

Appendix B

Forecasting Weather in the Mountains

The Air Force provides the bulk of the weather support required by the Army; however, reports from other branches of the military service, our own National Weather Bureau, or a foreign country's weather service can also aid in developing accurate forecasts (see FM 2-33.2). Weather at different elevations and areas, even within the same general region, may differ significantly due to variations in cloud height, temperature, winds, and barometric pressure. Therefore, general reports and forecasts must be used in conjunction with the locally observed weather conditions to produce reliable weather forecasts for a particular mountain area of operations.

INDICATORS OF CHANGING WEATHER

MEASURABLE INDICATORS

B-1. In the mountains, a portable aneroid barometer, thermometer, wind meter, and hygrometer are useful to obtain measurements that will assist in forecasting the weather. Marked or abnormal changes within a 12-hour period in the indicators listed in Figure B-1 may suggest a potential change in the weather.

- **Barometric Pressure**
- **Wind Velocity**
- **Wind Direction**
- **Temperature**
- **Moisture Content of the Air**

Figure B-1. Measurable Weather Indicators

CLOUDS

B-2. Clouds are good indicators of approaching weather conditions. By reading cloud shapes and patterns, observers can forecast weather even without additional equipment.

B-3. Shape and height are used to identify clouds. Shape provides information about the stability of the atmosphere, and height above ground level provides an indication of the distance of an approaching storm. Taken together, both indicate the likelihood of precipitation (see Figure B-2). The heights shown in the figure are an estimate and may vary, based on geographical location.

Clouds by Shape

B-4. Clouds may be classified by shape as cumulus or stratus.

- *Cumulus* clouds are often called “puffy” clouds, looking like tufts of cotton. Their thickness (bottom to top) is usually equal to or greater than their width. Cumulus clouds are primarily composed of water

droplets that cause them to have sharp, distinct edges. These clouds usually indicate instability at the altitude of the atmosphere where they are found. The stormy weather associated with cumulus clouds is usually violent with heavy rains or snow and strong, gusty winds. Precipitating cumulus clouds are called cumulonimbus.

