Cornell University
College of Agriculture and Life Sciences

Continentality in Relation to Vineyard Site Selection

Revised by Tim Martinson, 2011

What is Continentality?

(*Data for the next 4 figures is for 18 northern sites and was selected by N.J. Shaulis*)

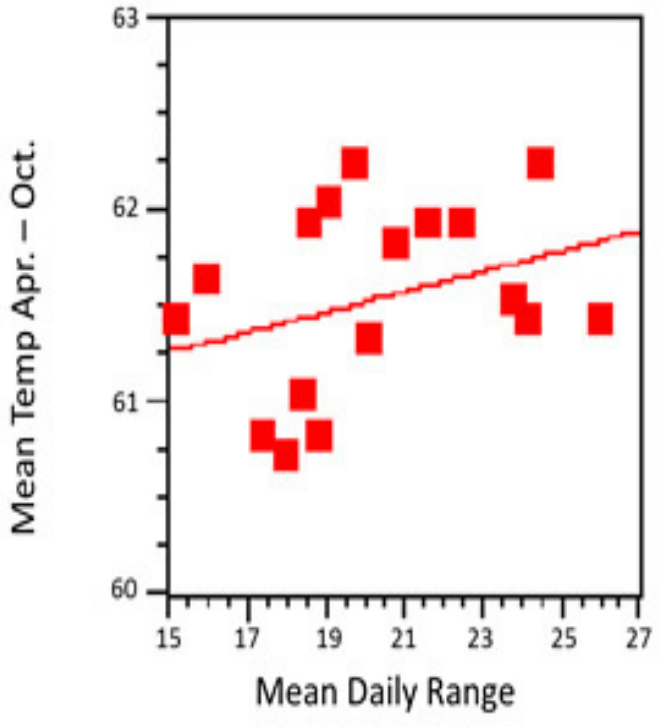


Figure 1. Mean daily range vs. mean growing season temperature (April-October) in 18 US States.

Continentality is a climate attribute that is inversely related to the degree of water moderation. Mean daily range (MDR), which is the difference between the annual average maximum and minimum temperatures, is an index that estimates continentality (Figure 1).

Temperatures in continental sites are more variable and extreme than in coastal or other areas near large bodies of water. In summer, continental sites receive more heat to assist fruit and vine maturation, but they also have increased hazard from other related weather events characteristics of continental sites which interfere with grapevine function.

Water Moderates Both Summer and Winter Temperatures.

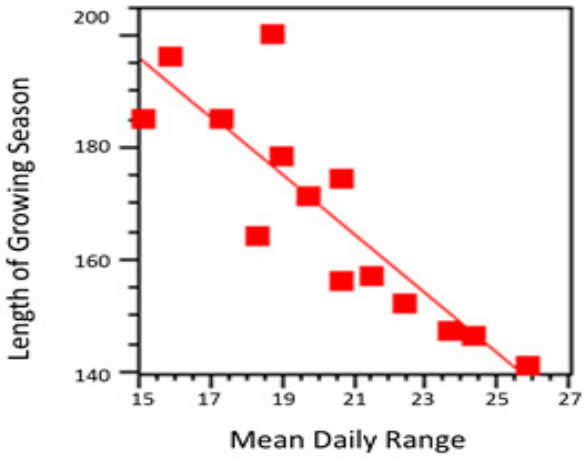


Figure 2. Relationship of mean daily range with the growing season length (no. Frost-Free days). Mean daily range is greater in 'continental sites' (at right) which tend to have shorter growing seasons than 'maritime sites' (at left).

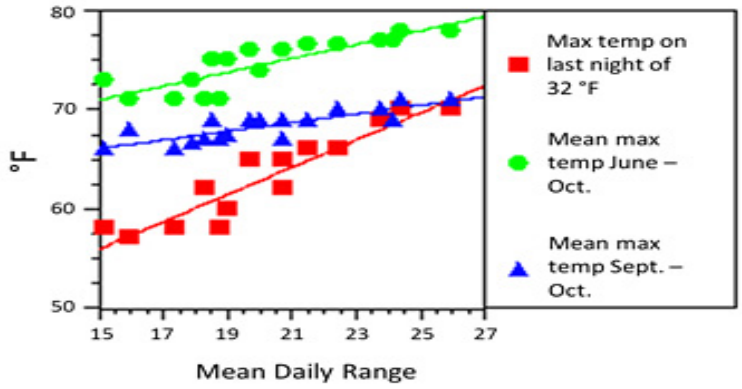


Figure 3. Continental sites (high MDR, towards right) tend to have higher temperatures preceding freeze events than do 'maritime sites' with a low MDR (towards left).

