APPENDIX I

Air Quality and Meteorological Analyses for the December 1990 Special Study in the El Paso/Juarez Air Basin

Objectives

In support of the development of this State Implementation Plan (SIP), Texas Air Control Board (TACB) staff conducted analyses of inhalable particulate matter (PM_{10}) and meteorological monitoring data obtained during the December 1990 special PM_{10} study in the El Paso/Juarez air basin. The purpose of the analyses was to examine spatial and temporal trends in PM_{10} concentrations in the basin, and analyze PM_{10} transport, particularly the potential for transport of PM_{10} from Juarez into El Paso.

This is the first time that a significant amount of air pollutant and meteorological monitoring data have been simultaneously available for El Paso/Juarez. Thus, this is the first significant opportunity to examine the mutual contribution of both cities to the air pollution of the El Paso/Juarez basin.

The December 1990 monitoring program was conducted jointly by the TACB, Environmental Protection Agency (EPA) and its contractors, El Paso City-County Health District (EPCCHD), and Secretariat of Urban Development and Ecology (SEDUE) during the period December 3-21, 1990.

Climatology and Pollutant Trapping Mechanisms

El Paso has a desert climate characterized by an abundance of sunshine and rainfall averaging less than eight inches annually, mostly from thunderstorms in July, August, and September. The dry desert air favors strong nighttime cooling of the atmosphere near the surface. During December, the period of the special monitoring, nights are 14 hours long, and days are only ten hours long, which increases the effect of nighttime cooling. The strong nighttime cooling forms inversions which trap pollutants emitted within the basin. These inversions are very shallow, thus reducing the volume of air available for vertical mixing and dispersion, and thus, causing high concentrations near the surface. Also, since the cooled air near the surface is relatively dense, drainage winds develop during the nighttime. These drainage winds tend to collect pollutants in the lower portions of the basin in the downtown area near the Rio Grande River, further increasing concentrations there. During the day, local heating disperses pollutants through a deep layer and allows the stronger winds at higher levels in the atmosphere to carry them away.

ANALYSIS OF SPATIAL AND TEMPORAL PM_{10} TRENDS

Procedures

During the December 1990 study, PM_{10} concentrations were measured at various El Paso/Juarez sites according to the normal six-day EPA schedule and were supplemented by dichotomous sampling data collected at five additional sites. As a result, data from the full monitoring array was available only on the 7th, 13th, and 19th of December. For the other days, only data from the special dichotomous samplers and PM_{10} data from the El Paso Tillman sites were available. PM_{10} and dichotomous sampler data obtained during the study are presented in Table I-1.

Dichotomous sampler data was collected twice per day on a 12-hour schedule. To determine whether PM_{10} levels varied diurnally, the dichotomous monitoring schedule (5 a.m. to 5 p.m., 5 p.m. to 5 a.m.) was chosen to roughly parallel the day and night hours at El Paso. For purposes of this analysis, the 12-hour dichotomous measurements were mathematically adjusted to develop a 24-hour concentration to match the collection schedule normally used for PM_{10} measurements.

Only one episode with high PM_{10} concentrations (December 7-10) occurred during the period of the special study. On the 7th,

TABLE I-1

El Paso/Juarez PM_{10} Concentrations ($\mu g/m^3$) - December 1990 Study

Station	UTM East	UTM North	Day of the Month December 1990 1	2	3	4	5	6	7	8	9	10	11
Tillman	359.565	3514.265	179	63	25	35	47	36	89	229	105	127	69
Northeast	366.769	3529.968	55									30	
Ivanhoe	374.867	3517.517	40									33	
Riverside	369.926	3511.604	75									108	
Vilas	357.941	3514.811	176									92	
Lindbergh	349.919	3525.889	62									31	
Techno	367.900	3509.566	125									141	
Pestalozzi	364.633	3511.364	125									115	
Zenco	363.154	3501.036	96									93	
Adv Trans	361.650	3506.815	---									222	
CAMS 6*	359.179	3514.886			41	48	58	47	78	159	131	75	47
Chamizal*	362.292	3515.551			27	24	40	38	72	93	91	113	65
Sun Metro*	357.858	3514.473			31	138	150	79	152	273	215	184	138
Adv Trans*	361.650	3506.815				153	233	144	246	363	282	392	299
Techno*	367.900	3509.566				29	42	26	83	148	148	112	49

Station	UTM East	UTM North	Day of the Month December 1990 12	13	14	15	16	17	18	19	20	21	22
Tillman	359.565	3514.265	39	45	65	55	19	21	24	43	36	46	---
Northeast	366.769	3529.968		28						17			
Ivanhoe	374.867	3517.517		26						22			
Riverside	369.926	3511.604		33						32			
Vilas	357.941	3514.811		39						32			
Lindbergh	349.919	3525.889		19						11			
Techno	367.900	3509.566		39						35			
Pestalozzi	364.633	3511.364		42						54			
Zenco	363.154	3501.036		38						20			
Adv Trans	361.650	3506.815		128						---			
CAMS 6*	359.179	3514.886	16	38	26	42	16	17	21	34	46	85	
Chamizal*	362.292	3515.551	28	37	32	43	13	13	13	37	32	13	
Sun Metro*	357.858	3514.473	75	59	83	74	17	27	50	80	100	38	
Adv Trans*	361.650	3506.815	84	114	97	121	20	38	68	183	116	56	
Techno*	367.900	3509.566	72	60	20	23	7	10	8	23	38	11	

All Data in micrograms per cubic meter (μ/m^3)

* Dichotomous sampler data (adjusted for sampling time)

one exceedance of the PM_{10} National Ambient Air Quality Standard (NAAQS) in El Paso was estimated from dichotomous sampler measurements, and one exceedance was measured directly at a Juarez site. On the 8th, an exceedance of the PM_{10} NAAQS was measured directly at one El Paso site, and exceedances were estimated from dichotomous sampler measurements at two other El Paso sites and one Juarez site. Previous work at El Paso had indicated that carbon monoxide (CO) and nitrogen oxides (NO_X) concentrations varied significantly on a diurnal basis. To determine whether PM_{10} concentrations exhibited a similar diurnal variation during the study period, day and night dichotomous sampler data for the December study period were averaged for all reporting stations in the network and plotted by day of the month (see Figure I-1 at the end of this appendix).

The diurnal variation of PM_{10} was also studied through examination of hourly nephelometer data obtained during the special study at the continuous air monitoring station (CAMS) 6 site in El Paso. A nephelometer is an instrument which continuously measures the light scatter (B-scat) of fine particulate matter mass. Fine particulate matter is a major component of PM_{10}.

Next, PM_{10} data (including adjusted dichotomous sampler data) from the entire period were plotted to assess spatial trends in the concentrations (see Figures I-2 through I-20 at the end of this appendix). Concentration isopleths were drawn by the Surfer computer program and were interpolated based on the inverse square of the distance to the monitor.

Results

Results of the analysis of spatial and temporal PM_{10} trends in the El Paso/Juarez basin are as follows:

- During the special study of December 1990, high PM_{10} concentrations occurred in the El Paso/Juarez air basin on clear, cold nights with light winds. Strong winds (e.g., dust storms) are not necessary for the occurrence of high PM_{10} events.

- PM_{10} concentrations in the basin tended to vary inversely with wind speed and temperature. A correlation coefficient (r^2) of 0.70 was calculated for the study period.

- Twelve-hour PM_{10} concentrations tended to show a strong diurnal variation. During periods when the PM_{10} NAAQS was exceeded during the special study, the nighttime PM_{10} values were much higher than the daytime values (see Figure I-1).

- Nephelometer readings tended to follow the same diurnal pattern as did the 12-hour PM_{10} concentrations. The maximum value of fine particulate B-scat typically occurred in the evenings. This maximum tended to occur between 8 p.m. and 10 p.m., following the same pattern as CO and NO_x concentrations. Since these concentrations continued to increase after the end of the evening rush hour, residential heating in the El Paso/Juarez air basin may have contributed to the PM_{10} concentrations.

- PM_{10} concentrations were generally higher in Juarez than in El Paso. PM_{10} concentrations at sites in the northern portion of El Paso were relatively low, even when the PM_{10} NAAQS was exceeded at other monitoring sites. PM_{10} concentrations tended to increase as the distance between the monitor and Juarez decreased (see Figures I-2 through I-20).

- A significant hot spot was identified in Juarez. The Advance Transformer monitor consistently reported higher PM_{10} concentrations than any other station during the special study period. A source or sources in Juarez, near the Advance Transformer site, probably accounts for a significant portion of the PM_{10} measured at that site during the special study.

Analysis of PM_{10} Transport in the El Paso/Juarez Basin

The second part of the analysis of the special study data evaluated the transport of PM_{10} within the El Paso/Juarez air basin. A study conducted in support of the Group I Interim PM_{10} SIP for El Paso (May 1989) indicated that background levels of PM_{10} in El Paso were higher for winds coming from the south, suggesting that Juarez was a source of at least a portion of the PM_{10} concentrations measured in El Paso.

Wind data from all monitoring stations taking measurements during the December 7-9 episode were plotted on a topographic map of El Paso/Juarez. Hourly wind flow maps for the area were generated from detailed meterological analysis of hourly patterns of wind direction and speed.

During the nighttime periods, these wind flow maps generally showed drainage flows from higher elevations moving toward the Rio Grande River. During the daytime, the patterns generally reflected upslope winds generated by strong solar heating. During the late morning and early evening hours, the patterns were generally irregular as a transition occurred in the air flow from drainage flow to upslope flow patterns.

From these flow patterns, 25 separate one- and two-hour trajectories were plotted to identify the sources of air parcels flowing past the Sun Metro and CAMS 6 stations in El Paso. Example trajectory plots are presented in Figures I-21 through I-24 (located at the end of this appendix). Trajectories longer than two hours back in time were not attempted because the paths became unreliable with increasing time and distance from the monitor. Such longer-term trajectories were unreliable because of the lack of stations providing meteorological data, and because of the complex flow patterns.

Results

Results of the analysis of PM_{10} transport in the El Paso/Juarez air basin are as follows:

- o Drainage flows dominated the nighttime wind patterns. Low concentrations of PM_{10} at monitoring stations in the northern and eastern portions of El Paso reflect drainage winds carrying cleaner air in from areas northeast of the city. During the early evening transition period, drainage flows tended to be blocked until the cool air was sufficiently heavy to push through to the river.

- o The drainage winds that flowed from the upper Rio Grande Valley were generally light and steered by terrain features. Drainage winds increased in speed in the narrow gap in the mountains near the Sun Metro monitoring station. Drainage flows generated complex eddy patterns that tended to mix the cool air (and entrained pollutants) draining down from both sides of the river.

- Trajectory analyses showed that many of the air parcels passing over El Paso monitors came from source regions within Mexico. In particular, 92 percent (23 out of 25) of the parcels passing over Sun Metro had passed over Juarez during the previous hour (see Table I-2).

TABLE I-2

Results of El Paso/Juarez Trajectory Analyses
December 7-9, 1990

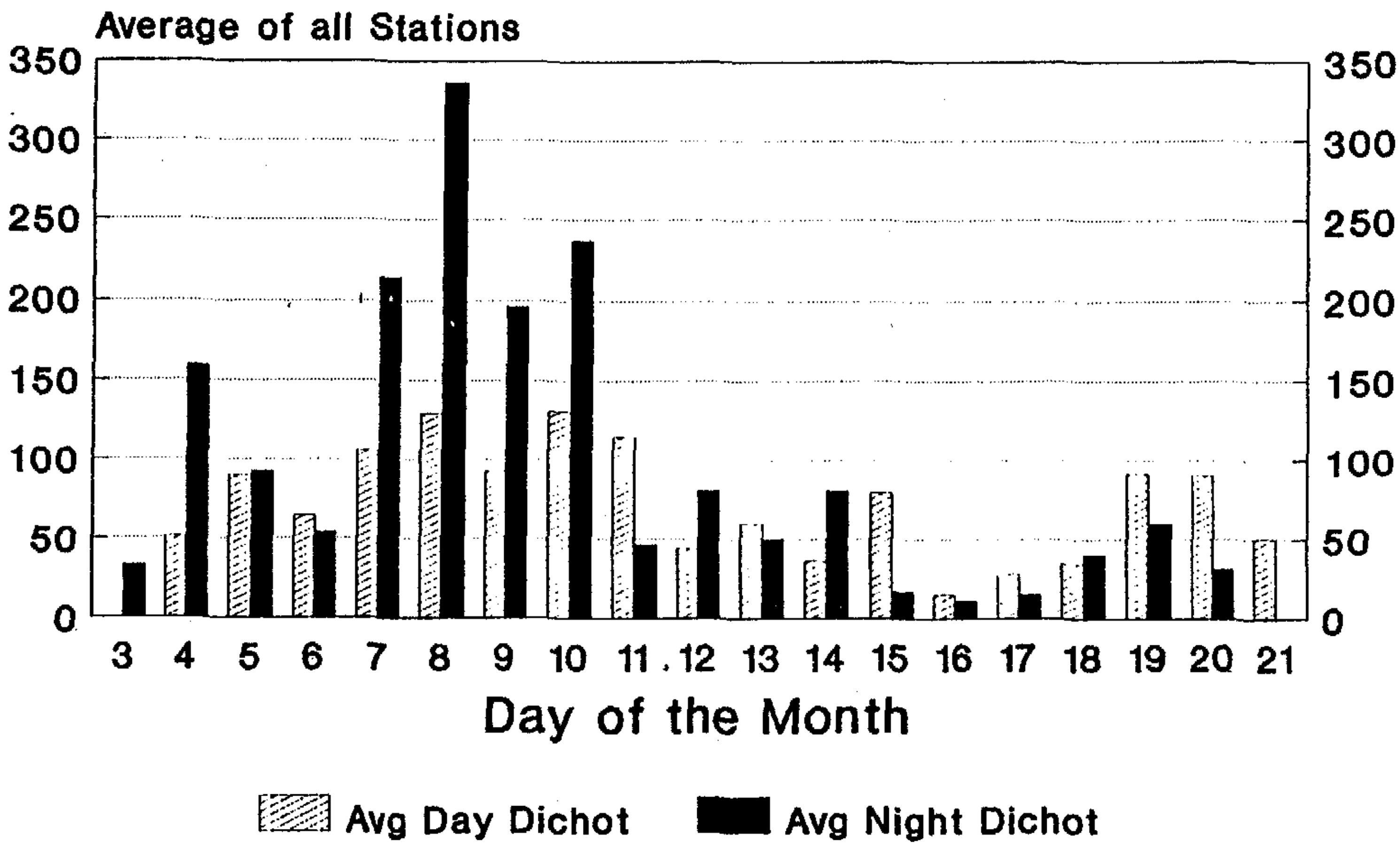
One-Hour Trajectories

Origination of Trajectory	Percent of Parcels Indicating Transport from Juarez or Mexico
Sun Metro	92 percent
CAMS 6	36 percent