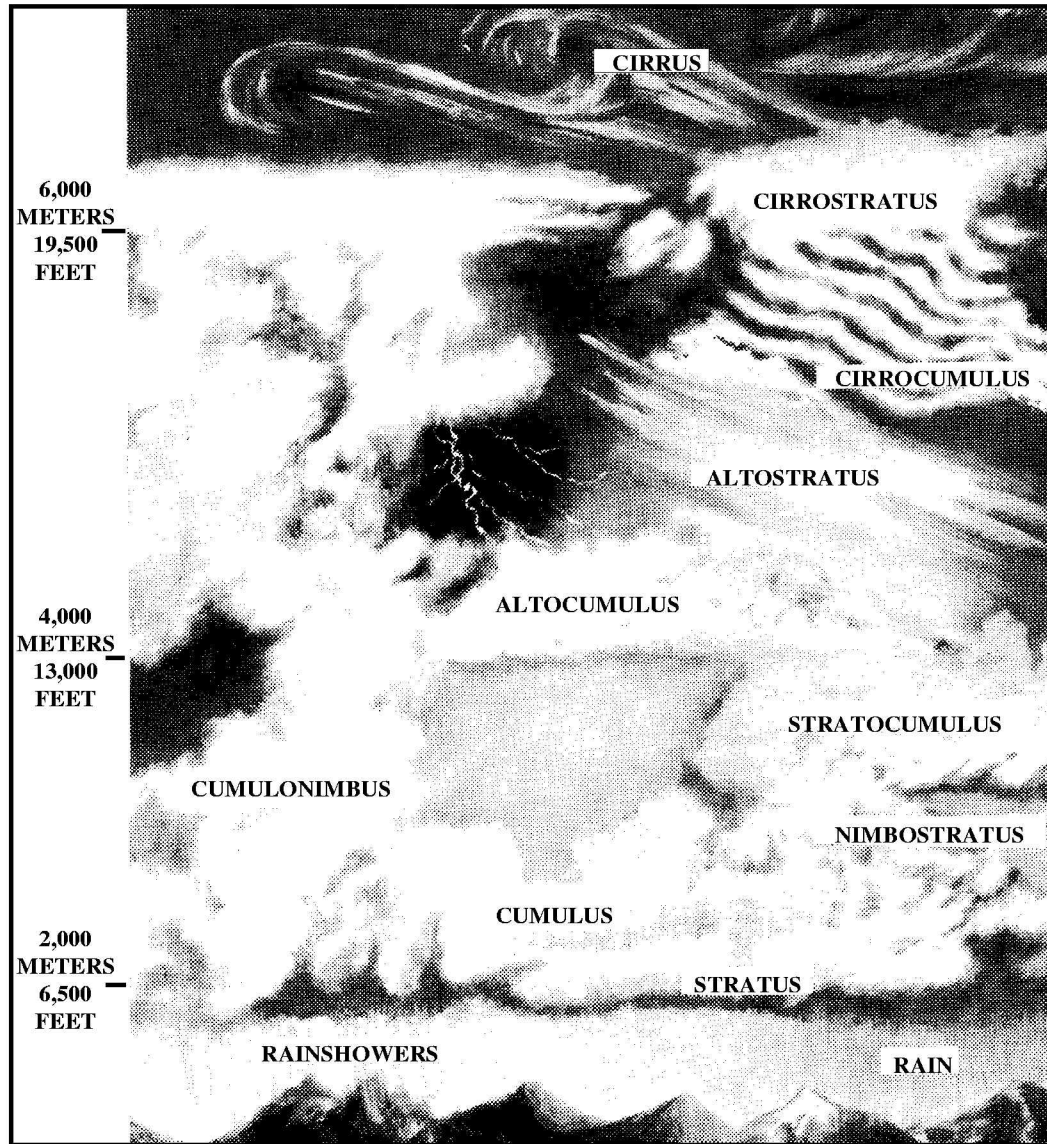


Figure B-2. Types of Clouds

- *Stratus* clouds are layered, often appearing flattened, with greater horizontal than vertical dimensions. They usually indicate a stable atmosphere, but can indicate the approach of a storm. Stormy weather associated with stratus clouds usually does not normally include violent winds, and precipitation is usually light but steady, lasting up to 36 hours. Lightning is rarely associated with stratus clouds,

however, sleet may occur. Fog is also associated with the appearance of stratus clouds. Precipitating stratus clouds are called nimbostratus, and clouds that cannot be determined as stratus or cumulus are referred to as stratocumulus. These latter types may be evolving from one type to another, indicating a change in atmospheric stability.

Clouds by Height

B-5. Clouds are also classified by the height of their base above ground level into three categories – low, middle, and high.

- *Low clouds*, below 2,000 meters (6,500 feet), are either cumulus or stratus, or their precipitating counterparts. Low clouds may be identified by their height above nearby surrounding relief of known elevation. Most precipitation originates from low clouds because rain and snow from higher clouds usually evaporates before reaching the ground. As such, low clouds usually indicate precipitation, especially if they are more than 1,000 meters (3,000 feet) thick (clouds that appear dark at the base usually are at least that thick).
- *Middle clouds*, between 2,000 and 6,000 meters (6,500 and 19,500 feet) above ground, have a prefix of “alto”, and are called either altostratus or altocumulus. Middle clouds appear less distinct than low clouds because of their height. Warm “alto” clouds have sharper edges and are composed mainly of water droplets. Colder clouds, composed mainly of ice crystals, have distinct edges that grade gradually into the surrounding sky. Middle clouds indicate potential storms, though usually hours away. Altocumulus clouds that are scattered in a blue sky are called “fair weather” cumulus and suggest the arrival of high pressure and clear skies. Lowering altostratus clouds with winds from the south indicate warm front conditions, decreasing air pressure, and an approaching storm system within 12 to 24 hours.
- *High clouds*, higher than 6,000 meters (19,500 feet), are cirrus, cirrostratus, and cirrocumulus. They are usually frozen clouds with a fibrous structure and blurred outlines. The sky is often covered with a thin veil of cirrus that partly obscures the sun or, at night, produces a ring of light around the moon. The arrival of cirrus indicates moisture aloft and the approach of a storm system. Precipitation is often 24 to 36 hours away. As the storm approaches, the cirrus thickens and lowers becoming altostratus and eventually stratus. Temperatures warm, humidity rises, and winds approach from the south or southeast.

Other Clouds

B-6. Some clouds indicate serious weather ahead.

