Extreme Heat

NWS Heat Wave Program

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Phoenix, Arizona

Heat Waves

in the news…

Tragic Heat Wave

191 DEATHS

CNN August 2, 1999

CHICAGO -- Thirty more…added to list of heat-related deaths across the country…authorities continued to find more bodies…

The heat contributed to the deaths of **80** people in Illinois…and **191** people nationwide…

…In Missouri, **44** peop

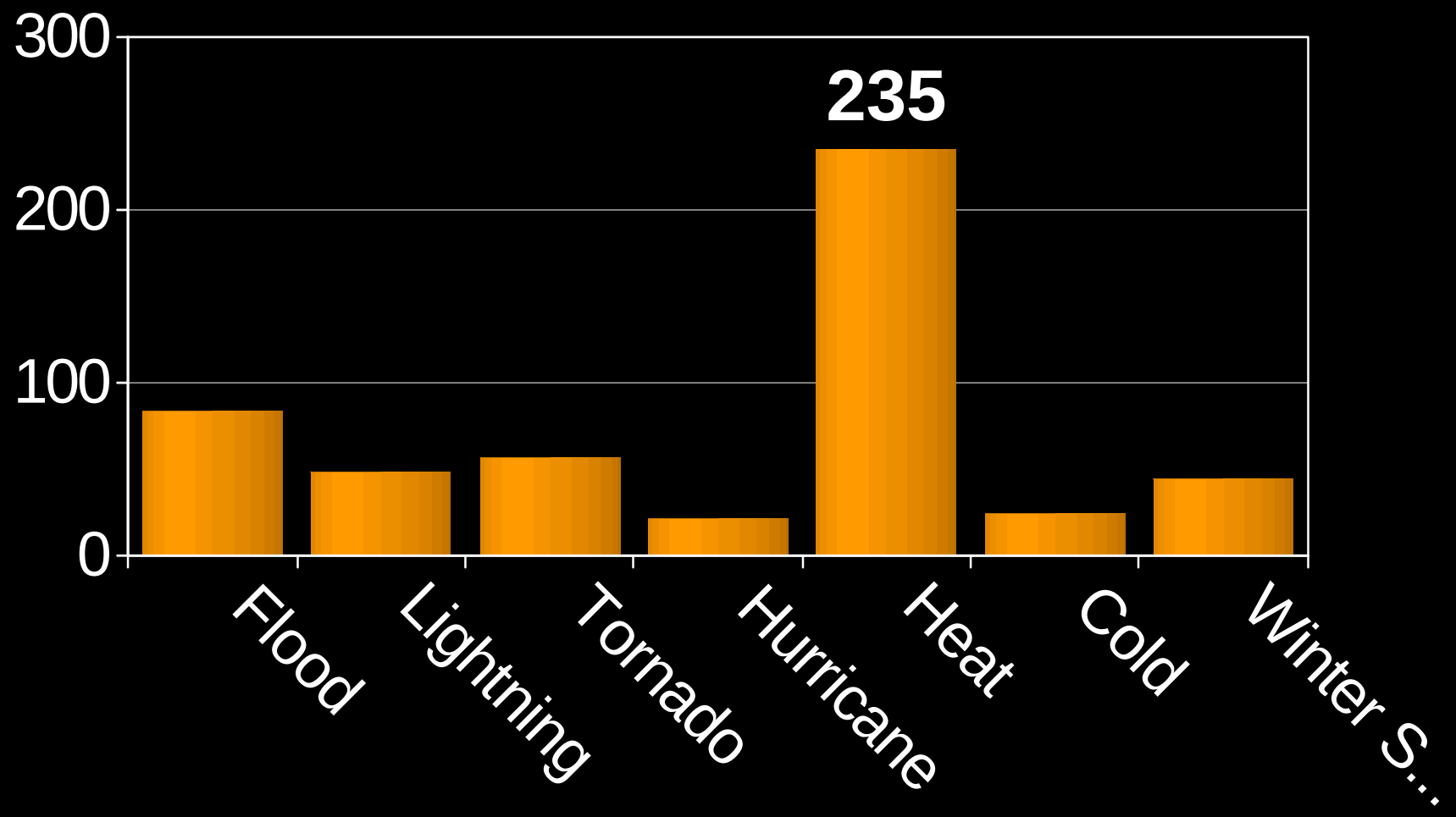
…Heat Wave! **700** People Dead in Chicago area

1995…

Chicago News…August 3, 1999

"…one doesn't see the kind of mortality like we have had here…"

National Average Deaths by Disaster



Pre 2005 August Hurricane Katrina 1,300 Deaths!

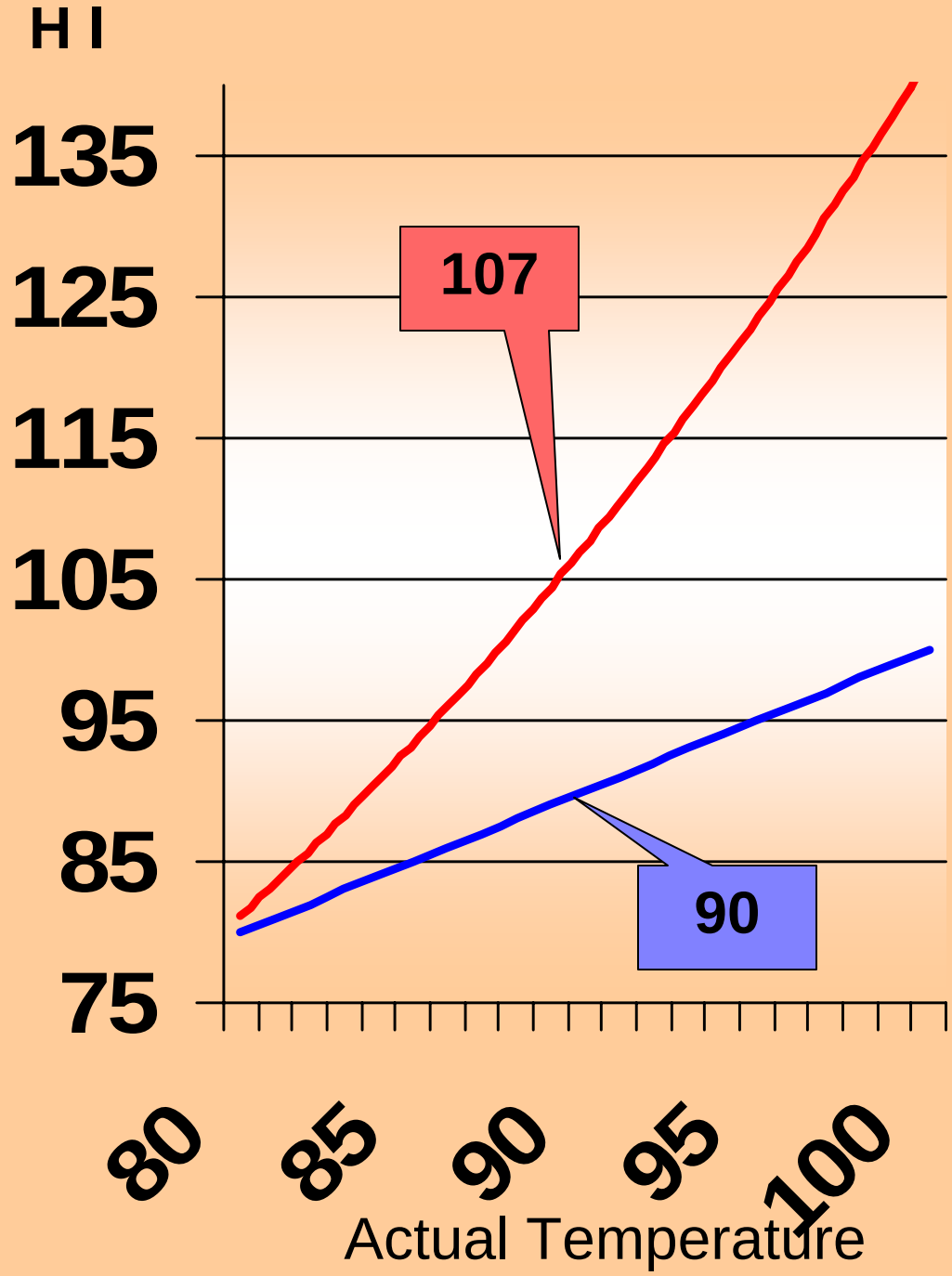
10 yr Avg 1995 -2004

The Challenge:
Minimize an Extreme Heat Disaster

- Meteorology - Forecast
  - Significant Extreme Heat in an Extremely Hot Climate
- Service
  - Issue Meaningful “Extreme Heat Warning”
- Public
  - Response to Extreme Heat Warning
- Emergency Management Response
  - How to deal with an Extreme Heat Disaster

