Use of CALPUFF for Regional Oil and Gas Analyses

D.N. Blewitt, CCM

Comments on behalf of the
American Petroleum Institute

Oil and Gas Use of CALPUFF

- CALPUFF is being used for analysis of future year regional air quality impacts under NEPA (Environmental Impact Statements) for oil and gas development in the West
- A typical NEPA analysis includes up to 700 sources and impacts are projected over a 20 year period
- Air quality modeling approach is: "**Use the best available science to support NEPA analyses, and give greater consideration to peer-reviewed science and methodology over that which is not peer-reviewed.**" (Bureau of Land Management (BLM) *National Environmental Policy Act Handbook H-1790-1*)

Oil and Gas Use of CALPUFF (continued)

- Visibility and deposition impacts from NOx emissions are the pollutants of concern
- AQRV modeling approach is to develop a baseline emission inventory of sources not included in the monitoring data which is then added to cumulative emissions from new sources

Issues with the Use of CALPUFF for Cumulative EIS Analyses

- Formulation of CALPUFF chemistry
- Lack of a robust model performance evaluation in a full chemistry mode
- Indication of model bias for NO_3 impacts compared to monitored values
- Outdated and prescriptive IWAQM methodology is required for model application

MESOPUFF II CALPUFF Chemistry

In the MESOPUFF II chemistry module used in CALPUFF, SO4 formation is described by 4 variables**:**

1) Solar Radiation;
2) Background Ozone (surface, user provided);
3) Atmospheric Stability; and
4) Relative Humidity (surrogate for aqueous-phase)

NO3 formation is described by 3 variables:

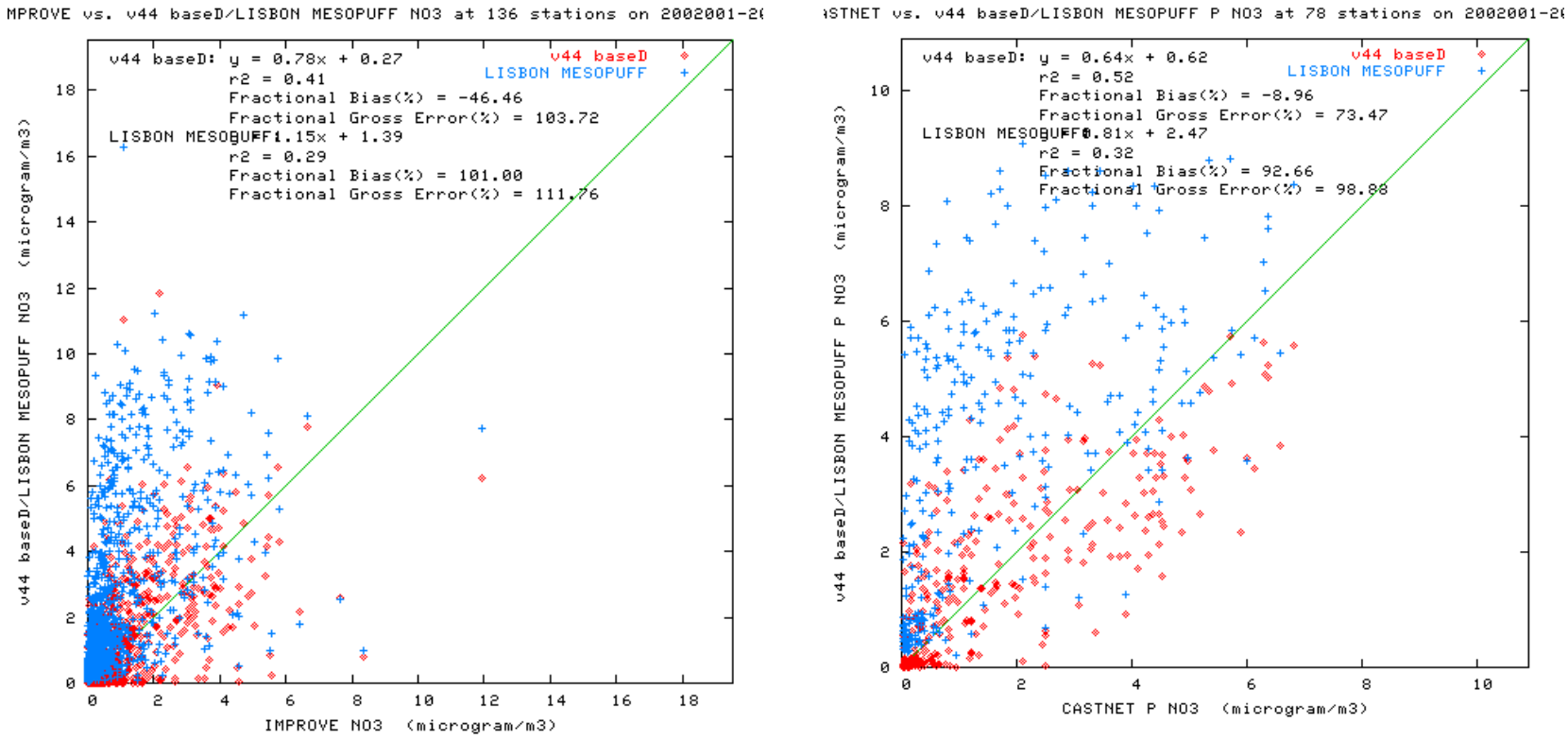
1) Background Ozone;
2) Atmospheric Stability; and
3) Plume NOx Concentration

