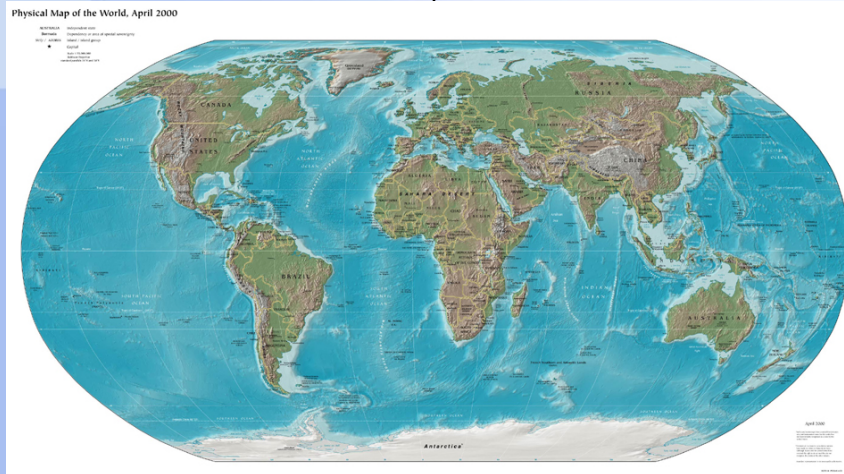# Amgen's Distribution Packaging Team

Global Thermal Profile Development

Ray Cowland

Developing a Thermal Profile

- Where are your distribution lanes

- What is the duration of the lanes

Considerations

- Northern/Southern Hemisphere

- Seasons

- Courier Used

  - Are the thermal properties of the distribution environment affected by the color of the transportation vehicle

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r1   Mode of transportation
   rcowland, 2/1/2007

Data Collection Requirements

- Qualified components
  - (i.e. Temperature monitoring devices)
- Data collection frequency
  - hourly reading / 72 hours
- Indicative of actual distribution channels
  - Hot (August to September)
    - Total of 183 shipments
  - Cold (February to March)
    - Total of 88 shipments
- Statistically Significant
  - Thermal profiles are established through regular real-world measure of your supply chain
  - Convert your thermal data into a profile:

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Domestic Distribution Lanes
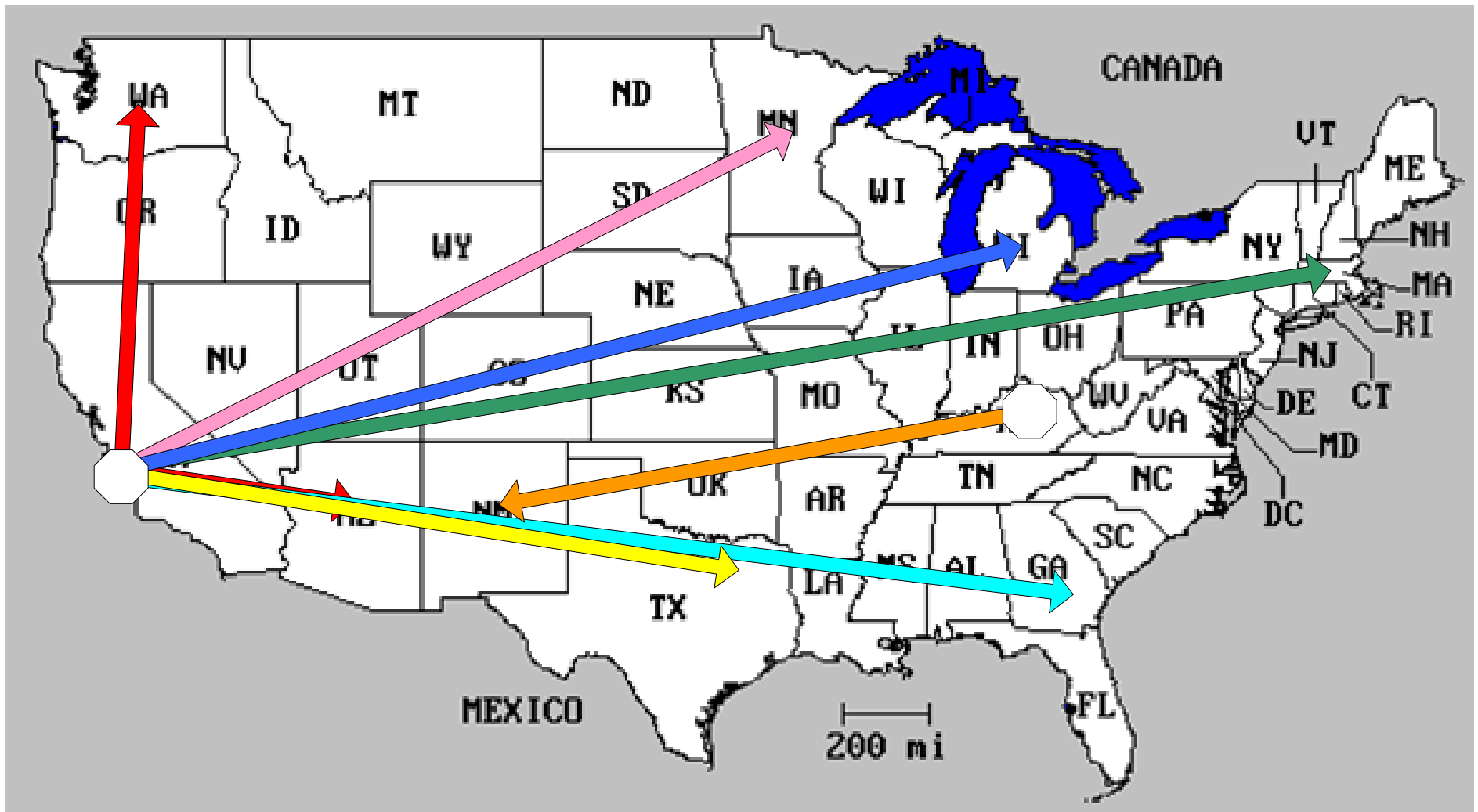
Summer = (Heat) Temperature Data
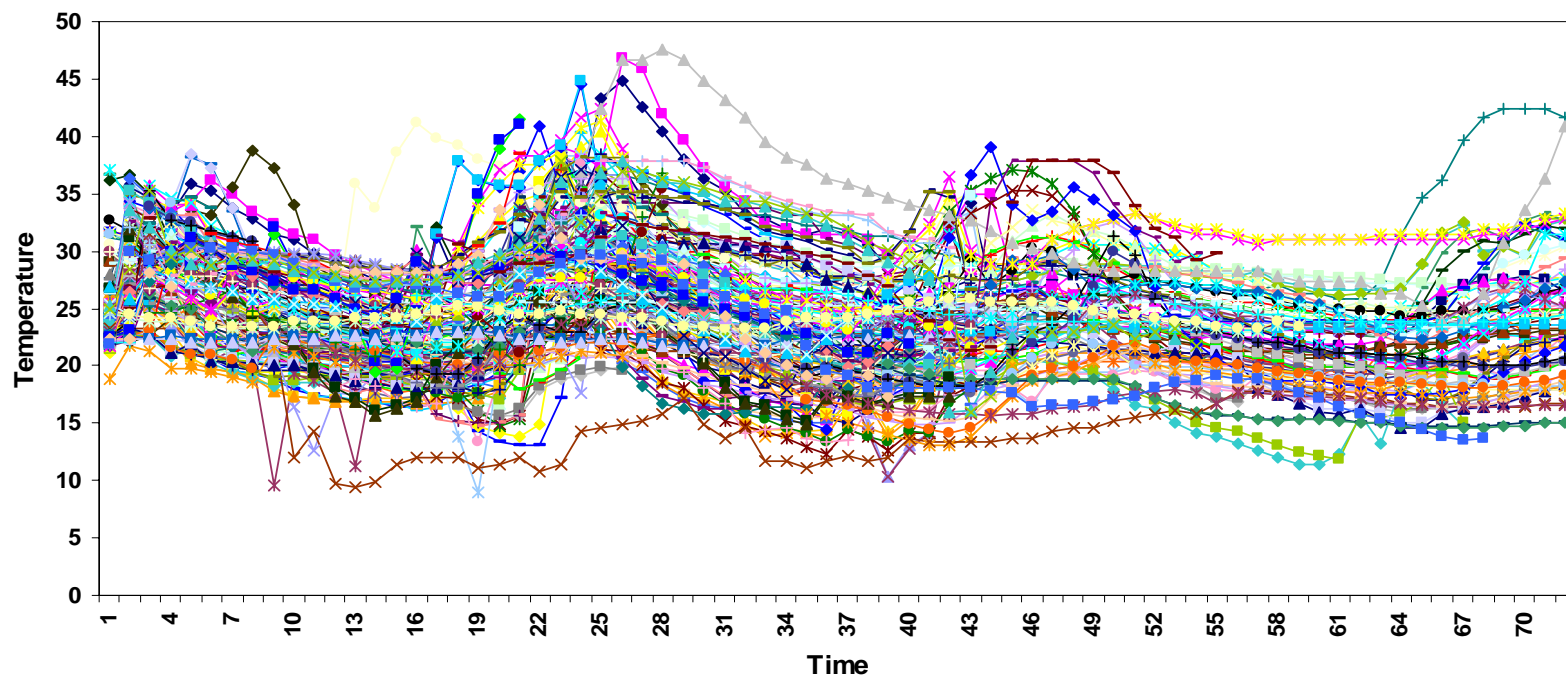
Confidence Interval Formula

$$CI = \bar{x} \pm (Z_{\alpha/2})(\frac{\sigma}{\sqrt{n}})$$

CI — **The confidence Interval**

$\bar{x}$ — **The mean of the sample population**

$\dfrac{\sigma}{\sqrt{n}}$ — **The standard error of mean, if n is bigger SE is low**

