13.2 USING VIRTUAL GLOBES TO IMPROVE SITUATIONAL AWARENESS IN THE NATIONAL WEATHER SERVICE

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1. INTRODUCTION

Geographic Information System (GIS) viewers including virtual globes are becoming an increasingly integral part of National Weather Service (NWS) operations (Stellman 2009, Smith and Lakshmanan 2006). GIS virtual globes such as Google™ Earth provide a means to observe and analyze multiple data sets that enhance situational awareness and decision making within the NWS operational environment.

Virtual globes have proven to be an effective tool for improving NWS operations and services, particularly during hazardous weather events such as severe convection, hurricanes, winter storms, flooding, wildfires, hazardous material spills, etc. Virtual globes provide a data-rich environment in which both meteorologists and hydrologists can integrate multiple data layers such as radar and surface observations with available layers such as roads, terrain, river basins, infrastructure, etc. The ability to combine these layers onto one interactive interface provides the NWS the capability to view critical information at a glance, and more readily assess a given situation beyond conventional meteorological parameters. Rather than simply viewing radar, a forecaster can quickly perform risk and impact analysis by assessing impacted population, infrastructure, etc. Knowing where and what the storm will impact heightens situational awareness while improving warning decisions.

Virtual globes also improve collaboration with local emergency management and other NWS offices. Ultimately, the use of virtual globes in the operational environment of the NWS is a valuable tool resulting in a higher degree of situational awareness, improved collaboration with critical decision makers, and enhanced warning services.

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2. APPLICATIONS

The data-rich environment within virtual globes enhances NWS operations and services. The integration of multiple geo-referenced layers such as infrastructure, geographical features, geo-political boundaries, locations of businesses, spotters, etc. give meteorological data more meaningful context.

2.1. Situational Awareness

As NWS operations and user needs become more complex, virtual globe applications such as Google Earth can enhance situational awareness and be utilized in situational display systems within NWS operations including on projector screens (Figure 1) or within a PC environment. Integrating multiple and pertinent data layers can provide critical information at a glance. Virtual globes take maps from merely an attractive picture to being an effective operational tool.

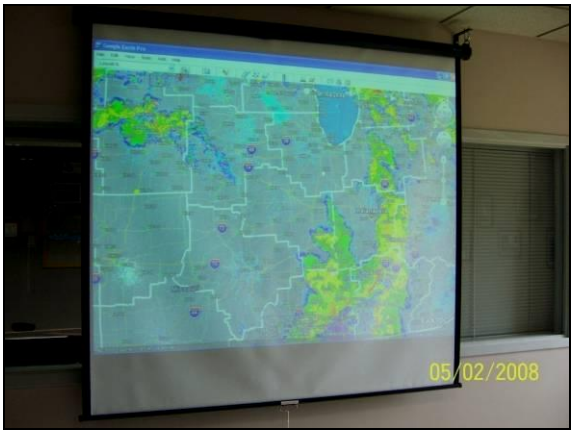

Figure 1: Situational Awareness Display in a National Weather Service Office

By using virtual globes, the NWS has the ability to integrate a variety of products based on their relevance to a given situation including severe storms, flooding, winter weather, fire weather, hazmat spills, etc. Rather than simply viewing a warning polygon, the population and infrastructure that has and will be impacted can be seen. This synergy of

data can be utilized to enhance warning operations, as well as provide emergency managers or other critical decision makers with more accurate and applicable information.

2.2. Radar and Warning Polygons

Google Earth and other virtual globes allow information such as warning polygons and radar data to be packaged (Figure 2). Not only can the warning polygon be observed in relation to radar, but the warning text can also be viewed. This ability to view warning polygons and radar in relation to pertinent geospatial information can be especially useful in maintaining successful warning operations. NWS personnel are able to more easily track the status of warnings and assess the need for coordination with emergency management.

