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KILLER STORMS

Chapter Highlights:

✓ Analysis of two real storms that killed a large number of climbers.

✓ Learn the indicators of a developing/dissipating mountain storm.

This chapter illustrates the nasty side of mountain weather: real weather experienced by real climbers, no artificial ingredients added. Even though you may never set foot in the Himalayas or climb in the Andes, chances are good that sooner or later you will experience life threatening weather in your own local mountains, in which case the same principles apply. While reading this chapter, ask yourself: "what would I have done given these same circumstances?" Some readers will not understand the technical terms that are introduced in this chapter, do not despair, by the time you finish this book you will know them all too well! There are two reasons that we have started this book off with this chapter: first, to make the reader aware that even very experienced climbers make serious mistakes regarding the dangers of mountain weather, and secondly; to illustrate the point that what would be considered relatively moderate weather at lower elevations, can be deadly at higher elevations.

Everest: May 1996

In terms of world-wide media coverage, this event is "the mother of all" climbing tragedies to date. During the storm of May 10-12, nine climbers of various abilities died. These deaths can be attributed in large part to the adverse weather which embroiled the mountain beginning on May 10th. The specific climbing narratives that we have used are as follows: Into Thin Air (Krakauer 1997); The Other Side of Everest (Dickinson 1999); The Climb (Boukreev and DeWalt 1999); and High Exposure (Breashers 1999).

Since Krakauer has the most descriptive weather narrative, we have used his account to construct a May 10th weather timeline which is displayed as Figure 1.1. We know that strong winds raked the upper mountain throughout April and the early part of May. On May 9th for example, Breashers who was at Camp II in the Western Cwm at the time, reported strong winds above the South Col as evidenced by snow plumes on the upper mountain. Krakauer, who with a large number of other climbers, reached the South Col (Camp IV at 7930 m) on the evening of the 9th. He notes in his book that the winds died down around 7:30 PM. As the climbing teams assembled for their

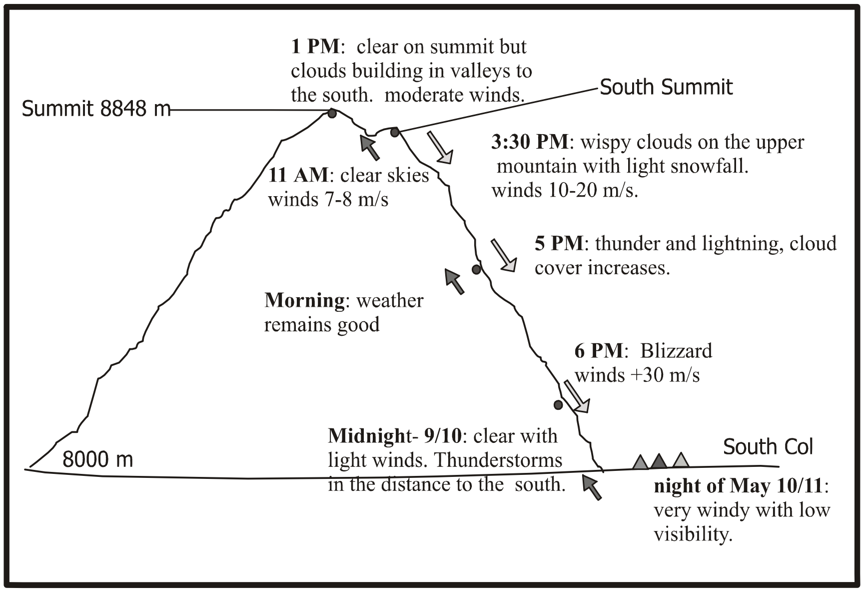

Figure 1.1- Mt. Everest climb May 10-11, 1996.

summit attempt sometime around midnight on the 9th/10th, thunderstorms could be seen over distant mountains to south. Let's pause here to ask an important question. Should the distant thunderstorms have been a warning of an imminent change in the weather? Not really, as you will learn later, pre-monsoon thunderstorms are common over northern India and southern Nepal.