Two-Hour Trajectories

Origination of Trajectory	Percent of Parcels Indicating Transport from Juarez or Mexico
Sun Metro	52 percent
CAMS 6	24 percent

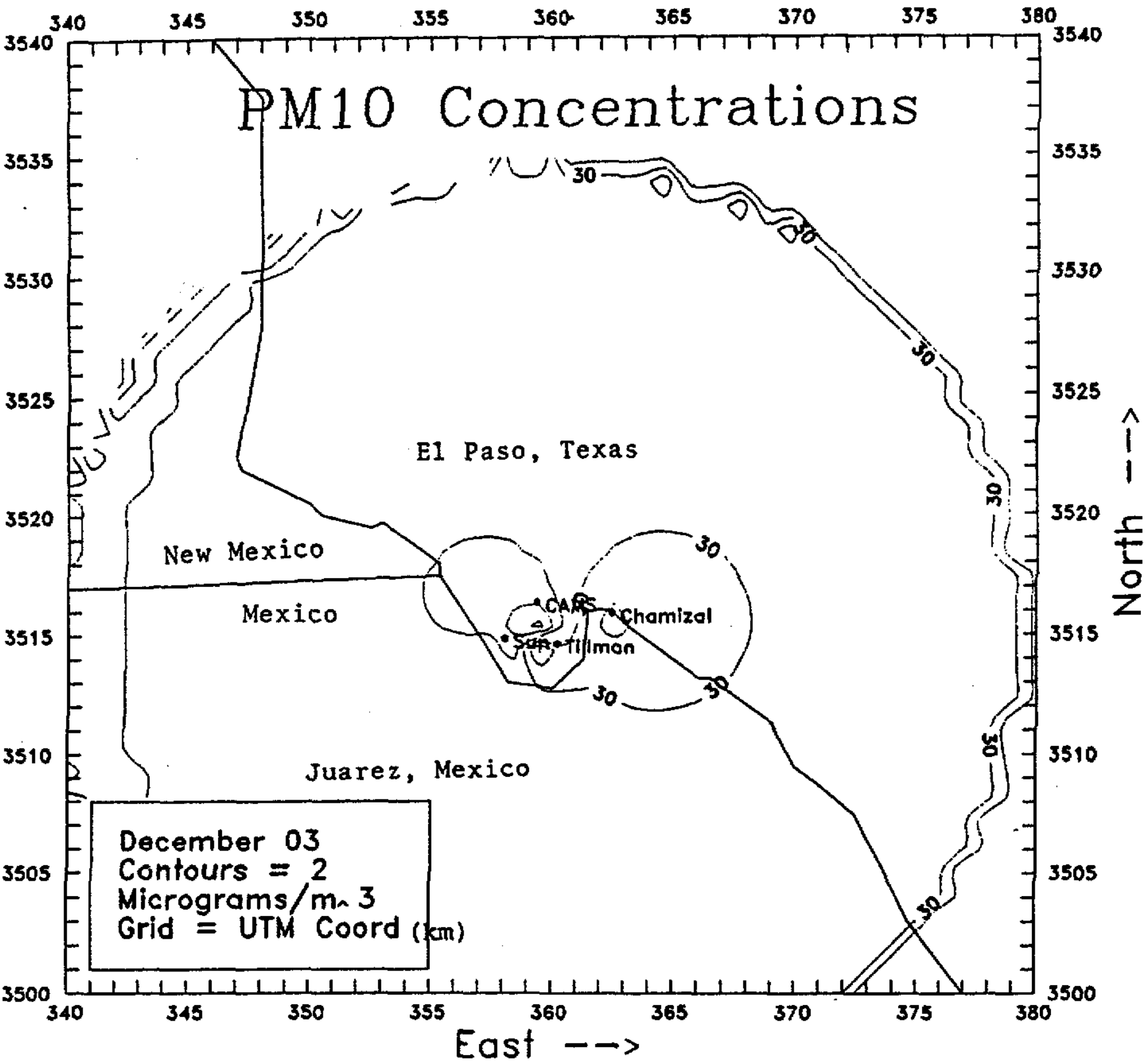
FIGU 1-1



December 1990

El Paso/Juarez Dichotomous Sampler
Data (Daytime And Nighttime Comparison)

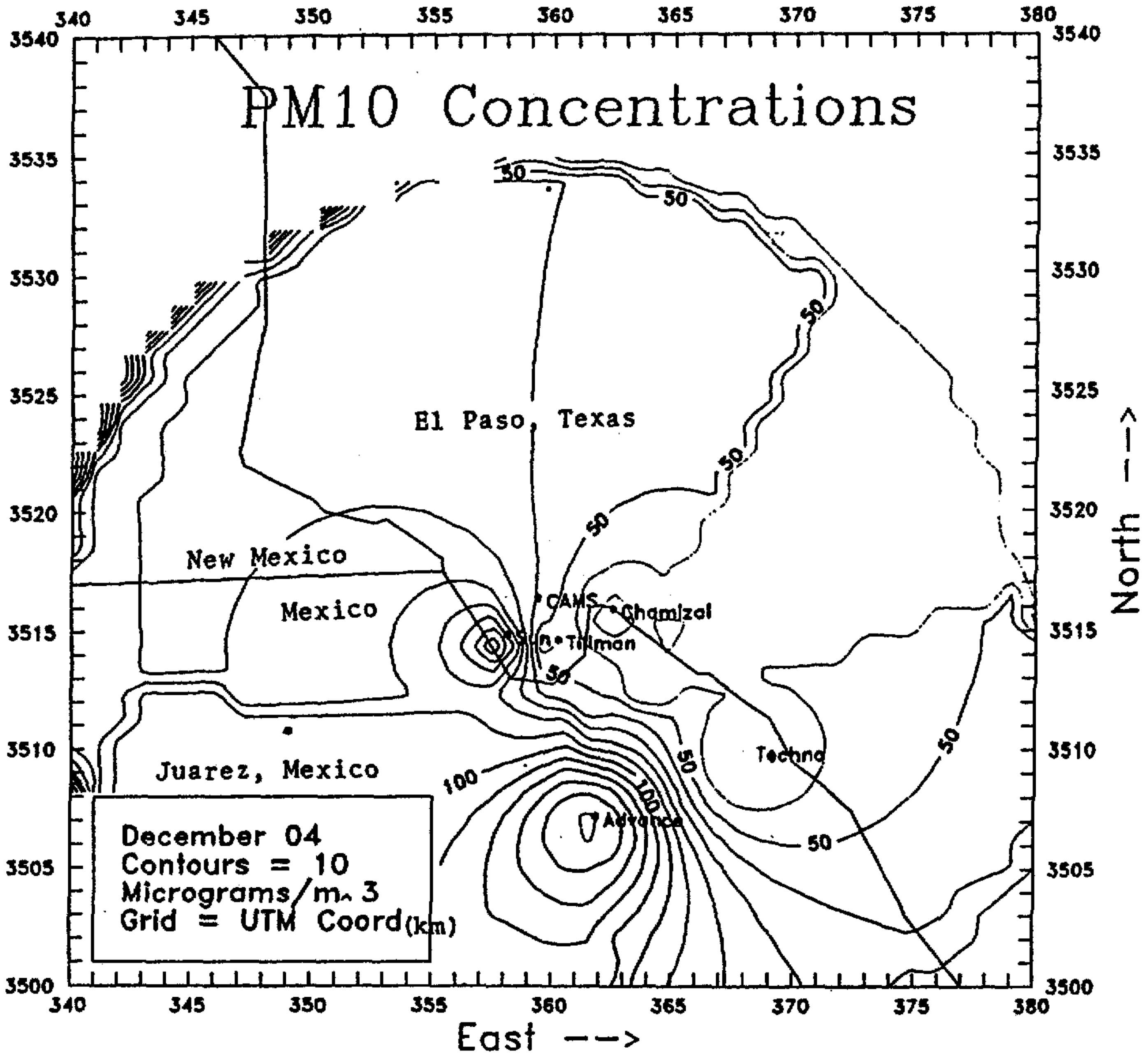
FIGURE I-2



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 3, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

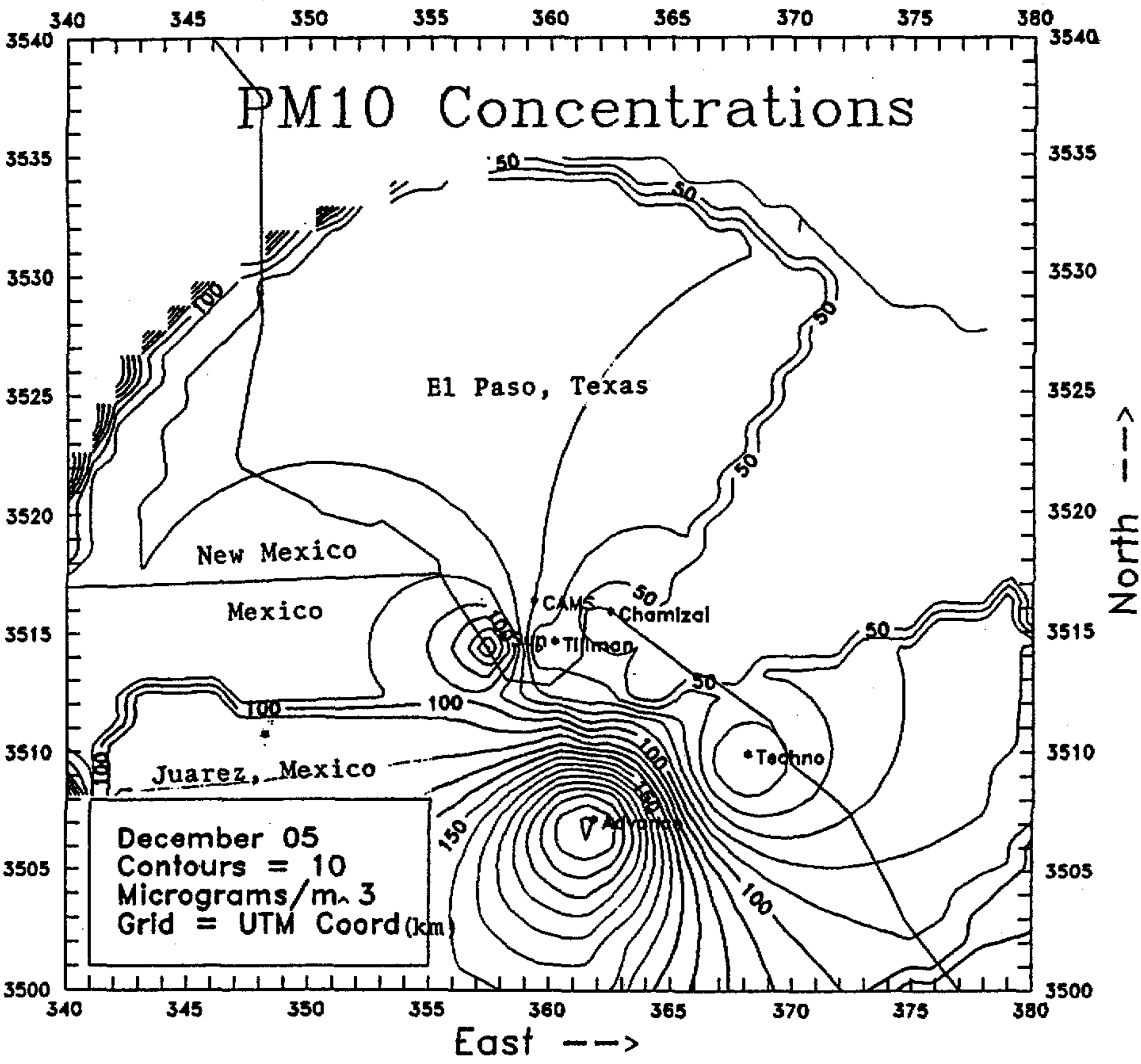
FIGURE I-3



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 4, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

