Evaluation of plant material as an adaptation strategy to climate change in Canadian vineyards

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“We didn’t start the fire” - Billy Joel

Global climate-related events in wine regions (2018/19)

- Wildfires
- Extreme heat
- Extreme drought
- Extreme cold
- Extreme precipitation

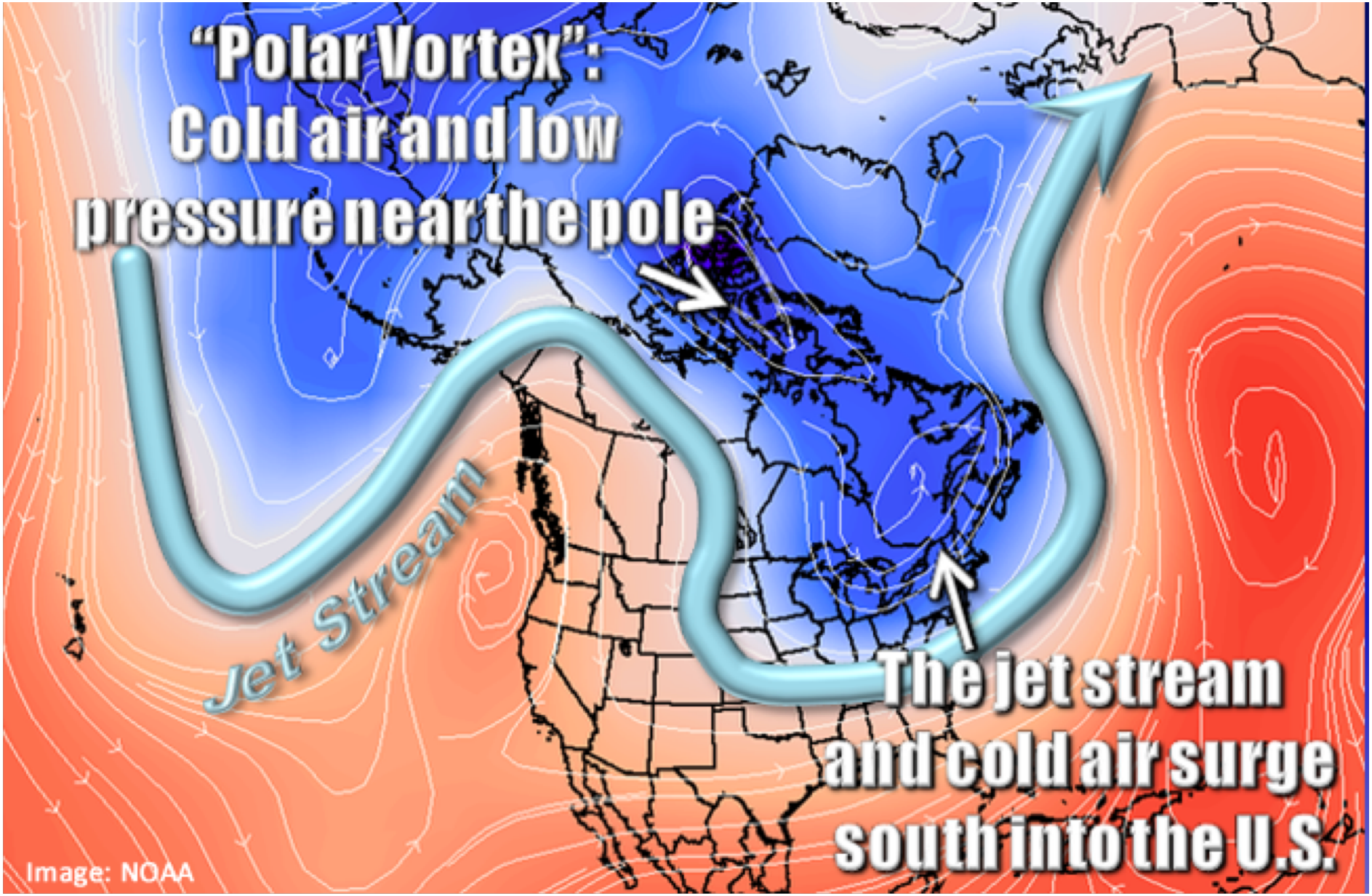
- **Pressures on reducing agrochemicals**
- **Cost of production increasing**
- **Many unknowns about climate change and many political disputes concerning policies around the issue**

Some impacts of Climate Change for agriculture

- **Higher CO_2 levels**
  - Impact production as a single factor
- **Extreme temperature and precipitation**
  - Includes both floods and droughts
  - Wildfire, habitat loss, lack of water
- **Many pests thrive in wetter, warmer environments with higher CO_2**
  - Insects, fungi, weeds
  - Pests moving to non-traditional areas

It isn't just warming

- "Climate change can lead to extremes; it's not like a regular change, everyone to the same extent at all times and places"
- "Despite the overall warming, you can get in places like the Northeastern U.S. extreme cold events. That's consistent with climate change and global warming."
  - Martyn Chipperfield, professor of atmospheric chemistry at the University of Leeds


"Polar Vortex":
Cold air and low
pressure near the pole
Jet Stream
The jet stream
and cold air surge
south into the U.S.
Image: NOAA

Trends and scenarios

- **Each viticulture region worldwide will be impacted**
  - Some more severely than others particularly areas already hot and dry
- **Shift to warmer growing seasons**
- **Earlier bud break, bloom, veraison**
- **Shorter periods from flowering to harvest**
- **More extremes in temperature and precipitation**
- **More variability and erratic weather**
- **Invasive pests or expansion of pests or vectors of disease to new regions**

Specific issues related to viticulture

- Grapevines are perennial woody plants
- Susceptible to pests and disease
- Sensitive to frost and freeze injury during dormancy
- Fruit quality is essential for typicity/regional style and identity is due to its ‘terroir’
- Monoculture in many cases and regions built on specific cultivars
- Environmental changes will impact physiology and fruit chemistry
  - Changes to our climate will influence all aspects of viticulture and oenology

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Climate change and agriculture

- Agricultural adaptation to potential climate impacts are becoming more urgent
- Many potential adaptation strategies
- Severity of impacts will limit the effectiveness of mitigation strategies
- There are many barriers and real solutions need to be well integrated

Adaptation strategies in viticulture

- **Training systems and Canopy management**
- **Cultural practices**
- **Irrigation**
- **Expansion of regions**
- **Plant material**
  - Selection, breeding, evaluation of material

Plant material

- The selection of plant material is an important resource for climate adaptation

- Species or crossings of different species
- Cultivar
- Clone
- Rootstock
- Quality of material

Cultivars are not created equal

- **Grapevines are diverse**
  - 60 species of *Vitis*
  - Roughly 14,000 cultivars of *V. vinifera* and 1000's of synonyms
  - Intravarietal diversity (clones and ecotypes within major cultivars)
- **Differ with respect to:**
  - growing season requirements
  - drought tolerance
  - chilling requirements, cold acclimation/deacclimation and max hardiness
  - fruit maturation
  - growth habits, etc.
- **Changes in environment will impact how they perform**

Rootstock benefits

- **Resistance**
  - Phylloxera, nematodes
- **Tolerance**
  - Lime, Salinity, Water stress
- **Growth**
  - Control, shorten vegetative cycle
- **Uptake**
  - Nutrients

Clones

Clonal selection

- Earlier or later maturing
- Growth habit
- Colour and Flavour
- Cluster morphology, berry size
- Disease
- Cold tolerance

Quality of material

- Important for quality, general performance and resistance to stress
- Quality of material
  - Good source of material
  - True to type
  - Clean from major viruses or diseases

Evaluation of plant material

- Most regions continually evaluate new material
- Climate change is driving traditional regions to put even more efforts
- In established regions focus on rootstocks, clones and even varieties possibly more adapted to future climate
  - Blasphemy!
- New crossings, use of traditional, indigenous varieties and other plant sources all being evaluated

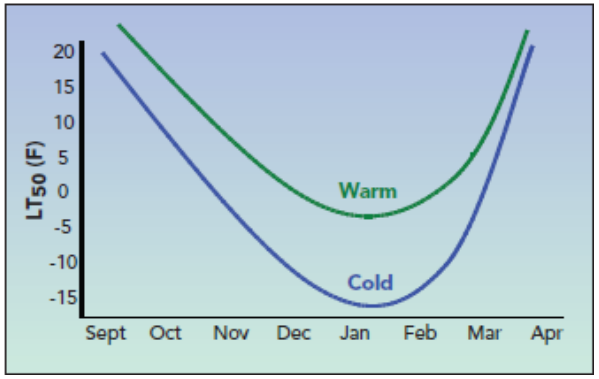
Regional and global efforts

- **Many efforts worldwide for more disease resistance in *Vitis* particularly in high quality wine grapes**
- **Most major wine regions have dedicated, long-term programs**
  - Strict policy on pesticide reduction and sustainability is leading the charge in many countries
- **Ontario/Canada has transitioned to more *V. vinifera* over the past few decades**
  - Regional evaluations of existing and new material are important (BC, ON, QC, NS have different needs)
  - Cold tolerance is a major trait of interest
  - Clean material

