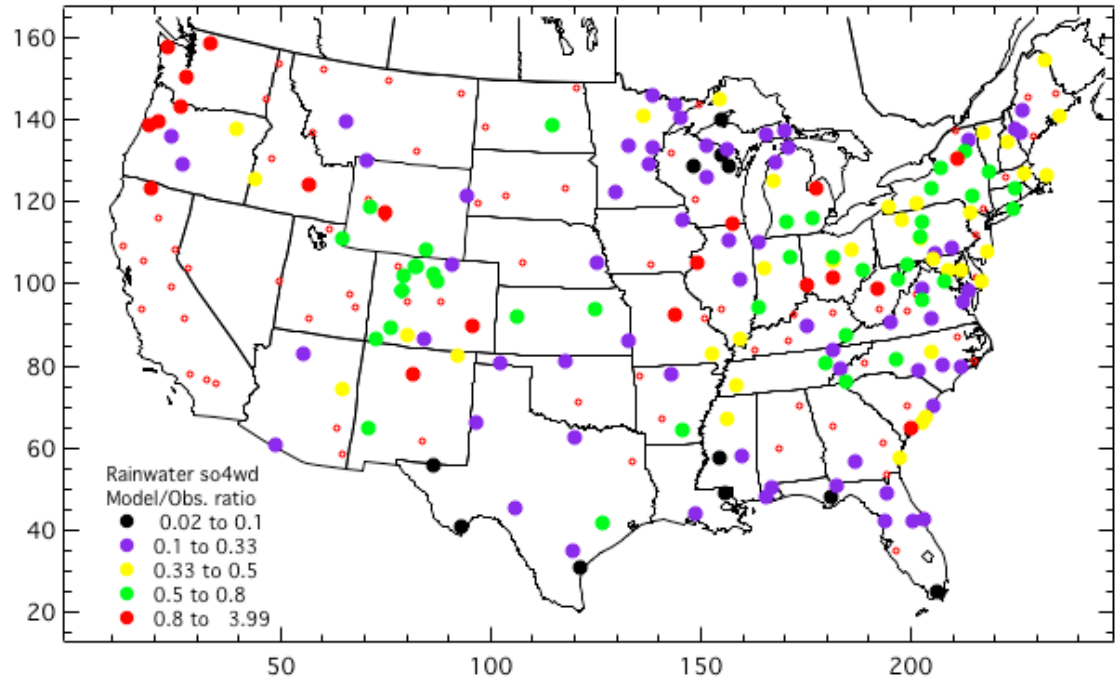
From Jan Kazil 20km WRF/Chem

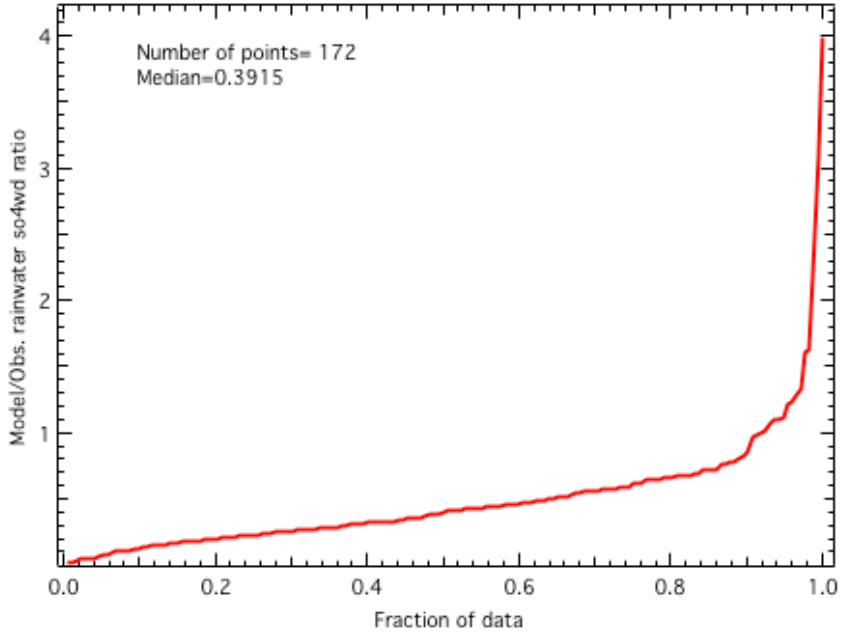
$mg/m^2/month$

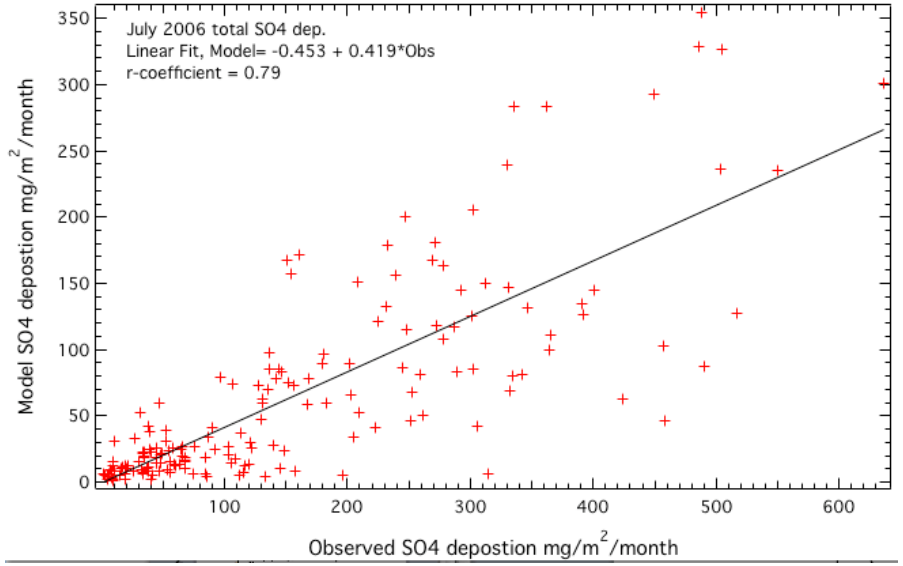


From NADP/NTN network

Model/Observed SO4 wet deposition (July 2006)

