J 5.7 **INTEGRATING SCIENCE AND VISUALIZATION WITH AWIPS FOR EFFECTIVE SEVERE WEATHER FORECAST AND WARNING OPERATIONS**

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1. Introduction

This paper will demonstrate how the Advanced Weather Interactive Processing System (AWIPS) can be used to support scientifically-based severe weather forecast and warning operations. Primary areas of concentration will illustrate 1) composite charts that visually summarize critical severe weather processes, 2) D2D radar configuration strategies that allow forecasters to effectively evaluate ongoing environmental potential while detecting severe storms, 3) enhanced visualization of radar products and numerical model data and, 4) an ingredients based approach to selecting meteorological fields from the AWIPS Volume Browser (VB).

2. Severe Weather Composite Charts

Given the growing volume of ***available data***, it is becoming increasingly important for forecasters to extract ***relevant information*** for effective severe weather forecasting and warning operations. Model forecast methods that focus on the processes that produce severe weather (Doswell 1987; Johns and Doswell 1992; Doswell et al. 1996) allow forecasters to anticipate the most probable range of convective evolutions for a given forecast environment. Ingredients-based mesoscale analysis techniques allow forecasters to better understand ongoing convective evolutions. Enhanced visualization of NWP model data makes it possible to quickly sort more from less important information.

Composite charts of surface analysis and model forecast fields are presented to highlight the processes supporting severe storm development, convective organization, and storm mode. These charts focus on evaluating the large scale potential for severe weather with the 40 km Eta, and monitoring real-time evolutions with the 40 km Rapid Update Cycle (RUC). Material composite charts include 1) measures of instability and vertical wind shear, 2) three dimensional moisture availability, content, and distribution and, 3) synoptic and mesoscale forcing mechanisms. Visualization techniques focus on using color, images, and contours effectively to highlight the convective potential. **Fig. 1** provides a schematic of low-level model forecast fields in a 4-panel composite chart; **Fig 2** provides a schematic of upper-level model forecast fields in a 4-panel composite chart.

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> Surface Pressure **>** Best Lifted Index < 0 **>** Sfc Dew Points > 66^{o} F	**>** Precipitable Water > 1.4" **>** Boundary Layer Moisture Flux Convergence **>** 1000-850 mb Moisture Flux Convergence **>** Moisture Flux / Flux - Magnitudes **>** K-Index
> 950 mb 2D Frontogenesis **>** 950 mb 2D Moist Fgen **>** Blyr Theta-e / Theta-e Advection **>** Surface Wind	**>** Surface-based CIN **>** Surface-based CAPE **>** EHI **>** Storm-relative Helicity **>** Surface - 700 mb Shear

Figure 1*. A schematic of low-level model forecast fields in a D2D 4-panel composite chart. The second field in each panel is displayed as an image.*

> 850 mb height / Temperature **>** 850 mb Isotachs **>** 850 mb Wind (Barbs)	**>** 500 mb Heights and Temperature **>** 500 mb Isotachs **>** 500 mb Wind (barbs) **>** Convergence of the Q-vector Field
> MSLP **>** 6 / 12 / 24 hr Precip **>** 1000 - 850 mb Mean RH	**>** 250 mb Height **>** 250 mb Isotachs **>** 250 mb Wind (barbs) **>** 850 - 300 mb Mean wind **>** 300 - 200 mb Positive Wind Divergence **>** 1000 - 850 mb Mean Model Omega

Figure 2*. A schematic of upper-level model forecast fields in a D2D 4-panel composite chart. The second field in each panel is displayed as an image.*

Fig. 3 illustrates upper-level model forecast fields in a grey scale representation of a color enhanced composite chart, and **Fig 4.** depicts the corresponding low-level model forecast fields. **Fig. 5** shows a schematic of surface processes in a 4-panel composite chart, derived from the 40 km RUC, and **Fig. 6** illustrates real-time surface processes in a grey scale representation of a color enhanced composite chart, derived from the 40 km RUC. The reader is also directed to the URL: http://www.werh.noaa.gov/msd/bestpractice/severe/topgunoutln.htm, where color enhanced versions of Figs. 3, 4, and 6 are presented.

