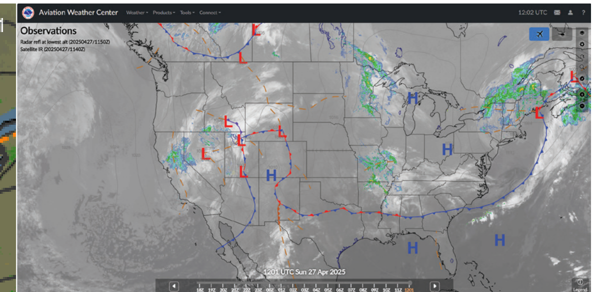
11 Graphical Observational Products



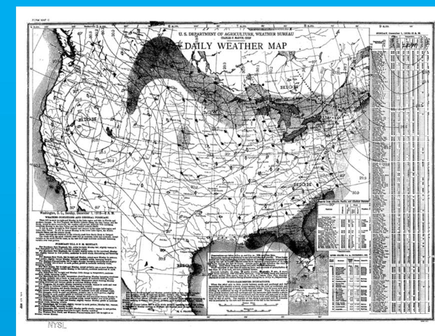
A revolution in weather graphics has taken place in the last one hundred and fifty years. First distributed by telegraph in the late nineteenth century, data was hand drawn at individual weather stations. As technology advanced "facsimile" became the standard method of distribution—as shown in the "black and white" image in the call-outs. (When I first worked in Flight Service at Lovelock, Nevada in 1974 we didn't have a facsimile machine. We received a teletype message with the location of highs, lows, and fronts. We occasionally copied information using a "grease pencil" onto a Plexiglas covered map.) In the twenty-first century data communications and digital dissemination have taken over the delivery process.

Technology can be a blessing and a curse. Before the digital age charts were black and white. Local offices occasionally "manually enhanced" products using color pens and pencils. This can be seen in the facsimile chart display at the Los Angeles FSS (callout). Not only are most of today's charts in "living color," but many provide overlays—often radar and satellite images, and many offer "zoom" and "loop" capabilities. Unfortunately, this may result in the unintended consequence of clutter.

Clutter

> Like aeronautical charts, too much information on graphical products results in clutter. Details are subjective and not all agree on what should, or should not, be included. Too much detail runs the risk of obscuring significant information.

Advances in computer technology have resulted in a plethora of graphical observational products. Graphics are available from Leidos Flight Service and the Aviation Weather Center, and through commercial, academic, and government sources. These entities



Surface map for December 1, 1918.

Facsimile chart display at the Los Angeles FSS circa 1975.

may add data sets and enhancements—just as we did with our colored pens and pencils!

Like most observations, graphical products are old by the time they're compiled, generated, and distributed (latency), they may be of limited use in an operational environment. However, they're often helpful in explaining the weather—the synopsis. Graphical products often depict areas of moisture and vertical motion and infer regions of stable and unstable air. In many instances they depict phenomena presented in Part One, Fundamental Principles of Aviation Weather; for this reason alone, they should be understood and reviewed by the "weather wise" pilot.

Latency

> The time between the actual occurrence of a phenomena (observation) and when it becomes available to the user. It includes data collection, processing, transmittal, and display.

Since weather occurs throughout the troposphere and occasionally pushes through the tropopause into the lower stratosphere, the surface analysis chart often cannot solely explain the weather, even that occurring at or near the surface.

This chapter presents traditional "graphical observational products." The following discussions are limited to data sets and colors available on Leidos Flight Service and National Weather Service products. Regardless of vendor, virtually all data comes from the National Weather Service. Analysis and application remain the same. (Due to their importance and complexity radar products appeared in ch12, Weather Radar Products and satellite images in ch13, Weather Satellite Imagery.)

Surface and upper air analysis charts provide a three-dimensional view of the atmosphere at the time of observation, based on selected locations, and at specific heights. Discussions include the following products.

- surface analysis chart
- 850mb chart

- 700mb chart
- 500mb chart
- 300mb chart
- 200mb chart

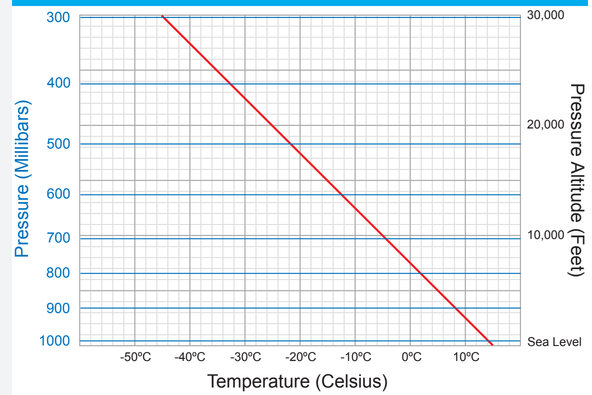
The International Standard Atmosphere (ISA) was presented in chapter 2. The ISA (callout) shows the height of the constant pressure levels in the standard atmosphere; each provides details on phenomena occurring at the depicted level. The most complete description of the atmosphere comes from a combined analysis.

Synopsis

> In aviation weather terminology (and pilot weather briefing) the synopsis refers to the location and movement of pressure systems and fronts, and weather patterns, usually as a brief, generalized statement. It should provide the "big picture." The synopsis should indicate the reason for adverse weather and tie in with current observations and forecasts. The synopsis often provides clues to turbulence and icing, even in the absence of weather advisories. (Refer to ch18, Pilot Briefing Services for a discussion on how the synopsis applies to FAA and compliant self-briefings requirements.)

Transcribed Weather Broadcast (TWEB) Route forecasts, and synopsis were the FAA's first attempt at mass dissemination. These products were developed in the 1960s as scripts for recorded broadcasts over low-frequency radio beacons and VORs, and Pilots Automatic Telephone Weather Answering Service (PATWAS). TWEBs were also used for the synopsis and enroute forecast portion of the Telephone Information Briefing Service (TIBS), a TWEB/PATWAS replacement, as well as the synopsis and enroute forecast portion of pilot weather briefings; all have been discontinued with Flight Service consolidation and privatization. The implementation of graphical forecasts for aviation have eliminated text Area Forecasts (FA)—including their synopsis sections.

The FAA and NWS have touted individual forecast office Area Forecast Discussions (AFD). Leidos Flight Service and Aviation Weather Center provide "links" to the aviation section of individual Weather Forecast Office (WFO) AFDs. The FAA state that the AFD, "Provide(s) additional aviation weather-related issues that cannot be encoded



into the TAF, such as reasoning behind the forecast....” This is certainly true, but AFDs rarely address the “big picture” and typically only focus on low-level phenomena within the WFO’s area of TAF responsibility. They are not an equivalent substitute for traditional text synopses. We’ll expand on these issues in subsequent chapters.

Product Availability

Pilots have two primary government sponsored sources for aviation weather products: Leidos Flight Service (FS) and the Aviation Weather Center (AWC). Leidos Flight Service provides various flight planning and briefing services. The Aviation Weather Center delivers observation and forecast products. This section provides an introduction, and primary navigation and access to observational products. Throughout the remainder of Part Three we’ll expand on specific procedures to access aviation weather products. The customization of individual products (observations and forecasts) will appear in the appropriate sections of each chapter. (Additional explanations and tutorials are available through each individual website.)

Note

> We touched on the problem of technology being a “blessing and a course” and the consequences of “clutter.” Another unintended drawback is that computer technology allows an almost infinite ability to “mix and match” data sets. There is no better example than the ability to customize aviation website weather reports and forecasts. How do we as General Aviation pilots, instructors, and learners sift through the mountains of data—formally the domain of the FSS pilot weather briefer—to obtain the information required to make an informed and compliant GO-NO GO decision? We’ll put some objective parameters to this process.

Leidos Flight Service (www.1800wxbrief.com)

Figure 11-1 shows the Leidos Flight Service “Home Page.” Access products and services using the top menu. Weather charts are available using the “Wx Charts” tab (highlighted). Access overlay products using the “Map” tab (highlighted).

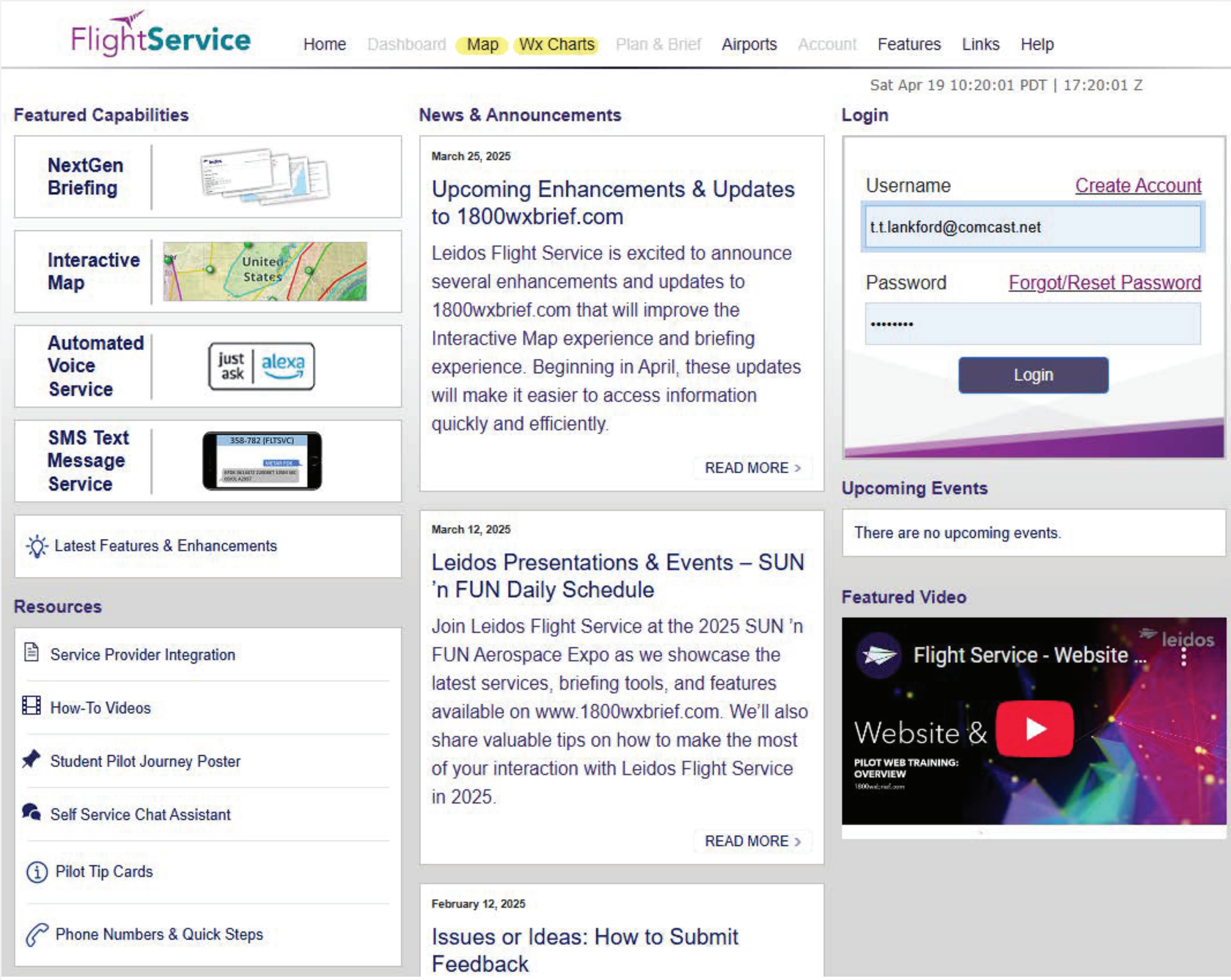


Fig. 11-1. The *Leidos Flight Service website provides access to flight planning and briefing services.*

The "Wx Charts" menu appears in the separate window shown in Fig. 11-2. Select geographical areas using the "top menu." In Fig. 11-2 the continental United States (CONUS) has been selected. Observational chart products presented in this chapter have been highlighted.