The weather during the morning of the 10th was near perfect for an Everest summit climb, clear skies with light winds. Krakauer reached the South Summit around 11 AM, at which time he estimates the winds were roughly 10 m/s (22 mph). This wind speed is mild for Everest standards, however, it was strong enough to produce a snow plume over the upper Kangshung Face (east). Krakauer reached the summit around 1 PM. It was during his short stay on the world's highest point that he observed <u>a rapid buildup of clouds in the valleys to the south and around Everest</u>, while the region to the north (Tibet) remained relatively cloud free. The fact that clouds preferentially build over Nepal and not over Tibet simply means that moisture moves into the region from the south and southwest. Therefore, if you happen to be at high altitude in the Himalaya, don't bother looking into Tibet for some indication of cloud development, most of the action will be in your immediate surroundings and to the south.

When small cumulus clouds form over valleys and at low-elevations, especially when it occurs on a daily basis, it is generally not an indicator that a major storm is developing. However, the nature of the quick transition in the weather which occurred on the afternoon of May 10th, was a clear sign that a storm of considerable magnitude was developing. The tip-off was the rapid development of large cumulus clouds. In Chapter 4 you will learn that clouds that grow vertically (large cumulus clouds), are typically associated with strong updrafts. The speed and height to which these clouds developed, signified that a large amount of moisture was being "pumped" into the middle and upper troposphere.

By 3:30 P.M. Krakauer had returned to the South Summit where the winds were between 10 and 20 m/s (22 to 45 mph) and light snow was beginning to fall. As he descended the Southeast Ridge, the visibility continued to decrease while the winds steadily increased. Sometime around 4 PM, David Breashers who was at Camp II, noted that a mass of clouds was building to the west of Everest. Shortly thereafter, this cloud bank moved into the Western Cwm and obscured the upper mountain from his view.

It was nearly 6 P.M. when Krakauer reached the lower section of the Southeast Ridge, where he estimates the winds were around 32 m/s (70 mph). He was able to reach the tents on the South Col by 6:45 P.M, at which time a blizzard was raging and visibility was reduced to about 6 m

(20 feet). The winds remained strong throughout the night. At dawn on the morning of the 11th, the mountain was free of clouds but the winds were still very strong. By late morning, however, clouds once again engulfed the upper mountain.

There was a period of several hours in the early afternoon of the 11th, in which the winds decreased to about 20 m/s (45 mph). But by late afternoon the storm re-intensifies, resulting in some very strong gusts of winds (unknown speeds). Blizzard conditions continued throughout the night. By the morning of the 12th, the storm had abated enough for the survivors to descend into the Western Cwm. They arrived at Camp II around 1:30 PM amidst sunshine and light winds.

Figure 1.2 shows the 300 mb height field (in meters) for midnight on May 11 (if you don't know what this plot is showing-no fear, you soon will). Notice the trough of low pressure over northern India, extending well into Central Asia. This weather pattern produced strong westerly winds in the middle and upper troposphere (5-12 km or 3-7 mi). The area of strongest winds remained over northwest India for the duration of the storm, which was fortunate for the Everest climbers, since sustained winds exceeded 50 m/s (110 mph). Although not shown in any of the plots displayed in this section, the upper-level winds over the Khumbu region were quite strong before, and several days after the May 10-12 storm as well.

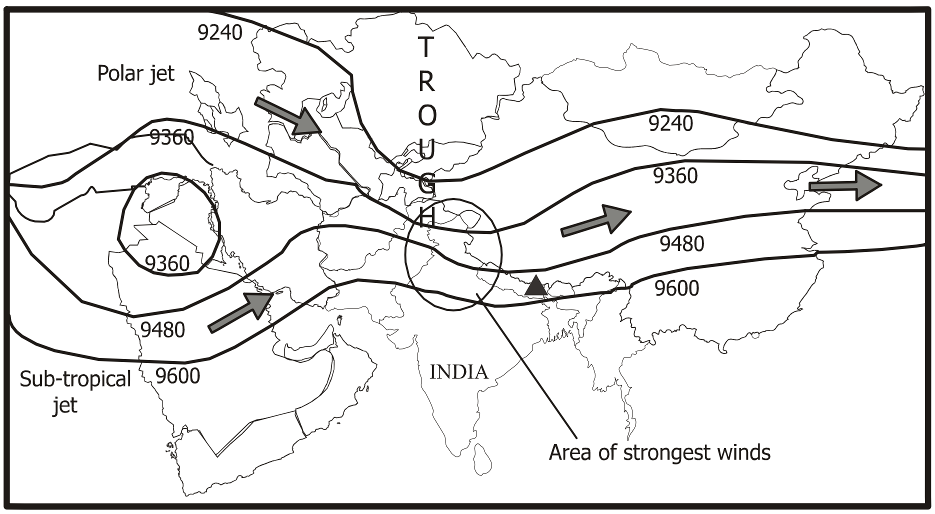

Figure 1.2- 300 mb geopotential heights for midnight May 11, 1996. Mt. Everest is denoted by a solid triangle. The strongest winds are over northern India (Kashmir).

