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ZSE Weather Watch

A newsletter from the Seattle ARTCC Center Weather Service Unit

Columbia Basin Stratus and Fog

by Gordon Hepburn, WFO Pendleton, OR

IN THIS ISSUE

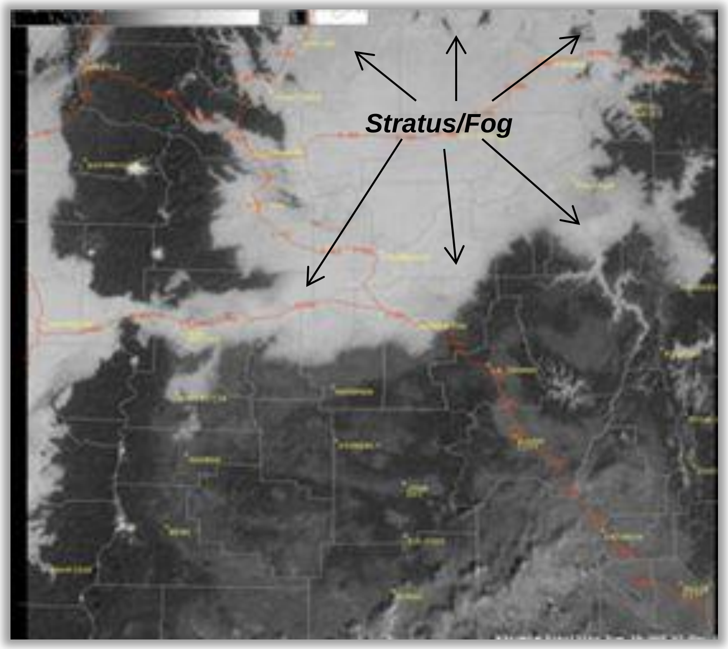


Figure 1 *– Visible satellite image showing a large area of stratus and fog over the Columbia Basin.*

Flying (including airport approaches and departures) across the interior Pacific Northwest is usually performed in VFR conditions. VFR conditions occur at rates of 90 percent or greater from March through October. From November through February, MVFR conditions or lower occur at rates of 25 to 45 percent. The lower rates occur over central and southeast Oregon, with the higher rates occurring in the Columbia Basin. Often the MVFR or lower conditions are the result of active weather systems producing rain or snow that result 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**).

The Columbia Basin cold pool initially develops as colder air behind a Pacific storm system settles into the basin and becomes trapped by the relatively higher surrounding terrain. Development of the cold pool is completed with the building of an upper level high pressure ridge over the Pacific Northwest. This ridge causes the air immediately above the cold pool to warm creating a temperature inversion which 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 nighttime. Fog and low clouds will form if there is available moisture within the cold pool. Usually there is enough moisture as the Pacific systems are generally accompanied by rain and/or snow. On rare occasions moisture is very 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 to 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/low cloud layer can extend to between 3,500 and 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 were MVFR ceilings and VFR visibilities can be reached 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, as 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.

