The SO_2 and NO_2 Increment Analysis for the Breton National Wilderness Area

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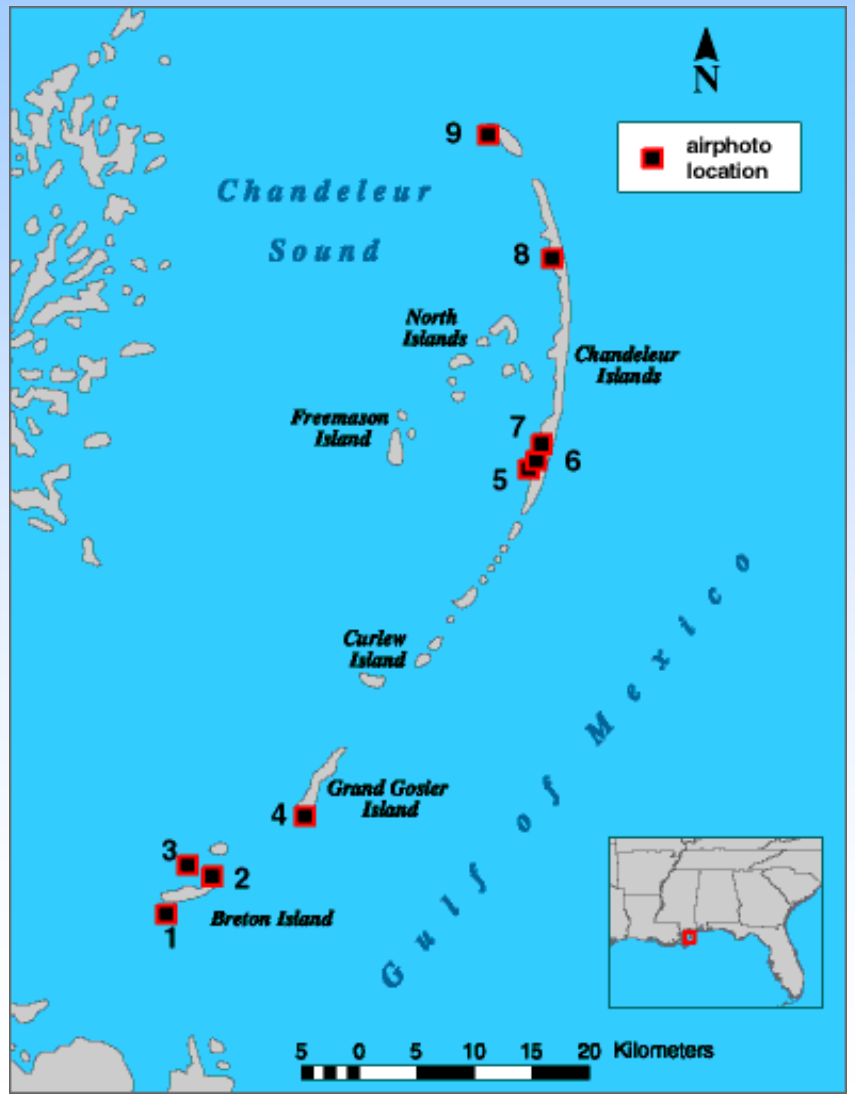
Overview

- Background
- Episode Selection
- Climatological Representativeness
- Meteorological Modeling
- Emission Inventory
- Air Quality Modeling
- Increment Analysis

Breton National Wilderness Area (BNWA)



Increments

- Clean Air Act Requirements – Class I Area
- Prevention of Significant Deterioration (PSD) Increments for Class I Areas ($\mu g/m^3$)

Pollutant	**Annual Arithmetic Mean**	**24-hour Maximum**	**3-hour Maximum**
Sulfur dioxide (SO_2)	**2.0**	**5**	**25**
Particulate matter < 10 μ (PM_{10})	*4.0*	*8*	*N/A*
Nitrogen dioxide (NO_2)	**2.5**	N/A	N/A

Background

- Federal Land Manager: Fish and Wildlife Service
- Emissions Sources
- NO_2 and SO_2 Increment Consumption
- Requisite Studies
  - Meteorology and Air Quality: Breton Aerometric Monitoring Program (BAMP)
  - Emissions: Breton Offshore Activities Data System (BOADS), Gulfwide Offshore Activity Data System (GOADS)

Study Objectives

- Meteorological, Air Quality, and Emissions Data Compilation
- Meteorological, Emissions, and Air Quality Modeling
- Cumulative Increment Analysis

Episode Selection

- Purpose
- Selection criteria
- Methods
  - Time series and scatter plots
  - Frequency distributions
  - Concentration rankings
  - Synoptic weather types

Selection Criteria

- SO_2 and NO_2 concentrations
  - 5 cases with concentrations in the top 10 percentile and greater than the increment
  - 1 case with lower concentrations
- Impacts from both onshore and offshore sources
- Both isolated events and regional impacts
- Representative distribution of weather classifications - Episodes selected were to have a distribution of weather patterns similar to annual distributions

Air Quality Monitoring Sites

Periods Selected

- 8–13 November 2000
- 1–6 December 2000
- 30 December 30 2000 – 4 January 2001
- 2–8 March 2001
- 9–14 July 2001
- 8–13 August 2001 (Non-Episode)

Climatological Representativeness

40 years of monthly mean values from the NOAA-CIRES Climate Diagnostics Center data were reviewed and compared to values for October 2000 through September 2001:

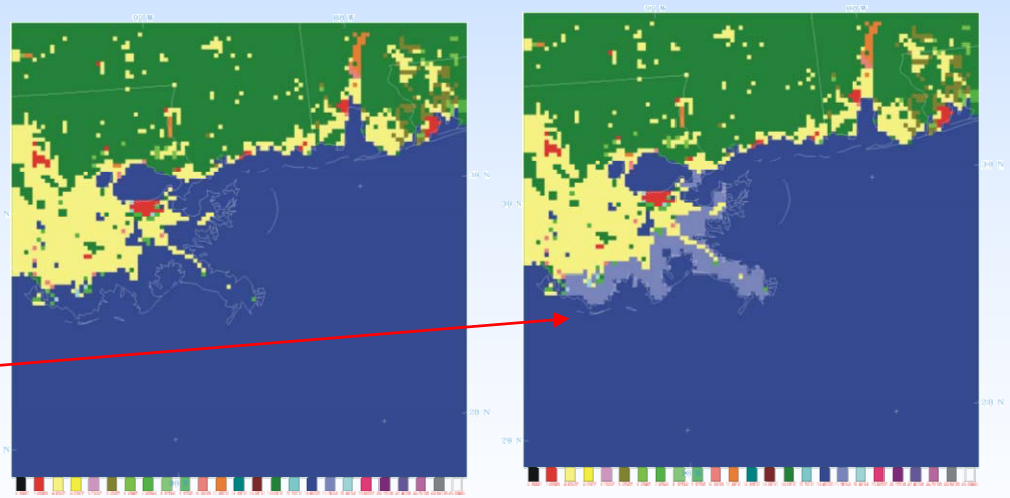
- Land surface temperature
- Sea surface temperature
- 850-mb temperature
- 500-mb height
- Precipitation

Meteorological Modeling

Penn State/NCAR Mesoscale Model

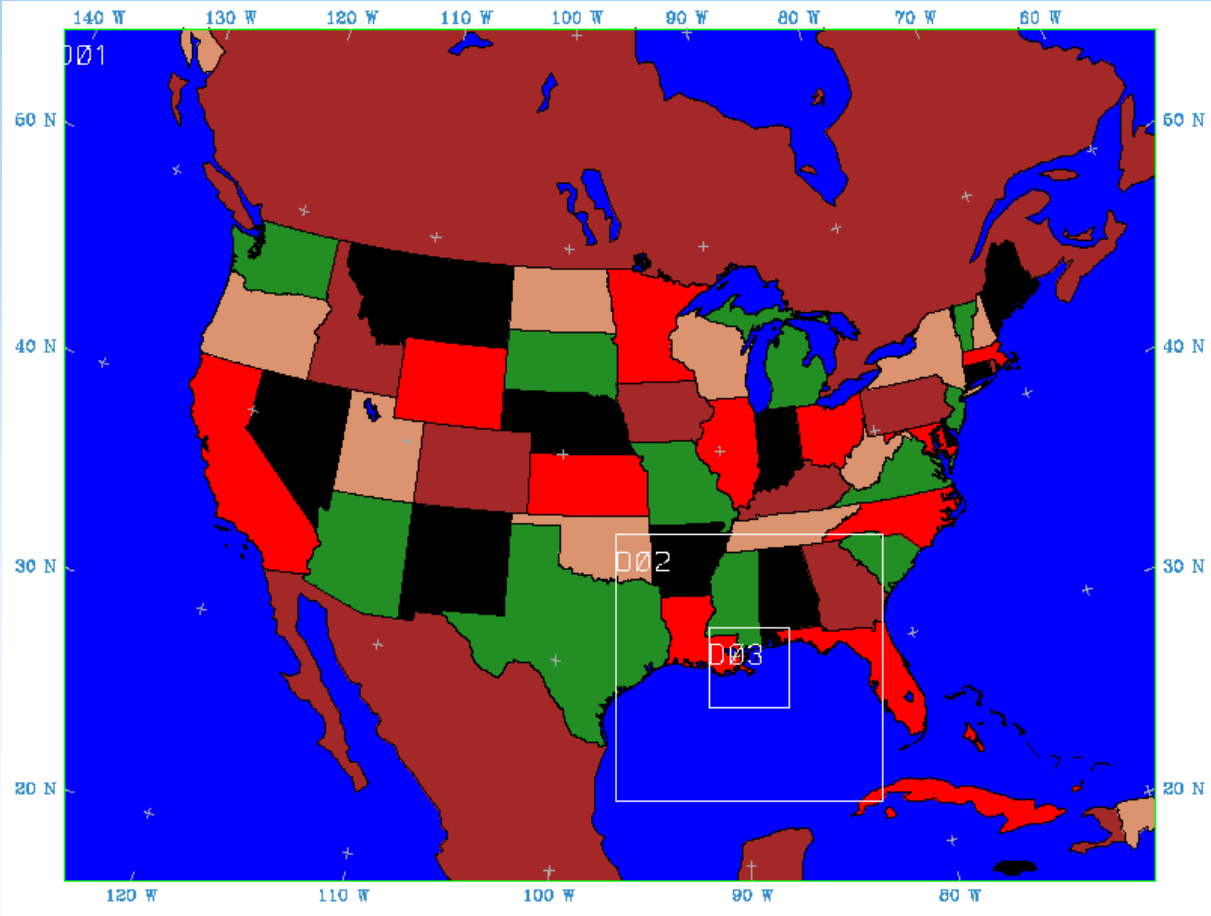
- MM5 Release 3-6-1
- MODIS Sea Surface Temperatures
- Updated Land Use

