AIR MASSES AND FRONTS

The Movers and Shakers of Weather

BY TOM HOFFMANN

Who has ever heard the doorbell ring at an odd hour and felt a sense of trepidation? The anxiety grows as you creep towards the door and slowly peel back the curtain. Taken by surprise, you quickly muster your best "authentic" smile as you notice your in-laws waving feverishly from the front step. Oh, and look … they brought your sister-in-law, Tootie, and her husband Randy, and their sweet two-year-old twin boys, too. You suppose the twins begin screaming because they're just so darn excited to see you. Awesome. After removing the palm from your forehead, you open the door to joyously greet your new guests. Internally, you sigh as just about everything you had planned for the day has forever changed.

Just like the surprise guests at your doorstep, weather has a tricky tendency to show up unannounced and throw a continent-sized wrench in your plans. Ask any pilot who's had to revert to a plan B mid-flight due to unexpected or deteriorating conditions (I suspect that covers about every pilot). Unfortunately, it's a scenario all too common within the GA arena. And for those lacking the foresight of a contingency plan, it can also have deadly consequences (just see this issue's *Angle of Attack*). So what can be done to help eliminate unwanted weather surprises from ruining your day? Given their monumental role in our ever-changing weather patterns, a look at the mechanics of air masses and fronts could provide some much-needed assistance. And who knows, maybe after reading this, Frank Fahrenheit's seemingly vague forecast on the 11o'clock news might provide more tactical information than you previously believed.

The Big Picture

During pre-flight weather planning, pilots are correct in wanting to focus on the local conditions and forecasts that affect their route of flight. However, it's the bigger picture of weather that often gets a casual glance, or worse, overlooked altogether. Having a more "global" perspective can provide that extra bit of insight that leads to a more informed go/no-go decision or backup plan. When it comes to influencing our climate, it doesn't get any more global than air masses and fronts — the true movers and shakers of weather on our planet. So let's start with a review of what these two players are and how their actions (and interactions) could influence what you encounter on your next flight.

By definition, air masses are large bodies of air that take on the characteristics of their surrounding environment — namely temperature and humidity — with fairly uniform distribution. They form in certain source regions where air can remain stagnant for days at a time. The weather here in the United States is influenced by air masses formed in four regions (see fig. 1). We have the continental polar (cP) air mass that brings cold, dry air from Canada; the maritime polar (mP) air that brings in moist, cool air from the northwest and northeast oceans; the maritime tropical (mT) regions that bring warm, moist air from the Gulf of Mexico and southern oceans; and finally, the continental tropical (cT) air mass with hot, dry air that forms over Mexico and the southwest United States. There is also a fifth, somewhat infamous region that can also affect U.S. weather known as continental arctic (cA). The polar

vortex you heard so much about last year was exactly this, the cA air mass pushing down over parts of the United States causing a deep freeze that forced its way into the deep south.

On the Front Lines

Much like the aforementioned two-year old twins, air masses can get fidgety. You can attribute that motion to the sun's energy as it heats the air mostly around the equator. Once the air is heated, it rises and then flows back towards the poles. Conversely, the colder and denser air at the poles sinks and slides down back toward the equator. Throw in gravity, a planet that spins at over 1,000 mph, and a complete range of orographic features, and you've got yourself a hive of climate activity. All this energy is what impacts air mass movement and ultimately determines whether we need sunglasses or an umbrella to face the day.

As different air masses move around in the atmosphere, they inevitably collide and try to push each other around. It's a massive and often violent game of give and take. Where two or more different air masses clash is an area appropriately known as a front.

Fronts come in four different varieties: cold, warm, stationary, and occluded. As even a non-aviation sort would know from watching the evening news, cold fronts are denoted with blue spikey bands pointed in the direction of movement and form when an advancing cold air mass is replacing a warmer air mass. It might help to imagine the spikey points as giant shovels picking up the warmer air in front of it. The action can sometimes be dramatic, especially when there are large differences in temperature, pressure, and humidity. A good example — and the reason why we see such violent springtime weather across the Great Plains — is when cool, dry air from Canada smacks into the much warmer, humid air rising up from the south.