CALPUFF MESOPUFF II Chemistry Limitations

1) Aqueous-phase SO_4 formation is inaccurate because it is solely based on surface relative humidity (RH). In reality, aqueous-phase SO_4 formation is not at all affected by RH.

2 The MESOPUFF II transformation rates were developed using temperatures of 86, 68 and 50°F. A 50°F minimum temperature will overstate SO_4 and NO_3 formation under cold conditions. – **A major issue in the intermountain West**

Scatter plots of predicted and observed Nitrate (NO3) concentrations by the CMAQ V4.4 (red) and CMAQ-MESOPUFF-II chemistry (left blue) for January 2002 at all IMPROVE (top), and CASTNet (right) sites in the United States

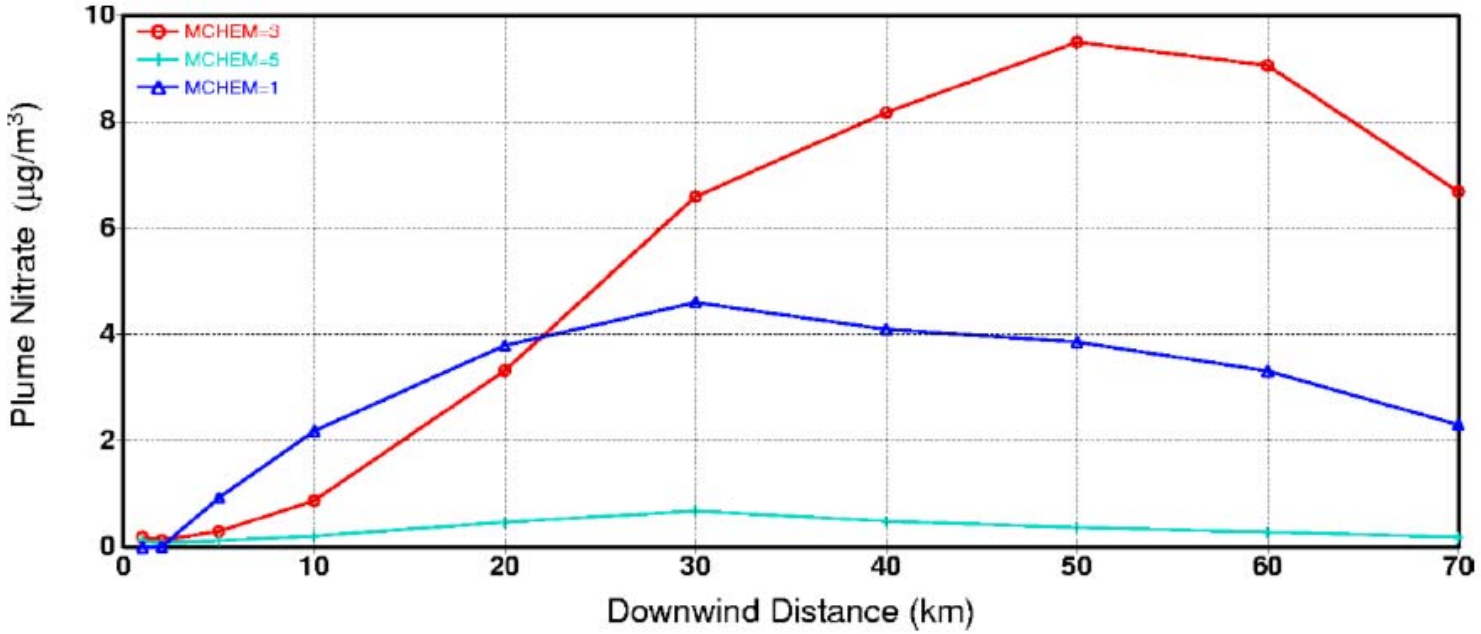


Source: Environ

Comparison of CALPUFF Chemistry Modules

Particulate nitrate concentrations as a function of downwind distance (relative humidity set to 95%)

MCHEM=1 MESOPUFF II chemistry
MCHEM=3 Original RIVAD treatment
MCHEM=5 refers to the new RIVAD treatment (ISORROPIA).



Verification of the CALPUFF Model

- **There is very limited data regarding accuracy of the CALPUFF Model in the mode in which it is being applied**
- **The Southwest Wyoming Technical Air Forum (SWWYTAF) is one study that examined CALPUFF Model accuracy in a full chemistry mode**

SWWYTAF Results

- **RIVAD chemistry was used**
- **When boundary conditions were included, model agreement was very good**
- **Results were unpaired in time and space**
- **Analysis indicated that NO_3 formation was limited by NH_3 concentrations**
- **This is not the way that agencies are requiring that the model should be used**

Examples of CALPUFF Monitor Comparisons

The following examples present a strong **indication** that the as CALPUFF Model using the IWAQM protocol, has a substantial bias towards over predicting NO_3 concentrations

