

Summary of the Emission Inventories compiled for the AQMEII Phase 2 Simulations

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What is AQMEII?

- **AQMEII – Air Quality Modelling Evaluation International Initiative**
- Promote research on regional air quality model evaluation across the European and North American atmospheric modeling communities
- Exchange of information on practices
- Realization of inter-community activities
- Identification of research priorities
- First Workshop was held in April 2009; most recent was the 5th workshop in August 2013

What is AQMEII Phase 2?

- Build credibility for coupled models and provide a better representation of feedback processes, aerosol, radiation, and cloud interactions and changes in air quality-climate interactions
- Large reduction in the emissions of SO₂ and NO_x from both electric power and motor vehicle sectors in the United States and Europe during the past 20 years.
- Examine coupled regional-scale models' ability to properly simulate the changes observed in surface radiation, temperature, and concentrations from emission reductions from regulatory programs implemented in North America and Europe over the past few decades

Purpose of this presentation

- Analysis of Emissions Used in Modeling exercise to help the understanding of the model results (dynamic evaluation)
- Provide an idea of what types of analysis we are doing in conjunction with the rest of the AQMEII phase 2 project
- Focus on US (and NA) in the presentation, but hope to do joint analysis with EU
- Extend what was done in phase 1 emissions paper:
- “Comparing emission inventories and model-ready emission datasets between Europe and North America for the AQMEII project” (Pouliot et al, 2012)

Emission Inventories

- Emission Inventories prepared for 2006 and 2010 for the modeling simulations will be compared
- Some of the Comparisons:
 - Changes in Criteria pollutants between 2006 and 2010
 - Compare with EPA Trends data (Caution!)
 - Compare 2006 AQMEII phase 2 with AQMEII phase 1

Focus on NO_x and SO₂ Emissions for this presentation but will include some of the other criteria pollutants.



US Sectors Used for NA Emissions in Phase 2

Emissions supplied for 12 US sectors typically used by U.S. EPA for regulatory modeling

Source Type	Description
afdust	Area source fugitive dust from anthropogenic sources, PM ₁₀ & PM _{2.5} only
ag	Area source emissions from agricultural operations, NH ₃ only
agfire	Area source emissions from crop residue burning
c1c2rail	Area source emissions from aircraft, locomotive, and marine (except class 3 vessels) (Aircraft includes only takeoff, landing, and ground operations.)
c3marine	Commercial marine port and inter-port Class 3 (C3) vessels defined as having displacement greater than 30 liters per cylinder.
nonpt	Area source emissions not included in other sectors (e.g., residential wood combustion)
nonroad	Off-road mobile source emissions from EPA's National Mobile Inventory Model (NMIM)
onroad	On-road mobile source emissions using SMOKE/MOVES system
ptipm	Electric generating unit (EGU) point source emissions, includes Continuous Emission Monitoring (CEM) hourly data
ptnonipm	Non-EGU point source emissions (industrial source and no power generation)
ptfire	Wildland fires and prescribed burning fire emissions modeled as point sources
rwc	Residential Wood Combustion



Canada/Mexico Sectors Used for NA Emissions in Phase 2

Emissions supplied for 8 sectors typically used by U.S. EPA for regulatory modeling

Source Type	Description
canafdust	2006 Canada Area source fugitive dust from anthropogenic sources, PM ₁₀ & PM _{2.5} only
canag	2006 Canada Area source emissions from agricultural operations, NH ₃ only
canar	2006 Area source emissions not included in other sectors including nonroad from Canada excluding c3marine emissions (included in US inventory)
canon	2006 Canada On-road mobile source emissions
canpt	2006 Canada point source emissions
Mexar	1999 Mexico area sources
mexon	1999 Mexico onroad sources
mexpt	1999 Mexico point sources



2006 North American Emissions

- Comprised of data from the United States, Canada, and Mexico
- Primary basis: U.S. EPA's 2008 National Emission Inventory, version 2 (NEIv3), translated onto the 2007/2008 modeling platform described in EPA's Technology Transfer Network Clearinghouse for Inventories and Emissions Factors (TTN/CHIEF)
- 2006-Specific Updates for AQMEII:
 - 2006 Continuous Emission Monitoring (CEM) data of SO₂ and NO_x from major point sources
 - 2006 wildfires
 - 2006 Canadian emissions and spatial surrogates
 - 2005 MOVES emission factors with 2006 VMT
- Pollutants: NO_x, VOC, CO, SO₂, NH₃, PM_{2.5}, and PM₁₀