Heat Index = Apparent Temperature

- Heat Index **HI**
  - A number in degrees Fahrenheit (F) that tells how hot it really feels when relative humidity is added to the actual air temperature.
  - The ability of the body to cool itself by perspiring – evaporation, decreases as **HI** increases.

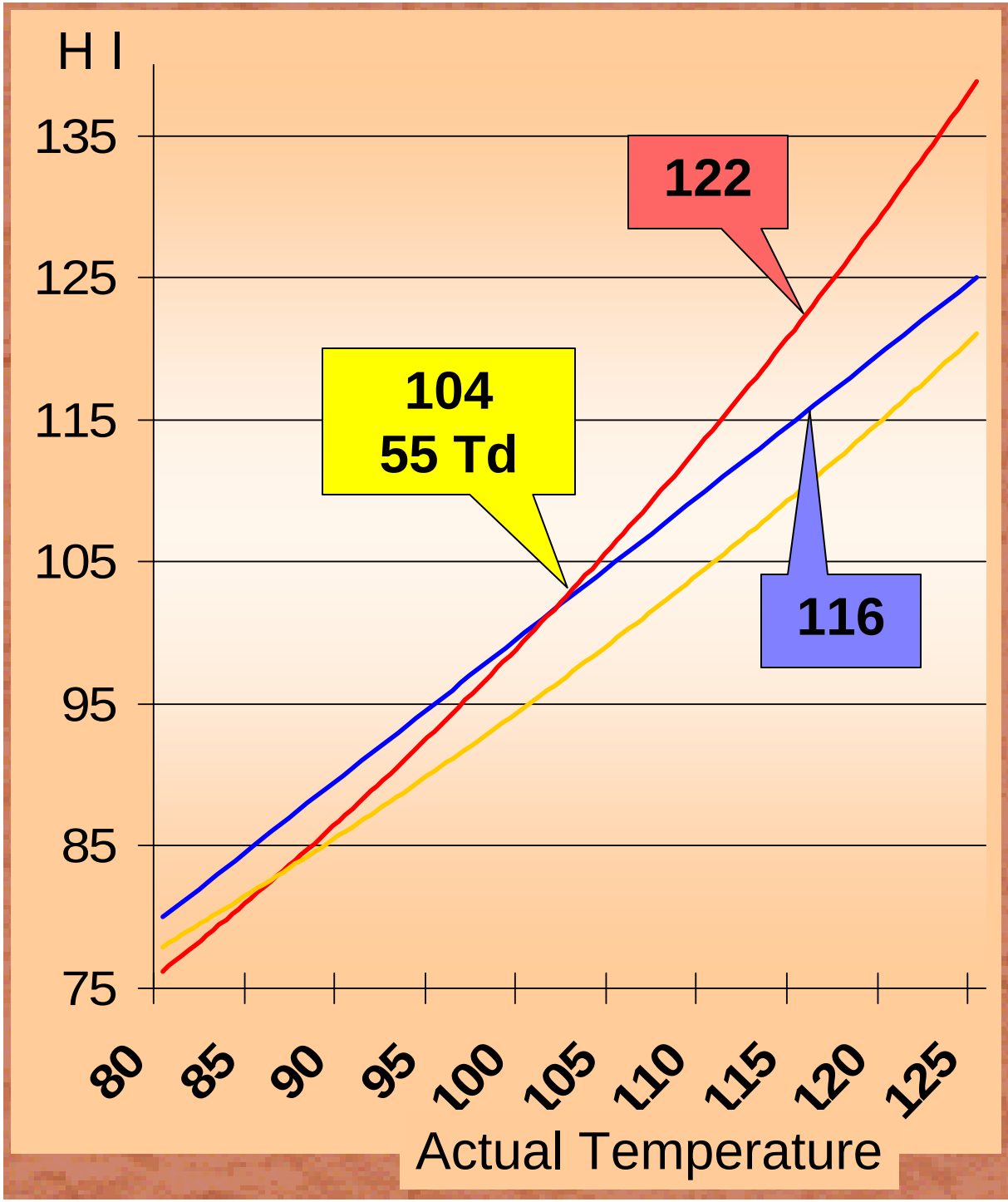


Mid West – Gulf and East Coast
Actual Temperature

vs

Heat Index Computed with 70 % RH Constant

Meteorology



Desert Southwest - Arizona Actual Temperature

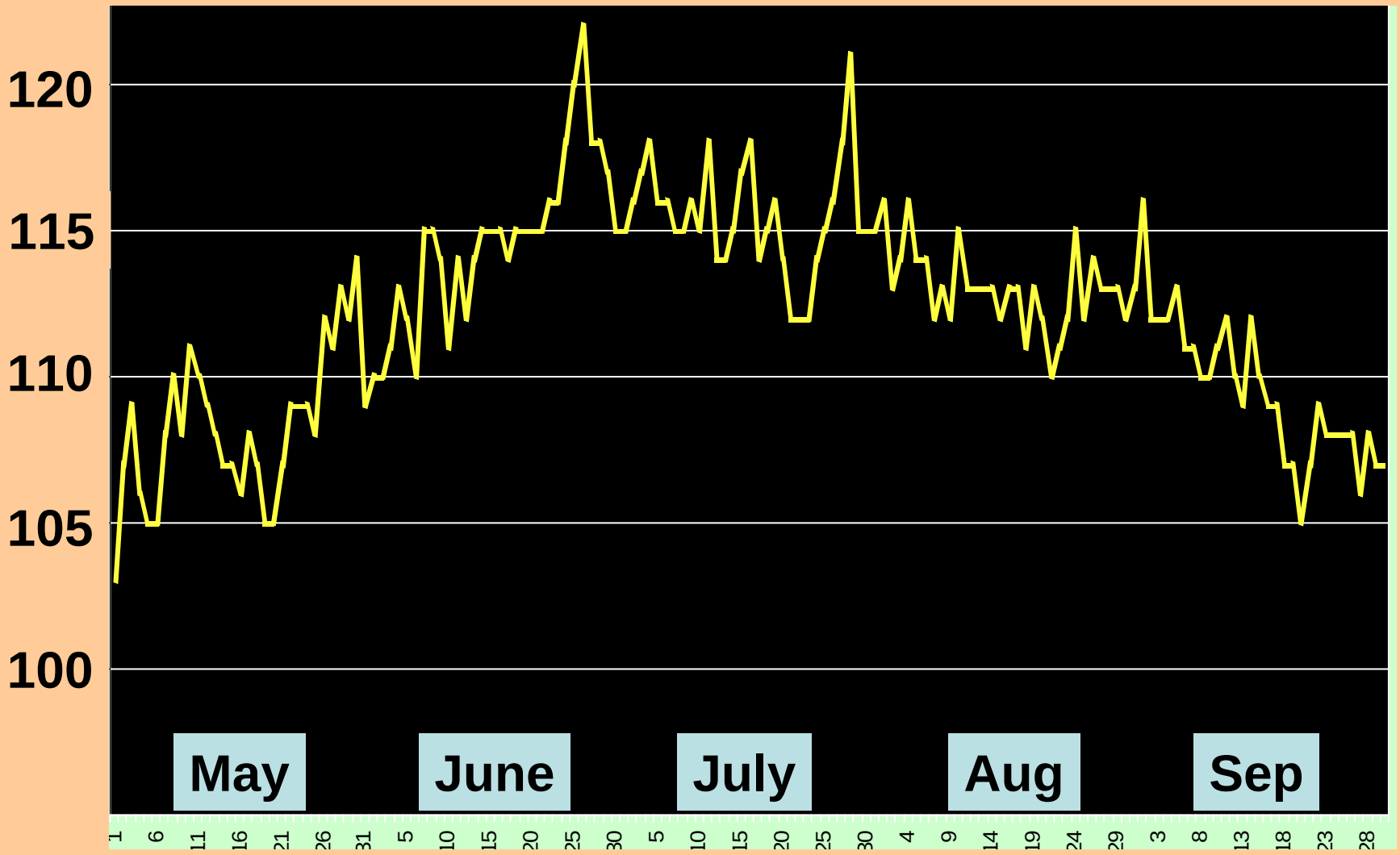
vs

Heat Index with 10 % RH Constant

Heat Index with 20 % RH Constant (Monsoon)

