Development of Hourly Inventories Utilizing CEM-Based Data

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Introduction

- Describe the development of hourly emission files and associated temporal allocation factors used in the VISTAS Phase II model performance evaluation

- Specifically for modeling ozone and PM precursor power sector (EGU) emission inventories for national, annual episodes

Background

- The Regional Haze Rule defines regulations to improve visibility in 156 national parks and wilderness areas across the country
  - Require States to develop long-term strategies including enforceable measures designed to meet reasonable progress goals

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VISTAS Class I Areas

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Conceptual Model of Visibility Impairment in Southeastern U.S.

- VISTAS has reported a preliminary analysis to characterize the components of PM2.5 and their contributions to visibility impairment in the VISTAS region

- “Which pollutants are contributing to poor visibility?”

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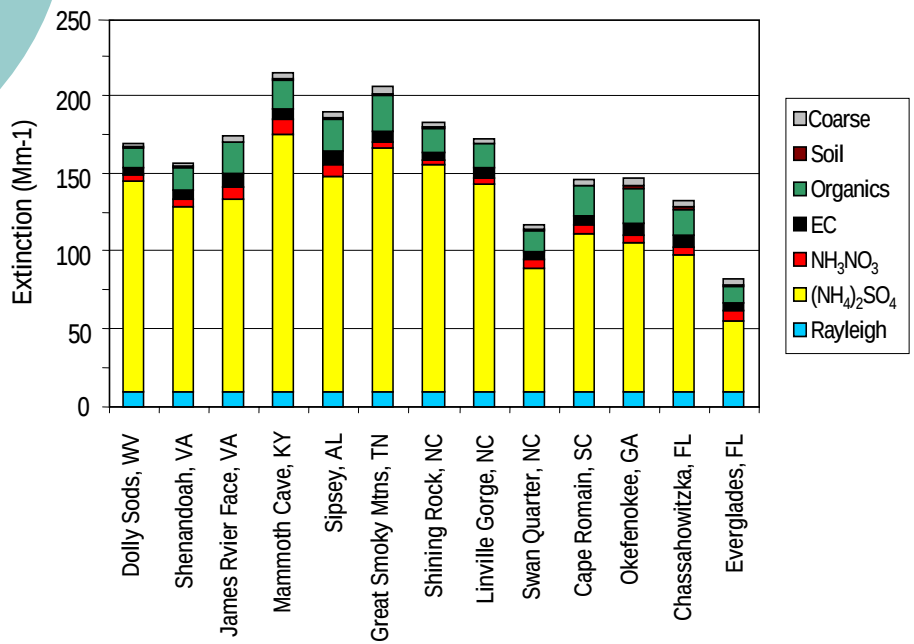
Monitoring Data

- Interagency Monitoring of Protected Visual Environments (IMPROVE) network
  - 1998 to 2001
- Southeast Aerosol Research Characterization Study (SEARCH) network
  - 1999 to 2001
- In both the IMPROVE and SEARCH networks, the 20% haziest days in the year occur most frequently in the summer and spring quarters and least frequently in the winter quarters

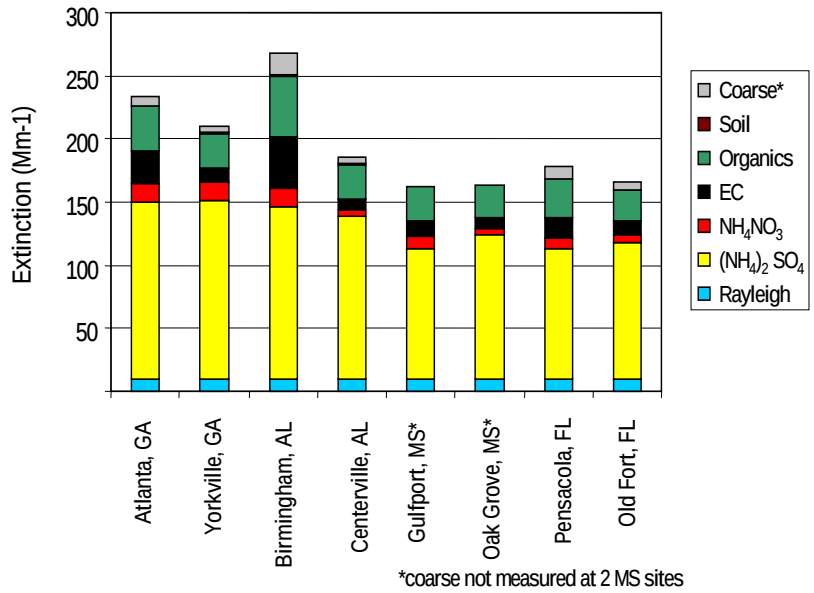
Components of Average Light Extinction (Mm-1)

20% Poorest Visibility Days

IMPROVE



SEARCH



*coarse not measured at 2 MS sites

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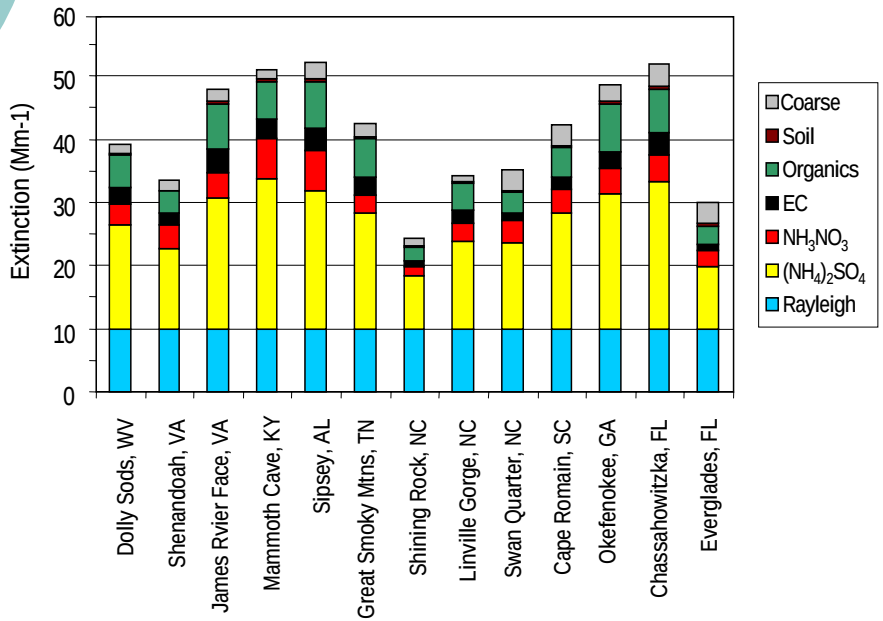
Components of Average Light Extinction (Mm-1)

