

## 8.12 A powerful and easy-to-use weather display tool for PCs and Macs

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### 1. INTRODUCTION

The Oklahoma Climatological Survey (OCS) has developed high-quality, easy to use software for displaying real-time and archived weather data. Called WeatherScope, this software includes visualization of surface observations, radar data, gridded data, lightning, and other GIS datasets. WeatherScope can be downloaded freely for non-profit use at <http://sdg.ocs.ou.edu>.

### 2. WEATHERSCOPE CAPABILITIES

To aid customers in viewing weather information on their personal computers (PC), OCS software engineers have developed WeatherScope. WeatherScope is a stand-alone HTTP-based display and analysis tool that operates on Microsoft Windows 2000/XP and Apple Macintosh OS X. WeatherScope is written in C++ and employs OpenGL visualization tools. It can be used for many applications in meteorology, geosciences, and geography.

Originally designed to display Oklahoma weather information, WeatherScope can display weather and geographical information as data plots, wind vectors, color contours, or line contours from sources both within and outside Oklahoma. WeatherScope can update data automatically in real-time, or the user may specify the date and time of the map to examine archived datasets. WeatherScope also produces time-series graphs of data.

#### 2.1 Design

A primary design goal for OCS's software development group is to generate visual displays dynamically on a client PC rather than rendering images on a server. As a result, data are served to the customer in a more timely fashion because the server does not have to render a large number of permutations of possible display products. In addition, graphics processing cycles

are distributed to client machines, allowing server-side processing to focus on ingest and quality assurance of data files.

Another design goal of WeatherScope is its tight focus on the display of real-time and archived weather data. Although the software will display other georeferenced data, WeatherScope does not attempt to perform complex spatial queries as those found in traditional geographic information system (GIS) packages.

WeatherScope also is designed to be cross-platform. OCS customers primarily utilize Apple Macintosh computers or Intel-based computers. Rather than supplementing the large number of workstation-based display packages used by the university or government meteorological communities, WeatherScope is intended for use by non-meteorologists on inexpensive computers typically found in the office or home environments.

#### 2.2 General Features

WeatherScope can display geographical weather data as a continuous field in either vector, gradient, or point data displays. After data are downloaded to the user's PC, images are created via an XML file that can be customized by the decision maker through a user interface. Geographic overlays and data are displayed, layered, and colored according to the XML file. The file also contains information about the map projection, font type and size, line or symbol size, zoom level, translucency of the map layer, refresh rate, and the data source.

WeatherScope displays point data with known latitude-longitude pairs (Fig. 1), such as surface observations from the Oklahoma Mesonet (Brock et al. 1995), Automated Surface Observing System (ASOS) measurements from the National Weather Service (NWS), radiosonde observations, and lightning strikes. ASCII data files can reside on a remote server or the client's machine.

Radar data from the NWS's NEXt generation RADar (NEXRAD) can be displayed using either Level II or Level III (formerly called "NIDS") data or regional/national mosaics. Level II data in

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NetCDF format, as distributed by the National Climatic Data Center, includes 256 color bins and 16 tilt angles for base reflectivity and base velocity. Level III data includes 16 color bins and four tilts for base reflectivity and two tilts of base velocity. In addition, Level III products include storm-relative velocity, echo tops, 1-h and 3-h precipitation estimates, storm-total rainfall, composite reflectivity, and vertically integrated liquid. Figure 2 demonstrates the visible difference between the Level II and III data for the lowest tilt of base reflectivity at 5:05 PM CDT on 8 May 2003 near Oklahoma City, OK.

Storm attributes are displayed when the user selects the Level III composite reflectivity product (e.g., file in which attributes are embedded by the NWS) and holds the cursor over storm locations (Fig. 3). Similarly, an “inspector window” shows the dBZ value of the base reflectivity when the user selects this product and scrolls the cursor over the region of interest.

Geographic overlays, in ESRI shapefile format, are available for every state in the U.S. and include state and county borders, highways (limited access, principle, and other), urban areas, and U.S. Congressional districts. Currently, WeatherScope supports line shapefiles only (Fig.

