Graphical Displays of Pollen Concentration Forecasts

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Abstract

Saint Louis University's Pollen prediction group has begun to make pollen concentration forecasts for specific locations and times via trajectory and mesoscale numerical models. Several other research teams are also creating pollen concentration forecasts via source-oriented models. Although these groups have different end goals in mind, each group needs to make the information available to a diverse audience ranging from agricultural agents and farmers who are concerned with pollination of crops and wind borne diseases to the medical community and allergy sufferers who need to know when to prescribe and take medications. The tremendous amount of data created by these source-oriented models creates a number of challenging problems. Integrating the wealth of meteorological and concentration data from these models into a coherent form that can be understood by the researcher is a challenging task. The secondary problem of providing the end-user with information in a readily understandable form is also a complex task. A review of current graphical tools that can be used to make this complex information more readily understandable is presented. Examples of how Oak pollen concentrations from Saint Louis University's pollen forecasting project are displayed in both time and space are discussed. How can be incorporated into web page displays and television broadcasts in the Saint Louis area will also be shown.

Introduction

Forecasting pollen concentrations both spatial and temporally is now possible due to development of high-resolution mesoscale and trajectory models. Developments in mesoscale and pollution modeling allow experiments with the source-oriented technique to be conducted. The MM5 mesoscale model (Dudhia et al.; 2001) is now capable of making accurate forecasts with resolutions as fine as 1 km^2 and allows experimentation with various boundary layer prediction schemes. The Air Resources Laboratory's (ARL's) HYSPLIT_4 (Draxler and Hess; 1998) readily accepts as input the meteorological data from mesoscale models to compute the dispersion rate from the vertical diffusivity profile, wind shear and the horizontal deformation of the wind field. Combined with an understanding of the biology of the plants releasing the pollen, the sources of the allergens can be mapped both spatially and temporally. The use of high resolution mesoscale models, advanced trajectory based dispersion models and the distribution of allergens releasing plants allow for detailed forecasts of pollen concentrations over a wide region for up to 24 hours.

Pollen and mold forecasting using the source-oriented technique is currently being performed by at least two different groups. The University of Tulsa Aerobiology Lab is forecasting Mountain Cedar pollen even though Mountain Cedar trees are not found in the Tulsa area (Levetin, 1998). This group uses the National Meteorological Centers (NMC) numerical model, as input for ARL's HYSPLIT_4 trajectory model. HYSPLIT_4 to forecast the origin of the air that will pass over Tulsa for the following two days. The Departments of Plant Pathology and Marine, Earth and Atmospheric Sciences at North Carolina State University at Raleigh, NC also use a source-oriented model. The focus of this project is to forecast the transport of tobacco blue mold spores. Once tobacco blue mold is found, trajectories are produced using HYSPLIT_4. Areas within the transport region are warned that the air may contain these mold spores (Main et al.; 1999).

The goal of both these groups is not to determine the concentration of pollen spatially or temporally, but to produce a simple yes/no forecast of the presence of pollen or mold. In order to forecast the concentration of the pollen both spatially and temporally is a more complex problem. The spatial and temporal distribution of the pollen releases, the method used to model the structure of the boundary layer, the model resolution, the method for determining the dispersion and trajectories of the pollen will all significantly affect the accuracy of the forecast. Although the development of this forecasting technique is proceeding, an unforeseen and significant problem has arisen. MM5 and

HYSPLIT_4 trajectory model both generate tremendous amount of forecast data. Interpretation of this mountain of data is one of the most difficult tasks facing users of MM5 and HYSPLIT_4 today. The pollen group at Saint Louis University faces the additional problem of reducing the results of the pollen forecasts generated by MM5 and HYSPLIT_4 to a forecast that is understandable by the public.

Discussion

Both MM5 and HYSPLIT_4 come with tools to display the results of the numerical integrations. Unfortunately, these tools do not provide a means of displaying the results in context with other variables over time. Most commonly, wind vectors and contours of other significant variables are plotted over a base map of the geographic area. This does not allow the complex interaction of variables in both time and space to be explored. This has spawned a number of auxiliary tools to interpret the forecasts produced by MM5 and HYSPLIT_4. The most common of these tools are VIS5D (Hibbard, 1990) and GrADS. These tools have a divergent view of how the data should be viewed, but both provide a means of viewing the data in an integrated context.

