16 Enroute Forecast Products

The Graphical Forecasts for Aviation (GFA) suite has replaced the legacy text Area Forecast. “Enroute” forecasts consist of the GFA suite and Winds and Temperatures Aloft Forecasts (FB). Winds and Temperatures Aloft Forecasts allow the calculation of the effects of winds and temperatures on aircraft operations and provide insight into turbulence, icing, and density altitude.

Continental U.S. (CONUS) Significant Weather Forecast (SIGWX PROG) charts provide *Supplemental* and *Outlook* flight planning products. Additionally, SIGWX PROGs provide the second element of the synopsis—the expected movement of pressure systems, fronts, weather patterns, and selected weather phenomena. World Area Forecast System SigWX Charts deliver flight planning guidance for international civil aviation.

Graphical forecast scope, purpose, and limitations:

SCOPE: A mostly synoptic scale product, graphical forecasts describe conditions produced by weather systems such as high and low pressure, air masses, and fronts. Graphical forecasts typically predict conditions that may affect flight operations over relatively large areas.

PURPOSE: Graphical forecasts provide a forecast for the enroute phase of flight and for locations without a Terminal Aerodrome Forecast (TAF).

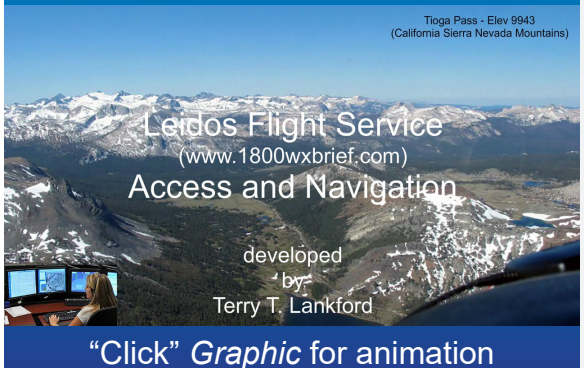
LIMITATIONS: Graphical forecasts require users to view several pages to obtain pertinent data. Displays may suffer from clutter. Users may disable certain grids/overlays eliminating areas of potentially significant weather. Grid point forecasts may not represent surrounding conditions. No amendments—automated; products may not be as accurate as those with forecaster input.

Graphical Forecasts for Aviation Suite

In October 2023 the Aviation Weather Center's revised/updated website (www.aviationweather.gov) became operational. Intended to provide consistent page layout, the site's "new look" reduces duplication, limits the number of pages, and enhances mobile displays.

Note

Preliminary access and navigation for aviation products on the Aviation Weather Center (AWC) and Leidos Flight Service (FS) websites are provided in previous chapters. (Graphical Observational Products are contained in chapter 11 (Figures 11-1 through 11-5), Radar and satellite imagery are described in chapters 12 and 13, and Weather Advisories in chapter 15.)



Additional introductory AWC and FS Access-Navigation animations (callouts) are available.

Access Aviation Weather Center (AWC) GFA products from the AWC "Home Page."

1. Select Weather option from the Top Menu.

The GFA FORECAST Suite consists of: Ceiling & Visibility, Clouds, Precipitation, Thunderstorms, Temperature, Winds, Turbulence, and Icing.

2. "Select" an option.
3. "Click" Active Layers.
4. "Check" the appropriate box to view desired products.
5. "Check" the Layers Selector for additional options.

Access Leidos Flight Service (FS) GFA products from the FS website "Home Page."

1. Select Map option from the Top Manu.
2. On the Map page, select the Layers Control panel.
3. "Click" Graphical Forecasts for Aviation.

GFA layers consist of: Ceiling & Visibility, Clouds, Precipitation, Winds, Turbulence, and Icing.

4. “Click” to view desired products.
6. Additional options appear below the selected GFA layer.

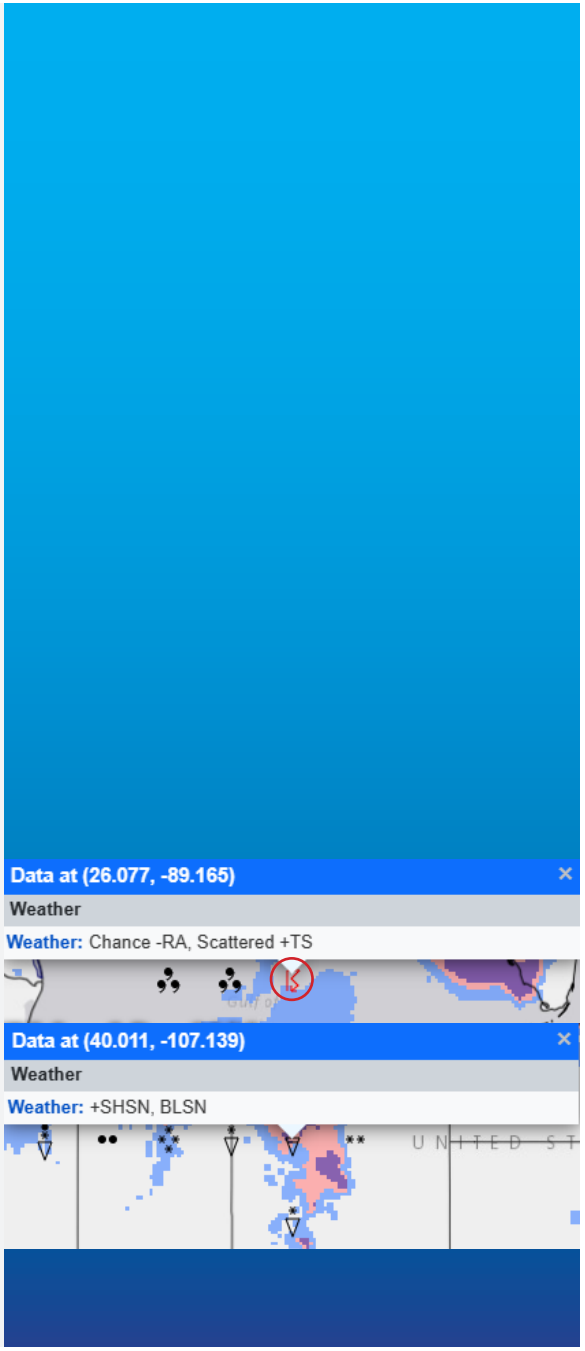
AWC product displays provide flexibility and customization using the Options panel. However, this results in more complexity. FS provides basic product displays. On the FS GFA menu *Thunderstorm* and *Temperature* layers are not available, although similar data can be found on the *WX Charts* page.

Weather Symbols

“Weather Symbol” grids are selectable on the Ceiling & Visibility, Precipitation, and Thunderstorms layers. Chapter 11, Graphical Observational Products, Table 11-3, Weather Symbols/Descriptions, describes weather symbols used on GFA products. Additional decode options include Legends menus which provide a *Weather Symbols* “hot spot” that links to the “Graphical Forecasts for Aviation (GFA) Help” symbols page.

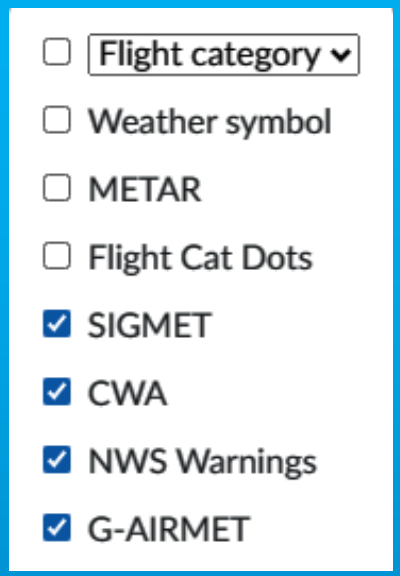
Graphical “Weather Symbol” forecasts provide all or some of the following parameters: type, intensity, probability, and coverage. *Type* describes precipitation (DZ, RA, SN, GR) and weather/obstructions (FG/BR, HZ, FU, DU/SA). Descriptors may be added (SH, TS, BL, DR). *Intensity* consists of light, moderate, or heavy. *Probability* refers to the likelihood of an occurrence. *Coverage* describes the arial extend of the phenomena.

“Click” the weather symbol icon to display text—which may include Type, Descriptors and Probability. (Refer to the callout.) The top example (red circle)—although partially obscured by the data block—expands on the icon symbol by showing heavy snow showers (+SHSN), accompanied by blowing snow (BLSN). The lower symbol text shows a “chance” of light rain (-RA) with “scattered” severe thunderstorms (+TS).



Weather Advisories

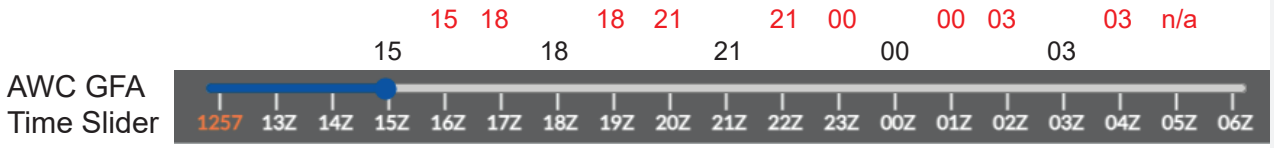
Selectable weather advisories are available on Aviation Weather Center’s Ceiling & Visibility, Clouds, Precipitation, Thunderstorms, Winds, Turbulence, and Icing layers.



For an additional discussion of AIRMET limitations refer to ch15, Weather Advisories, AIRMET Interpretation.

Use the *Options* Panel Layer Selector (callout) for available weather advisories. Weather advisory overlays provide additional insight into the phenomena described in the "parent layer." As shown on Fig. 16-1 weather advisories vary in resolution and valid time. The Precipitation and Thunderstorms layers do NOT include G-AIRMTs since they are not directly related to these phenomena.

Weather advisory depictions on GFA products may not comply with advisory limitations; nor be displayed within the valid period of the GFA product.



Product	Issuance	Resolution	Valid/Outlook Hours											
			1	2	3	4	5	6	7	8	9	10	11	12
G-AIRMET	Sch	3 Hr												
WS	Unsch	4 Hr												
WST	Unsch	2 Hr												
CWA	Unsch	2 Hr												

Fig. 16-1. *Weather advisory depictions on GFA products are for situational awareness, and supplemental and outlook purposes, not operational.*

Warning

The G-AIRMET provides a "snapshot" of expected conditions at a specific valid time. Spatial coverage will change at a regular or irregular rate at an unspecified time between valid periods. Users should avoid interpolation.

G-AIRMETs are valid at three hour intervals as shown by the black numbers above the *Time Slider* in Fig. 16-1. Intervening hours between valid times are shown in red. These represent either the preceding or the subsequent valid time. These are supplemental, NOT operational products—for situation awareness. SIGMETs, Convective SIGMETs, and Center Weather Advisories may only be displayed for two to five hours, then disappear from the display until the next advisory update time.

Not all advisories are displayed on each GFA layer. Table 16-1 lists advisories shown on specific GFA layers.

Table 16-1. *Forecast Weather Products/Advisories*

Layer[1]	AIRMETs	SIGMETs	NWS Warnings
Ceiling & Visibility	Sierra-Ceiling & Visibility (IFR)	Duststrom/Sandstorm (IFR) Volcanic Ash	Winter Storm; Blizzard
Clouds	Sierra-Mountain obscuration	Volcanic Ash	Severe Thunderstorm[2]; Winter Storm; Blizzard; Ice Storm
Precipitation		Duststrom/Sandstorm (IFR) Volcanic Ash	Severe Thunderstorm[2]; Winter Storm; Blizzard; Ice Storm; Lake Effect Snow
Thunderstorms			Severe Thunderstorm[2]
Winds	Tango-LLWS, Surface Winds		Winter Storm; Blizzard; Ice Storm; Gale; High Wind
Turbulence	Tango-Turbulence, LLWS	Turbulence	
Icing	Zulu	Icing	Winter Storm; Blizzard; Ice Storm; Lake Effect Snow

[1]All Layers display Convective SIGMETs (WST), Center Weather Advisories (CWA), and International Tropical Cyclone (TC) and Thunderstorm (TS) SIGMETs.
[2]NWS Severe Thunderstorm: tornado, hail ≥1 inch, wind ≥50 knots).

