



WEATHER AND SEA ICE

Antarctic Weather

Weather in Antarctica is characterized by extremes in temperature, wind and the variability of local conditions, making Antarctica a challenging place to work and live. Weather conditions also depend substantially on elevation, topography and distance from the ocean. Temperatures can vary from below -40°C (-40°F) to above freezing (0°C , or 32°F) during the austral summer.

It is an unusual day when there is not at least a breeze. The wind can take its toll on people, making tent setup and other camp chores difficult. Improperly anchored tents can blow away or rip apart. Tent guylines must be continually retensioned. And wind chill raises the risk of hypothermia and frostbite. The wind chill chart in the References section shows how wind affects how we experience temperature.

Storms Around McMurdo

Around McMurdo Station, storms arrive quickly and are sometimes fierce enough to halt all outside activity. Storms can also be very localized. The station can experience near-zero visibility with blowing snow that halts flight operations, while the McMurdo Dry Valleys are calm and sunny 50 miles away. High, thin bands of cirrus clouds (aka mare's tails) followed by thicker layers of cirrus, which may produce halo-like effects around the Sun, often precede a storm, with clouds growing thicker and lower during the next six to 12 hours until low cumulus clouds and the main storm front arrive. Blizzards can happen any time of year and may last from hours to days.

Storms usually approach McMurdo Station from the south, through the gap between Black Island and White Island. They eventually obscure Minna Bluff with blowing snow or low clouds, signaling bad weather will likely arrive in less than one hour. Travel is difficult and dangerous during storms and should be avoided. Blowing snow can hide crevasses or sea-ice cracks. Even moderate winds can produce a layer of dense, blowing snow that may be as thin as a few feet or as thick as 1,000 feet. Whiteouts are equally dangerous phenomena.

In a whiteout, thick, low clouds reduce surface definition, the horizon is obscured, and it is difficult or impossible to determine distance, object size, and if a surface is flat or sloping.

Travel during a whiteout may be attempted only if there is an emergency. People caught unexpectedly in a whiteout should stop and wait for visibility to improve enough to reveal a recognizable landmark.

Working in the Continental Environment

Weather conditions vary widely throughout the Antarctic continent, depending on a location's elevation, topography and relative distance from the ocean. The polar plateau is extremely cold due to its higher altitude and distance from the moderating effects of the seas. Areas near the coast can be subject to wet, heavy precipitation and warm days with intense sunlight. Winds at remote Antarctic sites range from calm and light to sustained hurricane force. Past reports and weather data can help remote field parties plan for weather conditions at a given site. Still, it is safest to expect the unexpected when it comes to weather.

Forecasting

Weather forecasting for USAP is done under the auspices of NSF and coordinated through the Naval Information Warfare Center Atlantic (NIWC), which has a presence at McMurdo Station. Antarctic weather forecasters have fewer data collection sites to feed their forecasting models than do forecasters elsewhere in the world. Antarctic forecasters rely heavily on weather observations called in from remote field sites. They also use satellite imagery, data from automated weather stations, and the Antarctic Mesoscale Prediction System, which produces twice daily forecasts for the Antarctic continent.

Terminal Aerodrome Forecasts

A weather forecast for a remote site is called a Terminal Aerodrome Forecast (TAF). TAFs are generated each day for sites scheduled to receive an LC-130, the only aircraft with

instrument-landing capabilities that USAP utilizes. A TAF is automatically generated for a given site based on the aircraft schedule. Field teams do not need to request one in advance. TAFs are usually issued every eight hours for a 24-hour period and are effective for 24 hours from the time they are issued.

Occasionally, an amended or corrected TAF is issued between the standard issue times. Amended TAFs are issued when the current TAF no longer adequately describes the current or expected weather. Corrected TAFs are also issued if there is an error on the original TAF.

Weather Observations in the Field

Observing weather conditions at a camp is important for making safe decisions about daily activities. Field team members should maintain awareness of changing weather conditions and note drops in barometric pressure, which signal changing weather and potentially an approaching storm. Watch for changes in cloud cover or appearance, changes in wind direction or intensity, rapid changes in temperature, decreasing visibility and increasing precipitation.

Prepare early for shelter from storms. Have a predetermined set of weather guidelines for field parties. Be aware of the increased risk of hypothermia due to wind chill. Blizzards and whiteout conditions can make any travel hazardous. Double-check the camp area to ensure all equipment and supplies are secure. Check all tent anchors and guylines before gale force winds arrive.