$Z_{\alpha/2}$ — **The confidence level at $\alpha = 0.05$ for 95% confidence level, Z values can be looked up from std Z-tables**
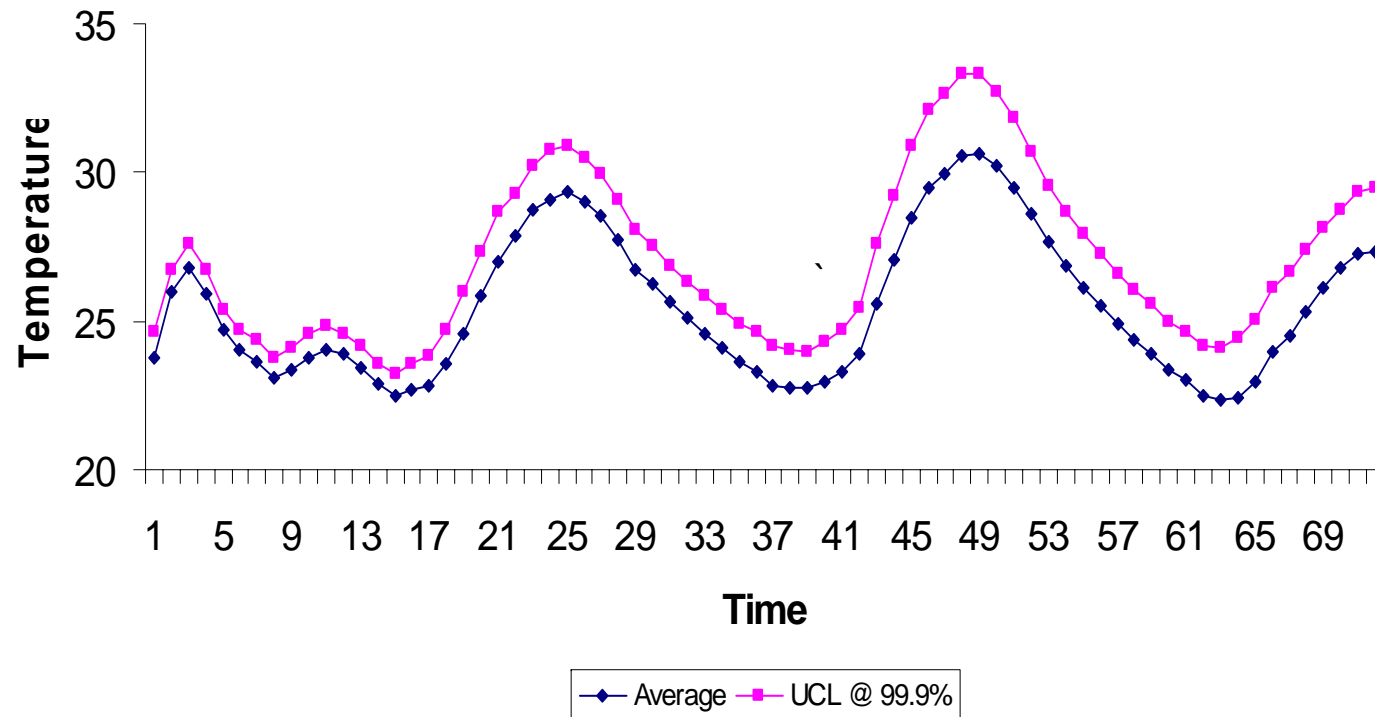
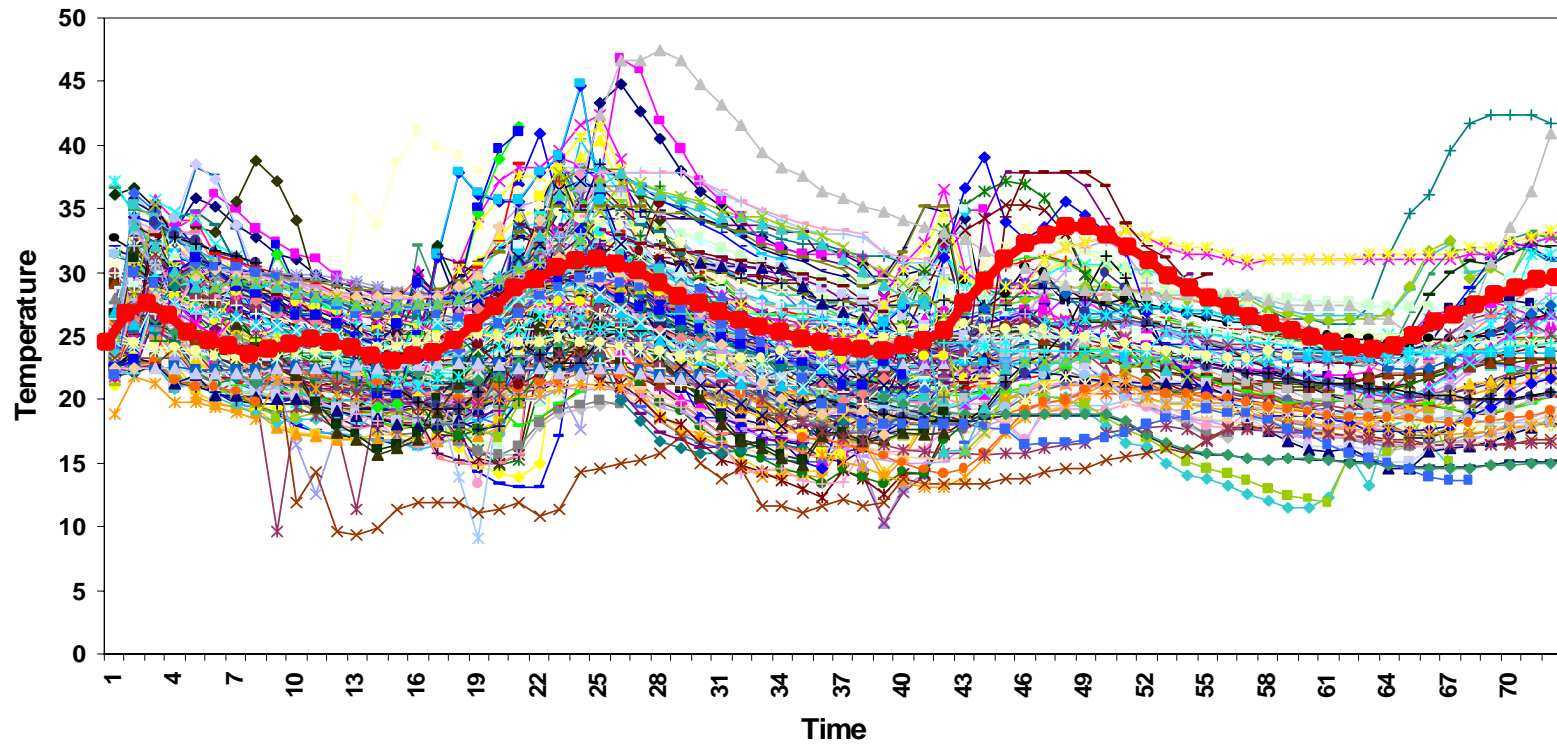$(Z_{\alpha/2})(\dfrac{\sigma}{\sqrt{n}})$ — **The confidence limit**

Heat Profile with Upper Control Limit

| Average 23.8 | **+** | 99% Confidence 0.86 | **=** | 99% Upper Control Limit 24.6 |