NWS Warnings

"NWS Warnings" overlays are selectable on the Ceiling & Visibility, Precipitation, Thunderstorms, Winds, Turbulence, and Icing layers. Table 16-1 lists NWS warnings shown on each GFA layer.

Table 16-2 provides NWS warning hazards, symbols, and definition of each product when "NWS Warnings" is selected.

Table 16-2. *GFA National Weather Service (NWS) Warnings*

Hazard	Symbol	Definition
Tornado	TO	A tornado is imminent.
Severe Thunderstorm	SV	Severe thunderstorms are occurring or imminent (winds ≥50 knots and/or hail ≥1 inch in diameter.
Winter Storm	WS	A significant combination of hazardous winter weather is occurring or imminent (snow/sleet ≥1 in within 12 hr.)
Blizzard	BZ	Snow and/or blowing snow—visibility ≤ 1/4 mile; winds/gusts ≥ 30 knots.
Gale	GL	An advisory issued for sustained winds or gusts of 34 to 47 knots.
High Wind	HW	An advisory issued when sustained winds ≥ 34 knots or gusts ≥ 50 knots.
Ice Storm	IS	An ice storm event expected with an ice accumulation ≥ 1/8 inch.
Lake Effect Snow	LE	Widespread or localized lake-induced snow squalls or heavy showers.
Tropical Storm	TR	Organized convection over tropical or sub-tropical waters with wind speeds > 34 knots
Hurricane	HU	Sustained surface winds ≥64 knots associated with tropical storms.
Tsunami	TS	Dangerous coastal flooding.

These are supplemental and outlook products, for situation awareness and advance planning.

Ceiling and Visibility

From the "Weather" dropdown menu select *Ceiling & Visibility*. Use the Options Panel Layer selector (callout) for the desired grids/overlays.

Figure 16-2 displays “Ceiling” and “Visibility” overlay options. (The Active Layers dropdown menu has been selected in the “Ceiling” display layer.) The “Weather symbol” option has also been “checked.” Decoded categorical layer values using the *Legend* icon shown in Fig. 16-4. The Weather Symbols link appears on the legend menu. “Close” the legend display by re-clicking the Legend icon. “Ceilings” (broken or overcast) values are feet above ground level (AGL) and “Visibility” values are statute miles (sm). Select desired forecast valid time using the *Time Slider* at the bottom of the layer.

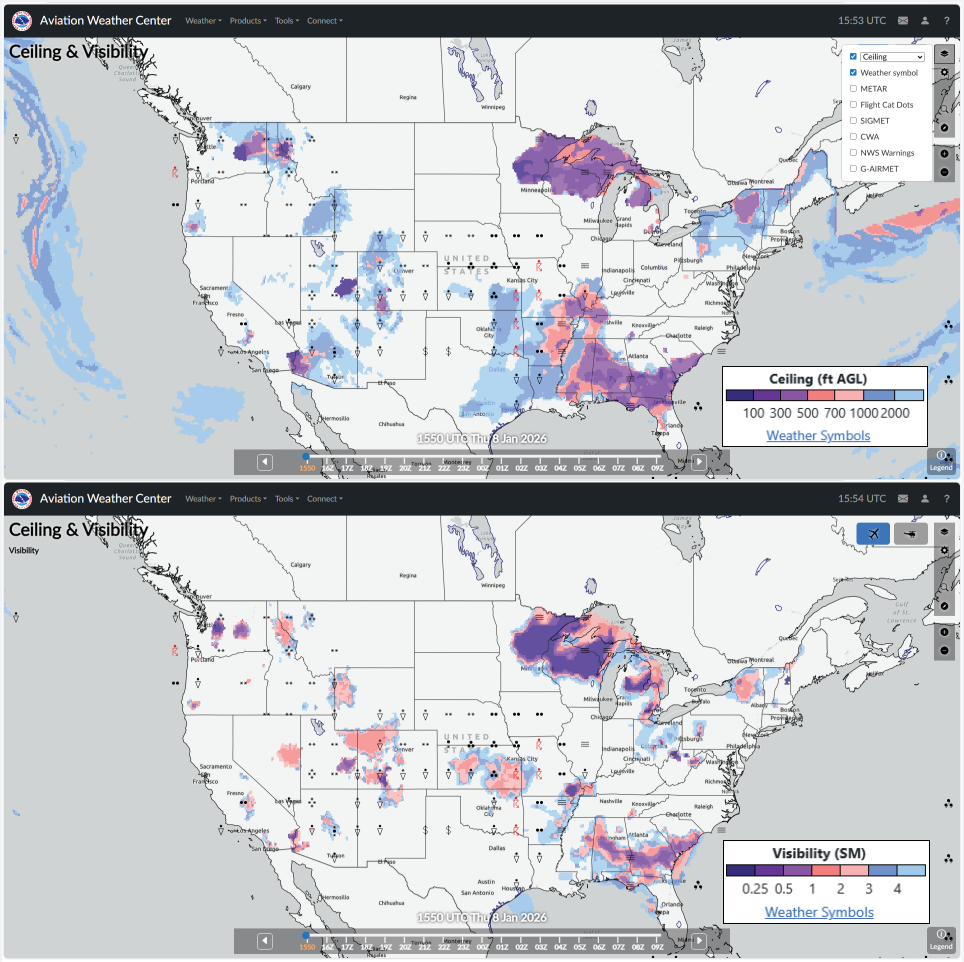
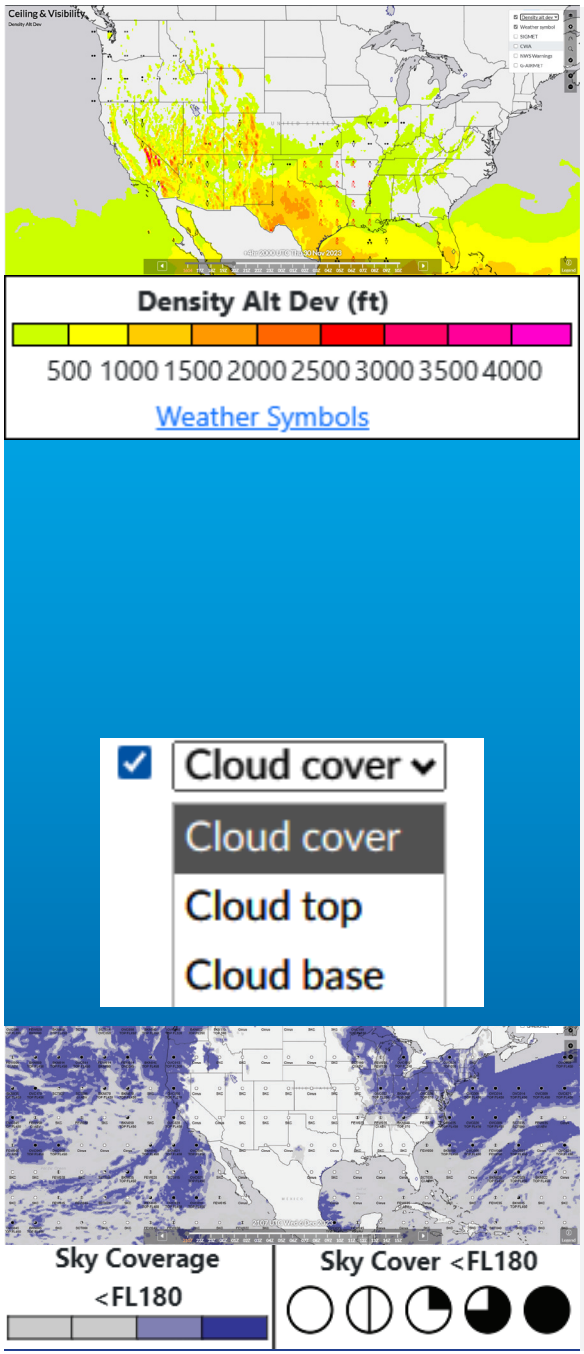


Fig. 16-2. *Operational options on the Ceiling & Visibility layer consist of Ceiling and Visibility.*

Note

The Flight category option reflects both Ceiling and Visibility. Flight categories were discussed in ch11, Graphical Observation Products Fig. 11-7. Categories are color coded overlays divided into LIFR/IFR/MVFR/VFR.

This option serves as a replacement for the legacy Weather Depiction Chart.



The "Density alt dev" option provides density altitude deviation effects of high surface temperatures (callout). (The Legend appears in the callout.) Values range from zero to 4000 ft above surface elevations—add the deviation value to field elevation for approximate density altitude.

Caution

> Density Altitude is an indicator of aircraft performance. The maximum GFA deviation value is 4000 ft. Extremely high surface temperatures may result in higher values. (Other factors affect aircraft performance. Refer to Ch19, Aircraft Performance for a complete discussion.) The GFA "Density alt dev" layer is NOT a substitute for calculating aircraft performance using observed conditions prior to takeoff and landing. It is a supplemental/outlook product for advanced planning.

Additional *Ceiling & Visibility* layers menu options include METARs and Flight Cat Dots options (covered in Ch11, Graphical Observational Products) and weather advisory overlays.

Clouds

From the "Weather" dropdown menu select *Clouds*. Use the Options Panel dropdown selector (callout) for the desired girds/overlays—Cloud cover, Cloud top, and Cloud base.

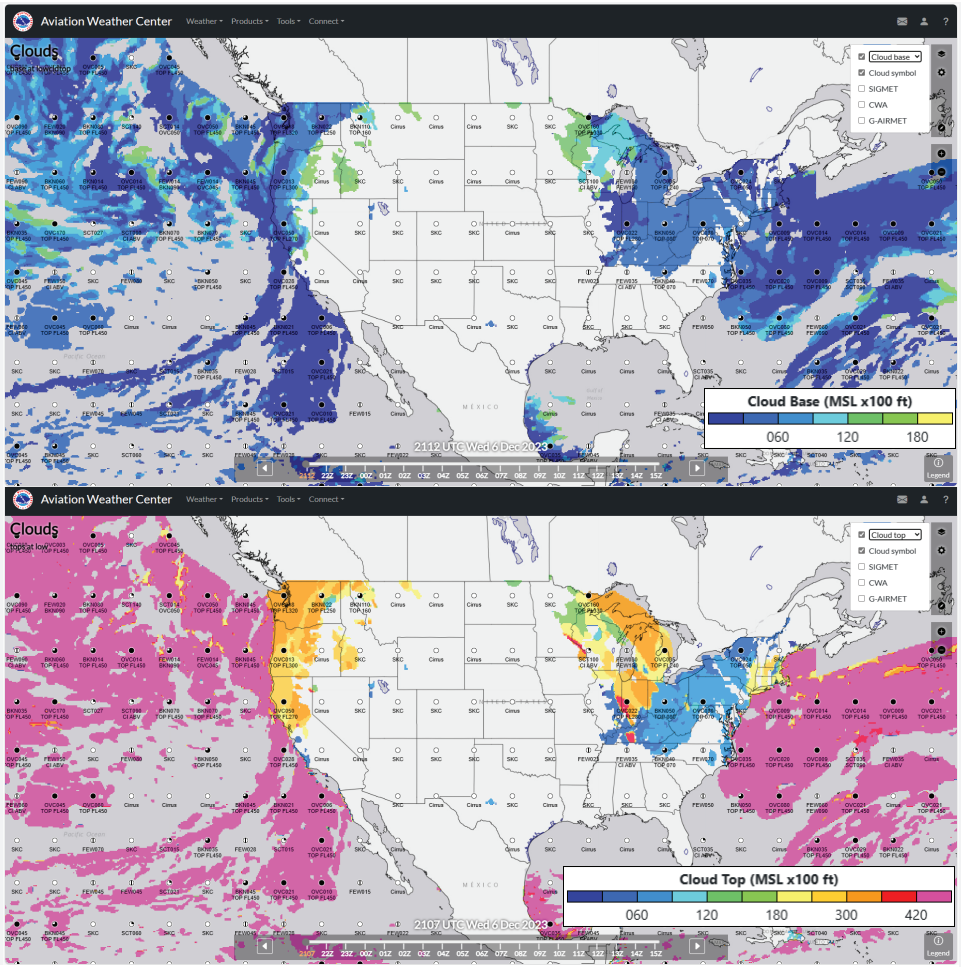
The "Cloud cover" overlay (callout) displays sky cover (few and scattered, broken, or overcast). The "Weather Symbols" Sky Cover *Legend* is also shown. These apply to clouds below FL180. Cloud symbol grid point forecast circles indicate coverage at specific locations. "Cloud cover" overlay and "Cloud Symbols" grids depict cloud heights above mean sea level (MSL). Cirrus or CI above indicates cirrus clouds above FL180.