2010 North American Emissions

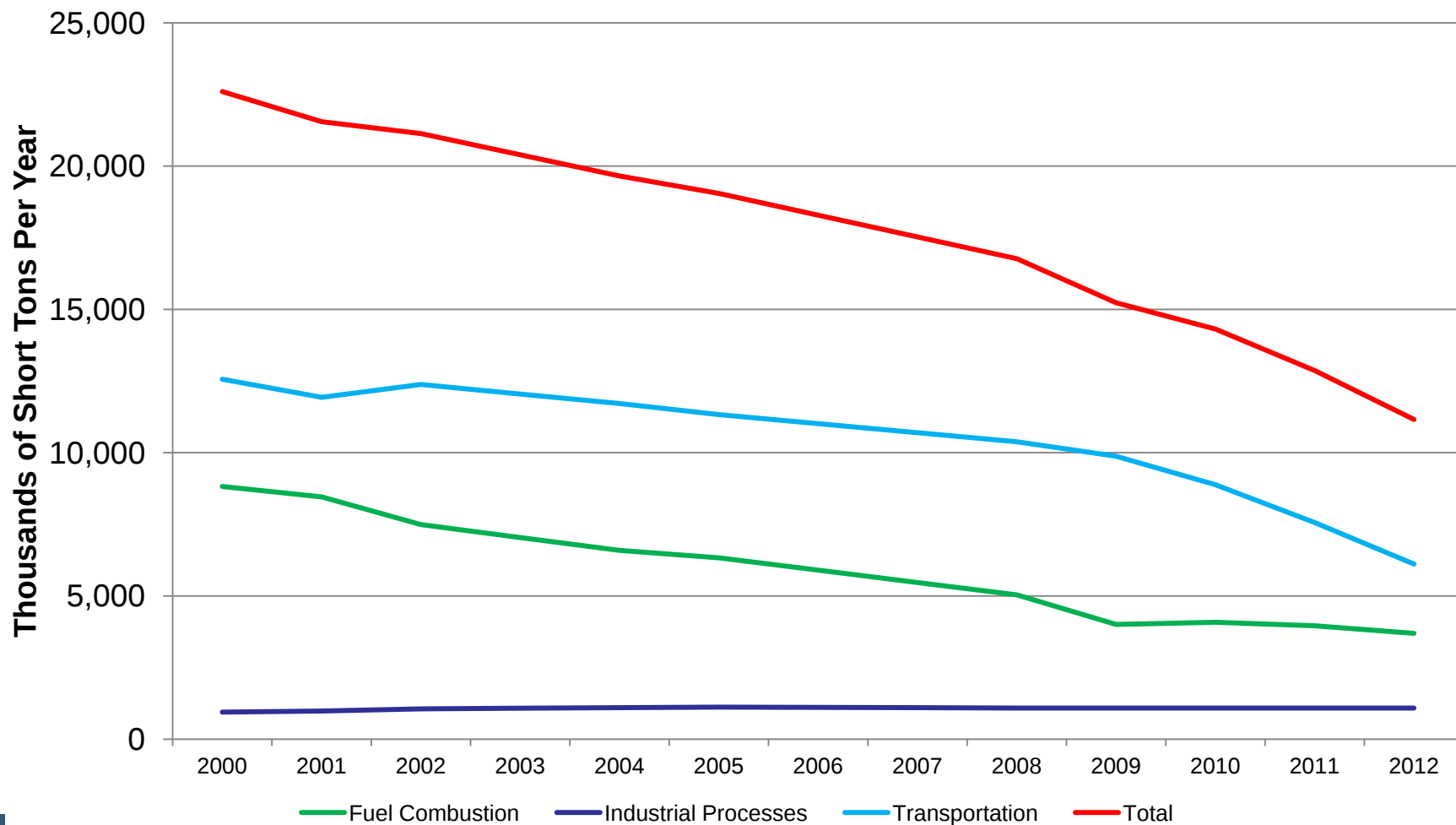
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Processing of NA Emissions for Phase 2

