Status of Air Quality in Central California and Needs for Further Study

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Introduction

Ozone and fine particulate matter (PM2.5) levels frequently exceed the National Ambient Air Quality Standards (NAAQS) in Central California. Additional emission reductions are needed to attain and maintain the standards there. Agencies are developing cost-effective emission control strategies along with complementary incentive programs to reduce emissions when exceedances are forecast. These approaches require accurate modeling and forecasting capabilities.

Background

Comprehensive data from special field studies such as the 2000 Central California Ozone Study and the 1999-2001 California Regional Particulate Air Quality Study and routine measurements were used to develop computer models over Central California. A variety of models have been rigorously applied, including MM5 and WRF for meteorological simulations and CMAQ and CAMx for air quality simulations. Despite the vast amount of land-based measurements and significant effort, computer models have historically exhibited marginal performance. It is hypothesized that data for the vast marine environment over the Pacific Ocean immediately adjacent to Central California could be used to improve model performance.

Hypothesis

Satellite data may help overcome limitations of using only land-based measurements. Analysis of the linkage between remotely sensed conditions and land-based measurements would considerably improve conceptual understanding of pollutant formation over Central California. Satellite data may improve model performance by: establishing IC/BC over outlying areas of the modeling domain having unknown conditions; enabling FDDA over the Pacific Ocean to characterize important marine inflows and pollutant outflows; and filling in the gaps of the land-based monitoring network, especially for localized, stagnating, polluted conditions. Insights gained from satellite data would aid forecasters.

Approach

The Bay Area Air Quality Management District, in collaboration with the NASA AQAST, plans to conduct four studies that include satellite-based data in Central California air quality analysis and modeling as described below.

Projects

The first project enhances and refines weather patterns, especially aloft, that impact summer ozone formation. Surface analyses were unable to characterize the strong attenuating effect of the complex terrain to steer marine winds impinging on the California coast. The dense summer clouds and fog over the Pacific Ocean form spatial patterns that can be related to downstream air flows through polluted areas. The goal of this project is to explore, characterize, and quantify these relationships using cloud cover data. Specifically, cloud agreement statistics will be developed using satellite data and model clouds. Model skin temperature predictions will be compared to both MODIS and GOES skin temperatures.

Fig. 1a shows a typical non-exceedance day. Cloud tops over the Berkeley Hills are visible from the east, signifying the presence of a deep boundary layer, and cool air is thus able to penetrate inland over the Berkeley Hills in morning hours. Fig. 1b shows a typical exceedance day. The absence of visible clouds over the Berkeley Hills signifies a shallow boundary layer and blockage of cool air by the hills, a prerequisite for exceedance. In this project, we will use satellite data to identify the type, top height, and coverage of clouds in several regions over the Pacific Ocean adjacent to the Bay Area. Statistical analyses will be conducted to relate this cloud information to the amount of ozone in the Bay Area and in the Central Valley.

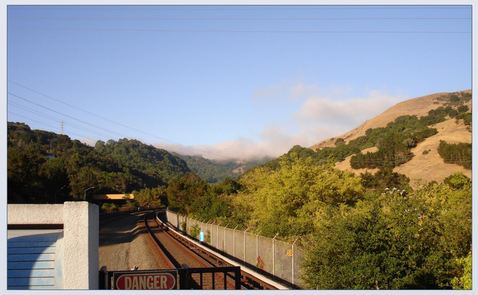

Figure 1a. The view looking west to the Berkeley Hills on a non-exceedance day.

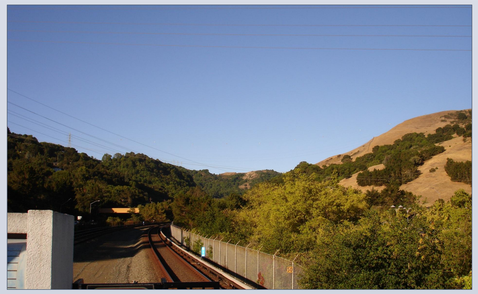

Figure 1b. The view looking west to the Berkeley Hills on an exceedance day.

The second project evaluates and improves the initial and simulated fields of meteorological models that provide inputs to air quality models. The study will attempt to determine whether a cloud dynamical adjustment developed by University of Alabama in Huntsville can improve model performance for maritime stratus and whether a moisture adjustment scheme in the Pleim-Xiu boundary layer scheme can use satellite data in place of coarse surface air temperature measurements. The goal is to improve meteorological model performance that leads to improved air quality model performance. Fig. 2 shows significant improvement in the agreement index (AI) between the modeled and satellite-observed cloud cover. The improved cloud cover estimation in the model not only provides better computation of the photolysis rate but also moderately improves the temperature and wind forecast.