Daily Tasking

Field parties must identify the person or persons responsible for making daily weather observations in the field and reporting them to MacWeather. These observations assist with safe and timely aircraft operations to remote locations and support the continentwide weather forecasting system. Determine which team members will be weather observers before deploying to the field so expectations and roles are clear. Before deploying to the field, you must meet with

MacWeather for information on the tempo and type of weather observations it expects.

Here is an example of a normal weather-observation schedule if no aircraft activity is planned:

1. Make three daily weather observations and report them to MacWeather at six-hour increments (e.g., 18:00, 00:00, and 06:00 Zulu). See the References section for Zulu time conversions.
 - A. Only three of the four six-hour increments in a day need be reported.
 - B. On holidays, report only two observations at 18:00 Zulu (morning) and 06:00 Zulu (evening).
2. Begin the observation about 15 minutes before the top of the hour. Weather observations take 10 to 15 minutes to complete.
3. You may be asked to record the observation on AF Form 3803.
4. Call in the observation to MacWeather within five minutes of the hour.

Do the following when a fixed wing aircraft is scheduled to arrive in camp:

1. Make hourly weather observations, beginning six hours before an LC-130 takes off or three hours before a Basler or Twin Otter departs for a remote camp.
2. Continue hourly observations while the aircraft is on the ground at camp.
3. If there is a change in the weather before an hour has passed since the last observation, report a special observation.
4. When the aircraft is halfway back to its point of origin, return to the normal weather-observation schedule.

5. If a helicopter is scheduled to arrive, field teams must call the hangar's Iridium satellite phone with a weather update between 0715 and 0730 hours or between 0745 and 0800 hours.

Observation Site Setup

The aircraft pilot can provide key information for setting up a weather observation site. Upon arriving in the field, the designated weather observer asks the pilot for an exact altitude reading, which is required to take accurate pressure readings with the Kestrel handheld weather meter. The pilot can also identify which direction is grid north, which is used to set up the flagged weather observation site.

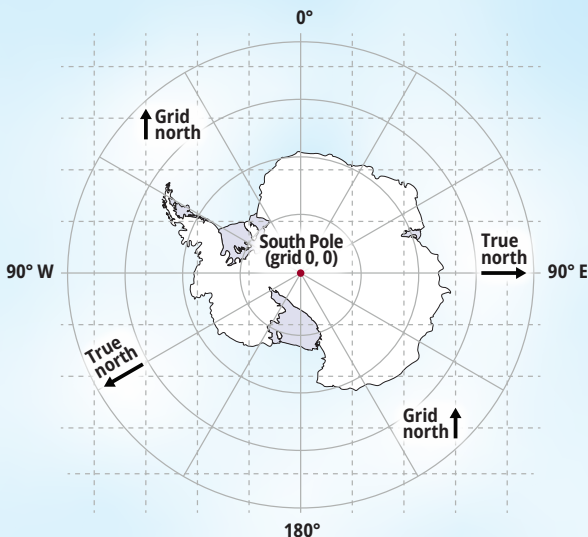
Grid Markers

Grid north is defined on the Antarctic polar stereographic grid, with 0 degrees longitude acting as the reference (central) meridian and the South Pole as the origin (0, 0). In comparison, true north is the direction of a line of longitude that ends at the North Pole. To avoid confusion, especially when traveling where lines of longitude converge near the South Pole, fixed wing pilots navigate using directions based on grid north rather than true compass directions.

The designated weather observer in a fixed wing-supported camp must always report observations in grid directions, not true or magnetic directions. Observers using a magnetic compass to determine grid north must use an accurate declination for their position, as declination between magnetic north and true north varies widely throughout Antarctica.

To determine grid north, face true north and treat your meridian as the prime meridian (00 or 360). For east longitude camps, grid north is true north (360) minus the longitude of the camp. For west longitude camps, grid north is true north (0) plus the longitude of the camp.

Grid North and True North



After identifying grid north, stand up a flag representing grid north, label it as grid north, then repeat the process for grid south, grid east and grid west, ensuring the four flags are a few meters from each other. For example, subtract 1670 from 3600 for a camp at 1670 E, place a grid north flag at 1930 true (i.e., “true” to your subjective orientation, where 1670 E is treated as 00), then use the grid north flag to set up the remaining flags. For a camp located at 600 W, add 600 to 00 (true north) and place the grid north flag at 600 true.

