The Front

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Airborne Weather Radar Limitations

by John Werth, Seattle ARTCC Center Weather Service Unit

Is airborne weather radar better, more timely or accurate, than the Weather and Radar Processor (WARP) NEXRAD mosaics used by Federal Aviation Administration (FAA) air traffic controllers? In early November, a senior air traffic investigator with the National Transportation Safety Board gave a presentation to NWS Center Weather Service Unit (CWSU) supervisors, discussing some of the strengths and weaknesses between the two systems. The information provided here was taken from that presentation.

It should be noted there is no perfect ground or airborne method for detecting hazardous weather. Cockpit weather radar systems are not inherently better than NEXRAD or any other Air Traffic Control weather detection systems, they're just different.

The reflectivity of precipitation particles varies considerably depending on the type of precipitation particle. For example, wet hail, rain and wet snow are much more reflective than dry hail, ice crystals or dry snow. Unfortunately, aircraft radars do not see frozen precipitation as well as they see wet precipitation. So thunderstorm tops, which are composed of mostly low-reflectivity precipitation particles, aren't seen well by aircraft radar. NEXRADs on the other hand, don't suffer from this limitation, especially at the higher altitudes where most commercial aircraft operate.

Another limitation of airborne weather radars is called shadowing or attenuation. A phenomenon which occurs when the weather is simply unable to make the two way trip through it, meaning the size, shape and intensity of that weather as displayed to the pilot may not be accurate.

The more intense the precipitation, the less distance the radar can see into and through a storm. What appears to be a thin, crescent-shaped band of precipitation (**Figure 1**) could just be the leading edge of a much larger area of heavy to extreme precipitation.

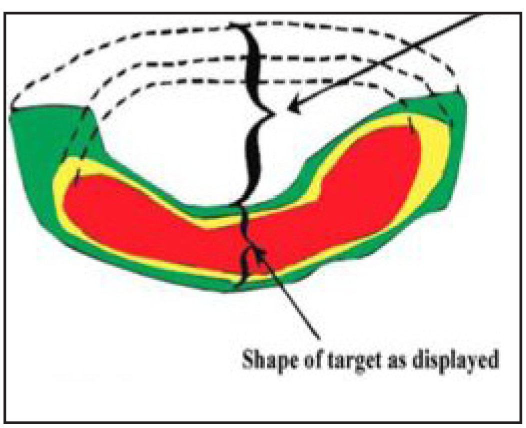

***Figure 1:** Airborne radar attenuation caused by moderate to extreme precipitation*

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The Front

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Mission Statement

To enhance aviation safety by increasing the pilot's knowledge of weather systems and processes and National Weather Service products and services.

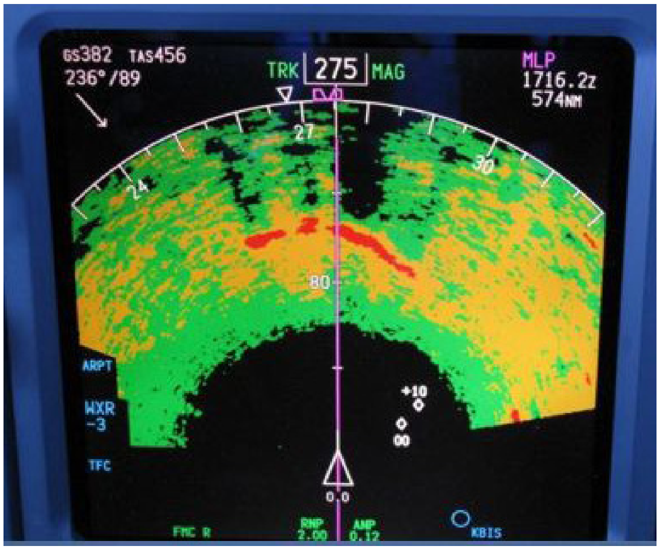

Figure 2 *Cockpit weather radar display: precipitation: yellow/red; ground: green/yellow*

Figure 3: *Ice buildup on an aircraft's radome*

Radar attenuation shows up as black areas on a pilot's weather radar display (**Figure 2**). Attenuation can also occur when heavy rain or ice builds up on the radome (**Figure 3),** when the radome is damaged, or when it isn't well maintained.

