Wildfires Make Their Own Weather

BY ED BROTAK

Fire-induced phenomena are rare but threatening for aviation.

At 2300 local time on April 22, 2009, the reported conditions at the North Myrtle Beach (South Carolina, U.S.) Airport were calm winds with 10 mi (16 km) visibility and a temperature of 52 degrees F (11 degrees C). Some 90 minutes later, the winds were gusting to 16 kt, the visibility was 2.5 mi (4 km), and the temperature was 66 degrees F (19 degrees C). The dramatic change in conditions was not due to an approaching weather system. It was due to an approaching wildfire.

During that day, a fire which started on the outskirts of Conway, a small town west of Myrtle Beach, made a 5 mi (8 km) run to the east, driven by strong westerly winds gusting to 29 kt. In the evening, the winds died down and the fire was seemingly contained by major highways to east and northeast.

But around midnight, the fire blew up. Flames shot up over 200 ft (61 m) into the air. A massive convective column developed over the fire and extended 10,000 ft into the atmosphere. The fire was responsible for the deteriorating conditions at the nearby North Myrtle Beach Airport.

Wildfires are common throughout the world. With the exception of deserts and areas with permanent snow and ice cover, wherever there is continuous vegetation cover, fires can occur. Recent headlines are full of wildfire stories. In summer 2010, historic wildfires ravaged western Russia. Then, in December, the worst wildfire ever in Israel claimed many lives. In 2009, the

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deadliest wildfires in the history of Australia hit the southeastern part of that country.

From the high-latitude boreal forests to the subtropical grasslands, wildfires are a threat. Whenever the vegetation dries out, there is the potential for fire. All that is needed is an ignition source. Lightning strikes cause the majority of wildfires. Dry lightning — lightning without rain — is the most dangerous. In the drier regions of the world, the rain from thunderstorms can evaporate before it reaches the ground.

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Other wildfires can be attributed to man. These can be accidental or sometimes even deliberately set. Overall, fires are beneficial to the environment. They help recycle vital elements back into the ground, which is the rationale behind the "slash and burn" tradition of agriculture. Fires also can benefit nature by renewing older, less productive ecosystems. Problems arise when man's possessions or activities are affected by wildfire.

The usual perception is that drought conditions precede major wildfires. It is true that the fuel for the fire, the vegetation, needs to be dry. Surface leaves and litter can dry out quickly, though. The Myrtle Beach fire had no antecedent drought. The surface fuels dried out enough to support a fire in only one week without rain.

Brush, such as the chaparral of California, dries quickly and is very flammable. In forests, the evergreen needle leaves burn readily under most conditions and surface fires can quickly become crown fires, traveling through the tops of the trees.

Drought is a natural occurrence in almost all regions. Some areas have dry seasons every year. Dry summers are common on the west side of continents in the middle latitudes. Dry winters occur in some tropical and subtropical locations. Wildfires often occur in the dry season. Periodic droughts affect just about all other regions that usually have consistent rainfall year-round.

Wildfires pose unique problems for the aviation community. There is the obvious physical danger of the fire itself to aviation facilities and aircraft on the ground. At one point, the recent fires in Russia destroyed 13 hangars and much equipment at one military facility. The most common problem is the reduction in visibility because of the smoke. For example, last August, measured visibilities at one point dropped to 1/8 mi (200 m) at several major international airports around Moscow due to smoke from the nearby wildfires, forcing many incoming flights to divert to other locations. In April 2005, all four major airports in Honduras had to close because of limited visibility caused by smoke from numerous wildfires.

Visibility effects strongly depend on wind direction. Simply put, any wind direction that puts the fire upwind of you causes problems. And visibility can decrease quickly. For example, at the Boise (Idaho, U.S.) Municipal Airport, on July 28, 2010, the visibility went from 10 mi

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(16 km) to 1 3/4 mi (2.8 km) in nine minutes when the wind shifted and started blowing in smoke from a nearby wildfire.