4). Point data, such as locations of power plants, communications towers, or schools, can be displayed via an XML-based file format. As geographic information has become more distributed on the Internet, users have expanded the types of spatial features they incorporate into their personal weather maps.

Users can customize WeatherScope maps or graphs by selecting items through the user interface or by generating their own overlays and data sources. Options in the user-interface menus include New Map (or Graph), Save As (e.g., as a PNG, JPEG, TIFF, QuickTime Movie, Photoshop document), animation controls (e.g., play, pause, next frame, first frame), projection (e.g., Lambert Conformal, Mercator, Albers Conic Ellipse), Date/Time, Zoom In/Out, Start/Stop Archiving, Track Real Time, New Product (e.g., Radar, Shape, Symbol, Observation, Image), product properties (e.g., data set, network or station, color, line thickness, opacity), Hide/Show product, layer arrangement (e.g., Move to Front), and Show Inspector, Animator, or Data Manager.

WeatherScope has language localization for both the user interface and associated configuration files. Currently, WeatherScope is configured for English and French.

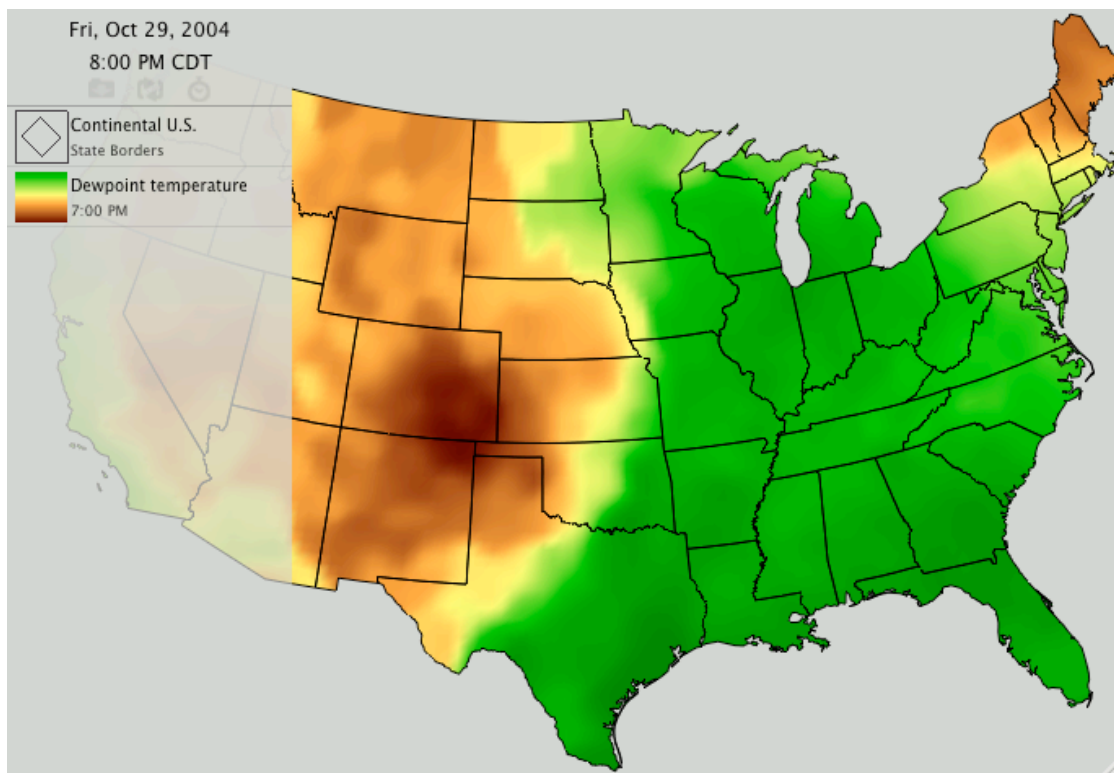


FIG. 1. Example of WeatherScope display of NWS ASOS observations of dewpoint temperature on 29 October 2004. The U.S. geographic overlay is applied as a mask to limit the extent of the color gradient.

