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Project Summary

Green River Air Quality Model Development: Meteorological Data—August 1980 Field Study in the Piceance Creek Basin Oil Shale Resources Area

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Special meteorological and air quality studies were conducted during August 1980 in the Piceance Creek Basin oil shale resource area of northwestern Colorado as part of the U.S. Environmental Protection Agency (EPA)-sponsored Green River Ambient Model Assessment program. The objective of the limited field study was to collect initial data for developing, calibrating, and validating a mesoscale air quality model. The specific goals of the study were to investigate the growth and characteristics of convective boundary layers that form over the area during the daytime; to characterize background pollutant levels, visibility, and atmospheric structure over the area; and to investigate, by means of tracer experiments, the dispersion and dry deposition of *pollutants released in nocturnal valley* drainage flows.

A DC-3 aircraft was equipped with air pollution and meteorological instruments; air quality and visibility data were collected during flights over the test area. A balloon-borne upper *air sounding* system was used to monitor temporal changes in the convective boundary layer structure. Dual tracer experiments were conducted on four occasions in the shallow Corral Gulch near the federal *oil shale lease tract C-a using nonde*positing SF_6 gas and depositing lithium-traced particles collected on two to five sampling arcs during well-defined drainage flow events. The processed data, collected during the two-week field study is summarized and presented. Analysis and interpretation of these data will be presented in future reports as part of the Green River Air Quality model development program.

This Project Summary was developed by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A special meteorological and air quality measurement study was conducted in the complex terrain of the Piceance Basin of northwestern Colorado to aid in the design, calibration, and validation of a mesoscale air quality model that is being developed under the U.S. Environmental Protection Agency (EPA)-sponsored Green River Ambient Model Assessment (GRAMA) program. The GRAMA program's overall objective is to develop dispersion models with

demonstrated applicability for evaluating air quality impact development of the Green River Oil Shale deposits in Wyoming, Utah, and Colorado. The specific goals of the two-week field study were:

- to investigate the growth and characteristics of convective boundary layers (CBLs) or mixing layers that form over the oil shale region during the daytime,
- to characterize background pollutant levels, atmospheric visibility, and atmospheric structure over the region, and
- to investigate, by means of a dual tracer experiment using a particulate and a gaseous tracer, the dispersion and deposition of pollutants released into well-developed, nocturnal valley drainage flows.

It was clearly recognized that a single two-week study would insufficiently characterize the meteorological phenomena investigated. It was expected, however, that the initial experimental design and results would lead to improved designs and refined physical hypotheses that could be tested further in future experiments.

The purpose of this report is to present the processed data obtained in the field study in a basic form that will be useful to other investigators. Also, the study will facilitate a scientific interchange of ideas that may lead to progress in understanding the meteorology and air quality of this complicated terrain region. Data analysis will be presented in future reports, as part of the Green River Air Quality model development program.

Field experiments were conducted jointly with other investigators who performed related work in the oil shale region during the same experimental period. By combining forces with other investigators, it was possible to reduce costs and, at the same time, obtain a larger data set for later analysis and use by all investigators. The field program described in this report was conducted cooperatively with investigators from the University of California Los Alamos National Laboratory, who, under U.S. Department of Energy and EPA sponsorship, investigated the transport and diffusion of SF_6 tracer material in the nocturnal drainage flows of Corral Gulch near the federal oil shale lease Tract C-a. Their work included upper air and tethered balloon profiles taken to characterize atmospheric conditions during the tracer experiments and the operation of an acoustic sounder and surface meteorological stations. The meteorological and tracer data collected in their investigations have been published in a separate report prepared by the researchers of the Los Alamos National Laboratory.

The Piceance Creek Basin of northwestern Colorado is one of several basins in Colorado, Utah, and Wyoming that are part of the Green River Oil Shale Formation. The Piceance Basin is a shallow basin that is inclined toward the north-northeast. The two major drainages in the basin, Piceance Creek and Yellow Creek, drain northward into the westward-flowing White River, a major tributary to the Green River and ultimately the Colorado River. The major topographical features of the region include the Cathedral Bluffs, the steep cliffs forming the western rim of the basin; the Roan Plateau, the name given to the flat-topped highlands on the south edge of the basin; and the Grand Hogback, a sharp ridge of resistant rock running from north to south forming the eastern boundary of the basin.

