Cool Climate Oenology & Viticulture Institute

Brock University

Cold Hardiness: Current Issues and Research Developments

Jim Willwerth, PhD
CCOVI, Brock University

CCOVI Lecture Series
March 10th 2014

Overview

- CCOVI has been actively involved with research and outreach initiatives concerning grapevine cold hardiness since 2010
- Launch of VineAlert program in fall 2010
- Website that posts regional information on cold hardiness, bud survival, temperatures, alerts and key information concerning cold hardiness
- Research program for optimizing cold hardiness – crop level, water stress, disease, timing of harvest etc.
- Funding through AAFC - Developing Innovative Agri-Products initiative (DIAP), Ontario Ministry of Economic Development and Innovation's (MEDI) Ontario Research Fund (ORF).
- Collaboration between AAFC, MEDI, GGO, CCOVI

Freeze Injury

- Can occur during acclimation, mid-winter, deacclimation or post bud break
- Some freeze injury occurs in Ontario EVERY year and may not result in significant loss

Consequences of cold injury

- Loss of fruit
- Uneven or poor vegetative growth
- Loss of vines
- Disease incidence (crown gall)
- Loss of uniformity
- Loss of consistency
- Increased management costs
- Ultimately reductions in yield, quality and profit

What is Cold Hardiness?

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- **Ability of plant tissue to survive freezing temperature stresses**
- **Very complex trait with many contributing factors**
- **Limited by inherent genetic potential**
  - *V. riparia* – 40C; *V. vinifera* -20's C
- **Influenced by environmental conditions**
- **Highly dynamic condition**

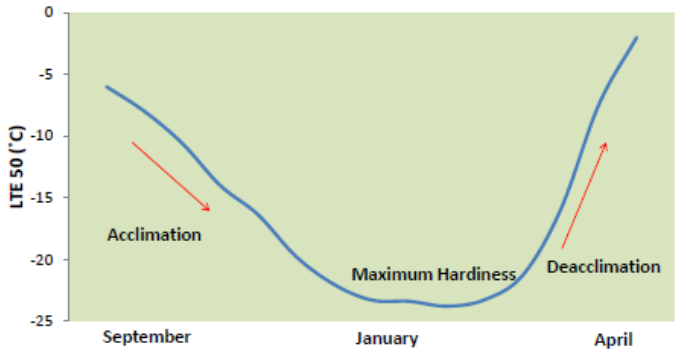


Figure 1. Profile of bud cold hardiness during the dormant season

Cold Hardiness: Dynamic condition

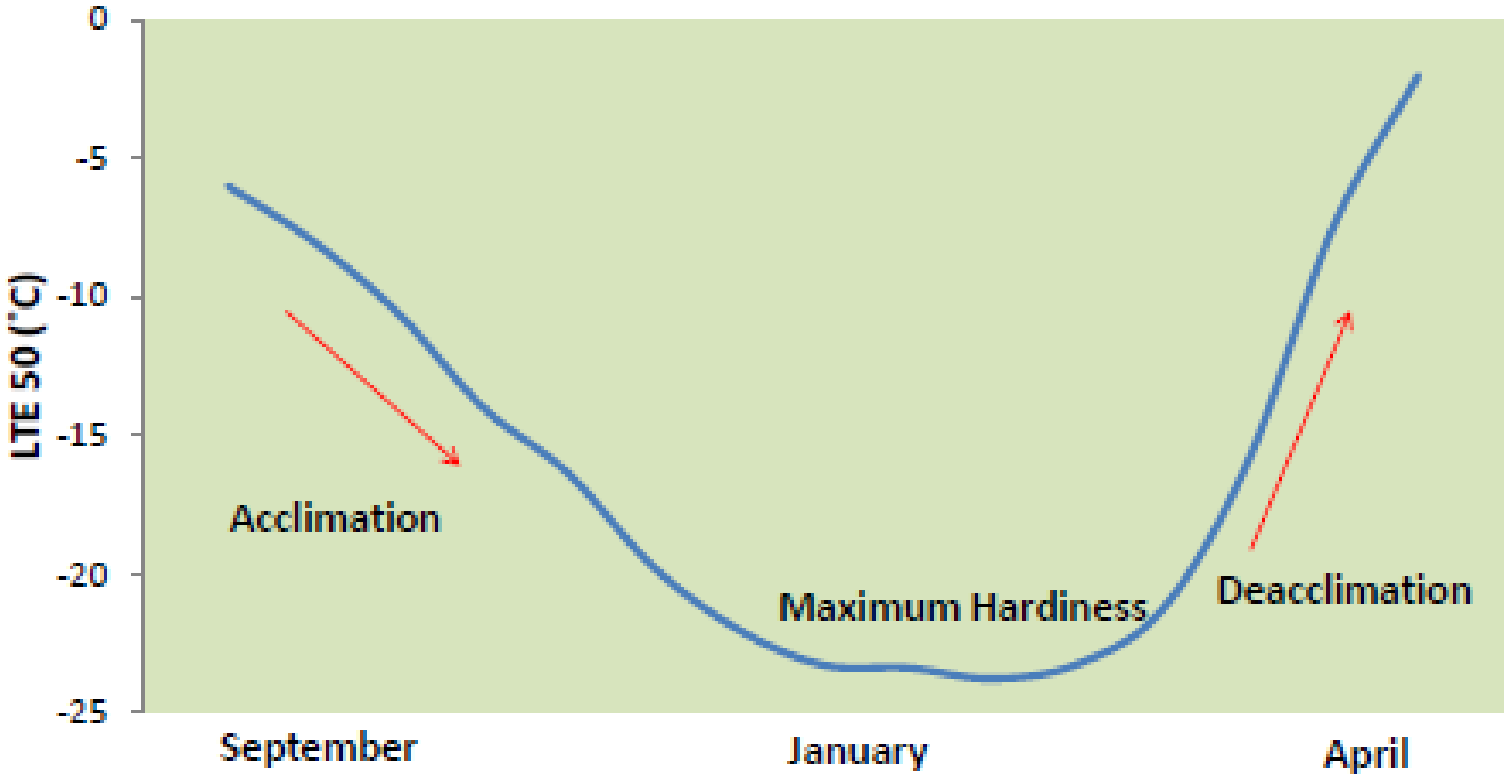


Figure 1. Profile of bud cold hardiness during the dormant season

(CCOVI VineAlert Website)

Cultivar differences in cold tolerance

- Ontario alone grows over 32 varieties (VQA-approved)
- *V. vinifera (different groups of origin)*
- French hybrids
- New hybrids with extreme cold hardiness
- New cultivars to our region
- Variation within and between these categories

Cultivar differences in cold tolerance

- **Some key Cool Climate cultivars in Ontario**

Cultivar	DATE	LTE10	LTE50	LTE90
Riesling	07-Feb-13	-23.1	-24.4	-26.0
Chardonnay	14-Feb-13	-21.4	-23.9	-25.3
Pinot noir	14-Feb-13	-21.4	-22.9	-24.1

Cultivar differences in cold tolerance

Bordeaux varieties (2012/13)

Cultivar	DATE	LTE10	LTE50	LTE90
Sauvignon blanc	14-Feb-13	-20.71	-22.03	-23.7
Semillon	07-Feb-13	-18.1	-21.4	-24.3
Cab Sauvignon	06-Feb-13	-21.64	-23.87	-24.97
Merlot	05-Feb-13	-17.48	-20.08	-22.41
Cabernet franc	14-Feb-13	-21.32	-22.87	-24.25
Malbec	07-Feb-13	-22.25	-23.7	-25.11
Petit verdot	07-Feb-13	-22.35	-23.99	-25.68

Cultivar differences in cold tolerance

Other cultivars (2012/13)

Cultivar	DATE	LTE10	LTE50	LTE90
Syrah	07-Feb-13	-19.1	-21.0	-23.3
Gewurztraminer	07-Feb-13	-19.8	-22.6	-25.0
Tannat	07-Feb-13	-20.8	-22.5	-23.9
Tempranillo	07-Feb-13	-18.9	-21.9	-23.8
Viognier	07-Feb-13	-21.2	-23.8	-25.6
Sangiovese	07-Feb-13	-20.6	-21.9	-23.0
Auxerrois	22-Jan-13	-21.85	-24.3	-25.8

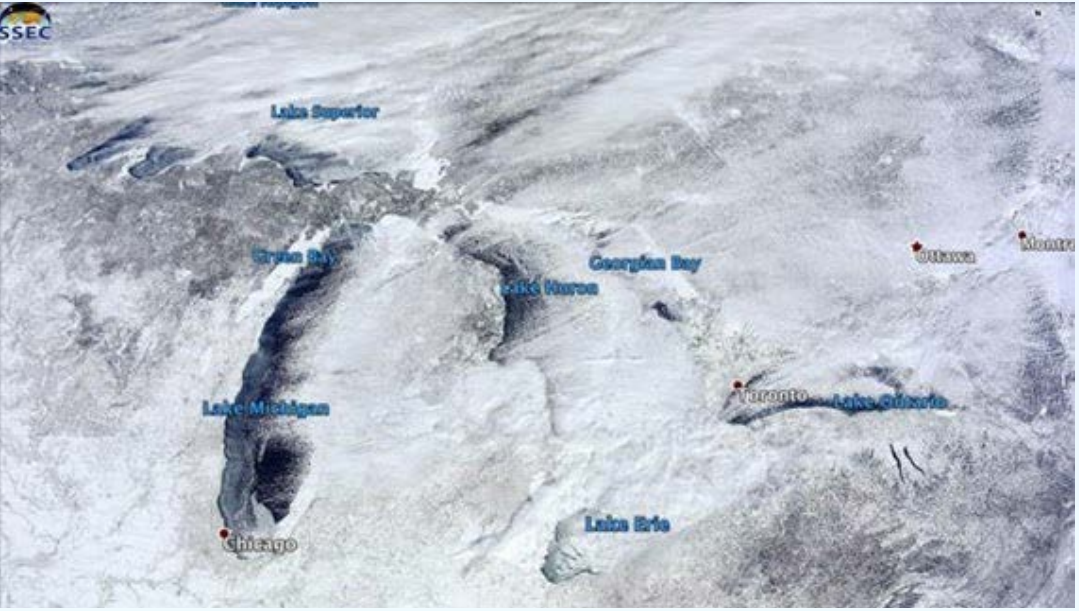
Cultivar differences in cold tolerance

Other cultivars

Cultivar	DATE	LTE10	LTE50	LTE90
Vidal	13-Feb-14	-26.45	-27.68	-28.67
Regent	14-Feb-13	-20.08	-22.99	-24.49
Bianca	14-Feb-13	-22.7	-24.19	-25.52
HG01	14-Feb-13	-22.12	-23.68	-24.94
Gr7	10-Feb-13	-25.21	-26.50	-27.66
Frontenac	10-Feb-14	-30.72	-31.59	-32.45
Sabrevois	10-Feb-14	-27.84	-29.58	-30.80
Marquette	10-Feb-14	-28.91	-30.26	-32.45

CURRENT STATE OF THE VINES:
Summary of 2013 to present

- Variable growing season- wet periods, dry periods, hot periods, cool periods
- Record breaking crop
- Vines acclimated at an average rate and similar to 2011
- Warm periods in Nov and Dec followed by cold snaps – Dec 16/17, Dec 24/45
- Cold January, February, March
- Polar Vortex: End of 1st week Jan into 2nd week; End of 3rd week Jan into 4th week
- More events in February
- Over 10 events below -20C and some below -24C
- Bud survival rates impacted


SSEC
Lake Superior
Georgian Bay
Lake Huron
Ottawa
Toronto
Lake Michigan
Lake Erie
Chicago

