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Dusty AND

BY ED BROTAK

It was a typical early summer evening in southern Arizona, U.S., this past July 5. At 1751 local time, the Phoenix Sky Harbor International Airport was reporting 10 mi (16 km) visibility with winds of 7 kt. But all that changed in a matter of minutes.

A 1 mi (1.6 km)-high, 100-mi (1610 km)-wide wall of dust roared in from the southeast, moving at 30–40 mph (48–64 kph). At the airport, the leading edge of the dust cloud moved through at 1847. Within minutes, a full-blown dust storm or haboob — Arabic for "strong wind" — was well under way. At its worst, the visibility dropped to 1/8 mi (200 m) and the winds gusted to 46 kt. The airport was closed for 45 minutes. The reduced visibilities and strong winds lasted for hours.

Dust storms pose a significant hazard for aviation. Not only do they drastically reduce visibility, they also are associated with very strong winds that can seriously affect an aircraft in flight. Engines can be damaged by ingesting the dust.

Strong winds associated with a dust storm were believed to be the cause of the May 26, 2011, crash of an air ambulance just outside Delhi, India. Seven people in the airplane and three on the ground were killed when the Pilatus PC-12 turboprop fell from the sky into a residential neighborhood. Officials there said the airplane hit a "wall of air" and was "unable to move due to the strong winds." At the time of the crash, surface winds at the airport were gusting to 40 mph.

Even large airplanes can encounter difficulties. On March 11, 2005, an Airbus A321-200 operated by British Mediterranean Airways encountered a dust storm while

Gusty

Dust storms, including high winds, can occur anywhere there is lots of dry soil.

trying to land at Khartoum Airport, Sudan (*ASW*, 3/08, p. 29). After two aborted approaches, a third approach was attempted. This approach also became unstable when the airplane descended too quickly as it neared the runway. With visibilities below acceptable minimums, the pilot initiated a go-around. The airplane was within 121 ft (37 m) of the ground before the crew pulled up. The event was officially described as a “serious incident.” Three years later at the same airport, a Sudan Airways Airbus crashed on landing in a dust storm. Twenty-eight people lost their lives.

Ground operations at air terminals can be brought to a standstill by dust storms. Outside workers can be extremely hampered in, if not prohibited from, doing their jobs. And in the aftermath of the storm, there is the cleanup to deal with. Just as in a snowstorm, the sand/dust must be removed from runways and other critical areas.

To explain the workings of dust storms, we start by clarifying the difference between dust storms and sandstorms. True sandstorms only occur when there is actual sand in the air and therefore are usually confined to the sandy desert regions of the world and their immediate surroundings. Sand grains are larger and heavier than dust and generally cannot be carried as high into the air. Dust storms comprise smaller soil particles which can be carried much higher into the atmosphere, sometimes thousands of feet. Dust storms are much more common than sandstorms. They occur in arid regions, but can also occur in other places and with other soil types, as long as the soil is dry. Drought conditions are often a prerequisite.

Besides loose, dry soil, significant wind is necessary for dust storm formation. Strong winds are needed to mix the dust from the surface into the air and then keep it suspended for a significant time. The wind, of course, will transport the dust particles and make the dust storm move. Fortunately, strong winds without precipitation are fairly unusual outside desert regions. Atmospheric instability can also play a role. The more instability, the more vertical mixing can occur. It is this vertical mixing that can allow the dust to be carried to great heights, as high as 20,000 ft.

As would be expected, dust storms are common in and around the arid and desert regions of the world. The lack of vegetation leaves the soil exposed, with nothing to slow the wind near the surface. However, even the more humid climates are not immune from dust storms. Droughts can dry topsoils and make them more prone to blowing. A weather system associated with strong winds but no precipitation can lead to significant blowing dust.

The strong winds associated with dust storms are produced by a variety of weather systems. In the desert Southwest of the United States, they are usually convective. Strong downdrafts from thunderstorms produce most of the dust storms. At times, the precipitation from the storm evaporates in the dry air before reaching the surface. Only the strong winds make it to the ground. Even when rain reaches the ground under the main convective column, the outflow from the storm's downdrafts has spread out, well ahead of the main storm. The outflow boundary or gust front will be the leading edge of the dust storm. In time, the rain shaft may follow, turning the dust to mud. In the Phoenix dust storm, thunderstorms first developed over 100 mi away, just east of Tucson, in the afternoon. This complex of strong to severe storms moved northwest, with its outflow boundary, the leading edge of the dust storm, reaching Phoenix by evening.

