Making Sense of the Weather

Scott Crosby – 1978 Cessna 182Q Skylane N422SP

http:// weather.scottcrosby.info **http:// flying.scottcrosby.info**

➢ Who Am I?

Flying since 1986, private pilot, IFR-rated since 1988; 2500+ hours total time, 350+ hours IMC.

Aircraft: since 1992, Cessna 182Q Skylane N422SP;
1990-92, Cessna 172 N234RM; 1986-89, Cessna 150 N6673S; all IFR-rated.
also checked out in Piper Archer, Cessna 177-RG

Furthest flights:
Black Hills, South Dakota; San Antonio, Texas; Houghton, Michigan (UP); Portland, Maine.

Making Sense of the Weather

➢ Weather Basics

from: https://scottcrosby.info/weather/index.html#about

Air pressure is shown in millibars or inches. The average air pressure at sea level is 1013 millibars, or 29.92 inches.

Any area with a lower value is an area of low pressure. Any area with a higher value is an area of high pressure. The further the pressure is from 1013, the greater the speed of the associated winds.

Weather charts will also label an area as a low, even if it is above 1013 but it is surrounded by higher air pressures.

Low pressure tends to bring clouds and precipitation – rain, sleet, or snow, depending on the temperature.

High pressure tends to bring sunny weather.

A front is a meeting of two air masses, usually with differing winds, temperature, and humidity.

Low pressure areas tend to be part of a front.

High pressure areas tend to be the central part of an air mass.

Air masses, highs, and lows vary in intensities, and when the differences are minimal, they are not always clearly defined. In the northern hemisphere, winds circulate clockwise around a high, and counter-clockwise around a low. In the southern hemisphere, circulation is the opposite.

Warm fronts tend to lie more or less east-west, and divide two fairly static air masses.

Cold fronts tend to run more or less north-south and move eastward, with (in the northern hemisphere) the south end trailing, and can stretch for a thousand miles or more. Cold fronts are usually the leading edge of a cooler air mass moving east.

A cold front, being an area of low pressure, will generally be preceded by winds bringing warmer southern air northward.

Cold fronts often include precipitation, due to moisture carried north from the Gulf of Mexico. As that moisture moves northward, it cools and so condenses, resulting in precipitation, because cooler air can hold less water than warmer air.

A cold front will be followed by winds bringing cooler northern air south behind the front; i.e., circulating in a counter-clockwise direction around the front, as noted.

The stronger the winds, the greater the temperature swings: warmer southern air reaches further north, and cooler northern air reaches further south.

Examples are most obvious in the winter, when unusually warm temperatures extend up into Iowa, preceding rain or snow on the leading edge of the cold front, or a cold snap reaches down into the Carolinas, after the passage of a cold front.

That pattern is a fairly reliable predictor of the next 2-3 days' weather: if it is unusually warm, expect precipitation. The higher the temperature, the more intense the precipitation and the less time it will take to pass through.

The quicker and more intense the precipitation, the colder the temperatures will be when it has passed.

The passage of the front will be followed by a gradual return to more seasonal temperatures, until above average temperatures and southern winds signal the approach of another cold front.

Air temperature declines about 3°F / 2°C per thousand feet rise in altitude.

Air pressure declines as the altitude rises above sea level. At 11,000 feet, the air pressure is only two-thirds; at 18,000 feet, it is only half.

The lowest pressure ever recorded was 867.93 millibars, in the eye of typhoon Tip over the Pacific Ocean on 12 October 1979.

The highest air pressure ever recorded was 1085.68 millibars at Tosontsengel, Mongolia, on 19 December 2001.

Making Sense of the Weather

➢ Surviving Instrument Failure in IMC

Can it be done? Lost vacuum three times – all in IMC

1. 1994 – Returning from Alabama at 7000'; no VFR airports within 100 miles; 1 passenger
2. 2002 – Departed Donaldson, over Greer at 7,000'; 1 passenger; broke out at 500' on approach
3. 2008 – Returning from Williamsburg-Jamestown at 8,000'; 3 passengers

Know your airplane – Instruments powered by:

- **Mechanical** – airspeed, altimeter, the ball in the turn coordinator, vertical airspeed, compass
- **Vacuum** – artificial horizon (AH), directional gyro (DG)
- **Electric** – turn coordinator, nav-coms, Garmin G-5 AH (w/ electronic "turn coordinator")
- **Battery backups** – Garmin G-5, handheld com radio, Garmin Aera 510, iPad, second iPad, iPhone
  ForeFlight allows 3 copies – mine on iPad, wife's iPad, iPhone – all in the airplane on long trips
- **Alternate Vacuum** for AH and DG; **Alternate Static** for Garmin G-5

Traditional "six-pack" vs. flat-panel displays

- Techniques: scan vs. stare
- Flat-panel backups – airspeed, AH, altimeter – below line-of-sight?
- Instrument failure – six-pack vs. flat-panel
  - Six-pack – familiar panel minus some capability
  - Flat-panel – switch to unusual instruments, at difficult instrument location; **stare to scan**
    total change from familiar ***stare*** to unfamiliar ***scan*** – can you do it?

