PERFORMANCE COMPARISON OF THE PGEMS AND MIDAS MODELS USING DATA FROM THE DCPP GAS TRACER EXPERIMENTS

by

Richard H. Thuillier
Research and Development

and

Gene Shelar
Technical and Ecological Services

Pacific Gas & Electric Company
3400 Crow Canyon Rd.
San Ramon, CA

5th NUMUG Workshop
South Bend, Indiana

EXECUTIVE SUMMARY

Two candidate models are available for replacing the transport and dispersion module of the Diablo Canyon Power Plant (DCPP) Emergency Assessment and Response System (EARS). These are the MIDAS model purchased from PLG, Inc. and the PGEMS model developed for PG&E by Battelle, Pacific Northwest Laboratories. Recently, the Meteorology Services Group, Atmospheric and Biological Sciences, Technical and Ecological Services, was asked to compare the two models with the results of gas tracer experiments conducted in 1986 on and around DCPP.

The comparison described in this report indicates that the MIDAS configuration currently in use at DCPP, with input meteorological conditions from the plant site only, does not provide a good representation of effluent transport trajectories from the DCPP site. Specifically, MIDAS modeled plumes, based on actual plant site meteorological conditions during the tracer releases, were substantially misplaced in relation to observed concentrations of tracer material. For this reason, the current configuration of MIDAS appears inappropriate as an aid in formulating protective action recommendations in a real emergency. Using meteorological input from a more extensive measurement network, PGEMS modeled plumes were very consistent with the patterns of measured tracer material. It is recommended, therefore, that PGEMS, or a MIDAS configuration with more extensive meteorological input, or a combination of PGEMS and MIDAS be acquired for use at DCPP. It is further recommended that the chosen configuration be tested again, using tracer data, prior to acceptance. Extensive evaluation of PGEMS performance, beyond the placement of plumes, is available in PGEMS project reports. A similar evaluation of MIDAS would have to await a correction of the MIDAS plume placement problem.

BACKGROUND

Since 1984, through contracts with Battelle, Pacific Northwest Laboratories, PG&E's RandD and TES departments have been developing the PGEMS dispersion model (Thuillier, 1987, and Allwine, 1995) to simulate the transport and dispersion of power plant effluents in complex terrain areas. For the purpose of evaluating performance of the PGEMS model, tracer experiments, using sulfurhexafluoride (SF_6) gas, were performed on and in the vicinity of the Diablo Canyon Nuclear Power Plant site (DCPP) during August and September 1986. Evaluation of PGEMS performance against the tracer data (Thuillier, 1988a, 1988b, 1991) indicated that PGEMS would represent an improvement over the dispersion model embodied in the original Emergency Assessment and Response System (EARS) at DCPP. A project was initiated to update the EARS system with the inclusion of PGEMS as the radiological dispersion module. Prior to completion of the PGEMS module, an immediate need arose at one point for an EARS replacement, at least on an interim basis, and the turnkey Meteorological Information and Dose Assessment System (MIDAS), developed by PLG, Inc., was acquired as the replacement. MIDAS contains its own effluent transport and dispersion module. PG&E's Meteorological Services Group was asked to evaluate the performance of the MIDAS dispersion module on the same meteorological and tracer data used to evaluate PGEMS, so that the relative merits of the two models could be assessed. This report provides the results of the comparison that was done in response to that request.

THE MODELS

The PGEMS model comprises meteorological transport and dispersion sub-modules. The meteorological module provides spatial and temporal interpolation and extrapolation of measured wind data throughout the modeling domain to provide horizontal spatial fields of air flow on terrain following surfaces at various levels above ground and at temporal intervals of 15-minutes or longer. Interpolation is done in a manner that is mass-consistent, that is, in a manner that is consistent with the physics of an incompressible fluid. PGEMS is configured to make use of wind and stability data from various existing surface measurement sites within a 100 km radius of the DCPP plant, including the primary and backup tower data at the plant site. The model is also able to use vertically resolved wind data from Doppler acoustic sounder data at the backup tower site and at the Community Center near Bassi Ranch. The PGEMS transport and dispersion model calculates concentration and radiological dose related to effluent "puffs" that are transported through the interpolated wind fields and dispersed in accordance with the Gaussian assumption, as a function of wind speed and stability.

The MIDAS model also has meteorological and transport and dispersion modules. The MIDAS system configuration in use at DCPP uses meteorological data from the single primary or backup tower site in conjunction with a simple physics-based model of flow around terrain obstacles (potential flow model). Since a single site is used to provide meteorological data, a set of wind fields based on finite combinations of wind speed, wind direction, and stability classes, are pre-calculated by the model and provided for table

look-up for the purpose of reducing wind field calculation time. The MIDAS transport and dispersion model calculates concentration and radiological dose related to effluent plume segments that are transported through the modeled wind fields and dispersed in accordance with the Gaussian assumption as a function of wind speed and stability.

APPROACH TO MODEL EVALUATION AND COMPARISON

Since the PGEMS model has already been evaluated against the 1986 tracer data, a three-way comparison of PGEMS, MIDAS, and the tracer data requires only that the MIDAS model be run on the same meteorological and source term conditions used for the PGEMS runs. Isotopic and meteorological release rate files were prepared for MIDAS based on data in Tables 1 through 7. Meteorological input was obtained from data measured at the primary and/or backup towers on the six days of the 1986 tracer experiments for which gas tracer was released within the DCPP plant complex. Isotopic release rate data corresponds to the rate of release of SF_6 tracer gas during the experiments. The MIDAS model was then run on the input data.

Seven dates/times were chosen for illustration of comparison, that are indicative of various tracer transport trajectories along the coast, around and over the hills, and into the inland valleys. The results are presented in Figures 1-7. In each figure, a graphic of the MIDAS plume concentration is presented along with a graphic of the PGEMS plume and the measured tracer data. PGEMS graphics were taken directly from Thuillier, 1988b. Locations of measurable tracer gas concentration are shown on the PGEMS graphics as large black squares. White numerals within the black squares are SF_6 concentrations in nanograms per cubic meter (ng/m^3), corresponding to a release rate in grams per second. Isopleths of concentration output by the PGEMS model, also in ng/m^3, are superimposed. The MIDAS graphic contains isopleths of concentration output by the MIDAS model in units of microcuries per cubic centimeter, corresponding to a release rate in microcuries per second. Equivalence of the concentration values in the two models can be obtained if output MIDAS concentrations are multiplied by a factor of 10^3.

COMPARISON RESULTS

Figure 1 shows the observed distribution of tracer concentration at 1500 Pacific Daylight Time (PDT) on August 31, 1986. The gas tracer plume released from the plant was transported southeast along the coast, turned inland near Avila Beach, approached San Luis Obispo, and eventually turned southeastward. The PGEMS plume simulated the condition well, but the MIDAS plume headed downwind toward the Five Cities area without turning inland. Concentration magnitude was equivalent in the two models with both models overestimating slightly the measured downwind concentration.

Figure 2 shows the observed distribution of tracer concentration at 1500 PDT on September 2, 1986. Tracer gas released at the plant on this day had traveled northwestward along the coast and eventually entered the inland valley through the Morro Bay area as the sea breeze developed and the local wind field rotated clockwise over the

area. The PGEMS plume simulated the inland location of the tracer material at the indicated time. The MIDAS plume rotated slightly, but never entered the inland valley. Concentration data for the tracer and the two models were equivalent.

Figure 3 shows the observed distribution of tracer concentration at 1200 PDT on September 4, 1986. Tracer released from the plant on this day was transported southeastward along the coast, penetrated inland slightly, into See Canyon and the Five Cities area, and proceeded onward toward Santa Maria. PGEMS reflected the inland penetration well, except in the upper reaches of See Canyon. The MIDAS plume proceeded directly to Santa Maria without the inland penetration at See Canyon and Five Cities. Modeled concentrations were equivalent, slightly overestimating tracer measurements.

Figures 4 and 5 show the observed distribution of tracer concentration at 1200 PDT and 1500 PDT on September 9, 1986. By 1200 PDT, tracer had been transported southeastward along the coast to the Five Cities area and also inland across the Irish Hills toward San Luis Obispo and the Emergency Operations Facility. Inland tracer concentrations were subsequently transported toward the southeast. PGEMS followed the plume inland, initially, and southeastward later in the day, but missed the earlier transport toward Five Cities. MIDAS completely missed the inland penetration and the transport of inland tracer past the Five Cities area. Instead, the MIDAS plume hung along and off the coast, within 10 miles of the plant early on, and moved southeastward toward Santa Maria later in the day.