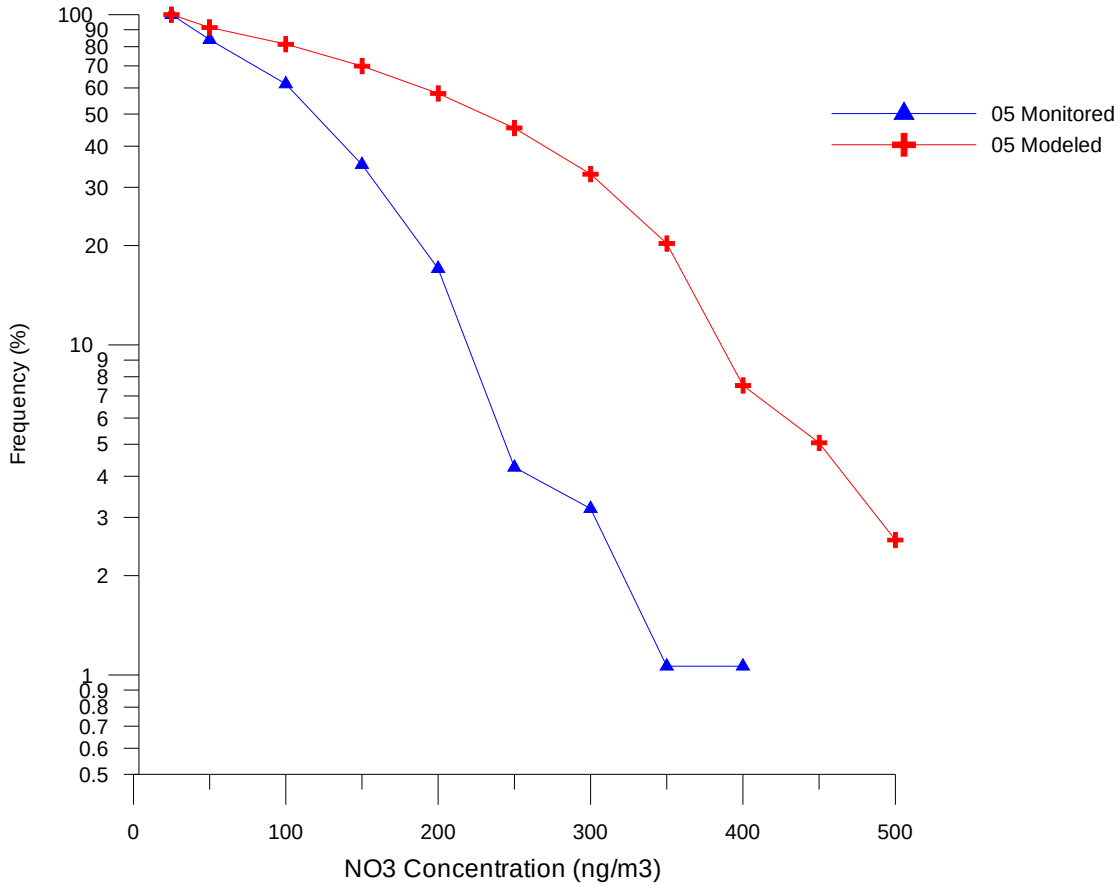


Figure 2. Cumulative Frequency Distribution for Bridger Class I Area NO3 Concentrations Modeled versus Monitored 1988-2005