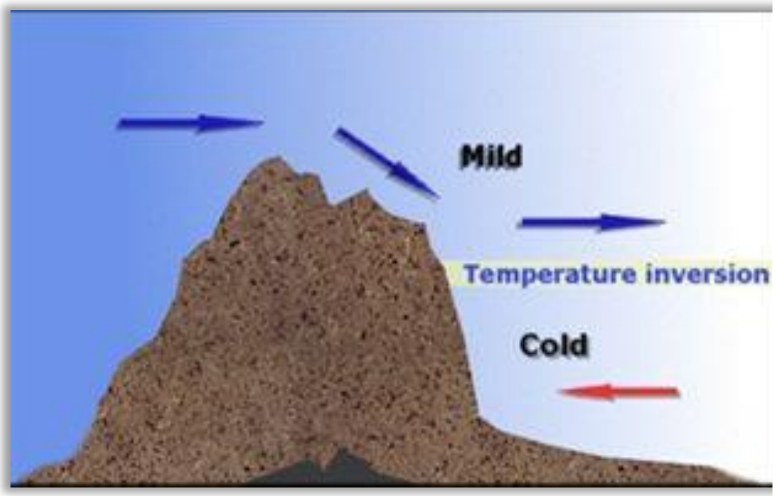


***Figure 2** – Cold air trapped near the surface by terrain features and a layer of warmer air aloft.*

ZSE Mountain Wave Forecasts *by Alexander Dodd*

With autumn in full swing and winter almost upon us, stronger winds aloft have begun tracking farther south across the Pacific Northwest. This means it’s time to be on the lookout for mountain wave activity. As of October 1st, Center Weather Service Units have begun issuing Center Weather Advisories and Meteorological Impact Statements for mountain wave activity not covered by previously issued AIRMETs or SIGMETs from the Aviation Weather Center. Weather Stories (**Figure 3**), web page headlines, Facebook and Twitter will also be used to alert pilots of the potential hazard.

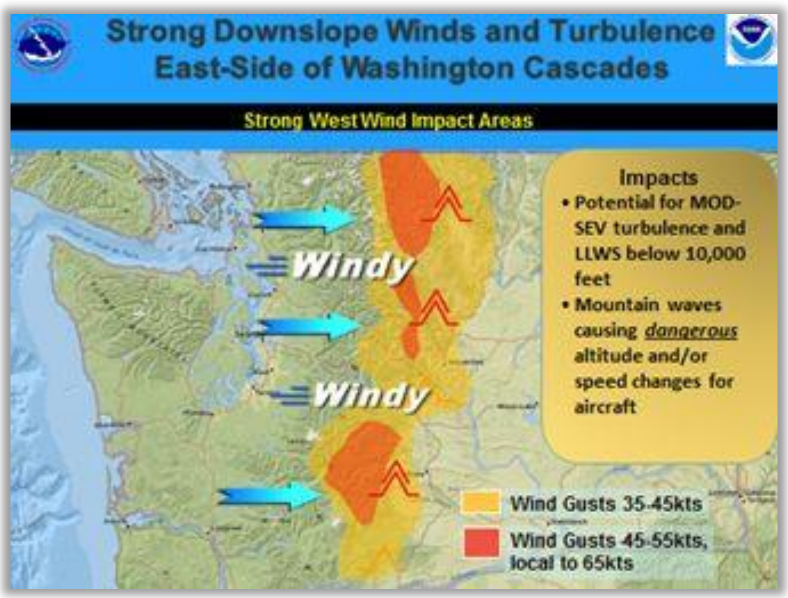


Figure 3 – Example Weather Story for mountain wave activity issued by Seattle CWSU.

Mountain waves are ‘standing waves’ to the lee-side of mountain ranges such as the Cascades in Oregon and Washington, and the Siskiyou and Sierra Mountains farther south in California. They can result in severe turbulence throughout the atmosphere, which can damage all sizes of aircraft. Over the years, we have seen aircraft destroyed, and unfortunately a number of casualties, as a result of severe mountain wave turbulence.

Mountain waves can sometimes occur in clear air. However, if enough moisture is present, they provide visual clues such as cap clouds and/or lenticular clouds near and over the mountainous terrain (**Figure 4**).

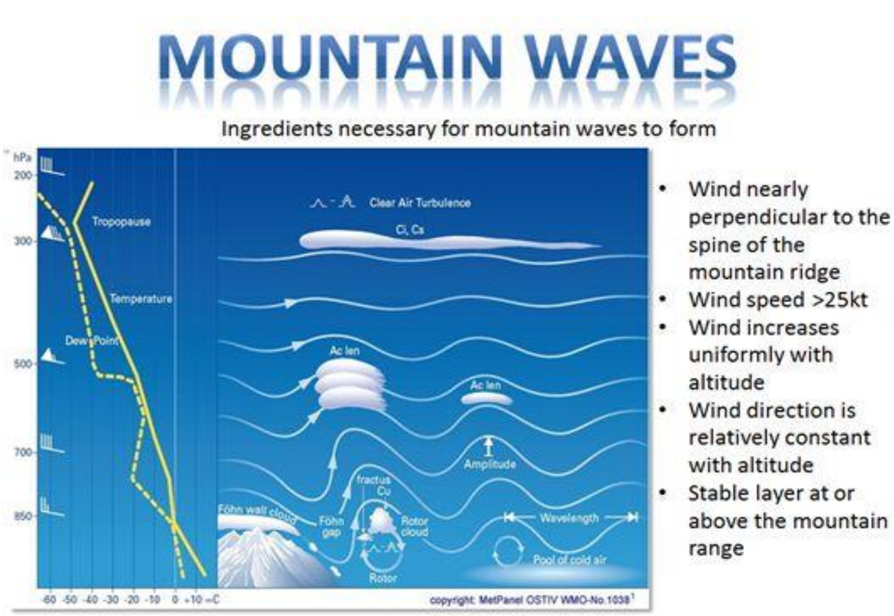
Whether or not mountain waves develop generally depends on three factors: 1) topography of the mountain range, 2) the speed and direction of air flow across the mountain, and 3) the stability of the atmosphere around the terrain.