20% Best Visibility Days

IMPROVE



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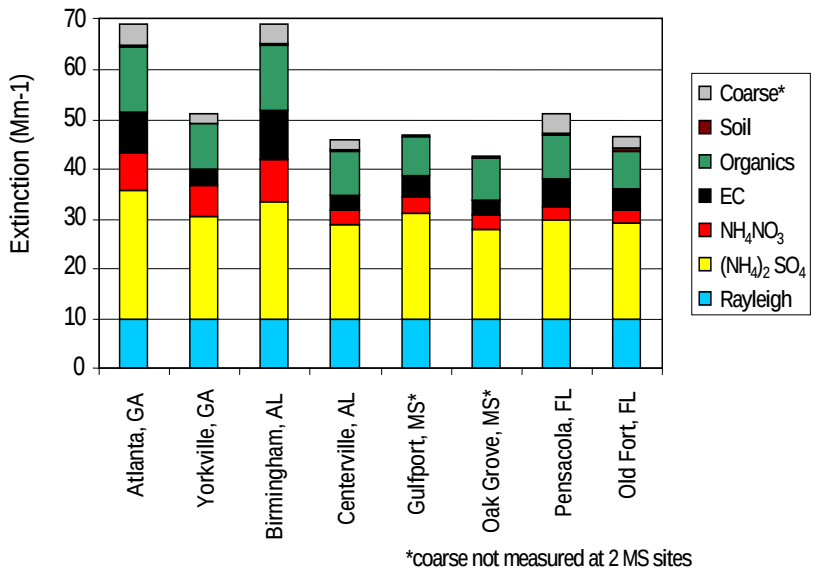

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VISTAS Phase II Modeling

- Multi-year effort to address the regional haze reduction requirements for the southeastern U.S.
- Use of meteorological, emissions and regional PM/ozone models to project visibility at VISTAS Class I areas in future years
  - Entails detailed performance testing of the CMAQ modeling system in base year

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Optimal Performance Configuration

- The contribution of individual source types to the degradation of visibility in the Class I areas is estimated most reliably by modeling each source with as fine a temporal resolution as possible

- Recent improvements in emissions recording, reporting and modeling have allowed for analysis at an hourly level of temporal resolution

Continuous Emissions Monitoring (CEM)

- CEM is the continuous measurement of pollutants from combustion or industrial processes

- The U.S. EPA has established requirements for the continuous monitoring of SO2, volumetric flow, NOx, diluent gas, and opacity for units regulated under the Acid Rain Program

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Using CEM Data

- Direct and indirect application to allocate emissions to specific episodes of time during the emissions processing of inventories for air quality modeling analyses

- Used to develop actual 2002 hourly emission data sets for power sector (EGU) emissions in modeling domain

Base Year Inventory Development

- Through other mechanisms, VISTAS generated a base year 2002 annual emission inventory of ozone, PM, and haze contributing pollutants

- Point, non-point, mobile, fire, misc.
  - VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, NH_3

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VISTAS State Base Year Emissions (Selected Pollutants)

	2002 Annual Emissions (Tons)			Percent of 2002 Total		
Source Category	**NOx**	**SO2**	**PM-10**	**NOx**	**SO2**	**PM-10**
Fuel Comb. Elec. Util.	1,514,950	3,720,703	111,810	29%	78%	3%
Fuel Comb. Industrial	484,885	449,373	112,110	9%	9%	3%
Fuel Comb. Other	106,405	109,595	100,218	2%	2%	3%
Chemical & Allied Product Mfg	20,366	77,450	10,733	<1%	2%	<1%
Metals Processing	11,904	49,367	28,992	<1%	1%	1%
Petroleum & Related Industries	7,112	53,381	2,425	<1%	1%	<1%
Other Industrial Processes	116,839	97,586	84,945	2%	2%	2%
Solvent Utilization	5,675	92	4,315	<1%	<1%	<1%
Storage & Transport	1,071	232	8,798	<1%	<1%	<1%
Waste Disposal & Recycling	30,042	6,186	120,019	1%	<1%	3%
Highway Vehicles	2,152,993	87,167	50,393	41%	2%	1%
Off-highway	799,063	89,168	69,514	15%	2%	2%
Miscellaneous	44,089	11,344	3,089,978	1%	<1%	81%
Total	**5,295,394**	**4,751,644**	**3,794,249**	**100%**	**100%**	**100%**

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Available CEM Data

- Through Clean Air Markets Division website, unit-level hourly emissions data by State were obtained
  - Used in developing temporal allocation factors
    - State, facility name, facility identification (ORISPL), unit identification code
    - Date and hour of record
    - SO2, CO2, and NOx mass (in lbs per hour), heat input (MMBtu), and NOx emission rate (lbs/MMBtu)

Temporal Profile Calculation

- SO2, NOx, heat input were used to develop unit, facility, and State level profiles