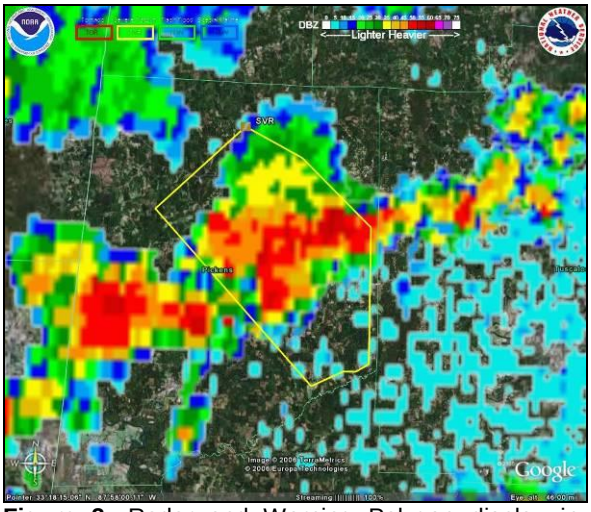

Figure 2: Radar and Warning Polygon display in *Google™ Earth*

2.3. Flash Flood Analysis

Flash flooding is a complex phenomenon s influenced by physiographic and hydrologic characteristics. Also, the impact on local population and infrastructure is affected by socio-economic factors. Virtual globes provide an effective means of plotting known flash flood prone locations as well as analyzing flash flood potential and impact (Brice and Foster 2009). Radar data, including one hour rainfall rates, can be incorporated into Google Earth or other virtual globes to analyze the potential of flooding and its impact. Rather than just viewing radar data, NWS forecasters can view where the rain is falling and where flood waters will go.

Figures 3 and 4 depict how NWS offices have utilized virtual globes to plot points such as low water crossings which are particularly dangerous during flooding. Viewing these data results in a greater awareness of locations especially prone to flooding, and provides more specific information that can be included in warnings.

Figure 3: Low water crossing and corresponding drainage basin in *Google™ Earth*

Figure 4: Low water crossing in *Google™ Earth*

2.4. Impact Analysis

Virtual globes provide an environment where multiple data sets can be integrated to assess potential impact and support strategic and tactical response. Geographic layers integrated with radar products can be utilized to perform risk assessment for the purpose of warnings and collaboration with emergency management. Knowledge of where and what the storm will impact heightens situational awareness and improves warning services. This is useful for severe thunderstorms, hurricanes, winter storms, etc.

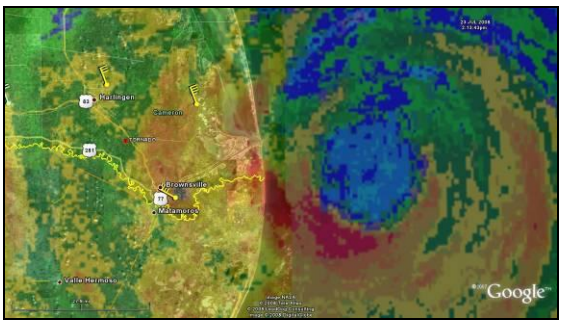

Figure 5: Display of Hurricane Dolly approaching the south Texas Coast on *Google™ Earth*

An example of this usefulness occurred on March 14, 2008, when a tornadic supercell tracked into downtown Atlanta during the 2008 Southeastern Conference basketball tournament. This storm caused extensive damage to downtown Atlanta infrastructure including the Georgia Dome where the tournament was being held. Figure 6 shows that by viewing radar data within a virtual globe environment, one can more readily assess the threat and potential impact. By closer examination, it is possible to view the Georgia Dome as well as other critical infrastructure in relation to the storm. Critical weather data can be viewed in relation to population centers, tourist and recreational centers, major highway arteries, location of a hazardous material spill or recovery efforts following a disaster, etc. Again, virtual globes can be utilized as an effective tool for strategic planning and impact analysis.

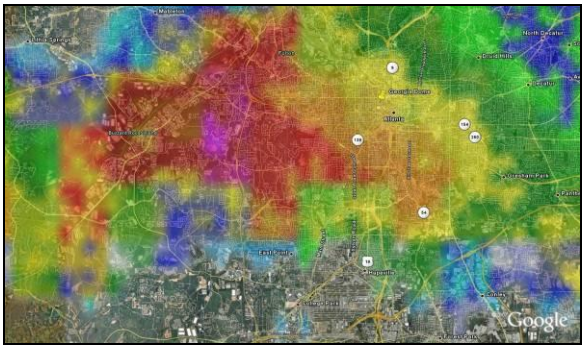

Figure 6: Radar depiction in *Google™ Earth* of tornadic supercell as it tracks into downtown Atlanta, GA on 14 March 2008.

