Friday, January 29, 2010

9:00 am – 11:00 am

Unified WINE & GRAPE SYMPOSIUM
PRESENTED BY ASEV & CAWG

High Elevation/High Latitude Seminar: Wine Growing on the Edge

Greg Jones

2010

How Weather/Climate vary with Elevation and Latitude: Implications for Winegrowing

SOUTHERN OREGON UNIVERSITY

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High Elevation/High Latitude Seminar:
Wine Growing On the Edge
January 29, 2010
Sacramento, California

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Talk Outline

- Weather and Climate Influences and Hazards
- What Defines “High Elevation”?
- Weather and Climate Influences of Upland Zones
- Weather and Climate Influences of High Latitudes
- Summary/Conclusions

Weather & Climate Influences/Hazards

- Extreme Winter Temperatures
  - Vine hardiness, survival
- Spring & Fall Frosts, Frost-Free Period
  - Spring: damage to tender shoots
  - Fall: leaf drop, end of photosynthetic activity & ripening, damage to next year's buds
- Growing Season Temperatures
  - Averages, Extremes
  - Heat Accumulation
  - Ripening Period DTR
- Ambient Moisture & Precipitation
  - Growth Potential, Disease Potential
  - Bloom Disruption (coulure)
  - Ripening Disruption (dilution/splitting)
- Extreme Events
  - Hail, wind, heavy rain, etc.

Geographical Factors

Characteristics of weather and climate are broadly influenced by four main geographical factors:

- Latitude
- Continentality
- Altitude
- Topography

Large Scale Terrain Effects on Weather

Elevated areas have 3 types of effects on weather in their immediate and downwind vicinity:

1. The modification of synoptic weather systems (airflow) by both dynamic and thermodynamic processes (with considerable depth).
2. Recurring and distinctive regional weather conditions … local winds and cloudiness and precipitation patterns.
3. Slope and aspect variations that operate on the scale of 100-1000 ft and produce a mosaic of topoclimates.

What Defines “High Elevation”

A vineyard planted in Argentina

The difference in vineyards planted in Carneros vs Amador County

Or a block at the bottom and top of this vineyard

Stone Mountain Vineyards, VA 1700 ft

Alta Seca Vineyards, OR 2450 ft

Terror Creek Vineyard, CO 6417 ft

Etchart Cafayate Vineyard, Argentina 5560 ft

Central Atago, NZ 1400 ft

Madroña Vineyards, CA 3000 ft

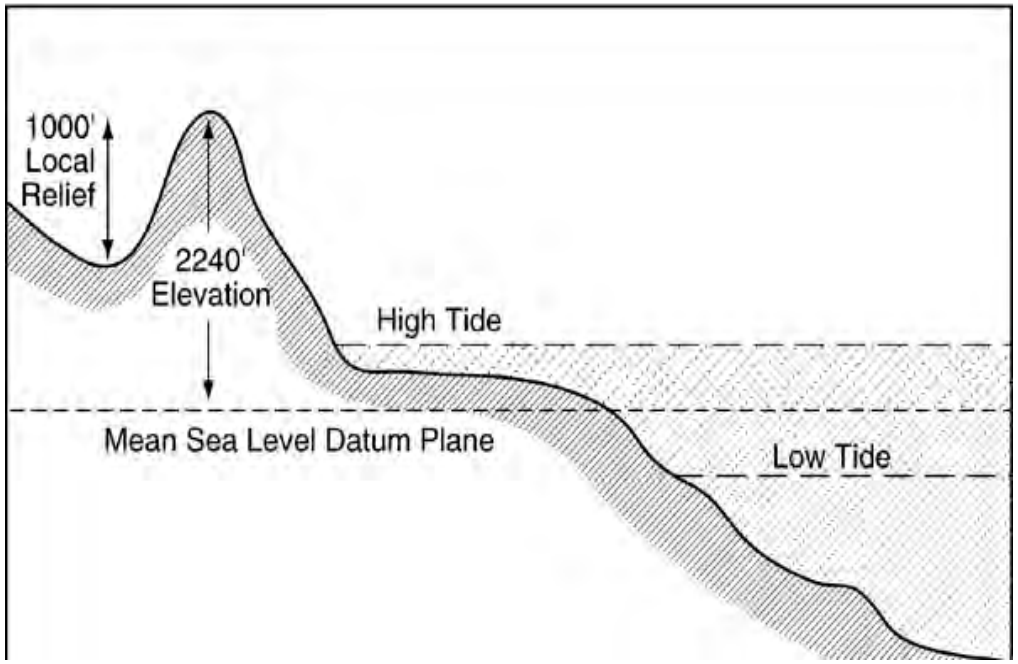
Douro Valley, Portugal 2000 ft

Chateau Aigle, Switzerland 3100 ft

Elevation and Relief

Relative Relief – the difference in elevation between the highest and lowest points in an area

Absolute Relief – the difference in elevation between a given location and sea level



Elevation and Relief

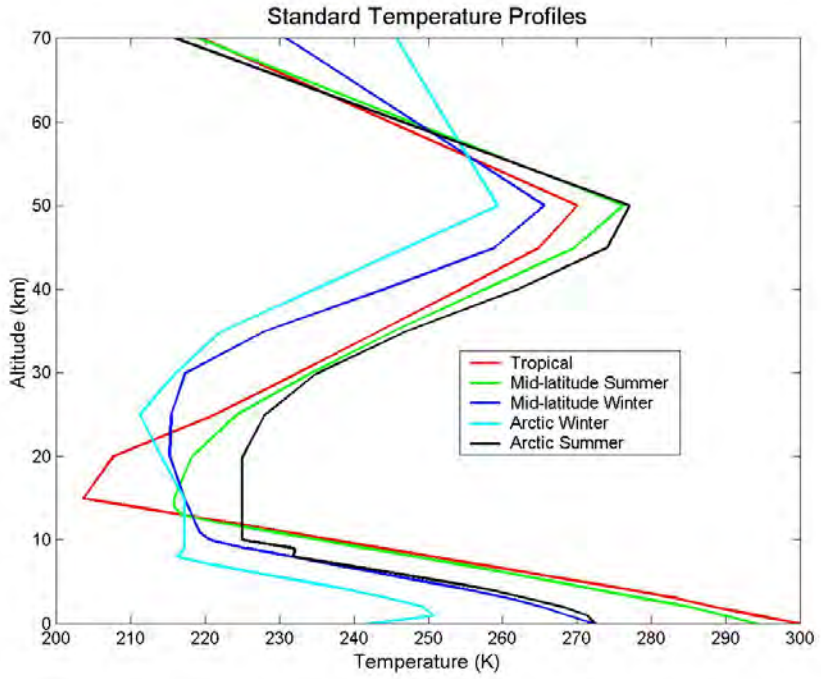
Relative Relief – the difference in elevation between the highest and lowest points in an area

Absolute Relief – the difference in elevation between a given location and sea level

- In most vineyard areas relative relief is the most important aspect of elevation differences … producing local topographical effects on weather and climate
- However, very high absolute relief can drive significant differences in weather and climate compared to lower elevations at similar latitudes

