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A NEW GENERATION OF WEB-BASED WEATHER PRODUCTS FOR EDUCATION AND FORECASTING

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(<http://ww2010.atmos.uiuc.edu/>)

1. Introduction

It isn't much of a feat anymore to put weather maps and images on the Web. It has clearly "been done" many times over. Despite the large number of sites offering such products or how extensive some of them are, there is still room for improvement. The result of two years of development, we have created an entirely new suite of web-based weather products that offer many improvements over existing products.

2. Design Goals / Specific Improvements

Legibility: One of our primary goals was to offer improved legibility. Generally, the legends, annotation of contour lines and other features on weather maps found on the web are in tiny, fuzzy vector-based fonts that are sometimes completely illegible. Instead we've employed high-quality rendered fonts, ensured that they are sufficiently large, tried to minimize over-plotting of labels, and have employed techniques such as drop shadow effects to make labels stand out. The legibility of non-text graphical features is also very important and to that end we've given careful consideration to avoid having too many contour lines, too many overlays, and other sources of visual clutter that impair legibility.

Representation: For each product we took great care to choose appropriate representations, combinations of fields and colors. We asked what each type of product is useful for and whether the representation chosen (contour lines, color-filled contours, vectors, plotted data, etc.) makes those features clearly visible. A 300mb upper air map, for example, is primarily used to

locate the jet stream, so the jet stream ought to be the most clearly evident feature of the map. We asked "Should this field be a color-filled contour and the other field be contour lines overlaid or vice-versa? What is easier to see?" And realizing that the rainbow color map is not universally ideal, we designed customized color maps for each specific color-filled contour plot, satellite enhancement, and so forth, again to emphasize important features of the map. For example, for color-filled contours of surface dew point, "wetter" colors (like green and blue) are used for high dew points, and "drier" colors such as tan are used for areas of low humidity. No shading at all is used for areas of extremely low humidity where the data values are mostly noise.

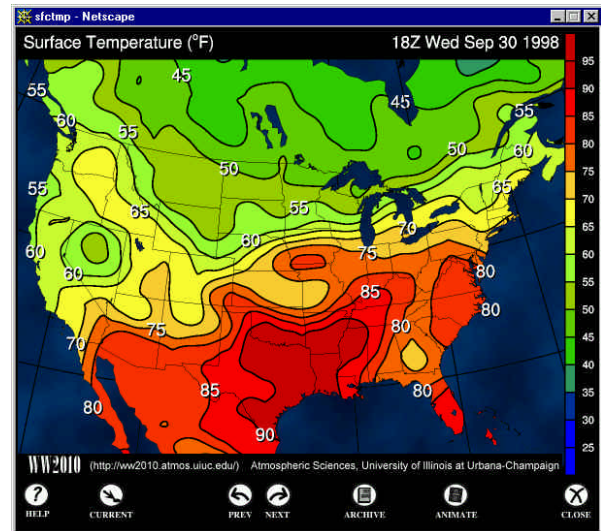


Figure 1: Showing an example product inside the product-viewing window.

Web Access: We gave much thought to how these products would be accessed from the web. Because our experience has been that web sites with simple layouts are both easier and faster to use, we decided to keep the access to these products simple. The main access page is divided into broad categories such as Surface, Upper Air, Satellite, etc., which are further subdivided into logically arranged groupings. Simple text-based links without lots of extraneous

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graphics are provided for the fastest access. Clicking on a link brings up a product-viewing window (shown in Figure 1). Controls at the bottom of the window allow the user to move to the next or previous image in time, bring up an inventory of archived images to choose from, animate the image, request help text or close that product-viewing window. The user can decide if a new product viewer is launched for each product requested from the main window or if the image is replaced in the current product viewer. The former allows multiple products to be viewed side by side if one's display is large enough.

Printing: It is often desirable to print a hardcopy of a weather map that one is viewing on the web. However, no matter how nice a graphic may look on the screen, the results of invoking the print function of one's web browser are often less than optimal. Printed GIF images tend to look very grainy. This is due to the great difference in resolution between the screen, which the GIF images are formatted for, and the printer. When the printer has to use patterns of dots to represent different colors (dithering), this compounds the problem. There is also the problem of printing a colored image on a grayscale printer. Perfectly legible yellow text on a blue background becomes a considerably less legible lighter gray text over a darker gray background. Maps with dark backgrounds can quickly wear out toner and ink cartridges. And finally, the size of the image often is not appropriate for a standard letter size page.