Cold hardiness program

Cold hardiness

- **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**



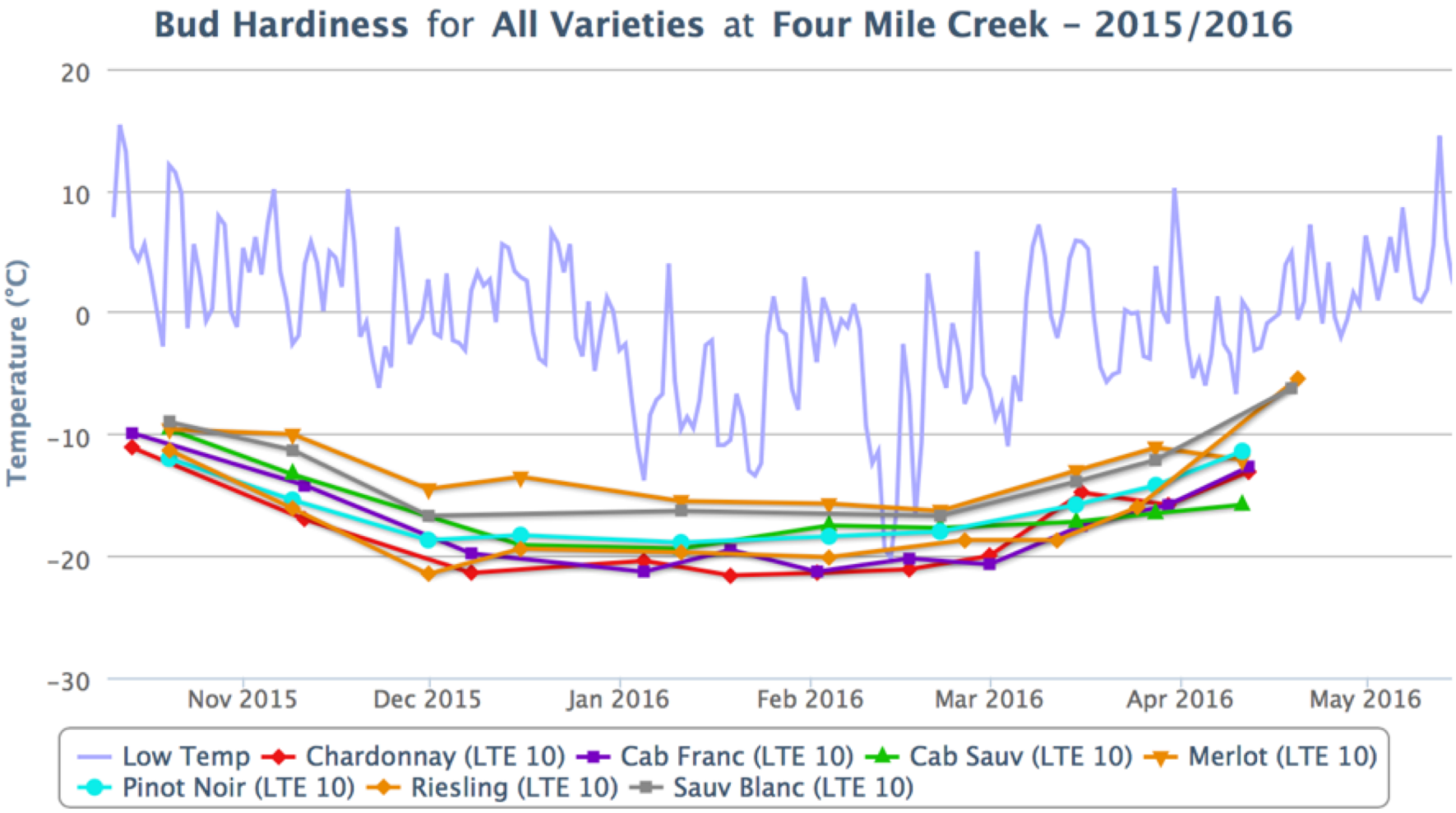
(MSU Extension Bulletin E2930, 2007)

Cultivar differences in cold tolerance

V. vinifera (different groups of origin)

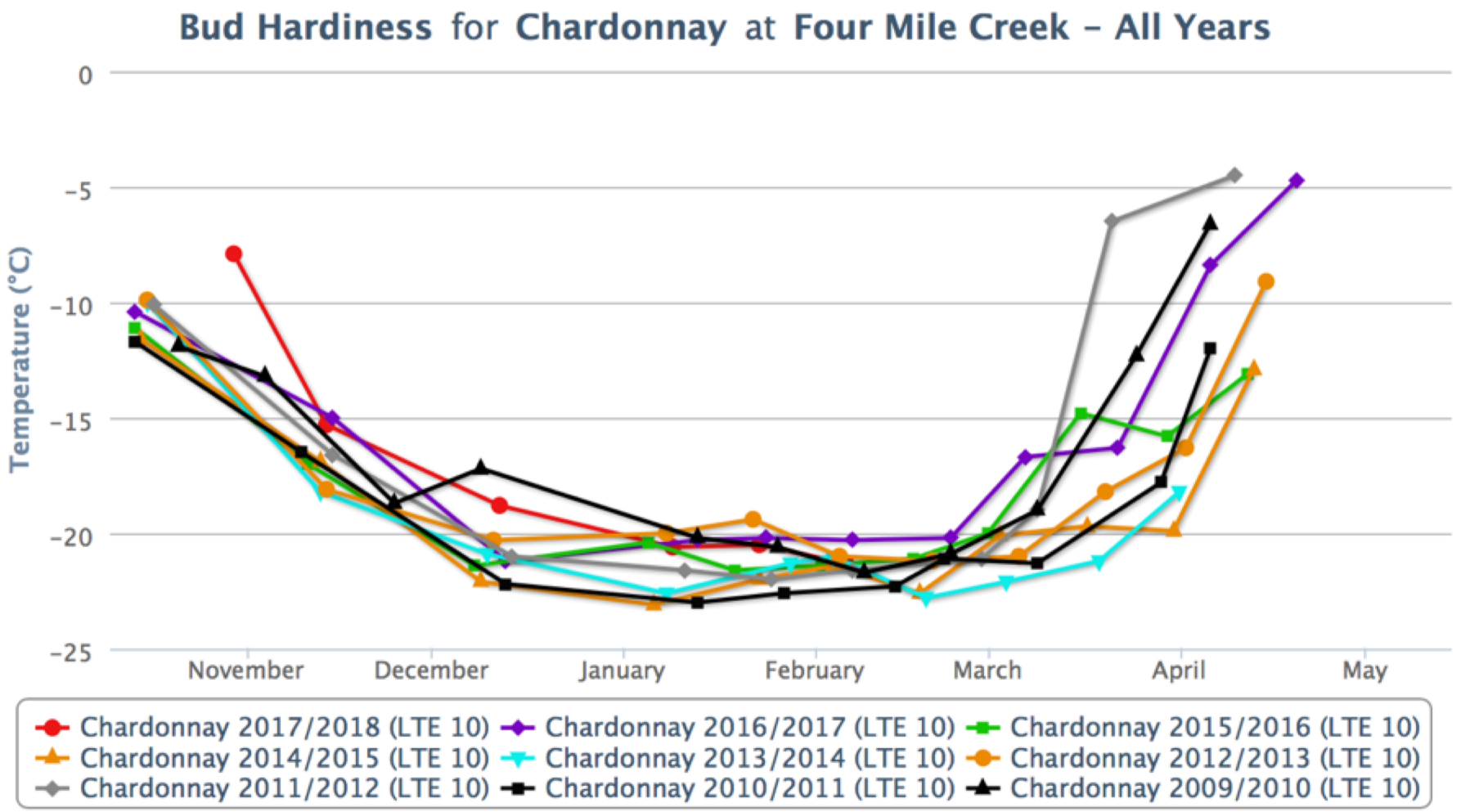
- Traditional French hybrids
- New hybrids with better cold hardiness
- Native N. American species
- Variation within and between these categories

