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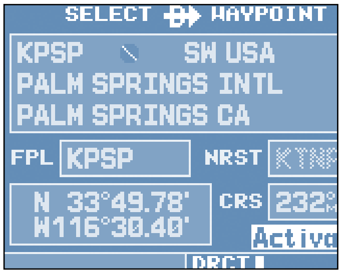
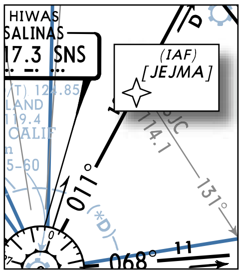
Training that's more real than reality ... page 15



Where to now? ... page 12



Why we arc ... page 6

ALSO INSIDE THIS ISSUE ...

FINDING THE BIG DROPS

What we teach about freezing rain is true less than 10 percent of the time. During the other 90, there may be no safe haven above you.

by Scott C. Dennstaedt

The tale goes like this.:"If liquid precipitation is falling into a subfreezing layer, there must be a layer above you that is warm enough to melt the frozen precipitation into a liquid form. The best move is to climb."

Sound familiar? If using only this strategy, pilots would be wrong most of the time — and you don't get a second chance on making decisions in freezing rain.

Some SLD Water

Supercooled Large Droplets, or SLD, are undeniably the worst icing hazard to *all* aircraft. You might be astonished to learn that a droplet greater than 50 microns in diameter is considered "large." To put this in perspective, the average human hair is 100 microns in diameter. Hold a hair between your forefinger and thumb and think about droplets that are half that width.

Even aircraft certified for flight into known icing conditions are limited to droplet sizes less than 50 microns.

There are two primary processes in the atmosphere that lead to SLD: convective and non-convective. Convective SLD is normally found in vertically-developed cumulus clouds like towering cumulus and cumulonimbus at altitudes where the temperature is below zero degrees C. Updrafts in cumulus clouds allow droplets to remain suspended for a considerable amount of time. The smaller droplets collide and coalesce into larger droplets and grow to a size greater than 50 microns especially near the top of the cumulus cloud. At temperatures from 0 degrees Celsius to about -25 degrees Celsius, these large droplets can remain suspended in liquid form producing an SLD icing threat any time of the year.

A pilot would have to be lucky enough to bust through the high tops or smart enough perform a 180 and return for landing.

Luckily, you can often bob and weave your way around these clouds as long as you stay visual.

In a non-convective scenario within stratiform clouds, SLD is rare except during a freezing rain or freezing drizzle event. Drizzle drops are typically 200 to 500 microns in diameter with freezing rain consisting of drops 1,000 to 3,000 microns in diameter or about one to three millimeters. Therefore, freezing rain and freezing drizzle represent a subcategory of SLD. For brevity, when I refer to "freezing rain" it will also encompass "freezing drizzle" unless otherwise noted. It's this non-convective form of SLD that we need to look at further.

Classical vs. Non-Classical

Freezing rain comes in two flavors, *classical* and *non-classical*, which is a little known fact that you won't find in the 1975-revised FAA's *Aviation Weather*. (AC 00-6A). Sure, it's freezing rain either way and the results can be deadly. I don't expect any pilot to depart in conditions that are clearly reporting or forecasting the potential for freezing rain. However, non-classical freezing rain is stealthy and a forecaster may overlook the event entirely. It may not make it into a TAF or area forecast (FA) and it will often go unreported in METARs.

Cloud droplets or ice crystals are what make a cloud visible to the naked eye. In a stratified cloud deck, these droplets or crystals are tiny and are happy to remain suspended within the cloud. However, as they collide with other droplets or crystals, they may grow in size

Right: *In non-classical freezing rain, that stratus deck could hold 8000 feet of supercooled water.*

THE WARM NOSE: BAD FOR DOGS BUT GOOD FOR PILOTS

In a classical freezing rain event, forecasters will often refer to the warm layer aloft as the "warm nose." A warm nose is typically present whenever warm air "overruns" or slides up and over cold, dense air at the surface. This, of course, is a good description of the movement of warm air northward associated with a warm front. Depending on where you are located at the surface along this cross section, you may experience SN, PL, FZRA or RA. The location and strength of the warm nose will normally dictate the precipitation type.