$$hi_{ratio,hr,date} = hi_{hr,date} / \sum_{Dec31}^{Jan1} hi$$

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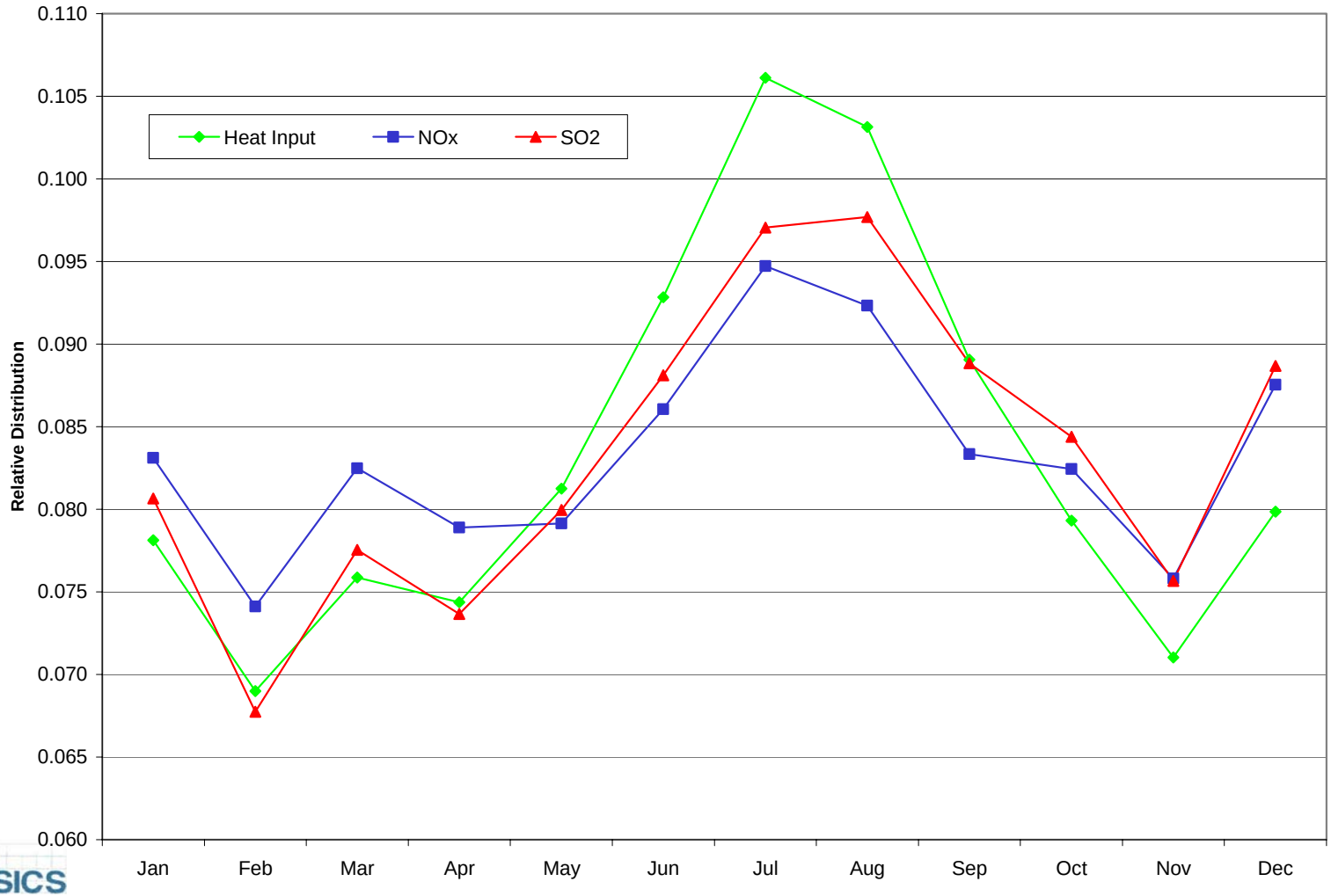
Multiple Calculation Requirement

- Three parameter values (SO2 mass, NOx mass, heat input) were calculated at each aggregation
  - Fuel blend, sulfur content, or seasonal control
  - Each unique and are not necessarily representative of the other variables' seasonal, daily, or even hourly profile

Monthly Variation in VISTAS 2002 CEM-based Data



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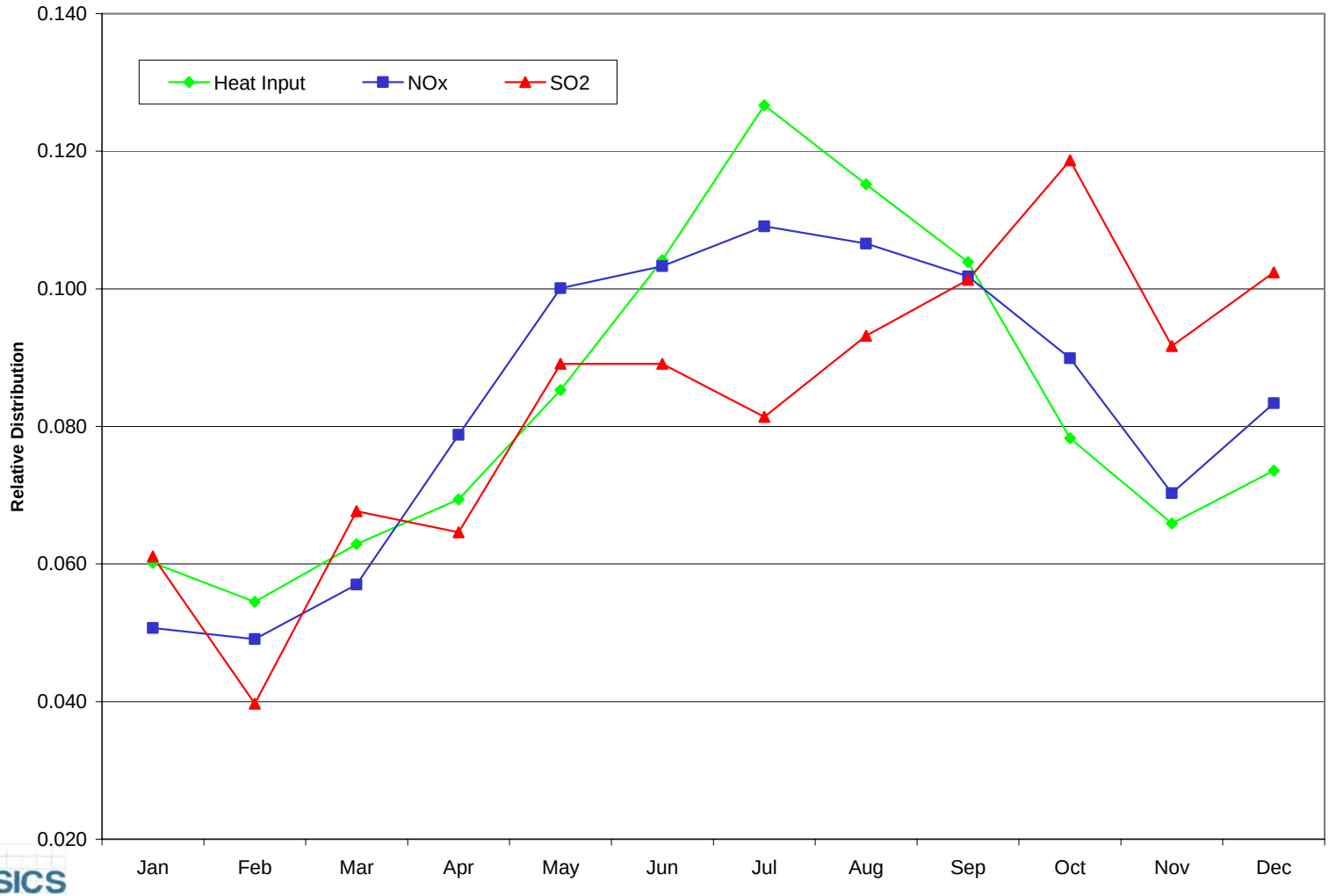
Monthly Variation in Mississippi 2002 CEM-based Data