We've attempted to address these problems by giving the user the option to request one of several printable versions of each map. These are available in either color or black and white/grayscale friendly versions with printer friendly backgrounds and are oriented and scaled to efficiently fill the printable area of the page. To combat the problem of printing grainy GIF images, the printable version is available in both the Adobe Postscript or PDF (Portable Document Format) formats. Rather than contain a fixed-resolution bitmap of the whole image, these files contain the drawing commands to produce the image. This allows the printer to render text, annotations, lines, symbols, etc at the printer's full resolution for very crisp looking output. Postscript is intended for those with Postscript capable printers. For those without Postscript capable printers, the PDF format is provided. Adobe's freely available and commonly used Acrobat reader can open these PDF files and format them for any sort of common printer.

Integration of Archived Data: Most weather product web sites only carry the most recent hour or last day's worth of products. Frequently we wish to access recent (in the last week or two) but not necessarily current data for instructional purposes. We also frequently need to access archived older data for the purposes of doing case studies (assigned as projects in several of our undergraduate and graduate classes). We wanted to create an environment that seamlessly integrates the presentation of current, recent, and archived data.

Selecting a particular product brings up the most recent image. A previous button successively recalls the previous image. An archive button displays a directory of recent products still available online (the online retention time for products varies with available disk space, but up to a month is typical). This directory is also available in pictorial format as a time series of tiny images. Although too small to see much detail, one can often still locate the relative position of fronts and other synoptic scale features and decide which hour would be the most appropriate to start with (based for example on the front passing through the area of interest at that time).

The administrator can grant any period of data protected status such that it is not automatically purged from the system. Collections of data from significant events can be preserved online for future study.

For older data no longer stored online, the system is set up such that the raw data files can be loaded from tape by the administrator and then be automatically reprocessed in the same manner that current data is and added to the current online inventory of products.

Integrated explanations: You can show someone a map, but that doesn't mean they will understand what it is showing or how to meaningfully interpret it. While primarily intended for internal college-level instructional and forecasting use, the large majority of our audience tends to be students and other individuals with no prior background in meteorology. These users frequently have questions (the lack of answers to which impedes their understanding) such as what the colors in an enhanced infrared satellite image mean, or the difference between cold, warm and stationary fronts. Even long-time students of meteorology often don't understand how to best interpret advanced products such as isentropic analyses.

This is why every single weather product is tightly integrated with instructional material. An ever present help button brings up a page describing in detail the fields shown on the map, what the map is useful for, and shows examples of notable cases that best illustrate this. Many of the terms and concepts in this description are hyperlinked to concise definitions, which in turn have links to more detailed discussions on particular topics in our WW2010 Server framework. (See Figure 2)

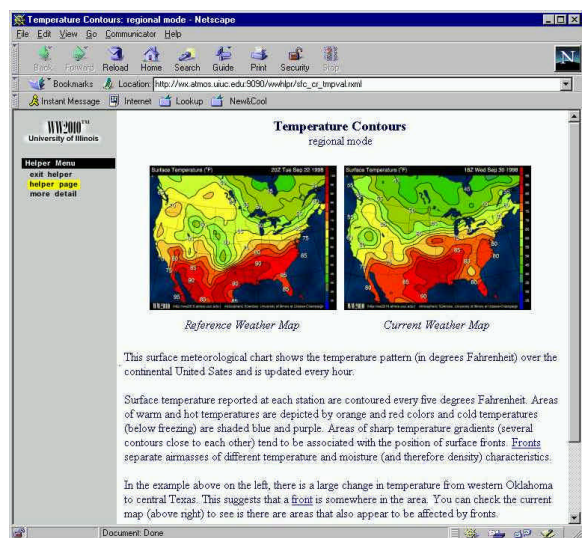


Figure 2: Example of an integrated product description page

Aesthetic Qualities: While not necessarily important from a purely scientific point of view, the process of generating such weather products is somewhat of an art and aesthetic qualities count (although accuracy and understanding necessarily take precedence). Nicer looking images better hold the attention of students and aid in comprehension. Another consideration was the potential use of a customized set of these products as television weather graphics in collaboration with our on-campus PBS affiliate, WILL-TV.

3. Implementation

Unfortunately, in trying to accomplish these many goals, we found after several months of experimentation that existing UNIDATA¹ provided meteorological analysis packages such as WXP², GEMPAK³ and McIDAS⁴ were limited in their

¹ <http://www.unidata.ucar.edu/>

² <http://wpx.eas.purdue.edu/>

³ <http://www.unidata.ucar.edu/packages/gempak>

⁴ <http://www.unidata.ucar.edu/packages/mcidas>

flexibility and extensibility. Therefore, we decided to build our own software package, leveraging where possible off of existing packages.

