



How Potential Changes in Climate Could Affect Pistachio Production

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Outline of Talk

- Introduction to winter chill
- Central Valley winters in the future?
- What warmer winters could mean for pistachio production.



Three Take Aways

- We will experience more “low chill” winters in the future.
- Kerman will not be appropriate for many parts of the San Joaquin Valley in 30-40 years.
- Dormancy breaking chemicals *may* help in the short term. New low chill varieties will be necessary long term.



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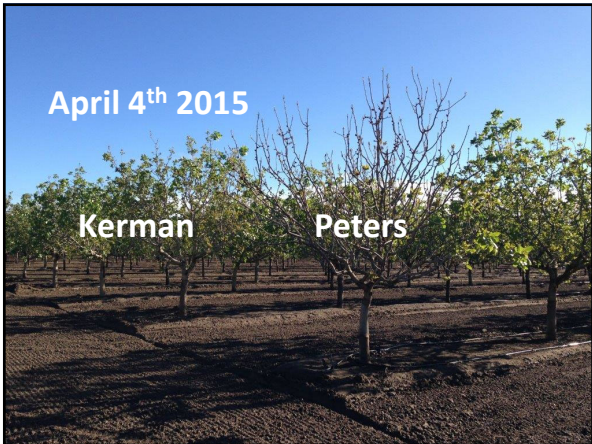
Why is
winter chill
important?

Photo: D. Doll

April 4th 2015

Kerman

Peters



Chill models work very differently

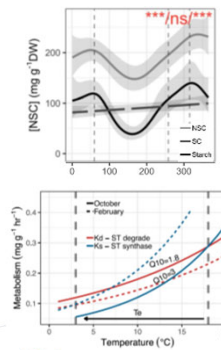
Chill Hours

- 1 hour between 32-45° F = 1 chill hour

Chill Portions (Dynamic Model)

- Different temps have dif. 'chill value.'
 - Max: hours at 43-47° F.
 - No chill value at 32° F and 54° F.
- Expands the range of temps considered effective for chill accumulation.
- ★ Warm temperatures can subtract from chill accumulation. ★

Winter Heat Delays Budbreak, Decreases Yield



Budbreak in the spring is preceded by a big up-swing in starch in the tree. (Tixier et al., 2019)

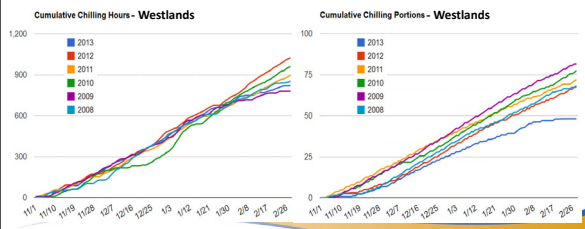
If conditions are warm in the winter, trees adjust their starch-making system to keep starch low & sugars stable mid-winter. But then it **takes more heat than normal years to achieve high starch pre-budbreak.** (Sperling et al., 2019)


Warm temperatures in winter (>65 F) had more influence on yield than cold temperatures (<45 F). (Kallsen, 2017)

2013-2014: Hours vs. Portions

Chill Hours:
Average winter.

Chill Portions:
Unusually Warm.





Spring
2014

Photo: D. Doll

UC | University of California
CE | Agriculture and Natural Resources | Cooperative Extension

How to count and use chill portions



Tracking chill portions on FNRIC



Tracking chill portions on FNRIC

Chilling Accumulation Models: Their Calculation, Explanation, & Comparison

Using Various Models

- Calculations of Current and Historic Chilling Accumulation at California CRMS Sites
- Chilling Hour & List Accumulation: Historic Accumulation of Chill Hours, Modified Chill Hours, & Chill Units (Dish Model) Hours Below 45°F Hours Between 32°F and 45°F September 1 through August 31
- Cumulative Chilling Hours: Modified Chill Hours, Modified Chill Hours, & Chill Units (Dish Model) Hours Below 45°F Hours Between 32°F and 45°F September 1 through August 31
- Cumulative Chilling Portion: Dynamic Model September 1 through August 31

Chill Model Updates Email List

The Fruit & Nut Center is closely monitoring Chill Portion calculations for the following stations: Shafter, Parker, Sacramento, Modesto, Arvin (Elmore), San Joaquin, Lodi, Patterson, Lodi, Porterville, Delano and Madro. If you would like to be notified of specific issues or when updates are released for these stations, subscribe for our [Chill Model Updates Email List](#).

