Appendix A-4

Ozone Impact Analysis

Ozone Impact Analysis
Grays Harbor Energy
Units 3 &4

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Contents

1 Introduction

This analysis of ozone impacts attributable to the Grays Harbor Energy Center (GHEC) facility has been prepared by ENVIRON International, Inc. (ENVIRON) in support of a combined Prevention of Deterioration (PSD) and Notice of Construction (NOC) application. The proposal is to increase the facility's overall capacity by adding two more combined-cycle combustion turbines and a second steam turbine (referred to as Units 3 and 4).

Title 40 of the Code of Federal Regulations, Section 52.21(i)(5)(i)(3) requires an ambient ozone impact analysis be performed for any net emissions increase of 100 tons per year (TPY) of more of volatile organic compounds (VOCs) or oxides of nitrogen (NOx). VOC and NOx emissions attributable to the current proposal each exceed 100 TPY. The ozone impact analysis was performed using the Community Multiscale Air Quality (CMAQ) dispersion model. Two simulations were developed: a base case scenario which included all existing regional emissions other than the GHEC facility, and a potential-to-emit (PTE) scenario which combined the base case scenario emissions with the GHEC facility's maximum post-project emissions. The ozone concentrations predicted by the two simulations were compared to determine the ozone impact attributable to the project.

The modeling simulations were based on those developed by the Washington State University (WSU) Laboratory for Atmospheric Research in support of a state implementation plan (SIP) for Ozone for the Portland, OR/Vancouver, WA region. This is essentially the same dataset used by WSU as the base case scenario to analyze future emission scenarios for the Puget Sound Clean Air Agency (PSCAA). In those analyses, as well as this, a three-day period beginning July 26, 1998 was selected because the episode had the highest observed ozone levels in recent years for the Seattle/Portland airshed. ENVIRON obtained input and output files from WSU for this episode.

2 Model Description

The modeling system used for this work was the Mesoscale Meteorological model Version 5 (MM5)/Sparse Matrix Operator Kernel Emissions (SMOKE)/CMAQ system. Each component is independent: MM5 supplies the meteorology, SMOKE pre-processes emissions information, and CMAQ combines the emissions with the meteorology to calculate concentrations.

MM5 (Grell et al., 1994) was used to provide the 3-D meteorological field for air quality modeling. Three one-way nested domains with grid cell horizontal sizes of 36 km, 12 km, and 4 km were applied. The two outer domains consisted of 98x95 and 133x151 grid cells, respectively. The innermost domain consisted of 112x112 grid cells which extended from north of Puget Sound in Washington to south of Salem, OR and from the Pacific coast on the west to beyond the Cascade Mountain range on the east. Vertically, 38 sigma layers were specified. WSU performed a sensitivity analysis and determined that using the more advanced land surface model (NOAH LSM) produced the best overall results for air quality modeling. A detailed analysis is available in the Portland SIP report.

The SMOKE Modeling System allows emissions data processing methods to integrate high-performance-computing (HPC) sparse-matrix algorithms. It provides a mechanism for preparing specialized inputs for air quality modeling research, and it makes air quality forecasting possible. Although version 2.5 is the most recent available version, ENVIRON used SMOKE version 2.1 to maintain compatibility with the emissions inventory of the previous WSU modeling. Emissions classes included biogenic, area, non-road mobile, on-road mobile, and industrial point sources. Emissions inventories obtained from WSU for Oregon, Washington and British Columbia were included.

EPA Models-3 CMAQ Modeling System (Byun and Ching, 1999) version 4.6 was used for photochemical air quality modeling. Based on state-of-science techniques, CMAQ is a multi-scale, multi-pollutant air quality model that simulates the transportation, transformation, and deposition of atmospheric pollutants including photochemical precursors and oxidants, particulate matter, and airborne toxics. It simulates chemical transport using the CMAQ Chemical Transport Model (CCTM) by incorporating the output fields from the MM5 meteorological simulations and emissions derived from SMOKE.

The [California] Statewide Air Pollution Research Center (SAPRC99) photochemical mechanism, including aqueous chemistry, was used, but the aerosol dynamics module was not employed due to the lack of emission inventory data for key aerosol precursors. Chemical speciation of the emission inventory was performed by SMOKE according to the SAPRC99 mechanism. The Modified Euler Backward Interactive (MEBI) solver was used to solve the chemical kinetic equations.

3 Source Description

The base case scenario emissions inventory is based on the 1999 National Emissions Inventory, using its point sources, area sources and some non-road sources (ships, locomotives, aircraft, etc.). A detailed discussion of the base case scenario emission inventory is presented in the appendixes of the WSU SIP and PSCAA reports.

The PTE scenario included all the emissions in the base case, plus the point sources associated with this project. Because the ozone analysis is concerned with regional impacts that are generally distant from the facility, the ten cooling towers were represented in the model by a single stack with exhaust characteristics equivalent to a single tower but ten times the emissions. Emission rates are summarized in Table 3-1, and emission release parameters are provided in Table 3-2. These emission source data were prepared for use with CMAQ using SMOKE pre-processing programs.

The rates used are the maximum hourly emission rates for each pollutant, regardless of operating scenario. For example, the NOx and CO rates are their maxima for the startup/shutdown scenario, while the SO2 rate is its maximum for the continuous operation scenario.

Table 1: Point source release parameters

Source	UTM X (m)	UTM Y (m)	Height (ft)	Temperature (ºF)	Velocity (ft/s)	Diameter (ft)
CTG3	463675	5201629	180	160.78	66.14	18.00
CTG4	463718	5201627	180	160.78	66.14	18.00
AUXB2	463775	5201616	49	398.03	68.10	1.76
DG2	463748	5201628	13	909.90	310.25	0.50
FPMP2	463677	5201652	13	1032.00	238.59	0.42
CoolingTowers	463739	5201684	52	102.00	17.85	42.59

Table 2: Point source emission rates

Source	NOx (TPY)	SO2 (TPY)	PM10 (TPY)	CO (TPY)	VOC (TPY)
CTG3	126.79	61.98	83.22	2013.39	127.16
CTG4	126.79	61.98	83.22	2013.39	127.16
AUXB2	1.4117	0.7412	0.6417	4.7484	0.5133
DG2	0.7203	0.0319	0.0360	15.1265	17.2875
FPMP2	0.2476	0.0146	0.0330	5.1508	5.9433
CoolingTowers	0	0	3.4527	0	0

4 Results

As a preliminary exercise, the base case scenario provided by WSU was replicated and the results compared to those reported by WSU. Figures 1 and 3 present the maximum predicted concentrations in parts per million by volume (ppmV) for the replicated base case, and Figures 2 and 4 present the corresponding plots from the WSU/PSCAA report (Figures 17a and 18a in that document). Qualitatively, the plots for the same time periods are similar, and differences between the corresponding plots are slight, with a less than two percent difference in the maximum predicted ozone concentration for the hours depicted. Perhaps the most notable feature is the increased ozone at the north end of Puget Sound in Figure 1, which is presumably attributable to sources in Canada. For the purposes of this modeling exercise, exact duplication of previous work is not necessary; this comparison is provided as confirmation that predictions from the more recent version of CMAQ are consistent with those of previous versions.

