

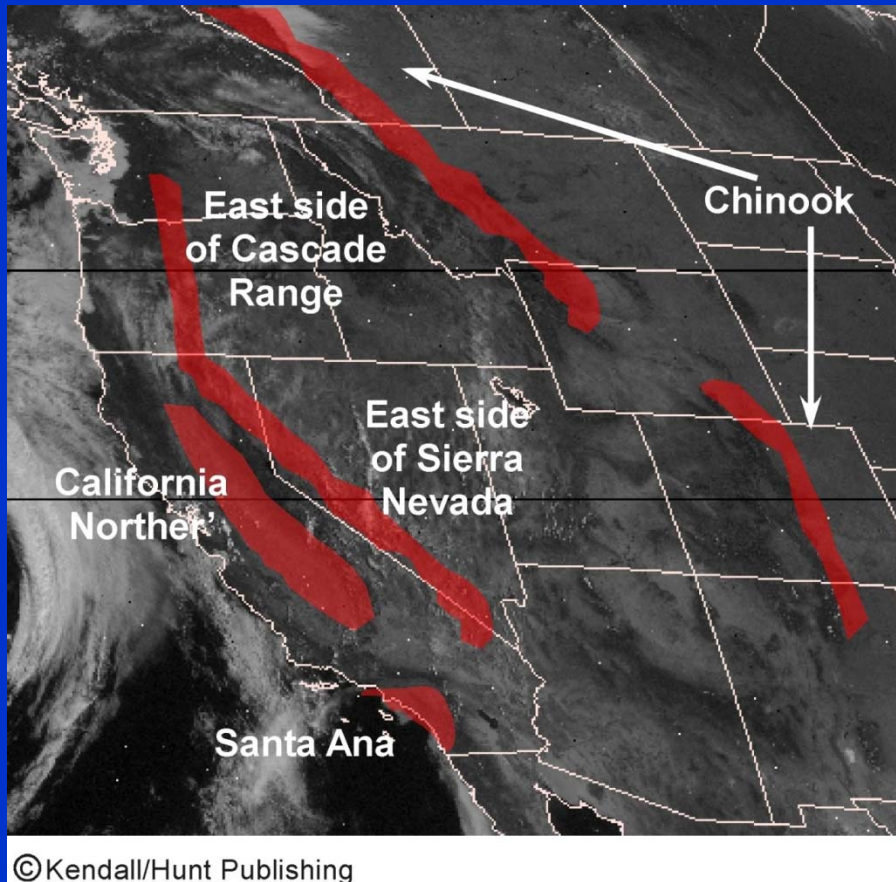
# Chapter 17: Mountain Windstorm



- ☐ Dynamics of Downslope Windstorms
- ☐ Chinook Windstorms of the Rockies
- ☐ Santa Ana Windstorms of California
- ☐ Katabatic Winds



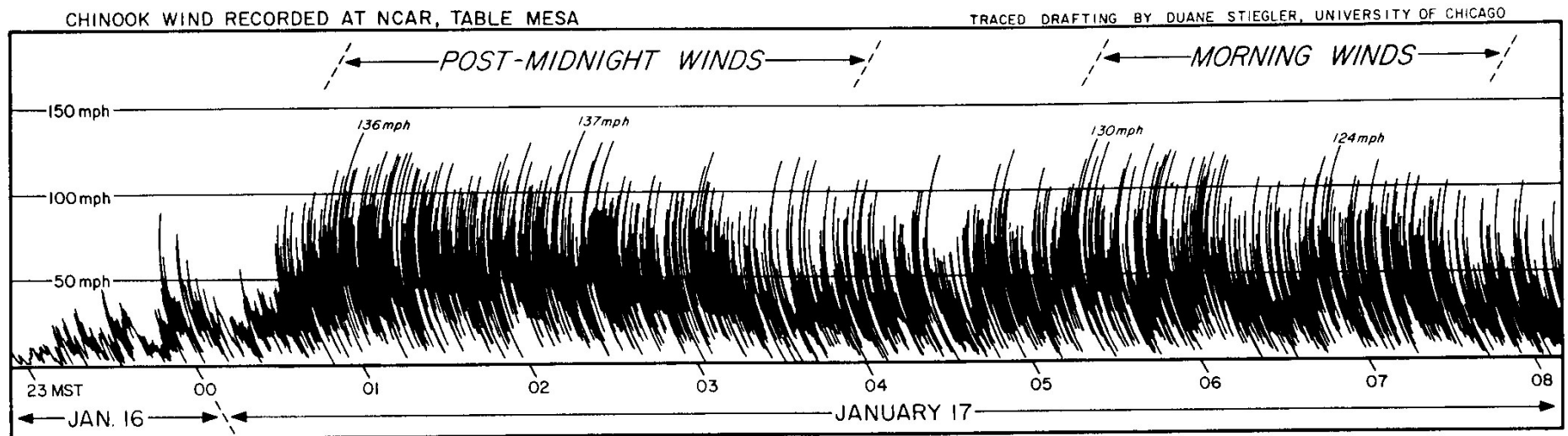
# Mountain Windstorms



- ❑ Downslope windstorms occur along many of the major mountain ranges of the world.
- ❑ In North America, downslope windstorms occur (1) along the east slope of the Rocky Mountain from Alberta to New Mexico, (2) along the east slope of the Sierra Nevada and Cascade Range, (3) on the west slope of San Bernardino, Santa Ana, and San Gabriel Mountains, (4) leeward side of the Alaskan and Chugach mountains in Alaska.



