7.5 ASSESSMENT OF BASELINE AIR QUALITY IN WYOMING'S GREEN RIVER BASIN PRIOR TO ACCELERATED GAS AND OIL WELL DEVELOPMENT

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1. INTRODUCTION

Southwest Wyoming has traditionally enjoyed very good air quality, thanks to low population and a lack of industrial development, so motivation for air quality monitoring has, in general, been minimal. Increasing commercial activities, associated primarily with the oil, natural gas, and mineral extraction industries in the last 15 years, have led to the perception that visibility in the region has declined, resulting in air quality studies being initiated and carried out. These investigations have primarily focused on characterizing the composition of the local atmosphere and the influence of trace constituents on visibility. Notable studies include the 1996 Southwest Wyoming Visibility Study (SWYVIS, Han et al., 2002), the Green River Basin Visibility Study (GRBVS, Gribovicz, 2001), the Mt. Zirkel Visibility Study (Watson, 1996) in northern Colorado, the Southwest Wyoming Technical Air Forum (SWWYTAF, Wyoming, 2003a), and regional components of the Interagency Monitoring of Protected Visual Environments Visibility Data Assessment (IMPROVE, Wyoming, 2003b). Measurements in all of these studies have focused on particulates ($PM_{2.5}$) and particulate precursors, including organic carbon (OC), elemental carbon (EC), ammonium sulfate, and sulfur dioxide (SO_2), as well as aerosol light extinction, leading to visibility impairment. Additionally, wintertime surface ozone levels have been very recently monitored in the Upper Green River Basin. The acceleration in exploratory gas well drilling has occurred largely since these visibility studies were conducted. Analysis of the available data therefore provides an opportunity to establish a 'baseline' dataset that characterizes air quality before the onset of most of the industrial activity in the region.

2. STUDY DOMAIN

The results reported here focus on an analysis of the airborne observations made during SWYVIS using the Wyoming KingAir research aircraft, on 9 flights during February and March 1996. The study domain, located in the Green River Basin (GRB) of Wyoming, is bordered by the Wind River Mountain range to the northeast and the Wyoming mountain range to the west. Flights overflew areas of the GRB subsequently developed as the Jonah and Pinedale Anticline gas well fields, just south of Pinedale, WY, as well as the 'trona patch', a 15 km radius area that is home to five large trona mines, northwest of Green River, and the coal-fired Naughton power plant just northwest of Kemmerer, WY. Analyses focus on measurements obtained at low altitudes, below 3000 msl, that were obtained in the mixed layer, within a few hundred meters of the surface.

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3. ANALYSIS OF FLIGHT OBSERVATIONS

An appraisal of the lower altitude distribution of pollutant species represented by aerosol particle concentration, black carbon (BC) mass loading, and SO_2 mixing ratio, indicates that under conditions when the prevailing wind directions are from the SW to NW quadrant, maximum concentrations occur in areas east of the center of the study region, while air quality is invariably good to the west. This suggests that there are significant sources within the study region. The highest pollutant concentrations are invariably found immediately downwind of known industrial sites, such as the 'trona patch' and the Naughton power plant. The variability of concentrations along the flight tracks indicates the existence of multiple sources. Some flight track sections show minimal pollutant concentrations, particularly those that are close to the upwind perimeter of the basin. Notable among these are flight track segments either above or close to areas now occupied by the Jonah field and the Pinedale Anticline. Figures 1, 2, and 3, which show the BC mass loading, the measured scattering extinction, and aerosol particle number density along the flight track, respectively, on the morning of March 15, 1996, illustrate these observations. The figures also show that there are significant correlations between several of the measured pollutant characterizing variables. Time series plots of the data (not shown) illustrate this conclusion for March 15. However, not all flights show such strong correlations, again suggesting multiple pollutant sources. An example time series plot for BC mass loading for the morning March 15 flight is shown in Figure 4. The largest uncertainty values occur when the aircraft flight attitude is rapidly changing. Also apparent in the flight track figures is that the aircraft occasionally revisited the same locations, typically after an elapsed time interval of about one hour. On this time scale, analyses reveal that there were minimal changes in wind speed, wind direction, and concentration of the principal pollutant species.