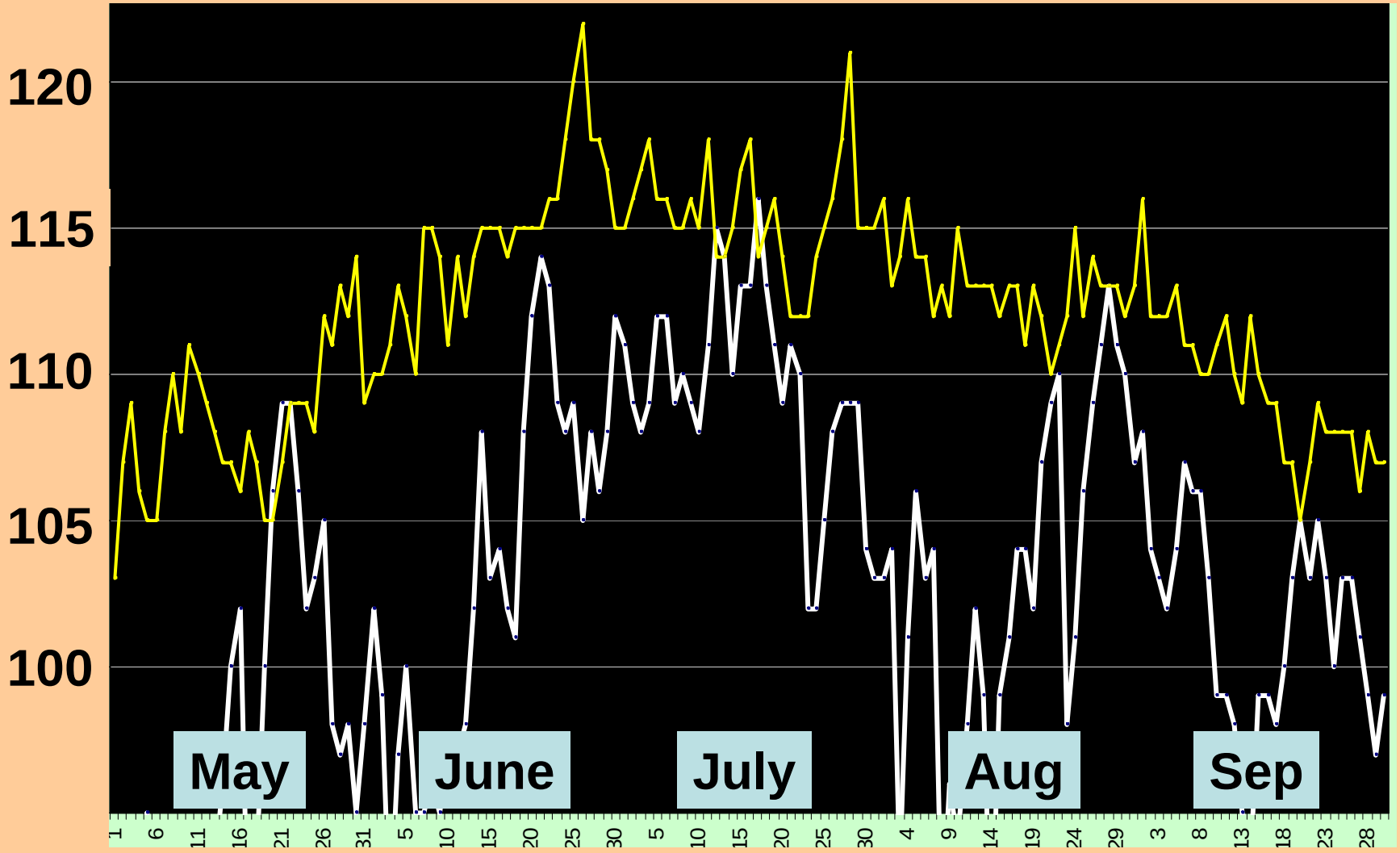
Meteorology

Phoenix Record Max T 1896 – 2004



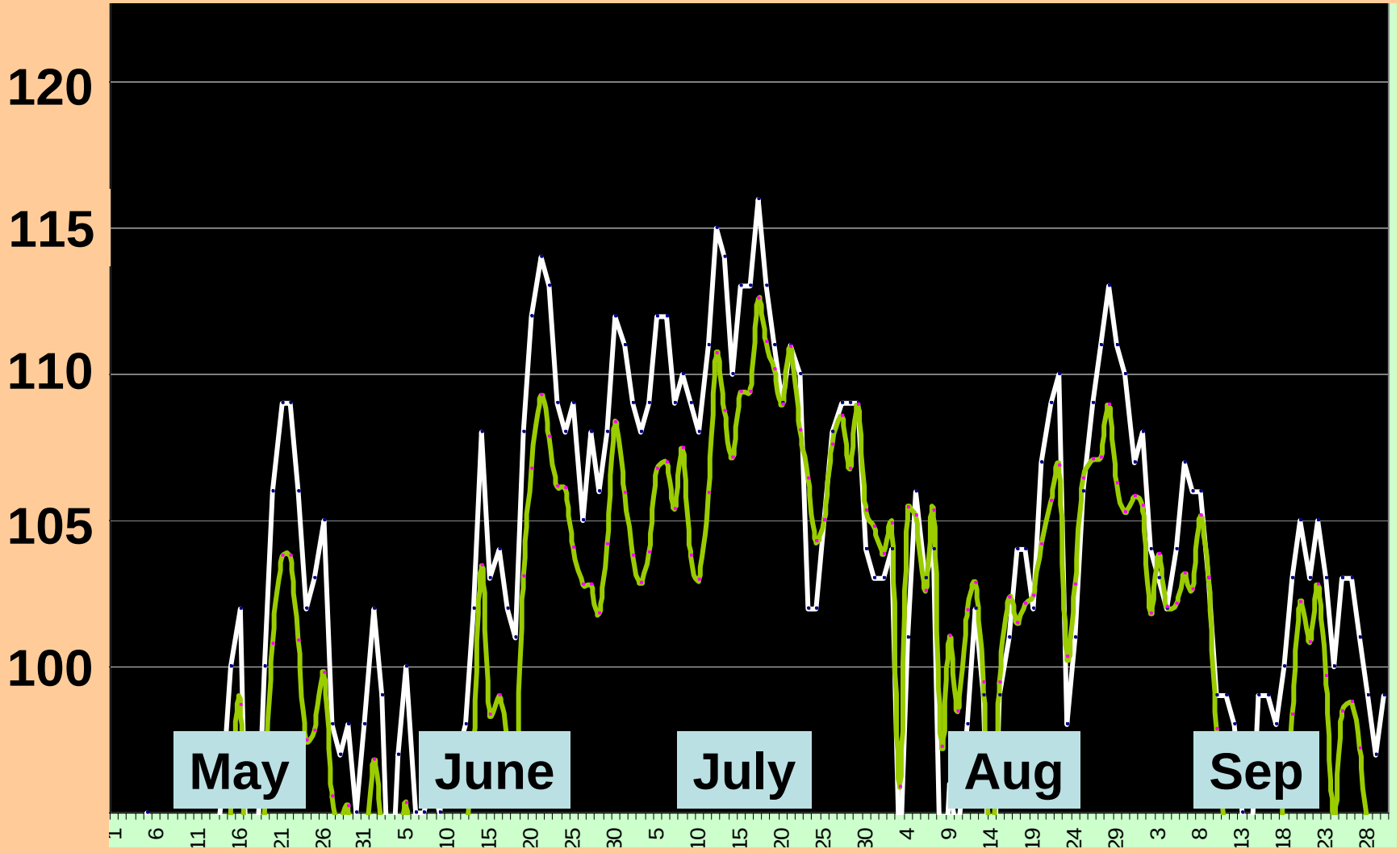
Meteorology