# The Chinook Wind Event on January 16-17, 1982

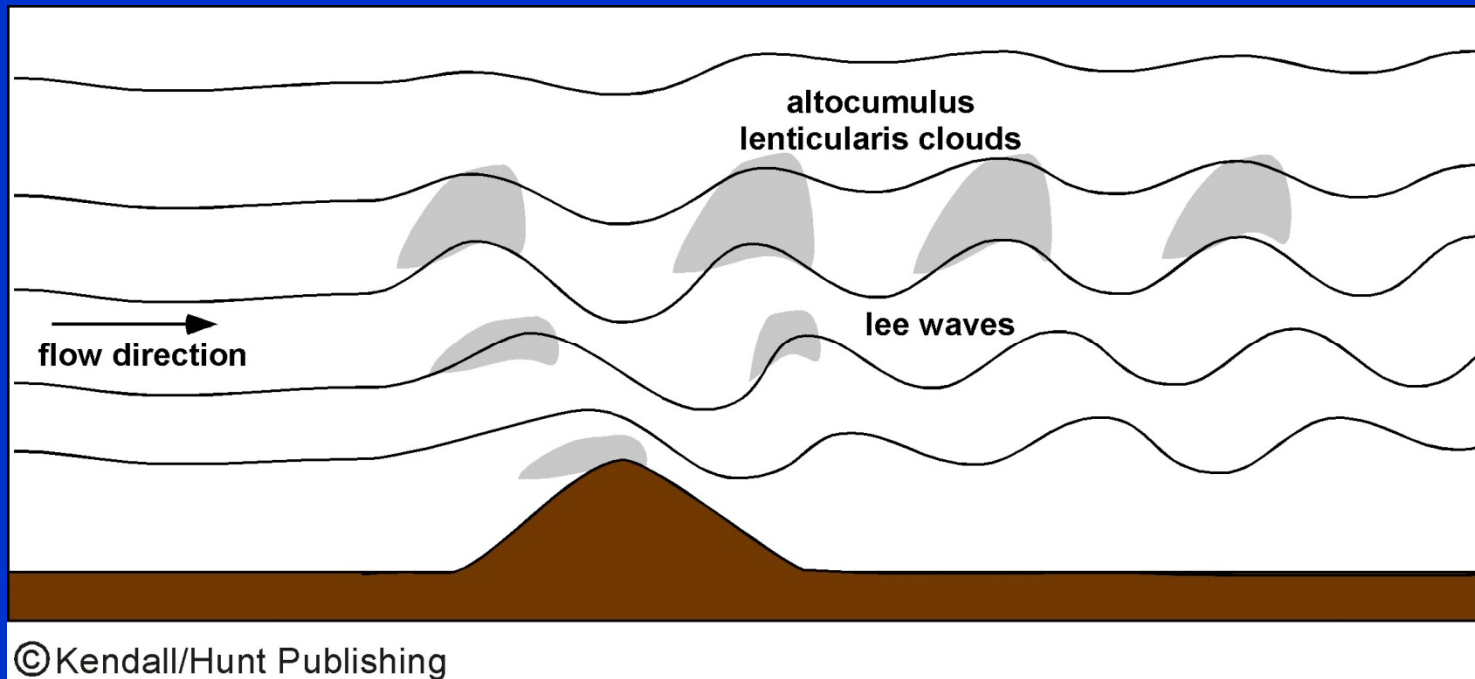


Courtesy of NOAA and NCAR

- ❑ Chinook winds are usually warm and dry and may exceed 100 knots (115 mph) in the worst storms.
- ❑ Chinook winds are violent and are always extremely gusty, with the winds vary from over 100 to less than 10 miles per hour and back again in less than a minute.