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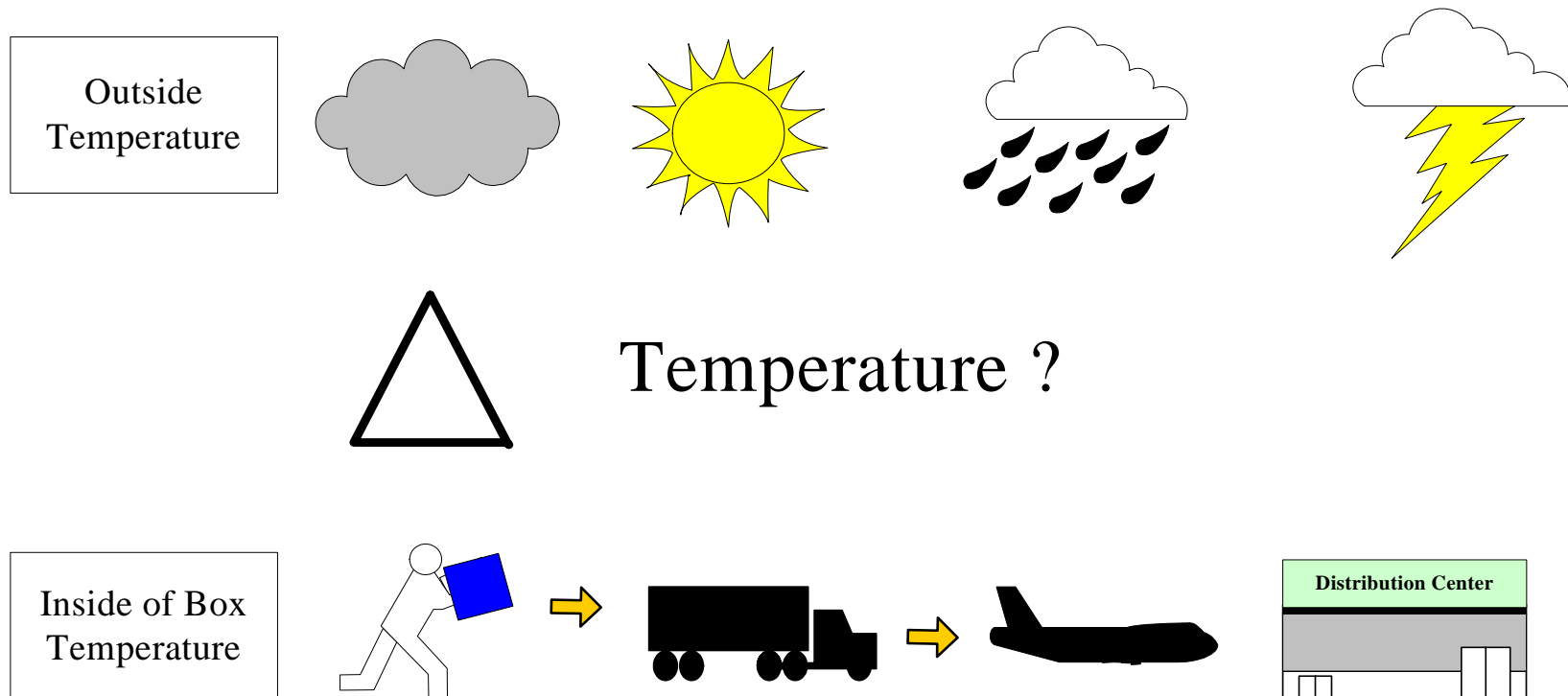# Heat Profile Average with Upper Control Limits at 99% Confidence
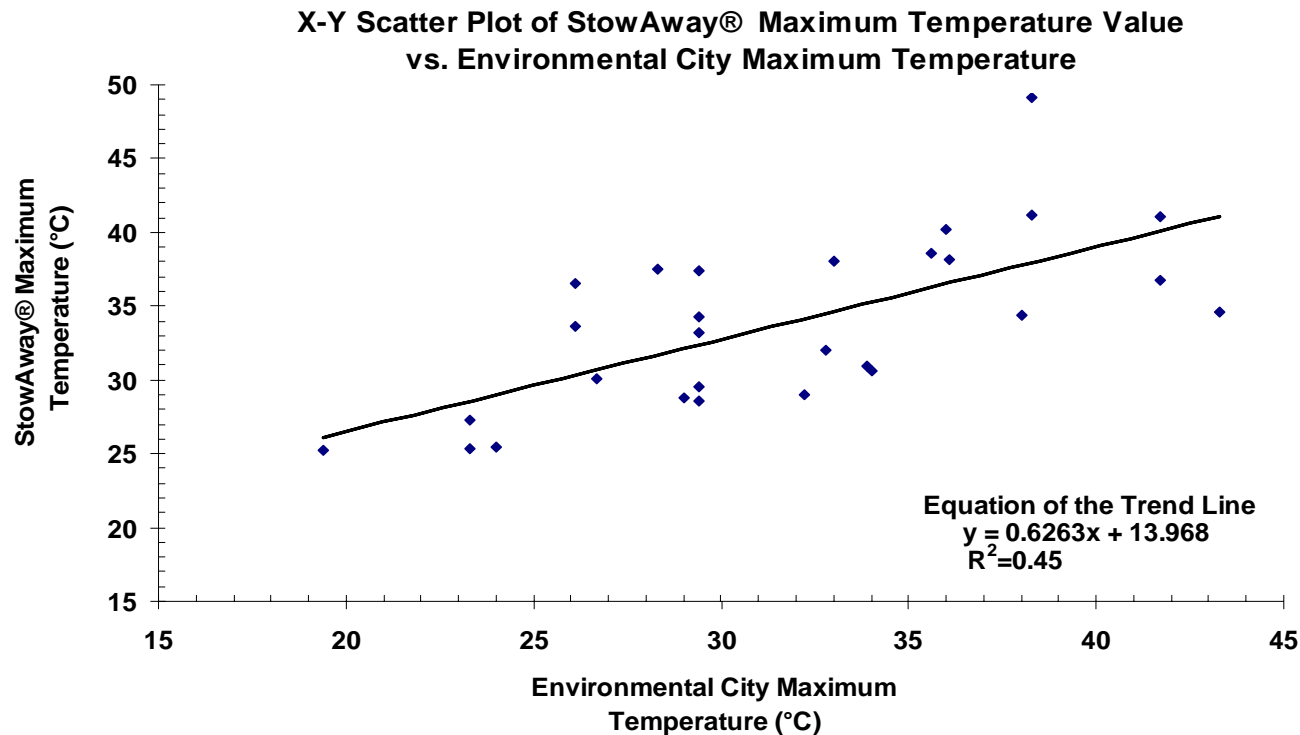
Raw Data / 99% Profile

To Spike or Not to Spike

– Spike to what temperature ?

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Develop a correlation between environmental temperatures and internal temperature of the corrugated shipper.

Outside Temperature

Inside of Box Temperature

Temperature ?

Distribution Center

Spike your profile per X-Y Scatter Plot

X-Y Scatter Plot of StowAway® Maximum Temperature Value vs. Environmental City Maximum Temperature