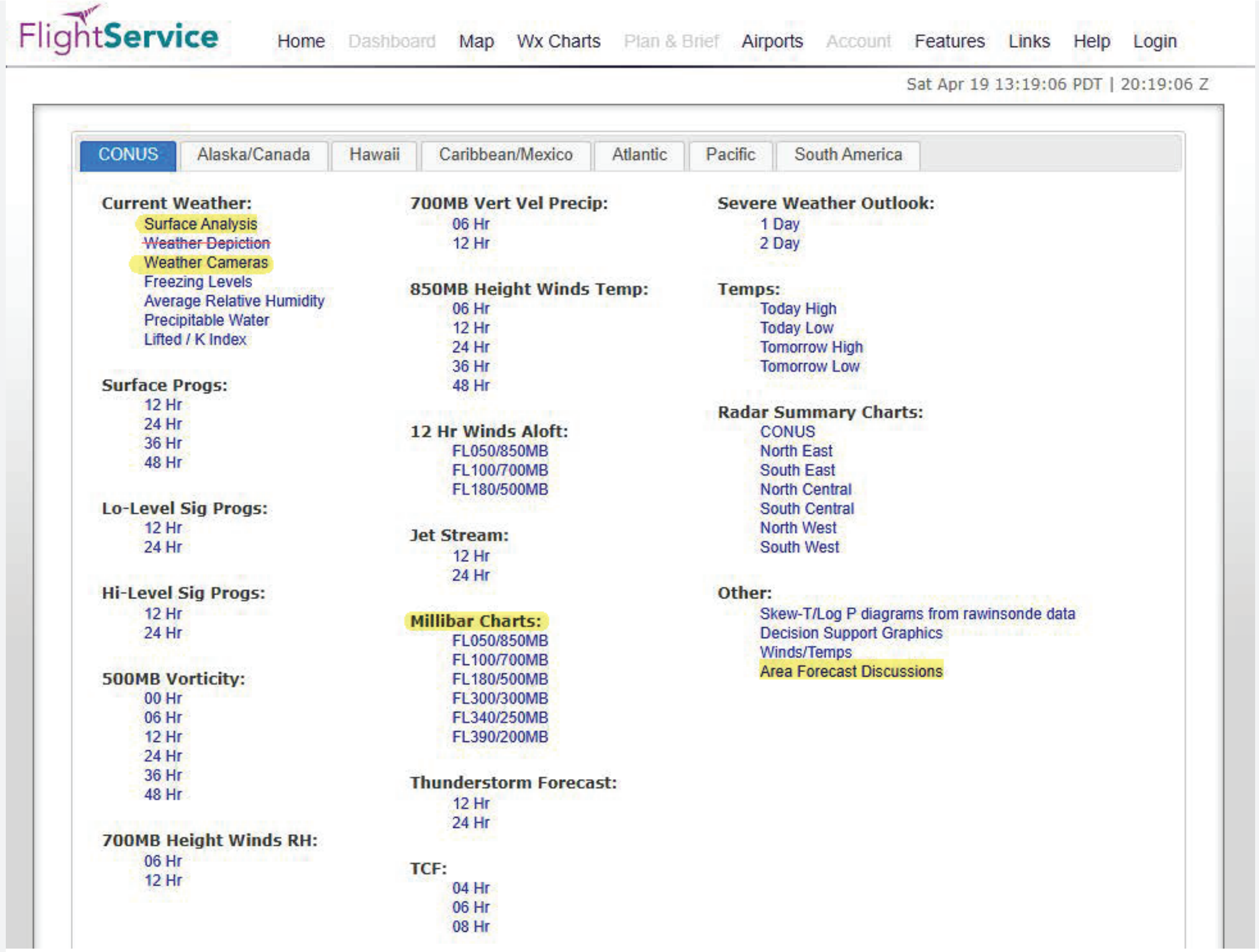


Fig. 11-2. *Access Leidos Flight Service charts through the "Wx Charts" option on the "Home Page."*

The **Current Weather** menu provides access to "Surface Analysis" and "Weather Camera" products. "Weather Camera" provides a link to the FAA's Weathercams page. (The "Weather Depiction" chart remains on the menu; however, weather categories have not been analyzed since the termination of the product in 2024.) Upper air analysis products are available using the **Millibar Charts** menu. The **Other** menu provides a link to the AWC's Area Forecast Discussion page.

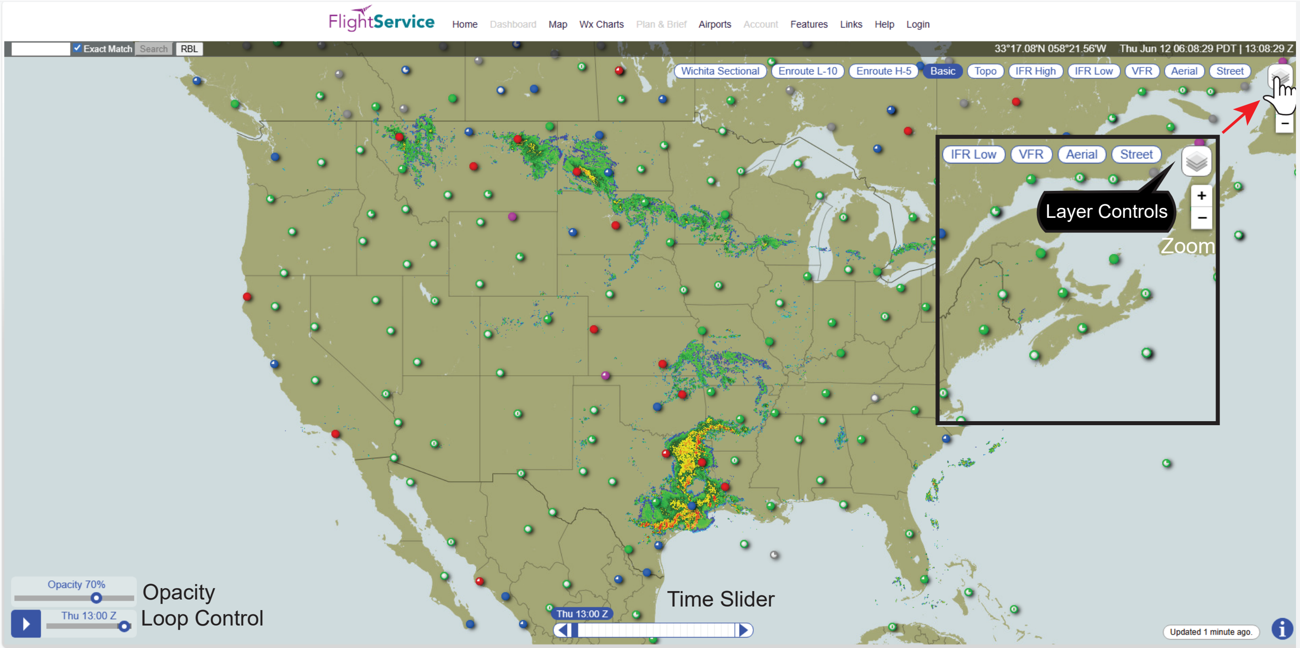
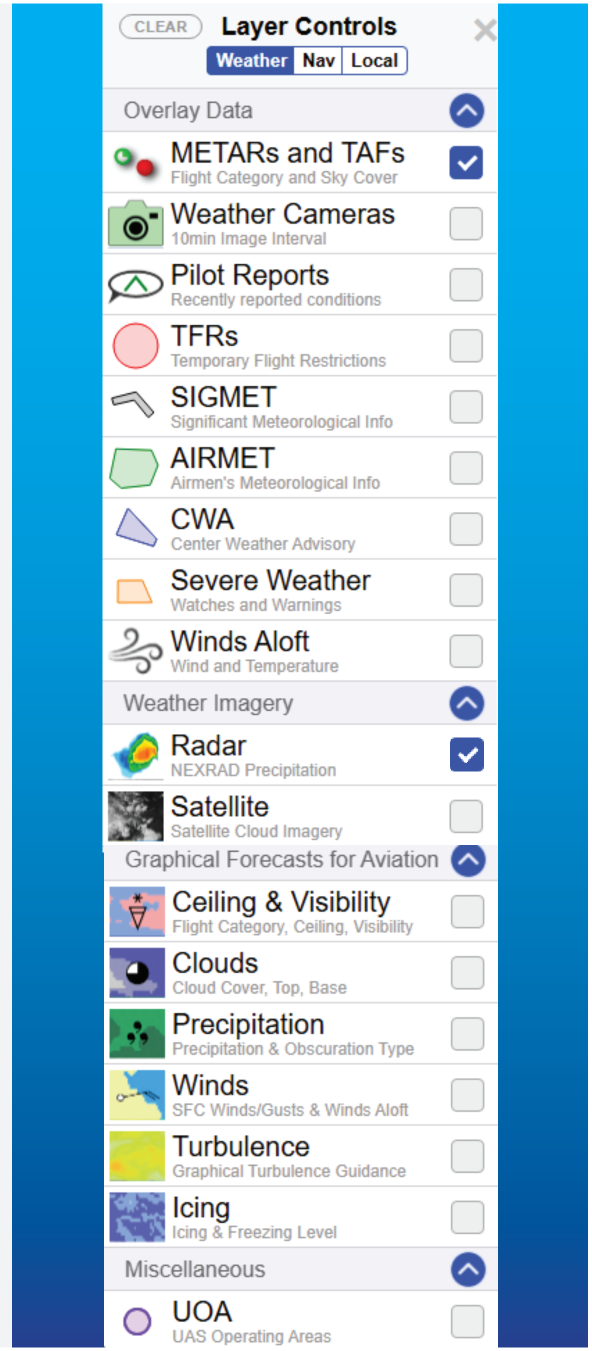


Fig. 11-3. *The Flight Service "Map" layers page provides various report and forecast overlay options.*



Select the "Map" tab on the top menu of the "Home Page." The "Map" page appears in the separate window illustrated in Fig. 11-3. "Hover" over the *layers icon* in the top right corner of the page (red arrow). The "pointer" changes into a "finger." "Click" the icon to display the Layers Controls panel (callout). In Fig. 11-3 the "METARs and TAFs," and "Radar" layers have been selected.

Aviation Weather Center (www.aviationweather.gov)

The following discussion provides a *background* for navigation through the AWC's website. Graphical products are a revolution in the presentation of aviation reports and forecasts. However, the shear amount of data, and to facilitating display customization, has resulted in website complexity. Like digital avionics displays, this requires study to become familiar with access, adaptation, and presentation of the various weather reports and forecasts available.

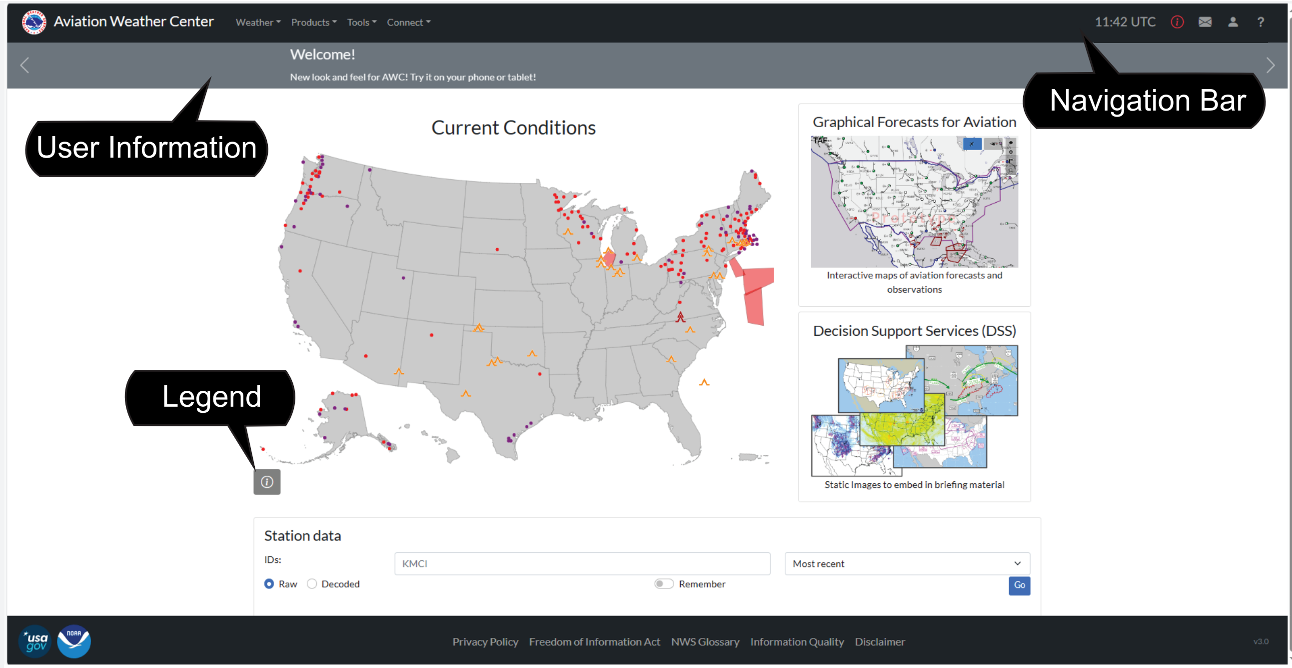


Fig. 11-4. *The Aviation Weather Center provides customizable observation and forecast products.*

The AWC's "Home Page" is shown in Fig. 11-4. A Navigation Bar appears at the top with the following dropdown menu selections: Weather, Products, Tools, and Connect. The "Weather" dropdown menu provides links to Observation and the GFA FORECAST pages. A "Products" menu allows access to various observations and forecasts. The "Tools" menu links additional data and aviation decision support products. The "Connect" menu provides links to AWC informational dialogs and social media.