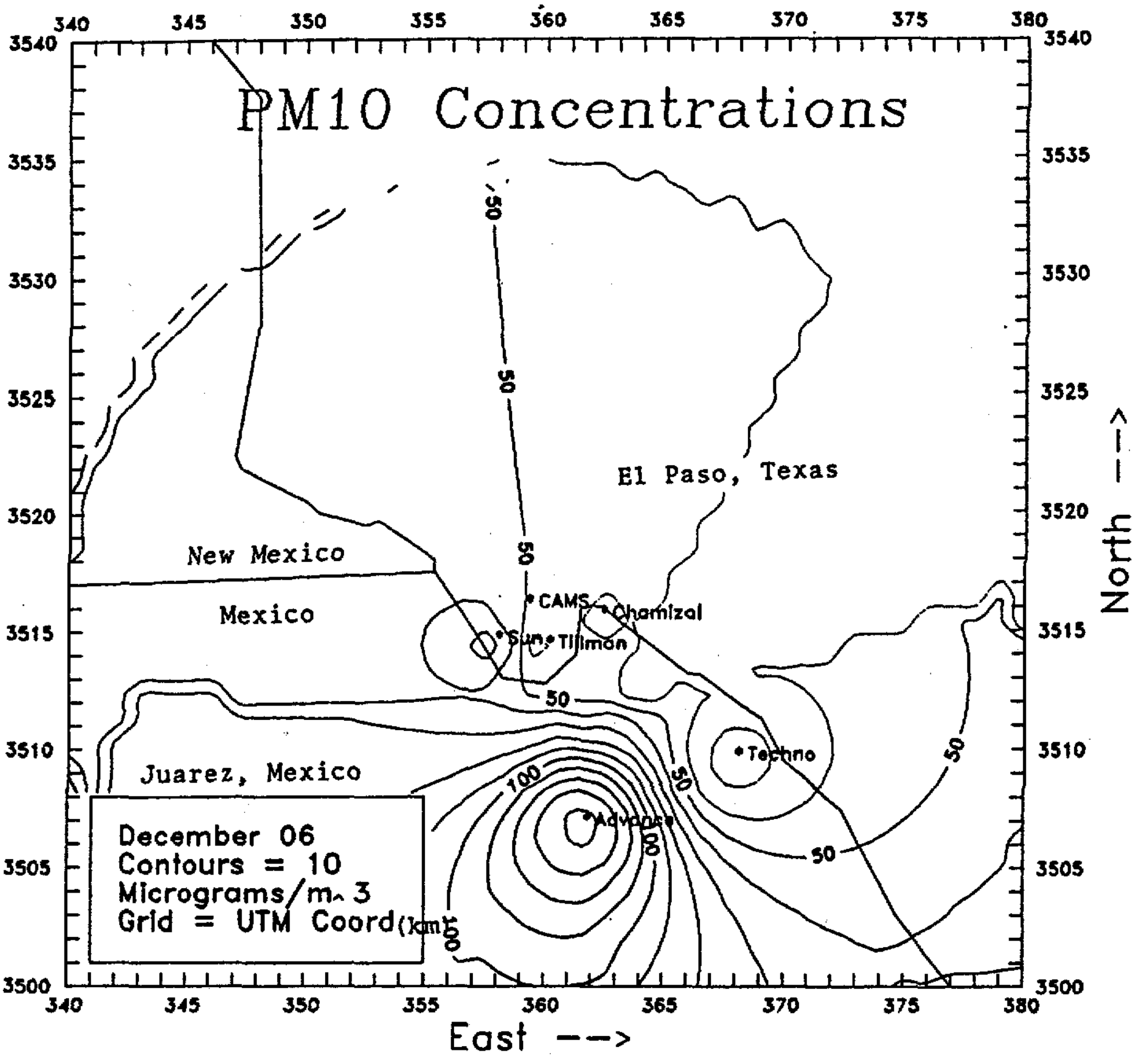
FIGURE I-4



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 5, 1990

The circular isopleth pattern located at the periphery of the *monitored area is caused by an extrapolation anomaly* generated by Surfer's 20-km "search radius."

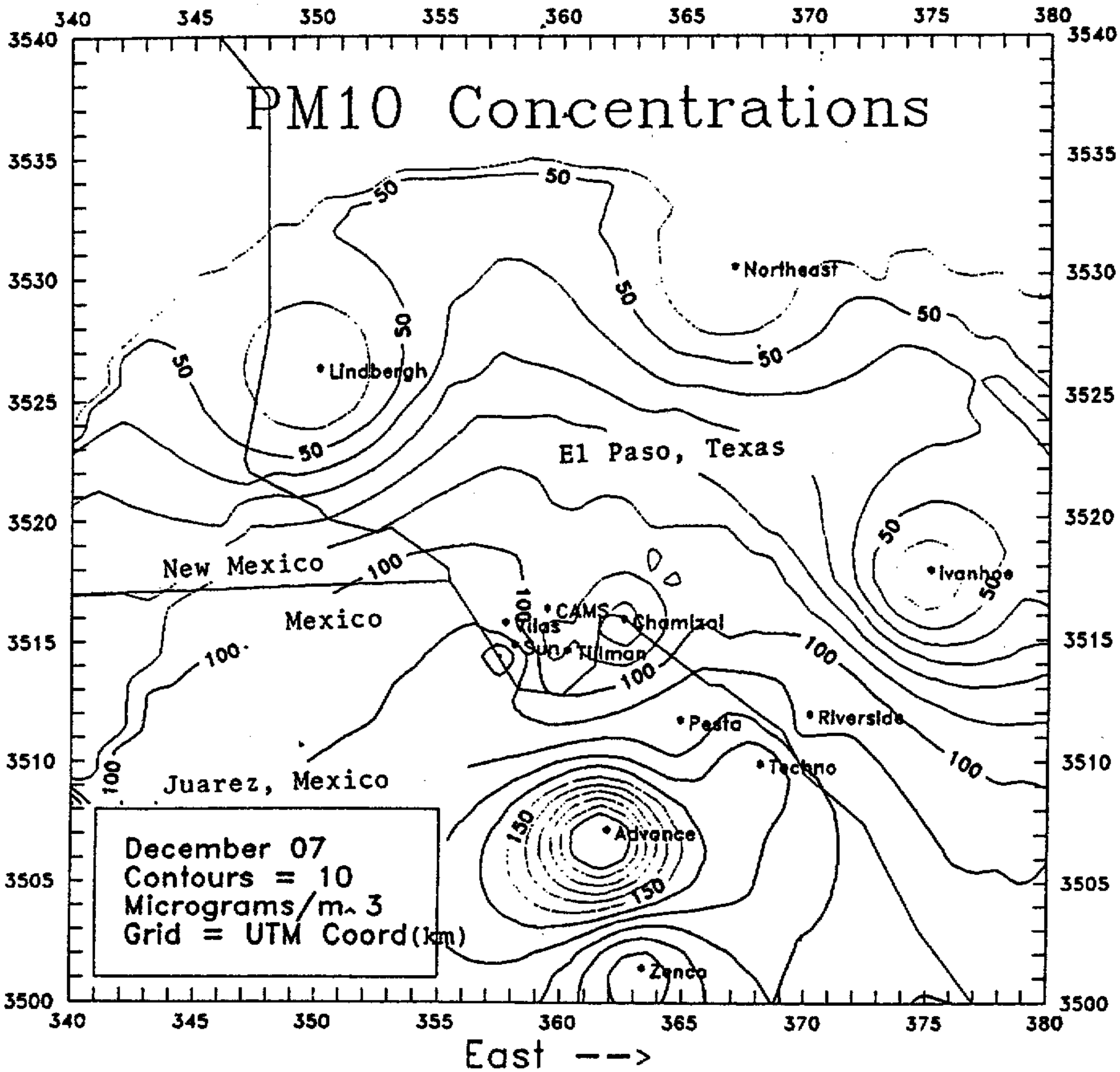
FIGURE I-5



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 6, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

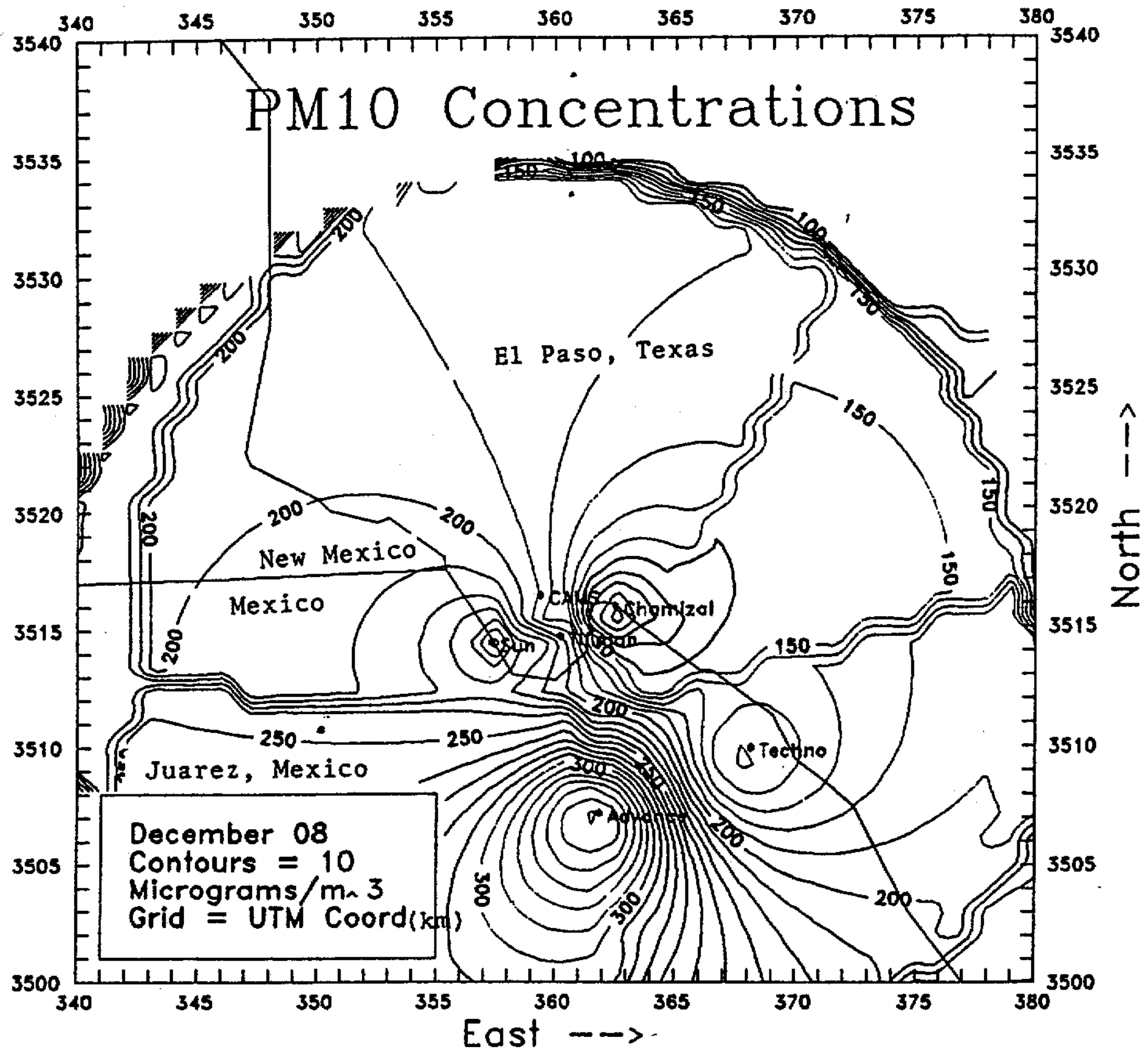
FIGURE I-6



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 7, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

