FieldEx Field Guide

Best Practices and Safety Measures for Fieldwork in Cold Environments



2026

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1 PREFACE

The aim of this field guide is to provide information on preparing and conducting fieldwork, including best practices and safety considerations, with a particular focus on cold region environments. The guide was developed as part of the course "Field Safety and Preparedness" held at Finse Research Station in Finse, Norway from 6-16 April 2025, and organized by the Department of Geosciences of the University of Oslo, Norway. The course provided practical training in glacier safety including crevasse rescue, arresting falls on snow, avalanche safety and rescue, emergency sheltering in snow, as well as theoretical training in topics such as health precautions, wildlife risks, communication in remote areas, weather forecasts, field gear and clothing, field emergency plans, code of conduct for fieldwork, harassment in the field, field preparation and fieldwork documentation.

The course was run as part of the program "FieldEx - Field Instrumentation and Measurements in Cold Region Environments" (2025-2028), an exchange program between Norway, Canada, USA, and Japan for geoscience MSc and PhD students, which aims to foster educational partnerships through short-term student exchanges focused on field techniques in cold region environments. FieldEx is funded by the Norwegian Directorate for Higher Education and Skills (HK-dir) under the UTFORSK program (grant UTF-2024/10399). UTFORSK is a central measure under the Panorama strategy (2021-2027), the Norwegian government's strategy for cooperation on higher education and research with prioritised countries outside of Europe with strategic importance to the knowledge sector in Norway.

The field guide was written by the instructors and the graduate students of the course, and is based on the topics covered in the course.

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Disclaimer

This field guide is not a substitute for comprehensive safety training and does not claim to be exhaustive or free of errors. Instead, it is intended solely as a convenient reference to provide useful information for investigators, staff and students when preparing and conducting fieldwork in remote cold region environments such as the Arctic.

The authors assume no responsibility or liability for any errors or omissions in this document and bear no responsibility for any use made of the information it contains.

2 PREPARATION FOR SAFE FIELDWORK

2.1 Key environmental and local challenges

Fieldwork in remote cold region environments such as the Arctic can be particularly challenging compared to other regions due to specific environmental conditions:

- **Weather**: often characterized by extreme cold, high wind speeds and solar radiation
- **Remoteness**: makes rescues difficult and costly; can lead to mental stress
- **Logistics**: lack of or limited infrastructure for housing, food supply, and transport
- **Risks/hazards**: glaciers (crevasses), snow (avalanches), frozen rivers, dangerous wildlife

In addition, the following aspects should be considered carefully, especially when fieldwork is performed in regions/countries with different cultural norms, laws, and environmental conditions:

- **Altitude** (Need for acclimatization?)
- **Climate** (Expected ranges of meteorological variables)
- **Wildlife** (Bears, moose, mosquitoes ...)
- **Health and safety** (Local medical facilities, emergency evacuation options, endemic diseases, required or recommended vaccinations, availability of qualified rescue services, access to clean water)
- **Access to field site** (Which modes of transportation are available?)
- **Communications coverage** (Which devices work?)
- **Legal constraints** (Are visas or permits needed?)
- **Cultural awareness** (Respect for cultural norms and heritage, especially in foreign countries and indigenous communities, e.g., rules on alcohol and drugs, dress code, gender roles, public conduct; prevalence of corruption . . .)
- **Political issues** (Political stability, unrest . . .)
- **Financial and administrative issues** (Currency, banking . . .)
- **Environmental protection** (Local conservation rules, waste management . . .)
- **Insurance** (Need for extra health / rescue insurances?)
- **Seasonal and daily variations in daylight** (e.g., midnight sun vs. polar night in polar regions; rapid sunsets near the equator)
- **Practical issues** (Are specific adapters needed for electronic equipment? . . .)

2.2 Best practices on clarity of expectations and responsibilities

The combination of logistical hurdles, the need for self-sufficiency, small field parties, and the psychological strain of isolation can make fieldwork in such environments taxing. Thus, **clarity about expectations** regarding all aspects of the planned fieldwork and team member responsibilities prior to the fieldwork is essential to the success and safety of the fieldwork, and to avoid conflicts:

Define expectations and responsibilities:

- Science (scientific goals, fieldwork implementation plan)
- Logistics (food, housing/sleeping arrangements, transportation)
- Safety standards
- Behavior (e.g., smoking, alcohol; code of conduct)
- Physical fitness
- Roles and responsibilities/tasks in the field

Prepare written documents:

- Code of conduct specific to fieldwork (Section 2.3)
- Rights of team members (Section 2.4)
- Field safety / emergency plan (Section 2.5)
- Field "contract" summarizing scientific goals, instrumentation, fieldwork implementation plan, responsibilities, logistics, safety standards . . .)

During the fieldwork:

- Hold regular meetings with all team members; daily planning meetings.
- Perform "wellness checks" with team as well as individual team members.

2.3 Fieldwork code of conduct

A fieldwork code of conduct outlines expected behaviors and ethical standards for all members of a field party, ensuring safety, respect, and inclusivity. It addresses potential issues like harassment, discrimination, and safety concerns, and aims to promote a positive and productive environment for everyone involved. The field leader should ensure a code of conduct is formulated and all field members are familiar with it. An example is given below:

All field participants are expected:

Social aspects

- To refrain from inappropriate physical contact, bullying, harassment, intimidation or acts of aggression or verbal and physical violence.
- Not to engage in any forms of discrimination regardless of sex, sexual orientation and/or gender identity, disability, physical appearance, race, nationality, ethnicity, and religion. In particular, profanity or inappropriate language including sexual language and imagery, sexist, racist, discriminatory, or otherwise exclusionary comments/jokes, are not appropriate.
- To treat each other with respect and be courteous with the opinions of others, refraining from personal attacks or insults.
- To welcome questions and answer them respectfully, paying particular attention to those new to fieldwork and making space for learners of all levels.
- To work cooperatively and not claim credit for the work or achievements of others, including in group settings.
- To respect each other's possessions and act conscientiously when using field equipment.
- To follow directions from, and show respect to, the staff members of any facilities used by or hosting the field party (e.g., research station, field camp, hotel).

Environmental / regulatory aspects

- To follow the field team's fields field safety plan at all times.
- To obtain all required permits in advance and comply with applicable laws and local regulations.
- To show respect for local communities and for cultural heritage sites, including those that may still be in active use.
- To adhere to "Leave no Trace" principles: do not to pollute or litter, and pick up any litter that you may find.

- To refrain from altering the natural or built environment unless such actions are explicitly authorized as part of the approved fieldwork.
- To remove their scientific instruments and camping equipment, whenever possible, at the latest by the end of the project.

2.4 Fieldwork rights

Fieldwork participants should have the fundamental right to a safe and healthy work environment. This entails specific protections against hazardous conditions and retaliation for reporting safety concerns, including the right to receive information about potential hazards, relevant safety training, and under certain conditions the right to refuse work. The list below outlines commonly applicable rights and protections, although the specific details may vary from case to case.

Field participants have the right:

1. ***INFORMATION***: To adequate information about field plans, housing arrangements, logistics and nature of and risks involved with the planned fieldwork.
2. ***SHELTER/HOUSING***: To adequate and safe housing, which includes the right to refuse to share living spaces with individuals with whom they do not feel comfortable. Tents should not be leaking or inadequate for the conditions in which they are being used.
3. ***FOOD***: To adequate quality and quantities of food/water (e.g. participants should not be required to go without meals).
4. ***REST***: To adequate rest and sleep, personal time, and privacy. These needs should be respected, but individual decisions should not interfere with the progress or cohesion of the group.
5. ***SANITATION***: To safe and hygienic sanitation. While facilities may necessarily vary depending on environmental and logistical conditions, all members should have access to arrangements that preserve hygiene, dignity, and privacy.
6. ***EQUIPMENT/TRAINING***: To training in appropriate field safety equipment, including communication devices in emergency situations (e.g. bear spray, mosquito netting, satellite phones, location trackers), as well as use of the scientific equipment to be used.
7. ***COMMUNICATION***: To access to communication devices to report emergencies, safety issues and harrassment. The criteria for personal use should be clearly defined in advance and may vary depending on costs.
8. ***SOCIAL ENVIRONMENT***: To a social environment free of harassment and discrimination, where everyone's concerns are taken seriously and considered.
9. ***SAFETY***: To refuse to do activities that participants feel are unsafe (e.g. flying in a helicopter in poor weather, driving an ATV without training, crossing a dangerous glacial stream, ascending a steep snow slope under avalanche conditions, being left alone in remote field settings).
10. ***EVACUATION***: To be able to leave or be evacuated at no personal cost in case of: (1) a medical emergency that poses a serious health threat and requires immediate specialized medical attention, (2) a serious violation of the code of conduct by a team

member. The criteria for a reasonable cause for evacuation should be clearly defined in advance and may vary based on remoteness and evacuation costs.

11. ***RECOGNITION***: To be recognized adequately in the scientific products evolving from the fieldwork (e.g., co-authorship, naming in acknowledgments).

All field safety rights above shall be exercised without retaliation or other adverse effects on the participant.

2.5 Field safety plan

A field safety plan outlines procedures and precautions to ensure the safety of all participants engaged in fieldwork. It should contain all relevant information for an emergency response. The plan, often mandated by the employer, should be entrusted to at least one designated person not participating in the fieldwork. This ensures that someone is available to manage communications and coordinate assistance in case of an emergency.

The plan typically includes information about the field party, relevant contact information, location, planned work, potential hazards, mitigation strategies, emergency procedures, and communication plans. While the format and content of a field safety plan may vary based on the scope and remoteness of the fieldwork, the example below highlights common elements typically included in such a plan.

Contact Information

Field Members (add information for each field member)

Name	Email / Phone	Affiliation	Role Principal investigator / graduate student / field assistant / . . .
1.			
2.			
3.			
...			

Designated Field Emergency Contacts

Name	Email / Phone / Institution	Location	Role Emergency contact / employer contact / . . .
1.			
2.			
3.			

Field Site Information and Transportation

Dates of fieldwork (including travel)

General location (country, nearest towns)

Detailed list of locations (include for each site the geographic name and/or coordinates, dates of stay and type of housing (e.g., hostel, number and color of tents). If the group is split, indicate who is where/when.)

Transportation (list types of transportation to/from the field site and in the field, e.g., commercial flight, train, bus, helicopter, snow mobile)

Scientific Work

Brief summary of research project and goals

Brief description of planned measurements (instruments, methods)

Risks and Safety

Expected weather conditions

Potential risks (wildlife, avalanches, sea-ice, fire, etc.)

Safety equipment (other than communication devices. List type, quantity)

Medical Training and Equipment

Medical training (e.g., wilderness first responder / physician / nurse / CPR training; and who it applies to)

Medical equipment (trauma kit, epipen, medication, etc.)

Closest town/hospital and estimated travel time

Communication Devices

Devices and contact numbers (type, how many)

Communication Protocol

Name of contact for check-ins

Protocol for check-ins (frequency, mode of communication, plan B)

Rescue triggers and emergency response protocol (how long after failed check-in is an emergency response triggered by designated contact person; protocol for response)

Other information

Relevant information not covered above (e.g., maps of field camps and instrumentation / observation sites; colors of tents, clothing; relevant experiences of field members)

2.6 Medical information and privacy

Remote fieldwork usually takes place in environments where medical facilities are far away, communication is limited, and evacuation can be difficult and costly. Therefore, having access to relevant health information of all participants can be crucial to prevent and respond to medical emergencies.

However, disclosing personal medical information a-priori raises legitimate privacy concerns. Balancing these two imperatives—medical safety and confidentiality—is a core ethical challenge

in remote fieldwork but important to address with the field team in advance. Access to information about certain physical and health conditions or medications can be crucial to field safety. For example, strong allergies, asthma, diabetes, heart conditions, seizure disorders, pregnancy or mental health vulnerabilities may all impact how a person reacts to high altitude, cold temperatures, physical exhaustion, or stress, and how first responders need to respond.

Therefore, many field campaigns ask participants to disclose relevant medical information in advance. Ethically sound practices for doing so include:

- Minimizing the amount of information shared to what is directly needed for field safety and emergency response.
- Restricting access to those that need to know, e.g., the safety lead or team leader and emergency responders; however, certain conditions require all team members to know (e.g., severe food allergies), so a nuanced tiered procedure is needed.
- Storing the information in a way that secures confidentiality while ensuring that it is accessible during an emergency.
- Establishing clear and transparent routines agreed upon by all team members, specifying what data are collected and who has access to which information and when.

An example of a medical information form to be completed by all participants is provided below.

2.7 Permits and regulations

Fieldwork may require securing permits and ensuring compliance with local regulations. Regulations can broadly can be categorized by:

- **National level** (e.g. visa to enter country, customs, vaccination requirements, environmental laws)
- **Legal entities** (e.g. National Park Service; other protected areas; private land, indigenous communities)
- **Employer** (e.g., administrative requirements may include field rescue plan, specific safety trainings, volunteer regulations, specific insurances).

Recommended steps:

- Identify the local authority (legal entity) overseeing the land on which the fieldwork is performed: city, borough, corporation, private company, government agency.
- Contact local authority for permit and regulation concerning fieldwork (authorization for equipment staying on the field, explosives, firearms for wildlife protection, transportation in sensitive areas).
- Identify requirements for every member of the field team (e.g. visa, customs, vaccination).
- Have every member of the field team contact their home institution for specific requirements (e.g. travel authorization, insurance, training, other regulations).
- Identify requirements for transportation (e.g., carrying bear spray, gas, fuel on helicopters and planes); legal requirements for snowmobiles (e.g., driver´s license, helmet).

Health Inventory Form

Please provide the following information that may be shared with health providers, first responders and the safety lead in case of an emergency.

Please complete the form, print two copies, and place each in a sealed envelope. Keep one envelope in your daypack and leave the other at camp.

Date:
Name:

	Yes/No	Further details/Comment
Allergies		
Respiratory issues (e.g. asthma)		
Diabetes		
Seizure disorder		
Cardiac/heart problems		

Blood type	
Current medications (incl. dosage and purpose	
Do you wear a Medic Alert?	
Any other medical conditions of relevance in case of emergency?	
Any other issues first responders should know (e.g., special precautions to take in an emergency)?	

Emergency contact (family/friend; name and phone/email):

NOTE: The sealed envelope containing this sheet will only be opened in case you have an emergency. The form will be returned to you after departing camp.

2.8 Cultural awareness

Cultural awareness is crucial when conducting fieldwork, especially in other countries and indigenous communities. It helps scientists engage respectfully and effectively with local communities and populations.

Understanding customs and traditions

- Before entering or engaging with a community or new culture, you should learn about and understand local customs, traditions, and social norms as best you can. Customs and traditions may differ greatly from what you are accustomed to.
- Be mindful of body language, dress codes, and social hierarchies. Be aware of cultural differences.

Building relationships

- Establish trust with, and report to, local communities.
- Connect with local communities and inform them about your plans where appropriate.

Ethical considerations

- Obtain informed consent where necessary.
- Respect the community's autonomy.
- Be transparent about the purpose of the research and, if you wish to disclose, funding source(s). People often like to know about you and your work.

Language barriers

- Be aware of communication style and potential need for translation efforts or other. This can be as simple as the occasional Google Translate, or the procurement of formalized translation services.
- Consider learning basic phrases in the local language to facilitate better communication and show respect for the community.

Local Knowledge and Expertise

- Recognize and value the knowledge and expertise of local people.
- Collaborating with community members can enhance the research and ensure it is relevant and beneficial to them. Encourage knowledge co–creation.