Table 1.1 is an estimate of the actual and wind chill temperatures at several elevations during the storm, based on available weather data. It was obviously very cold on the South Col and above. The wind chill temperatures give some indication of the "apparent temperature" that exposed skin would be subject to, in a wind of 18 m/s (40 mph). In this extremely cold environment there was obviously little margin for error.

Table 1.1

Elevation (m)	Air Temp (C)	Wind Chill (C)
7,000	-19° (-2 F)	-49° (-56 F)
8,000 (South Col)	-27° (-17 F)	-62° (-80 F)
8,848 (Summit)	-33° (-27 F)	-71° (-96 F)

The next three paragraphs are some of our own comments on what transpired from May 10-12. First of all, the speed at which clouds developed on the afternoon of May 10 was an indicator that a major change in the weather was occurring. Cloud development, plus the increasing wind speeds should have been the signal to the guides to turn everyone around during the early afternoon and descend to the South Col. Since the winds over the summit of Everest were strong before and after May 10-12, you're probably wondering what produced the storm. The key element is the trough depicted in figure 1.2. In this book you will learn that there is strong large-scale vertical motion to the east of a trough axis (area of low pressure), which, if it happens to be coupled with a supply of moisture, will produce a very large mass of clouds and precipitation. In addition, the New Delhi (India) upper-air sounding shows a considerable increase in the moisture content in the 3 to 5 km (1.9 to 3.1 mile) layer in the early hours of May 10. Additional data also shows periods of modest southwest flow at 850 mb (1,400 m or 4,590 ft) into Nepal on May 10 and 11. In other words, despite strong winds before and after the storm, it was the development of the trough that produced strong vertical lifting, and allowed for the transport of moisture into Nepal.

Secondly, the clearing that occurred on the morning of the 11th, with little reduction in wind speed, is typical of high-mountain environments. The bulk of moisture in the troposphere is not transported at jet-stream levels. During the warmer months of the year, the primary source of moisture in the Himalayas comes from the Bay of Bengal, with some moisture transported from the Arabian Sea as well. The important point is that just because the clouds dissipated on the morning of May 11, it didn't mean the storm had ended. In this particular case, moisture was moving into the region in a series of impulses. In this type of situation it's very easy for climbers to get 'suckered' into thinking that the storm is over, when in reality it's only in a lull. Trying to determine whether a storm is truly over is a very tough call while hanging on the side of a mountain. Even a seasoned meteorologist, without the help of computer models and weather observations from surrounding regions, would have a difficult time deciding whether or not the storm was indeed over. The primary indicators that a storm like this is dissipating are: a major decrease in cloud cover not only on the mountain itself, but in the surrounding areas as well, and a significant and sustained decrease in wind speeds.

Thirdly, Krakauer's account of the descent from the South Col to Camp II on May 12 clearly illustrates how the winds in the Western Cwm are no indication of wind speeds on the upper third of the mountain. The upper third of a mountain like Everest is considerably windier than the lower two-thirds for two reasons: first, the upper third is closer to the jet stream; and second, because the lower two-thirds is sheltered, in large part, by the surrounding higher terrain of the Lhotse-Nuptse ridge. The South Col is a natural wind tunnel for winds from the west to northwest, as air is squeezed between Everest and Lhotse. No one knows how much wind acceleration occurs on the South Col, but at times it's probably substantial.

In terms of the severity of the May 10-12 storm, from a meteorological perspective, it could have been considerably worse. In fact, according to Everest storm standards, we would have to speculate that this was probably an "average" storm. This could have been a worse storm in several ways. The winds were strong, but they could have been considerably stronger. For example, if the jet streak (area of very strong winds) located over northern India/Pakistan, had moved over Nepal on the 11th, there probably would have been fewer survivors. In addition, the blizzard conditions and associated low visibility could have been continuous. The clear skies on the mornings of the 11th and 12th certainly were a much-needed break for the survivors who were on the South Col.