The four flags delineate the weather observation site. The observer stands in the middle of the flags when making weather observations. This helps the observer determine wind direction and maintain a consistent reference point for observing sky and ground conditions.

Visibility Markers

To help determine visibility levels, field teams should set up a second set of flags that are 400 meters (1/4 mile) away from and in line with each grid marker. If possible, also place flags at 800 meters (1/2 mile), 1,600 meters (one mile) or 3,200 meters (two miles) from the grid markers. Also record distances to landmarks that are visible from camp and can serve as aids for assessing visibility levels.

Kestrel Setup

Weather observers in remote locations often use a Kestrel handheld weather meter to measure wind speed, temperature, dew point and pressure. This manual covers the Kestrel 4000. Observers using a different meter should refer to its user instructions.

The Kestrel 4000 is available from the BFC. The field team member picking up the equipment must ensure the Kestrel is set to measure temperature in degrees Celsius, wind speed in knots, and altitude in feet. Also carry extra batteries in case the installed batteries lose power in the field.

Store the Kestrel in an inside coat pocket or a warm area when not in use. The liquid crystal screen will function only at temperatures above -10°C (-14°F). At colder temperatures, the screen is sluggish and eventually fades, although the device will still record data. Return the Kestrel to a warm, inside coat pocket as soon as possible after use. At the end of the field season, promptly return the Kestrel to the BFC.

Reference Altitude and Barometric Pressure

Obtain the remote camp's altitude in feet from the pilot. Be sure to notify the pilot in advance so they know to provide this information before departing.

Navigate to the barometric pressure (BARO) screen and press the center COMMAND button to enter. On the screen, go to the reference altitude (Ref Alt) line. Use the left and right buttons to increase or decrease its value to equal the altitude

in feet (0 at sea level). Ensure the Kestrel is set with feet as its default altitude measurement. Notice that the barometric pressure reading changes in response to changes in the altitude number. Press the COMMAND button to save and exit the adjustment mode.

Next, go to the altitude screen and navigate to the reference pressure line. Enter the barometric pressure number now shown in the BARO screen. Since the Kestrel is used to monitor barometric pressure for weather reporting, it should be kept in the same location (i.e., at the same altitude) because the pressure will change with altitude. Read the pressure from the BARO screen.

AF Form 3803

Record weather observations on a digital or hardcopy version of AF Form 3803 – Surface Weather Observations (METAR/SPECI). (See the References section for an example.) Each observation does not need to be recorded, as MacWeather records and tracks the observations called in.

Before field teams deploy to the field, MacWeather provides the form during a weather briefing and discusses how and when to complete it. Below is an overview of the main data entries.

Latitude and Longitude

List the latitude and longitude of the camp. If the camp has a name, provide that too (e.g., Whillans Ice Plain Camp, Latitude 83.65 S, Longitude 167.4 W).

Time

Report the observation time in Zulu (e.g., a weather observation at 07:00 New Zealand Daylight Savings Time is recorded as 18:00 Z).

Wind / Speed

Confirm the Kestrel is set to record wind in knots. Power up the Kestrel and navigate to the wind speed screen. Expose the impeller (the small, revolving wheel at the top of the weather meter) by rotating open the plastic cover. While viewing the Min/Max/Avg screen, hold the unit into the wind, with the screen facing the observer.

When the screen displays "--average," press the button to begin collecting data. Press it again when the screen displays "--stop" to cease data collection and hold the values on the display. Press the button when the screen displays "--clear" to remove the data. Collect enough data to calculate a two-minute average for all measurements.

Visibility

Visibility is determined as the distance that an observer at ground level can see objects (e.g., flags, rock outcrops) that are not obscured by weather. Measure visibility in meters as an average of all quadrants, then use the Reportable Visibility Values table to find and report the visibility value (e.g., 700 meters of visibility is reported as either 600 or 800 meters since 700 is not a reportable value; visibility of 9,999 or more meters is reported as "unrestricted").