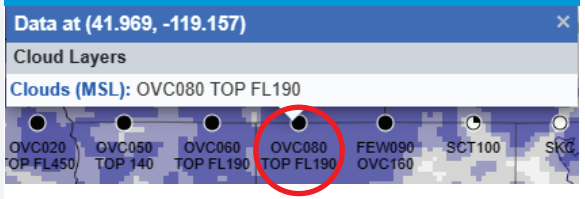
Figure 16-3 displays "Cloud base" and "Cloud top" color-coded overlay options. Decode categorical layer values using the *Legend* icon. Cloud symbols grids have also been selected. "Click" individual icons for sky condition point forecasts.

"Cloud base" overlays depict broken or overcast sky cover. "Cloud top" overlays provide cloud tops. These satisfy the operational compliant briefing requirements for enroute forecasts and locations without a TAF. "Click" Cloud symbol icons to display text. In the callout sky cover example (red circle) shows overcast (OVC080) clouds with bases at 8000 ft MSL and tops FL190.

Caution

Unlike Flight Category overlays, cloud base heights are depicted in feet above mean seal level (MSL).





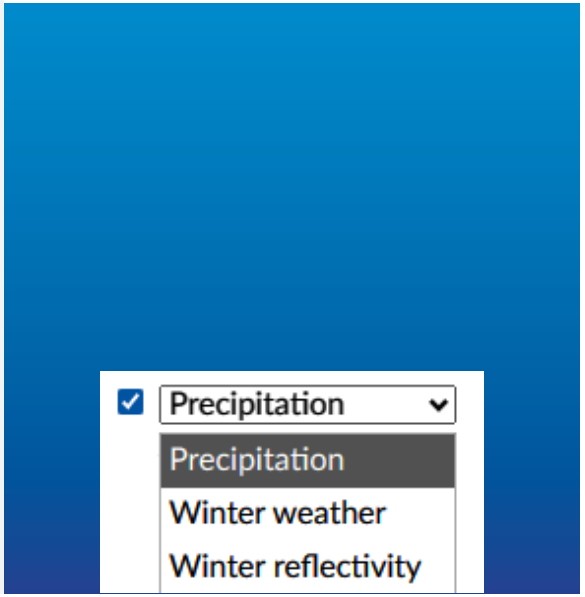


Fig. 16-3. Clouds provides sky cover, and bases and tops above mean sea level (MSL).

Precipitation

From the "Weather" dropdown menu select *Precipitation*. Use the Options Panel Layer Selector (callout) for the desired girds/overlays.

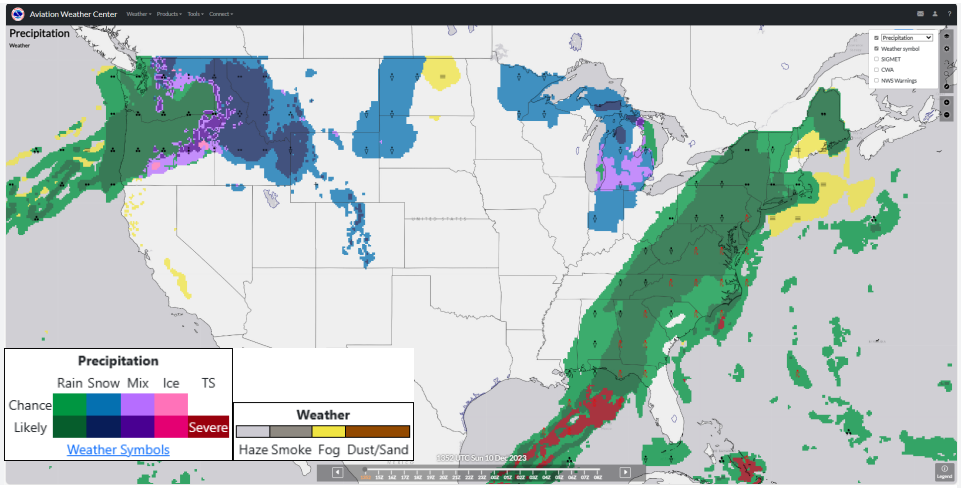


Fig. 16-4. Both *precipitation and weather/obstructions are displayed on the Precipitation layer.*

Figure 16-4 displays the *Precipitation* overlay option. The "Weather symbol" option has also been "checked." Decode categorical layers using the *Legend* icon—various weather and obstructions are included on the display.

The *Precipitation* overlay depicts precipitation *type*, *probability*, and *coverage*. Point forecast *intensity* is available using the "Weather symbol" option grid. Probability of precipitation: "chance" ≤50%, "likely" >50%. (Operational translation "chance" as scattered and "likely" as widespread.) As shown in the *Legend*, the layer includes specific color-coded weather/obstruction (FG/BR, HZ, FU, DU/SA) phenomena.

Refer to Table 16-3. Color overlays represent precipitation type, hue probability: light "chance," dark "likely." "Mix" refers to a combination of precipitation: rain and snow, rain and ice pellets, or snow and ice pellets. "Ice" refers to freezing rain. Supercooled large drops are inferred in areas of freezing precipitation. The "T-Storm" overlay in (dark red) indicates a "likely" probability of thunderstorms and/or the potential for severe thunderstorms.

Table 16-3. *Precipitation Types*

Type	Probability	
	Chance (≤50%)	Likely (>50%)
Rain (RA)		
Snow (SN)		
Mix (RA/SN/IP)		
Ice (FZRA)		
T-Storms (TS)		Severe

Warning

On the Precipitation overlay, as shown in Table 16-3, a "chance" probability of non-severe thunderstorms is NOT displayed. To determine areas of non-severe thunderstorms, select the "Weather symbols" grid. On Fig. 16-4 a thunderstorm potential exists in Florida, Georga, along the Appalachian mountains, and the central Atlantic coast and coastal plain. Or refer to the *Thunderstorms* layer.

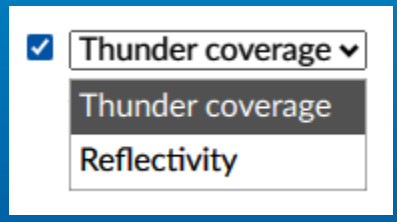
Widely scattered or isolated precipitation and thunderstorms may occur without being depicted. There may be "holes" in areas shown as widespread. This is not inconsistent but reflects the limitations of this product.

The *Winter weather* layer emphasizes areas of potentially hazardous surface weather (snow, mixed, and ice). Overlays use the same symbology and probability as the Precipitation layer. Selecting the NWS Warnings option may be helpful in determining the extent and duration of hazardous surface conditions. It serves as a "heads up" for potential Field Condition (FICO) NOTAMS.

The *Winter reflectivity* layer depicts surface forecast (dBz) of the probability of RA, FZRA, PL, and SN. (Both *Winter weather* and *Winter reflectivity* are supplemental/outlook products.)

Thunderstorms

From the "Weather" dropdown menu select *Thunderstorms*. Use the Options Panel Layer Selector (callout) for the desired girds/overlays. *Thunderstorms* layer graphics enhance situational awareness and provide supplemental/outlook products.



Color coded thunderstorm coverage and intensity definition are shown in the *Legend*.

- Isolated (ISOL)—Limited in duration and/or coverage and/or intensity.
- Scattered (SCT)—Short-lived and or not widespread, isolated intense storms possible.
- Numerous (NUM)—More persistent and/or widespread, a few intense storms.

The Thunder coverage layer (Fig. 16-5) highlights areas of convection.

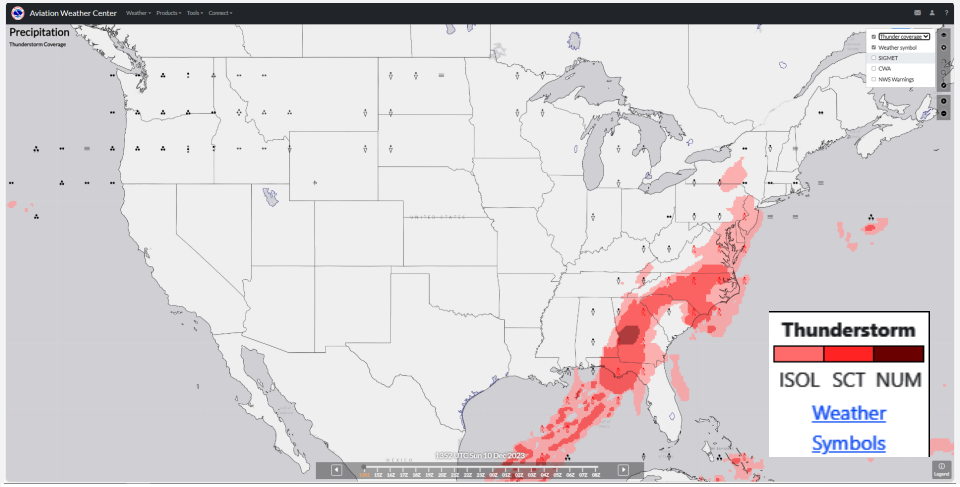


Fig. 16-5. *The Thunderstorms layer enhance situational awareness and provide supplemental/outlook products.*

The "Weather symbol" option has also been "checked" in Fig. 16-5. Convective, tropical cyclone, and international thunderstorm SIGMETs are available options on the Layers Selector menu.

Additional options on the Layers Selector menu include the Convective Outlook (AC), and the Traffic Flow Management (TCF) Convective Forecast and the Extended Convective Forecast Product (eTCF). (The TCF and eTCF provide convective guidance for Flow Control managers. Product description and criteria are available in the FAA's Aviation Weather Handbook FAA-H-8083-28A 2024.)