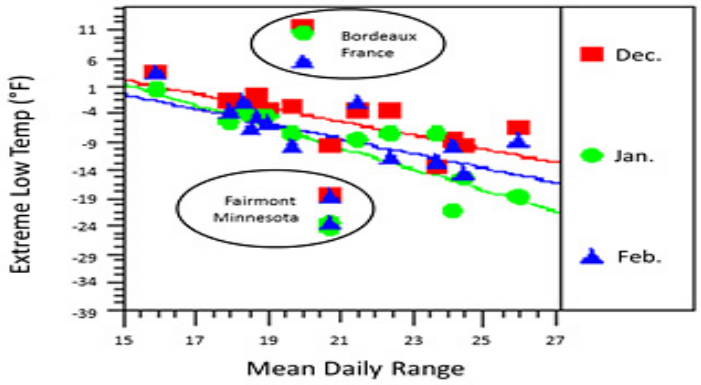


Figure 4. Extreme winter low temperatures vs. MDR. Maritime sites with water moderation tend to have higher 'extreme lows' than do continental sites. Bordeaux, France stands out with exceptionally high winter lows, while Fairfield MN stands out with both variable temperatures and low heat accumulations.

In the fall, continental sites have greater temperature fluctuation (meaning higher day temperatures and lower night temperatures) than do maritime (water moderated) sites. This aids fruit maturation, but increases the risk of early fall and late spring frosts. With active green tissue, when the temperature drop below 28° F, grape foliage is killed and the season can be abruptly terminated. This not only interferes with fruit maturation, but can prevent complete cold hardiness development. Regions with high MDR tend to have shorter growing seasons
(Figure 2).

Where MDR is high, the probability of spring freeze increases. Bud development begins when the temperature exceeds 50°F. High MDR sites experience early season high temperatures which promote early bud growth (Figure 3). They also tend to simultaneously have more frequent low temperatures which may result in freeze injury.

The primary benefit of water moderation for New York vineyards is that it reduces winter cold hazard, but water moderation also provides the benefit of reducing the risk of spring and fall freeze injury. More continental sites may require freeze protection (sprinkle irrigation, wind machines or heaters) in the spring, early summer and fall to prevent freeze injury to green tissues.

Latitude is the most important factor related to cold hazard. Water moderation of winter cold is required for successful production of most grape varieties in high latitudes. Vine production in Northern Europe benefits from the moderating influence of the Atlantic Ocean and especially of the Gulf Stream (Note the relatively high December, January and February expected monthly low temperatures in Bordeaux France relative to North American sites in Figure 4.) The very continental Fairmont, MN, site also stands out as having more extreme temperatures. In the latter case the problem is both variable temperatures and low total heat supply. Water moderation, which reduces continentality, makes grape production possible at higher latitudes.

In Summary

A site with a continental climate has a high MDR. This means more heat is available during the growing season to promote fruit maturation. The day and night temperatures during the September - October period have a very important, positive impact on fruit composition and wine quality. However, more continental climates also bring greater winter cold injury hazard. They induce bud growth in the spring before freeze hazard has ended. Sites with a continental climate will also experience earlier fall freezes than water moderated sites.

The Impact of Continentality on Site Suitability for Grape Growing in New York

Traditionally, winter low temperatures, frost-free days and growing degree days (GDD) are the climate indices that are used to indicate site suitability. However, applied to New York state, maps that incorporate only degree-days tend to identify some areas with warm growing season temperatures as being more favorable for cold-sensitive varieties than experience of growers in those areas would suggest. Incorporating MDR as a measure of continentality could correct this apparent anomaly.

Using data from The National Climate Data Center, we explored the relationship between water moderation and suitability of NY site climate for grape production. Two different data sets from the Center were used to create the charts and maps below.

First data set. The first data set contains "corrected" weather data for all states. There are 82 New York stations. Data for this set have been fully checked and corrected for such influences as urban impact. A random selection of weather stations in California, Michigan, Minnesota, Oregon and Washington were used in addition to the NY stations. Average monthly high, low and mean temperatures were calculated and used to generate the line figures below.