Equation of the Trend Line
$y = 0.6263x + 13.968$
$R^2 = 0.45$

StowAway® Maximum Temperature (°C)
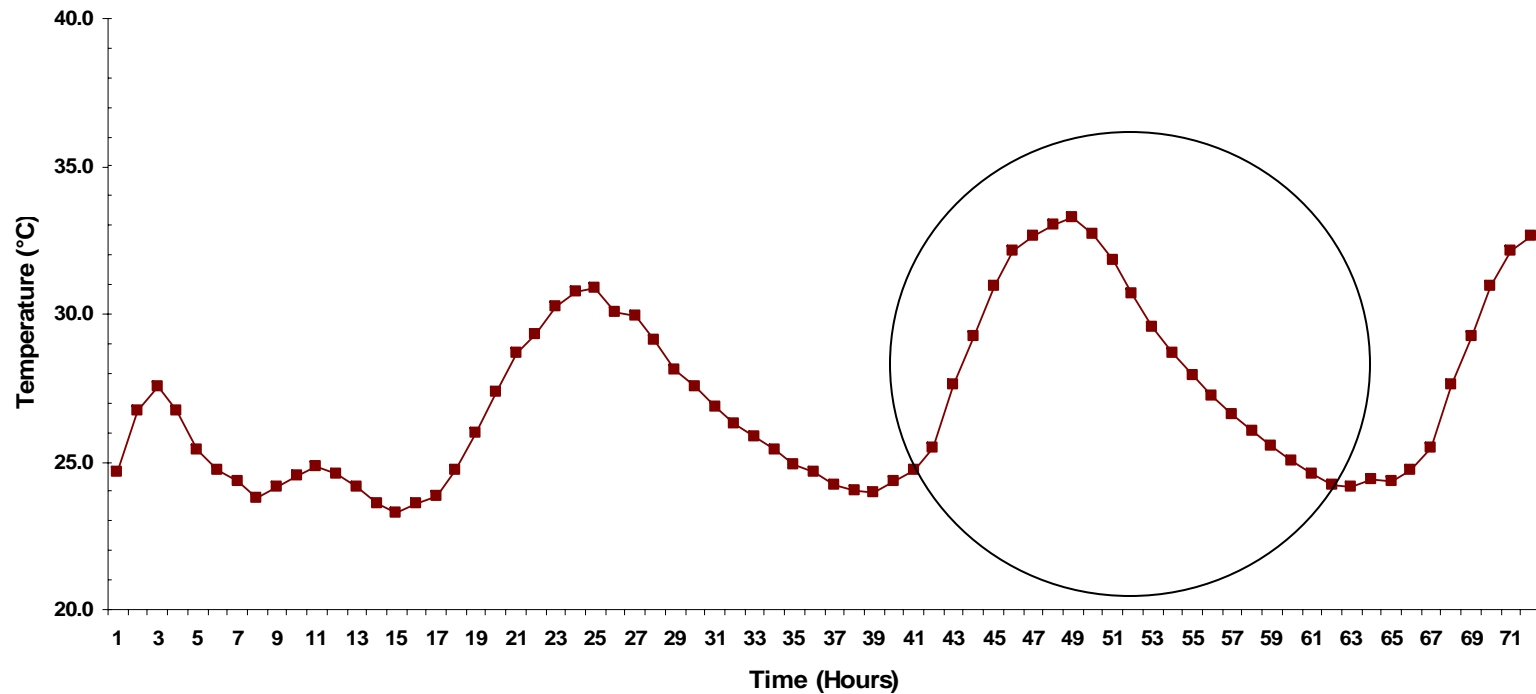
Environmental City Maximum Temperature (°C)

Shipper temperature (Y) = 36.5°C, Environmental Temperature 39°C
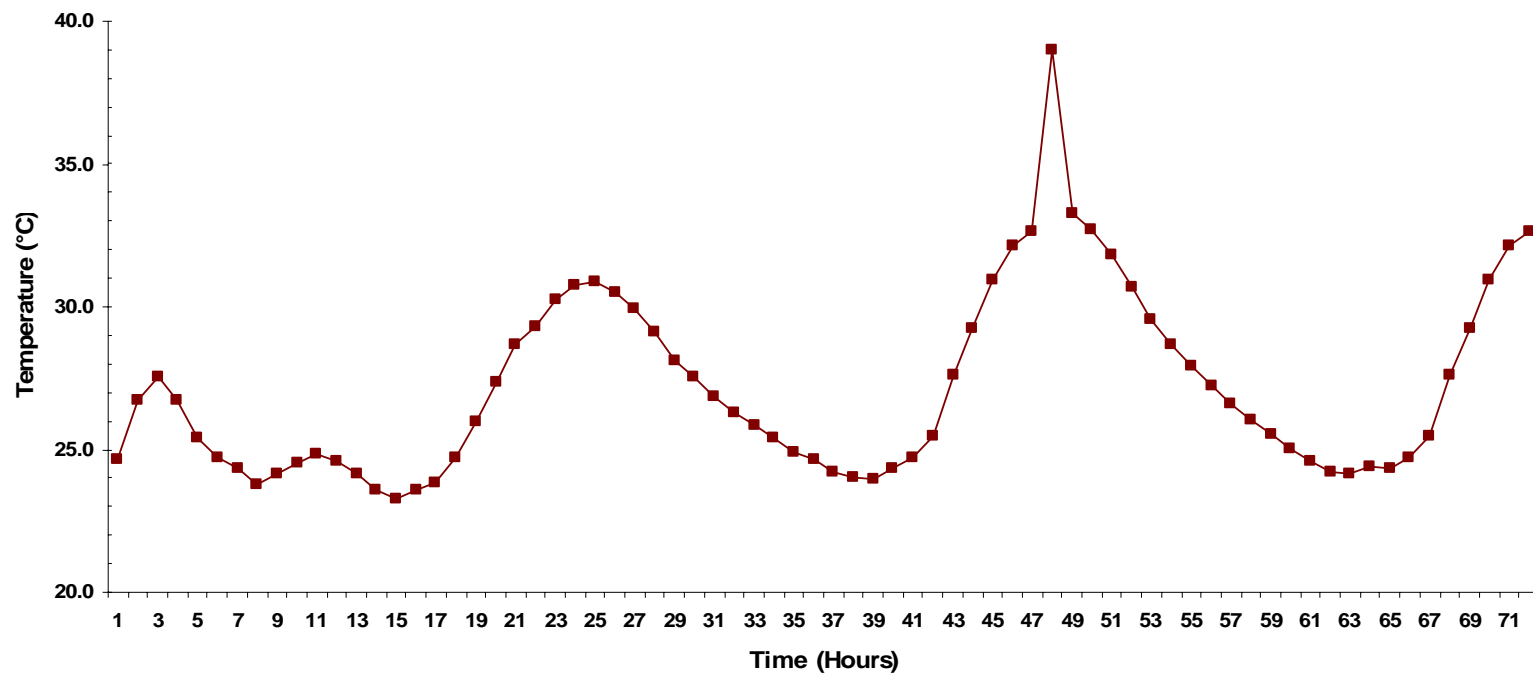
Where to Spike?

– Between hours 40 and 64

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Where ?
Between Hours 40 and 64

72- Hours Heat Profile

Convert Domestic Data into a Global Profile

- Develop relationship between USA data and International Sites

- Use Historical Data for other sites

- Maintain 99% confidence

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Data Gathering from other Countries (Historical Monthly Avg.)

- San Juan, Puerto Rico
  - High Temperature
  - Low Temperature

- Toronto, Canada
  - High Temperature
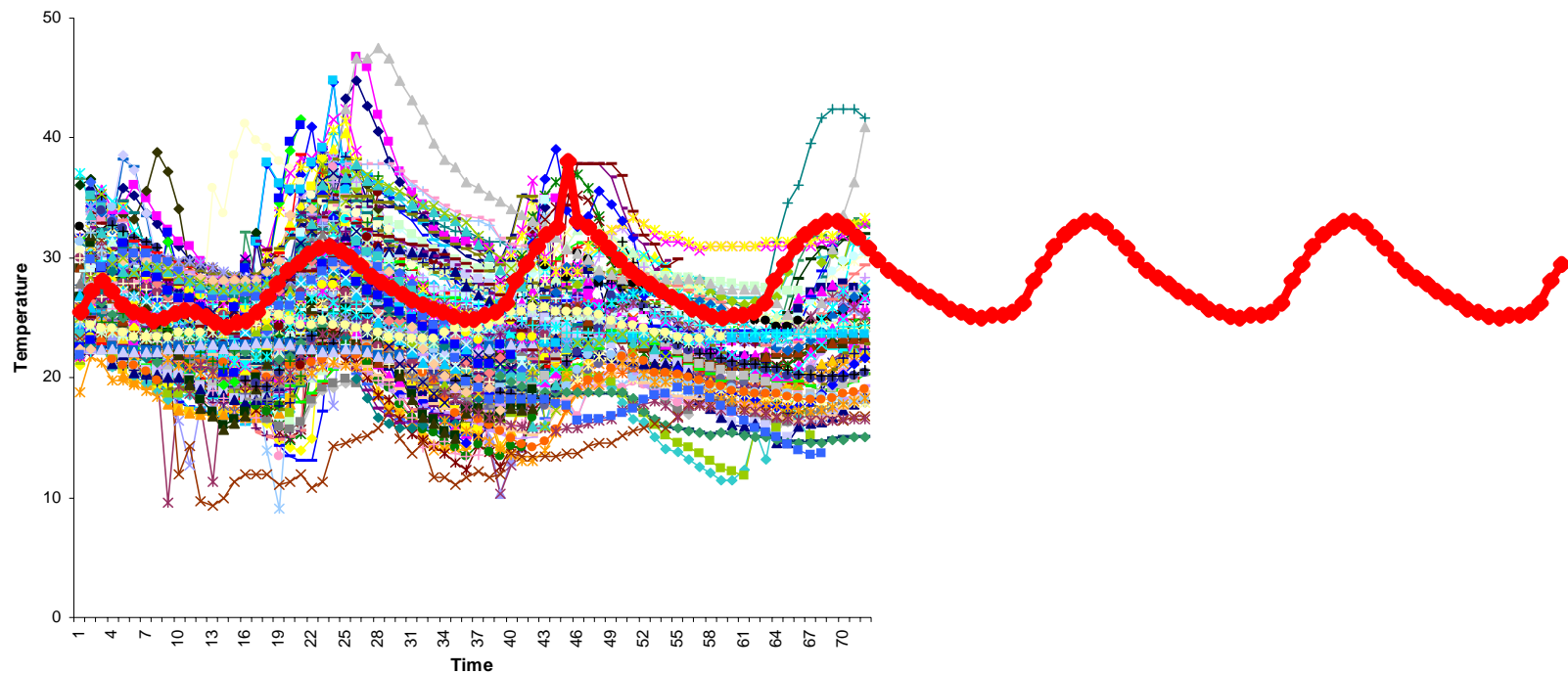 - Low Temperature

