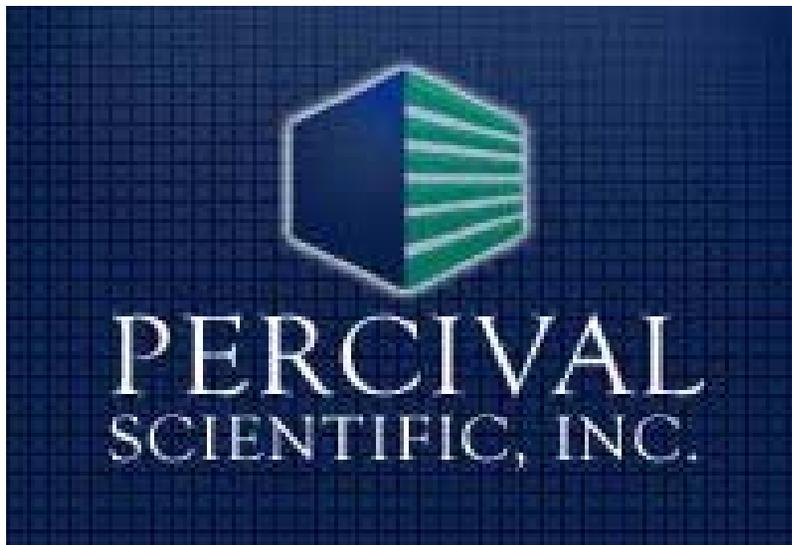


2008 International Meeting on Controlled Environment Agriculture

Thank You!



**Daniel Kiekhaefer
Engineering Manager**

**Henry Imberti
Sr. Vice President**



Tools for Research



- Percival Scientific, Inc. – Controlled Environment Manufacturer
- Current methods for growing plants in a Percival Environmental Chamber
 - Static Settings
 - Diurnal Program (2 program steps)
 - Multi-step programs (more than 2 steps)
 - Multi-step programs linked in a sequence
 - Ramping and Non-ramping
- What if a research project required, or could benefit from the use of a realistic weather model for growing plants?
- No all-encompassing tool is currently available which can accurately simulate all the major weather variables used for growing plants
- Percival now has a product to meet this need

Percival Scientific Introduces...



WeatherEze

The Next Generation of Environmental Control

A Collaborative Effort...



- WeatherEze is a result of a cooperative research and development agreement (CRADA) with the United States Department of Agriculture-Agricultural Research Service.
- Neither this CRADA nor the results of this CRADA are an endorsement by USDA-ARS of Percival's products or services, including this software.



Project Goal



- Create a tool capable of reproducing or simulating natural weather conditions in a Percival Plant Growth Chamber
- Provide a previously unavailable degree of accuracy and control
- Base weather simulations on empirical data
- Keep the system user-friendly and convenient to use
- Allow for user-specific settings
- Provide global coverage

Select a Location



WeatherEze Setup Wizard

Enter Experiment Location Information / Lighting Simulation

Please enter experiment location information and Lighting Simulation Option, then click 'Next >.'

Select Method to Retrieve Latitude / Longitude (Optional)

Morris Municipal Automatic Weather Observing / R

OR

Manually Enter Latitude / Longitude

Latitude

Longitude

Elevation (m)

Time Zone: ▼

Lighting Simulation Options

Match Solar Quality (default)