If replacing vacuum AH with G-5, don't remove vacuum; move vacuum AH to right panel

- allows right-seat pilot to have AH directly in front for proper viewpoint
- having right-panel AH helps your scan: when looking at right panel, AH is included
- G-5 and vacuum AH = mutual back-up redundancy

Note **two** weather sources:
ADS/B on iPad – radar;
XM on Aero 510 – satellite.

Two versions of the weather: the differences help you understand the weather.

Also redundancy if one fails.

Know your equipment and full ranges of capabilities – modern nav-coms are **not as easy as KX-170B**s

- Fly in VFR conditions, practicing IFR techniques until everything available to you is second nature

  Example: 6-8 hours practice flying with new Garmin GNS-650 and GNS635 nav-coms
  in every crazy IFR scenario that I could imagine ATC might call for
  plus heavy annotation of user manual carried in flight-bag !

  A New One: "Approach clearance cancelled; immediate right turn to 090" (from ILS-01)

IFR Training – Know How to Survive Instrument Failure

Your IFR instructor will have you practice partial-panel flying

Be sure you can fly instrument approaches *down to minimums* with partial-panel

Minimum: 250-300 feet for RNAV-GPS; **200 feet for ILS** – can make all the difference
Assume no VFR airports will be available
Inability to fly approach condemns you and your passengers to ending up as fatalities
Keep in practice; maintain your ability – make that a part of your IFR currency
If necessary, get another pilot to sit right seat, and wear a hood – practice, practice, practice

In-flight Actions

Fly the airplane! Ignore distractions!

Inform ATC you have partial loss of instruments

Decide what to do:

- Return to departure airport
- Continue to destination airport
- Proceed to VFR conditions and VFR airport – inform ATC of direction and airport
- if out of contact with ATC, continue on IFR flight plan ***if able***
  - if become able to switch to VFR, (land and) inform ATC;
    can use **1-800-WXBRIEF**
  - If VFR, optionally reduce altitude enough so cellphone works
  - **Close or cancel flight plan asap**

Usually no need to declare emergency – just fly the airplane

ATC Communications

When informing ATC of lost instruments:

Let them know what you want to do – let them know your intentions

***You* are pilot-in-command! Not ATC.**

If they ask, "What are your intentions?"

They are discreetly trying to remind you that you are PIC

It is up to *them* to help and accommodate *you*

In a dire situation, you have priority over all other traffic

ATC will likely give you your own com frequency and controller

Depending on situation and severity, let them know:

you can change direction or altitude, but not both at once

Making Sense of the Weather

➢ Surviving Icing

Ice accumulates first and most importantly on wing's leading edge

Building up of ice changes shape of wing from curved lifting-shape to brick, to pronghorn.

Understanding Weather Conditions Is Part of Preflight Preparation

If possibility of ice, do not fly in it.

Air temperatures typically vary by 3°F / 2°C per thousand feet
do the math and know what altitudes are available to you

In-flight Actions

If icing, get out fast. Climb or descend, but get out.
Air temperatures typically vary by 3°F / 2°C per thousand feet
Compute and decide on your needed altitude

If have any icing, ***keep airspeed <u>up</u>*** – add 10-15 knots to descent and touch-down speed

Learn from My Worst Icing Experience

In the 182, IFR on top of a cloud layer, ATC said 500' of clouds on descent, was actually 2500' or more. On approach, came over the runway low but *10-15 knots fast*. Above the numbers at 30 feet, started to slow, wings immediately stalled – luckily only a 30-foot fall to the ground. Once on ramp and stopped, got out and checked leading edges – found solid ***brick-shaped*** ice leading edge.

NOTE: No recovery from stall due to icing – wings no longer work, period. No way to get rid of ice. Go faster and hope.