Reportable Visibility Values

Meters	Statue Miles	Feet
0	0	0
100	1/16	328
200	1/8	656
300	3/16	984
400	1/4	1,312
500	5/16	1,640
600	3/8	1,969
800	1/2	2,625

Meters	Statue Miles	Feet
100	5/8	3,281
1,200	3/4	3,937
1,400	7/8	4,593
1,600	1	5,249
1,800	1 1/8	5,906
2,000	1 1/4	6,562
2,200	1 3/8	7,218
2,400	1 1/2	7,818
2,600	1 5/8	8,530
2,800	1 3/4	8,858
3,000	1 7/8	9,843
3,200	2	10,500
3,600	2 1/4	11,810
4,000	2 1/2	13,120
4,400	2 3/4	14,440
4,800	3	15,750
6,000	4	19,690
8,000	5	26,250
9,000	6	29,530
Unrestricted (≥ 9,999)	≥ 7	≥ 36,960

Weather and Obstructions to Vision

Describe the weather effects that may be restricting visibility as seen at ground level (e.g., snowfall, fog, drifting snow, snow showers, blowing snow) using the following terms. Report the type of present weather first, then any weather amplification.

Terms for Weather and Obstructions

Term	Description
Present Weather	
Blowing Snow	Snow blowing ≥ 1.8 meters high from the ground. Visibility $< 9,000$ meters.
Drifting Snow	Snow blowing < 1.8 meters high from the ground. Visibility $\geq 9,000$ meters.
Fog	Ground-level clouds. Reported only when visibility is $< 1,200$ meters.
Ice Crystals	Crystallized ice that may fall as snowflakes, form on surfaces, or create cirrus clouds or ice fog. Can be present in any level of visibility.
Ice Pellets	Steady precipitation of small ice balls (< 5 -millimeter diameter). Aka sleet. Visibility $< 9,000$ meters. Rare in Antarctica.
Mist	Like fog but less dense. Reported when visibility is $1,200$ – $9,000$ meters.
No Significant Weather	Visibility not obstructed by any weather condition.
Snow	Steady precipitation of discrete ice crystals. Visibility $< 9,000$ meters.
Snow Grains	Steady precipitation of small, round, flat grains of ice. Visibility $< 9,000$ meters.
Snow Showers	Intermittent snow precipitation. Visibility $< 9,000$ meters.
Weather Amplification	
Light	Weather severity with low effect on visibility (e.g., light ice pellets with unobstructed visibility, light snow with > 800 meters of visibility).
Moderate	Weather severity with medium effect on visibility (e.g., moderate ice pellets with $4,800$ – $9,000$ meters of visibility, moderate snow with 400 – 800 meters of visibility).
Heavy	Weather severity with high effect on visibility (e.g., heavy ice pellets with $< 4,800$ meters of visibility, heavy snow with < 400 meters of visibility).

Cloud Layers

Each cloud layer is reported using two entries:

- Amount of sky covered by a cloud layer
- Altitude of the cloud layer in feet (not meters)

Report the absence of clouds as “sky clear.” Reports usually include two or three cloud layers, with the lowest layer first (e.g., “Cloud layer 1, few at 1,000. Cloud layer 2, scattered at 5,000. Cloud layer 3, broken at 10,000). The clouds’ appearance or type will provide clues about their altitude.

Cloud Types

Cloud	Description	Usual Altitude
Stratus	Low, gray, wide, shapeless sheet of clouds	≤ 1,500 feet
Stratocumulus	Low, lumpy, rounded clouds amid some visible blue sky	1,000–5,000 feet
Cumulus	Low, puffy, popcorn-like, clouds with vertical development	1,000–5,000 feet
Altostratus	Midlevel, gray, uniform sheet of clouds	4,000–9,000 feet
Alto cumulus*	Midlevel, puffy clouds that may form patterns or castle-like upward projections	4,000–9,000 feet
Cirrus	High, transparent, wispy or feathery clouds	10,000–19,000 feet
Cirrostratus	High, transparent, very thin sheet of clouds	10,000–19,000 feet
Cirrocumulus	High, thin, wavy or rippled clouds in part of the sky	10,000–19,000 feet
* Includes lenticular clouds, which are dangerous for air operations and must be reported in the RMK (i.e., remarks) section of AF Form 3803.		

Cloud altitude can also be estimated by releasing ceiling balloons (aka weather balloons) from ground level, timing their

ascent, and observing them until they are obscured by clouds. Cloud height is then calculated based on a chart indicating the speed a given balloon will rise. Ceiling balloons require additional training and are not available for remote camps where compressed helium cannot be transported.

In limited cases, observers can also request a PIREP (pilot report; pronounced “pie rep”) of cloud altitude from incoming aircraft, whose instrumentation allows pilots to determine exact heights of cloud layers as they fly through them. Use this option only periodically.

