Main features of the Grand Valley

- High mountain valley (~4,700’)
  - In the North, the Bookcliffs rise almost 2,000’ above the valley floor
  - In the East, Grand Mesa rises >6,000’ above the valley floor
  - In the South, the Uncompahgre Plateau rising >1,500’ above the valley floor
  - The valley widens and gently slopes to the West
How important is micro-climate?
CAVE weather station network

www.rmavv.org/weatherstations/cave-weather-station-network
How important is micro-climate?
How important is micro-climate?
CAVE weather station network

Legend:

<table>
<thead>
<tr>
<th>Color</th>
<th>Name</th>
<th>Last Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>/CSU 2010 database, start 1 Oct 2009/Public/17365 - CSU Block 10/Temperature (*F)</td>
<td>33.2 °F at Feb 15, 2010 11:33:05 AM</td>
</tr>
<tr>
<td></td>
<td>/CSU 2010 database, start 1 Oct 2009/Public/17365 - CSU Block 10/Temperature (*F)</td>
<td>35.1 °F at Feb 14, 2010 7:00:00 PM</td>
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<tr>
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<td>/CSU 2010 database, start 1 Oct 2009/Public/17365 - CSU Block 10/Temperature (*F)</td>
<td>31.4 °F at Feb 15, 2010 11:34:32 AM</td>
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<td>/CSU 2010 database, start 1 Oct 2009/Public/17365 - CSU Block 10/Temperature (*F)</td>
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<td>/CSU 2010 database, start 1 Oct 2009/Public/17365 - CSU Block 10/Temperature (*F)</td>
<td>35.0 °F at Feb 15, 2010 11:45:00 AM</td>
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<td>/CSU 2010 database, start 1 Oct 2009/Public/17365 - CSU Block 10/Temperature (*F)</td>
<td>33.7 °F at Feb 15, 2010 11:39:00 AM</td>
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</table>
CAVE weather station network

- Grand Junction West: -20.4
- Two Rivers Winery: -13.4
- Garfield: -2.7
- Riverview: -2.7
- Lovies: -9.2
- Orchard Mesa: -5.3
- Fruitvale: -5.3
- Clifton: -9.2
- CSU: -9.2
- Grand Junction: -20.4
Grape vine bud cold hardiness

Temperature (°F)

max 2009 | min 2009 | max 2008 | min 2008

LT<sub>10</sub> Chardonnay | LT<sub>10</sub> Syrah

15 Sep | 15 Oct | 15 Nov | 15 Dec | 15 Jan | 15 Feb | 15 Mar | 15 Apr
Dead **primary** bud
Percentage of dead primary buds as affected by temperature.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date</th>
<th>Field sample</th>
<th>0°F</th>
<th>-5°F</th>
<th>-10°F</th>
<th>-15°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chardonnay</td>
<td>2 Dec 2009</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Chardonnay</td>
<td>9 Dec 2009</td>
<td>4</td>
<td>25$^1$</td>
<td>70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Syrah</td>
<td>2 Dec 2009</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Syrah</td>
<td>9 Dec 2009</td>
<td>15</td>
<td>5$^1$</td>
<td>70</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

$^1$ Samples were taken on the morning of 9 Dec 2009. The overnight (8-9 Dec 2009) minimum temperatures in our vineyards ranged from -5.5 F to -10 F.

Caspari and Montano, 2009
Dead bud
Percentage of dead (primary, secondary & tertiary killed) buds as affected by temperature.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date</th>
<th>Field sample</th>
<th>0°F</th>
<th>-5°F</th>
<th>-10°F</th>
<th>-15°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chardonnay</td>
<td>2 Dec 2009</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Chardonnay</td>
<td>9 Dec 2009</td>
<td>0</td>
<td>0¹</td>
<td>55</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Syrah</td>
<td>2 Dec 2009</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Syrah</td>
<td>9 Dec 2009</td>
<td>0</td>
<td>0¹</td>
<td>45</td>
<td>95</td>
<td></td>
</tr>
</tbody>
</table>

¹ Samples were taken on the morning of 9 Dec 2009. The overnight (8-9 Dec 2009) minimum temperatures in our vineyards ranged from -5.5 F to -10 F.