Figure 6 provides a second example of transport northwestward along the coast and into the inland valley through the Morro Bay area. Both the PGEMS and MIDAS results, as well as the tracer concentration pattern were similar to those on September 2, Figure 2.

Figure 7 provides yet a third instance of transport northwestward and into the inland valley. Again, PGEMS follows the tracer while MIDAS does not.

CONCLUSIONS AND RECOMMENDATIONS

The comparison with tracer results indicates that the MIDAS configuration currently in use at DCPP, with input meteorological conditions from the plant site only, does not provide a good representation of transport and dispersion of effluents. For this reason, the current configuration of MIDAS would be inappropriate as an aid in formulating protective action recommendations in a real emergency. With meteorological input from sites throughout the local area, PGEMS does provide an adequate treatment of transport and dispersion in the vicinity of DCPP. It is recommended, therefore, that PGEMS, or another MIDAS configuration, or a combination of the two be obtained for use at DCPP and it is further recommended that the chosen configuration be tested again using the tracer data, prior to acceptance. When this is done, the various assumptions, sub-modules, and parameter settings of the selected model could be re-evaluated in even greater detail.

Since PGEMS interpolates a measured sample of actual wind fields throughout the complex terrain surrounding the plant, PGEMS will provide reasonable trajectories for effluent plumes as long as sufficient wind observations are available. Since measured winds are used, the difficult task of modeling the complex physical processes leading to the wind fields is avoided.

In the case of the MIDAS configuration currently in use at DCPP, stability conditions at the plant site are assumed uniform throughout the region. Given this uniform regional stability, and wind conditions at the plant site only, wind fields are developed on the basis of a theoretical model of flow around obstacles. MIDAS cannot reproduce the complex sea breeze and slope flow effects, that draw coastal plumes across terrain, through terrain gaps, and deep into the inland valleys. Such effects are caused not only by obstacle flow, as assumed by MIDAS, but by thermally induced slope and sea breeze flows in response to highly variable temperature, stability, and inversion conditions throughout the region.

REFERENCES

Allwine, K.J., 1995. "PGEMS 2.0 - An Atmospheric Dispersion Model for Routine Air Quality Assessments and Emergency Response Applications, Battelle, Pacific Northwest Laboratories, Richland, Washington.

Thuillier, R. H., 1987. "Incorporation of Doppler Acoustic Radar Data into a Dispersion Model-Phase I: Model Development," PG&E Research and Development Report No. 009.5-87.6, San Ramon, California.

Thuillier, R. H., 1988a. "Incorporation of Doppler Acoustic Radar Data into a Dispersion Model-Phase II: Field Experiment," PG&E Research and Development Report No. 009.5-88.3, San Ramon, California.

Thuillier, R. H., 1988b. "Incorporation of Doppler Acoustic Radar Data into a Dispersion Model-Phase III: Data Analysis and Model Evaluation, Volumes I and II" PG&E Research and Development Report No. 009.5-88.4, San Ramon, California.

Thuillier, R. H., 1991. "Incorporation of Doppler Acoustic Radar Data into a Dispersion Model-Phase IV: Project Summary," PG&E Research and Development Report No. 009.4-91.5, San Ramon, California.

Table 1.

Release Rates of Iodine 131 (μCi/s) Used by MIDAS to Simulate Tracer Gas Releases.

Date	Release Time (PDT)	Release Rate (μCi/sec)
August 31, 1986	0815-1000	5.70E+06
August 31, 1986	1115-1300	3.23E+06
August 31, 1986	1415-1600	4.50E+06
September 2, 1986	0815-1000	5.01E+06
September 2, 1986	1115-1300	4.71E+06
September 2, 1986	1415-1600	4.11E+06
September 4, 1986	0815-1600	5.07E+06
September 9, 1986	0815-1600	5.00E+06
September 11, 1986	0815-1600	5.15E+06
September 13, 1986	0815-1600	5.09E+06

Table 2

METEOROLOGICAL DATA FOR DATES AUGUST 31, 1986

HR:MN	SPD-P (MPH)	DIR-P (DEG FM)	STABY-SG (1-7)	STABZ-DT (1-7)	TEMP (DEG F)	RAIN (IN/15M)
8:00	1.8	204.0	1	4	60.0	0.00
8:15	2.2	172.0	1	4	60.0	0.00
8:30	1.5	169.0	1	4	60.0	0.00
8:45	2.6	188.0	1	4	60.0	0.00
9:00	2.9	259.0	1	4	60.0	0.00
9:15	7.2	292.0	1	4	60.0	0.00
9:30	8.4	291.0	1	4	60.0	0.00
9:45	8.2	289.0	1	4	60.0	0.00
10:00	9.8	292.0	1	4	60.0	0.00
10:15	10.0	293.0	1	4	60.0	0.00
10:30	10.1	289.0	4	4	60.0	0.00
10:45	11.2	292.0	4	4	60.0	0.00
11:00	11.4	291.0	4	4	60.0	0.00
11:15	10.8	292.0	4	3	60.0	0.00
11:30	10.9	292.0	4	3	60.0	0.00
11:45	10.4	290.0	4	3	60.0	0.00
12:00	10.5	291.0	4	3	60.0	0.00
12:15	9.8	290.0	4	2	60.0	0.00
12:30	8.7	290.0	4	2	60.0	0.00
12:45	9.8	291.0	4	2	60.0	0.00
13:00	11.0	289.0	4	2	60.0	0.00
13:15	9.8	289.0	4	2	60.0	0.00
13:30	9.3	290.0	4	2	60.0	0.00
13:45	9.7	288.0	4	2	60.0	0.00
14:00	11.4	289.0	4	2	60.0	0.00
14:15	12.0	290.0	4	4	60.0	0.00
14:30	13.1	291.0	4	4	60.0	0.00
14:45	13.0	293.0	4	4	60.0	0.00
15:00	14.2	293.0	4	4	60.0	0.00
15:15	14.4	295.0	4	3	60.0	0.00
15:30	15.2	296.0	4	3	60.0	0.00
15:45	15.8	301.0	4	3	60.0	0.00
16:00	17.2	303.0	4	3	60.0	0.00

Table 3

METEOROLOGICAL DATA FOR DATES SEPTEMBER 2, 1986

HR:MN	SPD-P (MPH)	DIR-P (DEG FM)	STABY-SG (1-7)	STABZ-DT (1-7)	TEMP (DEG F)	RAIN (IN/15M)
8:00	4.3	110.0	1	4	60.0	0.00
8:15	3.3	116.0	1	4	60.0	0.00
8:30	2.9	80.0	1	4	60.0	0.00
8:45	3.6	142.0	1	4	60.0	0.00
9:00	4.4	131.0	1	4	60.0	0.00
9:15	5.7	144.0	3	4	60.0	0.00
9:30	5.5	132.0	3	4	60.0	0.00
9:45	5.4	145.0	3	4	60.0	0.00
10:00	5.2	146.0	3	4	60.0	0.00
10:15	4.5	145.0	2	2	60.0	0.00
10:30	5.8	150.0	2	2	60.0	0.00
10:45	6.9	151.0	2	2	60.0	0.00
11:00	7.1	156.0	2	2	60.0	0.00
11:15	7.2	150.0	5	3	60.0	0.00
11:30	8.4	149.0	5	3	60.0	0.00
11:45	8.2	152.0	5	3	60.0	0.00
12:00	6.4	152.0	5	3	60.0	0.00
12:15	5.4	152.0	4	1	60.0	0.00
12:30	5.6	151.0	4	1	60.0	0.00
12:45	5.7	150.0	4	1	60.0	0.00
13:00	6.3	152.0	4	1	60.0	0.00
13:15	6.1	151.0	3	1	60.0	0.00
13:30	5.5	156.0	3	1	60.0	0.00
13:45	5.8	175.0	3	1	60.0	0.00
14:00	4.1	176.0	3	1	60.0	0.00
14:15	3.7	176.0	1	2	60.0	0.00
14:30	1.5	181.0	1	2	60.0	0.00
14:45	2.3	259.0	1	2	60.0	0.00
15:00	1.1	261.0	1	2	60.0	0.00
15:15	2.2	271.0	1	3	60.0	0.00
15:30	2.5	287.0	1	3	60.0	0.00
15:45	2.4	266.0	1	3	60.0	0.00
16:00	2.8	295.0	1	3	60.0	0.00