The absolute best way to diagnose classical versus non-classical freezing rain is using a temperature sounding or thermodynamic diagram such as a Skew-T Log P diagram (lower right). The temperature and dew point temperature are plotted as a function of pressure or altitude. On the left is a simpler graph showing just temps vs. altitude and the altitudes of the probible cloud layer(s).

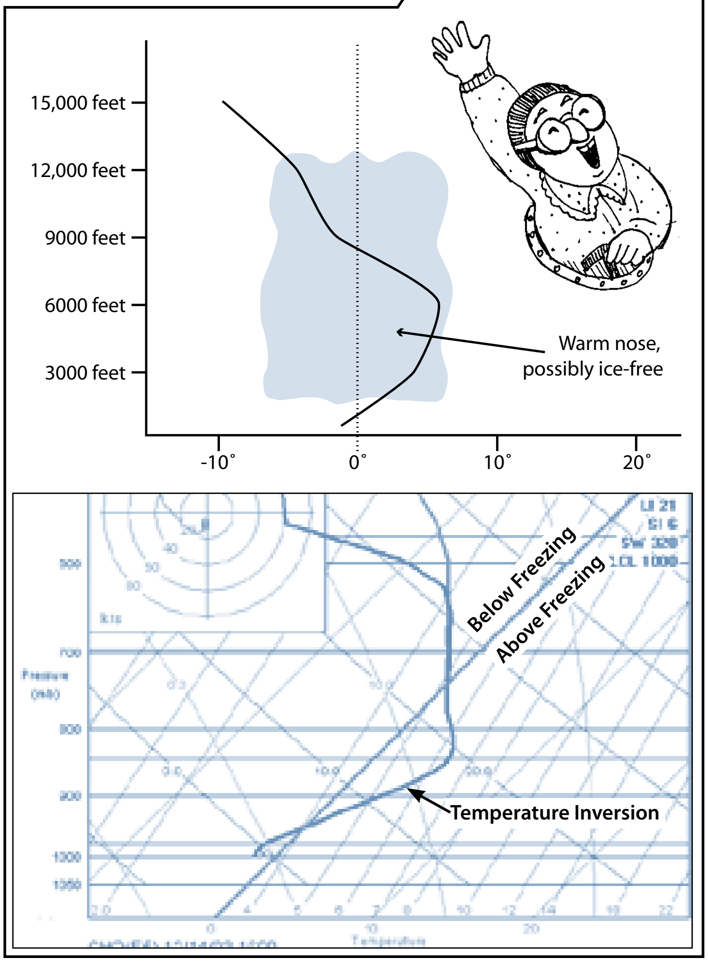
On both of the Skew-Ts (lower right) diagrams, the zero degree Celsius isotherm is shown. When the environmental temperature (or dew point) is on the left side of this isotherm, the temperature is below zero. When the environmental temperature is on the right side of this isotherm, the temperature is above zero.

Both of these diagrams are an example of a non-classical freezing rain event. Both exhibit a temperature inversion and the cloud top temperatures are both warmer than -12 degrees Celsius which implies an all-liquid process (stratus cloud tops are identified where the temperature and dew point diverge by at least 5 degrees Celsius).

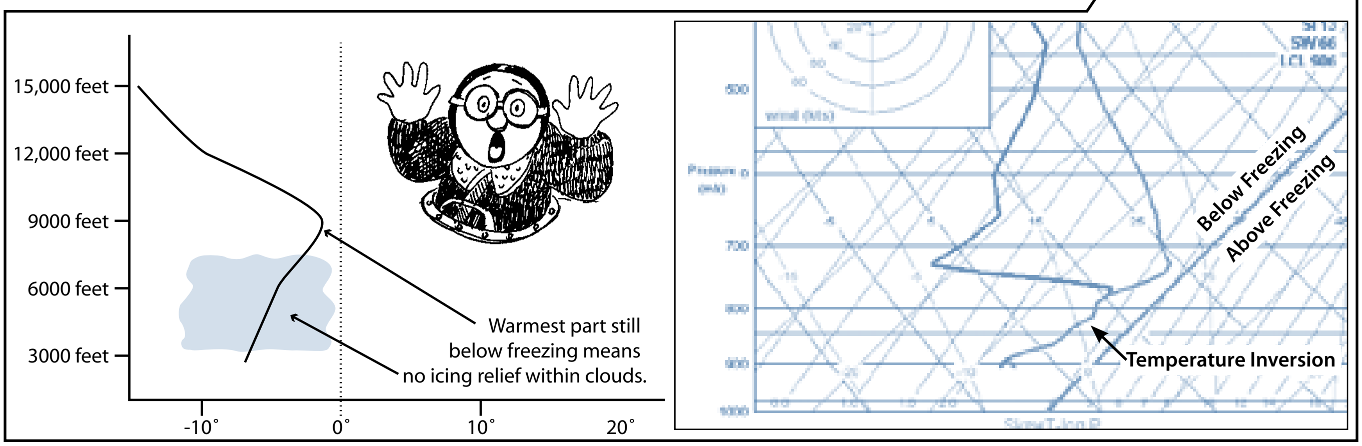
In the non-classical freezing rain event at Charlottesville, Va., (KCHO), there are two freezing levels defining the warm nose in between. The saturated layer above the top freezing level consists of supercooled liquid water and is not likely producing snow due to the warmer temperatures. As the cloud droplets become large enough, they fall out of the cloud as rain or drizzle and remain in liquid form all the way down to the surface. Flight in between the freezing levels will be ice free.