Cultivar differences



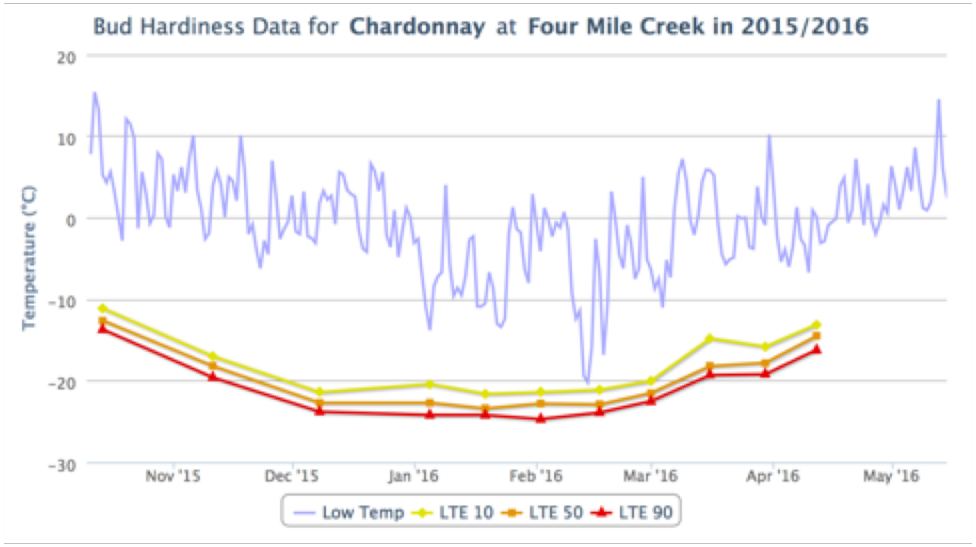
Cultivar differences of cold hardiness dynamics, Four Mile Creek sub-appellation, NOTL. 2015-2016. (CCOVI VineAlert website)

Weather variation impacts seasonal differences in cold hardiness

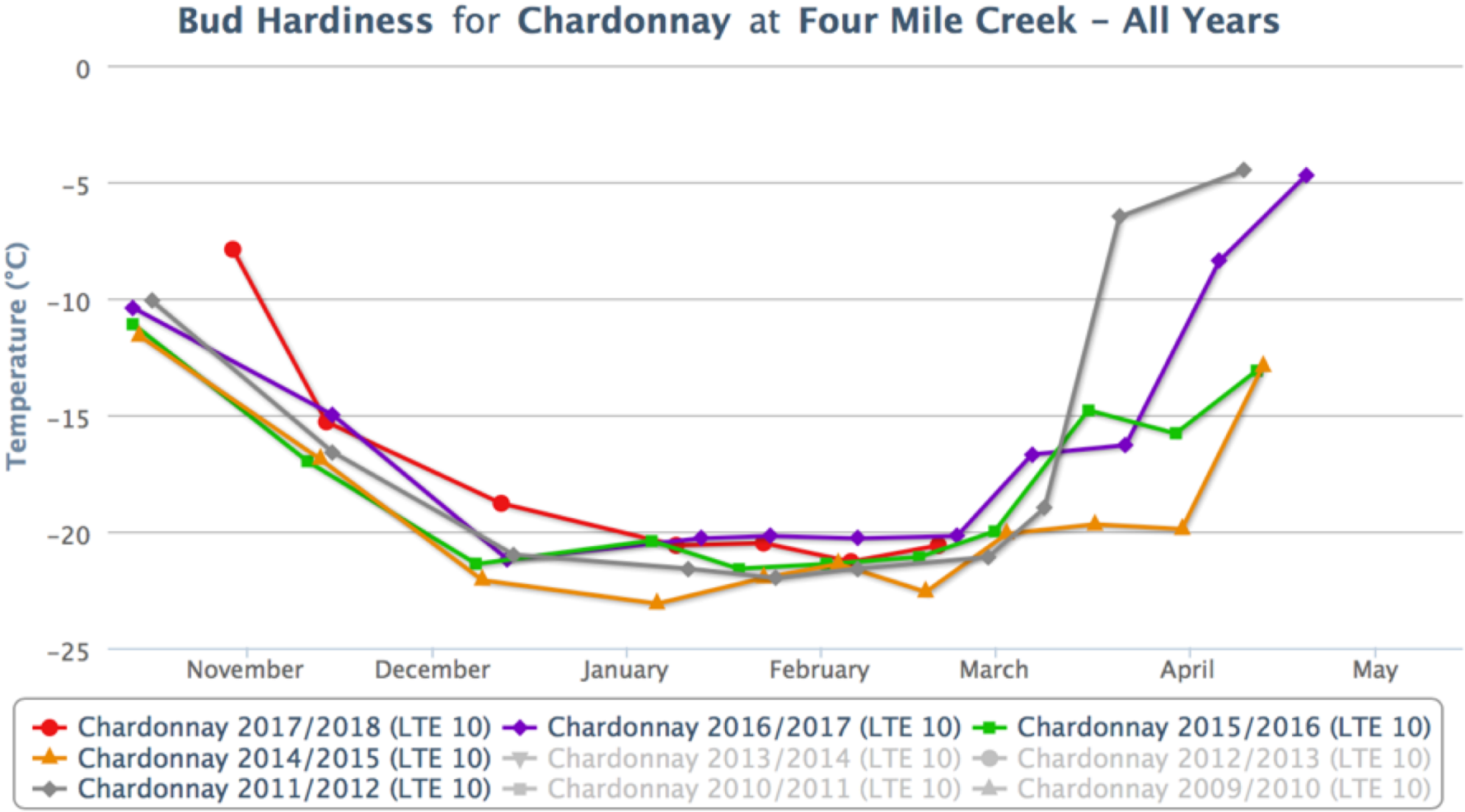


Warming during ecodormancy

- Probably the greatest risk of freeze injury due to climate change
- More erratic winter temperatures
- Periods of warming followed by ‘extreme’ cold can have devastating consequences