Common by-products of an advancing cold front include pronounced wind shifts and cloud creation. The type of cloud depends on the stability of the air mass in the frontal zone, but you can generally expect billowy cumulus, or its more stormy relative, cumulonimbus, if sufficient instability and moisture abounds. Cold fronts also move rapidly — around 25 to 30 mph in most cases — but some have been clocked at highway speeds of 60 mph! That might make you think twice about trying to outrun one of these weather-makers.

On The Warm and Fuzzy Side

On the opposite end, warm fronts are caused when an advancing warm air mass is replacing a colder air mass. Maps depict them with red, semi-circles, which you could envision as bubbles of warm air rising up

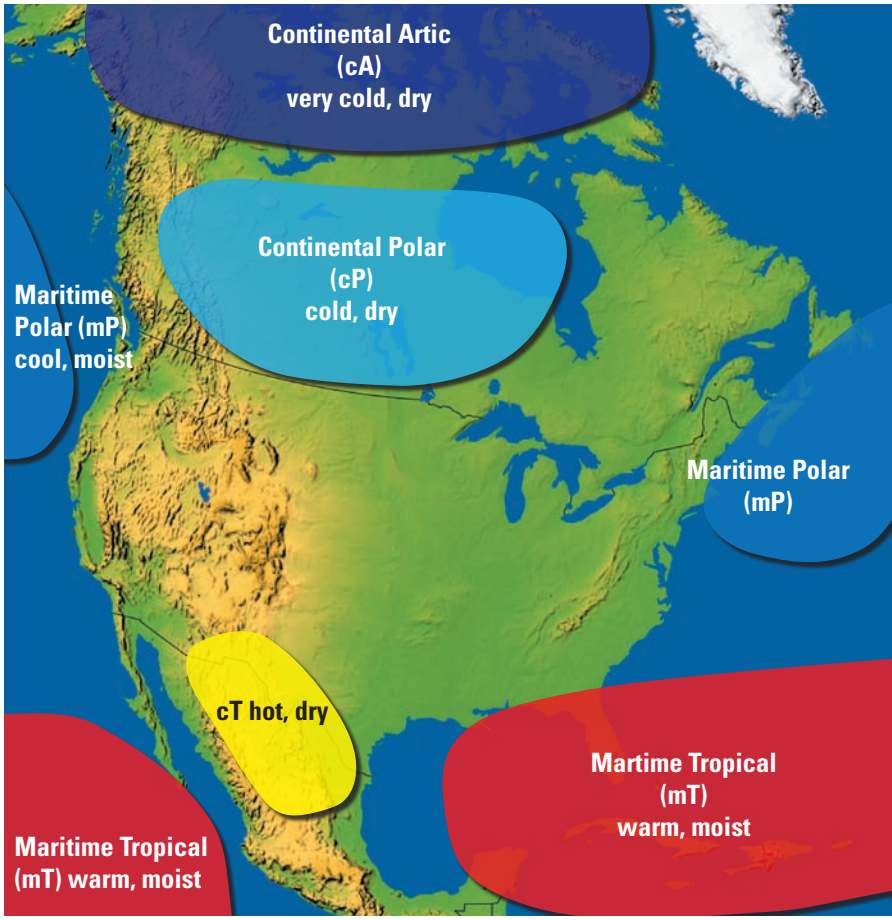


Fig. 1 - Map of air mass types and where they develop.

and displacing the cooler air in front of it. Warm fronts are slower than their colder cousins and less pronounced with regard to their overtaking action. There's usually more of a gentle slope as warmer and less dense air rides up over colder air. Because of this, the humidity in this warmer air condenses as it rises, causing more widespread areas of thick and soupy weather. In fact, clouds and rain can often precede the surface passage of a warm front by hundreds of miles — something a VFR-only pilot will want to watch out for. Your weather map may show a warm front over Missouri, but its IFR-inducing effects could already be several hundred miles east over central Kentucky.