Record MAX T 1896 - 2004
2005 Daily Max T



Meteorology

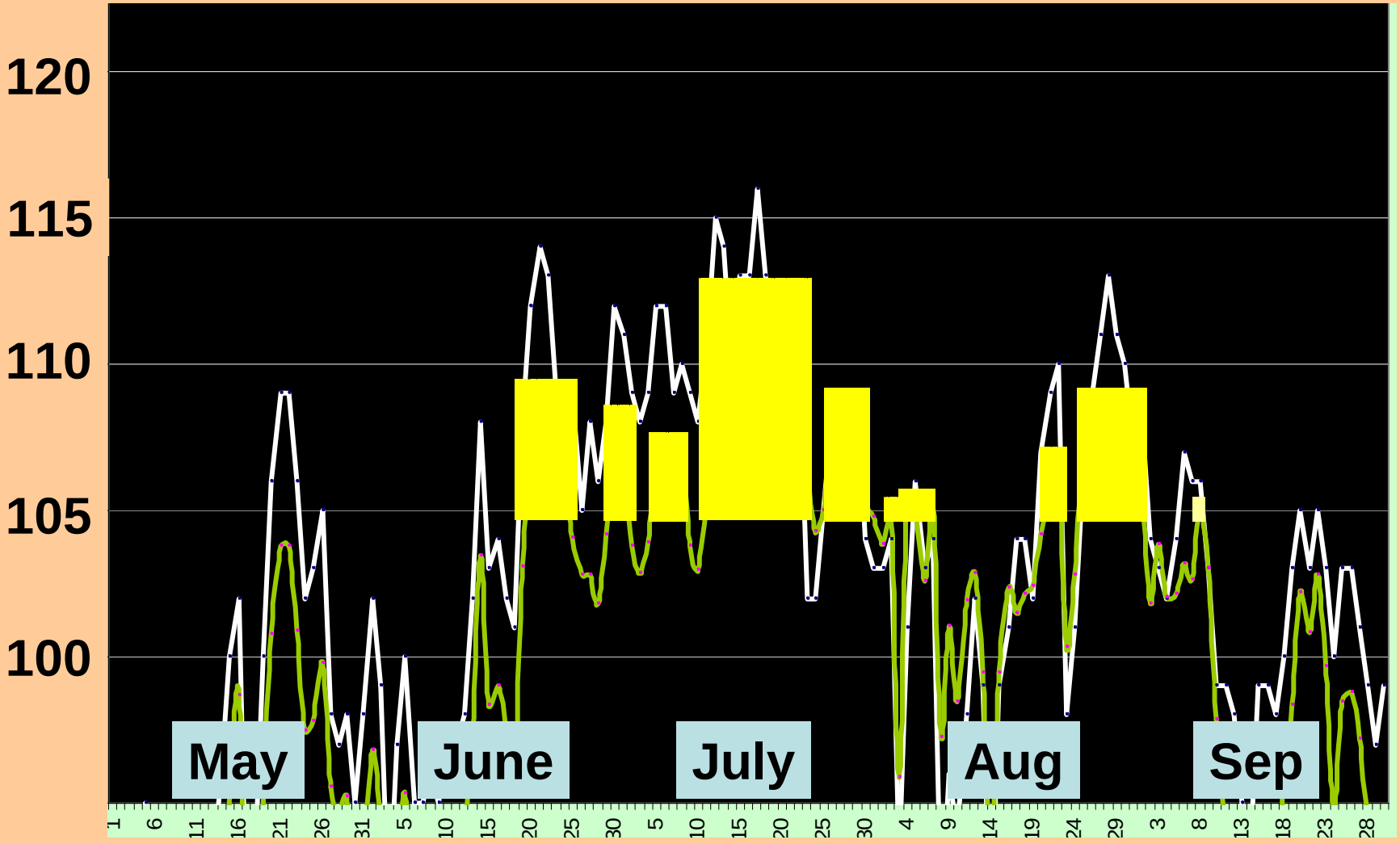
Daily MAX T 2005
Daily Max Heat Index (HI)