- Melbourne, Australia
  - High Temperature
  - Low Temperature

- Amsterdam, Netherlands
  - High Temperature
  - Low Temperature

- Phoenix, Arizona
  - High Temperature
  - Low Temperature
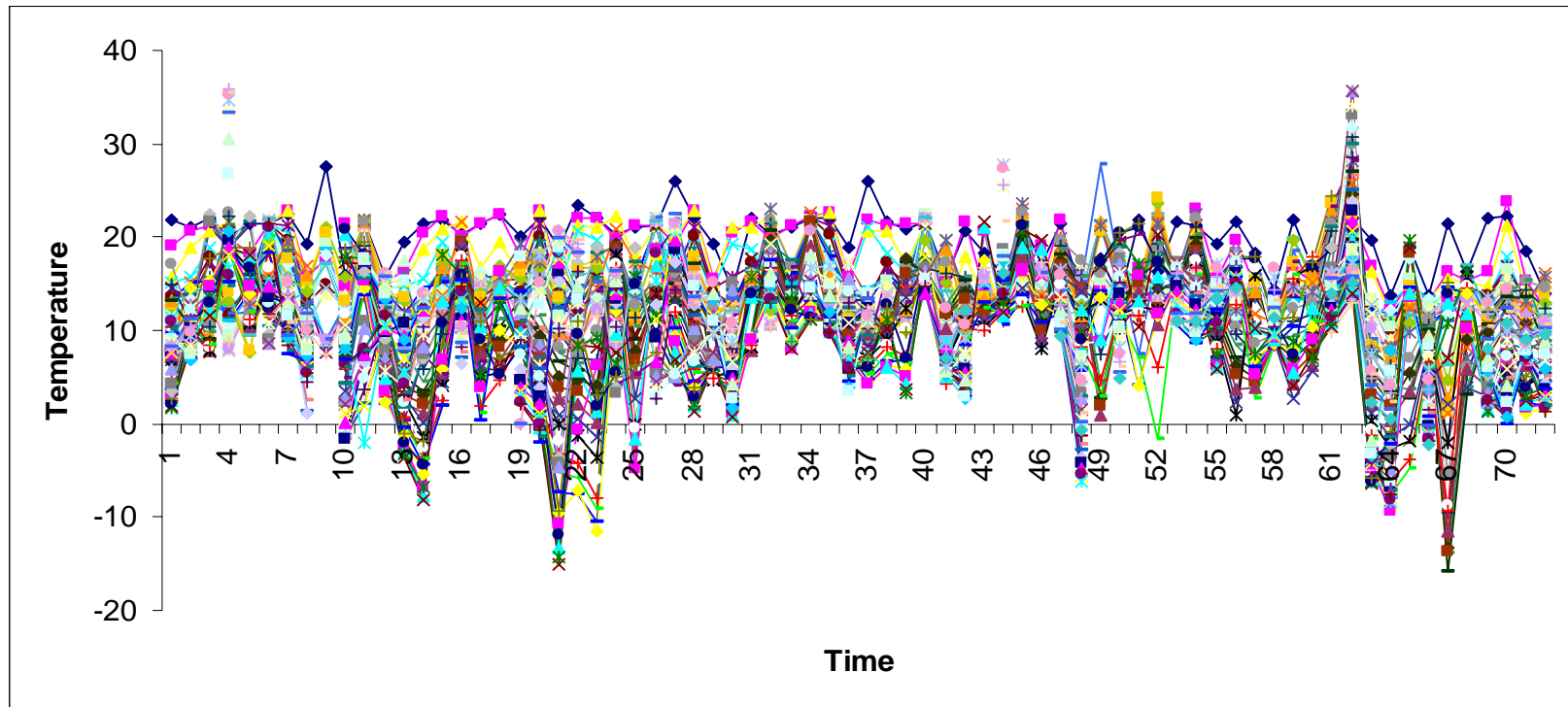
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Ensure Global Data Encompassed into Heat Profile