Rounding out the four frontal types are stationary fronts and occluded fronts, which are a "hybrid" of a cold and warm front. In a stationary front, neither the cold nor the warm side has enough energy to replace the other. They both remain in sort of a stalled out pattern, sometimes for days, with resulting weather being a mixture of the two. While this may seem like a somewhat stable scenario, it's not uncommon for the edges of a stationary front to kink or bend and become a breeding ground for bad weather. When an upper level trough (or an area of lower pressure aloft) approaches a stationary front, the front will begin evolving into a frontal

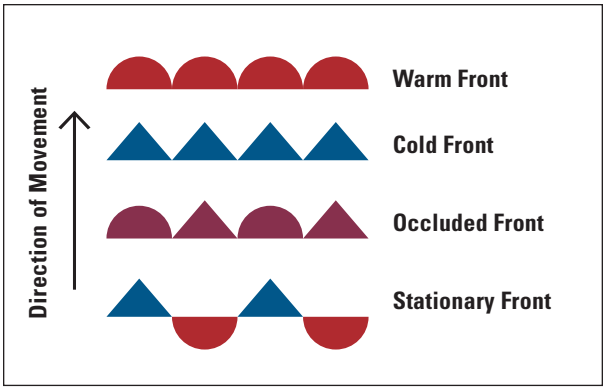


Fig. 2 - The four main types of fronts as depicted on a weather chart.

system consisting of a warm front and cold front that will typically start moving eastward. Weather maps depict stationary fronts with alternating red and blue line segments that have the cold/warm symbols pointed in opposite directions.

Occluded fronts form when air masses of three different temperatures meet up. It's basically a cold front that catches up and passes a warm front, displacing the warm air mass aloft in the process of pushing into the cold air mass ahead. This air mass "sandwich" is a recipe for having the *worst* of both worlds, so to speak, as there's potential for the hazardous features of both cold and warm fronts to be on full display. That mean thunderstorms, poor visibility, and shifting winds are all possible. An occluded front is depicted as a purple line with alternating triangles and semi-circles.

Get Up Front with Fronts

So how does one know where frontal activity is or is expected to be? As the saying goes, pictures are worth a thousand words. There's obvious truth in that when it comes to glancing at the many weather charts that provide tons of useful planning data before a flight. A surface analysis chart, for example, provides you with a "big picture" visual of areas of high and low pressure that span the lower 48, along with frontal boundaries, temperatures, dew points, wind directions and speeds, local weather, and visual obstructions (see fig. 3). Using this chart as part of your preflight can help you discover any potential trouble spots you'll want to focus on or discuss further with a weather briefer. Significant weather and surface prognostic charts are two others that can help with painting a good mental picture of weather.

I can recall when I came to fully appreciate the utility of these charts while working towards a lab credit at my university's flight school weather center. Because the Internet was still something of a foreign concept at that time, my duties included retrieving black-and-white weather charts off an old (and noisy!) dot-matrix printer and posting them along the walls of the lab. To help my fellow flight students with their weather preparation, we would color and highlight frontal boundaries as well as areas of precipitation, strong winds, and freezing levels. In retrospect, the exercise helped expand my ability to "see" and understand weather on a macro scale and helped add to the resources in my flight planning toolbox.

Another source of information for the "big picture" is the Area Forecast Discussions (AFD) provided by each National Weather Service Office across the nation. These text discussions, produced four times daily, cover the critical weather features that will be causing the expected weather over the next seven days. Not to be mistaken for the Area Forecast Synopsis, these discussions can give you the equivalent of a flight briefing synopsis and more.

Forward, March!

So now that we know how different air masses interact and where to find them, let's look at a few strategies you'll want to consider the next time you're in the vicinity of a front.

