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**STUDY TITLE:** Synthesis, Analysis, and Integration of Meteorological and Air Quality Data for the Atlantic Region

**REPORT TITLE:** Synthesis, Analysis, and Integration of Air Quality and Meteorological Data for the Atlantic Coast Region

Volume I: User's Manual for the Atlantic Region Air Quality Database (Volume 1.0)

Volume II: Technical Reference Manual for the Atlantic Region Air Quality Database

Volume III: Data Analysis

CONTRACT NUMBER: GS-10F-0124J

SPONSORING OCS REGION: Atlantic

APPLICABLE PLANNING AREA(S): North, Mid, and South Atlantic; Straits of Florida

FISCAL YEAR(S) OF PROJECT FUNDING: 2011, 2012, 2013, 2014

COMPLETION DATE OF REPORT: January 2014

COSTS: Cumulative Project Cost: $320,827

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KEY WORDS: Air quality data, meteorological data, emission inventory, offshore wind-based energy generation, CART.

**BACKGROUND:** In establishing wind-based energy generation areas offshore of the Atlantic Coast, BOEM and its partners must consider any potential impacts on air quality in nearby coastal areas. This requires an understanding of the relationships between meteorology, emissions, and air quality within each area of interest. Federal, state and private organizations have collected a variety of meteorological, air quality, and emission inventory data for the Atlantic Outer Continental Shelf (OCS) region and nearby onshore areas. The focus of this data synthesis study was to assemble these data into a coherent dataset, so that an integrated analysis of the data could be conducted. The dataset includes data from the Environmental Protection Agency (EPA), the National Weather Service (NWS), the National Buoy Data Center (NBDC), and other sources. It is expected that this integrated dataset will provide new information about

meteorological and air quality conditions in the Atlantic OCS region, including the relationships between meteorology, emissions, and air quality revealed by the data.

**OBJECTIVES:** The objective of this analysis was to prepare an integrated dataset that could be used to provide the basis for an improved understanding of the relationships between meteorology, emissions and air quality in the Atlantic region and support future data and modeling analyses related to ozone, fine particulate matter ($PM_{2.5}$) and regional haze. The data synthesis study also included some basic analyses of the data, which were conducted in order to ensure the integrity and usability of the dataset, and to provide new information about meteorological and air quality conditions in the Atlantic region.

**DESCRIPTION:** The Atlantic Region Air Quality Database (ARAQDB) incorporates air quality, meteorological, and emission data for both onshore and offshore areas along the Atlantic coast, with emphasis on key port/harbor areas and Class I protected areas. The database includes:

- Air quality data from the EPA including ozone, particulate matter ($PM_{10}$ and $PM_{2.5}$), speciated particulate matter, sulfur dioxide ($SO_2$), and carbon monoxide (CO) for sites within approximately 50 kilometers (km) of the Atlantic coast, as available from the Air Quality System (AQS) database.

- Air quality and meteorological data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) sites located in Class I areas along the Atlantic Coast

- Surface meteorological data from the National Weather Service (NWS) for sites within approximately 50 kilometers (km) of the Atlantic coast and within or nearby to port and harbor areas.

- Upper-air meteorological data from the NWS for sites within approximately 50 kilometers (km) of the Atlantic coast.

- Meteorological data from buoys and C-MAN stations in the western Atlantic Ocean, from the NDBC, with emphasis on the OCS region (within approximately 40 nautical miles or about 75 km from the coast.)

Available data for the period 2000 through 2012 were included in the database. Initially, all available data for the period 2000 through 2010 were included in the database and the data analysis was based on those data. At the end of the project, the database was expanded to include data from 2011 and 2012.

The resulting ARAQDB is a relational database that contains hundreds of millions of data points. An interactive database tool has been designed to provide users with easy-to-use query capabilities to retrieve specific subsets of the data based on a variety of criteria such as date range, location and parameter type. The graphical user interface

(GUI) consists of menus, forms and reports developed with Microsoft Access 2010. The form controls, such as list views, drop-down list boxes, command buttons etc., are standard controls used in many Microsoft Windows applications and should be familiar to most users.

A variety of data analyses were conducted in order to "mine" the integrated ARAQDB and ensure the integrity and usability of the dataset. Statistical and graphical summaries were prepared to provide an overview of the meteorological, air quality and emission data and to highlight key features/components of the integrated dataset.

