

effects of relative humidity on light scattering and the relative effects of fine and coarse particles on light scattering and light absorption. To help separate the effects from different sources, a source characterization program (sampling and chemical analysis of emissions) was conducted for several source types (section 4.4).

Unfortunately, the study design was constrained by the inability of the United States and Mexico to agree on the design for a joint U.S.- Mexico study. This resulted in a study design that included monitoring and source characterization only in the United States. Earlier versions of the proposed study plan included substantial aerosol and source monitoring and tracer release in Mexico. The final plan includes additional monitoring and tracer release along the U.S.- Mexico border to partly alleviate the limitations imposed from conducting a U.S. only study.

3 Tracer Release

3.1 Tracer Study Objectives

The objectives of the tracer study are to:

- 1) Tag (track emissions transport from) large individual sources with the potential for significant visibility impairment at Big Bend National Park
- 2) Tag source areas with the potential for significant visibility impairment at Big Bend National Park
- 3) Evaluate and improve performance of air quality models used for BRAVO.

For objective 1, tagging large individual point sources can be used in direct attribution analysis methods, such as TAGIT (Kuhns, et. al. 1998), which looks for gradients in particulate sulfur between source affected areas and areas outside the influence of emissions from the tagged source. The tracer can also be used to determine periods when the tagged source did not affect Big Bend National Park.

In objective 2, the tracer is used to give the general transport pattern and dispersion for emissions from a given source area. Because tracer is released from a point within an area of multiple sources, direct source attribution is not possible. The results are a qualitative demonstration of transport from the source region as well as information useful for objective 3. It identifies periods in which a source area is likely contributing to visibility impairment, but does not give a direct estimate of the impairment attributable to the source area.

Meeting objective 3 is useful for modeling the effects of tagged and non-tagged sources alike. This includes obtaining transport and dispersion, against which model results can be evaluated. Ideally, transport time would also be given. Model performance may be improved by adjusting dispersion parameters, etc. within a reasonable range that provides for improved model performance. As discussed in the following section, the tracer study is subject to constraints that affect the study design.

3.2 Tracer Study Constraints

The most significant constraint is that tracer release and sampling will not occur in Mexico. The conceptual study plan proposed tracer releases from the Carbon power plants in Mexico, about 20 km south of Eagle Pass, Texas. Also proposed was a tracer release from Tula-Vito-Asasco, a large Mexican area source for SO₂. The tracer study design described here reflects an attempt to mitigate the effects of this constraint.

Another political constraint on the tracer release study is that even though Mexico is not a participant in the study, the U.S. government desires a balanced study that is fair to Mexico. Thus the tracer study must be designed in a manner that does not unduly focus on Mexican sources while neglecting the effects of U.S. sources.

A physicochemical constraint is the availability of only four different perfluorocarbon tracers. This limits to four the number of sources or source areas that can be concurrently tagged.

3.3 Tracer Study Design

Emissions of SO₂ from the Carbon I and Carbon II powerplants are estimated to be on the order of 240,000 tons per year. The powerplants are located 1 km apart at a distance of 270 km east-southeast of Big Bend National Park. Because of the size of these plants and the closeness of the plants to Big Bend, relative to other large emission sources, tracking the emissions from these plants is the highest priority. Based upon dispersion estimates and reasonable SO₂ to sulfate conversion rates, there is a potential for the Carbon powerplants to, by themselves, cause a perceptible decrease in visibility at Big Bend. Other sources of substantial emissions of SO₂ and other compounds which may lead to visibility impairment are located in eastern Texas. These include many powerplants along the lignite belt, along with the cities of Houston, Dallas-Fort Worth and San Antonio. The Houston area contains numerous industrial sources and the nearby Parish powerplant. The San Antonio area is near powerplants in the southern lignite belt.

The most frequent wind flow patterns are from the southeast, which would take emissions from Mexican sources such as Tula-Vito-Asasco and Monterrey toward Big Bend National Park. However, as noted in the previous section, tracer releases cannot be done from these areas. Less frequently, but not uncommonly, transport from the Carbon powerplants is expected to be transported to Big Bend. Sources in east Texas are transported still less frequently toward Big Bend National Park. Transport from east Texas is rare in July and August, but increases in frequency in September and October. As a result of these emission and transport patterns and the constraints described earlier, the tracer study is designed to track emissions from the Carbon powerplants and sources in eastern Texas (more information on flow is given in section 2).

Because of the inability to gain access to the Carbon stacks, tracer will be released from Eagle Pass, Texas, approximately 20 km north-east of the Carbon plants. An

elevated (tower) release will be done at Eagle Pass to better simulate stack releases than would be possible with a near ground-level release. Tracer releases will also be done from a location in northeastern Texas to represent emission sources in that area, particularly from powerplants in the northern lignite area, the Houston area to represent urban and industrial emissions from east-central Texas, and San Antonio to represent powerplants and urban sources in the southern lignite area. The release in northeastern Texas will be from a powerplant stack to represent transport and dispersion of elevated releases that would be applicable to multiple plants in the area. Because flow from eastern Texas is uncommon in the first two months of the study (July and August), tracer releases from multiple Texas locations during these months is not the best use of resources. Providing information about the adequacy of the Eagle Pass tracer release to represent emissions from the Carbon plants is a more effective use of resources. Concern over the Eagle Pass releases arises from the facts that there is a horizontal separation of 20 km between Eagle Pass and Carbon I/II and a vertical separation of varying amount between any release location and the effective stack heights from Carbon I/II. The vertical separation is of concern especially at nighttime and early morning hours when the atmosphere is stable and significant vertical wind shear may occur. Radiosonde data from Del Rio indicates substantial vertical wind shear during the morning sounding (Figure 3-1).