In the non-classical freezing rain case at Amarillo, Texas, (KAMA), the temperature never crosses over the zero degree isotherm. In other words, the temperature and dew point temperature remain on the cold side of this isotherm. If the saturated layer is thick enough and the droplets become large enough, they may fall out of the cloud as freezing rain or more likely freezing drizzle. For this case, there isn't a warm nose present and climbing isn't an option unless you get lucky enough to make it through the tops.

Charlottesville, Va.



Amarillo, Texas



and weight over time. Through this collision-coalescence process they can become heavy enough to fall out of the cloud as light snow, freezing rain, or freezing drizzle. On the other hand, the result may be a garden-variety, non-precipitating stratus cloud with light to occasionally moderate icing potential.

Classical freezing rain begins in the cloud aloft as snow. The snow then falls into a layer sufficiently warm enough to melt it into raindrops. These melted drops then fall into a second subfreezing layer near the surface where it becomes supercooled and deposits as clear ice on your supercooled airframe. This is the scenario that most pilots are taught during their private and instrument training. According to icing researchers at the National Center for Atmospheric Research (NCAR), however, only eight percent of all freezing rain events are classical.

The other 92 percent are non-classical freezing rain, which is an all-liquid process from the top of the stratus cloud all the way to the ground; the ice phase is not necessarily involved. That's right, no ice crystals. The water is supercooled but still liquid.

This doesn't mean no icing. It freezes just fine when in hits something ... like your airplane.

The Warm Nose

Many pilots were led to believe that all freezing rain events have a layer of warmer air aloft that is above zero degrees Celsius. This warm air is essentially squeezed between two layers of subfreezing air producing two freezing levels. Forecasters refer to the layer between the two freezing levels as the "warm nose." The icing threat exists in two areas: the supercooled saturated layer above the warm nose and in the supercooled liquid precipitation below the warm nose.

All classical freezing rain events have a warm nose present. They must, because the precipitation in the higher layer is frozen and must fall through a warm band of air to melt. The depth of the warm layer needs to be about 1,200 feet to completely melt any frozen precipitation. If the depth is not at least 1,200 feet, the snow or ice crystals do not completely melt and ice pellets will likely be reported at the surface.

With classical freezing rain, the entire layer of freezing rain is usually shallow and happens within 3000 feet of the surface.

Pilots are trained to climb toward the warm nose to escape the layer producing freezing rain. That's fine, if the freezing rain event is shallow and the warm nose is there. The unfortunate truth is that you're highly likely to find the non-convective form of SLD right where you hoped to find a safe haven. Here's why.

Non-classical freezing rain has a temperature inversion, but it may or may not get above zero degrees. In other words, there might not be any warm nose. In the non-classical freezing rain scenario with a warm nose, the temperature increases rapidly to a temperature above 0 degrees C. In this case, there should be an altitude free of freezing rain.

In a non-classical event without a warm nose, the inversion is typically weaker, which results in a temperature profile that never climbs above 0 degrees C.

