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AIRPACT VERSION 2: AN AIR-QUALITY FORECAST SYSTEM FOR OZONE, PARTICULATES AND AIR-TOXICS FOR THE PACIFIC NORTHWEST

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1. INTRODUCTION

The original AIRPACT air-quality forecasting system (AIRPACT-1) was developed in 2000-2001 with the objectives of 1) providing air-quality managers in the Puget Sound region with timely forecasts of air pollution episodes and 2) allowing for the potential notification of sensitive populations [Vaughan et al. 2004]. AIRPACT-1, which became operational in May, 2001, developed in the context of a multi-institutional, multi-PI collaborative effort that has resulted in the creation of a unique regional environmental prediction system for the Pacific Northwest US and nearby Canada [Mass et al. 2003]. This environmental prediction system has developed around the MM5 forecasting operation at University of Washington [http://www.atmos.washington.edu/mm5rt/info.html].

AIRPACT-1 has utilized daily MM5 forecasts, for a 4-km grid-spacing domain based on a 00Z initialization. The CALMET preprocessor CALMM5 is used to re format and window out a subdomain of the MM5 results to generate input for the CALMET model. The AIRPACT-1 domain is seen in Figure 1. Emissions processing used area, mobile and point source emissions from a July 1996 base-case spanning four days and GLOBEIS-derived biogenic emissions as a basis. The functional dependence of mobile emissions upon temperature was developed by the Washington State Department of Ecology using the Mobile5b model. Using these results, AIRPACT-1 generated daily mobile emissions by making adjustments using MM5-predicted temperatures. Similarly, GLOBEIS was used to generate a basic emissions map for the vegetation of the domain for a standard temperature and UV-flux. Daily biogenic emissions were then generated using MM5-derived temperature and UV-flux (using down-welling short wave radiation as a proxy). Initial and boundary conditions were provided either by a simple ASCII file or, alternatively, passing the chemical state from the end of one run to the beginning of the next. With CALMET meteorology and necessary emissions in place, CALGRID was run to generate 24 hours of predicted concentrations for air pollutant species such as O_3, NOx and CO. CALGRID results were then visualized using the PAVE tool and images moved to the project web-site. An automated verification system was also developed to provide comparisons of predictions against observations on an hourly basis for available air-quality monitoring sites. Verification graphics were typically posted to the website the following day. AIRPACT-1 was operated over 2001--2003, providing abundant experience in the challenges and benefits attending operation of a high-resolution air-quality forecast and verification system [Snow et al, 2003]. Evaluation of the AIRPACT forecasts for August 2001 against surface ozone observations from seven sites, paired by location and hour, gave a normalized bias of 15% and a normalized gross error of 51%.

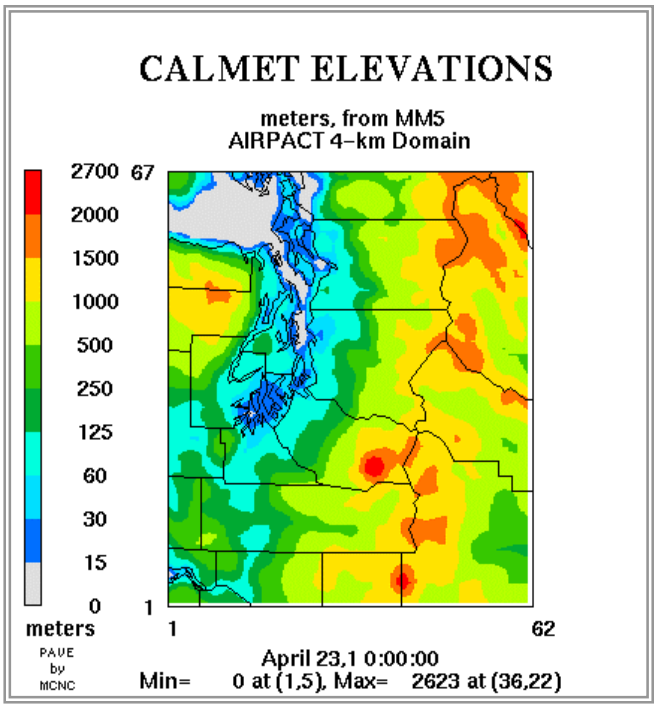

Figure 1. The original AIRPACT domain was centered on the Puget Sound Region.

2. RECENT DEVELOPMENTS

The original system was updated in 2003 to create AIRPACT-2 [http://www.airpact.wsu.edu/index2.html]. A primary reason for the system expansion and modification is the growing interest in toxic air pollutant species such as are being measured in the Urban Air Toxics measurement program in Seattle (c.f. Table 1).