Temperature

From the "Weather" dropdown menu select *Temperature*. Use the Options Panel Layer Selector, upper right Fig. 16-6, for the desired grids/overlays. Selections consist of the Temperature color-coded

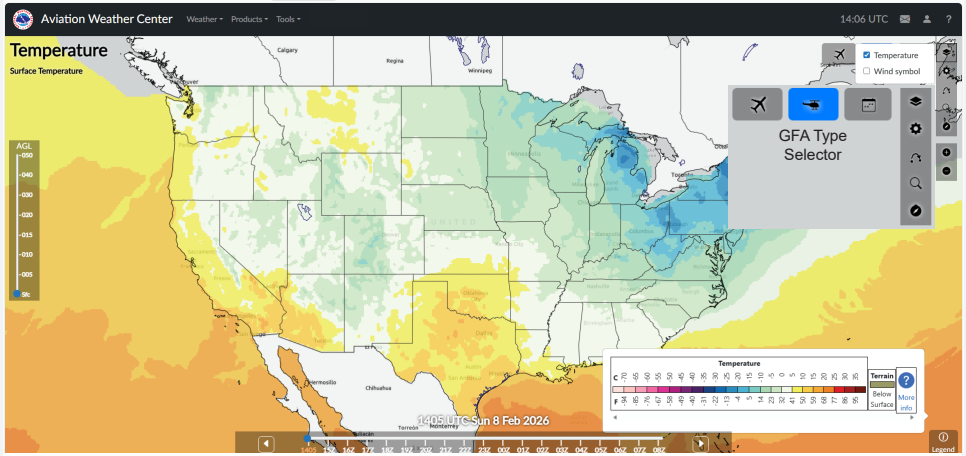


Fig. 16-6. *Temperatures and winds are factors in determining aircraft performance*

overlay and Wind symbol grid point forecasts. “Check” Wind symbols to display gridded wind barbs —not selected in Fig. 16-6. Use the *Vertical Level* selector to select altitude. In Fig. 16-6 surface (Sfc) has been selected. Decode temperatures using the *Legend* icon.

Note

In Fig. 16-6 the GFA Type Selector, inset upper right corner, allows the selection of altitude stratum. The Low Altitude Mode (helicopter icon) has been selected which provides altitudes through 5000 ft AGL.

The Temperature layer can be used to determine airport surface temperatures and winds—aircraft performance—through the end of the forecast period (up to 18 hours).

Winds

From the “Weather” dropdown menu select Winds. Use the Options Panel Layer Selector, upper right Fig. 16-7, for the desired grids/overlays. Selections consist of the “Wind speed” color-coded overlay and “Wind symbol” grided point forecast stem lines and wind barbs. Decode layer values using the Legend icon. (For an additional discussion of wind symbols refer to ch11, Graphical Observation Products.)

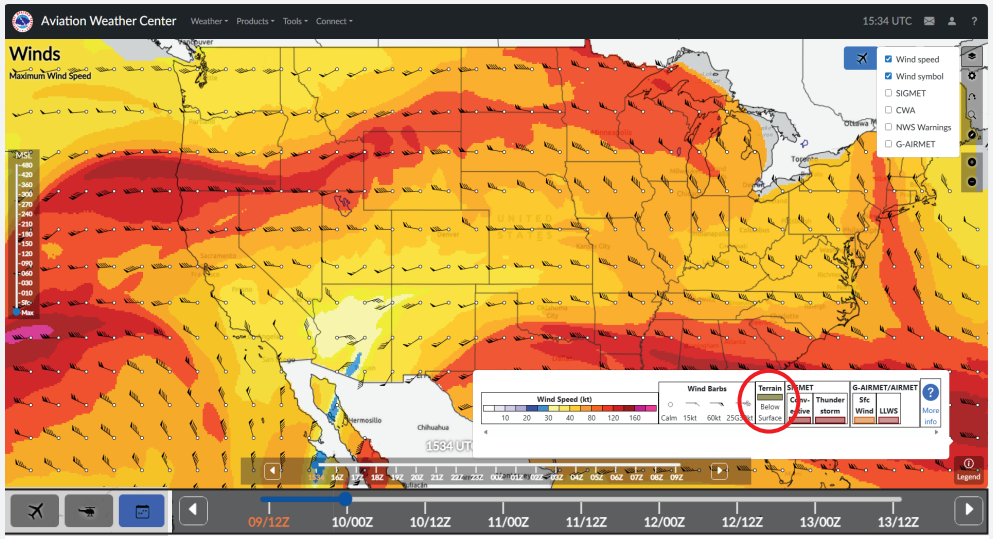
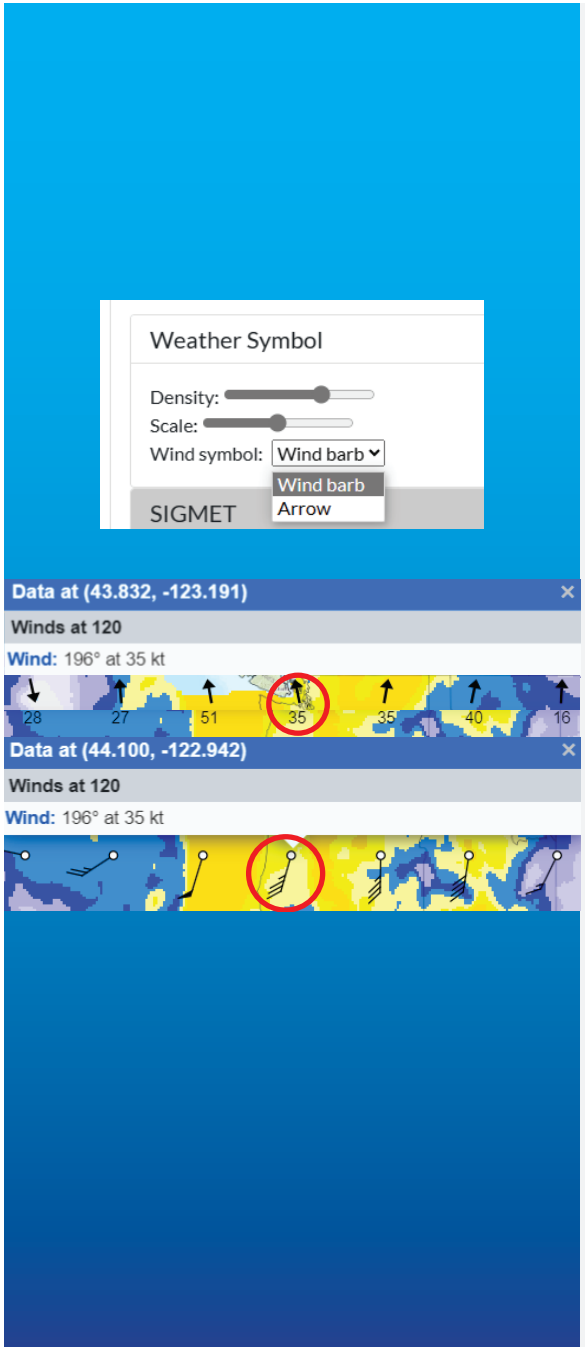


Fig. 16-7. *The Winds layer includes an “Extended Range Mode” valid to four days*



Note

On the "Winds," "Turbulence," and "Icing" layers when using the *GA Mode* (airplane icon) GFA Type Selector vertical levels are above mean sea level (MSL). To indicate areas where the selected level is *below the surface* the area is depicted in brown (red circle *Legend* Fig. 16-7).

Winds (direction True, speed Knots) are available from the surface to FL480 using the *Vertical Level* selector. Options include surface (Sfc) and MAX (maximum—based on all levels).

Use the Map Options, Data, Weather Symbol, "Wind Symbol," dropdown menu (callout) to select grid point forecast "Wind barb" or "Arrow." (It may be necessary to select wind symbol options and "Click" reset on Map Options to display the desired layers.)

"Click" the grid point forecast "barb" or "arrow" symbol icon to display text (callout). In the "arrow" symbol example (top red circle) winds at 12,000 ft are forecast from 196° at 35 knots. In the "barb" symbol example (bottom red circle) winds at 12,000 ft are forecast from 196° at 35 knots. (The examples in the callout represent two separate locations.)

Note

The *Temperature* layer Fig. 16-7 illustrates the GFA Type Selector Low Altitude Mode (helicopter icon) The *Vertical Level* selector provides altitudes through 5000 ft above ground level (AGL).

The *Winds* layer includes an "Extended Range Mode." Select the "Extended Range Mode" using the GFA Type Selector (top right Fig. 16-7). Refer to the inset at the bottom of Fig. 16-7. "Click" the blue *Folder* icon. The *Timeline* slider provides winds out to four days at 12 hour intervals. (When using the "Extended Range Mode" recall the limitations of aviation forecasts. These are supplemental/outlook products ONLY and must be used with operational products prior to departrure.)

Turbulence

From the "Weather" dropdown menu select *Turbulence*. Use the Options Panel Layer Selector (callout) for the desired grids/overlays—Turbulence, Clear air turb, Mountain wave turb, and Low level wind shear.

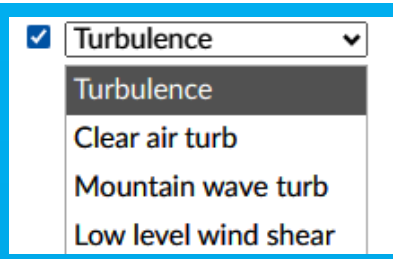


Figure 16-8 displays the *Turbulence* layer. Decode categorical layer values using the Legend icon. (An excerpt from the *Legend* is shown on Fig. 16-8.)

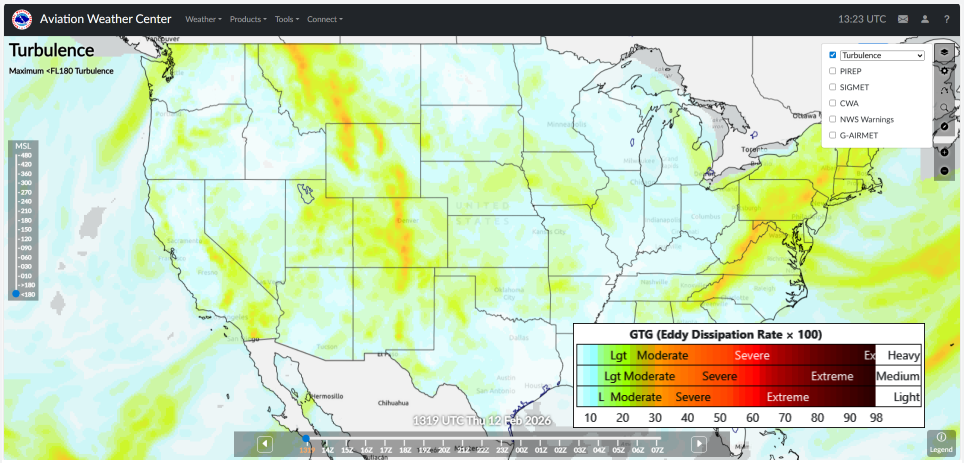


Fig. 16-8. *The Turbulence layer is derived from the GTG product and has limitations.*

Select altitudes using the *Vertical Level* selector. At the bottom of the selector, available options include low altitude (LO)—below 18,000 ft (<180), or high altitude (HI)—above FL180 (>180). When selected only LO or HI weather advisories are displayed.

Derived from model data and airborne turbulence observations, Graphical Turbulence Guidance (GTG) provides an automated turbulence forecast product. Eddy Dissipation Rate (EDR) intensities are based on the state of the atmosphere, rather than a subjective pilot evaluation of the effects on an aircraft. Table 16-4 shows aircraft weight categories, EDR turbulence thresholds, and GTG turbulence intensity values. Weight categories consist of:

- Light—less than 15,500 lbs.
- Medium—15,500 to 300,000 lbs.
- Heavy—Greater than 300,000 lbs.