(Updated with herbaceous marshland)



- Modeling performed by the Pennsylvania State University

MM5 Modeling – Domains

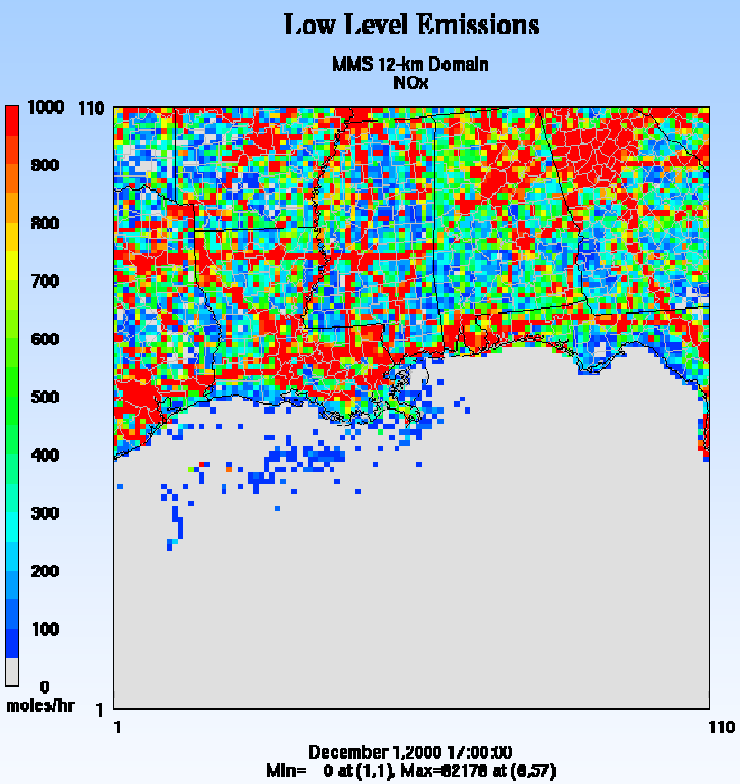


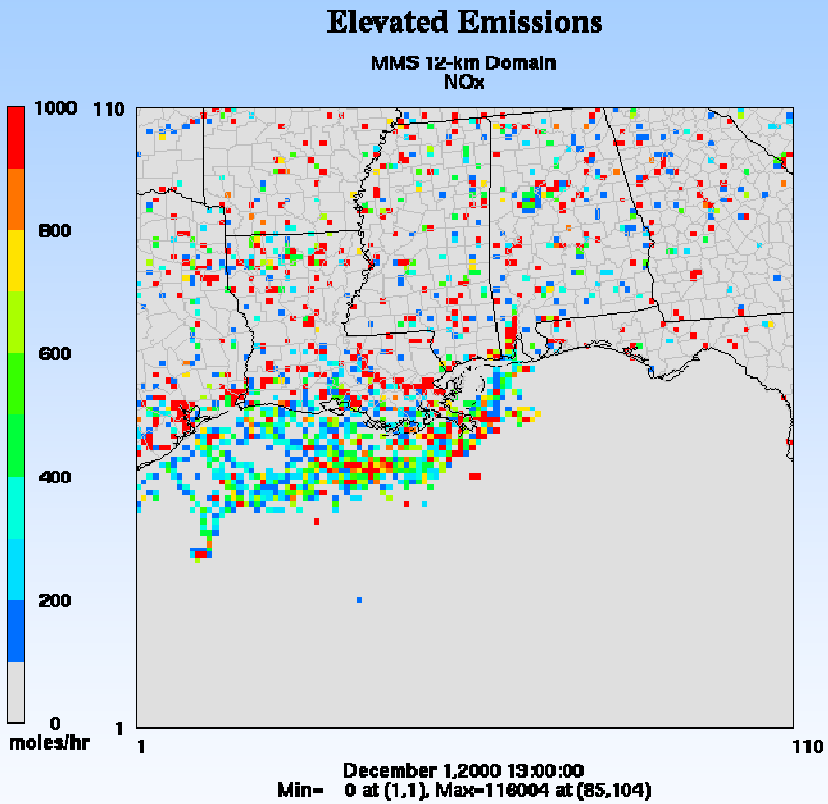
- Domain D01: 165x129 36-km cells (RPO MM5 domain)
- Domain D02: 121x121 12-km cells
- Domain D03: 109x109 4-km cells (selected episodes)
- 45 vertical levels: surface to 50 mb

Emission Inventories

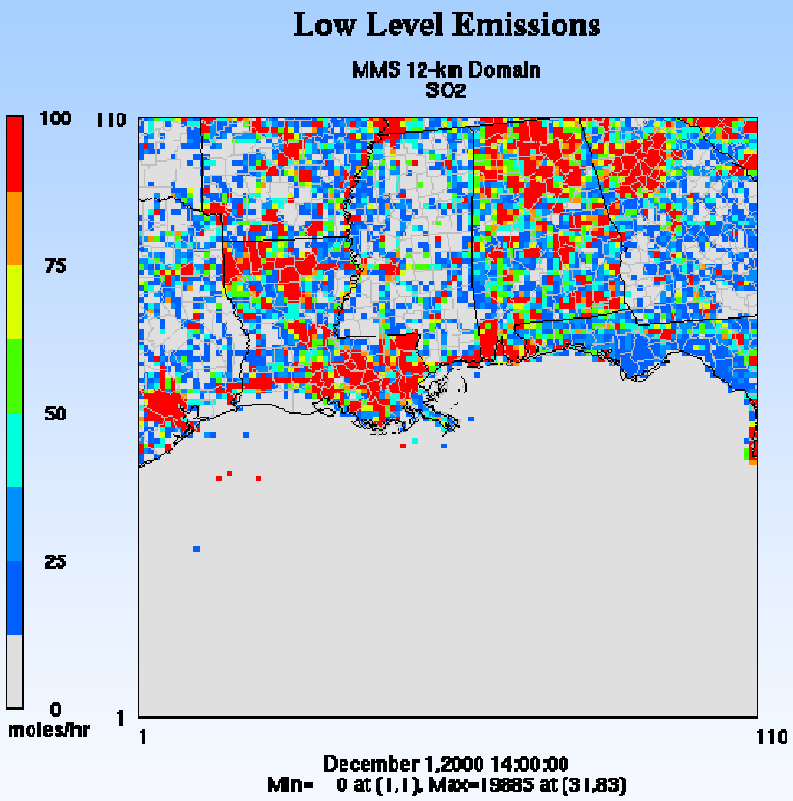
- Three inventories: 2000/2001, 1988, and 1977
- Based on 1999 National Emission Inventory (NEI) Version 3 for onshore sources
- Gulfwide Offshore Activity Data System (GOADS) and Breton Offshore Activity Data System (BOADS) (October 2004)
- Offshore inventory estimates for baseline years (1977 and 1988) – Emission Inventories of OCS Production and Development Activities in the Gulf of Mexico (February 2003)
- Non-OCS production and development emission inventory estimates for baseline years – Economic Growth Analysis System (EGAS) and EPA emission trends
- National RPO 4-km Surrogates (September 2003)
- Sparse Matrix Operator Kernel Emissions (SMOKE) processing system – Version 2
- Conversion to CALPUFF input formats