Thunderstorms and the dust storms they produce occur in the summer in the Southwest. It is then that the usually dry region is invaded by moist, tropical air from the south. The "summer monsoons" usually begin in June but occasionally are delayed until July. The Phoenix area usually gets one to three dust storms each summer. Convective dust storms are also common in other parts of the world, such as the Sahara region.

"Convective dust storms" cannot be forecast in advance, and that makes them extremely dangerous. In August 2000, a Bellanca 17-30 single-engine airplane crashed into the mountains outside of Scottsdale, Arizona, killing two. The situation was similar to the Phoenix event — a thunderstorm-generated dust storm.

The best forecast that meteorologists can make is to warn when conditions favor convective development. It is impossible to know exactly where the convective cells will develop and if they will produce a dust storm. Convective dust storms are fairly small — usually tens of miles across. After a dust storm has formed, the U.S. National Weather Service issues either an "advisory" or a full-fledged "warning." A "blowing dust advisory" is issued if the visibility is forecast to temporarily decrease to between 1/4 mi (0.4 km) and 1 mi due to wind-borne sand or dust with winds of 25 mph (40 kph) or greater. A "dust storm warning" is issued if the visibility is expected to drop below 1/4 mi frequently, with winds of 25 mph or greater. The criterion of 25 mph is a minimum; winds frequently range from 40 to 60 mph (65 to 95 kph) in a dust storm.

In the more poleward arid regions and in other drier areas in the mid-latitudes, the strong winds that produce dust storms usually are associated with larger weather systems. To further the discussion, we need to discuss how wind is actually produced. Wind, or horizontal air movement, is the result of pressure differences. Air tries to move from higher to lower pressure. The greater the pressure difference, the stronger the winds. Standard surface weather maps use isobars, lines of equal pressure, to illustrate the pressure field. When the isobars are closer together, there is

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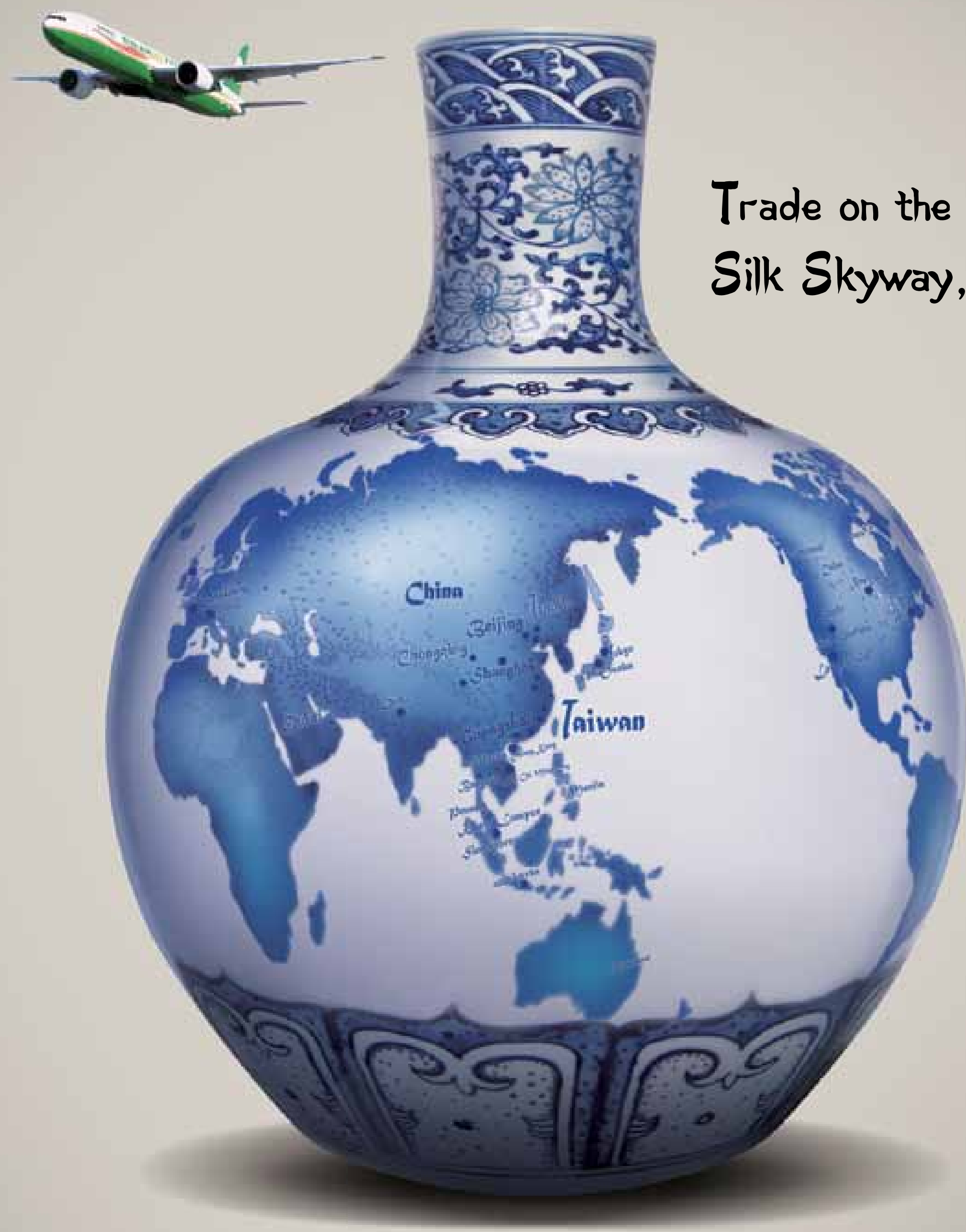