# Mountains and Lee Waves

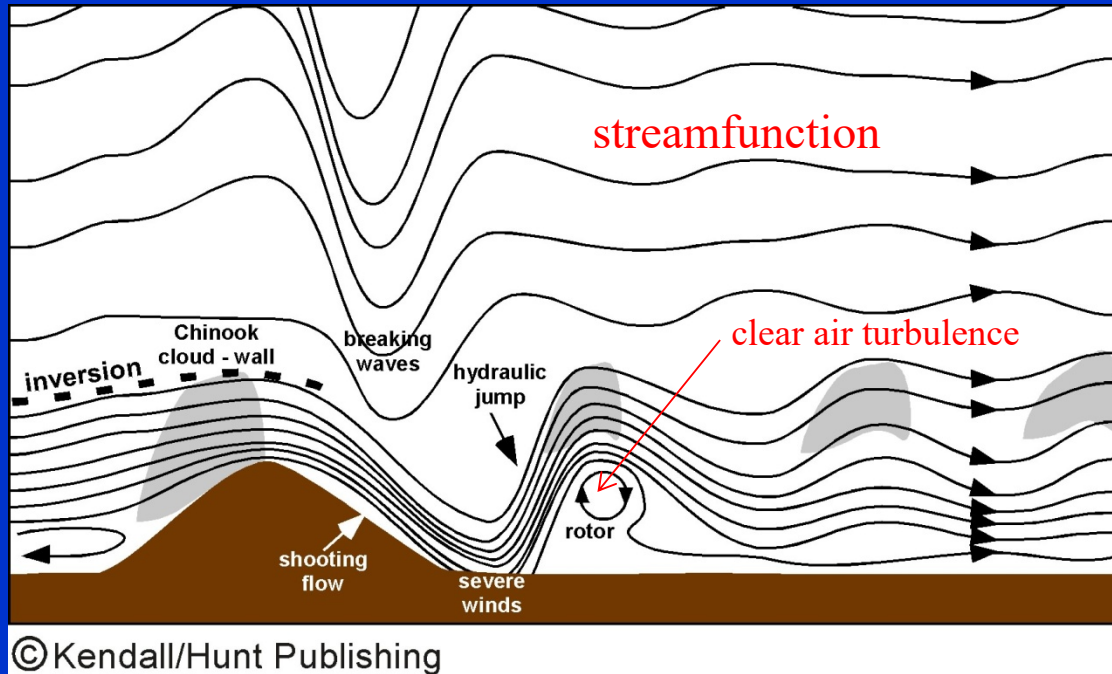


- ❑ When air approaches a mountain, it must rise on the windward side and descend on the leeward side.
- ❑ A series of waves will form downstream of the mountain.
- ❑ These waves are called lee waves and are commonly observed east of the Rockies.





# Dynamically-Driven Chinook Winds

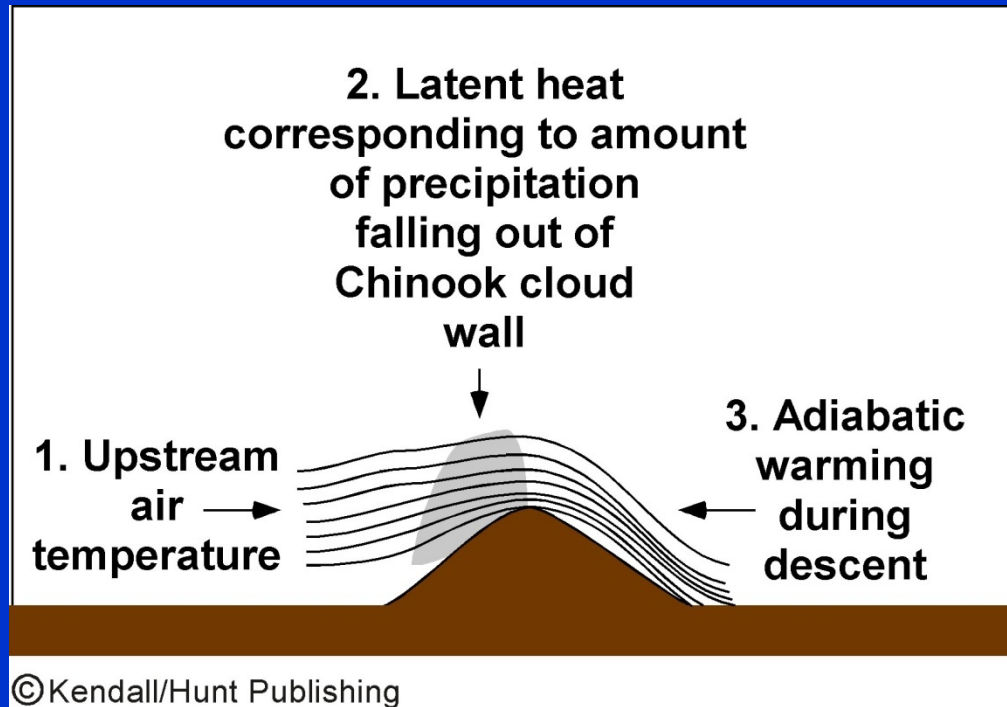


- When the cross-mountain flow near the mountain-top is strong and an inversion is present upstream just above the mountaintop, the mountain wave pattern will take a form called “hydraulic jump”.
- Air passing over the mountain between the inversion level and mountaintop accelerates downslope in a shooting flow toward the base of the mountain.

- The strongest winds in downslope windstorms occur as the shooting flow reaches the mountain base.
- Near or just beyond the mountain base, the flow abruptly rises to produce the “hydraulic jump”.
- Changes in the upstream wind speed and the height and strength of the inversion influence the character of a downslope windstorm.



# Factors Affect the Temperature of Chinook Windstorms



- ❑ Upstream air temperature: Air upstream of the Rockies can be warm when it originates over the Pacific, or cold when it originates over western Canada and Alaska.
- ❑ Latent heat release: Latent heat is released when upstream air ascends on the windward side. Air descends on the lee side will be warmer than the air at the same altitude on the windward side.

