P3R.1 RADAR BASED APPLICATIONS OF A NOWCAST DECISION SUPPORT SYSTEM

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1. INTRODUCTION

Weather Decision Technologies (WDT) has developed a Nowcast Decision Support System (NDSS). NDSS ingests multiple data sources to provide users with meteorological and hydrological applications with both workstation and Web based displays. A large component of NDSS includes radar based applications through the licensing of the latest state-of-the-science technologies and internal WDT development. The purpose of the radar based applications is to provide detections and short-term predictions of hazardous weather situations. WDT has setup a Central Processing Facility to ingest all available Level II data from the Integrated Radar Data Services (www.radarservices.org) and other data sources using NOAA-Port (www.noaaport.com) all in real-time, process these data through multiple algorithms, and serve data and algorithm results to customers of various industries. The continental US version of NDSS is also called NEXRAD-HD. WDT also builds custom standalone hardware/software radar based systems. This paper discusses the radar based applications of the NDSS.

2. NDSS COMPONENTS

The Nowcast Decision Support System components include licensed technologies from the National Severe Storms Laboratory (NSSL) and McGill University (Canada), along with WDT developed applications. The full suite of radar based applications that are applied in real-time to the WSR-88D network include:

3D Radar Mosaicking Algorithm (Zhang et al., 2005) - provides a high-resolution 3-D national grid of radar reflectivity from Level II data that are quality controlled for clutter, beam filling, and beam blockage through the use of hybrid scans.

Quantitative Precipitation Estimation and Segregation Using Multiple Sensors- (QPE-SUMS – Gourley et al., 2001) Provides accumulated precipitation estimates for any period of time, using a sophisticated algorithm that utilizes artifact free, gridded reflectivity data output from the 3-D Mosaic Algorithm and different Z-R relationships based upon the type of precipitation (i.e., convective vs. stratiform). This algorithm also utilizes satellite and rain gauge data (if available) to calibrate the radar precipitation estimates and remove any biases. It also uses a Vertical Profile of Reflectivity (VPR) correction to the QPE. Additionally, using sounding or model data, QPE-SUMS provides precipitation classification including rain, snow or mixed identification.

The McGill Algorithm for Precipitation Nowcasting using Semi-Lagrangian Extrapolation (MAPLE – Germann and Zawadski, 2002, 2003) – provides forecasts of radar reflectivity out to several hours in advance. Additionally a forecast of rainfall (QPF) for the forecast period is derived using variable Z-R relationships.

The Storm Cell Identification and Tracking (SCIT) algorithm (Johnson, 1998) - a storm centroid tracking and diagnosis algorithm that provides forecasts of storm centroid locations out to 60 minutes in advance and also provides storm attributes.

Damaging Downburst Prediction Algorithm (DDPDA – Smith and Eilts, 1997) - predicts which thunderstorms will produce damaging winds and strong wind shear near the surface 20 minutes in advance.

Hailswath Prediction Algorithm – uses the Hail Detection Algorithm (HDA – Witt et al., 1998) and attributes from the SCIT algorithm to predict the areal extent of hail 30 minutes in advance and differentiate between hail less than 2 cm, 2-4 cm and >4 cm in diameter.

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Mesocyclone Detection Algorithm (MDA – Stumpf et al., 1998) – detects vortices of all sizes and strengths and provides a probability that they will produce hail, damaging winds, or tornadoes in the next 20 minutes.

Tornado Detection Algorithm (TDA – Mitchell et al., 1998) - detects and predicts short-term movement of tornadoes and strong near-surface potential tornadoes.

Lightning Prediction Algorithm (LPA – Conway et al., 2002) – uses data from the US Precision Lightning Network (USPLN), MAPLE and model data to predict lightning locations at least 30 minutes.

GIS-Based Asset Monitoring System (GAMS) –a WDT developed application that utilizes a database of all of the assets of the user to provide alerts to any number of personnel or devices. These asset locations in the database can either be point locations, line segments, or polygons. GAMS compares predicted threat areas with the location of each of the assets. If there is overlap between the predicted threat areas and an asset then an alarm is provided to the display systems, and optionally to wireless devices. The content of the alarm is generated automatically by GAMS. This content includes which asset is alerted and the Estimated Time of Arrival of the threat and the Estimated Time of Departure of the threat.