2.5. Verification

A critical part of NWS severe weather operations is accurately assessing storm impact for a matter of climatological reference and warning verification. As shown in Figure 7, virtual globes such as Google Earth provide a very effective tool for obtaining near real time verification during and after severe weather events. Within the "search" section of the table of contents it is possible to simply enter generic business types (gas station, convenience store, etc.) and those businesses will be plotted. The same can be done for law enforcement and emergency services by typing "police station" or "fire department" to plot these locations. Phone number and address information is easily viewed by clicking on the data balloon.

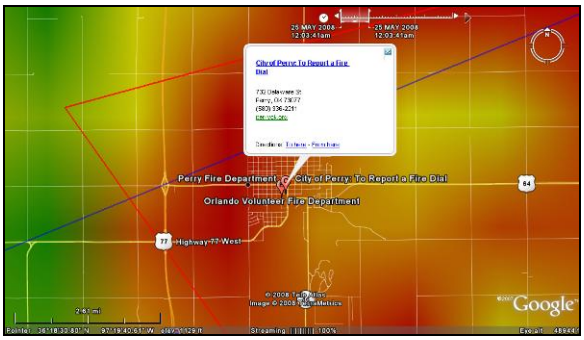

Figure 7: Overlay of business locations, radar reflectivity and warning polygons in *Google™ Earth*

Viewing these plotted locations in conjunction with radar and warning polygons immediately indicates verification may be obtained. By using this approach, NWS Shreveport, Louisiana demonstrated a 10% increase in the number of verified Severe Thunderstorm and Tornado Warnings during 2007 (Stellman 2009).

This feature can also be utilized in coordinating with local emergency management for the purpose of providing advanced warning and locating potential high impact areas or events.

The NWS can also import live spotter network data such as those available from Spotternetwork.com into virtual globes (Figure 8). This network is comprised of spotters signed up through Espotter. The actual real time location of spotters can be observed as they track a storm. Contact information for these spotters is easily obtained by clicking on the data points.

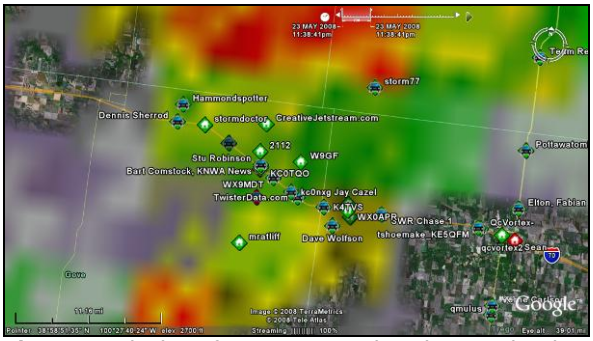

Figure 8: Display of storm spotter locations and radar reflectivity in *Google™ Earth*

It is possible to import locally derived data such as a database of trained spotters into a virtual globe. As with finding businesses or government entities, plotting spotter locations along with radar and warning polygons greatly enhances verification efforts. Similar to using business search, a trained spotter database can also be used to obtain other data such as rainfall and snowfall amounts. Lastly, plotting spotter information makes it easy to identify where greater spotter recruitment is needed.

2.6. Fire Weather

Virtual globes greatly enhance fire weather support to critical agencies where understanding of the terrain and georeferenced features is vital. Figure 9 shows how the location of wildfire spot forecasts is viewed in relation of the terrain and aspect.

The "sun" tool in Google Earth can be utilized to view the solar aspect which is potentially critical to fire weather behavior. Also, through the use of the terrain and tilt functions, the topography and slope may be easily viewed. In addition, fire weather observations are available for displaying critical thresholds that describe fire behavior.

Figure 9: Location of a prescribed burn in *Google™ Earth*

2.7. Storm Surveys / Post Storm Assessment

Virtual globes provide useful utilities for post storm assessment and coordination of storm surveys. The National Severe Storms Laboratory has developed Key Markup Language (KML) products for plotting radar algorithm data such as hail swaths and mesocyclone paths. This has proven to be very helpful in identifying storm tracks and potential damage paths during and following an event.