Extending 72 hr. profile to 144 hr. profile

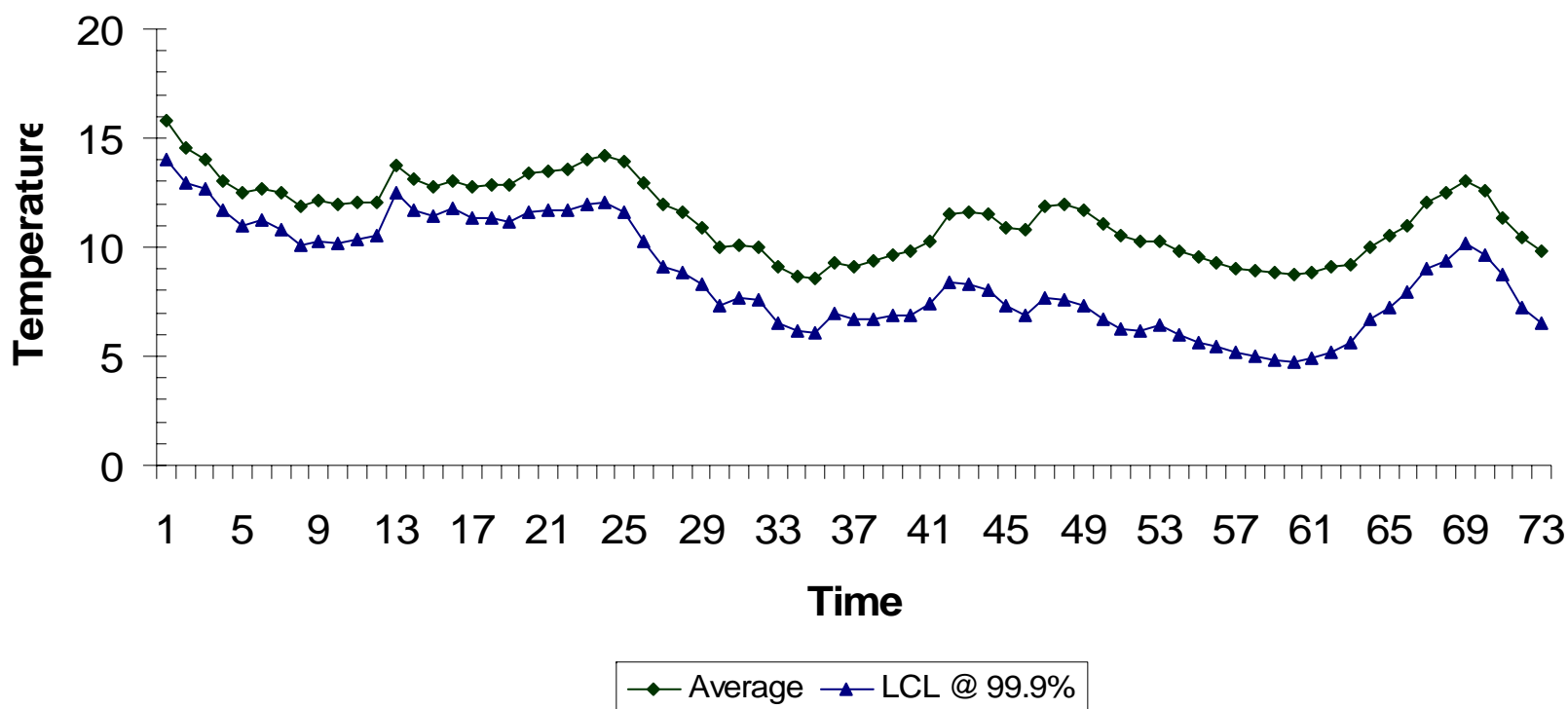# 144 Hour Hot Profile

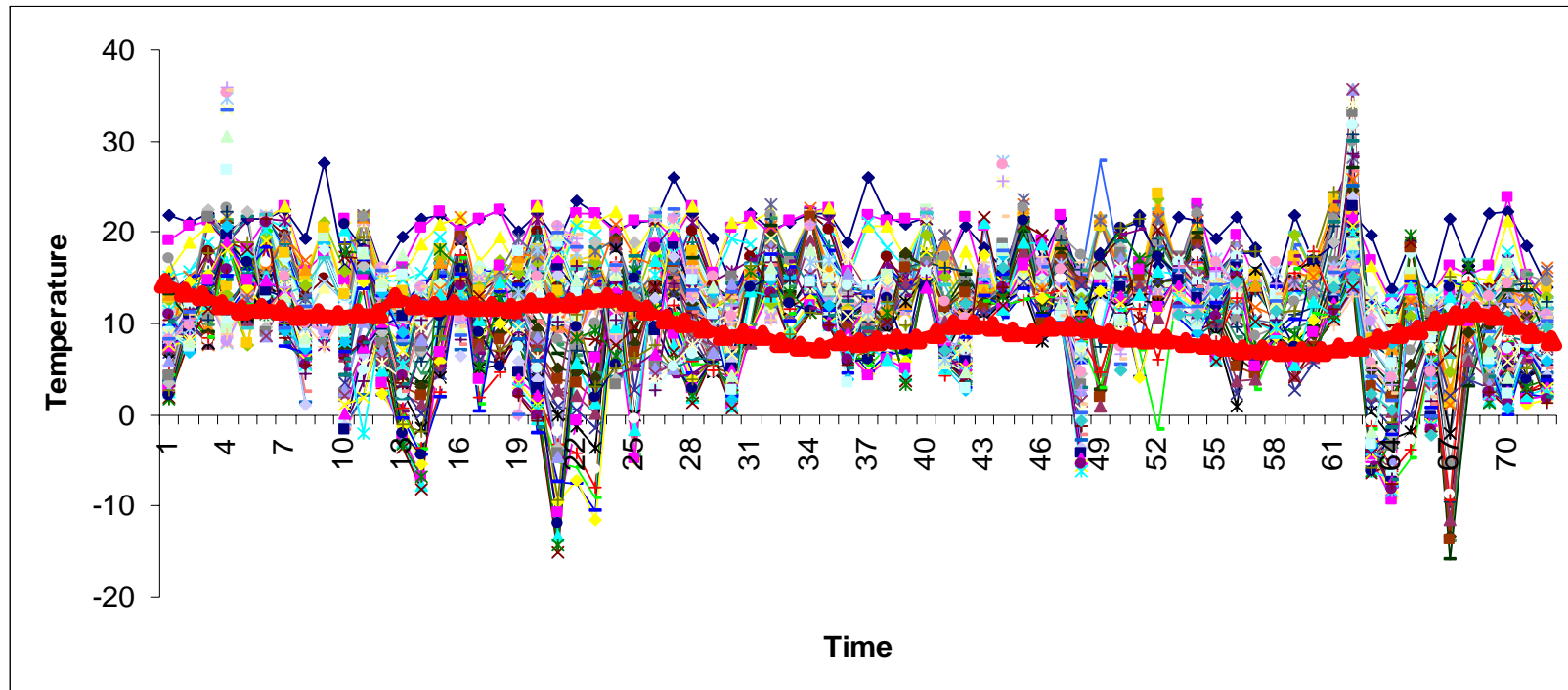# Creating a Cold Profile with Confidence

Winter = (Cold) Temperature Data

How to Create Cold Profile with Lower Control Limits

Average **15.8**	—	**99% Confidence** **1.78**	**99%** **Lower Control Limit** **14.0**

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Cold Profile Average with Lower Control Limits at 99% Confidence
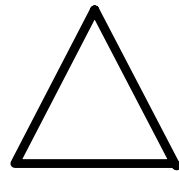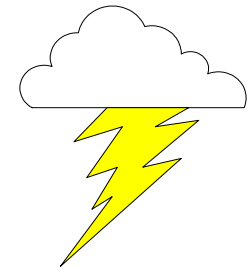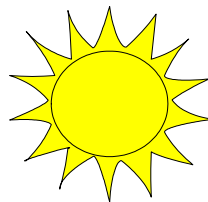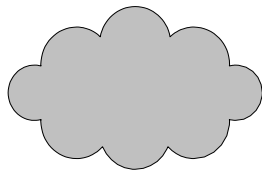
Raw Data / 99% Profile

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To Spike or Not to Spike
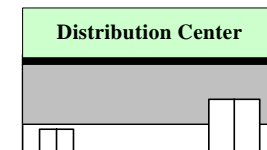
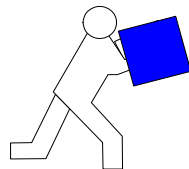– Spike to what temperature ?

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Develop a correlation between environmental temperatures and internal temperature of the corrugated shipper.
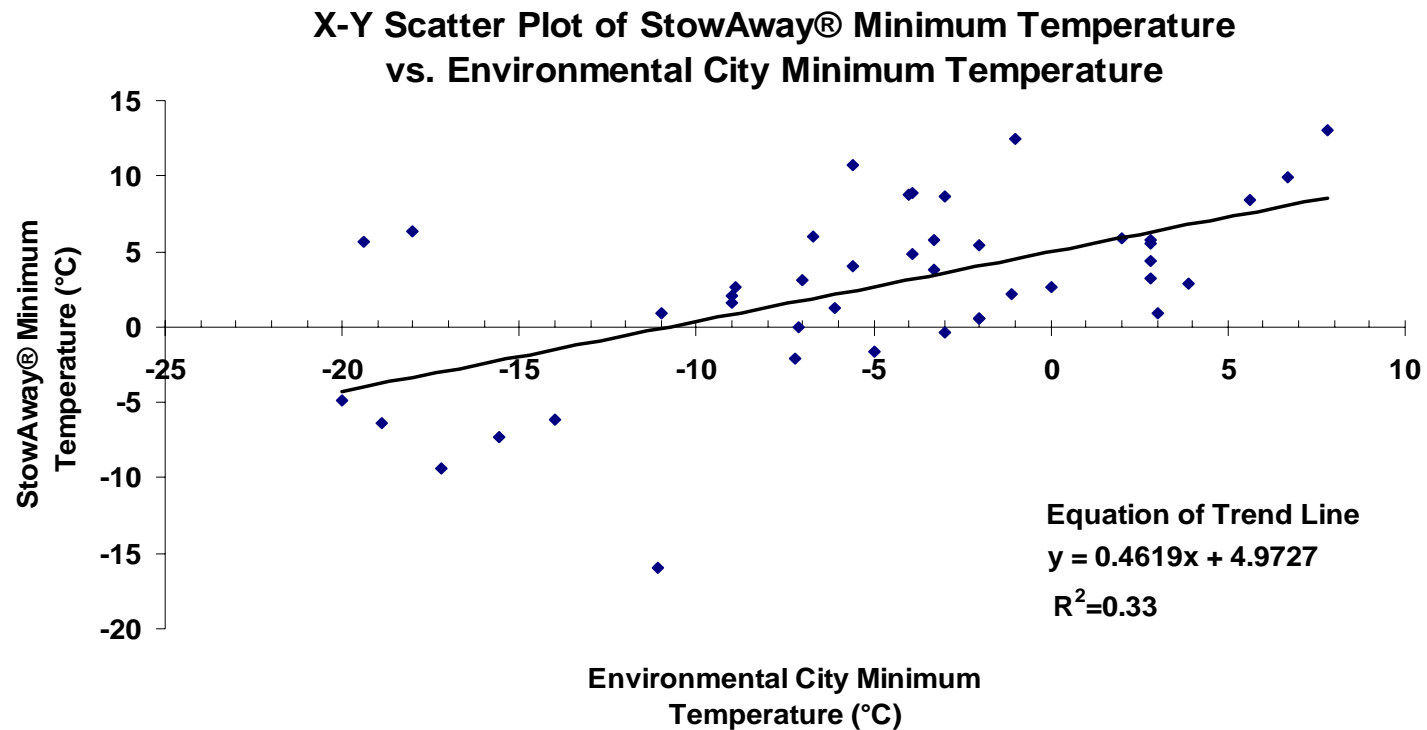
Outside Temperature
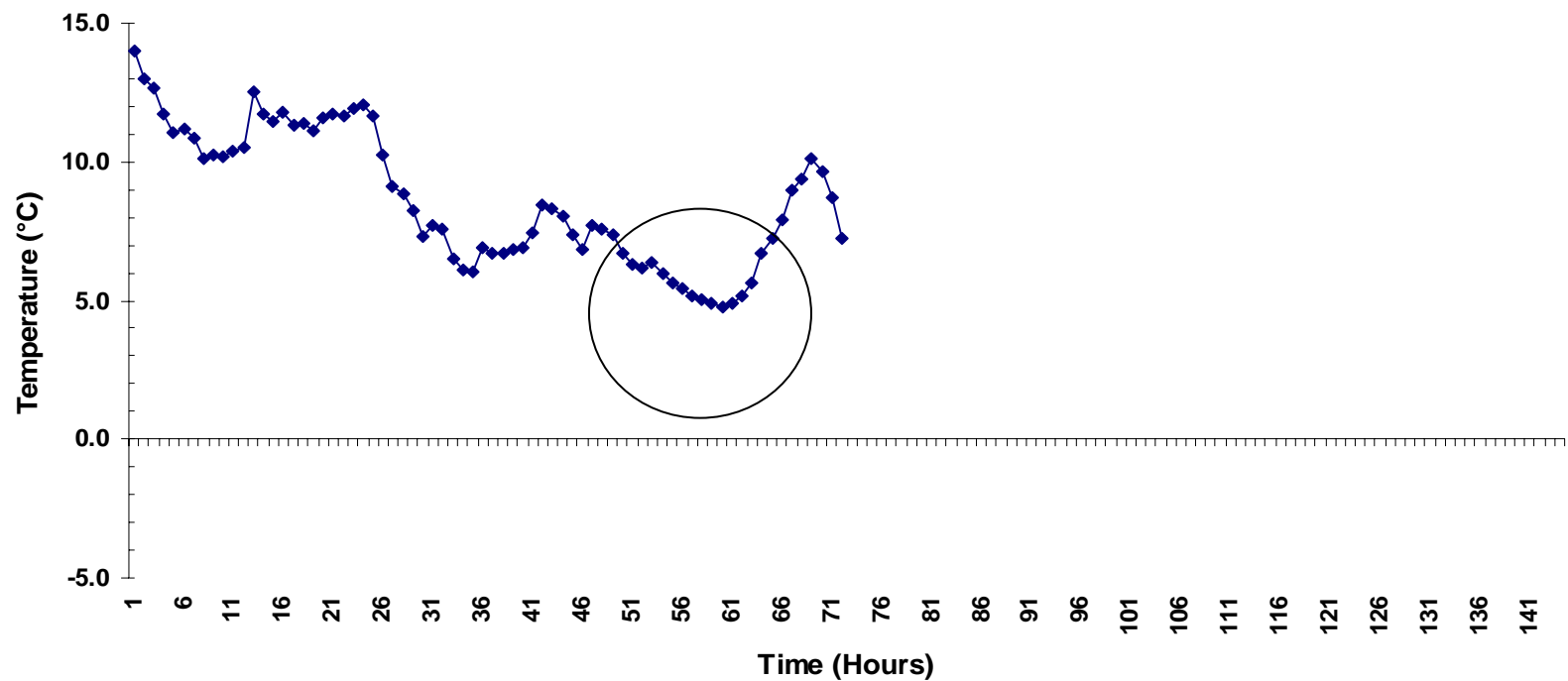
Temperature ?

