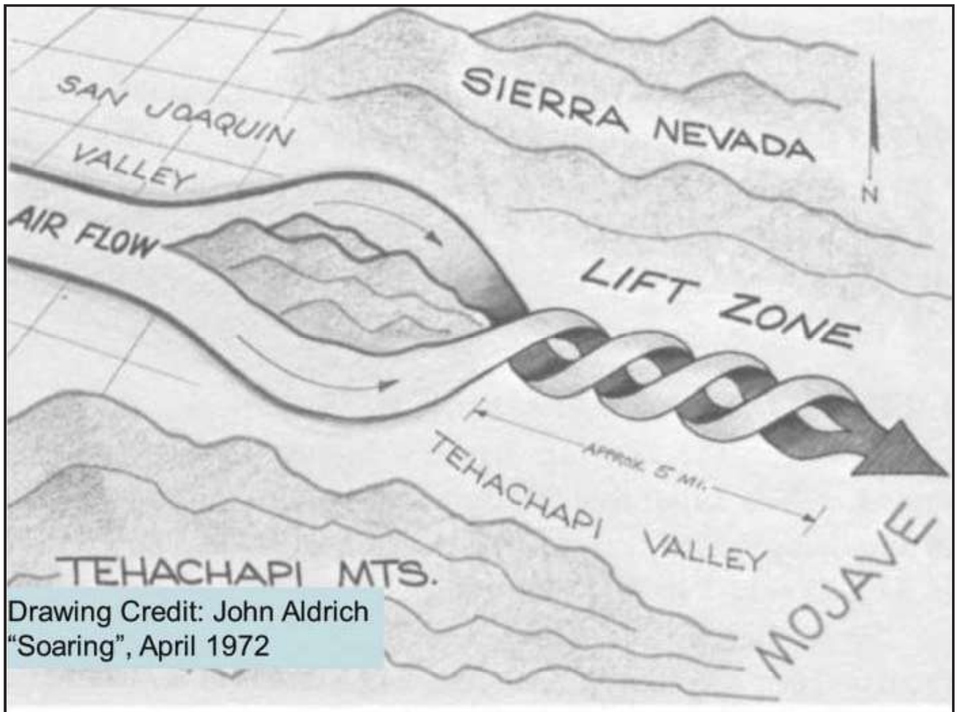
ner downwind of Bear Mountain. Larry Barrett, with his own flying experiences, also references comments made by longtime retired NWS District Ag Forecaster and pilot Darwin Wilkins that the "shear line" seemed to exhibit horizontal roll characteristics at times with the strongest lift on the south side of the lift line (See *Diagram #2: "Tehachapi Shear Line Roll"*). While the convergence line has occasionally been observed with lower atmosphere instability markers, (low-ceiling cumulus), it seems to form most consistently and with the strongest lift when some degree of "capping" stable layer below 9,000 feet MSL is present. This stable layer is produced by the subsidence in high pressure aloft following a winter cold frontal passage, or by the resident high pressure that lies over the Pacific Ocean along the California coast during the warm season. If the moisture content is sufficient in combination with the "shear line" uplift, the line of lift will be marked as a cloud street (See *Picture: "Tehachapi Shear Line Cloud Street"*). Atmospheric moisture for shear line cloudiness can be provided by the air layer at the Tehachapi Valley level, or by moisture contributions from upslope air flow from the San Joaquin Valley. Even with widespread cloudiness from upslope air flow on the northwest slopes of the Tehachapi Mountains, often the shear line presence can still be detected by a heavier line of clouds embedded within the low-lying overcast over the valley. The best visual evidence of the shear line, however, is the development of a cloud street formed due to the convergent uplift…and clear conditions prevailing elsewhere.

Thus, the meteorological scenario for the Tehachapi Shear Line development starts with a sufficient pressure gradient in the lower atmosphere that supports a northwest wind typically of 12 to 20 knots through and over the Tehachapi area. Less frequently, however, the shear line has been observed to occur with higher wind speeds.