After determining cloud altitudes, round the values and report them as follows:

- **Clouds at or below 5,000 feet:** Round to the nearest 100 feet.
- **Clouds from 5,001 to 10,000 feet:** Round to the nearest 500 feet.
- **Clouds at 10,001 feet or higher:** Round to the nearest 1,000 feet.

For example, report a cloud layer with a 1,150-foot altitude as 1,100 and a cloud layer with a 5,300-foot altitude as 5,500.

Temp and Dew Point

Use the Kestrel to record temperature and dew point. Navigate to the correct screen by using the up and down arrows and to lines within the screen by using the left and right arrows. Report temperature and dew point as the nearest whole °C (e.g., 2.8°C is 03). Report negative temperatures and dew points with an “M” prefix, not a minus sign (e.g., 6°C is M06).

The dew point will never be higher than the temperature. In extreme cold, the Kestrel may be unable to register the dew point. If this occurs, omit the dew point report from the weather observation.

Sta Pressure

Report the station pressure, not the altimeter. Station pressure is the atmospheric pressure at the weather observation site’s

elevation. Read the value directly from the Kestrel and report it in inches of mercury, rounding down to the nearest five-thousandths of an inch (e.g., report 29.249 inches as 29.245).

Total Sky Cover

Report all layers of clouds together in eighths (i.e., oktas, as if the sky were a pie divided into eight equal parts). Four-eighths coverage (i.e., four oktas) means half the entire sky is cloudy.

Sky Cover

Sky Coverage	Aviation Term	Description
0/8	Sky Clear	Sky completely clear and free of clouds
1/8	Few	0.1%–12.5% cloud cover or 1 small cloud
2/8		12.6%–25.0% cloud cover
3/8	Scattered	25.1%–37.5% cloud cover
4/8		37.6%–50.0% cloud cover
5/8	Broken	50.1%–62.5% cloud cover
6/8		62.6%–75.0% cloud cover
7/8		75.1%–87.5% cloud cover
8/8	Overcast	100% cloud cover with no breaks, including semitransparent clouds
Vertical Visibility	Vertical Visibility	Obscured. Unknown cloud cover due to fog, blowing snow, etc. Distance to cloud ceiling reported instead.

RMK

In the RMK (i.e., remarks) section of the form, report the surface definition first then the horizon description (e.g., “good and good,” “fair and poor,” “nil and nil”). These data help pilots anticipate visual conditions for landing. If a poor or nil horizon is visible in one grid direction only and the rest of the horizon is more easily seen, report the grid direction as well (e.g., “poor horizon grid south through west,” “nil horizon grid east”). Terms for surface and horizon definitions are detailed below.

Surface Definition

Surface definition is critical data for helicopter pilots, as they are not allowed to fly over poor surface definition. Helicopter-supported groups on the ice shelf or sea ice must convey this information to the helicopter coordinator or helicopter supervisor if they are expecting a flight.

Be aware of how surfaces appear in good weather as a reference point. Report how the contours of the ground and/or snow surface appear. Judge by the relative distinctness of features on the surface (e.g., sastrugi, vehicle tracks).

Terms for Surface Definition

Term	Description
Good	Easily identify surface features (e.g., sastrugi, drifts, tracks) by shadows. Sun usually not obscured.
Fair	Can identify surface features by contrast, but no definite shadows visible. Sun often dimly visible.
Poor	Cannot readily identify surface features except up close. Sun often fully obscured.
Nil	Cannot identify surface features at all. No shadows or contrast visible. Dark objects appear to float in air. Sun fully obscured. May have considerable glare that is equally bright in all directions and reflecting from snow surfaces.

Horizon Definition

Report horizon definition as the ease with which you can distinguish the sky from the ground or snow surface.

Terms for Horizon Definition

Term	Description
Good	Horizon is sharply defined by shadow or contrast. Obvious difference between surface and sky (i.e., white surface and blue sky).
Fair	Can identify horizon, but contrast between sky and surface lacks definition (though is still distinguishable). Often observed when clouds approach or during light precipitation.
Poor	Horizon is barely discernible. Sky is difficult to distinguish from surface, but a faint separation between them can be detected. Similar to nil horizon definition but less severe.
Nil	Total loss of visible horizon. Surface merges with whiteness of the sky. Common amid low stratus clouds and blowing snow.

Other Data

In the RMK section, also describe any significant weather-related phenomena not otherwise reported on AF Form 3803. Examples include weather in the distance, a small quadrant or the vicinity (e.g., fog, mist, lenticular clouds at 2,000 feet grid northwest). Use plain language for these observations. No code is needed.

