'Rogue' Air Currents

By Bob Thompson

There is a saying in the educational community – "If you continue to ask the wrong questions, you will continue to get the wrong answers." There have been, and continue to be, many comments by the general soaring community of "Why are so many glider pilots dying in stall / spin accidents, particularly very experienced pilots?" I used to sing in that chorus. Dead pilots can't share their unfortunate stories with us, so these questions will continue to be asked. The RAS (rec.aviation.soaring newsgroup) overfloweth with opinions / proposed answers, mostly dealing with pilot training or reactions and some with glider type. However, there's more to flying and crashing than just pilot and aircraft… there's also the air we fly in. Yes, some accidents are caused by pilot error, and some are caused by mechanical problems or particular glider characteristics. Doesn't it seem reasonable there is a possibility that the atmospheric arena could sometimes have some affect, too?

We are flying in a very dynamic fluid – air. Perhaps looking at other examples of fluid mechanics and their impact(s) on the equipment humans move through them with might give us something to think about and compare to. Physicists look at both air and water as fluids, with differing viscosities.

Oceans and other large bodies of water occasionally have very large "rogue" waves about which not a lot is known, although recent research using satellite data indicates they are more common than originally thought. They are single exceptional waves more than double the height of the average large ocean waves, and with very steep faces. Occasionally more than 100 feet high, these rare waves surprise mariners and can cause considerable harm, sometimes sinking ships. "Previously, data collected by weather ships suggested that such waves would occur only every 50 years or more. In 2004, the European Space Agency (ESA) used data from two radar-equipped satellites to see how frequent rogue waves actually are. After analyzing radar images of worldwide oceans taken over a period of three weeks, the ESA's MaxWave Project found 10 waves 82 feet (25 meters) or higher. That was an astonishingly high number for such a relatively short time span; it forced scientists to seriously rethink their ideas on rogue waves."[1]

The atmosphere also has dangerous phenomena, which can come in a variety of forms. Quoting an article in the magazine *Nature Climate Change*, "Atmospheric turbulence causes most weather-related aircraft incidents. Commercial aircraft encounter moderate-or-greater turbulence tens of thousands of times each year worldwide, injuring probably hundreds of passengers (occasionally fatally), costing airlines tens of millions of dollars and causing structural damage to planes. Clear-air turbulence is especially difficult to avoid, because it cannot be seen by pilots or detected by satellites or on-board radar. Clear-air turbulence is linked to atmospheric jet streams, which are projected to be strengthened by anthropogenic climate change."[2]

The gliding community is aware of the concept of clear air turbulence affecting commercial and general aviation, and the atmospheric turbulence associated with rotors in wave flight and

Opposite page: Two dust devils with very different shapes; one broader and widening up higher, and the other very narrow and getting even more narrow with altitude, Imagine hitting either of these, or the one on the cover, at very low altitude with only wing while flying slowly. Photographed at Crystalaire Airport in Llano, California, by Chuck Coyne.

sink on the lee side of ridges and mountains. Those will not be the focus of this discussion.

There are visible, powerful updrafts which occur close to the Earth's surface and suck up dust, dirt, and other available loose materials from the land surface. Called by most folks "dust devils" if small and "tornados" when they are large and attached to clouds, these are easily observed and avoided by pilots. However, in clear air, tight cores still have the potential to create upset hazards for glider pilots.

"The family of atmospheric columnar vortices includes tornadoes, waterspouts, fire whirls, dust devils, and a variety of other whirlwinds. Each member of the family is characterized by the presence of a relatively tall, concentrated vertical core. Descriptions of such swirling flows are inherently complex, reflecting the presence of a multiplicity of length and velocity scales. In many cases, the flow is both three-dimensional and unsteady." [3]

Scientific research into tight vertical air currents ("vertical vortex convection" is the scientific term often used in the literature) has mostly centered on dust devils, with the topic getting a huge boost from interest in Mars and studies of the surface of that planet. Recent Martian atmospheric research and related dust devil studies here on Earth have produced some data that can be extrapolated to help understand rogue air here on Earth. Researchers have found internal downdrafts within some dust devils, with these downdrafts noted to be more intense as you get higher. Figure 1 (below left) shows a conceptual cross-section of a dust devil taken from some of this research that shows shears between internal rising and sinking air. Tight core rising air masses were also noted sometimes to be clear and absent of any dust or other particulate matter.