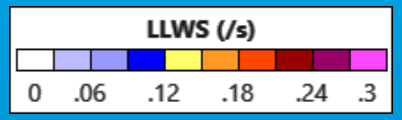


Table 16-4. *Graphical Turbulence Guidance/Eddy Dissipation Rate*

Weight	EDR Threshold				GTG (Eddy Dissipation Rate)
	LGT	MOD	SEV	EXTRM	
Light	13	16	36	64	LGT MOD SEV EXTRM
Medium	15	20	44	79	LGT MOD SEV EXTRM
Heavy	17	24	54	96	LGT MOD SEV EX
					10 20 40 60 80

Clear air turb, Mountain wave turb, and Low level wind shear layers display computer generated potential locations for these phenomena. Clear air turb and Mountain wave turb display magnitude using the same criteria and graphiology as the *Turbulence* layer. The low-level wind shear layer (LLWS) displays the magnitude of non-convective wind shear (≤2000 ft AGL). Values >0.12 indicate areas with stronger wind shear—possibly severe. The LLWS layer *Legend* is shown in the callout.

Warning

These are supplemental/outlook products ONLY, without forecaster input. Graphical Turbulence Guidance products have limitations. The GTG is NOT a substitute for AIRMETs, SIGMETs, and Center Weather Advisories.

Icing

Overall icing probability and severity begins with the Forecast Icing Product (FIP).

Note

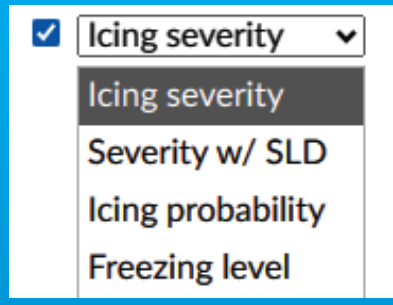
The Current Icing Product (CIP) and Forecast Icing Product (FIP) are available on the AWC website. From the "Tools" dropdown menu select *Decision support imager*, Icing, "Forecast type," then "Click" CIP or FIP for the desired product. The CIP and FIP are available on the Leidos FS website from the *WX Charts* menu, on the **Other** dropdown menu, select "Decision Support Graphics."

Icing intensities are determined from an atmospheric set of conditions roughly based on the rate of ice accretion, determined by the time it would take an airfoil to accrete 1/4 inch on ice. Rates are estimated from the amount of supercooled liquid water expected with a nominal drop diameter. Table 16-5 describes meteorological icing intensities.

Table 16-5. *Meteorological Icing Environment*

Intensity	Description
Trace	1/4 inch of ice/hour
Light	1/4 inch of ice/15 minutes
Moderate	1/4 inch of ice/5-15 minutes
Heavy	1/4 inch of ice/less than 5 minutes

From the "Weather" dropdown menu select *Icing*. Use the Options Panel Layer Selector (callout) for the desired grids/overlays—Icing severity, Severity w/ SLD, Icing probability, and Freezing level.



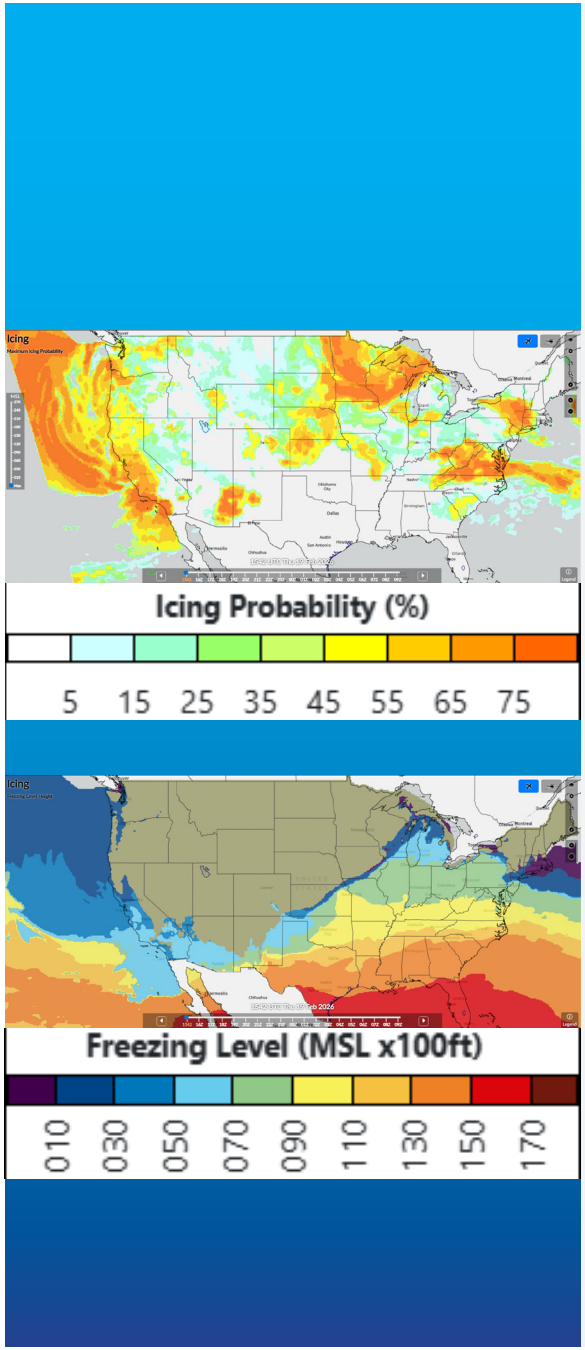
Icing layers provide color-coded icing severity depictions at various altitudes. Icing layer products combine a multitude of sources to determine potential icing and identify areas of expected trace, light, moderate, and heavy *meteorological icing*. Icing intensities are not synonymous with icing PIREP values. Icing PIREPs are subjective estimates by the pilot of the rate of accumulation combined with the use of aircraft antiice/deicing systems.

The "Icing severity" layer depicts four icing intensities based on the Meteorological Icing Environment. The "Severity w/ SLD" layer provides an additional depiction of expected supercooled large droplet (SLD) icing threat. SLDs are predominantly found at temperatures ranging from 0°C to -20°C, but can be found at temperatures as cold as -40°C. (For an additional discussion of SLD icing refer to ch22, Icing.)

Warning

> Current and forecast icing products and Icing layers are intended for flight planning purposes and NOT a substitute for icing information contained in AIRMETs, SIGMETs, and CWAs—which have forecaster input.

Figure 16-9 displays the "Severity w/ SLD" layer option. Decode categorical values using the *Legend* icon. Meteorological icing intensities are shown in blue, with SLD



threats overlayed in red

Icing layers provide intensities at various levels. Select altitudes using the *Vertical Level* selector to display products at 3000 ft intervals up to FL270. At the bottom of the selector, choose MAX to display the maximum severity regardless of altitude.

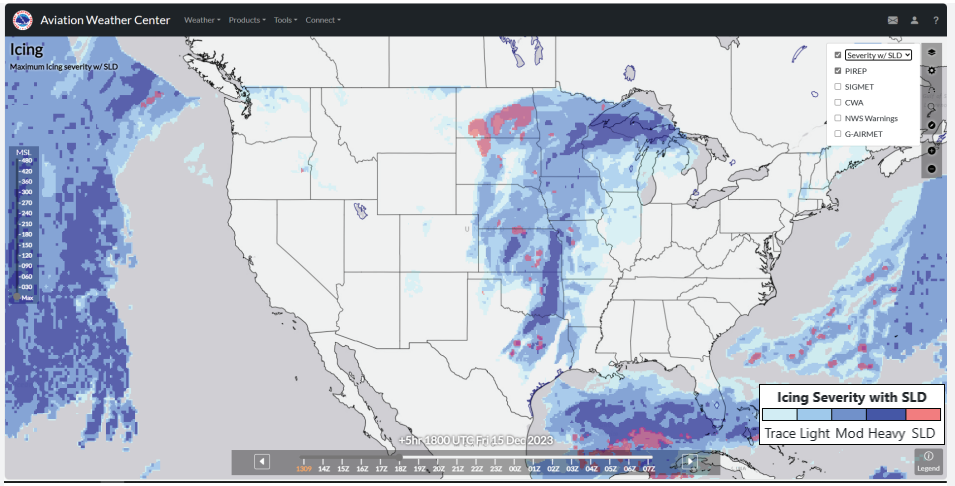


Fig. 16-9. *Like Turbulence, Icing layer products have limitations.*

Icing severity products depict intensity *likelihood* at locations where the "Icing probability" product (callout) indicates areas of possible icing. *Probabilities* range from 0% (no icing expected) to ≥85% (nearly certain icing).

The "Freezing level" layer supplements AIRMET Zulu forecast freezing level data, in feet above mean sea level (callout). The layer shows the lowest altitude in the atmosphere over a given location with an air temperature of 0°C. (Areas shown in brown indicate the freezing level at the surface.)

Winds and Temperatures Aloft Forecasts

As well as wind direction and speed, Winds and Temperatures Aloft Forecasts (FB) provide a source of potential high density altitude, turbulence, and icing. High temperatures aloft signify regions of reduced aircraft performance. Low-level winds over mountains and through passes indicate areas of potential turbulence and low-level wind shear. Significant wind direction and/or speed changes over relatively short distances alert users to potential wind shear turbulence. Below freezing temperatures aloft infer areas of potential icing.

Table 16-6. *Winds Aloft Forecast Issuance Times (UTC)*			
Issued	**"FOR USE"**		
	6 hour	**12 hour**	**24 hour**
0200	0200-0900	0900-1800	1800-0600
0800	0800-1500	1500-0000	0000-1200
1400	1400-2100	2100-0600	0600-1800
2000	2000-0300	0300-1200	1200-0000

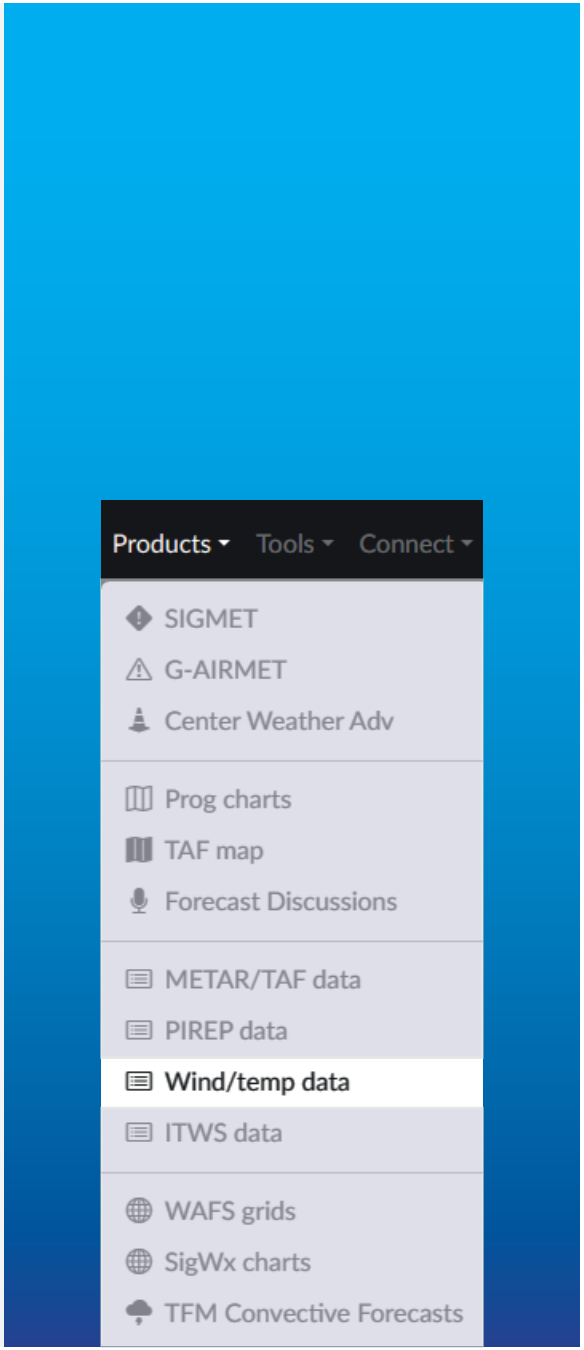
Generated four times a day, tabulated Winds and Temperatures Aloft Forecasts consist of three periods: six, 12, and 24 hours. Table 16-5 provides approximate issuance and "FOR USE" times. Limitations apply to twenty-four hour FBs, which must be viewed with skepticism. The 24 hour product should only be used for advanced planning, then updated with the latest forecasts prior to departure.