The Visualization Environment for Rich Data Interpretation (VERDI) was used to explore and visualize the differences between the base and PTE cases. The figures presented in the WSU/PSCAA report were prepared using The Package for Analysis and Visualization of Environmental data (PAVE), which is no longer supported. Unfortunately, certain features of PAVE have not been implemented in VERDI. These include the ability to smooth tile plots (creating contour-like plots shown in Figures 2 and 4) and the ability to plot N-hour average concentrations. CMAQ outputs 1-hour average concentrations only. The m3tproc program from the Input/Output Applications Programming Interface[1] (I/O API 3) was used to calculate 8-hour averages of ozone concentration.

The results of the base and PTE cases are small enough that a side-by-side visual comparison of the two plots is not useful for discerning differences. To facilitate examination of the differences between the two scenarios (the PTE scenario and the base case scenario), the remainder of the figures present concentration differences in parts per billion by volume (ppbV), a thousand-fold increase in the concentration scale used in Figures 1 through 4.

Figure 5 shows a time series plots of the ozone concentration difference at the cell with the maximum 8-hour average difference (an increase of 2.25 ppbV at cell 22,70). Figure 6 shows the spatial variation of the 8-hour average ozone concentration difference between the two scenarios during the period with the maximum difference (0900 PDT on July 28, 1998). As this figure shows, the effects of the facility's NOx and VOC emissions is quite localized.

Figures 7 through 11 present time series plots of 8-hour averaged differences in simulated ozone concentrations (PTE scenario minus base case scenario) near the closest Class I areas. As can be seen, the maximum change to 8-hour average ozone concentrations near Class I areas is less than 0.01 ppbV, which is less than 0.02 percent of the current ozone NAAQS.[2]

Figure 12 presents a time series of 8-hour averaged differences in simulated ozone concentrations (PTE scenario minus base case scenario) near the Mud Mountain site outside of Enumclaw, WA. The maximum difference is less than 0.0004 ppbV, which is close to the smallest number the program can resolve.

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[1] http://www.baronams.com/products/ioapi/

[2] The current ozone NAAQS is 75 ppb. To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm

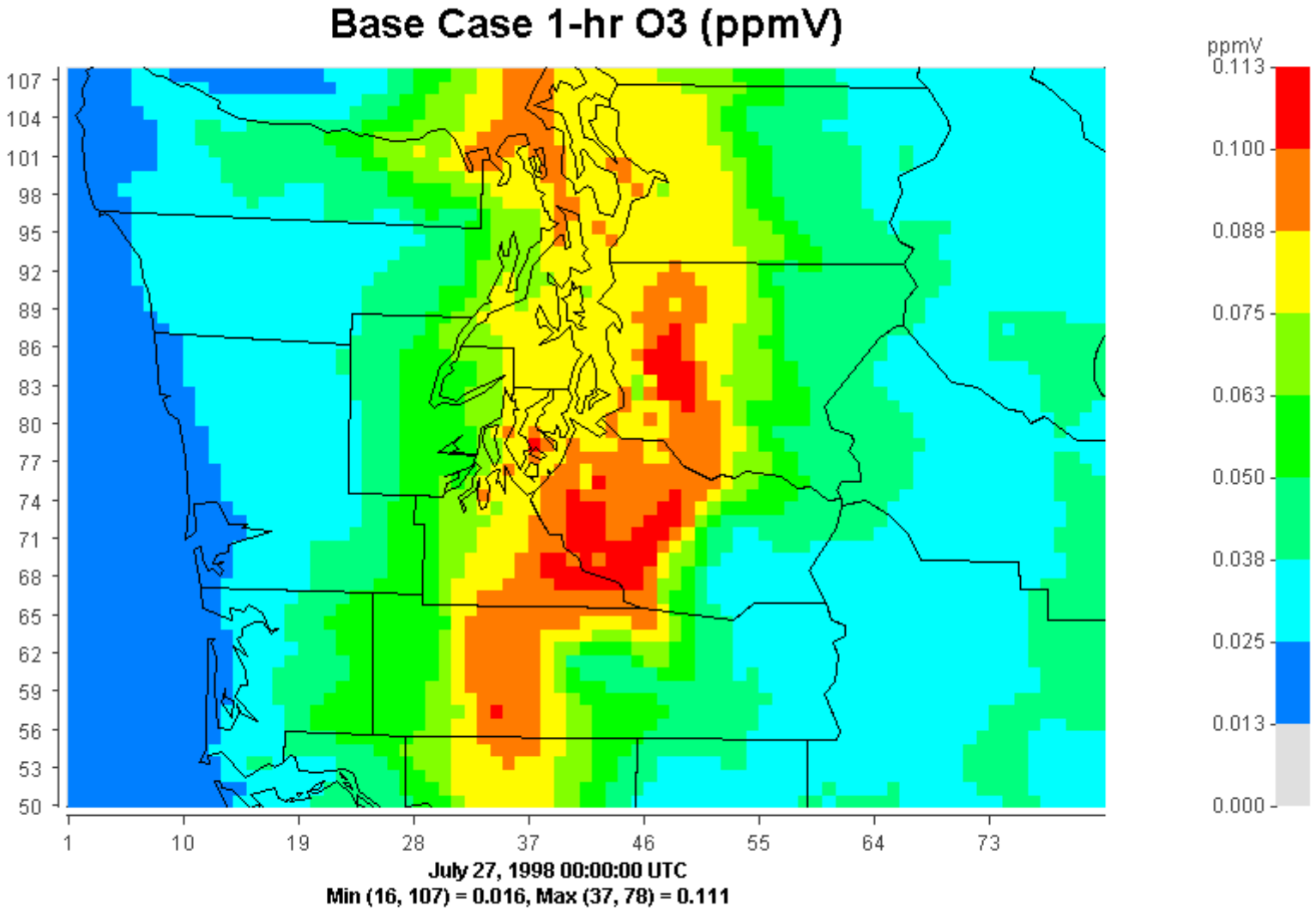

Figure 1 Simulated 1-Hour Average Ozone At 1700 PDT On July 26 (Base Case)