> Surface Pressure > Best Lifted Index < 0 > Sfc Dew Points > 66 °F	> Precipitable Water > 1.4" > Boundary Layer Moisture Flux Convergence > 1000-850 mb Moisture Flux Convergence > Moisture Flux and Flux Magnitudes > K-Index
> 950 mb 2D Frontogenesis > 950 mb 2D Moist Fgen > Blyr Theta-e / Theta-e Advection > Surface Wind	> Surface-based CIN > Surface-based CAPE > EHI > Storm-relative Helicity > Surface - 700 mb Shear

Figure 5. *A schematic of surface fields derived from the 40 km RUC in a D2D 4-panel composite chart. The second field in each panel is displayed as an image.*

3. D2D Radar Configuration Strategy

D2D configuration strategies support forecaster expectations for probable events. Situational awareness is enhanced by templates that allow forecasters to simultaneously monitor storm scale, County Warning Area (CWA) scale, and regional/larger scale processes. Storm scale and CWA scale processes are evaluated with radar and lightning data; regional and larger scales are assessed with satellite. Templates provide guidance for infusing scientifically-based storm detection techniques, maintaining a high level of situational awareness, and monitoring ongoing changes in convective storm potential.

Fig. 7 depicts a radar display template for the right D2D screen and **Fig. 8** represents a radar display template for the left D2D screen. In this configuration, the storm view is a zoomed-in view of an important storm or cluster of storms. The CWA view helps maintain situational awareness, and the regional view allows a coherent picture of the entire system of storms. The only D2D pane that is changed is the “Dump” screen, where a variety of products (and model data) can be alternately displayed and cleared.

The advantage to this setup is that all of the D2D panes provide useful and resolvable data, with a minimum of housekeeping chores (e.g., moving virtual screens, zooming on different storms, re-aligning cross section lines, etc.). The template presented in Figs. 7 and 8 represents one of several configuration strategies, depending on the type of severe weather anticipated. The important point is to implement a structured D2D display strategy before the onset of severe weather.

4. Enhanced Visualization

Enhanced visualization schemes reveal the details of important features contained in WSR-88D radar products. The reader is directed to the URL: http://www.werh.noaa.gov/msd/bestpractice/severe/topgunoutln.htm. A strategy for radar visualization is presented that limits “visual noise” with color gradients, while highlighting relevant physical and flow structures. Color schemes are presented for a number of WSR-88D base and derived products. Enhanced visualization of WSR-88D radar products sets the stage for more effective warning operations.

5. A Process-Oriented Volume Browser

The AWIPS Volume Browser (VB) provides access to numerical models and other gridded data sources, including Radiosonde Observations (RAOBs) and Profiler data. The VB interface allows forecasters to choose a numerical model, from which meteorological fields can be selected and displayed as contours, vectors, or images. Static or time-animated fields can be displayed in plan view on constant pressure, isentropic, or constant height levels/layers. In addition to plan view, meteorological fields can be displayed as time-height sections, cross sections (time or space), time series, and upper air soundings. This presentation will focus on the VB Field menus.

The meteorological Fields menus included in the AWIPS Build 5 VB contain Basic, Derived, Sfc/2D, and Other **(Fig. 9)**. The Basic menu includes fields that can be calculated directly from state variables without finite differencing. Derived fields require horizontal finite differencing calculations before plots are generated. The Sfc/2D menu contains fields that are valid only at the surface, and the Other menu includes miscellaneous atmospheric fields which can be defined in three dimensions.

Although the AWIPS Build 5 VB Fields menus separate meteorological variables in a scientifically rigorous manner, they are non-intuitive, and difficult to use operationally. For example, forecasters do not generally envision state variables, finite differencing, or the dimensional characteristics of variables when they select meteorological fields for diagnosing the current state, or forecasting a future state of the atmosphere; forecasters are encouraged to think of physical processes, not variable abstractions. Since the VB menus distinguish basic from derived variables, related fields (e.g., temperature, temperature advection; moisture, moisture flux convergence) are located in different menus, resulting in a disjointed selection process. The process is further complicated because available field variables are intermingled with numerous unavailable fields. The current design is especially problematic when adding additional fields to the VB; it is difficult to decide where they should be added.