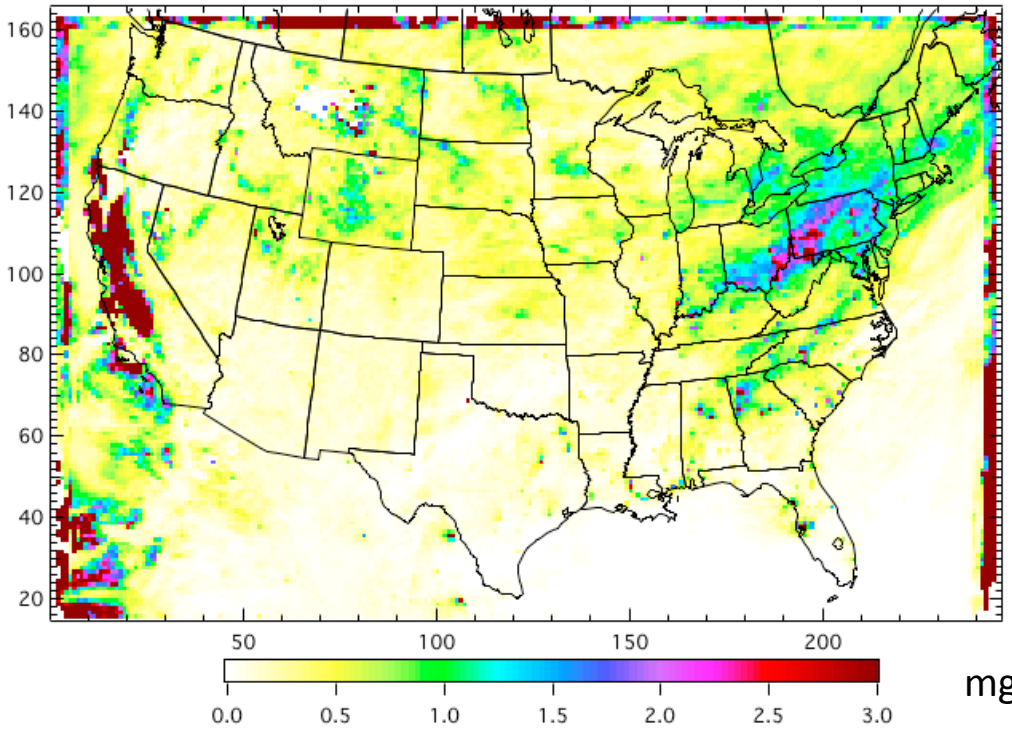






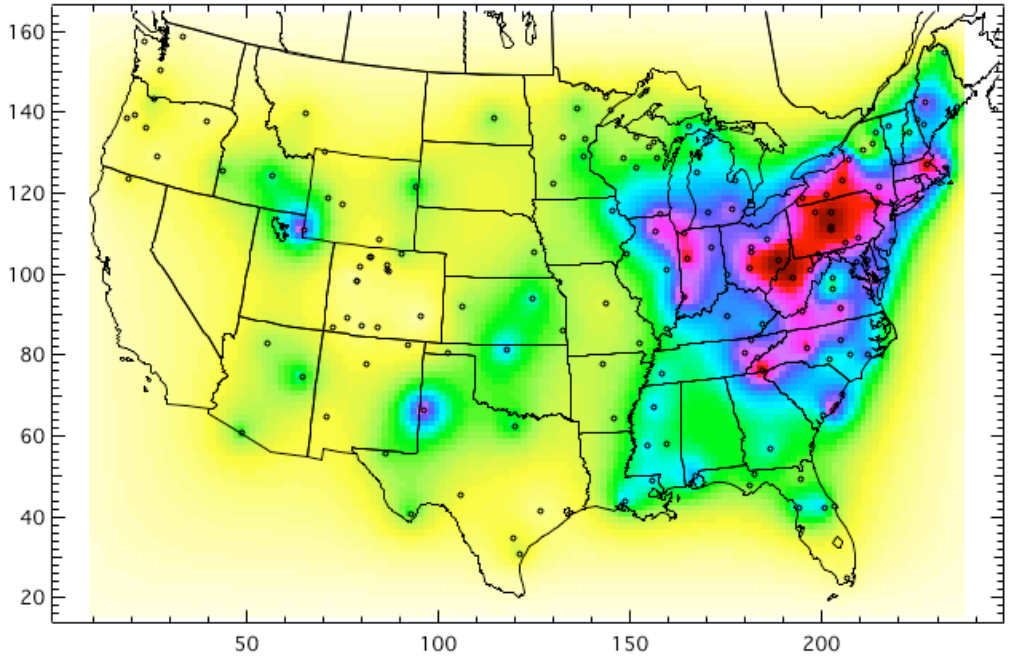
July 2006 SO4 average rainwater concentration

