From Changing Atmospheric Circulation to Berry Temperature: Macro-, Meso-, Topo-, and Microclimate in Vineyards

Stuart B. Weiss
Creekside Center for Earth Observation
Precision Viticulture International
Environmental Biophysics
Grape Energy Balance

Simplified representation of primary heating vectors.

$T_{\text{air}}$

$T_{\text{grape}}$

Longwave

Latent

Sensible

Reflected Shortwave

Diffuse Shortwave

Direct Shortwave

Albedo

Storage
“Sunburn” in the Vineyard

Tens of millions of dollars lost annually in California alone.
The Climate Near the Ground

- **Macroclimate**: 1000 - 20 km
  Global Circulation, Synoptic Meteorology, Pacific Coast N-S
- **Mesoclimate**: 20 – 0.5 km
  Coastal-Inland, broad elevation
  Fulton – Healdsburg- Cloverdale
- **Topoclimate**: 0.5 km - 10 m
  solar radiation, relative elevation
  N-S slopes, frost pockets
- **Microclimate**: 100 m – 1 cm
  vegetation canopies, either side of trellis
- **Organism**: i.e. grape cluster
  physiology, thermal characteristics
Fulton (Russian River Valley)  
Apr-Oct Temp Westmap

Total Mean Temperature for point centered at 38.4796 N -122.770973 W  
6 month period ending in October

* 10 year running mean
Fulton Max/Min Apr-Oct Temp

Total Maximum Temperature for point centered at 38.4796 N -122.770973 W
6 month period ending in October

Total Minimum Temperature for point centered at 38.4796 N -122.770973 W
6 month period ending in October

* 10 year running mean
Topoclimate

Crooked Creek All Stations
Average Hourly Temperature July 23 - Oct 6 2006
Extrapolate across the landscape.

Modeled Minimum Temperature at Crooked Creek

$R^2_{adj} = 0.92, \quad RMSE = 0.61^\circ C$
Microclimate: Fish-eye Photography
Grapes’-Eye View
$T_{grape} = T_{air} + \left(\frac{W/m^2}{45}\right) (°F)$

Hot day, No Wind, Exposed Grape “hotspot”
Effect of Row Direction
Heat Damage Comparison

North-South Row

NE-SW Row

NW-SE Row

East-West Row

Air Temp

Northeast Side

Southwest Side

South Side

North Side = Air Temp.
## Degree-Hours VSP 105° Day

<table>
<thead>
<tr>
<th>VSP</th>
<th>DH &gt; 100°F</th>
<th>DH &gt; 105°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>111</td>
<td>69</td>
</tr>
<tr>
<td>N</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>39</td>
<td>2</td>
</tr>
<tr>
<td>W</td>
<td>94</td>
<td>63</td>
</tr>
<tr>
<td>SE</td>
<td>69</td>
<td>27</td>
</tr>
<tr>
<td>NW</td>
<td>61</td>
<td>34</td>
</tr>
<tr>
<td>NE</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>SW</td>
<td>107</td>
<td>72</td>
</tr>
</tbody>
</table>
Hourly Irradiance for Spottswoode
Y-Trellis 30° Row SE side

Hourly Irradiance at Spottswoode
Y-Trellis 30° Row NW Side
Berry temperatures Jul 31- Aug 31
Sprawl Trellis

SE -Side

NW -Side

Air
Climate change adaptation

• 30-year lifetime of a vineyard
• Canopy management
• Re-trellis (crossarms)
• Re-graft to different variety
• Replant
Conclusions

• Macro-, meso-, topo-, micro-climate
• Winegrapes are very sensitive to temperature
• Excellent model system for climate impacts
• Tools to predict grape temperatures from weather station data