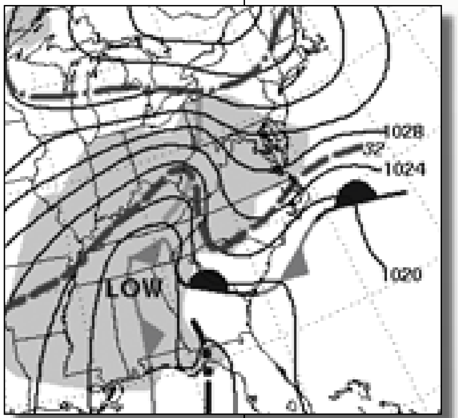
The latter is the stealthier form of freezing rain and is probably to blame for the 1994 ATR-72 commuter aircraft accident over Roselawn, Ind., that killed all 68 passengers and crew on board.

Non-classical freezing rain events with no warm nose can reach a depth of eight to 10 thousand feet or more. A pilot who attempts to climb

(continued on page 22)

CLASSIC, CLASSICAL FREEZING RAIN

Except for the southern most regions of the U.S., freezing rain will occur in just about any part of the country. If you live east of the Appalachian Mountains, you are probably familiar with classical freezing rain. If you live in the region from Lynchburg, Va., extending southwest to Charlotte, N.C., you live in the classical freezing rain capital of the country.



The typical synoptic scenario for a classical freezing rain event in the east begins with a strong and cold high pressure parked over northern New England. The clockwise low level circulation around the area of high pressure advects cold and moist air down from New England into the Piedmont of North Carolina and Virginia. This subfreezing cold air is dense and wedges up against the Appalachians. The air is said to be dammed against the mountains.

The next component is an area of low pressure with a storm track that rides northeast along the spine of the Appalachians. This low is ushering in a warm and moist air mass into New England as a warm front moves northeast bound from the southeastern U.S. The warm, moist air from the southeast rides up and over the Appalachians creating a deep temperature inversion aloft with warm air overrunning the cold, dense air wedged in at the surface. Warm air that is above 0 degrees C over the top of cold air creates a stable situation with little mixing from below.

On the other hand, few classical freezing rain events occur just west of the Appalachian Mountains. This is typically a region that is on the north or west side of the storm track and sees more snow in this same storm system. *— S.D.*

QUIZ ANSWERS *(questions on page 14)*

1. **d.** The audio signal triggers the light to light. If you can hear the signal, the problem is in your equipment, although it's possible it's not the bulb.

2. **c.** Look at AIM Table 1-1-4.

3. **a.** AIM 1-1-9 d (3)

4. **c.** Other factors (including d) may be true, but c is required.

5. **c.** We don't understand it, either, but clocks in orbit run at a different speed than clocks on earth. GPS uses precise time measurement, and without corrections for this effect, cumulative errors could be over six miles per day.

flying? A big airport might have two or three different approach plates for the ILS to 29R at Metropolis, ILS 29L, ILS 29L (Cat II), and a Converging ILS 29L. With three more ILSs to 29R, confirming the name of the approach is important.

From there, move to the briefing boxes across the top of the plate, and begin with the frequency. When that is tuned and identified, the approach course is next; set the CDI or the lubber line on the HSI. At this point make sure the CDI is being driven by the NAV/LOC or GPS as needed. In some airplanes this is automatic, but check. The runway lengths and airport elevations are next, and then a box with some notes. Few of them require action, just awareness.

The missed approach box has instructions and, while reading through them is important, only memorize the first action on the missed approach procedure. Climb straight ahead, or turn to a heading. Whatever the first action on the missed approach is, know it, and be prepared to execute it. The ATIS or the AWOS frequency is next. You probably have this already, but if not just ask that helpful controller for it and listen for the key items: visibility, ceiling, winds, and altimeter.

The following boxes have the approach and tower frequencies. Approach or Center will tell you the frequencies to use, so unless you get lost, you can skip these boxes. Ground frequencies are next and if you have time they can be tuned up in Com 2, or dealt with on the ground. The last box is Clearance Delivery. That is for another time; skip that too.

Using the plan view and the profile view move your finger across the plate from your current position following the path you will take as you fly the approach. Take note of any obstacles or obstructions and use the profile to determine the altitudes at each fix.

The minimums are at the bottom and should be memorized. If a non-precision approach requires timing, the timing box will have the time to determine the missed approach point. Finally, the airport plan view shows the airport layout, runway and approach lighting, and runway lengths. Knowing the airport configuration will help make sure you don't head for the wrong runway after you break out.