From Jan Kazil 20km WRF/Chem

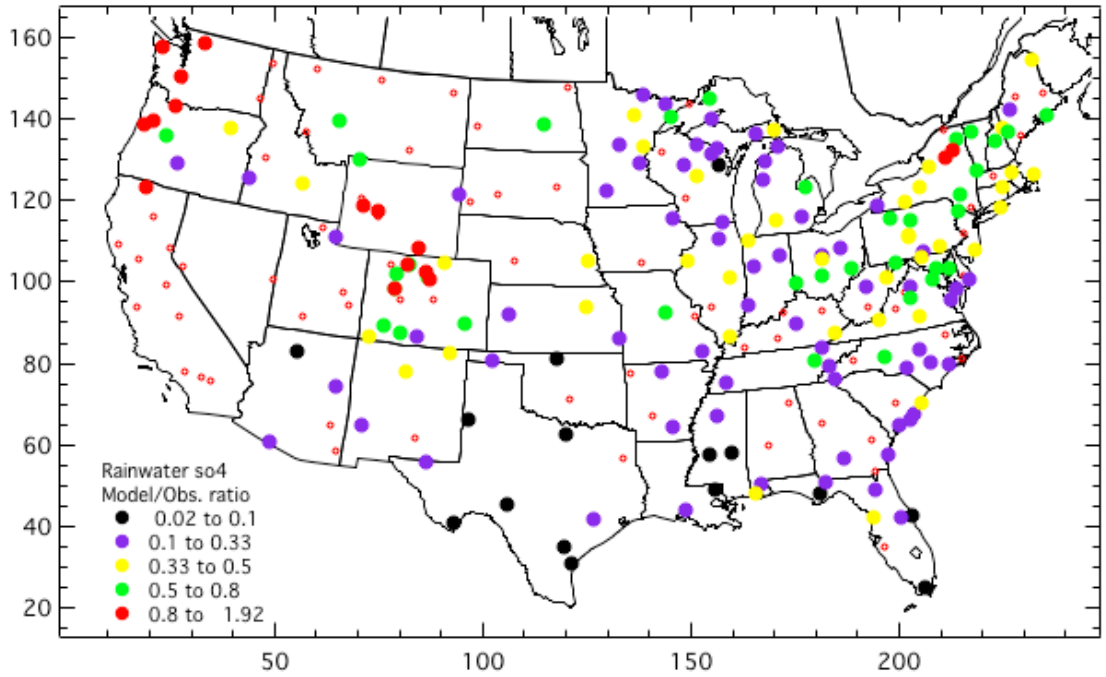


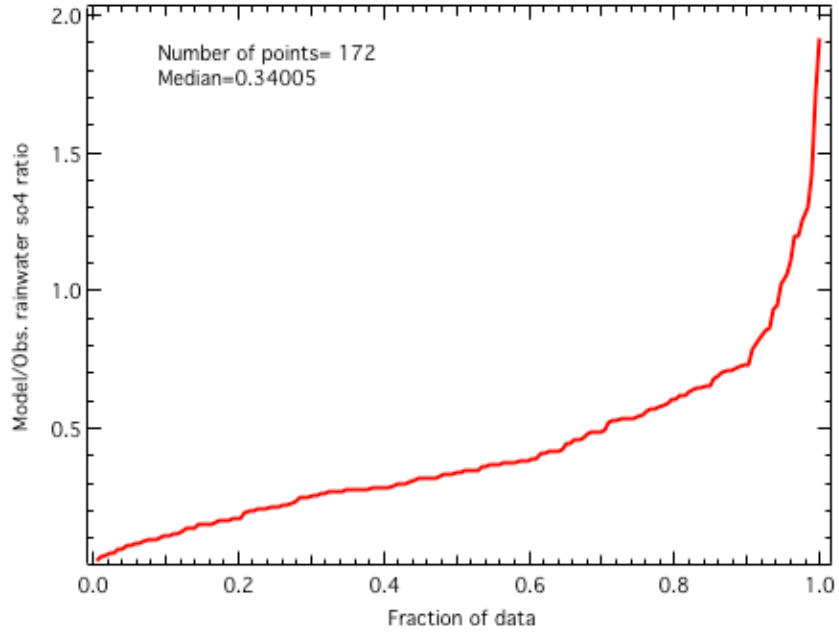
mg/liter

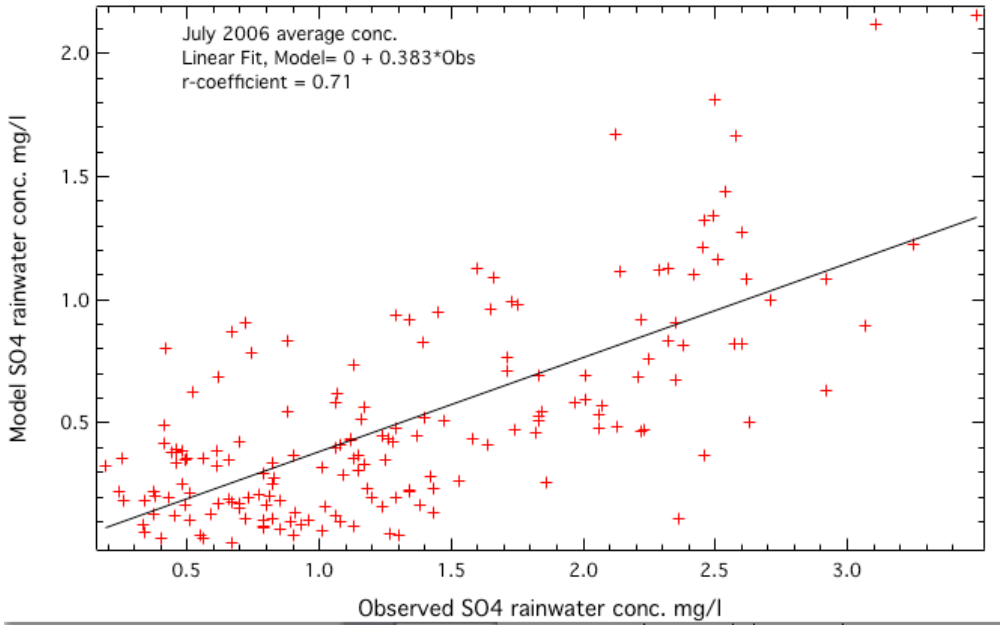
From NADP/NTN network



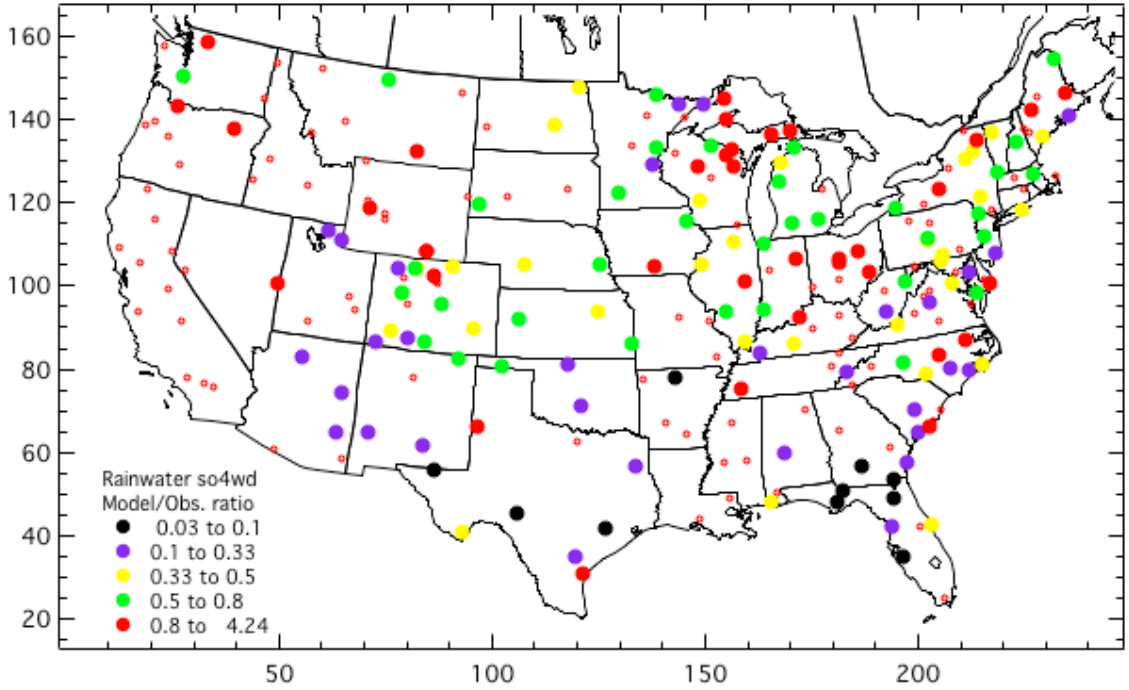
Model/Observed SO4 rainwater concentration (July 2006)

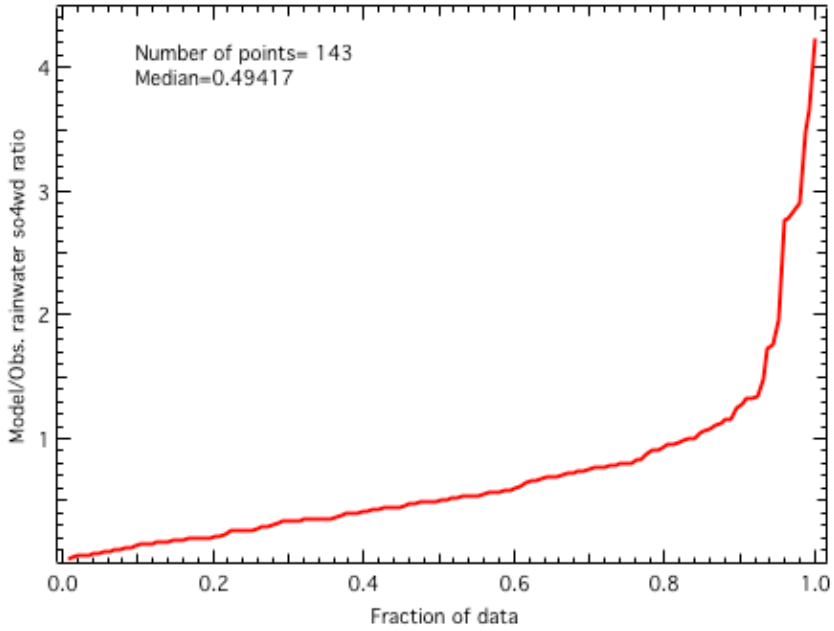


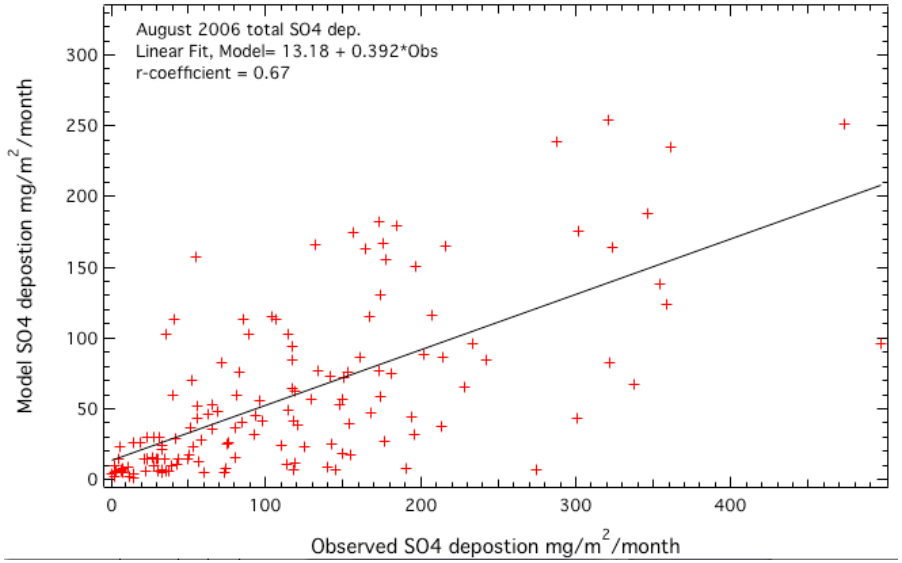




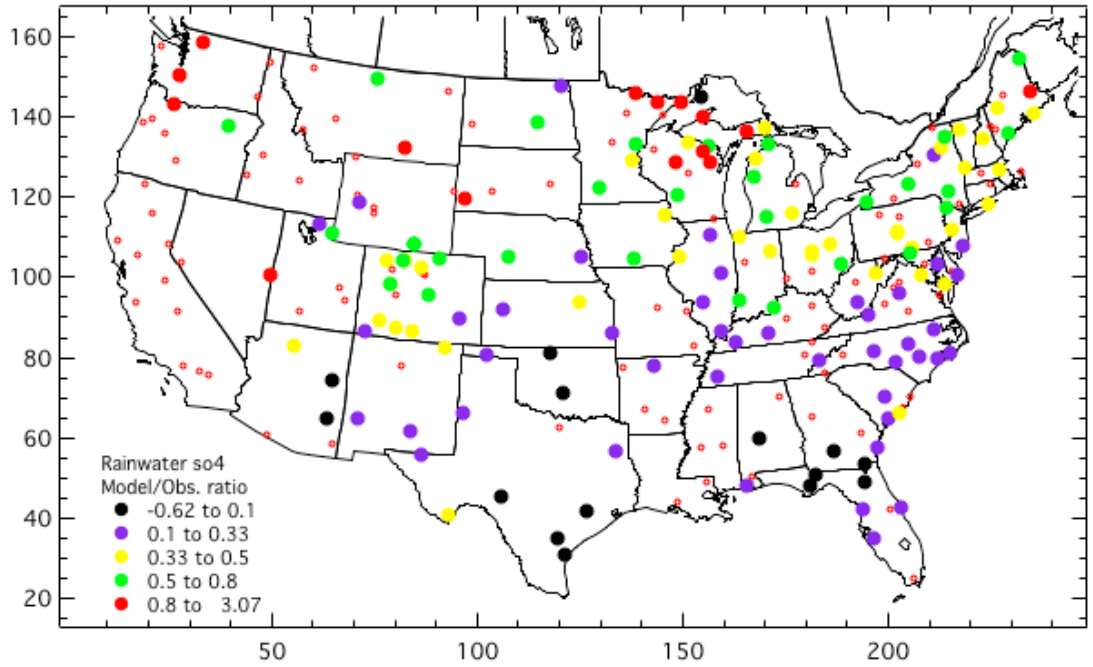
Model/Observed SO4 wet deposition (August 2006)