The CBL experiments were designed to allow frequent soundings through the entire depth of the CBL so that its height, temperature and wind structures could be determined as a function of time during the day. These data were collected primarily by balloon-borne sondes released from a point on the ground within the Piceance Basin. Soundings were released at approximately three-hour intervals from sunrise until late afternoon. Release times were coordinated, as much as possible, to allow comparison of Piceance Basin profiles with rawinsonde profiles over Grand Junction and with aircraft profiles over other parts of the Piceance Basin. The upper air data were obtained with a commercial balloon-borne sounding system using expendable sondes that were towed aloft by a 50-g helium-filled balloon. The time-multiplexed radio frequency data were received by a ground receiving station and decoded into time, pressure, temperature, and wet-bulb temperature information.

Upper air winds were obtained for the sounding ascents by merging the desired height data with data obtained with an optical theodolite. Further characteristics of the CBL were determined from aircraft soundings made with it, including observations of temperature, wind, and pollutant profiles with height, atmospheric aerosol characteristics within the layer, and visibility measurements. In connection with the CBL observations, components of the surface energy budget were measured at a site representative of the valley floor in general, having a sparse cover of sagebrush, bare soil, and natural grasses. At this site, solar and net radiation instruments were mounted at the 1-m level on booms that extended out 1 m from a guyed mast. Nearby, temperature sensors were inserted into undisturbed soil at depths of 2, 5, and 20 cm in the walls of a 20-cm deep excavated pit.

In addition to the supporting role played by the DC-3 aircraft in the CBL experiments, separate experiments were designed to use the aircraft as a platform from which to measure background pollutant concentrations in the oil shale region and to better define horizontal variations in atmospheric structure over the region during both daytime and nighttime flights. Measurements taken from the DC-3 aircraft included ozone and sulfur dioxide concentrations, aerosol concentrations, and light-scattering coefficients, as well as aerosol size distributions and elemental compositions. Vertical profiles were made over the oil shale region at altitudes generally between 2300- and 4300-m MSL.

The tracer experiments were designed to answer basic scientific questions about the transport, diffusion, and deposition of pollutants introduced into a valley drainage flow. In these experiments two types of tracer materials were utilized. The first type was a gaseous SF_6 tracer released by researchers from Los Alamos National Laboratory. The second type, a lithium-traced aerosol, was released by researchers from Battelle, Pacific Northwest Laboratory so that comparisons could be made between gas and aerosol tracer concentrations to determine how diffusion and deposition will affect pollutant concentrations downwind of the pollutant sources. These experiments were conducted during the nighttime when the valley drainage flow had become well established and had attained a near-steady state. Tracers were released for 1 h so that transport velocities within the drainage flow would allow tracer to be carried through the length of the sampling station grid. Sampling stations were located along multiple lines perpendicular to the valley axis at various downwind distances from the source. The lines extended across the

valley floor and up the valley sidewalls. Using this grid and the two tracer materials, the experiments determined transport, diffusion, and aerosol deposition as a function of downwind distance from the tracer source.

Airborne tracer concentrations downwind of the release point were measured using one of three methods:

- Samples of SF_6 and lithium-traced particles were collected and detected in real time at the Tract C-a Visitor's Center and at Meteorological Site 3 using commercial instrumentation.
- Samples of SF_6 were collected using bag samplers distributed along four radio-controlled sampling lines oriented perpendicular to the valley axis at distances of 1.6, 2.5, 4.6, and 5.6 km down valley from the release point. SF_6 concentrations were determined from these samples after collection.
- Samples of SF_6 were collected in syringes at various points along a road that runs perpendicular to the valley axis approximately 6.8-km below the release point. Concentrations were determined from these samples after collection.

Conclusions and Recommendations

The field experiments are described, the design and characteristics of the data collection systems are specified, and the data are summarized in the form of figures and tables. The experiments, rather than focusing on the collection of large quantities of general background meteorological and air quality data, were directed at investigating specific meteorological phenomena, including the evolution and characteristics of atmospheric mixing layers and the dispersion capabilities of nocturnal valley drainage flows. The reported data will constitute important input into development of a mathematical model of pollutant transport and diffusion in the oil shale region now being developed at Pacific Northwest Laboratories. It is important to note, however, that further investigations of the meteorology and air quality of this sparse and very complicated topographic region are essential. It is recommended that a much more comprehensive set of experiments be initiated in the near future to obtain a better understanding of regional environmental effects of the development of oil shale resources in the Piceance Basin. Modeling work will benefit from the phenomenological approach advocated here, but other phenomena (e.g., the buildup and breakdown of temperature inversions, the evolution of local wind systems, the coupling and decoupling of synoptic and valley flows, etc.) must be observed and the scope of the observational work in both time and space be expanded.

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The complete report, entitled "Green River Air Quality Model Development: Meteorological Data—August 1980 Field Study in the Piceance Creek Basin Oil Shale Resources Area," (Order No. PB 82-258 609; Cost: $15.00, subject to change) will be available only from:
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