Storms and Avalanches of November 1995, Khumbu Himal, Nepal

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ABSTRACT

A severe storm struck the Nepal Himalaya on November 9 and 10, 1995. This storm was the most intense event to occur during the autumn in at least 50 years. The autumn season in the Himalaya tends to be quite dry, so this storm seemed extraordinary. Precipitation gages at lower elevations caught 50 to 200 mm of rain during the storm. Cold temperatures led to snowfall above 3,500 m in the Khumbu region of east Nepal, and snow depths increased rapidly with elevation. About 30-50 cm of snow fell at 3,800 m; 50-100 cm of snow was found at about 4,000 m; and 100-200 cm of snow was deposited above 5,000 m. The intense snowfall generated numerous avalanches throughout the region. A few had tragic consequences. The worst incident occurred near the village of Pangkha in the Gokyo Valley where a crowded lodge was destroyed by an isolated avalanche. Twenty-four people were killed there. Seven other deaths resulted from an avalanche in the Kanchenjunga area of far eastern Nepal. Many other people were involved in non-fatal avalanche accidents. Hundreds of people were stranded by the deep snows and approximately 550 people were flown out of the snow zone by helicopters. At least 100 animals were lost by burial in the deep snows. Village life in the higher areas was disrupted through much of the winter. The residual deep snows resulted in another avalanche cycle in March as percolating melt water destabilized slopes.

INTRODUCTION

The snow climate and avalanche regime of the Nepal Himalaya is poorly documented in western literature. Occasional scientific work has been conducted in association with mountaineering expeditions (e.g., Roch, 1954; Muller, 1959), and some expedition reports contain anecdotal information that might be useful to compile. Much of our current knowledge has been developed during the Japanese Glaciological Expedition to Nepal (e.g., Higuchi, 1976 and 1993). Nepal's Department of Hydrology and Meteorology has expanded routine data collection into higher elevation areas in recent years (Grabs and Pokhrel, 1993). If these stations can be continued, the systematic record should eventually yield a characterization of the snow climate of the Nepal Himalaya. However, for now, we are left with sporadic snapshots of storm activity and snow cover of this high mountain area. This paper provides a brief description of the most severe snow storm and avalanche cycle known to have occurred in east Nepal.

The climate of the Himalayan region is dominated by the monsoon circulation that results in high precipitation from June through September, and relatively little precipitation during the balance of the year (e.g., Mani, 1981). About 75-80 percent of the annual precipitation of the Khumbu Himal (Mount Everest region) of east Nepal occurs during the summer monsoon period (Inoue, 1976). Average annual precipitation at valley stations is about one meter at elevations of 3,400 to 3,900 m, and less than a half meter at 4,400 m (Inoue, 1976). There are indications that precipitation may be considerably greater on the upper slopes than in the valleys in this area (Higuchi, et al. 1982). Although extraordinary amounts of rainfall (hundreds of millimeters per day) can occur during the summer in the Himalayan foothills, daily amounts exceeding 50 mm are relatively rare in the high-elevation valleys of the Khumbu Himal. In the post-monsoon period, skies are typically cloud-free and precipitation is unusual (Yasunari, 1976). During winter, westerly disturbances occasionally deposit a few centimeters of snow. Total winter-season accumulation at two sites above 5,500 m in the Langtang region of central Nepal averaged about 200 mm of water equivalence (Steinegger, et al., 1993). This region is believed to receive considerably more precipitation than the Khumbu area (Steinegger, et al., 1993).

Avalanches are not known to have been the subject of any systematic study in the Nepal Himalaya. Most of the scientific work on Himalayan avalanches has been conducted at the Snow and Avalanche Study Establishment in Manali, India (e.g., Mohan Rao, et al., 1987). Additional research has been conducted even farther west in the Karakorum (e.g., de Scally and Gardner, 1990 and 1994). A brief description of avalanche phenomena in the Khumbu Himal was written by Andre Roch (1954) during the Swiss reconnaissance expeditions to Mount Everest. Most of the observations of avalanches in the area have been made by climbers. Avalanches on the high peaks have killed a surprisingly large fraction of climbers, especially when expressed in relation to successful ascents (McClung, 1981). The avalanche hazard to Himalayan climbers ranges from small sluffs that cause a climber to fall to giant ice avalanches that descend thousands of meters and impact exposed base camps (McClung, 1981). Countless mountaineering articles describe avalanche releases from the steep terrain after even a few centimeters of snowfall.

THE STORM OF NOVEMBER 1995

Although cyclonic storms routinely develop in the Bay of Bengal in the post-monsoon period, they typically remain at low latitudes and do not approach the Himalaya. The storm that began to develop on November 7, 1995 did not appear unusual at its onset. However, it soon took a trajectory almost due north, the only such event documented in November between 1891 and 1970 (more recent storm track data was not available) (Yamada, et al., 1996). Initially, the path of the storm was directed toward west-central Nepal, but rapidly changing circulation moved the air mass into east Nepal on November 9. Orographic lifting

resulted in heavy precipitation in the higher Himalaya. Unfortunately, the Department of Meteorology failed to forecast the trajectory of the storm or its intensity and did not issue any special warnings inside Nepal. However, both the BBC and CNN were broadcasting special bulletins about the developing cyclone. The Department's weather stations at higher elevations apparently were not functional at the time of the storm and have not provided any storm data. A spokesman for the Department was quoted as saying, "Obviously, things have gotten totally out of hand" (Kathmandu Post, November 17 and The Nepal Digest).