Bias

- Attempt to reflect on cultural biases and how this may influence your work.

2.9 Harrassment in the field

Fieldwork places researchers in settings that differ significantly from everyday academic environments. Certain associated conditions may make individuals more vulnerable to inappropriate behavior, thereby undermining safety, well-being and the integrity of research. This section provides an overview of the forms harassment can take, why field conditions can intensify risks, and how these behaviours affect individuals and teams. It also outlines practical measures to reduce harm and promote a safe, respectful and inclusive field environment for everyone.

What is harassment?
According to the United Nations, harassment is defined as "any improper and unwelcome conduct that might reasonably be expected or be perceived to cause offence or humiliation to another person" (United Nations, 2013). Harassment can stem from prejudice related to gender, race, sexual orientation, physical or mental health, age, religion or socioeconomic status, or it may be ungrounded. Behaviors categorized as harassment range from remarks, name-calling and discrimination to stalking, misconduct, assault and violence.

A useful reference point is the movie documentary "Picture a Scientist" (2020), which illustrates how harassment often accumulates through small, repeated behaviours rather than isolated incidents.

Cabin fever
Some extreme cases of misconduct in isolated field settings are associated with cabin fever, also known as polar madness or over-winter syndrome. Long periods of isolation can impair

mental health and lead to unpredictable or dangerous behaviors, including, in extreme cases, mutiny or suicide.

In remote cold-region fieldwork, low visibility, disorientation and the absence of clear environmental cues can intensify these risks. Concepts such as veneer theory highlight how thin layers of social norms can erode under prolonged stress and isolation.

Sexual and gender harassment
Sexual harassment is a significant issue in scientific fieldwork. Survey data show that 64% of respondents have experienced sexual harassment (of which 87% were women), and 20% experienced sexual assault (94% women) (Clancy et al., 2014). The majority of cases is assumed to go unreported.

Many women experience gender bias in the field: under-expectation of physical strength, unequal distribution of domestic tasks, or being assigned less field-intensive roles. Reported experiences include equipment being taken away with claims that certain tasks are "not women's work" or being denied opportunities due to assumptions about emotional or family-related constraints. These patterns can reinforce inequality and, if unaddressed, escalate into more serious forms of misconduct.

LGBTQ+ harassment
Acceptance of LGBTQ+ identities varies widely across the world. In an international survey, more than half of respondents reported feeling unsafe in a region because of their identity, expression or presentation (Olcott and Downen, 2020). Over 80% reported a lack of LGBTQ+ role models during their studies, and 87% believed they would have benefitted from stronger mentorship.

A lack of visibility and support can heighten vulnerability during fieldwork, especially when researchers must travel alone, share accommodation or operate within unfamiliar cultural norms.

Racism
There is a lack of reliable statistics on racism in academic fieldwork, largely due to the underrepresentation of people of color in geosciences. Limited data should not be interpreted as an absence of incident risk; rather, it reflects structural exclusion. Statements from researchers indicate that people of color may feel less safe in certain environments or worry about being misinterpreted when conducting field observations.

Inequality in academia
Academic demographics remain unequal across many STEM (Science, Technology, Engineering, Mathematics) fields. Two concepts help explain this:

- Leaky pipeline: Describes how the number of women, Black, Indigenous, People of Color and other minoritized groups in STEM fields progressively decreases at every stage of their academic careers. Implies passive leaking.
- Hostile obstacle course: Refers to the existence of cultural and structural barriers that have been put in place deliberately or unconsciously, slow down or exclude certain groups.

Together, these mechanisms reinforce long-term demographic imbalances and reduce access to mentoring, leadership and safe reporting structures.

How can fieldwork aggrevate harrassment?
Certain characteristics of fieldwork environments can increase the risk of harassment or misconduct:

- Isolation and lack of an exit option
- Fading of societal norms and limited law enforcement
- Reduced privacy and autonomy
- Unfamiliar legal, cultural or environmental conditions
- Underrepresentation of minorities and gender imbalance
- Hierarchical group structures and interdependence
- Long and physically intensive work days
- Multi-institutional teams with varied expectations.

An implicit "what happens in the field stays in the field" mindset can discourage reporting. Biases such as assumptions about unequal physical ability or dismissal of certain team members can reinforce harmful dynamics. Alcohol consumption frequently lowers boundaries and is cited as a contributing factor in many incidents.

Impacts of harrassment
Victims of harassment in academia experience trauma and lowered self-esteem. Constant 'discomfort' can lead to reduced performance during fieldwork. Some report reluctance to do further fieldwork and a fear of losing their career if they report it. Some have even left their academic field after experiencing harassment. Survey data indicate that roughly one-third of respondents have avoided fieldwork due to concerns related to their identity (Olcott and Downen, 2020).

Solutions
Solutions operate across four domains: increasing awareness of risks, establishing open discussions about expectations, implementing mitigation measures, and ensuring effective responses to misconduct:

- **Increased awareness** may involve self-education on cultural differences, sexism, identity and local laws; participation in field safety and harassment training.
- **Discussions** should focus on the fieldwork plan as well as possible risks with the whole research team, as well as creating time and space to talk to individual researchers. Have a shared understanding of everyone's expectations. It can also be useful to be open about personal quirks and weak spots. A code of conduct (Section 2.3) is useful to set clear expectations and standards for all members of the fieldwork.
- **Responding** to misconduct is important, but it is equally important to have a robust reporting system in which concerns are taken seriously and acted upon. Sanctions for misconduct can be effective. Prohibiting alcohol can be a useful measure for mitigating unwanted behavior, as alcohol consumption impairs critical thinking and can exacerbate problematic behavior.

3 TRAVELING IN REMOTE TERRAIN

3.1 Modes of transportation

Snowmobiles and helicopters are frequently used for transportation in polar fieldwork, since field sites are often not accessible by foot or car. However, they pose significant safety risks, necessitating diligent attention to safety measures and protocols.



Figure 1: Examples of how to appropriately pack a snowmobile (Photos: Greenland, R. Hock).

3.1.1 Snowmobiles

A snowmobile is an easy way of traveling across large distances in snow-covered terrain. However, there are some safety measures to go through before setting off on a snowmobile trip.

In remote and difficult terrain, always travel with a minimum of two snowmobiles.

Protection from the cold

- Helmet
- Goggles
- Proper face protection, e.g., balaclava/facemask (frostbite on your face can be hard to notice before it's too late.)
- Gloves/mittens

Packing your snowmobile

- Use adequate sledges and do not pack too high to prevent equipment from falling off (Fig. 1).
- Use proper straps for securing the cargo (or ropes with trucker's hitch knot).
- Place the heaviest items near the balance point of the sled.
- Use additional fabric or foam pads or other other friction-enhancing materials to secure the cargo in place.
- Rescue/safety equipment should be carried by the second and the last drivers (pack smaller items, especially emergency equipment in easily accessible sled bags).

Safety while driving

- Define signals for when to slow down or stop.
- Drive in a line behind each other.
- Maintain visual contact with the other drivers, while still maintaining a safe distance from each other.
- Regularly turn around to ensure that the driver behind is still within view.
- Pay attention to the terrain, snow and ice conditions, and do not cross slush or open water.
- Bring additional fuel!

3.1.2 Helicopters

Always **STAY CALM** around a helicopter!

How to move safely around a helicopter

- NEVER walk behind the helicopter! (Fig. 2a)
- Wait for acknowledgement from the pilot to enter or leave the rotor arc.
- Do not approach or leave a helicopter when the engine and rotors are starting up or running down.
- In sloping areas (relevant for glacial and snowy fieldwork sites), always approach and leave on the downsloping side for maximum rotor clearance (Fig. 2b).
- Crouch when approaching or exiting the helicopter for extra head clearance (Fig. 2c).
- Hold on to loose articles, such as hats, and do not chase after any lost objects.
- Carry your tools, poles and other equipment horizontally and below waist level to prevent any contact with the rotor blades (Fig. 2d).

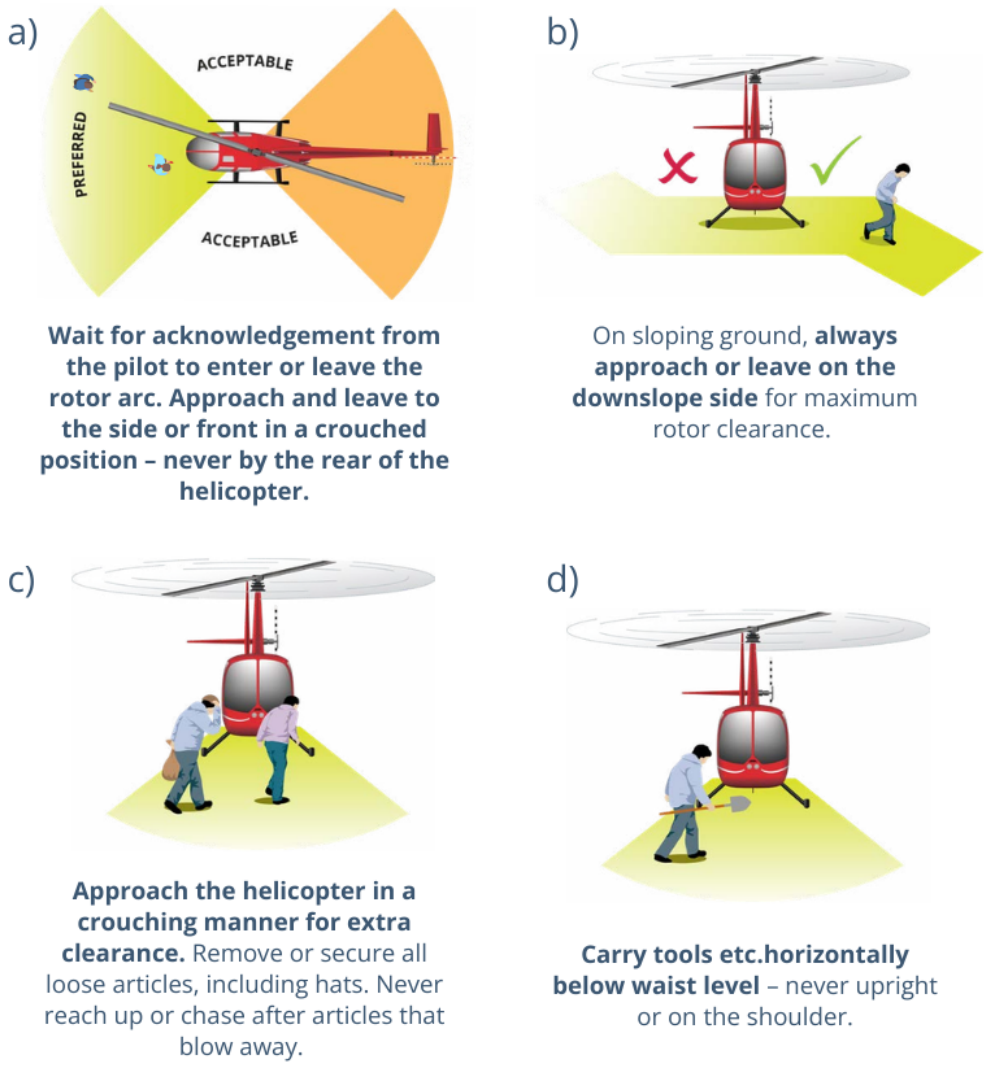


Figure 2: Guidelines on how to move safely around a helicopter. Adapted from the Civil Aviation Safety Authority of the Australian Government (https://creativecommons.org/licenses/by/4.0/).

Other things to consider

- When a helicopter is expected to land in a low-contrast area (e.g., snow-covered terrain), walk or ski around the landing zone to create visible tracks to improve surface definition for the pilot.
- When being dropped off by a helicopter that will return later, ALWAYS bring essential gear (extra clothing, food, water, and safety equipment) in case weather or mechanical issues prevent the helicopter from coming back as planned.

3.2 Sea, lake and river ice

Sea, lake or river ice is typically considered safe to travel on (by foot) if it is > 10 cm thick; however, small-scale variations in thickness, cracks and open water leads, ice motion due to wind and currents, melt pools and rough terrain can make traveling over such ice hazardous. A fall through the ice can be fatal due to near-freezing water, and because self-rescue is often difficult due to unstable ice edges and limited grip.

Cold shock can kill within seconds to 2 minutes.
Cold incapacitation can kill within 2 - 30 minutes.



Figure 3: (a) Ice picks and (b) how to use them to pull yourself out of the water (Photos: (a) R. Hock, (b) R. Ekker).

Be prepared:

- Wear ice picks/ice claws with a whistle around your neck so you can pull yourself out if you fall through (Fig. 3).
- Bring a throw rope / throw bag to help others if needed.
- Bring a long ice pick to probe.
- Bring spare clothes in a waterproof bag.
- Measure the ice thickness (with an ice auger or ice chisel) and check it regularly along the way as it can vary greatly.

Be aware of the environment:

- Ice is considerably weaker at river in/outflows or around currents.
- The quality of the ice can quickly degrade in case of a rise in temperature, high wind or swell.

- The water level in dammed lakes can drop suddenly. Check with the reservoir operator for information about planned water level changes.
- Black ice is generally the safest kind of ice to travel on. Avoid white or yellow ice (weaker, may contain wind holes)
- Avoid snow-covered ice.

What to do if you fall through?

- Move toward the direction you came from (that ice held your weight before). If you end up under the ice, swim toward the dark spot on bare ice and toward the light spot on snow-covered ice.
- Pull yourself out by driving the ice picks into the ice in front of you while kicking your legs to get into a horizontal position.
- Keep crawling or rolling forward until you are well away from the hole before carefully standing up.
- Change into dry clothes as soon as possible; get warm immediately!

3.3 River crossings

Crossing turbulent rivers is one of the leading causes of fatalities in backcountry hiking! It's important to know when, how, and where to cross rivers to minimize the associated risks (Fig. 4).

Assessing the river situation

- *When is it generally safe to cross?*
  - Flow speed $<$ walking speed
  - River depth $\leq$ knee height of shortest team member
  - No flooding or debris flow
- *When do you cross?*
  - In glacier/snow melt affected environments, the preferred time to cross a river is early in the morning, due to the diurnal cycle of glacier/snow melt with melt maxima in the afternoon.
- *Where do you cross?*
  - Cross at a straight stretch of the river.
  - Cross at a wider part of the river (the wider the river, the slower the flow velocity and the shallower the water).
  - Identify an exit point before you start crossing.
  - Avoid steep and/or obstructed banks.

Preparation before crossing

- Pack crucial items (e.g., fire starters, sleeping bags, clothes) in waterproof bags.
- Keep your shoes on, or have a spare pair (e.g., river sandals) to change into (do NOT go barefoot).
- Release the waist and chest straps on your backpack to reduce the risk of becoming tangled or trapped.
- Plan an escape/return option and don't push beyond the point of safe retreat.

During crossing

- Face upstream when crossing, and have a slight angle downstream.

- Watch the opposite bank while crossing.
- When crossing in a group, walk in single file with the strongest person first, holding each other's backpacks for balance.
- Use poles or sticks for balance and check the water depth as you go.



Figure 4: A duo crossing a river holding each other for balance, with the person in front using a stick for additional stability (Photo: National Park Service, USA).

4 CAMPING, SNOW SHELTERS AND CLOTHING

4.1 Camping on snow and ice

Before setting up camp on a glacier or snow cover, thoroughly probe the area with an avalanche probe to ensure that there are no crevasses or other dangers. On a glacier, do not remove your skis or ropes until you have confirmed that it is safe to do so.