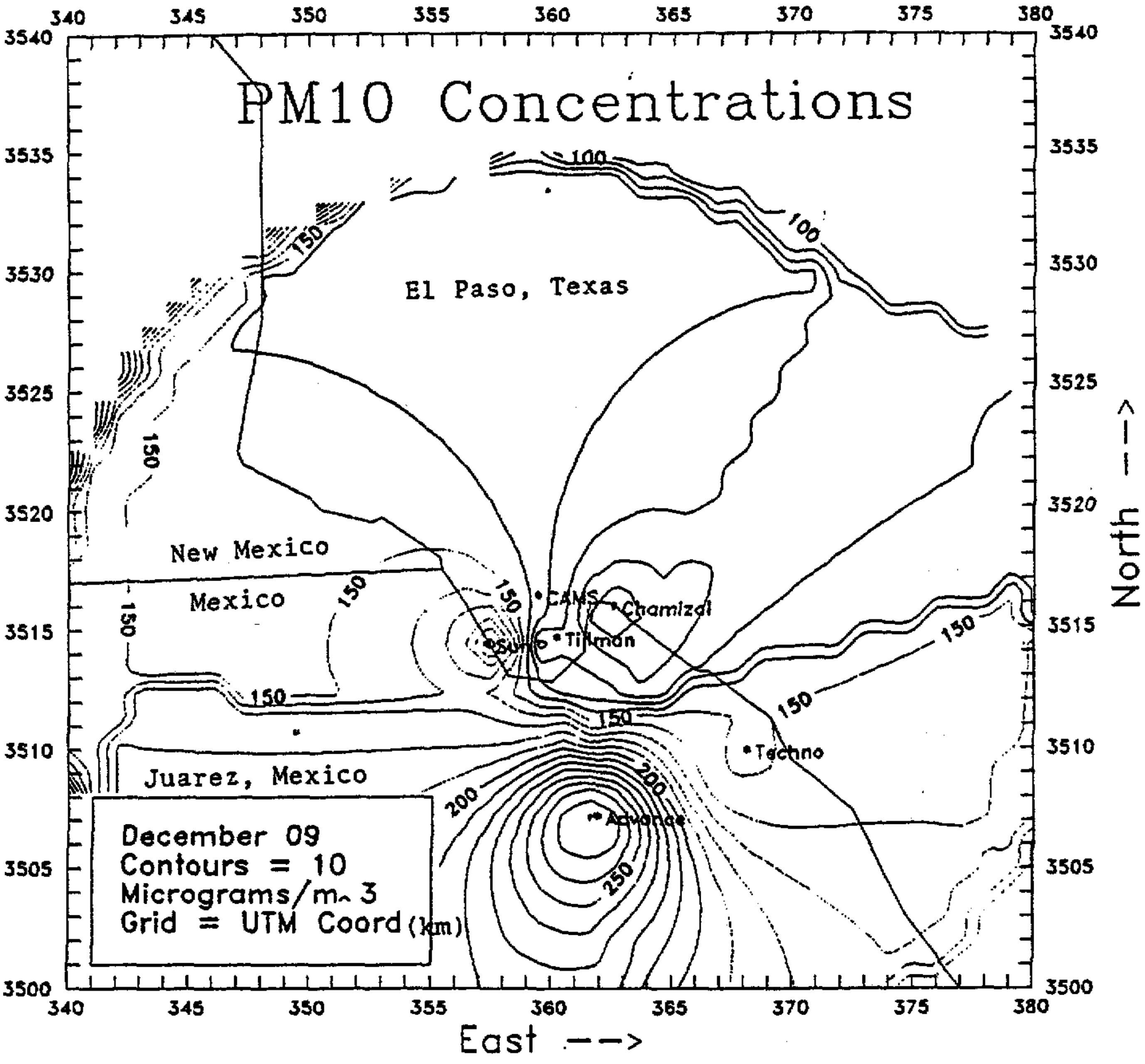
FIGURE I-7



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 8, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

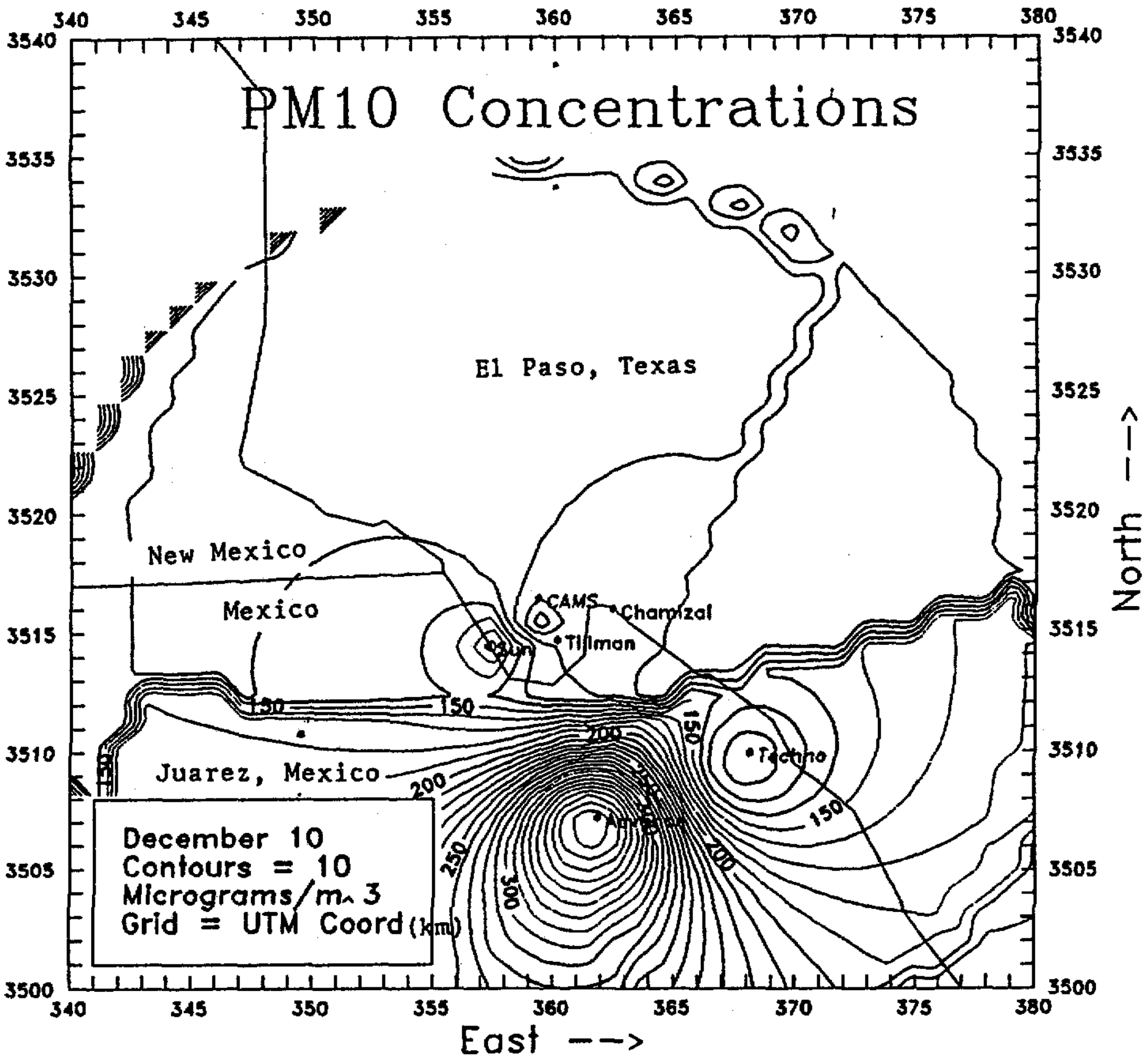
FIGURE I-8



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 9, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

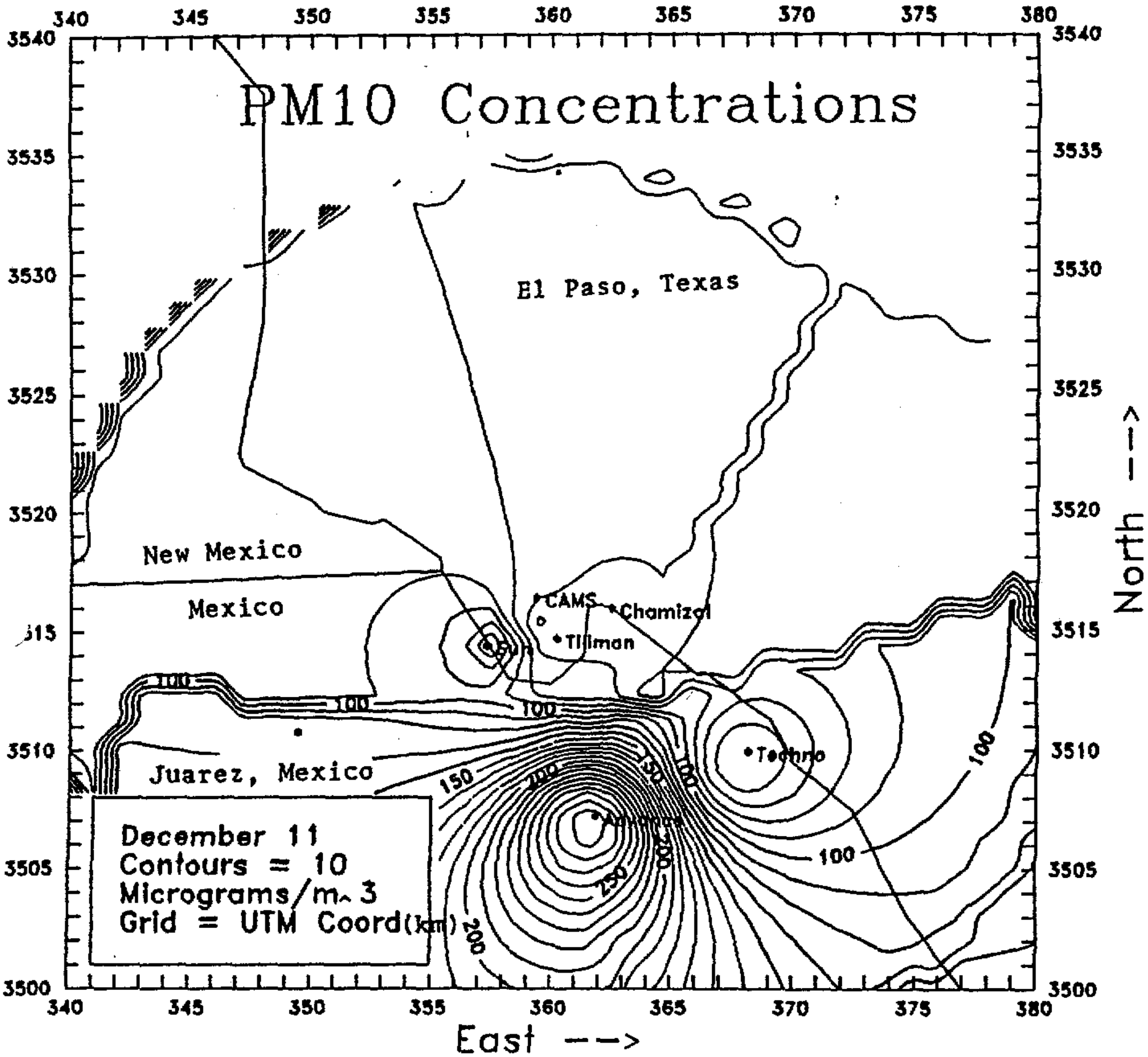
FIGURE I-9



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 10, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

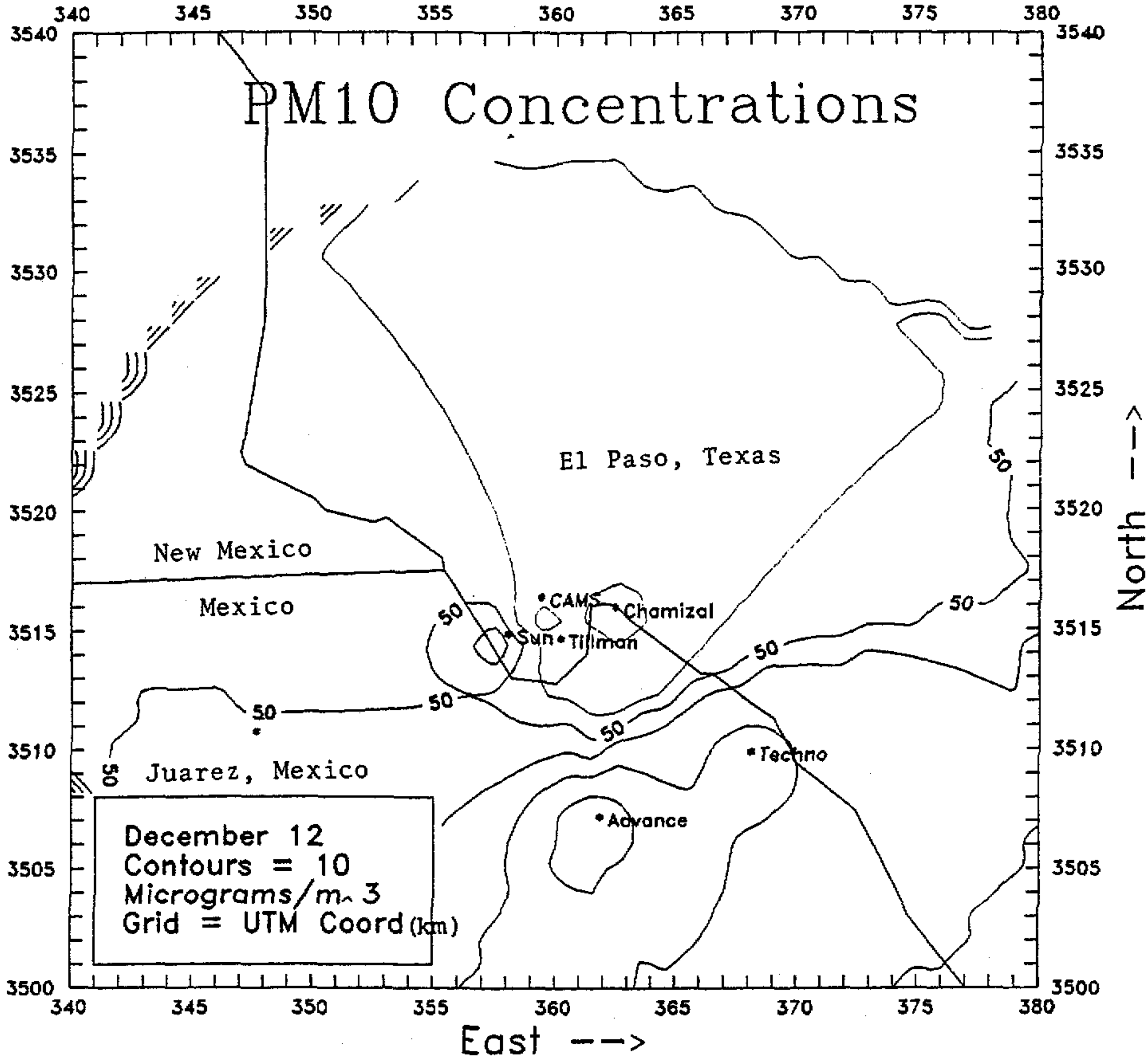
FIGURE I-10



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 11, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