VIS5D was developed at the Space Sciences and Engineering Center of the University of Wisconsin Madison in response to the need to display data sets that have a four dimensional character. VIS5D has evolved into a tool that can be used to visualize both gridded and irregularly spaced data, as well as, viewing the time varying three-dimensional structure of a data set. VIS5D can volume render any of the variables in the data set and combine the volume rendered display with contoured or shaded displays of other variables. These displays can then be rotated and animated in real-time. Data from multiple data sets can also displayed in the same display or viewed side-by-side spreadsheet style aligned in both space and time. VIS5D also provides then ability to quickly incorporate a VIS5D image into a web page to allow others to view the results. Texas A&M, University of Wisconsin and the National Environmental Satellite Data Center all produce web-pages with VIS5D date embedded within them. These web pages allow researchers and end-users to study these model forecasts.

The Grid Analysis and Display Systems (GrADS) from the Center for Ocean-Land-Atmosphere Studied (COLA) at the University of Maryland College Park was designed as a tool to make accessing, visualizing and manipulating earth-science data easier. GrADS allows 4-dimensional data environmental data to be displayed using a wide variety of graphical techniques including shading and contouring. GrADS also provides scripting to allow displays that are more sophisticated and repeated analysis of model data to be conducted. GrADS also provides the ability to create images in common graphics formats allowing static images to be displayed on web pages. An additional advantage of GrADS is that it was initially designed to work with earth-science data and as such has defaults that are intuitive in a geophysical sense.

Both GrADS and VIS5D both have there own internally format for storing data and the data sets have to be converted to this internal format. Although conversion utilities exist for most common formats, many of these conversion utilities are out of date due to format changes in the model data set formats due to the rapid development of these models.

The pollen forecasting group at Saint Louis University is using both of these tools to verify the MM5 and HYSPLIT_4 forecasts as well as to understand the how pollen concentrations are being controlled by boundary layer and mesoscale weather. An example of a VIS5D display in use is presented in Fig. 1. The shaded volume is pollen concentrations larger than 541 and the winds have been decimated. The layout of the buttons and panels is self-explanatory. Both contoured and colored slices can be draw both vertically and horizontally for any of the variables listed below each type. The color of each variable can also be easily controlled. A more detailed view of the pollen forecasts can be seen in Fig. 2. In this case the pollen concentrations larger than 350 are overlaid on topography of the region. Six hours after the release of the pollen, the plume the Ozark Mountains in southern Missouri has been distributed throughout Missouri.

Fig. 3 shows GrADS being used in the same fashion as VIS5D was in Fig. 1. Note that GrADS has a primarily Command Line Interface (CLI) rather than the Graphical User Interface (GUI) that Vis5D uses. The CLI of GrADS has some advantages over the GUI of VIS5D when a knowledgeable user displays the results of pollen forecast. VIS5D's strength lies in its ability to easily explore many different views of the data set to be examined without creating the script that is necessary to do the same work under GrADS.

When both of these tools are being used to create web pages, GrADS has an advantage when creating simple static web pages. Since GrADS is scriptable and can create images in all the common web page graphics formats, it simple to create images needed for the static web page. VIS5D has the advantage of allowing VIS5D files to be explored from a web page in collaboration with other remote users. Altering the helper applications list in all web browsers allows a web browser to open and display VIS5D data files. The only drawback to this approach is the large size of typical VIS5D data files.

Although both of these tools provide the researcher with a rich graphical environment to explore the large forecast data sets, these tools also present challenges to the forecaster presenting this information to the end-user. Recently television weather forecasters have successfully made use of the newest complex forecast tools to present detailed forecasts to the public. When detailed forecasts are presented in a clear and concise manner, the graphics used in the presentation make the information more readily understood. In addition, modern technology has made these kinds of presentations more common. Other users, such as the medical community and farmers are already familiar with these kinds of tools and expect the kinds of details available. Although an easy to understand forecast similar to the red, yellow, green air-quality forecasts, might prove useful for public service type announcements, the detailed graphical forecast proves more useful to the community in the end provided the graphics are presented in a clear and concise fashion. Presenting the pollen forecasts in fashion similar to a weather forecast and directing the public to more detailed information and forecasts from a web page appears to be a more fruitful way to make this information available.

Conclusions

The results from initial experiments show that it is possible to forecast pollen concentrations via MM5 and HYSPLIT_4. The large data sets created by these tools create interpretation problems for both the forecaster and the public. Using graphically rich display makes this information readily understandable. In the past complex information was presented out of context of the other variables or in a hard to interpret form. The rich graphical display tools minimizes these problems and allows both the researcher and end-user to the relationship between atmospheric, topographic and biological variables.