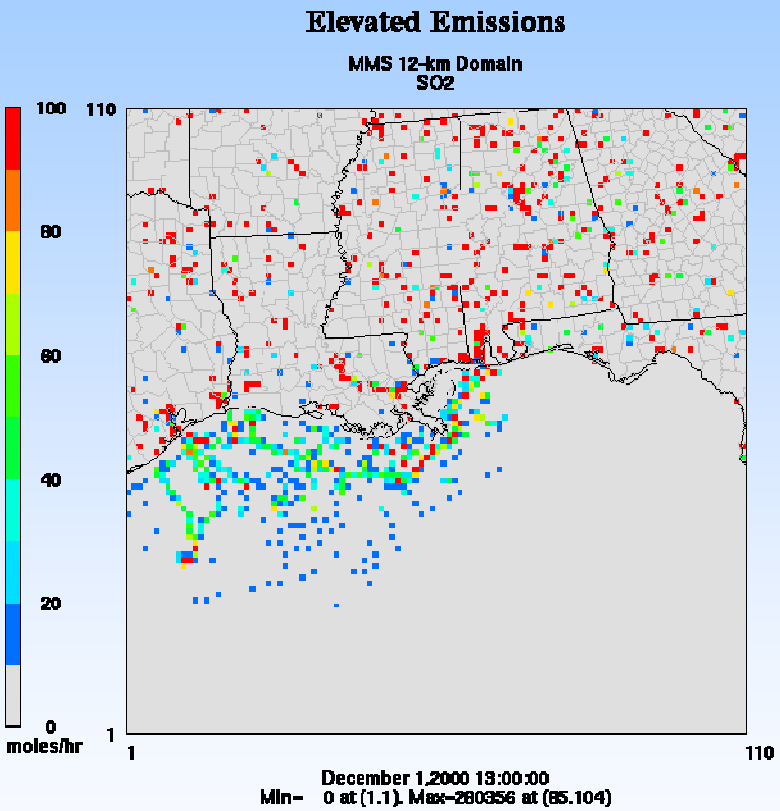
NO_x Emissions



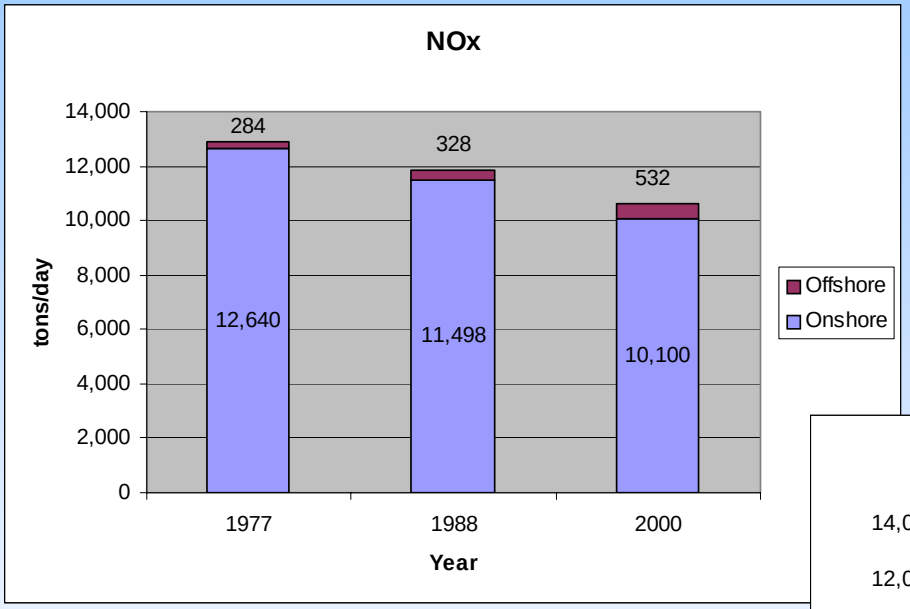


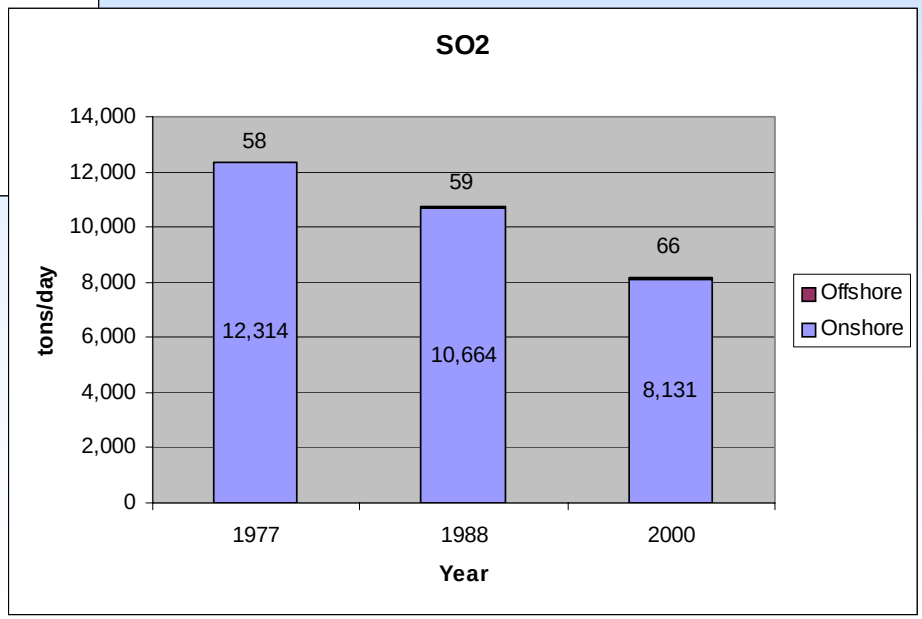
SO_2 Emissions





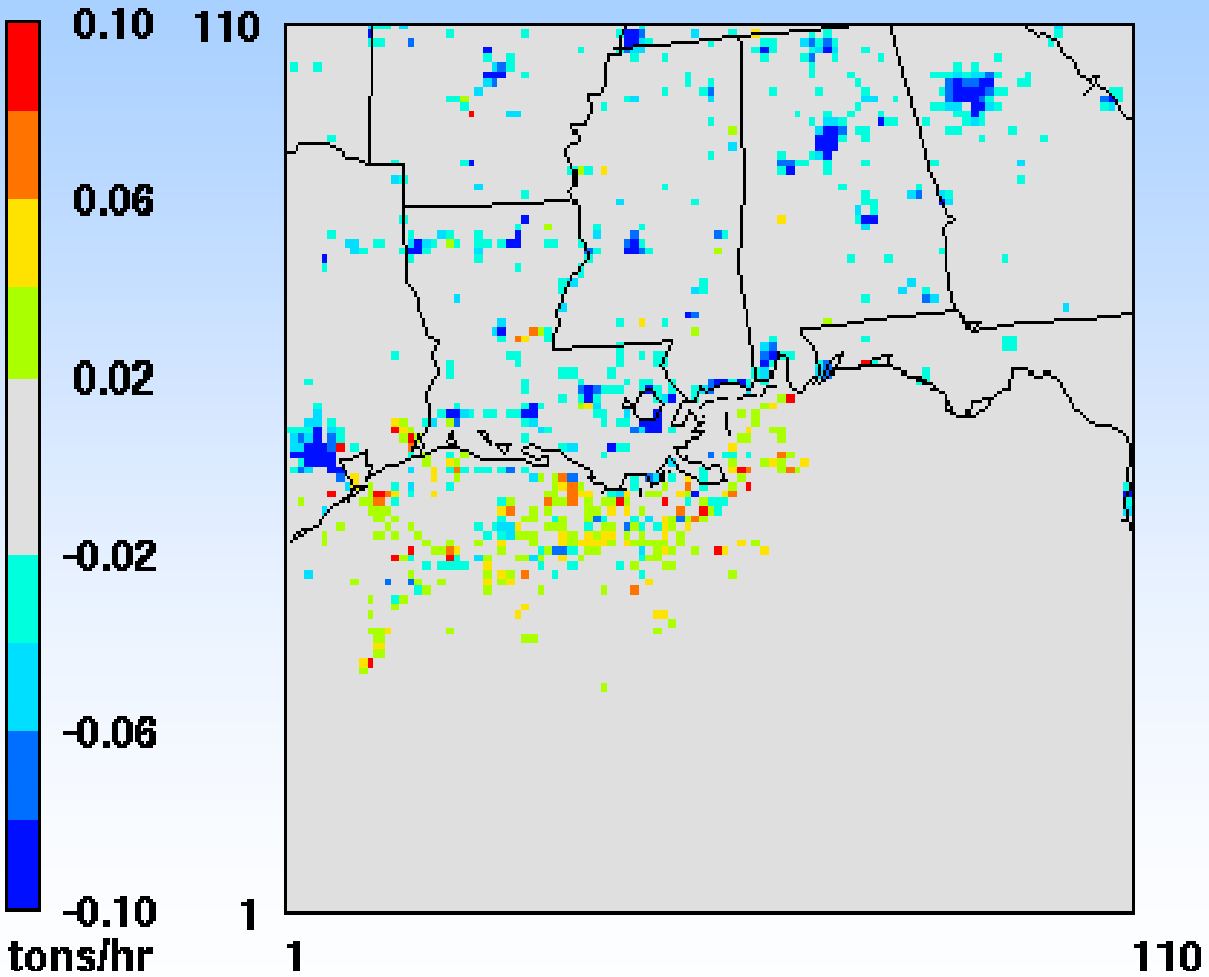
Emission Trends



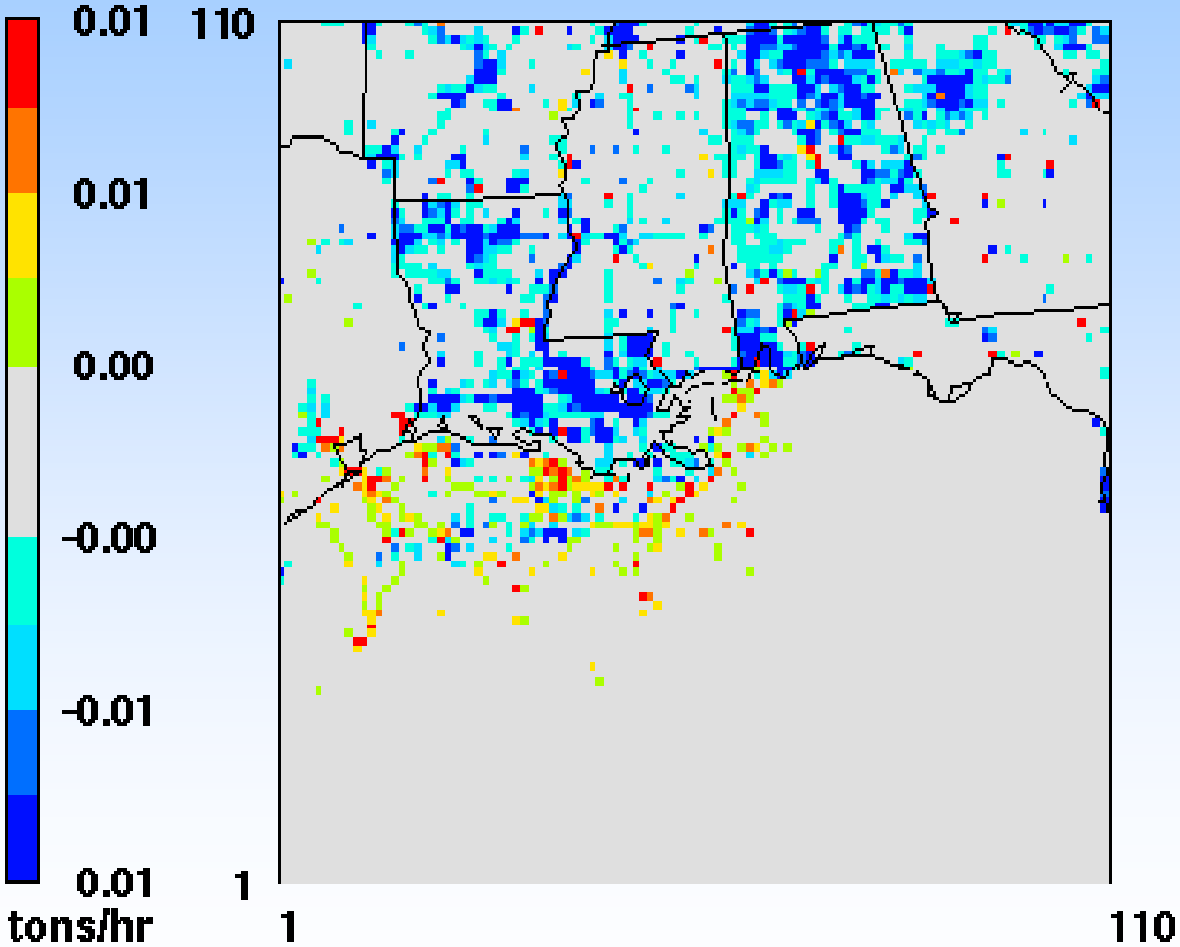


Daily Emissions in
12-km Modeling Domain

Change in NO_x Emissions 1988–2000



Change in SO_2 Emissions 1977–2000



