19th Conference on IIPS 15.2

3-DIMENSIONAL ANIMATED DISPLAYS FOR SIFTING OUT MEDIUM RANGE WEATHER EVENTS AND SEVERE WEATHER USING NCEP MODEL ENSEMBLES

Jordan C. Alpert[1*]

[1]NOAA/NWS/NCEP, Camp Springs, Maryland 20746

1. Introduction

The potential for forecasters to view operational model output as 3-dimensional animated displays using weather service AWIPS workstations is now a reality given the advances in Display Three-Dimensions (D3D) software. D3D is an Operational system for AWIPS workstations to display and animate 2- and 3-dimensional displays of model and observations to improve the manual forecasts at Weather Forecast Offices (WFO). The software was originally derived at the University of Wisconsin under the name, Vis5D (Hibbard, 1994). It is a system for interactive visualization, the "5" in the name Vis5D, visualization 5-dimensional, standing for 5-dimensional data sets, 3 space, time and variable space. The graphical package can display iso-surfaces, contour line slices, trajectories, etc and is freely available as open source software. The graphical package, Vis5D provides a solution to the display of model data where 3-dimensional animated views are required. Many improvements were made to Vis5D when it was converted to the National Weather Service operational AWIPS system D3D software. There have been formal evaluations (Szoke et., al., 2001) of the D3D software for many operational scenarios where comparisons were made between the AWIPS D3D and Display 2-Dimensional (D2D) software which is currently used in operations. The D3D software is intended to work along side the existing software and not as a replacement. A question remains as to the extent that 3-dimensional D3D displays can provide unique and useful views of model output that distinguish them as an indispensable tool that directly improves the ability of forecasters and reduce the risk to weather service customers and commerce.

[*]Corresponding author address: Jordan C. Alpert, DOC/NOAA/NWS/NCEP/Environmental Modeling Center, 5200 Auth Road, Rm. 207, Camp Springs, MD 20746;
e-mail: jordan.alpert@noaa.gov

2. A Severe Weather Proxy

A challenge in reducing severe weather risk is to utilize above mentioned new display software to lengthen the lead time in numerical weather prediction For example, the success of NWP 2-dimensional (NWP) model products, indicators and weather elements. products has been verified by the routine use of indicators such as model predicted lifted index, CAPE and other stability measures as indicators of future severe weather. Indicators such as these are an important forecaster tool even though the NWP model does not accurately resolve small space and time scales of the severe weather phenomena scale.

A forecaster utilizes information on many vertical levels and horizontal indicators to formulate a 3-dimensional view of the future state of the atmosphere. We believe that there are 3-dimensional images that can benefit the array of tools now available. For example we will explore the 3-dimensional structure of model predicted convergence as a proxy to server weather.

The Vis5D or D3D visualization display systems can be used to view data sets as iso-surfaces, and as standard contour plots. This is used to view the 3-dimensional animated rendering of the volume and depth of the convergence patterns along cyclones and fronts which we hypothesize can indicate the location and intensity of severe weather. 3-dimensional views of the size and shape of the convergence patterns appear correlated to severe weather as measured by observed winds and radar intensity. To test the usefulness of this hypotheses quantitatively, model predictions of convergence patterns form the NCEP global model will be analyzed for volume and vertical extent. The 3-dimensional animated convergence renderings as shown by Vis5D will be compared with composite radar observations. For the purposes of this report, the 3-dimensional renderings of Vis5D and D3D will be taken as equivalent. The model predictions

of 2-dimensional quantities such as lifted index will be compared with the model predictions of convergence.

3. Visualization of Ensembles

Ensemble forecasts attempt to address the uncertain nature of numerical weather prediction, Both initial condition and formulation errors are compounded in NWP models, degrading the accuracy of forecasts. However, as pointed out in Toth et al. (1997), models are now more sophisticated and for large scales, forecast errors that arise from instabilities are a dominating factor in the atmosphere. The NCEP operational ensemble model suite utilizes a breeding process (Toth et al. 1997) to account for the increased uncertainty from growing instabilities. It is noted that an ensemble can also be constructed from any group of separate model runs, e.g. the daily runs from national meteorological centers (Alpert and Brill, 1998).

A goal in the construction of ensembles is to properly span the space of possible forecasts. In addition, if the ensemble members are equally probable (otherwise a suitable normalization can be applied), then probability estimates can be defined simply as the percentage of predictions of the total that satisfy a specified given event. To the extent that these goals are met, we can use a 3-dimensional graphic display system to provide quantitative probability estimates of desired events.

Ensemble model forecasts are presented in a Vis5D display format for the parameters of height, temperature, relative humidity, wind, mean sea level pressure and precipitation. A Vis5D 3-dimensional display in the ensemble case is configured such that the equally spaced vertical coordinate is the i^{th} ensemble forecast model. The horizontal field can be over any region, in this case the CONUS. The ensembles are stacked vertically so that the 3-dimensional iso-surface displays are used to visualize the probability of user selected meteorological events desired by forecasters. This is done by observing the 3-dimensional iso-surface of a selected atmospheric parameter and event. The volume shown by the resulting 3-dimensional iso-surface, compared to the total volume at a location, is the probability of a particular forecasted event outcome at the given location and time.

In addition to 3-dimensional displays, the display of standard contour or color fill maps of maximum and minimum temperature, height, mean sea level pressure, precipitation and wind for each individual forecast is available from the ensemble in Vis5D. It is a quick and efficient process to digest and comprehend any of the meteorological parameters from the entire ensemble member set as well as derived quantities. This is accomplished by rendering a horizontal slice to present the maps from each individual ensemble member. Slicing through the vertical coordinate is the same as displaying each ensemble component map individually.

4. Summary

NWP models have clearly shown success in prediction of severe weather events. In addition to showing the future state of weather elements such as wind, pressure, temperature and moisture in the form of fields and vertical plots at stations, NWP models have shown moderate accuracy in quantities such as divergence and vertical motion. As NWP model resolution and physical parameterization improves, forecasters can expect better definition of the future state of severe weather activity. Combining a compact display of ensembles for probability predictions and finding new proxies to predict severe weather or rare weather events, leads to improved weather prediction from model output.

Vis5D is freeware available at the www address: http://www.ssec.wisc.edu/~billh/vis5d.html.
The ensemble files are available from http://sgi62.wwb.noaa.gov:8080/research/vis5d.html.

5. References

Alpert, J. C.,, and K. Brill, 1998: Display of multi-model regional ensemble forecasts using 3-dimensional animated Vis5D, The 12th Conference on Numerical Weather Prediction, Phoenix, AZ., Amer. Meteor. Soc., 11.6, 277-278.

Hibbard, W. L., B. Paul, D. Santek, C Dyer, A. Battaiola, and M-F. Voidrot-Martinez, 1994: Interactive Visualization of Earth and Space Science Computations. Computer, 27 65-72. Readers can contact William Hibbard at the Space Sciences Engineering Center, University of Wisconsin-Madison.

Szoke, E. J., U. H. Grote, P. C. Kucera, P. T.

McCaslin, P. A. McDonald, and W.F. Roberts, 2001: D3D: A Potential 3D Visualization Tool for the National Weather Service, The International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology, Albuquerque, NM. Amer. Meteor. Soc., 10-14.

Toth, A., E. Kalnay, S. M. Tracton, R. Wobus and J. Irwin 1996: A synoptic evaluation of the NCEP ensemble. Wea. & For., 12, 140-153.