Inside of Box Temperature

Distribution Center

X-Y Scatter Plot to Determine Profile Spike
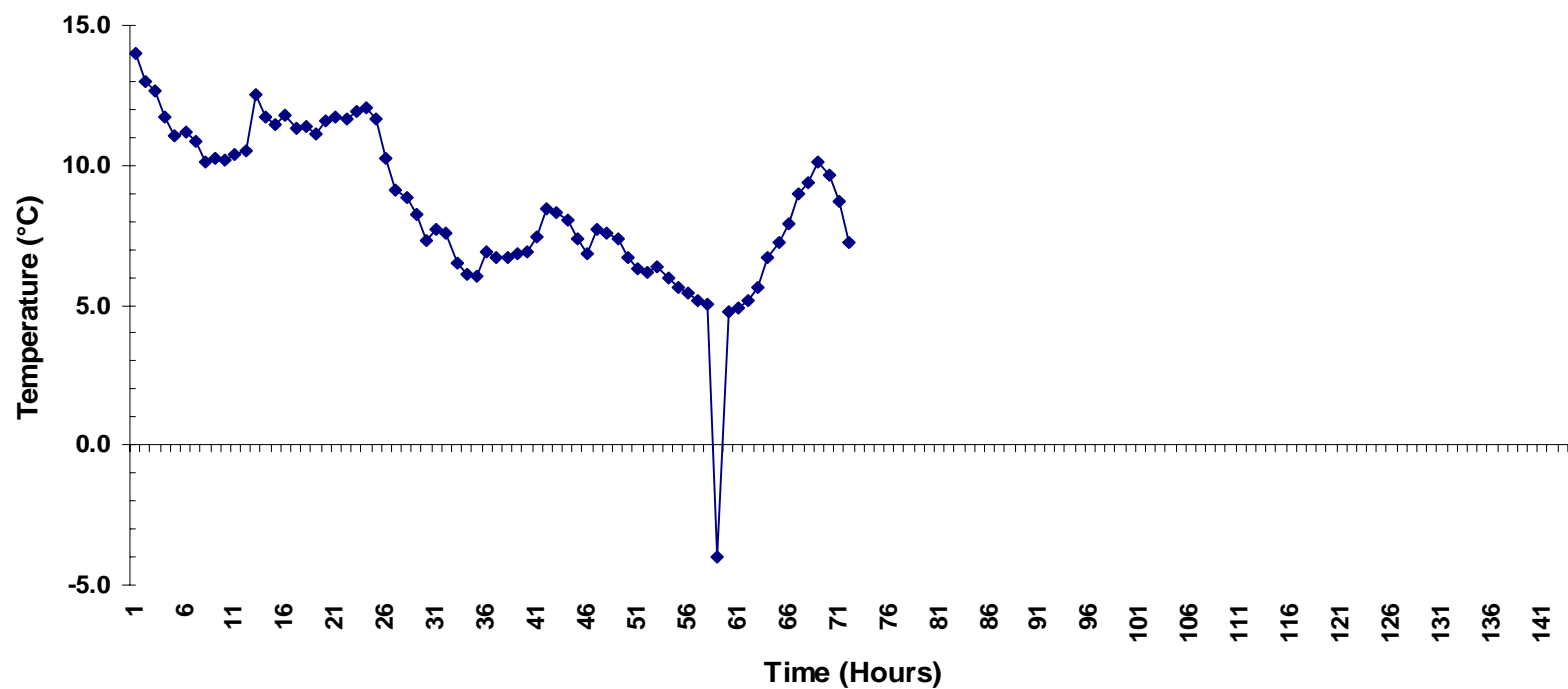

X-Y Scatter Plot of StowAway® Minimum Temperature vs. Environmental City Minimum Temperature