Call-ins and TAF Requests

Call in weather observations as follows:

- Contact MacWeather via Iridium (dial 8816-763-20030) or HF radio (use a stable frequency to call Central Comms and request the observation be passed to MacWeather).
- Hail the party you are calling (e.g., "Hello, this is Chris from Whillans Ice Plain Camp with the six Z observation."
- Pause for a moment after pressing to transmit, to ensure the entire transmission gets through.
- Wait for acknowledgment.
- Provide observation data (e.g., "We are at 83.65 south latitude and 167.4 west longitude. Winds, grid northwest at 12 knots. Visibility, 1,600 meters. Present weather, snow and mist. Amplification of weather, light snow. Clouds, broken at 1,000, overcast at 5,000. Total sky cover, eight-eighths. Temperature, negative 10. Dew point, negative 15. Barometric pressure, 28.245. Surface definition, poor, Horizon definition, poor. Remarks, all winds grid, mist in the vicinity at grid north. Thanks. Goodbye."

Request a TAF as follows:

- Any time of day that a flight is scheduled for your camp, contact MacWeather via Iridium or HF radio as detailed above.
- Have a pencil and paper ready at the start of each call to note down the TAF, which is relayed in an abbreviated format.
- Only the most recently generated TAF will be provided, regardless of the request time.
- Record the TAF, and translate it (see next table for guidance).

Terms in TAFs

Abbreviation	Description	Example	Translation
1st 3 letters	Station identifier	• NBY TAF 0915/1015 (1004/1104NZDT) GRID08010KT 8000 • -SN BR BKN010 OVC020 QNH2837INS • TEMPO 0920/0924 (1009/1013) 2400 -SN BR OVC010 • BECMG 0923/1001 (1012/1014) VRB06KT 9999 NSW SCT010 BKN030 QNH2834INS AMD 1900	Byrd Surface Camp. Other examples: AGO3 = AGO Site #3, NZSP = South Pole, WSD = WAIS Divide.
2nd 3 letters	Report type (i.e., TAF)	NBY TAF 0915/1015 (1004/1104NZDT) GRID08010KT 8000	Terminal Aerodrome Forecast.
####/####	Forecast date and time	NBY TAF 0915/1015 (1004/1104NZDT) GRID08010KT 8000	Forecast from 9th day at 15:00 Z to 10th day at 15:00 Z of current month.
(#####/#####NZDT)	Conversion to New Zealand Daylight Savings Time	NBY TAF 0915/1015 (1004/1104NZDT) GRID08010KT 8000	Forecast from 9th day at 04:00 NZDT to 10th day at 04:00 NZDT of current month (this conversion may not be provided).

Abbreviation	Description	Example	Translation
GRID###_KT	Wind direction and speed	NBY TAF 0915/1015 (1004/1104NZDT) GRID08010KT 8000	Wind from grid 80 degrees (grid east) and wind speed of 10 knots. VRB = variable wind direction.
####	Visibility in meters	NBY TAF 0915/1015 (1004/1104NZDT) GRID08010KT 8000	Visibility on the ground is 8,000 meters.
XX XX	Forecast weather	-SN BR BKN010 OVC020 QNH2837INS	Light snow and mist. BLSN = blowing snow, BR = mist (e.g., baby rain), DRSN = drifting snow, FG = fog, IC = ice crystals, NSW = no significant weather, PL = ice pellets, SG = snow grains, -SN = light snow, SN = snow or moderate snow, +SN = heavy snow, SW = snow showers.
BKN010	Cloud layer 1 type and altitude in feet	-SN BR FEW005 BKN010 OVC020 QNH2837INS	Lowest layer involves few clouds (i.e., 1/8–2/8 coverage) at 500 feet. BKN = broken, FEW = few, OVC = overcast, SCT = scattered, SKC or CLR = Sky clear, W = vertical visibility (obscured sky). 005 = 500 feet, 010 = 1,000 feet, 100 = 10,000 feet, etc.
OVC020	Cloud layer 2 type and altitude in feet	-SN BR FEW005 BKN010 OVC020 QNH2837INS	Second layer up involves broken clouds (i.e., 5/8–7/8 coverage) at 1,000 feet.

