12.4 THE APPLICATION OF VIRTUAL GLOBE SOFTWARE IN FIRE WEATHER FORECASTING

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1. INTRODUCTION

Virtual globes have already proven to be a useful tool for meteorologist (Smith 2006). Its ability to correlate surface observations to geographic locations have proved very useful to weather forecasters, but additional capabilities of virtual globes will also make them even more useful for meteorologists involved in fire weather forecasting. Wildfire behavior is influenced by the three elements that make up the wildland fire behavior triangle. The three sides of the triangle are made up of weather, topography and fuels. Virtual globes, with their ability to geo-reference surface observations and with three dimensional rendering of topography, will allow fire weather forecasters to provide better forecasts and warnings to the fire weather community. With the aid of virtual globes, like Google Earth, forecasters will have a better understanding of the weather and topography legs of the fire weather triangle. Though general information about fuels can be made from virtual globe imagery, this paper will only briefly address using virtual globe technology to evaluate the fuel leg of the wildfire behavior triangle. Virtual globes hold great potential in helping weather forecasters to better service the wildland fire community.

2. FIRE WEATHER FORECASTING

In the pre-fire time frame a fire weather forecaster is asked to give a forecast for a very specific point. The forecaster usually understands the regional scale forecast picture, but for a forecast requested at a specific point, topography and aspect have a very important influence on the weather and therefore the forecast. In the past, fire weather forecasters had paper topography maps to help them understand the layout of the area surrounding a fire location. This required forecasters to develop the skill to read and interpret these maps. But now with the use of virtual globes not only can forecasters correlate surface observations to a fire location, but the forecaster can visualize how the three dimensional topography around the fire location will affect the fire weather related meteorological elements.

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2.1 Weather

When a forecast for a fire site is requested (a spot forecast) the fire weather forecaster must issue a weather forecast for the fire location and the immediate surrounding area. Sometimes that is a small area (less than an acre) and other times it is a large area (several square miles). The fire weather forecaster is usually very aware of the synoptic and even sub-synoptic weather conditions. However, the forecaster is expected to provide a forecast on the meso or even micro scale. Forecasting on the sub-synoptic or meso scale can be challenging but forecasting on the micro scale is very difficult. One of the advantages of virtual globes is their ability to overlay numerous GIS/KML layers. Those layers can be anything from previous day's high and low temperature to MOS guidance and other numeric model fields. With its ability to overlay current and past weather conditions of surrounding weather stations, the virtual globe software helps the fire

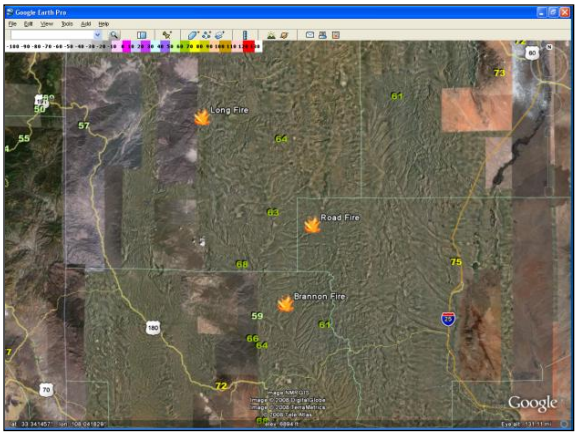

Fig 1 *Spot forecast locations with surface observations*

weather forecaster geo-reference those observations relative to the spot forecast location. In addition, vegetation type, grasses versus forest, is known to cause observable differences in local weather conditions (Baughman 1979). General knowledge of vegetation type as identified in virtual globe imagery can be used by the forecaster to adjust meteorological forecast parameters such as temperature, relative humidity, and wind speed. Being able to compare the current and past weather of the surrounding

observations along with model data helps the forecaster to better formulate his short term fire weather forecast.