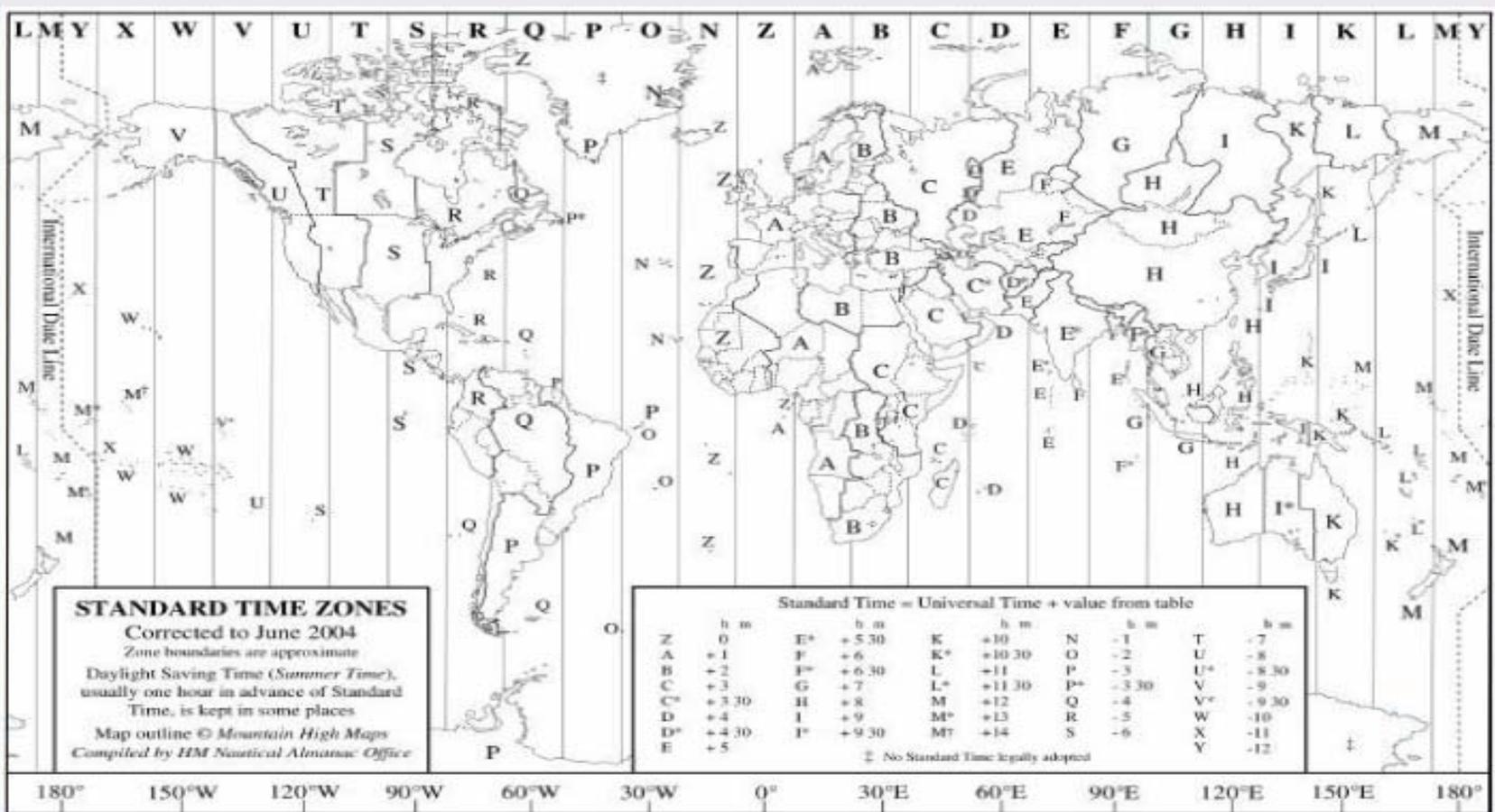
Match Solar Intensity (including daylength timing)

Fixed Intensity (with manual setpoints)

Select a Location – World Map



World Map



STANDARD TIME ZONES
Corrected to June 2004
Zone boundaries are approximate
Daylight Saving Time (Summer Time), usually one hour in advance of Standard Time, is kept in some places
Map outline © Mountain High Maps
Compiled by HM Nautical Almanac Office

Standard Time = Universal Time + value from table

Z	h m	E ⁺	h m	K	h m	N	h m	T	h m
A	+1	F ⁺	+6	K ⁺	+10 30	O	-2	U	-8
B	+2	F ⁺	+6 30	L	+11	P	-3	U ⁺	-8 30
C	+3	G	+7	L ⁺	+11 30	P ⁺	-3 30	V	-9
C ⁺	+3 30	H	+8	M	+12	Q	-4	V ⁺	-9 30
D	+4	I	+9	M ⁺	+13	R	-5	W	-10
D ⁺	+4 30	I ⁺	+9 30	M7	+14	S	-6	X	-11
E	+5							Y	-12

‡ No Standard Time legally adopted

180° 150°W 120°W 90°W 60°W 30°W 0° 30°E 60°E 90°E 120°E 150°E 180°

Click mouse on desired location

Close Map Window

Select a Control Mode



WeatherEze Setup Wizard

Enter Program Options

Please enter program options, then click 'Finish'.

