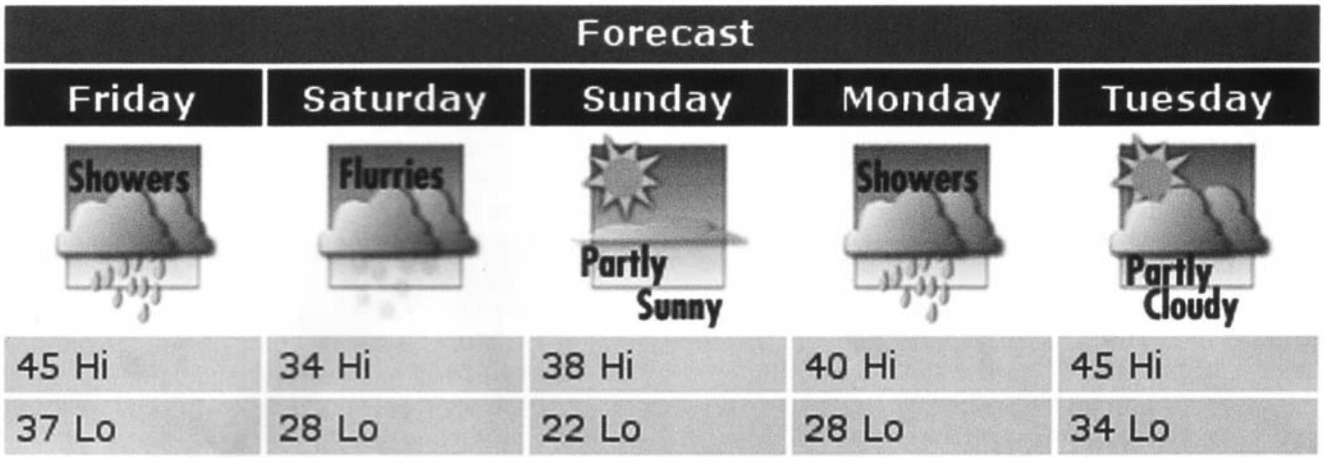

Forecasting Fundamentals

How to teach effective weather lessons

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For many CFIs, teaching weather theory is like pulling teeth without Novocain. It doesn't help that students share the feeling about the subject. The vocabulary, symbology, and science students need to learn can be overwhelming, and the way it's presented in most texts encourages only rote understanding of some of the most important elements of the atmosphere.

Practicality is the key to a proper weather theory lesson. Naturally, the lesson must be tailored to the student's level. Instrument students must have a broader understanding of the weather than a VFR pilot. In both cases, however, the same phenomena should be dealt with—at the very least, thunderstorms, low ceilings or visibility, cold weather phenomena (like ice and snow), and high winds—though the more advanced student may draw different conclusions from the same data.

All weather conditions are generally caused by combinations of four distinct characteristics of the atmosphere—temperature, instability, moisture content, and pressure gradient. Addressing the applicability of each of these characteristics to each "bad weather" phenomena can simplify a student's understanding of their genesis.

To preclude any surprises, have a few copies of the nasty weather forecasts in question with you for the discussion. On the days you're not flying due to the weather, print out a copy of a DUATS briefing for future use. If you're more constrained for time, look for poor weather on a surface analysis. There's bound to be a thunderstorm or low IFR, for instance, somewhere in the country, so get a printed weather briefing for that area in particular.

Thunderstorms, as we all know, need instability, moisture, and some sort of "lifting source." METARs (aviation routine weather reports), in this case, provide a lot more information than most people give them credit. First of all, the temperatures give a good impression of the amount of energy available for upward movement and the development of air mass thunderstorms. Temperatures in the mid-20°C range and higher tend to foster enough of a lifting source to create a thunderstorm. Comparing temperatures across a group of METAR reports can also give a more accurate picture of the location of the cold front if such a system is responsible for convective weather.

In addition, a strong pressure gradient is evidence of a low-pressure system, particularly if the barometer has been falling for a consistent period of time. Examining the altimeter settings from the METAR (and the isobars on the surface analysis) can give you even more insight into what's helping to move air upward.

Next, the dew point is a direct measure of fuel (moisture) for a thunderstorm. Any dew point above about 15°C has more than enough moisture to produce severe thunderstorm activity. The higher the dew point, the more latent energy is available for the production of thunderstorm cells. Students tend to appreciate the idea that we don't get thunderstorms in very cold weather—the atmosphere can't hold enough water to support thunderstorm growth at dew points much below 5°C, even with plenty of lifting and instability.