Flying Up North

Flying to Maine in mid-<u>June</u>
over Massachusetts at 7,000 feet, in the clouds
mostly sunny, but not a nice warm summer day – light icing on leading edges
outside air temperature indicated I needed to go down 2,000 feet
requested lower to 5,000 – told ATC had icing and needed it ***now***
ATC delayed (welcome to flying in the northeast); repeated request
about to declare an emergency
attitude – ***I* am PIC**, not ATC
when they let me down to 6,000
ice stopped growing but did not dissipate; again urgently requested 5,000
ATC let me down to 5,000 and ice disappeared

Don't Forget Carb-Icing

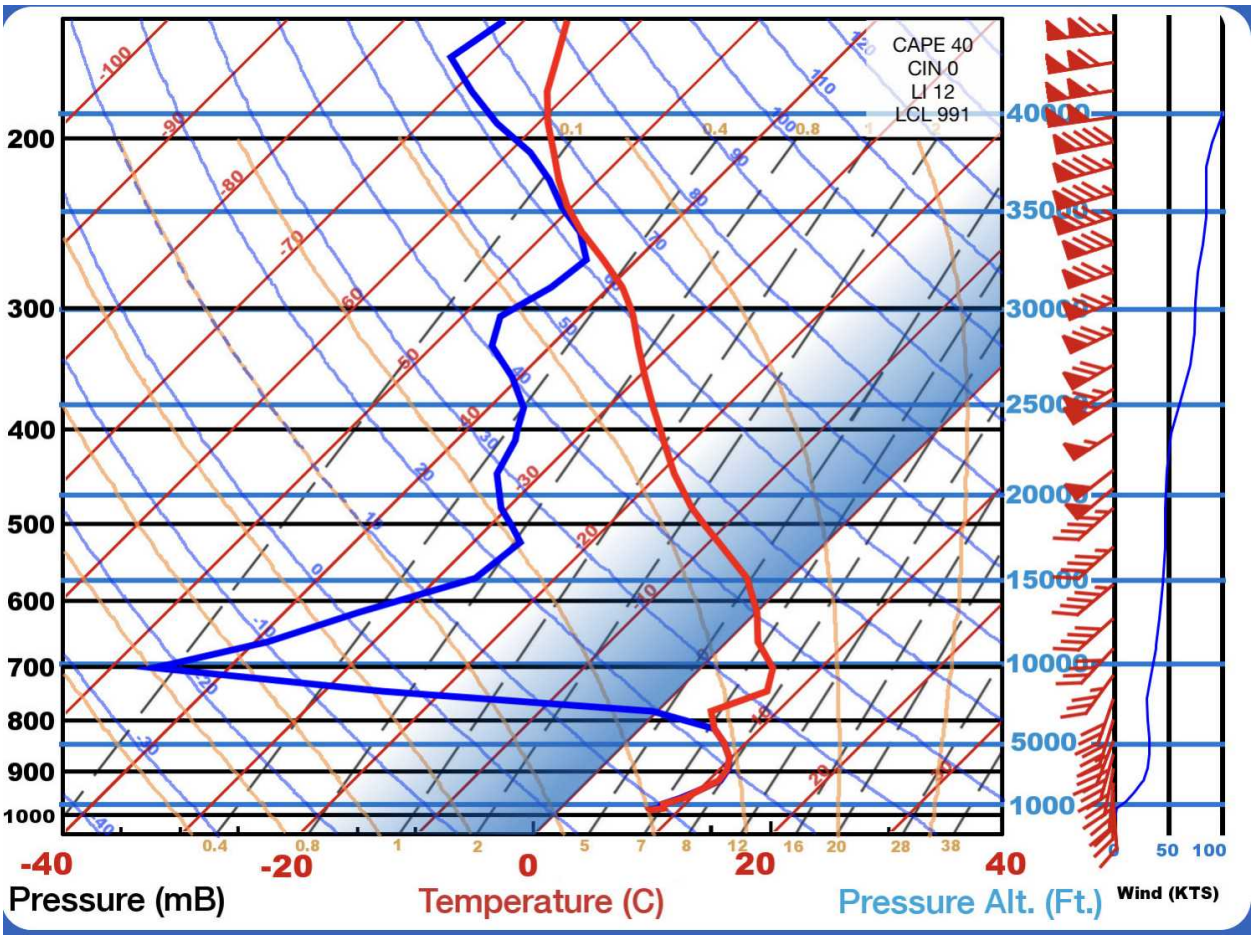
Carb-icing can happen at temperatures much warmer than freezing. The higher the *relative humidity*, or if you hear the ice breaking up when you use it, the more frequently you should use carb-heat.

Making Sense of the Weather

➢ Introduction to Skew-T Log-P Charts – Seeing What They Tell You

A SkewT-LogP chart shows you the "Vertical weather" for a given location.

Example 1.