On the right side of the Navigation Bar (Fig. 11-4) an "envelope" icon provides feedback or questions, the "person" icon allows sign-in for functions that require an account, and the "question mark" icon directs users to help pages.

Note

When data is unavailability or during a system outage, a "red" information icon appears on the Navigation Bar. "Click" the icon for details.

Updates and additional User Information appear below the Navigation Bar. For example, the “Welcome!” message in Fig. 11-4. (“Click” the arrows on either end of the bar for additional items.) Display the Legend using the Information icon. (A Legend icon appears on each page, most often in the bottom right hand corner.) Access individual reports using the “Station data” box. “Click” the “Current Conditions” map in Fig. 11-4 to display the *Observations* page

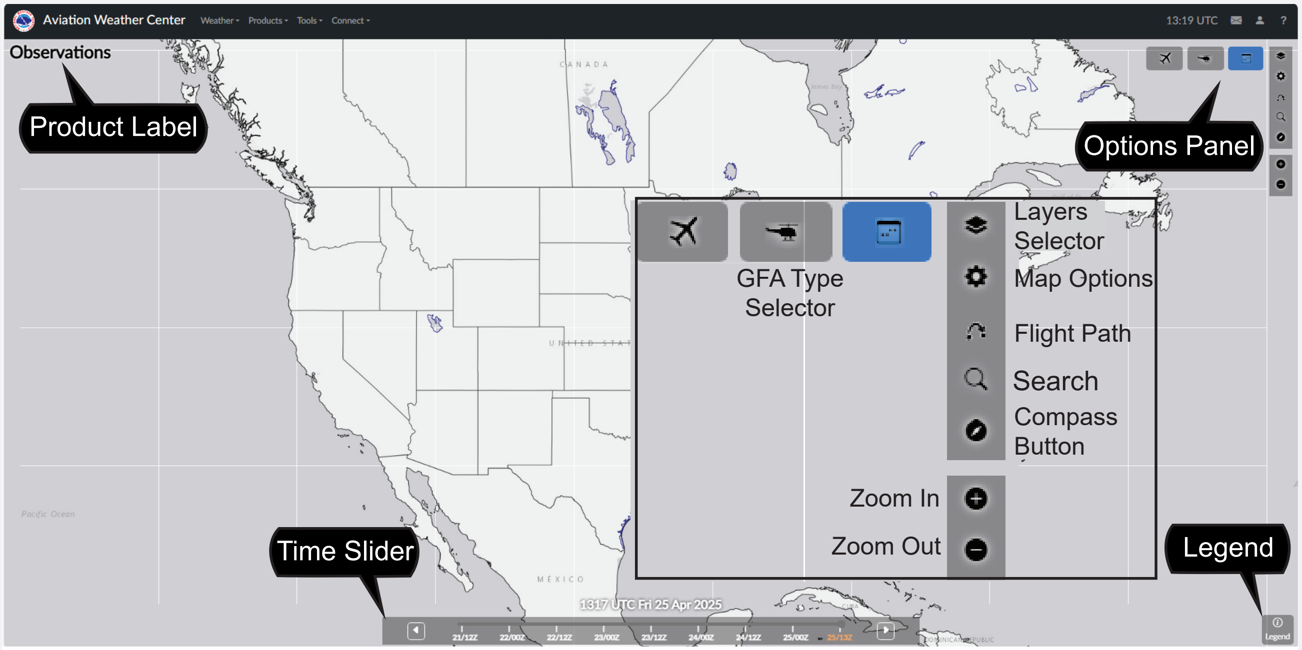
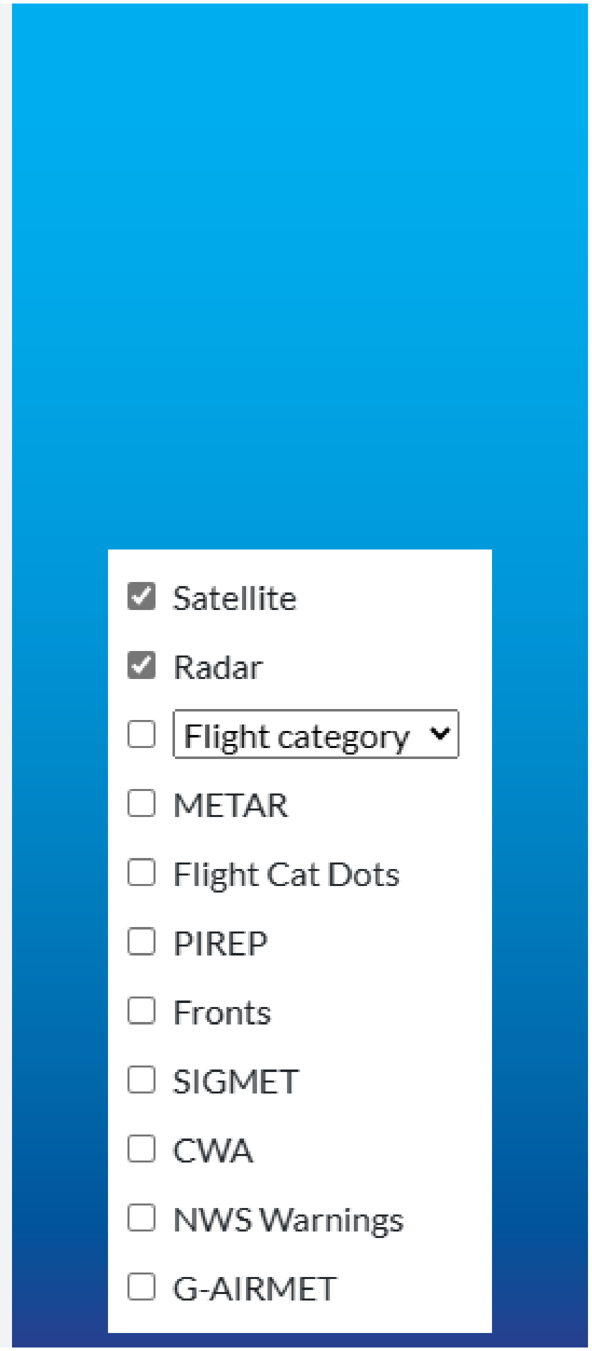
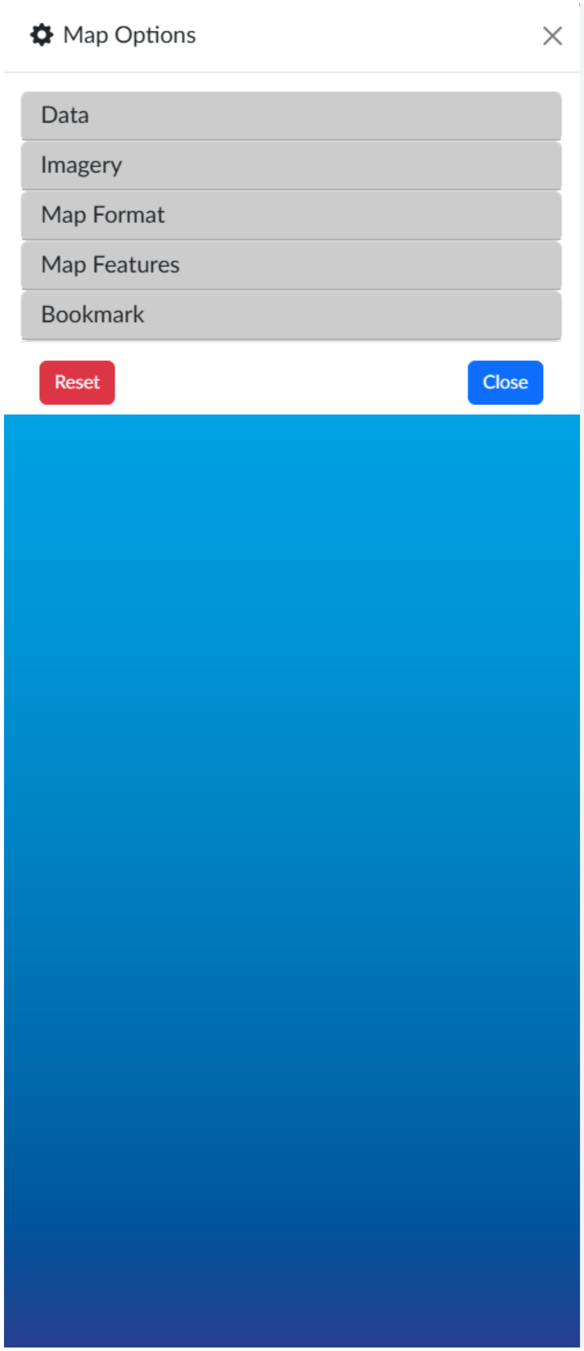


Fig 11-5. *Access interactive observations from the Layers Selector menu on the Observations page.*

Figure 11- 5 show the Observation page. *Product Label* appears in the top left corner. “Click” or “drag” the Time Slider at the bottom of the page or use the arrow keys to select desired time. The Options Panel customizes GFA Type, Layers, Map Options, additional features, and Zoom function. The GFA Type Selector allows selection of altitude stratum and forecast valid period.

“Click” the Layers Selector icon in the *Options Panel* (inset Fig. 11-5) to view products. The Layers Selector menu is shown in the callout. Layers include various reports and forecasts. “Click” check boxes to customize displayed products. A “down arrow” in the





menu (Flight category) indicates sub-menu options. (Observational products are presented in this chapter; we'll continue the discussion of forecast options in ch16, Enroute Forecast Products.)

The second selection on the Options Panel provides "Map Options" (callout). Operationally we're only concerned with the Data and Imagery options. Map Format, Map Features, and Bookmark options are supplement, "organizational" attributes.

Surface Analysis Charts

Computer generated and distributed by the Weather Prediction Center (WPC) outside Washington DC; surface analysis charts provide a "first look" at mostly synoptic scale patterns. Observed station pressure, converted to sea level, provides a common reference. Sea level conversion, however, introduces errors—especially in mountainous areas. *Isobars*—lines of equal sea level pressure—are drawn at four millibar intervals.

The spacing of isobars represents the relative strength of the wind—pressure gradient. Moderate to strong winds flow out of areas of high pressure and into areas of low pressure. Coriolis deflects the wind to the right in the northern hemisphere. Near the surface, frictional force causes the wind to blow at an angle across isobars. Fronts depict boundaries between air masses, resulting in upward vertical motion from the surface to about the mid-troposphere—about 20,000 ft. Upward vertical motion occurs in low pressure areas, drylines, and along troughs. Downward vertical motion takes place in areas of high pressure and along ridges.

Often the exact location, and sometimes even the presence, of a front is a matter of judgment—a front can be a zone several hundred miles across. Fronts do not necessarily reach the surface; they may be found in layers aloft. This is especially true in the western United States and the Appalachians where mountain ranges break up fronts.

Station models, when depicted, provide temperature and dewpoint. High and low temperatures affect aircraft performance and may indicate adverse surface conditions—snow and ice. Temperature/dewpoints indicate surface moisture content. Precipitation types provide clues to atmospheric stability.