Local Relief or Topographical Influences

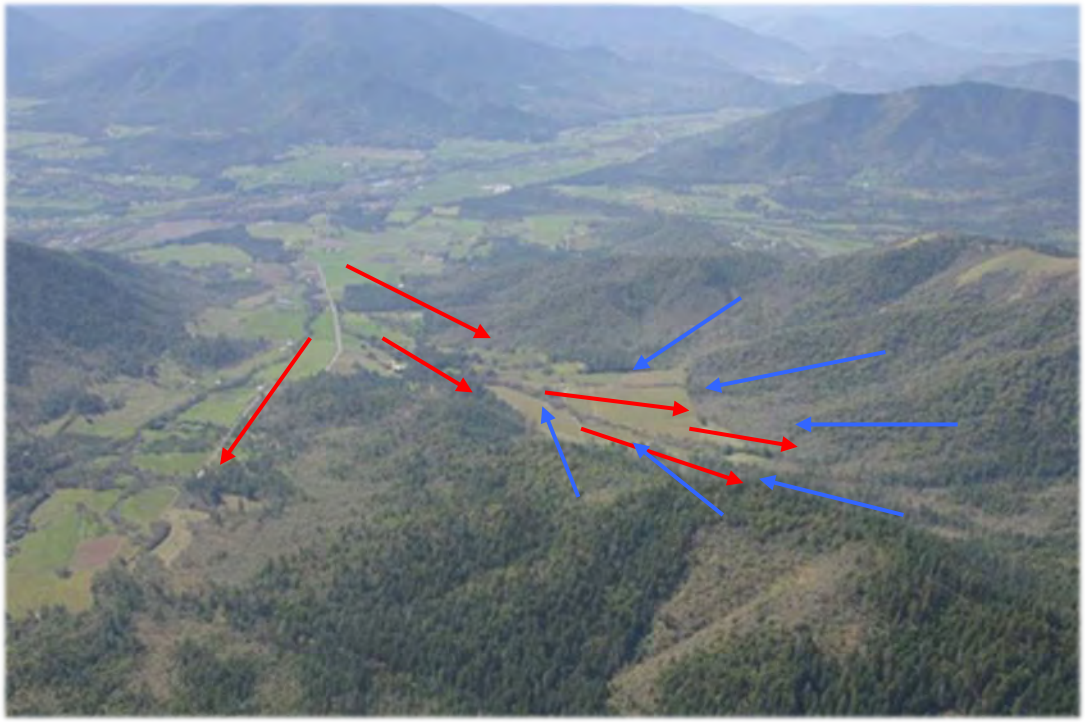
1. Local elevation differences (~ 1 F per 275 ft or 3.6°F per 1000 ft)
   - Highly modified by slope, aspect, diurnal characteristics, proximity to coast, etc.
   - Varies by latitude, season, and moisture level



Local Relief or Topographical Influences

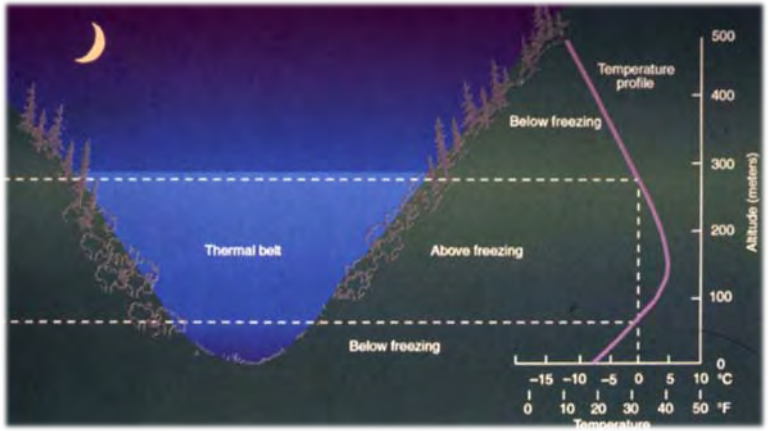
2. Slope effects on air movement (varies by aspect)
   - Diurnal winds
3. Isolation of Terrain
   - Cold air source

Thermally-driven by mountain-valley configuration, more mesoscale influences but can be driven by macroscale factors

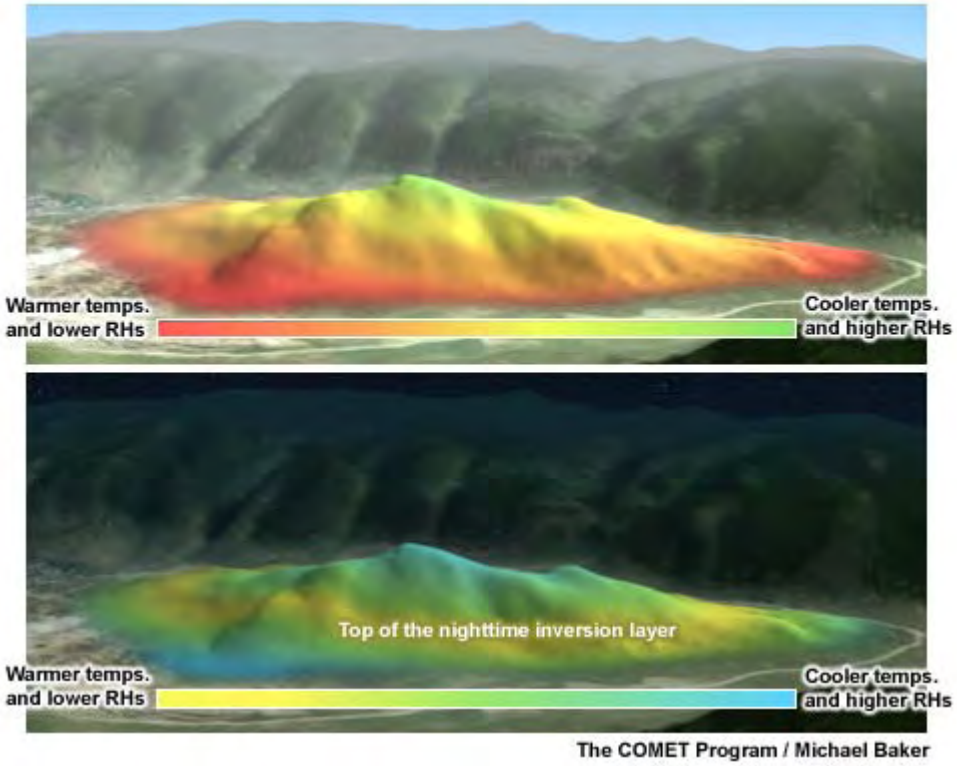


Local Relief or Topographical Influences

4. Local topography effects on inversions, thermal zones
   - Effects temperature, moisture and frost risk
   - Size and shape of the valley determines depth