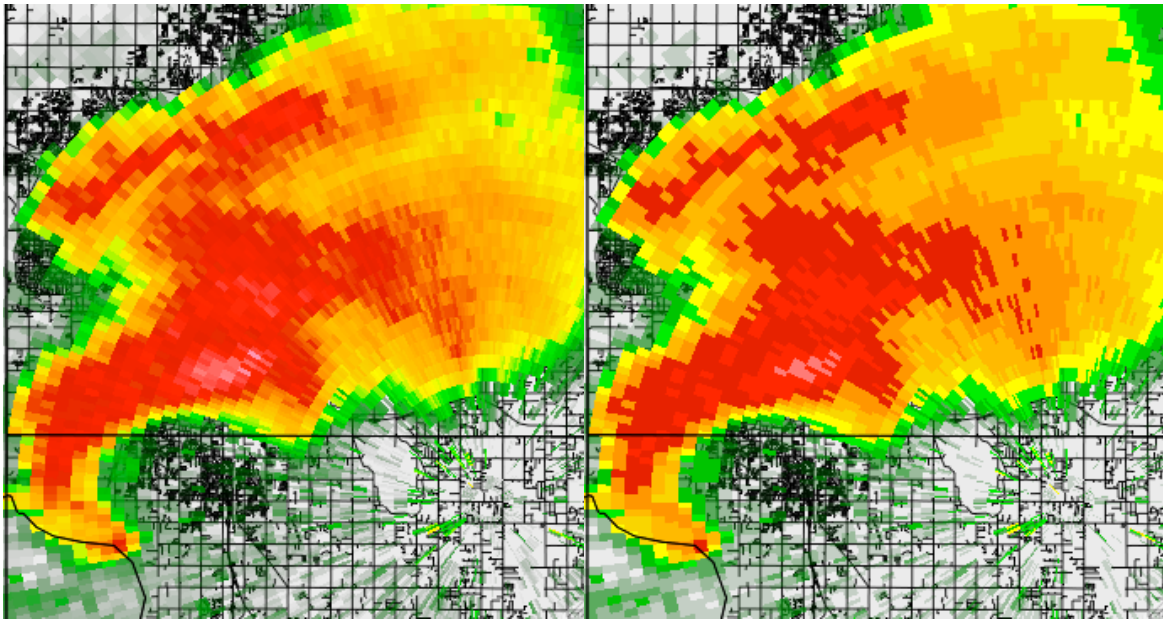


FIG. 2. Example of WeatherScope display of Level II (left) and Level III (right) NEXRAD radar data from KTLX (near Oklahoma City, OK) at 5:05 PM CDT on 8 May 2003. Radar data are displayed with 100% opacity below the county boundaries and above the city streets.