Meteorology

2005 Daily max T and HI

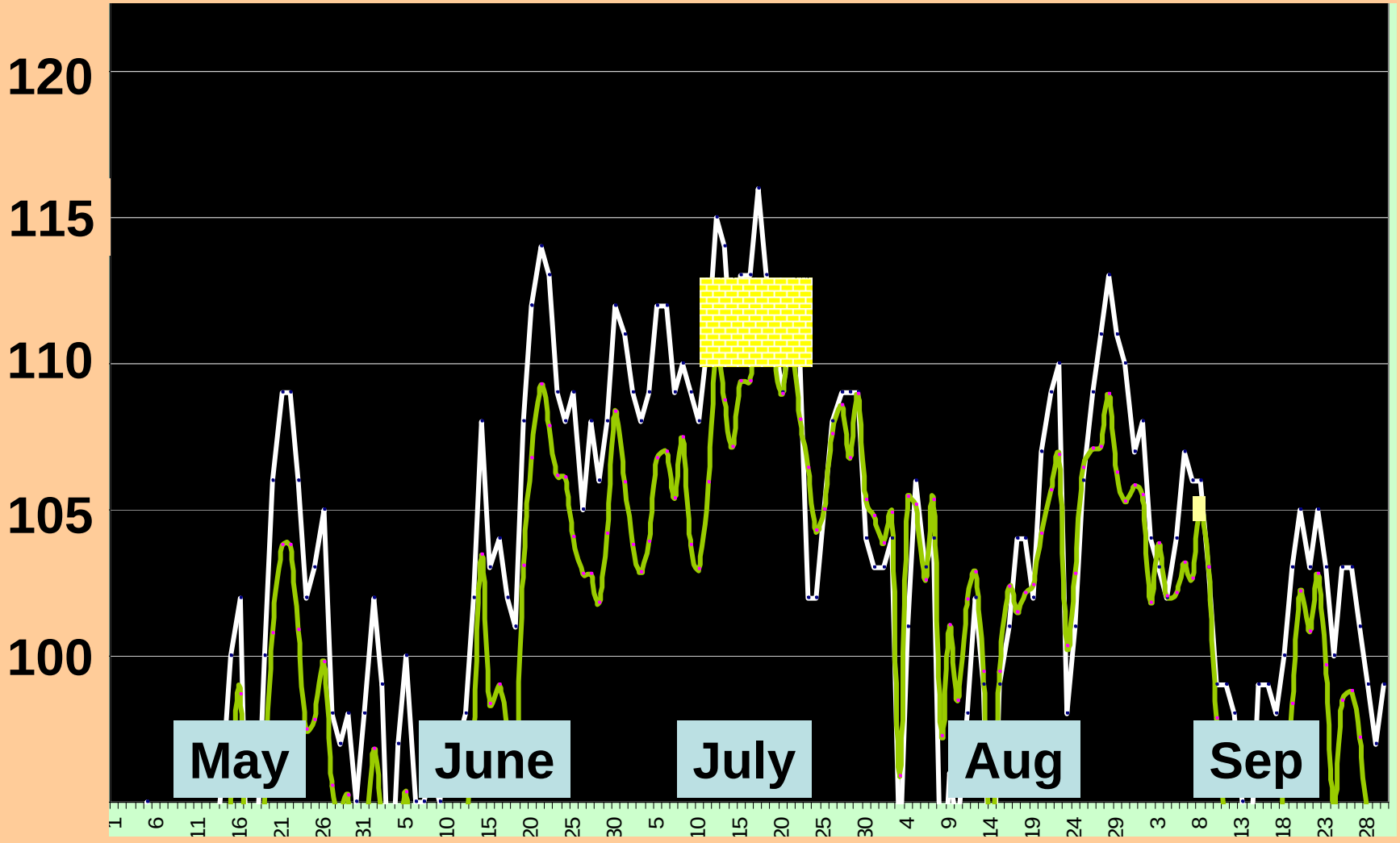
HI ≥ 105



Meteorology

2005 Daily Max T and HI

HI ≥ 110

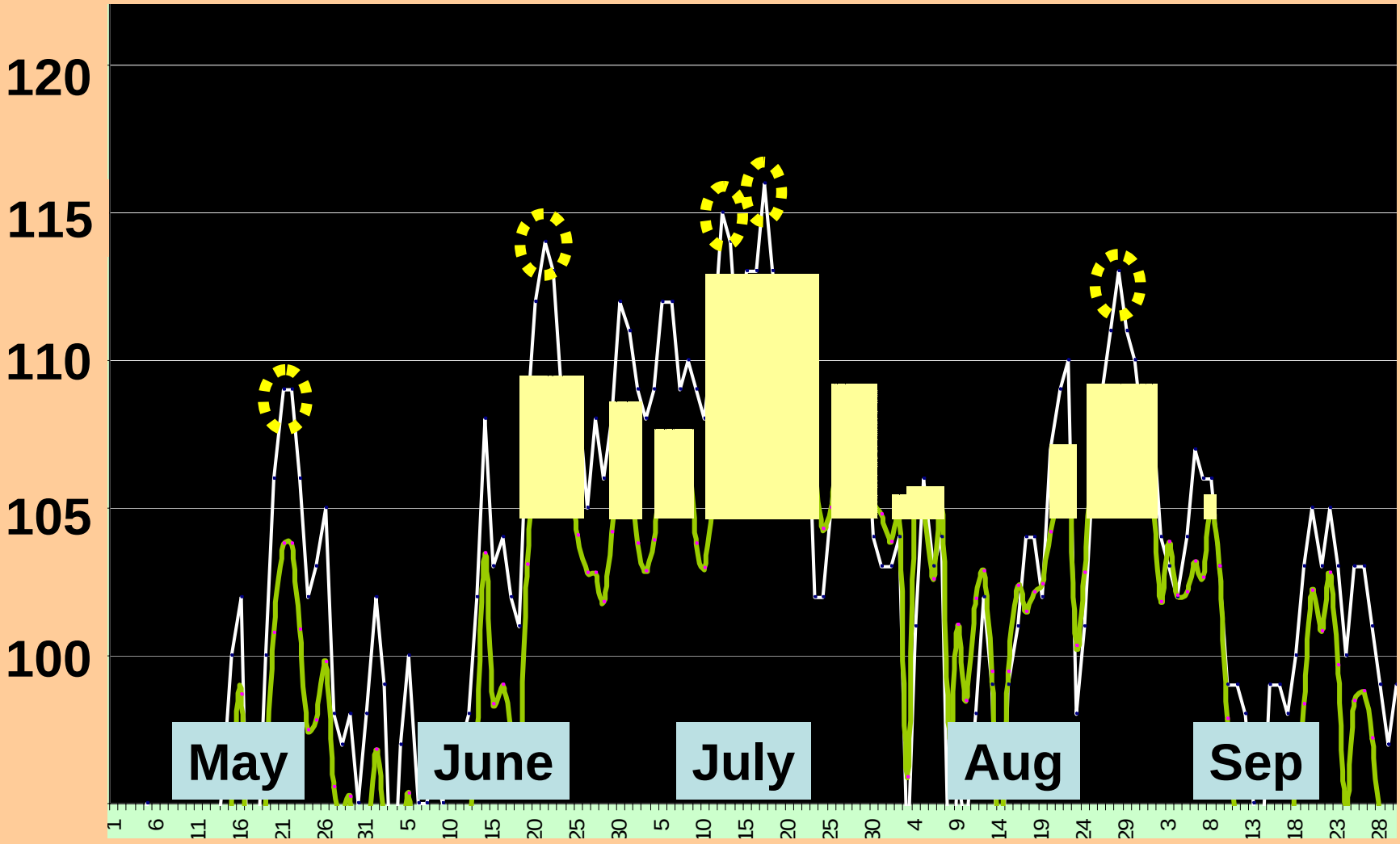


Meteorology

2005 Daily Max T and HI

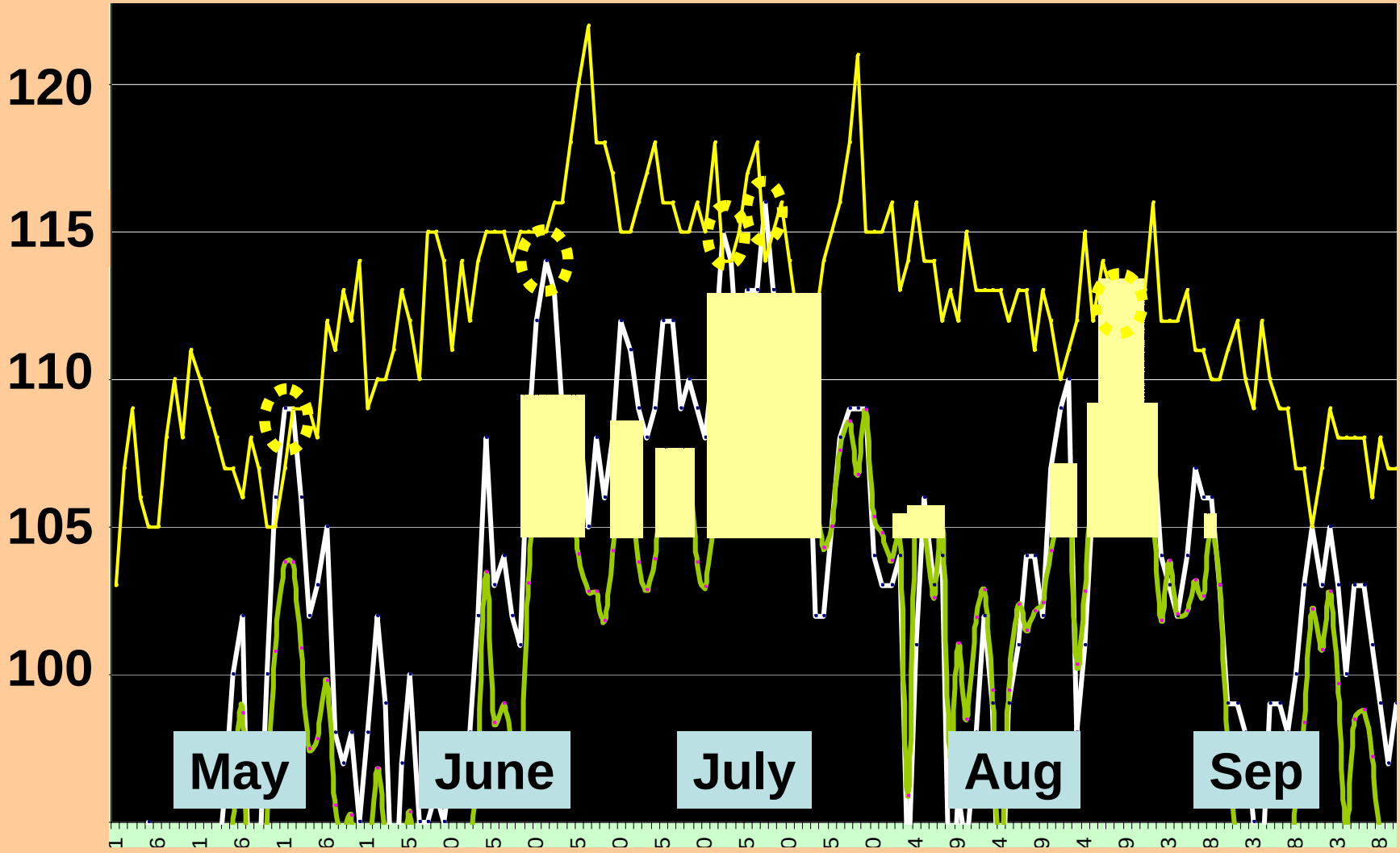
HI ≥ 105

Excessive Heat Warning Days



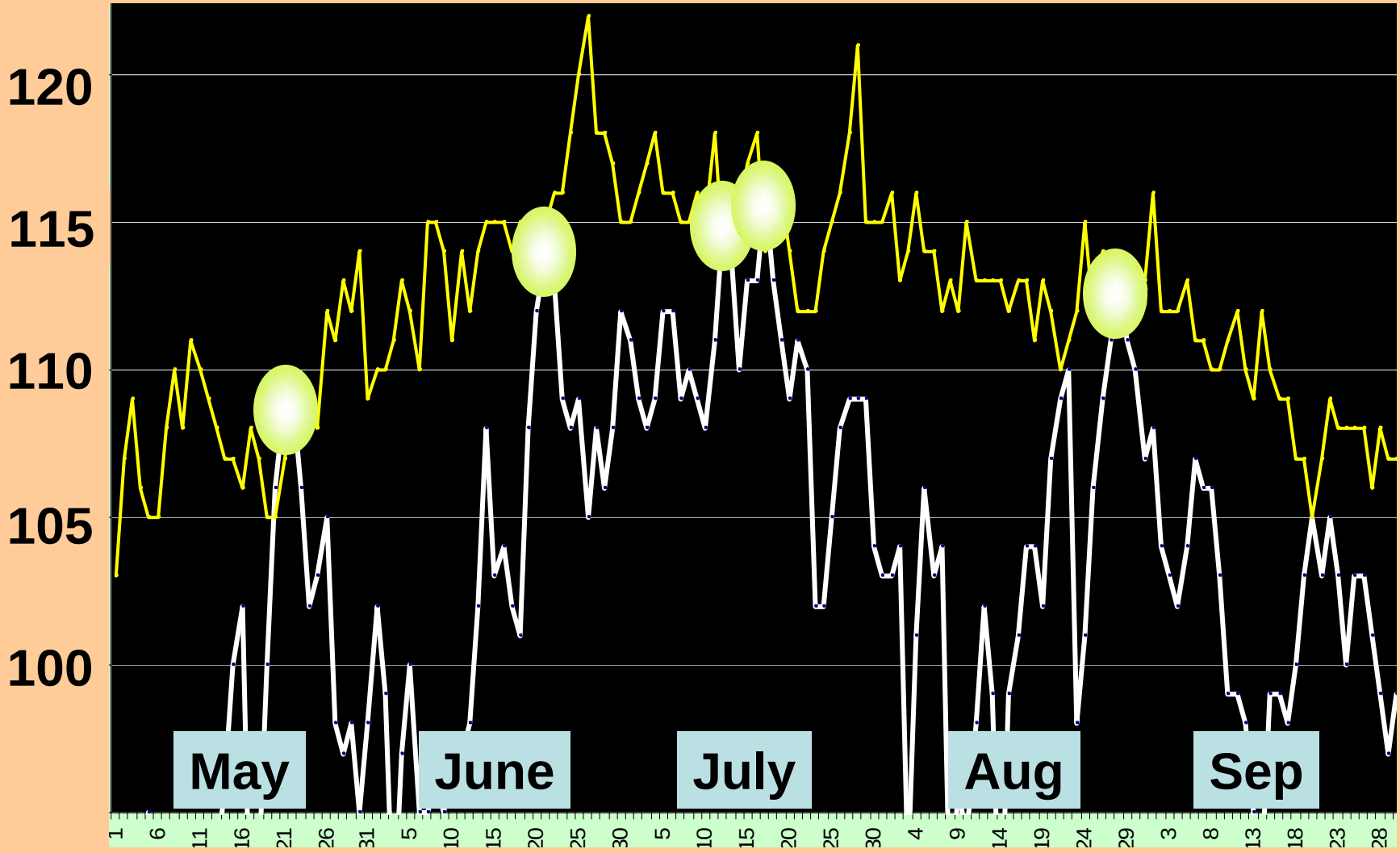
Meteorology

Record Max T 1896 - 2004
2005 Daily Max T & HI
Excessive Heat Warning Days



Meteorology

Record Max T 1896 - 2004
2005 Daily Max T
Excessive Heat Warning Days



Meteorology

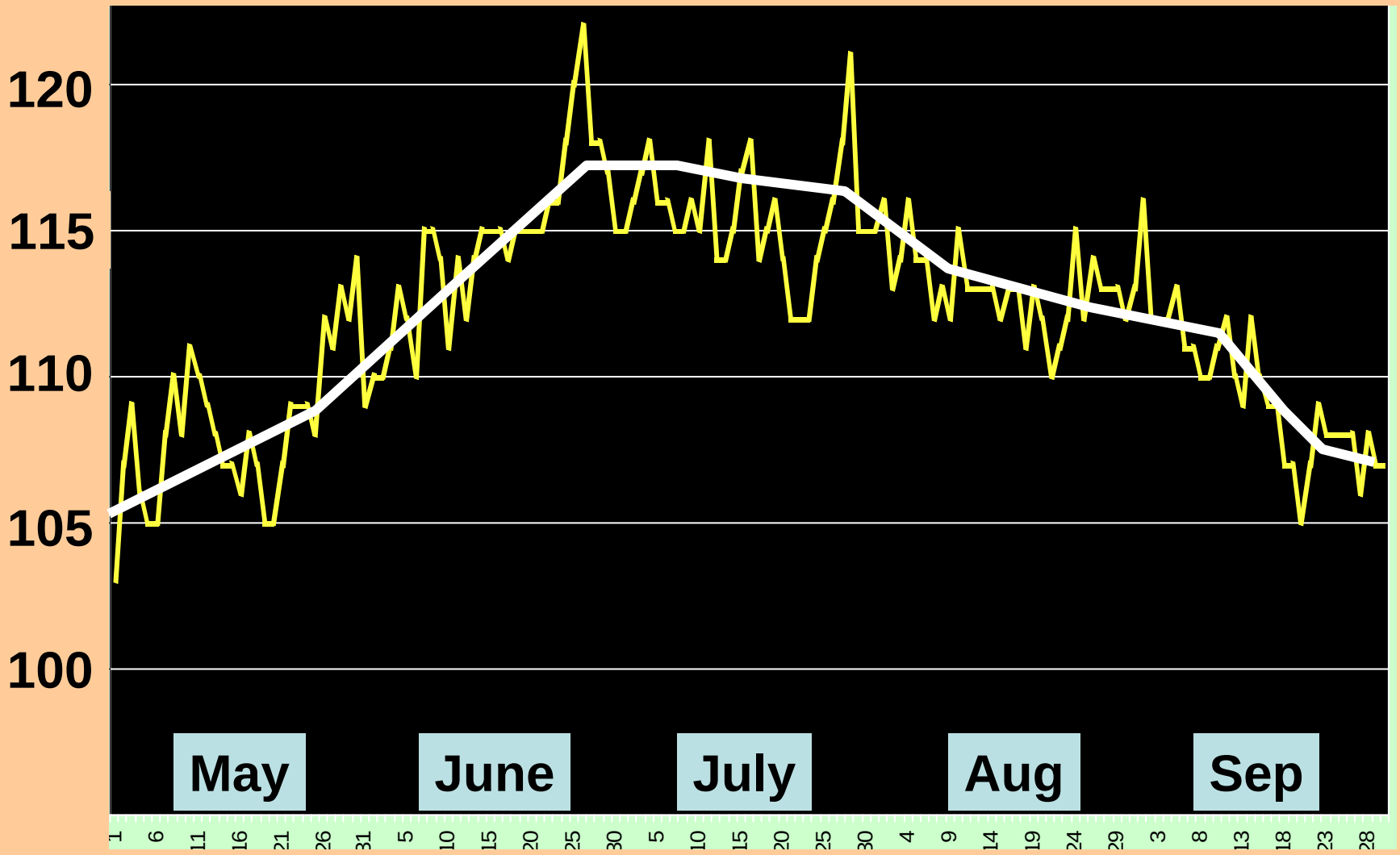
Dr. Kalkstein's Approach

- Customize The Heat Warning Decision Process For A Given Locale, Based Upon Mortality Trends Correlated With Observed Weather.

WFO Phoenix
Dr. Kalkstein's Approach
+
Evolutionary Adjustments

- Based on additional parameters that includes "approaching" Record Daily Maximum Temperature.

Phoenix Record Max T 1896 - 2004



Meteorology

…What about Public Response?

…tornado hits mobile home park, Evansville, Ind., Nov. 9, 2005. …devastation…tornado kills **18** people…injures scores of others… **(Photo: AP)**

Public Response

Before

After

Public Response

Phoenix Metropolitan – Maricopa County Most Vulnerable

- **10,000 Homeless**
  - Gloria Hurtado, Phoenix city's human service director
- **600,000 People work out-of-doors**
  - 2004 Arizona Department of Commerce County Profile
- **Aged, Sick, or Injured**

