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1. INTRODUCTION

Model calculations have been carried out that attempt to simulate tracer release experiments at the Geysers Area. Comparisons with the experimental data provide a test of our current ability to model pollutant transport. The calculations are carried out with a windfield code (ATMOS1) and an advection-diffusion code (ATMOS2). The resulting concentrations permit prediction of tracer particle collections at the measurement stations. Comparison of the observations and predictions of sequential and integrated counts shows generally good agreement, but with discrepancies in some instances. The method appears to be a useful one for pollutant transport predictions and for parametric studies such as determining useful meteorological monitoring networds.

2. MEASUREMENTS

The tracer experiments, conducted by the LASL Atmospheric Sciences group in Anderson Creek Valley, California, in July 1979, have been described in detail elsewhere (Clements et al. 1979, 1980). In summary, the experiments consisted of fluorescent particle releases (500 grams over approximately 20 minutes) and collection on type H Rotorods. We have utilized the measurements made on July 22-23 and July 24-25, 1979. Comparison is made with integrated collections (several hours) at four measurement locations and sequential collections (10 minutes each) at two locations. The fluorescent particle tracer has been shown to be nonconservative in the atmospheric surface layer and therefore not appropriate to absolute concentration estimates. However, elements of plume morphology such as relative concentrations, arrival time, and cloud passage time at spatially distributed samplers represent a fair test of the tracer.

3. WINDFIELDS

The windfields used for these calculations were based upon the results of fitting by ATMOS1 to the observed wind measurements. The procedure is described by Davis and Bunker (1980). The code develops a mass-consistent windfield from the observations. Cells are 190 m x 190 m in the horizontal plane (25x31 cells) and a σ-coordinate scheme in the vertical direction determines cells ranging from about 1 meter in height at the surface to 300 m at the upper boundary (10 cells). We have assumed stationary winds during the periods 22:00 to 24:00 and from 24:00 to 02:00 (P.S.T. throughout).

4. TRANSPORT CALCULATIONS

The transport modeling is performed by the code ATMOS2 that carries out advection and diffusion calculations utilizing the ATMOS1 windfields. Advection and diffusion transport are solved through a standard continuity equation in finite difference form. Some characteristics of the ATMOS2 calculations are:

1. a σ-coordinate scheme in the vertical direction with an implicit solution to avoid time steps becoming too short;

2. a Crowley 2nd order procedure to limit numerical diffusion;

3. boundary conditions include a set of buffer cells on the lateral and upper surfaces into which diffusion does not occur and through which the pollutant cannot pass;

4. diffusivities are based upon the algorithms of Smith and Howard (1972) and the work of Lantz et al. (1971);

5. Pasquill stability Class E is used throughout;

6. deposition is neglected; and

7. cell structure is identical to that employed in ATMOS1.

A simple test indicates conservation of particles to within a few hundredth percent over a 3-hour period. Rotorod collector predictions are carried by appropriate integrations over volume and time and assuming no wind effect on collection rate at the Rotorod. A value of 2.31 x 10^{10} particles per gram of dispersed material is assumed. The calculations with ATMOS2 require about 40 seconds of 7600 time per hour of model time.

5. CINE GRAPHICS

A computer-generated movie has been prepared of the tracer transfer calculations for the July 22-23 experiment. Time steps range from 23 to 28 seconds and the duration covers the pertinent portion of the 4-hour experiment. Each particle of the plots represents 0.1 grams of tracer. The movie permits an appreciation of the predicted flow characteristics including such features as the general flow down Anderson Creek and the formation of the tracer plume.

6. RESULTS

Figure 1 indicates the area included in these calculations, the release point, and the sampling stations. Figures 2 and 3 show the sequential measurements and predictions at sampling stations S1 and S2. Both observations and predictions are normalized to unity at maximum. The time interval is 10 minutes for each collection with time measured from the initiation of the 30-minute release. Both the shapes and timing of the calculated curves show reasonably good agreement with measurements. The S2 July 24-25 measures show a conspicuous late-time plateau that is not predicted.

Figure 4 shows the time integrated results for all stations. Experimental or calculated counts at each station have been divided by those at station S1 in each instance, thus providing a normalized indication of the down wind concentration profiles relative to the sampler nearest the release point. The calculations for July 22-23 show excellent agreement with the observations. By contrast, the comparisons for July 24-25 are very poor, suggesting that the estimated winds for this case do not represent the volume of air occupied by the plume very well. It is quite possible that the local drainage wind affecting the plume was confined to a narrow channel along Anderson Creek and that some of the measurements were outside of the localized flow. In order to test this hypothesis theoretical downslope profiles derived from a one-dimensional code, ATMOS3 (Davis and Freeman 1980) were applied at two positions on the valley axis. Two observed soundings that were slightly off the valley axis were removed for the purposes of this test. Figure 5 shows that the result of this exercise is a much closer agreement between modeled and observed tracer concentrations. We are not advocating the deletion of data in favor of hypothetical profiles, but this simple analysis suggests the critical importance of representative measurements.

7. CONCLUSIONS

It appears that in some cases good predictions of relative pollutant concentrations are possible at 5 kilometers from a source in complex terrain under nocturnal conditions. A mass-consistent wind field model coupled to an advection-diffusion module was able to use a moderately dense array of meteorological observations to estimate the behavior of a tracer plume under two different sets of nocturnal conditions. One case was largely affected by an externally driven gradient wind. The existing meteorological array, and subsequent analysis by ATMOS1, appeared to represent the plume behavior quite well. A second case was dominated by shallow and narrow cold air drainage patterns within which the tracer plume was apparently contained. Wind observations very near but probably still outside this flow domain were poor indicators of the plume behavior when incorporated into the model. A major conclusion is that in estimating the transport and diffusion of a pollutant plume we must know the meteorological structure of that volume of air occupied by the plume. Very serious and complex questions of what constitutes a representative measurement of that volume need to be addressed by the meteorological community.