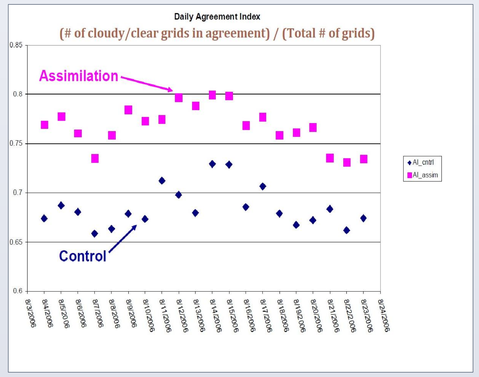

Figure 2. The agreement index between the modeled and satellite observed cloud cover.

The third project evaluates and improves forecasting skills of the National Air Quality Forecasting Model in CC by using land-based routine measurements as well as satellite data. Local forecasts are mostly based on surface meteorological and air quality measurements and weather charts provided by the NWS. The goal is to improve the average accuracy in forecasting exceedances, which is around 60%. Fig. 3 shows a comparison of PM2.5 predicted by the National Air Quality Forecast System with observations. The model did a good job on this day in the Sacramento Valley and in the Los Angeles area. It underpredicted PM2.5 in the San Joaquin Valley. The underprediction also appeared in the San Joaquin Valley on many other high PM2.5 days. We will investigate the reasons for the underprediction, including the accuracy of the meteorological simulation and the estimations of emissions.

The fourth project uses satellite data to monitor trends in fine particulate matter (PM2.5) in the San Francisco Bay Area. It evaluates the effectiveness of a rule adopted in 2008 that restricts household wood burning on days forecast to have high PM2.5 levels. The goal is to complement current analyses based on surface data covering the largest subregions and population centers. Fig. 4 shows the MODIS aerosol optical thickness versus observed PM2.5 at several sites over northern Alabama in 2002. The correlation is impressive. We will use this method to identify high PM2.5 areas in the San Francisco Bay Area to try tracking and reducing the pollution sources.

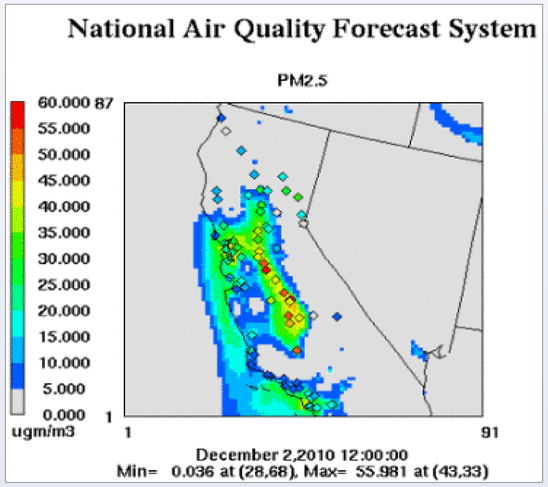

Figure 3. Comparison of simulated and observed daily PM2.5 on December 2, 2010.

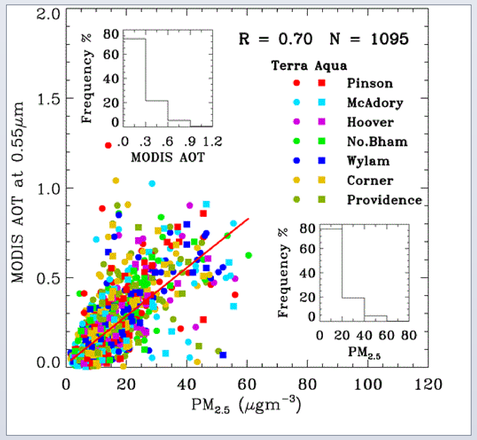

Figure 4. MODIS AOT vs. observed PM2.5 over northern Alabama in 2002.

Summary

The overall goal is to use satellite data to overcome limitations of land-based measurements. The outcomes will be further conceptual understanding of pollutant formation, improved regulatory model performance, and better optimized forecasting programs.

Reference

Additional information can be found at BAAQMD's website: http://www.baaqmd.gov/Divisions/Planning-and-Research/Research-and-Modeling/Publications.aspx