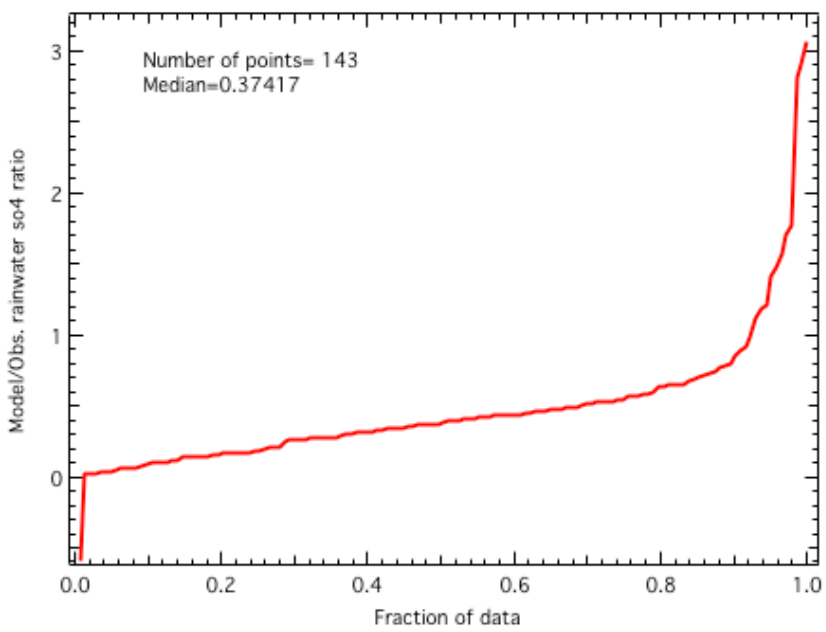


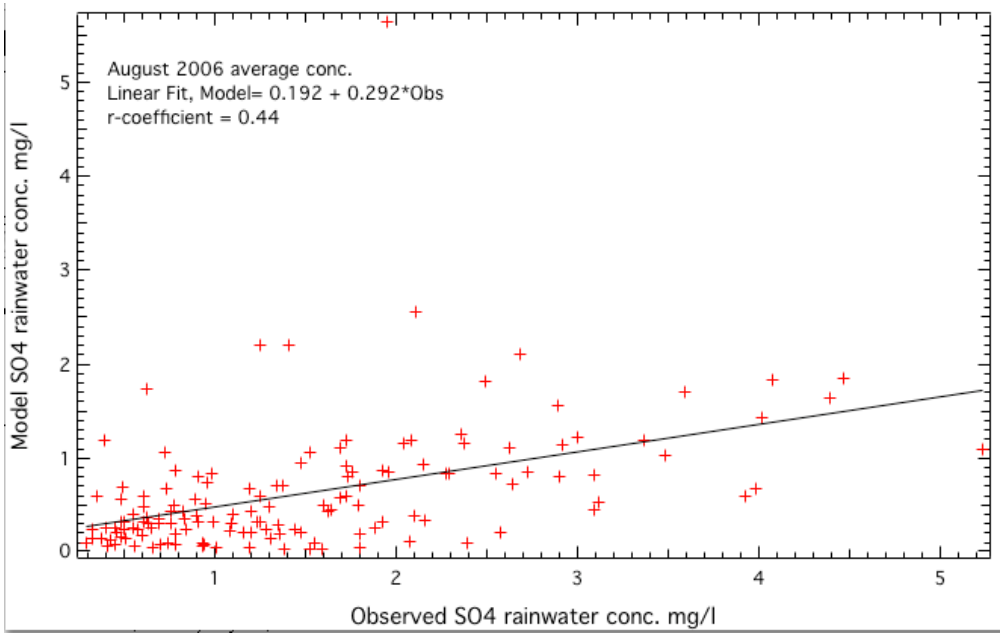




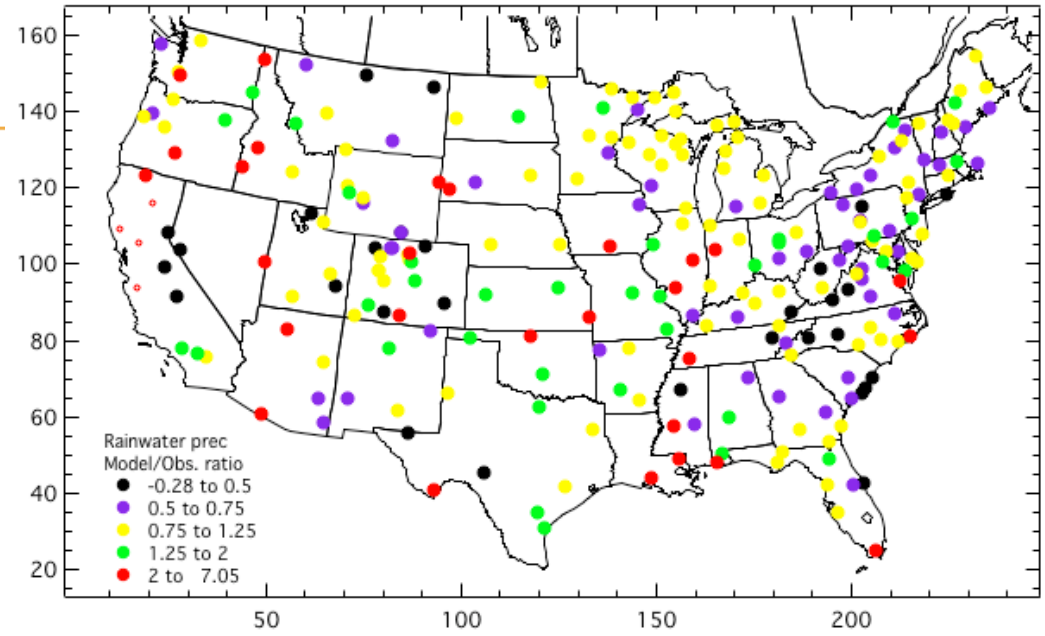
Model/Observed SO4 rainwater concentration (August 2006)

