ACCESS NUMBER: 30604

STUDY TITLE: Gulf of Mexico Air Quality Study

REPORT TITLE: Gulf of Mexico Air Quality Study, Final Report, Volume 1: Summary of Data Analysis and Modeling, Volume 2: Data analysis, Appendices A-M, and Volume 3: Inventory preparation, Appendices N-P

CONTRACT NUMBER: 14-35-0001-30604

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREAS: Western and Central Gulf of Mexico

COMPLETION DATE OF REPORT: August 1995

COSTS: FY 1992: $534,976; FY 1993: $2,612,312; FY 1994: $1,893,407; FY 1995: $816,265; FY 1996: $1,114

CUMULATIVE PROJECT COST: $5,858,074

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KEY WORDS: Western Gulf, Central Gulf, ozone, emission inventory, field study, radar profiler, radio acoustic sounder system (RASS), aircraft measurements, prognostic meteorological model, four dimensional data assimilation, photochemical model, SAIMM, UAM-V.

BACKGROUND: The Gulf of Mexico Air Quality Study (GMAQS) was performed in response to a mandate written into the Clean Air Act Amendments of 1990 (CAAA Title VIII, Sec 801(b) to assess the potential impacts of emissions from oil and gas exploration, development, and production in the Outer Continental Shelf (OCS) regions of the Gulf of Mexico on ozone concentrations in the onshore areas of Texas and Louisiana (Figure 1) that are designated by the EPA as nonattainment of the National Ambient Air Quality Standard (NAAQS) for one-hour average ozone 124 parts per billion (ppb). Ozone is a secondary pollutant formed in the presence of sunlight from the reaction of volatile organic compounds (VOC) and oxides of nitrogen (NO_x). Exceedances of the ozone standard occur during all seasons in the study area, but about 85 percent of the exceedance days occur between April and October and are usually associated with generally stagnant or weak synoptic-scale wind conditions, subsidence (high pressure), low humidity, suppressed convection (little cloudiness), and ample solar radiation. Historically most exceedances of the NAAQS for ozone in the study area occur near major urban and industrial source regions (Baton Rouge, New

Orleans, Lake Charles, Houston, Galveston, Beaumont, Port Arthur, and Victoria Count, Texas). Since 1980, ozone concentrations in excess of 124 ppb and as high as 340 ppb have been observed at shoreline and inland locations that could potentially be influenced by emission sources in the Gulf of Mexico.

OBJECTIVES: The overall goal of this study was to assess, through supplemental data collection, data analysis, and computer simulation modeling (meteorological and photochemical), the effects of current and future OCS petroleum development (OCSPD) in the Gulf of Mexico on ozone nonattainment areas in Texas and Louisiana.

DESCRIPTION: The project was divided into seven major tasks conducted in the following sequence: (1) analysis and preliminary modeling of historical episodes; (2) design and execution of a field study to collect appropriate meteorological and air quality data during the summer of 1993; (3) development of emission inventories for the 1993 ozone episodes and projection of the emissions to prepare future-year (1999) emission inventories; (4) analysis of the 1993 data; (5) meteorological and photochemical modeling of selected 1993 ozone episodes using the SAIMM data assimilating prognostic meteorological model and the UAM-V photochemical model; (6) assessment of the ozone impacts of alternative OCS future (1999) development scenarios in the Gulf Coast area on the onshore ozone nonattainment areas; and (7) evaluation of the needs for future research or data collection efforts to provide an improved understanding of the related effects of OCSPD emissions on ambient ozone onshore.

SIGNIFICANT CONCLUSIONS: The analysis of the 1993 supplemental field program data included estimates of shoreline flux, air parcel trajectories, and ventilation parameters. The results of the data analysis suggest that the contribution of the OCSPD emission sources on onshore ozone concentrations is small. The photochemical modeling analysis conducted with UAM-V indicates that the maximum impact form OCSPD sources for 1993 and 1999 is in the range of 25-35 ppb, in offshore locations of the central Gulf of Mexico. The maximum simulated onshore impacts from OCSPD sources are in the range of 6-8 ppb when onshore concentrations are low. During the time of maximum measured onshore ozone concentrations, the simulated impacts from OCSPD sources were generally less than 2 ppb.

