

# Advancements in Forecast Technology for Improving Heat Safety in Sports

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## Introduction

Wet bulb globe temperature (WBGT) is a composite temperature indicator, calculated using a formula that factors the effect of temperature, humidity, wind speed, and solar radiation on humans. The utilization of WBGT as the key assessment of heat stress on the human body continues to gain momentum throughout the athletic industry, from the student-level up to professional organizations.

Traditionally, organizations measure WBGT with expensive, black globe thermometers that provide the temperature indicator at the moment, for the specific location of the sensor, with no visibility to future WBGT readings.

Schneider Electric has recently introduced a WBGT forecast technology utilizing existing peer-reviewed methodology, the integration of advanced meteorological datasets, user-defined alerting criteria, and location-based alerting, ultimately providing schools, medical staff, and coaches with flexibility in making operational decisions pertaining to athlete safety.

## Wet bulb globe temperature vs. Heat Index

	WBGT	Heat Index
Measured in the Sun	✓	✗
Measured in the Shade	✗	✓
Uses Temperature	✓	✓
Uses Relative Humidity	✓	✓
Uses Wind	✓	✗
Uses Cloud Cover	✓	✗
Uses Sun Angle	✓	✗

Organizations such as the National Athletic Trainer's Association (NATA) and National Collegiate Athletic Association (NCAA) recognize both WBGT and Heat Index in their respective rules and procedures as acceptable metrics for decision-making purposes [1].

WBGT	Level of Risk	Comments
< 65°F (<18°C)	Low	Risk low but still exists
65°-73°F (18°-23°C)	Moderate	Risk level increases as event progresses through the day
73°-82°F (23°-28°C)	High	Everyone should be aware of injury potential; individuals at risk should not compete
> 82°F (>28°C)	Extreme	Consider rescheduling or delaying the event. Be on high alert. Take steps to reduce risk factors

## Derivation of WBGT Equation

Schneider Electric recently integrated a fourth degree polynomial equation to derive the Black Globe temperature ( $T_{bg}$ ) estimate for forecast locations worldwide. This equation stems from the research of Dimiceli, Piltz, and Amburn [2] which highlights that  $T_{bg}$  can be derived from common atmospheric measurements rather than utilization of an expensive and non-scalable Black Globe Thermometer. The approximation equation is defined as the following:

$$T_{gt} = \frac{B + CT_a + 7680000}{C + 25600}$$

Where B and C are defined as:

$$B = S \left( \frac{f_{db}}{4\sigma \cos(z)} + \frac{(1.2)}{\sigma} f_{dif} \right) + (\epsilon_a) T_a^4$$

$$C = \frac{hu^{0.58}}{5.3865 \times 10^{-8}}$$

Where  $\sigma$  is the Stefan-Boltzman Constant and  $h$  is an approximated convective heat transfer coefficient.

$S$  = Solar Irradiance  
 $f_{db}$  = Direct Beam Radiation  
 $f_{dif}$  = Diffuse Radiation  
 $z$  = Zenith Angle  
 $T_a$  = Ambient Temperature  
 $u$  = Wind Speed

Thermal Emissivity,  $\epsilon_a$ , is defined as:

$$\epsilon_a = 0.575e_a^{(1/7)}$$

Where  $e_a$  is Atmospheric Vapor Pressure can be defined as:

$$e_a = \exp \left( \frac{17.67(T_a - T_d)}{T_a + 243.5} \right) \times (1.0007 + 0.00000346P) \times 6.112 \exp \left( \frac{17.502T_d}{240.97 + T_d} \right)$$

$T_d$  = Dew Point Temperature

Knowing Black Globe Temperature ( $T_{bg}$ ), we can now calculate the WBGT ( $T_{wbgt}$ ) as defined by the Occupational Health and Safety Administration [3]:

$$T_{wbgt} = (0.7 \times T_{nwb}) + (0.2 \times T_{gt}) + (0.1 \times T_{db})$$

$T_{nwb}$  = Natural wet-bulb temperature

$T_{gt}$  = Globe thermometer temperature

$T_{db}$  = Dry bulb temperature

## Advanced Datasets and functionality for use in WBGT Estimation

Utilizing the equation to approximate the Globe Temperature, Schneider Electric provides its customer base with an hourly forecast (out to 72 hours) of WBGT within its software-as-a-service, MxVision WeatherSentry Online®. To ensure the highest quality professional grade weather forecast, the WBGT calculation has been integrated into Schneider Electric's Advanced Weather Forecast System [4] to create highly localized, hourly updating, consistently accurate weather forecasts, suitable for critical business decision support surrounding heat stress.

