4.11 Air Pollution Forecasting in an Undergraduate Advanced Synoptic Meteorology Course

Eric G. Hoffman*
Plymouth State University, Plymouth, NH

1. Introduction

Air quality forecasting is rapidly becoming an important issue for operational meteorologists in both the public and private sectors. In fact, the National Weather Service will begin including air quality forecasts into their suite of public forecast products in the very near future. Therefore, there will be a need for meteorologists to have some training and education in the area of air quality and air pollution forecasting. In response to this need and as part of Plymouth State University's continuing involvement with the National Oceanic and Atmospheric Administration’s (NOAA) AIRMAP air quality research project, air quality forecasting education and training has been added into our undergraduate curriculum. Plymouth State already has an elective course for upper-division students entitled "Air Pollution". However, in that course there is very little pedagogy devoted to the forecasting aspects of poor air quality events. In addition “Air Pollution” is currently only offered every 3rd spring semester. Therefore, we have developed an air quality forecasting “mini-course” to be taught over a four to five week period as part of the "Advanced Synoptic Meteorology" course. Advanced Synoptic Meteorology is also an upper-level elective course, but it has the advantage of being taught each fall semester. Five weeks is a brief amount of time to dedicate to a complex topic, but we feel that at least the students will be getting some exposure to the ideas and concepts involved in generating air quality forecasts. Section 2 will give an overview of the course topics and discuss the assignments and forecasting exercises given to the students. The paper will conclude in section 3 with some ideas for future course development.

2. Course Topics

The curriculum was developed for this course through a search of the published literature, textbooks, and web sites on the topics of air pollution and air quality forecasting. In addition, a good deal of useful web information was obtained with the help of Mr. Jim Black of the New Hampshire Department of Environmental Services. The focus of the curriculum is on air quality forecasting, but it was necessary to present a good deal of background information to the students to supplement and refresh their knowledge of basic atmospheric chemistry.

The first three weeks of the course were used to give students an overview of the following topics: 1) important atmospheric chemical species and their background concentrations; 2) a refresher on basic chemical reactions; 3) primary and secondary atmospheric pollutants and their adverse health effects; and 4) chemical production of photochemical smog. Chapters 1 through 4 of Jacobsen (2002) were used as the primary reference for much of this information. It was essential to include these elements during the first few weeks of the course because meteorology students at Plymouth State, while taking 2 semesters of General Chemistry, get little information in those courses about organic molecules and their reactions or atmospheric chemistry in general.

During this section of the course the students were given an assignment designed to get them to start thinking about air pollution and public policy. The assignment asked them to write a paper in the style of newspaper article providing information about the Clean Air Act. Informal feedback from the students indicates that they found this to be an interesting and valuable assignment because they knew very little about atmospheric pollution regulatory efforts. Not surprisingly, the student papers tended to focus on the history and details of the regulatory provisions of the act and stayed away from the socio-political impacts of the legislation. However, the students were given the opportunity to rewrite the papers and most of those did address the political implications.

The last two weeks of the course were dedicated to air quality forecasting. Various methods for producing air quality forecasts were discussed with the students including: persistence forecasting; climatological methods; developing statistical criteria and statistical regression models; and using 3-D air quality models. The primary source of this information was the Environmental Protection Agencies (EPA) Guideline for Developing an Ozone Forecasting Program (EPA, 1999). In addition, information about the various atmospheric influences on air quality such as the height

* Corresponding author address: Dr. Eric G. Hoffman, Dept. of Chemical, Earth, Atmospheric, and Physical Sciences, Plymouth State University, Plymouth, NH 03264. E-mail: ehoffman@plymouth.edu

of the mixed layer, presence of inversions, wind speed and direction, length of daylight, and local topography were discussed. Particular attention was given to forecasting ozone as an indicator of photochemical smog. The EPA color coded Air Quality Index (AQI) levels were introduced and discussed (e.g., yellow = moderate, orange = unhealthy for sensitive groups, red = unhealthy, etc…)

(http://www.epa.gov/airnow/aqibroch/).

In the forecasting section of the course, students were given a second assignment to investigate the atmospheric influences of a prior poor air quality event due to high ozone concentrations. The students used the EPA's AirNow website: (http://www.epa.gov/airnow) to identify a period during the summer of 2003 in which the AQI reached orange level for anywhere in the United States except for the Northeast. The Northeast was excluded because students are generally familiar with the combination of weather conditions and orography that produce poor air quality in the Northeast, but much less so for other regions. Students were then asked to gather all the pertinent weather information for that period such as the surface weather maps, soundings, upper-air maps, satellite images etc… The students then wrote a 1-2 page summary of the important weather elements that led to poor air quality for their chosen case. Student responses were in general very good (none earned less than a "B-"). However, their papers often emphasized the role of surface based radiation inversions that they identified from 12 UTC soundings, but neglected to look at the 00 UTC sounding to see how the boundary layer developed during the daylight hours.

During the last week of the mini-course, a significant amount of class time was devoted to making and verifying forecasts of AQI levels in real-time. Once again, the real-time AQI information available from the EPA AirNow web site was valuable. Luckily, for our students, the central valley of California and Houston, Texas were still having significant poor air quality days in the beginning of October 2003. Students split into two groups and each group produced 24 and 48-hour forecasts of AQI for one of the regions. Unfortunately, we did not have access to real-time 3-D air quality model output, but output from the NOAA-ARL Hysplit trajectory model was made available to the students:

(http://www.arl.noaa.gov/ready/hysplit4.html).

The forecasting exercise was an excellent learning experience for the students. The really began to understand the complex nature of the interaction between the atmosphere and chemistry. Each group had several lively discussions about the various forecast scenarios and the relative influence of each meteorological variable. Upon verification of their forecasts, the students realized that forecasting AQI was as difficult as quantitative precipitation forecasting and that they would need to get more experience for local areas before considering themselves competent as air quality forecasters

3. Conclusions and Further Course Development

In general, informal student feedback regarding inclusion of air quality forecasting to the Advanced Synoptic Meteorology course has been very positive. In fact, some of the student's that are also enrolled in a course, entitled "Current Weather Seminar", have included air quality information into these presentations. Thus, there is some circumstantial evidence that they have learned something and that some interest air quality forecasting continues.

This mini-course will be included in Advanced Synoptic Meteorology again next fall. This year the forecasting section of the course focused on ozone forecasting. However, it would be good to include an exercise that involves forecasting for particulate matter. In the future, we are hoping to be able to either do more real-time forecasting exercises or develop forecasting exercises that simulate real-time forecasting of a previous case study. We would also like to provide students access to 3-D air quality model data for theses exercises so that they could get some experience viewing this type of output. These sort of exercises seem to be the most interesting to the students and of course will give them better experience to take into the workplace after they graduate. The author would like to invite comments, suggestions for additional topics, or any other feedback so that the mini-course can continue to develop.

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