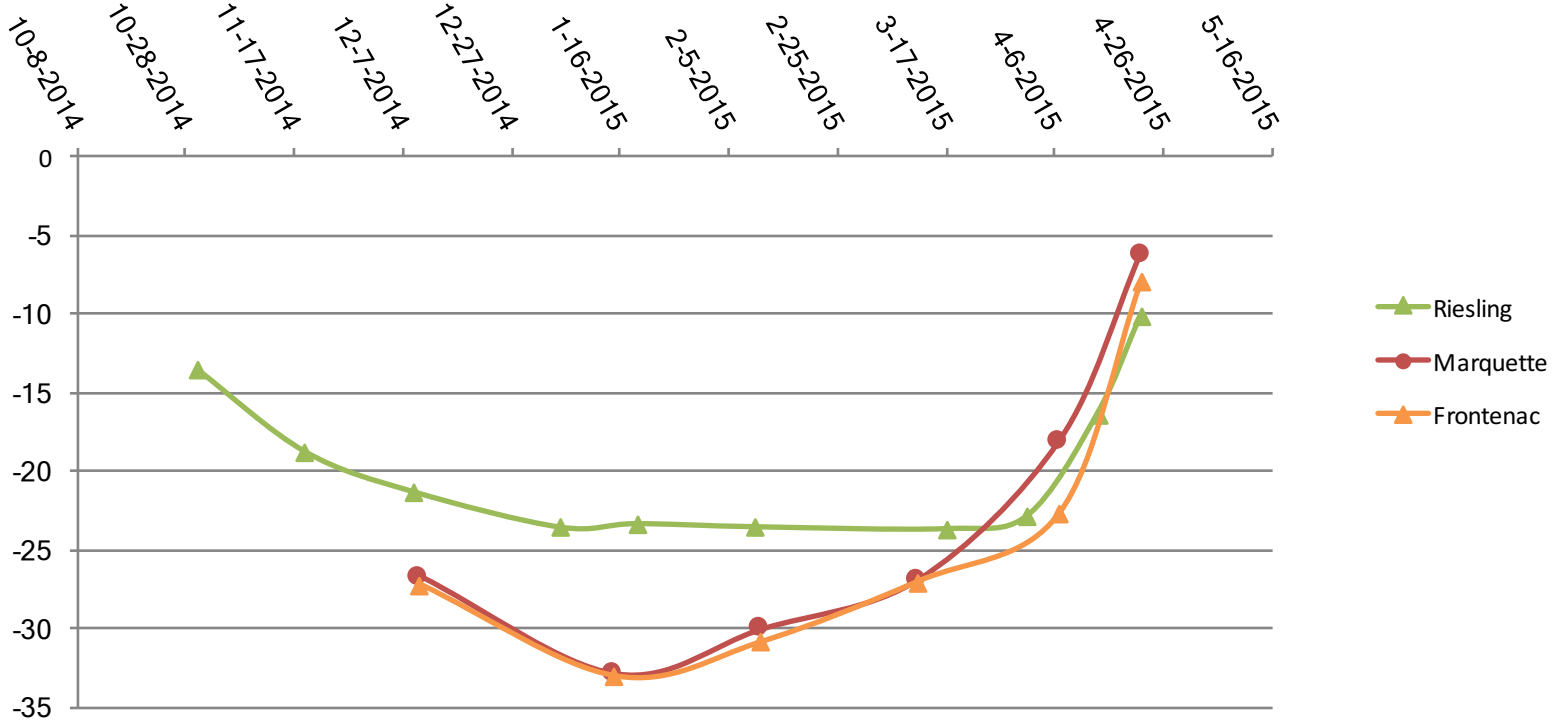


Impacts of warm weather on deacclimation

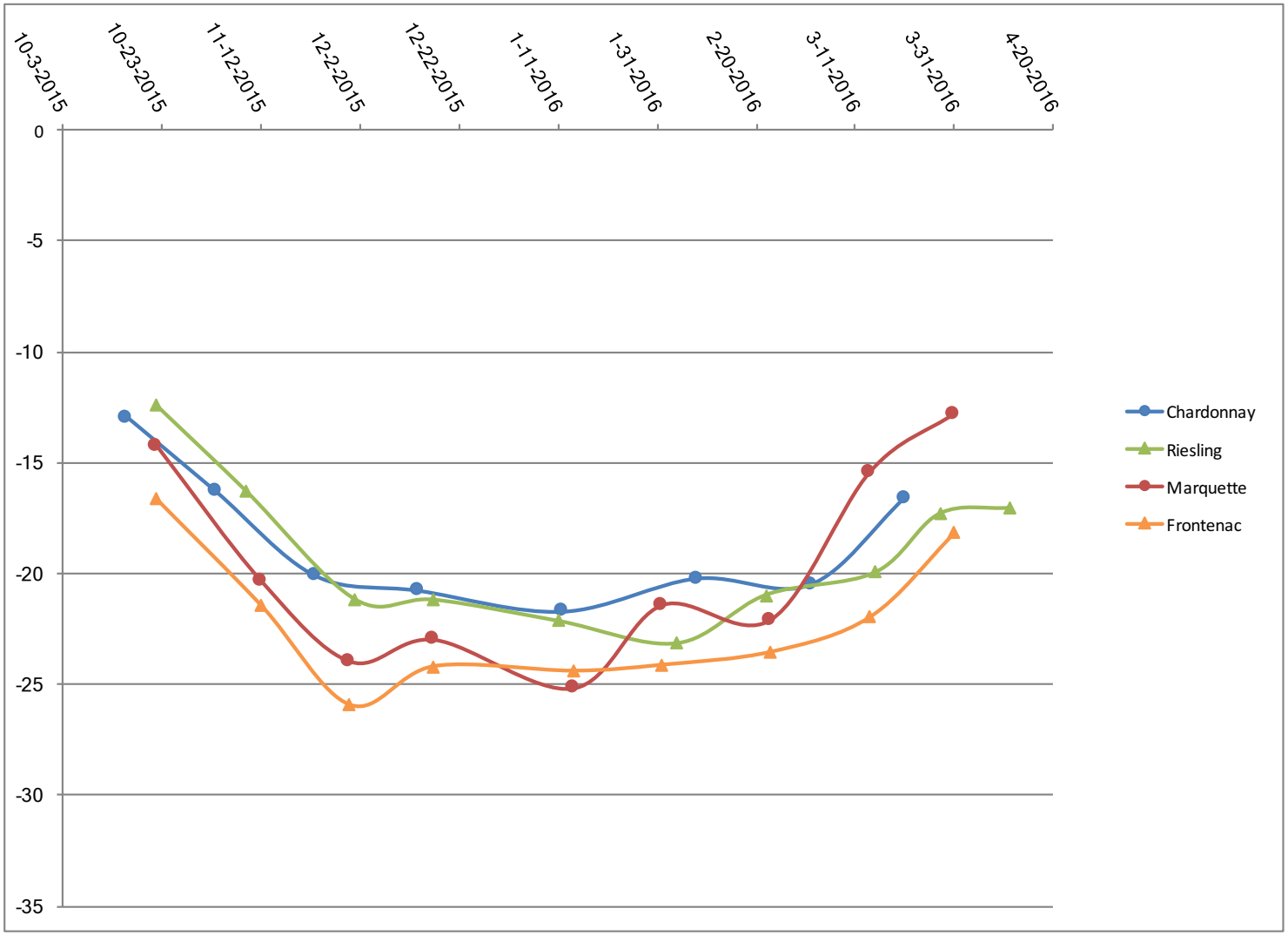


Case study: Understanding cold hardiness response in cold hardy hybrids

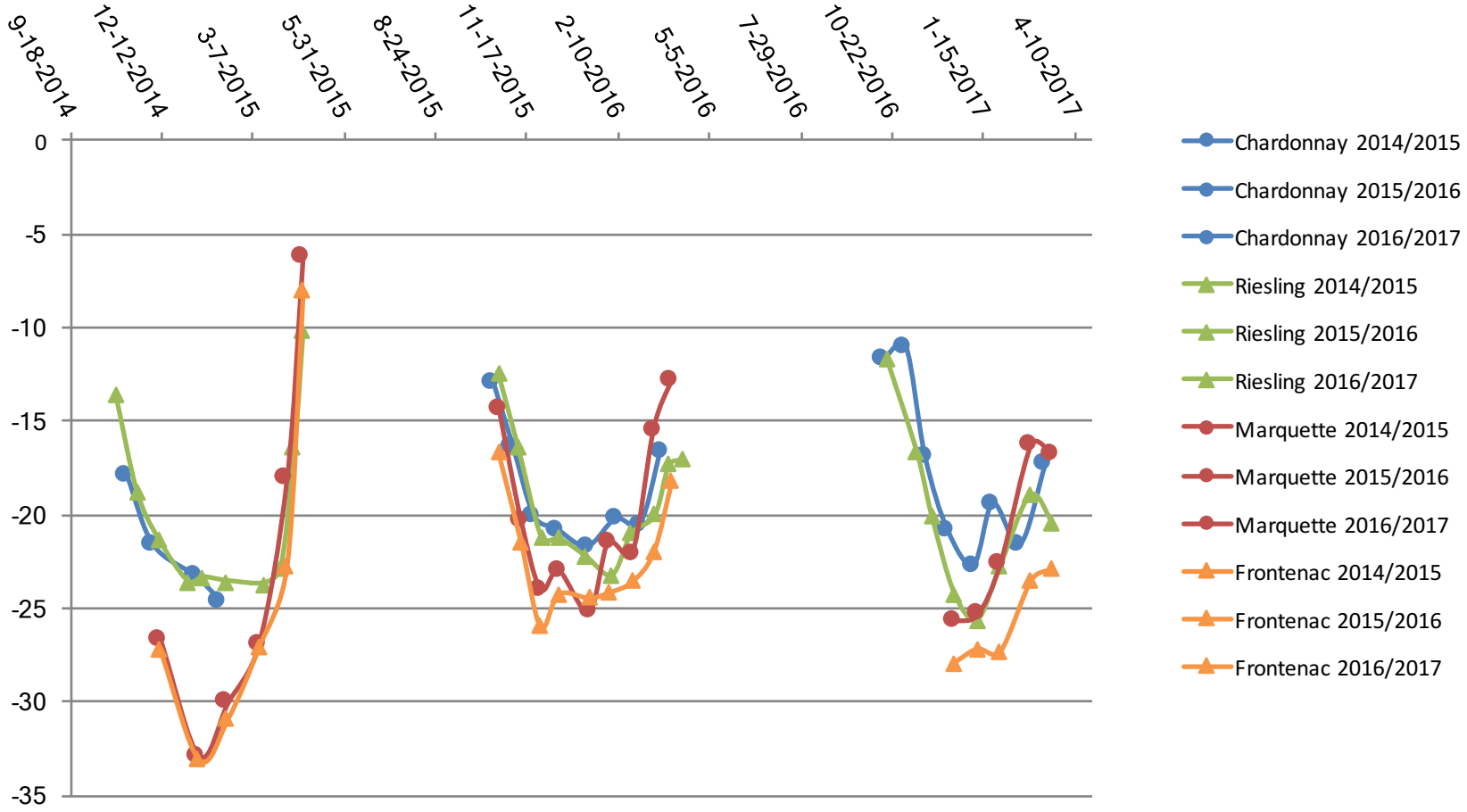
- Extreme cold hardiness is the desired trait
- Response during a cold winter



Warm temperatures during dormancy Influences hardiness (15/16)



The difference a winter makes



Evaluations for highest performing grapevine material

- **Industry is built on quality core *V. vinifera* cultivars**
- **After cold winters not all cultivars nor clones had similar survival rates**
  - Clone or rootstock related?
- **Need for formal evaluation programs to complement Canadian grapevine certification network**
- **Created research program to evaluate clones and rootstocks including formal experimental blocks**
- **“Vine to glass” approach**
- **Long term solution to mitigate climate change and continue to build quality and consistency of industry**