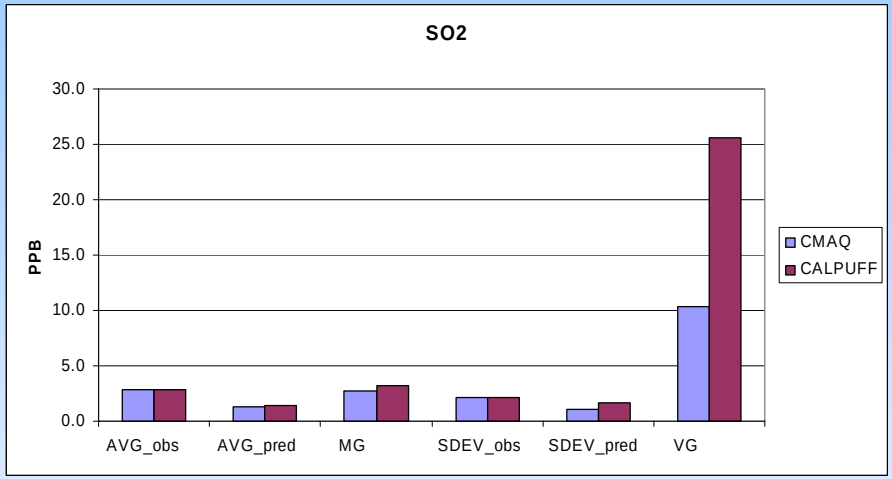
Air Quality Modeling and Analysis

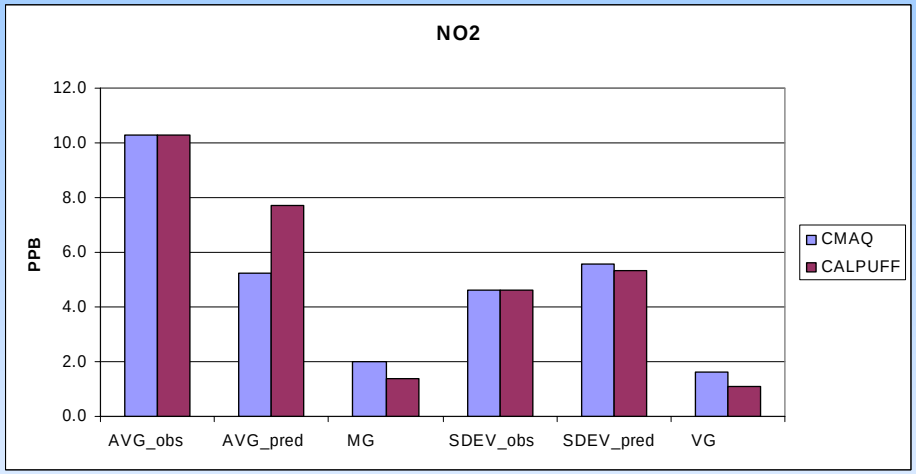
- Episodic Modeling
  - CMAQ 4.3 with Plume-in-Grid
  - CALPUFF 5.7
  - Model Performance Evaluation
  - Sensitivity Analysis
- Annual Modeling: 1 Oct 1 2000 – 30 Sep 2001
- Modeling Baseline Years (1977 and 1988)
- Increment Analysis