Easiest and most important things to read from the chart:

- Clouds from the surface (i.e., fog) to 6,000' and from 32,000' to 36,000 feet
- Freezing level is about 14,000'
- No icing – low-level clouds too warm, high-level clouds too cold
- Surface elevation at this location is about 1000'
- Flight in-cloud and through cloud-tops (5,000'-6,000') should be smooth, not bumpy

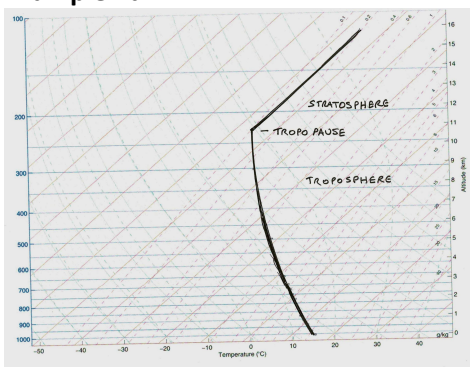
Explanation:

Atmospheric *pressure* in millibars on the chart's left side – a *logarithmic* scale
hence the "**Log-P**" in the chart's name, "**Skew-T Log-P**")
altitude is also shown in feet on the right side of the chart
Red line is temperature at each altitude; blue line is dew-point at each altitude
where red and blue lines overlap, clouds form
where red and blue lines are relatively close, clouds may form due to atmospheric variations
further apart = scattered, closer together = broken
where red line crosses 0° line is the freezing level

Smooth vs. bumpy ride: high clouds shield low clouds from heating by the sun. Heat fuels turbulence.

Temperature is indicated horizontally at the bottom of the chart, and by the slanted (skewed) lines in the chart – i.e., being the "**Skew-T**" in the chart's name, "**Skew-T Log-P**". By skewing the temperature graph-lines on the chart, a "normal" temperature will be roughly vertical (see **Example 1a** at right). Deviations of the temperature line indicate non-normal temperature variations.

Example 1a



The blue shaded area above the temperature's 0°C line on the graph of Example 1 shows the range of temperatures where icing is possible, *if* any clouds exist at that altitude.

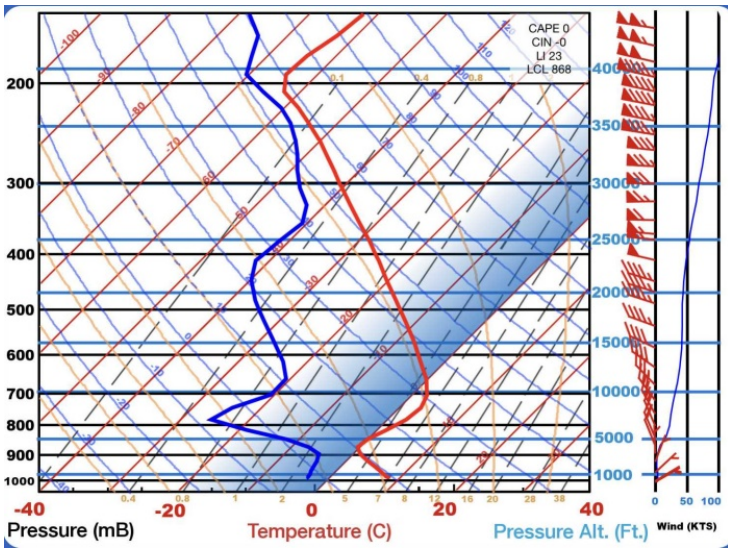
Elevation: Note where the red temperature line and blue dew-point line stop at the bottom of the chart: that indicates the surface elevation at that location.

Winds: Note that winds at each altitude are shown on the far right of the chart, both in symbols and in the narrow secondary graph.

Decoding the winds symbol: 
The symbol indicates **winds of 75 knots coming from the west-southwest**. The pointer's direction shows the wind's heading (east northeast), and so points away from the wind's source. A triangular red flag stands for 50 knots; a full-length line stands for 10 knots, and a half-length line stands for 5 knots. The total wind-speed is read by summing the amounts indicated: 50+10+10+5 = 75.

Example 2 – Scattered indicated on a Skew-T Log-P chart, scattered in the sky.

Example 2



A beautiful sunset: As noted previously, where red and blue lines are relatively close, scattered-to-broken clouds can be expected. The chart at right tells you these high cirrus clouds in the photo are at 35,000 to 40,000 feet.

Given the time of day (sunset), and having that sliver of the Moon in the sky, the chart also tells you that you might want to get your camera and take a picturesque sunset photo.