Future improvements in the calculation will include better diffusivities and a treatment of stratification. ATMOS2 should be a useful tool for a better understanding of the effects of windfield fitting and of assumed parameters on pollution transport modeling.

8. REFERENCES

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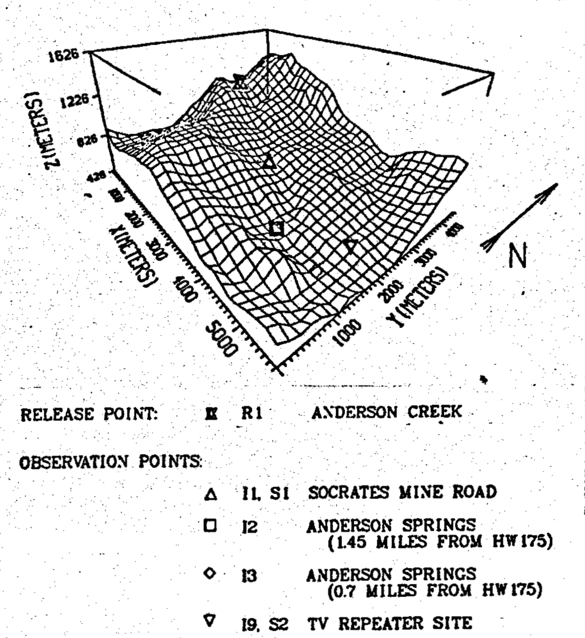

Figure 1. Anderson Creek Drainage.

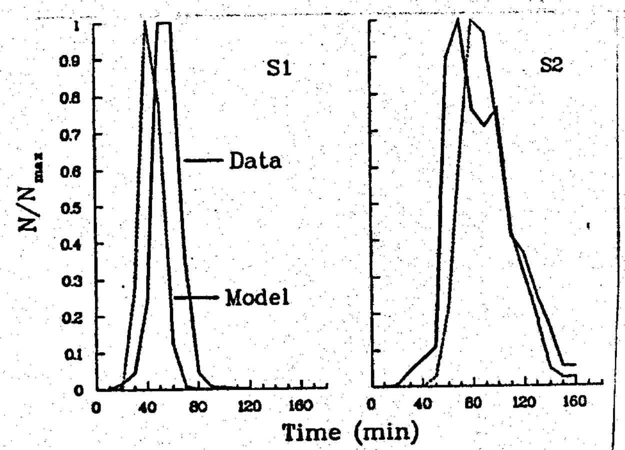

Figure 2. July 22, 1979 22:00 Release FP2.

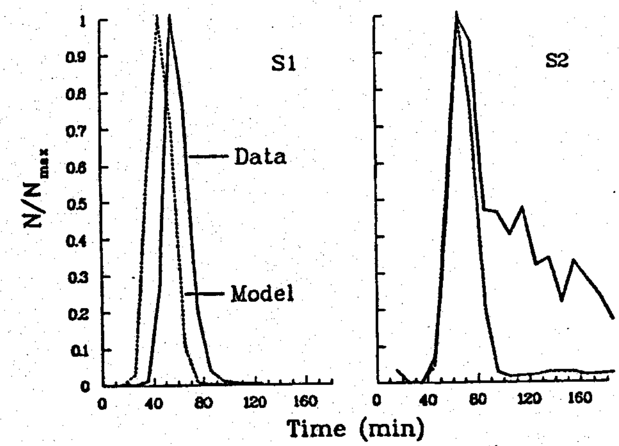

Figure 3. July 24, 1979 22:25 Release FP2.

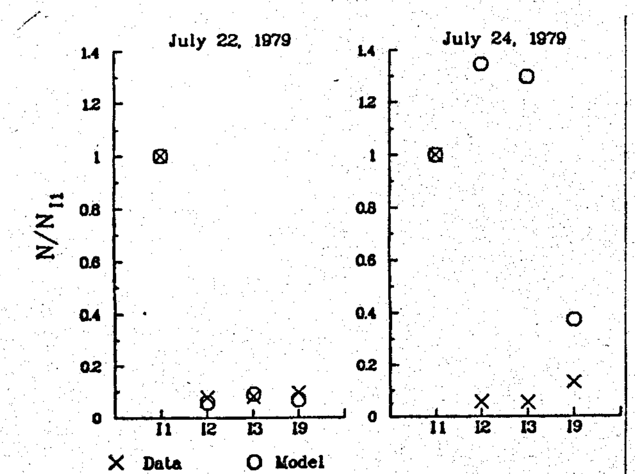

Figure 4. Integrated Sampling Stations.

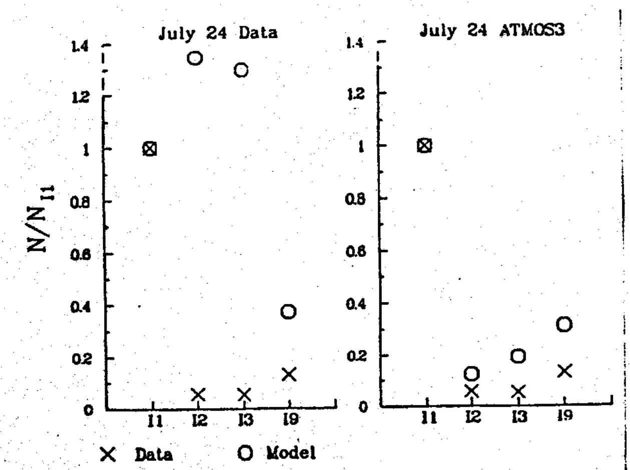

Figure 5. Integrated Sampling Stations.