3D Sigma Display – a WDT developed customizable workstation based display that allows for complete analysis of radar data and other data sets in 3D including “fly-through” capabilities.

WxScope Web Display – a Web-based display developed by the Oklahoma Climate Survey, WxScope, provides a system for which products and meteorological data can be viewed from any Windows based PC.

3. NDSS EXAMPLES

Figure 1 shows the WDT Central Processing Facility which houses a Dell Poweredge Linux cluster of over 160 processors for all data ingest, processing, and serving. In addition to the WSR-88D processing, the Weather and Forecast (WRF) model is run once an hour at the facility. Figure 2 shows an example output of the WDT Hailswath Algorithm in a customized Web page. The elliptical shapes in the figure show the extent of the hailswath and a 30 minute prediction of the swath location. Figure 3 shows an example of several algorithm outputs including SCIT, Hailswath, MDA, and TDA. A cell table is also created from the algorithm outputs that ranks the severity of the storms across the radar domain and provides numerous attributes of the storms. Figure 4 shows output from LPA. The LPA outputs are shapefiles of 30 minute forecasts of high and moderate lightning threat. Figure 5 shows an example of 3D Mosaic output using Level II data from all available WSR-88Ds. Data from each individual radar are quality controlled and then interpolated to a 1x1 km grid in the horizontal. Figure 6 shows an example of GAMS output. In this case the asset base is an electric power distribution grid including locations of power plants, sub-stations, and transformer sites. The asset database is check against output from all the algorithms and warnings are issued if an intersection occurs between an asset and a warning output. ETA/ETD data are also calculated for each warning. Figure 7 shows an example of 3D Mosaic output in the 3D Sigma display. The resolution of the data are 1x1 km in the horizontal with 20 vertical levels. An example cross-section is also shown.

4. CONCLUSIONS

WDT has developed a highly versatile Nowcast Decision Support System that ingests the nationwide WSR-88D Level II data stream, other data sources, and applies multiple algorithms to these data, and serves customized data and products to operational users. These data and products can be view via a Web browser plugin, or a three-dimensional workstation. NDSS contains the latest technologies available for radar based nowcasting.

Future NDSS work includes the integration of NSSL WDSS-II (Lakshmanan, 2002) applications, further refinement of the MAPLE processing to include model based growth and decay, and continually enhanced display capabilities.

5. References

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Figure 1. WDT Central Processing Facility showing the monitoring area (left) and example rack cluster configuration (right).