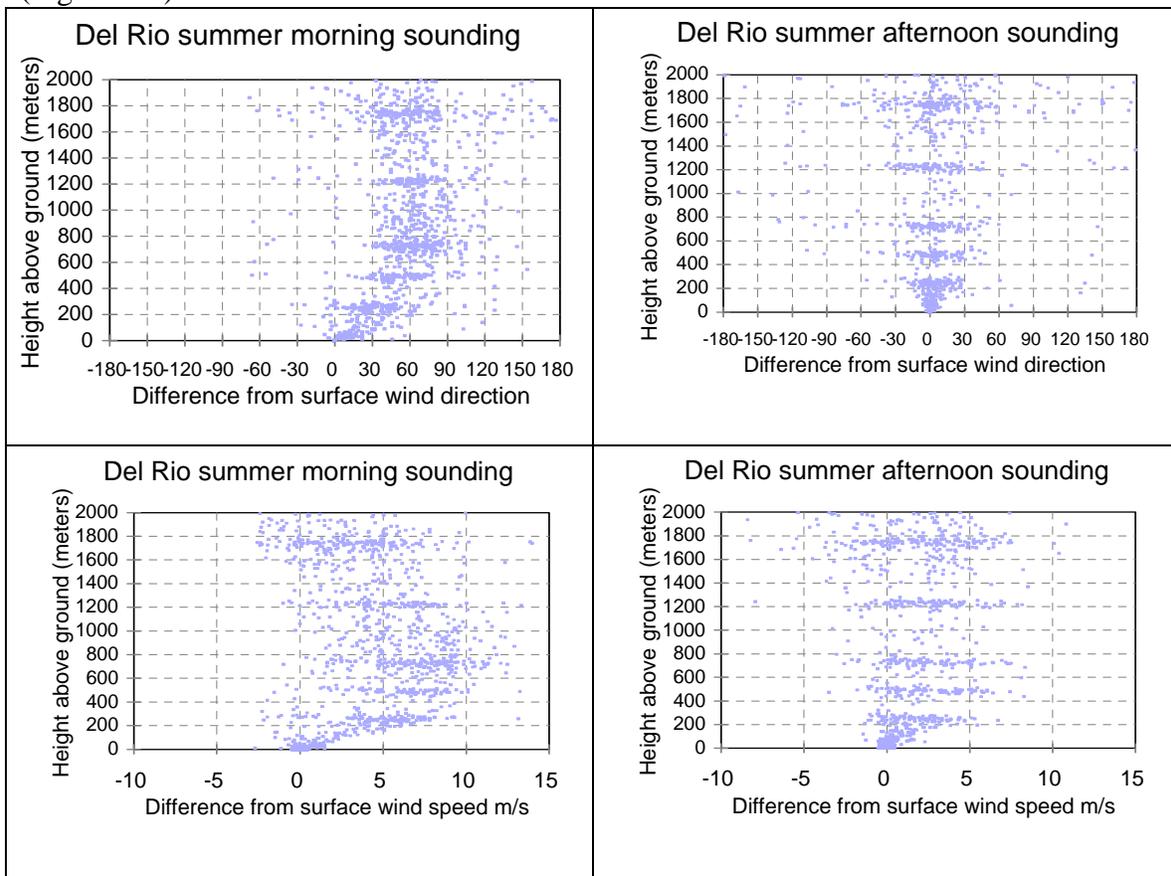


Figure 3-1. Differences from surface wind speed and direction as a function of height. Plot is for Del Rio, Texas radiosonde data, July to September 1992. Morning sounding taken at 6am CST. Afternoon sounding at 6 pm CST. Positive wind direction differences represent a clockwise direction of wind shear with height.

Composite virtual potential temperature soundings shown in Figure 3-2 illustrate the stable conditions in the morning and well-mixed conditions in afternoon.