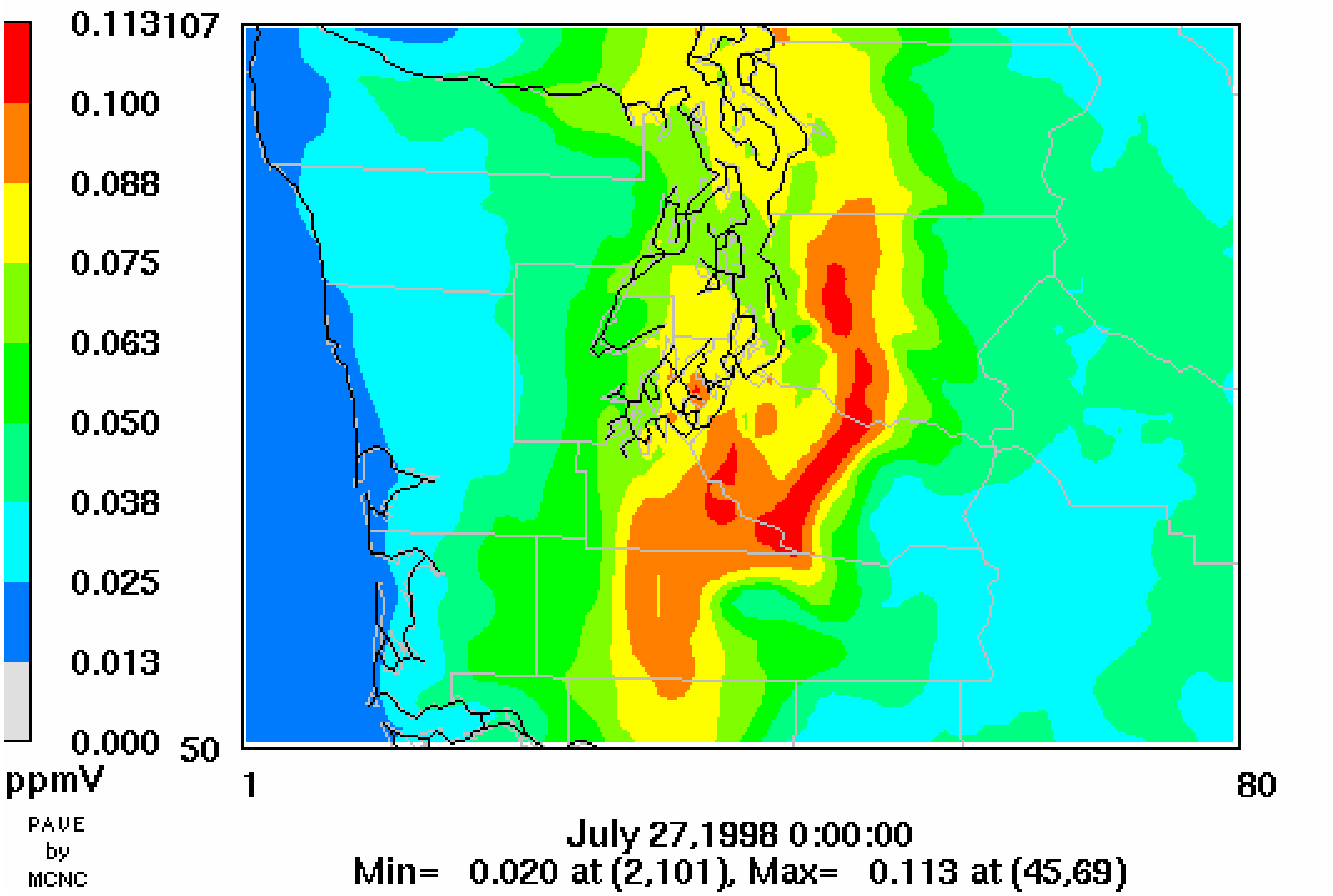

Figure 2 Figure 17a of the WSU/PSCAA Report

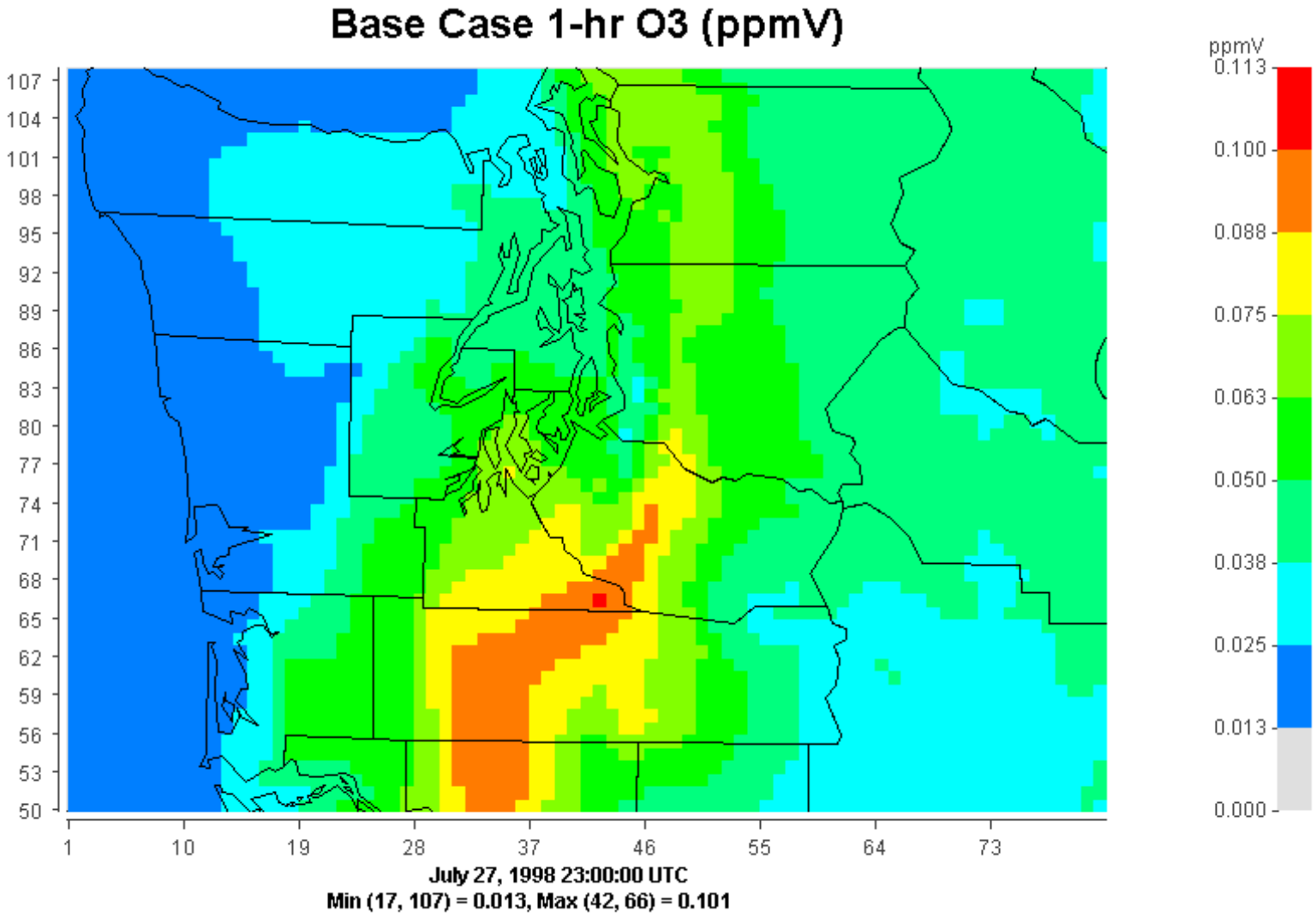

Figure 3 Simulated 1-Hour Average Ozone at 1600 PDT On July 27 (Base Case)