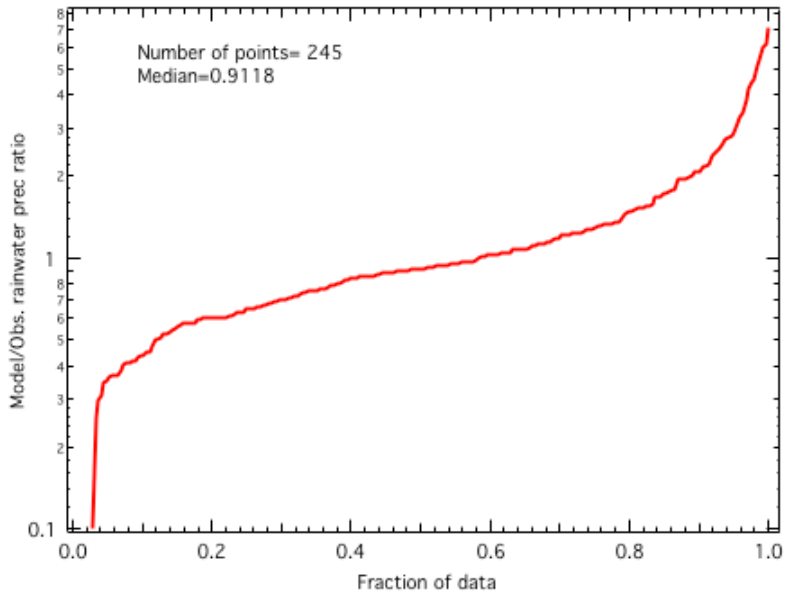


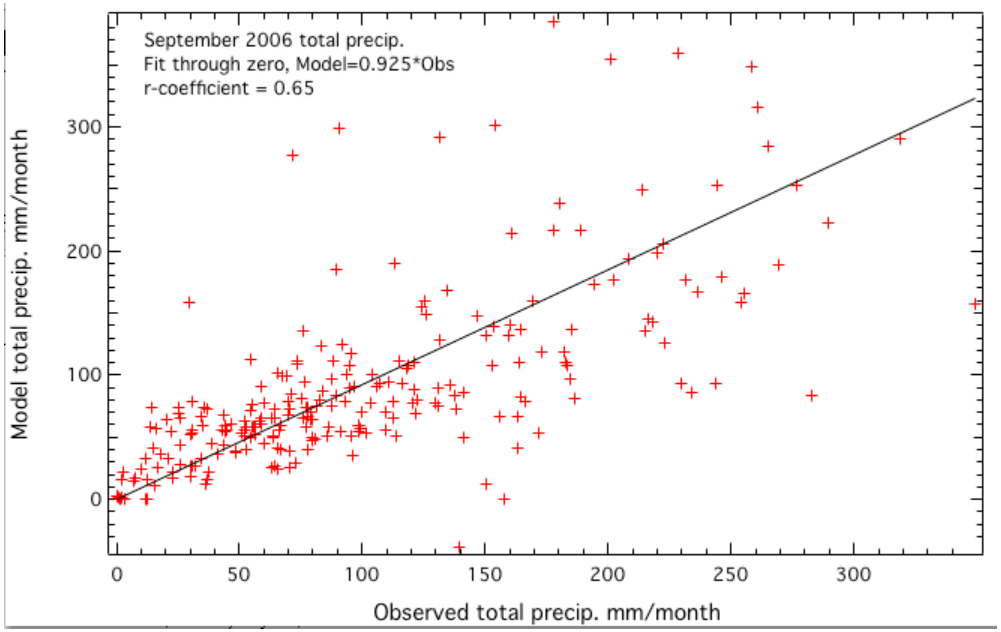




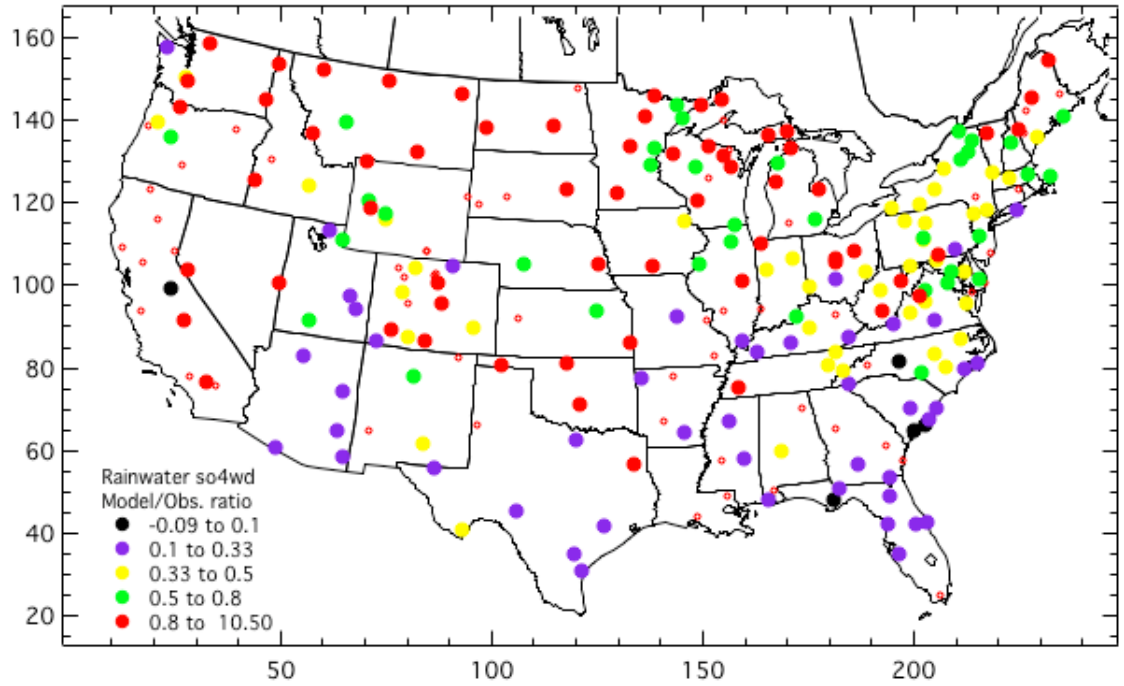
Model/Observed Total Rainfall (September 2006)