4. MODEL CONFIGURATION AND SIMULATIONS

Preliminary attempts to numerically simulate the 3-D meteorological fields and time dependent 3-D pollutant concentration fields are being carried out using Penn State's Mesoscale Model (MM5 version 3.63, Grell et al., 1994) in tandem with the Sparse Matrix Operator Kernel Emissions (SMOKE) model version 2.4 and the Community Multi-Scale Air Quality (CMAQ) model version 4.6 (Binkowski, 2003). The computed fields can be used to derive calculated meteorological state parameters and species concentrations along the flight track so that they can be compared to aircraft observations. Model simulations are being conducted for 2 episodes, March 11-12 and March 15, 1996. The model physics (Table 1) and the modeling domain given in Figure 5, are for 3 horizontal nested grids at 27, 9, and 3 km resolution respectively. Each contains a minimum of 136 by 136 grid points, with the exception of the 3 km grid which is 196 by 136. The 27 km grid covers parts of Canada and Mexico, as well as most of the United States, west of Illinois. All MM5 modeling domains are being executed for a 51-hour or 81-hour forecast, depending on the simulation, and include 38 sigma-coordinate layers in the vertical. Results of modeling simulations will be presented at the conference.

Table 1: Key MM5 Physics for Model Simulations

PBL	MRF
Microphysics	Duddhia (simple ice moist scheme)
Cloud	Grell convective parameterization
Initialization	MM5

5. ACKNOWLEDGEMENTS

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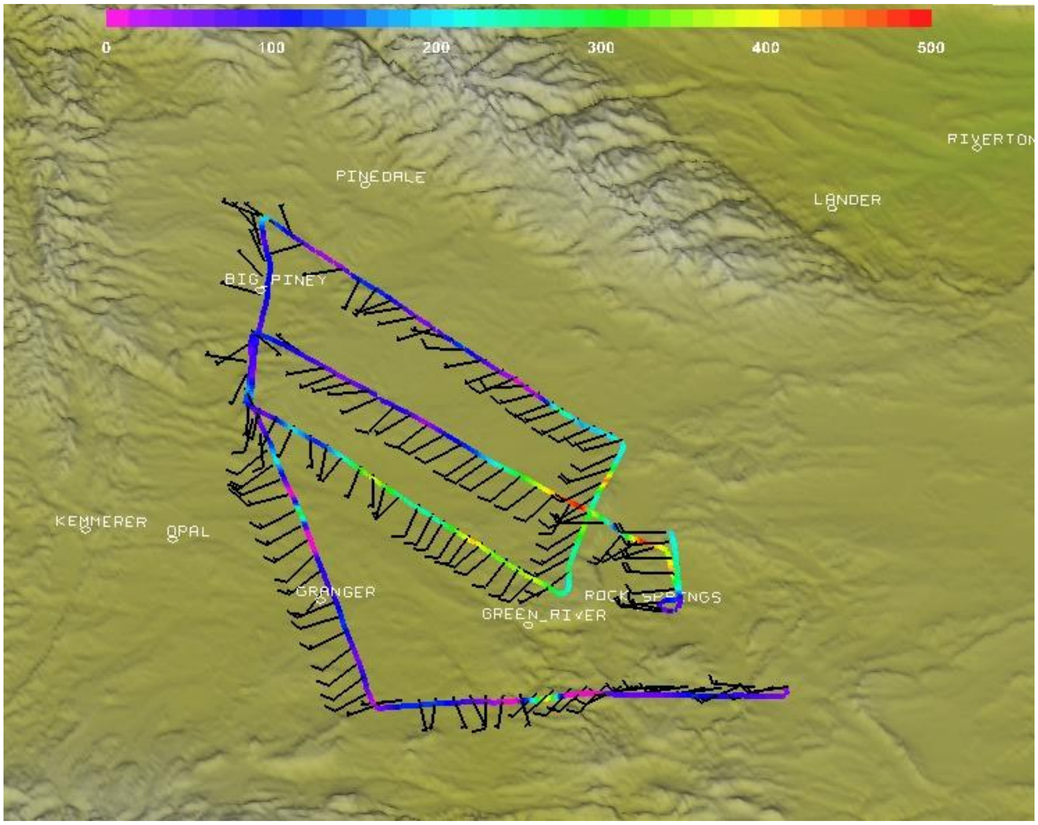