- ❑ Adiabatic warming: The temperature of air arriving on the plains is adiabatic warm during descent.
- ❑ Air descending to the base of the mountains can have relative humidity lower than 10 percent.



# Chinook Wall



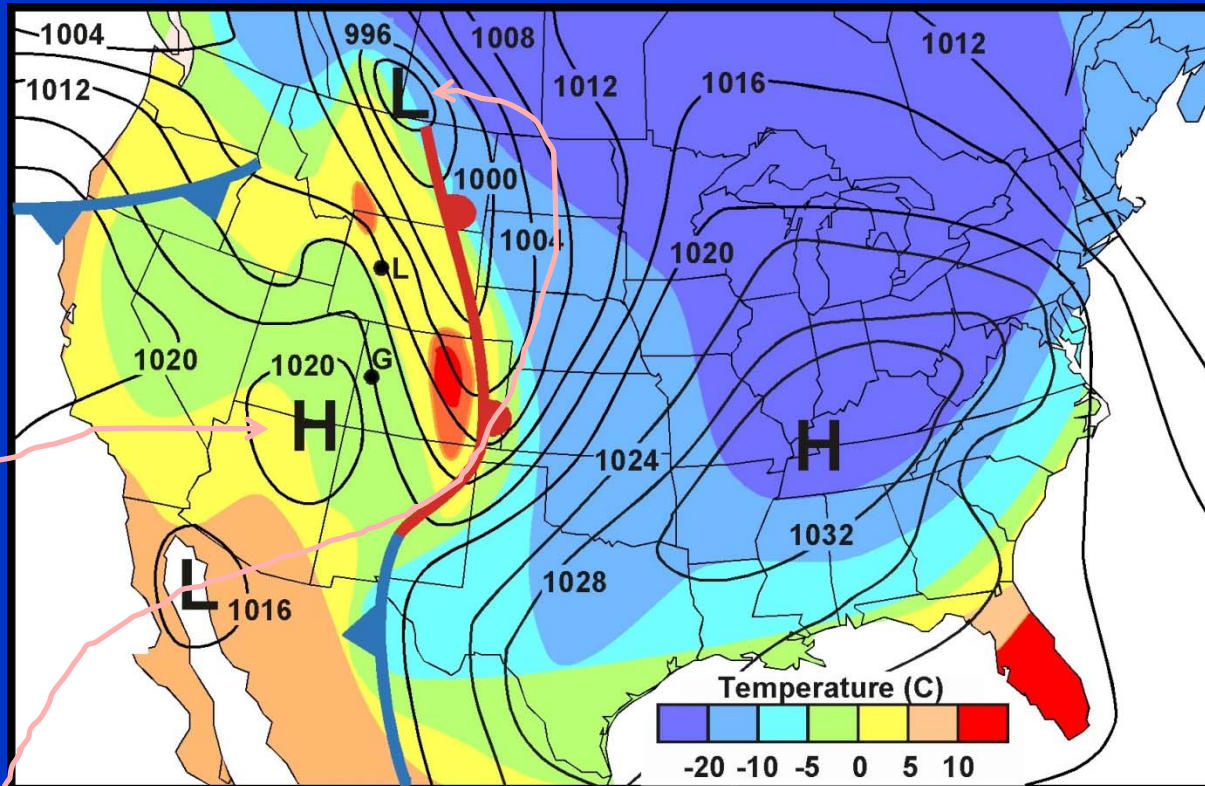
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The Chinook Wall, a wall of clouds that follows the mountain crest, is often present during downslope windstorms.



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# Forecasting Chinook Windstorms