Abbreviation	Description	Example	Translation
#####	Cloud layer 3 type and altitude in feet	-SN BR FEW005 BKN010 OVC020 QNH2837INS	Third layer up is overcast (i.e., 8/8 coverage) at 2,000 feet.
QNH#####INS	Barometric pressure	-SN BR FEW005 BKN010 OVC020 QNH2837INS	Station pressure is 28.37 inches of mercury (inHg).
TEMPO ...	Temporary weather condition lasting < 1 hour	TEMPO 0920/0924 (1009/1013) 2400 OVC010	Forecast on 9th day of current month during 20:00–24:00 Z (10th day during 09:00–13:00 NZDT), is 2,400 meters of visibility and a single overcast layer at 1,000 feet (excluded data [e.g., wind speed] remain the same).
BECMG ...	Becoming. New forecast will be in effect by end of BECMG period.	BECMG 0923/1001 (1012/1014) VRB06KT 9999 NSW SCT010 BKN030 QNH2834INS AMD 1900	Forecast starting 9th day at 23:00 Z and in effect by 10th day at 01:00 Z of current month (10th day 12:00–14:00 NZDT), is variable winds at 6 knots, unrestricted visibility, no significant weather, scattered clouds at 1,000 feet, broken clouds at 3,000 feet, and station pressure of 28.34 inHg, with this amended forecast issued at 19:00 Z.

Sea Ice Assessment

A McMurdo Sound Sea Ice Report is available biweekly while the sea ice is open for travel. The report consists of a satellite image overlaid with sea ice routes and text on current conditions. Review the report before traveling on the sea ice, and contact FS&T with questions.

Field parties can obtain current and historical satellite imagery for research areas from the Polar Geospatial Center. This imagery is gathered throughout the winter to track sea ice movement and development. Throughout the summer, imagery is gathered weekly.

Low-resolution visible imagery: This is published daily, but sea ice may be obscured by cloud cover. Historical imagery is available to 2000.

High-resolution visible imagery: This is published five to six times a year, mostly during the summer. The last two years of historical imagery are available.

Radar (SAR) imagery: This is typically published each week and can see through clouds. Only four or five days of historical imagery is available.

Sea ice concentration: This is published daily with a two-day lag. Historical imagery is available to 2002.

Managing the risk of traveling on sea ice requires teams to pay attention to weather conditions, ice thickness, ice color, ice temperature and cracks. All participants traveling on the sea ice must attend the sea ice training. If it is your first year in USAP, this includes a full day on the sea ice learning hands-on to measure sea ice thickness, recognize cracks and understand how weather affects the sea ice. The following information reflects much of what is covered in the training. Keep this manual with you in the field to aid your sea-ice travel decisions.

Weather

Poor weather conditions will obscure surface definition, making it difficult to impossible to detect cracks. Use extra caution if surface definition or visibility is poor. Strong winds can be particularly dangerous, especially at the ice edge, where large chunks of the sea ice break off and blow north with little warning.

Thickness

Strong currents can erode sea ice from below. This is hazardous because there may be no obvious indication of ice thinning at the surface. Strong currents typically occur later in the season and usually over underwater shoals. Land formations that indicate a potential shoal are long, low-angle ridges or peninsulas that descend into the sea. However, shoals can also occur offshore of steep slopes, such as the north side of Little Razorback Island. At McMurdo Station, areas near Cape Armitage (at the base of Observation Hill), Hut Point, and Knob Point/Cinder Cones can sustain strong currents and thinning ice later in the season. In addition, as the air and sea temperatures rise later in the season, the sea ice becomes progressively weaker and thinner everywhere.

Color

The color of the sea ice is a good indication of its thickness and safety. In general, white or milky blue ice is the safest. In McMurdo Sound, these colors indicate solid ice that is at least 24 inches thick. Ice that is sky blue and has a slick, scalloped surface is multiyear ice that is several feet thick.

Ice of different ages and thickness are marked by a thin line on the surface and usually slight differences in elevation. If the color of the ice changes abruptly, travelers should stop immediately and investigate. Darker ice indicates a hazard. Ice that is young or has thinned to six inches or less will appear grayish, even beneath a thin crust of snow. This ice may support an adult on skis but should never be traversed by vehicle. Gray ice can also form as a result of surface flooding

and subsequent freezing of the surface water, which often occurs at tidal cracks. It is always important to investigate areas of gray ice. Sea ice that appears black is thin and must always be avoided. Field team members should drill the ice every 100 meters if the ice surface is consistent, and much more frequently if there are variations in color or texture.