Fig. 10 offers an alternative, process-oriented approach to the VB Fields menus. For example, basic and derived temperature variables are grouped in a Temperature menu; basic and derived moisture variables are included in the Moisture menu. A Forcing menu contains quasi-geostrophic and other forcings (e.g., divergence of the Q-vector field, geostrophic and 2D frontogenesis), stability measures are included in a Stability menu, and estimates of vertical wind shear (e.g., storm-relative helicity, height normalized shear) are contained in the Shear menu. Wind-related fields are available in a Wind menu, Vorticity-related fields are accessible through a Vorticity menu, and isentropic fields are grouped in the Isentropic menu. Relatively short, non-cascading menus simplify the selection process, and only existing variables are offered for selection. A process-oriented approach is intuitive, makes it easy to add new fields, and encourages physical reasoning.

6. References

Doswell, C. A. III, 1987: The distinction between large-scale and mesoscale contribution to severe convection: A case study example. *Wea. Forecasting*, **2,** 3-16.

Doswell, C. A. III, H. E. Brooks, and R. A. Maddox, 1996: Flash flood forecasting: An ingredients-based methodology. *Wea. Forecasting*, **11,** 560-581.

Johns, R. H., and C. A. Doswell III, 1992: Severe local storms forecasting. *Wea. Forecasting*, **7,** 588-612.