Frequency Distribution of NO3 at Bridger IMPROVE Monitor

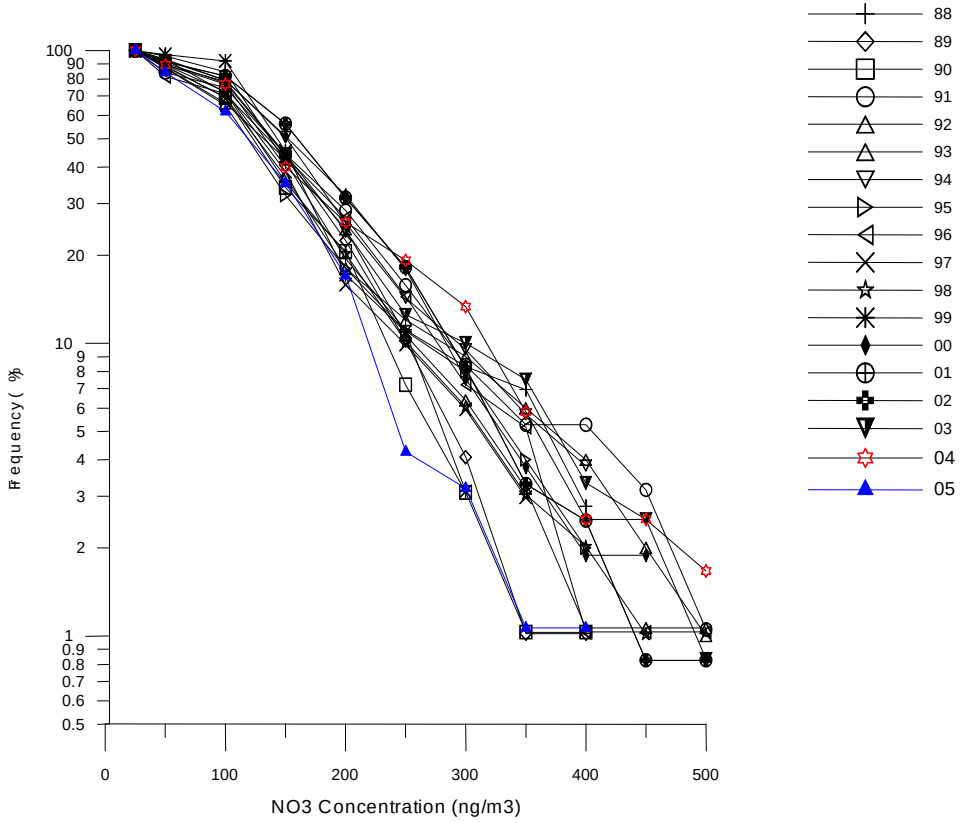
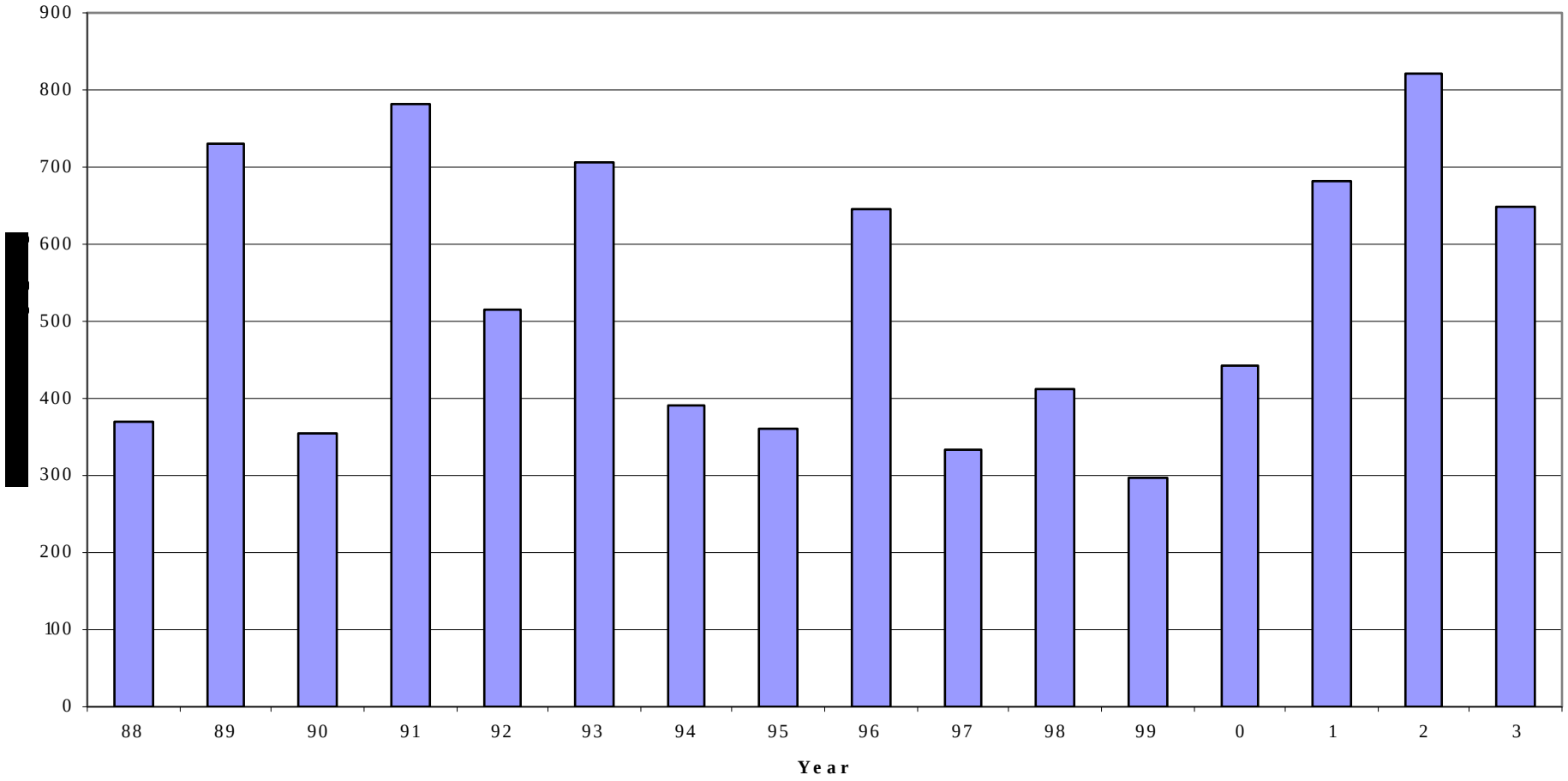