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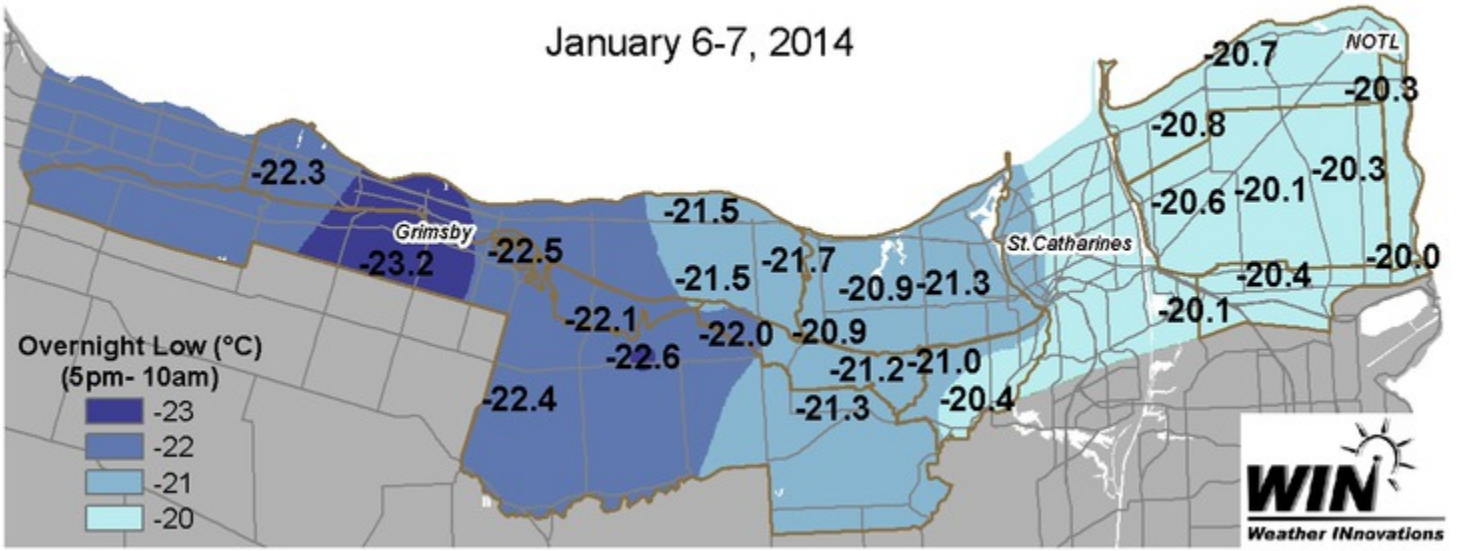

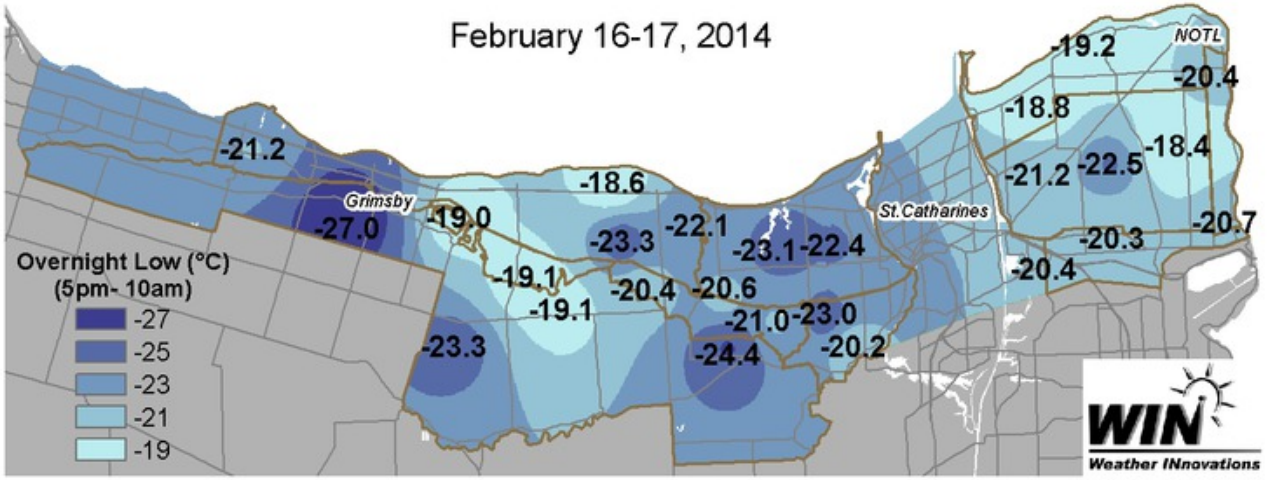

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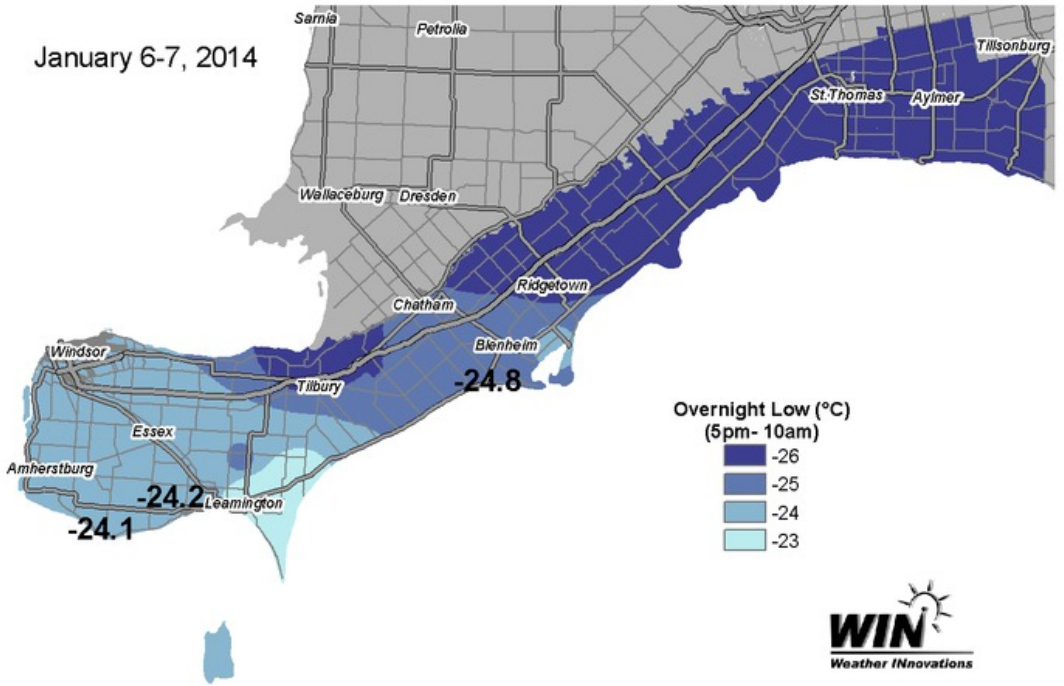

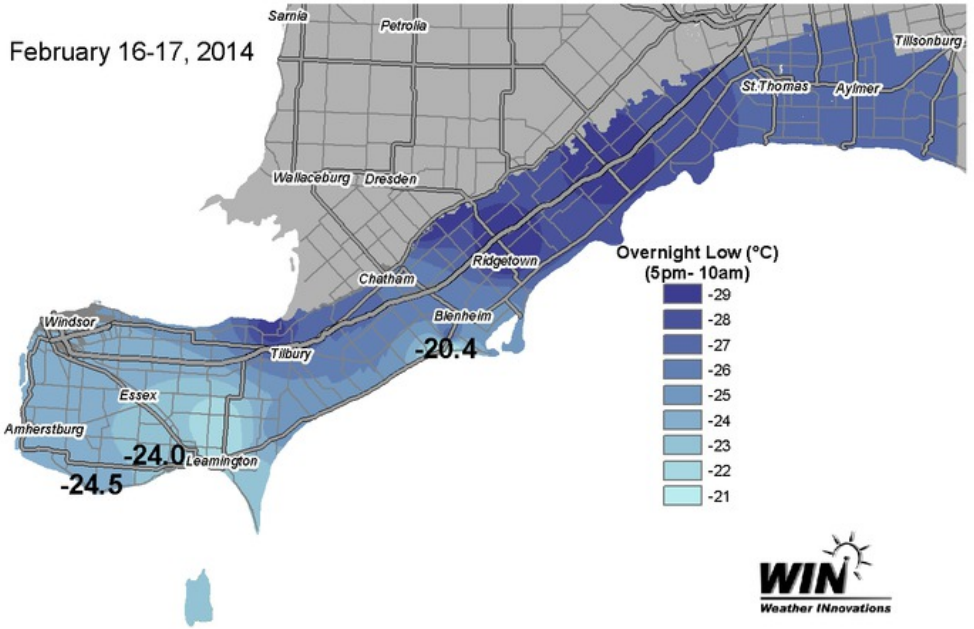

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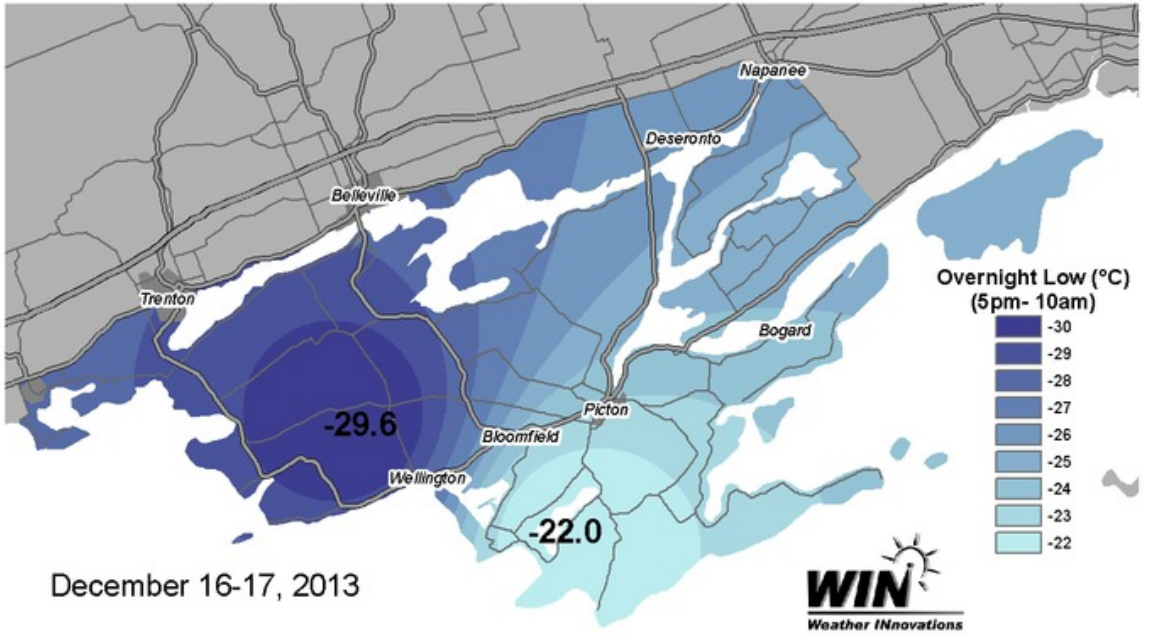
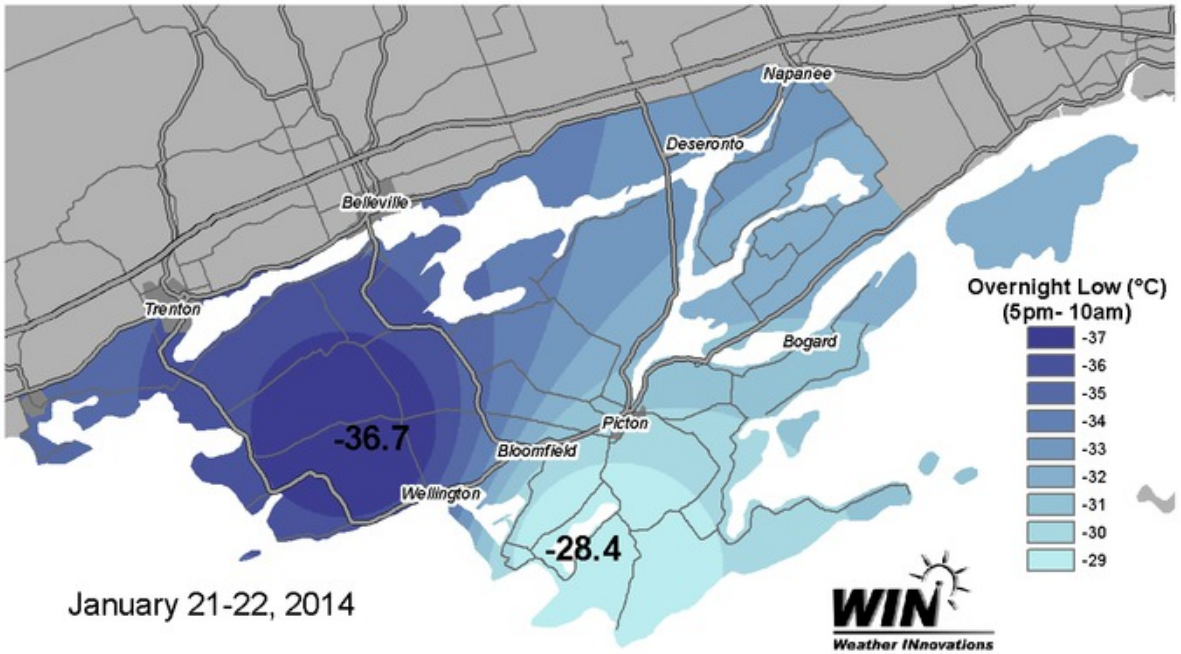