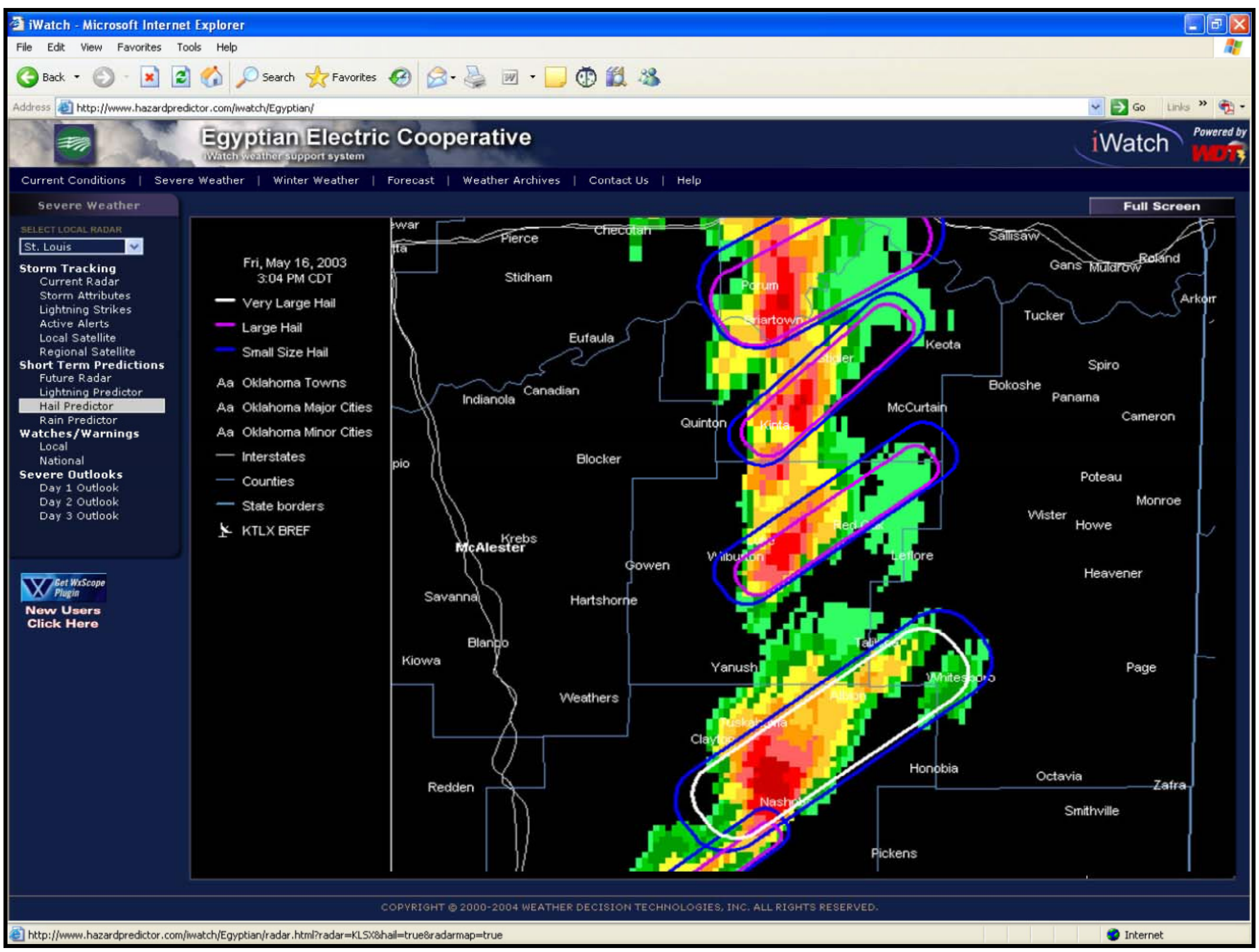

Figure 2. Example of Hailswath Prediction Algorithm shown in WxScope browser. White, purple, and blue shapefiles represent very large, large, and any size hail .