Setting up tents:

- Be aware of the wind direction; the lowest and narrowest end of the tent should face the wind.
- Where high wind speeds can be expected, set up tents in a line perpendicular to the wind direction spaced far enough apart to prevent drifting snow from endangering them (Fig. 5).
- Anchor the tents sufficiently with poles, snow, skis or other suitable devices.
- Set up a safety line between tents (e.g., a rope attached to flag poles) to prevent people from getting lost in low visibility, such as during strong snowdrift in a snowstorm. Weather can change abruptly in cold environments.
- Cold air sinks, so dig out a small area in front of the tent entrance to allow the cold air to settle there, helping to keep the inside of the tent warmer for sleeping.
- Check sleeping pads before going into the field. At camp, make sure they are fully inflated and the valve is tightly closed.

Other considerations

- **Wind** can be strong and persistent in the field. You can protect yourself from the wind by, for example, building snow walls upwind of the camp. Keep your gear organized so things don't get lost by wind and snowfall. Secure and mark equipment.



Figure 5: Tent setup with safety lines, proper anchoring and snow walls (left) and equipment secured and marked with poles (right) (Photos: Greenland, R. Hock).

- **Melting snow and cooking** can take hours. Prevent build up of **carbon monoxide** when cooking in a tent or other (semi-) enclosed space. Ensure sufficient ventilation.
- **Cooking shelters** provide excellent protection against wind and precipitation. They also provide a communal space for sharing meals and field preparations and discussions (Fig. 6).



Figure 6: Diagram of a cooking shelter on snow. A tarp or tent fly supported by a trekking pole covers a dug-out kitchen pit with bench seats cut into the snow. The tarp must be pitched high enough above the stove to keep the fabric from burning.

4.2 Snow shelters

A snow shelter is a structure built from snow to insulate against freezing temperatures and wind, using snow's low thermal conductivity to keep the interior above freezing conditions. Snow shelters require packed snow. It is important that the sleeping platform is higher than the entrance, and there are ventilation holes to prevent suffocation and melting. Examples include

- **Snow caves**: A cave dug horizontally into a deep snowdrift, to create a tunnel and a raised sleeping platform (Fig. 7).
- **Igloos**: A dome-shaped structure built from packed snow blocks, ideal for longer-term shelter.

In addition, **windsack shelters** are lightweight, portable and durable emergency shelters (without a floor) that offer rapid protection during bad weather or emergencies (Fig. 7). They can be quickly pulled over field members while sitting on their backpacks, creating a small enclosed space where people's body heat quickly warms the interior, reducing heat loss and the risk of hypothermia.





Figure 7: Snow cave for shelter (left, Photo: Manouchehrmehvar, CC BY-SA 4.0, via Wikimedia Commons). Windsack shelter for two persons (orange) and three persons (red) (right, Photo: R. Hock).

4.3 Clothing and layering

In mountainous terrain, proper clothing layering is critical for thermoregulation and protection against rapidly changing weather conditions. The three-layer system (base, mid, and outer layer) serves as a standard approach to maintaining comfort and safety.

- The **base layer** must prioritize moisture management. Synthetic fabrics or merino wool are optimal, as they wick perspiration away from the skin. Cotton should be avoided due to its poor moisture-wicking properties and slow drying time.
- The **mid layer** functions as insulation, retaining body heat while allowing breathability. Fleece or down materials are commonly used, with the choice depending on activity intensity and ambient temperature. Down is typically warmer than synthetic insulation materials, but loses its insulating properties when wet or damp.
- The **outer layer** layer acts as a barrier against wind, precipitation, and abrasion. A waterproof, breathable shell is essential. Quality-of-life features, such as hoods and ventilation zips, further help adapting to varying conditions.

In addition, accessories play a key role in staying warm and dry. Always carry extra gloves, hats, and socks than anticipated, because once these items get wet, they lose much of their insulating properties. Fingerless gloves are useful for fine motor tasks in the field, such as handling instruments or writing when regular mittens and gloves are too bulky. Waterproof gaiters are also recommended to prevent snow or rain from entering footwear.

5 WEATHER

The weather in cold region environments can be harsh and change quickly. The primary weather hazards are reduced visibility, which increases the risk of becoming disoriented or lost, and cold-related injuries such as hypothermia and frostbite. It's important to research the expected weather conditions for the specific location and time of the year, and frequently check the weather forecast.

5.1 Weather forecast apps

Useful apps/websites for weather forecasts are, for example, ***Windy*** and ***Meteoblue*** *or https://www.yr.no*.

Windy provides detailed forecasts, with the opportunity to choose different forecast models and a wide range of different variables. Different weather models may have different results, and it can be helpful to compare them. Forecasts are updated regularly and become increasingly accurate as they get closer to real time (Fig. 8).

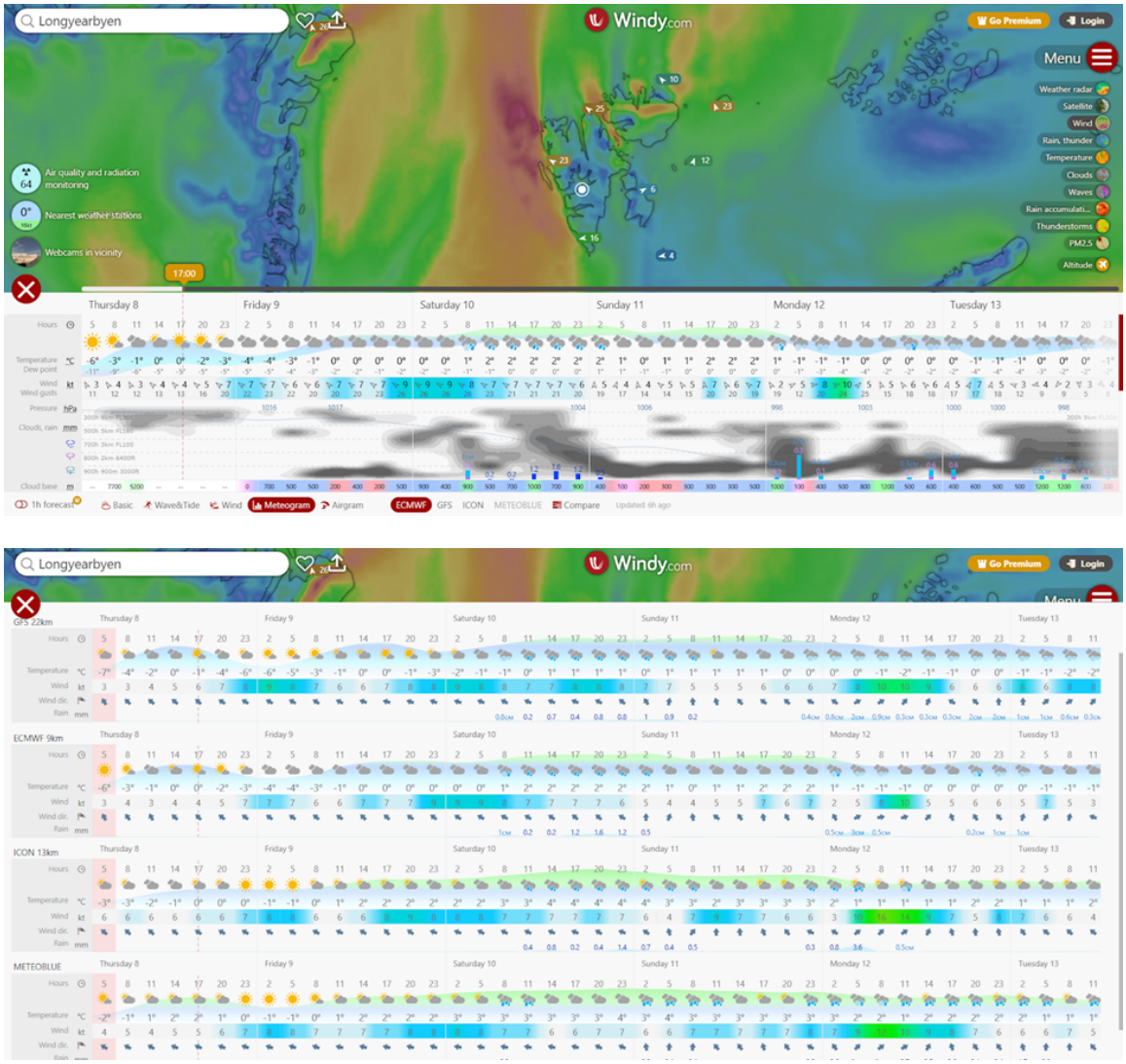


Figure 8: Example of a *Windy* weather forecast for Svalbard (top) and a *Windy* weather forecast comparing different forecast models (bottom).

5.2 Weather precautions

- Check **weather forecast** regularly for any changes or updates.
- **Talk to locals** to learn about typical weather conditions, including whether there are specific areas where the winds tend to be particularly strong.
- Be aware of the **wind chill factor**: strong wind will make the air feel much colder!
- Pack extra clothes, food, and water just in case, even when the forecast predicts good weather.

- When the weather worsens, returning to camp or shelter is more important than continuing the fieldwork as planned and risk getting stuck in a remote area.
- Always inform your designated contact person if you are delayed returning from the field due to weather conditions.

6 WILDLIFE ENCOUNTERS

There is a significant risk of encountering wildlife in cold region environments. While most animals are not inclined to attack unless they feel threatened, do not approach any wildlife, keep a distance of at least 100-200 m and don't leave food, dishes or waste in the field.

6.1 Bears

Precautions:

- **Carry bear spray:** keep it accessible (not in your pack) and know how to use it. Note that bear spray is not allowed inside planes or helicopters, but can be stored in an external helicopter ski basket.
- **Maintain a distance** of approx. 100 m between sleeping tents, cooking area, and food storage (Fig. 9).
- **Secure attractants:** store all food, garbage and toiletries including toothpaste (anything that smells) in bear-resistant containers such as bear bags/barrels (Fig. 9) away from the tent, indoors, or in vehicles.
- **Make noise:** talk loudly, clap, or sing while hiking to avoid surprising a bear, especially near rushing water or in thick brush.
- **If a mother bear is present:** never get between a mother and her cubs.
- **Use electric fences** around camps in high-risk areas.



Figure 9: Precautionary measures when camping in bear country involve adopting the "bear safety triangle" to separate your sleeping area, cooking area, and food storage (left panel), and storing food and other scented products in airtight bear barrels (right panel).

If you encounter a bear and it has noticed you:

- **NEVER RUN:** running can trigger a chase response.
- Stay calm and talk to the bear in low tones.
- Remain still and make yourself look large by standing close together and raising your arms above your head.
- Move away slowly and leave the area or detour.

If challenged/attacked:

- **Use bear spray:** remove safety clip, aim at the bear (be mindful of the wind), spray in quick bursts when the bear is within range (<10 m). If it attacks you:
- **Black bear: FIGHT BACK.** Do not play dead. Use bear spray, rocks or sticks.
- **Brown/grizzly bear: PLAY DEAD.** Leave your pack on, lie flat on your stomach, and cover your neck.

Bluff charges with the bear running toward you but then veering off are common for brown/grizzly bears and black bears. Brown bears can appear almost black, and black bears can be brownish, so coat color alone is not a reliable indicator to tell the two species apart (Fig. 10).



Figure 10: How to distinguish a brown (grizzly) bear from a black bear. Note: Color and size are not reliable indicators. Source: Government of Alberta, https://www.alberta.ca/know-your-bears.

Use extra caution in areas with **Polar Bears**: treat any close approach as serious, since they are more likely to treat humans as prey:

- **Carry a firearm** if permitted (e.g., a 12-gauge shotgun with magnum slugs, or a high-powered rifle).
- **Carry non-lethal deterrents:** flares, bangers, cracker shells, bright lights.
- **Use physical barriers:** electric fences around camps, solid buildings or vehicles as secure shelters.
- **Maintain 24/7 bear watch** when camping in polar bear terrain.

Obtain training in the use of firearms and non-lethal deterrents, and carry them in accordance with local regulations.

If you encounter a bear and cannot safely leave the area, use an appropriate deterrent, such as a flare gun, to try to scare it away.

If a bear charges, shoot to kill, aiming for the chest from the front and the lower shoulder from the side.

6.2 Moose

Moose are frequently encountered in northern environments (Fig. 11). They can be extremely dangerous if they feel threatened, but their threat is often underestimated. Moose can become aggressive when protecting their young, during mating season, or when they feel cornered or harassed. They can charge, knock people down, and stomp on them, which can lead to serious injury or death.



Figure 11: Moose on a road in Alaska (Photo: R Hock).

- **DO NOT** approach a moose but back away.
- If a moose charges towards you: RUN! Try to get out of its way and duck behind obstacles (e.g., tree).
- In case of an attack: curl into a ball and protect head and stomach.
- Moose encounters on the road can result in a deadly collision. Scan ahead to both sides of the road when driving.

7 COMMUNICATION SYSTEMS

Effective communication is essential in the field, both for routine check-ins and in case of emergency situations. Various communication devices are suitable for such cases, but a few general tips apply to all communication systems:

- Ensure batteries are charged before going to the field.
- Bring spare batteries.
- Always have at least two devices per team.
- Carry devices on you (e.g., do not leave in the helicopter, snowmobile, at camp).

Common devices are:

Personal Locator Beacons (PLBs)

- Only for emergency situations
- Sends emergency rescue signal to national agency; no two-way communication
- No subscription required, ~7-year battery life, works globally

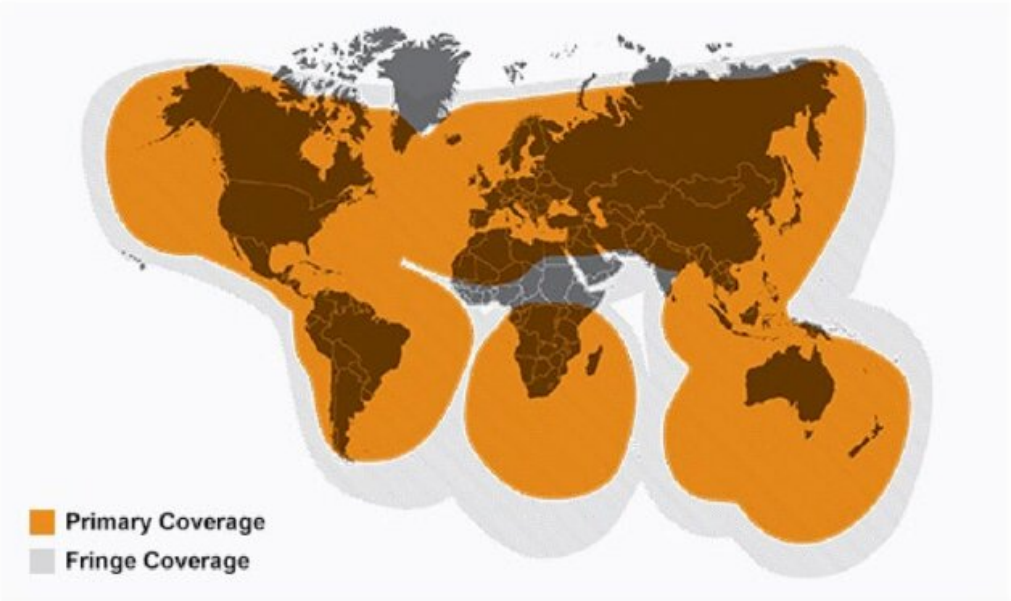


Figure 12: Globalstar network coverage used by SPOT Messenger devices (Source: Štambuk and Malarić, 2024, licensed under CC BY 4.0).