K2: August 1986

During the 1986 climbing season on K2 (8611 m), 13 climbers were killed, five of whom died while high up on the mountain during the storm of August 4-10. This event differs from Everest in 1996 in two respects: the climbers on K2 all had considerable high-altitude experience; and the storm that began on August 4 continued, except for several short periods, almost totally unabated for 6 days.

For a description of this event I have relied on the narrative of Jim Curran in his book- K2: Triumph and Tragedy (1987). I have also to some degree used Kurt Diemberger's-: K2, Mountain of Dreams and Destiny (found in- The Endless Knot. 1999).

On August 3, the day before the storm began, a team of Korean climbers reached the summit of K2. In the course of their summit climb, three meteorological events were occurring: first, wispy clouds were starting to form around the summit pyramid; second, wind speeds were increasing, and finally, a cloud cap was forming over neighboring Broad Peak (8010 m). The wispy cloud forming around the summit in and of itself is not much of an indicator of changing weather. The modest increase in wind speeds, is important, especially when it occurs in conjunction with additional factors. The developing cloud cap over Broad Peak signifies that the moisture content of the atmosphere was increasing.

These three factors in combination, should have been an indicator to those high on the mountain that the weather was probably going to deteriorate. The questions that the climbers should have been asking themselves were: if a storm develops, how long will it last, and how adverse will the conditions get? No one has ever studied the frequency or duration of major storms in the Karakoram or Himalayas. But most climbers, based on previous experience, know that a storm of moderate intensity generally lasts two to three days. Over the course of the climbing season however, it's not uncommon for these giant peaks to get hit by several storms that can last for a week. As it turned out, the August 4-10 storm was one of those where the only safe place to be was base camp.

Figure 1.3 shows the 300-mb height field (in meters) during the early days of the storm. A trough of low pressure had formed over the Caspian and Aral Seas around August 2. This trough intensified and moved south, reaching the Karakoram on the night of the 4th/5th. Over the next week, this system slowly moved to the east. The area of strongest winds associated with the trough was located to the northeast of the Karakoram for most of the event. For example, the 200 mb (11,500 m or 37,700 ft) wind speeds exceeded 50 m/s (110 mph). By the 11th, the trough had

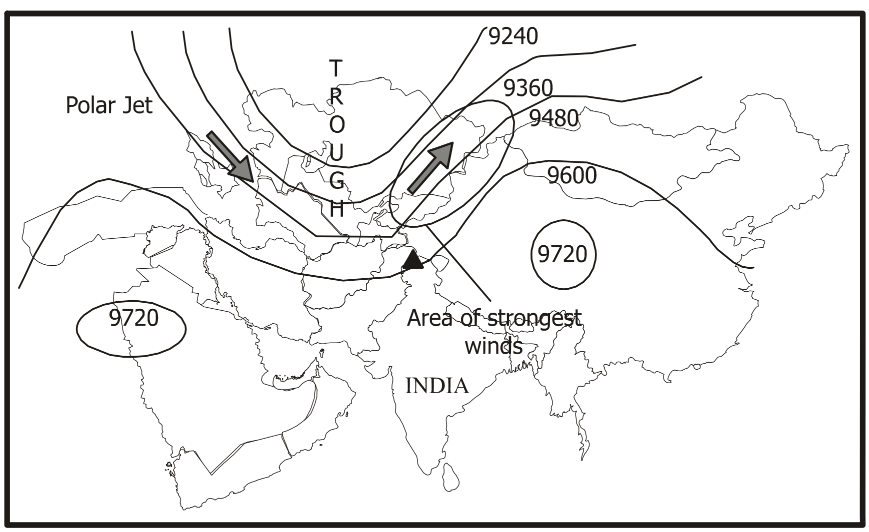

Figure 1.3- 300 mb geopotential heights for August 6, 1986. K2 is denoted by a solid triangle. The strongest winds are over Central Asia.

almost completely dissipated, but strong westerly winds continued to blow over much of central Asia.