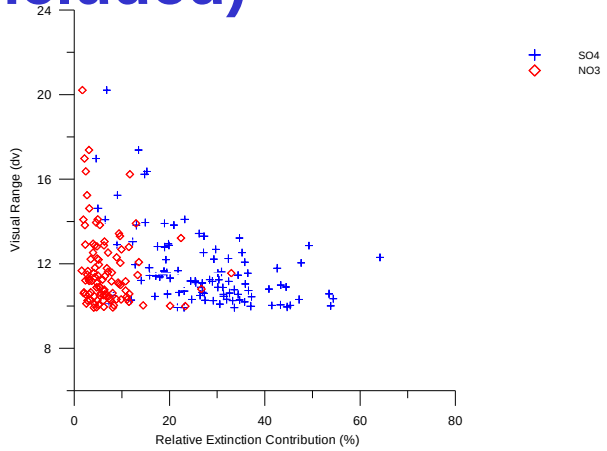
Figure 10. Cumulative Frequency Distribution for Bridger Class I Area NO3 Concentrations 1988-2005

NO3 Concentrations Have Not Changed Over Period of Record

Maximum Measured NO_3 Concentrations Measured at the Bridger Class I Area

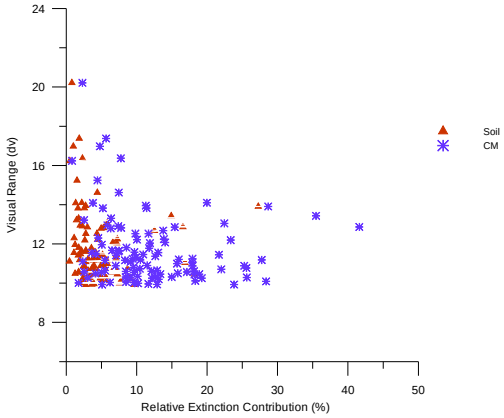


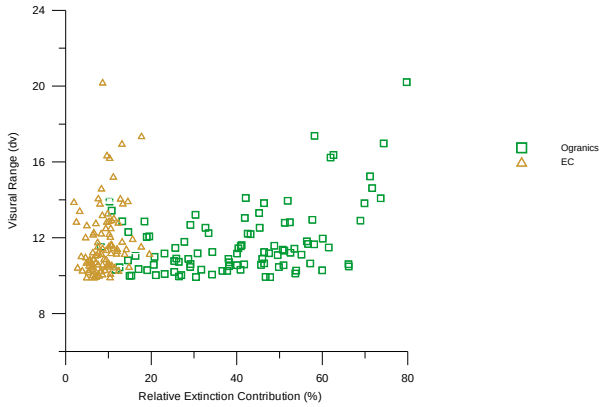
Relative Extinction Contribution for Various Species for the 100 Worst Days at Bridger (Raleigh Scattering is not included)