Table 4

METEOROLOGICAL DATA FOR DATES SEPTEMBER 4, 1986

HR:MN	SPD-P (MPH)	DIR-P (DEG FM)	STABY-SG (1-7)	STABZ-DI (1-7)	TEMP (DEG F)	RAIN (IN/15M)
8:00	8.8	312.0	4	4	60.0	0.00
8:15	11.4	305.0	4	4	60.0	0.00
8:30	13.3	307.0	4	4	60.0	0.00
8:45	14.4	309.0	4	4	60.0	0.00
9:00	15.0	311.0	4	4	60.0	0.00
9:15	13.7	313.0	4	4	60.0	0.00
9:30	13.8	318.0	4	4	60.0	0.00
9:45	13.3	313.0	4	4	60.0	0.00
10:00	14.1	315.0	4	4	60.0	0.00
10:15	15.1	316.0	5	4	60.0	0.00
10:30	16.0	316.0	5	4	60.0	0.00
10:45	17.2	314.0	5	4	60.0	0.00
11:00	16.7	310.0	5	4	60.0	0.00
11:00	18.5	310.0	5	4	60.0	0.00
11:15	18.5	308.0	5	4	60.0	0.00
11:30	19.7	308.0	5	4	60.0	0.00
11:45	22.0	306.0	5	4	60.0	0.00
12:00	23.6	307.0	5	4	60.0	0.00
12:15	23.3	307.0	5	4	60.0	0.00
12:30	23.4	308.0	5	4	60.0	0.00
12:45	23.6	310.0	5	4	60.0	0.00
13:00	23.3	308.0	5	4	60.0	0.00
13:15	23.8	310.0	5	4	60.0	0.00
13:30	24.1	309.0	5	4	60.0	0.00
13:45	23.5	309.0	5	4	60.0	0.00
14:00	23.1	309.0	5	4	60.0	0.00
14:15	24.7	310.0	5	4	60.0	0.00
14:30	26.2	311.0	5	4	60.0	0.00
14:45	26.0	312.0	5	4	60.0	0.00
15:00	25.9	312.0	5	4	60.0	0.00
15:15	25.9	313.0	5	4	60.0	0.00
15:30	24.6	314.0	5	4	60.0	0.00
15:45	26.1	311.0	5	4	60.0	0.00
16:00	25.7	311.0	5	4	60.0	0.00

Table 5

METEOROLOGICAL DATA FOR DATES SEPTEMBER 9, 1986

HR:MN	SPD-P (MPH)	DIR-P (DEG FM)	STABY-SG (1-7)	STABZ-DT (1-7)	TEMP (DEG F)	RAIN (IN/15M)
8:00	7.5	307.0	2	4	60.0	0.00
8:15	9.0	322.0	2	4	60.0	0.00
8:30	6.7	315.0	2	4	60.0	0.00
8:45	4.7	348.0	2	4	60.0	0.00
9:00	3.8	80.0	2	4	60.0	0.00
9:15	3.3	50.0	1	4	60.0	0.00
9:30	5.9	314.0	1	4	60.0	0.00
9:45	5.1	318.0	1	4	60.0	0.00
10:00	5.5	298.0	1	4	60.0	0.00
10:15	6.0	284.0	4	1	60.0	0.00
10:30	6.1	283.0	4	1	60.0	0.00
10:45	5.6	278.0	4	1	60.0	0.00
11:00	5.7	288.0	4	1	60.0	0.00
11:15	6.7	306.0	3	1	60.0	0.00
11:30	6.3	300.0	3	1	60.0	0.00
11:45	4.2	282.0	3	1	60.0	0.00
12:00	2.6	230.0	3	1	60.0	0.00
12:15	4.8	164.0	1	1	60.0	0.00
12:30	5.8	154.0	1	1	60.0	0.00
12:45	4.7	177.0	1	1	60.0	0.00
13:00	8.6	298.0	1	1	60.0	0.00
13:15	13.9	309.0	4	2	60.0	0.00
13:30	18.3	309.0	4	2	60.0	0.00
13:45	22.6	311.0	4	2	60.0	0.00
14:00	23.3	311.0	4	2	60.0	0.00
14:15	22.7	310.0	5	4	60.0	0.00
14:30	21.8	312.0	5	4	60.0	0.00
14:45	21.4	312.0	5	4	60.0	0.00
15:00	22.0	313.0	5	4	60.0	0.00
15:15	21.0	313.0	5	3	60.0	0.00
15:30	21.5	313.0	5	3	60.0	0.00
15:45	21.2	314.0	5	3	60.0	0.00
16:00	21.0	312.0	5	3	60.0	0.00

Table 6

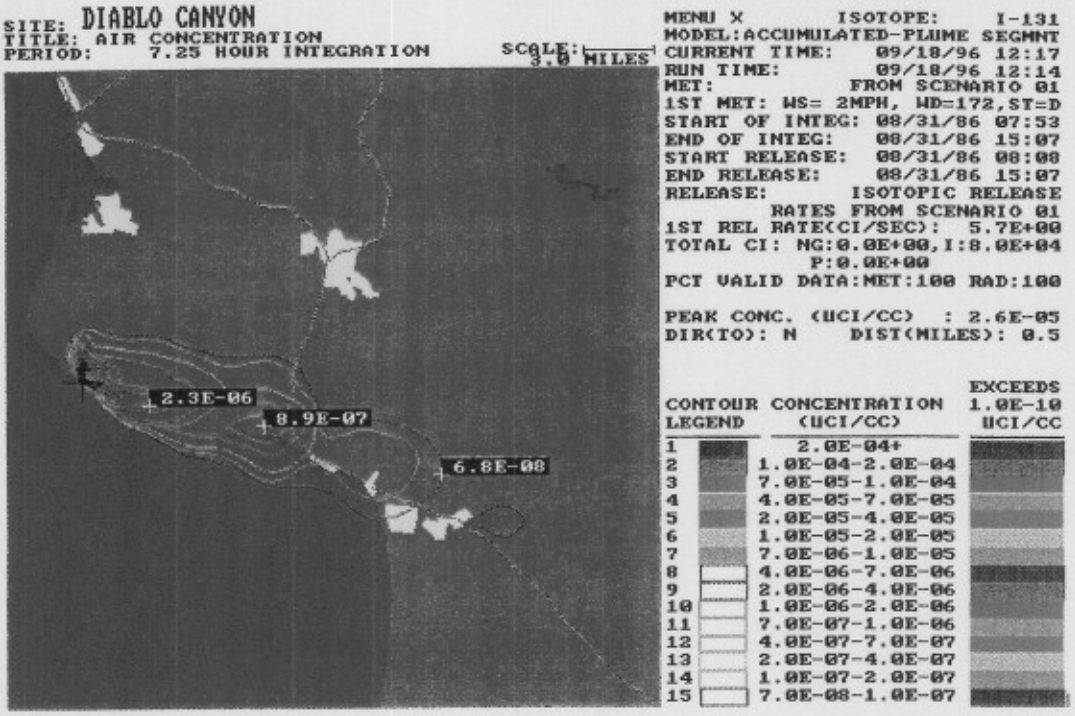
METEOROLOGICAL DATA FOR DATES SEPTEMBER 11, 1986