In worst-case scenarios, visibility can drop to near zero and close airports. In some instances, the reduced visibility is accompanied by strong winds that can easily affect aircraft operations. When the Myrtle Beach fire made its first run on April 22, at one point the tower at Myrtle Beach International Airport recorded visibility of 2 mi (3.2 km) to the northeast while reporting winds gusting to 22 kt.

Most wildfires are wind driven. The winds are usually produced by large-scale weather systems that are fairly easy to forecast. Although the wind forecast predicts which direction the fire is headed, fire control can still be difficult. If a heavy fuel supply is available to the fire, it is pushed forward by the wind, often at exceptional speed. Add any terrain factors that inhibit firefighting and the fire may be uncontrollable. Such fast-moving fires usually do not send heated air very high.

But when a fire develops a vertical component, the dangers multiply and the situation becomes much more complex and less predictable. Any glider pilot will tell you about good "thermals" over a fire. Air, heated by the fire, becomes buoyant and rises, causing a "convective column" overhead.

For small fires and most rapidly moving ones, convection doesn't pose much of a problem to aviation. Larger fires, especially ones not driven by strong winds, can develop significant convective columns that shoot upward for thousands of feet. The so-called "Station fire" just outside Los Angeles burned more than 160,000 acres in August and September 2009, the largest fire ever recorded in Los Angeles County. At its peak, it produced a convective column estimated at 23,000 ft. Some fires have produced convective columns estimated at 40,000 ft.

Convective columns of this magnitude are similar to thunderstorms. They contain both updrafts and downdrafts and can produce extreme turbulence. Aircraft en route have to detour around them. If near a terminal, they can present a serious obstacle to takeoffs and landings. The powerful updrafts in these convective columns carry dense smoke and even small, burning debris well up into the atmosphere. There, upper level winds can transport them far downwind.

At the surface, burning embers can fall out of the sky sometimes a mile (1.6 km) or more ahead of the main fire. They can cause spot fires that eventually merge with the main fire and greatly increase the forward speed of the fire. The smoke can be carried even farther downstream. Visibility may be reduced miles ahead.

With a significant convective column, a wildfire can literally start producing its own weather. A low-level inflow of air is induced to replace the air that is being taken aloft. This produces strong winds directed towards the fire. The downdrafts from wildfire-induced convection reaches the surface, producing strong winds from varying directions, again very similar to thunderstorms. This type of wind shear also poses a threat to low-flying aircraft.

The main part of a wildfire-induced updraft contains superheated, smoke-filled air, the smoke column from the fire. Under the right atmospheric conditions, a true cloud may form on top of this updraft. A "pyrocumulus" cloud is composed of water droplets and/or ice crystals at great heights. It appears white as opposed to the dark smoke column below. Such clouds have been known to produce lightning, yet another aviation threat. In some instances, they have even produced rain.

To make matters worse, the convective or "plume-driven" fire can develop under seemingly benign weather conditions. Light winds at the surface and aloft, which normally make a wildfire easy to contain, allow the heated air to rise straight up, forming the convective column. Atmospheric instability, as indicated by steep lapse rates, also allows air parcels to rise more, increasing convective column growth.

The "Station fire" was an excellent example of "fire-induced weather" and was extensively studied because two firefighters were killed battling the blaze. On August 30, a firestorm engulfed a base camp where a crew was stationed. Two of the men attempting to flee the fire were killed when their truck plunged off a cliff. Wind gusts estimated at 40 kt unexpectedly drove the fire toward the camp. The prevailing winds in the region were much lighter, and it is believed that a strong inflow into a nearby fire's convective column was responsible for the high winds and resultant rapid fire spread.

Now, transpose this scenario to an aviation situation: Imagine the effects on aircraft operations if winds suddenly change direction and increase velocity to this magnitude. Such a situation is virtually impossible to forecast. These are convectively driven winds, and convection is not a smooth, continuous process but occurs in spurts. Bursts of upward-moving air can raise the convective column to great heights. Then, just as quickly, the convective column can collapse, initiating downdrafts.

In recent years, extreme weather events have become more frequent. They include droughts and the resultant wildfires. We can expect the aviation problems caused by wildfires to also become more frequent.