Figure 1: BC concentration values (ng m^{-3}) for the morning flight of March 15, 1996

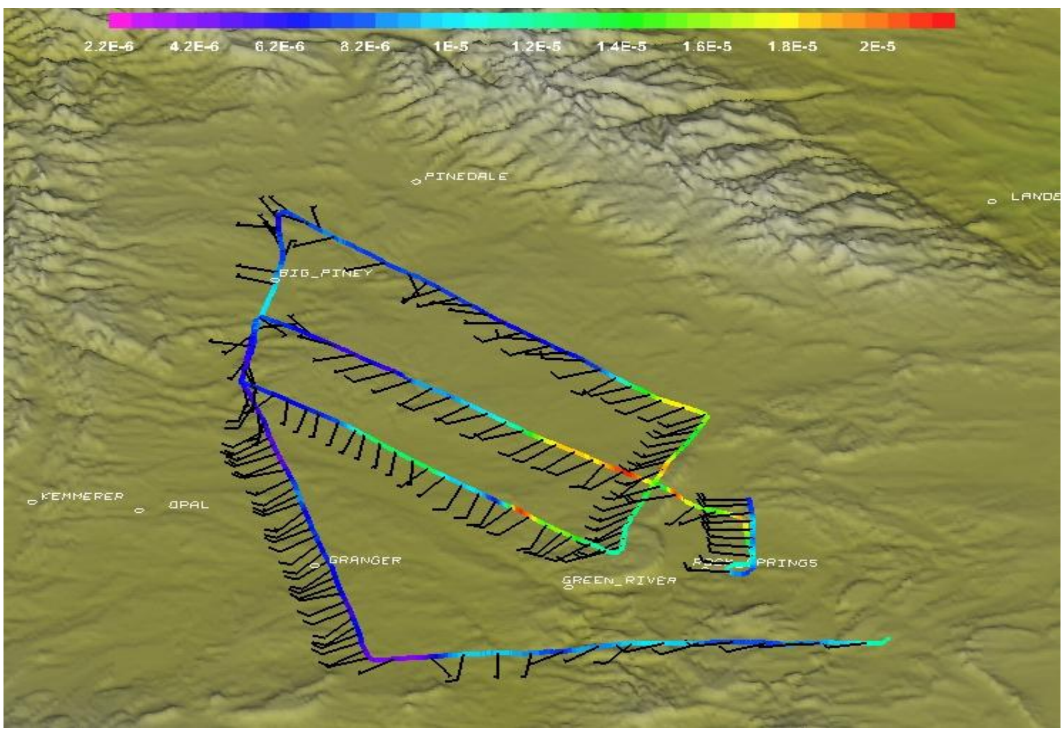

Figure 2: Aerosol scattering extinction (m^{-1}) for the morning flight of March 15, 1996.