Dynamic Model & Chill Portion Accumulation Guide

- A how-to guide (PDF) by Miles Chapp, retired Project Scientist, Dept. of Plant Sciences, for calculating chill portions (including converting 10 and 30 minute data to hourly data for the model), using weather data from a data logger in your orchard, and the Dynamic Model (Good Wet). Both available for download.

Tracking chill portions on FNRIC

Chill Calculators

Cumulative Chilling Portions - Select Stations from List

County	Station	Portions
Alameda	175 Pleasanton	1
Alameda	175 Stockton	0
Amador	227 Fairbairn	1
Bates	812 DuRoi	2
Colusa	612 Colusa	1
Contra Costa	647 Brentwood	0
Contra Costa	179 Concord	0
Contra Costa	213 El Cerrito	0
El Dorado	178 Flanagan	2
El Dorado	615 Sutter	0
El Dorado	224 Diamond Springs	3
Fresno	295 Colusa	0
Fresno	897 Independence	0
Fresno	199 Fine Pointe South West	0

Tracking chill portions on FNRIC

Chill Calculators

Cumulative Chilling Portions

CRMS weather station Challenge (Select Fresno County)

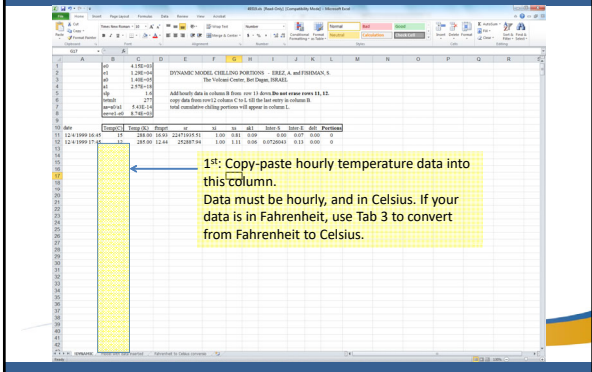
Reporting Date: Current Season

Historical Accumulations

Start Date: 01/01/14

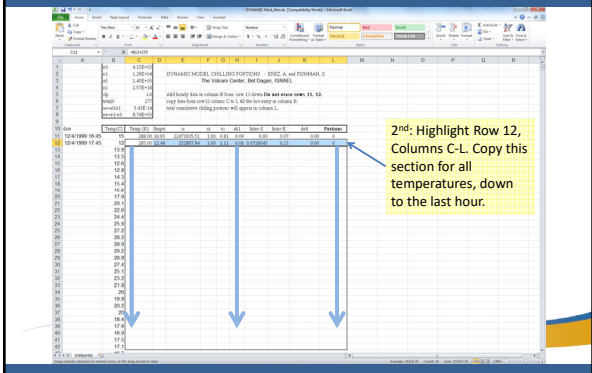
End Date: 10/31/14

DIY Spreadsheet Chill Portions



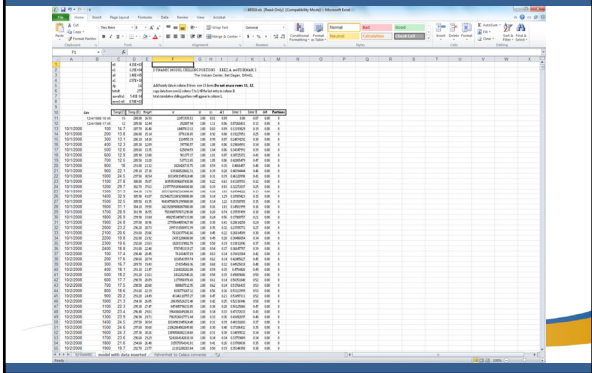
1st: Copy-paste hourly temperature data into this column.
Data must be hourly, and in Celsius. If your data is in Fahrenheit, use Tab 3 to convert from Fahrenheit to Celsius.