Pilots have no control over the horizontal sweep of their weather radar; however, they can adjust the tilt of the antenna, raising or lowering it from 15 degrees above the horizon to 15 degrees below the horizon. Often though, pilots keep the antenna on auto-tilt, which essentially means the antenna may not maintain the appropriate tilt setting.

High altitude aircraft using the auto-tilt setting run the risk of overlooking weather or underestimating the severity of the weather, since the radar would only be detecting the upper portion of the cell (composed of low-reflectivity, ice crystals)**. Figure 4** is an example of radar overshooting a storm cell with the tilt set incorrectly, in this case too high, while in the auto-tilt mode. When the radar was tilted down 2 degrees, the cockpit display showed a much stronger cell (**Figure 5**). At the same time, the WARP NEXRAD display indicated the storm contained an area of heavy to extreme precipitation. Pilots would likely fly through the weather depicted in **Figure 4** but would deviate around the cell depicted in **Figure 5**.

Figure 4*: Cockpit weather radar display with the antenna set to auto-tilt too high (0 degrees in this case), showing a small, weak echo in green, to the north (left) of the eastbound aircraft.*

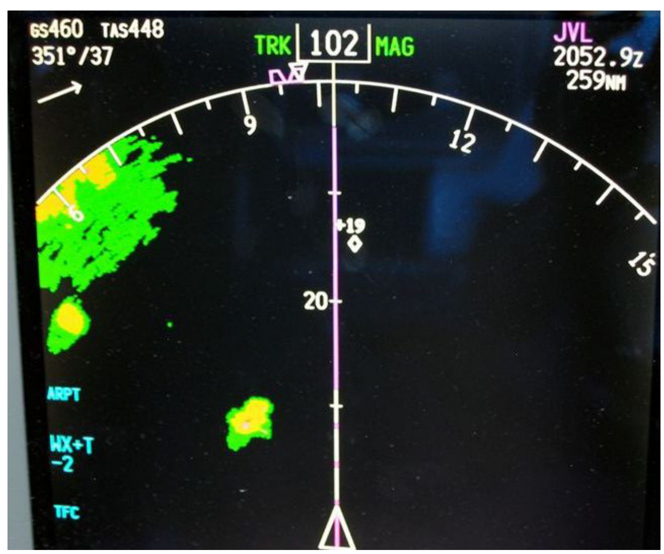

Figure 5: *This figure is the same as Figure 4 but shows the antenna tilting down 2 degrees; the radar now detects more of the storm with areas of lighter precipitation shown in green and moderate precipitation in yellow. Red, when visible would be heavy.*

Figure 6: *Cockpit weather display showing four strong cells 25-35 miles ahead of the aircraft.*