Caspari and Montano, 2009
CAVE weather station network

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<tbody>
<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/17365 - CSU Block 10/Temperature (°F)</td>
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</tr>
<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/18154 - CSU Tower/Temp (°F)</td>
<td>32.0 °F at Feb 15, 2010 11:33:05 AM</td>
</tr>
<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/19199 - Riverview/19199 - Riverview/Temperature (°F)</td>
<td>31.4 °F at Feb 15, 2010 11:34:32 AM</td>
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<td>/CSU 2010 database, start 1 Oct 2009/Public/25480 - Lovie's/Temp (°F)</td>
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<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/25492 - Grand Junction West/Temp (°F)</td>
<td>33.8 °F at Feb 15, 2010 11:33:05 AM</td>
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<td>/CSU 2010 database, start 1 Oct 2009/Public/25492 - Grand Junction West/Temperature (°F)</td>
<td>33.8 °F at Feb 15, 2010 11:33:05 AM</td>
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<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/25492 - Grand Junction West/Temperature (°F)</td>
<td>33.8 °F at Feb 15, 2010 11:33:05 AM</td>
</tr>
<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/40182 - Garfield/Temp (°F)</td>
<td>33.8 °F at Feb 15, 2010 11:33:05 AM</td>
</tr>
<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/41542 - Canyon Wind/Temp (°F)</td>
<td>33.8 °F at Feb 15, 2010 11:33:05 AM</td>
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<tr>
<td>/CSU 2010 database, start 1 Oct 2009/Public/41542 - Canyon Wind/Temperature (°F)</td>
<td>33.8 °F at Feb 15, 2010 11:33:05 AM</td>
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</tbody>
</table>
CAVE weather station network
Grape vine bud cold hardiness
Percentage of dead primary buds after an overnight low of -13 F to -16 F (9-10 Dec, 2009).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date</th>
<th>Field sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chardonnay</td>
<td>10 Dec 2009</td>
<td>81</td>
</tr>
<tr>
<td>Syrah (North)</td>
<td>10 Dec 2009</td>
<td>97</td>
</tr>
<tr>
<td>Syrah (South)</td>
<td>10 Dec 2009</td>
<td>92</td>
</tr>
</tbody>
</table>

Samples were taken on the morning of 10 Dec 2009. Bud damage was assessed after keeping samples at 70 F for a minimum of 24 hours.

Caspari and Montano, 2009
Percentage of dead buds after an over-night low of -13 F to -16 F (9-10 Dec, 2009).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date</th>
<th>Field sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chardonnay</td>
<td>10 Dec 2009</td>
<td>40</td>
</tr>
<tr>
<td>Syrah (North)</td>
<td>10 Dec 2009</td>
<td>70</td>
</tr>
<tr>
<td>Syrah (South)</td>
<td>10 Dec 2009</td>
<td>47</td>
</tr>
</tbody>
</table>

Samples were taken on the morning of 10 Dec 2009. Bud damage was assessed after keeping samples at 70 F for a minimum of 24 hours.

Caspari and Montano, 2009
CAVE weather station network
Percentage of dead primary buds after over-night lows of -6 F, -13 F, and -6 F (9-11 Dec, 2009).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date</th>
<th>Field sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syrah (high cordon, South)</td>
<td>15 Dec 2009</td>
<td>97</td>
</tr>
</tbody>
</table>

Samples were taken on the morning of 15 Dec 2009. Bud damage was assessed after keeping samples at 70 F for a minimum of 24 hours.

Caspari and Montano, 2009
Percentage of dead buds after over-night lows of -6 F, -13 F, and -6 F (9-11 Dec, 2009).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date</th>
<th>Field sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syrah (high cordon, South)</td>
<td>15 Dec 2009</td>
<td>72</td>
</tr>
</tbody>
</table>

Samples were taken on the morning of 15 Dec 2009. Bud damage was assessed after keeping samples at 70 F for a minimum of 24 hours.

Caspari and Montano, 2009
Cold injury in Mesa County

How much damage did we have in the Grand Valley?
Cold injury in Mesa County

First estimate done shortly after the December cold event was >25 % crop loss.