A chart is the *average* for a 12.5 mile x 12.5 mile square. The photograph illustrates that the atmosphere always has slight variations in temperature, dew-point, winds, etc., from locale to locale. These variations reflect slight

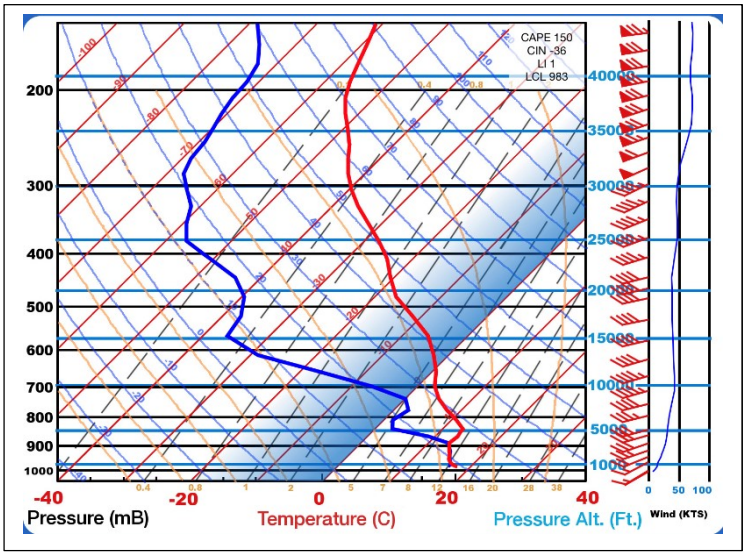
deviations from the SkewT-LogP chart's spread of the temperature and dew-point lines.

A weather front, of course, would have a massive *change*, not just a variation.

Example 3 – Fog and Blue Sky

The chart at right shows a dreary day on the ground, but a bright sunny day and beautiful blue sky for IFR flights above 4,000'.

The temperature line and dew-point line stay wide apart above 4,000', so pick the altitude you prefer given the winds and the distance you will be going, and enjoy the flight.



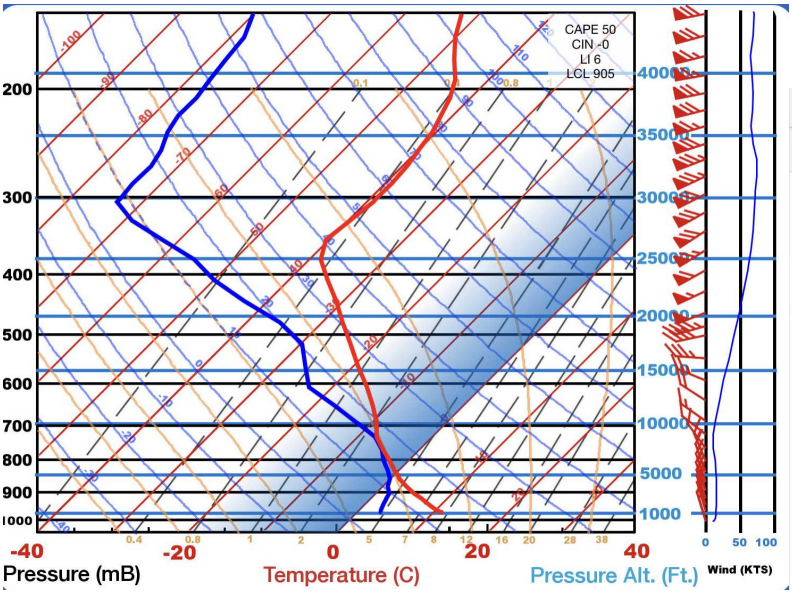
Example 4 – Clouds at the freezing level

The SkewT-LogP chart for Example 4 tells us there are clouds at the freezing level, which is at 5,000'.

Compare that to **ForeFlight**'s Winds report, shown below to the right of the graph for GYH, which agrees with the chart but is less informative, only listing 3,000' and 6,000'. With **SkewTLogPro**, you know you can use 3,500' VFR and 4,000' IFR (with caution), but at 5,000' icing should be expected.

You can infer that from the temperature changes on the Winds report; they are what you would expect. But the information regarding the winds provided on the SkewT-LogP chart is more detailed.

If your intended route's IFR Minimum Enroute Altitude (MEA) is over 4,000', your flight is a no-go.



1h 19m ago

11:30 AM EST

3,000'	3°C (ISA-6)	336° at 9 kts
6,000'	-2°C (ISA-5)	335° at 10 kts
9,000'	-8°C (ISA-5)	313° at 10 kts
12,000'	-13°C (ISA-4)	288° at 20 kts
15,000'	-19°C (ISA-4)	273° at 30 kts
18,000'	-25°C (ISA-4)	258° at 40 kts
21,000'	-31°C (ISA-4)	247° at 48 kts
24,000'	-37°C (ISA-4)	242° at 55 kts
27,000'	-40°C (ISA-2)	240° at 61 kts