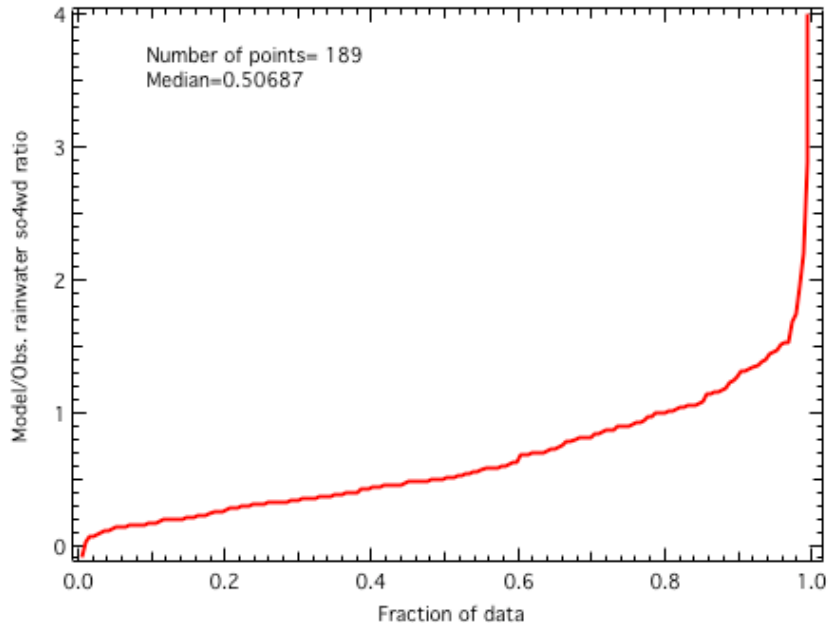


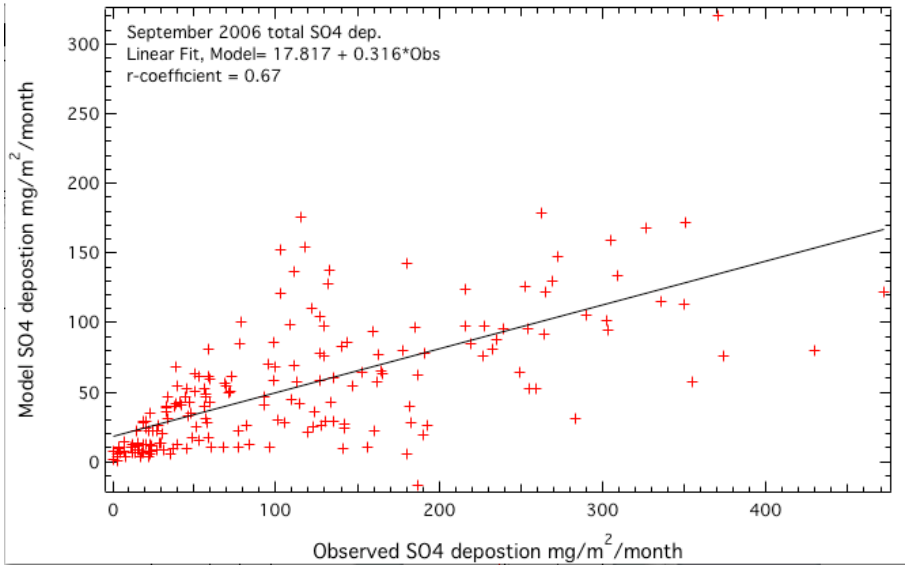




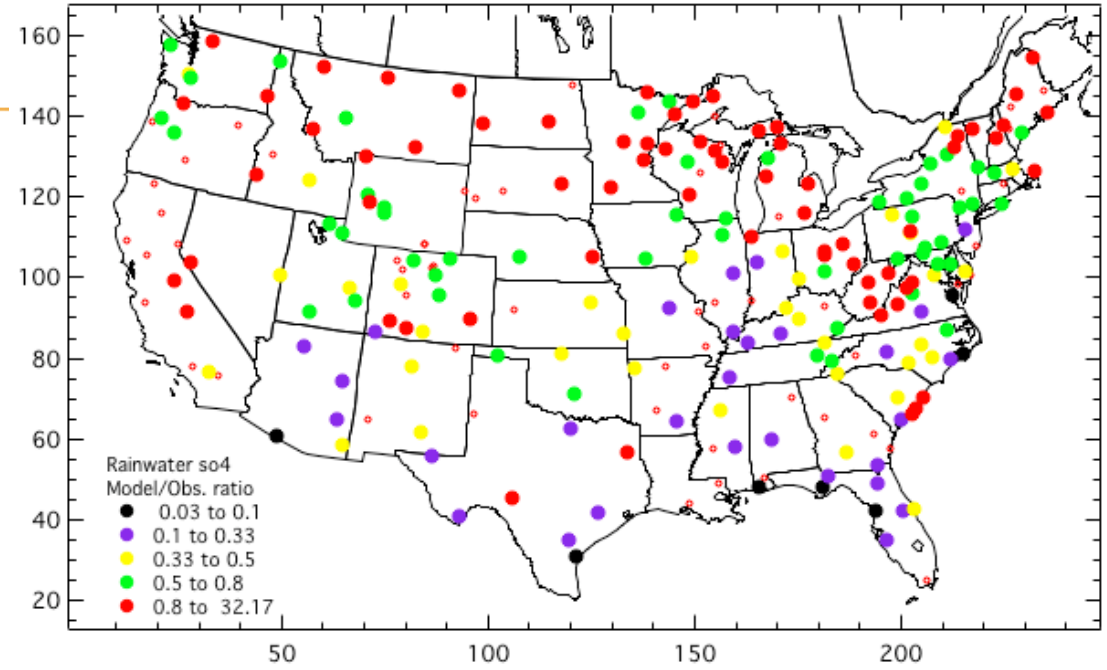
Model/Observed SO4 wet deposition (September 2006)

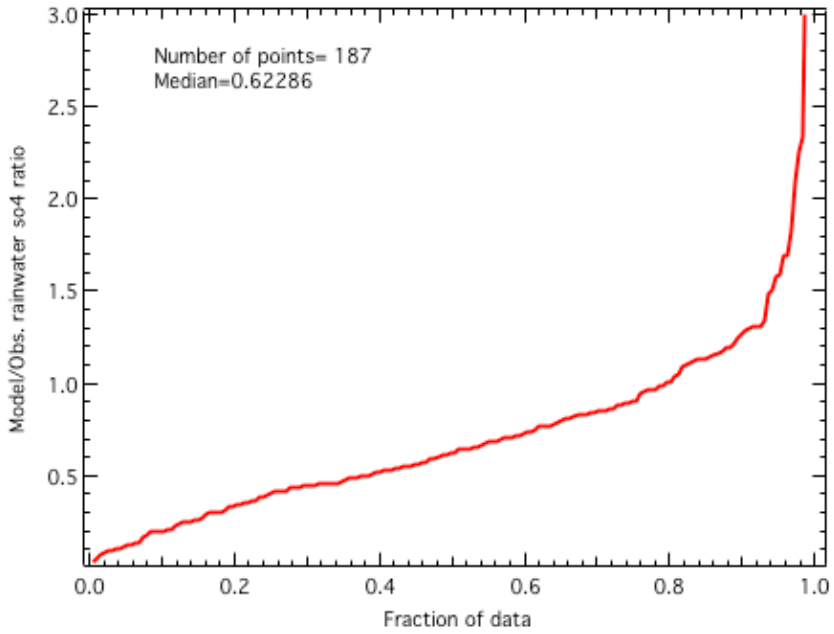


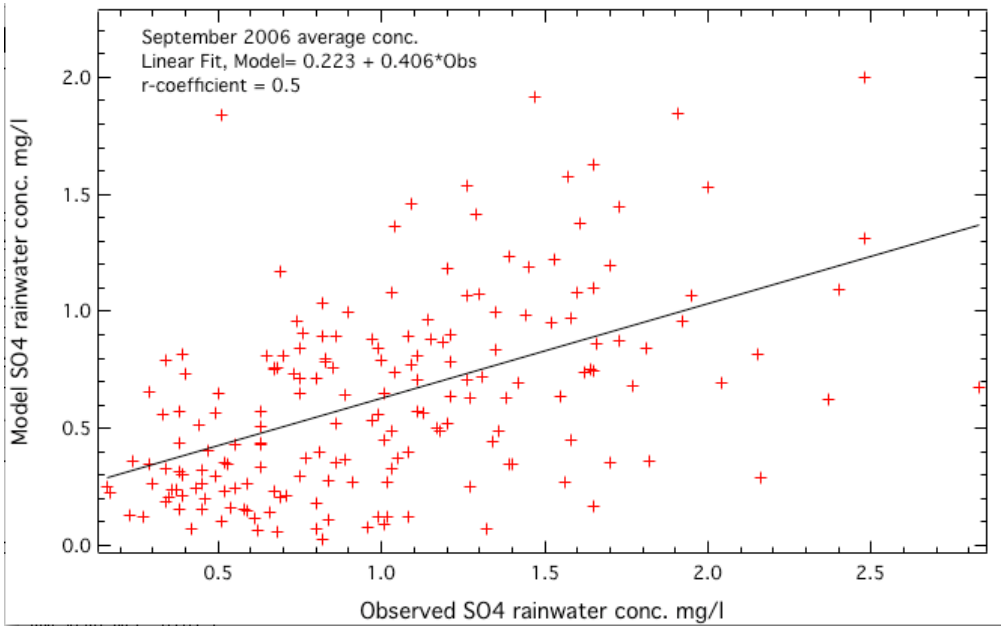




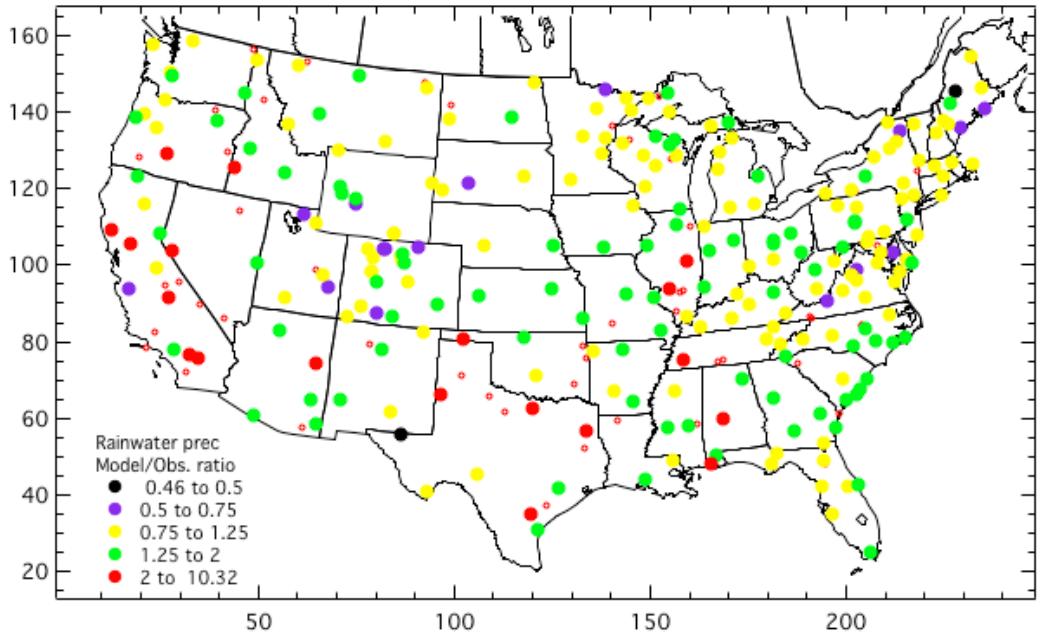
Model/Observed SO4 rainwater concentration (September 2006)