Bibliography

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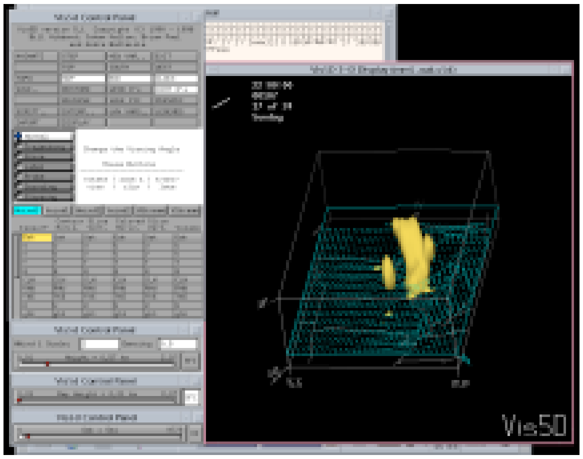

Figure 1
Screen Capture of active VIS5D windows.

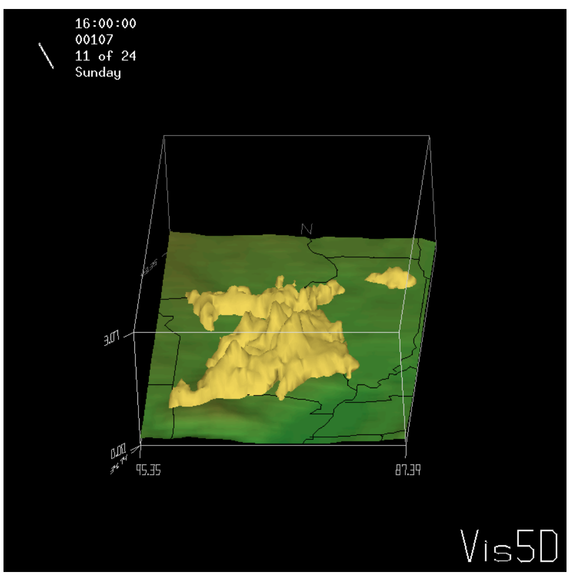

Figure 2
Active VIS5D display from a forecast animation

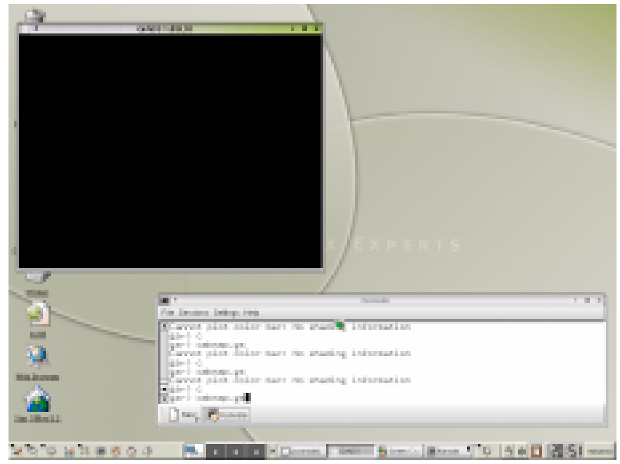

Figure 3
Screen Capture of an Active GrADS display

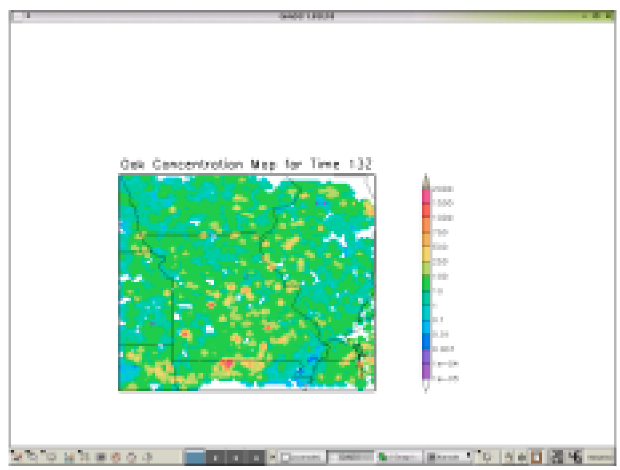

Figure 4
Active GrADS display from a forecast animation