These products are delivered as part of Leidos Flight Service telephone and WEB briefings, and through commercial vendors. (The Leidos FS website links the AWC GFA *Winds* layer from the *WX Charts* menu, **Other** dropdown menu, select "Winds/Temps.")

Obtain tabulated forecasts from the AWC's WEB site. From the "Products" dropdown menu select *Wind/temp data* (callout).

Winds and Temperatures Aloft Forecast levels are True Altitude—true height above sea level—below 18,000 ft. From 18,000 through 53,000 ft levels are Pressure Altitude (Flight Levels). Levels within the friction layer between the wind and the Earth's surface are normally omitted. Forecast levels within approximately 1500 ft of the surface and temperatures for the 3000-foot level or levels within 2500 ft of the surface, do not appear. Temperatures aloft are forecast in degrees Celsius. Above 24,000 ft temperature sign (+ or -) is omitted, above this altitude all temperatures are negative (-).

Figure 16-10 shows a *Wind/temp data* page. Select one of 9 regions, which includes "Alaska," "Hawaii," and the "West Pacific." In Fig. 16-10 the "Pacific Coast" region has been selected. Next select the appropriate time frame Forecast (hrs): six, 12, or 24, and Levels: Low (through 39,000 ft) or High (45,000 and 53,000 ft). The "Raw date" button option removes the selection menu.



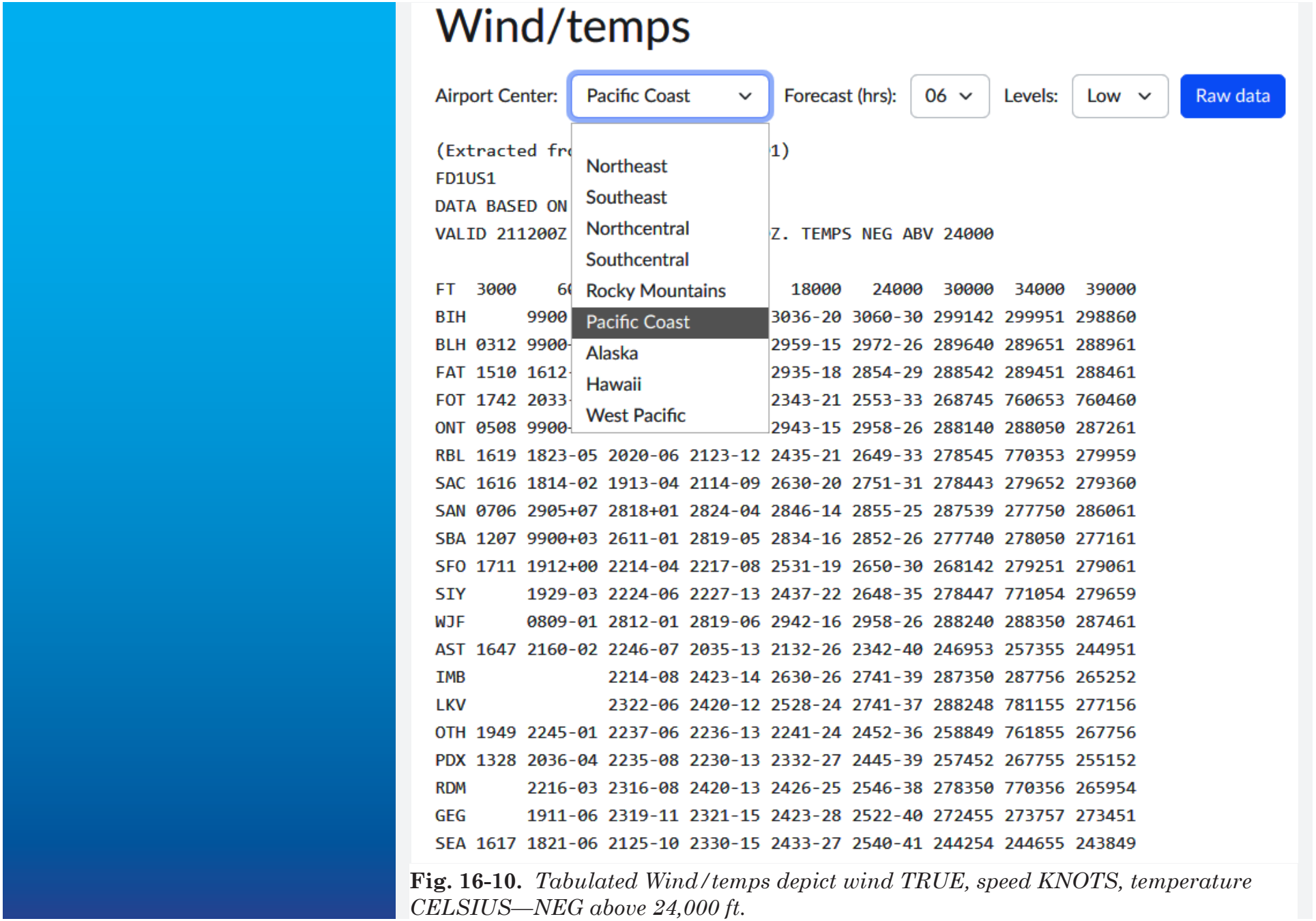


Fig. 16-10. *Tabulated Wind/temps depict wind TRUE, speed KNOTS, temperature CELSIUS—NEG above 24,000 ft.*

The example shows FBs for SFO (San Francisco, California) and RNO (Reno, Nevada).

DATA BASED ON 041800Z
VALID 050000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT	3000	6000	9000	12000	18000	24000	30000	34000	39000
SFO	3513	3316+10	3220+06	3224+01	3138-11	3148-24	325539	315846	315954
RNO		0605	3308+02	3217-02	3134-16	3052-28	316542	316848	316853

These examples contain FB forecasts based on the fourth day of the month 1800Z data run (DATA BASED ON 041800Z). The DATA BASED ON should always be checked. From time to time old forecasts fail to be purged and remain in the system. The next line states VALID 050000Z FOR USE 2000-0300Z. These FBs are FOR USE between 2000Z and 0300Z.

Like other forecasts, these are NOT an average; the model predicts winds and temperatures for one specific time—a *snapshot*, in this case 0000Z (VALID 050000Z). This accounts for some perceived inaccuracies. Forecasts are based on the expected movement of synoptic systems. With rapidly moving, intensifying, or dissipating systems, FBs can change significantly during the period. This is especially true for flights at the beginning or end of the "FOR USE" time.

Refer to the SFO 12,000-foot winds (blue highlight). The first two digits represent true direction, from which the wind blows, to the nearest 10° ("32"24+01). The third and fourth digits indicate speed in knots (32"24"+01) The last two digits indicate the temperature in degrees Celsius (3224"+01"). Temperature, plus or minus, appears on forecast through 24,000 ft. Therefore, 3224+01 forecasts wind blowing from 320° true at 24 knots, temperature +01° C. Forecast speeds of less than five knots are encoded 9900 and translated as "light and variable."

Case Study

Pilots periodically asked, "What's the direction and speed of the light and variable winds?" In an extreme case a rather irate pilot callout Flight Service

demanding to know what was "actually written on the paper." The specialist replied, "niner-niner-zero-zero!" Oh well.

Is a forecast of "701548" a misprint or garbled? With forecast winds of 100 knots or more, five is added to the first digit of the wind direction group. Therefore, to decode, subtract five from the first digit of the wind direction, and add 100 to the speed. In this example wind direction, speed, and temperature are:

Direction	Speed	Temperature
70	15	48
-5	+100	
200°	115 knots	-48°

Since no mathematical sign (+ or -) was assigned for temperature, it must be negative. (Winds of 200 knots or greater are encoded as 199.)

Interpolation

It may be necessary to interpolate—compute intermediate values—to determine wind direction, speed, and temperature between forecast levels and reporting locations. Plan a flight from Oakland to South Lake Tahoe at 13,500 ft; use the SFO and RNO FBs. Average the 12,000-foot and then the 18,000-foot levels. At 12,000 ft direction is the same. The difference in speed of seven knots results in an average of 21 knots (7 ÷ 2 = 4; 17 + 4 = 21). The average temperature is zero degrees. At 18,000, again the direction is the same. The difference in speed of four knots results in an average of 36 knots (4 ÷ 2 = 2; 34 + 2 = 36). The difference in temperature is five degrees, resulting in an average of -14 (-5 ÷ 2 = -3; -11 + (-3) = -14). Be careful with the algebraic sign. The result: 12,000 ft, 320° at 21 knots -01°C and at 18,000 ft, 310° at 36 knots -14°C.

The 13,500 level is one-quarter of the way between 12,000 and 18,000 feet. Therefore, divide the difference between levels by four and add the result to the 12,000-foot values. This results in wind direction 320°, speed 25 knots (15 ÷ 4 = 4; 21 + 4 = 25) and temperature -04°C (-13 ÷ 4 = -3; -1 + (-3) = -4). Because direction is to the nearest 10°, speed in whole knots, and temperature in whole degrees Celsius, the result cannot have a value in smaller increments than the original data—rounded off values. Be

careful of the algebraic sign. (Naturally, the only place this would be required is for FAA exams!)

Interpretation and Application

Winds and temperatures aloft provide wind direction and speed, and temperature. Both can significantly affect aircraft operations and performance. Failure to properly consider and apply either can be potentially hazardous.

Never ignore winds and temperatures forecasts despite their limitations. Pilots are required to consider "...fuel requirements...;" and, are prohibited from beginning a flight either VFR or IFR "...unless (considering wind and forecast weather conditions)..." the aircraft will have enough fuel to fly to destination, an alternate if required, and still have appropriate fuel reserves. Regulatory fuel reserves, which do not necessarily mean "safe," in no way relieve a pilot from keeping careful track of ground speed and revising the flight plan (tactical decision making) accordingly. With marginal reserves good operating practice dictates the careful tracking of position and ground speed.

A fuel reserve of 30 minutes with clear weather reported and forecast might be sufficient. With marginal weather or thunderstorms, and the nearest suitable alternate 35 minutes away, a 30-minute reserve doesn't make any sense. (Recall ch7, Personal Minimums.)

Case Study

> At the time seemingly insignificant factors have the potential to lead to disaster. The flight from Van Nuys, California to Tonopah, Nevada was based on four hours of fuel and a 10 knot head wind, time enroute was estimated to be 3:15. My Cessna 150 was fueled Friday when I arrived at Van Nuys. During the preflight Sunday morning I noticed the fuel was not at the top of the filler neck—precursor one. This was not unusual because the airplane was parked on a slight incline and some fuel tends to vent overboard. The departure required an IFR climb to on top, which added about 15 minutes to the time enroute—precursor two.

Over Trona, California, about halfway, ground speed checks indicated winds were as forecast. Calculations indicated adequate fuel for Tonopah based on four hours of fuel and ignoring the extra time required for departure —precursor three.

The Cessna 150 climbs like a wet mop—especially on warm days, so I decided not to land at Trona for fuel—precursor four. The fuel gauges were bouncing on empty, and I still had 30 minutes to get to the destination. There were no suitable alternates at this point—precursor five. I made a straight-in approach and had everything stowed ready to crash, but despite some extremely poor planning landed safely. By the way, they put 22.6 gallons in my 22.5-gallon usable fuel airplane. Never again!

The venturi effect accelerates winds over ridges and through passes. Stronger than forecast winds should be expected in these areas, especially within 3000 ft of mountain crests.