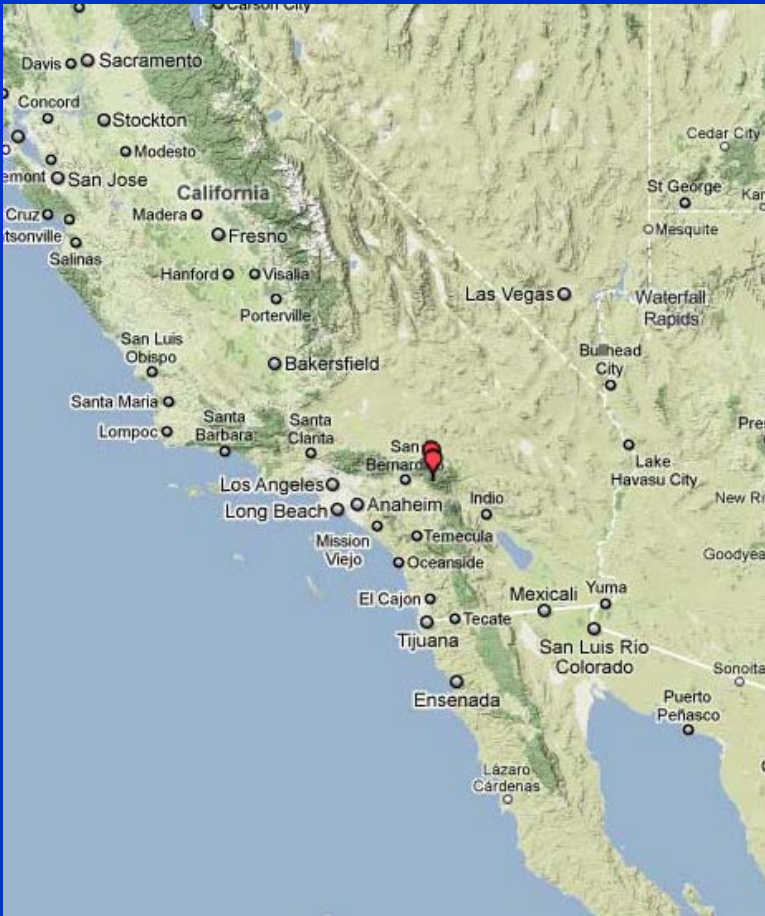
©Kendall/Hunt Publishing

- ☐ A stable (inversion) layer upstream of the mountain
- ☐ Strong surface-pressure gradient across the mountain
- ☐ Strong westerly background flow at the mountain top





# Santa Ana Windstorms of California



- ❑ The Santa Ana River Canyon, which runs from the San Bernardino Mountain southwest through the cities of Riverside, Anaheim, and Santa Ana, experiences episodes of strong downslope windstorms that called Santa Ana winds.
- ❑ Santa Ana winds are generally not as strong as the Chinooks of Colorado, but are dangerous because of their ability to spread wild fires.
- ❑ Santa Ana winds are most common during late fall and winter.
- ❑ About 20 Santa Ana winds occurs every year, lasting for about 1.5 days.



# Santa Ana Wind

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This is a picture of Fremont Canyon, located in the Santa Ana Mountains in Orange County. This canyon is known for its extremely high winds during Santa Ana wind events, where the winds can gust over 100 MPH during very strong Santa Ana wind events (picture from the Orange County Register).

## DEFINITION

**Strong** **warm** and **dry** winds blow over the southern California from the Great Basin, with speeds exceed 25 knots (46 km/hr).

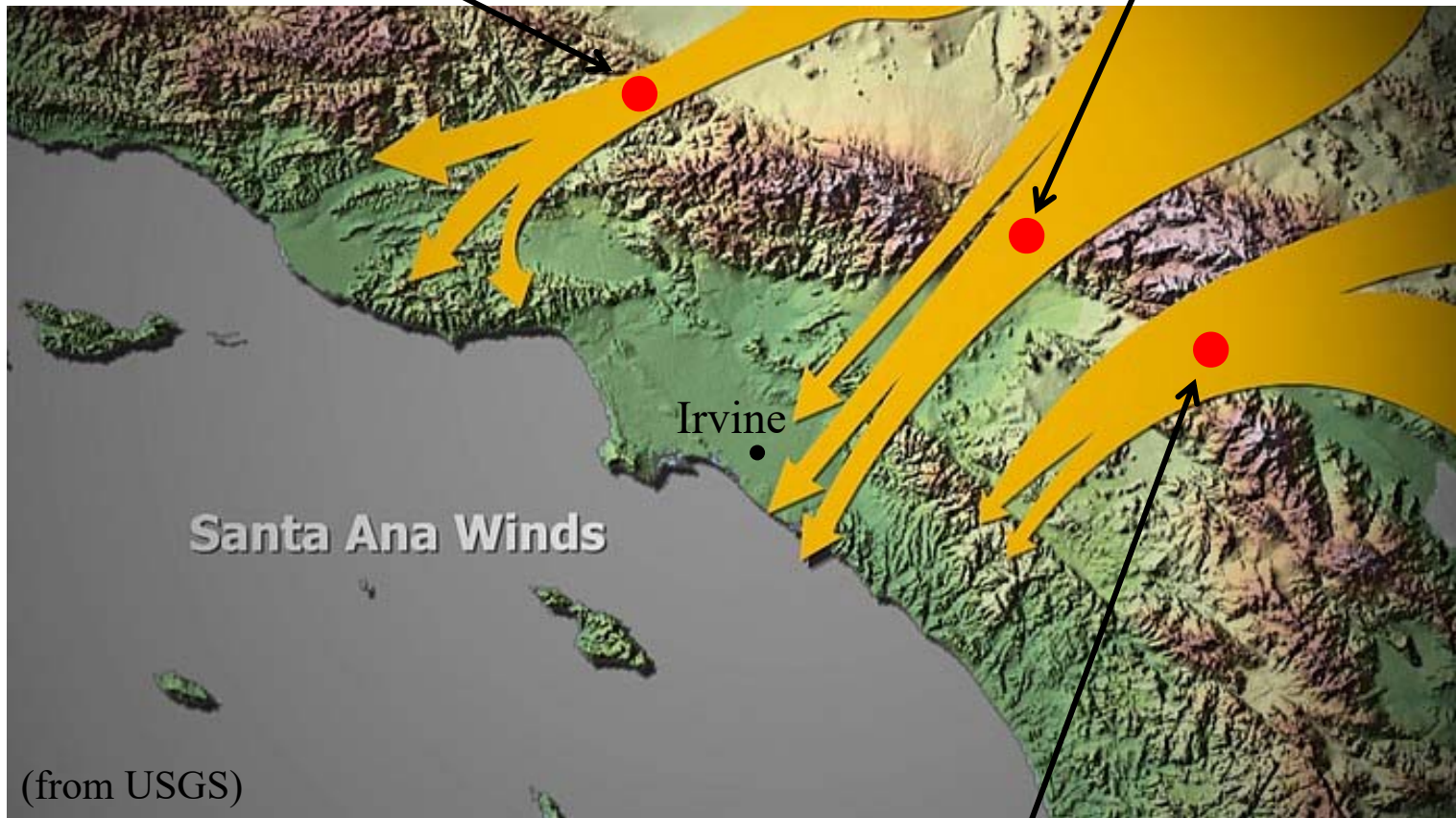
*The averaged number of days with Santa Ana wind is 23.6 days per year during 1948-2010 (Li, Paek, and Yu 2016).*