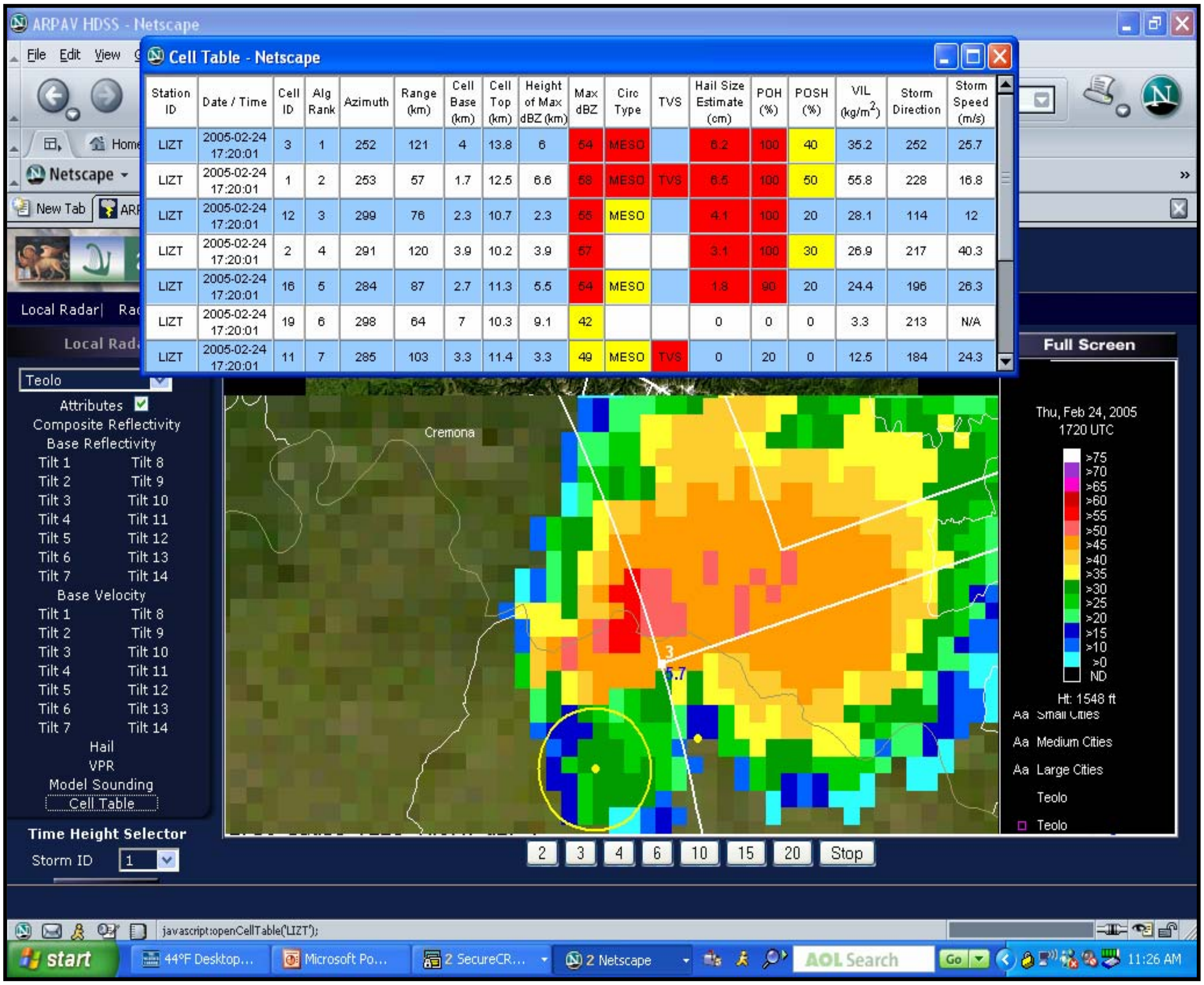

Figure 3. Example output of several NDSS features. White outlines show SCIT output in cone of influence format and cell ID number. Yellow circle represents mesocyclone detection from MDA. The table insert shows various storm attributes.