Making Sense of the Weather

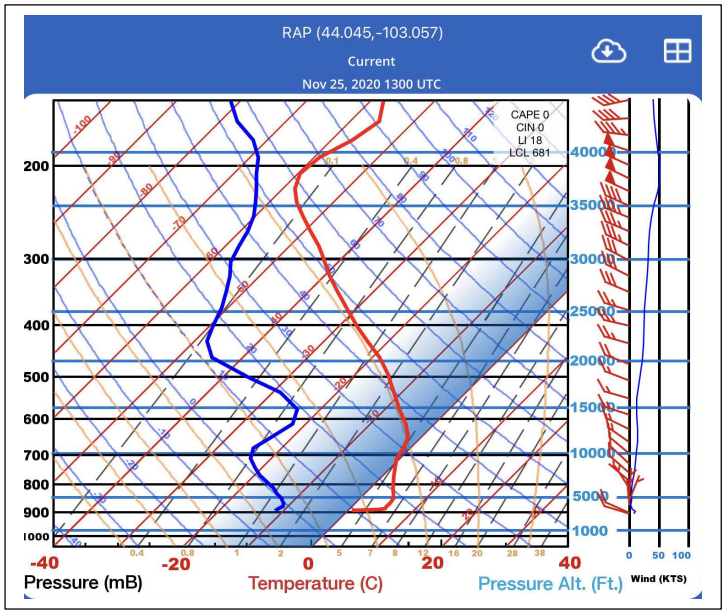
Example 5 – 7:00am in Rapid City, South Dakota

No icing; sky clear. Note how cold it is on the ground – barely above 32°F. But the air warms quickly as you get just a little higher, and does not drop back down to 32° until about 7,500'.

Also note the field elevation: just over 3,000'.

Most of us in South Carolina have never been on an airport at such a high elevation. In the summer, **density altitude** at RAP can be up to 6,000'. **Do the math; make sure you can get off the runway at that altitude.**

Being that cold and with such low humidity, a take-off should be no problem. But better to *do the math* and make sure.



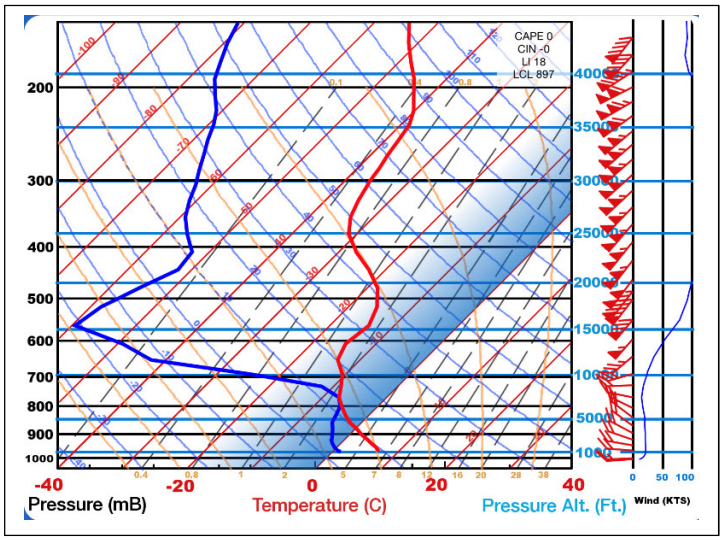
Example 6 – Icing at 6,000'-7,000'?

There are clouds at 6,000'-7,000' feet, but is there icing? Hard to say.

In a 182, headed northeast for a long flight and given the winds, I might chance a climb to 11,000'. If icing did show up late in the climb through the clouds, I would keep going. If icing shows up right away, descending back down to 5,000' might not be enough to clear the icing off the wings; if I had to go lower, I might cancel the flight, return home, and **switch to plan B**.

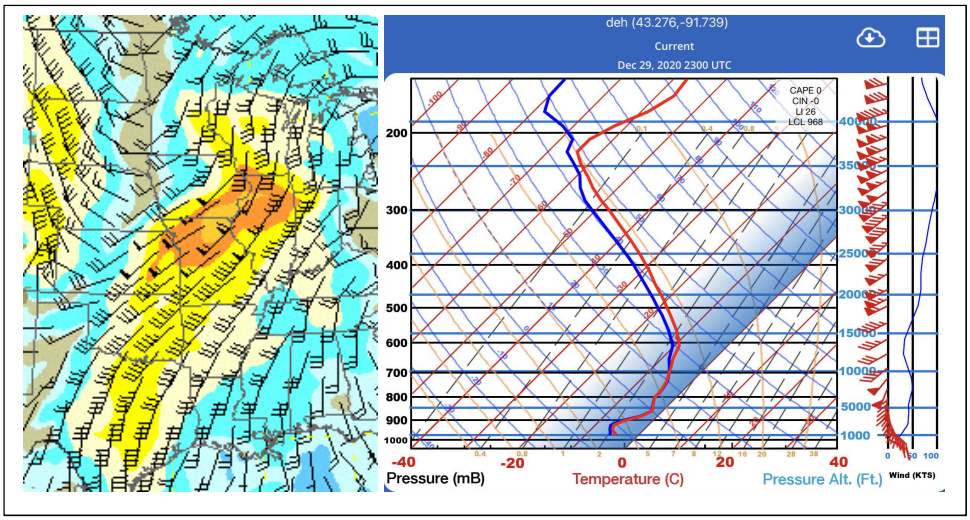
In a 172, I would go no higher than 5,000'.