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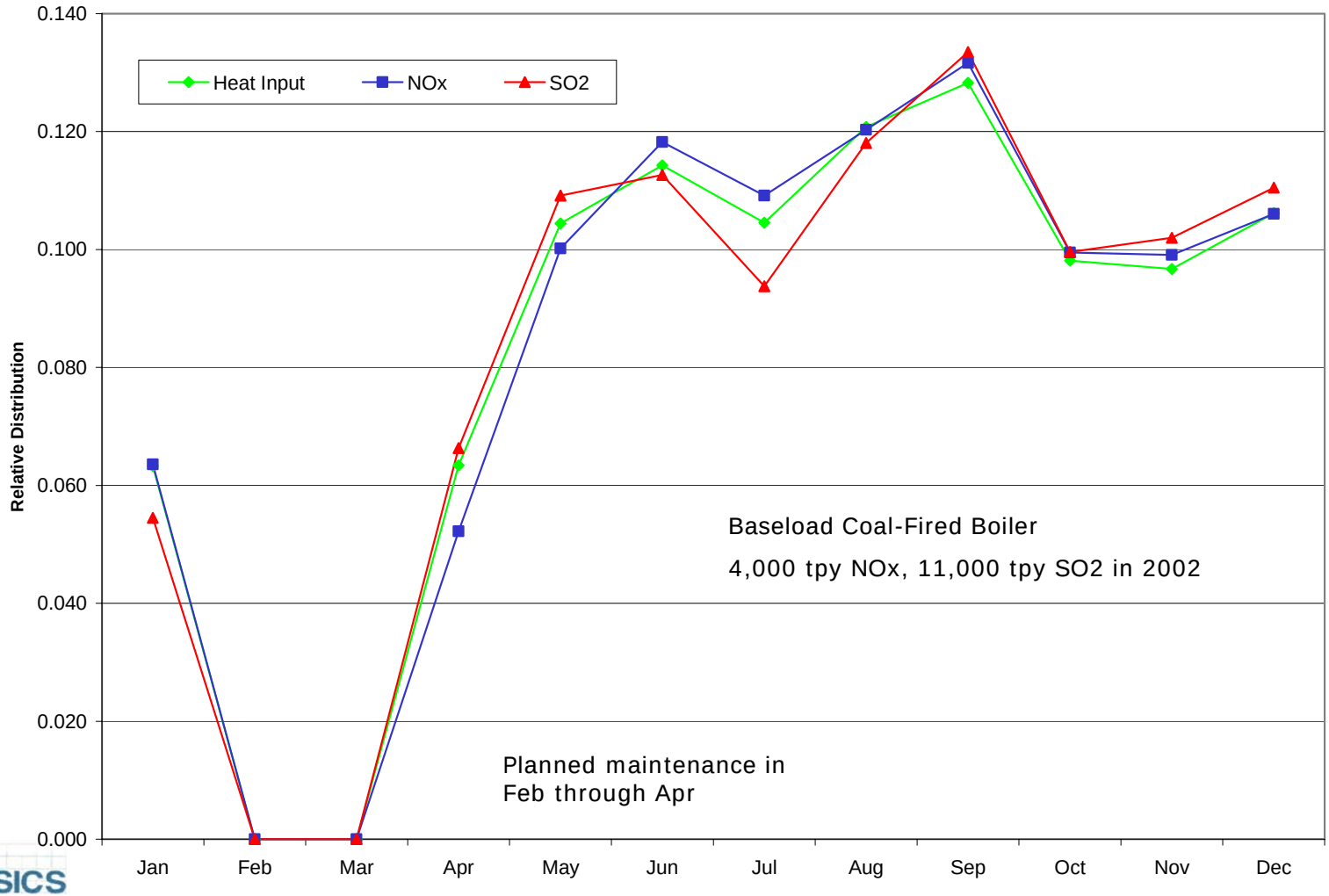
Monthly Variation in Mississippi Example Unit 2002 CEM-based Data