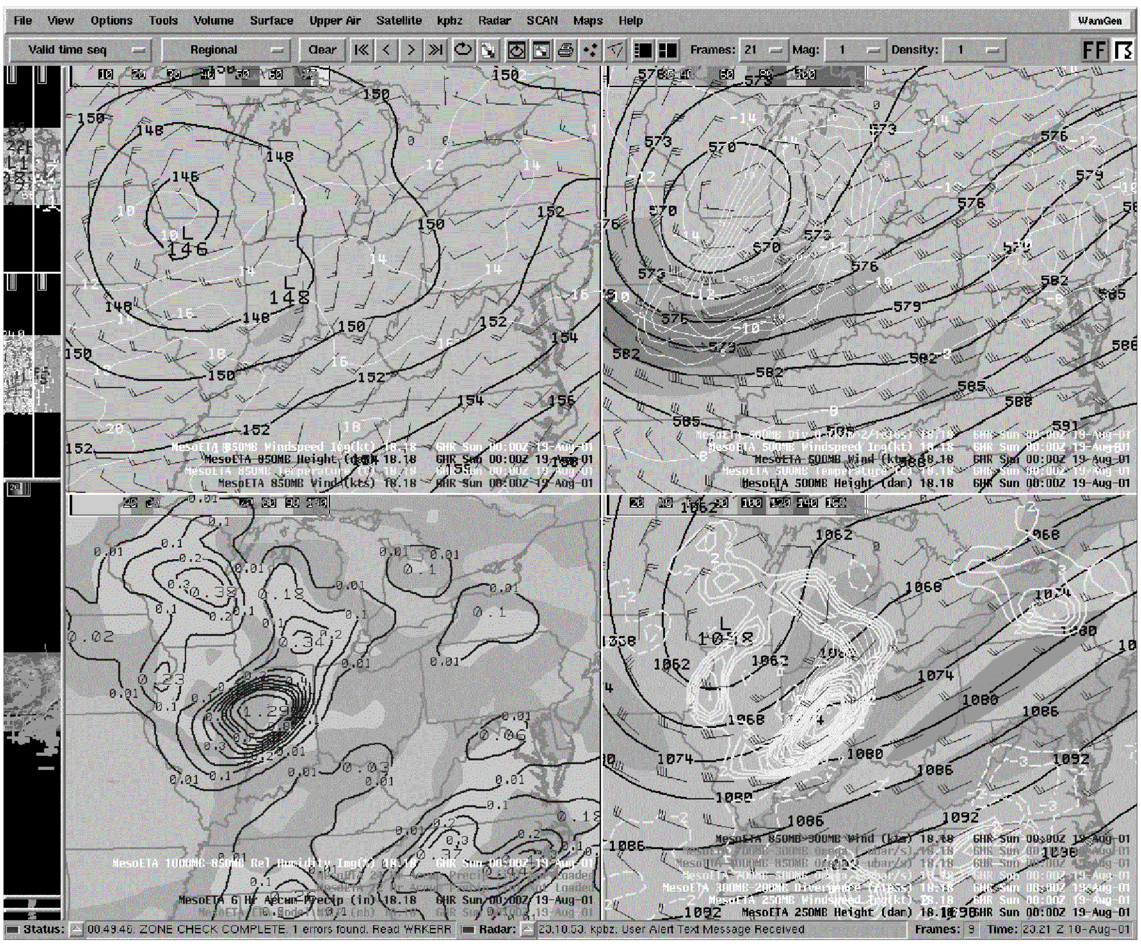

Figure 3. *Upper-level forecast meteorological fields for the 40 km Eta, valid 0000 UTC 19 Aug 2001. Upper left panel contains 850 mb fields, including heights (dark contours) temperature (light contours), isotachs (image), and wind (barbs). Upper right panel contains 500 mb fields, including heights (dark contours) temperature (light contours), vorticity (light contours), isotachs (image), and wind (barbs). Lower left panel contains 1000-850 mb mean RH (image) and 12 hour accumulated precipitation. Lower right panel contains 250 mb fields, including heights (dark contours) 700-500 mb mean Omega (light contours), isotachs (image), and wind (barbs). Additional fields (not displayed) are depicted schematically in Fig. 2.*

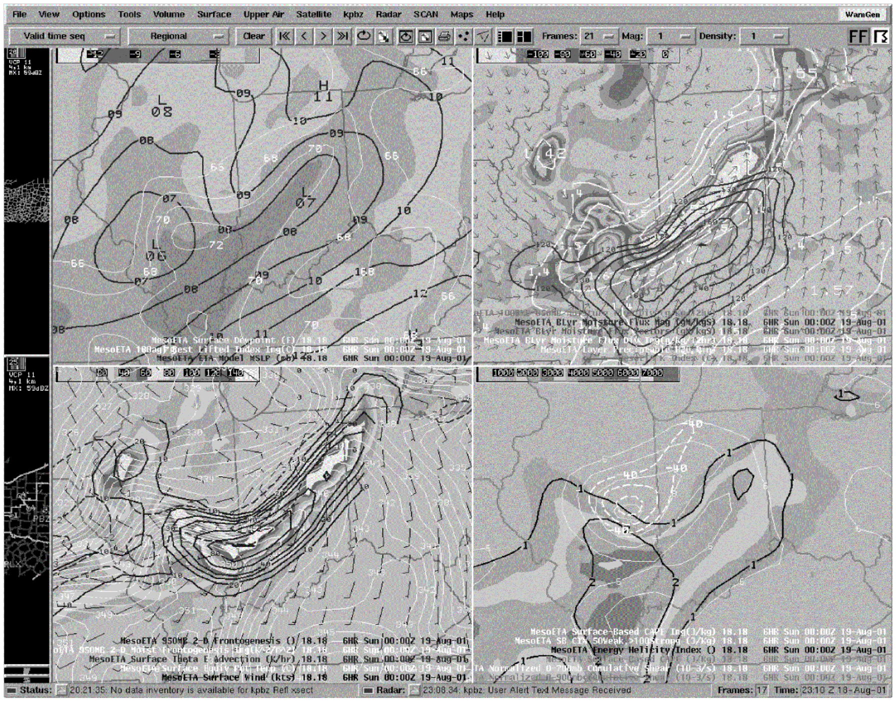

Figure 4*. Low-level forecast fields corresponding to Fig. 3. Upper left panel contains MSLP, dew points > 66°F(light contours), and Best LI (image). Upper right panel indicates BL moisture flux, flux convergence (image), flux magnitudes (dark contours), and PW > 1.4 in. Lower left panel shows theta-e (light contours), theta-e advection, and 2D 1000-950 mb frontogenesis (image). Lower right panel depicts surface-based CAPE (image), CIN (dashed contours), EHI (dark contours), and surface-700 mb normalized cumulative shear.*