Through the integration of multiple data sets following an event, it is possible for the NWS to quickly determine areas of storm impact and more effectively coordinate storm survey teams. These maps can be quickly created to display for partner agencies and the general public.

Latitude and longitude coordinates obtained on storm surveys are easily utilized to provide the storm track or storm damage location within a virtual globe (Figure 10).

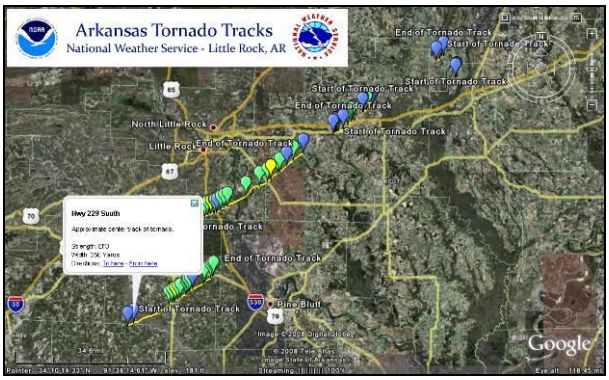

Figure 10: Tornado track and damage information plotted in *Google™ Earth*

2.8. Observations

Google Earth and other virtual globes are not only useful for hazardous weather operations but are also used effectively to monitor real time data including observations (METARs, CoCoRaHs, RAWs, APRS, etc.) Integrating these data sets is useful for meso-analysis during severe, non-precipitation or winter events. For example, the impact to highways and population centers is easily assessed during winter storm events. This synergy of data provides much richer information that aids decision making during routine forecast or high impact events.

2.9. Hydrology

Hydrology plays a critical role in NWS operations, and virtual globe applications can be a very useful tool for this as well. Stream flow data obtained from the USGS can be plotted to monitor flood or drought situations. Advanced Hydrologic Prediction System (AHPS) data can be plotted and includes the latest observed and forecast stage information. Virtual globes are useful in viewing the potential impact during a flood and accurately locate flood prone areas and gage sites. NWS offices even incorporate locally developed E-19 data by displaying areas that flood given a specific stage.

2.10. Equipment Status

Monitoring the status of observational equipment is critical to ensuring a quality weather watch in the NWS. Virtual globes have the ability to plot METAR data and WSR-88D status. Again, information for a given site is easily viewed by clicking on a data point.

2.11. Hazmat

The NWS is providing increased incident support for events such as hazardous material spills. Dispersion model information can be imported into virtual globes to analyze the area affected by a potential plume originating from the hazardous material spill site

(Figure 11). This allows the NWS to relay much more detailed information to emergency management and assess the impact given changing weather conditions.

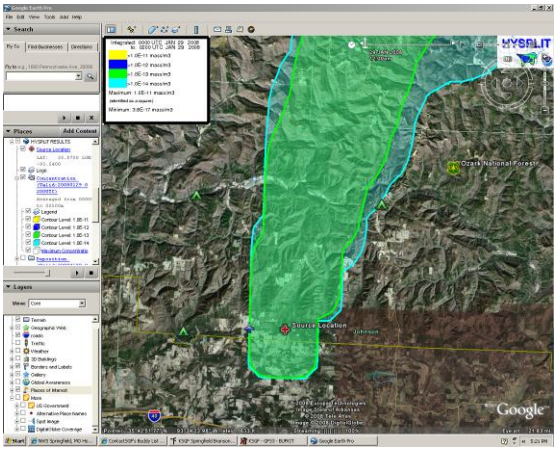

Figure 11: Dispersion plume depicted in *Google™ Earth*

3. SUMMARY

Virtual globes such as Google Earth provide an easy-to-use GIS platform that is widely available and allows easy real-time sharing of data, thus making it a useful tool for the integration of weather data with GIS information.

Virtual globes are quite useful in internal NWS operations as well as enabling the NWS to provide products and services where the integration of meteorological and GIS information enhances product quality.

GIS applications including the use of virtual globes will become an even more integral part of NWS operations and services. Virtual globes are especially useful in providing decision support to emergency management and other critical users. Not only will virtual globes be valuable as an operational tool but also as a system of information delivery.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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