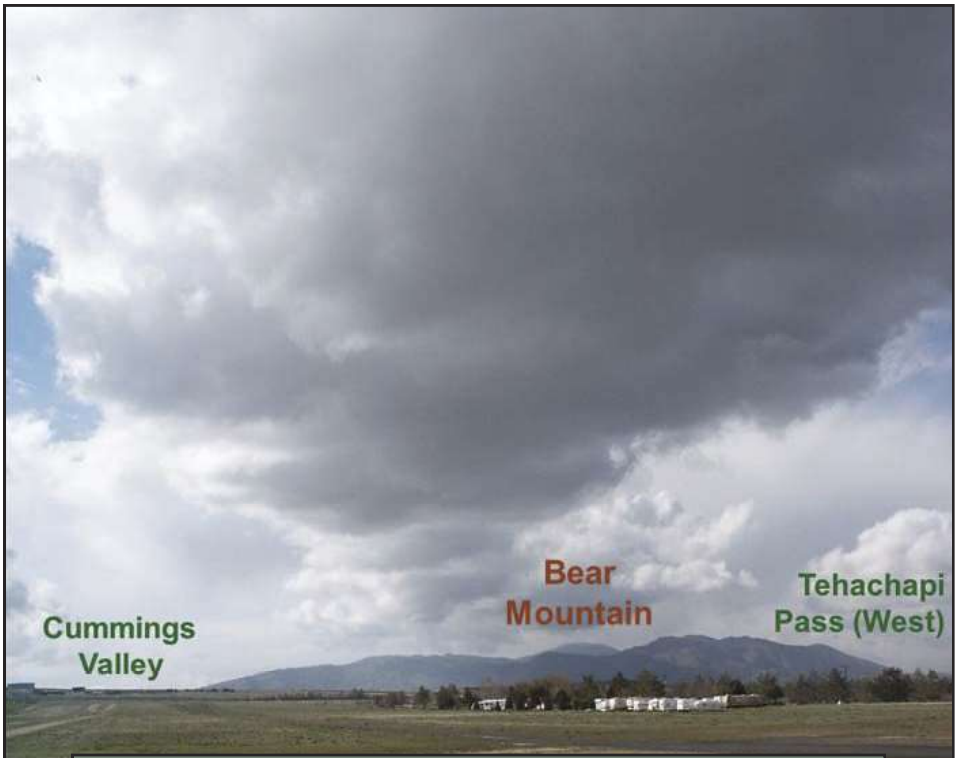
The surface pressure pattern that supports this kind of flow is one where higher pressure resides northwest of the Tehachapi Valley with lower pressure inland and southeast of the area. This type of surface pressure pattern can come about following a synoptic scale event such as a frontal passage, or the more typical interior California pressure pattern resulting from a large meso-scale Valley-Mountain wind in combination with Mojave Desert heating.



Drawing Credit: John Aldrich
"Soaring", April 1972

Tehachapi Shear Line Roll

An air layer subsides (sinks) and warms ahead of the high pressure center result-



Tehachapi Shear Line Cloud Street
(Looking WNW from Mountain Valley Airport)

ing in a temperature inversion aloft. Subsequently this inversion acts as a "cap" over the Tehachapi Valley thus keeping air motion below the cap in its own vertical circulation around the shear line. (The presence of subsiding air aloft associated with high pressure likely supports shear line development by limiting its vertical extent for some form of a closed vertical circulation.) This "cap" also keeps air flow in a horizontal plane to flow "around" both sides of Bear Mountain rather than passing over it.