Second data set. NCDC also has a more extensive collection of data from cooperating weather stations. For New York, there are data for almost 300 weather stations. However, the data has not been corrected. There are many gaps and no adjustments have been made for local or regional influences which might bias the data. NCDC makes no claims about completeness or accuracy. The only advantage for the second set is that it provides data for about 5 times the number of locations. A mapping software program, ArcView (ESRI), was used to generate the weather maps found below from the second set. Data for a given year and station were excluded when there was missing data.

Data from both sets were used to calculate:

Average January Temperature – Monthly January maximum and minimum temperatures were used to calculate average January temperature for each station. A low average January temperature indicates increased winter cold hazard. No single value can separate acceptable from non-acceptable sites, but few present vineyards are located where the January average temperature is less than 14°F. Cold injury is rare where the winter January temperature is greater than 19°F.

Seasonal Growing Degree Days – Monthly mean maximum and minimum temperatures were used to calculate monthly accumulated degree days (50°F base). Seasonal accumulations included the months April through October.

Seasonal Degree Days

$$\sum_{Apr}^{Oct.} = \left(\left(\frac{Max + Min}{2}\right) - 50\right)\left(Days\ in\ Month\right)$$

Winkler and Amerine of the University of California (Davis) first used seasonal degree day accumulation to categorize California grape production regions (Table 1).

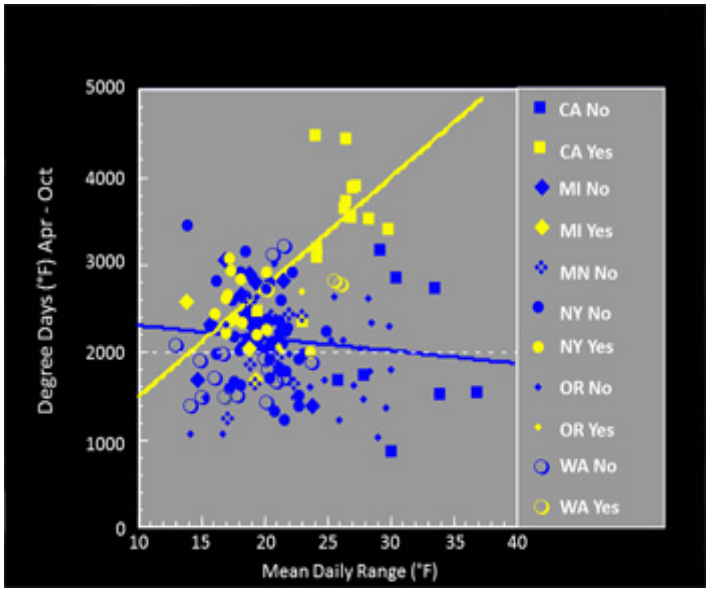
Table 1. Winkler and Amerine's classification of California grape growing regions by growing degree-days.

Region	DD Range	Region
I	< 2,500	Very Cool
II	2,501 – 3,000	Cool
III	3,000 – 3,500	Warm
IV	3,501 – 4,000	Hot
V	> 4,000	Very Hot

Region I is similar to the coolest European districts such as Champagne in France and the Rhine in Germany. Region II is similar to Bordeaux in France. Region III is like the Rhone in France or Tuscany in Italy. Region IV is like the San Joaquin Valley and only table grapes are usually grown commercially in Region V. Most existing New York grape production regions have a seasonal degree day accumulations of 2,200 or more.

Mean Daily Range (MDR) – Mean Daily Range (Yearly Average High Temperature – Yearly Average Low Temperature) reflects the influence of water moderation on local climate. High MDR values indicate a continental climate and low MDR values a maritime climate. Most present New York grape producing regions have MDR values below 20°F.

Grape Growing vs. Non-grape Growing Stations (climate set 1- national trends)



For non-grape growing stations, there is no relationship between MDR and Degree Day accumulation, but the two values are positively correlated for grape growing stations. Great Lakes and coastal Atlantic grape growing stations have low MDR values and relatively low Degree Day accumulation. Grape growing stations with high MDR values also have very high Degree Day accumulation. They are located in the Southern San Joaquin Valley and in a low elevation, early table grape producing desert region. Their tendency to have high variability in daily temperature is offset by the fact that their winter low temperatures are also high.

Figure 5. Association between Mean Daily Range and Seasonal degree day accumulation for weather stations in several states. (Yellow values indicate temperatures at stations near grape growing locations. Blue values indicate there is no commercial grape production near the station. The lines represent the line of best linear fit for grape or non-grape growing station.)