DIY Spreadsheet Chill Portions



2nd: Highlight Row 12, Columns C-L. Copy this section for all temperatures, down to the last hour.

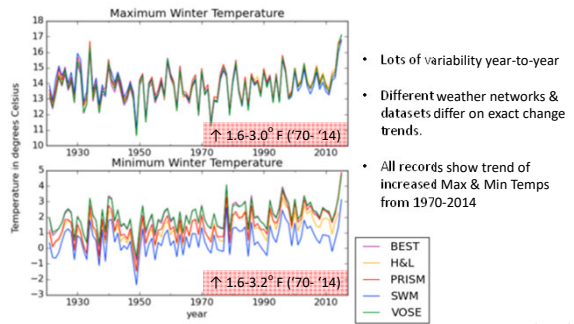
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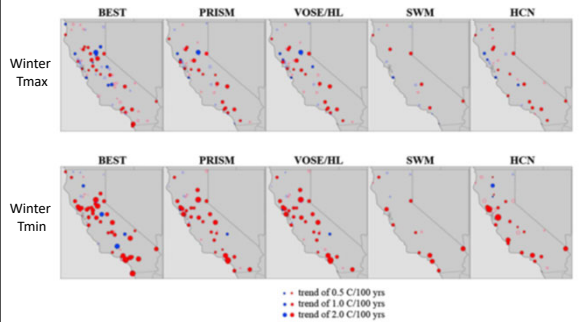
Outline of Talk

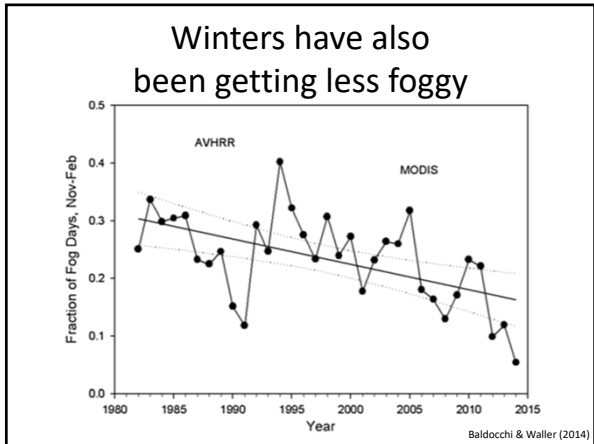
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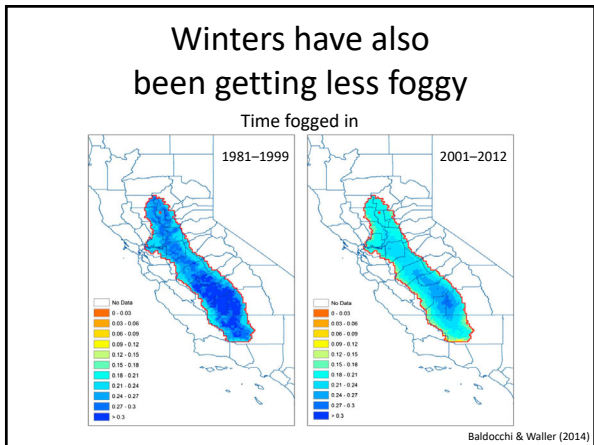
Have California winters been getting warmer?
Yes. Especially in the last 40 years.

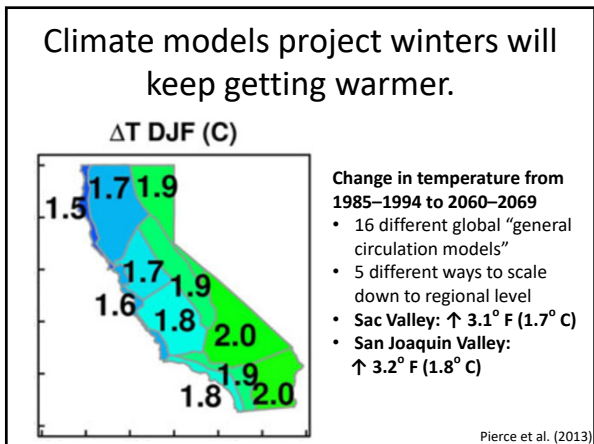


Have Central Valley winters been getting warmer?
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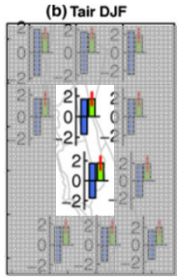








Climate models project winters will continue to vary a lot from year to year.