December 16-17, 2013



January 21-22, 2014

VineAlert
http://www.ccovi.ca/vine-alert

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- **Our advanced cold hardiness database and alerting system during periods of risk**

Cab franc cold hardiness profile – 2013/14, Colchester, LENS

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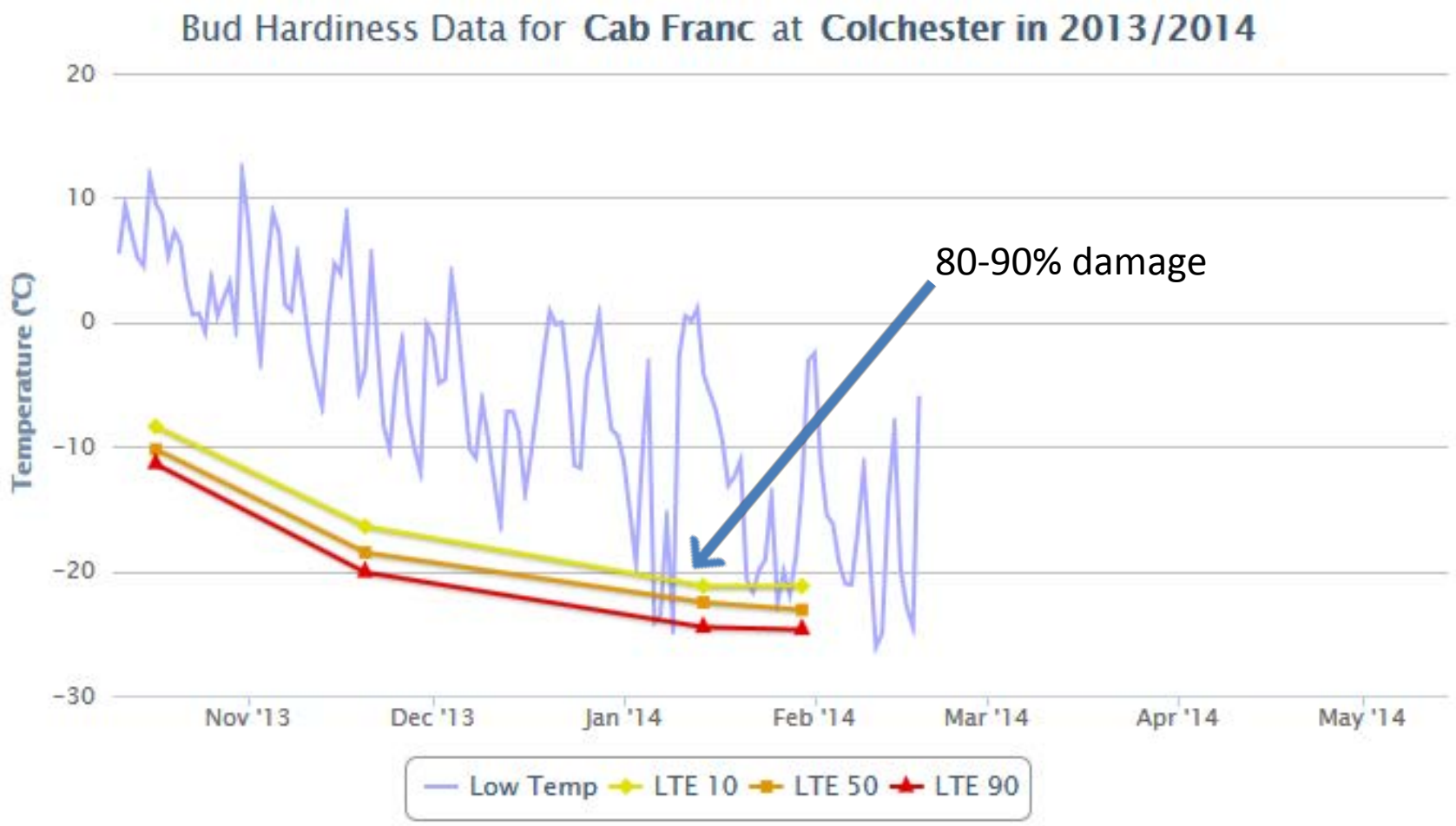

Chardonnay cold hardiness profile- 2013/14, Beamsville Bench

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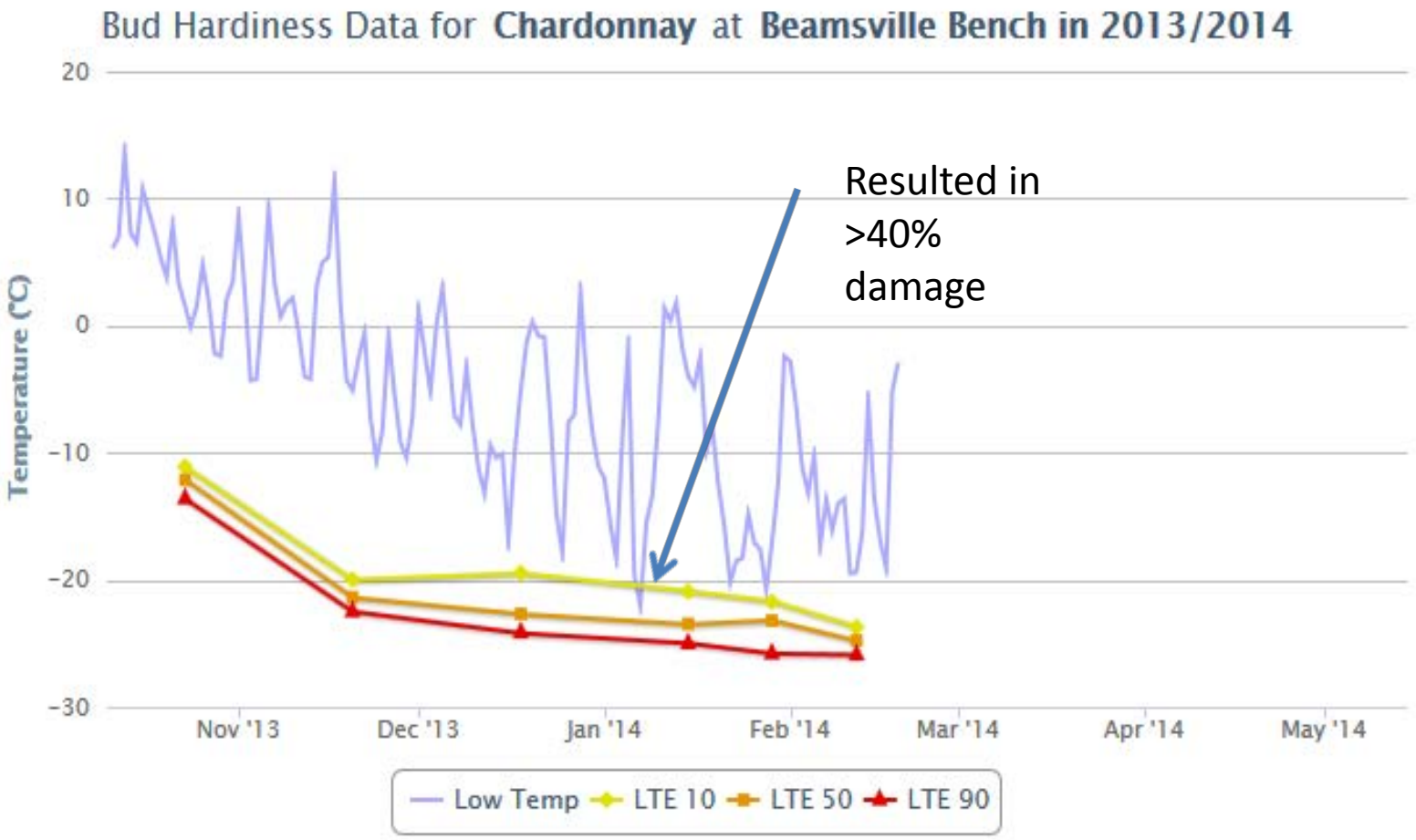

Seasonal differences and Cold hardiness

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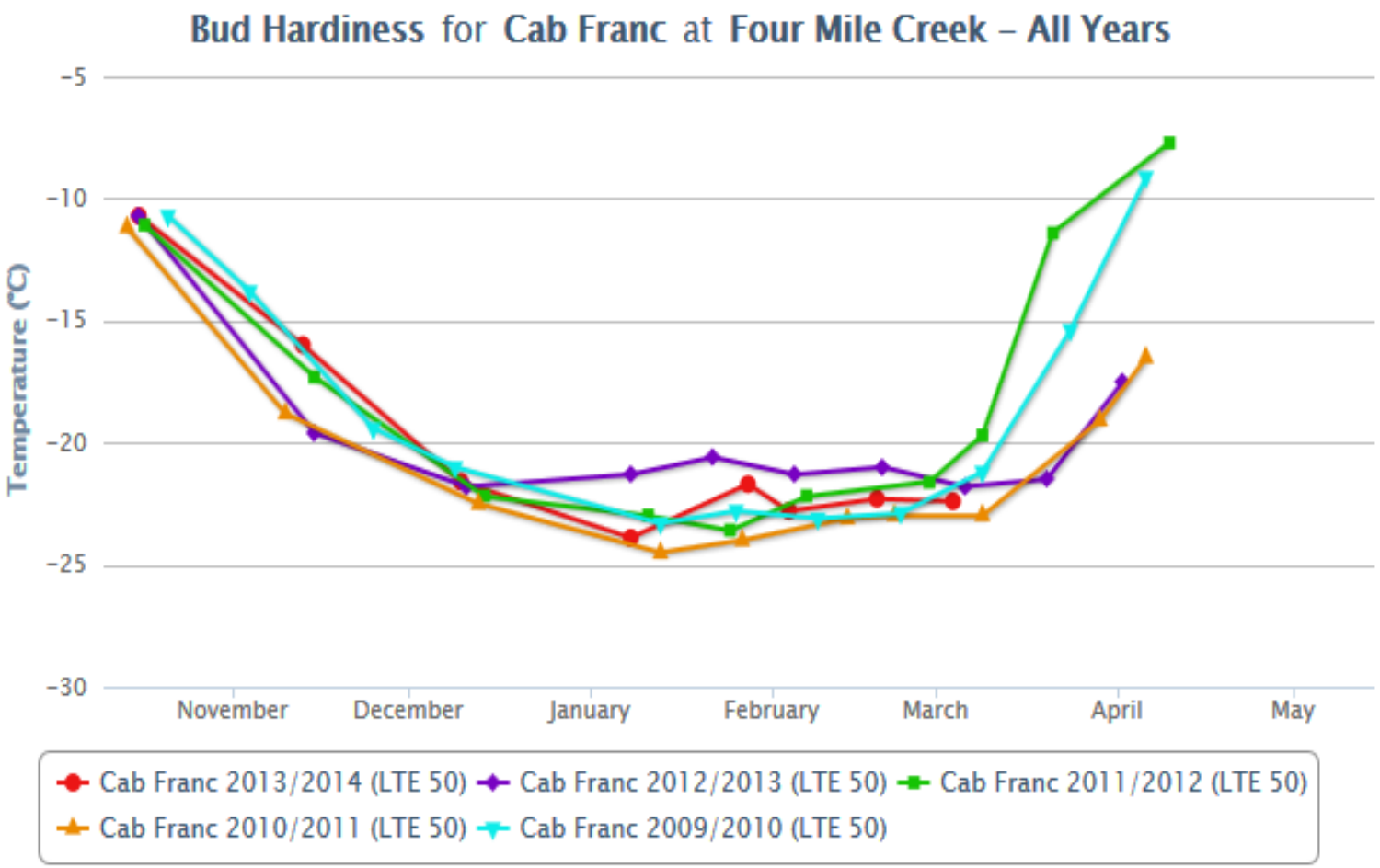
Compare Years | LTE 50



Niagara Peninsula Bud Survival

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Cabernet franc	6	88	62
Cabernet sauvignon	50	91	66.5
Chardonnay	34	93	64
Gewurztraminer	53	90	73
Merlot	30	84	48
Pinot gris	82	92	87
Pinot noir	48	97	77
Riesling	40	100	69
Sauvignon blanc	17	85	49
Semillon	47	47	47
Syrah	28	51	39
Average			**62**