Researchers have found internal downdrafts within some dust devils

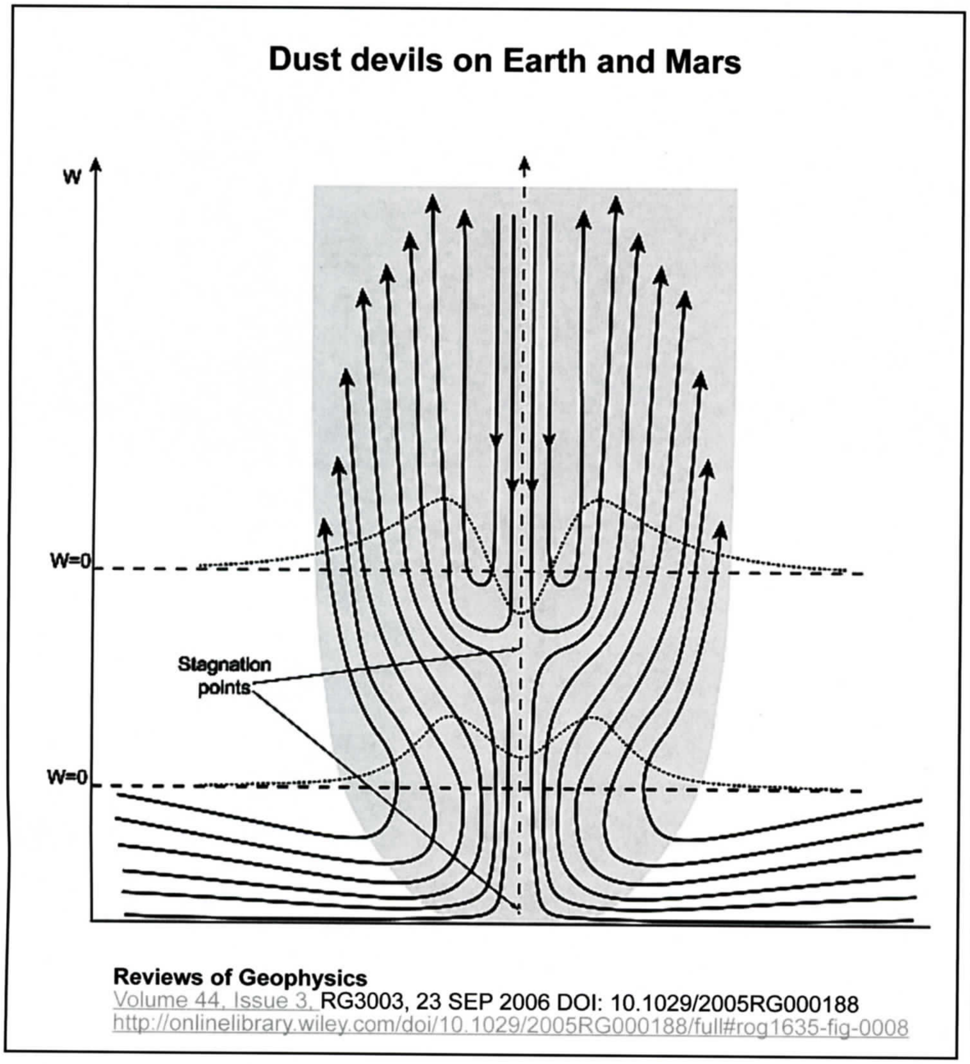

Figure 1. Sketch showing possible vertical flow in a dust devil. The solid, arrowed lines show the flow directions. The dotted lines represent the vertical wind speed profile that would be measured at that height if the dust devils' velocity field were sampled. The existence of a stagnation point above the ground level might explain why downward flow has been found at the center of dust devils at some heights above the surface, but not near the ground. This might also explain why some dust devils appear to have downward flow in the core, while others do not. Source: "Dust devils on Earth and Mars" Balme and Greely, 2006

The reversal in flow might occur at considerable height above the surface (as shown here) or at ground level (downward flow throughout the dust devil) or might not be present at all (upward flow throughout dust devil). Source: "Dust devils on Earth and Mars" Balme and Greely, 2006.

Much like mariners dealing with rogue waves in oceans and large lakes, perhaps it is time for glider pilots to "rethink our ideas" on vertical air move-

Above: Ultra tight core thermal. Photo taken looking straight up through the canopy while flying near Durango, Colorado at 14,000'. Note the clear air above and below the visual spinner. Undoubtedly, there was strong turbulence associated with that rogue air. Photo by Bob Thompson

ments and the causes of some crashes, spinning *or* straight ahead. There are, occasionally, invisible, powerful, yet very small, vertical air currents with very sharp edges ("rogue thermals and down gusts" – our own variety of clear air turbulence) .... mixed in with the thousands of thermals and areas of sink that we maneuver our craft through every year. Being acclimated to the many thousands of more common up and down drafts could very easily lull us into getting caught off guard by the one in a million or one in ten million sharp up or down gusts when we happen to be too close to the ground to recover from an ensuing stall spin or dive.