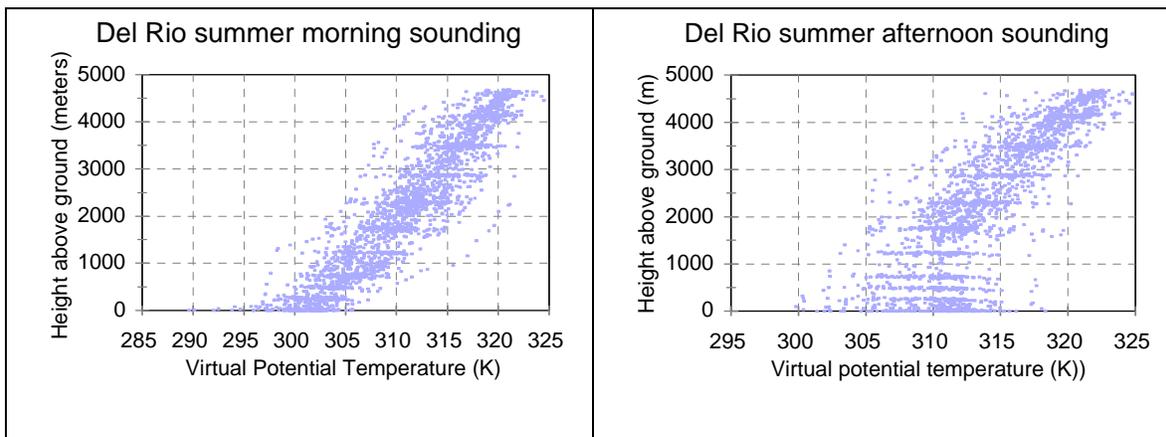


Figure 3-2. Virtual potential temperature as a function of height July-September 1992 for morning and afternoon soundings. Vertical line would indicate well-mixed conditions. A strong inversion is apparent throughout the soundings in the morning. For the afternoon, conditions are generally well-mixed through about 2 km AGL.

It might be expected that for tracer releases during periods of well-mixed atmospheric conditions Eagle Pass is a suitable surrogate for Carbon I/II emissions. Well-mixed conditions are likely to occur during daytime from about 1-2 hours after sunrise until approximately sunset. The tracer release program calls for continuous release of one tracer compound plus a separate tracer to be released during the daytime so that the concentrations measured at receptors can be designated as resulting from daytime, nighttime, or a known mixture of daytime and nighttime releases. A third tracer will be released on alternate days to provide information on which day the tracers were released and to help resolve ambiguities over the release time of the tracer. If the Eagle Pass releases are representing transport from Carbon I/II there should be significant relationships between SO_2 and tracer concentrations. Two months of release using 3 tracers should be sufficient to understand the conditions during which tracer releases at Eagle Pass are representative of emissions from the Carbon plants.

During the second two months of the study, only one tracer will be released at Eagle Pass. The two tracers previously used for timing will be moved to Houston and San Antonio. The September-October period is the time of year with most frequent transport from these source areas toward Big Bend National Park.

The four perfluorocarbon tracers used were oPDCH, PDCB, PTCH, and i-PPCH. Criteria for selection of the tracer compounds included background concentration, cost, and ability to separate the compounds during chromatographic analysis. Release rates were determined using estimated dispersion factors from the release locations to Big Bend (extrapolated from Project MOHAVE tracer data), and estimated precision for the new chromatographic system developed for BRAVO. Concentration uncertainty for 6 hour and 24 hour samples was estimated to be in all cases less than 10% of maximum concentration expected at Big Bend. Sample volume will be the same for the 6 and the

24 hour samples because the 6 hour sampler pumps 4 at times the rate as the 24-hour sampler. Concentration uncertainty for the 1-hour samples at Big Bend will be higher due to the lower sample volume. The sampling network is described in section 4.

Release rates for the first period of the study are shown in the Table 1. oPDCH and i-PPCH were released continuously. PDCB was released on alternate days from 8am to 8am CDT. PTCH was released every day but only from 8am to 8pm CDT.

Table 1. Tracer release schedule first phase of study.

Location	Eagle Pass	Eagle Pass	Eagle Pass	Big Brown
Tracer	OPDCH	PDCB	PTCH	i-PPCH
Release period	7/5/99-11/1/99	7/5/99-9/13/99	7/5/99-9/13/99	7/9/99-11/1/99
Release Rate (kg/hr)	0.155	0.525 alternate days (8am-8am) CDT	0.184 8am – 8pm CDT only	0.092

Release rates for the second period of the study are shown in Table 2. There was a hiatus of 4 days (8am to 8am) from terminating PDCB and PTCH at Eagle Pass and initiating release at San Antonio and Houston to allow these tracers to clear the study area. oPDCH at Eagle Pass and i-PPCH at Big Brown continued to be released during this interim period. In early September, PDCB and PTCH releases from Eagle Pass were terminated. Release at San Antonio and Houston began 5 days later at 8am and terminated at 8am CDT (7am CST) on November 1 along with the releases from Eagle Pass and the Big Brown power plant. Note that all tracers were released continuously during the second half of the study.

Table 2. Tracer release schedule for the second half of the study.

Location	Eagle Pass	San Antonio	WA Parish	Big Brown
Tracer	OPDCH	PDCB	PTCH	i-PPCH
Release period	7/5/99-11/1/99	9/17/99-11/01/99	9/17/99-10/25/99	7/9/99-11/1/99
Release Rate (kg/hr)	0.155	0.442	0.115	0.092

This program provides balance with 3 tracers representing Mexican emissions and 1 representing American emissions during the first half of the study when flow is more frequently from the south and 3 tracers representing American emissions and 1 representing Mexican emissions during the second half of the study when flow from the east is more likely.

Locations of tracer release and sampling sites are shown in the next section.