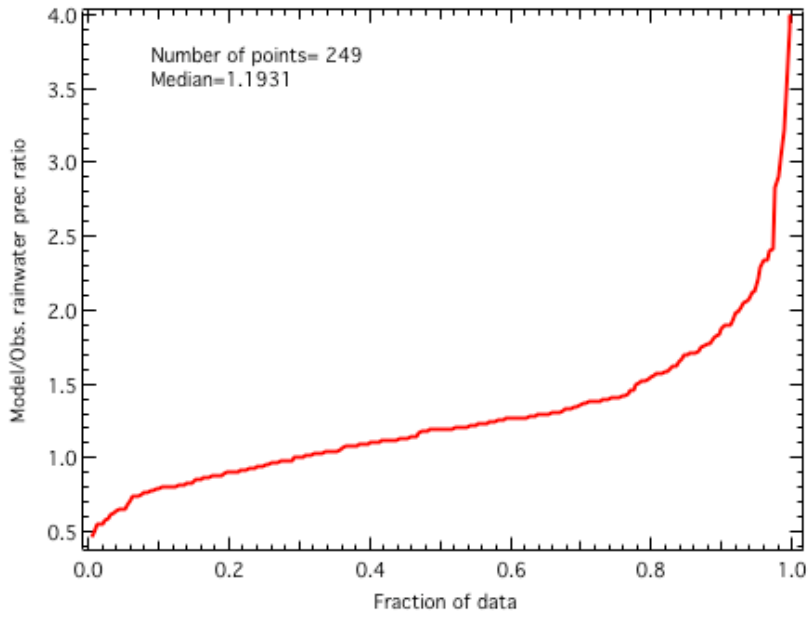


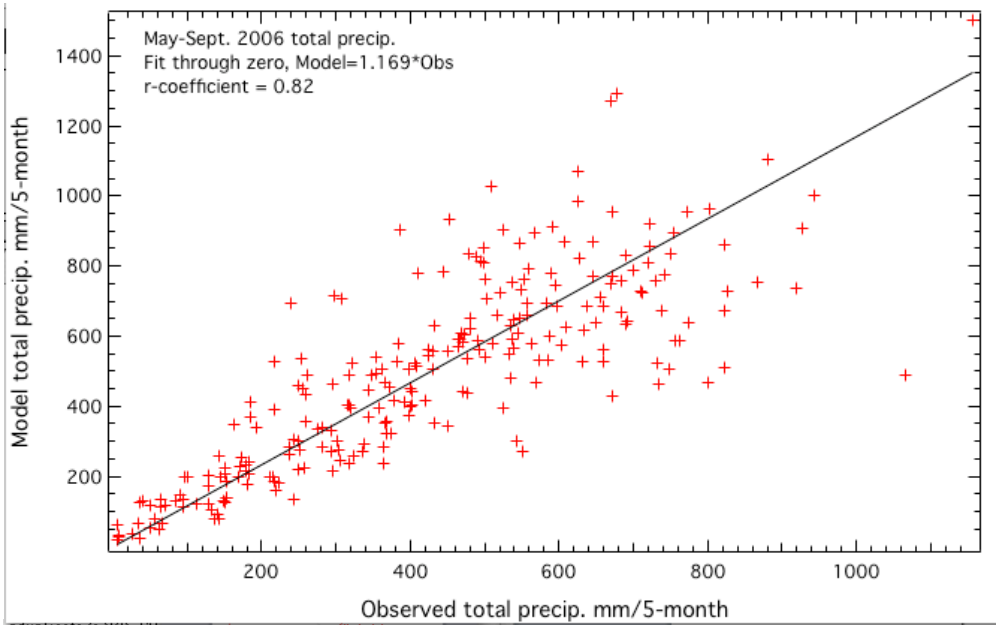




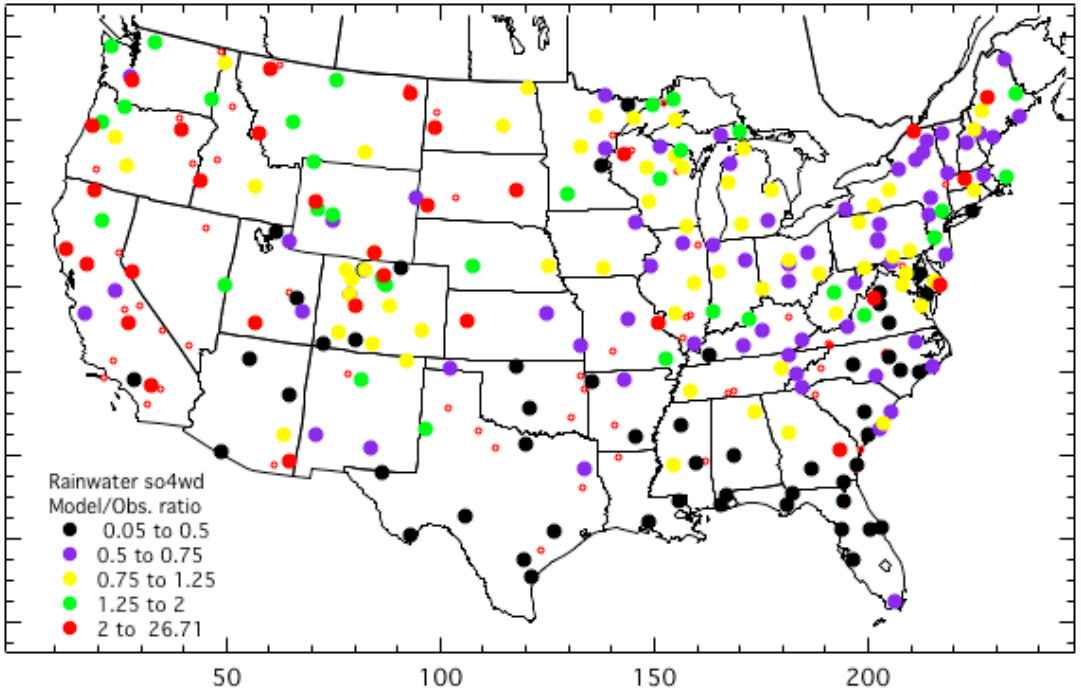
Model/Observed Total Rainfall (May through September 2006)