It is the invisible vertical vortex convection events that present the greatest danger to slow flying aircraft such as gliders thermalling at low altitudes or in landing patterns. Look carefully at the dust devils in the photo on page 20 and the front cover photo. Imagine them invisible, and you flying into one of them with your right wing while turning left base to final, or scratching at 600 feet AGL, desperately trying to stay aloft in a contest. A perfect setup for a left wing stall into a spin!

We think of dust devils occurring during hot days, which is when we mostly see them. But, it is also important to realize that it is not just high ambient temperatures that cause vertical vortex convection. It is temperature *differential* (warmer air below rising through the cooler air above). I have watched some of the most violent convection events at around 8:30 am. Just as the morning sun was beginning to strike the steep rocky slopes north of our cabin in the San Juan

Mountains of Colorado around Christmas time, with an ambient temperature close to zero outside ….. SNOW devils! They were huge, and looked so violent I imagined at the time they could have brought down a small airliner. On a less violent note – on Christmas Eve day in 2004, with a takeoff temperature in the 20s, I flew with my friend Jim McCann in his Ximango motor glider from La Plata County airport in Durango, and we hit an 8 knot thermal about 5 miles after takeoff and took it to 15,000' ASL. Air masses can rise regardless of ambient temperatures – sometimes relatively smoothly and sometimes violently. Temperature differential can also be caused by localized moisture content differential (see Lift Markers – Ponds and Stock Tanks article in *Soaring* – August 2009, page 17). Moist thermals on dry days can be violent, too!

Science has focused substantial resources studying clear air turbulence and microburst activity, but far less effort has been directed towards very localized powerful convection events. Unfortunately, naysayers will likely scoff at even the idea of rogue thermals and down gusts…..just as most mariners figure rogue waves are incredibly rare and will never affect them. The Flat Earth Society IS alive and well.

In reality, we all have most likely happened onto potentially deadly strong down or up gusts, but while at cruising altitudes and speeds instead of when flying slower while thermalling or in a landing pattern. Who hasn't had their head smack into the canopy and have anything not tied down fly all over the cockpit during a flight?

I have observed, and photographed, a few incredibly tight thermals (which were shaped like very tight dust devils on the ground), at altitudes where condensation had occurred, but were not visible below that altitude. I refer to these as "pencil" or "rogue" thermals. (See attached photo of one taken at about 14,000' msl near Durango, CO a few years ago looking straight up through my canopy.) I didn't fly into them at the time of the photos, but felt that had anyone done so, those super tight cores would have most likely caused severe control problems for the unlucky pilot who happened into them.

I suspect several of us met with some of these invisible monsters one week this past summer, and my original thoughts of them were quite accurate. While each encounter was serious, the results were different due to our individual flight situations at the time; Joe was on tow, I was thermalling, and another pilot was land-

Ultra tight core thermal extends below cumulus cloud north of Phoenix, Arizona. Photo by Bob Thompson ing. Joe hit a powerful down gust, his head slammed into the canopy, things flew around in the cockpit, and the trailing-edge integrated air brake/flap handle in his Mini-Nimbus was knocked loose from its very tightly locked detent setting to full open.

As his glider was attached to a tow plane and moving much faster than I was, his glider's attitude changed little. But, as he suddenly had full landing flaps deployed, lots of drag was created, and his airspeed and climb rate on tow were severely degraded….. until he looked at his wing and noticed the air brakes fully deployed and closed them.

I was flying slower, banked in a thermal, and hit an incredibly powerful upgust; control was lost, and I was thrown into an unusual attitude. A few days earlier, another very experienced pilot was landing his glider at nearby airport and according to witnesses, "When the airplane was about 40 to 50 feet above the ground the right wing dropped and the glider suddenly nosed into the ground short of the runway."[4] How many times have we heard THAT kind of description?

Joe said his experience was the worst turbulence he had ever encountered. For me, it was both the worst turbulence I had ever encountered and the greatest scare I have ever had in my flying career. No comments from the other pilot were possible about what happened, as he was killed in his landing approach crash. Was his crash just pilot error, or could possibly an errant rogue gust have come along at a very inopportune time? We'll never know on that one. But, the possibility is certainly something to consider.