Table 11-1. *Surface Analysis Boundaries/Centers*

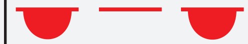
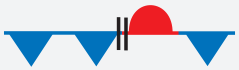
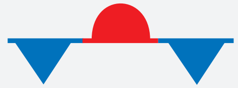
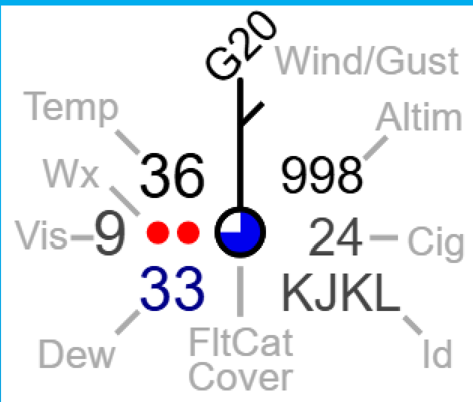
Type	Symbol	Type	Symbol	Type	Symbol
Cold Frontogenesis		Cold Front		Cold Frontolysis	
Warm Frontogenesis		Warm Front		Warm Frontolysis	
Change of Front Type		Occluded Front		Occluded Frontolysis	
Stationary Frontogenesis		Stationary Front		Stationary Frontolysis	
Trough		Ridge		Dryline	
High	H	Squall Line		Tropical Wave	
Low	L	Tropical Storm		Hurricane	

Table 11-1 contains common surface analysis symbols and suggested color hues. (Refer to ch3, Clouds and Fronts for a detailed description of frontal types and characteristics.) Although rarely used, in the past a *ridge* has been depicted as a YELLOW zigzag line. Various publication have begun depicting a ridge in BLUE—most recently FAA-H-8083-28 Aviation Weather Handbook. A *tropical wave* describes the migratory wavelike disturbance embedded in the tropical easterlies. They often signal the development of more significant tropical weather, such as tropical depressions, tropical storms, and hurricanes.

Note

Charts in this chapter were issued on February 28, 2024 at 0900Z, unless otherwise noted.

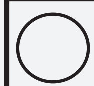
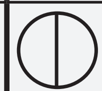
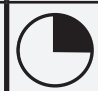
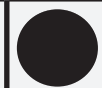
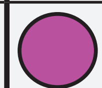
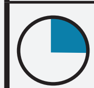
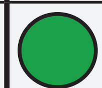
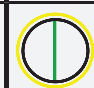
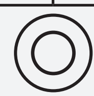
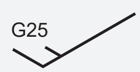
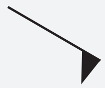
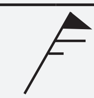


Weather Symbols

Station Models

Fairly standard, station model plots appear on various graphical products. They provide additional data but usually add clutter. The callout shows an AWC station model plot. (In any legend "Click" Weather Symbols (callout) to link to the AWC's weather symbols decode page.) Table 11-2 contains operationally significant symbols, codes and colors, and descriptions of information used on AWC and other commercially available charts. (Leidos Flight Service "WX Charts" and "Map" layers do not display station models.)

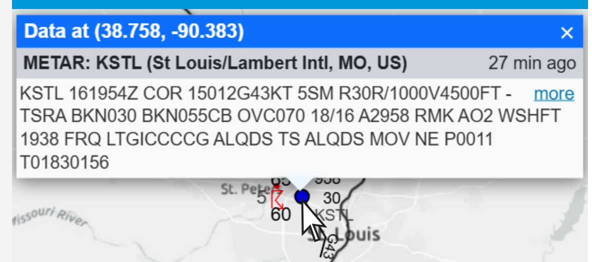
Table 11-2. *Station Model Sky Cover/Wind Symbols*

Symbol	Code	Description	Symbol	Code	Description	Symbol	Code	Description
	CLR/ SKC	CLR below 12,000 SKC sky clear		FEW	Less than 1/8 to 2/8 coverage		SCT	3/8 to 4/8 coverage
	BKN	5/8 to 7/8 coverage		OVC	8/8 coverage.		VV	Vertical visibility into obscuration.
		Sky cover missing		LIFR	CIG ≥200-<600 &/or VIS ≥1/2-<2		IFR	CIG ≥600-<1000 &/or VIS ≥2-<3
	M-VFR	CIG 1000-3000 &/or VIS 3-5		VFR	CIG >3000 and VIS >3		NO CIG	CLDS <3000 AGL NO ceiling
		Wind 000000KT; calm			Wind 090005KT			Wind 270010KT
		Wind 240015G25KT			Wind 120050KT			Wind 030065KT

A sky cover symbol appears at the center of the plot using the same criteria as surface observations (METARs). Color codes display weather category. Most often these consist of three or four categories: VFR—Visual Flight Rules, MVFR—Marginal Visual Flight Rules, IFR—Instrument Flight Rules, and LIFR—Low Instrument Flight Rules. On the Layers Selector menu, the "Flight Cat Dots" option displays color code categorical values as shown in Table 11-2. (Leidos Flight Service "Map" layer provides selectable Flight Category dots ONLY—Fig. 11-3.) A yellow circle around a sky cover plot indicates a cloud layer (that does not constitute a ceiling) based below 3000 ft which may pose a hazard to low-level flights.

Stem lines and *wind barbs* depict wind direction and speed. The stem shows "true direction" from which the is blowing. A circle around the station indicates calm wind. Wind barbs depict speed (half-barb 5 KT, barb 10 KT, flag 50 KT). Gusts are indicated by the letter "G" and the gust speed.

The right side of the plot provides altimeter setting, ceiling, and station identifier. The altimeter setting shows the last three digits in inches of Hg ("998" 29.98); followed by the ceiling, plotted in thousands of feet (2400 ft), and the station four letter identifier "KJKL"). The left side of the plot shows surface temperature, present weather and visibility (statute ML), and dewpoint temperature.



Note

> Text versions of Data icons (observation/forecast) on AWC charts and Leidos Flight Service "Map" layers are normally available. To display text "Click" the data icon. The callout illustrates an AWC example. "Click" the station model to display METAR text.

Case Study

> In the past, the only time station models were of operational value were at locations with limited access to text data (mostly international) or during communication system failures. (On several occasions as a pilot and FSS briefer I have used station model information and other chart data.)

Table 11-3 depicts the most common weather symbols used on weather charts. Symbols may be combined to show the simultaneous occurrence of liquid, freezing, and frozen precipitation. For example, rain and snow falling together. (Refer to ch9, Surface Observations for a detailed description of weather qualifiers and phenomena, and their limitations.)

Table 11-3. Weather Symbols/Descriptors

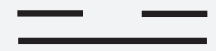
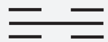
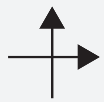
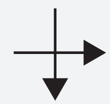
Symbol	Code	Description	Symbol	Code	Description
	MIFG	Shallow Fog		PRFG	Partial Fog
	BCFG	Parchy Fog		FZFG	Freezing Fog
$	BLDU	Blowing Dust	$	BLSA	Blowing Sand
	BLSN	Blowing Snow		DRSN	Drifting Snow
	-SHRA	Light Rainshowers		SHRA/ +SHRA	Moderat/Heavy Rainshowers
	-SHSN	Light Snow Showers		SHSN/ +SHSN	Moderat/Heavy Snow Showers
	TSRA	Thunderstorms with Light to Moderate Rain		+TSRA	Thunderstorms with Heavy Rain
	TSSN	Thunderstorms with Light to Moderate Snow		VCTS	Thunderstorms in the Vicinity

Table 11-3. Weather Symbols/Precipitation

Symbol	Code	Description	Symbol	Code	Description
	-DZ	Light Drizzle		-RA	Light Rain
	DZ	Drizzle (Moderate—no intensity assigned)		RA	Rain (Moderate—no intensity assigned)
	+DZ	Heavy Drizzle		+RA	Heavy Rain
	-FZDZ	Light Freezing Drizzle		-FZRA	Light Freezing Rain
	FZDZ +FZDZ	Moderate to Heavy Freezing Drizzle		FZRA +FZRA	Moderate to Heavy Freezing Rain
	-SN	Light Snow		SG	Snow Grains
	SN	Moderate Snow		IC	Ice Crystals
	+SN	Heavy Snow		PL	Ice Pellets
	GS	Snow Pellets		GR	Hail

Table 11-3. Weather Symbols/Obscuration/Other

Symbol	Code	Description	Symbol	Code	Description
=	BR	Mist	≡	FG	Fog
	FU	Smoke	∞	HZ	Haze
S	DU	Dust	S	SA	Sand
	VA	Volcanic Ash	?	UP	Unknown Precipitation/ Weather
	SQ	Squalls		FC	Funnel Cloud/ Tornado
	SS	Sand Storm		PO	Dust Devil

PIREPs can be displayed as a separate layer or in combination with other parameters as shown in the Layers Selector. Table 11-4 shows turbulence and icing icons, and a low-level wind shear icon identifies LLWS reports. An Airplane icon indicates other parameters, such as sky cover, weather, or remarks.

Note

Like other Data icons (observation/forecast) to display PIREP text "Click" the data icon.

Table 11-4. *PIREP Symbols*								
	NIL	No Turbulence		LGT	Light Turbulence		MOD	Moderate Turbulence
	SEV	Severe Turbulence		LLWS	Low-Level Wind Shear		NIL	No Icing
	LGT	Light Icing		MOD	Moderate Icing		SEV	Severe Icing

Surface Chart Analysis and Interpretation

Chapter 2, Atmospheric Properties introduced The Weather Equation—the effects of moisture, vertical motion, and stability. Surface charts depict the location and imply the strength of many atmospheric properties and provide a synoptic depiction of the lower atmosphere.

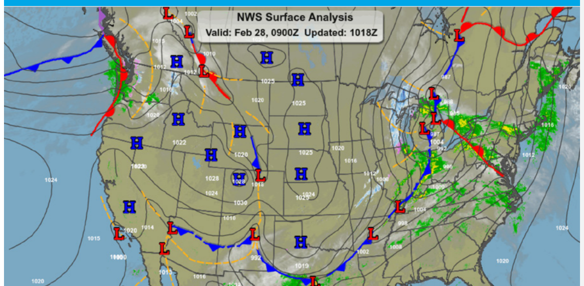
moisture ± vertical motion ± stability = weather

Convergence (downward vertical motion) occurs at the center of low pressure and along fronts and drylines, troughs, and areas of the narrowing of isobars. Divergence (upward vertical motion occurs at the center of high pressure, along ridges, and in areas of widening of the isobars.

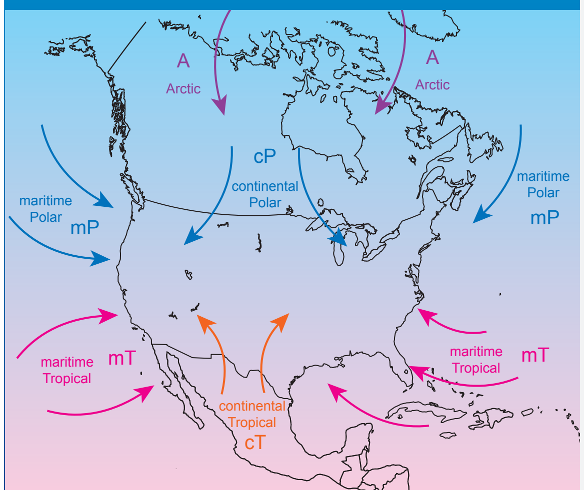
Caution

> Station models are point observations. Not all locations are depicted. Automated reports, rarely if ever, represent surrounding conditions—even those adjacent to the station—a significant limitation, especially in mountainous areas. When evaluating weather categories (Table 11-2), avoid interpolation between reporting locations.

Figure 11-6 displays an AWC surface analysis chart overlayed with station models. The Observations Layer Selector menu has both “Fronts” and “METAR” selected (upper right Fig. 11-6.) Under the Observations Product Label (upper left Fig. 11-6) read “Fronts/pressure 20240228/0900Z,” the date and time of this product (year, month, day/time)—2024 February 28, 0900Z. The Options Panel has METAR and Fronts selected.