Garmin InReach

- For emergencies, tracking and short text messages
- Global coverage using Iridium (the only satellite network that provides 100% global coverage, including polar regions)
- Requires monthly subscription, but devices allow real-time tracking and two-way communication

SPOT Messenger

- For emergencies, tracking and short text messages
- Limited coverage at high latitudes due to reliance on the Globalstar satellite network (Fig. 12)
- Requires monthly subscription, but allows real-time tracking and two-way communication

Handheld radios

- For local communications (e.g., between field teams)
- Good for line-of-sight communications
- ~1 km range per watt power (radios up to 2 W permitted in Canada, 5 W in USA)

Other communication devices

- **Satellite phones**: Be aware of coverage and know which numbers to call (national emergency numbers such as 911/999/112/119 typically don't work).
- **Phones**: iPhone models 13 or later work with Globalstar's satellite network for Emergency SOS and satellite messaging, but map coverage is greatly reduced compared to dedicated devices like the SPOT Messenger. They can also work on Starlink through a new "Direct-to-Cell" service for satellite texting and data in areas without cellular coverage, but require iOS updates and a participating carrier. Other brands and devices have (or are beginning to offer) similar satellite capabilities, but these solutions are still less polished and less standardized than Apple's Globalstar integration.

8 USEFUL KNOTS

Knots are a critical part of glacier and climbing safety, because they connect you reliably to your rope team and to the gear that is supposed to catch you if you fall. Most relevant knots for fieldwork in glacierized or steep terrain are described below.

8.1 Figure-8

Purpose
The figure-8 knot is one of the safest ways to tie someone into a rope, while it is also relatively easy to untie after being loaded. Its design allows for easy visual inspection and makes it less prone to jamming than other stopper knots.

How to tie?
First tie a simple figure-8 approximately 90 cm from the end of the rope. Then, thread the rope through the harness's tie-in points and trace back along the figure-8 pattern (Fig. 13, top).

The Figure-8 can also be tied "on a bight" (Fig. 13, bottom), to create a fixed loop in the middle of a rope, which can be clipped into carabiners, anchors, or used for various climbing and rescue applications (Section 10.4).

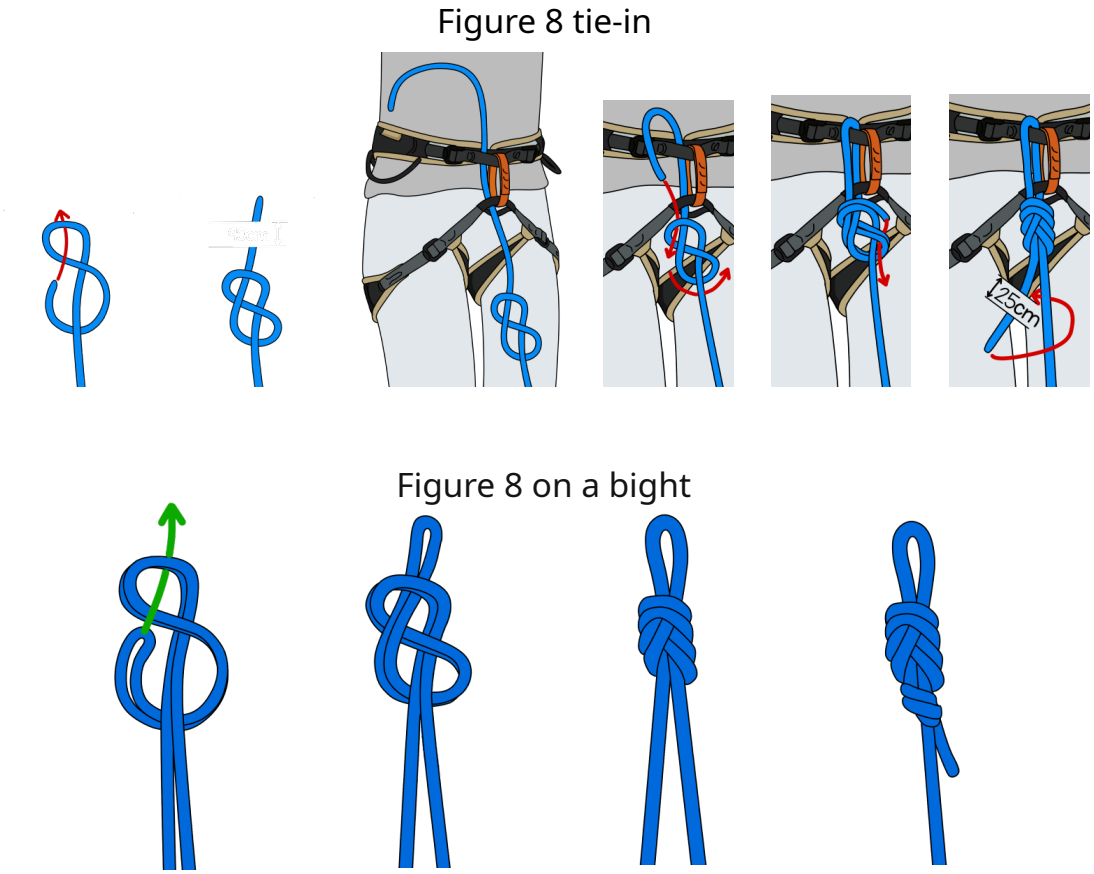


Figure 13: Top: Figure-8 follow-through or tie-in as used to tie into a harness loop, Bottom: Figure-8 on a bight, used to form a loop, for example, to clip into a carabiner (Source: https://www.vdiffclimbing.com/).

8.2 Friction hitches

Purpose
Friction hitches or locking knots are a type of sliding knot tied around a rope (usually with a smaller cord) that can move freely when not weighted but locks firmly in place when loaded. They are commonly used to hold tension on a line, acting as "ratchets" to capture progress on a rope, used for example when ascending a rope or backing up a rappel. Three types are common: Prusik, autoblock (French Prusik) and Klemheist (Fig. 14):

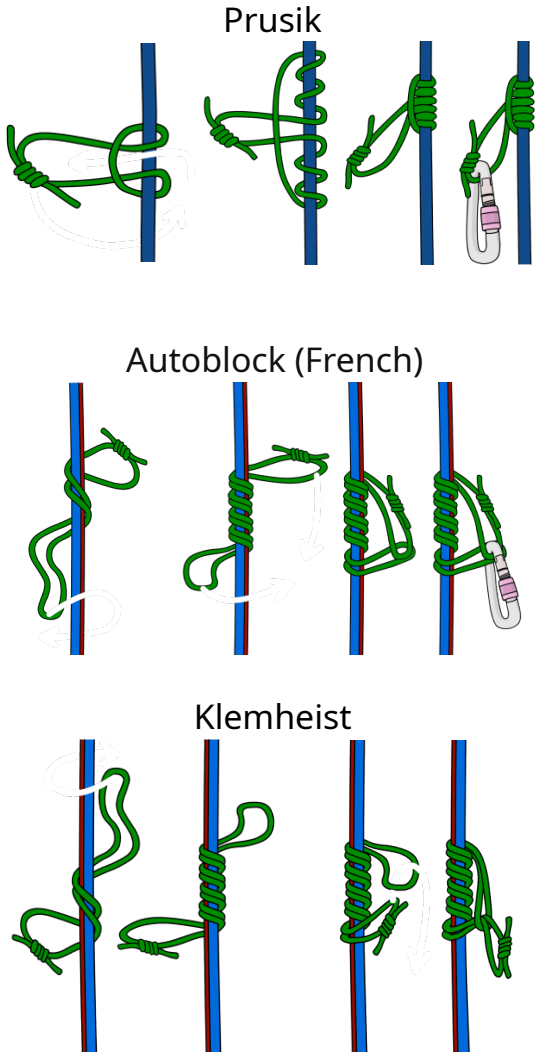


Figure 14: Different types of friction hitches (Source: https://www.vdiffclimbing.com/).

Prusik
The Prusik hitch is tied using a loop of cord wrapped around a main rope two or three times inside itself, then pulled tight. When weighted, it grips the rope securely, but slides easily when not under load. The Prusik can slip on icy or muddy ropes and may cause wear to the rope if left under tension for extended periods.

Autoblock
The Autoblock hitch is created by wrapping a loop of cord or webbing around the rope, then clipping a carabiner through both ends the loop. It automatically locks when weighted and slides when not. The Autoblock is quick to set up and works well with a carabiner, but it can be less secure on slippery or icy ropes and is not as strong as a Prusik for heavy loads.

Klemheist
The Klemheist is tied by wrapping a loop of cord around the rope with the end threaded through the wraps and pulled tight. The Klemheist is intended for a load in one direction only: it grips the rope when loaded and slides when not. It is especially useful for hauling or as a progress capture and offers more security than a Prusik on icy or muddy ropes, but it is bulkier and harder to adjust.

8.3 Clove hitch

Purpose
A simple hitch is used when you need to be able to feed slack through it (Fig. 15). This can be used to hitch a sling to an ice axe, ski pole, or other object for a snow anchor.

How to tie?
Wrap the rope around a carabiner or post once, then wrap it around a second time so the second loop crosses over the first. Pull both strands to snug the hitch in place.

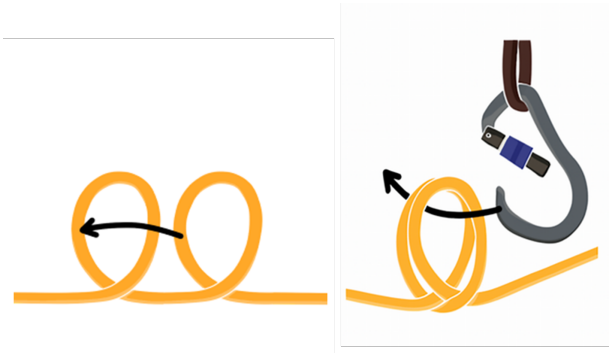


Figure 15: Clove hitch (Adapted from: https://www.vdiffclimbing.com/).

8.4 Overhand knot

Purpose
The overhand knot is a simple stopper knot that is slightly weaker than a figure-8 in terms of strength (Fig. 16). It is used to prevent rope from fraying or slipping through holes. It is a quick and easy knot but can be hard to untie after loading.

How to tie?
Make a loop in the rope by crossing the working end over the standing part. Pass the working end through the loop and pull both ends to tighten the knot.

8.5 Munter hitch

Purpose
Versatile knot particularly used for belaying and rappelling without the need for a belay device (Fig. 17).

How to tie?
Form a loop in the rope and twist it once to create a second loop, then clip both strands of the twisted loop into a locking carabiner. Lock the carabiner and pull on the rope to ensure it flips into the correct braking position.

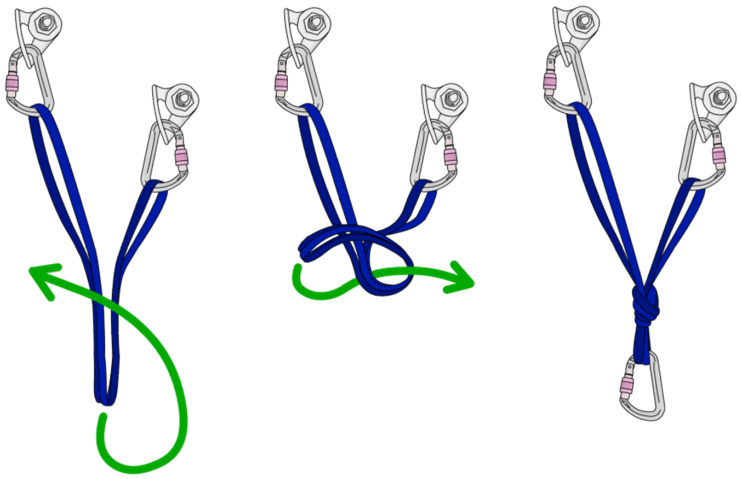


Figure 16: Overhand knot on a sling (Source: https://www.vdiffclimbing.com/).

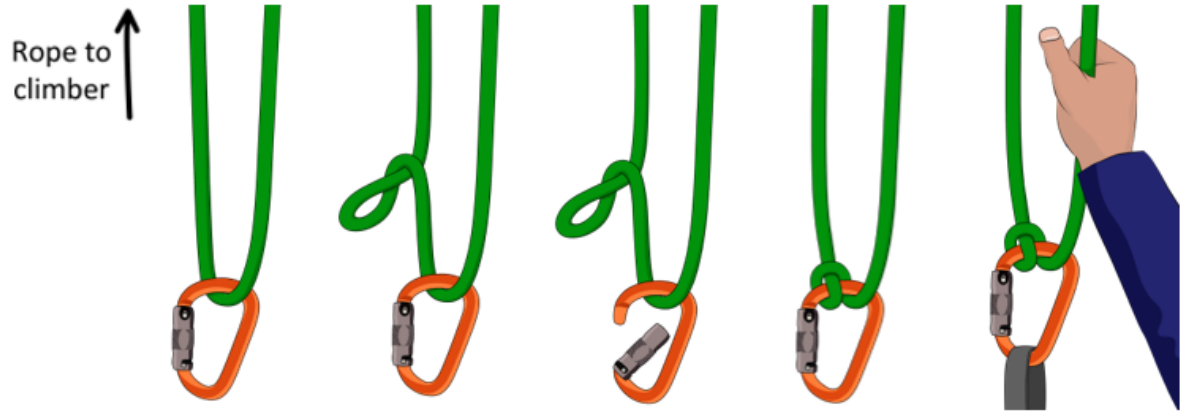


Figure 17: Munter hitch (Adapted from: https://www.vdiffclimbing.com/).

8.6 Brake knot

Purpose

A brake knot is used on a two-person glacier rope team to increase the chances that the person still on the surface can hold the fall if their partner drops into a crevasse (Fig. 18). This knot provides a larger size knot than other knots that can be used for this purpose and therefore offers more friction against the snow.

How to tie?

Start with a standard figure-8 on a bight, with a loop of about 30 cm. Next, tuck the loop around the knot and pass the loop back through the upper part of the figure-8, then snug down each strand to dress it. The final loop created should be about 10 cm tall.

8.7 Double Fisherman's knot

Purpose

A strong, compact bend used to join two rope ends, commonly for making prusik loops or joining two ropes for glacier travel systems (Fig. 19). The knot holds securely under high and repeated loads and is unlikely to slip. Its main drawback is that it can jam tightly after loading, making it difficult to untie.

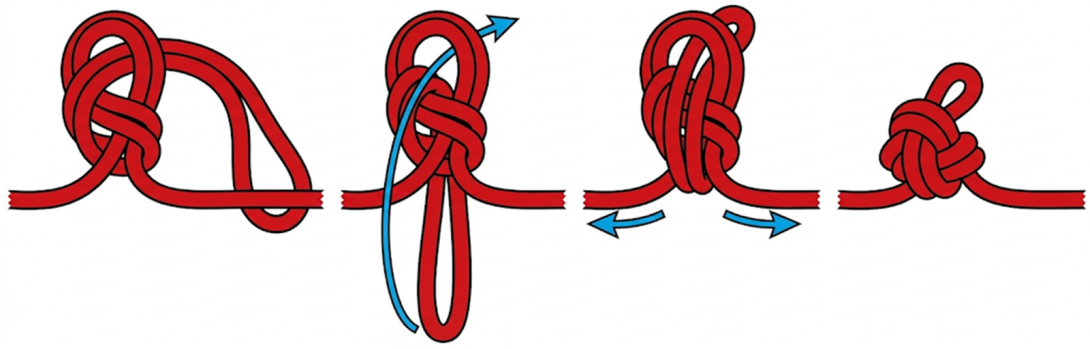


Figure 18: Brake knot (Source: https://www.alpenverein.de).