# Where do the winds enter California?

Soledad Pass

Cajon Pass



Irvine

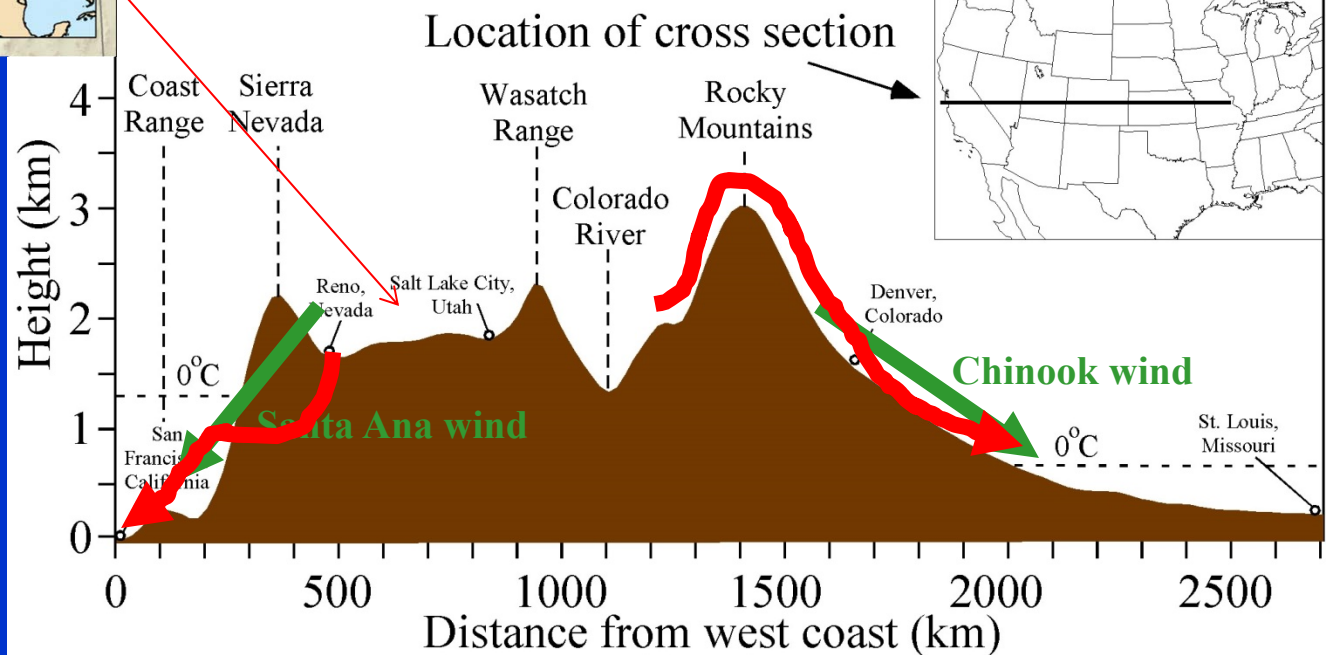
Santa Ana Winds

(from USGS)