The perceived "roll" of the shear line may be attributed to the differential heating of air rising from the South San Joaquin Valley through the Tehachapi Pass north of Bear Mountain versus the air arriving in the Tehachapi Valley after passing through Cummings Valley. A more gradual lifting of air through the Tehachapi Pass on the north side of Bear Mountain does not warm the air as much as that warmed from the steep Tehachapi Mountain slopes south of Bear Mountain and its passage through the Cummings Valley on its way into the Tehachapi Valley. With the air warmer on the south side of the line, it flows over the air converging from the north and, thus, the "roll" of the line (Again, see *Diagram #2: "Tehachapi Shear Line Roll"*).

On days when the Tehachapi Shear Line is broad, the south side of the convergence line is much sharper in the transition into the line with stronger lift rates. This is in comparison to the north side of the shear line that is characterized by lower lift rates and higher sink rates adjacent to the shear line. Flight utilizing the lift of the Tehachapi Shear Line is like other types of shear lines, i.e., typically wings-level flying. Pilot and any passengers are provided comfortable "ride" conditions as opposed to the circling necessary to use thermals for soaring flight. Additionally, the Tehachapi Shear Line does have some interesting characteristics:

1) The "lift line" can be narrow at times. In fact, the pilot can perceive the shear line lift as if it were a sharp ridge with a rapid diminishing of lift immediately to the left and right. Under this situation, the lift line is so sharp that a pilot may feel that the lift can be felt to shift from one wing tip to the other with just a small heading change;

2) With a narrow line-of-lift, turning in the line is typically unrewarding as any turn only puts the pilot into sink adjacent to the converging air. Therefore, "dolphin" flight along the line is a far more efficient soaring technique;

3) The lift rate along the shear line is typically not steady. There are areas of stronger and weaker lift (if not absent altogether at "weak" spots). General lift rates under "non-thermal enhancement" conditions vary from "neutral"/no-loss-of-altitude to six knots of lift. During the warm-season months, the shear line can enhance thermal development along its axis. In this instance, soaring pilots are able to turn with positive climb rates for the entire circle, with observed lift rates of six to ten knots not uncommon. However, climbing to altitudes higher than 9,000 feet MSL is generally not productive in the shear line, and pilots usually move to adjacent higher terrain in searches for thermals that extend higher;

4) In thermal lift, gliders circle and are easier to spot. However, like all shear line soaring, gliders fly for extended periods of time in wings level configuration. Thus, there is an added difficulty in collision avoidance as gliders approach each other with minimal cross-sectional area exposed. The Tehachapi Shear Line is no exception and adherence to accepted practices for right-of-way is prudent with gliders passing each other on the right. However, it becomes difficult to adhere strictly to this right-of-way rule when the shear line has "lift pockets" from thermal enhancement and gliders are able to circle within the shear line. Again, flight within the shear line demands an increased awareness for collision avoidance scanning and procedures; and,

5) Flight in a line through the axis of the Tehachapi Valley and farther west is not exclusively from convergent flow. Pilots have been able to fly westward toward the peak of Bear Mountain by transitioning from convergence in the Tehachapi Valley to that of thermals coming off both the north and south slopes of the NW-SE spine of Bear Mountain with some degree of low-level instability supporting thermal development.

My purpose in writing this series of articles entitled "Weather to Fly" was to provide some meteorological information and concepts for soaring pilots. The "Elsinore Shear Line" in Southern California is often cited as "the Classic Example" of terrain-induced convergence in numerous aviation textbooks and publications. A quick review of the topography of the Southern California coastal area shows its coastal plain rising to higher coastal area terrain features. These features include the Inland Empire plateau around 1,500 feet MSL east of Corona, and the Santa Ana Mountains southeast of Los Angeles varying from 4000 feet MSL to the high point of Santiago Peak, at 5,720 feet.

Having discussed the sea breeze and its density-driven winds in the May 2012 installment of "Weather to Fly," the Elsinore Shear Line develops from terrain channeling and diversions of the Southern California Sea Breeze as it pushes inland off the immediate coastal plain (See *Diagram #3: "Elsinore Shear Line"*).