- *Towering cumulus clouds* have bases below 2,000 meters (6,500 feet) and tops often over 6,000 meters (19,500 feet). They are the most dangerous of all types and usually do not occur when temperatures at the surface are below 32-degrees Fahrenheit. They indicate extreme instability in the atmosphere, with rapidly rising air currents caused by solar heating of the surface or air rising over a mountain barrier. Mature towering cumulus clouds often exhibit frozen stratus clouds at

their tops, producing an “anvil head” appearance. Towering cumulus clouds may be local in nature, or they may be associated with the cold front of an approaching storm. The latter appears as an approaching line of thunderstorms or towering cumulus clouds. Towering cumulus clouds usually produce high, gusty winds, lightning, heavy showers, and occasionally hail and tornadoes (although tornadoes are rare in mountainous terrain). Such thunderstorms are usually short-lived and bring clear weather.

- *Cloud caps* often form above pinnacle and peaks, and usually indicate higher winds aloft. Cloud caps with a lens shape (similar to a “flying saucer”) are called *lenticular* and indicate very high winds (over 40 knots). Cloud caps should always be watched for changes. If they grow and descend, bad weather can be expected.

APPLYING THE INDICATORS

B-7. Weather forecasts are simply educated estimations or deductions based on general scientific weather principles and meteorological evidence. Forecasts based on past results may or may not be accurate. However, even limited experience in a particular mountainous region and season may provide local indications of impending weather patterns and increased accuracy. Native weather lore, although sometimes greatly colored and surrounded in mystique, should not be discounted when developing forecasts, as it is normally based on the local inhabitants’ long-term experience in the region.

BAD WEATHER

B-8. Signs of approaching bad weather (within 24 to 48 hours) may include—

- A gradual lowering of the clouds. This may be the arrival or formation of new lower strata of clouds. It can also indicate the formation of a thunderhead.
- An increasing halo around the sun or the moon.
- An increase in humidity and temperature.
- Cirrus clouds.
- A decrease in barometric pressure (registered as a gain in elevation on an altimeter).

STORM SYSTEMS

B-9. The approach of a storm system is indicated when—

- A thin veil of cirrus clouds spreads over the sky, thickening and lowering until altostratus clouds are formed. The same trend is shown at night when a halo forms around the moon and then darkens until only the glow of the moon is visible. When there is no moon, cirrus clouds only dim the stars, but altostratus clouds completely hide them.
- Low clouds, which have been persistent on lower slopes, begin to rise at the time upper clouds appear.

- Various layers of clouds move in at different heights and become abundant.
- Lenticular clouds accompanying strong winds lose their streamlined shape, and other cloud types appear in increasing amounts.
- A change in the direction of the wind is accompanied by a rapid rise in temperature not caused by solar radiation. This may also indicate a warm, damp period.
- A light green haze is observed shortly after sunrise in mountain regions above the timberline.

THUNDERSTORMS

B-10. Indications of local thunderstorms or squally weather are—

- An increase in size and rapid thickening of scattered cumulus clouds during the afternoon.
- The approach of a line of large cumulus or cumulonimbus clouds with an “advance guard” of altocumulus clouds. At night, increasing lightning windward of the prevailing wind gives the same warning.
- Massive cumulus clouds hanging over a ridge or summit (day or night).

STRONG WINDS

B-11. Indications of approaching strong winds may be—

- Plumes of blowing snow from the crests of ridges and peaks or ragged shreds of cloud moving rapidly.
- Persistent lenticular clouds, a band of clouds over high peaks and ridges, or downwind from them.
- A turbulent and ragged banner cloud that hangs to the lee of a peak.

PRECIPITATION

B-12. When there is precipitation and the sky cannot be seen—

- Small snowflakes or ice crystals indicate that the clouds above are thin, and fair weather exists at high elevations.
- A steady fall of snowflakes or raindrops indicates that the precipitation has begun at high levels, and bad weather is likely to be encountered on ridges and peaks.

FAIR WEATHER

B-13. Continued fair weather may be associated with—

- A cloudless sky and shallow fog, or layers of haze at valley bottoms in early morning.
- A cloudless sky that is blue down to the horizon or down to where a haze layer forms a secondary horizon.
- Conditions under which small cumulus clouds appearing before noon do not increase, but instead decrease or vanish during the day.

- Clear skies except for a low cloud deck that does not rise or thicken during the day.

B-14. Signs of approaching fair weather include—

- A gradual rising and diminishing of clouds.
- A decreasing halo around the sun or moon.
- Dew on the ground in the morning.
- Small snowflakes, ice crystals, or drizzle, which indicate that the clouds are thin and fair weather may exist at higher elevations.
- An increase in barometric pressure (registered as a loss in elevation on an altimeter).