However, by February 2010 we have looked at many different sites and have heard back from many growers.

Estimate at that time was ~50 % crop loss, and possibly more.

Actual 2010 yield in the Grand Valley AVA was down 59 % on 2009.
Cold injury in Mesa County

Where did we have bud/vine damage in the Grand Valley?
Minimum temperatures, Dec 9-11

- Grand Junction West: -22.3
- Two Rivers Winery: -18.0
- Garfield: -4.0
- Riverview: -4.7
- Lovies: -9.3
- Orchard Mesa: -12.2
- Fruitvale: -12.5
- Clifton: -9.3
Cold injury in Mesa County

Initial assessment:
Anything West of Sink Creek (~34 Rd) and vineyards on the valley floor West of Palisade have near 100 % crop loss.

The area to the East of Sink Creek (East Orchard Mesa) and the Vinelands might be ok.
Cold injury in Mesa County

Actual assessment: Anything West of 35 ½ or 36 Rd and vineyards on the valley floor West of Palisade had near 100 % crop loss.

There were vineyards with substantial damage in the eastern part of East Orchard Mesa and also in the Vinelands.
Cold injury in Mesa County

Why did we have bud damage in the eastern part of the Grand Valley when the minimum temperatures recorded were >-5 F?
Cold injury in Mesa County

Why did we have bud damage in the eastern part of the Grand Valley when the minimum temperatures recorded were >-5 F?

Three possibilities (and combinations thereof):

A – cold-sensitive varieties

B – insufficient acclimation

C – it was actually colder than -5 F
Cold injury in Mesa County

C – it was colder than -5 F

Case study: Riverview Vineyard

Minimum temperatures: -2.7 F, -4.7 F, -4.0 F

Strong wind throughout the nights (= no inversion)

Expected: Little to no bud damage

Reality: Almost 100 % damage to Chardonnay and Merlot in low spots, yet little to no damage on high ground
CAVE weather station at Riverview vineyard
Cold injury in Mesa County

Case study: Riverview Vineyard

While it was windy most of the time, there were four periods of no wind during Dec 8-11, resulting in very rapid drops in temperatures and the formation of temperature inversions.

It is VERY likely that during each of those periods the temperatures in the low spots differed significantly from those recorded by the weather station.
CAVE weather station at Riverview vineyard
CAVE weather station at Riverview vineyard
Temp. Logger (low spot)  
Riverview (high ground)

Temperature (F)  
Wind speed (mph)

09-Feb-10 16:00 09-Feb-10 22:00 10-Feb-10 04:00
The image displays a graph showing temperature and wind speed data from Feb 12 to Feb 13.

**Temperature (F):**
- **Temp. Logger (low spot):** Red line
- **Riverview (high ground):** Black line

**Wind speed (mph):** Blue line

The graph indicates a significant drop in temperature over time, with the temperature logger (low spot) showing a more severe decline compared to Riverview (high ground). Wind speed data is also shown, with peaks indicating higher wind activity.
Cold injury in Mesa County

Summary:

Crop losses were substantial in the Grand Valley AVA.

Crop losses were near 100 % in the western part of the AVA, and >50 % overall.

Surprisingly, there were also substantial crop losses in vineyards in the eastern part of the AVA.

In many vineyards we found a strong influence of topography on bud damage, suggesting pronounced temperature differences between “high” and “low” ground.
Cold injury in Mesa County

Summary:

These differences in bud damage are the result of brief periods with no or low wind speeds, causing strong temperature inversions.

In many vineyards in the eastern part of the AVA damage could have been reduced, if not eliminated, through the use of wind machines.
Cold injury in Mesa County

Lessons learned:

1. Wind machines should be operational during winter (I suggest to have them operational by late September to protect from early fall freezes).

2. Know the topography of your vineyard and understand its impact on temperature.

3. Locate your frost alarm sensors in the areas you want to protect.

4. Know the threshold temperatures for cold injury, and set/update your frost alarms accordingly.
Thank you for your attention

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http://www.colostate.edu/programs/wcrc/pubs/viticulture/viticulturehome.htm