How to tie?
Lay the two rope ends parallel, overlapping each other, then wrap one end around the other rope twice and pass it back through the two wraps to form a double overhand knot. Repeat the same process with the other end around the opposite rope, then pull both standing parts to slide the knots together tightly.

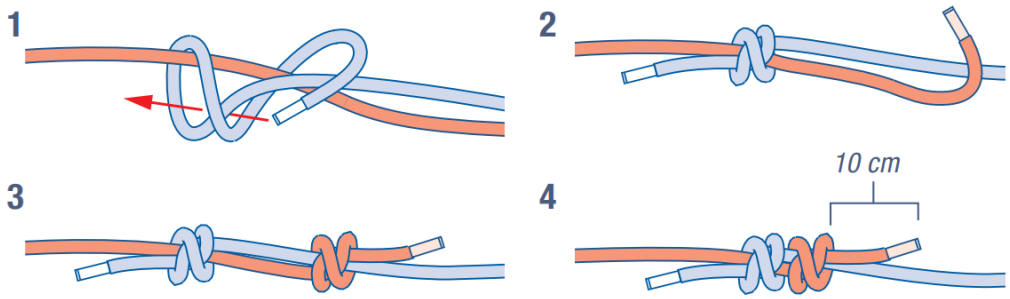


Figure 19: Double fisherman's knot (Source: Swiss Alpine Club).

9 GLACIER TRAVEL

9.1 Risks

Glacier travel carries many dangers — particularly crevasses, moulins, glacial streams, glacier caves, and steep and unstable moraines — so careful route planning, proper equipment, and glacier-travel training are essential.

Moulins are natural vertical holes in a glacier formed by flowing meltwater that drains surface water down through the glacier, often to the glacier's base (Fig. 20). Moulins often form when a supraglacial meltwater stream hits a crevasse. They can be up to several tens of meters deep on valley glaciers and more than a hundred meters deep on the Greenland and Antarctic ice sheets. They enlarge as more meltwater enters them; diameters can vary widely, from under 1 m to several metres.

Crevasses are deep cracks at the glacier surface (Fig. 21, 22) and can be tens of meters deep. They typically form where the glacier's flow rate changes due to variations in ice thickness, slope, or friction along the bed and margins (Fig. 21). Steep sections of a glacier are therefore often highly crevassed.



Figure 20: Examples of moulins. Snow still conceals the moulin on the right, even though the surrounding area is snow-free (Photos: I. Bij de Vaate, R. Hock).

- **Moulins and crevasses** often occur in roughly the same areas on a glacier (Fig. 21), but their exact location, size, frequency and shape change from year to year and even from day to day. Spatial patterns can also shift as the climate (and thus the shape of the glacier) changes. During a glacier surge (characterized by abnormally fast flow over months to years), glaciers are often highly crevassed, even in areas that were previously crevasse-free.
- While visible on bare ice, they are particularly hazardous when covered by a layer of snow making them hard to spot. They are most dangerous in late spring when rising air temperatures melt and weaken snow bridges, and in early winter, when those bridges are still too thin to bear the weight of a person. During the melt season snow cover often lingers longer on top of crevasses and moulins than the surrounding ice.

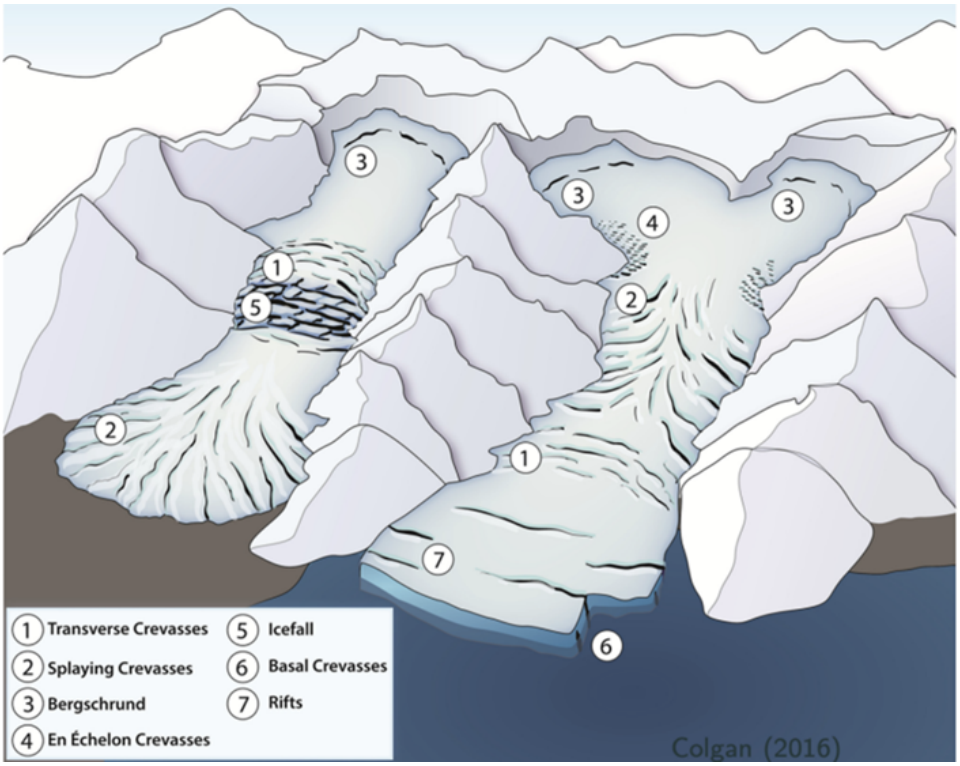


Figure 21: Schematic showing typical location of crevasses on a glacier (Colgan et al., 2016).



Figure 22: Crevasse field, ice cave, glacial stream and debris-covered glacier ice including ice cliffs (Photos: R. Hock).

Supraglacial streams evolve seasonally on bare ice and erode channels into the ice that can be several meters wide and deep (Fig. 22). Jumping across such channels can be risky because the banks are slippery, and a fall can be fatal if someone is swept downstream into a moulin. Wear crampons or microspikes!

Subglacial channels and ice caves are tunnels within or beneath glaciers carved by flowing meltwater (Fig. 22). While fascinating features, they pose severe risks since they can collapse anytime due to ice flow and melt. Avoid entering ice caves during the melt season! Wear a helmet!

Debris cover on many glaciers' lower parts creates rough, hummocky surfaces with ice cliffs and ponds that are hard to navigate (Fig. 22). The thin (often only a few cm thick) layer of sharp, unconsolidated rock debris provides poor footing and carries a high risk of slipping.

Rockfall is a potential hazard, especially on glaciers with steep, precipitous adjacent valley walls, and it can be triggered either naturally or by people. Also, ice collapsing from steep disintegrating glacier fronts can pose serious danger.

Glacier lake outburst floods pose one of the most devastating glacier hazards, caused by sudden drainage of lakes dammed by the glacier or nearby moraines.

9.2 Route finding

Travel on exposed ice rather than snow-covered areas! Snow can hide crevasses, moulins and meltwater streams beneath weak snow bridges. Bare ice is generally safe to walk on, but wear crampons or microspikes to avoid slipping.

- **Never step on isolated rounded or elongated snow patches** which are indicative of dangerous voids such as moulins and crevasses (Fig. 20).
- **Avoid hazardous zones** (crevasses, moulins, streams . . .) whenever possible.
- **Use historical knowledge**: Review recent photos and satellite imagery to identify persistent patterns of crevasses, moulins and supraglacial streams, and speak with local guides or researchers familiar with the glacier.
- **Time your fieldwork carefully**: Late winter or early spring is usually safer than early-winter or late spring when snow bridges are most deceptive and least stable.

9.3 Roping Up

Always rope up when traveling in the accumulation area or over other snow-covered sections of a glacier.

Building a rope team

- A rope team typically includes three or four people. Teams of two are risky. At least two team members should possess expert-level training in crevasse rescue.
- The minimum length of rope required for glacier travel is 40 meters for a team of two and 50 meters for a team of three or four.
- The distance between team members depends on how many people are on the rope and should be between approximately 12 and 20 m, and should be equal between all team members (Fig. 23).
- Put the least experienced person(s) in the middle.
- If possible, distribute the group's weight toward the rear so the back can act as an anchor; the lead is at greater risk of falling into a crevasse.
- Optional: Add friction knots to the rope between people to help arrest a crevasse fall - note that this only works if the surface of the glacier is snow-covered.

Walking on a rope team

- Walk in the same track as the person in front of you.
- Keep the rope fairly tight; it should NOT be dragging on the ground.
- Carry your ice axe in the uphill hand (switch hands when changing direction as necessary). Hold the head of the axe, with the spike facing backward to avoid self-injury if you stumble.

Other considerations

- Static ropes are better for crevasse rescue than dynamic ropes, because they prevent the victim from bouncing around.

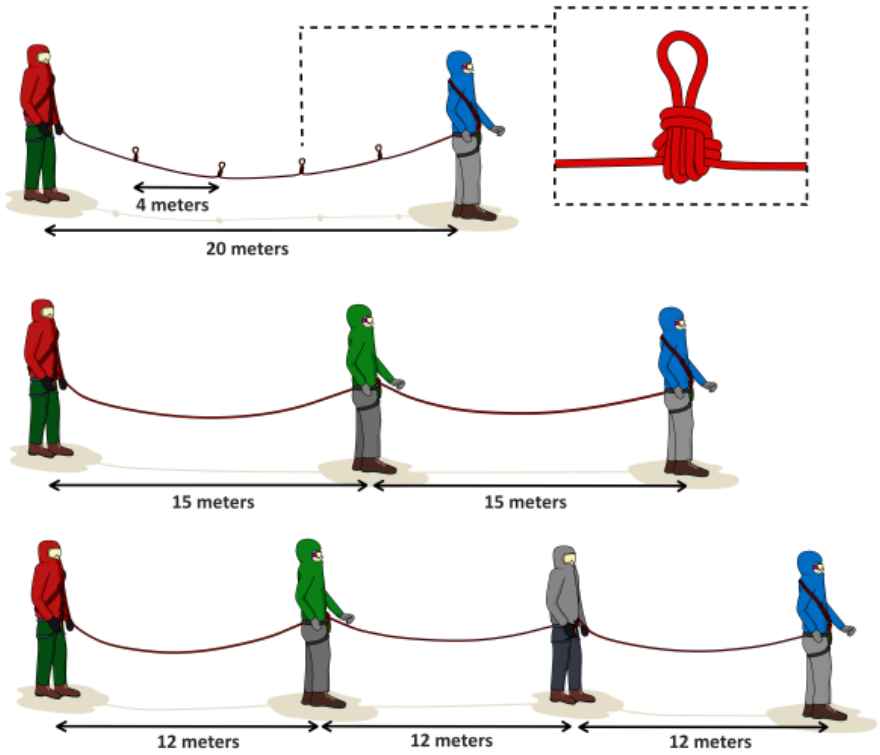


Figure 23: Roping up on a glacier (Source: https://www.vdiffclimbing.com/glacier-travel-using-rope/).

- Carry multiple prusiks, cordelettes and carabiners, as these are very versatile in the event of a rescue.
- Skis make crevasse falls less likely, but can complicate a rescue.

10 CREVASSE RESCUE

Techniques and hauling systems for crevasse rescue vary widely between regions and change over time. Different countries and guiding cultures favor specific setups. As equipment and techniques evolve, recommended systems shift. Accordingly, this guide focuses only on core principles of a crevasse rescue, including mechanical advantage and progress capture, and presents a few common options. Field parties should stay current with practices taught by professional instructors and practice these skills regularly.

The core of any rescue system is to set up a stable anchor, transfer the load of the fallen person securely to that anchor, and then set up a hauling system that provides mechanical advantage to minimize the effort required to pull the person out (Fig. 24).

10.1 Arresting a fall

If someone on a rope falls into a crevasse, the immediate priority is to stop any further movement of the fallen person. To do so all teammates should immediately drop to the ground, and perform a self-arrest by driving the ice axe head firmly into the snow. Do not stand up until the fallen person is secure and the rope is locked.

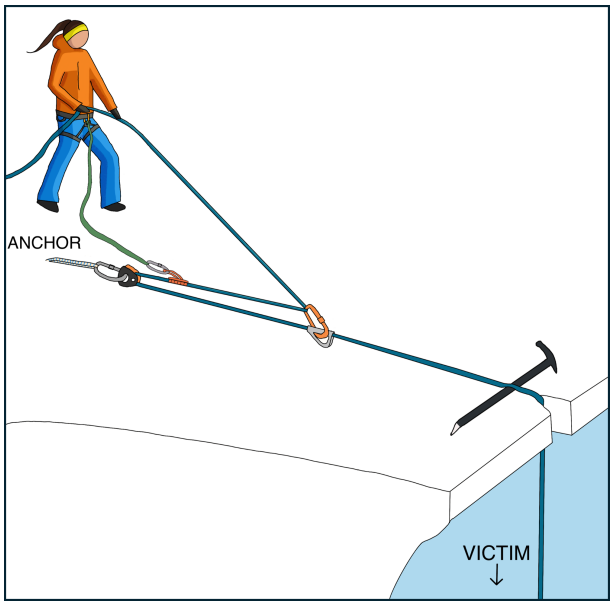


Figure 24: Components of a 3:1 crevasse rescue haul system (Source: Satu Innanen).

10.2 Building an anchor

Once the fall is arrested, set up an anchor (Figs. 25, 26). The rescuer(s) need to transition the load with the weight of the fallen person from their harness to a stable anchor so they can move freely and begin rescue operations.

When building an anchor, a useful mnemonic to remember is ***IDEAS***:

- ***Independent***
  - Each piece of protection (ice screw, picket, etc.) should be as independent as possible so that failure of one does not compromise the others.
- ***Direction***
  - The anchor should be placed so its load is directed straight toward the victim to lower the risk of anchor failure and to make hauling more efficient.
- ***Equalized***
  - Each piece (e.g., ice screw) should carry the same amount of stress.
- ***Angle***
  - The angle formed by the sling between the two anchor points should not exceed 60 degrees.
- ***Safety***
  - The system should be redundant, clean (no clutter) and backed up (double-check that carabiners are locked).

Building an anchor on ice

Necessary equipment: 2 ice screws (16-22 cm long), 3 locking carabiners and 1 sling

1. Place two ice screws in solid ice, about 30-60 cm apart; typically one screw is roughly 10-20 cm closer to the victim than the other (Fig. 25).
2. Attach one carabiner to each ice screw.
3. Clip the sling into each carabiner. Pull down the middle of the sling to form a V which should create an angle of $<$60 degrees between ice screws. There should be equal tension on both sides of the sling when bearing weight.

4. Tie an overhand knot or a figure-8 knot on a bight in the middle of the sling to form a loop (master point, Fig. 25a) OR use the *Twist Method*: Create a twist in one strand of the sling (Fig. 25b).
5. Attach a carabiner to the loop created below the overhand knot or through both the twisted loop and the other strand. This carabiner is then attached to the rope which holds the load. Check that all carabiners are locked before using the anchor system.