"Worst bent prop I've ever seen." Pawnee damaged by instant violent updraft during the start of a tow at Nephi, Utah. The airport is surrounded by thousands of acres of green farmland - which would not provide any dirt to make a visible "dust devil" out of any strong vertical vortex convection that might be pushed by a cross wind onto the runway. Any surface – bare rock, pavement, green cropland, whatever – can produce invisible vertical vortex convection events that can catch pilots and ground crews off guard. Photo by Bob Thompson

Back in my hang gliding days, a number of pilots met with sharp-edged gusts that would suddenly slam the hang glider up, down, or sideways, sometimes forcing the hang glider to tuck / tumble upside down, or at the very least cause very severe control problems. As hang gliders fly much slower than gliders and general aviation aircraft and have much lower wing loadings, it is reasonable that they would be more easily affected by less violent vertical wind shears than gliders or powered aircraft.

Hang gliding manufacturers came up with "luff lines," cables that run from the king post sticking above the center of the sail down to the trailing edges of the sail, resulting in sort of an "automatic up-elevator" effect, that helped keep hang gliders upright, or at least help the pilots rapidly pull out of dives caused by the upsets. However, although highly reduced, there were still a number of documented violent events of hang gliders that would tumble in strong conditions. Most hang glider pilots flew with parachutes that could be used if such problems occurred, and they saved lives when the hang gliders were high enough off the ground for full deployment. At lower altitudes, these events were often fatal.

I logged over 3,000 hours in my 23 years of hang gliding, mostly in thermally cross-country conditions, and never had the need for my parachute, although sometimes things did get incredibly turbulent and very scary…. more so as time went along. But, several times others near me did have their gliders tumble and get torn up by violent up or down drafts with sharp edges, and did use their parachutes, and walked / limped away from the events. I also attended a number of funerals of hang glider and paraglider pilots who met violent severe sink or lift ("rogue" air) too close to the ground to either recover control of their craft or use their parachutes.

I remember well a day that my best friend in flying, Hans Heydrich, and I were flying our hang gliders cross country from Oatman Mountain, a small mountain west of Gila Bend, AZ, near Painted Rock Dam. We were making good time, and when we got over the top of the Esterella Mountains near Phoenix, the air became very violent. We had flown into a "rogue" thermal. After a couple of turns in huge violent lift with little control, I radioed I had enough and was heading east to smoother air. Hans responded "I'm going to try to work this up." About a minute later, I was well east of the peaks, and Hans radioed "My glider tumbled and broke up. I'm gonna throw my chute!" I did a 180 and watched the wreckage drop like a bullet and then a canopy open above it. (In hang gliding, the pilot and glider stay tethered and both come down together. The parachute, which has a 20 foot long strap, is pulled from a pouch on the pilot's harness and thrown as hard as possible to get it away from the descending wreckage).

We both drifted east of the mountains and over the desert. I landed, unhooked from my glider, stabilized it sideways into the wind so it wouldn't blow away, and ran over to Hans as he and his wrecked glider smacked into the ground. Grabbing the chute to deflate it, I stuffed it quickly into the torn wing so he wouldn't be dragged across the land by the wind. Hans escaped that day with a cracked rib, destroyed glider, and new appreciation of what violent updrafts with very sharp edges could do to hang gliders. Unfortunately, a stall spin crash during an outlanding attempt in his Ventus took Hans' life a decade later.


Virga dodging. Photo taken while flying over Nephi, Utah, detouring around expected down air below the virga. Photo by Bob Thompson

I already had my FAA private pilot's license (acquired it in 1972), and in 1996 dropped out of the sport of hang gliding and added gliding to my FAA license. Since then I have logged over 2000 hours, mostly in my 1981 Ventus B with 17.6 meter tips (NOT 16.6). The 17.6 tips bend up about 18 inches from the outer edges, much like Nimbus tips, and create a VERY stable aircraft which has a very slow stall speed (around 34 kts indicated). I have become very confident about the incredible stability of my glider in the air I have flown in. I had full confidence that by keeping reasonable speed and yaw string straight that a stall / spin was not ever going to happen to me. However, in June of 2014, I had a very rude, and scary, awakening! Never say never.