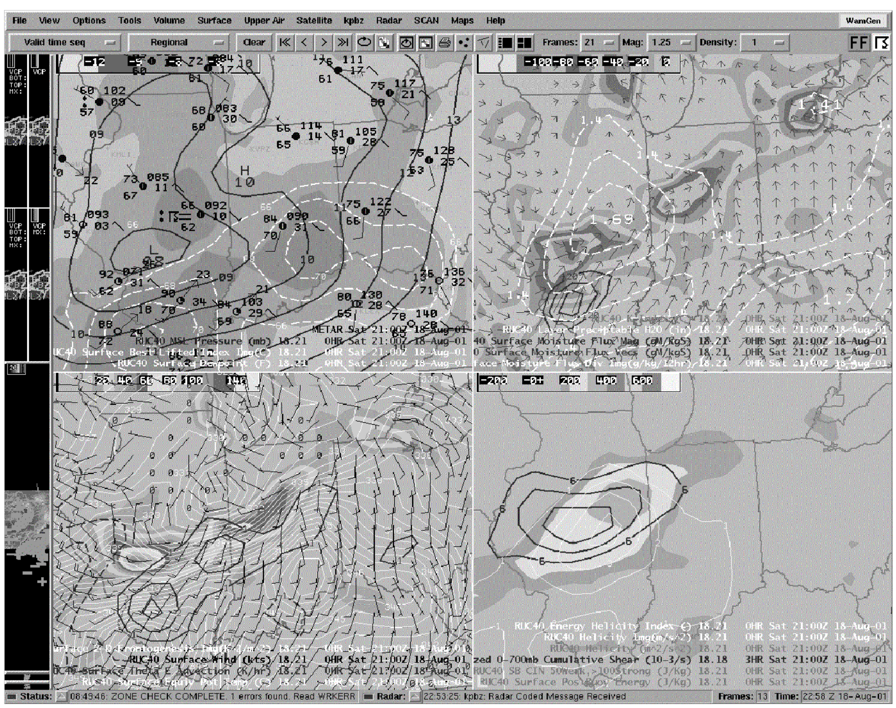

Figure 6. *Low-level analysis fields from the 40 km RUC. Meteorological fields are similar to those in Fig. 3, but with the inclusion of METARS in upper left panel.*