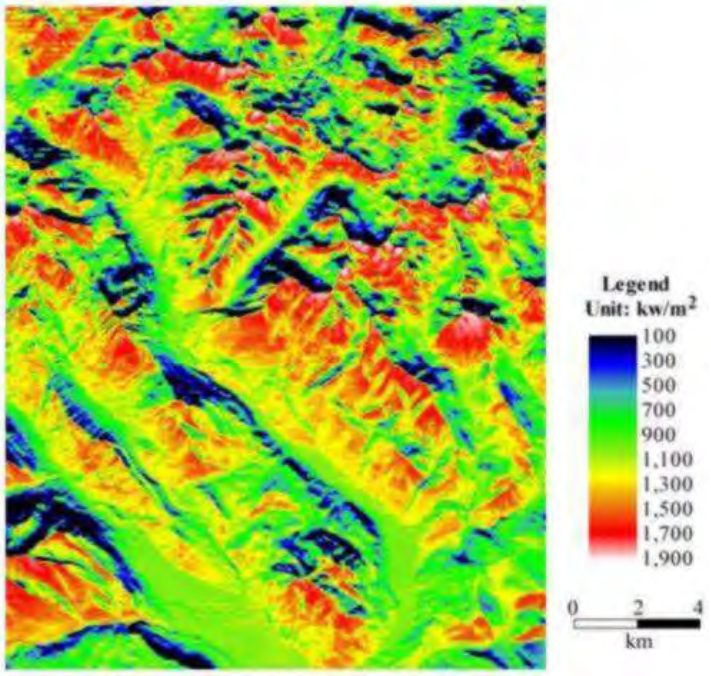
- Daytime – mixing, temperatures decrease and RH increases with elevation
- Nighttime – cold air drainage, temperature and RH increase at low elevations



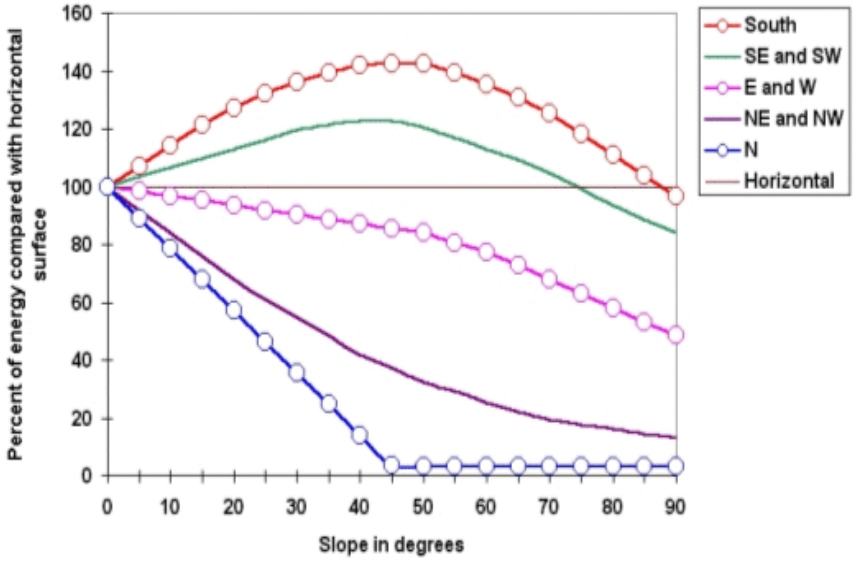
Local Relief or Topographical Influences

5. Slope & Aspect effects on heat loading and retention
   - Both air & soil temperatures, high latitude effects

Solar Illumination based on Radiative Potential

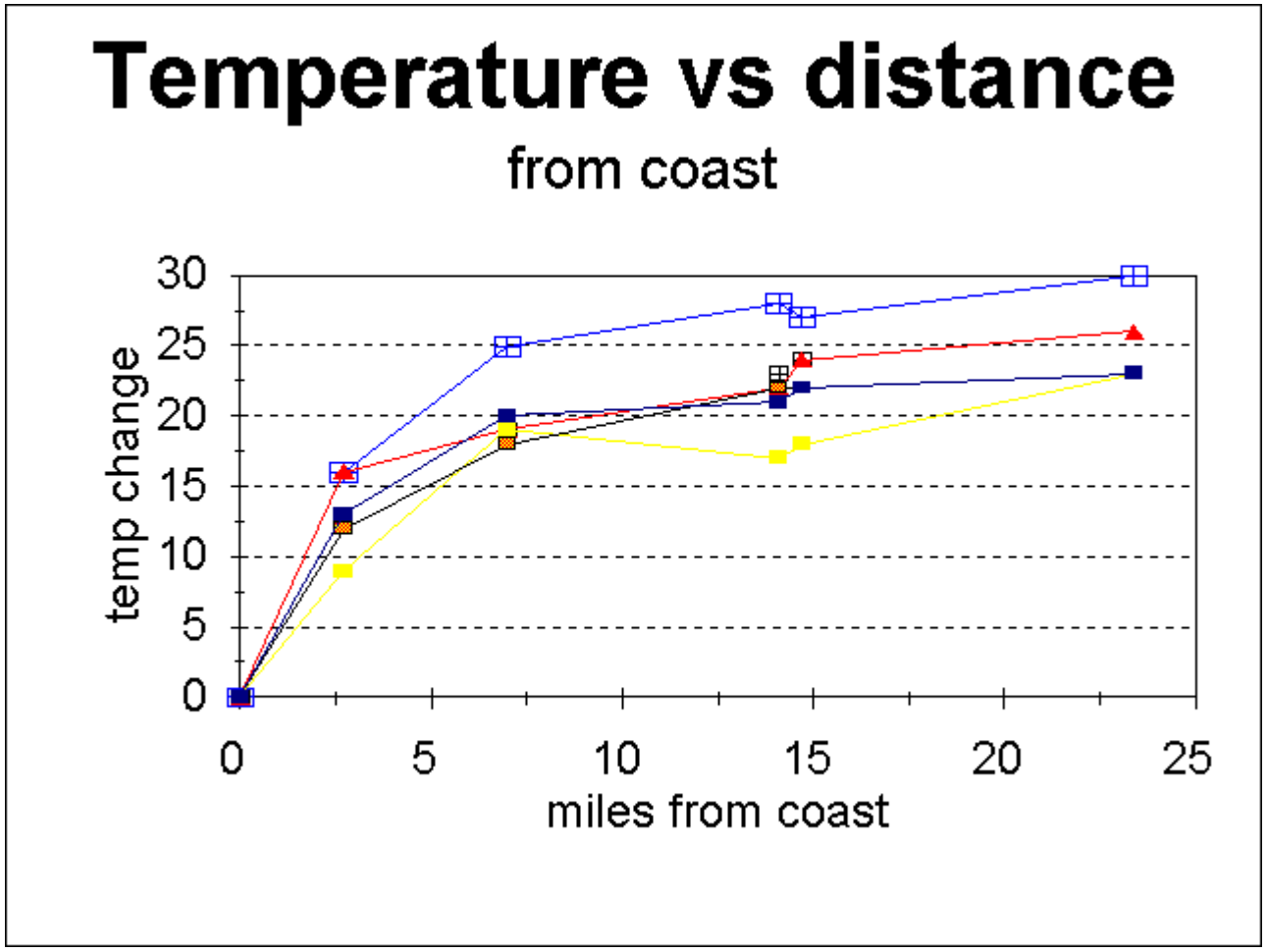


Amount of energy received by a sloping surface compared with a horizontal surface (NH, 45° latitude).