Middle and upper-level winds over the Karakoram are displayed in Figure 1.4 (this data is from standard meteorological analysis). Notice the weak winds at both 5800 m (19,000 ft) and 7500 m (24,600 ft). Jim Curran, who was at Base Camp (5500 m) during the storm, indicates in his book that the winds were periodically much stronger than what is shown in figure 1.4. Likewise, at higher elevations the winds were no doubt considerably stronger than what is depicted. Temperatures at 8000 m (26,000 ft) during this storm were about -18°C (0°F). Combined with a wind of 18 m/s (40 mph), that would produce a wind chill in the neighborhood of -47°C (-53°F).

Storm Awareness

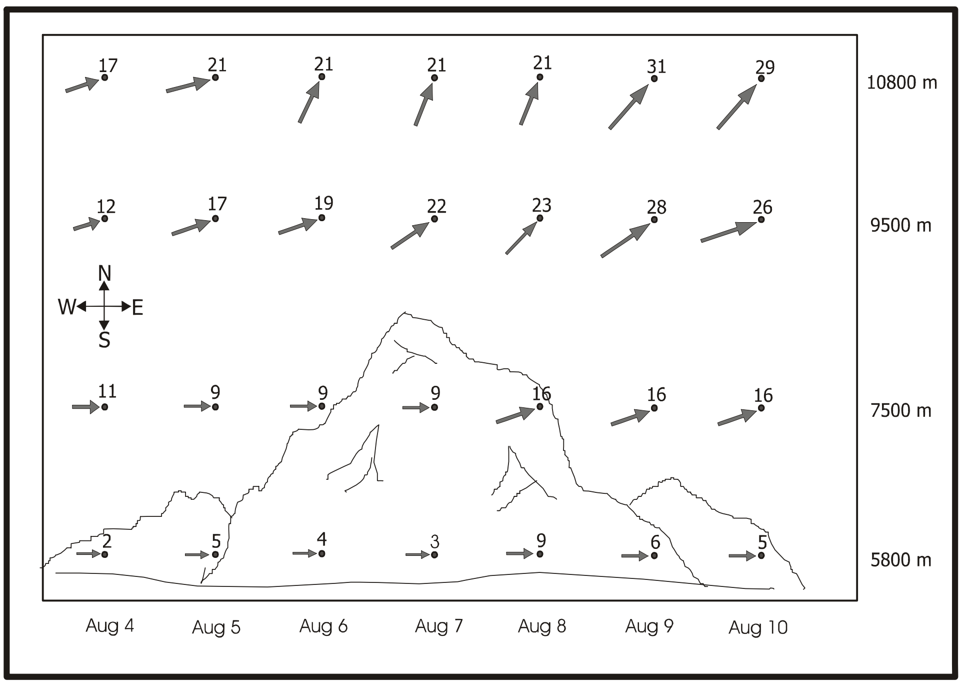

Figure 1.4- Winds over the Karakorum region August 4-10, 1986. Arrows indicate wind direction while numbers show wind speed (m/s).

The following is a list of weather parameters that you can use to monitor the evolution of mountain storms. Notice that these guidelines are pretty general, for example; "substantial increase in wind speed". The reason for this is because conditions vary from storm-to-storm. Remember that meteorology is not an exact science. In some situations a 10 m/s (22 mph) increase in wind speed may be significant, in other cases it may not. Also, changes in one or two of these parameters may occur without the development of a storm. However, when a number of them change, beware! Where appropriate we have given some rough indication of the duration in which these parameters should change.

<u>Pre-storm</u>

- Drop in barometric pressure [rising altimeter] (> 4 hours)

- During the summer months, large storms transport cooler air-therefore a drop in temperature of 4° C (7° F) or more over a period of 6 to 12 hours is significant.
- Thick layer of clouds on horizon. Usually in the direction of the prevailing wind.
- Formation of cloud caps and lenticular clouds.
- The height of the cloud base continues to lower.

Storm Development

- Substantial increase in wind speed.
- Significant change in wind direction-may or may not occur. When a front moves across a region winds will frequently change direction. (< 2 hours)
- Rapid build-up of clouds. (1-2 hours)

Diminishing Storm

- An extended period of decreased winds, including a reduction in the frequency and intensity of wind gusts. (> 4 hours)
- Depletion of moisture- this will result in a reduction in cloud cover not only in your immediate surrounding, but across the region as well.
- Increase in barometric pressure [falling altimeter]- this indicates that the storm is weakening or moving out of the region. (> 4 hours)