GEMPAK: The data processing back-end of our system is based on GEMPAK. Although we first experimented with our own code to convert and (re)grid raw observations and model output we decided to take advantage of GEMPAK's extensive capabilities. It can convert raw observations and perform objective analysis on them as well as perform many operations on grids (both on analyzed observations and already gridded model output) and derive fields from them. We encapsulated the needed functionality into several Perl scripts that call the individual GEMPAK programs in sequence to convert and grid raw observations, convert NWS model output GRIB grid files, regridding as necessary and to calculate derived fields (such as vorticity) as needed. To this we added some extra executables to perform a quality control step on observational data (to statistically eliminate bad values) and to output station and gridded data in a highly compressed, easily accessible format for use by our plotting programs. These scripts are run hourly as needed to preprocess incoming data as well as on demand to reprocess archived older raw data.

NCAR Graphics: To produce the graphics we turned to the NCAR Graphics⁵. Although many (even long time users) mistakenly consider this package to be nothing more than a bunch of hard-to-use, dusty, old FORTRAN subroutines to draw basic black and white contour plots, this is hardly the case. NCAR Graphics offers a rich set of highly customizable meteorological map production oriented graphic capabilities. Sadly, few take full advantage of them. NCAR Graphics' contouring algorithms are still some of the best around. For example, it goes to great lengths to ensure that contour labels are spaced and positioned in the best manner possible. A large variety of map projections are possible. Most of the capabilities are highly customizable. Individual components of the base map can be turned on or off or customized, individual contours can be drawn differently. Contours and vectors can be plotted only in specific geographic area (making it easy to make a surface temperature map with color filled contours that extends only over land area, leaving the oceans a solid blue color for example).

⁵ <http://ngwww.ucar.edu/>

Perl: Unfortunately, having to write lengthy FORTRAN (or C) programs for each specific map proved to be too time consuming for rapid development. This was especially the case since when one was repeatedly compiling the code (slow due to the size of the libraries), running the executables and viewing the output to try different things. To speed this process we created a Perl⁶ binding for NCAR Graphics, linking the NCAR libraries directly to the Perl interpreter so that the NCAR subroutine calls become directly callable as Perl subroutines. (NCAR Graphics' High Level Utilities [HLU] and NCAR Command Language [NCL] were considered and tried but not used for reasons there is insufficient space here to detail.) Although Perl is much slower than a compiled language like FORTRAN, this is not an issue here because all Perl is doing is controlling the basic flow of operations...the computationally intensive parts (such as the NCAR library code and additional code we added) were still in processor-native compiled form.

By taking advantage of the fact that Perl scripts require no compilation and by using NCAR Graphics' underutilized ability to output graphics directly to an X display on the fly (rather than by using metafiles) we were able to greatly reduce the cycle time for experimentation. Simply edit, run and quickly see the results. The many low-level NCAR calls needed to produce a complicated plot were further encapsulated into higher level routines. A basic script to produce a plot consists, for example, of only a short list of high-level function calls to open the plot, set the map parameters, contour a field, overlay another field and close the plot.

Of course, NCAR Graphics didn't do everything we needed to do. Two such things were the incorporation of satellite and radar imagery. To bring both data types into the NCAR arena, we added code to convert these formats (McIDAS Area files and WSI NOWRAD Mosaics) into NCAR Graphics cell arrays, which can be projected onto a map in any way desired and contoured over, etc. Additional enhancement included adding additional important outlines to NCAR Graphics map database (such as the notably missing Canadian province boundaries).

To achieve the highest quality output, direct output to Postscript is used. This bypasses the lower quality vector-based fonts that metafile output involves. A series of post processing

steps renders the Postscript data into GIF images. Anti-aliasing combined with very careful color reduction (as the resulting images have many more than the 256 colors allowed by the GIF format) are employed to achieve further aesthetic gains when producing GIF images. Otherwise the Postscript is directly available for printing or may be converted to PDF format as mentioned previously.

4. Future Work

Interactive Product Builder: This tool will allow the user to interactively choose the fields to be overlaid and to be able to interactively adjust the transparency such that a color-filled contour field would still be visible behind a semi-transparent satellite image for example.

VRML: We plan to offer three-dimensional representations such as isosurfaces and cross sections of several kinds of current weather data in VRML (Virtual Reality Modeling Language) format. With the appropriate plug-in viewer, the user can rotate the objects to examine them from any angle. (Ramamurthy, 1999)

5. Additional Information

Additional information and the weather products themselves can be found on our Weather World 2010 web site under the current weather section.

<http://ww2010.atmos.uiuc.edu/>

See Also:

Bramer, et al., 1999: Integrating Real-Time Weather Into An Internet Learning Environment: WW2010 Current Weather Products. *Proceedings of the 8th Symposium on Education*. Dallas, Texas, American Meteorological Society.

Plutchak, et al., 1999: Advanced Multimedia for Education on the Internet. *Proceedings of the 15th IIPS Symposium*. Dallas, Texas, American Meteorological Society.

Ramamurthy, et al., 1999: A Virtual Reality Learning Environment. *Proceedings of the 8th Symposium on Education*. Dallas, Texas, American Meteorological Society.

⁶ <http://www.perl.com/>