As illustrated, the approximation requires multiple inputs to calculate the Globe Thermometer Temperature used for the final WBGT equation. Schneider Electric's Advanced Weather Forecast System takes into account hourly updates of these critical core variables both in observation and forecast formats. Schneider Electric WBGT forecasts are updated hourly, incorporating the most current weather observations and forecast datasets, ensuring that the resultant WBGT forecasts are updated so that they always reflect reality.

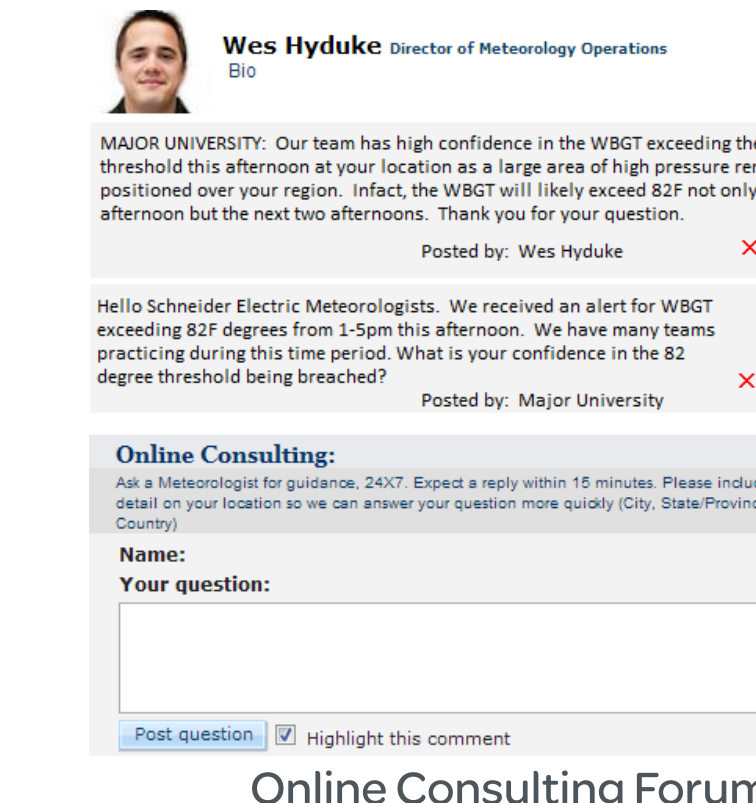
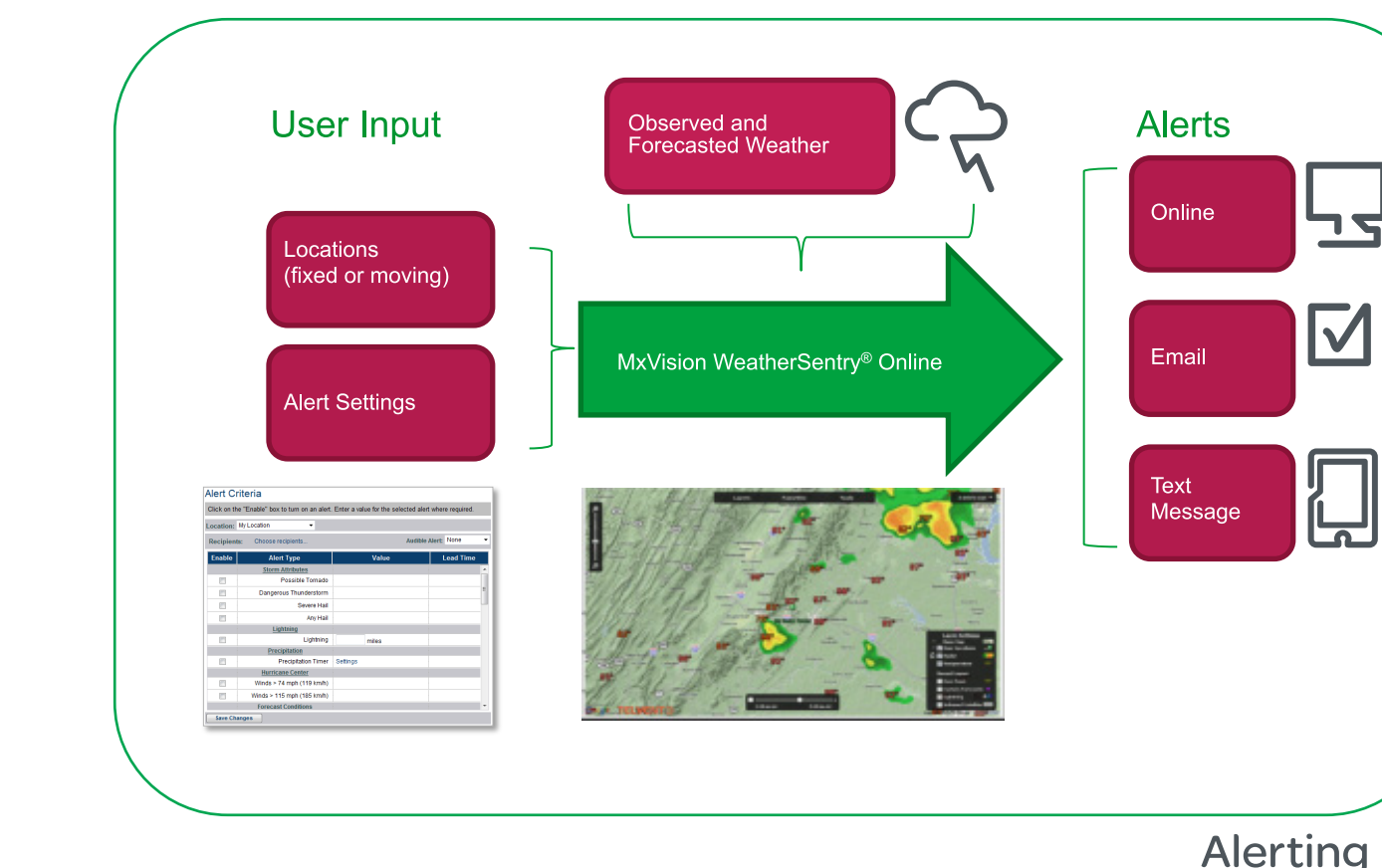
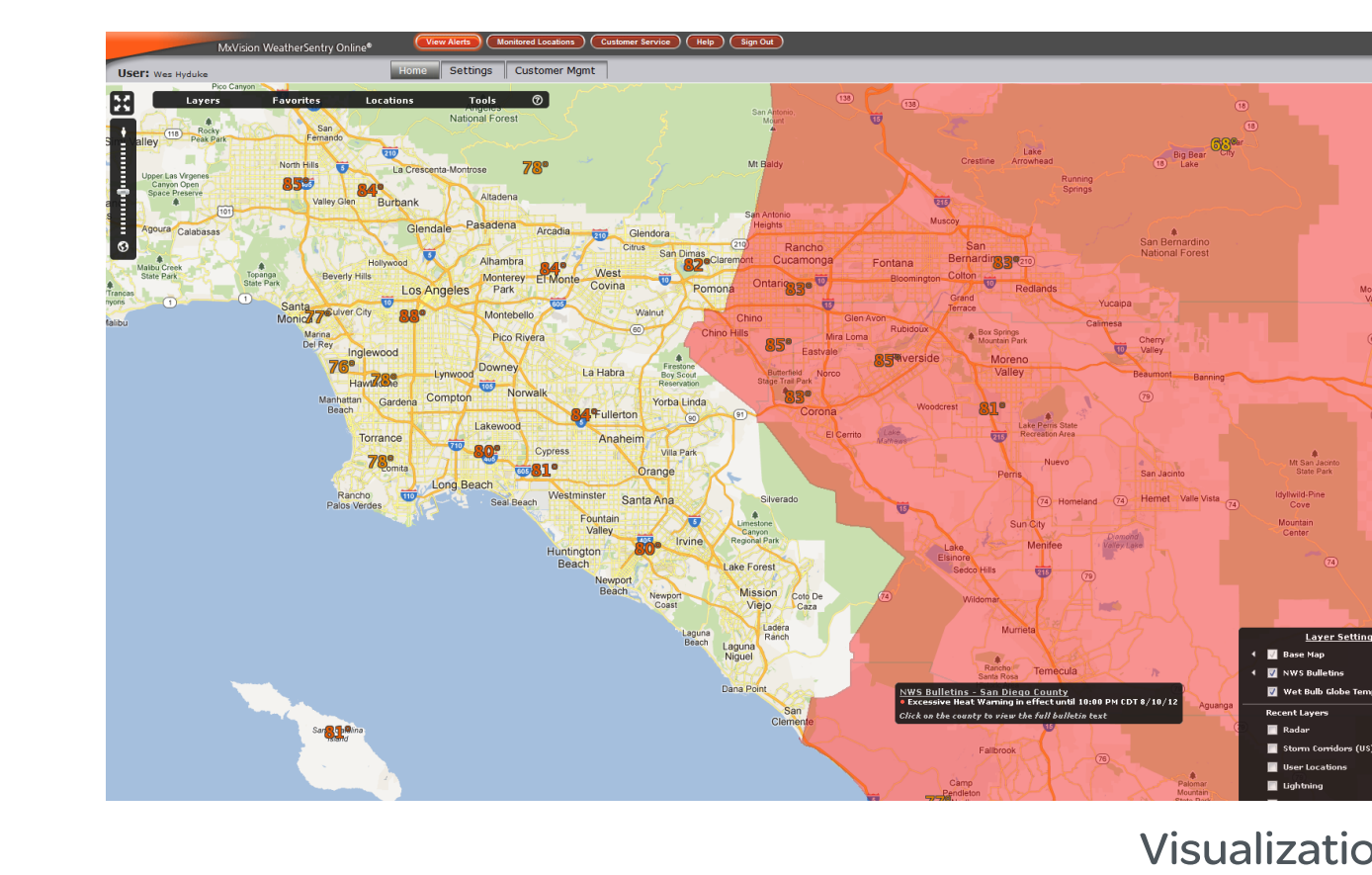