Equation of Trend Line

y = 0.4619x + 4.9727

R^2=0.33

Shipper Temperature (Y)=0.85ºC, Environmental Temperature -4 ºC

Where ?
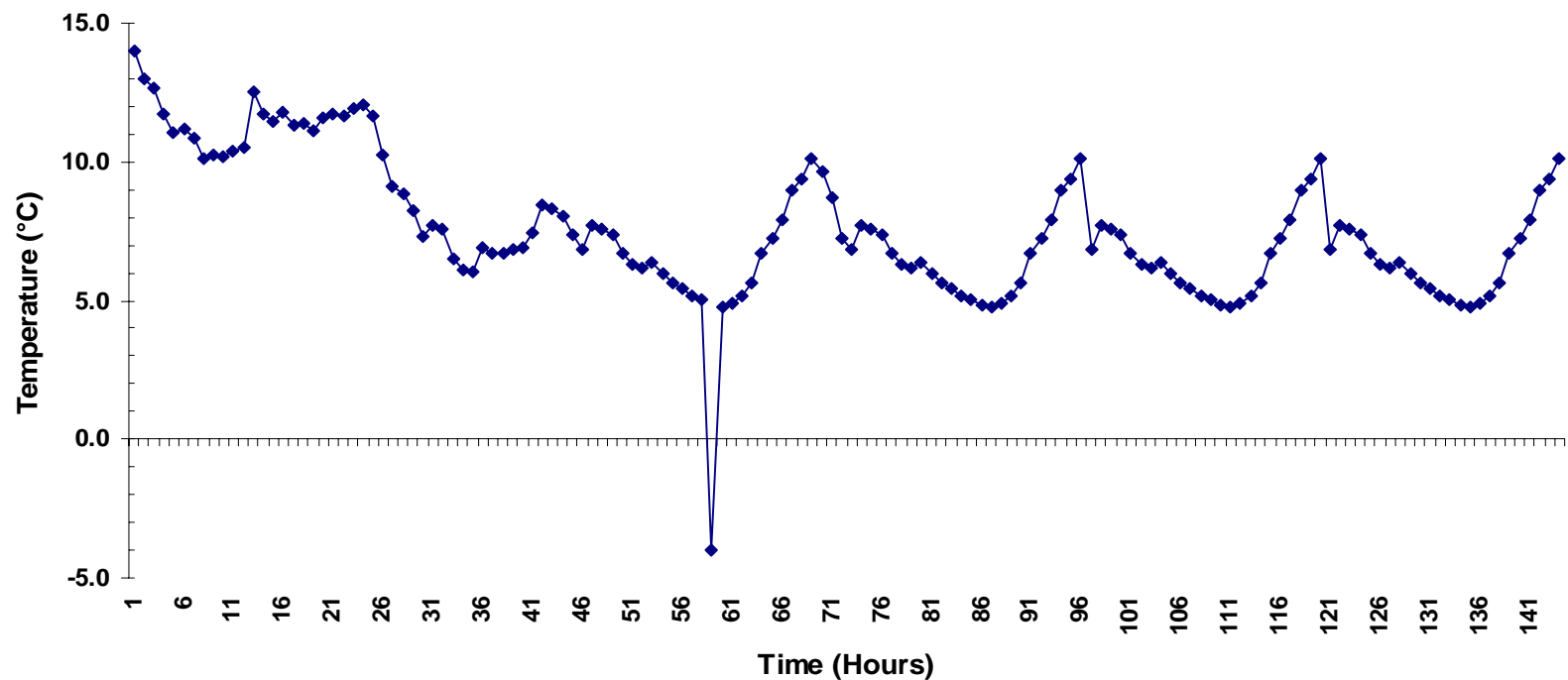# Between Hours 46 and 69

What Temperature (-4.0ºC)

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Convert Domestic Data into a Global Profile

- Develop relationship between USA data and International Sites

- Use Historical Data for other sites
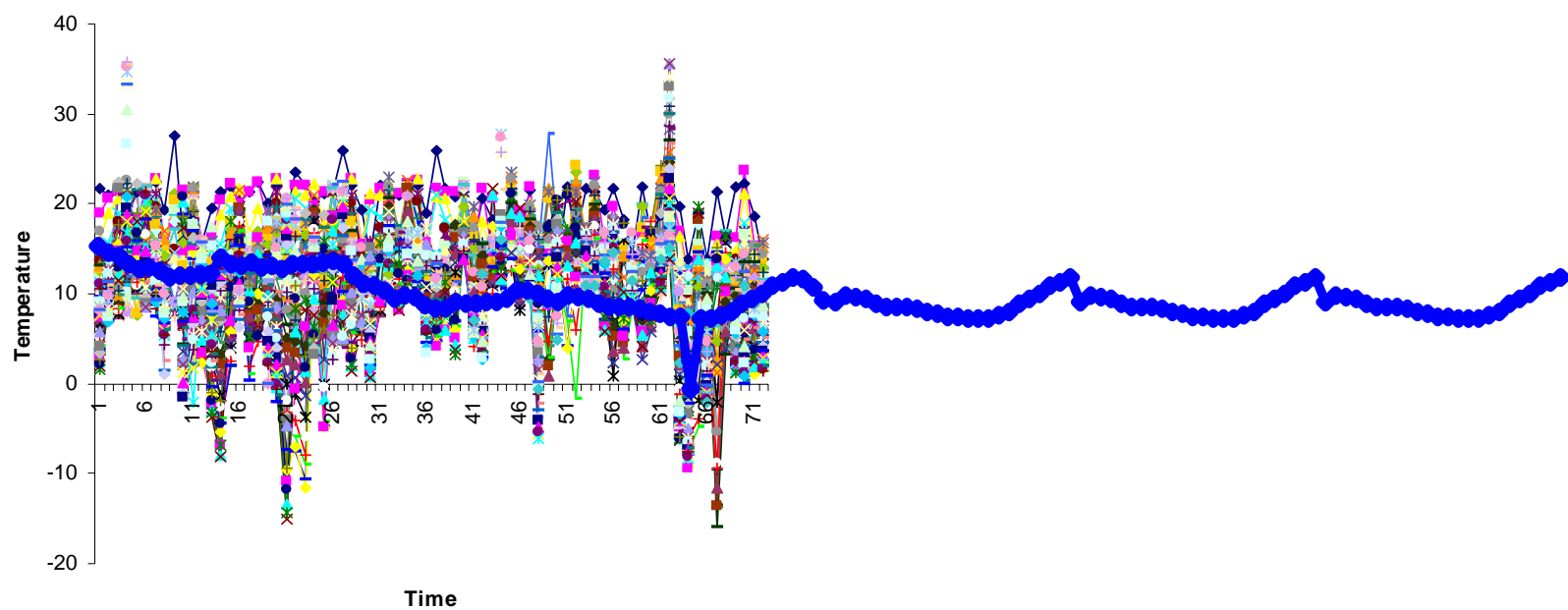
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Ensure Global Data Encompassed into Cold
Profile

Extend 72 hr. profile to 144 hr. profile

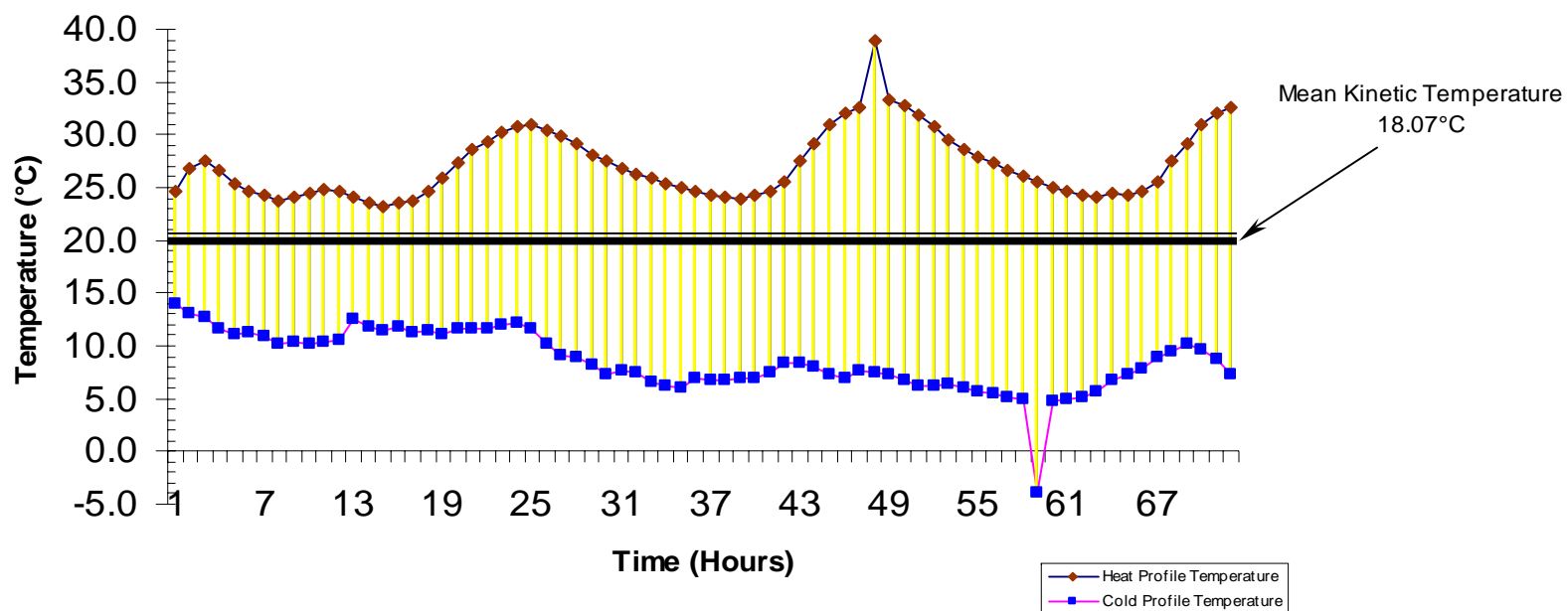# Repeat between hours 46 thru 69 excluding spike

144 Hour Cold Profile

Mean Kinetic Temperature

$$T_k = \frac{\Delta H/R}{-ln\left(\dfrac{e^{-\Delta H/RT_1} + e^{-\Delta H/RT_2} + \ldots + e^{-\Delta H/RT_n}}{n}\right)} \; ,$$

**Mean Kinetic Temperature of
the Heat and Cold Profiles**

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Effect of Profiles on Shipper Design

- Circadian profiles provide a greater challenge to an insulated shipper than constant ambient profiles

- Both the heat and the cold profiles provide unique thermal challenges to shipper design

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Heat and Cold Profiles Representative of Global Distribution Lanes