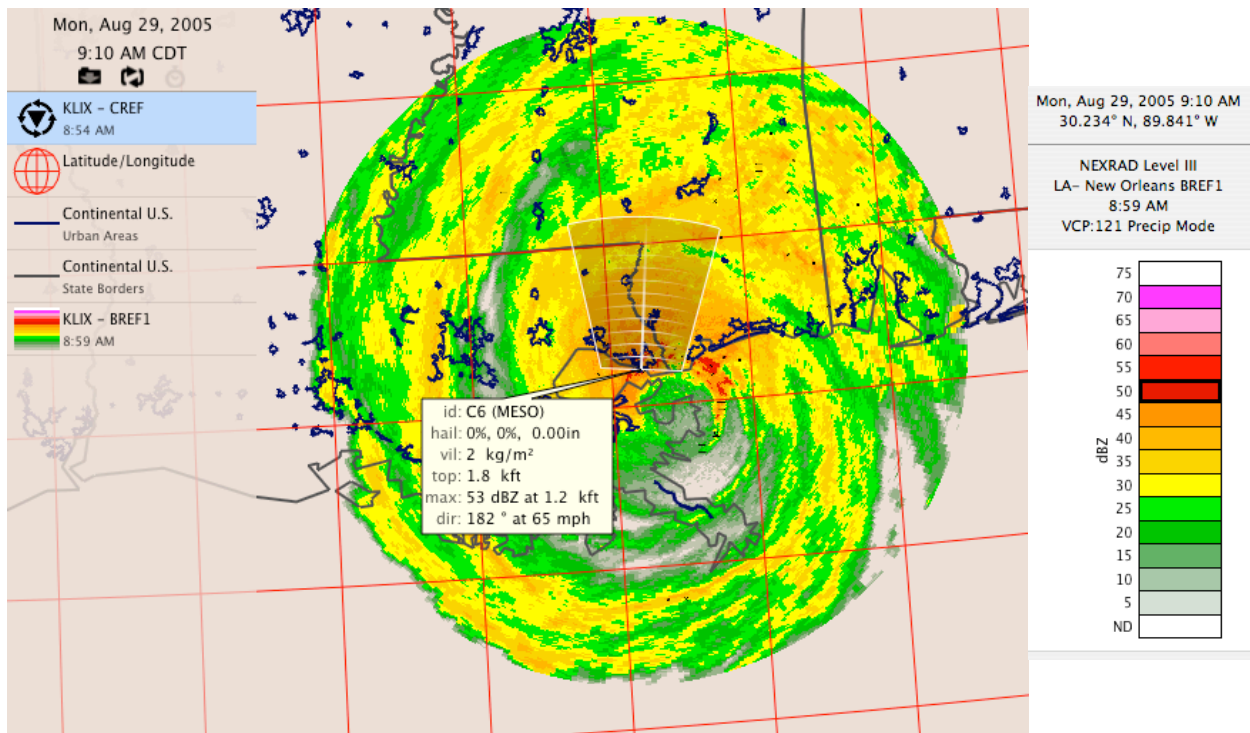


FIG. 3. Example of storm attributes information (middle of map) and WeatherScope inspector window (right of map) for Hurricane Katrina on 29 August 2005. Storm attributes include the storm ID, storm motion, maximum reflectivity (in dBZ), percent chance of hail (and associated size, if appropriate), and whether the storm has a mesocyclone (MESO) or tornado vortex signature (TVS), as determined by NWS algorithms. Level III radar data from KLIX (New Orleans, LA) are overlain by state borders (grey), urban areas (dark blue), and latitude/longitude lines (red).