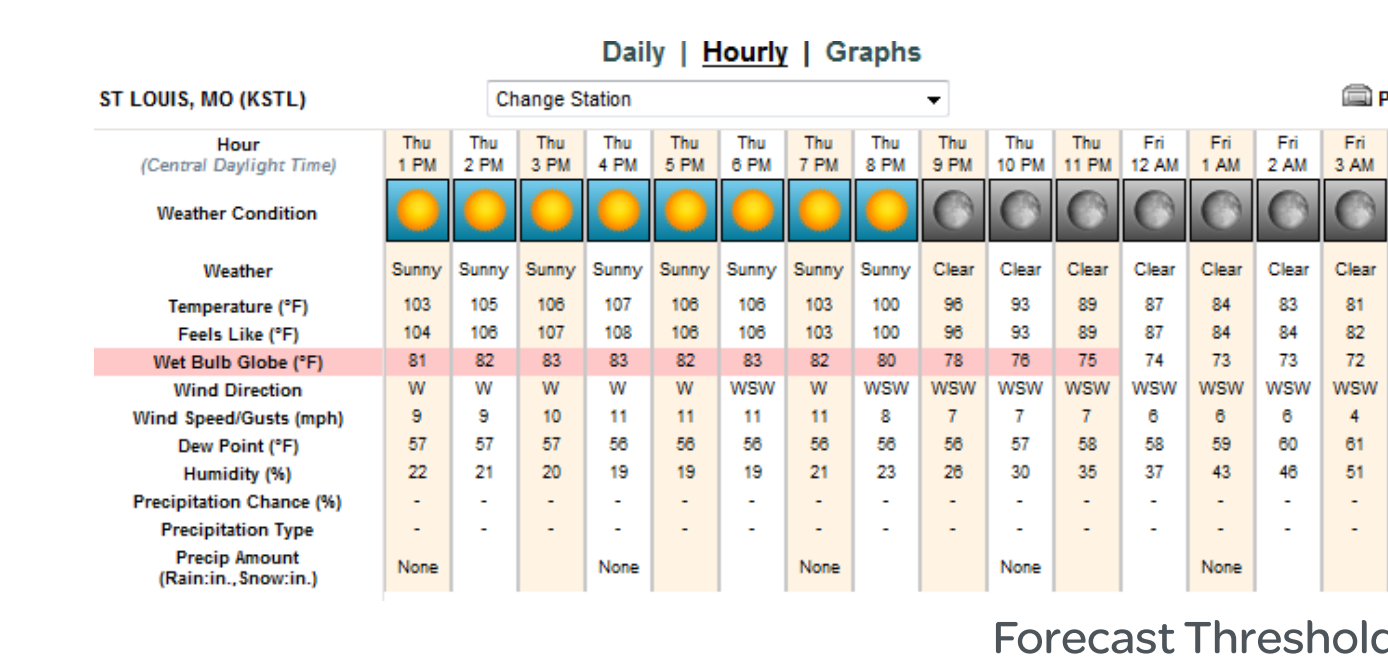
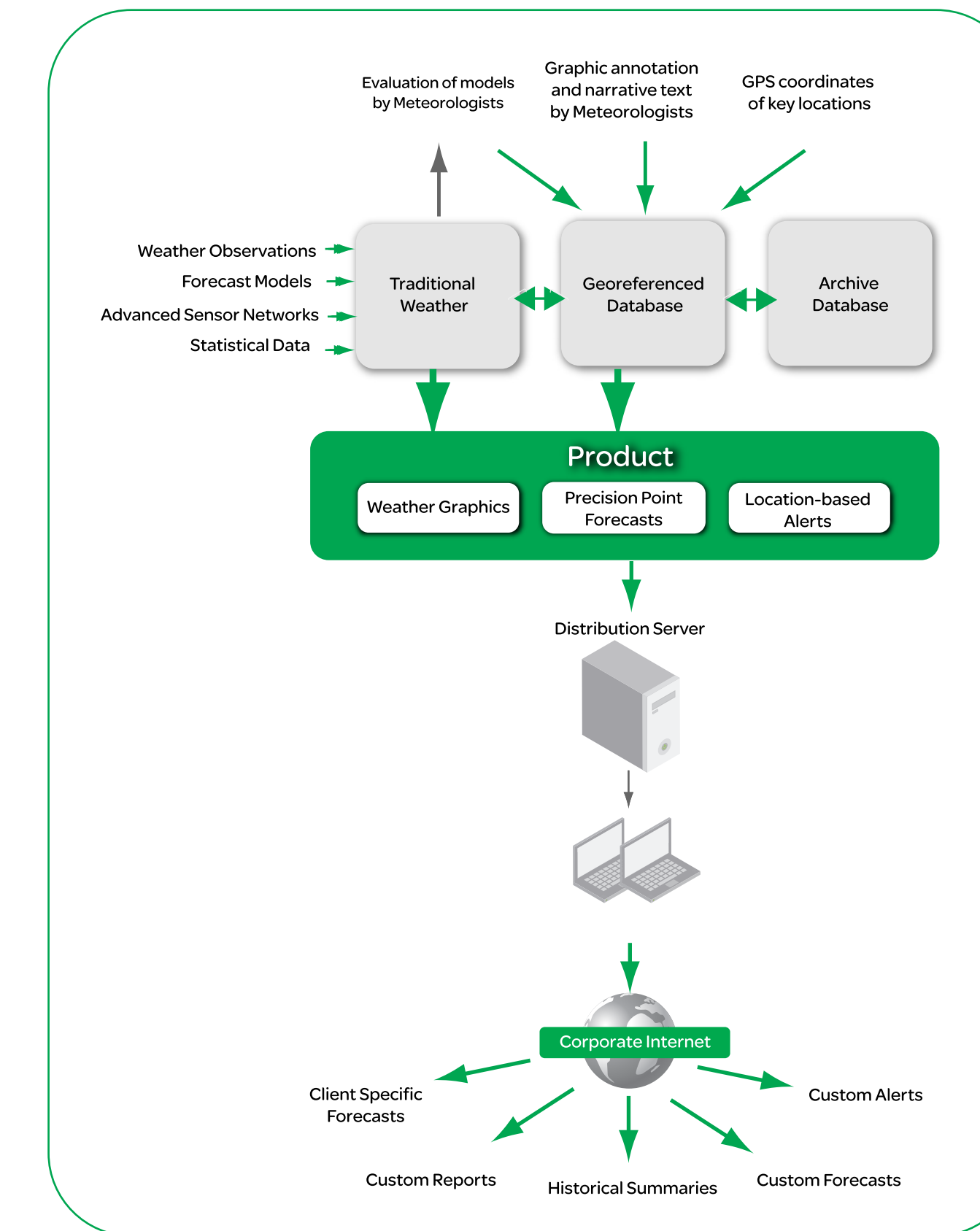
The MxVision WeatherSentry Online software features one-of-a-kind, customizable tools that you can tailor to your operations.