2.2 Topography

Topography, the second leg of the fire behavior triangle, greatly influences the local weather and should be accounted for in the spot forecast. The ability to see the location of a fire relative to its surrounding terrain will help the forecaster to adjust his/her spot forecast according to the micro-scale influences. As an example, synoptic scale winds could be from the west…but the forecaster sees that the spot location is in a north-south running valley. This allows the forecaster to adjust the wind forecast to account for a northerly drainage wind at night as opposed to a prevailing west wind for the rest of the area. In addition some virtual globe software allows a forecaster to adjust the shadows of the sun, to simulate when the sunlight would strike a certain location at a certain time. Thus if the forecaster sees that the spot request is on the west side of a hill, he/she will be able to determine whether the location will remain in shadow for a longer period of the morning than the surrounding area. Knowing this information allows the forecaster to keep the temperature a little lower and the relative humidities a little higher during the morning. It also allows the forecaster to adjust the forecast by keeping the temperatures higher and the relative humidities lower later into the evening.

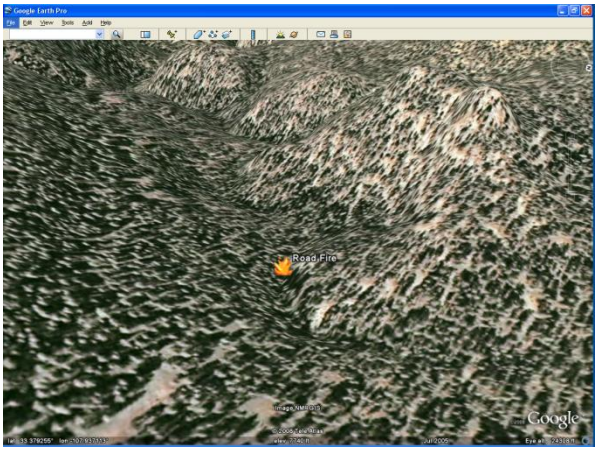

Fig 2 *Spot location as depicted in the 3D topography*

3. FIRE WEATHER MONITORING

Once the fire spot forecast has been issued then the forecaster must monitor weather conditions at the spot location to evaluate the accuracy of the forecast. Virtual globe software aids the forecaster by helping him/her to better correlate the surrounding weather and topography to the spot location. The ability to overlay meteorological data sets like radar and wind data, allows the forecaster to better correlate local weather conditions to fire-site conditions and determine if updated weather forecasts or even warnings are needed.

3.1 Weather

In the real-time environment it is critical for the forecaster to be able to geo-reference the spot location to surface observation and radar returns. It has already been shown that virtual globe software helps improve forecaster's situational awareness (Foster 2008). One of the advantages of virtual globe software is its ability to overlay various weather data sets on the surface of the earth.

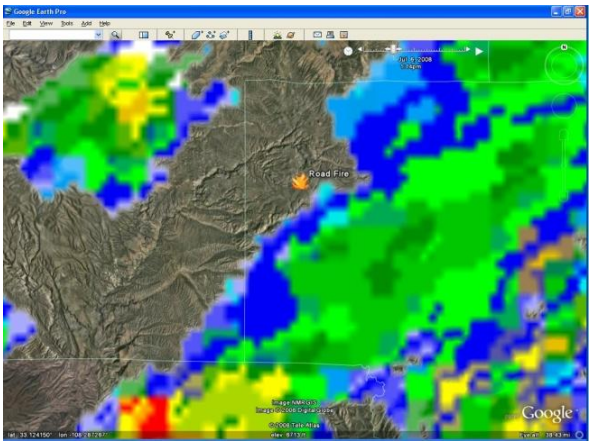

Fig 3 *Spot location collocated with radar returns*

Two years ago the National Weather Service began to produce weather radar data in the Keyhole Markup Language (KML) format. This allows the radar data to be overlaid in virtual globe programs like Google Earth and NASA's World Wind. This advent of GIS friendly radar data allows the forecaster to better see how radar returns will approach and affect a fire spot location. In addition to radar data, local observations from the fire site or nearby stations can also be included in the weather overlays. This helps the forecaster to better time wind shifts and to see micro scale weather patterns that might otherwise have been missed.