HR:MN	SPD-P (MPH)	DIR-P (DEG FM)	STABY-SG (1-7)	STABZ-DI (1-7)	TEMP (DEG F)	RAIN (IN/15M)
8:00	8.2	136.0	5	4	60.0	0.00
8:15	8.0	138.0	5	4	60.0	0.00
8:30	8.4	142.0	5	4	60.0	0.00
8:45	8.8	141.0	5	4	60.0	0.00
9:00	8.1	141.0	5	4	60.0	0.00
9:15	7.5	139.0	3	4	60.0	0.00
9:30	7.3	121.0	3	4	60.0	0.00
9:45	7.7	113.0	3	4	60.0	0.00
10:00	8.1	111.0	3	4	60.0	0.00
10:15	7.6	121.0	3	3	60.0	0.00
10:30	8.4	121.0	3	3	60.0	0.00
10:45	8.9	141.0	3	3	60.0	0.00
11:00	7.7	145.0	3	3	60.0	0.00
11:15	7.7	152.0	5	2	60.0	0.00
11:30	8.0	155.0	5	2	60.0	0.00
11:45	8.9	153.0	5	2	60.0	0.00
12:00	8.4	150.0	5	2	60.0	0.00
12:15	7.0	133.0	3	1	60.0	0.00
12:30	5.7	122.0	3	1	60.0	0.00
12:45	6.5	121.0	3	1	60.0	0.00
13:00	5.3	155.0	3	1	60.0	0.00
13:15	6.4	131.0	3	1	60.0	0.00
13:30	5.3	145.0	3	1	60.0	0.00
13:45	6.0	155.0	3	1	60.0	0.00
14:00	4.5	160.0	3	1	60.0	0.00
14:15	4.3	180.0	3	4	60.0	0.00
14:30	3.4	188.0	3	4	60.0	0.00
14:45	5.7	184.0	3	4	60.0	0.00
15:00	7.0	180.0	3	4	60.0	0.00
15:15	5.6	194.0	2	4	60.0	0.00
15:30	5.4	206.0	2	4	60.0	0.00
15:45	4.0	217.0	2	4	60.0	0.00
16:00	4.1	247.0	2	4	60.0	0.00

Table 7

METEOROLOGICAL DATA FOR DATES SEPTEMBER 13, 1986

HR:MN	SPD-P (MPH)	DIR-P (DEG FM)	STABY-SG (1-7)	STABZ-DI (1-7)	TEMP (DEG F)	RAIN (IN/15M)
8:00	4.9	308.0	1	4	60.0	0.00
8:15	4.8	305.0	1	4	60.0	0.00
8:30	1.9	234.0	1	4	60.0	0.00
8:45	6.3	146.0	1	4	60.0	0.00
9:00	6.9	141.0	1	4	60.0	0.00
9:15	6.4	135.0	4	4	60.0	0.00
9:30	5.9	145.0	4	4	60.0	0.00
9:45	5.8	146.0	4	4	60.0	0.00
10:00	5.8	145.0	4	4	60.0	0.00
10:15	4.7	146.0	4	4	60.0	0.00
10:30	3.4	153.0	4	4	60.0	0.00
10:45	3.5	150.0	4	4	60.0	0.00
11:00	3.0	160.0	4	4	60.0	0.00
11:15	3.0	158.0	4	4	60.0	0.00
11:30	2.4	155.0	4	4	60.0	0.00
11:45	3.6	147.0	4	4	60.0	0.00
12:00	3.5	142.0	4	4	60.0	0.00
12:15	4.3	141.0	4	2	60.0	0.00
12:30	5.5	142.0	4	2	60.0	0.00
12:45	5.3	150.0	4	2	60.0	0.00
13:00	6.3	146.0	4	2	60.0	0.00
13:15	5.3	153.0	4	1	60.0	0.00
13:30	4.6	163.0	4	1	60.0	0.00
13:45	4.5	165.0	4	1	60.0	0.00
14:00	2.3	215.0	4	1	60.0	0.00
14:15	2.9	310.0	1	1	60.0	0.00
14:30	3.5	284.0	1	1	60.0	0.00
14:45	4.3	266.0	1	1	60.0	0.00
15:00	4.6	287.0	1	1	60.0	0.00
15:15	4.2	254.0	3	1	60.0	0.00
15:30	4.0	269.0	3	1	60.0	0.00
15:45	3.9	264.0	3	1	60.0	0.00
16:00	4.3	283.0	3	1	60.0	0.00



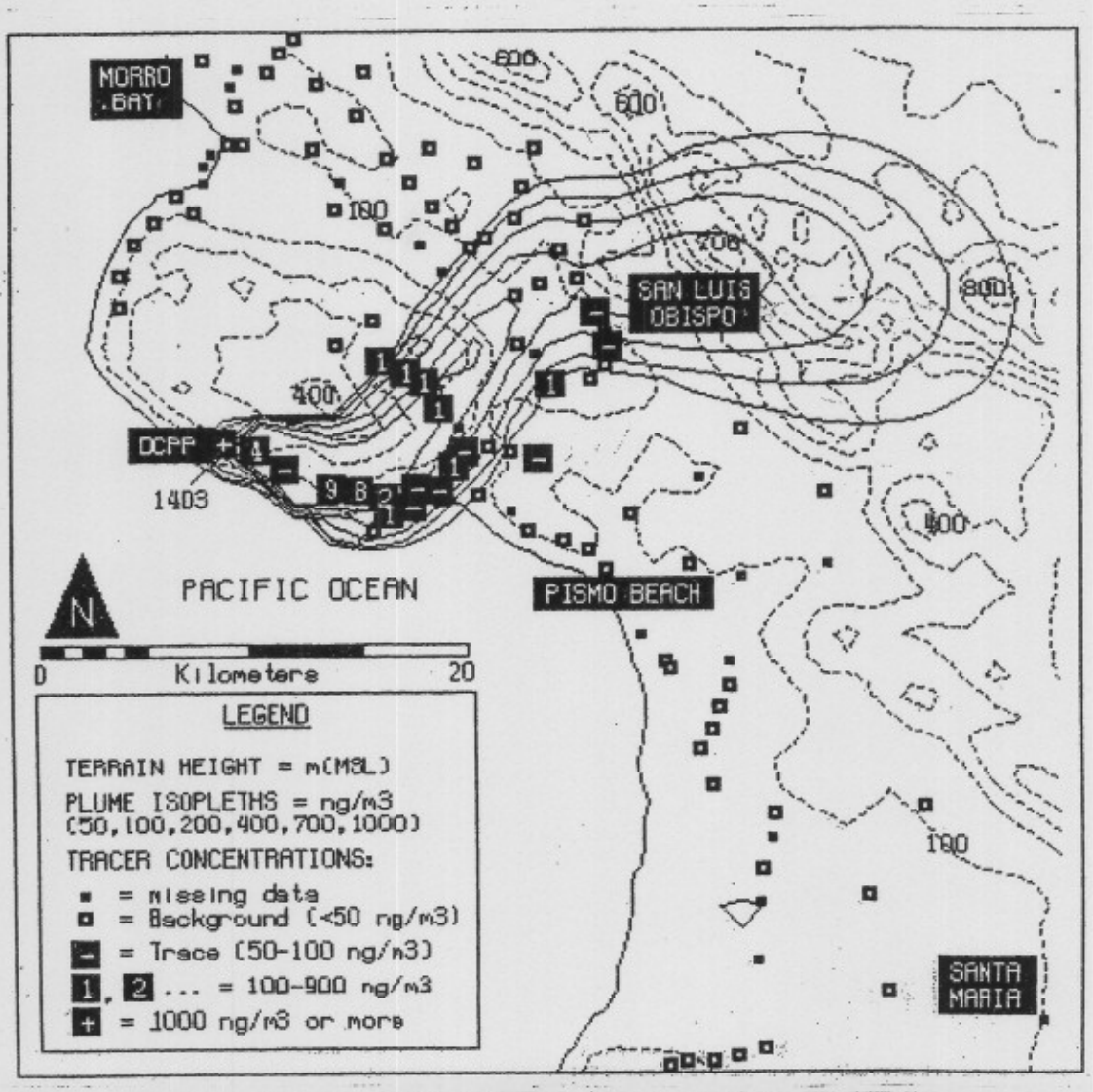


Figure 1. Comparison of MIDAS and PGEMS model output with SF6 gas tracer data for 8/31/86 at 1500 PDT