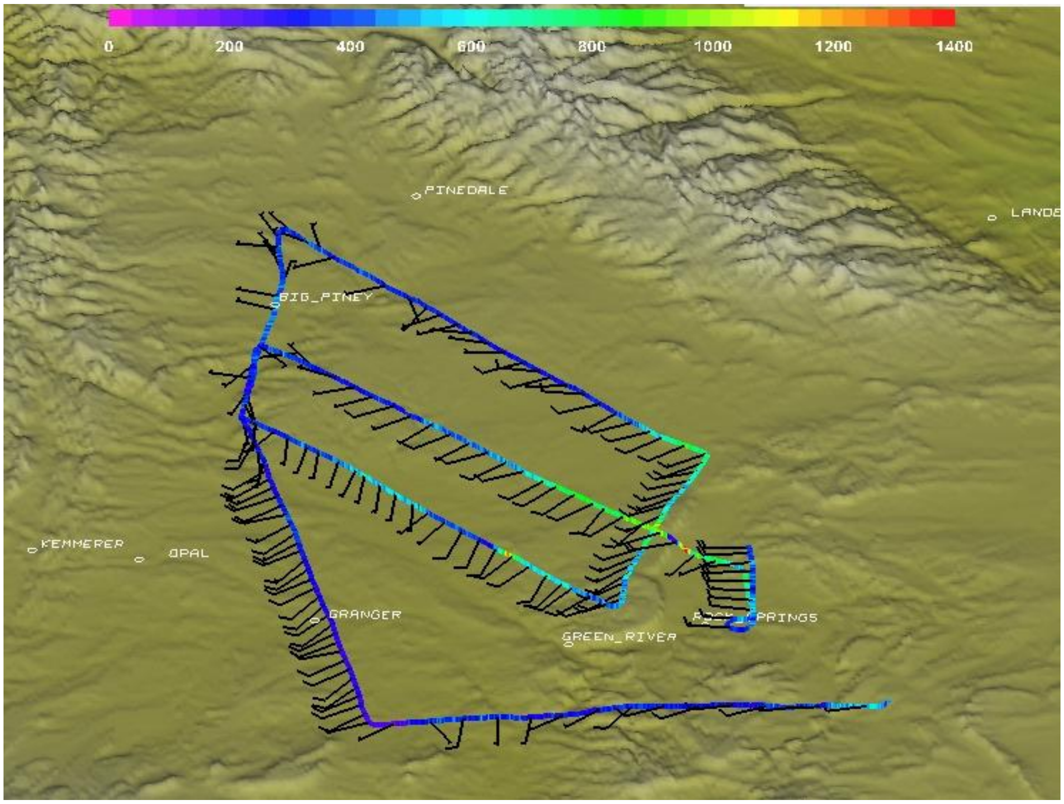

Figure 3: Particle number density (cm^{-3}) for the morning flight of March 15, 1996.