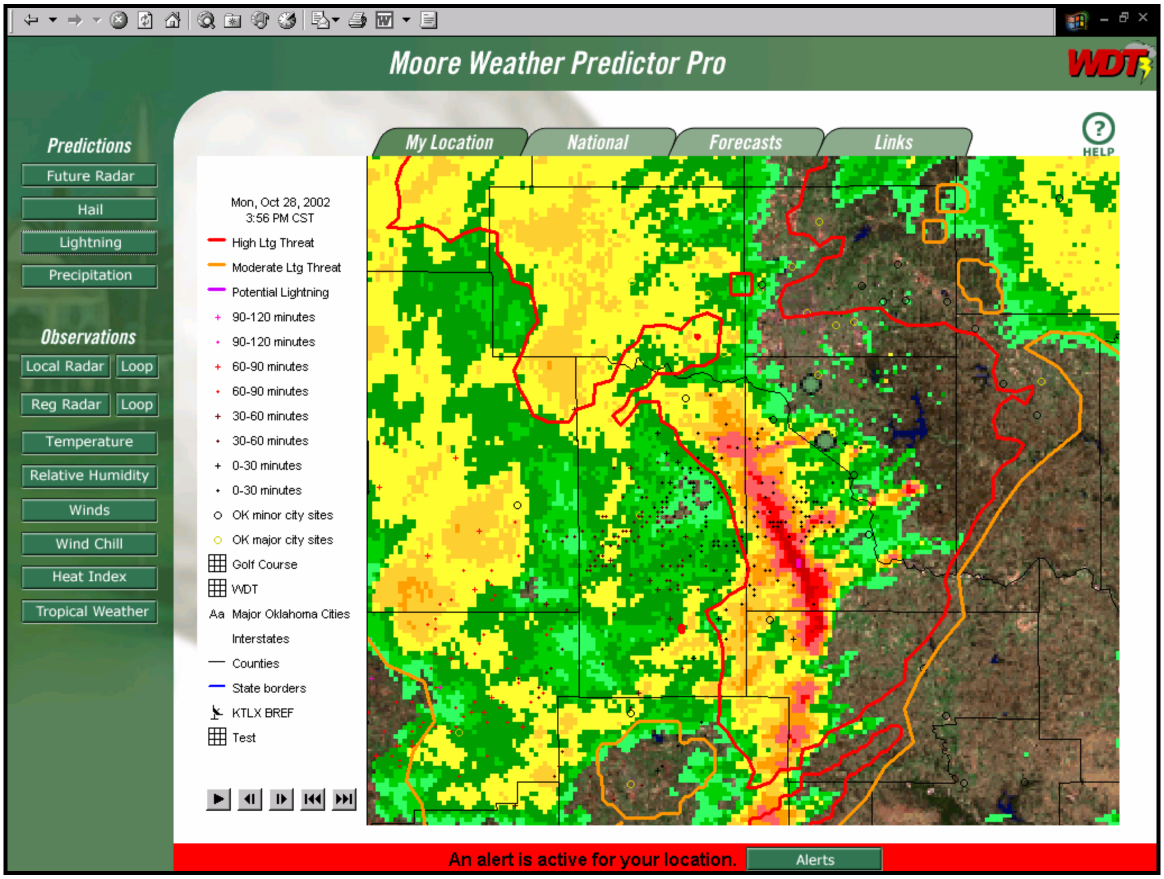

Figure 4. Example of WDT Lightning Prediction Algorithm in customized Web page. Red/orange contours show 30 minute forecasts of high/moderate lightning activity.