Leidos Flight Service Surface Chart



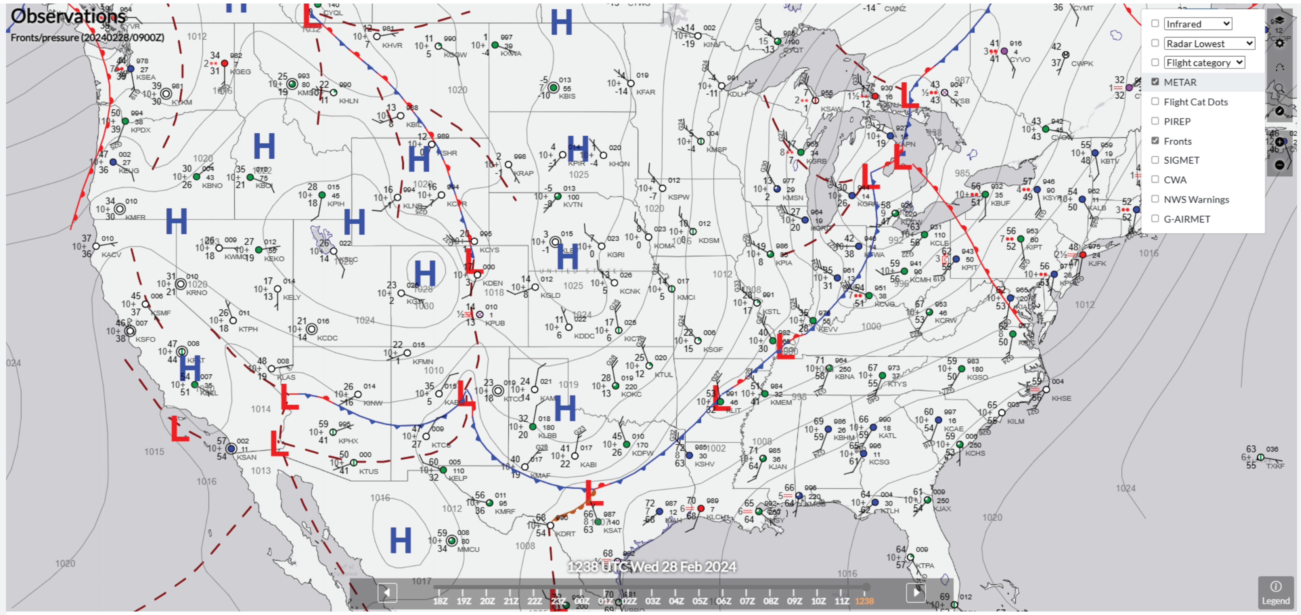


Fig 11-6. *The surface analysis chart graphically depicts boundaries, centers, and wind flow, and moisture and vertical motion at the surface and in the lower atmosphere.*

On the Observations Layer the Time Slider provides a "trend" of up to 18 hours in the past.

The callout shows a Leidos Flight Service surface analysis chart for the same period as the AWC chart in Fig. 11-6. (The Flight Service chart comes with Fronts/pressure patterns, satellite, and radar overlays.)

Refer to Fig. 11-6 and the Air Mass Source Regions in the callout for the following discussion. Only IFR/LIFR weather categories will be addressed; they serve as a "red flag" for VFR operations.

Note

> Terrain plays an important part in the weather. A knowledge of terrain is essential in understanding the weather picture. In the following discussion callouts define major terrain features affecting weather patterns in the U.S.

Western

A warm front and trough marks the boundary between lower pressure off the Pacific northwest coast (maritime Polar air mass) and the Great Basin high (continental Polar air mass). The system has produced a moderate south to southeasterly convergent, upslope flow over the region. Temperature/dewpoints indicate a relatively moist air mass at the surface, especially in the vicinity of the front and trough. Temperatures in the mountain interior are close to or below freezing. Precipitation consists of light rain and snow indicating a stable air mass. Skies are mostly overcast with IFR weather reported at Spokane, Washington.

Note

For our purposes in the following discussion, we'll define wind strength as:

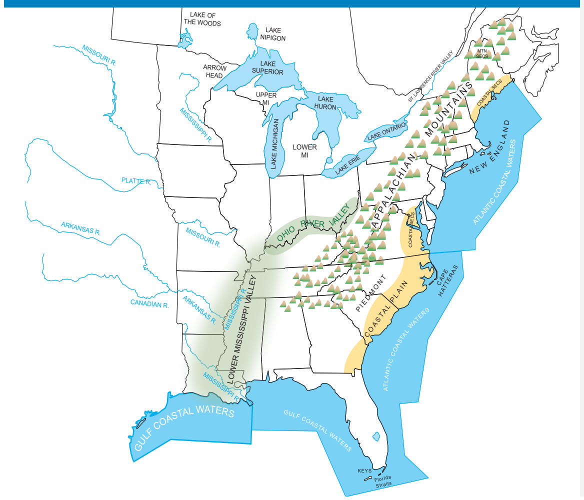
Light <15KT
Moderate 15-25KT
Strong >25KT

An eastern Pacific high dominates the eastern Pacific Ocean the off the California coast, with lower pressure inland—typical for coastal advection fog. Weak pressure gradients indicate generally light winds through California and the Great Basin. Temperature/dewpoints indicate the air mass at the surface is generally dry, except along the southern California coast and the southern San Joquin Valley.

The Great Basin high (a dry, stable air mass) dominates the intermountain region. Isobar patterns producing a light anticyclonic flow persist throughout the region. Pueblo, Colorado is reporting an indefinite ceiling in freezing fog—most likely radiation fog. (No absolutes! Under the conditions depicted in Fig. 11-1, expect possible strong, gusty Santa Ana winds in southern California and Chinook winds along the east slopes of the Rockies.) The air mass is mostly dry and cold, with below freezing temperature. A stationary front/trough indicates the eastern extent of the Great Basin high.

To the south, a cold/stationary front divides the Great Basin high from the continental Tropical air mass over the southwest U.S. and northern Mexico. This air mass extends

back side of low—Usually a reference to the north and west side of a low pressure system.



eastward to the dryline in Texas. Weak pressure gradients (light winds) and relatively large temperature/dewpoint spreads indicate little surface moisture, with moderate temperatures throughout the region.

Central

East of the stationary front/trough boundary over the Rockies, high pressure dominates the Great Plains (continental Polar air mass) the central U.S. High pressure extends east to a low center over the Great Lakes and south to a cold frontal boundary. Over the Great Plains a relatively light, divergent, clockwise flow out of high pressure covers the region. This flow is mostly cold, dry, and stable, with weak upslope over the northern Plains and eastern Rockies and downslope to the east and south.

Low pressure, with cyclonic flow, covers the Great Lakes. On the back side of the low moderate to strong, gusty winds flow into the low. Temperatures are cold with areas of light to moderate snow and mostly overcast skies in stable air. Marquette, Michigan is reporting IFR visibility in snow.

A cold frontal boundary extends from the Great Lakes low southwestward into Texas, with a moderate northwesterly flow behind the front. Skies remain overcast with no surface precipitation in the stable air behind the front.

In southwestern Texas a cold front separates the Great Basin high from the high in Mexico. Pressure gradients have produced light to moderate, gusty and dry winds behind the front.

Eastern

Over the Great Lakes counterclockwise convergent with moderate to strong, gusty winds flow into the low pressure center. East of the low and associated cold frontal boundary, a warm front extends from the Great Lakes low to the mid-Atlantic coast, indicating overrunning warmer, moist air moving up from the south. Temperatures are cool with dew points indicating abundant low level moisture. Skies are mostly overcast with moderate rain indicating a stable air mass. New York is reporting IFR in fog.

The Bermuda high is centered well off the Atlantic Coast. Anticyclonic circulation brings maritime Tropical air to the southeastern U.S., bounded on the west by the Great Lakes low and cold front extending to the southwest. The southerly wind flow becomes light to moderate and gusty along the Appalachians, into the Ohio River Valley and New England. Temperature/dewpoints indicate moderate temperature with considerable surface moisture. Station models show mostly overcast skies, with a moist upslope flow throughout the region. The air mass becomes unstable to the north as indicated by the thunderstorm reported at Pittsburg, Pennsylvania.

In southern Texas, a dryline separates the continental Tropical airmass in northern Mexico from the maritime Tropical airmass along the Gulf coast. A moist onshore flow has resulted in fog and low clouds, indicating stable air at the surface. Lake Charles, Louisiana is reporting IFR in fog.

Weather Depiction Products

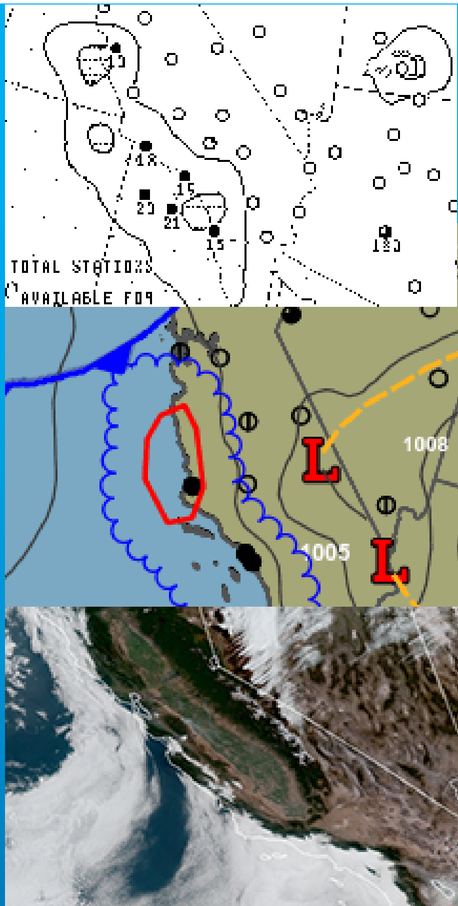
Weather depiction products provide a graphical display of weather categories. They consist of VFR—Visual Flight Rules, MVFR—Marginal Visual Flight Rules, IFR—Instrument Flight Rules, and LIFR—Low Instrument Flight Rules. Categories do not necessarily correspond to their 14 CFR Part 91 General Operating and Flight Rules definitions (callout). Depiction graphics provide a big, over-simplified, picture of surface conditions; intended as a quick-reference visualization of current weather and aid situational awareness. Charts depict areas of potentially hazardous low ceilings and visibilities; and assist in the recognition, avoidance, and escape from areas of hazardous weather. They're often a good place to begin looking for an IFR alternate.

Category	Ceiling (FT)		Visibility (SM)
VFR	> 3000	and	> 5
MVFR	1000 to 3000	and/or	3 to 5
IFR	≥600 to < 1000	and/or	≥ 2 to < 3
LIFR	≥ 200 to < 600	and/or	≥ 1/2 to < 2

Warning

> Weather depiction graphics are supplementary products and CANNOT be used operationally to determine current or forecast conditions. Products must be used along with Weather Advisories, METARs, Graphical Forecasts for Aviation, and TAFs.

Not all stations analyzed are depicted. Analysis cannot consider terrain; nor is it intended to represent conditions between reporting locations. Gross errors between depicted categories and actual weather can occur. Conditions can improve or deteriorate between issuance times. (The GFA upgrade addresses many of these issues. However, product limitations remain.)



Dedicated Weather Depiction Charts were discontinued and replaced with Graphical Forecast for Aviation products in 2024. National Weather Service legacy Weather Depiction Charts are illustrated in the callout. Images represent the same date and time: top a facsimile product (prior to 1990s), middle computer graphic image (after 1990), bottom a satellite image.