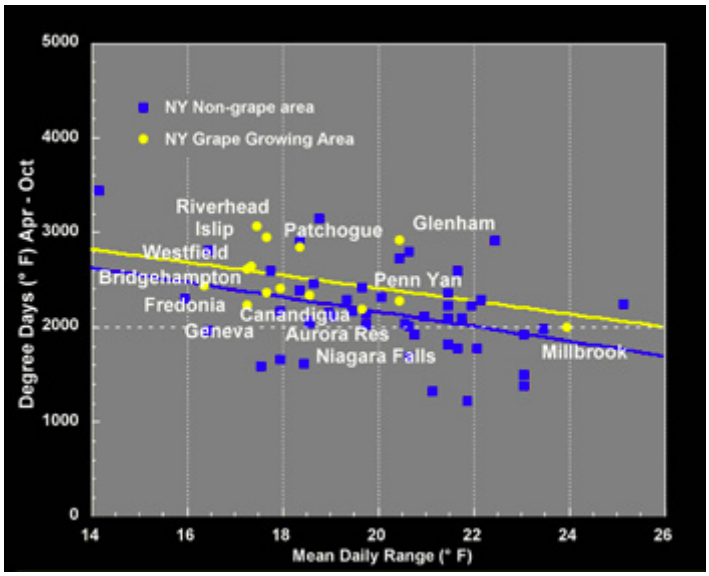


Figure 6. Mean Daily Range and Seasonal Degree Day Accumulation for New York weather stations (Yellow values indicate temperatures at stations near grape growing locations. Blue values indicate there is no commercial grape production near the station. The lines represent the line of best linear fit for grape or non-grape growing station.)

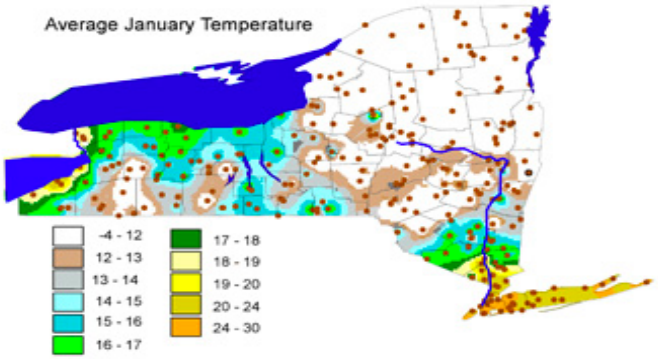


Figure 7. Average January temperature (°F).

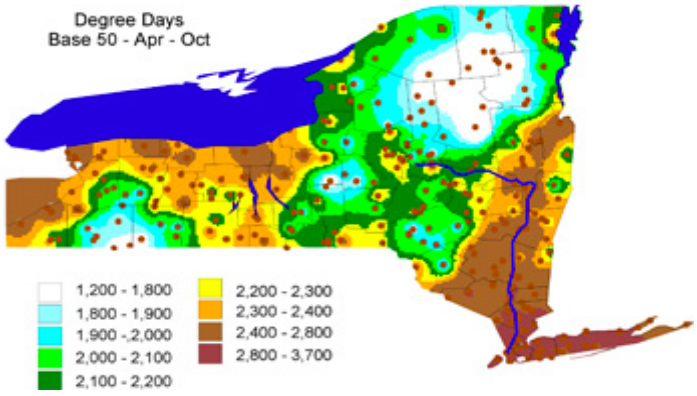


Figure 8. Growing degree-days (°F, base temperature 50°).

Degree Day Accumulation and Mean Daily Range in New York

Unlike the national trends, the slope of the regression lines for New York grape growing and non-grape growing stations do not differ. Grape growing sites have significantly higher average degree day accumulations than non-grape stations. This indicates that above-average heat accumulation is needed to ripen grapes in New York.

Grape sites also need water moderation. All but one grape growing site has MDR values below 21. The exception is Millbrook in the Hudson Valley. A commercial vineyard is located in Millbrook, but it is plagued with season ending fall freezes that sometimes prevents fruit from fully maturing and also experiences frequent winter cold damage. The Millbrook vineyard also produces very fine red wines, a fact which can be partially attributed to the higher MDR which indicates above average day time and below average night time temperatures during the fruit maturation season.