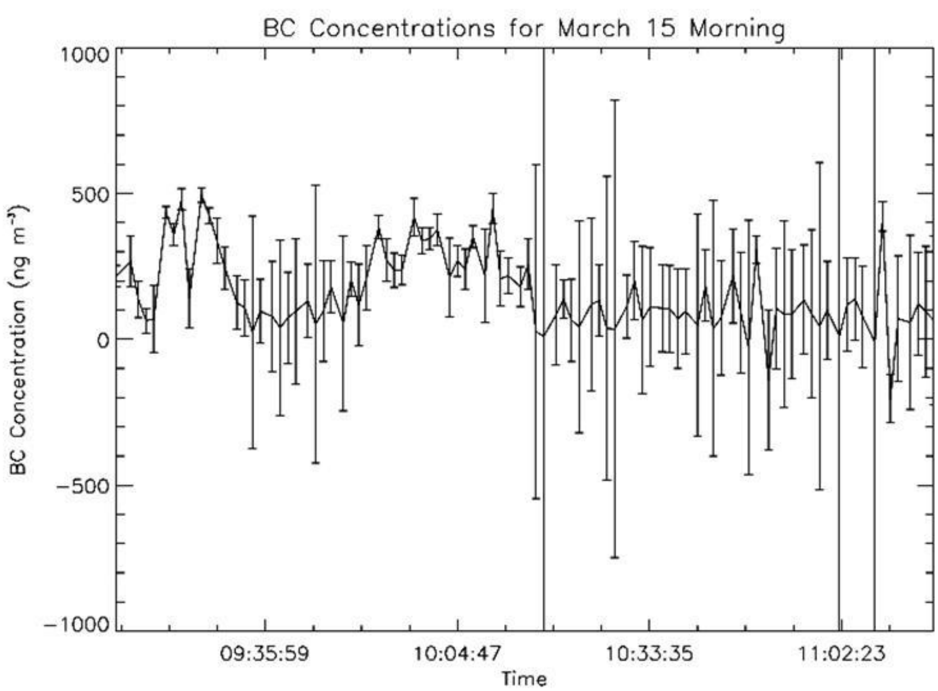

Figure 4: BC mass concentration (ng m^{-3}) plot with error analysis for the morning flight of March 15, 1996.

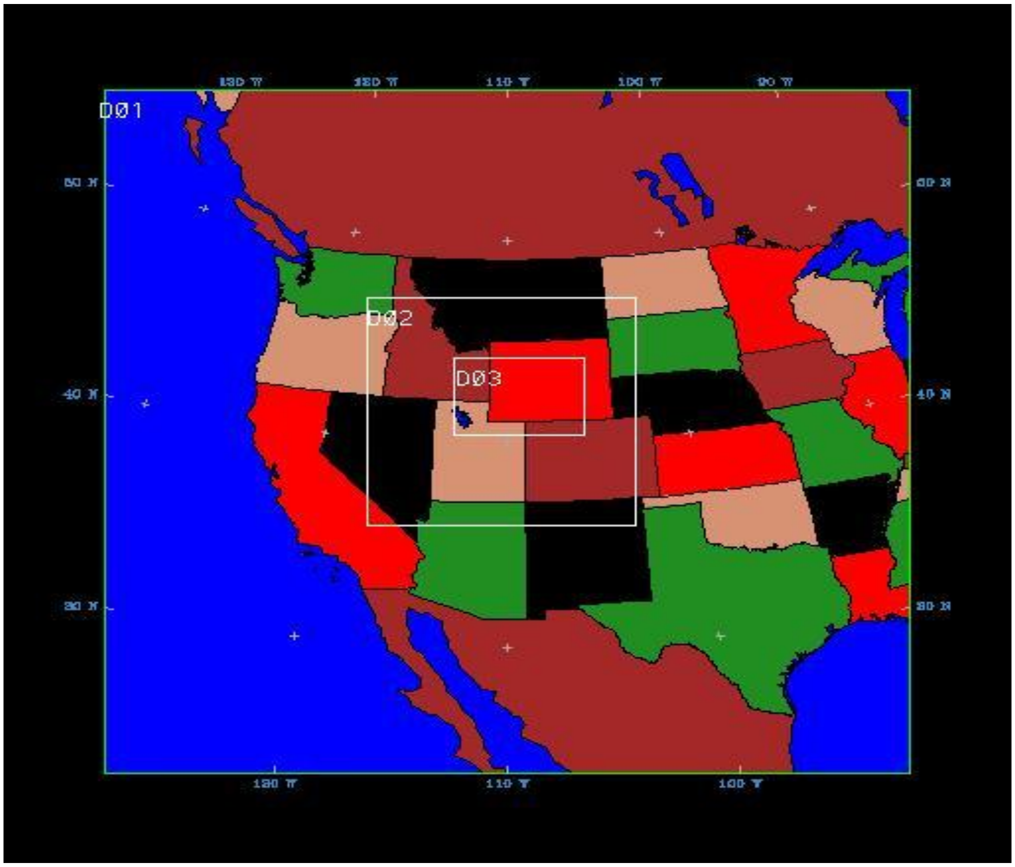

Figure 5: Model domain used in models, with Green River Basin located in domain 3.