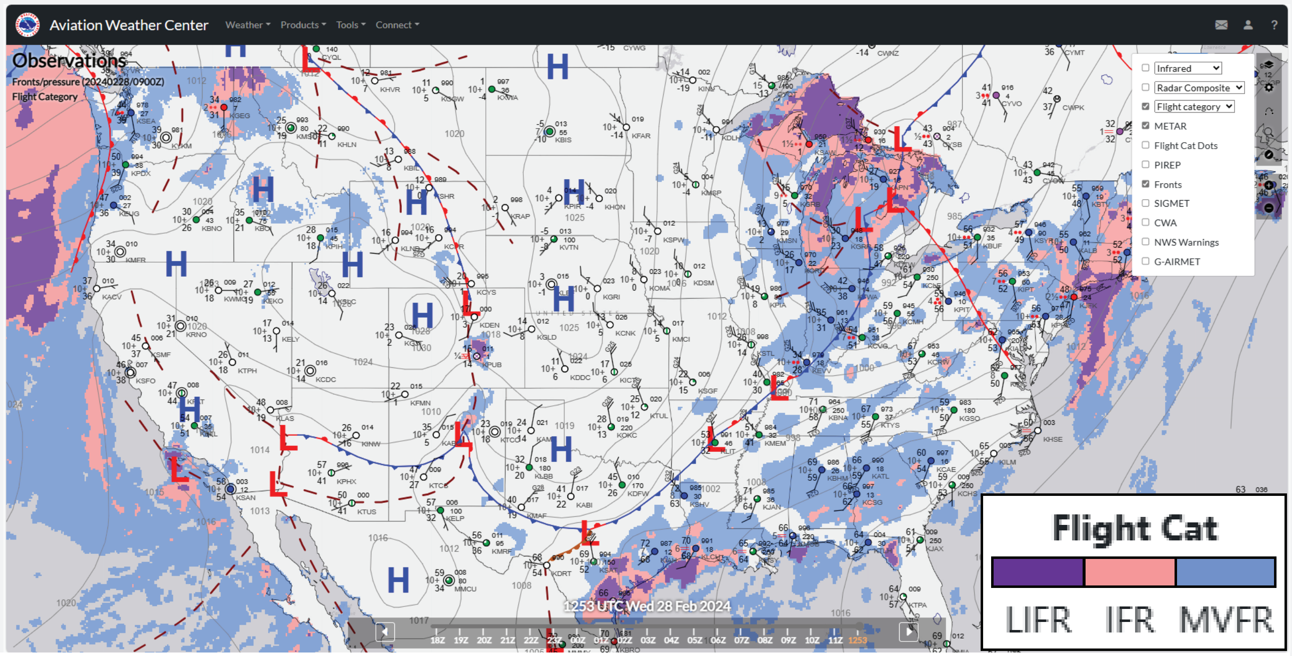
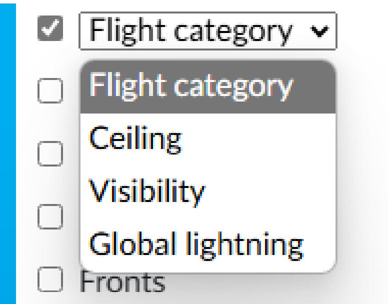


Fig 11-7. *Surface analysis and weather depiction products provides a "first look" at mostly synoptic scale weather.*

Figure 11-7 shows Flight Categories overlayed on the Observations "Fronts" and "METAR" layer—accompanied by an increase in "clutter" with additional data. It's important to consider that the analysis consists of gridded points that may not represent conditions between reporting locations, especially in mountainous areas!

Note

> The Flight Categories dropdown menu on the Layers Selector Option Panel (callout) allows the selection of Ceiling or Visibility. (The *Flight category* option includes both Ceiling and Visibility.)



Global lightning displays will be covered in ch12, Weather Radar Products.

MVFR exists along the Pacific northwest coast, lowering in the mountains, with IFR at the higher elevations. MVFR to IFR persists along the southern California coast. Otherwise, mostly clear skies and VFR weather throughout the west.

The frontal boundary separating the Great Basin and Great Plains highs has produced mostly VFR weather. The exception is the high Plains of Colorado and northern New Mexico. Local flight conditions are MVR/IFR due to radiation/upslope produced by the anticyclonic circulation around the Great Plains high. LIFR/IFR/MVFR are associated with the back side of the low over the Great Lakes. These conditions become mostly MVFR behind the cold front southwest of the low.

LIFR/IFR/MVFR prevails along the Gulf coast. MVFR to locally IFR continues with the moist, southerly flow in the southeast U.S. Another region of LIFR/IFR/MVFR exists northeast of the warm front.

Radar/Satellite Products

Figure 11-8 contains “Radar Composite” and “Infrared” satellite products overlayed on the Observations “Fronts” layer. Radar Composites infers conditions vertically through the atmosphere. (Radar images have a “loop” function.) Infrared satellite provides an indication of cloud tops. As well as understanding depicted products, consider observation times. Radar/satellite data is updated more frequently than Fronts/pressure systems. In Fig. 11-8. Fronts/pressure represent observed data at 0900Z, Radar at 1240Z, and Infrared satellite at 1220Z—time differences of over three hours. (Observation “time” does not include the period needed for observation, compilation, and dissemination.) Expect differences between the location of Fronts/pressure positions and radar/satellite depictions—a latency limitation of these products.

In the Pacific northwest radar indicates mostly light precipitation; satellite shows

Radar Intensity Levels		
Intensity	**dBZ**	**NEXRAD Color**
Light	<30	
Moderate	30 - 40	
Heavy	>40 - 50	
Extreme	>50	

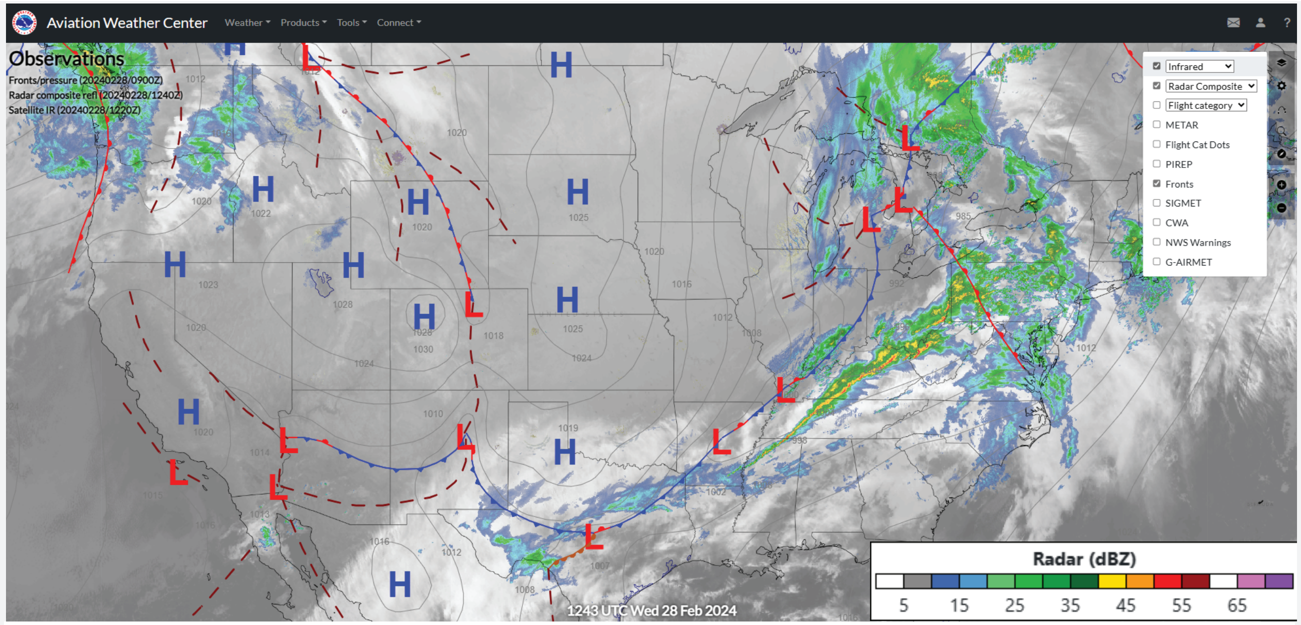


Fig 11-8. *Composit images allow the display of several data layers, but suffer from specific limitation.*

medium gray along the coast—mid level tops and white over the interior—high tops. Based on this and previous analysis we can infer a mostly stable air mass. For most of the southwest and Great Basin mostly clear skies and a stable air mass.

Into the Great Plains, mostly clear skies prevail. The lack of satellite and radar indicates a stable air mass. From southern New Mexico, into Texas, and along the southern portion of the front in the Midwest radar and satellite indicate light precipitation and high cloud tops, inferring a mostly stable air mass.

On the back side of the low over the Great Lakes radar and satellite indicate light precipitation and mid to high cloud tops. Again, inferring a mostly stable air mass. Similar conditions are indicated along and to the west of the frontal boundary into Texas.

Radar and satellite indicate no precipitation along the Gulf Coast with low to middle cloud tops—stable air. (It's difficult to distinguish specific cloud top heights with only an Infrared image.) Further north thing get interesting. A line of what appears to be convective weather is depicted ahead of the frontal boundary—or is it ahead of the front? Recall the time difference between products. Radar shows a line of moderate to heavy precipitation. Based on all the date thus far, it appears to be an unstable air mass in this region. Further east along the Atlantic coast light to moderate precipitation and high cloud tops are indicated. A mostly stable air mass but expect thing to change with the added lifting of the approaching frontal boundary. North of the warm front light to moderate precipitation and high cloud tops prevail in a generally stable air mass.

AWC Surface Map Options

Customize individual observations using the Options Panel, *Map Options* icon (Fig. 11-5). (“Click” the *gear* icon below the Layers Selector to view Map Options.) Map Options (callout) consists of five dropdown menus: *Data*, *Imagery*, *Map Format*, *Map Features*, and *Bookmark*. Customize “Data” within each menu. The “Data” and “Imagery” submenus support operational products. Figure 11-9 shows *METAR* and *PIREP* options.

METAR

Select “All” or “None,” or individual report elements. A “Density” slider controls the number of reports displayed. Use the “Scale” slider to adjust the size of displayed date. Customize “Units” as *US customary* (temperature/dew point Fahrenheit), *US aviation* (temperature/dew point Celsius), or *Metric SI* (temperature/dew point Celsius, visibility/ceiling kilometers/meters, altimeter setting hectopascals). “Click” the station model to display METAR text. “Decode METAR” and “Include TAF” options are available.

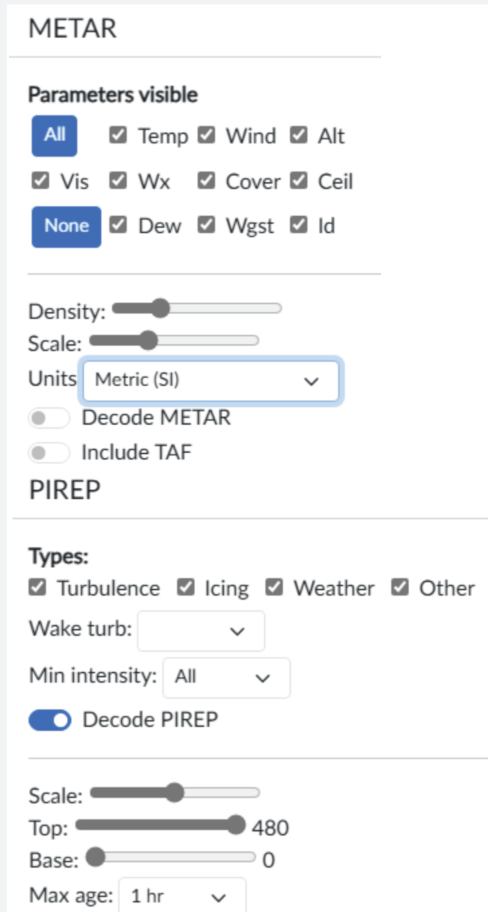
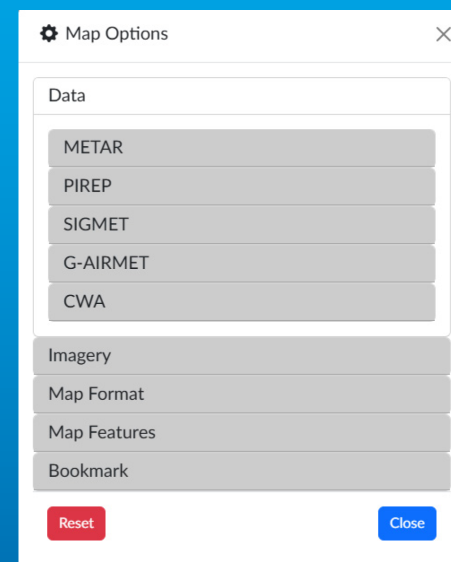
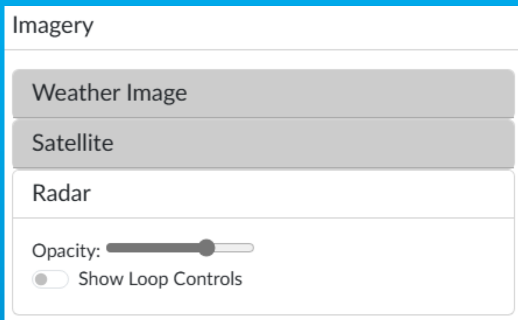


Fig. 11-9. METAR and PIREP customizable options.