San Geronio Pass



# Great Basin



© Kendall/Hunt Publishing



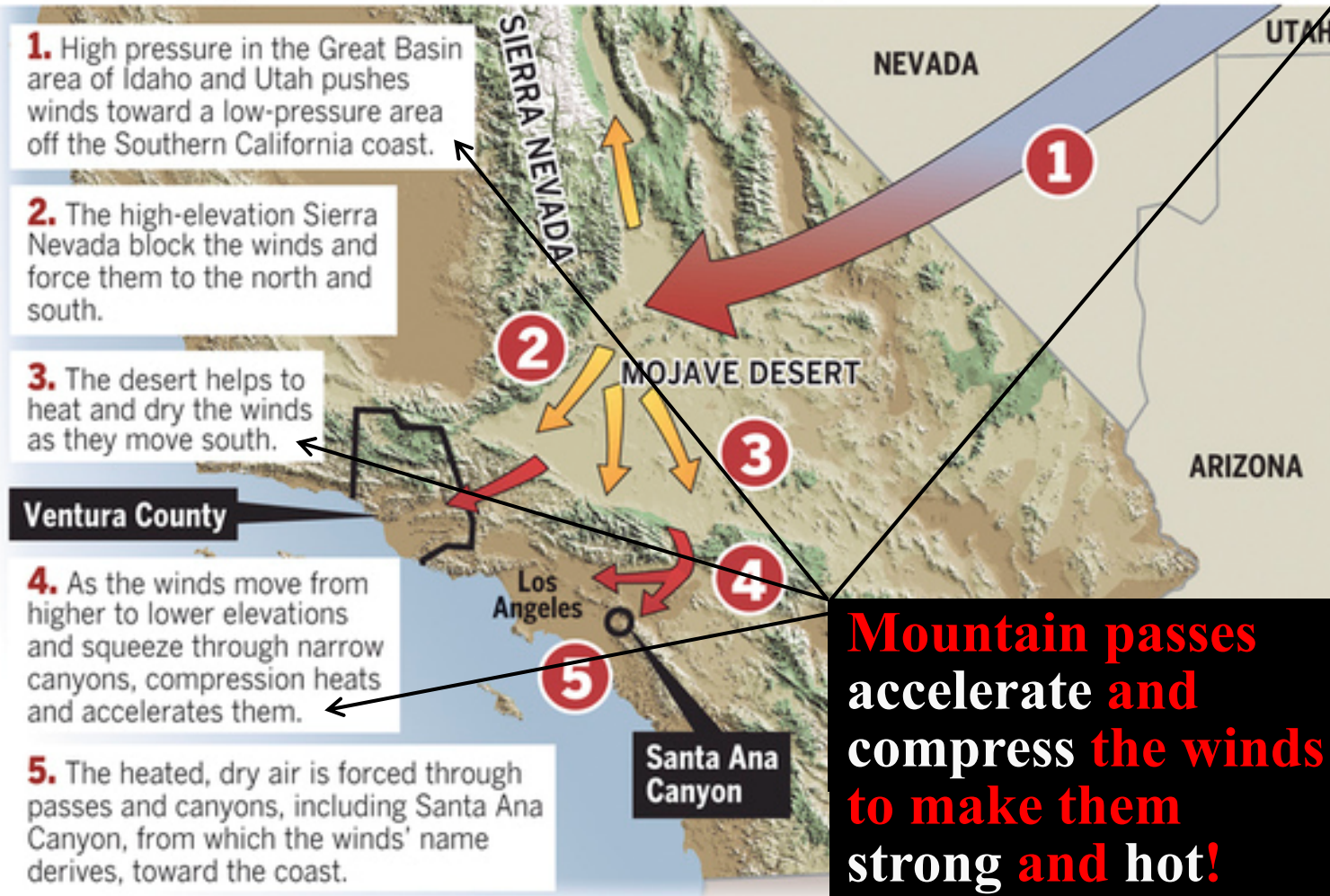
(from Ventura County Star)

## A primer on the Santa Anas

Santa Anas are dry, sometimes hot, winds in Southern California that blow westward through canyons toward coastal regions. They typically occur from October through March and tend to peak in December. The winds often spread wildfires in the fall across areas that have gone without rain for months.



(from LA Times)



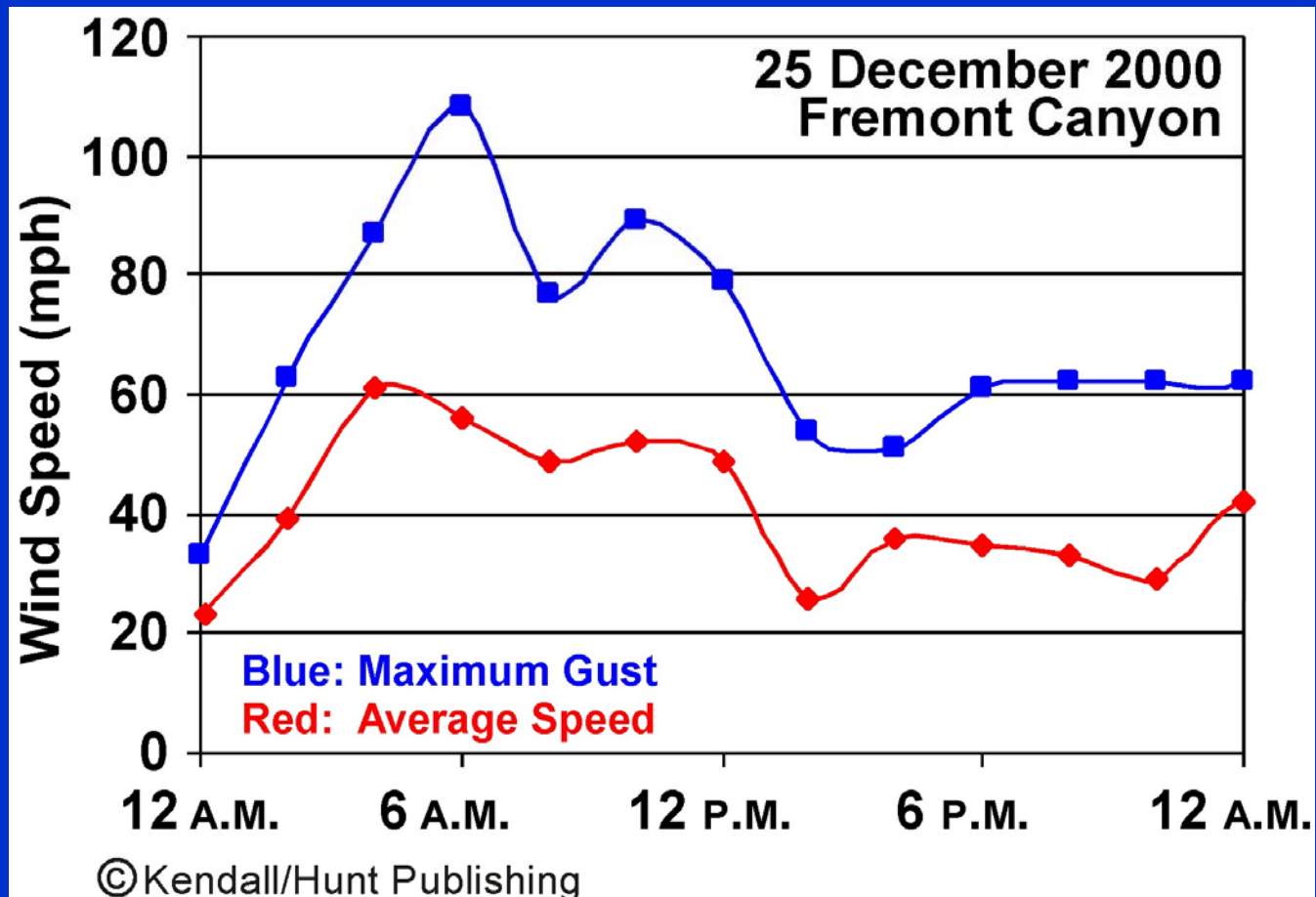
**Mountain passes  
accelerate and  
compress the winds  
to make them  
strong and hot!**