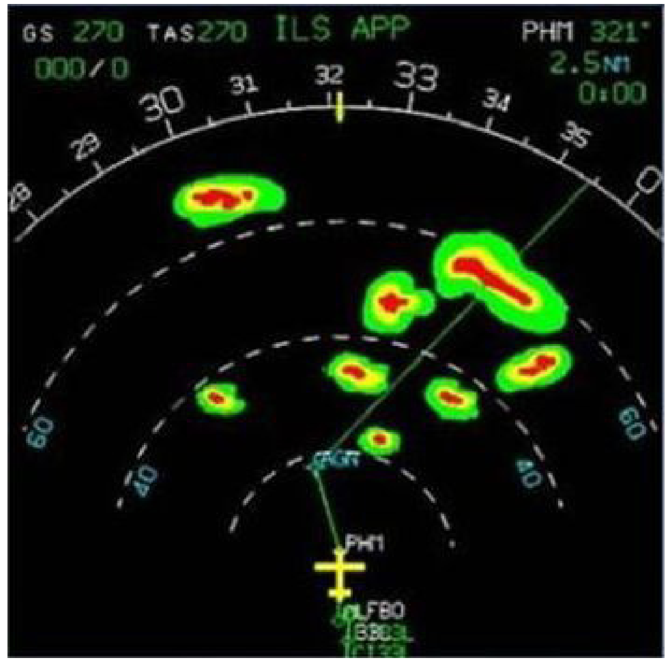

Figure 7: *Shown is the same display as Figure 6 but with the range increased from 40 miles to 80 miles.*

WARP NEXRAD displays can also help mitigate some of the range issues common to airborne radars. Most airborne weather radars only have a useful range of about 80 miles. The useful range of NEXRAD ranges from 143 and 286 miles depending on the surveillance mode.

Figure 6 shows a cockpit radar display depicting four strong cells approximately 25–35 miles ahead of the aircraft. This area is known as the "blind alley," because it is set to such a range that pilots cannot see off-scale weather that is a potential problem. The blue line depicts the course the pilot chose to deviate through the storms. However, switching to the 80 mile range (**Figure 7**) shows this would have been a bad decision since another strong cell, approximately 55–60 miles away, would block the way. ATC controllers can provide this type of information to pilots before the decision is made to deviate since NEXRAD detects weather at much greater distances and is not as prone to attenuation as aircraft radar. Also, if an intervening cell is intense enough, the pilot may not be able to see more distant weather behind it with the aircraft radar regardless of range selected due to attenuation.

This is an example where the ATC controller's perspective can help keep pilots safe. Don't assume the pilot has a better perspective on what lies ahead because they have airborne weather radar.

This article details some of the limitations of airborne weather radars but NEXRAD also has limitations. The two systems really complement each other and offer pilots the best perspective of what lies ahead.

Columbia Basin Stratus and Fog

By Gordon Hepburn, WFO Pendleton, OR

Flying, including airport approaches and departures, across the interior Pacific Northwest is usually performed in VFR conditions. VFR conditions typically occur more than 90 percent of the time from March through October.

From November through February, the Northwest experiences MVFR conditions or lower 25 to 45 percent of the time. The lower rates occur over central and southeast Oregon; the higher rates tend to occur in the Columbia Basin. Often the MVFR or lower conditions are the result of active weather systems producing rain or snow resulting in lower ceilings and visibilities. The Columbia Basin is also prone to extended periods of low ceilings and fog that develop within trapped pools of cold air (**Figure 1**).

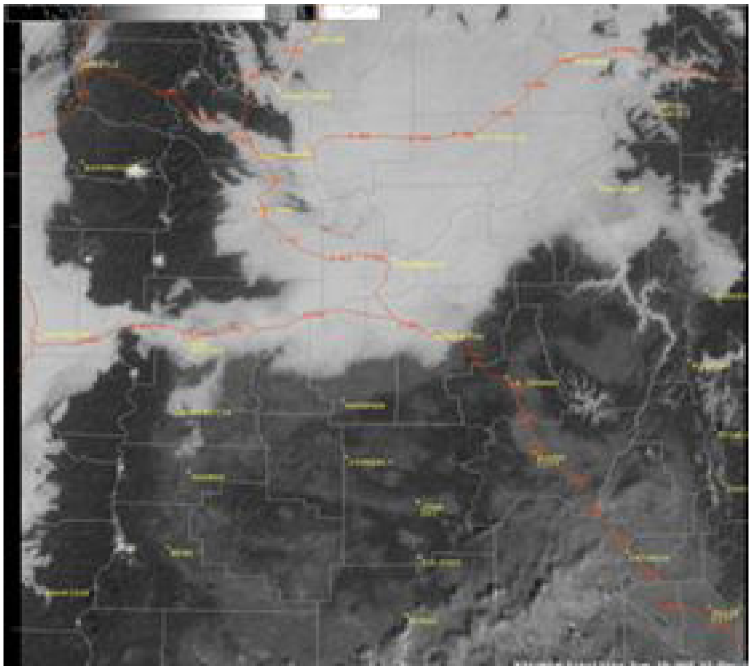

Figure 1: Visible satellite image showing a large area of stratus and fog over the Columbia Basin

