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## 1. INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory (FSL) has been developing FX-Net, a weather visualization software package, as a low cost clone of the graphical meteorological display window of an Advanced Weather Interactive Processing System (AWIPS) workstation. Madine and Wang (1999) discussed the architecture of this Internet delivery system that easily works on current generation personal computers with fast Internet access.

For over two years, the Plymouth State College (PSC) meteorology program has been beta testing and incorporating FX-Net into its curriculum. Koermer et al. (2001) reviewed the details of implementing this tool at PSC. As a beta test site, PSC has been able to provide "many eyes" to test the thousands of combinations of possible display features and evaluate the overall functionality of FX-Net. As a result, they have been able to provide timely feedback to assist FSL in improving performance and the capabilities of their software. PSC students have also written an online users manual for this system (Dumont et al., 2001) that is now an integral part of the "Help" feature of the FX-Net. This manual is updated to reflect new features as they become available.

This paper will focus on the need for and the benefits of the FX-NET package for the education and training of current and future meteorologists. We will also mention some of the operational benefits of such a system.

## 2. THE NEED FOR AN FX-NET CAPABILITY

Throughout most of the latter part of the 1980s and well into the 1990s, many universities and even some small colleges with atmospheric

science or meteorology programs had graphical interactive workstations with near real-time display capabilities that often exceeded those of the operational forecasters in the National Weather Service (NWS). The Unidata Program Office served as a focal point and provided assistance to many institutions with expertise and visualization software packages, such as, McIDAS, WXP, and GEMPAK. They also helped the institutions with acquiring McIDAS, DDPLUS, and DIFAX data—initially by satellite receives and later through the Internet Data Distribution (IDD) network using Unidata's Local Data Manager (LDM) software.

With the implementation of AWIPS, the NWS offices generally caught up with and in some ways exceeded a portion of the capabilities previously found in the university community. Although it doesn't offer quite the flexibility and programmability of the university packages, it does provide numerous capabilities to display current weather and forecast data. The FX-Net attempts to echo that capability in the form of a low cost, Internet-based workstation.

FX-Net particular fills the AWIPS niche as a tool for education and training. There are no large clusters of AWIPS workstations that can be used for training groups of more than a few people at a time. However, for less than the cost of a single AWIPS workstation, an FX-Net cluster of computers could be acquired and used for such things as regional training workshops. One such workshop took place in Albany, NY, in June 2000.

At the university/college level, FX-Net provides a very easy-to-use interface for students to access current observations and forecast model data. Most students can quickly learn the features or can easily find out how to use them or more advanced capabilities from the online users manual. At PSC, first-year meteorology majors receive a short introduction to FX-Net during their freshman orientation course. FX-Net has now become an integral part of the curriculum (Koermer et al., 2001) and it provides PSC

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students with an AWIPS-like visualization tool that should make for an easy transition for graduates that join the NWS to become operational forecasters.

Besides filling an education/training need, FX-Net can be used to support some limited NWS operational needs. It can be used as a weather visualization tool for small offices or operations where an AWIPS system is not feasible or practical. It can also be used for temporary support requirements. For example, it will be used for NOAA support to the disperse venues of the Winter Olympics that will take place this winter in the Salt Lake City area.

### **3. RECENT CAPABILITY ENHANCEMENTS**

FSL implemented a number of significant enhancements to the FX-Net hardware and software over the past year that have made it a much more reliable and capable system. Many of the problems and shortcomings previously cited by Koermer et al, (2001) have been remedied with various solutions.

On the hardware-side, FSL installed a powerful new server to support the FX-Net. Since this is an Internet-based system, there are many demands placed on the server, especially when you may have up to 16 simultaneous requests for data from PSC alone. The old server seemed to become overburdened with more than 8 users. Because of thrashing and timeouts, the experience could often be frustrating with larger groups. However, a new server was installed during the summer of 2001 and it now seems to be able to handle PSC classes utilizing their cluster's 16 PC workstations. This was a very important improvement because of a newly added ability to access CONUS NEXRAD radar products that will be discussed later.

The software has also seen some major improvements over the past year. Some of the changes have been behind the scenes in how data are handled, but many have added significant new display capabilities that previously were not available and without which somewhat limited the usefulness of the FX-Net in some areas.

On the server-side software, FSL devised new methods of handling and processing. They included additional compression and improved data compression techniques to make the product sizes smaller to speed up Internet transmission. As an example, some improvement has been seen in the receipt of color-contoured products that used to take a very long time to receive at PSC after submitting a request to the server.

On the client workstation side, there have been some very significant improvements, especially, in added capabilities to display data previously unavailable over the FX-Net. The three areas most dramatically enhanced were in radar, surface, and upper air products.

Some of these improvements, were a change in the local workstation setup. In earlier versions, the FX-Net workstation was configured for a specific local region. The PSC workstations were configured as though they were the GYX (Gray, ME) NWS weather forecast office. This meant that regional and zoomed maps were only available for this region of the northeast. With this older version of FX-Net, PSC was only able to access GYX (Gray, ME), radar. The display was quite coarse (pixilated); radar products were primarily limited to one level of base reflectivity; and the data were slow loading. For education and training purposes, it also restricted you from using the workstations to study radar data in other parts of the country, where some more interesting weather may be occurring. Earlier restrictions on NIDS dissemination played a role in the earlier FX-Net radar capabilities.

With the removal of these restrictions and this summer's release, now called "FX-Net – National", many of those obstacles were eliminated. It provides the capability to access a "Radar Chooser" map for CONUS that consists of the latest Radar Control Message (RCM) summary data and the identifiers of CONUS radar sites. By clicking on any location on the map, the nearest NEXRAD radar site becomes the "Home Radar" and currently you can access any of the six products currently disseminated over NOAAPORT. This product list will expand when additional NEXRAD products are added to the data stream. The image resolution of these radar has also been greatly improved and PSC has been able to load eight frames of these data for these sites in as little as 10 seconds--very good performance. The radar chooser capability allows users to go where the active weather is located, a feature that is very important for using a real-time display system for education and training purposes.