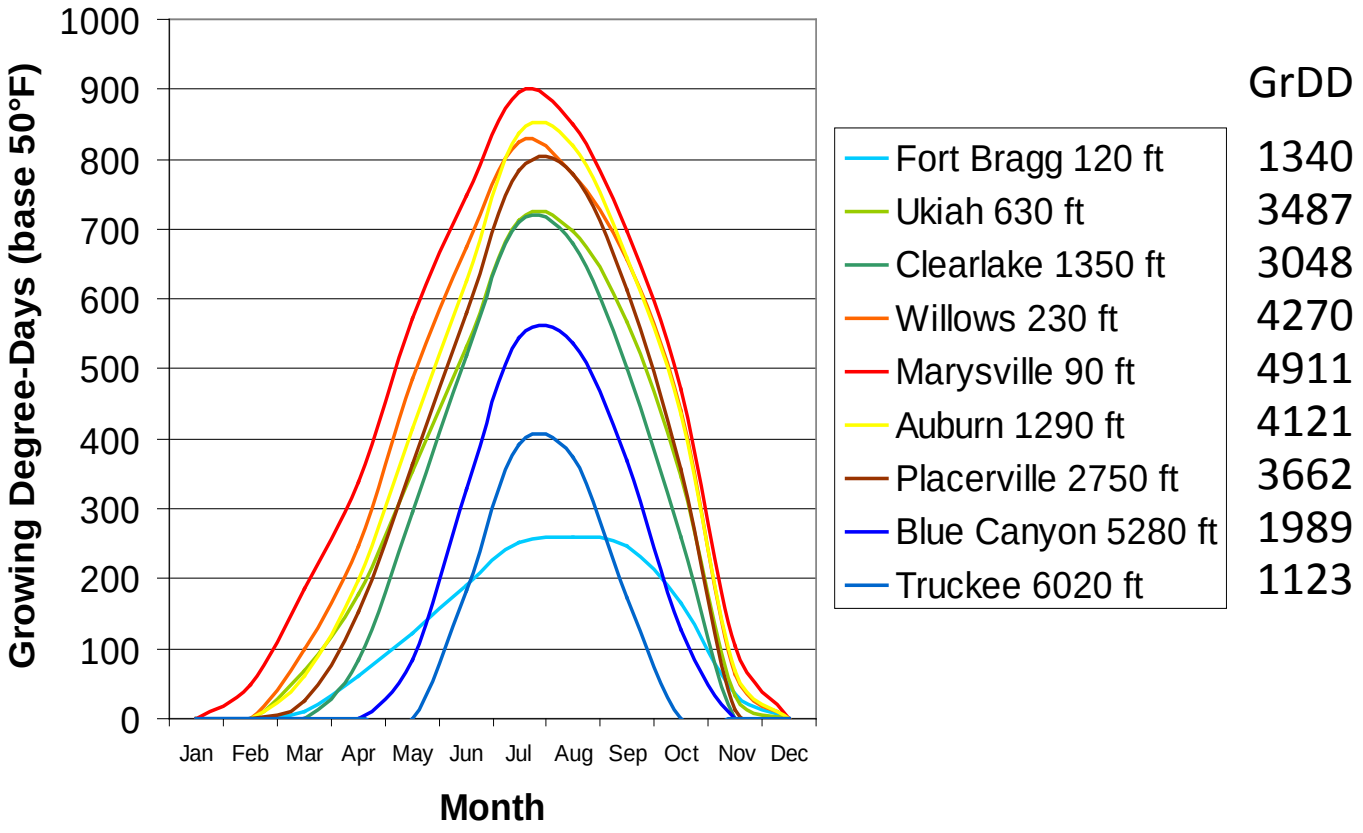
Local Relief or Topographical Influences

6. Proximity to bodies of water
   - Latent heat retention, buffered temperatures



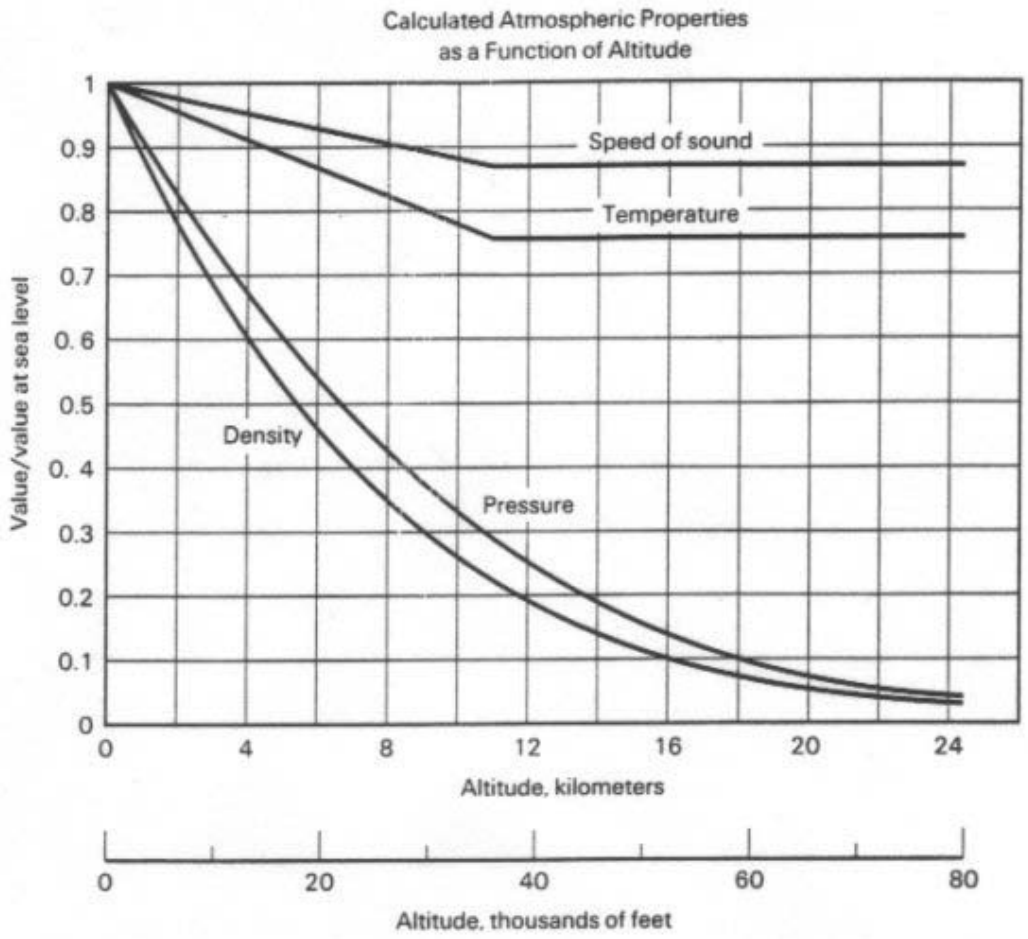
Absolute Relief Influences

1. Temperature differences (~ 1 F per 275 ft)
   - Typically lower averages, lower heat accumulation, higher diurnal temperature range (lower respiration)



Absolute Relief Influences

2. Pressure and density differences
   - Effect of gravity, lower density of all constituents



Roughly …

89% at 3000 ft

78% at 6000 ft

60% at 9000 ft

Carbon Dioxide

Along with water and nitrogen, CO_2 levels are one of the major limitations to plant growth

- The percentage of CO_2 in the air at two miles is roughly the same as at sea level (0.03%). However, the relative abundance of CO_2 compared to O_2 decreases
- CO_2 uptake by plants is typically less at higher altitudes and limits photosynthesis and productivity … nanism common.
- CO_2 gradient from atmosphere into leaves is less, plants physiologically adapt to lower gradient by increasing stomata size and number.
- An integrated, full impact on grapevines and wine is not completely known at this time.