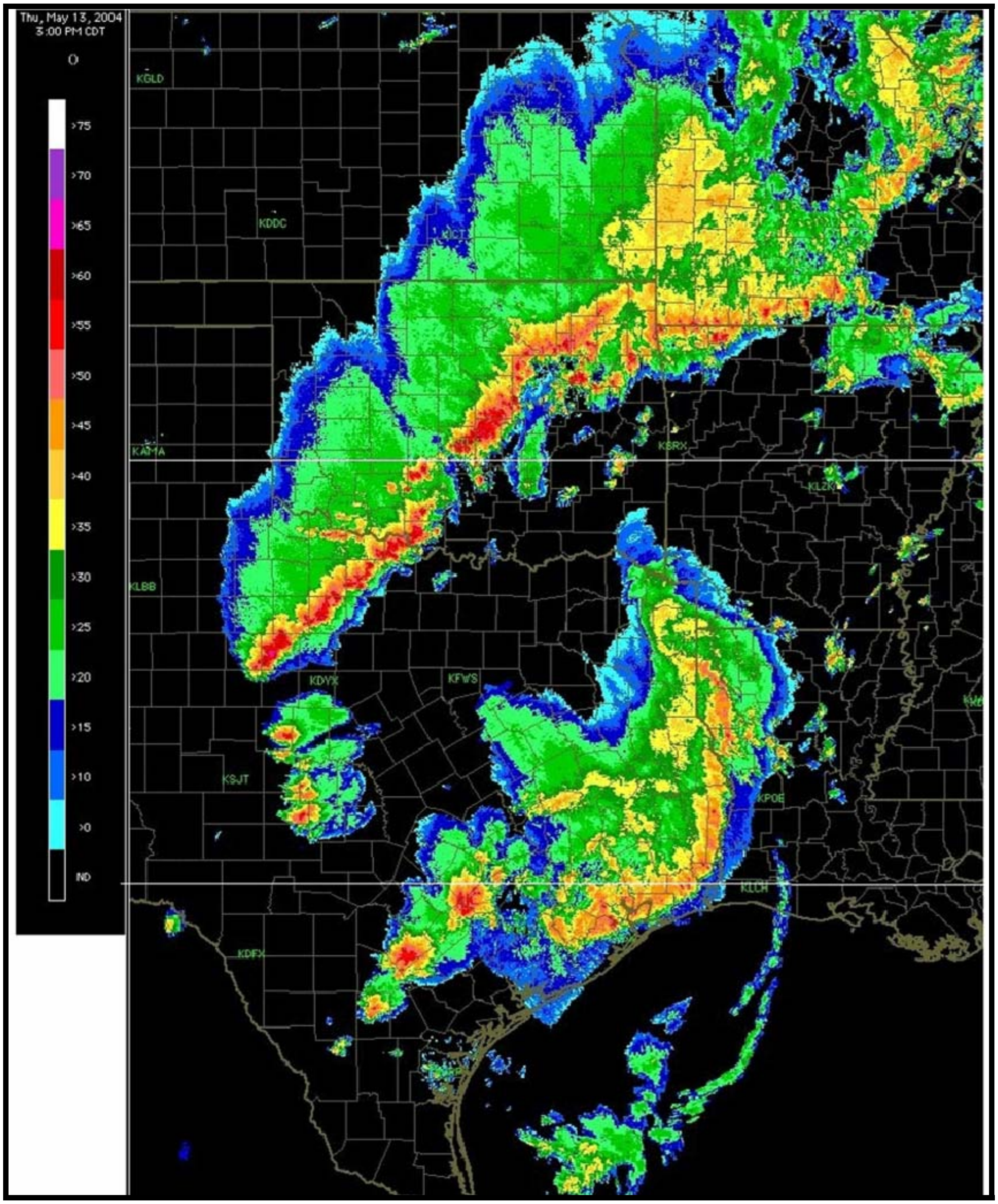

Figure 5. Example of 3D Mosaic output using WSR-88D Level II data. Mosaic contains data from all available radars across the given domain.