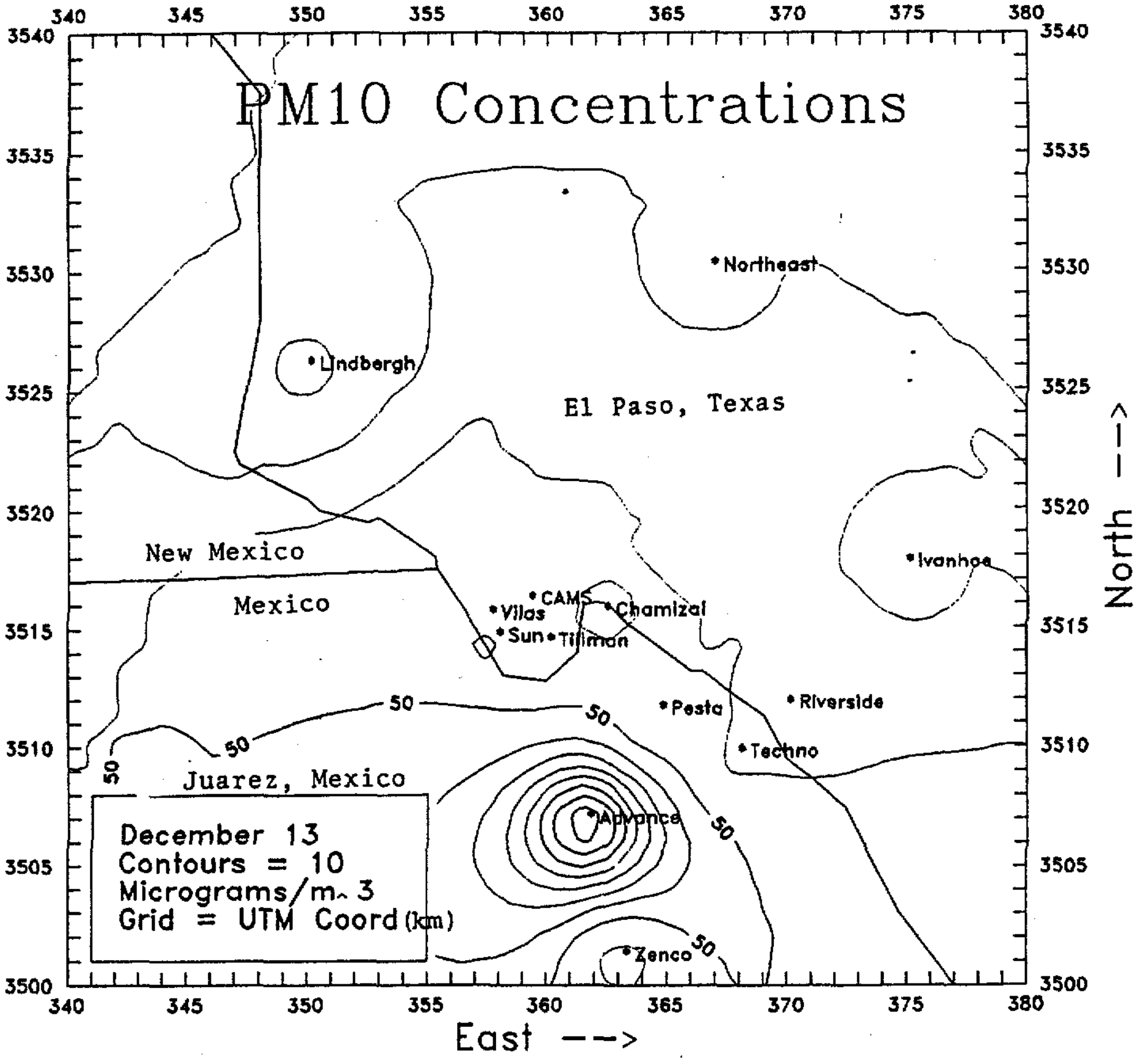
FIGURE I-11



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 12, 1990

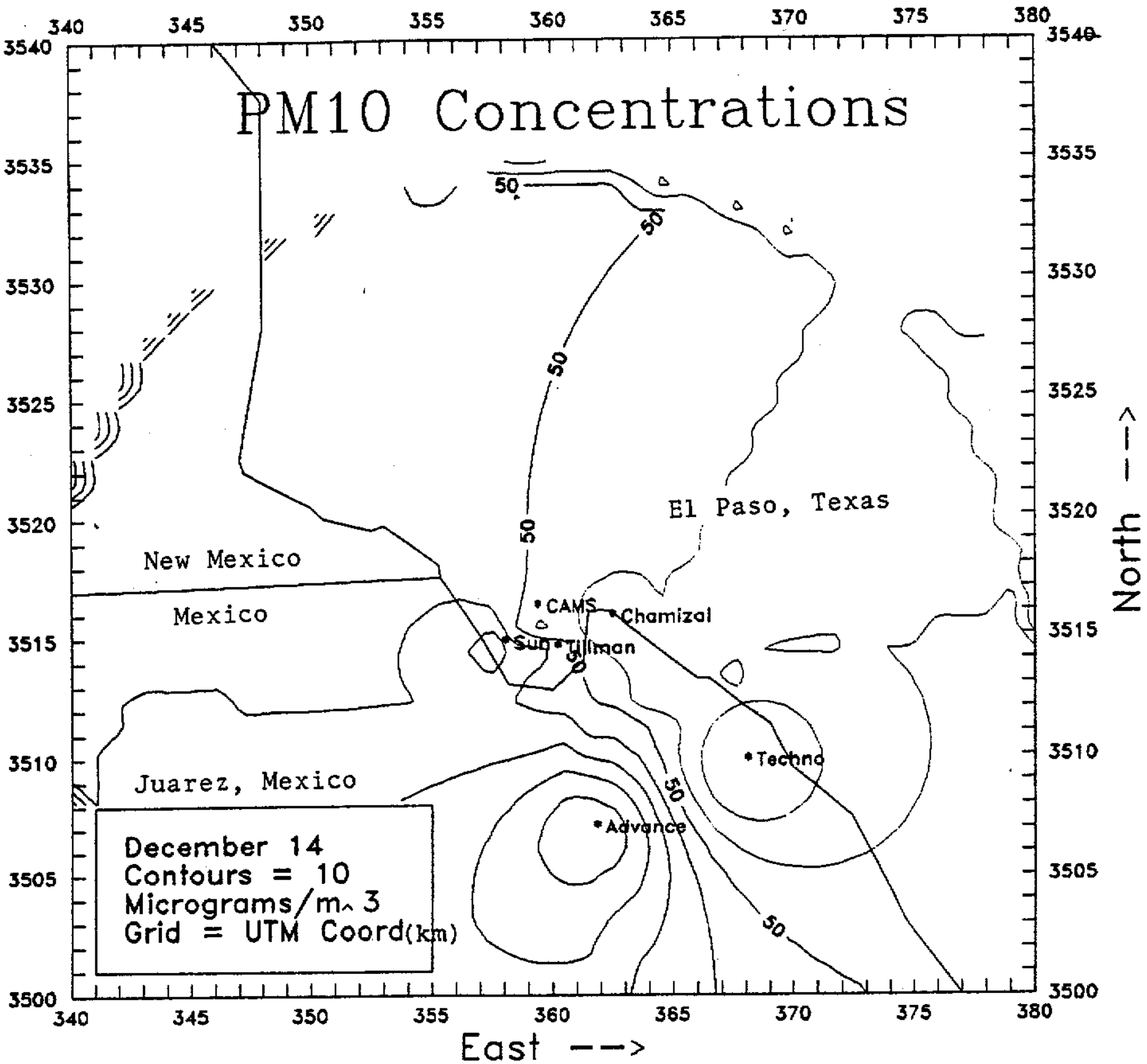
The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

FIGURE I-12



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 13, 1990

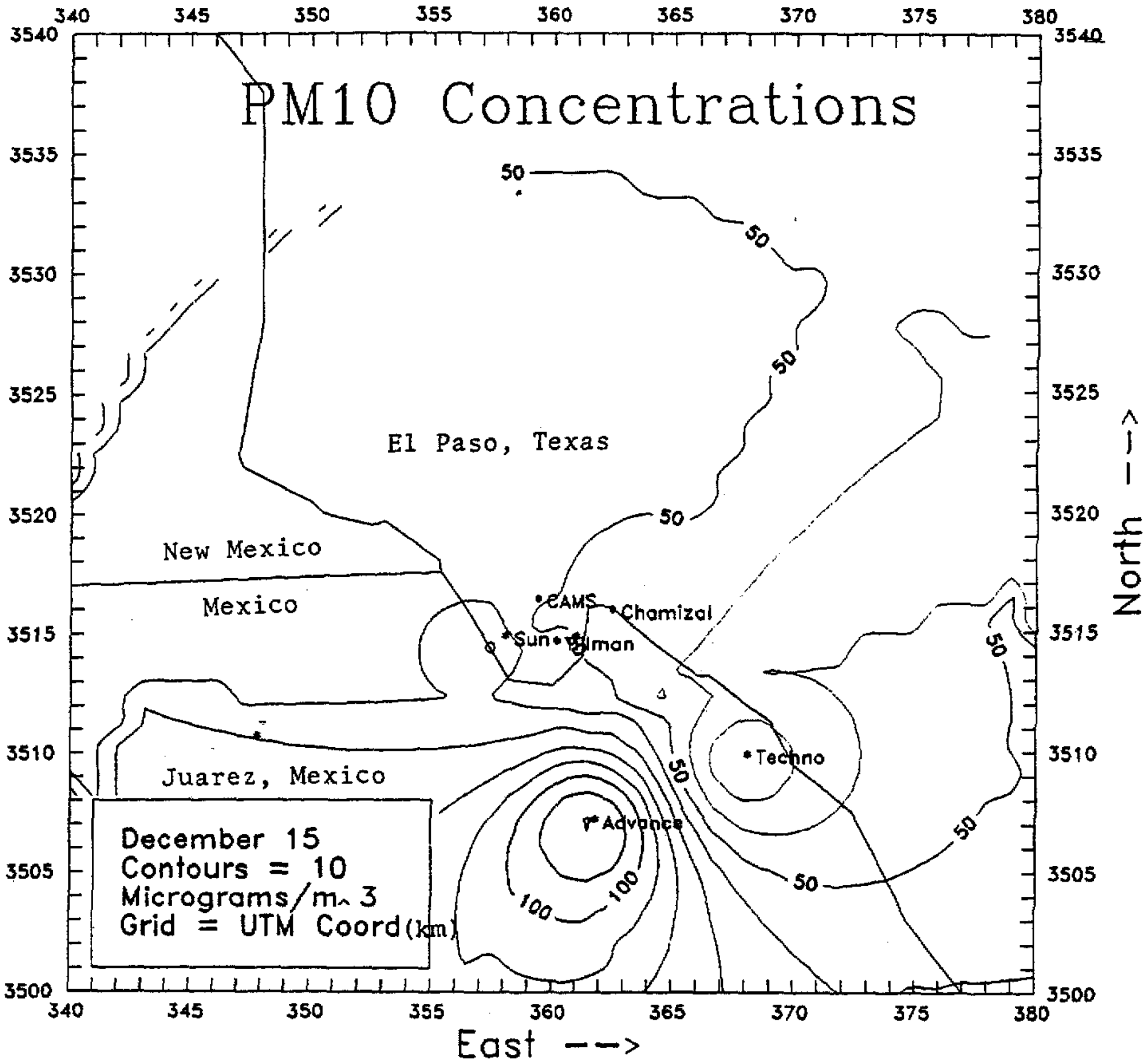
FIGURE I-13



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 14, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