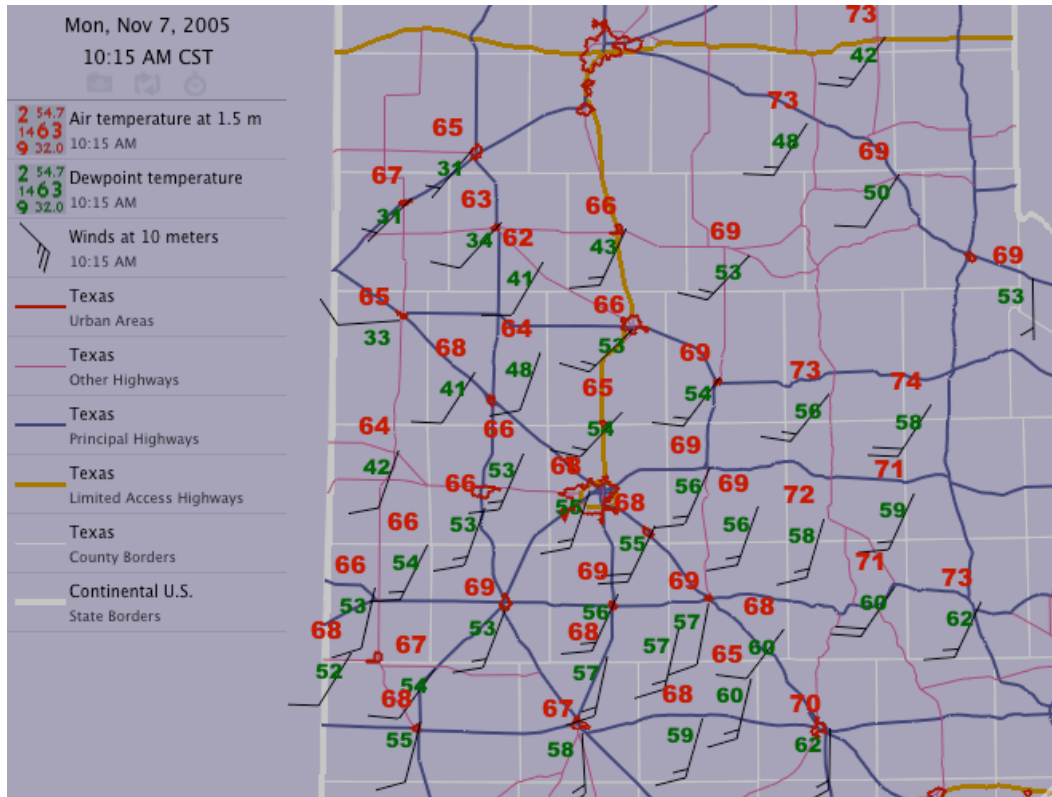


FIG. 4. Example of a WeatherScope map with various geographic overlays, including highways, urban area outlines, and governmental borders. West Texas Mesonet data are plotted for 10:15 AM CST on 7 November 2005.

### 2.3 Configuration

Configuration of data, network, and geographic overlay sources is straightforward and highly configurable in WeatherScope. A network is defined by a set of XML configuration files. A point-source network, such as ASOS, has three configuration files. The first file describes where the software can find updated network information on the internet. This file includes the location of data files, the location of updates to the configuration files, URLs for information on the data and its producer, and an e-mail address to correspond with the data manager (Fig. 5). The file also includes information on the temporal resolution of the data, how often the program should check for new data, and when the data becomes too old.

A second configuration file provides site information (Fig. 6). This file includes the geographic location of sites, the site names and IDs, and any site-specific configuration

information. The final configuration file defines the variables supplied by the network (Fig. 7). This file includes a variable ID and name, data representation type (e.g., float or integer), and measurement units. Also, derived variables are defined in terms of variable IDs and the WeatherScope algorithm to use for computation. The order of information in the file determines the order in which variables are presented in the user's menu.

These files are utilized when the main WeatherScope XML file is opened by the program. This file, using the extension ".wxscript," describes every feature of the display, including zoom level, window size, and data/overlay layers. For example, Figure 8 shows the .wxscript file used to generate the map displayed in Figure 3.

Radar data have similar configuration files except that the variable information file is replaced by a product information file. This file contains information defining the number of

ordinal data levels, radial vs. cartesian grid, pixel or bin size, and units.

Geographic overlays have a main configuration file similar to those previously mentioned. In addition, a shape information file defines the various shapes available (e.g., square, circle, cross, lightning bolt) for point overlays. Line overlays are in ESRI shapefile format.

Configuration of these files is straightforward, making new data sources easy to include without re-compiling any source code. For data sources not served by OCS, users can generate their own

datasets by creating the XML files that describe the dataset configuration, site information, and variable information. Figure 9 shows a map generated from storm reports issued by the NWS's Storm Prediction Center. This dataset and its display capabilities within WeatherScope were developed by a user, independent of the OCS software development group.

Data, network, and geographic overlays can be changed by the network administrator, resulting in the dynamic update of WeatherScope's configuration when the user connects to the web.

```
<datasetconfig>
  <property id="name" value="NWS Surface Observations"/>
  <property id="provider" value="Oklahoma Climatological Survey" url="http://www.ocs.ou.edu"/>
  <property id="source" value="US National Weather Service" url="http://www.nws.noaa.gov"/>
  <property id="contact" value="OCS Operator" url="mailto:operator@mesonet.org"/>
  <property id="baseUrl" value="http://sdg.ocs.ou.edu/weathersoft/datasets/edu.ou.ocs.asos"/>
  <property id="configUrl" value="/info/config.xml"/>
  <property id="siteInfoUrl" value="/info/siteinfo.xml"/>
  <property id="parmlInfoUrl" value="/info/parminfo.xml"/>
  <property id="dataUrlFormat" value="http://www.mesonet.org/data/public/noaa/metar/mdf/conus/
%04Y_%02m_%02d_%02H_%02M.mdf"/>
  <property id="dataResolution" value="60"/>
  <property id="staleThreshold" value="61"/>
  <property id="minimumCheckThreshold" value="30"/>
</datasetconfig>
```