Table 1. Annual mean mixing ratios [ppbv] for toxic air pollutant VOC species for 2001 for the Beacon Hill site in downtown Seattle, Washington, based on a one-day-in-six sampling program. Simulated maxima for 9/3/2003 are also shown.

Air Toxic Species	Annual Mean Mixing Ratio [ppbv]	Simulated Maximum Concentrations For 9/3/2003
Benzene	0.394	2.7
1,3-butadiene	0.072	0.29
carbon tetrachloride	0.098	
chloroform	0.050	
tetrachloroethylene	0.024	
trichloroethylene	0.038	
acetaldehyde	0.074	0.99
formaldehyde	1.35	2.1

An expanded 4-km domain (Figure 2) ranges from the environs of Vancouver, BC in the north and Salem, OR in the south, and from the Pacific coast in the west to beyond the crests of the Cascades in the east.

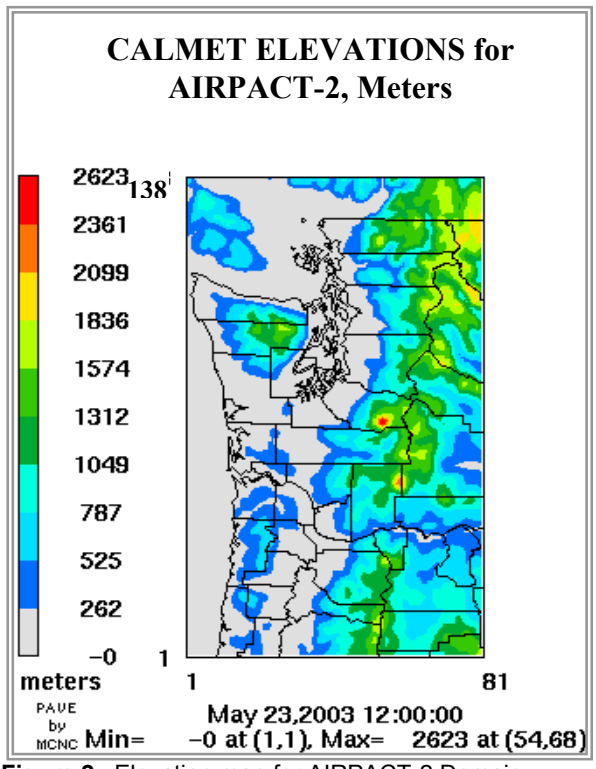

Figure 2. Elevation map for AIRPACT-2 Domain, including the Vancouver, BC area and northeast Oregon.

Air-toxics chemical and particulate species have been added as tracers to provide for comparisons against current measurement programs for air-toxic species. The specific air toxics include gaseous species treated with first order reactions to account for removal as well as several PM2.5 tracers:

- Formaldehyde
- Acetaldehyde
- 1,3 butadiene
- benzene
- perchloroethylene
- diesel PM2.5
- wood smoke PM2.5
- total PM2.5
- a PAH tracer, Phenanthrene.

AIRPACT-2 MM5 processing now also uses the Models-3 MCIP2 meteorological preprocessor to pass through MM5-derived boundary layer variables to be reinserted in the CALMET mass-conserving wind field results.

A SMOKE-based emissions generation sub-system replaces the original (highly idiosyncratic) implementation. SMOKE is the Sparse Matrix Operator Kernel for Emissions processing system that is part of the Models-3 suite. This includes changing from using GLOBEIS in AIRPACT-1 to using BEIS3 for biogenic emissions in AIRPACT-2.

The verification system from AIRPACT-1 is being redesigned and re-implemented to:

- Utilize observational air quality data from Oregon and possibly British Columbia, in addition to the data being obtained for Washington by AIRPACT-1.
- Provide enhanced graphics including superimposing hourly observations over CALGRID predictions in web-site animations.

3. RESULTS

Examples of AIRPACT-2 emissions for NOx, benzene and diesel PM2.5 are shown in Figures 3-5, respectively. Examples of CALGRID predictions are shown in Figures 6-8 for ozone, benzene and diesel PM2.5, respectively. The system has not yet been evaluated with respect to the air toxic simulations. However, it was worth noting that the range of concentrations simulated on a warm fall day (see Figure 7 and Table 1) appears quite reasonable in comparison to the annual average observations listed in Table 1. The the maximum concentrations simulated on 9/3/2003 yield peak to mean ratios (using the means in Table 1) ranging from approximately 2 to 13. While these maxima seem plausible, quantitative evaluation of the simulations is an immediate goal for our AIRPACT-2 efforts.