Lake Erie North Shore Survival

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Cabernet franc	6	14	11
Cabernet sauvignon	6	6	6
Chardonnay	3	10	7
HG01	32	32	32
HG03	26	26	26
HG04	22	22	22
Merlot	0	25	8
Pinot noir	23	24	23.5
Riesling	17	24	20.5
Sauvignon blanc	8	8	8
Syrah	3	13	10
Vidal	68	68	68

Key Cultivars
Cabernet franc, Niagara

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Cabernet franc	**6**	**88**	**62**
Beamsville Bench	49	55	52
Creek Shores	62	62	62
Four Mile Creek	60	88	74
Lincoln Lakeshore	56	58	57
Niagara Lakeshore	69	72	70.5
Niagara River	54	79	66.5
Short Hill's Bench	**75**	**81**	**78**
St. David's Bench	74	81	77.5
Twenty Mile Bench	73	74	73.5
Vinemount Ridge	6	6	6

Key Cultivars
Cabernet Sauvignon, Niagara

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Cabernet Sauvignon	**50**	**91**	**66.5**
Creek Shores	50	62	56
Four Mile Creek	53	73	63
Niagara River	91	91	91
St. David's Bench	70	70	70

Key Cultivars
Merlot, Niagara

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Merlot	**30**	**84**	**48**
Creek Shores	41	41	41
Four Mile Creek	43	84	58
Lincoln Lakeshore	18	30	30
Niagara Lakeshore	**62**	**64**	**63**
Niagara River	64	64	64
Short Hill's Bench	41	41	41
St. David's Bench	32	32	32
Twenty Mile Bench	56.5	59	58

Key Cultivars
Pinot noir, Niagara

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Pinot noir	**48**	**97**	**78**
Creek Shores	85	85	85
Four Mile Creek	**94**	**97**	**95.5**
Lincoln Lakeshore	48	79	63.5
Niagara Lakeshore	59	96	74
Niagara River	**95**	**96**	**95.5**
St. David's Bench	52	52	52
Twenty Mile Bench	77	97	87

Key Cultivars
Chardonnay, Niagara

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Chardonnay	**34**	**93**	**64**
Beamsville Bench	39	58	48.5
Creek Shores	46	46	46
Four Mile Creek	73	90	80
Lincoln Lakeshore	61	67	63
Niagara Lakeshore	72	89	75
Niagara River	85	85.5	85
Short Hill's Bench	80	81	80.5
St. David's Bench	55	93	55
Twenty Mile Bench	53	87	72
Vinemount Ridge	34	34	34

Key Cultivars
Riesling, Niagara

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Riesling	**40**	**100**	**69**
Beamsville Bench	51	54	52
Creek Shores	67	67	67
Four Mile Creek	75	93	77
Lincoln Lakeshore	54	73	63.5
Niagara Lakeshore	**97**	**97**	**97**
Niagara River	54	100	76
Short Hill's Bench	60	78	69
Twenty Mile Bench	77	77	77
Vinemount Ridge	40	40	40

Other varieties
Niagara

Variety	Minimum Survival (%)	Maximum Survival (%)	Average Survival (%)
Gewurztraminer	**53**	**90**	**73**
Four Mile Creek	53	75	64
Niagara River	90	90	90
Pinot gris	**82**	**92**	**87**
Four Mile Creek	82	82	82
Twenty Mile Bench	85	92	88
Sauvignon blanc	**17**	**85**	**49**
Four Mile Creek	55	85	69
Niagara River	17	68	46
Short Hill's Bench	32	32	32
St. David's Bench	55	55	55
Twenty Mile Bench	40	57.5	47
Vidal			
Vinemount Ridge	**12**	**90**	**60**
Syrah	**28**	**51**	**39**
Creek Shores	29	29	29
Four Mile Creek	51	51	51
Niagara River	28	43	37.5
St. David's Bench	40	40	40
Grand Total	17	92	57

Cold events and bud damage

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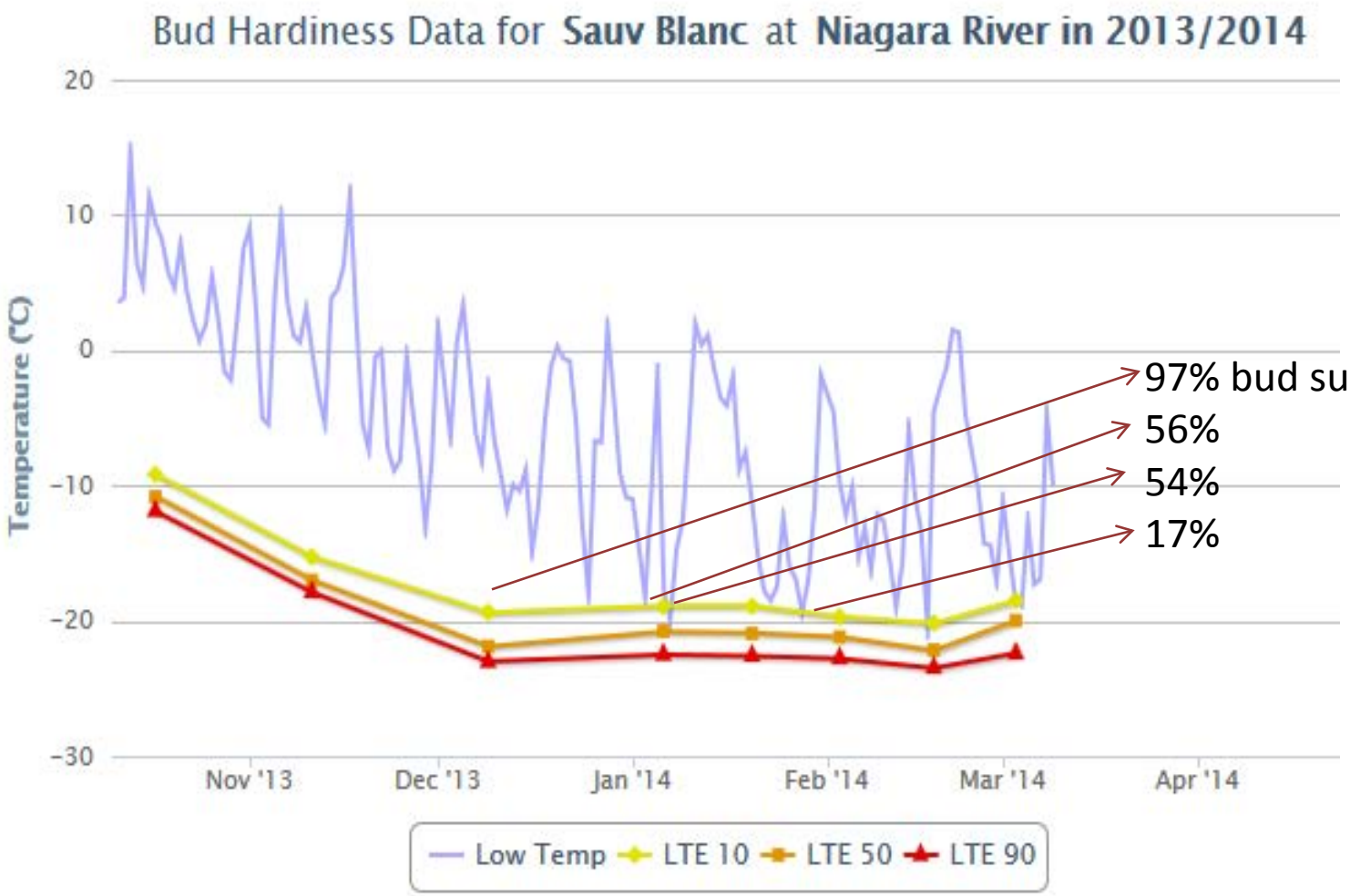

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Why do I have more damage than my neighbour???

Factors impacting bud survival

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- Combination of factors
- Variety*
- Site location and temperatures reached*
- Vine health and age
- Management practices – training system, use of spare parts, canopy management
- Water – too little or too much
- Drainage – both water and air drainage
- Crop levels – over cropping and under cropping

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Study #1: Crop level x harvest date

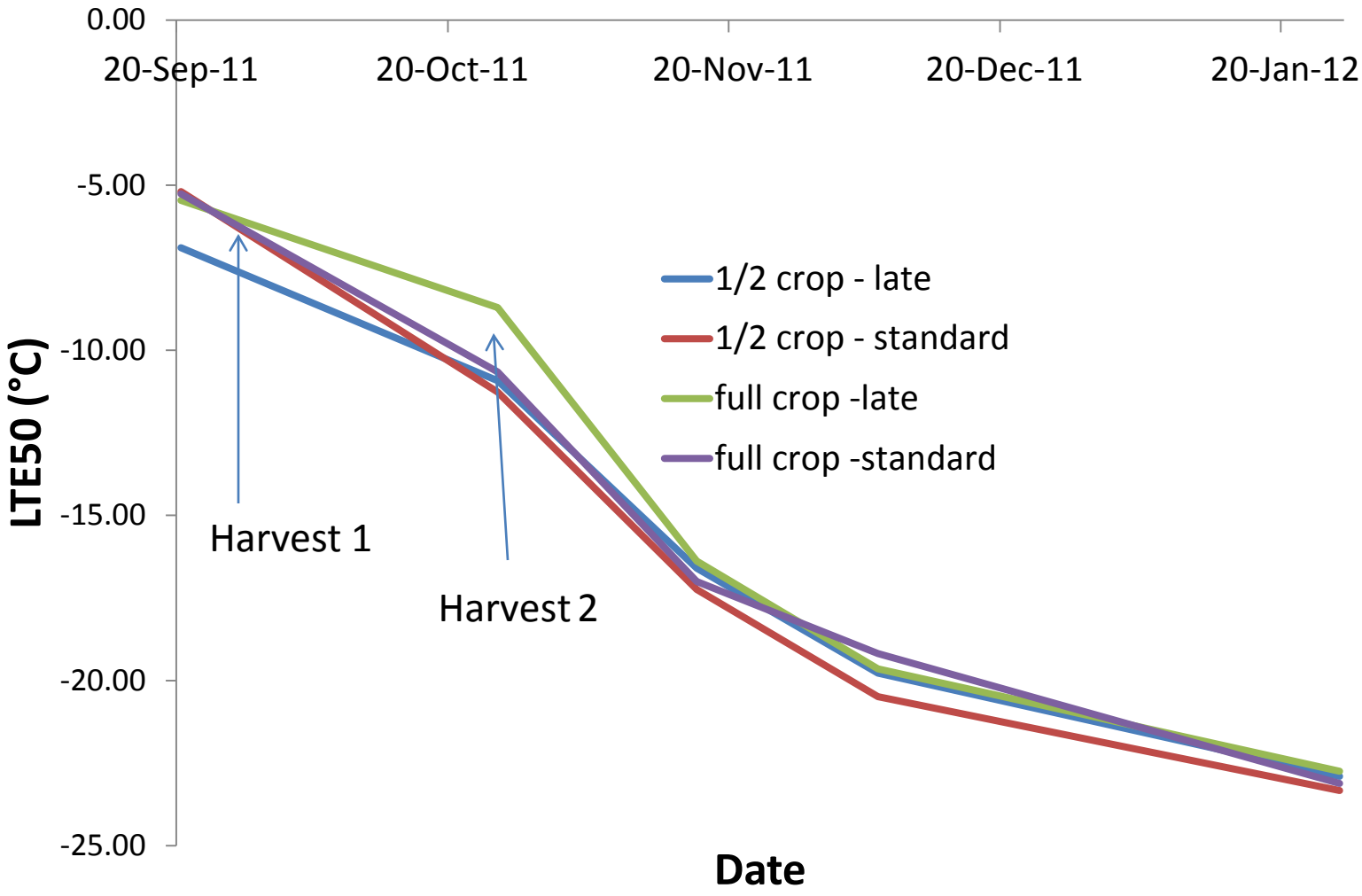
Crop level x harvest date trials

- **Heavy crop load can enhance the probability and severity of cold injury**
- **High crop levels can lead to poor acclimation and shoot maturation (Edson et al. 1995)**
- **Optimal crop levels can be cultivar and site specific**
  - Cluster thinning when warranted can improve hardiness and quality
  - Achieve balance between crop and vigour