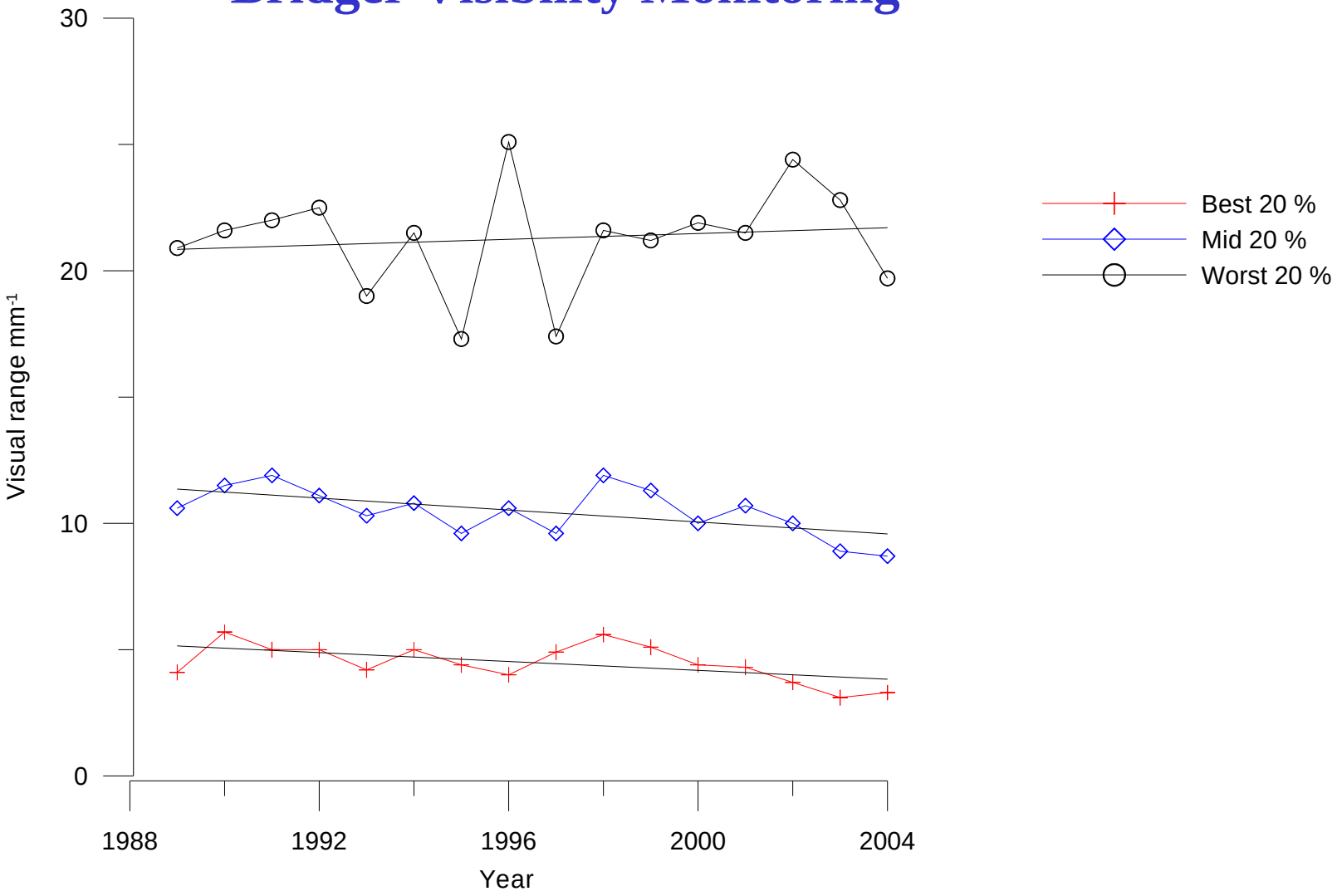
X Axis = Relative Extinction Contribution (%)

Y Axis = Visual Range (dv)





Bridger Visibility Monitoring



Trends in Visual Range 1988 through 2004

Note: Straight line is least square fit

CDPHE BART Hayden
CALPUFF Analysis

	Ratio of NO3/SO4 CALPUFF	Ratio of NO3/SO4 Monitoring 2002	Ratio of NO3/SO4 Monitoring Period of Record
Average	**8.67**	**0.44**	**0.28**

Conclusion: CALPUFF does not replicate the actual monitored NO3/SO4 ratio.