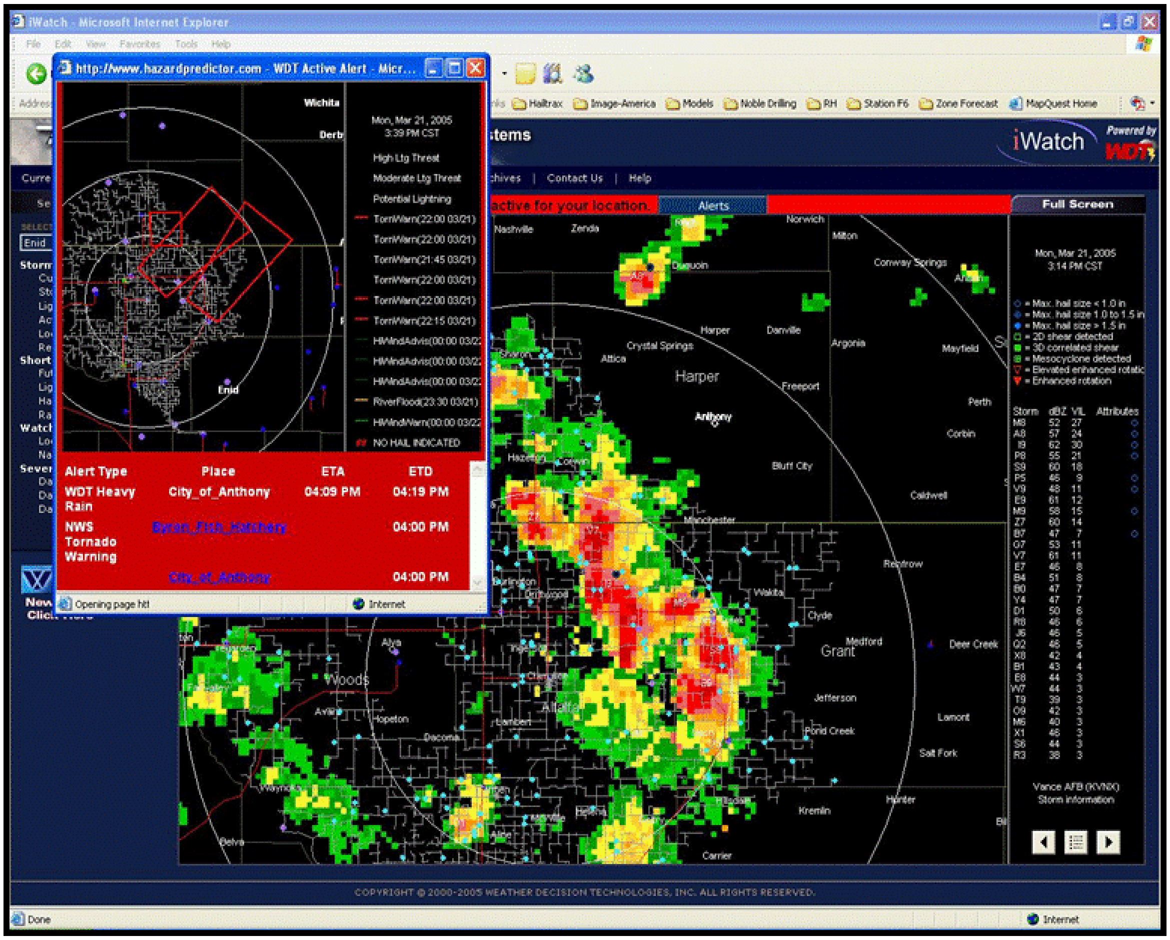

Figure 6. Example of asset monitoring output. Light lines represent customer power distribution grid. Insert shows pop-up alarm of ETA/ETD for heavy rain for transformer stations.

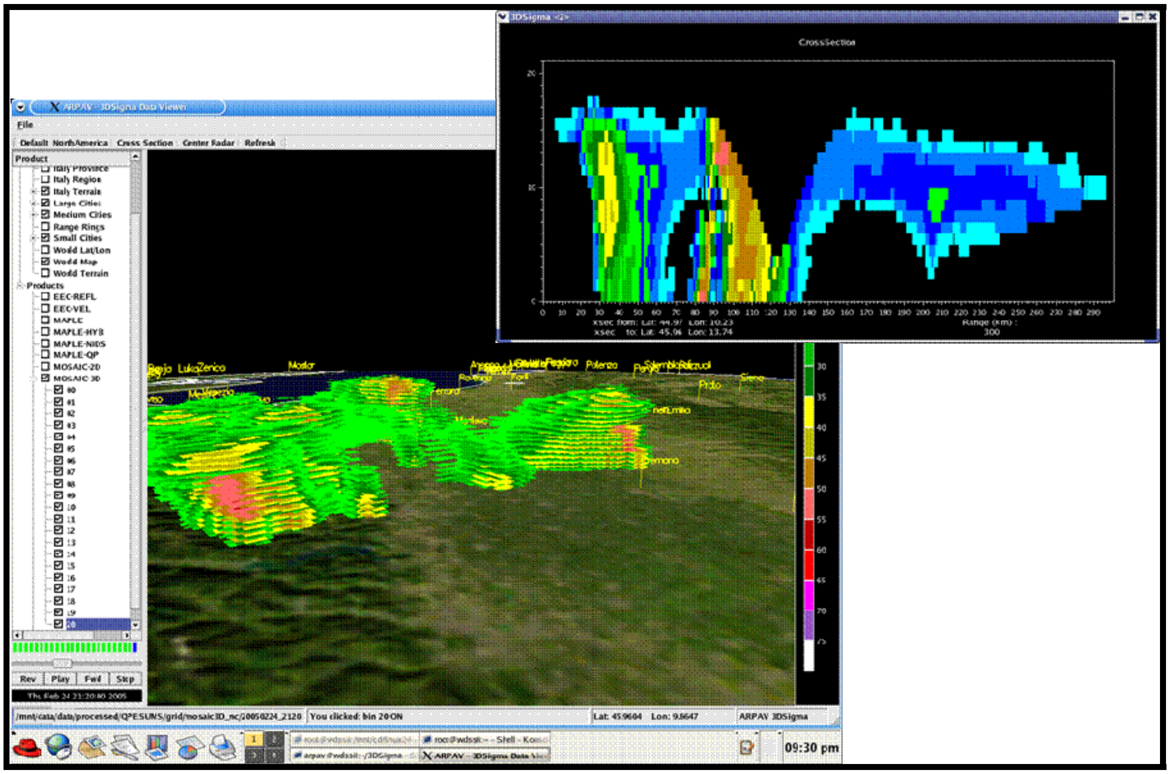

Figure 7. Example of 3D Sigma display. The reflectivity field shows gridded data at 20 vertical levels from 3D Mosaic. Insert shows an example cross-section from the 3D field.