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CLASSROOM VISUALIZATIONS OF WEATHER

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1. INTRODUCTION

Depicting weather in three-dimensional space and time has been a challenge to both authors and graphic artists. From black and white diagrams, where readers strained to understand what was going on, texts transformed to color and air-brush shadings, and a significant step was made towards visualizing weather phenomena. But still something was missing for a dynamic understanding of atmospheric processes!. In recent years, computers have enabled the fast processing of data, and programs have evolved to render this into animations in three-dimensional space. And so the art and science of weather visualizations have now become part of our everyday expectations.

2. INTRODUCING EWB

Visualization programs are readily available, even as inexpensive share-ware products. Some are freely available, others are not quite so 'free'ly available. The more costly products will have better rendition techniques and even faster algorithms for doing the data manipulations and transitioning between time steps. But, with these also come added features and often a more complex user interface and learning curve. There is a product, *Environmental WorkBench*[®] (EWB) by SESCO¹, which in our opinions, has some of the best techniques for weather data visualization we have encountered. It is being used as a component program within the LEADS² software system that the US Air Force has recently adopted as part of their OPS II upgrade. It is also available and used as a stand-alone package. US Air-Weather personnel at Weather hubs, who we trained on this package were all enthusiastic about it. The excitement of seeing, visualizing and perhaps really understanding, certain weather phenomena by seasoned weather folk, was revealing. The benefit to classroom educators (at all levels) was obvious.

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¹ SESCO – Software Solutions & Environmental Services Co., St Paul, Minnesota

² LEADS – Leading Environmental Analysis & Display System, IPS Meteostar, Aurora, CO

EWB operates through a series of surrounding control panels where the user can set, change and choose data types, views and motions. Experienced users can load in most data-types, but in normal classroom use, we anticipate that the instructor would prefer to have a custom dataset on which to work and demonstrate. Thus, a basic module on weather could start with a depiction of surface pressure on a continental 3-D map of the USA, having chosen pressure as the active parameter and setting the units to millibars and spacing at 4-mb intervals (Figure 1).

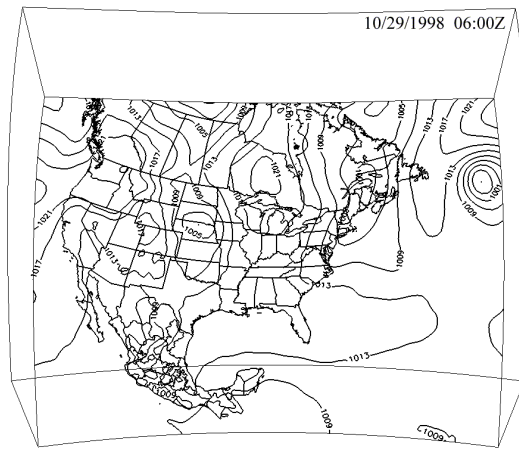


Figure 1: Surface isobars from an MM5 gridded dataset showing the 06:00Z time frame.

In the classroom setting instructors would explain that on the continental scale we are looking at a horizontal area of 3000 x 2500 miles. On this scale the vertical extent of the troposphere (20 miles) would be only as thick as the lines used in the drawing if a vertical exaggeration were not applied to the graphic. Here the vertical scale is about 120 times the horizontal.

Instructors could then show (Figure 2) the grid spacing used in this particular MM5 dataset and explain that observational data (randomly spaced) is extrapolated to fill this grid system so that at each intersection a data value would be calculated. Data values would then be anywhere from tens of kilometers apart (when using the ETA or MM5 models) to only a few kilometers for some of the meso-scale models currently available. Instructors could use their State as a rough means of calculating the data spacing and develop the concepts of the scale of weather features (say a thunderstorm cell) and whether such a cell would even appear on the model being depicted.

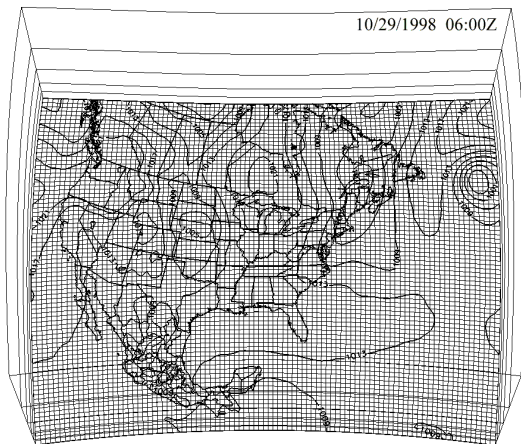


Figure 2: The 'grid' of the MM5 showing the spacing between data points for the data being used with the isobaric pattern for the 06:00Z time frame.