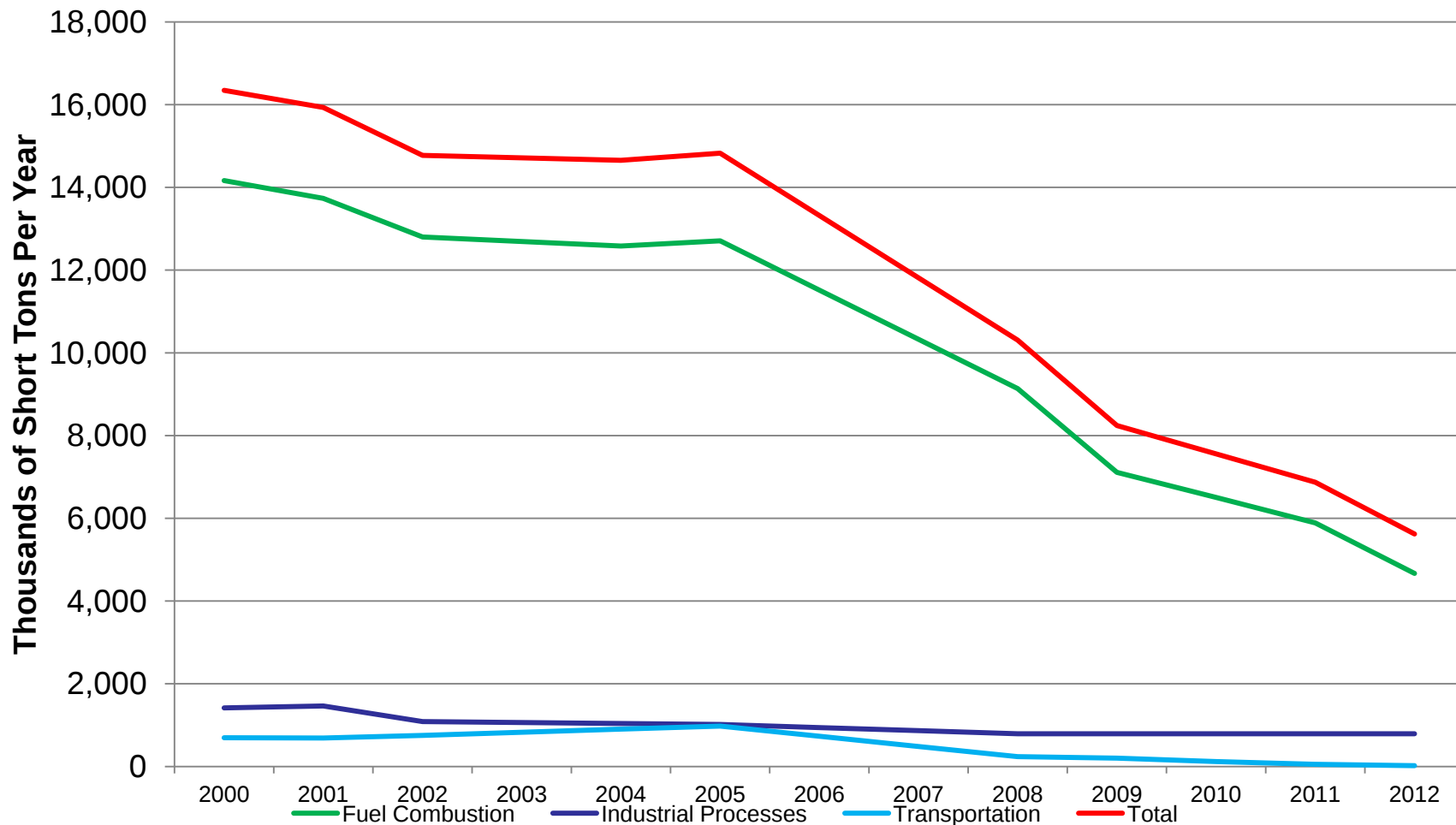
- Emission Processing
 - Performed using SMOKE system version 3.0
 - Temporal allocation:
 - Hour-specific for major point sources equipped with Continuous Emission Monitors (CEM), wildfire emissions, and biogenic emissions
 - Annual emissions allocated to individual hours based on source-specific monthly, weekly, and diurnal factors
 - Speciation:
 - VOC speciated both for the CB-05 and SAPRC07 mechanism based on source-specific profiles
 - Primary PM_{2.5} emissions split into sulfate, nitrate, EC, OC, and other primary PM_{2.5}
 - Spatial allocation:
 - 12km by 12km modeling grid using a Lambert Conformal projection
 - Used 60+ spatial surrogates (population, roadways, railroads, ports, etc.) to perform source-specific spatial allocation of county-based emissions to the modeling grid
 - No spatial allocation was performed for point sources because the exact latitude and longitude are known