Public Response

July 21, 2005… Headlines

Phoenix Heat Kills At Least ~~32~~ 54

Phoenix Emergency Management …Scramble to Provide Shelter

"I don't know why I'm not burnt to pieces," said Chris Cruse taking refuge in a shelter.

Four more bodies found Wednesday…

"…the people we found have been dead for awhile…"

Ultimately…

- The Public and the Media wanted someone to step up and lead, to take action.

Understand the Threat
Heat Related Illnesses

- Sunburn, Heat cramps, Heat rash
- **Heat Exhaustion**
  - Untreated can progress to **Heatstroke**
- **Heatstroke**
  - Even with prompt medical care, 15% of heatstroke cases are fatal.
  - Young, healthy persons are as vulnerable to heatstroke as are the elderly and those who are already ill.
  - Onset of heatstroke is rapid, it is an emergency.

What We've Learned

- Communities must have an extreme heat emergency response plan.
- Local officials must use meteorological information
  - Effectively respond
  - Efficiently implement prevention strategies
- Public health messages must be widely disseminated to all age groups and to relief/shelter agencies.
- Public, Law Enforcement and Health Officials need to be educated to recognize symptoms of heat-related illness.
- **Forecasts, Warnings and Prevention messages must be delivered as early as possible.**

A New Generation of Heat/Health Warning Systems

Laurence Kalkstein