GLOSSARY

ABN	airborne
acclimatization	the physiological changes that allow the body to adapt or get used to the effects of a new environment, especially low oxygen saturation at higher elevations
ACE	armored combat earthmover
acetazolamide	a pharmaceutical drug used to accelerate acclimatization
ADA	air defense artillery
ADAM	area denial artillery munitions
AH-64	attack helicopter also called the Apache
aid	in mountaineering, a climbing device, such as pitons, bolts, chocks, and stirrups, used for body support and upward progress; also used for artificial height in the absence of handholds and footholds
ALOC	air lines of communications
AM	amplitude modulation
ambient temperature	encompassing atmosphere
AMS	acute mountain sickness
anchor	a secure point (natural or artificial) to which a person or rope can be safely attached
aneroid	using no liquid
ANZAC	Australia and New Zealand Corps
AO	area of operations
apnea	temporary suspension of respiration
ARSOF	Army special operations forces
ART	Army tactical task
ARTEP	Army training and evaluation program
assault climber	military mountaineer possessing advanced (Level 2) skills, capable of leading small teams over class 4 and 5 terrain and supervising rigging/operation of all basic rope systems
AT4	a man-portable, lightweight, self-contained, antiarmor weapon
ATGM	anti-tank guided missile
basic mountaineer	a military mountaineer trained in fundamental (Level 1) travel/climbing skills necessary to move safely and efficiently in mountainous terrain

belay	a rope management technique used to ensure that a fall taken by a climber can be quickly arrested; belay techniques are also used for additional safety/control in rappelling, raising and lowering systems, and for mountain stream crossings
BFV	Bradley fighting vehicle
BSFV	Bradley Stinger fighting vehicle
BN	battalion
C ²	command and control
CAFAD	combined arms for air defense
CFV	cavalry fighting vehicle
CHS	combat health support
CNR	combat net radio
continental climate	bitterly cold winters, extremely hot summers; annual rain and snowfall is minimal and often quite scarce for long periods
cordillera	principal mountain ranges of the world, named after the Spanish word for rope
crampons	climbing irons, attached to the bottom of boots, used on ice or snow in mountaineering
crevice	a narrow opening resulting from a split or crack as in a cliff
CS	combat support
CSS	combat service support
DA	Department of the Army
defile	a narrow passage or gorge
DPICM	dual-purpose improved conventional munition
DZ	drop zone
ECWCS	extended cold weather clothing system
edema	a local or general condition in which the body tissues contain an excessive amount of tissue fluid
evacuation team	a team trained to move casualties over steep slopes, cliffs, and other obstacles that would significantly impede the mobility of standard litter bearers
EW	electronic warfare
F	Fahrenheit
FARP	forward arming and refueling point
FASCAM	family of scatterable mines
FEBA	forward edge of the battle area

fixed alpine path	a mountain path created by any combination of aids, to include steps, stanchions, standoff ladders, suspended walkways, cableways, or other improvements made of materials available; normally an engineering task.
fixed rope	a rope, or series of ropes, anchored to the mountain at one or more points to aid soldiers over steep, exposed terrain; usually installed by lead climbing teams (normally Level 2 qualification)
flash defilade	to arrange fortifications to protect from fire
FM	field manual; frequency modulation
FSMC	forward support medical company
FOX system	a lightly-armored, wheeled laboratory that takes air, water, and ground samples and immediately analyzes them for signs of weapons of mass destruction
gabion	a wicker basket filled with earth and stones often use in building fortifications; can also be created out of similar materials, such as wire mesh/fence, lumber, plywood, or any suitable material that forms a stackable container for rocks, gravel, and soil
giardiasis	parasitical illness
glaciated	covered with glacial ice
GPS	global positioning system
GTA	graphic training aid
guide	a soldier experienced in all aspects of mountaineering who has the skills and knowledge to identify obstacles and ways to overcome them; commander's advisor on technical mountaineering matters that could affect the tactical scheme of maneuver; primary function of mountain leaders (Level 3 qualification)
HACE	high altitude cerebral edema
HAPE	high altitude pulmonary edema
HE	high explosives
Hellfire	tank-killing missile carried by the Apache attack helicopter
high mountains	mountains that have a local relief usually exceeding 900 meters (3,000 feet)
HUMINT	human intelligence
HWY	highway
hygrometer	an instrument used to measure humidity or moisture content in the air
hypoxia	a deficiency of oxygen reaching the tissues of the body
ice fog trails	steam/smoke trails created by firing weapons
ID	infantry division