PIREP

Use the Map Options, PIREP dropdown menu to customize PIREP type, wake turbulence category (light, moderate, severe), and minimum intensity (all, light, moderate, severe). "Click" the station model to display PIREP text. A "Decode PIREP" options is available. Use the scale, top and base altitude to customize reports. The "MAX age" option allows the selection of reports up to 12 hours old.



The "Imagery" menu controls the "Opacity" of the Weather Image, Satellite, and Radar layers (callout). The Radar layer dropdown menu controls the "loop" display. When selected the radar loop control panel appears at the bottom of the Observations panel.

Upper Air Charts

Each chart represents a constant pressure level and has particular significance. Table 11-5 describes the features and use of each chart. *Contours* represent lines of equal height of the constant pressure surface—in meters (m). Like isobars on surface charts, contours represent wind flow patterns. Temperature (Celsius) and dewpoint spread—*dewpoint depression*—appear with station models on 850, 700, and 500mb charts. *Isotherms* depict lines of equal temperature. Temperature alone appears on 300 and

Table 11-5. *Constant Pressure Chart Analysis*

Press Level	Press Alt (ft)	Height (m)	TEMP /DP	Isotherms	Isotachs	Primary Uses
850 mb	5000	585 (1585)	Yes/ Yes	Yes	No	Advection; Convergence/Divergence
700 mb	10,000	928 (2928)	Yes/ Yes	Yes	No	Advection; Convergence/Divergence
500 mb	18,000	572 (5720)	Yes/ Yes	Yes	No	Troughs/Ridges; Highs and Lows; Synopsis
300 mb	30,000	911 (9110)	Yes/ No	No	Yes	Advection; Jet Stream; Convergence/Divergence
200 mb	39,000	192 (11,920)	Yes/ No	No	Yes	Advection; Jet Stream; Convergence/Divergence

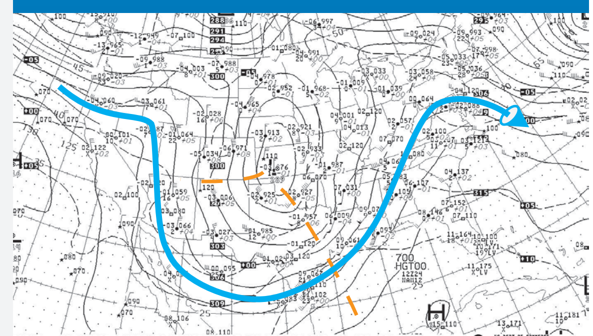
200mb charts. (The air is too dry to measure dewpoint at these levels.) *Isotachs* depict lines of equal wind speed. Charts graphically depict advection of atmospheric properties—temperature, moisture, pressure, and vorticity.

As discussed in ch 4, Upper-Level Weather Systems troughs transport cold air down from the north and warm air from the south. Warm air rides northward on the east side of the trough (trough-to-ridge flow). Lifted air moves northward, resulting in upward vertical motion. With enough moisture clouds and precipitation develop in the mid troposphere. Conversely, in the ridge-to-trough flow cold air sinks southward, resulting in downward vertical motion. Short-wave troughs move through the long-wave patterns enhancing upward vertical motion. Short-wave upper-level troughs are a key to the evolution of weather systems. Station models show the height of the constant pressure surface, wind direction and speed, and temperature and dewpoint depression. Blue numerals (lower left in the station model), show dewpoint depressions of 5°C or less, indicating areas of relatively high moisture content. Isotherms show temperature patterns and can be used to determine areas of cold- and warm-air advection and possible icing.

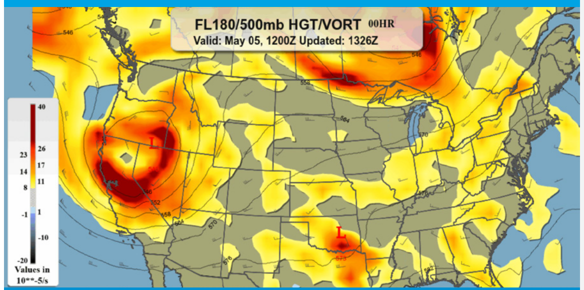
Note

> Upper air analysis charts graphically depict the effects of vertical motion producers. Like the material in Part One, don't become overly concerned about these meteorological processes. On the other hand, don't overlook this material. They provide a background for *operational* weather and its *application* to flight planning, execution, and decision making. They'll assist in your understanding of supplement forecast products presented in the remainer of Part Three: Weather Resources.

Eight hundred and fifty and 700mb charts depict the lower troposphere. The 850mb chart might be more representative of surface conditions west of the Rockies than the surface analysis. In the west, areas of frictional convergence/divergence can often be located on these charts. Short waves are usually best seen on the 700mb chart. (The callout shows the long-wave pattern as a heavy blue arrow with short-wave troughs embedded in the overall flow.) Winds exceeding 40 knots imply moderate or greater turbulence. The 700mb chart is usually the reference level for mountain waves. When



Legacy 700mb analysis April 24, 2010.



Leidos Flight Service 500mb Heights/Vorticity chart 1200Z May 5, 2024.

winds blow perpendicular to a mountain range, accompanied by cold-air advection, a strong potential for mountain waves and associated turbulence exists. Single cell thunderstorms tend to move with the 700mb winds. In mid latitudes a 700mb temperature of 14°C or greater tends to inhibit convection at this level. If convection occurs, clouds tend to stop rising and spread out at about the 700mb level.

Probably the most important and useful chart—maybe even more important to meteorologists than the surface analysis—the 500mb chart describes the atmosphere in the middle troposphere (approximately 18,000 ft). The 500mb chart depicts upper-level pressure patterns: highs and lows, troughs and ridges. Just as the surface analysis chart provides a low-level synopsis, the 500mb chart depicts the location and strength of upper-level systems. The chart provides a guide to vertical motion aloft. Surface weather systems tend to follow the 500mb flow. Organized multicell/supercell thunderstorms usually move in the direction of the 500mb winds. High moisture content at the 500mb level can be determined by small temperature/dewpoint depressions. This chart is a good indicator of upper-level icing in the warm season and with well-developed storms or systems that contain tropical moisture. Certain 500mb charts display vorticity (callout).

At and above the 500mb level, the shape of the contours rather than wind speed determines the most significant turbulence. At these levels, wind shear turbulence occurs as an aircraft flies through areas of changing wind direction and/or speed. Therefore, the greater the curvature or direction change, the greater the potential for, and intensity of, turbulence. The horizontal distance where this change occurs is critical. Developing low pressure troughs moving from the northwest are particularly dangerous.

Upper-Level weather systems are depicted on 500, 300, and 200mb charts. Strong surface storms are reflected in these patterns; weaker systems lose their identity. These charts depict the location and strength of the jet.

Three hundred and 200mb charts provide details of pressure, wind flow, and temperature patterns at the top of the troposphere and occasionally into the lower stratosphere. Charts indicate the strength of features in the lower atmosphere. Strong surface storms are reflected in the 300 and 200mb patterns; weaker systems lose their identity. These charts depict the location and strength of the jet stream.

Contour curvature and wind speed provide a clue to clear air turbulence (CAT). Areas of potential significant turbulence occur in:

- sharp troughs and ridges,
- a divergent flow,
- a converging (merging) flow, and
- the neck of cutoff lows.

Case Study

> I was riding "jump seat" on a Delta Boeing 737 from Oakland to Salt Lake City. At FL370 the ride was smooth to occasional light turbulence. Over the radio we could hear a Delta Boeing 757 constantly complaining of moderate turbulence at FL390. As chance would have it, I flew with that crew, from Salt Lake City to Washington's Dulles airport. It turned out they flew their first leg from San Jose to Salt Lake City, on almost the same route I had flown at FL370. This illustrates how the intensity of jet stream CAT can change significantly with only small altitude differences.

Warm-air advection above the 500mb level diminishes low pressure troughs and strengthens high pressure ridges. Cold air aloft and strong cold-air advection strengthen low pressure trough and weaken high pressure ridges. Cold air and cold-air advection indicate strong systems and possible severe weather.

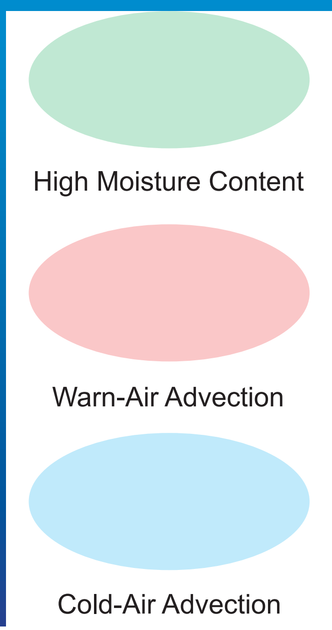
Note

> National Oceanic and Atmospheric Administration (NOAA) Constant Pressure Charts are NOT available from the AWC. The easiest aviation access is through the Leidos Flight Service website "Wx Charts" tab as shown in Fig. 11-2.

The following constant pressure charts were based on February 28, 2024, 0000Z observations. These products were issued 9 hours before the surface analysis chart in Fig. 11-6 and 12 hours before the radar/satellite images in Fig. 11-8. Expect differences between the location of phenomena, a product limitation.

850/700mb Constant Pressure Charts

Eight hundred and fifty and 700mb charts describe the lower troposphere. Analysis and application are the same for each level. Figure 11-10 provides enhanced Leidos Flight Service charts. Synoptically, on February 24, 2024, relatively weak weather systems dominated the CONUS. Troughs and ridges, and areas of high moisture content (green shading), warm-air advection (magenta shading) and cold-air advection (blue shading) have been superimposed on the graphics. Surface lows and



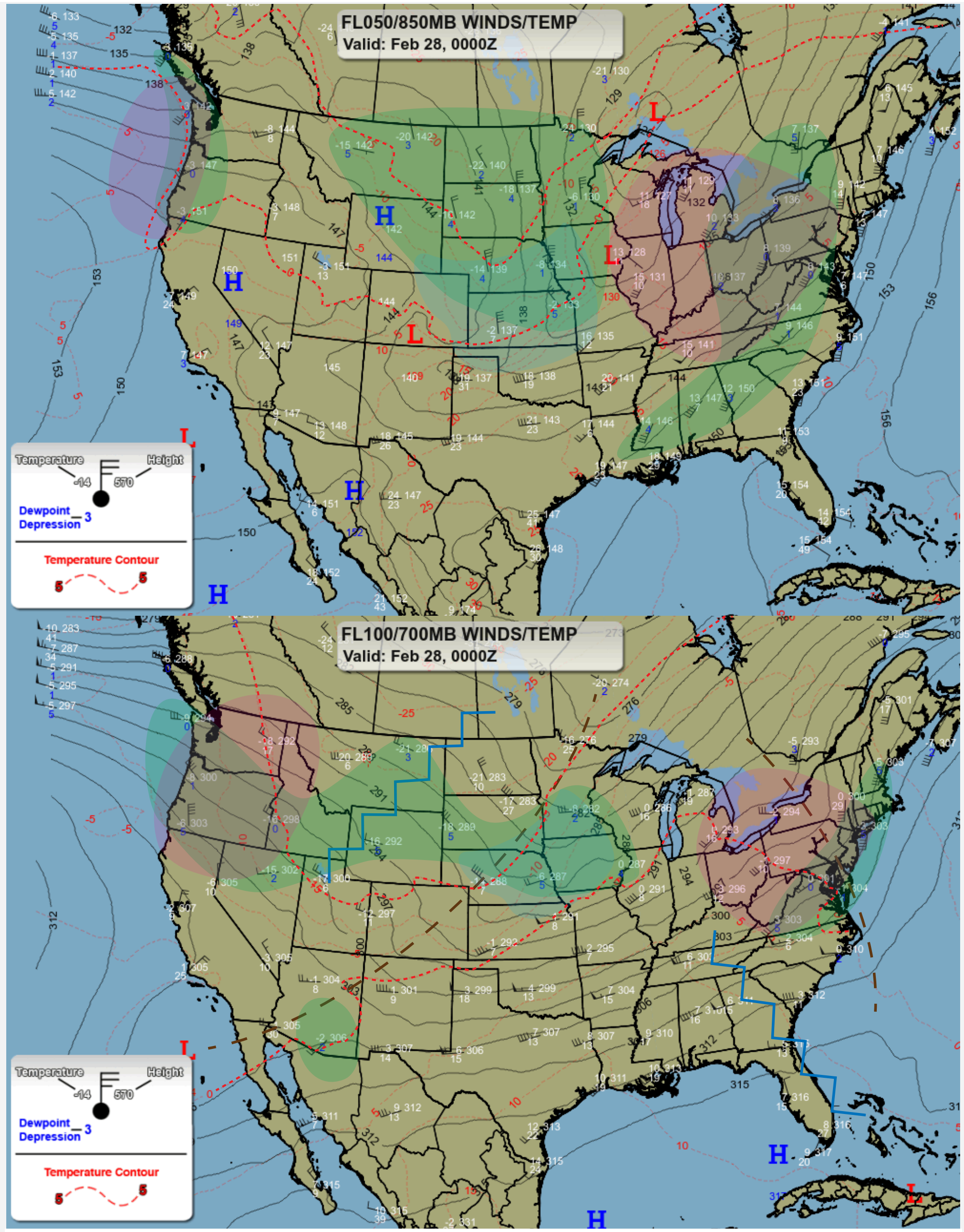


Fig. 11-10. *The 850 and 700 mb charts describes the atmosphere in the lower troposphere.*

highs, and associated troughs and ridges depicted at the 850mb level lose most of their identity at 700mbs. There are several short-wave troughs and ridges embedded in the overall flow. (Since constant pressure charts are 9 hours behind surface analysis issuance times, expect phenomena to be generally west—upstream of their surface charted locations.)