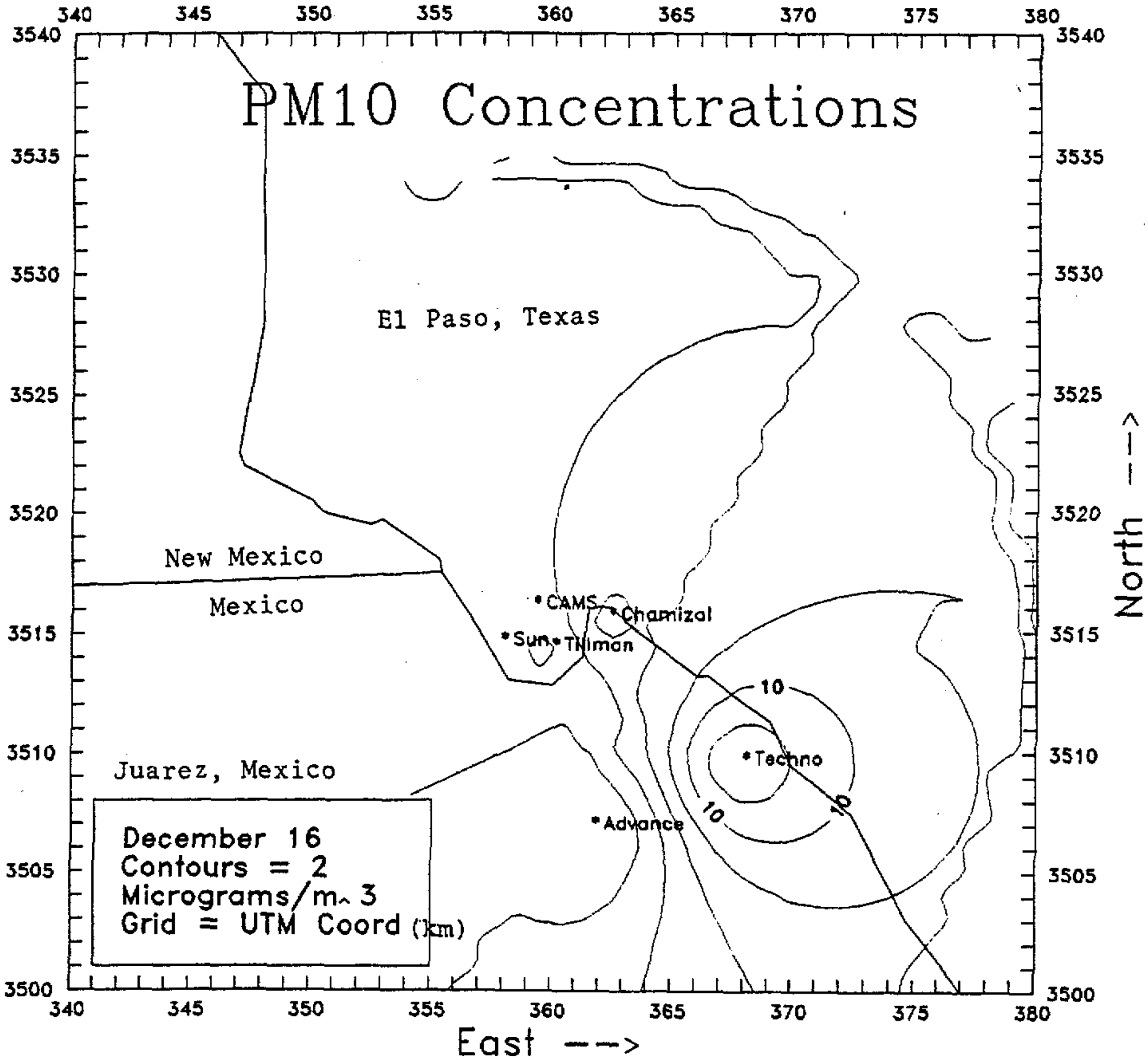
FIGURE I-14



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 15, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

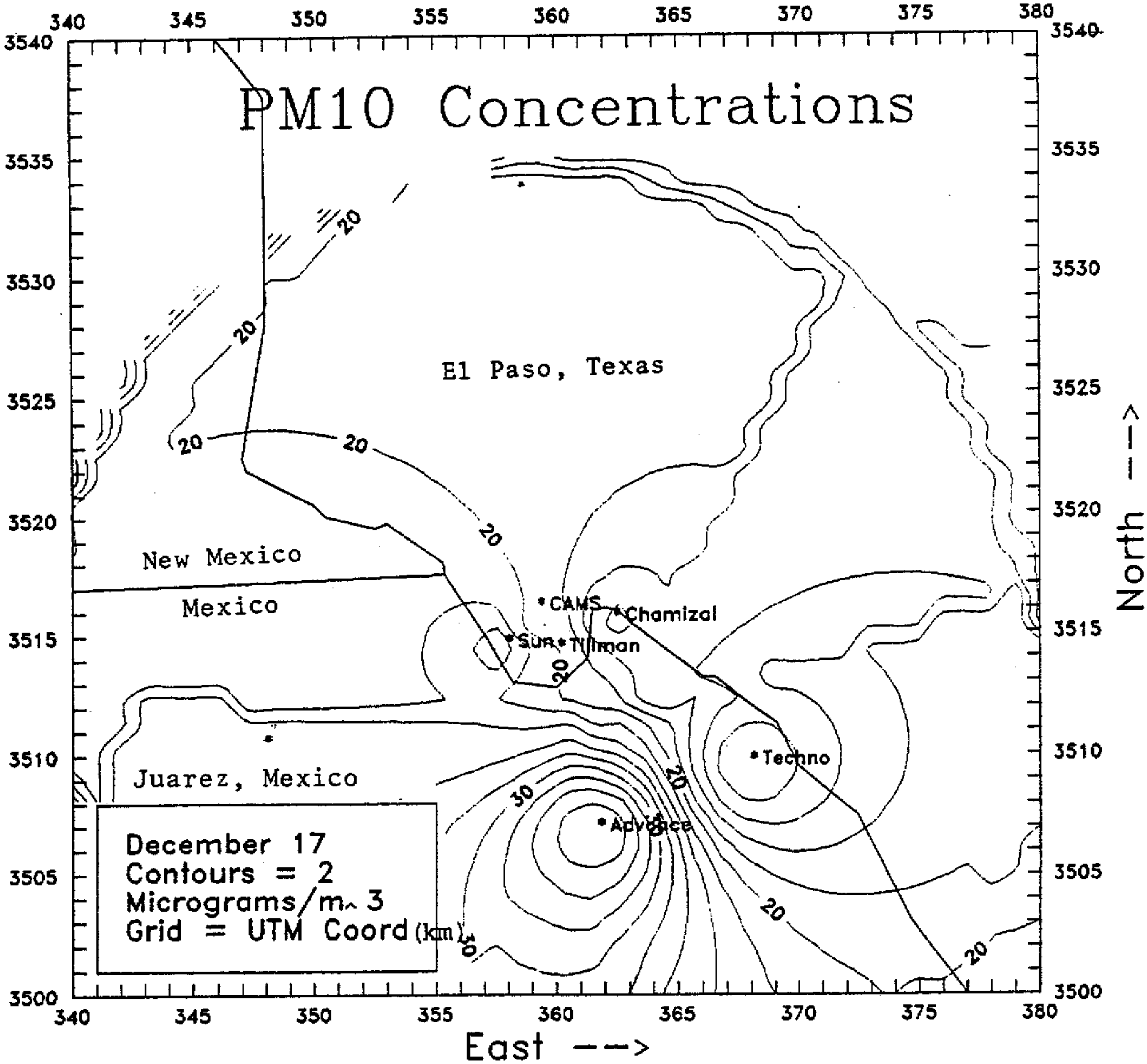
FIGURE I-15



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 16, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

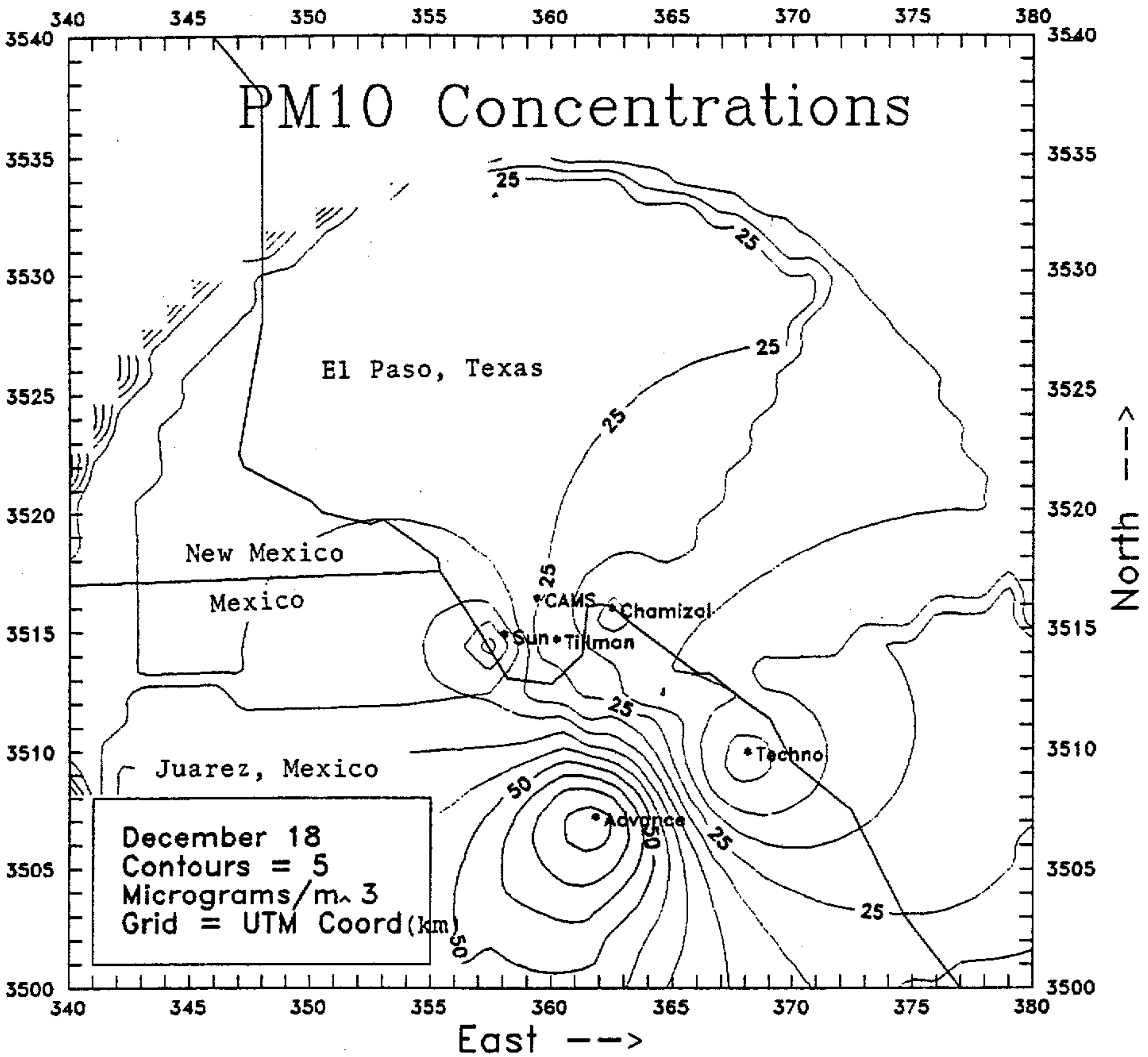
FIGURE I-16



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 17, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