Sources: UCLA and UC San Diego research studies

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Figure 17.11



## **Diurnal and Seasonal Variations**

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### **Diurnal variation:**

**Stronger Santa Ana wind at night and weaker Santa Ana wind on the day.**

### **Seasonal Variation:**

**Occurs most frequently in winter (November to March).**





10/22/2007



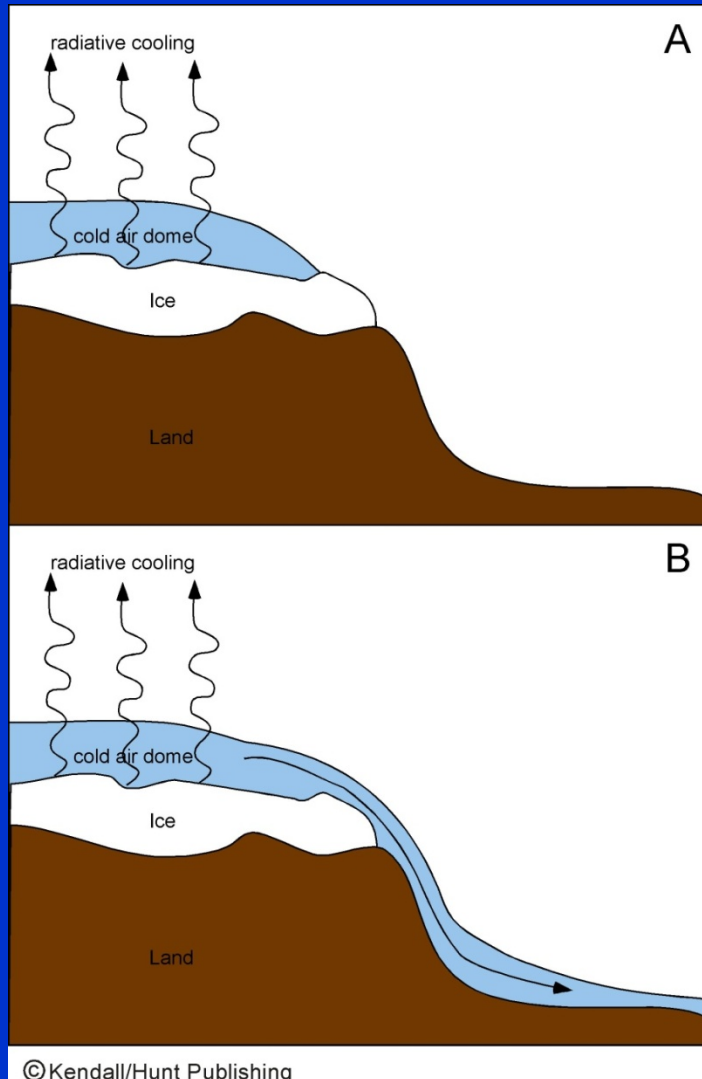
## CALIFORNIA FIRESTORM

### BREAKING NEWS





# Katabatic Winds



❑ Chinook and Santa Ana winds are dynamically driven by the pressure gradient across the mountain.

❑ Katabatic winds are driven by the cold, dense air flow downslope off the ice sheets.

❑ Katabatic winds can occur any time of the year, but are most common during winter, with gusts exceeding 100 knots.