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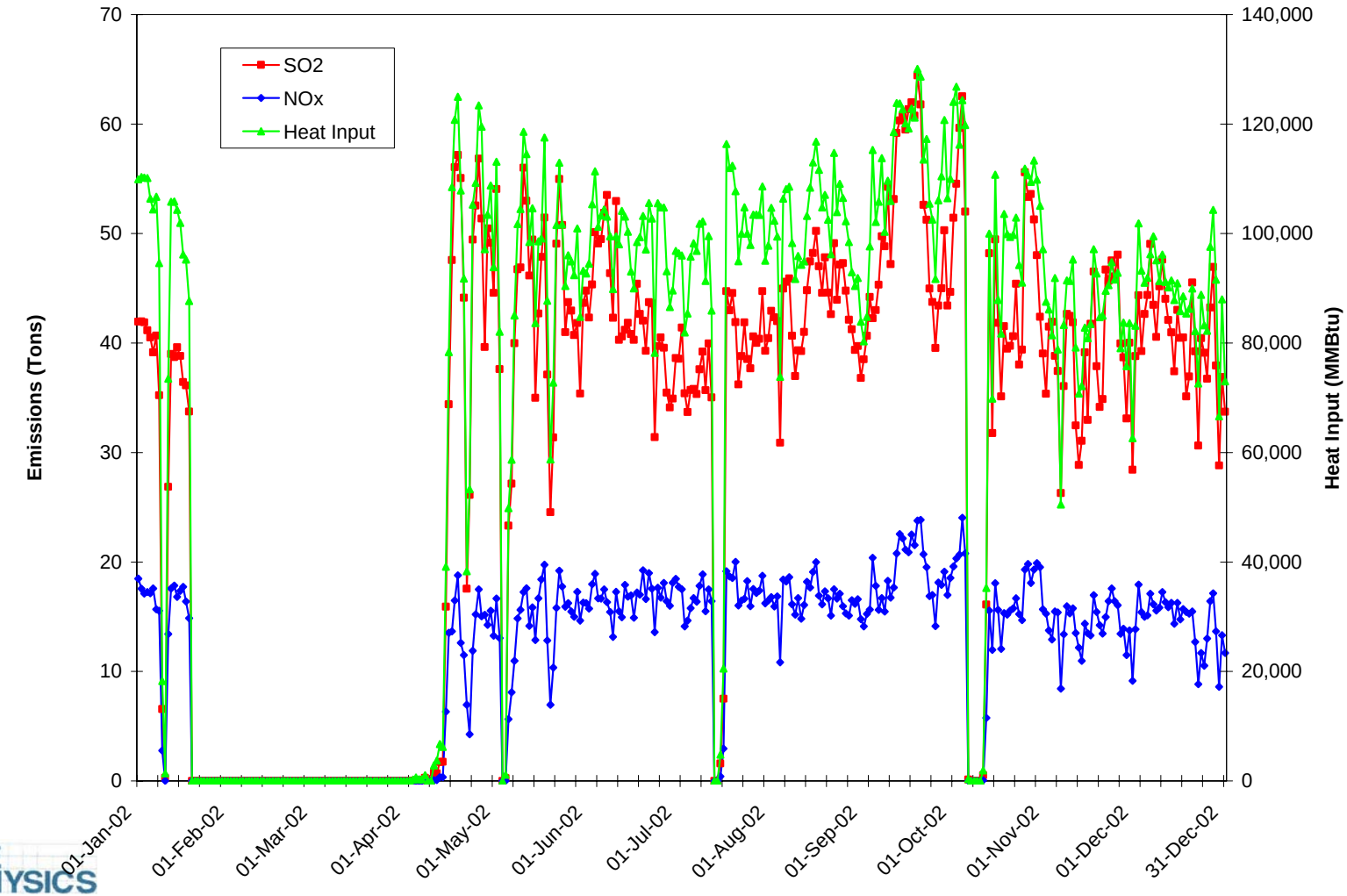
Actual Hourly Distribution of Mississippi Example Unit 2002 CEM-based Data



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CEM Ratios to Inventory Matching

- Ratios required to be matched to existing 2002 base year inventory
  - Unit, facility, or State-level

- Recall in VISTAS domain:
  - 3.7 million tons SO2
  - 1.5 million tons NOx
  - 861 units/boilers in CEM database

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Matching Process

- Automated unit ID basis
  - Based on ORIS-Boiler codes

- Facility level
- County-level reports
- State-level reports
- Ad-hoc visual inspection

Matching Success

- Units
  - 650 of 861 units/boilers matched
- SO2 Emissions
  - 99.95% captured with match
  - 3.7 million tons
- NOx Emissions
  - 99.46% captured with match
  - 1.49 million tons