US NO_x Emission Trends 2000-2012



Source: Derived from US EPA Trends Data: <http://www.epa.gov/ttn/chief/trends/>
(1970 - 2012 Average annual emissions, all criteria pollutants in MS Excel - June 2013)

US SO₂ Emission Trends 2000-2012



2006 Emission Estimates across all sectors in thousands of short tons

Pollutant	AQMEII Phase 1 (Full Domain)	AQMEII Phase 2 (Full Domain)	EPA Trends estimate (US only)
SO ₂	16,839	15,477	13,320
NO _x	20,863	23,165	18,286
PM _{2.5}	4,047	5,316	5,636
NH ₃	4,698	5,087	4,714
CO	90,064	98,339	88,077

2010 Emission Estimates across all sectors in thousands of short tons

Pollutant	AQMEII Phase 2 (Full Domain)	EPA Trends estimate (US only)
SO ₂	11,032	7,557
NO _x	19,060	14,310
PM _{2.5}	4,663	5,636
NH ₃	4,963	4,714
CO	75,797	88,077

2010 - 2006 Changes in emission Estimates across all sectors in thousands of short tons Delta Emissions with % change in ()

Pollutant	2010-2006 AQMEII Phase 2 (Full Domain)	2010-2006 EPA Trends estimate (US only)
SO₂	-4,445 (-29%)	-5,762 (-43%)
NO_x	-4,105 (-18%)	-3,976 (-22%)
PM _{2.5}	-653 (-12%)	-309 (-5%)
NH ₃	-124 (-2%)	+162 (+4%)
CO	-22,542 (-23%)	+14,403 (+20%)

Basic Demographics and Related Statistics for US 2006 & 2010 (excluding AK, HI)

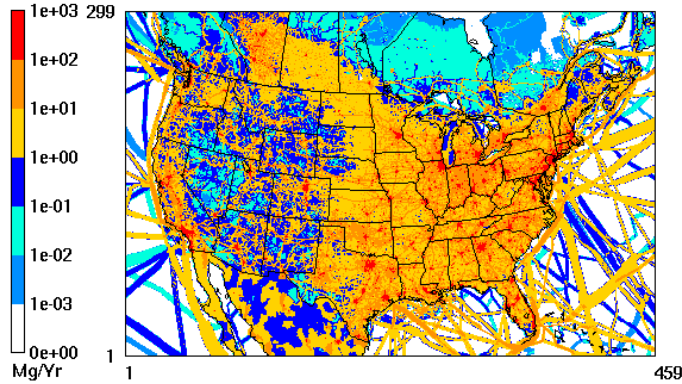
Year	Area(mi2)	Pop (millions)	Number of Vehicles (millions)	Electric Generatin g Capacity Millions GWHr
2006	2.95	296	243	4.06
2010	2.95	307	240	4.13

Sources:

<http://quickfacts.census.gov/qfd/states/00000.html>
<http://www.fhwa.dot.gov/policy/ohim/hs06/htm/mv1.htm>
<http://www.fhwa.dot.gov/policyinformation/statistics/2010/mv1.cfm>
<http://www.eia.gov/electricity>