FIG. 5. Network configuration file for the NWS's Automated Surface Observing System (ASOS) network, as defined for use by WeatherScope.

```
<siteinfo>
  <table>
    <fieldref id="stid" type="string"/>
    <fieldref id="lat" type="float"/>
    <fieldref id="lon" type="float"/>
    <fieldref id="elev" type="float"/>
    <fieldref id="name" type="string"/>
    <record> "kokc", 35.3886, -97.6003, 394, "OKC, Will Rogers World, OK" </record>
    <record> "kjfk", 40.6386, -73.7622, 3, "NYC, Kennedy Int'l, NY" </record>
    <record> "klax", 33.9381, -118.3889, 38, "Los Angeles Int'l Apt, CA" </record>
    <record> "kord", 41.9797, -87.9044, 203, "Chicago-O'Hare Int'l, IL" </record>
    <record> "kiah", 29.9925, -95.3639, 29, "Houston Intercontinental, TX" </record>
    <record> "kdfw", 32.8969, -97.0219, 183, "Dallas-Fort Worth Int'l, TX" </record>
    <record> "kphl", 39.8683, -75.2311, 6, "Philadelphia Int'l, PA" </record>
    ...
  </table>
</siteinfo>
```

FIG. 6. Portion of the site configuration file for the NWS's Automated Surface Observing System (ASOS) network, as defined for use by WeatherScope.

```

<parminfo>
  <parm id="relh" type="float" units="prct" name="relative humidity"/>
  <parm id="r01h" type="float" units="mm" unitset="prec" name="1 hour rainfall"/>
  <parm id="r03h" type="float" units="mm" unitset="prec" name="3 hour rainfall"/>
  <parm id="r24h" type="float" units="mm" unitset="prec" name="24 hour rainfall"/>
  <parm id="tair" type="float" units="cels" name="air temperature"/>
  <parm id="tdew" type="float" units="cels" name="dewpoint temperature"/>
  <parm id="dewd" type="float" units="celsd" name="dewpoint depression"/>
  <parm id="thte" type="float" units="kelv" name="equivalent potential temperature"/>
  <parm id="lat" type="float" units="degr" name="latitude"/>
  <parm id="lon" type="float" units="degr" name="longitude"/>
  <parm id="elev" type="float" units="m" unitset="dist" name="elevation"/>
  <parm id="name" type="string" units="nada" name="site name"/>
  <parm id="stid" type="string" units="nada" name="site ID"/>
  ...
  <derivation id="chil" func="chil" args="tair wspd"/>
  <derivation id="tdew" func="tdew" args="tair relh"/>
  <derivation id="dewd" func="diff" args="tair tdew"/>
  <derivation id="thta" func="thta" args="tair pres"/>
  <derivation id="thte" func="thte" args="tair tdew pres"/>
  ...
  <vector id="wind10m" name="winds at 10 meters" samag="wspd" dir="wdir" ucomp="uwnd"
vcomp="vwnd" gust="wmax"/>
</parminfo>

```

FIG. 7. Portion of the variable configuration file for the NWS's Automated Surface Observing System (ASOS) network, as defined for use by WeatherScope.

## 2.4 Maps

WeatherScope allows the user to produce weather maps according to individual needs. Several kinds of map features are available. A station-model map can be produced with values located at the site location or at one of eight positions adjacent to the site location. The user defines this location as well as the color, font, size, and style of the text. Wind barbs can be created from either wind speed and direction or U and V wind components, also with user-defined colors and sizes. Several symbols are available to indicate site location (e.g., open circle, filled square).

Other data display features include vectors at grid points, continuous color gradients, and line contours, accomplished by performing an objective analysis on point data. The color palette of the color gradient can be customized through the user interface to allow for specific colors to represent specific data values. Geo-referenced images, radar data, and line or point overlays can be combined in data/overlay layers to complete a custom map. These layers can be dragged in different orders within the legend to define its position (i.e., above or below) relative to other layers.

The map projection is chosen by the user and all datasets and overlays, including geo-referenced images, are rendered on-the-fly. Currently available projections include Mercator, Polar Stereographic, Lambert Conformal Conic, Albers Conic Ellipse, Albers Conic Sphere, Orthographic, and flat-earth.