3.2 Topography

Understanding the topography of a burn site and that of the surrounding area is very important when keeping a weather watch on a spot location. Thunderstorm development and movement, temperature profiles, wind speeds and directions, and relative humidity changes can all be affected by topography. Thunderstorms often form on ridge lines; cool air pools in valleys at night; ridges indicate where upslope flows could intersect. All of these things can be missed if the topography around a spot, location is not well understood. The virtual globes three dimensional depiction of the topography helps the forecaster better understand and visualize the interaction between the spot location, the weather and the topography and leads to more timely forecast updates and warnings.

4. BURN SCAR FLOOD MONITORING

Extinguishing a wildfire does not always end all fire related hazard threats to life and property. Often a fire burns hot enough to burn away all vegetation, including roots, which anchor the soil to their location. Hot fires can also fuse the top soils creating a crust of hydrophobic soils. The results are two-fold; dangerous landslides and flash floods. Since virtual globes are a GIS platform, forecasters are able to overlay the burn scar outline and other burn over information. This information helps the forecaster to evaluate the burn scar, to anticipate problem areas and to detect flooding potential, increasing warning lead times.

4.1 Weather

The ability of virtual globes to geo-reference the burn scar with ongoing weather will greatly improve flood warning lead times and verifications. Overlaying radar data over the burn scar and the three dimensional topography allows forecasters to better see what part of the burn scar is receiving rain and how much rain has fallen. Though the virtual globes cannot “see” a flood, with a few rules of thumb a forecaster can interpret radar returns and storm precipitation estimates and easily infer where flooding may be occurring. Additionally, a forecaster can overlay basin and stream information. With the radar and basin overlays forecasters will not only be able to infer where flooding may be occurring, but, more importantly, to anticipate areas to be impacted down drainage.

4.2 Topography

The option for forecasters to utilize virtual globes to depict the three dimensional environment of a burn scar and its surroundings is a tool which should show big improvements in how well forecasters detect burn scar flash flooding and its spatial impacts. Not only can forecasters get a better understanding of how the water drains off the mountain side, but with the virtual globes high resolution photography the forecaster can actually see at least some of the buildings and structures that would be impacted immediately downstream of the burn scar, depending on the age of the virtual glove images. The geo-reference of the burn scar with the radar returns, along with the street and/or location names will help the forecaster better explain the threat in a warning and narrow down the area that would be affected and thus prevent some local residents from needlessly expecting a flood.

5. SUMMARY

Producing forecasts and monitoring weather over fire sites and burn scars has always been a challenge for weather forecasters. Virtual globes improve upon flat paper maps with their ability to overlay a variety of geo referenced weather data sets and to display that data in a three dimensional topographic environment. With the help of virtual globes fire weather forecasters can better understand the interaction between the two legs of the wildland fire behavior triangle of weather and topography. With that better understanding, it is expected that forecasters will be able to provide more accurate forecasts, as well as more timely updates and warnings to both the fire weather community and the affected public.

6. ACKNOWLEDGMENTS

The author would like to thank Val MacBlain (SOO-EPZ) and Tom Bird (IMET-EPZ) for their review of this paper and suggestions to improve it.

7. REFERENCES

R. Baughman and F. Albini, 1979: Estimating Midflame Windspeeds. 6th Conf. on Fire and Forest Meteorology

Andy Foster, Keith Stellman, Darrin Hansing, 2008: Using Virtual Globes to Improve Situational Awareness in the National Weather Service. Preprints, 25th Conf. on IIPS, National Amer. Meteor. Soc.

T. M. Smith, Lakshmanan, V., 2006: Utilizing Google Earth as a GIS Platform for Weather. Preprints, 22nd Conf. on IIPS, National, Amer. Meteor. Soc.