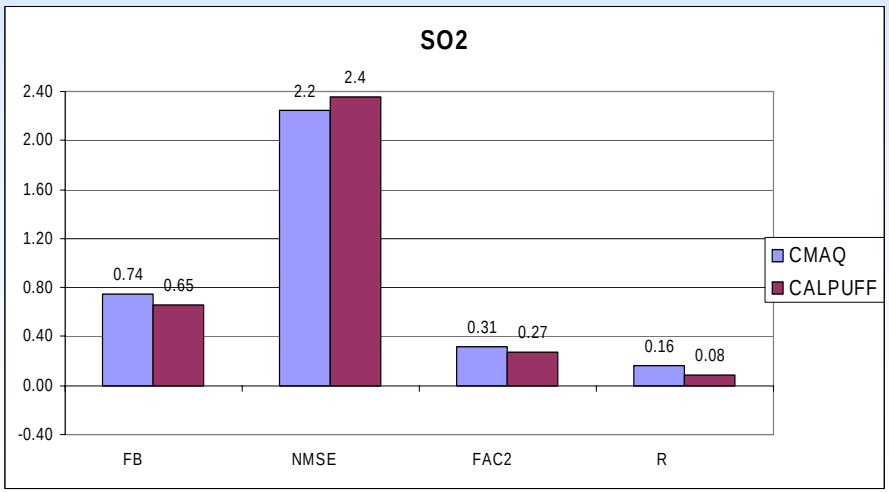
Model Performance Evaluation

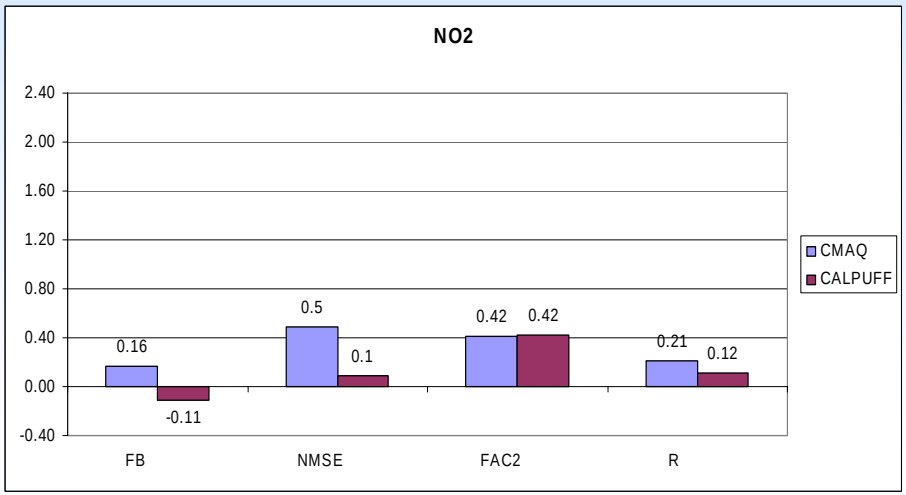
- Three Sites
  - Breton Island Platform (BIP)
  - Fort Morgan (FTM)
  - West Delta Platform (WDP)
- Graphic Evaluations
  - Time Series Comparisons
  - Spatial Plots
  - Scatter Plots
- Statistical Evaluations
  - Fractional bias (FB)
  - Geometric mean bias (MG)
  - Normalized mean square error (NMSE)
  - Geometric mean variance (VG)
  - Correlation coefficient (R)
  - Fraction of predictions within a factor of two of observations (FAC2)