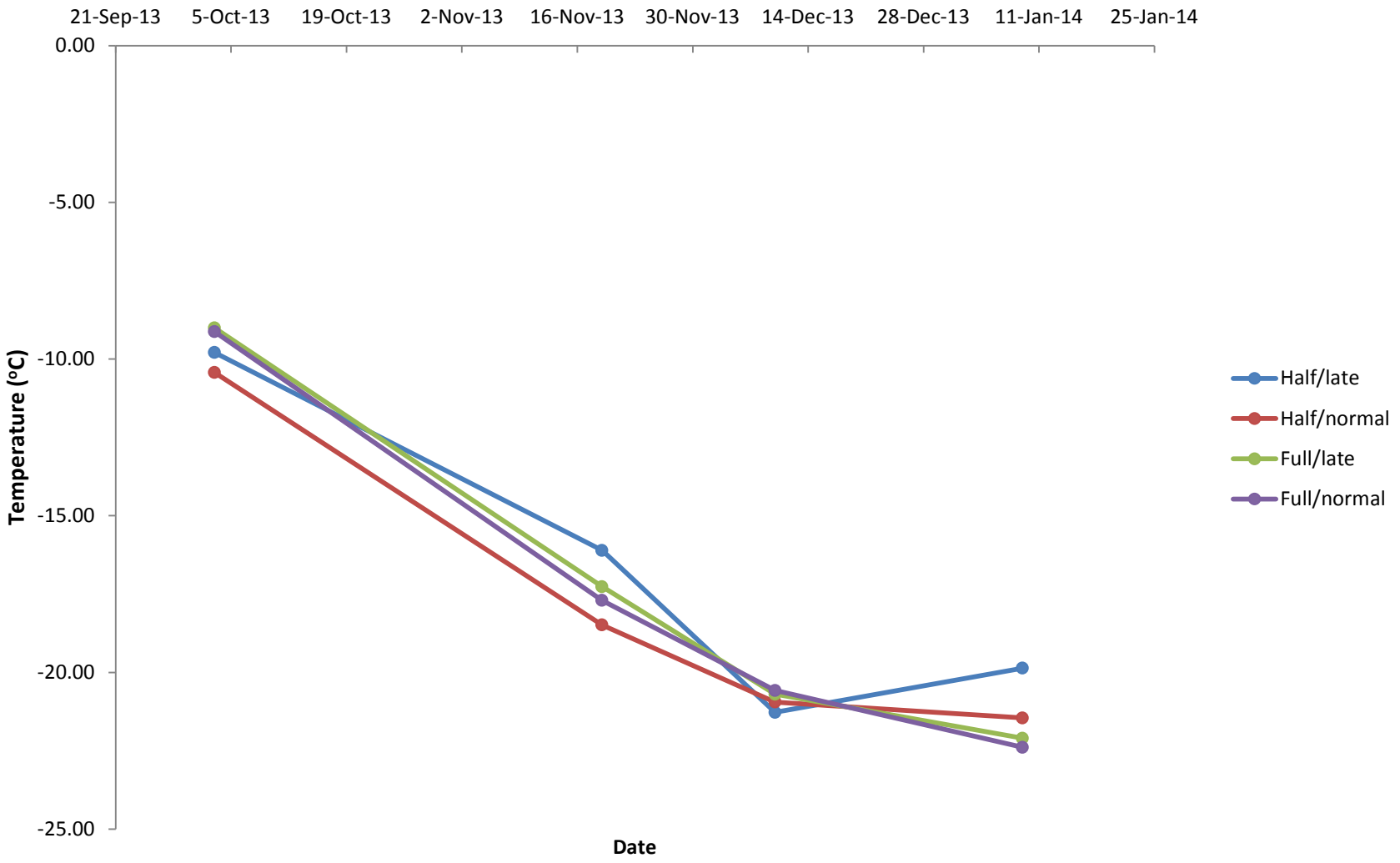
Manipulation through crop levels

- By restricting growth, more energy can be diverted into fruit development
- Removal of fruit early encourages root development
- Too much fruit will restrict growth, root development
- If too much fruit left late in season, it will not mature and lead to poor reserves for overwintering success
- Everything is interconnected!

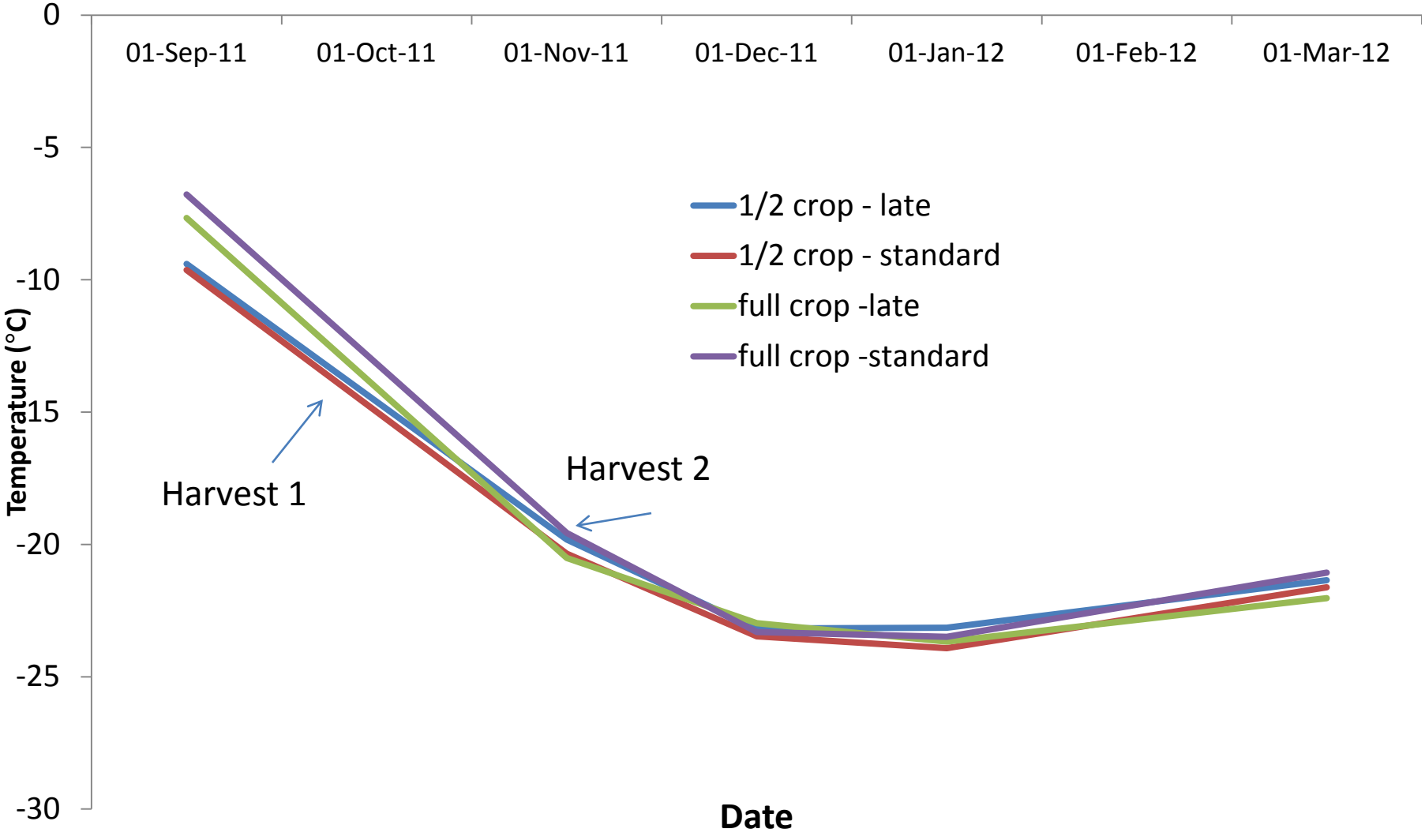
Impact of Crop level and harvest date Sauvignon blanc: Acclimation (2011)



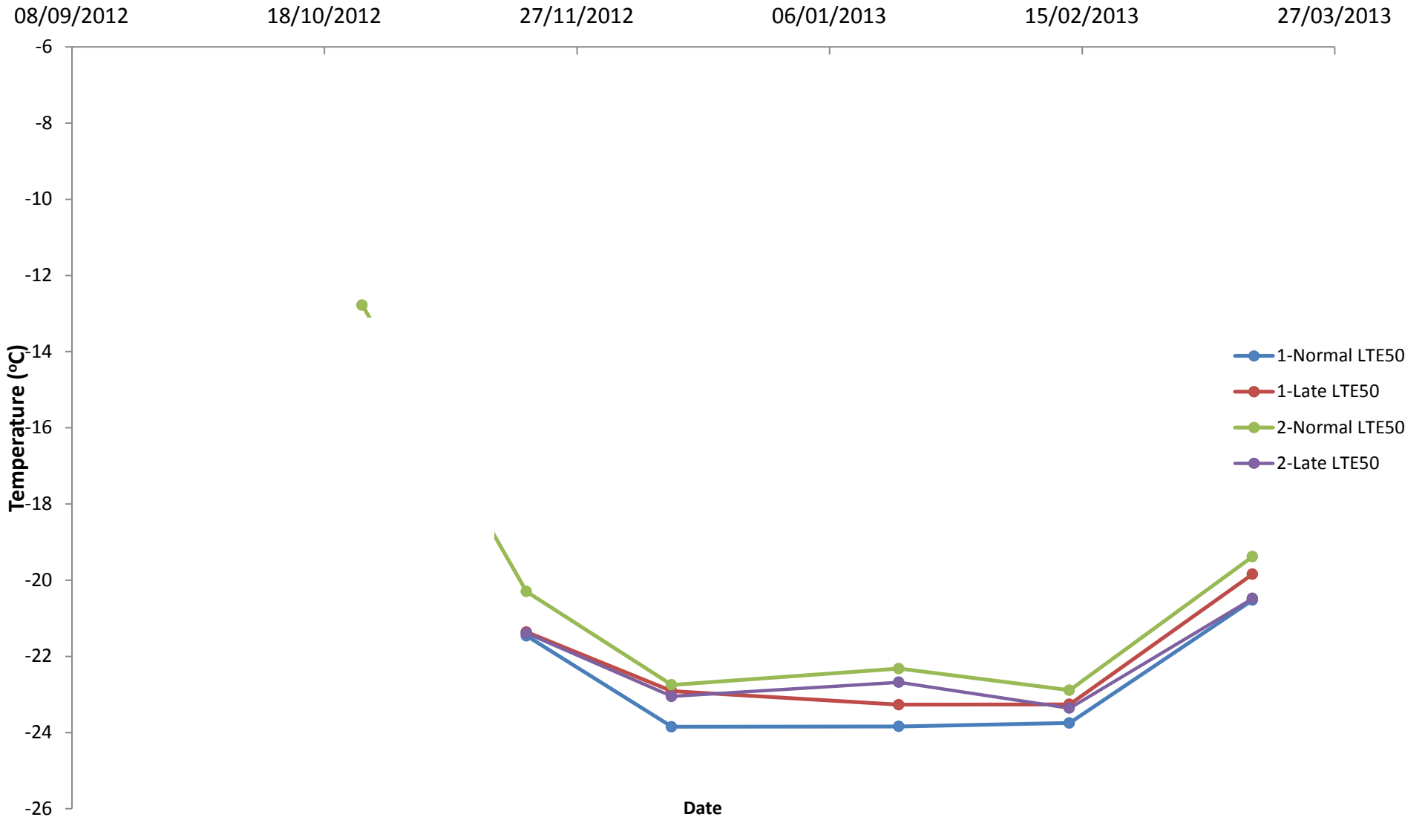
Crop level/harvest date studies
Sauvignon blanc – Acclimation -2013



