SAMPLE

Earth's Dynamic Systems: Avalanches

Snow in Motion

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Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

An avalanche is a rapid flow of snow down a slope, such as a hill or mountain. Avalanches can be triggered spontaneously, by factors such as increased precipitation or snowpack weakening, or by external means such as humans, other animals, and earthquakes. Primarily composed of flowing snow and air, large avalanches have the capability to capture and move ice, rocks, and trees.

Avalanches occur in two general forms, or combinations thereof: slab avalanches made of tightly packed snow, triggered by a collapse of an underlying weak snow layer, and loose snow avalanches made of looser snow.

After being set off, avalanches usually accelerate rapidly and grow in mass and volume as they capture more snow. If an avalanche moves fast enough, some of the snow may mix with the air, forming a powder snow avalanche.

Though they appear to share similarities, avalanches are distinct from slush flows, mudslides, rock slides, and serac collapses. They are also different from large scale movements of ice. Avalanches can happen in any mountain range that has an enduring snowpack. They are most frequent in winter or spring, but may occur at any time of the year. In mountainous areas, avalanches are among the most serious natural hazards to life and property, so great efforts are made in avalanche control.

There are many classification systems for the different forms of avalanches. Avalanches can be described by their size, destructive potential, initiation mechanism, composition, and dynamics. Most avalanches occur spontaneously during storms under increased load due to snowfall and/or erosion. Metamorphic changes in the snowpack, such as melting due to solar radiation, is the second-largest cause of natural avalanches. Other natural causes include rain, earthquakes, rockfall, and icefall. Artificial triggers of avalanches include skiers, snowmobiles, and controlled explosive work.

A snowpack will fail when the load exceeds the strength. The load is straightforward; it is the weight of the snow. However, the strength of the snowpack is much more difficult to determine and is extremely heterogeneous.

Second, the relationship between readily observable snowpack characteristics and the snowpack's critical mechanical properties has not been completely developed.

That gap between what can be observed and what must be known is the space this book explores. The chapters that follow treat avalanches the way modern

snow science does: as a phenomenon with a discoverable structure — layers, climates, mechanics, statistics — that rewards systematic study while punishing casual confidence. The hazards that follow people into the mountains have rarely been tamed by engineering alone; they have been tamed by being understood, and avalanches are becoming one of the discipline's clearest case studies.

Chapter 1: The Discovery of Avalanches

It varies in detail with properties of the snow grains, size, density, morphology, temperature, water content; and the properties of the bonds between the grains. These properties may all metamorphose in time according to the local humidity, water vapour flux, temperature and heat flux. The top of the snowpack is also extensively influenced by incoming radiation and the local air flow.

One of the aims of avalanche research is to develop and validate computer models that can describe the evolution of the seasonal snowpack over time. A complicating factor is the complex interaction of terrain and weather, which causes significant spatial and temporal variability of the depths, crystal forms, and layering of the seasonal snowpack. Slab avalanches are formed frequently in snow that has been deposited, or deposited by wind.

They have the characteristic appearance of a block (slab) of snow cut out from its surroundings by fractures. Elements of slab avalanches include a crown fracture at the top of the start zone, flank fractures on the sides of the start zones, and a fracture at the bottom called the stauchwall. The crown and flank fractures are vertical walls in the snow delineating the snow that was entrained in the avalanche from the snow that remained on the slope.

Slabs can vary in thickness from a few centimetres to three metres. Slab avalanches account for around 90% of avalanche-related fatalities. The largest avalanches form turbulent suspension currents known as powder snow avalanches or mixed avalanches, a kind of gravity current. These consist of a powder cloud, which overlies a dense avalanche. They can form from any type of snow or initiation mechanism, but usually occur with fresh dry powder.

They can exceed speeds of 300 km/h (190 mph), and masses of 1,000,000 tons; their flows can travel long distances along flat valley bottoms and even uphill for short distances. In contrast to powder snow avalanches, wet snow avalanches are a low velocity suspension of snow and water, with the flow confined to the track surface (McClung, 1999, p. 108). The low speed of travel is due to the friction between the sliding surface of the track and the water saturated flow.