IFV	infantry fighting vehicle
IHFR	improved high frequency radio
IMINT	imagery intelligence
installation team	a team organized to construct and maintain rope installations used to facilitate unit movement; usually comprised of Level 1 and 2 mountaineers
interdiction	to stop or hamper
ionospheric	a part of the earth's atmosphere of which ionization of atmospheric gases affects the propagation of radio waves; starts at about 30 miles above ground
IPB	intelligence preparation of the battlefield
IV	intravenous
JSTARS	joint surveillance, target attack radar system
km	kilometer
lead climbing team	a roped climbing team (usually Level 2 qualification) trained to lead on class 4 and 5 terrain; establishes/prepares the entire route for the remainder of the unit
leeward	the side sheltered from the wind
lenticular	having the shape of a double-convex lens
LOC	line of communication
local relief	the difference in elevation between valley floors and the surrounding summits
look-down angles	the angle from the aircraft to the target
low mountains	mountains that have a local relief of 300 to 900 meters (1,000 to 3,000 feet)
LPT	logistics preparation of the theater
LRS	long-range surveillance
LRSU	long-range surveillance unit
LSDIS	light and special division interim sensor
LTC	lieutenant colonel
LZ	landing zone
MANPADS	man-portable air defense system
maritime climate	mild temperatures with large amounts of rain or snow
MBA	main battle area
METT-TC	mission, enemy, terrain and weather, troops and support available, time available, civil considerations
MK-19	40-mm grenade machine gun, MOD 3

MOPP	mission-oriented protective posture
motti	Finnish word meaning “a pile of logs ready to be sawed into lumber”; used in military terms to describe setting the conditions so a larger force can be defeated in detail
mountain leader	a military mountaineer possessing the highest level (Level 3) of mountaineering skills with extensive experience in a variety of mountain environments in both winter and summer months
MSE	mobile subscriber equipment
MSRT	mobile subscriber radio terminal
MTF	manual terrain following
NBC	nuclear, biological, and chemical
OCOKA	observation and fields of fire, cover and concealment, obstacles, key terrain, and avenues of approach
OH-58D	a scout and attack helicopter known as the Kiowa Warrior
OP	observation post
OPORD	operation order
OPSEC	operations security
OR	operational readiness
orographic	pertaining to the physical geography of mountains and mountain ranges
PADS	Position Azimuth Determining System
POL	petroleum, oils, and lubricants
protection	in mountaineering, special anchor points established during a roped party climb to limit potential fall distances, protecting climbers from severe fall/ground-fall consequences
PSYOP	psychological operations
RAAMS	remote antiarmor mine system
rappel	method of controlled frictional descent down a rope
RCW	ration, cold weather
rockfall	rockfall occurs on all steep slopes. It is caused by other climbers or by the continual erosion of the rock on a mountainside resulting from freezing, thawing, and heavy rain; grazing animals; or enemy action.
SATCOM	satellite communications
scree	small unconsolidated rocks or gravel, fist-size or smaller, located mostly below rock ridges and cliffs
screening crest	a hill or ridge located in front of a radar set to mask it from unwanted returns (clutter) at close range, and to provide security

	against electronic detection or jamming; screening crest also prevents visual observation and attack by direct fires
SEE	small emplacement excavator
SHELREP	shelling report
SHORAD	short-range air defense
SINGARS	Single-channel Ground and Airborne Radio System
SOF	special operations forces
squall	a sudden, violent wind
SR	special reconnaissance
talus	accumulated rock debris that is much larger than scree, usually basketball-size or larger
TBP	to be published
TC	training circular
TCF	tactical combat force
TCP	traffic control point
temperature inversion	when the temperature is warmer at higher elevations than lower elevations
TM	technical manual
TOC	tactical operations center
TOW	tube-launched, optically tracked, wire-guided, heavy antitank missile system
TRADOC	United States Army Training and Doctrine Command
tundra	treeless, black, mucky soil with permanently frozen subsoil; located in mountainous regions above the timberline
tussocks	grassy clumps
UAV	unmanned aerial vehicle
UGR	unitized group ration
UHF	ultrahigh frequency
Venturi effect	as a fluid (such as air) flows through a constriction (like a mountain pass), the speed increases and the pressure drops
VFR	visual flight rules
VT	variable time
wind chill	the rate at which a man or object cools to the ambient temperature; wind increases the rate of cooling and adds to the risk of frostbite, hypothermia, and other cold-weather injuries
windward	being in or facing the direction from which the wind is blowing
WP	white phosphorous

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