Overlays can be used as "masks" to limit the area of data viewing. Hence, if an overlay mask is above a gradient layer, then only the data within the extent of the overlay will be shown (e.g., Fig. 1). The opacity of layers also is user configurable. For example, radar data may overlay point data, but if opacity is set to less than 100%, then the point data are allowed to show through.

## 2.5 Graphs

To make a time-series graph, the user defines start and end times and the variables and sites to display (Fig. 10). Multiple variables and multiple sites can be displayed on a single graph. The data range for each axis can be set by the user or will be determined by the software according to the range of data selected. Also, the color and thickness of the plotted lines are customizable. Symbols are available to help denote data points.

```

<?wxscript version="1.2d1" encoding="UTF-8"?>
<?FxWindow frameBounds="17,48,717,558"?>
<wxscript>
  <map color="#E6D7CDFF" date="2005-08-29 14:10:00 UTC" fieldOfView="138.181" scale="1.034"
mapLon="-90.679" mapLat="30.161" legendVisible="true" archiving="true" rate="10">
  <projection id="orthographic">
    <property id="stdLon" type="float" value="-97.278"/>
    <property id="stdLat" type="float" value="35.333"/>
  </projection>
  <loop>
    <duration value="3" units="hour"/>
    <anchor date="2005-08-29 12:00:00 UTC" type="loopFrom"/>
    <step value="15" units="min"/>
  </loop>
  <radar visible="true" selected="false" alpha="1.0" dataset="edu.ou.ocs.nids" site="KLIX"
product="BREF1" storms="false"/>
  <shape visible="true" selected="false" alpha="1.0" dataset="edu.ou.ocs.usshapes" color="#444444FF"
width="2.0" feature="outline" region="conus" mask="false"/>
  <shape visible="true" selected="false" alpha="1.0" dataset="edu.ou.ocs.usshapes" color="#000055FF"
width="2.0" feature="urbanareas" region="conus" mask="false"/>
  <gridlines visible="true" selected="false" alpha="1.0" color="#FF0000FF" width="1.0" startLat="-90.000"
endLat="90.000" startLon="-180.000" endLon="180.000" lonInterval="1.000" latInterval="1.000"/>
  <radar visible="true" selected="true" alpha="1.0" dataset="edu.ou.ocs.nids" site="KLIX"
product="CREF" storms="true">
    <toggled>
      <color index="15"/>
      <color index="14"/>
      ...
    </toggled>
  </radar>
</map>
</wxscript>

```

FIG. 8. Portion of the XML file used to generate the WeatherScope map displayed in Fig. 3.

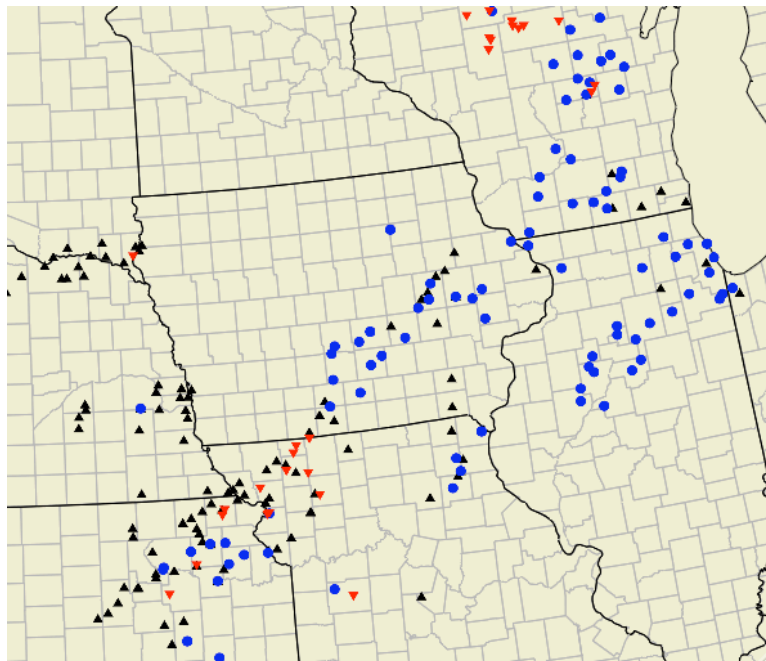


FIG. 9. Example of a WeatherScope map with tornado (red triangles), hail (black triangles), and severe wind (blue circles) reports for 5 June 2005 from the NWS Storm Prediction Center in Norman, OK.