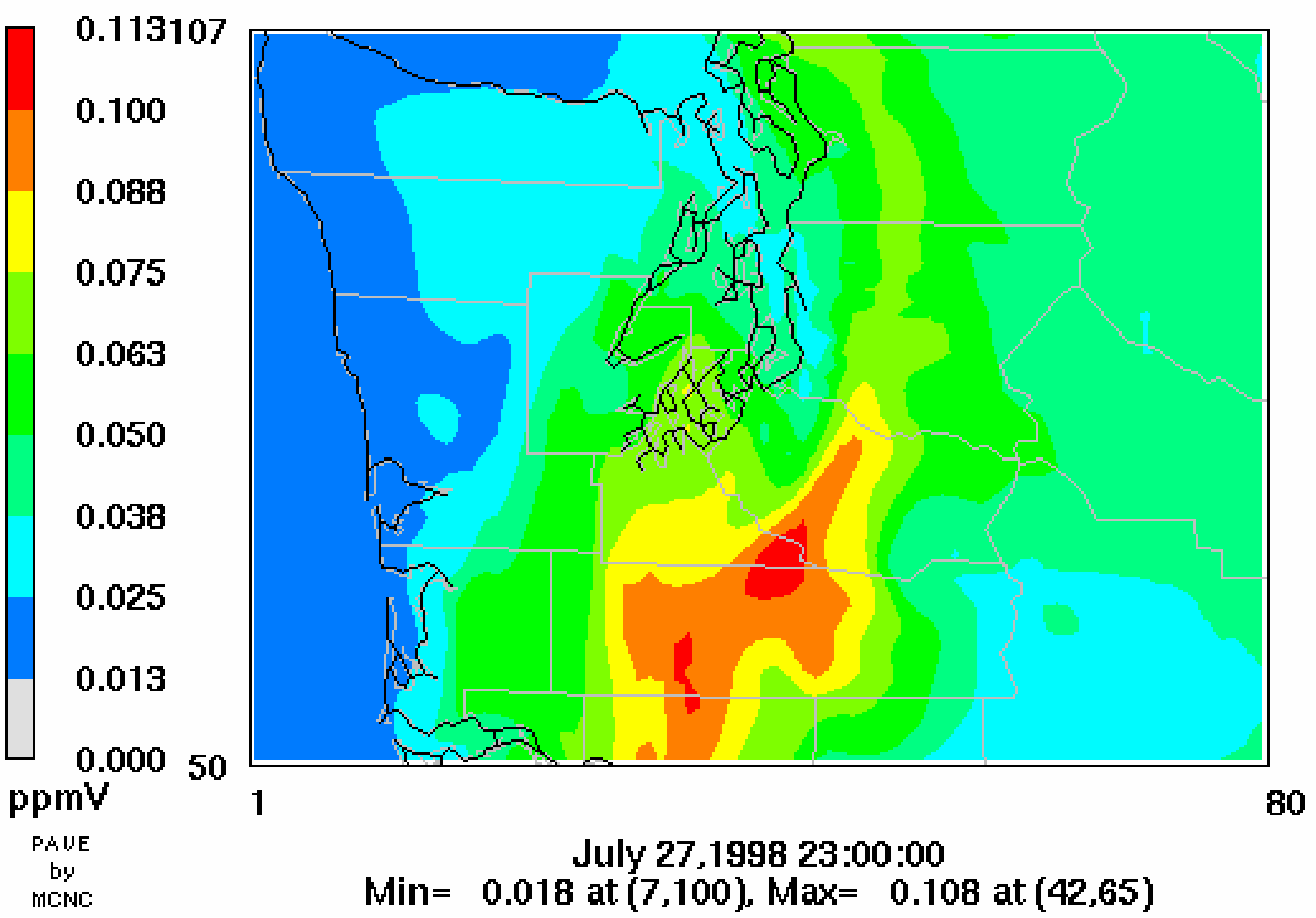

Figure 4 Figure 18a of the WSU/PSCAA Report

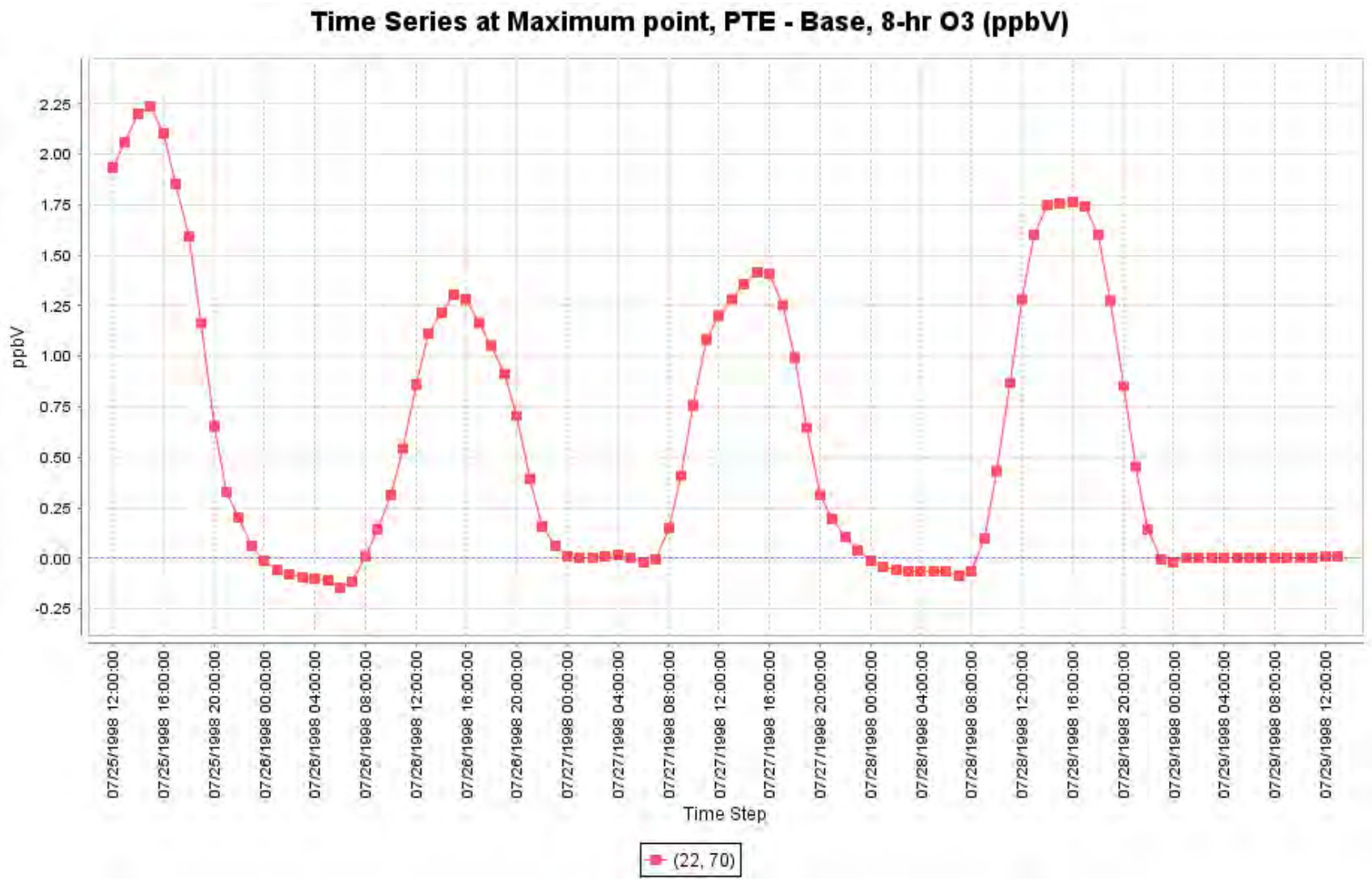

Figure 5 Time series at maximum point of PTE-Base 8-hour ozone

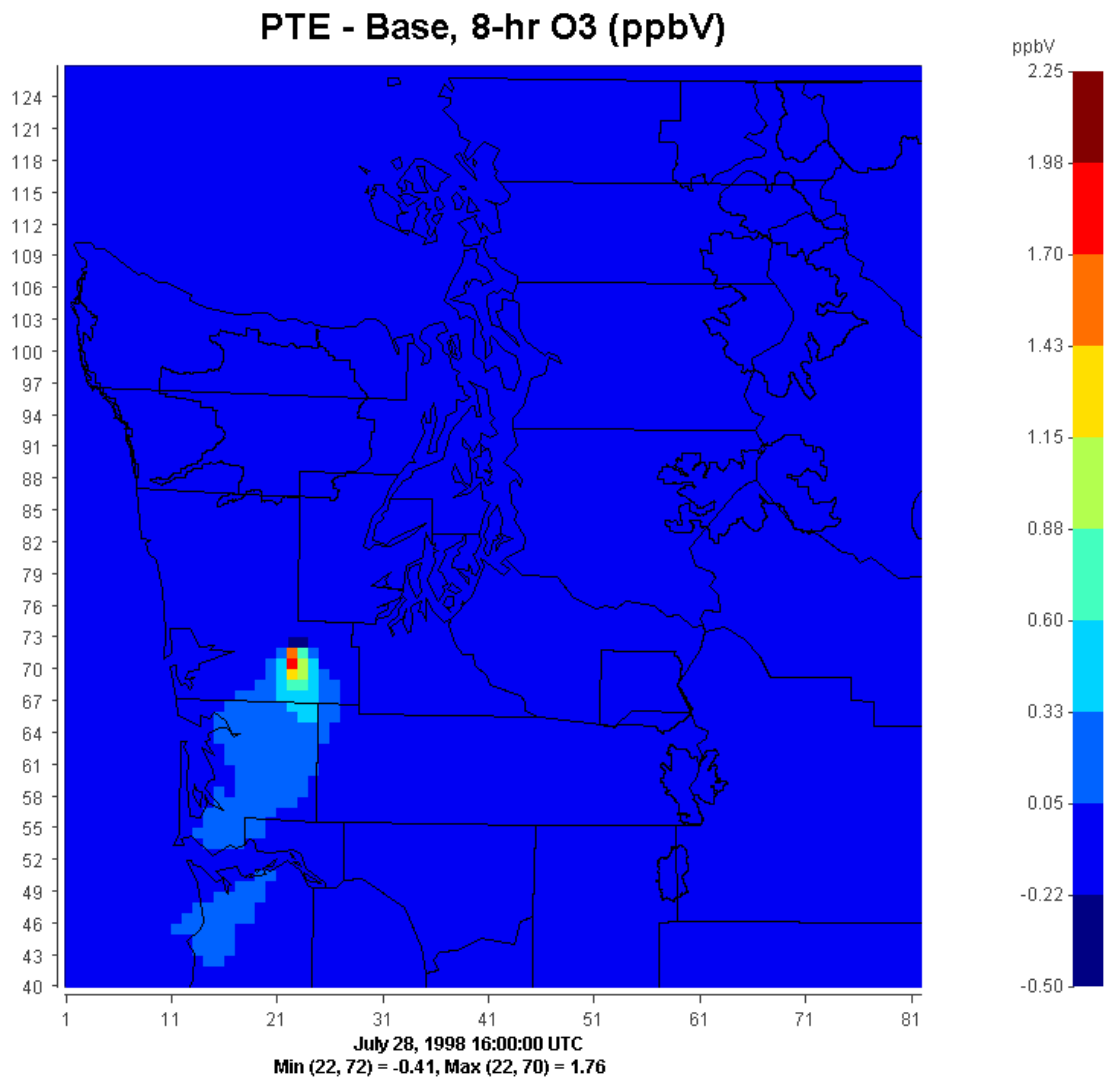

Figure 6 PTE-Base 8-hour ozone at time of maximum

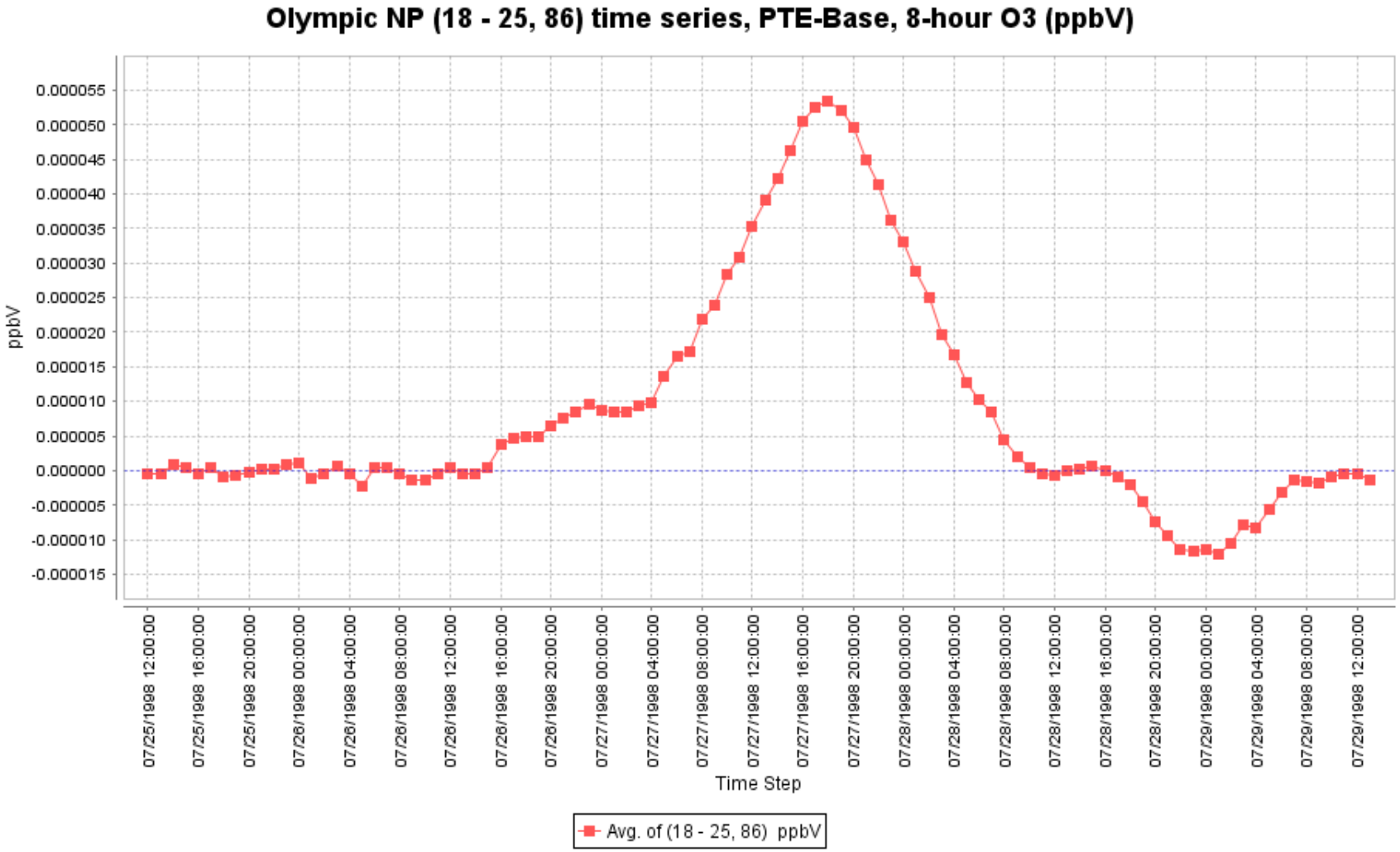

Figure 7 Time series of PTE-Base 8-hour ozone, southern edge of Olympic NP

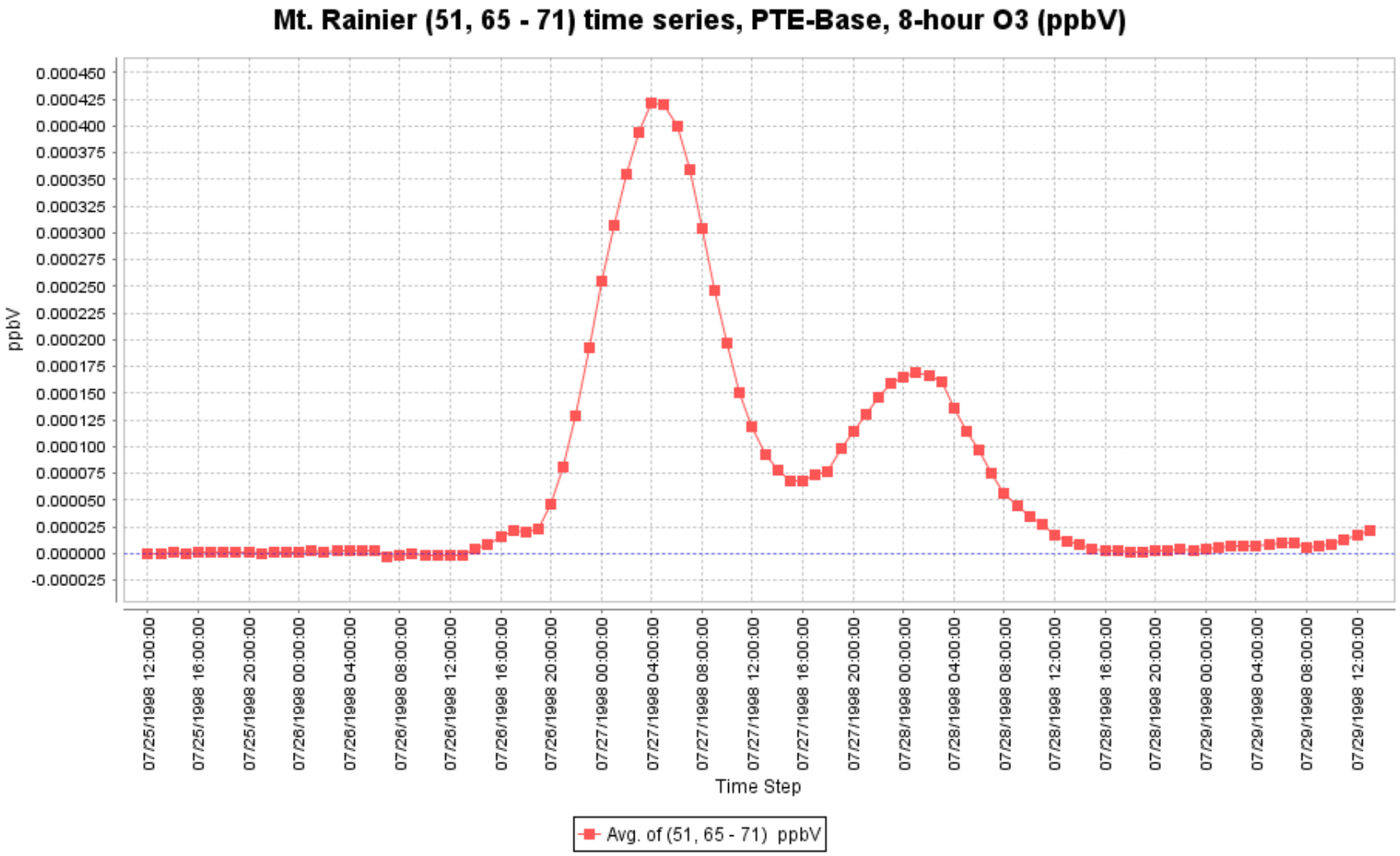

Figure 8 Time series of PTE-Base 8-hour ozone, western edge of Mt. Rainier

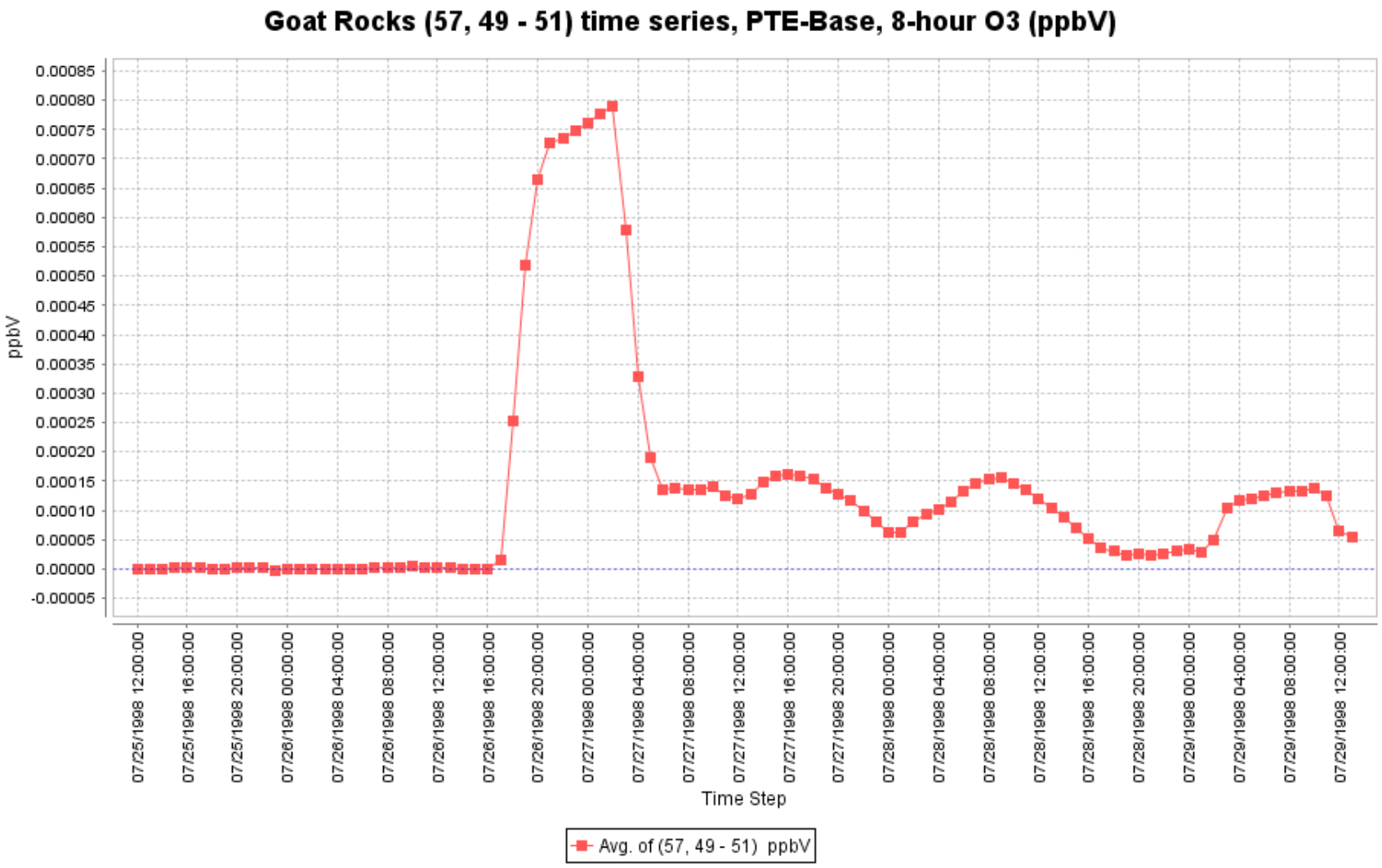

Figure 9 Time series of PTE-Base 8-hour ozone, western edge of Goat Rocks

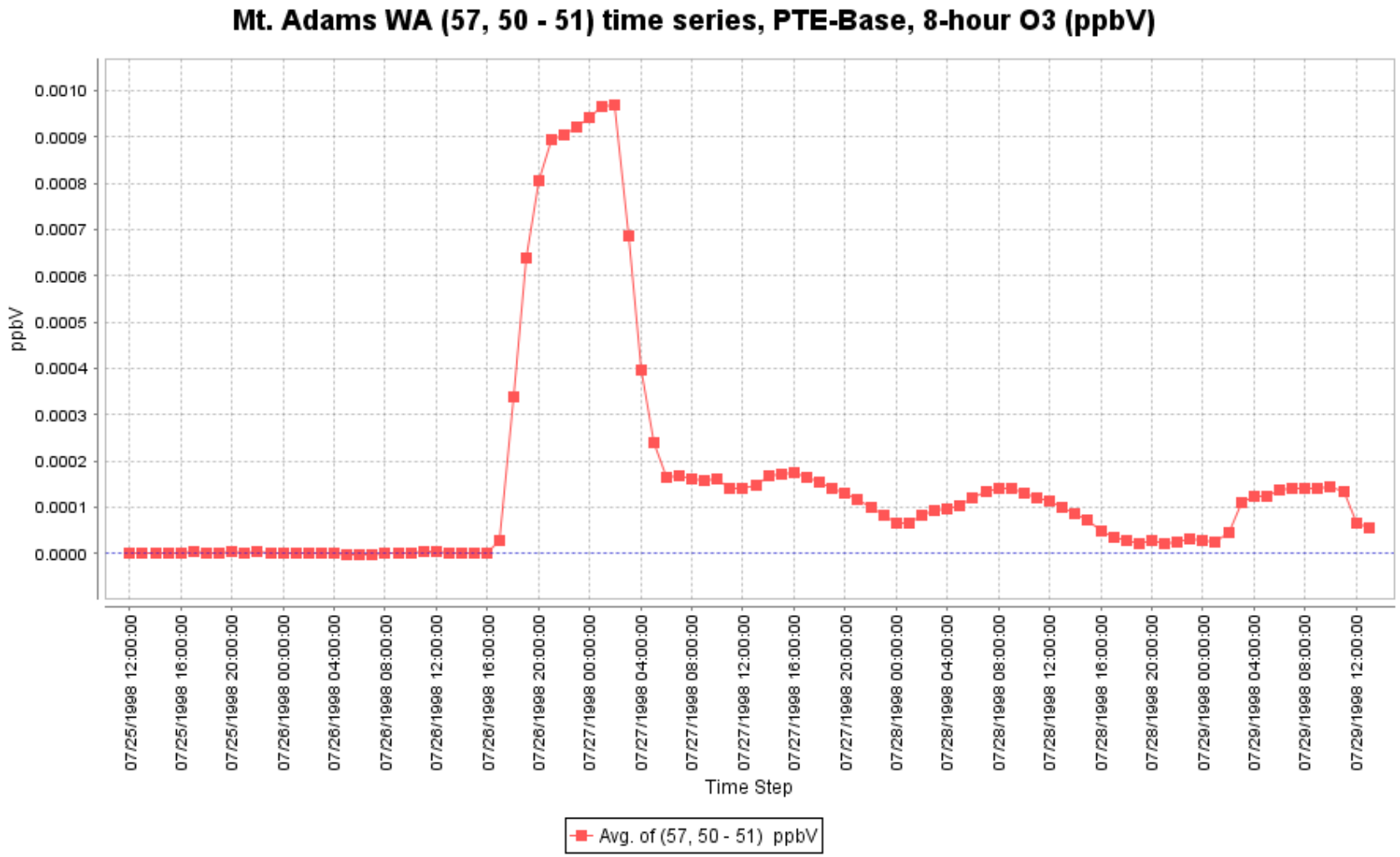