Know your airplane's capabilities.



Example 7 – Winds and Snow

Winter-time – Strong winds from the Gulf of Mexico bring its moisture to the cold climate of an Iowa winter, with the dew point equal to the temperature – and that is how to make snow. No flying today.



Exercise – Use Your Judgement

Given the weather shown at right, any flight will definitely be **IFR**.

Where is your destination?

How high do you need to fly due to terrain? How high due to MEAs?

How high would you prefer to fly?

Note that the NOTAM at right calls for **moderate icing starting at 4,000'**.

The Skew-T Log-P for GMU (at right) indicates you should not encounter icing until closer to 5,500'.

But beware: icing can occur a couple of degrees *above* freezing.

Are you flying north? You should expect the freezing level to drop lower as you fly north.

The Skew-T Log-P for RDU (at right, below) indicates the freezing level near Raleigh is at 5,000'.

But **notice the difference** between the SkewT-LogP charts for GMU and RDU:

The temperature at GMU stays well above freezing until **6,000'**.

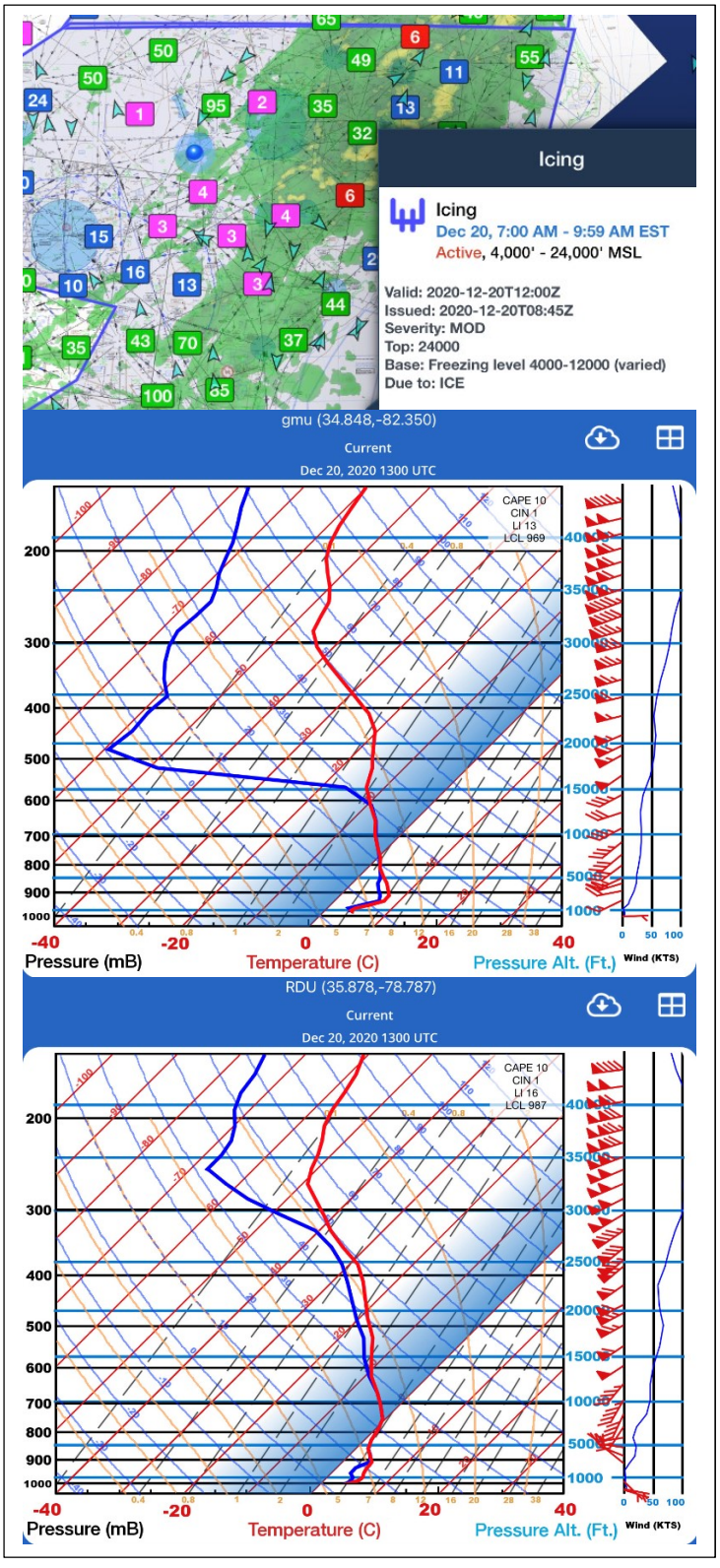
Even though the temperature at RDU also crosses the freezing level at 6,000', it hovers just above freezing starting at 5,000'.