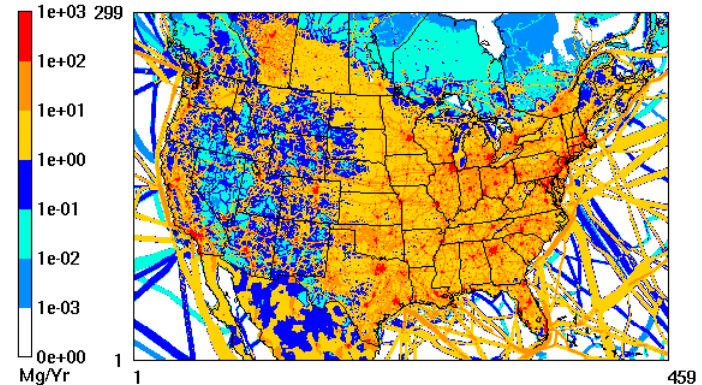
NOX Emissions Difference

NOx Emissions
2006



January 1, 2006 0:00:00
Min=0e+00 at (1,1), Max=1e+04 at (182,38)

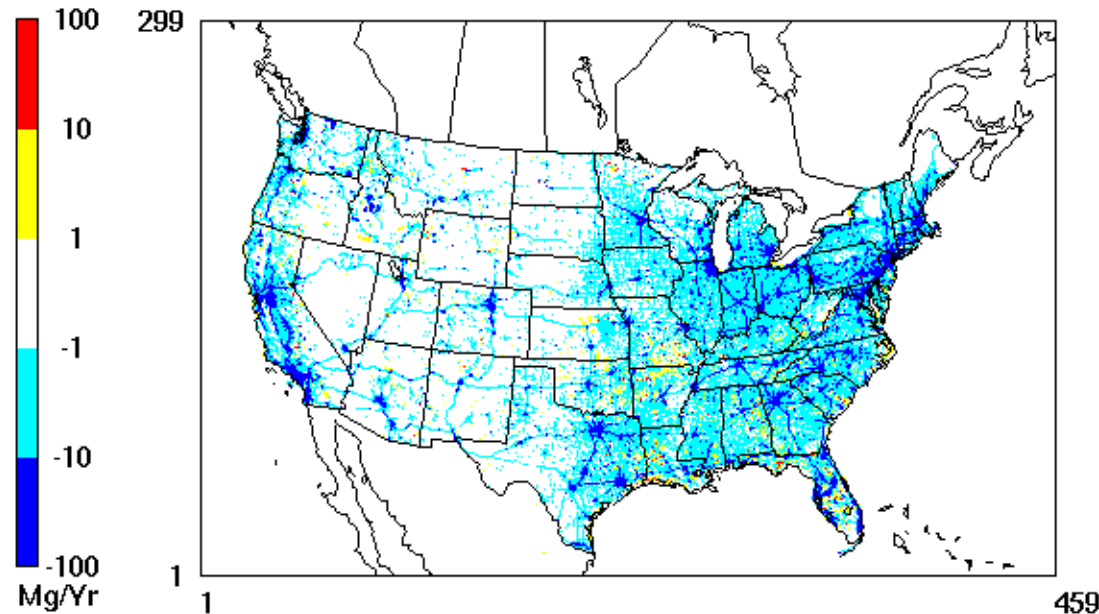
NOx Emissions
2010



January 1, 2010 0:00:00
Min=0e+00 at (1,1), Max=1e+04 at (182,38)

Difference in Annual NOx Emissions AQMEII Phase

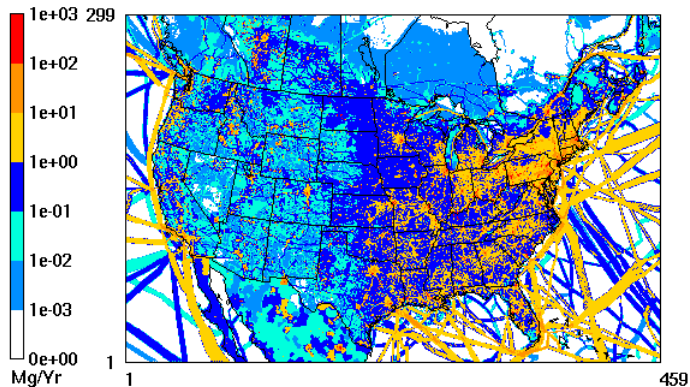
NOx Emissions
2010-2006



Hour: 00
Min=-3670 at (320,143), Max= 360 at (356,161)