**Forecast Thresholds** - End users can set forecast thresholds (highlighted in pink) for over 40 weather parameters, including WBGT. The forecast threshold alerting tool clearly depicts times when your specific threshold will be breached.

**Visualization** - WBGT can also be plotted in real-time within the MxVision WeatherSentry Online Layered Map. From this setting, users have a spatial view of WBGT in real-time over their territory. Overlaying National Weather Service (NWS) watch/warning information is also an option, including excessive heat warnings. Note in the image to the right how portions of Los Angeles are observing dangerous WBGT values, yet the NWS Excessive Heat Warning is issued for counties to the East.

**Alerting** - The system's Alert Manager® notifies you of significant weather changes for your specific area. Set custom audio or visual alarms for WBGT and other critical parameters. Additionally, key weather alerts and warnings can be delivered directly to an unlimited number of users via cell phone with our simple set up for critical weather updates anywhere. With forecast lead time warnings of up-to 12 hours, those responsible for the safety of athletes can take a pro-active measure on high WBGT values.

**Online Consulting Forum** - Should you require further information about the WBGT forecast, you can access Schneider Electric's team of experienced meteorologists via the MxVision WeatherSentry Online, Consulting Forum. You can access the forum from your computer or on your mobile device. Ask a question and receive an answer. This direct, 24/7 access to our forecasting center provides invaluable insight to further mitigate risk.



## Summary

Wet bulb globe temperature is being adopted by more sports organizations as their standard for identifying possible heat related risks to athletes. It better represents the potential of environmental heat stress than does the traditional heat index indicator, because it factors the wind, cloud and sun-angle factors significant when athletes are exerting themselves at a facility with no sun cover.

Schneider Electric's advanced forecasting technology includes current and forecasted WBGT readings, along with proactive alerting to notify users when their specified thresholds exist or are forecast. This industry-unique functionality provides value far beyond that delivered by dedicated WBGT equipment.

## References

- [1] National Athletic Trainers' Association Position Statement: Exertional Heat Illnesses. Journal of Athletic Training 2002;37(3):329-343.
- [2] Dimiceli, V.E., Piltz, S.F., and Amburn, S.A. (2011). Estimation of Black Globe Temperature for Calculation of the Wet Bulb Globe Temperature Index. Proceedings of the World Congress on Engineering and Computer Science 2011, Volume II.
- [3] Occupational Safety & Health Administration Technical Manual (1999). Section III, Chapter 4, Appendix III: 4-3 Measurement of Wet Bulb Globe Temperature. Washington D.C., U.S. Department of Labor.
- [4] Block, J. and Foerster, J. (2006). Integrating New Weather Technology in Forecast Operations at Meteorlogix - A New Paradigm. 22nd International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology.



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