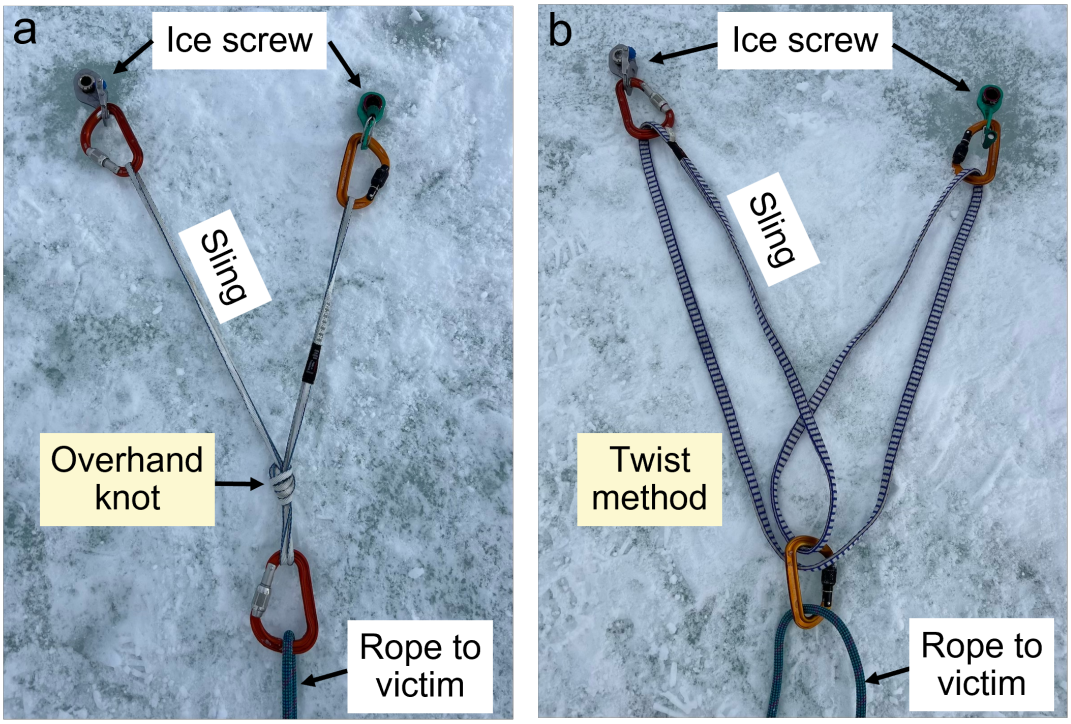


Figure 25: Ice anchor using (a) an overhand knot to isolate the master point and (b) the "Twist Method". In complex terrain, method (a) can unevenly load the two points, while method (b) risks shock-loading the remaining screw if one fails.

Building an anchor on snow

Necessary equipment: 1 snow anchor to be buried (e.g., ice axe or picket), 1 long sling and 1 locking carabiner

1. Bury an object ("deadman") such as an ice axe, skis, snow shoes or a backpack into the snow to create a secure, load-bearing anchor point: Dig a trench for the object, long enough for its full length of and deep enough that it holds under load. The object's long axis should be oriented perpendicular to the direction of the applied load (Fig. 26).
2. Tie a 120 cm sling around the centre of the object.
3. Dig a small trench in the snow in the direction of the victim to place the sling.
4. Backfill the trench with the object and sling with snow and compact thoroughly. The deeper and more densely packed, the more secure the anchor will be.
5. Attach a carabiner to the sling.

If the snow is firm, you can also insert a top-clipped picket vertically into the snow as an anchor.

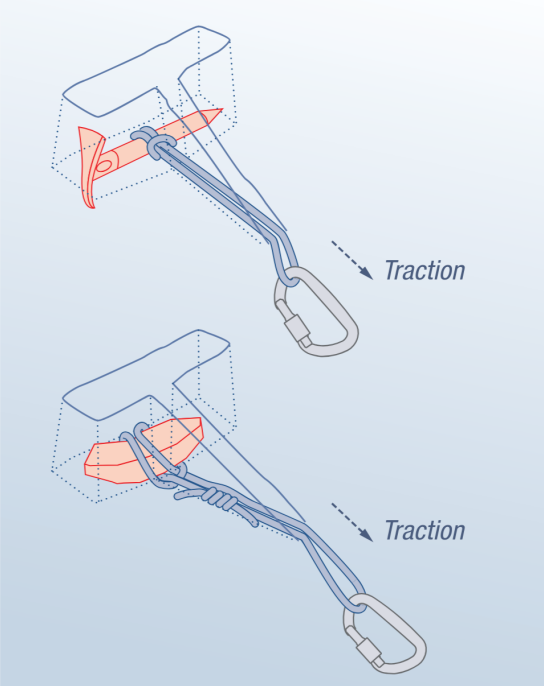


Figure 26: Schematic of a snow anchor with an ice axe and another object such as a backpack (Source: Swiss Alpine Club).

10.3 Preparing for the rescue

Two key elements in any crevasse rescue hauling system are

- ***progress capture***, a device that is placed on the anchor rope, close to the anchor, to act as a one-way brake: once you pull the rope with the victim and then let go, the rope cannot slide back. You can use a friction hitch (Fig. 14) or a progress capture pulley (Fig. 27). This allows the hauling team to reset their system safely and efficiently for the next haul without losing gained progress or risking shock loads.
- ***tractor***, which refers to the primary friction hitch or locking device that attaches the hauling system to the rope leading to the victim (Fig. 27). It is the component that moves back and forth to "pull" the load.

- **Off-load the victim's weight to the anchor**
  The person who built the anchor must take the load off their body and fully transfer the weight of the victim onto the anchor.

  1. Instal a **progress capture** close to the anchor either
     (a) by tying a **friction hitch** (Fig. 14) onto the loaded strand of rope, i.e., the strand that goes to the victim, and clip the loop to the carabiner on the anchor, *OR*
     (b) by attaching a **progress capture pulley** (e.g., a micro traxion) to the loaded strand of the rope and attach it to the carabiner of the anchor.
  2. Gently release the tension of the rope from the rescuer´s harness to the anchor, so that the load goes onto the progress capture attached to the anchor.
  3. Ensure that you are always secured yourself: Tie in to the rope below the anchor with a personal prusik loop and then remove your figure-8 knot.

Now the anchor, not your body, is holding the victim's weight, and you are free to move and conduct the rescue.

- **Check on the victim**
  If you cannot hear/see that the victim is OK, send someone to check on them. If the first person on the rope fell, the rescuer can be either the person at the back (who can remain tied to the rope) or the person nearest to the victim (secured by a prusik loop). This person calls to the victim to assess responsiveness and any injuries.

- **Reduce rope friction at the crevasse lip**
  If possible, remove loose snow from the lip of the crevasse and place an ice axe or a backpack under the rope close to the lip to reduce friction when hauling up the victim. Secure the ice axe or backpack to the rope with a prusik loop and carabiner.

10.4 Haul systems and rescue

The 1:1 and 3:1 haul systems are most common. The same principles apply regardless of who on the rope team falls in (e.g., the first versus the middle person).

- **1-to-1 haul system**
  Direct-pull method in which the fallen person is lifted by pulling the rope away from the crevasse, with the pulling force approximately equal to the weight of the load. It is effective when multiple rescuers are available and when the victim can assist in their own rescue:

  1. Restore tension to the line by spreading the rope team out.
  2. Pull by walking away from the crevasse until the victim is out.

- **3-to-1 haul system (single mariner)**
  A system that allows the rescuer to pull with three times the force of a direct pull (Fig. 27), and thus should be used when the 1:1 haul system fails.

  1. Walk the free strand of the rope a few meters down toward the crevasse and connect it to the loaded strand with a **tractor**: Tie a **friction hitch** (Fig. 14) on the loaded strand or attach a **mechanical ascender/rope clamp** (e.g., a Tibloc) to it.
  2. Clip a locking carabiner into the hitch loop or the ascender/rope clamp (if not integrated).
  3. Clip the free strand of rope into that carabiner.
  4. Feed the rope through the carabiner or add a pulley if you have one.
  5. Pull the rope coming out of the pulley or carabiner until the ascender or friction hitch reaches the anchor.
  6. Move the tractor (ascender or friction hitch) down the rope as far as possible.
  7. Repeat steps 5 and 6 until the victim is out. Make sure the rescue team is secured to the anchor or the loaded rope at all times.

  If you use a friction hitch, use a smaller-diameter prusik cord than the main rope so it can bite properly. As a rule of thumb, choose a prusik cord with a diameter about 60–80% of the main rope's diameter, typically 2–3 mm thinner than the rope. For example, pair a 10 mm rope with a 6–7 mm cord, a 9 mm rope with a 6 mm, and a 8 mm rope with a 5–6 mm cord. If the rope is icy, wet, or muddy, friction hitches may slip under load. In these conditions, mechanical devices such as progress-capture pulleys or mechanical ascenders are preferred.

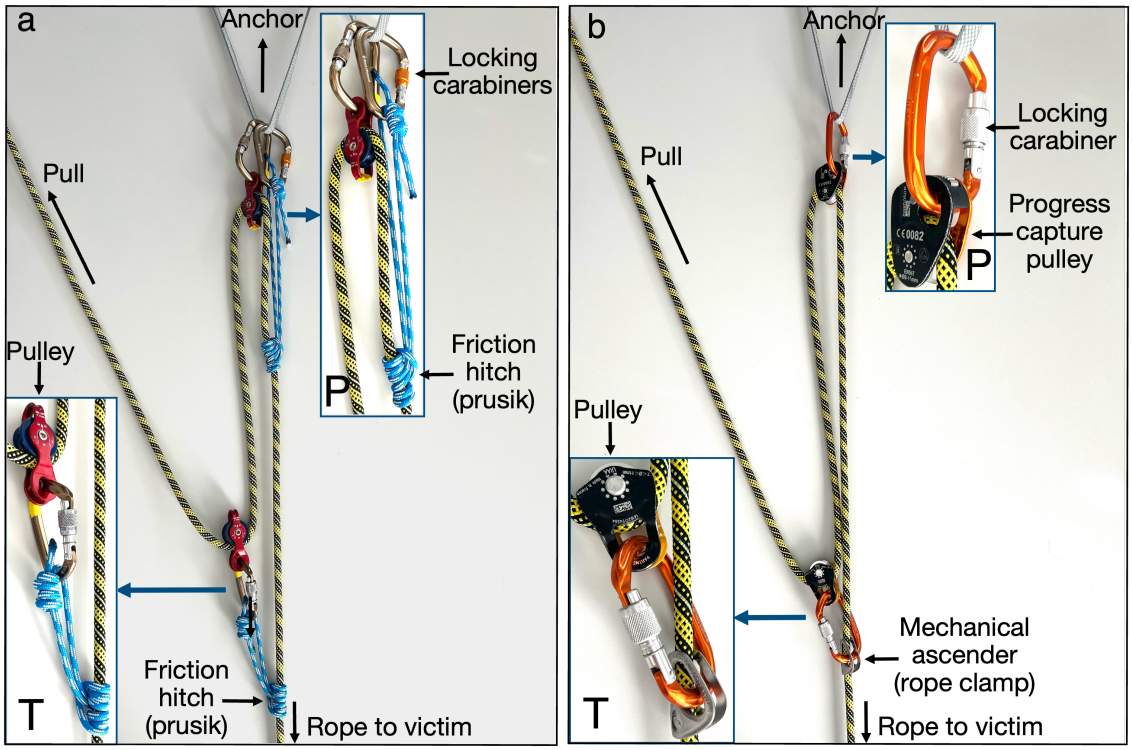


Figure 27: Set-up of a 3:1 crevasse rescue haul system (also known as a single mariner). Boxes show zoomed-in views of a tractor (T) and progress capture (P). (a) Both T and P are provided by friction hitches (here, prusiks). (b) T is provided by a mechanical ascender and P by a progress-capture pulley. In (a) the rope can also run directly through the carabiner of the tractor, but pulleys reduce friction and make hauling easier.

- **7-to-1 haul system (double mariner)**
  A 3:1 haul works well for a large team rescuing one victim but is nearly impossible with a single rescuer and an incapacitated victim. In that case, use a 7:1 double mariner (Fig. 28), which is more complex and should only be used by trained teams with the proper gear.

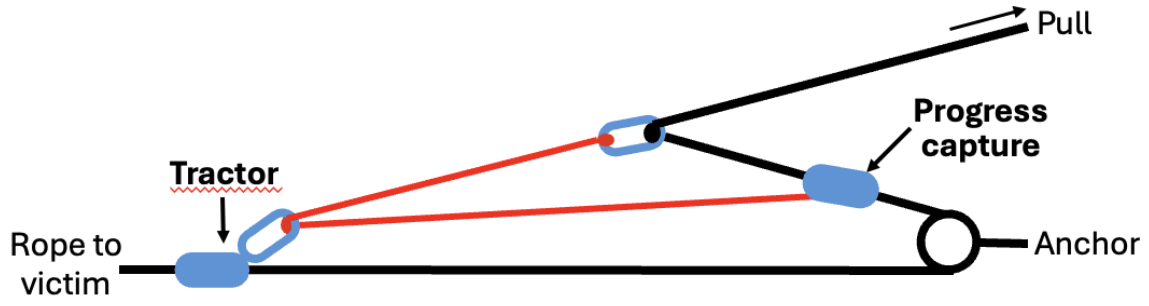


Figure 28: Schematic of the 7:1 haul system (also known as double mariner). Note the use of an extra 5 m long cordelette (red) compared to the simple mariner. See Fig. 27 for device options for tractor and progress capture.

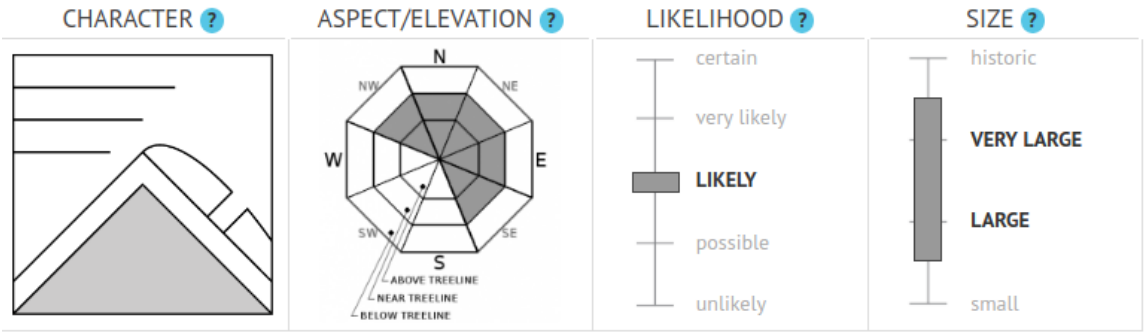


Figure 29: Example of an avalanche bulletin in the USA describing an avalanche problem (here a wind slab), and in dark grey the elevations and aspects where you most likely find the problem, as well as the likelihood and expected size of avalanches.

11 AVALANCHE SAFETY AND RESCUE

This section is not a substitute for professional avalanche training. Obtain accredited avalanche education and refresh your knowledge and skills on a regular basis!

11.1 Types of avalanches

An avalanche is any gravity-driven slide of snow — from a small, harmless sluff adjusting to a new angle of repose to a massive, destructive flow of snow, ice, and debris capable of destroying everything in its path.

Avalanches can be categorized in two main types (McClung and Schaerer, 2006):

- **Loose-snow avalanches**, which start at a single point and spread out as they move downslope.
- **Slab avalanches**, caused by failure of a weak layer at depth, resulting in the destabilization of a whole section of a slope. They are usually more dangerous.

Prime terrain for avalanches are slopes between 30 and 45°. On steeper slopes, loose snow sluffs off frequently, which often prevents thicker avalanche-prone slabs from forming. Lower-angled slopes don't usually avalanche because the pull of gravity along the slope is too weak to overcome the snowpack's strength, but they can still be hit if they lie in the runout zone of a steeper avalanche path.