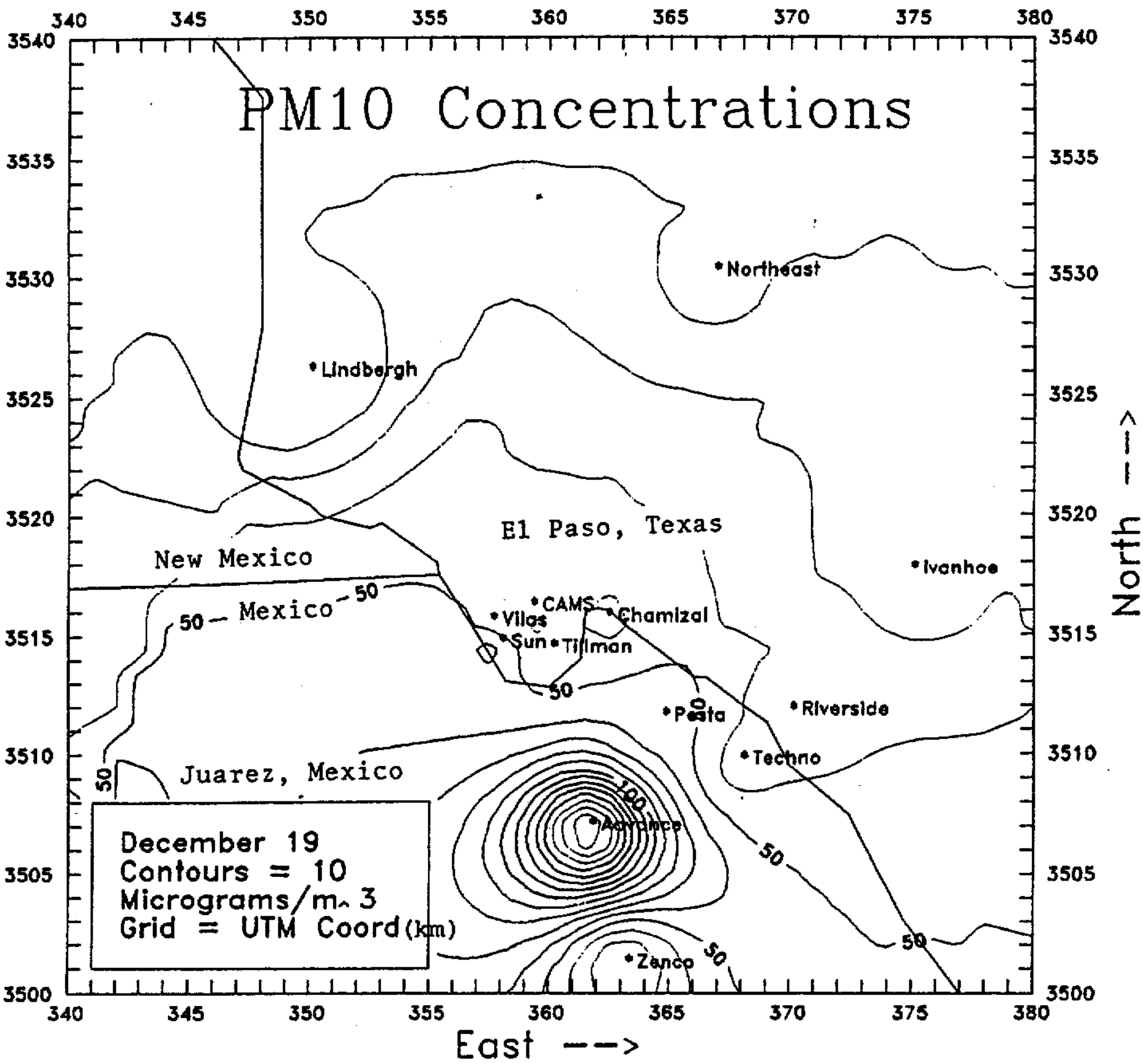
FIGURE I-17



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 18, 1990

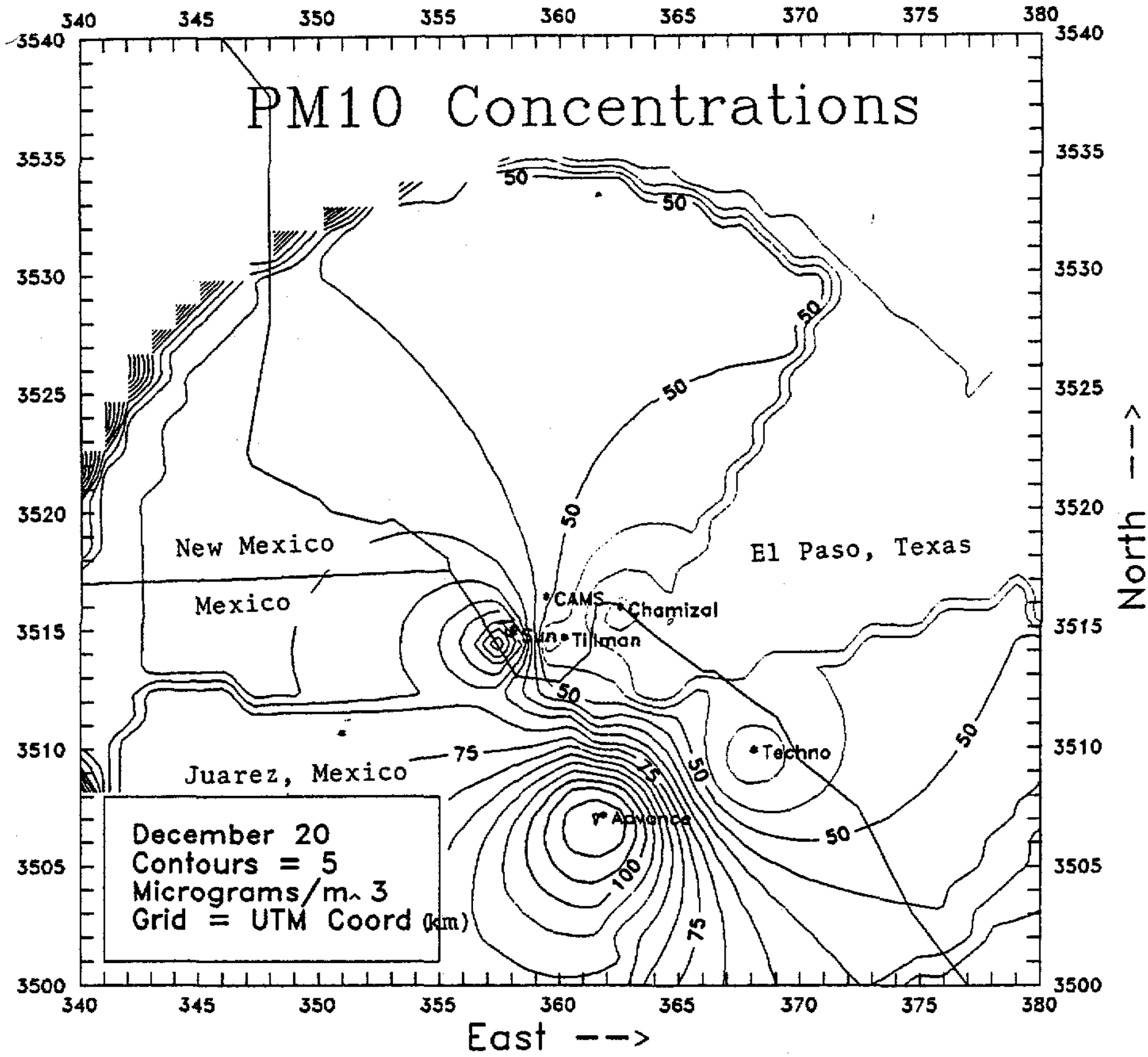
The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius:"

FIGURE I-18



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 19, 1990

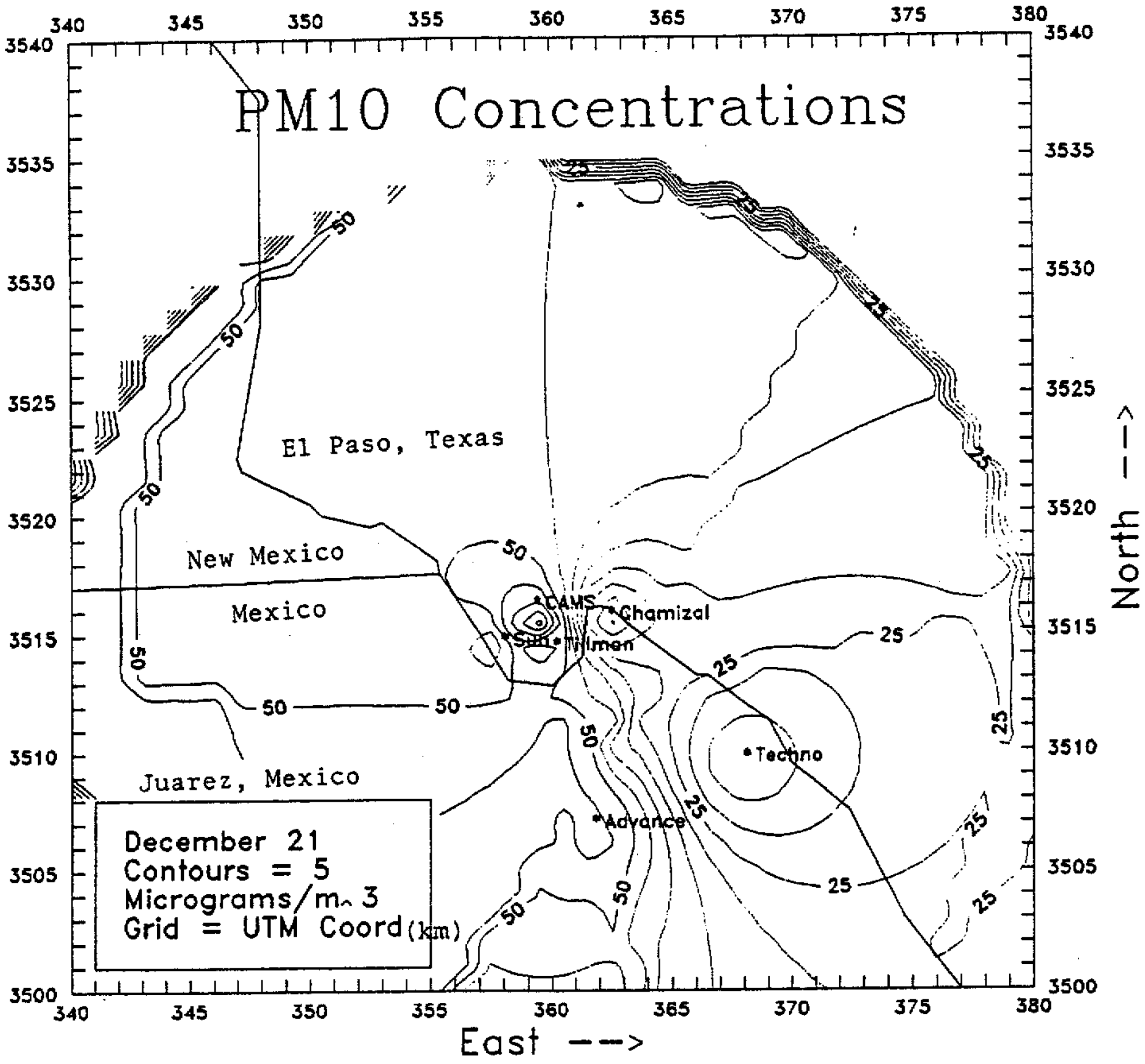
FIGURE I-19



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 20, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

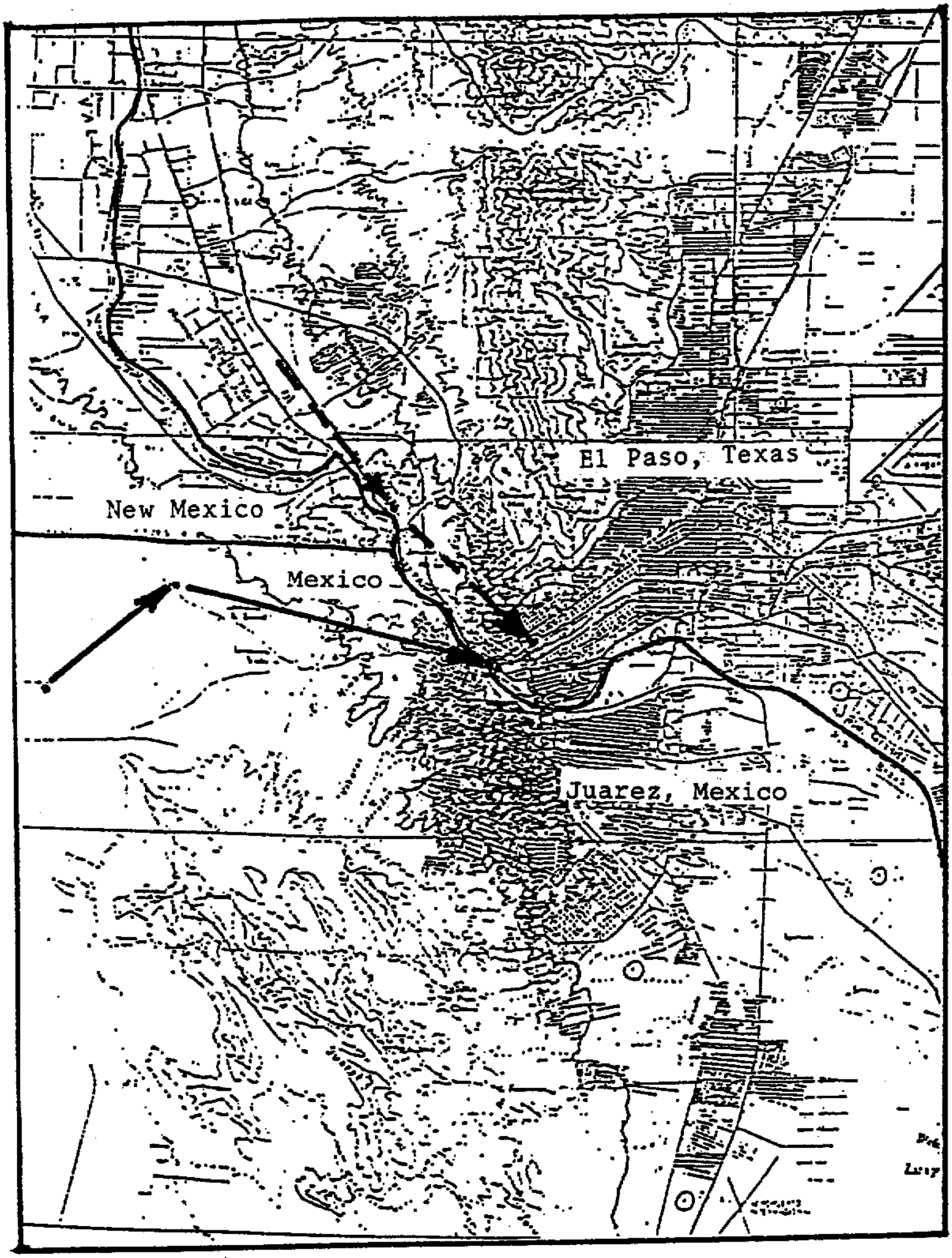
FIGURE I-20



El Paso/Juarez 24-Hour PM_{10} Concentrations
December 21, 1990

The circular isopleth pattern located at the periphery of the monitored area is caused by an extrapolation anomaly generated by Surfer's 20-km "search radius."