Temperature

Colder ice is stronger. The colder the ambient air temperature, the more the ice grows. The colder the ice, the stronger the overall structure. Just looking at the surface will not indicate the true strength of the ice. Sea ice strength is measured according to four periods of ice surface temperature.

Sea Ice Periods

Period	Surface Temperature	
	Celsius	Fahrenheit
1	< -10°C	< 14°F
2	-10°C to < -5°C	14°F to < 23°F
3	-5°C to < -2.78°C	23°F to < 27°F
4	-2.78°C to < -1.94°C	27°F to < 28.5°F

Sea Ice Cracks

Cracks are fissures or fractures in the sea ice that form in response to environmental, geographical and mechanical pressures (e.g., wind, waves, tidal action, pressure applied by ice shelves and glaciers). Tidal cracks form along coastlines and around islands, grounded icebergs and glacier tongues. Other cracks radiate out from the land, especially from headlands and glacier tongues, like the spokes of a wheel.

Avoid cracks whenever possible. If one must be crossed, do so in a line perpendicular to the crack. Never cross a system of multiple, closely set cracks in a way that places a vehicle on two or more cracks at once or on a small piece of ice between cracks. Avoid sets of cracks that form triangular wedges, which could break off and flip over under a vehicle's weight.

Snow cover on the sea ice can hide cracks. Look for continuous linear features and sagging areas of snow, sometimes of different color tones. Watch for areas where snow has drifted differently, especially if the drifted area is in a long, straight line. Good visibility and lighting are essential to seeing these features. Also pay attention to seals or signs of seals (e.g., feces, urine, seal shadows, breathing holes). Their presence anywhere on the sea ice indicates the presence of a crack. Seal breathing holes may become covered and obscured by thin ice or snow. A small mound of ice or snow on the otherwise flat surface of the sea ice may indicate the presence of a breathing hole.

Poor weather conditions and snow can hide or obscure surface definition, making it difficult or impossible to detect cracks in the ice. Use extra caution if surface definition or visibility is poor, especially in low light conditions. Strong winds can be particularly dangerous, especially at the ice edge, where large chunks of the sea ice can break off and blow away with little warning.

There are four types of sea ice cracks:

- Tidal
- Straight edge
- Working (active)
- Pressure ridge

Each is described and discussed during sea ice training. Field party members working on the sea ice must learn to identify and evaluate each type of crack.

Sea Ice Travel and Work

Sea ice must be at least 12 inches thick to allow for travel within 300 meters (~985 feet) of shore. Ice must be 20 inches thick to allow for travel beyond 300 meters. These thicknesses are the same for ski, foot and snowmobile travel due to the distributed pounds per square inch of ground pressure for each method.

The effective crack width is the distance over which the sea ice in a crack is less than the minimum required for a vehicle, based on the ice surface temperature's period. The effective width cannot exceed one-third of a vehicle track length or area of a tire in contact with the ice. Use the following guidelines to determine the required ice thickness and maximum effective width for vehicles.

Sea Ice Crack Guidelines for Light Vehicles

Vehicle	Maximum Effective Crack Width	Minimum Ice Thickness by Ice Surface Temperature			
		Period 1 ($< -10^{\circ}\text{C}$)	Period 2 (-10°C to $< -5^{\circ}\text{C}$)	Period 3 (-5°C to $< -2.78^{\circ}\text{C}$)	Period 4 (-2.78°C to $< -1.94^{\circ}\text{C}$)
PistenBully	36"	12"	12"	17"	17"
Hägglunds	27"	15"	16"	21"	7"
Snowmobile	20"	5"	5"	6"	7"
Mattracks	15"	12"	13"	17"	18"

Note: If towing a sled or trailer, different ice thickness requirements may apply. Contact Field Safety & Training at x2345 for more information.

Profiling a Sea Ice Crack

1. Stop the vehicle before reaching a crack, and check for other cracks nearby.
2. Determine the nearest edge of the crack by removing snow down to bare ice.
3. Using an ice ax, probe for open water or weak spots to determine if it is safe to cross by foot.
4. If safe, shovel the snow out of the crack from edge to edge, clearing at least one shovel blade's width of snow.
5. Drill holes every 12 inches in a straight line, beginning outside one crack edge and ending outside the other. Be sure to drill healed shelves and any visible fractures.
6. Drill each hole either to water level or a full Kovacs drill flight length (> 30 inches).

7. Measure the ice thickness in each hole.
8. Pay attention to the characteristics of the ice shavings (i.e., dry, moist or slushy).