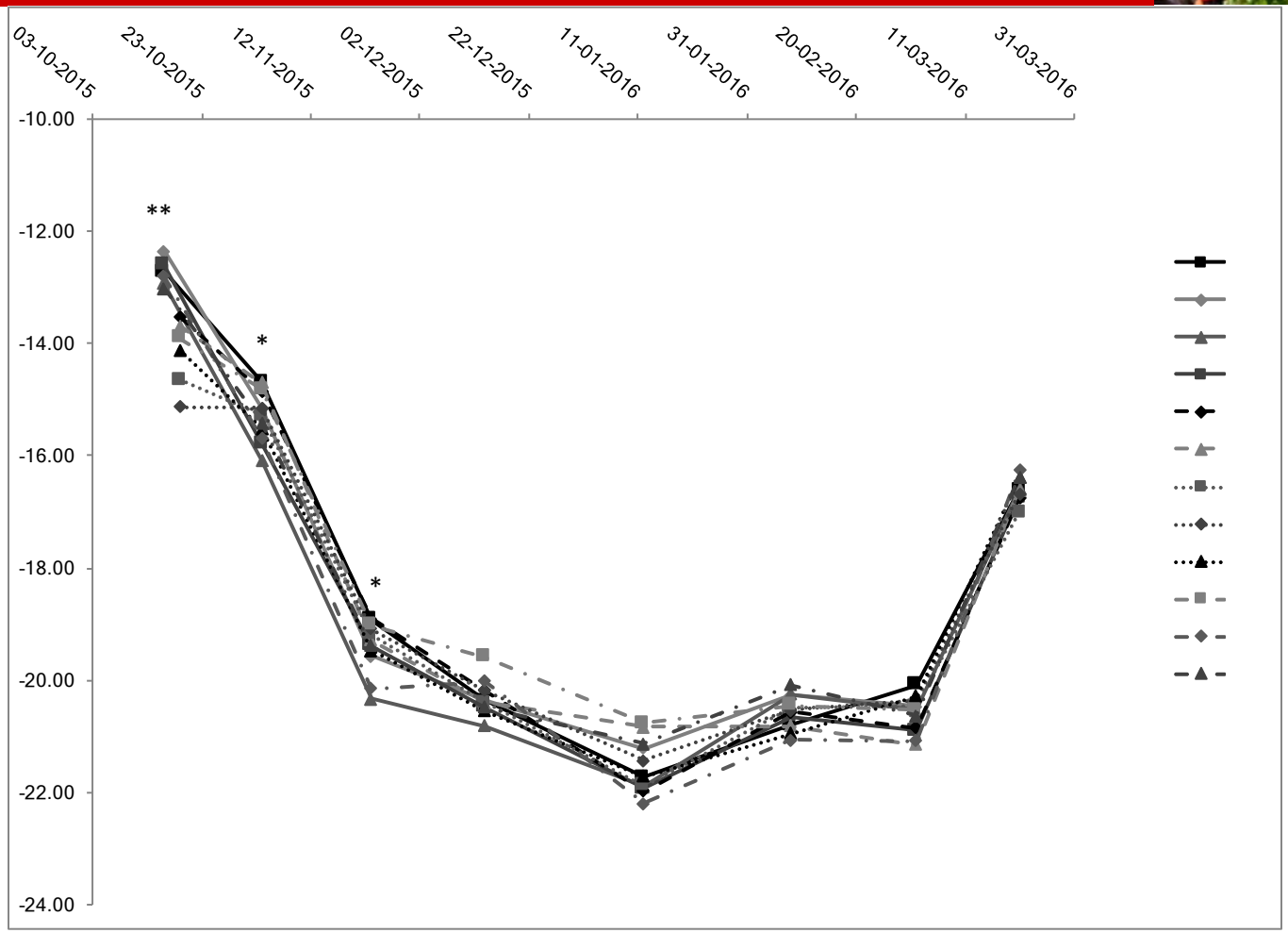
Cultivar x clone x rootstock evaluations

- Currently funded through OGWRI and NSERC-CRD (Inglis, Willwerth, Kemp)
- Industry partnerships for vineyard blocks
- Different soils, clones x rootstocks of core varieties

How can clone x rootstock impact cold tolerance?

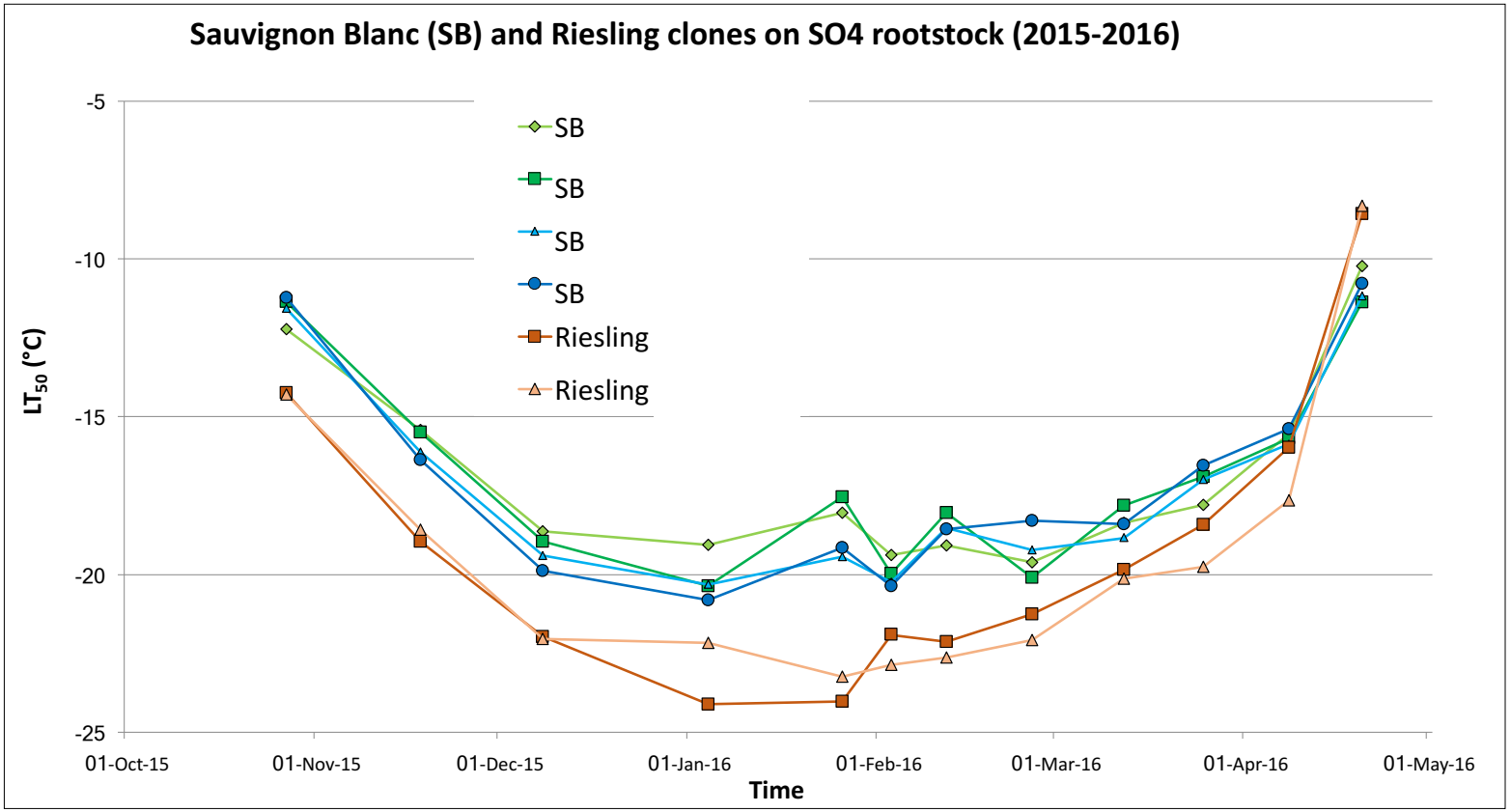
- Study using existing vineyard plantings
- 4 different Sauvignon blanc clones on one common rootstock (SO4) and 2 different Riesling clones on 2-3 different rootstock (3309, SO4, Riparia Gloire)
- 12 different Chardonnay clones on SO4

Cold hardiness in Chardonnay clones



Bud hardiness of 12 Chardonnay clones during dormancy. St. David's Bench. 2015-16.

Hardiness impacts of variety x clone



Cold hardiness of Sauvignon blanc and Riesling clones grafted to SO4 rootstock. Four Mile Creek. 2015-16.