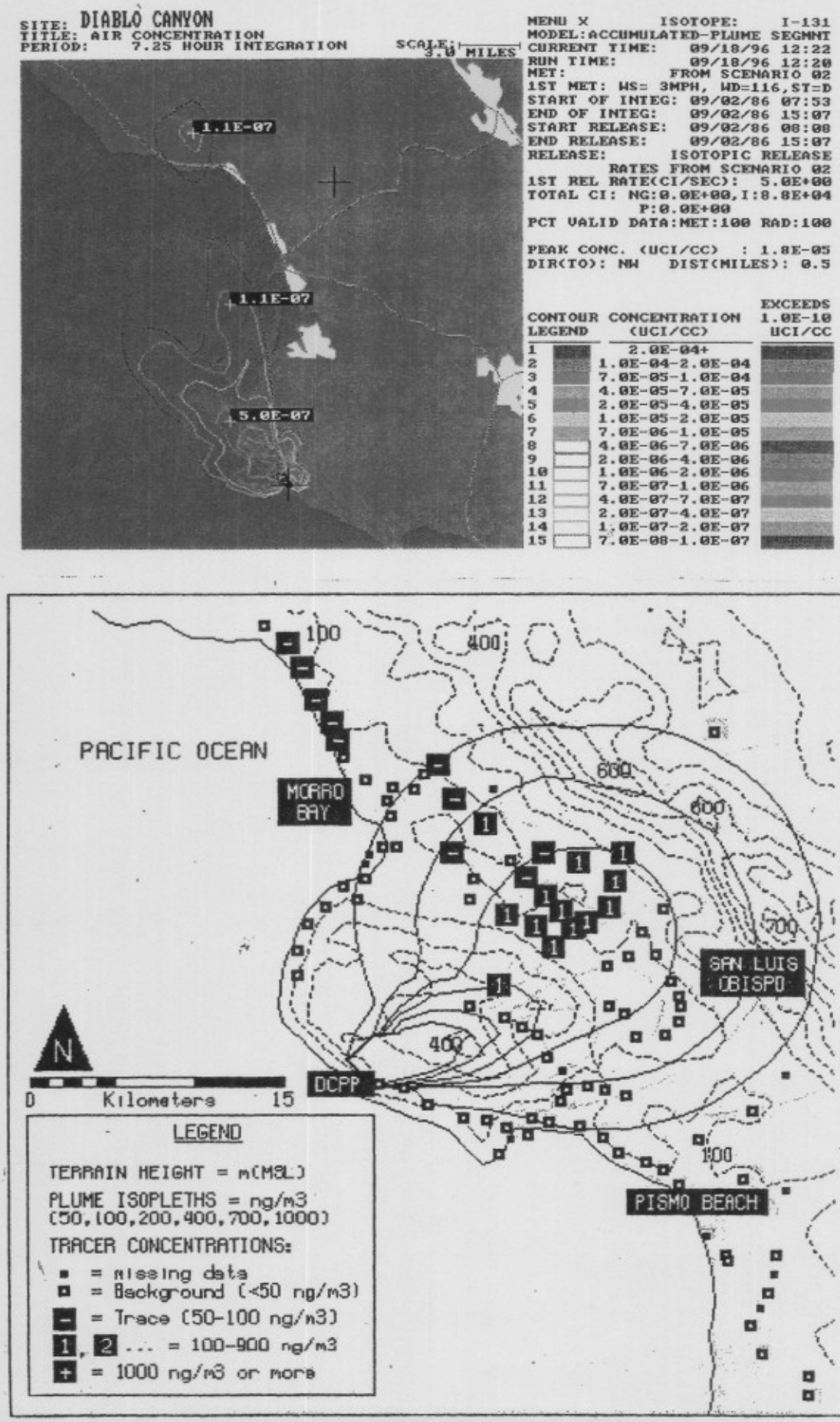
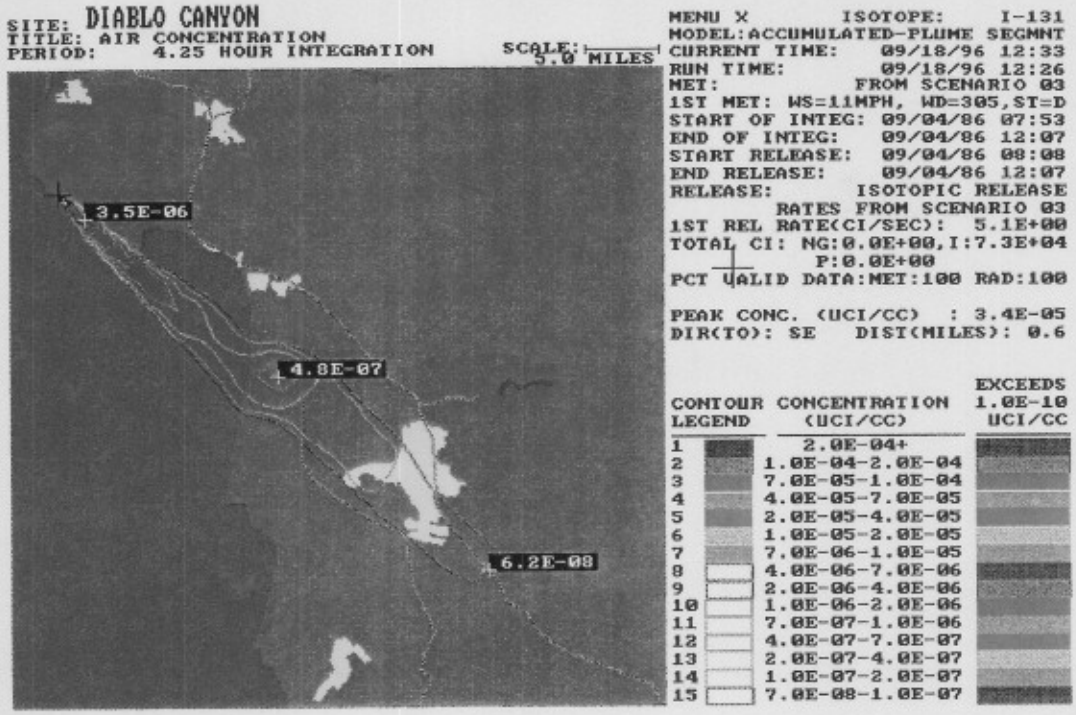


Figure 2. Comparison of MIDAS and PGEMS model output with SF6 gas tracer data for 9/02/86 at 1500 PDT