Figure 10 Time series of PTE-Base 8-hour ozone, western edge of Mt. Adams

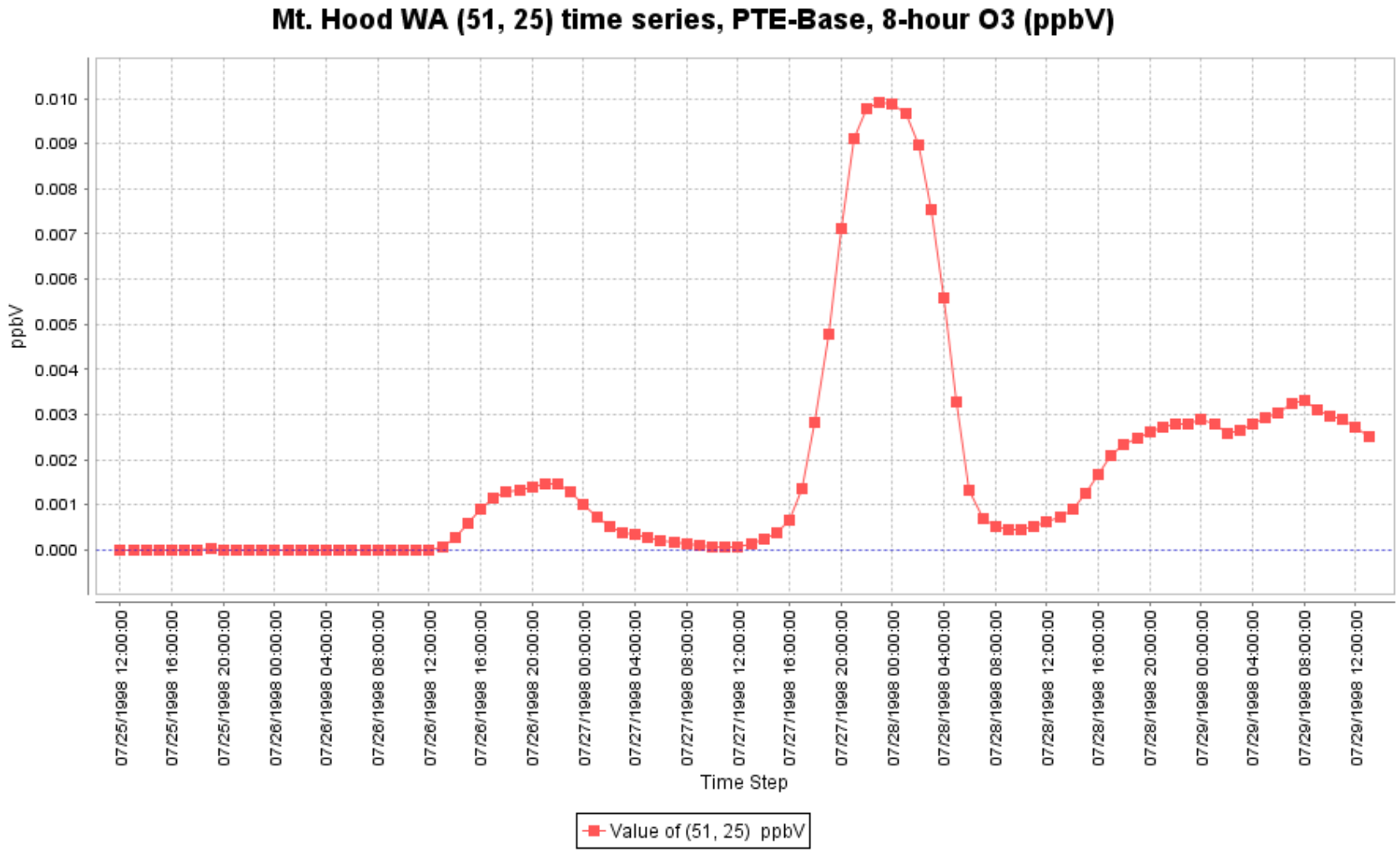

Figure 11 Time series of PTE-Base 8-hour ozone, at a point in Mt. Hood

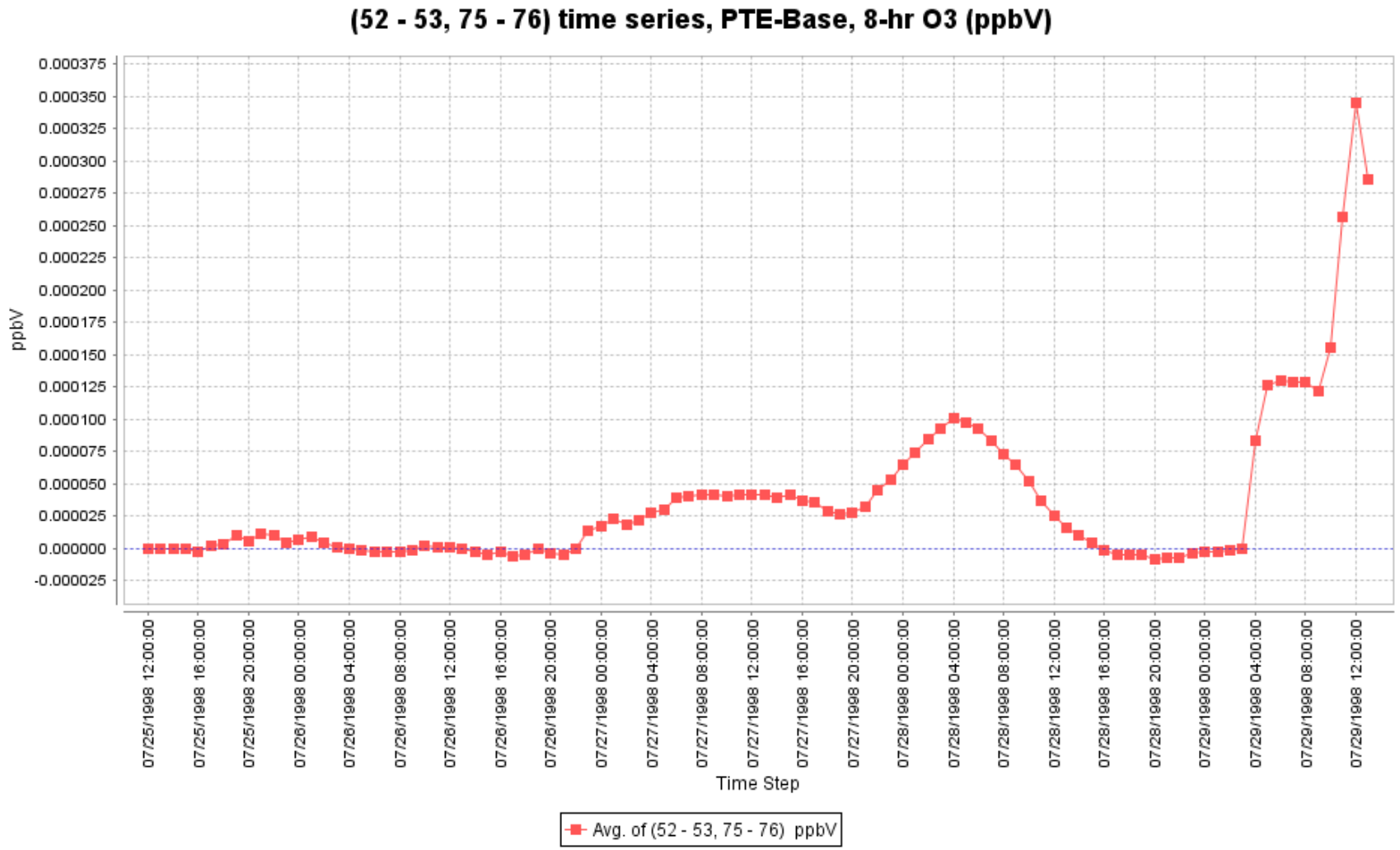

Figure 12 Time series of PTE-Base 8-hour ozone, near Enumclaw and Mud Mountain

5 Conclusions

ENVIRON acquired the relevant input data and control files and replicated the MM5/SMOKE/CMAQ runs performed by WSU for PSCAA and ODEQ in support of the various ozone studies conducted by those organizations. The scenarios in question simulate the 26-28 July 1998 ozone episode, which was meteorologically more severe than the 1996 case used previously. We