Absolute Relief Influences

3. Radiative differences
   - Higher elevation surfaces both gain and give off heat quickly (sun/shade effect), higher intensity, more UV

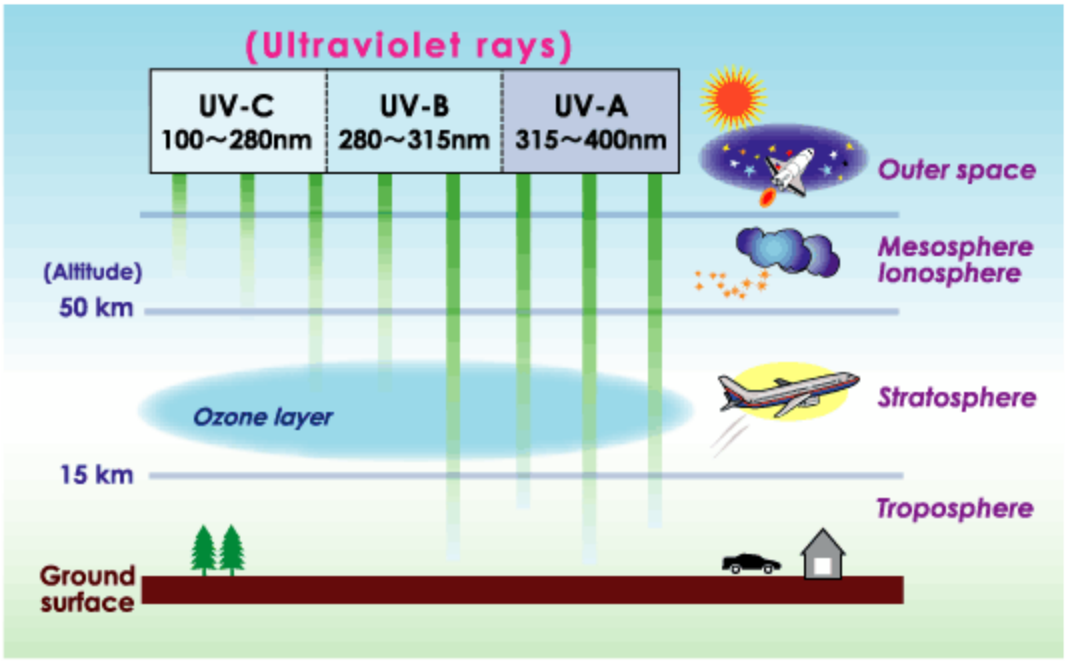


Figure 1. UV radiation at ground level

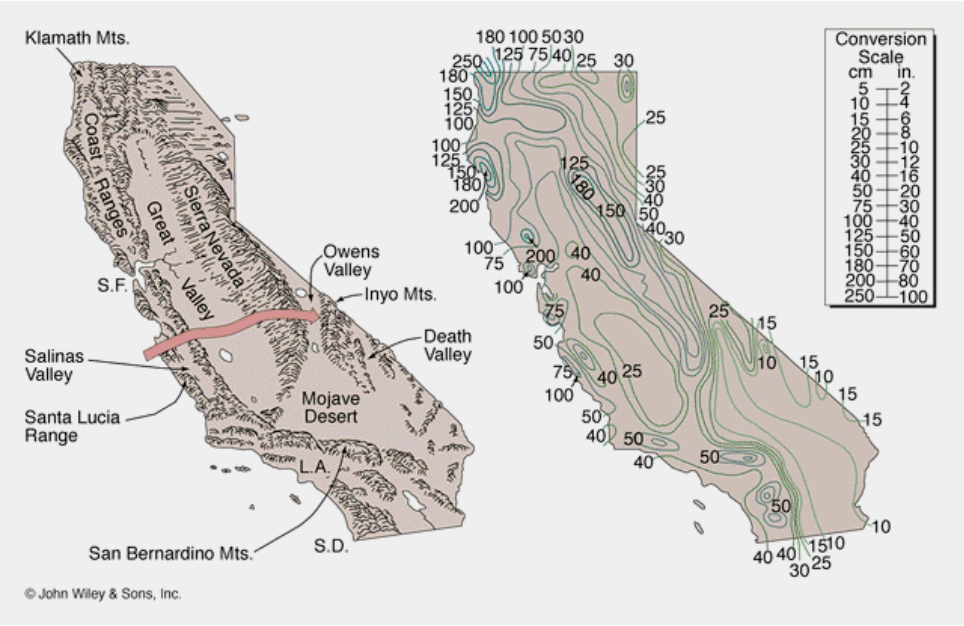
Ultraviolet Radiation

Rarefaction – at higher altitudes, a thinner atmosphere filters less UV radiation … + 3% to 4% per 1000 ft.

- Research is not conclusive, UV exposure should increase phenolic and color levels … but other factors may lesson the influence.
- Some recent research shows that some diseases in grapes are due to a combination of water stress and high UV-B radiation.
- Chlorophyll degradation in the leaves and berry skins also tends to occur more rapidly in high UV-radiation environments.
- UV radiation levels are mostly stable, but some regions have shown an increasing trend (S. Hemisphere & Europe) and others a declining trend … global dimming (cloud & pollutant effect).

Absolute Relief Influences

4. Moisture patterns … marked spatial and temporal variability
   - Orographic rainfall, valley and upslope fogs



Absolute Relief Influences

4. Moisture patterns … marked spatial and temporal variability
   - Combination of drying winds and low humidity result in more rapid dehydration in some regions
   - Potential evapotranspiration also undergoes altitudinal changes.
   - In spite of usually dryer air, the effect of temperature results in ET decreasing by 1 to 3 inches (annually) per 1000 ft of elevation.
   - The result is high elevation tend to have lower evaporation from soils leaving wetter soils and higher organic matter.

Mechanisms of orographic precipitation:

(a) Seeder-Feeder mechanism;

(b) upslope condensation;

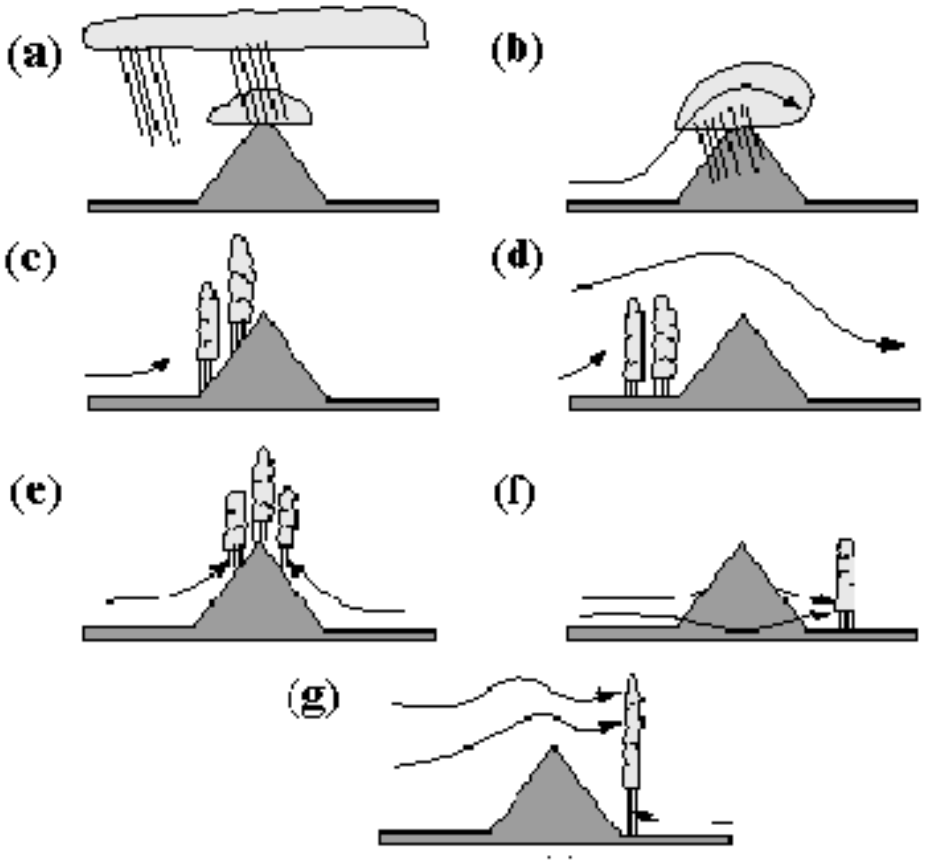
(c) upslope triggering of convection;