3.2 UPPER LEVEL FEATURES

By choosing say the 300 mb dataset (as opposed to the surface) similar displays can be made at this or any of the standard levels available. As many levels of data as the eye can absorb could be displayed. Several parameters can be displayed on the same level by using different colored lines, different shading or coloring schemes (Figure 3). The user should be cautioned against going for artistic pizzazz and color in these visualizations. Very often the simple graphic, with the instructor using the interactive capabilities of the program, is a more effective teaching and learning experience. All of these displays can be animated through time giving the viewer the opportunity of seeing the interactions between not only various parameters but also the spatial changes that occur as the weather systems progress.

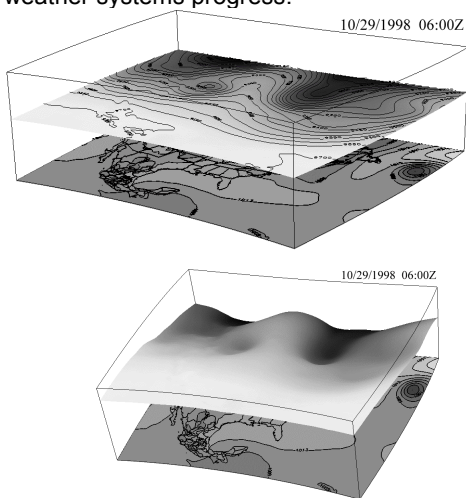


Figure 3: A surface pressure slice showing shaded isobar levels with 300mb height contours and shaded temperature patterns at 300 mb. Bottom; same as Top but employing a distortion to the 300 mb height surface.

3.3 CROSS-SECTIONAL VIEWS

In addition to horizontal slices, the user can choose any vertical slice through the data so that vertical and horizontal interactions can be demonstrated.

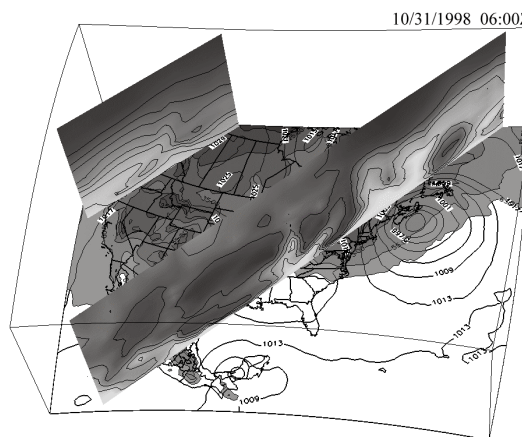


Figure 4: Double vertical slices showing dew point in the NW cross-section mapped by shaded contours, and relative humidity in the southern slice shown also by shaded contours. Surface isobars are also shown and the surface is shaded where temperatures are less than 65F.

The two vertical slices shown in Figure 4 can be positioned anywhere and at any angle so as to best show any dynamic interactions that may occur in the data used. Furthermore, any combination of parameters can be used and once again these can be animated through time to show the interactions.

Not only can gridded model data be used but observational data like METARS can be loaded as a dataset and can be viewed as such, or can be shown in combination with model (Figure 5), satellite and/or Radar data sets.

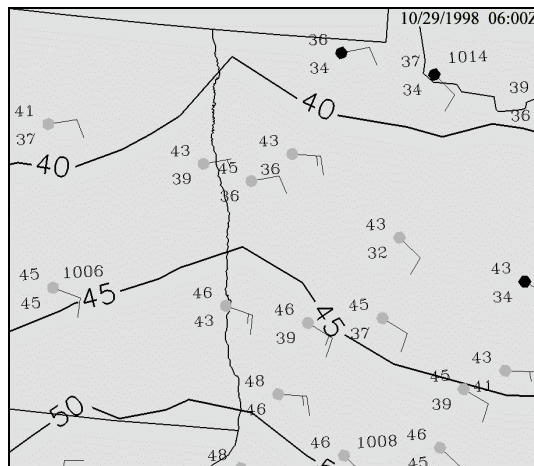


Figure 5: Observational data showing station models for the upper mid-west. The contour lines show temperature values from the MM5, giving a means of comparing model and observational data.