An exception are **slush flows (or slush avalanches)** which can release on gentle slopes less then 10°, making them a distinct and dangerous hazard. They form when the snowpack becomes completely saturated with water.

11.2 Avalanche problems

An avalanche problem is a specific categorization of avalanche danger to identify the type, location, and likelihood of an avalanche (Fig. 29). It describes the character of the instability rather than just the danger level, serving as a crucial tool for predicting avalanche behavior. The five types of avalanche problem described by the European Avalanche Warning Services are:

European Avalanche Danger Scale (2018/19)				
	Danger level	**Icon**	**Snowpack stability**	**Likelihood of triggering**
5	very high		The snowpack is poorly bonded and largely unstable in general.	Numerous very large and often extremely large natural avalanches can be expected, even in moderately steep terrain*.
4	high		The snowpack is poorly bonded on most steep slopes*.	Triggering is likely, even from low additional loads**, on many steep slopes*. In some cases, numerous large and often very large natural avalanches can be expected.
3	considerable		The snowpack is moderately to poorly bonded on many steep slopes*.	Triggering is possible, even from low additional loads**, particularly on the indicated steep slopes*. In certain situations some large, and in isolated cases very large natural avalanches are possible.
2	moderate		The snowpack is only moderately well bonded on some steep slopes*; otherwise well bonded in general.	Triggering is possible, primarily from high additional loads**, particularly on the indicated steep slopes*. Very large natural avalanches are unlikely.
1	low		The snowpack is well bonded and stable in general.	Triggering is generally possible only from high additional loads** in isolated areas of very steep, extreme terrain*. Only small and medium natural avalanches are possible.

Figure 30: European Avalanche Danger Scale (Müller et al., 2025). Danger level 5 terrain is extremely dangerous and should be avoided by all means. Danger level 4 indicates very dangerous conditions and travel is not recommended. Danger level 3 indicates dangerous conditions; heightened caution, and conservative decision-making are essential. Danger level 2 requires careful snowpack evaluation. Identify terrain features of concern. The danger scale is largely consistent with the North American Avalanche Danger Scale (Statham et al., 2010).

- **New snow**: Newly fall snow that lacks of cohesion. Avalanches occur because the fresh snow is weak or adds extra load to existing weak layers. The problem is widespread, often affecting all aspects, and usually lasts for a few days after the snowfall event.
- **Wind slab**: Denser, often harder snow deposits formed by wind transporting and packing snow on leeward slopes, behind ridges, in gullies, and other other wind-sheltered locations. These slabs typically rest on weaker underlying snow layers and can be easily triggered, especially near ridgelines and convexities.
- **Persistent weak layers**: A buried weak layer (e.g., faceted crystals, depth hoar, surface hoar, or crust-related weaknesses) which can persist for weeks to months. The overlying snow can form a cohesive slab that is prone to avalanching.
- **Gliding snow**: The entire snowpack slowly sliding on the ground due to poor bonding at the snow–ground interface. Such full-depth avalanches are difficult to predict in time but often recognizable by glide cracks.
- **Wet snow**: Snow that has been weakened by liquid water from melting or rain.

11.3 Route planing

- **Use maps and apps** including angle shading to identify avalanche prone terrain based on slope.
- **Check weather report and local avalanche bulletin/forecast**, which provides a danger rating (typically on scale 1 (low) to 5 (extreme), Fig. 30), and information on the avalanche problem(s), probability and aspect and elevation where the problem(s) are worst (Fig. 29). Note that the danger level applies to a region, not to individual slopes. Most avalanche fatalities occur at danger level 3. Key resources include, for example, Avalanche.org (USA), Avalanche Canada, European Avalanche Warning Services (EAWS) and varsom.no (Norway).
- **Avoid terrain traps**, where snow can pile up such as steep, open slopes, gullies, depressions, flat areas immediately below steep slopes, and areas with recent snow or wind loading. The safest terrain is typically on broad ridges or through dense, mature forests.

11.4 On-the-ground red flag signs

These factors, especially in combination, can indicate that the snowpack is unstable:

- **Recent avalanches**: especially on terrain with same aspect/elevation you're on
- **Cracking**: shooting cracks around your skis/boots
- **Whumphing**: The snowpack settles with a "whumpf" sound indicating a weak layer collapsing under your weight.
- **Heavy snowfall**: e.g., $>$2 cm/hour
- **Strong wind loading**: snow drifts, plumes on ridges, pillows on leeward slopes
- **Rapid warming, melting**: especially after fresh snow and previously cold conditions

11.5 Snow instability tests

These tests artificially load a small part of the snowpack to identify weak layers and assess how likely a real slope is to avalanche under similar conditions. We describe two examples below.

Snow instability tests are indicators; they can not guarantee safety. They sample only a tiny portion of the snowpack, so results may not be representative and must never override clear red flags or a high avalanche danger rating.

Standard compression test
The test (Figs. 31, 32) works best for weak layers in the upper snowpack, giving information about their triggering potential, but is not ideal for deep weak layers (e.g., more than 1 m below the surface).

- **Pick a safe spot** with representative slope with conditions similar to those of the slope you plan to travel across.
- **Dig a snow pit** about 1 meter wide and deep enough to reach possible weak layers. Make a vertical, smooth wall face with your shovel blade. The face should be in the shade.

- **Examine the snow hardness** using your hand/fingers to identify weak layers. Press into the wall face with steady, moderate force, until you can no longer penetrate. For each layer, working from the surface down, use the following sequence:
  - Your whole fist in (F)
  - Four fingers (4F)
  - One finger (1F)
  - Pencil (P)

  Weak layers are the ones you can easily penetrate with your whole fist or with four fingers.
- **Cut out a snowpack column** about 30 cm wide and 30–40 cm deep, leaving it attached only at the bottom: Use a snow saw to cut the sides and the back of the column. Alternatively, insert two avalanche probes at the corners, loop a cordelette or string around them, and saw back and forth to cut deeper and isolate the column (Fig. 32a). Further isolate the sides with a saw or other tools (e.g., ski edges) to prevent the block from binding on the sides.
- **Perform the compression test**: Place your shovel blade face down on the top of the column (Fig. 32b):
  - Lightly tap ten times the shovel with a your flat hand, initiating the movement from the wrist.
  - If the snowpack remains stable, tap the shovel with your flat hand, but initiate the movement from the elbow.
  - If still stable, tap the shovel with a fist, initiating the movement from the shoulder.
- **Record the results** noting the number of taps when the column fails and the depth of the failure:
  - 1-10 (taps from wrist): very unstable
  - 11-20 (taps from elbow): likely unstable
  - 21-30 (taps from shoulder): possible instability

  No failure after 30 taps indicates no obvious weak layer in that column, or it's not sensitive to this test. Also observe if the fracture was sudden (fast and smooth) or slow. Sudden fractures are more dangerous.

Rutschblock test

- Similar to compression text but using a much larger block (2 m $\times$ 1.5 m); very informative but time-consuming to isolate such a large block
- **Load the block with a skier** who applies progressively more load, and record the Rutschblock score (RB) when the block fails. Note whether the entire block or just a portion of it fails.
  - RB1: Failure of the block during digging or cutting.
  - RB2: Gently step onto the upper part of the block.
  - RB3: Drop from a straight leg to a bent-knee position, pushing downwards (no jumping).
  - RB4: Jump once from a standing position.
  - RB5: Jump multiple times.
  - RB6: Move closer to the downhill edge and jump multiple times.
  - RB7: No failure of the block after all steps above.
- **Interpretation of scores**
  - RB1–RB3: Very unstable. Avoid similar terrain.

  - RB4–RB5: Questionable stability; human triggering of avalanches is quite possible, especially on steeper slopes.
  - RB6–RB7: More stable at that specific site, but no guarantee. Also consider terrain, recent weather, and other signs of instability.

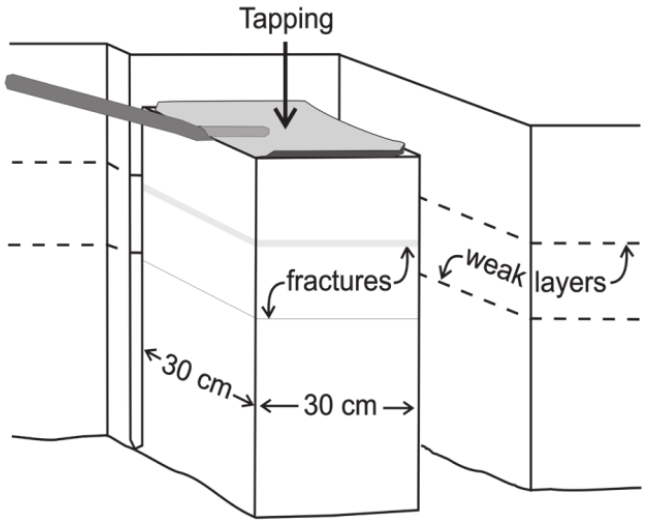


Figure 31: Compression test technique and column dimension (Canadian Avalanche Association, 2024).

11.6 Avalanche Rescue

Take the following steps if you suspect people are buried in an avalanche:

Preparing the search

- Choose/assign leader to coordinate the response.
- Call for help on the phone/radio or other device. **Do not** leave the scene to go for help.
- Assure safety of the search party.
- Head count: determine how many people are missing.
- Identify and mark last-seen points if possible.
- Switch all avalanche transceivers to search mode.
- Define the search area considering:
  - the fall-line below the last-seen point
  - the main deposition area of the avalanche
  - the line connecting any visible clues or equipment
  - terrain traps (e.g. gullies, hollows, depressions).

Transceiver search

- If you are alone, follow a tight zigzag pattern with consistent spacing between tracks. If you are several rescuers, spread out and walk in parallel lines with appropriate spacing so that your combined search strips fully cover the area without gaps (Fig. 33).
- Once your transceiver picks up a signal, continue the search using the *induction line method*. Follow the direction arrow or strongest signal, continuously adjusting your walking direction so the arrow stays centered and the distance reading decreases (Fig. 34, left).



Figure 32: Compression test in the field: (a) Isolating a snow block by placing a string around two avalanche probes at the back corners of the snow block and sawing it out. (b) performing a tap test to assess snowpack stability (Photos: I. Bij de Vaate).

- Once you are within about 3 m of the victim, refine the search using the grid method: move the beacon in a systematic pattern (e.g., a small cross- or rectangle-shaped grid) over the snow surface to locate the point of minimum distance and strongest signal.

Probing
Locate the victim with an avalanche probe (Fig. 34, right):

- Probe outward from point identified with the receiver.
- Probe as you wish to be probed upon, be careful.
- When probe hits victim, **do not** remove the probe.

Digging out the victim

- Estimate the burial depth.
- Start digging 1.5 times away from burial depth downhill from the probe.
- Dig towards the probe as fast and hard as possible. Be careful as you get close to the probe. If several rescuers are present, take turns.

11.7 Avalanche First Aid

This section is intended as an informal aid, not authoritative guidance. Avalanche first aid practices and rescue procedures evolve over time and may differ between countries and regions. Always seek up-to-date information from certified avalanche and medical professionals.

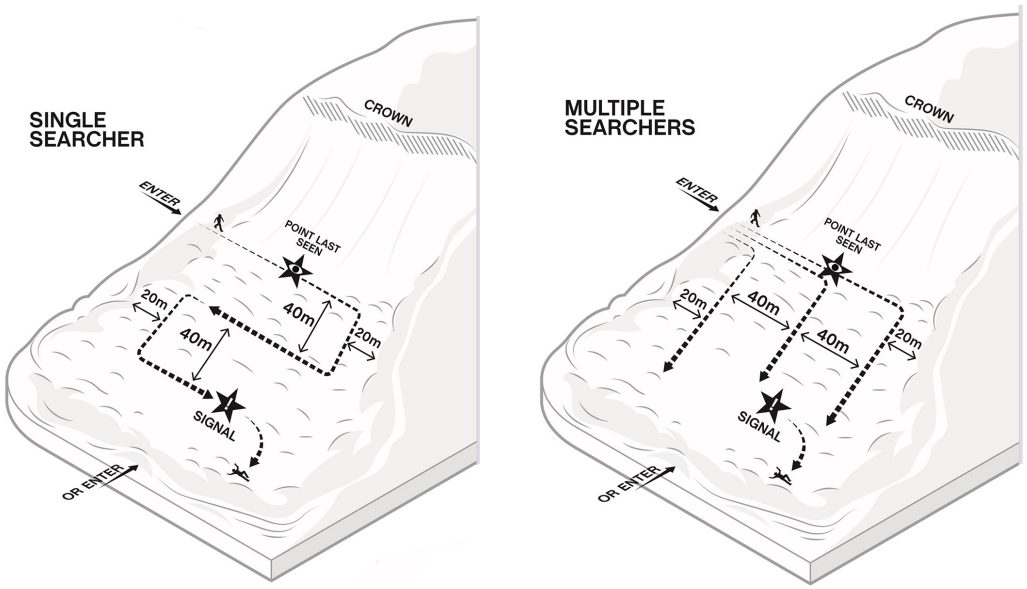


Figure 33: Avalanche rescue search pattern before a transceiver signal is acquired: for a single rescuer (left) and for multiple rescuers (right). In the single-rescuer case, a zigzag pattern can alternatively be used (Source: Baker Mountain Guides).

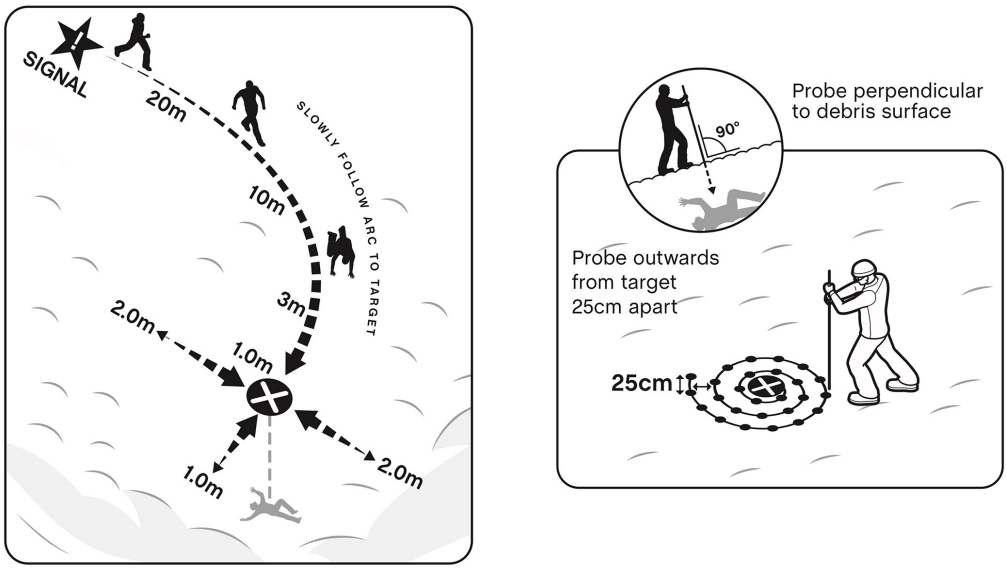


Figure 34: Avalanche rescue search pattern once a transceiver signal is acquired. Left panel: The closest signal is located by bracketing — moving forward and backward, then side to side to find the strongest reading. Right panel: Then a systematic probe search begins at the point indicated by the transceiver. If multiple rescuers are available, they should form a probe line, standing shoulder to shoulder (Source: Baker Mountain Guides).