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a stronger pressure gradient and the winds are stronger. The laws of physics confirm what we see in real-world high-pressure areas that have weaker pressure gradients and light winds, whereas lows with tighter pressure gradients have stronger winds. Fronts, associated with lower pressure, can also be accompanied by strong winds.

Low-pressure areas, or cyclones, produce winds that rotate counterclockwise in the northern hemisphere, clockwise below the equator. Stronger cyclones, with lower pressures, produce stronger winds. Winds over 50 mph (80 kph) can be expected with these storms. The winds occur regardless of precipitation. If a source of moisture is available, then as the air is lifted into the low-pressure centers, clouds and precipitation usually form. If moisture is not available, the low only produces wind and the potential for dust storms.

Dust storms associated with these larger, "synoptic-scale" systems are much more widespread than those associated with thunderstorms, often affecting hundreds or even thousands of square miles. On April 4, 2009, a strong low-pressure area to the north generated a dust storm that affected all of central Texas. Lubbock reported wind gusts to 41 kt and reduced visibilities due to blowing dust. At Amarillo, it was even worse, with winds gusting to 55 kt and visibilities as low as 3 mi (5 km) in blowing dust.

In May 2004, dust storms were generated in five different countries on the Arabian peninsula by the same weather system. On Sept. 23, 2009, a dust storm 300 mi (483 km) wide and 600 mi (965 km) long affected two states in Australia. It was the worst dust storm in Sydney in 70 years. Air traffic was halted at Sydney Airport, where the visibility dropped to 1/4 mi with gale-force winds. An intense cyclone and frontal system produced the strong winds.

Besides low-pressure areas themselves, fronts associated with some lows can also cause problems. Dry cold fronts are the worst. Again, the lack of a moisture source prohibits precipitation formation. Dry cold fronts are also often accompanied by steep temperature lapse rates, which increase instability and the vertical depth of any dust storm. On Feb. 24, 2007, a major low-pressure area moved out of the U.S. Rocky Mountains and into the central Great Plains. With a tight pressure gradient, the system was producing strong winds throughout much of the central part of the United States. Of particular concern was a strong, dry cold front extending southward from the low and moving through Texas. At the Dallas/Fort Worth International Airport, strong southerly winds ahead of the front gusted over 20 kt. But the air was moist with dew points near 60 degrees F (16 degrees C). A wind shift to west-southwest near 0900 local time accompanied the frontal passage.

Although a few rain showers had preceded the front, the air quickly dried behind it. Dew points dropped precipitously, reaching as low as 9 degrees F (minus 13 degrees C). Winds increased and at times gusted to nearly 50 kt. By 1500, dust and sand moved in from the west. Horizontal visibility plummeted, dropping at times below 1 mi with the vertical visibility below 1,000 ft (305 m). The combination of low visibility and strong winds persisted for hours. Much of Texas dealt with similar conditions.

Even with these larger weather systems, dust storms are difficult to predict. It takes just the right combination of wind and dry soil. And dust storms are becoming more common around the world. In the United States, the Colorado Plateau region saw a record 14 large dust storms in 2009. Northern China now averages 30 dust storms a year. Iran is reporting an ever-increasing number of events. In some regions, dust storms can be linked to poor agricultural practices. In other areas, drier conditions and more drought occurrences are significant factors. Some believe that global climate change is tied into this. Regardless of the causes, dust storms will continue to be a major aviation hazard in many parts of the world.

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