Weather Options

- Simulate weather
 - Enable Random Temperature Factor
- Real time weather link-up

Selected Station ID:

Simulation Start

Date: **March, 2008**

Sun	Mon	Tue	Wed	Thu	Fri	Sat
24	25	26	27	28	29	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

Time:

Daily Temperature Interpolations

- Cesaraccio et al. (2001) (dual sine; squart root function) (Recommended)
- Sine Wave Fit (6AM/6PM)

Time Display

- 24 Hour
- 12 Hour (AM/PM)

File Logging

- Enable File Logging



Modes of Control



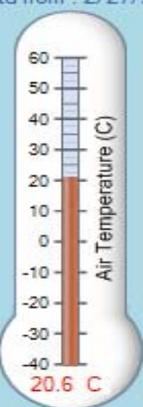
- **Simulation:** Allows the user to select any start date at any location on the globe. The program will simulate daily temperature, relative humidity, CO₂ and light conditions and automatically program them into the Intellus Controller on any Percival Environmental Chamber with communications.
- **Real-time:** Allows the user to recreate weather conditions from any location on the globe where weather data is available in near real-time. The conditions are automatically programmed into the Intellus Controller on any Percival Environmental Chamber with communications.



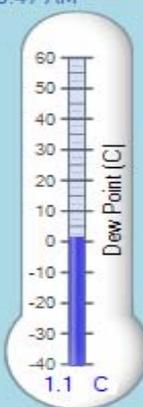
WeatherEze Control Panel [-] [□] [✕]

Chamber | Temperature | Relative Humidity | CO2 | Solar Spectrum | **METAR** | Status

Data from : 2/27/2008 09:47 AM Next Download : 2/27/2008 10:02 AM



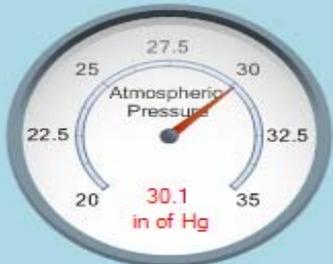
Air Temperature (C)
20.6 C



Dew Point (C)
1.1 C



Relative Humidity
27



Atmospheric Pressure
30.1 in of Hg



METAR Errors

Metar String: 2008/02/27 16:50 KLAX 271650Z VRB04KT 10SM FEW250 21/01 A3008 RMK AO2 SLP185 T02060011

METAR Location: Los Angeles, Los Angeles International Airport , United States

Use Simulated Temperature/Relative Humidity

Previous METAR Data:

2/27/2008 11:47:16 AM -->Metar Data Downloaded: 2008/02/27 16:50 KLAX 271650Z VRB04KT 10SM FEW250 21/01 A3008 RMK
 2/27/2008 11:47:58 AM -->Metar Data Downloaded: 2008/02/27 16:50 KLAX 271650Z VRB04KT 10SM FEW250 21/01 A3008 RMK
 2/27/2008 11:47:59 AM :: METAR DATA Retrieved - Air Temp :20.6 RH:27 BP:30.1

Return to Settings
Exit

Chamber Last Updated at 11:53 AM on 02/27/08. Next Update in 4.8 minutes.