Low-level jet streams can develop under certain meteorological conditions. Such low-level jets occur during the springtime in California's San Joaquin Valley and the Midwest. Compare surface winds and winds aloft forecasts, and TAFs for clues to their existence. On one such occasion surface wind was reported calm, winds at 3000 ft were 080 degrees at 30 knots! These conditions are strong indicators of moderate or greater non-convective low-level wind shear.

Conversely, after strong afternoon mixing surface winds within the mixing layer can develop to altitudes higher than normal. Under such conditions low-level winds, especially within about 2000 to 4000 ft of the surface, are more likely to reflect surface winds than winds aloft. On low-level flights, pilots are usually better off using surface wind observations and forecasts, rather than winds aloft forecasts. This also indicates a turbulent layer and possible wind shear.

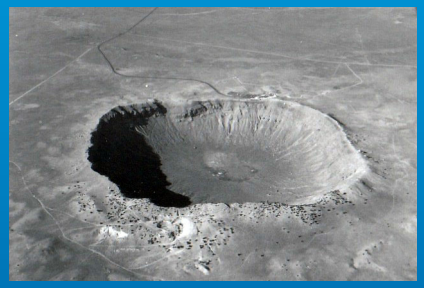
Winds and temperatures aloft are a source of forecast freezing level. They should be in general agreement with AIRMET ZULU because they're based on the same data—but without forecaster input. Differences result from FB freezing levels representing only one point in time over the valid period, whereas Graphical AIRMET forecasts have a

finer temporal resolution. However, if a significant difference occurs, be alert for other possible forecast errors. (From the text examples, the expected freezing level at 1800Z over SFO is approximately 12,500 ft, lowering to 11,000 ft in the RNO area.)
Winds and temperatures aloft forecasts can be used to determine density altitude en-route. On our example flight from San Francisco to Reno temperatures aloft are higher than standard. In fact, with an average temperature of -04°C, density altitude is 15,000 ft. This density altitude exceeds the ceiling of many small single engine and the single engine ceiling of numerous low-performance multi-engine airplanes! High humidity and low pressure would further increase density altitude.

Winds aloft forecast limitations must be understood for effective flight planning. Product preparation plus the advantages—and to some extent the limitations of computer models have been discussed. Surface heating, as well as terrain, affects winds aloft. Today's technology cannot completely account for land/sea and mountain/valley winds, nor frictional effects between the wind and surface. Other forecast problems include the extent and availability of data and timing. Winds and temperatures aloft forecasts are based on the forecast movement of weather systems. Errors result when systems move faster or slower than expected, intensify or dissipate. Careful tracking of position and ground speed will verify the accuracy of forecasts.

PIREPs are one of the few direct sources of observed winds. Many GPS and other area navigation systems provide wind readouts. (Anyone remember how to calculate winds with the E6B flight computer—besides MR. Spock?) Electronic flight computers make these calculations easy. This is a reminder for pilots to become actively involved by providing PIREPs. Observed winds aloft, whether they confirm or refute the forecast, should be routinely reported.

With the general criticism of winds aloft forecasts, it's amazing how many pilots must absolutely have winds two or even three days in the future. (The 2025 version of the AWC's *Winds* layer includes an "Extended Range Mode," which provides winds out to four days at 12 hour intervals. Don't forget the limitations of aviation forecasts.) Then there's the person who can't understand why the winds are 20° and five knots off forecast. Oh well, you can't please everyone. By now we should have some insight into winds aloft limitations, perceived errors and inaccuracies of this valuable, but often maligned product.



Meteor Crater east of Winslow, AZ

Pilots have no option but to use winds and temperatures aloft forecasts. Local or short flights might mean nothing more than an "eyeball interpolation." Exams and flight tests require computer calculations. Flights toward the limit of aircraft range will require careful interpolation and calculation.

I have on many occasions flown from California to destinations in the Midwest and east. Most of these flights were completed in Cessna 150s and 172s. The legs through the intermountain region often stretch the airplane's range.

Case Study

> On a leg from Phoenix, Arizona to Albuquerque, New Mexico I selected a point, a little over halfway, to make the decision to divert—strategic planning. On this occasion the promised 10 knot tailwind was "as advertised" and the flight was completed as planned—tactical decision.

Sometimes it just not meant to be.

Case Study

> Crossing Winslow, Arizona on a flight from Prescott, Arizona to Albuquerque, New Mexico the Cessna 150's ground speed never reached three digits. I changed the flight plan and preceded to Gallup, New Mexico—tactical decision. Hoping that a stronger than forecast headwind will abate is folly.

The theme of the preceding examples is to have a plan; then follow it! (Recall the chapters in Part Two: Risk Assessment and Management.)

Forecast winds and temperatures aloft graphics visually depict expected winds. These graphics were presented in the section on the Graphical Forecasts for Aviation Suite, Temperature and Winds sections. Graphical products are especially helpful for long distance flights. They provide winds at various levels and allow the determination for the most favorable routes and altitudes.

Note

"There is no official wind and temperature aloft model for flight planning." Depending on the computer model, the validity times, time intervals, and altitude levels will vary."

"Because each computer model is based on different algorithms and physics, the wind and temperature forecasts will vary from model to model. These differences are due, in part, to the model's forecast pressure patterns on the surface and aloft. In addition, some models have more detailed terrain as well as finer spacing between data points."

Aviation Weather Handbook,
FAA-H-8083-28A, 2024

Significant Weather Forecast Charts

Twenty-first century forecast technology and dissemination have significantly improved the quality and extended valid times of Significant Weather forecasts products. The National Weather Service produces Surface Weather Forecast Charts, and Low- and High-Level Significant Weather (SIGWX) Charts for aviation.

Note

A Mid-Level Significant Weather chart provides a forecast of significant enroute weather from FLl00 to FL450. Content and symbology are similar to High-Level Significant Weather charts. The Mid-Level SIGWX PROG covers the North Atlantic Ocean region and is planned to be phased out and incorporated into other products.

Synopsis

Recall from ch11, Graphical Observational Products that in 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—the "big picture." The synopsis should indicate the reason for adverse weather and tie in with current weather 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 sponsored and compliant self-briefing requirements.) Text access to a synopsis has virtually been eliminated. Surface/Significant Weather Forecast charts provide the forecast portion of the synopsis.

Surface Forecast Charts, and Low- and High-Level Significant Weather (SIGWX) Charts are available on the AWC website. From the *Products* dropdown menu select Prog charts or from the *Tools* dropdown menu select Decision support imager, (surface) Prog chart, SigWX-low level, or SigWX-high level. On the Leidos FS website from the *WX Charts* menu select **Surface Progs:**, **Lo-Level Sig Progs:**, or **Hi-Level Sig Progs:**. On the **Other** dropdown menu, select "Decision Support Graphics" to link to the AWC's website.

The Weather Prediction Center (WPC) produces Surface Prognostic (PROG) charts valid for up to seven days. Leidos FS surface PROGs are available for up to 48 hours. Charts cover the CONUS and coastal waters. Surface PROGs depict those elements, using the same symbology, as the section on the Graphical Forecasts for Aviation Suite, Precipitation (Fig. 16-4 and Table 16-3).

Products provide synoptic depictions; charts cannot consider mesoscale features. Local conditions might not be accurately portrayed. These charts tend to underestimate convection in the west, along with the intensity of Pacific storms. The forecast tends to smooth over local variations due to terrain.

Warning

These are "outlook" forecasts. Apply appropriate AIRMETs, SIGMETs, Center Weather Advisories, GFA products, and TAFs for operational enroute and destination conditions.

Low-Level Significant Weather (SIGWX) Forecast Charts

The legacy Low-Level Significant Weather (SIGWX) Forecast Chart consisted of four-panels. The top two panels provided surface forecast charts, and the two lower panels contained significant weather forecasts. Charts provide 12 and 24 hour valid times—from the time the chart was prepared. Figure 16-11 combines surface progs with the same valid times as the low-level SIGWX PROGs.

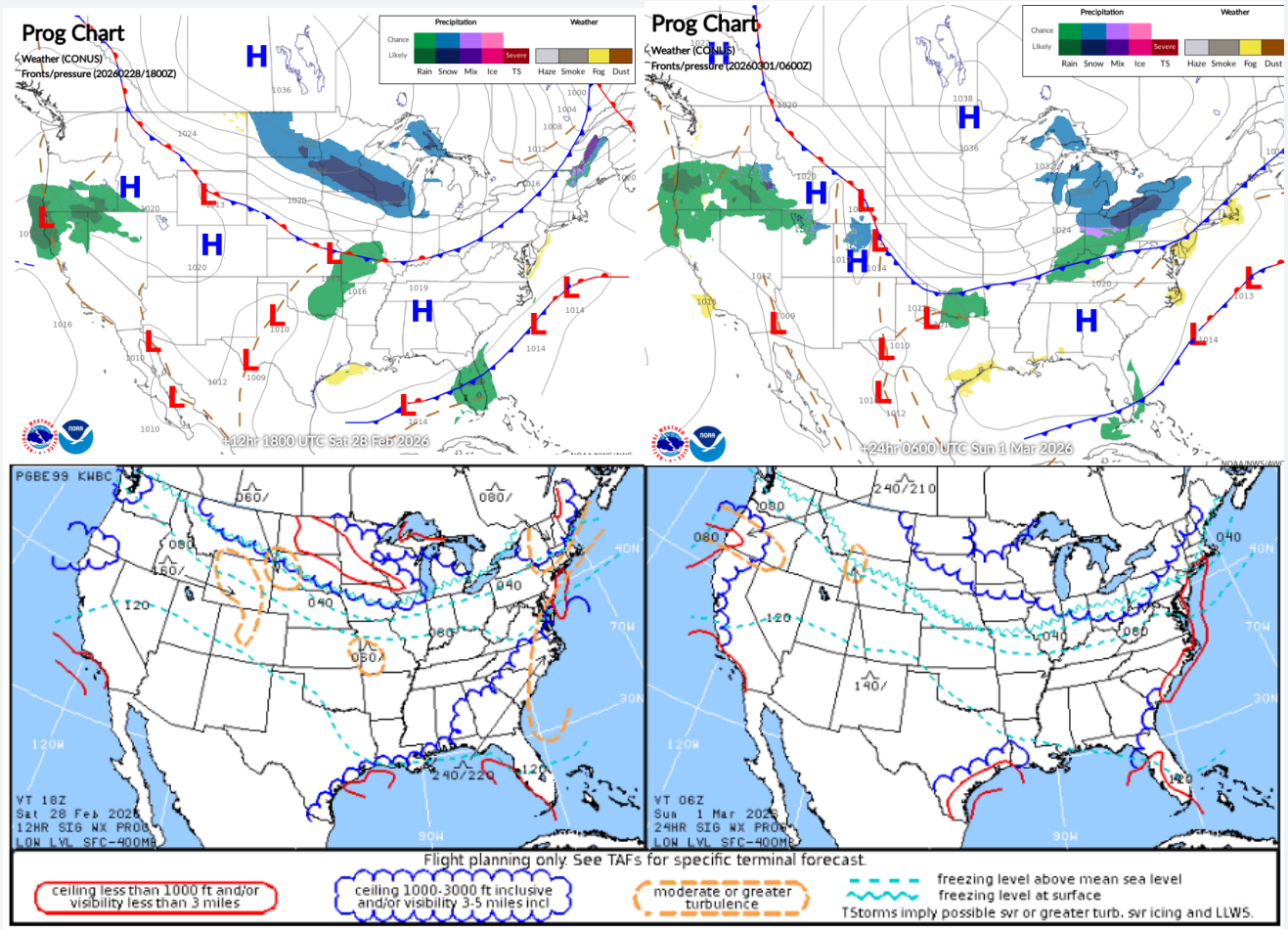


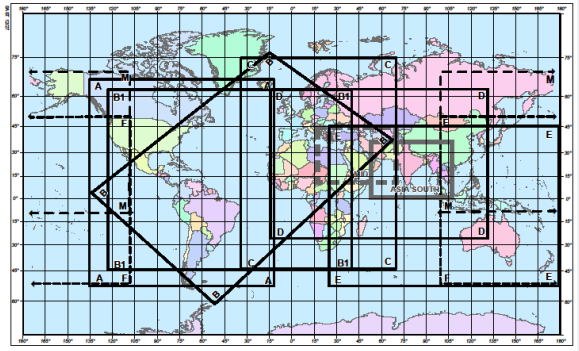
Fig. 16-11. *The WPC produces surface PROGs out to seven days; Leidos FS surface PROGs are available for up to 48 hours.*

Low-Level Significant Weather charts predict weather categories (IFR—enclosed by solid red lines, MVFR—enclosed by blue scalloped lines, and VFR). Dashed orange lines depict areas of moderate or severe turbulence from the surface to 400 mb (~24,000 ft/FL240) using standard intensity symbols, with altitudes in hundreds of feet MSL. For example, turbulence "150/" (15,000 ft "150" to the surface "/"). (The absence of a lower limit means to the surface.) The PROG depicts freezing levels at 4000-foot intervals using standard symbology. A solid blue zig-zag line indicates the freezing level at the surface. Although not directly forecast, icing is inferred in areas of clouds and precipitation above the freezing level.