performed a "base case" scenario that closely resembled those of the PSCAA and Portland SIP studies, and a "PTE scenario," which was comprised of all base case scenario emissions in addition to the maximum post-project emissions from the facility.

The maximum change to 8-hour average ozone concentrations between the PTE and base case scenarios is an increase of 2.25 ppbV in the cell adjacent to the facility. The spatial variation of the difference between the two scenarios during the period with the maximum difference is quite localized, falling to less than 0.33 ppbV within about 20 km of the facility.

The largest increase in 8-hour ozone concentration near a Class I area is about 0.01 ppbV near Mount Hood Wilderness Area. This is less than 1 percent of the relevant NAAQS, indicating that the facility will not cause or significantly contribute to degradation of our natural wild areas. The largest increase in 8-hour ozone concentration near the Enumclaw (Mud Mountain) observation site is less than 0.0004 ppbV.

6 References

Grell, G. A., J. Dudhia, and D. R. Stauffer, 1994: *A description ofthe fifth-generation Penn State/NCAR Mesoscale Model (MM5),* NCAR Tech. Note, NCAR/TN-398+STR, 122pp.

Byun, D.W. and Ching, J.K.S., editors. 1999: *Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modeling System*. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R-99/030.

Ying Xie and Brian Lamb, 2005: *Historical and Future Ozone Simulations using the MM5/SMOKE/CMAQ System in the Portland/Vancouver Area*, Laboratory of Atmospheric Research, Department of Civil & Environmental Engineering, WSU. December 31, 2005.

Brian Lamb and Ying Xie, Laboratory of Atmospheric Research, Department of Civil & Environmental Engineering, WSU; Clint Bowman, Sally Otterson, and Doug Schneider, Washington State Department of Ecology; and Kathy Himes, John Anderson, Kwame Agyei, and Beth Carper, PSCAA, 2006: *Modeling Analysis of Future Emission Scenarios for Ozone Impacts in the Puget Sound Area*, August, 2006.