All we need now is some evidence of instability. The winds aloft forecast (or more appropriately the temperatures aloft forecast) provides the most concise and available information. High temperature lapse rates, especially in the mid-to-upper altitudes, are an excellent sign that convective activity is likely. Since dry air is cooled adiabatically (or without the addition or subtraction of energy) at a rate of 3°C per thousand feet, any lapse rate greater than that is a sure sign of danger.

Even smaller lapse rates can be a sign of trouble. Once the air is cooled to the dew point as it's lifted by surface heating or frontal activity, the adiabatic lapse rate can be as small as 1.5 °C per thousand feet. However, if there's a temperature inversion, or a condition where the temperature is going up with altitude, chances are you'll not see any convective activity without the presence of extremely strong lifting and moisture conditions.

Now that you've covered the basics, take your conditions assessment and compare it to the forecast. If your sample report is a good one, it will show a pattern—either very warm temperatures or cold frontal activity, a high dew point, and a high temperature lapse rate. These conditions will generally translate into a forecast (or actual reports) of thunderstorm activity. Though the actual methods used to forecast poor weather are far more complex than the number crunching we've done, the presence of these conditions is generally a sure sign.

If you have a good example, take a day where a cold front rolled through and there weren't any thunderstorms, and see if the student can pick up on either the very stable atmosphere or the lack of available moisture as the cause. Notice there's no calculus involved here, just a little common sense. Some very simple trends can determine a lot about the conditions present on a particular day.

Low ceilings and visibilities are the other real showstoppers for private pilots, and they can also wreak havoc on the best instrument pilot's day. Many of the same factors play a part, though differently than convective activities.

The METAR, once again, gives you some big hints. High moisture content (dew points) gives a much better chance of producing low clouds, but the temperature dew point spread speaks directly to the altitude at which the moisture will start to condense.

Every pilot knows to beware of a converging temperature/dew point spread, though this condition is much more volatile when their values are on the high side because there's so much more moisture available. If the spread is more than four or five degrees, you'll see marginal VFR-level clouds, at worst.

Too much wind will also help spoil nature's attempt to sock us in, so examining the altimeter settings across a wide geographic area will give a direct indication of the potential for that wind. Examining stability in the temperatures aloft forecast gives us another hint, though this time a low-level temperature inversion or a small lapse rate will tend to trap the moisture over a horizontal area (rather than a vertical one, as with thunderstorms) and induce lower visibilities. Of course, once above that inversion, you can usually see a hundred miles. Once you pick out the signs, make sure you show the results—visibilities less than a mile, low ceilings, and widespread IFR conditions.

Take your assessments of the conditions and compare them to what's forecast.

Cold weather, especially in the upper latitudes, can keep those without the fortune of deicing equipment out of the clouds for the whole season. Though the AIRMET actually forecasts icing conditions, it generally refers to the presence of it from the freezing level up to a specific altitude, and the temperatures aloft can, once again, let us know how high we can go without getting ourselves into trouble. Snowstorms tend to follow the same pattern of conditions that thunderstorms do, without the higher levels of moisture required for thunderstorm development, so the same strategy may be used to predict their formation.

Winds, as I've already brought up, are the easiest to predict. Examining the altimeter settings across a region will give you the strength and direction of wind patterns. Tightly packed isobars equal strong winds. Students should be aware that no other phenomena are necessary to make it a tough crosswind day.

Once you throw in the relationship between low-pressure systems and, say, thunderstorm development, an astute student will start to make the association between wind direction and weather to come. For instance, a northwesterly wind aloft (which generally translates into a more westerly wind at the surface) tends to indicate that you're on the backside of the low-pressure system, and typically better weather is on the way.

Once a student has a firm background in what goes into making a report, it's easy for you to bring out the important facets of the forecast products, like the TAF, Convective SIGMETs, SIGMETs, AIRMETs, and area forecasts. From this awareness, students will also begin to find the relationship between a poor forecast and an accurate one through analysis of the data that goes into their production.

It's important to ensure that the students continue to have faith in the system, since we all know that on occasion the forecasts have been overly conservative or wildly liberal. With well-designed lessons, you can help your students read between the lines.