On my scary flight in June, flying through lots of sink after tow release, I happened onto a bumpy 5 kt thermal about 1500 ft above the ground, about 3/4 mile west of the Nephi, UT airport in my Ventus and cranked a 45 degree banked left turn (left wing down). After about 3 or 4 turns, the left wing was instantly lifted up past vertical to upside-down and over, throwing my glider into a 70+ degree nose-down right spiral dive / spin. This was NOT your classic inside wing stall into a spin! The inside wing was pushed UP, very rapidly. Quick corrections resulted in straight down dive at high speed, and a pull up into a right wing-over. Seeing the ground rotate and come towards me so fast was really scary. I remember a fleeting thought of surprise that the wings stayed on after such a high-speed pull up. Very shaken up by the event, once back in level flight, I checked out the controls, looked the wings and tail over (I have a rearview mirror like self-launchers have), and was quite relieved to see all appeared okay.

In my early flying days, I used to love to spin a Cessna 150.....always with plenty of altitude, and after a good clearing turn to make sure the area below me was clear of other aircraft. Spins in the 150 were great fun, only descending at about a 45 or so degree nose-down angle, not very fast, and easy to recover from. I also had to do stalls into spins to get qualified in the 1-28 Lark when our club got one. Still nothing scary. Up to that day in June, all my spins were intentional. But, nothing prepared me for so instantly going over the opposite (upper) wing and into a 70-80 degree nose-down spin / spiral and then a straight down dive going very fast – while not very high off the deck, and with other gliders around. Heart in throat and need to change underwear time! Handily, my reactions were quick, and apparently correct. And, when impacted by the rogue thermal, I was high enough to recover control of my glider...... and not become another NTSB statistic and reason for more questions on the RAS.

I added considerable speed to my thermalling and landing approach speeds the rest of the day and week, and have thought long and hard about my experience. I was suddenly aware of how glider pilots could get into a stall / spin that would be fatal if experienced at a lower altitude. An exceptionally powerful rising air mass with a very sharp edge taught me quite a lesson.

I didn't share my experience with anyone until weeks later, as I was going over and over everything in my mind trying to piece it all together and come to grips with what had happened to me. Plus, a number of recent fatal crashes (one at a contest I flew in during the previous month.... that I also suspect some down-gusts at an inopportune time at low altitude contributed to) were also weighing heavily on my mind. Lots of sad, scary things to absorb and come to grips with.... along with the realization that I could have easily been the fourth to auger-in in a short time.

Having lost six good friends in glider crashes in my 17 years of glider flying was in the back of my mind, also. Bruno Gantenbrink's talk titled "Safety Comes First," which can be read in English at: http://www.dg-flugzeugbau.de/safety-comes-first-e.html has come home to roost for me. Never say never.

The day after Joe's and my "encounters" it was impressed on many of us just how powerful an updraft could be all the way to the ground. There was a west crosswind, and, still smarting from my rogue air experiences the day before, I had chosen not to fly. Watching others taking off occupied my early afternoon, and gave me a good view of a very startling occurrence. A Pawnee was just starting to give it the gas to pull a heavy glider (DuoDiscus, if I remember correctly), and as the rope was tightened and the glider seemed to have only moved a foot or so, the tail of the Pawnee was suddenly jerked up to about a 45-degree nose down attitude, and the plane was spun about 45 degrees to the right. The prop hit the runway with a bang, and the Pawnee slammed back down. Roar, bang bang, silence, all within a second or two. Worst bent prop I have ever seen, *(see photo on page 24).*

Above and below photos: Potential havoc-wrecker en route along the flight-line. Photos by Bob Thompson

Leading up to this event, there was *nothing* visible to anyone to indicate what was to come. A couple of seconds after the event a huge dust devil appeared in the grass / dirt area to the east of the runway and moved on towards the taxi way. The result: one tow plane with a very bent prop and damaged engine, many startled people, and a bummed-out tow pilot. The only personal physical injury was one of the ground crew helpers caught a chunk of prop-induced flying runway asphalt in the chest, resulting in a sizable welt. It took a very powerful, very small, tight updraft to lift and turn that tow plane while attached to a heavy glider, yet not affect the other nearby aircraft!

Very powerful down air occurs also, often related to virga and / or microbursts, and these vertical winds can exceed 80 mph straight down. Virga is a great indicator of down air beneath. Microbursts can be either wet or dry. Dry microbursts often have little to no visual indicators of their location until they reach the ground. Once this occurs, dust is often created radiating in all directions from the point of impact. Very strong invisible down gusts can also occur without any virga nearby. Think back to your cruising along and suddenly smacking your head on the canopy and things flying around in the cockpit.