Mountain waves form under **stable** conditions. In a stable atmosphere, rising air will encounter warmer environmental air, and sink, or return to its original level (warm air rises and cool air sinks without outside forcing mechanisms). However, air will continue to accelerate downward past its original level until it becomes warmer than its surrounding environment once again. As wind moves horizontally through a stable layer of air, mountain barriers help initiate this process by forcing air upward. The more stable the atmosphere, the stronger the force will be to restore air to its original level once it passes the mountain range…resulting in a more rapid and turbulent, oscillation. Air moves through these waves in the atmosphere like water flows through rapids in a river.

However, in a stable atmosphere, if the wind is not strong enough, there will not be enough force to carry air completely up and over the mountain barrier. Mountain waves, which can result in severe turbulence, require just the right combination of wind velocity and environmental stability for air to flow up and over the mountain barrier, resulting in highly amplified waves and rapid oscillations. These waves can and sometimes do amplify and propagate upward in the atmosphere. Just like ocean waves that “break” as they approach a beach, waves in atmosphere can “break”, resulting in severe to extreme turbulence. When this “breaking” action occurs, the most severe turbulence typically occurs between 20,000 and 40,000 feet directly above or just downwind of the mountain barrier. If the mountain wave does not break, an aircraft traveling through it may experience significant changes in altitude and air speed as it ‘rides the wave’, but little or no turbulence.

Figure 4 – *Lenticular clouds and mountain wave activity downwind of Mt. Rainier.*

As you can see, mountain wave forecasting is not only complicated but very challenging. It is often difficult to give the aviation community advance warning of these dangerous weather conditions. Sometimes the best we can do is rely on current satellite imagery and weather observations to show that mountain waves and turbulence are occurring, and even then these sort of observations can be deceiving. That’s why it is critical we receive pilot reports. Any report of mountain wave activity, whether it’s a change in altitude, indicated air speed, or significant turbulence, is extremely valuable to aviation forecasters and pilots. PIREPs are the best way to alert us and the rest of the aviation community that dangerous mountain wave activity is occurring!



ZSE MTN WAVE CRITERIA

MODERATE MOUNTAIN WAVE

UDDF = 250-500 feet per minute

or

IAS change = +/- 20 knots

SEVERE MOUNTAIN WAVE

UDDF = >500 feet per minute

or

IAS change >= +/- 20 knots

or

Net Altitude Change >= 1,000 feet

2014-1015 Pacific Northwest Winter Outlook *by Steve Adams*

The Climate Prediction Center (CPC) has issued a forecast for **below-normal** precipitation and **above-normal** temperatures for the Pacific Northwest for the upcoming winter months (**Figures 6a** and **6b)**.

Figure 6a – *Winter precipitation outlook*

Figure 6b – *Winter temperature outlook*

The primary reason for CPC's forecast is the expected development of El Nino conditions, which the CPC places at a 67% probability. El Nino is the warmer than normal phase for sea-surface temperatures (SST) in the central and eastern tropical Pacific Ocean. During El Nino conditions, the jet stream tends to split, with a stronger southern branch shifting further south. This causes above normal precipitation along the southern tier of the United States. The northern branch of the jet stream shifts further north into Canada, keeping significant precipitation events to a minimum over the Pacific Northwest, resulting in below-normal precipitation. This pattern also generally inhibits arctic air mass intrusions into the Pacific Northwest, resulting in warmer than normal temperatures across the area (**Figure 7)**.