Hébert-Haché et al. 2019 (unpublished)

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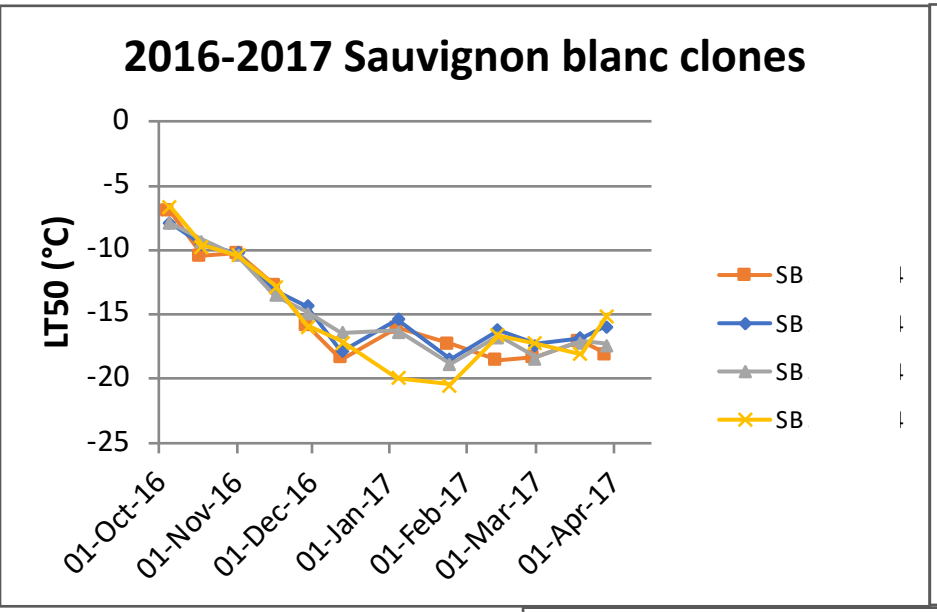