3.4 USING MACROS IN EWB

A significant advantage for the classroom instructor is the ability of creating and using macros within the EWB program. If there are views and combinations of parameters the teacher/user employs on a regular basis, these settings may be made into a 'macro list'. The concept of macro within the EWB framework is slightly different to that in normal computer usage, but the end result is that the user, through a menu screen (side of Figure 6), can check the parameter(s)/views wanted (created in some previous session), and these can be instantly shown in any series of combinations.

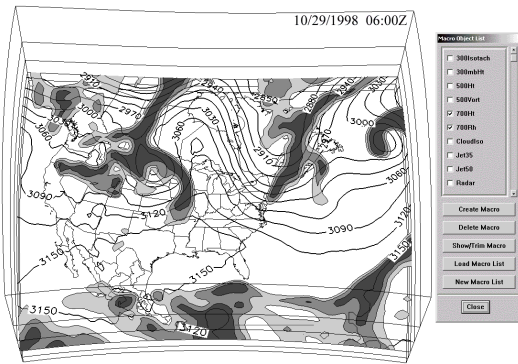


Figure 6: Height contours at 700mb with shaded contours of relative humidity above 70%. The side panel is the Macro Menu showing these parameters checked in the list.

Figure 6 shows a combination of 700 mb. height contours overlaid by relative humidity shaded in 10 percent intervals for values above 70%. All of these were instantly available to the user by a simple series of choices and checks in the macro menu list. The user could have chosen satellite imagery, radar or any of the other macros shown in the list.

3.5 USING ISOSURFACES

As a final example of the creativity that the instructor could employ in using this program is the ability to create isosurfaces of various parameters. Such an isosurface could be of wind speeds (or clouds, or turbulence etc) that encase a predefined wind speed(s). Figure 7 shows wind patterns with speeds 35 kt. and greater. This is shown over a map of surface pressures

An even more enterprising example is shown in Figure 8 where the same jets as in Figure 7 are shown in combination with a North-South cross-section of winds arrows. In the animations of these last two figures, it is possible to clearly see (and better understand) the temporal dynamics that occur within the weather space shown.

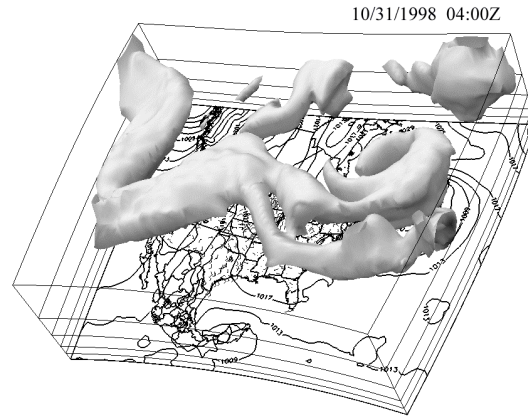


Figure 7: Surface pressures are overlaid by isosurfaces of wind speeds of 30 kt. and above. These illustrate the upper air westerly waves and jet streams.

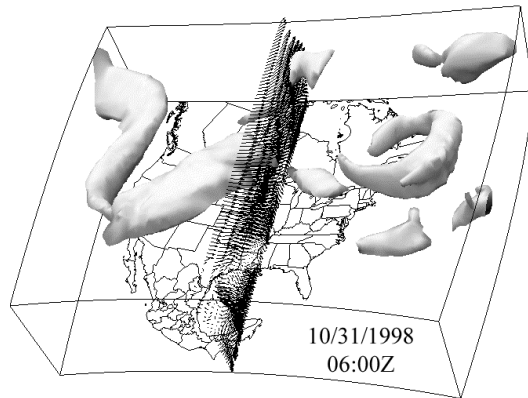


Figure 8: A combination of an isosurface of 35 kt. winds with a cross section along the 94°W meridian showing wind speed arrows along this slice.

4 CONCLUSIONS

It is our contention that schools and universities could greatly enhance the teaching of the dynamics of weather by using visualization programs such as EWB. Furthermore, having a set of authentic 'canned' data sets available will enable the instructor to focus more on what the weather data is showing, rather than spending the time and effort in either getting the data to load, converting it to a readable format, or fiddling with the graphic interface.

The creators of EWB have recognized the need in teaching and will be making the program and data available on a CD. The CD will contain a demo version of the program together with a series of data sets useable in classroom settings. A full version of EWB can be purchased (provided it is used in an educational institution for instructional purposes) at an educational discounted price. We believe that the understanding of weather processes should and can be enhanced by employing such visualization techniques as demonstrated here.