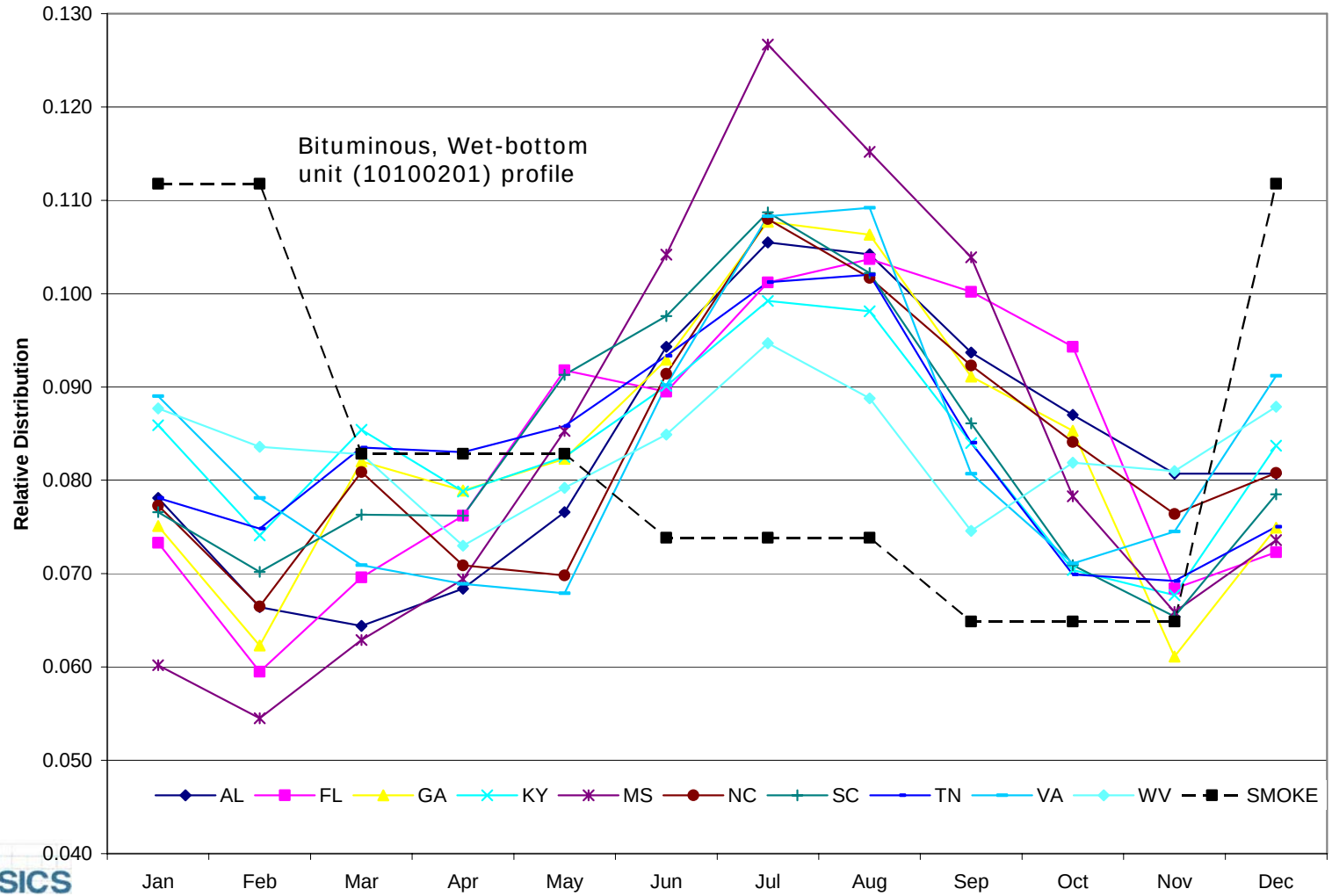
Application of Factors

- VISTAS chose SMOKE v2.0 for emissions processing
  - CEM input option available but only for NOx, SO2
- Chose to prepare hourly emission files (“EMS format”) for CEM-matched EGU source emissions

Assignment of Ratios

- Profiles assigned to annual emissions as submitted under CERR by S/L/T
  - Retains annual value
- NOx and SO2 received profiles based on NOx and SO2 calculations, respectively
- Other pollutants (VOC, CO, PM, NH3) received ratios based on heat input distribution
  - Less dependent on control / fuel content

Relative Distribution of Monthly VISTAS State CEM-based Heat Input



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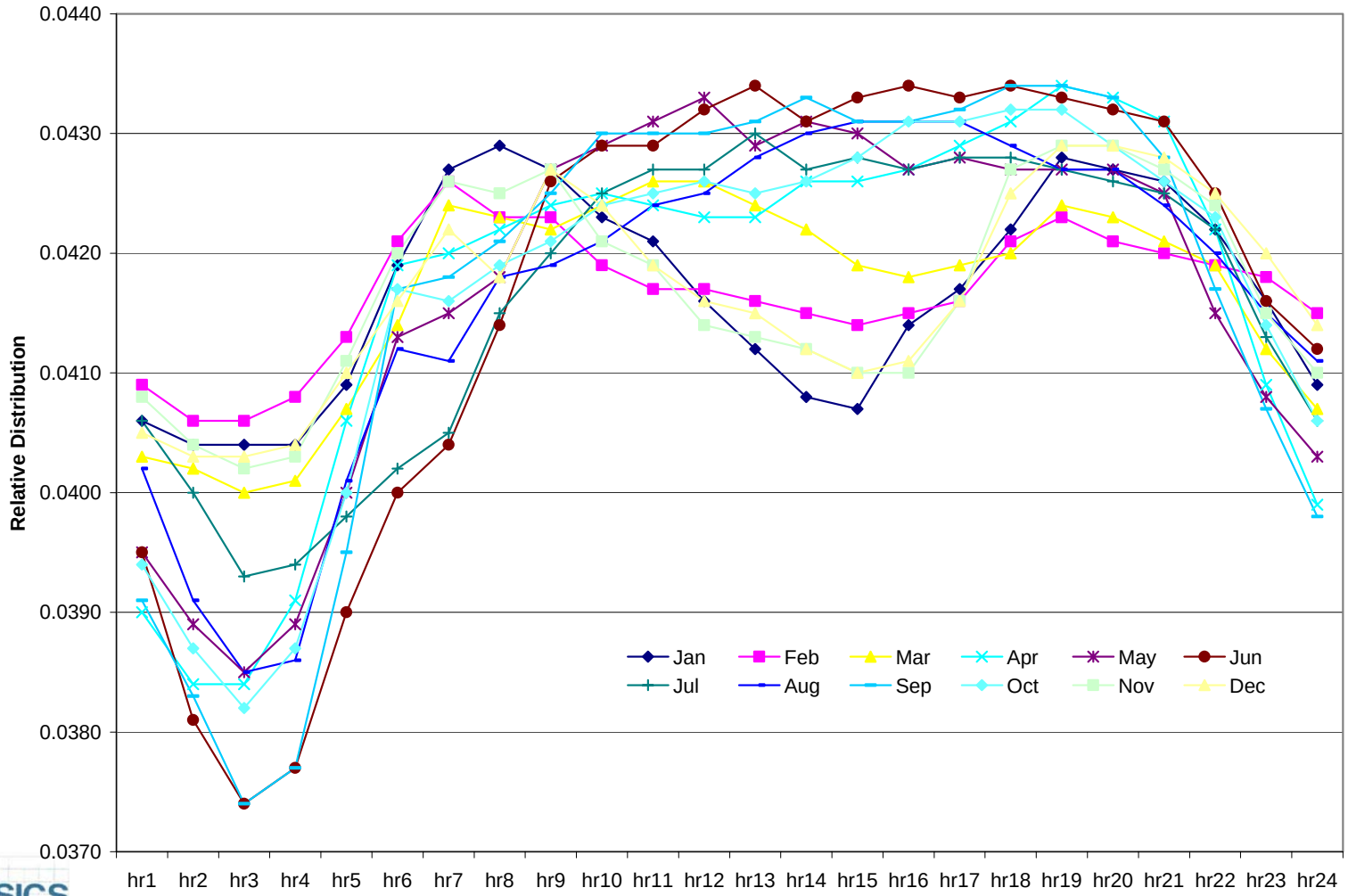
Relative Distribution of 2002 CEM-based NOx Emissions for Tennessee



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Results

- Application of the CEM-based temporal profiles to annual emission totals in the VISTAS domain exhibit the uniqueness of individual sources and their operating characteristics

- This hourly distribution of emissions greatly enhanced the inputs provided to the air quality model and improved model performance in more than one season and sub episode