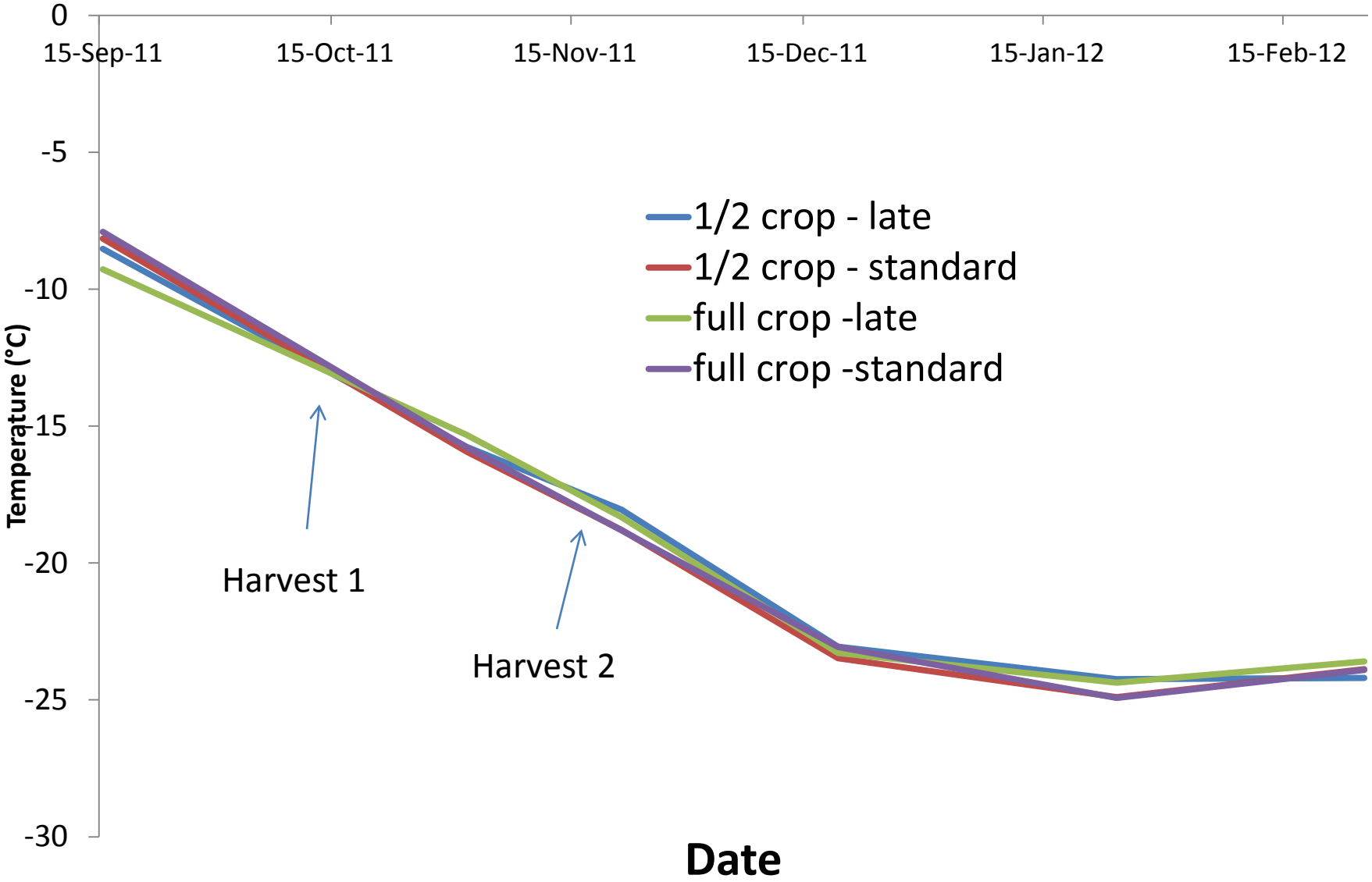
Pinot noir LTE 50 – 2011/12



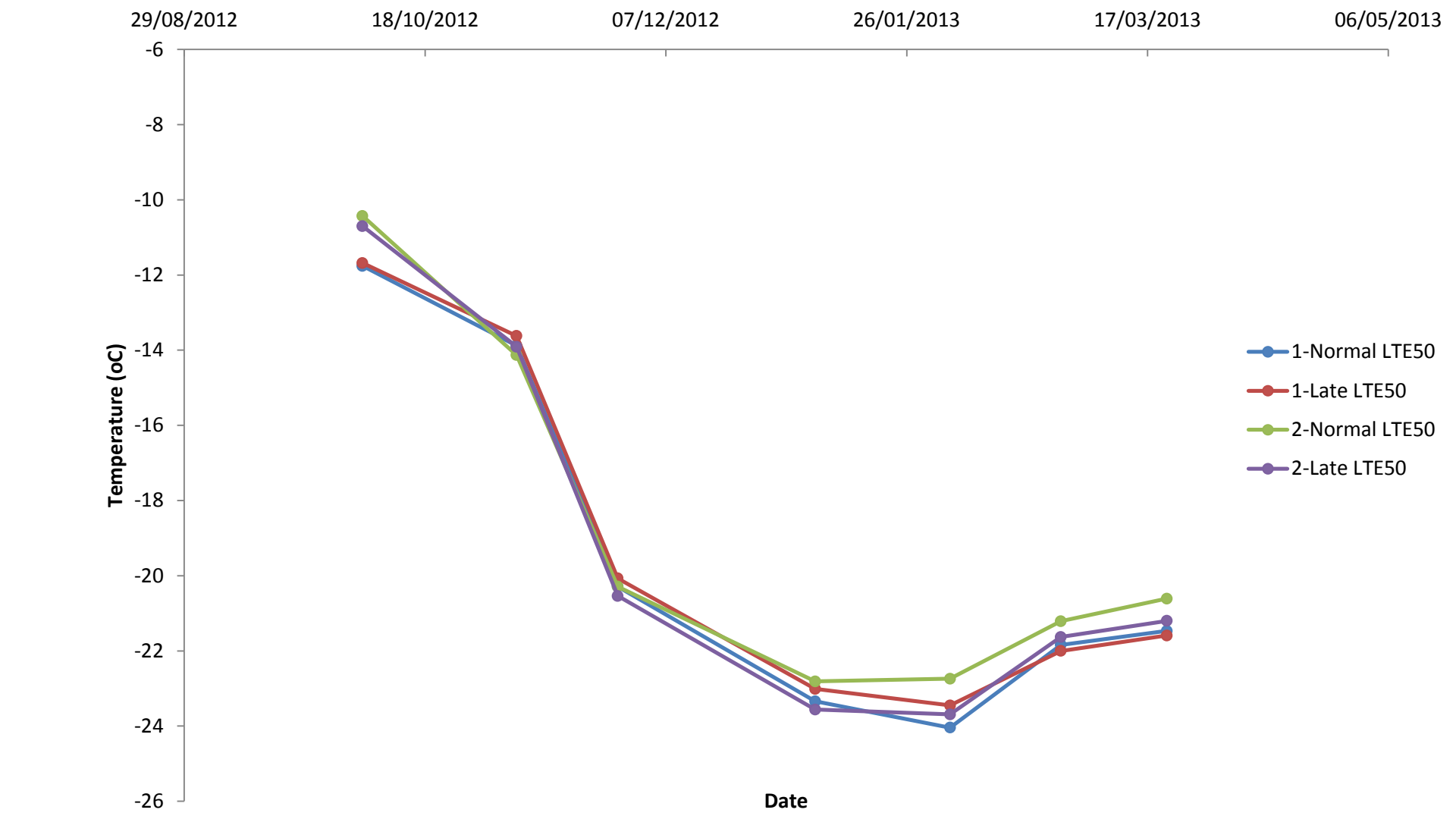
Pinot noir LTE 50 – 2012/13



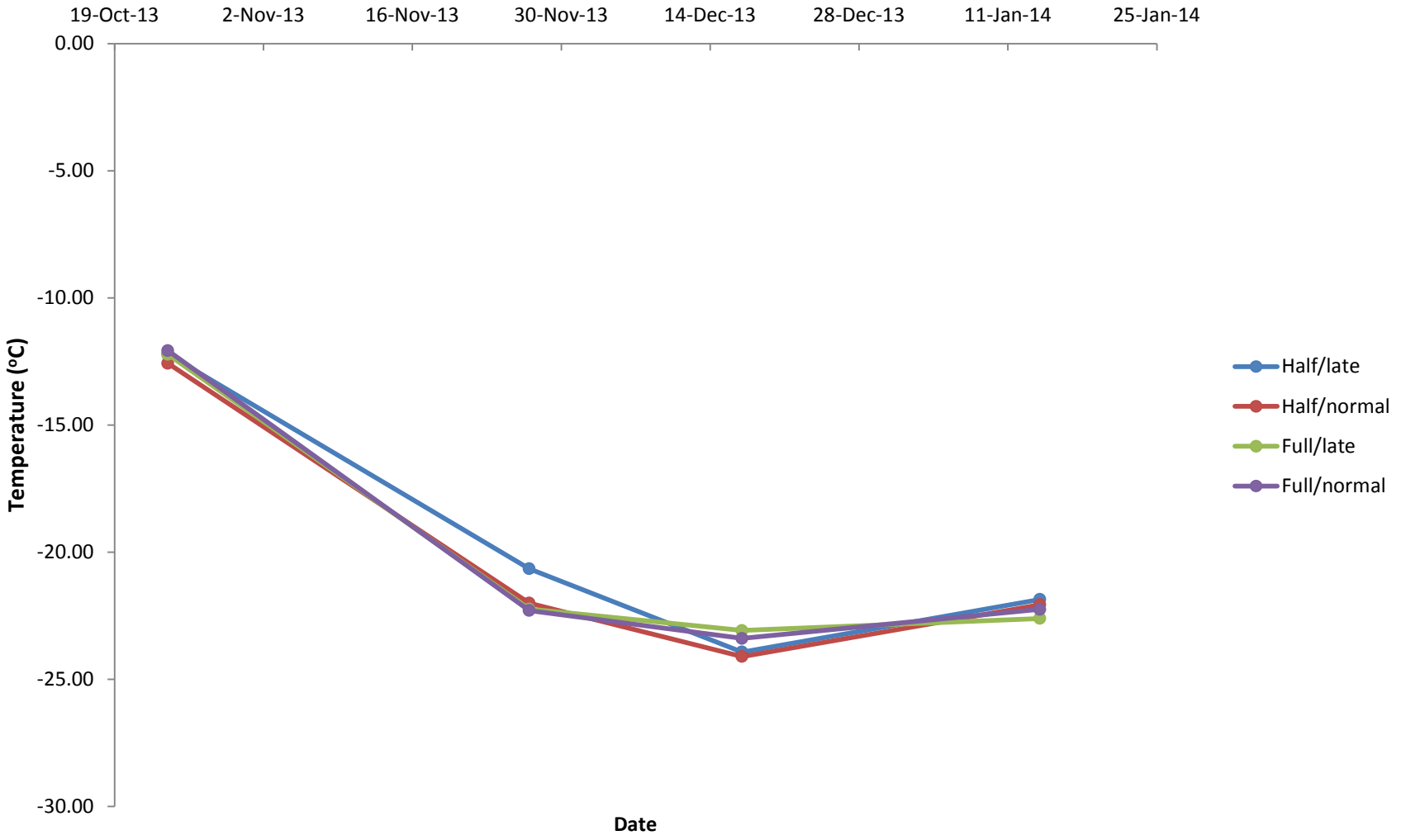
Impact of Crop level and harvest date Riesling (2011/12)



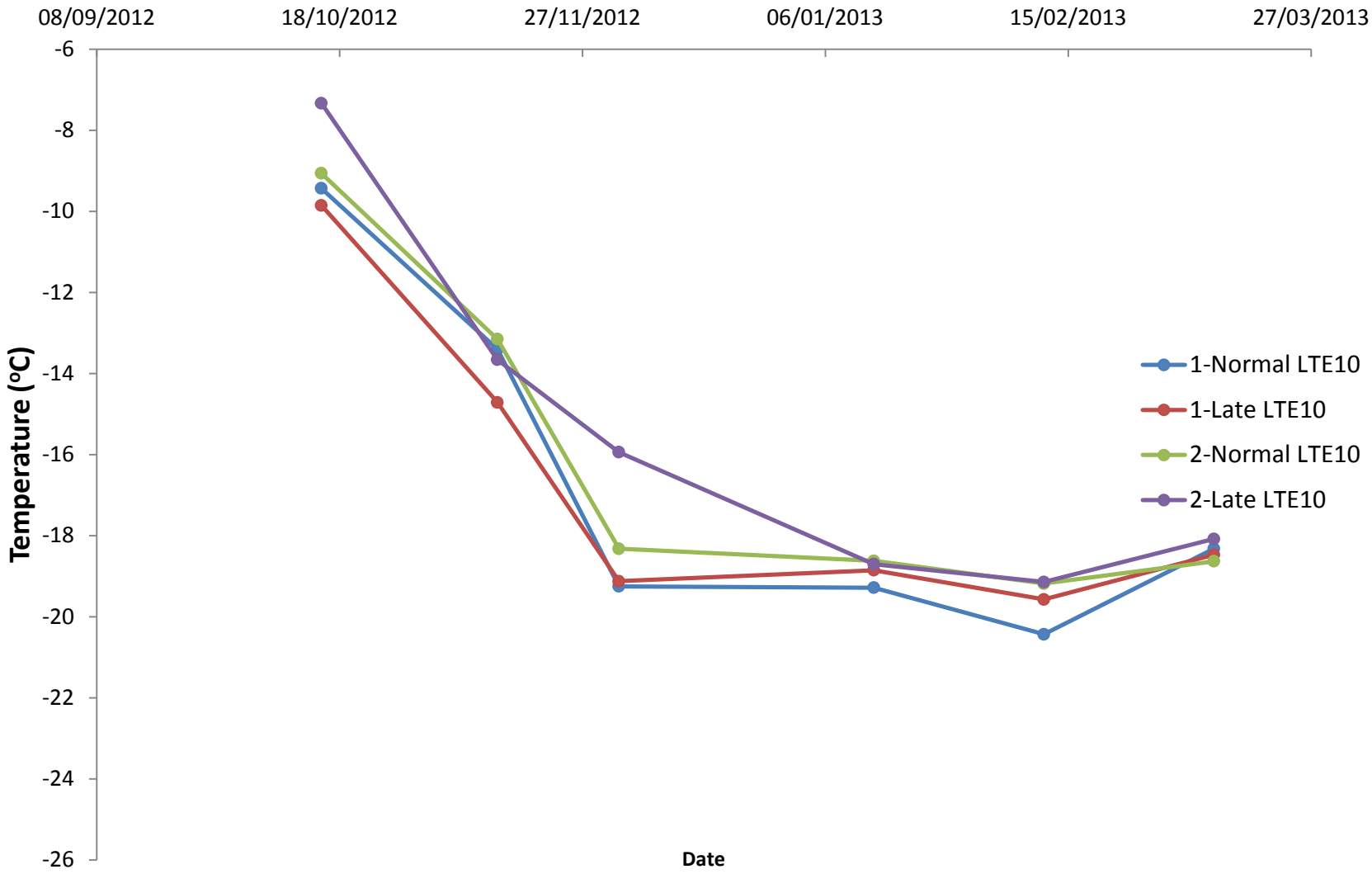
Riesling LTE50 data (2012-13)