As the sea breeze sweeps inland beginning in the midmorning hours, it pushes through both the Santa Ana Pass toward Corona on the northwest side of the Santa Ana Mountains, and through Temecula Pass on the southeast side of the mountains (locally known as the Ortega Mountains north of this pass).

Soaring is possible along any sea breeze front due to speed convergence, but the added directional component of convergence near Lake Elsinore makes it particularly distinctive. The air coming from the northwest typically contains more pollutants from the south Los Angeles Basin as well as its more dense cool, moist air. At the onset of the sea breeze immediately along the coast, the air pushed ahead of the sea breeze at Temecula Pass is drier, a little warmer, and has better flight visibility associated with it. With the air arriving from the northwest on the east side of the Santa Ana Mountains, there is a very discernible line-of-discontinuity in regard to air mass moisture, visibility, wind speed, and wind direction marking the location of the convergence.

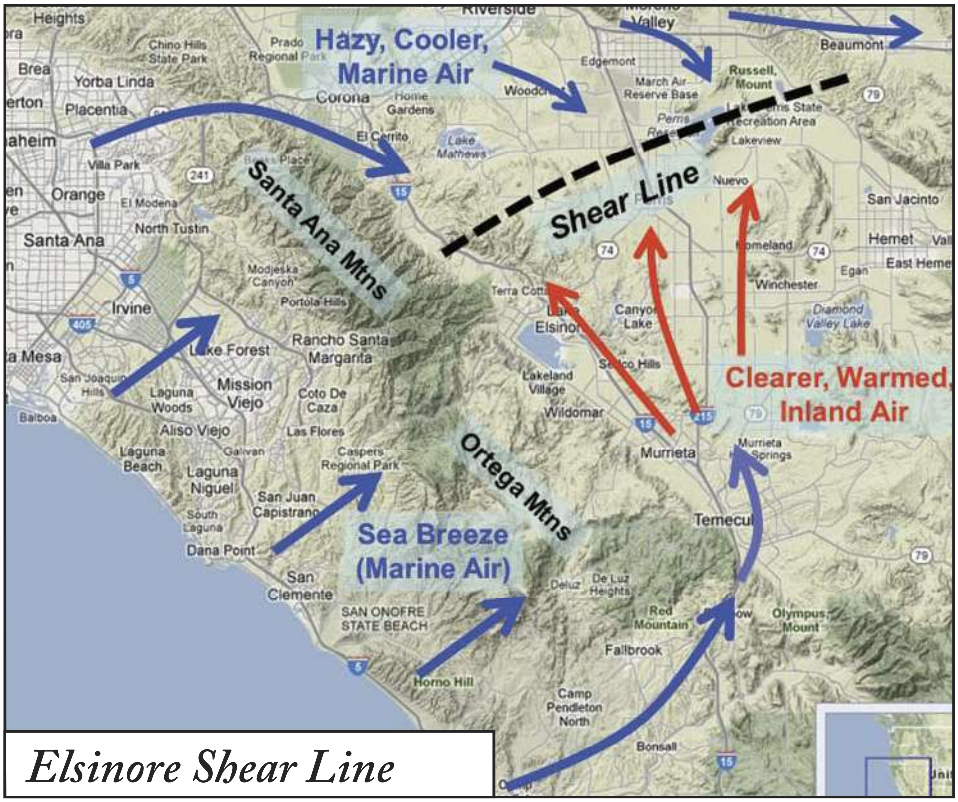
Due to its higher density, the cool marine air arriving from the northwest drives not only under the resident inland air, but also drives under the arriving air from the southeast. The best lift zone for soaring literally has the glider pilot placing one wing in the "smog" arriving from the northwest and the other wing in the clearer air to the southeast. Typically, the sea breeze encircling the Santa Ana Mountains meets from opposite directions about 5 miles northwest of Lake Elsinore on the inland side of the mountains around 10:00-11:00 a.m. However, this initial convergence location is not geographically fixed, as it is influenced by the day-to-day changes in the orientation of larger-scale surface pressure gradients. These diurnal changes in the pressure gradient influence the sea breeze speed and direction changes around in the Los Angeles area.