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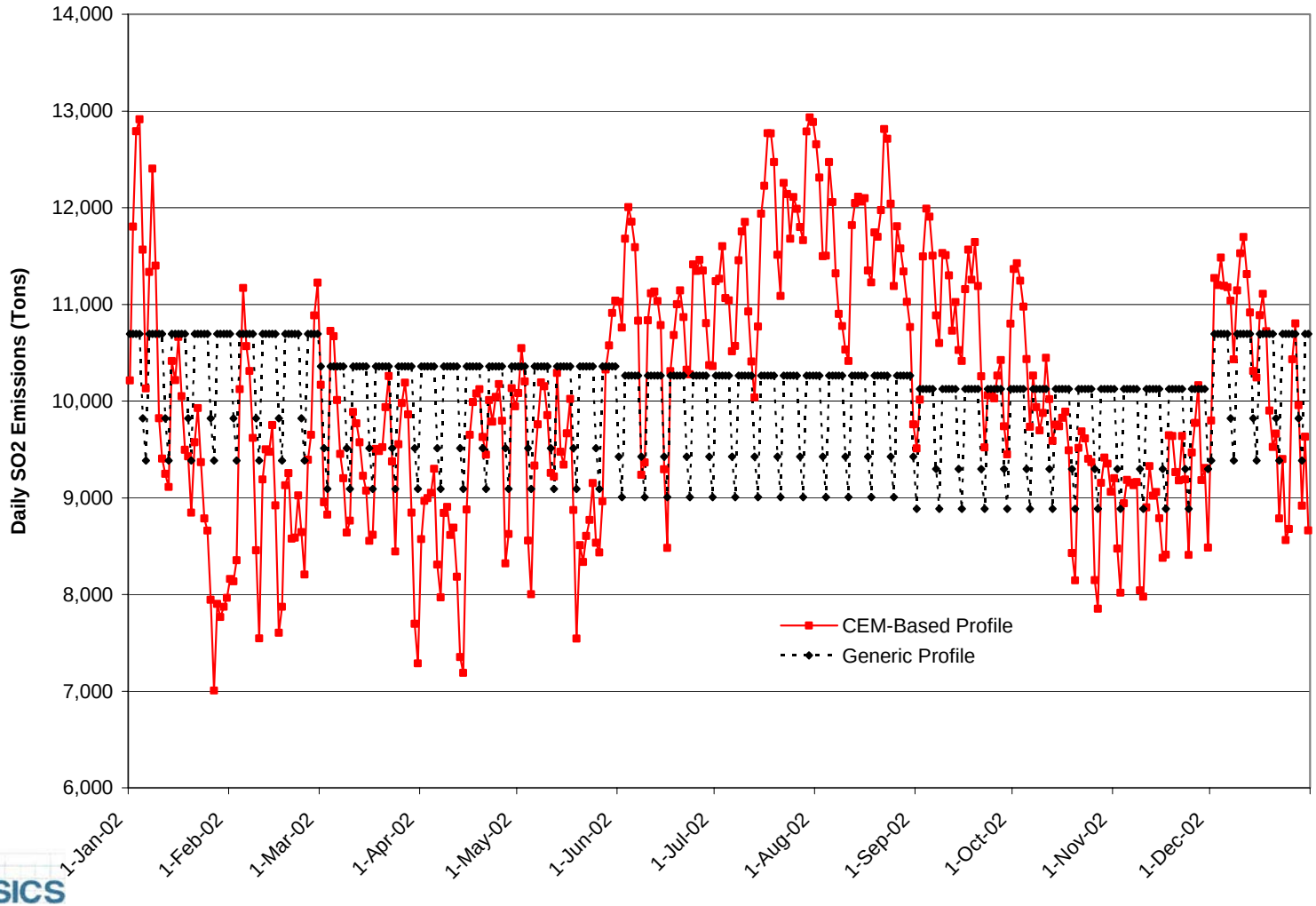
VISTAS EGU SO2 Emissions for 2002 Base Year Modeling



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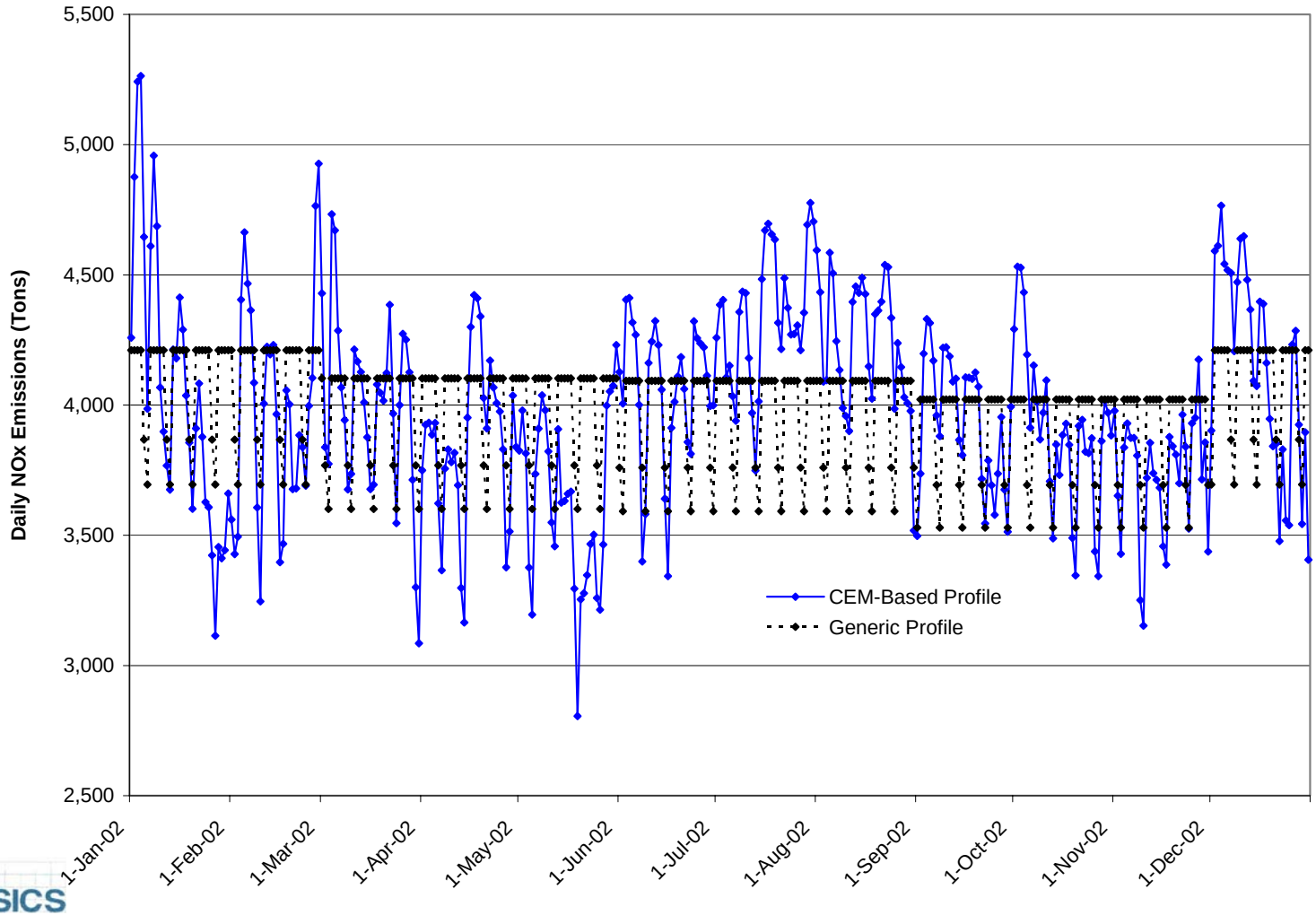
VISTAS EGU NOx Emissions for 2002 Base Year Modeling