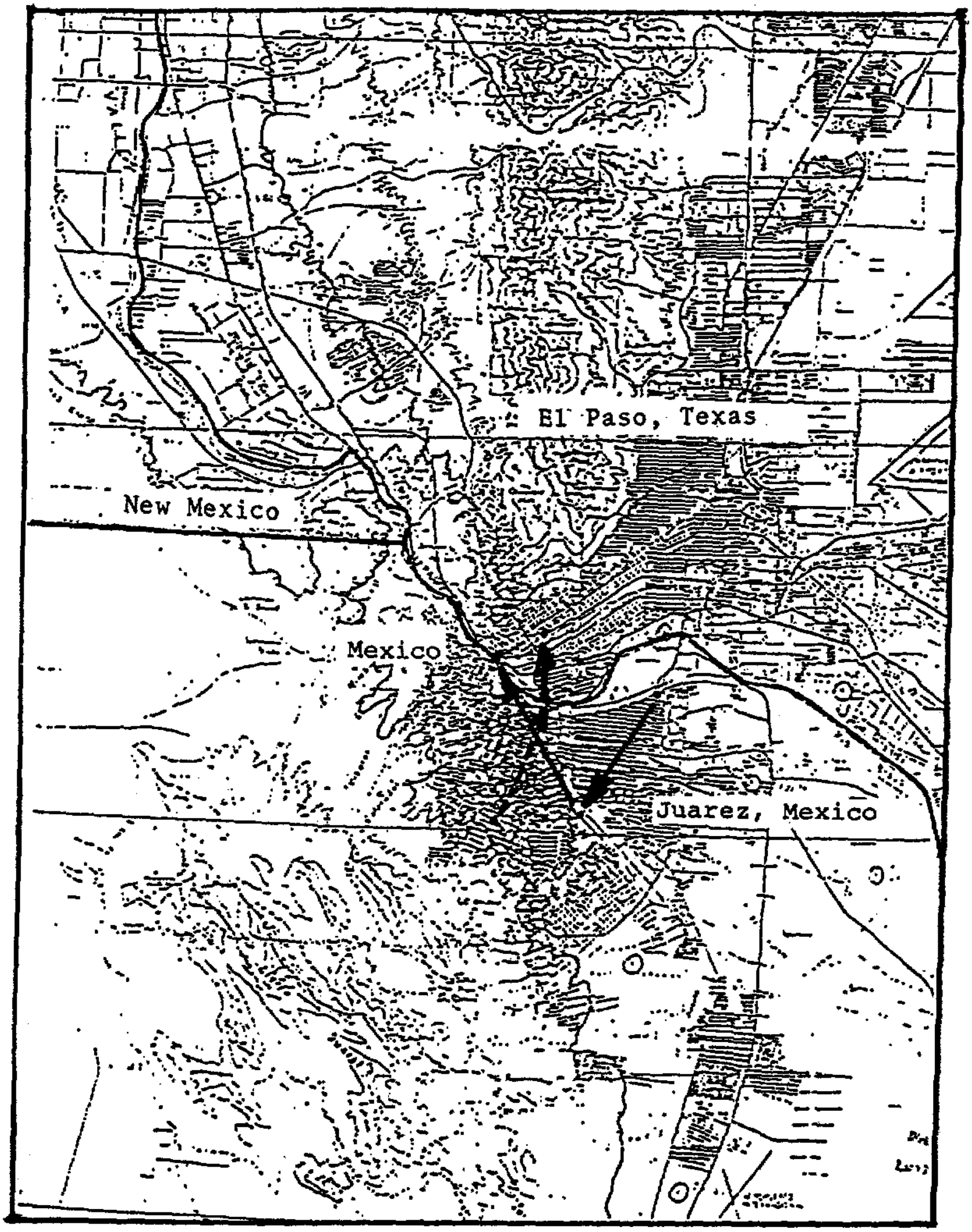
FIGURE I-21



Two-Hour Trajectory for Period Ending at Hour 0500 MST
on December 8, 1990

CAMS 6 -----
SUN METRO ______

FIGURE I-22

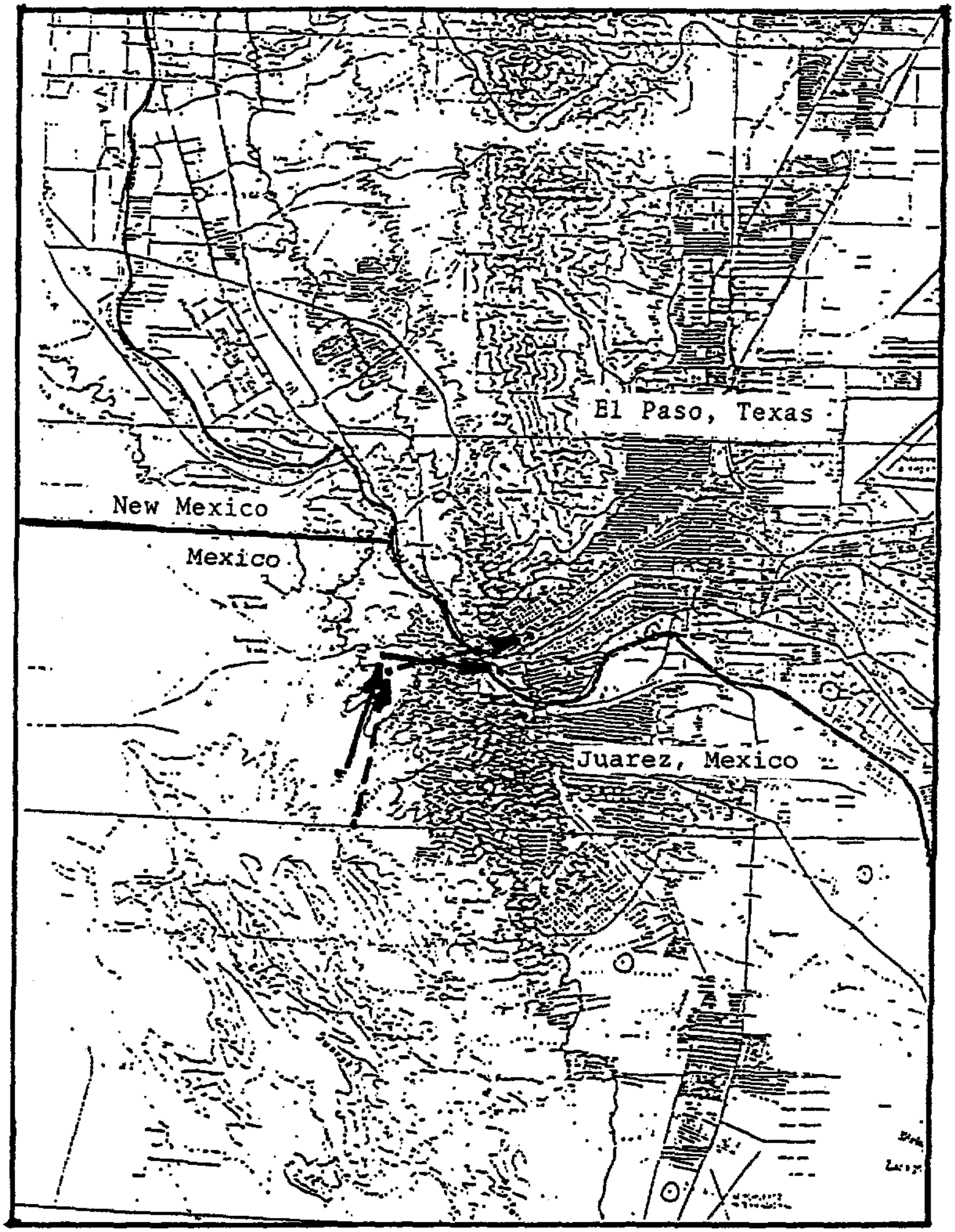


Two-Hour Trajectory for Period Ending at Hour 1100 MST
on December 9, 1990

CAMS 6 -----

SUN METRO ______

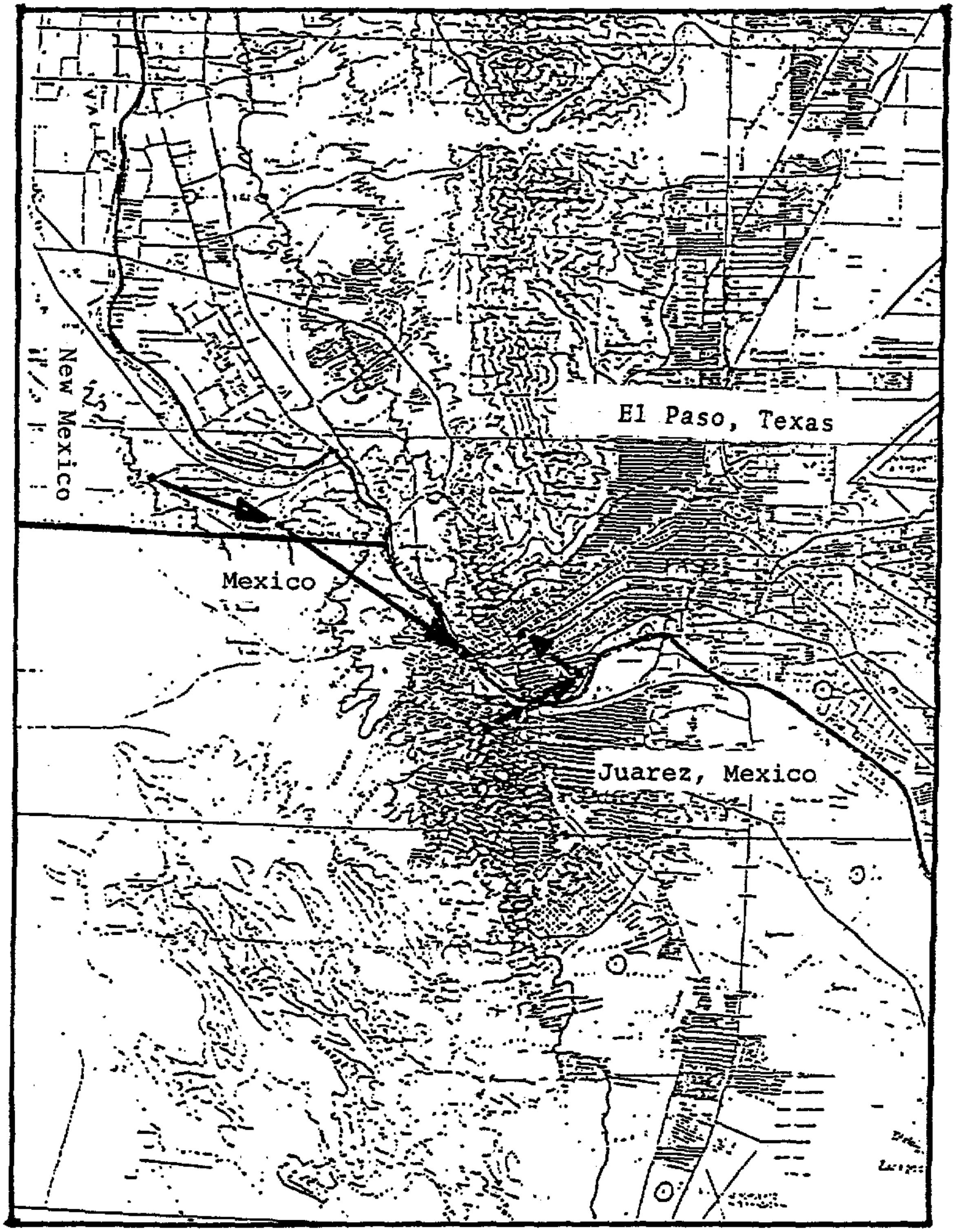
FIGURE I-23



Two-Hour Trajectory for Period Ending at Hour 1700 MST
on December 8, 1990

CAMS 6 -----
SUN METRO ______

FIGURE I-24



Two-Hour Trajectory for Period Ending at Hour 2300 MST
on December 8, 1990

CAMS 6 -----

SUN METRO ______