In response to the inland advance of the sea breeze toward the Ontario and Riverside areas as well as air pushed through Temecula Pass, the Elsinore convergence line typically drifts southeast and begins extending toward the northeast and Banning Pass during the early and mid-afternoon hours. The sea breeze front generally reaches the vicinity of March Air Reserve Base (ARB) in the 2:30 to 3:30 p.m. time period, with typical winds from the west-northwest in the 10-15 knot speed range. Movement of this convergence zone is inland at about 5 knots.

Again, the Elsinore Shear Line is not geographically fixed with variation in its location in the area around March ARB to Hemet. And, much like the Tehachapi Shear Line, the convergence zone shows some serpentine characteristics along its line. Nonetheless, the shear line lift is not only the result of the speed convergence of the inland pushing sea breeze, but the lift rate is augmented by the conflicting wind direction for added convergence provided by wind from the Temecula Pass.

Typical altitudes reached along the Elsinore Shear Line are in the neighborhood of 4,000 to 6,000 feet MSL. With summer days, the lower layer air residing over the Inland Empire Plateau destabilizes due to stronger daytime surface heating. Afternoon thermal development is enhanced along the shear line with the shear line arrival and subsequent climbs to altitudes of 11,000 feet MSL are not uncommon.

The shear line tends to focus thermal activity to the extent that thermal activity adjacent to the line is more widely spaced and weaker even as thermals along the line become better organized and stronger. The width of the Elsinore Shear Line lift may approach one-half mile and it is very often marked by a cloud street. Climb rates due to the shear line are generally 3-5 knots but shear line enhanced thermals reach to the 8-10 knot range. The conflicting air flow around the Santa Ana Mountains typically continues to provide some con-



Elsinore Shear Line

vergence for useful lift to the 6:00-7:00 p.m. time period, even though the most active convergence has moved southeast and extended more to the northeast.

At the end of the afternoon the northeast side of the Santa Ana Mountains becomes shaded. This late-afternoon shading combines with the long-lived marine air influences to wash out the convergence line, resulting in sink in the vicinity of Elsinore. The active lift of the shear line at this point is typically from Perris and east towards Hemet.

Much like the Tehachapi Shear Line, flight right-of-way rules need to be adhered to for safety-of-flight in regard to collision avoidance. Unlike Tehachapi, however, the proximity of the Elsinore Shear Line to the complex airspace over the Los Angeles area adds additional burdens to fully utilize the convergence lift:

1) Consideration must be given to flight rules directly associated with the March ARB Class "C" airspace that hosts the shear line. Any flights west of March ARB begin to have other airspace considerations for the Ontario Class "C" and Riverside and Chino Class "D" airspaces. Even without the March ARB airspace encumbrance, the airspace to the north becomes quite busy with lower altitude general aviation traffic, and higher altitude heavy turbine and prop-jet aircraft; and,

2) The Lake Elsinore and Perris Airports have active skydiving operations adding to the airspace use in the shear line.

The presence of mountains and valleys results often in winds being channeled, blocked, or diverted. Although present in various forms around the country, I have presented just a couple of simple examples in regard to the interaction of elevated terrain with air flow that results in convergence or shear lines providing upward moving air sufficient for soaring flight.

Acknowledgments

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Lastly, I would like to thank Mark Grubb, a well-experienced Glider Instructor and Tehachapi resident, for his help in reviewing this article and his confirming insights into the behavior of the Tehachapi Shear Line.

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{Writer Note: John Aldrich was the Supervising Aviation Forecaster for the Los Angeles Office of the U.S. Weather Bureau and an active supporter of soaring through his contest forecasting as well as frequent informational articles on aviation meteorology.}

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