In addition, meteorological data from selected onshore and offshore monitoring sites for the period 2005–2009 were formatted and processed for input to the Offshore Coastal Dispersion model (OCD5). The model-ready input data are expected to support future modeling studies focused on selected portions of the coastline in which the OCD5 model is used to examine the effects of changes in emissions on coastal air quality.

**SIGNIFICANT CONCLUSIONS:** Air quality, meteorological, and emission inventory data for the Atlantic Coast Region for a 13-year period have been successfully integrated into a master database tool that can be used to further evaluate and explore relationships among the data throughout the region.

**STUDY RESULTS:** The ARAQDB can be used to support a variety of air quality studies for the Atlantic region. Based on a review of recent data, key air quality issues include attainment of the 8-hour ozone standard for a number of port/harbor areas and visibility at Class I and other areas along the coast. Analysis of visibility data for selected coastal areas indicates that sulfate is the greatest contributor to poor visibility.

Onshore meteorological data indicate that the southern Atlantic coast is characterized by greater precipitation amounts and greater month-to-month variation in precipitation compared to more northern areas. For all coastal areas included in the analysis, average wind speeds are lower during the summer months and higher during the winter months. For most areas, average wind directions have a westerly component during the winter months and a southerly component during the summer months.

Offshore, sea surface temperature is lowest in March and highest in August. The buoy data indicate that a sea breeze circulation is most frequent in spring and late summer/early fall. Wind speeds are lower during the summer months, and daytime winds (on average) exhibit a westerly component during the winter months and a southerly component during the summer months.

The combined analysis of wind and air quality data reveals that 1) moving along the coast from north to south, there is a shift from southerly to northerly wind components on higher ozone days, 2) the lowest ozone concentrations tend to occur with easterly winds, although this varies slightly from area to area, 3) for most sites, higher $PM_{2.5}$ concentrations occur under conditions of low surface wind speeds, and 4) recirculation of pollutants leads to poorer visibility along the middle and southern portions of the Atlantic Coast.

The CART analysis results indicate that different combinations of the input parameters can lead to high ozone, high $PM_{2.5}$, and poor visibility in each area (i.e., that there are multiple pathways leading to poor air quality). Key factors influencing high ozone and high $PM_{2.5}$ include wind direction and regional-scale build-up and transport of pollutants. Most poor visibility days are associated with stable atmospheric conditions and lower than average wind speeds aloft.

Meteorologically adjusted ozone trends indicate that the year-to-year trend in ozone is relatively flat or slightly downward between 2000 and 2010. The results for $PM_{2.5}$ indicate that for several areas (for example, Portland, Baltimore, Norfolk, and Savannah), the apparent downward trend in $PM_{2.5}$ is in part attributable to meteorology (conditions conducive to higher PM2.5 in 2000–2001 and lower PM2.5 in 2008–2010). For visibility, both the actual and meteorologically adjusted values indicate a relative flat trend in annual average extinction coefficient.

**STUDY PRODUCT(S):**

1) Study report consisting of three volumes as follows:

a) Davis-Noland, B., J. Ward, and J. Adlhoch. 2014. Synthesis, analysis, and integration of meteorological and air quality data for the Atlantic coast region. Volume I: User's manual for the Atlantic region air quality database (Version 1.0). U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA 20170. AR Study BOEM 2014-008. 50 pp.

b) Davis-Noland, B., J. Ward, and J. Adlhoch. 2014. Synthesis, analysis, and integration of meteorological and air quality data for the Atlantic coast region. Volume II: Technical reference manual for the Atlantic region air quality database. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA 20170. AR Study BOEM 2014-008. 47 pp.

c) Douglas, S.G., J.L. Haney, and A.B. Hudischewskyj. 2014. Synthesis, analysis, and integration of meteorological and air quality data for the Atlantic coast region. Volume III: Data analysis. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Herndon, VA 20170. AR Study BOEM 2014-008. 224 pp.

2) Atlantic Region Air Quality Database (ARAQDB) consisting of Graphical User Interface and Oracle-based background database.

* P.I.'s affiliation may be different than that listed for Project Manager(s).