Episodic Model Performance



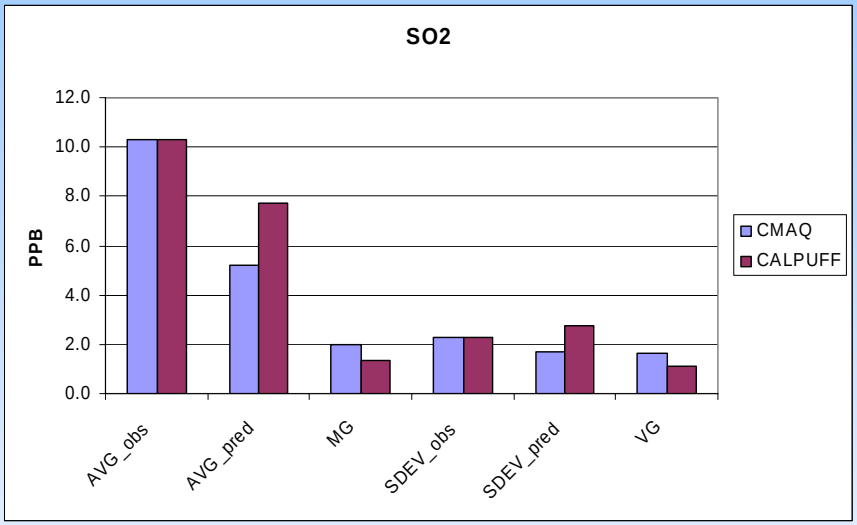


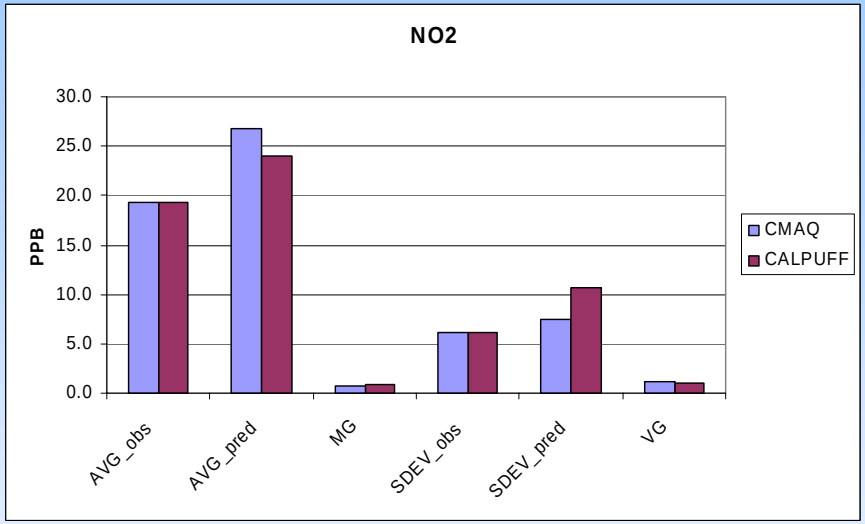


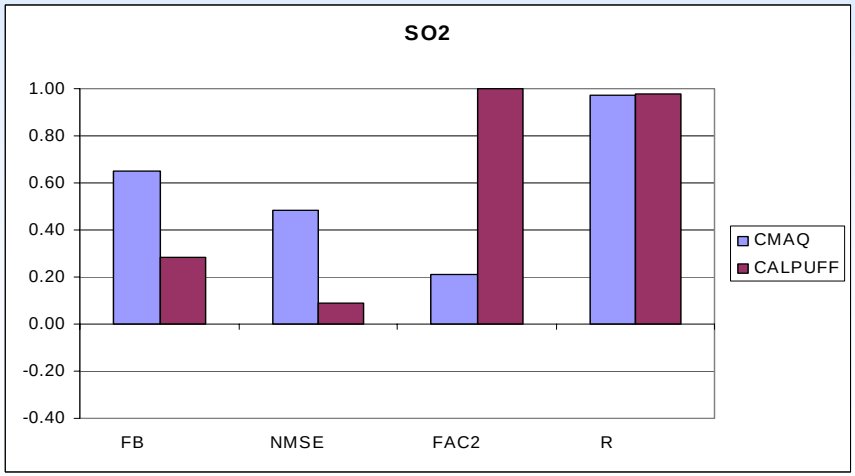


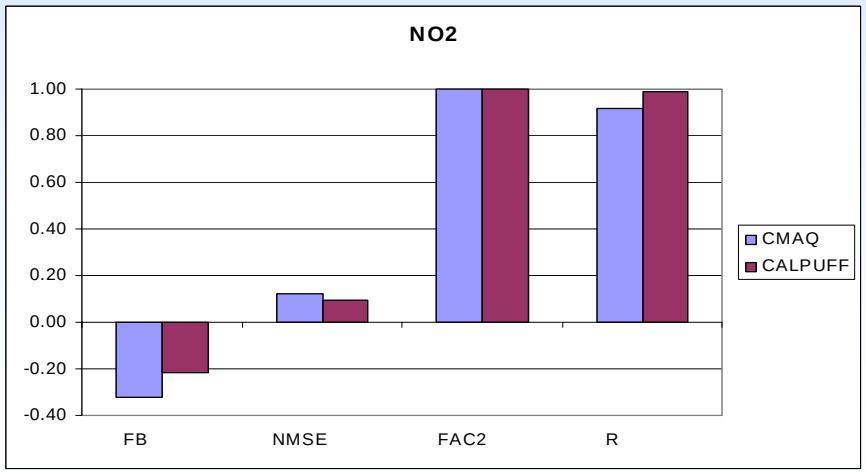
Paired in time and space

Top 5% of Concentrations









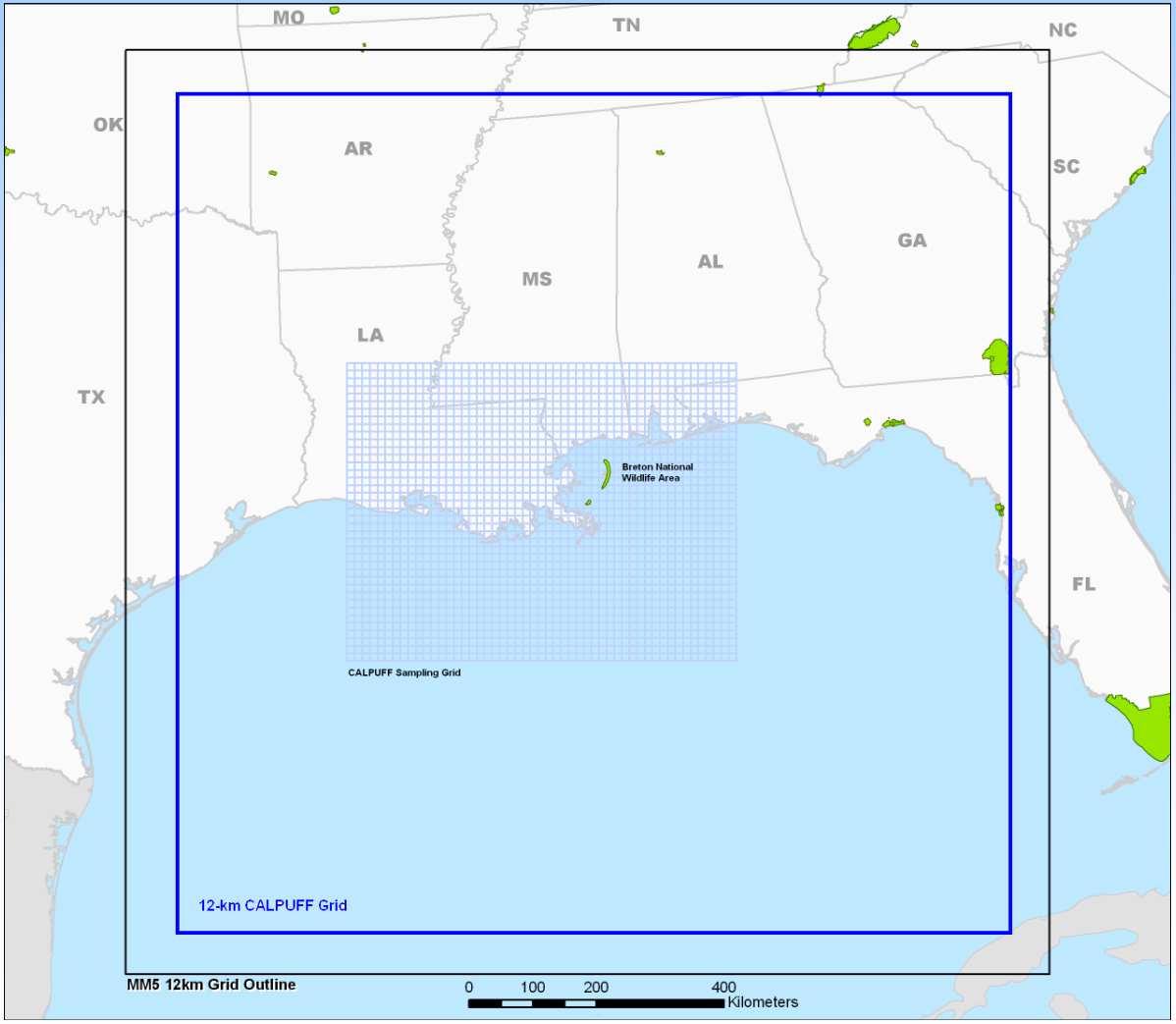
Unpaired in time and space

Sensitivity Simulations

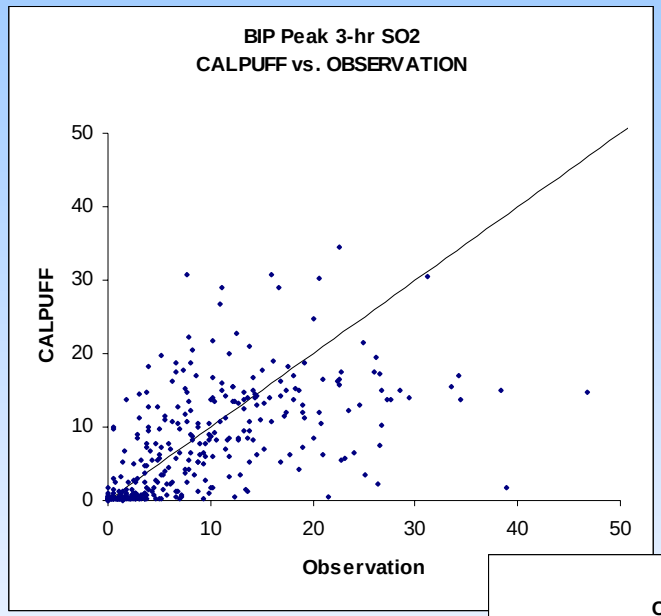
- Ozone Concentrations (CALPUFF)
- Alternative MM5 Configurations (CMAQ/CALPUFF)
- Plume-in-Grid (CMAQ)
- Zero Low-Level Emissions (CMAQ/CALPUFF)
- PBL Heights (CALMET/CALPUFF)
- Puff Splitting (CALPUFF)
- Accelerated Puff Removal (CALPUFF)
- 4-km Meteorology (CALPUFF)

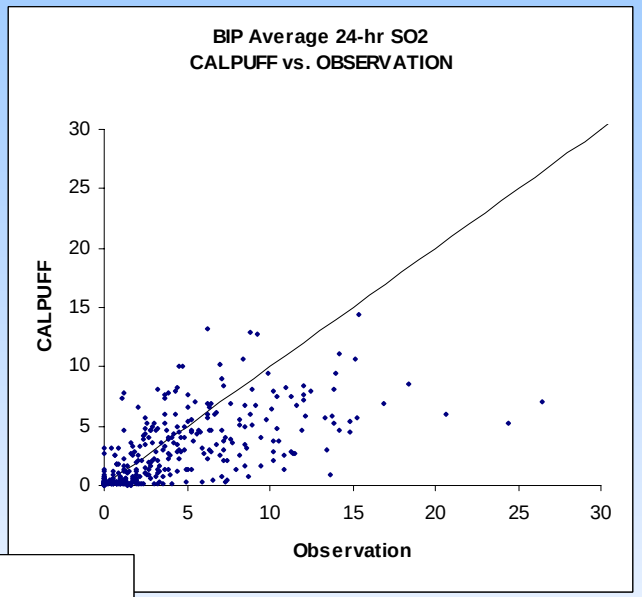
Annual Simulations

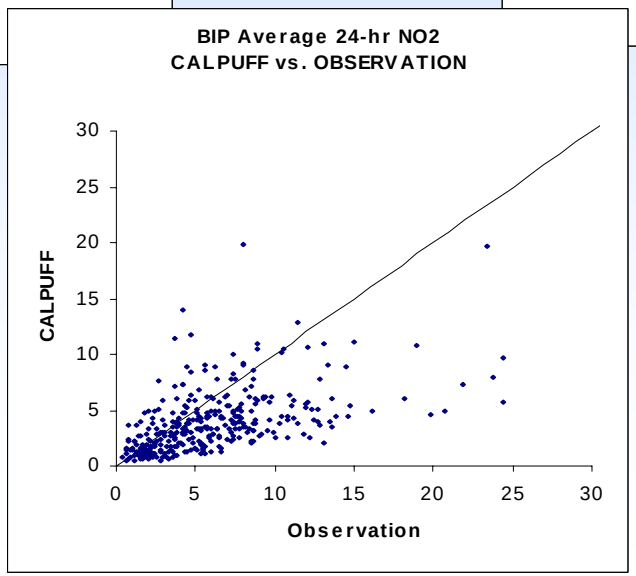
- CALPUFF 5.7+
- Reduced Receptor Grid
- Emissions within 200 km