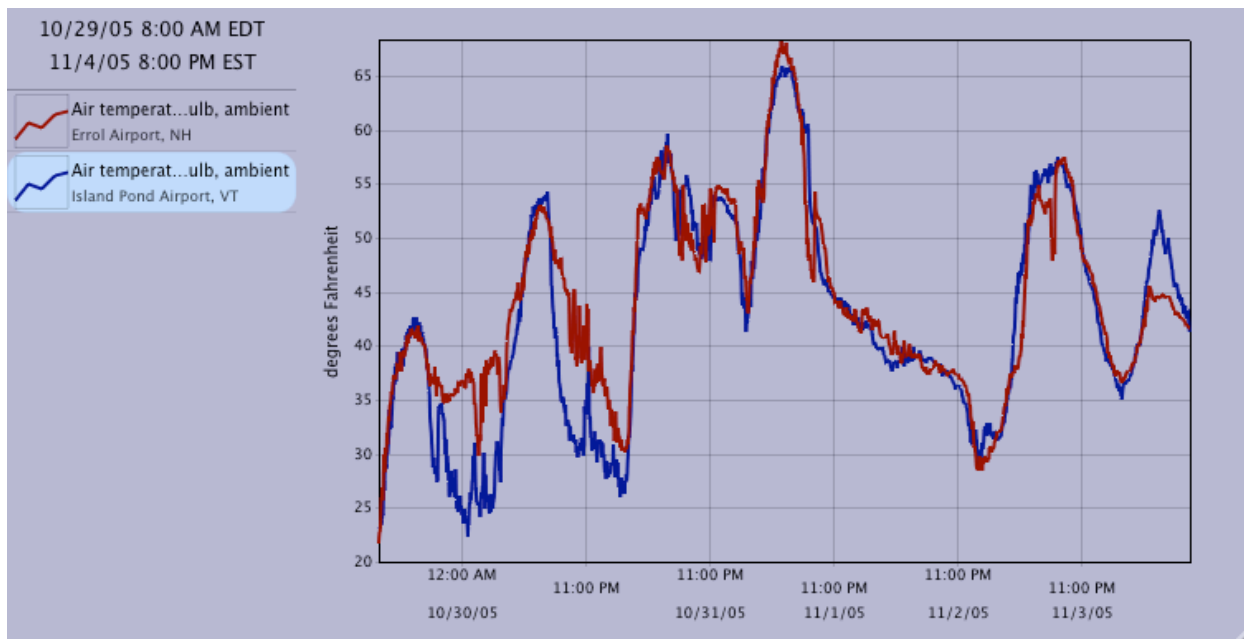


FIG. 10. Example of a WeatherScope graph of dry-bulb air temperature from Errol Airport, NH (red) and Island Pond Airport, VT (blue) using data from NOAA's Environmental Real-time Observing Network (NERON).

### 3. WEATHERSCOPE USES

The WeatherScope software is used by laypeople, weather forecasters, governmental personnel, and research scientists. Emergency managers use the software to maintain situational awareness, especially during hazardous weather. Decision makers and weather enthusiasts alike keep track of current weather by using the Track Real Time feature, resulting in automatic updates of the data. K-12 students use archived data for science fair projects and other experiments.

University undergraduate and graduate students use the software for laboratory exercises (e.g., Oklahoma Climatological Survey 2005), forecast contests (e.g., <http://wxchallenge.com/>), and research projects (e.g., Morgan 2005). Most of the features added to each version of the software result from feedback of university students, especially those who push the limits of the software while working on thesis or dissertation research.

### 4. SUMMARY

WeatherScope is an easy-to-use display package that takes advantage of the graphics capabilities of the current generation of personal computers. It can be downloaded freely for non-profit use at <http://sdg.ocs.ou.edu>.

### 5. ACKNOWLEDGMENTS

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