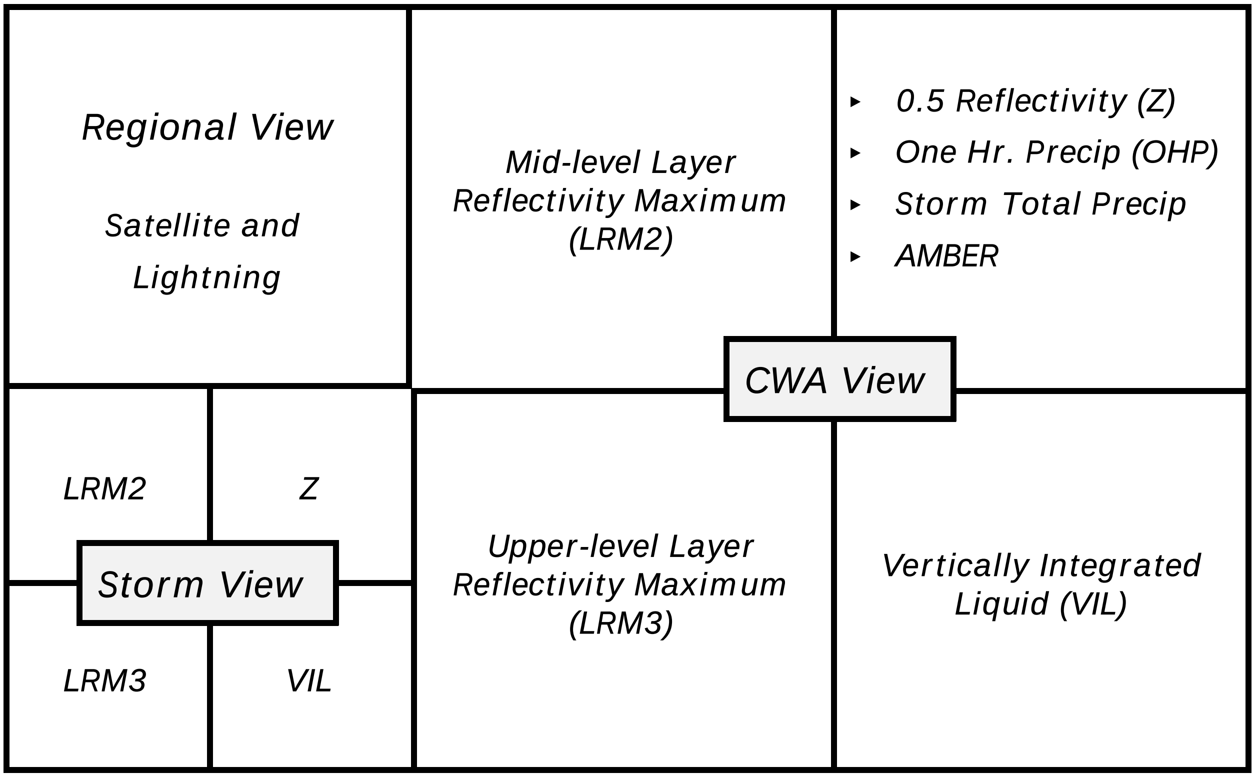

Figure 7. *Radar display template for right D2D screen.*

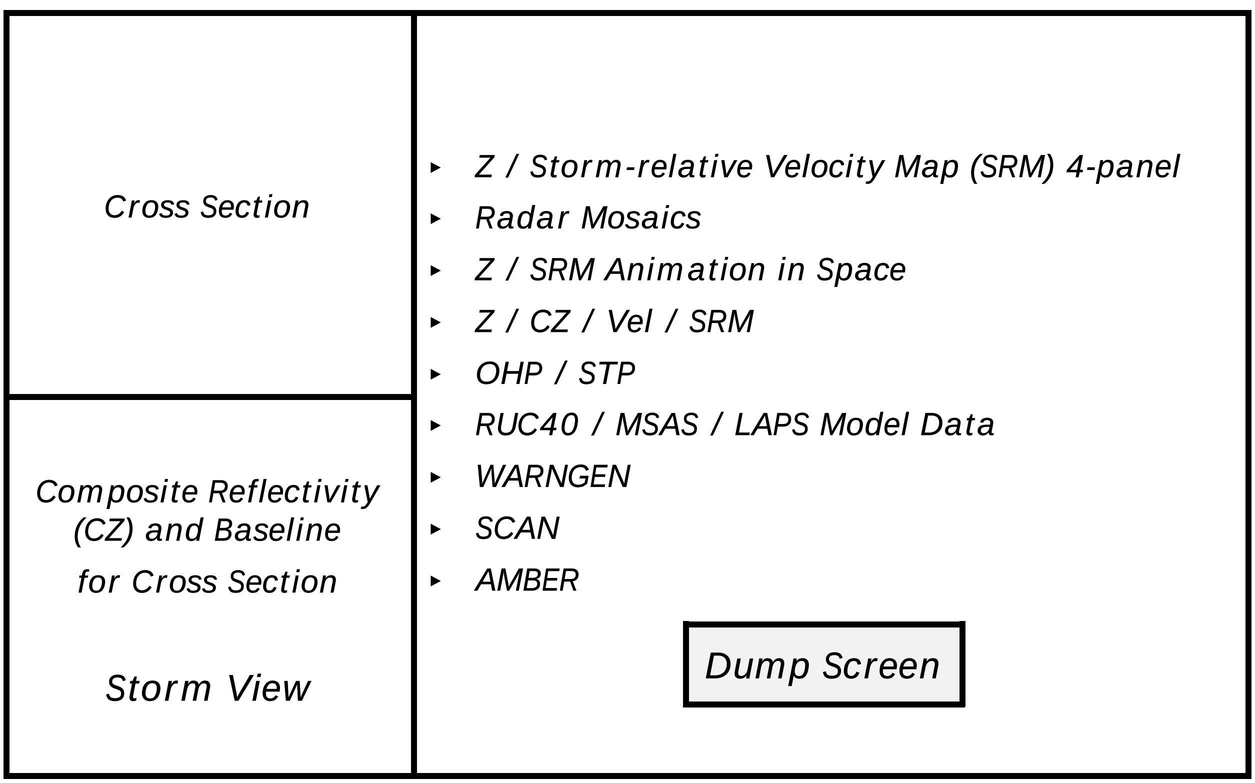

Figure 8. *Radar display template for left D2D screen.*