Temperature Control

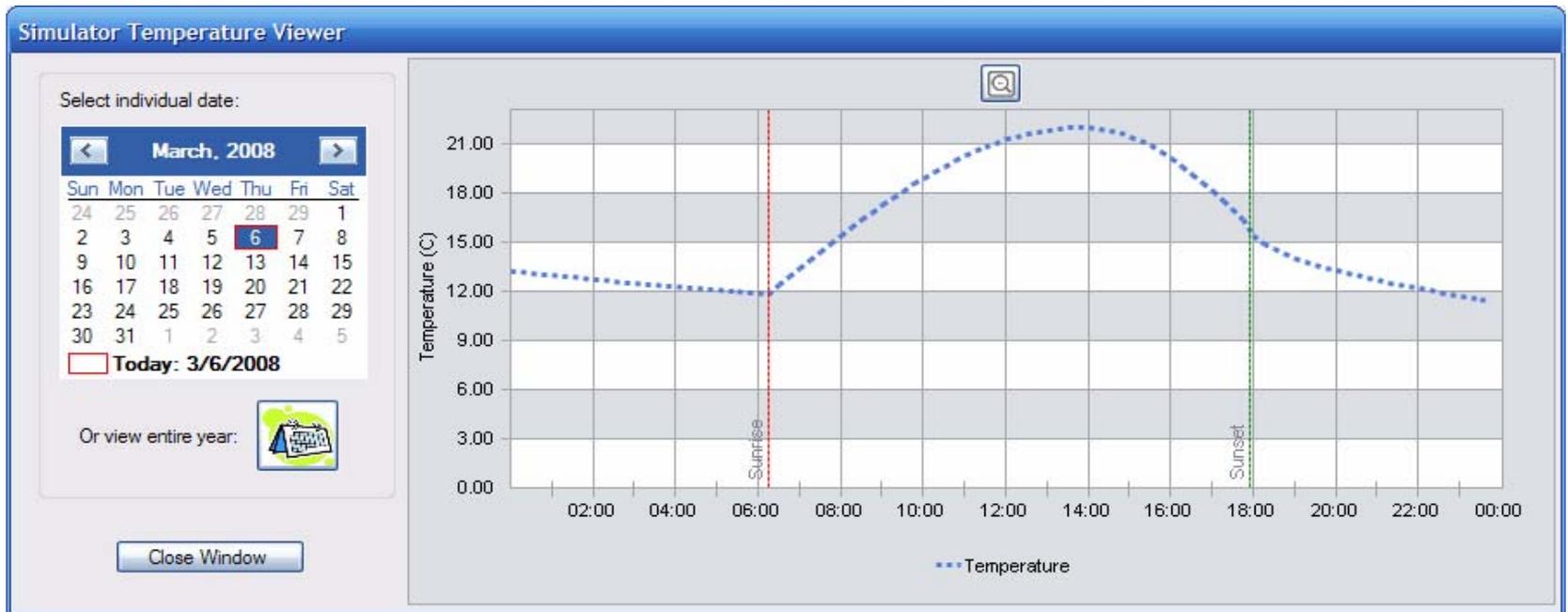


- Simulation:
 - Simulated temperature profiles are averaged values, based on the last 30 years of global climate data
 - Temperature profiles for any point on the globe can be simulated
 - Simulations can be run for past, present and future time periods
 - A random factor can be applied to the annual temperature cycle which simulates diurnal temperature variability
- Real-time Control:
 - Weather data can be acquired in near real-time from any METAR station (which typically update every hour)
 - Requires an internet connection
 - Can automatically switch over to simulated temperature settings if communications are lost

