Background and Motivation

Meteorology, in conjunction with local emissions, play an important role in determining regional air quality (AQ) via a number of processes including pollutant transport and deposition at various scales, radiation, and dispersion. Previous studies (Hong et al. 2004; Stein et al. 2005) suggested that the climate change induced by the increase in atmospheric greenhouse gases will adversely influence future air quality. This is an important concern in Southern California which suffers from frequent severe air quality episodes. Assessments of the impact of climate change on air quality include significant uncertainties due to uncertainties in future emissions and meteorology.

In order to improve assessments of the impact of climate change on weather, the Joint Institute For Regional Earth System Science and Engineering (JIFRESSE) has been developing a Regional Earth System Model (JRESM) which consists of the WRF-MRF model and a variety of impact assessment modules. The WRF-MRF used in JRESM is improved with the regional dataset (RSM) and VMS to simulate coastal low pressure circulation and land-surface fields, respectively. The WRF model receives special attention. The AQ part of JRESM utilizes the Community Multiscale Air Quality (CMAQ) model (Figure 1). The focus of the study is the coupling between WRF and CMAQ and the evaluation of O3 concentration simulated using the model.

Figure 1. A schematic illustration of the AQ part of JRESM.

July 2005 Air Quality Simulation

We present results from a month-long AQ simulation for July 2005 using the JRESM. The major goal of this study is to evaluate the AQ part of JRESM in preparation for a climate change study. The meteorological field was simulated at 12 km horizontal resolution using the improved WRF model and the large-scale forcing data from the North American Regional Reanalysis (NARR). The hourly met forcing data were then used to drive the CMAQ model in conjunction with an emission dataset generated using the WRF-MRF model in preparation for the JRESM model evaluation study in conjunction with the 1999 EPA National Emission Inventory (NEI) dataset. Results from the WRF and CMAQ simulations were evaluated against the emission dataset generated using the California Air Resources Board (CARB) and the observed data from the Southern California Analysis Center (SACRA) at 11 Southern California locations: Los Angeles-Long Beach-OC (LAB), Pasadena (PAS), Riverside-Rialto (RVR), and Palm Springs (PS). These 4 CARB site records were selected in order to identify the model evaluation in geographically and meteorologically distinct regions.

Figure 4. The simulated monthly mean concentrations of O3 and CO (a) shows strong daily diurnal cycle and geophysical variations in Southern California. The O3 daily diurnal cycle is characterized by daytime maximum and nighttime minima due to local emissions and met. The O3 and CO concentrations vary according to the region and are high in Southern California which suffers from frequent severe air quality episodes.

Figure 5. The simulated monthly diurnal cycle of O3 and NO emissions (b) shows strong diurnal cycle and geophysical variations in Southern California.

Conclusions

An air quality simulation in the Los Angeles basin during July 2005 using the WRF-CMAQ part of JRESM has been evaluated. This study was performed as a part of preparation for a study in which the impact of climate change on the air quality in Southern California will be investigated. Using the large-scale forcing from North American Regional Reanalysis (NARR), the WRF-AQ model was able to generate the low-level wind and temperature fields as well as their diurnal variations with reasonable accuracy.

Emissions in Southern California are characterized by a strong diurnal cycle with maximum and nocturnal minimum. On-road mobile emissions are the largest source of CO and NOx in the region. The meteorological diurnal cycle of simulated O3 concentration agrees well with observations during the daytime and nocturnal periods. The regional O3 concentration shows strong positive bias at most of the verification sites, which might be due to problems in simulating local meteorological conditions and the uncertainties in local emissions. The negative bias in O3 concentration at the coastal West Los Angeles station during nighttime is partially related to the errors in low-level wind affecting the coastal urban area and the effects of complex topography.

Acknowledgement

This project was supported by JPL RDF program.

References


Figure 7. Comparison of the modeled mean wind speed and direction during the daytime and nocturnal periods at WSLA.

Figure 8. Low-level temperatures are closely related to the diurnal cycle of the low-level wind in the LA basin because the low-level winds in this region are strongly influenced by land-sea and mountain-valley breezes. The low-level temperatures in the simulation agree well with those in the NARR in daytime. However, the ERA-40 generally mismatches the nocturnal temperatures. This may be due to model errors in simulating surface temperature under stable stratification. It can also be related to the fact that ERA-40 is run at much coarser spatial resolutions than the RESM, under-representing the effects of local terrain.