Senior Research Fellow
Center for Climatic Research
University of Delaware

National Severe Weather Workshop
Midwest City, Oklahoma
March 4, 2006

Applied Climatologists, Inc.

UNIVERSITY OF DELAWARE

How Are These Systems Unique?

- A custom-made system is developed for each urban area, based on specific meteorology for each locale, as well as urban structure and demographics

- These systems are based on actual weather-health relationships, as determined by daily variations in human mortality

- These systems are based on much more than just temperature and humidity

System Summary

System development

- Offensive air mass identification
- Algorithm development
- Webpage creation

System implementation

- Real-time data acquisition
- Decision tree to call advisory/warning

SSC Air Mass Types

DP	Dry Polar (cP)
DM	Dry Moderate (Pacific)
DT	Dry Tropical (cT)
MP	Moist Polar (mP)
MM	Moist Moderate (Overrunning)
MT	Moist Tropical (mT)
MT+	Moist Tropical Plus
TR	Transition between air masses

Sheridan, S.C., 2002: The redevelopment of a weather-type classification scheme for North America. *Int. J. Climatology*, **22**, 51-68.

Kalkstein, L.S., C.D. Barthel, J.S. Greene and M.C. Nichols, 1996. A New Spatial Synoptic Classification: Application to Air Mass Analysis. *Int. J. Climatology*, **16**, 983-1004.

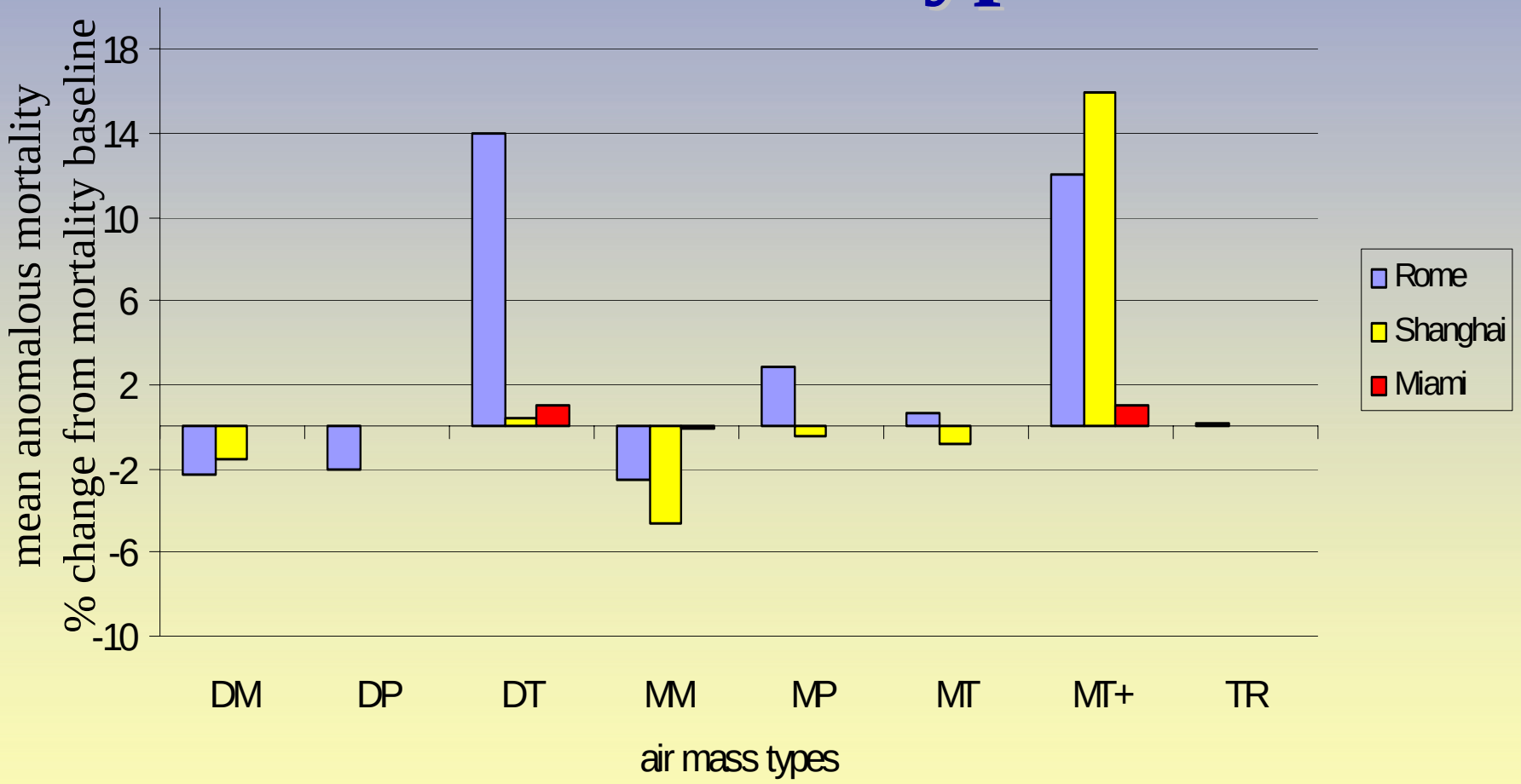
Mean Mortality Increases Within Offensive Air Mass Types

