# 3. MODEL SELECTION

An emissions, meteorological, and photochemical air quality modeling system was selected that we believed best meets the District's needs in providing high quality modeling databases that can be used for developing local SFBA and regional ozone control plans. This belief is based on the technical features of the selected modeling system and its ability to address the challenges of modeling in the SFBA, the experience and capabilities of the District staff, and the need to maximize the likelihood of a successful model application that achieves the model performance objectives. Specifically, the system we originally proposed comprised the EMS-95 emissions processing model, the RAMS meteorological model, and the CAMx photochemical model. Based on the widespread use of the MM5 meteorological model for CCOS, as well as newly acquired MM5 capabilities among the BAAQMD staff, the BAAQMD subsequently adopted this meteorological modeling platform as well to maintain consistency among the various CCOS modeling efforts concurrently undertaken by various groups and agencies.

## CHALLENGES OF THE STUDY

There are numerous challenges related to air quality modeling of the Bay Area that had to be overcome in performing this work effort.

Meteorology: The meteorology of the SFBA and surrounding regions in the CCOS domain is quite complex, and appropriately simulating the effects of micro-climates and flow regimes is a significant challenge that requires the attention of experts, experienced modelers, and state-of-science meteorological models:

- Land/sea/bay breezes
- Mountain/valley wind systems in complex terrain
- Role of maritime stratus
- Mesoscale eddies
- Low-level jets
- Convergent flow regimes critical for generating high ozone in the SFBA

Emissions: Emissions modeling of the Bay Area and central California presents a challenge due to the multitude of diverse sources and the need to remain consistent with the CARB's emissions data and modeling system. Thus, the CARB's emissions modeling system was needed along with full knowledge of how CARB staff generate their emission rate estimates and spatial surrogates:

- On-road mobile sources
- Non-road sources
- Area sources
- Refinery and other industrial sources
- Electric generating sources
- Biogenic and fire emissions
- Translation from "foundation" inventories to model-ready inputs
- Quality assurance and quality control (QA/QC)

Photochemical Modeling: The challenges of the meteorological and emissions modeling of the Bay Area are combined with additional chemical and physical challenges in the photochemical modeling. A state-of-science photochemical grid model with the latest model sensitivity analysis capabilities will be needed to address this component, along with the use of:

- Multiscale two-way nested grid resolution (e.g., 1/4/12-km)
- Sufficient vertical resolution
- Current chemical mechanisms (updated CB4, SPARC99)
- Efficient and accurate numerical solvers
- Accurate and mass consistent interface between the meteorological and photochemical grid models
- Probing tools such as Process Analysis, Decoupled Direct Method of sensitivity tracking, and Ozone Source Apportionment Technology

Regulatory Issues: The original objective of the study was to develop a photochemical modeling database that can be used for revising the SFBA 1-hour ozone SIP. Nevertheless, any air quality modeling undertaken for future regulatory analyses must be consistent with the requirements of such SIPs and must satisfy:

- EPA's SIP guideline documents and requirements including those for photochemical modeling (EPA, 1991; 1996; 1999)
- CARB's guidance documents including those for photochemical modeling (CARB, 1992)
- Continuous contact with the CARB to assure that the modeling meets CARB's approval
- Continuous contact with EPA to assure that the modeling is performed to level that leads to an approvable SIP

Strategic Issues: The modeling and computer systems set up for this project are applicable to numerous air quality issues facing the District within the next few years:

- The District will be able to use the system to develop a historical ozone modeling "climatology" and to analyze SFBA impacts on downwind areas due to transport over a wide range of episodes.
- The modeling system will be directly applicable for addressing 8-hour ozone when EPA issues the final 8-hour ozone implementation plan.
- A photochemical model that includes advanced particulate matter (PM) and toxics treatments can be readily adapted to treat many additional air quality issues
- The modeling and computer system will be powerful enough to perform real-time ozone forecasting for the Bay Area.

## SELECTED MODELING SYSTEMS

The modeling components originally selected for this project were specifically identified and requested by the BAAQMD before the study was initiated. All of the models recommended by the District are considered state-of-the-science, and District staff possess a sound experience base for most of the modeling components. All of the selected models have been, or are currently being, used nationally for various ozone, carbon monoxide, and PM SIPs and/or regional regulatory analyses, and thus have been accepted by the EPA and many States for this purpose.

Emissions Model: The processing of episode- and grid-specific emission estimates must use the CARB's emissions data and modeling system, which is based on a California version of the 1995 Emissions Modeling System (EMS-95). Use of any other processing system would result in inconsistencies with ozone SIP modeling in other areas of the CCOS domain (e.g., Sacramento and San Joaquin Valleys) and could produce conflicting results (e.g., inconsistent conformity budgets). Thus, use of EMS-95 is an essential component of the modeling system.

Meteorological Model: Either the RAMS or MM5 prognostic meteorological models were the most logical choice for this component of the modeling system. Both models are state-of-science, have a large user community, and are available to all public agencies. Both have been used for air quality assessments for almost 20 years. We believe that RAMS provides a better treatment of the highly non-hydrostatic processes associated with mesoscale land/sea/lake breeze and planetary boundary layer (PBL) circulations in complex terrain. We originally selected RAMS over MM5 because District staff had used this model for several years and so are quite familiar with it, it has demonstrated good performance in the Bay Area, and it provides more flexible grid nesting arrangements (MM5 is limited to a 3:1 ratio when using it in 2-way nested mode). Ultimately, MM5 was adopted as well for this project for consistency with CCOS modeling being undertaken by numerous groups around California (similarly to the arguments made for EMS-95).

Photochemical Grid Model: The logical candidate photochemical grid models for this study included the two leading state-of-the-science platforms currently in widespread regulatory use throughout the U.S.: Models-3/CMAQ and CAMx. Both CAMx and Models-3/CMAQ are modern codes (1995+) that incorporate state-of-the-science features for all physio-chemical processes. For this study we selected CAMx over CMAQ because:

1) CAMx meets or exceeds all of the process, regulatory, and strategic requirements listed above;
2) CAMx can accept meteorological input fields derived from any meteorological model, while CMAQ is limited to the use of MM5;
3) CAMx supports flexible two-way grid nesting at any nesting ratio (e.g., 2:1, 3:1, 4:1), whereas CMAQ supports only one-way nesting;
4) CAMx has demonstrated good ozone model performance in southern California (Morris et al., 2002), whereas to date only some limited CMAQ modeling for California has been undertaken;
5) Early tests with CMAQ for CCOS indicated significant performance problems, prompting the CARB to use CAMx in their CCOS modeling;
6) CAMx has demonstrated successful application in several ozone SIP modeling studies nationally, whereas CMAQ has not yet been used in an ozone SIP;
7) CAMx supports a full suite of probing tools (DDM, OSAT, and Process Analysis) that may be important in ensuring that the model is working correctly, whereas the current public release version of CMAQ just supports Process Analysis;
8) the District has a greater familiarity with CAMx and has used it before; and
9) the project team's familiarity with the model ensures that a working, fully acceptable modeling system is developed.