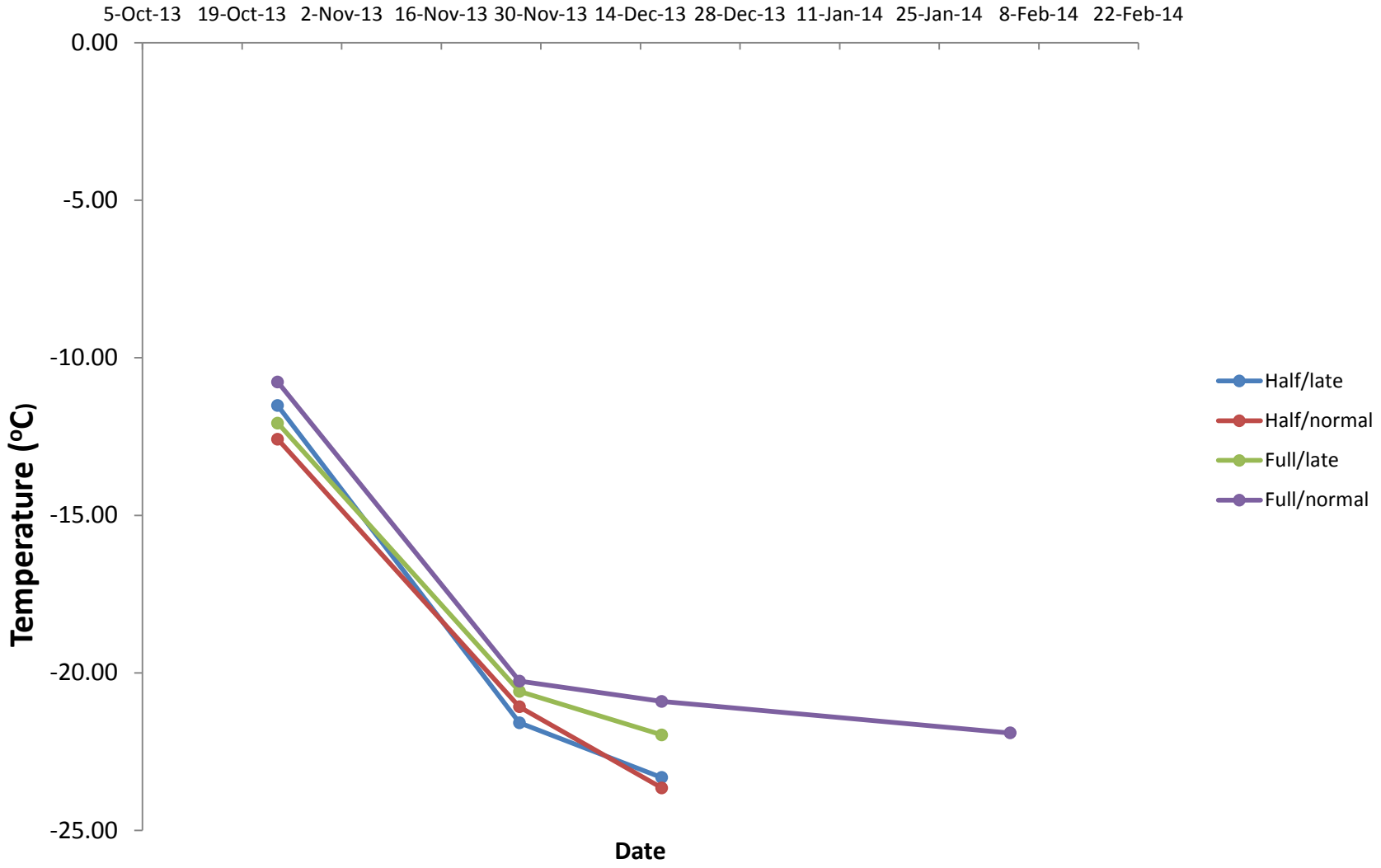
Riesling LTE50 data (2013/14)



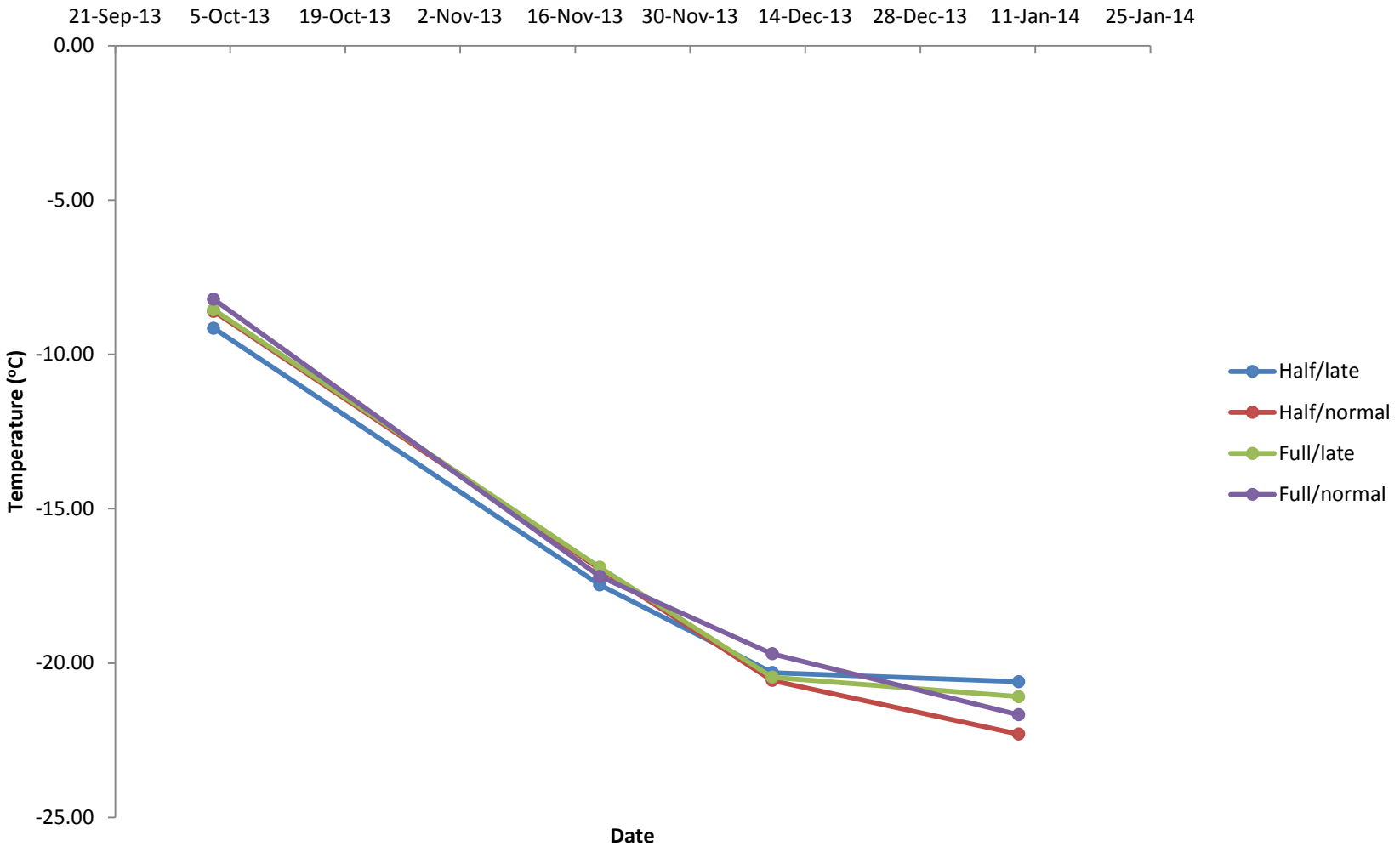
Chardonnay LTE data 2012/13



Chardonnay LTE data 2013/14



Merlot LTE data 2013/14



Results to date - Crop level x harvest date

- **Crop level appears to have some effects on cold hardiness dynamics**
  - during acclimation but some mid to late winter differences
- **Harvest date has less of an impact but an early harvest can lead to quicker acclimation**
- **Vintage effects – 2012 vs 2011, 2013**
- **Large crops in 2013 combined with a later vintage likely compromised vines to some degree**
- **Importance of vine balance and variety specific in some cases**

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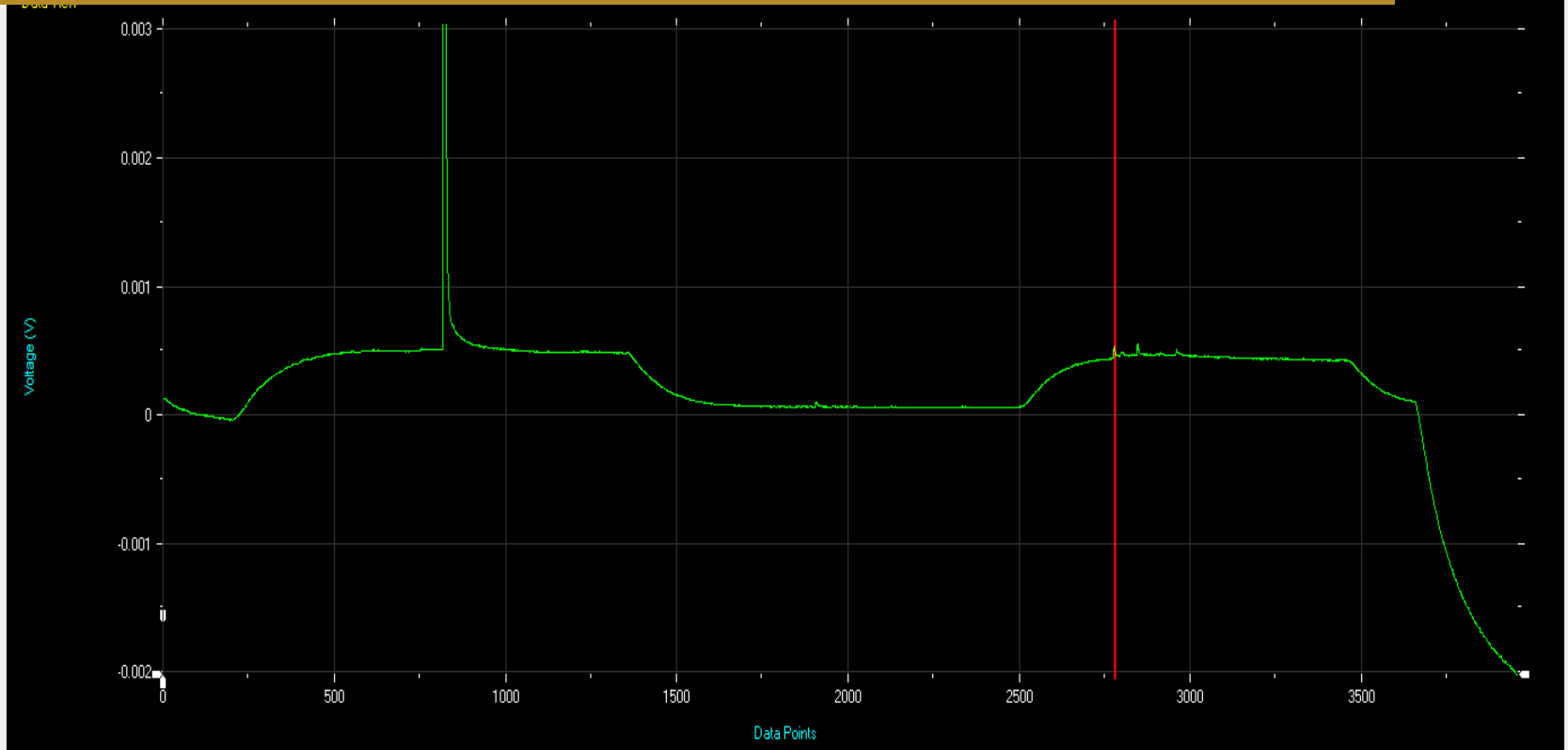
Long cold periods and bud freeze injury