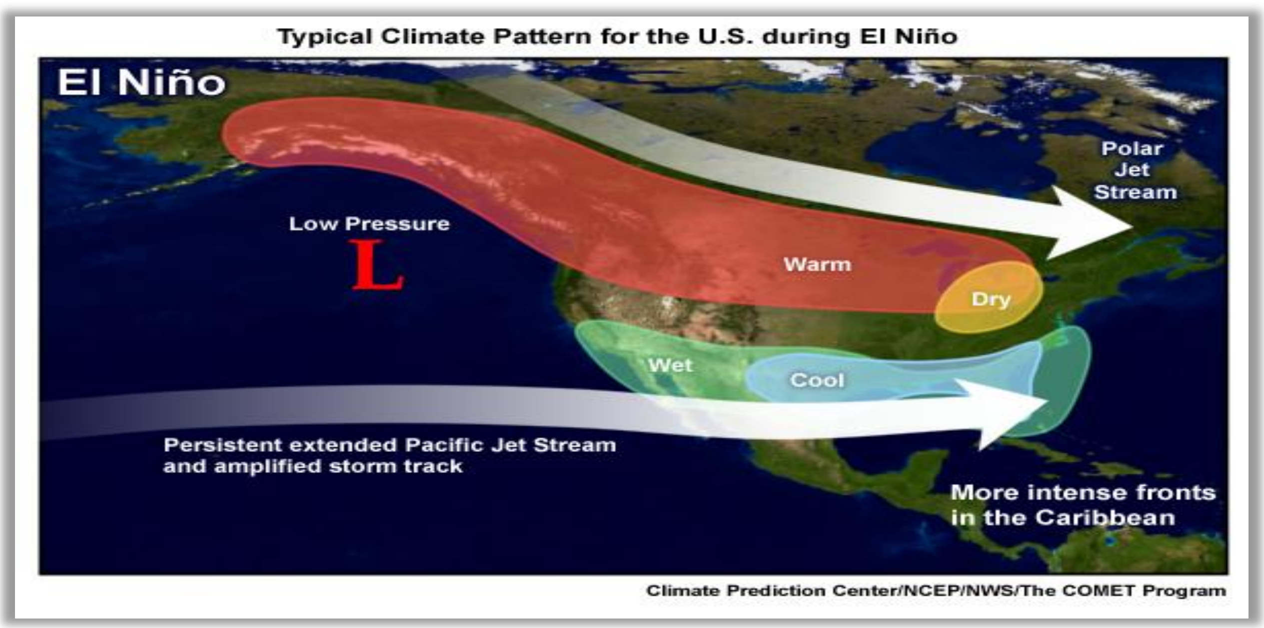


Figure 7 - *Typical climate and jet stream patterns during El Nino events.*

Airborne Weather Radar Limitations *by John Werth*

Is airborne weather radar better (e.g., more timely and/or more accurate) than the WARP NEXRAD mosaics used by FAA air traffic controllers? In early November, a senior air traffic investigator with the NTSB gave a presentation to NWS 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 displays are not inherently "better" than NEXRAD or any other ATC 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 very 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 whereby energy from the radar is completely reflected back to the aircraft, due to the intensity of the precipitation. 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 8**) could also just be the leading edge of a much larger area of heavy to extreme precipitation. Radar attenuation shows up as black areas on a pilot's weather radar display (**Figure 9**). Attenuation can also occur when heavy rain or ice builds up on the radome (**Figure 10),** or when the radome is damaged, or when there has been poor maintenance.

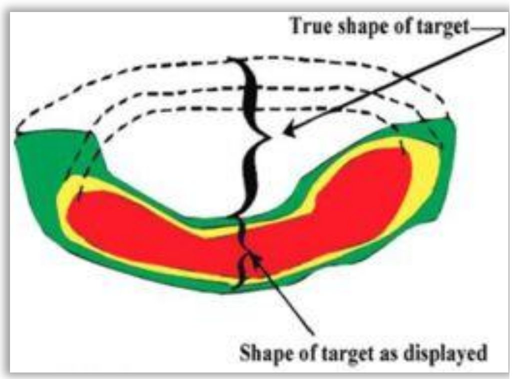


Figure 8 - *Airborne radar attenuation caused by moderate to extreme precipitation.*