Flying through microbursts is often deadly for any size of aircraft.... from gliders to giant airliners. There have been a number of general aviation and commercial airline crashes caused by microbursts. On August 2, 1985, Delta Flight 191, a Lockheed L-1011, brought this danger to the flying community's attention in spades when it crashed after hitting a microburst while attempting to land at DFW, killing 8 of the 11 crew members and 128 of the 152 passengers on board, and one person on the ground. Full-throttle power on the three Rolls-Royce RB-211 turbofan jet engines with 42,000 pounds of thrust each was no match for the massive downdraft. With a powerful jumbo jet lawn-darting because of a microburst, a glider would be in serious trouble, too. Some glider pilots like to fly along wet virga shelfs, working the lift from air beside them being displaced. I, on the other hand, just prefer to keep my distance from them.

The reversal in flow might occur at considerable height above the surface

A spectacular video of what can happen to gliders and other aircraft on the ground when a horizontal wind is created by the impact of a microburst on the ground can be viewed at http://oppositelock.jalopnik.com/55-kt-gusts-force-super-cub-tow-planes-to-takeoff-from-1597005838/1597062545/+travis Radical stuff for tow pilots and glider ground crews!

Also, there was an "interesting," although non-flying related, incident that occurred near Durango, Colorado on July 20, 2014, which showed some of the power that can be found as microbursts hit the ground. A Ford E-450 15-passenger van was lifted off the ground and dropped on top of another van. See http://www.durangoherald.com/article/20140713/NEWS01/140719816/-1/News01/Powerful-downdraft-lifts-vans-in-Rockwood – for details.

In reading the RAS, *Soaring* Magazine, Soaring Café, and NTSB reports, it is evident that there are many glider pilots, many very experienced, who have ended their flights, and lives in many instances, in stall spin crashes, or even straight ahead crashes. I suspect a fair number of these unfortunate pilots may have just encountered severe downdrafts or updrafts ("rogue" air) at very vulnerable times, when both airspeed and altitude were low. My thoughts are "it was their time to go, not mine."

Having experienced smacking my head on the canopy a number of times because of running into small strong down-air currents, been flipped over into a spin by a powerful up-gust, and watched a tow plane being lifted and spun around on the runway by a powerful up-gust, I am now a believer in the potential dangers of rogue air currents… up and down. One needs to be aware of what can happen out of the blue while flying. Imagine yourself turning base to final or scratching low in a weak thermal and happening onto one of those rogue air currents. Not fun!

Fly safe. Get high, stay high, keep your speed up, never thermal low. And, never say never.

FOOTNOTES

1. http://science.howstuffworks.com/environmental/earth/oceanography/rogue-wave3.htm
2. http://www.nature.com/nclimate/journal/v3/n7/full/nclimate1866.html
3. http://onlinelibrary.wiley.com/doi/10.1029/RG025i003p00371/abstract
4. (NTSB Identification: WPR-14LA263)http://www.ntsb.gov/aviationquery/brief.aspx?ev_id=20140623X11029&key=1

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2. "Intensification of winter transatlantic aviation turbulence in response to climate change" by Paul D. Williams & Manoj M. Joshi in NATURE CLIMATE CHANGE published online April 8, 2013
3. "Dust devils on Earth and Mars", by Matt Balme and Ron Greely, Review of Geophysics, Volume 44, Issue 3, September 2006
4. "The formation of vertical vortices in the convective boundary layer", by Katharine M. Kanak, Douglas K. Lilly,

Multiple tracks are evidence of past dust devils, as well as the active one photographed here. Note the direction of dust raised by the field equipment. Photo by Bob Thompson

Sky full of virga, east of Nephi Airport in Nephi, Utah. Note there are a number of down-air virga vortices visible, some rolling down, and some straight down. A sky full of rogue air. Photo by Bob Thompson

and John T. Lilly, Quarterly Journal of the Royal Meteorological Society, Volume 126, Issue 569, pages 2789-2810, October 2000 Part A

5. "Atmospheric columnar vortices", by John T. Snow, Review of Geophysics, Volume 25, Issue 3, pages 371-385, April 1987

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7. "The lower structure of dust devils", by Sinclair, P.C., (1973) Journal of Atmospheric Science, 30, 1599-1619

8. "Dust devils as aeolian transport mechanisms in southern Nevada and in the Mars Pathfinder landing site", Ph.D. thesis, 1999, University of Nevada, Reno

9. National Transportation Safety Board – June 2014 Aviation Accidents – Sunday, June 22, 2014 – WPR-14LA263

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