Some indications of precipitation amounts were compiled from news stories, trekker's accounts, and interviews with residents. In the Hinku Valley south of Khumbu, snow began falling mid-morning on November 9 and continued until late on November 10 — about 36 hours. In the Imja Valley in the heart of Khumbu, snowfall did not begin until the afternoon of the 10th. Rainfall at lower-elevation stations in east Nepal was 8 to 30 times greater than average rainfall for the entire month of November (News from Nepal, Dec. 1995). Rainfall for November 9 and 10 at two of the closest reporting stations, Dhankuta and Taplejung, was 220 mm and 150 mm, respectively. Estimates of storm precipitation at two sites in the Khumbu area were 120 mm at Syangboche (3,800 m) and 160 mm at Pangkha (4,500 m) (Yamada, et al., 1996). During the storm, air temperatures varied between 0 and -3°C at Syangboche (3,800 m) and Khumbu Glacier (5,000 m). Only rain was observed below 3,500 m.

The deposition of snow was highly unusual for the Khumbu area with the greatest precipitation in the higher-elevation valleys, generally considered to be subject to a rain-shadow influence. A mixture of rain and snow was observed at the Tengboche monastery (3,900 m) where the maximum snow depth did not exceed 0.5 m. Snow in Dingboche (4,300 m) briefly rose above the tops of some windows, 1.5 to 2 m. Similar depths were reported in Gorak Shep (5,200 m, near Everest base camp) and in the Gokyo Valley above 5,000 m. Reports of maximum snow depth in the Hinku Valley were also up to 2 m. Snow in the western valley of the Khumbu region was up to 1.5 m deep in the village of Thame, where no one walked in or out for 8 days. Movement was extremely difficult throughout the higher elevations in the first days following the storm. Several hours were required to break trail of even a few hundred meters. Because deep snow is almost unknown in the area, skis or snowshoes are not kept in local homes. Settling of the storm's snow cover was rapid, and depths had declined to 1.2 m in Gorak Shep (5,200 m) and 0.6 m in Periche (4,250 m) by November 14 (Yamada, et al., 1996).

AVALANCHES AND CASUALTIES

The deep and intense snowfall on steep terrain obviously resulted in widespread instability, and avalanches released throughout the Khumbu. Most of the slides occurred on November 10 and 11, during and shortly after the storm. The worst tragedy occurred in the village of Pangkha, in the Gokyo valley, where one trekkers' lodge was destroyed. The lodge was occupied by 13 Japanese and 12 Nepali guides and porters when the avalanche struck. All occupants were killed except a 17-year-old kitchen boy who survived burial in the wreckage for 40 hours before being rescued. The lodge and another unoccupied house happened to be in the runout zone of two avalanches that descended about 300 m and 800 m in isolated narrow tracks before joining just above Pangkha (Yamada, et al., 1996). About 50 cm of snow fell after this avalanche occurred. In far eastern Nepal near the base camp for Kanchenjunga, four Nepalis and three Japanese perished in another avalanche. Official government counts attributed 33 deaths to avalanches and about 30 other deaths to storm-related causes. The Trekking Workers' Association of Nepal claims that many additional porters perished (Limbu, 1995). Many other cases of partial burial by avalanches and near-misses were reported by the news media. Two houses are known to have been damaged by avalanches in Dingboche, and heavy snow loads collapsed several roofs, including one of the buildings of the Khumjung school. At least 100 animals were lost by burial in the deep snows.

Given the potential for catastrophe from such an intense storm, casualties could be considered remarkably low. Fortunately, the storm coincided with the Mani Rimdu festival at the Tengboche monastery, which attracted more than 1,000 trekkers and their support staffs to the relatively low elevation of Tengboche (3,900 m) where snow accumulation was not excessive. If the storm had occurred a few days before or after the festival, hundreds of additional people would have been at higher elevations and exposed to the avalanche hazard.

RESCUE EFFORTS

Most people stranded by the storm waited for the snow to settle before attempted to move or laboriously struggled towards lower altitudes. The first news of the avalanches and deep snow reached Kathmandu on the afternoon of November 11. A rescue mission began to form as a joint effort among the police, army, Himalayan Rescue Association, Nepal Mountaineering Association, trekking companies, Ministry of Tourism, and airlines with helicopters available. The first helicopters arrived in Khumbu on the morning of November 12 and began relaying people from high-elevation villages and mountaineering camps to the snow line. A few people were transported to Kathmandu for medical attention. The official count states that 300 Nepalis and 250 foreigners were rescued by helicopter between November 12 and 16 (News from Nepal, December 1995). This effort was the largest rescue mission in Nepal's history and was aided by the recent availability of large Russian helicopters in commercial service.

SUBSEQUENT STORMS

Two additional storms in late November deposited more than 30 cm of snow in some parts of the upper Khumbu region, resulting in an unusually deep winter snow cover. Strong radiative cooling and low temperatures during the winter resulted in metamorphism to kinetic-growth forms. By March 1996, some of the snow cover near Thame and Dingboche consisted of about 50 cm of depth hoar, overlain by a wet layer of melt-freeze clusters. A significant wet-

snow avalanche cycle was evident on many slopes that still held residual snow from November.

Other storms and tragic events in 1996 may suggest that severe weather was more common in the past year. Some climatologists believe that the climate of many regions is shifting toward extremes. On March 24, 1996, an avalanche onto the main highway linking Sichuan and Tibet resulted in 56 deaths. On May 10, 1996, a severe and widely publicized storm on Mount Everest led to 8 deaths. An unusually cold storm during the monsoon period killed more than 100 religious pilgrims near Amarnath in northern India on August 23, 1996. Regardless of any climate-change indications, this series of events in the Himalayan region during 1995-1996 clearly demonstrates that more people are becoming exposed to natural hazards in the high mountains.

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