(d) upstream triggering of convection;

(e) thermal triggering of convection;

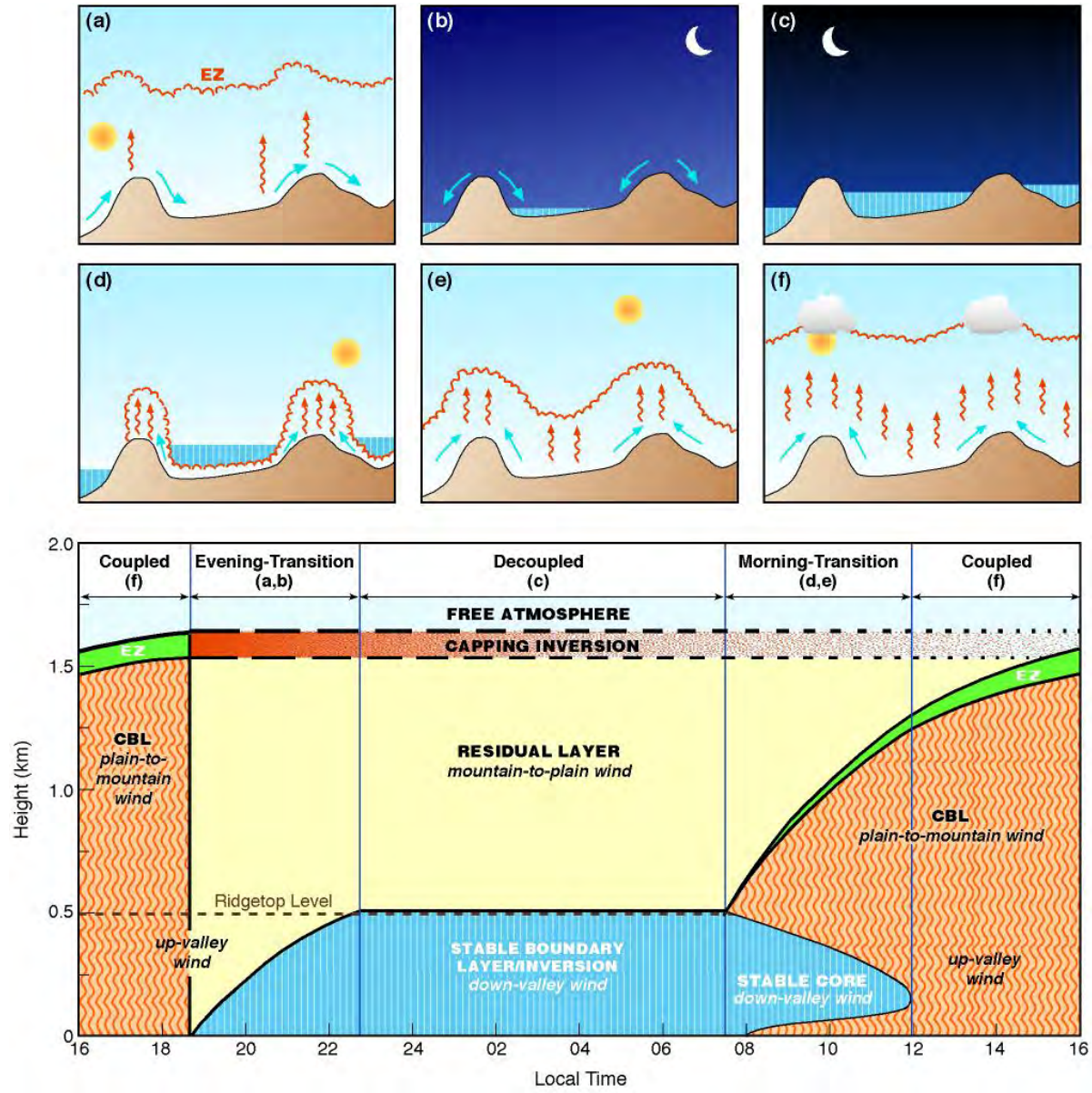
(f) leeside triggering of convection;

(g) leeside enhancement of convection.



Complex Terrain = Complex Inversions

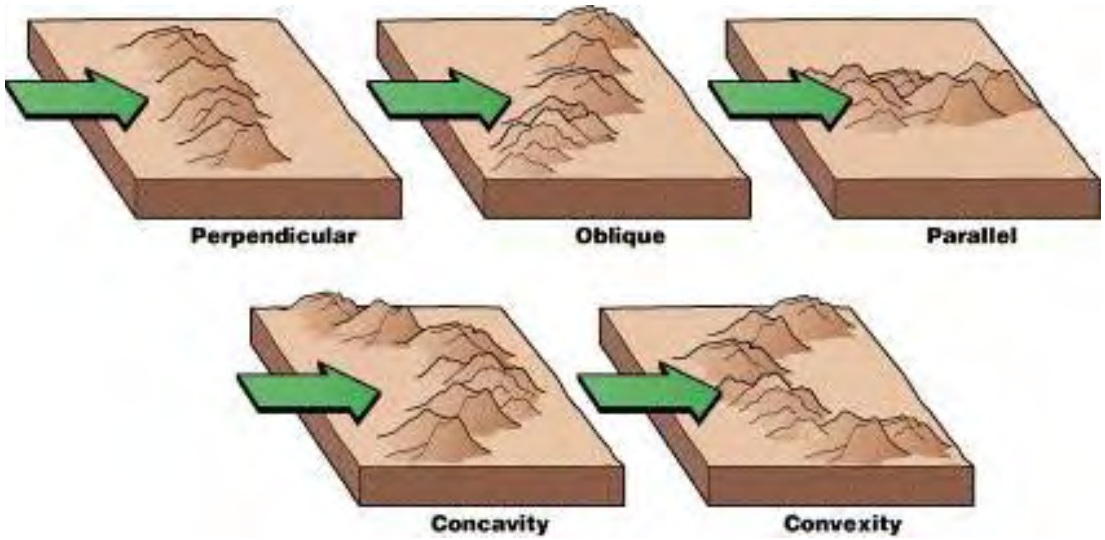
- Inversion depths
  - Depends on the size/shape of the valley
- Inversion strength
  - Depends on the season and macro-scale controls
- Inversion break timing
  - Strong localized controls