For starters, if you're flying towards a front, and you notice conditions starting to deteriorate, land and let the front pass before continuing. That will give you a chance to reassess the conditions, recalibrate your plan, and perhaps refuel (both yourself and your aircraft). A passing front will likely also cause a shift in wind direction and velocity. The approach you are already set up to use at your destination may no longer be an option, despite what your initial forecast indicated. Instead you might need to land on a much shorter runway or at an alternate airport if the crosswind component is too much to handle. Keep an eye on your altimeter, too. A pressure change when crossing a front is a given.

And just because you pass through a front does not necessarily mean you're in the clear. Even with a cold front, clouds and rain that are usually confined to within a few miles of its boundaries could, in some cases, extend well behind it. And for that matter, you also don't need a front nearby to experience adverse weather; that can happen anywhere! Upper level troughs and lows can generate adverse weather without having an associated surface front.

Without preparation and a good plan, it's easy to paint yourself into a corner. Instead, have an out, several if possible. Reassess the weather continuously during the flight and use as many inflight sources as you can: onboard radar, ADS-B provided weather, ATC, and of course your own two eyes. Allowing for a greater margin of error, especially at night or in low-visibility situations, can be crucial.

Even though we've outlined some fairly specific expectations with frontal weather, it's important to

remember that no two fronts are the same; always expect the unexpected. Forecasts are generally accurate, but far from exact. About the only sure thing you can count on with any approaching front is that some type of weather change is imminent.

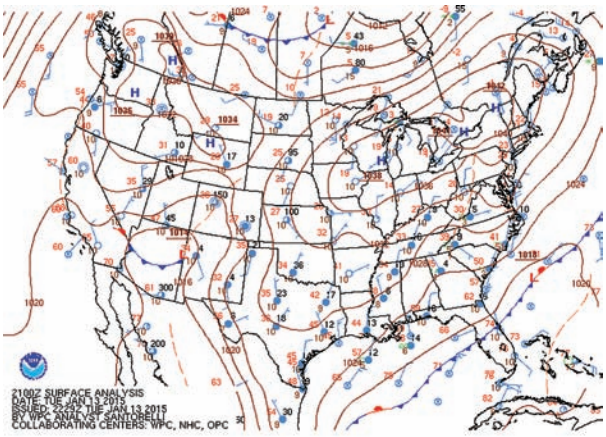
Play your cards right with being prepared for weather and you will stack the odds in your favor for not having any unwanted surprises. I just wish I had better advice for those unexpected in-law drop-ins!

Tom Hoffmann is the managing editor of FAA Safety Briefing. He is a commercial pilot and holds an A&P certificate.

Learn More

Advisory Circular 00-6A, *Aviation Weather for Pilots and Flight Operations Personnel*
http://go.usa.gov/JF3x

GA Pilot's Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision-Making
http://go.usa.gov/JFjW



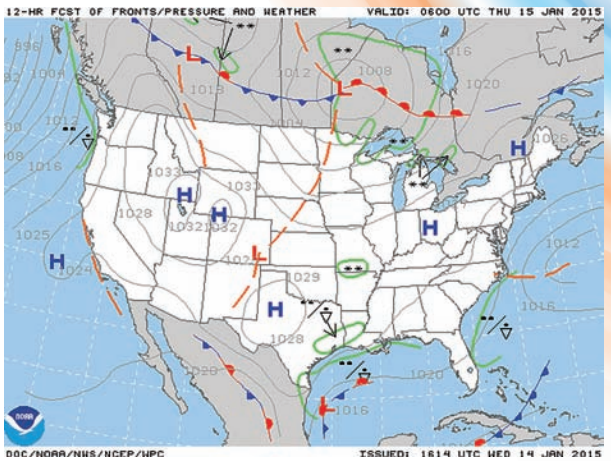


Fig. 3 – A sample surface analysis chart (l) and a 12-hour surface prognostic chart (r).