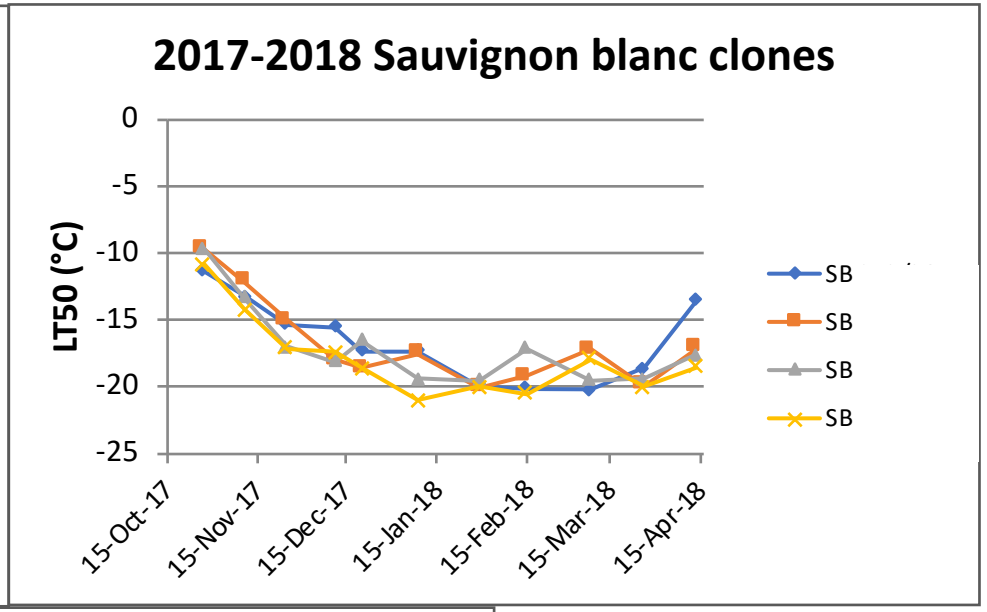

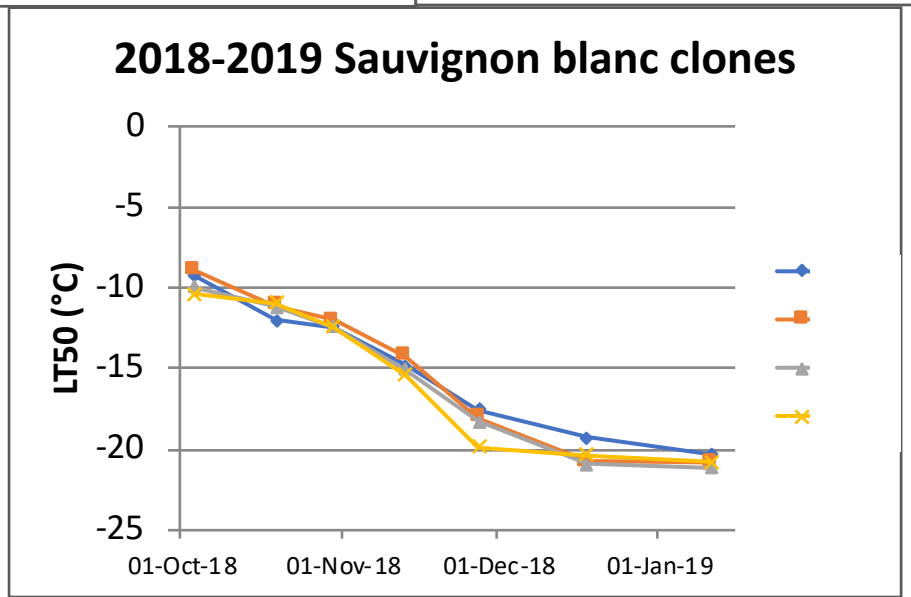

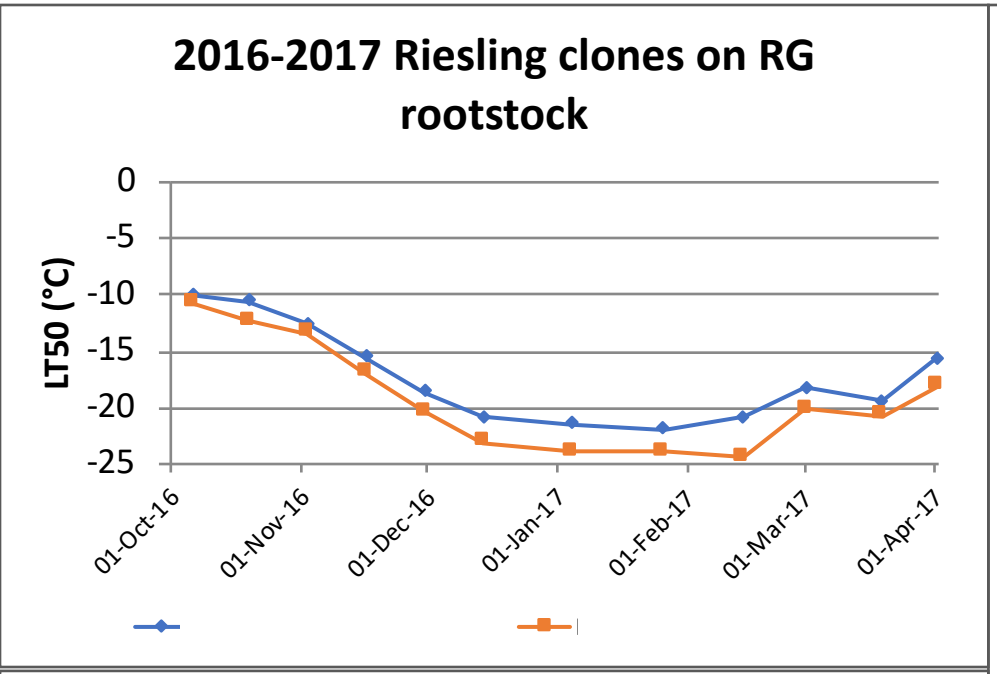

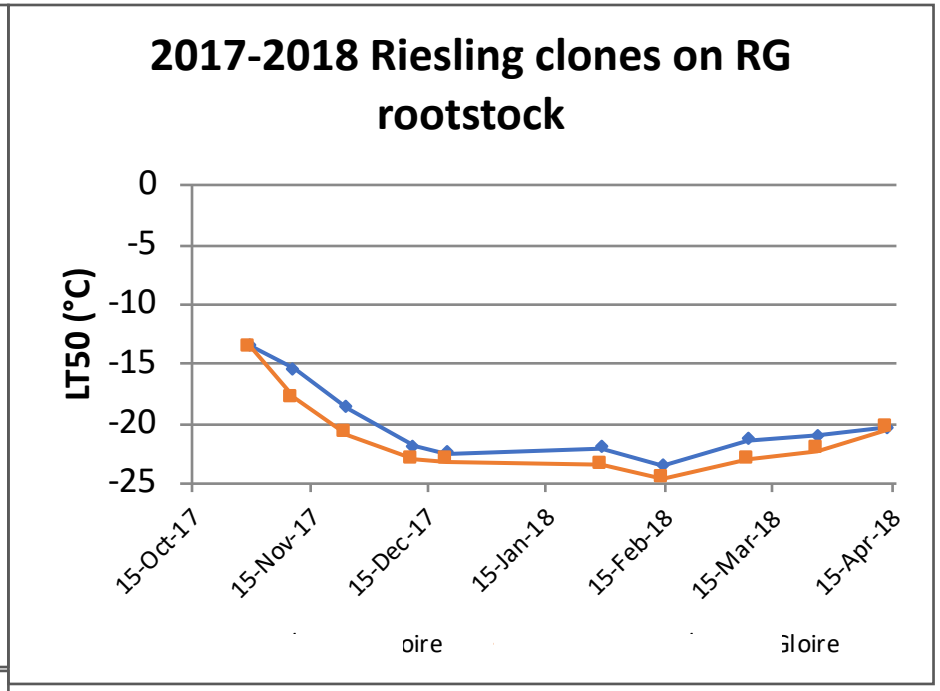

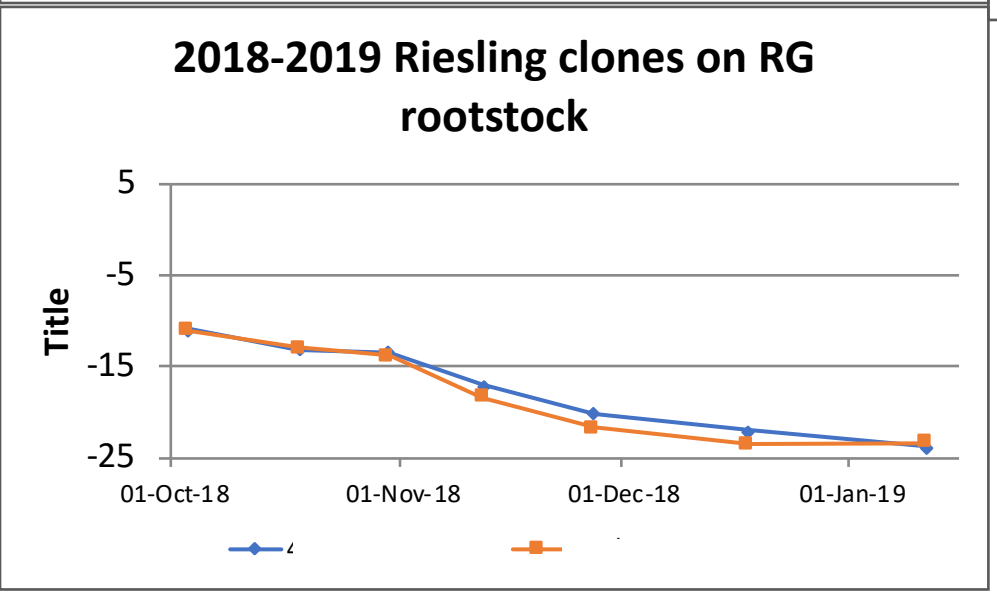

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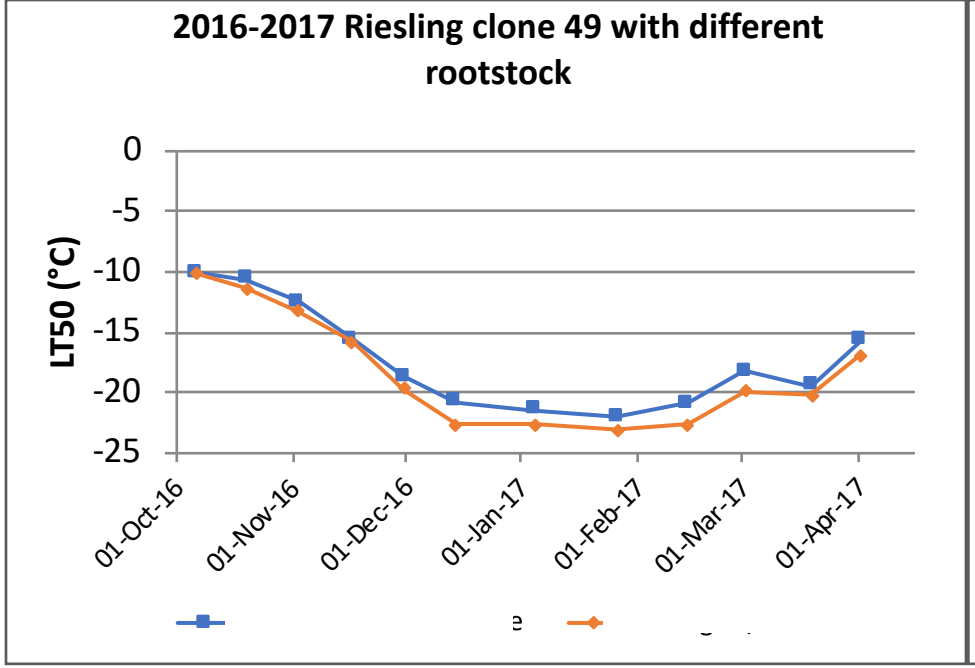
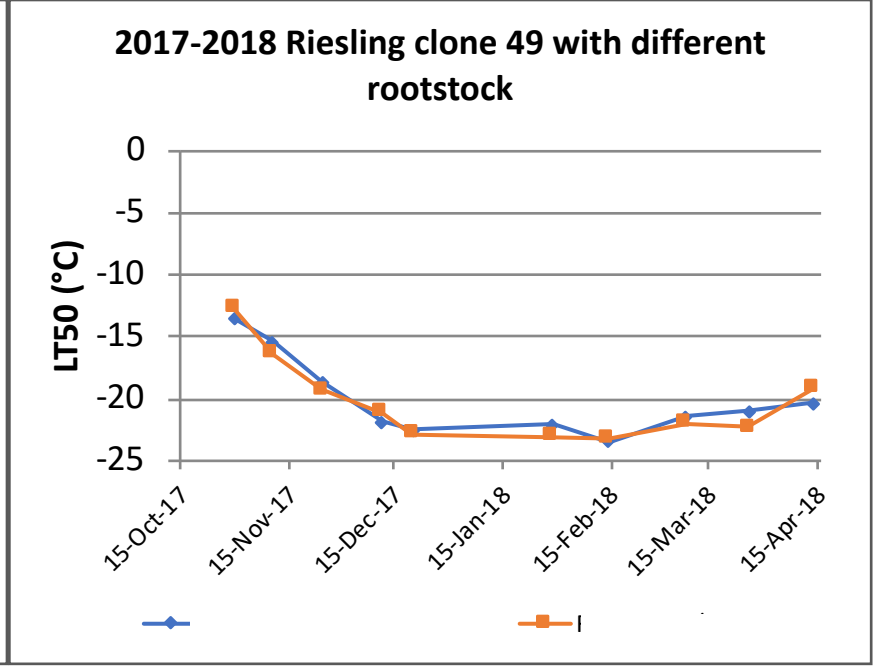
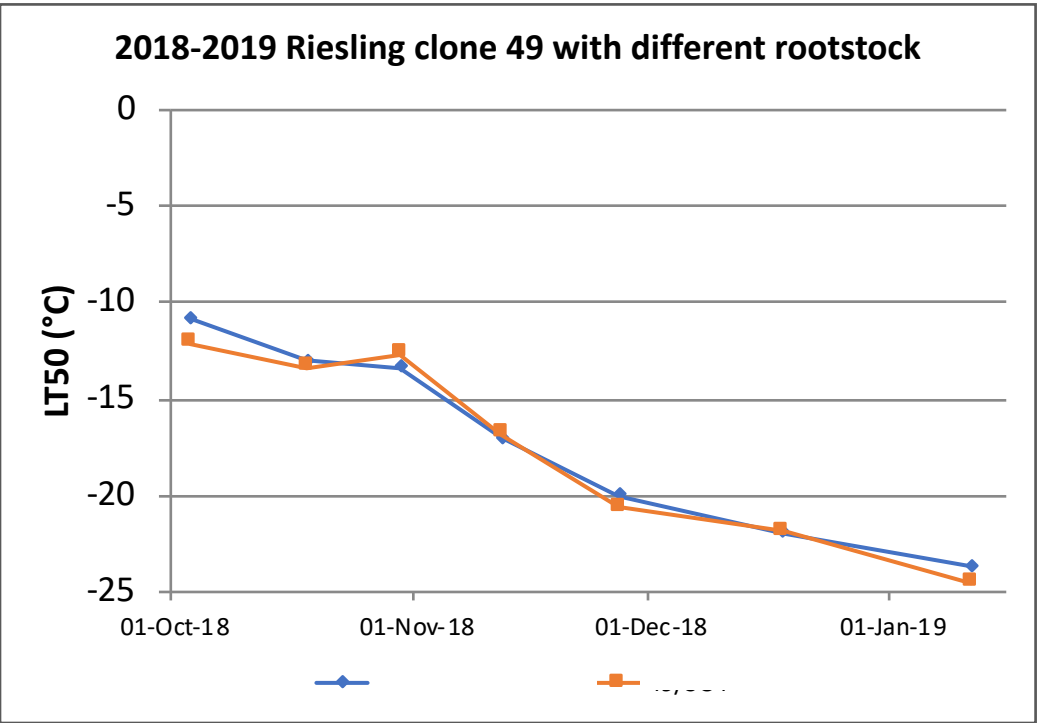
ROOTSTOCK EFFECT