An organized, step-by-step approach is much faster than randomly looking for the information as needed, and reduces the risk of missing an important item in the notes. With practice, the whole thing takes a couple minutes to do, tops.

It would be great if there were some simple shortcuts. The problem is the approach phase is the most dangerous part of the trip. It's the last place to take chances. Single Pilot CRM (June 2000 *IFR*) says: To avoid errors, trap the errors that you make, and mitigate the consequences of those errors. A quick and simple approach briefing is the quickest and safest way to accomplish that.

Knowing that you can react quickly and safely to a change in the plan at the last minute makes it much easier to smile before you push the mike button. Smiling before you talk to Approach just might get you to that steak on time.

Doug Rozendaal gets most of his steak in the Midwest.

FINDING THE BIG DROPS

continued from page 11

to get to that promised warmer layer will have to be lucky enough to bust through these high tops or smart enough perform a 180 and return for landing to exit the SLD potential. There just isn't a safety layer aloft in this particular case.

There may be little warning either, as precipitation at the surface may be reported as rain (RA), drizzle (DZ), freezing rain (FZRA), freezing drizzle (FZDZ), ice pellets (PL), or unknown precipitation (UP), but never snow (SN). More importantly, there may not be any precipitation falling or reported at the surface.

Icing without Ice

So what clues do you have? The primary difference between the two

SNOW THAT'S HALF BAKED: ICE PELLETS

Ice pellets (PL), also known as sleet, are a close cousin of freezing rain. Besides removing the paint on the leading edges, ice pellets themselves are not an icing threat per se. However, they are a sign of potential SLD. In the cold layer (layer below 0 degrees C), ice pellets tend to exist with other precipitation types such as snow, rain or freezing rain about two-thirds of the time.

Ice pellets are typically indicative of a transition zone associated with a warm front. Picture yourself north of a warm front in the cold air with the warm front moving toward you. As you move from the cold side to the warm side, precipitation type changes from SN to PL to FZRA to RA. Keep in mind that not all precipitation types have to show up in the transition. Just to keep you honest, sometimes you won't see a precipitation type transition at all. As a result, warm fronts tend to be sloppy.

Transition zones such as this are not just limited to warm fronts. However, warm fronts are the most likely to create the warm layer over top the cold layer with multiple freezing levels.

In the case of PL, only partial melting takes place; the warm nose isn't quite deep enough or warm enough to change the entire droplet to water. Some snowflakes may melt all the way, while others may not. Those that melt all the way become rain and fall into the cold layer below to become FZRA. In the case of PL, snowflakes that don't melt quite all the way are liquid drops with a potentially active ice nucleus in it.

When these drops fall into a layer cold enough for the nucleus to re-activate, then the FZRA drop will refreeze into a pellet. It could happen at any point during its fall through cold layer. Chances are greatest that it will occur at the coldest point in this layer, but it could happen above or below it – a small detail that is hard to predict. Since it could refreeze at any point, that means that FZRA could still be present at any point in the cold layer; thus, the SLD threat is present throughout the cold layer when PL is also present. *— S.D.*

forms of non-classical freezing rain is in the magnitude of this temperature inversion and how cold the air is at the surface.

Temperature is the key to whether a cloud produces snow versus rain. As long as the cloud top temperature remains warmer than -12 degrees C, supercooled liquid water is favored. Below -12 degrees C, ice crystals tend to grow at the expense of supercooled liquid water.

Now the fun begins. Assume for the moment that the cloud-top temperatures are warmer than -12 degrees C and no warm nose exists. In other words, the entire temperature and dew point profile is between zero degrees C and -12 degrees C from the cloud top all the way down to the surface. This is a set up for freezing rain or freezing drizzle, even though precipitation may not be reaching the surface.

We live in an outdated world where the FAA doesn't want to challenge pilots with the newest tools and techniques available on the internet. Sure, the Aviation Weather Center's Aviation Digital Data Service (ADDS) is "FAA-approved" and much better than most of those antiquated charts you had to study to pass the instrument knowledge and practical exams.

Unfortunately, there's more to the story. At present, there has been very little connection between the real world of meteorology and the pilot's world of FAA perception. Freezing rain is just another example where the FAA has not provided the pilot with the complete picture.

Scott Denstaedt is a meteorologist, CFI, and IFR *contributing editor.*