2000–2001 Observed vs. Predicted



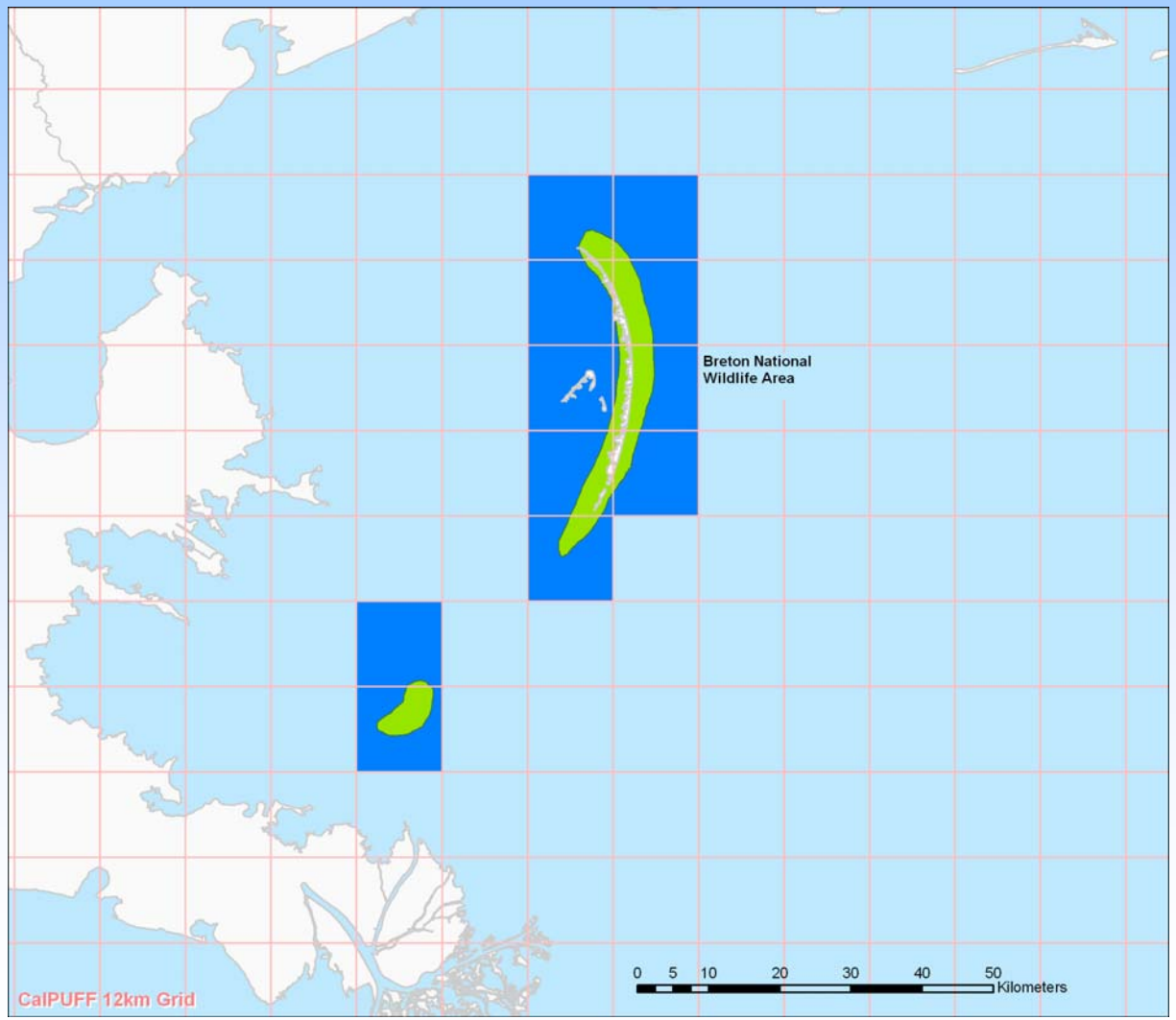




Increment Analysis

- Breton Area Increments
  - 11-Cells
  - Maximum Increments
  - Annual NO_2 (2000/2001-1988)
  - Annual SO_2 (2000/2001-1977)
  - 24-hr SO_2 (2000/2001-1977)
  - 3-hr SO_2 (2000/2001-1977)
- Regional Increments

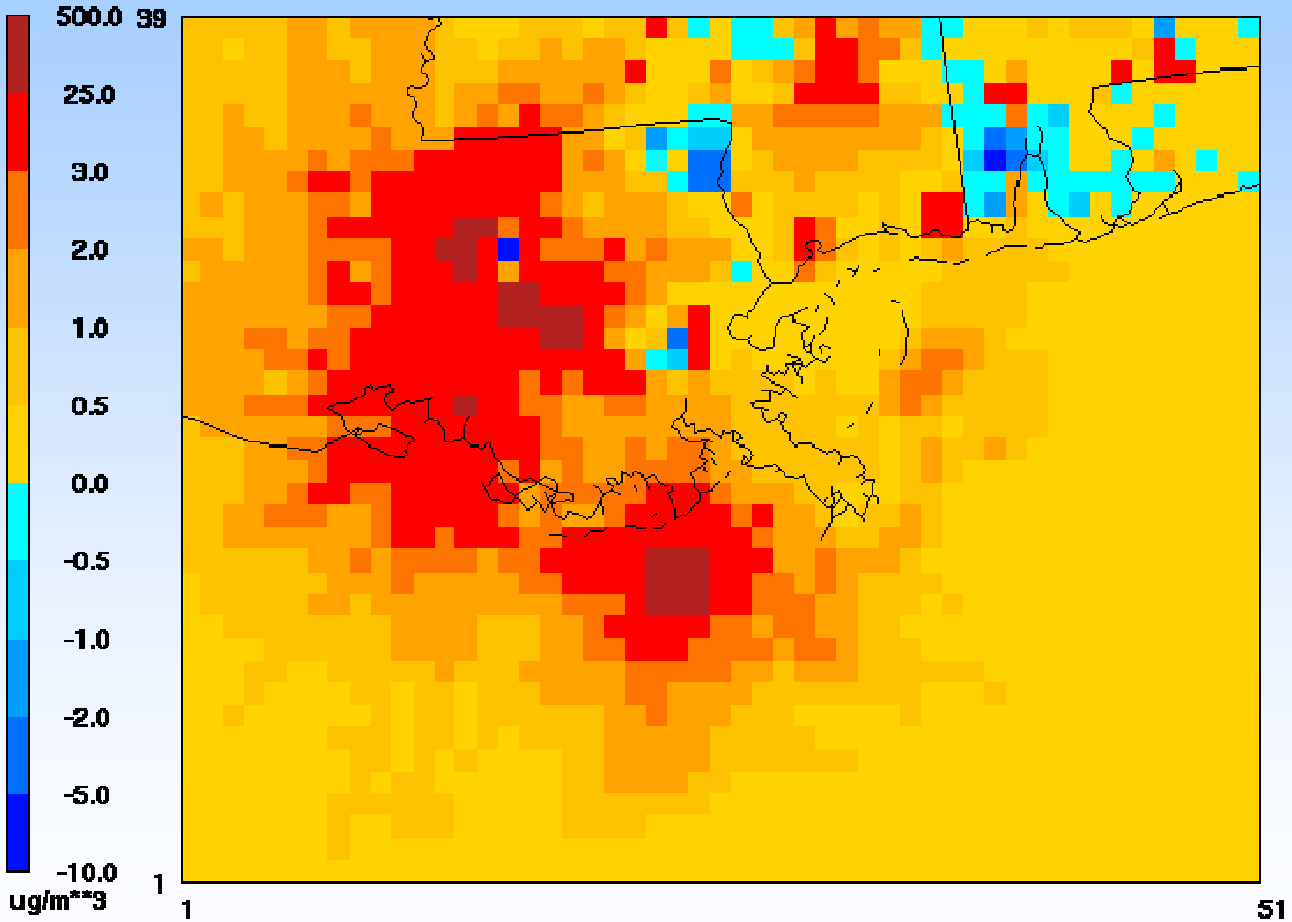
Breton Area – 11 Cells



Breton Area Maximum Increments

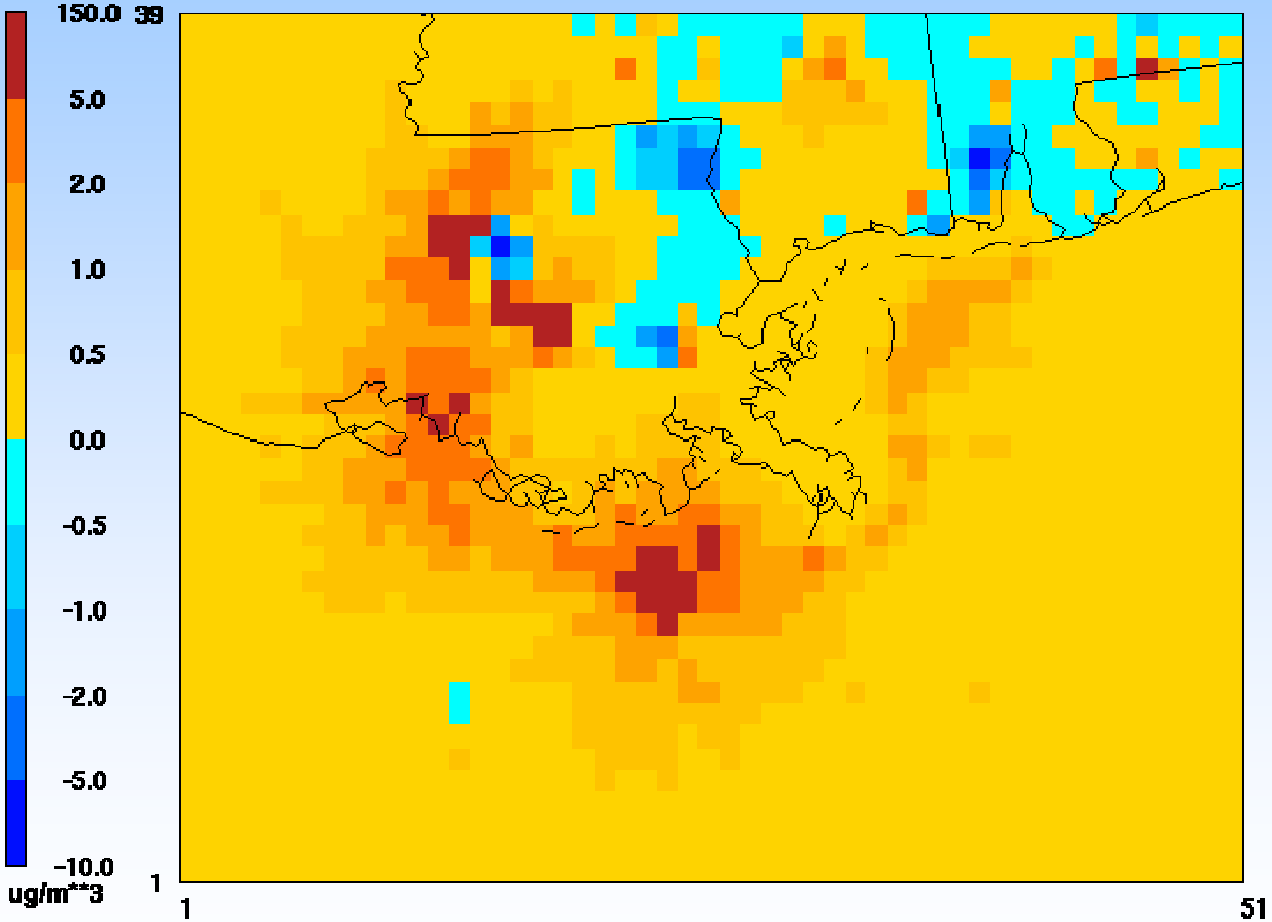
- The maximum 3-hr SO_2 increment consumed was1.70 µg/m^3 [25 µg/m^3 allowable]
- The maximum 24-hr SO_2 increment consumed was 1.18 µg/m^3 [5 µg/m^3 allowable]
- The maximum annual SO_2 increment consumed was -1.07 µg/m^3 (increment expanded) [2.0 µg/m^3 allowable]
- The maximum annual NO_2 increment consumed was 0.10 µg/m^3 [2.5 µg/m^3 allowable]