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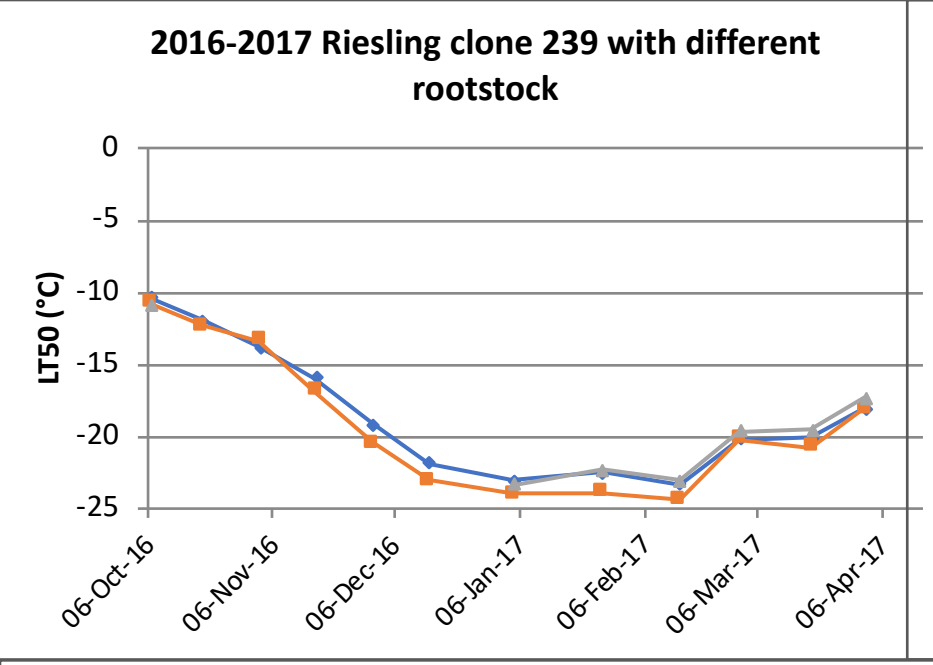

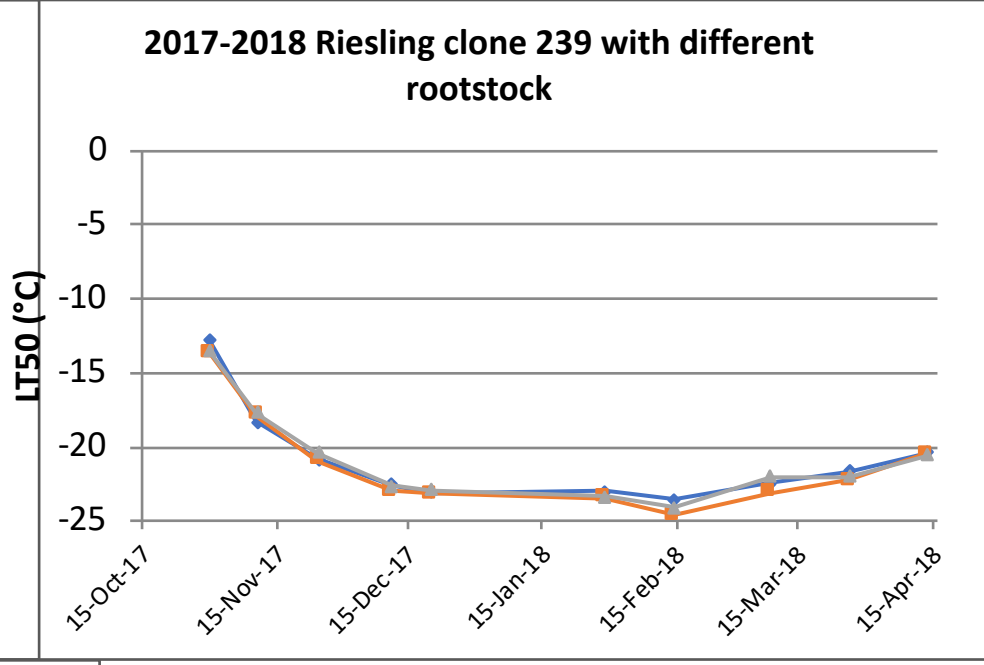

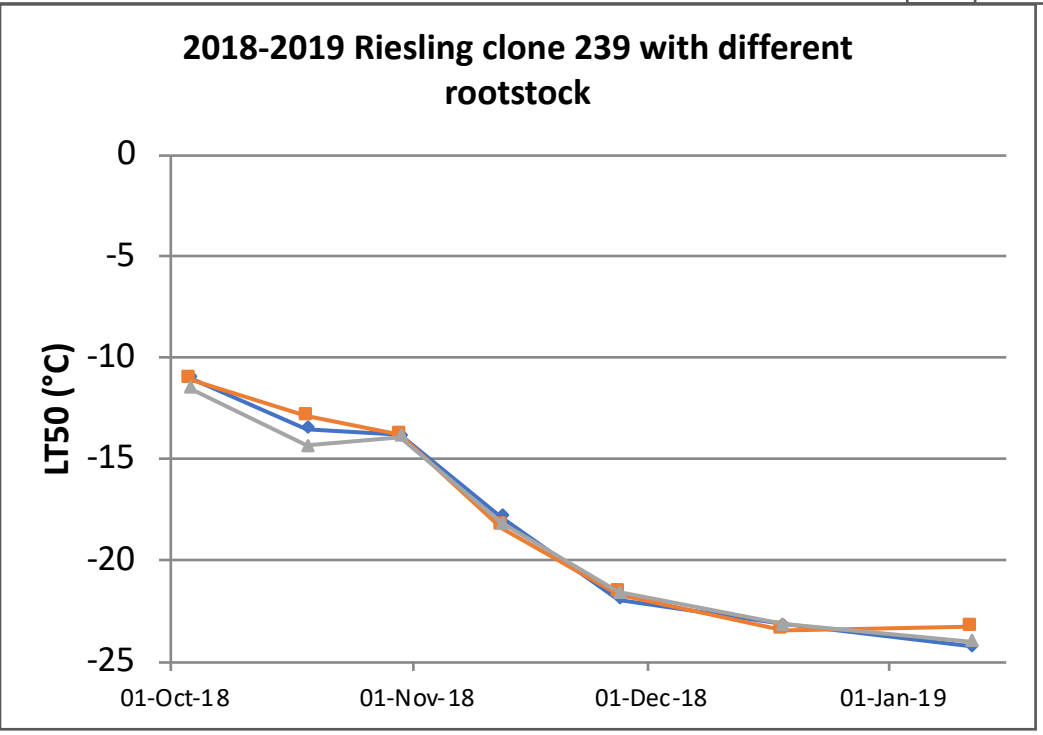

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More research being conducted

- **Continuing to evaluate many of the varieties grown in Ontario for hardiness and understand environmental influences**
  - Help establish models of future trends in vine hardiness responses to climate
- **Vine performance, fruit quality and wine quality potential for clone x rootstock combinations**
- **Further evaluations and potential selections with greater resistance to freeze injury within core *V. Vinifera* varieties.**

AAFC Cluster Activity for the Canadian Grapevine Certification Network

“Grapevine evaluation and cold hardiness program to ensure superior plant material for the Canadian Grapevine Certification Network and to improve the sustainability of the Canadian Grape and Wine Industry”

Objectives

- **Key Objectives:**
- 1) To evaluate grapevine material for performance, cold tolerance and quality and improve the sustainability of the entire Grape and Wine Industry.
- 2) Assist with selection of superior plant material for the Canadian Grapevine Certification Network as well as future plantings across Ontario.

Conclusions

- Freeze injury will continue to be huge threat across Canada even with general warming trends
- Plant material will be the most cost effective long-term mitigation tool for climate impacts
- Continuous challenge of selection for new plant material, market demands and regulations
- Many efforts worldwide – truly needs to be a global effort for selection and evaluation of *Vitis* material

Moving forward

- The Canadian grape and wine industry will benefit tremendously through coordinated efforts and collaborative research
- Ultimately better plant material, optimum health and improved winter survival will lead to a more sustainable and quality industry
- Better adapted to deal with climate change but unknowns and extremes in climate will present great challenges
- An integrated climate change mitigation strategy is necessary

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