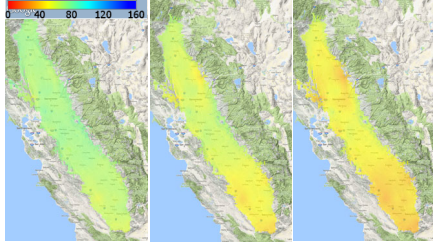
- Winter-to-Winter variability will be 2x the expected shift in temperature.
- So, we'll still experience some cold winters, and winters that we now consider average.
- But we'll also experience more "low chill" winters **AND** lower chill winters than before.

Blue bars: Natural climate variability across all models.
Green bars: Average warming projected in period 2060-2069.
Red line: 90% CI projected warming across models.

Pierce et al. (2013)

Chill Projections 90% of years, for Mid, End of Century

	Turn of the Century	Mid 21 st Century	End 21 st Century
Sac Valley	70	59 (↓ 16%)	49 (↓ 30%)
N. San Joaquin	71	61 (↓ 14%)	51 (↓ 28%)
S. San Joaquin	64	51 (↓ 20%)	42 (↓ 34%)



Luedeling et al. (2009)

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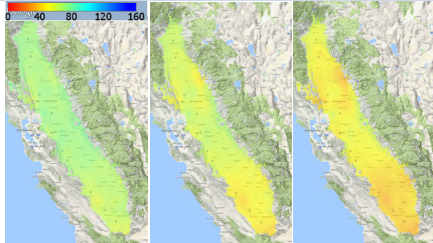
Chill requirements of current cultivars

Crop (CA Cv.'s)	Chill Portions Requ.
Kerman*	54-58
Peters*	60-65
Lost Hills	
Golden Hills	
Gumdrop	
Randy	

*Based on how chill & harvest, 2014

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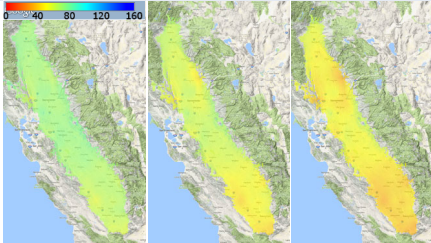
Luedeling et al. (2009)

Dormancy breaking products could help with 10-20% chill decrease

- Kaolin clay, calcium carbonate in winter decreases bud, shoot heat (Doll, Culumber)
- Dormant/Horticultural Oil can increase budbreak, make it earlier (Beede, Ferguson)
- Early data shows ethylene, GA₃ may have similar results to oil (Brar, 2018)
- Hydrogen cyanamide can increase budbreak, make earlier. Not reg'd (Beede, Ferguson, Intl)
- New research on the physiology of dormancy may help generate other solutions (Dr. Z)

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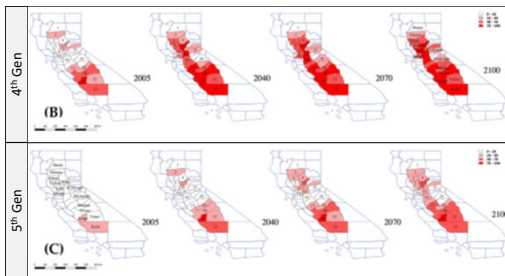


Luedeling et al. (2009)

Lower chill varieties will be necessary production in many areas after mid-Century

Type	Cultivar	Chill Hours (>7 C)	Country of Origin
Female	Mateur	206 (36 CP)	Tunisia
	Uzun	600	Turkey
	Halebi	650	Turkey
	Siirt	700	Turkey
	Kale-Ghuchi	775	Iran
	Kerman	800	California
Male	Male-1	500	Turkey
	Male-2	750	Turkey
	Peters	900	California

More Heat → More NOW generations



Percent of years in which 4th (B) or 5th (C) generation occurred. Dark = More frequent. Middle of the road warming scenario (RCP 4.5)

Three Take Aways

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Thank you! Questions?