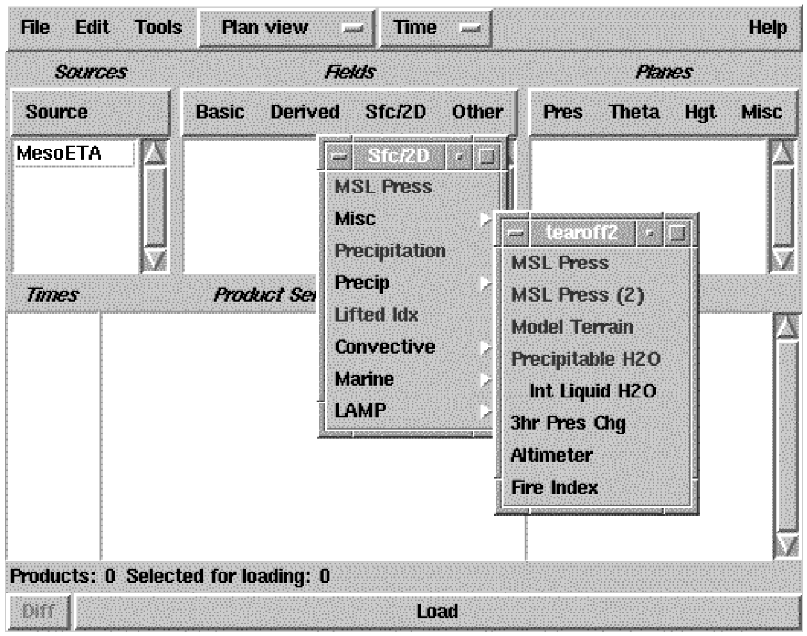

Figure 9. *Default Volume Browser for AWIPS Build 5x.*

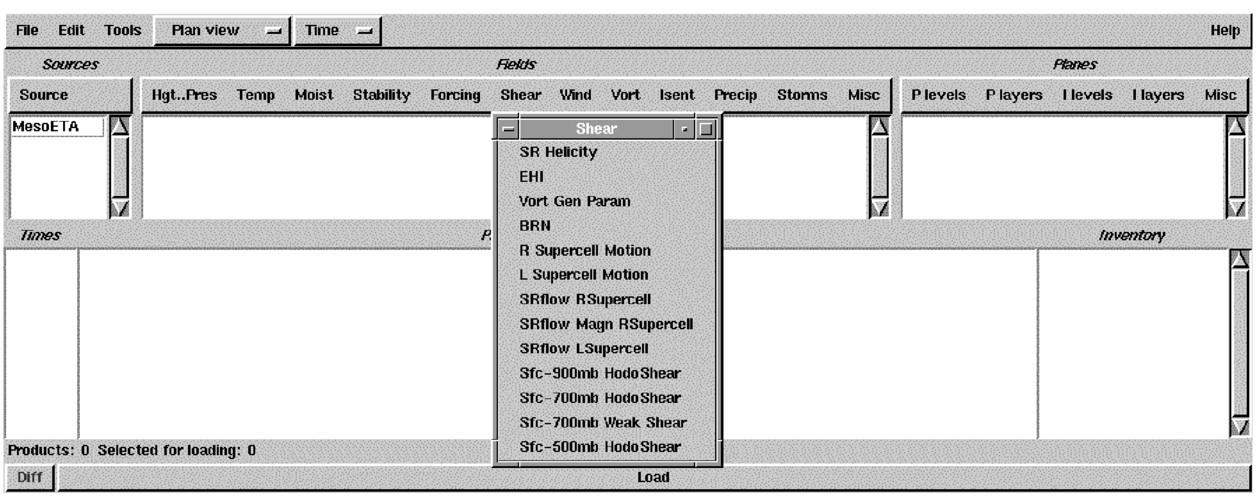

Figure 10. *Process-oriented Volume Browser.*