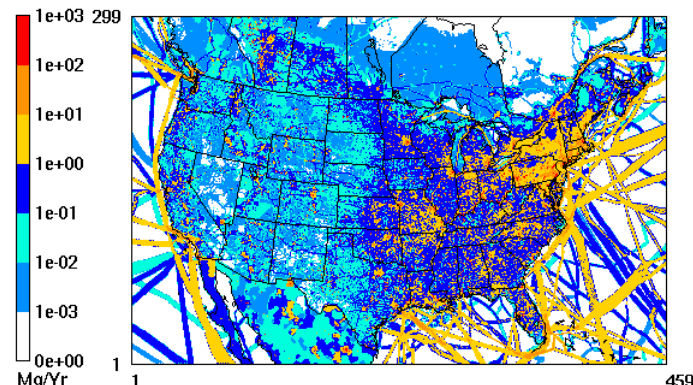
SO2 Emissions Difference

SO2 Emissions
2006



January 1, 2006 0:00:00
Min=0e+00 at (1,1), Max=2e+04 at (182,38)

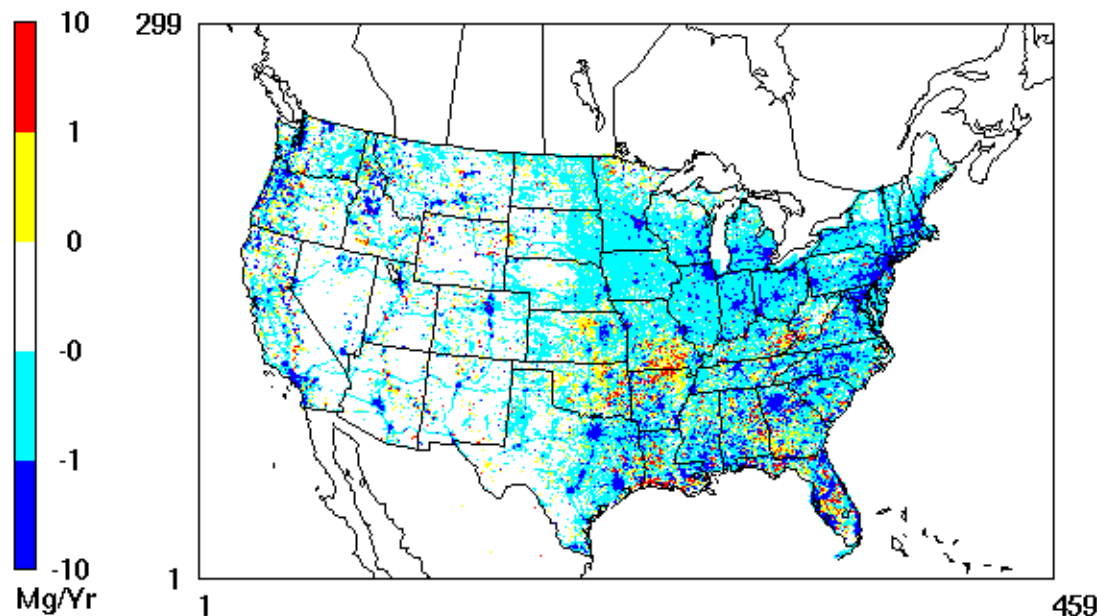
SO2 Emissions
2010



January 1, 2010 0:00:00
Min=0e+00 at (1,1), Max=2e+04 at (182,38)

Difference in Annual SO2 Emissions AQMEII Phase :

SO2 Emissions
2010-2006



Hour: 00
Min=-18038 at (306,97), Max=3905 at (320,143)

Further Steps

- Do analysis for all Pollutants
- Temporal Analysis
- Biogenic/Natural Emissions Comparisons
- Include EU data and analysis?
- Other?

For an overview and evaluation of the WRF/CMAQ model results, Christian Hogrefe's Presentation

- **Overview and Evaluation of AQMEII Phase 2
Coupled Simulations over North America**
- **Model Evaluation Session, Dogwood Room**
- **Wednesday October 30, 2013 3:30 PM**