Figure 7 plots the average January temperature for the NY stations in the cooperative data set. Most grape growing sites have an average January temperature above 14 degrees. This map indicates that only the northern tip of Keuka Lake lies in the below 14 degree zone. This, to some extent, is consistent with grower experience, but the actual division line may be skewed because of the fact that the only Keuka Lake weather station is at Penn Yan on the northern tip of Keuka Lake. Other local weather stations are well away from grape growing sites. This illustrates problems associated with the use of widely scattered weather station data to make local climate decisions.

The data for the mid- to upper Hudson River valley indicate a winter cold hazard similar to or worse than Keuka Lake. The relatively warm Broome county temperatures may reflect distortions caused by urban influences on a local weather stations rather than true winter cold hazard.

Figure 8 indicates the areas where grapes can be expected to ripen. The mid-Hudson region is very favorable for fruit maturation. As stated above this is because the more continental climate is characterized by higher day temperatures and lower night temperatures.

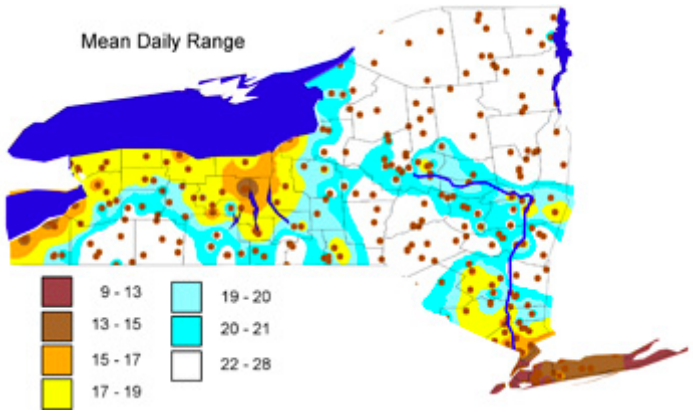


Figure 9. Mean daily range (yearly average maximum – minimum temperature °F).

Mean Daily Range

Figure 9 shows MDR in New York. Lower MDR values indicate greater water moderation. The effects of Lake Erie, Lake Ontario, Long Island Sound and the Atlantic Ocean can be seen on the map. It also indicates that higher elevation Finger Lakes and mid-Hudson Valley sites get less water moderation of their local climate than do other New York grape producing regions.

Suitability of General Climate for Grape Growing

This composite map (Figure 10) evaluates climate using average January temperatures, degree-day accumulations, and MDR. Green areas represent portions of the state where the average January temperature is greater than 15, the degree day accumulation is more than 2,300 and the Mean Daily Range is less than 20. The climate in these zones will usually support grape production. Of course every region experiences exceptional weather; this map just presents the probability that temperature will be unsuitable. These maps also do not indicate local site suitability. Within any region site quality will vary greatly depending on local influences such as air drainage and exposure.

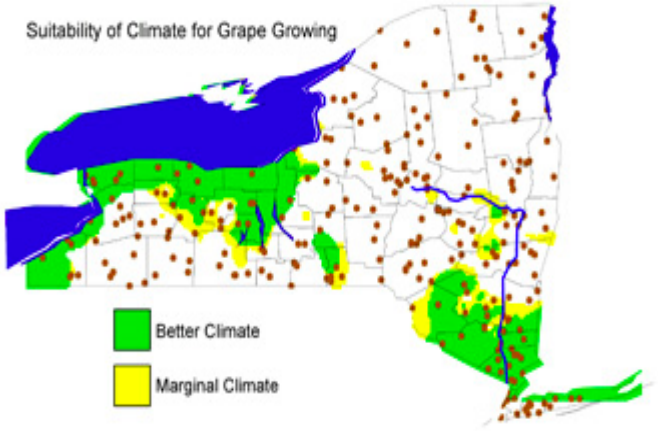


Figure 10. Composite map combining average January temperatures, growing degree-days, and mean daily range into an overall climate index.

Yellow areas represent places where the average January temperature is greater than 14, the degree day accumulation is greater than 2, 100 and the Mean Daily Range is less than 21. Vineyards in these areas will have a greater chance of success if they are devoted to earlier ripening, cold hardy varieties.

As is pointed out elsewhere, temperature is only one aspect of site selection. These maps are based on data which is not authenticated by NOAA. However, the maps do indicate the importance of water moderation and one approach to measuring its extent.

Reference

Winkler AJ, Cook JA, Kliewer WM and Lider LA (1974). General Viticulture (2nd ed.). University of California Press. ISBN 0-520-02591-1.