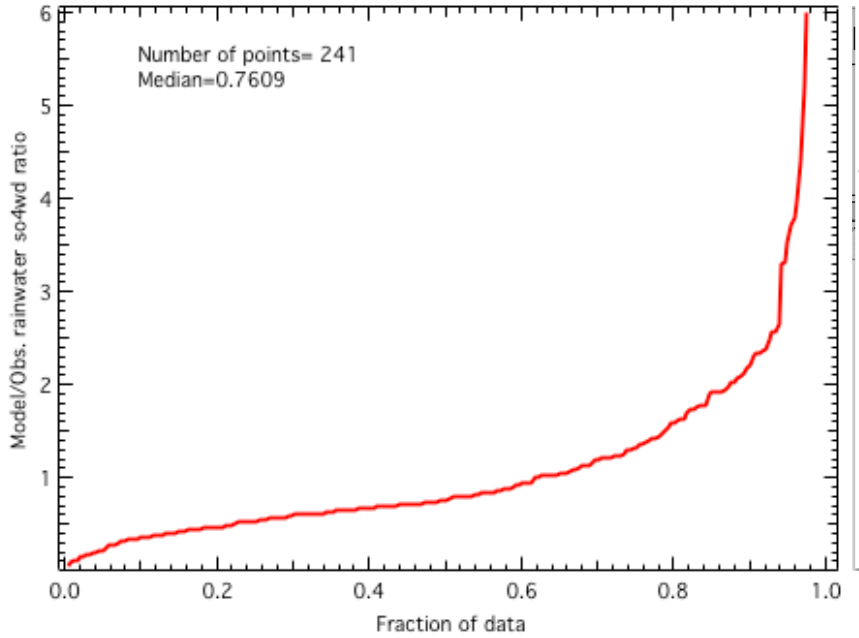


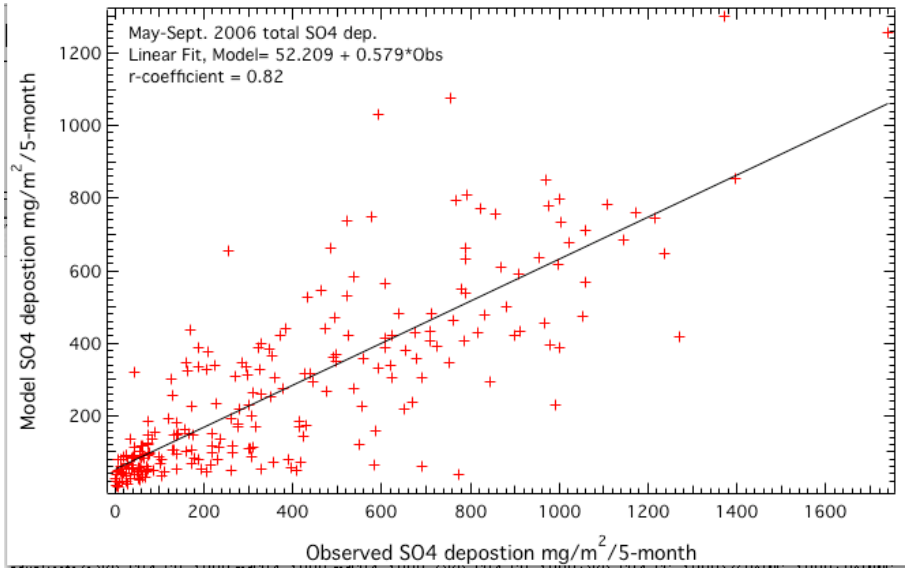




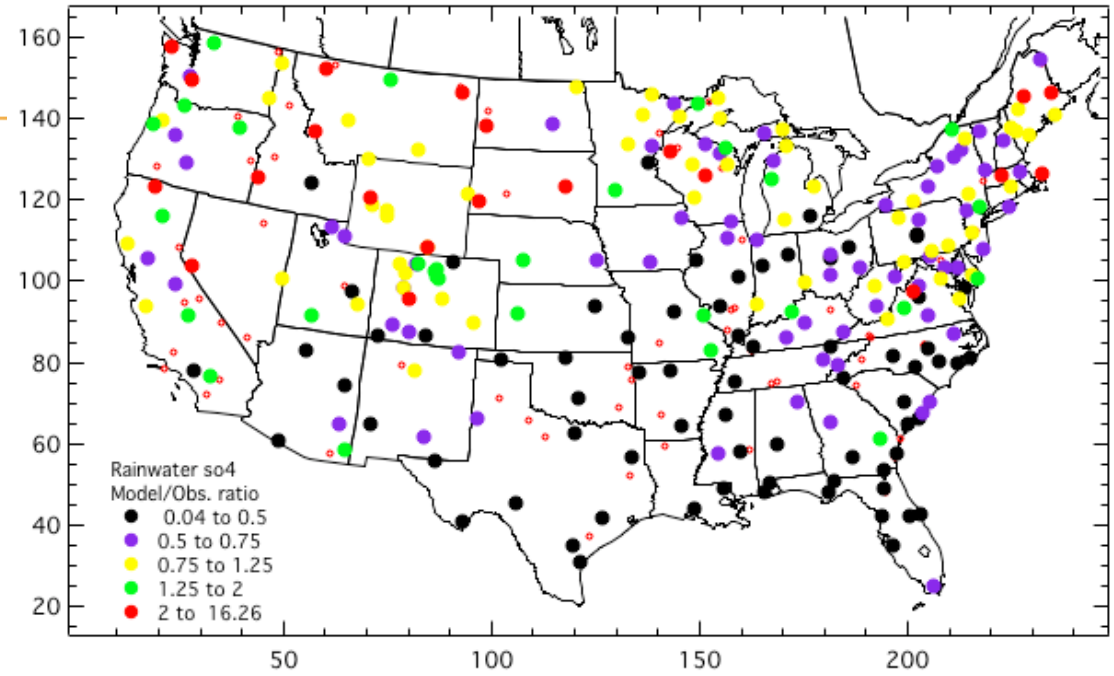
Model/Observed SO4 wet deposition (May through September 2006)

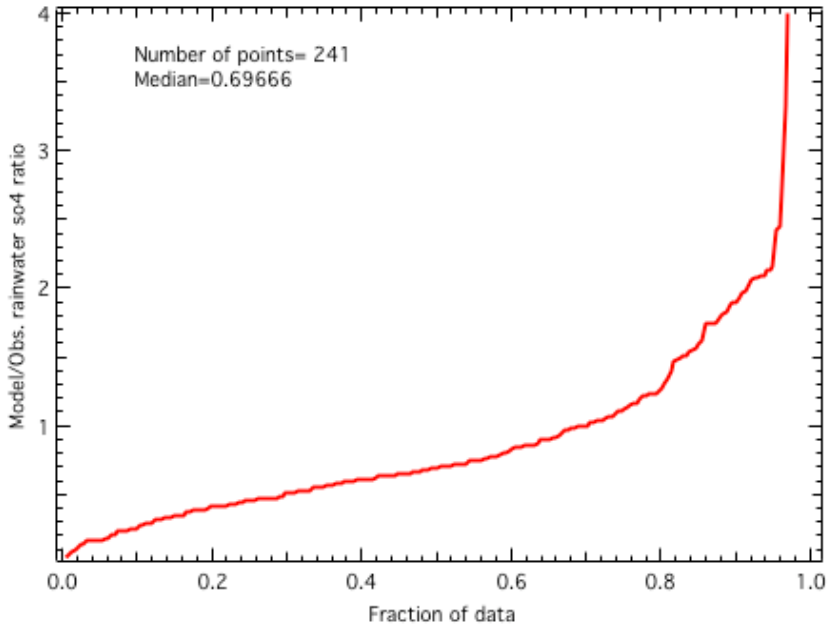


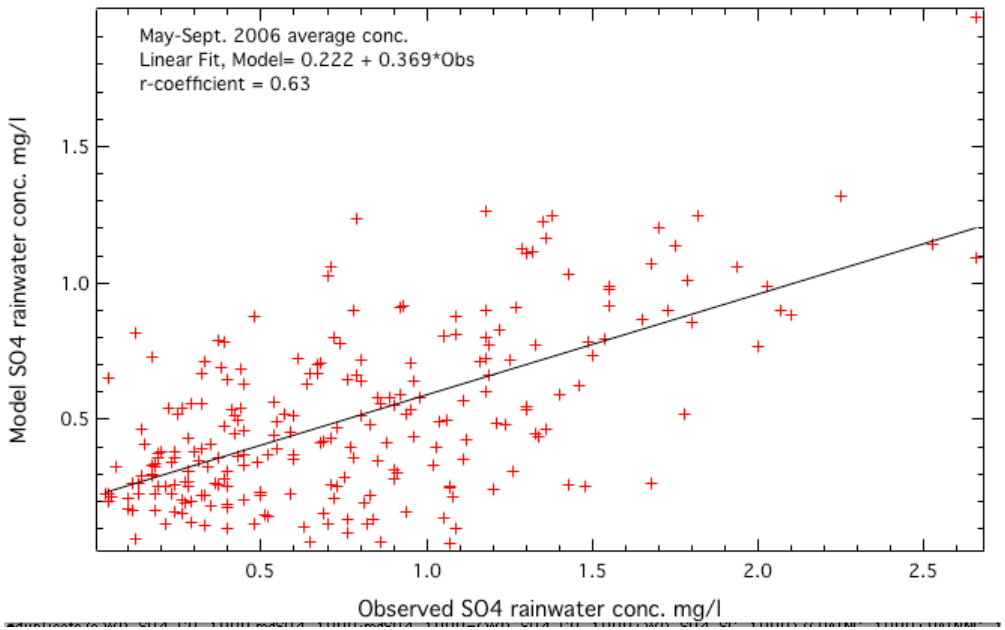




Model/Observed SO4 rainwater concentration (May through September 2006)







Model/Observed SO4 wet deposition (August 2006)