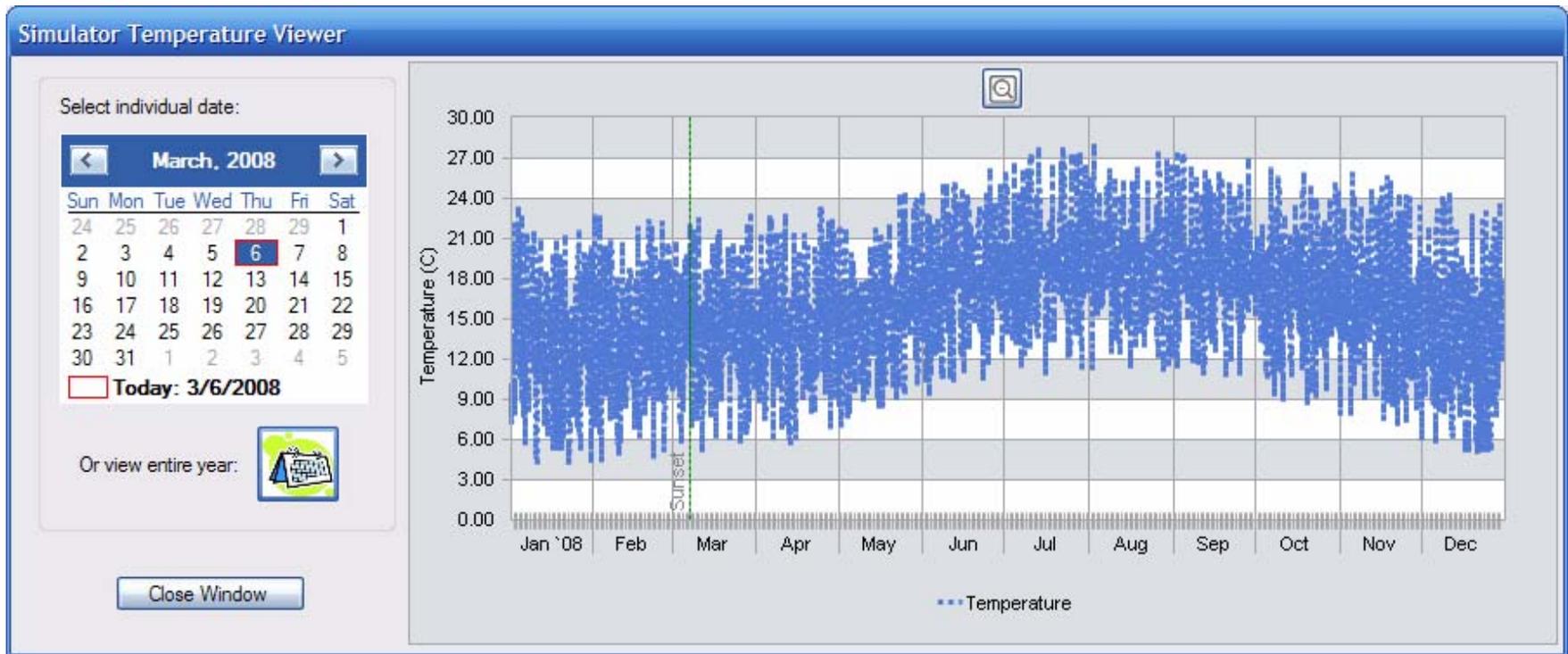
Temperature Control



View Any Individual Date



View the Entire Year



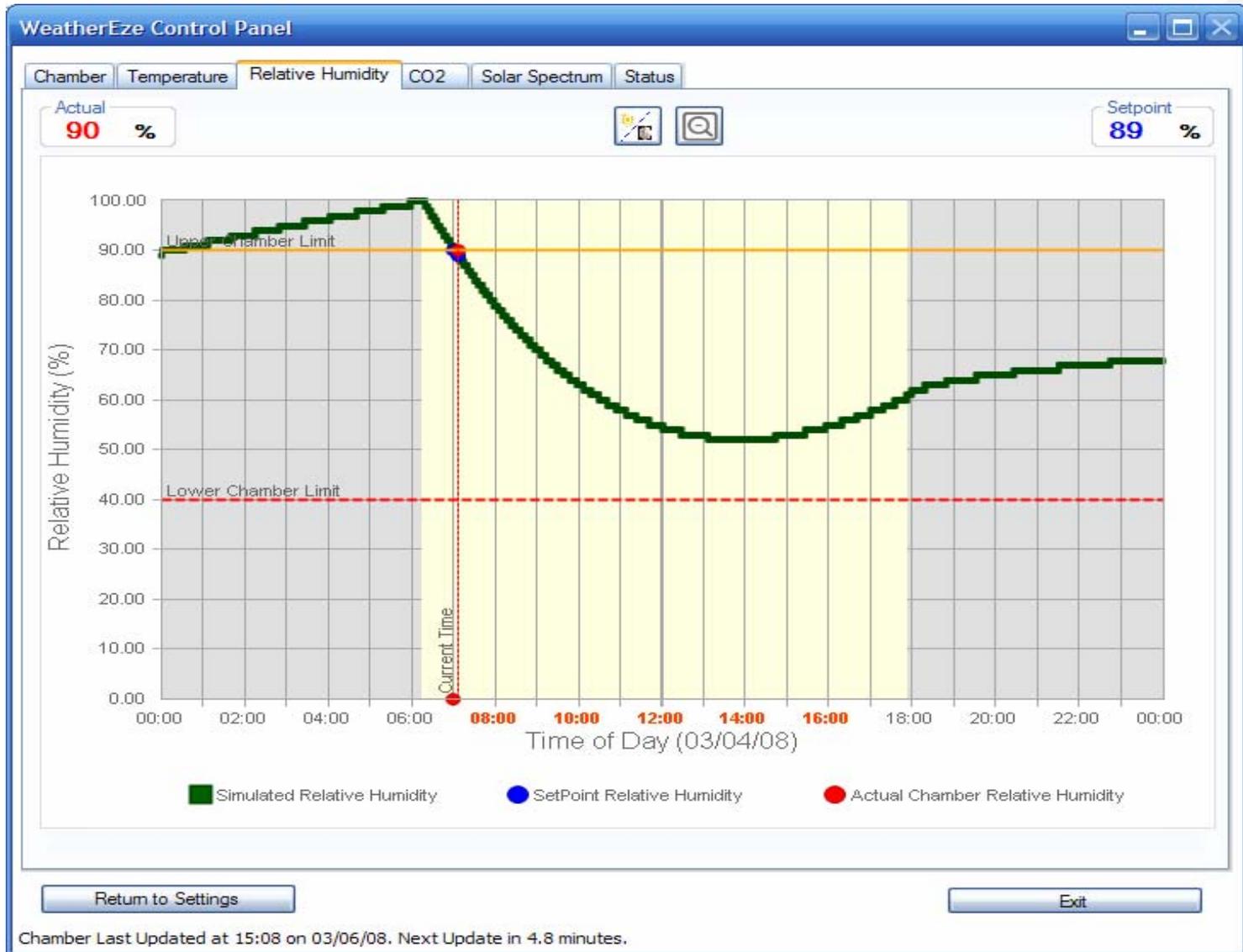


Relative Humidity Control



- Simulation:
 - Simulated relative humidity profiles are calculated based on the daily temperature
 - Relative humidity profiles for any point on the globe can be simulated
 - Simulations can be run for past, present and future time periods
- Real-time Control:
 - Relative humidity data can be acquired in near real-time from any METAR station (which typically update every hour)
 - Requires an internet connection
 - Can automatically switch over to simulated temperature settings if communications are lost

Relative Humidity Control





- Simulation:
 - Simulated CO₂ profiles are based on geographical and seasonal variations gathered from previous scientific studies
 - Also provides the ability for the user to account for any diurnal fluctuations in CO₂
 - Account for fluctuations resulting from position within a plant canopy
 - Account for ambient levels resulting from location (urban, rural, remote)
 - Simulations can be run for past, present and future time periods
- Real-time Control:
 - These values are typically not available in real-time. All CO₂ control is accomplished through the simulation





Lighting Control



- Setup
 - WeatherEze software is easily configured to any specific Percival Controlled Environment
- Quality
 - Solar quality can be simulated at any position and point in time on the globe
 - Takes into account the spectral output of the chamber's lighting system, and matches it as closely as possible to the global solar spectrum
 - This mode is focused on reproducing the actual spectrum in terms of wavelength ratios as opposed to intensity
 - Well suited for single spectrum light sources
- Quantity
 - Solar intensity can be simulated at any position and point in time on the globe
 - Total intensity is matched over the entire solar spectrum