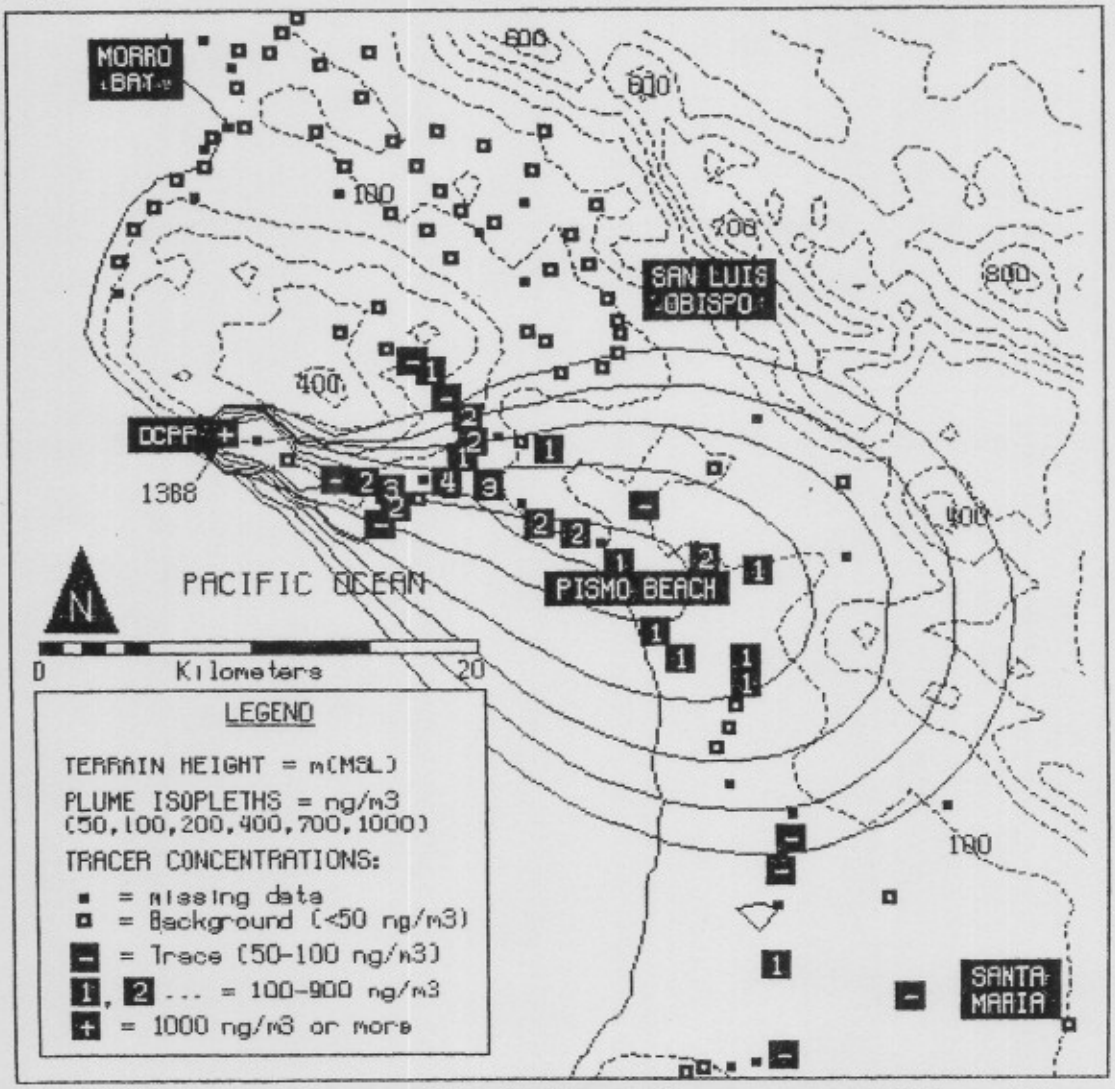
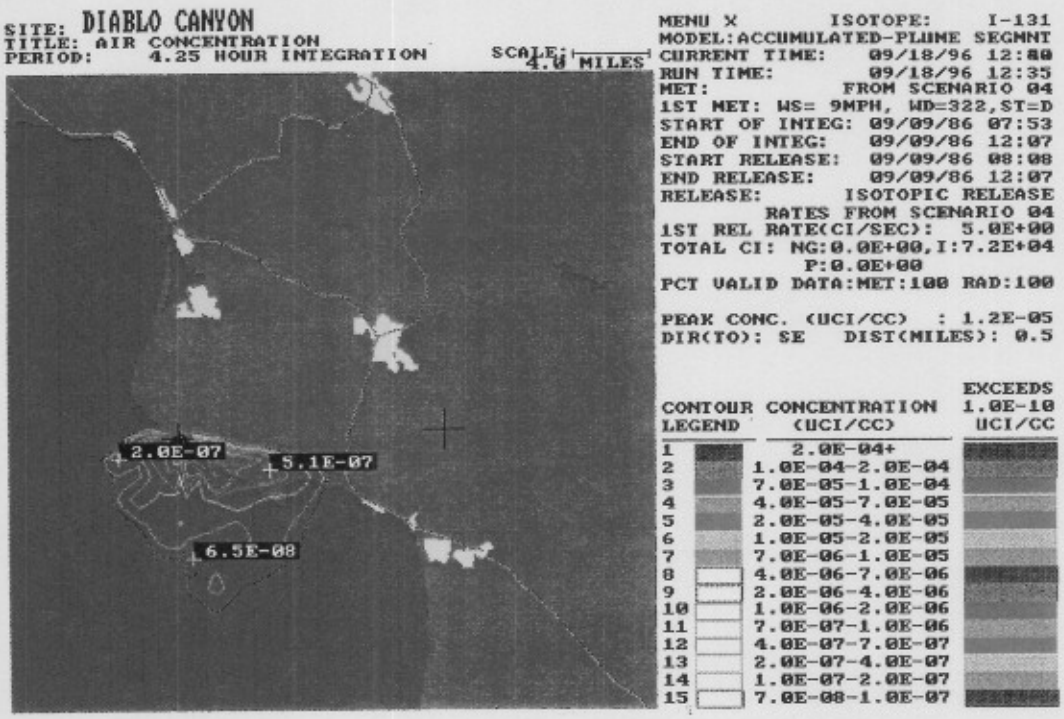


Figure 3. Comparison of MIDAS and PGEMS model output with SF6 gas tracer data for 9/04/86 at 1200 PDT



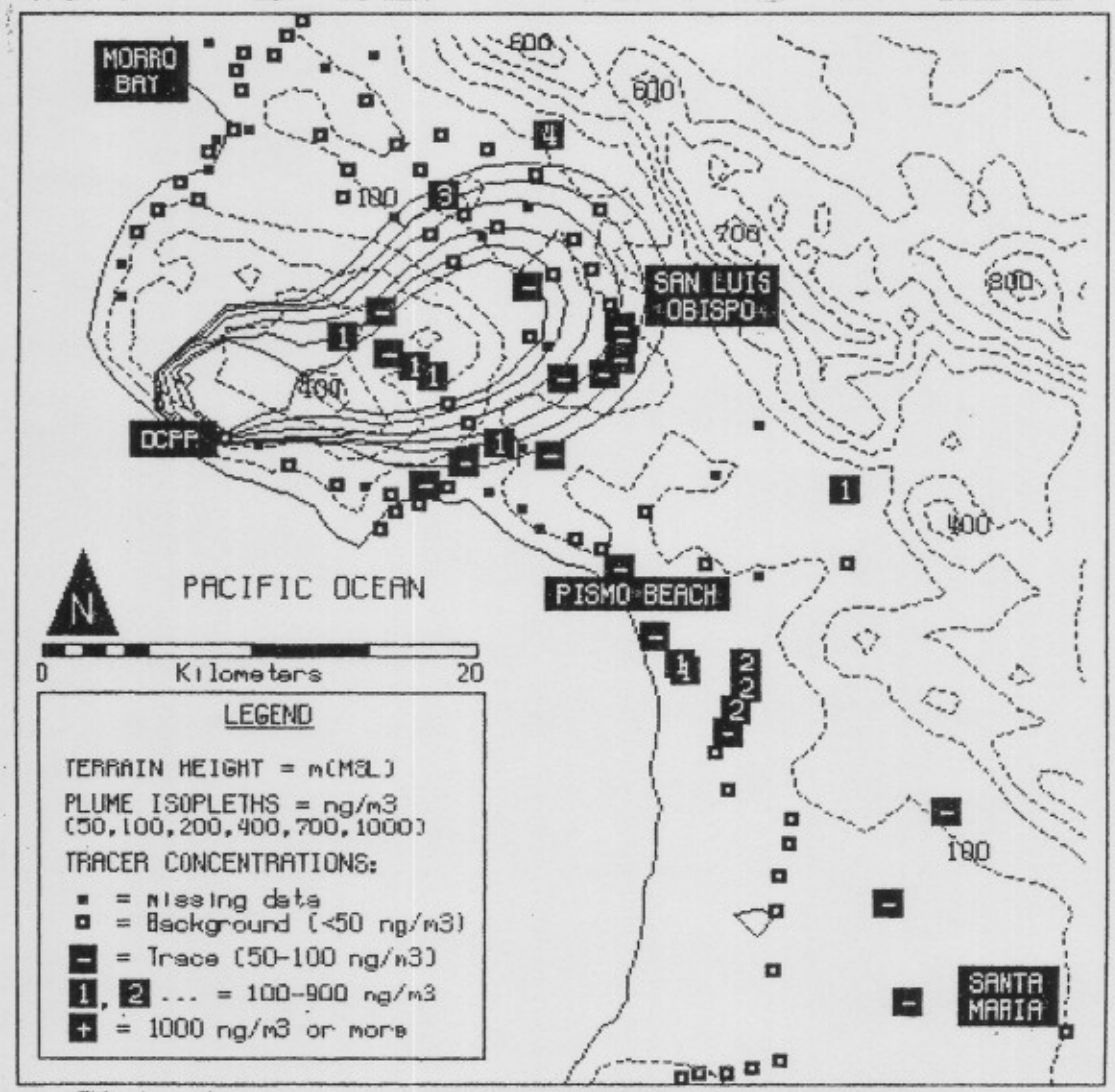


Figure 4. Comparison of MIDAS and PGEMS model output with SF6 gas tracer data for 9/09/86 at 1200 PDT