Relatively moist air flows into the Pacific Northwest. As well as orographic lifting and weak trough to ridge flow, warm-air advection enhances upward vertical motion producing widespread clouds and precipitation (refer to Fig. 11-8).

Despite relatively moist air in the upper Mid-West, subsidence— downward vertical motion from high pressure, ridge-to-trough flow, and cold-air advection—has resulted in mostly clear skies. A patch of moist air east of the low off Baja California has moved eastward producing light precipitation into Texas.

Along with the surface low in the vicinity of the Great Lakes and associated front, trough-to-ridge flow enhances vertical motion. Into the northeast a combination of the moisture, surface front, trough-to-ridge flow, warm-air advection, and relatively unstable air from the south has produced widespread clouds and precipitation and some convection.

Expect an icing potential in areas of visible moisture with temperatures between 0°C and -15°C. On the 700mb chart the 0° isotherm extends from the low off Baja California to the Great Lakes, then to the mid-Atlantic coast. The -15° isotherm dips out of Canada into northern Utah and Colorado, then northeastward into Canada.

500mb Constant Pressure Chart

The 500mb level reflects storm intensity. As shown in Fig. 11-11, low pressure centers off Baja California and over the Great Lakes have lost their identity. Weak ridge-to-trough flow continues over the northwest into the central U.S. with weak trough-to-ridge flow into the northeast. Additionally, there is weak cold-air advection ahead of the trough—an upward vertical motion producer. High moisture content is depicted in the northwest and northcentral states, and the southeast into New England. Except for the south central and southeastern U.S. temperature are below -15°C, indicating little icing potential at this level—except in area of convective activity. Especially during the late cool and warm seasons incursions of maritime Tropical air can result in significant icing will into the lower flight levels.

Since the 500mb chart is 9 to 12 hours behind the surface/radar/satellite composite (Fig. 11-8), expect frontal boundaries, cloud cover, and precipitation to be downstream of where they might be expected. Based on chart valid times and a relatively weak pattern, charts in this sequence are consistent with the composite in Fig. 11-8.

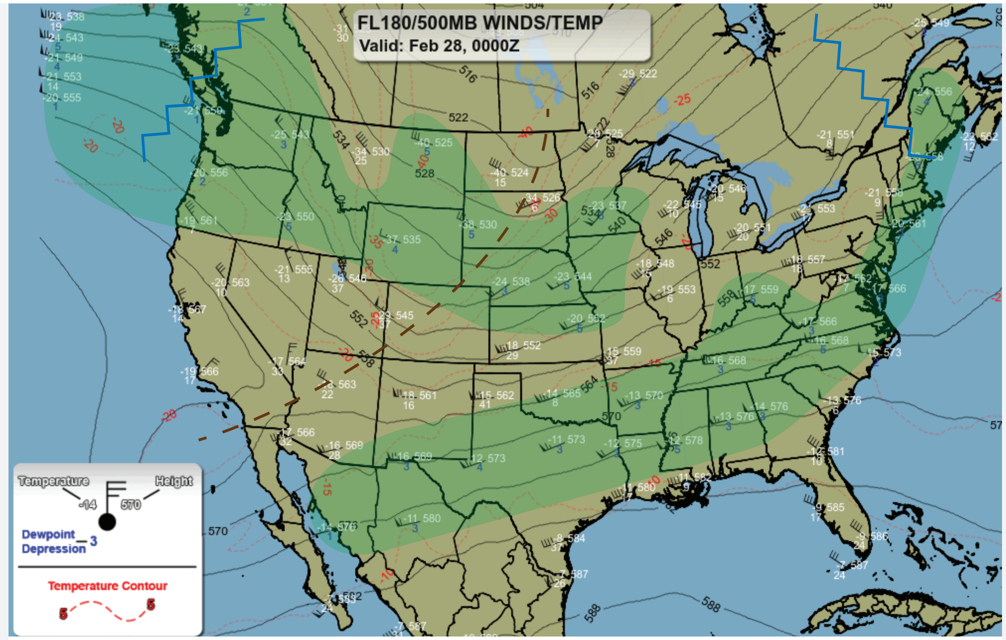
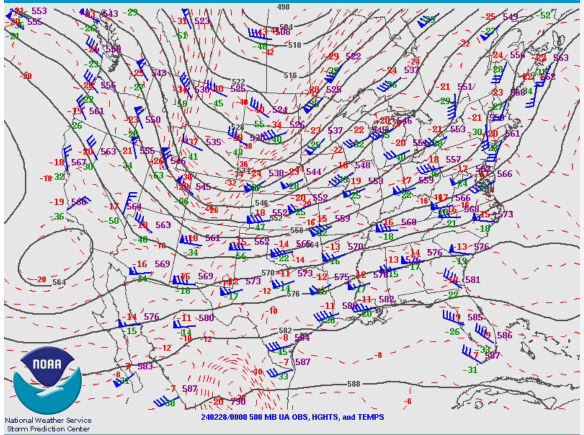


Fig. 11-11. *The 500 mb chart might be more important to meteorologists than the surface analysis.*



SPC 500mb Constant Pressure Chart from February 28, 2024 at 00Z.

National Oceanic and Atmospheric Administration (NOAA) constant pressure charts (callout) are available from the Storm Prediction Center (SPC) at:

www.spc.noaa.gov/obswx/maps/

300/200mb Constant Pressure Charts

Refer to the 300/200mb charts in Fig. 11-12. Low and high pressure centers have lost their identities at these levels, indicating weak surface systems. The ridge continues over the Pacific Northwest with a trough extending through the western third of the country.

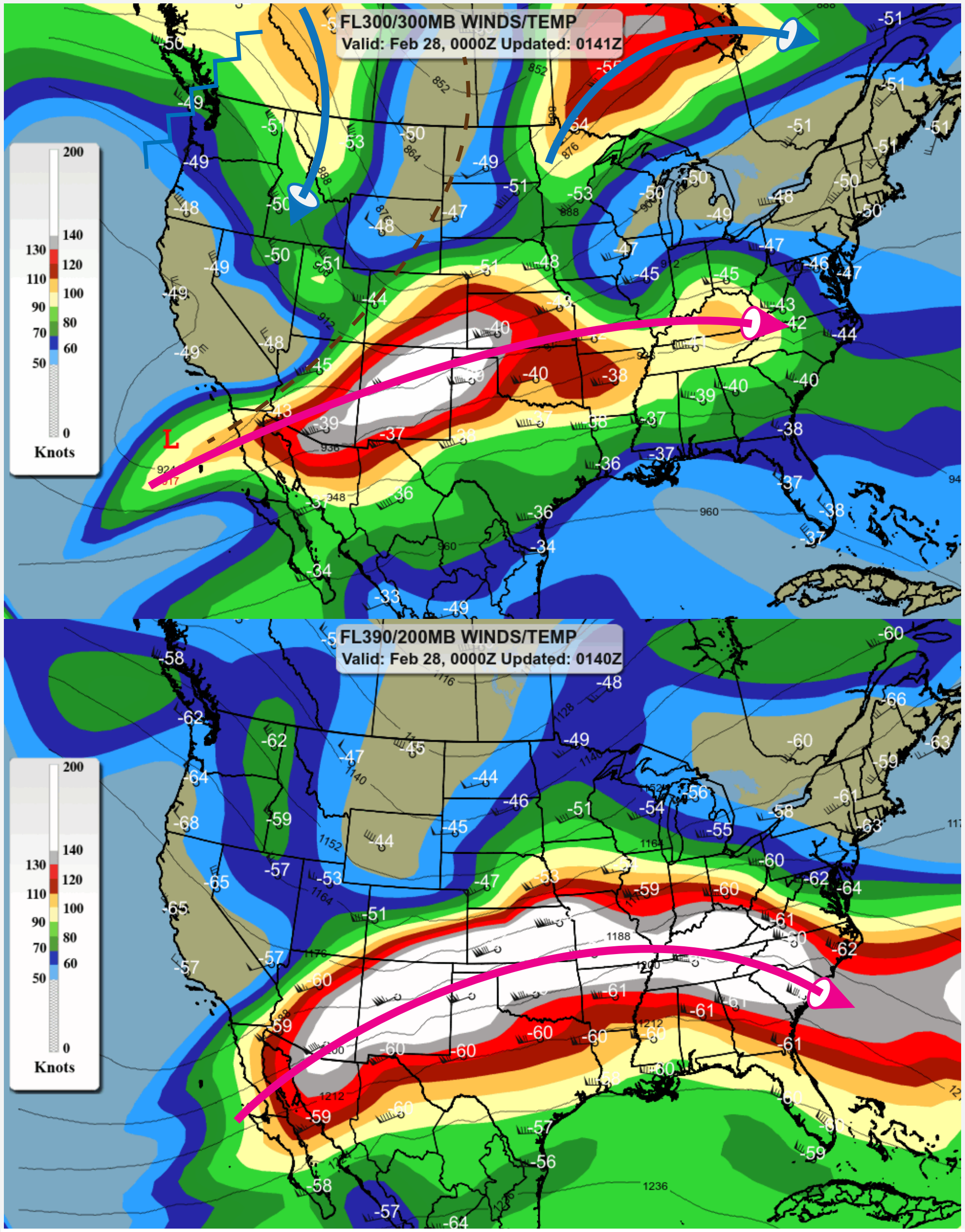


Fig. 11-12. *The 300 and 200mb charts describe the atmosphere at the top of the troposphere and occasionally the lower stratosphere.*

At mid latitudes jet streams can be found on these products. Because wind speed and direction are of primary interest, color overlays depict speed—often obscuring other data. Polar jets are usually best displayed at the 300mb level. Polar jets are typically at a lower altitude than the Subtropical jet—best seen at the 200mb level.

The core of Polar jet flows out of western Canada into the northwestern states. Another segment of the Polar jet rises out of the Mid-West, then into the Canadian maritime provinces—with core speed of about 120 knots. A Subtropical jet exists at the 300mb level and extends through the 200mb level with core speeds above 150 knots. The Subtropical jet has a core depth exceeding 10,000 feet. Expect the most significant turbulence where the Polar jet merges with the north side of the Subtropical jet where speed contours are steepest, and direction changes greatest.

Case Study

> A passenger aboard a United Boeing 747 died as the result of head injuries when the aircraft flew into an area of severe clear air turbulence (CAT) over the Pacific Ocean. The passenger was not wearing a seat belt. Other less severe injuries have resulted from CAT, mostly due to the failure to wear seat belts.

You've probably noticed the interrelationship between weather theory and weather products. The charts in this chapter pictorially depict moisture and vertical motion presented in Part One: Fundamental Principles of Aviation Weather. This association will continue through subsequent chapters.

Warning

> Weather elements discussed in this chapter are observations! They're only half of the weather picture. Forecasts must be considered and applied to any flight decision.