- Custom
 - Allows the user to enter customized lighting periods and bulb outputs
 - Can customize day start, end, and light output during the day cycle





Key Features



- Offers more realism than more conventional static or ramping environmental control profiles
- Quickly and easily configures to any Percival Environmental Chamber equipped with communications
- Easy to use for beginners, highly configurable for advanced use
- Once a control mode is started, the software will control a chamber without requiring any further user intervention
- All values from both control modes are automatically relayed and entered into the Intellus Controller as set points
- Software outputs and chamber status can be checked in real-time on the master status screen
- Automatic data logging of all chamber set points (simulated or real-time) and actual chamber values
- Sunrise & Sunset times can be overlaid on most graphs

Global Coverage





Pushing Chamber Technology Forward



- Currently provides a level of control that our chambers cannot currently achieve
 - Cannot reproduce the sun inside a chamber
 - Dew points
 - Rapid temperature cycles
 - Daily minimum and maximum values
- We believe a control system should be at least as accurate as the device its controlling
 - Key to maximizing performance and avoiding under-utilization of current environmental chambers
 - Promotes and enhances a natural progression of current product refinement and new product development
- A plant growth chamber capable of reproducing actual weather conditions is now ultimately within reach
- WeatherEze software and Intellus Ultra with communications has the potential to revolutionize plant growth research



Future Software Enhancements



- Lighting Control
 - Revised functionality
 - Additional modes of control
 - Increased library of bulb spectra
- Plant Growing Guidelines
 - Quick reference
 - Chamber configuration & optimization
- Precipitation values and automatic watering