Despite the low speed of travel (?10-40 km/h), wet snow avalanches are capable of generating powerful destructive forces, due to the large mass and density. The body of the flow of a wet snow avalanche can plough through soft snow, and can scour boulders, earth, trees, and other vegetation; leaving exposed and often scored ground in the avalanche track.

Wet snow avalanches can be initiated from either loose snow releases, or slab releases, and only occur in snowpacks that are water saturated and isothermally equilibrated to the melting point of water. The isothermal characteristic of wet snow avalanches has led to the secondary term of isothermal slides found in the literature (for example in Daffern, 1999, p. 93).

At temperate latitudes wet snow avalanches are frequently associated with climatic avalanche cycles at the end of the winter season, when there is significant daytime warming.

An ice avalanche occurs when a large piece of ice, such as from a serac or calving glacier, falls onto ice (such as the Khumbu Icefall), triggering a movement of broken ice chunks. The resulting movement is more analogous to a rockfall or a landslide than a snow avalanche. They are typically very difficult to predict and almost impossible to mitigate.

As an avalanche moves down a slope it follows a certain pathway that is dependent on the slope's degree of steepness and the volume of snow/ice involved in the mass movement. The origin of an avalanche is called the Starting Point and typically occurs on a 30-45 degree slope. The body of the pathway is called the Track of the avalanche and usually occurs on a 20-30 degree slope. When the avalanche loses its momentum and eventually stops it reaches the Runout Zone.

This usually occurs when the slope has reached a steepness that is less than 20 degrees. These degrees are not consistently true due to the fact that each avalanche is unique depending on the stability of the snowpack that it was derived from as well as the environmental or human influences that triggered the mass movement. People caught in avalanches can die from suffocation, trauma, or hypothermia. From "1950-1951 to 2020-2021" there were 1,169 people who died in avalanches in the United States.

For the 11-year period ending April 2006, 445 people died in avalanches throughout North America. On average, 28 people die in avalanches every winter in the United States. In 2001 it was reported that globally an average of 150 people die each year from avalanches. Doug Fesler and Jill Fredston developed a conceptual model of the three primary elements of avalanches: terrain, weather, and snowpack.

Descriptors vary depending on country. There are nine different types of avalanche problems:

Storm slab

Wind slab

Wet slab avalanches

Persistent slab

Deep persistent slab

Loose dry avalanches

Loose wet avalanches

Glide avalanches

Cornice fall

The Canadian classification for avalanche size is based upon the consequences of the avalanche. Half sizes are commonly used.

Both size scales range from 1 to 5. With the D-scale, half sizes can be used.

The discovery of all this is oddly recent for a hazard so old. Systematic classification began only in the twentieth century, when ski touring and alpine warfare pushed people onto winter slopes in numbers great enough to generate statistics, and the science that follows in later chapters — pits, layers, weak crystals, fracture mechanics — grew from the accident record backwards. Every classification in this chapter began as a coroner's question.

The accident record that drove this discovery was assembled almost entirely in the twentieth century, and it carries a geography: the Alps first, then North America's mountain west, then Japan's snow country, the Norwegian fjords, the Himalaya, and the Andes, each adding its own terrain and its own snow climate to the sample. What emerged was not one avalanche problem but a family of regional regimes, which is why the classifications here read like a field guide rather than a taxonomy: they are organised around what a practitioner needs to notice in the minutes before making a decision, not around what a museum would label.

The vocabulary of the subject rewards attention at the start. A "slab" throughout this book means cohesive snow over something weaker; a "weak layer" means a horizon that fails first; a "release" means the moment a slope converts stored storm energy into motion; and a "burial" means the outcome that turns a meteorological event into a medical emergency. Holding those four terms steady, the chapters that follow can afford to vary everything else

— climates, instruments, continents — and still be talking about one thing.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.