Note

Leidos Flight Service Surface PROGs depict a "chance" of thunderstorms using cross-hatched red lines. Additionally, Surface PROGs extend out to 48 hours—from the time the chart was prepared.

High-Level Significant Weather (SIGWX) Charts



High-Level Significant Weather charts provide a graphic forecast for the enroute phase of international flights. Charts cover phenomena from FL250 to FL600, valid at three hour intervals, up to 48 hours. Areal coverage regions are shown in the callout.

High-Level Significant Weather charts depict:

- Thunderstorms and cumulonimbus clouds
- Moderate or severe turbulence
- Moderate or severe icing
- Jet streams
- Tropopause heights
- Tropical cyclones
- Volcanic eruption
- Sandstorm/Dust storm
- Radiation

Figure 16-12 shows an example of the High-Level Significant Weather chart.

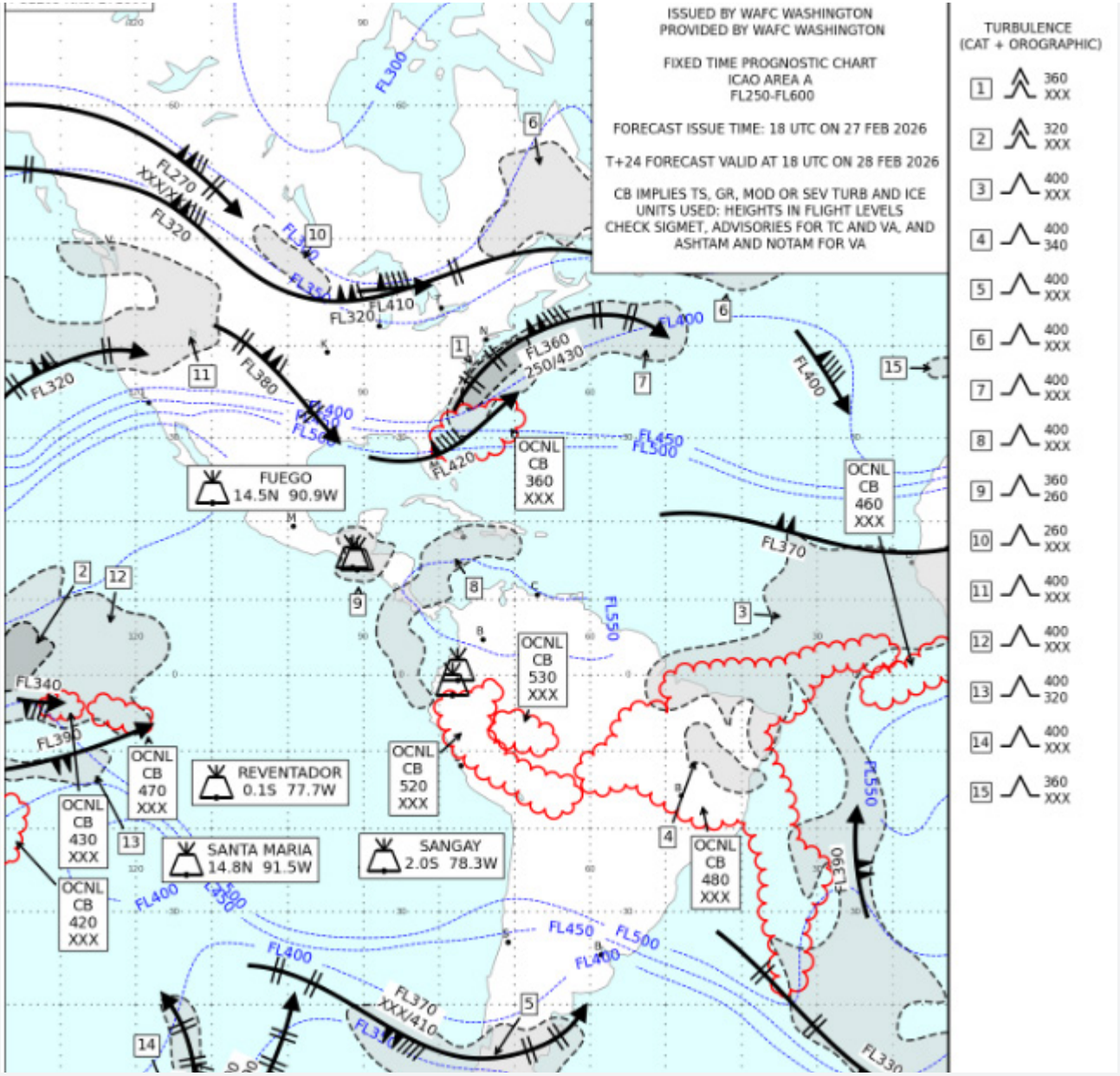


Fig. 16-12. *High-Level Significant Weather PROGs provide a graphic forecast for the enroute phase of international flights covering phenomena from FL250 to FL600.*

Thunderstorms and Cumulonimbus Clouds

"CB" refers to the expected occurrence of an area of Cumulonimbus clouds. A "CB" forecast implies thunderstorms (TS), hail (GR), moderate or severe turbulence and moderate or severe icing. Refer to Fig. 16-13. Scalloped, red lines enclose areas of cumulonimbus clouds associated with thunderstorms. Occasional (OCNL) identifies an area with maximum coverage between 50% and 75%. Frequent (FRQ) represents an area greater than 75% coverage. As shown in Fig. 16-13, areas of "CB" are labeled using coverage "OCNL CB" with tops and bases. In the example, tops are FL260 and bases XXX below the valid range of the chart. (Should both the tops and bases be higher and lower than the chart range XXX/XXX appears.)

Caution

"CB" (Cumulonimbus clouds) imply thunderstorms (TS), Hail (GR), moderate or severe turbulence, and moderate or severe icing.

Moderate or Severe Turbulence

Moderate or severe turbulence associated with wind shear or mountain waves, not associated with cumulonimbus clouds, is depicted within dashed lines filled in gray—a darker grey is used for severe turbulence. Each region is identified by a call-out or reference number linked to the corresponding key. (In Fig. 16-13 the key is a column on the right side of the chart; Fig. 16-4 illustrates a "callout" style used by some visualization systems.) Bases and tops use the symbology presented in the section of "CBs." Turbulence intensity is indicated using standard symbols (MOD or SEV).

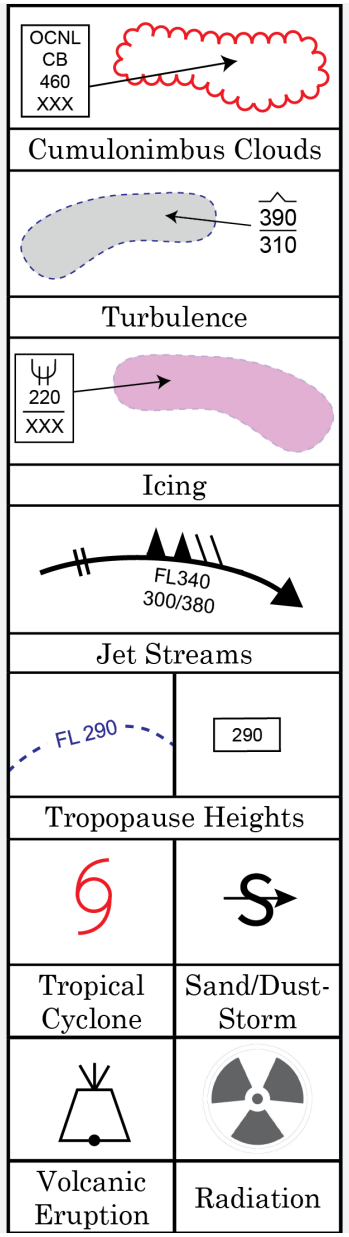


Fig. 16-13. *Symbology is similar to that used on domestic forecasts.*

Moderate or Severe Icing

Moderate or severe icing in clouds—not associated with convective activity—is rare at most chart levels. When significant icing is expected charts are marked with a purple "T" line and purple shading to indicate areas of significant icing—a darker purple is used to designate severe intensity. Icing data blocks use standard symbols to identify intensity (MOD or SEV) and heights (Fig. 16-13).

Jet Streams

The expected location of jet streams with core speeds of at least 80 knots is depicted as a continuous line. Speed is indicated by wind arrows—using standard symbology, with the height printed below the core. Double-hashed lines indicate a speed change of 20 knots. The vertical depth of the 80 knot wind field above and below the jet core is shown with a maximum jet speed of 120 knots or more. In Fig. 16-13, the jet core has a speed of 120 kts, the base of the 80 knot wind field is FL310 and the top FL390.

Tropopause Heights

As shown in Fig. 16-13 the height of the tropopause—the troposphere/stratosphere boundary—is indicated as contours or spot heights. The left example shows a tropopause contour—a thin blue dotted line—with a height of FL290. Close contour spacing indicates a rapid change in the level of the tropopause. On the right is a spot height of FL290.

Tropical Cyclones

Tropical cyclones (Fig. 16-13), with storm names, are depicted with surface wind speeds of 34 knots or more. They are based on information from Tropical Cyclone Advisory messages and Tropical Cyclone SIGMETs.

Sandstorm/Dust Storm

Although it is an extremely rare occurrence, widespread Sandstorm/Dust Storms are depicted on SIGWX forecasts (Fig. 16-13). (The inclusion of sand and dust storms is

scheduled to be formally retired in November 2027.)

Volcanic Eruptions

A trapezoidal symbol indicates volcanic activity (Fig. 16-13). The dot on the base of the symbol identifies its location. The name of the volcano, and latitude and longitude are included (FUEGO; 14.5N 90.9W).

Radiation

A Radioactive Release marker symbol (Fig. 16-13), positioned on the chart at the location of the incident, represents the incident location. A "callout" box in the proximity contains the name of the site (if known) and the latitude and longitude of the source.

Caution

Check advisories and SIGMETs for tropical cyclones (TC), widespread Sandstorm/Dust Storm (SS, +SS) volcanic ash (VA), and Radiation events.

"Whatever may be the progress of the sciences, never will observers who are trustworthy and careful of their reputations venture to forecast the state of the weather."

Dominique Argo
French Astronomer-Physics (1786-1853)