Maximum 3-hr SO_2 Increments



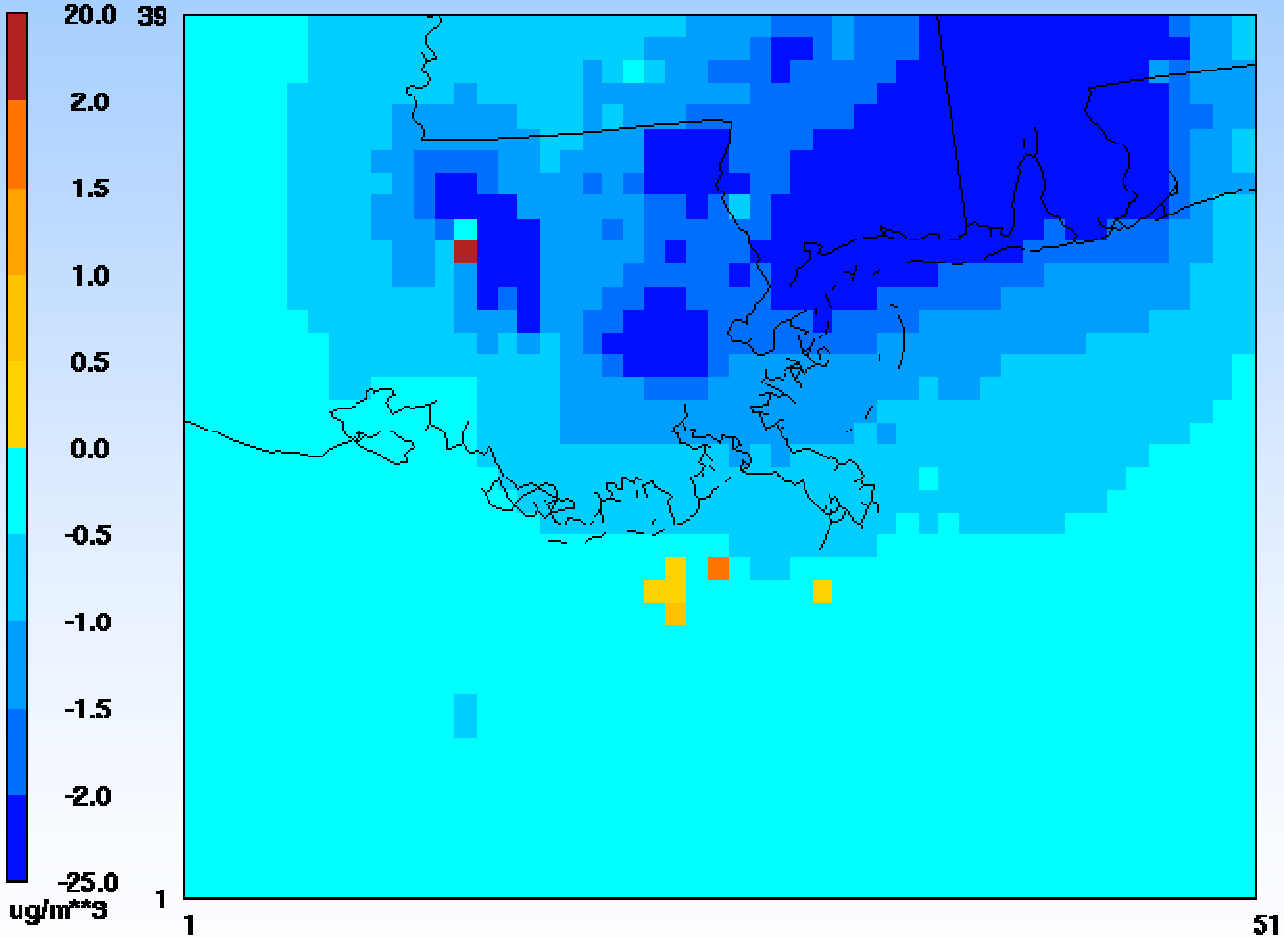
Min= -9.8 at (39,33), Max= 439.2 at (14,29)

Maximum 24-hr SO_2 Increments



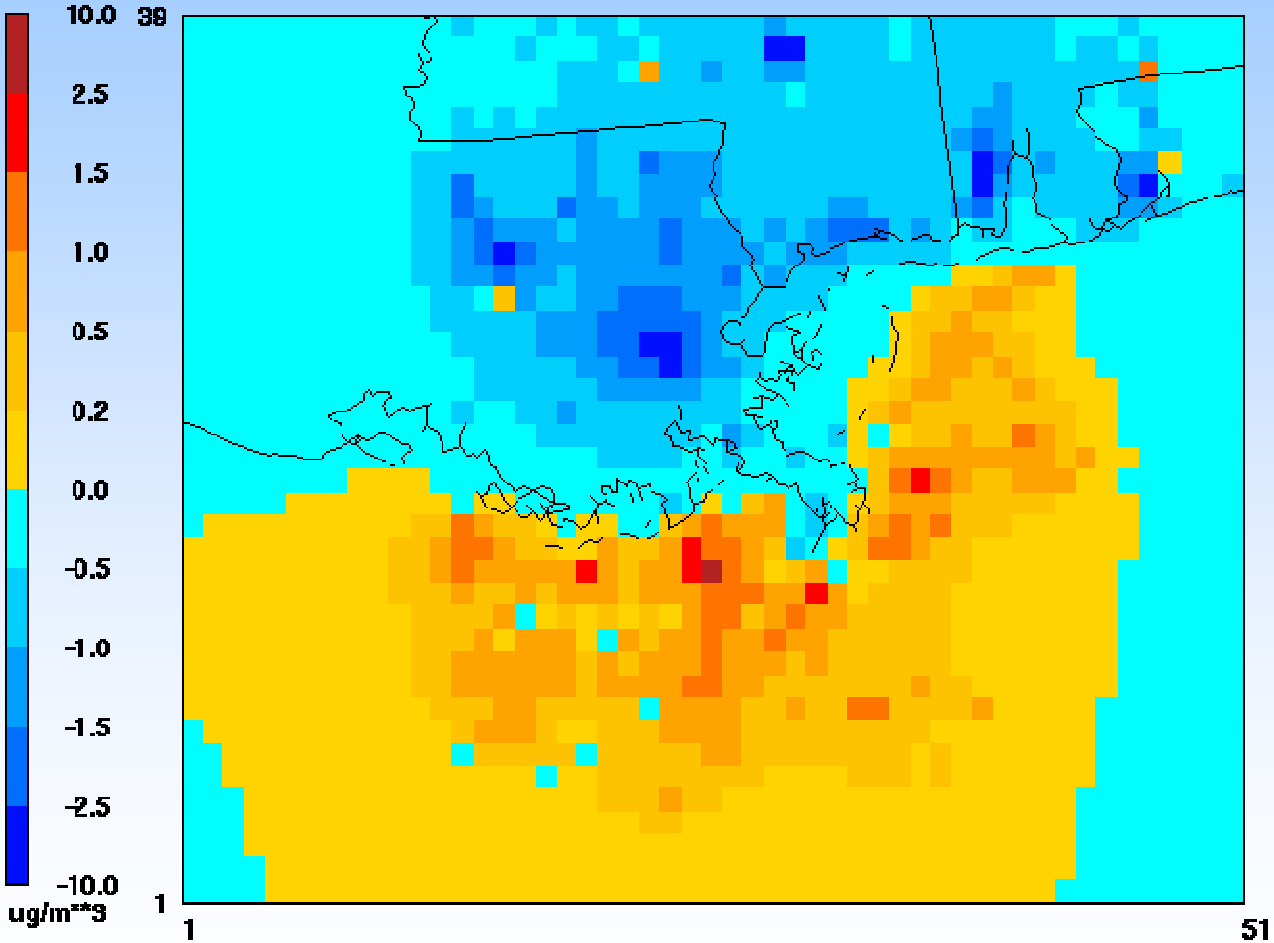
Min= -7.7 at (39,33), Max= 114.3 at (14,29)

Annual SO_2 Increments



Min= -27.8 at (39,33), Max= 11.0 at (14,29)

Annual NO_2 Increments



Min= -6.7 at (24,25), Max= 6.1 at (26,15)

Summary

- Meteorological Modeling
- Emissions
- Episodic Air Quality Modeling
- Annual Air Quality Modeling
- Increment Analysis