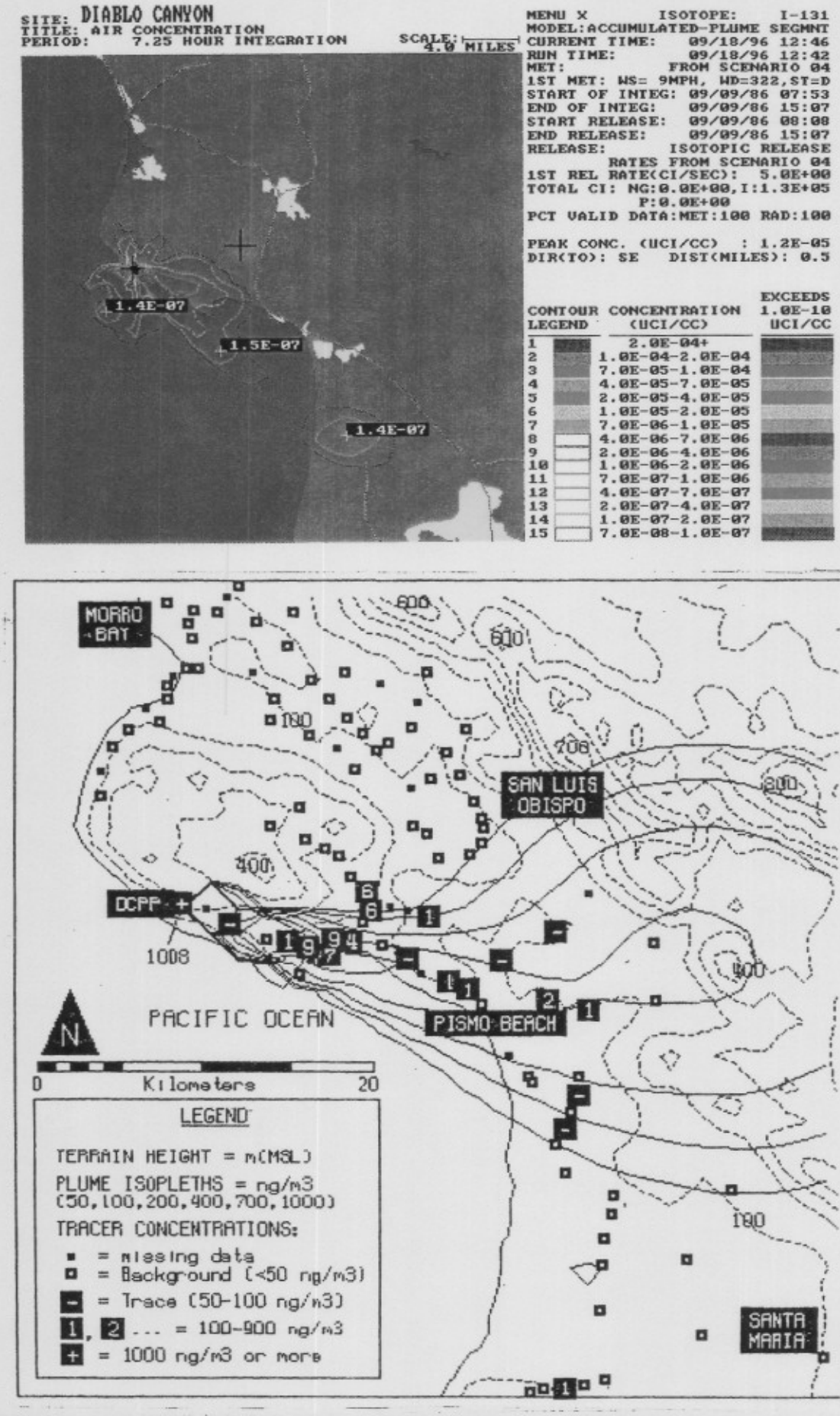
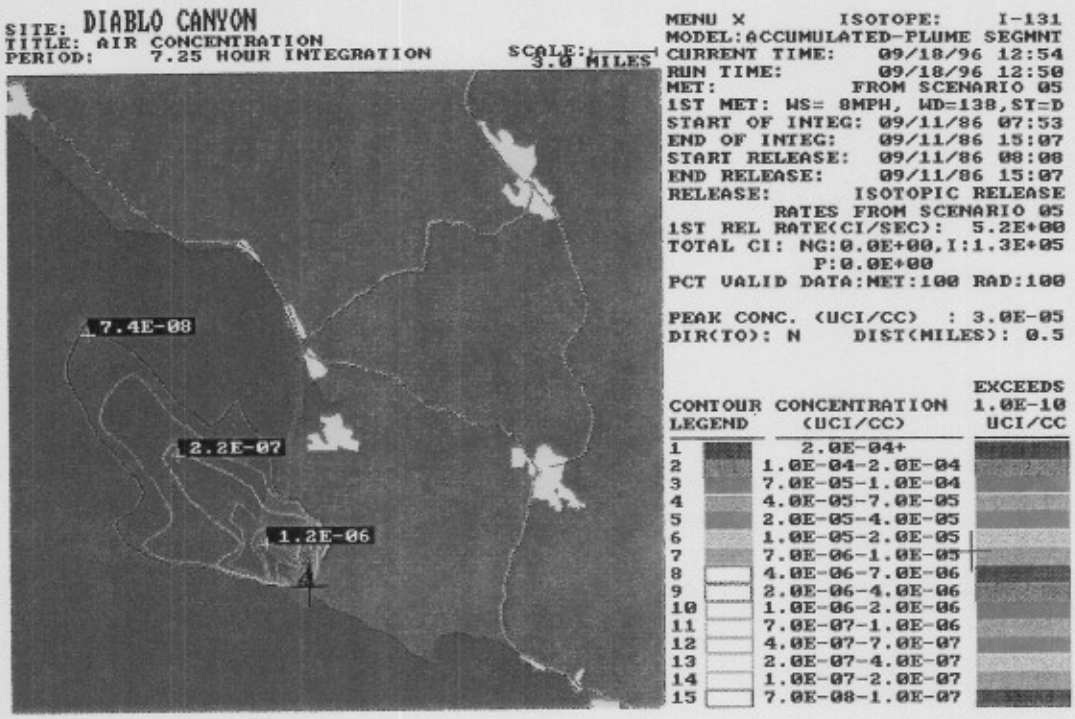


Figure 5. Comparison of MIDAS and PGEMS model output with SF6 gas tracer data for 9/09/86 at 1500 PDT