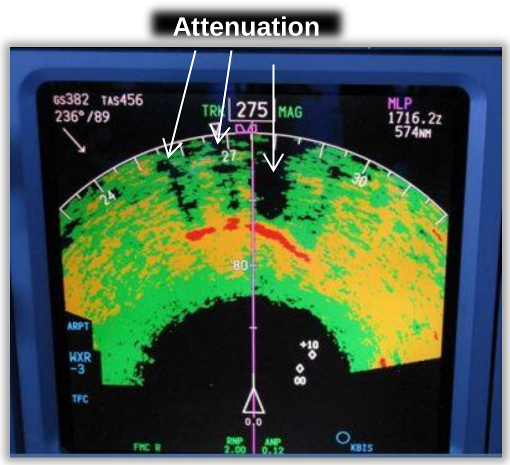


Figure 9 – *Cockpit weather radar display: precipitation (yellow/red), ground (green/yellow).*

Figure 10 – *Ice buildup on an aircraft's radome.*

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. Oftentimes though, pilots keep the antenna on "auto-tilt", which essentially means the antenna is looking straight ahead. High altitude aircraft using the "auto-tilt" setting run the risk over 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 11** is an example of radar overshooting a storm cell in the "auto-tilt" mode. When the radar was tilted down 2 degrees, the cockpit display showed a much stronger cell (**Figure 12**). 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 11** but would deviate around the cell depicted in **Figure 12**.

WARP NEXRAD displays can also help mitigate some of the range issues common to airborne radars. Most airborne weather radars only have a useful

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Figure 11*- Cockpit weather radar display with the antenna set to auto-tilt (0 degrees) showing a small, weak echo in green, approximately 10 miles to the northwest.*

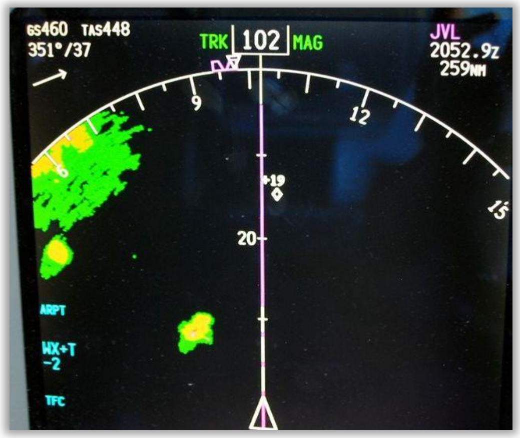

Figure 12 – *Same image tilting the antenna down 2 degrees. Radar now detects more of the storm with areas of moderate to extreme precipitation shown in yellow and red.*

range of about 80 miles, whereas the useful range of NEXRAD varies between 143 and 286 miles depending on the surveillance mode**. Figure 13** is a cockpit radar display showing 4 strong cells approximately 25-35 miles ahead of the aircraft. The blue line depicts the course the pilot chose to deviate through the storms. However…switching to the 80 mile range (**Figure 14**) showed this would have been a bad decision, since another strong cell at 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.

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 its own limitations and issues. These will be discussed in a future issue of ***ZSE Weather Watch***. However, the two systems complement each other and clearly offer pilots the best perspective of what lies ahead.

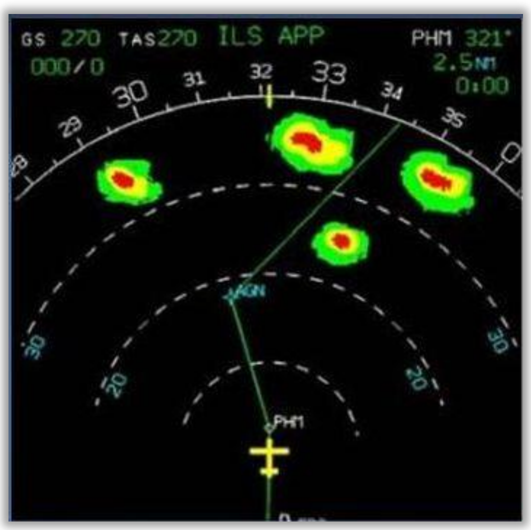

Figure 13 – *Cockpit weather display showing four strong cells 25-35 miles ahead of the aircraft.*

Figure 14 – *Same display with range increased from 40 miles to 80 miles.*