The Columbia Basin cold pool initially develops when colder air behind a Pacific storm system settles into the basin and becomes trapped by the relatively higher surrounding terrain. The cold pool develops completely when an upper level high pressure ridge builds over the Pacific Northwest. This ridge causes the air immediately above the cold pool to warm, creating a temperature inversion that further traps the cold air in the Basin (**Figure 2**). Post-system winds can delay inversion development by a day.

The high pressure aloft will also cause skies across the region to clear, allowing for excellent radiational cooling during the night.

Fog and low clouds will form if moisture is available within the cold pool. Usually there is enough moisture because the Pacific systems generally are accompanied by rain or snow. On rare occasions, moisture is limited and it can take a number of days before the trapped cold air mass in the Basin accumulates enough particulates and moisture to form fog and low clouds.

Initially, the fog and low clouds form at the lowest elevations within the Basin, roughly below 1,500 feet MSL. Over a period of 2–3 days, weak daytime heating within the cold pool causes the fog and low clouds to lift and spread out in all directions within the Basin. Tops of the fog or low cloud layer can extend to between 3,500–4,500 feet MSL during fully formed, extended events.

Airports such as Pasco (KPSC), Yakima (KYKM), Walla Walla (KALW), Moses Lake (KMWH) and The Dalles (KDLS) will be impacted by LIFR and IFR conditions during the initial fog/low cloud development period. As the fog/low cloud area lifts and spreads across the Basin, these locations generally improve. This improvement is particularly evident at KPSC and KDLS which can reach MVFR ceilings and VFR visibilities within a day or two.

Higher elevation airports such as Pendleton (KPDT) and Madras (KS33) will usually become fogged in within a day or two of the initial development when the fog/low cloud area lifts and spreads out. During the deepest events, Redmond (KRDM) and other airports above 2,500 feet MSL can become fogged in.

These cold pools, along with the associated fog and low clouds, will persist until a strong Pacific storm moves through the area, breaking the inversion and mixing out the fog and low clouds.

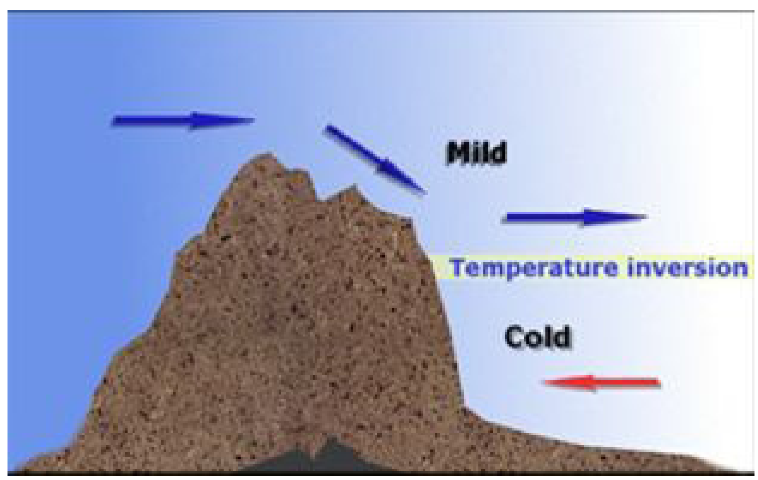

Figure 2: Cold air is trapped near the surface by terrain features and a is capped by a layer of warmer air aloft.

Articles in this edition were adapted from ZSE Weather Watch*, a newsletter from the NWS Seattle Air Route Traffic Control Center, Center Weather Service Unit.*