4. SUMMARY

AIRPACT-2 is the most recent version of a system providing daily, real-time, high-resolution air quality forecasts for the Pacific Northwest. We anticipate an ongoing development path for this system, including conversion to use of CMAQ, for example, within the next year, and expansion to include more of region.

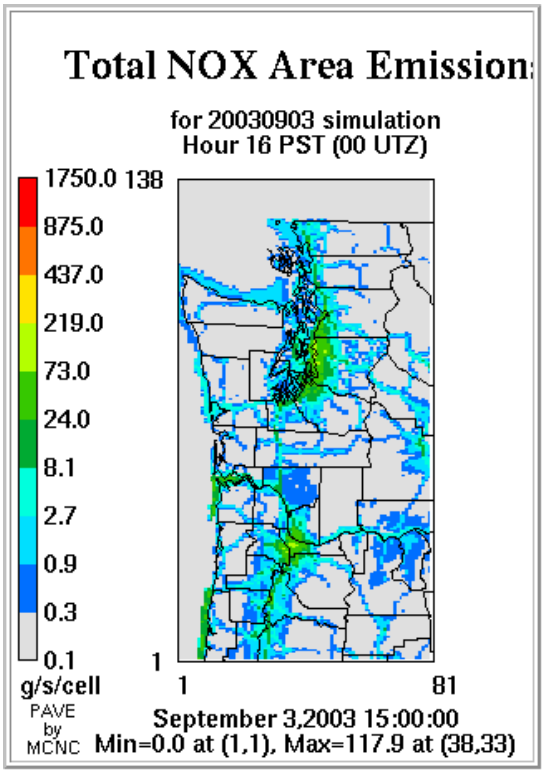

Figure 3. NOx area emissions.

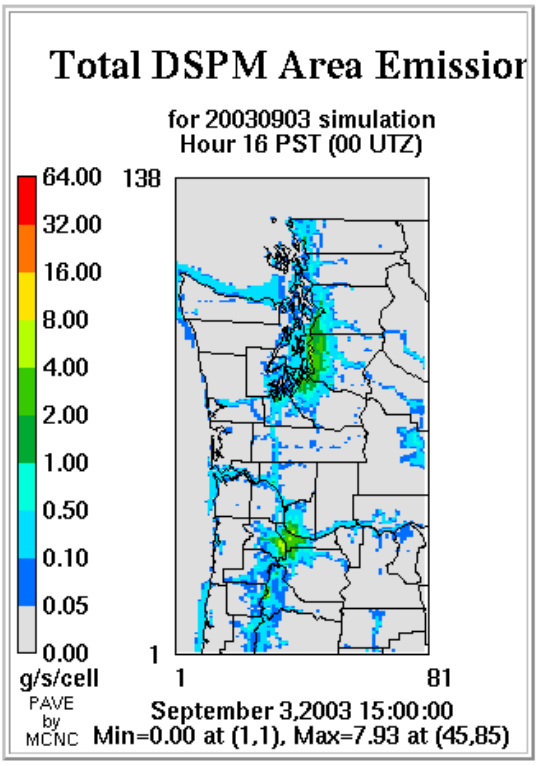

Figure 5. Diesel PM2.5 area emissions.

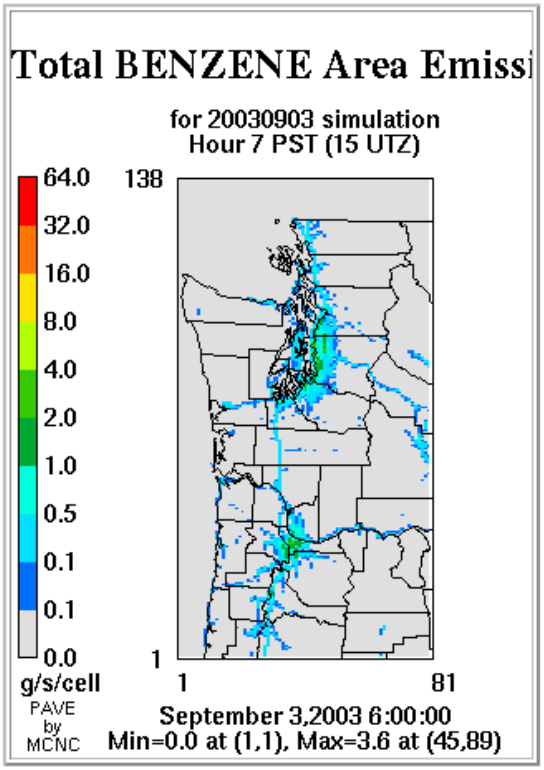

Figure 4. Benzene area emissions.