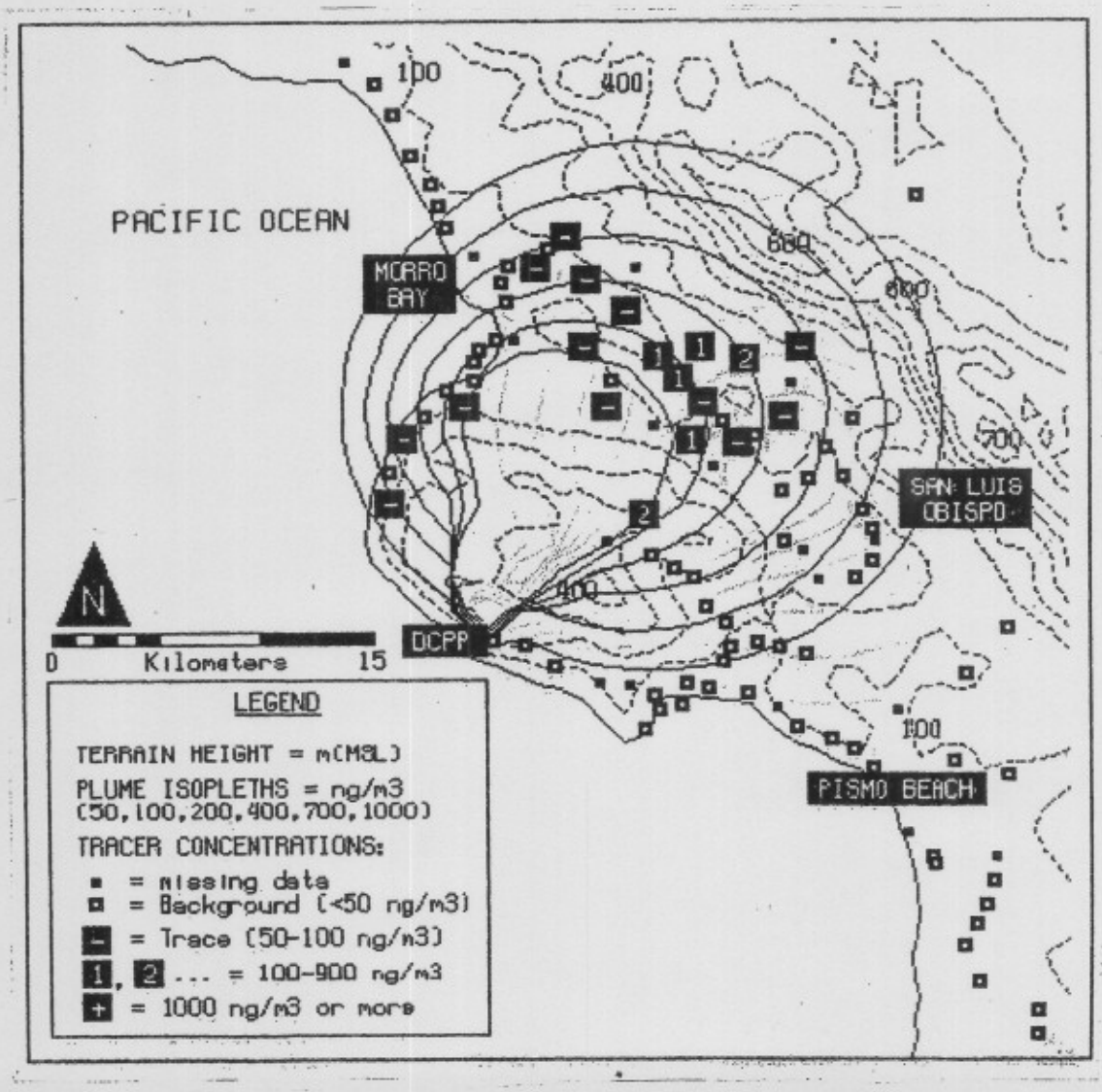
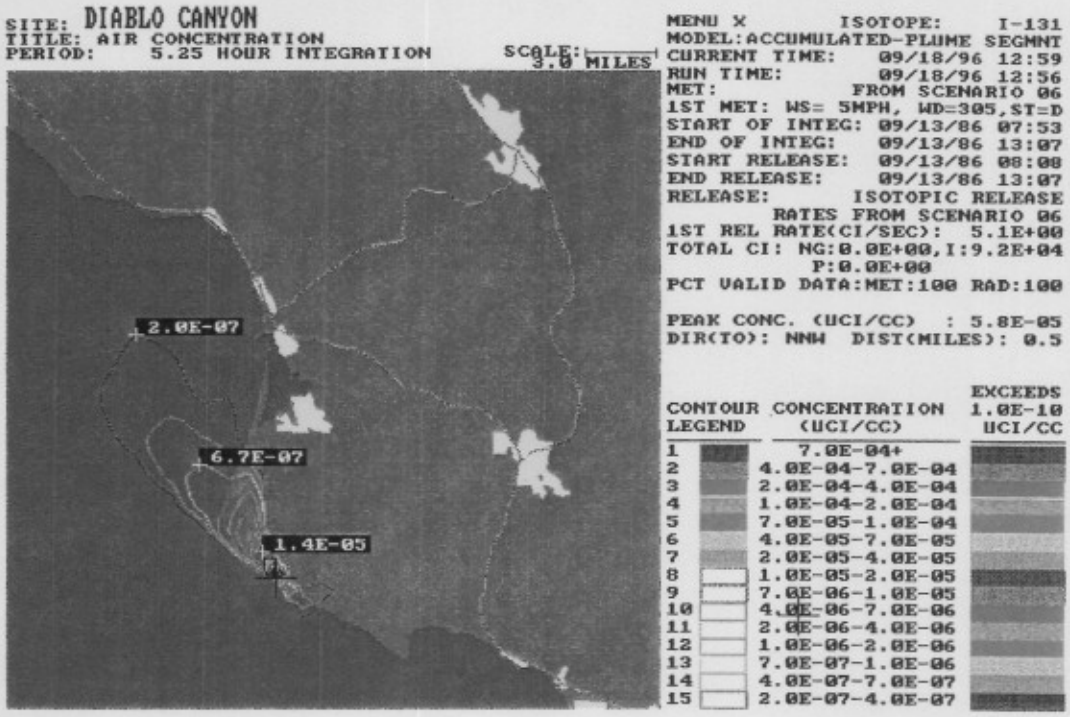


Figure 6. Comparison of MIDAS and PGEMS model output with SF6 gas tracer data for 9/11/86 at 1500 PDT



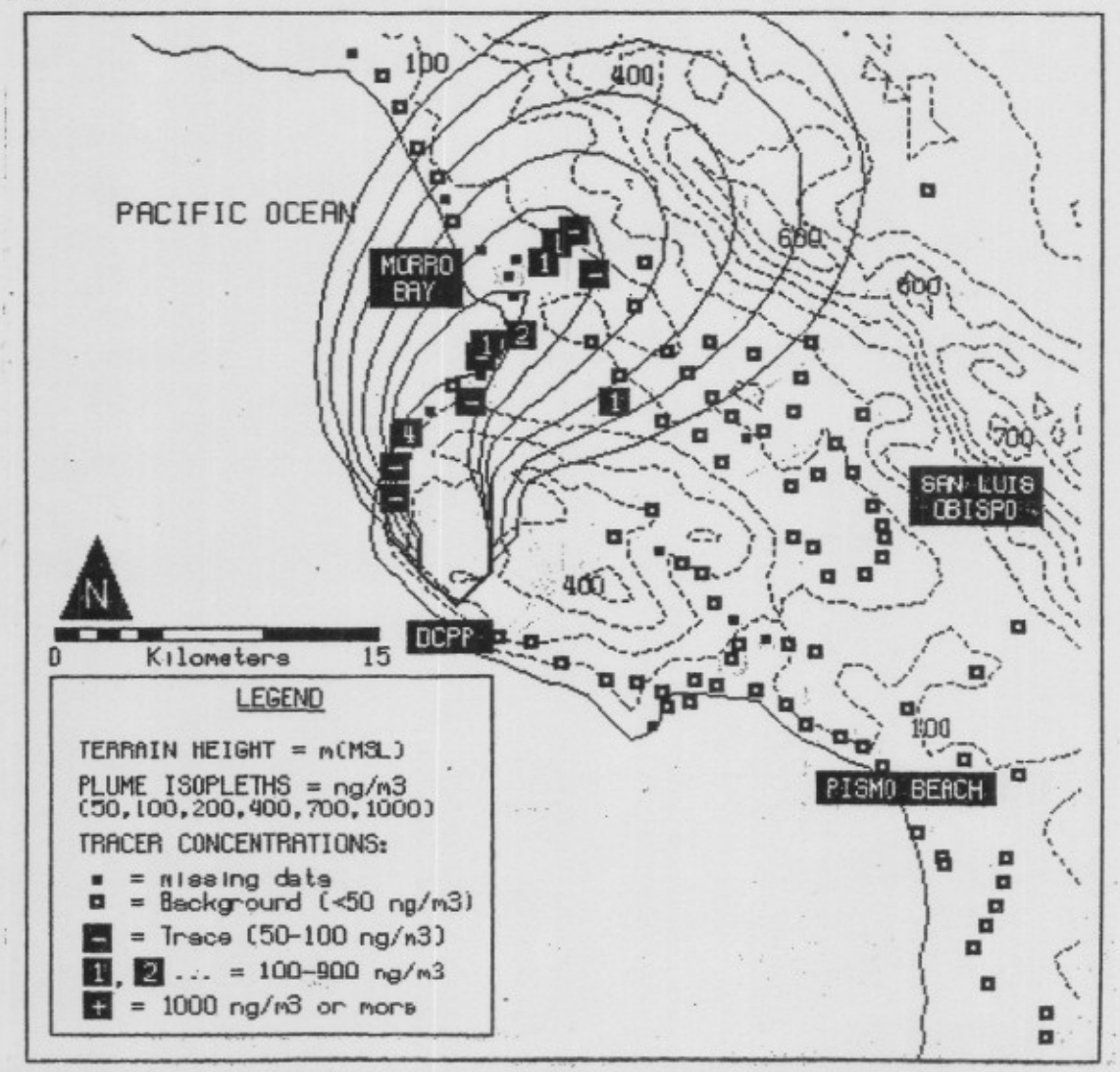


Figure 7. Comparison of MIDAS and PGEMS model output with SF6 gas tracer data for 9/13/86 at 1300 PDT