Absolute Relief Influences

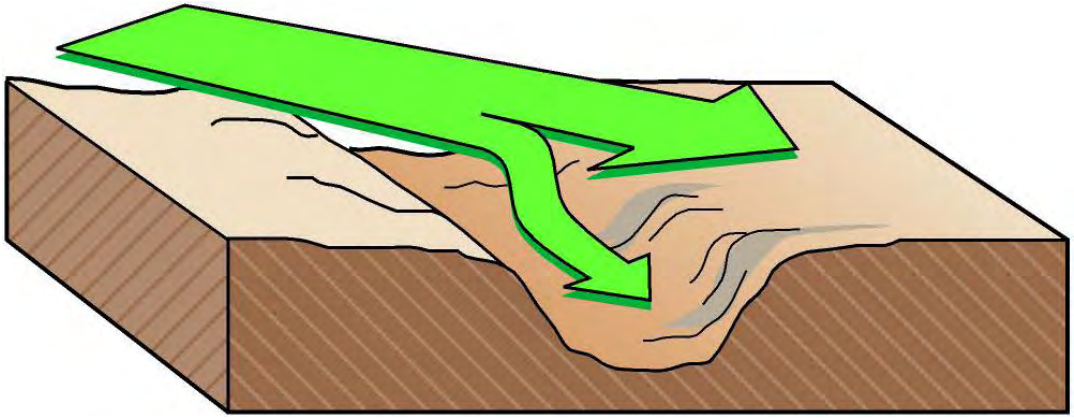
5. Wind characteristics
   - Channeled flow, turbulence, desiccation potential

The direction of the winds relative to the shape of the mountainous area will affect the way that winds move over the mountains.

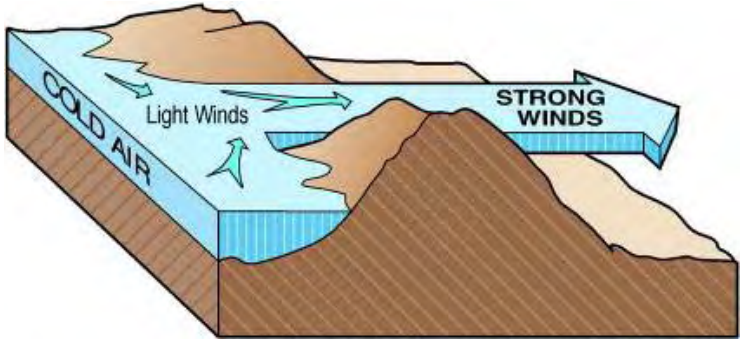


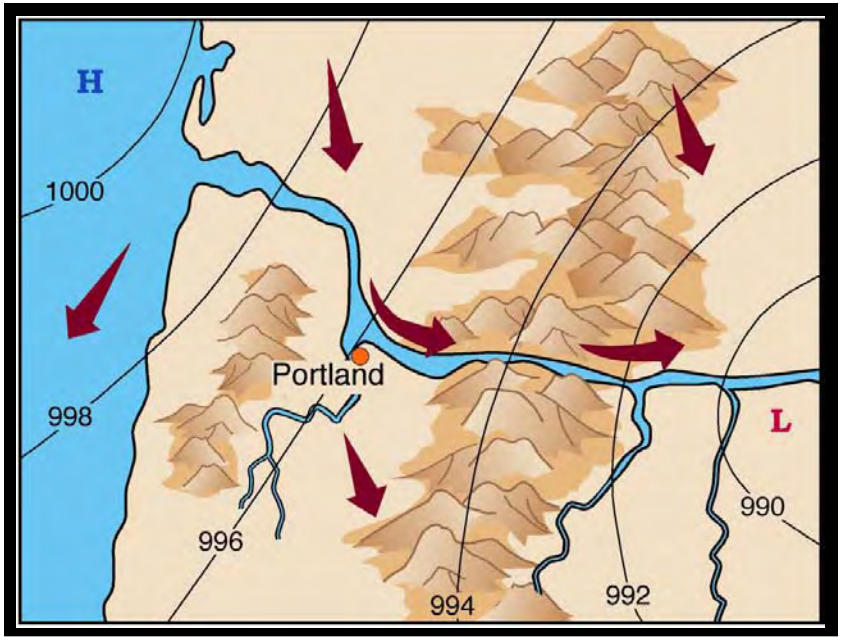
The greatest vertical motion is created with winds that move <u>perpendicular</u> to the mountain range.

Channeling of Synoptic/Mesoscale Winds



Forced Channeling

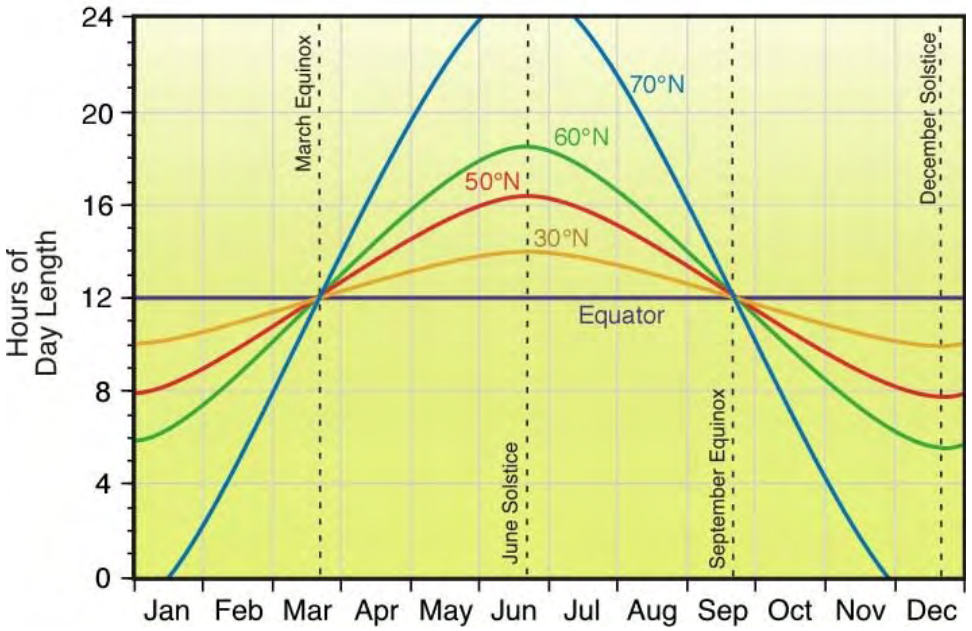


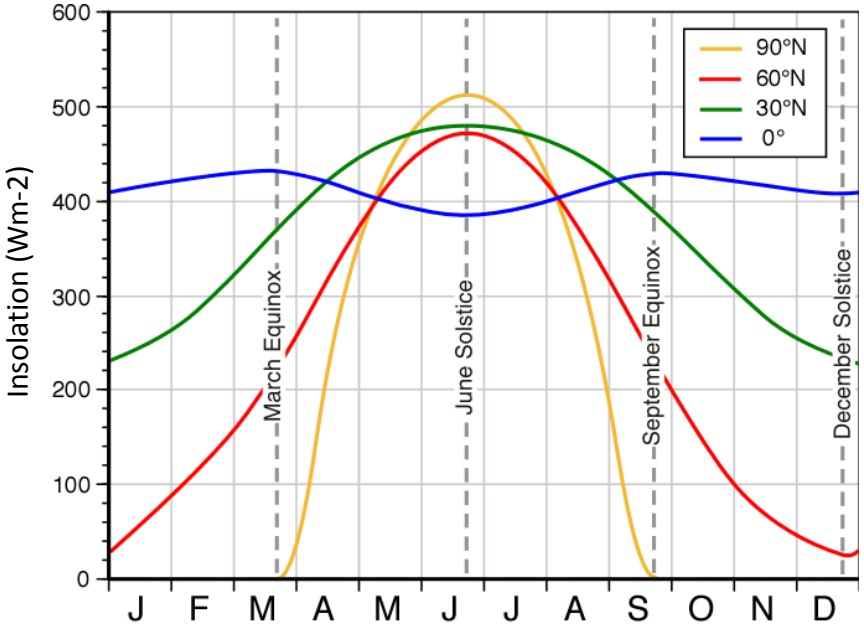


Pressure Driven Channeling

Weather and Climate Influences of High Latitudes

- Most weather/climate influences are similar, albeit with different source region influences
- Typically colder air masses and higher rainfall on poleward fringes of seasonally dominant high pressure regions
- The most dominant effects are on the length of the day (photoperiod) and solar radiation receipt