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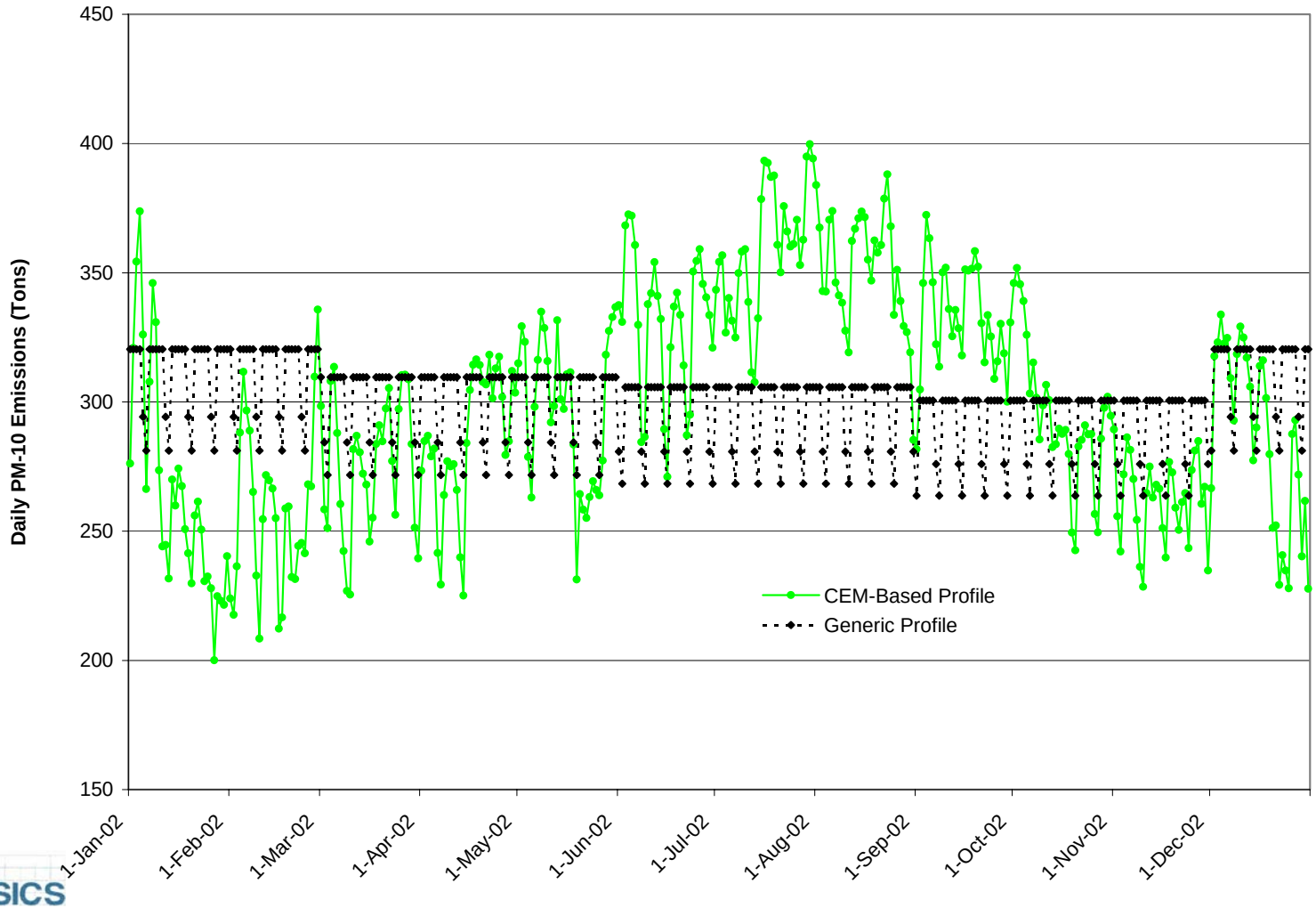
VISTAS EGU PM-10 Emissions for 2002 Base Year Modeling



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Summary

- Rigorous evaluation of regional ozone/fine particulate air quality models requires:
  - Focused testing of the air quality model
  - Examination of:
    - emissions and meteorological pre-processor programs and their input data sets

Summary (2)

- If one of the measured or modeled parameters is imprecise or incorrectly estimated, the air quality model's performance might be judged inadequate for the wrong reason

- Even more vexing is the existence of compensatory errors
  - Two sets of model inputs are incorrectly prescribed but their errors cancel
  - Yielding performance that appears to be good but for the wrong reasons

Conclusions

- Our research with the VISTAS inventories and other studies has demonstrated that the use of actual hourly emissions is indeed valuable

- However, today's mechanisms and procedures for collecting and reporting these emissions and associated data are limited to a few source types

Conclusions (2)

- The utilization of CEM-based temporal profiles allows for this best modeling practice with respect to EGU emissions
- Enhances the reliability of chemical transport model predictions
- Provides technical support for policy makers increased confidence in decisions on future strategies based on air quality simulations

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Conclusions (3)

- In VISTAS Phase II modeling and model performance evaluation for calendar year 2002
  - Demonstrated to improve model performance, thereby affording increased confidence in the control strategy evaluation results

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