STUDY RESULTS: The analysis of historical episodes for the period 1932-1992 provided the basis for the design of the 1993 field program study. This analysis provided information for episode selection, development of a conceptual model of ozone formation, and the preliminary estimate of onshore impacts. The field program, which ran from April to October 1993, included the installation of supplemental air quality and/or meteorological measurement systems at three offshore platforms and five onshore sites. Then intensive measurement portion of the field study ran from 18 July to 28 August 1993. During this time, two highly instrumented twin-engine aircraft were on alert in Beaumont to fly when conditions were favorable for ozone exceedances. The National Weather Service, which collects twice daily measurement of wind, temperature, and humidity aloft, provided one additional upper-air meteorological measurement daily as needed from Slidell and Lake Charles, Louisiana. Additional soundings were made from the Garden Banks platform. The 1993 GMAWS field study

was uncommonly successful: several high-ozone episodes were captured, including those with peak ozone concentrations approximating historically high levels throughout the study area. A number of ozone episodes (29-31 July, 10-13 August, 18-21 August, and 7-11 September) occurred during the summer of 1993. The days 9-11 August, 17-21 August, and 7-11 September were selected for analysis, and from these the day 17-20 August and 7-11 September were selected for modeling.

The key findings of the data analysis were that ozone exceedance days in the southeast Texas portion of the GMAQS study are associated with a distinct flow reversal and that the land breeze "front" typically traveled 75 to 100 km offshore before the winds reversed and began blowing onshore again. After the passage of the gulf-breeze front and establishment of steady onshore flow (gulf breeze), ozone concentrations measured at coastal locations dropped dramatically. Shoreline flux estimates, calculated for both the August and September episodes, indicated that the amount of NO_x emissions transported into the Houston area from OCSPD sources is small compared to that from onshore sources. Similarly, for ozone, the flux calculations indicate that the amount of ozone transported onshore is small compared to that produced in the Houston area.

Meteorological fields for application of the UAM-V to the GMAQS modeling domain were prepared using the SAI Mesoscale Model (SAIMM). The model was exercised using a one-way nested-grid approach with 16-km horizontal resolution for the coarse grid or outer domain and 4-km resolution for the inner domain. Routine and supplementary meteorological data collected during the GMAQS and COAST field programs were incorporated into the SAIMM simulations using four-dimensional data assimilation (FDDA). The evaluation of the model revealed that the model provided a reasonable representation of the observed regional-scale flow patterns and the temporal and spatial features of the gulf breeze and associated airflow patterns.

An advanced photochemical air quality model, the variable-grid version of the Urban Airshed Model (UAM-V), was applied for the GMAQS domain to provide simulations of the chemical and physical mechanisms affecting observed ozone concentrations within the study domain and to provide quantitative estimates of the impacts of OCSPD emissions on ozone concentrations within the Houston area. Three multiday ozone episodes were simulated: 27-18 July 1988, 17-20 August 1993, and 6-11 September 1993. The assessment of UAM-V model performance for the August and September episodes indicated that the modeling system provided a reasonable simulation of each of the episodes. The simulation results were generally consistent with the conceptual models of the episodes developed through analysis of the air quality and meteorological data, and the statistical measures were generally within the ranges provided by the EPA for acceptable photochemical model performance.

The meteorological and air quality inputs were fixed and the UAM-V was used as a forecasting tool to provide likely future ozone concentration estimate ("prediction") for a number of future-year (1999) onshore and OCSPD emission scenarios to assess the simulated impacts of emissions from growth factors for all components of the inventory to estimate the emissions for 1999. To assess the incremental impacts of expected OCSPD emissions for 1999 relative to the ozone standard of 124 ppb, two simulations

of UAM-V were run; one simulation included OCSPD emissions and the other did not. The incremental impacts due to OCSPD emissions were derived by subtracting the ozone concentrations in the simulation without OCSPD emissions from those in the simulation that included OCSPD emissions. Modeling of OCSPD impacts for 1999 for the August and September episodes revealed: (1) the maximum incremental increases to peak hourly ozone concentrations due to OCSPD emissions for both episodes were approximately 25-34 ppb, in locations over the central Gulf of Mexico region, more than 120 km south of the Louisiana coastline (near the area of highest OCSPD emission density); (2) the maximum simulated onshore incremental impacts due to OCSPD emissions were in the range of 6-8 ppb and were greatest during the nighttime hours for all episode days - these maximum simulated onshore incremental impacts occurred at coastal and inland locations throughout the GMAQS domain, when observed and simulated ozone concentrations were relatively low, and (3) during periods and at locations where ozone concentrations were simulated to exceed 124 ppb, the incremental ozone impacts due to OCSPD emissions, for both episodes in all nonattainment areas, were simulated to be 2-6 ppb.

Recommendations regarding future ozone air quality work in the Western and Central Gulf of Mexico include additional meteorological and air quality measurements, improvements in the meteorological modeling analysis (e.g. use of surface temperature nudging and higher grid resolution), and the application of process-oriented model performance evaluation procedures.

STUDY PRODUCTS: Systems Applications International, Sonoma Technology Inc., Earth Tech, Alpine Geophysics, and A.T. Kearney. 1995. Gulf of Mexico air quality study, final report. Volume 1: Summary of data analysis and modeling. OCS Study MMS 95-0038. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region New Orleans, La. 654 pp.

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