The likelihood that you will encounter icing near RDU at 5,000' is much greater than near GMU.

Your route would take you near Hickory (HKY) and Greensboro (GSO). Their charts (not shown) look more like the GMU chart.

ForeFlight's Profile mode says you can make the whole trip at 3,000'. But **some en route MEAs are as high as 4,000'**.

You would most likely prefer to get past the mountains at 5,000', then drop down to 3,000' (being eastbound) between HKY and GSO for the rest of your flight to RDU.



But at 5,000', keep a constant eye on the leading edges of your wings. Be ready to request 4,000'. In this weather, other traffic is unlikely.

What is the forecast four hours from now? For tomorrow? What is your Plan B? What will you choose?

Making Sense of the Weather

More Information on Skew-T Log-P Charts and the Weather Generally

The preceding examples show you how much more information is available to you through SkewT-LogP charts, and how that information can affect your flying plans and decisions.

Use **http://weather.scottcrosby.info** for the most comprehensive current and forecast weather information available anywhere. All webpages have a menu bar (at right) with links to the other webpages.

Use **http://www.scottcrosby.info/weather/ceilings.html** – the main aviation-weather webpage, with ceilings, visibility, radar, turbulence, icing, convective activity, etc., plus links to METARs and TAFs, and links to other aviation-related weather resources.

Use **http://www.scottcrosby.info/weather/skew-t.html** – for SkewT-LogP charts, information, terms and definitions, training videos, and links to many other sources for further information. Spend time watching the videos. Follow the external links to get more thorough technical explanations and to learn more about the weather. Get a better understanding of the impact of all types of weather on your flying.

Buy the iPad/iPhone app **SkewTLogPro** at the **App Store** or at **https://skewtlogpro.com/** . The **SkewTLogPro** app will supply SkewT-LogP charts for any given location, or for any airport. It can also provide a series of charts if you give it a departure point and a destination point.

Unfortunately, **SkewTLogPro** is only available for the iPad and the iPhone; not Google, Android, etc. (however, there is a similar app **Skew-t** on Google Play). If you do not already own one of those, and prefer not to, find a used iPad or iPhone that somebody is willing to sell, just to be able to load it with **SkewTLogPro**. There is no ongoing cost, once you purchase and load the **SkewTLogPro** app. You can use the app through any wi-fi connection (or via cellular if you have an iPad capable of cellular access or if you have an iPhone, and you subscribe to a cellular service).

I have the **SkewTLogPro** app on both my iPad and my iPhone. It is too valuable a pilot's aid to be without, and it is so informative that I often check it, even when no flying is planned.

➢ Summary

Know the weather. Using **XM** weather, **ADS/B** weather, **Skew-T Log-P** charts, **1-800-WxBrief** eliminates virtually all the guesswork that prevents us from flying, or that sends us blindly into too-severe weather.

"Expect what happens." – great advice from the pilot who helped me get started flying. Be prepared for the flight conditions, including the airplane's condition, that you encounter on each flight.

All our lives, each of us pays tuition and takes classes at the ***University of Hard Knocks***. That is a normal part of being alive. Nobody ever *graduates* from the UofHK; we just keep paying tuition and attending a steady stream of classes. We only have three real goals – when flying, or in life generally:

1. Don't repeat a class at the UofHK – the cost, aggravation, and pain are too high.
   This is also stated as "***Learn from your mistakes.***"
2. Learn from the classes others have taken at the UofHK – save yourself the tuition costs, aggravation, and pain of having to take a similar class yourself.
   This is also stated as "***Those who fail to learn from history are doomed to repeat it.***"
3. Don't fail a class.
   This is also stated as "***Live to tell the story.***"

Flying is too much fun to be spending time taking classes at the UofHK. Fly safe!

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