Estimated Change in NOx Emissions in Southwestern Colorado and Northern New Mexico Versus Measured Visual Range At Mesa Verde

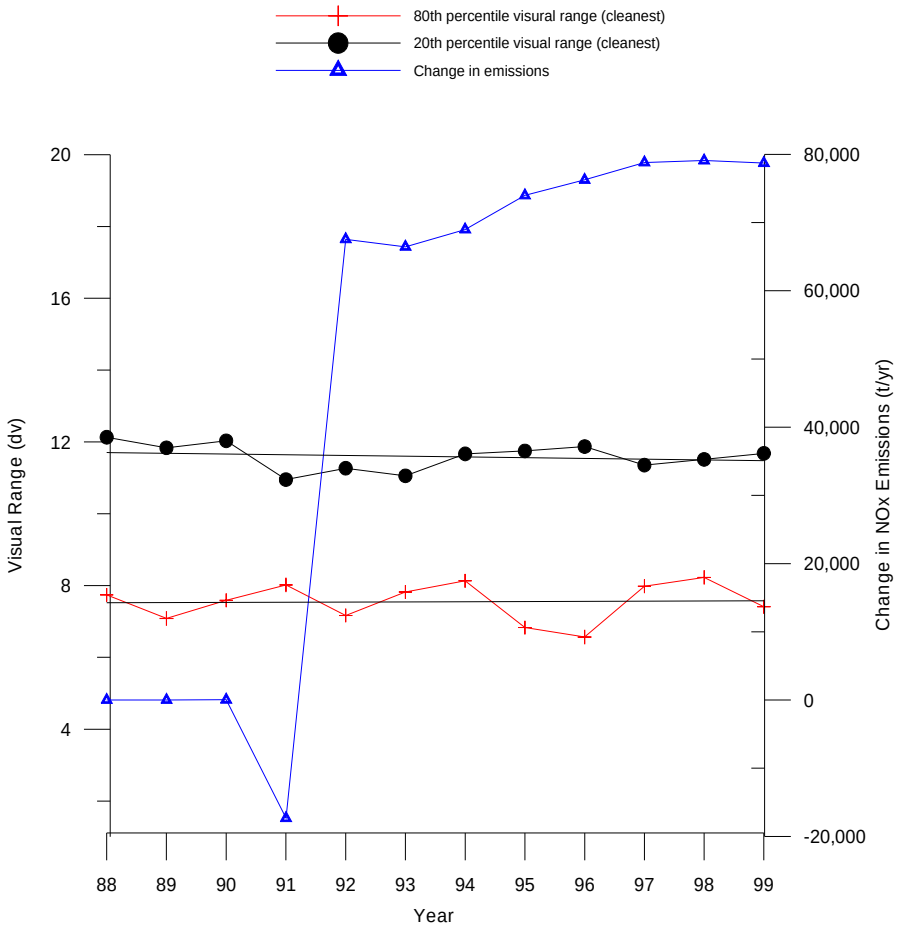


Figure 7. Estimated Change in NOx Emissions in the Southwestern Colorado and Northern New Mexico versus Measured Visual Range

Southwest Colorado Measured Changes in Visibility Compared to CALPUFF Modeled Visibility

Case	Estimated Increase in NOx Emissions (t/yr)	Max Increase in Visibility (dv)	Number of Days with Projected Change in Visibility Greater than 1 dv
Monitoring Data	80,000	Neg.	0
CALPUFF Modeling for SUIT	7,482	0.8	0

Recommendations

EPA needs to revisit the use of CALPUFF in regional AQRV analyses

Long Term

- There is a strong need to perform a comprehensive model evaluation of CALPUFF using full chemistry
- Other candidate models should be included in such an analysis
- Data bases are becoming available in Wyoming and Colorado (NEPA and Four Corner analyses) that could be used for such an analysis
- After a model evaluation is conducted, IWAQM should revise the guidance on model application of CALPUFF (public process)

Recommendations (continued)

Short Term

Until a comprehensive model evaluation is conducted, CALPUFF analyses should include a simulation of existing conditions that can be compared to monitoring data in order to provide an analysis of model performance

– Future year CALPUFF analyses should be used in a relative mode for AQRV analyses