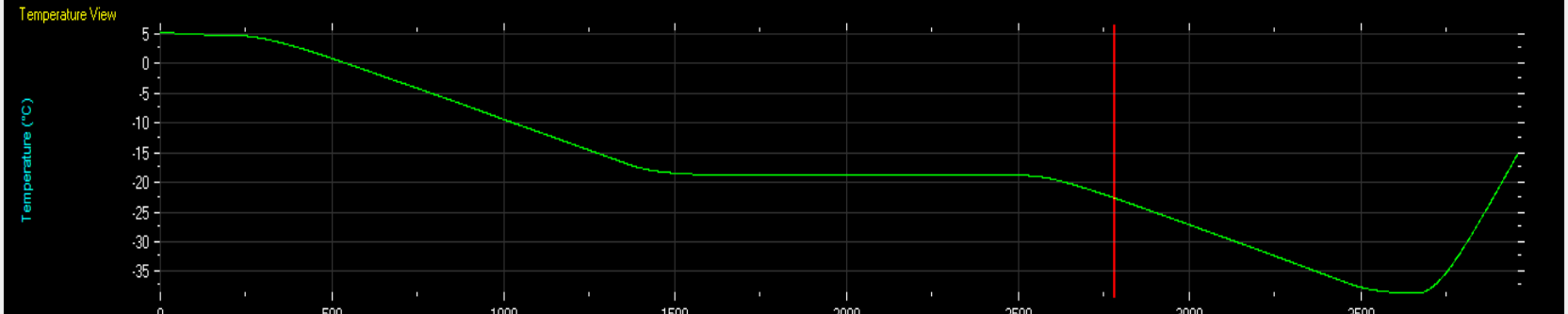
Duration of cold and freeze damage

- Many long periods with sustained temps below -15C for 2014 winter
- Does this lead to more damage?
- Quick freezing temps will likely cause localized damage
- Long cold periods will cover more areas of the vineyard leading to greater likelihood that vines reach critical temps

- Currently performing tests in lab to predict bud mortality due to extended cold events

Programmable freeze run to mimic extended cold event





Freezer Name
Freezer3

[Tray A] Riesling

[Cell 1] Hold temp run

Cell Information
Location: Lincoln Lakeshore
Count: 5

Cursor Value
Index: 2783
Voltage: 0.000485V
Time: 06:46:05 AM
Date: 26/02/2014
Temperature: -22.61°C

Exotherms from lab testing

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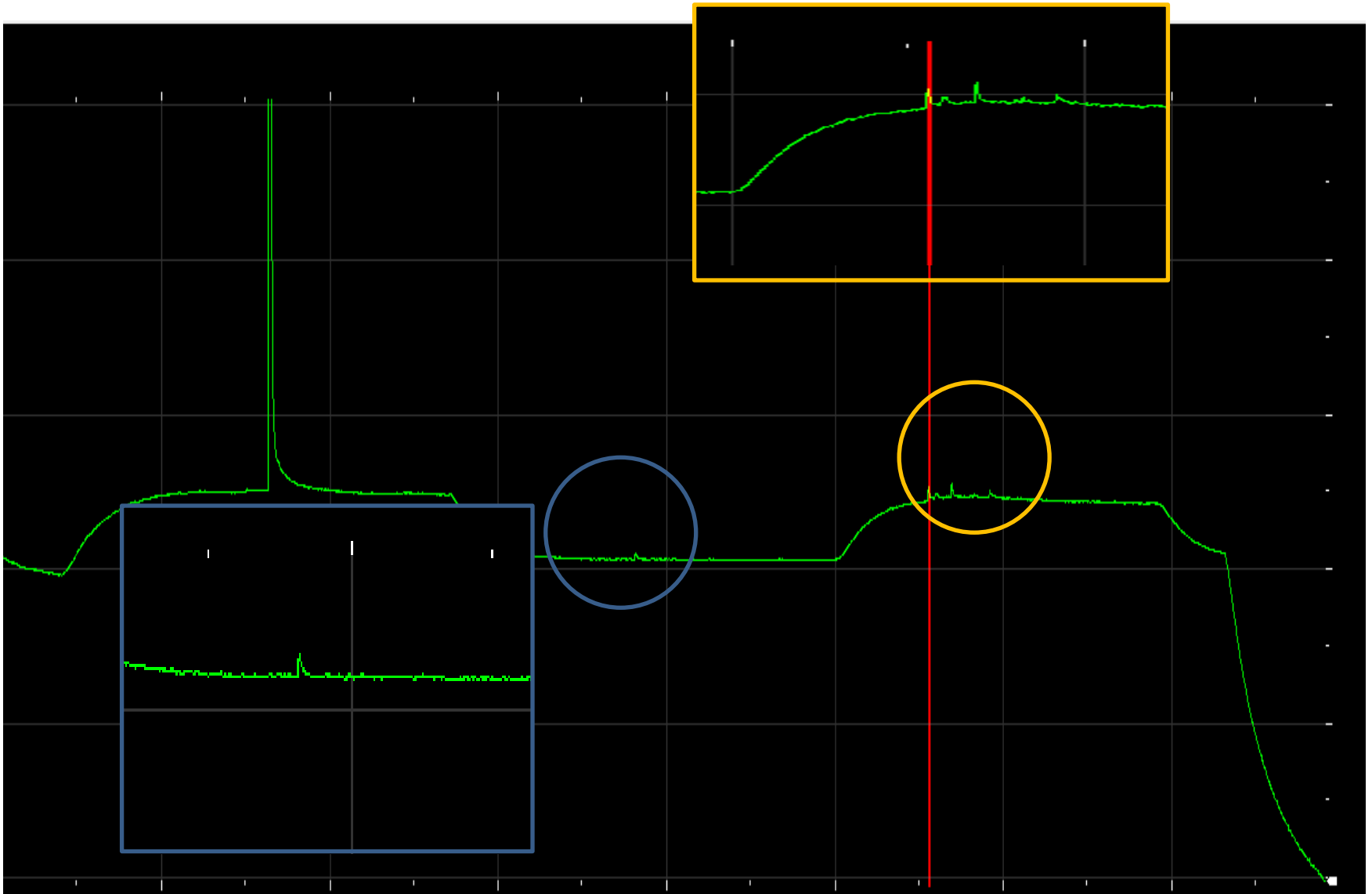

Extended freeze testing

- **Standardized freeze run (4 to -40C; 4C/hr)**
- **Extended freeze run (4 to -18C; held for 16h; then ramp down to -40C)**

Predicted hardiness	Standard Run	Extended Freeze run
LTE10	-22.38	-22.81
LTE50	-25.12	-24.56
LTE90	-26.4	-26.24

- **17.65 % of buds froze prior to predicted LTE10**
- **Time for bud death @ -18.9 C for Riesling**

Average	10.46 h
Min	8 h
Max	13 h

What to do after cold injury

- **ASSESS level of Damage**
- **1st priority is maintaining and keeping vine alive**
- **Mitigate effects of cold injury on production**
- **Keep renewal parts of vine to ensure improved growth and production next year**
- **Change management practices during growing season**
  - Pruning
  - Suckering
  - Training and Canopy/sucker management
  - Crop levels
  - Nutrition program
  - Weed/pest management

Assessment of Freeze Injury

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- Proper assessments to determine level of injury is critical
- Level of injury = what guidelines to use

Pruning strategies

- Goal of pruning after winter injury is to get the vine back to full health, get it productive and in balance.
- Some vines may die immediately or trunks may collapse over a period of 2-4 years after damage.
- Removal of the parts known to be damaged or suspected as being injured should be part of the pruning process.
- Use of spare parts

Mitigating cold injury through Pruning

Bud Mortality and Suggested Pruning Modifications

Primary Bud Mortality (%)	Pruning Adjustments
0-15 %	None – prune as normal for balanced crop
16 to 30%	Increase buds retained by 50% Bring up renewal suckers to establish future trunks
31 to 50%	Leave double the number of buds Use of 'Kicker canes' Extra canes or longer spurs Bring up multiple renewal suckers to establish future trunks
>60%	LEAVE LONGER 6 BUD SPURS or don't prune Bring up multiple suckers if scion pushes any from above graft union

Variability of bud hardiness and survival for a vine

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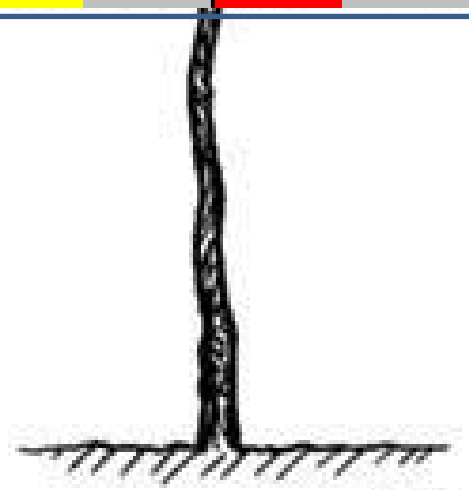
	North							South				
	7	6	5	4	3	2	1	1	2	3	4	5
9		-25.91				-25.58		-12.37	-26.57	-21.71	-21.38	
8	-23.95		-24.23		-25.16	-25.15		-26.42				
7		-25.09	-27.4			-23.07	-19.52	-25.86	-24.65	-22.25	-25.98	
6		-24.49				-24.51	-20.62		-24.93	-24.34	-26.15	
5	-24.27	-23.79		-25.65		-24.66	-23.79		-24.72	-24.32		-24.82
4	-23.95	-24.49	-23.84			-21.49			-23.78		-20.95	
3				-24.89	-24.11				-16.68		-25.04	-23.62
2				-23.35	-26.07			-25.36	-24.88	-24.27	-24.46	-23.56
1	-24.88	-24.87	-26.19	-23.74	-27.55	-24.17		-17.17		-25.59	-26.85	



Spur Prune

2 bud spurs = 16 viable buds
3 bud spurs = 21 viable buds
4 bud spurs = 27 viable buds
5 bud spurs = 35 viable buds

Cane Prune

X 2 = 8 viable buds
X 4 = 22 viable buds

Factors impacting final crop in grapevines

- **Based on environment, physiology and management decisions**
  - Primary bud survival
  - # of buds RETAINED following pruning
  - Variety – fruitfulness of buds (primaries and secondaries)
  - Overall vine health – cold injury, disease, stress
  - Environmental conditions during bud development (2013 growing season – Bloom)
  - Environmental conditions during current growing season and fruit development – water, timing
  - Level and timing of crop removal
  - Timing of leaf removal
  - Timing of harvest
- **Bottom line: difficult to predict especially right now**

Take home message from winter 2014

- Cold winter with many events
- Severity of injury is appellation, variety AND site specific
- Both acute and chronic injury
- Critical to know level of damage at your sites to make correct decisions
- Impossible to predict 2014 harvest at this stage of the game but will be impacted by this winter
- Use of ‘spare parts’ in our climate is important
- Remember: 2006 was a big crop following winter of 2004/05 (64000 vs 21000 Tonnes)

Conclusions and final thoughts

- Variety, crop level, vintage and other factors impact cold tolerance
- Use resources available through CCOVI VineAlert, OMAF, GGO etc.
- There are opportunities to learn from this winter – networking of information and “reactive” cold hardiness projects

Acknowledgments

Thank you for your attention.

Cool Climate Oenology & Viticulture Institute
Brock University

http://www.ccovi.ca/vine-alert