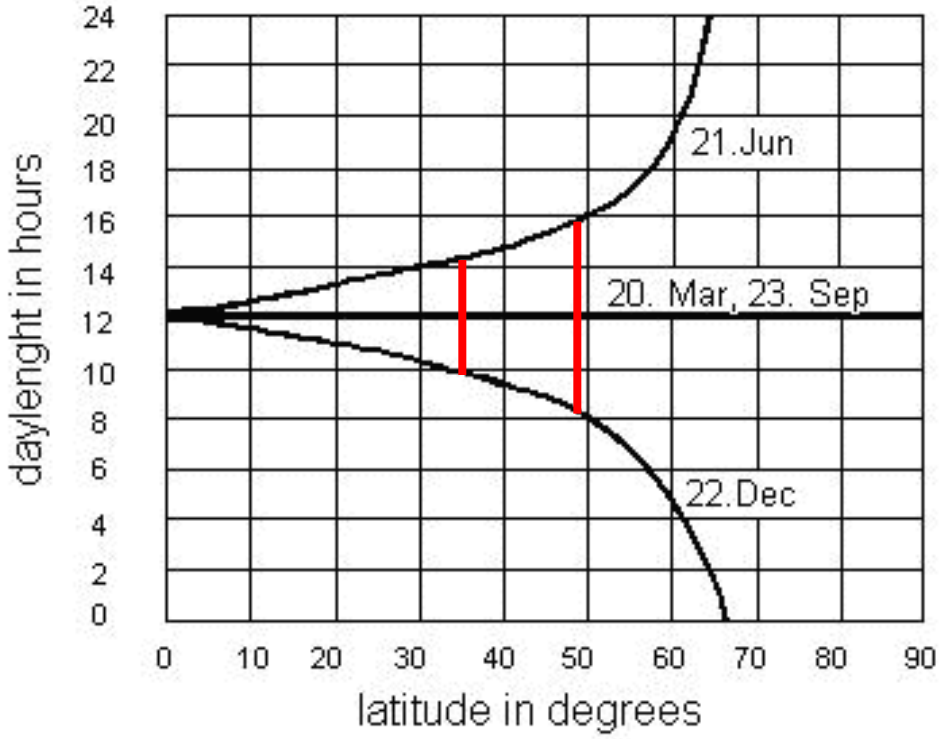


Weather and Climate Influences of High Latitudes

Paso Robles ~35.5°N

Annually day length varies from 10-14 hours

Growing season day length varies from 12-14 hours



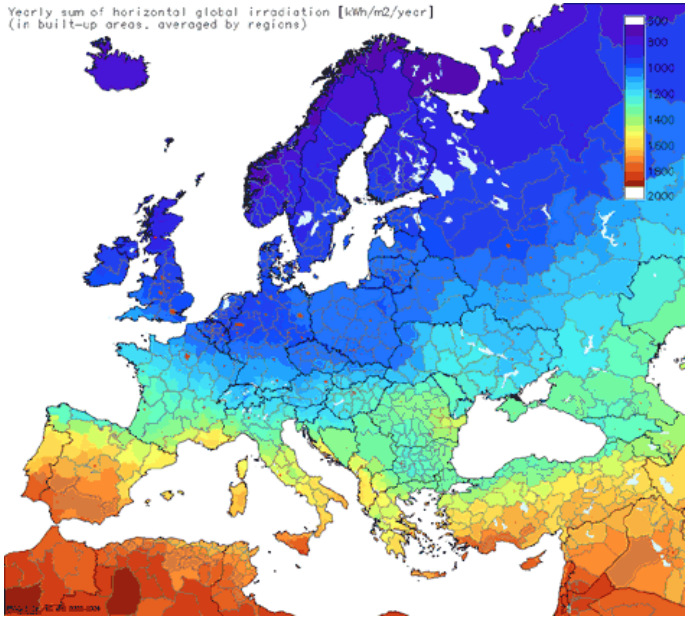
Okanagon Valley ~49.5°N

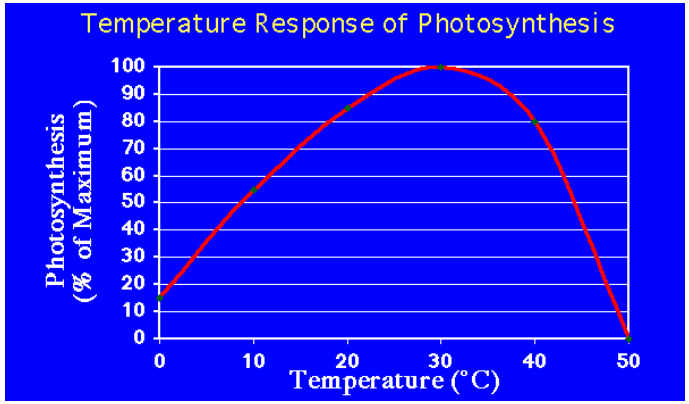
Annually day length varies from 8-16 hours

Growing season day length varies from 13-16 hours

Weather and Climate Influences of High Latitudes

- On an annual basis lower latitudes always receive more radiation
- During the growing season higher latitudes typically receive the same or slightly more solar radiation due to longer days
- Even if equal, higher latitude photosynthetic activity tends to be more efficient due to lower ambient temperatures and longer activity time
- Slope enhancement of solar radiation receipt more effective
- Rapid truncation of day length and solar receipt at high latitudes hastens ripening queues in the vines





Summary/Conclusions

- Elevated climates can be characterized by a rather distinctive combination of temperature, radiation, wind and rainfall patterns, as well as larger climate variability, over both spatial and temporal scales compared with lowlands at the same latitude.
- Many complex interactions and effects are hard to isolate
- While growing seasons are shorter at higher elevations, plant growth can be intense because of a favorable radiation climate and a marked contrast between day-time and night-time temperature (reduced respiratory loss).

Summary/Conclusions

- Radiative (especially UV) and CO_2 effects are likely the most important
- Higher latitudes, while cooler overall, have longer day lengths with longer and possibly more efficient photosynthetic activity. Rapid truncation of season in autumn clearly benefits ripening in some varieties.
- High elevation sites at high latitudes are more limited due to dual impacts on weather/climate and radiative effects.
- Clearly more research into how the various weather and climate parameters at higher elevations and increased day lengths higher latitudes influence vine growth, fruit composition, and wine quality is needed.

Thank You!

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