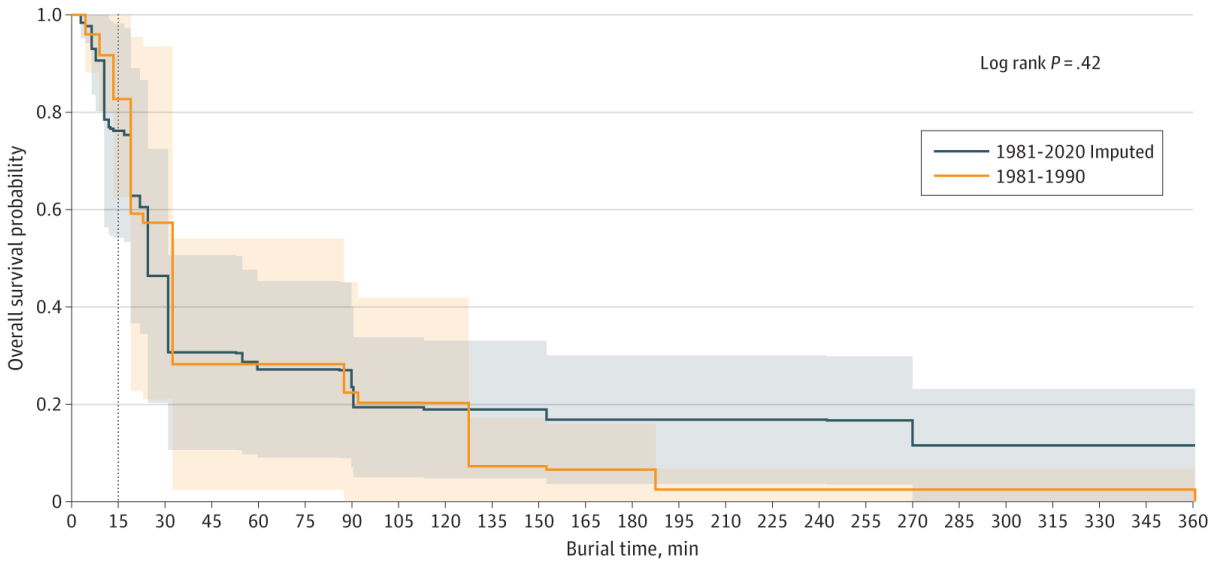


Figure 35: Avalanche survival function showing chances of surviving exponentially decreasing with time (Source: Rauch et al., 2024).

About $\simeq 25\%$ of avalanche victims are killed by trauma. Of those surviving, more than 50% will die of asphyxiation due to lack of oxygen within the first 15 minutes of burial (Fig. 35). Thus accessing the victim and clearing their airway is the top priority. Victims should be checked for injuries, placed comfortably, and kept warm. Lay them on a bivy bag, insulate them from the ground (e.g. with backpacks), cover with spare clothing, and wrap them tightly in a rescue blanket.

For unresponsive patients, rescuers should assess their **ABCs**: Airway, Breathing, Circulation.

- **Airway**: Clear any snow plug or obstruction from the patient's airway.
- **Breathing**: Check the victim's breathing by rolling them onto their back, tilting their head back, and placing one hand on their victim stomach. From there, the rescuer should bend over the victim, with their ear over the victim's mouth. Then check for breath for 10 seconds by listening for breathing noises, feeling for breath or any movement of their hand, and by looking for movement of the victim's chest. If the patient is not breathing, **begin CPR**.
- **Circulation**: Check for a pulse, either a carotid or wrist (radial) pulse. If victim has no pulse, **begin CPR**.

When to call for help? As soon as the rescuers are unsure whether they can manage the situation by themselves.

12 HEALTH PRECAUTIONS IN COLD REGIONS

There are several unique health risks in polar and high-alpine environments, including:

- **Medical issues**: Sunburn, snow blindness, frostbite, hypothermia, dehydration, acute mountain sickness (AMS)
- **Climatic conditions**: High albedo, high ultraviolet radiation, extreme temperatures, windy, dry, high altitude (low air pressure, low oxygen)

Field participants often do not feel these medical issues coming, or feel the need to push through early, milder symptoms. It is therefore important to remind participants to always speak up if they've forgotten prevention measures, or if they're starting to feel unwell or are close to their physical limit.

12.1 Sunburn

Prevention

- Avoid sun directly on skin: Use sun hat, buff/neck gaiter, sunglasses, long-sleeved clothing.
- Apply sunscreen with a sun protection factor (SPF) or at least 30 before going outside.
- Use sunscreen whether it is sunny or cloudy/foggy. Even in overcast or foggy conditions, you can still get severely sunburnt due to enhanced UV radiation, especially when the albedo is high due to snow cover. Remember all exposed areas: face, ears, neck, hands, etc.

Symptoms

- *Mild to moderate*: Redness, pain, inflammation, hot skin
- *Severe*: Blisters, headache, fever, nausea

Immediate care

- Cool the skin: apply cool, damp towels or take a cool bath.
- Moisturize: use aloe vera gel or calamine lotion.
- Pain Relief: take non-prescription pain relievers (e.g., ibuprofen: Advil, Motrin; acetaminophen: paracetamol, Tylenol).
- Blister care: leave blisters intact. If a blister breaks, clean gently and apply antibiotic ointment.

12.2 Snow blindness

Essentially, the eyes become sunburned due to ultraviolet (UV) light reflected off snow and ice. This is exacerbated by thinner atmosphere at high altitude, and can develop within minutes without sunglasses.

Prevention

- Eye protection (e.g., polarized wraparound-style sunglasses), at all times in snow-covered environments.

Symptoms

- Eye pain, redness, swelling
- Gritty feeling in and watering of eyes
- Headache, light sensitivity
- Seeing halos around bright lights

Immediate care

- Get out of the sunlight: move to a dark room or shaded area.
- Remove contact lenses: take out contacts until symptoms subside.
- Cool compress: apply cold compresses to eyes for 20 minutes.

- Pain relief: take over-the-counter pain relievers (e.g., ibuprofen: Advil, Motrin; acetaminophen: paracetamol, Tylenol).

Seek medical help if symptoms persist for more than a few days, or in the case of severe pain or vision distortion.

12.3 Hypothermia

Prevention

Prevention in particular rests on avoiding getting cold in the first place. This can by accomplished by:

- Moving if you're starting to freeze
- Not holding your pee (your body is using more energy when you need to pee)
- Changing to dry clothes if your clothes are getting wet
- Eating enough food so your body has energy to produce heat
- Consuming warm drinks and food.

Symptoms

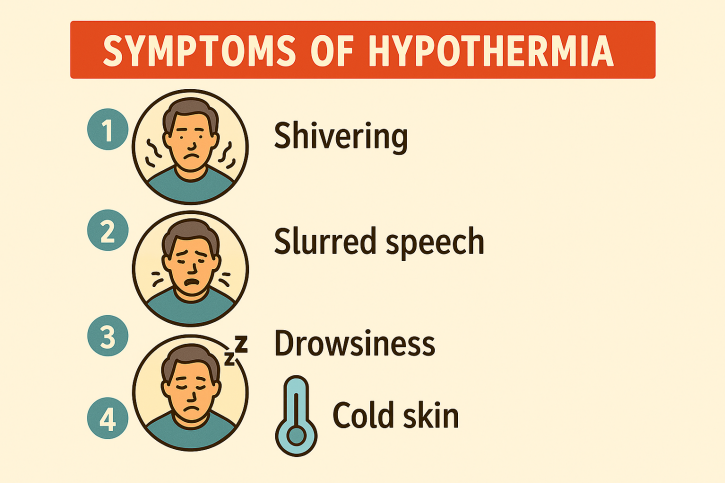


Figure 36: Symptoms of hypothermia.

Immediate care

- Move person out of the cold; protect from wind, especially around neck and head.
- Remove wet clothing.
- Warm gradually; focus on warming the center of the body; avoid rapid rewarming (e.g., hot bath) as it can cause cardiac arrest.
- Provide warm, sweet, non-alcoholic drinks.

12.4 Frostbite

Prevention

- Same as for hypothermia: avoid getting cold in the first place. Ensure good blood circulation to extremities (e.g. fingers and toes), and avoid skin being exposed to the cold.

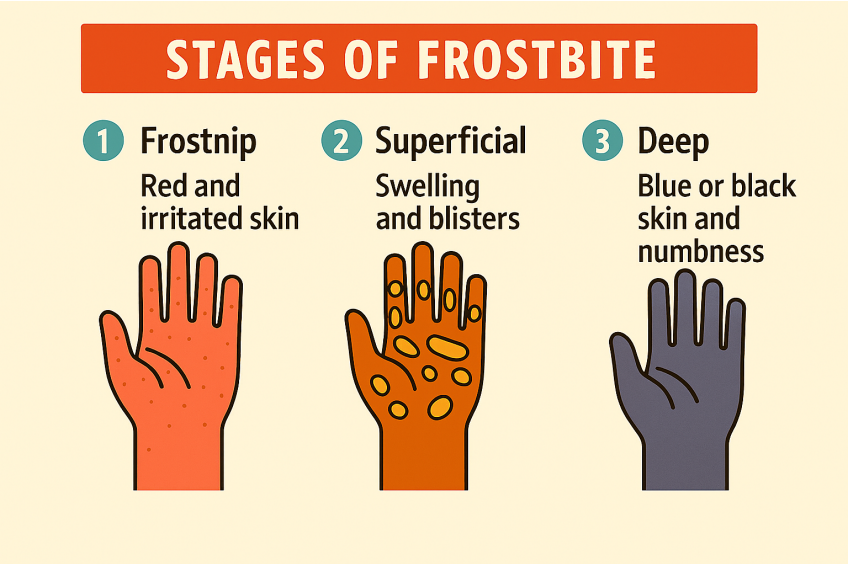


Figure 37: Stages of frostbite.

- Common vulnerable areas are cheeks and fingers.

Symptoms

- Cold skin, numbness
- Red, white, bluish-white, grayish-yellow, or black (necrosis; tissue death) skin according to severity (Fig. 37)
- Hard or waxy-looking skin

Immediate care

- Protect from further damage:
  - Avoid refreezing thawed areas
  - Warm hands by tucking them into armpits
  - Get out of the cold/wind
  - *Avoid* rubbing affected skin, direct heat (e.g. stove, heating pad), and walking on frostbitten feet or toes.
- Gently rewarm frostbitten areas:
  - Soak in warm (not hot!) water for 20-30 mins
  - Use warm, wet cloths for nose or ears

12.5 Dehydration

Prevention

- Bring plenty of fluids for the day and drink and eat frequently.

Symptoms
Mild to moderate

- Thirst, dry mouth and lips
- Headaches, dizziness
- Reduced urination, dark-colored urine

Severe

- Extreme thirst
- Sunken eyes
- Rapid heartbeat
- Confusion

Care

- Rehydrate (offer water, oral rehydration solutions or sport drinks) and keep the person comfortable.

Seek medical help if there is persistent vomiting or diarrhea, or when severe symptoms like confusion or rapid heartbeat occur.

12.6 Altitude illness

High altitudes affect many bodily functions and can cause severe illness, especially for those not accustomed to such environments. While some symptoms are normal and disappear with acclimatization, others can persist and worsen with altitude and ascent speed; this is called **Acute Mountain Sickness (AMS)**. If in doubt, the safest course of action is always to descend.

Altitude is considered 'high' starting at 1500 m asl, and extreme above 5500 m asl. Environmental differences at high altitude explain the body's required adaptations to maintain normal function:

- Air pressure, oxygen, temperature and humidity decrease
- UV radiation and ozone increase

Blood oxygen saturation ($\mathbf{SpO_2}$) is a useful proxy for state of wellness in high altitudes. Many smart watches contain a pulse oximeter, which measures O_2 bound to hemoglobin in blood. Levels below 85% signify the body is having trouble acclimating to the change in altitude.

- $\mathbf{SpO_2 < 85\%}$ decreases capacity for mental concentration and fine motor coordination.
- $\mathbf{SpO_2 < 75\%}$ leads to faulty judgement, emotional instability and impaired muscle function.

AMS is not indicative of physical fitness level and can affect anyone. Prevention, as with any other field illness, is key.

12.6.1 Mild to Moderate Acute Mountain Sickness (AMS)

Mild AMS is common, affecting 25-50% of people ascending rapidly to altitudes of about 2500 m asl. However, deterioration into more severe forms of AMS should be recognized and treated immediately.

Symptoms

Mild

- Headache common and one of the following symptoms:
- Nausea
- Vomiting
- Lack of appetite
- Dizziness/lightheadedness
- Sleeplessness
- Fatigue/weakness
- Pulse-ox 5-10% below average

Moderate

- Ataxia (unsteady on feet): single most useful sign for deterioration
- Lack of energy
- Strange behaviour
- Confusion
- Impaired judgement
- Consciousness level down, can lead to coma
- Shortness of breath

Prevention

- Don't ascend >300 m per day above 3000 m asl.
- Climb high, sleep low.
- Take Diamox (acetazolamide) two days prior to ascent and when above 2500 m asl. Common side effects: diuretic, tingling of extremities.

Treatment

- Stay at altitude, do NOT ascend.
- Descend if symptoms do not improve or get worse.
- Take drugs (e.g., Diamox - see above).
- Give oxygen if available.
- Use hyperbaric bag to increase pressure.

12.6.2 Severe Acute Mountain Sickness (AMS)

High-altitude pulmonary edema (HAPE) and high-altitude cerebral edema (HACE), respectively affecting the lungs and brain, are life-threatening conditions that require immediate medical assistance.

High altitude pulmonary edema (HAPE)

- Fluid leaks from blood into lungs
- Typically occurs on second night at altitude
- Severe breathlessness
- Rales/crackles in lungs
- High pulse, low blood oxygen

High altitude cerebral edema (HACE)

- Swelling of brain
- Ataxia/loss of balance
- Altered mental status: hallucinations, slurred speech, can't talk
- Severe headache

Treatment
Both HAPE and HACE require the following treatment, with the additional administration of dexamethasone for HACE cases.

- Hyperbaric bag (inflatable, airtight bag). Air is pumped in to increase the pressure inside simulating going to a lower altitude.
- Nifedipine (lowers blood pressure)
- Expiratory Positive Airway Pressure (EPAP) mask (small breathing device with one-way valves)
- Diuretics (medications that help the body eliminate excess salt and water through increased urination)

13 MISCELLANEOUS FIELDWORK TIPS

Below are some assorted, experience-based pointers that may help you navigate the various everyday challenges of fieldwork:

- Build in redundancy for essential instruments and tools.
- Assemble and test all instrumentation before going into the field.
- Fully charge all batteries before deployment.
- Keep battery-powered devices warm in cold conditions to reduce rapid discharge.
- Use a large, comfortable backpack—there is always more to carry than expected.
- Pack extra straps (including short ones) to secure equipment and attach items to your backpack.
- Bring an insulating pad or mat to sit on (also useful for first aid purposes).
- Wear in new boots well before the field campaign. Bring blister plaster.
- Assume checked luggage can be delayed or lost; carry essential items as hand luggage.
- Plan for the possibility that the helicopter (or other transport) cannot pick you up the same day.
- Use waterproof field books.
- Document field measurements with ample detail: record full dates (including year), names of all team members, weather conditions, data values with units, specific instrument identifiers, time zone used in logging devices, etc.
- Document instruments and field sites with photos.
- Digitize or photograph field book notes at the end of each day.
- Use clear, meaningful filenames and a consistent structure when organizing field data.

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