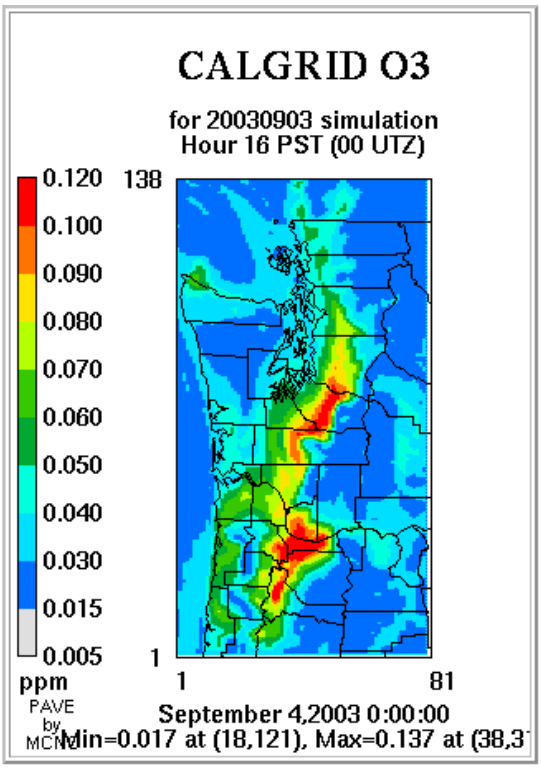

Figure 6. CALGRID predicted ozone.

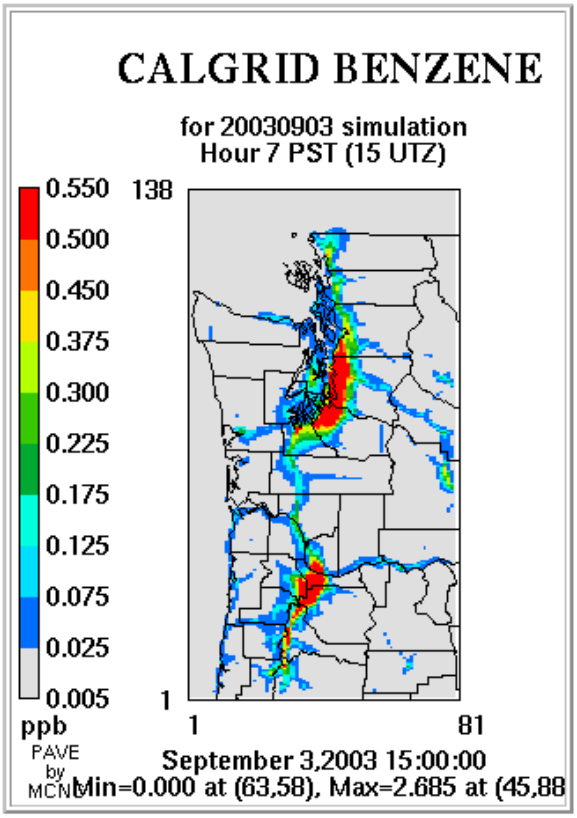

Figure 7. CALGRID predicted Benzene.

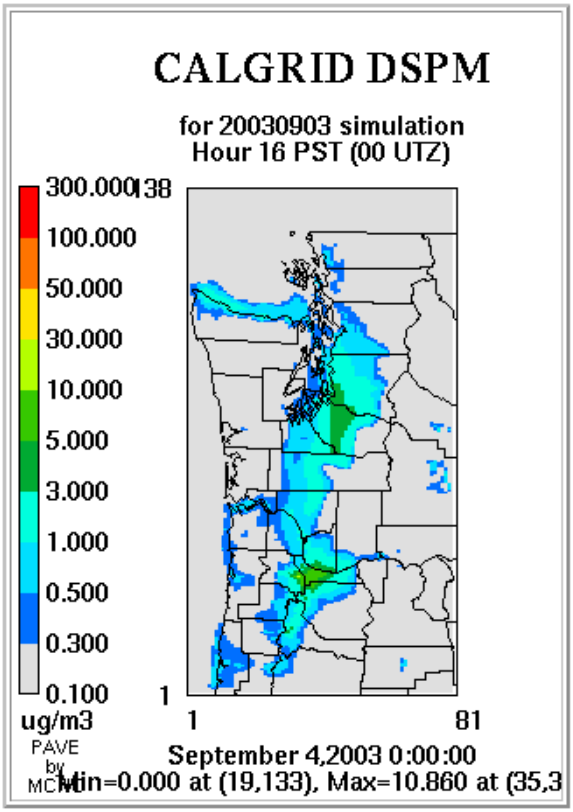

Figure 8. CALGRID prediction of diesel PM2.5.

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