Location (Freq)	DT	MT+
Seattle (6%)	+3.7 (8%)	+4.7[a] (10%)
Portland (6%)	+3.0 (9%)	+1.1[a] (4%)
Washington (11%)	+0.9 (4%)	+1.7 (7%)
New Orleans (2%)	None	+3.7 (9%)
Phoenix (1%)	+2.7* (7%)	None
Rome (11%)	+6.2 (14%)	+5.0 (12%)
Shanghai (11%)	None	+42.4 (16%)
Toronto (7%)	+4.2 (11%)	+4.0 (10%)

[a] MT+ does not occur in Seattle or Portland; the moist air mass that is oppressive is MT.

* DT+ air mass for Phoenix

Mean Anomalous Mortality by Air Mass Type



Responses vary considerably among cities, which underscores the need for individual systems for each urban area

Development of Offensive Air Mass Algorithms

- Location and air mass-specific
  - Cincinnati, MT+
    - *Mort.* = -19.7 + 1.87 *Day in Seq.* + 0.88 *Tmin*
  - Milan, MT+
    - *Mort.* = -3.36 + 0.67 *Day in Seq.* + 0.36 *Tmin* – 0.039 *Day of Season*
- Predict actual excess mortality (in deaths) or likelihood of excess mortality (in percent)
- Restriction to within-oppressive air mass days increases R^2 significantly

Threshold Determination

EXCESSIVE HEAT WARNING

Deaths forecast within 24 hours

HEAT ADVISORY

Offensive air mass forecast

EXCESSIVE HEAT WATCH

Deaths forecast for 24-48 hours in future

EXCESSIVE HEAT OUTLOOK

Deaths forecast for 48-120 hours in future

NO ADVISORY

Webpage Development

PHILADELPHIA HEAT WATCH WARNING SYSTEM

Morning Forecast
06/17/2004 11:04:00
Forecast for 6/17 - 6/21/2004

6/17: HEAT ADVISORY

6/18: EXCESSIVE HEAT WATCH

6/19: NO ADVISORY

6/20: NO ADVISORY

6/21: NO ADVISORY

DATE	06/17				06/18				06/19				06/20				06/21			
HOUR (LT)	06	12	18	00	06	12	18	00	06	12	18	00	06	12	18	00	06	12	18	00
TEMPERATURE (F)	71	85	86	76	72	85	86	74	70	82	83	69	64	79	80	68	64	79	81	72
DEW POINT (F)	71	72	72	71	70	69	68	66	64	63	64	63	61	61	61	61	61	62	63	64
CLOUDINESS (10ths)				7.0				4.8				5.5				4.0				4.0
AIR MASS				MT+				MT+				MT				MT				MT
DAY IN ROW				1				2				0				0				0
EXC. DEATHS				4				4				0				0				0

SYSTEM LEVELS

EXCESSIVE HEAT WARNING

Dangerous heat stress conditions are forecast to occur within the next 24 hours.

HEAT ADVISORY

Heat stress conditions are forecast to occur within the next 24 hours.

EXCESSIVE HEAT WATCH

Heat stress conditions are forecast to occur in the next 24 to 48 hours.

EXCESSIVE HEAT OUTLOOK

Data Acquisition Schedule

Original "morning run"

- Usually ~03h LST

Original "afternoon run"

- Usually ~15h LST

Forecast Data Needed

- Model output from Point-forecast matrix (PFM)
- Automatically acquired and processed; web page created

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FOUS54 KLIX 301020
PFMLIX

POINT FORECAST MATRICES
NATIONAL WEATHER SERVICE NEW ORLEANS, LA
430 AM CST TUE DEC 30 2003

MSZ070-302230-
MCCOMB-PIKE MS
31.18N 90.46W
430 AM CST TUE DEC 30 2003

DATE            TUE 12/30/03            WED 12/31/03            THU 01/01/04
UTC 3HRLY    09 12 15 18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00
CST 3HRLY    03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18

MAX/MIN                     62          32          65          43          72
TEMP            33 47 56 59 46 40 38 35 33 50 59 65 51 48 46 45 44 53 67 72 66
DEWPT           30 31 28 29 32 33 32 32 33 37 37 39 42 42 42 42 44 48 50 52 53
RH              89 53 34 32 58 76 79 89100 61 44 38 71 80 86 89100 83 54 49 63
WIND DIR         N NE NE NE  E  E  E  E  E SE  S  S SE SE SE SE SE SE SE  S  S
WIND SPD         5  6  6  8  5  8  6  5  1  2  2  2  3  4  5  4  3  4  4  4  5
CLOUDS          FW FW FW FW CL CL CL CL FW FW SC SC SC SC SC SC BK BK BK BK BK
POP 12HR                    0           0           0           0           0
QPF 12HR                    0           0           0        0.09           0
RAIN SHWRS                                                                S  S
```

Forecast Updates

- PFM is reissued by forecast office with updated values should forecast conditions change

- System checks for updates
  - –To morning run, every 15 min from 03 - 12h
  - –To afternoon run, every 15 min from 15 - 00h

- System will re-run automatically if update found

Systems We are Presently Operating

USA

- Chicago, IL
- Dallas/Ft. Worth, TX*
- Dayton/Cincinnati, OH
- Jackson/Meridian, MS
- Lake Charles/Alexandria, LA
- Little Rock/Pine Bluff, AR
- Memphis, TN/Tupelo, MS
- Minneapolis, MN^
- New Orleans/Baton Rouge, LA
- Philadelphia, PA*
- Phoenix, AZ
- Portland, OR
- Seattle, WA
- St. Louis, MO
- Shreveport/Monroe, LA
- Washington, D.C.
- Yuma, AZ

International

- Bari, Italy
- Bologna, Italy
- Florence, Italy
- Genoa, Italy
- Milan, Italy
- Mississauga/Brampton, Canada^
- Naples, Italy
- Palermo, Italy
- Rome, Italy
- Shanghai, China
- Turin, Italy
- Toronto, Canada
- Twenty more Italian cities proposed

* New five-day forecast systems
^Proposed for summer 2006

Checking System Effectiveness

Effectiveness can be monitored in three manners, and improvements can be implemented:

- Forecasting effectiveness
  - –false positives or negatives
- Accuracy in estimating health impacts of offensive weather
  - –are we estimating heat related mortality accurately?
- Noting if we are saving lives
  - –are there reduced deaths during extreme magnitude heatwaves?