Although FX-Net still currently lacks a NOWRAD-type composite, it does now allow the user to generate RCM radar displays, upon which, a user can overlay other data, such as, surface observations, lightning strike data, etc. There was no similar radar display capability with previous versions.

Perhaps, the next most important area of improvement in FX-Net is with the additional

surface features that are now available to users. Many of these data, previously available to PSC only on DIFAX charts, can now be displayed with FX-Net. Some items include analyzed and forecast positions of fronts and pressure features; MOS data; and UKMET and ECMWF surface analysis. These displays can be used individually or in an overlay mode with many other FX-Net products. From there, as with other displays, a user can toggle on/off various layers of the overlay, zoom in/out, or animate multiple frames of data. This provides for a very flexible and interactive display of "map room" kinds of products and is a very useful instructional tool for understanding and interpreting various surface products.

The "Upper Air" menu has also greatly expanded with the latest version of FX-Net. With the older version, a user was primarily limited to getting skew-T log-P plots of radiosonde observations. Now you can get constant pressure level plots of radiosonde data or the plotted NCEP data; height-time cross-sections of profiler data; and some model graphics including some trajectory selection. Again, this helps bring some DIFAX products to life on an interactive display system and provides new features not readily available from previous sources. The standard FX-Net features again provide superb methods of relating products in an educational environment.

Another feature now working well with FX-Net is the ability of a user to create pre-defined "procedures" as you can on an AWIPS workstation. With this capability, a user can display a composite of products with a single click. Map controls have also been enhanced to allow users to interactively change colors of the map features as well as the meteorological data. Color bars legends have also been added to color contoured products and satellite imagery displays.

Although not connected to the display of meteorological data, another very important improvement has been in the installation package of the software. FSL now uses the Windows Install Shield with FX-Net. This checks for existing previous or current versions of the FX-Net and supporting JAVA software and will upgrade both. The procedure is similar to the installation of a good commercial software package for Windows and it only takes a few minutes per PC. This means that even a non-dedicated cluster of networked computers could be set up quickly for a training session.

For a more permanent configuration, the ease and speed of installation greatly reduces system administrator requirements, since anyone

even remotely familiar with Windows should be able to easily install this package. This has been very important at PSC, since the meteorology program does not have a dedicated information technologist for its computers.

All of these enhancements and additions have made the FX-Net an excellent tool for meteorological education and training.

#### **4. CURRENT LIMITATIONS**

As with any Internet-based data delivery system, FX-Net is only as good as the bandwidth and connectivity allow. For the most part, FX-Net has performed well at PSC. Naturally, it performs best during slower network periods during the morning and evening and worst during the afternoons, when Internet traffic is at its peak. Local network difficulties have sometimes posed problems, but these can usually be readily and quickly resolved. The biggest problems encountered seem to be elsewhere along the Internet path between Boulder, CO, and Plymouth, NH, often far removed from either site. Although most times, those bottlenecks often get corrected without intervention, sometimes Internet service providers have more significant problems that take longer to address.

An application area that could use improvement is in the area of vertical cross-sections of model data. Currently, FX-Net allows a user to choose only cross-sections either aligned west to east or north to south. The lateral cross-section domain was also restricted to that of pre-defined map regions. Sometimes, a user would like to see another orientation across the data and over a narrower or broader domain. This shortcoming is currently being addressed at FSL at the time of this writing and an interactive cross-section chooser is being developed that will allow a user to select starting and ending points for a cross-section on a map. This enhancement will make an already strong cross-section display capability even better. This will definitely aid in the teaching of courses, such as synoptic meteorology and atmospheric thermodynamics, where cross-sections play an important role in the instructional process.

Outside of Internet slowdown issues, the main products that still need to be generated faster are colored contour maps of model data. Although as mentioned before, performance in this area has improved and the model graphics with the new color bar and interactive color adjustment capabilities are quite impressive, generating color

contours still remains too slow for more frequent and general use.

The final major current limitations are the lack of somewhat related facilities for data archival, printing, and scripting. If a user comes across an interesting case that he/she would like to recall at a later time, the only option is to do a window capture with a separate graphics program. This other software would also be the only way to print a display. For one or two maps, this is not overly burdensome, but it would be if an instructor was trying to build a case study. Relating to archiving, scripting would be a nice feature to be able to capture certain events that may occur at inopportune times. Scripting would be less important, if there was a capability to access archived historical data directly with FX-Net. This option is being studied by FSL.

## 5. SUMMARY

The FX-Net weather visualization package offers an excellent and affordable way to present meteorological education and training using real-time weather data. The software does not require any specialized hardware, other than a current generation PC and a fast Internet connection. It installs very easily and quickly without the need for any real technical expertise. Training clusters for regional workshops at a wide variety of possible venues could be set up and computers configured in minimal time without any specialized preparation. FX-Net can also play a significant role in supporting some smaller scale or temporary NOAA forecast operations.

Besides these obvious administrative benefits, the latest releases of FX-Net software have removed many of the previous limitations

and provided enhanced capabilities for radar, surface, and upper air displays. These have made it a very comprehensive tool for the graphical viewing of real-time weather information.

Some limitations still exist with Internet connectivity and reliability. However, FSL is addressing most of the remaining software-related issues, such as, improved cross-section generation features, as their resources permit. Even with the few existing limitations, FX-Net is an extremely strong tool for meteorological education and training.

## 6. REFERENCES

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